

# EPSON

SCARA ROBOT

*E2H series*

MANIPULATOR MANUAL

Rev. 4

EM069R1411F

MANIPULATOR MANUAL    E2H series    Rev. 4

SCARA ROBOT

**E2H series Manipulator Manual**

Rev. 4

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## FOREWORD

Thank you for purchasing our robot products.

This manual contains the information necessary for the correct use of the manipulator.

Please carefully read this manual and other related manuals before installing the robot system.

Keep this manual handy for easy access at all times.

## WARRANTY

The Manipulator 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 Manipulator 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.

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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.

## INQUIRIES

Contact the following service center for robot repairs, inspections or adjustments.

If service center information is not indicated below, please contact the supplier office for your region.

Please prepare the following items before you contact us.

- Your controller model and its serial number
- Your manipulator model and its serial number
- Software and its version in your robot system
- A description of the problem

## SERVICE CENTER

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## MANUFACTURER & SUPPLIER

Japan & Others

### **SEIKO EPSON CORPORATION**

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Factory Automation Systems Dept.  
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E-MAIL: [robot.infos@epson.de](mailto:robot.infos@epson.de)


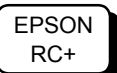
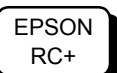
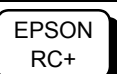
## Before Reading This Manual

This section describes what you should know before reading this manual.

### Structure of Control System

E2H Manipulators can be used with the following combinations of Controllers and software.

The operating methods and descriptions are different depending on which software you are using. The following icons are put beside appropriate text as necessary. Use the descriptions that pertain to the software you are using.

Controller		Software	
Type	Composition (Hardware)		
RC520	Control Unit Drive Unit	 SPEL CT	SPEL CT
		 EPSON RC+	EPSON RC+ 4.* or before
RC420	Controller	 EPSON RC+	EPSON RC+ 4.* or before
RC170	Controller	 EPSON RC+	EPSON RC+ 5.0 or later


For details on commands, refer to User's Guide or "On-line help".


### Turning ON/OFF Controller

When you see the instruction "Turn ON/OFF the Controller" in this manual, be sure to turn ON/OFF all the hardware components. For the Controller composition, refer to the table above.

### Differences in Terminology according to Software

Some expressions are different according to software.

 For SPEL CT, a coordinate point including the arm pose is defined as "pose". The data is called "pose data".

 For EPSON RC+, a coordinate point including the arm pose is defined as "point". The data is called "point data".

### Shape of Motors

The shape of the motors used for the Manipulator that you are using may be different from the shape of the motors described in this manual because of the specifications.





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# Setup & Operation

This volume contains information for setup and operation of the E2H series Manipulators.

Please read this volume thoroughly before setting up and operating the Manipulators.






# 1. Safety

Installation and transportation of robots and robotic equipment shall be performed by qualified personnel and should conform to all national and local codes. Please read this manual and other related manuals before installing the robot system or before connecting cables.

Keep this manual handy for easy access at all times.

## 1.1 Conventions

Important safety considerations are indicated throughout the manual by the following symbols. Be sure to read the descriptions shown with each symbol.


 WARNING	This symbol indicates that a danger of possible serious injury or death exists if the associated instructions are not followed properly.
 WARNING	This symbol indicates that a danger of possible serious injury or death caused by electric shock 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.


## 1.2 Design and Installation Safety

Only trained personnel should design and install the robot system. Trained personnel are defined as those who have taken robot system training and maintenance training classes held by the manufacturer, dealer, or local representative company, or those who understand the manuals thoroughly and have the same knowledge and skill level as those who have completed the training courses.

To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the *Installation and Design Precautions* in the *Safety* chapter of the EPSON RC+ User's Guide or the *Safety: 1.3 Design Precautions* in the SPEL CT User's Guide.

The following items are safety precautions for design personnel:



 WARNING	<ul style="list-style-type: none"> <li>Personnel who design and/or construct the robot system with this product must read the <i>Safety</i> chapter in the EPSON RC+ User's Guide or the <i>Safety</i> part in the SPEL CT User's Guide to understand the safety requirements before designing and/or constructing the robot system. Designing and/or constructing the robot system without understanding the safety requirements is extremely hazardous, may result in serious bodily injury and/or severe equipment damage to the robot system, and may cause serious safety problems.</li> </ul>
--	---

 WARNING	<ul style="list-style-type: none"> <li>■ The Manipulator and the Controller must be used within the environmental conditions described in their respective manuals. This product has been designed and manufactured strictly for use in a normal indoor environment. Using the product in an environment that exceeds the specified environmental conditions may not only shorten the life cycle of the product but may also cause serious safety problems.</li> <li>■ The robot system must be used within the installation requirements described in the manuals. Using the robot system outside of the installation requirements may not only shorten the life cycle of the product but also cause serious safety problems.</li> </ul>
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Further precautions for installation are mentioned in the *chapter Setup & Operation 3. Environments and Installation*. Please read this chapter carefully to understand safe installation procedures before installing the robots and robotic equipment.

### 1.3 Operation Safety

The following items are safety precautions for qualified Operator personnel:

 WARNING	<ul style="list-style-type: none"> <li>■ Please carefully read the <i>Safety-related Requirements</i> in the <i>Safety</i> chapter of the EPSON RC+ User's Guide or the <i>Safety: 1.1 Safety-related Requirements</i> in the SPEL CT User's Guide before operating the robot system. Operating the robot system without understanding the safety requirements is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.</li> <li>■ Do not enter the operating area of the Manipulator while the power to the robot system is turned ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even if it seems to be stopped.</li> <li>■ Before operating the robot system, make sure that no one is inside the safeguarded area. The robot system can be operated in the mode for teaching even when someone is inside the safeguarded area. The motion of the Manipulator is always in restricted (low speeds and low power) status to secure the safety of an operator. However, operating the robot system while someone is inside the safeguarded area is extremely hazardous and may result in serious safety problems in case that the Manipulator moves unexpectedly.</li> <li>■ Immediately press the Emergency Stop switch whenever the Manipulator moves abnormally while the robot system is operated.</li> </ul>
 WARNING	<ul style="list-style-type: none"> <li>■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.</li> </ul>



 <b>WARNING</b>	<ul style="list-style-type: none"> <li>■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.</li> <li>■ Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.</li> </ul>
 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>■ Whenever possible, only one person should operate the robot system. If it is necessary to operate the robot system with more than one person, ensure that all people involved communicate with each other as to what they are doing and take all necessary safety precautions.</li> </ul>

## 1.4 Emergency Stop

If the Manipulator moves abnormally during operation, immediately press the Emergency Stop switch. The motor power will be turned OFF, and the arm motion by inertia will be stopped with the dynamic brake.

However, avoid pressing the Emergency Stop switch unnecessarily while the Manipulator is running normally. Otherwise, the Manipulator may hit the peripheral equipment since the operating trajectory while the robot system stops is different from that in normal operation.

To place the system in emergency mode during normal operation, press the Emergency Stop switch when the Manipulator is not moving.

Refer to the Controller manual for instructions on how to wire the Emergency Stop switch circuit.

### Free running distance in emergency

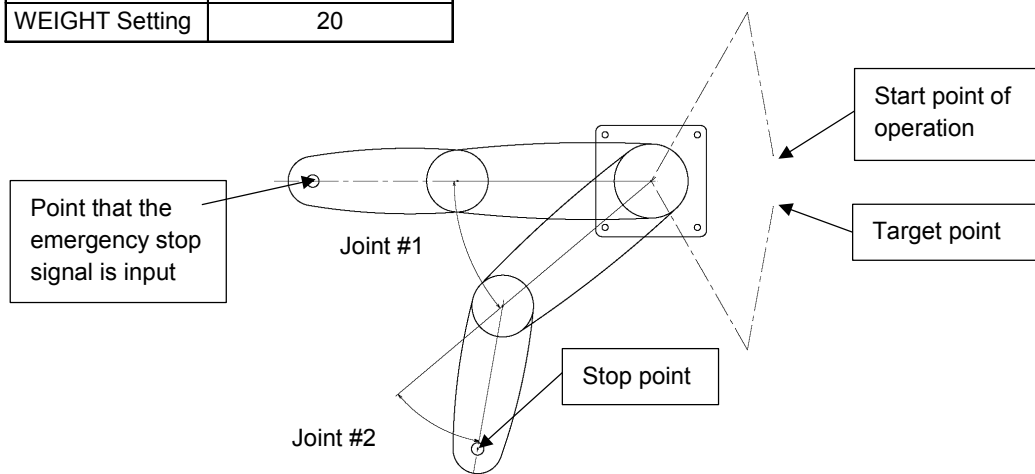
The operating Manipulator cannot stop immediately after the Emergency Stop switch is pressed.

The free running time/angle/distance of the Manipulator are shown below. However, remember that the values vary depending on following conditions.

Weight of the end effector	WEIGHT	
Weight of work piece	SPEED	
Operating pose	ACCEL	etc.

Conditions of Measurement

ACCEL Setting	100
SPEED Setting	100
Load [kg]	20
WEIGHT Setting	20



		RC420 / RC520	RC170
Free running time	Joint #1+Joint #2 [sec.]	1.0	0.7
	Joint #3 [sec.]	0.8	0.3
Free running angle	Joint #1 [deg.]	30	50
	Joint #2 [deg.]	30	25
	Joint #1+Joint #2 [deg.]	60	70
Free running distance	Joint #3 [mm]	30	75

## NOTE



The free running distance of RC170 differs from RC520/RC420 for the differences of the braking process.

RC170 stops with the dynamic brake after the deceleration motion as Quick Pause to keep the operating trajectory while the robot system stops for safety.

Because of this, RC170 may increase the free running distance compared to RC520/RC420 that stop instantly with the dynamic brake at emergency.

## 1.5 Emergency Movement Without Drive Power

When the system is placed in emergency mode, push the arm or joint of the Manipulator by hand as shown below:

Arm #1 ..... Push the arm by hand.

Arm #2 ..... Push the arm by hand.

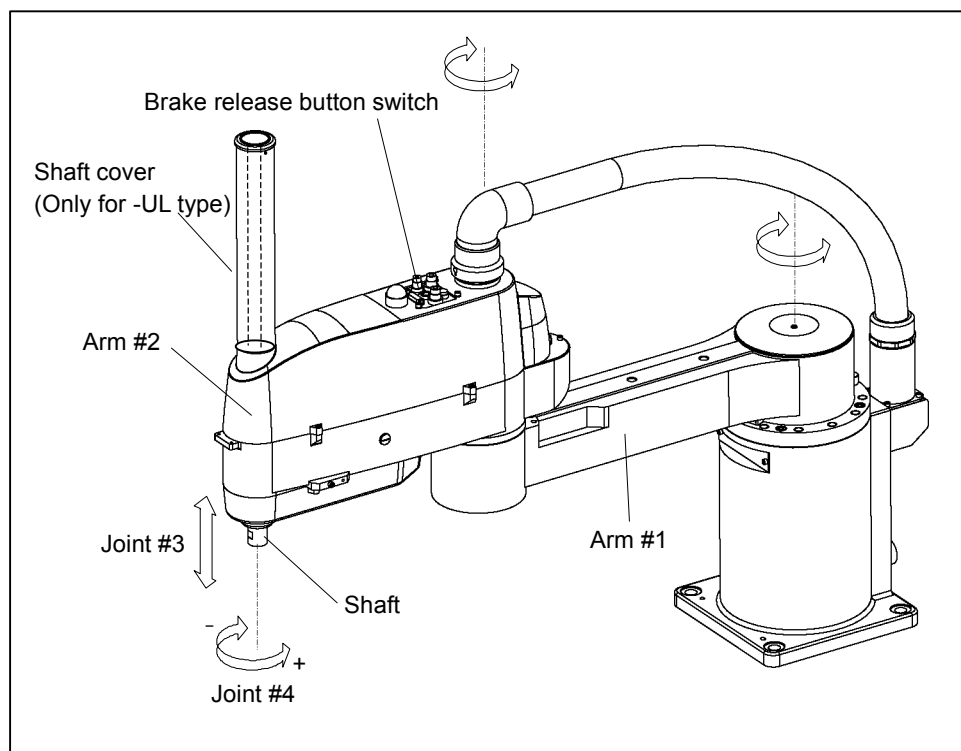
Joint #3 ..... The joint cannot be moved up/down by hand because the electromagnetic brake is applied to the joint. Move the joint up/down while pressing the brake release button switch.

Joint #4 ..... The joint cannot be rotate by hand because the electromagnetic brake is applied to the joint. Move the joint up/down while pressing the brake release button switch.



The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed in emergency mode, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

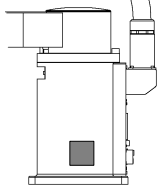
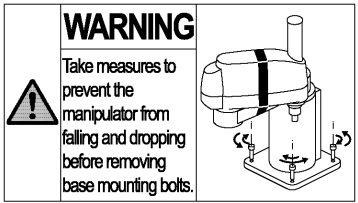
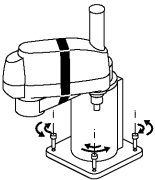
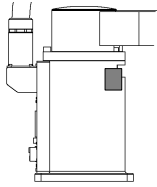

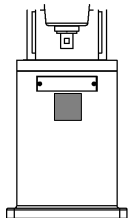
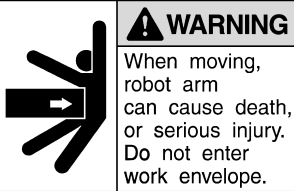
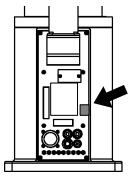

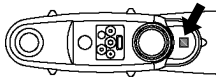



## 1.6 Manipulator Labels

The following labels are attached around the locations of the Manipulator where specific dangers exist.

Be sure to comply with descriptions and warnings on the labels to operate and maintain the Manipulator safely.

Do not tear, damage, or remove the labels. Use meticulous care when handling those parts or units to which the following labels are attached as well as the nearby areas:

Location of Labels	Labels
	<div>  <p><b>WARNING</b> Take measures to prevent the manipulator from falling and dropping before removing base mounting bolts.</p> </div> <div>  <p><b>NOTE:</b> Before unscrewing the base mounting screws, hold the arm and secure it tightly with a band to prevent hands or fingers from being caught in the Manipulator.</p> </div>
	<div>  <p><b>WARNING</b></p> <ol style="list-style-type: none"> <li>1. Do not lift without arm retaining.</li> <li>2. To pick up the manipulator arm, use two wirerores of equal length connected to eyebolts on the J1 arm.</li> <li>3. Remove the arm retaining bolt, bracket and plastic strap before turning power on.</li> <li>4. Follow the instruction manual during lifting / transportation.</li> </ol> <p>Weight : 37 Kg 83 lb.</p> <p>Labels: Eyebolts, Wirerores, Arm retaining bolt and bracket</p> </div>
	<div>  <p><b>WARNING</b> When moving, robot arm can cause death, or serious injury. Do not enter work envelope.</p> </div>
	<div>  <p><b>WARNING</b></p> </div> <p><b>NOTE:</b> Hazardous voltage exists while the Manipulator is ON. To avoid electric shock, do not touch any internal electric parts.</p>
	<div>  <p><b>WARNING</b> Do not put your hand on moving parts.</p> </div> <p><b>NOTE:</b> You will catch your hand or fingers between the shaft and cover when bringing your hand close to moving parts. (This label is attached to only E2H853S, not to UL1740 conformance type or cleanroom model.)</p>

## 2. Specifications

### 2.1 Features of E2H series Manipulators

E2H series Manipulators are designed based on the “EH series” and have high performance: large payload; high inertia; space saving; and improvement of cost performance. The features of E2H series Manipulators are as follows:

#### (1) Available for Large Payloads

- The capacity for large payloads has been improved: the allowable moment of inertia of the U axis has been increased.
- Optimal control for payloads makes handling large payloads more stable.

#### (2) Compatible with EH series Manipulators

- The installation procedure and mounting dimensions of the end effector for E2H series Manipulators are completely compatible with those for EH series Manipulators.
- Major maintenance parts for E2H series Manipulators are common with those for EH series; consequently, maintenance costs are reduced.

#### (3) Space Saving

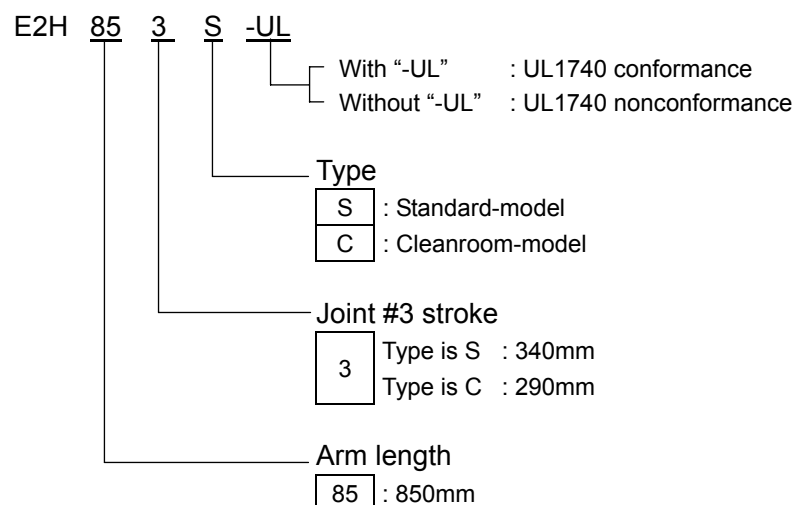
- E2H series Manipulators have been downsized: the height of the cable duct has been lowered.

### UL1740 Conformance Type

UL1740 is the Standard for Industrial Robots and Robotic Equipment established by Underwriters Laboratories Inc. (UL). The UL1740 conformance product has a safety mark which shows that Underwriters Laboratories Inc. (UL) has recognized it.

In the United States, the robot system is recommended to be used with the Manipulators and Controller that conform to UL1740 in accordance with ANSI/RIA R15.06.

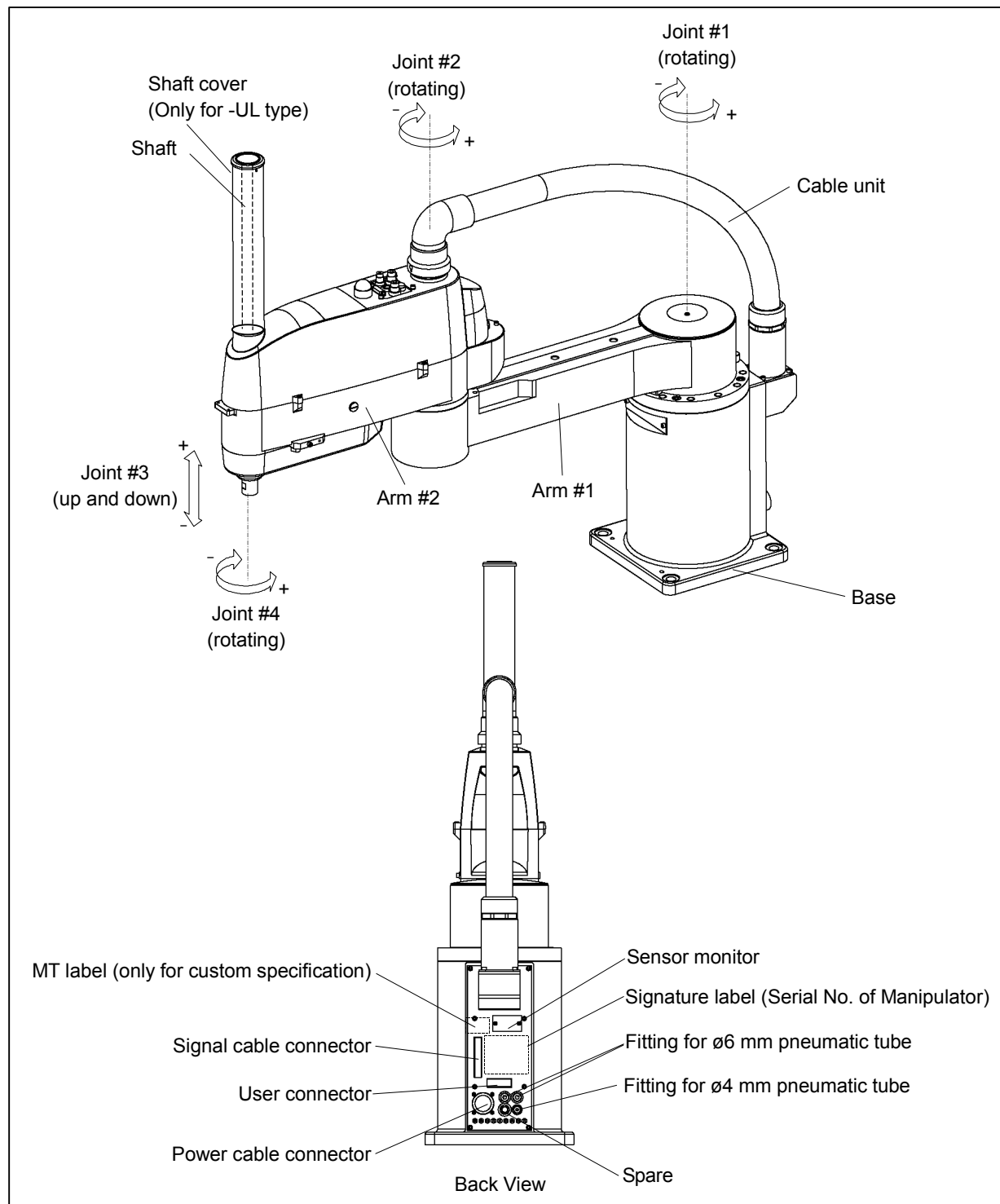
### 2.2 Model Number and Model Differences



## 2.3 Standard-model

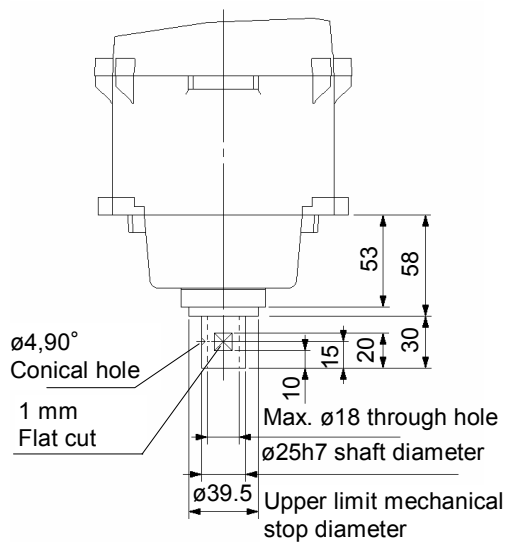
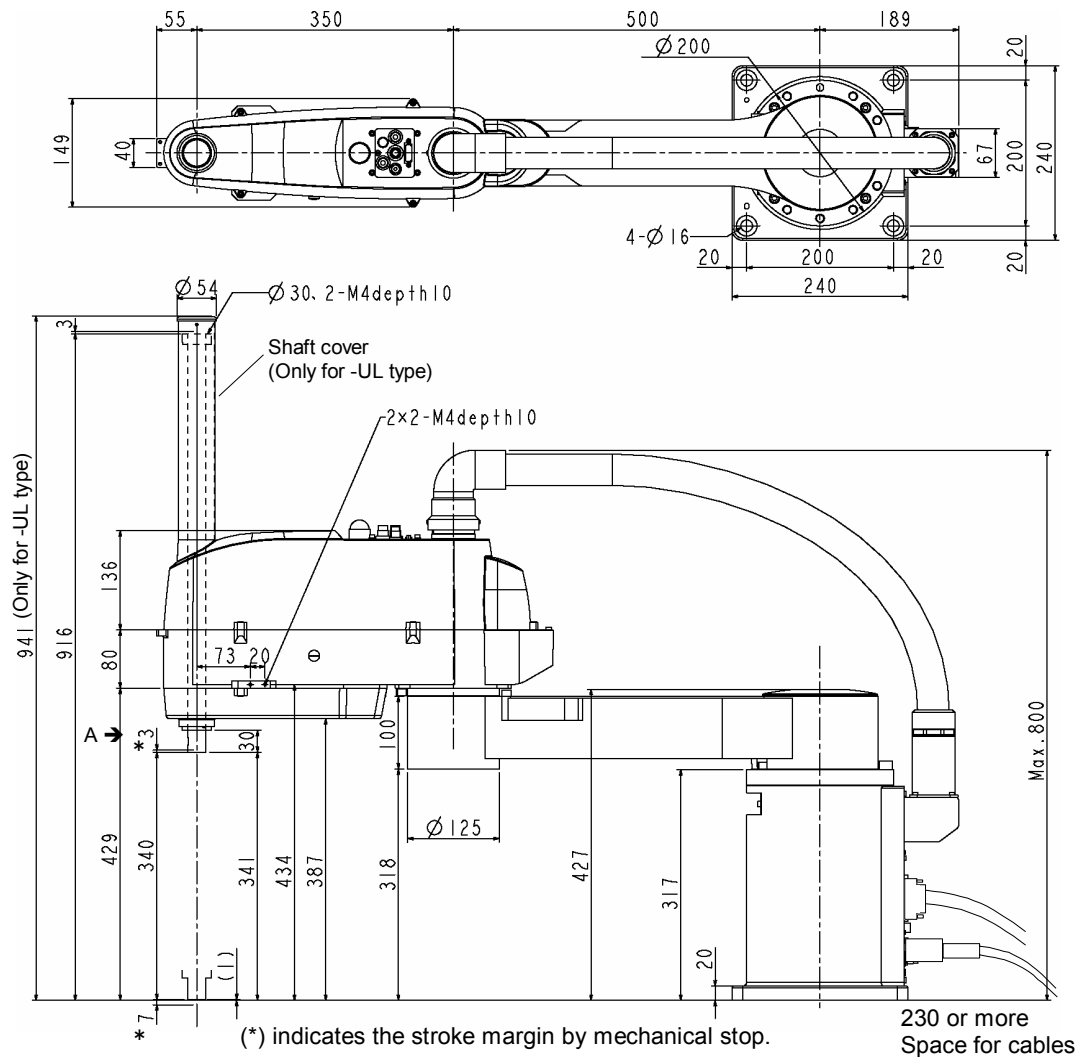
### 2.3.1 Part Names (Standard-model)

#### Part Names

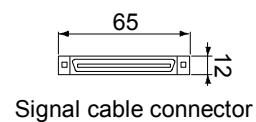


### 2.3.2 Outer Dimension (Standard-model)

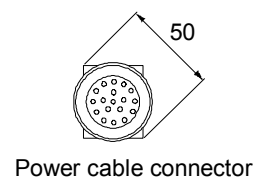
E2H853S [unit: mm]



Detail of "A"  
(Calibration point position of Joints #3 and #4)



Signal cable connector



Power cable connector

## 2.4 Cleanroom-model

### 2.4.1 Outline

The following figure shows the additional parts and specifications for the Table Top Cleanroom-model when compared with the Standard-model in appearance.

The amount of dusting in E2H series Cleanroom-model Manipulator

In  $28317 \text{ cm}^3$  (1 cft) sample-air around the center of the motion range

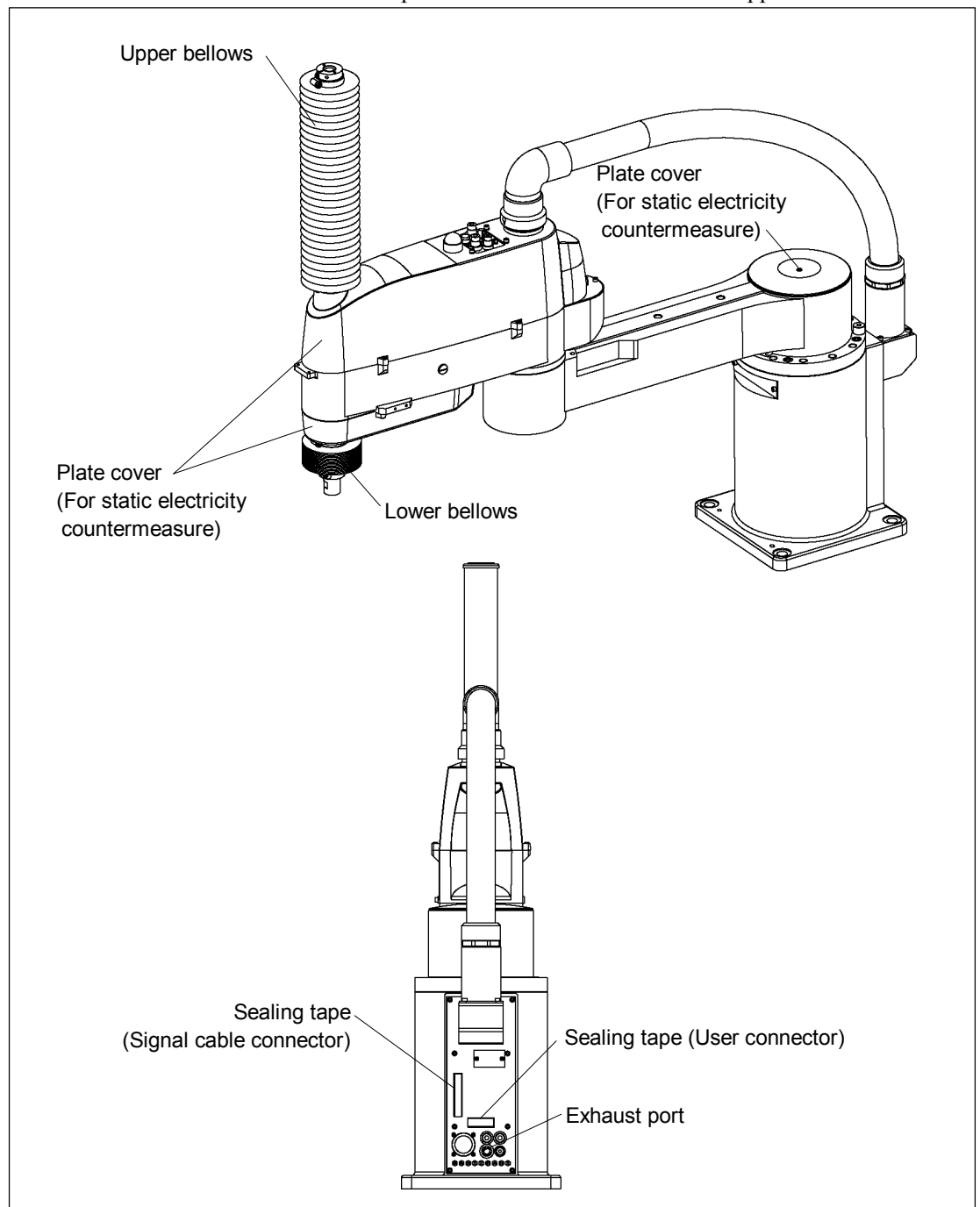
: 10 particles or less ( $0.3 \text{ }\mu\text{m}$  or more dusting in diameter)

Countermeasures for Electrostatic Discharge (ESD) have been taken.



### 2.4.2 Part Names (Cleanroom-model)

The following figure shows the additional parts and specifications for the Table Top Cleanroom-model when compared with the Standard-model in appearance.



### 2.4.3 Exhaust System (Cleanroom-model)

The Cleanroom-model requires the following type of exhaust system to prevent emission of dust particles from the Manipulator.

Seal the exhaust port and the exhaust tube with vinyl tape so that the joint is airtight.

<Exhaust port size> Inner diameter:  $\varnothing 12$  mm / Outer diameter:  $\varnothing 16$  mm

<Exhaust tube> Polyurethane tube Outer diameter:  $\varnothing 12$  mm  
(Inner diameter:  $\varnothing 8$  mm)  
or Inner diameter:  $\varnothing 16$  mm or more

<Recommended exhaust flow rate>  
Approximately  $1000 \text{ cm}^3/\text{s}$  (Normal)

NOTE



If the exhaust flow is not sufficient, dust particle emission may exceed the specified maximum level.

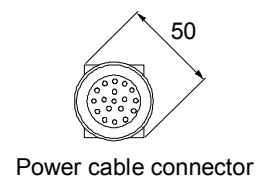
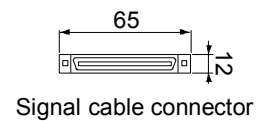
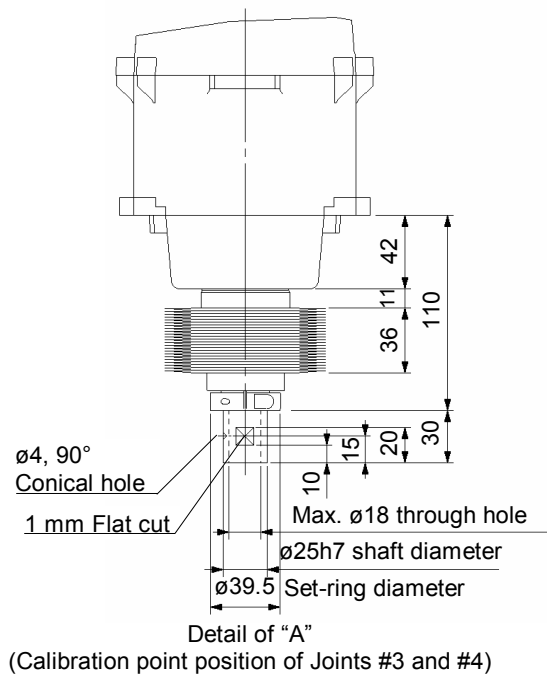
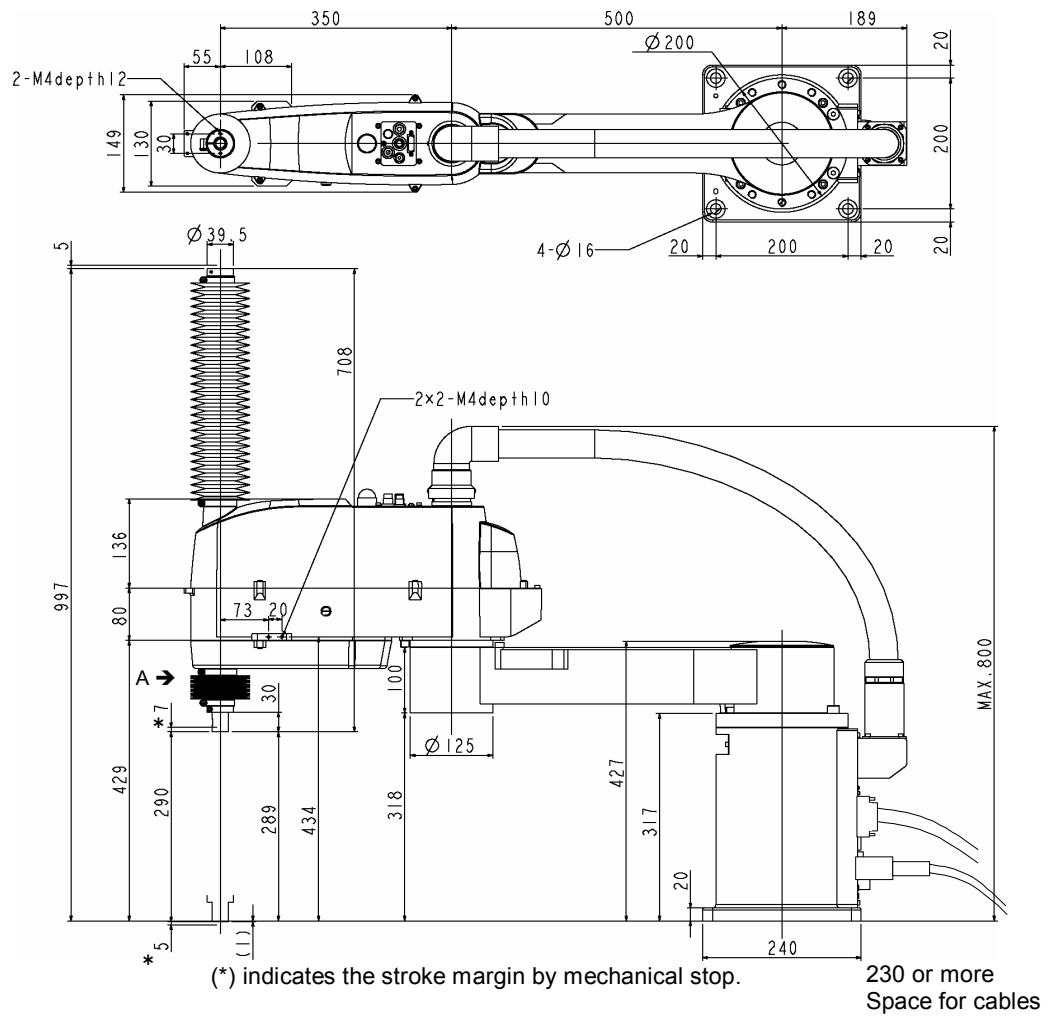
NOTE



The exhaust system in the Cleanroom-model Manipulator draws air from the base interior and arm cover interior. A crack or other opening in the base unit can cause loss of negative air pressure in the outer part of the arm, which can cause increased dust emission. Do not remove the maintenance cover on the front of the base, the acrylic cover on the back of the base, or the sealing tape on the connector.

