EPSON

EPSON RC+ 7.0 Option

Force Guide 7.0

Rev.6

EM186S3692F

EPSON RC+ 7.0 Option   Force Guide 7.0   Rev.6

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FOREWORD

Thank you for purchasing our robot products. This manual contains the information necessary for the correct use of the Force Guide7.0.

Please carefully read this manual and other related manuals when using this software.

Keep this manual in a handy location for easy access at all times.

WARRANTY

The robot and its optional parts are shipped to our customers only after being subjected to the strictest quality controls, tests and inspections to certify its compliance with our high performance standards.

Product malfunctions resulting from normal handling or operation will be repaired free of charge during the normal warranty period. (Please ask your Regional Sales Office for warranty period information.)

However, customers will be charged for repairs in the following cases (even if they occur during the warranty period):

1. Damage or malfunction caused by improper use which is not described in the manual, or careless use.
2. Malfunctions caused by customers' unauthorized disassembly.
3. Damage due to improper adjustments or unauthorized repair attempts.
4. Damage caused by natural disasters such as earthquake, flood, etc.

Warnings, Cautions, Usage:

1. If the robot or associated equipment is used outside of the usage conditions and product specifications described in the manuals, this warranty is void.
2. If you do not follow the WARNINGS and CAUTIONS in this manual, we cannot be responsible for any malfunction or accident, even if the result is injury or death.
3. We cannot foresee all possible dangers and consequences. Therefore, this manual cannot warn the user of all possible hazards.

TRADEMARKS

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TRADEMARK NOTIFICATION IN THIS MANUAL

Microsoft® Windows® XP Operating system
Microsoft® Windows® Vista Operating system
Microsoft® Windows® 7 Operating system
Microsoft® Windows® 8 Operating system
Microsoft® Windows® 10 Operating system

Throughout this manual, Windows XP, Windows Vista, Windows 7, Windows 8, and Windows 10 refer to above respective operating systems. In some cases, Windows refers generically to Windows XP, Windows Vista, Windows 7, Windows 8, and Windows 10.

NOTICE

No part of this manual may be copied or reproduced without authorization.

The contents of this manual are subject to change without notice.

Please notify us if you should find any errors in this manual or if you have any comments regarding its contents.

MANUFACTURER

SEIKO EPSON CORPORATION

SAFETY PRECAUTIONS

Installation of robots and robotic equipment should only be performed by qualified personnel in accordance with national and local codes. Please carefully read this manual and other related manuals when using this software.
Keep this manual in a handy location for easy access at all times.

⚠ WARNING	This symbol indicates that a danger of possible serious injury or death exists if the associated instructions are not followed properly.
⚠ CAUTION	This symbol indicates that a danger of possible harm to people or physical damage to equipment and facilities exists if the associated instructions are not followed properly.

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Installation

The following chapters contain information to be known before using Force Guide 7.0.
Please be sure to read these chapters.

1. Introduction

1.1 Overview of Force Guide 7.0

Force Guide 7.0 is an option product and generic name for the following parts:

Force sensor
Intermediate unit (between force sensor and robot controller)
Cable
Software

Force Guide 7.0 supports various applications such as Peg In Hole, surface processing, pressing, inspection or teaching.

It also allows jogging the robot while checking the output of force sensor and assists with shortening the teaching time.

Force Guide 7.0 has the following features.

Force Guidance Function

Operation using force control function, force trigger function, and force monitor function can be created by GUI without using SPEL+ language.

Force Control function

Position adjustment is done on the coordinate axis moved by external force independently. (Such as only Z-axis or U-axis)
Allows different control characteristics for each axis.
Covers tolerances of provided work pieces.

Force Trigger function

Keeps monitoring precise force, torque, and their changes.

- Possible to program the judgments of success and failure and the conditional branching with operations in an assigned task.
- Detects the position of an end of work piece or protruding and dent position.
- Detects force or torque abnormalities.

Force Monitor function

Displays charts of force, torque, and position information of the robot in different coordinate systems. Saves log files in PC.

- Read the saved files on the force monitor to analyze them. You can also read several files simultaneously and compare.
- Utilizes them for shorter optimization time and process management information.

Gravity compensation function

Minimizes the effect of gravity in the following functions while the orientation changes.
Force Control, Force Trigger, and Force Monitor functions.

Mass property wizard

Measures the gravity center and the mass of an end effector without CAD data or hand removal.

Impedance wizard

Estimates the effect of the Force Control parameters on motion.

1.2 Necessary Basic Knowledge of EPSON RC+ 7.0

Force Guide 7.0 is an option used in the EPSON RC+ 7.0 environment. Knowledge of the EPSON RC+ 7.0 development environment and EPSON robots is required to use Force Guide 7.0. This manual is intended for users who have knowledge about the following.

- Concept and use of the EPSON RC+ 7.0 project management
- Procedure to create and edit a SPEL$^+$ program in EPSON RC+ 7.0
- Procedure to run a SPEL$^+$ program from the Run window
- Basic language structure, functions, and use of SPEL$^+$

First-time users of EPSON RC+ 7.0 are required to take an introduction training course provided by Epson.

1.3 Training

Before using the Force Guide 7.0, be sure to take our “Force Sensing introduction training”. The training provides safe and easy operation of the product and also helps you to improve productivity of your system.

2. Definition of Terms

Position

Position of an object or a coordinate system in a coordinate system, expressed using position data (X, Y, Z).

Posture

Posture of an object or a coordinate system in a coordinate system, expressed using posture data (U, V, W).

Position/posture

Position and posture of an object or a coordinate system in a coordinate system, expressed using position and posture data (X, Y, Z, U, V, W).

Force Sensor

Sensor made by Epson, which detects the force and torque in six axes in the translation direction (Fx, Fy, Fz) and rotating direction (Tx, Ty, Tz). There are the following eight types.

S250N, S250L, S250P, S250H, S2503, S2506, S25010, SH250LH

Force Sensor I/F unit

Unit that connects the Epson sensor and the controller.
Connect the unit and the controller with a communication cable to use.

Force Sensor I/F board

Option board that connects the Epson sensor and the controller.
Mount the board on the option slot of the controller to use.

Sensor flange

Part to be mounted between the Force Sensor and the robot wrist flange to mount the Force Sensor to the robot.

Flange offset

Offset of the sensor flange. Use the bottom center position of the Force Sensor viewed from the tool 0 coordinate system of the robot as the origin and set the position and posture of the coordinate system so its direction aligns with the Force Sensor coordinate system.

Force functions

Functions using the Force Sensor provided by Force Guide 7.0.

Force Control function

Function to control the robot to achieve a given target force and torque using the Force Sensor.

Virtual inertia coefficient (Mass)

Parameter for the virtual mass of the force control function. It impacts the acceleration of the force control function.

Virtual viscosity coefficient (Damper)

Parameter for the virtual viscosity of the force control function. It impacts the speed of the force control function.

Virtual elasticity coefficient (Spring)

Parameter for the virtual spring coefficient of the force control function. It impacts the amount of movement of the force control function.

Force trigger function

Function to detect that the force and torque measured using the Force Sensor reached the set value and branch the process.

Force monitor function

Function to measure the force information detected by Force Sensor and the position information of the robot.

Force information	:	Force and torque detected by the force sensor.
Positon information	:	Command positions including the position control and the force control, command positions only including the position control, and the difference of the force control.

Measured data can be saved in the files. You can analyze or compare the saved files by reading them.

Force Guidance Function

Operation using the force control function, force trigger function, and force monitor function can be created by GUI without using SPEL+ language.

Force Sensor coordinate system

Coordinate system in which the Force Sensor detects the force. It is a Force Sensor-specific coordinate system. It cannot be changed.

Force coordinate system

Coordinate system in which the force functions are performed. It is defined by the offset of the currently used tool coordinate system.

Gravity compensation

Function to reduce the impact of gravity on the Force Sensor.

Mass properties

Mass characteristic parameter used for gravity compensation. Set the weight and gravity center position of all objects (hand, workpiece, etc.) mounted to the area closer to the tip than the Force Sensor.

Gravity direction

Direction of gravity relative to the robot used for gravity compensation. It is defined by gravity direction vectors (X, Y, Z) in the base coordinate system.

Force Guide Sequence

It is groupings of force guide objects that are required for operation in specific order.

Force Guide Object

The following is a group of processes that realizes specific motions used by force guidance function.
Types of force guide object are as follows:

- Contact Object
- Relax Object
- FollowMove Object
- SurfaceAlign Object
- PressProbe Object
- ContactProbe Object
- Press Object
- PressMove Object
- Decision Objects
- SPELFunc Object

Force object

A set of properties for each function that is necessary to use the force functions.
There are the following types of force objects.

- Force control object
- Force coordinate object
- Force trigger object
- Force monitor object

Force control object

Force object used for the force control function.

Force coordinate object

Force object for defining the coordinate system in which the force functions are performed.

Force trigger object

Force object for using the force trigger function.

Force monitor object

Force object for using the force monitor function.

Property

Parameters included in the below. Properties can be set and acquired.
  Force guide sequence
  Force guide object
  Force object

Result

It is included in the below and a value that is returned after the execution of force guide sequence or force guide object.
  Force guide sequence
  Force guide object

Status

Value included in the force object which is returned after a force function is executed.

Force File

File in which the force object is stored.

Force Editor

Graphical user interface (GUI) used to edit the force file. It can be opened from Robot Manager and Project Explorer.

Force Monitor

Graphical user interface (GUI) used to display the force sensor values or position of the robot in graphs.

Impedance Wizard

Wizard used to adjust the parameters of the force control function.

Mass/Gravity Wizard

Wizard used to adjust mass properties.

Rated Load

The maximum load to satisfy the specifications of the sensor.

Overload capacity

The maximum load to retain the sensor accuracy.

3. System Overview

There are two procedures as follows to use the Force Sensor.

1: Force Sensor I/F Unit
A procedure which connect the Force Sensor I/F unit and the robot controller with a communication cable.

2: Force Sensor I/F Board
A procedure which mount the Force Sensor I/F Board on the option slot of the robot controller.

Then, connect the Force Sensor and the Force Sensor I/F unit (or board) with a sensor cable and a Force Sensor M/I cable.

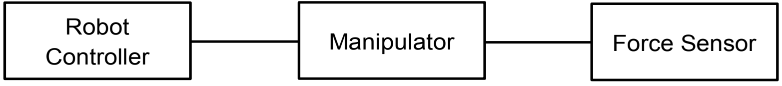
By connecting the Force Sensor and the Drive Unit, multiple manipulators and Force Sensors can be used together.

To use the Force Sensor I/F unit, install the Drive Unit at the following location and connect with cables:

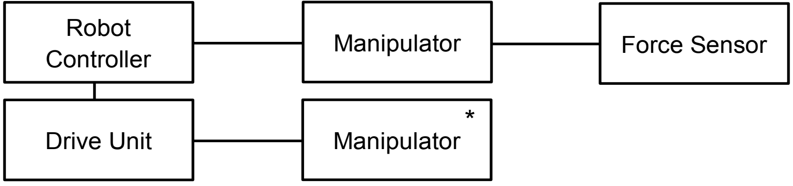
- IN connector of the Force Sensor I/F unit and
  OUT connector of the Robot Controller.
- Connect to the OUT connector of the Force Sensor I/F unit.

When using multiple manipulators and Force Sensors together, setup the system by any of the following combination patterns.

A: One Force Sensor
When using Force Sensor I/F unit or Force Sensor I/F board
One Manipulator (One Robot Controller)



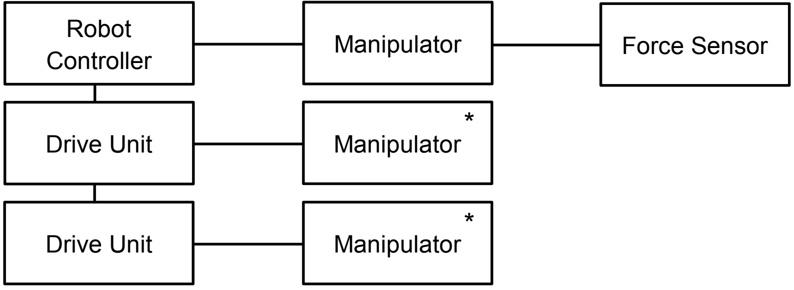
B: One Force Sensor
When using Force Sensor I/F unit
Two Manipulators (One Robot Controller and one Drive Unit)



C: One Force Sensor

When using Force Sensor I/F unit

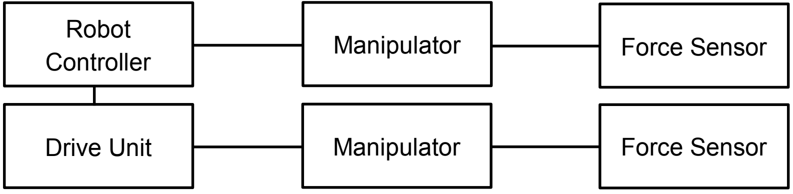
Three Manipulators (One Robot Controller and two Drive Units)



D: Two Force Sensors

When using Force Sensor I/F unit

Two Manipulators (One Robot Controller and one Drive Unit)

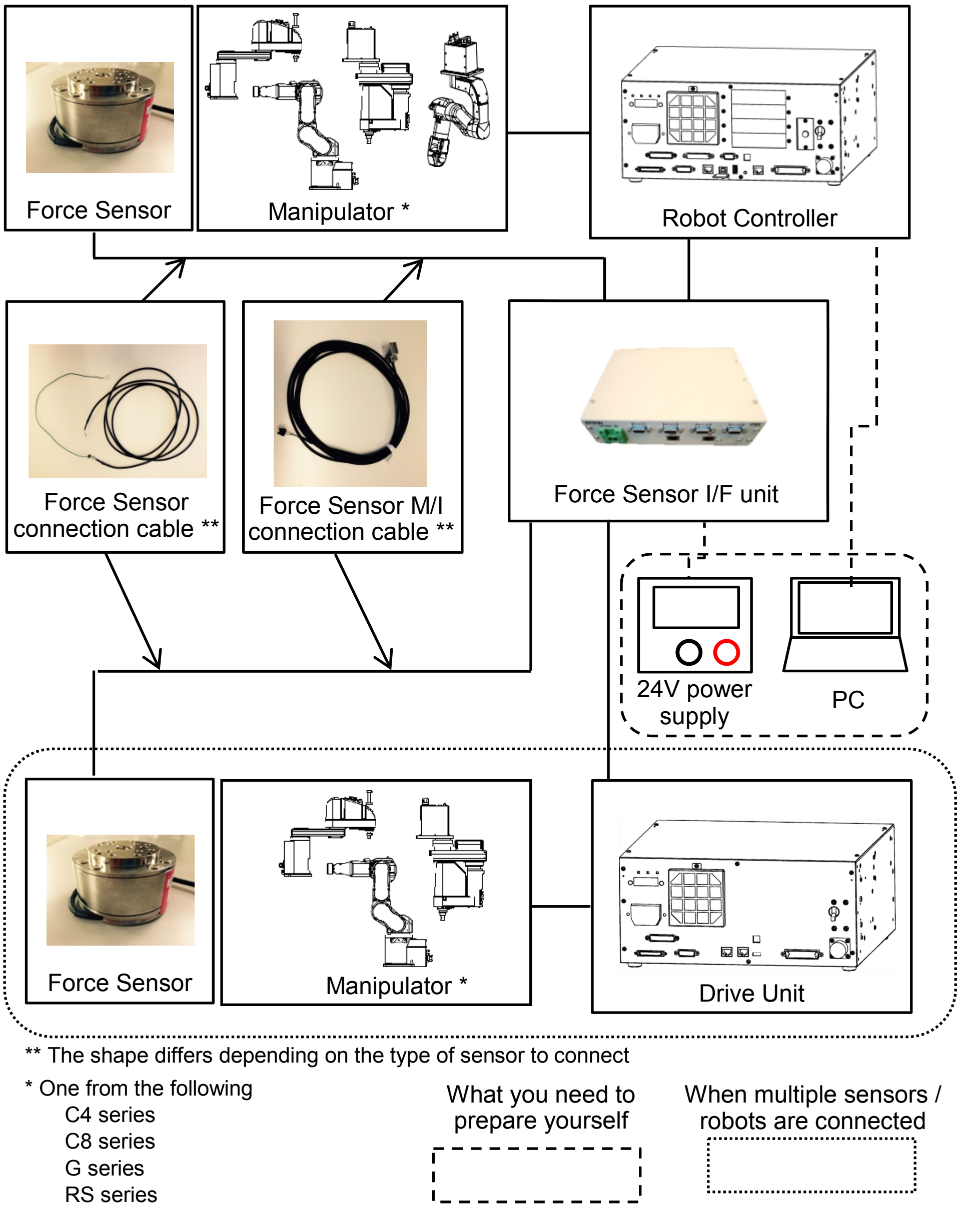


NOTE ☞

X5 series manipulators cannot use the Force Sensor.

However, X5 series manipulators can be used for Manipulators with “*” mark in the above diagrams as a part of the robot system.

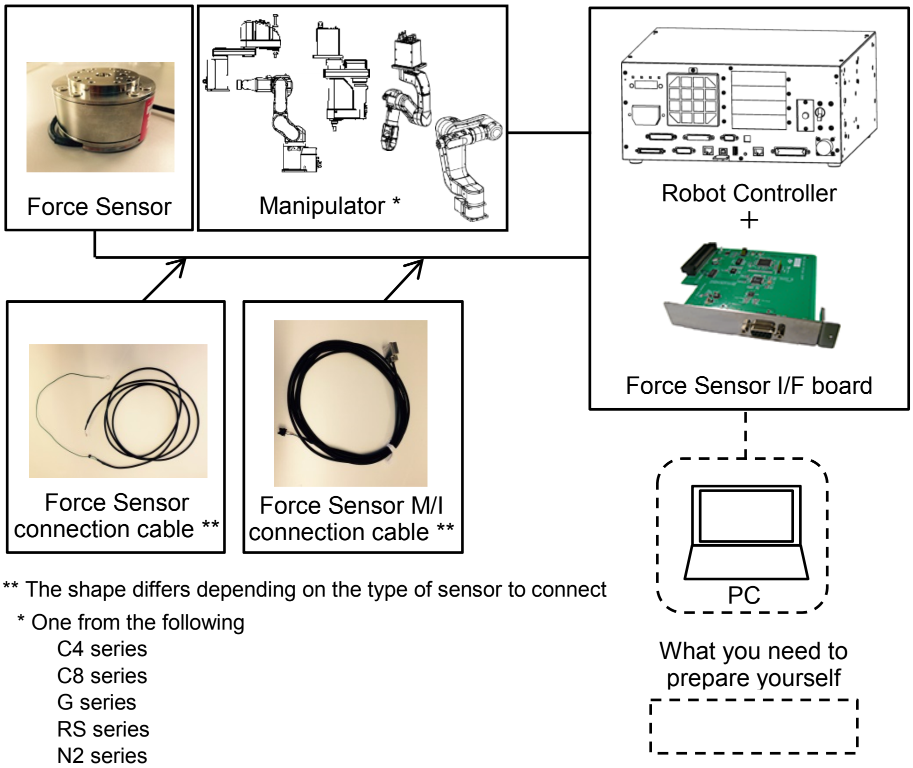
Example of system configuration using the Force Sensor I/F unit.



** The shape differs depending on the type of sensor to connect

* One from the following
- C4 series
- C8 series
- G series
- RS series
- N2 series (cannot be connected to the Drive Unit.)

Example of system configuration using the Force Sensor I/F board.



** The shape differs depending on the type of sensor to connect

* One from the following

C4 series
C8 series
G series
RS series
N2 series
N6 series

4. Functions of Force Guide 7.0

4.1 Overview

The following describes the main functions provided by Force Guide 7.0.

- Force control function
- Force trigger function
- Force monitor function
- Force guidance function

⚠ CAUTION	■ Functions provided by Force Guide 7.0 are not functions to ensure safety. To ensure safety, refer to and observe the safety regulations in each country and region.

4.2 Force Control Function

4.2.1 Overview of the Force Control Function

A force control function is a function to control the robot to achieve a given target force and torque using an Epson Force Sensor.

Normally, a robot moves to the given target position by position control. The force control function is used to ensure that a target force can be achieved. Furthermore, it enables the robot to perform high precision positioning and Peg In Hole tasks.

The force control function can be used in conjunction with normal CP operation commands or it can be used alone.

The force control function is performed in the specified coordinate system and can be performed independently in each of the six axes (X, Y, Z, U, V, and W). Therefore, the force control function can be enabled for all the axes at the same time or only for the specified axis.

Furthermore, since the characteristics of the force control function can be changed for each axis, it can be used for various applications; for example, the pressing operation is performed in an axis, while force is not controlled in another axis.

4.2.2 Parameters of the Force Control Function

The following describes the three important parameters of the force control function.

Force control with various characteristics can be performed by changing the following three parameters and target force.

Virtual inertia coefficient (Mass)

Virtual mass of the force control function. The unit is as follows.

Translation direction (Fx, Fy ,Fz)	: mN/(mm/sec^2)
Rotating direction (Tx, Ty, Tz)	: mN·mm/(deg/sec^2)

The mass parameter impacts the acceleration of the force control function. When the change in force is the same, decreasing the mass parameter increases the acceleration and increasing the mass parameter decreases the acceleration.

Virtual viscosity coefficient (Damper)

Virtual viscosity of the force control function. The unit is as follows.

Translation direction (Fx, Fy ,Fz) : N/(mm/sec)
Rotating direction (Tx, Ty, Tz) : N·mm/(deg/sec)

The damper parameter impacts the speed of the force control function. Decreasing the damper parameter increases the speed and the response to changes in force, but may cause the motion of the robot to become vibratory. Conversely, increasing the damper parameter decreases the speed and suppresses the vibration, but decreases the response to changes in force.

Virtual elasticity coefficient (Spring)

Virtual spring coefficient of the force control function. The unit is as follows.

Translation direction (Fx, Fy ,Fz): N/mm
Rotating direction (Tx, Ty, Tz): N·mm/(deg)

The spring parameter impacts the amount of movement of the force control function. Setting the spring parameter provides a virtual spring to limit the maximum amount of movement of the robot. Using this parameter can prevent the robot from interfering with objects around it.

Setting “0” does not limit the amount of movement. When the same constant force continues to be applied, decreasing the spring parameter increases the amount of movement, and increasing the spring parameter decreases the amount of movement.

4.3 Force Trigger Function

A force trigger function is a function to detect that the force and torque measured using an Epson Force Sensor reached the set value and branch the process.

The force trigger function can be used with the following commands.

Commands: TILL, Wait, Trap, Find

Using these commands can continue the operation until a certain force is reached or detect changes in force and find an edge or hole on a workpiece. They also can detect excessive force and process the error.

4.4 Force Monitor Function

Force monitor function is a function to measure the force information detected by Epson's Force Sensor and the position information of the robot.

Force information	:	Force and torque detected by the force sensor.
Positon information	:	Command positions including the position control and the force control, command positions only including the position control, and the difference of force control

The force monitor function can acquire and record forces applied during the operation and measure the average and peak values of the forces.

Measured data can be saved in the files. You can analyze or compare the saved files by reading them.

Using this function can adjust the parameters while creating an application, and record and manage forces applied during the operation for each workpiece.

4.5 Force Guidance Function

4.5.1 Overview of Force Guidance Function

Force guidance function creates an operation using force control function, force trigger function, and force monitor function without programming by SPEL+ language.

In the force guidance function, operations are created by the force guide sequence and the force guide object.

Force guide sequence
It is like a container that the required force guide objects are aligned in a specific order to execute whole or part of the specific operation.

Force guide object
It is like a specific process such as a specific motion including the force control function and conditional branching.

In the force guidance function, create a specific operation by aligning processes (force guide objects) in a container (force guide sequence).

Force guide sequence and force guide object have properties and results.

Property
Value that decides a process of force guide sequence or force guide object.
Depending on the property setting, different motion can be performed even the force guide object is the same.

Result
Value which indicates the execution result of the force guide sequence or force guide object.

4.5.2 Force Guide Sequence

Force guide sequence is like a container that the required force guide objects are aligned in a specific order to execute whole or part of the specific operation. Therefore, it is not possible to operate by force guide sequence alone. You can realize a specific operation by aligning force guide object.

In force guidance function, you can specify the force guide sequence and execute by SPEL+ or GUI.

Property of force guide sequence is a setting that affect to the whole force guide sequence or a process setting when executing the force guide sequence.

Result of force guide sequence displays the result of force guide sequence in [Value].

4.5.3 Force Guide Object(s)

It is like a specific process such as a specific motion including force control function or conditional branching.

In the force guidance function, it is not possible to execute by force guide object only. Always execute as the force guide sequence.

Basically, property of force guide object affect to force guide object. However, property setting of force guide object is restricted depending on the setting of previous object. For example, if connecting force control function of two force guide objects, property setting of the second force guide object will be restricted.

Result of force guide object displays the result of force guide object in [Value].

In the force guidance function, you can select the required force guide object(s) from the following ten force guide objects, and align them in the force guide sequence.

Contact Object

Contact object moves the robot to the specified direction until it contacts with an object such as a workpiece, and stops it when contacting with the object.
This object is used for positioning of the start position for other force guide objects or the grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, next motion or the force guide object can be executed stably since the contact position can be detected.

Relax Object

Relax object moves the robot to a position where the force to the specified direction will be “0”.
This object is used for safety releasing of pressing status after pressing by Press object or removal of extra force which is applied during assembly. Also, by combining with the hand motions, this object can follow and grasp. Even if the workpiece dimension or the grasp positions of the workpiece have a margin of error, the robot can grasp the workpiece stably without applying extra force.

FollowMove Object

FollowMove object moves the robot along with the specified path while following so that the force to the specified direction will be “0”.

This object is used for a move of the fixed path of operation targets such as opening/closing the door. In the case of the position control, the operation targets may get damages since extra force is applied if the path moves. However, FollowMove object controls the applied force to be “0”. Therefore, the robot can move operation targets without teaching the accurate path.

SurfaceAlign Object

SurfaceAlign object moves the robot to a position where the torque of the rotation direction will be “0” while the robot presses the workpiece to a specified direction.

At this time, the workpiece surface grasped by the robot and the surface of the working desk or the workpiece on the working desk is parallel. This object is used for positioning during assembly or stable placing of the workpiece. Stable contact status is provided even if the workpiece dimension or the grasp positions of the workpiece have a margin of error.

PressProbe Object

PressProbe object presses the workpiece grasped by the robot to the working desk or a workpiece on the working desk. Then, the robot moves along the specified path and stops when a hole or a convex shape is detected.

This object is used for detection of fitting holes or positioning during assembly. Hole position or a convex shape can be detected stably even if the workpiece dimension or the grasp position of the workpiece have a margin of error. We recommend using this object after the following objects:

Contact object
SurfaceAlign object
Press object.

ContactProbe Object

ContactProbe object moves the robot to the specified direction until it contacts with an object such as a workpiece, and detects a position that is moved for a specified distance as a hole. If the robot contacts with an object without moving the specified distance, returns to the start position and changes the position to repeat the contact motion.

This object is used for the hole position detection of workpiece that is difficult to perform by “PressProbe” such as lead part or connector. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the hole position can be detected stably.

Press Object

Press object operates the robot to press to the specified direction with the specified force. Also, as with Relax object, it is possible to follow another specified direction simultaneously. When executing the Press object without contacting, the robot moves to a direction of the specified force. This object is used for pressing of assembly. Even if the workpiece dimension or the grasp positions of the workpiece have a margin of error, the robot can maintain a certain amount of force.

PressMove Object

PressMove object moves the robot along with the specified path while pressing to the specified direction with the specified force.

Also, as with FollowMove object, it is possible to follow another specified direction simultaneously. When executing the PressMove object without contacting, the robot moves to a direction of the specified force in addition to the specified path. This object is used for pressing, screw driving, or polishing for Peg In Hole or assembly tasks. Even if the workpiece dimension or the grasp positions of the workpiece have a margin of error, the robot can maintain a certain amount of force to move.

Decision Object

Decision object changes the force guide object to be executed based on the results of the objects in the force guide sequence.

This object is used for determination for execution of PressProbe object for Peg In Hole task. This object allows executing the required force guide objects based on the actual motion status of the robot.

SPELFunc Object

SPELFunc object specifies a function in SPEL+ language and executes it.

This object is used when you want to execute functions except the force function such as I/O operations. This object is for advanced-level user.

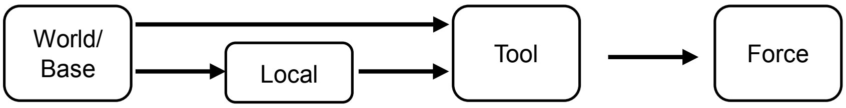
5. Coordinate Systems

5.1 About Coordinate Systems

The following describes the coordinate systems necessary to use Force Guide 7.0; in particular, the Force Sensor coordinate system and force coordinate system. All of the coordinate systems are right handed, and the following coordinate systems are used according to the application.

Robot Coordinate System	: Robot-specific coordinate system. This is also called a default base coordinate system (Base) or world coordinate system (World).
Local Coordinate System	: User-defined coordinate system positioned in the operation area. (Local)
Tool Coordinate System	: Coordinate system of a tool mounted to the sixth joint flange of the robot. (Tool) This is generally also called an end-effector coordinate system.
Force Coordinate System	: Coordinate system with an offset from the tool coordinate system. (Force) All of the force functions are performed in the force coordinate system.
Force Sensor Coordinate System	: Force Sensor-specific coordinate system, regardless of the robot. (ForceSensor)

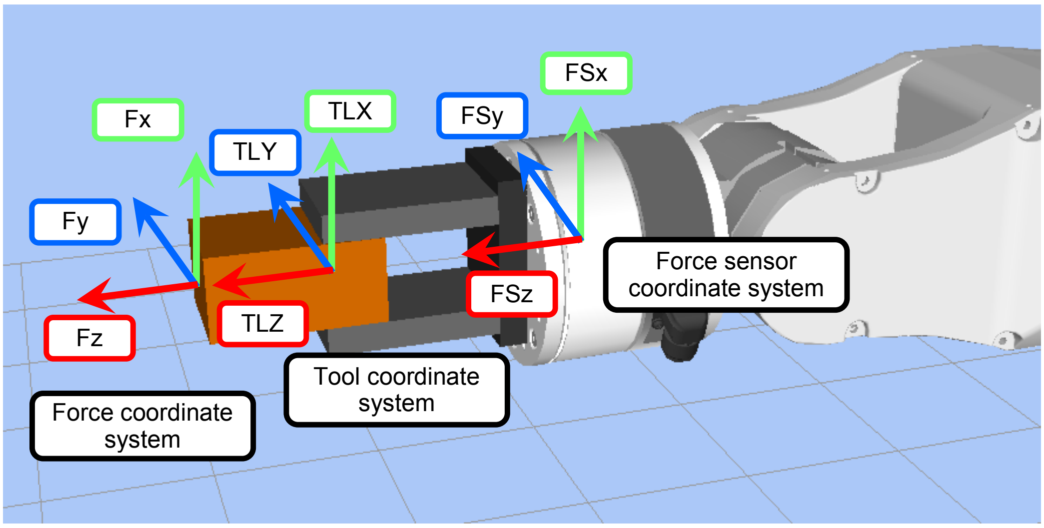
Changes in Position and Posture from Origin to Force Coordinate System



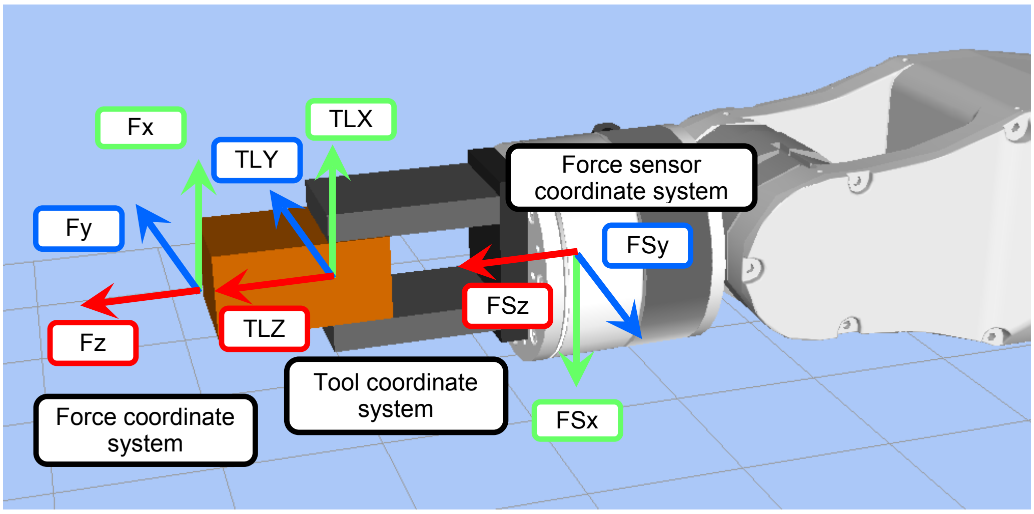
The force coordinate system is impacted by the robot, local, and tool coordinate systems. For details on the coordinate systems that have an impact on the force coordinate system, refer to the following manual.

EPSON RC+ 7.0 User's Control

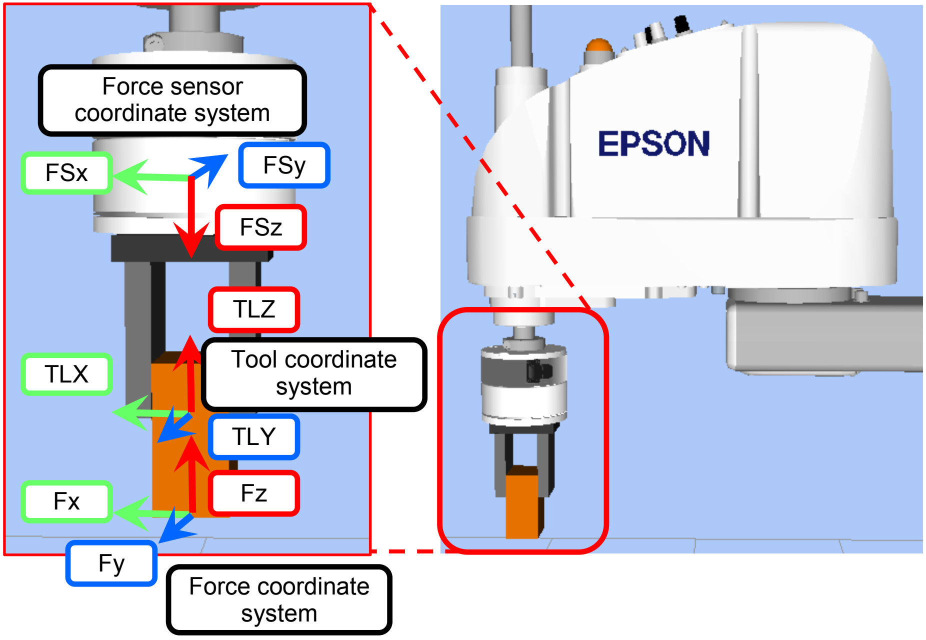
Example: Coordinate Systems of Tabletop-mounted 6-axis Robot



Example: Coordinate Systems of Ceiling-mounted 6-axis Robot



Example: Coordinate Systems of SCARA Robot



5.2 Force Coordinate System

A force coordinate system is a coordinate system in which the force functions are performed.

It is defined by translation directions (Fx, Fy, Fz) and rotating directions (Tx, Ty, Tz). Tx, Ty, and Tz represent a clockwise rotation in the positive directions of Fx, Fy, and Fz.

It is defined by the offset of the currently used tool coordinate system. Therefore, moving the robot or changing the tool settings changes the position and posture of the force coordinate system in the base coordinate system. For the force coordinate system, specify a position where a force is actually applied by contact, such as an edge of a workpiece.

In case of SPEL+ language:

The force coordinate system is defined by the force coordinate object FCS. It is set by the FSet statement or in the Force panel in Robot Manager.
The default force coordinate system is a coordinate system that is aligned with the selected tool coordinate system and is defined by FCS0. It cannot be changed.

In case of force guidance function:

The force coordinate system is defined by the property of force guide sequence.
It is set on the force guide window.

5.3 Force Sensor Coordinate System

Coordinate system in which the Force Sensor detects the force.

It is defined by translation Fx, Fy, Fz and axis rotating Tx, Ty, Tz. Tx, Ty, and Tz represent a clockwise rotation in the positive directions of Fx, Fy, and Fz.

It is Force Sensor-specific and cannot be changed. When using the force functions, force values detected in the Force Sensor coordinate system are automatically converted to those in the force coordinate system.

When the Force Sensor and the 6-axis robot are connected using an EPSON sensor flange, the Force Sensor can be mounted to a robot only in a unique manner, so a tabletop-mounted or ceiling-mounted robot rotates at 180 degrees around the TLZ axis in the tool 0 coordinate system when 0 Pulse is selected for the posture.

6. Setting Up Force Guide 7.0

The following describes the setup procedure to use Force Guide 7.0.

To use the force functions provided by Force Guide 7.0, perform the following tasks.

1. Setting up the robot system

   Refer to the following manual and set up the robot system.

   Safety Installation Manual

   EPSON RC+ 7.0 User's Guide

   Manipulator Manual

   Controller Manual

2. Checking the accessories

   Check the parts included in the Force Sensor package.
   For details, refer to the following section.

   Hardware: 1. Accessories

3. Mounting and wiring the Force Sensor

   Mount the Force Sensor to the robot and connect it with the controller.
   For details, refer to the following section.

   Hardware: 6. Mounting Procedure

4. Installing the software

   The software of Force Guide 7.0 is included in EPSON RC+ 7.0.
   For the installation procedure, refer to the following manual.

   EPSON RC+ 7.0 User's Guide

5. Setting up the Force Sensor

   First link the Force Sensor with the robot. Then, check that the Force Sensor is connected with the controller correctly and communication is successful.
   For details, refer to the following section.

   Software: 1. Checking the Connection

6. Configuring the Force Sensor correction

   Configure the settings necessary for Force Sensor correction and check that the sensor values that were corrected correctly in the force coordinate system can be acquired.
   For details, refer to the following section.

   Software: 2. Force Sensor Correction

7. Execute force function

   Execute each force functions.
   Select either 7-1 or 7-2. We recommend using force guidance function.

7-1. Execute force function by force guidance function

Execute each force function by combinations of force guide sequence and force guide object.

For details, refer to the following section:

Software: 4. Force Guidance Function

7-2. Execute force function by SPEL＋ program

Execute each force function by SPEL+ program.

Software: 5. SPEL+ Programming of the Force Functions

Hardware

1. Included Items

This section describes the items included in the option by product specification.

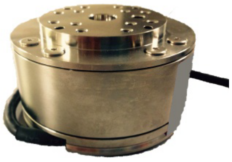
1.1 S250N (For C4 series)

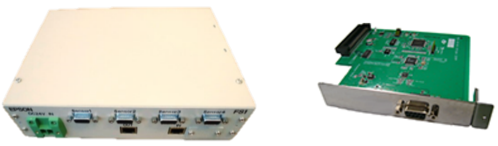
Item	Quantity
1. Force Sensor (For C4: S250N)	1
2. Force Sensor I/F (unit or board) ***	1
3. Force Sensor cable (For C4) *	1
4. Force Sensor M/I connection cable (For C4)	1
5. Connector cover *	1
6. Motion network cable **	1
7. Sensor flange (For C4) *	1
8. Robot fixing bolts (Hexagon socket low head cap bolts: M4×6)	4
9. Force Sensor fixing bolts (Hexagon head bolts: M4×12) *	4
10. Cable mount *	1
11. Wire tie *	1
12. Protection sheet *	1
13. Labels for cables	1
14. Ground terminal fixing bolt (Hexagon socket head cap bolt: M8×12)	1
15. Labels for Ceiling-mount shaft	1
16. Power connector **	1

* : Items 3, 5, 7, 9, 10, 11, and 12 are incorporated in "1. Force Sensor (For C4: S250N)" at the time of shipment.

** : Items 6 and 16 may not be included with shipment depending on the type of option.

*** : Item 2 may not be included with shipment depending on the type of option. If included with shipment, either I/F unit or I/F board.


1. Force Sensor (For C4: S250N)


Unit Board

2. Force Sensor I/F


3. Force Sensor cable (For C4)


4. Force Sensor M/I connection cable (For C4)


5. Connector cover


6. Motion network cable


7. Sensor flange (For C4)


8. Robot fixing bolts (Hexagon socket low head cap bolts: M4×6)


9. Force Sensor fixing bolts (Hexagon head bolts: M4×12)


10. Cable mount


11. Wire tie


12. Protection sheet

13. Labels for cables


14. Ground terminal fixing bolt (Hexagon socket head cap bolt: M8×12)

15. Labels for Ceiling-mount shaft


16. Power connector

1.2 S250L (For C8 series: IP20 compliant)

Item	Quantity
1. Force Sensor (C8-IP20 compliant: S250L)	1
2. Force Sensor I/F (unit or board) ***	1
3. Force Sensor cable (C8-IP20 compliant) *	1
4. Force Sensor M/I connection cable (For C8)	1
5. Motion network cable **	1
6. Sensor flange (C8-IP20 compliant) *	1
7. Robot fixing bolts (Hexagon socket button head bolts: M5×15)	4
8. Force Sensor fixing bolts (Hexagon head bolts: M5×12) *	4
9. Cable mount *	1
10. Wire tie *	1
11. Protection sheet *	1
12. Labels for cables	1
13. Labels for Ceiling-mount shaft	1
14. Power connector **	1

* : Items 3, 6, 8, 9, 10, and 11 are incorporated in "1. Force Sensor (C8-IP20 compliant: S250L)" at the time of shipment.

** : Items 5 and 14 may not be included with shipment depending on the type of option.

***: Item 2 may not be included with shipment depending on the type of option.
If included with shipment, either I/F unit or I/F board.


1. Force Sensor
(C8-IP20 compliant:
S250L)


Unit Board
2. Force Sensor I/F


3. Force Sensor cable
(C8-IP20 compliant)


4. Force Sensor M/I
connection cable (For C8)


5. Motion network cable


6. Sensor flange
(C8-IP20 compliant)


7. Robot fixing bolts
(Hexagon socket button
head bolts: M5×15)


8. Force Sensor fixing bolts
(Hexagon head bolts:
M5×12)


9. Cable
mount


10. Wire tie


11. Protection sheet

12. Labels for cables

13. Labels for
Ceiling-mount shaft


14. Power connector

1.3 S250P (For C8 series: IP67 compliant)

Item	Quantity
1. Force Sensor (C8-IP67 compliant: S250P)	1
2. Force Sensor I/F (unit or board) ***	1
3. Force Sensor cable (C8-IP67 compliant) *	1
4. Force Sensor M/I connection cable (For C8)	1
5. Motion network cable	1
6. Sensor flange (C8-IP67 compliant) *	1
7. Robot fixing bolts (Hexagon socket cap bolts: M5×18)	4
8. Seal washer *	4
9. Force Sensor fixing bolts (Hexagon head bolts: M5×12) *	1
10. Cable mount *	1
11. Wire tie *	1
12. Protection sheet *	1
13. Labels for cables	1
14. Labels for Ceiling-mount shaft	1
15. Power connector **	1

* : Items 3, 6, 8, 9, 10, 11, and 12 are incorporated in "1. Force Sensor (C8-IP67 compliant: S250P)" at the time of shipment.

** : Item 15 may not be included with shipment depending on the type of option.

***: Item 2 may not be included with shipment depending on the type of option. If included with shipment, either I/F unit or I/F board.


1. Force Sensor (C8-IP67 compliant: S250P)


Unit
Board
2. Force Sensor I/F

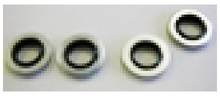

3. Force Sensor cable (C8-IP67 compliant)


4. Force Sensor M/I connection cable (For C8)


5. Motion network cable


6. Sensor flange (C8-IP67 compliant)


7. Robot fixing bolts (Hexagon socket cap bolts: M5×18)


8. Seal washer


9. Force Sensor fixing bolts (Hexagon head bolts: M5×12)


10. Cable mount


11. Wire tie


12. Protection sheet

13. Labels for cables

14. Labels for Ceiling-mount shaft


15. Power connector

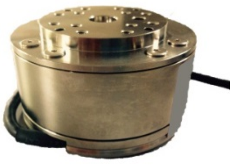
1.4 S250H (For N2 series)

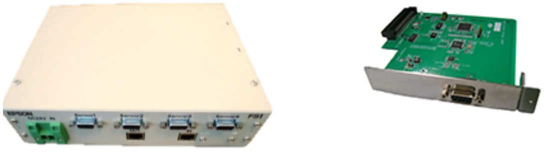
Item	Quantity
1. Force Sensor (For N2: S250H)	1
2. Force Sensor I/F (unit or board) ***	1
3. Force Sensor cable (For N2) *	1
4. Force Sensor M/I connection cable (For N2)	1
5. Motion network cable **	1
6. Sensor flange (For N2) *	1
7. Robot fixing bolts (Hexagon socket cap bolts: M4×6)	4
8. Force Sensor fixing bolts (Hexagon head bolts: M4×12) *	4
9. Cable mount *	1
10. Wire tie *	1
11. Protection sheet *	1
12. Labels for cables	1
13. Labels for Ceiling-mount shaft	1
14. Power connector **	1

* : Items 3, 6, 8, 9, 10 and 11 are incorporated in “1. Force Sensor (for N2: S250H)” at the time of shipment.

** : Items 5 and 14 may not be included with shipment depending on the type of option.

***: Item 2 may not be included with shipment depending on the type of option.
If included with shipment, either I/F unit or I/F board.


1. Force Sensor
(For N2: S250H)


Unit Board
2. Force Sensor I/F


3. Force Sensor cable
(For N2)


4. Force Sensor M/I
connection cable (For N2)


5. Motion network cable


6. Sensor flange (For N2)


7. Robot fixing bolts
(Hexagon socket cap bolts:
M4×6)


8. Force Sensor fixing bolts
(Hexagon head bolts:
M4×12)


9. Cable mount


10. Wire tie


11. Protection sheet

12. Labels for cables

13. Labels for


14. Power connector

1.5 SH250LH (For N6 series)

Item	Quantity
1. Force Sensor (For N6: SH250LH)	1
2. Force Sensor I/F or board *	1
3. Force Sensor cable (For N6) **	1
4. Force Sensor M/I connection cable (For N6)	1
5. Robot fixing bolts (Hexagon head bolts: M4×12)	4
6. Cable mount	1
7. Wire tie	1
8. Protection sheet	1

* : Item 2 may not be included with shipment depending on the type of option.

** : Items 3 is incorporated in “1. Force Sensor (for N6: SH250LH)” at the time of shipment.


1. Force Sensor
(For N6: SH250LH)


2. Force Sensor I/F Board


3. Force Sensor cable
(For N6)


4. Force Sensor M/I
connection cable (For N6)


5. Robot fixing bolts
(Hexagon head bolts: M4×12)


6. Cable mount


7. Wire tie


8. Protection sheet

1.6 S2503, S2506, S25010 (For G, RS series)

Item	Qty.
1. Force Sensor (S2503, S2506, S25010)	1
2. Force Sensor I/F (unit or board) *5	1
3. Force Sensor cable (S2503, S2506, S25010)	1
4. Force Sensor M/I connection cable (S2503, S2506, S25010)	1
5. Relay cable for external wiring *1*2	1
6. Branch cable *1	2
7. Motion network cable *1	1
8. Adapter *3	1
9. Sensor flange (S2503, S2506, S25010) *4	1
10. Force Sensor fixing bolts (Hexagon socket cap bolts: M4×15) *4	4
11. Sensor flange fixing bolts (Hexagon socket cap bolts: M5×15)	4
12. Cable mount	2
13. Wire tie	2
14. Protection sheet	1
15. Labels for cables	1
16. Labels for Ceiling-mount shaft	1
17. Power connector *1	1
18. Cable mount fixing bolt	2

*1 : Items 5, 6, 7 and 17 may not be included with shipment depending on the type of option.

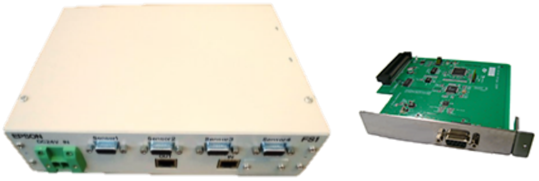
*2 : Item 5
G3 series only.
Optional for G6, G10 and G20 series.

*3 : Item 8 differ for each Manipulator.

*4 : Items 9 and 10 are incorporated in "1. Force Sensor (S2503, S2506, S25010)" at the time of shipment.

*5 : Item 2 may not be included with shipment depending on the type of option.
If included with shipment, either I/F unit or I/F board.


1. Force Sensor
(S2503, S2506, S25010)



Unit Board
2. Force Sensor I/F


3. Force Sensor cable
(S2503, S2506, S25010)


4. Force Sensor M/I connection cable
(S2503, S2506, S25010)


5. Relay cable
for external wiring


6. Branch cable


7. Motion network
cable


8. Adapter


9. Sensor flange
(S2503, S2506, S25010)


10. Force Sensor fixing bolts
(Hexagon socket cap bolts: M4×15)


11. Sensor flange fixing bolts
(Hexagon socket cap bolts: M5×15)


12. Cable mount


13. Wire tie


14. Protection sheet

15. Labels for cables

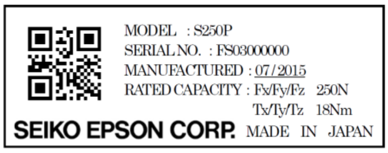
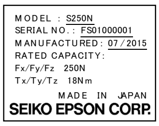
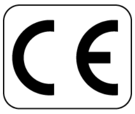
16. Labels for
Ceiling-mount shaft


17. Power connector


Cross recessed round head screws:M4×8 Hexagon socket extra low head cap bolts: M4×6
18. Cable mount fixing bolts

2. Labels

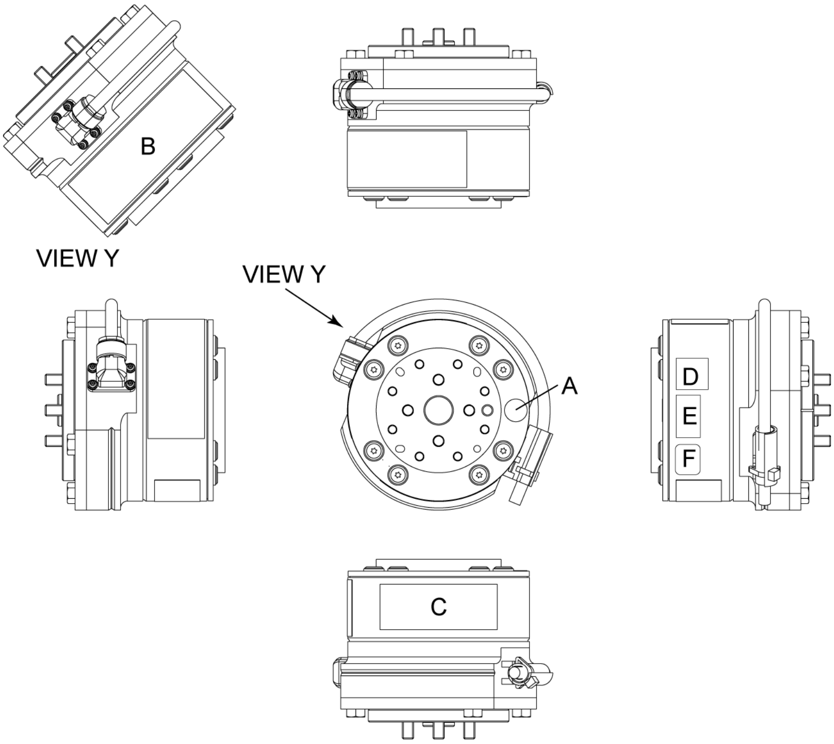
The following labels are attached to the Force Sensor and Force Sensor I/F unit. Be sure to comply with descriptions and warnings on the labels to operate the Force Sensor safely.

<table>
<tr><th>Location</th><th colspan="2">Label</th><th>Note</th></tr>
<tr><td>A</td><td colspan="2"></td><td>Do not loosen or remove the screws on the top face of the Force Sensor. If the screws are loosened or removed, the end effector may come off while the Manipulator is moving or accuracy of the Force Sensor may not be achieved.</td></tr>
<tr><td rowspan="2">B</td><td>−⇦X⇨+ −⇧Z⇩+ +⇦Y⇨−</td><td>S250N
S250L
S250P
S250H
S2503
S2506
S25010</td><td rowspan="2">The coordinate system of the Force Sensor on table top mount Manipulator.</td></tr>
<tr><td>−⇦X⇨+ −⇧Z⇩+ −⇦Y⇨+</td><td>SH250LH</td></tr>
<tr><td rowspan="2">C</td><td>
MODEL : S250P
SERIAL NO. : FS03000000
MANUFACTURED : 07/2015
RATED CAPACITY : Fx/Fy/Fz 250N
Tx/Ty/Tz 18Nm
SEIKO EPSON CORP. MADE IN JAPAN</td><td>S250N
S250L
S250P
S250H
S2503
S2506
S25010</td><td rowspan="2">Serial number label
(Force Sensor)</td></tr>
<tr><td>
MODEL : S250N
SERIAL NO. : FS01000001
MANUFACTURED : 07/2015
RATED CAPACITY :
Fx/Fy/Fz 250N
Tx/Ty/Tz 18Nm
MADE IN JAPAN
SEIKO EPSON CORP.</td><td>SH250LH</td></tr>
<tr><td>D</td><td colspan="2">
 </td><td>China RoHS label</td></tr>
<tr><td>E</td><td colspan="2">
 </td><td>KC label
(Force Sensor)</td></tr>
<tr><td>F</td><td colspan="2"></td><td>CE label</td></tr>
<tr><td>G</td><td colspan="2">
FORCE SENSOR I/F UNIT
MODEL : FS1
SERIAL NO. : FS04000001
MANUFACTURED : 04/2016
DC24V 12W
MANUFACTURER :
SEIKO EPSON CORPORATION
3-5, OWA 3-CHOME, SUWA-SHI
NAGANO-KEN, 392-8502 JAPAN
http://global.epson.com/company/
ENTITY PLACING ON EU MARKET :
EPSON DEUTSCHLAND GmbH
OTTO-HAHN-STR.4, D-40670
MEERBUSCH GERMANY
https://neon.epson-europe.com/de/en/robots/
FS04000001</td><td>Serial number label
(Force Sensor I/F unit)</td></tr>
</table>

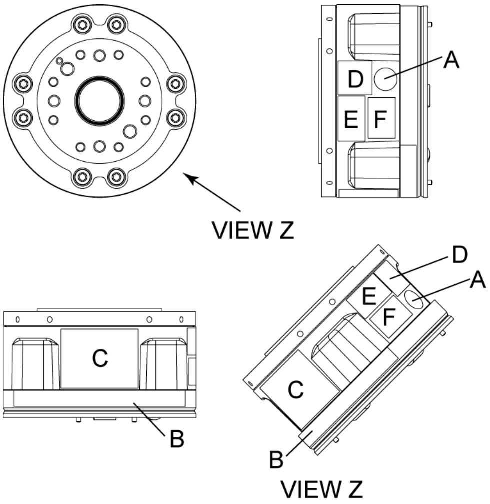
Location	Label	Note
H	 EPSON 기기의 명칭 : Force Sensor (S250/FS1) 방송통신기기 인증받은 자의 상호 : 한국엡손(주) 제조자/제조국가 : SEIKO EPSON CORPORATION / 일본 MSIP-REI-EKL-RE-FS250 MADE IN JAPAN	KC label (Force Sensor I/F unit)

Location of the labels

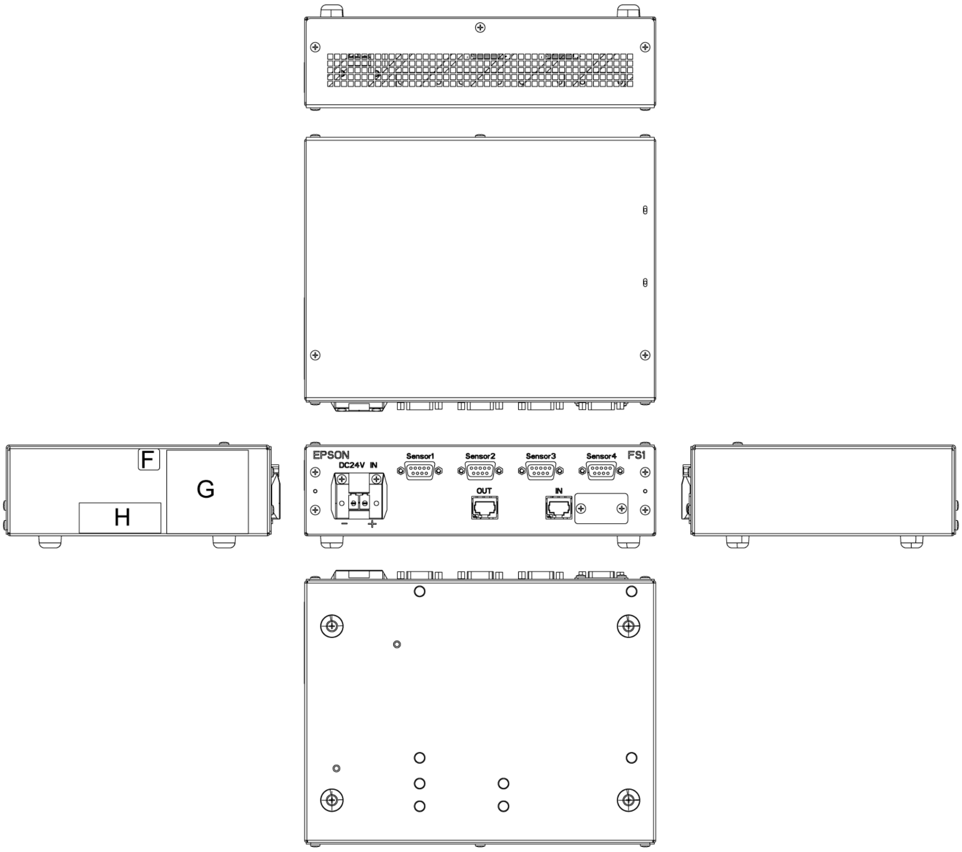
Force Sensor (S250N, L, P, H)



Force Sensor (SH250LH)



Force Sensor I/F Unit



3. Connection Example

The following are the connection examples of the robot system and Force Sensor.

For the combination patterns for using multiple manipulators and Force Sensors, refer to the following section.

Installation 3. System Overview

NOTE

The following items must be prepared by customers.

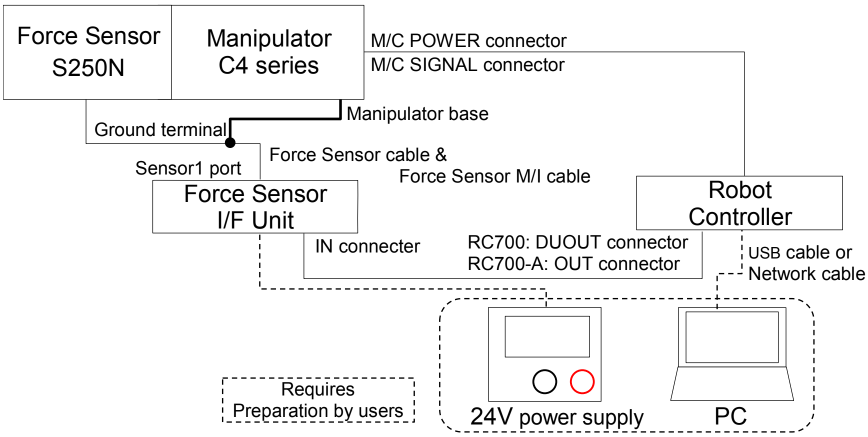
24 V power supply *1
Power connector *1
PC for operating the Manipulator *2

*1 : 24V power supply and power connector are necessary when using Force Sensor I/F unit.
*2 : Force Guide 7.0 supports the EPSON RC+ 7.0 Ver.7.2.0 or later.

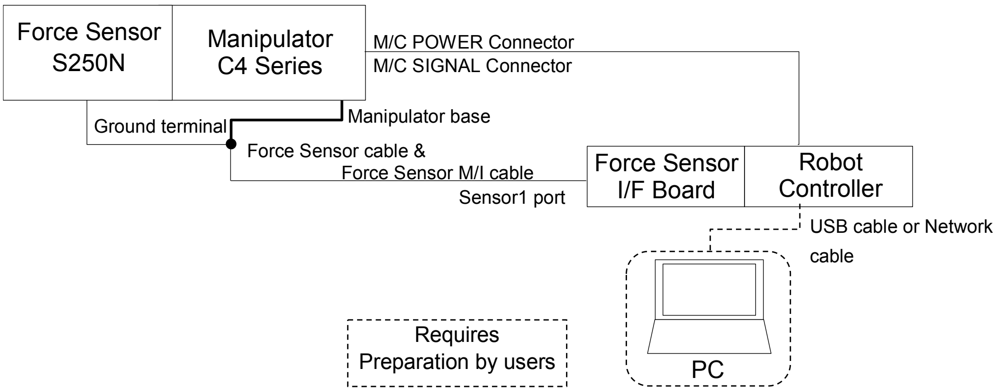
3.1 C4 series-S250N

Example: Connecting one Manipulator and one Force Sensor

Force Sensor I/F unit

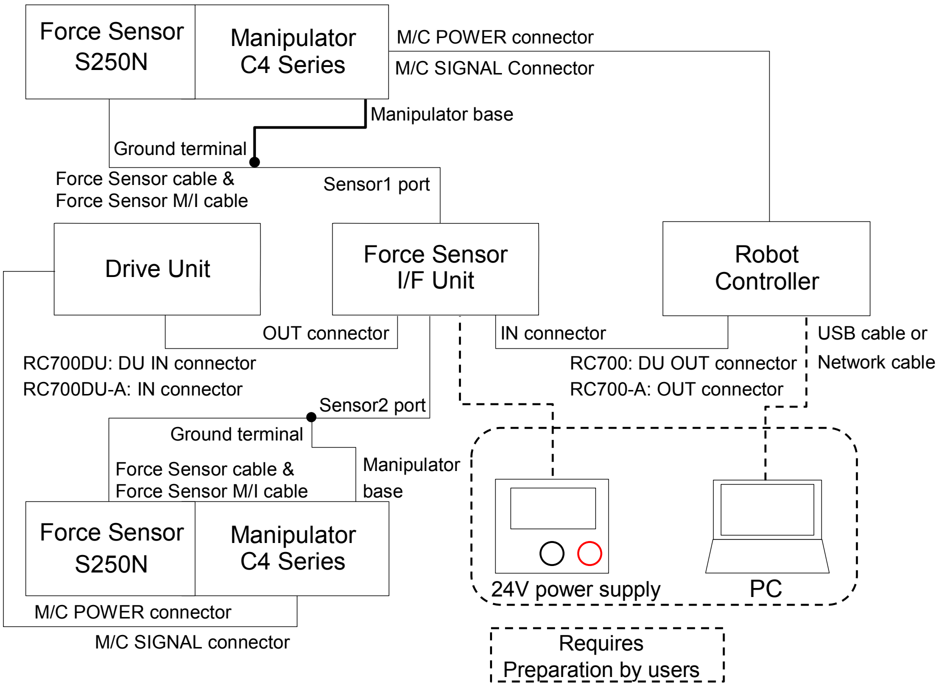


Force Sensor I/F board



Example: Connecting two Manipulators and two Force Sensors

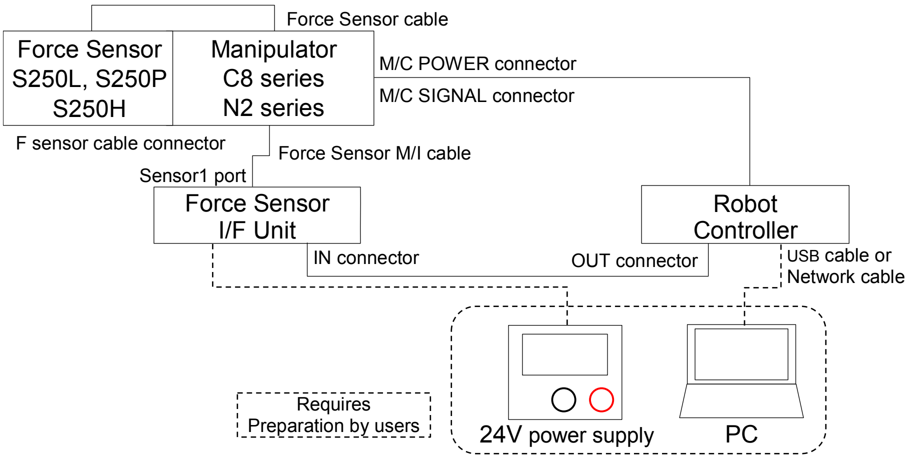
Force Sensor I/F unit



3.2 C8 series-S250L, C8 series-S250P, N2 series-S250H, N6 series-SH250LH

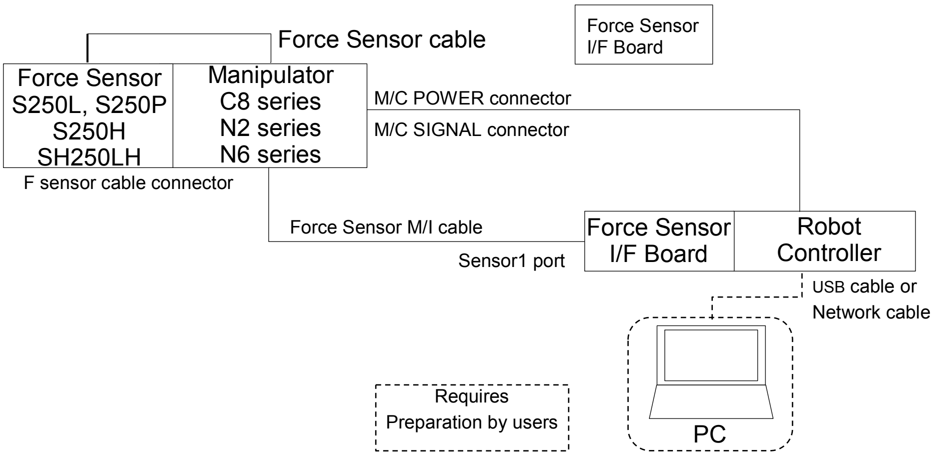
Example: Connecting one Manipulator and one Force Sensor

Force Sensor I/F unit



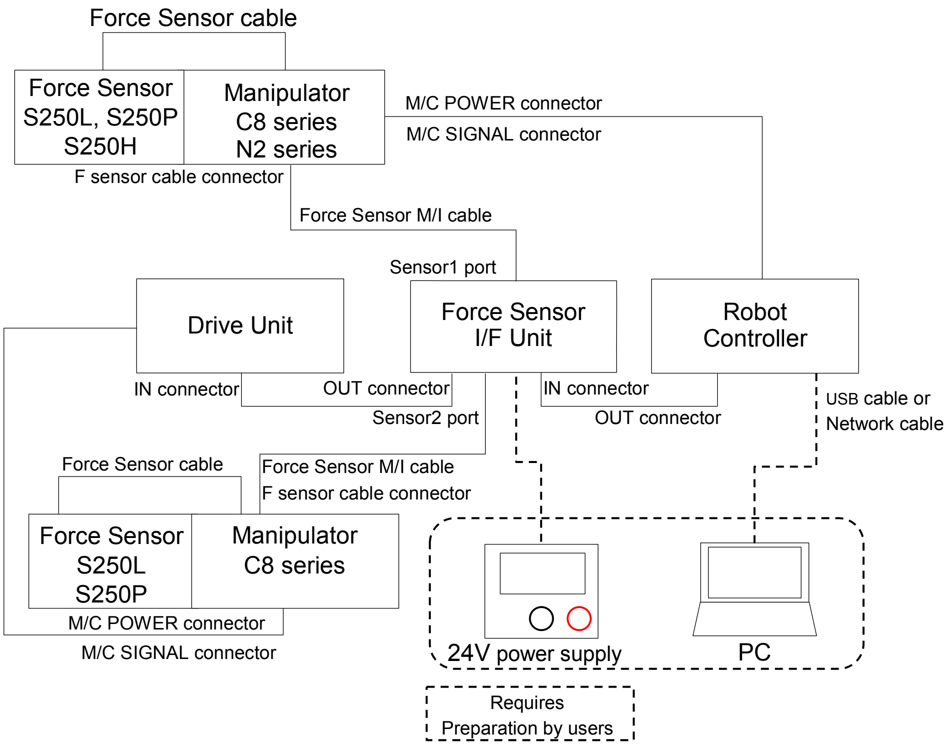
(N6 series cannot connected to the Force Sensor I/F unit)

Force Sensor I/F board



Example: Connecting two Manipulators and two Force Sensors

Force Sensor I/F unit



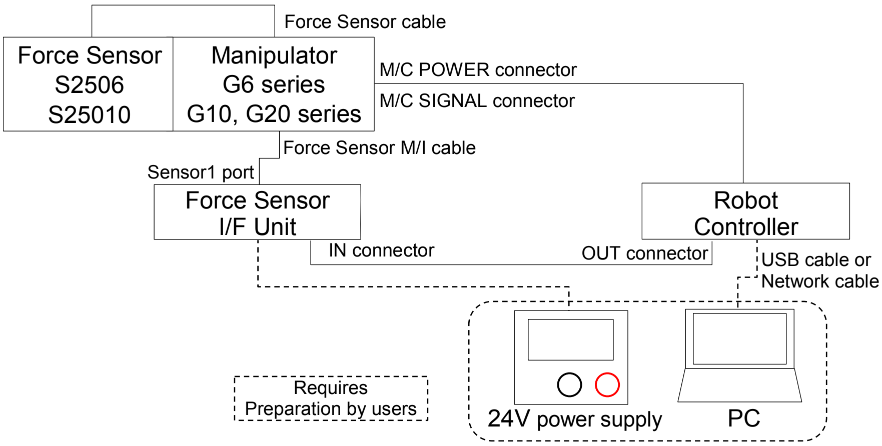
(N6 series cannot be connected to the Force Sensor I/F unit.
N2 series cannot be connected to the Drive Unit)

3.3 G series-S2503, S2506, S25010

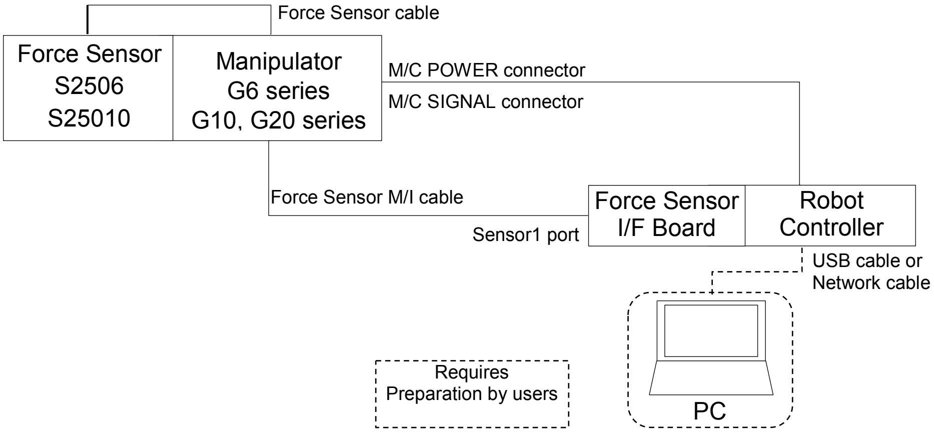
3.3.1 Internal wiring

Example: Connecting one Manipulator and one Force Sensor

Force Sensor I/F unit

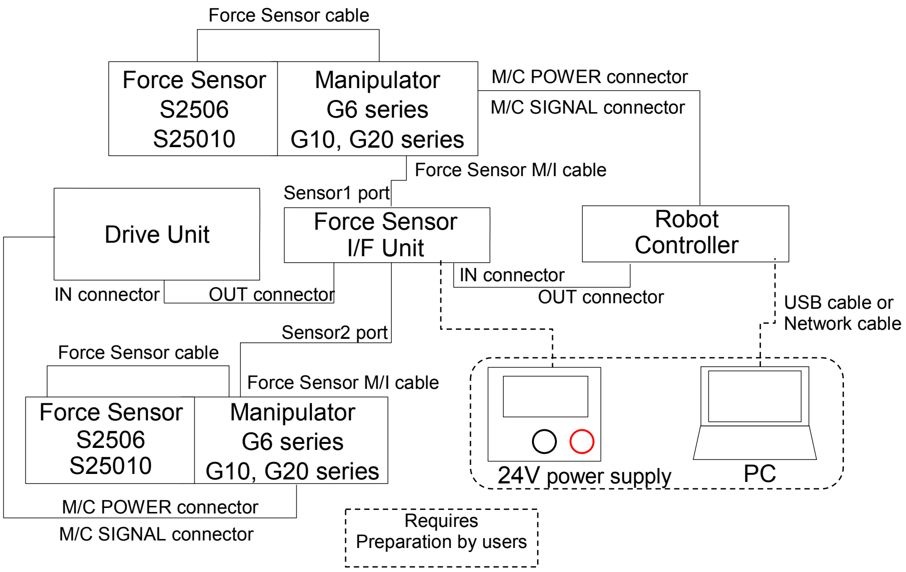


Force Sensor I/F board



Example: Connecting two Manipulators and two Force Sensors

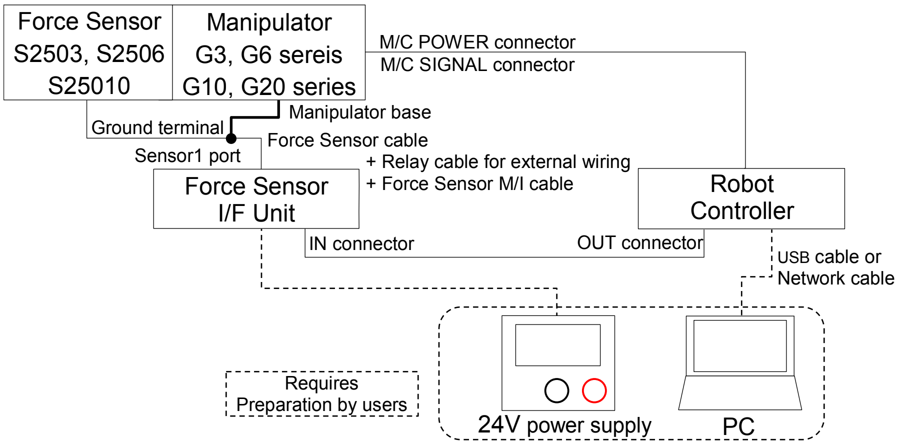
Force Sensor I/F unit



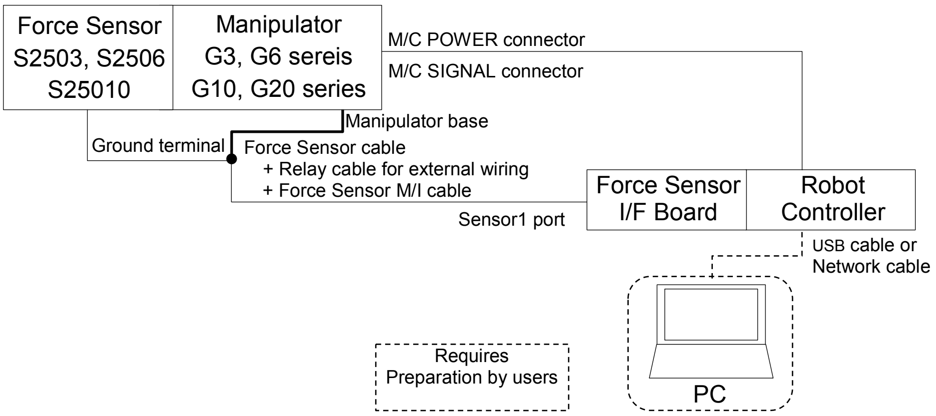
3.3.2 External wiring

Example: Connecting one Manipulator and one Force Sensor

Force Sensor I/F unit

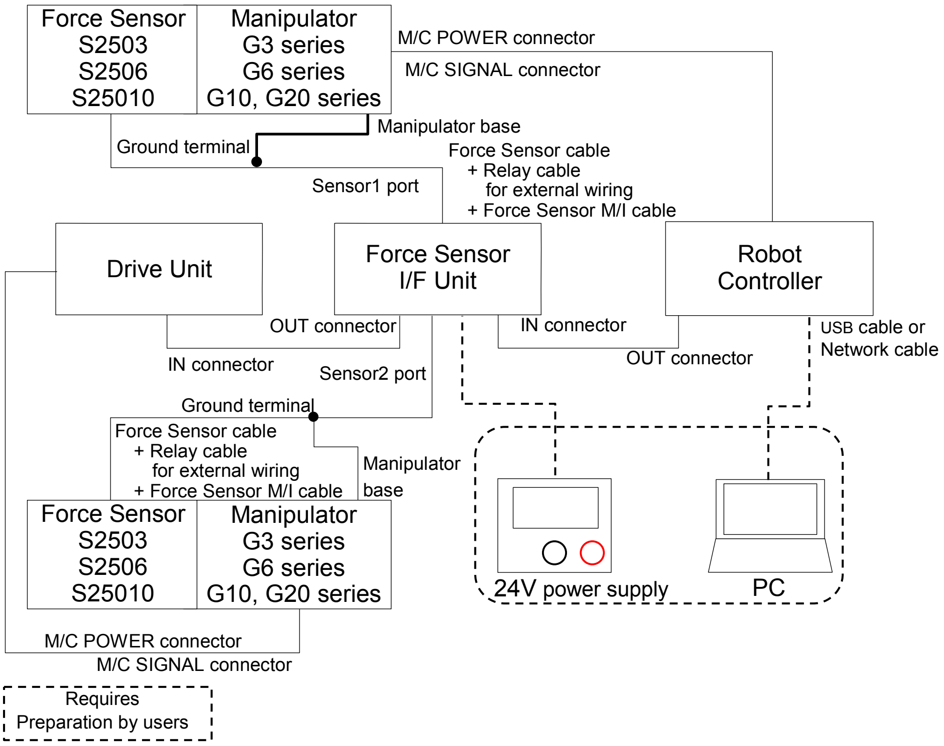


Force Sensor I/F board



Example: Connecting two Manipulators and two Force Sensors

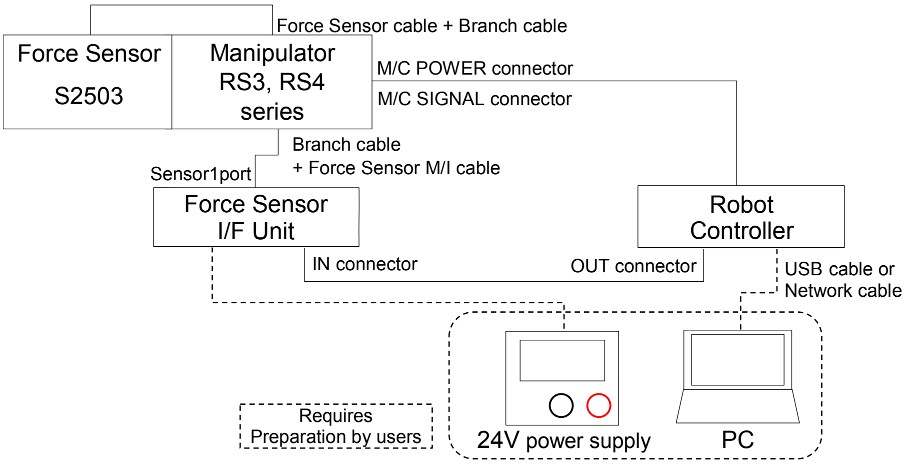
Force Sensor I/F unit



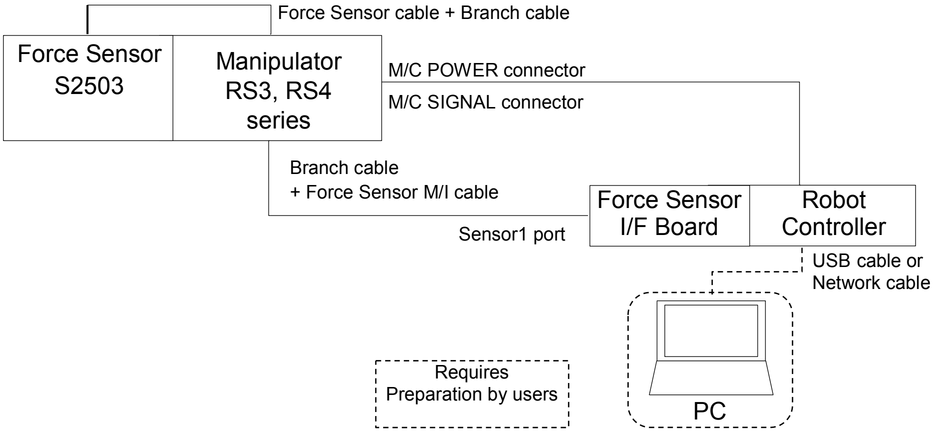
3.4 RS series-S2503

Example: Connecting one Manipulator and one Force Sensor

Force Sensor I/F unit

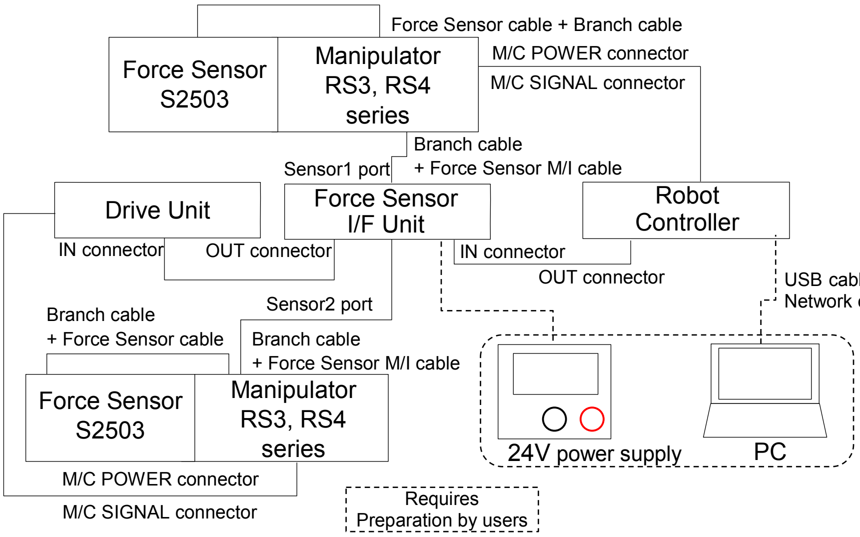


Force Sensor I/F board



Example: Connecting two Manipulators and two Force Sensors

Force Sensor I/F unit



4. Force Sensor

⚠ CAUTION

- The allowable load does not guarantee the sensor's performance. The force may not be detected properly if the load exceeding the allowable value is applied. Be sure to use the sensor within the rated load range.
- If the option is used in an environment with rapid temperature change, a drift may increase.

4.1 Specifications

4.1.1 Specification Table

Item				Specification	Remarks
Outer dimensions		S250N, S250H		ø80 × H49 mm	Including the sensor flange Reference: *Hardware 4.2 Outer Dimensions*
		S250L		ø88 × H49 mm	
		S250P		ø88 × H66 mm	
		S2503, S2506, S25010		ø80 × H52 mm *1	
		SH250LH		ø85 × H48 mm	
Weight *2		S250N, S250H		460 g	Including the sensor flange
		S250L		520 g	
		S250P		680 g	
		S2503, S2506		620 g	Including the sensor flange and the adaptor
		S25010		640 g	
		SH250LH		460 g	Not including the cables.
Rated load		Fx / Fy / Fz		250 / 250 / 250 [N]	
		Tx / Ty / Tz		18 / 18 / 18 [N·m]	
Overload capacity		Fx / Fy / Fz		1000 [N]	
		Tx / Ty / Tz		36 [N·m]	
Measurement resolution *3		Fx / Fy / Fz		± 0.1 (5 sec, 25 °C) [N]	
		Tx / Ty / Tz		± 0.003 (5 sec, 25 °C) [N·m]	
	Noise level	Fx / Fy / Fz		0.035 [N]	
		Tx / Ty / Tz		0.001 [N·m]	
	Time drift	25 °C	Fx / Fy / Fz	± 0.01 [N/s]	
			Tx / Ty / Tz	± 0.0003 [N·m/s]	
		40 °C	Fx / Fy / Fz	± 0.02 [N/s]	
			Tx / Ty / Tz	± 0.0006 [N·m/s]	
Measurement accuracy *4		Fx / Fy / Fz Tx / Ty / Tz		± 5 % RO [*5] or less	
Temperature drift		Fx / Fy / Fz Tx / Ty / Tz		0.2 [% / °C] or less at 250 [N], 18 [N·m] (full-scale)	
Operating environment		Temperature		– 10 ~ 40 [°C]	
		Humidity		10 ~ 80 %Rh no condensation	
Protection rating				IP67 : S250P IP20 : S250N, S250L S250H, S2503, S2506, S25010	
Safety standard				CE Mark : EMC Directive KC Mark	

*1 Sensor height + height to the bottom edge of the sensor flange.
When installed with the attached adapter, distance between the Z-axis end face and the sensor end face are as follows: (Reference: *Hardware 4.2 Outer Dimensions*)
S2503, S2506: 66mm
S25010: 68mm

*2 The cable options are not included in weight.

*3 The measurement resolution including the noise level and time drift (25 °C), when the measurement time is 5 seconds.

*4 The measurement accuracy when the measurement time is 6 minutes.

*5 RO, Rated Output, is accuracy for the rated output.

4.1.2 ACCEL Setting under Heavy Load

When using the force sensor on the following Manipulators, see the following and set ACCEL properly according to the tip load.

Manipulator models: G10 series, G20 series

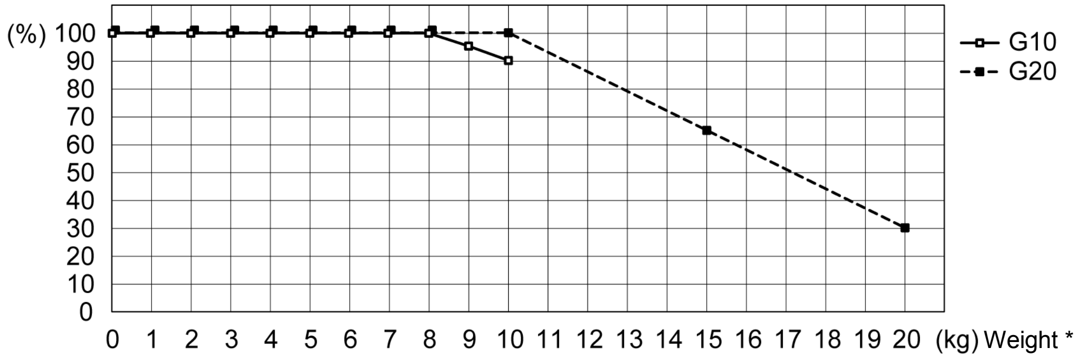
For details of the ACCEL setting and the setting procedures, refer to the Manipulator manuals.

NOTE ☞

Improper setting may cause load exceeding the rated torque for the force sensor depending on operation conditions, and may result in the following problem.

Reduction of the life and damage of the force sensor

Accel setting value

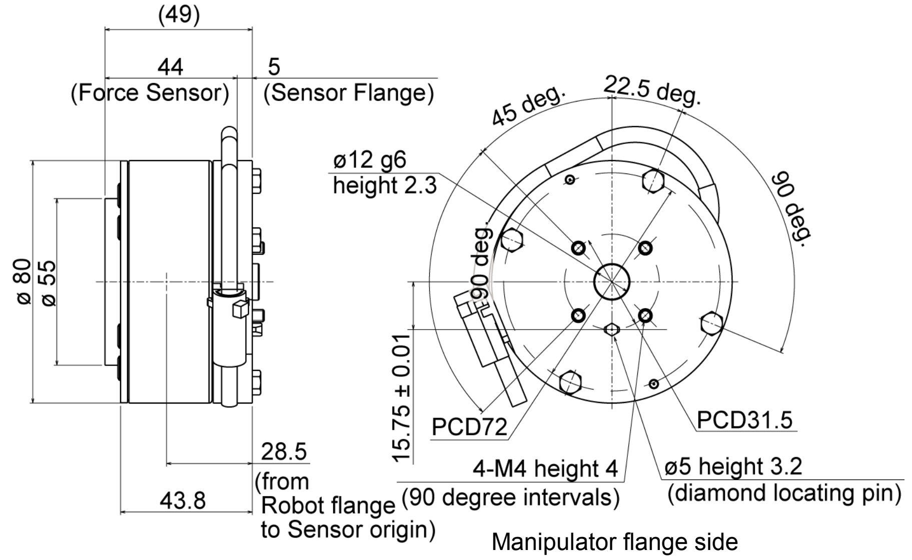


* Weight : Including the weight of the Force Sensor

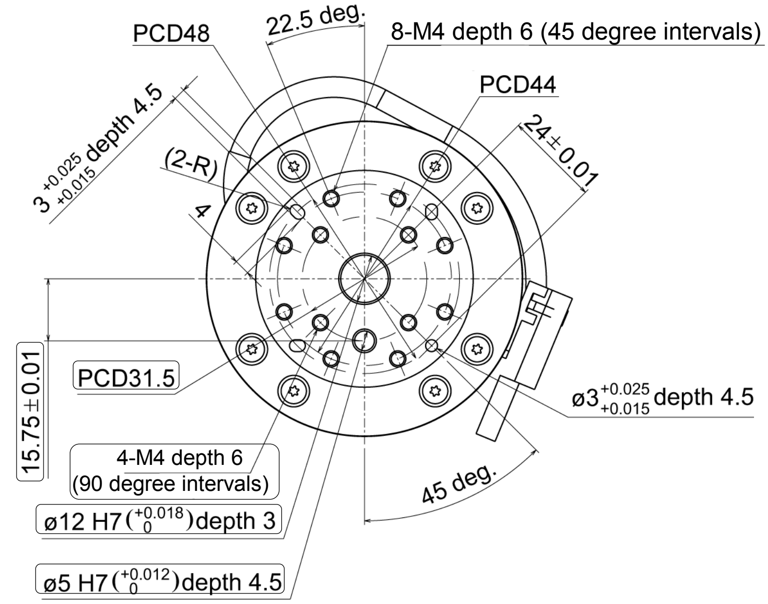
4.2 Outer Dimensions

The following are the dimensions of the assembled sensor flange and Force Sensor.

4.2.1 S250N (For C4 series)

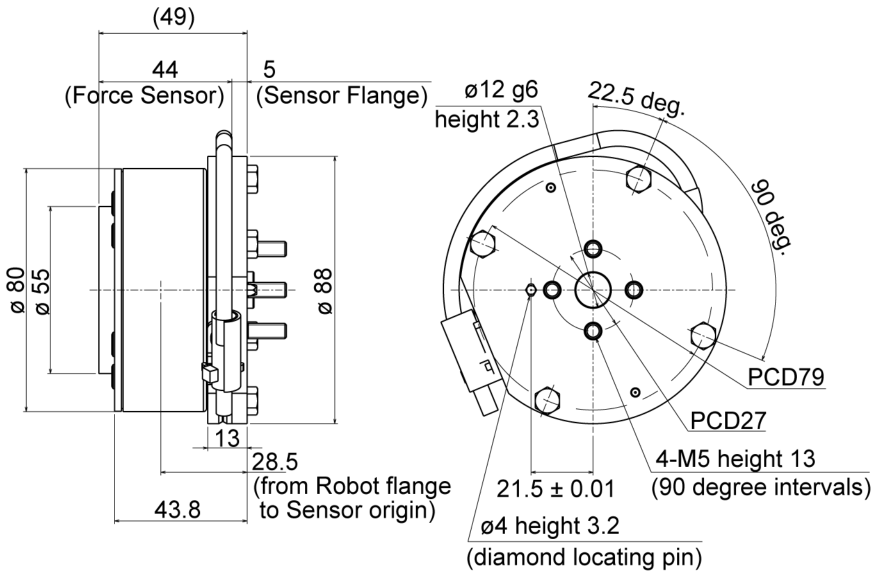


End effector side



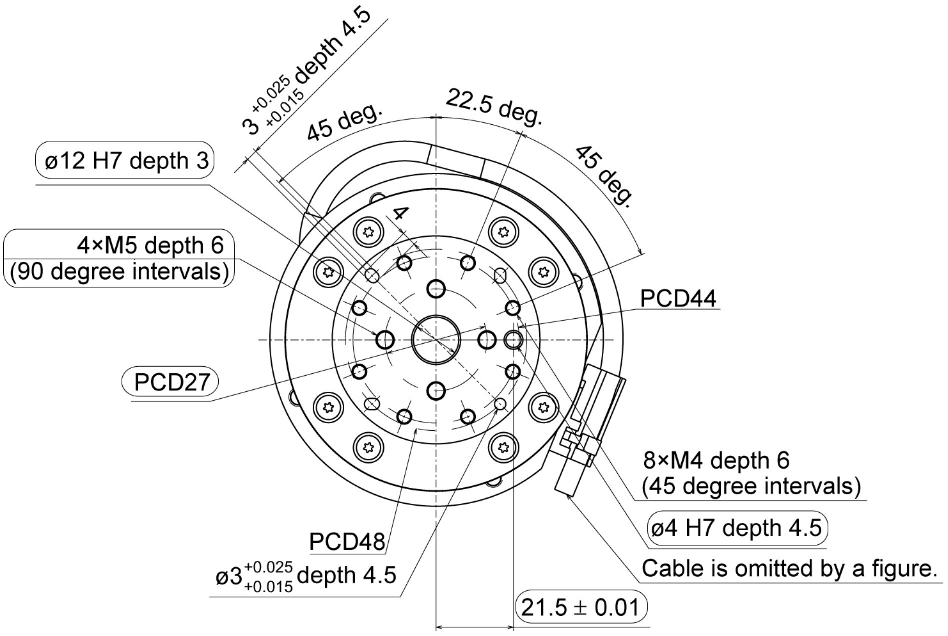
▭ : Dimension is C4 series Manipulator Flange Compatible Form

4.2.2 S250L (For C8 series: IP20 compliant)



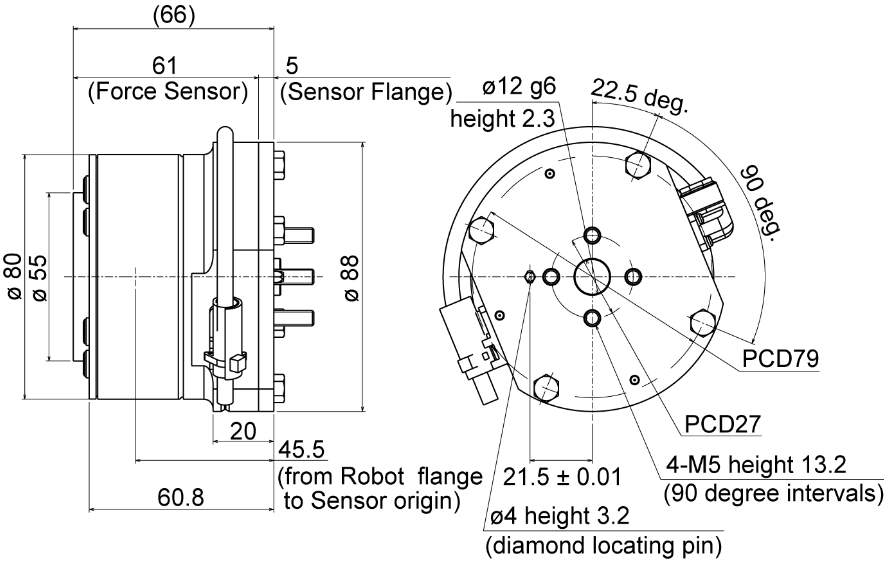
Manipulator flange side

End effector side



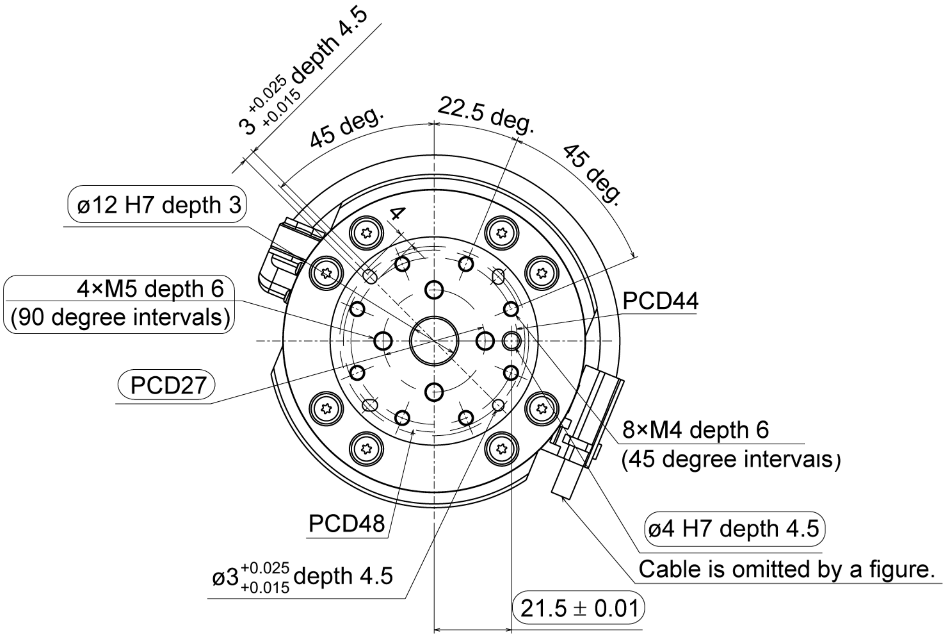
▭ : Dimension is C8 series Manipulator Flange Compatible Form

4.2.3 S250P (For C8 series: IP67 compliant)



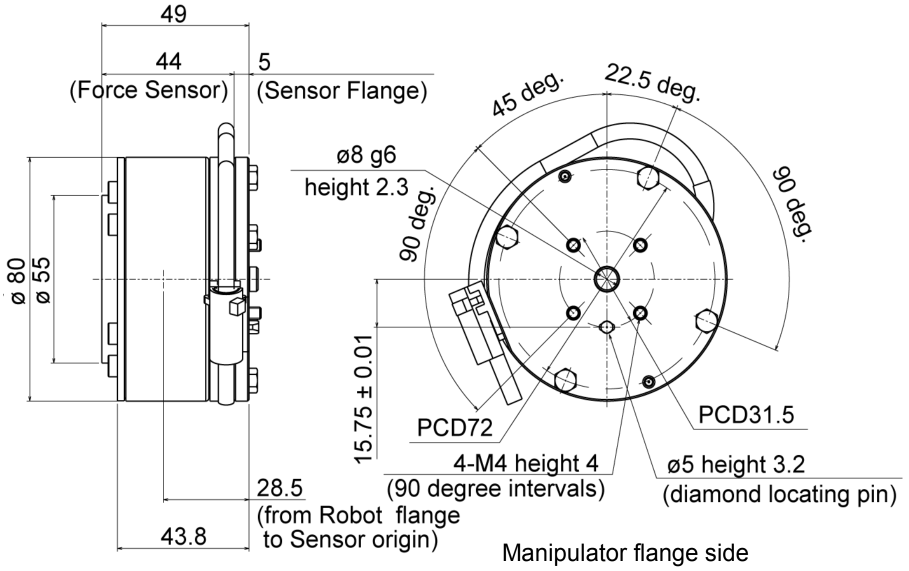
Manipulator flange side

End effector side



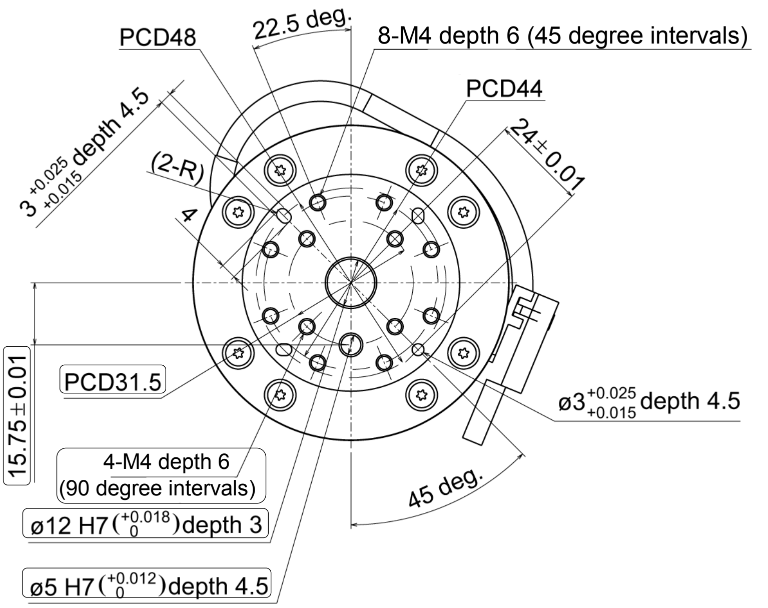
▭ : Dimension is C8 series Manipulator Flange Compatible Form

4.2.4 S250H (For N2 series)



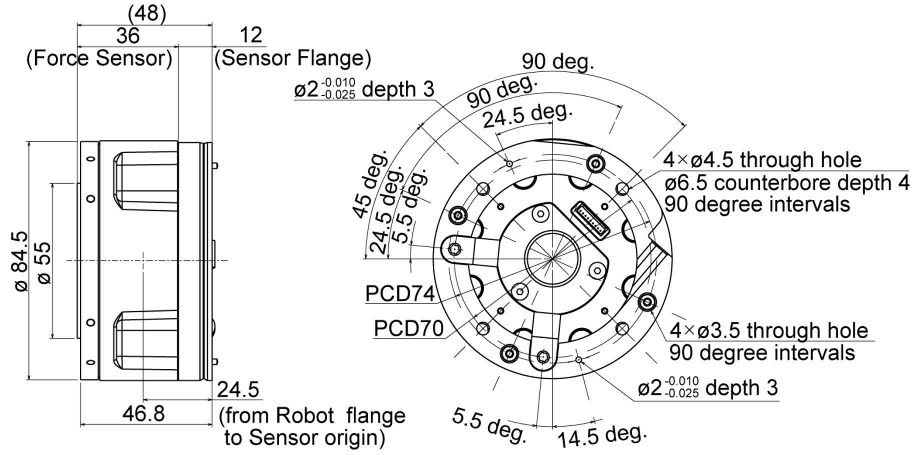
Manipulator flange side

End effector side



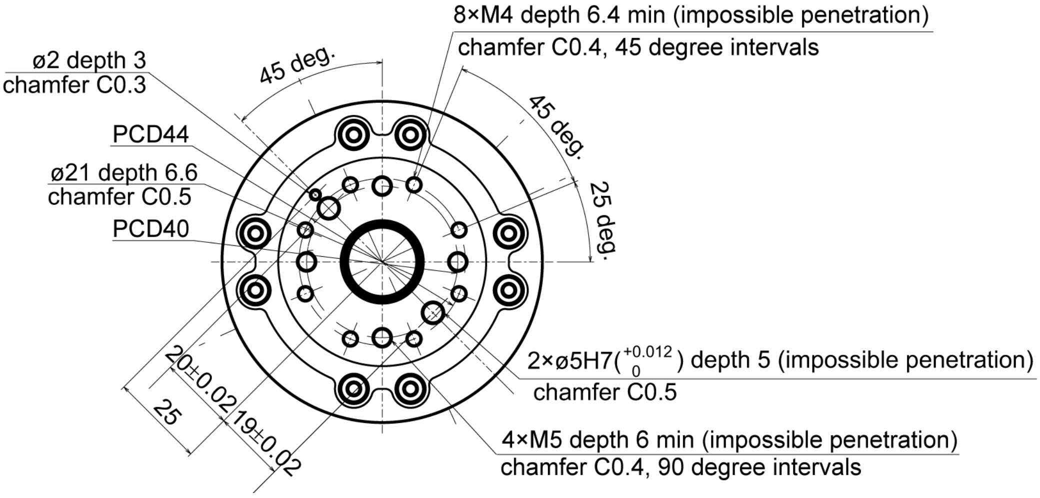
▭ : Dimension is C4 series Manipulator Flange Compatible Form

4.2.5 SH250LH (For N6 series)

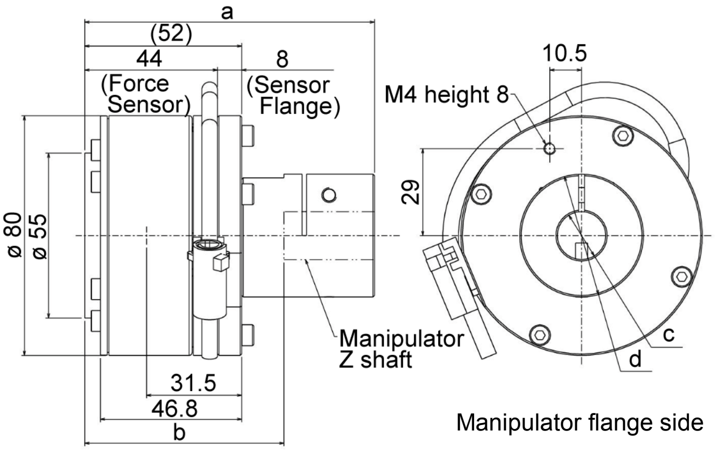


Manipulator flange side

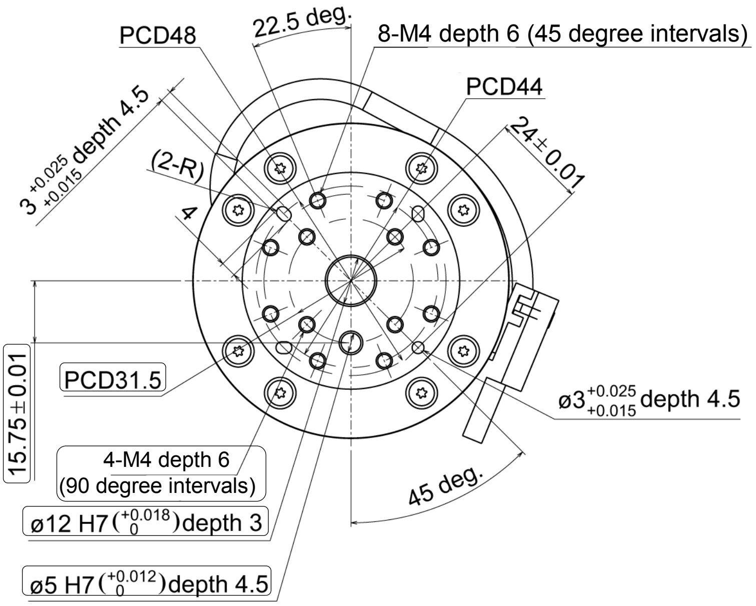
End effector side



4.2.6 S2503, S2506, S25010 (For G, RS series)



End effector side



▭ : Dimension is C4 series Manipulator Flange Compatible Form

(Unit: mm)

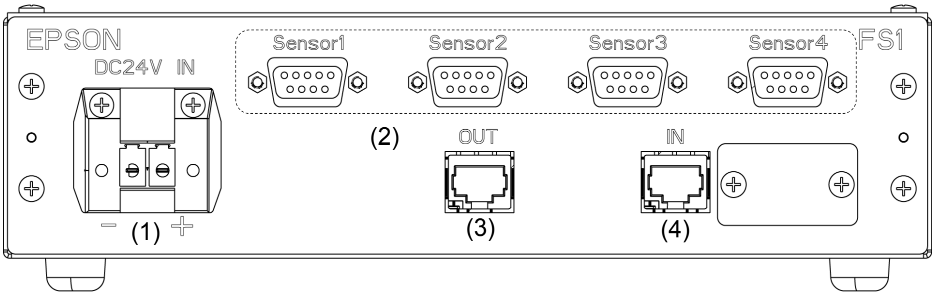
		S2503	S2506	S25010
a	Distance from the upper end of the adapter to the end face of the force sensor	96		98
b	Distance from the end face of the Manipulator Z-shaft to the end face of the force sensor	66		68
c	Diameter of the installation hole for the adapter shaft	16	20	25
d	Outer diameter of the adapter	41		45.5

5. Force Sensor I/F Unit

5.1 Force Sensor I/F Unit (FS1)

5.1.1 Specifications

Item		Specification
Outer dimensions		232 mm × 70 mm × 175 mm
Weight		1360 g
Interface	Power input	Terminal block (1), DC 24V (± 10 %)
	Motion network port	RJ45 (2 ports), IN port/OUT port
	Force Sensor communication port	D-sub 9pin (4 ports), Two communications are supported
Operating environment	Temperature	5 to 40 °C
	Humidity	10 to 80 % (with no condensation)



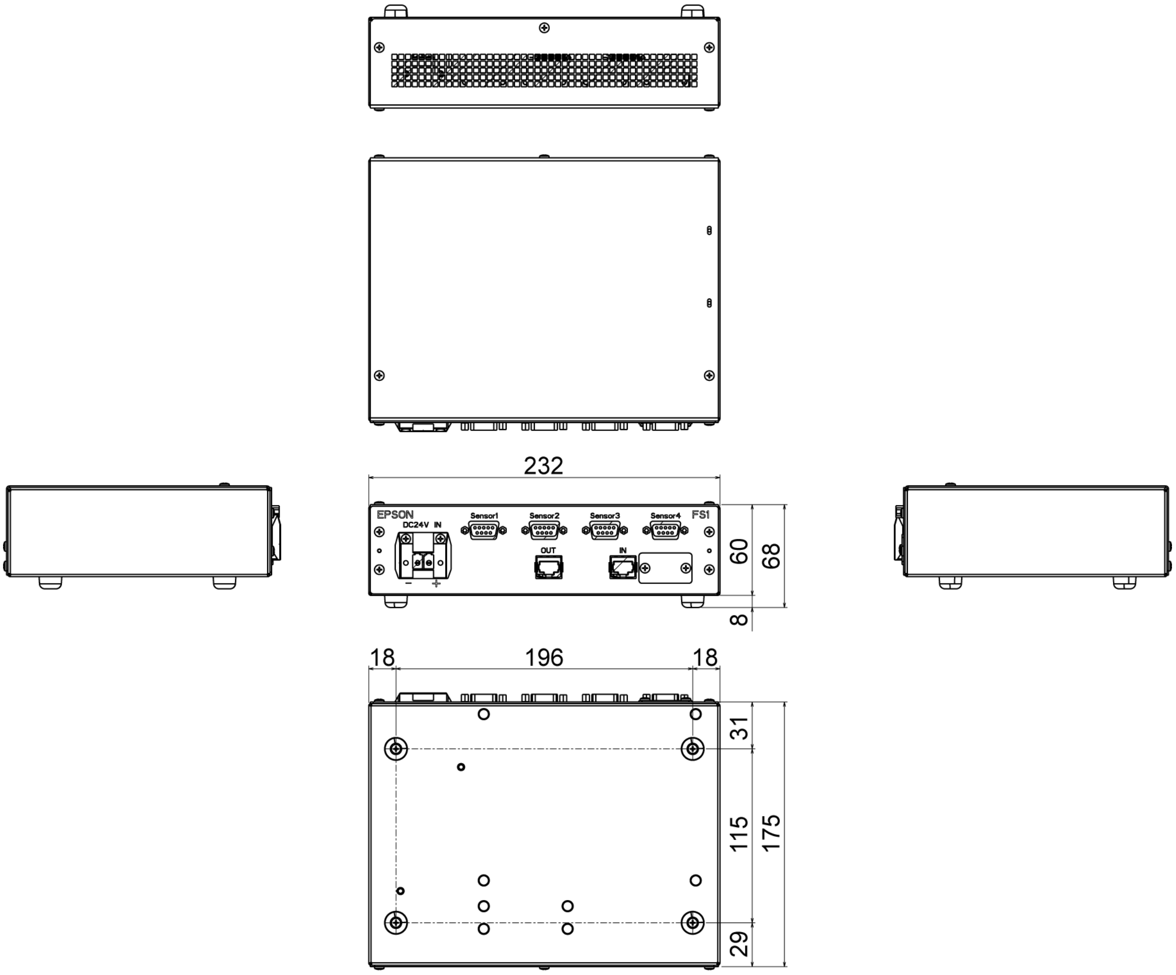
No.	Name	Function
1	24V Input Connector	The connector to supply 24V from the 24V power source.
2	Force Sensor connector	The connector to connect the Force Sensor. 2 sensors can be connected.
3	OUT connector	The connector to connect the Drive Unit.
4	IN connector	The connector for the Robot Controller and Drive Unit

NOTE

For the combination patterns for using multiple manipulators and Force Sensors, refer to the following section.

Installation 3. System Overview

5.1.2 Outer Dimensions



5.1.3 Installation

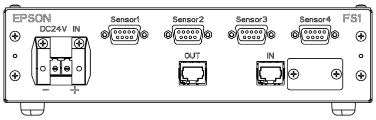
Installation environment

In order to use the Force Sensor I/F unit safely while maintaining performance, it must be installed in the environment that satisfies the following conditions:

- Install indoors only.
- Place in a well-ventilated area.
- Keep away from direct sunlight and radiation heat.
- Keep away from dust, oily mist, oil, salinity, metal powder or other contaminants.
- Keep away from water.
- Keep away from shocks or vibrations.
- Keep away from sources of electronic noise which generate static electricity and surge
- Prevent the occurrence of strong electric or magnetic field.
- Leave 100 mm of space at the rear

Mounting Direction

It is recommended to install the Force Sensor I/F unit horizontally.



5.1.4 Power Supply

Ensure that the power supply to the Force Sensor satisfies the following specifications.

- Voltage: 24 VDC (± 10 %)
  Current limit setting value: 2 A
- Satisfies the EMC standards in an industrial setting
- Have a reinforced insulation against the AC power source
- Have an overcurrent protection circuit build-in

It is recommended to use the power supply specialized for the Force Sensor I/F unit. When sharing the power supply with other equipment, do not to use the power supply connected to the equipment which generates electronic noise, or take adequate measures against electronic noise.

5.1.5 Wiring of Force Sensor I/F Unit and Power Connector

WARNING

- Be sure to turn OFF power when wiring the power supply. Performing any work with the power ON is extremely hazardous and it may result in electric shock and/or improper function of the robot system.
  Make sure that wiring and voltage are correct before turning ON power.
- Do not insert and remove the connector while applying current to the 24 VDC connector. Performing any work with the power ON is extremely hazardous and it may result in electric shock and/or improper function of the robot system.

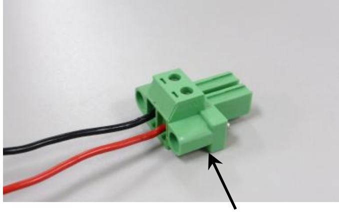
CAUTION

- Use a twisted pair cable for wiring the 24 VDC power supply, and use as thick and short a wire as possible.
- Keep the 24 VDC power cable away from peripheral noise sources as possible.
- Install the ON/OFF switch at AC side of the 24 VDC power supply.
  Inserting and removing the connector while applying current to the 24V connector, or turning ON/OFF at 24 VDC side may cause a fusing inside the Force Sensor I/F unit.
  If fusing occurs, replace the fuse by referring to the following section.

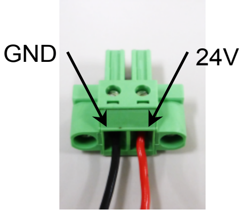
  Hardware 5.6 Replacing the Force Sensor I/F Unit Fuse

Refer to the following and wire the 24 VDC power supply to the connector.

Pin No.	Signal	Description
1	GND	Grounding (24V grounding)
2	24V	24VDC power supply



Force Sensor I/F unit
Power connector (male)

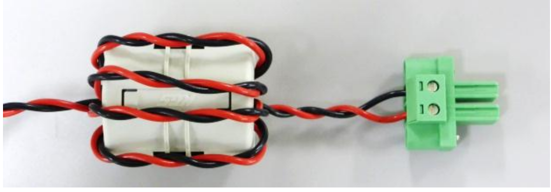


Power Connector (female) Model No. : DFK-PC4/2-GF-7.62 (Phoenix Contact)

Power Connector (male) Model No. : PC4/2-STF-7.62 (Phoenix Contact)

Appropriate Wire Diameter : 0.2 mm^2 to 4.0 mm^2 (manufacturer reference)

Wiring length : Should be within 2.5 m.
If the length exceeds 2.5 m, wrap the power supply wiring (twisted pair) around the ferrite core * with five turns as shown in the photo.



*Ferrite core: Kitagawa Industries Co., LTD RFC-20

5.1.6 Replacing the Force Sensor I/F Unit Fuse

Preparation

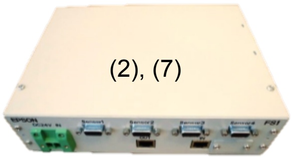
Prepare the following parts.

Name	Standard	Manufacturer	Quantity	Remark
Glass fuse	FGBO 125V 1A	FUJI Terminal Industry	1	Equivalent product available
Wire tie	SG-100	S.G. Industrial	1	Equivalent product available

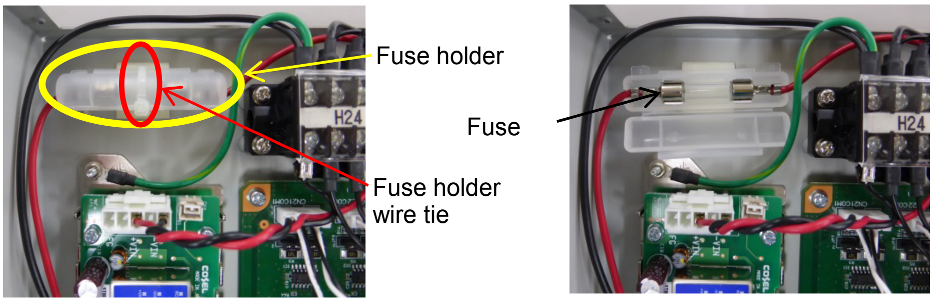
Replacement

(1) Shut down the power, and then remove the power connector of the Force Sensor I/F unit.

