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EPSON

SCARA ROBOT

E2C series

MANIPULATOR MANUAL

Rev. 6 EM069R1409F

SCARA ROBOT

E2C series Manipulator Manual

Rev. 6

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FOREWORD

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

No part of this manual may be copied or reproduced without authorization.
The contents of this manual are subject to change without notice.
Please notify us if you should find any errors in this manual or if you have any comments regarding its contents.

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

MANUFACTURER & SUPPLIER

Japan & Others

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Factory Automation Systems Dept.
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Germany
TEL : +49-(0)-2159-538-1391
FAX : +49-(0)-2159-538-3170
E-MAIL : robot.infos@epson.de

Before Reading This Manual

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

Structure of Control System

E2C 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.

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

EPSON RC+ 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 E2C 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	■ Personnel who design and/or construct the robot system with this product must read the *Safety* chapter in the EPSON RC+ User's Guide or the *Safety* 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.

 WARNING	■ 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. ■ 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.

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 For Operations

The following items are safety precautions for qualified Operator personnel:

 WARNING	■ Please carefully read the *Safety-related Requirements* in the *Safety* chapter of the EPSON RC+ User's Guide or the *Safety: 1.1 Safety-related Requirements* 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. ■ 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. ■ 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. ■ Immediately press the Emergency Stop switch whenever the Manipulator moves abnormally while the robot system is operated.

 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. ■ 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.

 CAUTION	■ 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.

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.

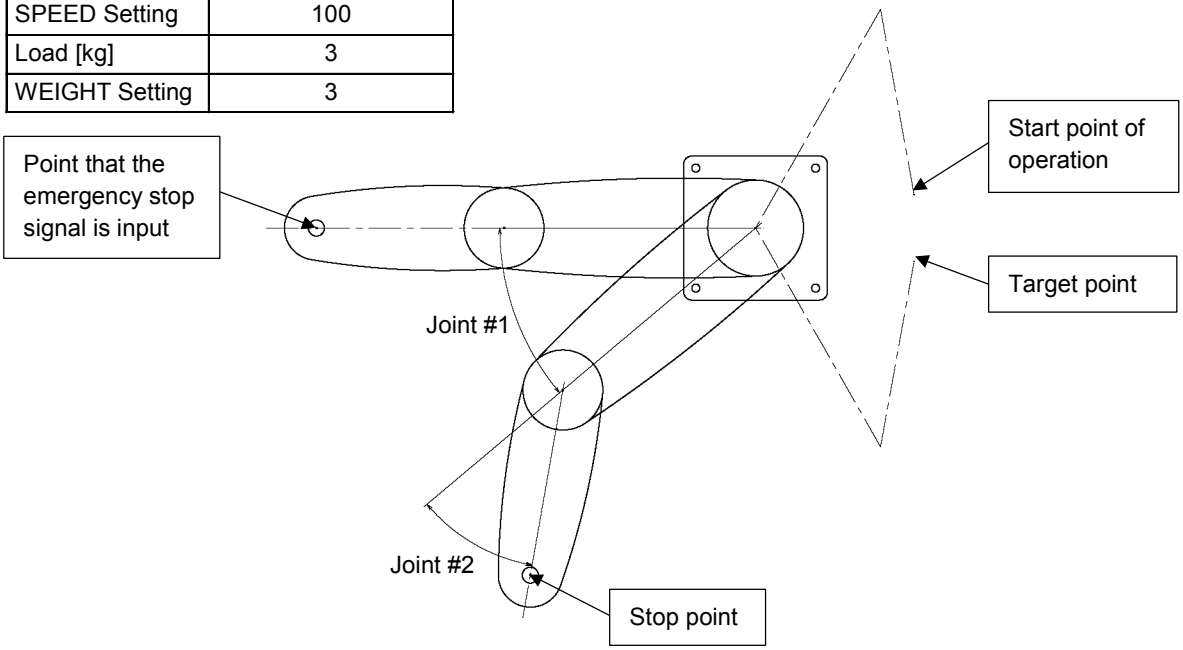
Free running distance in emergency

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]	3
WEIGHT Setting	3



		E2C251*		E2C351*	
		RC420 RC520	RC170	RC420 RC520	RC170
Free running time	Joint #1+Joint #2 [sec.]	0.2	0.3	0.3	0.4
	Joint #3 [sec.]	0.3	0.2	0.3	0.2
Free running angle	Joint #1 [deg.]	20	40	35	50
	Joint #2 [deg.]	30	55	35	55
	Joint #1+Joint #2 [deg.]	50	90	70	105
Free running distance	Joint #3 [mm]	25	65	25	65

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

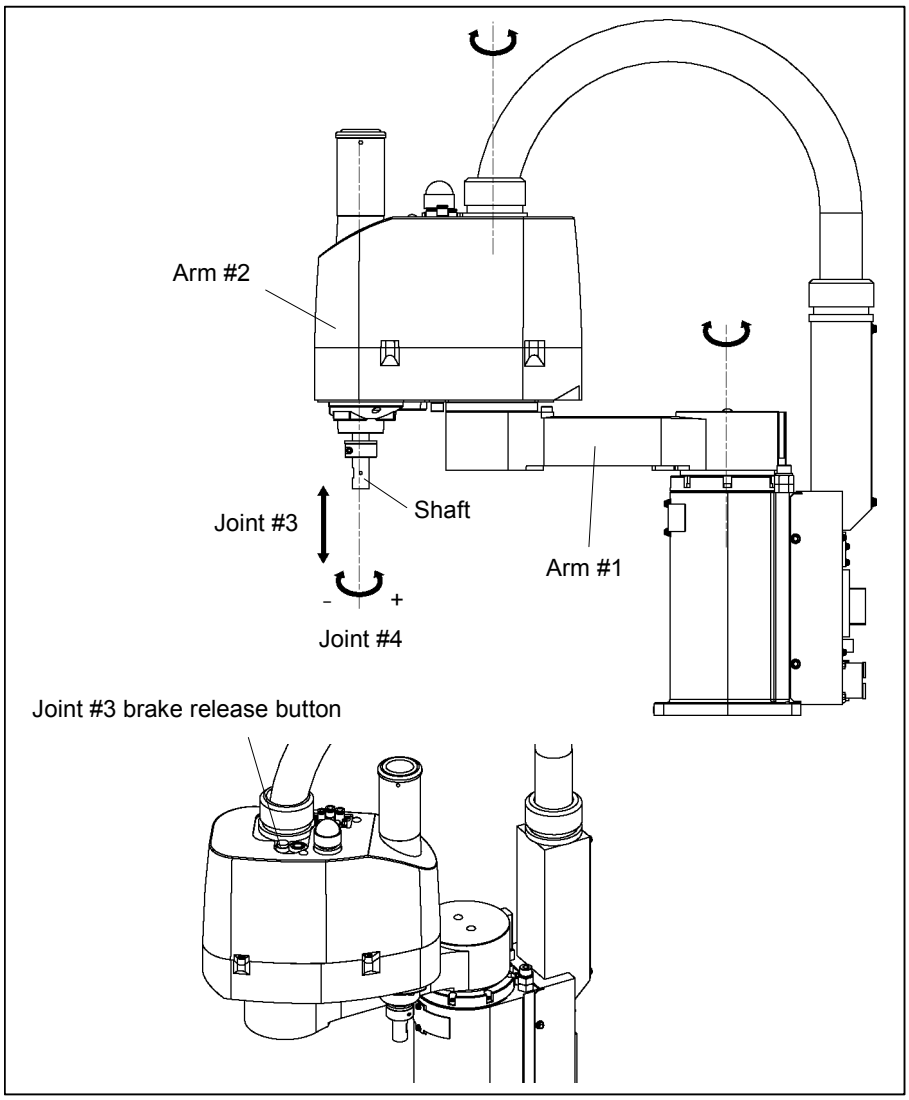
When the system is placed in emergency mode, push the arm or joint of the Manipulator by hand as shown below:

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 pushing the Joint #3 brake release button.

Joint #4 ..... Rotate the shaft by hand.

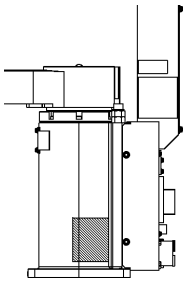
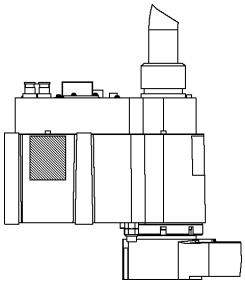
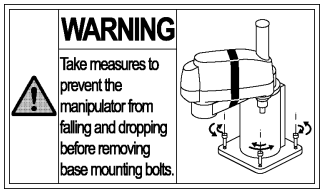


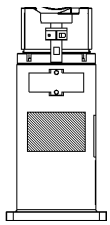
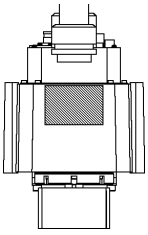
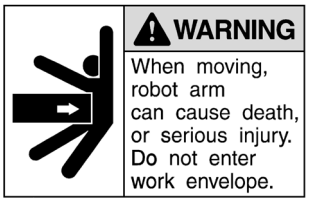
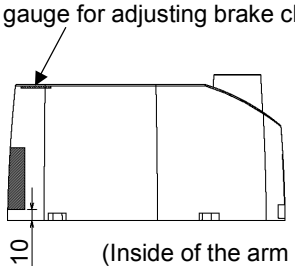
1.6 Manipulator Labels

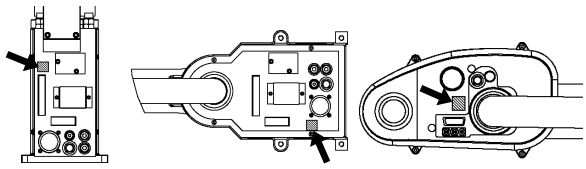
The following labels are attached around the locations of the Manipulator where specific dangers exist.

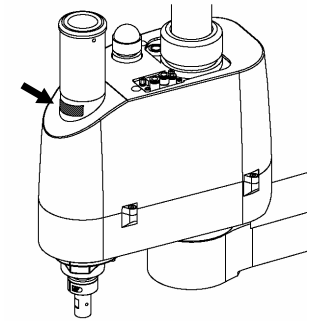
Be sure to comply with descriptions and warnings on the labels to operate and maintain the Manipulator safely.

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:

<table>
<tr><th colspan="2">Location of Labels</th><th rowspan="2">Labels</th></tr>
<tr><th>Table Top</th><th>Multiple Mountings</th></tr>
<tr><td></td><td></td><td>

NOTE:
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.</td></tr>
<tr><td></td><td></td><td>
</td></tr>
<tr><td>Gap gauge for adjusting brake clearance


(Inside of the arm top cover)</td><td></td><td>
</td></tr>
<tr><td colspan="2"></td><td>

NOTE:
Hazardous voltage exists while the Manipulator is ON. To avoid electric shock, do not touch any internal electric parts.</td></tr>
<tr><td colspan="2"></td><td>

NOTE:
You will catch your hand or fingers between the shaft and cover when bringing your hand close to moving parts.</td></tr>
</table>

2. Specifications

2.1 Features of E2 series Manipulators

E2 series Manipulators are designed based on the “E series” and have high performance: high speed; high precision; space saving; and improvement of cost performance.
The features of E2 series Manipulators are as follows:

(1) Compatible with E series Manipulators

- E2 series Manipulators are highly compatible with E series Manipulators; the installation procedure and mounting dimension of end effector for E2 series are completely compatible with those for E series.
- Major maintenance parts for E2 series Manipulators are common to those for E series; consequently, the maintenance cost is reduced.

(2) Space Saving/Multiple Mountings

- E2 series Manipulators have been downsized since the height of the cable duct has been lowered.
- Installation available for ceiling and wall as standard model (Multiple Mountings)

(3) Available for Large-load

- The capacity for large-load has been improved since allowable moment of inertia of U-axis has been increased.
- Optimal control for load makes the handling in large-load stable.

(4) High Speed/High Duty Operation

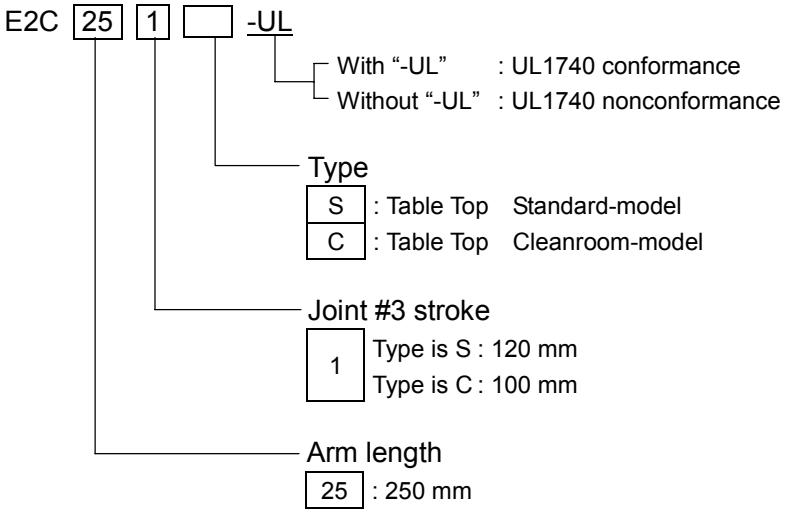
- The ability for high duty operation has been improved since the capacities of motors have been increased.
- Cycle time has been shortened since vibration has been lower and operating speed has been higher.

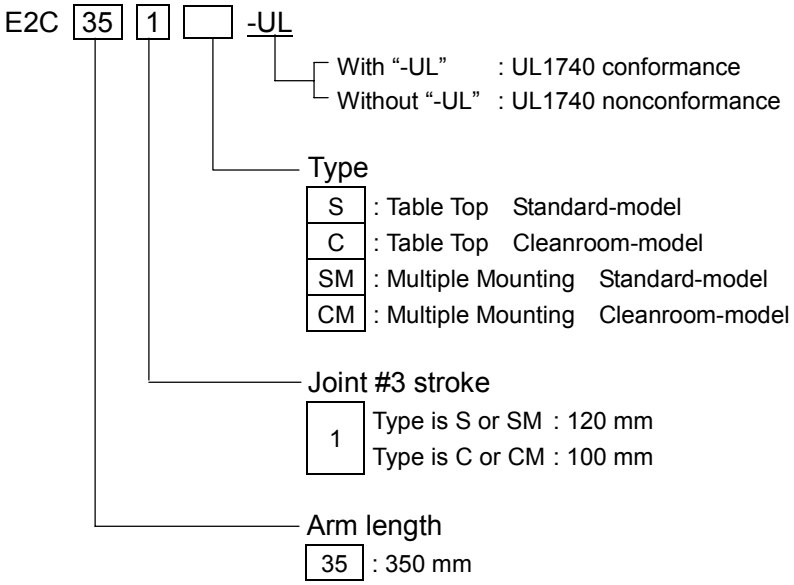
UL1740 Conformance Type

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

E2C Series Model Number





When the manual conveys information that applies to all models regardless of "Joint #3 stroke" or "Arm length", asterisks "*" are used in the model number.

Example : E2C***S

(This model number means that the Manipulator is E2C series Table Top Standard-model corresponding to all arm lengths.)

The "-UL" is indicated in this manual only when the specifications of UL1740 conformance type are different from those of nonconformance type.

Figures in this manual are for the UL1740 conformance type.

Model Differences

Mechanism Mounting	Use Environment	Name	Applicable Series
Table top	Standard	S type	E2C251 E2C351
	Cleanroom - Available for clean rooms * Countermeasure for Electrostatic Discharge (ESD) has been taken.	C type	E2C251 E2C351
Multiple Mountings Side Top shelf (See "NOTE" below.) Bottom shelf (See "NOTE" below.) Ceiling	Standard	SM type	E2C351
	Cleanroom - Available for clean rooms * Countermeasure for Electrostatic Discharge (ESD) has been taken.	CM type	E2C351

NOTE: The "shelf" also means beam.
For the example of the installation, refer to *Setup & Operation: 3.4.3 Installation Procedure: Multiple Mountings*.

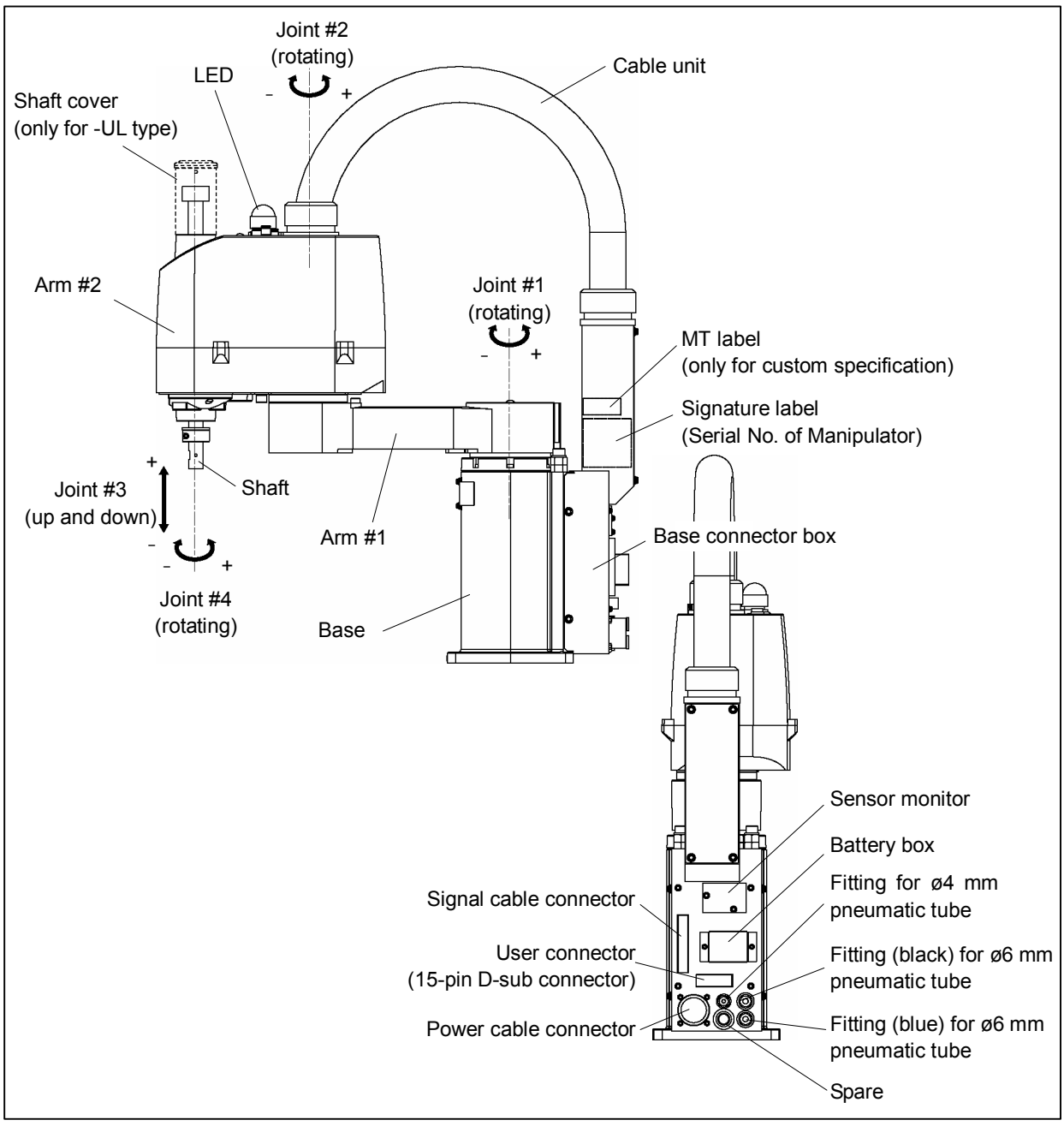
Cleanroom-model (C, CM Types)

Cleanroom-model Manipulators include additional features that reduce dust emitted by the Manipulator to enable use in clean room environments.
For details on the specifications, refer to *Setup & Operation: 2.4 Specifications*.

2.3 Appearance

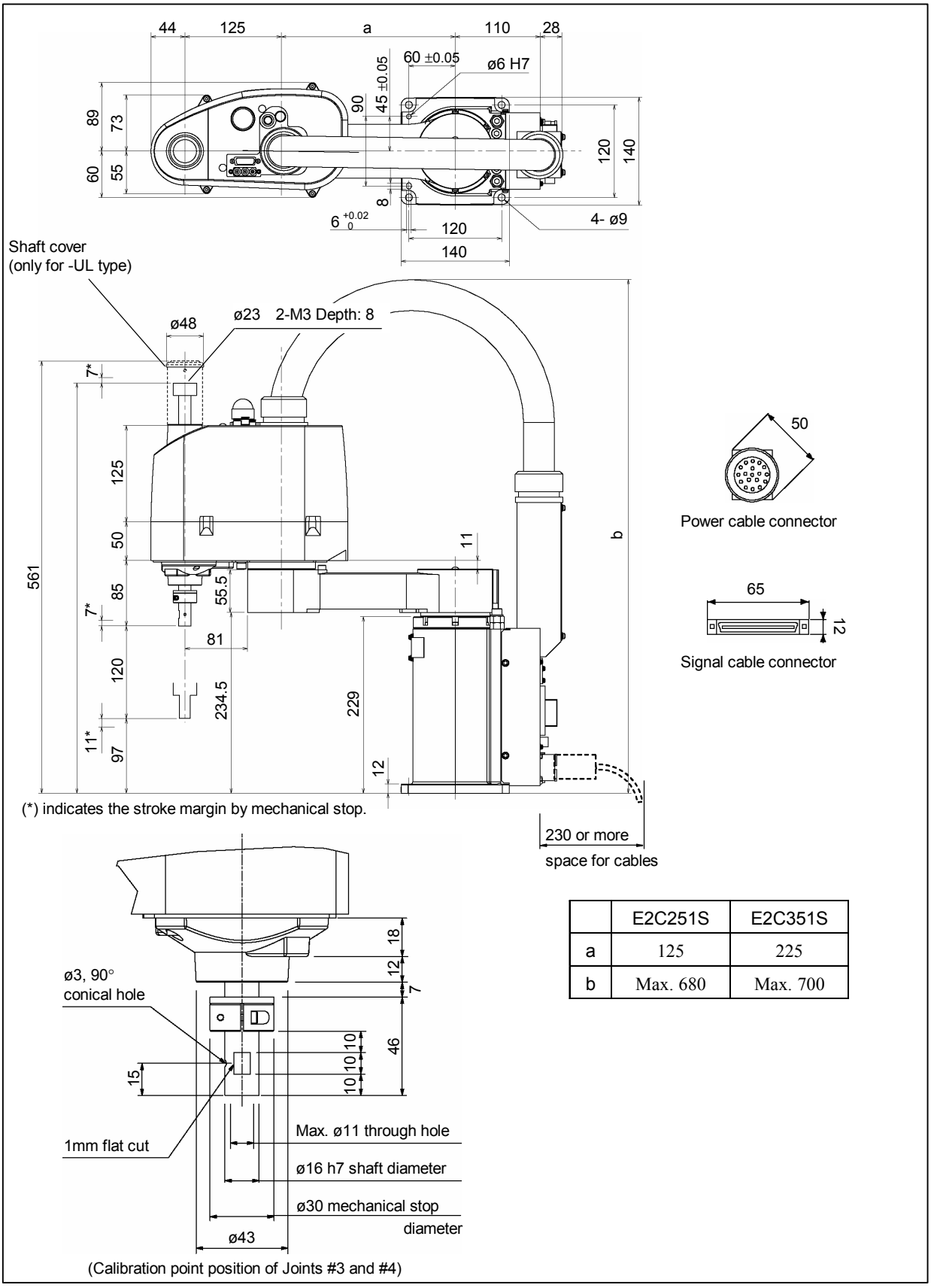
2.3.1 Table Top Standard-model: S Type

Part Names



Outer Dimension

E2C series S type [unit: mm]



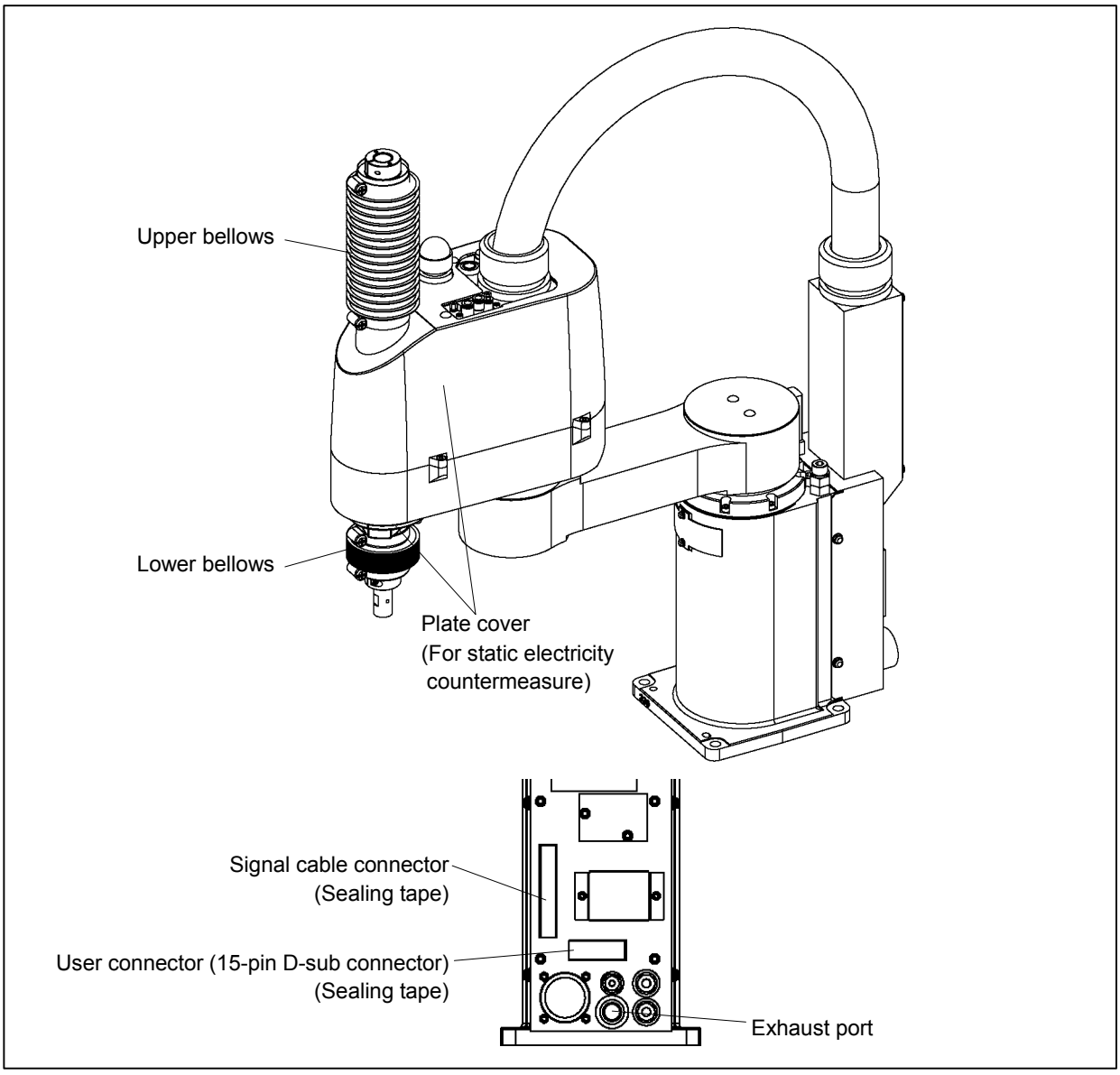
	E2C251S	E2C351S
a	125	225
b	Max. 680	Max. 700

■ The flat cut and conical hole on the end of the shaft can be used for orienting Joint #4 by tightening a setscrew.