### 2.4.4 Outer Dimension (Cleanroom-model)

E2H853C [unit: mm]



## 2.5 Specifications

### E2H series

Item		E2H853S/C
Arm length	Arm #1+#2	500 mm +350 mm
Weight (not include the weight of cables)		37 kg : 83lb.
Driving method	All joints	AC servo motor
Max. operating speed *1	Joint #1+#2	5266 mm/s
	Joint #3	1100 mm/s
	Joint #4	1428 degrees/s
Repeatability	Joint #1+2	± 0.025 mm
	Joint #3	± 0.01 mm
	Joint #4	± 0.03 degrees
Max. motion range  Value in ( ) is Cleanroom-model	Joint #1	± 145 degrees
	Joint #2	± 147 degrees
	Joint #3	340 (290) mm
	Joint #4	± 360 degrees
Max. pulse range  Value in ( ) is Cleanroom-model	Joint #1	-62578 to +267378
	Joint #2	± 133803
	Joint #3	- 100271 (-85525) to 0
	Joint #4	± 86016
Resolution	Joint #1	0.0008789 degrees/pulse
	Joint #2	0.0010986 degrees/pulse
	Joint #3	0.0033908 mm/pulse
	Joint #4	0.0041852 degrees/pulse
Motor power consumption	Joint #1	400 W
	Joint #2	400 W
	Joint #3	400 W
	Joint #4	150 W
Payload	rated	2 kg
	max.	20 kg
Joint #4 allowable moment of inertia *2	rated	0.02 kg·m <sup>2</sup>
	max.	0.45 kg·m <sup>2</sup>
Shaft diameter		ø25 (h7) mm
Through hole		ø18 mm
Joint #3 down force		200N
Installed wire for customer use		15 wires (15-pin D-sub connector)
Installed pneumatic tube for customer use	2 pneumatic tubes (ø6 mm), 1 pneumatic tube (ø4 mm) Allowable pressure: 0.59 MPa (6 kgf/cm <sup>2</sup> : 86psi)	
Environmental requirements	Ambient Temperature	5 to 40 °C (with minimum temperature variation)
	Ambient relative humidity	10 to 80% (no condensation)
Equivalent continuous A-weighted sound pressure level *3		L <sub>Aeq</sub> = 75 dB (A)

Item			E2H853S/C
Applicable Controller			RC520 RC420 RC170
Default values	SPEED		5
	ACCEL		10,10
	SPEEDS		50
	ACCELS		200
	FINE		10,10,10,10
	WEIGHT		2,350
Cleanroom-model	Cleanliness level		Clean Class: 10 or its equivalent Amount of Dust: 10 particles or less (0.3μm diameter or larger) (In 28317cm <sup>3</sup> (1cft) sample-air around the center of the motion range)
	Exhaust System	Exhaust port size	Inner diameter: ø12 mm Outer diameter: ø16 mm
		Exhaust tube	Polyurethane tube Outer diameter: ø12 mm (Inner diameter: ø8 mm) or Inner diameter: ø16 mm or more
		Recommended exhaust flow rate	Approximately 1000 cm <sup>3</sup> /s (Normal)
Safety standard			ANSI/RIA R15.06 conformance CE conformance UL1740 conformance: E2H853*-UL (No compliance by RC170 adoption)

- \*1: In the case of PTP control. Maximum operating speed in CP control is 1120 mm/s on horizontal plane.
- \*2: In the case where the center of gravity is at the center of Joint #4. If the center of gravity is not at the center of Joint #4, set the parameter using INERTIA command.
- \*3: Conditions of Manipulator at measurement as follows:  
 Operating conditions : Under rated load, 4-joints simultaneous motion, maximum speed, maximum acceleration, and duty 50%.  
 Measurement point : At the front of Manipulator, 1000 mm apart from the motion range, 50 mm above the base-installed surface.

## 2.6 How to Set the Model

The Manipulator model for your system has been set before the shipment from the factory. It is normally not required to change the model when you receive your system.



CAUTION

- When you need to change the setting of the Manipulator model, be sure to set the Manipulator model properly. Improper setting of the Manipulator model may result in abnormal or no operation of the Manipulator and/or cause safety problems.

### NOTE



If an MT label is attached to the rear of a Manipulator, the Manipulator has custom specifications. If the Manipulator has custom specifications, the methods for setting the model may differ from those described below. Please contact us with the number on the MT label.

The method for setting the Manipulator model depends on the software used. Refer to the chapter *Robot Configuration* in the EPSON RC+ User's Guide or the *Setup & Operation 11.5 Setting Up the Robot Manipulator* in the SPEL CT User's Guide.

## 3. Environments and Installation

### 3.1 Environmental Conditions

A suitable environment is necessary for the robot system to function properly and safely. Be sure to install the robot system in environments that meet the following conditions:

Item	Conditions
Ambient temperature	5 to 40°C (with minimum temperature variation)
Ambient relative humidity	10 to 80% (no condensation)
First transient burst noise	2 kV or less
Electrostatic noise	6 kV or less
Environment	<ul style="list-style-type: none"> <li>· Install indoors.</li> <li>· Keep away from direct sunlight.</li> <li>· Keep away from dust, oily smoke, salinity, metal powder or other contaminants.</li> <li>· Keep away from flammable or corrosive solvents and gases.</li> <li>· Keep away from water.</li> <li>· Keep away from shocks or vibrations.</li> <li>· Keep away from sources of electric noise.</li> </ul>

NOTE



Manipulators are not suitable for operation in harsh environments such as working in painting areas, etc. When using Manipulators in inadequate environments that do not meet the above conditions, please consult your supplier.

## 3.2 Base Table

A base table for anchoring the Manipulator is not supplied. Please make or obtain the base table for your Manipulator. The shape and size of the base table differs depending on the use of the robot system. For your reference, we list some Manipulator table requirements here.

The base table must not only be able to bear the weight of the Manipulator but also be able to withstand the dynamic movement of the Manipulator when the Manipulator operates at maximum acceleration. Ensure that there is enough strength on the base table by attaching reinforcing materials such as crossbeams.

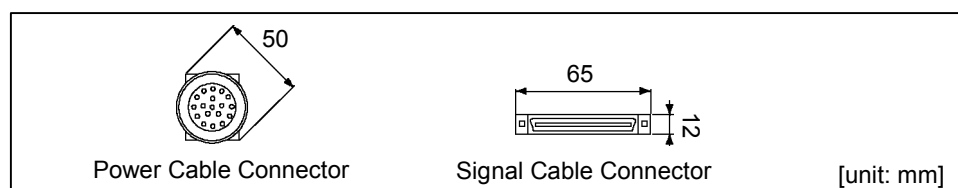
The torque and reaction force produced by the movement of the Manipulator are as follows:

Max. Reaction torque on the horizontal plate : 900Nm

Max. Horizontal reaction force : 1500N

Max. Vertical reaction force : 2000N

- ◆ The threaded holes for the Manipulator base are M12. Use mounting bolts with specifications conforming to ISO898-1 property class: 10.9 or 12.9.  
For the dimensions, refer to *Setup & Operation: 3.3 Mounting Dimensions*.
- ◆ The plate for the Manipulator mounting face should be 20 mm thick or more and made of steel to reduce vibration. The surface roughness of the steel plate should be 25  $\mu$ m or less.
- ◆ The table must be secured on the floor or wall to prevent it from moving.
- ◆ The Manipulator must be installed horizontally.
- ◆ When using a leveler to adjust the height of the base table, use a screw with M16 diameter or more.
- ◆ If making holes for the cables and passing the cables through the holes on the base table, see figures below.



For environmental conditions regarding space when placing the Controller on the base table, refer to the Controller manual.



**WARNING**

- To ensure safety, a safeguard must be installed for the robot system.  
For details on the safeguard, refer to the User's Guide.



### 3.3 Mounting Dimensions



The maximum space described in figures shows that the radius of end effector is 60 mm or less. If the radius of the end effector exceeds 60 mm, define the radius as a distance to the outer edge of maximum space.

If the camera and the electromagnetic valve are bigger than the arm, set the maximum range including the space that they may reach.

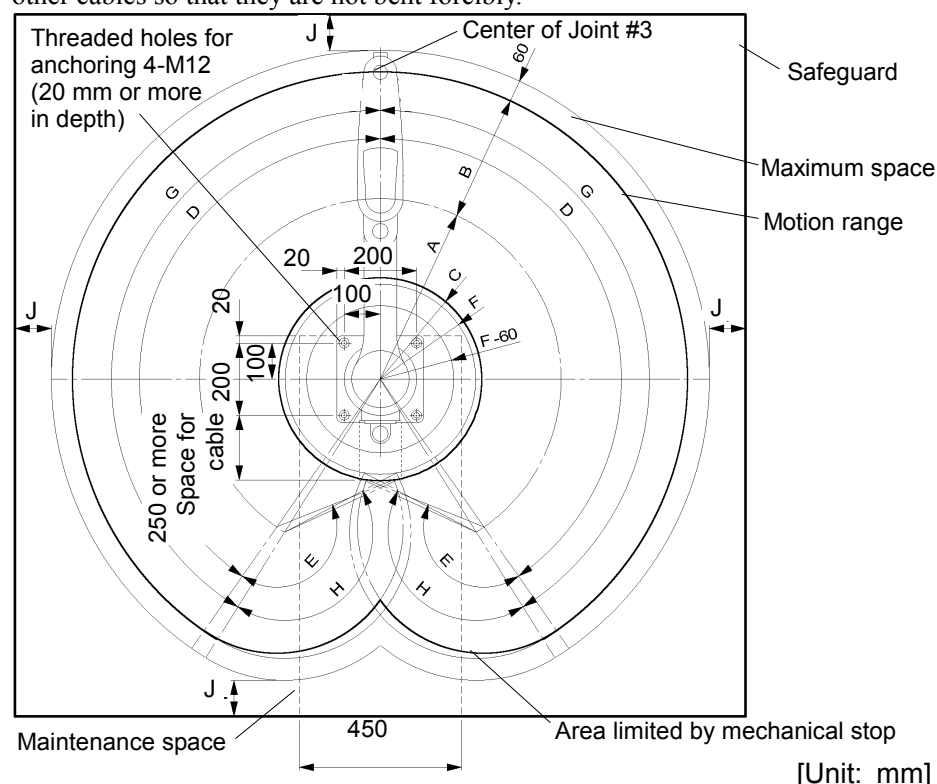
#### Mounting Area

Be sure to have the following spaces besides the space for mounting the Manipulator, Controller, and peripheral equipment.

- ◆ space for teaching
- ◆ space for maintenance and inspections
- ◆ space for cables



The minimum bend radius of the power cable is 130 mm. When installing the cable, be sure to maintain sufficient distance from obstacles. In addition, leave enough space for other cables so that they are not bent forcibly.





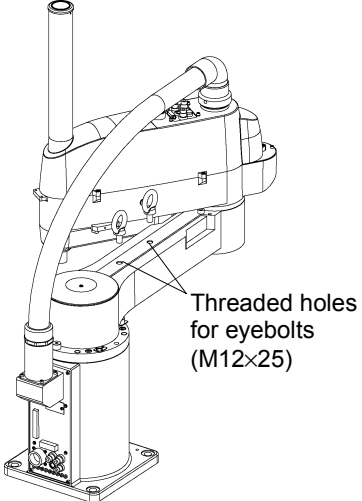
Standard Motion Range of Manipulator		E2H853S/C
A	Length of Arm #1	500 mm
B	Length of Arm #2	350 mm
C	C	282 mm
D	Motion range of Joint #1	145 degrees
E	Motion range of Joint #2	147 degrees
F		263 mm
G	Range to the mechanical stop of Joint #1	148 degrees
H	Range to the mechanical stop of Joint #2	150 degrees
J	Range to the safeguard	Approx. 100 mm*

\* "J" shows the necessary distance (minimum) between the maximum space and safeguard.

## 3.4 Unpacking and Transportation

### 3.4.1 Precautions for Transportation

THE INSTALLATION SHALL BE MADE BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES.

 <b>WARNING</b>	<ul style="list-style-type: none"> <li>Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.</li> </ul>
 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>Using a cart or similar equipment, transport the Manipulator in the same manner as it was delivered.</li> <li>After removing the bolts securing the Manipulator to the delivery equipment, the Manipulator can fall. Be careful not to get hands or fingers caught.</li> <li>The arm is secured with a wire tie. Leave the wire tie secured until you finish the installation so as not to get hands or fingers caught.</li> <li>To carry the Manipulator, secure the Manipulator to the delivery equipment, or pass belts through the eyebolts (as shown in the figure) and hoist it with your hands. Do not hold the duct joint on the back of the base. The weight of an E2H series Manipulator is 37 kg (83lb.).</li> <li>Be careful not to get hands or fingers caught when holding the bottom of the base by hand.</li> <li>Stabilize the Manipulator with your hands when hoisting it.</li> <li>When transporting the Manipulator for a long distance, secure it to the delivery equipment directly so that the Manipulator never falls. If necessary, pack the Manipulator in the same style as it was delivered.</li> </ul> 

### 3.4.2 Transportation

Transport the Manipulator following the instructions below:

- (1) Attach the eyebolts to the top of the Arm #1.
- (2) Pass the belts through the eyebolts.
- (3) Hoist the Manipulator slightly so that it does not fall. Then, remove the bolts securing the Manipulator to the delivery equipment or pallet.
- (4) Hoist the Manipulator holding it by hand so that it can keep its balance. Then, move it to the base table.

### 3.4.3 Contents

1. Manipulator
2. Accessories (Standard-model/Cleanroom-model)

Item	Quantity
Power cable	1
Signal cable	1
Connector and Clamp hood for user wiring	2 sets
Grease for ball screw spline	1

3. Manual or CD manual

## 3.5 Installation Procedure

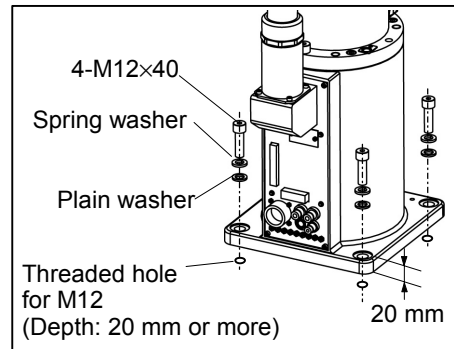
### 3.5.1 Standard-model

- (1) Secure the base to the base table with four bolts.

NOTE



Use bolts with specifications conforming to ISO898-1 Property Class: 10.9 or 12.9.



- (2) Using nippers, cut off the wire tie binding the cable clamp on the side of Arm #2 and arm retaining bracket on the base.

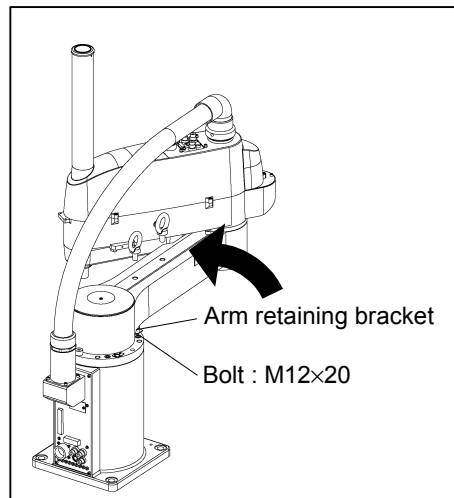


- (3) Push Arm #1 slowly in the direction shown with an arrow in the figure on the right. Remove the arm retaining bracket and bolt from the base, and also the cable clamp from the side of Arm #2.

NOTE





If the bolt is not removed, the motion range of Joint #1 will be limited. Be sure to remove the bolt.



### 3.5.2 Cleanroom-model

- (1) After unpacking the Manipulator outside of the clean room, secure it to the delivery equipment or pallet with bolts so that it will not fall.
- (2) Wipe off any dust on the Manipulator with a little alcohol or distilled water on a lint-free cloth.
- (3) Carry the Manipulator into the clean room.
- (4) Mount the Manipulator by following the steps (1) to (3) in *Setup & Operation: 3.5.1. Standard-model*
- (5) Connect an exhaust tube to the exhaust port.  
For details, refer to *Setup & Operation: 2.4.3 Exhaust System (Cleanroom-model)*.

## 3.6 Connecting the Cables

 <b>WARNING</b>	<ul style="list-style-type: none"> <li>■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.</li> <li>■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.</li> <li>■ 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.) The 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 robot system.</li> </ul>
 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>■ When connecting the Manipulator and the Controller, make sure that the serial numbers on each equipment match. Improper connection between the Manipulator and Controller may not only cause improper function of the robot system but also serious safety problems. The connection method varies with the Controller used. For details on the connection, refer to the Controller manual.</li> </ul>

### Connecting the Cables for Cleanroom-model

If the Manipulator is a Cleanroom-model, use it with an exhaust system.

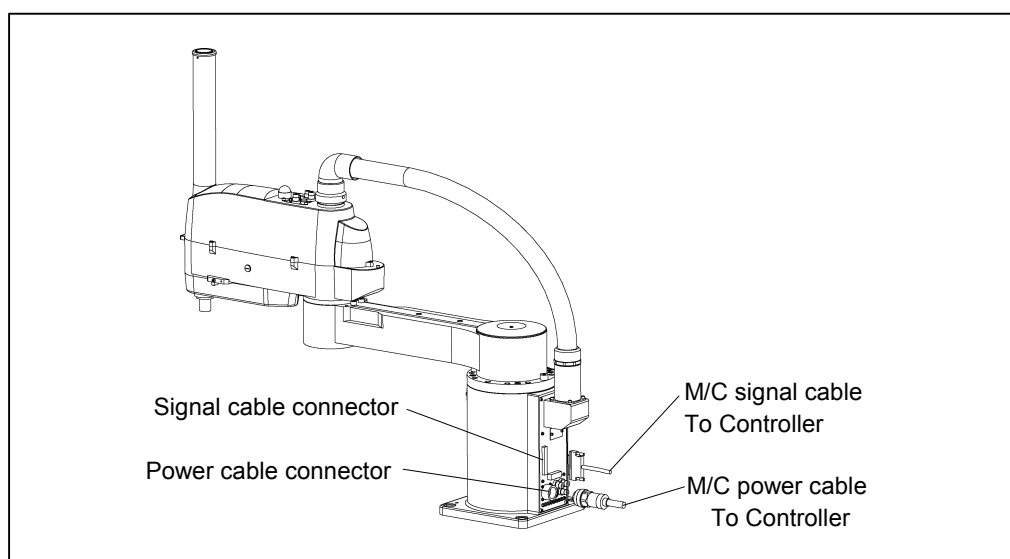
For details, refer to *Setup & Operation: 2.4.3 Exhaust System (Cleanroom-model)*.

### Cable Connections


Connect an M/C power cable to the power cable connector. Connect an M/C signal cable to the signal cable connector.

The connection method for the Controller side varies with the Controller used.

For details, refer to the Controller manual.



### 3.7 User Wires and Pneumatic Tubes

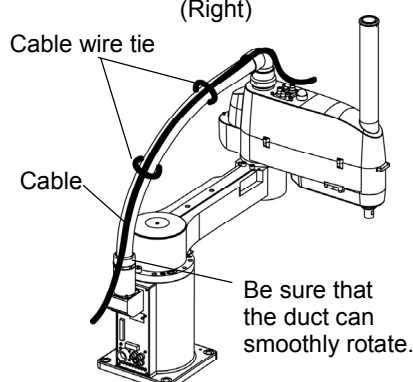


**WARNING**

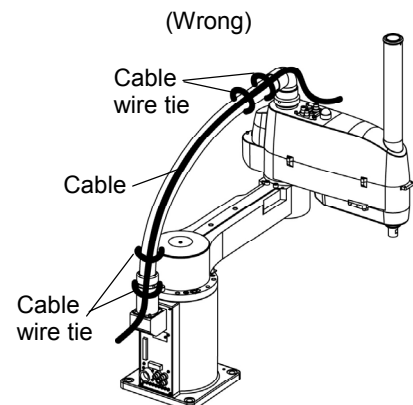
■ When adding wires and tubes along the outside of the duct, pay attention to following:


- Be careful not to move or bend the duct. Moved or bent duct may result in damage to the duct and/or duct cables, disconnection, and/or contact failure. Damaged duct/cables, disconnection, or contact failure may result in electric shock and/or improper function of the robot system.
- Be sure that the duct can rotate in the main cable fitting and duct joint. When the duct is inserted in the main cable fitting and/or duct joint too deep or the cable is bound on the duct, main cable fitting, and duct joint with the wire ties, the duct cannot smoothly rotate in the main cable fitting and/or duct joint. The difficulty in rotating the duct may result in damage to the duct. (See the figures below.)

(Right)



(Wrong)





**CAUTION**

■ Only authorized or certified personnel should be allowed to perform wiring. Wiring by unauthorized or uncertified personnel may result in bodily injury and/or malfunction of the robot system.

User electrical wires and pneumatic tubes are contained in the cable unit.

#### Electrical Wires

Rated Voltage	Allowable Current	Wires	Nominal Sectional Area	Outer Diameter	Note
AC/DC30 V	1 A	15	0.211 mm <sup>2</sup>	ø8.3±0.3 mm	Shielded

	Maker	Standard
Suitable Connector	JAE	DA-15PF-N (Solder type)
Clamp Hood	JAE	DA-C8-J10-F2-1 (Connector setscrew: #4-40 NC)

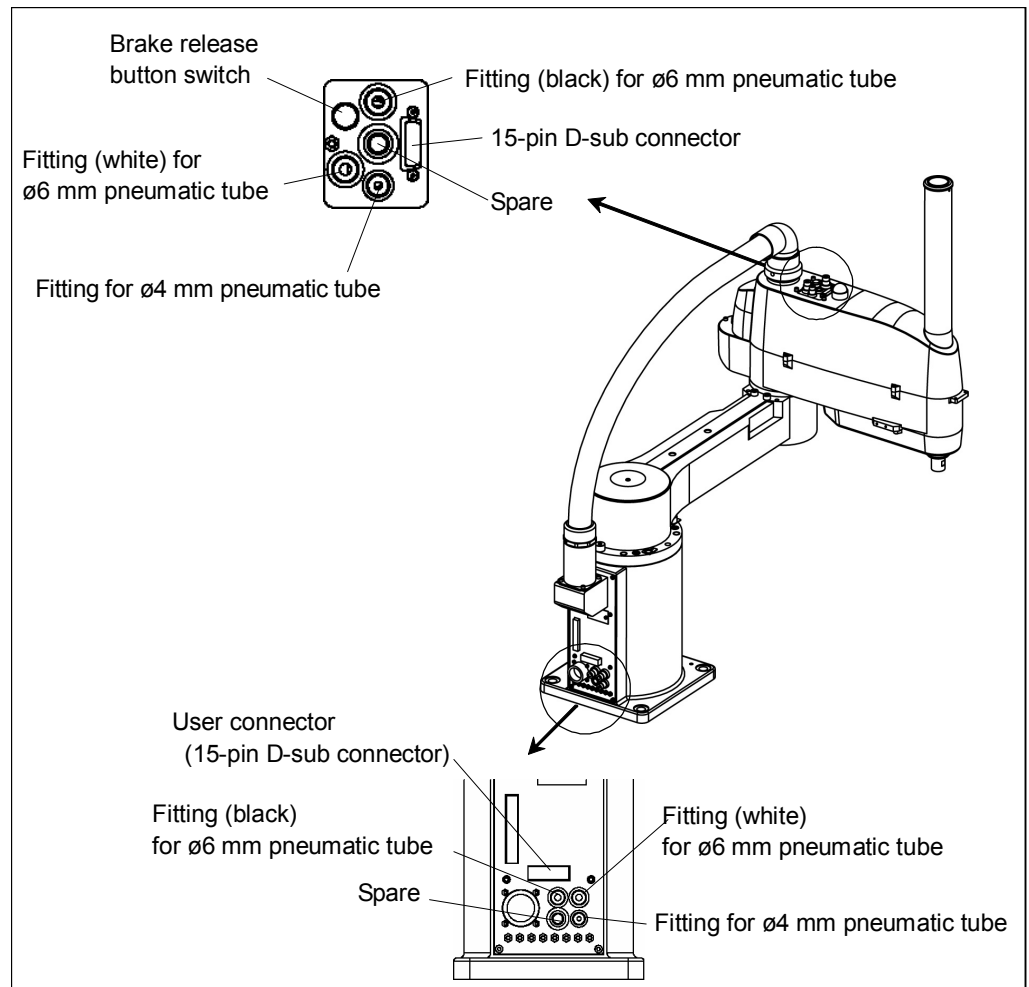
Pins with the same number, indicated on the connectors on both ends of the cables, are connected.

## Pneumatic Tubes

Max. Usable Pneumatic Pressure	Pneumatic Tubes	Outer Diameter × Inner Diameter
0.59 MPa (6 kgf/cm <sup>2</sup> : 86psi)	2	ø6 mm × ø4 mm
	1	ø4 mm × ø2.5 mm

Fittings for ø6 mm and ø4 mm (outer diameter) pneumatic tubes are supplied on the both ends of the pneumatic tubes.

The pneumatic tubes for the Standard-model are the same type as the Cleanroom-model. The details on the fittings are shown in the following figure for the Standard-model.





## 3.8 Relocation and Storage

### 3.8.1 Precautions for Relocation and Storage

Observe the following when relocating, storing, and transporting the Manipulators.

THE INSTALLATION SHALL BE MADE BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES.

 <b>WARNING</b>	<ul style="list-style-type: none"> <li>Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.</li> </ul>
 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>Before relocating the Manipulator, fold the arm and secure it tightly with a wire tie to prevent hands or fingers from being caught in the Manipulator.</li> <li>When removing the anchor bolts, support the Manipulator to prevent falling. Removing the anchor bolts without supporting may result in fall of the Manipulator, and then get hands, fingers, or feet caught.</li> <li>To carry the Manipulator, have two or more people to work on it and secure the Manipulator to the delivery equipment or hold the bottom of Arm #1, bottom of the main cable fitting, and bottom of the base by hand. When holding the bottom of the base by hand, be very careful not to get hands or fingers caught. Do not hold the duct joint on the back of the base.</li> <li>Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in fall of the Manipulator.</li> </ul>

When transporting the Manipulator for a long distance, secure it to the delivery equipment so that the Manipulator cannot fall.

If necessary, pack the Manipulator in the same way as it was delivered.

When the Manipulator is used for robot system again after long-term storage, perform a test run to verify that it works properly, and then operate it thoroughly.

Transport and store the Manipulator in the range of -25°C to +55°C.

Humidity within 10% to 90% is recommended.

When condensation occurs on the Manipulator during transport or storage, turn ON the power only after the condensation dries.

Do not shock or shake the Manipulator during transport.



### 3.8.2 Relocating

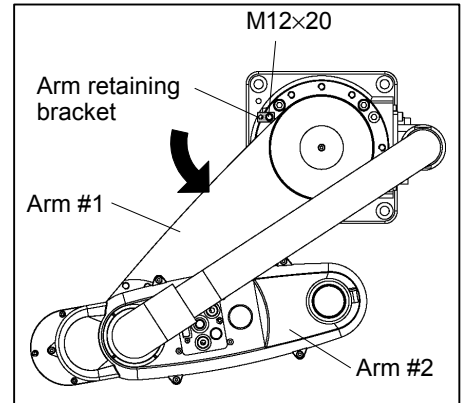
Follow the procedures described below when relocating the Manipulator.

- (1) Turn OFF the power on all devices and unplug the cables.

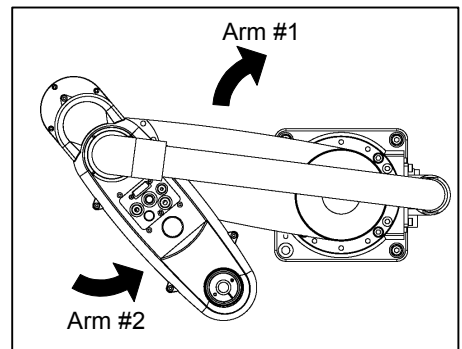


Remove the mechanical stops if using them to limit the motion range of Joints #1 and #2. For details on the motion range, refer to *Setup & Operation: 5.2 Motion Range Setting by Mechanical Stops*.

- (2) Push Arm #1 by hand in the direction shown with the arrow (in the figure on the right) until the threaded hole for the arm retaining bracket appears. Secure the arm retaining bracket with a bolt.



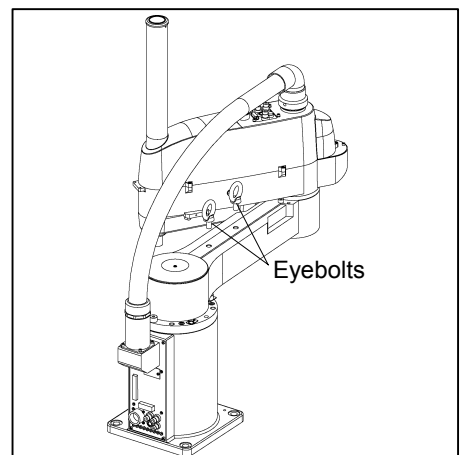
- (3) Push Arms #1 and #2 by hand in the direction shown with the arrows (in the figure on the right) until the arms touch the mechanical stop.



- (4) Attach the cable clamp to the side of Arm #2 and bind the cable clamp and arm retaining bracket.



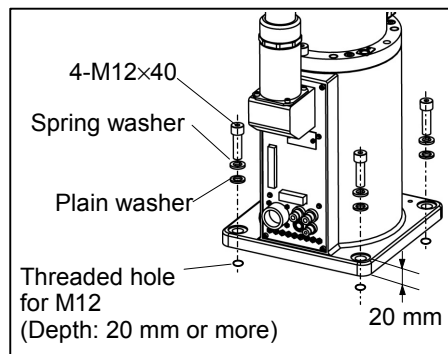
- (5) Attach the eyebolts on the top of Arm #1.



- (6) Pass the belts through the eyebolts.

- (7) Hoist the Manipulator slightly so that it does not fall.

Remove four bolts securing the Manipulator.



- (8) Hoist the Manipulator holding it by hand so that it can keep its balance. Then, move the Manipulator to the delivery equipment or another location and anchor it.




Stretch the belts tight until you finish anchoring the Manipulator.

## 4. Setting of End Effectors

### 4.1 Attaching an End Effector

Users are responsible for making their own end effector(s). Before attaching an end effector, observe these guidelines.

 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>■ If you use an end effector equipped with a gripper or chuck, connect wires and/or pneumatic tubes properly so that the gripper does not release the work piece when the power to the robot system is turned OFF. Improper connection of the wires and/or pneumatic tubes may damage the robot system and/or work piece as the work piece is released when the Emergency Stop switch is pressed. I/O outputs are configured at the factory so that they are automatically shut off (0) by power disconnection, the Emergency Stop switch, or the safety features of the robot system.</li> </ul>
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#### Shaft

- ◆ Attach an end effector to the lower end of the shaft.  
For the shaft dimensions, and the overall dimensions of the Manipulator, refer to *Setup & Operation: 2. Specifications*.
- ◆ Do not move the upper limit mechanical stop on the lower side of the shaft. Otherwise, when “Jump motion” is performed, the upper limit mechanical stop may hit the Manipulator, and the robot system may not function properly.
- ◆ Use a split muff coupling with an M4 bolt or larger to attach the end effector to the shaft.

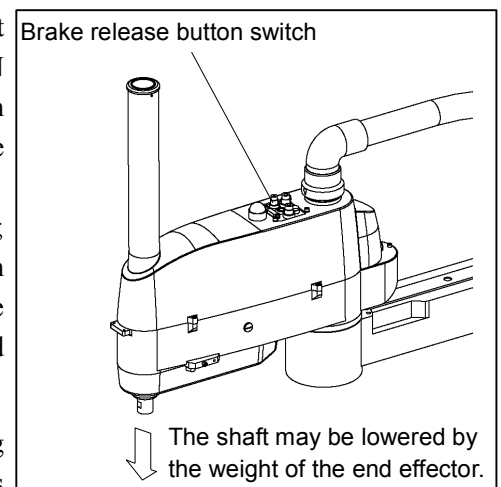
#### Brake release button switch

- ◆ Joints #3 and #4 cannot be moved up/down by hand because the electromagnetic brake is applied to the joints while power to the robot system is turned OFF. This prevents the shaft from hitting peripheral equipment and rotating in the case that the shaft is lowered by the weight of the end effector when the power is disconnected during operation, or when the motor is turned OFF even though the power is turned ON.

To move Joint #3 up/down or rotate Joint #4 while attaching an end effector, turn ON the Controller and move the joint up/down or rotate the joint while pressing the brake release button switch.

This button switch is a momentary-type; the brake is released only while the button switch is being pressed. The respective brakes for Joints #3 and #4 are released simultaneously.

- ◆ Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of the end effector.

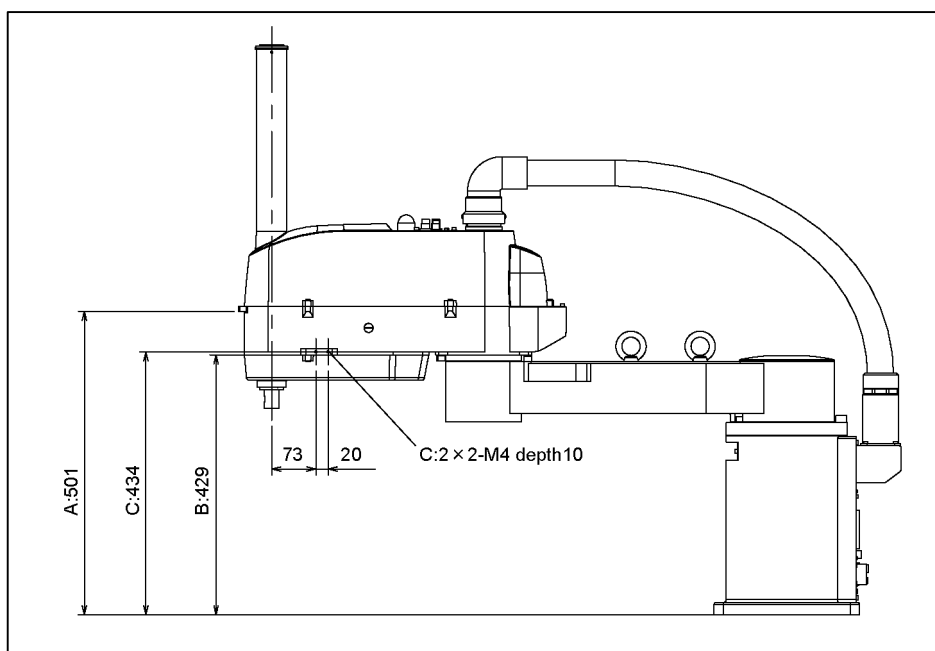
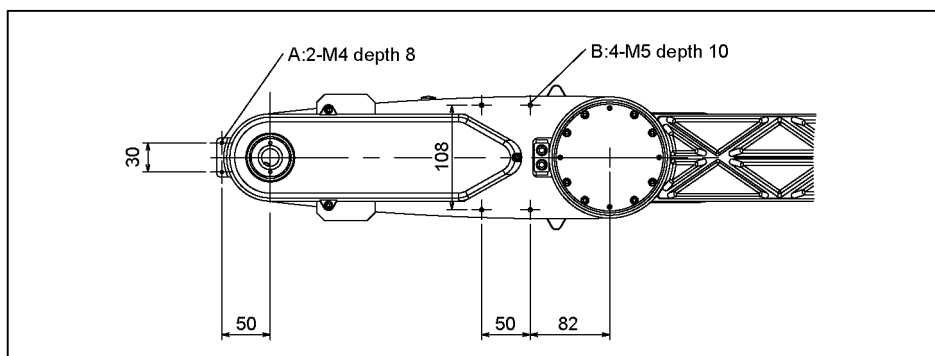


## Layouts

- ◆ When you operate the manipulator with an end effector, the end effector may interfere with the Manipulator because of the outer diameter of the end effector, the size of the work piece, or the position of the arms. When designing your system layout, pay attention to the interference area of the end effector.

## 4.2 Attaching Cameras and Valves

Arm #2 has threaded holes as shown in the figure below. Use these holes for attaching cameras, valves, and other equipment.




### 4.3 WEIGHT and INERTIA Settings

To ensure optimum Manipulator performance, it is important to make sure that the load (weight of the end effector and work piece) and moment of inertia of the load are within the maximum rating for the Manipulator, and that Joint #4 does not become eccentric.

If the load or moment of inertia exceeds the rating or if the load becomes eccentric, follow the steps below, “4.3.1 WEIGHT Setting” and “4.3.2 INERTIA Setting” to set parameters.

Setting parameters makes the operation of the Manipulator optimal, reduces vibration to shorten the operating time, and improves the capacity for larger loads. In addition, it reduces persistent vibration produced when the moment of inertia of the end effector and work piece is larger than the default setting.

#### 4.3.1 WEIGHT Setting

 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>■ The total weight of the end effector and the work piece must be 20 kg or less. The E2H series Manipulators are not designed to work with loads exceeding 20 kg. Always set the WEIGHT parameters according to the load. Setting a value that is smaller than the actual load may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.</li> </ul>
---	--

The acceptable weight capacity (end effector and work piece) in E2H series is 2 kg at the default rating and 20 kg at the maximum. When the load (weight of the end effector and work piece) exceeds the rating, change the setting of WEIGHT parameter.

After the setting is changed, the maximum acceleration/deceleration speed of the robot system corresponding to the “WEIGHT Parameter” is set automatically.

#### Load on the Shaft

The load (weight of the end effector and work piece) on the shaft can be set by WEIGHT parameter.

The method for setting parameter varies with the software used.

**SPEL CT**

Enter the combined total weight of the end effector and work piece into the [Weight:] text box on the [WEIGHT] panel ([Setup] - [Robot Parameters]).

**EPSON  
RC+**

EPSON RC+ 4.\* or before (RC520/RC420)

Enter the combined total weight of the end effector and work piece into the [Weight:] text box on the WEIGHT panel ([Project]-[Robot Parameters]).