(2) Remove the top cover of the Force Sensor I/F unit.



(3) Cut off the wire tie from the fuse holder.



(4) Open the fuse holder, and then remove the blown glass fuse.

When removing the fuse, be careful of breakage of glass.

(5) Install a new fuse. (The fuse can be installed in either direction.)

Make sure to install the fuse of appropriate standard (equivalent product is available).

(6) Fix the fuse holder with a wire tie.

Fix the holder firmly so as not to move.

(7) Install the top cover of the Force Sensor I/F unit.

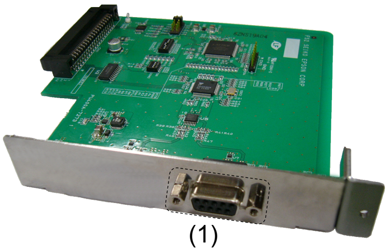
5.2 Force Sensor I/F Board (FS2)

Force Sensor I/F board is an option board to perform 24V power supply and communication for Force Sensor S250 series.

Mount the controller on the option slot and connect the Force Sensor to communicate the controller and the Force Sensor.

5.2.1 Specifications

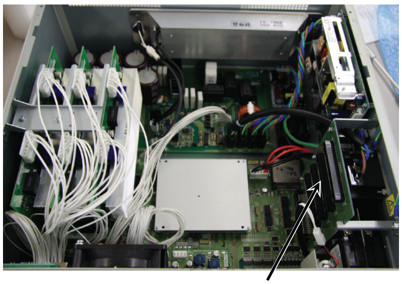
Item		Specification
Outer dimensions		206 mm × 102 mm × 24.5 mm
Weight		135 g
Interface	Force Sensor communication port	D-sub 9pin (1 port), One communications are supported
Operating environment	Temperature	5 to 40 °C
	Humidity	10 to 80 % (with no condensation)



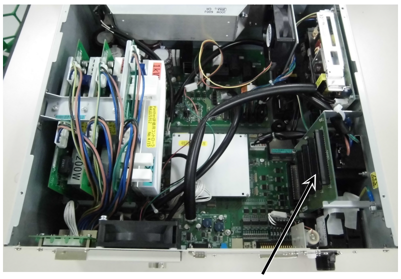
No.	Name	Function
1	Force Sensor connector	The connector to connect the Force Sensor. 1 sensor can be connected.

5.2.2 How to Install

RC700



RC700-A



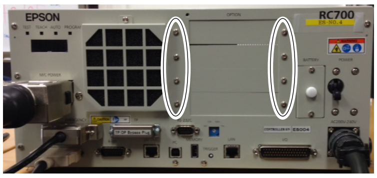
Force Sensor I/F Board Installation

(1) Turn OFF the controller.

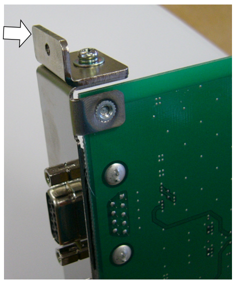
(2) Disconnect the power plug.

(3) Remove the top board. (six mounting screws)

(4) Unscrew the option slot panel.
Remove the option panel on the side you want to mount the Force Sensor I/F board.

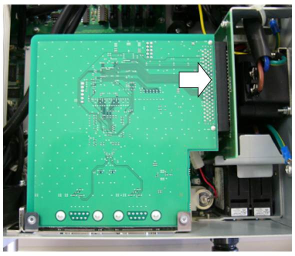


(5) Mount the L-shaped plate on the Force Sensor I/F board.



(6) Mount the Force Sensor I/F board as shown the picture on the right.

Push the board into option slot.
(Direction of an arrow)



(7) Fix the attached L-shaped plate from the front side with screws.

At this time, one screw of the option slot panel will be left.

(8) Mount the top board. (six mounting screws)

(9) After connecting the power plug, turn ON the controller and make sure to operate properly without vibration or abnormal sound.

5.2.3 Cautions about Connection

Force Sensor I/F board supplies DC24V from the connector of the Force Sensor to operate Force Sensor S250 series. Be careful about the followings.

1 : Do not connect a device to the connector for the Force Sensor except the Force Sensor.
It may result in damage of connected device, Force Sensor I/F board, and the controller.

2 : Do not change the each DIP switches and jumper pins.
If you changed those, refer to the following manual and put those back. Force Sensor I/F board may not be recognized properly if changing DIP switches and jumper pins.

Robot Controller RC700/RC700-A
Setup & Operation 14.6 Force Sensor I/F Board

6. How to Install

This section describes how to install the Force Sensor.

WARNING

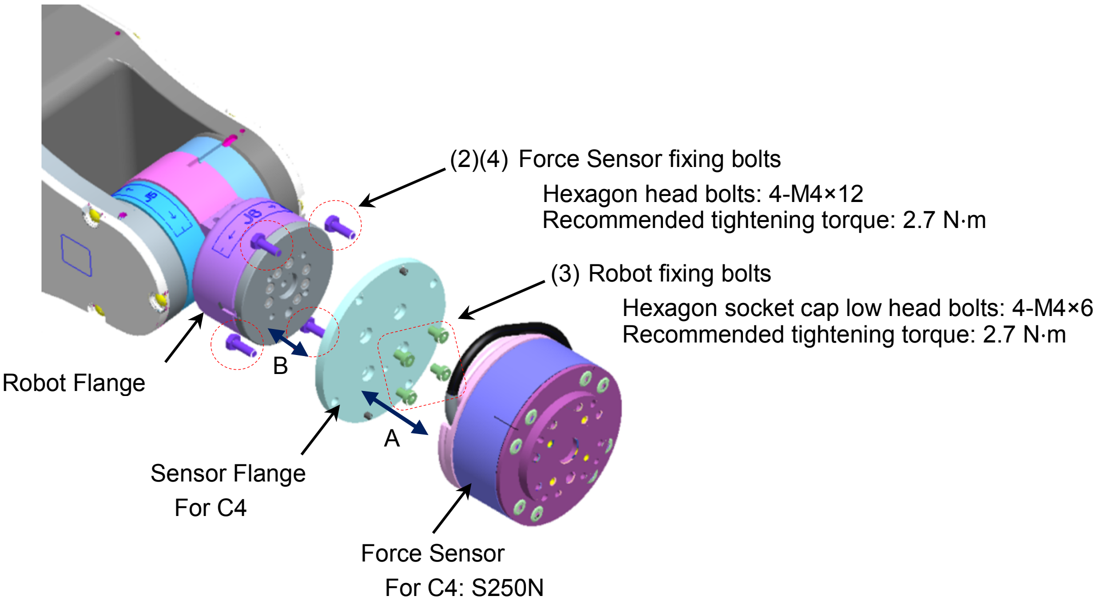
- Before performing any work, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any work with the power ON is extremely hazardous and it may result in electric shock and/or improper function of the robot system.
- Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) Unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the system.
- Do not touch the sensor circuit board and FFC cables when mounting the Force Sensor. It may result in damage to the cables and connectors, disconnection, and/or contact failure, and may result in electric shock and/or improper function of the system.

CAUTION

- Install the Force Sensor to the Manipulator properly by referring to the following section.
  Hardware 6.1 Installing the Force Sensor.
  Installing the Force Sensor in an improper manner may cause accuracy degradation or malfunction of the sensor.
- Install the Force Sensor to the Manipulator with the recommended tightening torque.
  If the Force Sensor is fixed with an improper torque, it may result in abnormal sensor performance.
  If the Force Sensor is fixed with the tightening torque lower than the recommended torque, the Force Sensor may fall during the Manipulator operation and may result in damage to the sensor and the system.
- When installing the sensor cables to the Manipulator, fix them so as not to interfere with the Manipulator's operation range. Also, load may be applied to the cables even in the movable range of the cables and it may cause cable breakage.

6.1 Installing the Force Sensor

6.1.1 S250N (For C4 series)

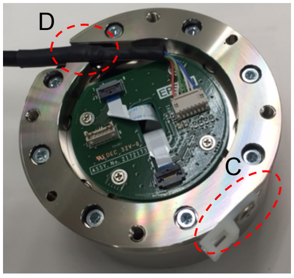


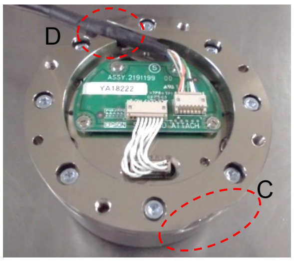
(1) Turn OFF the Controller.

(2) Remove the sensor flange from the Force Sensor. (A)
Force Sensor fixing bolts (Hexagon head bolts: 4-M4×12)
(The sensor is installed to the sensor flange at the time of shipment.)

(3) Install the sensor flange to the robot flange. (B)
Insert the sensor flange while aligning the two positioning points on the sensor flange (positioning pins and projection at the center) to the robot flange.
Fix the sensor flange to the robot flange with the robot fixing bolts included with shipment.
Robot fixing bolts (Hexagon socket cap low head bolts: 4-M4×6)
Recommended tightening torque: 2.7 N·m

(4) Install the Force Sensor to the sensor flange fixed in the step (3). (A)
There are two types of board for the sensor. Please note that the sensor installation method is different depending on the sensor.

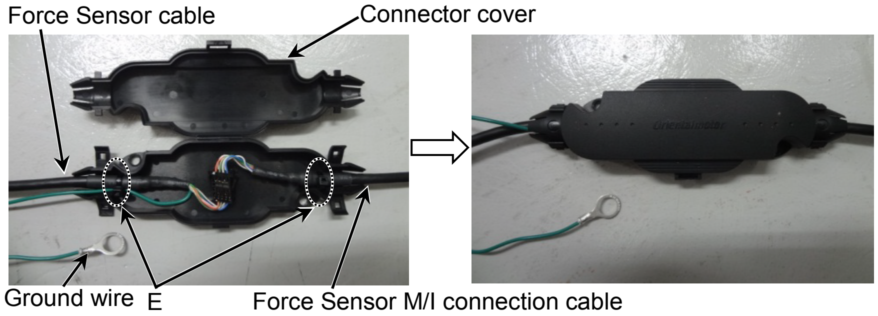




Align the cutouts (C) on the sensor flange and the Force Sensor. Install the sensor by inserting the two positioning pins of the sensor flange to the sensor.
At this time, adjust the position of the Force Sensor cable so that the part wrapped with the heat shrinkable tube to be at (D).
Fix the sensor flange and the Force Sensor with the bolts removed in the step (2).
Force Sensor fixing bolts (Hexagon head bolts: 4-M4×12)
Recommended tightening torque: 2.7 N·m

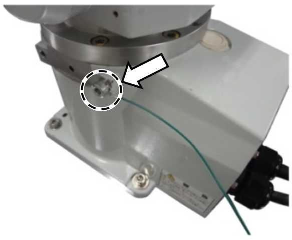
(5) Fix the Force Sensor cable to the Manipulator.
Set the cable so as not to interfere with Manipulator motion and not to apply load on the cable.

(6) Connect the Force Sensor cable and Force Sensor M/I connection cable.
Store the connecting part to the connector cover.
Fix the cables with wire ties included with shipment. (E)
Close the connector cover.



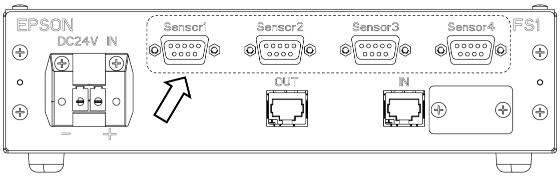
(7) Fix the connector cover to the position where does not interfere with Manipulator motion and not apply load on the cable.

(8) Fix the ground terminal of the Force Sensor lead to the Manipulator base.
Hexagon head bolts: M8×12

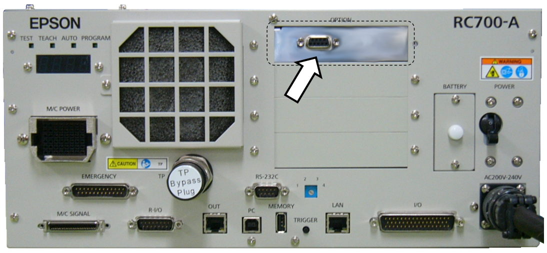


(9) Connect the Force Sensor M/I connection cable to the Force Sensor I/F to be used.
Connect to the Connector Sensor Port for Force Sensor.

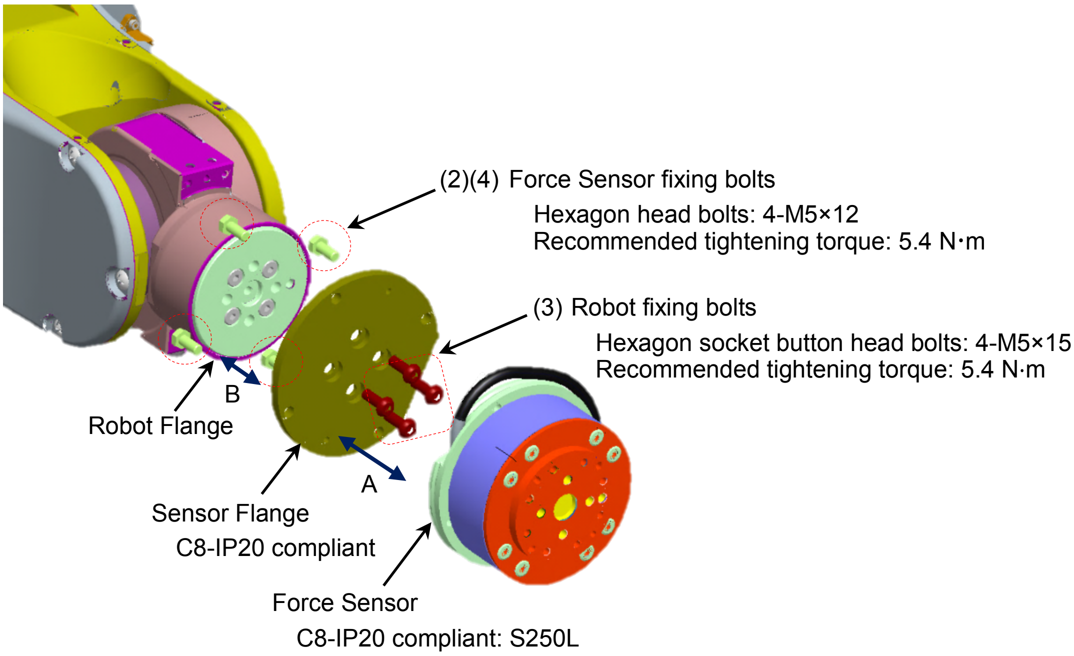
Force Sensor I/F unit:



Force Sensor I/F board:



6.1.2 S250L (For C8: IP20 compliant)

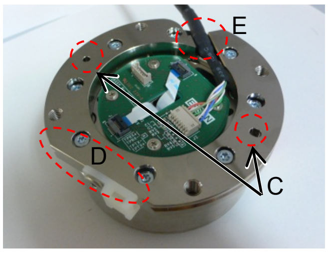


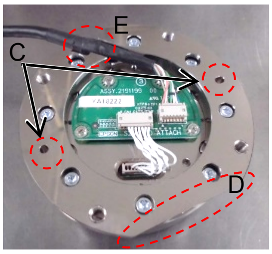
(1) Turn OFF the Controller.

(2) Remove the sensor flange from the Force Sensor. (A)
  Force Sensor fixing bolts (Hexagon head bolts: 4-M5×12)
  (The sensor is fixed to the sensor flange at the time of shipment.)

(3) Install the sensor flange to the robot flange. (B)
  Insert the sensor flange while aligning the two positioning points on the sensor flange (positioning pins and projection at the center) to the robot flange.
  Fix the sensor flange to the robot flange with the robot fixing bolts included with shipment.
  Robot fixing bolts (Hexagon socket button head bolts: 4-M5×15)
  Recommended tightening torque: 5.4 N·m

(4) Install the Force Sensor to the sensor flange fixed in the step (3). (A)
  There are two types of board for the sensor. Please note that the sensor installation method is different depending on the sensor.



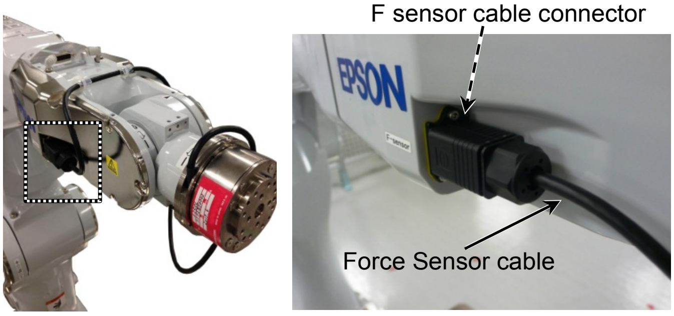


Align the cutouts (D) on the sensor flange and the Force Sensor. Insert the sensor flange by inserting the two positioning pins on the sensor flange to the positioning holes (C) on the sensor.

At this time, adjust the position of the Force Sensor cable so that the part wrapped with the heat shrinkable tube to be at (E).

Fix the sensor flange and the Force Sensor with the bolts removed in the step (2).
  Force Sensor fixing bolts (Hexagon head bolts: 4-M5×12)
  Recommended tightening torque: 5.4 N·m

(5) Connect the Force Sensor cable to the F-sensor cable connector on the Manipulator.

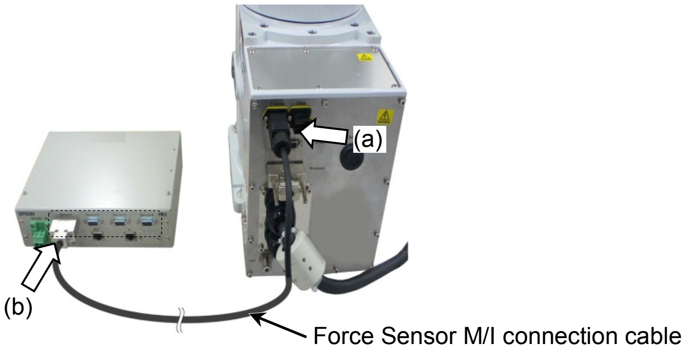


(6) Connect the Force Sensor M/I connection cable to (a) and (b).

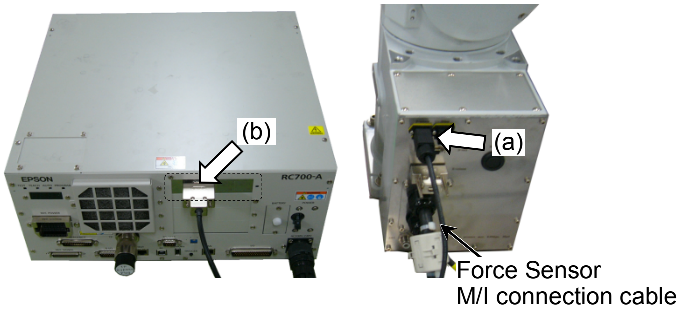
(a) F-sensor cable connector

(b) Connector Sensor Port for Force Sensor of Force Sensor I/F to be used.

Force Sensor I/F Unit:

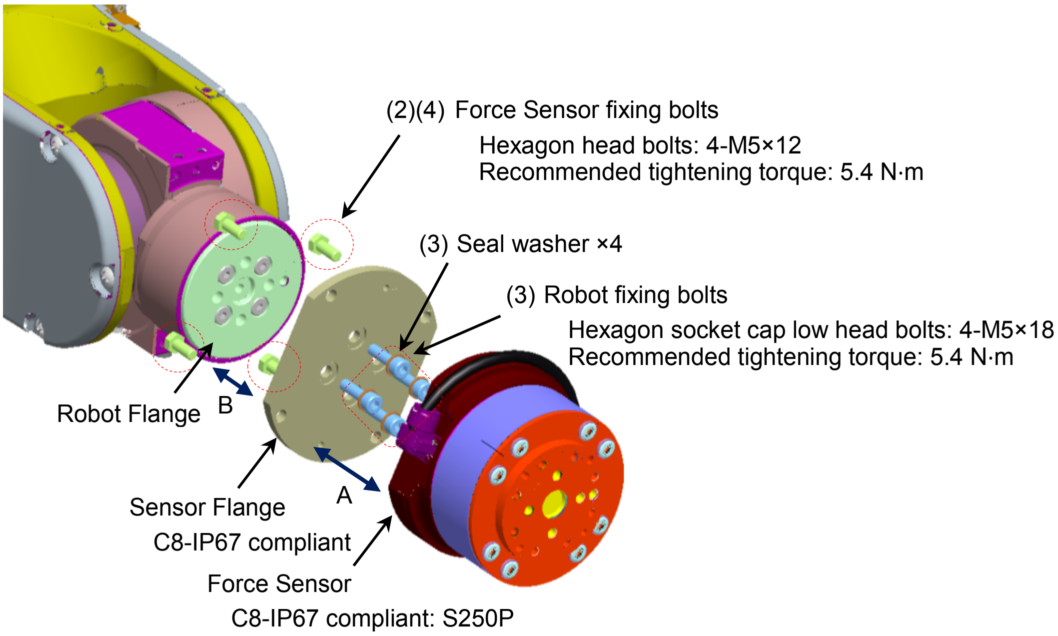


Force Sensor I/F Board:



(7) Operate the Manipulator to any posture, and then record the initial sensor output data.

6.1.3 S250P (For C8: IP67 compliant)

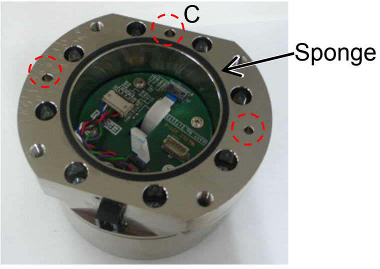


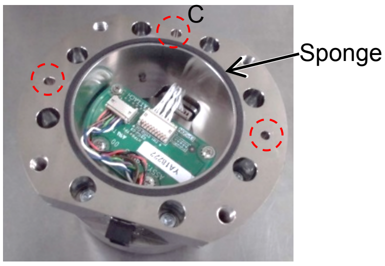
(1) Turn OFF the Controller.

(2) Remove the sensor flange from the Force Sensor. (A)
Force Sensor fixing bolts (Hexagon head bolts: 4-M5×12)
(The sensor is installed to the sensor flange at the time of shipment.)

(3) Install the sensor flange to the robot flange. (B)
First, insert the sensor flange while aligning the two positioning points on the sensor flange (positioning pins and projection at the center) to the robot flange.
Then, insert the seal washers to the root of the robot fixing bolts included with shipment.
Fix the sensor flange and the robot flange with the bolts.
Robot fixing bolts (Hexagon socket cap low head bolts: 4-M5×18)
Recommended tightening torque: 5.4 N·m

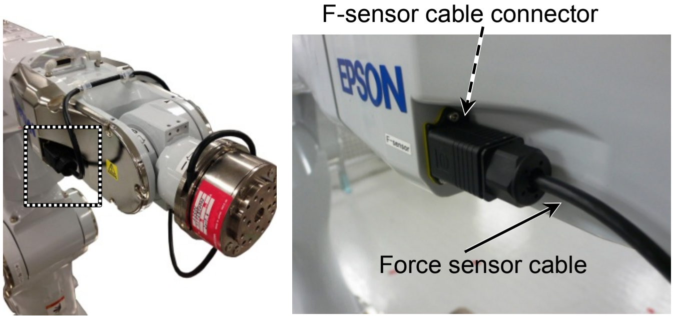
(4) Install the Force Sensor to the sensor flange fixed in the step (3). (A)
There are two types of board for the sensor. Please note that the sensor installation method is different depending on the sensor.





Install the Force Sensor so that the three positioning pins on the sensor flange and the positioning holes (C) on the sensor fit each other.
When inserting the sensor, try to prevent the foreign material from attaching to the mounting face. Also, be careful not to touch the sponge.
Fix the sensor flange and the Force Sensor with the bolts removed in the step (2).
Force Sensor fixing bolts (Hexagon head bolts: 4-M5×12)
Recommended tightening torque: 5.4 N·m

(5) Connect the Force Sensor cable to the F-sensor cable connector on the Manipulator.

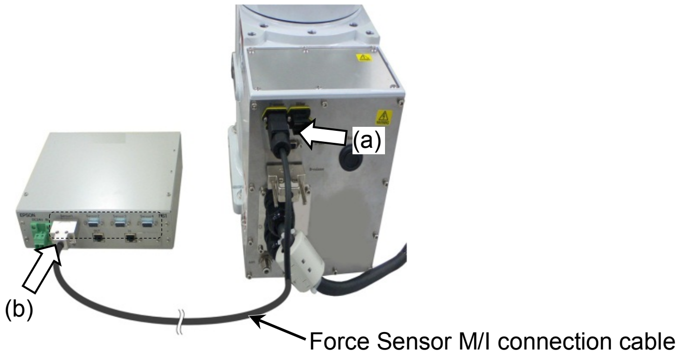


(6) Connect the Force Sensor M/I connection cable to (a) and (b).

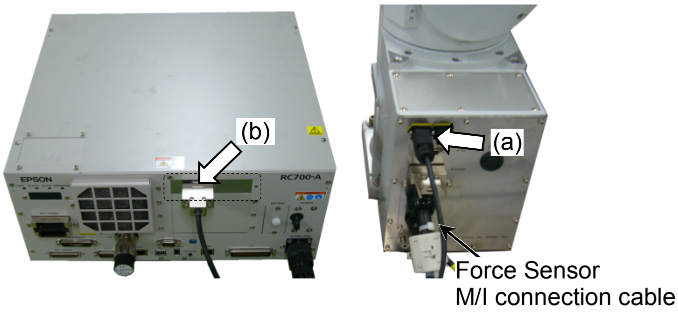
(a) F-sensor cable connector

(b) Connector Sensor Port for Force Sensor of Force Sensor I/F to be used.

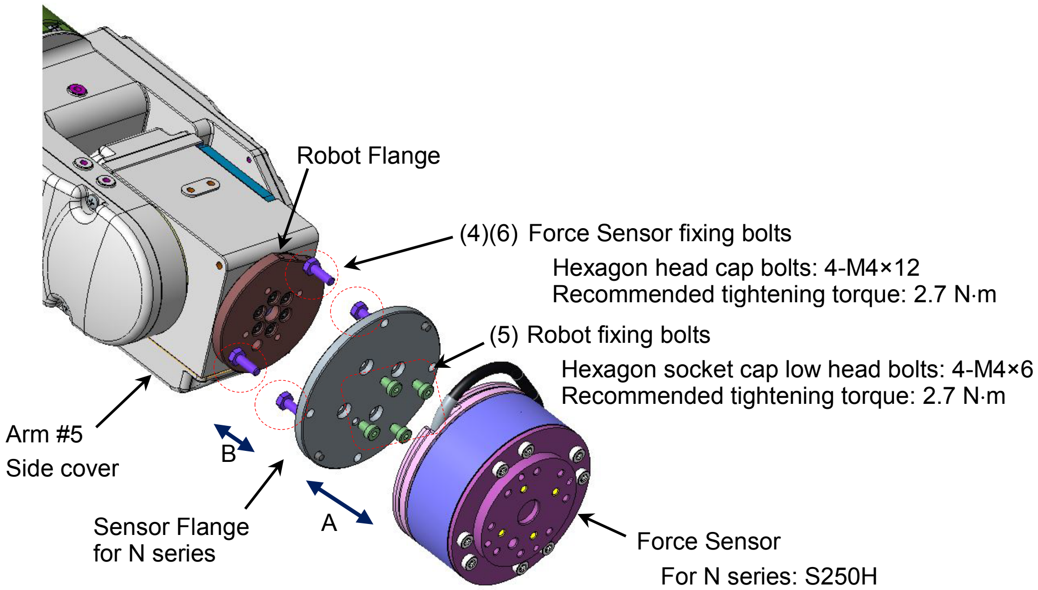
Force Sensor I/F Unit:



Force Sensor I/F Board:



6.1.4 S250H (For N2 series)



(1) Tilt the Joint #6 about +20° from the origin posture.

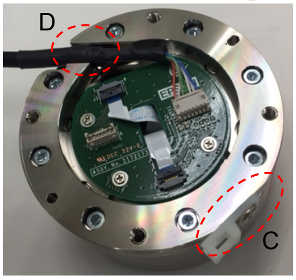
(2) Turn OFF the Controller.

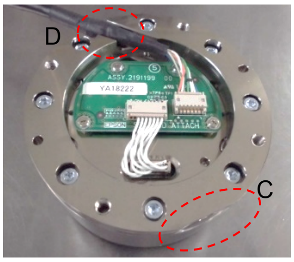
(3) Remove the Arm #5 side cover of the Manipulator.
(Cross recessed head screw: 4-M3×6)

(4) Remove the sensor flange from the Force Sensor. (A)
Force Sensor fixing bolts (hexagon head bolts: 4-M4×12)
(The sensor is installed to the sensor flange at the time of shipment.)

(5) Install the sensor flange to the robot flange. (B)
First, insert the sensor flange while aligning the two positioning points on the sensor flange (positioning pins and projection at the center) to the robot flange.
Fix the sensor flange and the robot flange with the bolts.
Robot fixing bolts (Hexagon socket cap low head bolts: 4-M4×6)
Recommended tightening torque: 2.7 N·m

(6) Install the Force Sensor to the sensor flange fixed in the step (5). (A)
There are two types of board for the sensor. Please note that the sensor installation method is different depending on the sensor.



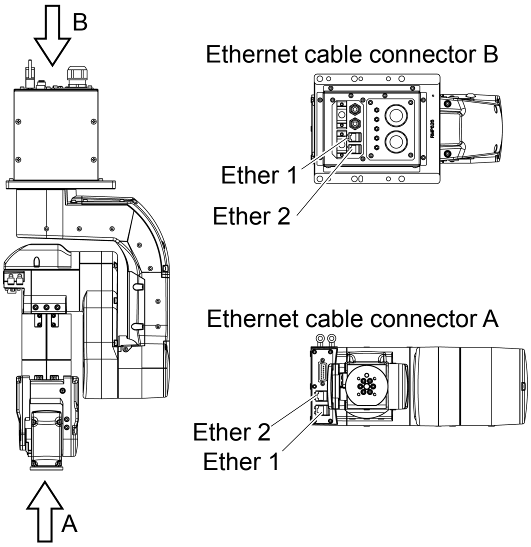


Align the cutouts (C) on the sensor flange and the Force Sensor. Insert the sensor flange while inserting the two positioning pins on the sensor flange to the sensor.
At this time, adjust the position of the Force Sensor cable so that the part wrapped with the heat shrinkable tube to be at (D).
Fix the sensor flange and the Force Sensor with the bolts removed in the step (4)
Force Sensor fixing bolts (Hexagon head bolts: 4-M4×12)
Recommended tightening torque: 2.7 N·m

(7) Install the Arm #5 side cover of the Manipulator.
(Cross recessed head screw: 4-M3×6 Recommended tightening torque: 0.45 N·m)

(8) Fix the Force Sensor cable to the Manipulator.
Set the cable so as not to interfere with Manipulator motion and not to apply load on the cable.

(9) Connect the Force Sensor cable to the following connector.
Ethernet cable connector A (Ether1, or Ether2)

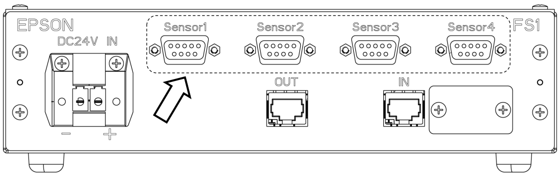


(10) Connect the Force Sensor M/I connection cable to (a) and (b).

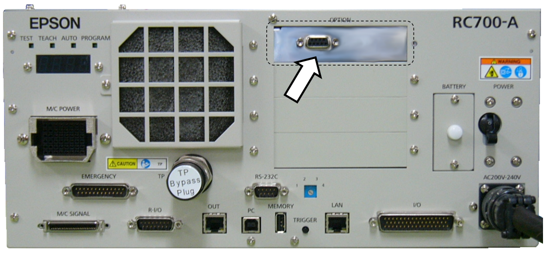
(a) : Ethernet cable connector B
Connector with the same name as the one connected in the step (9)
(Ether1, or Ether2)

(b) : Connect to Force Sensor I/F to be used
Connect to the Connector Sensor Port for Force Sensor.

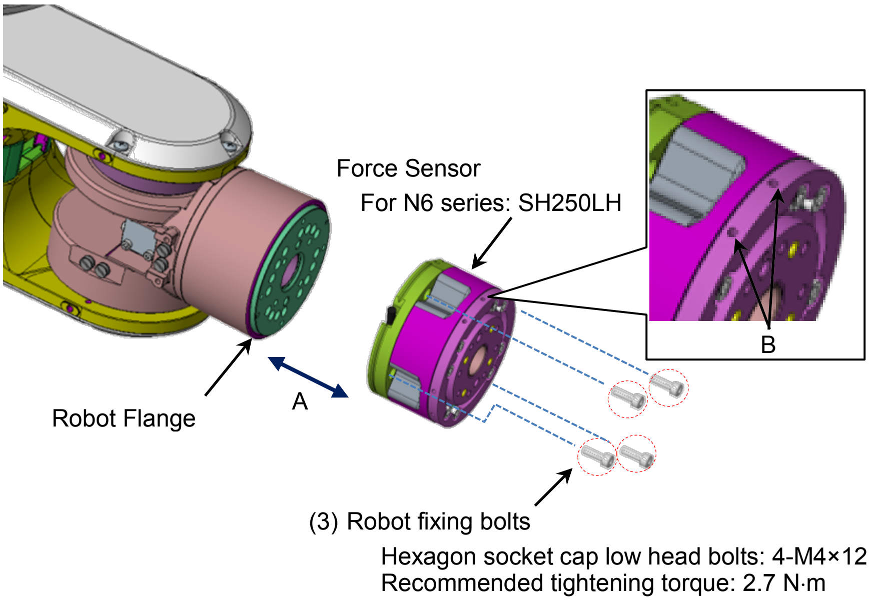
Force Sensor I/F Unit:



Force Sensor I/F Board:



6.1.5 SH250LH (For N6 series)

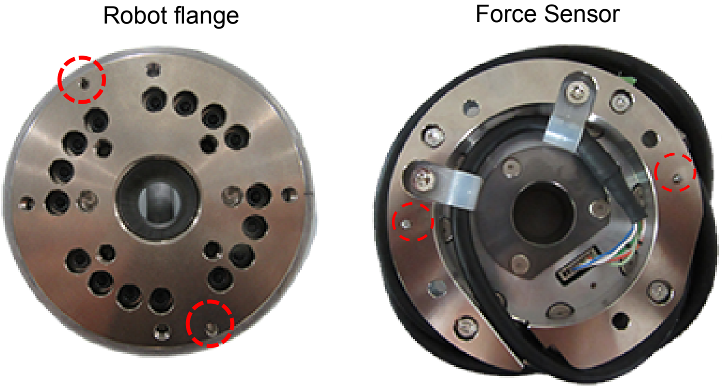


⚠ CAUTION	■ If fixing the cables in B parts, force sensor value may be affected. For the wiring example, refer to the following section. *6.3.4 N6 series-SH250LH*

(1) Move the Joint #6 of the robot the origin posture.

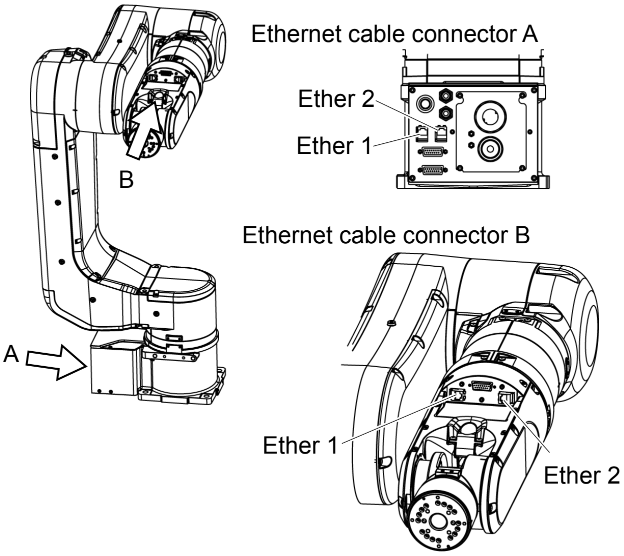
(2) Turn OFF the controller.

(3) Install the sensor flange to the robot flange. (A)
First, insert the sensor flange while aligning the two positioning points on the force sensor (positioning pins) to the robot flange. (Red circles on the pictures below)
Fix the sensor flange and the robot flange with the bolts.
Robot fixing bolts (Hexagon socket cap low head bolts: 4-M4×12)
Recommended tightening torque: 2.7 N·m



(4) Fix the Force Sensor cable to the Manipulator.
Set the cable so as not to interfere with Manipulator motion and not to apply load on the cable.

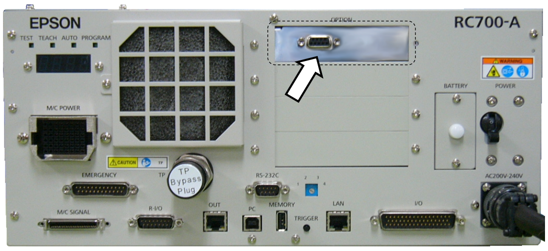
(5) Connect the Force Sensor cable to the following connector.
Ethernet cable connector A (Ether1, or Ether2)



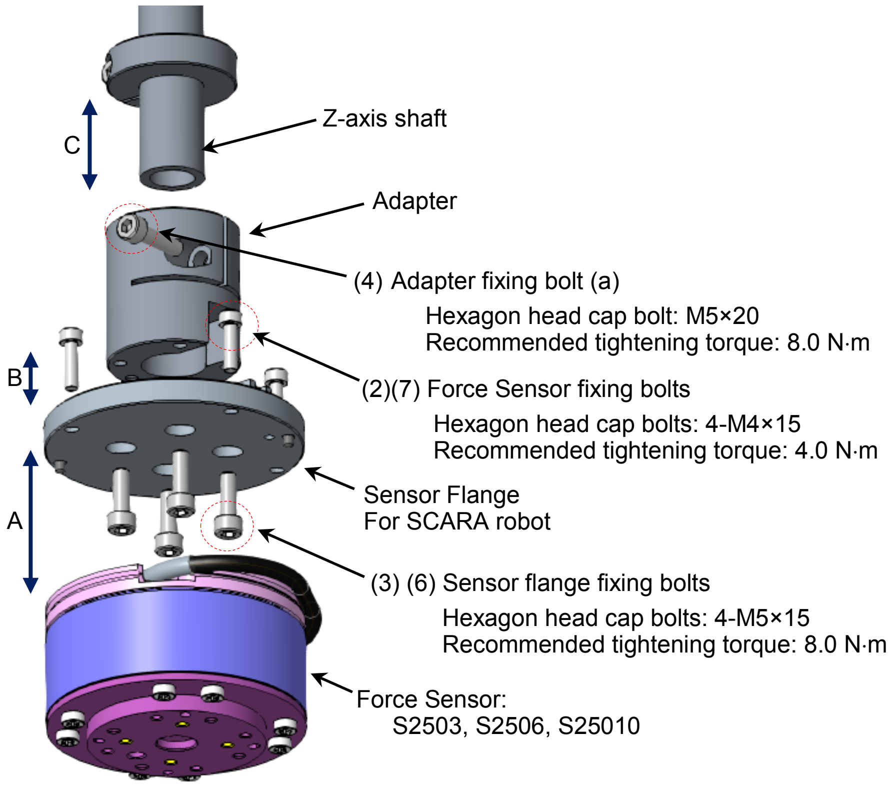
(6) Connect the Force Sensor M/I connection cable to (a) and (b).

(a) : Ethernet cable connector B
Connector with the same name as the one connected in the step (5)
(Ether1, or Ether2)

(b) : Connect to Force Sensor I/F to be used
Connect to the Connector Sensor Port for Force Sensor.



6.1.6 S2503, S2506, S25010 (For G, RS series)



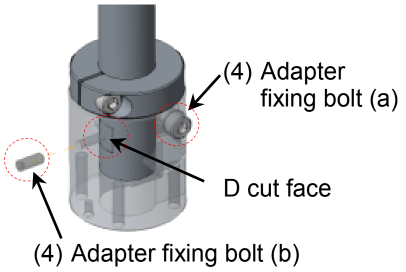
(1) Turn OFF the Controller.

(2) Remove the sensor flange from the Force Sensor. (A)
Force Sensor fixing bolts (Hexagon head bolts: 4-M4×15)
(The sensor is installed to the sensor flange at the time of shipment.)

(3) Fix the sensor flange and the adapter (B)
Sensor flange fixing bolts (Hexagon head bolts: 4-M5×15)
Recommended tightening torque: 8.0 N·m

(4) Insert and fix the adapter at 30 mm from the end of the Z-axis shaft. (C)
If the Z stopper position has not been changed since the time of shipment, fix the adapter where it touches the Z stopper.

Fix with the following bolts (a) and (b). Adjust the direction of the bolt (b) so as to touch the D-cut face on the Z-axis shaft vertically.



Adapter fixing bolt (a):
Stud clamp bolt
(Hexagon socket head cap bolt: M5×20)
Recommended tightening torque: 8.0 N·m

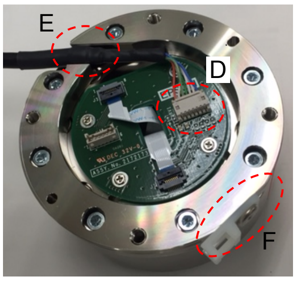
Adapter fixing bolt (b):
Set screw
(Hexagon socket set screw: M4×10)
Recommended tightening torque: 2.4 N·m

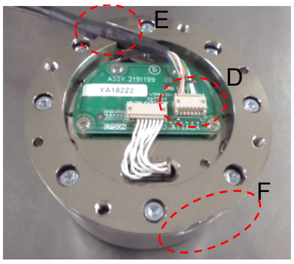
(5) Connect the Force Sensor cable to the connector (D) on the Force Sensor.

There are two types of board for the sensor. Please note that the sensor installation method is different depending on the sensor.

When passing the Force Sensor cable to the Z-axis hollow shaft, follow the following steps.

1. Pass the Force Sensor cable from the upper part of the shaft.
2. Pull out the cable from the opening on the adapter.
3. Connect the Force Sensor cable to the connector (D) on the Force Sensor.





(6) Install the Force Sensor to the sensor flange fixed in the step (3). (A)
Align the cutouts (F) on the sensor flange and the Force Sensor. Insert the sensor flange while inserting the two positioning pins on the sensor flange to the sensor.
At this time, adjust the position of the Force Sensor cable so that the part wrapped with the heat shrinkable tube to be at (E).

(7) Fix the sensor flange and the Force Sensor with the bolts removed in the step (2).
Force Sensor fixing bolts (Hexagon head bolts: 4-M4×15)
Recommended tightening torque: 4.0 N·m

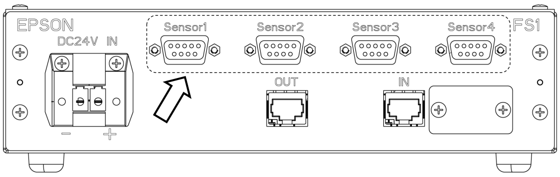
(8) Fix the Force Sensor cable to the Manipulator.
Set the cable so as not to interfere with Manipulator motion and not to apply load on the cable.
For details of cable wiring and grounding, refer to the following section.
Hardware 6.3 Wiring of the Force Sensor cable

(9) Connect the Force Sensor M/I connection cable to (a) and (b).

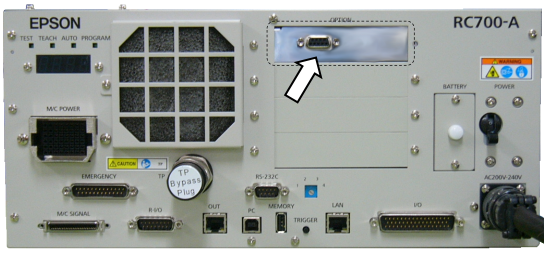
(a) :F Sensor Cable Connector

(b) :Connect to Force Sensor I/F to be used
Connect to the Connector Sensor Port for Force Sensor.

Force Sensor I/F Unit:



Force Sensor I/F Board:



⚠ CAUTION	■ In the case of RS series, when connecting with aligning the Force Sensor with D cut face, positive and negative of X axis and Y axis will be inverted 180 degrees. Sensor labels will be inverted as well. Please take the following actions since force control of X axis and Y axis will be worked in reverse. (When using the flange supplied by us.) When using the firmware that is Ver.7.3.4.0 or before: Execute the following SPEL+ command. `> FSet Robot.FlangOffset, 0, 0, -22, 180, 0, 180` Ref: EPSON RC+ 7.0 Option Force Guide 7.0 Property &Status Reference: *FlangeOffset property* When updating the firmware from Ver.7.3.4.0 or before to Ver.7.3.4.0 or later: Click the <Defaults> button in EPSON RC+ Menu - [Tool] - [Robot manager] - [Mass/Gravity] Panel. Ref: EPSON RC+ 7.0 Option Force Guide 7.0 Software *3.5.1 [Robot Manager] (Tools Menu)*

6.2 End Effector

The end effector must be fabricated by customers.

NOTE ☞

For details about mounting screw holes position on end effector side, refer to the following section.
Hardware 4.2 Outer Dimensions

⚠ CAUTION	■ Design the sensor installation face of the end effector so that the sensor can be completely contacted to the end effector. Also, use the end effector with sufficient rigidity in order to achieve high performance of the sensor. ■ When operating the Manipulator with the end effector installed, the end effector may collide with the Manipulator body due to following factors. End effector outer diameter / Work piece size / Force Sensor outer diameter/ Arm position, etc. When designing the system, be very careful of interference area of the end effector and Force Sensor.

6.2.1 Guidelines of Allowable Moment

The following describes precautions when designing an end effector.

There is an allowable moment on joints of the robot. You need to design the robot not to exceed the limit of the allowable moment of corresponding joints. Allowable moment is calculated as follows.

When the direction of the load and pressing moment are the same:

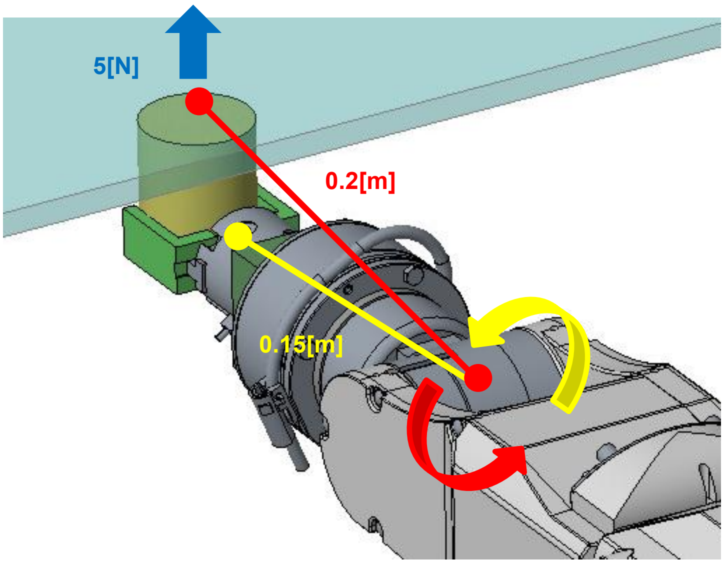
Moment [N·m]
= Load mass (Force Sensor, end effector, workpiece) [kg]×Gravity acceleration [m/s^2] ×Joint distance between center of rotation and gravity center of load [m]+pressing force [N]×Joint distance between center of rotation and contact point [m]

When the direction of the load and pressing moment are different:

Moment [N·m]
= Load mass (Force Sensor, end effector, workpiece) [kg]×Gravity acceleration [m/s^2] ×Joint distance between center of rotation and gravity center of load [m]– pressing force [N]×Joint distance between center of rotation and contact point [m]

Calculation example: Upward (C4: J5)

Calculation procedure of allowable moment which is applied J5 on C4 series manipulator when applying 5N to upward.



Moment [N·m] applied on J5

= Load mass (Force Sensor, end effector, workpiece) [kg]×Gravity acceleration [m/s^2] ×J5 Distance between center of rotation and gravity center of load [m] + pressing force [N]×J5 Distance between center of rotation and contact point [m]

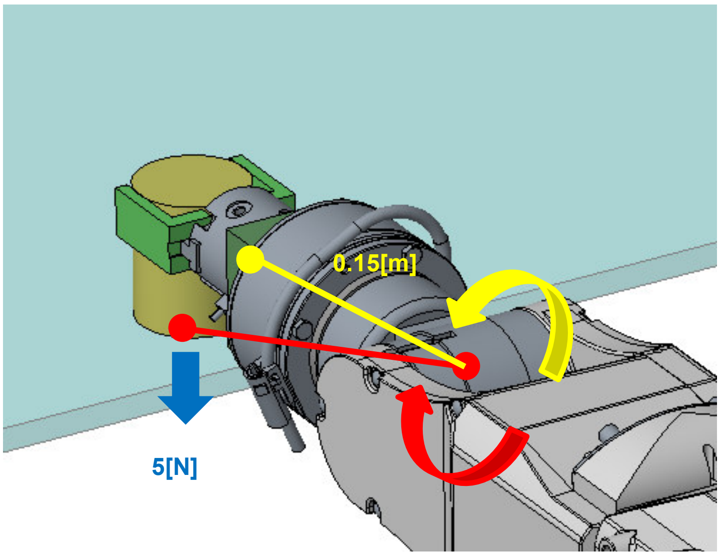
= 1[kg]×9.8[m/s^2]×0.15[m]+5[N]×0.2[m]

= 2.47[N·m]

There is no problem since moment 2.47[N·m] applied on J5 does not exceed the allowable moment 4.41[N·m] of J5.

Calculation example: Downward (C4: J5)

Calculation procedure of allowable moment which is applied J5 on C4 series manipulator when applying 5N to downward.



Moment [N·m] applied on J5

= Load mass (Force Sensor, end effector, workpiece) [kg]×Gravity acceleration [m/s^2]×J5 Distance between center of rotation and gravity center of load [m] – pressing force [N]×J5 Distance between center of rotation and contact point [m]

= 1[kg]×9.8[m/s^2]×0.15[m]-5[N] ×0.2[m]

= 0.47[N·m]

There is no problem since moment 0.47[N·m] applied on J5 does not exceed the allowable moment 4.41[N·m] of J5.

Perform the same consideration or verification for other joints.

6.2.2 Guidelines of Joint Torque

When application applies a great force or load of end effector/workpiece is heavy, follow the directions shown below and check the joint torque.

Check of Joint Peak Torque

PTRQ can acquire or display the peak torque. (Refer to sample program for usage.)

When PTRQ is “1”, problems of security may occur. Make sure to check the PTRQ is less than “1”.

```
Function PTRQ_Check        ' Sample program to acquire or display PTRQ
   Integer i
   Double PT(6)
   Do                      'Repeat motion part and PTRQ acquisition part
      PTCLR                'Clear the peak torque
'--- Motion part (Example)---Motion part is an example and is described by user
      TLSet 1, XY(0, 0, -49, 0, 0, 0) 'Set the tool 1
      Tool 1               'Specify the tool 1
      Motor On             'Motor On
      Power High           'Power high
      Speed 100            'PTP motion speed setting
      Accel 100, 100       'PTP motion acceleration setting
      SpeedS 50            'CP motion speed setting
      AccelS 500, 500      'CP motion speed setting

      Go P1                'PTP motion to P1
      Go P2 +Z(20)         'Move to P2+Z20mm
      Move P2

      FSet FC1.Fz_Enabled, True 'Enable force control function only for Fz
      FSet FC1.Fz_Spring, 0     'Spring value is 0
      FSet FC1.Fz_Damper, 10    'Damper value is 10
      FSet FC1.Fz_Mass, 10      'Mass value is 10
      FSet FC1.Fz_TargetForce, -50 'Set the target force of Fz to -50N
      Wait 0.3             'Wait for 0.3 s
      FSet FS1.Reset       'Reset the Force Sensor
      FCKeep FC1, 10       'Execute force control function for 10 s

      Move P2              'Move to P2
      Go P2 +Z(20)         'Move to P2+Z20mm
'-------------------------------------------------------
      For i = 1 To 6       'Repeat 1 to 6
         PT(i) = PTRQ(i)   'Acquire PTRQ
         Print "PT_J", i, "=", PTRQ(i) 'Display PTRQ
      Next
   Loop
Fend
```

Overload Rate of Joint

OLRate can acquire or display the overload rate. (Refer to sample program for usage.)

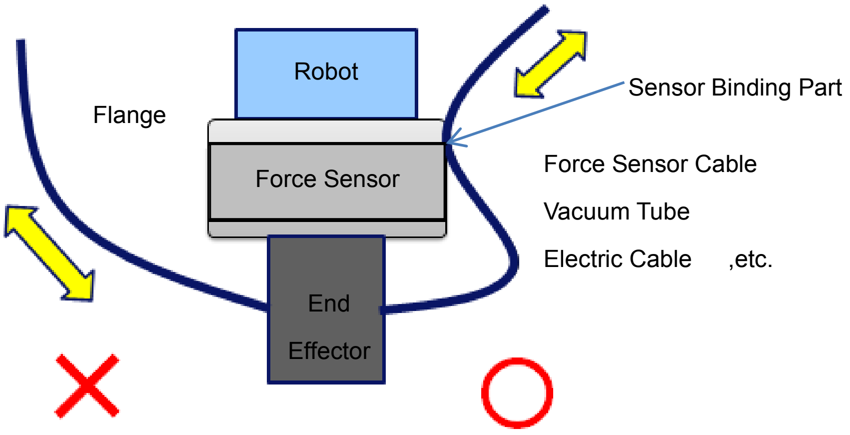
OLRate rises when overload is applied on the joints and falls when overload is no longer applied.
Stop as servo error when OLRate keeps rising and becomes “1”. Make sure that OLRate does not keep rising.
In particular, check the OLRate rising amount of one motion cycle is “0”.

```
Function OLRate_Check      'Program to acquire or display OLRate
   Integer i, j
   Double OLCheck(6), OL(6)
   Do                      'Repeat motion part and PTRQ acquisition part
'--- Motion part (Example)--- Motion part is an example and is described by user
      TLSet 1, XY(0, 0, -49, 0, 0, 0) 'Set the tool 1
      Tool 1               'Specify the tool 1
      Motor On             'Motor On
      Power High           'Power high
      Speed 100            'PTP motion speed setting
      Accel 100, 100       'PTP motion acceleration setting
      SpeedS 50            'CP motion speed setting
      AccelS 500, 500      'CP motion speed setting

      Go P1                'PTP motion to P1
      Go P2 +Z(20)         'Move to P2+Z20mm
      Move P2              'CP motion to P2

      FSet FC1.Fz_Enabled, True ' Enable force control function only for Fz
      FSet FC1.Fz_Spring, 0          'Spring value is 0
      FSet FC1.Fz_Damper, 10         'Damper value is 10
      FSet FC1.Fz_Mass, 10           'Mass value is 10
      FSet FC1.Fz_TargetForce, -50 'Set the target force of Fz to -50N
      Wait 0.3             'Wait for 0.3 s
      FSet FS1.Reset       'Reset the Force Sensor
      FCKeep FC1, 10       'Execute force control function for 10 s

      Move P2              'Move to P2
      Go P2 +Z(20)         'Move to P2+Z20mm

'--------------------------------------------------
      For i = 1 To 6            'Repeat 1 to 6
         If j = 1 Then          'For the second cycle or later
           OLCheck(i) = OLRate(i) - OL(i)
                           'Acquire OLRate rise amount of one motion cycle
           OL(i) = OLRate(i)'Acquire OLRate
           Print "OLCheck_J", i, "=", OLCheck(i)
                           'Display OLRate rise amount of one motion cycle
         Else                   'For the first cycle
           OL(i) = OLRate(i)'Acquire OLRate
         EndIf
      Next
      j = 1
   Loop
Fend
```

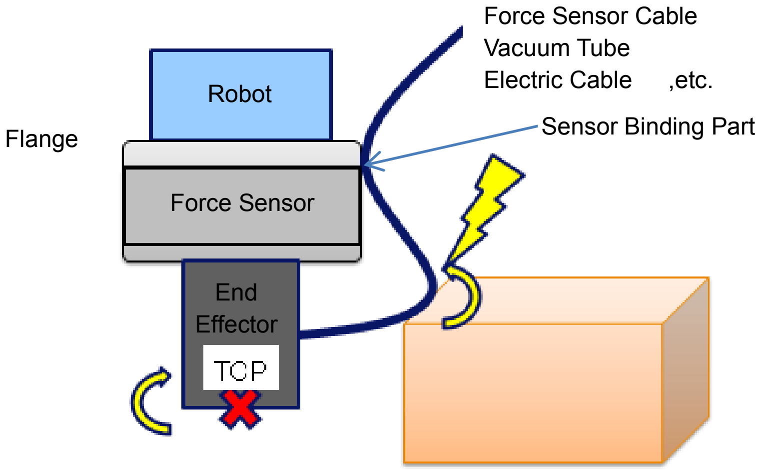
6.2.3 Cautions about Wires and Pipes

Force may be applied to the end effector due to the cable which is connected to the end effector or pulling from the pipes. The force sensor also detects this force. This force may have bad influence for the operation. Therefore, fix the cables and pipes to the sensor binding part.

Fix the wires and pipes to the sensor binding part to reduce the influence of elastic force or gravity.



Force or torque will be generated when wires or pipes touch to surrounding objects. Fix the wires and pipes so as not to touch surroundings.



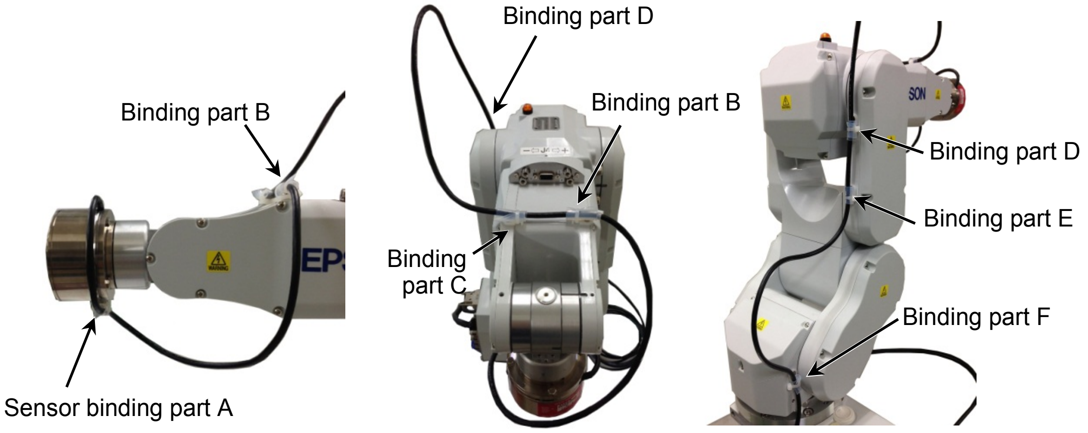
6.3 Wiring of the Force Sensor Cable

The following are recommended wiring examples of the Force Sensor and rough operation ranges of the Manipulator.

For actual applications, fix the wiring according to your manipulator use.

6.3.1 C4 series-S250N

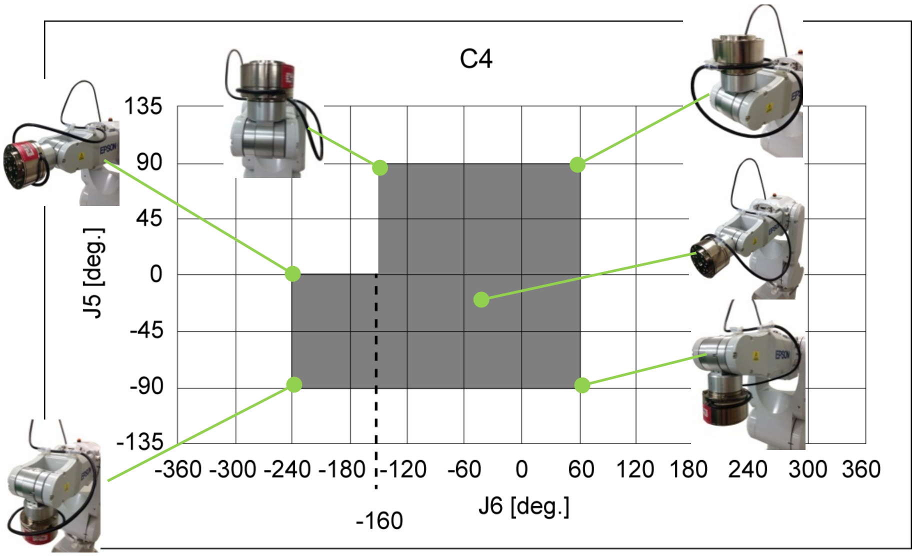
C4 series Manipulator wiring example



Length of A-B (excess length for rotation of J5 and J6): 400 mm

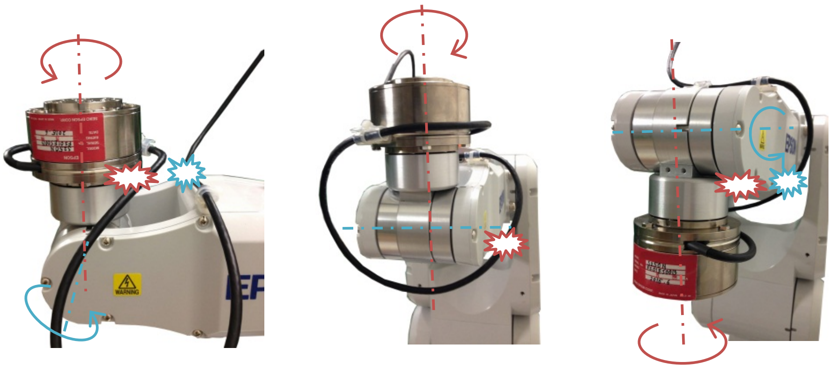
Adjust the lengths of C-D and E-F according to the Manipulator motion.

C4 series Manipulator rough operation range



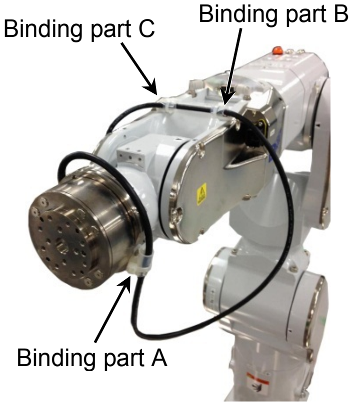
J5	J6
+ 90 deg.	–160 to + 60 deg.
0 to –90 deg.	–240 to + 60 deg.

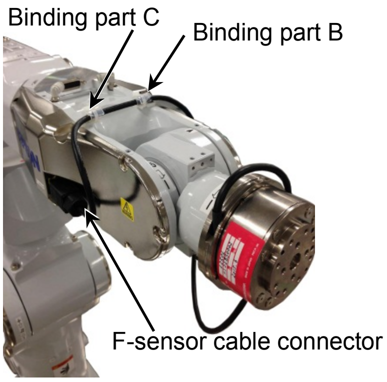
⚠ CAUTION	■ The cable may deform during storage. Please be careful and make sure that the cable’s bend radius is five times larger than the cable diameter (R=30 mm or larger). ■ The cable may rub against the Manipulator as shown in the photos below depending on the Manipulator motion. When routing the cables, make sure to check if the cables touch and rub against the Manipulator.



6.3.2 C8 series-S250L, C8 series-S250P

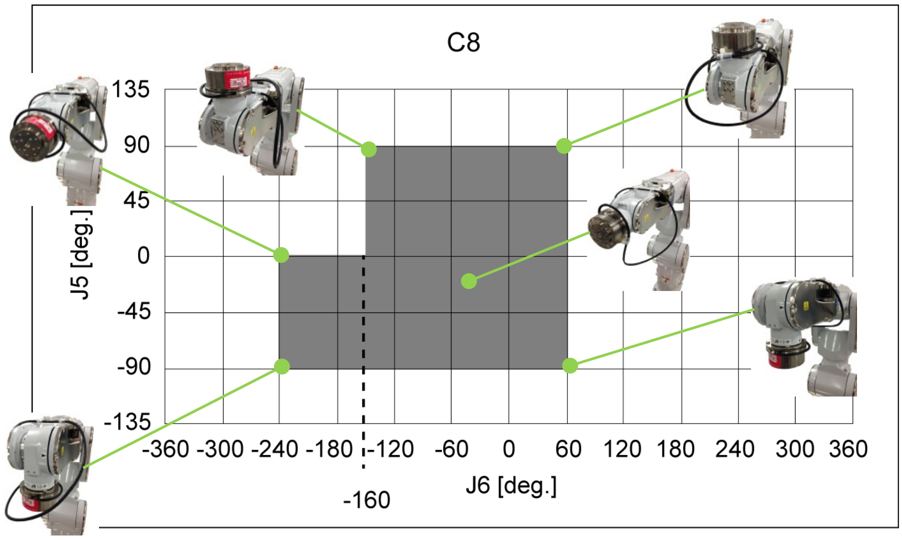
C8 series Manipulator wiring example





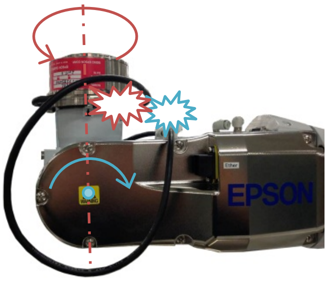
Length of A-B (excess length for rotation of J5 and J6): 475 mm

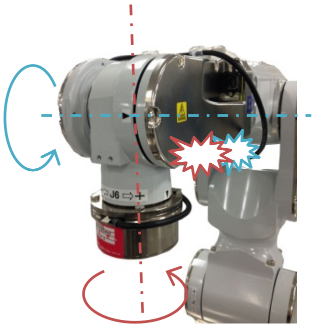
C8 series Manipulator rough operation range



J5	J6
+ 90 deg.	–160 to + 60 deg.
0 ~ to 90 deg.	–240 to + 60 deg.

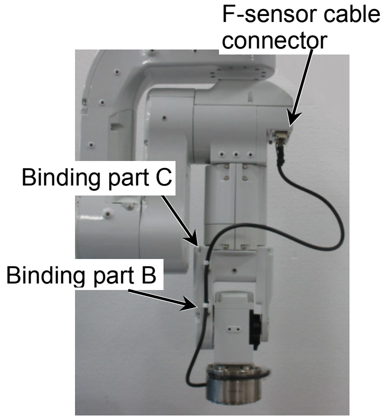
⚠ CAUTION	■ The cable may deform during storage. Please be careful and make sure that the cable’s bend radius is five times larger than the cable diameter (R=30 mm or larger). ■ The cable may rub against the Manipulator as shown in the photos below depending on the Manipulator motion. When routing the cables, make sure to check if the cables touch and rub against the Manipulator.

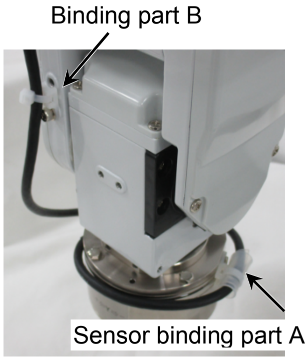




6.3.3 N2 series-S250H

N2 series Manipulator wiring example

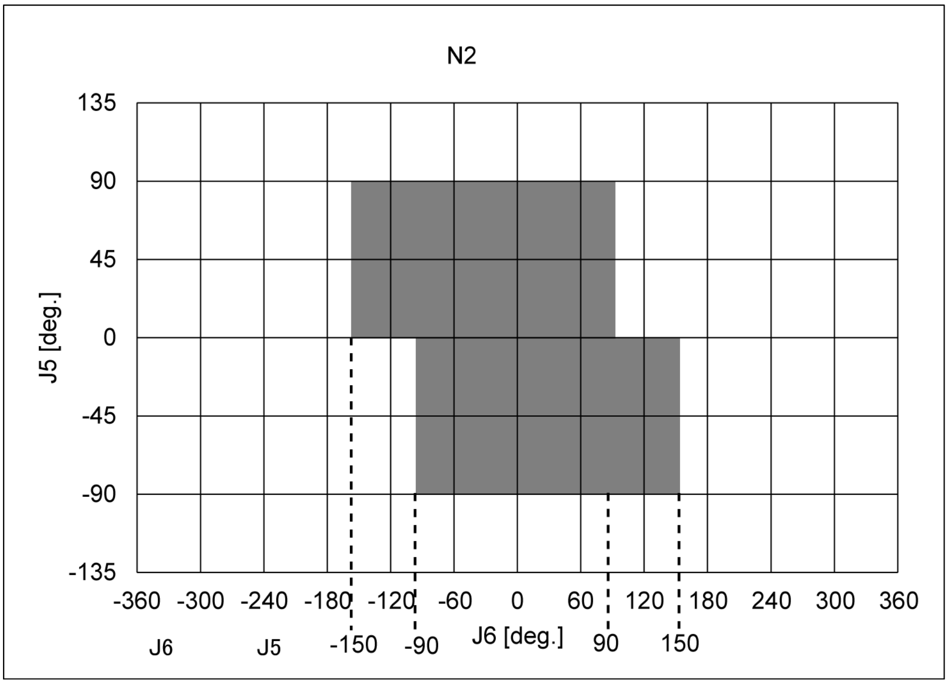




Length of A-B (excess length for rotation of J5 and J6): 330 mm

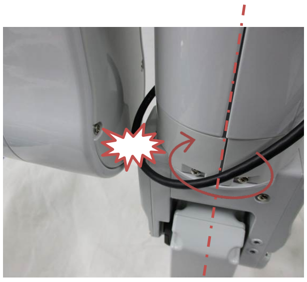
When installing the cables with the above example, the cable diameter should be 13 mm or less.

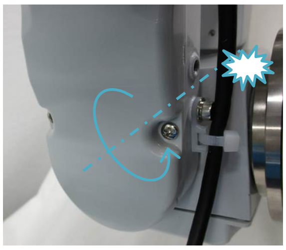
Rough indication of motion range for the N2 series Manipulator when wiring with above example



J5	J6
+ 90 deg.	–150 ~ + 90 deg.
0 deg.	–150 ~ + 150 deg.
-90 deg.	–90 ~ + 150 deg.

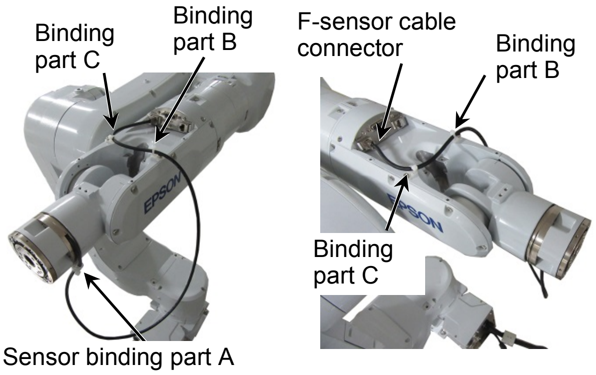
⚠ CAUTION	■ The cable may deform during storage. Please be careful and make sure that the cable's bend radius is five times larger than the cable diameter (R=30 mm or larger). ■ The cable may rub against the Manipulator as shown in the photos below depending on the Manipulator motion. Be very careful when routing the cables and be sure to check if the cables touch and rub against the Manipulator. In particular, if the Joint #4 is rotated when the Arm #2 and #4 overlap each other, the cables may get caught between them. Caution is required in this regard.





6.3.4 N6 series-SH250LH

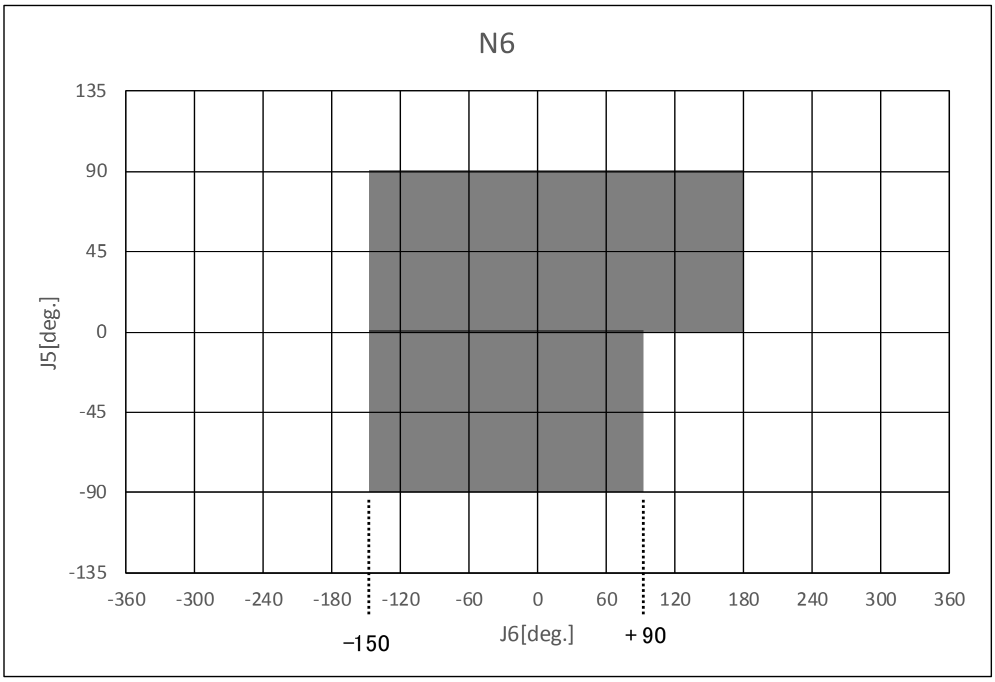
N6 series Manipulator wiring example



Length of A-B (excess length for rotation of J5 and J6):: 500mm

When installing the cables with the above example, the cable diameter should be 13 mm or less.

Rough indication of motion range for the N6 series Manipulator when wiring with above example



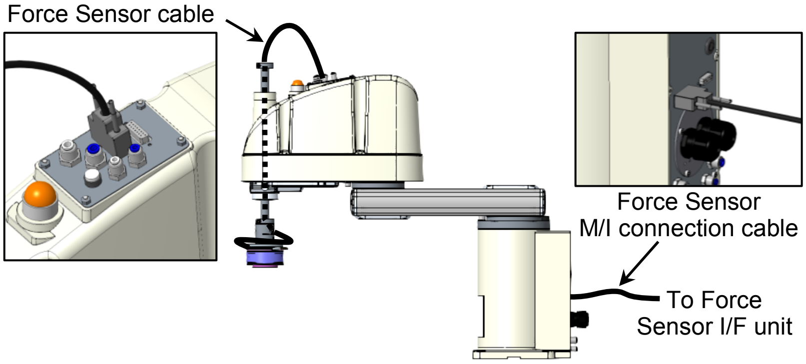
J5	J6
+ 90 deg.	−150 ~ + 180 deg.
0 deg.	−150 ~ + 180 deg.
−190 deg.	−150 ~ + 90 deg.

⚠ CAUTION	■ The cables may deform during storage. Please be careful and make sure that the cables' bend radius is five times larger than the cable diameter (R=30 mm or larger). ■ The cable may rub against the Manipulator as shown in the photos below depending on the Manipulator motion. When routing the cables, make sure to check if the cables touch and rub against the Manipulator. In particular, if the Joint #4 is rotated when the Arm #2 and #4 overlap each other, the cables may get caught between them. Caution is required in this regard. ■ When passing cables through the center hole, weight of the cable may affect to the sensor value. When routing the cable, be careful for the fixing position. If the cable weight affects to operations, refer to the wiring example in this section and fix the cable.

6.3.5 G series-S2503, S2506, S25010

Wiring example 1: When using the D-sub

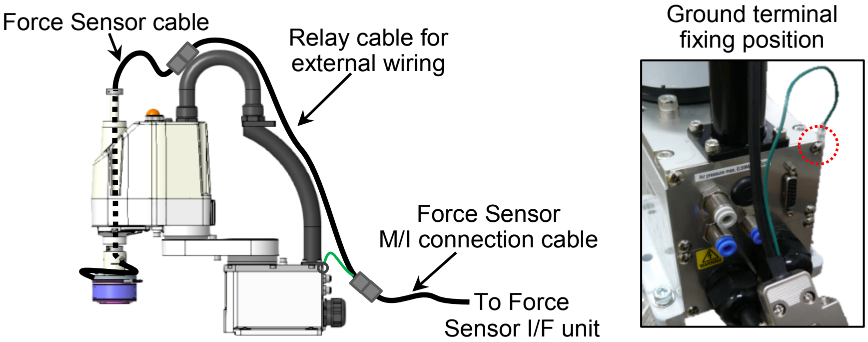
G6, G10, and G20 series use the user connector D-sub (9-pin) to install the Force Sensor.



Wiring example 2: When using the cable duct, external wiring option, etc.

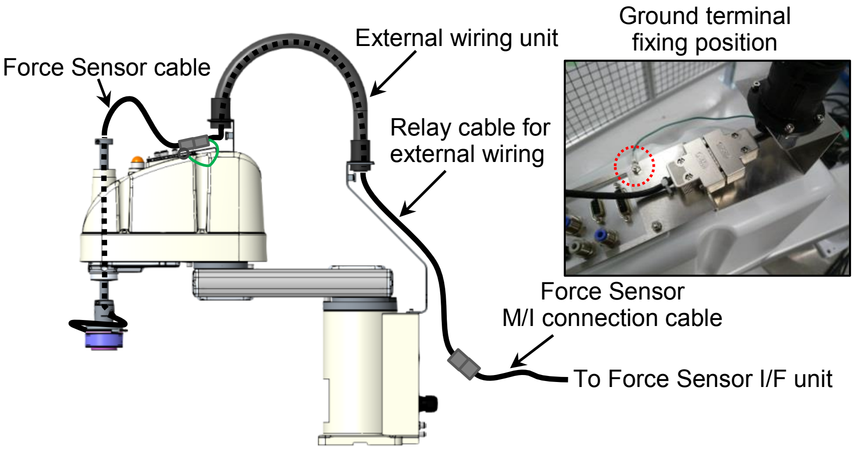
For G3 series, install the cables on the exterior of the Manipulator using the cable duct.

When installing the cables outside the Manipulator, make sure to install the ground wire of the relay cable to the specified position on the Manipulator.

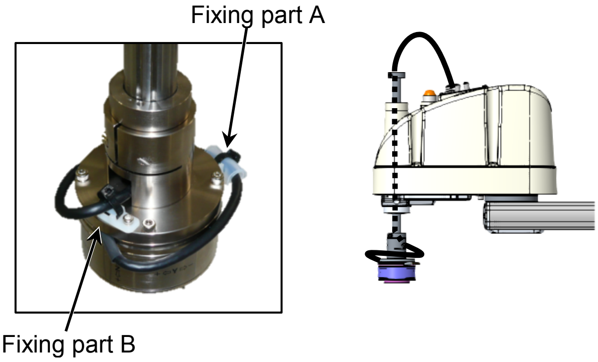


For G6, G10, and G20 series, external wiring is available with the following option products.

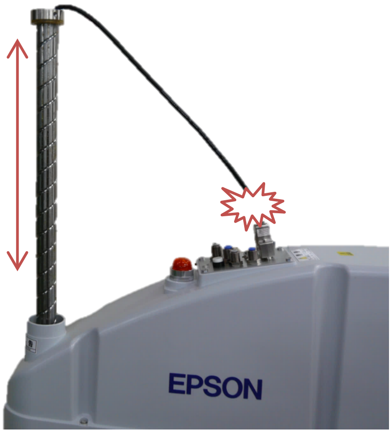
Option product			Code
External wiring unit	G6-***S	For Table top mounting /standard model	R12B031909
	G6-***SR/SW	For Ceiling /Wall mounting /standard model	R12B031910
	G10/G20-***S	For Table top mounting /standard model	R12B031911
	G10/G20-***SR/SW	For Ceiling /Wall mounting /standard model	R12B031912
Relay cable			R12NZ900RW



Wiring example 1 and 2 use the attached cable mounts and wire ties for the following fixing parts A and B. For other parts, fix the cables according to the Manipulator motion.

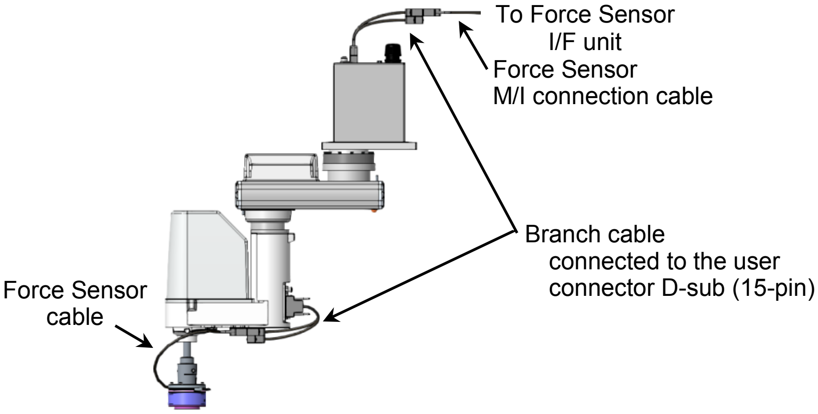


CAUTION	■ The cables may deform during storage. Please be careful and make sure that the cables' bend radius is five times larger than the cable diameter (R=30 mm or larger). ■ The cable may rub against the Manipulator or get under tension as shown in the photo below depending on the Manipulator motion. When routing the cable, be careful in this regard and check if it touches and rubs against the Manipulator or is under tension.



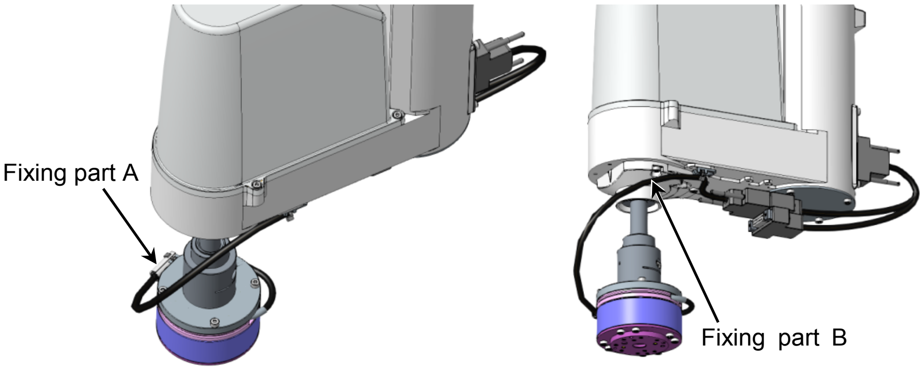
6.3.6 RS series-S2503

RS series uses the user connector D-sub (15-pin) for installing the Force Sensor.
Connect the user connector and the Force Sensor cable by using the attached branch cable.
The branch cable divides the user connector D-sub (15-pin) to 6-pin and 9-pin.



Fix the fixing parts A and B using the attached wire ties and the cable mounts.
For other parts, fix the cables according to the Manipulator motion.

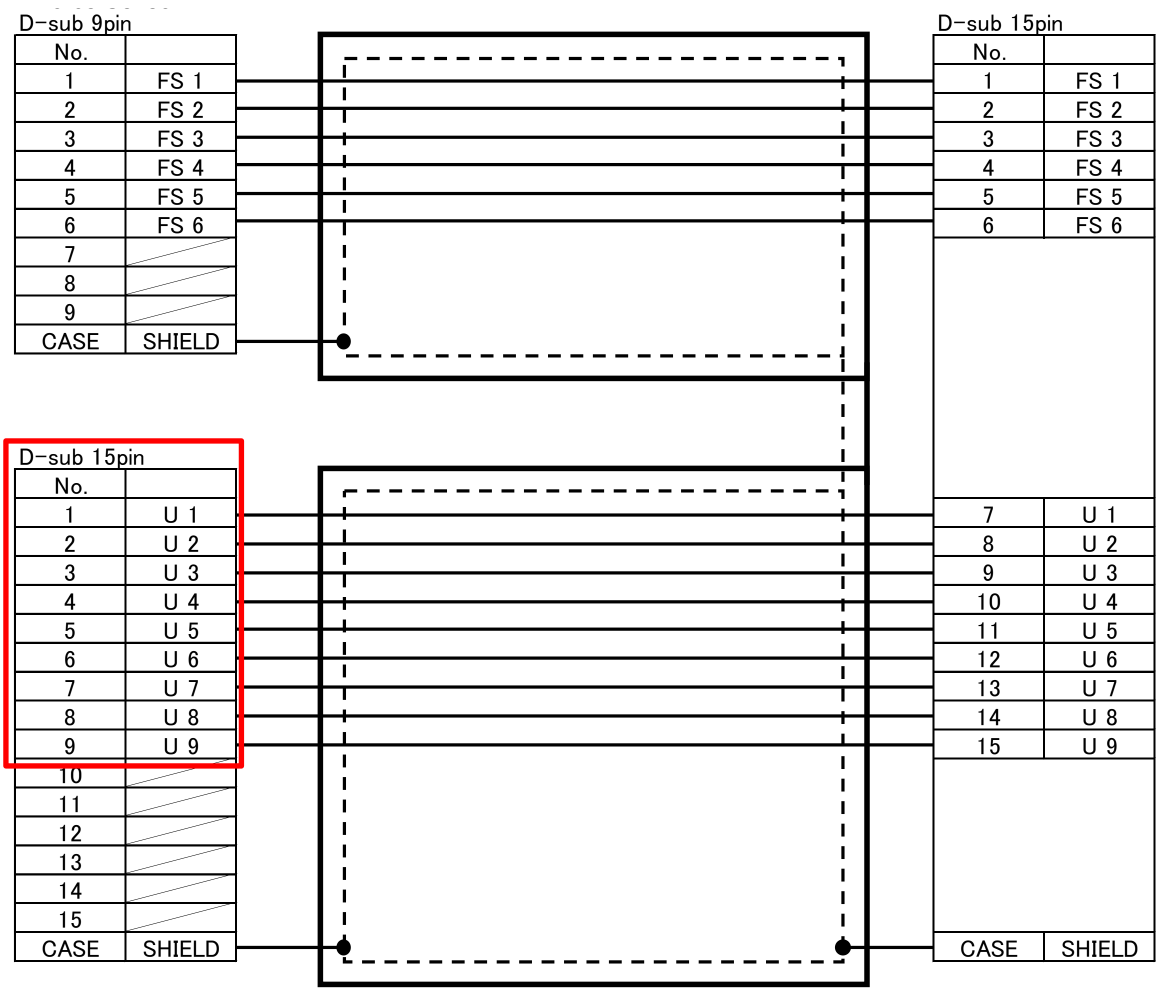
Length of A-B (excess length for rotation of J4): 350 mm



When installing the cables with the above example, set the Manipulator motion with the following range as a rough guide.

J4
+ 180 deg.
– 180 deg.

Among the user connector D-sub (15-pin), branches 6-pin with the branch cable and use it for the Force Sensor. Use the remaining 9-pin by referring to the figure below.



CAUTION	■ The cable may deform during storage. Please be careful and make sure that the cable's bend radius is five times larger than the cable diameter (R=30 mm or larger). ■ The cable may rub against the Manipulator as shown in the photos below depending on the Manipulator motion. When routing the cable, be careful in this regard and check if it touches and rubs against the Manipulator.

7. Maintenance Parts List

To purchase the maintenance parts listed in this chapter, please contact the distributor of your region.

7.1 Force Sensor

Name				Code	Remarks
For C4 series	S250N	Force Sensor *1		1673545	S250N
		Force Sensor cable *2		2174940	C4_STD_FS-RB_CABLE_UNIT
		Force Sensor M/I connection cable *3	3m	2172839	C4_CABLE_UNIT_3m
			5m	2172841	C4_CABLE_UNIT_5m
			10m	2172842	C4_CABLE_UNIT_10m
			20m	2172843	C4_CABLE_UNIT_20m
		Sensor flange		1673548	C4_J6_FLANGE_PLATE_UNIT
		Robot fixing bolt *4		1665754	Hexagon socket cap low head bolt: M4×6 CSHBTT-ST3W-M4-6
		Force Sensor fixing bolt *4		1665741	Hexagon head bolt: M4×12 H.BOLT.SCREW,4×12,F/ZN-3C
		Connector cover		1680038	
For C8 series	S250L (IP20 compliant)	Force Sensor *1		1673546	S250L
		Force Sensor cable *5		2172845	C8STD_FS-RB_CABLE_UNIT
		Sensor flange		1673549	C8_STD_J6_FLANGE_PLATE_UNIT
		Robot fixing bolt *4		1665764	Hexagon socket button head bolt: M5×15 H.B.BOLT.SCREW,5×15,F/ZN-3C
	S250P (IP67 compliant)	Force Sensor *1		1673547	S250P
		Force Sensor cable *5		2172856	C8_IP_FS-RB_CABLE_UNIT
		Sensor flange		1673550	C8IP67_J6_FLANGE_PLATE_UNIT
		Robot fixing bolt *4		1665760	Hexagon socket head cap bolt: M5×18 H.S.C.BOLT.SCREW,5×18,F/ZN-3C
		Seal washer *4		1665759	SEAL WASHER_M5
	S250L S250P	Force Sensor M/I connection cable *3	3m	2172846	C8_RB-BOX_CABLE_UNIT_3m
			5m	2172847	C8_RB-BOX_CABLE_UNIT_5m
			10m	2172848	C8_RB-BOX_CABLE_UNIT_10m
			20m	2172849	C8_RB-BOX_CABLE_UNIT_20m
		Force Sensor fixing bolt *4		1665765	Hexagon head bolt: M5×12 H.BOLT.SCREW,5×12,F/ZN-3C
For N2 series	S250H	Force Sensor *1		1673545	S250H
		Force Sensor cable		2177523	FSSPC01-S250H-HPARM-MV-00
		Force Sensor M/I connection cable *3	3m	2179196	N2_RB-BOX_CABLE_UNIT_3m
			5m	2179197	N2_RB-BOX_CABLE_UNIT_5m
			10m	2179198	N2_RB-BOX_CABLE_UNIT_10m
		Sensor flange		1700933	N2_J6_FLANGE_PLATE_UNIT
		Robot fixing bolt *4		1665754	Hexagon socket cap low head bolt: M4×6 CSHBTT-ST3W-M4-6
		Force Sensor fixing bolt *4		1665741	Hexagon head bolt: M4×12 H.BOLT.SCREW,4×12,F/ZN-3C

Name				Code	Remarks
For N6 sries	SH250LH	Force Sensor *1		1749809	SH250LH
		Force Sensor cable		2189943	N6_CABLE_UNIT
		Force Sensor M/I connection cable *3	3m	2177520	FSSPC3M-HPBASE-FS1-MV-00
			5m	2177521	FSSPC5M-HPBASE-FS1-MV-00
			10m	2177522	FSSPC10M-HPBASE-FS1-MV-00
			20m	2189877	FSSPC20M-N6BASE-FSIF-MV-01
		Robot fixing bolt *4		1546620	Hexagon socket cap low head bolt: M4×12 H_S_C_BOLT_4X12_F_NI
For RS, G series	S2503 S2506 S25010	Force Sensor *1		1673545	
		Sensor flange *6		1701390	SC_FLANGE_PLATE_UNIT
		Force Sensor cable *7	0.4m	2178628	FSSPC0P4-S250-SCARM-MV-00
			1.2m	2178629	FSSPC1P2-S250-SCARM-MV-00
			1.5m	2178630	FSSPC1P5-S250-SCARM-MV-00
			2m	2178631	FSSPC2P0-S250-SCARM-MV-00
		Force Sensor M/I connection cable *3	3m	2179199	SC_RB-BOX_CABLE_UNIT_3m
			5m	2179200	SC_RB-BOX_CABLE_UNIT_5m
			10m	2179201	SC_RB-BOX_CABLE_UNIT_10m
		Relay cable *7	2m	2178635	FS_RELAY_CABLE-MV-00
		Branch cable *7	0.3 m	2178636	FS_BRANCH_CABLE-00
	S2503	Adapter *8		1701391	For G3, RS3, RS4 SC_16ADAPTER_UNIT
	S2506			1701392	For G6 SC_20ADAPTER_UNIT
	S25010			1701393	For G10, G20 SC_25ADAPTER_UNIT
For C4, C8, N2, RS, G series	S250N S250L S250P S250H S2503 S2506 S25010	Cable protection sheet		1675521	CABLE_PROTECTION_SHEET_S250
		Shaft label for ceiling mount		1692029	AXIS_LABEL_S250_FOR_CEILING-MOUNTED_RB

*1 The following parts are not included in the Force Sensor.
Force Sensor cable, Force Sensor M/I connection cable, and Sensor flange

*2 The followings are attached to Force Sensor Cable.
Connector cover, Cable mount, Wire tie, and Protection sheet.

*3 Label for cable is attached to Force Sensor M/I connection cable.

*4 Bolts and washers are provided in a unit of one.
(Four screws and washers are necessary for fixing the parts.)

*5 The followings are attached to Force Sensor Cable of C8.
Cable mount, Wire tie, and Protection sheet.

*6 The following bolts are attached to the sensor flange.
Force Sensor fixing bolts (Hexagon socket head cap bolts 4-M4×15)

*7 The cables vary depending on the Manipulator.

*8 The following bolt is attached to the adapter.
Adapter fixing bolt (Hexagon socket head cap bolt: M5×20, Hexagon socket set screw: M4×10)

7.2 Force Sensor I/F Unit

Name	Code	Remarks
Force Sensor I/F unit	2172811	Power connector (male) and motion network cable are not included.
Power connector (male)	2172812	
Circuit board	2172813	
Power supply board	2172814	
Motion network cable	R12NZ9006R	1.5m
Fuse	2172341	

7.3 Force Sensor I/F Board

Name	Code	Remarks
Force Sensor I/F Board	2184536	Board only

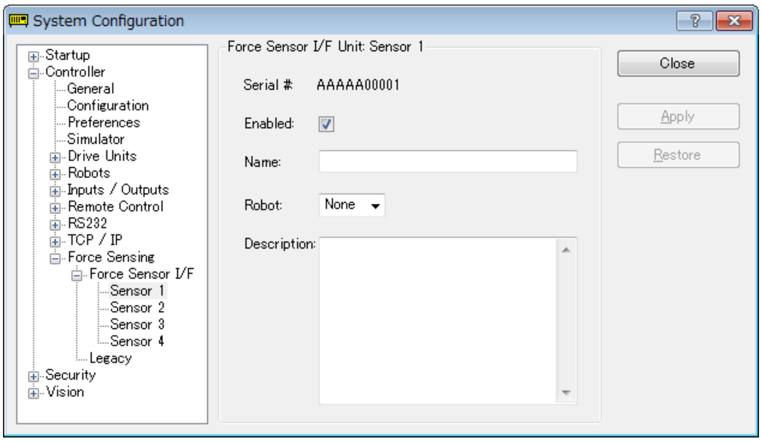
Software

1. Checking the Connections

⚠ CAUTION	■ With improper connection setting of the Force Sensor and the robot, the robot moves according to the output of the improperly configured sensor. If the force control function is executed in this state, it may function unintentionally. Be careful when configuring the settings and check operation before executing the force control.

1.1 Configuring the Force Sensor I/F Unit

From the tree, select [Controller]-[Force Sensing]-[Force Sensor I/F]-[Sensor *].
Configure the Force Sensor I/F unit in [System Configuration].



Force Sensor I/F Unit: Sensor 1

Serial # AAAAA00001

Enabled: ☑

Name:

Robot: None

Description:

Item	Description
Serial #	This is the serial number of the Force Sensor (up to 10 characters).
Enabled	Set the use of the Force Sensor. Checkbox selected: Gets the force information from the sensor.
Name	Set the name of the Force Sensor (up to 32 single-byte characters).
Robot	Set the link of the Force Sensor with the added robot. Select the number of the robot to which the Force Sensor is connected.
Description	The user can enter any comments (up to 255 single-byte characters).
Close	Closes the [System Configuration] dialog box. Restart the system if the settings are changed.
Apply	Saves the changed values.
Restore	Restores the original values.

Force Sensor Connection Procedure

Connect the Force Sensor with the following procedure.

(1) When using Force Sensor I/F unit:
Connect the robot controller and the Force Sensor I/F unit with a communication cable.
When using Force Sensor I/F board:
Mount the Force Sensor I/F board on the option slot of the robot controller.

(2) Connect the Force Sensor and the Force Sensor I/F unit or board with a Force Sensor cable and a Force Sensor M/I cable.

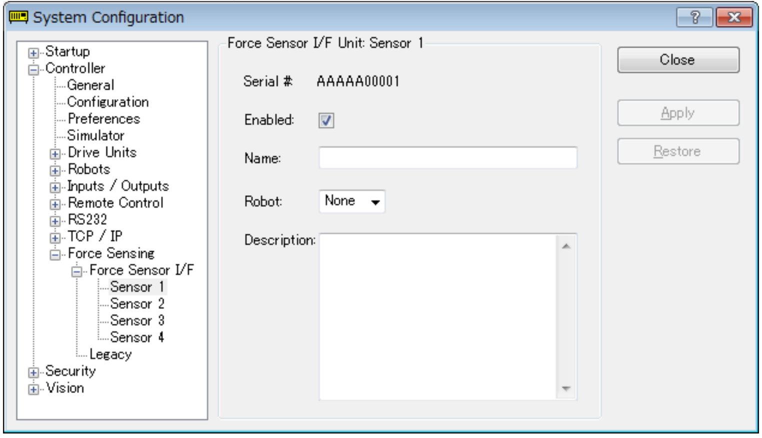
(3) When using Force Sensor I/F unit:
Turn ON the Force Sensor I/F unit.

(4) Turn ON the robot controller.

(5) Start EPSON RC+7.0 and establish a connection with the robot controller.

(6) From the Setup menu, select [System Configuration].
The [System Configuration] dialog box appears.

(7) From the tree, select [Controller]-[Force Sensing]-[Force Controller I/F]-[Sensor 1].
(Select the number of the sensor port of the Force Sensor I/F unit to which the Force Sensor is connected.)



Force Sensor I/F Unit: Sensor 1

Serial #: AAAAA00001

Enabled: ☑

Name:

Robot: None

Description:

(8) In [Robot], set the number of the robot to which the Force Sensor is mounted.

(9) To apply the changes to the settings, click the <Apply> button.
To cancel the changes, click the <Restore> button.

(10)Click the <Close> button.
Clicking the button restarts the system and applies the changes to the settings.

Force Sensor Disconnection Procedure

Disconnect the Force Sensor with the following procedure.

(1) Start EPSON RC+7.0 and establish a connection with the robot controller.

(2) From the Setup menu, select [System Configuration].

(3) From the tree, click [Controller]-[Force Sensing]-[Force Sensor I/F]-[Sensor 1].
(Select the number of the sensor port of the Force Sensor I/F unit to which the Force Sensor is connected.)

(4) Unselect the [Enabled] checkbox.

(5) Click the <Apply> button.

(6) Click the <Close> button.
The robot controller restarts and the changes to the settings are applied.

(7) Turn OFF the robot controller.

(8) When using Force Sensor I/F unit:
Turn OFF the Force Sensor I/F unit

(9) Disconnect the Force Sensor from the Force Sensor I/F unit or board.

Force Sensor Replacement Procedure

Replace the Force Sensor with the following procedure.

(1) Refer to “Force Sensor Disconnection Procedure” described above and disconnect the Force Sensor.

(2) Refer to “Force Sensor Connection Procedure” described above and connect a new Force Sensor.

1.2 Checking the Connection

Checking the Connection

Check the connection between the Force Sensor and the robot system with the following procedure.

(1) Start EPSON RC+7.0 and establish a connection with the robot controller.

(2) Check that there is no error.

(3) From the Setup menu, select [System Configuration].
Check that tree-[Controller]-[Force Sensing]-[Force Sensor I/F]-[Sensor *] are displayed.

(4) Click [Sensor 1] and check that the serial code of the connected Force Sensor is displayed correctly.
(It is the number of the sensor port of the Force Sensor I/F unit to which the Force Sensor is connected.)

(5) If an error does not occur and [Force Sensor I/F] is displayed in the tree, the connection is successful.

If an error occurs, select [System History] from the View menu, identify the error, and take action.

If [Force Sensor I/F] is not displayed in the tree, please check the followings.

When using Force Sensor I/F unit:
Force Sensor I/F unit may not be turned ON or the cable may not be connected.
Check the power and wiring.

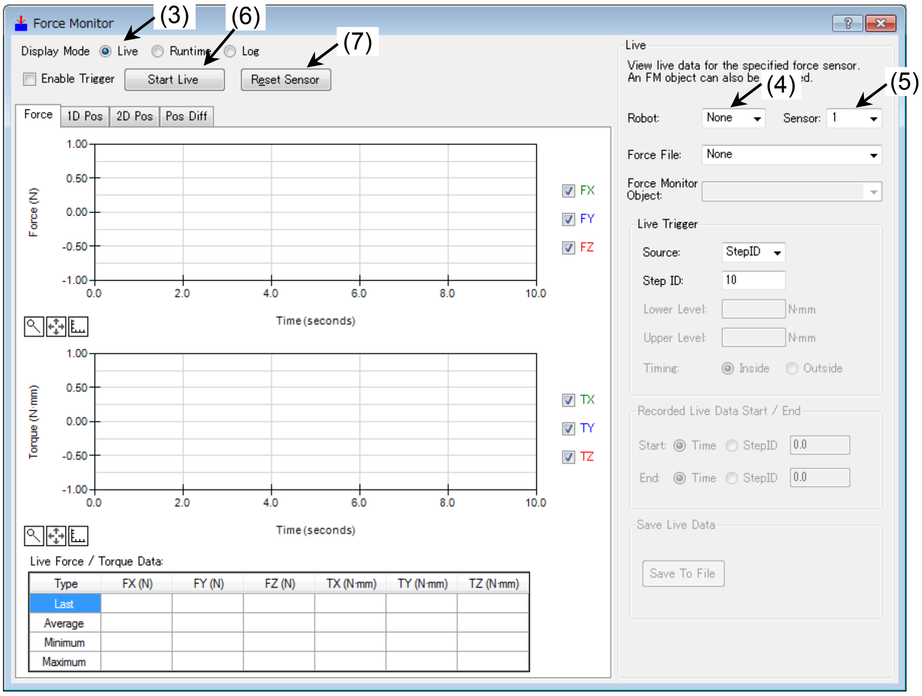
When using Force Sensor I/F board:
Force Sensor I/F board may not be mounted properly on the option slot of the robot controller. Make sure to mount properly.

Checking the Acquisition of Output Values

Perform the following procedure to check that the output values of the Force Sensor can be acquired correctly.

(1) Start EPSON RC+7.0 and establish a connection with the robot controller.

(2) From EPSON RC+ 7.0 menu, click [Tools]-[Force Monitor].



Display Mode: ● Live

View live data for the specified force sensor.
An FM object can also be

Robot: None

Sensor: 1

Force File: None

Source: StepID

Step ID: 10

Start: ● Time ○ StepID 0.0

End: ● Time ○ StepID 0.0

Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last						
Average						
Minimum						
Maximum						

(3) Select <Live> in [Display Mode].

(4) Select "None" in [Live]-[Robot].

(5) Select the sensor number to be checked in [Live]-[Sensor].
(The force and torque in the Force Sensor coordinate system are displayed.)

(6) Select the <Start Live> button.

(7) Click the <Reset Sensor> button.

(8) Apply a force in each of the axis directions of the Force Sensor coordinate system and check that the force is detected within the specified accuracy of the Force Sensor.

CAUTION	■ When entering the safe guarded area in order to apply a force to the Force Sensor, ensure safety by safety measures such as setting the Manipulator to operation-prohibited status. For details of safety, refer to the following manual. *EPSON RC+ 7.0 User's Guide*

1.3 Checking the Accuracy of the Force Sensor

1.3.1 Overview

This section describes a method to check if the Force Sensor is working properly.

Accuracy abnormality may occur when the Force Sensor is damaged by being hit during operation or applied the load which exceeds the rated load.

Accuracy abnormality can be checked by comparing the data acquired before use of the Force Sensor (initial data) and the data acquired after the accuracy error was found (comparison data).

If abnormality is found while using the Force Sensor, follow the steps below to check the accuracy of the Force Sensor.

When performing the accuracy check, be sure to obtain the initial data before using the Force Sensor.

Accuracy guaranty of the Force Sensor is ±5%. We recommend to replace the Force Sensor if the guaranty value is exceeded when checking the accuracy. However, depending on the applications, some of them are still available if the guaranty value is exceeded. Replace the Force Sensor depending on the usage.

1.3.2 Acquisition of the Initial Data

This section describes how to obtain the initial data.

The initial data can be obtained by sample programs on the following pages. The programs differ between 6-axis robots and SCARA robots. Choose the program according to your Manipulator.
This data is used when checking the accuracy of the Force Sensor. Be sure to save the acquired data.

⚠ CAUTION	■ Change the initial position and motion of the Manipulator according to your usage environment, and make sure that the robot, end effector, cables, and peripherals do not interfere with each other.

```
Function ForceSensorLog6Axis              ' Sample program for 6-axis robots
  Integer iFileNum
  iFileNum = FreeFile                     ' Gets an empty file number

  ChDir "C:¥Temp"                         ' Specifies a file destination path
  WOpen "Forcelog.csv" As #iFileNum       ' Specifies a file name and opens the file

  Tool 0                                  ' Specifies Tool 0
  FSet FM1.CoordinateSystem, FCS0         ' Specifies the Tool coordinate system for the
                                          ' Force coordinate system
  FSet FM1.ForceSensor, 1                 ' Specifies the Force Sensor number
  FSet FM1.LPF_Enabled, False, False, False, False, False, False, False, False
                                          ' Disables a low pass filter
  MP 0                                    ' Stops the gravity compensation

  Motor On                                ' Motor ON
  Go AglToPls (0, 0, 0, 0, 0, 0)          ' Moves to the initial position

  FSet FS1.Reset                          ' Resets the Force Sensor
  FSet FM1.LogStart, 60, 0.1, #iFileNum' Starts logging the Force Sensor values
  '-----------------Operation part------------------
  Motor On                                ' Motor ON
  Wait 2
  Go AglToPls (0, 0, 0, 0, 90, 0)
  Wait 2
  Go AglToPls (0, 0, 0, -90, 90, 0)
  Wait 2
  Go AglToPls (0, 0, 0, -90, -90, 0)
  Wait 2
  Go AglToPls (0, 0, 0, 0, -90, 0)
  Wait 2
  Go AglToPls (0, 0, 0, 0, 0, 0)
  Wait 2
  '-------------------------------------------
  FSet FM1.LogEnd                         ' Finishes logging the Force Sensor values
  Close #iFileNum                         ' Closes the file
Fend
```

```
Function ForceSensorLogSCARA           ' Sample program for SCARA robots
  Integer iFileNum
  iFileNum = FreeFile                  ' Gets an empty file number

  ChDir "C:¥Temp"                      ' Specifies a file destination path
  WOpen "Forcelog.csv" As #iFileNum    ' Specifies a file name and opens the file

  Tool 0                               ' Specifies Tool 0
  FSet FM1.CoordinateSystem, FCS0      ' Specifies the Tool coordinate system for the
                                       ' Force coordinate system
  FSet FM1.ForceSensor, 1              ' Specifies the Force Sensor number
  FSet FM1.LPF_Enabled, False, False, False, False, False, False, False, False
                                       ' Disables a low pass filter
  MP 0                                 ' Stops the gravity compensation

  Motor On                             ' Motor ON
  Go AglToPls(0, 0, 0, 0)              ' Moves to the initial position

  FSet FS1.Reset                       ' Resets the Force Sensor
  FSet FM1.LogStart, 60, 0.1, #iFileNum' Starts logging the Force Sensor values
  '----------------- Operation part ------------------
  Motor On                             ' Motor ON
  'Power High                          ' High power mode
  'Accel 50, 50                        ' Acceleration setting
  'Speed 50                            ' Speed setting
  Wait 2
  Go AglToPls(0, 90, 0, 0)
  Wait 2
  Go AglToPls(0, 90, 0, -90)
  Wait 2
  Go AglToPls(0, 0, 0, -90)
  Wait 2
  Go AglToPls(0, 0, -50, -90)
  Wait 2
  Go AglToPls(0, 0, 0, -90)
  Wait 2
  Go AglToPls(0, 0, 0, 0)
  Wait 2
  '------------------------------------------
  FSet FM1.LogEnd                      ' Finishes logging the Force Sensor values
  Close #iFileNum                      ' Closes the file
Fend
```

Description

(1) Specify a file location and name, and then open a file.

Set arbitrary file location and name for the file.

(2) Specify Tool 0, and specify the Tool coordinate system for the Force coordinate system.

User-configured Force coordinate system can be used. Also, the user-defined Force coordinate objects can be used while FCS0 is a Force coordinate system which matches the default Tool coordinate system.

(3) Specify the sensor number.

Specify the sensor number of the Force Sensor that the initial data will be acquired.

(4) Disable a low pass filter and stop the gravity compensation.

(5) Turn ON the motor, and move the robot to the initial position.

In the sample program, the robot moves to the home position. The robot also can be moved to the user-specified position.

(6) Reset the Force Sensor.

(7) Start recording the Force Sensor values.
The values will be recorded for 60 seconds with 0.1 second intervals.

(8) Move the robot to change the Force Sensor posture.

In the sample program for 6-axis robots, Joints #4 and #5 are moved from the home position to change posture of the Force Sensor. User-specified motion is also available. Note, however, that motion should contain 10 or more degree angle change of the sensor in each direction from the initial position.
In the sample program for SCARA robots, Joints #2, #3, and #4 are moved from the home position to apply an inertia force to the Force Sensor. In order to record the inertia force, the measurement interval for the sensor values is shorter compared to the sample program for 6-axis robots.
User-specified motion is also available. Note, however, that 1[N] or more force should be applied in each direction of the sensor from the initial position.
In the sample program, the speed and acceleration settings are commented out. Confirm that the motion has no problem and enable the commands.

(9) Stop recording the Force Sensor values.

(10)Close the file and finish the program.

NOTE

Acquired Force Sensor values are affected by the following settings.

Base coordinate setting (Base)
Local coordinate setting (Local)
Tool setting (Tool, TLSet)
Flange offset setting (F_FlangeOffset)
Force coordinate object (FCS#)

Save the above setting values so that these can be reproduced when acquiring the comparison data.

NOTE ☞ The Force Sensor values are affected by physical installation conditions, such as the tilt of the robot, and shapes and weight of the sensor flange and end effectors. Therefore, be sure to acquire the initial data again when the usage environment changes.

1.3.3 Acquisition of the Comparison Data and Comparison with the Initial Data

When the accuracy abnormality of the Force Sensor is found, obtain the comparison data and compare it with the initial data.

The comparison data should be obtained with the same procedure and conditions as the initial data acquisition.
Note that the conditions include physical installation environment, setting values, and motion in data acquisition.

If a large difference between the outputs of the Force Sensor is found by comparing the initial data and the comparison data acquired with the same condition as the initial data, the Force Sensor cannot be used.

Accuracy abnormality may occur if the Force Sensor is damaged by being hit or applied the load which exceeds the rated load. Use the Force Sensor within the range of specifications.

For details on the specifications, refer to the following section.

Hardware 4.1 Specifications

2. Force Sensor Correction

2.1 Resetting the Force Sensor

The Force Sensor has drift characteristics. Therefore, it must be reset every time immediately before using the force functions. Use the force functions within 10 minutes after resetting the Force Sensor.

Executing the reset command initializes the Force Sensor and sets the current force and torque to “0”. A reset can be performed in the Reset property of the force sensor object. For details on the Reset property, refer to the following manual.
EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

If the Force Sensor is used for long hours without resetting it, drift errors are accumulated. A Force Sensor error may also occur. Caution is required in this regard. If an error occurs, execute the Reboot property of the Force Sensor object.

⚠ CAUTION	■ Be sure to reset the Force Sensor with no external force applied to it. If it is reset with an external force applied to it, the state in which an external force applied is “0”. Therefore, if the force applied is removed, the Force Sensor detects a force even if no force is applied. If the force control function is performed in this state, the robot may move unintentionally. Caution is required in this regard.

2.2 Coordinate Conversion

Coordinate conversion of the Force Sensor refers to converting the output values of the Force Sensor to the force and torque in the force coordinate system.

All of the force functions are performed in the force coordinate system. Coordinate conversion is always performed automatically.

The force coordinate system can be set by the focus coordinate object. The force functions are performed while dynamically switching between the coordinate systems.

⚠ CAUTION	■ If the flange offset or force coordinate object is set incorrectly, the output values of the Force Sensor are converted to the force and torque in a wrong coordinate system. If the force control function is performed in this state, the force control function may perform an unintended operation. Configure the settings carefully, and first verify the operation and then perform the force control function.

Correspondence between the Force Sensor Coordinate System and Tool Coordinate System

To perform coordinate conversion of the output values of the Force Sensor, you need to set the flange offset which means a relative relation between the Force Sensor and the robot.

The physical meaning of the flange offset is the amount of offset by the sensor flange. For the flange offset, use the bottom center position of the Force Sensor viewed from the tool 0 coordinate system of the robot as the origin and set the position and posture of the coordinate system so its direction aligns with the Force Sensor coordinate system.

The offset depending on the robot mounting method using the EPSON sensor flange is as follows.

Manipulator model	Sensor model	Mounting type	Flange offset (X, Y, Z, U, V, W)
C4 series	S250N	Table top mounting	(0, 0, 5, 0, 0, 0)
		Ceiling mounting	(0, 0, 5, 180, 0, 0)
C8 series	S250L, S250P	Table top mounting	(0, 0, 5, 0, 0, 0)
		Ceiling mounting	(0, 0, 5, 180, 0, 0)
		Wall mounting	(0, 0, 5, 0, 0, 0)
N2 series	S250H	Table top mounting	(0, 0, 5, 0, 0, 0)
		Ceiling mounting	(0, 0, 5, 180, 0, 0)
N6 series	SH250LH	Table top mounting	(0, 0, 0, 0, 0, 0)
		Ceiling mounting	(0, 0, 0, 180, 0, 0)
G3, G6 series	S2503, S2506	All	(0, 0, -22, 180, 0, 180)
G10, G20 series	S25010		(0, 0, -24, 180, 0, 180)
RS series	S2503		(0, 0, -22, 180, 0, 180)

When you make a sensor flange yourself, measure the offset and set the flange offset.

The flange offset can be set in [Robot Manager]-[Sensor Panel] or by the F_FlangeOffset statement. For details on the setting procedure, refer to the following section and manual.

Software: 3.5.1 [Robot Manager] (Tools Menu)
[Tools]-[Robot Manager]-[Force] Panel

EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

Correspondence between the Tool Coordinate System and Force Coordinate System

The force coordinate system is a coordinate system with an offset from the tool coordinate system. Therefore, when the tool tip of the robot moves or the offset of the selected tool coordinate system is changed, the force coordinate system also moves following the movement or change.

The offset of the force coordinate system is set in the force coordinate object.

The origin of the focus coordinate system is defined by the offset from the currently selected tool coordinate system using the Position property.

The orientation of the force coordinate system can be selected from the following coordinate systems. The Orientation property is used.

Base coordinate system:	The orientation of the coordinate system is always aligned with the base coordinate system. It does not change even though the posture of the robot or the tool setting is changed.
Local coordinate system:	Select the number of the local coordinate system to be used simultaneously. The orientation of the coordinate system is always aligned with the local coordinate system with the selected number. It does not change even though the posture of the robot or the tool setting is changed.
Tool coordinate system:	The orientation of the coordinate system is always aligned with the tool coordinate system. It changes according to the posture of the robot or the tool setting.
Custom coordinate system:	The values of the rotating movement from the tool coordinate system are set in U, V, and W simultaneously. The orientation of the coordinate system is the orientation with an offset from the tool coordinate system. It changes according to the posture of the robot or the tool setting.

The force coordinate object can be set in [Force Editor] or by the FSet statement.
For details on the setting procedure, refer to the following section and manual.

Software: 3.5.1 [Robot Manager] (Tools Menu)
[Tools]-[Robot Manager]-[Force] Panel

EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

2.3 Gravity Compensation

2.3.1 Overview

Gravity compensation is a function to reduce the impact of the gravity on the Force Sensor.

The Force Sensor measures the difference from “0” that indicates the state of force at the moment the force sensor is reset. Therefore, if the posture of the robot is changed to another posture after resetting the Force Sensor, the Force Sensor also measures the weight of the hand and workpiece impacted by the gravity as the force. As a result, the force control function sometimes cannot perform the intended operation due to this effect. Gravity compensation reduces the impact of gravity from the measured force to retrieve only the force from an external object that is applied during the intended operation.

⚠ CAUTION	■ If the setting of the mass property or gravity direction is incorrect or if the mass property number to be used is incorrect, the force control function may perform an unintended operation. Configure the settings carefully, and first verify the operation and then perform the force control function.

2.3.2 Mass Properties

A mass property object is an object to handle the mass properties for gravity compensation.

The mass property object is an object that has the weight (Mass property) and the center of gravity (GravityCenter property) of all objects (e.g. hand and workpiece) mounted to the area closer to the tip than the Force Sensor. For the weight, set the value including the weight of all objects such as the hand and workpiece, and for the center of gravity, set the gravity center position in the tool 0 coordinate system.

Up to 15 mass property object values can be set for each robot simultaneously. They can be set in the [Mass/Gravity] panel in Robot Manager or by the MPSet statement.

The weight and gravity center position can be set directly in the [Mass/Gravity] panel. They can also be set automatically in Mass / Gravity Wizard for 6-axis robots.

For details, refer to the following section.
Software: 3.5.1 [Robot Manager] (Tools Menu)
[Tools]-[Robot Manager]-[Mass/Gravity] Panel

The value of each property can be set directly in the MPSet statement.
For details, refer to the following manual.
EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

2.3.3 Gravity Direction

Gravity direction is the direction of gravity for the robot necessary for gravity compensation.