2.3.2 Table Top Cleanroom-model: C Type

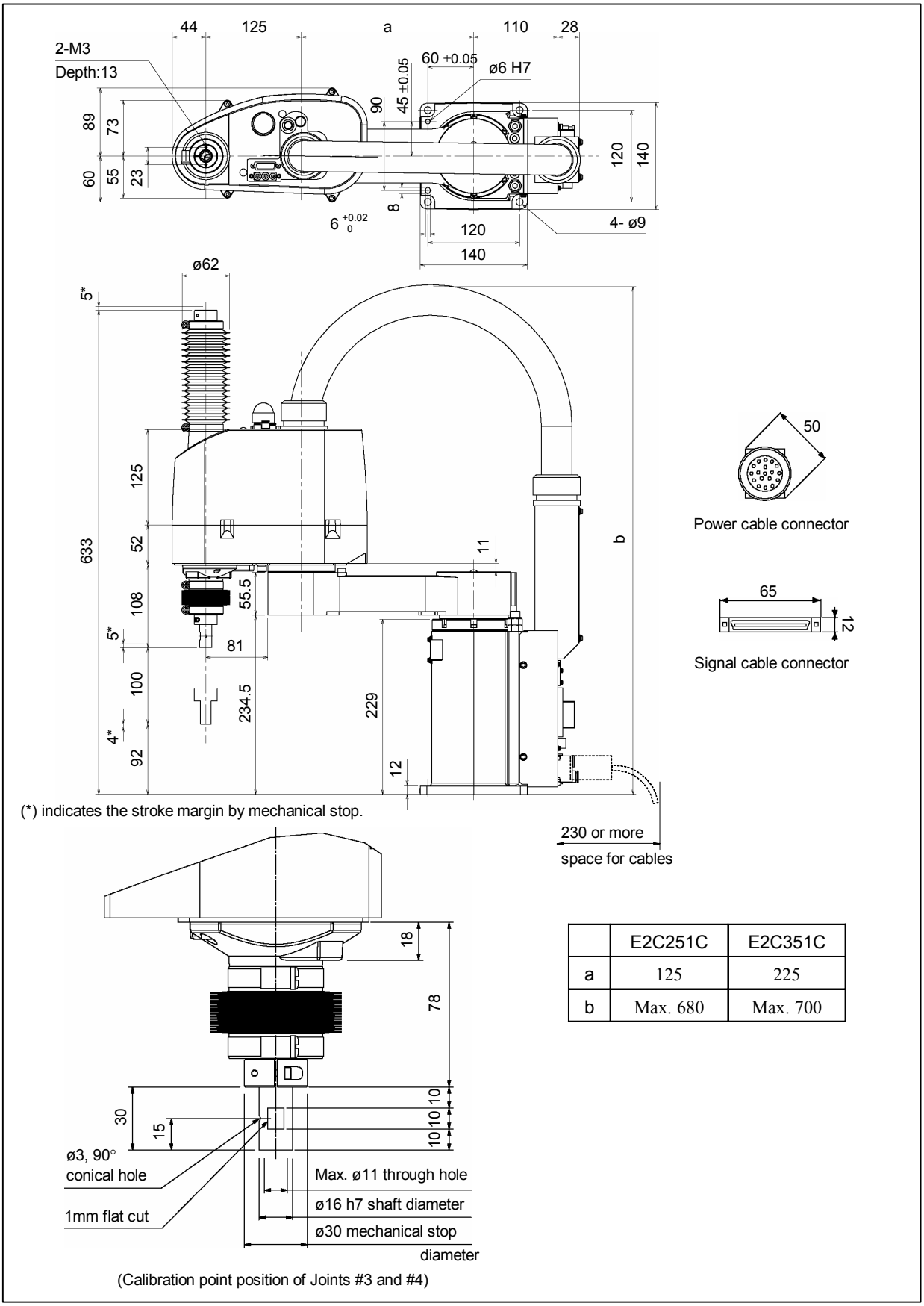
Part Names

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



Outer Dimension

E2C series C type [unit: mm]

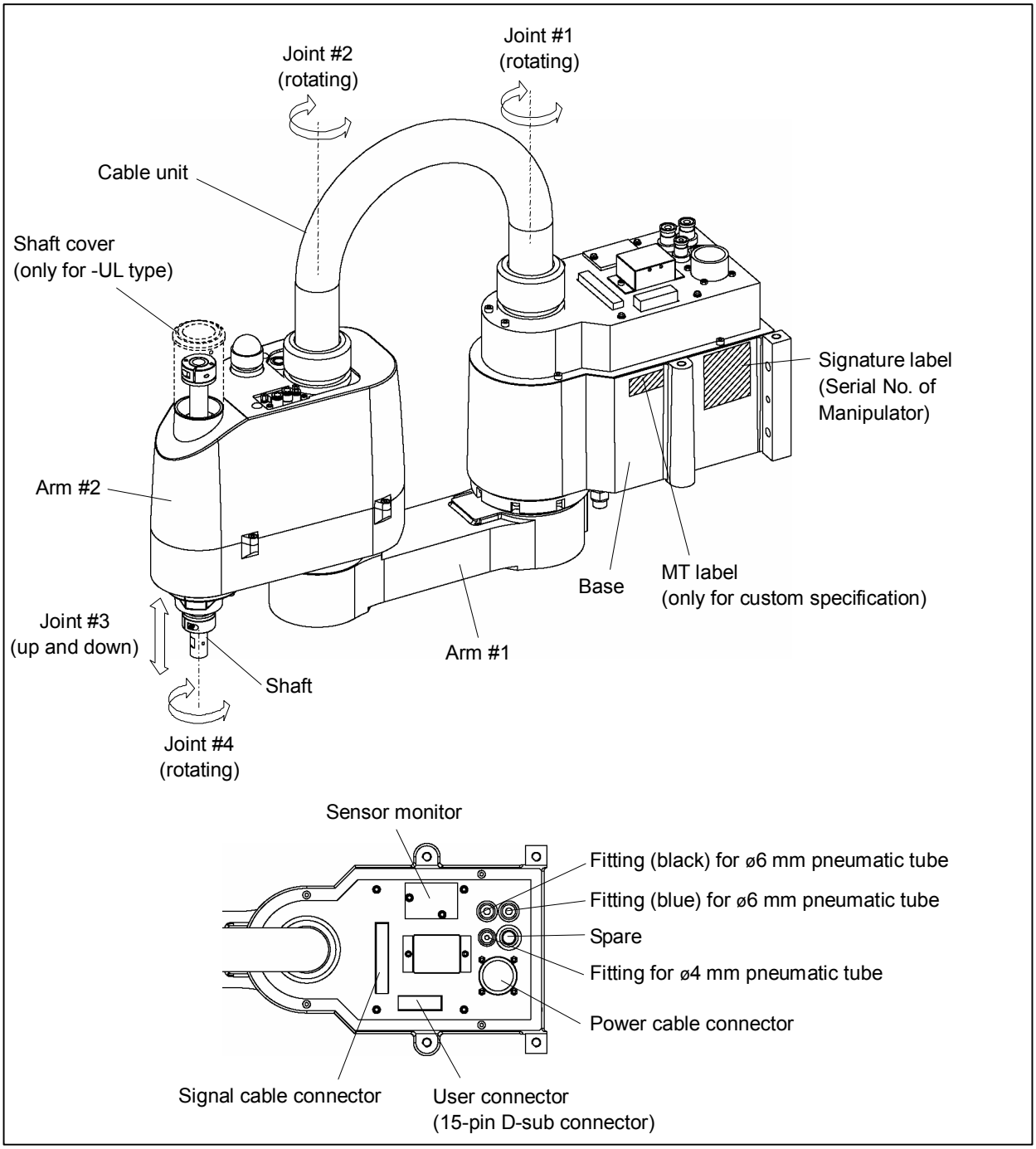


	E2C251C	E2C351C
a	125	225
b	Max. 680	Max. 700

■ The flat cut and conical hole on the end of the shaft can be used for orienting Joint #4 by tightening a setscrew.

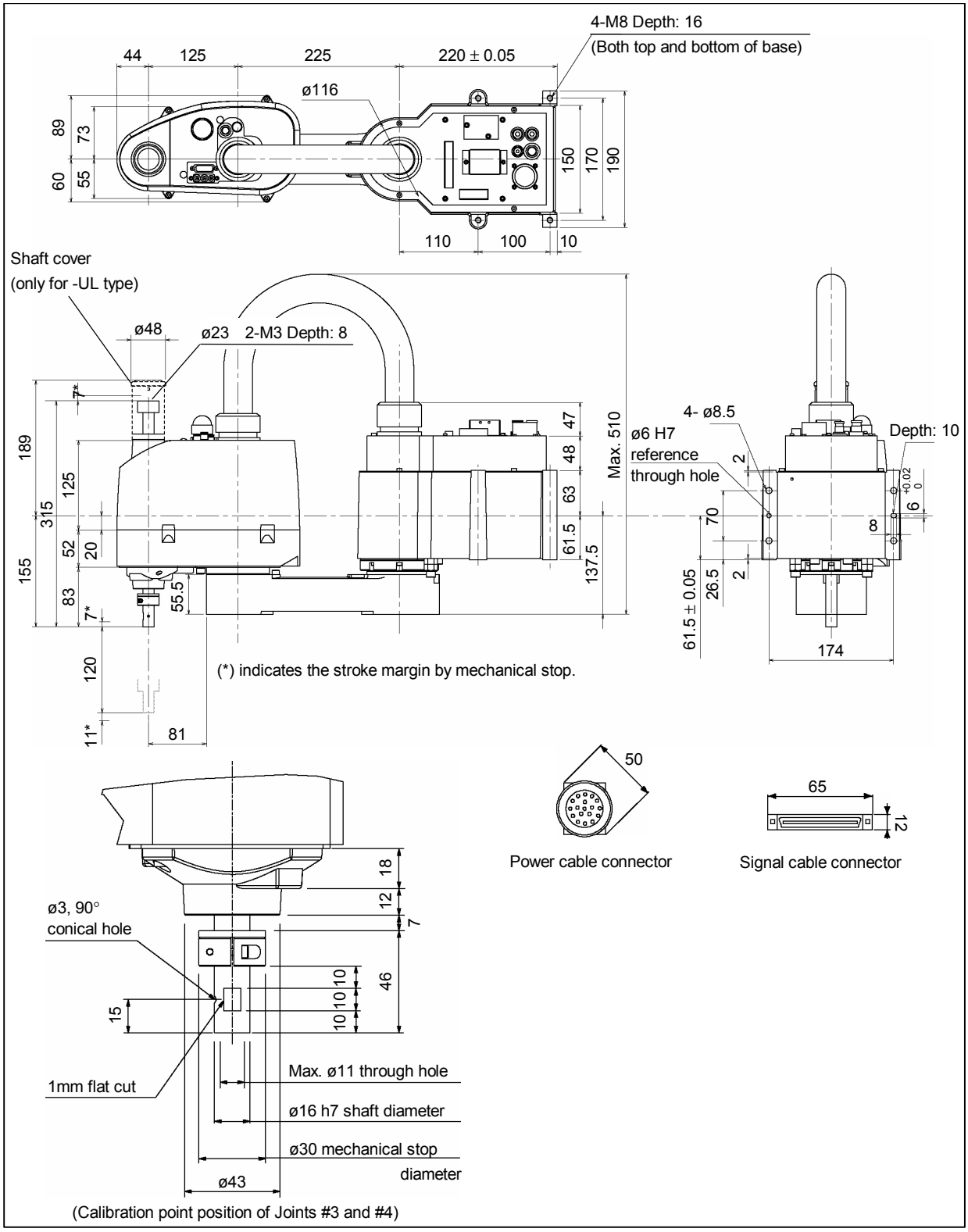
2.3.3 Multiple Mounting Standard-model: SM Type

Part Names



Outer Dimension

E2C351SM [unit: mm]

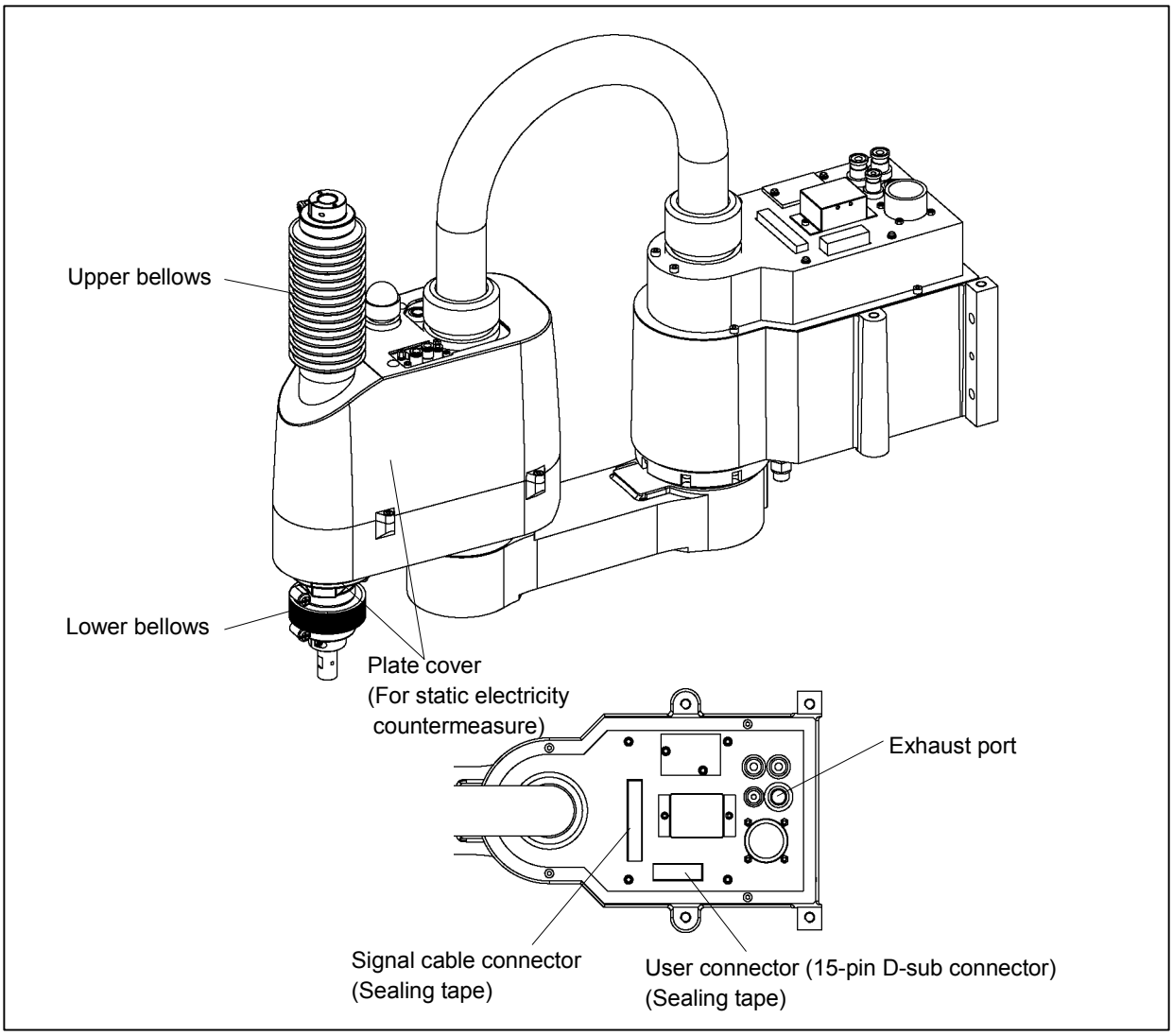


■ The flat cut and conical hole on the end of the shaft can be used for orienting Joint #4 by tightening a setscrew.

2.3.4 Multiple Mounting Cleanroom-model: CM Type

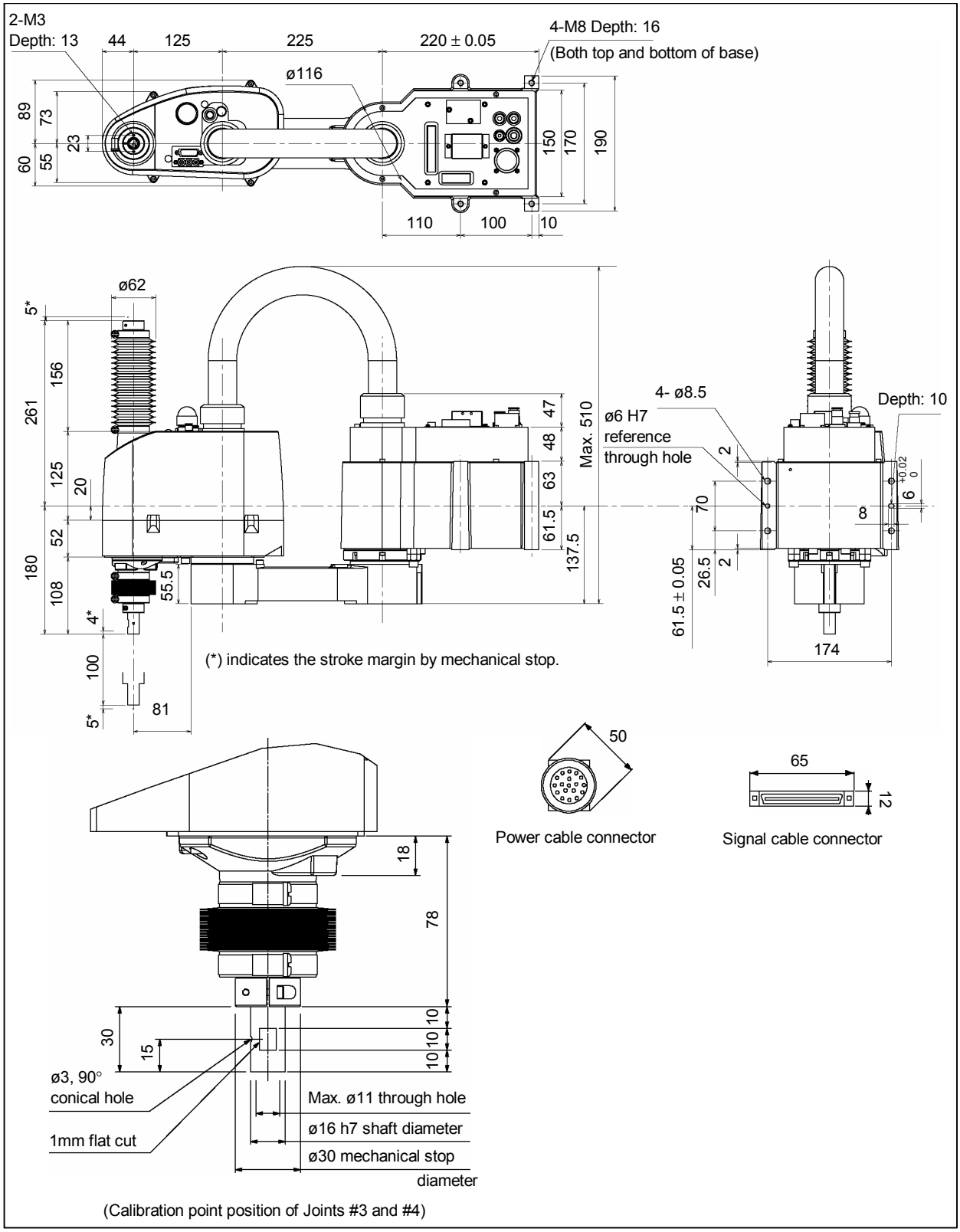
Part Names

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



Outer Dimension

E2C351CM [unit: mm]



■ The flat cut and conical hole on the end of the shaft can be used for orienting Joint #4 by tightening a setscrew.

2.4 Specifications

Item			E2C251*	E2C351*
Arm length		Arm #1, #2	125 mm / 125 mm	225 mm / 125 mm
Weight (not include the weight of cables)			E2C**1S, C: 14 kg : 31lb. / E2C351SM, CM: 16 kg : 36lb.	
Driving method		All joints	AC servo motor	
Max. operating speed *1		Joint #1, #2	2900 mm/s	3600 mm/s
		Joint #3	1100 mm/s	
		Joint #4	2600 degrees/s	
Repeatability		Joint #1, #2	± 0.008 mm	± 0.010 mm
		Joint #3	± 0.010 mm	
		Joint #4	± 0.02 degrees	
Max. motion range *2		Joint #1	± 90 degrees	± 110 degrees
		Joint #2	± 135 degrees	± 145 degrees
		Joint #3	E2C**1S, SM 120 mm / E2C**1C, CM: 100 mm	
		Joint #4	± 360 degrees	
Max. pulse range		Joint #1	0 to +163840	-18205 to +182045
		Joint #2	± 76800	± 82489
		Joint #3	E2C**1S, SM: -36864 to 0 / E2C**1C, CM: -30720 to 0	
		Joint #4	± 46695	
Resolution		Joint #1	0.0010986 degrees/pulse	
		Joint #2	0.0017578 degrees/pulse	
		Joint #3	0.0032552 mm/pulse	
		Joint #4	0.0077097 degrees/pulse	
Motor power consumption		Joint #1	150 W	
		Joint #2	150 W	
		Joint #3	150 W	
		Joint #4	150 W	
Payload		Rated max.	1 kg 3 kg	
Joint #4 allowable moment of inertia *3		Rated max.	0.005 kg·m^2 0.050 kg·m^2	
Shaft diameter through hole			ø16 (h7)mm ø11 mm	
Joint #3 down force			150 N	
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^2 : 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 *4			L_{Aeq} = 66.3 dB (A) or under	
Applicable Controller			RC520 RC420 RC170	
Default values		SPEED	5	
		ACCEL	10,10	
		SPEEDS	50	
		ACCELS	200	
		FINE	10,10,10,10	
		WEIGHT	1,125	
Cleanroom-model	Cleanliness level		Clean Class: 10 or its equivalent Amount of Dust: 10 particles or less (0.13µm diameter or larger) (In 28317cm^3 (1cft) sample-air around the center of the motion range)	
	Exhaust System *5	Exhaust tube	Polyurethane tube Outer diameter: ø8 mm	
		Recommended exhaust flow rate	Approximately 1000 cm^3/s (Normal)	
Safety standard			ANSI/RIA R15.06 conformance CE conformance: All models UL1740 conformance: E2C**1S-UL, E2C**1C-UL, E2C351SM-UL, E2C351CM-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: The motion range of some models is limited by the Cartesian (rectangular) range. For details, refer to *Setup & Operation: 5.4 Standard Motion Range*.

*3: 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.

*4: 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.

*5: - 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.
- Seal the exhaust port and the exhaust tube with vinyl tape so that the joint is airtight.
If the exhaust flow is not sufficient, dust particle emission may exceed the specified maximum level.

2.5 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	· Install indoors. · Keep away from direct sunlight. · Keep away from dust, oily smoke, salinity, metal powder or other contaminants. · Keep away from flammable or corrosive solvents and gases. · Keep away from water. · Keep away from shocks or vibrations. · Keep away from sources of electric noise.

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.