You may also execute the Weight command from the [EPSON RC+ Monitor Window].

EPSON RC+ 5.0 or later (RC170)

Enter into the [Weight:] text box on the [Weight] panel ([Tools]-[Robot Manager]).

You may also execute the Weight command from [Command Window].

## Load on the Arm

When you attach a camera or other devices to the arm, calculate the weight as the equivalent of the shaft. Then, add this to the load and enter the total weight to the WEIGHT parameter.

### Equivalent Weight Formula

When you attach the equipment near Arm #2:	$W_M = M (L_1)^2 / (L_1 + L_2)^2$
When you attach the equipment to the end of Arm #2:	$W_M = M (L_M)^2 / (L_2)^2$
$W_M$ : equivalent weight	
$M$ : weight of camera etc.	
$L_1$ : length of Arm #1	
$L_2$ : length of Arm #2	
$L_M$ : distance from rotation center of Joint #2 to center of gravity of camera etc.	

<Example> A “1 kg” camera is attached to the end of the E2H series arm (450 mm away from the rotation center of Joint #2) with a load weight “2 kg”.

$$M = 1$$

$$L_2 = 350$$

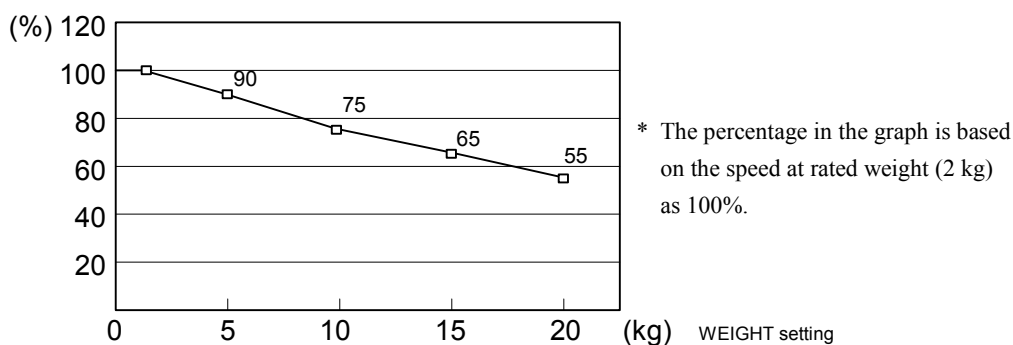
$$L_M = 450$$

$$W_M = 1 \times 450^2 / 350^2 = 1.65 \rightarrow 1.7 \text{ (round up)}$$

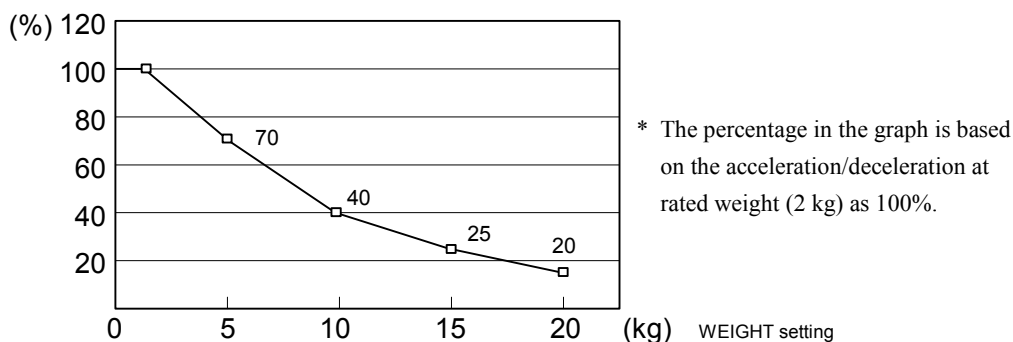
$$W + W_M = 2 + 1.7 = 3.7$$

Enter “3.7” to the WEIGHT Parameter.

### Automatic speed setting by WEIGHT




### Automatic acceleration/deceleration setting by WEIGHT



### 4.3.2 INERTIA Setting

#### Moment of Inertia and the INERTIA Setting

The moment of inertia is defined as “the ratio of the torque applied to a rigid body and its resistance to motion”. This value is typically referred to as “the moment of inertia”, “inertia”, or “ $GD^2$ ”. When the Manipulator operates with additional objects (such as an end effector) attached to the shaft, the moment of inertia of load must be considered.

 <b>CAUTION</b>	<p>■ The moment of inertia of load (weight of the end effector and work piece) must be <math>0.45 \text{ kg}\cdot\text{m}^2</math> or less. The E2H series Manipulators are not designed to work with moment of inertia exceeding <math>0.45 \text{ kg}\cdot\text{m}^2</math>.</p> <p>Always set the moment of inertia (INERTIA) parameter according to the moment of inertia. Setting a value that is smaller than the actual moment of inertia may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.</p>
---	--

The acceptable moment of inertia of load in E2H series is  $0.02 \text{ kg}\cdot\text{m}^2$  at the default rating and  $0.45 \text{ kg}\cdot\text{m}^2$  at the maximum. When the moment of inertia of load exceeds the rating, change the setting of the moment of inertia (INERTIA) parameter of the INERTIA command. After the setting is changed, the maximum acceleration/deceleration speed of Joint #4 corresponding to the “moment of inertia” value is set automatically.

#### Moment of inertia of load on the shaft

The moment of inertia of load (weight of the end effector and work piece) on the shaft can be set by “moment of inertia (INERTIA)” parameter of the INERTIA command.

The method for setting parameter varies with the software used.

**SPEL CT**

Enter the combined total moment of inertia of the end effector and work piece into the [Load inertia:] text box on the [INERTIA] panel ( [Setup] – [Robot Parameters] ).

**EPSON  
RC+**

**EPSON RC+ 4.\* or before (RC520/RC420)**

Enter the combined total moment of inertia of the end effector and work piece into the [Load inertia:] text box on the [INERTIA] panel ( [Project] – [Robot Parameters] ).

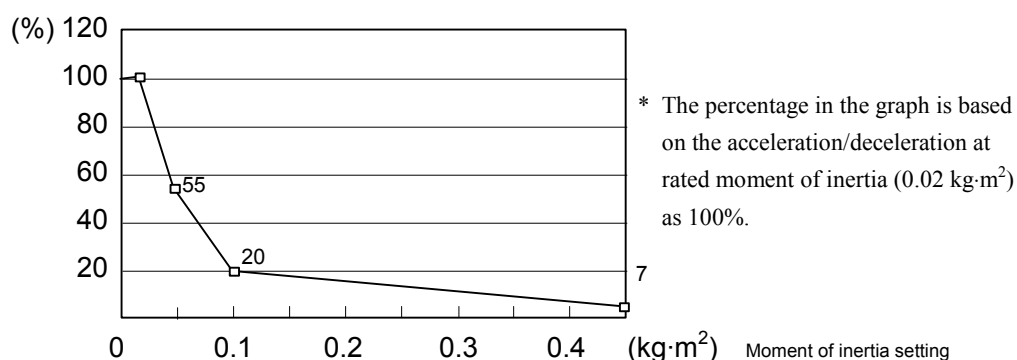
You may also execute the INERTIA command from the [EPSON RC+ Monitor Window].

**EPSON RC+ 5.0 or later (RC170)**

Enter into the [Load inertia:] text box on the [Inertia] panel ([Tools]–[Robot Manager]).

You may also execute the Inertia command from [Command Window].

## Automatic acceleration/deceleration setting of Joint #4 by INERTIA (moment of inertia)



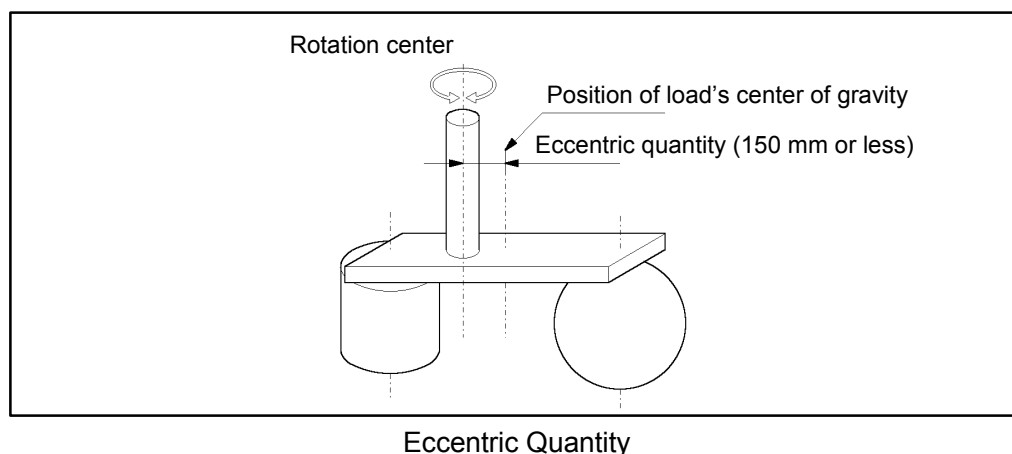
## Eccentric Quantity and the INERTIA Setting



CAUTION

- The eccentric quantity of load (weight of the end effector and work piece) must be 150 mm or less. The E2H series Manipulators are not designed to work with eccentric quantity exceeding 150 mm. Always set the eccentric quantity parameter according to the eccentric quantity. Setting a value that is smaller than the actual eccentric quantity may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.

The acceptable eccentric quantity of load in E2H series is 0 mm at the default rating and 150 mm at the maximum. When the eccentric quantity of load exceeds the rating, change the setting of eccentric quantity parameter of INERTIA command. After the setting is changed, the maximum acceleration/deceleration speed of the Manipulator corresponding to the “eccentric quantity” is set automatically.





## Eccentric quantity of load on the shaft

The eccentric quantity of load (weight of the end effector and work piece) on the shaft can be set by “eccentric quantity” parameter of INERTIA command.

The method for setting parameter varies with the software used.

**SPEL CT**

Enter the combined total eccentric quantity of the end effector and work piece into the [Eccentricity:] text box on the [INERTIA] panel ( [Setup] – [Robot Parameters] ).

**EPSON  
RC+**

EPSON RC+ 4.\* or before (RC520/RC420)

Enter the combined total eccentric quantity of the end effector and work piece into the [Eccentricity:] text box on the [INERTIA] panel ( [Project] – [Robot Parameters] ).

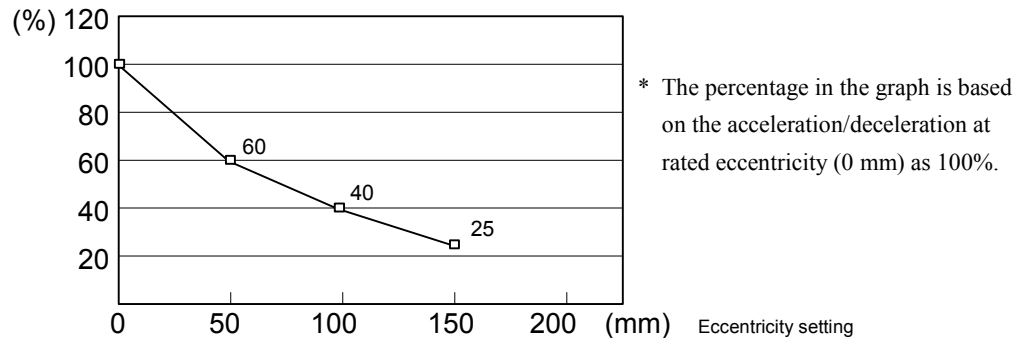
You may also execute the INERTIA command from the [EPSON RC+ Monitor Window].

EPSON RC+ 5.0 or later (RC170)

Enter into the [Eccentricity:] text box on the [Inertia] panel ([Tools]–[Robot Manager]).

You may also execute the Inertia command from [Command Window].

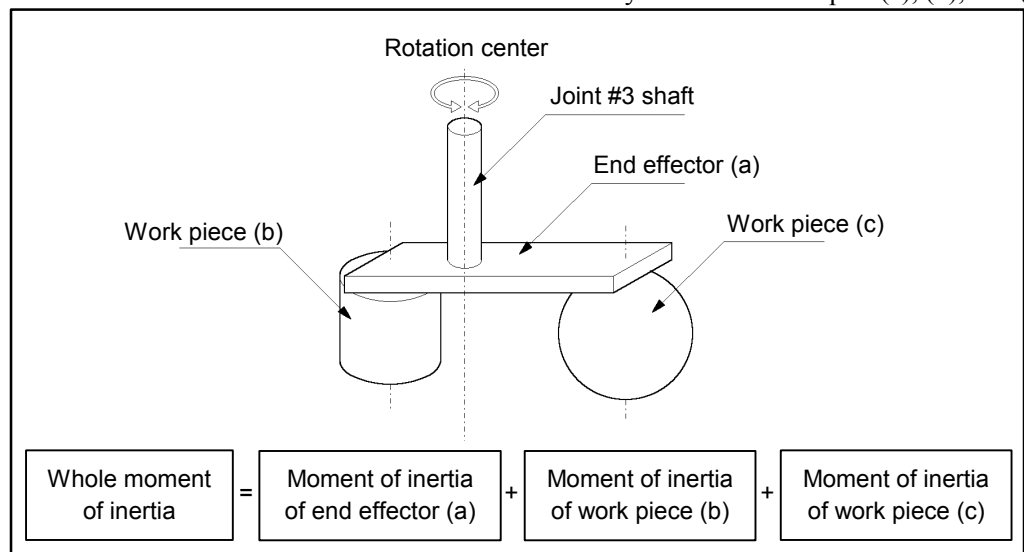
## Automatic acceleration/deceleration setting by INERTIA (eccentric quantity)



## Calculating the Moment of Inertia

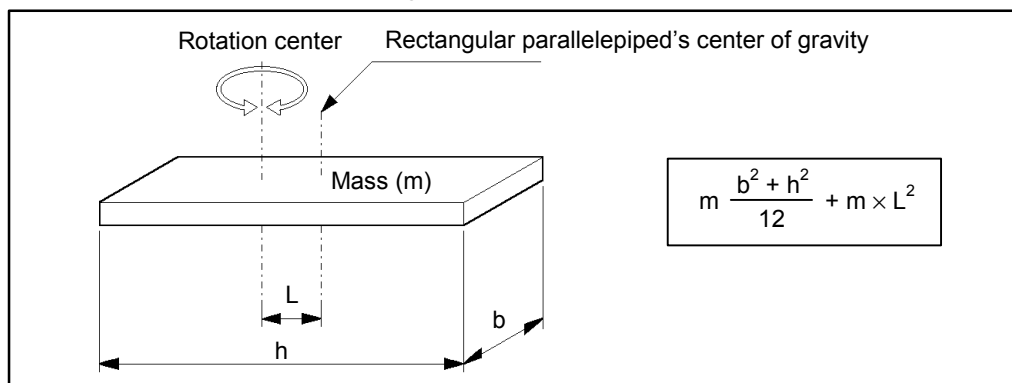
Refer to the following examples of formulas to calculate the moment of inertia of load (end effector with work piece).

The moment of inertia of the entire load is calculated by the sum of each part (a), (b), and (c).

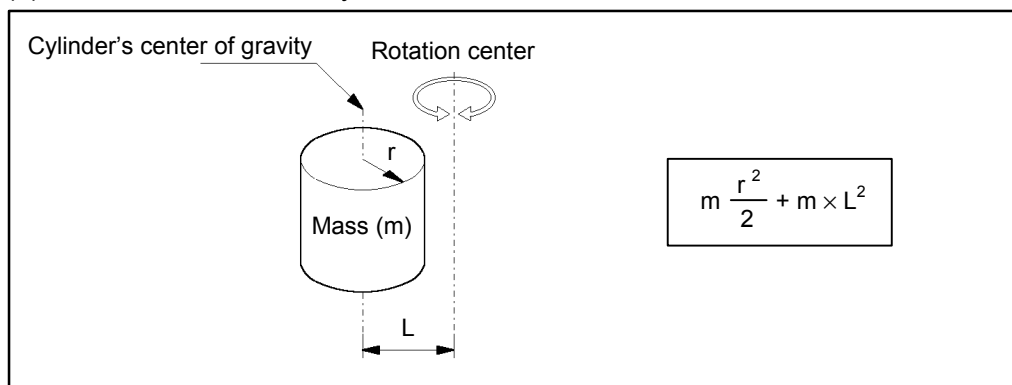


The methods for calculating the moment of inertia for (a), (b), and (c) are shown on this page or the next page. Find the whole moment of inertia using the basic formulas on the next.

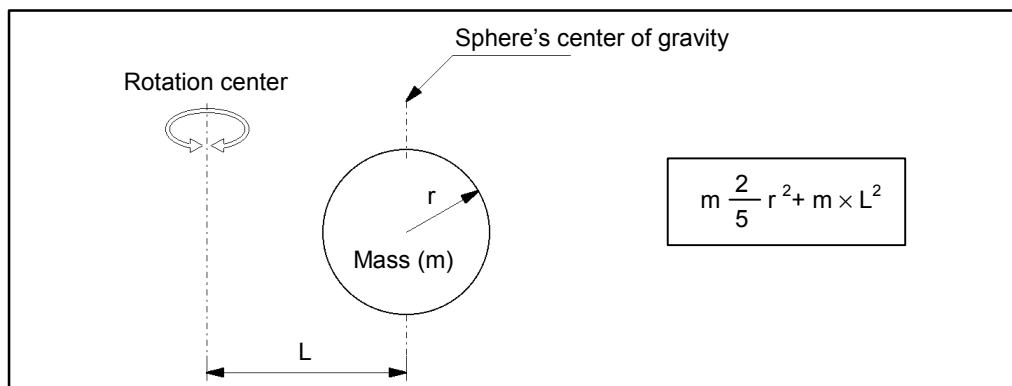
(a) Moment of inertia of a rectangular parallelepiped



(b) Moment of inertia of a cylinder



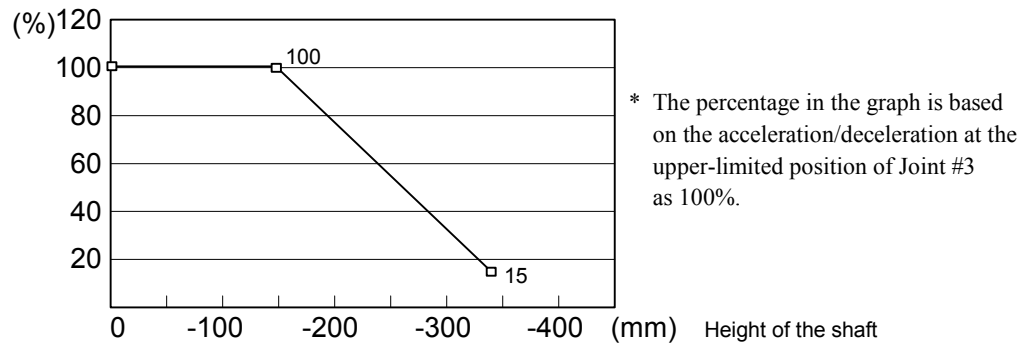
(c) Moment of inertia of a sphere



#### 4.4 Precautions for Auto Acceleration/Deceleration of Joint #3

When you move the Manipulator horizontally with Joint #3 (Z) at a high position, the motion time will be faster. When Joint #3 gets below a certain point, then auto acceleration/deceleration is used to reduce acceleration/deceleration. (Refer to the figure below.) The higher the position of the shaft is, the faster the motion acceleration/deceleration is. However, it takes more time to move Joint #3 up and down. Adjust the position of Joint #3 for the Manipulator motion after considering the relation between the current position and the destination position. The upper limit of Joint #3 during horizontal motion can be set by the LIMZ command.

##### Automatic acceleration/deceleration vs. Joint #3 position



When moving the Manipulator horizontally while the shaft is being lowered, it may cause over-shoot at the time of final positioning.



## 5. Motion Range

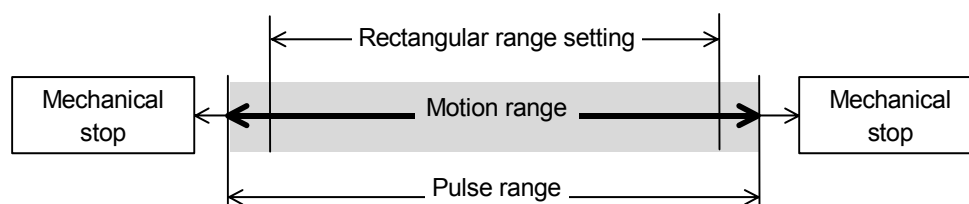


- When setting up the motion range for safety, both the pulse range and mechanical stops\* must be always set at the same time.
- \* For the Cleanroom-model Manipulator, the motion range set with the Joint #3 mechanical stop cannot be changed.

The motion range is preset at the factory as explained in *Setup & Operation: 5.4 Standard Motion Range*. That is the maximum motion range of the Manipulator.

There are three methods for setting the motion range described as follows:

1. Setting by pulse range (for all joints)
2. Setting by mechanical stops  
(for Joints #1 to #3 of Standard-model / Joints #1 and #2 of Cleanroom-model)
3. Setting the Cartesian (rectangular) range in the X, Y coordinate system of the Manipulator (for Joints #1 and #2)



When the motion range is changed due to layout efficiency or safety, follow the descriptions in 5.1 to 5.3 to set the range.

### 5.1 Motion Range Setting by Pulse Range (for All Joints)

Pulses are the basic unit of Manipulator motion. The motion range of the Manipulator is controlled by the pulse range between the pulse lower limit and upper limit of each joint. Pulse values are read from the encoder output of the servo motor.

For the maximum pulse range, refer to the following sections.  
The pulse range must be set inside of the mechanical stop range.

*5.1.1 Max. Pulse Range of Joint #1*

*5.1.2 Max. Pulse Range of Joint #2*

*5.1.3 Max. Pulse Range of Joint #3*

*5.1.4 Max. Pulse Range of Joint #4.*



Once the Manipulator receives an operating command, it checks whether the target position specified by the command is within the pulse range before operating. If the target position is out of the set pulse range, an error occurs and the Manipulator does not move.

The method for setting pulse ranges varies with the software used.

**SPEL CT**

The pulse range can be set on the [RANGE] panel shown by selecting the [Setup]- [Robot Parameters].

**EPSON RC+**

**EPSON RC+ 4.\* or before (RC520/RC420)**

The pulse range can be set on the [RANGE] panel shown by selecting the [Project]-[Robot Parameters].

You may also execute the RANGE command from the [EPSON RC+ Monitor Window].

**EPSON RC+ 5.0 or later (RC170)**

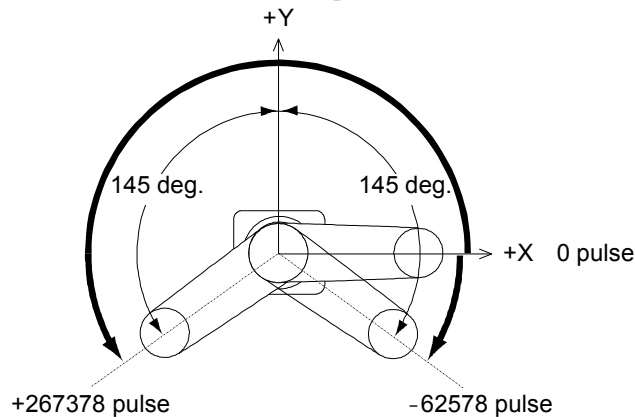
The pulse range can be set on the [Range] panel shown by selecting the [Tools]-[Robot manager].

You may also execute the Range command from the [Command Window].

### 5.1.1 Max. Pulse Range of Joint #1

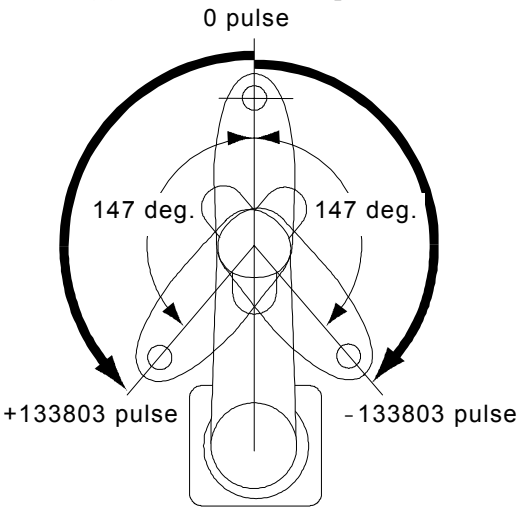
The 0 (zero) pulse position of Joint #1 is the position where Arm #1 faces toward the positive (+) direction on the X-coordinate axis.

When the 0 pulse is a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).



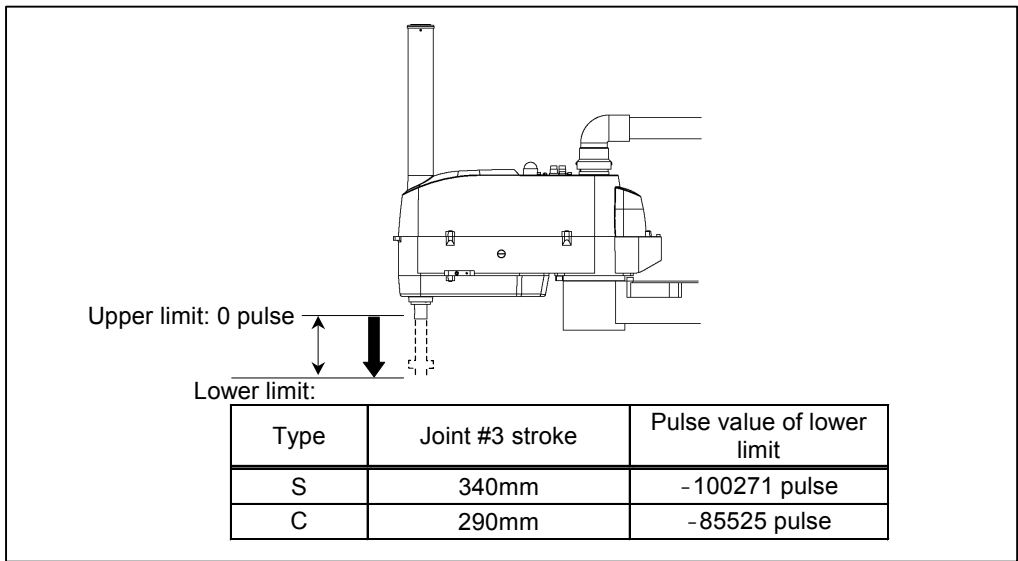
### 5.1.2 Max. Pulse Range of Joint #2

The 0 (zero) pulse position of Joint #2 is the position where Arm #2 is parallel to Arm #1. With the 0 pulse as a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).



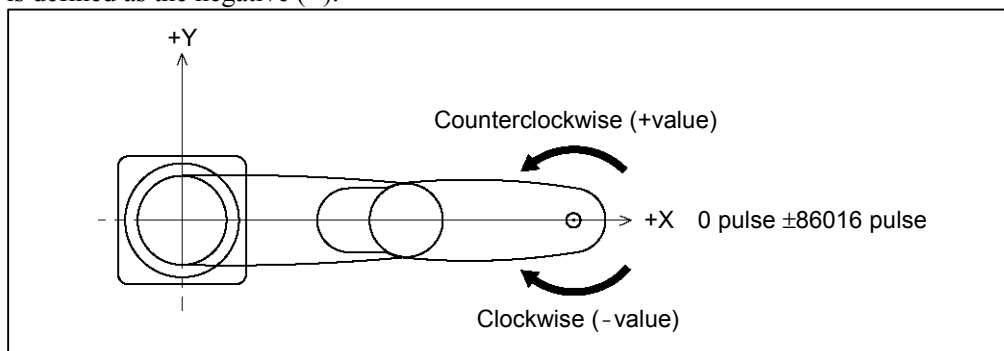
### 5.1.3 Max. Pulse Range of Joint #3

The 0 (zero) pulse position of Joint #3 is the position where the shaft is at its upper limit. The pulse value is always negative because Joint #3 always moves lower than the 0 pulse position.



### 5.1.4 Max. Pulse Range of Joint #4

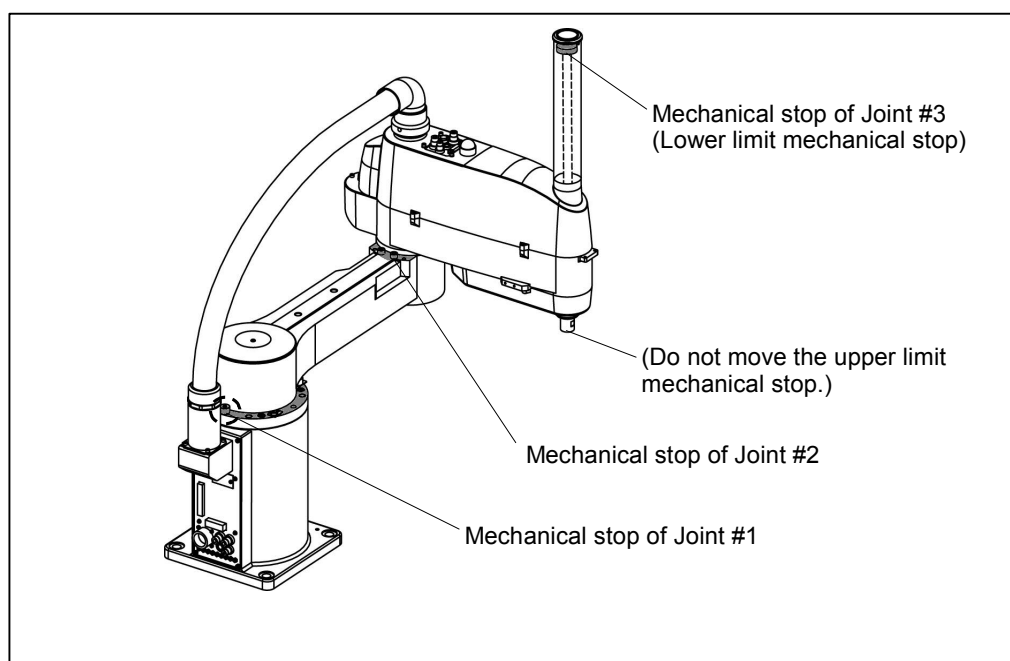
The 0 (zero) pulse position of Joint #4 is the position where the flat near the end of the shaft faces toward the end of Arm #2. With the 0 pulse as a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).



## 5.2 Motion Range Setting by Mechanical Stops

(for Joints #1 to #3 of Standard-model / Joints #1 and #2 of Cleanroom-model)

Mechanical stops physically limit the absolute area that the Manipulator can move.



For the Cleanroom-model Manipulator, the motion range set with the Joint #3 mechanical stop cannot be changed.

The mechanical stop can be set at the angle shown in the table below.

If the position of the mechanical stop is changed, re-specify the pulse range.

(° : degree)

Joint	Type	Position for area setting by mechanical stops									
1	S/C	+145°	+115°	+85°	+55°	+25°	-25°	-55°	-85°	-115°	-145°
2	S/C	+147°	+132°							-132°	-147°
3	S	Less than the maximum stroke									

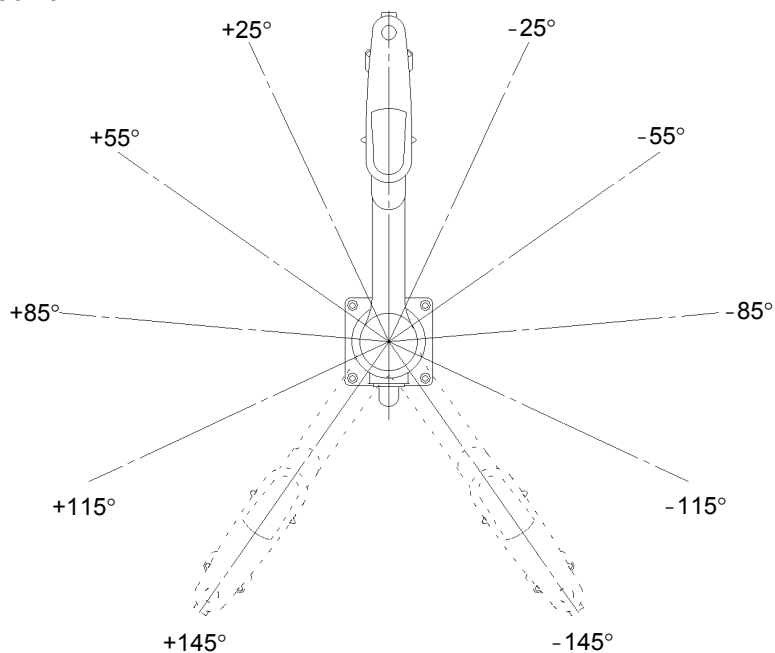


### 5.2.1 Setting the Mechanical Stops of Joints #1 and #2

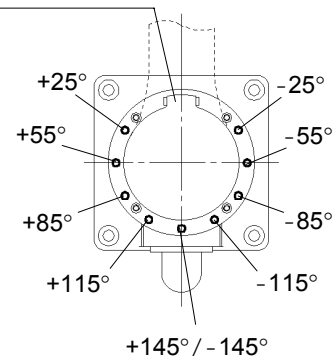
Both Joints #1 and #2 have threaded holes in the positions corresponding to the angle for the mechanical stop settings. Tighten the bolts in holes corresponding to the angle that you want to set.

The following figures show the positions of the threaded holes for the mechanical stop settings of Joints #1/#2 and the setting angles (pulse value).

Joint #1

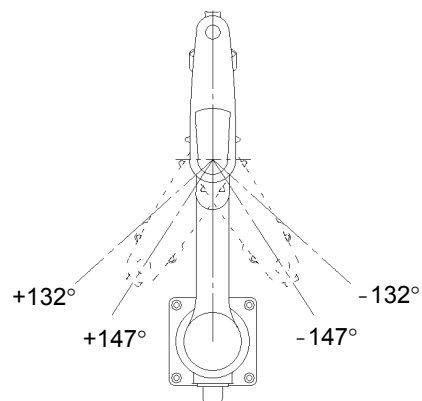


Mechanical stop of Joint #1

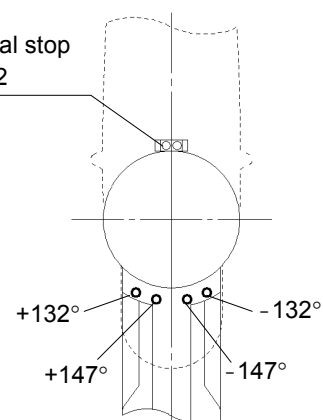


(° : degree)

Joint #2



Mechanical stop of Joint #2



(° : degree)

E2H series: Setting Angle and Pulse Value

(° : degree)

Joint #1	Setting angle	+145°	+115°	+85°	+55°	+25°	-25°	-55°	-85°	-115°	-145°
	Pulse value	267378	233245	199112	164978	130845	73955	39822	5688	-28445	-62578
Joint #2	Setting angle	+147°	+132°	-132°	-147°						
	Pulse value	133803	120150	-120150	-133803						

- (1) Turn OFF the Controller.
- (2) Install a hexagon socket head cap bolt into the hole corresponding to the setting angle, and tighten it.

Joint	Hexagon socket head cap bolt (fully threaded)	The number of bolts	Recommended tightening torque
1	M12 × 20	1 bolt / one side	12740 N·cm (1300 kgf·cm)
2	M8 × 10		3720 N·cm (380 kgf·cm)

- (3) Turn ON the Controller.
- (4) Set the pulse range corresponding to the new positions of the mechanical stops.

## NOTE



Be sure to set the pulse range inside the positions of the mechanical stop range.

<Example: The angle of Joint #1 is set from -85 degrees to +115 degrees  
The angle of Joint #2 is set from -132 degrees to +132 degrees>

The method for setting pulse ranges varies with the software used.

## SPEL CT

Select the [RANGE] panel. Set the lower limit value at “5688” and the upper limit value at “233245” for Joint #1. Additionally, set the lower limit value at “-120150” and the upper limit value at “120150” for Joint #2.

## EPSON RC+

Execute the following commands.

[Monitor Window] EPSON RC+ 4.\* or before (RC520/RC420)

[Command Window] EPSON RC+ 5.0 or later (RC170)

>J RANGE 1, 5688, 233245 ' Sets the pulse range of Joint #1

>J RANGE 2, -120150, 120150 ' Sets the pulse range of Joint #2

>RANGE ' Checks the setting using RANGE

5688, 233245, -120150, 120150, -100271, 0, -86016, 86016

- (5) Move the arm by hand until it touches the mechanical stops, and make sure that the arm does not hit any peripheral equipment during operation.
- (6) Operate the joint changed at low speeds until it reaches the positions of the minimum and maximum pulse range. Make sure that the arm does not hit the mechanical stops.

<Example: The angle of Joint #1 is set from -85 degrees to +115 degrees  
The angle of Joint #2 is set from -132 degrees to +132 degrees>

The method for setting pulse ranges varies with the software used.

**SPEL CT**

Click the <Debug Pane> button, and execute the following commands from the [Command Execution] Window.

```

MOTOR ON           ' Turns ON the motor
SPEED 5            ' Sets at low speeds
GO PULSE (5688,0,0,0) ' Moves to the min. pulse position of Joint #1
GO PULSE (233245,0,0,0) ' Moves to the max. pulse position of Joint #1
GO PULSE (102400,-120150,0,0) ' Moves to the min. pulse position of Joint #2
GO PULSE (102400,120150,0,0) ' Moves to the max. pulse position of Joint #2

```

**EPSON  
RC+**

Execute the following commands.