The gravity direction is specified by the gravity vector in the base coordinate system of each robot. The robot coordinate system is a coordinate system in which “+z” indicates the upward vertical direction and “+y” indicates the front direction of the robot, and by default, the base coordinate system is also aligned with the robot coordinate system. The gravity works in the downward vertical direction so the gravity direction is represented by the vector (0, 0, -1). This applies to both cases where the robot is mounted to the table and to the ceiling. However, if the base coordinate system was changed using the Base statement, or if the robot is mounted in an inclined state, you need to calculate and set the gravity direction vector in the base coordinate system.

For the gravity direction, set one value for each robot. The gravity direction can be set in the [Mass/Gravity] panel in Robot Manager or in the F_GravityDirection statement.

The values of the gravity direction can be set in the [Mass/Gravity] panel. Furthermore, the gravity direction can be set automatically in Mass / Gravity Wizard for 6-axis robots.

For details, refer to the following section.
Software: 3.5.1 [Robot Manager] (Tools Menu)
[Tools]-[Robot Manager]-[Mass/Gravity] Panel

The values of the gravity direction can be set in the F_GravityDirection statement.
For details, refer to the following manual.
EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

2.3.4 Executing the Gravity Compensation

Gravity compensation is always performed for the Force Sensor that is linked with the robot. Gravity compensation cannot be performed for a Force Sensor that is not linked with the robot. Furthermore, selecting the object to be used from the stored mass property objects allows you to select a parameter according to the operation state at any time. Object selection is performed in the MP statement. After executing the MP statement, reset the Force Sensor in the Reset property of the Force Sensor object.

Example: When performing gravity compensation using Mass Property 1

```
MP 1
```

For details on the MP statement, refer to the following manual.
EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

When performing the force control in each of the states where there is a workpiece and where there is not a workpiece, set the mass property in each of the states since a workpiece has also a weight, and perform the force control while switching between both states.

Selecting number 0 (MP0) or selecting the mass property object with a weight of “0” stops the gravity compensation function. If the gravity compensation is not required for operations where, for example, the posture change is small, select "MP0" to stop the gravity compensation. Selecting a mass property object other than "MP0" after stopping it restarts the gravity compensation.

The selected mass property number and set mass property are retained after the robot controller is turned off until they are changed. Turning on the robot controller also automatically starts the gravity compensation.

2.4 Checking the Gravity Compensation Operation

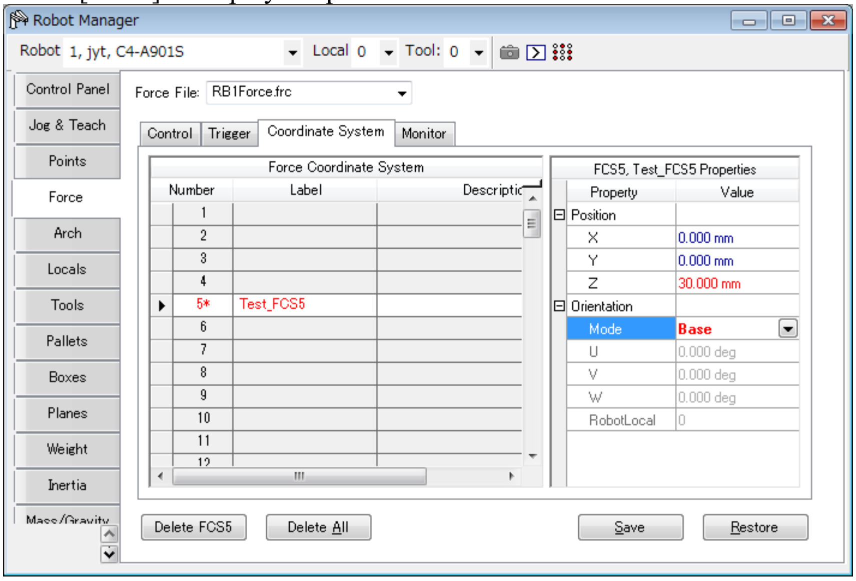
The following describes the procedure to check the Force Sensor correction operation.

1. Setting the force coordinate object
2. Setting the force monitor object
3. Checking that the coordinate conversion is correct in Force Monitor
4. Setting the mass properties and gravity direction
5. Checking that the gravity compensation is correct in Force Monitor

1. Setting the Force Coordinate Object

(1) From the EPSON RC+ 7.0 menu, click [Tools]-[Robot Manager].
The [Robot Manager] dialog box appears.

(2) Select [Force] to display the panel.



Robot 1, jyt, C4-A901S Local 0 Tool: 0

Force File: RB1Force.frc

Force Coordinate System

Number	Label	Descriptic
1		
2		
3		
4		
5*	Test_FCS5	
6		
7		
8		
9		
10		
11		
12		

FCS5, Test_FCS5 Properties

Property	Value
⊟ Position	
X	0.000 mm
Y	0.000 mm
Z	30.000 mm
⊟ Orientation	
Mode	Base
U	0.000 deg
V	0.000 deg
W	0.000 deg
RobotLocal	0

If the force file is not created, the [Force] panel does not appear. If the panel does not appear, refer to the following section to create a force file.

Software: 3.2.1 [New File] (File Menu)

(3) Select the [Coordinate System] tab.

(4) In the [Position] property of any force coordinate object, set the origin position of the force coordinate system viewed from the tool coordinate system.

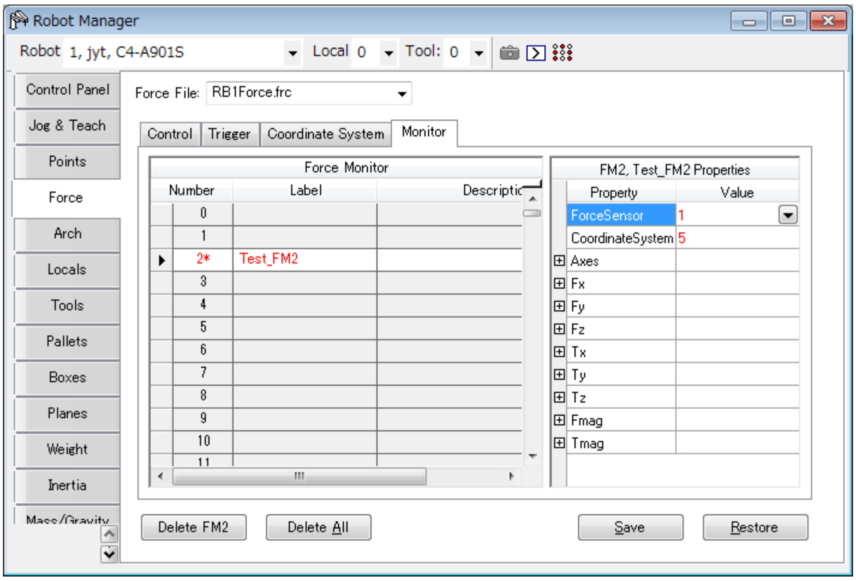
(5) In the [Orientation] property of any force coordinate object, set the orientation of the force coordinate system.

(6) Click the <Save> button to save the changes.

2. Setting the Force Monitor Object

(1) From EPSON RC+ 7.0 menu, click [Tools]-[Robot Manager].
The [Robot Manager] dialog box appears.

(2) Select [Force] to display the panel.



Robot 1, jyt, C4-A901S
Local 0
Tool: 0
Force File: RB1Force.frc

Number	Label	Description
0		
1		
2*	Test_FM2	
3		
4		
5		
6		
7		
8		
9		
10		
11		

Property	Value
ForceSensor	1
CoordinateSystem	5

(3) Select the [Coordinate System] tab.

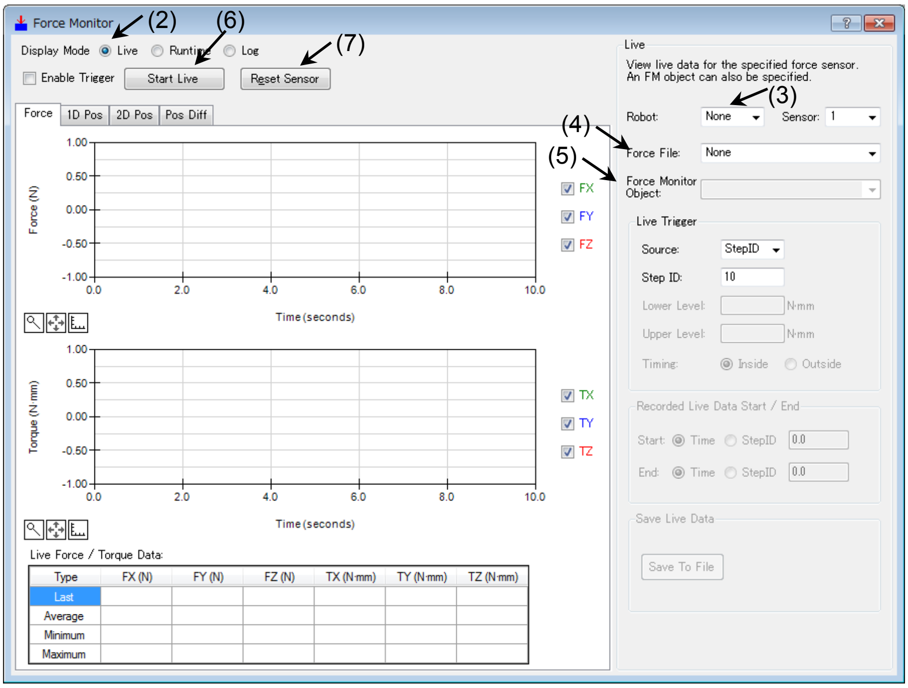
(4) Specify the Force Sensor number to be used in the [ForceSensor] property of any force monitor object.

(5) Specify the created force coordinate system object number in the [CoordinateSystem] property of any force monitor object.

(6) Click the <Save> button to save the changes.

3. Checking that the Coordinate Conversion is Correct in Force Monitor

(1) From the EPSON RC+ 7.0 menu, click [Tools]-[Force Monitor].



Display Mode ● Live ○ Runtime ○ Log

☐ Enable Trigger Start Live Reset Sensor

Live

View live data for the specified force sensor.
An FM object can also be specified.

Robot: None Sensor: 1

Force File: None

Force Monitor Object:

Live Trigger

Source: StepID

Step ID: 10

Lower Level: N·mm

Upper Level: N·mm

Timing: ● Inside ○ Outside

Recorded Live Data Start / End

Start: ● Time ○ StepID 0.0

End: ● Time ○ StepID 0.0

Save Live Data

Save To File

Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last						
Average						
Minimum						
Maximum						

(2) Select <Live> in [Display Mode].

(3) Select the robot to be checked in [Live]-[Robot].

(4) In [Live]-[Force File], select the force file for which the force monitor object was set.

(5) In [Live]-[Force Monitor Object], select the set force monitor object.
If the set force monitor object cannot be selected, check whether the force file is correct and the set ForceSensor property is correct.

(6) Select the <Start Live> button.

(7) Click the <Reset Sensor> button.

(8) Apply a force in each of the axis directions in the set force coordinate system to check that the force is detected within the specified accuracy of the Force Sensor.

If the force is not detected in the set force coordinate system, review the following settings.

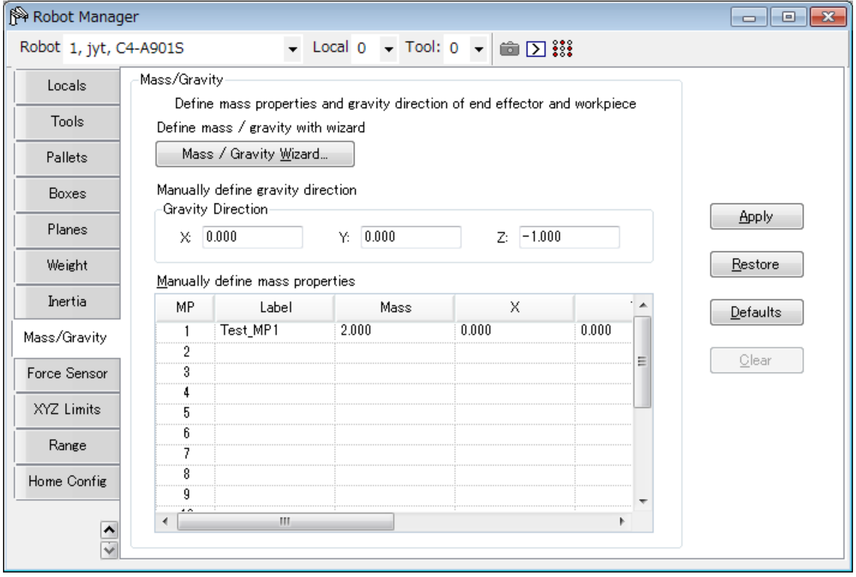
Flange Offset, Base, Tool, Local

Force Coordinate Object, Force Monitor Object

CAUTION	■ When entering the safe guarded area in order to apply a force to the Force Sensor, ensure safety by safety measures such as setting the Manipulator to operation-prohibited status. For details of safety, refer to the following manual. *EPSON RC+ 7.0 User's Guide*

4. Setting the Mass Properties and Gravity Direction

(1) From the EPSON RC+ 7.0 menu, click [Tools]-[Robot Manager].
The [Robot Manager] dialog box appears.



Robot 1, jyt, C4-A901S Local 0 Tool: 0

Mass/Gravity

Define mass properties and gravity direction of end effector and workpiece

Define mass / gravity with wizard

Manually define gravity direction

Gravity Direction

X: 0.000 Y: 0.000 Z: -1.000

Manually define mass properties

MP	Label	Mass	X	
1	Test_MP1	2.000	0.000	0.000
2				
3				
4				
5				
6				
7				
8				
9				

(2) Select [Mass/Gravity] to display the panel.

(3) Directly enter the values in [MP] and [Gravity Direction], or click <Mass / Gravity Wizard> to run the wizard.

(4) Click the <Apply> button to save the settings.

5. Checking that the Gravity Compensation is Correct in Force Monitor

(1) From EPSON RC+ 7.0 menu, click [Tools]-[Command Window].

(2) Execute the MP statement and specify "MP0" to stop the gravity compensation.

(3) In the [Force Monitor] dialog box, click the <Reset Sensor> button.

(4) From the EPSON RC+ 7.0 menu, click [Tools]-[Robot Manager].

(5) Select the [Jog & Teach] panel.

(6) In Force Monitor, perform the jog operation while measuring the Force Sensor values to change the posture of the robot.
Make sure that the robot does not come in contact with surrounding objects and no force from external objects is applied.
No external force is applied, but since the gravity compensation is stopped, the sensor may be affected by gravity depending on the posture and detect a force.

(7) Execute the MP statement and specify the set mass properties.

(8) In the [Force Monitor] dialog box, click the <Reset Sensor> button.

(9) In Force Monitor, perform the jog operation while measuring the Force Sensor values to change the posture of the robot.
When the gravity compensation works correctly, the absolute sensor value decreases compared with when the gravity compensation is stopped. However, when the robot is operating, a force actually generated by an increase or decrease in speed may be detected as a Force Sensor value.
If there is no change from when the gravity compensation is stopped or the absolute Force Sensor value is larger, identify the set mass properties, and check that the gravity direction is correct and the set mass properties are selected.

3. Force Guide 7.0 Graphical User Interface (GUI)

The following describes the Force Guide 7.0 graphical user interface (GUI) that was added to the EPSON RC+ 7.0.

- Project Explorer	- [Project] menu
- [File] menu	- [Tools] menu
- [Edit] menu	- Force Editor

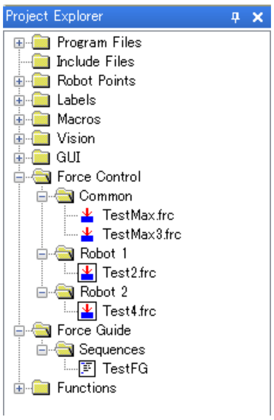
Please also read the following manual.

EPSON RC+ 7.0 User's Guide

3.1 Project Explorer

3.1.1 Force File

Project force files are added in the [Force Control] tree in Project Explorer.



Double-click [Force Control] to display the [Force Editor] window.

For details, refer to the following section.

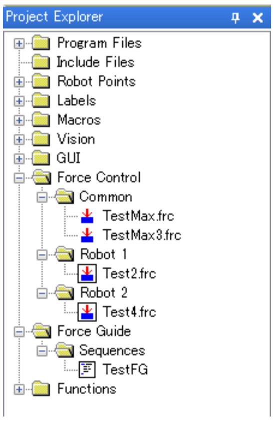
Software: 3.6 Force Editor

Right-click [Force Control] to display the following context menu of the force file.

Menu Item	Description
New	Creates a new force file. For details, refer to the following section. *Software: 3.2.1 [New File] (File Menu)*
Open	Displays the [Force Editor] window to edit the force file. For details, refer to the following section. *Software: 3.6 Force Editor*
Rename	Renames the force file. For details, refer to the following section. *Software: 3.2.7 [Rename Force File] (File Menu)*
Remove	Removes a force file from the current project. The force file remains.
Delete	Removes a force file from the current project and deletes it.

3.1.2 Force Guide

[Force Guide]-[Sequences] are added to Project Explorer.



Double-click the sequence in [Force Guide]-[Sequences] to display the [Force Guide] window.

For details, refer to the following section:

Software: 3.5.4 [Force Guidance] (Tools Menu)

Right-click the sequence in [Force Guide]-[Sequences] to display the following context menu that operates Force Guide. *

Menu Item	Description
New	Create a new force guide sequence. For details, refer to the following section. *Software : 3.5.4 [Force Guidance] (Tools Menu)* *- Create a new force guide sequence*
Open	Displays the [Force Guide] window to edit the selected force guide sequence. For details, refer to the following section. *Software : 3.5.4 [Force Guidance] (Tools Menu)*
Delete	Delete the selected force guide sequence from the current project. For details, refer to the following section. *Software : 3.5.4 [Force Guidance] (Tools Menu)* *- Delete a force guide sequence*

3.2 [File] Menu

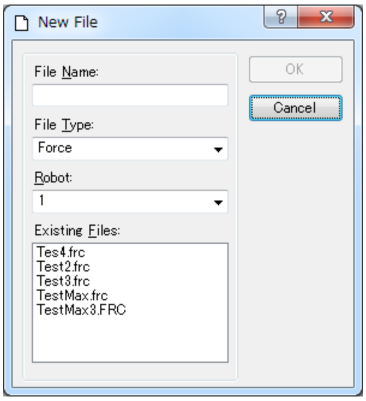
A force file in the current project can be manipulated in EPSON RC+ 7.0 menu-[File].

3.2.1 [New File] (File Menu)

: Ctrl + N

Adds a new force file to the current project.

Select “Force” in [File Type] to display the force files in the project folder in [Existing Files].



File Name:

File Type: Force

Robot: 1

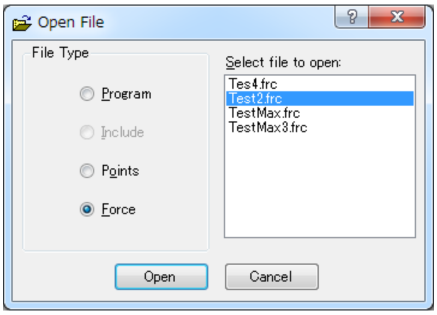
Existing Files:
- Tes4.frc
- Test2.frc
- Test3.frc
- TestMax.frc
- TestMax3.FRC

3.2.2 [Open File] (File Menu)

: Ctrl+O

Opens at least one force file to be edited in the current project.

Select the <Force> button to display a list of the force files in the current project.



File Type
- ○ Program
- ○ Include
- ○ Points
- ● Force

Select file to open:
- Tes4.frc
- Test2.frc
- TestMax.frc
- TestMax3.frc

3.2.3 [Close File] (File Menu)

Ctrl+D

Closes the window of a force file or a force guide being edited.

3.2.4 [Save File] (File Menu)

Ctrl+S

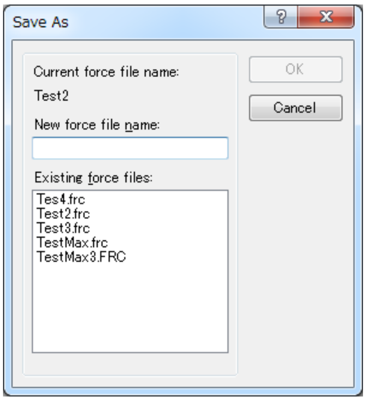
Saves the latest file to the disk.

3.2.5 [Save As] (File Menu)

Saves a force file under a new name and adds it to the project.

The original file is removed from the project but remains on the disk.

Please note that Japanese characters cannot be used in the file name.



Current force file name:
Test2

New force file name:

Existing force files:
Tes4.frc
Test2.frc
Test3.frc
TestMax.frc
TestMax3.FRC

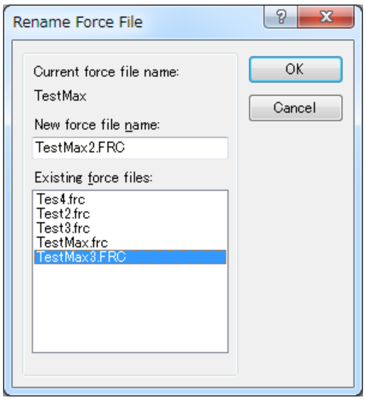
3.2.6 [Restore File] (File Menu)

Restores the force file or a force guide file being edited.

Use this function to restore the file to the last saved state. Executing it displays a dialog box to confirm the operation.

3.2.7 [Rename Force File] (File Menu)

Changes the name of the force file being edited.



Current force file name:
TestMax

New force file name:
TestMax2.FRC

Existing force files:
Tes4.frc
Test2.frc
Test3.frc
TestMax.frc
TestMax3.FRC

For details, refer to the following manual.

EPSON RC+ 7.0 User's Guide: 5.6.7 [Rename File] (File Menu)

3.2.8 [Delete File] (File Menu)

Deletes a force file in the project folder.

The file to be deleted must be listed in the project.

3.2.9 [Import File] (File Menu)

Imports a force file or a force guide sequence from another EPSON RC+ 7.0 project.

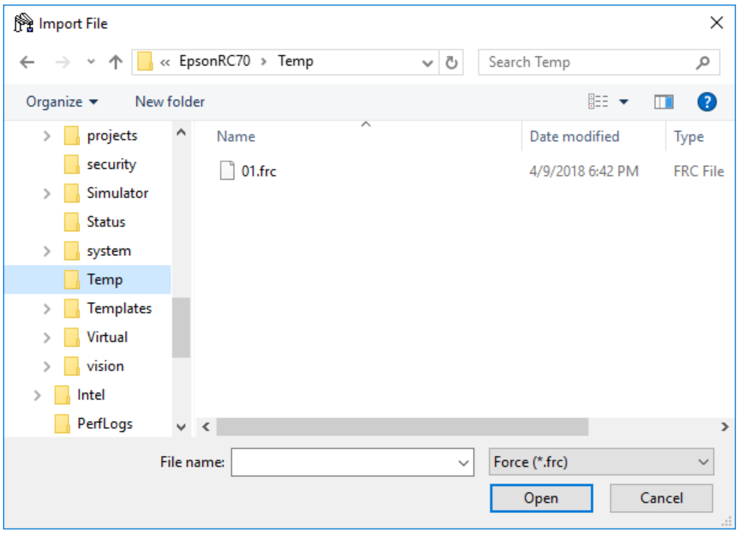
Pay attention to the following point for the file name.

When importing a force file:
The force file to be imported must have an ".frc" extension

When importing a force guide sequence:
The force file to be imported must have an ".fg" extension.

Importing a Force File

(1) Select "Force (*.frc)" from the file type list.

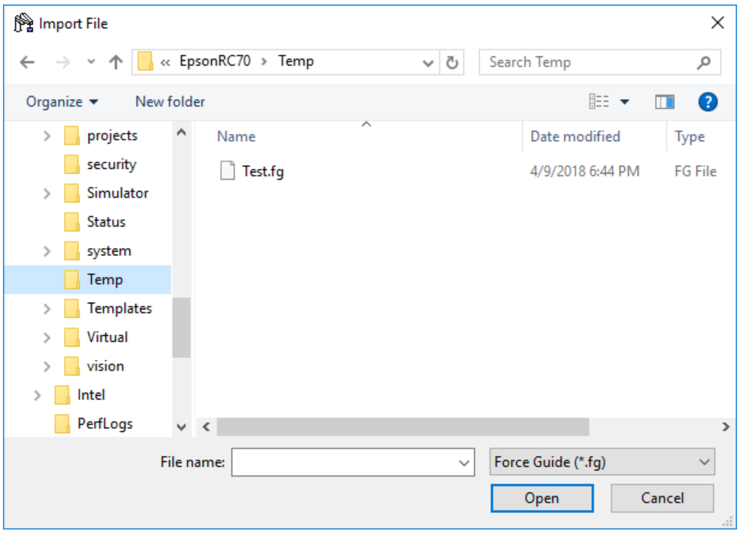


(2) Select the drive, folder, and file name to be imported.
A file that is already listed in the current project cannot be imported. Select a file that is not listed in the current project.

(3) Click the <Open> button.
If a file with the same name is already listed in the project folder, a message confirming whether to overwrite the existing file appears. The file is copied to the current project folder.

Importing a Force Guide Sequence

(1) Select "Force Guide (*.fg)" from the file type list.



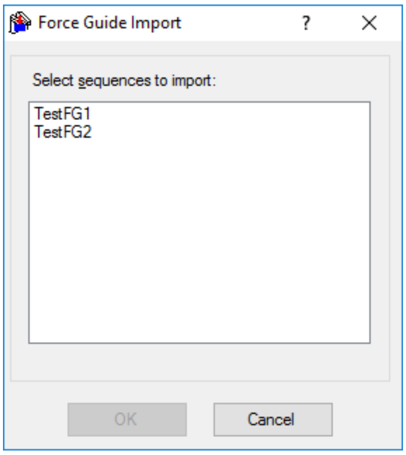
Test.fg 4/9/2018 6:44 PM FG File

File name:

Force Guide (*.fg)

(2) Select the following information including a force guide sequence to be imported.
Drive, folder, and file name

(3) Click the <Open> button.
The list of the force guide sequences which are included in the selected file is displayed



Select sequences to import:

TestFG1
TestFG2

(4) Select the force guide sequence to be imported.

(5) Click the <OK> button.
If a file with the same name is already listed in the project folder, a message confirming whether to overwrite the existing file appears. The force guide sequence is added to the current project.

3.2.10 [Exit] (File Menu)

Alt+F4

Exits EPSON RC+ 7.0.

If the force file or the force guide file is not saved, a dialog box confirming whether to save the file appears. Click the <Yes>, <No>, or <Cancel> button.

3.3 [Edit] Menu

A force file can be edited from EPSON RC+ 7.0 menu, [Edit].

3.3.1 [Cut] (Edit Menu)

✂ : Ctrl+X

Cuts the selected data (string, force object, etc).

3.3.2 [Copy] (Edit Menu)

⎘ : Ctrl+C

Copies the selected data (string, force object, etc).

3.3.3 [Paste] (Edit Menu)

📋 : Ctrl+V

Pastes the cut or copied data (string, force object, etc) to the cursor position.

3.3.4 [Select All] (Edit Menu)

Ctrl+A

Selects all force object items of the force file being edited. The selected items can be cut and copied.

3.4 [Project] Menu

Projects can be managed and built in the EPSON RC+ 7.0 menu, [Project].

3.4.1 [Open Project] (Program Menu)

Opens an EPSON RC+ 7.0 project.

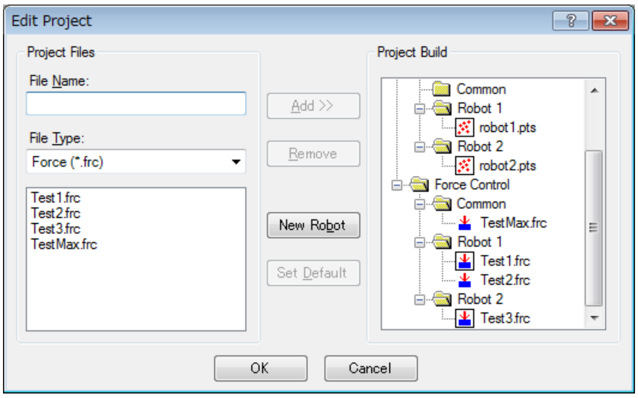
Opening a project closes the open project. A message for confirming whether to save the changes appears.

When a project is opened with the [Read Only] checkbox selected, the force file cannot be edited.

3.4.2 [Edit Project] (Project Menu)

Set the force file to be used in the current project.

The “Force Control” is added to [Project Build].



File Type: Force (*.frc)

Adding a New Force File

(1) Enter the name of a force file to be created in [File Name]. Be sure to add extension “.frc” to the file name.
Please note that Japanese characters cannot be used for a file name.
Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

(2) From [Project Build]-[Force Control], select the robot folder to be added.

(3) Click the <Add> button.
A message for confirming whether to create a new file appears. Click the <Yes> button.
A file is created and added to the robot folder selected in [Project Build]-[Force Control].

Adding an Existing Force File to the Project

(1) Select “Force (*.frc)” on the [File Type] box.

(2) Select the robot folder to be added from [Project Build]-[Force Control].

(3) From the list, select the force file name to be added to the project.

(4) Click the <Add> button.
The file is added to the robot folder selected in [Project Build]-[Force Control].

Removing a Force File

(1) Select the file to be removed from the [Project Build] tree.

(2) Click the <Remove> button.
The file name is removed from the [Project Build] tree. Since the file is not deleted from the project folder, it is displayed in the file list.

Setting Default for a Force File

(1) From a robot folder in [Project Build]-[Force Control], select the force file which you want to set to the default.

(2) Click the <Set Default> button.
The force file is set to the default of the listed robot.

NOTE

A common force file is a force file that can be used in all robots on the controller. To use a common force file, you need to load it from the SPEL+ program using the FLoad command.

A default force file is a force file that is automatically loaded to the robot when loading a project. One force file can be set to the default for each robot.

3.4.3 [Save Project] (Project Menu)

The following items are saved. If nothing needs to be saved, this menu is displayed in gray and cannot be selected.

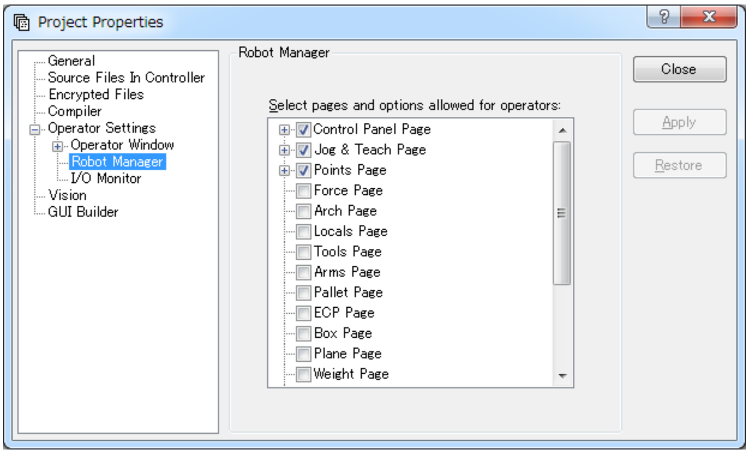
- Program file
- Include file
- Point file
- Force file
- I/O label
- User error

3.4.4 [Project Properties] (Project Menu)

[Project]-[Project Properties]-[Operator Settings]-[Robot Manager]

Set up Robot Manager.

To enable the operator to edit the force data when displaying the operator window, place a checkmark in the [Force Page] checkbox.



Select pages and options allowed for operators:

- ☑ Control Panel Page
- ☑ Jog & Teach Page
- ☑ Points Page
- ☐ Force Page
- ☐ Arch Page
- ☐ Locals Page
- ☐ Tools Page
- ☐ Arms Page
- ☐ Pallet Page
- ☐ ECP Page
- ☐ Box Page
- ☐ Plane Page
- ☐ Weight Page

3.5 [Tools] Menu

The EPSON RC+ 7.0 has some GUI tools to support system development. You can access all tools from the EPSON RC+ 7.0 menu-[Tools].

3.5.1 [Robot Manager] (Tools Menu)

: F6

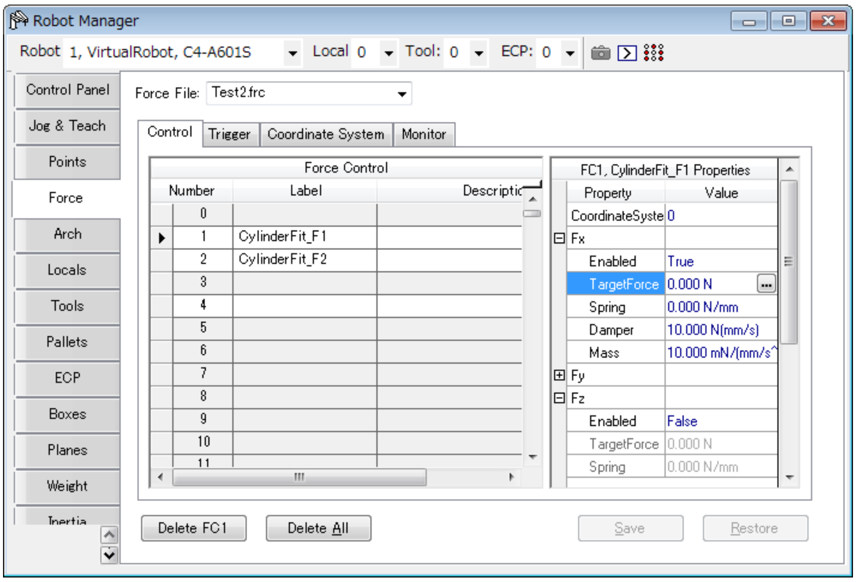
[Tools]-[Robot Manager]-[Force] Panel

Force: You can enter and delete the force control, force trigger, force coordinate system, and force monitor objects.

When you select a force file, the controller loads it into the memory. When using Robot Manager as an MDI sub-window, enter “Ctrl+S” to save the force data.

[Control] Panel

You can edit the force control object.



Robot 1, VirtualRobot, C4-A601S Local 0 Tool: 0 ECP: 0

Force File: Test2.frc

Force Control

Number	Label	Descriptio
0		
1	CylinderFit_F1	
2	CylinderFit_F2	
3		
4		
5		
6		
7		
8		
9		
10		
11		

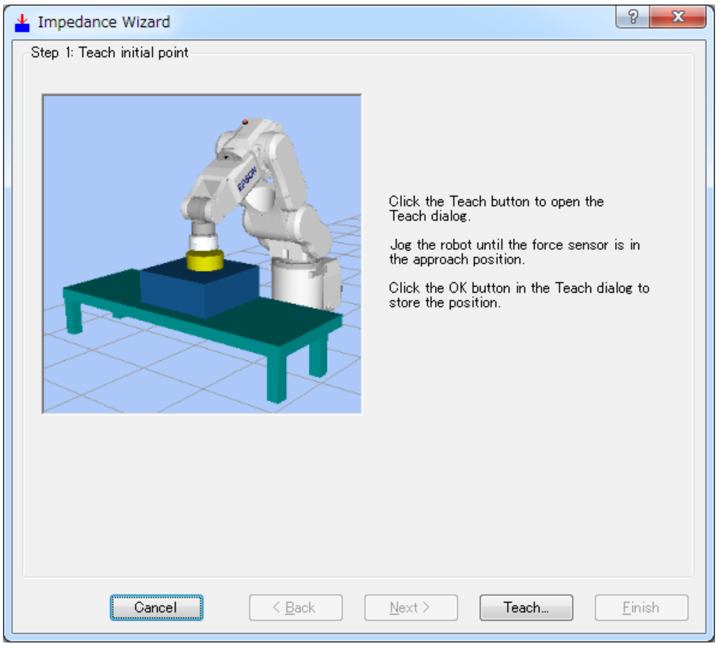
FC1, CylinderFit_F1 Properties

Property	Value
CoordinateSyste	0
⊟ Fx	
Enabled	True
TargetForce	0.000 N
Spring	0.000 N/mm
Damper	10.000 N(mm/s)
Mass	10.000 mN/(mm/s^
⊞ Fy	
⊟ Fz	
Enabled	False
TargetForce	0.000 N
Spring	0.000 N/mm

Item	Description
Force File	Selects the force file.
Label	Sets the label (Label property).
Description	Sets the description (Description property).
Properties	Selects the properties to set the value.
<Drop-down list> ▼	Displays a list of values that can be selected. Select a value.
<Impedance Wizard> …	Displays Impedance Wizard, in which you can set each of the property values for force control objects (TargetForce, Spring, Damper, and Mass).
Delete Fxxx	Deletes the force object. A confirmation screen appears.
Delete All	Deletes all the force objects in the selected tab. A confirmation screen appears.
Save	Saves the values.
Restore	Restores the original values. A confirmation screen appears.

Impedance Wizard

(1) Click the <Impedance Wizard> ... button in Properties.
The [Impedance Wizard] window appears.



Impedance Wizard

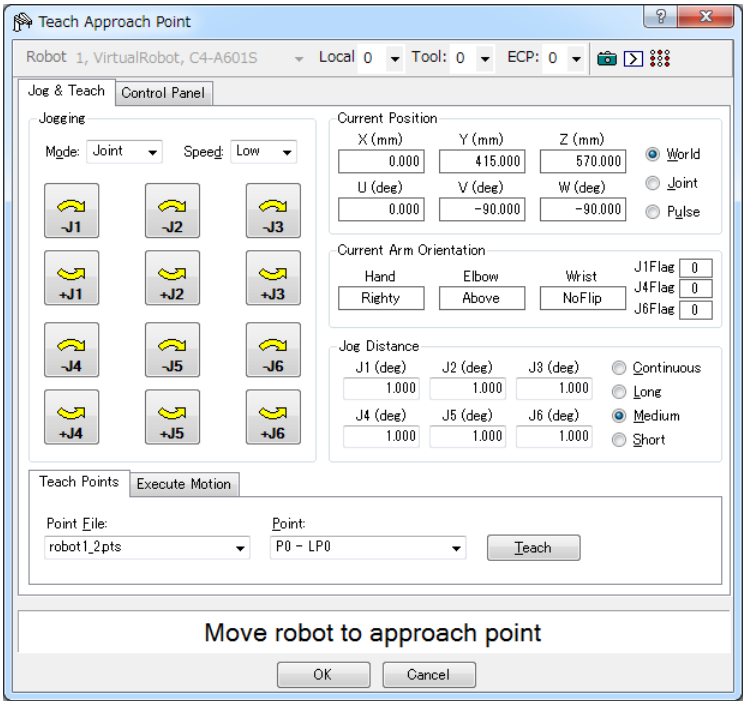
Step 1: Teach initial point

Click the Teach button to open the Teach dialog.

Jog the robot until the force sensor is in the approach position.

Click the OK button in the Teach dialog to store the position.

(2) Click the <Teach...> button.
The [Teach Approach Point] dialog box appears.
Select the [Jog & Teach] tab.
Move the robot to the point where the workpiece is about 1 mm above the object to be pressed.



Teach Approach Point

Robot 1, VirtualRobot, C4-A601S Local 0 Tool: 0 ECP: 0

Jogging

Mode: Joint Speed: Low

Current Position

X (mm)	Y (mm)	Z (mm)
0.000	415.000	570.000
U (deg)	V (deg)	W (deg)
0.000	-90.000	-90.000

● World ○ Joint ○ Pulse

Current Arm Orientation

Hand	Elbow	Wrist
Righty	Above	NoFlip

J1Flag 0
J4Flag 0
J6Flag 0

Jog Distance

J1 (deg)	J2 (deg)	J3 (deg)
1.000	1.000	1.000
J4 (deg)	J5 (deg)	J6 (deg)
1.000	1.000	1.000

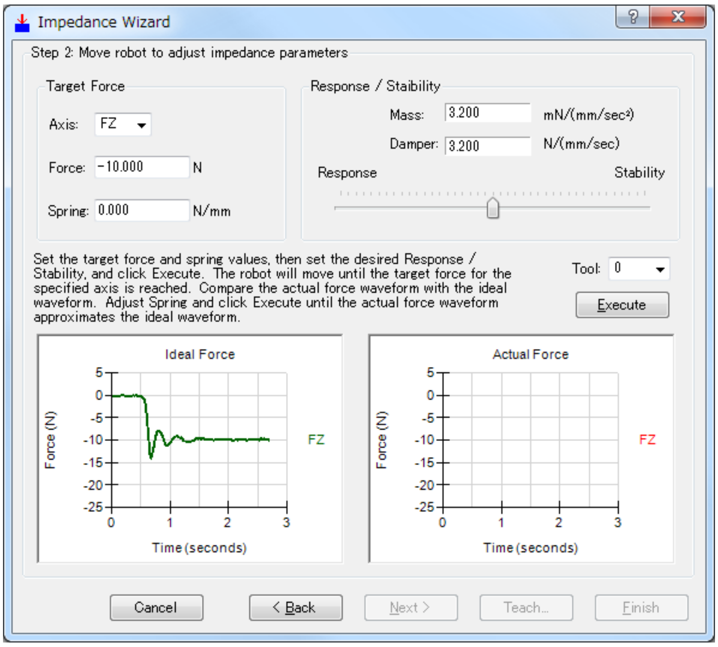
○ Continuous ○ Long ● Medium ○ Short

Point File: robot1_2pts

Point: P0 - LP0

Move robot to approach point

(3) Click the <OK> button.
Save the current position and return to the [Impedance Wizard] window.
Set the values in [Force] and [Spring] of [Target Force].
Set the values in [Mass] and [Damper] of [Response / Stability] with a slider.
Set the slider to the “Stability” side first and adjust the values while checking the waveform of the actual force.



Step 2: Move robot to adjust impedance parameters

Axis: FZ

Force: -10.000 N

Spring: 0.000 N/mm

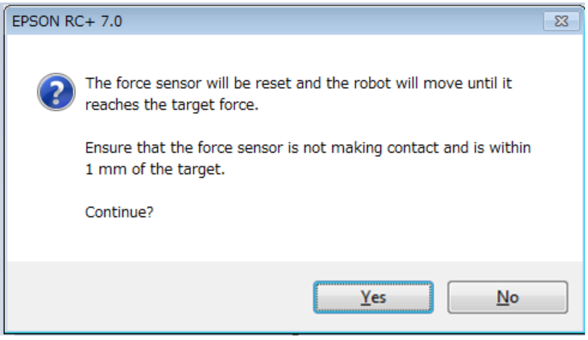
Mass: 3.200 mN/(mm/sec²)

Damper: 3.200 N/(mm/sec)

Tool: 0

Set the target force and spring values, then set the desired Response / Stability, and click Execute. The robot will move until the target force for the specified axis is reached. Compare the actual force waveform with the ideal waveform. Adjust Spring and click Execute until the actual force waveform approximates the ideal waveform.

(4) Click the <Execute> button. A confirmation dialog box appears.
Check that the distance between the workpiece at the initial position and the object to be pressed is within 1 mm, and then click the <Yes> button.

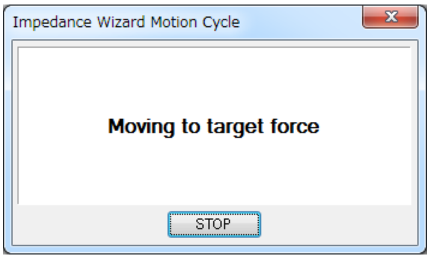


The force sensor will be reset and the robot will move until it reaches the target force.

Ensure that the force sensor is not making contact and is within 1 mm of the target.

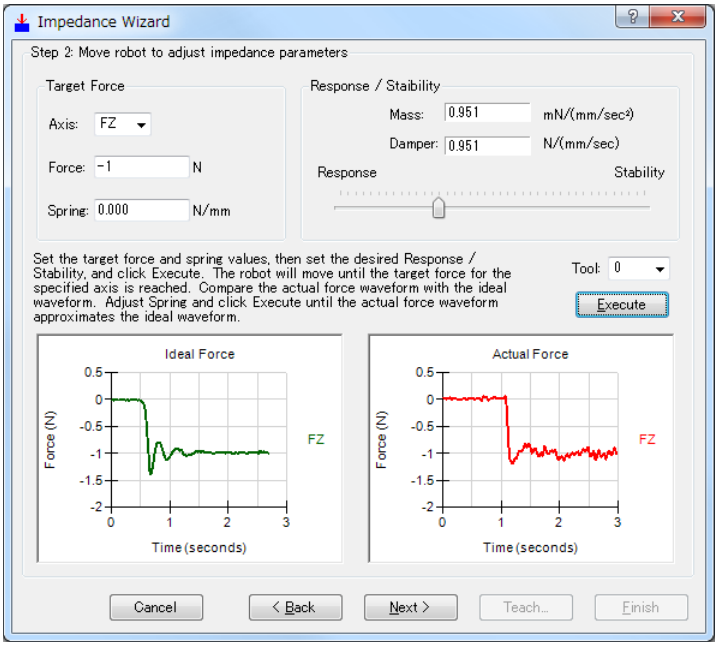
Continue?

(5) The robot moves until the set axis reaches the target force.
To stop the robot part way through, click the <STOP> button.



Moving to target force

(6) Adjust the [Spring] value with a slider until the measured data of force approximates the ideal waveform, and then click the <Execute> button.
Repeat the procedure until the actual force waveform approximates the ideal waveform.
If the waveform is vibrating or cannot settle at the target force, move the slider to “Stability” side. If the waveform is too smooth, move the slider to “Response” side.
If the slider is moved largely, the force being applied may greatly change. Move the slider little by little to adjust the values.
Note that if the [Spring] value is too large or the slider position is too stable, the robot may not be able to contact the workpiece.



Impedance Wizard

Step 2: Move robot to adjust impedance parameters

Target Force

Axis: FZ

Force: -1 N

Spring: 0.000 N/mm

Response / Staibility

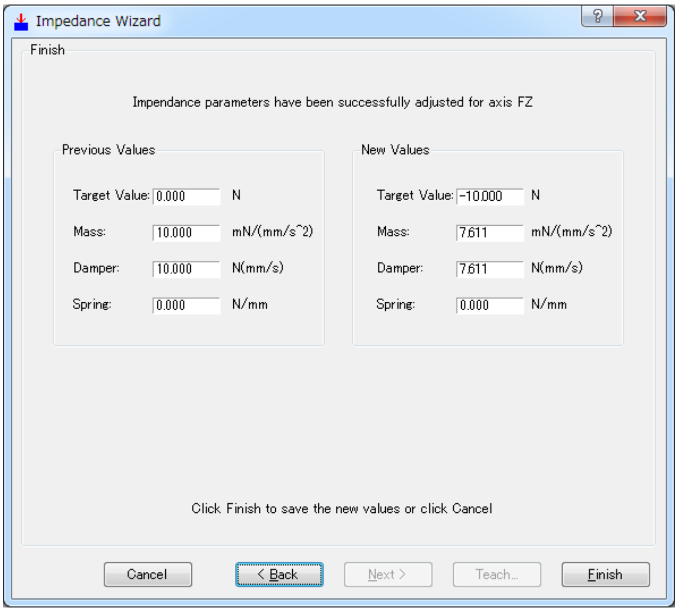
Mass: 0.951 mN/(mm/sec²)

Damper: 0.951 N/(mm/sec)

Set the target force and spring values, then set the desired Response / Stability, and click Execute. The robot will move until the target force for the specified axis is reached. Compare the actual force waveform with the ideal waveform. Adjust Spring and click Execute until the actual force waveform approximates the ideal waveform.

Tool: 0

(7) Click the <Next> button.
The impedance parameters before and after the adjustment for the set axis are displayed.
To save the new values, click the <Finish> button, and to cancel them, click the <Cancel> button.



Impedance Wizard

Finish

Impendance parameters have been successfully adjusted for axis FZ

Previous Values

Target Value: 0.000 N

Mass: 10.000 mN/(mm/s^2)

Damper: 10.000 N(mm/s)

Spring: 0.000 N/mm

New Values

Target Value: -10.000 N

Mass: 7.611 mN/(mm/s^2)

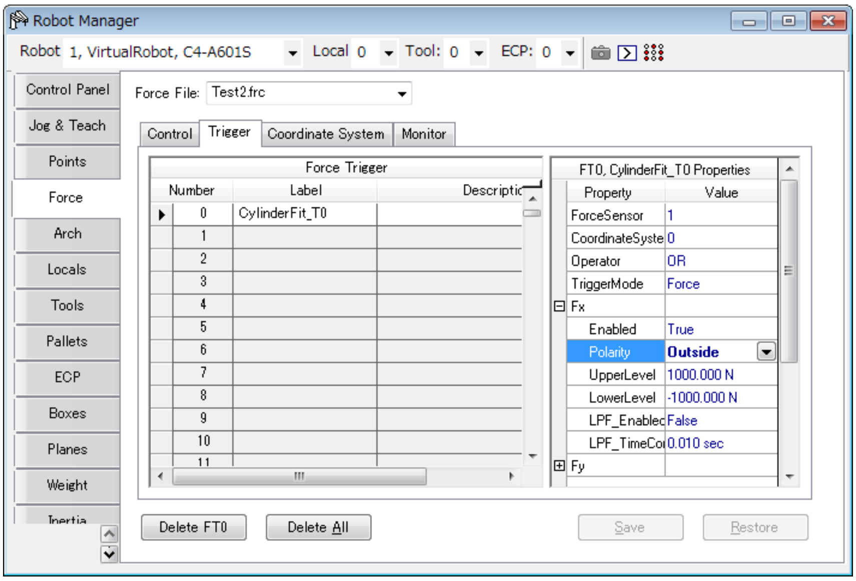
Damper: 7.611 N(mm/s)

Spring: 0.000 N/mm

Click Finish to save the new values or click Cancel

[Force Trigger] Panel

You can edit the force trigger object.



Robot 1, VirtualRobot, C4-A601S Local 0 Tool: 0 ECP: 0

Force File: Test2.frc

Force Trigger

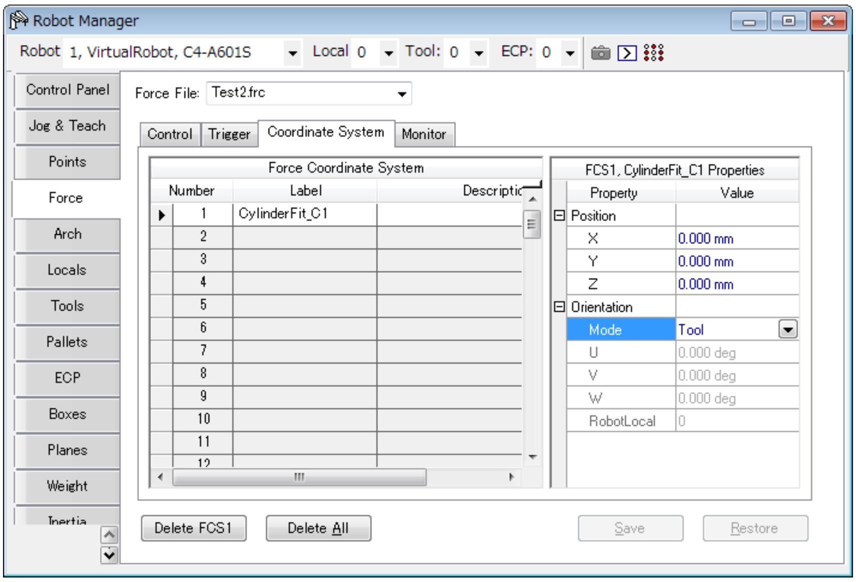
Number	Label	Description
0	CylinderFit_T0	
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

FT0, CylinderFit_T0 Properties

Property	Value
ForceSensor	1
CoordinateSyste	0
Operator	OR
TriggerMode	Force
⊟ Fx	
Enabled	True
Polarity	**Outside**
UpperLevel	1000.000 N
LowerLevel	-1000.000 N
LPF_Enablec	False
LPF_TimeCo	0.010 sec
⊞ Fy	

[Force Coordinate System] Panel

You can edit the force coordinate system object.



Robot 1, VirtualRobot, C4-A601S Local 0 Tool: 0 ECP: 0

Force File: Test2.frc

Force Coordinate System

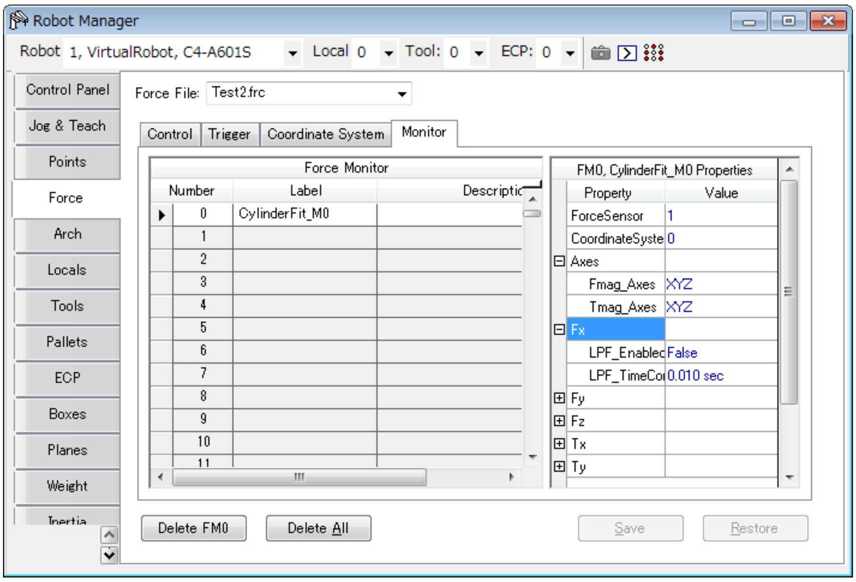
Number	Label	Description
1	CylinderFit_C1	
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

FCS1, CylinderFit_C1 Properties

Property	Value
⊟ Position	
X	0.000 mm
Y	0.000 mm
Z	0.000 mm
⊟ Orientation	
Mode	Tool
U	0.000 deg
V	0.000 deg
W	0.000 deg
RobotLocal	0

[Force Monitor] Panel

You can edit the force monitor object.



Robot 1, VirtualRobot, C4-A601S   Local 0   Tool: 0   ECP: 0

Force File: Test2.frc

Force Monitor

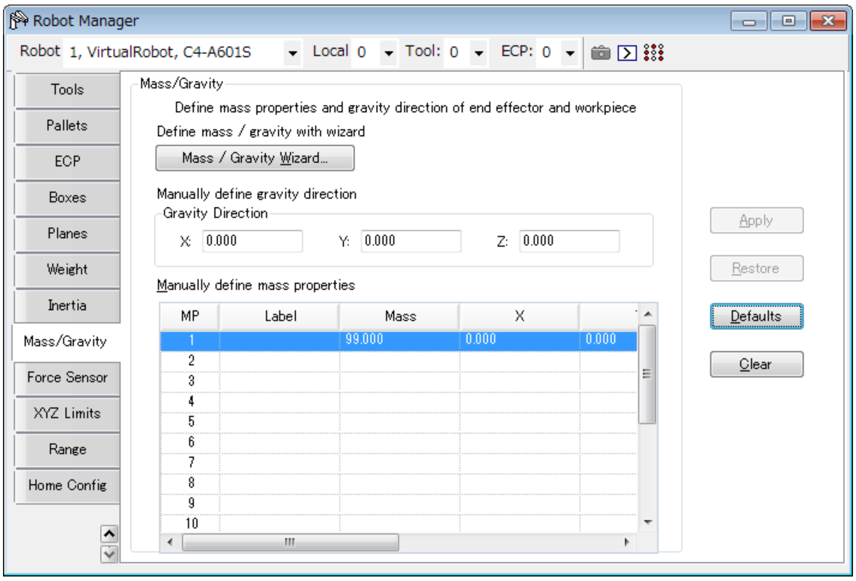
Number	Label	Description
0	CylinderFit_M0	
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

FM0, CylinderFit_M0 Properties

Property	Value
ForceSensor	1
CoordinateSyste	0
⊟ Axes	
Fmag_Axes	XYZ
Tmag_Axes	XYZ
⊟ Fx	
LPF_Enablec	False
LPF_TimeCo	0.010 sec
⊞ Fy	
⊞ Fz	
⊞ Tx	
⊞ Ty	

[Tools]-[Robot Manager]-[Mass/Gravity] Panel

You can set the values of the mass properties.



Robot 1, VirtualRobot, C4-A601S   Local 0   Tool: 0   ECP: 0

Mass/Gravity

Define mass properties and gravity direction of end effector and workpiece

Define mass / gravity with wizard

Manually define gravity direction

Gravity Direction

X: 0.000   Y: 0.000   Z: 0.000

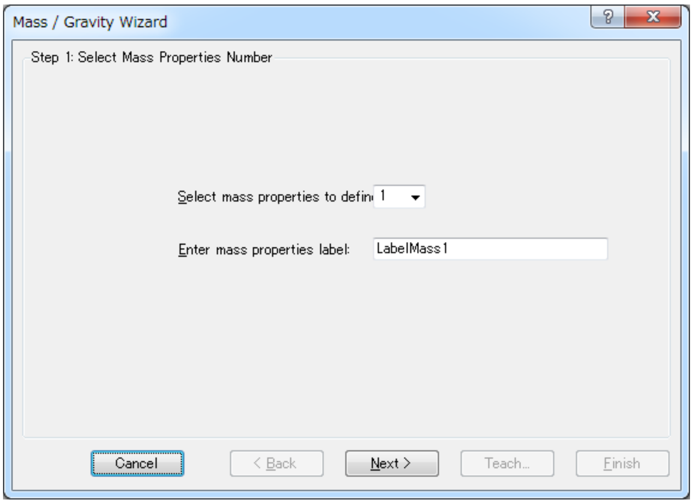
Manually define mass properties

MP	Label	Mass	X	
1		99.000	0.000	0.000
2				
3				
4				
5				
6				
7				
8				
9				
10				

Item	Description
Mass / Gravity Wizard	Displays Mass / Gravity Wizard, in which you can set the property values of the mass property object.
Gravity Direction	Set the gravity direction of the robot (robot object GravityDirection property).
Manually define mass properties	Set the following items of the mass property object with MP (number). Label (Label property) Mass property X / Y / Z (GravityCenter property) Description (Description property)
Defaults	Sets the default value in the gravity direction.
Clear	Deletes the selected mass property object.

Mass/Gravity Wizard

(1) Click the <Mass / Gravity Wizard> button.
[Step 1: Select Mass Properties Number] appears in the [Mass / Gravity Wizard] window.
You can define the mass properties.



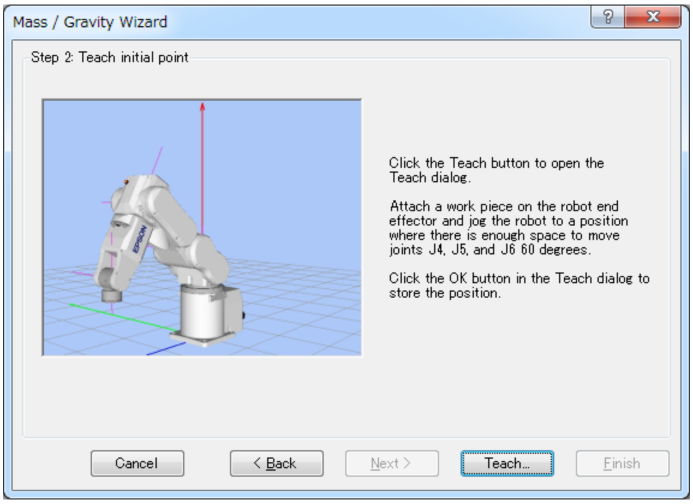
Step 1: Select Mass Properties Number

Select mass properties to defin: 1

Enter mass properties label: LabelMass1

(2) Select the number in [Select mass properties to define].
The mass properties label for the selected number is displayed in [Enter mass properties label]. The label name can be changed.

(3) Click the <Next> button.
[Step 2: Teach initial point] appears in the [Mass / Gravity Wizard] window.



Step 2: Teach initial point

Click the Teach button to open the Teach dialog.

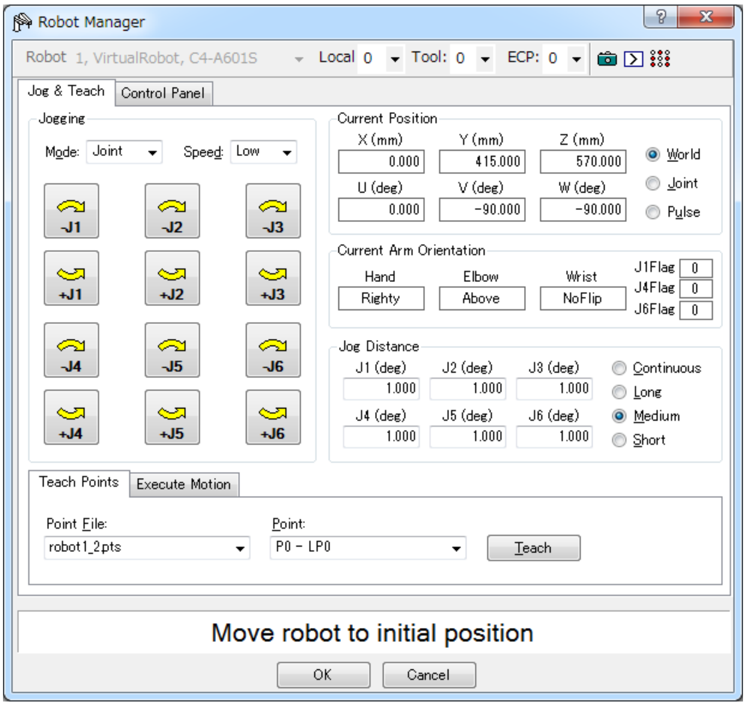
Attach a work piece on the robot end effector and jog the robot to a position where there is enough space to move joints J4, J5, and J6 60 degrees.

Click the OK button in the Teach dialog to store the position.

(4) Click the <Teach...> button.

The [Jog & Teach] window appears.

Mount the workpiece to the end effector (hand tip) of the robot and move the robot to the position where J4, J5, and J6 can move at 60 degrees.



Robot 1, VirtualRobot, C4-A601S   Local 0   Tool: 0   ECP: 0

Mode: Joint   Speed: Low

Current Position

X (mm)	Y (mm)	Z (mm)
0.000	415.000	570.000
U (deg)	**V (deg)**	**W (deg)**
0.000	-90.000	-90.000

● World ○ Joint ○ Pulse

Current Arm Orientation

Hand	Elbow	Wrist
Righty	Above	NoFlip

J1Flag 0
J4Flag 0
J6Flag 0

Jog Distance

J1 (deg)	J2 (deg)	J3 (deg)
1.000	1.000	1.000
J4 (deg)	**J5 (deg)**	**J6 (deg)**
1.000	1.000	1.000

○ Continuous ○ Long ● Medium ○ Short

Point File: robot1_2pts   Point: P0 - LP0

Move robot to initial position

(5) Click the <OK> button.

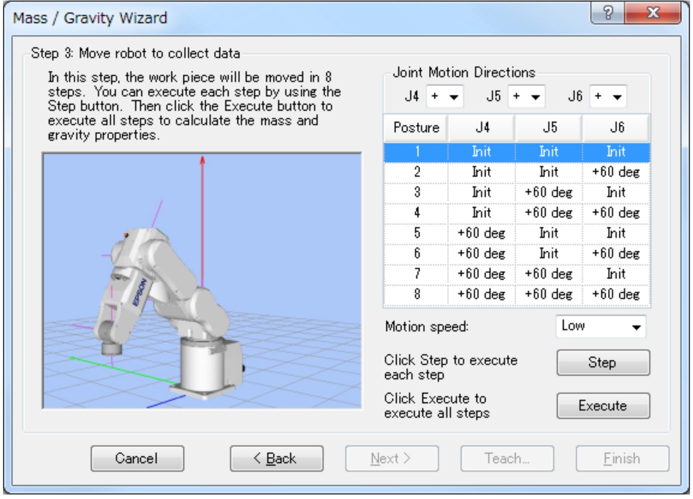
The position information is saved.

[Step 3: Move robot to collect data] appears in the [Mass / Gravity Wizard] window.

In this step, the robot moves in 8 steps.

You can select the motion direction of joints [J4], [J5], and [J6] from “+” and “-” in [Joint Motion Directions].

You can select the speed for the posture check using step buttons from “Low” and “High” in [Motion speed].



Step 3: Move robot to collect data

In this step, the work piece will be moved in 8 steps. You can execute each step by using the Step button. Then click the Execute button to execute all steps to calculate the mass and gravity properties.

Joint Motion Directions
J4 +   J5 +   J6 +

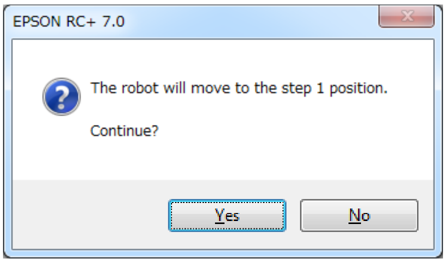
Posture	J4	J5	J6
1	Init	Init	Init
2	Init	Init	+60 deg
3	Init	+60 deg	Init
4	Init	+60 deg	+60 deg
5	+60 deg	Init	Init
6	+60 deg	Init	+60 deg
7	+60 deg	+60 deg	Init
8	+60 deg	+60 deg	+60 deg

Motion speed: Low

Click Step to execute each step

Click Execute to execute all steps

Click the <Step> button in (5) to view the posture of each step.
The following message appears.


EPSON RC+ 7.0

The robot will move to the step 1 position.

Continue?

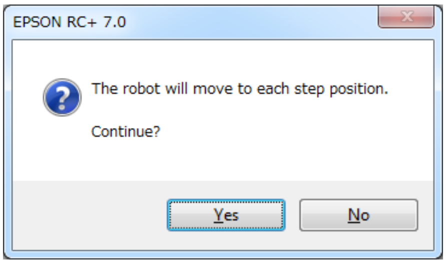
Click the <Yes> button to display the [Execute Command] dialog box and start moving the robot.
Click the <Step> button to check if the robot interferes with the end effector and peripherals for the posture of each step.


Execute Command

Move to step 1 position

To stop the robot part way through, click the <STOP> button.

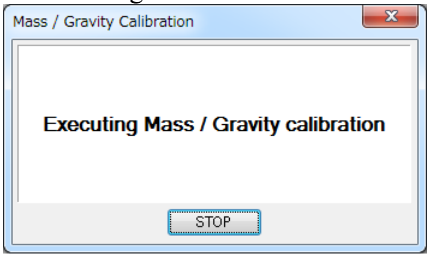
Click the <Execute> button in (5) to execute all the steps to measure the mass properties. The following message appears.


EPSON RC+ 7.0

The robot will move to each step position.

Continue?

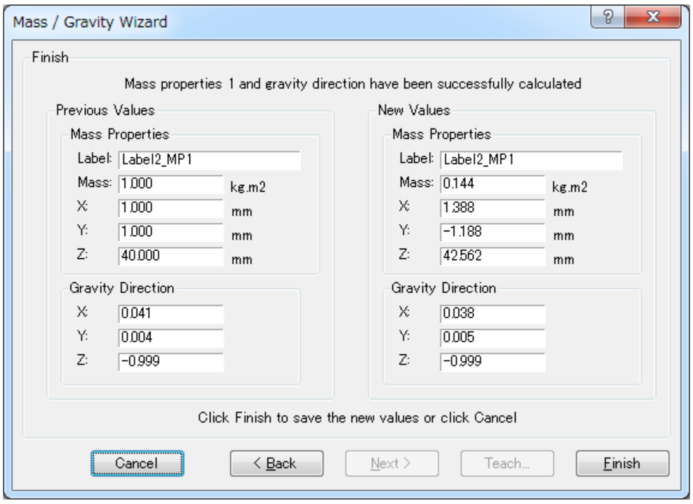
Click the <Yes> button to display the [Mass / Gravity Calibration] dialog box and start moving the robot.


Mass / Gravity Calibration

Executing Mass / Gravity calibration

To stop the robot part way through, click the <STOP> button.

(6) When the movement is completed, the [Finish] button appears in the [Mass / Gravity Wizard] window.
The mass properties and gravity direction values are displayed in [Previous Values] and [New Values].


Mass / Gravity Wizard

Finish

Mass properties 1 and gravity direction have been successfully calculated

	Previous Values		New Values	
Mass Properties				
Label:	Label2_MP1		Label2_MP1	
Mass:	1.000	kg.m2	0.144	kg.m2
X:	1.000	mm	1.388	mm
Y:	1.000	mm	-1.188	mm
Z:	40.000	mm	42.562	mm
Gravity Direction				
X:	0.041		0.038	
Y:	0.004		0.005	
Z:	-0.999		-0.999	

Click Finish to save the new values or click Cancel

(7) Click either of the following buttons.

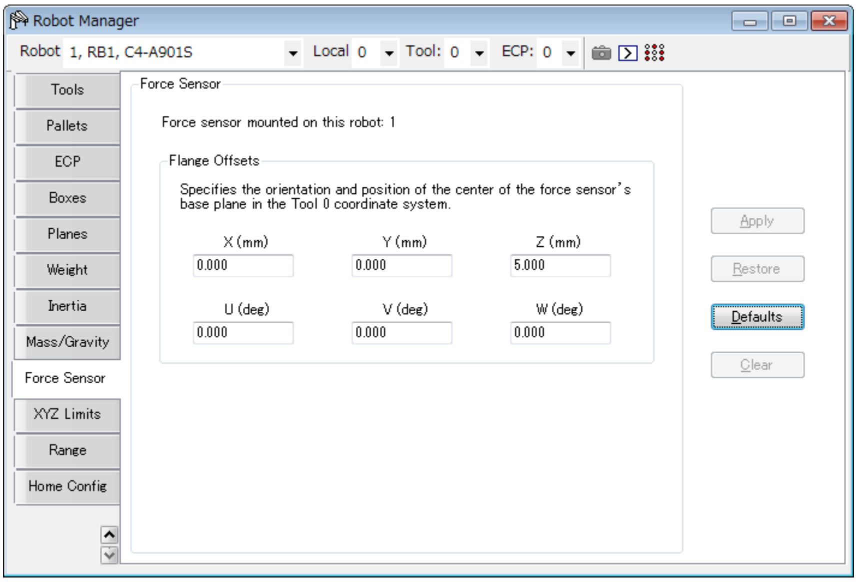
<Finish> button : Saves the new values.

<Cancel> button : Cancel the new values.

[Tools]-[Robot Manager]-[Force Sensor] Panel

You can define the Force Sensor values.

(1) Select the [Force Sensor] tab in the [Robot Manager] window.


Robot Manager

Robot 1, RB1, C4-A901S Local 0 Tool: 0 ECP: 0

Force Sensor

Force sensor mounted on this robot: 1

Flange Offsets

Specifies the orientation and position of the center of the force sensor's base plane in the Tool 0 coordinate system.

X (mm)	Y (mm)	Z (mm)
0.000	0.000	5.000

U (deg)	V (deg)	W (deg)
0.000	0.000	0.000

(2) Set the robot object and flange offset properties in [Flange Offsets].
Click the <Defaults> button to set the default values.

3.5.2 [Force Monitor] (Tools Menu)

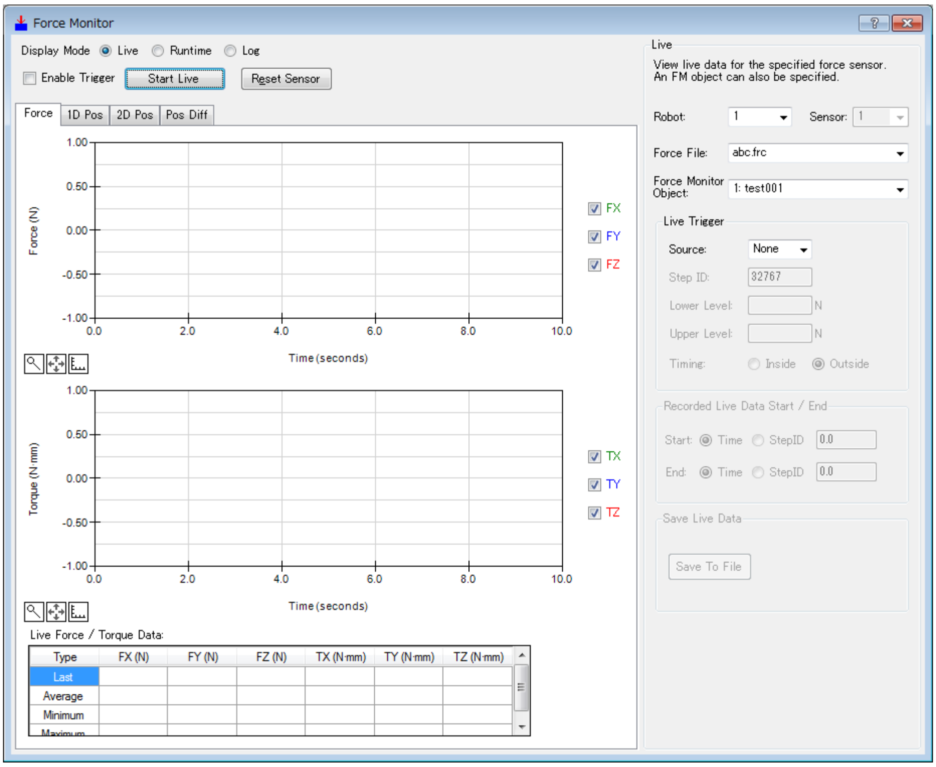
It is possible to display the current force values and analyze or compare the past values.
From the EPSON RC+ 7.0 menu, select [Tools]-[Force Monitor], or click the <Force Monitor> button on the toolbar.
The [Force Monitor] window appears.

The window displays different dialog box depending on selection of [Display Mode] (Live, Runtime, Log).

1. [Display Mode]-the <Live> button

1-1 Detail of the displayed dialog box

Select [Display Mode]-the <Live> button to display the following dialog box.



Display Mode ● Live ○ Runtime ○ Log

☐ Enable Trigger

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1 Sensor: 1

Force File: abc.frc

Force Monitor Object: 1: test001

Source: None

Step ID: 32767

Lower Level: N

Upper Level: N

Timing: ○ Inside ● Outside

Start: ● Time ○ StepID 0.0

End: ● Time ○ StepID 0.0

Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last						
Average						
Minimum						
Maximum						

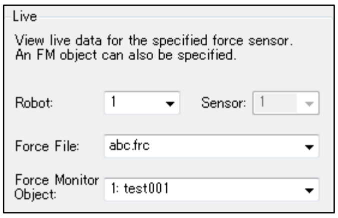
Item	Description
Graph area	By starting "Live", the force information detected by force sensor and the the position information of the robot are displayed on a graph in real-time. There are [Force], [1D Pos], [2D Pos], and [Pos Diff] tabs in graph area. You can switch them depending on the use. For details on each tab, refer to the following section. *4. Graph* (describe in a later page)
[Enable Trigger] checkbox	When placing a checkmark in the checkbox and starting "Live", start to display the data in the graph by satisfying the conditions set by trigger.

Item	Description
<Start Live> button	Click the button to start “Live”. After clicking the <Start Live> button, “Live” continues for 600 seconds at the maximum. Displayed button is changed to <Stop Live>.
<Stop Live> button	Click the button to stop “Live”. Displayed button is changed to <Start Live>.
<Reset Sensor> button	Reset the force sensor. Values of force and torque will be “0”.
Robot	Set a robot number that will be a target of “Live”. When selecting a robot, force sensor that will be a target of “Live” is automatically selected.
Sensor	Set a number of force sensor that will be a target of “Live”. Specifying the force sensor number displays the force information in force sensor coordinate system.
Force File	Set the file in which the force monitor object is stored. When “None” is selected, the force information of force sensor coordinate system is displayed.
Force Monitor Object	Select from a list of objects (number: label) that are defined by files set in force file. When specifying the force monitor object, force information of the force coordinate system is displayed.
Live Trigger	Set a trigger of start conditions when placing a checkmark in the [Enable Trigger] check box and starting “Live”. Source : Select a trigger of the target. When you do not set a trigger, select “None”. Step ID : Set StepID as a start condition. Lower Level : Set the lower threshold value of the trigger. Upper Level : Set the upper threshold value of the trigger. Timing : Set the timing of the trigger. <Inside> : When the value falls inside the range set above. <Outside> : When the value falls outside the range set above.
Recorded Live Data Start / End	Set a display range of Live data. Time : Set a start time or an end time. StepID : Set StepID to start or end.
Save Live Data	Save the “Live” result data which is currently displayed in the graph to a file. When the <Save To File> button is clicked, [Save Data To File]dialog box of the log data is displayed. To save the data to a file, set the destination to save and a file name and click the <Save> button.

1-2 “Live” Flow

1-2-1 Start “Live”

Before starting “Live”, make sure to check the contents of Live setting are correct. (robot number, sensor number, force file, and force monitor object)

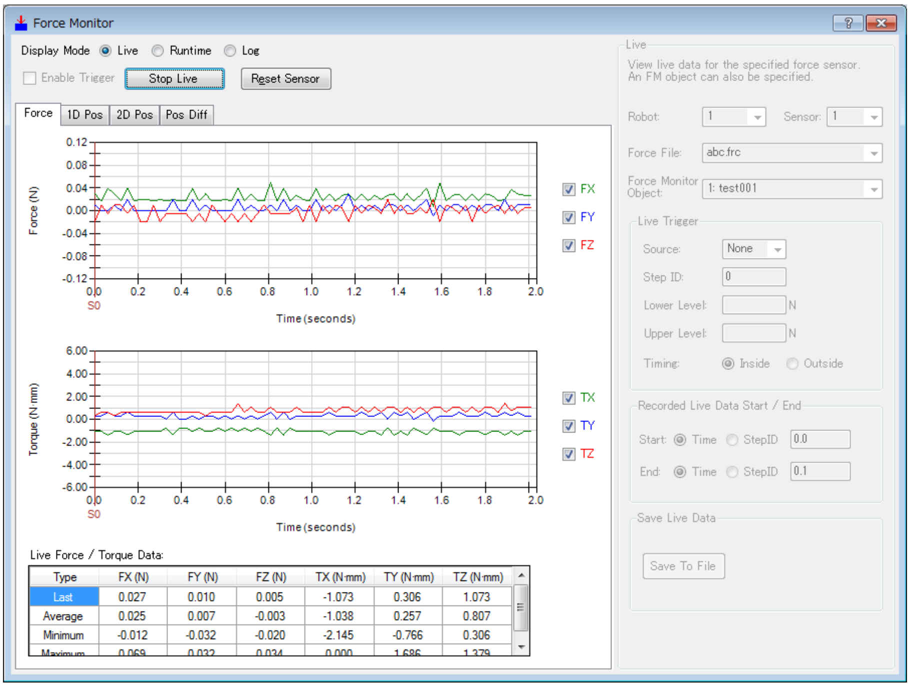


Live

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1
Sensor: 1
Force File: abc.frc
Force Monitor Object: 1: test001

Click the <Start Live> button to start “Live”. When “Live” is started, the data will be displayed in the graph and updated in real-time.



Live

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1
Sensor: 1
Force File: abc.frc
Force Monitor Object: 1: test001

Live Trigger
Source: None
Step ID: 0
Lower Level: N
Upper Level: N
Timing: ● Inside ○ Outside

Recorded Live Data Start / End
Start: ● Time ○ StepID 0.0
End: ● Time ○ StepID 0.1

Save Live Data

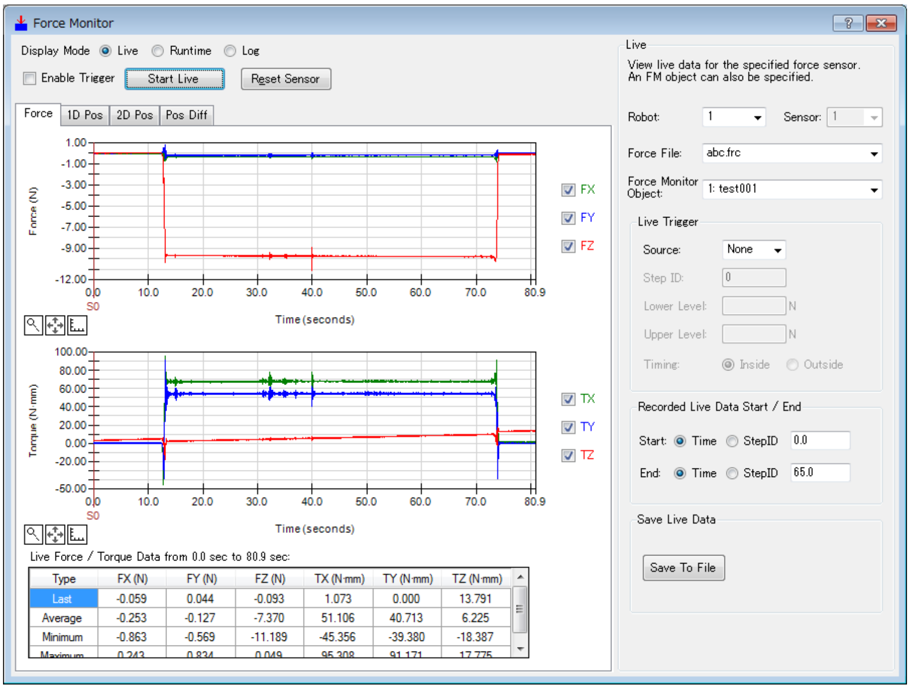
Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	0.027	0.010	0.005	-1.073	0.306	1.073
Average	0.025	0.007	-0.003	-1.038	0.257	0.807
Minimum	-0.012	-0.032	-0.020	-2.145	-0.766	0.306
Maximum	0.069	0.032	0.034	0.000	1.686	1.379

1-2-2 Stop “Live”

To stop “Live”, click the <Stop Live> button. It stops automatically When 600 seconds has passed after the <Start Live> button has been clicked.

When the <Stop Live> button is clicked, the data update will stop.



Display Mode ● Live ○ Runtime ○ Log

☐ Enable Trigger

Live

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1
Sensor: 1
Force File: abc.frc
Force Monitor Object: 1: test001

Live Trigger
Source: None
Step ID: 0
Lower Level: N
Upper Level: N
Timing: ● Inside ○ Outside

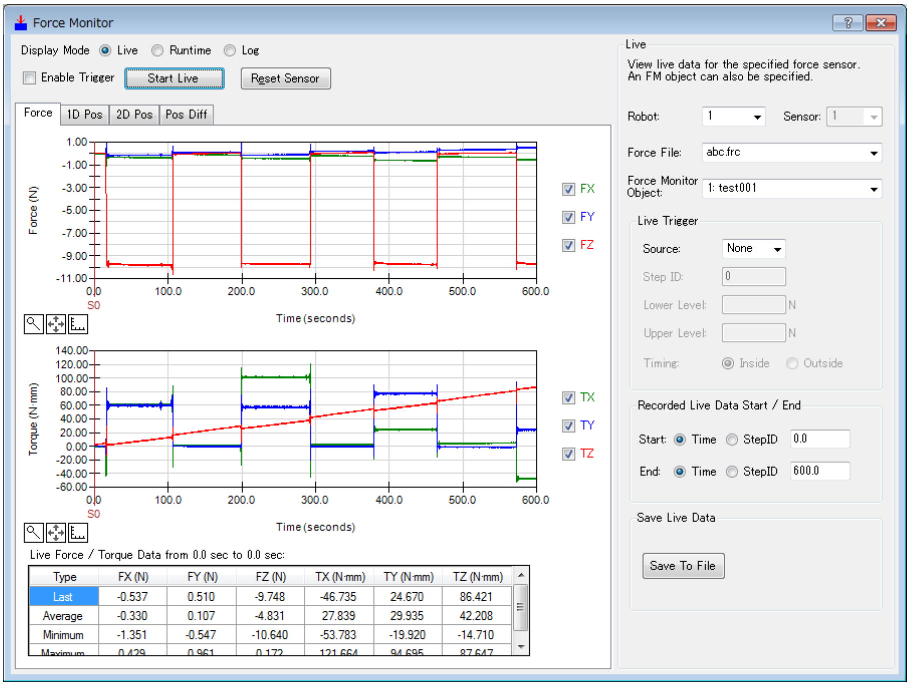
Recorded Live Data Start / End
Start: ● Time ○ StepID 0.0
End: ● Time ○ StepID 65.0

Save Live Data

Live Force / Torque Data from 0.0 sec to 80.9 sec:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-0.059	0.044	-0.093	1.073	0.000	13.791
Average	-0.253	-0.127	-7.370	51.106	40.713	6.225
Minimum	-0.863	-0.569	-11.189	-45.356	-39.380	-18.387
Maximum	0.243	0.834	0.049	95.308	91.171	17.775

When 600 seconds has passed after the <Start Live> button has been clicked, the data update will automatically stop.



Display Mode ● Live ○ Runtime ○ Log

☐ Enable Trigger

Live

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1
Sensor: 1
Force File: abc.frc
Force Monitor Object: 1: test001

Live Trigger
Source: None
Step ID: 0
Lower Level: N
Upper Level: N
Timing: ● Inside ○ Outside

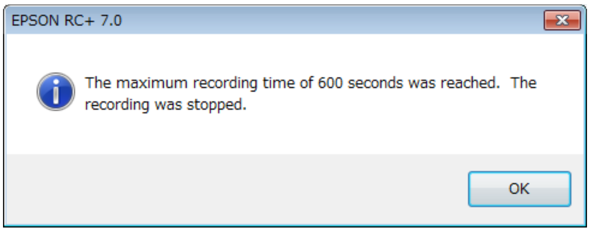
Recorded Live Data Start / End
Start: ● Time ○ StepID 0.0
End: ● Time ○ StepID 600.0

Save Live Data

Live Force / Torque Data from 0.0 sec to 0.0 sec:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-0.537	0.510	-9.748	-46.735	24.670	86.421
Average	-0.330	0.107	-4.831	27.839	29.935	42.208
Minimum	-1.351	-0.547	-10.640	-53.783	-19.920	-14.710
Maximum	0.429	0.961	0.172	121.664	94.695	87.647

When 600 seconds has passed, the following message is displayed.
To restart "Live", click the <OK> button and click the <Start Live> button again.



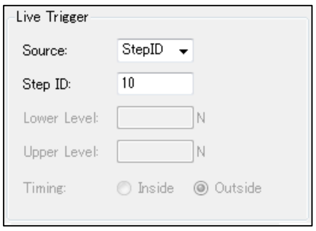
The maximum recording time of 600 seconds was reached. The recording was stopped.

1-3 "Live" flow when enabling the trigger function

1-3-1 Start "Live"

Place a checkmark in the [Enable Trigger] checkbox.

Before starting "Live", make sure to check the contents of Live setting or Live trigger are correct.


Live Trigger

Source: StepID

Step ID: 10

Lower Level: N

Upper Level: N

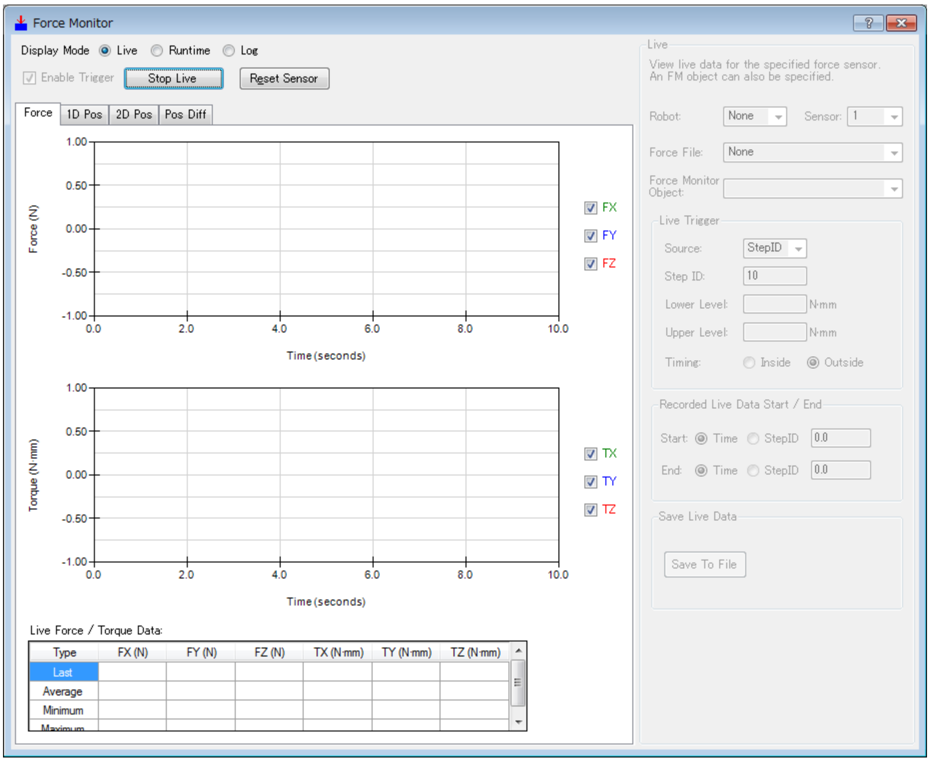
Timing: ○ Inside ● Outside

Make sure that the target trigger or trigger conditions are correct.

Click the <Start Live> button and start "Live".

Until the trigger conditions are satisfied, data will not be displayed in the graph.

Before the trigger conditions are satisfied: The data is not displayed in the graph.

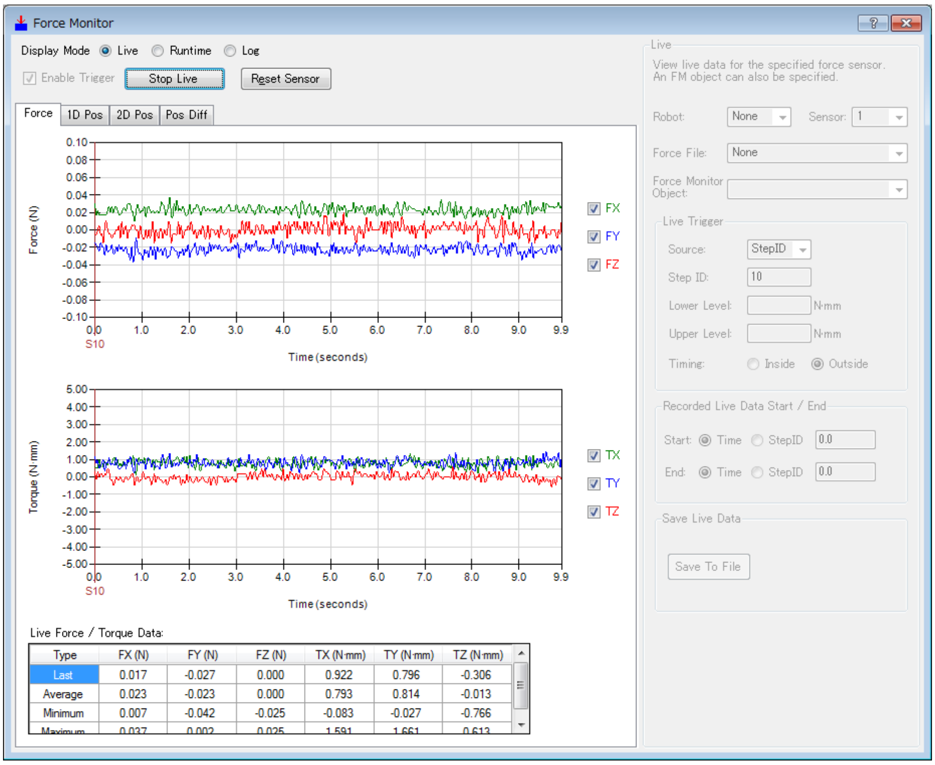


Robot: None
Sensor: 1
Force File: None
Force Monitor Object:
Source: StepID
Step ID: 10
Lower Level: N·mm
Upper Level: N·mm
Timing: ○ Inside ● Outside
Start: ● Time ○ StepID 0.0
End: ● Time ○ StepID 0.0

Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last						
Average						
Minimum						
Maximum						

After the trigger conditions are satisfied: The data is displayed in the graph and keep updating in real-time.



Robot: None
Sensor: 1
Force File: None
Force Monitor Object:
Source: StepID
Step ID: 10
Lower Level: N·mm
Upper Level: N·mm
Timing: ○ Inside ● Outside
Start: ● Time ○ StepID 0.0
End: ● Time ○ StepID 0.0

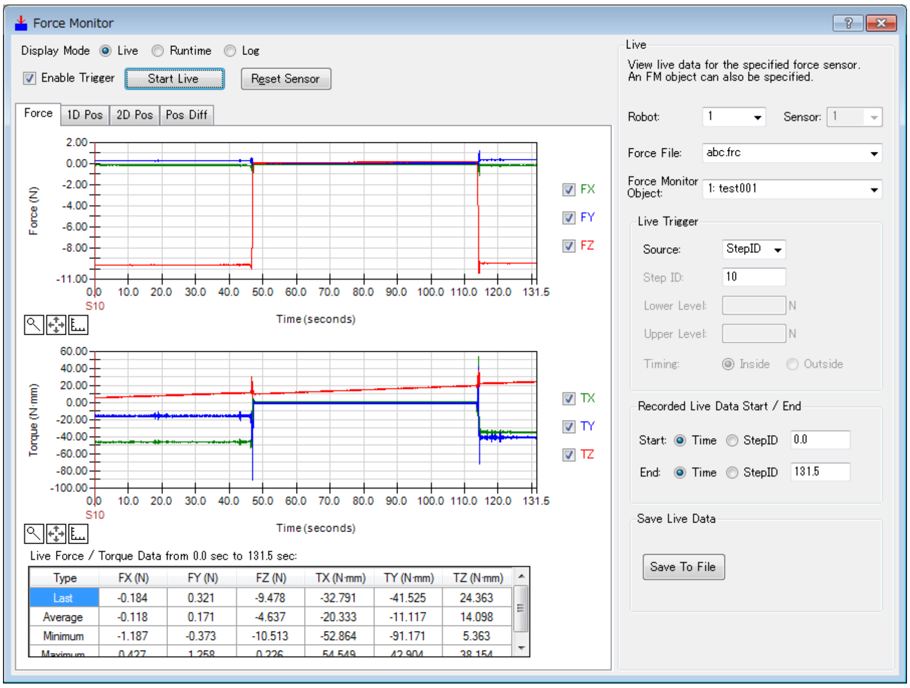
Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	0.017	-0.027	0.000	0.922	0.796	-0.306
Average	0.023	-0.023	0.000	0.793	0.814	-0.013
Minimum	0.007	-0.042	-0.025	-0.083	-0.027	-0.766
Maximum	0.037	0.002	0.025	1.591	1.661	0.613

1-3-2 Stop “Live”

To stop the “Live”, click the <Stop Live> button. When 600 seconds has passed after the <Start Live> button has been clicked, “Live” is stopped automatically.
(It is not 600 seconds after the data is started to be displayed.)

When the <Stop Live> button is clicked, the data update will stop.



Display Mode: ● Live ○ Runtime ○ Log

☑ Enable Trigger

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1 Sensor: 1

Force File: abc.frc

Force Monitor Object: 1: test001

Source: StepID

Step ID: 10

Lower Level: N

Upper Level: N

Timing: ● Inside ○ Outside

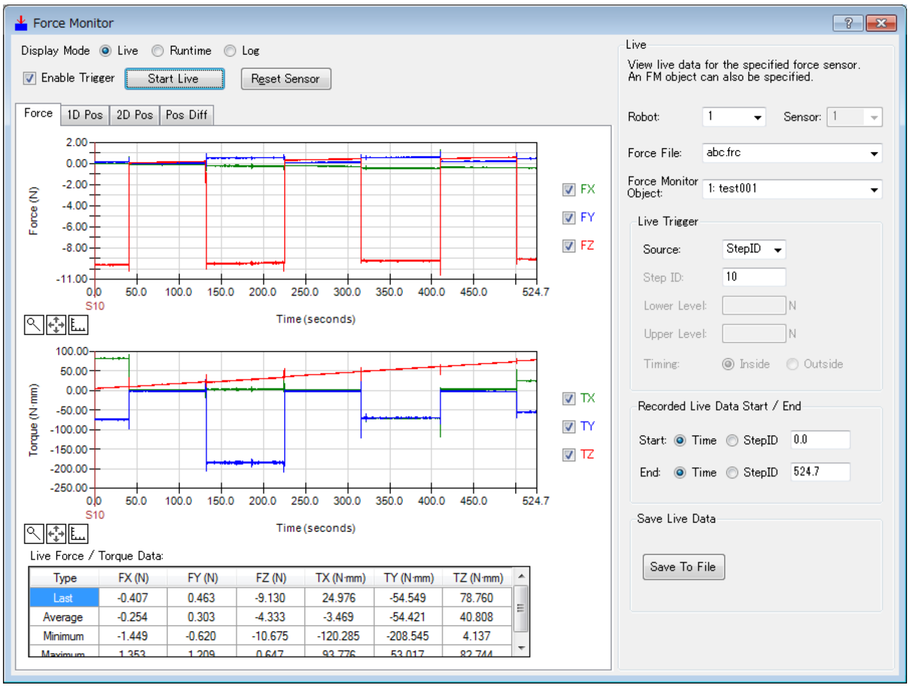
Start: ● Time ○ StepID 0.0

End: ● Time ○ StepID 131.5

Live Force / Torque Data from 0.0 sec to 131.5 sec:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-0.184	0.321	-9.478	-32.791	-41.525	24.363
Average	-0.118	0.171	-4.637	-20.333	-11.117	14.098
Minimum	-1.187	-0.373	-10.513	-52.864	-91.171	5.363
Maximum	0.427	1.258	0.226	54.549	42.904	38.154

When 600 seconds has passed after the <Start Live> button has been clicked, the data update will automatically stop.



Display Mode: ● Live ○ Runtime ○ Log

☑ Enable Trigger

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1 Sensor: 1

Force File: abc.frc

Force Monitor Object: 1: test001

Source: StepID

Step ID: 10

Lower Level: N

Upper Level: N

Timing: ● Inside ○ Outside

Start: ● Time ○ StepID 0.0

End: ● Time ○ StepID 524.7

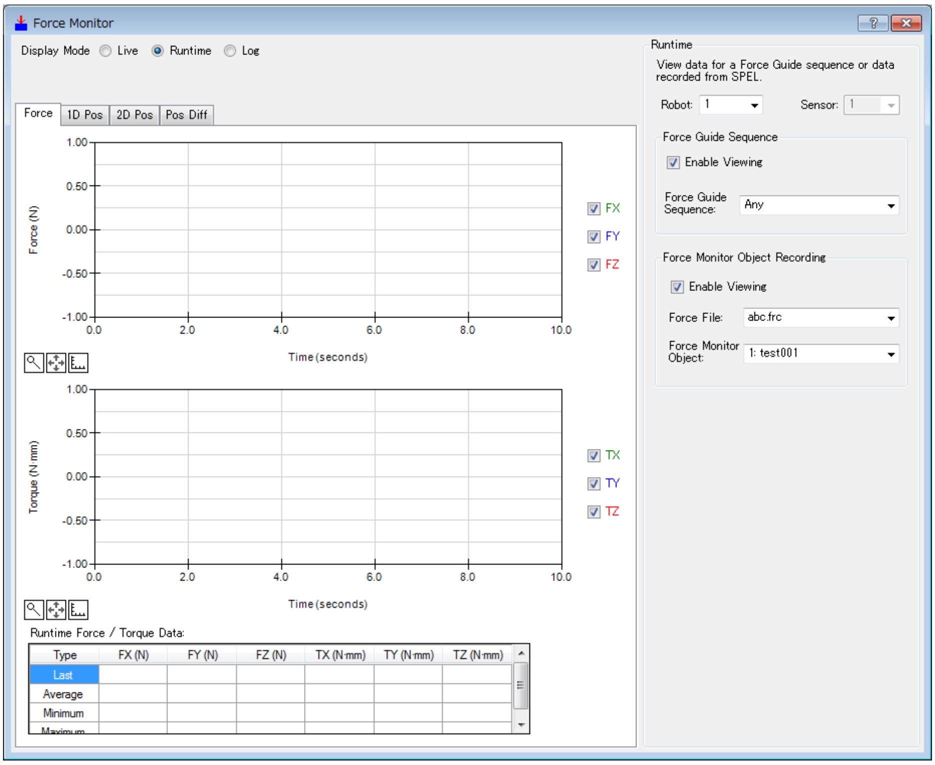
Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-0.407	0.463	-9.130	24.976	-54.549	78.760
Average	-0.254	0.303	-4.333	-3.469	-54.421	40.808
Minimum	-1.449	-0.620	-10.675	-120.285	-208.545	4.137
Maximum	1.353	1.209	0.647	93.776	53.017	82.744

2. [Display Mode]-<Runtime> button

2-1 Detail of displayed dialog box

Select [Display Mode]- the <Runtime> button, the following dialog box is displayed.



Display Mode ○ Live ● Runtime ○ Log

View data for a Force Guide sequence or data recorded from SPEL.

Robot: 1

Sensor: 1

Force Guide Sequence: ☑ Enable Viewing

Force Guide Sequence: Any

Force Monitor Object Recording: ☑ Enable Viewing

Force File: abc.frc

Force Monitor Object: 1: test001

Runtime Force / Torque Data:

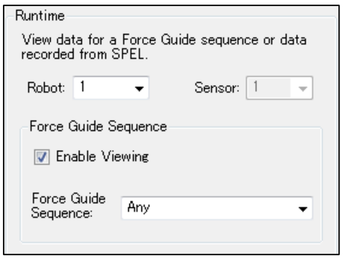
Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last						
Average						
Minimum						
Maximum						

Item	Description
Graph area	By execution of the force guide sequence or record execution by the force monitor object, the force information detected by Force Sensor and the the position information of the robot are displayed on a graph in real-time. There are [Force], [1D Pos], [2D Pos], and [Pos Diff] tabs in graph area. You can switch the tab depending on the use. For details of each tab, refer to the following section. *4. Graph* (describe in a later page)
Robot	Select a robot number that will be a target of “Runtime”. When selecting a robot, force sensor that will be a target of “Runtime” is automatically selected.
Sensor	Set a number of force sensor that will be a target of “Runtime”.
Force Guide Sequence	Set a force guide sequence to be displayed on a graph when executing a program. Graph display : Select enable/disable the graph display. Force guide sequence: Select a force guide sequence to be displayed on a graph. If selecting “Any”, all force guide sequences will be displayed.

Item	Description
Force Monitor Object Recording	Set conditions of the graph display for the recording by RecordStart property. Graph display : Select enable/disable the graph display. Force file: Set a force file that the force monitor object to be displayed on a graph is saved. When "None" is selected, all force monitor objects will be displayed on a graph. Force monitor object : Set a force monitor object to be displayed on a graph. When the force monitor object is set: Even the RecordStart property is executed by the other force guide object, the data is saved in a file, but not displayed in the graph.

2-2 Graph display when executing the force guide sequence

Before executing the force guide sequence, make sure to check the Runtime setting is correct.



Runtime

View data for a Force Guide sequence or data recorded from SPEL.

Robot: 1

Sensor: 1

Force Guide Sequence

☑ Enable Viewing

Force Guide Sequence: Any

Check the following items:

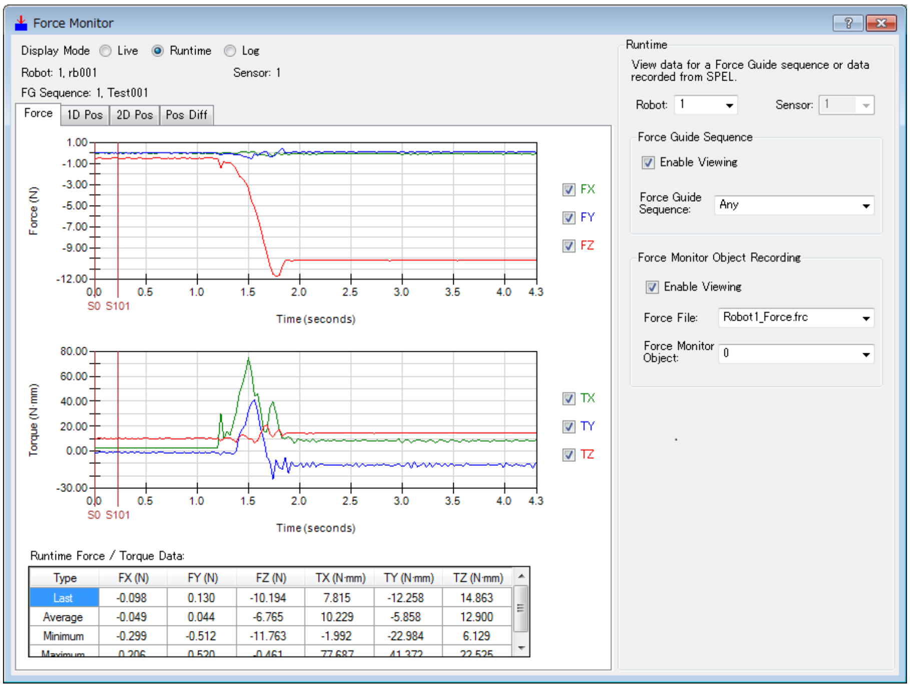
- Target robot number or sensor number is correct.
- Graph display of force guide sequence setting or target force guide sequence is correct.

When the setting is correct, execute the force guide sequence on Force Guide window or by the FGRun Statement.

When executing the force guide object which does not satisfy the condition:
Force guide sequence is not displayed on a graph.

When executing the force guide object which satisfies the condition:
Force guide sequence is displayed on a graph.

When the conditions are satisfied, the data is displayed on a graph.



Display Mode ○ Live ● Runtime ○ Log

Robot: 1, rb001

Sensor: 1

FG Sequence: 1, Test001

Runtime

View data for a Force Guide sequence or data recorded from SPEL.

Robot: 1

Sensor: 1

Force Guide Sequence

☑ Enable Viewing

Force Guide Sequence: Any

Force Monitor Object Recording

☑ Enable Viewing

Force File: Robot1_Force.frc

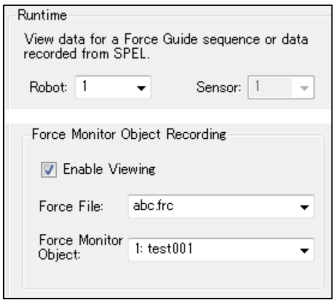
Force Monitor Object: 0

Runtime Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-0.098	0.130	-10.194	7.815	-12.258	14.863
Average	-0.049	0.044	-6.765	10.229	-5.858	12.900
Minimum	-0.299	-0.512	-11.763	-1.992	-22.984	6.129
Maximum	0.206	0.520	-0.461	77.687	41.372	22.525

2-3 Graph display when the record is executed by the force monitor object

Before executing the record by the force monitor object, make sure to check the Runtime setting is correct.



Runtime

View data for a Force Guide sequence or data recorded from SPEL.

Robot: 1

Sensor: 1

Force Monitor Object Recording

☑ Enable Viewing

Force File: abc.frc

Force Monitor Object: 1: test001

Check the following items:

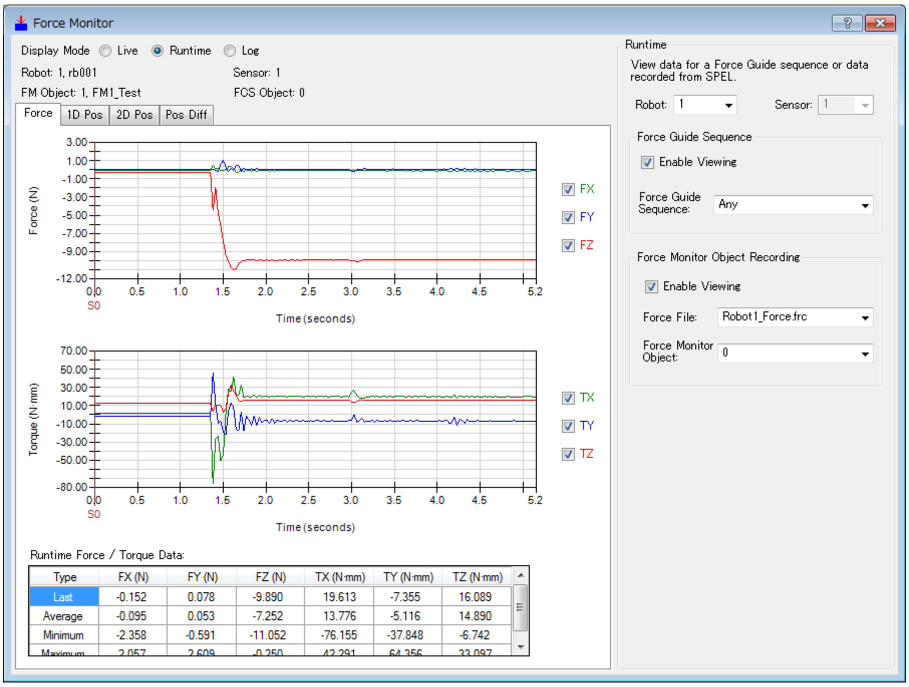
- Target robot number or sensor number is correct.
- Graph display of the record setting by force monitor object, or target force file or force monitor object is correct.

When the setting is correct, execute the record by force monitor object.

When the specified force monitor object does not satisfy the condition:
Data is saved in a file, but not displayed on a graph.

When the specified force monitor object satisfies the condition:
Data is saved in a file and displayed on a graph.

When the conditions are satisfied, the data is displayed on a graph.



Display Mode ○ Live ● Runtime ○ Log

Robot: 1, rb001

Sensor: 1

FM Object: 1, FM1_Test

FCS Object: 0

Runtime

View data for a Force Guide sequence or data recorded from SPEL.

Robot: 1

Sensor: 1

Force Guide Sequence

☑ Enable Viewing

Force Guide Sequence: Any

Force Monitor Object Recording

☑ Enable Viewing

Force File: Robot1_Force.frc

Force Monitor Object: 0

☑ FX ☑ FY ☑ FZ

☑ TX ☑ TY ☑ TZ

Runtime Force / Torque Data:

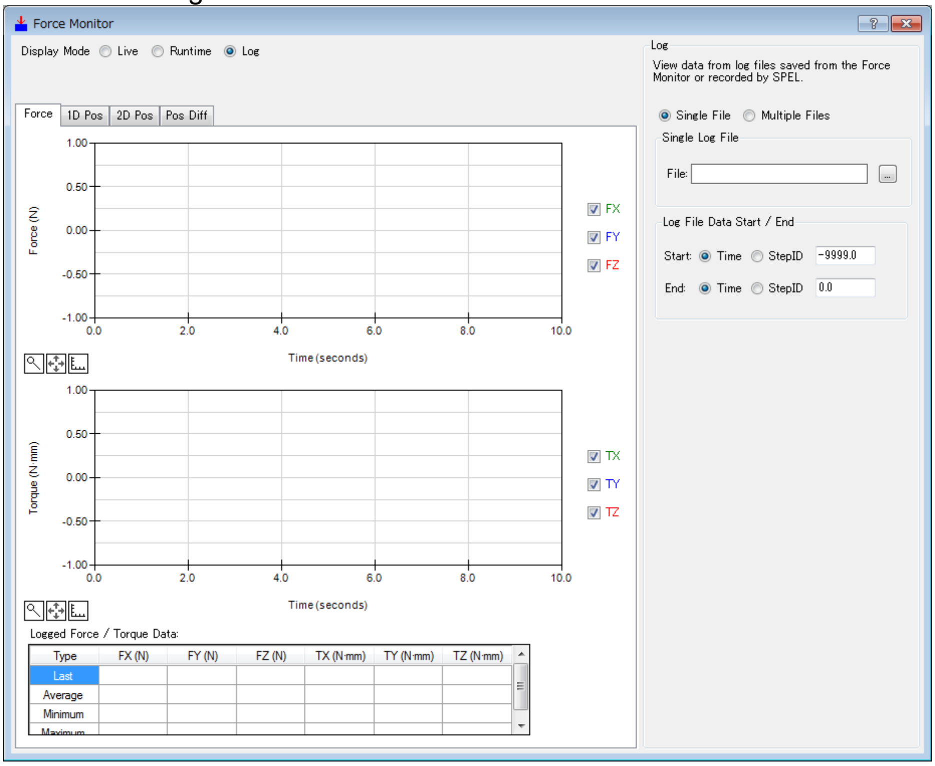
Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-0.152	0.078	-9.890	19.613	-7.355	16.089
Average	-0.095	0.053	-7.252	13.776	-5.116	14.890
Minimum	-2.358	-0.591	-11.052	-76.155	-37.848	-6.742
Maximum	2.057	2.609	-0.250	42.291	64.356	33.097

3. [Display Mode]-<Log> button

3-1 Detail of the displayed dialog box

Select [Display Mode]-the <Log> button to display the following dialog box.

When the <Single File> button is selected



Force Monitor

Display Mode ○ Live ○ Runtime ● Log

Log

View data from log files saved from the Force Monitor or recorded by SPEL.

● Single File ○ Multiple Files

Single Log File

File:

Log File Data Start / End

Start: ● Time ○ StepID -9999.0

End: ● Time ○ StepID 0.0

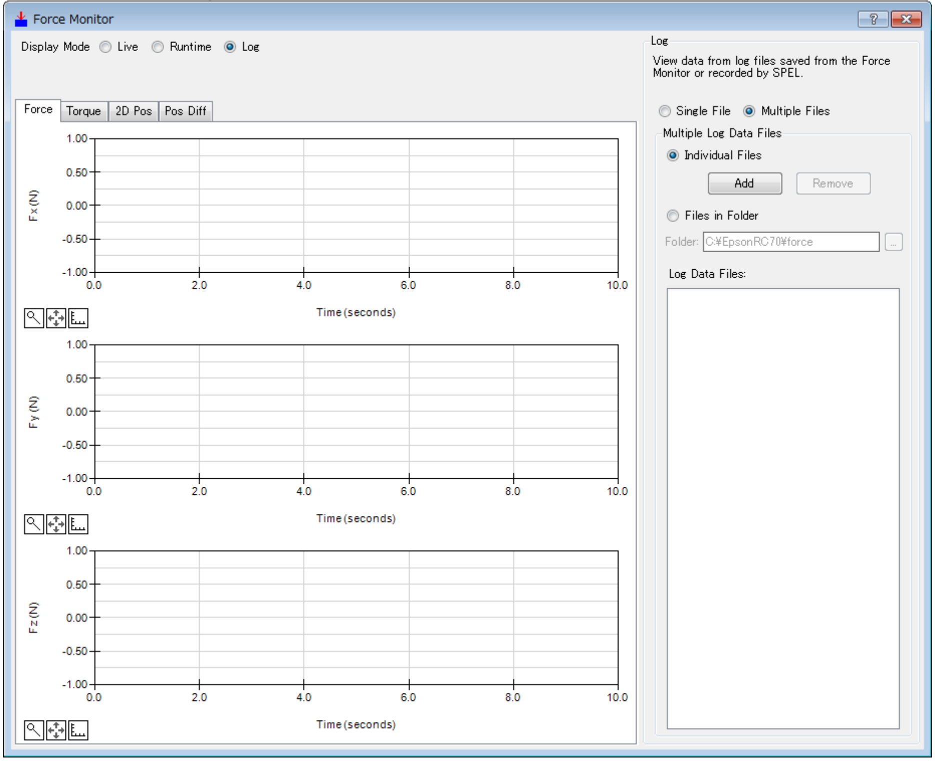
☑ FX ☑ FY ☑ FZ

☑ TX ☑ TY ☑ TZ

Logged Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last						
Average						
Minimum						
Maximum						

When the <Multiple Files> button is selected



Force Monitor

Display Mode ○ Live ○ Runtime ● Log

Log

View data from log files saved from the Force Monitor or recorded by SPEL.

○ Single File ● Multiple Files

Multiple Log Data Files

● Individual Files

○ Files in Folder

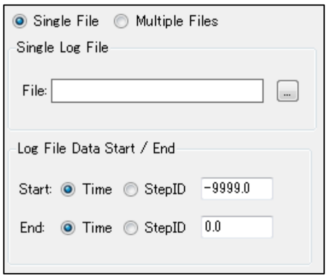
Folder: C:¥EpsonRC70¥force

Log Data Files:

Item	Description
Graph area	Force information or positional information of the robot which is saved in a file is displayed in a graph. You can select several files and compare them on the graph. When selecting a single file: There are [Force], [1D Pos], [2D Pos], and [Pos Diff] tabs. When selecting multiple files: There are [Force], [Torque], [2D Pos], and [Pos Diff] tabs. You can switch a tab depending on usage. For details of each tab, refer to the following section. *4. Graph* (describe in a later page)
Single File	Display a single log data file on a graph. You can analyze or check it.
Single Log File	Set a log data file to display. Select a target file from the [Select Data File] dialog box of log data file. Click the <Open> button to display it on a graph.
Log File Data Start / End	Set a display range of the log data. Time : Set time (sec) Set a start time or an end time (sec). StepID : Set StepID to start or end.
Multiple Files	Overlay multiple log data files on a graph to display. You can compare them or check variations.
Multiple Log Data Files	You can select the either one of the following loading methods by clicking the <Multiple Files> button. Individual Files Files in Folder <Individual Files> button: You can add or remove a target file in a unit of file. <Add> button : The [Select Data File] dialog box is displayed. Select a target file and click the <Open> button to add the file. <Remove> button : Select and click the target files to be removed from a list of log data file. Removal message is displayed. Click the <Yes> button and remove the file. <Files in Folder> button: You can select a target file in a unit of folder. Folder : Click the icon to display the reference dialog box of the folder. Select a target folder and click the <OK> button to add the file. Added file is displayed on the [Log Data Files]. Files with checkmarks are displayed on graph. You can display up to 50 files on a graph simultaneously.