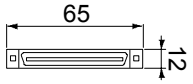
The base table must not only be able to bear the weight of the Manipulator but also be able to withstand the dynamic movement of the Manipulator when the Manipulator operates at maximum acceleration. Ensure that there is enough strength on the base table by attaching reinforcing materials such as crossbeams.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

Max. Reaction torque on the horizontal plate : 250Nm

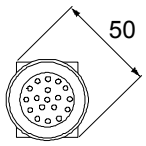
Max. Horizontal reaction force : 900N

Max. Vertical reaction force : 1000N

- The threaded holes for the Manipulator base are M8. Use the mounting bolts conforming to the strength, 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 μm 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.



Power Cable Connector



Signal Cable Connector [unit: mm]

NOTE 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

NOTE ☞ The maximum space described in figures shows that the radius of end effector is 44 mm or less. If the radius of the end effector exceeds 44 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.

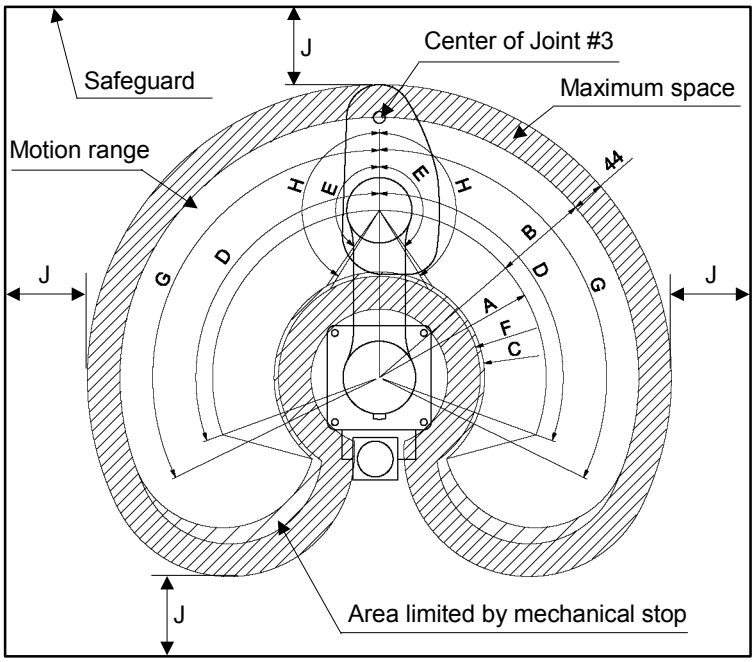
Mounting Area

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

NOTE ☞ 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.

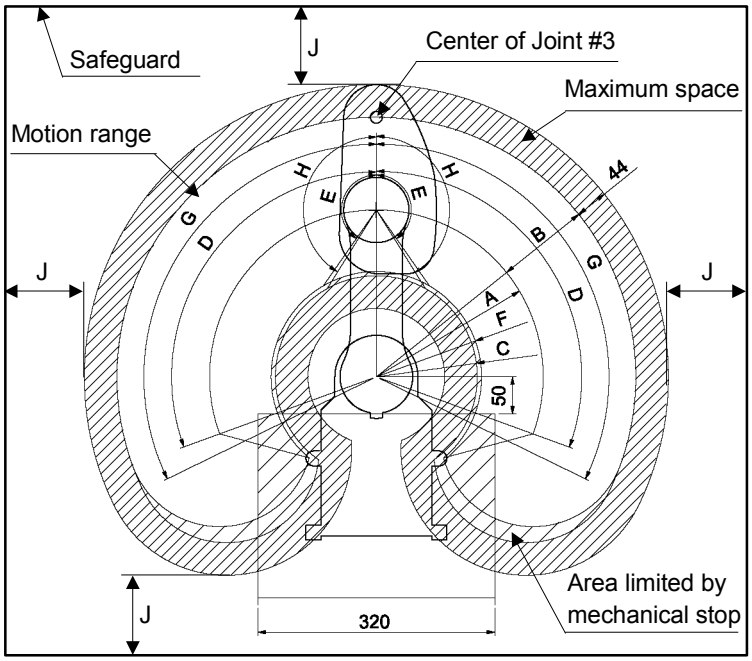
3.3.1 Table Top



Standard Motion Range of Manipulator	E2C251S/C	E2C351S/C
A (Length of Arm #1)	125 mm	225 mm
B (Length of Arm #2)	125 mm	125 mm
C	95.7 mm	142 mm
D (Motion range of Joint #1)	90 degrees	110 degrees
E (Motion range of Joint #2)	135 degrees	145 degrees
F	89.6 mm	136 mm
G (Range to the mechanical stop of Joint #1)	98 degrees	116 degrees
H (Range to the mechanical stop of Joint #2)	138 degrees	148 degrees
J (Range to the safeguard)	approx. 100 mm*	

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

3.3.2 Multiple Mountings



Standard Motion Range of Manipulator	E2C351SM/CM
A (Length of Arm #1)	225 mm
B (Length of Arm #2)	125 mm
C	136 mm
D (Motion range of Joint #1)	110 degrees
E (Motion range of Joint #2)	145 degrees
F	142 mm
G (Range to the mechanical stop of Joint #1)	116 degrees
H (Range to the mechanical stop of Joint #2)	148 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.

WARNING	■ 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.

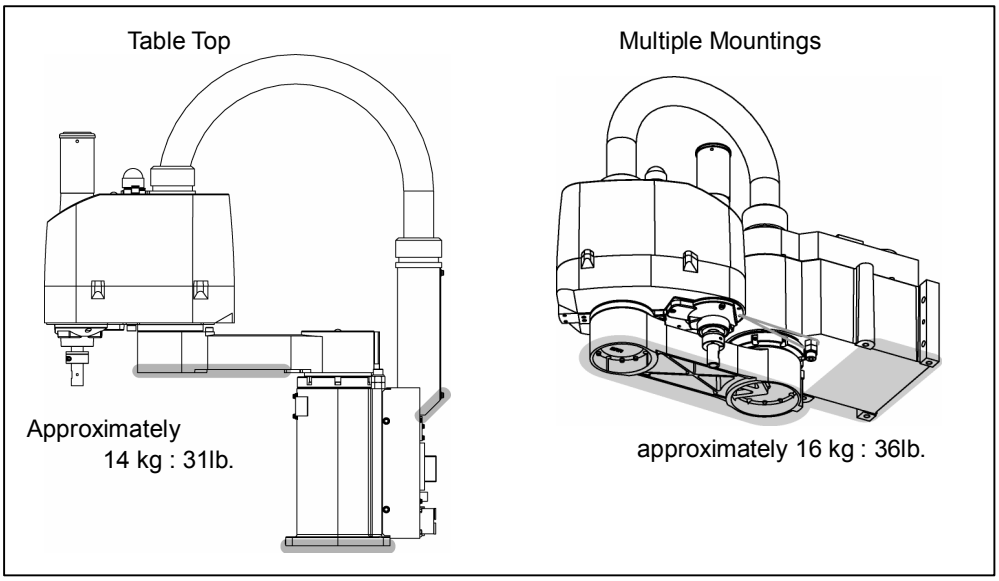
CAUTION

■ Using a cart or similar equipment, transport the Manipulator in the same manner as it was delivered.

■ After removing the bolts securing the Manipulator to the delivery equipment, the Manipulator can fall. Be careful not to get hands or fingers caught.

■ 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.

■ To carry the Manipulator, have two or more people to work on it and secure the Manipulator to the delivery equipment or hold the areas indicated in gray in the figure (bottom of Arm #1/main cable elbow fitting/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.



■ Be careful not to get hands or fingers caught when holding the bottom of the base by hand.

■ Stabilize the Manipulator with your hands when hoisting it.

■ 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.

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

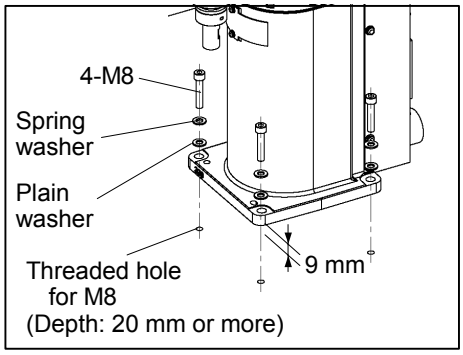
3.5.1 Table Top

*This section describes the installation procedure with the figures for the Standard-model.

When the Manipulator is C type, unpack it outside of the clean room.
Secure the Manipulator not to fall, and then wipe off the dust on the Manipulator with a little alcohol or distilled water on a lint-free cloth. After that, carry the Manipulator in the clean room.

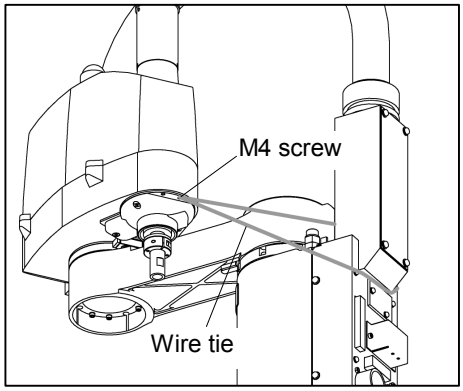
(1) Secure the base to the base table with four bolts.

NOTE
Use the bolts conforming to the strength, ISO898-1 Property Class: 10.9 or 12.9.



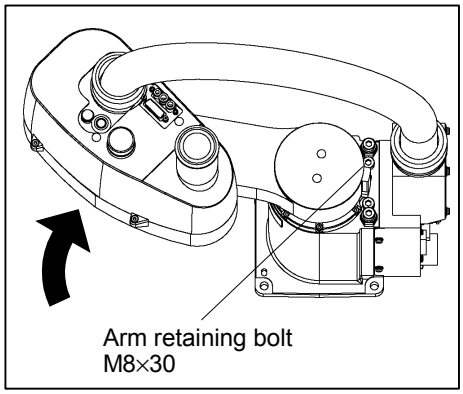
(2) Using nippers, cut off the wire tie securing Arm #2.

(3) Unscrew the M4 screw on the end of Arm #2.



(4) Push Arm #1 slowly in the direction shown with an arrow in the figure on the right.
Fasten the arm retaining bolt on the base.

NOTE
The arm retaining bolt must be fastened. Otherwise, the motion range of Joint #1 is limited.

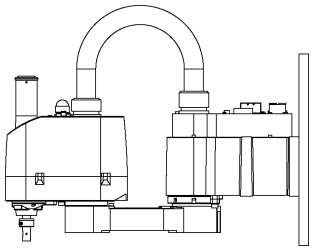
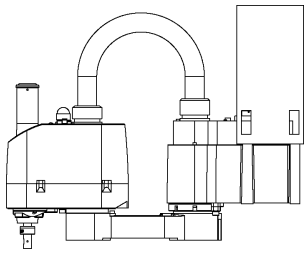
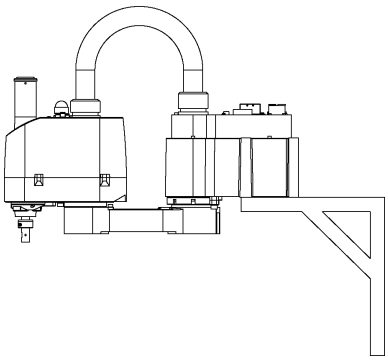
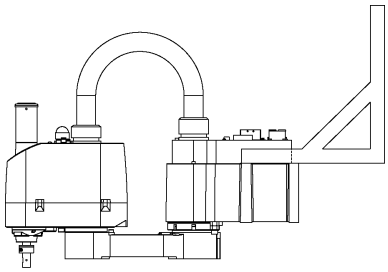


When the Manipulator is C type, connect an exhaust tube to the exhaust port.

3.5.2 Multiple Mountings

WARNING	■ Install the Multiple Mounting Manipulator with two or more people. The Manipulator weighs approximately 16 kg. Be careful not to get hands, fingers, or feet caught and/or have equipment damage by the fall of the Manipulator. ■ When mounting the Manipulator on the wall, do not remove the support until all the anchor bolts are secured. Removing the support while the anchor bolts are not secured sufficiently is extremely hazardous and may result in fall of the Manipulator.

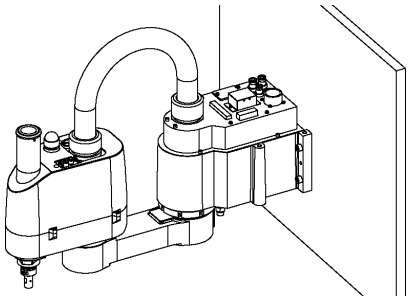
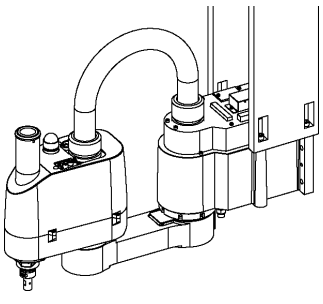
The Multiple Mountings Manipulators have mounting holes available for the following installation patterns.

Side 	Ceiling 
Top Shelf 	Bottom Shelf 

NOTE

Design and make the base table for anchoring the Multiple Mounting Manipulators so that it does not touch any cable connected to the base connector plate.

The recommended installation patterns are as follows:

Side 	Ceiling 

Installation Procedure

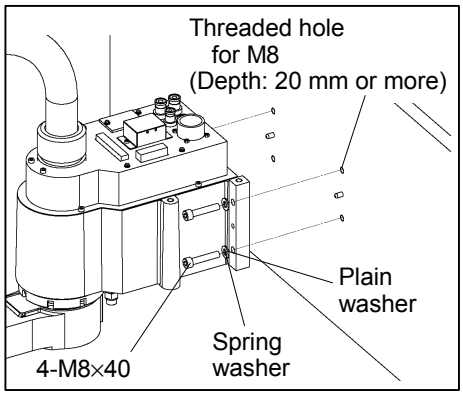
The following shows a recommended procedure for installing the Multiple Mounting Manipulators to a wall.

When the Manipulator is CM type, unpack it outside of the clean room.
Secure the Manipulator not to fall, and then wipe off the dust on the Manipulator with a little alcohol or distilled water on a lint-free cloth. After that, carry the Manipulator in the clean room.

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

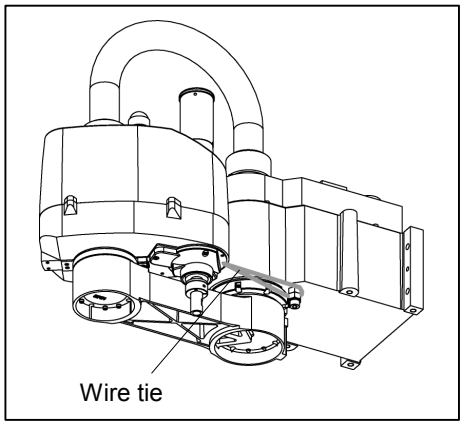
NOTE

Use the bolts conforming to the strength, ISO898-1 Property Class: 10.9 or 12.9.



(2) Using nippers, cut off the wire tie securing Arm #2.

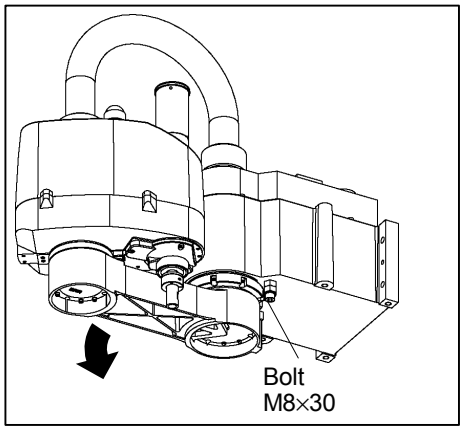
(3) Unscrew the M4 screw on the end of Arm #2.



(4) Push Arm #1 slowly in the direction shown with an arrow in the figure on the right.
Fasten the arm retaining bolt under the base.

NOTE

The arm retaining bolt must be fastened. Otherwise, the motion range of Joint #1 is limited.



When the Manipulator is CM type, connect an exhaust tube to the exhaust port.

3.6 Connecting the Cables

 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. ■ 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.

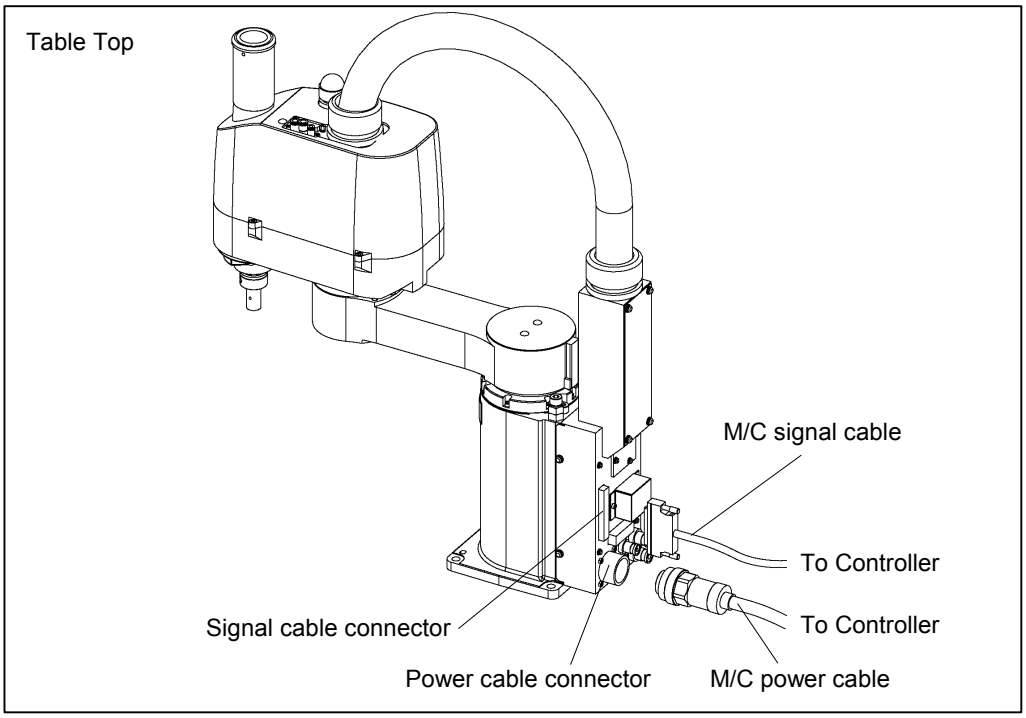
 CAUTION	■ When connecting the Manipulator and the Controller, make sure that the serial numbers on each equipment match. Improper connection between the Manipulator and Controller may not only cause improper function of the robot system but also serious safety problems. The connection method varies with the Controller used. For details on the connection, refer to the controller manual.

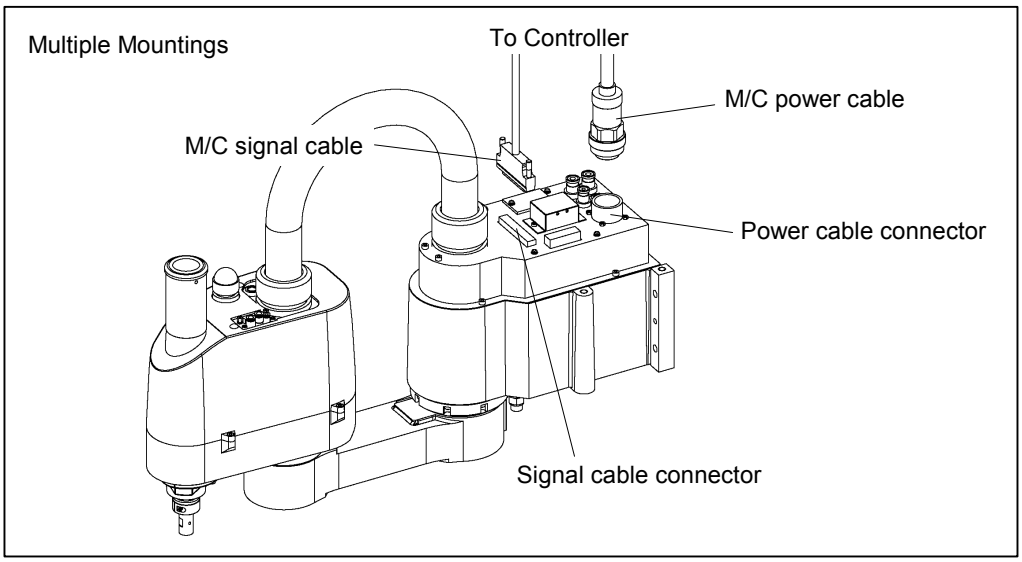
Connecting the Cables for Cleanroom-model (C, CM Types)

When the Manipulator is a Cleanroom-model (C, CM types), use it with an exhaust system. For details, refer to *Setup & Operation: 2.4 Specifications.*

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.



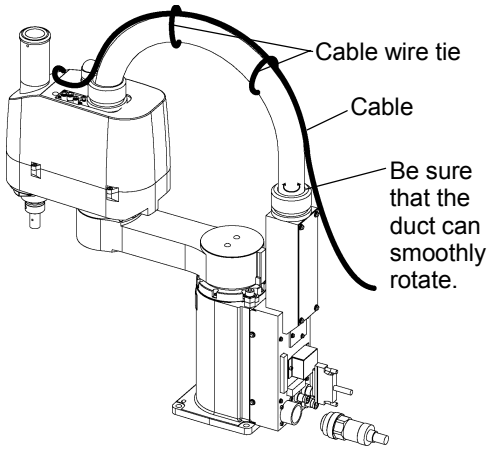


3.7 User Wires and Pneumatic Tubes

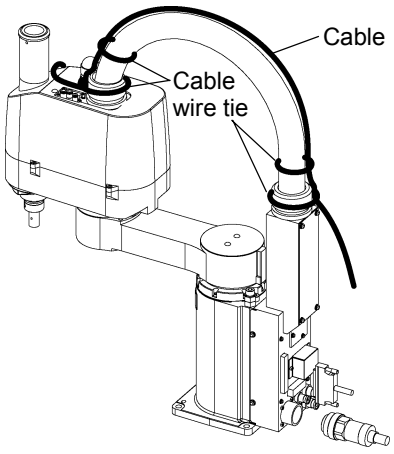
WARNING

- 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 elbow fitting and duct joint. When the duct is inserted in the main cable elbow fitting and/or duct joint too deep or the cable is bound on the duct, main cable elbow fitting, and duct joint with the wire ties, the duct cannot smoothly rotate in the main cable elbow 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^2	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)

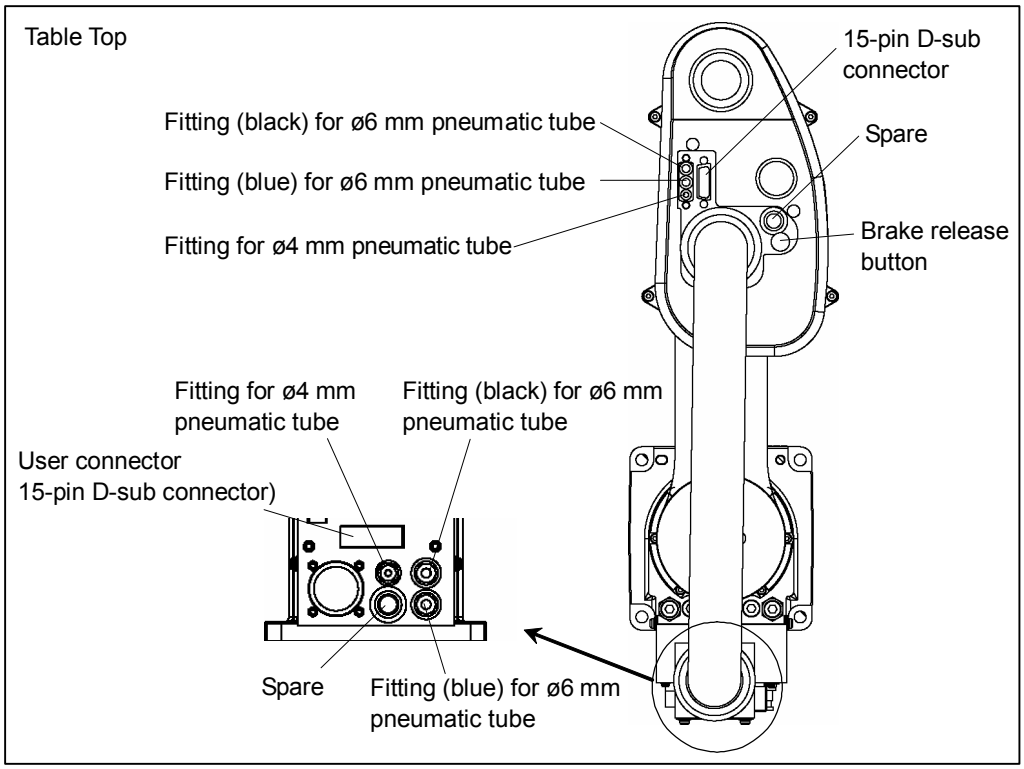
Pins with the same number, indicated on the connectors on both ends of the cables, are connected.