[Monitor Window] EPSON RC+ 4.\* or before (RC520/RC420)

[Command Window] EPSON RC+ 5.0 or later (RC170)

```

>MOTOR ON           ' Turns ON the motor
>SPEED 5            ' Sets at low speeds
>PULSE 5688,0,0,0    ' Moves to the min. pulse position of Joint #1
>PULSE 233245,0,0,0  ' Moves to the max. pulse position of Joint #1
>PULSE 102400,-120150,0,0 ' Moves to the min. pulse position of Joint #2
>PULSE 102400,120150,0,0 ' Moves to the max. pulse position of Joint #2

```

The PULSE command (GO PULSE command) moves all joints to the specified positions at the same time. Specify safe positions after considering motion of not only the joints whose pulse range have been changed, but also other joints.

In this example, Joint #1 is moved to the center of its motion range (pulse value: 102400) when checking Joint #2.

If the arm is hitting the mechanical stops or if an error occurs after the arm hits the mechanical stops, either reset the pulse range to a narrower setting or extend the positions of the mechanical stops within the limit.

## 5.2.2 Setting the Mechanical Stop of Joint #3

## NOTE

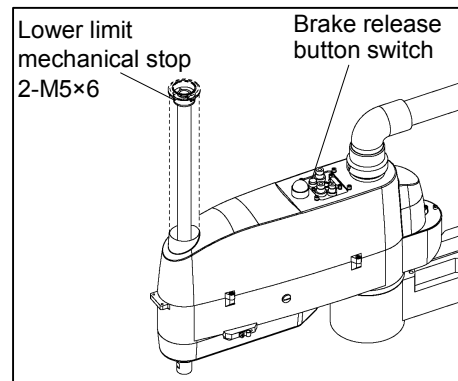


This method applies only to the Standard-model Manipulator.

For the Cleanroom-model Manipulator, the motion range set with the Joint #3 mechanical stop cannot be changed.

- (1) Turn ON the Controller and turn OFF the motors using the MOTOR OFF command.
- (2) Push up the shaft while pressing the brake release button switch.

Do not push the shaft up to its upper limit since it is difficult for the arm top cover to be removed. Push the shaft up to a position where the Joint #3 mechanical stop can be changed.



## NOTE



When you press the brake release button switch, the shaft may lower and rotate due to the weight of the end effector. Be sure to hold the shaft by hand while pressing the button switch.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover. (Only for -UL type)

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (5) Loosen the lower limit mechanical stop.

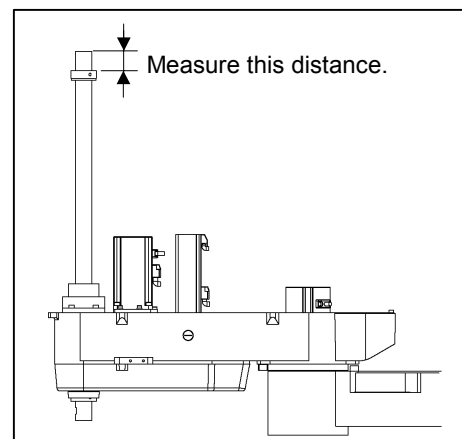
## NOTE



A mechanical stop is mounted on both the top and bottom of Joint #3. However, only the position of the lower limit mechanical stop on the top can be changed. Do not remove the upper limit mechanical stop on the bottom because the calibration point of Joint #3 is specified using the stop.

- (6) The upper end of the shaft defines the maximum stroke. Move the lower limit mechanical stop down by the length you want to limit the stroke.

For example, when the lower limit mechanical stop is set at “340 mm” stroke (standard), the lower limit Z coordinate value is “-340”. To change the value to “-250”, move the lower limit mechanical stop down “90 mm”. Use calipers to measure the distance when adjusting the mechanical stop.



- (7) Firmly tighten two setscrews which are open at a 120 degree interval so that they do not enter the shaft groove.  
Recommended tightening torque: 980 N·cm (100 kgf·cm)

- (8) Install the arm top cover. (Only for -UL type)

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (9) Turn ON the Controller.

- (10) Move Joint #3 to its lower limit while pressing the brake release button switch, and then check the lower limit position. Do not lower the mechanical stop too far. Otherwise, the joint may not reach target position.

- (11) Calculate the lower limit pulse value of the pulse range using the formula shown below and set the value.

The result of the calculation is always negative because the lower limit Z coordinate value is negative.

$$\text{Lower limit of pulse} = \text{lower limit Z coordinate value} / 25 \times 4096 \times 1.8$$

<Example: When lowering the mechanical stop by 90 mm and changing the lower limit Z coordinate value to “-250” in 340 mm stroke>

$$(-250) / 25 \times 4096 \times 1.8 = -73728$$

The method for setting pulse ranges varies with the software used.

SPEL CT

Select the [RANGE] panel, and set the lower limit value at “-73728” and the upper limit value at “0” for Joint #3.

EPSON  
RC+

Execute the following command.

[Monitor Window] EPSON RC+ 4.\* or before (RC520/RC420)

[Command Window] EPSON RC+ 5.0 or later (RC170)

>J RANGE 3, -73728, 0 ' Sets the pulse range of Joint #3

- (12) Using the PULSE command (GO PULSE command), move Joint #3 to the lower limit position of the pulse range at low speeds. If the mechanical stop range is less than the pulse range, Joint #3 will hit the mechanical stop and an error will occur. When the error occurs, either change the pulse range to a lower setting or extend the position of the mechanical stop within the limit.

The clearance between the lower-limit pulse position and the mechanical stop should be approximately 5 mm.



If it is difficult to check whether Joint #3 hits a mechanical stop, turn OFF the Controller and lift the arm top cover to check the condition causing the problem from the side.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

<Example: When lowering the mechanical stop by 90 mm and changing the lower limit Z coordinate value to “-250” in 340 mm stroke>

The method for setting pulse ranges varies with the software used.

**SPEL CT**

Click the <Debug Pane> button, and execute the following commands from the [Command Execution] window.

```
MOTOR ON           ' Turns ON the motor
SPEED 5            ' Sets low speed
GO PULSE (0,0,-73728,0) ' Moves to the lower limit-pulse position of Joint #3.
                    (In this example, all pulses except those for Joint #3 are “0”.
                    Substitute these “0s” with the other pulse values specifying
                    a position where there is no interference even when
                    lowering Joint #3.)
```

**EPSON  
RC+**

Execute the following commands.

[Monitor Window] EPSON RC+ 4.\* or before (RC520/RC420)

[Command Window] EPSON RC+ 5.0 or later (RC170)

```
>MOTOR ON          ' Turns ON the motor
>SPEED 5           ' Sets low speed
>PULSE 0,0,- 73728,0 ' Moves to the lower limit-pulse position of Joint #3.
                    (In this example, all pulses except those for Joint #3 are “0”.
                    Substitute these “0s” with the other pulse values specifying
                    a position where there is no interference even when lowering
                    Joint #3.)
```

### 5.3 Setting the Cartesian (Rectangular) Range

#### in the XY Coordinate System of the Manipulator (for Joints #1 and #2)

Use this method to set the upper and lower limits of the X and Y coordinates.

This setting applies only to the software. Therefore, it does not change the physical range. The maximum physical range is based on the position of the mechanical stops.

The method for changing the XYLIM setting varies with the software used.

**SPEL CT**

Set the XYLIM setting on the [XYLIM] panel shown by selecting the [Setup]- [Robot Parameters].

**EPSON  
RC+**

EPSON RC+ 4.\* or before (RC520/RC420)

Set the XYLIM setting on the [XYLIM] panel shown by selecting the [Project]-[Robot Parameters].

You may also execute the XYLIM command from the [EPSON RC+ Monitor Window].

EPSON RC+ 5.0 or later (RC170)

Set the XYLIM setting on the [XYZ Limits] panel shown by selecting the [Tools]-[Robot manager].

You may also execute the XYLIM command from the [Command Window].

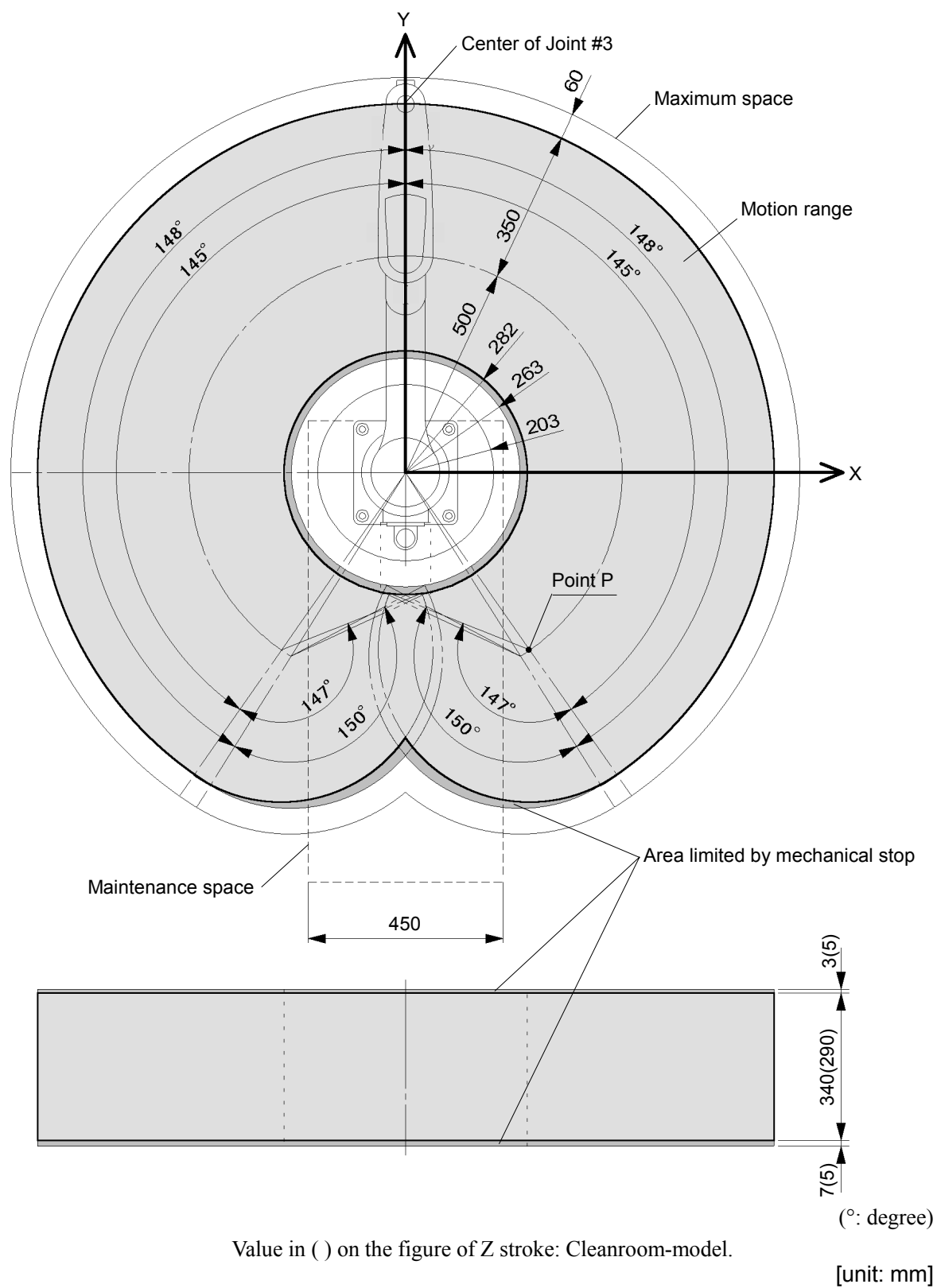
## 5.4 Standard Motion Range

The “motion range” shows the standard (maximum) specification. When each Joint motor is under servo control, the center of Joint #3’s (shaft’s) lowest point moves in the area shown in the figure.

“Area limited by mechanical stop” is the area where the center of Joint #3’s lowest point can be moved when each joint motor is not under servo control.

“Mechanical stop” sets the limited motion range so that the center of Joint #3 cannot move beyond the area mechanically.

“Maximum space” is the area that contains the farthest reach of the arms. If the maximum radius of the end effector is over 60 mm, add the “Area limited by mechanical stop” and “radius of the end effector”. The total value is specified as the maximum area.





# Maintenance

This volume contains maintenance procedures with safety precautions for E2H series Manipulators.



# 1. Safety Maintenance

Please read this chapter, this manual, and other relevant manuals carefully to understand safe maintenance procedures before performing any routine maintenance.

Only authorized personnel who have taken safety training should be allowed to maintain the robot system.

Safety training is the program for industrial robot operators that follows the laws and regulations of each nation.

The personnel who have taken safety training acquire knowledge of industrial robots (operations, teaching, etc.), knowledge of inspections, and knowledge of related rules/regulations.

The personnel who have completed the robot system-training and maintenance-training classes held by the manufacturer, dealer, or locally-incorporated company are allowed to maintain the robot system.




WARNING

- Do not remove any parts that are not covered in this manual. Follow the maintenance procedure strictly as described in this manual. Improper removal of parts or improper maintenance may not only cause improper function of the robot system but also serious safety problems.
- Keep away from the Manipulator while the power is ON if you have not taken the training courses. Do not enter the operating area while the power is ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even it seems to be stopped.
- When you check the operation of the Manipulator after replacing parts, be sure to check it while you are outside of the safeguarded area. Checking the operation of the Manipulator while you are inside of the safeguarded area may cause serious safety problems as the Manipulator may move unexpectedly.
- Before operating the robot system, make sure that both the Emergency Stop switches and safeguard switch function properly. Operating the robot system when the switches do not function properly is extremely hazardous and may result in serious bodily injury and/or serious damage to the robot system as the switches cannot fulfill their intended functions in an emergency.



WARNING

- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

 <p>CAUTION</p>	<ul style="list-style-type: none"><li>■ 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.) The 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 robot system.</li></ul>
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## 2. General Maintenance

This chapter describes maintenance inspections and procedures. Performing maintenance inspections and procedures properly is essential for preventing trouble and ensuring safety. Be sure to perform the maintenance inspections in accordance with the schedule.

### 2.1 Schedule for Maintenance Inspection

Inspection points are divided into five stages: daily, monthly, quarterly, biannual, and annual. The inspection points are added every stage.

If the Manipulator is operated for 250 hours or longer per month, the inspection points must be added every 250 hours, 750 hours, 1500 hours, and 3000 hours operation.

	Inspection Point				
	Daily inspection	Monthly inspection	Quarterly inspection	Biannual inspection	Annual inspection
1 month (250 h)	Inspect every day	√			
2 months (500 h)		√			
3 months (750 h)		√	√		
4 months (1000 h)		√			
5 months (1250 h)		√			
6 months (1500 h)		√	√	√	
7 months (1750 h)		√			
8 months (2000 h)		√			
9 months (2250 h)		√	√		
10 months (2500 h)		√			
11 months (2750 h)		√			
12 months (3000 h)		√	√	√	√
13 months (3250 h)		√			
⋮	⋮	⋮	⋮	⋮	⋮

h = hour

## 2.2 Inspection Point

### 2.2.1 Inspection While the Power is OFF (Manipulator is not operating)


Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts/screws. Tighten them if necessary. (For the tightening torque, refer to <i>Maintenance: 2.4 Tightening Hexagon Socket Head Cap Bolts.</i> )	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
	Each arm locking bolts	√	√	√	√	√
	Bolts/screws around shaft					√
	Bolts/screws securing motors, reduction gear units, etc.					√
Check looseness of connectors. If the connectors are loosen, push it securely or tighten.	External connectors on Manipulator (on the base connector plates etc.)	√	√	√	√	√
	Manipulator cable unit		√	√	√	√
Visually check for external defects. Clean up if necessary.	External appearance of Manipulator	√	√	√	√	√
	External cables		√	√	√	√
Check for bends or improper location. Repair or place it properly if necessary.	Safeguard etc.	√	√	√	√	√
Check tension of timing belts. Tighten it if necessary.	Inside of Arm #2				√	√
Grease conditions	Refer to <i>Maintenance: 2.3 Greasing.</i>					

### 2.2.2 Inspection While the Power is ON (Manipulator is operating)

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check motion range	Each joint					√
Move the cables back and forth lightly to check whether the cables are disconnected.	External cables (including cable unit of the Manipulator)				√	√
Push each arm in MOTOR ON status to check whether backlash exists.	Each arm					√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√
Measure the accuracy repeatedly by a gauge.	Whole					√


## 2.3 Greasing

The ball screw spline and reduction gear units need greasing regularly. Only use the grease specified in the following table.

 <b>CAUTION</b>	<p>■ Keep enough grease in the Manipulator. Operating the Manipulator with insufficient grease will damage sliding parts and/or result in insufficient function of the Manipulator. Once the parts are damaged, a lot of time and money will be required for the repairs.</p>
---	---

	Greasing part	Greasing Interval	Grease	Refer to:
Joint #3	Ball screw spline shaft	First time: after 50 km operation 2nd or more: after 100 km operation	AFB	<i>Maintenance: 10.3 Greasing the Ball Screw Spline Unit</i>
Joint #1 Joint #2	Reduction gear units	In the replacement of motor*	SK-1A	<i>Maintenance: 6.5 Replacing the Joint #1 Reduction Gear Unit 6.6 Replacing the Joint #2 Reduction Gear Unit</i>

\* Under normal conditions, the reduction gear units shall be greased only when the motor is replaced. However, in case of severe working conditions (such as high duty, high speeds, large payloads, etc.), the reduction gear units must be greased every 10,000 hours.

 <b>CAUTION</b>	<p>■ If grease gets into your eyes, mouth, or on your skin, follow the instructions below.</p> <p>If grease gets into your eyes : Flush them thoroughly with clean water, and then see a doctor immediately.</p> <p>If grease gets into your mouth : If swallowed, do not induce vomiting. See a doctor immediately. : If grease just gets into your mouth, wash out your mouth with water thoroughly.</p> <p>If grease gets on your skin : Wash the area thoroughly with soap and water.</p>
---	---

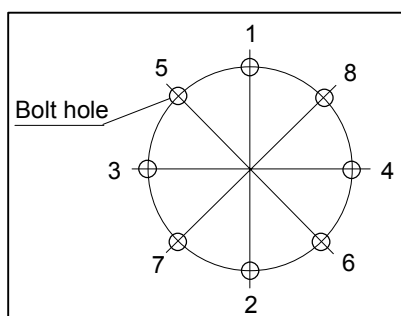
## 2.4 Tightening Hexagon Socket Head Cap Bolts

Hexagon socket head cap bolts are used in places where mechanical strength is required. (A hexagon socket head cap bolt will be called a “bolt” in this manual.) These bolts are fastened with the tightening torques shown in the following table.

When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

Bolt	Tightening Torque
M3	245 N·cm (25 kgf·cm)
M4	490 N·cm (50 kgf·cm)
M5	980 N·cm (100 kgf·cm)
M6	1,760 N·cm (180 kgf·cm)
M8	3,720 N·cm (380 kgf·cm)
M10	7,350 N·cm (750 kgf·cm)
M12	12,740 N·cm (1,300 kgf·cm)

We recommend that the bolts aligned on a circumference should be fastened in a crisscross pattern as shown in the figure below.



Do not fasten all bolts securely at one time. Divide the number of times that the bolts are fastened into two or three and fasten the bolts securely with a hexagonal wrench. Then, use a torque wrench so that the bolts are fastened with tightening torques shown in the table above.



## 2.5 Matching Origins

After parts have been replaced (motors, reduction gear units, a brake, timing belts, a ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller. After replacing the parts, it is necessary to match these origins.

The method of calibration is different depending on the software used. Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using.

For calibration, the pulse values for a specific position must be recorded in advance.

Before replacing parts, select easy point (pose) data from the registered point data to check the accuracy. Then, follow the steps below to display the pulse values and record them.

SPEL CT

Click the <Debug Pane> button and execute the following command from the [Command Execution] window.

WHERE

pulse 1: [Joint #1 Pulse value] 2: [Joint #2 Pulse value] 3: [Joint #3 Pulse value] 4: [Joint #4 Pulse value]

EPSON  
RC+

Execute the following command.

[Monitor Window] EPSON RC+ 4.\* or before (RC520/RC420)

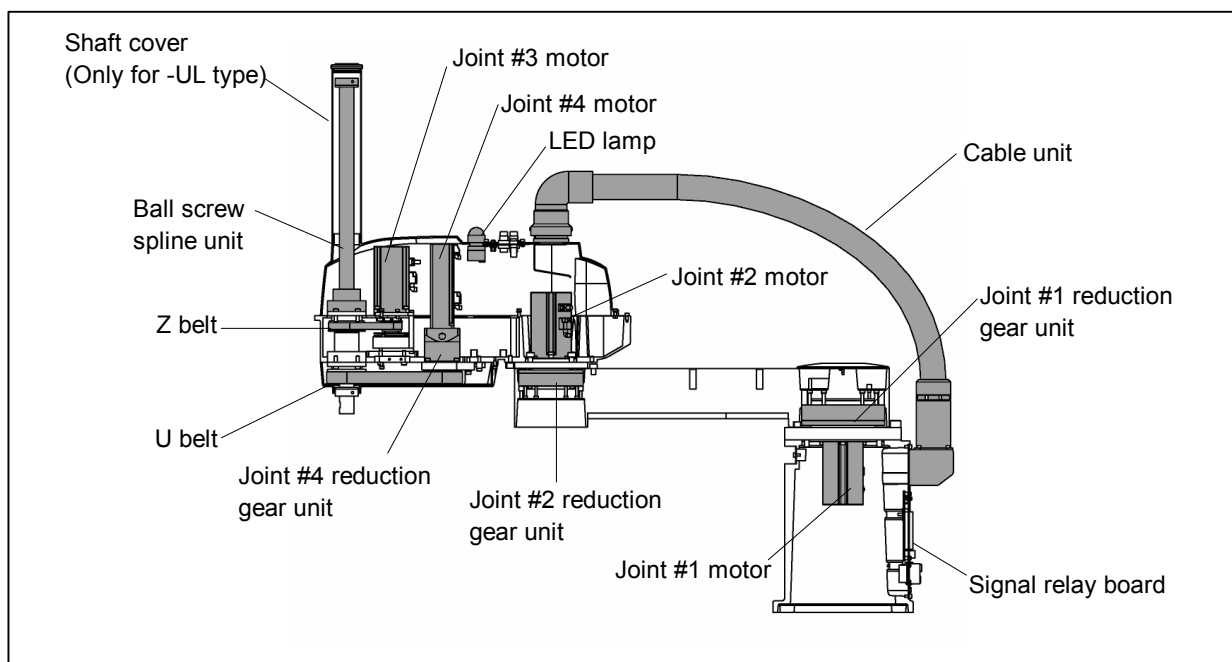
[Command Window] EPSON RC+ 5.0 or later (RC170)

>PULSE

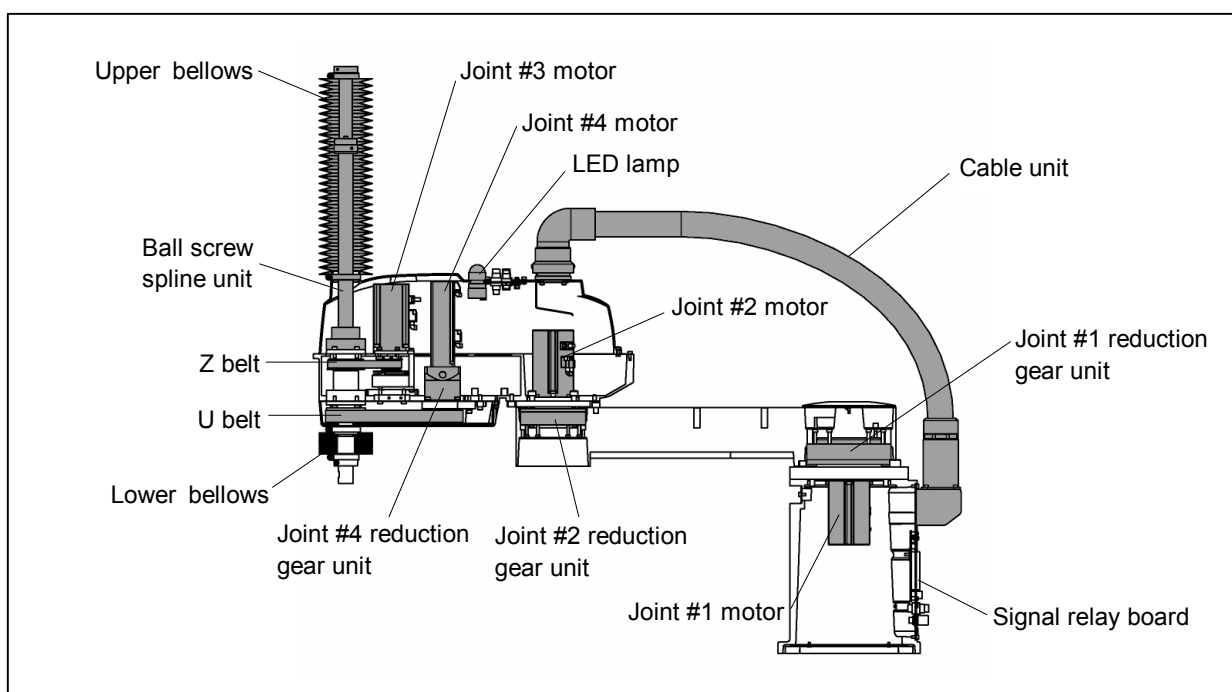
PULSE: [Joint #1 Pulse value] pls [Joint #2 Pulse value] pls [Joint #3 Pulse value]  
pls [Joint #4 Pulse value] pls

## 2.6 Layout of Maintenance Parts

### 2.6.1 Standard-model (S type)



### 2.6.2 Cleanroom-model (C Type)



### 3. Removing and Installing the Covers

All procedures for removing and installing covers in maintenance are described in this chapter.



WARNING

- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

### 3.1 Arm Top Cover

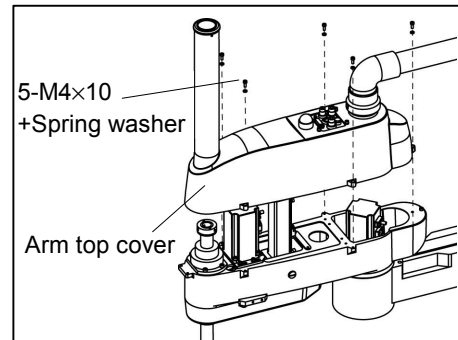


CAUTION

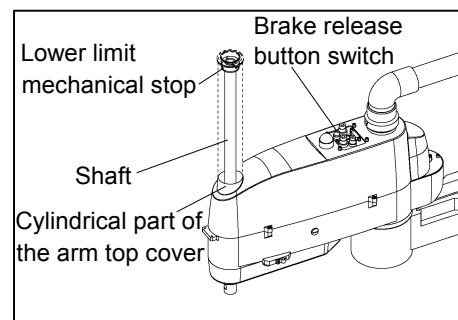
- Do not remove the arm top cover forcibly. Removing the cover forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
  - When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on 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 robot system.
- When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations.

Unscrew the arm top cover fastening bolts, and then lift the cover.

The cover cannot be removed completely because user wires and tubes are connected. However, you can continue regular maintenance.



After installing the arm top cover, press and hold the brake release button switch to let the shaft down. Make sure that the lower limit mechanical stop does not touch the cylindrical part of the arm top cover.



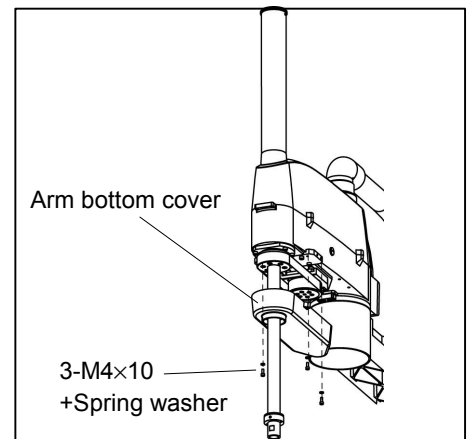
### 3.2 Arm Bottom Cover

Unscrew the arm bottom cover fastening bolts, and then pull the cover downward and remove it.

The arm bottom cover may not be removed from the shaft because the end effector is installed.

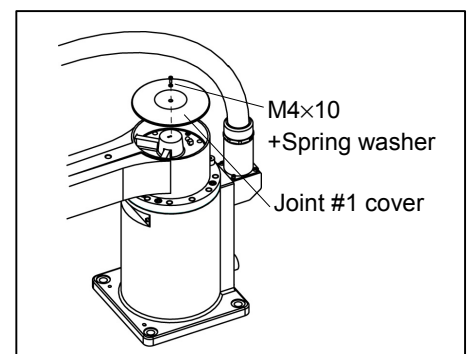
If it is necessary to remove the cover completely (for replacement of the ball screw spline unit etc.), remove the end effector.

If it is not necessary to remove the cover completely, move the shaft to the lower limit, and lower the arm bottom cover. Then, perform maintenance or inspection.



### 3.3 Joint #1 Cover

Unscrew the Joint #1 cover fastening bolt and remove the cover.



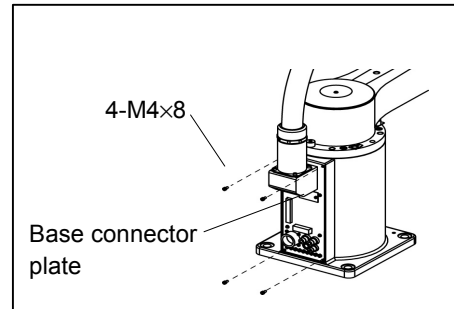
### 3.4 Base Connector Plate



CAUTION

- Do not remove the base connector plate forcibly. Removing the base connector plate forcibly 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 robot system.
- When installing the base connector plate, be careful not to allow the cables to interfere with the plate mounting and do not bend these cables forcibly to push them into the cover.  
Unnecessary strain on 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 robot system.  
When routing the cables, observe the cable locations after removing the base connector plate. Be sure to place the cables back to their original locations.

Unscrew the base connector plate mounting bolts and remove the plate.



## 4. Replacing the Cable Unit



WARNING

- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



CAUTION

- 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.) The 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 robot system.

### 4.1 Before Replacing the Cable Unit

Before replacing the cable unit, turn ON the Controller and keep it ON for 30 or more minutes. Then, turn OFF the Controller.

This preparation is necessary to charge the super-capacitors that provide the power to retain the position data when the cable is disconnected from the motor.

A super-capacitor is mounted on each motor. The charged motors can keep their position data for about 2 hours after their cables are disconnected.

Since the power is supplied to each motor from the lithium battery on the signal relay board via the signal connectors, the position data will not be lost when the Controller is turned OFF. When the signal connectors are disconnected, only the super-capacitors in the motors will retain the position data.

When the data storage time of the super-capacitor is exceeded, the position data will be lost, and an error\* will occur when the Controller is turned ON.

\*: In the case of SPEL CT, the “Error F-5016” occurs. In case of EPSON RC+, the error message that “Encoder alarm has occurred” is displayed.

If the error occurs, execute the calibration of all joints and axes.

For details on the calibration method, refer to *Maintenance: 14 Calibration*.

## 4.2 How to Replace the Cable Unit



CAUTION

- If the connectors have been disconnected during the replacement of the cable unit, be sure to reconnect the connectors to their proper positions. Refer to the block diagrams.  
Improper connection of the connectors may result in improper function of the robot system.  
For details on the connections, refer to *Maintenance: 4.5 Connector Pin Assignments*.
- When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on 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 robot system.  
When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations.
- 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.) The 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 robot system.

### Removal

- (1) Turn OFF the Controller.
- (2) Disconnect all the connectors and tubes from the base connector plate (outside).
- (3) Remove the base connector plate.

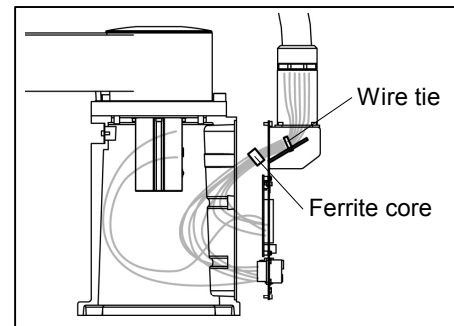
For details on the removal method, refer to *Maintenance: 3.4 Base Connector Plate*.



NOTE

Remember the cable layout so that the cables can be reconnected correctly after replacement.

- (4) Cut off the wire tie binding cables inside the base connector plate.  
Detach the ferrite core.
- (5) Disconnect X110 connector by holding the claw next to the connector number on the motor side.



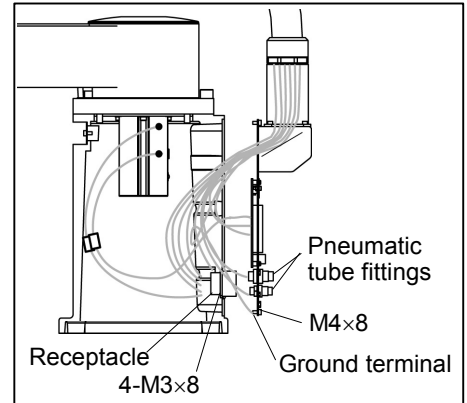


- (6) Remove the receptacle from the base connector plate.

- (7) Disconnect the pneumatic tubes and ground terminal from the base connector plate (inside).

To disconnect the pneumatic tube, push the ring on each pneumatic tube fitting and pull out its tube.

To disconnect the ground terminal, unscrew the bolt from the ground terminal.



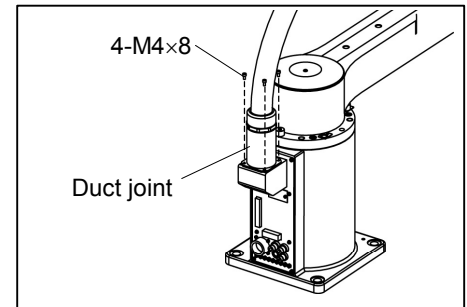
- (8) Disconnect X20, X30, X40, and X50 connectors from the signal relay board.



NOTE

Be sure to connect motors to the signal relay board with a new cable unit within 2 hours after the connectors are disconnected. Otherwise, the motor will lose position data and the calibration must be executed again.

- (9) Unscrew the bolts from the duct joint.



- (10) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.



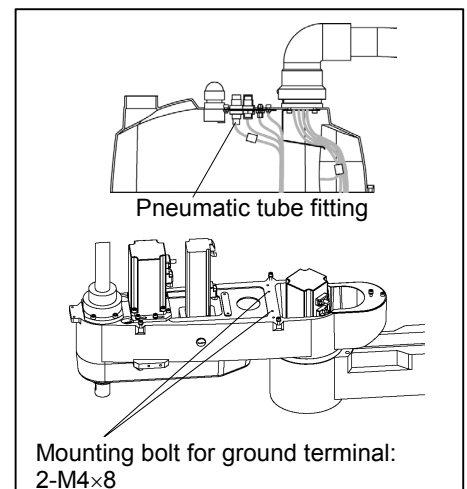
NOTE

Remember the cable layout so that the cables can be reconnected correctly after replacement.

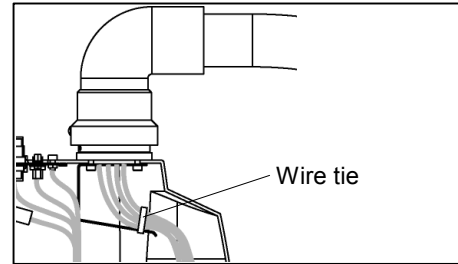
- (11) Disconnect the pneumatic tubes and ground terminal on the arm side.

To disconnect the pneumatic tubes, push the ring on each pneumatic tube fitting and pull out its tube.

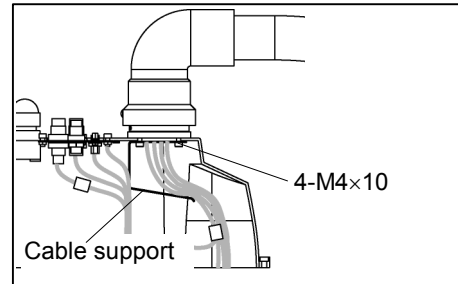
To disconnect the ground terminal, unscrew two mounting bolts for ground terminal on Arm #2.



- (12) Cut off the wire tie used for binding the cables to the cable support inside the arm top cover.

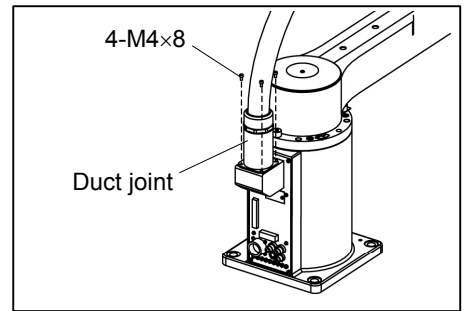


- (13) Remove the mounting bolts for the cable support, and then pull out the cable unit.

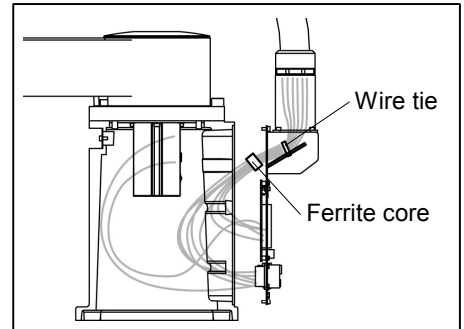


## Installation

- (1) Pass cables through the base connector plate.  
Secure the duct joint.