3-2 How to load Single Log File

1. Select the <Single File> button.



● Single File ○ Multiple Files

Single Log File

File:

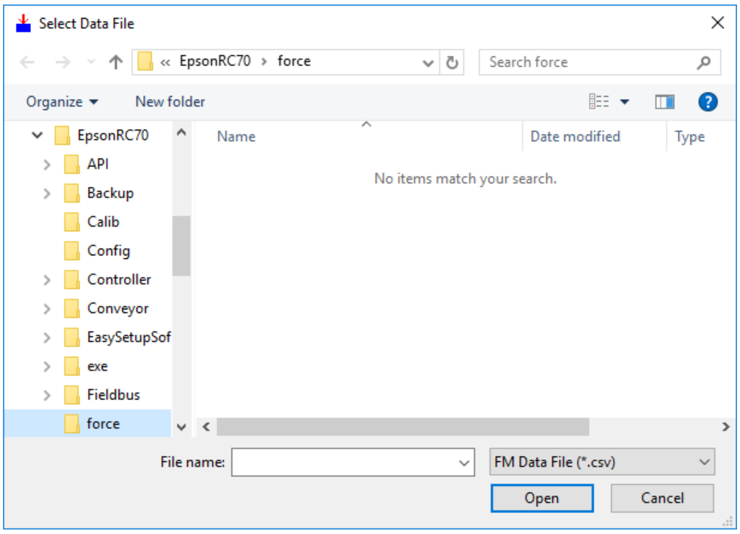
Log File Data Start / End

Start: ● Time ○ StepID -9999.0

End: ● Time ○ StepID 0.0

2. Click [File]- the <…> icon.

3. The [Select Data File] dialog box is displayed.
   Select a target file on the [File name] box.



Select Data File

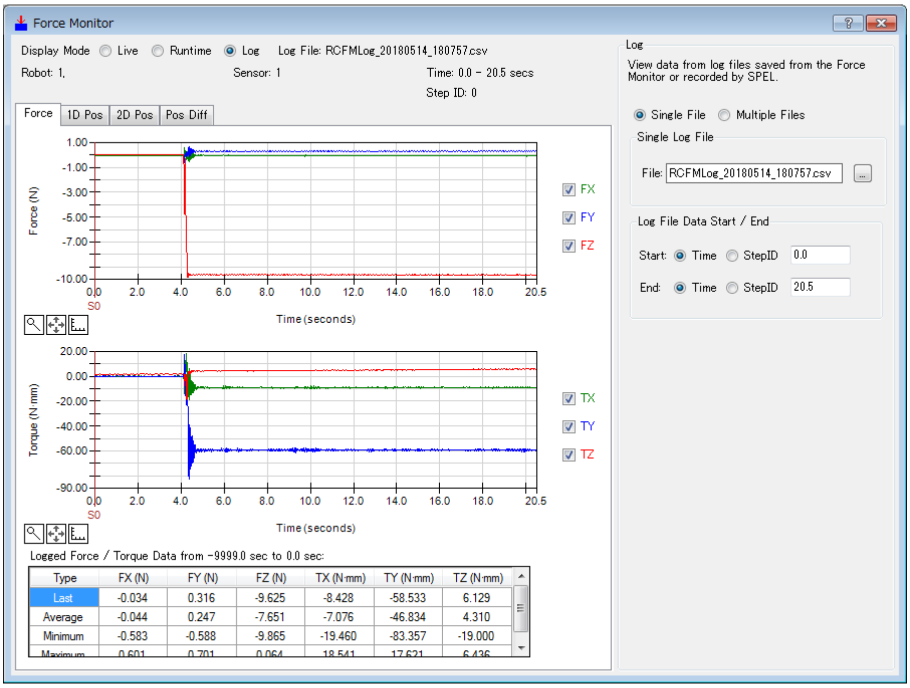
« EpsonRC70 › force

No items match your search.

File name:

FM Data File (*.csv)

4. Click the <Open> button.
   Log data is displayed in the graph.



Force Monitor

Display Mode ○ Live ○ Runtime ● Log Log File: RCFMLog_20180514_180757.csv

Robot: 1, Sensor: 1 Time: 0.0 - 20.5 secs

Step ID: 0

Log

View data from log files saved from the Force Monitor or recorded by SPEL.

● Single File ○ Multiple Files

Single Log File

File: RCFMLog_20180514_180757.csv

Log File Data Start / End

Start: ● Time ○ StepID 0.0

End: ● Time ○ StepID 20.5

☑ FX ☑ FY ☑ FZ

☑ TX ☑ TY ☑ TZ

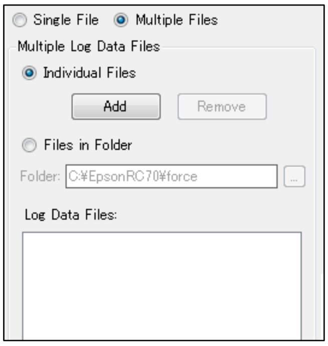
Logged Force / Torque Data from -9999.0 sec to 0.0 sec:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-0.034	0.316	-9.625	-8.428	-58.533	6.129
Average	-0.044	0.247	-7.651	-7.076	-46.834	4.310
Minimum	-0.583	-0.588	-9.865	-19.460	-83.357	-19.000
Maximum	0.601	0.701	0.064	18.541	17.621	6.436

3-3 How to load Multiple Log Data Files

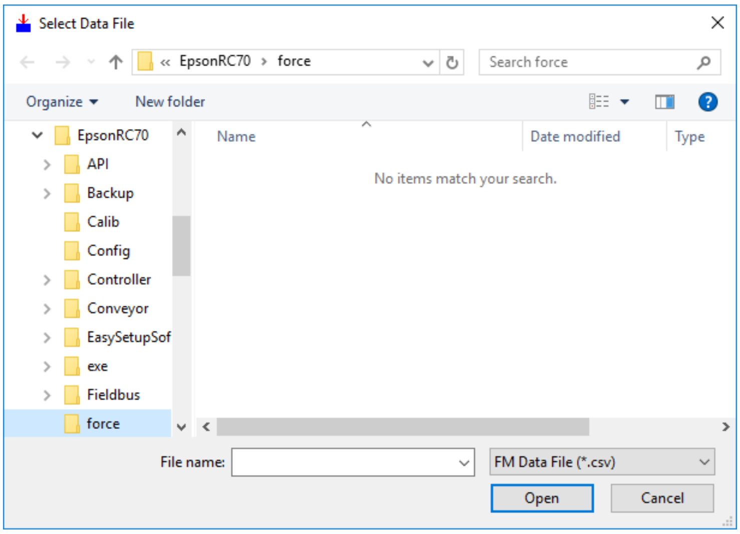
3-3-1 Select individual files

(1) Click the <Multiple Files> button.



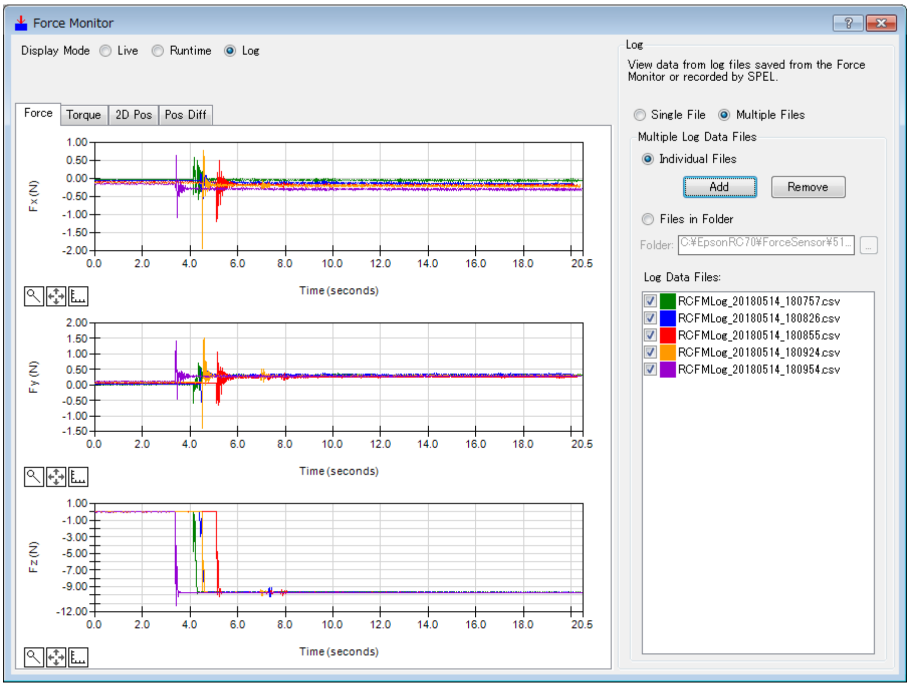
(2) Select the <Individual Files> button.

(3) Click the <Add> button.
The [Select Data File] dialog box is displayed.



(4) Select a target file on the [File name] box.

(5) Click the <Open> button.
File is added to the [Log Data Files]. When placing a checkmark in the checkbox, the log data is displayed in the graph.



Display Mode ○ Live ○ Runtime ● Log

Log

View data from log files saved from the Force Monitor or recorded by SPEL.

○ Single File ● Multiple Files

Multiple Log Data Files

● Individual Files

○ Files in Folder

Folder: C:¥EpsonRC70¥ForceSensor¥51...

Log Data Files:

- ☑ 🟩 RCFMLog_20180514_180757.csv
- ☑ 🟦 RCFMLog_20180514_180826.csv
- ☑ 🟥 RCFMLog_20180514_180855.csv
- ☑ 🟧 RCFMLog_20180514_180924.csv
- ☑ 🟪 RCFMLog_20180514_180954.csv

NOTE

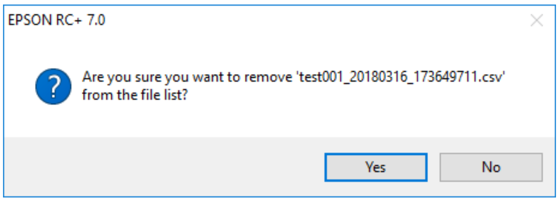
When you restart the [Force Monitor] dialog box while the check marks are placed in the checkboxes of the files displayed in [Log Data Files], it will take time to load the files.

When you want to add files to be displayed on a graph:
Click the <Add> button.

When you want to remove a file to be displayed from a graph:

There are two methods.

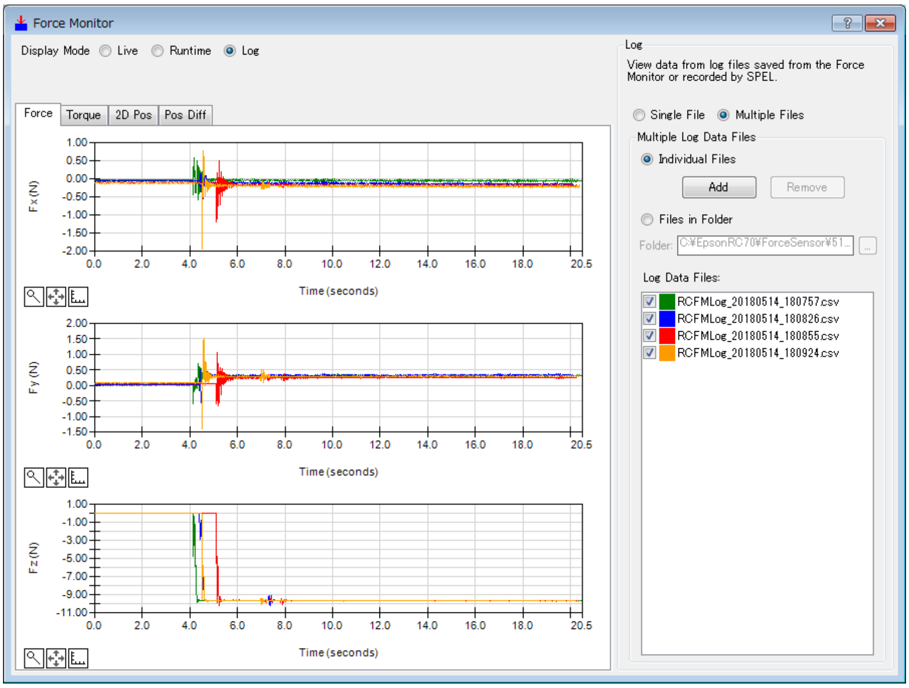
1. Remove a checkmark from the list of [Log Data Files].
2. Select the target file and click the <Remove> button.
   When you click the <Remove> button, the following message is displayed.



EPSON RC+ 7.0

Are you sure you want to remove 'test001_20180316_173649711.csv' from the file list?

Confirm the message and click the <Yes> button.
Target file is removed from the list of [Log Data Files].



Force Monitor

Display Mode ○ Live ○ Runtime ● Log

Log

View data from log files saved from the Force Monitor or recorded by SPEL.

○ Single File ● Multiple Files

Multiple Log Data Files

● Individual Files

○ Files in Folder

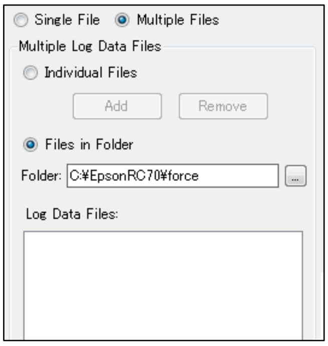
Folder: C:¥EpsonRC70¥ForceSensor¥51...

Log Data Files:

☑ 🟩 RCFMLog_20180514_180757.csv
☑ 🟦 RCFMLog_20180514_180826.csv
☑ 🟥 RCFMLog_20180514_180855.csv
☑ 🟧 RCFMLog_20180514_180924.csv

3-3-2 Select a folder

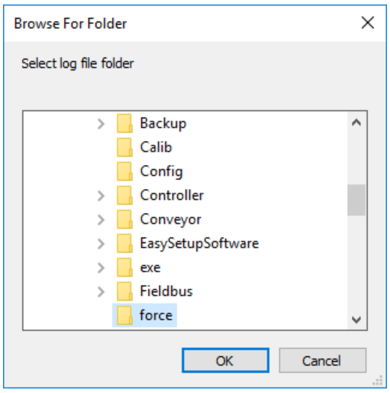
(1) Click the <Multiple Files> button.



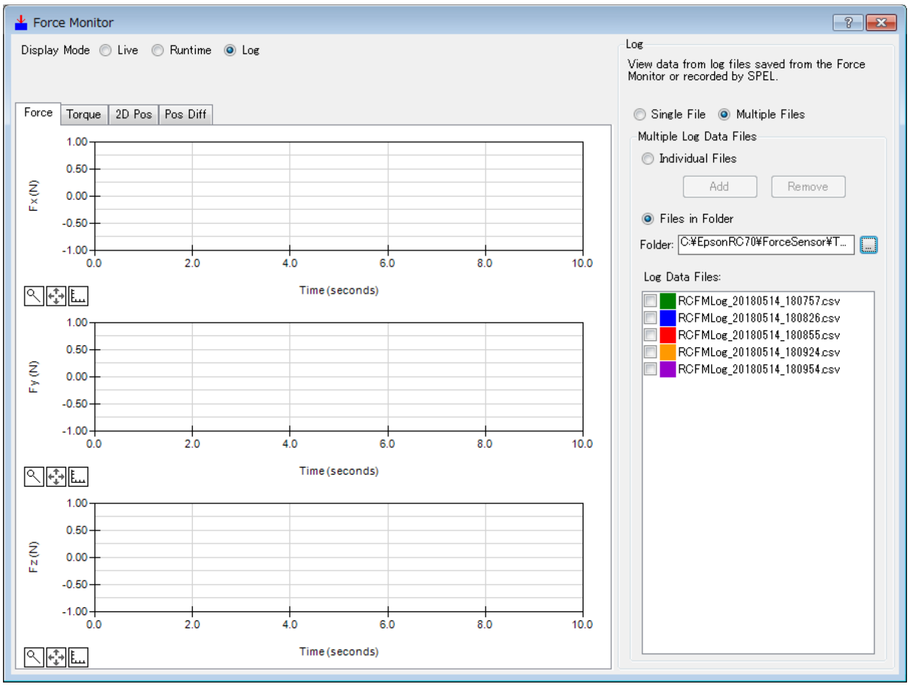
(2) Click the <Files in Folder> button.

(3) Click the [Folder]- the <...> icon.

(4) The [Browse For Folder] dialog box is displayed.
Select a target folder.



(5) Click the <OK> button.
File is added to the [Log Data Files].



Force Monitor

Display Mode ○ Live ○ Runtime ● Log

Log

View data from log files saved from the Force Monitor or recorded by SPEL.

○ Single File ● Multiple Files

Multiple Log Data Files

○ Individual Files

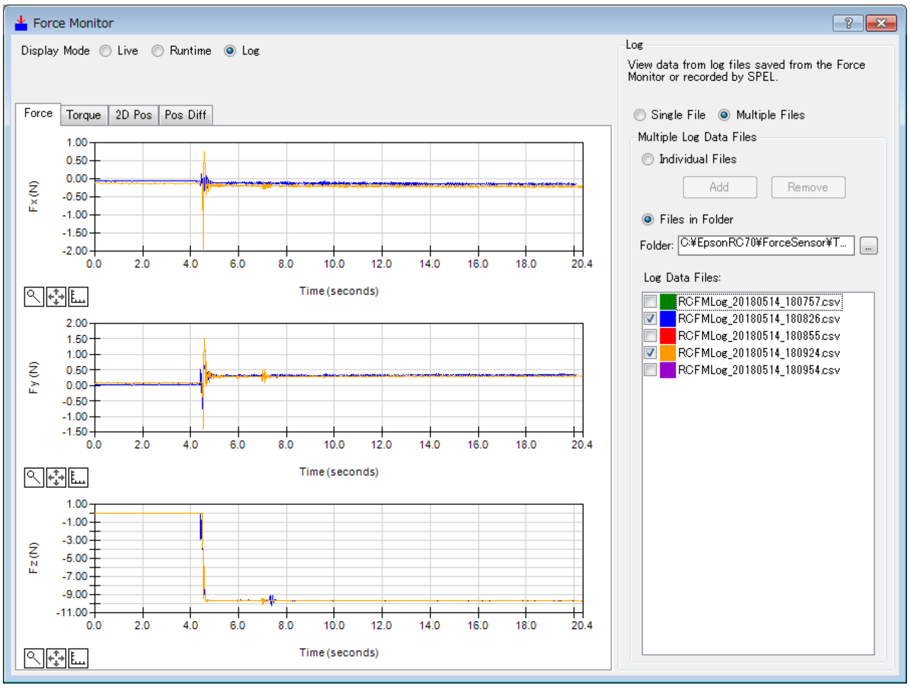
● Files in Folder

Folder: C:¥EpsonRC70¥ForceSensor¥T...

Log Data Files:

☐ 🟩 RCFMLog_20180514_180757.csv
☐ 🟦 RCFMLog_20180514_180826.csv
☐ 🟥 RCFMLog_20180514_180855.csv
☐ 🟧 RCFMLog_20180514_180924.csv
☐ 🟪 RCFMLog_20180514_180954.csv

When placing a checkmark in the checkbox, the log data is displayed on a graph.



Force Monitor

Display Mode ○ Live ○ Runtime ● Log

Log

View data from log files saved from the Force Monitor or recorded by SPEL.

○ Single File ● Multiple Files

Multiple Log Data Files

○ Individual Files

● Files in Folder

Folder: C:¥EpsonRC70¥ForceSensor¥T...

Log Data Files:

☐ 🟩 RCFMLog_20180514_180757.csv
☑ 🟦 RCFMLog_20180514_180826.csv
☐ 🟥 RCFMLog_20180514_180855.csv
☑ 🟧 RCFMLog_20180514_180924.csv
☐ 🟪 RCFMLog_20180514_180954.csv

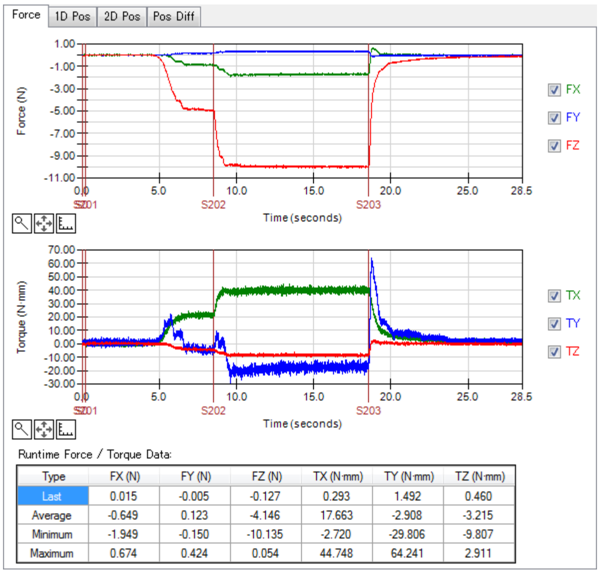
4. Graph

Select items to be displayed with the checkbox next to the graph.
With a checkmark: Target items are displayed in the graph.
Without a checkmark: Target items are not displayed in the graph.

4-1 Single File

4-1-1 [Force] tab (Single File)

Graph on the [Force] tab displays the translational force, torque and StepID values.



Runtime Force / Torque Data:

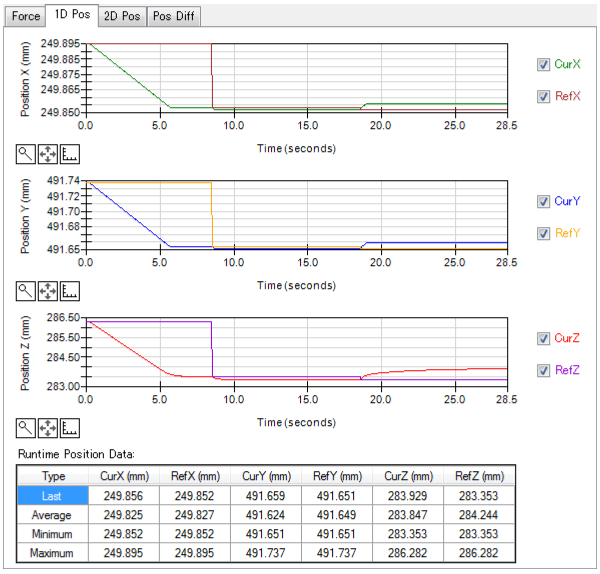
Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	0.015	-0.005	-0.127	0.293	1.492	0.460
Average	-0.649	0.123	-4.146	17.663	-2.908	-3.215
Minimum	-1.949	-0.150	-10.135	-2.720	-29.806	-9.807
Maximum	0.674	0.424	0.054	44.748	64.241	2.911

When selecting the [Force] tab in the following modes, the graph is displayed.
Live mode
Runtime mode
Log mode (Select the <Single File> button)

Item	Description
Force graph	Display the translational force (Fx, Fy, Fz) in a graph. Vertical axis: Force [N] Horizontal axis: Time [s] Changes of StepID are displayed in a graph with a red line.
Torque graph	Display torque (Tx, Ty, Tz) in a graph. Vertical axis: Torque [N･mm] Horizontal axis: Time [s] Changes of StepID are displayed in a graph with a red line.
Force / Torque Data	For the translational force (Fx, Fy, Fz) and torque (Tx, Ty, Tz), display the values (last, average, minimum, and maximum) of the data displayed in a graph.

4-1-2 [1D Pos] tab (Single File)

Graph on the [1D Pos] tab displays the command position (CurPos) including the force control and the command position (RefPos) only including the position control on the graph by dividing them into X, Y, and Z components.



Runtime Position Data:

Type	CurX (mm)	RefX (mm)	CurY (mm)	RefY (mm)	CurZ (mm)	RefZ (mm)
Last	249.856	249.852	491.659	491.651	283.929	283.353
Average	249.825	249.827	491.624	491.649	283.847	284.244
Minimum	249.852	249.852	491.651	491.651	283.353	283.353
Maximum	249.895	249.895	491.737	491.737	286.282	286.282

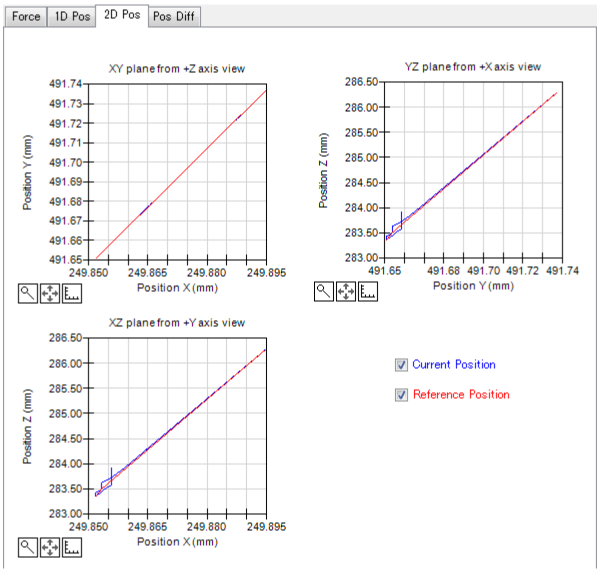
When selecting the [1D Pos] tab in the following modes, the graph is displayed.

Live mode
Runtime mode
Log mode (select the <Single File> button)

Item	Description
Position X graph	Display the command positions (CurPos and RefPos) in X direction in a graph. Vertical axis: Position in X direction [mm] Horizontal axis: Time [s]
Position Y graph	Display the command positions (CurPos and RefPos) in Y direction in a graph. Vertical axis: Position in Y direction [mm] Horizontal axis: Time [s]
Position Z graph	Display the command positions (CurPos and RefPos) in Z direction in a graph. Vertical axis: Position in Z direction [mm] Horizontal axis: Time [s]
Position Data	For each component of X, Y, and Z of each command position, display the values (last, average, minimum, and maximum) of the data displayed in a graph.

4-1-3 [2D Pos] tab (Single File)

Graph on the [2D Pos] tab displays the command position (CurPos) including force control and the command position (RefPos) only including position control on the graph by dividing them into XY, YZ, and XZ planes.



☑ Current Position

☑ Reference Position

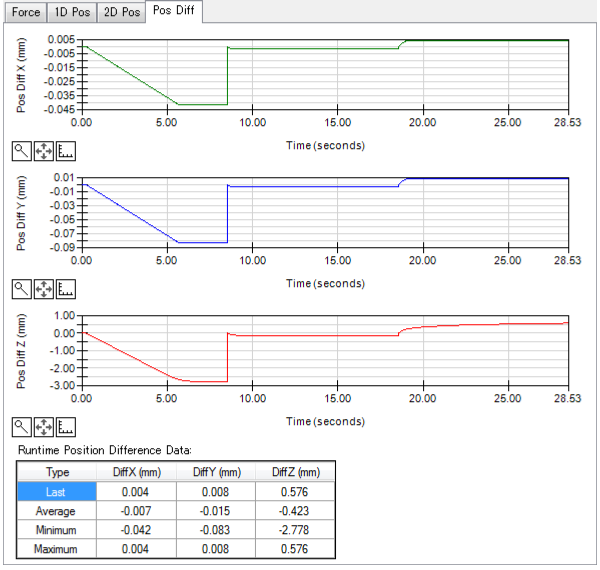
When selecting the [2D Pos] tab in the following modes, the graph is displayed.

Live mode
Runtime mode
Log mode (select the <Single File> button)

Item	Description
XY plane graph	Display the command positions (CurPos and RefPos) projected on XY plane in a graph. Vertical axis: Position in Y position [mm] Horizontal axis: Position in X position [mm]
YZ plane graph	Display the command positions (CurPos and RefPos) projected on YZ plane in a graph. Vertical axis: Position in Z position [mm] Horizontal axis: Position in Y position [mm]
XZ plane graph	Display the command positions (CurPos and RefPos) projected on XZ plane in a graph. Vertical axis: Position in Z position [mm] Horizontal axis: Position in X position [mm]
Command Position	You can select the command position to be displayed in the lower right check box. With a checkmark: Target command positions are displayed in the graph. Without a checkmark: Target command positions are not displayed in the graph. This setting is reflected to all graphs.

4-1-4 [Pos Diff] tab (Single File)

Graph on the [Pos Diff] tab displays the difference between the command position (CurPos) including force control and the command position (RefPos) only including position control on the graph by dividing them into each component: X, Y, and Z.



Runtime Position Difference Data:

Type	DiffX (mm)	DiffY (mm)	DiffZ (mm)
Last	0.004	0.008	0.576
Average	-0.007	-0.015	-0.423
Minimum	-0.042	-0.083	-2.778
Maximum	0.004	0.008	0.576

When selecting the [Pos Diff] tab in the following modes, the graph is displayed.

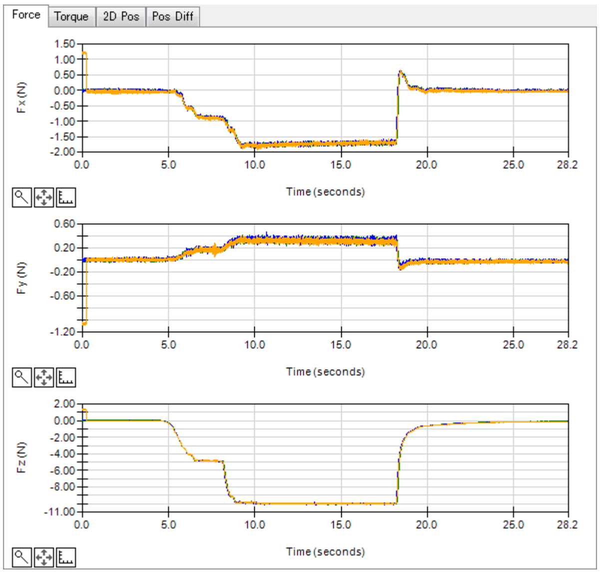
Live mode
Runtime mode
Log mode (select the <Single File> button)

Item	Description
Pos Diff X graph	Display a position difference of the command positions (CurPos and RefPos) in X direction in a graph. Vertical axis: Position difference in X direction [mm] Horizontal axis: Time [s]
Pos Diff Y graph	Display a position difference of the command positions (CurPos and RefPos) in Y direction in a graph. Vertical axis: Position difference in Y direction [mm] Horizontal axis: Time [s]
Pos Diff Z graph	Display a position difference of the command positions (CurPos and RefPos) in Z direction in a graph. Vertical axis: Position difference in Z direction [mm] Horizontal axis: Time [s]
Position Difference Data	For each component of Pos Diff: X, Y, and Z, display the values (last, average, minimum, and maximum) of the data displayed in a graph.

4-2 Multiple Files

4-2-1 [Force] tab (Multiple Files)

Graph on the [Force] tab (multiple files) displays the translational force on a graph for each axis. Data of multiple log data files which are specified on each graph is overlaid to display.

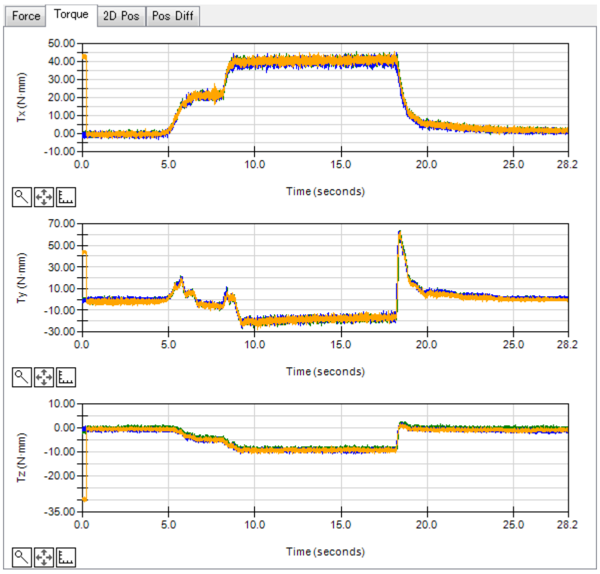


When selecting the [Force] tab in the following mode, the graph is displayed.
Log mode (select the <Multiple Files> button)

Item	Description
Fx graph	Overlay the translational force in X direction up to 50 files on the graph and display. Vertical axis: Force in X direction [N] Horizontal axis: Time [s]
Fy graph	Overlay the translational force in Y direction up to 50 files on the graph and display. Vertical axis: Force in Y direction [N] Horizontal axis: Time [s]
Fz graph	Overlay the translational force in Z direction up to 50 files on the graph and display. Vertical axis: Force in Z direction [N] Horizontal axis: Time [s]

4-2-2 [Torque] tab (Multiple Files)

Graph on the [Torque] tab displays the torque on a graph for each axis. Data of multiple log data files which are specified on each graph is overlaid to display.

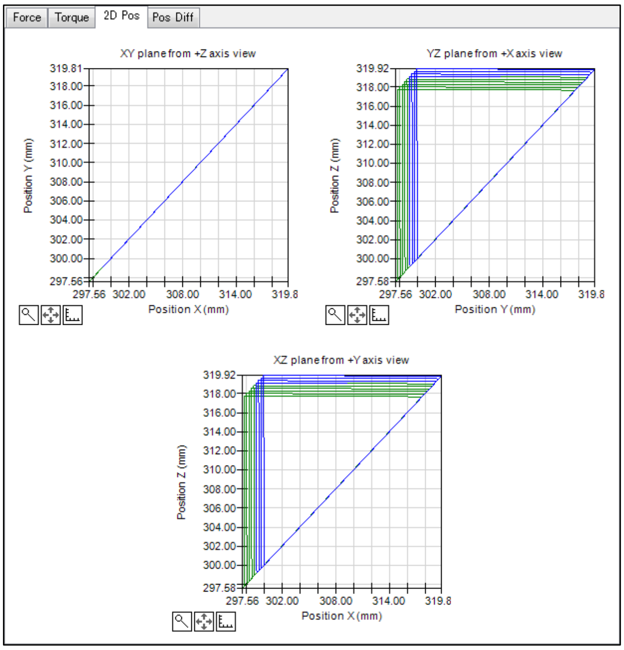


When selecting the [Torque] tab in the following mode, the graph is displayed.
Log mode (select the <Multiple Files> button)

Item	Description
Tx graph	Overlay the torque in X direction up to 50 files on the graph and display. Vertical axis: Torque in X direction [N·mm] Horizontal axis: Time [s]
Ty graph	Overlay the torque in Y direction up to 50 files on the graph and display. Vertical axis: Torque in Y direction [N·mm] Horizontal axis: Time [s]
Tz graph	Overlay the torque in Z direction up to 50 files on the graph and display. Vertical axis: Torque in Z direction [N·mm] Horizontal axis: Time [s]

4-2-3 [2D Pos] tab (Multiple Files)

Graph on the [2D Pos] tab displays the command position (CurPos) including the force control and the command position (RefPos) only including the position control on the graph by dividing them into XY, YZ, XZ planes. Data of multiple log data files which are specified on each graph is overlaid to display.

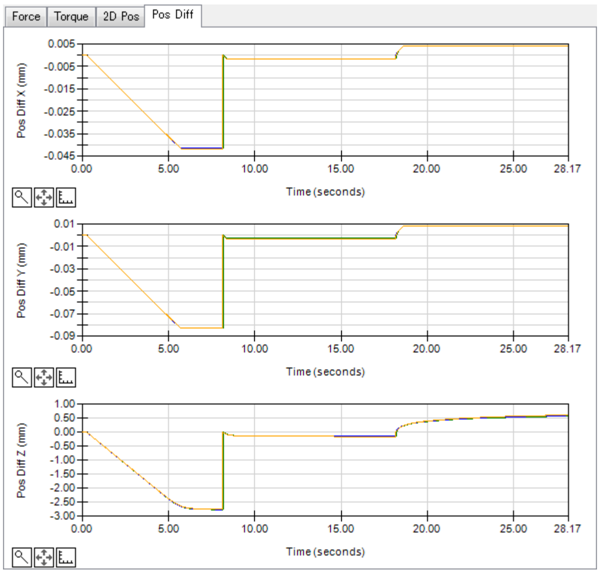


When selecting the [2D Pos] tab in the following mode, the graph is displayed.
Log mode (select the <Multiple Files> button)

Item	Description
XY plane graph	Display the command positions (CurPos and RefPos) projected on the XY plane by overlaying up to 50 files on the graph. Vertical axis: Position in Y direction [mm] Horizontal axis: Position in X direction [mm]
YZ plane graph	Display the command positions (CurPos and RefPos) projected on the YZ plane by overlaying up to 50 files on the graph. Vertical axis: Position in Z direction [mm] Horizontal axis: Position in Y direction [mm]
XZ plane graph	Display the command positions (CurPos and RefPos) projected on the XZ plane by overlaying up to 50 files on the graph. Vertical axis: Position in Z direction [mm] Horizontal axis: Position in X direction [mm]

4-2-4 [Pos Diff] tab (Multiple Files)

Graph of the [Pos Diff] tab (Multiple Files) displays the difference between the command position (CurPos) including force control and the command position (RefPos) only including position control on the graph by dividing them into each component: X, Y, and Z. Data of multiple log data files which are specified on each graph is overlaid to display.



When selecting the [Pos Diff] tab in the <Log> mode which selected several files, the graph is displayed.

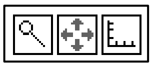
Item	Description
Pos Diff X graph	Display the positional difference of the command positions (CurPos and RefPos) in X direction by overlaying up to 50 files on the graph. Vertical axis: Positional difference in X direction [mm] Horizontal axis: Time [s]
Pos Diff Y graph	Display the positional difference of the command positions (CurPos and RefPos) in Y direction by overlaying up to 50 files on the graph. Vertical axis: Positional difference in Y [mm] Horizontal axis: Time [s]
Pos Diff Z graph	Display the positional difference of the command positions (CurPos and RefPos) in Z direction by overlaying up to 50 files on the graph. Vertical axis: Positional difference in Z [mm] Horizontal axis: Time [s]

4-3 Common function

The following functions are common for each graph:

Enlarged display of graph
Move an enlarged area
Change of graph scale

You can use the above functions when the graph is not updating.

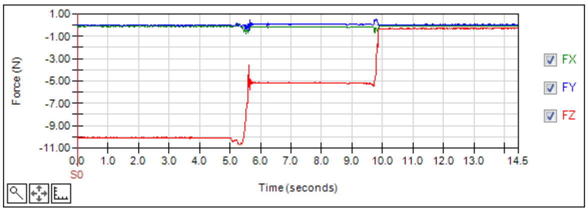


Item	Description
Enlarged display of graph	Click the 🔍 icon and move a mouse cursor on the graph. When the cursor moves on the graph, it changes to a cross-hair cursor. While left-clicking the mouse at the start position, move the mouse to the end position and release the left-click button. Then, an area from the start position to the end position will be enlarged to display. To return to the original graph, click the 🔍 icon again.
Move an enlarged area	Click the ✥ icon and move a mouse cursor on the graph. When the cursor moves on the graph, it changes to an arrow cursor. While left-clicking the enlarged area and moving up and down, the area moves with the mouse motion.
Change of graph scale	When the ∟ icon is clicked, the [Set Graph Axis Scales] dialog box is displayed. You can select scale of each axis. When setting “Auto”, scale changes automatically depending on values.

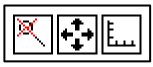
4-3-1 Enlarge a graph

The following describes steps to enlarge the following ranges for the following graph.

From −6.00N to −4.00N
From 5 to 6sec



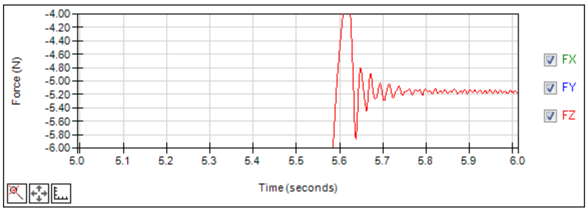
(1) Click the icon.
When clicking it, the icon will change. (The icon changes to the selected status.)



(2) Move a mouse cursor on a graph.

(3) To select an area, left-click a start position (5sec, −4.00N) to an end position (6sec, −6.00N) of an area where you want to enlarge.

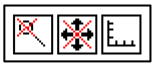
(4) Release the left-click.
Display is switched to a range selected in the step (3).



4-3-2 Move an enlarged area

The following describes steps to move the display range for the graph enlarged in the example of “*4-3-1 Enlarge a graph*”.

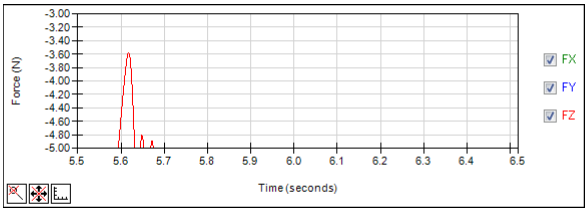
(1) Click the icon.
When clicking it, the icon will change. (The icon changes to the selected status.)



(2) Move a mouse cursor on a graph.

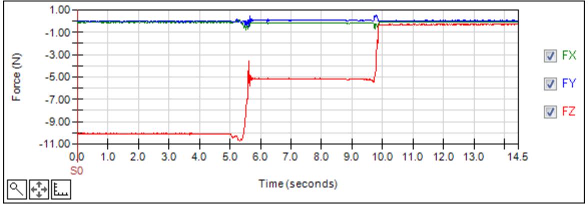
(3) Move a mouse to any position while left-clicking.

(4) Release the left -click.
Display is switched to a position where is moved in the step (3).

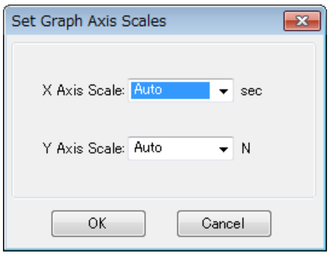


4-3-3 Example of changing a graph scale

The following describes steps to change the force scale to 10N and the time scale to 10sec for the following graph.



(1) Click the icon.
The [Set Graph Axis Scales] dialog box is displayed.

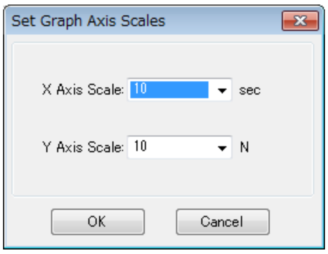


Set Graph Axis Scales

X Axis Scale: Auto sec

Y Axis Scale: Auto N

(2) Change [Y axis Scale] (force scale) to “10” and [X axis Scale] (time scale) to “10”.

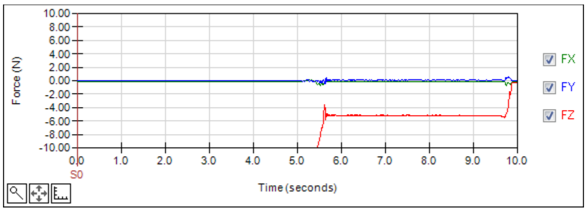


Set Graph Axis Scales

X Axis Scale: 10 sec

Y Axis Scale: 10 N

(3) Click the <OK> button.
Display changes to the specified scale.



3.5.3 [Maintenance] (Tools Menu)

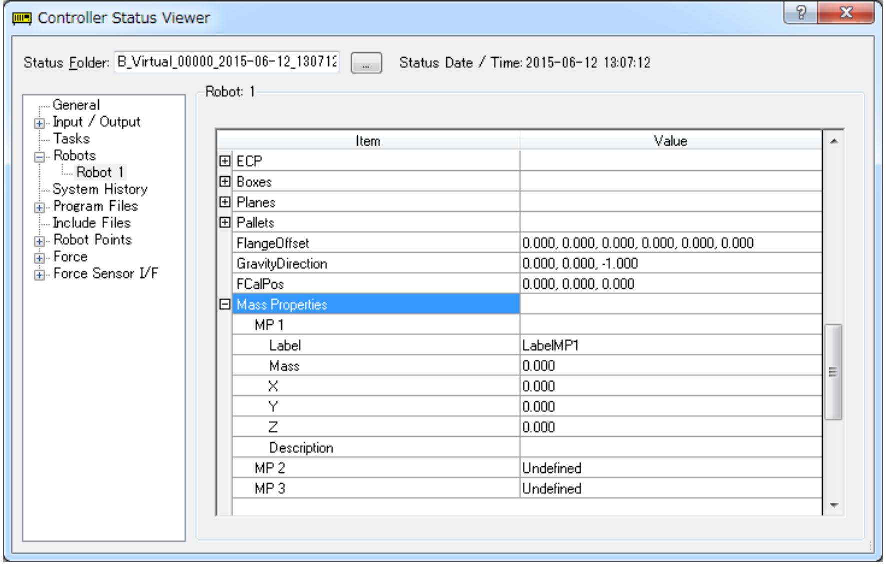
Force sensor-related values can be referred to when displaying the controller status.

(1) Click the <Restore Controller Settings> button.
The [Browse Folder] dialog box appears.

(2) Select the folder in which the information is stored. (The folder with "controller type name, serial number, and date/time" after "B_")

(3) Click the <OK> button to display the controller status.

(4) From the tree in the [Controller Status Viewer] window, select [Robots]-[Robot*].
The property values of FlangeOffset, GravityDirection, and Mass Properties (mass property object) of the selected robot (robot object) are displayed.



Status Folder: B_Virtual_00000_2015-06-12_13071

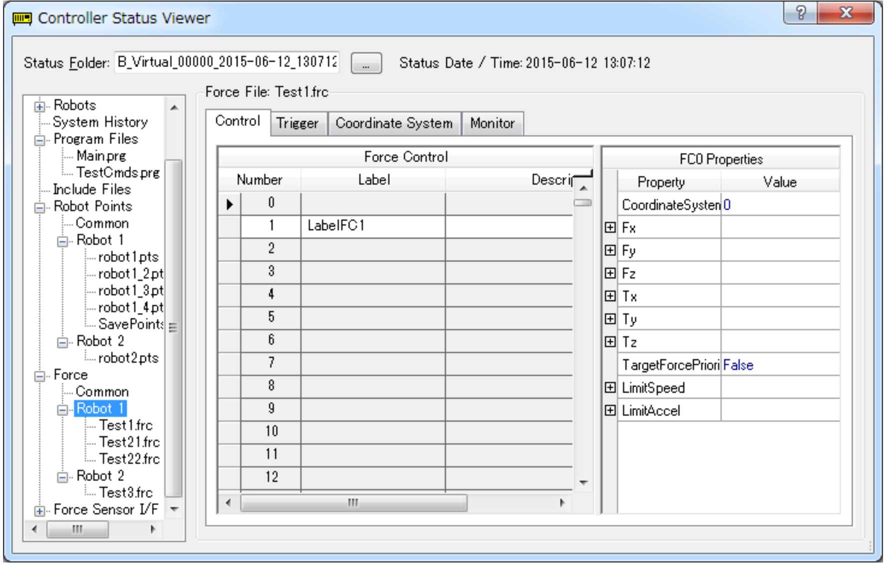
Status Date / Time: 2015-06-12 13:07:12

Robot: 1

Item	Value
⊞ ECP	
⊞ Boxes	
⊞ Planes	
⊞ Pallets	
FlangeOffset	0.000, 0.000, 0.000, 0.000, 0.000, 0.000
GravityDirection	0.000, 0.000, -1.000
FCalPos	0.000, 0.000, 0.000
⊟ Mass Properties	
MP 1	
Label	LabelMP1
Mass	0.000
X	0.000
Y	0.000
Z	0.000
Description	
MP 2	Undefined
MP 3	Undefined

(5) Select [Force]-[Robot*]-[***.frc].

The values of the selected force object and properties are displayed.



Status Folder: B_Virtual_00000_2015-06-12_130712

Status Date / Time: 2015-06-12 13:07:12

Force File: Test1.frc

Force Control		
Number	Label	Descri
0		
1	LabelFC1	
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

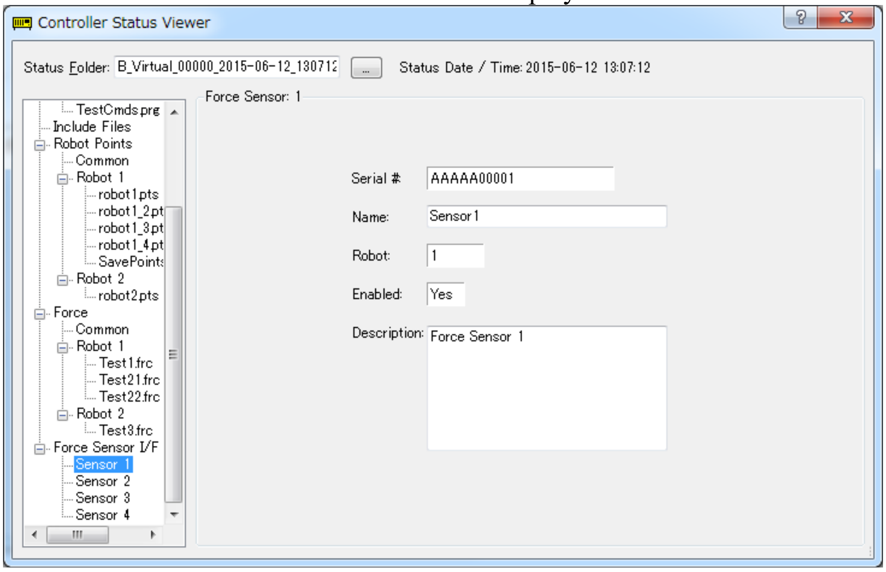
FC0 Properties	
Property	Value
CoordinateSysten	0
⊞ Fx	
⊞ Fy	
⊞ Fz	
⊞ Tx	
⊞ Ty	
⊞ Tz	
TargetForcePriori	False
⊞ LimitSpeed	
⊞ LimitAccel	

For details, refer to the following section.

Software: 3.5.1 [Robot Manager] (Tools Menu) - [Tools]
[Robot Manager]-[Force] Panel

(6) Select [Force Sensor I/F]-[Sensor *].

The values of the selected Force Sensor are displayed.



Status Folder: B_Virtual_00000_2015-06-12_130712

Status Date / Time: 2015-06-12 13:07:12

Force Sensor: 1

Serial #: AAAAA00001

Name: Sensor1

Robot: 1

Enabled: Yes

Description: Force Sensor 1

For details, refer to the following section.

Software: 1.1 Configuring the Force Sensor I/F Unit

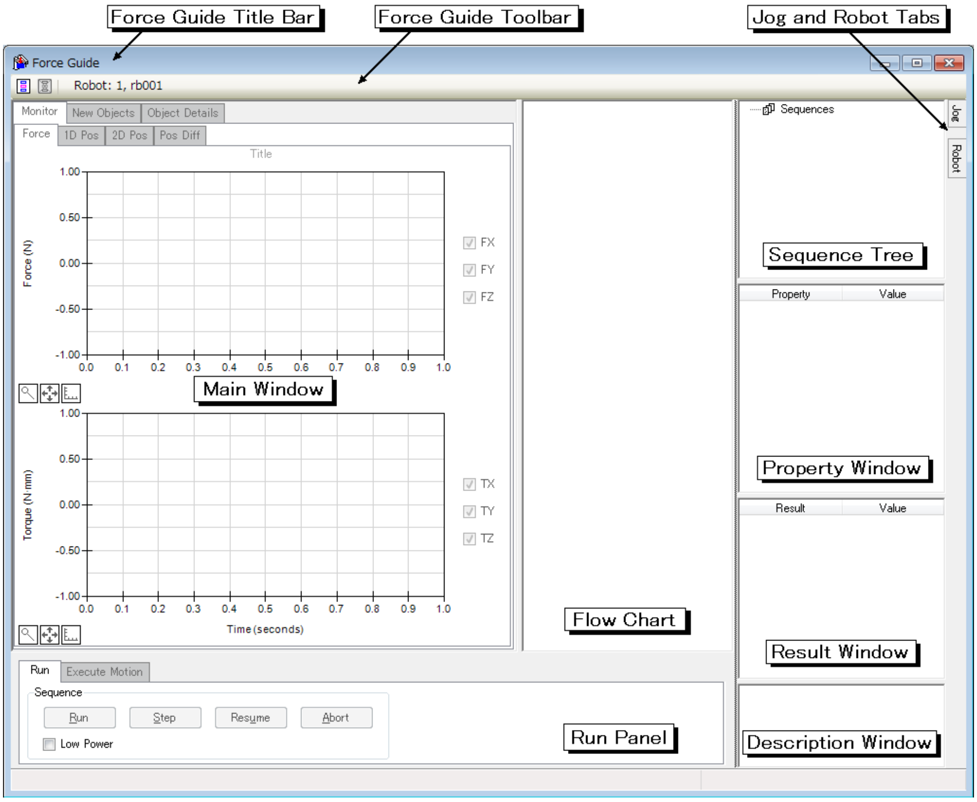
3.5.4 [Force Guidance] (Tools Menu)

You can create an operation using the force control function, force trigger function, and force monitor function without programming by SPEL+ language.

[Force Guide] window display

There are the following two ways to display the [Force Guide] window.

1. Select EPSON RC+ 7.0 - menu-[Tools]-[Force Guide].
2. Click the <Force Guide> button on the toolbar.



Force Guide Title Bar

Title bar shows the window title and a name of currently selected force guide sequence. The force guide sequence name is displayed with [bracket].

When the force guide sequence is updated, "*" is displayed next to the [bracket]. When it saved, "*" is disappeared.

Force Guide - [Test001]

Note that the title bar of EPSON RC+ 7.0 and that of Force Guide is different.

Difference:

EPSON RC+ 7.0 title bar	:	Working project name is displayed.
Force Guide title bar	:	Name of the currently selected force guide sequence is displayed.

Force Guide Toolbar

Force Guide toolbar is displayed above the Force Guide window and under the title bar.

Brief describes about tool bar are as follows:

Icon	Tool tip	Description
▤	New sequence	Create a force guide sequence. Click it to display the sequence wizard. To create a force guide sequence, set basic information, select tasks, and select a template according to the sequence wizard. Reference : *Create a new force guide sequence* (describe in a later page)
☒	Delete sequence	Delete a force guide sequence. Click it to display the [Delete Force Guide Sequence] dialog box. To delete the force guide sequence, select the force guide sequence to delete on the dialog box. Reference : *Delete a force guide sequence* (describe in a later page)
Robot	-	Display a target robot number and robot name.

Main Window

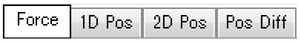
The main window can switch the displays by the following tabs:

Monitor tab	:	Display the data when executing the force guide sequence.
New Objects tab	:	Select the force guide objects to be added to the force guide sequence.
Object Details tab	:	Set or check a currently selected force guide sequence or force guide object.

Brief describes about each function are as follows:

[Monitor] tab

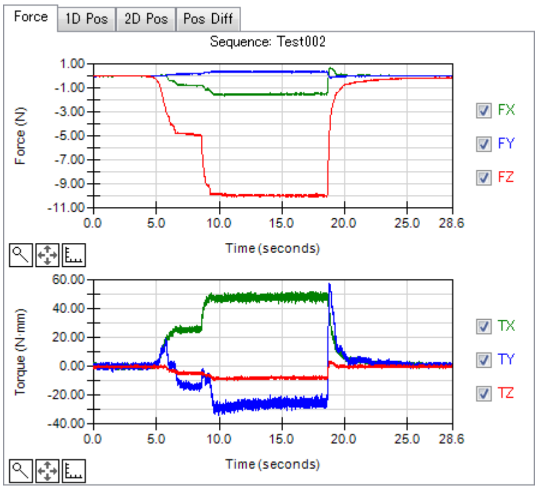
Monitor tab has [Force], [1D Pos], [2D Pos], and [Pos Diff] tabs.



[Force] tab

Translational force and torque are displayed in each graph.

You can select items to be displayed on the check box next to the graph.
With a checkmark: Display the selected items in a graph.
Without a checkmark: The selected items are not displayed in a graph.

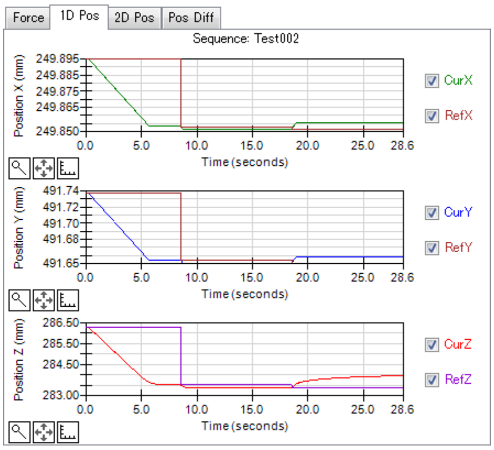


Item	Description
Force graph	Display translational force (Fx, Fy, Fz) in a graph. Vertical axis: Force [N] Horizontal axis: Time [s]
Torque graph	Display torque (Tx, Ty, Tz) in a graph. Vertical axis: Torque [N·mm] Horizontal axis: Time [s]

[1D Pos] tab

Display the command position (CurPos) including force control and the command position (RefPos) only including position control on the graph by dividing them into X, Y, and Z components.
You can select items to be displayed on the check box next to the graph.

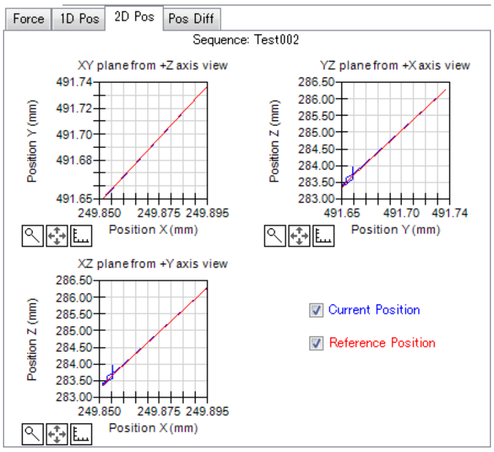
With a checkmark : Display the selected items in a graph.
Without a checkmark : The selected items are not displayed in a graph.



Item	Description
Position X graph	Display the command positions (CurPos and RefPos) in X direction in a graph. Vertical axis: Position in X direction [mm] Horizontal axis: Time [s]
Position Y graph	Display the command positions (CurPos and RefPos) in Y direction in a graph. Vertical axis: Position in Y direction [mm] Horizontal axis: Time [s]
Position Z graph	Display the command positions (CurPos and RefPos) in Z direction in a graph. Vertical axis: Position in Z direction [mm] Horizontal axis: Time [s]

[2D Pos] tab

Display the command position (CurPos) including force control and the command position (RefPos) only including position control on the graph by dividing them into XY, YZ, and XZ planes.



Sequence: Test002

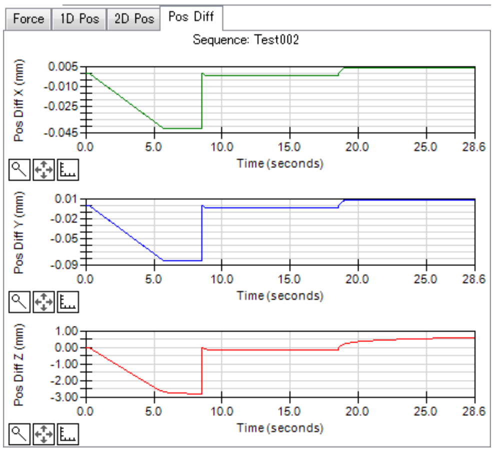
☑ Current Position

☑ Reference Position

Item	Description
XY plane from +Z axis view	Display the command positions (CurPos and RefPos) projected on XY plane in a graph. Vertical axis: Position in Y direction [mm] Horizontal axis: Position in X direction [mm]
YZ plane from +X axis view	Display the command positions (CurPos and RefPos) projected on YZ plane in a graph. Vertical axis: Position in Z direction [mm] Horizontal axis: Position in Y direction [mm]
XZ plane from +Y axis view	Display the command positions (CurPos and RefPos) projected on XZ plane in a graph. Vertical axis: Position in Z direction [mm] Horizontal axis: Position in X direction [mm]
Command Position	You can select command positions to be displayed in the right bottom check boxes (Current Position and Reference Position). With a checkmark: Display the selected command positions in a graph. Without a checkmark: The selected command positions are not displayed in a graph. This setting is reflected to all graphs.

[Pos Diff] tab

Display the difference between the command position (CurPos) including force control and the command position (RefPos) only including position control on the graph by dividing them into each component: X, Y, and Z.



Item	Description
Pos Diff X graph	Display the position difference between the command positions (CurPos and RefPos) in X direction in a graph. Vertical axis: Position difference in X direction [mm] Horizontal axis: Time [s]
Pos Diff Y graph	Display the position difference between the command positions (CurPos and RefPos) in Y direction in a graph. Vertical axis: Position difference in Y direction [mm] Horizontal axis: Time [s]
Pos Diff Z graph	Display the position difference between the command positions (CurPos and RefPos) in Z direction in a graph. Vertical axis: Position difference in Z direction [mm] Horizontal axis: Time [s]

Common functions

There are the following functions common for each graph.
Enlarge a display of graph
Move an enlarged area
Change of the graph scale
You can use the above functions when the graph is not updating.

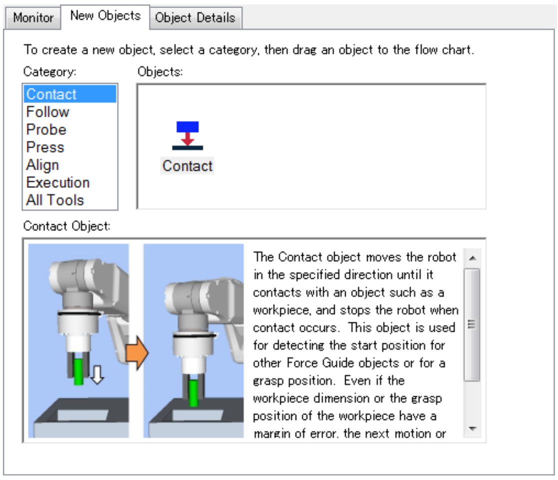
🔍 ✥ ∟

Icon	Tool tip	Description
🔍	Zoom	To enlarge a graph, select an area where you want to enlarge. Click the icon, then move a mouse cursor on the graph. When the cursor moves on the graph, it changes to a cross-hair cursor. While left-clicking the mouse at the start position, move the mouse to the end position and release the left-click. Then, an area from the start position to the end position will be enlarged. To return to the original graph, click the icon again.
✥	Pan	Move an enlarged area. Click the icon, then move a mouse cursor on the graph. When the cursor moves on the graph, it changes to an arrow cursor. While left-clicking the enlarged area and moving up and down, the area moves with the mouse motion.
∟	Set scales for axes	Change scales for graph. Click the icon to display the [Set Graph Axis Scales] dialog box. You can change scales for each axis. When specifying "Auto", scale changes depending on values. When "Auto" is not specified, scale changes to the specified value.

[New Objects] tab

In New Objects tab, you can add a new force guide object to the force guide sequence.

To add the force guide object to the force guide sequence, select the force guide object and drag it on the flow chart.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error. the next motion or

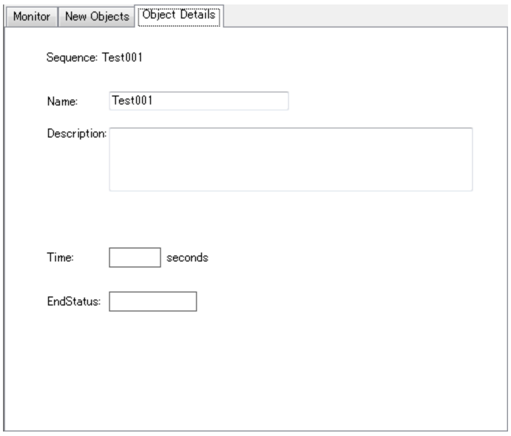
<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Category</td><td>Items that are classified objects according to functions.
You can select the following items.
Contact, Follow, Probe, Press, Align, Execution, All Tools</td></tr>
<tr><td>Object</td><td>Display the force guide object list of items selected in [Category].
<table>
<tr><th>[Category]</th><th>[Object]</th></tr>
<tr><td>Contact</td><td>Contact</td></tr>
<tr><td>Follow</td><td>Relax, FollowMove</td></tr>
<tr><td>Probe</td><td>PressProbe, ContactProbe</td></tr>
<tr><td>Press</td><td>Press, PressMove</td></tr>
<tr><td>Align</td><td>SurfaceAlign</td></tr>
<tr><td>Execution</td><td>Decision, SPELFunc</td></tr>
<tr><td>All Tools</td><td>All force guide objects</td></tr>
</table>

To add the force guide object to the force guide sequence, select (click) the force guide object that you want to add, and drag it to the flow chart (release the mouse button).

When selecting the force guide object from the force guide object list, an image and descriptions of the force guide object are described under the [Category] and the [Object].</td></tr>
</table>

[Object Details] tab

For the force guide object and the force guide sequence which are currently selected, you can check its names, description settings, execution time, and execution result (EndStatus).



Sequence: Test001

Name: Test001

Description:

Time: seconds

EndStatus:

Set or check the selected force guide sequence or force guide object.

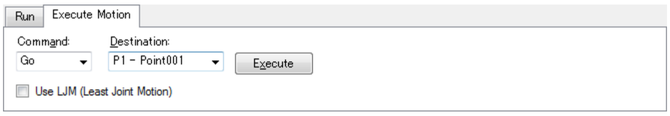
Item	Description
Name	Set up a name. You can enter up to 16 alphanumeric characters.
Description	Set a description. You can enter up to 255 alphanumeric characters.
Time	Display an execution time.
EndStatus	Display an execution result.

Run panel

In the Run panel, you can execute the force guide sequence and debug. Also, you can move the robot to the specified target position.

There are the [Run] tab and the [Execute Motion] tab on the Run panel.

Sequence: Test001



Command: Go

Destination: P1 - Point001

[Run] tab

Operate a target force guide sequence.

Reference: Execute a force guide sequence (describe in a later page)

Item	Description
<Run> button	Execute the selected force guide sequence.
<Step> button	Execute the force guide object of the selected force guide sequence from the top.
<Resume> button	Restart the paused force guide sequence.
<Abort> button	Pause the running force guide sequence.

Item	Description
[Low Power] check box	When placing a checkmark in the check box, the robot operates in low power mode. The checkmark is not placed by default.

[Execute Motion] tab

Specify a motion command and move the robot to a specified target position.

Item	Description
<Execute> button	Move the robot to the specified position using the specified motion command.
[Use LJM] check box	With a checkmark: When executing a motion command, the robot automatically changes the orientation to decrease the amount of joint movement and operates. The checkmark is not placed by default.

Flow chart

Flow chart shows the force guide object flows of the currently selected force guide sequence.

Flow chart order

Initial	: Force guide sequence which is currently selected.
Second or later	: Force guide object which is included in the selected force guide sequence. Force guide objects are in execution order.

Flow frame color

Blue	: Normal display.
Pink	: When the force guide sequence or force guide object is clicked.

You can call up various operations by right-clicking the flow.

When right-clicking on the force guide sequence flow:

Item	Description
New sequence	Create a force guide sequence. To create a force guide sequence, set basic information, select tasks, and select a template according to the sequence wizard. Reference: *Create a new force guide sequence*
Delete sequence	Delete a force guide sequence. To delete the force guide sequence, select the force guide sequence to delete in the [Delete Force Guide Sequence] dialog box. Reference: *Delete a force guide sequence*
Run sequence	Execute the selected force guide sequence. Reference: *Execute a force guide sequence*
Paste	Paste a copied or cut force guide object.
Create SPEL sequence	Convert a created force guide sequence into a program file of SPEL+. When selecting it, SPEL creation dialog box is displayed. Input the required information on the dialog box and create a SPEL+ program file. Reference: *SPEL creation of force guide sequence*

When right-clicking on the object flow:

Item	Description
Toggle Breakpoint	Set or release a breakpoint. Select when a breakpoint is not set: You can set a breakpoint. When setting is done, an icon is displayed on the upper right of the object flow. Select when a breakpoint is set: You can release a breakpoint. When releasing it, the icon displayed on the upper right of the object flow is cleared If you execute the force guide sequence when setting the breakpoint, the object pauses at the object flow which the breakpoint is set.
Copy	Copy the selected force guide object.
Cut	Cut the selected force guide object.
Paste	Paste a copied or cut force guide object.
Delete	Delete the selected force guide object. When you select it, a confirmation message is displayed. <Yes> button: Force guide object is deleted. <No> button: Force guide object is not deleted.

You can check the execution status and the execution results of the sequences in sequence/object flow on the flow chart.

Item	Condition	Description
Color of frame	Blue	Indicate the normal conditions.
	Purple	Indicate the selected conditions.
	Black	Indicate the pause condition.
	Green	Indicate the in-execution condition.
Color within a frame	White	Indicate normal condition.
	Yellow	Indicate the pause condition.
	Light blue	Indicate the in-execution condition.
Upper left icons within a frame	Image ✔	Indicate that the execution of the force guide sequence or force guide object had succeeded.
	Image ×	Indicate that the execution of the force guide sequence or force guide object had failed.

Sequence tree

Tree shows all sequences.

Sequence node and object node in the sequence tree can operate the same operation flow as the flow chart.

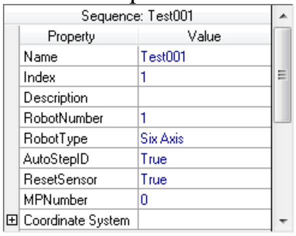
Property window

In the property window, you can change each property value of the force guide object or force guide sequence.

Display the property window by the following ways:

Select a sequence flow or an object flow on the flow chart.

Select a sequence node or an object node on the sequence tree.



Sequence: Test001

Property	Value
Name	Test001
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True
MPNumber	0
⊞ Coordinate System	

For details of each property, refer to the following section.

Software 4. Force Guidance Function

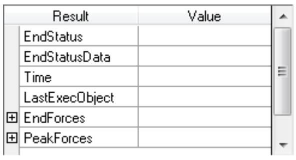
Result window

In the result window, you can check the execution results of the force guide sequence or force guide object.

Display the result window by the following ways:

Select a sequence flow or an object flow on the flow chart.

Select a sequence node or an object node on the sequence tree.



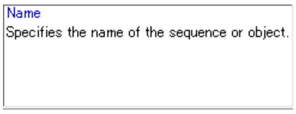
Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

For details of each result, refer to the following section.

Software 4. Force Guidance Function

Description window

The description window displays the name and simple descriptions for selected properties or results on the property window or the result window.



Name

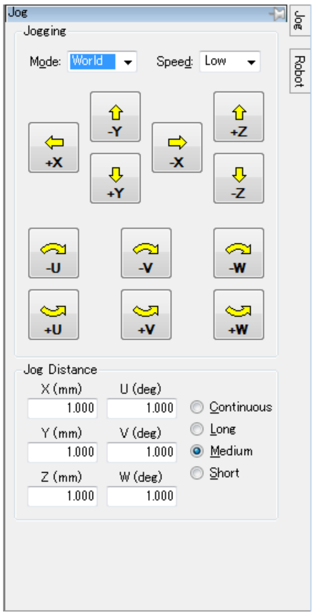
Specifies the name of the sequence or object.

[Jog] tab

[Jog] tab is displayed when selecting the [Jog] tab on the right side of the sequence tree.

[Jog] tab is a fly-out panel that can be placed at any position.

When performing Jog motion, you need to turn ON the robot motor.
Turn ON the motor by [Robot] tab.



Mode: World
Speed: Low

X (mm) 1.000
U (deg) 1.000
Y (mm) 1.000
V (deg) 1.000
Z (mm) 1.000
W (deg) 1.000

○ Continuous
○ Long
● Medium
○ Short

Item	Description
[Mode] box	Set the jog mode. (World, Tool, Local, Joint, ECP)
[Speed] box	Set the jog speed. (Low speed, high speed)
[Jog Distance] group	Set the distance of jog motion. (continuance, large, medium, small) When selecting "large", "medium", or "small", you can change the distance by entering a value in the text boxes.
Jog button	To operate a robot in jog mode, click the jog button after setting the jog mode, jog speed, and a distance of jog motion. Select [Jog Distance]- the <Continuous> button Robot will continue jog motion until the jog button is released. Select [Jog Distance]- other than the <Continuous> button Robot will operate the jog distance as one step. If you keep clicking the jog button, the robot keeps operating the jog motion.

[Robot] tab

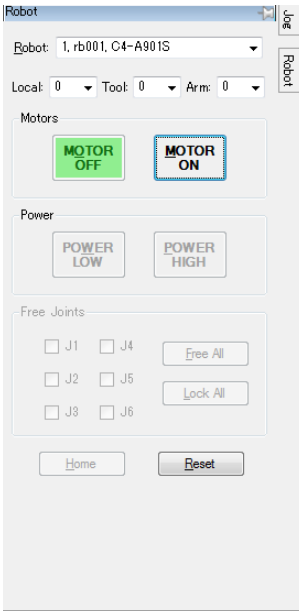
Click the [Robot] tab under the [Jog] tab to display the [Robot] tab.

[Robot] tab is a fly-out panel that can be placed at any position.

Set required functions when operating the robot in jog motion.

The following operations are available:

Select the current robot
Motor power ON/OFF
Change the power
Set the joint
Execute Home
Reset



Robot: 1, rb001, C4-A901S
Local: 0
Tool: 0
Arm: 0

Create a new force guide sequence

Overview

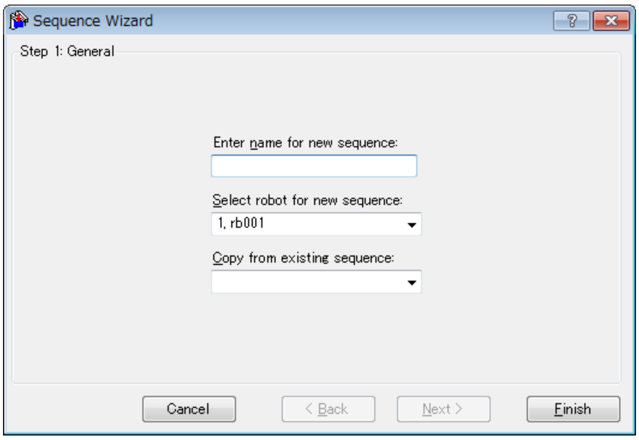
Create a force guide sequence by using sequence wizard. Display the wizard by the following ways:

- Click the <New sequence > button on the Force Guide tool bar.
- Right-click the sequence flow on the flow chart or the sequence node on the sequence tree to select [New sequence].

When the sequence wizard is displayed, set Step 1 through Step 3 according to the each window

Sequence Wizard

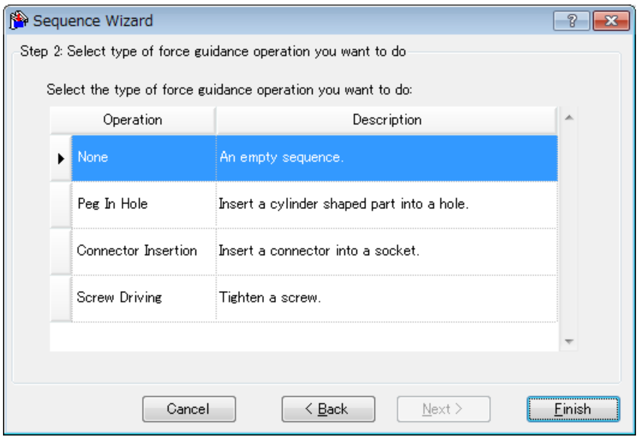
Step 1: General



Select robot for new sequence: 1, rb001

Item	Description
General	Enter name for new sequence: Enter a force guide sequence name. (up to 16 characters in alphanumeric characters.) Select robot for new sequence: Select a robot that uses a new force guide sequence from the list of currently registered robots. Copy from existing sequence: To create a force guide sequence by copying the existing force guide sequence, select a force guide sequence to be copied from the list. When you do not copied, select a blank space from a list.
<Cancel> button	Cancel a new sequence creation. Click the button to end the sequence wizard.
<Back> button	Back to the previous step. You cannot click the button since the current step is Step 1.
<Next> button	Proceed to the next step. In [Copy from existing sequence] When you select “Force guide sequence” You cannot click the button. When you select a blank space: You can click the button.
<Finish> button	Complete to create a new force guide sequence. Create a new force guide sequence with the entered consents.

Step 2: Select type of force guide operation you want to do



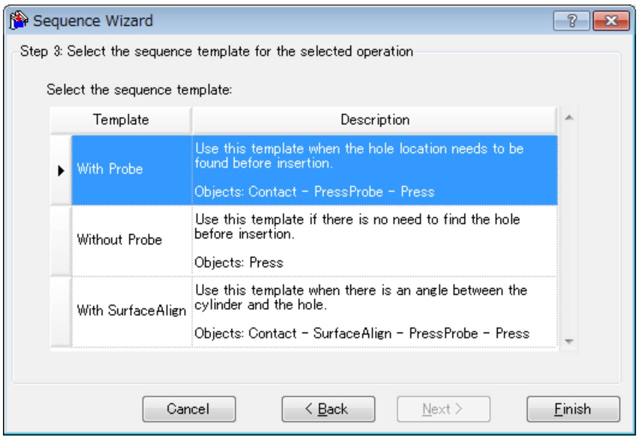
Step 2: Select type of force guidance operation you want to do

Select the type of force guidance operation you want to do:

Operation	Description
None	An empty sequence.
Peg In Hole	Insert a cylinder shaped part into a hole.
Connector Insertion	Insert a connector into a socket.
Screw Driving	Tighten a screw.

Item	Description
Select type of force guide operation you want to do	Select the following template items when using a template as a force guide sequence. Peg In Hole Connector Insertion Screw Driving Select the following when you do not use a template. None
<Cancel> button	Cancel a new force guide sequence creation. Click it to end the sequence wizard.
<Back> button	Back to the previous step.
<Next> button	Proceed to the next step. When you select [Select type of force guide operation you want to do]-[None]: You cannot click the button. When you select other than [Select type of force guide operation you want to do]-[None]: You can click the button.
<Finish> button	Complete to create a new sequence. When you select [Select type of force guide operation you want to do]-[None]: You can click the button. When you select other than [Select type of force guide operation you want to do]-[None]: You cannot click the button.

Step 3: Select the sequence template for the selected operation



Step 3: Select the sequence template for the selected operation

Select the sequence template:

Template	Description
With Probe	Use this template when the hole location needs to be found before insertion. Objects: Contact - PressProbe - Press
Without Probe	Use this template if there is no need to find the hole before insertion. Objects: Press
With SurfaceAlign	Use this template when there is an angle between the cylinder and the hole. Objects: Contact - SurfaceAlign - PressProbe - Press

(The above dialog box is an image when selecting [Peg In Hole] in the Step 2.)

Item	Description
Select the sequence template for the selected operation	Select a template from the following. When selecting [Peg In Hole]: With Probe, Without probe, With SurfaceAlign. When selecting [Connector Insertion]: With Probe, Without probe When selecting [Screw Driving]: Standard
<Cancel> button	Cancel a force guide new sequence creation. Click it to end a sequence wizard.
<Back> button	Back to the last step.
<Next> button	Proceed to the next step. You cannot click the button since the current step is Step 3.
<Finish> button	Complete to create a new force guide sequence. Create a new force guide sequence with the entered contents.

Delete Force Guide Sequence

Overview

(1) Display the [Delete Force Guide Sequence] dialog box by the following ways.

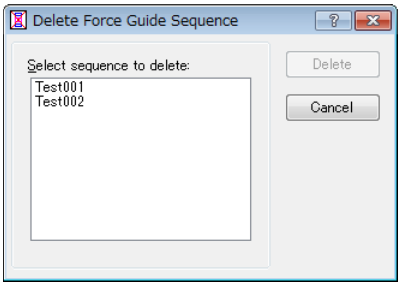
- Click the <Delete sequence > button on the Force Guide tool bar.
- Right-click the sequence flow on the flow chart or the sequence node on the sequence tree to select [Delete sequence].

(2) Select a sequence that you want to delete by using a mouse or an arrow key.

(3) When the force guide sequence name that you want to delete is highlighted, click the <Delete> button.

(4) Confirmation message is displayed.
Click the <Yes> button to delete a sequence. If you want to cancel a deletion, click the <No> button.

[Delete Force Guide Sequence] dialog box



Test001
Test002

Item	Description
Selection list	Select a force guide sequence to be deleted.
<Delete> button	Delete a highlighted force guide sequence. When you click the button, a confirmation message is displayed. <Yes> button: Delete a force guide sequence. <No> button: Cancel a deletion.
<Cancel> button	Cancel a deletion of a force guide sequence. End the [Delete Force Guide Sequence] dialog box.

Execute a force guide sequence

Overview

(1) Execute a force guide sequence in the following ways.

- Click the <Run> button.
- To select [Run Sequence], right-click the sequence flow on the flow chart or the sequence node on the sequence tree.

(2) Execution confirmation message of the force guide sequence is displayed.
Click the <Yes> button to execute the sequence. If you want to cancel execution, click the <No> button.

Execution result of the force guide sequence execution:
You can check the results on flow chart or result window.

Success or failure of execution result:
You can check it on flow chart.
For more detailed information, check the result window.

Breakpoint setting

Breakpoint is a function to pause the force guide sequence execution when the force guide object starts by setting to a force guide object.

Set or release a breakpoint by the following way:

- Right-click a target force guide object on the object flow of the flow chart or the object node on the sequence tree, and select the [Toggle Breakpoint].
- After selecting the target force guide object, click the <F9> key.

Step

“Step” is a function to execute the force guide object step-by-step.

For example, when executing the force guide sequence with step execution, the program pauses at the first force guide object. Every time you click the <Step> button, the program repeats the operation to execute the paused force guide object and pause at the next force guide object.

To execute a force guide sequence in step execution, click the [Run] panel- the <Step> button.

You can click the <Step> button when the force guide sequence is not executed or the program is paused during the force guide sequence execution. You can execute the next force guide object by clicking the button.

Resume

“Resume” is a function to restart the execution from where it is paused during the force guide sequence execution.

To execute a force guide sequence in continuous execution, click the [Run] panel- the <Resume> button.

You can click the <Resume> button when the sequence is paused during the force guide sequence execution. You can restart the program from where it paused.

Abort

“Abort” is a function to stop the running force guide sequence.

To stop the force guide sequence, click the [Run] panel- the <Abort> button.

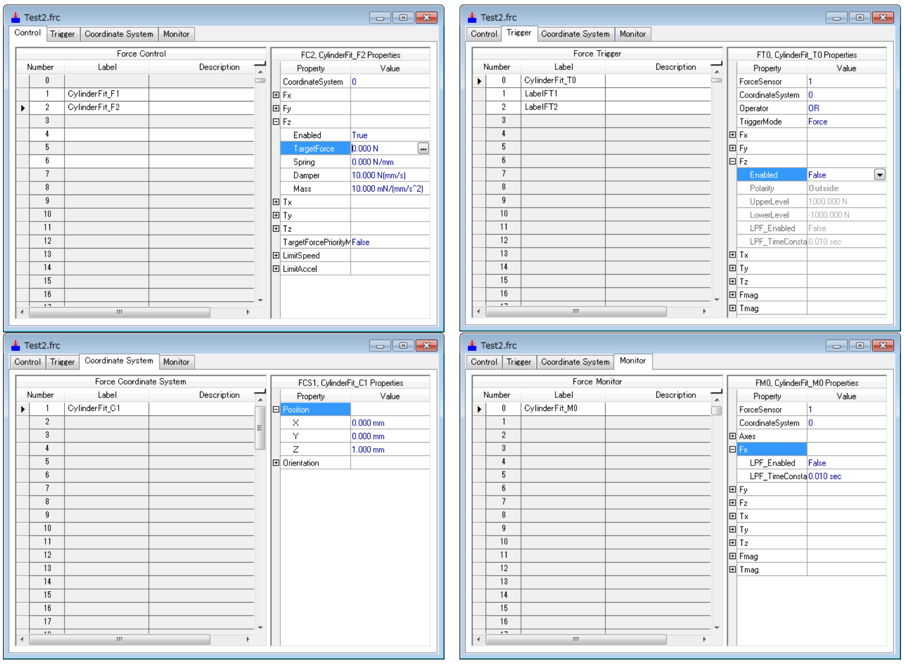
You can click the <Abort> button when the force guide sequence is running or the program is paused. Click the button to stop the running force guide sequence. You cannot restart the stopped force guide sequence.

3.6 Force Editor

Open a force file from the object tree of Project in [Project Explorer] to display the [Force Editor] window.
The display can be selected using the tabs, and each object and property can be edited.

When values are changed, a message confirming whether to save the changes appears when closing the window.

For details, refer to the following section.
Software: 3.5.1 [Robot Manager](Tools Menu)
[Tools]-[Robot Manager]-[Force] Panel



Force Control

Number	Label	Description
0		
1	CylinderFit_F1	
2	CylinderFit_F2	
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

FC2, CylinderFit_F2 Properties

Property	Value
CoordinateSystem	0
⊞ Fx	
⊞ Fy	
⊟ Fz	
Enabled	True
TargetForce	0.000 N
Spring	0.000 N/mm
Damper	10.000 N(mm/s)
Mass	10.000 mN/(mm/s^2)
⊞ Tx	
⊞ Ty	
⊞ Tz	
TargetForcePriorityM	False
⊞ LimitSpeed	
⊞ LimitAccel	

Force Trigger

Number	Label	Description
0	CylinderFit_T0	
1	LabelFT1	
2	LabelFT2	
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

FT0, CylinderFit_T0 Properties

Property	Value
ForceSensor	1
CoordinateSystem	0
Operator	OR
TriggerMode	Force
⊞ Fx	
⊞ Fy	
⊟ Fz	
Enabled	False
Polarity	Outside
UpperLevel	1000.000 N
LowerLevel	-1000.000 N
LPF_Enabled	False
LPF_TimeConsta	0.010 sec
⊞ Tx	
⊞ Ty	
⊞ Tz	
⊞ Fmag	
⊞ Tmag	

Force Coordinate System

Number	Label	Description
1	CylinderFit_C1	
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		

FCS1, CylinderFit_C1 Properties

Property	Value
⊟ Position	
X	0.000 mm
Y	0.000 mm
Z	1.000 mm
⊞ Orientation	

Force Monitor

Number	Label	Description
0	CylinderFit_M0	
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

FM0, CylinderFit_M0 Properties

Property	Value
ForceSensor	1
CoordinateSystem	0
⊞ Axes	
⊟ Fx	
LPF_Enabled	False
LPF_TimeConsta	0.010 sec
⊞ Fy	
⊞ Fz	
⊞ Tx	
⊞ Ty	
⊞ Tz	
⊞ Fmag	
⊞ Tmag	

4. Force Guidance Function

The following describes the force guidance function.

Force guidance function creates an operation using force control function, force trigger function, and force monitor function without programming by SPEL+ language.

Call up an operation (force guide sequence) created by force guidance function from SPEL+ language and execute it. It allowing you to execute the force function at any timing in the created SPEL+ program.

4.1 Steps to use Force Guidance Function and Basic Concepts

The following describes the basic concepts to use the force guidance function according to the steps. More specific examples are described in Tutorial. This chapter describes general steps and concepts.

For more specific examples, refer to the following section.
Software: 6. Tutorial

Steps to use the force guidance function are as follows: This section describes about the following items.

4.1.1 Use SPEL+ language to create motions until force guidance function starts

4.1.2 Set a force guide sequence

4.1.3 Set force guide object(s)

4.1.4 Adjust with test execution

4.1.5 Execute a force guide sequence from SPEL+ language

4.1.1 Use SPEL+ language to create motions until force guidance function starts

Force guidance function creates an operation using force control function. Therefore, a motion without using force control function such as movement to a start position is created by using SPEL+ language.

Here is a simple example:

```
Function main
   Motor On
   Go P1           'Go to a start position

Fend
```

Generally, the force control function is operated in low speed compared to a normal robot motion. To shorten a cycle time, we recommend operating minimum necessary tasks by the force guidance function. Therefore, make sure to set a start position where the grasped workpiece or tool does not contact with a workpiece to be contacted. Also, set a start position as close as possible to the workpiece to be contacted.

When setting a start position, consider workpiece variations. Avoid setting a start position where cannot be contacted by a certain workpiece but the other workpiece can.

In a case of Peg In Hole task, when all workpieces including variations are within a taper range of a hole, cycle time can be shortened. This is because a process to probe a hole can be omitted. As described, cycle time will be shortened by omitting a process such as a hole/a step probing during an operation.

As a summary of the above descriptions, conditions of an ideal start position are as follows:
When operating Peg In Hole task and the robot grasps a cylinder,

- Workpiece is as close as possible to the other workpiece with a hole
- Position of the workpiece does not contact with the workpiece with a hole
- Workpiece is within a taper range of the hole

In addition, the force control function cannot be executed near the singular point of the robot. Make sure to set a start position with avoiding near the singular point even during the operation of tasks created by the force guidance.

4.1.2 Set a force guide sequence

In the force guidance function, operations to be executed are shown as a “group” of force guide sequences. It is like a container that the required force guide objects are aligned in a specific order to execute the whole or part of the specific operation.

Force guide sequence has properties and results.

Property	: Value for force guide sequence. Some properties affect to the whole force guide sequence, and other properties are processing settings when executing the force guide sequence.
Result	: Execution result value of the force guide sequence.

Set a force guide sequence by the following steps.

Step 2-1. Create a force guide sequence

Step 2-2. Set properties of force guide sequence

However, Epson Force Sensor has a characteristic to accumulate errors due to the drift. Therefore, the force control function must be executed within 10 minutes after resetting the force sensor. If operating the operation for 10 minutes or more, divide the force guide sequences into two sequences and review the operation to restart the second force guide sequence after changing it to a non-contact state.

Also, the force guide sequence needs adjustment depending on the usage environment (robot, hand, workpiece, or position). When operating the same operation in different position, a single force guide sequence may only operate the either operation. In that case, divide the force guide sequence into two sequences and adjust for each.

Step 2-1. Create a force guide sequence

Create a force guide sequence on the force guide window. To create a force guide sequence, create an empty force guide sequence first. Then, align any force guide objects. Or, specify a template when creating the force guide sequence and automatically align the required force guide objects for an operation.

For more details on the creation steps, refer to the following section.
Software: 3.5.4 [Force Guidance] (Tools Menu)

Step 2-2. Set properties of force guide sequence

Set properties of force guide sequence. You need to set properties depending on operations.

For more details on each property, refer to the following section.
Software : 4.2 Force Guide Sequence

For more details on the setting steps of the properties, refer to the following section.
Software: 3.5.4 [Force Guidance] (Tools Menu)

4.1.3 Set force guide object(s)

Force guidance function indicates the specific processes such as a specific motion including the force control function or conditional branching as a force guide object. Align processes (force guide objects) in a container (force guide sequence) to realize a specific operation.

In the force guidance function, you can select the required force guide objects from the ten types of the force guide objects, and align them in the force guide sequence.

Operation using the force control function can be divided into the following five basic motions:

“Contact” “Follow” “Align” “Probe” “Press”

Force guide object can be divided into six categories: the above five basic motions + “Run” which is a processing other than the force control function. In addition, some force guide objects run more than two basic motions simultaneously.

Contact : Motion to move the robot from non-contact state to it contacts with an object and stop it when contacting with the object. Use this motion to detect a position of workpiece.
Contact object performs the contact motion.

Follow : Motion to follow the applied force and torque and adjust a position. Use this motion to move the robot to a position where the applied force will be “0”.
Relax object and FollowMove object perform the follow motion.

Align : Motion to adjust a position of workpiece to be grasped with its shape or orientation while pressing to an object. Use this motion to align a workpiece to be grasped with an object.
SurfaceAlign object performs the align motion.

Probe : Motion to detect a hole or a step on an object. Use this motion to detect a hole or a step.
PressProbe object and ContactProbe object perform the probe motion.

Press : Motion to keep applying a certain amount of force and torque to an object.
Use this motion to apply a certain amount of force and torque to an object.
Press object and PressMove object perform the press motion.
Also in the operation using the force control function, especially the press motion often presses and follows to different directions simultaneously. Insertion operation of workpiece, for instance, presses to insertion direction and follow two directions perpendicular to the insertion direction. Therefore, Press object and PressMove object can perform the press and the follow motions in different axis at the same time.

Execution : Processing other than the force control. The following objects perform it:

Decision object : Force guide object which performs conditional branching.

SPELFunc object : Force guide object which execute a function of SPEL+ program.

The following is a list of categories and force guide objects.

For more details on each object, refer to the following section.

Software : 4.3 Force Guide Object(s)

Category	Object name	Description
Contact	Contact	Move the robot to the specified direction and stop it when contacting with the object.
Follow	Relax	Adjust the position of the robot so that the applied force and torque to the specified axis will be “0”.
	FollowMove	While moving the specified trajectory, adjust the position of the robot so that the applied force and torque to the specified axis will be “0”.
Align	SurfaceAlign	Align a surface of the grasped workpiece and that of the object.
Probe	PressProbe	Detect a hole or a step on the object while pressing the grasped workpiece.
	ContactProbe	Detect a hole on the object while contacting the grasped workpiece.
Press	Press	Press to the specified axis direction.
	PressMove	Press to the specified axis direction while moving the specified trajectory.
Execution	Decision	Branch off a processing depending on success/failure of the object.
	SPELFunc	Execute a function of the specified SPEL program.

Force guide object has properties and results.

Property	: Basically, affect to force guide object. For example, there is a property which sets a motion direction.
Result	: Display the result of force guide object in [Value].

Set force guide objects by the following steps:

Step 3-1. Break down an operation into force guide objects

Step 3-2. Align force guide objects

Step 3-3. Set properties of force guide objects

Step 3-1. Break down an operation into force guide objects

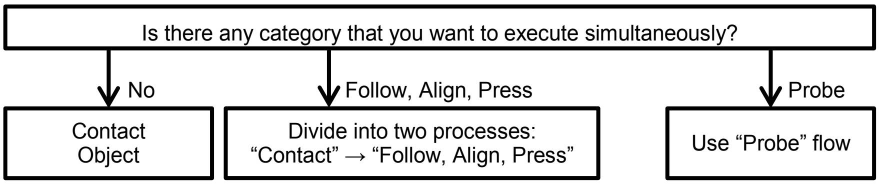
Decide a force object to be used depending on operations which you want to realize by using force guide sequence.

The following describes the basic concept. Please be aware that some operations, such as complex operations, may not be applied to the basic concepts.

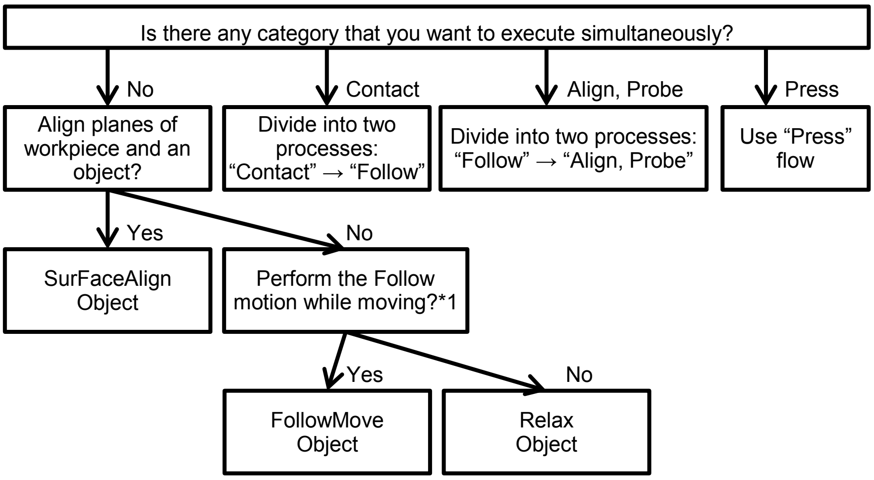
Break down operations which you want to realize by using force guide sequence into the categories (“Contact” “Follow” “Align” “Probe” “Press”).
If you want to perform a continuous motion such as performing “Press” motion after “Follow” motion, divide a process into two processes. Divide processes into a single category as much as possible. However, if you want to perform two categories simultaneously, temporary divide into either category depending on the major objective. For example, when moving a robot without considering a contact state, think how many Move commands will be used. Then, divide them into a category.

Next, use the following five flow charts to decide a force guide object.

"Contact"

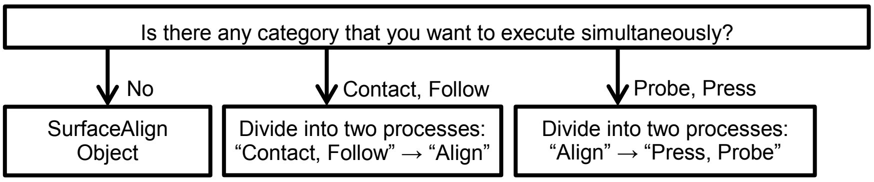


"Follow"

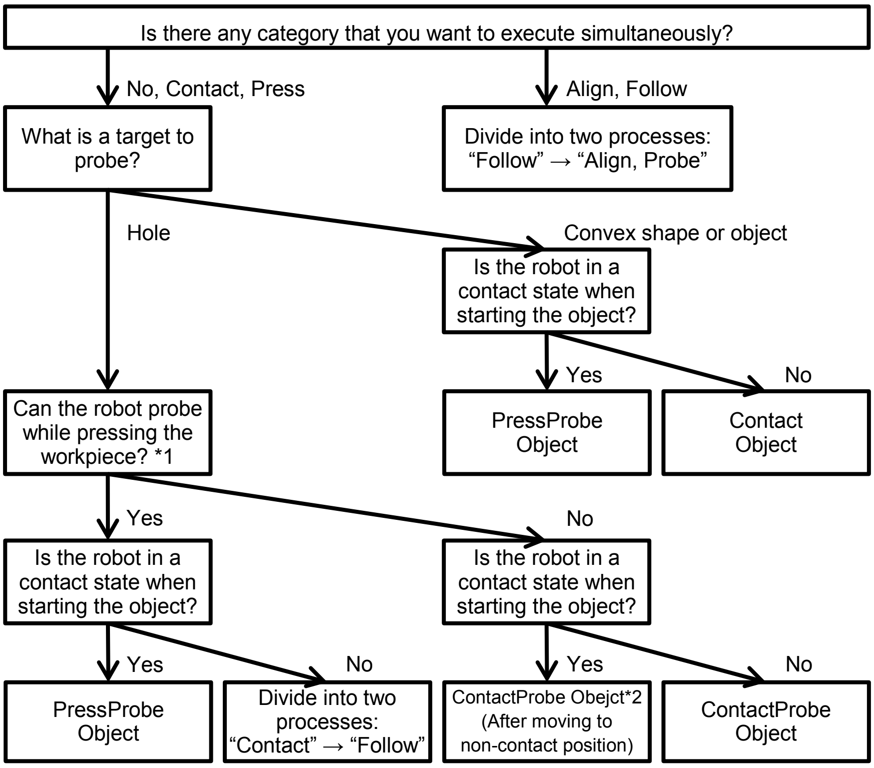


*1: It is when perform a follow motion while the robot moves the specified trajectory. Select "No" when the robot moves by the force control function.

"Align"



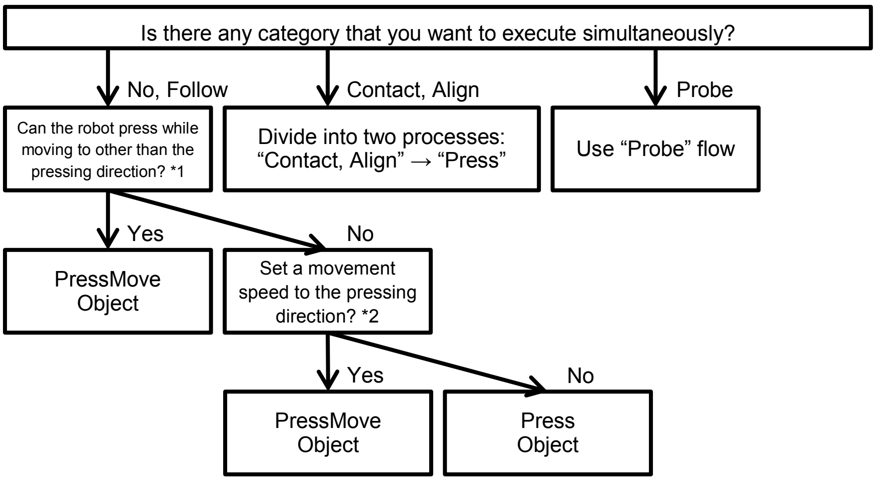
"Probe"



*1: Select "No" when workpiece such as lead parts get damages or are deformed by performing the PressProbe motion.

*2: If you considered "Contact" as a preceding process, delete it.

"Press"



*1: It is when using the force control function while the robot moves the specified trajectory. Select "No" when the robot moves by the force control function.

*2: It is when you need to set speed depending on a workpiece or a tool.
Normally, select "No". For example, when performing screw driving by using an electric screw driver, select "Yes" since the speed to the pressing (screw insertion) direction is set by screw's pitch and rotation speed of the driver.

Example: Break down the pressing operation with a certain amount of force into force guide objects

It is an operation to press an object after contacting it.
You can divide into "Contact" and "Press" processes.

"Contact" will be the Contact object since there is no other category which is executed simultaneously.

"Press" will be the Press object according to the following reasons.

- There is no other category which is executed simultaneously.
- "Press" moves to the pressing direction only and does not set a movement speed to the pressing direction.

Example: Break down the Peg In Hole task into force guide objects

It is an operation to perform the following motions:
Probe a hole after contacting an object → follow it while adjusting → press to the hole direction →and insert
To perform "Follow" and "Press" simultaneously, consider them as a single process.
Temporary divide into "Press" since a major objective is insertion.

You can divide into three processes: "Contact", "Probe", and "Press".

"Contact" will be the Contact object since there is no other category which is executed simultaneously.

"Probe" will be the PressProbe object according to the following reasons.

- There is no other category which is executed simultaneously.
- Probe target is a hole. It is possible to probe while pressing a workpiece and it is a contact state when starting the object.

"Press" will be the Press object according to the following reasons.

- The follow category is executed simultaneously.
- "Press" moves to the pressing direction only and does not set a movement speed to the pressing direction.

Example: Break down a connector insertion operation into force guide objects

It is an operation to perform the following motions:
Contact an object → probe a hole → follow it while adjusting → press to the hole direction → and insert.

To perform "Follow" and "Press" simultaneously, consider them as a single process. Temporary divide into "Press" since a major objective is insertion.

You can divide into three processes: "Contact", "Probe", and "Press".

"Contact" will be the Contact object since there is no other category which is executed simultaneously.

"Probe" will be ContactProbe object according to the following reasons.

- There is no other category which is executed simultaneously.
- Probe target is a hole. It is not possible to probe while pressing a workpiece and it is a contact state when starting the object.

Also, since it starts with the non-contact state, delete the preceding process: "Contact".

Though processes were divided into three at first, this operation has two processes: "Probe" and "Press" since "Contact" is deleted.

"Press" will be the Press object according to the following reasons.

- The Follow category is executed simultaneously.
- "Press" moves to the pressing direction only and does not set a movement speed to the pressing direction.

Example: Break down a screw driving operation by using an electric screw driver into a force guide object.

It is an operation to perform the following motions:
Contact an object → follow it while adjusting → press to the hole direction → and insert.

However, screw may fall out when pausing after contacting with an object. Therefore, consider as a single process such as following while contacting an object, and press it. Temporary divide into "Press" since a major objective is insertion. This operation can be considered as a single process: "Press".

"PressMove" will be the Press object according to the following reasons.

- The Contact and Follow categories are executed simultaneously.
- "Press" moves to the pressing direction only and set a movement speed to the pressing direction.

The following additional descriptions are for users who understand the force functions using SPEL+ programing.

Motions of the force guide objects with five basic motions consist of the force control function, position control, and end conditions.
In each object, what you need for the motion can be selected or is set automatically.
The following is a list of force guide objects:

Category	Object name	Force control function A: Optional B: Set automatically		Position control A: Execute simultaneously B: Execute separately	End conditions A: Optional B: Set automatically		
		Press	Follow		Force	Position	I/O
Contact	Contact	A (1-axis only)	-	-	B	-	-
Follow	Relax	-	A (All axes)	-	A	-	A
	FollowMove	-	A (All axes)	A	-	A	A
Align	SurfaceAlign	A (translation, 1-axis only)	B *1	-	A	-	-
Probe	PressProbe	A (translation, 1-axis only)	-	A	A *2	A *2	-
	ContactProbe	A (translation, 1-axis only)	-	B *3	B	B	-
Press	Press	A (All axes)	A (All axes)	-	A	A	A
	PressMove	A (All axes)	A (All axes)	A	A	A	A
Execution	Decision	-	-	-	-	-	-
	SPELFunc	-	-	-	-	-	-

*1: Rotational direction of axis which is perpendicular to the axis set in the pressing direction is set.

*2: You need to enable either one.

*3: Use the position control for the depart motion and the movement to the next contact start position.
It cannot be executed with the force control function simultaneously.

Step 3-2. Align force guide objects

Force guide objects are selected and aligned on the [Force Guide] window. Align the force guide objects which are set in Step 3-1 in order.

If a template is selected when creating a force guide sequence, you do not need to align the force guide objects. Depending on an operation, you can add force guide objects to the template or delete the force guide objects.

For more details on the creation steps, refer to the following section.
Software: 3.5.4 [Force Guidance] (Tools Menu)

Step 3-3. Set properties of force guide objects

Set properties of the force guide objects. You need to set properties depending on an operation.

For more details on each property, refer to the following section.
Software : 4.3 Force Guide Object(s)

For more details on each property, refer to the following section.
Software: 3.5.4 [Force Guidance] (Tools Menu)

The following describes some concepts that you should know when setting properties of the force guide object.

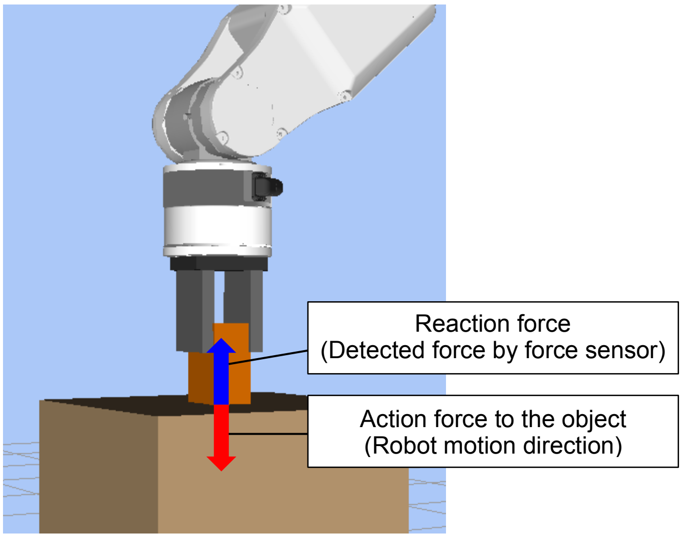
Basic robot motion when executing force control function

Force control function maintains force or toque in the specified value. To maintain the value, the robot moves to a position where the force will be applied. Therefore, if you use a force control function which specified "Press" in the non-contact state, the robot moves to a position where the force will be applied.

Force direction and robot motion direction

Force sensor detects the applied force.

In the example below, the robot presses a workpiece to vertical-downward (the direction shown as a red arrow). Since the force is balanced, the reaction force (blue arrow) is applied to the robot while the robot applies the action force (red arrow).



Force sensor is a sensor to detect the reaction force. Be careful that the direction between the robot motion direction and the pressing force/detection force to be set are always opposite.

For example, if you specify Press+ (pressing to the positive direction) in Fx_ControlMode of the Press object, you need to set a negative value to Fx_PressForce. Recorded value as the motion result will be a negative value.

Firmness of force control function (Firmness)

Force guidance function indicates the firmness of the force control function in Firmness property.

Actual property name is different depending on the force guide object such as ContactFirmnessF or Fx_Firmness. Features are the same.

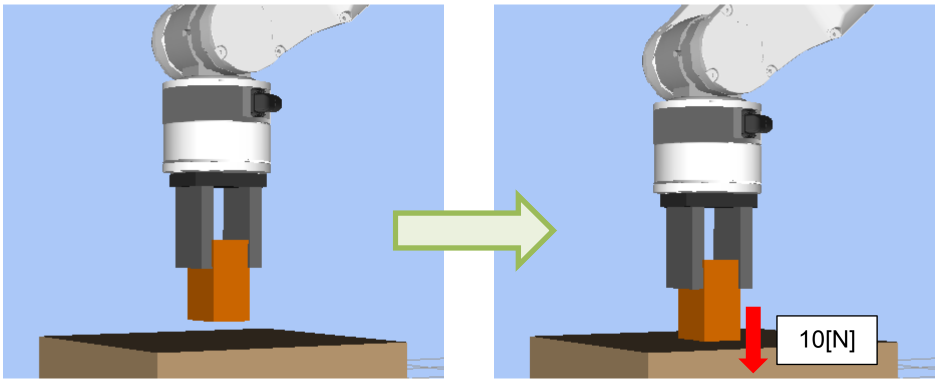
The following describes the common concepts of the Firmness property.

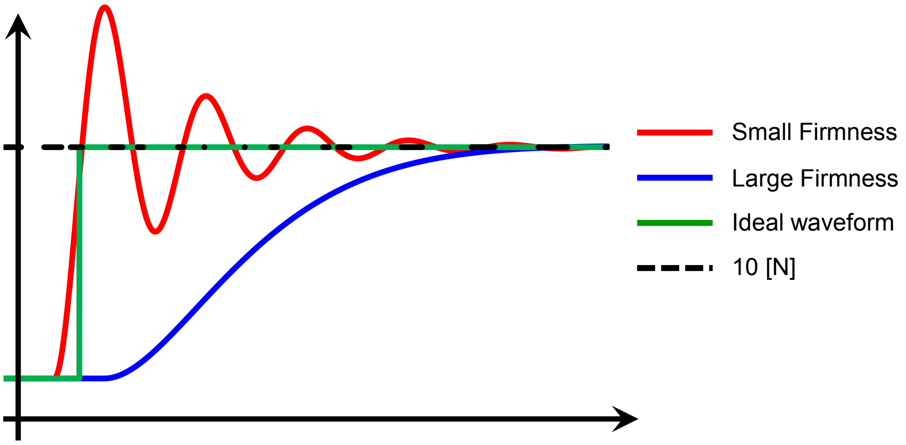
When the Firmness property is large, force control function will be firm and reaction will be slow.

When the Firmness property is small, force control function will be soft and reaction will be fast. However, if the Firmness property is too small, the robot motion may vibrate.

As shown in the figures below, the robot starts the motion above the object and presses the grasped workpiece with 10 [N]. Use this operation as an example and describe effects of the Firmness property.

The following is a graph of force when fixing other properties and executing with the both large and small values of the Firmness property.





In the non-contact state, when the Firmness property is smaller, the movement speed will be faster. Therefore, the time to contact with an object will be shortened and the time to start rising up the waveforms in the graph will be different. Since the contacting speed is fast, overshoot of the force will be large. Time to reach a target force will be shortened, however, vibrations may be generated.

An ideal force change by using the force control function is the green line (ideal waveform) in the graph. The force does not overshoot when contacting and become a target force immediately, and it is stable. However, it is not possible to realize the ideal force change in the actual operation since the relation between the overshoot or vibrations of the force and the cycle time are trade-off. Please perform proper adjustments for your operations.

Relationship between the Firmness property value and the force when executing changes with the environment (robot, hand, workpiece, position). Therefore, you need to adjust each force guide object in the actual environment. We recommend setting a large value at the initial state of the Firmness property. Then, decrease the value gradually (e.g. decrease the value by 10%) and adjust it.

4.1.4 Adjust with test execution

Adjust the created force guide sequence.

Perform the test execution on the [Force Guide] window. We recommend adjusting a force guide sequence only as much as possible. If it is necessary to connect with other devices, you can adjust while executing as SPEL+ programming.

Perform the test execution and adjust a property of the force guide object with the force, position, and result when executing.

To adjust each object, refer to the following section.
Software: 4.3 Force Guide Object(s)

To perform the test execution or check the force or position when executing, refer to the following section.
Software: 3.5.4 [Force Guidance] (Tools Menu)

We recommend starting the adjustment in low power. After confirming that the rough motions are correct, perform the adjustment in high power. When performing a final adjustment, perform the adjustment in the same power as when using the force guide sequence. When adjusting in low power, the maximum speed or the maximum acceleration is limited not to exceed the limitation of the low power. Therefore, when you switch the power to different mode, conditions were changed and re-adjustment will be necessary.

In the [Force Guide] window, you can execute the force guide objects one by one by the step execution function. Also, by setting a breakpoint, you can stop the force guide sequence in front of an object. Main objective of this is to confirm that the rough motions are correct at the early stage of adjustment. To adjust parameters, click the <Run> button without setting breakpoints. When pausing the force guide sequence by the step execution or breakpoints, the operation may be affected by the force which is applied until the next force guide object starts or the force control function which is kept working during the pause. If you perform adjustment in this state, re-adjustment will be required since the conditions are changed.

4.1.5 Execute a force guide sequence from SPEL+ language

You can call up and execute the adjusted force guide sequence by using FGRun statement from SPEL+ language.

The following is an example to add FGRun statement.
Add to the example in *4.1.1 Use SPEL+ language to create motions until force guidance function starts.*

```
Function main
    Motor On
    Go P1               'Go to a start position
    FGRun MyFGSeq       'Execute the created force guide sequence
Fend
```

Execute it as the whole SPEL+ programming including the force guide sequences.

If there is an error in the force guide sequence, return to *4.1.4 Adjust with test execution* and perform adjustment.

You can adjust it while executing as the whole SPEL+ programing.

An error may occur when executing the sequence as the whole SPEL+ programing even though the operations are normal when performing the test execution of the single force guide sequence. In that case, you need to adjust the sequence as the whole SPEL+ programing.

Executed results can be acquired as results of force guide sequence or force guide object. Result has force or position at the end of the operation and success/failure.

The following is an example to execute a force guide sequence and acquire the force when the sequence ends.

```
Function main
    Double dEndForce(6)
    Motor On
    'Go to a start position
    Go P1
    'Execute the created force guide sequence
    FGRun MyFGSeq
    ' Acquire the force when the force guide sequence ends.
    FGGet MyFGSeq.EndForces, dEndForce()
Fend
```

For more details on FGRun, FGGet, and results, refer to the following manual.
EPSON RC+ 7.0 Option Force Guide 7.0 Properties and Statuses Reference

4.2 Force Guide Sequence

The following describes properties of the force guide sequences and its setting steps.

4.2.1 Property setting guidelines for force guide sequence

General setting steps and setting methods for each property are as follows:

Step 1. Set basic information

Set properties (Name, Description, RobotNumber, AutoStepID) related to the basic information.

Property	Description
Name	Force guide sequence name. Set a particular name.
Index	Particular number for a force guide sequence. It is assigned automatically. You cannot set this.
Description	Descriptions for force guide sequence. Describe the tasks. Set a character string.
RobotNumber	Robot number to execute a force guide sequence. Set a robot number to be executed.
RobotType	Robot type which is set by RobotNumber. You cannot set this.
AutoStepID	Set whether to set StepID of force guide object automatically. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. True : Normal False : When you want to set StepID manually.

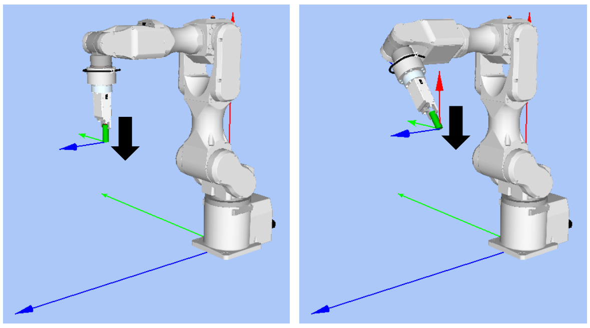
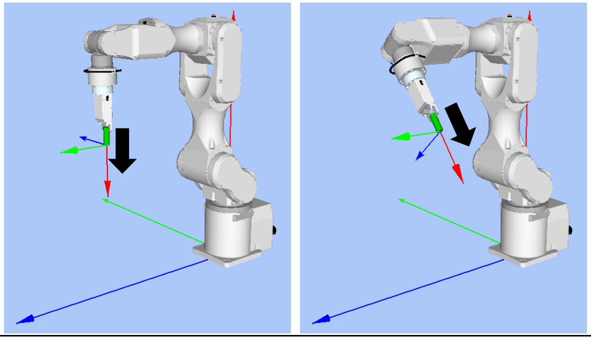
Step 2. Set for correction of sensor value

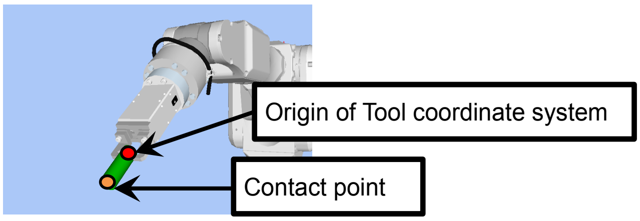
Set properties (ResetSensor, MPNumber) related to sensor value correction.

Property	Description, setting guide
ResetSensor	Set whether to reset the force sensor when executing a force guide object other than Decision object and SPELFunc object for the first time during the force guide sequence execution. True : When a workpiece is not contacted with anything at the start of the force guide sequence. (Normally, it is the non-contact state at the start of the force guide sequence.) False : In a rare case such as executing another force guide sequence with the contact state after executing the force guide sequence.
MPNumber	Specify the number of Mass Property Object which is used during the force guide sequence execution. Mass Property Object is a collection of properties using for gravity compensation. "0" : When the orientations (U,V,W) do not change largely during the force guide sequence execution. Created Mass Property number : When changing the orientations largely during the force guide sequence execution. For more details on Mass Property, refer to the following section. *Software: 2.3 Gravity Compensation*

Step 3. Set for coordinate system of force control function

Set properties (ForceOrient, RobotLocal, RotationCenterType, RotationCenterTLX, RotationCenterTLY, RotationCenterTLZ) related to a coordinate system of the force control function.

Property	Description, setting guide
ForceOrient	Set a coordinate system direction which executes the force control function. Base, Local : When you want to execute the force control function to a define direction as viewed from outside, such as pressing to vertical-downward, even if the start orientation of force guide sequence is changed. Local is specified when a define direction is different from the axis of the Base coordinate system. The following is an example to set Base. When pressing to -Z direction, the robot always presses to the vertical-downward (-Z direction in Base coordinate system) even the orientation of robot fingers changed. (Black arrow is a direction of the robot motion.)  Tool: When you want to execute the force control function depending on an orientation at the start. The following is an example to set Tool. When pressing to +Z direction, the pressing direction changes depending on the orientation of robot fingers at the start. 
RobotLocal	Set Local coordinate system number which is used when ForceOrient is Local.