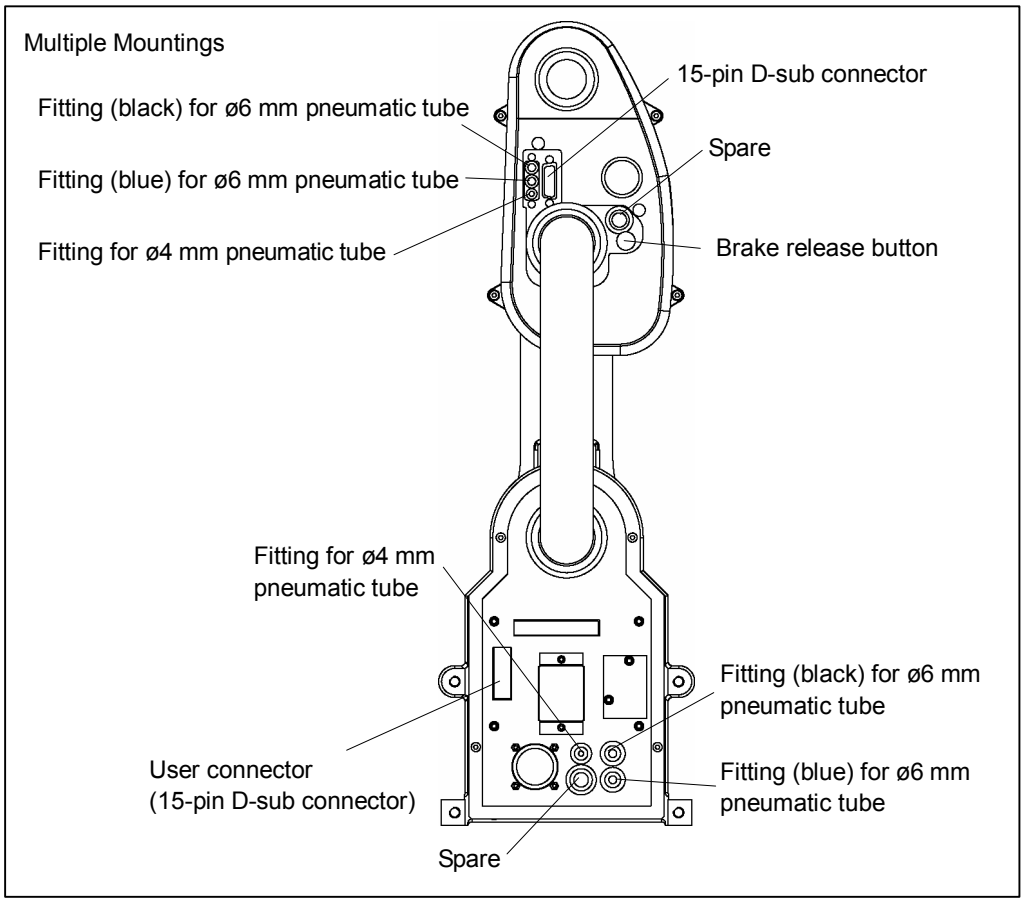
Pneumatic Tubes

Max. Usable Pneumatic Pressure	Pneumatic Tubes	Outer Diameter × Inner Diameter
0.59 MPa (6 kgf/cm^2 : 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.

 CAUTION	■ 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. ■ 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. ■ 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. ■ Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in fall of the Manipulator.

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 of it 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 the Table Top Models

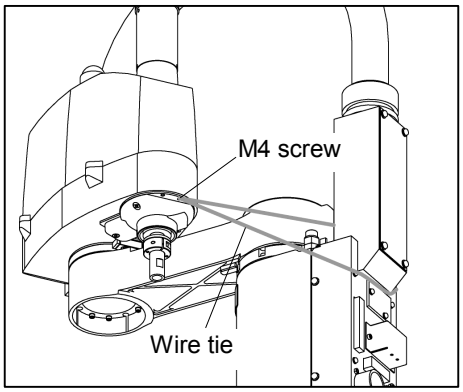
Follow the procedures described below when relocating the Manipulator.

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

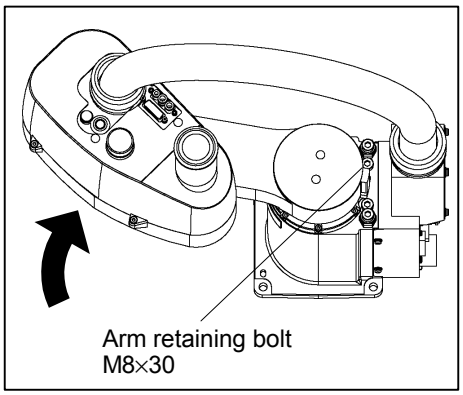
NOTE


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

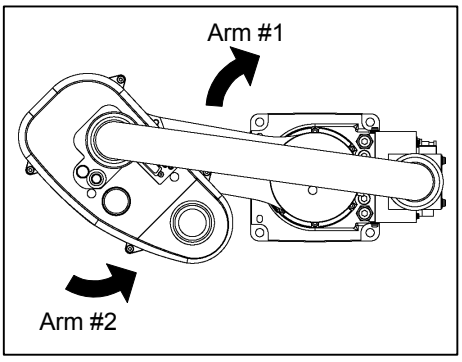
(2) Tighten the M4 screw on the bottom of Arm #2' end.



(3) Push Arm #1 by hand in the direction shown with the arrow in the figure on the right until the arm retaining bolt appears.
Turn the arm retaining bolt upward until the part under the head of the bolt appears by 15 mm.

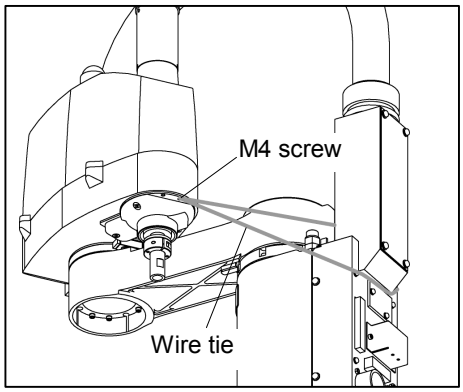


(4) Push Arms #1/#2 by hand in the direction shown with the arrows in the figure on the right until the arms touch the arm retaining bolt and mechanical stop.



(5) Tie the M4 screw and the main cable elbow fitting together with a wire tie as shown in the figure on the right.

Be careful not to tie them too tight. Otherwise, the shaft may bend.



(6) Hold the bottom of Arm #1 by hand to unscrew the anchor bolts. Then, remove the Manipulator from the base table.

3.8.3 Relocating the Multiple Mounting Models

WARNING	■ Install the Multiple Mounting Manipulator with two or more people. The Manipulator weighs approximately 16 kg. Be careful not to get hands, fingers, or feet caught and/or have equipment damage by the fall of the Manipulator. ■ When relocating the Manipulator from wall, support the Manipulator, and then remove the anchor bolts. Removing the anchor bolts without supporting is extremely hazardous and may result in fall of the Manipulator.

Follow the procedures described below when relocating the Manipulator.

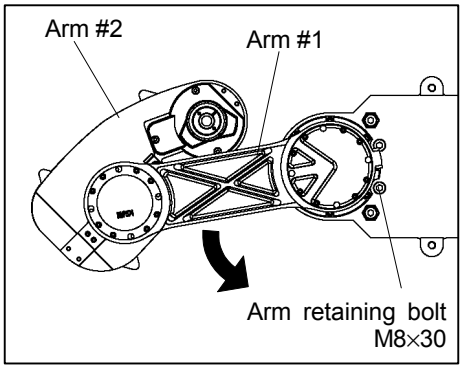
(1) Turn OFF the power on all devices and unplug the cables.

NOTE

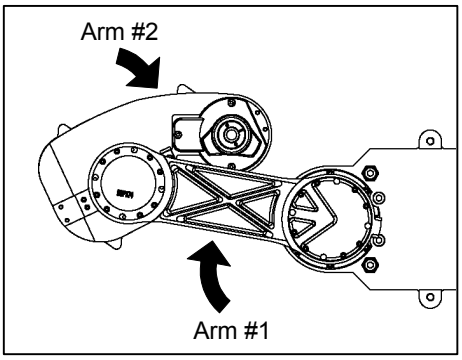
Remove the mechanical stops if using them to limit the motion range of Joint #1 and #2. For details on the motion range, refer to *Setup & Operation: 5.2 Motion Range Setting by Mechanical Stops*.

(2) Push Arm #1 by hand in the direction shown with the arrow in the figure on the right until the arm retaining bolt appears. Turn the arm retaining bolt upward until the part under the head of the bolt appears by 15 mm.

(3) Tighten the M4 screw on the bottom of Arm #2's end.

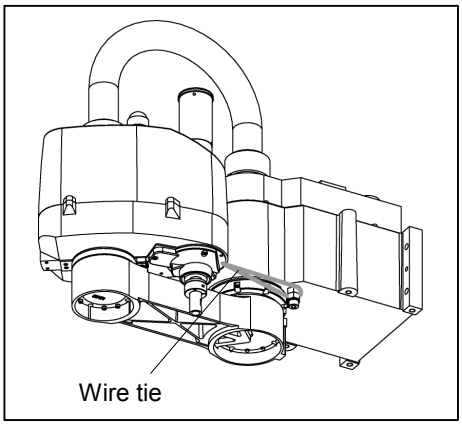


(4) Push Arms #1/#2 by hand in the direction shown with the arrows in the figure on the right until the arms touch the arm retaining bolt and mechanical stop.



(5) Tie the M4 screw and the main cable elbow fitting together with a wire tie as shown in the figure on the right.

Be careful not to tie them too tight. Otherwise, the shaft may bend.



(6) Hold the bottom of Arm #1 by hand to unscrew the anchor bolts. Then, remove the Manipulator from the base table.

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.

CAUTION	■ 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/Os are set 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.

Shaft

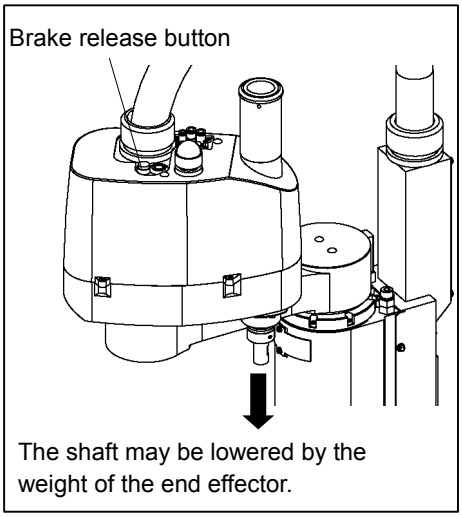
- Attach an end effector to the lower end of the shaft.
  For the shaft dimensions, and the overall dimensions of the Manipulator, refer to *Setup & Operation: 2. Specifications*.
- Do not move the upper limit mechanical stop on the lower side of the shaft. Otherwise, when "Jump motion" is performed, 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.

Joint #3 brake release button

- Joint #3 cannot be moved up/down by hand because the electromagnetic brake is applied to the joint while power to the robot system is turned OFF. This prevents the shaft from hitting peripheral equipment 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 thought the power is turned ON.

  To move Joint #3 up/down while attaching an end effector, turn the Controller ON and move the joint up/down while pushing the Joint #3 brake release button.
  This button is a momentary-type; the brake is released only while the button is being pushed.

- Be careful of the shaft falling while the Joint #3 brake release button is being pushed because it may be lowered by the weight of an end effector.

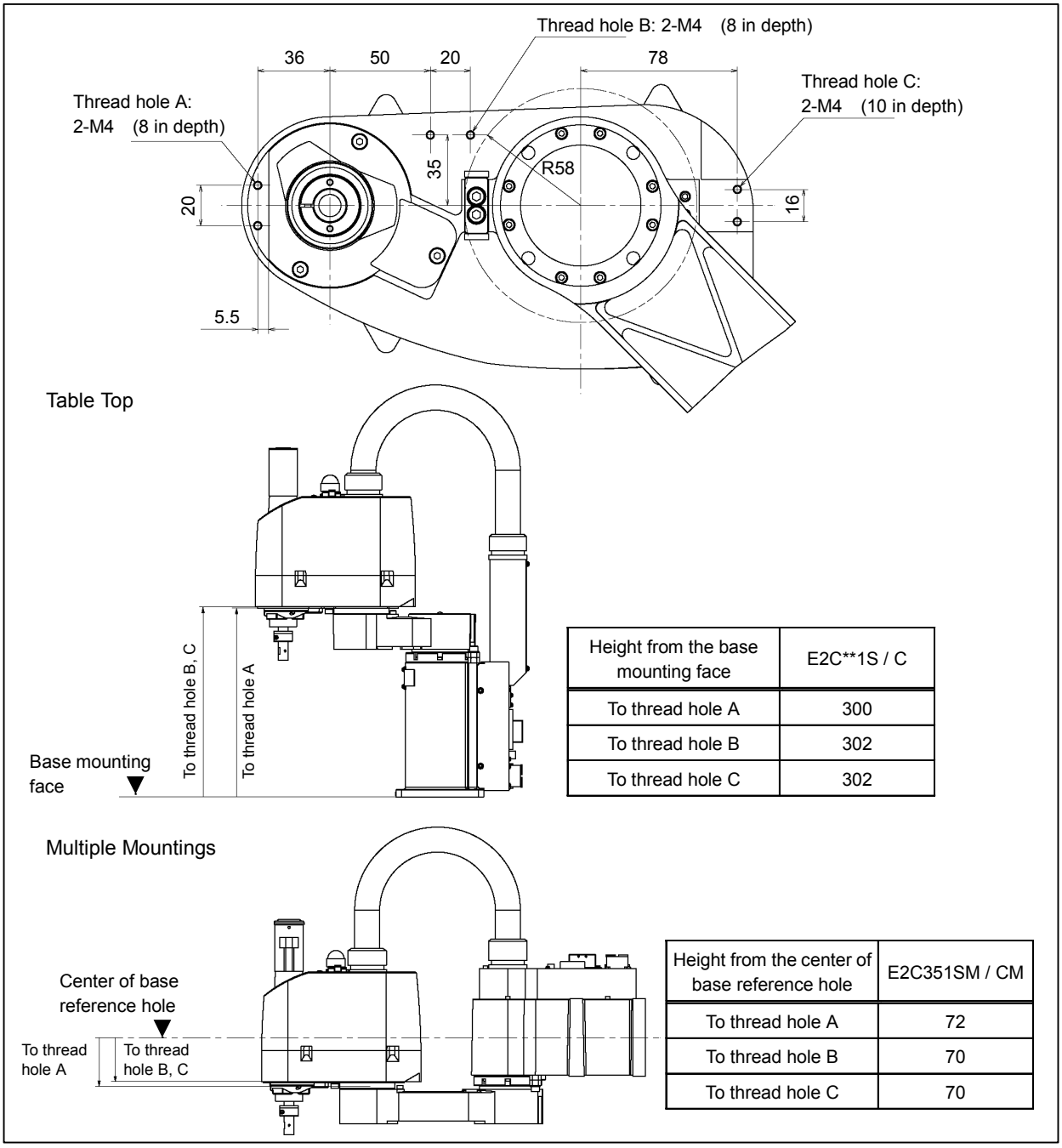


Layouts

- 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.
  If the maximum radius of the end effector is over 37 mm, the end effector may hit the Manipulator depending on the motion.

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.



Height from the base mounting face	E2C**1S / C
To thread hole A	300
To thread hole B	302
To thread hole C	302

Height from the center of base reference hole	E2C351SM / CM
To thread hole A	72
To thread hole B	70
To thread hole C	70

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* and *4.3.2*, to set parameters.
Setting parameters makes the operation of the Manipulator optimal, reduces oscillation to shorten the operating time, and improves the capacity for bigger load. In addition, it reduces persistent oscillation produced when the moment of inertia of the end effector and work piece is bigger.

4.3.1 WEIGHT Setting

CAUTION	■ The total weight of the end effector and the work piece must be 3 kg or less. The E2C series Manipulators are not designed to work with loads exceeding 3 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.

The acceptable weight capacity (end effector and work piece) in E2C series is 1 kg at the rating and 3 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 Joint #2: $W_M = M (L_1)^2/(L_1+L_2)^2$
When you attach the equipment to the end of Arm #2: $W_M = M (L_M)^2/(L_2)^2$

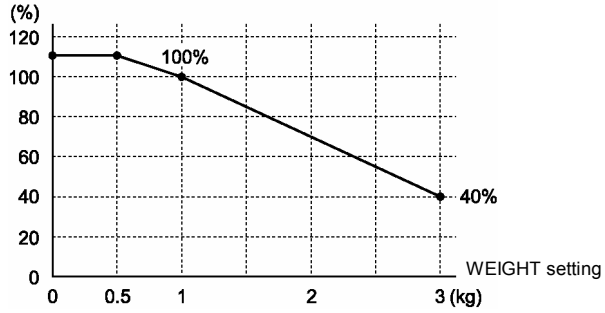
- W_M : equivalent weight
- M : weight of camera etc.
- L_1 : length of Arm #1
- L_2 : length of Arm #2
- L_M : distance from rotation center of Joint #2 to center of gravity of camera etc.

<Example> A “0.5 kg” camera is attached to the end of the E2C series arm (225 mm away from the rotation center of Joint #2) with a load weight “1 kg”.

$M = 0.5$
$L_2 = 125$
$L_M = 225$
$W_M = 0.5 \times 225^2/125^2 = 1.62 \rightarrow 1.7$ (round up)
$W+W_M = 1 + 1.7 = 2.7$

Enter “2.7” to the WEIGHT Parameter.

Automatic speed setting by WEIGHT



E2C25/35

* The percentage in the graph is based on the speed at rated weight (1 kg) as 100%.

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 after objects such as an end effector are attached to the shaft, the moment of inertia of load must be considered.

 CAUTION	■ The moment of inertia of load (weight of the end effector and work piece) must be 0.05 kg·m^2 or less. The E2C series Manipulators are not designed to work with moment of inertia exceeding 0.05 kg·m^2. 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.

The acceptable moment of inertia of load in E2C series is 0.005 kg·m^2 at the rating and 0.05 kg·m^2 at the maximum. When the moment of inertia of load exceeds the rating, change the setting of moment of inertia (INERTIA) parameter of load of INERTIA command. After the setting is changed, the maximum acceleration/deceleration speed of Joint #4 is corresponding to "moment of inertia" 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 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+

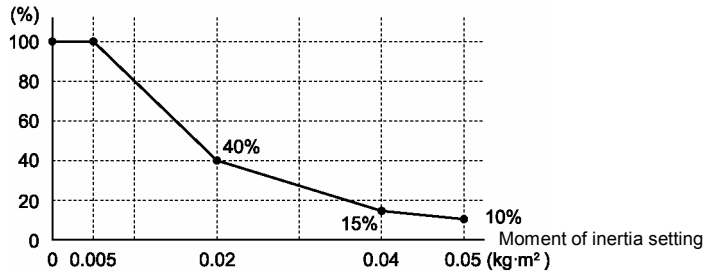
EPSON RC+ 4.* or before（RC520/RC420）

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)



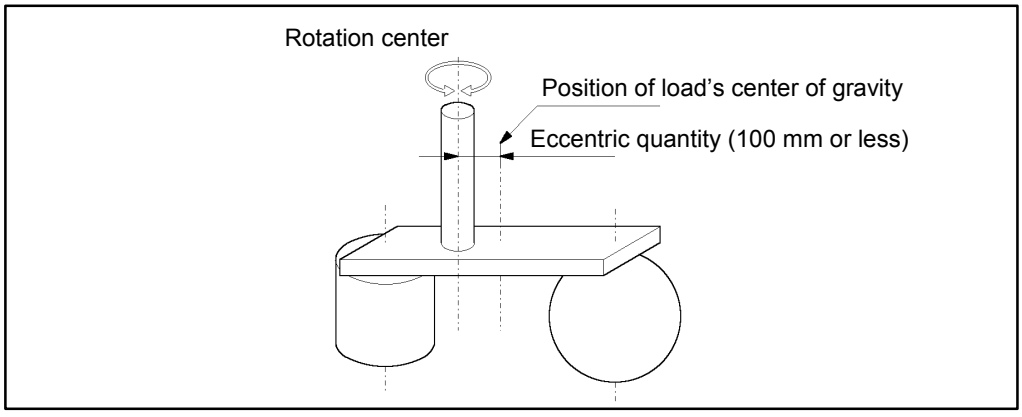
E2C25/35

* The percentage in the graph is based on the speed at rated moment of inertia (0.005 kg·m^2) as 100%

Eccentric Quantity and the INERTIA Setting

CAUTION	■ The eccentric quantity of load (weight of the end effector and work piece) must be 100 mm or less. The E2C series Manipulators are not designed to work with eccentric quantity exceeding 100 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 E2C series is 0 mm at the rating and 100 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 Manipulator corresponding to "eccentric quantity" is set automatically.



Eccentric Quantity

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+

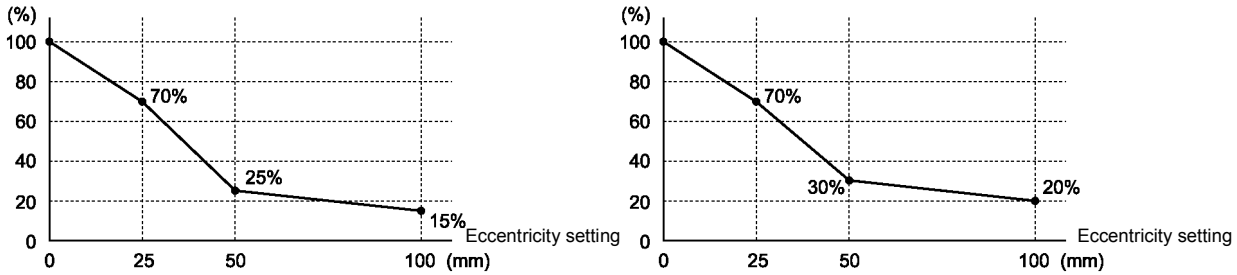
EPSON RC+ 4.* or before（RC520/RC420）

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)



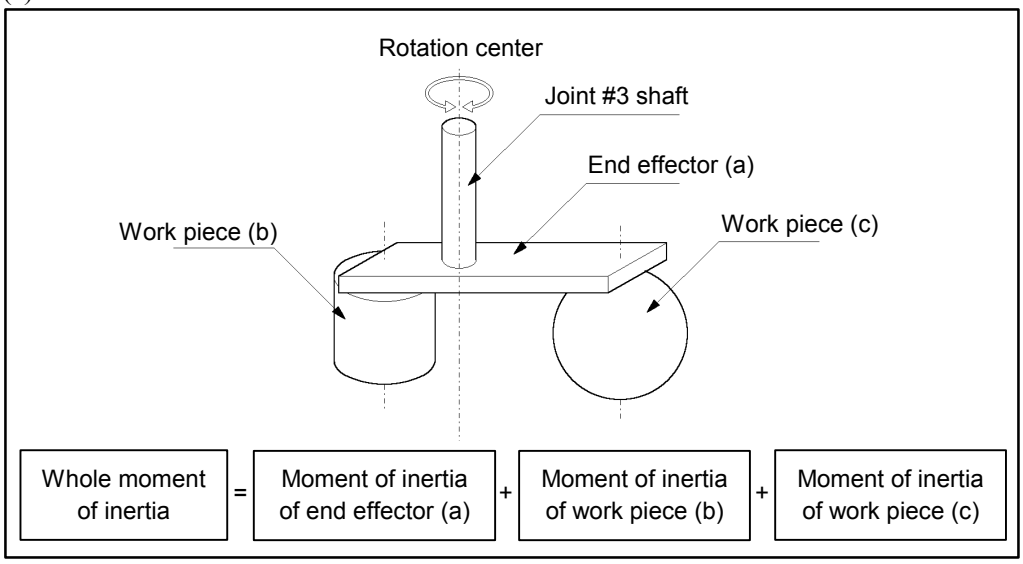
E2C25　　E2C35

* The percentage in the graph is based on the speed at rated eccentricity (0 mm) as 100%.

Calculating the Moment of Inertia

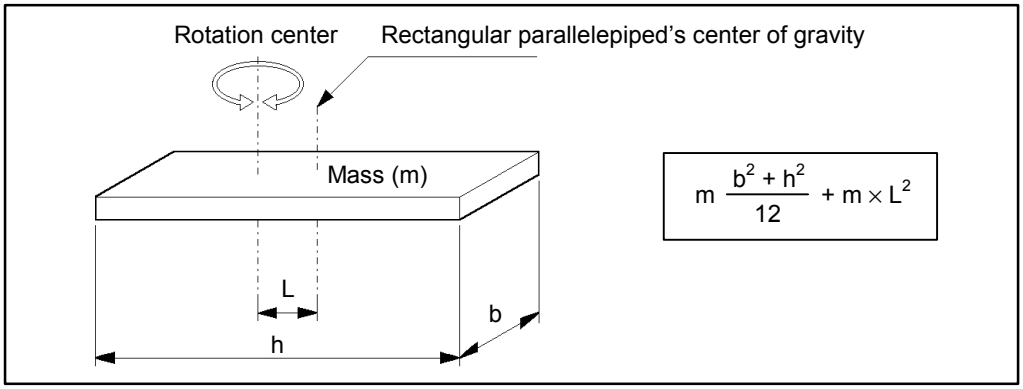
Refer to the following examples of formulas to calculate the moment of inertia of load (end effector with work piece).