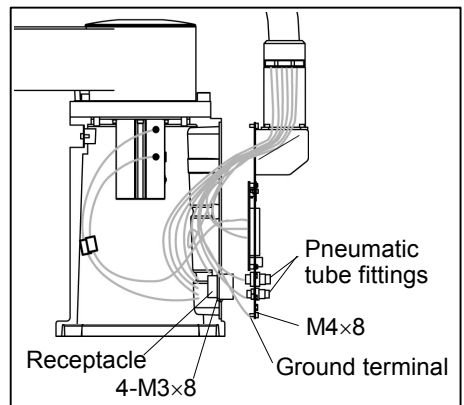
- (2) Fasten the cables with a wire tie.  
Attach a ferrite core to the bundle.



- (3) Connect pneumatic tubes, ground wire, and connectors.

For details, refer to *Maintenance: 4.3 Wiring Schematics/4.4 Block Diagrams*.

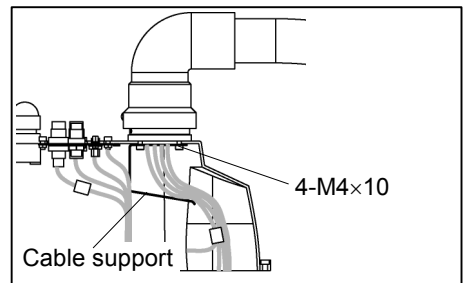
- (4) Secure the receptacle to the base connector plate.



- (5) Install the base connector plate.

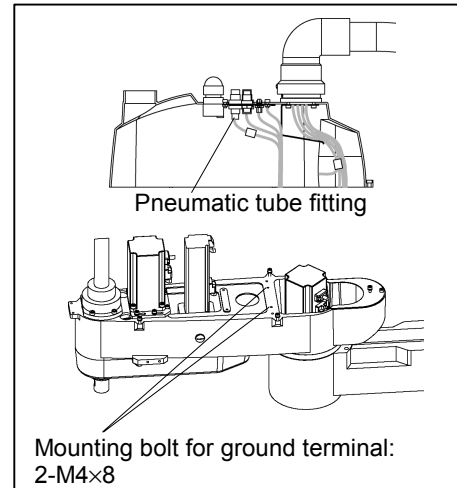
For details on the installation method, refer to *Maintenance: 3.4 Base Connector Plate*.

- (6) Pass the cable unit through the arm top cover and cable support. Then, secure them.



- (7) Connect the pneumatic tubes, ground wire, and connectors.

For details, refer to *Maintenance: 4.3 Wiring Schematics/4.4 Block Diagrams*.



- (8) Re-bundle the cables (that were released when the cable unit was removed) with wire ties.

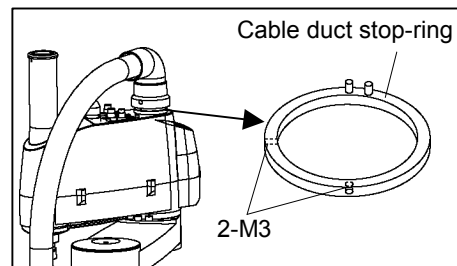
Observe the following when binding the cables with wire ties:

- The cables must not touch the pulleys, timing belts, or other movable parts/areas.
- Do not pinch the cables when attaching the covers.
- Do not allow unnecessary strain on the cables. (Do not bend these cables forcibly to push them into the cover. Otherwise, wire damage may occur.)
- The cables inside the duct must be long enough so that the cables will not be pulled.

- (9) Install the arm top cover.

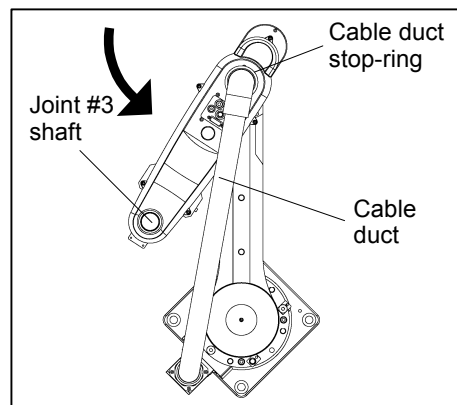
For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (10) Loosen the bolts securing the cable duct stop-ring.



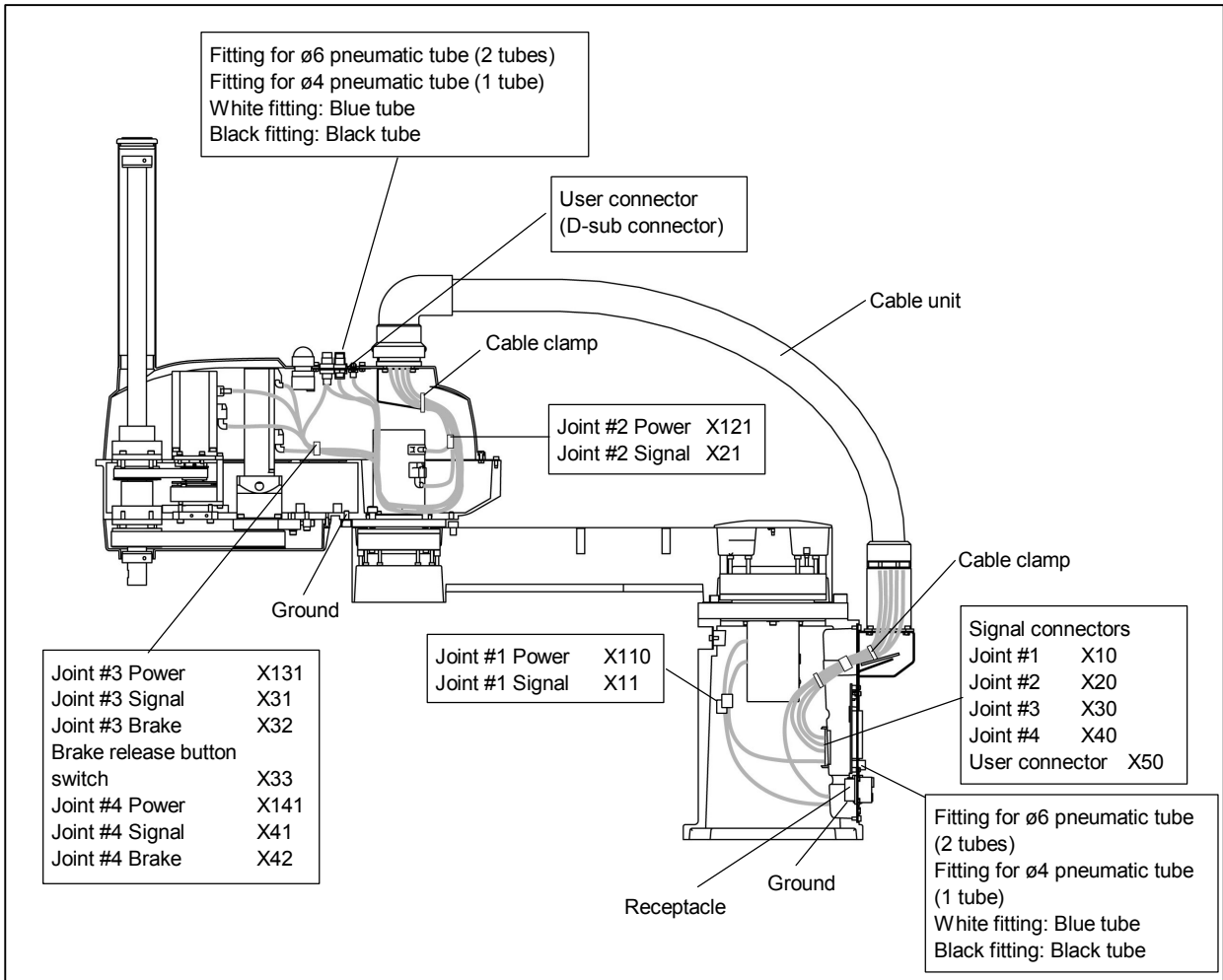
- (11) Move Arm #2 by hand until it stops after contacting the mechanical stop. Secure the cable duct stop-ring at a position where the cable duct does not interfere with the Joint #3 shaft.

Move Arm #2 to the other side by hand, and make sure that the cable duct does not interfere with the Joint #3 shaft.



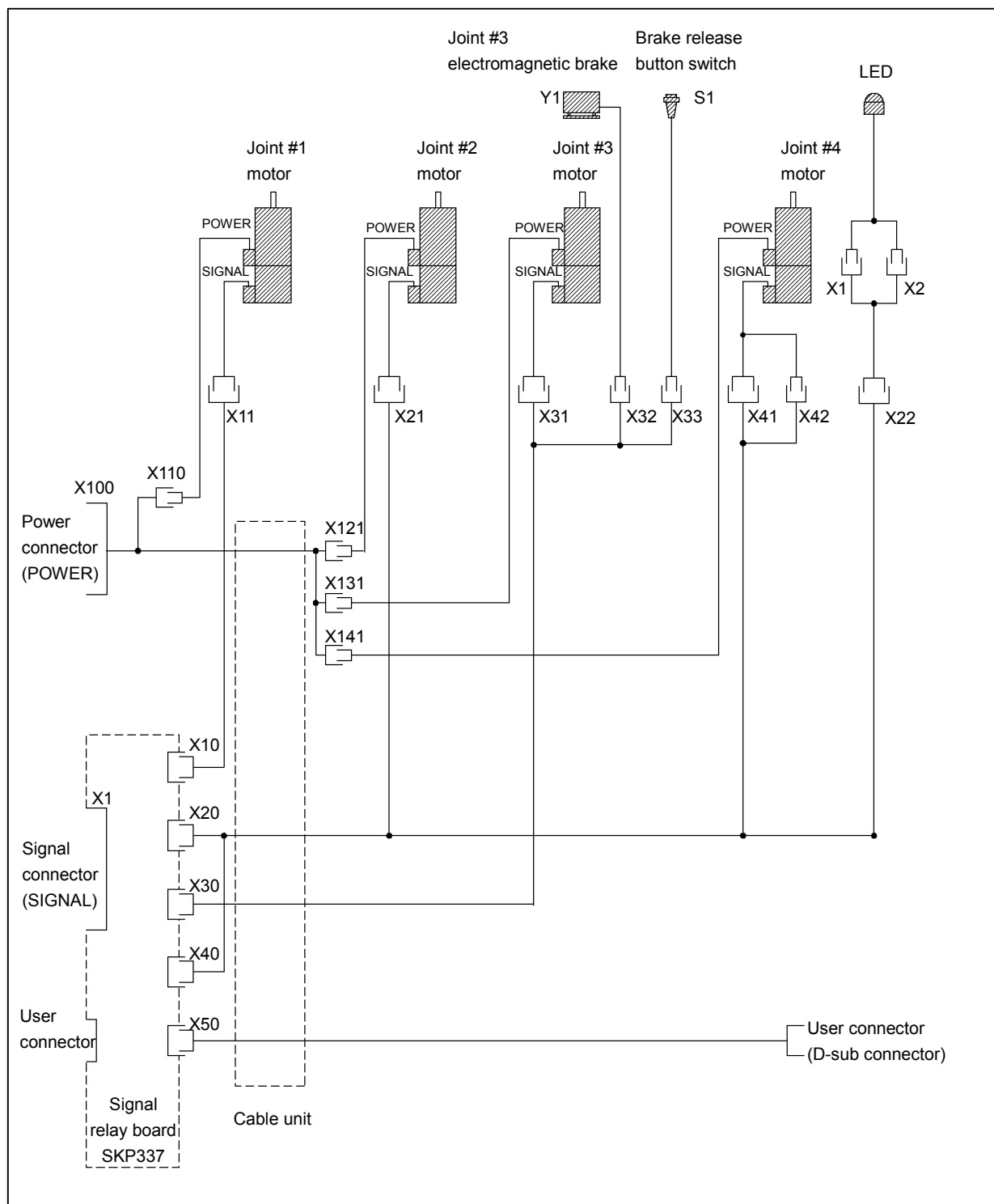
### 4.3 Wiring Schematics

S and C types have the same wiring layout.



For details on wiring, refer to *Maintenance: 4.4 Block Diagrams/4.5 Connector Pin Assignments*.

## 4.4 Block Diagrams



## 4.5 Connector Pin Assignments

X10 Signal Connector

No.	Line color	Connect to
1A	FGND	GRN
1B	N.C.	Shield
2A	1A	BLU/(WHT)
2B	$\overline{1A}$	X11-1
3A	1B	WHT/(BLU)
3B	$\overline{1B}$	X11-2
4A	1Z	YLV/(WHT)
4B	$\overline{1Z}$	X11-3
5A	1Z	GRN/(WHT)
5B	$\overline{1Z}$	X11-4
6A	1Z	WHT/(YLV)
6B	$\overline{1Z}$	X11-5
7A	1Z	GRN/(WHT)
7B	$\overline{1Z}$	X11-6
8A	1Z	WHT/(GRN)
8B	$\overline{1Z}$	X11-6
9A	N.C.	
9B	N.C.	
10A	ENC+5V	PPL/(WHT)
10B	EGND	X11-12
11A	BAT+	WHT/(PPL)
11B	BAT-	X11-13
12A	BAT+	BLU/(BRN)
12B	BAT-	X11-9
13A	RES	BRN/(BLU)
13B	RES	X11-10
14A	RES	YLV/(BRN)
14B	RES	X11-11
15A	N.C.	
15B	N.C.	
16A	N.C.	
16B	N.C.	
17A	N.C.	
17B	N.C.	
18A	N.C.	
18B	N.C.	
19A	N.C.	
19B	N.C.	
20A	N.C.	
20B	N.C.	

X11 Motor Signal Connector

No.	Line color	Connect to
1	1A	BLU/(WHT)
2	$\overline{1A}$	WHT/(BLU)
3	1B	YLV/(WHT)
4	$\overline{1B}$	WHT/(YLV)
5	1Z	GRN/(WHT)
6	$\overline{1Z}$	WHT/(GRN)
7	N.C.	Joint #1 motor encoder (SIGNAL)
8	N.C.	
9	BAT+	
10	BAT-	
11	RES	
12	ENC+5V	
13	EGND	
14	FGND	
15	BLU/(BRN)	
16	BRN/(BLU)	
17	YLV/(BRN)	
18	PPL/(WHT)	
19	WHT/(PPL)	
20	GRN	

X20 Signal Connector

No.	Line color	Connect to
1A	FGND	Shield
1B	N.C.	
2A	2A	BLU/(WHT) X21-1
2B	$\overline{2A}$	WHT/(BLU) X21-2
3A	2B	YLW/(WHT) X21-3
3B	$\overline{2B}$	WHT/(YLW) X21-4
4A	2Z	GRN/(WHT) X21-5
4B	$\overline{2Z}$	WHT/(GRN) X21-6
5A	N.C.	
5B	N.C.	
6A	ENC+5V	RED/(WHT) X21-12
6B	EGND	WHT/(RED) GRN X21-13
7A	BAT+	PPL/(WHT) X21-9
7B	BAT-	GRN X20-6B
8A	RES	WHT/(PPL) X21-11
8B	N.C.	
9A	N.C.	
9B	N.C.	
10A	N.C.	
10B	N.C.	
11A	N.C.	
11B	N.C.	
12A	Motor power monitor	BLU/(BRN) X22-1
12B	+24V	BRN/(BLU) X22-2
13A	N.C.	
13B	N.C.	

X21 Motor Signal Connector

No.		Line color	Connect to
1	2A	BLU/(WHT)	Joint #2 motor encoder (SIGNAL)
2	$\overline{2A}$	WHT/(BLU)	
3	2B	YLW/(WHT)	
4	$\overline{2B}$	WHT/(YLW)	
5	2Z	GRN/(WHT)	
6	$\overline{2Z}$	WHT/(GRN)	
7	N.C.		
8	N.C.		
9	BAT+	PPL/(WHT)	
10	N.C.		
11	RES	WHT/(PPL)	
12	ENC+5V	RED/(WHT)	
13	EGND	WHT/(RED)	
14	FGND	Shield	

X22 LED

No.	Line color	Connect to
1	X1	BLU/(BRN)
2	X2	BRN/(BLU)



X30 Signal Connector

No.	Line color	Connect to
1A	FGND	Shield
1B	N.C.	
2A	3A	BLU/(WHT) X31-1
2B	$\overline{3A}$	WHT/(BLU) X31-2
3A	3B	YLW/(WHT) X31-3
3B	$\overline{3B}$	WHT/(YLW) X31-4
4A	3Z	GRN/(WHT) X31-5
4B	$\overline{3Z}$	WHT/(GRN) X31-6
5A	N.C.	
5B	N.C.	
6A	ENC+5V	RED/(WHT) X31-12
6B	EGND	WHT/(RED) GRN X31-13
7A	BAT+	PPL/(WHT) X31-9
7B	BAT-	GRN X31-10
8A	RES	WHT/(PPL) X31-11
8B	N.C.	
9A	N.C.	
9B	N.C.	
10A	BRK.SW	BLU/(BRN) X33-2
10B	N.C.	
11A	N.C.	
11B	N.C.	
12A	$\overline{EMB2}$	YLW/(BRN) X31-2
12B	+24V	BRN/(YLW) X32-2
13A	N.C.	
13B	N.C.	

X31 Motor Signal Connector

No.		Line color	Connect to
1	3A	BLU/(WHT)	Joint #3 motor encoder (SIGNAL)
2	$\overline{3A}$	WHT/(BLU)	
3	3B	YLW/(WHT)	
4	$\overline{3B}$	WHT/(YLW)	
5	3Z	GRN/(WHT)	
6	$\overline{3Z}$	WHT/(GRN)	
7	N.C.		
8	N.C.		
9	BAT+	PPL/(WHT)	
10	N.C.		
11	RES	WHT/(PPL)	
12	ENC+5V	RED/(WHT)	
13	EGND	WHT/(RED)	
14	FGND	Shield	

X32 Brake Connector

No.	Line color	Connect to
1	$\overline{EMB2}$	YLW/(BRN) GRN
2	+24V	BRN/(YLW)

X33 Brake Switch Connector

No.	Line color	Connect to
1	$\overline{EMB2}$	GRN
2	BRK.SW	BLU/(BRN)

X40 Signal Connector

No.	Line color	Connect to
1A	N.C.	
1B	N.C.	
2A	4A	YLV/(BRN) X41-1
2B	4A	BRN/(YLW) X41-2
3A	4B	GRN/(BRN) X41-3
3B	4B	BRN/(GRN) X41-4
4A	4Z	RED/(BRN) X41-5
4B	4Z	BRN/(RED) X41-6
5A	N.C.	
5B	N.C.	
6A	ENC+5V	PPL/(BRN) X41-12
6B	EGND	BRN/(PPL) GRN X41-13 X40-7B
7A	BAT+	BLU/(BLK) X41-9
7B	BAT-	GRN X40-6B
8A	RES	BLK/(BLU) X41-11
8B	N.C.	
9A	N.C.	
9B	N.C.	
10A	N.C.	
10B	N.C.	
11A	N.C.	
11B	N.C.	
12A	YLV/(BLK)	X42-1
12B	BLK/(YLW)	X42-2
13A	N.C.	
13B	N.C.	

X41 Motor Signal Connector

No.		Line color	Connect to
1	4A	YLW/(BRN)	Joint #4 motor encoder (SIGNAL)
2	4A	BRN/(YLW)	
3	4B	GRN/(BRN)	
4	4B	BRN/(GRN)	
5	4Z	RED/(BRN)	
6	4Z	BRN/(RED)	
7	N.C.		
8	N.C.		
9	BAT+	BLU/(BLK)	
10	N.C.		
11	RES	BLK/(BLU)	
12	ENC+5V	PPL/(BRN)	
13	EGND	BRN/(PPL)	
14	FGND	GRN	

X42

No.	Line color	Connect to
1	EMB2	YLV/(BLK)
2	BRK.SW	BLK/(YLW)

Joint #4  
electromagnetic  
brake

X50 Signal Connector

No.		Line color	Connect to
1A		BLU/(WHT)	X51-1
1B		WHT/(BLU)	X51-2
2A		YLW/(WHT)	X51-3
2B		WHT/(YLW)	X51-4
3A		GRN/(WHT)	X51-5
3B		WHT/(GRN)	X51-6
4A		RED/(WHT)	X51-7
4B		WHT/(RED)	X51-8
5A		PPL/(WHT)	X51-9
5B		WHT/(PPL)	X51-10
6A		BLU/(BRN)	X52-1
6B		BRN/(BLU)	X52-2
7A		YLW/(BRN)	X52-3
7B		BRN/(YLW)	X52-4
8A		GRN/(BRN)	X52-5
8B		Shield	

User connector (D-sub Connector)

No.		Line color	Connect to
1		BLU/(WHT)	X53-1
2		WHT/(BLU)	X53-2
3		YLW/(WHT)	X53-3
4		WHT/(YLW)	X53-4
5		GRN/(WHT)	X53-5
6		WHT/(GRN)	X53-6
7		RED/(WHT)	X53-7
8		WHT/(RED)	X53-8
9		PPL/(WHT)	X53-9
10		WHT/(PPL)	X53-10
11		BLU/(BRN)	X53-11
12		BRN/(BLU)	X53-12
13		YLW/(BRN)	X53-13
14		BRN/(YLW)	X53-14
15		GRN/(BRN)	X53-15
16		Shield	

X100 Receptacle

No.	Line color	Connect to
1	1U	BLK
3	1V	WHT
6	1W	RED
10	2U	BLK
14	2V	WHT
16	2W	RED
15	3U	BRN
13	3V	BLU
9	3W	PPL
4	4U	GRY
2	4V	PNK
7	4W	ORN
5	FGND	GRN
Ground	FGND	GRN/YLW
8	N.C.	
12	N.C.	
11	N.C.	

X110 Motor Power Connector

No.	Line color	Connect to
1	1U	BLK
2	1V	WHT
3	1W	RED
4	FGND	GRN/YLW

Joint #1 motor  
(POWER)

X121 Motor Power Connector

No.	Line color	Connect to
1	2U	BLK
2	2V	WHT
3	2W	RED
4	FGND	GRN/YLW

Joint #2 motor  
(POWER)

X131 Motor Power Connector

No.	Line color	Connect to
1	3U	BRN
2	3V	BLU
3	3W	PPL
4	FGND	GRN/YLW



Joint #3 motor  
(POWER)


X141 Motor Power Connector

No.	Line color	Connect to
1	4U	GRY
2	4V	PNK
3	4W	ORN
4	FGND	GRN/YLW

Joint #4 motor  
(POWER)

## 5. Replacing the Motors


 <b>WARNING</b>	<ul style="list-style-type: none"> <li>■ Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.</li> <li>■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.</li> <li>■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.</li> </ul>
 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.</li> <li>■ Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.</li> <li>■ Keep enough grease in the Manipulator. Operating the Manipulator with insufficient grease will damage sliding parts and/or result in insufficient function of the Manipulator. Once the parts are damaged, a lot of time and money will be required for the repairs.</li> </ul>

**NOTE**  After parts have been replaced (motors, reduction gear units, brakes, timing belts, ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller.

After replacing the parts, it is necessary to match these origins.

The process of aligning the two origins is called “Calibration”.

Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

**NOTE**  A brake is mounted on each motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.



The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes for Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

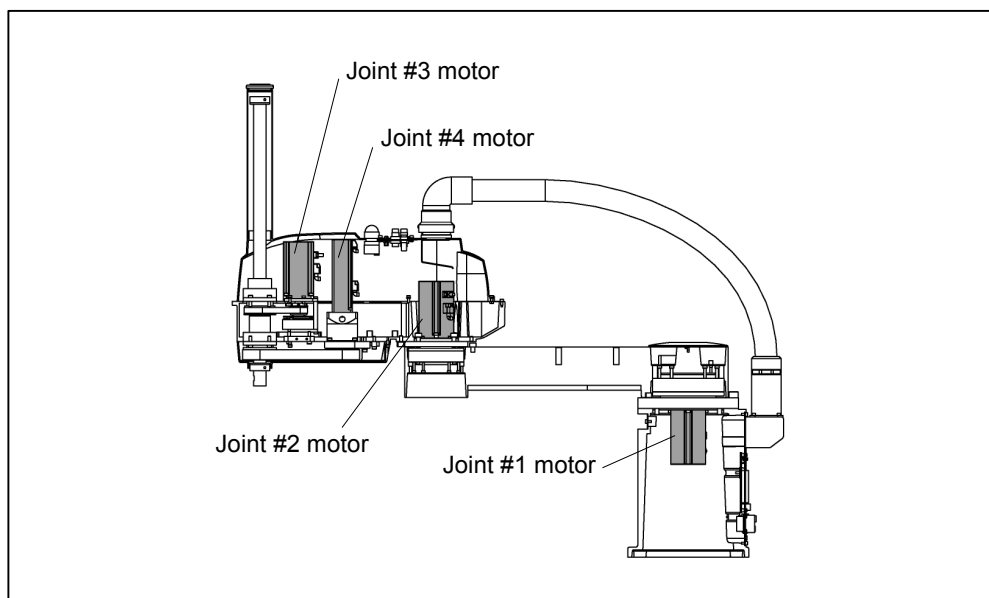
## 5.1 Types of Motors

The motor types used in E2H series Manipulators are shown in the table below.

When ordering a motor for replacement, check the working joint. Then, specify the code from the table below.

Item	Working Joint	Code	Note
AC servo motor	#1,2, and 3	R13A000600400	400 W
	#4	R13B000601	150 W with brake

## 5.2 Location of Motors



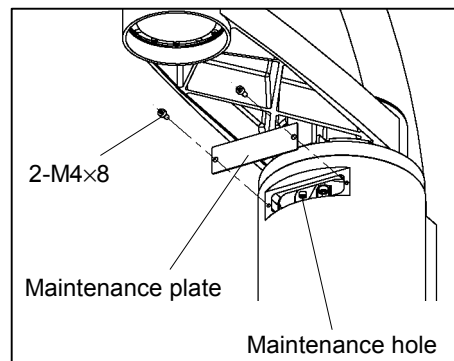
### 5.3 Replacing the Joint #1 Motor

#### Removal

- (1) Remove the base connector plate.

For details on the removal method, refer to *Maintenance: 3.4 Base Connector Plate*.

- (2) Remove the maintenance plate.



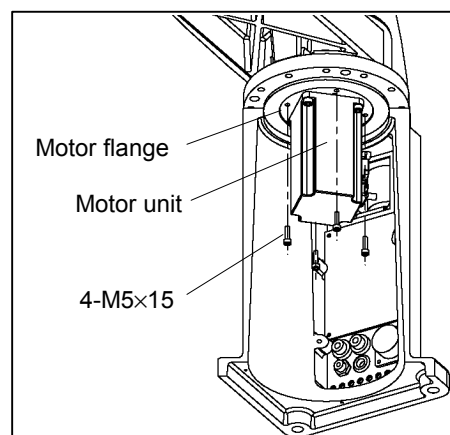
- (3) Disconnect the connectors X110 and X11.

To disconnect the X110 connector, pull it out while pushing the projection on the side of the connector.

- (4) Remove the Joint #1 motor unit from the base.

To do so, unscrew the bolts from the Joint #1 motor flange. Then, pull out the motor straight and downward.

To unscrew the two bolts on the maintenance hole side, insert a hexagonal wrench through the maintenance hole.



#### NOTE

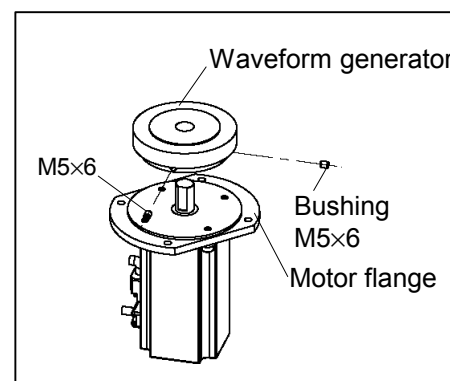


Be careful not to lose the oil seal coated with black rubber.

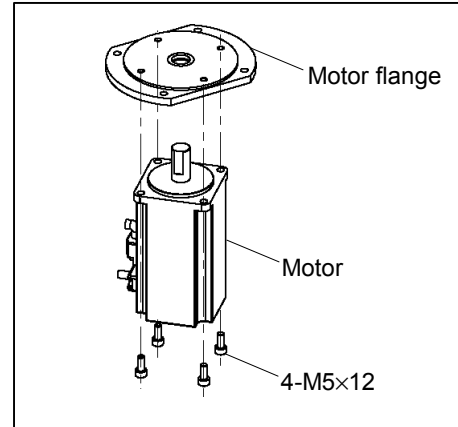
If the motor cannot be pulled out easily, pull it out while moving Arm #1 slowly by hand.

- (5) Remove the waveform generator from the Joint #1 motor.

There is a brass bushing in one of the setscrew holes. Be careful not to lose it.

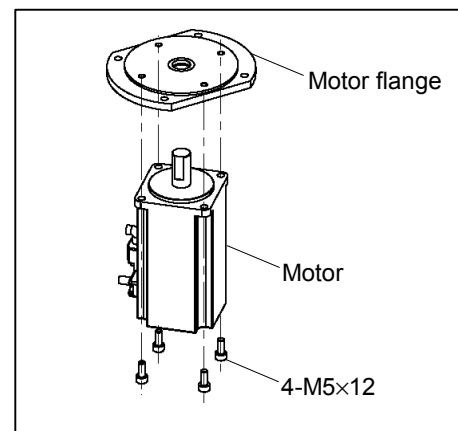


- (6) Remove the motor flange from the Joint #1 motor.



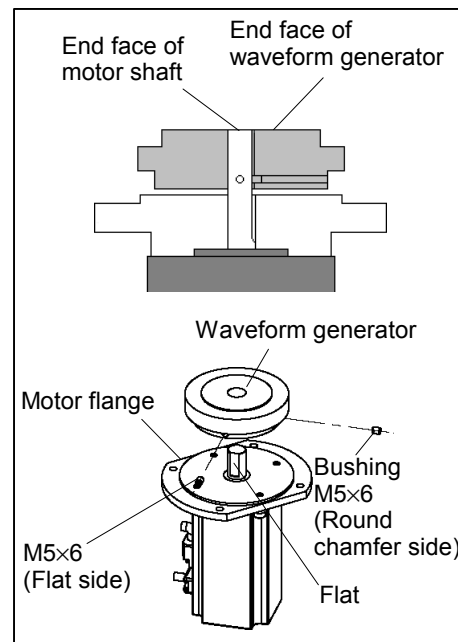
## Installation

- (1) Mount the motor flange on the Joint #1 motor.



- (2) Mount the waveform generator on the Joint #1 motor.

Be sure to fit the end face of the waveform generator to the end face of the motor shaft. Tighten one of the setscrews on the flat face of the motor shaft until the screw just touches the surface. Insert a bushing into the other setscrew hole to prevent damage to the motor shaft. Then, tighten both setscrews.



CAUTION

- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

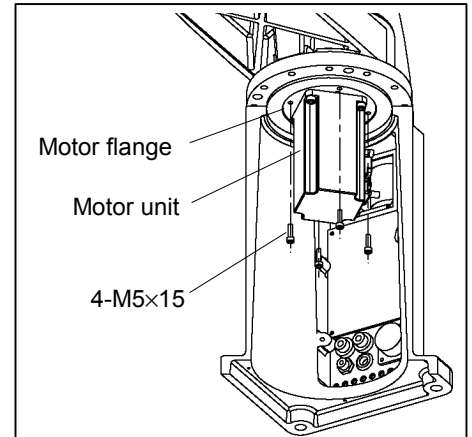


- (3) Insert the oil seal and mount the Joint #1 motor unit on the base.

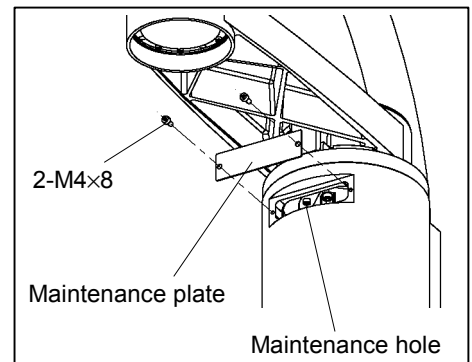
The motor cable must be located on the right side as you face the base connector plate.

To tighten the two bolts on the maintenance hole side, insert a hexagonal wrench through the maintenance hole.

If it is difficult to mount the motor, push it while moving Arm #1 slowly by hand.



- (4) Connect the connectors X110 and X11.
- (5) Attach the maintenance plate.



- (6) Install the base connector plate.

For details on the installation method, refer to *Maintenance: 3.4 Base Connector Plate*.

- (7) Perform the calibration of Joint #1.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 5.4 Replacing the Joint #2 Motor

### Removal

- (1) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

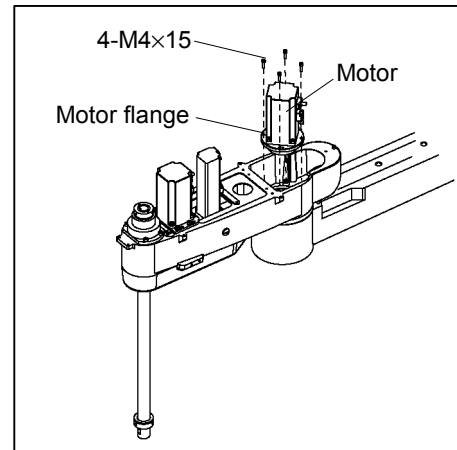
- (2) Cut off the wire tie used for binding the motor cables to the Joint #2 motor.
- (3) Disconnect the connectors X121 and X21.

To disconnect the X121 connector, pull it out while pushing the projection on the side of the connector.

- (4) Remove the Joint #2 motor unit from Arm #2.

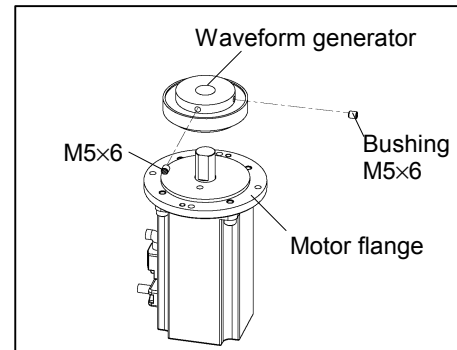
To do so, unscrew the bolts from the Joint #2 motor flange. Then, pull out the motor unit straight and upward.

If the motor cannot be pulled out easily, pull it out while moving Arm #2 slowly by hand. If a punched tap is on the motor flange, screw the two mounting bolts for motor flange into the tap.

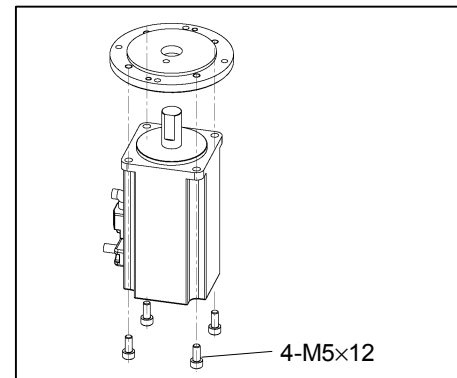


- (5) Remove the waveform generator from the Joint #2 motor.

There is a brass bushing in one of the setscrew holes. Be careful not to lose it.



- (6) Remove the motor flange from the Joint #2 motor.



## Installation

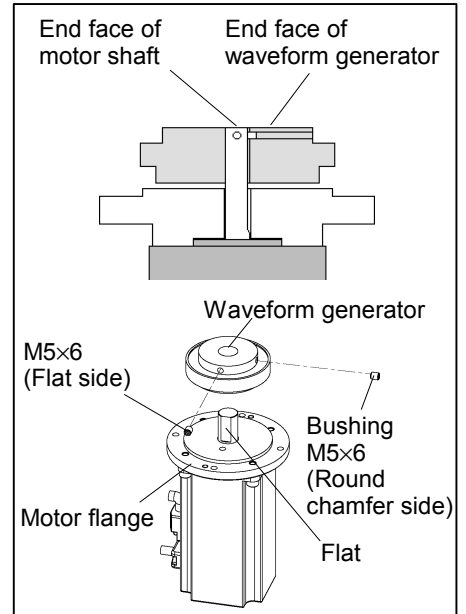
- (1) Mount the motor flange on the Joint #2 motor.
- (2) Mount the waveform generator on the Joint #2 motor.

Be sure to fit the end face of the waveform generator to the end face of the motor shaft.

Tighten one of the setscrews on the flat face of the motor shaft until the screw just touches the surface.

Insert a bushing into the other setscrew hole to prevent damage to the motor shaft.

Then, tighten both setscrews.

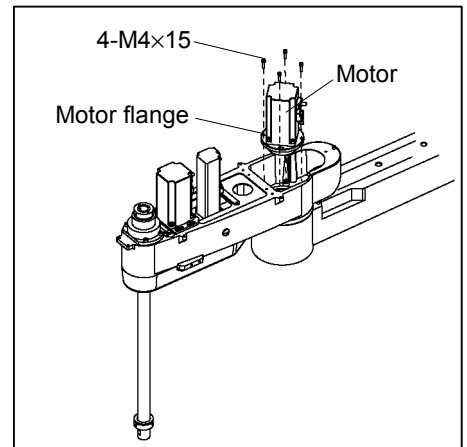


CAUTION

- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

- (3) Mount the Joint #2 motor unit on Arm #2.

If the motor cannot be put into the Manipulator base easily, push it into the base while moving Arm #2 slowly by hand.