Property	Description, setting guide
RotationCenterType	Set a type of the rotation center setting when executing the force control function. Relative: As shown in the following image, when an origin of Tool coordinate system is far from a contact point: We recommend setting a rotation center of the force control function to the contact point. However, basically be sure to set Tool coordinate system so that the contact point will be an origin of Tool coordinate system.  CurrentTool: When the origin of Tool coordinate system and the contact point are close or the force control function in the rotational direction is not used during the force guide sequence execution.
RotationCenterTLX RotationCenterTLY RotationCenterTLZ	When RotationCenterType is Relative, set an offset amount to each axis from Tool coordinate system to the rotation center.

You can check the settings related the coordinate system of the force control function by using a simulator. However, if no force guide object is aligned in the force guide sequence, check the setting after adding the force guide objects.

For details on how to check by using simulator, refer to the following manual.
EPSON RC+ 7.0 User's Guide: 8. Simulator, 8.3 Description of Functions

Step 4. Set the maximum speed and the maximum acceleration

Set properties (LimitAccelS, LimitAccelR, LimitSpeedS, LimitSpeedR) related to the maximum speed and the maximum acceleration.

Property	Description, setting guide
LimitSpeedS LimitSpeedR	Set the maximum speed during the execution of force guide sequence. LimitSpeedS: Maximum speed LimitSpeedR: Maximum rotational rotation speed In the force control function, the speed changes depending on the how the force is applied. It is controlled not to exceed LimitSpeedS and LimitSpeedR.
LimitAccelS LimitAccelR	Set the maximum acceleration during the execution of the force guide sequence. LimitAccelS: Maximum translational acceleration LimitAccelR: Maximum rotational rotation acceleration In the force control function, the acceleration changes depending on how the force is applied. It is controlled not to exceed LimitAccelS and LimitAccelT. If the value is small, reaction when the force is applied will be slow and the robot will bounce largely. Set the larger value when the robot bounces. When the robot vibrates, set the smaller value.

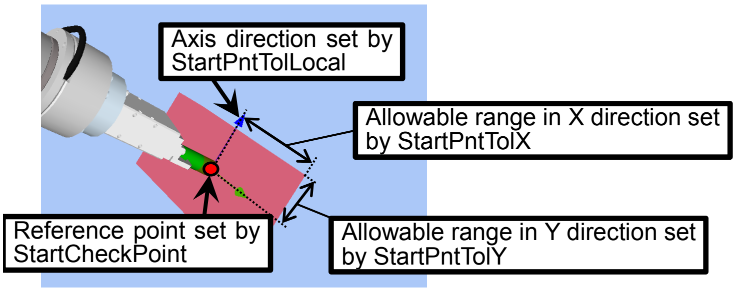
Step 5. Set conditions about recording

Set properties (LogRobotLocal, LogFileEnabled, LogFileAutoName, LogFileNameVar, LogFileMaxTime, LogFileInterval) related to recording.

Property	Description, setting guide
LogRobotLocal	Set a Local coordinate system number which will be a reference of the recording robot position. Log data related to positions is recorded as positions of the specified Local coordinate system. Base : Normal Local coordinate system number : When you want to record as a position in the specified Local coordinate system
LogFileEnabled	Set whether to save the log data which is executing a force guide sequence to a file. False : It is not saved in a file. You can check the log data on the graph of force guide window when executing.
LogFileAutoName	Set whether to set the log data file name automatically. True : When setting it automatically: Name the log file after the force guide sequence name and the start time. “Force guide sequence name_yyyymmdd_hh:mm:ss:ms” False : When specifying a name
LogFileNameVar	Set a global variable which indicates a log data file name when LogFileAutoName is False.
LogFileInterval	Set a sampling interval of log data when creating files.
LogFileMaxTime	Set the maximum time of log data when creating files.

Step 6. Set about checking of start position

Set properties (PointFile, RobotTool, PosCheckEnabled, OrientCheckEnabled, StartCheckPoint, StartPointTolLocal, StartPointTolX, StartPointTolY, StartPointTolZ, StartPointTolRot) related to the checking of start position.

Property	Description, setting guide
PointFile	Set a point file which will be used in a force guide sequence. An error occurs when the specified point file is not loaded at the start. This is a property for preventing a wrong operation. If a point file is not set, any point file whichever loads is executed.
RobotTool	Set a tool number which will be used in a force guide sequence. An error occurs when the set tool number is not selected at the start. This is a property for preventing a wrong operation.
PosCheckEnabled	Set whether to check that the position (X,Y,Z,U,V,W) at the start is within the specified range. When the robot moves after detecting a start position by using Vision, check that the position is within the range. When it is out of the range, the force guide sequence ends as failure. Error is not caused. When it failed, a recovery such as moving to other start position is available. The following is an image of setting a range. Red part is an allowable range. Set ranges for each property. Also, though it is not shown in the following image, set the allowable ranges in Z direction and rotational direction by StartPntTolZ and StartPntTolRot.  True : When checking the position
OrientCheckEnabled	Set whether to check that the arm orientation (Hand, Elbow, Wrist) at the start is matched the set state. When the robot moves after detecting a start position by using Vision, you can check that the arm orientation is the assumed one. When the arm orientation is not matched, the force guide sequence ends as failure. Error is not caused. When it failed, a recovery such as moving to other start position is available. True : When checking the arm orientation
StartCheckPoint	Set a point number which will be a reference for checking the position or the arm orientation at the start.

Property	Description, setting guide
StartPntTolLocal	When PosCheckEnabled is True, set a Local coordinate system number which will be a reference of the allowable error direction. Only the axis direction is used. The origin position in Local coordinate system does not affect.
StartPntTolX StartPntTolY StartPntTolZ	Set an allowable range in each direction in Local coordinate system specified by StartPntTolLocal. In X direction, an allowable range is a reference position ±StartPntTolX. The allowable range in Y and Z directions are the same way.
StartPntTolRot	Set an allowable range of the rotational direction. The allowable range is a reference orientation ±StartPntTolRot. It is set for all U, V, and W directions.

4.2.2 Details on properties of force guide sequence

Name Property

This property sets a particular name that is assigned to force guide sequences.
You cannot create the force guide sequence with the same name.

You can change the name. Set up 32 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character..

Index Property

This property displays a number of force guide sequence.
This property is set and updated automatically. You cannot change this.

	Value
Minimum value	1
Maximum value	16

Default: None

Description Property

This property sets a description of force guide sequence.
You can set the character string up to 255 characters.

RobotNumber Property

This property sets a robot number that uses a force guide sequence.
An error occurs when executing the force guide sequence by the robot which is not specified.

Value	Description
1 to 16	Robot number to use a force guide sequence.

Default: Robot number specified in the sequence wizard.

RobotType Property

This property is the robot types that use a force guide sequence.
It is automatically set from the robot number specified by RobotNumber. You cannot change this.

AutoStepID Property

This property sets an automatic assignment of StepID in force guide object execution.

When assigning automatically, force guide sequence number *100 + force guide object number is set.

StepID is recorded to files that the force and the position during the force guide sequence execution is recorded. It is used to determine which interval corresponds to which force guide object.

Value	Description
True	Set StepID automatically.
False	Set a property value of StepID of each force guide object.

Default: True

ResetSensor Property

This property sets whether to reset a force sensor when starting force guide object other than Decision object and SPELFunc object for the first time in the force guide sequence.

Value	Description
True	Reset the force sensor when starting a force guide object other than Decision object and SPELFunc object.
False	Force sensor is not reset.

Default: True

MPNumber Property

This property sets the number of Mass Property Object which is used during the force guide sequence execution.

Mass Property Object is a collection of properties using for gravity compensation. You need to define Mass Property Object in advance. If an angle will change largely during the execution of the force guide sequence, make sure to specify the proper Mass Property Object.

Value	Description
0	Turn OFF the gravity compensation.
1 to 15	Use the specified Mass Property.

Default: True

ForceOrient Property

This property specifies the direction of coordinate system that uses the force control functions during the force guide sequence execution.

You can select from Base, Local, and Tool. Normally, specify the coordinate system that the direction you want to press or follow is either of X, Y, or Z.

If Base or Local is specified, the direction to press or follow will not be changed even if the robot orientation changes.

If Tool is specified, the direction to press or follow changes since the direction of Tool coordinate system changes when the robot orientation is changed.

Value	Description
Base	The direction of the coordinate system to which the force control function is applied is the Base coordinate system
Local	The direction of the coordinate system to which the force control function is applied is the Local coordinate system
Tool	The direction of the coordinate system to which the force control function is applied is the Tool coordinate system

Default: Tool

RobotLocal Property

This property specifies the Local coordinate system number of coordinate system that applies the force control functions during the force guide sequence execution.

It is used when ForceOrient property is Local.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system). It is the same as when specifying Base in ForceOrient.
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

RotationCenterType Property

This property specifies the type of the rotation center which rotates due to the adjustments of the force control functions during the force guide sequence execution.

When specifying CurrentTool, rotate around the selecting Tool coordinate system.
When specifying Relative, rotate around the relative position from the Tool coordinate system which is specified below.

RotationCenterTLX, RotationCenterTLY, RotationCenterTLZ

Value	Description
CurrentTool	Set a position of the currently selected Tool coordinate system as a center of rotation.
Relative	Set a position where is apart from the currently selected Tool coordinate system by the specified distance as a center of rotation.

Default: CurrentTool

RotationCenterX Property

When RotationCenterType is Relative, this property sets a distance in X direction to the rotation center of the force control function.

It is the X direction of the Tool coordinate system which is selected in RobotTool.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

RotationCenterY Property

When RotationCenterType is Relative, this property sets a distance in Y direction to the rotation center of the force control function.

It is the Y direction of the Tool coordinate system which is selected in RobotTool.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

RotationCenterZ Property

When RotationCenterType is Relative, this property sets a distance in Z direction to the rotation center of the force control function.

It is the Z direction of the Tool coordinate system which is selected in RobotTool.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

LimitSpeedS Property

This property sets the maximum speed during the execution of force guide sequence.

The robot motion will change depending on applied force and torque when executing the force guide sequence since it is adjusted by the force control functions. However, it is restricted by the speed which is specified by this property.

	Value (unit: [mm/sec])
Minimum value	0.1
Maximum value	250

Default: 50

LimitSpeedR Property

This property sets the maximum rotation speed during the execution of force guide sequence.

The robot motion will change depending on applied force and torque when executing the force guide sequence since it is adjusted by the force control functions. However, it is restricted by the rotation speed which is specified by this property.

	Value (unit: [deg/sec])
Minimum value	0.1
Maximum value	180

Default: 25

LimitAccelS Property

This property sets the maximum acceleration during the execution of force guide sequence.

The robot motion will change depending on applied force and torque when executing the force guide sequence since it is adjusted by the force control functions. However, it is restricted by the acceleration which is specified by this property.

	Value (unit: [mm/sec^2])
Minimum value	0.1
Maximum value	5000

Default: 200

LimitAccelR Property

This property sets the maximum rotation acceleration during the execution of force guide sequence.

The robot motion will change depending on applied force and torque when executing the force guide sequence since it is adjusted by the force control functions. However, it is restricted by the rotation acceleration which is specified by this property.

	Value (unit: deg/sec^2])
Minimum value	0.1
Maximum value	5000

Default: 100

LogRobotLocal Property

For the position of the robot that is recorded during the force guide sequence execution, this property sets a Local coordinate system number as a reference.

The position of the robot is recorded as that of Tool coordinate system as viewed from the Local coordinate system specified by this property.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system).
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

LogFileEnabled Property

This property sets whether to save the force, torque, and the position of the robot during the force guide sequence execution in files.

When specifying True, value will be displayed in the graph on the monitor and saved in the files simultaneously.
When specifying False, value will be displayed in the graph on the monitor. However, the value is not saved in the files.

Value	Description
True	Save the log data in a file.
False	The log data is not saved in a file.

Default: True

LogFileAutoName Property

This property sets whether to automatically set the file name that records force, torque, and the position of the robot during the force guide sequence execution.

When specifying True, the file name is automatically set with the force guide sequence name + start time.

Force guide sequence name_yyyymmdd_hhmmssfff.csv

When specifying False, add ".csv" to the string in variables which is specified in LogFileNameVar to make it a file name.

Value	Description
True	Set the log data file name automatically.
False	Set a log data file name to the one which is specified by LogFileNameVar.

Default: True

LogFileNameVar Property

This property sets a global string variable that saves a file name which records force, torque, and the position of the robot during the force guide sequence execution.

It is used when False is specified in LogFileAutoName. Add ".csv" to the string in variables and set it as a file name.

Value	Description
None	Not specified (automatically set)
Variable name	Value of the specified global string variable will be a file name. Only a string variable can be specified.

Default: None

LogFileInterval Property

This property sets the sampling period for the files that record force, torque, and the position of the robot during the force guide sequence execution.

	Value (unit: [sec])
Minimum value	0.002
Maximum value	1

Default: 0.2

LogFileMaxTime Property

This property sets the maximum recording time for the files that record force, torque, and the position of the robot during the force guide sequence execution.

If the specified recording time is shorter than the execution time of the force guide sequence, nothing is recorded in the file after the recording time is passed. Caution is required in this regard.

	Value (unit: [sec])
Minimum value	60
Maximum value	600

Default: 60

PointFile Property

This property sets the point file name that is used during the force guide sequence execution.

If the point file which is not specified by this property is loaded when the force guide sequence starts, an error occurs. This is a property for preventing a wrong operation.

Value	Description
None	Not specified (Any point file whichever loads can be executed without checking it.)
Point file name	An error occurs when the specified point file is not loaded.

Default: None

RobotTool Property

This property sets the Tool coordinate system number that is used during the force guide sequence execution.

If the Tool coordinate system number which is not specified by this property is selected when the force guide sequence starts, an error occurs. This is a property for preventing a wrong operation.

Value	Description
0 to 16	An error occurs when the set tool number is not selected.

Default: None

PosCheckEnabled Property

This property sets whether to check the position (X, Y, Z, U, V, W) when starting the force guide sequence.

When specifying True, the force guide sequence starts when the specified conditions are satisfied. If the conditions are not satisfied, the force guide sequence ends as a failure without executing the force guide object. The next SPEL statement of FGRun is executed.
When specifying False, the force guide object is executed surely without checking the position.

Value	Description
True	Check the position at the start.
False	You can start at any position without checking the position at the start.

Default: False

OrientCheckEnabled Property

This property sets whether to check the arm orientation (Hand, Elbow, Wrist) when starting the force guide sequence.

When specifying True, the force guide sequence starts when it matches the specified arm orientation. If the arm orientations are not matched, the force guide sequence ends as a failure without executing the force guide object. The next SPEL statement of FGRun is executed.
When specifying False, the force guide object is executed surely without checking the arm orientation.

Value	Description
True	Check the arm orientation at the start.
False	You can start with any arm orientation without checking it at the start.

Default: False

StartCheckPoint Property

This property sets a reference point to check the arm orientation and the position when the force guide sequence starts. It is used when PosCheckEnabled is True.

	Value
Minimum value	0
Maximum value	999

Default: 0

StartPntTolLocal Property

To check the position when the force guide sequence starts, this property sets Local coordinate system number to specify the available range.

It is used when PosCheckEnabled is True. Only the axis direction is used. The origin position in Local coordinate system does not affect.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system).
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

StartPntTolX Property

To check the position when the force guide sequence starts, this property sets an available range in X direction.

It is used when PosCheckEnabled is True.

When the robot is between the position specified by StartCheckPoint and the position specified by this property in X direction of Local coordinate system specified by StartPntTolLocal, it is determined as conditions are satisfied. Conditions of each direction are determined as AND. Therefore, if one or more of X, Y, Z, or Rot is out of the range, it is determined as failure.

	Value (unit: [mm])
Minimum value	0
Maximum value	100

Default: 0

StartPntTolY Property

To check the position when the force guide sequence starts, this property sets an available range in Y direction.

It is used when PosCheckEnabled is True.

When the robot is between the position specified by StartCheckPoint and the position specified by this property in Y direction of Local coordinate system specified by StartPntTolLocal, it is determined as conditions are satisfied. Conditions of each direction are determined as AND. Therefore, if one or more of X, Y, Z, or Rot is out of the range, it is determined as failure.

	Value (unit: [mm])
Minimum value	0
Maximum value	100

Default: 0

StartPntTolZ Property

To check the position when the force guide sequence starts, this property sets an available range in Z direction.

It is used when PosCheckEnabled is True.

When the robot is between the position specified by StartCheckPoint and the position specified by this property in Z direction of Local coordinate system specified by StartPntTolLocal, it is determined as conditions are satisfied. Conditions of each direction are determined as AND. Therefore, if one or more of X, Y, Z, or Rot is out of the range, it is determined as failure.

	Value (unit: [mm])
Minimum value	0
Maximum value	100

Default: 0

StartPntTolRot Property

To check the position when the force guide sequence starts, this property sets an available range range in the rotational direction.

It is used when PosCheckEnabled is True.

If the difference between the current orientation when the force guide sequence starts and the orientation (UVW) specified by StartCheckPoint is within the angle of the value specified by this property, it is determined as conditions are satisfied. Conditions of each direction are determined as AND. Therefore, if one or more of X, Y, Z, or Rot is out of the range, it is determined as failure.

	Value (unit: [deg])
Minimum value	0
Maximum value	10

Default: 0

4.2.3 Details on results of force guide sequence

EndStatus Result

It is a result of the execution.

Result will be a success when the force guide sequences are executed to the end and the final force guide object is succeeded or AbortSeqOnFail property of the final force guide object is False.

Value	Description
Passed	Force guide sequence had succeeded.
Failed	Force guide sequence had failed.
NoExec	Force guide sequence had not executed.
Aborted	Aborted during the execution of force guide sequence.

EndStatusData Result

Detailed information on the executed results.

Failure reasons are described. Return a value from 0 to 7 depending on the each bit value (ON:1, OFF:0).

Bit	Description
0	When the force guide object which AbortSeqOnFail is set to True is failed, bit value will be ON.
1	When the position (X, Y, Z, U, V, W) at the start is out of the specified range, bit value will be ON.
2	When the arm orientation (Hand, Elbow, Wrist) at the start is different from the specified one, bit value will be ON.

Time Result

Required time for execution.
Unit: [sec]

LastExecObject Result

Force guide object name which is executed at the end.

EndForces Result

Force and torque when force guide sequence ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

4.3 Force Guide Object(s)

The following 10 force guide objects are available.

Category	Object name	Description
Contact	Contact	Move the robot to the specified direction and stop it when contacting with the object.
Follow	Relax	Adjust the position of the robot so that the applied force and torque to the specified axis will be “0”.
	FollowMove	While moving the specified trajectory, adjust the position of the robot so that the applied force and torque to the specified axis will be “0”.
Align	SurfaceAlign	Align a surface of the grasped workpiece with that of the object.
Probe	PressProbe	Detect a hole or a step on the object while pressing the grasped workpiece.
	ContactProbe	Detect a hole on the object while contacting the grasped workpiece.
Press	Press	Press to the specified axis direction.
	PressMove	Press to the specified axis direction while moving the specified trajectory.
Execution	Decision	Branch off a processing depending on the object results.
	SPELFunc	Execute a function of the specified SPEL program.

This chapter describes types and properties of each force guide object, and how to set or adjust the properties.

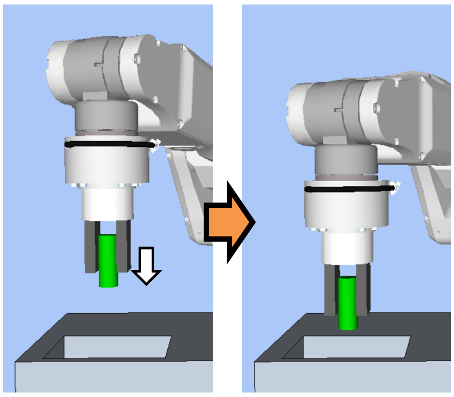
For more details on the settings of the force guide objects, refer to the following section.

Software 4.1.3 Set a force guide object

4.3.1 Contact Object

Contact object moves the robot to the specified direction until it contacts with an object such as a workpiece, and stops it when contacting with the object.

This object is used for setting the start position for other force guide objects or positioning the grasp position.
Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, next motion or the force guide object can be executed stably since the contact position can be detected.



The above figure is an image of a motion by the Contact object. The robot moves to the white arrow direction from the non-contact state and stops when contacting with the object.

The Contact object will be succeeded when the end conditions are satisfied within the specified time. End conditions related to force are always set.

Each condition is as follows:

End condition	Success condition
End conditions related to force	Satisfy either one of the following within the specified time of Timeout: When ContactOrient is Fx, Fy, Fz : Absolute value of the force in the specified direction exceeds that of ContactForceThresh. When ContactOrient is Tx, Ty, Tz: Absolute value of the torque in the specified direction exceeds that of ContactTorqueThresh.

Property setting guideline for Contact object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	Name of the force guide object. Set a particular name.
Description	Descriptions for the force guide object. Describe the operations. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead.
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	Set whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

Step 2. Set I/O processing before starting

Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting the force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	Set the output bit which is operated when the force guide object starts.
IOPreprocOutputStatus	Set whether to turn ON or OFF the output bit when the force guide object starts. Set the state to be output.

Step 3. Set the contacting direction and force control functions

Set properties (ContactOrient, ContactFirmnessF, ContactFirmnessT, CFEnabled) related to the contacting direction and force control functions.

Property	Description, setting guide
ContactOrient	Set a direction to contact. The robot moves or rotates to the specified direction.
ContactFirmnessF ContactFirmnessT	Set a firmness of the force control functions. ContactFirmnessF : When ContactOrient is Fx, Fy, Fz ContactFirmnessT : When ContactOrient is Tx, Ty, Tz When setting a large value: The force control function will become stronger. However, response to changes of the force/torque is slow. When setting a small value: The force control function will become weaker. Response to changes of the force/torque is fast, however, vibration is easy to occur. When setting a small absolute value: Movement speed of the contact motion will be fast.
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object. True : When you want to execute the next force guide object with remaining a steady force after contacting: The next force guide object must maintain the force control in the direction set in ContactOrient.

You can check the settings of ContactOrient by a simulator. A coordinate system with grayed out except the specified direction is displayed.
However, the robot is displayed based on the current position. When you check the settings, make sure to move the robot to the position where executing the force guide object.
For details on how to check by using simulator, refer to the following manual.

EPSON RC+ 7.0 User's Guide: 8. Simulator, 8.3 Description of Functions

Step 4. Set the end conditions

Set properties (ContactForceThresh, ContactTorqueThresh, Timeout Property) related to the end conditions.

Property	Description, setting guide
ContactForceThresh ContactTorqueThresh	Set a threshold to determine a contact. Be sure to set a proper threshold for your workpiece. ContactForceThresh : When ContactOrient is Fx, Fy, Fz, set approx. 3 to 5[N]. ContactTorqueThresh : When ContactOrient is Tx, Ty, Tz, set approx. 500[N·mm]. When setting a large absolute value: Movement speed until the robot contacts will be fast. When the value is too small: Robot may not move.
Timeout	Set a time-out period of the Contact object. It fails if the specified time is passed before contacting.

Adjustment guideline for Contact object

The following describes the adjustment methods for the Contact object.

When the contacting force is large:

Decrease the value of ContactForceThresh or ContactTorqueThresh.
Or, increase the value of ContactFirmnessF or ContactFirmnessT.

However, the movement speed will be slow.
Please perform proper adjustments for your operations.

When the force guide object ends before contacting:

If the execution time is short, increase Timeout value.

When incorrectly determining as “contacted” before contacting:

Contact object determines incorrectly due to the inertia force or noise when moving.

Increase the value of ContactForceThresh or ContactTorqueThresh.
However, force and torque when contacting will be large. Please perform proper adjustments for your operations.

Or, increase the value of ContactFirmnessF or ContactFirmnessT.
However, the movement speed will be slow. Please perform proper adjustments for your operations.

When the movement speed until the robot contacts is slow:

Increase the value of ContactForceThresh or ContactTorqueThresh.
Or, decrease the value of ContactFirmnessF or ContactFirmnessT.

However, force and torque when contacting will be large, or vibrations may be generated. Please perform proper adjustments for your operations.

When it takes time to contact:

If the start position of the force guide object is far from a contact position, it takes time since moving distance in long. Change the start position to a position where is as close as possible to the position to be contacted, but where does not contact with the position.

When the robot does not move to the contacting direction or move to an opposite direction:

The force sensor may not be reset properly. Check the ResetSensor setting of the force guide sequence.

When starting the force guide sequence, the object may start with the contact state.
Be sure to start from the non-contact state.

The absolute values of ContactForceThresh or ContactTorqueThresh may be small.
Increase the absolute value. However, force and torque when contacting will be large.
Please perform proper adjustments for your operations.

Details on properties of the Contact object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the Contact object, name is assigned automatically. Automatically assigned name is added a number after Contact (e.g. Contact01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
This property is used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program aborts the force guide sequence and proceeds to the next SPEL statement if the force guide object fails.
When specifying False, the program proceeds to the next force guide object without aborting the force guide sequence even if the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	Abort the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the execution of the force guide object.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.
It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.
It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF the specified output bit. (Set to 0)
On	Turn ON the specified output bit. (Set to 1)

Default: Off

ContactOrient Property

This property sets a target contact position as viewed from the start position.

Set the direction in the coordinate system specified by ForceOrient of the force guide sequence. You can select from translation direction (+Fx to −Fz) or rotation direction (+Tx to −Tz).
The robot moves to the specified direction and stops when contacting with an object.

Value	Description
+Fx	Move to the positive direction in Fx.
−Fx	Move to the negative direction in Fx.
+Fy	Move to the positive direction in Fy.
−Fy	Move to the negative direction in Fy.
+Fz	Move to the positive direction in Fz.
−Fz	Move to the negative direction in Fz.
+Tx	Move to the positive direction in Tx.
−Tx	Move to the negative direction in Tx.
+Ty	Move to the positive direction in Ty.
−Ty	Move to the negative direction in Ty.
+Tz	Move to the positive direction in Tz.
−Tz	Move to the negative direction in Tz.

Default: +Fz

ContactFirmnessF Property

This property sets a firmness of force control functions during execution of the force guide object. It is used when ContactOrient is translation direction (+Fx to −Fz).

When the value of ContactFirmnessF increases, the force control function will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When the value of ContactFirmnessF decreases, the force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

ContactFirmnessT Property

This property sets a firmness of force control functions during execution of the force guide object.
It is used when ContactOrient is rotation direction (+Tx to −Tz).

When the value of ContactFirmnessT increases, the force control function will become stronger. Response to changes of the torque is slow, however, vibration does not occur. When the value of ContactFirmnessT decreases, the force control function will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended. When the force guide sequence ends even CFEnabled is set to True, end the force control functions.

Value	Description
True	The force control functions continue to the next force guide object even the force guide object ends.
False	The force control functions end when the force guide object is ended.

Default: False

ContactForceThresh Property

This property sets a threshold of force to determine the contact.
It is used when ContactOrient is the translation direction (+Fx to −Fz).
If the threshold set by this property is exceeded during execution of Contact object, the robot recognizes that the robot is contacted and stops the motion. Then, proceed to the next force guide object.

When ContactOrient is in positive direction:

	Value (unit: [N])
Minimum value	−10
Maximum value	0

Default: −5

When ContactOrient is in negative direction:

	Value (unit: [N])
Minimum value	0
Maximum value	10

Default: 5

ContactTorqueThresh Property

This property sets a threshold of torque to determine the contact.
It is used when ContactOrient is rotation direction (+Tx to −Tz).
If the threshold set by this property is exceeded during execution of Contact object, the robot recognizes the contact and stops the motion. Then, proceed to the next force guide object.

When ContactOrient is in positive direction:

	Value (unit: [N·mm])
Minimum value	−1000
Maximum value	0

Default: −200

When ContactOrient is in negative direction:

	Value (unit: [N·mm])
Minimum value	0
Maximum value	1000

Default: −200

Timeout Property

This property sets the time-out period of the force guide object.

If it does not exceed the threshold specified by ContactForceThresh or ContactTorqueThresh even after the time specified by this property has passed, it is determined as contact is failed.

After the determination, end the force guide sequence according to AbortSeqOnFail or proceed to the next force guide object.

	Value (unit: [sec])
Minimum value	0.1
Maximum value	60

Default: 10

Details on results of the Contact object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.1 Contact Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

TimedOut Result

It is whether the time-out period set in Timeout property had been reached.

Value	Description
True	Reach to the time-out period.
False	End before reaching to the time-out period.

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

Average values of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution.
The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

ForceCondOK Result

It is whether to satisfy the end conditions related to force.

Value	Description
True	Satisfy the end conditions related to force.
False	The end conditions related to force are not satisfied.

TriggeredForces Result

It is the force and torque when satisfying the end conditions related to force.
Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredPos Result

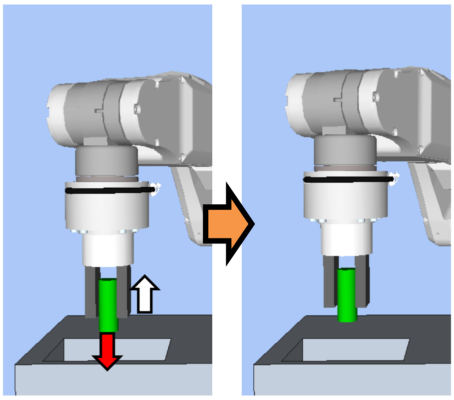
Positions when satisfying the end conditions related to force. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

4.3.2 Relax Object

Relax object moves the robot to a position where the force to the specified direction will be “0”.

Use this object for safety releasing of the pressing state after pressing by Press object or removal of extra force which is applied during assembly. Also, by combining with the hand motions, this object can follow and grasp. Even if the workpiece dimension or the grasp positions of the workpiece have a margin of error, the robot can grasp the workpiece stably without applying extra force.



The above figure is the image of a motion by the Relax object.
The robot moves from the red arrow state (the robot presses after contacting with an object) to the white arrow direction so that the applied force will be “0”.

The Relax object will be succeeded when the end conditions are satisfied within the specified time. The Relax object can use the end conditions related to force and I/O.

Each end condition sets whether to use in ForceCheckEnabled or IOCheckEnabled.
If no end condition is set, the object will always be succeeded. When more than one end conditions are set, you can select how to combine the end conditions from AND or OR in EndCheckOperator.

Each condition is as follows:

End condition	Success condition
End conditions related to force	Within the specified time of Timeout, keep satisfying the following two in the time specified by HoldTimeThresh. The axis which is specified to Follow by ControlMode in Fx, Fy, or Fz: The axis should be within the range of –FollowCheckTolF to +FollowCheckTolF. The axis which is specified to Follow by ControlMode in Tx, Ty, or Tz: The axis should be within the range of –FollowCheckTolT to +FollowCheckTolT.
End conditions related to I/O	Input bit specified by IOCheckInputBit should be the state specified by IOCheckInputStatus in the time specified by Timeout.

Property setting guideline for Relax object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	Name of the force guide object. Set a particular name.
Description	Descriptions for force guide object. Describe the operations. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead.
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	It is whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

Step 2. Set I/O processing before starting

Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting the force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	When starting the force guide object, set the output bit to be operated.
IOPreprocOutputStatus	When starting the force guide object, set whether to turn ON or OFF the output bit. When starting the force guide object, set whether to turn ON or OFF the output bit. Set the state to be output.

Step 3. Set force control functions

Set properties (Fx_ControlMode, …, Tz_ControlMode, Fx_Firmness, …, Tz_Firmness, CFEnabled) related to the force control function.

Property	Description, setting guide
Fx_ControlMode Fy_ControlMode Fz_ControlMode Tx_ControlMode Ty_ControlMode Tz_ControlMode	Set a mode of the force control functions to each direction. When specifying Follow: Perform the follow motion by the force control functions. When specifying Disabled: Force control functions are disabled. Set ControlMode of the direction where you want to follow to Follow. You need to set Follow to more than one direction.
Fx_Firmness Fy_Firmness Fz_Firmness Tx_Firmness Ty_Firmness Tz_Firmness	Set a firmness of the force control functions to each direction. When setting a large value: The force control function will become stronger. However, response to changes of the force is slow. When setting a small value: The force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object. True : When you want to execute the next force guide object with remaining steady force after contacting: The next force guide object must maintain the force control in the direction where is selected Follow for each ControlMode.

You can check the settings of ControlMode by a simulator. A coordinate system with grayed out except the enabled direction is displayed.
However, the robot is displayed based on the current position. When you check the settings, make sure to move the robot to the position where executing the force guide object.
For details on how to check by using simulator, refer to the following manual.

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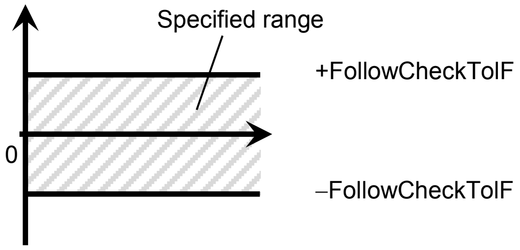
Step 4. Set basic information for end conditions

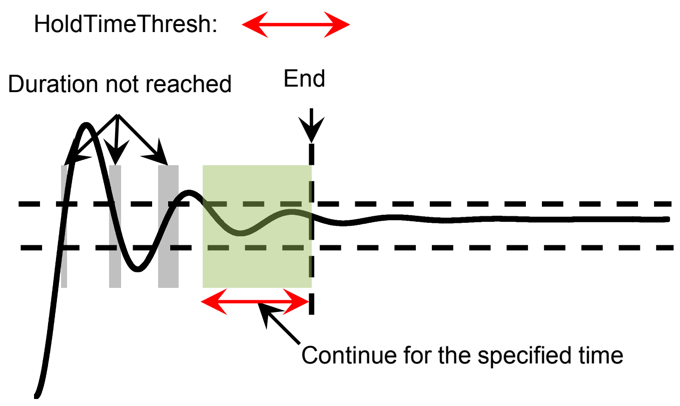
Set properties (EndCheckOperator, Timeout) related to combinations of end conditions and time-out.

Property	Description, setting guide
EndCheckOperator	This property sets how to combine the end conditions related to force and I/O. AND : End when the both conditions are satisfied. OR : End when the more than one conditions are satisfied.
Timeout	This property sets the time-out period. When the end conditions are not set: Time-out period is the execution time. When the end conditions are set: Fails when the end conditions are not satisfied within the specified time.

Step 5. Set end conditions about force

Set properties (ForceCheckEnabled, FollowCheckTolF, FollowCheckTolT, HoldTimeThresh) related to the end conditions of force.

Property	Description, setting guide
ForceCheckEnabled	This property sets whether to enable the end conditions related to force. True : When enabling the end conditions related to force.
FollowCheckTolF FollowCheckTolT	This property sets a range of the translational direction or the rotational direction of the end conditions related to force. FollowCheckTolF: This property indicates the translational direction. FollowCheckTolT: This property indicates the rotational direction. Monitor that the force direction which specified Follow by ControlMode in Fx, Fy, Fz is within the range of –FollowCheckTolF to +FollowCheckTolF. Monitor that the force direction which specified Follow by ControlMode in Tx, Ty, Tz is within the range of –FollowCheckTolT to +FollowCheckTolT. The following is the image of FollowCheckTolF. 

Property	Description, setting guide
HoldTimeThresh	Set the duration time which is used to determine whether the end conditions are satisfied. As shown below, if the specified condition continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.  Normally, set to "0". Set the time for stabilizing the motion when the results of the next force guide object are unstable. We recommend setting the time according to the actual result which is executed after temporarily disabling the end conditions.

Step 6. Set end conditions about I/O

Set properties (IOCheckEnabled, IOCheckInputBit, IOCheckInputStatus) related to the end conditions of I/O.

Property	Description, setting guide
IOCheckEnabled	This property sets whether to enable the end conditions of I/O. True : When the end conditions related I/O are enabled.
IOCheckInputBit	Set an input bit which is monitored as an end condition.
IOCheckInputStatus	Set a state of the input bit to be an end condition. If the input bit specified by IOCheckInputBit will be the state specified by IOCheckInputStatus, it is determined as the end conditions are satisfied.

Adjustment guideline for Relax object

The following describes the adjustment methods when using the Relax object.

When it takes time the force to be “0”:

This is an adjustment when the cause of the applied force is not changed. It is an exception when the force is kept applying even the robot moves.

Decrease the Firmness value of each direction. However, the robot motion may be easy to vibrate. Please perform proper adjustments for your operations.

When the robot motion vibrates:

Increase the Firmness value. However, response of the robot will be slow.
Please perform proper adjustments for your operations.

To adjust the Firmness, we recommend adjusting the value gradually (e.g. increase the value by 10%).

Details on properties of the Relax object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the Relax object, name is assigned automatically. Automatically assigned name is added a number after Relax (e.g. Relax01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default : Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program ends force guide sequence and proceeds to the next SPEL statement if force guide object fails.
When specifying False, the program proceeds to the next force guide object without ending the force guide sequence even if the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	End the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the force guide object execution.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.
It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.
It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF the specified output bit. (Set to 0)
On	Turn ON the specified output bit. (Set to 1)

Default: Off

Fx_ControlMode Property

Set the control mode in Fx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fx direction are not executed. When specifying Follow, the force control functions to Fx direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be “0”. Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fx_Firmness Property

This property sets a firmness of force control functions in Fx direction during the execution of force guide object.
It is used when Fx_ControlMode is Follow.

When the value of Fx_Firmness increases, the force control function in Fx direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When Fx_Firmness decreases, the force control function in Fx direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fy_ControlMode Property

Set the control mode in Fy direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fy direction are not executed. When specifying Follow, the force control functions to Fy direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be “0”. Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fy_Firmness Property

This property sets a firmness of force control functions in Fy direction during the execution of force guide object.
It is used when Fy_ControlMode is Follow.

When the value of Fy_Firmness increases, the force control function in Fy direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When Fy_Firmness decreases, the force control function in Fy direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fz_ControlMode Property

Set the control mode in Fz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fz direction are not executed. When specifying Follow, the force control functions to Fz direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be “0”. Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fz_Firmness Property

This property sets a firmness of force control functions in Fz direction during the execution of force guide object.
It is used when Fz_ControlMode is Follow.

When the value of Fz_Firmness increases, the force control function in Fz direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When Fz_Firmness decreases, the force control function in Fz direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Tx_ControlMode Property

Set the control mode in Tx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Tx direction are not executed. When specifying Follow, the force control functions to Tx direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tx_FirmnessProperty

This property sets a firmness of force control functions in Tx direction during the execution of force guide object. It is used when Tx_ControlMode is Follow.

When the value of Tx_Firmness increases, the force control function in Tx direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.
When Tx_Firmness decreases, the force control function to Tx direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Ty_ControlMode Property

Set the control mode in Ty direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Ty direction are not executed. When specifying Follow, the force control functions to Ty direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Ty_Firmness Property

This property sets a firmness of force control functions in Ty direction during the execution of force guide object.
It is used when Ty_ControlMode is Follow.

When the value of Ty_Firmness increases, the force control function in Ty direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.
When Ty_Firmness decreases, the force control function to Ty direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Tz_ControlMode Property

Set the control mode in Tz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Tz direction are not executed.
When specifying Follow, the force control functions to Tz direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”.
Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tz_Firmness Property

This property sets a firmness of force control functions in Tz direction during the execution of force guide object.
It is used when Tz_ControlMode is Follow.

When the value of Tz_Firmness increases, the force control function in Tz direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.
When Tz_Firmness decreases, the force control function to Tz direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended.
When the force guide sequence ends even if CFEnabled is True, the force control functions will end.

Value	Description
True	The force control functions continue to the next force guide object even the force guide object is ended.
False	The force control functions end when the force guide object is ended.

Default: False

EndCheckOperator Property

This property sets the combination conditions when using several end conditions of the force guide object.

When specifying AND, if all of the enabled end conditions are satisfied, the force guide object execution ends. The execution is determined as succeeded and proceed to the next force guide object.
When specifying OR, if some of the enabled end conditions are satisfied, the force guide object execution ends. The execution is determined as succeeded and proceed to the next force guide object.

Value	Description
OR	Combine as OR condition.
AND	Combine as AND condition.

Default: Disabled

ForceCheckEnabled Property

This property sets the end conditions of the force guide object related to force.

Value	Description
True	Enable the end conditions related to force.
False	Disable the end conditions related to force.

Default: False

FollowCheckTolF Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True.

It is used in the axis that specified Follow by each ControlMode in Fx, Fy, and Fz, and determined that it is within the range of –FollowCheckTolF to + FollowCheckTolF.

If all axes specified Follow are within the range set by either FollowCheckTolF or FollowCheckTolT, it is determined as the end conditions are satisfied.

	Value (unit: [N])
Minimum value	0.1
Maximum value	10

Default: 1

FollowCheckTolT Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True.

It is used in the axis that specified Follow by each ControlMode in Tx, Ty,and Tz, and determined that it is within the range of −FollowCheckTolF to +FollowCheckTolF. If all axes specified Follow are within the range set by either FollowCheckTolF or FollowCheckTolT, it is determined as the end conditions are satisfied.

	Value (unit: [N·mm])
Minimum value	100
Maximum value	10000

Default: 500

HoldTimeThresh Property

This property sets the duration time until the determination of the end conditions related to force.
It is used when ForceCheckEnabled is True.

If the state within the range specified by either FollowCheckTolF or FollowCheckTolT continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.

	Value (unit: [sec])
Minimum value	0
Maximum value	10

Default: 0

IOCheckEnabled Property

This property sets the end conditions of the force guide object related to I/O.

Value	Description
True	Enable the end conditions related to I/O.
False	Disable the end conditions related to I/O.

Default: False

IOCheckInputBit Property

This property sets the bit of determination target of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOCheckInputStatus Property

This property sets the determination conditions of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

According to the bit specified by IOCheckInputBit, it is determine as the end conditions are satisfied.

Value	Description
Off	When the input bit is OFF (0), it is determined as the end conditions are satisfied.
On	When the input bit is ON (1), it is determined as the end conditions are satisfied.

Default: Off

Timeout Property

This property sets the time-out period of the force guide object.

When it is not satisfied conditions enabled in ForceCheckEnabled or IOCheckEnabled after the time specified by Timeout has passed, it is determined as failure of the Relax object.

After the determination, abort the force guide sequence according to AbortSeqOnFail or proceed to the next force guide object.

When ForceCheckEnabled and IOCheckEnabled are False, end the force guide object after the time specified by Timeout is passed. Determine as succeeded and proceed to the next force guide object.

	Value (unit: [sec])
Minimum value	0.1
Maximum value	60

Default: 10

Details on results of the Relax object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying "success conditions" described in *4.3.2 Relax Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

TimedOut Result

It is whether the time-out period set in Timeout property had been reached.

Value	Description
True	Reach to the time-out period.
False	End before reaching to the time-out period.

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz[N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

Average values of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

ForceCondOK Result

It is whether to satisfy the end conditions related to force.

Value	Description
True	Satisfy the end conditions related to force.
False	The end conditions related to force are not satisfied.

TriggeredForces Result

It is the force and torque when satisfying the end conditions related to force.
Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredPos Result

Positions when satisfying the end conditions related to force. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

IOCondOK Result

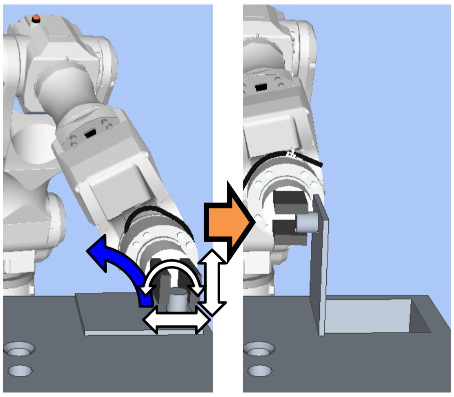
It is whether to satisfy the end conditions related to I/O.

Value	Description
True	Satisfy the end conditions related to I/O.
False	The end conditions related to I/O are not satisfied.

4.3.3 FollowMove Object

FollowMove object follows so that the force to the specified direction will be “0” and moves the robot along with the specified trajectory.

Use this object for a move of the fixed trajectory of operation targets such as opening/closing the door. In the case of the position control, the operation targets may get damages since extra force is applied if the trajectory moves. However, FollowMove object controls the applied force to be “0”. Therefore, the robot can move operation targets without teaching the accurate trajectory.



The above figure is an image of a motion by the FollowMove object. The object adjusts the position or the orientation so that the force which is applied to the directions (white arrows) will be “0” while the robot moves along the trajectory (blue arrow).

The FollowMove object will be succeeded when the end conditions are satisfied while the robot moves the specified trajectory. The end conditions related to positions and I/O are available.

Each end condition sets whether to use in PosCheckEnabled or IOCheckEnabled. If no end condition is set, the object will always be succeeded. When more than one end conditions are set, you can select how to combine the end conditions from AND or OR in EndCheckOperator.

Each condition is as follows:

End condition	Success condition
End conditions related to positions	Satisfy either one of the following before moving the specified trajectory: When PosCheckType is RobotPlane: Satisfy the state set by PlaneEndCondition for Plane set by PlaneNumber. When PosCheckType is RelativePlane: Satisfy the state set by PlaneEndCondition for the relative plane set by PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrg, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLocal.
End conditions related to I/O	Input bit specified by IOCheckInputBit should be the state specified by IOCheckInputStatus before moving the specified trajectory.

Property setting guideline for FollowMove object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	This property sets names of force guide objects. Set a particular name.
Description	This property sets descriptions about force guide objects. Describe the operation descriptions. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead.
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	Set whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

Step 2. Set I/O processing before starting

Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	When starting the force guide object, set the output bit to be operated.
IOPreprocOutputStatus	When starting the force guide object, set whether to turn ON or OFF the output bit. Set the state to be output.

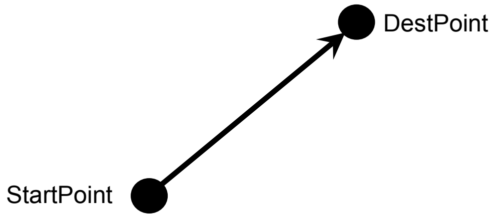
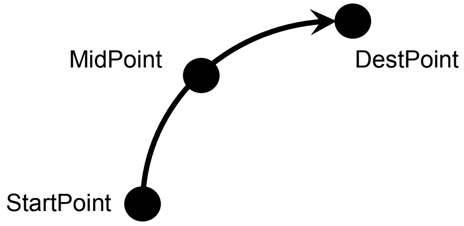
Step 3. Set a movement motion

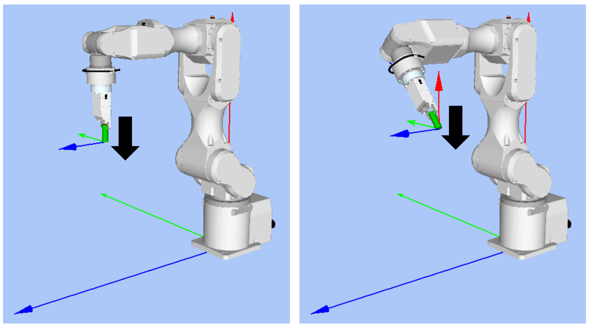
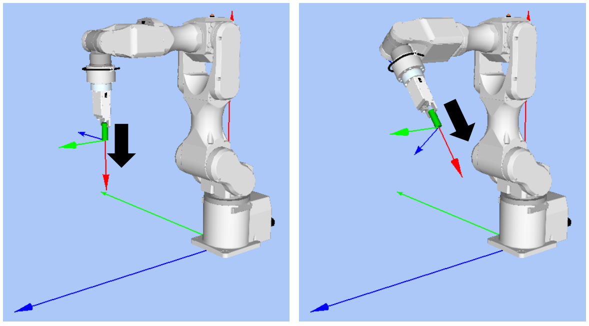
Set properties (MotionTrajectory, AccelS, AccelR, SpeedS, SpeedR, CPEnabled) related to movements.

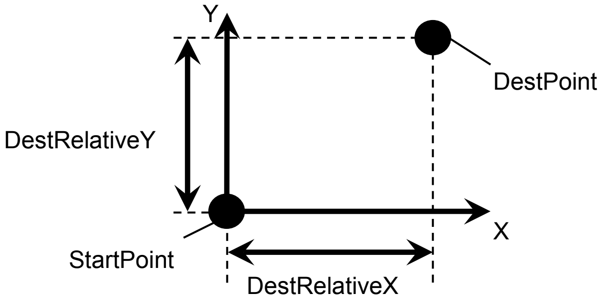
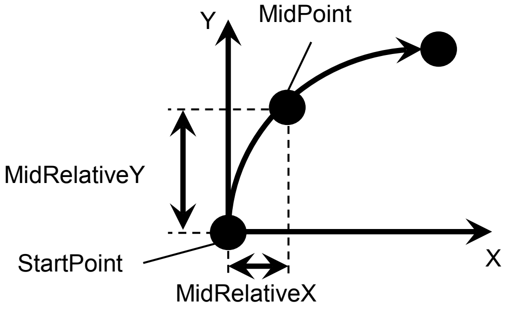
Property	Description, setting guide
MotionTrajectory	Set types of trajectory to move. You can select from Straight or Arc.
AccelS AccelR	Set the acceleration of the movement. AccelS: Acceleration AccelR: Rotational rotation acceleration Actual acceleration is adjusted by the force control functions.
SpeedS SpeedR	Set the speed of the movement. SpeedS: Speed SpeedR: Rotational rotation speed Actual speed is adjusted by the force control functions.
CPEnabled	Set whether to connect the trajectory of the FollowMove object and that of the following force guide object by Path Motion. True : When connecting complicated trajectory to operate by more than one FollowMove objects.

Step 4. Set a destination point

Set properties (DestType, DestPoint, MidPoint, RelativeOrient, RelativeRobotLocal, DestRelativeX, …, DestRelativeW, MidRelativeX, …, MidRelativeW) related to trajectories to move.

Property	Description, setting guide
DestType	This property can set how to set a destination point. If you use the force control functions, the robot positions are adjusted by the force. Therefore, we recommend specifying a destination point by a relative movement amount from the positioning point. RobotPoint : When moving to the specified point Relative : When specifying the relative movement amount
DestPoint	Set a point indicating a destination point (DestPoint). When selecting Straight in MotionTrajectory: As shown below, the robot moves a straight line from the StartPoint of the force guide object to the DestPoint. 
MidPoint	When the MotionTrajectory is Arc, set a point indicating a middle point (MidPoint). As shown below, the robot moves to the DestPoint with passing through the MidPoint. 

Property	Description, setting guide
RelativeOrient	Set a coordinate system direction which will be a reference of the relative movement. When specifying Base or Local: As viewed from outside, the robot always operates to a define direction. The following is an example to set Base. When moving to –Z direction, the robot always moves to the vertical-downward (–Z direction in Base coordinate system) even the orientation of robot fingers changed. Black arrow is a direction of the robot motion.) If you want to move the robot to the different direction from the Base coordinate system, specify in the Local coordinate system.  When specifying Tool: Movement direction changes along with the orientation at the start. The following is an example to set Tool. When moving to +Z direction, the moving direction changes depending on the orientation of robot fingers at the start.  Base, Local: To move the robot to a define direction as viewed from outside even the robot orientation at the start of the force guide object is changed. Tool: To move to the direction depending on the robot orientation.
RelativeRobotLocal	Set a Local coordinate system number which is used when specifying Local by RelativeOrient.

Property	Description, setting guide
DestRelativeX DestRelativeY DestRelativeZ DestRelativeU DestRelativeV DestRelativeW	Set a relative movement amount to each direction from the StartPoint of the force guide object to the DestPoint. As shown below, set a movement amount in the coordinate system specified by RelativeOrient. 
MidRelativeX MidRelativeY MidRelativeZ MidRelativeU MidRelativeV MidRelativeW	Set a relative movement amount to each direction from the StartPoint of the force guide object to the MidPoint. As shown below, set a movement amount in the coordinate system specified by RelativeOrient. 

Step 5. Set force control functions

Set properties (Fx_ControlMode, …, Tz_ControlMode, Fx_Firmness, …, Tz_Firmness, CFEnabled) related to the force control function.

Property	Description, setting guide
Fx_ControlMode Fy_ControlMode Fz_ControlMode Tx_ControlMode Ty_ControlMode Tz_ControlMode	Set a mode of the force control functions to each direction. When specifying Follow: Perform the follow motion for the force control functions. When specifying Disabled: Force control functions are disabled. Set ControlMode where you want to follow to Follow. More than one direction must set to Follow.

Property	Description, setting guide
Fx_Firmness Fy_Firmness Fz_Firmness Tx_Firmness Ty_Firmness Tz_Firmness	Set a firmness of the force control functions to each direction. When setting a large value: The force control function will become stronger. However, response to changes of the force is slow. When setting a small value: The force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object. True : When you want to execute the next force guide object with remaining steady force after contacting: The next force guide object must maintain the force control in the direction where is selected Follow for each ControlMode.

You can check the settings of ControlMode by a simulator. A coordinate system with grayed out except the enabled direction is displayed.
However, the robot is displayed based on the current position. When you check the settings, make sure to move the robot to the position where executing the force guide object.
For details on how to check by using simulator, refer to the following manual.

EPSON RC+ 7.0 User's Guide: 8. Simulator, 8.3 Description of Functions

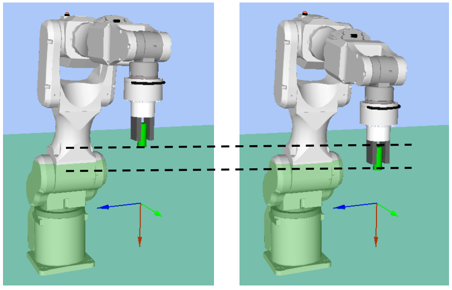
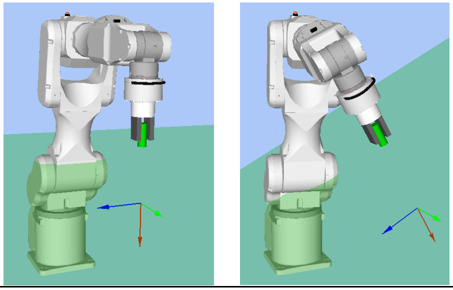
Step 6. Set basic information for end conditions

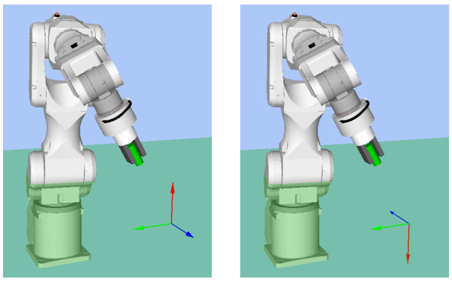
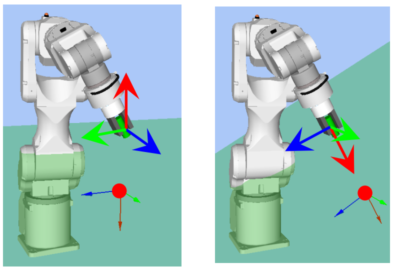
Set a property (EndCheckOperator) related to combinations of end conditions.

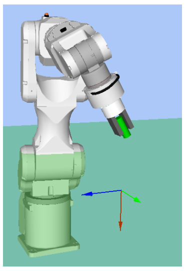
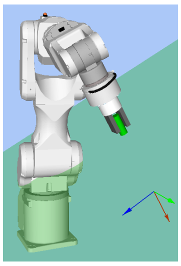
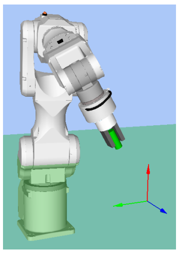
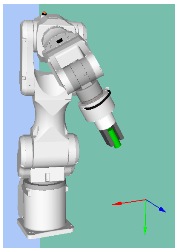
Property	Description, setting guide
EndCheckOperator	This property sets how to combine the end conditions related to position and I/O. AND : End when the both conditions are satisfied. OR : End when the more than one condition are satisfied.

Step 7. Set end conditions about position

Set properties (PosCheckEnabled, PosCheckType, PlaneNumber, PlaneEndCond, PlaneRelativeOrg, PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLoca) related to the end conditions of the positions.

Property	Description, setting guide
PosCheckEnabled	This property sets whether to enable the end conditions of positions. True : When the end conditions of positions are enabled. False : When the end conditions of positions are disabled.
PosCheckType	Select types of the end conditions related to positions. When selecting RobotPlane: End conditions are based on the set Plane. As shown below, use this property for setting the end conditions based on a define position regardless of the position of the robot  When selecting RelativePlane: Every time the force guide sequence is executed, create Plane at a relative position from the current position and set as an end condition of position. As shown below, use this property for changing the end condition positions depending on the position at the start. 
PlaneNumber	Set Plane number which is used for end condition of positions. When PosCheckType is RobotPlane: End conditions based on the specified Plane number are set. When PosCheckType is RelativePlane: Every time the force guide sequence is executed, set Plane to the specified number newly. Set an empty Plane number.

Property	Description, setting guide
PlaneEndCond	Set a state of the end condition of positions. Set either Inside (inside the Plane) or Outside (outside of the Plane) as an end condition. When the robot will be the specified state, it is determined as the end conditions of the positions are satisfied. Inside: It is in +Z direction of Plane.  Inside Outside
PlaneRelativeOrg	Set which coordinate system direction is used as a reference when expressing the offset amount to the origin of Plane. The left figure below is an example to set Base. Specify a relative distance based on the Base coordinate system. It is an example that the negative value is set in PlaneRelativeZ. The right figure below is an example to set Tool. Specify a relative distance based on the Tool coordinate system. It is an example that the positive value is set in PlaneRelativeZ.  Base Tool The Local or Tool coordinate systems are used only in that direction and origin position does not affect. To set the position of an end condition in the robot motion direction, normally set the same value as ForceOrient of the force guide sequence.

Property	Description, setting guide
PlaneRelativeX PlaneRelativeY PlaneRelativeZ	Set offset amount in each direction from the current position to the origin of Plane. Direction will be the coordinate system direction specified by PlaneRelativeOrg.
PlaneRelativeOrient	Set a coordinate system based on the Plane direction. The left figure below is an example to set Base. Reference direction of the Plane matches the Base coordinate system regardless of the robot orientation at the start of the force guide object. The right figure below is an example to set Tool. Reference direction of the Plane changes along with the robot orientation at the start of the force guide object.  Ex. to set Base  Ex. to set Tool Since a plane which is perpendicular to the robot motion direction will be the end conditions, normally set the same value as ForceOrient of the force guide sequence.
PlaneAxes	Set a Plane direction Based on the coordinate system specified by PlaneRelativeOrient, plane is set to a direction set by PlaneAxes. The following figure is an example when Base is set by PlaneRelativeOrient. Left figure: specified XY by PlaneAxes Right figure: specified YZ by PlaneAxes.  XY  YZ Normally, set Plane which is perpendicular to the robot motion direction.

Property	Description, setting guide
PlaneRelativeRobotLocal	Set Local coordinate system number which is used when PlaneRelativeOrg or PlaneRelativeOrient are Local. Normally, set a value which is the same as RobotLocal of the force guide sequence.

Step 8. Set end conditions about I/O

Set properties (IOCheckEnabled, IOCheckInputBit, IOCheckInputStatus) related to the end conditions of I/O.

Property	Description, setting guide
IOCheckEnabled	This property sets whether to enable the end conditions of I/O. True : When the end conditions of I/O are enabled.
IOCheckInputBit	Set an input bit which is monitored as an end condition.
IOCheckInputStatus	Set a state of the input bit to be an end condition. If the input bit specified by IOCheckInputBit will be the state specified by IOCheckInputStatus, it is determined as the end conditions are satisfied.

Adjustment guideline for FollowMove object

The following describes the adjustment methods when using the FollowMove object.

When it takes time the force to be “0”:

This is the adjustments when the force is kept applying. It is an exception when the force is kept applying even the robot moves or the robot keeps moving to an object.

Decrease the Firmness value of each direction. However, the robot motion may be easy to vibrate. Please perform proper adjustments for your operations.

When the robot motion vibrates:

Increase the Firmness value. However, response of the robot will be slow.
Please perform proper adjustments for your operations.

To adjust the Firmness, we recommend increasing the value gradually (e.g. increase the value by 10%).

When the robot does not reach to the destination point (DestPoint):

If the direction where the force control functions are not enabled is not reached to the DestPoint, it may be affected by the LimitAccel or LimitSpeed of the force guide sequence. Increase the value.

Also, in low power mode, it is restricted according to the maximum speed or maximum acceleration of the low power mode even the value of LimitSpeed or LimitAccel is large. Be sure to execute in high power mode.

Details on properties of the FollowMove object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the FollowMove object, name is assigned automatically. Automatically assigned name is added a number after FollowMove (e.g. FollowMove01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program aborts force guide sequence and proceeds to the next SPEL statement if force guide object fails.
When specifying False, the program proceeds to the next force guide object without aborting the force guide sequence even if the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	Abort the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the force guide object execution.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.
It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.
It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF (set to 0) the specified output bit.
On	Turn ON (set to 1) the specified output bit.

Default: Off

MotionTrajectory Property

This property sets trajectory for force guide objects.

Value	Description
Straight	Move a straight trajectory.
Arc	Move an arc trajectory.

Default: Straight

AccelS Property

This property sets acceleration of force guide objects.
However, this set value is the acceleration for the set trajectory. The actual acceleration is adjusted by the force control functions.

	Value (unit: [mm/sec^2])
Minimum value	1
Maximum value	200

Default: 50

AccelR Property

This property sets rotation acceleration of force guide objects during the execution.
However, this set value is the rotation acceleration for the set trajectory. The actual rotation acceleration is adjusted by the force control functions.

	Value (unit: deg/sec^2])
Minimum value	1
Maximum value	100

Default: 10

SpeedS Property

This property sets speed of force guide objects during the execution.
However, this set value is the speed for the set trajectory. The actual speed is adjusted by the force control functions.

	Value (unit: [mm/sec])
Minimum value	1
Maximum value	200

Default: 50

SpeedR Property

This property sets rotation speed of force guide objects during the execution.
However, this set value is the rotation speed for the set trajectory. The actual rotation speed is adjusted by the force control functions.

	Value (unit: [deg/sec])
Minimum value	1
Maximum value	25

Default: 10

CPEnabled Property

Set enable/disable the path motion.

Use this property to synthesize the trajectory for multiple force guide objects with movement.

When specifying True, path motion is enabled and the program starts the next force guide object when entering into the slowdown zone.

When specifying False, path motion is disabled and the program starts the next force guide object after the set trajectory ends.

However, if the end conditions are set and achieved, the program pauses once when they are achieved and proceeds to the next force guide object.

Value	Description
True	Enable the path motion.
False	Disable the path motion.

Default: False

DestType Property

This property sets the method to specify a destination point of the trajectory.

When specifying RobotPoint, set the destination point on by point.
When specifying Relative, set a relative distance (e.g. 10mm from the start point to X direction).

Value	Description
RobotPoint	Set a destination point by point.
Relative	Set a destination point by relative distance.

Default: False

DestPoint Property

This property sets the point using for the destination point of the trajectory.
It is used when specifying RobotPoint in DestType.

	Value
Minimum value	0
Maximum value	999

Default: 0

MidPoint Property

This property sets a mid point using for the arc trajectory.
It is used when specifying Arc in MotionTrajectory and RobotPoint in DestType.

	Value
Minimum value	0
Maximum value	999

Default: 0

RelativeOrient Property

This property sets the coordinate system that moves relatively.
It is used when specifying Relative in DestType.

Value	Description
Base	Specify a relative distance based on the Base coordinate system.
Local	Specify a relative distance based on the Local coordinate system.
Tool	Specify a relative distance based on the Tool coordinate system.

Default: Tool

RelativeRobotLocal Property

This property sets the number of local coordinate system for the coordinate system that moves relatively.
It is used when specifying Relative in DestType and Local in RelativeOrient.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system). It is the same as when specifying Base in RelativeOrient
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

DestRelativeX Property

For the destination point, this property sets the moving amount in X direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeY Property

For the destination point, this property sets the moving amount in Y direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeZ Property

For the destination point, this property sets the moving amount in Z direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeU Property

For the destination point, this property sets the rotation amount in U direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

DestRelativeV Property

For the destination point, this property sets the rotation amount in V direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

DestRelativeW Property

For the destination point, this property sets the rotation amount in W direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

MidRelativeX Property

For the mid point, this property sets the moving amount in X direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

MidRelativeY Property

For the mid point, this property sets the moving amount in Y direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

MidRelativeZ Property

For the mid point, this property sets the moving amount in Z direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

MidRelativeU Property

For the mid point, this property sets the rotating amount in U direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

MidRelativeV Property

For the mid point, this property sets the rotating amount in V direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

MidRelativeW Property

For the mid point, this property sets the rotating amount in W direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.

It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

Fx_ControlMode Property

Set the control mode in Fx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fx direction are not executed. When specifying Follow, the force control functions to Fx direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be "0". Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed to perform the Follow motion.

Default: Disabled

Fx_Firmness Property

This property sets a firmness of force control functions in Fx direction during the execution of force guide object.
It is used when Fx_ControlMode is Follow.

When the value of Fx_Firmness increases, the force control function in Fx direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When Fx_Firmness decreases, the force control function in Fx direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fy_ControlMode Property

Set the control mode in Fy direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fy direction are not executed. When specifying Follow, the force control functions to Fy direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be "0". Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fy_Firmness Property

This property sets a firmness of force control functions in Fy direction during the execution of force guide object.
It is used when Fy_ControlMode is Follow.

When the value of Fy_Firmness increases, the force control function in Fy direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When Fy_Firmness decreases, the force control function in Fy direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fz_ControlMode Property

Set the control mode in Fz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fz direction are not executed. When specifying Follow, the force control functions to Fz direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be "0". Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fz_Firmness Property

This property sets a firmness of force control functions in Fz direction during the execution of force guide object.
It is used when Fz_ControlMode is Follow.

When the value of Fz_Firmness increases, the force control function in Fz direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When Fz_Firmness decreases, the force control function in Fz direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Tx_ControlMode Property

Set the control mode in Tx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Tx direction are not executed.
When specifying Follow, the force control functions to Tx direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”.
Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tx_Firmness Property

This property sets a firmness of force control functions in Tx direction during the execution of force guide object.
It is used when Tx_ControlMode is Follow.

When the value of Tx_Firmness increases, the force control function in Tx direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.
When Tx_Firmness decreases, the force control function to Tx direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Ty_ControlMode Property

Set the control mode in Ty direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, t the force control functions to Ty direction are not executed. When specifying Follow, the force control functions to Ty direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be "0". Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Ty_Firmness Property

This property sets a firmness of force control functions in Ty direction during the execution of force guide object.
It is used when Ty_ControlMode is Follow.

When the value of Ty_Firmness increases, the force control function in Ty direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.
When Ty_Firmness decreases, the force control function to Ty direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Tz_ControlMode Property

Set the control mode in Tz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Tz direction are not executed. When specifying Follow, the force control functions to Tz direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be "0". Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tz_Firmness Property

This property sets a firmness of force control functions in Tz direction during the execution of force guide object.
It is used when Tz_ControlMode is Follow.

When the value of Tz_Firmness increases, the force control function in Tz direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.
When Tz_Firmness decreases, the force control function to Tz direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended.
When the force guide sequence ends even if CFEnabled is True, the force control functions will end.

Value	Description
True	The force control functions are continue to the next force guide object even the force guide object is ended.
False	The force control functions will end when the force guide object is ended.

Default: False

EndCheckOperator Property

This property sets the combination conditions when using several end conditions of the force guide object.

When specifying AND, if all of the enabled end conditions are satisfied, the force guide object execution has been completed and it determined as succeeded.
When specifying OR, if all of the enabled end conditions are satisfied, the force guide object execution has been completed and it determined as succeeded.

Value	Description
OR	Combine as OR condition.
AND	Combine as AND condition.

Default: Disabled

PosCheckEnabled Property

This property sets the end conditions of the force guide object related to positions.

Value	Description
True	Enable the end conditions related to position.
False	Disable the end conditions related to position.

Default: False

PosCheckType Property

For the end conditions related to positions, this property sets whether to use Plane which is defined in advance or set a relative position from the start position of force guide object.

When specifying RobotPlane, set the end conditions by using the defined Plane.
When specifying RelativePlane, reset Plane to the relative position from the force guide object start position each time the force guide object is executed.

Value	Description
RobotPlane	Use the defined Plane as the end condition.
RelativePlane	Set Plane to the relative position and use it as the end condition.

Default: RobotPlane

PlaneNumber Property

This property sets the Plane number to be used of the end conditions related to positions.

When specifying RobotPlane in the PosCheckType property, Plane of the specified number will not be changed.
When specifying Relative in the PosCheckType property, redefine a new Plane to the specified number each time the force guide object is executed. Therefore, note that the original setting will be lost.

	Value
Minimum value	1
Maximum value	15

Default: 1

PlaneEndCond Property

For the end conditions related to positions, this property sets the conditions to be determined as an end.

Value	Description
Outside	Being outside of the Plane is an end condition.
Inside	Being inside of the Plane is an end condition.

Default: Inside

PlaneRelativeOrg Property

For the end conditions related to positions, this property specifies which coordinate system sets the relative position setting Plane.
It is used when RelativePlane is specified by PosCheckType.

Value	Description
Base	Specify a relative position based on the Base coordinate system.
Local	Specify a relative position based on the Local coordinate system. Local coordinate system number is specified by PlaneRelativeRobotLocal.
Tool	Specify a relative position based on the Tool coordinate system.

Default: Tool

PlaneRelativeX Property

For the end conditions related to positions, this property sets the relative position in X direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
X direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeY Property

For the end conditions related to positions, this property sets the relative position in Y direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Y direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeZ Property

For the end conditions related to positions, this property sets the relative position in Z direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Z direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeOrient Property

For the end conditions related to positions, this property sets the coordinate system to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on the axis specified by PlaneAxes in the coordinate system which is specified by PlaneRelativeOrient.

When specifying Base, Plane is set on the axis specified by PlaneAxes in the Base coordinate system.
When specifying Local, Plane is set on the axis specified by PlaneAxes in the Local coordinate system of the number specified by PlaneRelativeRobotLocal.
When specifying Tool, Plane is set on axis specified by PlaneAxes in the Tool coordinate system.

Value	Description
Base	Specify a Plane direction based on the Base coordinate system.
Local	Specify a Plane direction based on the Local coordinate system.
Tool	Specify a Plane direction based on the Tool coordinate system.

Default: Tool

PlaneAxes Property

For the end conditions related to positions, this property sets the axis to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on axis specified by PlaneAxes that is the coordinate system specified by PlaneRelativeOrient.

Value	Description
XY	Set Plane on the XY plane.
YZ	Set Plane on the YZ plane.
XZ	Set Plane on the XZ plane.

Default: XY

PlaneRelativeRobotLocal Property

For the end conditions related to positions, this property sets Local coordinate system number that specifies the relative position or direction of Plane.
It is used in either of the following cases:

- RelativePlane is specified by PosCheckType and Local is specified by PlaneRelativeOrg
- RelativePlane is specified by PosCheckType and and Local is specified by PlaneRelativeOrient.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system). It is the same as when specifying Base by PlaneRelativeOrg or PlaneRelativeOrient.
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

IOCheckEnabled Property

This property sets the end conditions of the force guide object related to I/O.

Value	Description
True	Enable the end conditions related to I/O.
False	Disable the end conditions related to I/O.

Default: False

IOCheckInputBit Property

This property sets the bit of determination target of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOCheckInputStatus Property

This property sets the determination conditions of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

According to the bit specified by IOCheckInputBit, it is determine as the end conditions are satisfied.

Value	Description
Off	When the input bit is OFF (0), it is determined as the end conditions are satisfied.
On	When the input bit is ON (1), it is determined as the end conditions are satisfied.

Default: Off

Details on results of the FollowMove object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.3 FollowMove Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz[N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

It is an average value of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PosCondOK Result

It is whether to satisfy the end conditions related to position.

Value	Description
True	Satisfy the end conditions related to position.
False	The end conditions related to position are not satisfied.

IOCondOK Result

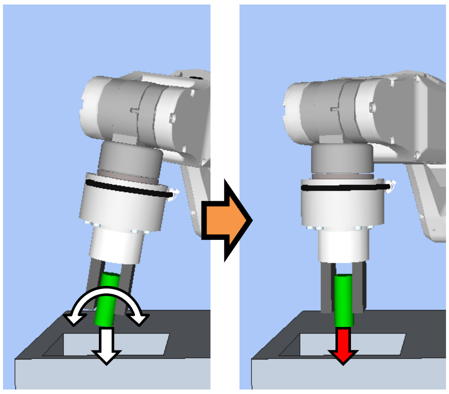
It is whether to satisfy the end conditions related to I/O.

Value	Description
True	Satisfy the end conditions related to I/O.
False	The end conditions related to I/O are not satisfied.

4.3.4 SurfaceAlign Object

SurfaceAlign object moves the robot to a position where the torque of the rotation direction will be “0” while the robot presses the workpiece to a specified direction. At this time, the workpiece surface grasped by the robot and the surface of the working desk or the workpiece on the working desk is parallel.

This object is used for positioning during assembly or stable placing of the workpiece. Stable contact status is provided even if the workpiece dimension or the grasped positions of the workpiece have a margin of error.



The above figure is an image of a motion by the SurfaceAlign object. As the white arrows show, the robot moves and presses to a downward direction and adjusts the orientation so that the applied torque will be “0”.

The SurfaceAlign object will be succeeded when the end conditions are satisfied within the specified time. It can use the end conditions related to force.
The end condition sets whether to use in ForceCheckEnabled. If no end condition is set, the object will always be succeeded.

End condition is as follows:

End condition	Success condition
End conditions related to force	Within the specified time of Timeout, keep satisfying the following two while the time specified by HoldTimeThresh. Force direction which is specified by PressOrient: The axis should be within the range of PressForce –PressCheckTolF to PressForce +PressCheckTolF. Torque in Follow direction specified by FollowOrient: The axis should be within the range of –FollowCheckTolT to +FollowCheckTolT.

Property setting guideline for SurfaceAlign object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	This property sets names of force guide objects. Set a particular name.
Description	This property sets descriptions about force guide objects. Describe the operation descriptions. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead..
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	Set whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

Step 2. Set I/O processing before starting

Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	When starting the force guide object, set the output bit to be operated.
IOPreprocOutputStatus	When starting the force guide object, set whether to turn ON or OFF the output bit. Set the state to be output.

Step 3. Set force control functions

Set properties (PressOrient, PressForce, PressFirmnessF, AlignOrient, AlignFirmnessT, CFEnabled) related to the force control functions.

Property	Description, setting guide
PressOrient	This property sets the direction to press. When aligning a surface by pressing the workpiece to be grasped to the object, set a perpendicular direction to the object surface.
PressForce	This property sets the force to press. When PressOrient is positive direction: Enter a negative value. When PressOrient is negative direction: Enter a positive value. Normally, approx. 3 to 5N is set. However, set a proper value for your workpiece. If the value is too small, the robot may not operate. If setting a small value, torque when pressing will be small and it may be difficult to align surfaces.
PressFirmnessF	Set a firmness of the force control functions to pressing direction. When the value increases, the force control function will become stronger and response to changes of the force is slow. When the value decreases, the force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.
AlignOrient	Rotational direction for aligning surfaces. It is changed automatically according to PressOrient. Read only. You cannot change this. Rotate around two translational directions which are not set by PressOrient. For example, when specifying +Fz or –Fz in PressOrient, Tx and Ty (rotation around Fx and Fy) will be AlignOrient.
AlignFirmnessT	Set a firmness of the force control functions to the rotational direction. When the value increases, the force control function will become stronger and response to changes of the torque is slow. When the value decreases, the force control function will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object. True : When you want to execute the next force guide object with remaining steady force after aligning the surface: The next force guide object must maintain the force control in the direction set in PressOrient and AlignOrient.

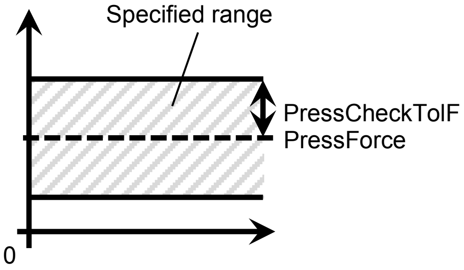
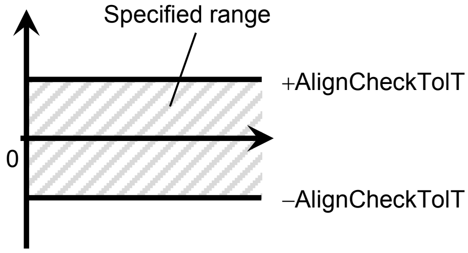
Step 4. Set basic information for end conditions

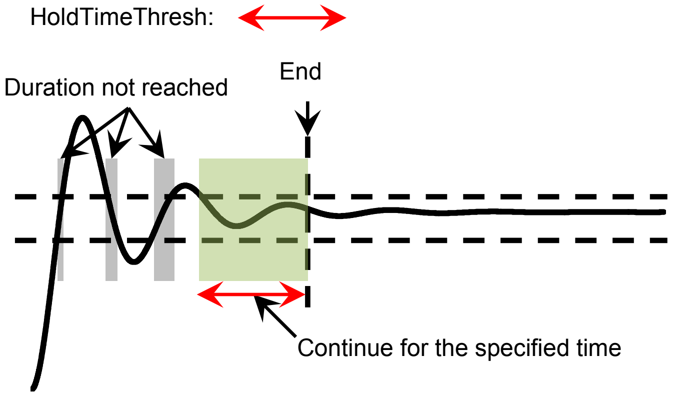
Set property (Timeout) related to time-out.

Property	Description, setting guide
Timeout	This property sets the time-out period. When the end conditions are not set: Time-out period is the execution time. When the end conditions are set: Fails when the end conditions are not satisfied within the specified time.

Step 5. Set conditions about force

Set properties (ForceCheckEnabled, PressCheckTolF, AlignCheckTolT, HoldTimeThresh) related to the end conditions of force.

Property	Description, setting guide
ForceCheckEnabled	This property sets whether to enable the end conditions of force. True : When the end conditions of force are enabled.
PressCheckTolF	Range of the translational direction of the end conditions related to force. Set a range of the end conditions of force. Monitor that the force direction specified by PressOrient is within the range of PressForce −PressCheckTolF to PressForce +PressCheckTolF. 
AlignCheckTolT	Range of the rotational direction of the end conditions related to force. Set a range of the end conditions of force. Monitor that the force in two directions specified by AlignOrient is within the range of −AlignCheckTolT to +AlignCheckTolT. 

Property	Description, setting guide
HoldTimeThresh	Set the duration time which is used to determine whether the end conditions have satisfied. As shown below, if the specified condition continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.  Normally, set to “0”. Set the time for stabilizing the motion when the motion is unstable (e.g. tilt is not aligned after aligning surface). We recommend setting the time according to the actual result which is executed after temporarily disabling the end conditions.

Adjustment guideline for SurfaceAlign object

The following describes the adjustment methods when using the SurfaceAlign object.

When it takes time to align a surface:

Decrease the value of FollowFirmnessT or increase the value of PressForce.

However, decreasing the value of FollowFirmnessT may result in the vibration of the robot motion. Please perform proper adjustments for your operations.

To adjust the FollowFirmnessT, we recommend adjusting the value gradually (e.g. change the value by 10%).

If increasing the value of PressForce, applied force to workpiece will be large. Set a proper value for your workpiece.

If the contact surface of the workpiece is small, torque when pressing will be small. If the torque is small, rotational speed will be slow depending on the force control functions. Therefore, even adjusting the above two properties, the operation will not be able to finish in the specified time.

When the robot motion vibrates:

Increase the PressFirmnessF or FollowFirmnessT value.
Adjust Firmness value in the direction where is vibrating.
However, response of the robot will be slow. Please perform proper adjustments for your operations.

To adjust the Firmness, we recommend increasing the value gradually (e.g. increase the value by 10%).

When the robot bounces largely in the pressing direction:

If the robot repeatedly bounces largely in a few seconds, the robot motion may be restricted by LimitAccelS of the force guide sequence.

Also, it likely to happen during the execution in low power mode.

If the robot still bounces even executing in high power mode, increase the value of LimitAccelS.
If the robot still bounces, decrease the value of PressFirmness.

When the SurfaceAlign object ends when aligning a surface:

If the specified time is not enough, increase the value of Timeout.

When the end conditions are satisfied even the surface is not aligned, decrease the value of FollowCheckTolT.
If it does not work, set HoldTimeThresh.

If the contact surface of the workpiece is small, torque when pressing will be small. Therefore, the object will be within the range specified by FollowCheckTolT even the surfaces are not aligned. In this case, decrease the value of FollowCheckTolT or Disabled the ForceCheckEnabled. Please consider to manage by the execution time specified by Timeout.

Details on properties of the SurfaceAlign object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the SurfaceAlign object, name is assigned automatically. Automatically assigned name is added a number after SurfAlign (e.g. SurfAlign01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program ends force guide sequence and proceeds to the next SPEL statement if force guide object fails.
When specifying False, the program proceeds to the next force guide object without ending the force guide sequence even if the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	End the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the force guide object execution.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.
It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.
It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF the specified output bit. (Set to 0)
On	Turn ON the specified output bit. (Set to 1)

Default: Off

PressOrient Property

This property sets the direction to press.

Set the direction in the coordinate system specified by ForceOrient of the force guide sequence. You can select from translation direction (+Fx to −Fz). The robot moves to the specified direction and presses.

Value	Description
+Fx	Move to the positive direction in Fx.
–Fx	Move to the negative direction in Fx.
+Fy	Move to the positive direction in Fy.
–Fy	Move to the negative direction in Fy.
+Fz	Move to the positive direction in Fz.
–Fz	Move to the negative direction in Fz.

Default: +Fz

PressForce Property

This property sets the force to press.

The robot presses to be the force specified by the PressForce property in PressOrient direction during the execution of SurfaceAlign object.
When pressing to positive direction, value will be negative.
When pressing to negative direction, value will be positive.

When PressOrient is positive direction:

	Value (unit: [N])
Minimum value	–50
Maximum value	0

When PressOrient is negative direction:

	Value (unit: [N])
Minimum value	0
Maximum value	50

Default: −5

PressFirmnessF Property

This property sets a gain that indicates a firmness of force control functions to pressing direction during the execution of SurfaceAlign object.

When the value of PressFirmnessF increases, the force control function will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When the value of PressFirmnessF decreases, the force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

AlignFirmnessT Property

This property sets a gain that indicates a firmness of force control functions to following direction during the execution of SurfaceAlign object.

When AlignFirmnessT increases, the force control function will become stronger.
Response to changes of the torque is slow, however, vibration does not occur.
When the value of AlignFirmnessT decreases, the force control function will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended.
When the force guide sequence ends even if CFEnabled is True, end the force control functions.

Value	Description
True	The force control functions are continue to the next force guide object even the force guide object is ended.
False	The force control functions will end when the force guide object is ended.

Default: False

ForceCheckEnabled Property

This property sets the end conditions of the force guide object related to force.

Value	Description
True	Enable the end conditions related to force.
False	Disable the end conditions related to force.

Default: False

PressCheckTolF Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True.
It determines that the force of the direction specified by PressOrient property enters into a range from PressForce −PressCheckTolF to PressForce +PressCheckTolF.

	Value (unit: [N])
Minimum value	0.1
Maximum value	10

Default: 1

AlignCheckTolT Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True.

It determines that the force of the direction specified by AlignOrient property enters into a range from −AlignCheckTolT to +AlignCheckTolT.

	Value (unit: [N·mm])
Minimum value	100
Maximum value	10000

Default: 500

HoldTimeThresh Property

This property sets the duration time until the determination of the end conditions related to force. It is used when ForceCheckEnabled is True.

If the state within the range specified by either PressCheckTolF or AlignCheckTolT continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.

	Value (unit: [sec])
Minimum value	0
Maximum value	10

Default: 0

Timeout Property

This property sets the time-out period of the force guide object.

When it is not satisfied conditions enabled in ForceCheckEnabled even if exceeding the time specified by Timeout, it is determined as failure of SurfaceAlign object object.

After the determination, end the force guide sequence or proceed to the next force guide object according to AbortSeqOnFail.

When ForceCheckEnabled is False, end the force guide object after time specified by Timeout is passed. Determine as succeeded and proceed to the next force guide object.

	Value (unit: [sec])
Minimum value	0.1
Maximum value	60

Default: 10

Details on results of the SurfaceAlign object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.4 SurfaceAlign Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

TimedOut Result

It is whether the time-out period set in Timeout property had been reached.

Value	Description
True	Reached to the time-out period.
False	End before reaching to the time-out period.

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz[N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

Average values of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

ForceCondOK Result

It is whether to satisfy the end conditions related to force.

Value	Description
True	Satisfy the end conditions related to force.
False	The end conditions related to force are not satisfied.

TriggeredForces Result

It is the force and torque when satisfying the end conditions related to force. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredPos Result

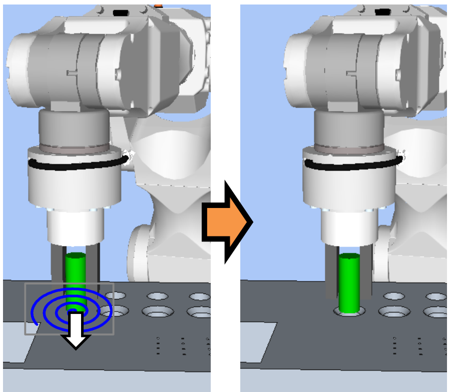
Positions when satisfying the end conditions related to force. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

4.3.5 PressProbe Object

PressProbe object presses the workpiece grasped by the robot to the working desk or a workpiece on the working desk. Then, the robot moves along the specified trajectory and stop when a hole or a convex shape is detected.

This object is used for detection of fitting holes or positioning during assembly. Hole position or a convex shape can be detected stably even if the workpiece dimension or the grasp position of the workpiece have a margin of error. We recommend using this object after Contact object, SurfaceAlign object, and Press object.



The above figure is an image of a motion by the PressProbe object. From the contact state, the robot presses to a downward (white arrow) direction and moves along the blue trajectory to probe a hole.

The PressProbe object will be succeeded when the end conditions are satisfied while the robot moves the specified trajectory. The PressProbe object can use the end conditions related to force and position.

Each end condition sets whether to use in ForceCheckEnabled or PosCheckEnabled. More than one end condition is required for the PressProbe object. When several end conditions are set, you can select how to combine the end conditions from AND or OR in EndCheckOperator.

Each condition is as follows:

End condition	Success condition
End conditions related to force	Satisfy either one of the following before the robot moves the specified trajectory: When ProbeDetectType is Hole, and PressOrient is Fx, Fy, Fz: Force in the specified direction exceeds ProbeDetectThresh. When ProbeDetectType is Hole, and PressOrient is −Fx, −Fy, −Fz : Force in the specified direction is less than ProbeDetectThresh. When ProbeDetectType is Obstacle: The square root of the sum of the squares of the force that is not specified by PressOrient exceeds ProbeDetectThresh (e.g.: When pressing to +Fz direction, sqr(Fx*Fx+Fy*Fy) exceeds ProbeDetectThresh.)
End conditions related to positions	Satisfy either one of the following before the robot moves the specified trajectory: When PosCheckType is RobotPlane: Satisfy the state set by PlaneEndCondition for Plane set by PlaneNumber. When PosCheckType is RelativePlane: Satisfy the state set by PlaneEndCondition for the relative plane set by PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrg, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLocal.

Property setting guideline for PressProbe object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	This property sets names of force guide objects. Set a particular name.
Description	This property sets descriptions about force guide objects . Describe the operation descriptions. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead..
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	Set whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included, or the force guide sequence will be able to continue.

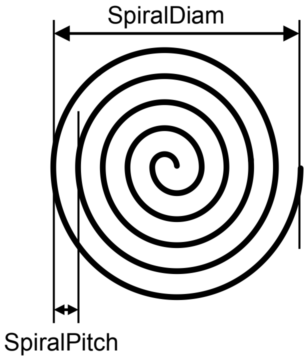
Step 2. Set I/O processing before starting

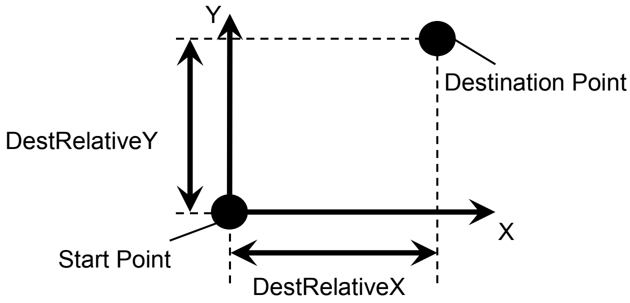
Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	When starting the force guide object, set the output bit to be operated.
IOPreprocOutputStatus	When starting the force guide object, set whether to turn ON or OFF the output bit. Set the state to be output.

Step 3. Set a probe motion

Set properties (ProbeTrajectory, ProbeDetectType, AccelS, SpeedS, SpiralDiam, SpiralPitch, DestRelativeX, DestRelativeY, DestRelativeZ) related to the probe motion.

Property	Description, setting guide
ProbeTrajectory	Set a trajectory to probe. Select from the following depending on the detection target. Spiral trajectory : When a detection target is a hole Straight line trajectory : When a detection target is an obstacle Straight : When it is clear that the target is on the specified straight line. Spiral : When the target is not on the specified straight line.
ProbeDetectType	Set a target to be detected. You can select a hole and an obstacle. The obstacle is a convex shape on the plane to probe.
AccelS	Set the translational acceleration of the movement. Actual translational acceleration is adjusted by the force control functions.
SpeedS	Set the speed of the movement. Actual speed is adjusted by the force control functions.
SpiralDiam SpiralPitch	Set a diameter and pitch of the spiral trajectory.  SpiralDiam : Set a value which is added a margin to the maximum value of the distance from the start point to the detection target (positional variations are included). Example: Value: 1.1 times larger than the maximum value SpiralPitch : Set a value that does not pass through the detection target. When detecting a hole, set a smaller value than the minimum interval between the holes.

Property	Description, setting guide
DestRelativeX DestRelativeY DestRelativeZ	Set a relative movement amount to each direction from the start point of the force guide object to the destination point. As shown below, set the movement amount in the coordinate system specified by ForceOrient of the force guide sequence. 

Step 4. Set force control functions

Set properties (PressOrient, PressForce, PressFirmnessF, CFEnabled) related to the force control functions.

Property	Description, setting guide
PressOrient	Direction to press. Set a vertical direction to a probe plane. To probe a detection target, move the robot along with the trajectory specified at Step.3 while pressing to the specified direction.
PressForce	This property sets the pressing force. When PressOrient is positive direction: Enter a negative value. When PressOrient is negative direction: Enter a positive value. Normally, approx. 3 to 5N is set. However, set a proper value for your workpiece. If the value is too small, the robot may move away from the probe plane.
PressFirmnessF	Set a firmness of the force control functions to pressing direction. When the value increases, the force control function will become stronger and response to changes of the force is slow. When the value decreases, the force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object. True : When you want to execute the next force guide object with maintaining a steady force even the target is detected: The next force guide object must maintain the force control in the direction set in ContactOrient.

Step 5. Set basic information for end conditions

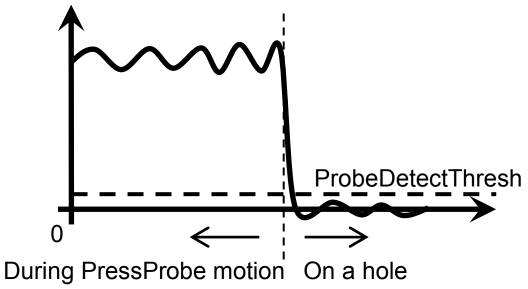
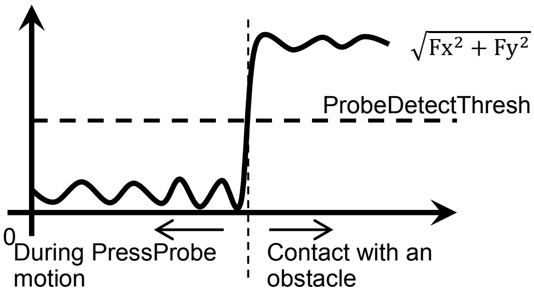
Set property (EndCheckOperator) related to combinations of end conditions.

Property	Description, setting guide
EndCheckOperator	This property sets how to combine the end conditions related to force and position. AND : End when the both conditions are satisfied. OR : End when the more than one condition is satisfied.

Step 6. Set end conditions about force

Set properties (ForceCheckEnabled, ProbeDetectThresh) related to the end conditions of force.

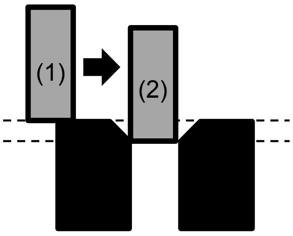
Property	Description, setting guide
ForceCheckEnabled	This property sets whether to enable the end conditions related to force. You need to enable ForceCheckEnabled and/or PosCheckEnabled in the PressProbe object. True : When enabling the end conditions related to force Select when ProbeDetectType is Obstacle. When ProbeDetectType is Hole, select True if necessary.

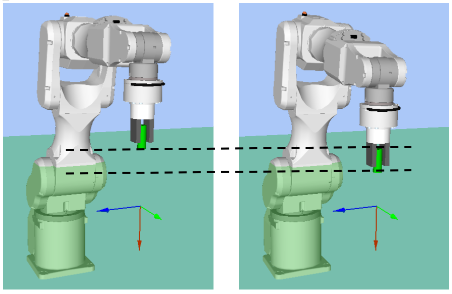
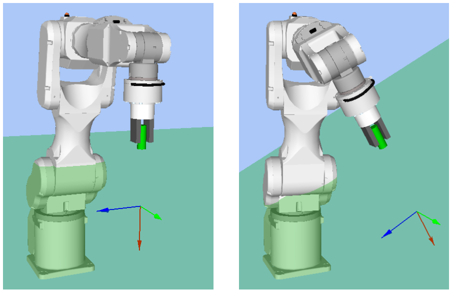
Property	Description, setting guide
ProbeDetectThresh	Set a threshold to determine that the target is detected. When ProbeDetectType is Hole: Threshold for the direction specified by PressOrient When PressOrient is positive direction: Set a negative value. When PressOrient is negative direction: Set a positive value. The following graph is an example to set a negative direction by PressOrient. Force is applied while the robot presses on the probe plane. However, when the robot moves above the hole, it will be the non-contact state and the absolute value of the force will be smaller.  When ProbeDetectType is Obstacle: Threshold for the square root of the sum of the squares to the two directions which are not specified by PressOrient Set a positive value. The following graph is an example to set –Fz direction by PressOrient. During the motion to Fx direction and the probe motion, small force is detected due to friction for the probe plane. When contacting with an obstacle, large force is detected. 

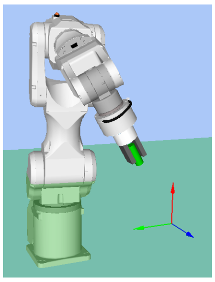
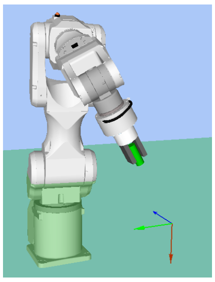
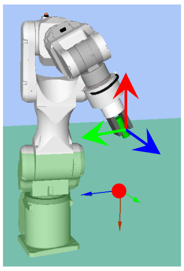
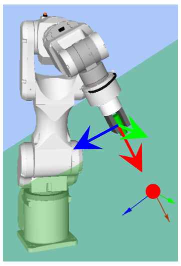
Property	Description, setting guide
	When detecting a hole: Normally, set “0”. When the force will not be “0” even the robot moves above the hole: Set a value which is small enough to the absolute value of the force during the probe motion. When detecting an obstacle: Set a value which is large enough to the force during the probe motion and smaller than the force when contacting.

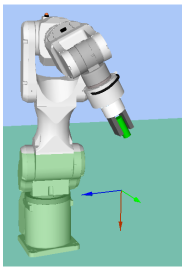
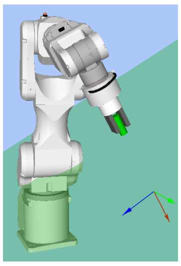
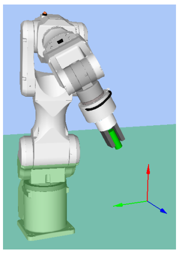
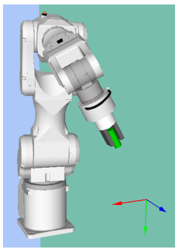
Step 7. Set end conditions related position

Set properties (PosCheckEnabled, PosCheckType, PlaneNumber, PlaneEndCond, PlaneRelativeOrg, PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLoca) related to the end conditions of the positions.

Property	Description, setting guide
PosCheckEnabled	This property sets whether to enable the end conditions of positions. You need to enable ForceCheckEnabled and/or PosCheckEnabled in the PressProbe object. This property may be used when ProbeDetectType is Hole. Normally, this property is not used when ProbeDetectType is Obstacle. As shown below, to detect a hole, you can make it an end condition that the robot moves to the hole direction by a certain distance from the probe plane.  True : When the end conditions of positions are enabled.

Property	Description, setting guide
PosCheckType	Select types of the end conditions related to positions. When selecting RobotPlane: End conditions are based on the set Plane. As shown below, use this property for setting the end conditions based on a define position regardless of the position of the robot.  When selecting RelativePlane: Every time the force guide sequence is executed, create Plane at a relative position from the current position and set as an end condition of position. As shown below, use this property for changing the end condition positions depending on the position at the start.  In PressProbe, we recommend using RelativePlane.
PlaneNumber	Set Plane number which is used for end condition of positions. When PosCheckType is RobotPlane: End conditions based on the specified Plane number are set. When PosCheckType is RelativePlane: Every time the force guide sequence is executed, set Plane to the specified number newly. Set an empty Plane number.

Property	Description, setting guide
PlaneEndCond	Set a state to be an end condition of positions. Set either Inside (inside the Plane) or Outside (outside of the Plane) as an end condition. When the robot will be the specified state, it is determined as the end conditions of the positions are satisfied. Inside: It is in +Z direction of Plane.  Inside  Outside
PlaneRelativeOrg	Set which coordinate system direction is used as a reference when expressing the offset amount to the origin of Plane. The left figure below is an example to set Base. Specify a relative distance based on the Base coordinate system. It is an example that the negative value is set in PlaneRelativeZ. The right figure below is an example to set Tool. Specify a relative distance based on the Tool coordinate system. It is an example that the positive value is set in PlaneRelativeZ.  Base  Tool The Local or Tool coordinate systems are used only in that direction and origin position does not affect. To set the position of an end condition in the robot motion direction, normally set the same value as ForceOrient of the force guide sequence.

Property	Description, setting guide
PlaneRelativeX PlaneRelativeY PlaneRelativeZ	Set offset amount in each direction from the current position to the origin of Plane. Direction will be the coordinate system direction specified by PlaneRelativeOrg.
PlaneRelativeOrient	Set a coordinate system based on the Plane direction. The left figure below is an example to set Base. Reference direction of the Plane matches the Base coordinate system regardless of the robot orientation at the start of the force guide object. The right figure below is an example to set Tool. Reference direction of the Plane changes along with the robot orientation at the start of the force guide object.  Example to set Base  Example to set Tool Since a plane which is perpendicular to the robot motion direction will set as the end condition, normally set the same value as ForceOrient of the force guide sequence.
PlaneAxes	Set a Plane direction Based on the coordinate system specified by PlaneRelativeOrient, plane is set to a direction set by PlaneAxes. The following figure is an example when Base is set by PlaneRelativeOrient. Left figure : specified XY by PlaneAxes Right figure : specified YZ by PlaneAxes.  XY  YZ Normally, PressProbe sets a vertical plane to the direction specified by PressOrient.

Property	Description, setting guide
PlaneRelativeRobotLocal	Set Local coordinate system number which is used when PlaneRelativeOrg and PlaneRelativeOrient are Local. Normally, set a value which is the same as RobotLocal of the force guide sequence.

Adjustment guideline for PressProbe object

The following describes the adjustment methods when using the PressProbe object.

When the robot motion vibrates:

Increase the PressFirmnessF value. However, response of the robot will be slow. Please perform proper adjustments for your operations.

To adjust the PressFirmnessF, we recommend increasing the value gradually (e.g. increase the value by 10%).

When the robot bounces largely in the pressing direction:

If the robot repeatedly bounces largely in a few seconds, the robot motion may be restricted by LimitAccelS of the force guide sequence.

Also, it likely to happen during the execution in low power mode.

If the robot still bounces even executing in high power mode, increase the value of LimitAccelS.
If the robot still bounces, decrease the value of PressFirmnessF.

When the robot does not move along the specified trajectory:

If the robot does not move along the specified trajectory, it may be affected by the LimitAccel or LimitSpeed of the force guide sequence. Increase those values.

Also, in the low power mode, the robot is restricted by the maximum speed or maximum acceleration of the low power mode even the value of LimitSpeed or LimitAccel is large. Be sure to execute in high power mode.

When the robot passes through a hole:

Decrease a value of SpiralPitch. However, it takes more time to probe the specified range. Please perform proper adjustments for your operations.

When the end conditions related force are used:
Check the force in the direction specified by PressOrient during the execution.

When there is a difference between the applied force when the robot moves on the probe plane and the applied force when the robot moves above the hole:

Adjust ProbeDetectThresh to a value which is smaller than the force while the robot moves on the probe plane and larger than the force while the robot moves above the hole.

When the end conditions related to position are used:
Check the robot position when the robot passes through the hole.

When there is a difference between the position when the robot moves on the probe plane and the position when the robot moves above the hole:
Adjust Plane to be between these two positions.

When PosCheckType is RobotPlane:
Adjust Plane set by PlaneNumber.

When PosCheckType is RelativePlane:
Adjust plane positions by PlaneRelativeX, PlaneRelativeY, and PlaneRelativeZ.

When the robot moves away from the target during the probe motion.

Check whether the PressOrient is correct.

When the PressOrient is correct, increase an absolute value of PressForce.

However, the specified force is applied to the workpiece. Be sure to set a proper value for your workpiece.

When it takes time:

Increase the values of SpeedS and AccelS.

However, the applied force to the workpiece will easy to vibrate. Please perform proper adjustments for your operations.

Also, adjust the start position of PressProbe object to the hole position as close as possible.

When the probe motion speed is slow:

Increase the values of SpeedS and AccelS.

However, the applied force to the workpiece will easy to vibrate. Please perform proper adjustments for your operations.

Details on properties of the PressProbe object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the PressProbe object, name is assigned automatically. Automatically assigned name is added a number after PressProbe (e.g. PressProbe01).

You can change the name. Set up 16 characters at the maximum. E Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program ends force guide sequence and proceeds to the next SPEL statement if force guide object fails.
When specifying False, the program proceeds to the next force guide object without aborting the force guide sequence even if the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. include the recovery processes in the force guide sequence when the force guide object fails.)

Value	Description
True	Abort the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the force guide object execution.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.

It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.

It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF the specified output bit. (Set to 0)
On	Turn ON the specified output bit. (Set to 1)

Default: Off

ProbeTrajectory Property

This property sets trajectory for force guide objects.

Value	Description
Straight	The robot moves along the straight line trajectory and stops at a hole or an obstacle.
Spiral	The robot moves along the spiral line trajectory and stops at a hole or an obstacle.

Default: Straight

ProbeDetectType Proeprty

This property sets a target type to be detected by PressProbe object.

Value	Description
Hole	Detect a hole on the trajectory to probe.
Obstacle	Detect an obstacle (convex shape) on the trajectory to probe.

Default: Hole

AccelS Property

This property sets acceleration when moving the specified trajectory.

	Value (unit: [mm/sec^2])
Minimum value	1
Maximum value	200

Default: 10

SpeedS Property

This property sets acceleration when moving the specified trajectory.

	Value (unit: [mm/sec])
Minimum value	1
Maximum value	50

Default: 10

SpiralDiam Property

Set a diameter of the spiral trajectory.

This property is used when Spiral is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	1
Maximum value	100

Default: 10

SpiralPitch Property

This property sets a pitch of the spiral trajectory.

This property is used when Spiral is specified by ProbeTrajectory property.

When decreasing SpiralPitch, spirals to probe are increased in the same range. Therefore, a risk that the robot passes through the target and cannot detect it is reduced, but more time is required for probing.
When increasing SpiralPitch, spirals to probe are decreased in the same range. Therefore, a risk that the robot passes through the target and cannot detect it is increased, but the required time for probing is reduced.

	Value (unit: [mm])
Minimum value	0.05
Maximum value	10

Default: 1

DestRelativeX Property

For the straight line trajectory, this property sets a moving amount to X direction in the coordinate system which is specified by ForceOrient and RobotLocal of force guide sequence.

This property is used when Straight is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeY Property

For the straight line trajectory, this property sets a moving amount to Y direction in the coordinate system which is specified by ForceOrient and RobotLocal of force guide sequence.

This property is used when Straight is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeZ Property

For the straight line trajectory, this property sets a moving amount to Z direction in the coordinate system which is specified by ForceOrient and RobotLocal of force guide sequence.

This property is used when Straight is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PressOrient Property

This property sets the direction to press. Set which direction in the coordinate system specified by ForceOrient of the force guide sequence.

You can select from translation direction (+Fx to −Fz). The robot moves along the specified trajectory while pressing to a define direction. In the spiral trajectory, generate a spiral trajectory on the plane which is perpendicular to the specified direction.

Value	Description
+Fx	Move to the positive direction in Fx.
−Fx	Move to the negative direction in Fx.
+Fy	Move to the positive direction in Fy.
−Fy	Move to the negative direction in Fy.
+Fz	Move to the positive direction in Fz.
−Fz	Move to the negative direction in Fz.

Default: +Fz

PressForce Property

This property sets the force to press.

The robot probes while pressing to be the force specified by the PressForce property in PressOrient direction during the execution of PressProbe object.

When pressing to positive direction, value will be negative.
When pressing to negative direction, value will be positive.

When PressOrient is positive direction:

	Value (unit: [N])
Minimum value	−10
Maximum value	0

Default: −5

When PressOrient is negative direction:

	Value (unit: [N])
Minimum value	0
Maximum value	10

Default: −5

PressFirmnessF Property

This property sets a firmness of force control functions to the pressing direction during the execution of PressProbe object.

When the value of PressFirmnessF increases, the force control function will become stronger. Response to changes of the force is slow, however, vibration does not occur.
When the value of PressFirmnessF decreases, the force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended.
When the force guide sequence ends even CFEnabled is set to True, end the force control functions.

Value	Description
True	The force control functions continue to the next force guide object even the force guide object is ended.
False	The force control functions will end when the force guide object is ended.

Default: False

ForceCheckEnabled Property

This property sets the end conditions of the force guide object related to force.

The end conditions related to force is the conditions specified by ProbeDetectThresh.

Value	Description
True	Enable the end conditions related to force.
False	Disable the end conditions related to force.

Default: False

ProbeDetectThresh Property

For the end conditions related to force, this property sets a threshold to be determined as "detected".

When specifying Obstacle by ProbeDetectType:
Set a positive value. At this time, the following will be an end condition of the force.
The square root of the sum of the squares of the force in the direction that is not specified by PressOrient (e.g.: sqrt(Fx*Fx+Fy*Fy) when selecting –Fz) exceeds the value specified by ProbeDetectThresh.
When specifying Hole by ProbeDetectType and Fx, Fy, or Fz by PressOrient:
Set a negative value. At this time, an end condition of the force is that the force in the direction specified by PressOrient is less than the value specified by ProbeDetectThresh.

When specifying Hole by ProbeDetectType and –Fx, –Fy, or –Fz by PressOrient
Set a positive value. At this time, an end condition of the force is that the force in the direction specified by PressOrient exceeds the value specified by ProbeDetectThresh.

When ProbeDetectType is Hole, and PressOrient is the positive direction.

	Value (unit: [N])
Minimum value	–50
Maximum value	0

Default: 0

When ProbeDetectType is Press, or PressOrient is the negative direction:

	Value (unit: [N])
Minimum value	0
Maximum value	50

Default: 0

PosCheckEnabled Property

This property sets the end conditions of the force guide object related to I/O.

Value	Description
True	Enable the end conditions related to position.
False	Disable the end conditions related to position.

Default: False

PosCheckType Property

For the end conditions related to positions, this property sets whether to use Plane which is defined in advance or set a relative position from the start position of force guide object.

When specifying RobotPlane, set the end conditions by using the defined Plane.
When specifying RelativePlane, reset Plane to the relative position from the force guide object start position each time the force guide object is executed.

Value	Description
RobotPlane	Use the defined Plane as the end condition.
RelativePlane	Set Plane to the relative position and use it as the end condition.

Default: RobotPlane

PlaneNumber Property

This property sets the Plane number to be used for the end conditions related to positions.

When specifying Plane in thePosCheckType property, Plane of the specified number will not be changed.
When specifying Relative in the PosCheckType property, redefine a new Plane to the specified number each time the force guide object is executed. Therefore, note that the original setting will be lost.

	Value
Minimum value	1
Maximum value	15

Default: 1

PlaneEndCond Property

For the end conditions related to positions, this property sets the conditions to be determined as an end.

Value	Description
Outside	Being outside of the Plane is an end condition.
Inside	Being inside of the Plane is an end condition.

Default: Inside

PlaneRelativeOrg Property

For the end conditions related to positions, this property specifies which coordinate system sets the relative position to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Value	Description
Base	Specify a relative position based on the Base coordinate system.
Local	Specify a relative position based on the Local coordinate system. Local coordinate system number is specified by PlaneRelativeRobotLocal.
Tool	Specify a relative position based on the Tool coordinate system.

Default: Tool

PlaneRelativeX Property

For the end conditions related to positions, this property sets the relative position in X direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
X direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeY Property

For the end conditions related to positions, this property sets the relative position in Y direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Y direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeZ Property

For the end conditions related to positions, this property sets the relative position in Z direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Z direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeOrient Property

For the end conditions related to positions, this property sets the coordinate system to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on axis specified by PlaneAxes that is on the coordinate system specified by PlaneRelativeOrient.

When specifying Base, Plane is set on axis specified by PlaneAxes on the Base coordinate system.
When specifying Local, Plane is set on the axis specified by PlaneAxes on the Local coordinate system of the number specified by PlaneRelativeRobotLocal.
When specifying Tool, Plane is set on axis specified by PlaneAxes on the Tool coordinate system.

Value	Description
Base	Specify a Plane direction based on the Base coordinate system.
Local	Specify a Plane direction based on the Local coordinate system.
Tool	Specify a Plane direction based on the Tool coordinate system.

Default: Tool

PlaneAxes Property

For the end conditions related to positions, this property sets the axis to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on axis specified by PlaneAxes that is on the coordinate system specified by PlaneRelativeOrient.

Value	Description
XY	Set Plane on the XY plane.
YZ	Set Plane on the YZ plane.
XZ	Set Plane on the XZ plane.

Default: XY

PlaneRelativeRobotLocal Property

For the end conditions related to positions, this property sets Local coordinate system number that specifies the relative position or direction of Plane.
It is used in either of the following cases:

- RelativePlane is specified in PosCheckType and Local is specified in PlaneRelativeOrg
- RelativePlane is specified in PosCheckType and and Local is specified in PlaneRelativeOrient.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system). It is the same as when specifying Base in PlaneRelativeOrg or PlaneRelativeOrient.
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

Details on results of the PressProbe object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.5 PressProbe Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

Time for execution.

Unit: [sec]

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz[N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

Average values of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

ForceCondOK Result

It is whether to satisfy the end conditions related to force.

Value	Description
True	Satisfy the end conditions related to force.
False	The end conditions related to force are not satisfied.

TriggeredForces Result

It is the force and torque when satisfying the end conditions related to force. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredPos Result

Positions when satisfying the end conditions related to force. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

PosCondOK Result

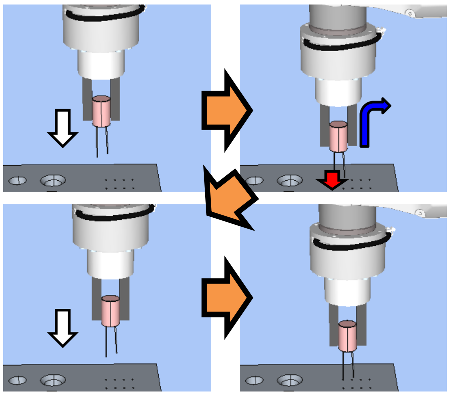
It is whether to satisfy the end conditions related to position.

Value	Description
True	Satisfy the end conditions related to position.
False	The end conditions related to position are not satisfied.

4.3.6 ContactProbe Object

ContactProbe object moves the robot to the specified direction until it contacts with an object such as a workpiece, and detects a position that is moved for a specified distance as a hole. If the robot contacts with an object without moving the specified distance, returns to the start position and changes the position and repeat the contact motion

This object is used for the hole position detection of workpiece that is difficult to be detected by PressProbe (e.g. a lead part or a connector). Even the workpiece dimension or the grasp position of the workpiece have a margin of error, the hole position can be detected stably.



The above figure is an image of a motion by the ContactProbe object. The robot moves from the non-contact state to a downward direction (white arrow). When the applied force (red arrow) is detected after the robot contacts with an object, it moves to the next start position of the contact (blue arrow). Repeat these motions to probe a hole.

The ContactProbe object will be succeeded when the end conditions of the positions are satisfied within the specified time in single contact motion. The ContactProbe object always uses the end conditions related to force and position.

When the end conditions related to the force is satisfied in single contact motion:
Determined as that there is no hole at this position and the robot moves to the next contact position.

When the end conditions related to the position is satisfied in single contact motion:
Determined as a hole position and the detection had succeeded.

When the both end conditions related to the force and position are not satisfied during single contact motion.
Detection has failed due to an error state (the robot does not contact with an object and movement amount is not enough).

Each condition is as follows:

End condition	Success condition
End conditions related to force	During single contact motion, the absolute value of the force in the specified direction does not exceed that of ContactForceThresh until the end conditions related to position are satisfied. If exceeding the absolute value, the robot determines as “contacted” (= position where has no holes) and moves to the next contact position to start next contact motion.
End conditions related to positions	Satisfy either one of the following within the specified time of Timeout during a contact motion: When PosCheckType is RobotPlane: Satisfy the state set by PlaneEndCondition for Plane set by PlaneNumber. When PosCheckType is RelativePlane: Move ContactDist + ContactDistMargin in ContactOrient direction.

Property setting guideline for ContactProbe object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	Name of the force guide object. Set a particular name.
Description	Descriptions for force guide object. Describe the operations. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead..
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	Set whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

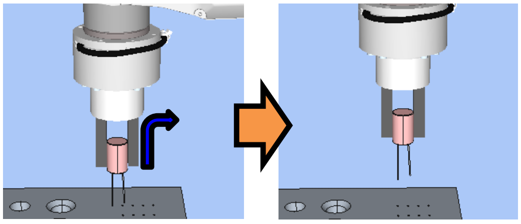
Step 2. Set I/O processing before starting

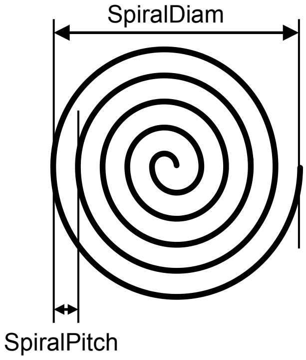
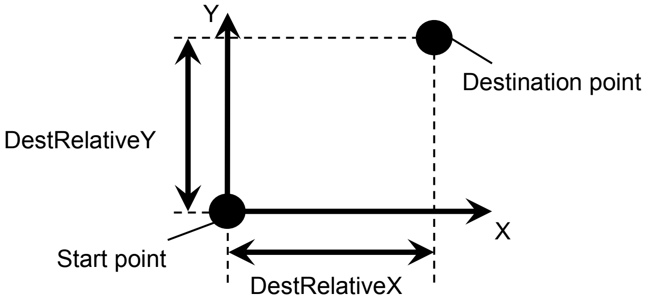
Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	When starting the force guide object, set the output bit to be operated.
IOPreprocOutputStatus	When starting the force guide object, set whether to turn ON or OFF the output bit. Set the state to be output.

Step 3. Set a probe motion

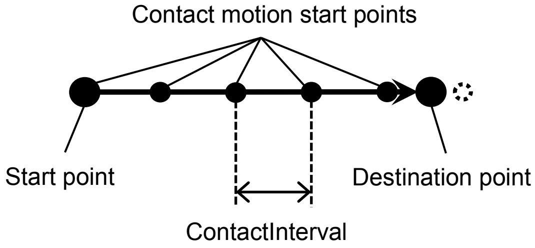
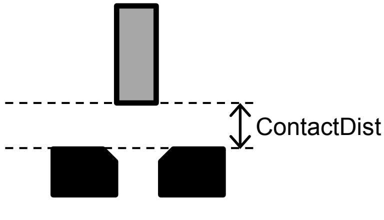
Set properties (ProbeTrajectory, ProbeDetectType, AccelS, SpeedS, SpiralDiam, SpiralPitch, DestRelativeX, DestRelativeY, DestRelativeZ) related to the probe motion.

Property	Description, setting guide
ProbeTrajectory	Set a trajectory to probe. You can select from the spiral trajectory and the straight line trajectory. Straight : When it is clear that the target is on the specified straight line. Spiral : When the target is not on the specified straight line. ContactProbe object needs more time than the PressProbe object. When a hole is on the specified straight line, reduce the positional difference of the start position. We recommend using Straight.
AccelS	Set the translational acceleration of the movement. As shown below, use this property for a motion which is moving to the next contact position when there is no hole and the robot contact with the object. This motion does not execute the force control functions. The robot moves with the position control.  It does not affect to the acceleration during the contact motion.

Property	Description, setting guide
SpeedS	Set the speed of the movement. As with AccelS, this property is used for a motion that moves to the next contact motion. It does not affect to the speed during the contact motion.
SpiralDiam SpiralPitch	Set a diameter and pitch of the spiral trajectory.  SpiralDiam : Set a value which is added a margin to the maximum value of the distance from the start position to the detection target (positional variations are included). Example: Value: 1.1 times larger than the maximum value SpiralPitch : Set a value which does not pass through the detection target. When detecting a hole, set a smaller value than the minimum interval between the holes.
DestRelativeX DestRelativeY DestRelativeZ	Set a relative movement amount to each direction from the start point of the force guide object to the destination point. As shown below, set the movement amount in the coordinate system specified by ForceOrient of the force guide sequence. 