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

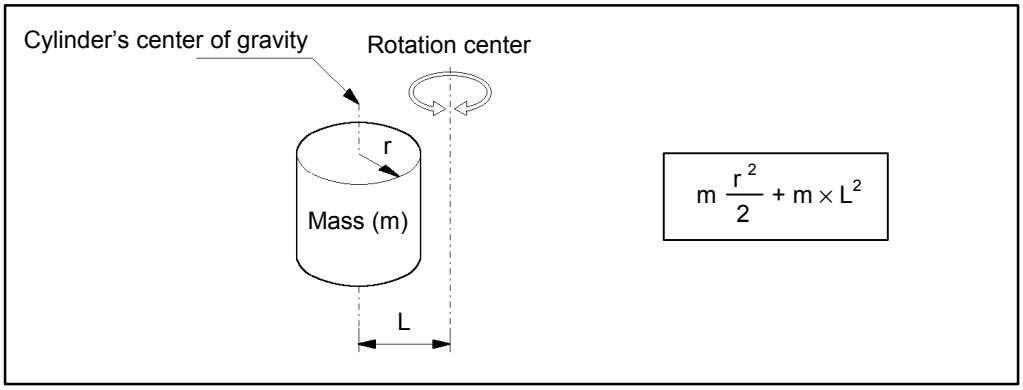


The methods for calculating the moment of inertia for (a), (b), and (c) are shown on this page or the next page. Find the whole moment of inertia using the basic formulas on the next page.

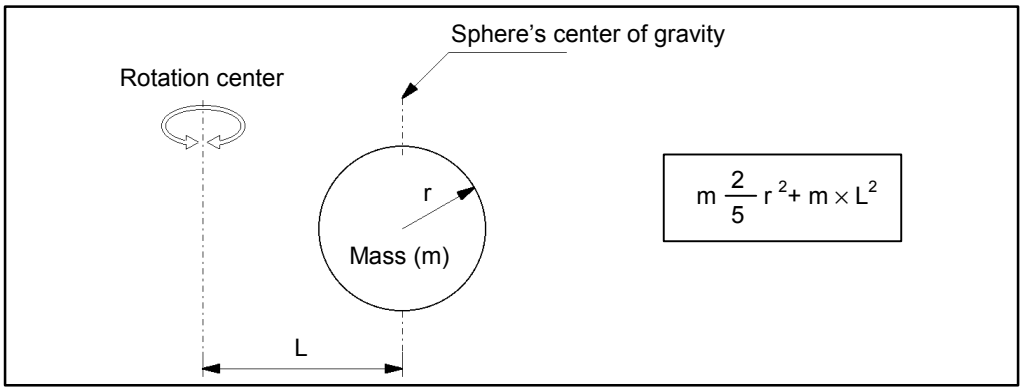
(a) Moment of inertia of a rectangular parallelepiped



(b) Moment of inertia of a cylinder



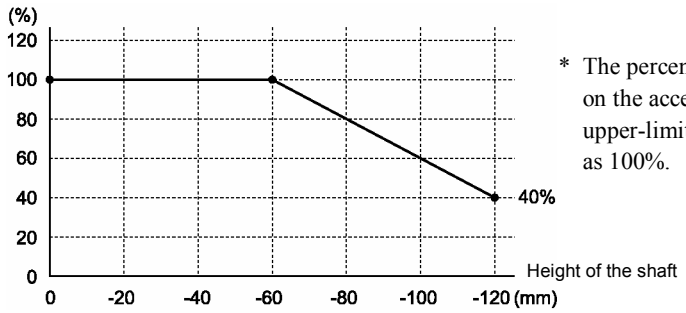
(c) Moment of inertia of a sphere



4.4 Precautions in 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 (-60 mm in figure below), then auto acceleration/deceleration is used to reduce acceleration/deceleration. 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



E2C25/35

* The percentage in the graph is based on the acceleration/deceleration at the upper-limited position of Joint #3 as 100%.

NOTE

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

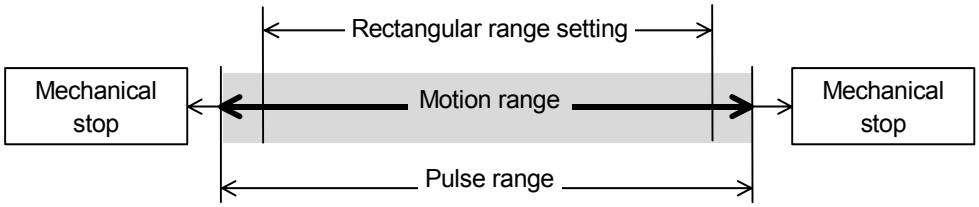
5. Motion Range

CAUTION	■ 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.

NOTE

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].

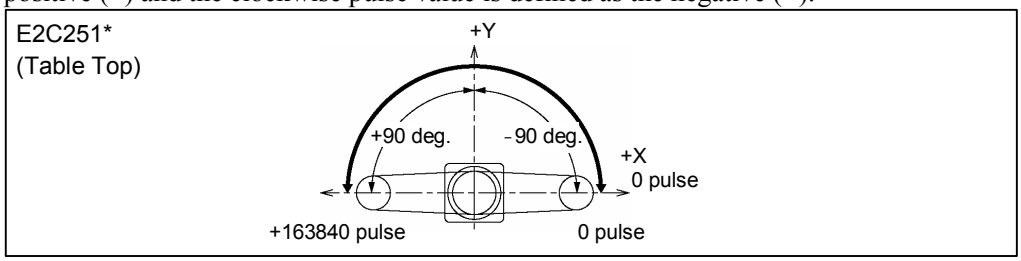
EPSON RC+ 5.0 or later（RC170）

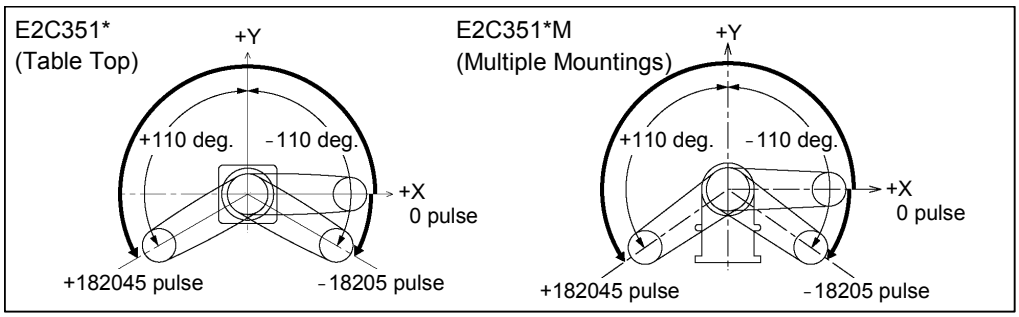
The pulse range can be set on the [Range] panel shown by selecting the [Tools]-[Robot manager].
You may also execute the Range command from the [Command Window].

5.1.1 Max. Pulse Range of Joint #1

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

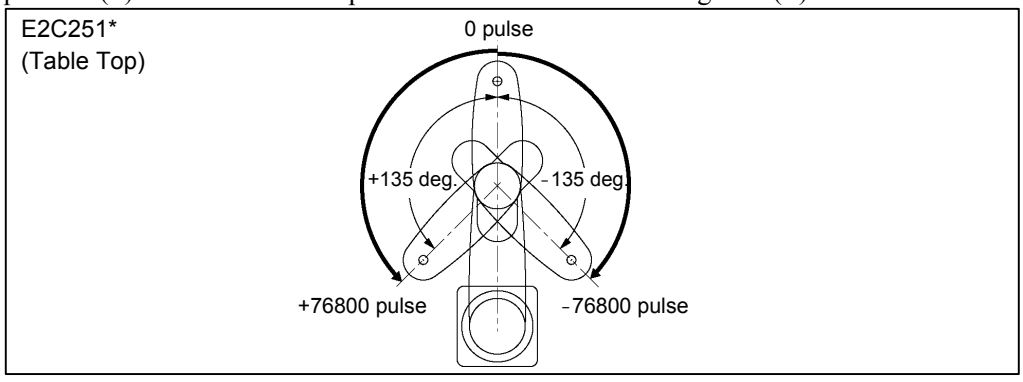
When the 0 pulse is a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).

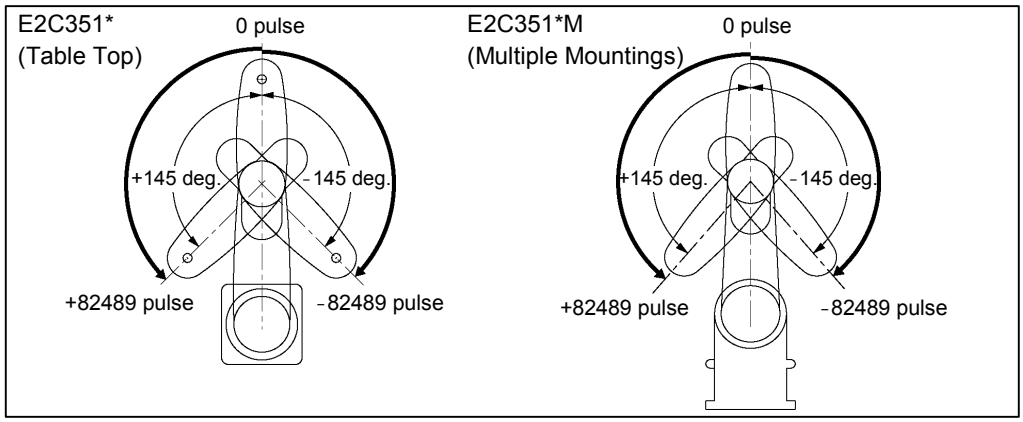




5.1.2 Max. Pulse Range of Joint #2

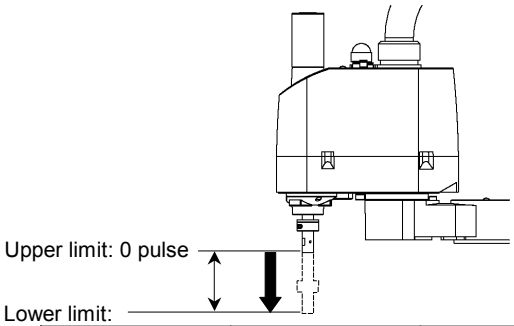
0 (zero) pulse position of Joint #2 is the position where Arm #2 is parallel to Arm #1. With the 0 pulse as a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).





5.1.3 Max. Pulse Range of Joint #3

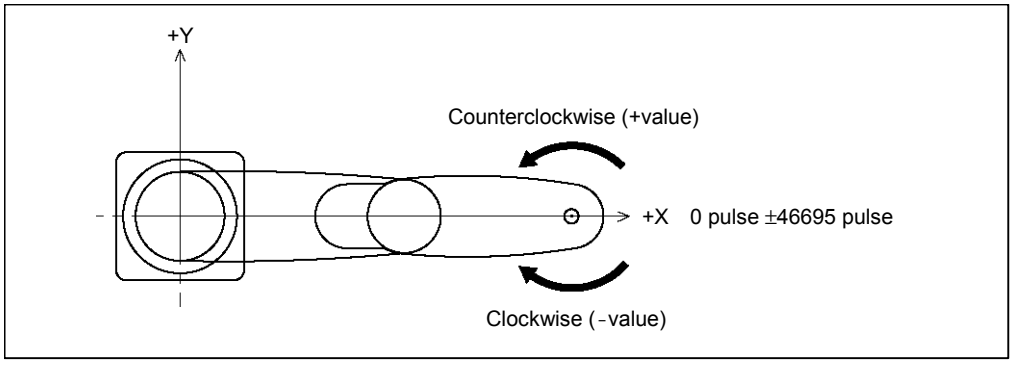
0 (zero) pulse position of Joint #3 is the position where the shaft is at its upper limit.
The pulse value is always negative because Joint #3 always moves lower than the 0 pulse position.



Manipulator	Joint #3 stroke	Pulse value of lower limit
E2C**1S / SM	120 mm	-36864 pulse
E2C**1C / CM	100 mm	-30720 pulse

5.1.4 Max. Pulse Range of Joint #4

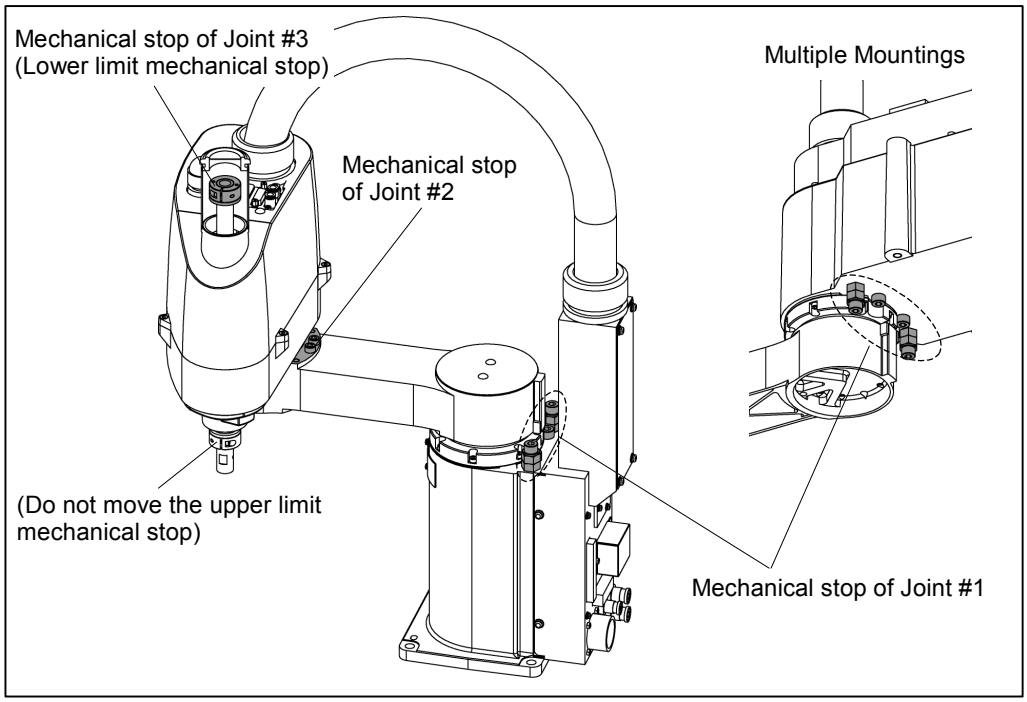
0 (zero) pulse position of Joint #4 is the position where the flat surface near the end of the shaft faces toward the end of Arm #2. With the 0 pulse as a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).



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.



NOTE 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.

(º: degree)

Manipulator	Joint	Position for area setting by mechanical stops	
E2C251*	1	+0°	-0°
	2	+110°	-110°
	3	less than the maximum stroke	
E2C351*	1	+0°	-0°
	2	+120°	-120°
	3	less than the maximum stroke	

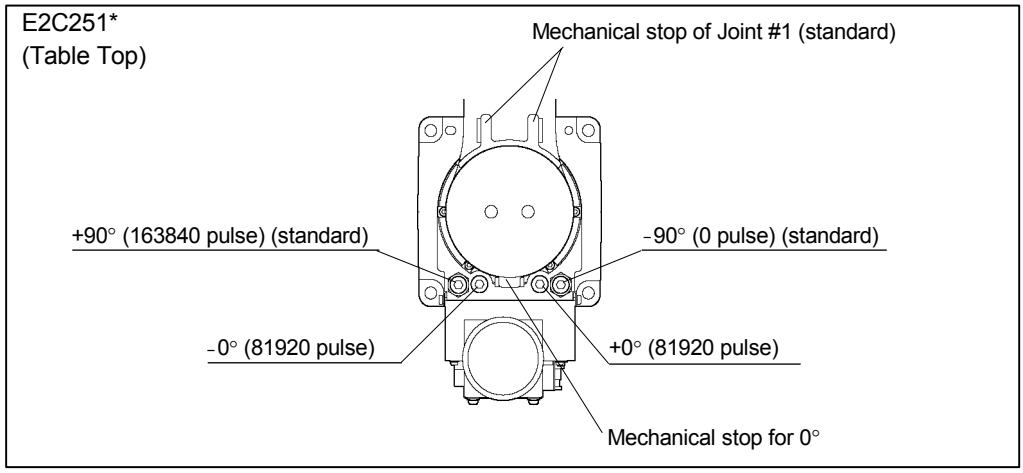
* In the E2C***C/CM, the position of the Joint #3 mechanical stop cannot be changed.

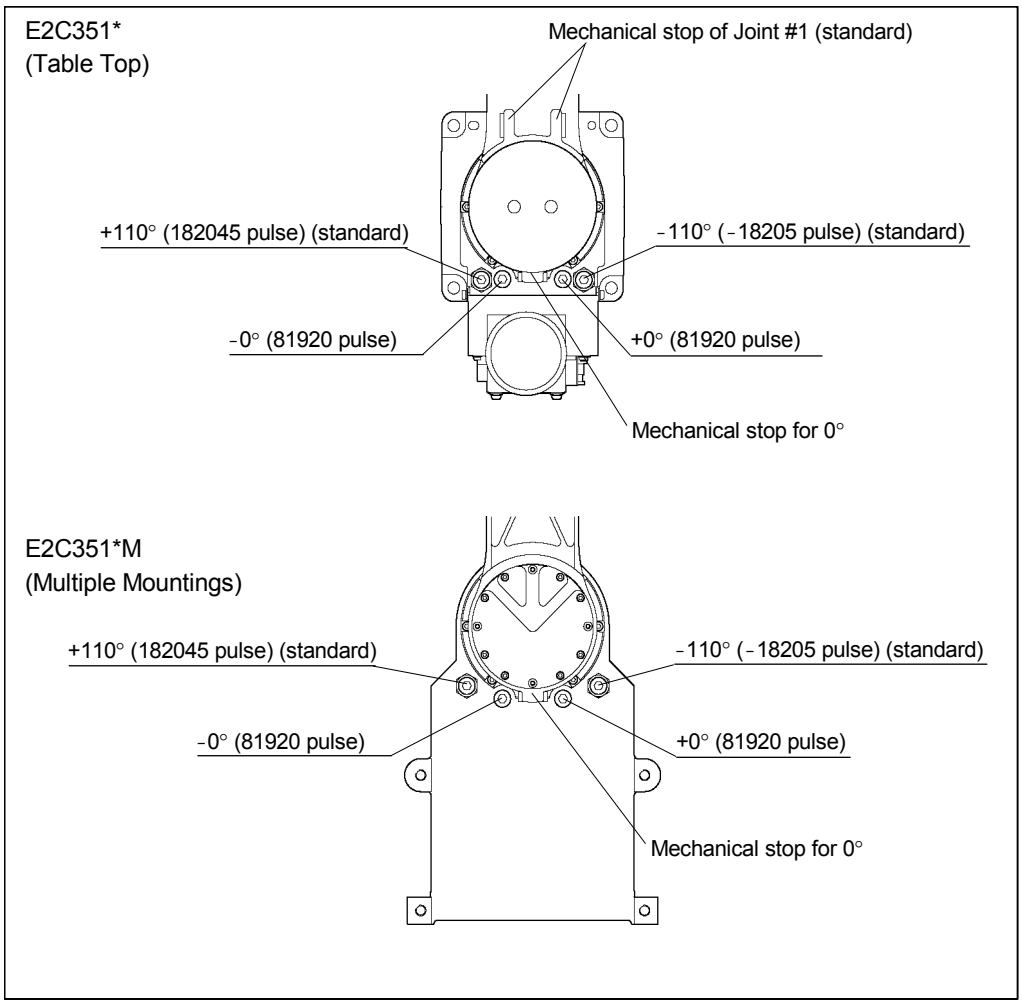
5.2.1 Setting the Mechanical Stops of Joints #1 and #2

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.

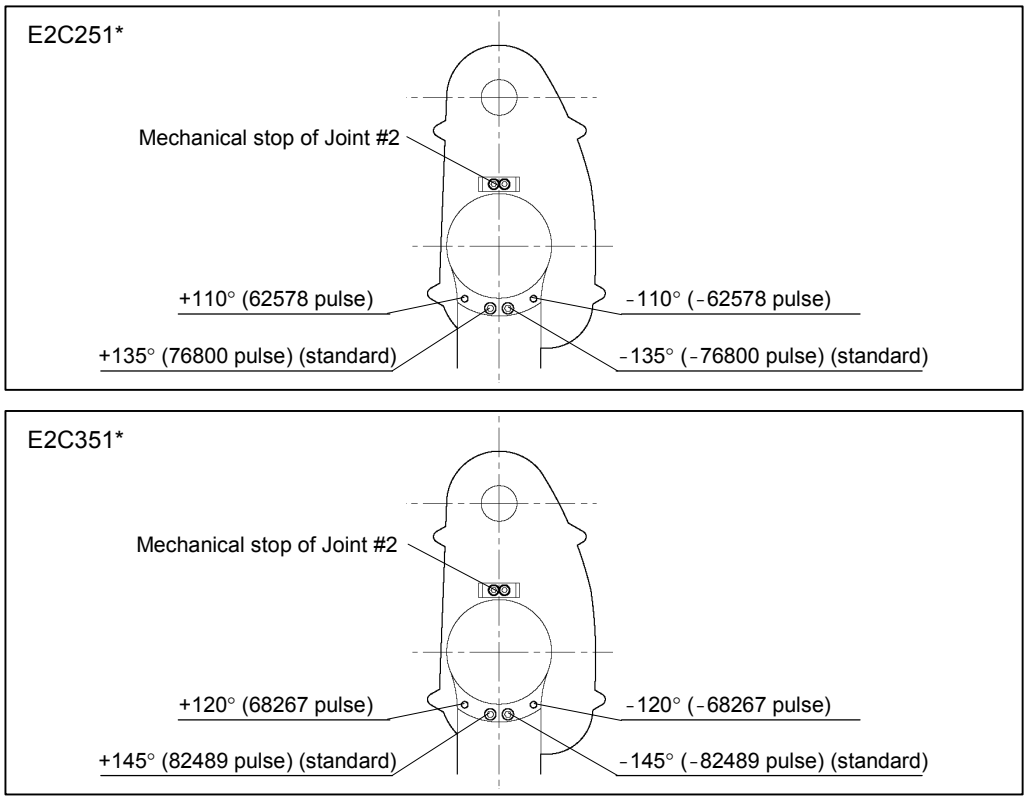
The following figures show the positions of the threaded holes for the mechanical stop settings of Joints #1/#2 and the setting angles (pulse value).

Joint #1 (º: degree)





Joint #2 (º: degree)



(1) Turn OFF the Controller.

(2) Tighten a hexagon socket head cap bolt into the hole corresponding to the setting angle.

Joint	Hexagon socket head cap bolt	The number of bolts	Recommended tightening torque
1	M8×10 (fully threaded) two M10 nuts one plain washer	1 (one side)	3720 N·cm (380 kgf·cm)
2	M6×10 (fully threaded)		1860 N·cm (190 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 – 90 degrees to + 0 degrees
The angle of Joint #2 is set from – 110 degrees to + 135 degrees>

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

SPEL CT

Select the [RANGE] panel. Set the lower limit value at "0" and the upper limit value at "81920" for Joint #1. Additionally, set the lower limit value at "– 62578" and the upper limit value at "76800" 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)

```
>JRANGE 1,0,81920          ' Sets the pulse range of Joint #1
>JRANGE 2,-62578,76800     ' Sets the pulse range of Joint #2
>RANGE                     ' Checks the setting using RANGE
 0,81920,-62578,76800,-36864,0,-46695,46695
```

(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 – 90 degrees to + 0 degrees
The angle of Joint #2 is set from – 110 degrees to + 135 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(0,0,0,0)                 ' Moves to the min. pulse position of Joint #1
GO PULSE(81920,0,0,0)             ' Moves to the max. pulse position of Joint #1
GO PULSE(40960,-62578,0,0)        ' Moves to the min. pulse position of Joint #2
GO PULSE(40960,76800,0,0)         ' 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 0,0,0,0                    ' Moves to the min. pulse position of Joint #1
>PULSE 81920,0,0,0                ' Moves to the max. pulse position of Joint #1
>PULSE 40960,-62578,0,0           ' Moves to the min. pulse position of Joint #2
>PULSE 40960,76800,0,0            ' Moves to the max. pulse position of Joint #2
```

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 position near the center of its motion range (pulse value: 40960) 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.

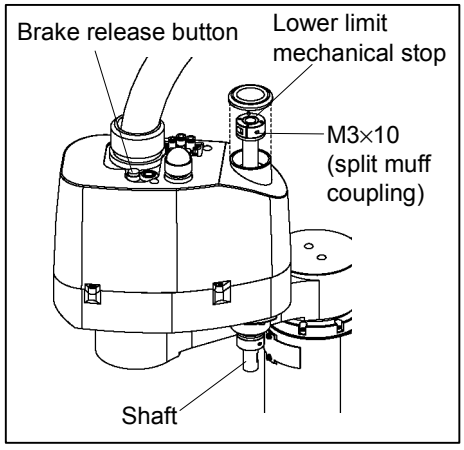
5.2.2 Setting the Mechanical Stop of Joint #3

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 pushing the Joint #3 brake release button.

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 the position where the position of the Joint #3 mechanical stop can be changed.



NOTE When you push the Joint #3 brake release button, the shaft may lower due to the weight of the end effector. Be sure to hold the shaft by hand while pushing the button.

(3) Turn OFF the Controller.

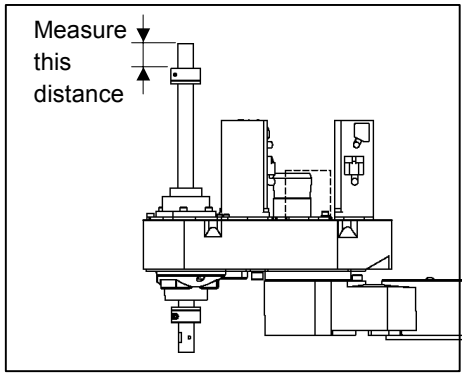
(4) Remove the arm top cover. (Only for -UL type)

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.

(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 “120 mm” stroke (standard), the lower limit Z coordinate value is “-120”. To change the value to “-100”, move the lower limit mechanical stop down “20 mm”. Use calipers to measure the distance when adjusting the mechanical stop.



(7) Securely tighten the bolt (for the split muff coupling) in the appropriate position.

Recommended tightening torque: 245 N·cm (25 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 pushing the brake release button, and then check the lower limit position. Do not lower the mechanical stop too far. Otherwise, the joint does 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.

Lower limit of pulse = lower limit Z coordinate value / 16 × 4096 × 1.2

< Example: When lowering the mechanical stop by 20 mm and changing the lower limit Z coordinate value to “–100” in 120 mm stroke>

(-100) / 16 × 4096 × 1.2 = -30720

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

SPEL CT

Select the [RANGE] panel, and set the lower limit value at “–30720” 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)

```
>JRANGE 3,-30720,0    ' 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 11 mm.