- (4) Connect the connectors X121 and X21.
- (5) Re-bundle the cables in their original positions with a wire tie.

Do not allow unnecessary strain on the cables.


- (6) Install the arm top cover.

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (7) Perform the calibration of Joint #2.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.


## 5.5 Replacing the Joint #3 Motor

**NOTE**  A brake is mounted on the motor of Joint #3 to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.

**NOTE**  The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

### Removal

- (1) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

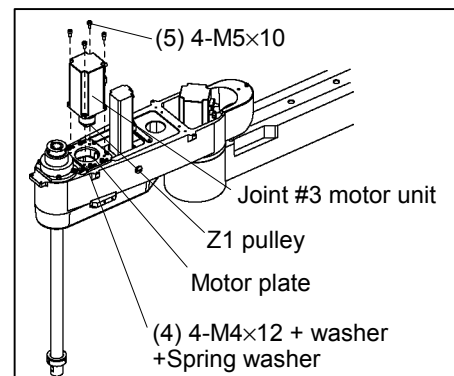
- (2) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (3) Disconnect the connectors X131 and X31.

To disconnect the X131 connector, pull it out while pushing the projection on the side of the connector.

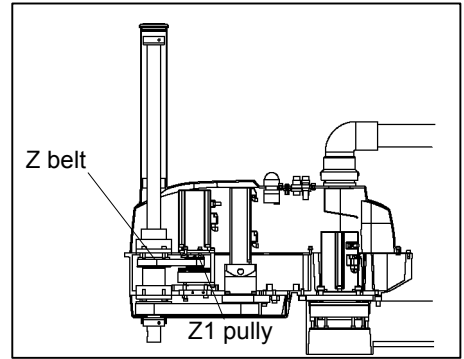
- (4) Loosen the Z belt.

Loosen four bolts on the motor plate.  
Slide the motor plate to the end of the arm.

- (5) Unscrew four bolts securing the Joint #3 motor unit to the Motor plate.

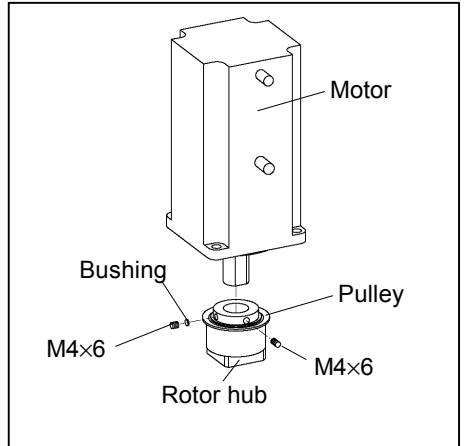


- (6) Remove the Z1 pulley from the Z belt. Pull the Joint #3 motor unit upward to remove.



- (7) Loosen two setscrews securing the pulley to the motor shaft.

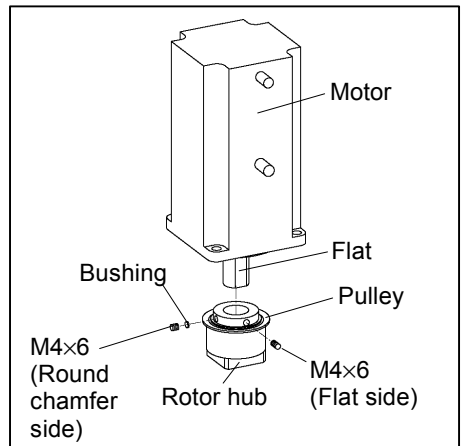
There is a brass bushing in one of the setscrew holes. Be careful not to lose it.



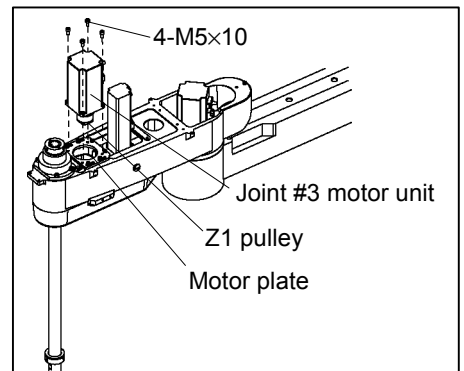
## Installation



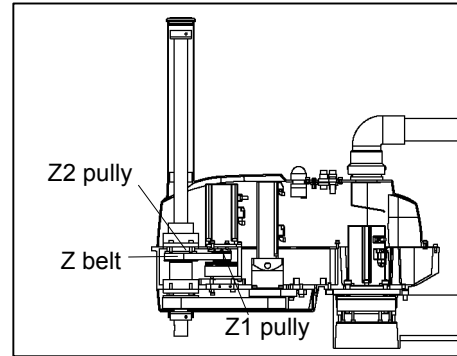
- (1) Secure the pulley to the new motor shaft. Be sure to fit the end face of the pulley to the end face of the motor shaft. Tighten one of the setscrews on the flat face of the motor shaft until the screw just touches the surface. Insert a bushing into the other setscrew hole to prevent damage to the motor shaft. Then, tighten both setscrews.



- (2) Place the Joint #3 motor unit in the arm so that the motor cable faces toward the back of the arm. Make sure that the rotor hub on the end face of the pulley is completely set in the square hole on the brake friction plate.



- (3) Place the Z belt around the Z1 pulley and the Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



- (4) Loosely secure the Joint #3 motor unit to Arm #2.

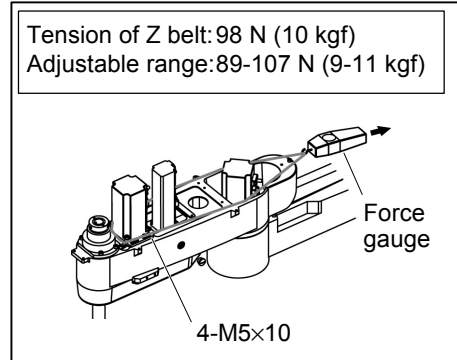


Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and will not be tilted when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

- (5) Apply the proper tension to the Z belt, and secure the Joint #3 motor unit.

To do so, pass a suitable cord or string around the Joint #3 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.

Make sure that the brake cables do not touch the pulley.



- (6) Connect the connectors X131 and X31.
- (7) Re-bundle the cables in their original positions with a wire tie.

Do not allow unnecessary strain on the cables.

- (8) Install the arm top cover.

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (9) Perform the calibration of Joint #3.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 5.6 Replacing the Joint #4 Motor



A brake is mounted on the motor of Joint #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.



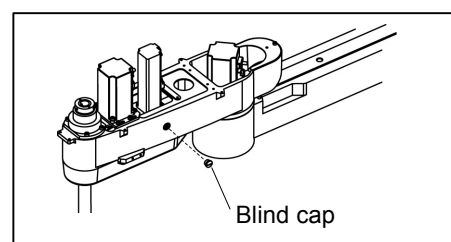
The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

### Removal

- (1) Remove the blind cap on the side of the arm.



- (2) Loosen the bolt for the split muff coupling that secures the motor shaft.

Insert a hexagonal wrench through the hole on the side of the arm. If the bolt hole location does not fit the hole on the side of the arm, turn ON the Controller and rotate the U axis while pressing the brake release button switch to adjust the bolt hole location. Turn OFF the Controller before going on the next step.



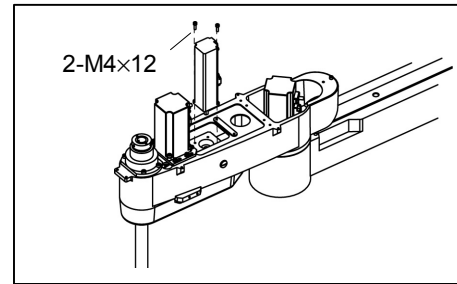
- (3) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Covers*.

- (4) Cut off the wire tie used for binding the motor cables to the Joint #4 motor.
- (5) Disconnect connectors X141, X41 and X42.

To disconnect the X141 connector, pull it out while pushing the projection on the side of the connector.

- (6) Remove the Joint #4 motor unit from the reduction gear unit.



## Installation

- (1) Insert the motor shaft into the reduction gear unit.

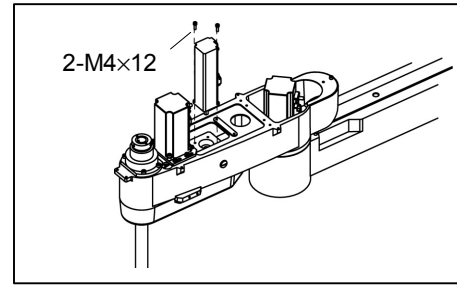
NOTE



Be sure to insert the motor vertically.

- (2) Secure the motor to the reduction gear unit.

Tightening torque: 310 N·cm (32kgf·cm)



- (3) Insert a hexagonal wrench through the hole on the side of the arm and tighten the bolt for the split muff coupling that secures the motor shaft.

Tightening Torque: 200N·cm (20kgf·cm)

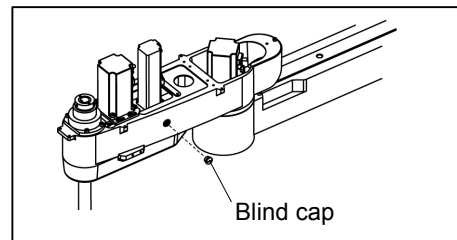
NOTE



Do not tighten the bolt too much. Tightening the bolt too much may break parts.



- (4) Insert the blind cap into the hole on the side of the arm.



- (5) Connect the connectors X141 and X41.

- (6) Re-bundle the cables in their original positions with a wire tie.

Do not allow unnecessary strain on the cables.

- (7) Install the arm top cover.

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (8) Perform the calibration of Joint #4.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.



## 6. Replacing the Reduction Gear Units



- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.

When replacing the Joint #2 reduction gear unit, liquid gasket is necessary.



After parts have been replaced (motors, reduction gear units, brakes, timing belts, ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller.

After replacing the parts, it is necessary to match these origins.

The process of aligning the two origins is called “Calibration”.

Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



A brake is mounted on the motor of Joint #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.

NOTE



The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

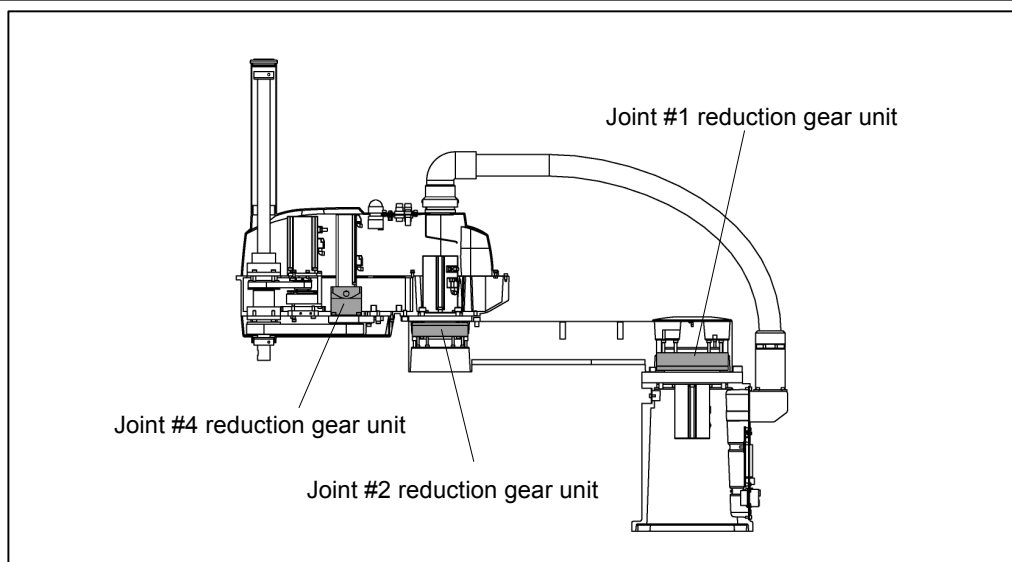
## 6.1 Types of Reduction Gear Units

The types of the reduction gear units used in E2H series Manipulators are shown in the table below.

When ordering a reduction gear unit for replacement, verify the corresponding working joint. Then, specify the code from the table below.

Item	Working Joint	Code	Note
Reduction gear unit	#1	R13ZA00100600	SHF-32-100
	#2	R13ZA00100700	SHF-25-80
	#3	R13B010001	HPG-14A-21-F0ABK

## 6.2 Location of Reduction Gear Units



### 6.3 Structure of Reduction Gear Unit

A reduction gear unit consists of the following three parts. When replacing the reduction gear unit, be sure to always replace the waveform generator, flexspline, and circular spline all together as one set.

(1) Waveform generator

This waveform generator consists of an ellipsoidal cam with ball bearings on its outer circumference.

The inner ring of bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.

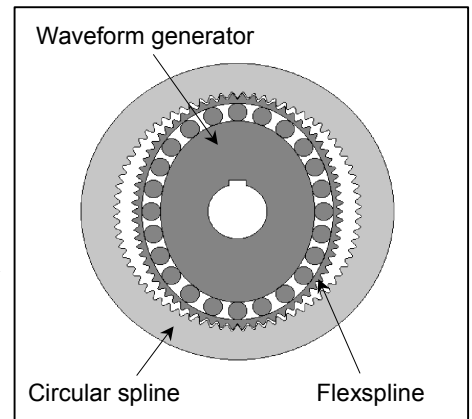
(2) Flexspline

A thin, elastic, cup-shaped metal body with gear teeth around the outer circumference of the opening.

(3) Circular spline

A rigid, ring-shaped body with gear teeth on the inner circumference.

The circular spline has two more teeth than the flexspline does.

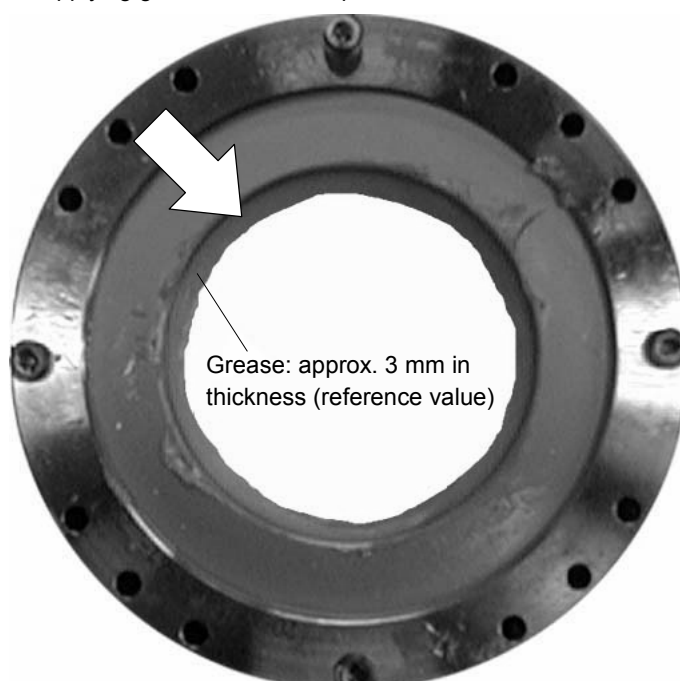


## 6.4 Greasing the Reduction Gear Units

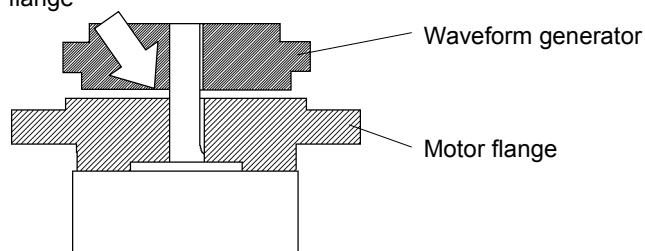
When greasing the reduction gear units, only use the grease specified for the reduction gear units. The type of grease is different from that used for the ball screw spline. While greasing the reduction gear units, be careful not to allow any foreign substances in the grease. Adequate quantities of grease are specified as follows:

Reduction gear unit	Grease quantity		Code	Note
	Flexspline	Between the waveform generator and motor flange		
Joint #1	60 g	6 g	R13ZA00330100	SK-1A
Joint #2	27 g	4 g		

Place for applying grease on the flexspline



Place for applying grease between the waveform generator and motor flange



## 6.5 Replacing the Joint #1 Reduction Gear Unit

### Removal

- (1) Remove the power cable and signal cable from the base connector plate (outside).
- (2) Remove the Joint #1 cover.

For details on the removal method, refer to *Maintenance: 3.3 Joint #1 Cover*.

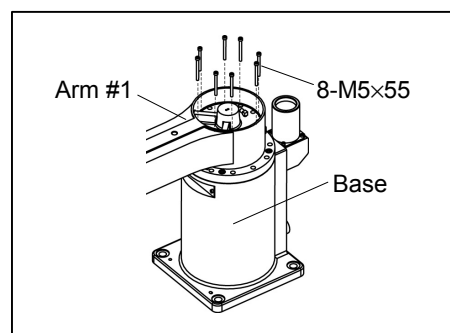


- When removing or installing the arm, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot system.

- (3) Remove Arm #1 from the base.

To do so, support Arm #1 with two or more people. Then, have another person unscrew the mounting bolts from Arm #1.

Place the removed arm gently on the floor to avoid shock.

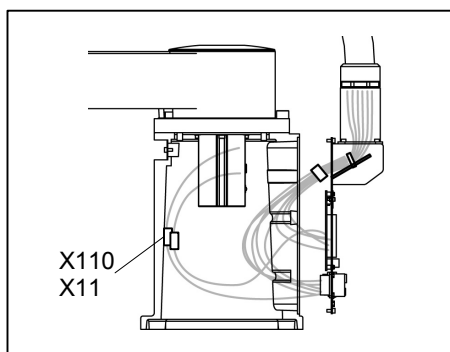


- (4) Remove the base connector plate.

For details on the removal method, refer to *Maintenance: 3.4 Base Connector Plate*.

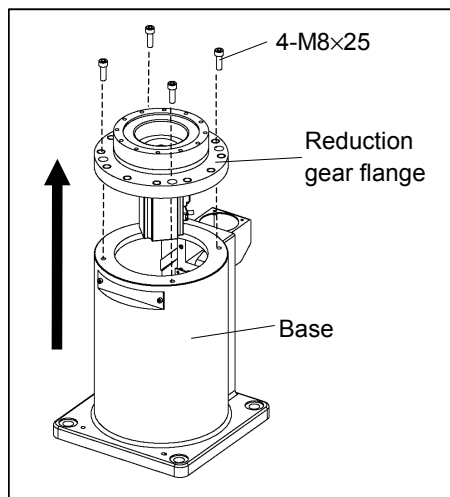
- (5) Disconnect the connectors X110 and X11.

To disconnect the X110 connector, pull it out while pushing the projection on the side of the connector.



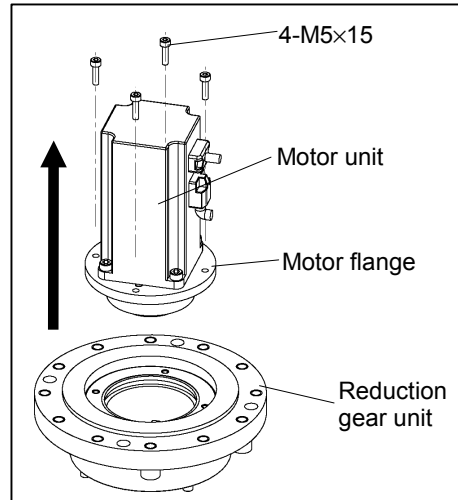
- (6) Remove the Joint #1 reduction gear unit from the base.

To do so, unscrew the bolts from the reduction gear flange. Then, pull the reduction gear unit upward to remove it.

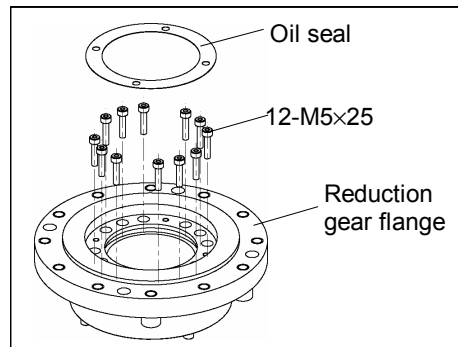


- (7) Remove the Joint #1 motor unit from the Joint #1 reduction gear unit.

To do so, unscrew the bolts from the motor flange. Then, pull the motor unit upward to remove it.

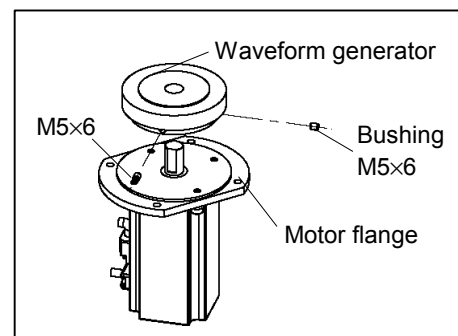


- (8) Detach the oil seal from the Joint #1 reduction gear, and then remove the reduction gear flange.



- (9) Remove the waveform generator from the Joint #1 motor.

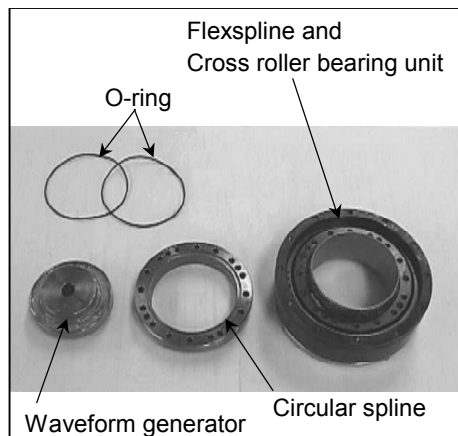
There is a brass bushing in one of the setscrew holes. Be careful not to lose it.



## Installation

- (1) A new reduction gear unit contains the parts shown in the picture on the right when it is unpacked.

The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.

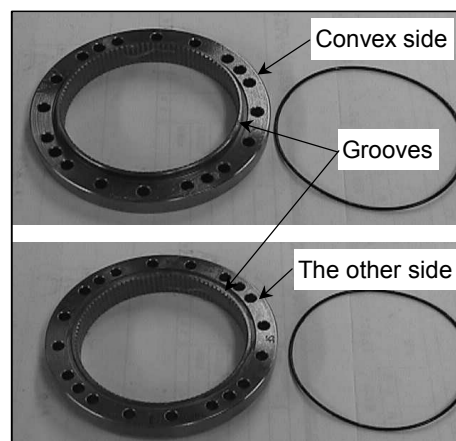


CAUTION

- Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

- (2) Fit the O-rings into the grooves on both sides of the new circular spline.

Make sure that the rings do not come out of the grooves.



- (3) Face the convex side of the circular spline down, and then fit it into the flexspline.

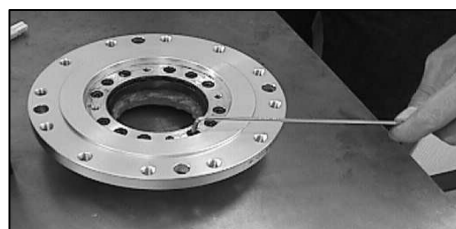


- (4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



- (5) Secure the reduction gear flange to the circular spline.

Loosely fasten all bolts in a crisscross pattern so that the bolts will be fastened evenly. Then, using a torque wrench, tighten each bolt securely in a crisscross pattern at the torque specified in the table below.



Item	Bolt Type	The Number of Bolts	Tightening Torque
Joint #1 reduction gear	M5×25	12	980 N·cm (100 kgf·cm)



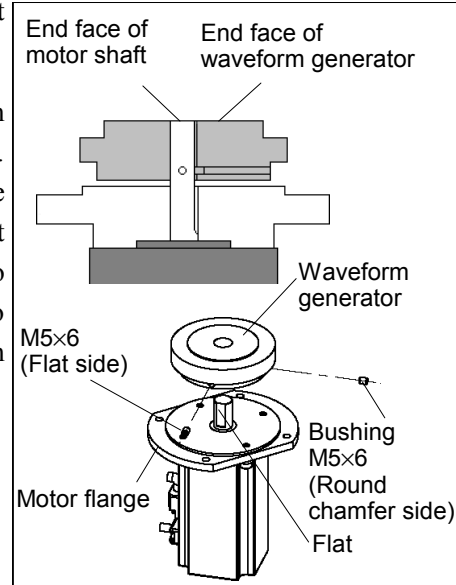
Be careful not to apply too much force since it may damage the parts.

- (6) Apply grease (SK-1A) between the waveform generator and motor flange.

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*.

- (7) Mount the waveform generator on the Joint #1 motor.

Be sure to fit the end face of the waveform generator to the end face of the motor shaft. Tighten one of the setscrews on the flat face of the motor shaft until the screw just touches the surface. Insert a bushing into the other setscrew hole to prevent damage to the motor shaft. Then, tighten both setscrews.

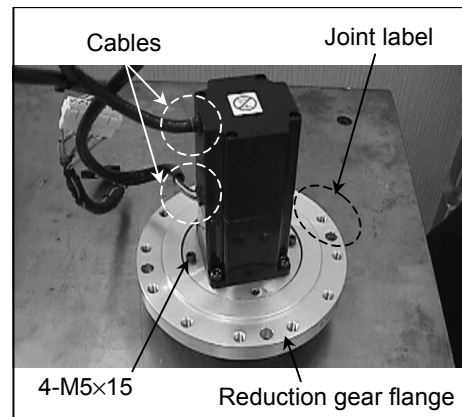


CAUTION

- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

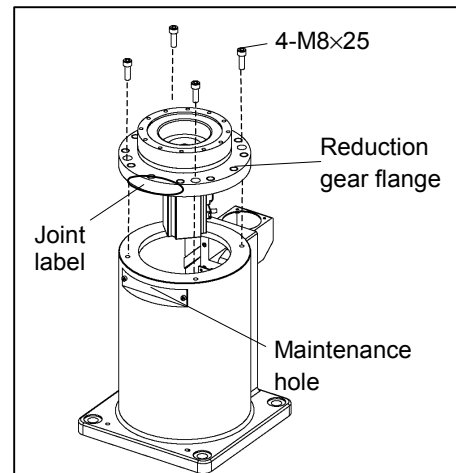
- (8) Mount the Joint #1 motor unit on the Joint #1 reduction gear unit.

Make sure that the motor cables are located in the position as shown in the picture on the right toward the joint label on the reduction gear flange.



- (9) Install the Joint #1 reduction gear unit on the base.

Be sure to fit the side that the joint label is attached on the side that the maintenance hole is located.




CAUTION

- Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.



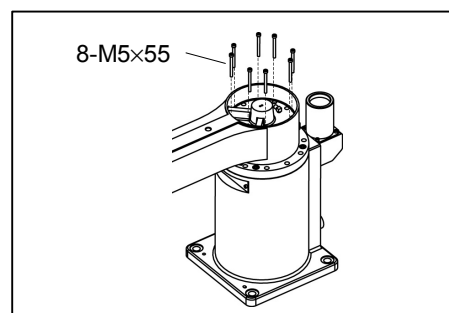
- (10) Apply grease (SK-1A) inside the flexspline.

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*.

 <b>CAUTION</b>	<p>■ When removing or installing the arm, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot system.</p>
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- (11) Mount Arm #1 on the base.

To do so, support the arm with two or more people. Then, have another person secure the mounting bolts for Arm #1.



- (12) Connect the connectors X110 and X11.

- (13) Install the base connector plate.

For details on the installation method, refer to *Maintenance: 3.4 Base Connector Plate*.

- (14) Install the Joint #1 cover.

For details on the installation method, refer to *Maintenance: 3.3 Joint #1 Cover*.

- (15) Connect the power cable and signal cable to the base connector plate (outside).

- (16) Perform the calibration of Joint #1.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 6.6 Replacing the Joint #2 Reduction Gear Unit

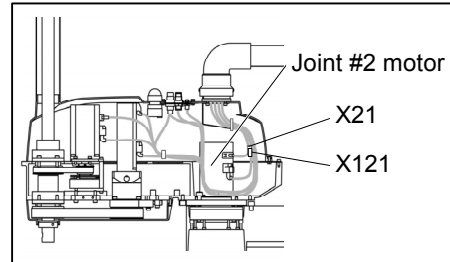
### Removal

- (1) Remove the power cable and signal cable from the base connector plate (outside).
- (2) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (3) Cut off the wire tie used for binding the cables to the Joint #2 motor.
- (4) Disconnect the connectors X121 and X21.

To disconnect the X121 connector, pull it out while pushing the projection on the side of the connector.



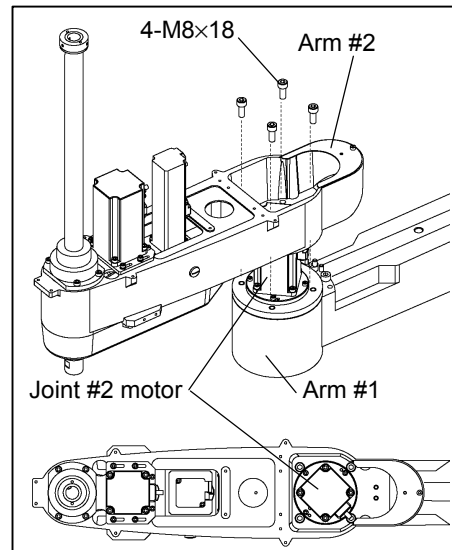
CAUTION

- When removing or installing the arm, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot system.

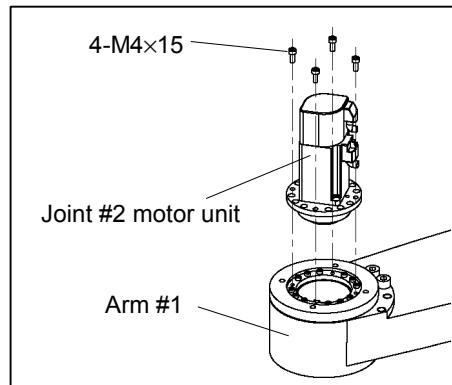
- (5) Remove Arm #2 from Arm #1.

To do so, support Arm #2 with two or more people. Then, have another person unscrew the mounting bolts from Arm #2.

Place the removed arm gently on the floor to avoid shock.

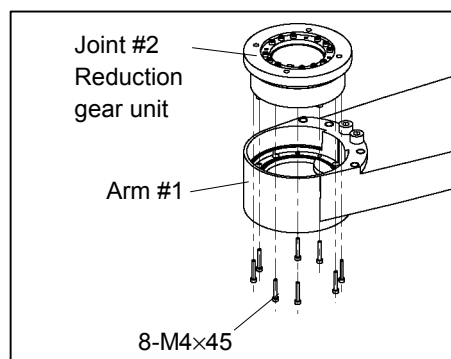


- (6) Remove the Joint #2 motor unit from Arm #1.



- (7) Remove the Joint #2 reduction gear unit from Arm #1.

To do so, unscrew the mounting bolts for the reduction gear unit on the lower side of Arm #1. Then, pull the reduction gear unit upward to remove it.



NOTE

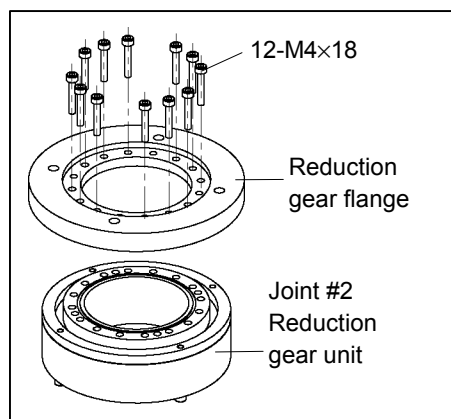


For the prevention of grease leakage, liquid gasket is used on the joint area between Arm #1 and the Joint #2 reduction gear unit.

The reduction gear unit may not come out easily.

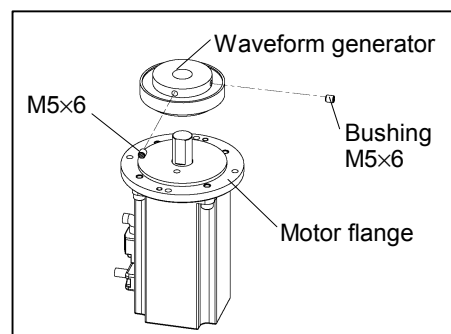
In that case, insert a flat screwdriver between the reduction gear flange and Arm #1. Then, gently pry them apart.

- (8) Remove the reduction gear flange from the Joint #2 reduction gear unit.



- (9) Remove the waveform generator from the Joint #2 motor.

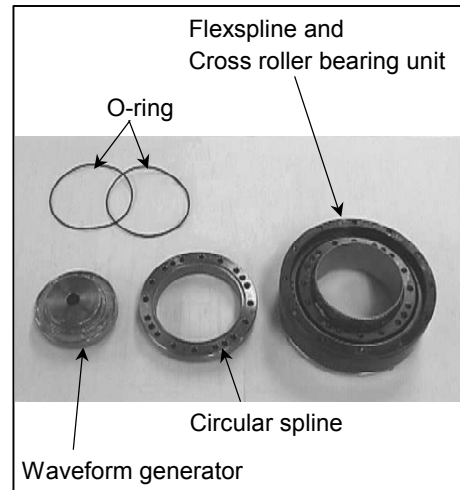
There is a brass bushing in one of the setscrew holes. Be careful not to lose it.



## Installation

- (1) A new reduction gear unit contains the parts shown in the picture on the right when it is unpacked.

The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.

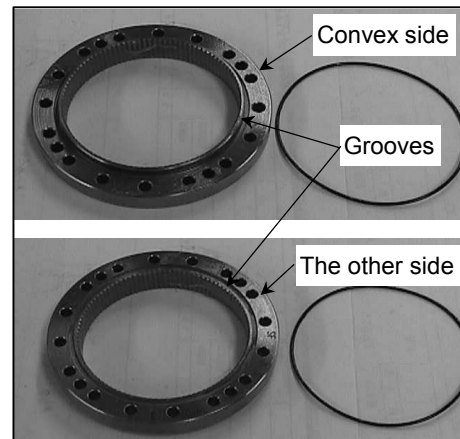


CAUTION

- Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

- (2) Fit the O-rings into the grooves on both sides of the new circular spline.

Make sure that the rings do not come out of the grooves.



- (3) Face the convex side of the circular spline down, and then fit it into the flexspline.

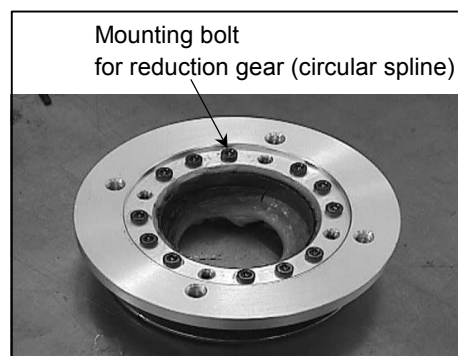


- (4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



- (5) Secure the reduction gear flange to the circular spline.

Loosely fasten all bolts in a crisscross pattern so that the bolts will be fastened evenly. Then, using a torque wrench, tighten each bolt securely in a crisscross pattern at the torque specified in the table below.



Item	Bolt Type	The Number of Bolts	Tightening Torque
Joint #2 reduction gear unit	M4 × 18	12	490 N·cm (50 kgf·cm)



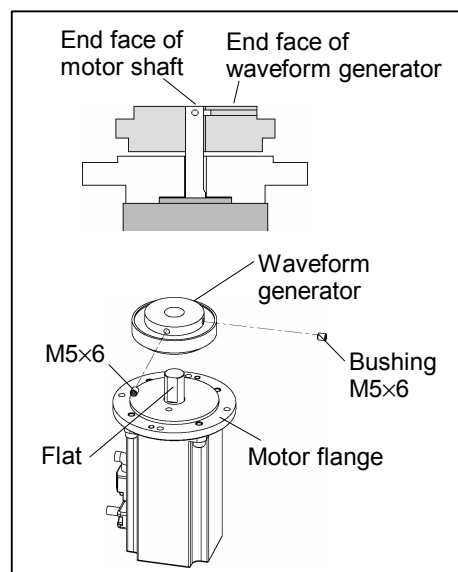
Be careful not to apply too much force since it may damage the parts.

- (6) Apply grease (SK-1A) between the waveform generator and motor flange.

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*.

- (7) Mount the waveform generator to the Joint #2 motor.

Be sure to fit the end face of the waveform generator to the end face of the motor shaft. Tighten one of the setscrews on the flat face of the motor shaft until the screw just touches the surface. Insert a bushing into the other setscrew hole to prevent damage to the motor shaft. Then, tighten both setscrews.



CAUTION

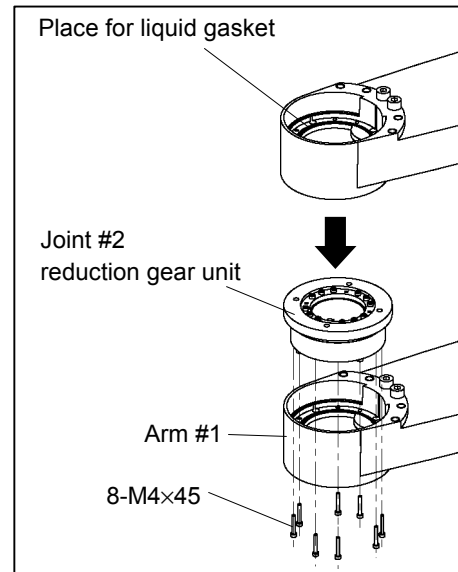
- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

- (8) For the prevention of grease leakage, put liquid gasket on the joint area between Arm #1 and the Joint #2 reduction gear unit.