Step 4. Set the contact motion and force control functions

Set properties (ContactInterval, ContactOrient, ContactDist, ContactDistMargin, ContactFirmnessF, CFEnabled) related to the contact motion and force control functions.

Property	Description, setting guide
ContactInterval	This property sets an interval of the contact motions. As shown below, the robot probes the trajectory from the start point of the ContactProbe object to the destination point based on the start point. Next contact motion starts where the robot moves the distance specified by ContactInterval.  ContactProbe object performs the contact motion at the contact motion start points where are between the start point and the destination point. When the destination point is not a multiple of ContactInterval: Contact motion is not executed in the destination point and the next contact motion start point that exceeds the destination point. Be sure to set ContactInterval not pass through the detection target. Set the smaller value than the minimum interval. However, it takes time with the small value. Please perform proper adjustments for your operations.
ContactOrient	This property sets a direction to contact. The robot moves to the specified direction.
ContactDist ContactDistMargin	This property sets a distance from the start point to the target contact point and its margin. ContactProbe object determines as "there is a hole" when the robot moves ContactDist+ContactDistMargin in the direction specified by ContactOrient.  As shown above, set a distance from the workpiece tip to the contact plane of the target in ContactDist. ContactDistMargin sets a margin including the variations of the start point and the workpiece. If the variations are not clear, calculate by percentage of the ContactDist. Example: 10% of ContactDist

Property	Description, setting guide
ContactFirmnessF	Set a firmness of the force control functions. When setting a large value: The force control function will become stronger. However, response to changes of the force is slow. When setting a small value: The force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur. ContactProbe object affects to the contact speed. Reference value of the contact speed can be calculated by (ContactForceThresh / ContactFirmnessF).
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object.

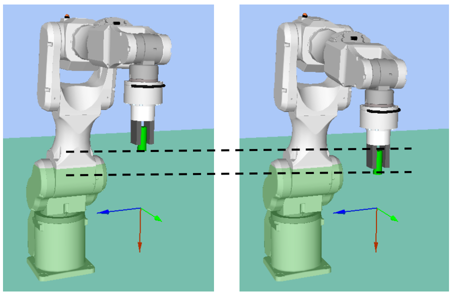
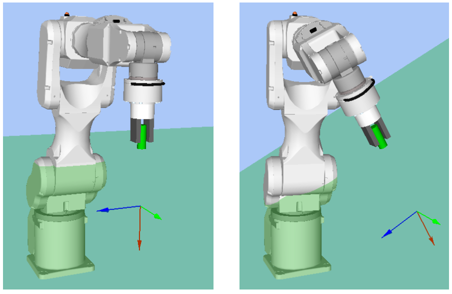
You can check the settings of ContactOrient by a simulator. A coordinate system with grayed out except the specified direction is displayed.
However, the robot is displayed based on the current position. When you check the settings, make sure to move the robot to the position where executing the force guide object.
For details on how to check by using simulator, refer to the following manual.

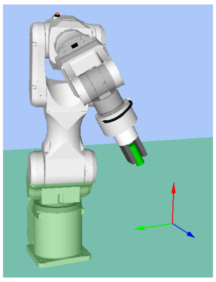
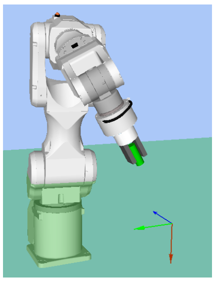
EPSON RC+ 7.0 User's Guide: 8. Simulator, 8.3 Description of Functions

Step 5. Set the end conditions

Set properties (ContactForceThresh, PosCheckType, PlaneNumber, PlaneEndCond, Timeout) related to the end conditions.

Property	Description, setting guide
ContactForceThresh	Set a threshold to determine a contact. Set approx. 3 to 5[N]. Be sure to set a proper threshold for your workpiece. When ContactOrient is in positive direction: Set a negative value. When ContactOrient is in negative direction: Set a positive value. When setting a large absolute value: Movement speed to a contact will be fast. When the value is too small: Robot may not move.

Property	Description, setting guide
PosCheckType	Select types of the end conditions related to positions. When selecting RobotPlane: End conditions are based on the set Plane. As shown below, use this property for setting the end conditions based on a define position regardless of the position of the robot  When selecting RelativePlane: Every time the force guide sequence is executed, create Plane at a position moved by ContactDist+ContactDistMargin in the direction specified by ContactOrient, and set as an end condition of position. As shown below, use this property for changing the end condition positions depending on the position at the start.  RobotPlane : To set an end condition which is always based on a define position. RelativePlane : Make it an end condition that the robot moves a relative amount from the start position.
PlaneNumber	Set Plane number which is used for end condition of positions. When PosCheckType is RobotPlane: End conditions based on the specified Plane number are set. When PosCheckType is RelativePlane: Every time the force guide sequence is executed, set Plane to the specified number newly. Set an empty Plane number.

Property	Description, setting guide
PlaneEndCond	Set a state of the end condition of positions. Set either Inside (inside the Plane) or Outside (outside of the Plane) as an end condition. When the robot will be the specified state, it is determined as the end conditions of the positions are satisfied. Inside: It is in +Z direction of Plane.  Inside  Outside
Timeout	Set a time-out period of a contact motion. Satisfy the force or position conditions in the specified time. Make sure that the value is larger than a value calculated by (ContactDist + ContactDistMargin) / (ContactForceThresh / ContactFirmnessF).

Adjustment guideline for ContactaProbe object

The following describes the adjustment methods for the ContactProbe object.

When the robot passes through a hole:

Decrease ContactInterval. However, it takes more time to probe.
Please perform proper adjustments for your operations.

When the robot does not move to the contact direction:

Check whether the ContactOrient is correct.
When ContactOrient is correct, increase the absolute value of ContactForceThresh.

When it takes time to perform the contact motion:

Decrease a value of ContactFirmnessF or increase an absolute value of ContactForceThresh. However, the applied force to the workpiece is increased.
Please perform proper adjustments for your operations.

When the probe motion speed is slow:

Increase SpeedS and AccelS.

When it takes time:

When the robot repeats the contact motions to a hole position several times, increase ContactInterval. However, the robot may pass through the hole.
Please perform proper adjustments for your operations.

Also, adjust the start point of ContactProbe object to the hole position as close as possible.

Details on properties of the ContactProbe object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the ContactProbe object, name is assigned automatically.
Automatically assigned name is added a number after ContactProbe (e.g. ContactProbe01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program ends force guide sequence and proceeds to the next SPEL statement if force guide object fails.
When specifying False, the program proceeds to the next force guide object without ending the force guide sequence if the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	Abort the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the force guide object execution.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.
It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.
It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF the specified output bit. (Set to 0)
On	Turn ON the specified output bit. (Set to 1)

Default: Off

ProbeTrajectory Property

This property sets trajectory for force guide objects.

Value	Description
Straight	Move the start point along with the straight line trajectory and repeat the contact motion.
Spiral	Move the start point along with the spiral trajectory and repeat the contact motion.

Default: Straight

AccelS Property

This property sets acceleration when moving to a start point of contact.

	Value (unit: [mm/sec^2])
Minimum value	1
Maximum value	5000

Default: 200

SpeedS Property

This property sets speed when moving to a start point of contact.

	Value (unit: [mm/sec])
Minimum value	1
Maximum value	250

Default: 100

SpiralDiam Property

Set a diameter of the spiral trajectory.

This property is used when Spiral is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	1
Maximum value	100

Default: 10

SpiralPitch Property

This property sets a pitch of the spiral trajectory.

This property is used when Spiral is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	0.05
Maximum value	10

Default: 1

DestRelativeX Property

For the straight line trajectory, this property sets a moving amount to X direction in the coordinate system which is specified by ForceOrient and RobotLocal of force guide sequence.

This property is used when Straight is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeY Property

For the straight line trajectory, this property sets a moving amount to Y direction in the coordinate system which is specified by ForceOrient and RobotLocal of force guide sequence.

This property is used when Straight is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeZ Property

For the straight line trajectory, this property sets a moving amount to Z direction in the coordinate system which is specified by ForceOrient and RobotLocal of force guide sequence.

This property is used when Straight is specified by ProbeTrajectory property.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

ContactInterval Property

This property sets a movement amount of the contact start position.

When the robot contacts during the contact motion, the next contact motion starts where the robot moves the distance specified by ContactInterval.

	Value (unit: [mm])
Minimum value	0.05
Maximum value	10

Default: 0.1

ContactOrient Property

Set a hole direction.

Set the direction in the coordinate system specified by ForceOrient of the force guide sequence. Select from translation direction (+Fx to −Fz).
The robot probes a hole while moving to the specified direction.

Value	Description
+Fx	Move to the positive direction in Fx.
−Fx	Move to the negative direction in Fx.
+Fy	Move to the positive direction in Fy.
−Fy	Move to the negative direction in Fy.
+Fz	Move to the positive direction in Fz.
−Fz	Move to the negative direction in Fz.

Default: +Fz

ContactDist Property

This property sets an assumed distance between the start position and the hole position.

When the robot moves ContactDist + ContactDistMargin, it determines as “a hole is detected” and proceeds to the next force object.

	Value (unit: [mm])
Minimum value	0.1
Maximum value	50

Default: 10

ContactDistMargin Property

This property sets a margin which is added to a distance between the start point and the hole position.

Be sure to set a value with consideration for the maximum difference of the each distance.
When the robot moves ContactDist + ContactDistMargin, it determines as “a hole is detected” and proceeds to the next force object.

	Value (unit: [mm])
Minimum value	0.1
Maximum value	50

Default: 10

ContactFirmnessF Property

This property sets a firmness of force control functions during execution of the force guide object.

When the value of ContactFirmnessF increases, the force control function will become stronger. Response to changes of the force is slow, however, vibration does not occur. When the value of ContactFirmnessF decreases, the force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended.
When the force guide sequence ends even if CFEnabled is True, the force control functions will end.

Value	Description
True	The force control functions are continue to the next force guide object even the force guide object is ended.
False	The force control functions will end when the force guide object is ended.

Default: False

ContactForceThresh Property

This property sets a threshold of force to determine the contact.
When the value specified by this property is exceeded during the execution of PressProbe object, the robot returns to the contact start position and moves to the next contact position.

When ContactOrient is in positive direction:

	Value (unit: [N])
Minimum value	–10
Maximum value	0

Default: –5

When ContactOrient is in negative direction:

	Value (unit: [N])
Minimum value	0
Maximum value	10

Default: – 5

PosCheckType Property

For the end conditions related to positions, this property sets whether to use Plane which is defined in advance or set a relative position from the start position of force guide object.

When specifying RobotPlane, set the end conditions by using the defined Plane.
When specifying RelativePlane, reset Plane to the relative position from the force guide object start position each time the force guide object is executed. Relative position is calculated by directions and movement amount specified by ContactOrient, ContactDist, and ContactDistMargin.

Value	Description
RobotPlane	Use the defined Plane as the end condition.
RelativePlane	Set Plane to the relative position and use it as the end condition.

Default: RobotPlane

PlaneNumber Property

This property sets the Plane number to be used of the end conditions related to positions.

When specifying Plane in the PosCheckType property, Plane of the specified number will not be changed.
When specifying Relative in the PosCheckType property, redefine a new Plane to the specified number each time the force guide object is executed. Therefore, note that the original setting will be lost.

	Value
Minimum value	1
Maximum value	15

Default: 1

PlaneEndCond Property

For the end conditions related to positions, this property sets the conditions to be determined as an end.

Value	Description
Outside	Being outside of the Plane is an end condition.
Inside	Being inside of the Plane is an end condition.

Default: Inside

Timeout Property

This property sets the time-out period of the force guide object.

When the single contact motion is not satisfied end conditions of force or position even if exceeding the time specified by Timeout, it is determined as failure of ContactProbe object object.

After the determination, end the force guide sequence according to AbortSeqOnFail or proceed to the next force guide object.

When the end conditions of force are satisfied, the robot moves to the next contact position and repeats the contact motion.
When the end conditions of positions are satisfied, the robot determines as “a hole is detected” and proceeds to the next force object.

	Value (unit: [sec])
Minimum value	0.1
Maximum value	60

Default: 10

Details on results of the ContactProbe object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.6 ContactProbe Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

TimedOut Result

It is whether the time-out period set in Timeout property had been reached.

Value	Description
True	Reached to the time-out period.
False	End before reaching to the time-out period.

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

Average values of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredForces Result

It is the force and torque when satisfying the end conditions related to force. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredPos Result

Positions when satisfying the end conditions related to force. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

PosCondOK Result

It is whether to satisfy the end conditions related to position.

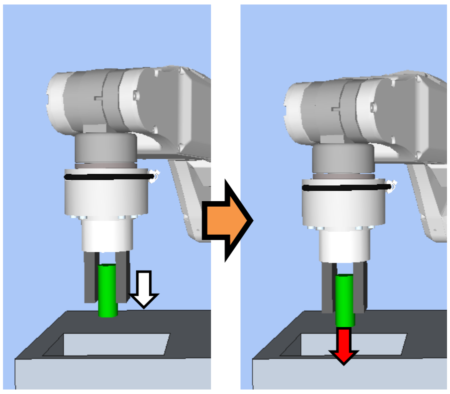
Value	Description
True	Satisfy the end conditions related to position.
False	The end conditions related to position are not satisfied.

4.3.7 Press Object

Press object operates the robot to press to the specified direction with the specified force.

Also, it is possible to follow another specified direction simultaneously like Relax object.

When executing the Press object without contacting with an object, the robot moves to a direction to be the specified force. Use this object for press motion or pushing of assembly. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the robot can keep a certain force stably.



The above figure is an image of a motion by the Press object. When executing in the non-contact state, the robot moves to the pressing direction (white arrow). After the robot contacts with the object, it keeps a state with a certain force (red arrow) is applied. You can start the object with a contact state.

The Press object will be succeeded when the end conditions are satisfied within the specified time. The Press object can use the end conditions related to force, position, and I/O.

Each end condition sets whether to use in ForceCheckEnabled, PosCheckEnabled, and IOCheckEnabled. If no end condition is set, the object will always be succeeded.

When more than one end conditions are set, you can select how to combine the end conditions from AND or OR in EndCheckOperator.

Each condition is as follows:

End condition	Success condition
End conditions related to force	Within the specified time of Timeout, keep satisfying the following all items in the time specified by HoldTimeThresh. When ForceCheckPolarity is Inside: In Fx, Fy, and Fz, the axis specified to Press – or Press + by ControlMode is inside the range of PressForce –PressCheckTolF to PressForce +PressCheckTolF. When ForceCheckPolarity is Outside: In Fx, Fy, and Fz, the axis specified to Press – or Press + by ControlMode is outside the range of PressForce –PressCheckTolF to PressForce +PressCheckTolF. When ForceCheckPolarity is Inside: In Tx, Ty, and Tz, the axis specified to Press – or Press + by ControlMode is inside the range of PressForce –PressCheckTolT to PressForce +PressCheckTolT. When ForceCheckPolarity is Outside: In Tx, Ty, and Tz, the axis specified to Press – or Press + by ControlMode is outside the range of PressForce –PressCheckTolT to PressForce +PressCheckTolT. When ForceCheckMode is PressFollow and ForceCheckPolarity is Inside: In Fx, Fy, and Fz, the axis specified Follow by ControlMode is inside the range of –FollowCheckTolF to +FollowCheckTolF. When ForceCheckMode is PressFollow and ForceCheckPolarity is Outside: In Fx, Fy, and Fz, the axis specified Follow by ControlMode is outside the range of –FollowCheckTolF to +FollowCheckTolF. When ForceCheckMode is PressFollow and ForceCheckPolarity is Inside: In Tx, Ty, and Tz, the axis specified Follow by ControlMode is inside the range of –FollowCheckTolT to +FollowCheckTolT. When ForceCheckMode is PressFollow and ForceCheckPolarity is Outside: In Tx, Ty, and Tz, the axis specified Follow by ControlMode is outside the range of –FollowCheckTolT to +FollowCheckTolT.

End condition	Success condition
End conditions related to positions	Satisfy either one of the following within the specified time of Timeout: When PosCheckType is RobotPlane: Satisfy the state set by PlaneEndCondition for Plane set by PlaneNumber. When PosCheckType is RelativePlane: Satisfy the state set by PlaneEndCondition for the relative plane set by PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrg, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLocal.
End conditions related to I/O	Input bit specified by IOCheckInputBit should be the state specified by IOCheckInputStatus within the time specified by Timeout.

Property setting guideline for Press object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	This property sets names of force guide objects. Set a particular name.
Description	This property sets descriptions about force guide objects. Describe the operation descriptions. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead..
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	Set whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

Step 2. Set I/O processing before starting

Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	When starting the force guide object, set the output bit to be operated.
IOPreprocOutputStatus	When starting the force guide object, set whether to turn ON or OFF the output bit. Set the state to be output.

Step 3. Set force control functions

Set properties (Fx_ControlMode, …, Tz_ControlMode, Fx_PressForce, …, Tz_PressForce, Fx_Firmness, …, Tz_Firmness, CFEnabled) related to the force control function.

Property	Description, setting guide
Fx_ControlMode Fy_ControlMode Fz_ControlMode Tx_ControlMode Ty_ControlMode Tz_ControlMode	Mode of the force control functions to each direction. Press+ : The robot moves to a positive direction of each axis and presses. Press–: The robot moves to a negative direction of each axis and presses. When specifying Follow: Perform the follow motion by the force control functions. When specifying Disabled: Force control functions are disabled. Set the ControlMode in pressing direction to Press+ or Press–. Set ControlMode where you want to follow to Follow. More than one direction must be set a value other than Disabled.
Fx_PressForce Fy_PressForce Fz_PressForce Tx_PressForce Ty_PressForce Tz_PressForce	Set the force and torque set to each direction. It is used when ControlMode is Press+ or Press–. When ControlMode is Press+: Set a negative value. When ControlMode is Press–: Set a positive value. For Peg In Hole or assembly tasks, usually 3 to 5[N] or –3 to –5[N] is used in Fx, Fy, Fz. However, a proper value differs depending on tasks or workpiece.
Fx_Firmness Fy_Firmness Fz_Firmness Tx_Firmness Ty_Firmness Tz_Firmness	Set a firmness of the force control functions to each direction. When setting a large value: The force control function will become stronger. However, response to changes of the force is slow. When setting a small value: The force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object. True : When you want to start the next force guide object with keeping the force constant after the robot contact with an object.

You can check the settings of ControlMode by a simulator. A coordinate system with grayed out except the enabled direction is displayed.
However, the robot is displayed based on the current position. When you check the settings, make sure to move the robot to the position where executing the force guide object.
For details on how to check by using simulator, refer to the following manual.

EPSON RC+ 7.0 User's Guide: 8. Simulator, 8.3 Description of Functions

Step 4. Set basic information for end conditions

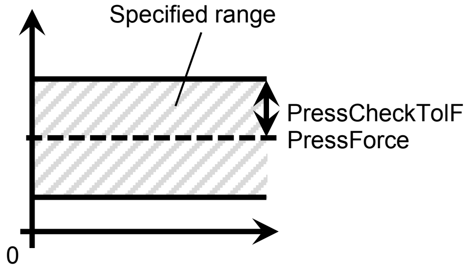
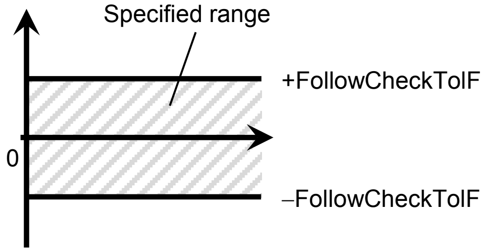
Set properties (EndCheckOperator, Timeout) related to combinations of end conditions and time-out.

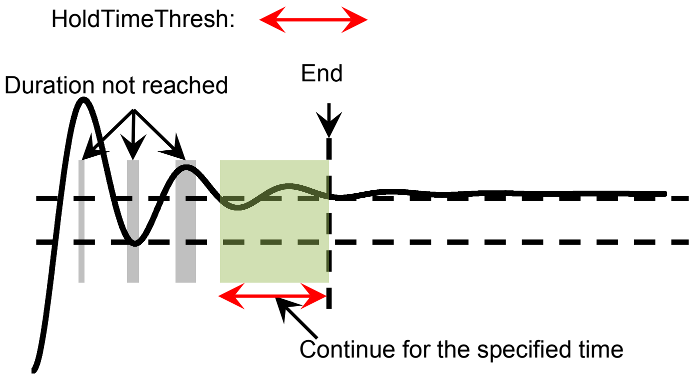
Property	Description, setting guide
EndCheckOperator	This property sets how to combine the end conditions related to force, position, and I/O. AND : End when the both conditions are satisfied. OR : End when one or more conditions are satisfied.
Timeout	This property sets the time-out period. When the end conditions are not set: Time-out period is the execution time. When the end conditions are set: Fails when the end conditions are not satisfied within the specified time.

Step 5. Set end conditions about force

Set properties (ForceCheckEnabled, ForceCheckMode, ForceCheckPriority, PressCheckTolF, PressCheckTolT, FollowCheckTolF, FollowCheckTolT, HoldTimeThresh) related to the end conditions of force.

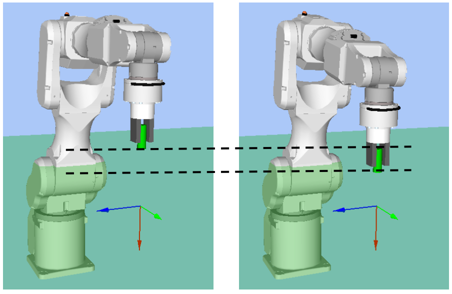
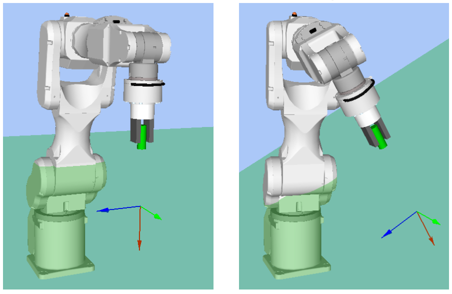
Property	Description, setting guide
ForceCheckEnabled	This property sets whether to enable the end conditions of force. True : When the end conditions of force are enabled.
ForceCheckMode	Target direction of determination. Press : Only the pressing direction is a target of determination. Directions (Press+, Press–) specified by ControlMode are a target of determination. PressFollow : The pressing direction and follow direction are a target of determination. Directions (Press+, Press–, Follow) specified by ControlMode are a target of determination.
ForceCheckPolarity	Polar of the end conditions related to force. Inside : Normally set. Being inside of the specified range is an end condition. Outside : Being outside of the specified range is an end condition. Use Outside when using a special end condition such as starting with the pressing state and making it as an end condition that the pressing state is released.

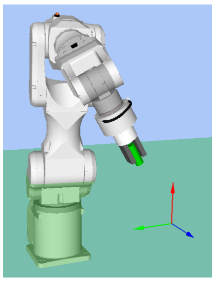
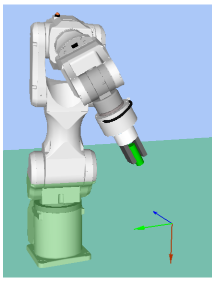
Property	Description, setting guide
PressCheckTolF PressCheckTolT	Range of the pressing direction of the end conditions related to force. Set a range of the end conditions of force. PressCheckTolF is applied for Fx, Fy, and Fz, and PressCheckTolT is applied for Tx, Ty, and Tz. Monitor that the force directions (Press+, Press–) specified by ControlMode is within the range of PressForce –PressCheckTol to PressForce +PressCheckTol. The following is an image of PressCheckTolF. 
FollowCheckTolF FollowCheckTolT	This property sets the range in the follow direction of the end conditions related to force. FollowCheckTolT is applied for Fx, Fy, and Fz, and FollowCheckTolT is applied for Tx, Ty, and Tz. It monitors that the force of the direction specified to Follow by ControlMode enters into a range of –FollowCheckTol to +FollowCheckTol. The following is the image of FollowCheckTolF. 

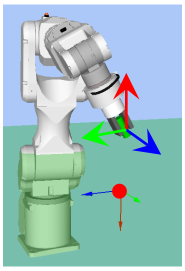
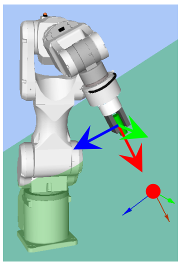
Property	Description, setting guide
HoldTimeThresh	Set the duration time which is used to determine whether the end conditions have satisfied. As shown below, if the specified condition continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.  Normally, set to “0”. Set the time for stabilizing the motion when the results of the next force guide object are unstable. We recommend setting the time according to the actual result which is executed after temporarily disabling the end conditions.

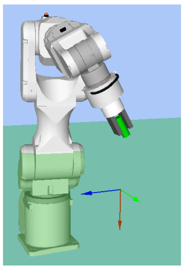
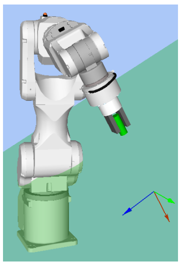
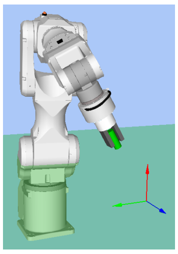
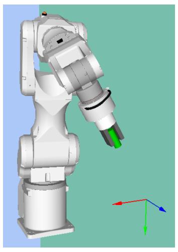
Step 6. Set end conditions about position

Set properties (PosCheckEnabled, PosCheckType, PlaneNumber, PlaneEndCond, PlaneRelativeOrg, PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLoca) related to the end conditions of the positions.

Property	Description, setting guide
PosCheckEnabled	This property sets whether to enable the end conditions of positions. True : When the end conditions of positions are enabled. False : When the end conditions of positions are disabled.
PosCheckType	Types of the end conditions related to positions. When selecting RobotPlane: End conditions are based on the set Plane. As shown below, use this property for setting the end conditions based on a define position regardless of the position of the robot  When selecting RelativePlane: Every time the force guide sequence is executed, create Plane at a relative position from the current position and set as an end condition of position. As shown below, use this property for changing the end condition positions depending on the position at the start.  RobotPlane : To set an end condition which is always based on a define position RelativePlane : Make it an end condition that the robot moves a relative amount from the start position.

Property	Description, setting guide
PlaneNumber	Set Plane number which is used for end condition of positions. When PosCheckType is RobotPlane: End conditions based on the specified Plane number are set. When PosCheckType is RelativePlane: Every time the force guide sequence is executed, set Plane to the specified number newly. Set an empty Plane number.
PlaneEndCond	Set a state of the end condition of positions. Set either Inside (inside the Plane) or Outside (outside of the Plane) as an end condition. When the robot will be the specified state, it is determined as the end conditions of the positions are satisfied. Inside: It is in +Z direction of Plane.  Inside  Outside

Property	Description, setting guide
PlaneRelativeOrg	Set which coordinate system direction is used as a reference when expressing the offset amount to the origin of Plane. The left figure below is an example to set Base. Specify a relative distance based on the Base coordinate system. It is an example that the negative value is set in PlaneRelativeZ. The right figure below is an example to set Tool. Specify a relative distance based on the Tool coordinate system. It is an example that the positive value is set in PlaneRelativeZ.  Base  Tool The Local or Tool coordinate systems are used only in that direction and origin position does not affect. To set the position of an end condition in the robot motion direction, normally set the same value as ForceOrient of the force guide sequence.
PlaneRelativeX PlaneRelativeY PlaneRelativeZ	Set offset amount in each direction from the current position to the origin of Plane. Direction will be the coordinate system direction specified by PlaneRelativeOrg.

Property	Description, setting guide
PlaneRelativeOrient	Set a coordinate system based on the Plane direction. The left figure below is an example to set Base. Reference direction of the Plane matches the Base coordinate system regardless of the robot orientation at the start of the force guide object. The right figure below is an example to set Tool. Reference direction of the Plane changes along with the robot orientation at the start of the force guide object.  Example to set Base  Example to set Tool Since a plane which is perpendicular to the robot motion direction will be the end conditions, normally set the same value as ForceOrient of the force guide sequence.
PlaneAxes	Set a Plane direction Based on the coordinate system specified by PlaneRelativeOrient, plane is set to a direction set by PlaneAxes. The following figure is an example when Base is set by PlaneRelativeOrient. Left figure : specified XY by PlaneAxes Right figure : specified YZ by PlaneAxes.  XY  YZ Normally, set Plane which is perpendicular to the robot motion direction.
PlaneRelativeRobotLocal	Set Local coordinate system number which is used when PlaneRelativeOrg and PlaneRelativeOrient are Local. Normally, set a value which is the same as RobotLocal of the force guide sequence.

Step 7. Set end conditions related to I/O

Set properties (IOCheckEnabled, IOCheckInputBit, IOCheckInputStatus) related to the end conditions of I/O.

Property	Description, setting guide
IOCheckEnabled	This property sets whether to enable the end conditions of I/O. True : When the end conditions of I/O are enabled.
IOCheckInputBit	Set an input bit which is monitored as an end condition.
IOCheckInputStatus	Set a state of the input bit to be an end condition. If the input bit specified by IOCheckInputBit will be the state specified by IOCheckInputStatus, it is determined as the end conditions are satisfied.

Adjustment guideline for Press object

The following describes the adjustment methods when using the Press object.

When the robot motion vibrates:

Increase the Firmness value. However, response of the robot will be slow.
Please perform proper adjustments for your operations.

To adjust the Firmness, we recommend changing the value gradually
(e.g. increase the value by 10%).

When the robot bounces largely in the pressing direction:

If the robot repeatedly bounces largely in a few seconds, the robot motion may be restricted by LimitAccelS of the force guide sequence.

Also, it likely to happen during the execution in low power mode.

If the robot still bounces even executing in high power mode, increase the value of LimitAccelS.
If the robot still bounces, decrease the value of Firmness in pressing direction.

When the robot does not reach to the target force:

Decrease the Firmness value of the pressing direction.

However, the robot motion may be easy to vibrate.
Please perform proper adjustments for your operations.

To adjust the Firmness, we recommend changing the value gradually
(e.g. decrease the value by 10%).

When the robot does not move to the pressing direction:

Confirm that the ControlMode where the robot does not move is either Press+ or Press−.

When Press+ or Press− is set, confirm whether the PressForce is set to “0”.

When the robot moves in the reverse direction:

Confirm that the ControlMode where the robot moves in the reverse direction is either Press+ or Press−.

When the robot is set to assumed direction, confirm the ForceOrient or RobotLocal of the force guide sequence, tool coordinate system, or local coordinate system.

Details on properties of the Press object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the Press object, name is assigned automatically. Automatically assigned name is added a number after Press (e.g. Press01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True:
If force guide object fails, the program ends force guide sequence and proceeds to the next SPEL statement.

When specifying False:
If force guide object fails, the program proceeds to the next force guide object without ending the force guide sequence.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	Abort the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the force guide object execution.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.
It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.
It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF the specified output bit. (Set to 0)
On	Turn ON the specified output bit. (Set to 1)

Default: Off

Fx_ControlMode Property

Set the control mode in Fx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fx direction are not executed.
When specifying Press+ or Press−, the force control functions to Fx direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Fx_PressForce.
When specifying Follow, the force control functions to Fx direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be "0". Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fx_PressForce Property

This property sets pressing force to Fx direction during the execution of force guide objects.
It is used when Fx_ControlMode is Press+ or Press−.

When ControlMode is Press+:

	Value (unit: [N])
Minimum value	–250
Maximum value	0

Default: 0

When ControlMode is Press–:

	Value (unit: [N])
Minimum value	0
Maximum value	250

Default: 0

Fx_Firmness Property

This property sets a firmness of force control functions in Fx direction during the execution of force guide object.
It is used when Fx_ControlMode is Press+, Press–, or Follow.

When the value of Fx_Firmness increases, the force control function in Fx direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.

When Fx_Firmness decreases, the force control function in Fx direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fy_ControlMode Property

Set the control mode in Fy direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fy direction are not executed.
When specifying Press+ or Press–, the force control functions to Fy direction is executed as the follow mode. In the press mode, the robot presses so that it will be a force specified by Fy_PressForce.
When specifying Follow, the force control functions to Fy direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be “0”. Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fy_PressForce Property

This property sets pressing force to Fy direction during the execution of force guide objects. It is used when Fy_ControlMode is Press+ or Press–.

When ControlMode is Press+:

	Value (unit: [N])
Minimum value	–250
Maximum value	0

Default: 0

When ControlMode is Press–:

	Value (unit: [N])
Minimum value	0
Maximum value	250

Default: 0

Fy_Firmness Property

This property sets a firmness of force control functions in Fy direction during the execution of force guide object. It is used when Fy_ControlMode is Press+, Press–, or Follow.

When the value of Fy_Firmness increases, the force control function in Fy direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.

When Fy_Firmness decreases, the force control function in Fy direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fz_ControlMode Property

Set the control mode in Fz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fz direction are not executed.
When specifying Press+ or Press–, the force control functions to Fz direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Fz_PressForce.
When specifying Follow, the force control functions to Fz direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be "0". Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fz_PressForce Property

This property sets pressing force to Fz direction during the execution of force guide objects. It is used when Fz_ControlMode is Press+ or Press–.

When ControlMode is Press+:

	Value (unit: [N])
Minimum value	–250
Maximum value	0

Default: 0

When ControlMode is Press–:

	Value (unit: [N])
Minimum value	0
Maximum value	250

Default: 0

Fz_Firmness Property

This property sets a firmness of force control functions in Fz direction during the execution of force guide object.
It is used when Fz_ControlMode is Press+, Press–, or Follow

When the value of Fz_Firmness increases, the force control function in Fz direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.

When Fz_Firmness decreases, the force control function in Fz direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Tx_ControlMode Property

Set the control mode in Tx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Tx direction are not executed.
When specifying Press+ or Press–, the force control functions to Tx direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Tx_PressForce.
When specifying Follow, the force control functions to Tx direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tx_PressForce Property

This property sets pressing force to Tx direction during the execution of force guide objects. It is used when Tx_ControlMode is Press+ or Press–.

When ControlMode is Press+:

	Value (unit: [N·mm])
Minimum value	–18000
Maximum value	0

Default: 0

When ControlMode is Press–:

	Value (unit: [N·mm])
Minimum value	0
Maximum value	18000

Default: 0

Tx_Firmness Property

This property sets a firmness of force control functions in Tx direction during the execution of force guide object.
It is used when Tx_ControlMode is Press+, Press–, or Follow.

When the value of Tx_Firmness increases, the force control function in Tx direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.
When Tx_Firmness decreases, the force control function to Tx direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Ty_ControlMode Property

Set the control mode in Ty direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Ty direction are not executed.
When specifying Press+ or Press–, the force control functions to Ty direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Ty_PressForce.
When specifying Follow, the force control functions to Ty direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Ty_PressForce Property

This property sets pressing force to Ty direction during the execution of force guide objects. It is used when Ty_ControlMode is Press+ or Press–.

When ControlMode is Press+:

	Value (unit: [N·mm])
Minimum value	–18000
Maximum value	0

Default: 0

When ControlMode is Press–:

	Value (unit: [N·mm])
Minimum value	0
Maximum value	18000

Default: 0

Ty_Firmness Property

This property sets a firmness of force control functions in Ty direction during the execution of force guide object.
It is used when Ty_ControlMode is Press+, Press–, or Follow.

When the value of Ty_Firmness increases, the force control function in Ty direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.

When Ty_Firmness decreases, the force control function to Ty direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Tz_ControlMode Property

Set the control mode in Tz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Tz direction are not executed.
When specifying Press+ or Press–, the force control functions to Tz direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Tz_PressForce.
When specifying Follow, the force control functions to Tz direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tz_PressForce Property

This property sets pressing force to Tz direction during the execution of force guide objects.
It is used when Tz_ControlMode is Press+ or Press–.

When ControlMode is Press+:

	Value (unit: [N·mm])
Minimum value	–18000
Maximum value	0

Default: 0

When ControlMode is Press–:

	Value (unit: [N·mm])
Minimum value	0
Maximum value	18000

Default: 0

Tz_Firmness Property

This property sets a firmness of force control functions in Tz direction during the execution of force guide object.
It is used when Tz_ControlMode is Press+, Press–, or Follow.

When the value of Tz_Firmness increases, the force control function in Tz direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.

When Tz_Firmness decreases, the force control function to Tz direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended.
When the force guide sequence ends even if CFEnabled is True, the force control functions will end.

Value	Description
True	The force control functions are continue to the next force guide object even the force guide object is ended.
False	The force control functions will end when the force guide object is ended.

Default: False

EndCheckOperator Property

This property sets the combination conditions when using several end conditions of the force guide object.

When specifying AND, if all of the enabled end conditions are satisfied, the force guide object execution has been completed and it determined as succeeded.

When specifying OR, if all of the enabled end conditions are satisfied, the force guide object execution has been completed and it determined as succeeded.

Value	Description
OR	Combine as OR condition.
AND	Combine as AND condition.

Default: Disabled

ForceCheckEnabled Property

This property sets the end conditions of the force guide object related to force.

Value	Description
True	Enable the end conditions related to force.
False	Disable the end conditions related to force.

Default: False

ForceCheckMode Property

For the end conditions related to force, this property sets a direction which will be a condition.

Value	Description
Press	Direction (Press+, Press–) specified by ControlMode is a force condition.
PressFollow	Direction (Press+, Press–, and Follow) specified by ControlMode is a force condition.

Default: False

ForceCheckPolarity Property

For an end condition related to force, this property sets whether the end condition is being inside or outside of the specified range.

Value	Description
Outside	Being outside of the specified range is an end condition.
Inside	Being inside of the specified range is an end condition.

Default: Inside

PressCheckTolF Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True in a direction where Press is specified by ControlMode in Fx, Fy, and Fz directions.

Determine that the force in each direction is inside or outside of the range of PressForce –PressCheckTolF to PressForce +PressCheckTolF.

	Value (unit: [N])
Minimum value	0.1
Maximum value	10

Default: 1

PressCheckTolT Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True in a direction where Press is specified by ControlMode in Tx, Ty, and Tz directions.

Determine that the force in each direction is inside or outside of the range of PressForce –PressCheckTolT to PressForce +PressCheckTolT.

	Value (unit: [N·mm])
Minimum value	100
Maximum value	10000

Default: 500

FollowCheckTolF Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True and ForceCheckMode is set to PressFollow in a direction where Follow is specified by ControlMode in Fx, Fy, and Fz directions.

Determine that the force in each direction is inside or outside of the range of –FollowCheckTolF to +FollowCheckTolF.

	Value (unit: [N])
Minimum value	0.1
Maximum value	10

Default: 1

FollowCheckTolT Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True and ForceCheckMode is set to PressFollow in a direction where Follow is specified by ControlMode in Tx, Ty, and Tz directions.

Determine that the force in each direction is inside or outside of the range of −FollowCheckTolT to +FollowCheckTolT.

	Value (unit: [N·mm])
Minimum value	100
Maximum value	10000

Default: 500

HoldTimeThresh Property

This property sets the duration time until the determination of the end conditions related to force.
It is used when ForceCheckEnabled is True.

When the specified condition continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.

	Value (unit: [sec])
Minimum value	0
Maximum value	10

Default: 0

PosCheckEnabled Property

This property sets the end conditions of the force guide object related to I/O.

Value	Description
True	Enable the end conditions related to position.
False	Disable the end conditions related to position.

Default: False

PosCheckType Property

For the end conditions related to positions, this property sets whether to use Plane which is defined in advance or set a relative position from the start position of force guide object.

When specifying RobotPlane, set the end conditions by using the defined Plane.
When specifying RelativePlane, reset Plane to the relative position from the force guide object start position each time the force guide object is executed.

Value	Description
RobotPlane	Use the defined Plane as the end condition.
RelativePlane	Set Plane to the relative position and use it as the end condition.

Default: RobotPlane

PlaneNumber Property

This property sets the Plane number to be used of the end conditions related to positions.

When specifying Plane in the PosCheckType property, Plane of the specified number will not be changed.
When specifying Relative in the PosCheckType property, redefine a new Plane to the specified number each time the force guide object is executed. Therefore, note that the original setting will be lost.

	Value
Minimum value	1
Maximum value	15

Default: 1

PlaneEndCond Property

For the end conditions related to positions, this property sets the conditions to be determined as an end.

Value	Description
Outside	Being outside of the Plane is an end condition.
Inside	Being inside of the Plane is an end condition.

Default: Inside

PlaneRelativeOrg Property

For the end conditions related to positions, this property specifies which coordinate system sets the relative position setting Plane.
It is used when RelativePlane is specified by PosCheckType.

Value	Description
Base	Specify a relative position based on the Base coordinate system.
Local	Specify a relative position based on the Local coordinate system. Local coordinate system number is specified by PlaneRelativeRobotLocal.
Tool	Specify a relative position based on the Tool coordinate system.

Default: Tool

PlaneRelativeX Property

For the end conditions related to positions, this property sets the relative position in X direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
X direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeY Property

For the end conditions related to positions, this property sets the relative position in Y direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Y direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeZ Property

For the end conditions related to positions, this property sets the relative position in Z direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Z direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeOrient Property

For the end conditions related to positions, this property sets the coordinate system to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on axis specified by PlaneAxes that is the coordinate system specified by PlaneRelativeOrient.

When specifying Base, Plane is set on axis specified by PlaneAxes in the Base coordinate system.
When specifying Local, Plane is set on axis specified in PlaneAxes in the Local coordinate system of the number specified by PlaneRelativeRobotLocal.
When specifying Tool, Plane is set on axis specified by PlaneAxes in the Tool coordinate system.

Value	Description
Base	Specify a Plane direction based on the Base coordinate system.
Local	Specify a Plane direction based on the Local coordinate system.
Tool	Specify a Plane direction based on the Tool coordinate system.

Default: Tool

PlaneAxes Property

For the end conditions related to positions, this property sets the axis to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on axis specified by PlaneAxes that is the coordinate system specified by PlaneRelativeOrient.

Value	Description
XY	Set Plane on the XY plane.
YZ	Set Plane on the YZ plane.
XZ	Set Plane on the XZ plane.

Default: XY

PlaneRelativeRobotLocal Property

For the end conditions related to positions, this property sets Local coordinate system number that specifies the relative position or direction of Plane.
It is used in either of the following cases:

- RelativePlane is specified in PosCheckType and Local is specified in PlaneRelativeOrg
- RelativePlane is specified in PosCheckType and and Local is specified in PlaneRelativeOrient.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system). It is the same as when specifying Base in PlaneRelativeOrg or PlaneRelativeOrient.
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

IOCheckEnabled Property

This property sets the end conditions of the force guide object related to I/O.

Value	Description
True	Enable the end conditions related to I/O.
False	Disable the end conditions related to I/O.

Default: False

IOCheckInputBit Property

This property sets the bit of determination target of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOCheckInputStatus Property

This property sets the determination conditions of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

According to the bit specified by IOCheckInputBit, it is determine as the end conditions are satisfied.

Value	Description
Off	When the input bit is OFF (0), it is determined as the end conditions are satisfied.
On	When the input bit is ON (1), it is determined as the end conditions are satisfied.

Default: Off

Timeout Property

This property sets the time-out period of the force guide object.

When the robot does not satisfy the conditions enabled by ForceCheckEnabled, PosCheckEnabled, or IOCheckEnabled even the time specified by Timeout has passed, it determined as failure of the Press object.

After the determination, end the force guide sequence according to AbortSeqOnFail or proceed to the next force guide object.

When ForceCheckEnabled, PosCheckEnabled, and IOCheckEnabled are False, end the force guide object after time specified by Timeout is passed. Determine as succeeded and proceed to the next force guide object.

	Value (unit: [sec])
Minimum value	0.1
Maximum value	60

Default: 10

Details on results of the Press object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.7 Press Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

TimedOut Result

It is whether the time-out period set in Timeout property had been reached.

Value	Description
True	Reached to the time-out period.
False	End before reaching to the time-out period.

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

Average values of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

ForceCondOK Result

It is whether to satisfy the end conditions related to force.

Value	Description
True	Satisfy the end conditions related to force.
False	The end conditions related to force are not satisfied.

TriggeredForces Result

It is the force and torque when satisfying the end conditions related to force.
Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredPos Result

Positions when satisfying the end conditions related to force. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

PosCondOK Result

It is whether to satisfy the end conditions related to position.

Value	Description
True	Satisfy the end conditions related to position.
False	The end conditions related to position are not satisfied.

IOCondOK Result

It is whether to satisfy the end conditions related to I/O.

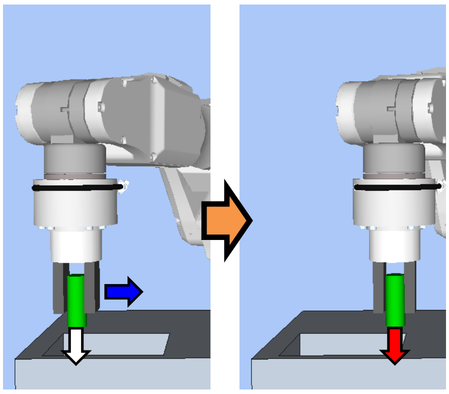
Value	Description
True	Satisfy the end conditions related to I/O.
False	The end conditions related to I/O are not satisfied.

4.3.8 PressMove Object

PressMove object moves the robot along with the specified trajectory while pressing to the specified direction with the specified force.

Also, it is possible to follow to another specified direction simultaneously like FollowMove object.

When executing the Press object without contacting with an object, the robot moves to a direction where will be the specified force in addition to the specified trajectory. Use this object for pressing, screw driving, or polishing for Peg In Hole or assembly. Even the workpiece dimension or the grasp positions of the workpiece have a margin of error, the robot can move with maintaining the stably force.



The above figure is an image of a motion by the PressMove object. When executing in the non-contact state, the robot moves to the pressing direction (white arrow) while moving the trajectory (blue arrow). After the robot contacts with the object, it moves the specified trajectory while maintaining a state with a certain force (red arrow) is applied.

The PressMove object will be succeeded when the end conditions are satisfied while moving the specified trajectory. It can use the end conditions related to positions, I/O, and force.

Each end condition sets whether to use in ForceCheckEnabled, PosCheckEnabled, and IOCheckEnabled. If no end condition is set, the object will always be succeeded. When more than one end conditions are set, you can select how to combine the end conditions from AND or OR in EndCheckOperator.

Each condition is as follows:

End condition	Success condition
End conditions related to force	While the robot moves the specified trajectory, keep satisfying the following all items in the time specified by HoldTimeThresh. When ForceCheckPolarity is Inside: In Fx, Fy, and Fz, the axis specified Press– or Press+ by ControlMode is inside the range of PressForce –PressCheckTolF to PressForce +PressCheckTolF. When ForceCheckPolarity is Outside: In Fx, Fy, and Fz, the axis specified Press– or Press+ by ControlMode is outside the range of PressForce –PressCheckTolF to PressForce +PressCheckTolF. When ForceCheckPolarity is Inside: In Tx, Ty, and Tz, the axis specified Press– or Press+ by ControlMode is inside the range of PressForce –PressCheckTolT to PressForce +PressCheckTolT. When ForceCheckPolarity is Outside: In Tx, Ty, and Tz, the axis specified Press– or Press+ by ControlMode is outside the range of PressForce –PressCheckTolT to PressForce +PressCheckTolT. When ForceCheckMode is PressFollow and ForceCheckPolarity is Inside: In Fx, Fy, and Fz, the axis specified Follow by ControlMode is inside the range of –FollowCheckTolF to +FollowCheckTolF. When ForceCheckMode is PressFollow and ForceCheckPolarity is Outside: In Fx, Fy, and Fz, the axis specified Follow by ControlMode is outside the range of –FollowCheckTolF to +FollowCheckTolF. When ForceCheckMode is PressFollow and ForceCheckPolarity is Inside: In Tx, Ty, and Tz, the axis specified Follow by ControlMode is inside the range of –FollowCheckTolT to +FollowCheckTolT. When ForceCheckMode is PressFollow and ForceCheckPolarity is Outside: In Tx, Ty, and Tz, the axis specified Follow by ControlMode is outside the range of –FollowCheckTolT to +FollowCheckTolT.

End condition	Success condition
End conditions related to positions	Satisfy either one of the following while the robot moves the specified trajectory: When PosCheckType is RobotPlane: Satisfy the state set by PlaneEndCondition for Plane set by PlaneNumber. When PosCheckType is RelativePlane: Satisfy the state set by PlaneEndCondition for the relative plane set by PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrg, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLocal.
End conditions related to I/O	Input bit specified by IOCheckInputBit should be the state specified by IOCheckInputStatus while the robot moves the specified trajectory.

Property setting guideline for PressMove object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	This property sets names of force guide objects. Set a particular name.
Description	This property sets descriptions about force guide objects. Describe the operation descriptions. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead.
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	Set whether to abort or continue the force guide sequence when the force guide object fails. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

Step 2. Set I/O processing before starting

Set properties (IOPreprocEnabled, IOPreprocOutputBit, IOPreprocOutputStatus) related to I/O processing before starting force guide object.

Property	Description, setting guide
IOPreprocEnabled	Set whether to operate the output bit when starting the force guide object. You can operate only one output bit. To operate several output bit, use SPELFunc object. False : Normal True : When operating the output bit such as operating/aborting peripherals.
IOPreprocOutputBit	When starting the force guide object, set the output bit to be operated.
IOPreprocOutputStatus	When starting the force guide object, set whether to turn ON or OFF the output bit. Set the state to be output.

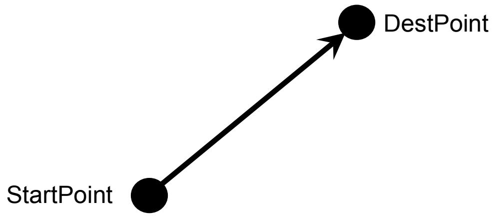
Step 3. Set a movement motion

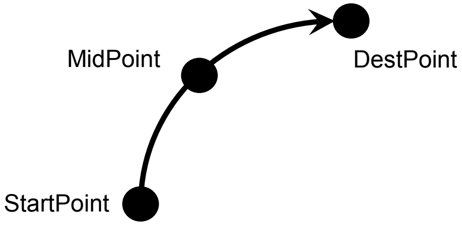
Set properties (MotionTrajectory, AccelS, AccelR, SpeedS, SpeedR, CPEnabled) related to movements.

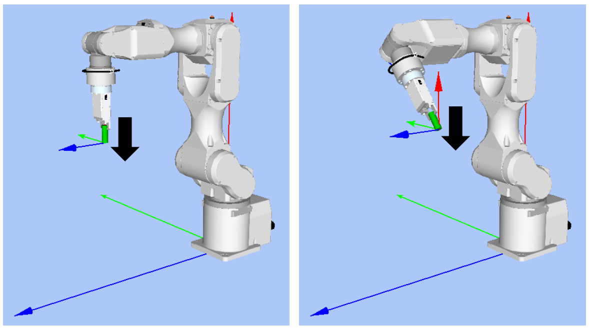
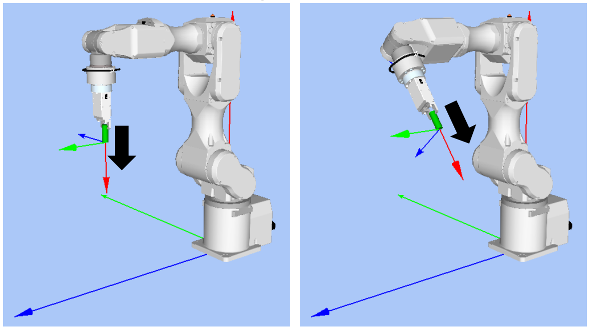
Property	Description, setting guide
MotionTrajectory	Set types of trajectory to move. You can select from Straight or Arc.
AccelS AccelR	Set the acceleration of the movement. AccelS: Translational acceleration AccelR: Rotational rotation acceleration Actual acceleration is adjusted by the force control functions.
SpeedS SpeedR	Set the speed of the movement. SpeedS: Speed SpeedR: Rotational rotation speed Actual speed is adjusted by the force control functions.
CPEnabled	Set whether to connect the trajectory of the PressMove object and that of the following force guide object by Path Motion. True : When connecting complicated trajectory to operate by more than one PressMove objects.

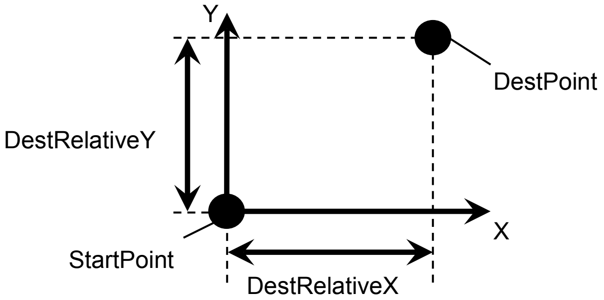
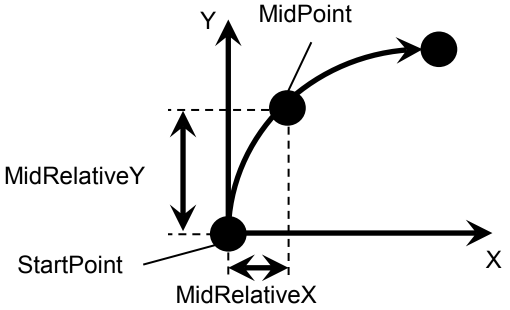
Step 4. Set a destination point

Set properties (DestType, DestPoint, MidPoint, RelativeOrient, RelativeRobotLocal, DestRelativeX, …, DestRelativeW, MidRelativeX, …, MidRelativeW) related to trajectories to move.

Property	Description, setting guide
DestType	This property can set how to set a destination point. If you use the force control functions, the robot positions are adjusted by the force. Therefore, we recommend specifying a destination point by a relative movement amount from the positioning point. RobotPoint : When moving to the specified point Relative : When specifying the relative movement amount
DestPoint	Set a point indicating a destination point (DestPoint). When selecting Straight in MotionTrajectory: As shown below, the robot moves a straight line from the start point of the force guide object to the DestPoint. 

Property	Description, setting guide
MidPoint	When the MotionTrajectory is Arc, set a point indicating a middle point (MidPoint). As shown below, the robot moves to the DestPoint after passing through the MidPoint. 

Property	Description, setting guide
RelativeOrient	Set a coordinate system direction which will be a reference of the relative movement. When specifying Base or Local: As viewed from outside, the robot always operates to a define direction. The following is an example to set Base. When moving to –Z direction, the robot always moves to the vertical-downward (–Z direction in Base coordinate system) even the orientation of robot fingers changed. (Black arrow is a direction of the robot motion.) If you want the robot to move to the different direction from the Base coordinate system, specify in the Local coordinate system.  When specifying Tool: Movement direction changes along with the orientation at the start. The following is an example to set Tool. When moving to +Z direction, the moving direction changes depending on the orientation of robot fingers at the start.  Base, Local: To move to a define direction as viewed from outside even the robot orientation at the start of the force guide object is changed. Tool: To move to the direction depending on the robot orientation.
RelativeRobotLocal	Set a Local coordinate system number which is used when specifying Local by RelativeOrient.

Property	Description, setting guide
DestRelativeX DestRelativeY DestRelativeZ DestRelativeU DestRelativeV DestRelativeW	Set a relative movement amount to each direction from the start point of the force guide object to the destination point. As shown below, set a relative movement amount to each direction in the coordinate system at by RelativeOrient. 
MidRelativeX MidRelativeY MidRelativeZ MidRelativeU MidRelativeV MidRelativeW	Set a relative movement amount to each direction from the start point of the force guide object to the mid point. As shown below, set a relative movement amount to each direction in the coordinate system at by RelativeOrient. 

Step 5. Set force control functions

Set properties(Fx_ControlMode, …, Tz_ControlMode, Fx_PressForce, …, Tz_PressForce, Fx_Firmness, …, Tz_Firmness, CFEnabled) related to the force control function.

Property	Description, setting guide
Fx_ControlMode Fy_ControlMode Fz_ControlMode Tx_ControlMode Ty_ControlMode Tz_ControlMode	Mode of the force control functions to each direction. Press+ : The robot moves to a positive direction of each axis and presses. Press– : The robot moves to a negative direction of each axis and presses. When specifying Follow: Perform the follow motion for the force control functions. When specifying Disabled: Force control functions are disabled. Set the ControlMode in pressing direction to Press+ or Press–. Set ControlMode where you want to follow to Follow. More than one direction must be set other than Disabled.

Property	Description, setting guide
Fx_PressForce Fy_PressForce Fz_PressForce Tx_PressForce Ty_PressForce Tz_PressForce	Set the force and torque set to each direction. It is used when ControlMode is Press+ or Press– When ControlMode is Press+: Set a negative value. When ControlMode is Press–: Set a positive value. For Peg In Hole or assembly tasks, usually 3 to 5[N] or –3 to –5[N] is used in Fx, Fy, Fz. However, a proper value differs depending on tasks or workpiece.
Fx_Firmness Fy_Firmness Fz_Firmness Tx_Firmness Ty_Firmness Tz_Firmness	Set a firmness of the force control functions to each direction. When setting a large value: The force control function will become stronger. However, response to changes of the force is slow. When setting a small value: The force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.
CFEnabled	Set whether to continue the force control functions to the next force guide object. False : Normal Turn OFF the force control functions once, then execute the next force guide object. True : When you want to start the next force guide object with keeping the force constant after the robot contact with an object.

You can check the settings of ControlMode by a simulator. A coordinate system with grayed out except the enabled direction is displayed.
However, the robot is displayed based on the current position. When you check the settings, make sure to move the robot to the position where executing the force guide object.
For details on how to check by using simulator, refer to the following manual.

EPSON RC+ 7.0 User's Guide: 8. Simulator, 8.3 Description of Functions

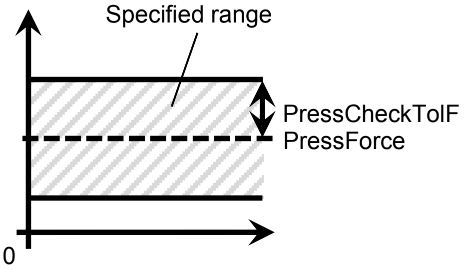
Step 6. Set basic information for end conditions

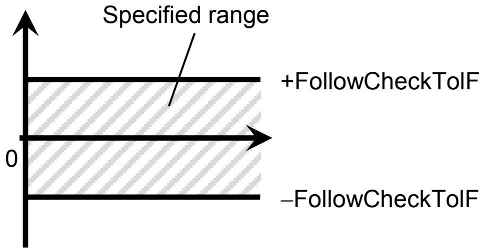
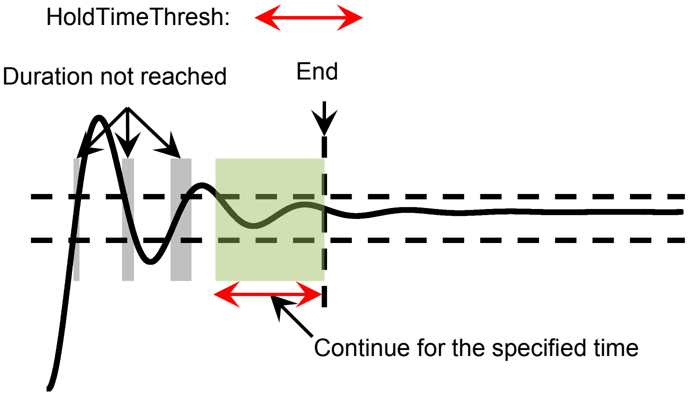
Set property (EndCheckOperator) related to combinations of end conditions.

Property	Description, setting guide
EndCheckOperator	This property sets how to combine the end conditions related to force, position, and I/O. AND : End when the all conditions to be used are satisfied. OR : End when one or more conditions are satisfied.

Step 7. Set end conditions about force

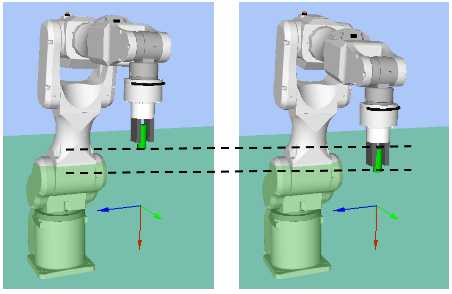
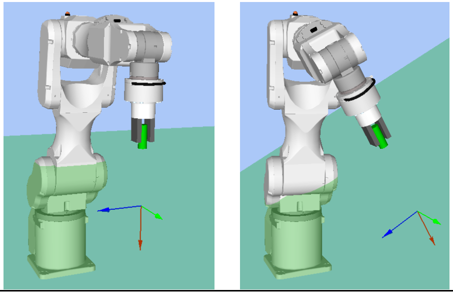
Set properties (ForceCheckEnabled, ForceCheckMode, ForceCheckPriority, PressCheckTolF, PressCheckTolT, FollowCheckTolF, FollowCheckTolT, HoldTimeThresh) related to the end conditions of force.

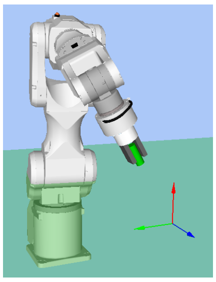
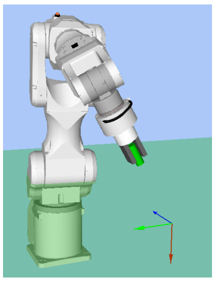
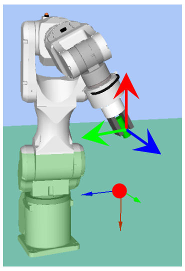
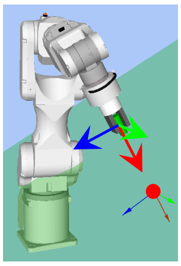
Property	Description, setting guide
ForceCheckEnabled	This property sets whether to enable the end conditions of force. True : When the end conditions of force are enabled.
ForceCheckMode	Target direction of determination. Press : Only the pressing direction is a target of determination. Directions (Press+, Press–) specified by ControlMode is a target of determination. PressFollow : The pressing direction and follow direction are a target of determination. Directions (Press+, Press–, Follow) specified by ControlMode is a target of determination.
ForceCheckPolarity	Polar of the end conditions related to force. Inside : Normally set. Being inside of the specified range is an end condition. Outside : Being outside of the specified range is an end condition. Use Outside when using a special end condition such as starting with the pressing state and making it as an end condition that the pressing state is released.
PressCheckTolF PressCheckTolT	This property sets the pressing direction range of the end conditions related to force. Set a range of the end conditions of force. PressCheckTolF is applied for Fx, Fy, and Fz, and PressCheckTolT is applied for Tx, Ty, and Tz. Monitor that the force directions (Press+, Press–) specified by ControlMode is within the range of PressForce –PressCheckTol to PressForce +PressCheckTol. The following is an image of PressCheckTolF. 

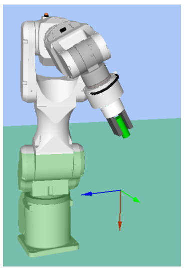
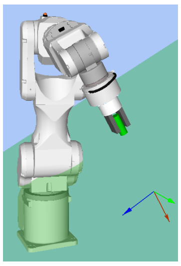
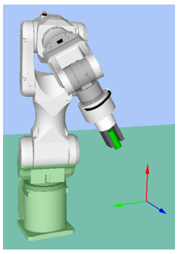
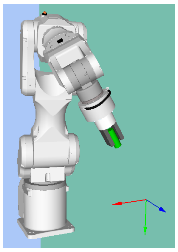
Property	Description, setting guide
FollowCheckTolF FollowCheckTolT	This property sets the follow direction range of the end conditions related to force. FollowCheckTolT is applied for Fx, Fy, and Fz, and FollowCheckTolT is applied for Tx, Ty, and Tz. It monitors that the force of the direction specified to Follow by ControlMode enters into a range of –FollowCheckTol to +FollowCheckTol. The following is the image of FollowCheckTolF. 
HoldTimeThresh	Set the duration time which is used to determine whether the end conditions have satisfied. As shown below, if the specified condition continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.  Normally, set to “0”. Set the time for stabilizing the motion when the results of the next force guide object are unstable. We recommend setting the time according to the actual result which is executed after temporarily disabling the end conditions.

Step 8. Set end conditions about position

Set properties (PosCheckEnabled, PosCheckType, PlaneNumber, PlaneEndCond, PlaneRelativeOrg, PlaneRelativeX, PlaneRelativeY, PlaneRelativeZ, PlaneRelativeOrient, PlaneAxes, PlaneRelativeRobotLoca) related to the end conditions of the positions.

Property	Description, setting guide
PosCheckEnabled	This property sets whether to enable the end conditions of positions. True : When the end conditions of positions are enabled. False : When the end conditions of positions are disabled.
PosCheckType	Select types of the end conditions related to positions. When selecting RobotPlane: End conditions are based on the set Plane. As shown below, use this property for setting the end conditions based on a define position regardless of the position of the robot  When selecting RelativePlane: Every time the force guide sequence is executed, create Plane at a relative position from the current position and set as an end condition of position. As shown below, use this property for changing the end condition positions depending on the position at the start. 
PlaneNumber	Set Plane number which is used for end condition of positions. When PosCheckType is RobotPlane: End conditions based on the specified Plane number are set. When PosCheckType is RelativePlane: Every time the force guide sequence is executed, set Plane to the specified number newly. Set an empty Plane number.

Property	Description, setting guide
PlaneEndCond	Set a state of the end condition of positions. Set either Inside (inside the Plane) or Outside (outside of the Plane) as an end condition. When the robot will be the specified state, it is determined as the end conditions of the positions are satisfied. Inside: It is in +Z direction of Plane.  Inside  Outside
PlaneRelativeOrg	Set which coordinate system direction is used as a reference when expressing the offset amount to the origin of Plane. The left figure below is an example to set Base. Specify a relative distance based on the Base coordinate system. It is an example that the negative value is set in PlaneRelativeZ. The right figure below is an example to set Tool. Specify a relative distance based on the Tool coordinate system. It is an example that the positive value is set in PlaneRelativeZ.  Base  Tool The Local or Tool coordinate systems are used only in that direction and origin position does not affect. To set the position of an end condition in the robot motion direction, normally set the same value as ForceOrient of the force guide sequence.

Property	Description, setting guide
PlaneRelativeX PlaneRelativeY PlaneRelativeZ	Set offset amount in each direction from the current position to the origin of Plane. Direction will be the coordinate system direction specified by PlaneRelativeOrg.
PlaneRelativeOrient	Set a coordinate system based on the Plane direction. The left figure below is an example to set Base. Reference direction of the Plane matches the Base coordinate system regardless of the robot orientation at the start of the force guide object. The right figure below is an example to set Tool. Reference direction of the Plane changes along with the robot orientation at the start of the force guide object.  Example to set Base  Example to set Tool Since a plane which is perpendicular to the robot motion direction will be the end conditions, normally set the same value as ForceOrient of the force guide sequence.
PlaneAxes	Set a Plane direction Based on the coordinate system specified by PlaneRelativeOrient, plane is set to a direction set by PlaneAxes. The following figure is an example when Base is set by PlaneRelativeOrient. Left figure: specified XY by PlaneAxes Right figure: specified YZ by PlaneAxes.  XY  YZ Normally, set Plane which is perpendicular to the robot motion direction.

Property	Description, setting guide
PlaneRelativeRobotLocal	Set Local coordinate system number which is used when PlaneRelativeOrg and PlaneRelativeOrient are Local. Normally, set a value which is the same as RobotLocal of the force guide sequence.

Step 9. Set end conditions about I/O

Set properties (IOCheckEnabled, IOCheckInputBit, IOCheckInputStatus) related to the end conditions of I/O.

Property	Description, setting guide
IOCheckEnabled	This property sets whether to enable the end conditions of I/O. True : When the end conditions of I/O are enabled.
IOCheckInputBit	Set an input bit which is monitored as an end condition.
IOCheckInputStatus	Set a state of the input bit to be an end condition. If the input bit specified by IOCheckInputBit will be the state specified by IOCheckInputStatus, it is determined as the end conditions are satisfied.

Adjustment guideline for PressMove object

The following describes the adjustment methods when using the PressMove object.

When the robot motion vibrates:

Increase the Firmness value. However, response of the robot will be slow. Please perform proper adjustments for your operations.

To adjust the Firmness, we recommend changing the value gradually (e.g. increase the value by 10%).

When the robot bounces largely in the pressing direction:

If the robot repeatedly bounces largely in a few seconds, the robot motion may be restricted by LimitAccelS of the force guide sequence.

Also, it likely to happen during the execution in low power mode.

If the robot still bounces even executing in high power mode, increase the value of LimitAccelS.
If the robot still bounces, decrease the value of Firmness in pressing direction.

When the robot does not reach to the target force:

Decrease the Firmness value of the pressing direction.

However, the robot motion may be easy to vibrate. Please perform proper adjustments for your operations.

To adjust the Firmness, we recommend changing the value gradually (e.g. decrease the value by 10%).

When the robot does not move to the pressing direction:

Confirm that the ControlMode where the robot does not move is either Press+ or Press−.

When Press+ or Press− is set, confirm whether the PressForce is set to “0”.

When the robot moves in the reverse direction:

Confirm that the ControlMode where the robot moves in the reverse direction is either Press+ or Press−.

When the robot is set to assumed direction, confirm the ForceOrient or RobotLocal of the force guide sequence, tool coordinate system, or local coordinate system.

When the robot does not reach to the destination point:

If the direction where the force control functions are not enabled is not reached to the destination point, it may be affected by the LimitAccel or LimitSpeed of the force guide sequence. Increase the value.

Also, in low power mode, it is restricted according to the maximum speed or maximum acceleration of the low power mode even the value of LimitSpeed or LimitAccel is large. Be sure to execute in high power mode.

Details on properties of the PressMove object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the PressMove object, name is assigned automatically. Automatically assigned name is added a number after PressMove (e.g. PressMove01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the force guide object.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program ends force guide sequence and proceeds to the next SPEL statement if force guide object fails.
When specifying False, the program proceeds to the next force guide object without ending the force guide sequence if the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	Abort the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

IOPreprocEnabled Property

This property sets I/O operations when the force guide object starts.

I/O operations are defined by IOPreprocOutputBit Property and IOPreprocOutputStatus Property. Use this property when you want to operate the hands or peripherals before the force guide object execution.

Value	Description
True	Execute I/O operation at the start.
False	I/O operation at the start is not executed.

Default: False

IOPreprocOutputBit Property

This property sets I/O operations (output bit) when the force guide object starts.
It is only used when IOPreprocEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOPreprocOutputStatus Property

This property sets the output state of I/O operations when the force guide object starts.
It is only used when IOPreprocEnabled is True.

Value	Description
Off	Turn OFF (set to 0) the specified output bit.
On	Turn ON (set to 1) the specified output bit.

Default: Off

MotionTrajectory Property

This property sets trajectory for force guide objects.

Value	Description
Straight	Move a straight trajectory.
Arc	Move an arc trajectory.

Default: Straight

AccelS Property

This property sets acceleration of force guide objects.
However, this set value is the acceleration for the set trajectory. The actual acceleration is adjusted by the force control functions.

	Value (unit: [mm/sec^2])
Minimum value	1
Maximum value	200

Default: 50

AccelR Property

This property sets rotation acceleration of force guide objects during the execution.
However, this set value is the rotation acceleration for the set trajectory. The actual rotation acceleration is adjusted by the force control functions.

	Value (unit: deg/sec^2])
Minimum value	1
Maximum value	100

Default: 10

SpeedS Property

This property sets speed of force guide objects during the execution.
However, this set value is the speed for the set trajectory. The actual speed is adjusted by the force control functions.

	Value (unit: [mm/sec])
Minimum value	1
Maximum value	200

Default: 50

SpeedR Property

This property sets rotation speed of force guide objects during the execution.
However, this set value is the rotation speed for the set trajectory. The actual rotation speed is adjusted by the force control functions.

	Value (unit: [deg/sec])
Minimum value	1
Maximum value	25

Default: 10

CPEnabled Property

Set enable/disable the path motion.

Use this property to synthesize the trajectory for multiple force guide objects with movement.

When specifying True, path motion is enabled and the program starts the next force guide object when entering into the slowdown zone.

When specifying False, path motion is disabled and the program starts the next force guide object after the set trajectory ends.

However, if the end condition is set and it is satisfied, the program pauses once when it is satisfied and proceeds to the next force guide object.

Value	Description
True	Enable the path motion.
False	Disable the path motion.

Default: False

DestType Property

This property sets the method to specify the target position of the trajectory.

When specifying RobotPoint, set the target position by point.
When specifying Relative, set the relative distance such as 10mm from the start position to X direction.

Value	Description
RobotPoint	Set a target position by point.
Relative	Set a target position by relative distance.

Default: False

DestPoint Property

This property sets the point using for the target position of the trajectory.
It is used when specifying RobotPoint in DestType.

	Value
Minimum value	0
Maximum value	999

Default: 0

MidPoint Property

This property sets a relay point using for the arc trajectory.
It is used when specifying Arc in MotionTrajectory and RobotPoint in DestType.

	Value
Minimum value	0
Maximum value	999

Default: 0

RelativeOrient Property

This property sets the coordinate system that moves relatively.
It is used when specifying Relative in DestType.

Value	Description
Base	Specify a relative distance based on the Base coordinate system.
Local	Specify a relative distance based on the Local coordinate system.
Tool	Specify a relative distance based on the Tool coordinate system.

Default: Tool

RelativeRobotLocal Property

This property sets the number of local coordinate system for the coordinate system that moves relatively.
It is used when specifying Relative in DestType and Local in RelativeOrient.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system). It is the same as when specifying Base in RelativeOrient
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

DestRelativeX Property

For the destination point, this property sets the moving amount in X direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeY Property

For the destination point, this property sets the moving amount in Y direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeZ Property

For the destination point, this property sets the moving amount in Z direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

DestRelativeU Property

For the destination point, this property sets the rotation amount in U direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

DestRelativeV Property

For the destination point, this property sets the rotation amount in V direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

DestRelativeW Property

For the destination point, this property sets the rotation amount in W direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

MidRelativeX Property

For the mid point, this property sets the moving amount in X direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

MidRelativeY Property

For the mid point, this property sets the moving amount in Y direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

MidRelativeZ Property

For the mid point, this property sets the moving amount in Z direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

MidRelativeU Property

For the mid point, this property sets the rotating amount in U direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

MidRelativeV Property

For the mid point, this property sets the rotating amount in V direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

MidRelativeW Property

For the mid point, this property sets the rotating amount in W direction of coordinate systems specified by RelativeOrient and RelativeRobotLocal.
It is used when specifying Arc in MotionTrajectory and Relative in DestType.

	Value (unit: [deg])
Minimum value	–360
Maximum value	360

Default: 0

Fx_ControlMode Property

Set the control mode in Fx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fx direction are not executed.
When specifying Press+ or Press–, the force control functions to Fx direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Fx_PressForce.
When specifying Follow, the force control functions to Fx direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be “0”. Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing to the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fx_PressForce Property

This property sets pressing force to Fx direction during the execution of force guide objects.
It is used when Fx_ControlMode is Press+ or Press–

When ControlMode is Press+:

	Value (unit: [N])
Minimum value	–250
Maximum value	0

Default: 0

When ControlMode is Press–

	Value (unit: [N])
Minimum value	0
Maximum value	250

Default: 0

Fx_Firmness Property

This property sets a firmness of force control functions in Fx direction during the execution of force guide object.
It is used when Fx_ControlMode is Press+, Press–, or Follow

When the value of Fx_Firmness increases, the force control function in Fx direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.

When Fx_Firmness decreases, the force control function in Fx direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fy_ControlMode Property

Set the control mode in Fy direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fy direction are not executed.
When specifying Press+ or Press–, the force control functions to Fy direction is executed as the follow mode. In the press mode, the robot presses so that it will be a force specified by Fy_PressForce.
When specifying Follow, the force control functions to Fy direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be “0”. Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fy_PressForce Property

This property sets pressing force to Fy direction during the execution of force guide objects.
It is used when Fy_ControlMode is Press+ or Press–

When ControlMode is Press+:

	Value (unit: [N])
Minimum value	–250
Maximum value	0

Default: 0

When ControlMode is Press–

	Value (unit: [N])
Minimum value	0
Maximum value	250

Default: 0

Fy_Firmness Property

This property sets a firmness of force control functions in Fy direction during the execution of force guide object. It is used when Fy_ControlMode is Press+, Press–, or Follow.

When the value of Fy_Firmness increases, the force control function in Fy direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.

When Fy_Firmness decreases, the force control function in Fy direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Fz_ControlMode Property

Set the control mode in Fz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Fz direction are not executed.
When specifying Press+ or Press–, the force control functions to Fz direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Fz_PressForce.
When specifying Follow, the force control functions to Fz direction is executed as the follow mode. In the follow mode, the robot moves so that the external force will be "0". Therefore, when the external force is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Fz_PressForce Property

This property sets pressing force to Fz direction during the execution of force guide objects.
It is used when Fz_ControlMode is Press+ or Press–

When ControlMode is Press+:

	Value (unit: [N])
Minimum value	–250
Maximum value	0

Default: 0

When ControlMode is Press–

	Value (unit: [N])
Minimum value	0
Maximum value	250

Default: 0

Fz_Firmness Property

This property sets a firmness of force control functions in Fz direction during the execution of force guide object.
It is used when Fz_ControlMode is Press+, Press– or Follow.

When the value of Fz_Firmness increases, the force control function in Fz direction will become stronger. Response to changes of the force is slow, however, vibration does not occur.

When Fz_Firmness decreases, the force control function in Fz direction will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.

	Value
Minimum value	0.1 (if C8 series: 0.5)
Maximum value	200

Default: 10

Tx_ControlMode Property

Set the control mode in Tx direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the robot does not move to Tx direction since the force control functions to Tx direction are not executed.
When specifying Press+ or Press–, the force control functions to Tx direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Tx_PressForce.
When specifying Follow, the force control functions to Tx direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tx_PressForce Property

This property sets pressing force to Tx direction during the execution of force guide objects.
It is used when Tx_ControlMode is Press+ or Press–

When ControlMode is Press+:

	Value (unit: [N·mm])
Minimum value	–18000
Maximum value	0

Default: 0

When ControlMode is Press–

	Value (unit: [N·mm])
Minimum value	0
Maximum value	18000

Default: 0

Tx_Firmness Property

This property sets a firmness of force control functions in Tx direction during the execution of force guide object.
It is used when Tx_ControlMode is Press+, Press–, or Follow.

When the value of Tx_Firmness increases, the force control function in Tx direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.

When Tx_Firmness decreases, the force control function to Tx direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Ty_ControlMode Property

Set the control mode in Ty direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Ty direction are not executed.
When specifying Press+ or Press–, the force control functions to Ty direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Ty_PressForce.
When specifying Follow, the force control functions to Ty direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Ty_PressForce Property

This property sets pressing force to Ty direction during the execution of force guide objects.
It is used when Ty_ControlMode is Press+ or Press–

When ControlMode is Press+:

	Value (unit: [N·mm])
Minimum value	–18000
Maximum value	0

Default: 0

When ControlMode is Press–

	Value (unit: [N·mm])
Minimum value	0
Maximum value	18000

Default: 0

Ty_Firmness Property

This property sets a firmness of force control functions in Ty direction during the execution of force guide object.
It is used when Ty_ControlMode is Press+, Press–, or Follow.

When the value of Ty_Firmness increases, the force control function in Ty direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.

When Ty_Firmness decreases, the force control function to Ty direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

Tz_ControlMode Property

Set the control mode in Tz direction in the coordinate system specified by ForceOrient of the force guide sequence.

When specifying Disabled, the force control functions to Tz direction are not executed.
When specifying Press+ or Press–, the force control functions to Tz direction is executed as the press mode. In the press mode, the robot presses so that it will be a force specified by Tz_PressForce.
When specifying Follow, the force control functions to Tz direction is executed as the follow mode. In the follow mode, the robot moves so that the external torque will be “0”. Therefore, when the external torque is applied, the robot moves to follow it.

Value	Description
Disabled	Disable the force control functions.
Press+	The force control functions are executed like pressing in the positive direction.
Press–	The force control functions are executed like pressing in the negative direction.
Follow	The force control functions are executed like the Follow motion.

Default: Disabled

Tz_PressForce Property

This property sets pressing force to Tz direction during the execution of force guide objects.
It is used when Tz_ControlMode is Press+ or Press–.

When ControlMode is Press+:

	Value (unit: [N·mm])
Minimum value	–18000
Maximum value	0

Default: 0

When ControlMode is Press–

	Value (unit: [N·mm])
Minimum value	0
Maximum value	18000

Default: 0

Tz_Firmness Property

This property sets a firmness of force control functions in Tz direction during the execution of force guide object.
It is used when Tz_ControlMode is Press+, Press–, or Follow.

When the value of Tz_Firmness increases, the force control function in Tz direction will become stronger. Response to changes of the torque is slow, however, vibration does not occur.

When Tz_Firmness decreases, the force control function to Tz direction will become weaker. Response to changes of the torque is fast, however, vibration is easy to occur.

	Value
Minimum value	10
Maximum value	1000000

Default: 3000

CFEnabled Property

This property sets whether to continue the force control functions after the force guide object is ended.
When the force guide sequence ends even if CFEnabled is True, the force control functions will end.

Value	Description
True	The force control functions are continue to the next force guide object even the force guide object is ended.
False	The force control functions will end when the force guide object is ended.

Default: False

EndCheckOperator Property

This property sets the combination conditions when using several end conditions of the force guide object.

When specifying AND, if all of the enabled end conditions are satisfied, the force guide object execution has been completed and it determined as succeeded.

When specifying OR, if all of the enabled end conditions are satisfied, the force guide object execution has been completed and it determined as succeeded.

Value	Description
OR	Combine as OR condition.
AND	Combine as AND condition.

Default: Disabled

ForceCheckEnabled Property

This property sets the end conditions of the force guide object related to force.

Value	Description
True	Enable the end conditions related to force.
False	Disable the end conditions related to force.

Default: False

ForceCheckMode Property

For the end conditions related to force, this property sets a direction which will be a condition.

Value	Description
Press	Direction (Press+, Press–) specified by ControlMode is a force condition.
PressFollow	Direction (Press+, Press–, and Follow) specified by ControlMode is a force condition.

Default: False

ForceCheckPolarity Property

For an end condition related to force, this property sets whether the end condition is being inside or outside of the specified range.

Value	Description
Outside	Being outside of the specified range is an end condition.
Inside	Being inside of the specified range is an end condition.

Default: Inside

PressCheckTolF Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True in a direction where Press is specified by ControlMode in Fx, Fy, and Fz directions.

Determine that the force in each direction is inside or outside of the range of PressForce –PressCheckTolF to PressForce +PressCheckTolF.

	Value (unit: [N])
Minimum value	0.1
Maximum value	10

Default: 1

PressCheckTolT Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True in a direction where Press is specified by ControlMode in Tx, Ty, and Tz directions.

Determine that the force in each direction is inside or outside of the range of PressForce –PressCheckTolT to PressForce +PressCheckTolT.

	Value (unit: [N·mm])
Minimum value	100
Maximum value	10000

Default: 500

FollowCheckTolF Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True and ForceCheckMode is set to PressFollow in a direction where Follow is specified by ControlMode in Fx, Fy, and Fz directions.

Determine that the force in each direction is inside or outside of the range of –FollowCheckTolF to +FollowCheckTolF.

	Value (unit: [N])
Minimum value	0.1
Maximum value	10

Default: 1

FollowCheckTolT Property

This property sets the range of the end conditions related to force.
It is used when ForceCheckEnabled is True and ForceCheckMode is set to PressFollow in a direction where Follow is specified by ControlMode in Tx, Ty, and Tz directions.

Determine that the force in each direction is inside or outside of the range of −FollowCheckTolT to +FollowCheckTolT.

	Value (unit: [N·mm])
Minimum value	100
Maximum value	10000

Default: 500

HoldTimeThresh Property

This property sets the duration time until the determination of the end conditions related to force.
It is used when ForceCheckEnabled is True.

When the specified condition continues for the time specified by HoldTimeThresh, it is determined as the end conditions are satisfied.

	Value (unit: [sec])
Minimum value	0
Maximum value	10

Default: 0

PosCheckEnabled Property

This property sets the end conditions of the force guide object related to I/O.

Value	Description
True	Enable the end conditions related to position.
False	Disable the end conditions related to position.

Default: False

PosCheckType Property

For the end conditions related to positions, this property sets whether to use Plane which is defined in advance or set a relative position from the start position of force guide object.

When specifying RobotPlane, set the end conditions by using the defined Plane.
When specifying RelativePlane, reset Plane to the relative position from the force guide object start position each time the force guide object is executed.

Value	Description
RobotPlane	Use the defined Plane as the end condition.
RelativePlane	Set Plane to the relative position and use it as the end condition.

Default: RobotPlane

PlaneNumber Property

This property sets the Plane number to be used of the end conditions related to positions.

When specifying Plane in the PosCheckType property, Plane of the specified number will not be changed.
When specifying Relative in the PosCheckType property, redefine a new Plane to the specified number each time the force guide object is executed. Therefore, note that the original setting will be lost.

	Value
Minimum value	1
Maximum value	15

Default: 1

PlaneEndCond Property

For the end conditions related to positions, this property sets the conditions to be determined as an end.

Value	Description
Outside	Being outside of the Plane is an end condition.
Inside	Being inside of the Plane is an end condition.

Default: Inside

PlaneRelativeOrg Property

For the end conditions related to positions, this property specifies which coordinate system sets the relative position setting Plane.
It is used when RelativePlane is specified by PosCheckType.

Value	Description
Base	Specify a relative position based on the Base coordinate system.
Local	Specify a relative position based on the Local coordinate system. Local coordinate system number is specified by PlaneRelativeRobotLocal.
Tool	Specify a relative position based on the Tool coordinate system.

Default: Tool

PlaneRelativeX Property

For the end conditions related to positions, this property sets the relative position in X direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
X direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeY Property

For the end conditions related to positions, this property sets the relative position in Y direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Y direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeZ Property

For the end conditions related to positions, this property sets the relative position in Z direction to set Plane.
It is used when RelativePlane is specified by PosCheckType.
Z direction follows the coordinate system specified by PlaneRelativeOrg.

	Value (unit: [mm])
Minimum value	–2000
Maximum value	2000

Default: 0

PlaneRelativeOrient Property

For the end conditions related to positions, this property sets the coordinate system to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on axis specified by PlaneAxes that is the coordinate system specified by PlaneRelativeOrient.

When specifying Base, Plane is set on axis specified by PlaneAxes in the Base coordinate system.
When specifying Local, Plane is set on axis specified in PlaneAxes in the Local coordinate system of the number specified by PlaneRelativeRobotLocal.
When specifying Tool, Plane is set on axis specified by PlaneAxes in the Tool coordinate system.

Value	Description
Base	Specify a Plane direction based on the Base coordinate system.
Local	Specify a Plane direction based on the Local coordinate system.
Tool	Specify a Plane direction based on the Tool coordinate system.

Default: Tool

PlaneAxes Property

For the end conditions related to positions, this property sets the axis to set Plane.
It is used when RelativePlane is specified by PosCheckType.

Plane is set on axis specified by PlaneAxes that is the coordinate system specified by PlaneRelativeOrient.

Value	Description
XY	Set Plane on the XY plane.
YZ	Set Plane on the YZ plane.
XZ	Set Plane on the XZ plane.

Default: XY

PlaneRelativeRobotLocal Property

For the end conditions related to positions, this property sets Local coordinate system number that specifies the relative position or direction of Plane.
It is used in either of the following cases:

- RelativePlane is specified in PosCheckType and Local is specified in PlaneRelativeOrg.
- RelativePlane is specified in PosCheckType and and Local is specified in PlaneRelativeOrient.

Value	Description
0 (Base)	Use the Local 0 coordinate system (Base coordinate system). It is the same as when specifying Base in PlaneRelativeOrg or PlaneRelativeOrient.
1 to 15	Use the Local coordinate system of the specified number.

Default: 0 (Base)

IOCheckEnabled Property

This property sets the end conditions of the force guide object related to I/O.

Value	Description
True	Enable the end conditions related to I/O.
False	Disable the end conditions related to I/O.

Default: False

IOCheckInputBit Property

This property sets the bit of determination target of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

	Value
Minimum value	0
Maximum value	7167

Default: 0

IOCheckInputStatus Property

This property sets the determination conditions of the end conditions related to I/O.
It is used when IOCheckEnabled is True.

According to the bit specified by IOCheckInputBit, it is determine as the end conditions are satisfied.

Value	Description
Off	When the input bit is OFF (0), it is determined as the end conditions are satisfied.
On	When the input bit is ON (1), it is determined as the end conditions are satisfied.

Default: Off

Details on results of the PressMove object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.8 PressMove Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

EndForces Result

It is force and torque when force guide object ends. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

EndPos Result

Positions when the force guide object ends. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

AvgForces Result

Average values of force and torque during the force guide object execution. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

PeakForces Result

Peak values of force and torque during the force guide object execution. The peak value is a value which absolute value is the largest. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

ForceCondOK Result

It is whether to satisfy the end conditions related to force.

Value	Description
True	Satisfy the end conditions related to force.
False	The end conditions related to force are not satisfied.

TriggeredForces Result

It is the force and torque when satisfying the end conditions related to force. Acquire values of Fx, Fy, Fz, Tx, Ty, and Tz.

Unit: Fx, Fy, Fz [N] / Tx, Ty, Tz [N·mm]

TriggeredPos Result

Positions when satisfying the end conditions related to force. Acquire values of X, Y, Z, U, V, and W.

Unit: X, Y, Z [mm] / U, V, W [deg]

PosCondOK Result

It is whether to satisfy the end conditions related to position.

Value	Description
True	Satisfy the end conditions related to position.
False	The end conditions related to position are not satisfied.

IOCondOK Result

It is whether to satisfy the end conditions related to I/O.

Value	Description
True	Satisfy the end conditions related to I/O.
False	The end conditions related to I/O are not satisfied.

4.3.9 Decision Object

Decision object changes the force guide object to be executed based on the results of the objects in the force guide sequence.

This object is used for determination for execution of PressProbe object for Peg In Hole task. This object allows executing the required force guide objects based on the actual motion status of the robot.

Property setting guideline for Decision object

Step 1. Set basic information

Set properties (Name, Description, Enabled) related to the basic information.

Property	Description, setting guide
Name	Name of the force guide object. Set a particular name.
Description	Descriptions for force guide object. Describe the operations. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead..

Step 2. Set a condition

Set properties (ConditionObject, TrueCond) related to conditions.

Property	Description, setting guide
ConditionObject	Force guide object to check the results. Set the force guide object that you want to check.
TrueCond	Set a condition to be True. Proceed to True branching when EndStatus of the force guide object specified by ConditionObject is satisfied a condition specified by TrueCond.

Details on properties of the Decision object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the Decision object, name is assigned automatically. Automatically assigned name is added a number after Decision (e.g. Decision01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, execute the next force guide object without executing the Decision object and all force guide objects in the branch.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

ConditionObject Property

Set the force guide object to be a target of the conditional determination.

Specify the force guide object which is written before the Decision object. Based on that result, the program proceeds to True or False branch.

TrueCond Property

Set a condition to branch to True.

Depending on a result of the force guide object (EndStatus result) specified by ConditionObject, the program proceeds to True branch.

Value	Description
TargetPassed	When the target force guide object had succeeded, the program proceeds to True branch.
TargetFailed	When the target force guide object had failed, the program proceeds to True branch.
TargetNoExec	When the target force guide object had not executed, the program proceeds to True branch.

Default: TargetPassed

4.3.10 SPELFunc Object

SPELFunc object executes the specified SPELFunc during the execution of the sequence.

Use this object for performing processing other than the force control function such as I/O operations or a safety movement to the start position. A function to be specified by SPELFunc object must have a string type variable for an argument and the return value type must be Boolean. Object name is passed to the argument.

SPELFunc object is succeeded when the return value of the specified function is True, and it failed when the return value is False.

Property setting guideline for SPELFunc object

Step 1. Set basic information

Set properties (Name, Description, Enabled, StepID, AbortSeqOnFail) related to the basic information.

Property	Description, setting guide
Name	This property sets names of force guide objects. Set a particular name.
Description	This property sets descriptions about force guide objects . Describe the operation descriptions. Set a character string.
Enabled	Set whether to execute the force guide object. True : Normal False : When you do not execute the force guide object such as executing another force guide object instead..
StepID	StepID during the force guide object execution. Set an ID. StepID is an ID which is recorded in the log data. It helps you to understand which log data support a process. It is applied when AutoStepID of the force guide sequence is False.
AbortSeqOnFail	It is whether to abort or continue the force guide sequence when the force guide object fails. SPELFunc object is failed when the return value of the SPELFunc to be executed is False. True : Normal Abort the force guide sequence. False : When the force guide sequence fails, the recovery motions are included or the force guide sequence will be able to continue.

Step 2. Set a function to be executed

Set a property (FuncName) related to a function to be executed.

Property	Description, setting guide
FuncName	Set a SPELFunc name to be executed. As the example below, a function to be specified by SPELFunc object must have a string type variable for an argument and the return value type must be Boolean.

```
Function MyFunc(ObjectName$ As String) As Boolean
    MyFunc = True
Fend
```

Details on properties of the SPELFunc object

Name Property

This property sets a particular name that is assigned to force guide object.
When creating the SPELFunc object, name is assigned automatically. Automatically assigned name is added a number after SPELFunc (e.g. SPELFunc01).

You can change the name. Set up 16 characters at the maximum. Please use alphanumeric characters and underscore [_]. Note: The initial character cannot be a numeric character.

Description Property

This property sets descriptions about force guide objects.
You can set the character string up to 255 characters.

Enabled Property

This property sets whether to enable force guide objects.

When specifying True, the force guide object is executed.
When specifying False, the next force guide object is executed without executing the Decision object and all force guide objects in the branch.

Use this property when you want to save the force guide sequence temporary or try with different parameters by copying the force guide object during the force guide sequence creation.

Value	Description
True	Enable a force guide object.
False	Disable a force guide object.

Default: True

StepID Property

This property sets StepID during the execution of the force guide objects.
It is only used when AutoStepID is False.

	Value
Minimum value	0
Maximum value	32767

Default: Automatically set according to the numbers of the force guide sequence and the force guide object.

AbortSeqOnFail Property

This property sets operations when force guide object fails.

When specifying True, the program ends force guide sequence and proceeds to the next SPEL statement if force guide object fails.
When specifying False, the program proceeds to the next force guide object without aborting the force guide sequence even the force guide object fails.

Use this property when you want to continue the force guide sequence (e.g. the recovery processes are included in the force guide sequence when the force guide object fails.)

Value	Description
True	Abort the force guide sequence when the force guide object fails.
False	Start the next force guide sequence when the force guide object fails.

Default: True

FuncName Property

Set a name of SPELFunc name to be executed.

A function to be specified by SPELFunc object must have a string type variable for an argument and the return value type must be Boolean.

SPELFunc object is failed when the return value of the SPELFunc to be specified is False.

The following is an example of the available SPELFunc.

```
Function MyFunc(ObjectName$ As String) As Boolean
    MyFunc = True
Fend
```

Details on results of the SPELFunc object

EndStatus Result

It is a result of the execution.

It will be succeed when satisfying “success conditions” described in *4.3.10 SPELFunc Object*.

Value	Description
Passed	Force guide object had succeeded.
Failed	Force guide object had failed.
NoExec	Force guide object had not executed.
Aborted	Aborted during the execution of force guide object.

Time Result

It is the required time for execution.

Unit: [sec]

5. SPEL+ Programming of the Force Functions

The following describes the SPEL programming for using the force functions.

The force functions are executed using special commands added to the SPEL+ language.

Various applications can be implemented using the force functions by combining the special commands added to Force Guide 7.0 with the existing SPEL+ language.

5.1 SPEL+ Commands of Force Guide 7.0.

The following describes the concept necessary for using the SPEL+ commands added to Force Guide 7.0.

5.1.1 Force Object

A force object is a set of properties for each function necessary for using the force functions.

Define this object and execute each force function. A force object can be defined using a GUI such as Robot Manager or SPEL+ commands.

There are the following types of force objects.

- "Force control object" used for the force control function
- "Force trigger object" used for the force trigger function
- "Force monitor object" used for the force monitor function
- "Force coordinate object" used commonly for the force functions

5.1.2 Properties

Properties are parameters included in the force objects. The properties can be set and obtained.

The properties can be set using Force Editor before executing a program or can be changed dynamically using SPEL+ commands in a program.

An FSet statement is used to set properties. An FGet statement is used to get properties. Properties set by FSet are copied to the force file at the time when a project is loaded. The set values can be saved in the file using the FSave statement.

5.1.3 Status

A status is a value that is included in the force object and is returned after the force function is executed.

A status can be obtained by a SPEL+ command in a program, and the process can be branched based on it. An FGet statement is used to get a status. Each status is cleared at a unique timing. For details on when each status is initialized, refer to each status in the following manual.

EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

5.2 SPEL+ Programming of the Force Control Function

5.2.1 Overview

A force control function is a function to control the robot to achieve a given target force and torque using the Force Sensor.

Programming of the force control function is performed with the following procedure.

1. Set the coordinate system to be executed
2. Set the parameters
3. Execute the force control function

5.2.2 Coordinate System of the Force Control Function

The force control function works in the force coordinate system.

The force control function calculates the force detected by the sensor, the force applied to the force coordinate system by the torque, and the torque itself, and controls the robot while moving and rotating the force coordinate system according to the results of the calculations.

Specify the origin of the force coordinate system in a point where contact actually occurs and a force is generated. (Example: Tip point of a workpiece)

Furthermore, the orientation of the force coordinate system varies depending on the application. When executing the force control function in a constant direction, regardless of the posture of the robot, like a case where a force is always applied in the vertical downward direction, specify the base coordinate system and local coordinate system.

When executing the force control function in a direction that changes according to the posture of the robot, like a case where a force is applied in a direction of the workpiece held by the robot, specify the tool coordinate system and custom coordinate system.

The force control function can be executed for the six axes (Fx to Tz) specified in the force coordinate system.

5.2.3 Parameters of the Force Control Function

Parameters of the force control function are defined in the properties of the force control object.

They can be set in the GUI before executing a program. For details on the settings in the GUI, refer to the following section.

Software: 3.5.1 [Robot Manager] (Tools Menu)
[Tools]-[Robot Manager]-[Force] Panel

If you want to dynamically change the parameters during executing a program, they can be set using an FSet statement.

CoordinateSystem Property

Specify the force coordinate object for which the force control function is executed.

Changing only the CoordinateSystem property enables the force control function with the same control characteristics to be executed in another coordinate system.

Enabled Property

Specify the axes (Fx to Tz) on which the force control function is executed.

You can enable only the axes necessary for an application; for example, you can enable Fx to Fz and disable Tx to Tz to execute the force control function only in the translation direction.

TargetForce Property

Set the target force and torque of the force control function for each axis.

The robot moves to detect the set force. Note that if a positive value is set, the robot moves in a negative direction to apply a force in the positive direction of the force coordinate system.

If you want to perform the pressing operation in the positive direction of the force coordinate system, set a negative target force.

The robot moves not to apply a force if the TargetForce property is set to 0. The robot can move while following the external force.

Spring Property

Set the spring value of the force control function.

Setting the Spring property enables the force control function to work as if there is a virtual spring, and if an external force is applied, the robot moves to the position to counterbalance the force, and if the applied external force is removed, the robot returns to the original position.

Increasing the value moves the robot as if a harder spring is provided. If “0” is set, there is no virtual spring, so the robot moves as far as it can according to the force.

Damper Property

Set the damper value of the force control function.

Decreasing the Damper property value increases the response of the force control function to changes in the force, but makes the motion of the robot more vibratory. To adjust the Damper property value, decrease the default value gradually.

Mass Property

Set the mass value of the force control function.

Setting a large value for the Mass property increases the overshoot until the target force is achieved and increases the hunting period. Set the Mass and Damper property values so they are about 1:1 to 10:1 in the translation direction and about 1:1 to 1000:1 in rotation to perform stable control.

However, note that the motion may be vibratory, or a ratio larger than those may be appropriate for some applications or operating conditions.

If the Mass property value is too small compared to that of the Damper property value, an error may occur when the force control function is executed.

TargetForcePriorityMode Property

Set the target force priority mode of the force control function. The target force may not be able to be achieved after the passing of enough time for some operating conditions such as mechanical rigidity. In this case, enabling the target force priority mode increases the movement and reduces the time to achieve the target force. However, the movement will differ from that specified in Spring, Damper, and Mass. Normally, disable the target force priority mode, and use the mode only when necessary upon fully understanding the characteristics.

LimitSpeed Property

Set the maximum value of the speed at which the hand tip of the robot works during executing of the force control function.

Specify the three values of translation, rotation, and joint speed. The speed is automatically limited to the specified maximum value during executing of the force control function. This property is useful, for example, if you need to move the robot in a high power mode to perform a pressing operation with a strong force, but want to move it at a low speed.

LimitAccel Property

Set the maximum value of the acceleration at which the hand tip of the robot works during executing of the force control function.

Specify the three values of translation, rotation, and joint acceleration. The acceleration is automatically limited to the specified maximum value during executing of the force control function.

5.2.4 Executing the Force Control Function

The force control function is executed alone as an operation command, or the position control and force control functions are executed simultaneously by adding a modification parameter to the operation command of the position control. When the force control function is executed, the operation always changes depending on the output of the Force

Sensor, so that the robot does not reach the target position of the position control, but even though the same command is executed, the operation ends at different positions every time.

To execute only the force control function, execute the FCKeep statement. The following operation commands can be used in combination with the force control function: Move, BMove, TMove, CVMove, FCSMove, Arc, and Arc3 statements.

To execute the force control function, add the force control object to each statement as a modification parameter.

Example of combination of the force control function with Move:

Move P1 FC1

For details on each statement, refer to the following manual.

EPSON RC+ 7.0 SPEL+ Language Reference

EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference

For details on operation commands with the force control function enabled, refer to the following manual.

EPSON RC+ 7.0 Option Force Guide 7.0 Property & Status Reference
- Move

The force control function starts at the same time as the operation command and stops when the travel time calculated at the time when the operation command started has elapsed. The execution of the force control function can be continued after the operation command ends by adding a CF modification parameter. However, if another force control function does not execute an effective operation command or a command to stop the force control function within 60 seconds, an error occurs.

Use an FCKeep statement, for example, in standby mode for a certain period of time with the force control function enabled after an operation command is executed.

The operation end conditions of the force control function (for example, the force control function works until a specified force is reached) can be set in combination with the Till modification parameter or force trigger function.

Furthermore, since errors are accumulated due to a drift of the Force Sensor, the force control function must be executed within 10 minutes after resetting the Force Sensor.

The Force Sensor should be reset immediately before using the force control function with no external force applied to it, and should be executed in as short a period of time as possible.

The force control function cannot be executed near the singular point of the robot. Execute the force control function avoiding the vicinity of the singular point. If the robot approaches the vicinity of the singular point during executing of the force control function, an error occurs.

5.3 SPEL+ Programming of the Force Trigger Function

5.3.1 Overview

A force trigger function is a function to detect that the force and torque measured using the Force Sensor reached the set value.

The process can be started, ended, and branched using the results.

Programming of the force trigger function is performed with the following procedure.

1. Set the coordinate system to be executed
2. Set the parameters
3. Execute the force trigger function
4. Get the results

5.3.2 Coordinate System of the Force Trigger Function

The force trigger function works in the force coordinate system.

The force trigger function calculates the force detected by the Force Sensor, the force applied to the force coordinate system by the torque, and the torque itself, and monitors whether the values met the set conditions.

Specify the origin of the force coordinate system in a point where contact actually occurs and a force is generated. (Example: Tip point of a workpiece)

Furthermore, the orientation of the force coordinate system varies depending on the application. When monitoring the force in a constant direction, regardless of the posture of the robot, specify the base coordinate system and local coordinate system.

When monitoring the force in a direction that changes according to the posture of the robot, specify the tool coordinate system and custom coordinate system.

The force trigger function can monitor the following total of 8-dimensional data specified in the force coordinate system.

Six axes Fx to Tz

Fmag: Composite translation force

Tmag: Composite torque

5.3.3 Parameters of the Force Trigger Function

Parameters of the force trigger function are set in the properties of the force trigger object.

They can be set in the GUI before executing a program. For details on the settings in the GUI, refer to the following section.

Software: 3.5.1 [Robot Manager] (Tools Menu)
[Tools]-[Robot Manager]-[Force] Panel

If you want to dynamically change the parameters during executing a program, they can be set using an FSet statement.

ForceSensor Property

Specify the Force Sensor number to execute the force trigger function.

CoordinateSystem Property

Specify the force coordinate object for which the force trigger function is executed.

Operator Property

Specify the criterion for meeting the condition of the force trigger function; specifically whether all conditions for each axis are met or whether the conditions of a particular axis are met.

TriggerMode Property

Specify whether to monitor the force and torque, or to monitor the changes in the force and torque.

If a change value is specified, the change value per second is monitored. Since the Force Sensor is susceptible to noise, use a low-pass filter.

Fmag_Axes Property

Specify the axis from the axes (Fx to Fz) to be combined to calculate the Fmag value.

To monitor the force applied to the X-Y plane, specify the direction to be monitored; for example, specify the X and Y axes.

Tmag_Axes Property

Specify the axis from the axes (Tx to Tz) to be combined to calculate the Fmag value.

Enabled Property

Specify the axis (Fx to Tmag) on which the force trigger function is executed.

The force trigger function can be enabled only for the axes necessary for an application.

Polarity Property

Specify the criterion for meeting the condition, whether the force and torque for each axis falls inside or outside the upper/lower threshold ranges.

To detect that a force outside the threshold range is applied, specify outside.

To detect that a force inside the threshold range is applied, specify inside.

UpperLevel Property

Set the upper level of the force trigger function.

This function monitors whether the value is below or rises above the set value.

LowerLevel Property

Set the lower level of the force trigger function.

This function monitors whether the value is above or falls below the set value.

LPF_Enabled Property

Specify the axis (Fx to Tmag) on which the low-pass filter is executed in the force trigger function.

Use this property to reduce the noise or when ignoring Force Sensor values such as impulse.

LPF_TimeConstant Property

Specify the time constant of the low-pass filter to be executed in the force trigger function.

Increasing the value reduces the noise, but also reduces the response to the Force Sensor values.

5.3.4 Executing the Force Trigger Function

The force trigger function can be specified by Till, Wait, Trap, and Find.

For the basic functions of the commands, refer to the following manual.

EPSON RC+ 7.0 SPEL+ Language Reference

The following describes the force trigger function. Up to 15 force triggers for monitoring can be set for each robot simultaneously. When the maximum number is exceeded, an error occurs.

Till

Specifying the force trigger object in the event expression of the Till statement sets the end condition for the operation of the force trigger function. Thus, when the force reaches the specified value, the operation ends.

Use example:

```
Till FT1
Move P1 FC1 Till
```

The force trigger is set to the Till condition by the Till statement. When the condition set in force trigger object FT1 is met during Move operation, the Move operation stops even if part way through the operation and the next statement is executed.

Trap

Specifying the force trigger object in the event expression of the Trap statement sets the condition for the force trigger function to start the interrupt processing. Thus, the force is always monitored, and when the force reaches the specified value, the interruption starts.

Use example:

```
Trap 1, FT1 Goto TrapLabel
```

The force trigger function is executed by the Trap statement to start monitoring of the condition. When the condition set in force trigger object FT1 is met, the transition to the specified label occurs.

Wait

Specifying the force trigger object in the event expression of the Wait statement sets the condition for the force trigger function to end the standby state. Thus, the force trigger function stands by until the force reaches the specified value.

Use example:

```
Wait FT1
```

The force trigger function is executed by the Wait statement to start monitoring of the condition. The program is stopped until the condition set in force trigger object FT1 is met, and the program is restarted when the condition is met.

Find

Specifying the force trigger object in the event expression of the Find statement sets the condition to save the coordinates while the force trigger function is in operation. Thus, the position at which the specified force is reached is recorded.

Use example:

```
Find FT1
P0=FindPos
```

The force trigger function is executed by the Find statement to start monitoring of the condition. The controller memorizes the position at which the condition set in force trigger object FT1 is met and gets that position with the FindPos function.

The force trigger function can get the position at which the condition is met using the TriggerdPos status. Therefore, Find is useful when specifying an event expression combining multiple conditions. The TriggerdPos status can be used to get the position at which the condition set in the force trigger object is met. The FindPos function can be used to get the position at which an event expression combining multiple conditions is met.

5.3.5 Getting the Results of the Force Trigger Function

Specifying the status of the force trigger object using the FGet statement after executing the force trigger function can get the results. The acquired results can be used to determine the pass or fail of the operation, or perform conditional branching.

The status is initialized when the force trigger function is executed, and the result is set when the force trigger function ends. The set result is retained until either the force trigger function is executed again or a project is loaded.

Triggerd Status

Returns the status of achievement of the force trigger condition.

Returns "True" if the condition is achieved in the previous force trigger condition. This result can be used to determine whether the force exceeded the specified value, and branch the process.

TriggerdAxes Status

Returns the status of achievement of the force trigger condition for each axis.

It can determine more detailed conditions; for example, determine the axis on which the force exceeded the specified value, and branch the process.

TriggerdPos Status

Returns the coordinates at which the force trigger condition was achieved.

It can determine whether the position at which the condition was achieved is within the specified range, and branch the process according to the position.

5.4 SPEL+ Programming of the Force Monitor Function

5.4.1 Overview

A force monitor function is a function to measure the force and torque using the Force Sensor.

The results can be used to adjust the parameters when an application is created, or record and manage the forces applied to each workpiece during the operation.

Programming of the force monitor function is performed with the following procedure.

1. Set the coordinate system to be executed
2. Set the parameters
3. Execute the force monitor function and take measurements

5.4.2 Coordinate System of the Force Monitor Function

The force monitor function works in the force coordinate system.

The force monitor function calculates the force detected by the Force Sensor, the force applied to the force coordinate system by the torque, and the torque itself, gets the values, and calculates the average and peak values.

Specify the origin of the force coordinate system in a point where contact actually occurs and a force is generated. (Example: Workpiece edge point, etc.)

Furthermore, the orientation of the force coordinate system varies depending on the application. When measuring the force in a constant direction, regardless of the posture of the robot, specify the base coordinate system and local coordinate system. When measuring the force in a direction that changes according to the posture of the robot, for example, in the forward direction of a workpiece held by the robot, specify the tool coordinate system and custom coordinate system.

The force monitor function can measure the following total of 8-dimensional data specified in the force coordinate system.

Six axes Fx to Tz

Fmag: Composite translation force

Tmag: Composite torque

5.4.3 Parameters of the Force Monitor Function

Parameters of the force monitor function are set in the properties of the force monitor object. They can be set in the GUI before executing a program. For details on the settings in the GUI, refer to the following section.

Software: 3.5.1 [Robot Manager] (Tools Menu)
[Tools]-[Robot Manager]-[Force] Panel

If you want to dynamically change the parameters during executing a program, they can be set using an FSet statement.

ForceSensor Property

Specify the Force Sensor number to execute the force monitor function.

CoordinateSystem Property

Specify the force coordinate object for which the force monitor function is executed.

Fmag_Axes Property

Specify the axis from Fx to Fz to be combined to calculate the Fmag value.

To measure the force applied horizontally to the X-Y plane, specify the direction to be measured; for example, specify the X and Y axes.

Tmag_Axes Property

Specify the axis from Tx to Tz to be combined to calculate the Fmag value.

LPF_Enabled Property

Specify the axis (Fx to Tmag) on which the low-pass filter is executed in the force monitor function.

Use this property to reduce the noise or when ignoring Force Sensor values such as impulse.

LPF_TimeConstant Property

Specify the time constant of the low-pass filter to be executed in the force monitor function.

Increasing the value reduces the noise, but also reduces the response to the Force Sensor values.

5.4.4 Executing the Force Monitor Function

The following operations can be performed with the force monitor function.

- Getting the Force Sensor values
- Recording the Force Sensor values
- Getting the average value
- Getting the peak value

Getting the Force Sensor Values

Execute the Force property of the force monitor object to get the Force Sensor values.

Use example:

```
FGet FM1.Forces, rVar()
```

Get the 8-dimensional Force Sensor values for Fx to Tmag in real array variable rVar. The Force Sensor values to be acquired are the latest values.

Getting the Average Value

Execute the AvgForceClear property of the force monitor object to start calculating the Force Sensor average value.

After the start, the average value can be acquired using the AvgForce status.

Use example:

```
FSet FM1.AvgForceClear, True, True, True, True, True,
True, True, True
FGet FM1.AvgForces, rVar()
```

Get the 8-dimensional Force Sensor average value for Fz to Tmag in real array variable rVar.

Before executing the AvgForce status, be sure to start calculating the average value using the AvgForceClear property. If the calculation is not started, “0” is acquired.

Executing the AvgForce status stops the calculation of the average value. To get the average value consecutively, every time the average value is acquired, start calculating the average value again and then get the average value.

Executing the AvgForce status more than one minute after starting calculating the average value causes an error to occur. Either execute the AvgForce status within one minute or start calculating the average value again.

Getting the Peak Value

Execute the PeakForceClear property of the force monitor object to start calculating the Force Sensor peak value.

After the start, the peak value can be acquired using the PeakForce status.

Use example:

```
FSet FM1.PeakForceClear, True, True, True, True, True, True,
 True, True
FGet FM1.PeakForces, rVar()
```

Get the 8-dimensional Force Sensor peak value for Fx to Tmag in real array variable rVar.

Before executing the PeakForce status, be sure to start calculating the peak value using the PeakForceClear property. If the calculation is not started, “0” is acquired.

Executing the PeakForce status stops the calculation of the peak value. To get the peak value consecutively, every time the peak value is acquired, start calculating the peak value again and then get the peak value.

Recording the Force Sensor Values

Execute the LogStart property of the force monitor object to record the Force Sensor values in a file.

This enables information on each operation to be stored in a file.

Use example:

```
WOpen "test.txt" As #30
FSet FM1.LogStart, 30, 0.1, #30
```

Open a file in file number 30 using the WOpen statement and execute the LogStart property to start recoding Force Sensor values, etc. in the file with file number 30 at 30-second or 0.1-second intervals. After starting recording, the program goes to the next statement.

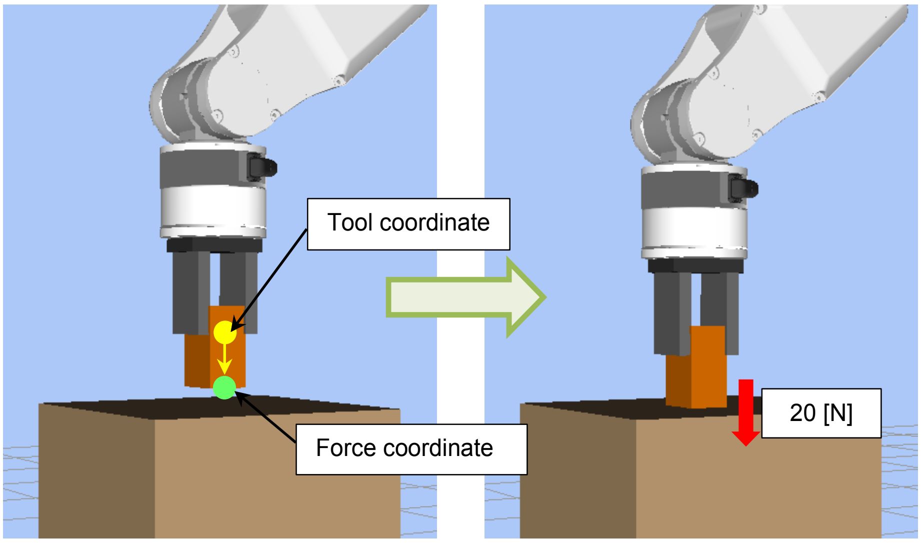
5.5 Example of a Force Function Program

The following describes an example of a simple operation in combination with the force functions.

⚠ CAUTION	■ The parameters described in the example are reference values. Please note that relatively stable parameters are used, but the operation may not be successful or the motion may be vibratory in some operating conditions, and the parameters may need to be adjusted. In addition, slow stable parameters are used for convenience of explanation. The parameters need to be adjusted for faster operations.

Pressing Operation

The following describes an example of a program to perform a pressing operation in a constant direction with a target force.



The example operation is to move a workpiece to the position 10 [mm] above the contact position and use the force control function to press the workpiece held by the hand against the worktable with a force of 20 [N].

At the same time, the force trigger function is used to monitor excessive force (100 [N] or more) during the operation, and detecting excessive force causes an error to occur.

Furthermore, the force monitor function is used to measure the Force Sensor values after the operation is completed and also measure the maximum force applied during the operation.

The tool coordinate system is set in the hand tip, and the forward direction of the hand is the Tlz axis direction.