NOTE

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 20 mm and changing the lower limit Z coordinate value to "–100" in 120 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 at low speeds
GO PULSE(0,0,-30720,0) '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 at low speeds
>PULSE 0,0,-30720,0    '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 X, Y 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].

For setting values of Table Top E2C251* and Multiple Mounting Manipulators at shipping, refer to *Setup & Operation: 5.4 Standard Motion Range.*

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.

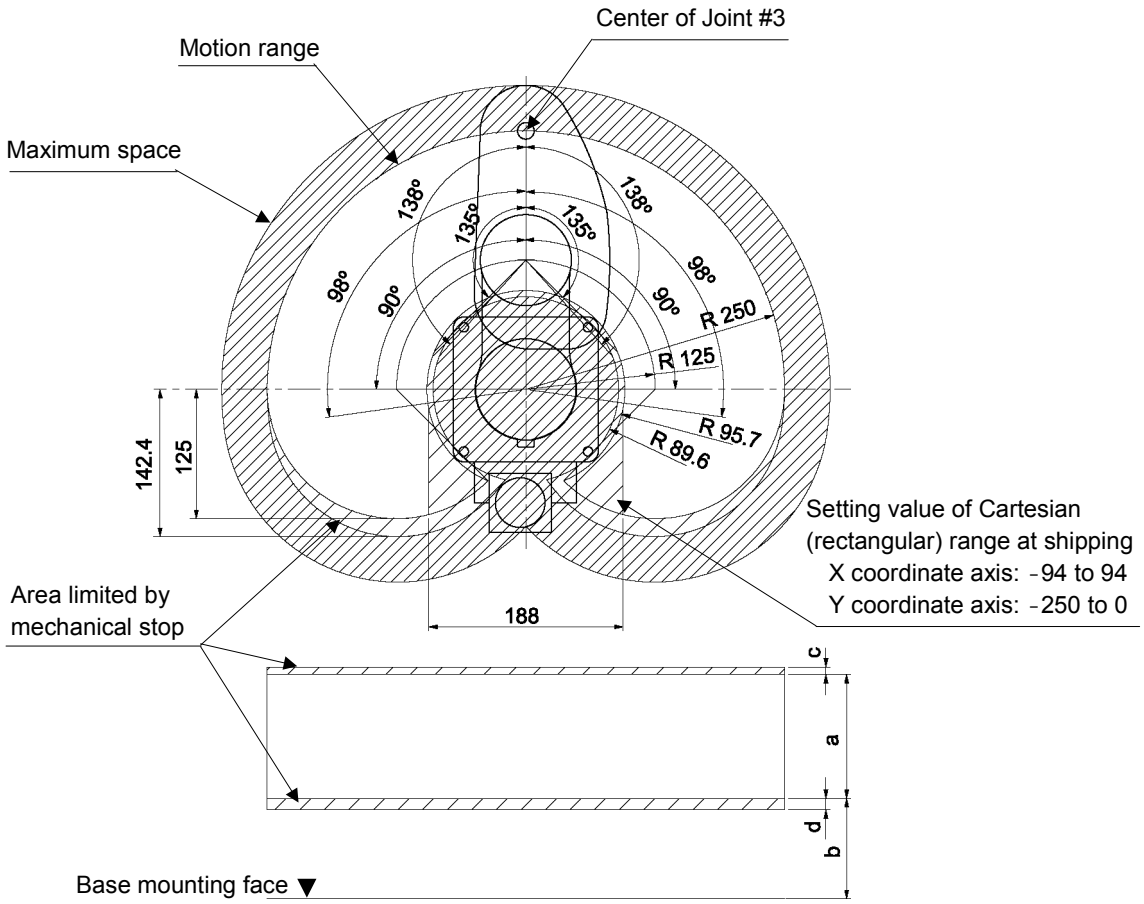
“Mechanical stop” sets the limited motion range so that the center of Joint #3 cannot move beyond the area mechanically.

“Maximum space” is the area that contains the farthest reach of the arms. If the maximum radius of the end effector is over 44 mm, add the “Area limited by mechanical stop” and “radius of the end effector”. The total value is specified as the maximum area.

5.4.1 Table Top

Motion Range of E2C251S/C

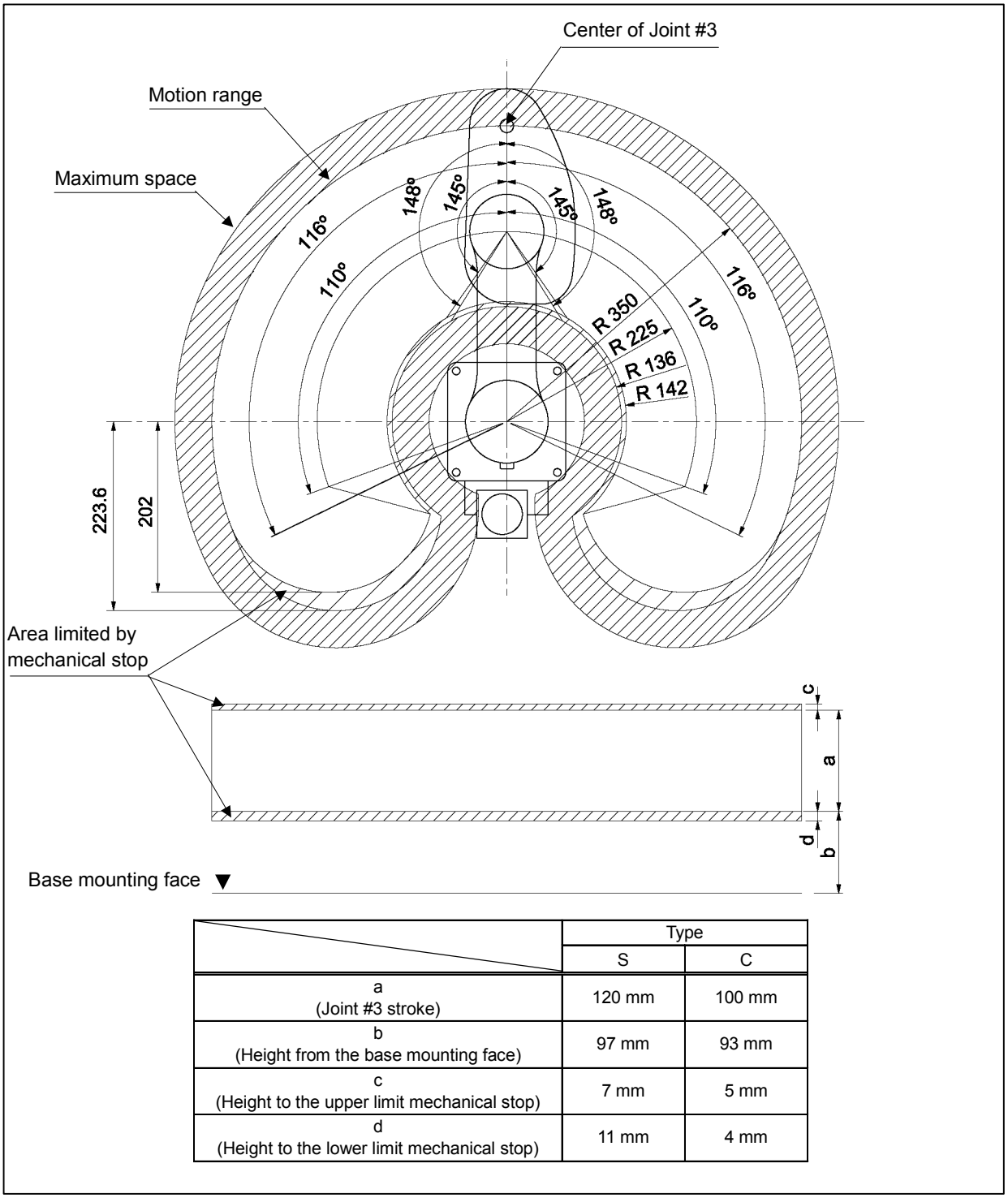
[unit: mm]



	Type	
	S	C
a (Joint #3 stroke)	120 mm	100 mm
b (Height from the base mounting face)	97 mm	93 mm
c (Height to the upper limit mechanical stop)	7 mm	5 mm
d (Height to the lower limit mechanical stop)	11 mm	4 mm

Motion Range of E2C351S/C

[unit: mm]

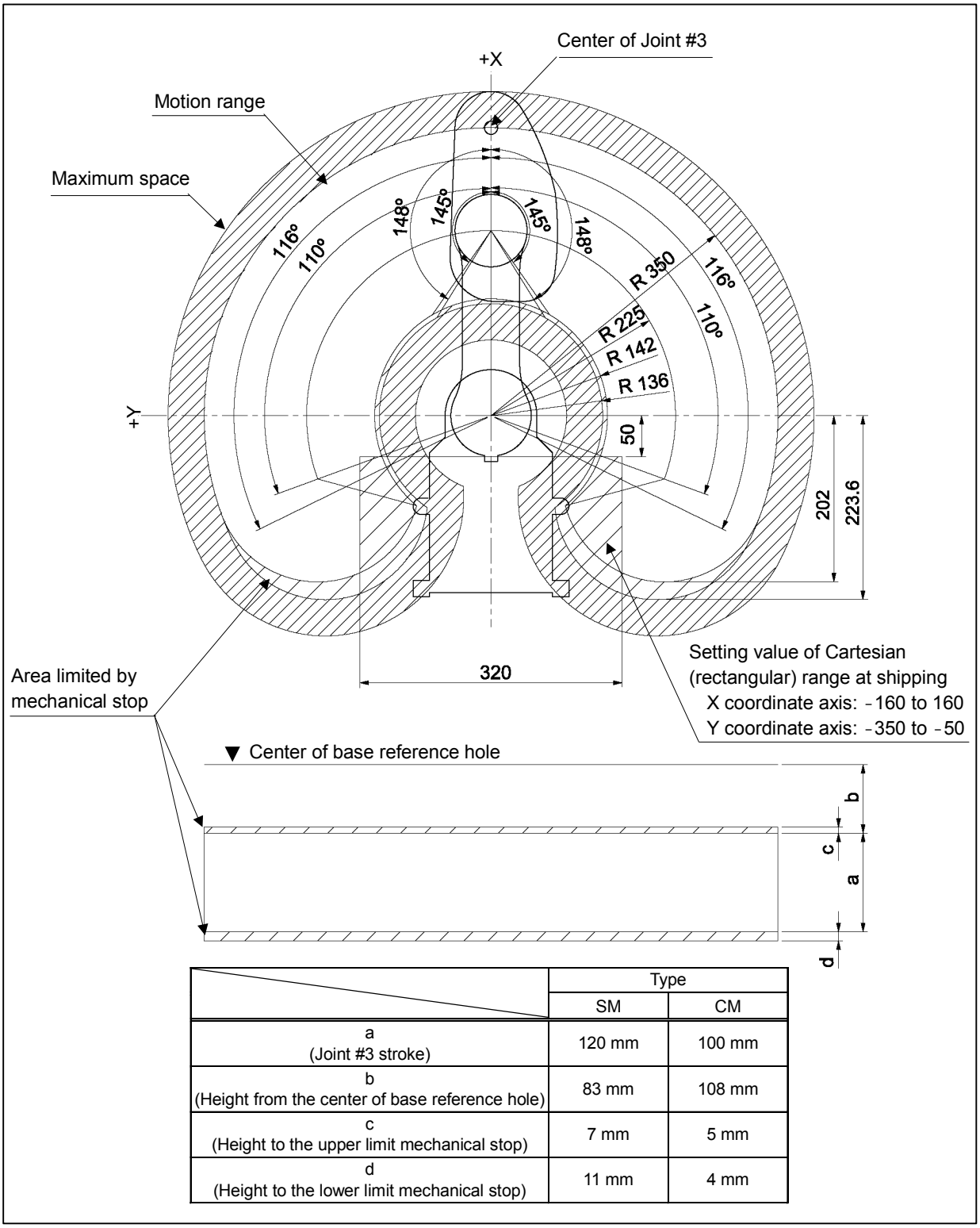


	Type	
	S	C
a (Joint #3 stroke)	120 mm	100 mm
b (Height from the base mounting face)	97 mm	93 mm
c (Height to the upper limit mechanical stop)	7 mm	5 mm
d (Height to the lower limit mechanical stop)	11 mm	4 mm

5.4.2 Multiple Mountings

Motion Range of E2C351SM/CM

[unit: mm]



	Type	
	SM	CM
a (Joint #3 stroke)	120 mm	100 mm
b (Height from the center of base reference hole)	83 mm	108 mm
c (Height to the upper limit mechanical stop)	7 mm	5 mm
d (Height to the lower limit mechanical stop)	11 mm	4 mm

Maintenance

This volume contains maintenance procedures
with safety precautions for E2C 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 the safety training should be allowed to maintain the robot system.
The safety training is the program for industrial robot operator that follows the laws and regulations of each nation.
The personnel who have taken the 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 safeguard area. Checking the operation of the Manipulator while you are inside of the safeguard 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.

 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.

2. General Maintenance

Performing the inspection steps properly is essential to preventing trouble and maintaining safety. This section describes schedule for maintenance inspection and the procedures. Be sure to perform the maintenance inspection 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 (250h)	Inspect every day	√			
2 months (500h)		√			
3 months (750h)		√	√		
4 months (1000h)		√			
5 months (1250h)		√			
6 months (1500h)		√	√	√	
7 months (1750h)		√			
8 months (2000h)		√			
9 months (2250h)		√	√		
10 months (2500h)		√			
11 months (2750h)		√			
12 months (3000h)		√	√	√	√
13 months (3250h)		√			
⋮	⋮	⋮	⋮	⋮	⋮

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 *Maintenance: 2.4 Tightening Hexagon Socket Head Cap Bolts*.)	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 box 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 *Maintenance: 2.3 Greasing*.					

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.

CAUTION	■ 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.

	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	*Maintenance: 10.3 Greasing the Ball Screw Spline Unit*
Joint #1	Reduction gear unit	In the replacement of motor*	SK-1A	*Maintenance:* *6.5 Replacing the Joint #1 Reduction Gear Unit*
Joint #2	Reduction gear unit	In the replacement of motor*	SK-2	*6.6 Replacing the Joint #2 Reduction Gear Unit*

* 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 loading, etc.), the reduction gear units must be greased every 10,000 hours.

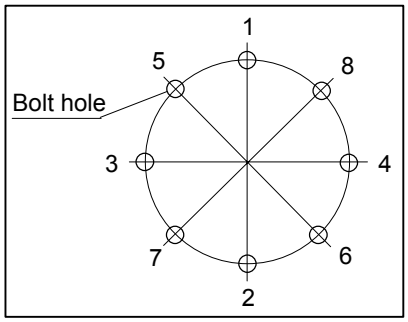
CAUTION	■ If grease gets into your eyes, mouth, or on your skin, follow the instructions below. If grease gets into your eyes : Flush them thoroughly with clean water, and then see a doctor immediately. If grease gets into your mouth : If swallowed, do not induce vomiting. See a doctor immediately. :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

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

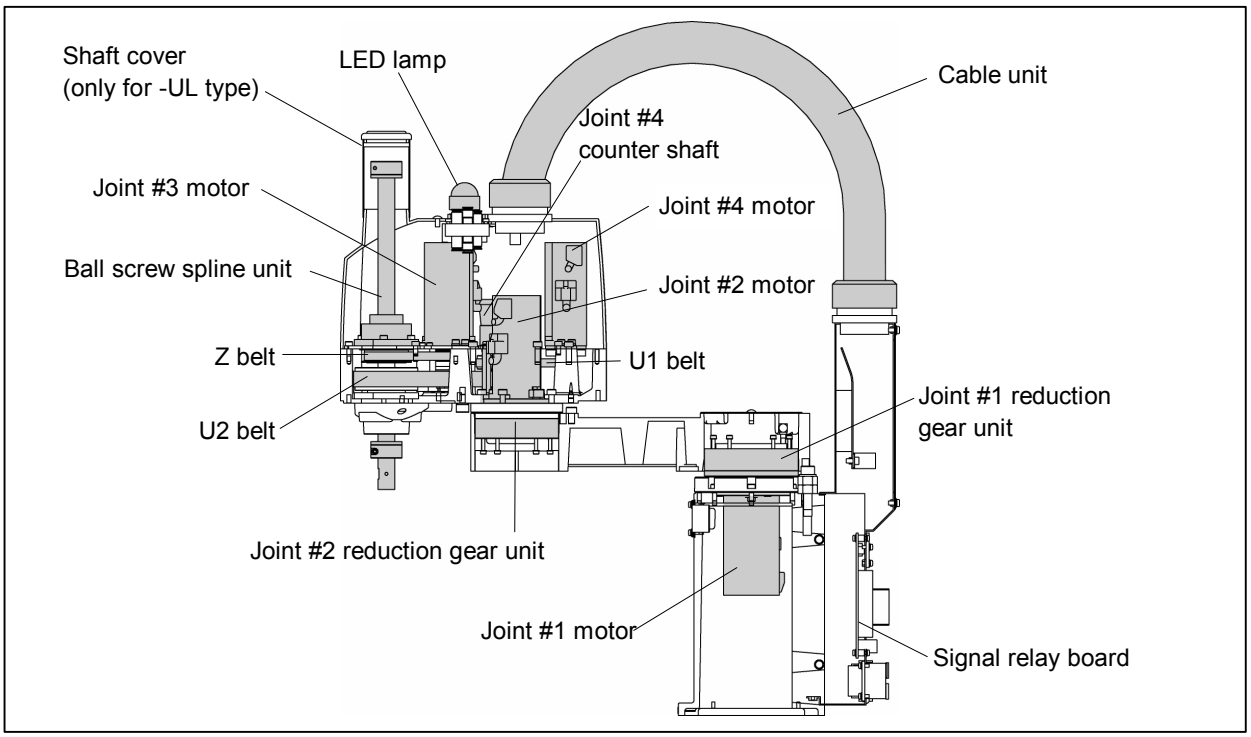
[Monitor Window] EPSON RC+ 4.* or before (RC520/RC420)
[Command Window] EPSON RC+ 5.0 or later (RC170)

```
>PULSE
```

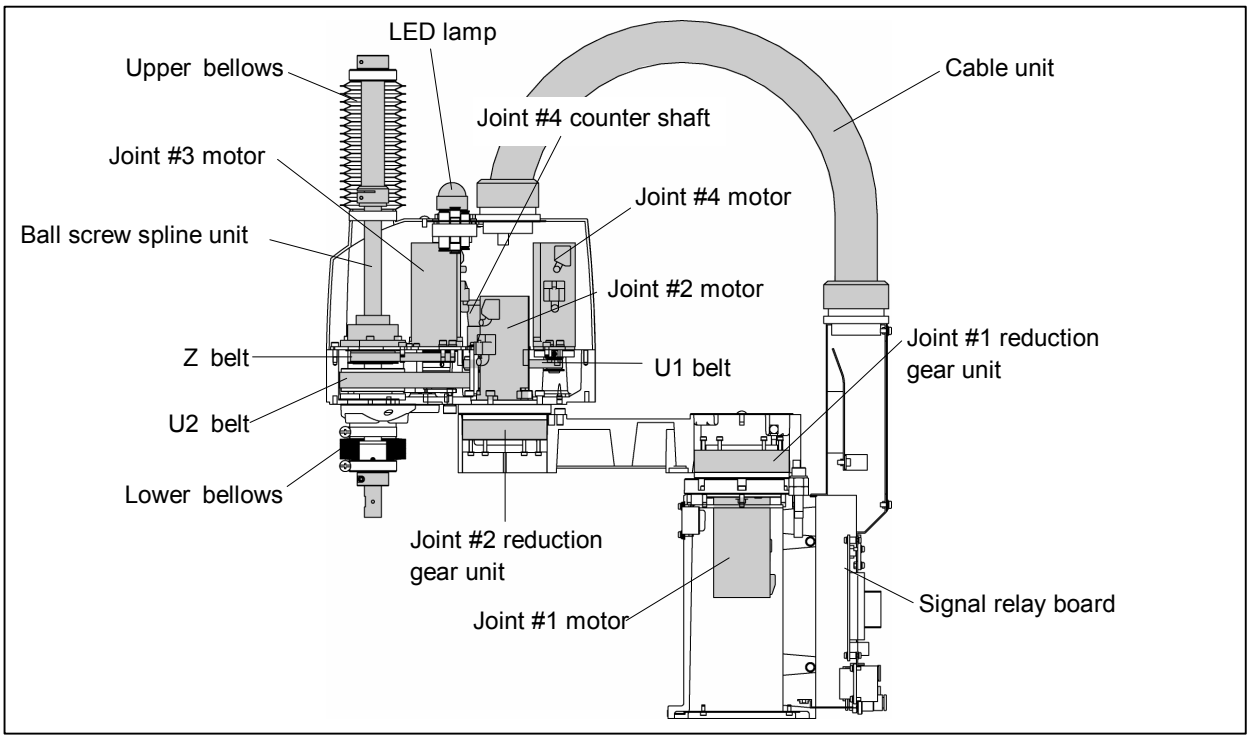
`PULSE:` [5Joint #1 Pulse value] `pls` [Joint #2 Pulse value] `pls` [Joint #3 Pulse value] `pls` [Joint #4 Pulse value] `pls`

2.6 Layout of Maintenance Parts

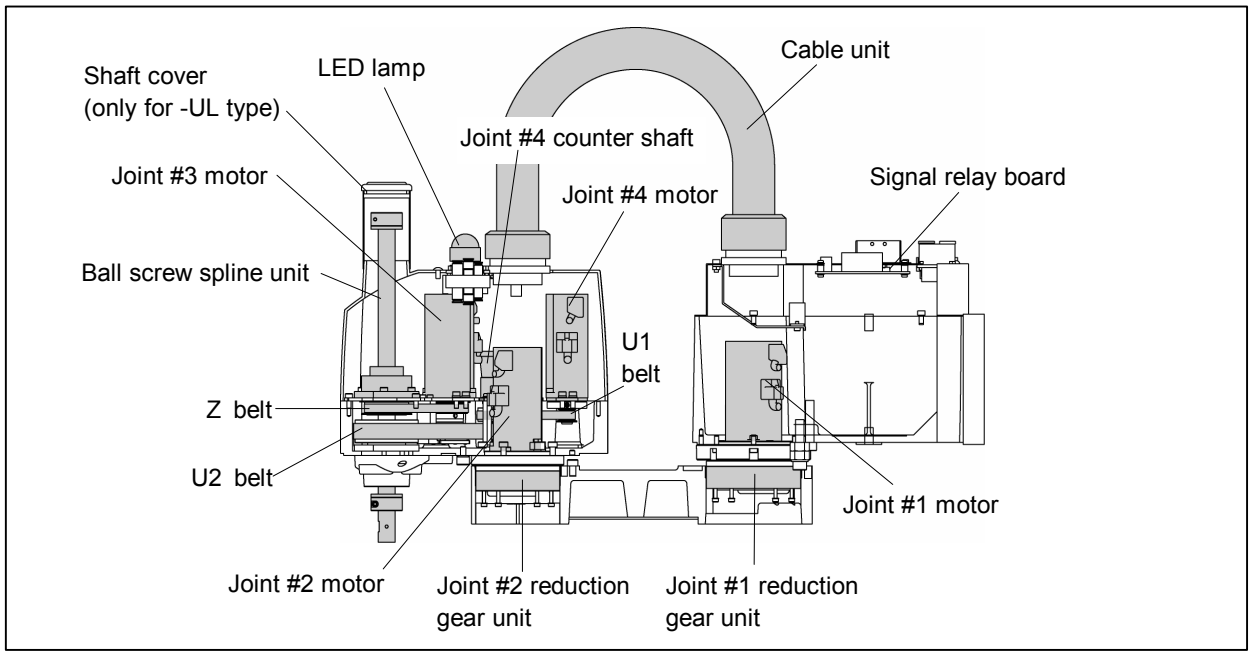
2.6.1 S Type Manipulator Layout



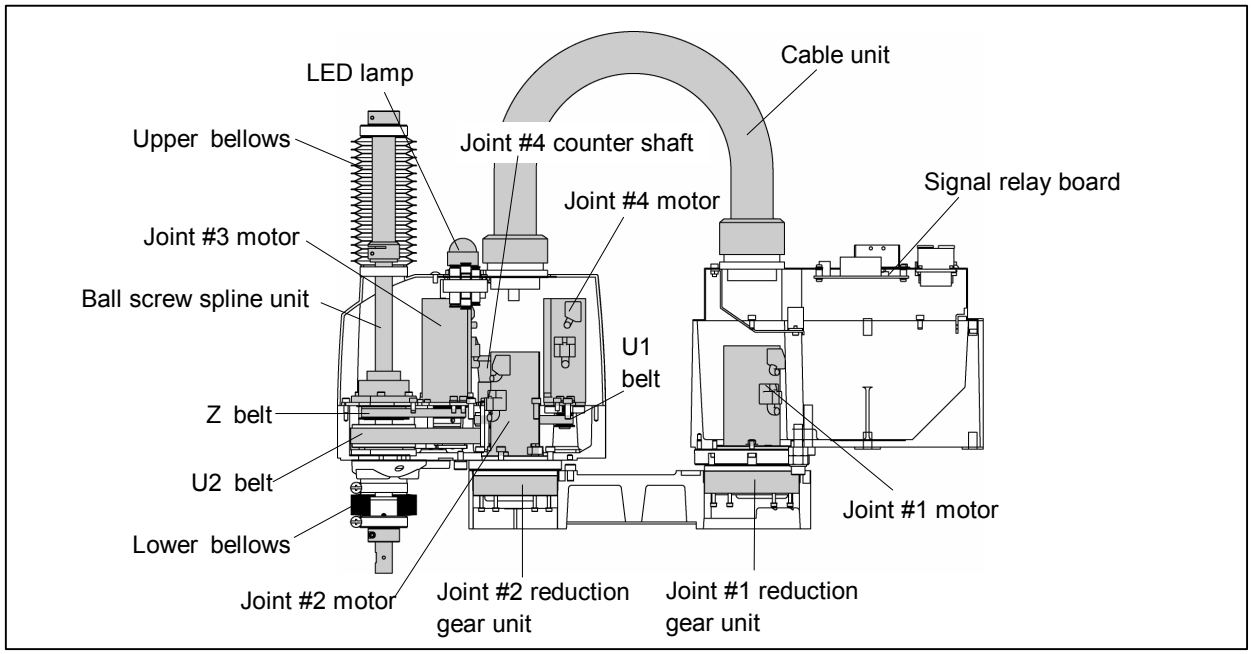
2.6.2 C Type Manipulator Layout



2.6.3 SM Type Manipulator Layout



2.6.4 CM Type Manipulator Layout



3. Removing and Installing the Covers

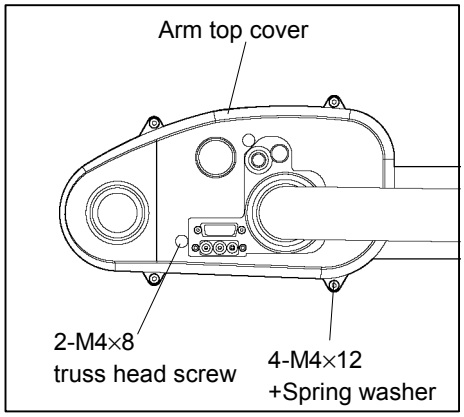
All procedures for removing/installing covers in maintenance are described in this chapter.