Remove the old liquid gasket from the clamp face on the Arm #1 side. Then, apply the new liquid gasket equally on a circle inside the bolt hole.

- (9) Mount Arm #1 on the Joint #2 reduction gear unit.

Loosely fasten all bolts in a crisscross pattern so that the bolts will be fastened evenly. Then, using a torque wrench, tighten each bolt securely in a crisscross pattern at the proper torque.

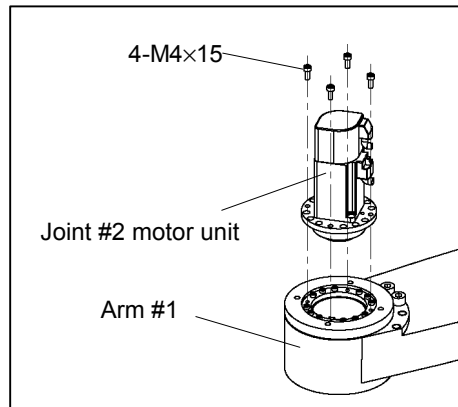


- (10) Apply grease (SK-1A) inside the flexspline.

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*.

- (11) Mount the Joint #2 motor unit on Arm #1.

Make sure that the motor cables face toward the direction as shown in the figure on the right.

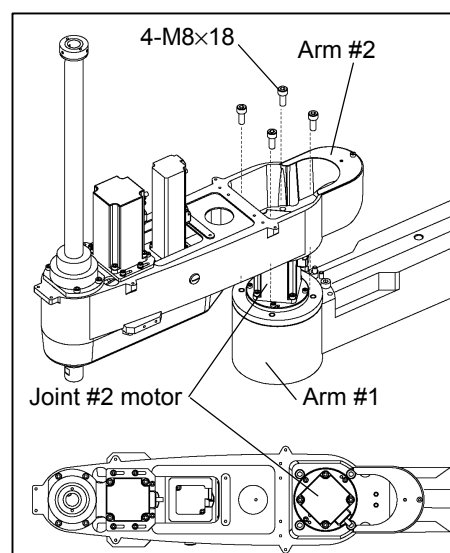


CAUTION

- When removing or installing the arm, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot system.

- (12) Mount Arm #2 on Arm #1.

To do so, support the arm with two or more people. Then, have another person secure the mounting bolts for Arm #2.



- (13) Connect the connectors X121 and X21.

- (14) Re-bundle the cables in their original positions with a wire tie.

Do not allow unnecessary strain on the cables.

- (15) Install the arm top cover.

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (16) Connect the power cable and signal cable to the base connector plate (outside).

- (17) Perform the calibration of Joint #2.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 6.7 Replacing the Joint #4 Reduction Gear Unit



A brake is mounted on the motor of Joint #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit peripheral equipment.



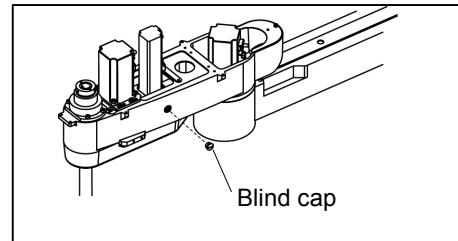
The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

### Removal

- (1) Remove the blind cap on the side of the arm.



- (2) Loosen the bolt for the split muff coupling that secures the motor shaft.

Insert a hexagonal wrench in the hole on the side of the arm. If the bolt hole location does not fit the hole on the side of the arm, turn ON the Controller and rotate the U axis while pressing the brake release button switch to adjust the bolt hole location. Turn OFF the Controller before going on the next step.



- (3) Remove the power cable and signal cable from the base connector plate (outside).
- (4) Remove the arm top cover and the arm bottom cover.

For details on the removal method, refer to *Maintenance: 3.Removing and Installing the Covers*.

- (5) Cut off the wire tie used for binding the cables to the Joint #4 motor.

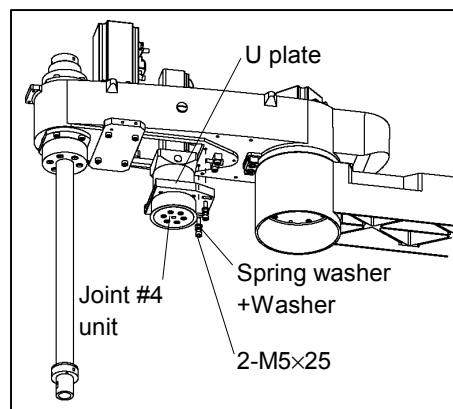


- (6) Disconnect the connectors X141, X41 and X42.

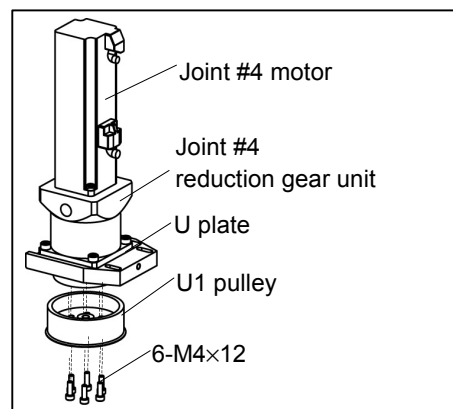
To disconnect the X141 connector, pull it out while pushing the projection on the side of the connector.

- (7) Remove the Arm #4 unit from the Arm #2.

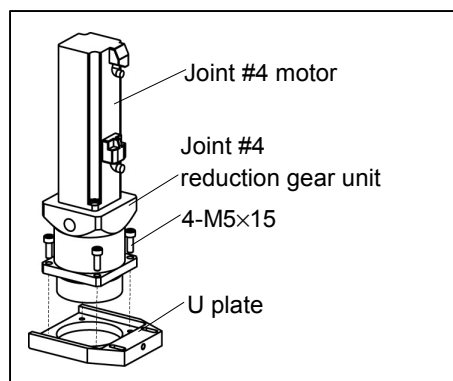
Unscrew the bolts from the Joint #4 unit and the tension adjustment screw for U belt. Pull the Joint #4 unit downward to remove it.



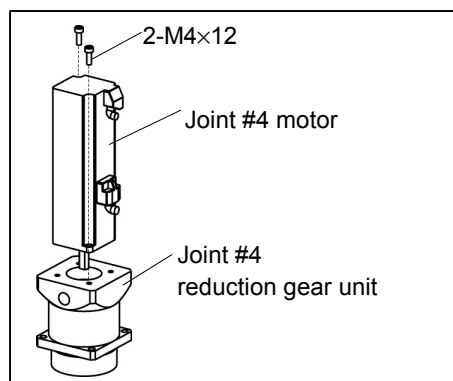
- (8) Remove the U1 pulley from the Joint #4 unit.



- (9) Remove the U plate from the Joint #4 unit.



- (10) Remove the Joint #4 motor from the reduction gear unit



## Installation

- (1) Mount the Joint #4 motor unit on the reduction gear unit.

(Be sure to mount the motor vertically.)

- (2) Secure the motor to the reduction gear unit.

Tightening Torque: 310 N·cm (32kgf·cm)

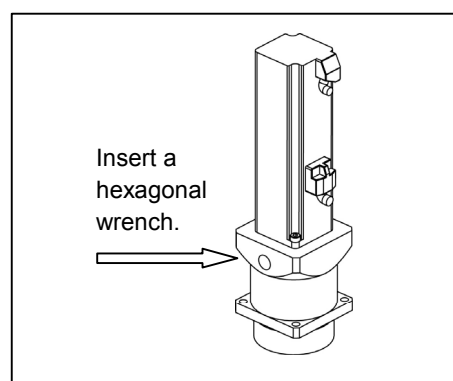
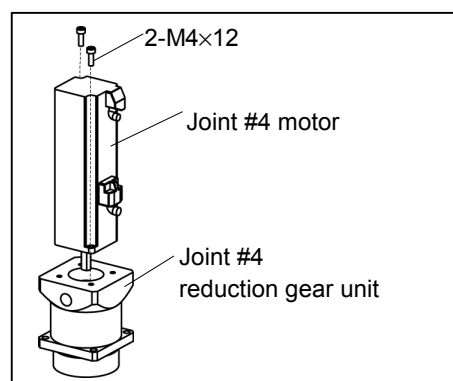
- (3) Insert a hexagonal wrench in the hole on the side of the reduction gear unit. Then, tighten the bolt for the split muff coupling that secures the motor shaft.

Tightening Torque: 200N·cm (20kgf·cm)

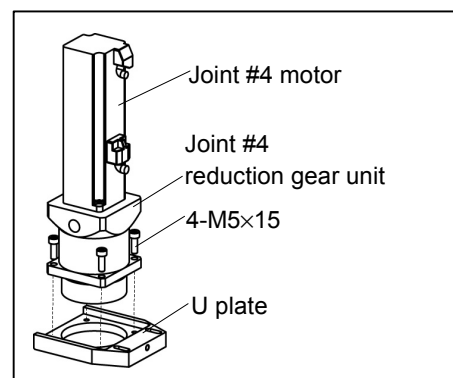
NOTE



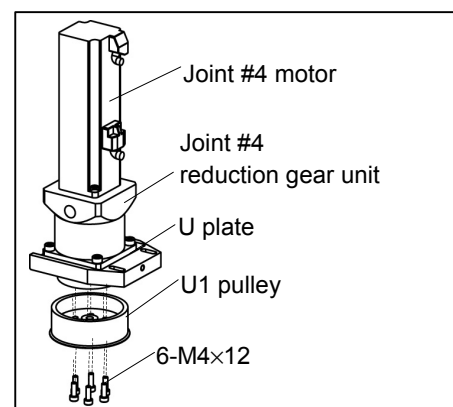
Be careful not to apply too much force since it may damage the parts.



- (4) Mount the U plate on the Joint #4 motor unit.

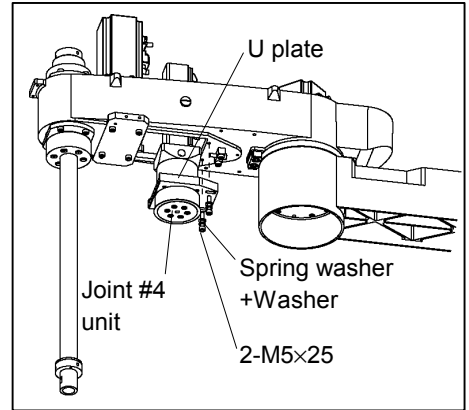


- (5) Mount the U1 pulley on the Joint #4 motor unit.



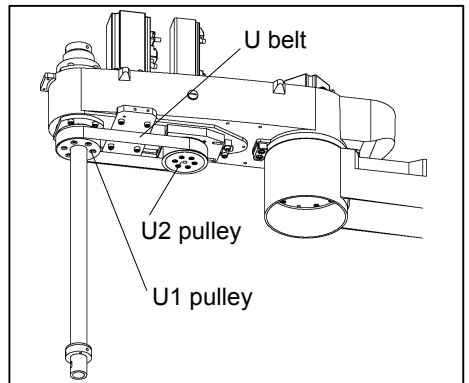
- (6) Mount the Joint #4 unit on Arm #2

Insert the Joint #4 unit from the bottom of the arm.

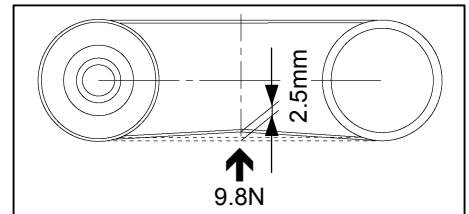


- (7) Place the U belt around the U1 and U2 pulleys so that the gear grooves of the belt fit into those of the pulleys completely.

- (8) Loosely secure the Joint #4 unit to the Manipulator while pulling the Joint #4 unit toward Joint #2.



- (9) Adjust the tension that is applied to one side of the U belt to 156.8N (16kgf) using the tension adjustment screw for U belt. To make a 2.5 mm bend, apply 9.8N (1.0kgf) force to the center of the belt span



Loosen the screw that was secured in step (8) before stretching the belt.

Pay attention that the motor plate does not tilt.

- (10) Secure the Joint #4 unit to Arm #2.

Tighten the screw that was loosened in step (9).

- (11) Connect the connectors X141, X41 and X42.

- (12) Re-bundle the cables in their original positions with a wire tie.

Do not allow unnecessary strain on the cables.

- (13) Install the arm top cover and arm bottom cover.

For details on the installation method, refer to *Maintenance: 3. Removal and Installing the Covers*.

- (14) Connect the power cable and signal cable to the base connector plate (outside).

- (15) Perform the calibration of Joint #4.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.



## 7. Replacing the Brake



- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

### NOTE



A brake is mounted on the motor of Joint #3 to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.

### NOTE



The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

### NOTE



After parts have been replaced (motors, reduction gear units, brakes, timing belts, ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller.

After replacing the parts, it is necessary to match these origins.

The process of aligning the two origins is called “Calibration”.

Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

## Removal

- (1) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (2) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (3) Disconnect the connectors X131, X31, and X32.

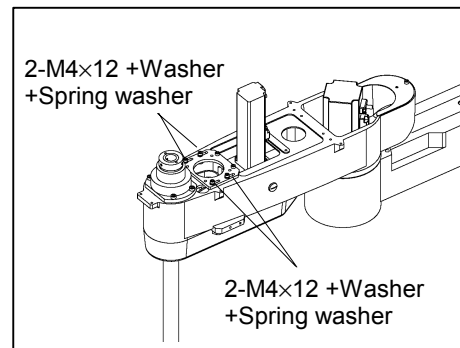
To disconnect the X131 connector, pull it out while pushing the projection on the side of the connector.

- (4) Remove the Joint #3 motor unit from Arm #2.

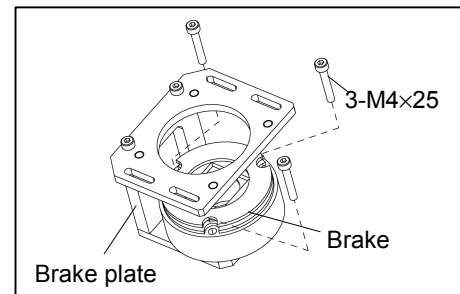
For details on the removal method, refer to *Maintenance:5.5 Replacing the Joint #3 Motor*.

- (5) Remove the brake unit from Arm #2.

To do so, unscrew the bolts from the motor plate. Then, pull the brake unit upward to remove it.

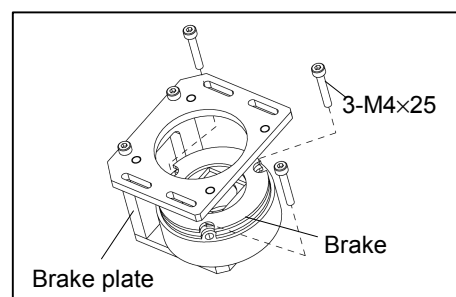


- (6) Remove the brake from the brake plate.

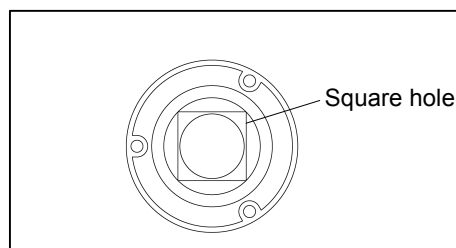


## Installation

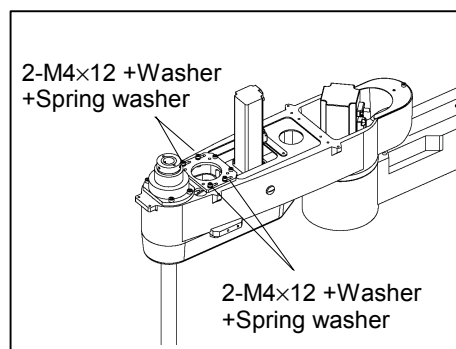
- (1) Mount the brake to the brake plate.



- (2) Manually adjust the brake unit so that the square hole for the rotor hub is positioned at the center of the brake unit.



- (3) Mount the brake unit to the arm so that the open side (  $\supset$  ) faces toward the end of the arm.



- (4) Place the Joint #3 motor unit back on Arm #2.

For details on the installation method, refer to *Maintenance: 5.5 Replacing the Joint #3 Motor*.

- (5) Connect the connectors X131, X31 and X32.

- (6) Re-bundle the cables in their original positions with a wire tie.

Do not allow unnecessary strain on the cables.

- (7) Install the arm top cover.

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (8) Perform the calibration of Joint #3.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.





## 8. Replacing the Timing Belts



- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



**NOTE** A brake is mounted on each motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).  
Note that the brake will not work during the replacement procedure.  
Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.



**NOTE** The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.  
Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.



**NOTE** After parts have been replaced (motors, reduction gear units, brakes, timing belts, ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller.

After replacing the parts, it is necessary to match these origins.

The process of aligning the two origins is called “Calibration”.

Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

## 8.1 Types of Timing Belts

The types of the timing belts used in the E2H series Manipulators are shown in the table below.

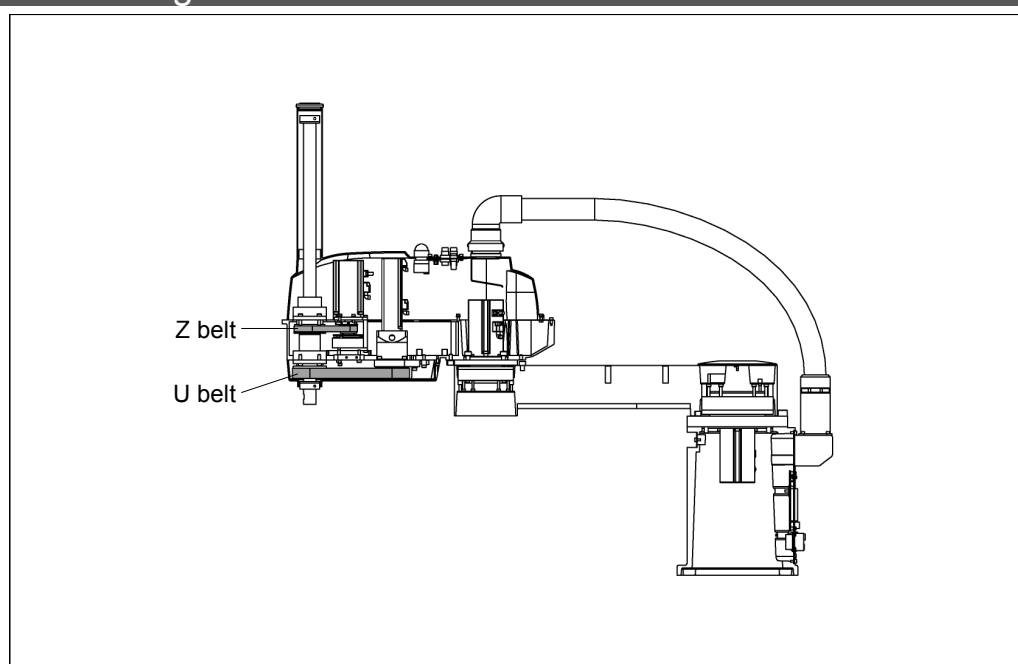
One timing belt is used for Joint #3, and two timing belts are used for Joint #4.

When ordering a timing belt for replacement, verify the corresponding working joint and timing belt.

Then, specify the code from the table below.

Working Joint	Timing belt	Code	Note
#3	Z belt	R13ZA00322400	303-3GT-12 (Width: 12 mm)
#4	U belt	R13ZA00322500	573-3GT-20-B939N1 (Width: 20 mm)

## 8.2 Location of Timing Belts



## 8.3 Replacing the Z Belt



NOTE

A brake is mounted on the motor of Joint #3 to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before the replacement procedure following the instructions below:

- (1) Turn ON the Controller.

- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.



The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

## Removal

- (1) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (2) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.

- (3) Disconnect the connectors X131, X31, and X32.

To disconnect the X131 connector, pull it out while pushing the projection on the side of the connector.

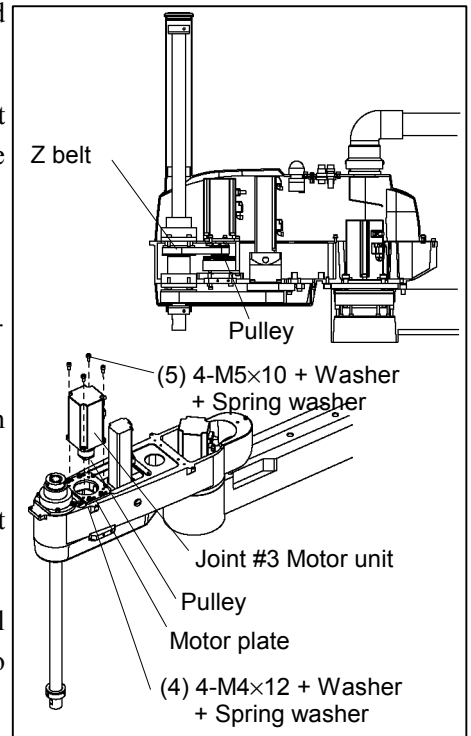
- (4) Loosen the Z belt.

Loosen four bolts on the motor plate. Slide the motor plate to the end of the arm.

- (5) Remove the Joint #3 motor unit from Arm #2.

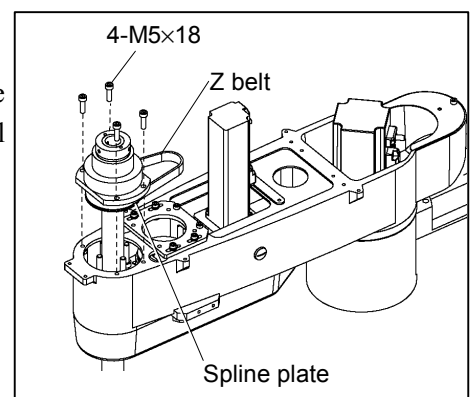
To do so, unscrew the bolts from the Joint #3 motor plate.

- (6) Remove the Z belt from the pulley and pull out the Joint #3 motor unit upward to remove it.



- (7) Remove the Z belt.

To do so, unscrew the bolts from the spline plate, and lift the spline plate. Then, pull the Z belt out of the shaft upward.

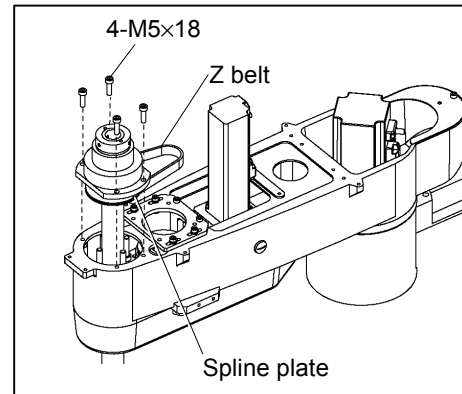


## Installation

- (1) Pass a new Z belt through the shaft from above, and then place it under the spline plate.

- (2) Loosely secure the spline plate to Arm #2.

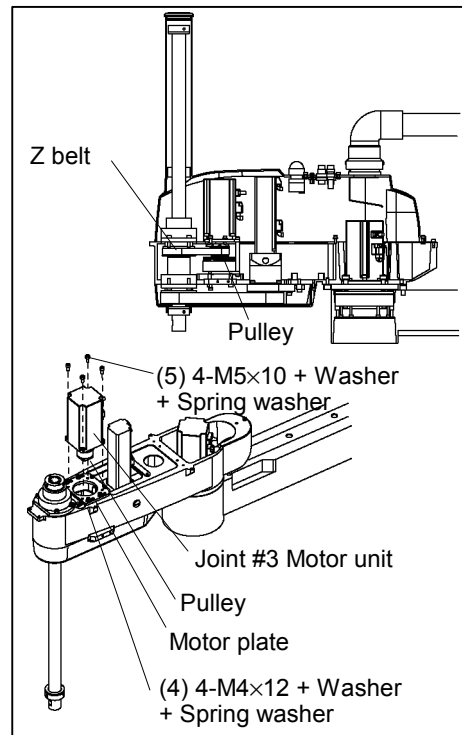
After moving the shaft up and down several times, secure the spline plate to Arm #2.



- (3) Set the Joint #3 motor unit in the arm so that motor cable faces toward the back of the arm. Make sure that the rotor hub on the end face of the pulley is completely set in the square hole on the brake friction plate.

- (4) Place the Z belt around the Z1 pulley and the Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.

- (5) Loosely secure the Joint #3 motor unit to Arm #2.



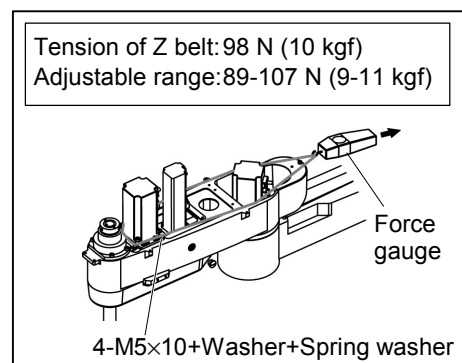
### NOTE



Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

- (6) Apply the proper tension to the Z belt, and then secure the Joint #3 motor unit.

To do so, pass a suitable cord or string around the Joint #3 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



Make sure that the brake cables do not touch the pulley.

- (7) Connect the connectors X131, X31 and X32.
- (8) Re-bundle the cables in their original positions with a wire tie.

Do not allow unnecessary strain on the cables.

- (9) Install the arm top cover.

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (10) Perform the calibration of Joint #3.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 8.4 Replacing the U Belt



A brake is mounted on the motor of Joint #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release button switch. Be careful that the end effector does not hit any peripheral equipment.



The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

## Removal

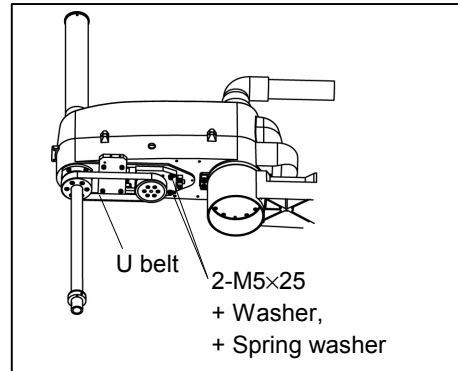
- (1) Remove the arm bottom cover.

For details on the removal method, refer to *Maintenance: 3.2 Arm Bottom Cover*.

- (2) Loosen the bolts securing the Joint #4 motor unit to slide the U plate.

- (3) Remove the U belt from the U1 pulley and U2 pulley.

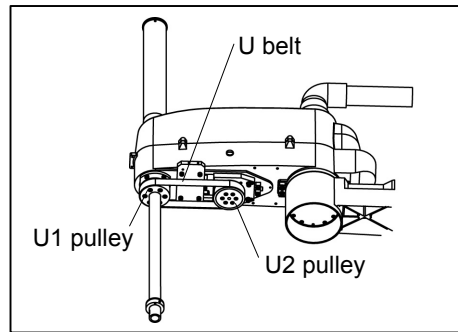
Loosen the tension adjustment screw for U belt and slide the U plate to the end of the arm.



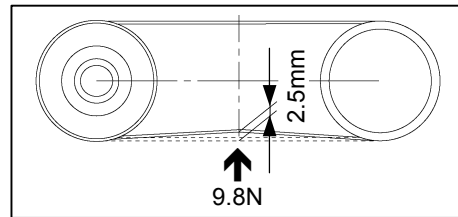
## Installation

- (1) Place a new U1 belt around the U1 and U2 pulleys.

Make sure that the gear teeth of the belt mesh with the pulleys completely.

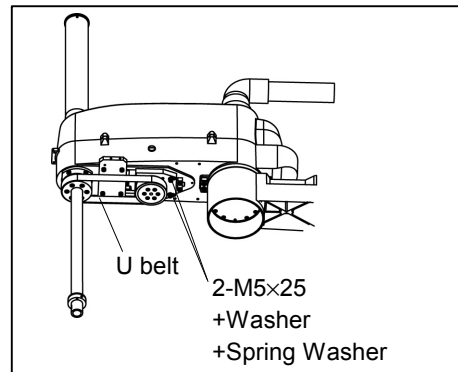


- (2) Adjust the tension that is applied to one side of the U belt to 156.8N (16kgf) using the tension adjustment screw for U belt. To make a 2.5 mm bend, apply 9.8N (1.0kgf) force to the center of the belt span.



- (3) Secure the Joint #4 unit to Arm #2.

Tighten the screws securing the U plate.




- (4) Install the arm bottom cover.

For details on the installation method, refer to *Maintenance: 3.2 Arm Bottom Cover*.

- (5) Perform the calibration of Joints #3 and #4.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 9. Replacing the Bellows

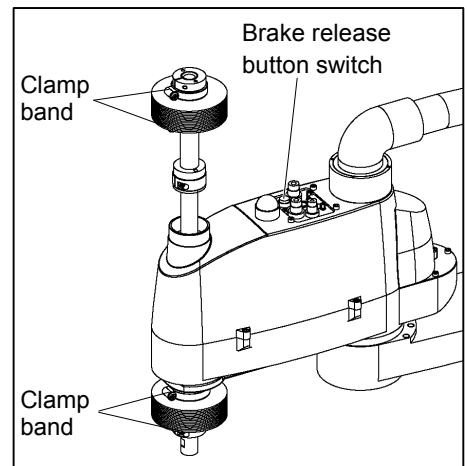
**NOTE**  Two bellows make a set as maintenance parts. There is no difference between the upper bellows and lower bellows.

A large amount of dust is emitted when replacing the bellows.

Take the Manipulator to an outer room such as the room in front of the clean room's entrance, or take the necessary countermeasures to prevent dust emission before removing the bellows.

### Removal

- (1) Detach the wires/tubes from the end effector, and remove the end effector.
- (2) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)
- (3) Loosen the two clamp bands on each bellows.



- (4) Pull the two bellows and four clamp bands out of the shaft.

## Installation

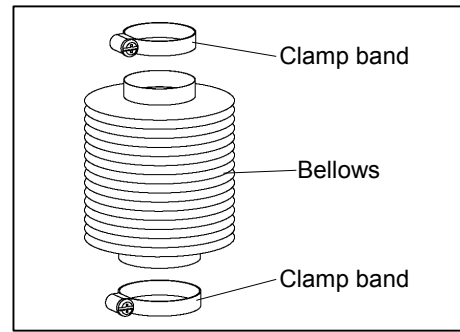
- (1) Attach the two clamp bands to each new bellows.

The bellows has two joints:

The larger joint must be attached to the cover side.

The smaller joint must be attached to the end face side of the shaft.

Be careful not to misplace the clamp bands.



- (2) Pass the shaft through the bellows from the larger joint.

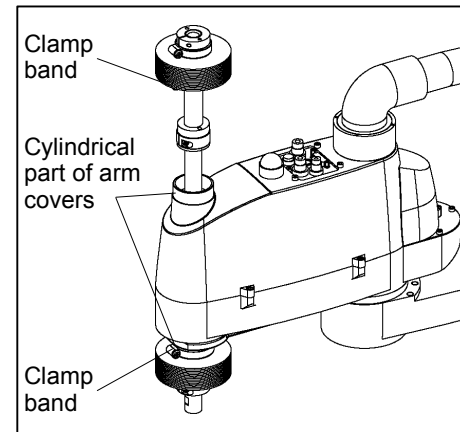
To attach the upper bellows, move the shaft to its lower limit.

To attach the lower bellows, move the shaft to its upper limit.

To move the shaft up/down, press and hold the brake release button switch.

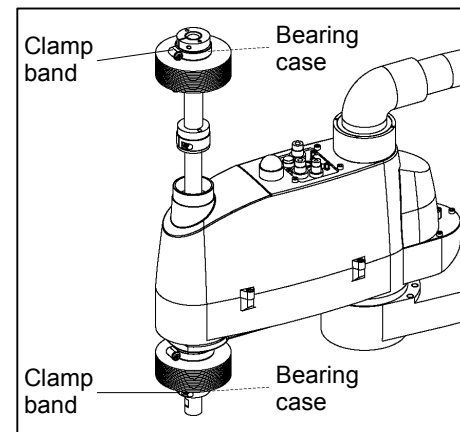
- (3) Secure the bellows with the clamp bands on the cover side.

To do so, place each joint of the bellows over the cylindrical part of the covers by 10 mm or more, and then fasten them with clamp bands.



- (4) Secure the bellows with clamp bands on the end face side of the shaft.

To do so, place each joint of the bellows over the bearing case on the end face of the shaft. Then, secure them with clamp bands.



- (5) After completing the attachment of the bellows, move the shaft up/down by hand several times and rotate Joint #4. Make sure that the bellows can expand and contract smoothly without any excessive force.
- (6) Turn OFF the Controller and peripheral equipment. Attach the end effector, and connect the wires and tubes to it.



## 10. Greasing and Replacing the Ball Screw Spline Unit



WARNING

- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

NOTE



After parts have been replaced (motors, reduction gear units, brakes, timing belts, ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller.

After replacing the parts, it is necessary to match these origins.

The process of aligning the two origins is called “Calibration”.

Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

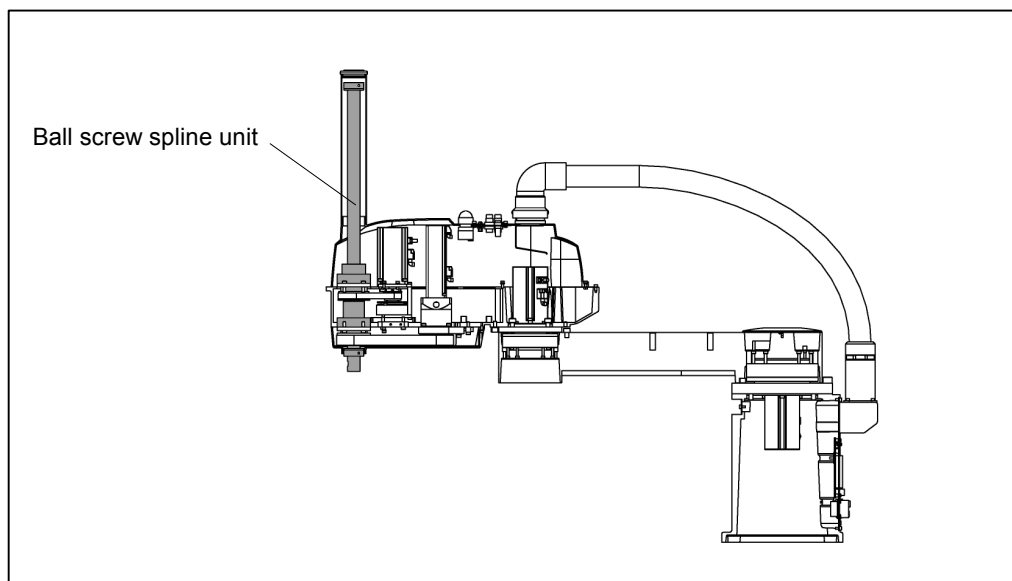
## 10.1 Types of Ball Screw Spline Units

The types of ball screw spline units used in the E2H series S and C type Manipulators are shown in the table below. When ordering the ball screw spline unit for replacement, check the model name of the Manipulator and the Joint #3 stroke.

Then, specify the code from the table below.

Model Name	Joint #3 Stroke	Ball Screw Spline Unit	Code	Note
E2H853S	340 mm	Ball screw spline unit for Z340	R13ZA00121100	BNS2525A-575B
E2H853C	290 mm	Cleanroom-model Ball screw spline unit for Z290	R13ZA00121500	BNS2525A+575LC5-b

## 10.2 Location of Ball Screw Spline Unit



### 10.3 Greasing the Ball Screw Spline Unit



The procedure for greasing the ball screw spline unit varies with the Manipulator used.

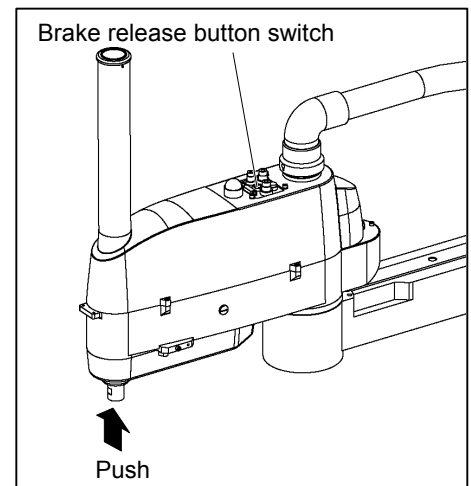
The brake release button switch is applied to both Joints #3 and #4. When the brake release button switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release button switch is being pressed because the shaft may be lowered by the weight of the end effector.

#### 10.3.1 Standard-model

Cover the surrounding area such as the end effector and peripheral equipment in case the grease drips.

- (1) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)
- (2) Move the arm to a position where Joint #3 can be moved in full stroke.
- (3) Move the shaft to its upper limit manually while pressing the brake release button switch.



- (4) Turn OFF the Controller.
- (5) Remove the arm top cover. (Only for -UL type)

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (6) Wipe off the old grease from the upper part of the shaft, and then apply new grease to it.

When applying the new grease to the upper part of the shaft, directly fill the grooves on it by hand. Wipe off excess grease from the shaft.

- (7) Install the arm top cover. (Only for -UL type)

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (8) Turn ON the Controller.
- (9) Move the shaft to its lower limit manually while pressing the brake release button switch.

- (10) Wipe off the old grease from the lower part of the shaft, and then apply new grease to it.

When applying the new grease to the lower part of the shaft, directly fill the grooves on it by hand. Wipe off excess grease from the shaft.

- (11) Move the shaft up and down several times while pressing the brake release button switch to smooth out the grease on the shaft. Wipe off excess grease from the shaft.