Sample Program

```
Function PressSample_Main
  Real rVar(8)
  Motor On
  Go P0                              'Go to the operation start position
  PressSample_PropertySetting        'Set the property
  FSet FS1.Reset                     'Reset the Force Sensor
  Trap 1, FT1 Call PressSample_EHandle 'Start monitoring excessive force
  FSet FM1.PeakForceClear, True, True, True, False, False, False, True, False
                                     'Start calculating the peak value
  FCKeep FC1, 10                     'Execute the force control function for 10 seconds
  Print "Motion End"
  FGet FM1.Forces, rVar()            'Get the Force Sensor value
  Print "Force Fz:", rVar(FG_FZ), ", Fmag:", rVar(FG_FMAG)
  FGet FM1.PeakForces, rVar()        'Get the peak value
  Print "PeakForce Fz:", rVar(FG_FZ), ", Fmag:", rVar(FG_FMAG)
Fend

Function PressSample_PropertySetting
  FSet FCS1.Position, 0, 0, 30       'The origin of the force coordinate system is Z30 mm
  FSet FCS1.Orientation, FG_TOOL     'The orientation is aligned with the tool coordinate system
  FSet FC1.CoordinateSystem, FCS1    'Specify the defined force coordinate No. 1
  FSet FC1.Enabled, False, False, True, False, False, False
                        'Enable the force control function only for the Fz direction.
  FSet FC1.Fz_TargetForce, -20       'Pressing of –20
  FSet FC1.Fz_Spring, 0              'The spring value is 0
  FSet FC1.Fz_Damper, 10             'The damper value is 10
  FSet FC1.Fz_Mass, 10               'The mass value is 10

  FSet FT1.ForceSensor, 1            'Specify the Force Sensor No. 1
  FSet FT1.CoordinateSystem, FCS1    'Specify the defined Force coordinate No. 1
  FSet FT1.TriggerMode, FG_FORCE     'Monitor the force
  FSet FT1.Fmag_Axes, FG_XYZ
  FSet FT1.Enabled, False, False, False, False, False, False, True, False
                                     'Enable only Fmag
  FSet FT1.Fmag_Polarity, FG_OUT
                           'Trigger detects when the value falls outside the threshold range
  FSet FT1.Fmag_Levels, 0, 100       'The range of Fmag is 0 to 100

  FSet FM1.ForceSensor, 1            'Specify the Force Sensor No. 1
  FSet FM1.CoordinateSystem, FCS1    'Specify the defined Force coordinate No. 1

Fend
```

```
Function PressSample_EHandle
   Real rVar(8)
   FGet FM1.PeakForces, rVar()            'Get the peak value
   Print "Error Handle"
   Print "PeakForce Fz:", rVar(FG_FZ), ", Fmag:", rVar(FG_FMAG)
   AbortMotion All                        'Abort the robot motion and put it into an
                                          'error state
Fend
```

Description

(1) Executing the PressSample_Main function moves the robot to the operation start position.

(2) Call PressSample_PropertySetting and execute the settings of the properties.
However, the settings of the properties can also be configured beforehand in Force Editor in the GUI. To do so, you need to call PressSample_PropertySetting.

  (a) Set the force coordinate object.
  For the force coordinate system, specify the Z30 [mm] position in the example to specify the workpiece edge position in the tool coordinate system. The orientation is the same as the orientation of the tool coordinate system.

  (b) Set the force control object.
  Specify FCS1 set as the coordinate system in which the force control function is executed. Specify a negative value for the target force, as the pressing operation is performed in the positive FZ direction. Set the spring, damper, and mass values.
  "0" is set in Spring in this example, so the robot does not have a virtual spring and continues to move until the target force is achieved.
  In addition, stable parameters are used for Damper and Mass. For faster operations, adjust these values by decreasing them gradually. However, decreasing the values increases the overshoot of the force.

  (c) Set the force trigger object.
  Specify the Force Sensor number to be used and the coordinate system in which the force trigger function is executed. Specify a force in the TriggerMode property to monitor excessive force. Specify X, Y, and Z, as the composite force to be monitored is calculated using all Fx to Fz. Specify 0 to 100 [N] for the Fmag range to set 100 [N] for the excessive force, and configure to monitor whether the value falls outside this range.

  (d) Set the force monitor object.
  Specify the Force Sensor number for measurement and the coordinate system.

(3) Reset the Force Sensor before using the force functions.

(4) Specify the force trigger object in Trap and execute the force trigger function.
Thus, excessive force is monitored.

(5) Calculation of the peak value of the force applied during the operation starts.

(6) Execute the force control function for 10 seconds.

(7) Get and display the current and peak values of the Force Sensor and then exit the program.
In this example, only the values are displayed. These values can be used to determine the pass or fail of the operation and branch the process.

(8) If excessive force is detected during the operation, the program is aborted and the interruption of the PressSample_EHandle function is executed.
The peak value applied during the operation is acquired and displayed, the robot motion is aborted, and an error state is entered. In this example, an error state is entered, but processes in the event of an error, such as a retry, also can be executed.

6. Tutorial

Tutorial describes basic operation steps of Force Guide 7.0 by the following operations or motions.

Tutorial for Force Guidance Function
- 6.2 Simple pressing (pressing to vertical-downward)
- 6.3 USB Connector Insertion
- 6.4 Peg In Hole
- 6.5 Screw Driving

Tutorial for SPEL+ command
- 6.6 Simple Pressing

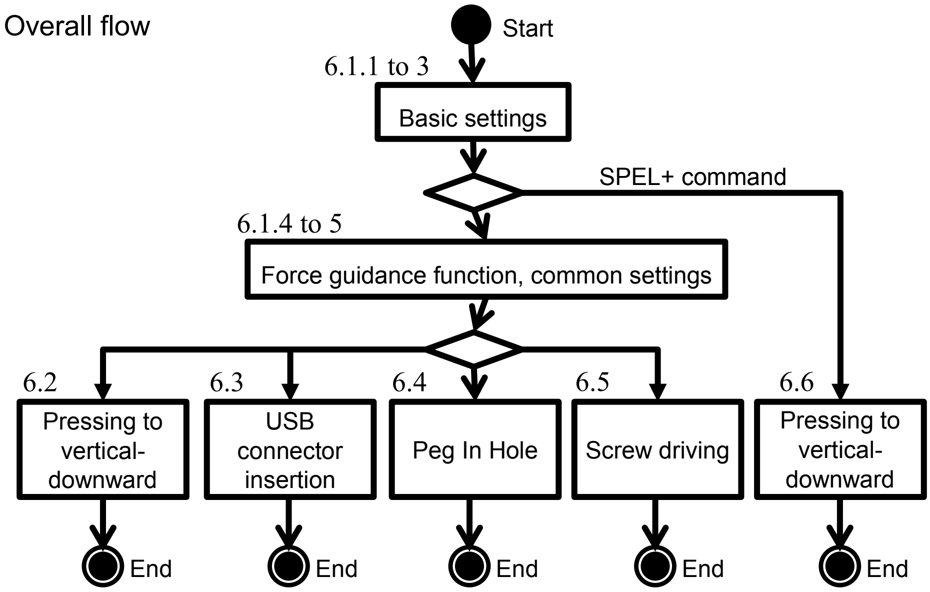
Before starting Tutorial, make sure that the following connections or settings have completed properly:

- Epson's sensor flange is used
- Force sensor is installed on the robot
- Force sensor is connected to force sensor I/F unit or the sensor 1 of the board
- Force sensor I/F unit is connected to controller
  Or force sensor I/F board is connected to controller properly
- EPSON RC+ can be communicated with controller
- Robot and controller are connected
- Robot is registered as robot 1

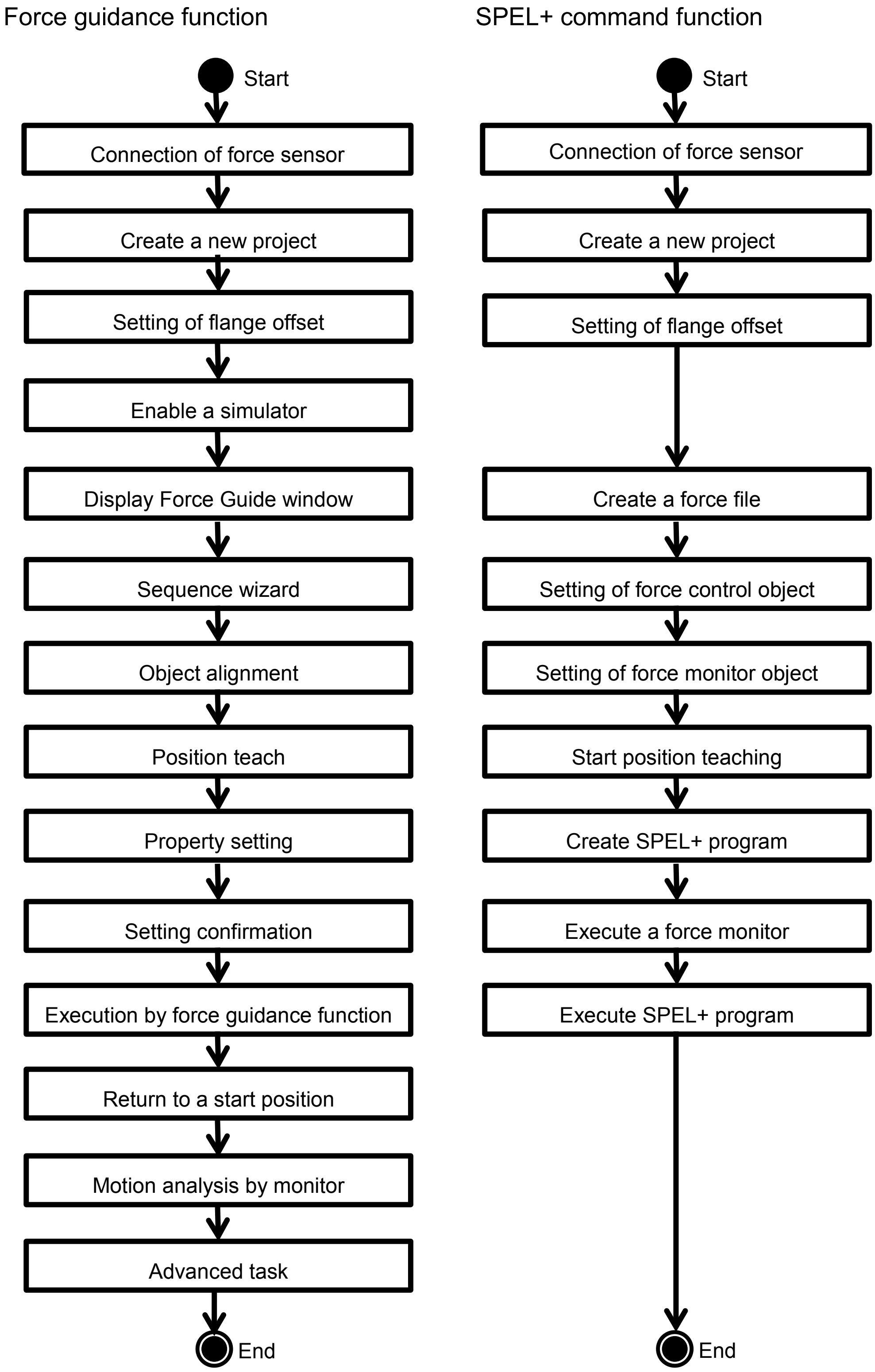
For details on connection or settings, refer to the next chapter and the following manuals:

Hardware: 6. How to Install

EPSON RC+ 7.0 User's Guide
3. Getting Started
10. Robot Configuration



Flow and details of Tutorial



6.1 Common Setting

Describe the required settings to use this option by using EPSON RC+.

First of all, install a force sensor to a robot. Then, refer to the following sections to complete the setting. It is only required when you use this option for the first time. You do not need to set every time.

6.1.1 Connection Setting of Force Sensor
6.1.2 Create a New Project
6.1.3 Setting of Flange Offset
6.1.4 Enable a Simulator

If the settings from 6.1.1 through 6.1.4 have already completed, refer to the following section and display the [Force Guide] window.

6.1.5 Display the [Force Guide] Window

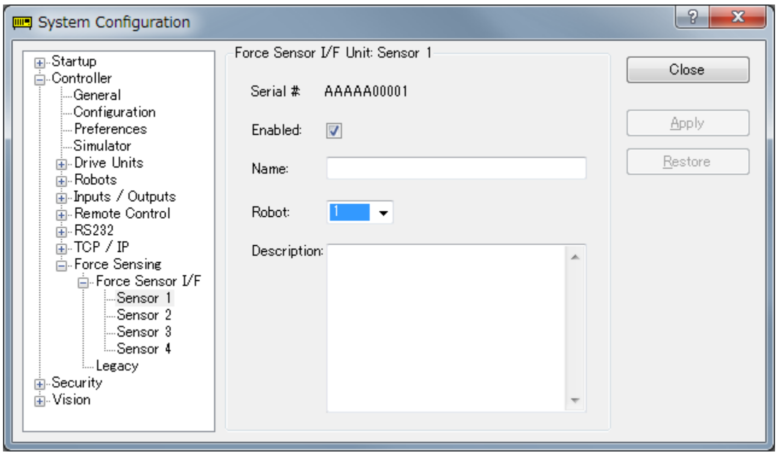
Then, proceed to the following tutorials:

6.2 Force Guidance Function (pressing to vertical-downward)
6.3 Force Guidance Function (USB Connector Insertion)
6.4 Force Guidance Function (Peg In Hole)
6.5 Force Guidance Function (Screw Driving)
6.6 Command Version (Simple Pressing)

6.1.1 Connection Setting of Force Sensor

The following describes how to relate the robot that executes the force function with force sensor.

(1) Select EPSON RC+ menu-[System Configuration]-[Controller]-[Force Sensing]-[Force Sensor I/F]-[Sensor 1].



Force Sensor I/F Unit: Sensor 1

Serial #: AAAAA00001

Enabled: ☑

Name:

Robot: 1

Description:

(2) Place a checkmark in the [Enabled] check box.

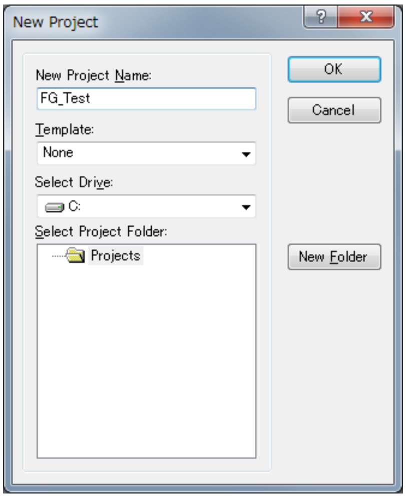
(3) Select “1” in [Robot].

(4) Wait for the robot controller to restart.

6.1.2 Create a New Project

The following describes how to create a project that executes force functions.

(1) Click EPSON RC+ menu-[Project]-[New Project].
The [New Project] dialog box is displayed.



New Project Name: FG_Test
Template: None
Select Drive: C:
Select Project Folder: Projects

(2) Enter “FG_Test” to [New Project Name].

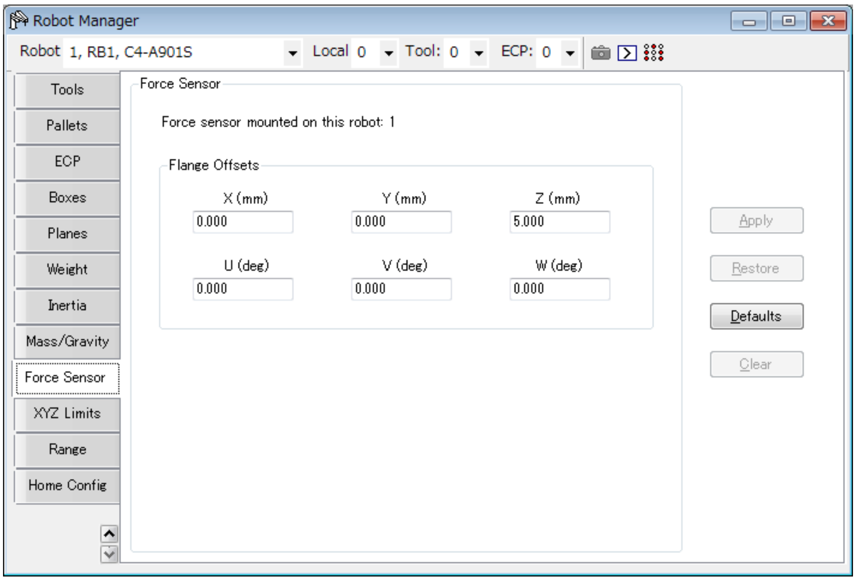
(3) Click the <OK> button.

6.1.3 Setting of Flange Offset

The following describes how to set the flange offset.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Select the [Force Sensor] tab.



Robot 1, RB1, C4-A901S
Local 0
Tool: 0
ECP: 0

Force Sensor

Force sensor mounted on this robot: 1

Flange Offsets

X (mm)	Y (mm)	Z (mm)
0.000	0.000	5.000
U (deg)	**V (deg)**	**W (deg)**
0.000	0.000	0.000

(3) Set the flange offset.

When using Epson's sensor flange:

Click the <Defaults> button, then click the <Apply> button.

Values are different depending on using manipulator.
Refer to the following section if necessary.
Software 2.2 Coordinate Conversion

When using own sensor flange:

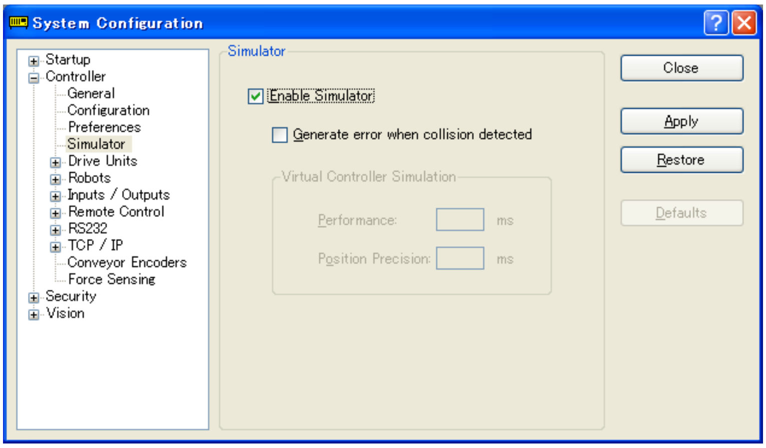
Enter each value and click the <Apply> button.

Sections after 6.1.4 are settings for force guidance function.
For SPEL+ command function, go on to the following section:
6.6 Command Version (Simple Pressing)

6.1.4 Enable a Simulator

The following describes how to enable the simulator function.

(1) Click EPSON RC+ menu-[Setup]-[System Configuration].
The [System Configuration] dialog box is displayed.



☑ Enable Simulator

☐ Generate error when collision detected

(2) Select [Controller]-[Simulator].

(3) Place a checkmark in the [Enable Simulator] checkbox.

(4) Click the <Apply> button.

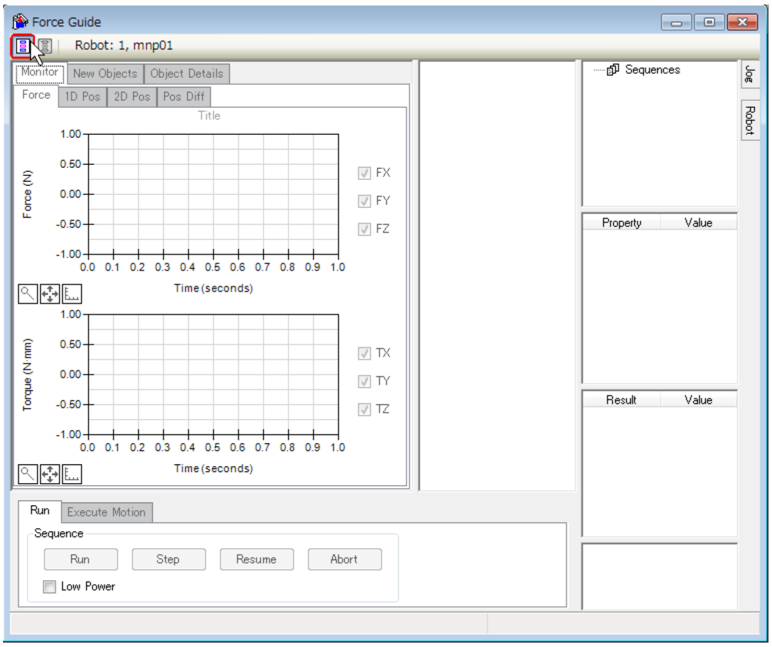
(5) Wait for the robot controller to restart.

6.1.5 Display the [Force Guide] Window

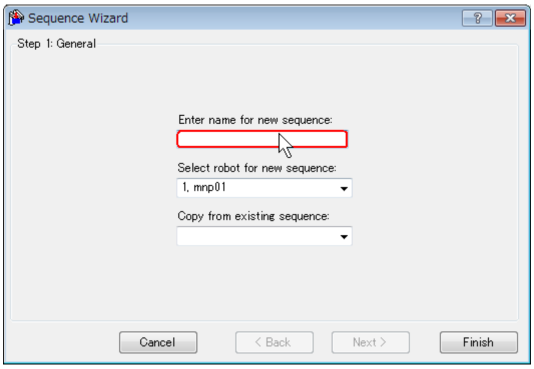
The following describes how to start the force guidance function.

(1) Click EPSON RC+ menu-[Tools]-[Force Guide].
The [Force Guide] window is displayed.

(2) Click the <New Sequence > button.



(3) Sequence Wizard is displayed.



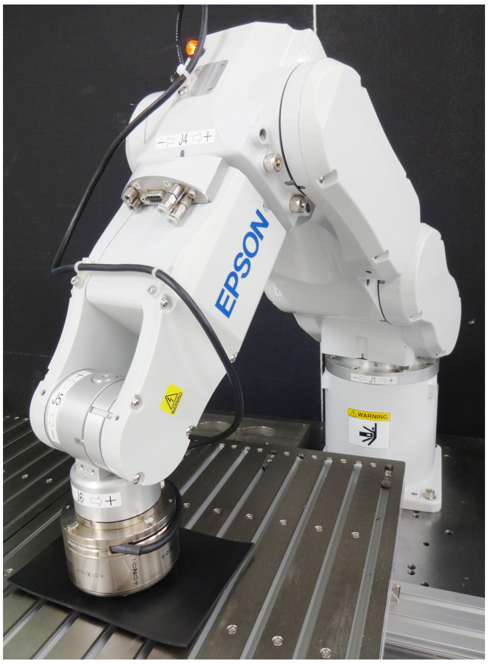
Enter name for new sequence:

Select robot for new sequence: 1, mnp01

Copy from existing sequence:

6.2 Force Guidance Function (pressing to vertical-downward)

As one of the easiest operations, this tutorial describes "pressing" operation to vertical-downward.



If pressing the top plate of force sensor to a hard desk or a shape-edged object directly, the plate will get damages or bent.

When performing "pressing" operations, be sure to take the following actions:

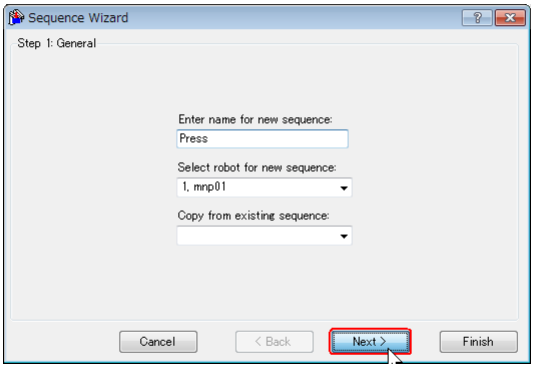
- Slip a rubber sheet or air cushions in between the "pressing" object and force sensor.
- Install a stick shaped end effector for practice.

⚠ CAUTION	■ The parameters described in tutorial are reference values. Please note that relatively stable parameters are used, but the operation may not be successful or the motion may be vibratory in some operating conditions, and the parameters may need to be adjusted. In addition, slow stable parameters are used for convenience of explanation. The parameters need to be adjusted for faster operations.

6.2.1 Sequence Wizard

The following describes how to create a force guide sequence that "pressing to vertical-downward".

(1) Enter "Press" in the [Enter name for new sequence] box.
Click the <Next> button.



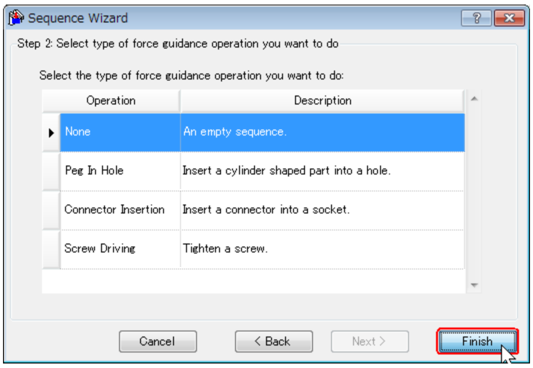
Step 1: General

Enter name for new sequence: Press

Select robot for new sequence: 1, mnp01

Copy from existing sequence:

(2) The [Step 2: Select type of force guidance operation you want to do] dialog box is displayed.
Select [None].
Click the <Finish> button.

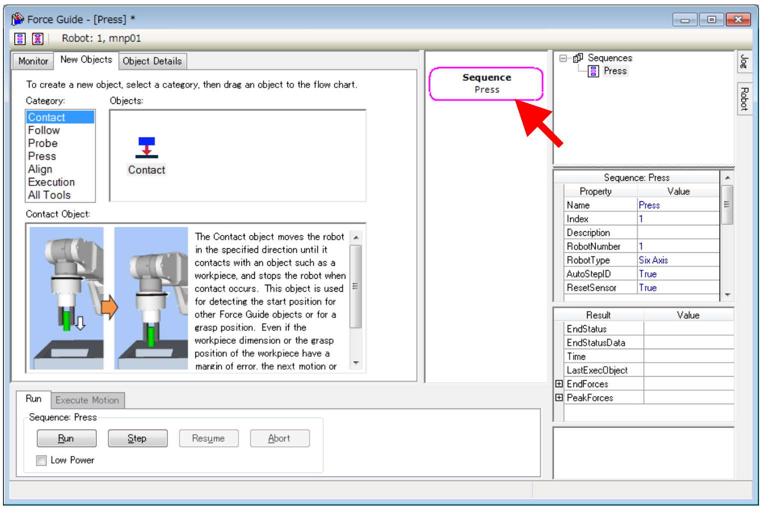


Step 2: Select type of force guidance operation you want to do

Select the type of force guidance operation you want to do:

Operation	Description
None	An empty sequence.
Peg In Hole	Insert a cylinder shaped part into a hole.
Connector Insertion	Insert a connector into a socket.
Screw Driving	Tighten a screw.

(3) Confirm that the [Press] sequence is created.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Sequence: Press

Property	Value
Name	Press
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

Sequence: Press

The [Press] sequence is an empty sequence. No objects are aligned.
Proceed to the next section.

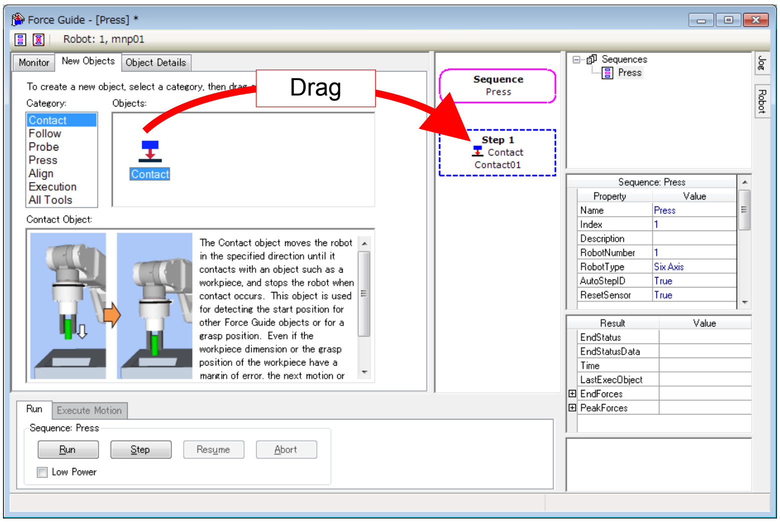
6.2.2 Object(s) Alignment

The following describes how to align the force guide objects in the flow chart.

Pressing operations can be performed by using "pressing" object only. However, when improving operation qualities and cycle time, operations will be performed effectively by dividing "contacting operation" from "pressing operation".

In this tutorial, divide "contact" from "press" and create a force guide sequence.

(1) Select the [Force Guide] window-[New Objects] tab.
Select "Contact" in [Category].
Click [Objects]-<Contact> icon.
Description is displayed on the lower half of the window.
Drag the <Contact> icon to the flow chart.



To create a new object, select a category, then drag

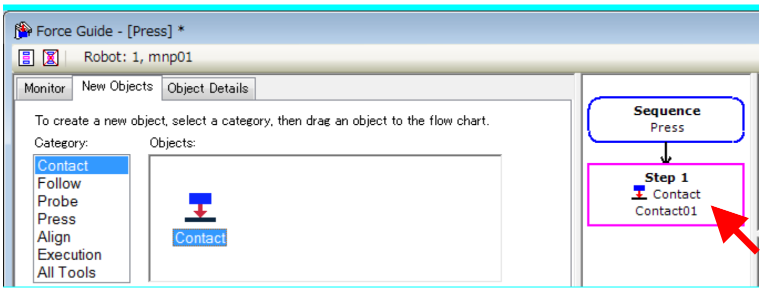
The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Sequence: Press

Property	Value
Name	Press
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

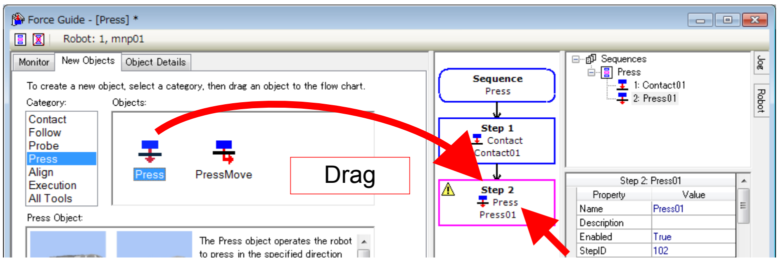
Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

The "Contact" object is registered as [Contact01] object.



To create a new object, select a category, then drag an object to the flow chart.

(2) Select “Press” in [Category].
Drag the [Objects]-<Press> icon to the flow chart.



To create a new object, select a category, then drag an object to the flow chart.

The Press object operates the robot to press in the specified direction

The “Press” object object is registered as [Press01] object.

Now, object settings have completed. Next section describes property setting.

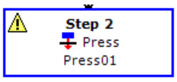
6.2.3 Property Setting

The following describes how to set the required properties for pressing operations.

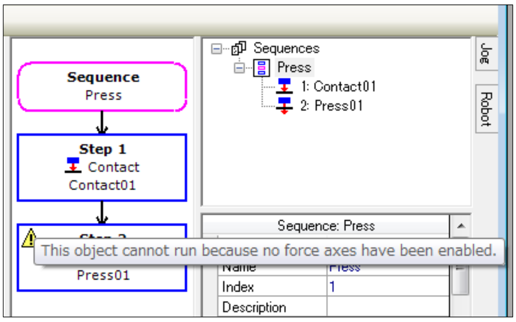
Values are as follows:

Threshold to end a contact object	: 4 [N]
Pressing force	: 4 [N]
Pressing time	: 1.0 [s]

(1) The ⚠ mark is displayed on the flow chart by default. You need to set properties.

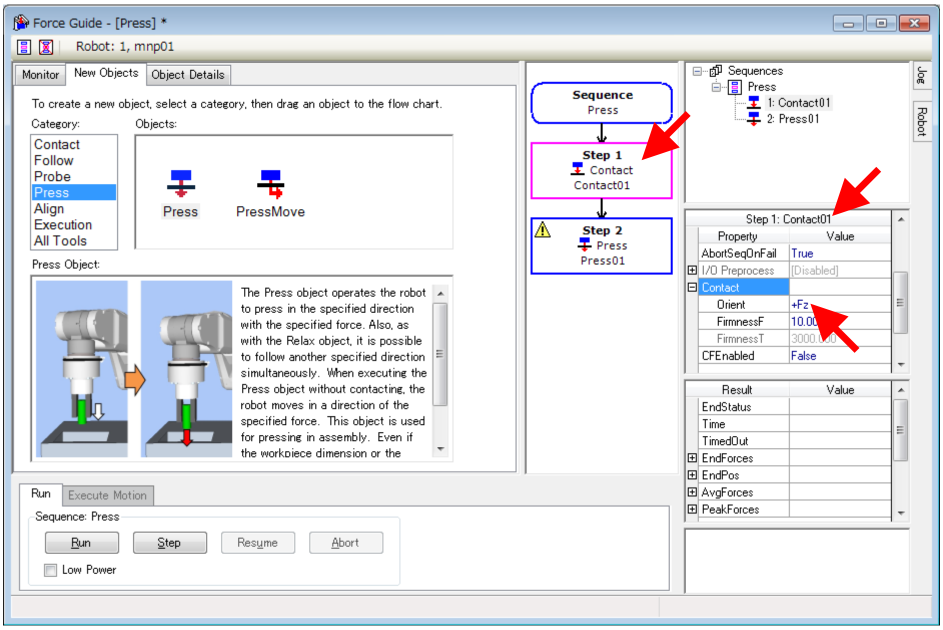


Move a mouse pointer on the ⚠ mark to display the tool tips. The tool tips show settings or contents which need to be modified.



This object cannot run because no force axes have been enabled.

(2) Click the object flow of [Contact01].
Properties and Results are displayed.



To create a new object, select a category, then drag an object to the flow chart.

The Press object operates the robot to press in the specified direction with the specified force. Also, as with the Relax object, it is possible to follow another specified direction simultaneously. When executing the Press object without contacting, the robot moves in a direction of the specified force. This object is used for pressing in assembly. Even if the workpiece dimension or the

Step 1: Contact01

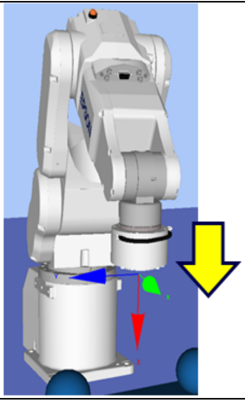
Property	Value
AbortSeqOnFail	True
I/O Preprocess	[Disabled]
Contact	
Orient	+Fz
FirmnessF	10.00
FirmnessT	3000.000
CFEnabled	False

Result	Value
EndStatus	
Time	
TimedOut	
EndForces	
EndPos	
AvgForces	
PeakForces	

(3) Confirm that the value of [Contact]-[Orient] property is "+Fz".
Contacting direction is the same as "+Fz" direction of tool setting.
It is set as "downward pressing" of 6-axis robot. At this time, only a negative (-) value can be entered to value of [ContactForceThresh] property.

"Pressing" direction is set depending on the direction of the tool setting.
In 6-axis and SCARA robots, when the mounting type is standard (floor mounting), tool settings for the sensor top plate will be opposite. Set as shown below.

[Reference]

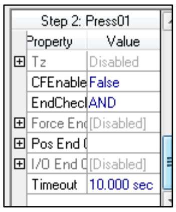
	6-axis robot	SCARA robot
Robot motion image **Pressing**		
(Press/Contact) Orient	+Fz	-Fz
Sign of Force (monitor display is included)	-	+

(4) Change the [Contact01] property.
You do not need to change items that are not shown in the following list.
Click on each item to display a property overview or a setting range in the quick help on the right bottom.

For details on the setting items, refer to the following section:
Software 4.3.1 Contact Object

Item	Value	Description
ContactOrient	+Fz	Set a direction to contact. The robot moves to the specified direction.
ContactFirmnessF	2	Set a firmness of the force control functions. When a large value is set: The force control function will become stronger. However, response to changes of the force is slow. When a small value is set: The force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur. When a small absolute value is set: Movement speed of the contact motion will be fast. Set a limit of speed advancement without damaging the workpiece or robot by yourself.
Force End Conditions - ContactForceThresh	- 4	Threshold to decide a contacting force. Absolute value of the force in the Fz direction exceeds that of ContactForceThresh in the specified time of Timeout. Approach speed to an object affects the force when the robot contacts with the object completely. Be sure to consider the possibility that the payload is applied to the workpiece or robot due to overshoot.
Timeout	10	If the end condition has not satisfied in 10 seconds, an error occurs. It can prevent an unintended motion such as a target of contact detection is far or a motion with improper setting.

(5) Click the [Press01] object.
Properties are displayed.



Step 2: Press01

Property	Value
⊞ Tz	Disabled
CFEnable	False
EndChec	AND
⊞ Force En	[Disabled]
⊞ Pos End	
⊞ I/O End	[Disabled]
Timeout	10.000 sec

(6) Change the property of [Press01].
You do not need to change items that are not shown in the following list.
Click on each item to display a property overview or setting range in the quick help on the right bottom.

Item	Value	Description
Fz - ControlMode	Press+	Mode of the force control functions to Fz direction. Press+: The robot moves to a positive direction of each axis and presses.
Fz - Force	-4	Set a pressing force. (negative value) For fittings or assembly tasks, usually the force is set 3 to 5[N] or −3 to −5[N] in Fx, Fy, and Fz. However, a proper value differs depending on tasks or workpiece.
Fz - Firmness	2	Set a firmness of the force control functions in Fz direction. When a large value is set: The force control function will become stronger. However, response to changes of the force is slow. When a small value is set: The force control function will become weaker. Response to changes of the force is fast, however, vibration is easy to occur.
Timeout	1	Set the time-out period. It is not the duration after the force reaches the [PressForce] but duration for the pressing force control.

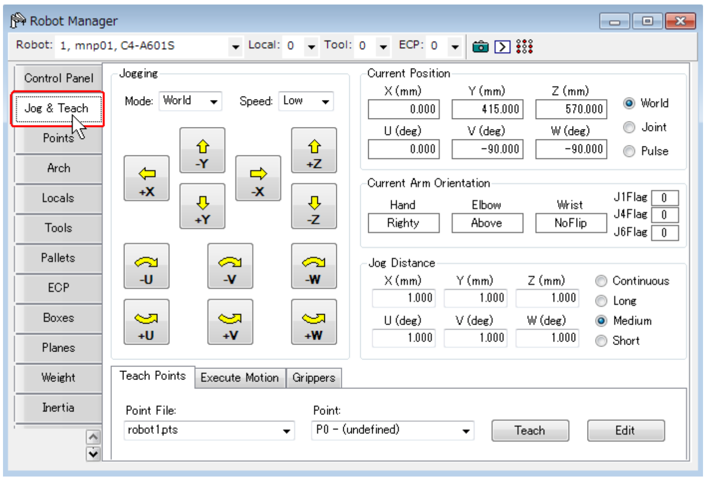
(1) Click EPSON RC+ menu-[File]-[Save File].
Modified property is saved in the project.

6.2.4 Position Teaching

The following describes how to teach a start point of "pressing" motion.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Select the [Jog & Teach] tab.



Robot Manager

Robot: 1, mnp01, C4-A601S Local: 0 Tool: 0 ECP: 0

Jogging

Mode: World Speed: Low

Current Position

X (mm) 0.000 Y (mm) 415.000 Z (mm) 570.000

U (deg) 0.000 V (deg) -90.000 W (deg) -90.000

● World ○ Joint ○ Pulse

Current Arm Orientation

Hand Righty Elbow Above Wrist NoFlip

J1Flag 0 J4Flag 0 J6Flag 0

Jog Distance

X (mm) 1.000 Y (mm) 1.000 Z (mm) 1.000

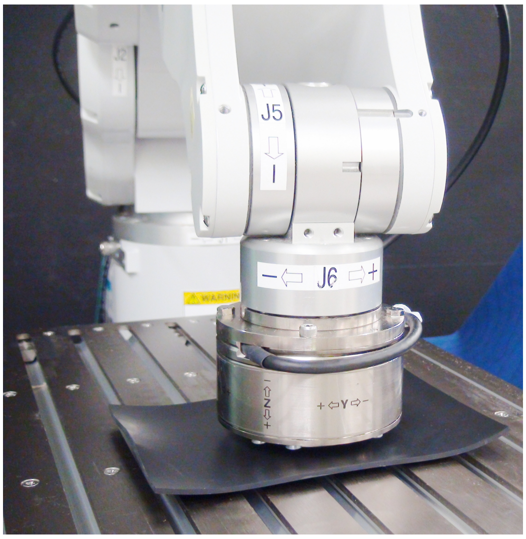
U (deg) 1.000 V (deg) 1.000 W (deg) 1.000

○ Continuous ○ Long ● Medium ○ Short

Point File: robot1pts

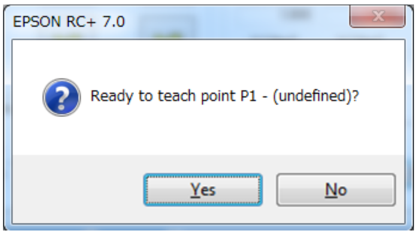
Point: P0 - (undefined)

(3) Click the Jog button and move the robot to 3mm above a target object to be pressed.



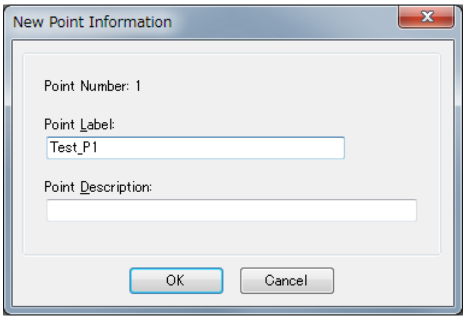
(4) Select "P1" in [Point].

(5) Click the <Teach> button.
The following message is displayed. Confirm the message and click the <Yes> button.



Ready to teach point P1 - (undefined)?

(6) The [New Point Information] dialog box is displayed.
Enter "Test_P1" to [Point Label] and click the <OK> button.



Point Number: 1

Point Label: Test_P1

Point Description:

(7) Click EPSON RC+ menu-[File]-[Save All].
Set contents will be saved in the file.

6.2.5 Check the Setting

The following describes how to check whether the setting of "pressing" direction is correct by using simulator.

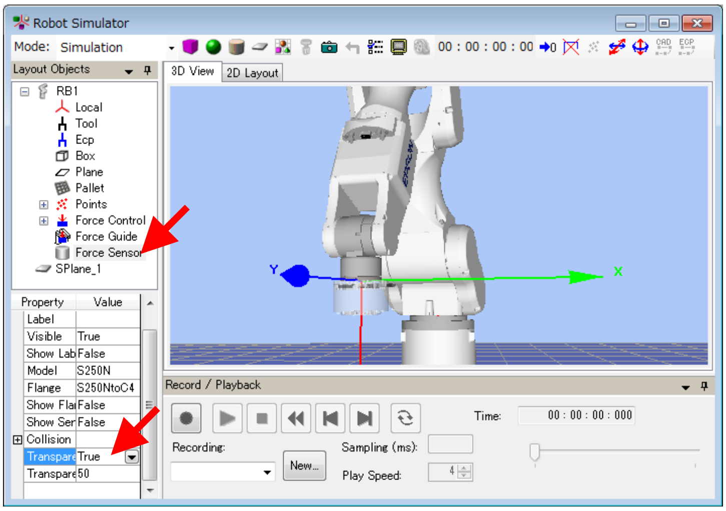
(1) Click EPSON RC+ menu-[Tools]-[Simulator].
Display the [Simulator] window.

(2) Click the object tree-[Tool].

(3) Place a checkmark in "No.0"-[Visible] checkbox. An arrow of "Tool 0" is displayed.

(4) Click the object tree-[Force Sensor].

(5) Set the [Transparent] property to “True”.
The arrow origin of “Tool 0” is displayed.

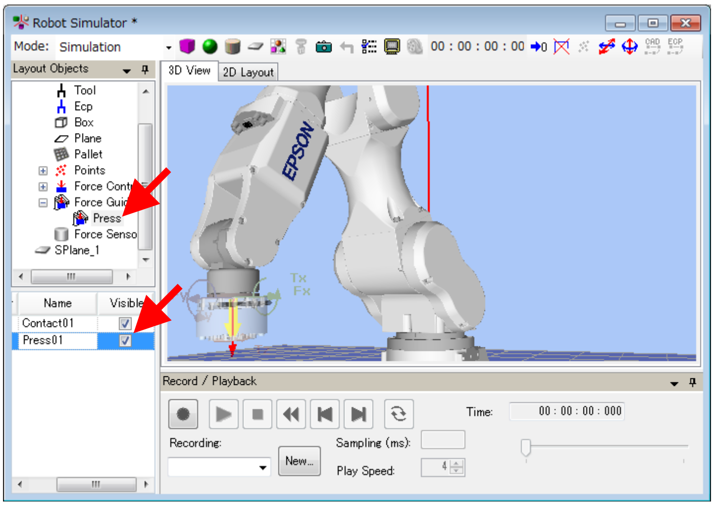


Property	Value
Label	
Visible	True
Show Lab	False
Model	S250N
Flange	S250NtoC4
Show Fla	False
Show Ser	False
Collision	
Transpar	True
Transpare	50

(6) Place a check mark in “No.0”-[Visible] check box.
The arrow of “Tool 0” will be hidden.

(7) Select the object tree-[Force]-[Force Guide]-[Press].
Place a check mark in “Contact01” and “Press01”-[Visible] check boxes.
Yellow arrow is displayed in a motion direction of the Contact and Press objects.
If the arrow direction is not downward, the following setting is improper.
Refer to the reference of the guidance function to change the setting.

Software 6.2.3 Property Setting

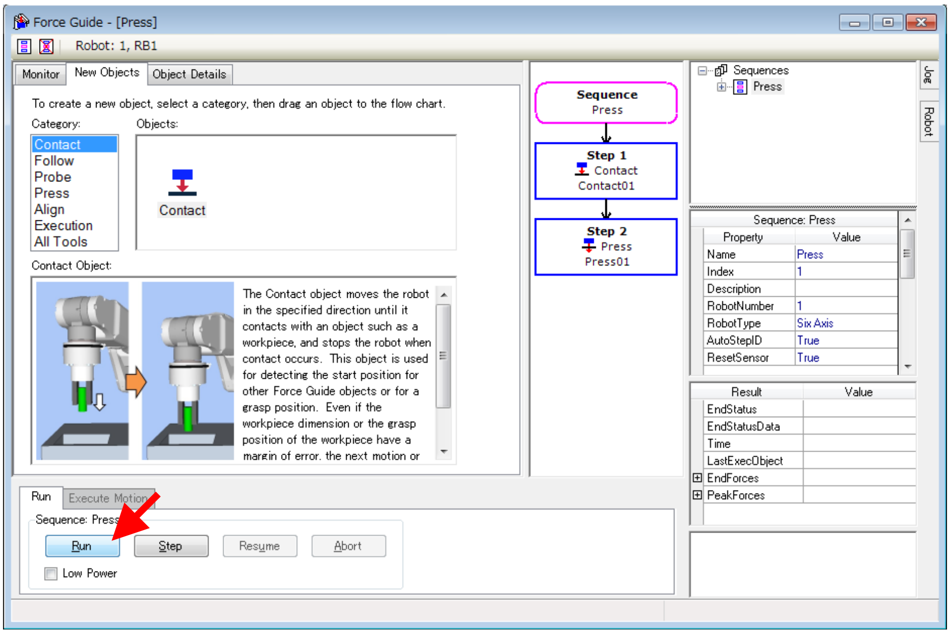


Name	Visible
Contact01	☑
Press01	☑

6.2.6 Motions by Force Guidance Function

The following describes how to run a force guide sequence that performs “pressing” operations by EPSON RC+.

(1) Display the [Force Guide] window.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Sequence: Press

Property	Value
Name	Press
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

(2) Click the <Run> button.
Compilation is executed. Program is transmitted to the robot controller. An error occurs if the setting is incorrect. If the error occurs, check the settings so far and modify the parameters according to the error message.

6.2.7 Return to Non-Contact State

The following describes how to return to non-contact state.

Force continues to be applied to between the robot and the pressing target object even the “pressing” operation has completed. To prevent the robot and the end effector from malfunction or damages, move the robot away from the object immediately after the operation ends, and make sure that no force is applied to the object. If it is obvious that no force is applied to the object, you can omit this step.

Steps to return to non-contact state are as follows:

- Click EPSON RC+ menu-[Tools]-[Robot Manager]-[Jog & Teach] panel-[Jog] group and perform jog motion manually to move the robot away from the object.
- Click EPSON RC+ menu-[Tools]-[Robot Manager]-[Jog & Teach] panel-[Execute Motion] tab and move the robot away from the object.
- Execute Move command on [Command Window] and move the robot away from the object.
- Add SPELFunc object after Press object, and automatically move the robot away from the object at the end of the force guide sequence.

The following describes how to return to non-contact state by clicking [Robot Manager]-[Jog & Teach].

(1) Display [Robot Manager] dialog box.

(2) Select the [Jog & Teach] tab.

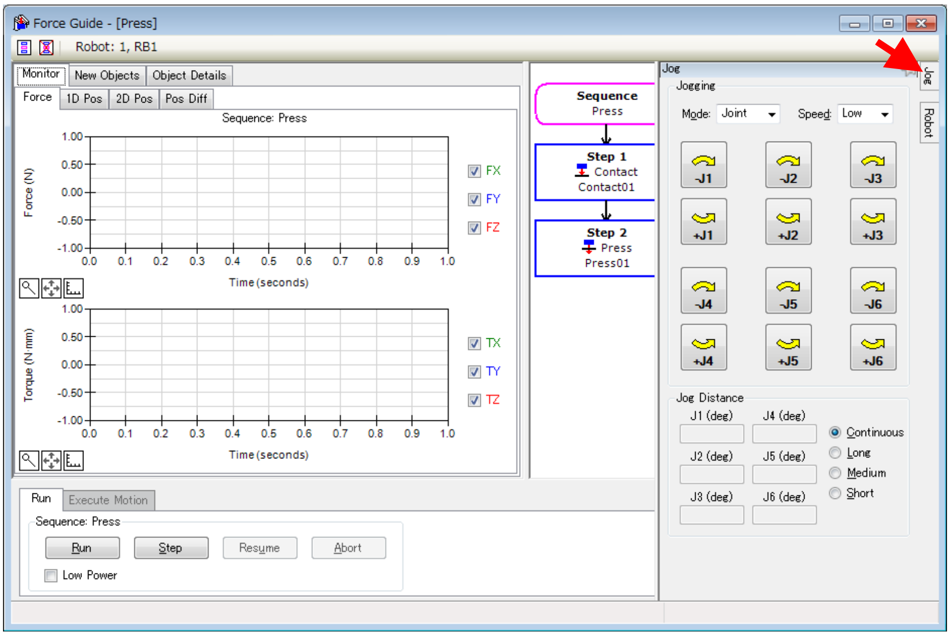
(3) Select the [Execute Motion] tab.

(4) Select “Move” in [Command].

(5) Select “P1” in [Destination].

(6) Click the <Execute> button.
The robot moves to the start point: “P1”. Now, the robot is non-contact state.

[Reference]
The [Jog] tab is displayed on the upper right of the [Force Guide] window.
When the [Jog] tab is selected, the [Jog] window is displayed. The robot will move and be set to non-contact state by clicking the Jog button or entering value.



Force Guide - [Press]

Robot: 1, RB1

Mode: Joint

Speed: Low

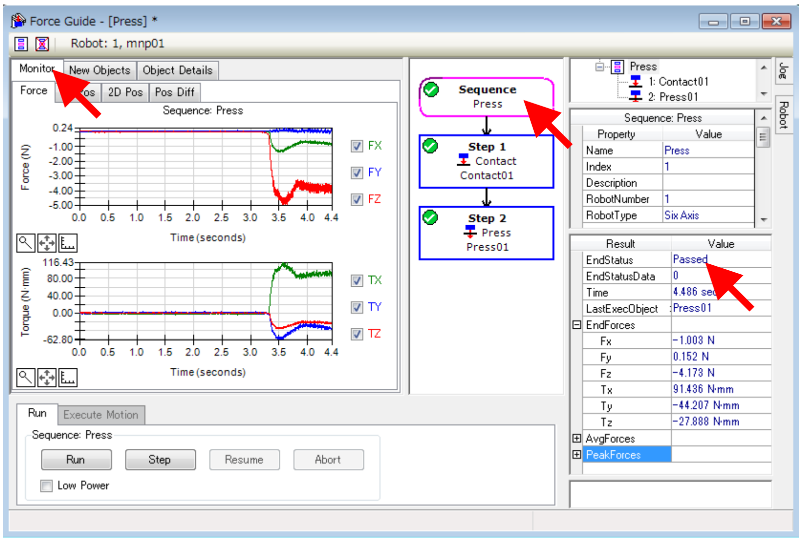
Sequence: Press

☐ Low Power

6.2.8 Motion Analysis by Monitor

The following described how to check the motion results of force guide sequence by EPSON RC+.

(1) Display the [Force Guide] window.



Sequence: Press

Property	Value
Name	Press
Index	1
Description	
RobotNumber	1
RobotType	Six Axis

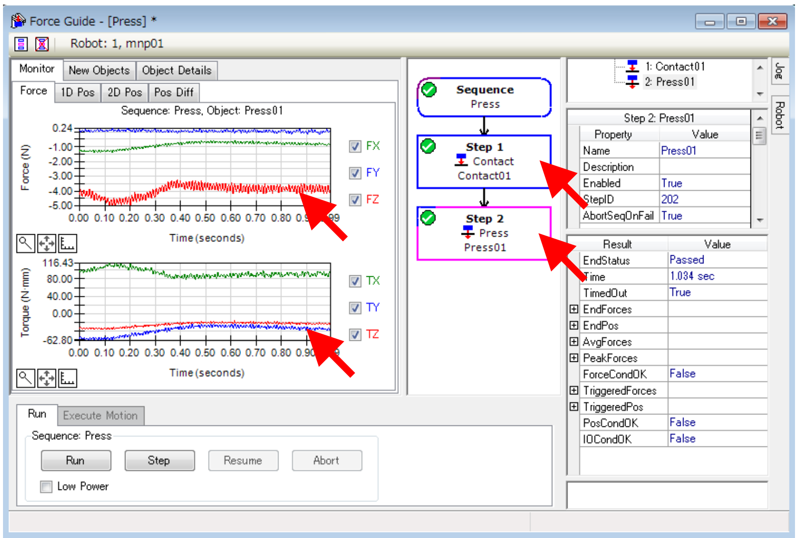
Result	Value
EndStatus	Passed
EndStatusData	0
Time	4.486 se
LastExecObject	Press01
EndForces	
Fx	−1.003 N
Fy	0.152 N
Fz	−4.173 N
Tx	91.436 N·mm
Ty	−44.207 N·mm
Tz	−27.888 N·mm
AvgForces	
PeakForces	

(2) Click the sequence flow of [Press].

(3) The operation results (Passed / Failed), detected force values at the end of the robot motion, and the required time are displayed on [Result].

[Monitor] tab:

Force and position during the [Press] sequence execution are displayed in the graph. Click the object flows of [Step1] and [Step2] to display the force and the position during the execution of the selected force guide object.



Sequence: Press

Step 2: Press01

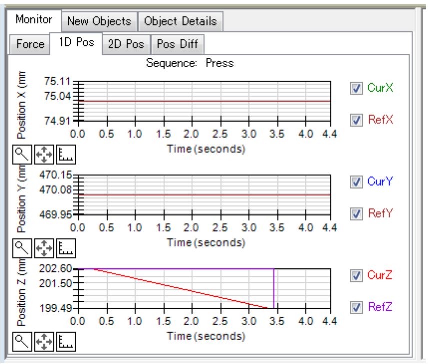
Property	Value
Name	Press01
Description	
Enabled	True
StepID	202
AbortSeqOnFail	True

Result	Value
EndStatus	Passed
Time	1.034 sec
TimedOut	True
EndForces	
EndPos	
AvgForces	
PeakForces	
ForceCondOK	False
TriggeredForces	
TriggeredPos	
PosCondOK	False
IOCondOK	False

[1D Pos] tab

It is a graph for analysis. (horizontal axis: Time, vertical axis: Position)

The robot moves to direction where CurZ of the position Z chart is getting low (small). Since the "Step 1" ends near 3.4 seconds and the force control has been completed, you can see that the value of RefZ (reference position) is falling (jumping) straight down to CurZ (current position).



[2D Pos] tab

It is a graph for analysis. (horizontal axis, vertical axis: Position)

It is not required for simple pressing operation to Z direction since the robot does not move to X-Y directions.

Execute the following and check the graph.

Software "3" in *6.2.9 Advanced Task*

[Pos Diff] tab

It shows relative change of positions due to the force control.

Change the unit of the graph and check the changes of force or positions.

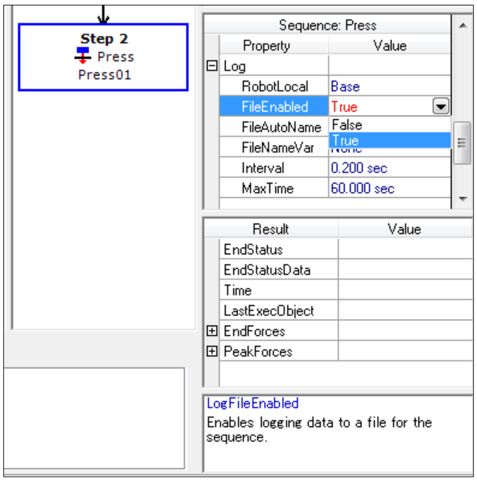
6.2.9 Advanced Tasks

Let’s do the following tasks.

1. First of all, set the pressing force to 1 [N] in 3 seconds.
   Next, execute a continuous motion that increases the force to 10 [N] in 3 seconds.
   Tip: You need to add objects. Three objects in total are required.

2. Set the properties of force guide sequence as follows, and record the log.
   In default setting, it is recorded in the same folder as the projects under development in csv format.
   Open the file in spreadsheet software and create a graph.

	Item	Value	Description
Log	RobotLocal	Base	For the positional orientation of the robot that is recorded during the force guide sequence execution, set a reference local coordinate system number. Set Base coordinate system to record the robot positions.
	FileEnabled	True	Set whether to save in a file. Enable the log creation.
	FileAutoName	True	Set whether to automatically set a file name to be recorded.
	Interval	0.05	Set a sampling period for the files to be recorded. Set the recording interval to 0.05 seconds.



Sequence: Press

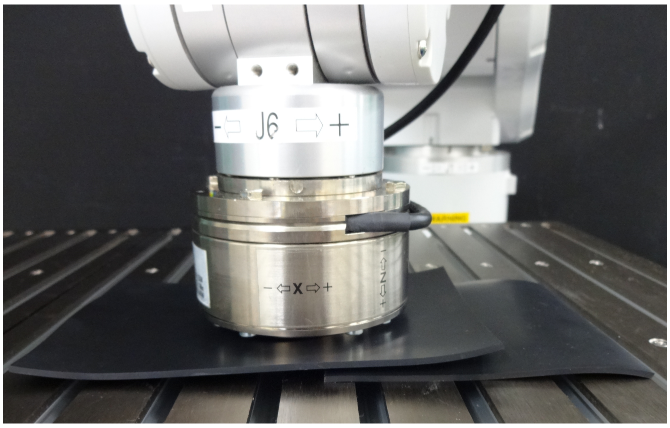
Property	Value
Log	
RobotLocal	Base
FileEnabled	True
FileAutoName	
FileNameVar	
Interval	0.200 sec
MaxTime	60.000 sec

Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
EndForces	
PeakForces	

LogFileEnabled
Enables logging data to a file for the sequence.

3. Follow to X and Y axis directions, and make sure to perform “pressing” to Z direction only.
   Tip: X and Y axis perform a follow motion by selecting “Follow”.

By setting the tool setting to the center of the contact position, you can assume a tilt of a contact plane or a contact position by torque, or perform the follow motion along the plane.

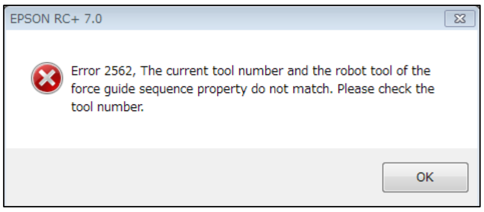


3-1 When only the force sensor is installed to C4 series Manipulator, the center thickness of the contact position is 49mm. Set Tool 1 and select.
Execute the following by command window.

```
> TLSet 1, XY(0, 0, 49, 0, 0, 0)

> Tool 1
```

3-2 Click the [Force Guide] window-the <Run> button.
The following error occurs.

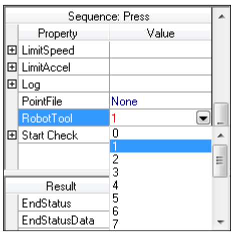


EPSON RC+ 7.0

Error 2562, The current tool number and the robot tool of the force guide sequence property do not match. Please check the tool number.

If the tool setting is not performed properly, the robot motion will not be operated properly or end effector/workpiece will get damages. This error occurs to prevent these problems.

3-3 Display the properties of [Press] sequence.
Select “1” in [RobotTool].



Sequence: Press

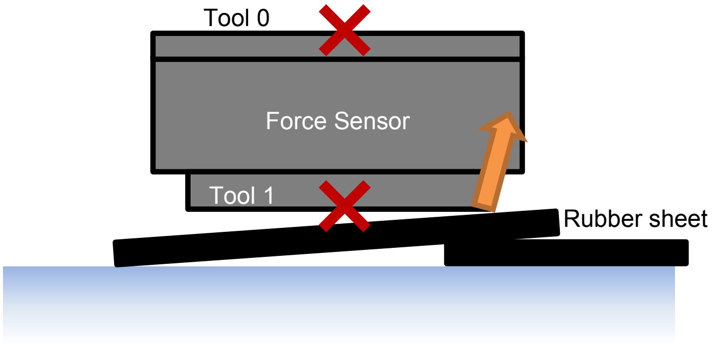
Property	Value
LimitSpeed	
LimitAccel	
Log	
PointFile	None
RobotTool	1
Start Check	

Result

EndStatus	
EndStatusData	

3-4 Since the tool setting is changed, actual arm joint angle of the robot is different even the same point data is used.
Refer to the following to re-teach the teaching positions.
Software 6.2.4 Position Teaching

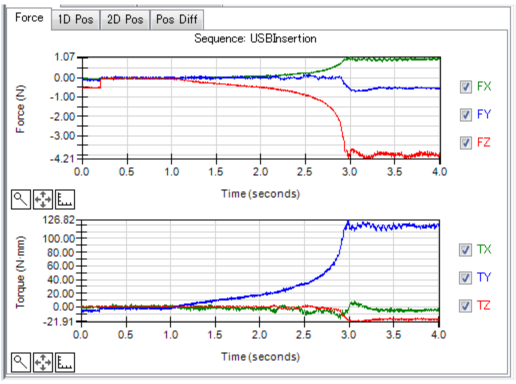
3-5 Different torque value corresponding to “Tool 0” and “Tool 1” is detected. (See the following figure). Translational force value is the same.



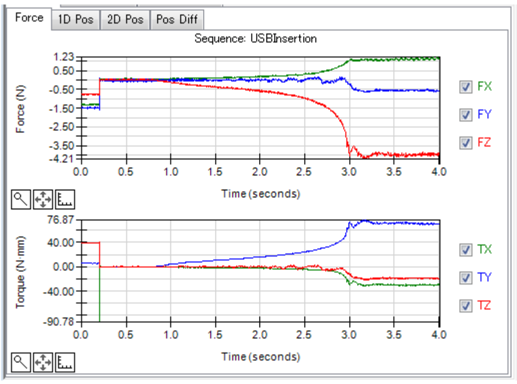
Torque is calculated by
Distance from the contact position as viewed from the origin of force coordinate system (normally, match the Tool coordinate system) × Force = Torque.

As shown below, waveforms of translational force are the same. However, waveforms of torque differ depending on the distance from the contact position, and “Tool 0” can measure larger values.

Tool 0



Tool 1



Now, tutorial for pressing to vertical-downward has completed.

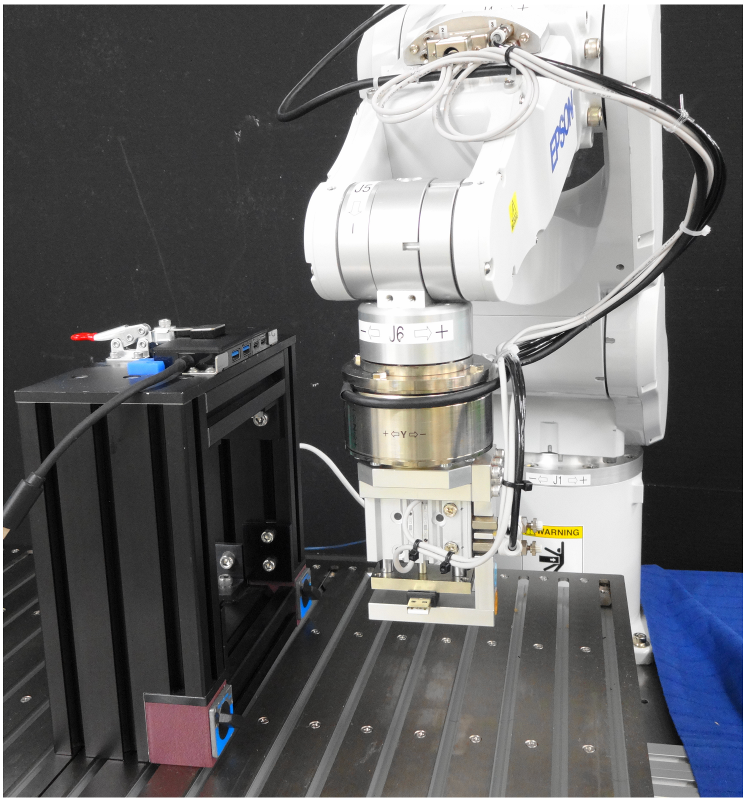
6.3 Force Guidance Function (USB Connector Insertion)

The following describes how to insert a USB connector.

Commercially available USB cable and USB hub can be used for workpiece.

Please prepare a gripper for fixing or grasping the workpiece by yourself. If the setting is not correct, the workpiece will get damages. Make sure to prepare the USB device which is okay to get damages. Also, proceed this tutorial with a workpiece in non-energized state.

Make sure to set the position of workpiece or inserting direction as same as the picture below.
To grasp the USB connector, in this tutorial, you can use "screws" to fix the USB connector.

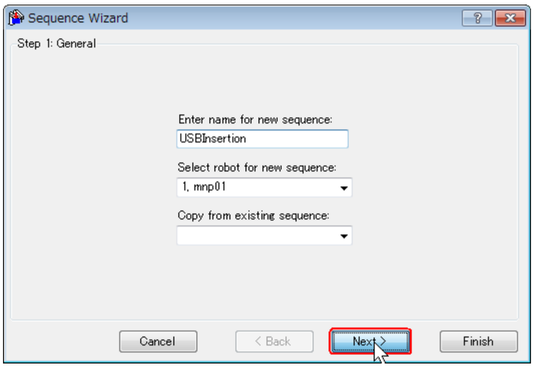


⚠ CAUTION	■ The parameters described in tutorial are reference values. Please note that relatively stable parameters are used, but the operation may not be successful or the motion may be vibratory in some operating conditions, and the parameters may need to be adjusted. In addition, slow stable parameters are used for convenience of explanation. The parameters need to be adjusted for faster operations.

6.3.1 Sequence Wizard

The following describes how to create a force guide sequence for “USB connector insertion”.

(1) Enter “USBInsertion” to the [Enter name for new sequence] box.
Click the <Next> button.



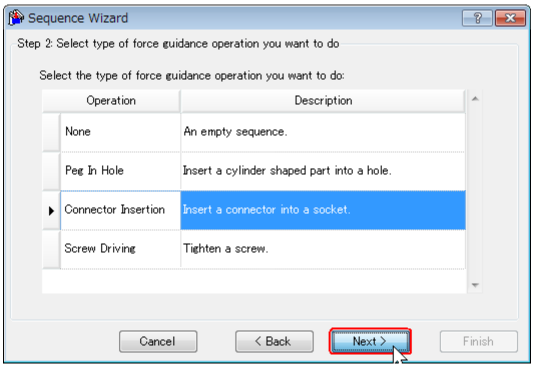
Step 1: General

Enter name for new sequence:
USBInsertion

Select robot for new sequence:
1, mnp01

Copy from existing sequence:

(2) The [Step 2: Select type of force guidance operation you want to do] dialog box is displayed.
Select [Connector Insertion].
Click the <Next> button.

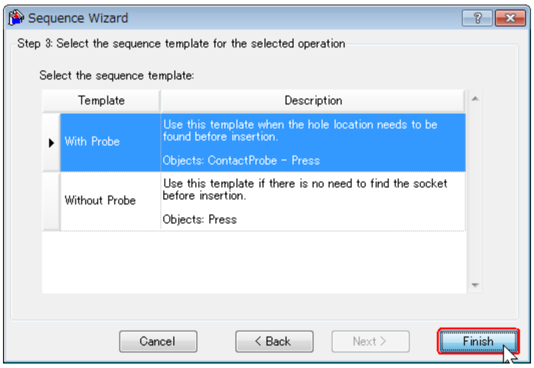


Step 2: Select type of force guidance operation you want to do

Select the type of force guidance operation you want to do:

Operation	Description
None	An empty sequence.
Peg In Hole	Insert a cylinder shaped part into a hole.
Connector Insertion	Insert a connector into a socket.
Screw Driving	Tighten a screw.

(3) The [Step 3: Select the sequence template for the selected operation] dialog box is displayed.
Select [With Probe].
Click the <Finish> button.

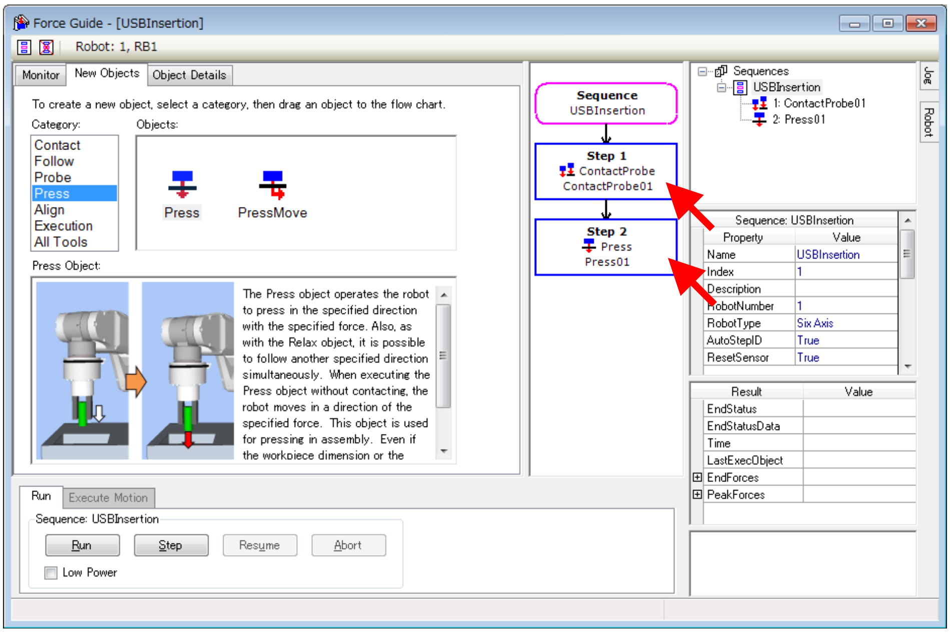


Step 3: Select the sequence template for the selected operation

Select the sequence template:

Template	Description
With Probe	Use this template when the hole location needs to be found before insertion. Objects: ContactProbe - Press
Without Probe	Use this template if there is no need to find the socket before insertion. Objects: Press

(4) Confirm that the [USBInsertion] sequence is created.
ContactProbe – Press



To create a new object, select a category, then drag an object to the flow chart.

The Press object operates the robot to press in the specified direction with the specified force. Also, as with the Relax object, it is possible to follow another specified direction simultaneously. When executing the Press object without contacting, the robot moves in a direction of the specified force. This object is used for pressing in assembly. Even if the workpiece dimension or the

Sequence: USBInsertion

Property	Value
Name	USBInsertion
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

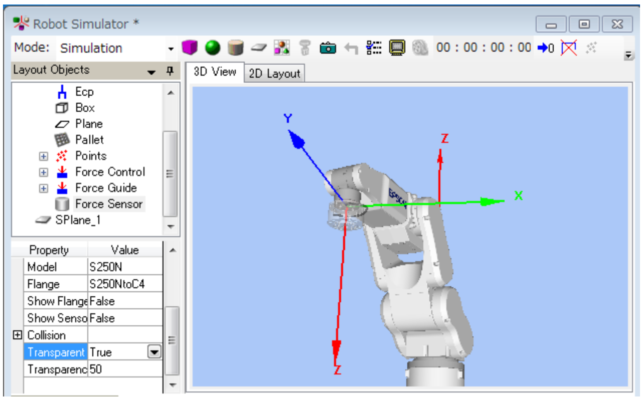
Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

Sequence: USBInsertion

6.3.2 Confirmation of Tool Setting

When inserting the connector, you need to pay attention to insertion direction of the actual connector and the setting of the current tool. The following describes how to confirm the setting by using simulator functions.

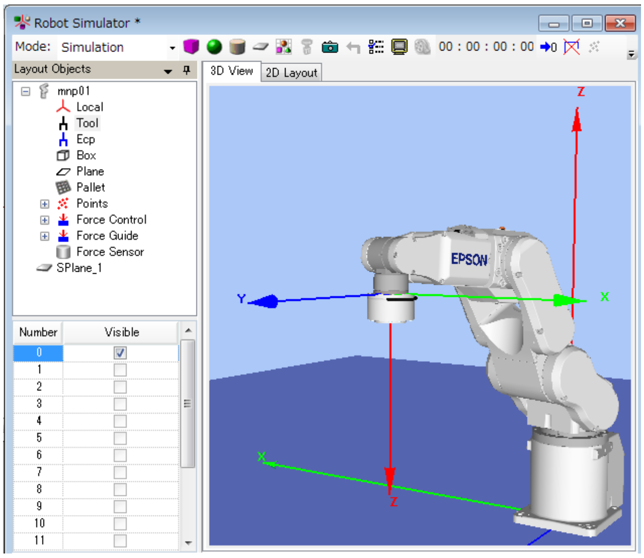
(1) Click EPSON RC+ menu-[Tools]-[Simulator].
The [Simulator] window is displayed.



Mode: Simulation

Property	Value
Model	S250N
Flange	S250NtoC4
Show Flange	False
Show Senso	False
⊞ Collision	
Transparent	True
Transparenc	50

(2) Click the object tree-[Manipulator Name]-[Tool].



Number	Visible
0	☑
1	☐
2	☐
3	☐
4	☐
5	☐
6	☐
7	☐
8	☐
9	☐
10	☐
11	☐

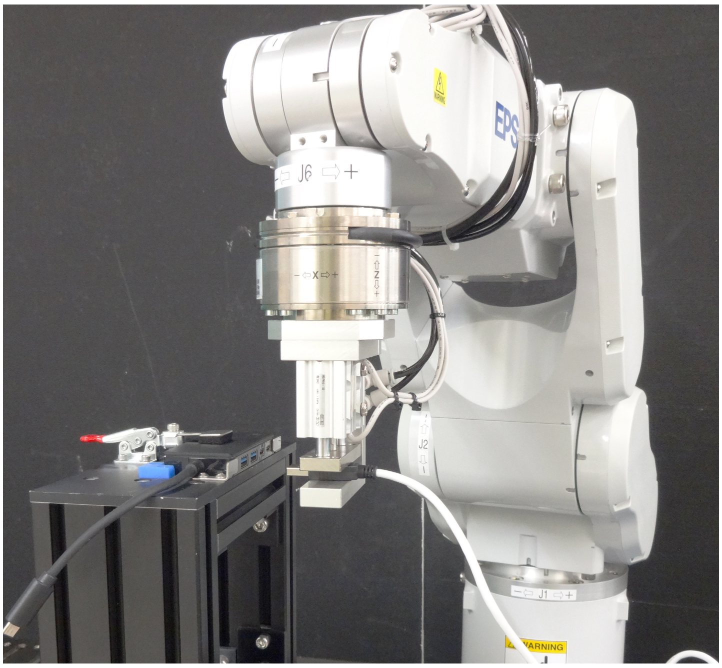
(3) Place a checkmark in “No.0”-[Visible] check box. “Tool 0” is selected.

Compared with the actual robot, you can see that the robot insets to “–X” direction of the tool in this tutorial.

To detect the force of rotational direction correctly, perform the tool setting to position to grasp or contact.

In this tutorial, only the force control function in the translational direction is used. Therefore, if you omit the setting, motion will be the same.

In this tutorial, proceed with “Tool 0”.

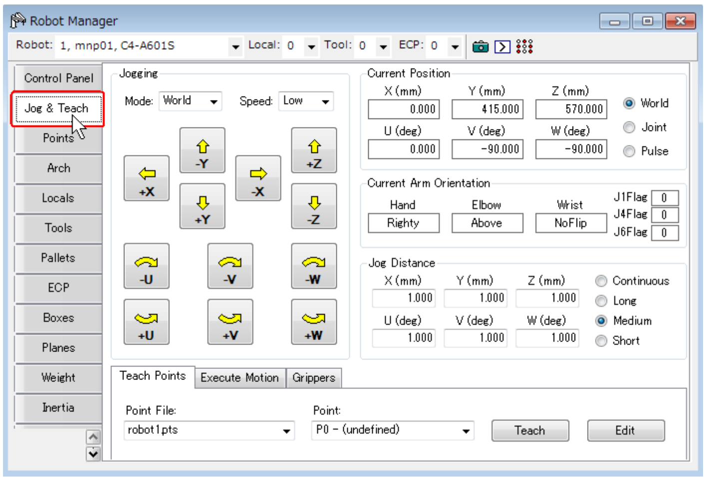


6.3.3 Point Teach

The following describes how to teach start position of the connector insertion motion.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Select [Jog & Teach].



Robot: 1, mnp01, C4-A601S Local: 0 Tool: 0 ECP: 0

Mode: World Speed: Low

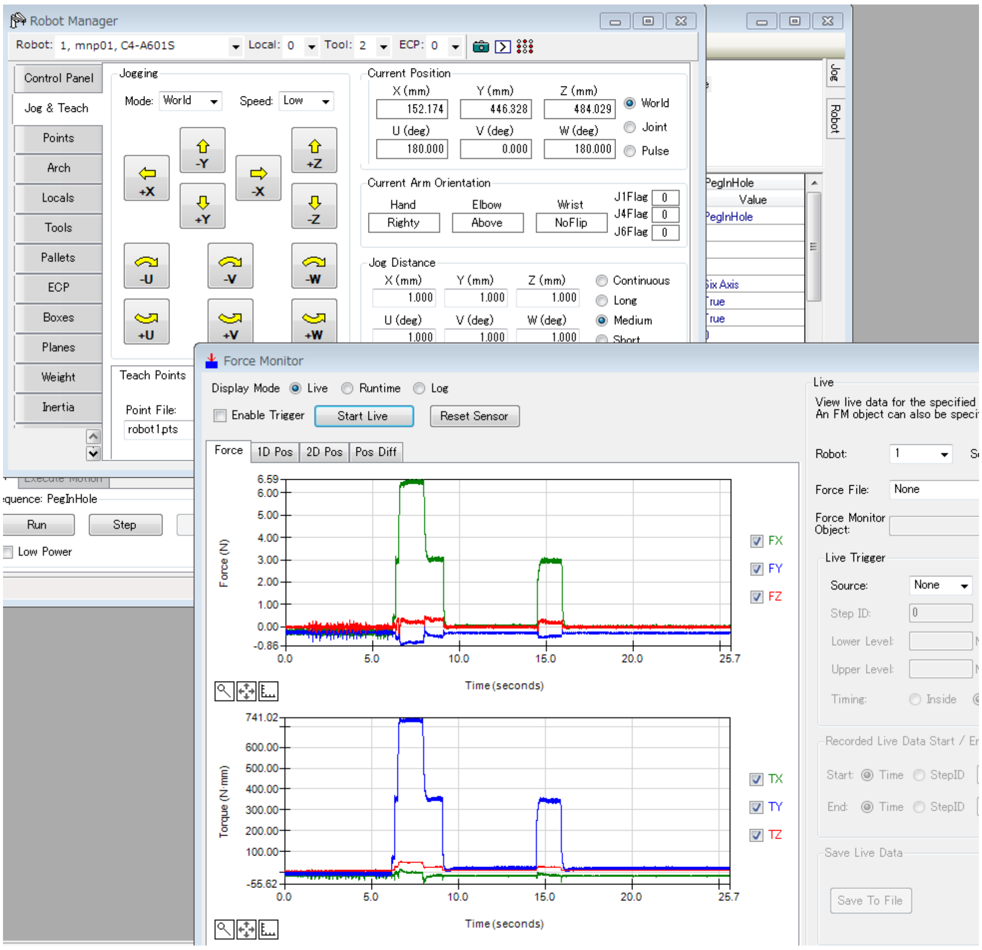
Current Position: X (mm) 0.000 Y (mm) 415.000 Z (mm) 570.000 U (deg) 0.000 V (deg) -90.000 W (deg) -90.000 ● World ○ Joint ○ Pulse

Current Arm Orientation: Hand Righty Elbow Above Wrist NoFlip J1Flag 0 J4Flag 0 J6Flag 0

Jog Distance: X (mm) 1.000 Y (mm) 1.000 Z (mm) 1.000 U (deg) 1.000 V (deg) 1.000 W (deg) 1.000 ○ Continuous ○ Long ● Medium ○ Short

Point File: robot1.pts Point: P0 - (undefined)

(3) Click EPSON RC+ menu-[Tools]-[Force Monitor].
The [Force Monitor] dialog box is displayed.



Robot: 1, mnp01, C4-A601S Local: 0 Tool: 2 ECP: 0

Mode: World Speed: Low

Current Position: X (mm) 152.174 Y (mm) 446.328 Z (mm) 484.029 U (deg) 180.000 V (deg) 0.000 W (deg) 180.000 ● World ○ Joint ○ Pulse

Current Arm Orientation: Hand Righty Elbow Above Wrist NoFlip J1Flag 0 J4Flag 0 J6Flag 0

Jog Distance: X (mm) 1.000 Y (mm) 1.000 Z (mm) 1.000 U (deg) 1.000 V (deg) 1.000 W (deg) 1.000 ○ Continuous ○ Long ● Medium ○ Short

Point File: robot1.pts

Sequence: PegInHole

Force Monitor — Display Mode: ● Live ○ Runtime ○ Log ☐ Enable Trigger

Live: View live data for the specified ... An FM object can also be speci...

Robot: 1 Force File: None Source: None Step ID: 0

(4) Click the <Start Live> button.
Start displaying the output value from the current force sensor.

(5) Click the Jog button and move the robot to a position where the two USB connectors will face each other to be parallel.

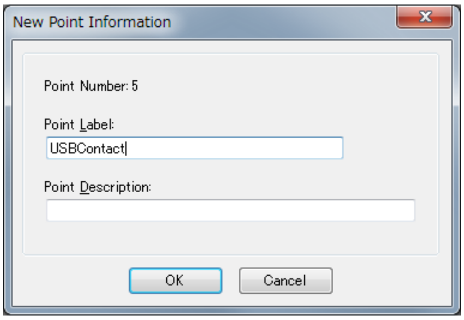
(6) Click the <Reset Sensor> button.
Since the effect of gravity and drift of sensor value are eliminated, the current value will be “zero” position.

(7) Select [Jog & Teach]-[Jog Distance] and click the <Short> button.
Move the robot to translational direction. Move the robot while clicking the Jog button several times until the USB connector contacts with the USB port.
When the connector contacts with the port, output value of the force sensor changes.
Check the change of monitor value according to the timing of jog motion.

(8) Select “P5” on [Point].

(9) Click the <Teach> button.

(10)The [New Point Information] dialog box is displayed.
Enter “USBContact” on [Point Label] and click the <OK> button.



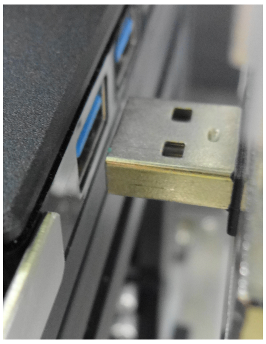
New Point Information

Point Number: 5

Point Label:
USBContact

Point Description:

(11) Select <Medium> on [Jog Distance].
Move the robot for 3mm (click the Jog button for three times) to direction where the USB connector does not contact with the USB port.
Also, visually move the robot to +Y direction by approx. 1mm from the center of the connector. Set this position as a start point of inserting the connector.



(12) Select "P4" on [Point].

(13) The [New Point Information] dialog box is displayed.
Enter "USBStart" on [Point Label] and click the <OK> button.

(14) Click EPSON RC+ menu-[File]-[Save All].
The file is saved.

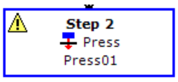
6.3.4 Property Setting

The following describes how to set properties that are necessary to insert connector.

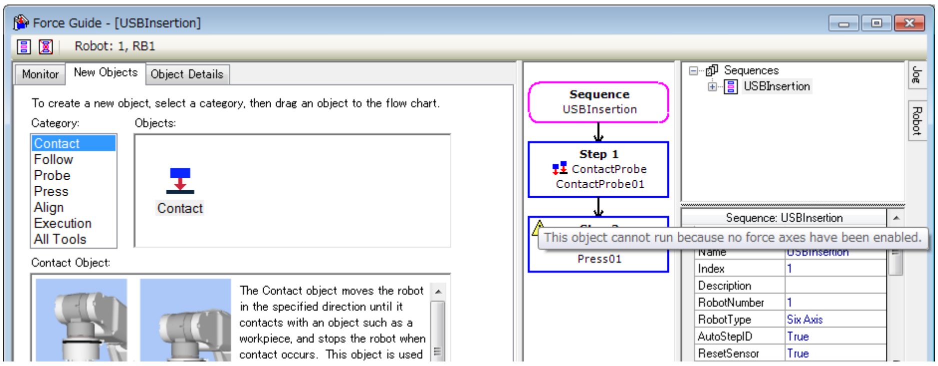
Specifications of USB TypeA connector are as follows:

Insertion force: 35N or less

(1) The ⚠ mark is displayed on the flow chart by default.
You need to set properties.



When a mouse pointer is moved on the ⚠ mark, tool tip is displayed. The tool tip shows contents that need to be set or modified.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used

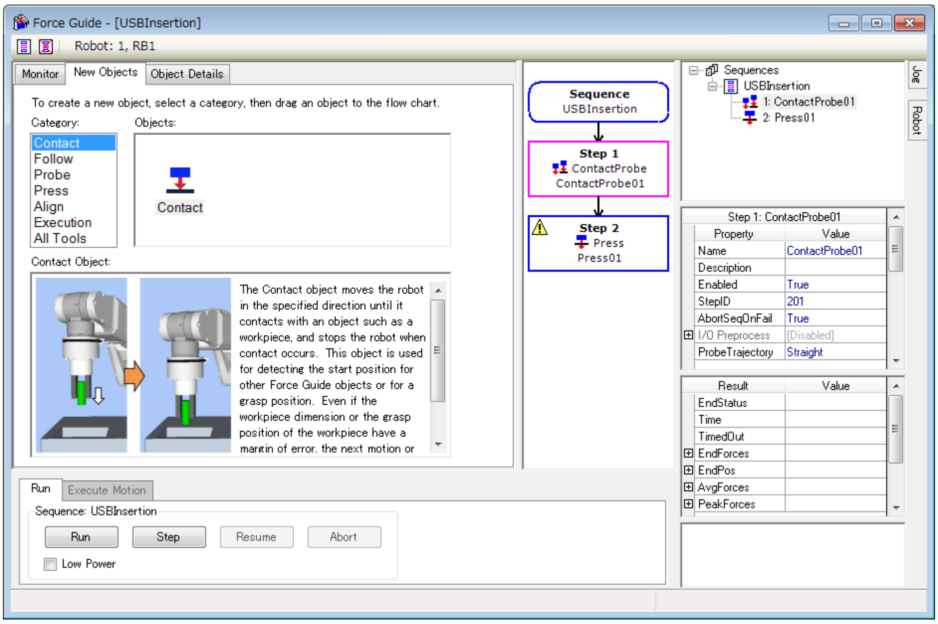
This object cannot run because no force axes have been enabled.

Sequence: USBInsertion

Name	USBInsertion
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

Set in order from the Step 1.

(2) Select the [ContactProbe01] object.
Properties and Results are displayed.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Step 1: ContactProbe01

Property	Value
Name	ContactProbe01
Description	
Enabled	True
StepID	201
AbortSeqOnFail	True
⊞ I/O Preprocess	[Disabled]
ProbeTrajectory	Straight

Result	Value
EndStatus	
Time	
TimedOut	
⊞ EndForces	
⊞ EndPos	
⊞ AvgForces	
⊞ PeakForces	

(3) Set a value of [Contact]-[Orient] property to “–Fx”.

(4) Set other properties as follows.

For more details, refer to the following:
Software 4.3.6 ContactProbe Object

Item		Value	Description
ProbeTrajectory		Straight	Set a straight line probe motion. The robot approaches to the plane at a regular interval (set by [Interval]).
AccelS		200	Set the translational acceleration of the movement.
SpeedS		50	Set the translational velocity of the movement. Velocity for depart motion or translation.
Destination	DestRelativeX	0	Set a relative movement amount to each direction from the start point to the destination point. The robot does not shift to X direction.
	DestRelativeY	-3	The robot shifts up to 3mm to -Y direction and probes.
	DestRelativeZ	0	The robot does not shift to Z direction.
Contact	ContactInterval	0.5	Set an interval of the contact motions. Set 0.5mm.
	Orient	-Fx	Set a direction to contact. The robot moves to the specified direction.
	Dist	3	Set a distance from the start point to the target contact point.
	DistMargin	0.5	Set a margin distance from the start point to the target contact point. Set 0.5mm for one side.
	FirmnessF	2	Set a firmness of the force control functions. ContactProbe object affects to the contact speed. Reference value of the contact speed can be calculated by the following: [ContactForceThresh] / [ContactFirmnessF]
ForceEnd Conditions	Contact ForceThresh	3	Set a threshold to determine a contact. Set 3[N]. When the force (more than 3N) is detected outside of the target contact point of [ContactDist], the robot determines as the probe motion is failed and shifts 0.5mm to -Y direction and repeats similar approaches.

Item		Value	Description
PosEnd Conditions	PosCheckType	Relative Plane	Select types of the end conditions related to positions. Set a Plane with a condition that the robot moves a relative amount from the start position. It is automatically generated by [ContactDist] +[ContactDistMargin].
	PlaneNumber	1	Set Plane number which is used for an end condition of positions. Overwrite Plane 1.
	PlaneEndCond	Inside	Being inside of the Plane is an end condition. When the robot moved to the specified state, determine as the end condition is satisfied.
Timeout		30	Set a time-out period of a contact motion. Maximum time-out period is 30 seconds.

(5) Click EPSON RC+ menu-[File]-[Save File] to save the setting.

(6) Set properties of [Press01] object as follows:

	Item	Value	Description
Fx	ControlMode	Press-	Mode of force control function. Press : The robot moves to a negative direction of the axis and presses.
	PressForce	20	Applied force when inserting. Set 20N.
	Firmness	2	Set a firmness of the force control functions in X direction.
Fy	ControlMode	Follow	Perform the follow motion by the force control functions.
	Firmness	2	Set a firmness of the force control functions in Y direction.
Fz	ControlMode	Follow	Perform the follow motion by the force control functions.
	Firmness	2	Set a firmness of the force control functions in Z direction.

	Item	Value	Description
ForceEnd Conditions	ForceCheckEnabled	True	Enable the end conditions related to force.
	ForceCheckMode	Press	Press: Only the pressing is a target of determination.
	ForceCheckPolarity	Inside	Polar of the end conditions related to force. Being inside of the specified range is an end condition.
	PressCheckTolF	10	Range of the pressing direction of the end conditions related to force. Set a range of the end conditions. X axis: State that the force value is inside the 20 ± 10N range continues.
	FollowCheckTolF	1	Y, Z axes: State that the force value is inside the 0 ± 1 N range continues.
	HoldTimeThresh	0.1	Set the duration time which is used to determine whether the end conditions have satisfied. Set 0.1 seconds.
Timeout		2	If the end condition has not satisfied for more than 2 seconds (e.g. no workpiece is existed), ends as a failure.

(7) Click EPSON RC+ menu-[File]-[Save File].
Modified property is saved to the project.

6.3.5 Setting Confirmation

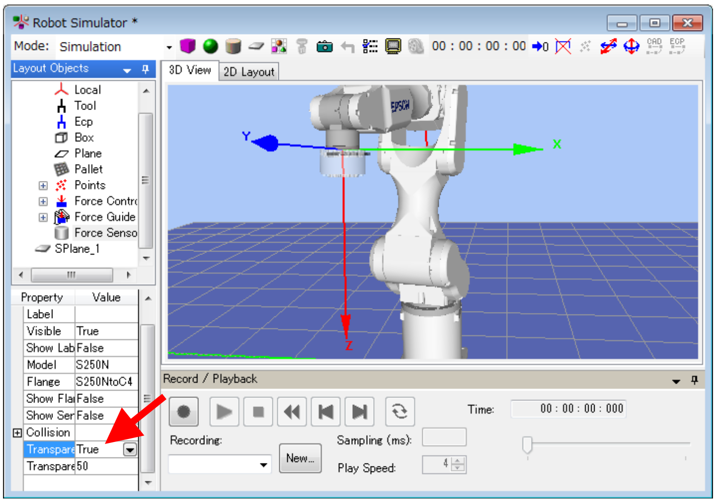
The following describes how to confirm the following setting by using a simulator.

1. Pressing direction when inserting
2. Approach detection plane (Plane) for determination to start insertion

(1) Click EPSON RC+ menu-[Tools]-[Simulator].
The [Simulator] window is displayed.

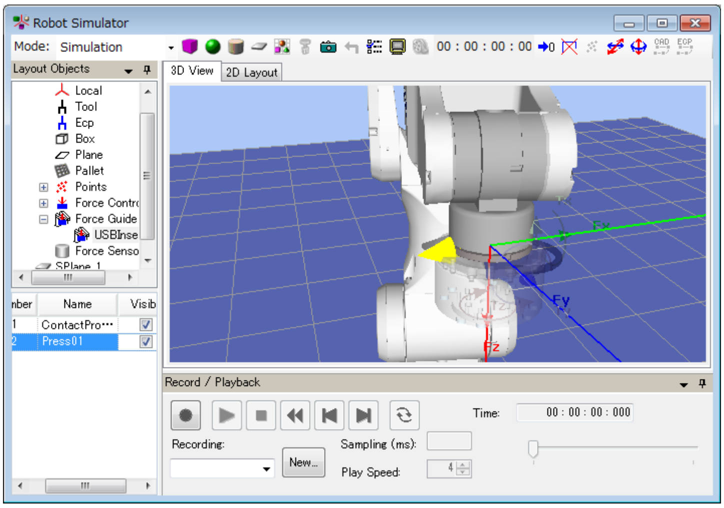
(2) Click the object tree-[Tool].
Place a checkmark in “No.0”-[Visible] check box. Display an arrow of “Tool 0”.

(3) Click the object tree-[Force Sensor].
Set the [Transparent] property to “True”.
The arrow origin of the “Tool 0” is displayed.



Property	Value
Label	
Visible	True
Show Lab	False
Model	S250N
Flange	S250NtoC4
Show Fla	False
Show Ser	False
Collision	
Transpare	True
Transpare	50

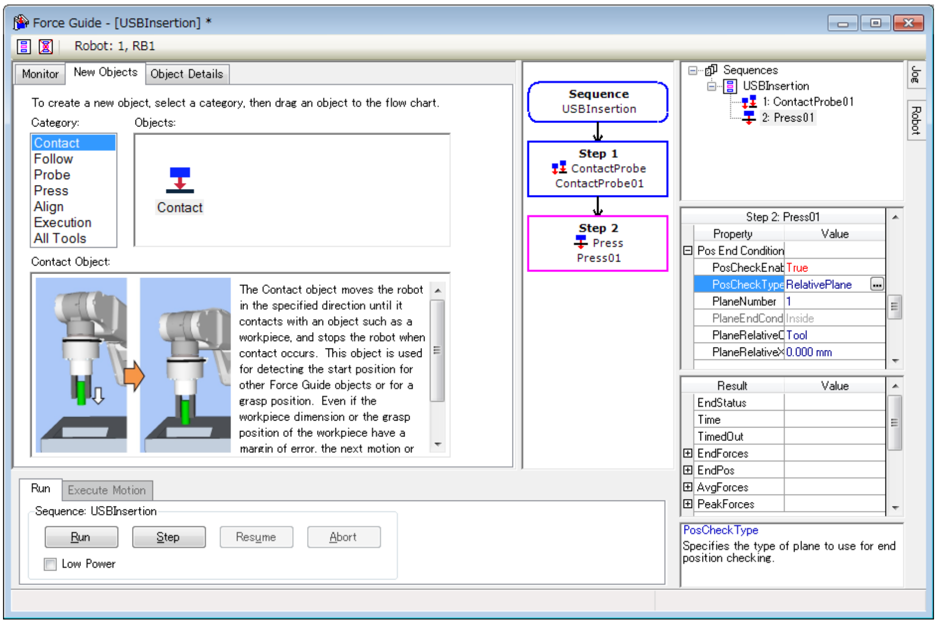
(4) Select the object tree -[Force]-[Force Guide]-[USBInsertion].
Place a checkmarks on “ContactProbe01” and “Press01”-[Visible] checkboxes.



nber	Name	Visib
1	ContactPro···	☑
2	Press01	☑

(5) Check the Plane setting.
To see the image more clearly by hiding the yellow arrow, remove the checkmark from the [Visible] checkbox in the step (4).

(6) Click the [Force Guide] window-[ContactProbe01] property-[Pos End Condition]-[PosCheckEnabled] to “True”.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Step 2: Press01

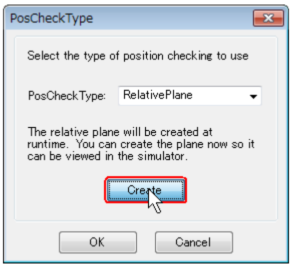
Property	Value
Pos End Condition	
PosCheckEnab	True
PosCheckType	RelativePlane
PlaneNumber	1
PlaneEndCond	Inside
PlaneRelativeC	Tool
PlaneRelativeX	0.000 mm

Result	Value
EndStatus	
Time	
TimedOut	
EndForces	
EndPos	
AvgForces	
PeakForces	

PosCheckType
Specifies the type of plane to use for end position checking.

(7) Click the [Force Guide] window-[ContactProbe01] property-[Pos End Condition]-[PosCheckType], and click the icon on the right side of “RelativePlane” which is the value of [PosCheckType].

(8) The following dialog box is displayed.
Check that the [PosCheckType:] is “RelativePlane”.
Click the <Create> button.

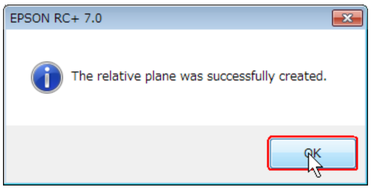


Select the type of position checking to use

PosCheckType: RelativePlane

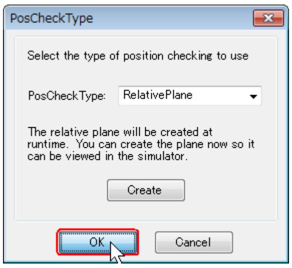
The relative plane will be created at runtime. You can create the plane now so it can be viewed in the simulator.

(9) The following message is displayed.
Click the <OK> button.



The relative plane was successfully created.

(10)Click the <OK> button on the [PosCheckType] dialog box.



Select the type of position checking to use

PosCheckType: RelativePlane

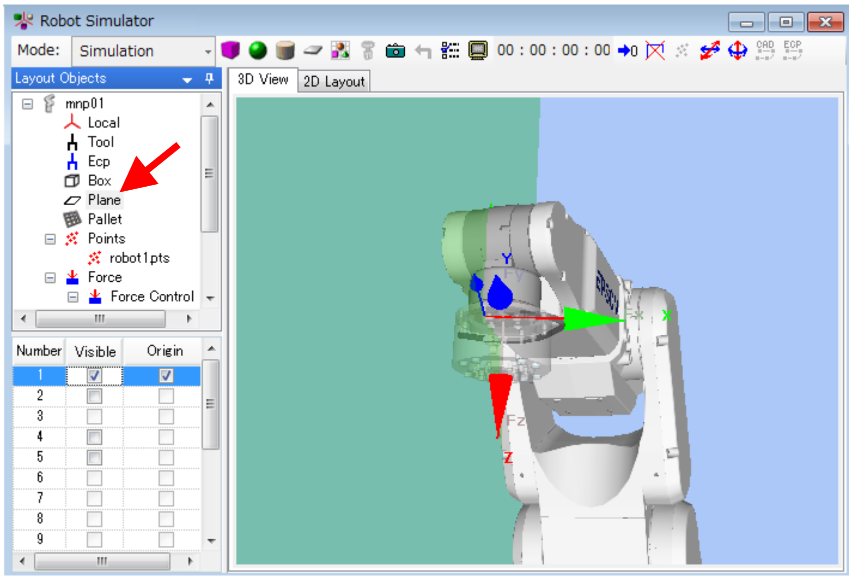
The relative plane will be created at runtime. You can create the plane now so it can be viewed in the simulator.

(11)Display the [Simulator] window.

Select the object tree-[Plane].

Place a checkmark in "Number 1"- the [Visible] and the [Origin] checkboxes.

Plane 1 is approach detection place of ContactProbe. If a tool exists inside the range of red arrow (Z direction) which displays an origin, return value of Plane is set to True. If it is not inside the range, the return value is set to False.

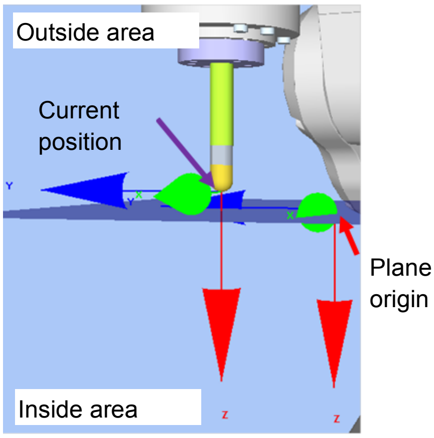
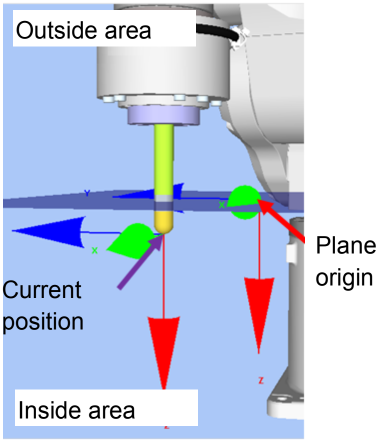


Mode: Simulation

Number	Visible	Origin
1	☑	☑
2	☐	☐
3	☐	☐
4	☐	☐
5	☐	☐
6	☐	☐
7	☐	☐
8	☐	☐
9	☐	☐

[Reference] Positional relationship with Plane

The positional relationship of the robot's current position and Plane is as shown below. If the robot's current position is in the +Z direction area from the Plane origin, it will be "Inside".

	Outside	Inside
Positional relationship with Plane 6-axis robot		
Determined value of Plane (GetRobotInsidePlane)	0 = Outside	1 = Inside

(12) If Plane or Z-axis direction of Plane (end determination condition) is displayed on different position from the insertion direction, refer to the following section and change the setting.

Software *6.3.4 Property Setting*

6.3.6 Motion by Force Guidance Function

The following describe how to execute a force guide sequence that inserts a USB connector by EPSON RC+.

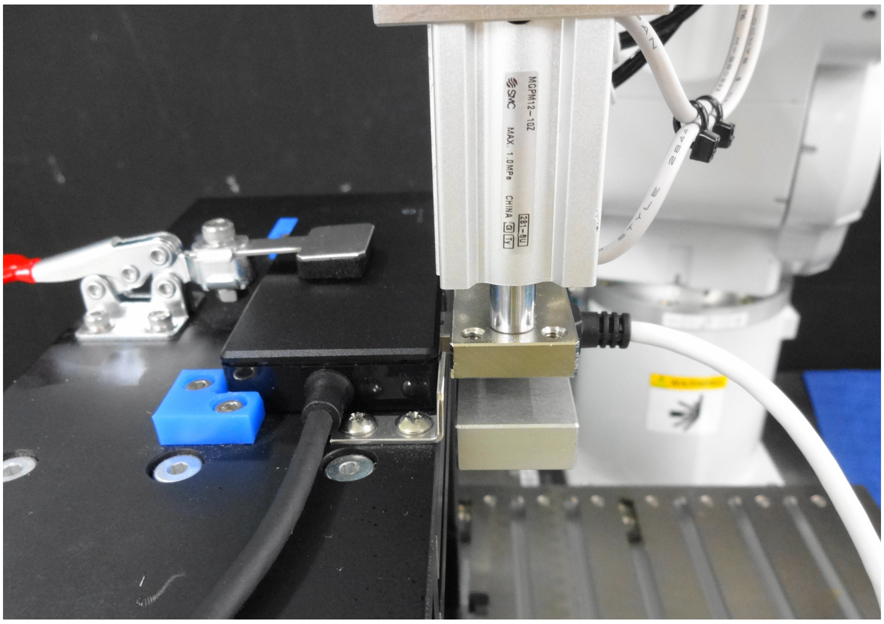
(1) Display the [Force Guide] window.

(2) Select the [Robot] tab.

(3) Click the <POWER HIGH> button.
If the robot will break the workpiece, consider to operate in "Low Power Mode".
(However, the robot motions by the force control motion are different from that in high power mode since settings of speed and acceleration are restricted in low power mode. Therefore, the force which is larger than in the high power mode may be applied to the workpiece.)

(4) Click the <Run> button.
Program is compiled and transmitted to the robot controller. If the setting is not correct, an error occurs. Check the settings so far and follow the error message to modify the parameters.

(5) When the operation is performed properly, the USB connector is connected completely.



If the connector insertion is failed, you can analyze a cause.

For details, refer to the following.

Software 6.3.8 Motion Analysis by Monitor

6.3.7 Return to Non-Contact State

The following describes how to return to non-contact state.

Force continues to be applied to between the robot and the USB device even the connector is connected. To prevent the robot and the end effector from malfunction or damage, move the robot away from the object immediately after the operation ends, and make sure that no force is applied to the object. If it is obvious that no force is applied to the object, you can omit this step.

There are the following methods to return the robot to non-contact state:

- Click EPSON RC+ menu-[Tools]-[Robot Manager]-[Jog & Teach] panel-[Jog] group and perform jog motion manually to move the robot away from the object.
- Click EPSON RC+ menu-[Tools]-[Robot Manager]-[Jog & Teach] panel-[Execute Motion] tab and move the robot away from the object.
- Execute Move command on [Command Window] and move the robot away from the object.
- Add SPELFunc object after Press object, and automatically move the robot away from the object at the end of the force guide sequence.

This section describes how to set the robot to non-contact state by clicking [Robot Manager]-[Jog & Teach].

(1) Display [Robot Manager] dialog box.

(2) Select the [Jog & Teach] panel.
Set the Jog Distance to <Continuous> or less than “1mm”.
If selecting <Long> and move the robot, the workpiece may get damage when you click the wrong direction button.

(3) Use the Jog button to move the robot to +X direction (opposite to insertion direction).

Now, the robot is non-contact state.

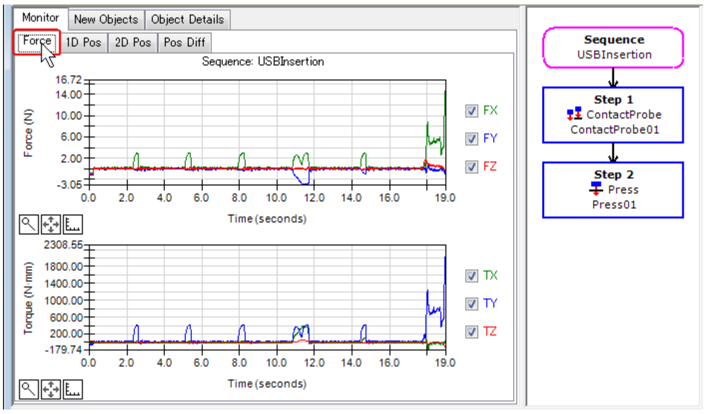
6.3.8 Motion Analysis by Monitor

The following describes how to check the operation results of force guide sequence by EPSON RC+. The following windows are when the sequence motions are operated successfully.

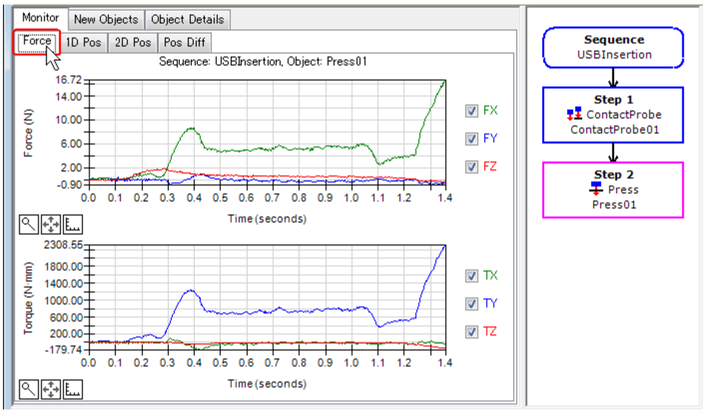
(1) Display the [Force Guide] window.

(2) Click the sequence flow of [USBInsertion].

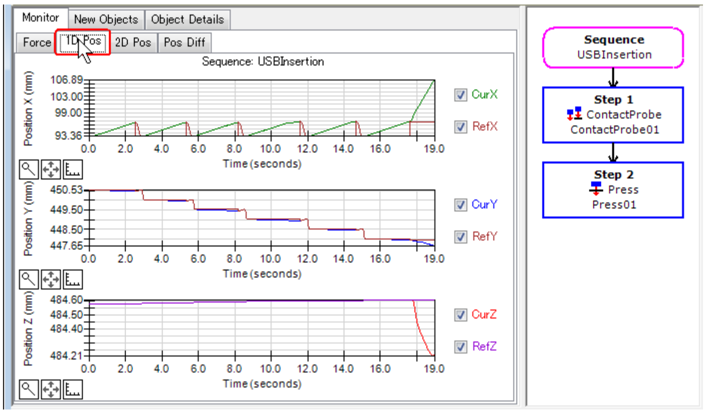
(3) Select the [Monitor] tab. Select the [Force] tab.
Force and position during the [USBInsertion] sequence execution are displayed in the graph.



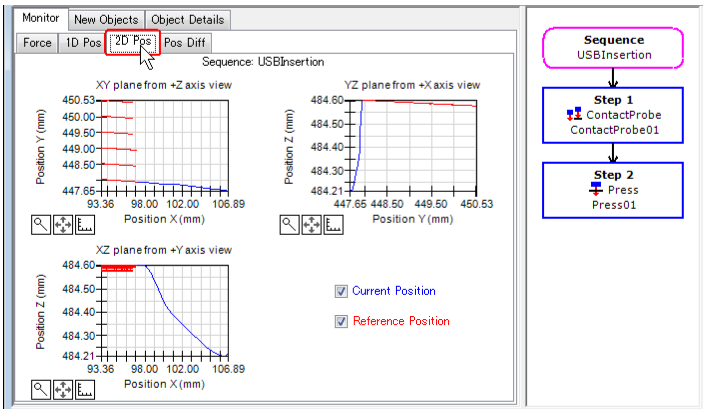
(4) Click the object flows of [Step1] and [Step2] to display the force and the position during the execution of the selected force guide object.



(5) Click the [USBInsertion] sequence.
Select the [Monitor] tab. Select the [1D Pos] tab.
Graph for analysis is displayed. (horizontal axis: Time, vertical axis: Position)

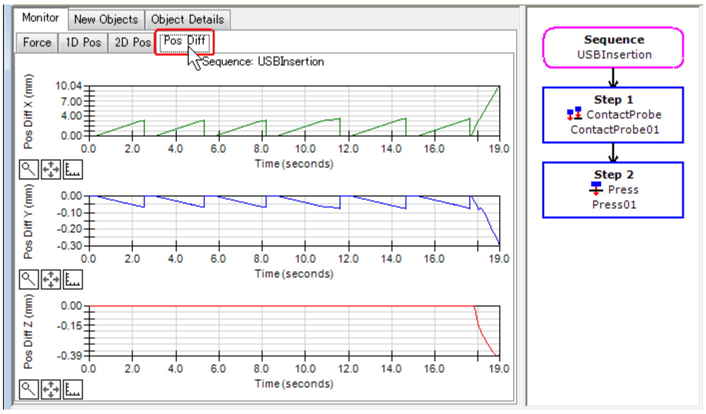


(6) Select the [2D Pos] tab.
Graph for analysis is displayed. (horizontal axis, vertical axis: Position)
It helps to imagine the follow trajectory on the Y and Z planes.
Red line: Probe motion cross-sectional trajectory
Blue line: Insertion trajectory to +X direction by the force control function



(7) Select the [Pos Diff] tab.

Record shifts by force control as relative position changes. It is different from the graph on the [1D Pos] tab.



(8) Change the unit of the graph and check the changes of force or positions.

If the connector is not connected properly, the setting may be not correct. Refer to the following and check Tutorial procedures again.

- Whether a direction of pressing force is correct
- Whether a Plane setting is correct
  (relative positon based on tool or base coordinate)
- Whether a start position is correct
  Or whether a position of height Z is not misaligned
- Whether a setting of [TimeOut] is too short.
- Whether a robot operates slowly in low power mode

6.3.9 Advanced Tasks

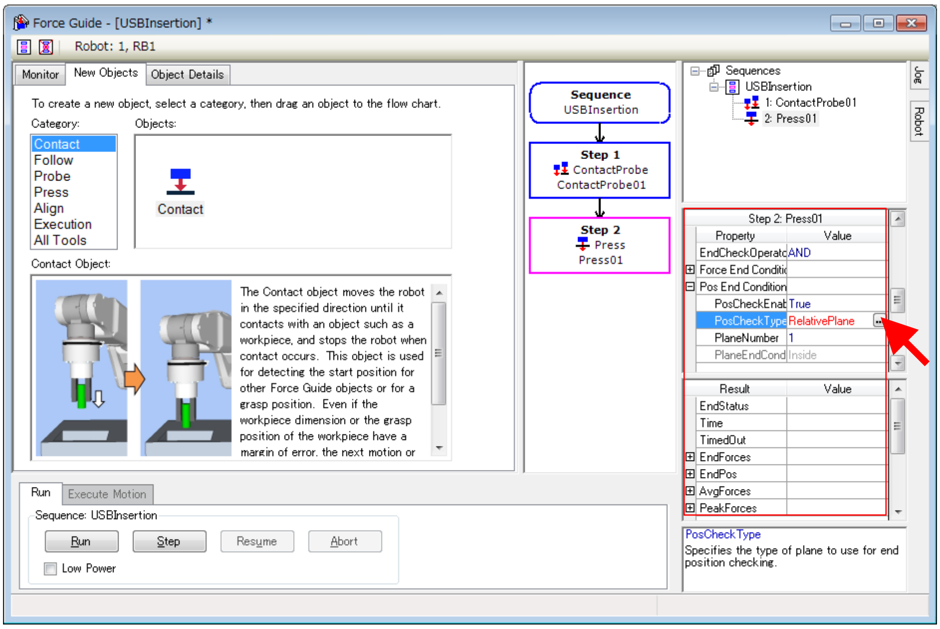
Let’s do the following operations.

1. If the operation ends due to the condition “the condition is satisfied by the force when inserting a connector”, the connector may get caught in the middle of the hole and not be inserted completely.
   As a remedy, add a position condition.
   Change the [Press01 (Press)] property as shown below and execute it.

   Check the difference from the last time. (Refer to: *Software 4.3.7 Press Object*)

Item	Value	Description
EndCheckOperator	AND	Set AND as the end conditions related to force, position, and I/O.
PosCheckEnabled	TRUE	Enable the end conditions related to position.
PosCheckType	Relative Plane	Types of the end conditions related to positions. Make it an end condition that the robot moves a relative amount from the start point.
PlaneNumber	2	Overwrite Plane number 2 and use as the end condition of positions.
PlaneRelativeOrg	Tool	Indicate an offset amount to the origin of Plane based on the Tool coordinate system direction.
PlaneRelativeX	-10	Set an offset amount in each direction from the current position to the origin of Plane. Position is where the robot shifts -10mm to X direction based on the Tool coordinate.
PlaneRelativeY	0	
PlaneRelativeZ	0	
PlaneRelativeOrient	Tool	Set a coordinate system based on the Plane direction. Use the Tool coordinate system.
PlaneAxes	YZ	Set a plane direction in parallel with the YZ plane in the tool coordinate. Normally, set Plane which is perpendicular to the robot motion direction.

Check the setting of [Plane] by using simulator.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the grasp workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Sequence: USBInsertion

Step 2: Press01

Property	Value
EndCheckOperatc	AND
Force End Conditic	
Pos End Condition	
PosCheckEnat	True
PosCheckType	RelativePlane
PlaneNumber	1
PlaneEndCond	Inside

Result	Value
EndStatus	
Time	
TimedOut	
EndForces	
EndPos	
AvgForces	
PeakForces	

PosCheckType
Specifies the type of plane to use for end position checking.

2. Perform the tool setting in the center of contacting position of a USB connector and execute tutorial.
   The force and torque values measured at this time are displayed based on the tool position. When the right or left side of the USB connector contacts with the USB port, you can assume a tilt level of the USB connector grasped by the end effector by its positive and negative.

3. Increase motion speed.
   The following properties affect to speed.
   - Increase the [PressForce].
     (However, connector’s insertion force is set as specification. Change the force within the range.)
   - Reduce [Firmness].
   - Increase probe motion such as [SpeedS] or [AccelS] that affects to depart or travel time for moving to other probe positions.

Now, tutorial for “Insert USB connector” is completed.