 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.

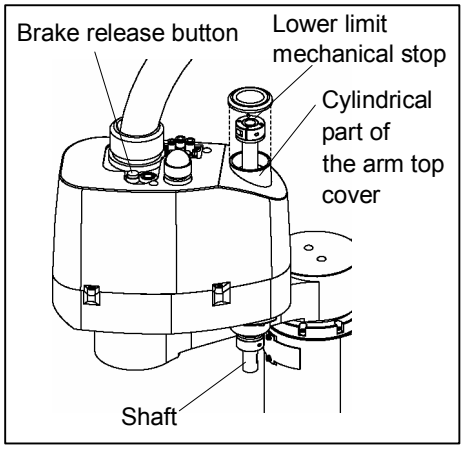
3.1 Arm Top Cover

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 bolts from the arm top cover, and then lift the cover.
The cover cannot be removed completely because user wires and tubes are connected. However, you can continue the regular maintenance.



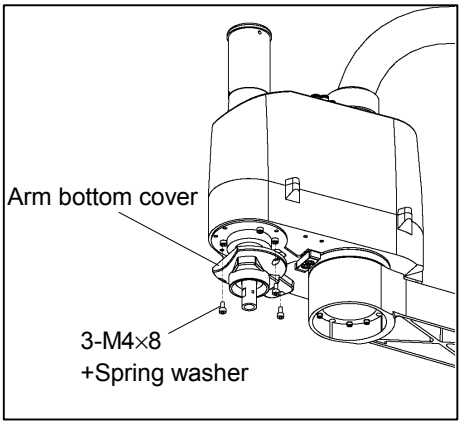
After installing the arm top cover, push and hold the brake release button to let the shaft down. Make sure that the lower limit mechanical stop does not touch the cylindrical part of the arm top cover.



3.2 Arm Bottom Cover

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

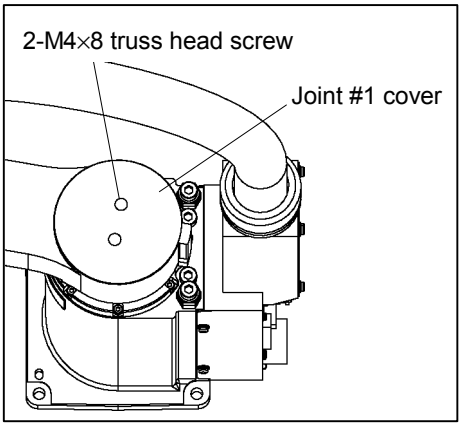
The arm bottom cover may not be removed from the shaft because the end effector is installed.
If it is necessary to remove the cover completely (for replacement of the ball screw spline unit etc.), remove the end effector.
If it is not necessary to remove the cover completely, move the shaft to the lower limit, and lower the arm bottom cover. Then, perform maintenance or inspection.



3.3 Joint #1 Cover

Only S and C types have the Joint #1 cover.

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



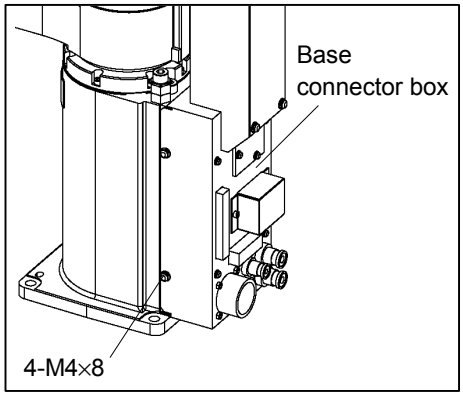
3.4 Base Connector Box

The procedure for removing/installing the base connector box varies with the Manipulator used.

CAUTION	■ Do not remove the base connector box forcibly. Removing the base connector box 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 box, be careful not to allow the cables to interfere with the box 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 box. Be sure to place the cables back to their original locations.

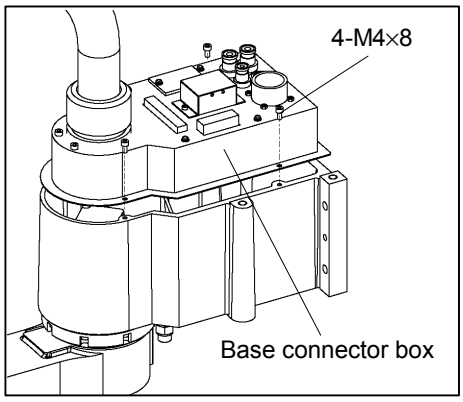
3.4.1 S, C Type Manipulators

Unscrew the bolts from the base connector box and remove the box.



3.4.2 SM, CM Type Manipulators

Unscrew the bolts from the base connector box and remove the box.



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 keep the position data.
A super-capacitor is mounted on each motor. The charged motors can keep the 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 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 the 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

The procedure for replacing the cable unit varies with the Manipulator used.

 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.

4.2.1 S, C Type Manipulators

Removal

(1) Turn OFF the Controller.

(2) Disconnect all the connectors and tubes from the base connector box (outside).

(3) Remove the base connector box.

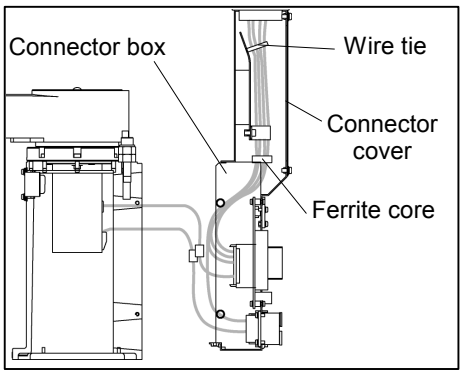
For details on the removal method, refer to *Maintenance: 3.4 Base Connector Box*.

NOTE

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

(4) Remove the connector cover and cut off the wire tie binding cables.
Detach the ferrite core.

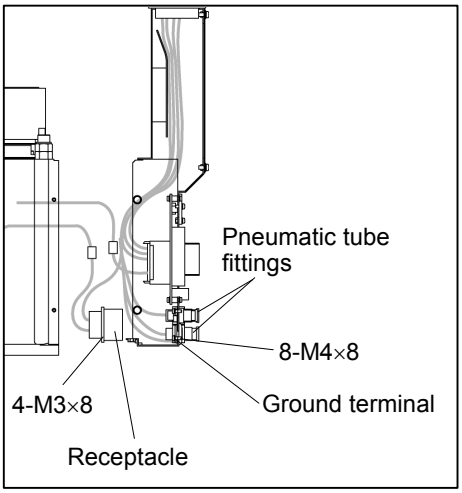
(5) Disconnect X110 connector by holding the claw next to the connector number on the motor side.



(6) Remove the receptacle from the base connector box.

(7) Disconnect the pneumatic tubes and ground terminal from the base connector box (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.

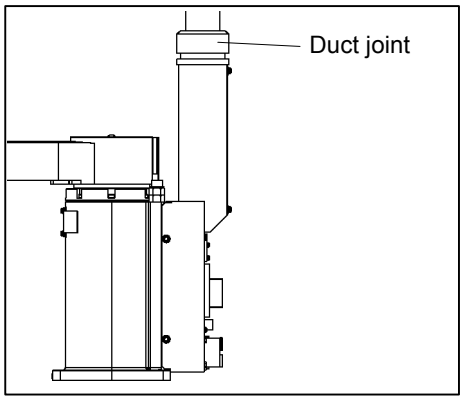


(8) Disconnect X20, X30, X40, and X50 connectors from the signal relay board.

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) Using a pair of water pump pliers, loosen the duct joint.



(10) Remove the arm top cover.

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

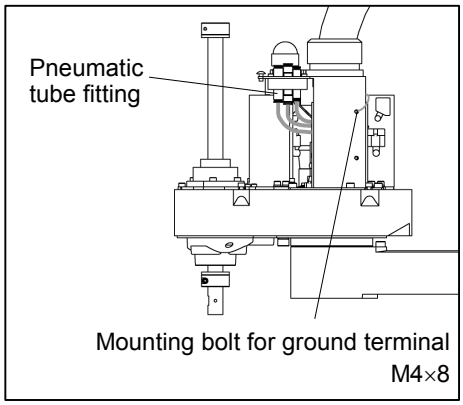
NOTE

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

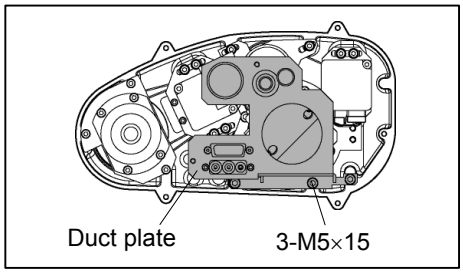
(11) Cut off the wire tie binding the duct plate, motor, and cables together.

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

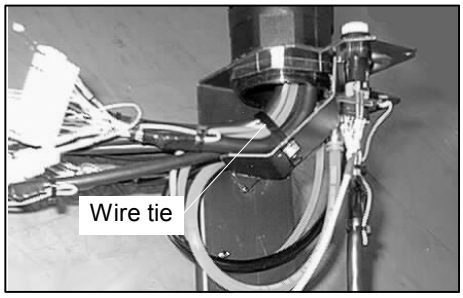
To disconnect the pneumatic tubes, push the ring on each pneumatic tube fitting and pull out its tube.
To disconnect the ground terminal, unscrew the mounting bolt for ground terminal on the duct plate.



(13) Remove the duct plate from Arm #2.

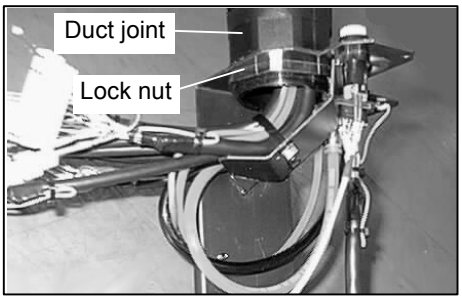


(14) Cut off the wire tie binding cables to the duct plate.



(15) Remove the duct joint from the duct plate and pull out the cables.

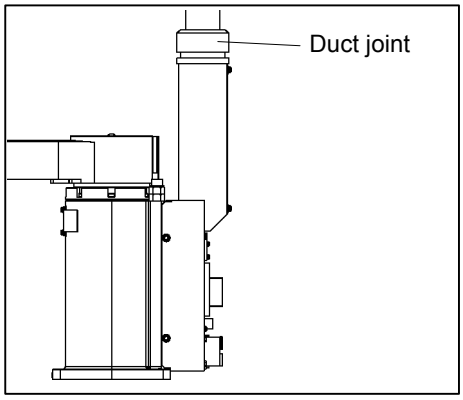
The lock nut securing the duct joint is prevented from rotating.



(16) Pull the cable unit out of the arm top cover.

Installation

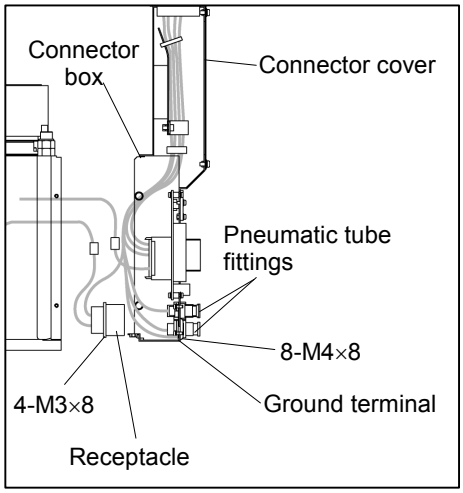
(1) Pass cables through the base connector box and a nut.
Secure the duct joint with the nut.



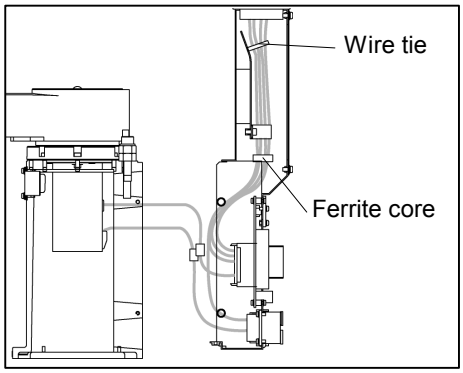
(2) Connect pneumatic tubes, ground wire, and connectors.

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

(3) Secure a receptacle to the base connector box.



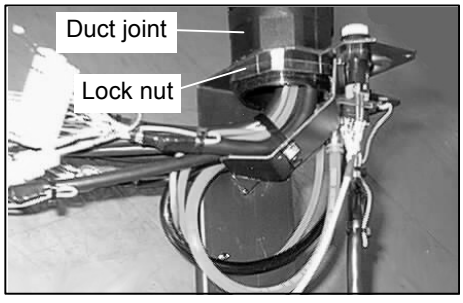
(4) Fasten the cables with a wire tie inside the main cable elbow fitting.
Attach a ferrite core to the bundle and install the connector cover.



(5) Install the base connector box.

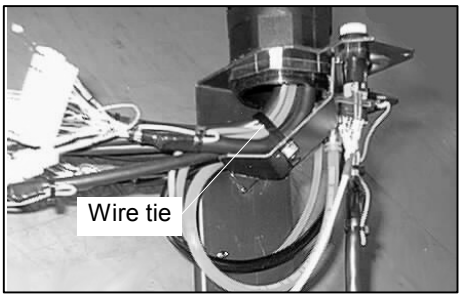
For details on the installation method, refer to *Maintenance: 3.4 Base Connector Box*.

(6) Pass the cable unit through the arm top cover and duct plate.
Install the duct joint to the duct plate.

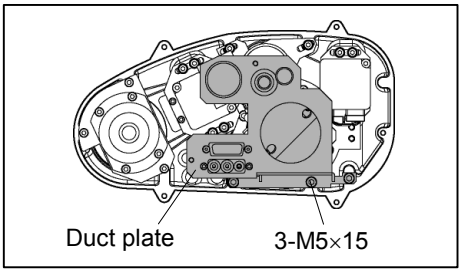


(7) Loosely fasten the cables to the duct plate using a wire tie.

Loosely fastening the cables will allow you to adjust the length of the cables when connecting pneumatic tubes, ground wires, and connectors.



(8) Mount the duct plate on Arm #2.

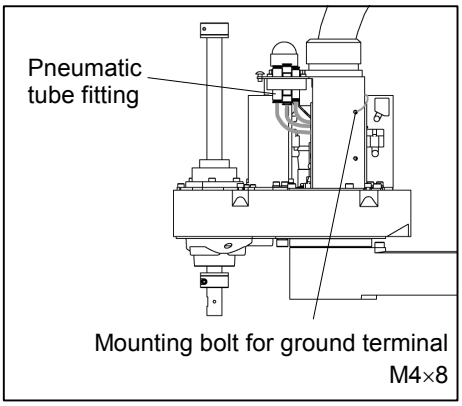


(9) Secure the duct joint to the duct plate.

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

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

After connecting them, securely fasten the cables to the duct plate with the wire tie.



(11) Re-bundle the cables (that have been released since 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.

(12) Install the arm top cover.

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

4.2.2 SM, CM Type Manipulators

Removal

(1) Turn OFF the Controller.

(2) Disconnect all the connectors and tubes from the base connector box (outside).

(3) Remove the base connector box.

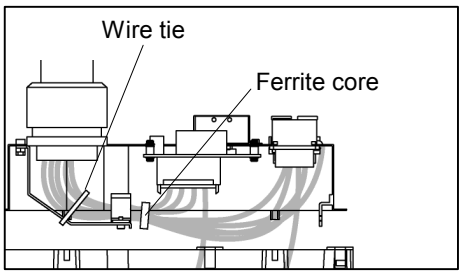
For details on the removal method, refer to *Maintenance: 3.4 Base Connector Box.*

NOTE

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

(4) Cut off the wire tie binding cables to the cable support.
Detach the ferrite core.

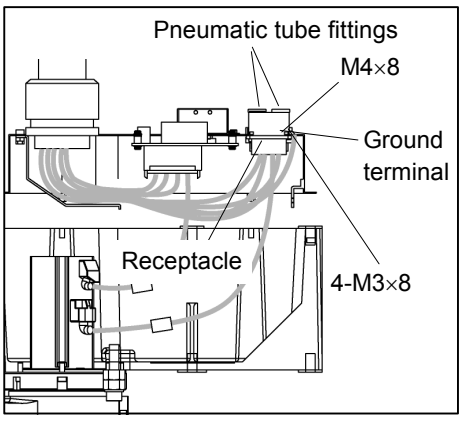
(5) Disconnect X110 connector by holding the claw next to the connector number on the motor side.



(6) Remove the receptacle from the base connector box.

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

To disconnect the pneumatic tubes, 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.



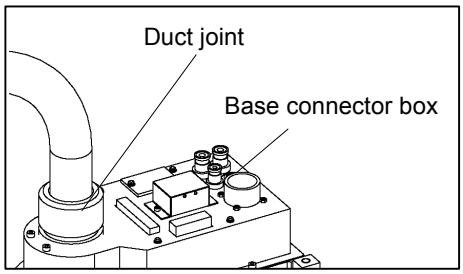
(8) Disconnect X20, X30, X40, and X50 connectors from the signal relay board.

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) Loosen the duct joint.

To loosen it, use either a spanner wrench (width across flats: 51 mm) or a pair of water pump pliers.



(10) Detach the duct joint from the nut, and then pull out the cables of the duct support and base plate.

(11) Remove the arm top cover.

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

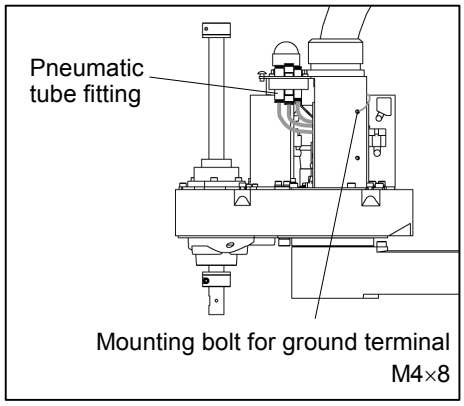
NOTE

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

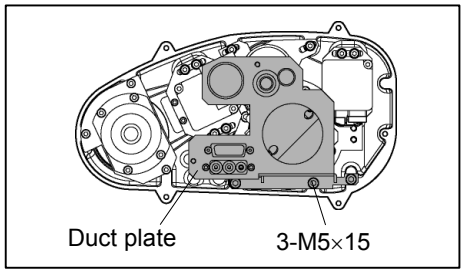
(12) Cut off the wire tie binding the duct plate, motor, and cables together.

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

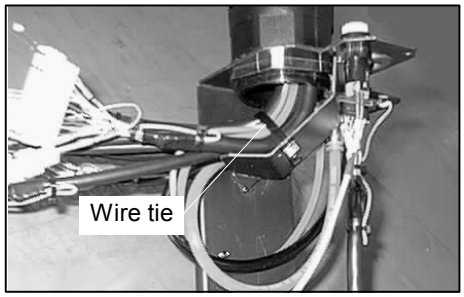
To disconnect the pneumatic tubes, push the ring on each pneumatic tube fitting and pull out its tube.
To disconnect the ground terminal, unscrew the mounting bolt for ground terminal on the duct plate.



(14) Remove the duct plate from Arm #2.

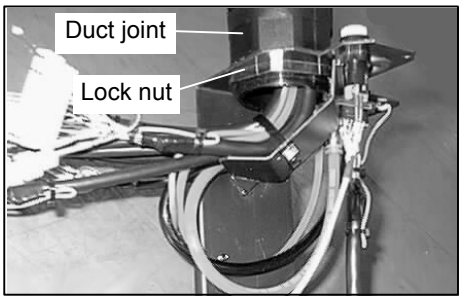


(15) Cut off the wire tie binding cables to the duct plate.



(16) Remove the duct joint from the duct plate and pull out the cables.

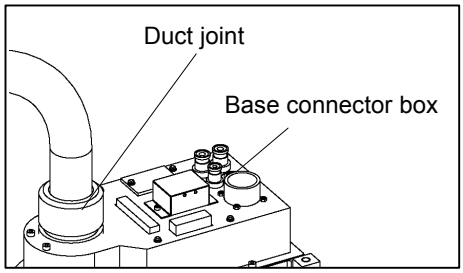
The lock nut securing the duct joint is prevented from rotating.



(17) Pull the cable unit out of the arm top cover.

Installation

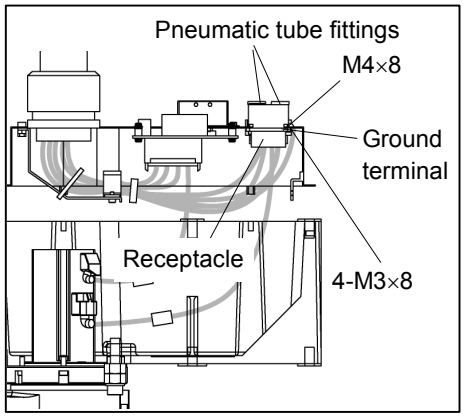
(1) Pass cables through the base connector box and a nut.
Secure the duct joint and cable support with the nut.



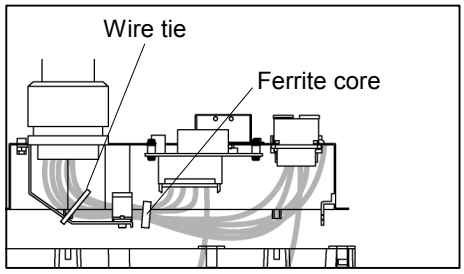
(2) Connect the pneumatic tubes, ground wire, and connectors.

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

(3) Secure a receptacle to the base connector box.



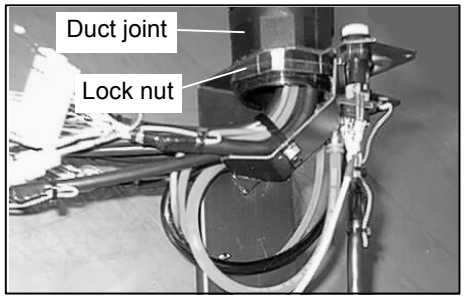
(4) Fasten the cables to the cable support with a wire tie.
Attach a ferrite core to the bundle.



(5) Install the base connector box.

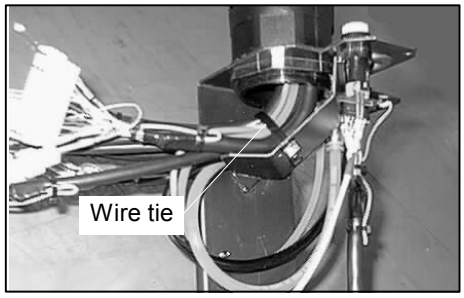
For details on the installation method, refer to *Maintenance: 3.4 Base Connector Box*.

(6) Pass the cable unit through the arm top cover and duct plate.
Install the duct joint to the duct plate.