When wiping off the excess grease from the upper part of shaft, turn OFF the Controller and remove the arm top cover.

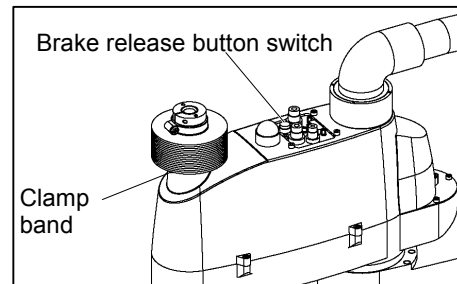
### 10.3.2 Cleanroom-model

**NOTE** A large amount of dust is emitted during the greasing procedure because the bellows must be removed. Before greasing the ball screw spline unit of the C type, take the unit to an outer room such as the room in front of the clean room's entrance, or take the necessary countermeasures to prevent dust emission.

Do not allow any grease to get on the outside of the bellows while greasing.  
Cover the surrounding area such as the end effector and peripheral equipment in case the grease drips.

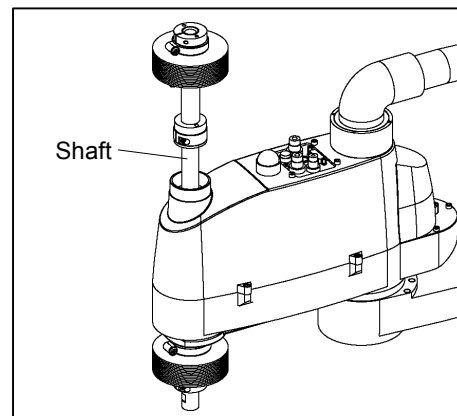
#### Upper Part of the Shaft

- (1) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)
- (2) Move the arm to a position where Joint #3 can be moved in full stroke.
- (3) Move the shaft to its lower limit manually while pressing the brake release button switch.
- (4) Loosen the clamp band under the bellows, and then lift the bellows.



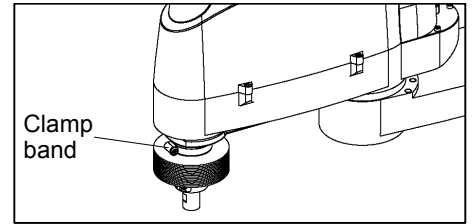
- (5) Move the shaft to its upper limit manually while pressing the brake release button switch.
- (6) Wipe off the old grease from the upper part of the shaft, and then apply new grease to it.

Directly fill the grooves on the shaft inside the bellows with grease by hand.  
Wipe off excess grease from the shaft.



### Lower Part of the Shaft

- (7) Loosen the clamp band on the bellows, and then move the bellows downward.

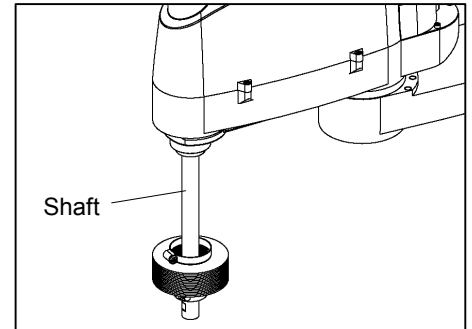


- (8) Move the shaft to its lower limit manually while pressing the brake release button switch.

- (9) Wipe off the old grease from the lower part of the shaft, and then apply new grease to it.

Directly fill the grooves on the shaft inside the bellows with grease by hand.

Wipe off excess grease from the shaft.



- (10) Move the shaft up and down several times while pressing the brake release button switch to smooth out the grease on the shaft. Wipe off excess grease from the shaft.

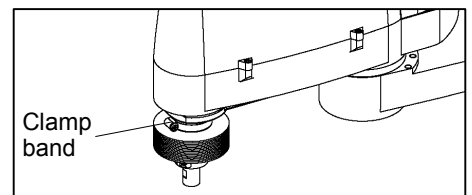
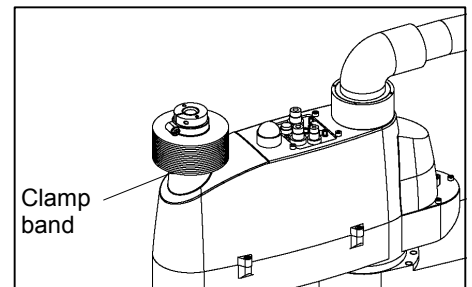
- (11) Secure the bellows.

To do so, place the bellows over the cylindrical part of the cover by 10 mm or more, and then fasten them with a clamp band.

When mounting the upper bellows, move the shaft down to its lower limit.

When mounting the lower bellows, move the shaft up to its upper limit.

To move the shaft up/down, press and hold the brake release button switch on the top of the cover.



## 10.4 Replacing the Ball Screw Spline Unit

### Removal

- (1) Detach the wires/tubes from the end effector, and remove the end effector and bellows.

- (2) Remove the arm top cover and arm bottom cover.

For details on the removal method, refer to *Maintenance: 3. Removing and Installing the Covers*.

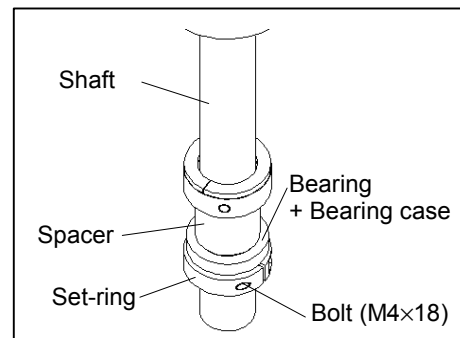
- (3) Remove the Z belt from the shaft.

For details on the removal method, refer to *Maintenance: 8.3 Replacing the Z Belt*.

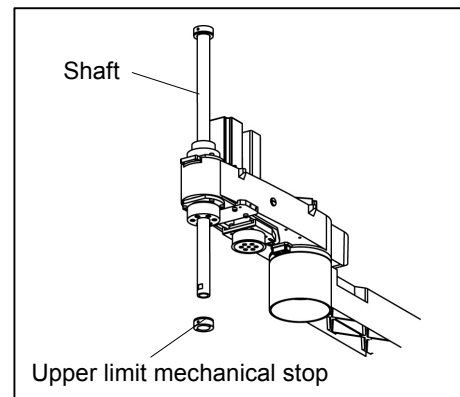
- (4) Remove the U belt from the shaft.

For details on the removal method, refer to *Maintenance: 8.4 Replacing the U Belt*.

- (5) If the Manipulator is a Cleanroom-model, loosen the bolt for the split muff coupling and remove the set-ring, bearing, bearing case, and spacer from the shaft.

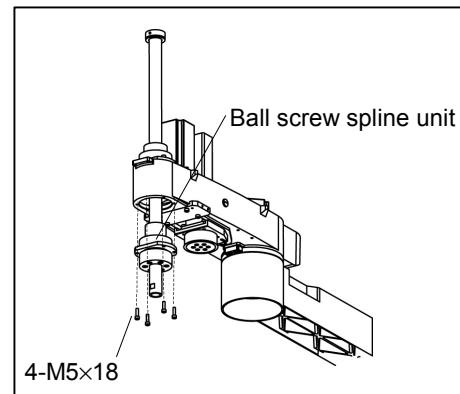


- (6) Remove the upper limit mechanical stop from the shaft.



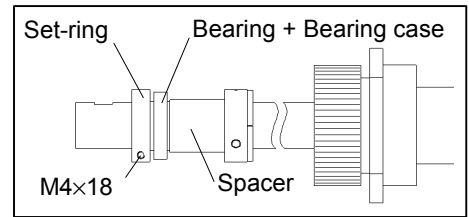
- (7) Remove the screws for the ball screw spline shaft from the bottom of Arm #2.

- (8) Pull the ball screw spline unit out of Arm #2.

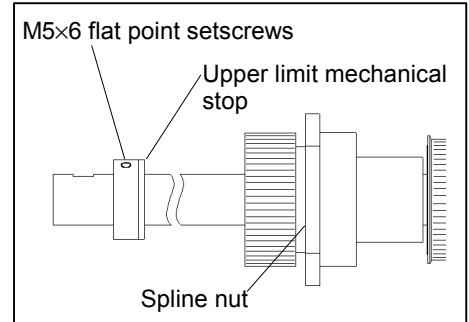


## Installation

- (1) If the Manipulator is a Cleanroom-model, loosen the bolt for the split muff coupling on the set-ring of a new ball screw spline unit. Then, remove the set-ring, bearing, bearing case, and spacer from the shaft.



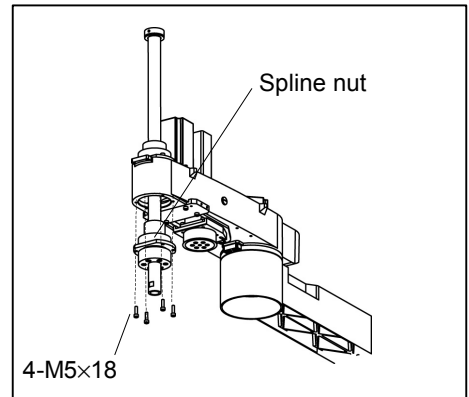
- (2) Loosen two flat point setscrews and remove the upper limit mechanical stop from the shaft.



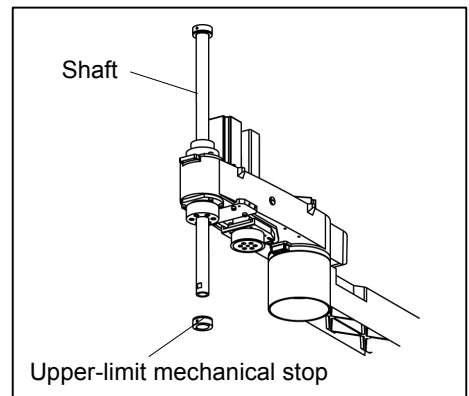
- (3) Remove the spline nut from the shaft.

- (4) Mount the spline unit on Arm #2.

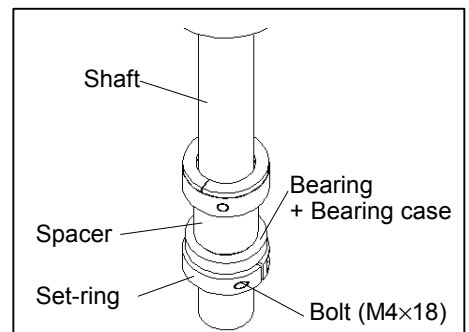
- (5) Attach the spline nut to the shaft, and fit each alignment mark. Secure the spline nut to Arm #2 with four bolts.



- (6) Pass the upper limit mechanical stop through the shaft from the rubber side. Secure the upper-limit mechanical stop to the position 30 mm (80 mm for Cleanroom-model) away from the end of the shaft with two flat point setscrews. Make sure the screws do not cover the shaft groove, and tighten the screws with 490 N·cm (50 kgf·cm) torque.



- (7) If the Manipulator is a Cleanroom-model, pass the spacer, bearing, bearing case, and set-ring through the shaft. Push up the set-ring, and secure it with a bolt.



- (8) Pass the Z belt through the shaft. Temporarily secure the spline plate to Arm #2.  
For details on the install method, refer to *Maintenance: 8.3 Replacing the Z Belt*.

- (9) Attach the U belt.

For details on the install method, refer to *Maintenance: 8.4 Replacing the U Belt*.

- (10) If the position of the lower limit mechanical stop has been changed because of the area limit, secure the mechanical stop to its proper position.

- (11) Install the arm top cover and arm bottom cover.

For details on the installation method, refer to *Maintenance: 3. Removing and Installing the Covers*.

- (12) Grease the shaft.

For details on the greasing method, refer to *Maintenance: 10.3. Greasing the Ball Screw Spline Unit*.

- (13) Turn OFF the Controller and peripheral equipment. Install the end effector and bellows, and connect wires and tubes to the end effector.

- (14) Perform the calibration of Joints #3 and #4.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.



## 11. Replacing the Signal Relay Board



- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

### 11.1 Before Replacing the Signal Relay Board

Before replacing the signal relay board, turn ON the Controller and keep it ON for 30 or more minutes. Then, turn OFF the Controller.

This preparation is necessary to charge the super-capacitor that is used to retain the position data.

A super-capacitor is mounted on each motor. The charged motors can keep their position data for about 2 hours after the motors are disconnected from the lithium battery on the signal relay board.

Since the power is supplied to each motor from the lithium battery on the signal relay board via signal connector, the position data will exist even when the Controller is turned OFF. When the signal connectors are disconnected, only the super-capacitors in the motors will retain the position data.

When the data storage time of the super-capacitor is exceeded, the position data will be lost, and an error\* will occur when the Controller is turned ON.

\* : In the case of SPEL CT, the “Error F-5016” occurs. In case of EPSON RC+, the error message that “Encoder alarm has occurred” is displayed.

If the error occurs, perform the calibration of all joints and axes. For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 11.2 How to Replace the Signal Relay Board

### Removal

- (1) Disconnect all the connectors and tubes from the base connector plate (outside).
- (2) Remove the base connector plate.

For details on the removal method, refer to *Maintenance: 3.4 Base Connector Plate*.

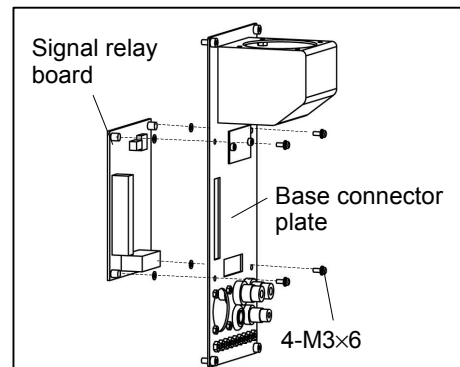
- (3) Disconnect the connectors (X10, X20, X30, X40, and X50) from the signal relay board.

To do so, open up the top and bottom clips of the connectors.



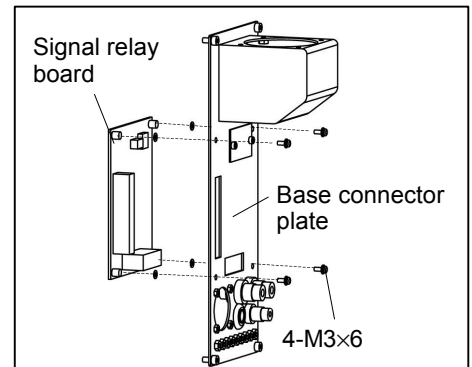
Connect motors and the signal relay board with a new cable unit within 2 hours after the connectors are removed. When the motors and the signal relay board are connected with a new cable unit after 2 hours have passed, the position data in motors will be lost and calibration will be required again.

- (4) Remove the signal relay board from the base connector plate.




## Installation

- (1) Install a new signal relay board to the base connector plate.



- (2) Connect the connectors (X10, X20, X30, X40, and X50) to the signal relay board.

 <b>CAUTION</b>	<p>■ 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.) The 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 robot system.</p>
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- (3) Install the base connector plate.

For details on the installation method, refer to *Maintenance: 3.4 Base Connector Plate*.

- (4) Connect the connectors and tubes to the base connector plate (outside).
- (5) Turn ON the Controller.
- (6) Check if the Manipulator moves to points (poses) correctly.



To do so, select 2 points (poses) or more from the registered points (poses) and move the Manipulator to the points (poses).

- (7) If the Manipulator does not move to the points (poses) correctly, perform the calibration of all joints and axes.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.



## 12. Replacing the Lithium Battery

 <b>WARNING</b>	<ul style="list-style-type: none"> <li>■ Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.</li> <li>■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.</li> <li>■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.</li> </ul>
 <b>CAUTION</b>	<ul style="list-style-type: none"> <li>■ Use meticulous care when handling the lithium battery. Improper handling of the lithium battery as mentioned below is extremely hazardous, may result in heat generation, leakage, explosion, or inflammation, and may cause serious safety problems.</li> </ul> <p>&lt;Improper Handling&gt;</p> <ul style="list-style-type: none"> <li>• Battery Charge</li> <li>• Deformation by Pressure</li> <li>• Disassembly</li> <li>• Short-circuit (Polarity; Positive/Negative)</li> <li>• Incorrect Installation</li> <li>• Heating (100°C or more)</li> <li>• Exposing to Fire</li> <li>• Soldering the terminal of the lithium battery directly</li> <li>• Forced Discharge</li> </ul>

When the lithium battery power is low, an error will occur to warn the user about the low battery status when the Controller is turned ON (when software is started up).

When the error occurs, the position data in motors will be lost and all joints need to be completely calibrated again.

The life span of the lithium battery is 3 years. Even if the Manipulator is constantly connected to power, the lithium battery needs to be replaced every 3 years.

## 12.1 Before Replacing the Lithium Battery

Before replacing the lithium battery, turn ON the Controller and keep it ON for 30 or more minutes. Then, turn OFF the Controller.

This preparation is necessary to charge the super-capacitors that retain the position data.

A super-capacitor is mounted on each motor. The charged motors can keep their position data for about 2 hours after the motors are disconnected from the lithium battery on the signal relay board.

Since the power is supplied to each motor from the lithium battery on the signal relay board via signal connector, the position data will exist even when the Controller is turned OFF. When the signal connectors are disconnected, only the super-capacitors in the motors will keep the position data.

When the data storage time of the super-capacitor is exceeded, the position data will be lost, and an error\* will occur when the Controller is turned ON.

\* : In the case of SPEL CT, the “Error F-5016” occurs. In case of EPSON RC+, the error message that “Encoder alarm has occurred” is displayed.

If the error occurs, perform the calibration of all joints and axes. For details on the calibration method, refer to *Maintenance: 14. Calibration*.

## 12.2 How to Replace the Lithium Battery

### Removal

- (1) Disconnect all the connectors and tubes from the base connector plate (outside).

- (2) Remove the base connector plate.

For details on the removal method, refer to *Maintenance: 3.4 Base Connector Plate*.

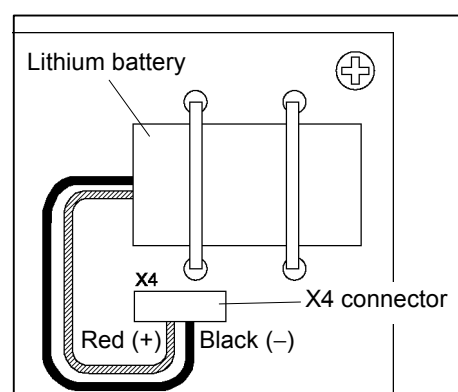
- (3) Remove the signal relay board from the base connector plate.

#### NOTE

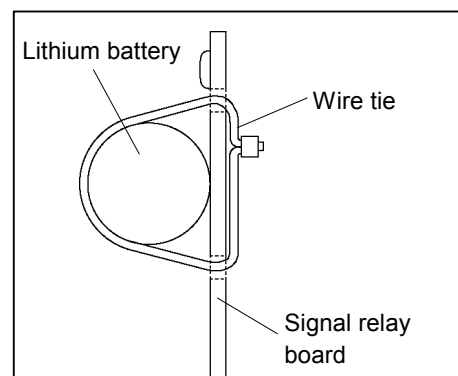


Do not pull out the signal relay board forcibly because cables and connectors are connected to the board.

- (4) Disconnect the X4 connector of the lithium battery from the signal relay board.



- (5) Cut off the wire ties securing the lithium battery, and then remove the lithium battery.



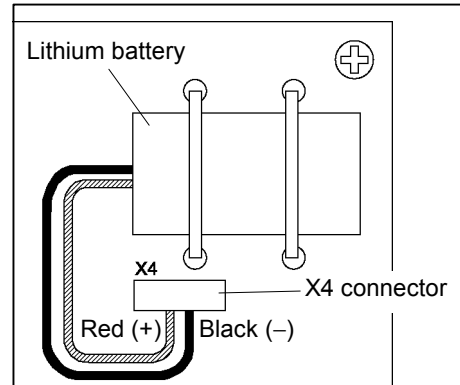
## Installation



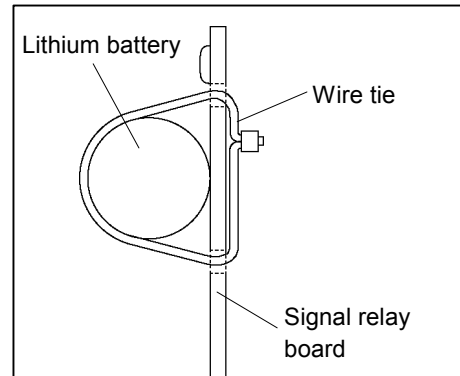
Be sure to use the specified “battery unit for signal relay board (code: R13ZA00600100)”.

Observe polarity (positive/negative) when connecting the lithium battery.

- (1) Connect the X4 connector of the new lithium battery to the signal relay board.



- (2) Secure the lithium battery to the signal relay board.



- (3) Secure the signal relay board to the base connector plate.
- (4) Install the base connector plate.

For details on the installation method, refer to *Maintenance: 3.4 Base Connector Plate*.

- (5) Connect the connectors and tubes to the base connector plate (outside).
- (6) Turn ON the Controller.
- (7) Check if the Manipulator moves to points (poses) correctly.

To do so, select 2 points (poses) or more from the registered points (poses) and move the Manipulator to the points (poses).

- (8) If the Manipulator does not move to the points (poses) correctly, perform the calibration of all joints and axes.

For details on the calibration method, refer to *Maintenance: 14. Calibration*.



## 13. Replacing the LED Lamp



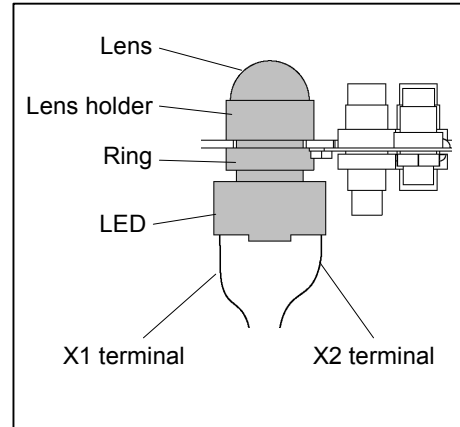
- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

## Removal

- (1) Remove the arm top cover.

For details on the removal method, refer to *Maintenance: 3.1 Arm Top Cover*.

- (2) Disconnect the X1 and X2 terminals from the LED.
- (3) Turn the lens clockwise to remove it. Then, turn the lens holder clockwise to remove it.
- (4) Remove the LED from the arm top cover.



## Installation

- (1) Connect the X1 and X2 terminals to the LED.

Each terminal must be connected to its terminal number on the LED.

- (2) Put the arm top cover between the ring and lens holder, and then mount the LED on the arm top cover.
- (3) Install the lens to the lens holder.
- (4) Install the arm top cover.

For details on the installation method, refer to *Maintenance: 3.1 Arm Top Cover*.

## 14. Calibration


### 14.1 About Calibration

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot execute the positioning properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller.

After replacing the parts, it is necessary to match these origins.

The process of aligning the two origins is called “Calibration”. Note that calibration is not the same as teaching\*.

\*: “Teaching” means to teach the Controller coordinate points (including poses) anywhere in the operating area of the Manipulator.

 <b>WARNING</b>	<ul style="list-style-type: none"> <li>■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the <i>Installation and Design Precautions</i> in the <i>Safety</i> chapter of the EPSON RC+ User's Guide or the <i>Safety 1.3 Design Precautions</i> in the SPEL CT User's Guide.</li> <li>■ Before operating the robot system, make sure that no one is inside the safeguarded area. The robot system can be operated in the mode for teaching even when someone is inside the safeguarded area. The motion of the Manipulator is always in restricted (low speeds and low power) status to secure the safety of an operator. However, operating the robot system while someone is inside the safeguarded area is extremely hazardous and may result in serious safety problems in case that the Manipulator moves unexpectedly.</li> </ul>
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#### Command Input

Calibration procedures include the process to input commands. The name of the windows and startup procedures are different depending on the software users use.

SPEL CT : Click the tool bar-<Debug pane> button to display the [Command Execution] window.

EPSON RC+ 4.\* : Select the menu-[Tools]-[Monitor] to display the [Monitor] window.

EPSON RC+ 5.\* : Select the menu-[Tools]-[Command Window].

The information above is omitted in the calibration procedure.

#### Jog Motion

The process to set the jog motion is included in the calibration procedures. The name of the windows and startup procedures are different depending on the software users use.

SPEL CT : Select menu-[Jog & Teach] to display the [Jog & Teach] panel.

EPSON RC+ 4.\* : Select [Tools]-[Jog & Teach] to display the [Jog & Teach] window.

EPSON RC+ 5.\* : Select menu-[Tools]-[Robot Manager] and select the [Jog & Teach] page.

The panel, window, or page above are indicated as [Jog & Teach] in the calibration procedure.

## 14.2 Calibration Procedure

The same calibration procedure is used for each joint. Follow the steps below to calibrate each joint. When calibrating Joint #4, you must calibrate Joint #3 and #4 at the same time. You cannot calibrate Joint #4 alone because of the structure of the Manipulator.

- (1) Turn ON the Controller with all joints in motion range.
- (2) Check whether an error occurs or not.

Immediately after a new motor is connected, the following error status may occur for the super-capacitor (condenser) in the motor encoder if it was not charged enough.

SPEL : Error F-5016

[Absolute Encoder backup alarm] occurs

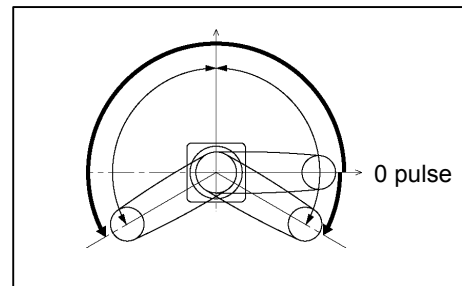
EPSON RC+ : “Encoder alarm has occurred. Check robot battery. EPSON RC+ must be restarted.” is displayed

In this case, leave the power ON for 3 or more minutes to sufficiently charge the capacitor. Then, go to the next step (3) below. (The error is still displayed.)

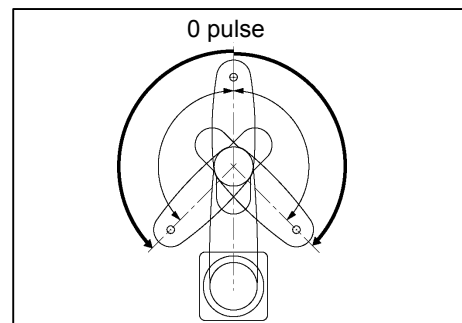
If the error does not occur, go to the next step (3) below.

- (3) Manually move the joint that needs origin alignment to its approximate 0 pulse position.

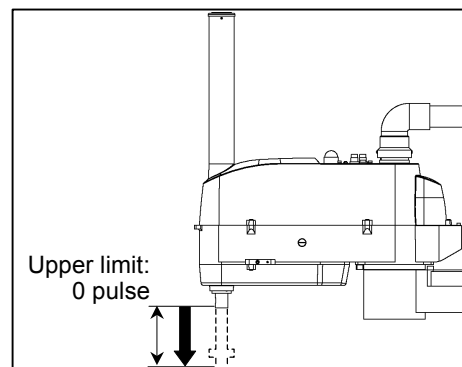
0 pulse position of Joint #1:  
position aligned with X-axis in  
Manipulator coordinate system



0 pulse position of Joint #2:  
position where Arms #1 and #2 are in  
a straight line  
(Regardless of the Joint #1 direction)

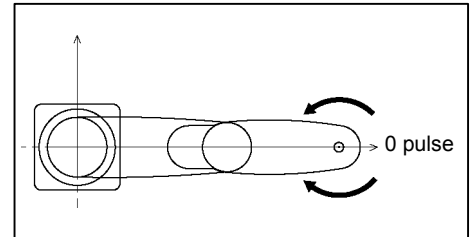


0 pulse position of Joint #3:  
upper limit position in motion range

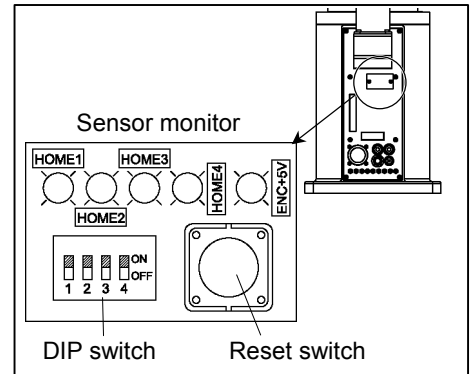


0 pulse position of Joint #4:

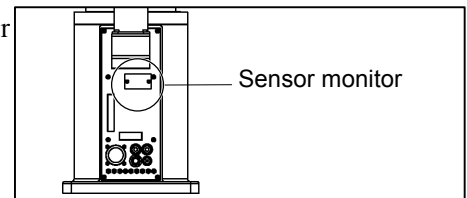
position where the flat surface on the shaft faces toward the tip of Arm #2



- (4) Remove the acrylic plate on the sensor monitor on the base connector box.



- (5) Set the DIP switch corresponding to the joint that needs origin alignment to its ON position. For Joint #4, place both “3” and “4” in their ON positions.
- (6) Press and hold the reset switch for 1 or more seconds.  
Error will still be displayed. (SPEL CT: F-5136, EPSON RC+: 5136)
- (7) Return the DIP switch(s) to the OFF position.
- (8) Re-install the acrylic plate on the sensor monitor.



- (9) SPEL CT : Reboot SPEL CT.

EPSON RC+ 4.\* : Right-click the <SPEL Runtime Drivers system tray> icon, and select [Restart SPEL Drivers].

EPSON RC+ 5.\* : Select menu-[Tools]-[Controller], and click the [Restart Controller] button.

- (10) Open the [Robot Control] window and click on the Motor <ON> button.  
Error [Absolute Encoder has been initialized] is displayed.  
(SPEL CT: F-5136, EPSON RC+: 5136)

Click the <RESET> button. (The error is cleared.)

- (11) Enter the current position that is visually determined as the 0 pulse position to perform a rough calibration.

>CALPLS 0, 0, 0, 0

- (12) Select pose data (point data) that is easy to verify the accuracy of the joint that needs origin alignment from the currently registered pose data (point data). And then move the Manipulator to the approximate position and orientation.

- (13) To perform temporary calibration, input the pulse value of the specified pose data (point data).

When the specified pose data (point data) is "P1," input the following command according to the joint being calibrated.

```
> Calpls Ppls(P1,1), Ppls(P1,2), Ppls(P1,3), Ppls(P1,4)
```

- (14) Perform the temporary calibration. Input one of the following commands according to the joint being calibrated.

```
Joint #1 :>Calib 1
Joint #2 :>Calib 2
Joint #3 :>Calib 3
Joint #4 :>Calib 3, 4
```

- (15) Put all joints back under servo control using the [Robot Control Panel].

- (16) Move the joint\* being calibrated to the specified pose (point) using a motion command.

\*You must also move Joint #1 and #2 to the position when calibrating Joint #4.

For example, when the specified pose data (point data) is "P1", "Motor On" is executed from [Robot Control Panel] ([Control Panel] for EPSON RC+ 5.\* and after), and "Go P1" is executed from [Jog & Teach].

- (17) Accurately align the joint\* being calibrated to the specified pose (point) using jog commands.

\*You must move Joint #3 and #4 to the position when calibrating Joint #4.

Select Joint jog mode from [Jog & Teach] to execute the jog motion.

- (18) Perform the calibration. Input one of the following commands according to the joint being calibrated.

```
Joint #1 :>Calib 1
Joint #2 :>Calib 2
Joint #3 :>Calib 3
Joint #4 :>Calib 3, 4
```

- (19) Move the Manipulator to another pose (point) to confirm that it moves to the same position.

If it does not move to the same position, re-calibrate using another pose (point). You must set the pose (point) again if reproducibility cannot be assured through calibration.

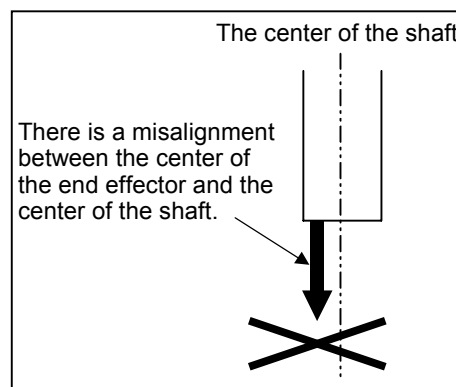
### 14.3 Accurate Calibration of Joint #2

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.

If the accuracy of Joint #2 is not obtained through the steps in the section *14.2 Calibration Procedure*, follow the steps below “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2.

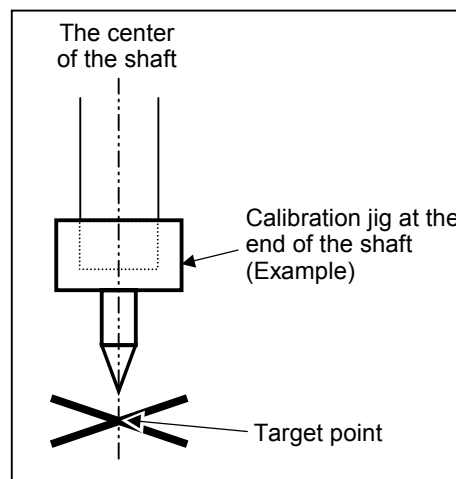
The reference point is the center of the ball screw spline shaft during this calibration.

When there is a misalignment between the center of the end effector and the center of the ball screw spline shaft, remove the end effector and perform the calibration of the shaft.



Make a calibration jig as shown in the right figure and attach it on the end of the shaft to make the center of the shaft clear.

Decide a target point and mark a cross (X) on it so that you can easily verify the center of the shaft after switching the arm pose between right and left.



After removing the end effector and performing the calibration, install the end effector and move the Manipulator to the teaching point to verify whether there is a positional gap. If there is a positional gap, fine-tune the installation position of the end effector and teach the point again.

Coordinates for the working point requires calculation in the following cases:

- Teaching the working point by entering the coordinate values (MDI teaching)
- Switching the arm orientation between right and left at a given point
- Using the PALET command (SPEL CT), or PALLET command (EPSON RC+)
- Executing CP control (such as linear or circular interpolation)
- Using the LOCAL command
- Pose data specified with relative coordinates <Example: P1+X(100) >
- Vision Guide camera calibrations
- Conveyor tracking

### Calibration Using Right / Left Arm Orientations

- (1) Select a pose (point) for which it is easy to verify the accuracy from the data in the accessible area for both right and left arm orientations. And then teach the pose (point) in the right arm orientation. This pose (point) is now called P1.

Specify the point number "1" in the [Jog & Teach] and click the <Teach> button.

- (2) Switch the arm orientation to left. Then, move the arm to the same point.

>JUMP P1:Z(0)/L ' Change the arm orientation from right to left

- (3) The joints are slightly out of position. Adjust the gap with the jog motion in the [Jog & Teach]. This pose (point) is now called P2.

- (4) Input the new Hofs value.

>Hofs Hofs (1), Hofs (2) + (Ppls(P1,2) + Ppls(P2,2)) /  
2, Hofs(3), Hofs(4)

- (5) Move the Manipulator to another pose (point). Make sure that the Manipulator moves to the correct position.



## 15. Maintenance Parts List

Specify the code when ordering maintenance parts.

### 15.1 Common Parts for All Manipulator Types

Part Name		Code	Note
AC servo motor	Joint #1, 2, 3	R13A000600400	SGM3-400W
	Joint #4	R13B000601	SGM3-150W with Brake **
Reduction gear unit	Joint #1	R13ZA00100600	SHF-32-100 *
	Joint #2	R13ZA00100700	SHF-25-80 *
	Joint #4	R13B010001	HPG-14A-F0ABK
Brake	Joint #3	R13ZA00350200	SBR-62z-10 *
Brake release button switch	Joint #3, 4	R13Z702640100	AB2M-M1W *
Cable unit		R13B020004	
Power cable		R13ZA00200200	3 m (standard) *
Signal cable		R13ZA00200300	3 m (standard) *
Timing Belts	Z belt	R13ZA00322400	303-3GT-12 (width: 6 mm) *
	U belt	R13ZA00322500	537-3GT-20-B939N1 (width: 9 mm) *
Grease	for ball screw spline shaft	R13ZA00330200	AFB grease (400 g) *
	for reduction gear unit	R13ZA00330100	SK-1A (500 g) *
Liquid gasket		R13ZA00371000	Single-liquid type of RTV rubber *
Signal relay board		R13ZA00450200	SKP337-ABS *
Battery unit for signal relay board		R13ZA00600100	Lithium battery (Battery unit) *
O-ring (for Reduction gear unit)	for SHF-32	R13A030700400	Joint #1 *
	for SHF-25	R13A030700300	Joint #2 *
LED lamp		R13A030000200	
Oil seal		R13A031200300	SEAL_32

\* : common to E series

\*\* : Apply motor driver module for 100 W to joint #4.

For the code of the motor driver module, refer to the *Maintenance Parts List* of the *Controller manual*.

## 15.2 Standard-model

Part Name		Code	Note
Ball screw spline unit		R13ZA00121100	BNS2525A-575B for 340 mm stroke *
Arm cover with shaft cover (Only for -UL type)	E2H853S-UL	R13B030401	for 340 mm stroke

\* : common to E series

## 15.3 Cleanroom-model

Part Name		Code	Note
Bellows (Round-type)		R13A030700700	ø90 - ø45 × st.300 (2 bellows)
Ball screw spline unit		R13ZA00121500	BNS2525A+575LC5-b for 290 mm stroke *

\* : common to E series