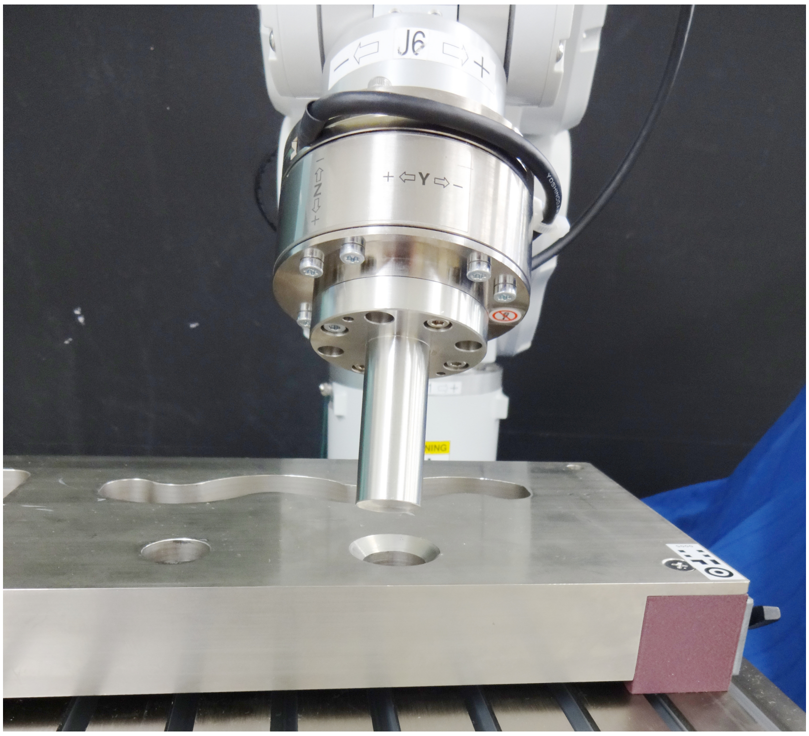
6.4 Force Guidance Function (Peg In Hole)

The following describes how to operate "Peg In Hole" tasks that probes a hole using the cylinder while contacting the surface in spiral trajectory.

Prepare a workpiece by yourself.

Workpiece used in the picture is a training kit. If you need a drawing, please contact us.

Cylinder on end effector side	Diameter: 20mm, Length: 40mm
Hole side	Diameter: approx. 20mm, C plane: approx. 7mm



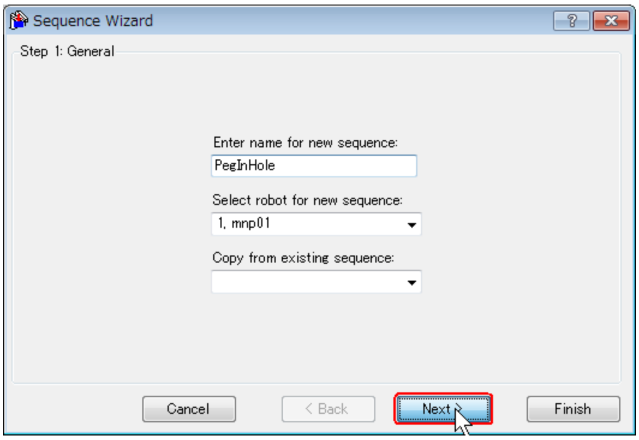
If you do not have a workpiece or a tool as shown above, you can try it easily by using a cylindrical wood, cork, and a plastic bottle. However, do not use a workpiece that has risks when it brakes such as a glass. Broken pieces will be scattered and may result in injury. Also, pay attention to surroundings when you proceed this tutorial.

⚠ CAUTION	■ The parameters described in tutorial are reference values. Please note that relatively stable parameters are used, but the operation may not be successful or the motion may be vibratory in some operating conditions, and the parameters may need to be adjusted. In addition, slow stable parameters are used for convenience of explanation. The parameters need to be adjusted for faster operations.

6.4.1 Sequence Wizard

The following describes how to create a force guide sequence for Peg In Hole.

(1) Enter "PegInHole" on [Enter name for new sequence].
Click the <Next> button.



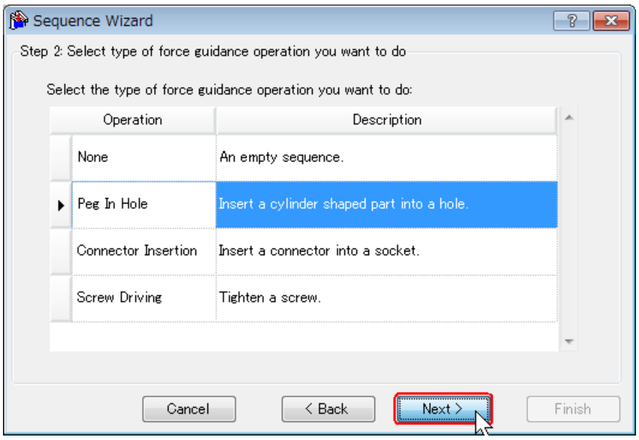
Step 1: General

Enter name for new sequence: PegInHole

Select robot for new sequence: 1, mnp01

Copy from existing sequence:

(2) The [Step 2: Select type of force guidance operation you want to do] dialog box is displayed.
Select [Peg In Hole].
Click the <Next> button.

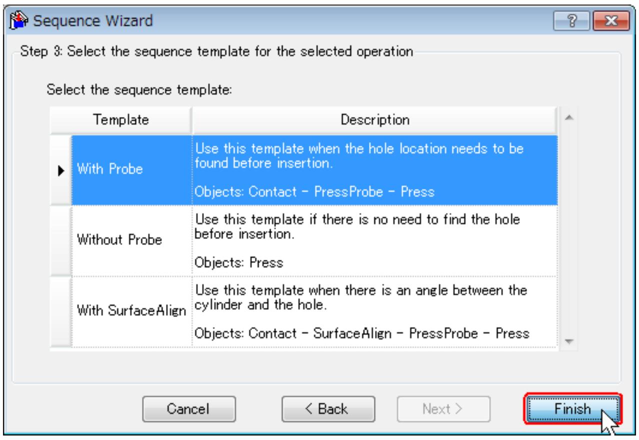


Step 2: Select type of force guidance operation you want to do

Select the type of force guidance operation you want to do:

Operation	Description
None	An empty sequence.
Peg In Hole	Insert a cylinder shaped part into a hole.
Connector Insertion	Insert a connector into a socket.
Screw Driving	Tighten a screw.

(3) The [Step 3: Select the sequence template for the selected operation] dialog box is displayed.
Select [With Probe].
Click <Finish> button.

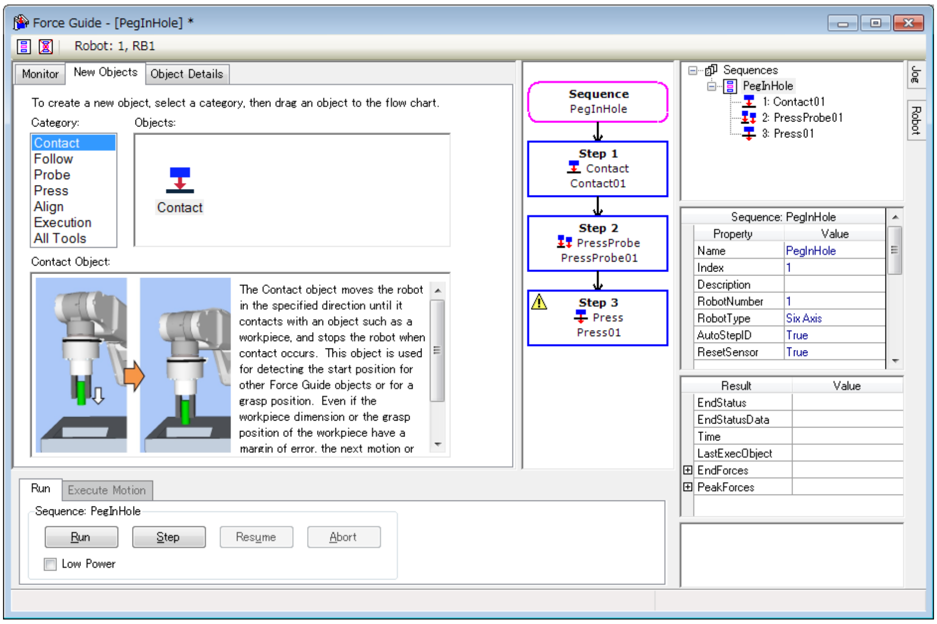


Step 3: Select the sequence template for the selected operation

Select the sequence template:

Template	Description
With Probe	Use this template when the hole location needs to be found before insertion. Objects: Contact - PressProbe - Press
Without Probe	Use this template if there is no need to find the hole before insertion. Objects: Press
With SurfaceAlign	Use this template when there is an angle between the cylinder and the hole. Objects: Contact - SurfaceAlign - PressProbe - Press

(4) Confirm that the [PegInHole] sequence is created.
Contact-PressProbe-Press



Force Guide - [PegInHole] *

Robot: 1, RB1

To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Sequence: PegInHole

Property	Value
Name	PegInHole
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

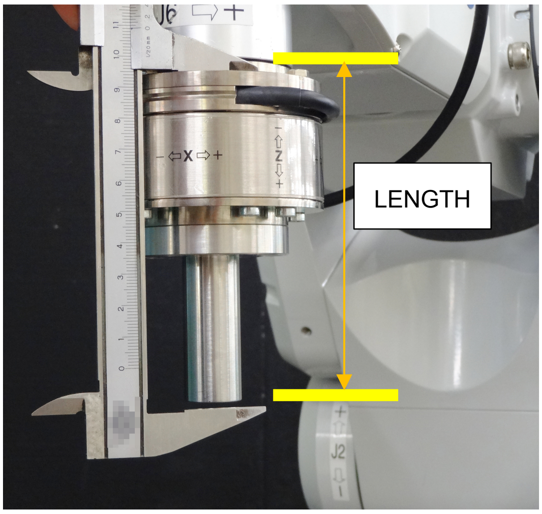
Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

6.4.2 Tool Setting

During “Peg In Hole” task, the robot moves to X, Y, and Z directions while following to each rotation direction.

Make sure to complete the tool setting when operating “Peg In Hole” task. Tool setting is also required when operating the surface align task.

(1) Use a caliper to measure distance from J6 flange plane to the end of the cylinder.
In the case of the following picture, the distance is 109mm.
(Force sensor : 49mm, end effector: 60mm)



(2) Execute the following command in [Command Window].
Enter the value measured in step (1) to "**LENGTH**". (unit: mm)
Set Tool 2 and select.

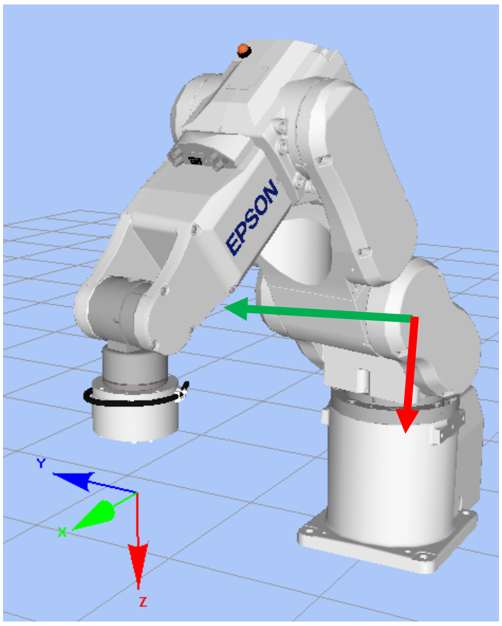
```
> TLSet 2, XY( 0, 0, LENGTH, 0, 0, 0)
> Tool 2
```

(3) Click EPSON RC+ menu-[Tools]-[Simulator].
The [Simulator] window is displayed.

(4) Click the object tree-[Tool].

(5) Place a checkmark in "No.2"-[Visible] checkbox.

(6) Confirm the position and the orientation (direction) of Tool 2 by using the both simulator and the actual robot.
If they are different, check the settings and reset Tool 2.

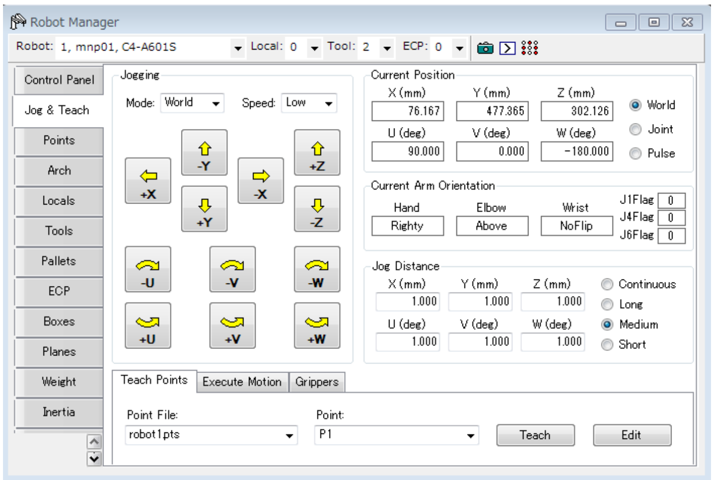


6.4.3 Position Teaching

The following describes how to teach a start position of the “Peg In Hole” task and a plane where the cylinder starts to fit.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Select the [Jog & Teach] to display the panel.



Robot: 1, mnp01, C4-A601S Local: 0 Tool: 2 ECP: 0

Mode: World Speed: Low

X (mm)	Y (mm)	Z (mm)	
76.167	477.365	302.126	● World
U (deg)	**V (deg)**	**W (deg)**	○ Joint
90.000	0.000	-180.000	○ Pulse

Hand	Elbow	Wrist
Righty	Above	NoFlip

J1Flag 0
J4Flag 0
J6Flag 0

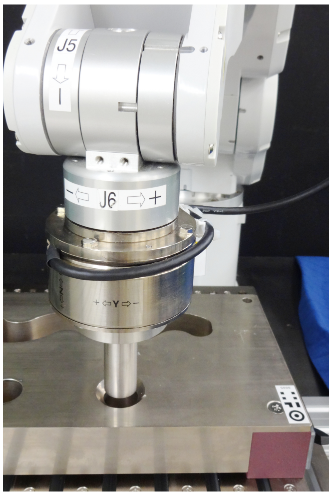
X (mm)	Y (mm)	Z (mm)	
1.000	1.000	1.000	○ Continuous ○ Long
U (deg)	**V (deg)**	**W (deg)**	● Medium
1.000	1.000	1.000	○ Short

Point File: robot1.pts Point: P1

(3) Click EPSON RC+ 7.0 menu-[Tools]-[Force Monitor].
The [Force Monitor] dialog box is displayed.

(4) Click the <Start Live> button on the [Force Monitor] dialog box.
Start to display the output value from the current force sensor.

(5) Click the Jog button on the [Jog & Teach] window to move the robot to a position where the cylinder and the hole face each other.



Execute the following command in the command window if necessary.

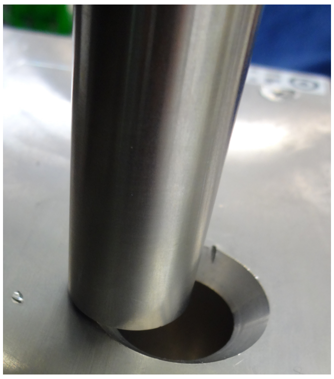
```
> Go Align(Here)
```

By executing the above command, the robot will be a parallel orientation against the Base coordinate system based on the current position It will be easier for the robot to move to the position where the cylinder and the hole face each other.

For details, refer to the following manual:

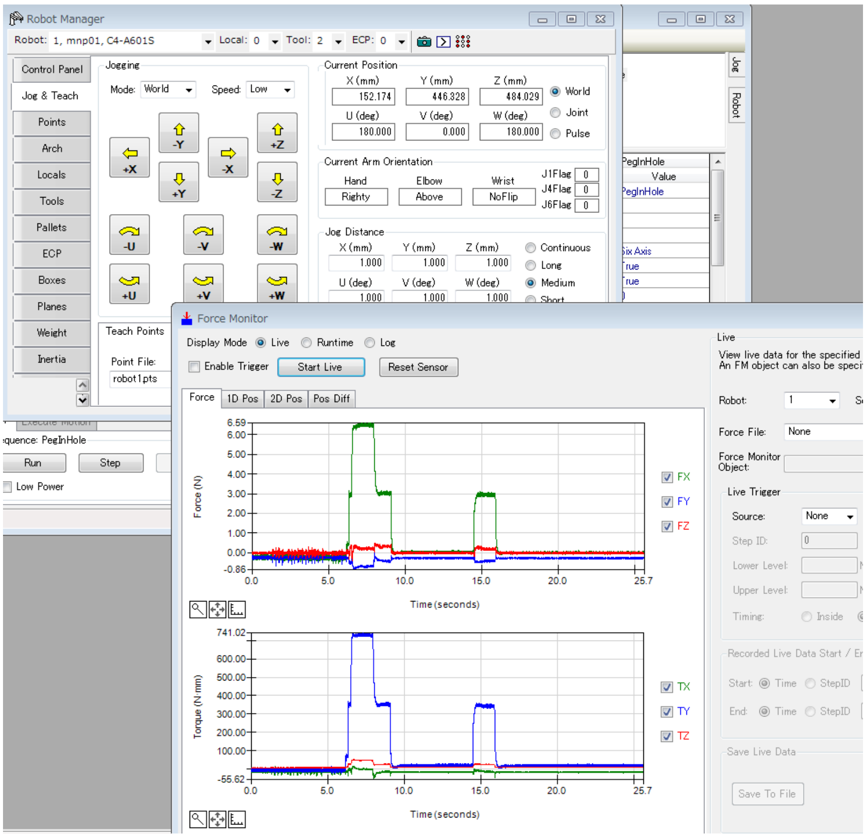
EPSON RC+ SPEL+ Language Reference
Align Function

(6) Click the <Reset Sensor> button on the [Force Monitor] dialog box.
Eliminate the effect of gravity and drift of the sensor value, set the current position to “zero”.



(7) Click the Jog button on the [Jog & Teach] window to move the robot to a position where is slightly away from the center of the insertion.
To perform the pressing and probe motions, move the robot to a position where is slightly outside of taper (C plane).

(8) Select <Short> button on [Jog Distance].
Click the Jog button several times to move the robot to –Z direction until it contacts with an object near the hole.
When the robot contacts with the object, output value of force sensor changes.
Check the changes of monitor value by the timing of the jog motion.



Robot Manager

Robot: 1, mnp01, C4-A601S
Local: 0
Tool: 2
ECP: 0

Jogging
Mode: World
Speed: Low

Current Position
X (mm): 152.174
Y (mm): 446.328
Z (mm): 484.029
U (deg): 180.000
V (deg): 0.000
W (deg): 180.000
● World ○ Joint ○ Pulse

Current Arm Orientation
Hand: Righty
Elbow: Above
Wrist: NoFlip
J1Flag: 0
J4Flag: 0
J6Flag: 0

Jog Distance
X (mm): 1.000
Y (mm): 1.000
Z (mm): 1.000
U (deg): 1.000
V (deg): 1.000
W (deg): 1.000
○ Continuous ○ Long ● Medium ○ Short

Teach Points
Point File: robot1.pts

Force Monitor

Display Mode ● Live ○ Runtime ○ Log
☐ Enable Trigger

Live
View live data for the specified
An FM object can also be speci
Robot: 1
Force File: None
Force Monitor Object:

Live Trigger
Source: None
Step ID: 0
Lower Level:
Upper Level:
Timing: ○ Inside

Recorded Live Data Start / Er
Start: ● Time ○ StepID
End: ● Time ○ StepID

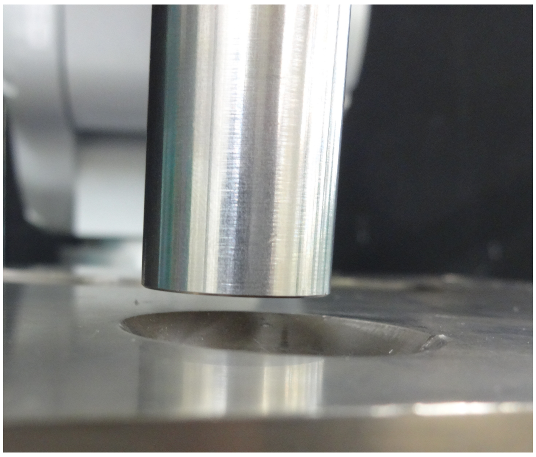
Save Live Data

(9) Select “P9” in [Point].

(10) Click the <Teach> button.

(11) The [New Point Information] dialog box is displayed.
Enter “PegInHolePlane” to [Point Label] and click the <OK> button.

(12) Select the <Medium> button on [Jog Distance].
Click the Jog button for three times and move the robot 3mm to +Z direction.
The cylinder will be non-contact state.



This is a start position of insertion and a position where the force sensor is reset.

(13) Select “P8” on [Point].

(14) The [New Point Information] dialog box is displayed.
Enter “PegInHoleStart” in [Point Label].
Click the <OK> button.

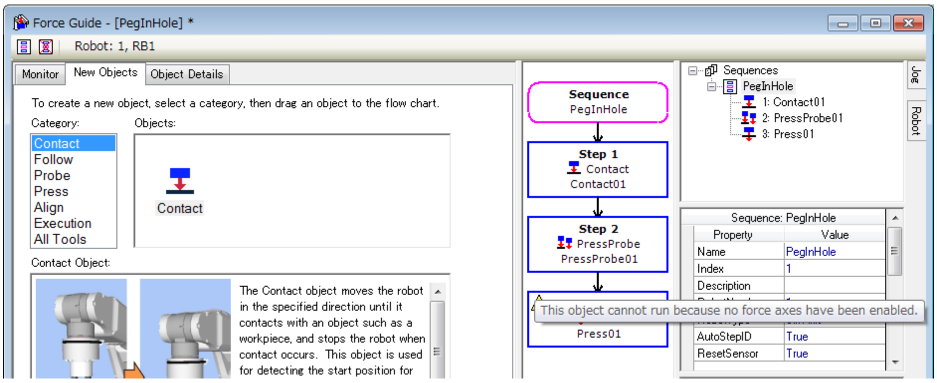
(15) Click EPSON RC+ menu-[File]-[Save All].
The file is saved.

6.4.4 Property Setting

The following describes how to set the required properties for the “Peg In Hole”.

(1) The ⚠ mark is displayed on the flow chart by default.
You need to set properties.

When a mouse pointer is moved on the ⚠ mark, tool tip is displayed. The tool tip shows contents that need to be set or modified.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for

Sequence: PegInHole

Property	Value
Name	PegInHole
Index	1
Description	
AutoStepID	True
ResetSensor	True

This object cannot run because no force axes have been enabled.

(2) Select the [PegInHole] sequence. Properties and Results are displayed.

(3) Change the following property:

Item	Value	Description
RobotTool	2	Select Tool 2

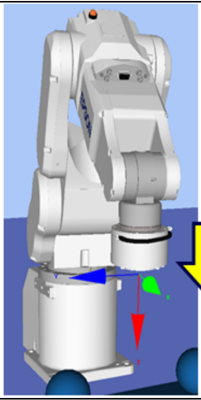
(4) Click EPSON RC+ menu-[File]-[Save File].
Settings are saved.

(5) Select the object flow of [Contact01] to display the properties.

(6) Change the following properties:

Item	Value	Description
Contact – Orient *1	+Fz	Set a direction to contact. The robot moves to +Fz direction.
Contact - FirmnessF	2	Set a firmness of the force control functions.
Force End Condition - ContactForceThresh	- 5	Set -5N to a threshold to determine a contact. Be sure to set a proper threshold for your workpiece.
Timeout	10	Set a time-out period of a contact motion. When 10 seconds have passed until the robot contacts, it fails.

*1 [Reference]

	6-axis robot	SCARA robot
Robot motion image Pressing		
(Press/Contact) Orient	+Fz	-Fz
Sign of Force (monitor display is included)	-	+

(7) Click EPSON RC+ menu-[File]–[Save File].
Modified property is saved to the project.

(8) Select the object flow of [PressProbe01] to display the properties.

(9) Change the following properties:

Item		Value	Description
ProbeTrajectory		Spiral	Set a trajectory to probe. Set Spiral trajectory.
ProbeDetectType		Hole	Set a target to be detected. Set Hole.
AccelS		100	Set the translational acceleration of the movement. Actual translational acceleration is adjusted by the force control functions. You need to set a large enough value such as ten times larger than SpeedS
SpeedS		10	Set the translational velocity of the movement. Actual translational velocity is adjusted by the force control functions. Set a value about 10mm/s.
SpiralDiam		30	Set a diameter of the spiral trajectory. Set 30mm.
SpiralPitch		3	Set a pitch of the spiral trajectory. Rotate around the center for ten times. Set 3mm.
Press *1	Orient	+Fz	Direction to press. Set a vertical direction to a probe plane.*
	Force	-3	Set the pressing force. When PressOrient is positive direction: Enter a negative value. When PressOrient is negative direction: Enter a positive value. Normally, a value approx. 3 to 5N is set. However, set a proper value for your workpiece. If the value is too small, the robot may move away from the probe plane.
	FirmnessF	1	Set a firmness of the force control functions in pressing direction.

Item		Value	Description
PosEnd Conditions *2	PosCheckEnabled	True	Set whether to enable the end conditions related to positions.
	PosCheckType	Relative Plane	Select types of the end conditions related to positions. Every time the force guide sequence is executed, create Plane at a relative position from the current position and set as an end condition of position.
	PlaneNumber	3	Overwrite the Plane number 3 for end condition of positions.
	PlaneRelativeOrg	Tool	Indicate an offset amount to the origin of Plane based on the Tool coordinate system direction.
	PlaneRelativeZ	0.5	Set 0.5mm to Fz direction in the Tool coordinate system as an offset amount from the current position to the origin of Plane.
	PlaneRelativeOrient	Tool	Set a Plane direction Create a Plane inside the XY plane in the Tool coordinate system.
	PlaneAxes	XY	

(10)Click EPSON RC+ menu-[File]–[Save File].

Modified property is saved to the project.

(11)Select the object flow of [Press01] to display the properties.

(12)Change the following properties:

	Item	Value	Description
Fx	ControlMode	Follow	Perform the follow motion by the force control functions.
	Firmness	2	Set a firmness of the force control functions in X direction.
Fy	ControlMode	Follow	Perform the follow motion by the force control functions.
	Firmness	2	Set a firmness of the force control functions in Y direction.

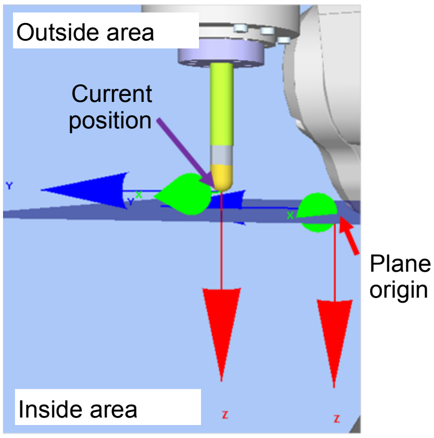
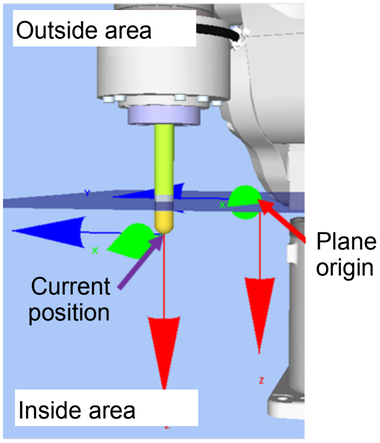
	Item	Value	Description
Fz *1	ControlMode	Press+	Mode of force control function. Press+: The robot moves to a positive direction in Fz axis and presses.
	Force	-10	Set an applied force when inserting. Set 10N.
	Firmness	2	Set a firmness of the force control functions in Z direction.
PosEnd Condition2 *2	PosCheckEnabled	True	Enable the end conditions related to position.
	PosCheckType	Relative Plane	Types of the end conditions related to positions. Every time the force guide sequence is executed, create Plane at a relative position from the current position and set as an end condition of position.
	PlaneNumber	3	Set Plane3 to the end condition of positions.
	PlaneRelativeOrg	Tool	Indicate an offset amount to the origin of Plane based on the Tool coordinate system direction.
	PlaneRelativeZ	10	Set an offset amount in Z direction from the current position to the origin of Plane. Direction will be the Tool coordinate system direction specified by PlaneRelativeOrg.
	PlaneRelativeOrient	Tool	Set a coordinate system based on the Plane direction to the Tool coordinate system.
	PlaneAxes	XY	Set XY plane as the plane direction.
TimeOut		20	This property sets the time-out period. Fails when the end condition (move 10mm) is not satisfied within 20 seconds.

(13)Click EPSON RC+ menu-[File]–[Save File].

Modified properties are saved to the project.

*2 [Reference] Positional relationship with Plane

The positional relationship of the robot’s current position and Plane is as shown below. If the robot’s current position is in the +Z direction area from the Plane origin, it will be “Inside”.

	Outside	Inside
Positional relationship with Plane 6-axis robot		
Determined value of Plane (GetRobotInsidePlane)	0 = Outside	1 = Inside

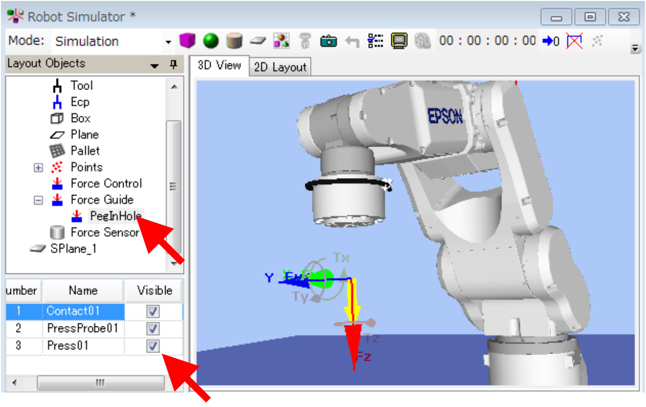
6.4.5 Setting Confirmation

The following describes how to check whether the settings such as pressing direction are correct.

(1) Click EPSON RC+ menu-[Tools]-[Simulator].
The [Simulator] window is displayed.

(2) Click the object tree-[Force]-[Force Guide]-[PegInHole].

(3) Place a checkmark on the following checkboxes.
[Contact01]-[Visible], [PressProbe01]-[Visible], [Press01]-[Visible]



umber	Name	Visible
1	Contact01	☑
2	PressProbe01	☑
3	Press01	☑

(4) Confirm that the yellow arrow direction is the same as the cylinder insertion direction.
If the direction is different, refer to the following section and check the setting.
Software 6.4.4 Property Setting

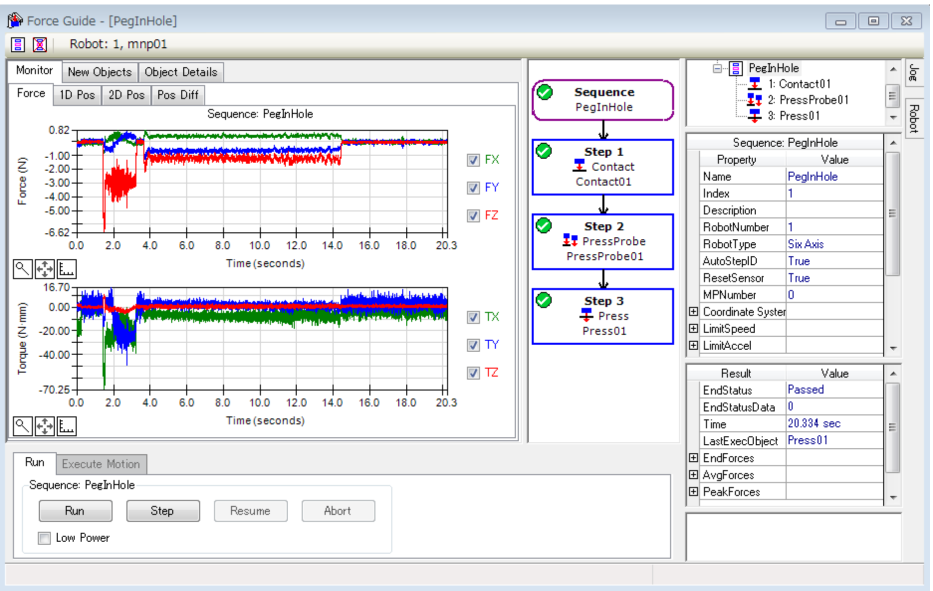
6.4.6 Motion by Force Guidance Function

The following describes how to execute a sequence that performs “Peg In Hole” task in the [Force Guide] window.

(1) Display the [Force Guide] window.

(2) Click the <Run> button.
Program is compiled and transmitted to the robot controller. If the setting is not correct, an error occurs. Check the settings so far and follow the error message to modify the parameters.

(3) When the program satisfies the conditions set in the properties and can be executed to the end, “✓” is displayed on the upper left of the flowchart and the robot motion stops.



Sequence: PegInHole

Property	Value
Name	PegInHole
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True
MPNumber	0
⊞ Coordinate Syster	
⊞ LimitSpeed	
⊞ LimitAccel	

Result	Value
EndStatus	Passed
EndStatusData	0
Time	20.334 sec
LastExecObject	Press01
⊞ EndForces	
⊞ AvgForces	
⊞ PeakForces	

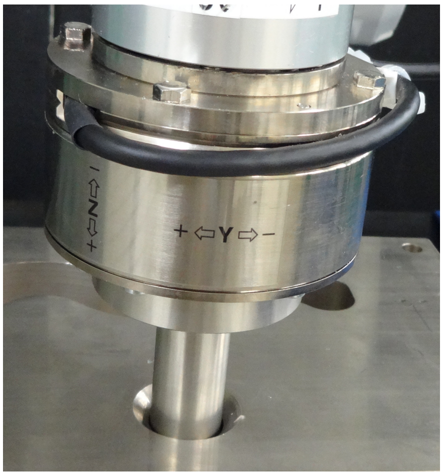
6.4.7 Return to Non-Contact State

The following describes how to return to the non-contact state.

Force to perform the Peg In Hole task is still applied even the task is completed.

If you operated an accurate Peg In Hole task such as an interval is tens of microns, large force may be applied even the task is in the end state.

To prevent the robot and the end effector from malfunction or damages, move the robot away from the object immediately after the operation ends, and make sure that no force is applied to the object. If it is obvious that no force is applied to the object, you can omit this step.



- Operate the jog motion at a small interval such as 0.1mm and set the robot to be non-inserting state.
- Make the cylinder to be non-grasped state.
- Create a force guide sequence that performs “pulling” (press in the opposite direction to the insertion) separately and pull the stick out.
  When five minutes have passed after the insertion task, you may not be able to pull the stick out since the detection values shift due to drift of the force sensor.
  For more details, refer to the following section.
  Software 6.4.9 Advanced Tasks - 2

In this tutorial, pull the stick out by the jog motion while checking on the force monitor.

(1) Click EPSON RC+ menu-[Tools]-[Force Monitor].
The [Force Monitor] dialog box is displayed.

(2) Click the <Start Live> button.
Graph of the currently selected force monitor object is displayed.

(3) Display the [Robot Manager] dialog box.

(4) Select the [Jog & Teach] panel.

(5) Click [Jogging]-[Mode] and select “Tool”.
It is a proper setting for removing perpendicular to the hole when the Peg In Hole task is performed to the hole with tilt while performing the follow motion.

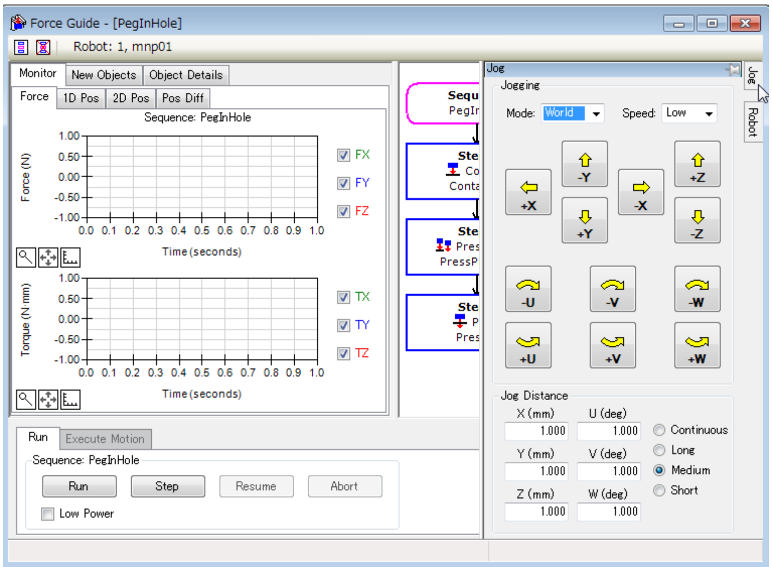
(6) perform fitting to the hole with tilt while following.

(7) Click the <Short> button on [Jog Distance].

(8) Move to –Z direction by 0.1mm.
Output value will be far from “0” with time due to the drift characteristic of the force sensor. Relative changes of the force value are reflected the contact state changes correctly.
While checking the graph values to be displayed, click the Jog button to move the robot to X, Y direction. The robot will be to non-contact state.

Reference: *Software 2.1 Resetting the Force Sensor*

[Reference]
The [Jog] tab is in the [Force Guide] window. When the tab is selected, the [Jog] window is displayed. You can move the robot and set to non-contact state by clicking the Jog button.



Force Guide - [PegInHole]

Robot: 1, mnp01

Sequence: PegInHole

Mode: World

Speed: Low

Jog Distance

X (mm)	U (deg)
1.000	1.000
Y (mm)	**V (deg)**
1.000	1.000
Z (mm)	**W (deg)**
1.000	1.000

○ Continuous
○ Long
● Medium
○ Short

Sequence: PegInHole

☐ Low Power

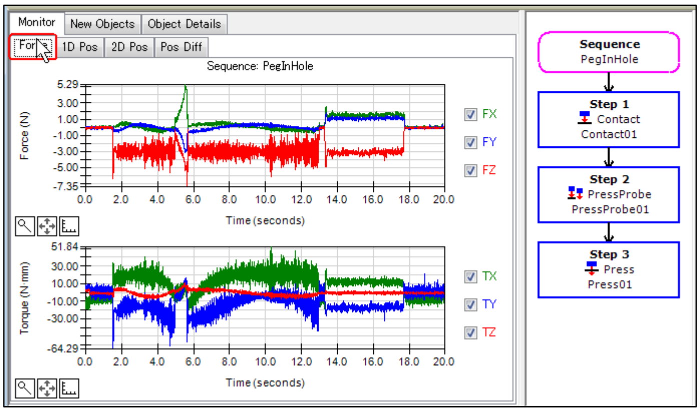
6.4.8 Motion Analysis by Monitor

The following describes how to check the operation results of force guide sequence by EPSON RC+.

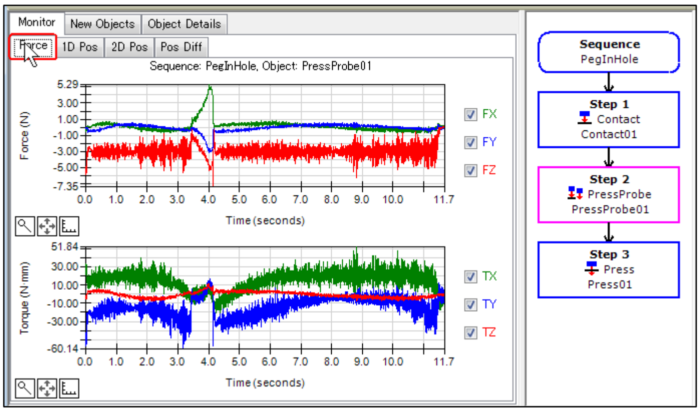
(1) Display the [Force Guide] window.

(2) Click the sequence flow of [PegInHole].

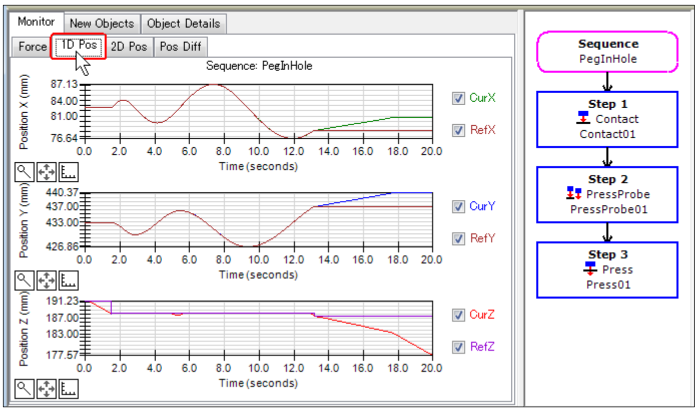
(3) Select the [Monitor] tab. Select the [Force] tab.
Force and position during the [PegInHole] sequence execution are displayed in the graph.



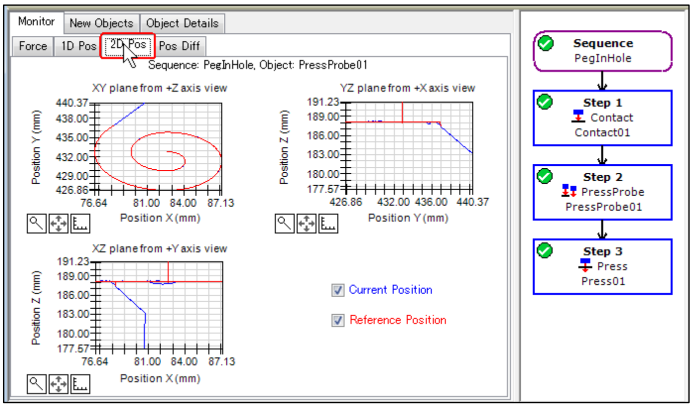
(4) Click the object flows of [Step1], [Step2], and [Step 3] to display the force and the position during the execution of the selected force guide object.



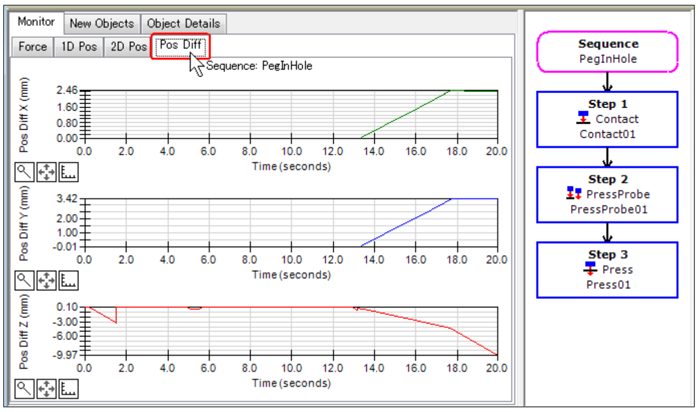
(5) Click the sequence flow of [PegInHole].
Select the [Monitor] tab. Select the [1D Pos] tab.
Graph for analysis is displayed. (horizontal axis: Time, vertical axis: Position)



(6) Select the [2D Pos] tab.
Graph for analysis is displayed. (horizontal axis, vertical axis: Position)
Focus on the blue line. You can see that the robot enters into a hole while the spiral probe motion and the motion switches to the pressing motion. Then, the robot moves to -Z direction and moves (follows) inside the X, Y plane.

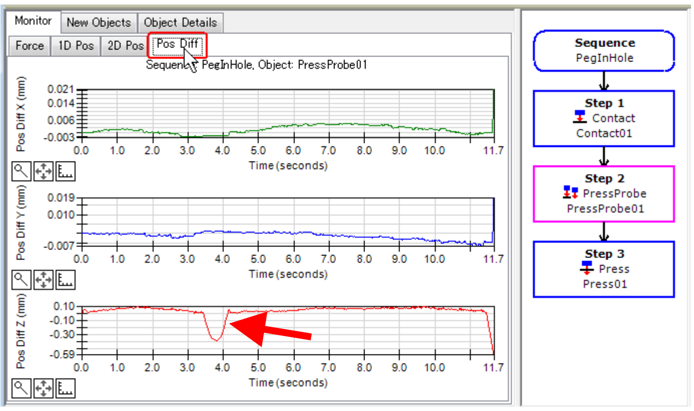


(7) Select the [Pos Diff] tab.
Record shifts by force control as relative position changes. It is different from the graph on the [1D Pos] tab.



(8) Change the unit of the graph and check the changes of force or positions.

(9) Look the monitor shown by Tutorial and check the motion results.
It can be assumed that the probe motion was continued since the robot nearly inserted into a hole in [Step2], however, it could not move downward more than 0.5mm which is set in position setting of [Plane Z].



6.4.9 Advanced Tasks

Let’s do the following operations.

1. When you perform a probe motion, task takes longer time since time for the probe motion is added.
   If you can omit the probe motion, task time can be shortened.
   Follow the steps below to try.

   (1) Change the position of task start position (taught point: PegInHoleStart) to inside of taper (C plane).

   (2) Right-click [Step2: PressProbe] and select [Delete].

   (3) Refer to the following and execute force control function.
   Software 6.4.6 Motion by Force Guidance Function

2. It takes time to perform jog motion for a distance of tens of millimeters such as “*Software 6.4.7 Return to Non-Contact State*”.
   Let’s try a method to pull the stick out using the force control function right after the Peg In Hole task.
   At this time, make sure not to reset the force sensor by clicking [Sequences]-[Property].

CAUTION

- When about five minutes have passed after Peg In Hole task, the robot cannot detect a proper value and fails to pull the stick out due to the drift characteristics of force sensor. At this time, a large force will be applied to the workpiece and it may result in damage to workpiece. Be sure to pull the stick out right after the force guide sequence is executed.

  If you reset the force sensor in the contact state, the force and value at that time will be “0”. In this state, the force control function cannot be performed properly and the robot may fail to pull the stick out or the workpiece may get damage. Be sure to set the [ResetSensor] property to “False”. Also, when you want to reset the force sensor (e.g. click the <Reset Sensor> button or reboot the controller), move the robot by using the jog motion without performing the force control function and set to the non-insertion state / the non-grasped state.

   (1) Create another empty force guide sequence which is different from [PegInHole].
   Example: PullFromHole

   (2) Add a Press object only and set the properties.
   For 6-axis robot, refer to the following settings and adjust the properties such as [Firmness].

   - Set “Press- ” direction in [Fz_ControlMode]
   - Set “Follow” in [Fx_ControlMode], [Fy_ControlMode]
   - Set a force less than 10N in [Fz_ControlMode]
     (If the force is too large, the robot will get caught in the hole.)
   - Set a large value in [Timeout] such as 60sec.
     (Robot keeps moving even the “pulling” task is performed. Click the <Abort> button to stop the robot.)
   - Set [Fx_Firmness], [Fy_Firmness], and [Fz_Firmness] to the same object as [Press01] of [PegInHole].

(3) Click the sequence flow on flowchart.

(4) Set the [ResetSensor] property to “False”.

(5) Refer to the following and execute the force control function.
6.4.6 Motion by Force Guidance Function

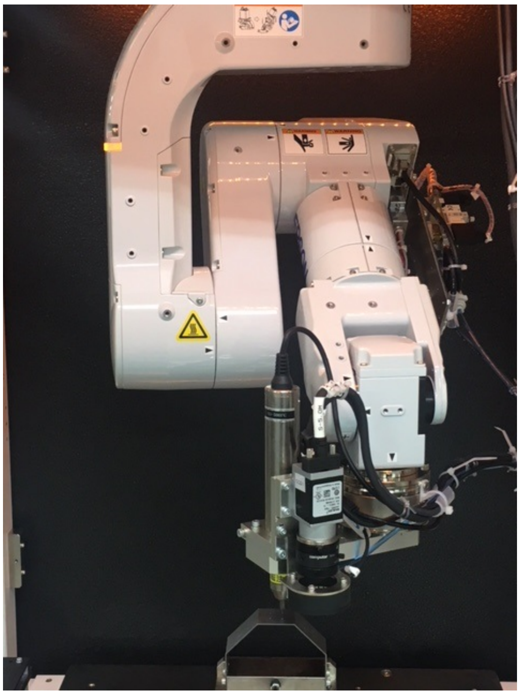
Now, tutorial for “Peg In Hole” is completed.

6.5 Force Guidance Function (Screw Driving)

The following describes how to perform screw driving task.

Please prepare an electric screwdriver, screws, and workpiece to fix screws by yourself. Workpiece will get damage due to incorrect settings. Make sure to prepare the workpiece which is okay to get damages and proceed the tutorial

Make sure to set the position of workpiece or screw driving direction as same as the picture below.

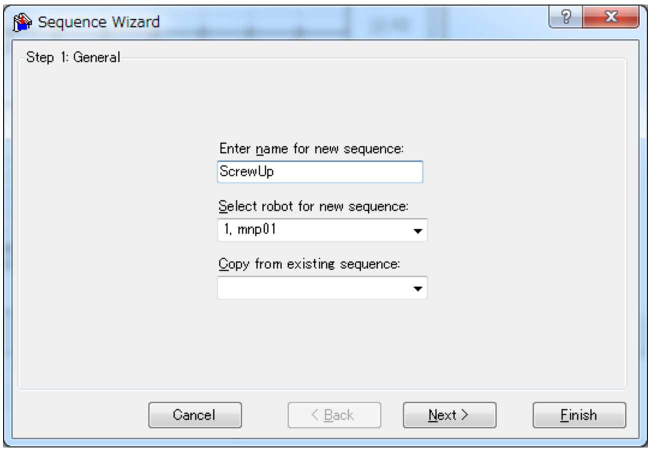


⚠ CAUTION	■ The parameters described in tutorial are reference values. Please note that relatively stable parameters are used, but the operation may not be successful or the motion may be vibratory in some operating conditions, and the parameters may need to be adjusted. In addition, slow stable parameters are used for convenience of explanation. The parameters need to be adjusted for faster operations.

6.5.1 Sequence Wizard

The following describes how to create a force guide sequence for “Screw Driving”.

(1) Enter “ScrewUp” to [Enter name for new sequence].
Click the <Next> button.

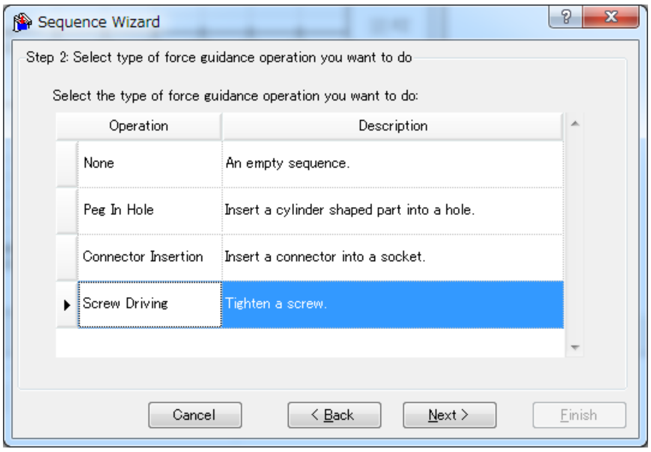


Enter name for new sequence: ScrewUp

Select robot for new sequence: 1, mnp01

Copy from existing sequence:

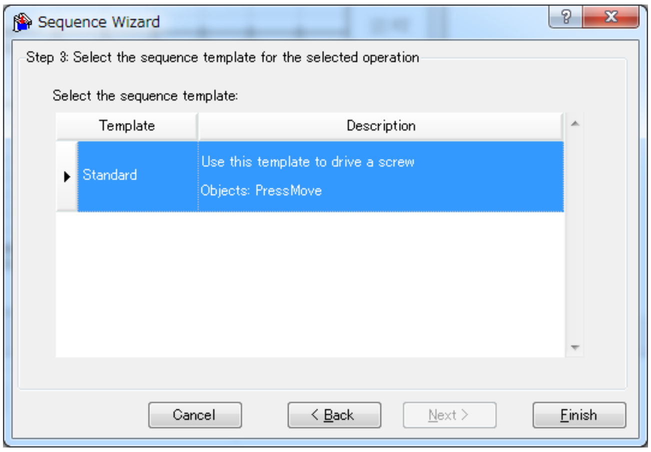
(2) The [Step 2: Select type of force guidance operation you want to do] dialog box is displayed.
Select [Screw Driving].
Click <Next> button.



Select the type of force guidance operation you want to do:

Operation	Description
None	An empty sequence.
Peg In Hole	Insert a cylinder shaped part into a hole.
Connector Insertion	Insert a connector into a socket.
Screw Driving	Tighten a screw.

(3) The [Step 3: Select the sequence template for the selected operation] dialog box is displayed.
Select [Standard].
Click the <Finish> button.

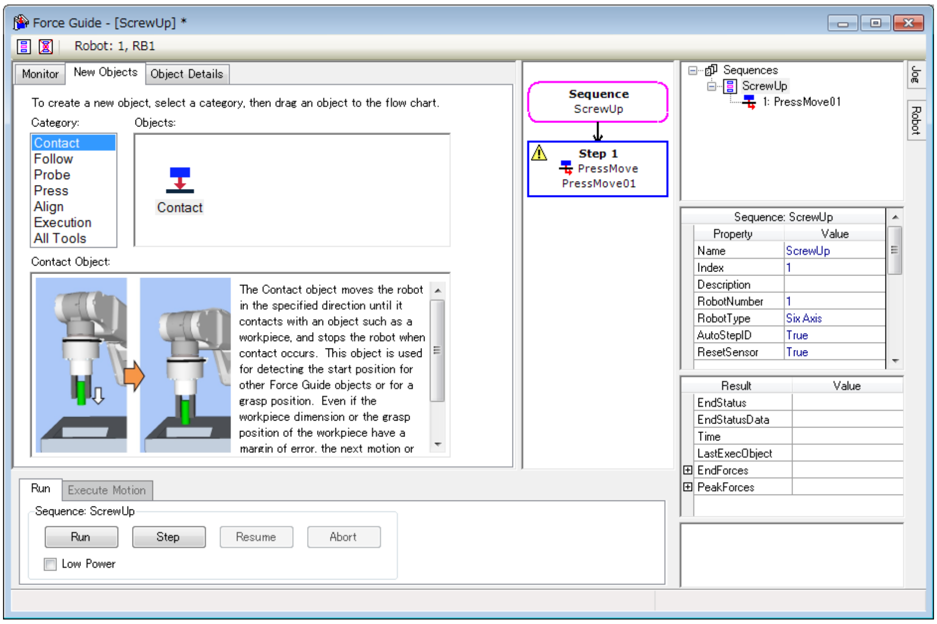


Step 3: Select the sequence template for the selected operation

Select the sequence template:

Template	Description
Standard	Use this template to drive a screw Objects: PressMove

(4) Confirm that the [ScrewUp] sequence is created.



To create a new object, select a category, then drag an object to the flow chart.

Category:

Objects:

Contact Object:

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Sequence: ScrewUp

Property	Value
Name	ScrewUp
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

Sequence: ScrewUp

6.5.2 Tool Setting Confirmation

The following describes tool setting procedures.

For “Screw Driving”, you need to be careful for correspondence between the direction of actual screw driving and the current tool setting.

(1) Use a caliper to measure distance of X, Y, and Z from J6 flange plane to the end of the electric screwdriver.

(2) Execute the following in [Command Window].
Enter the value measured in procedure (1) to **“LengthX, LengthY, LengthZ”**.

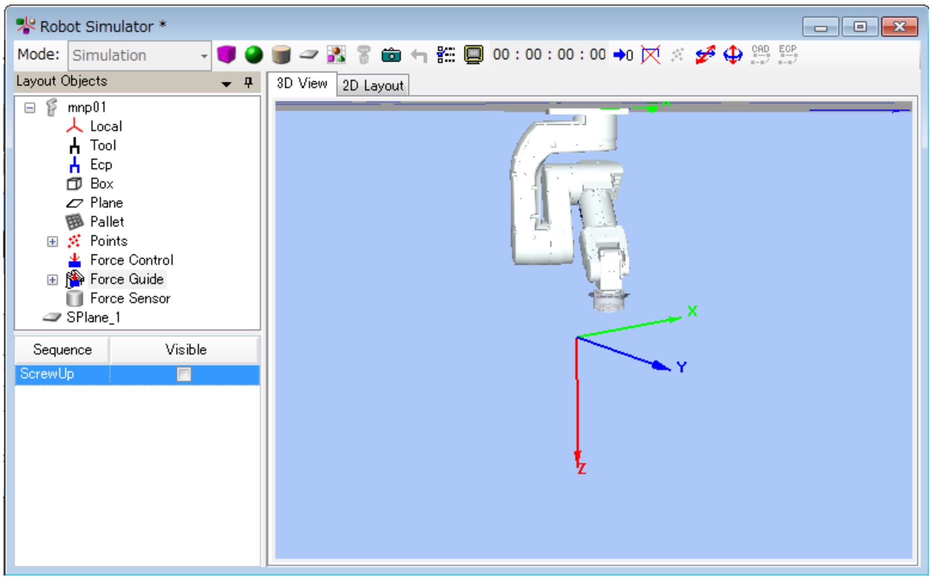
```
> Tlset 1,XY(LengthX,LengthY,LengthZ,0,0,0)
```

(3) Click EPSON RC+ menu-[Tools]-[Simulator].
The [Simulator] window is displayed.

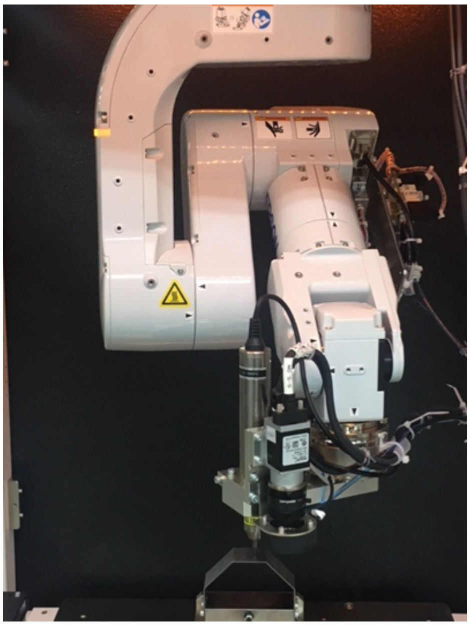
(4) Select the object tree-[Manipulator Name]-[Tool].

(5) Place a checkmark in “No.1”-[Visible] checkbox.

(6) To confirm that the tool setting is correct, compare the display of the [Simulator] window and the orientation of the actual robot.



According to the display of the [Simulator] window, you will see that screw driving is performed to +Z direction of the tool.



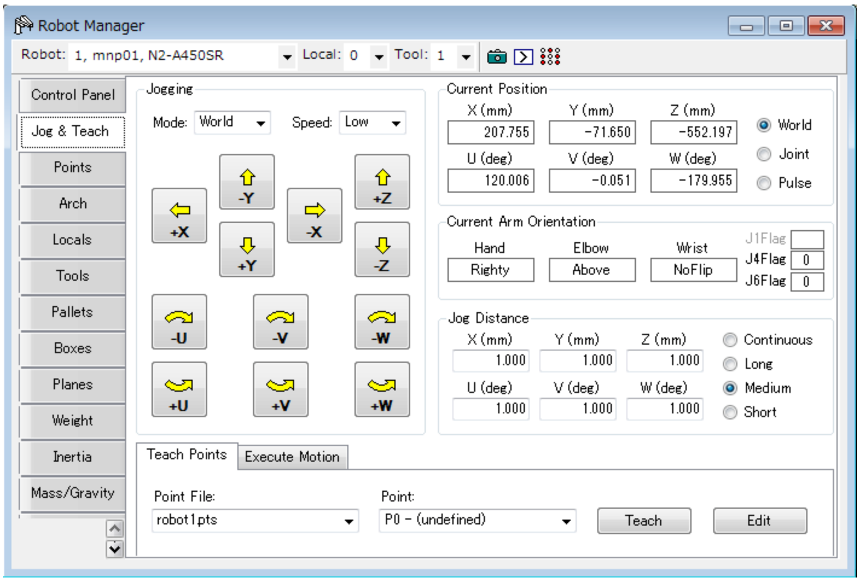
6.5.3 Start Position Teaching

The following describes how to teach a start position of “Screw Driving” motion.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Select the [Jog & Teach] panel and display the panel.

(3) Select “1” on [Tool].



Robot Manager

Robot: 1, mnp01, N2-A450SR Local: 0 Tool: 1

Jogging

Mode: World Speed: Low

Current Position

X (mm)	Y (mm)	Z (mm)
207.755	-71.650	-552.197
U (deg)	**V (deg)**	**W (deg)**
120.006	-0.051	-179.955

● World
○ Joint
○ Pulse

Current Arm Orientation

Hand	Elbow	Wrist
Righty	Above	NoFlip

J1Flag
J4Flag 0
J6Flag 0

Jog Distance

X (mm)	Y (mm)	Z (mm)
1.000	1.000	1.000
U (deg)	**V (deg)**	**W (deg)**
1.000	1.000	1.000

○ Continuous
○ Long
● Medium
○ Short

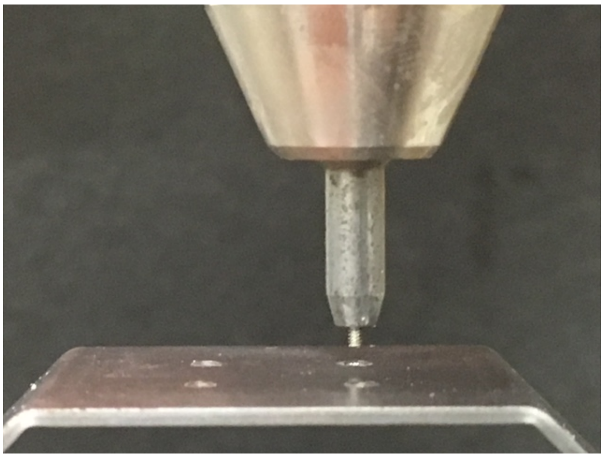
Point File: robot1.pts
Point: P0 - (undefined)

(4) Absorb a screw to the electronic screwdriver.

(5) Use the Jog button to move the robot to the following positions.

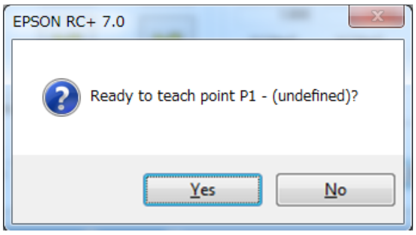
XY directions : The end of the screw is inside of the taper part of the screw hole

Z direction : The end of the screw is 1mm above of the screw hole



(6) Enter “P1” on [Point].

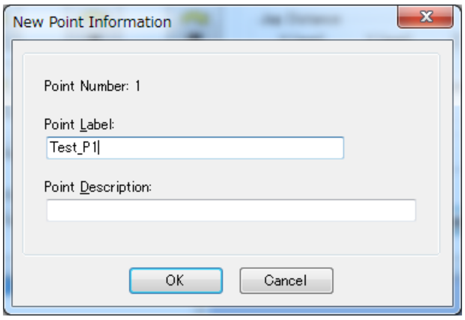
(7) Click the <Teach> button. The following message is displayed.
Confirm the message and click the <Yes> button.



EPSON RC+ 7.0

Ready to teach point P1 - (undefined)?

(8) The [New Point Information] dialog box is displayed.
Enter “Test_P1” on [Point label].
Click the <OK> button.



New Point Information

Point Number: 1

Point Label: Test_P1

Point Description:

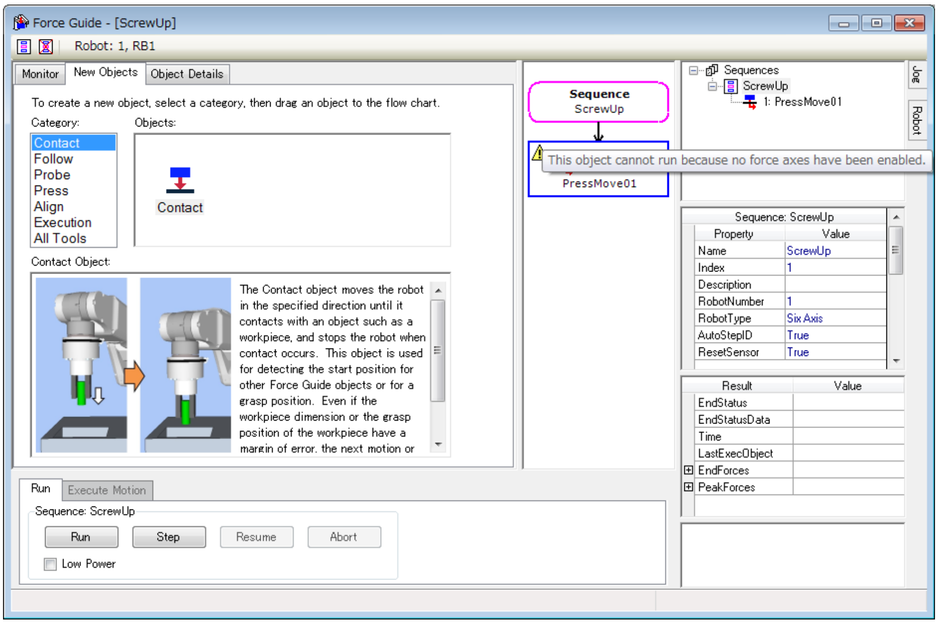
(9) Click EPSON RC+ menu-[File]-[Save All].
The file is saved.

6.5.4 Property Setting

The following describes how to set a property which is necessary for “Screw Driving”.

(1) The ⚠ mark is displayed on the flow chart by default.
You need to set properties.

Move a mouse pointer on the ⚠ mark to display the tool tips. The tool tips show settings or contents which need to be modified.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

This object cannot run because no force axes have been enabled.

Sequence: ScrewUp

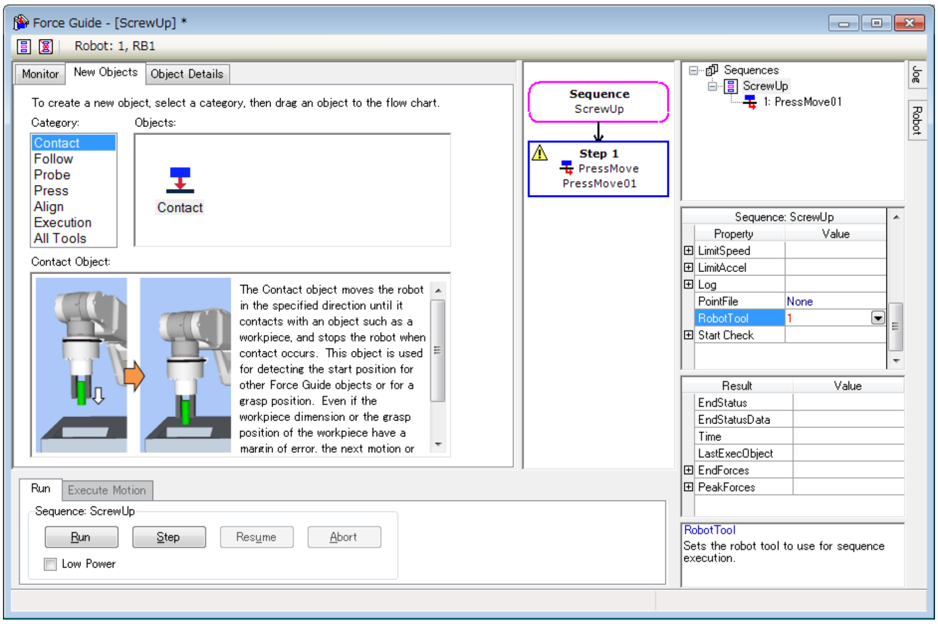
Property	Value
Name	ScrewUp
Index	1
Description	
RobotNumber	1
RobotType	Six Axis
AutoStepID	True
ResetSensor	True

Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

Sequence: ScrewUp

(2) Select the sequence flow of [ScrewUp]. Properties and Results are displayed.

(3) Select “1” on the [RobotTool] property.
Tool 1 is set.



To create a new object, select a category, then drag an object to the flow chart.

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Sequence: ScrewUp

Property	Value
⊞ LimitSpeed	
⊞ LimitAccel	
⊞ Log	
PointFile	None
RobotTool	1
⊞ Start Check	

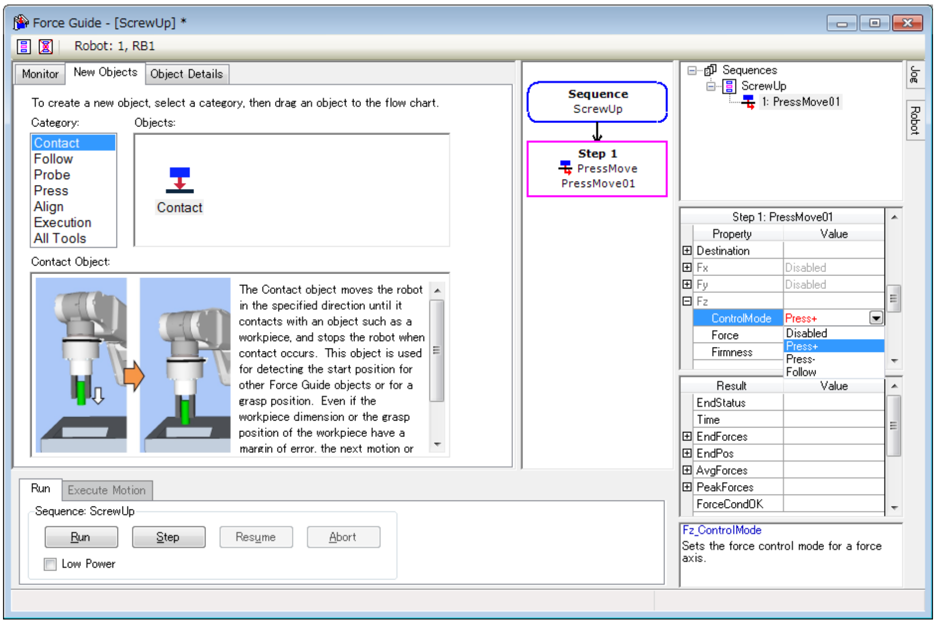
Result	Value
EndStatus	
EndStatusData	
Time	
LastExecObject	
⊞ EndForces	
⊞ PeakForces	

RobotTool
Sets the robot tool to use for sequence execution.

Sequence: ScrewUp

(4) Select the object flow of [PressMove01].
Properties and Results are displayed.

(5) Click [Fz]-[ControlMode] property and select "Press+".
Pressing downward is set to 6-axis robot. At this time, only the negative value can be entered in [Force].



To create a new object, select a category, then drag an object to the flow chart.

Category: Contact, Follow, Probe, Press, Align, Execution, All Tools

Objects: Contact

Contact Object:

The Contact object moves the robot in the specified direction until it contacts with an object such as a workpiece, and stops the robot when contact occurs. This object is used for detecting the start position for other Force Guide objects or for a grasp position. Even if the workpiece dimension or the grasp position of the workpiece have a margin of error, the next motion or

Step 1: PressMove01

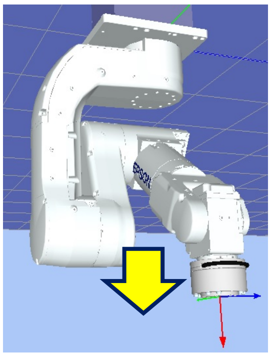
Property	Value
Destination	
Fx	Disabled
Fy	Disabled
Fz	
ControlMode	Press+
Force	Disabled
Firmness	Press+
	Press-
	Follow

Result	Value
EndStatus	
Time	
EndForces	
EndPos	
AvgForces	
PeakForces	
ForceCondOK	

Fz_ControlMode
Sets the force control mode for a force axis.

Sequence: ScrewUp

☐ Low Power

	6-axis robot	SCARA robot
Robot motion image Pressing		
(Press/Contact) Orient	+Fz	-Fz
Sign of Force (monitor display is included)	-	+

(6) Change the following properties:

Item		Value	Description
I/O PreProcess	Enabled	True	Operate a specified Bit when an object starts.
	OutputBit	Electric screwdriver rotation output bit	Set the electric screwdriver to rotate when the object starts.
	OutputStatus	On	Enable a specified Bit when the object starts.
Destination	DestType	Relative	Set a destination point by relative distance from the start point.
	RelativeOrient	Tool	Set a destination point by relative distance on Tool coordinate system from the start point.
Fx	ControlMode	Follow	Perform the follow motion by the force control functions.
	Firmness	1	Set a firmness of the force control functions in X direction.
Fy	ControlMode	Follow	Follow by the force control function.
	Firmness	1	Set a firmness of the force control functions in Y direction.
Fz	ControlMode	Press+	Mode of force control function. Press+: The robot moves to a positive direction in Fz axis and presses.
	Force	-1	Set an applied force in Z direction
	Firmness	1	Set a firmness of the force control functions in Z direction.
I/O End Conditions	Enabled	True	Set the end conditions related to I/O.
	InputBit	Completion of screw driving Input bit	Set the object to end by a completion signal of screw driving.
	InputStatus	On	Make it an end condition that the input Bit is “On”.

(7) To prevent the screw hole from damaging, make sure to tighten screws with appropriate speed for screws and an electric screwdriver. Calculate the following and set an appropriate speed.

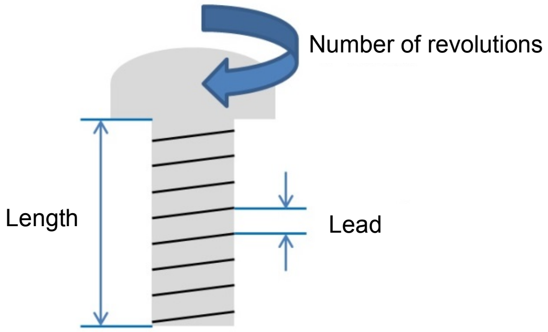
SpeedS(mm/sec)=
number of revolutions per second of electric screwdriver (rps) ×screw lead(mm)

AccelS(mm/sec^2)=SpeedS×10

If you set a distance for screw driving = screw length, tightening motion may stop in a middle of screw driving since the screw and its hole contact.

It is necessary to add a margin as follows:

DestRelativeZ(mm)= screw length (mm)+5(mm)



(8) Click EPSON RC+ menu-[File]-[Save All] to save the file.

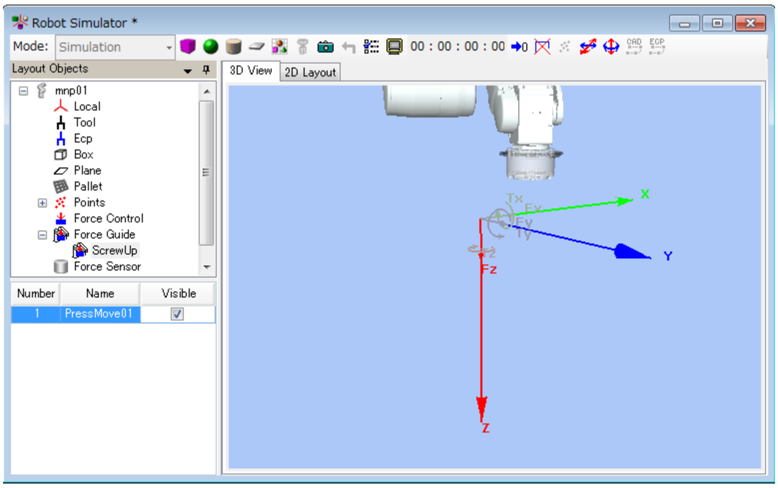
6.5.5 Setting Confirmation

The following describes how to check whether the settings for pressing direction are correct by using a simulator.

(1) Click EPSON RC+ menu-[Tools]-[Simulator].
The [Simulator] window is displayed.

(2) Click the object tree-[Tool].
Place a checkmark in “No.1”-[Visible] checkbox. An arrow of “Tool 1” is displayed.

(3) Click the object tree-[Force]-[Force Guide]-[ScrewUp].
Place a checkmark in [PressMove01]-[Visible] checkbox.



Mode: Simulation

Number	Name	Visible
1	PressMove01	☑

6.5.6 Motion by Force Guidance Function

The following describes how to execute a sequence that performs “Screw Driving” by EPSON RC+.

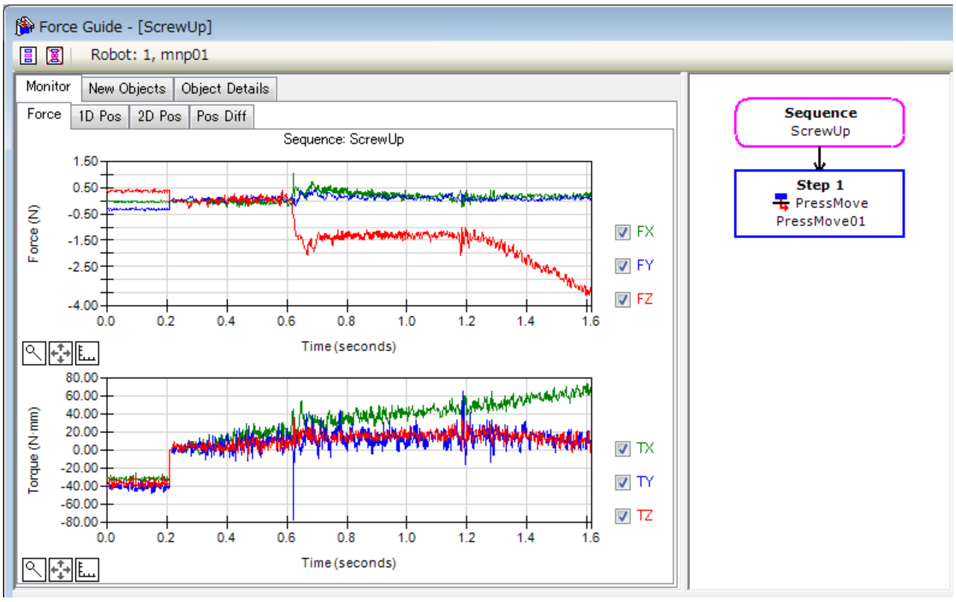
(1) Display the [Force Guide] window.

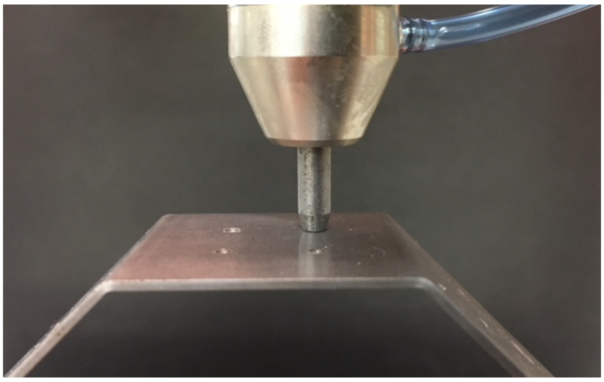
(2) Select the [Robot] tab.

(3) Click the <POWER HIGH> button.
If the workpiece will get damage, perform in low power mode.

(4) Click the <Run> button.
Program is compiled and transmitted to the robot controller. If the setting is not correct, an error occurs. Check the settings so far and follow the error message to modify the parameters.

When the operation is performed properly, screw driving is completed.





6.5.7 Return to the Non-Contact State

Force continues to be applied to between the robot and the workpiece even after "Screw Driving" is completed. To prevent the robot and the end effector from malfunction or damages, move the robot away from the object immediately after the operation ends, and make sure that no force is applied to the object. If it is obvious that no force is applied to the object, you can omit this step.

There are the following methods to set the robot to the non-contact state:

- Click EPSON RC+ menu-[Tools]-[Robot Manager]-[Jog & Teach] panel-[Jog] group and perform jog motion manually to move the robot away from the object.
- Click EPSON RC+ menu-[Tools]-[Robot Manager]-[Jog & Teach] panel-[Execute Motion] tab and move the robot away from the object.
- Execute Move command on [Command Window] and move the robot away from the object.
- Add SPELFunc object after Press object, and automatically move the robot away from the object at the end of the force guide sequence.

The following describes how to return to the non-contact state by clicking [Robot Manager]-[Jog & Teach]-[Execute Motion] tab.

(1) Display the [Robot Manager] dialog box.

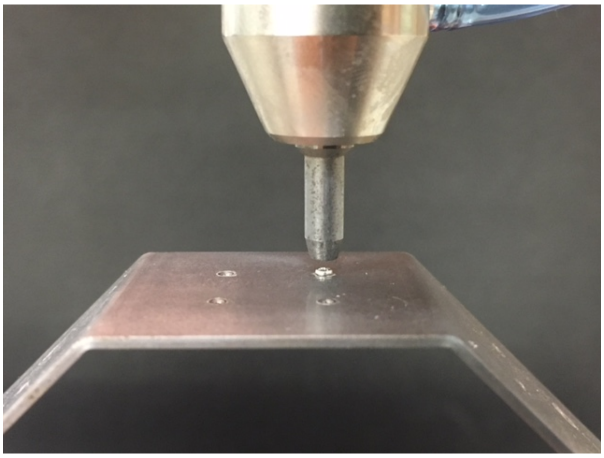
(2) Select the [Jog & Teach] tab.

(3) Select the [Execute Motion] tab.

(4) Select "Move" in [Command]

(5) Select "P1" in [Destination].

(6) Click the <Execute> button.
The robot moves to the start point: P1. Now, it is the non-contact state.



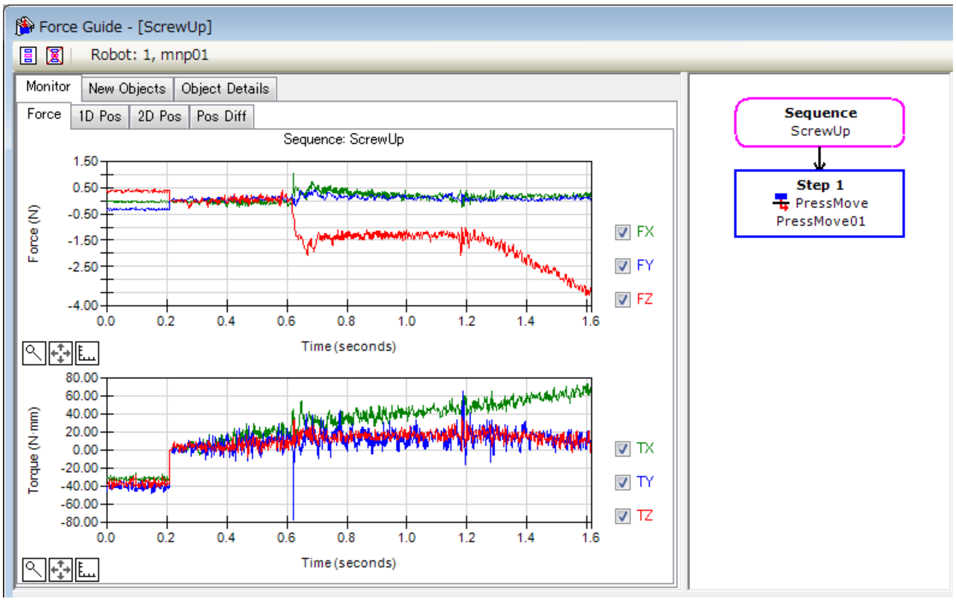
6.5.8 Confirmation of Motion Results

Describe how to check results on the [Force Guide] window.

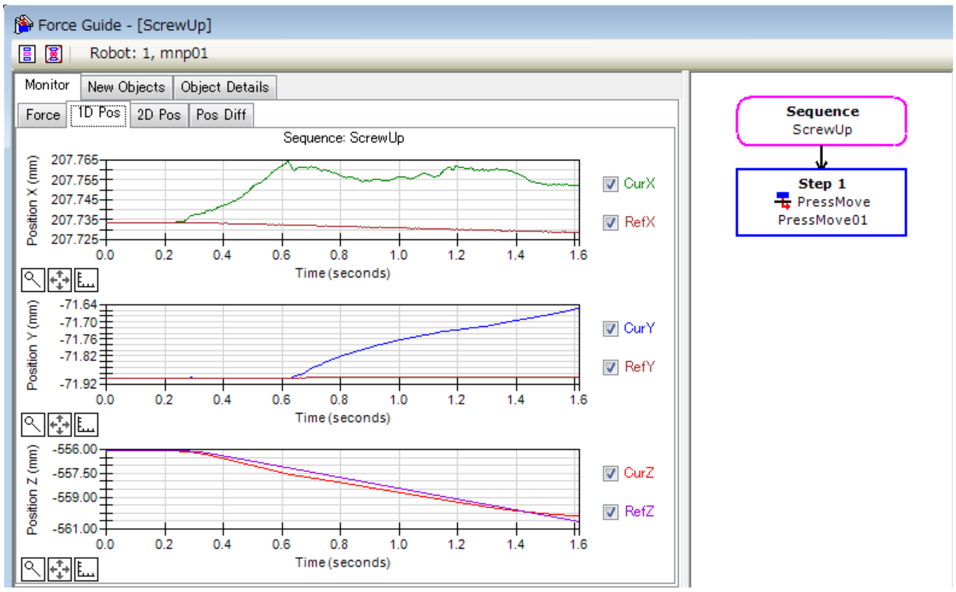
(1) Open the [Force Guide] window.

(2) Click the sequence flow of [ScrewUp].

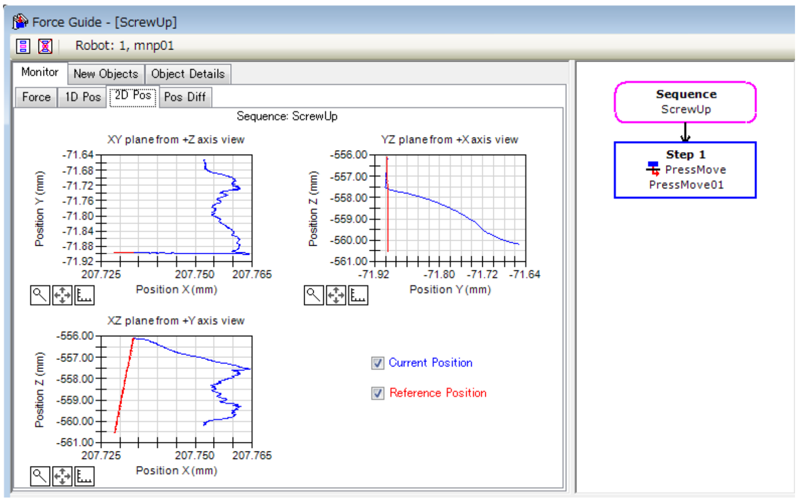
(3) Select the [Monitor] tab. Select the [Force] tab.
Force and position during the [ScrewUp] sequence execution are displayed in the graph.



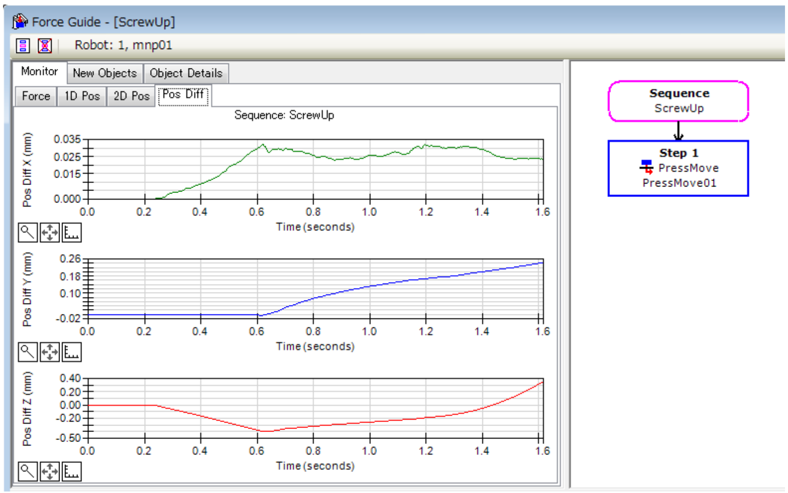
(4) Select the [1D Pos] tab.
Graph for analysis is displayed. (horizontal axis: Time, vertical axis: Position)
As the robot moves to Z direction, you can see that the robot follow X, Y directions by the force control.
As you can see by looking the Position Z graph, CurZ (current position) is lowered about 3mm. It indicates that the robot moves to the insertion direction of screws.
Also, in Position X and Position Y graphs, CurPos moves in the range: approx. 0.1mm. even RefPos (reference position) is fixed. It indicates that the robot follows the surface along with the screw insertion.



(5) Select the [2D Pos] tab.
Graph for analysis is displayed. (horizontal axis, vertical axis: Position)
You can check what you have checked on the [1D Pos] tab as a graph projected on each plane. Be careful for the scale difference of horizontal axis and vertical axis when checking the graphs.



(6) Select the [Pos Diff] tab.
Record shifts by force control as relative position changes. It is different from the graph on the [1D Pos] tab.



(7) Change the unit of the graph and check the changes of force or positions.

If it is not inserted correctly, setting may not be correct. Refer to the following and check the procedures of the tutorial.

- Whether a pressing force direction is correct
- Whether the start point is largely moved from a hole
- Whether settings of AccelS, SpeedS are correct
- Whether a setting value of DestRelativeZ is short

Now, tutorial for screw driving is completed.

6.6 Command Version (Simple Pressing)

The following describes how to perform a simple pressing by commands.

The pressing operation in this tutorial is that the robot's end effector tip moves to the positive direction of the Tool 0 coordinate system (TLZ), and presses an object for about 10 seconds with applying 20 [N].

The object to be pressed is fixed to a base table and the pressed surface is assumed to a flat metal block.

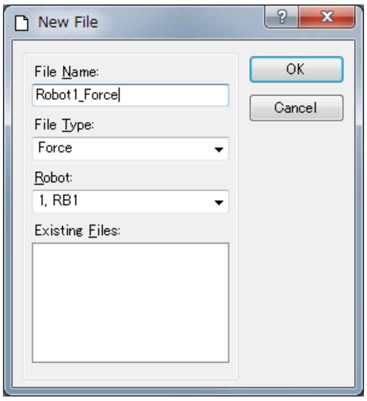
If the operation is performed with the end effector, ensure that the end effector can withstand a load: 20 [N] in the negative direction of TLZ.

⚠ CAUTION	■ The parameters described in the example on the following pages are reference values. Please note that relatively stable parameters are used, but the operation may not be successful or the motion may be vibratory in some operating conditions, and the parameters may need to be adjusted. In addition, slow stable parameters are used for convenience of explanation. The parameters need to be adjusted for faster operations.

6.6.1 Creating a Force File

The following describes how to create a force file and add it to the project list.

(1) Click EPSON RC+ menu-[File]-[New File].
The [New File] dialog box is displayed.



New File

File Name: Robot1_Force

File Type: Force

Robot: 1, RB1

Existing Files:

(2) Select "Force" in [File Type].

(3) Check that the robot is "1".

(4) Enter "Robot1_Force" in [File Name].

(5) Click the <OK> button.

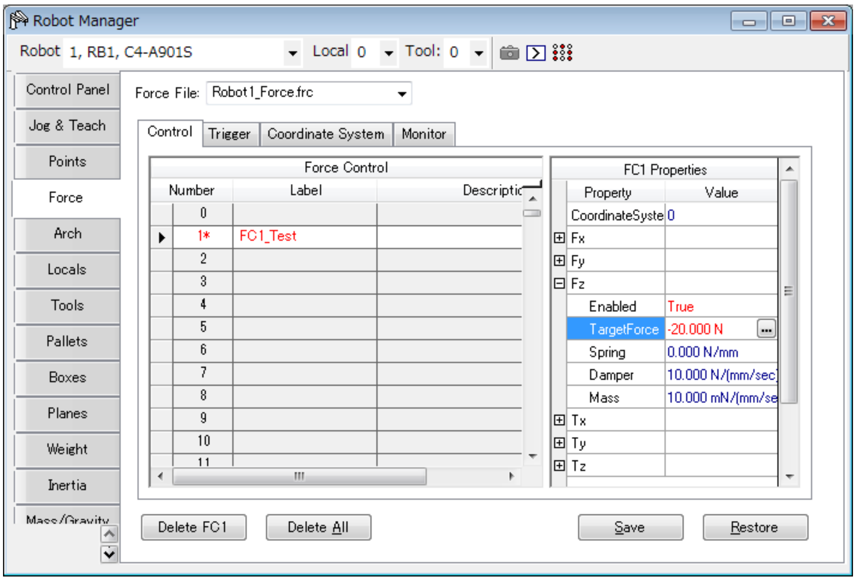
6.6.2 Setting the Force Control Object

The following describes how to set the force control object.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Select the [Force] tab.

(3) Select the [Control] tab.
The following panel is displayed.



Robot 1, RB1, C4-A901S Local 0 Tool: 0

Force File: Robot1_Force.frc

Number	Label	Description
0		
1*	FC1_Test	
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Property	Value
CoordinateSyste	0
⊞ Fx	
⊞ Fy	
⊟ Fz	
Enabled	True
TargetForce	-20.000 N
Spring	0.000 N/mm
Damper	10.000 N/(mm/sec)
Mass	10.000 mN/(mm/se
⊞ Tx	
⊞ Ty	
⊞ Tz	

(4) Set the following data for force control object “FC1”.

Item	Value
Label	FC1_Test
CoordinateSystem	0
Fx_Enabled	False
Fy_Enabled	False
Tx_Enabled	False
Ty_Enabled	False
Tz_Enabled	False
Fz_Enabled	True
Fz_TargetForce	–20
Fz_Spring	0
Fz_Damper	10
Fz_Mass	10
TargetForcePriorityMode	False
LimitSpeedS	50
LimitSpeedR	25
LimitSpeedJ	50
LimitAccelS	200
LimitAccelR	100
LimitAccelJ	100

(5) Click the <Save> button.

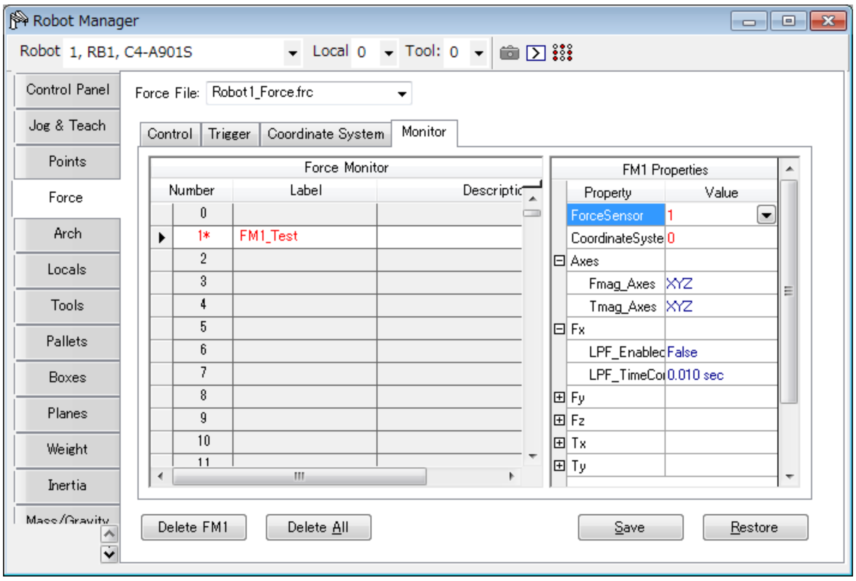
6.6.3 Setting the Force Monitor Object

The following describes how to set the force monitor object.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Select the [Force] tab.

(3) Select the [Monitor] tab.
The following panel is displayed.



Robot 1, RB1, C4-A901S Local 0 Tool: 0

Force File: Robot1_Force.frc

Number	Label	Description
0		
1*	FM1_Test	
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Property	Value
ForceSensor	1
CoordinateSyste	0
⊟ Axes	
Fmag_Axes	XYZ
Tmag_Axes	XYZ
⊟ Fx	
LPF_Enablec	False
LPF_TimeCo	0.010 sec
⊞ Fy	
⊞ Fz	
⊞ Tx	
⊞ Ty	

(4) Set the following data for force monitor object “FM1”.

Item	Value
Label	FM1_Test
ForceSensor	1
CoordinateSystem	0
Fmag_Axes	XYZ
Tmag_Axes	XYZ
Fx-Tmag_LPF_Enabled	False
Fx-Tmag_LPF_TimeConstant	0.01

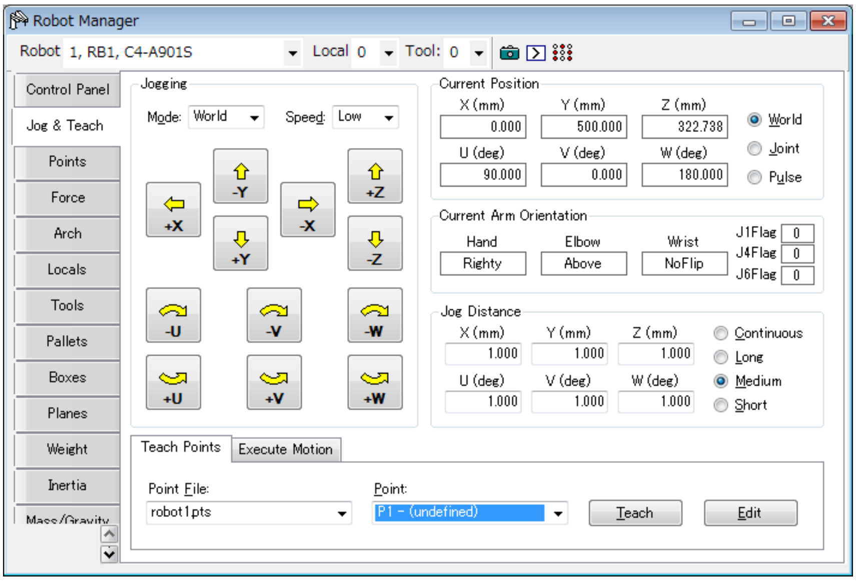
(5) Click the <Save> button.

6.6.4 Teaching the Start Point

The following describes how to teach the start position of the “pressing” operation.

(1) Click EPSON RC+ menu-[Tools]-[Robot Manager].
The [Robot Manager] dialog box is displayed.

(2) Click the [Jog & Teach] tab.



Robot 1, RB1, C4-A901S
Local 0
Tool: 0
Mode: World
Speed: Low

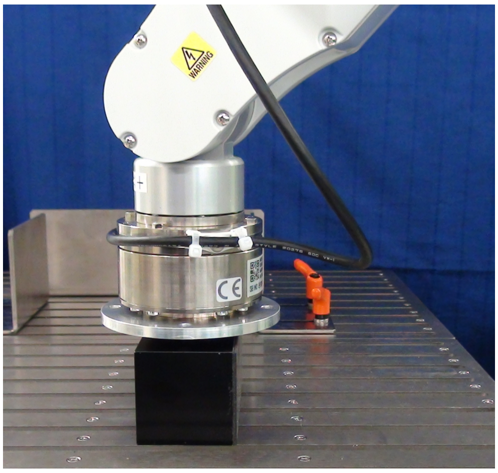
Current Position
X (mm) 0.000
Y (mm) 500.000
Z (mm) 322.738
U (deg) 90.000
V (deg) 0.000
W (deg) 180.000
● World
○ Joint
○ Pulse

Current Arm Orientation
Hand Righty
Elbow Above
Wrist NoFlip
J1Flag 0
J4Flag 0
J6Flag 0

Jog Distance
X (mm) 1.000
Y (mm) 1.000
Z (mm) 1.000
U (deg) 1.000
V (deg) 1.000
W (deg) 1.000
○ Continuous
○ Long
● Medium
○ Short

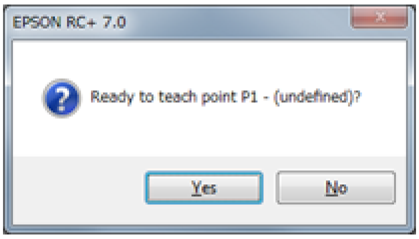
Point File: robot1.pts
Point: P1 - (undefined)

(3) Use the Jog button to move the Force Sensor or end effector to about 5 mm above the object to be pressed.



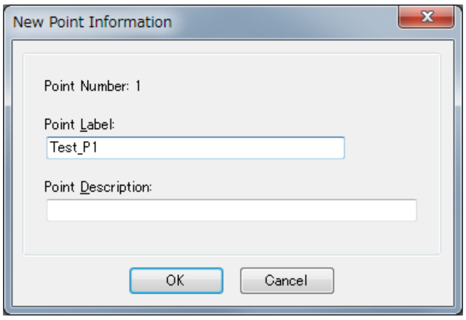
(4) Select “P1” in [Point].

(5) Click the <Teach> button. The following message is displayed.
Confirm the message and click the <Yes> button.



Ready to teach point P1 - (undefined)?

(6) The [New Point Information] dialog box is displayed.
Enter “Test_P1” in [Point Label] and then click the <OK> button.



Point Number: 1

Point Label: Test_P1

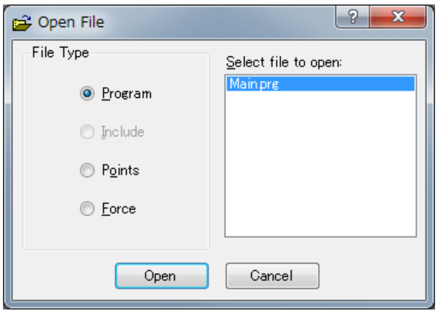
Point Description:

(7) Click EPSON RC+ menu-[File]-[Save All] to save the files.

6.6.5 Creating a SPEL+ Program

The following describes how to create a SPEL+ program to perform the “pressing” operation.

(4) Click EPSON RC menu-[File]-[Open File].
The [Open File] dialog box is displayed.



File Type

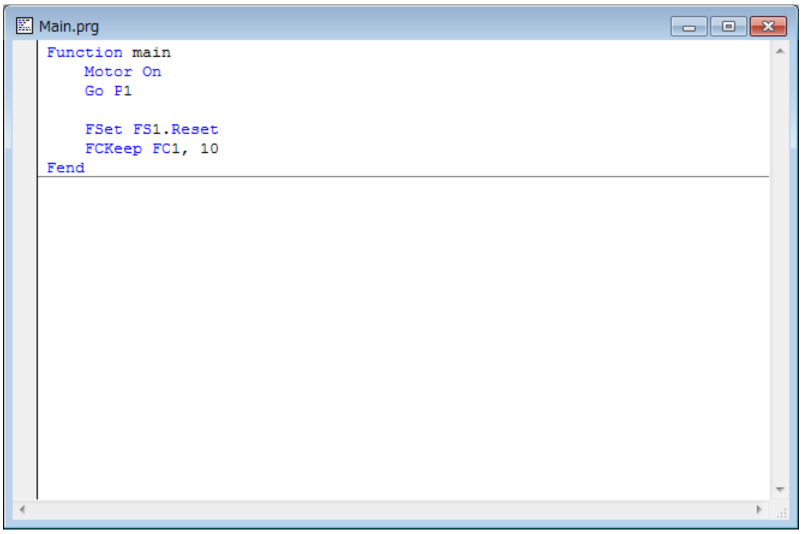
● Program
○ Include
○ Points
○ Force

Select file to open:
Main.prg

(5) Select “Program” in [File Type].

(6) Select “Main.prg” in [Select file to open].

(7) Click the <Open> button.
The Main.prg screen is displayed.



```
Function main
    Motor On
    Go P1

    FSet FS1.Reset
    FCKeep FC1, 10
Fend
```

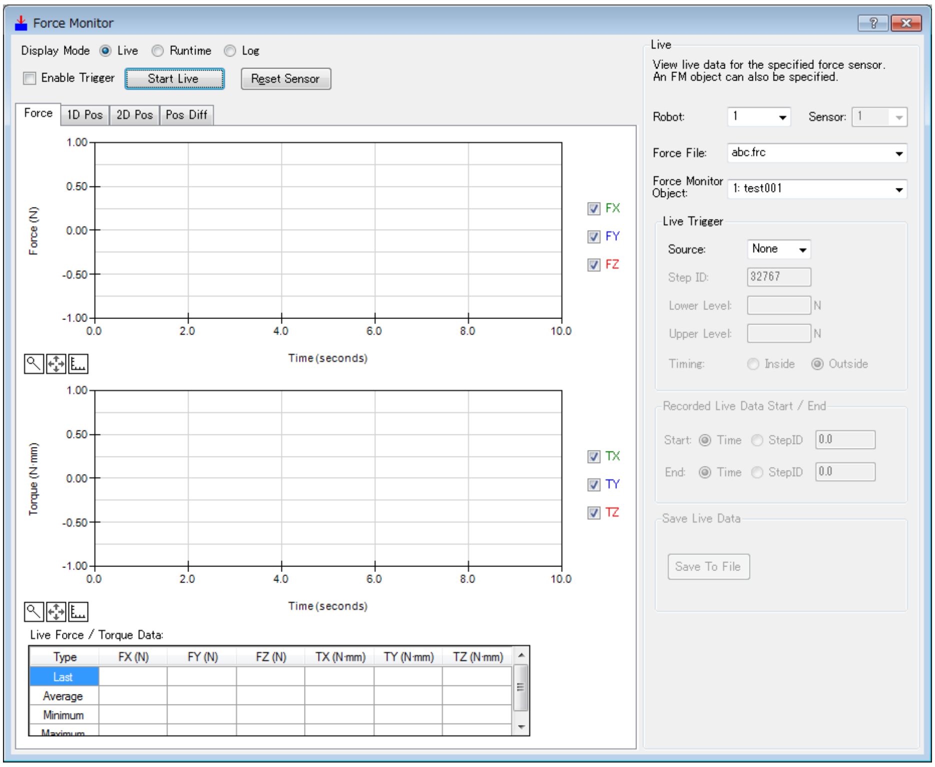
(8) Input the following sample program in the main function.

```
Function main
    Motor On
    Go P1            ' Go to the operation start point
    FSet FS1.Reset   ' Reset the Force Sensor
    FCKeep FC1, 10   ' Perform the pressing operation for 10 seconds
Fend
```

6.6.6 Executing the Force Monitor

To display a graph of the “pressing” operation, the following describes how to execute the force monitor.

(1) Select EPSON RC+ menu- [Tools]-[Force Monitor].
The [Force Monitor] dialog box is displayed.



View live data for the specified force sensor.
An FM object can also be specified.

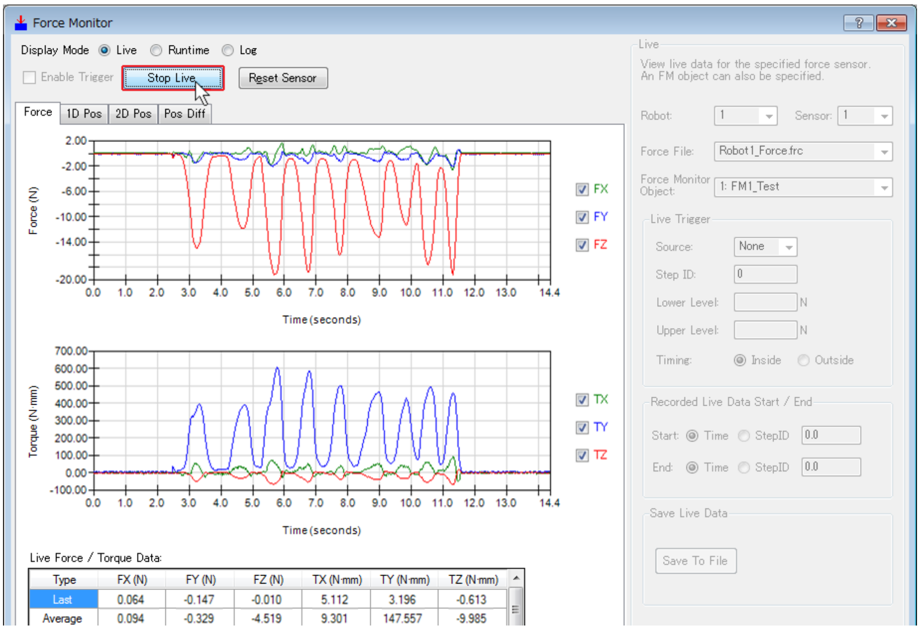
Robot: 1
Sensor: 1
Force File: abc.frc
Force Monitor Object: 1: test001
Source: None
Step ID: 32767
Lower Level: N
Upper Level: N
Timing: ○ Inside ● Outside
Start: ● Time ○ StepID 0.0
End: ● Time ○ StepID 0.0

(2) Set the following items in [Live].

Item	Value
Robot	1
Force File	Robot1_Force.frc
Force Monitor Object	FM1_Test

(3) Click the <Start Live> button.

The Force Sensor values are displayed in the graph.



Display Mode ● Live ○ Runtime ○ Log

☐ Enable Trigger

☑ FX ☑ FY ☑ FZ

☑ TX ☑ TY ☑ TZ

Robot: 1 Sensor: 1

Force File: Robot1_Force.frc

Force Monitor Object: 1: FM1_Test

Source: None

Step ID: 0

Lower Level: N

Upper Level: N

Timing: ● Inside ○ Outside

Start: ● Time ○ StepID 0.0

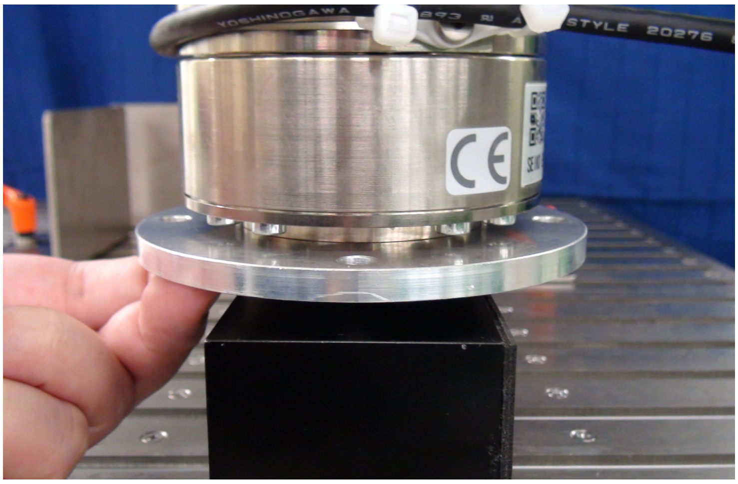
End: ● Time ○ StepID 0.0

Live Force / Torque Data:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	0.064	-0.147	-0.010	5.112	3.196	-0.613
Average	0.094	-0.329	-4.519	9.301	147.557	-9.985

When applying a force in the pressing direction, check that the Fz value changes. If the Fz value does not change and another axis value changes, refer to the following section and check the settings of the force coordinate system.

Software: 2. Force Sensor Correction

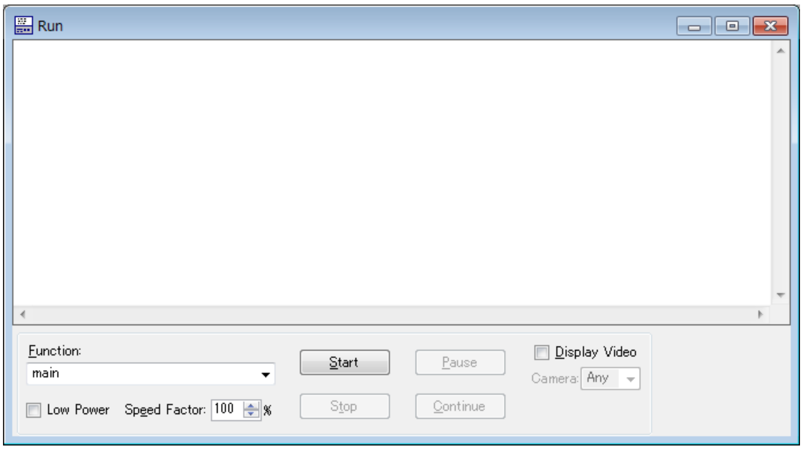


CAUTION	■ When entering the safe guarded area in order to apply a force to the Force Sensor, ensure safety by safety measures such as setting the Manipulator to operation-prohibited status. For details of safety, refer to the following manual. *EPSON RC+ 7.0 User’s Guide*

6.6.7 Creating the SPEL+ Program

The following describes how to execute the SPEL+ program to perform the “pressing” operation.

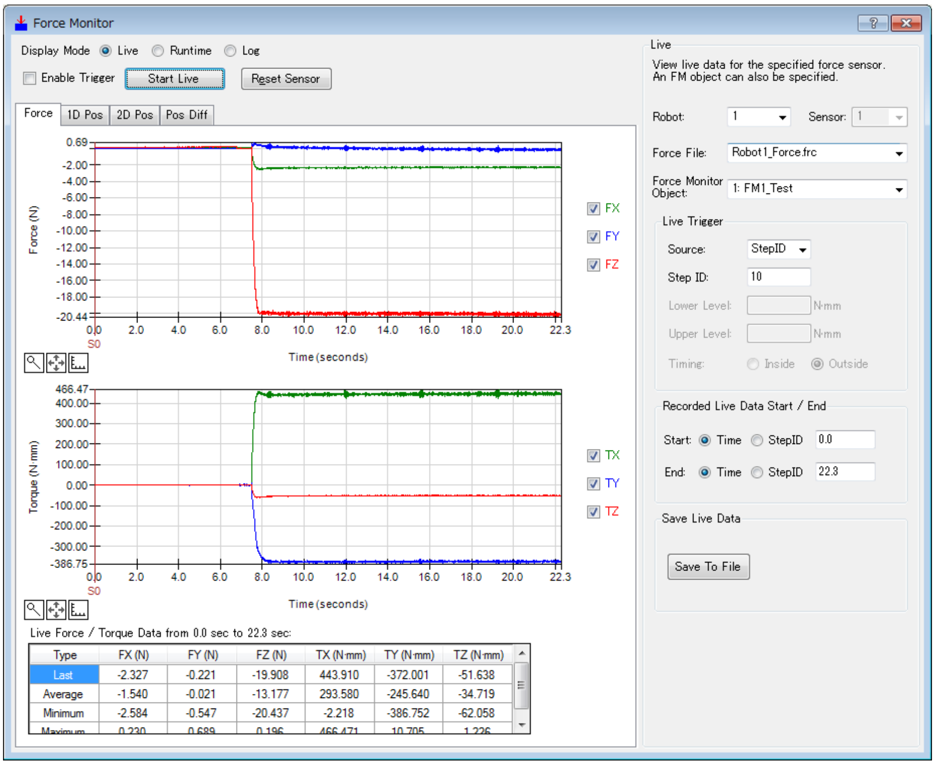
(1) Click EPSON RC+ menu-[Run]-[Run Window].
The [Run] window is displayed.
Build the project and the program and project file are sent to the controller. If an error does not occur while performing the build, the [Run] window is displayed.



Function: main

☐ Low Power Speed Factor: 100 %

(2) Click the <Start> button to run the program.
The robot starts “pressing” operation when running the program. You can check that the force is set to 20 N on the graph of the [Force Monitor] dialog box.



Display Mode ● Live ○ Runtime ○ Log

☐ Enable Trigger

View live data for the specified force sensor.
An FM object can also be specified.

Robot: 1 Sensor: 1

Force File: Robot1_Force.frc

Force Monitor Object: 1: FM1_Test

Live Trigger

Source: StepID

Step ID: 10

Lower Level: N·mm

Upper Level: N·mm

Timing: ○ Inside ● Outside

Recorded Live Data Start / End

Start: ● Time ○ StepID 0.0

End: ● Time ○ StepID 22.3

Live Force / Torque Data from 0.0 sec to 22.3 sec:

Type	FX (N)	FY (N)	FZ (N)	TX (N·mm)	TY (N·mm)	TZ (N·mm)
Last	-2.327	-0.221	-19.908	443.910	-372.001	-51.638
Average	-1.540	-0.021	-13.177	293.580	-245.640	-34.719
Minimum	-2.584	-0.547	-20.437	-2.218	-386.752	-62.058
Maximum	0.230	0.689	0.196	466.471	10.705	1.226

7. Troubleshooting

The Force Sensor I/F unit is not recognized

Refer to the following section and check the wiring.

Hardware: 3. Connection Diagram

Pay particular attention to the following items.

- Connecting the IN Connector
- Connecting the 24-V Power Supply

The Force Sensor is not recognized

Refer to the following section and check the wiring.

Hardware: 3. Connection Diagram

Pay particular attention to the following items.

- Force Sensor Cable
- Force Sensor M/I Cable

Check the hardware connections and then refer to the following section and enable the Force Sensor.

Software: 1. Checking the Connection

The output value of the Force Sensor differs from the actual force direction

Refer to the following section and check the coordinate system.

Introduction, 5. Coordinate Systems

All of the following items impact the Force coordinate system.

- Settings of the Base, Local, and Tool coordinates
- Setting of FlangeOffset
- Setting of the force coordinate object (FCS#)

The output value of the Force Sensor differs from the actual force

The output of the force and torque when the Force Sensor is reset is set as "0" for the Force Sensor. Therefore, if an external force is being applied when the Force Sensor is reset, the Force Sensor detects a force even if no force is actually applied after the external force is removed. To avoid this, reset the Force Sensor when no external force is being applied. Also, weight of the Force Sensor is applied depending of the robot posture since the detection position is located at the center of the Force Sensor structure.

Furthermore, if the posture of the Force Sensor changes from that when the Force Sensor is reset, the output value of the Force Sensor also changes due to the effect of gravity. If the posture of the Force Sensor does not change in the operation using the force functions (force control, force trigger, and force monitor), reset the Force Sensor immediately before using the force functions.

If the posture changes during executing of the force functions, the effect of gravity can be reduced by using gravity compensation. For details, refer to the following section.

Software: 2.3 Gravity Compensation

The output value of the Force Sensor changes over time.

Epson Force Sensor has drift characteristics. If the change is within the range of the time drift described in the following section, it is normal.

Hardware: 4.1 Specifications

To avoid the effect of the time drift, reset the Force Sensor immediately before using the force functions. Use the force functions within 10 minutes after resetting the Force Sensor.

Abnormality occurs on the Force Sensor

If an error regarding the Force Sensor occurs, refer to the following manual and take measures against the error.

EPSON RC+ 7.0 SPEL+ Language Reference
- *SPEL+ Error Messages*

If the Force Sensor is used for a long time without being reset, an error accumulates due to the drift. This may result in an element error of the Force Sensor. If the error occurs, executes the Reboot property of the force sensor object.

Furthermore, accuracy abnormality of the Force Sensor may occur when the Force Sensor is hit against the peripherals or when an error occurs on the Force Sensor. In this case, check that the Force Sensor is working properly. For the details, refer to the following section.

Software 1.3 Checking the Accuracy of the Force Sensor

You cannot perform the intended motion by the force guide object(s)

For the motions by the force guide object(s), if you cannot perform the intended motions (e.g. larger force than expected is applied), refer to the following section and adjust properties.

Software 4.3 Force Guide Object(s)
Adjustment guideline for each object described in 4.3.1 to 4.3.8