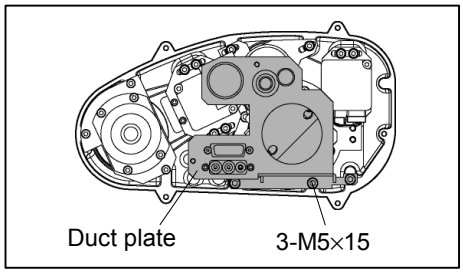


(7) Loosely fasten the cables to the duct plate using a wire tie.

Loosely fastening the cables will allow you to adjust the length of the cables when connecting pneumatic tubes, ground wires, and connectors.



(8) Mount the duct plate on Arm #2.

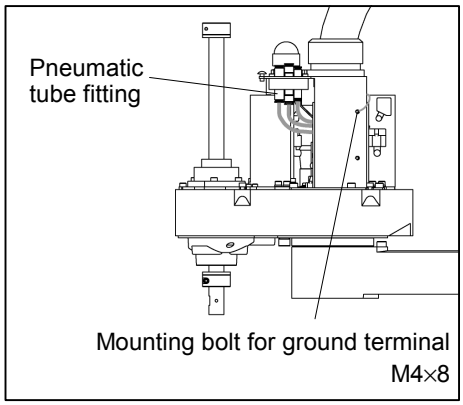


(9) Secure the duct joint to the duct plate.

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

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

After connecting them, securely fasten the cables to the duct plate with the wire tie.



(11) Re-bundle the cables (that have been released since 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.

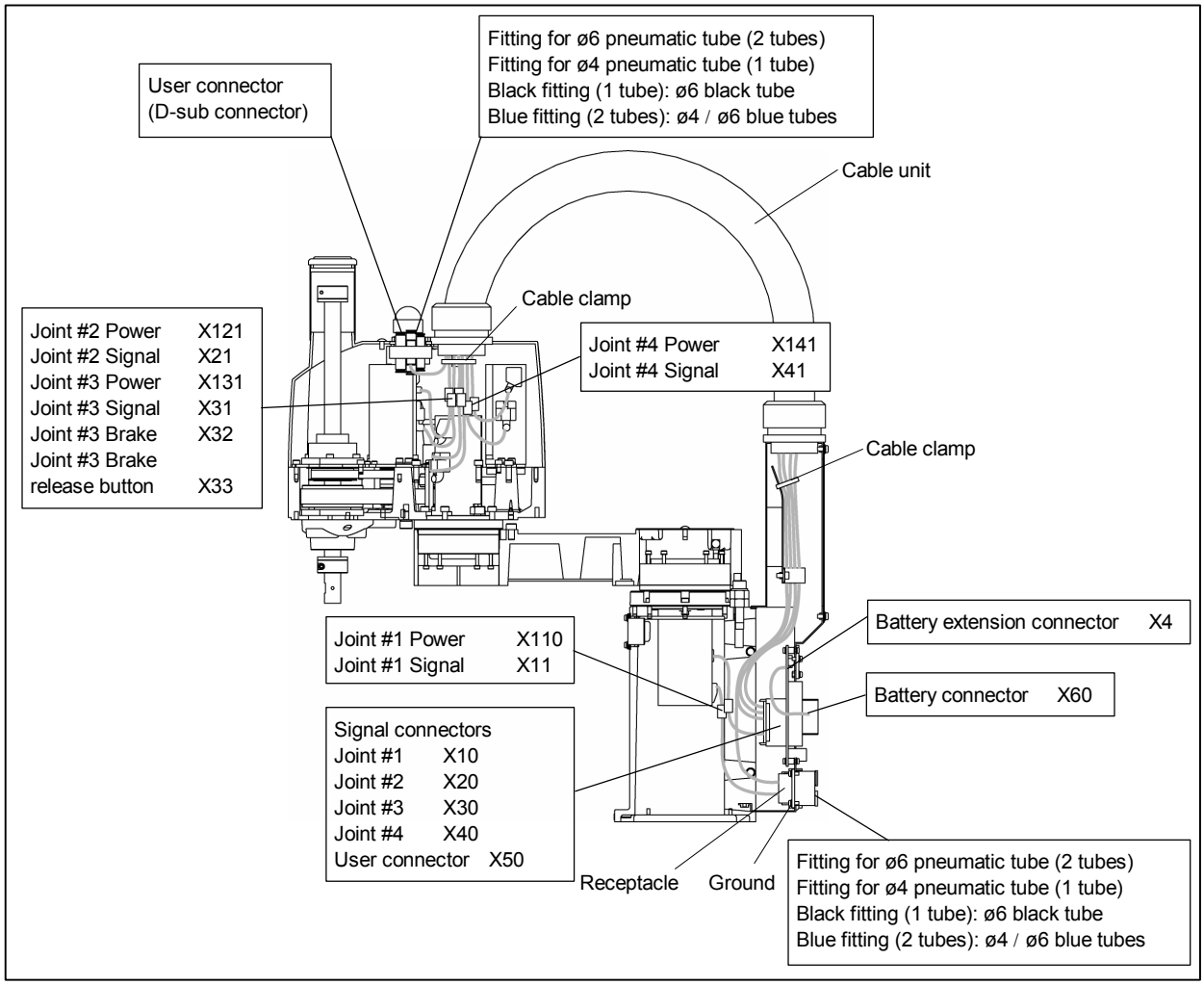
(12) Install the arm top cover.

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

4.3 Wiring Schematics

4.3.1 S, C Type Manipulators

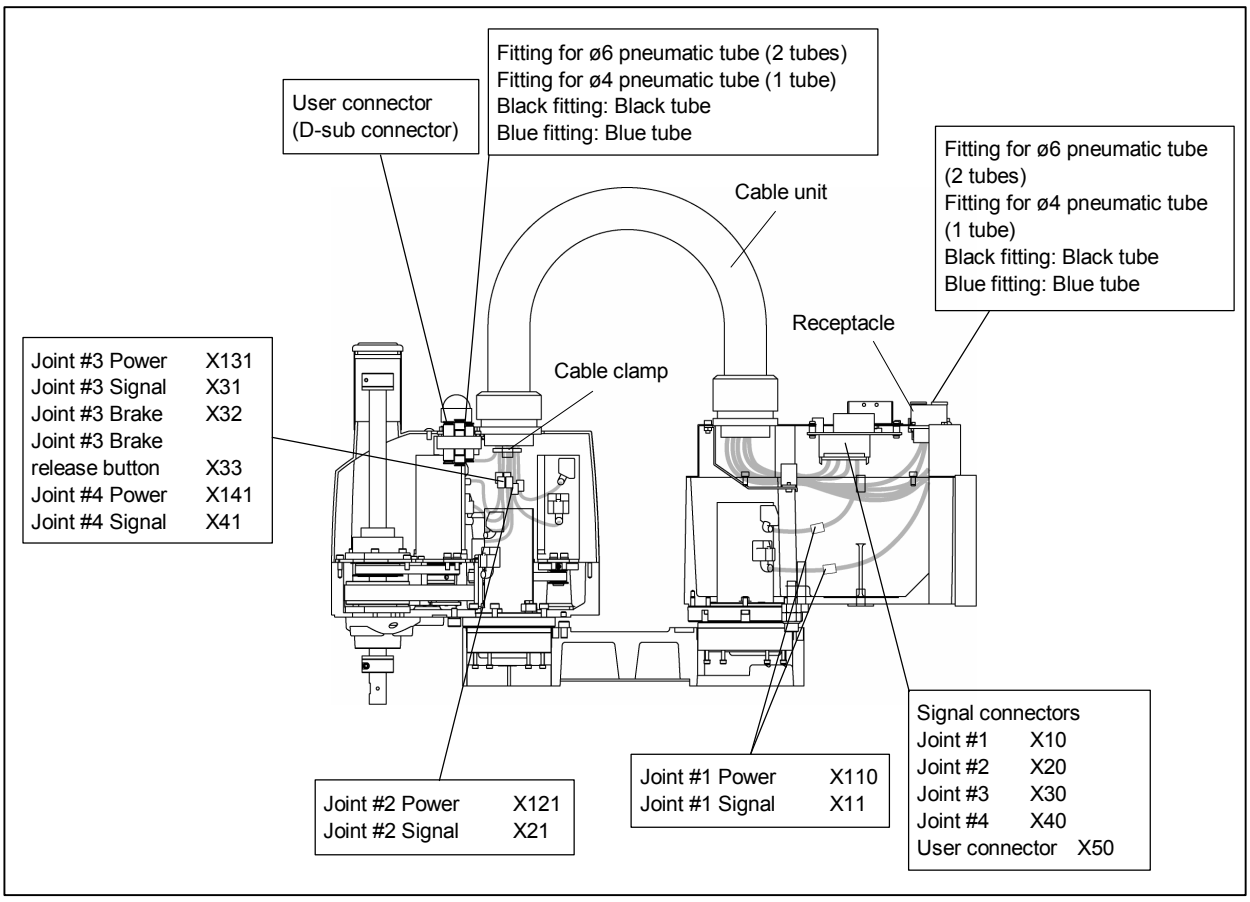
S and C types have the same wiring layout.



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

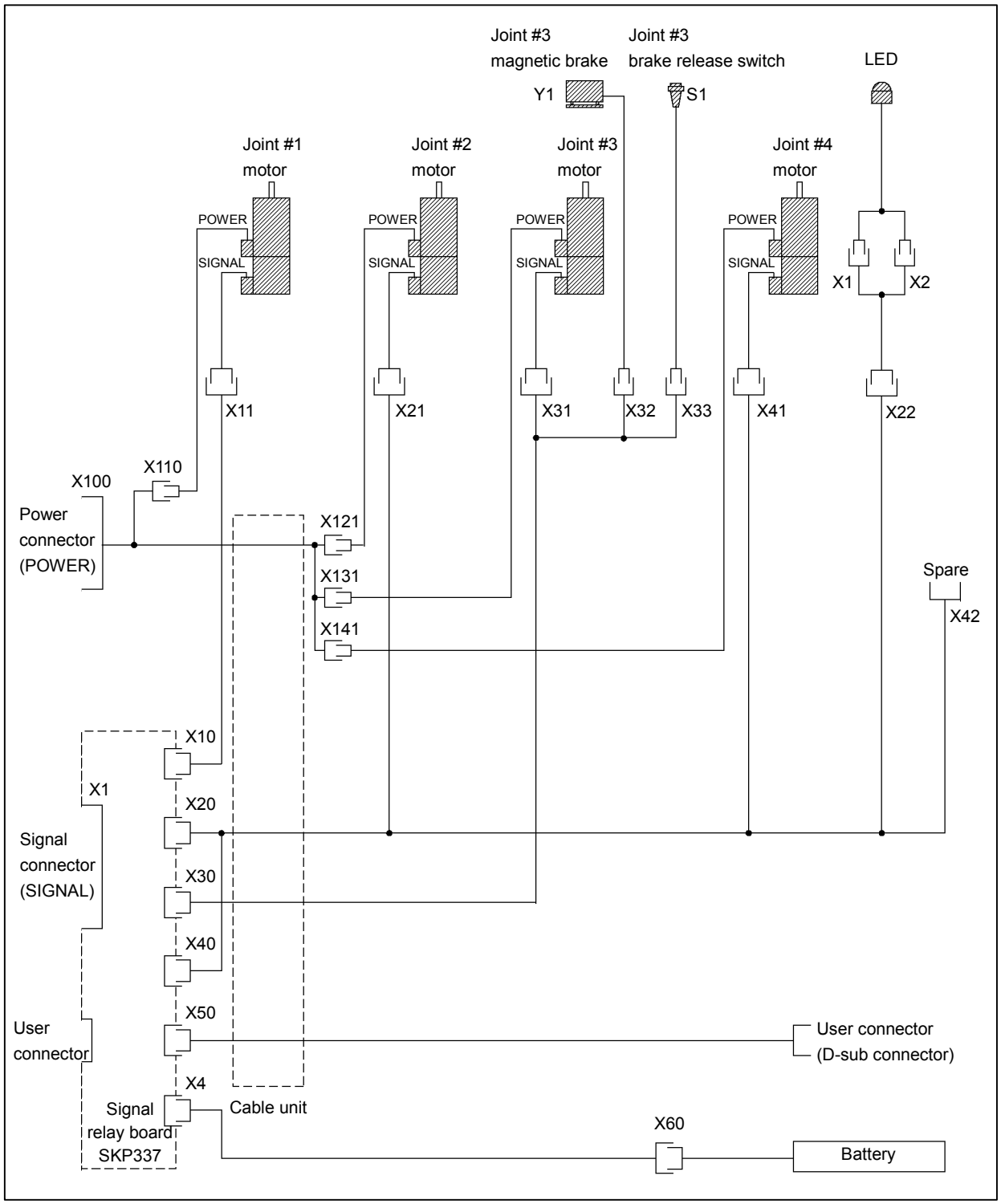
4.3.2 SM, CM Type Manipulators

SM and CM types have the same wiring layout.



NOTE ☞ 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	Shield
1B	N.C.		
2A	1A	BLU/(WHT)	X11-1
2B	$1\overline{A}$	WHT/(BLU)	X11-2
3A	1B	YLW/(WHT)	X11-3
3B	$1\overline{B}$	WHT/(YLW)	X11-4
4A	1Z	GRN/(WHT)	X11-5
4B	$1\overline{Z}$	WHT/(GRN)	X11-6
5A	N.C.		
5B	N.C.		
6A	ENC+5V	PPL/(WHT)	X11-12
6B	EGND	WHT/(PPL)	X11-13
7A	BAT+	BLU/(BRN)	X11-9
7B	BAT-	BRN/(BLU)	X11-10
8A	RES	YLW/(BRN)	X11-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	N.C.		
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	N.C.		
12B	N.C.		
13A	N.C.		
13B	N.C.		

X11 Motor Signal Connector

No.		Line color	Connect to
1	1A	BLU/(WHT)	Joint #1 motor encoder (SIGNAL)
2	$1\overline{A}$	WHT/(BLU)	
3	1B	YLW/(WHT)	
4	$1\overline{B}$	WHT/(YLW)	
5	1Z	GRN/(WHT)	
6	$1\overline{Z}$	WHT/(GRN)	
7	1S *	RED/(WHT)	
8	$1\overline{S}$ *	WHT/(RED)	
9	BAT+	BLU/(BRN)	
10	BAT-	BRN/(BLU)	
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	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	Joint #3 magnetic brake (Y1)
2	+24V	BRN/(YLW)	

X33 Brake Switch Connector

No.		Line color	Connect to
1	$\overline{EMB2}$	GRN	Joint #3 brake release switch (S1)
2	BRK.SW	BLU/(BRN)	

X40 Signal Connector

No.		Line color	Connect to
1A	N.C.		
1B	N.C.		
2A	4A	YLW/(BRN)	X41-1
2B	$\overline{4A}$	BRN/(YLW)	X41-2
3A	4B	GRN/(BRN)	X41-3
3B	$\overline{4B}$	BRN/(GRN)	X41-4
4A	4Z	RED/(BRN)	X41-5
4B	$\overline{4Z}$	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		YLW/(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	$\overline{4A}$	BRN/(YLW)	
3	4B	GRN/(BRN)	
4	$\overline{4B}$	BRN/(GRN)	
5	4Z	RED/(BRN)	
6	$\overline{4Z}$	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		YLW/(BLK)	Spare
2		BLK/(YLW)	Spare

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	

X60 Battery connector

	No.	Line color	Connect to
1		ORANGE	X60 battery (RED)
2		WHITE	X60 battery (BRK)

X4 Battery extension connector

	No.	Line color	Connect to
1		ORANGE	X60-1
2		WHITE	X60-2

X100 Receptacle

No.		Line color	Connect to
1	1U	BLK	X110-1
3	1V	WHT	X110-2
6	1W	RED	X110-3
10	2U	BLK	X121-1
14	2V	WHT	X121-2
16	2W	RED	X121-3
15	3U	BRN	X131-1
13	3V	BLU	X131-2
9	3W	PPL	X131-3
4	4U	GRY	X141-1
2	4V	PNK	X141-2
7	4W	ORN	X141-3
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	Joint #1 motor (POWER)
2	1V	WHT	
3	1W	RED	
4	FGND	GRN/YLW	

X121 Motor Power Connector

No.		Line color	Connect to
1	2U	BLK	Joint #2 motor (POWER)
2	2V	WHT	
3	2W	RED	
4	FGND	GRN/YLW	

X131 Motor Power Connector

No.		Line color	Connect to
1	3U	BRN	Joint #3 motor (POWER)
2	3V	BLU	
3	3W	PPL	
4	FGND	GRN/YLW	

X141 Motor Power Connector

No.		Line color	Connect to
1	4U	GRY	Joint #4 motor (POWER)
2	4V	PNK	
3	4W	ORN	
4	FGND	GRN/YLW	

5. Replacing the Motors

 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.

 CAUTION	■ 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. ■ Never disassemble the motor and encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again. ■ 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.

NOTE

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 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.

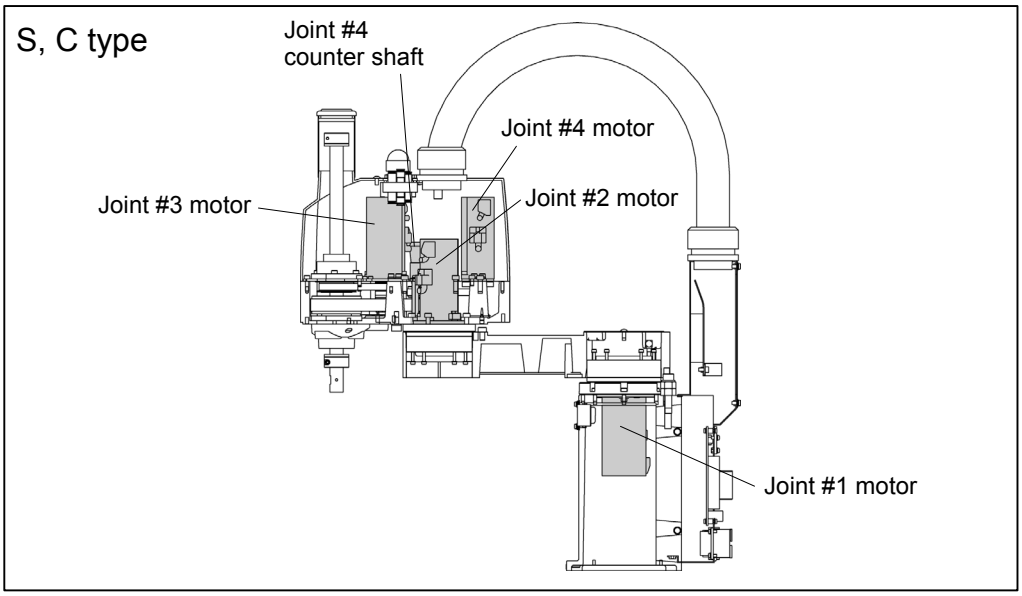
Move the shaft down to its lower limit before starting the replacement procedure by following the instructions below:

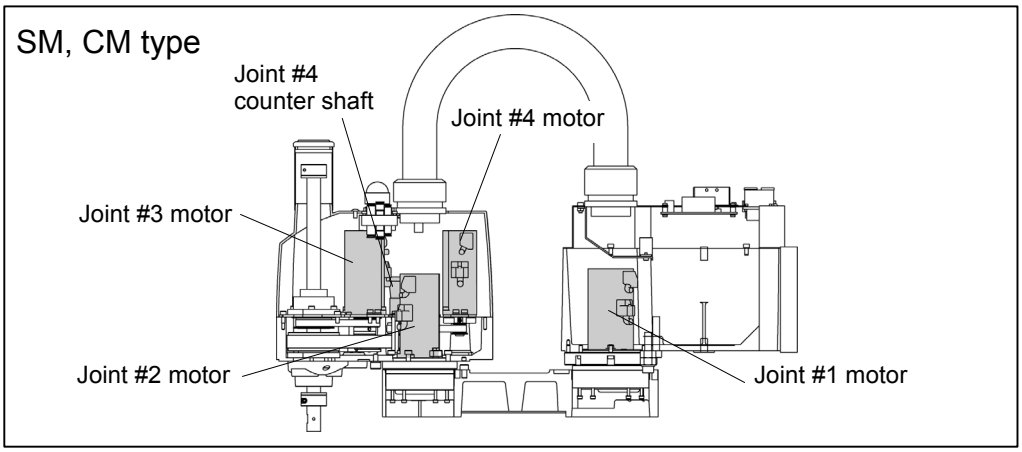
5.1 Types of Motors

The motor types used in E2C series Manipulators are shown in the table below.
When ordering a motor for replacement, check the series of Manipulator and the working joint. Then, specify the code from the table below.

Item	Series of Manipulator	Working Joint	Code	Note
AC servo motor	E2C	#1	R13A000600500	150 W
		#2, 3, and 4	R13A000600300	150 W

5.2 Location of Motors





5.3 Replacing the Joint #1 Motor

The procedure for replacing the Joint #1 motor varies with the Manipulator used.

5.3.1 S, C Type Manipulators

Removal

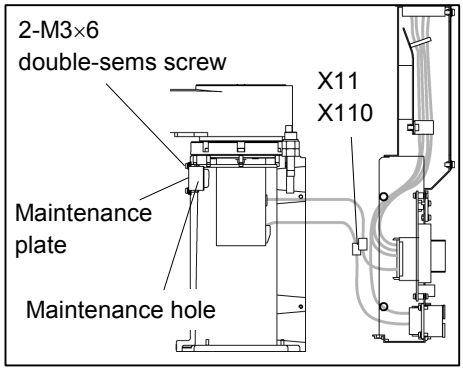
(1) Remove the base connector box.

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

(2) Remove the maintenance plate.

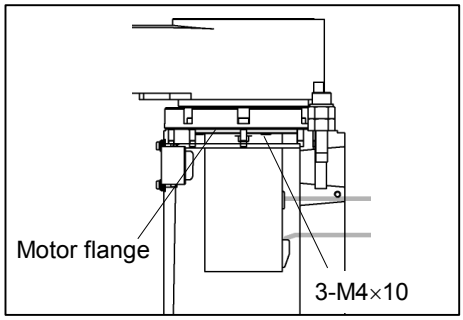
(3) Disconnect the connectors X110 and X11.

To disconnect the X110 connector, pull it out while pushing the projection next to 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 bolts on the maintenance hole side, insert a hexagonal wrench from the maintenance hole.



NOTE

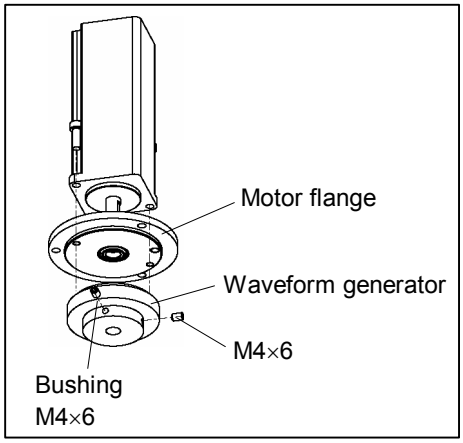
Be careful not to lose the oil seal coated with black rubber.

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.

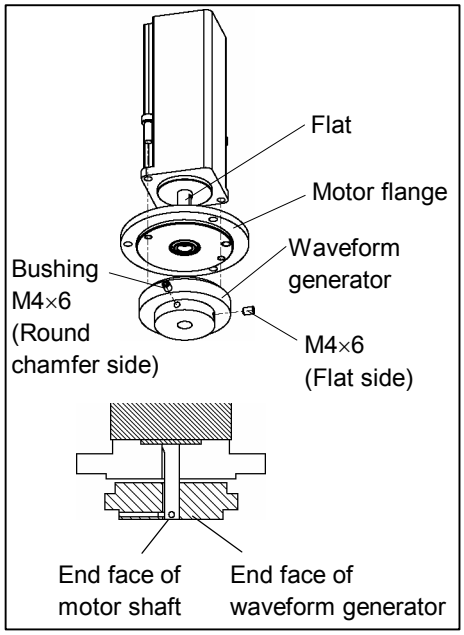


Installation

(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.



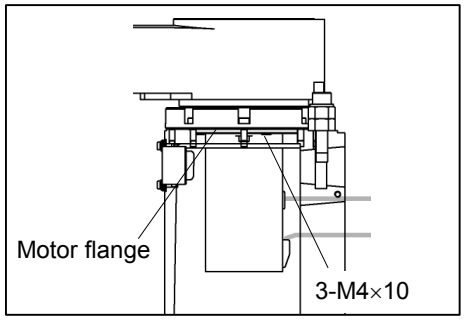
CAUTION

- 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.

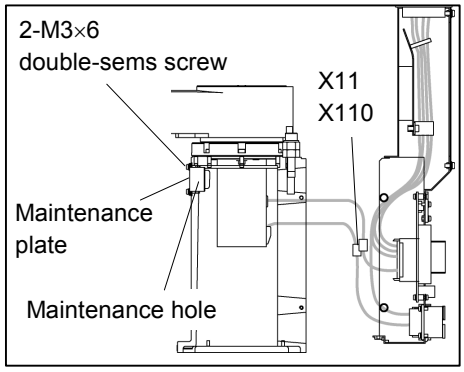
The motor cable must face toward the base connector box side.
For the bolt on the maintenance hole side, loosely fasten it with an accessory tool. Then, insert a hexagonal wrench from the maintenance hole and secure the bolt.

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 box.

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

(7) Perform the calibration of Joint #1.

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

5.3.2 SM, CM Type Manipulators

Removal

(1) Remove the base connector box.

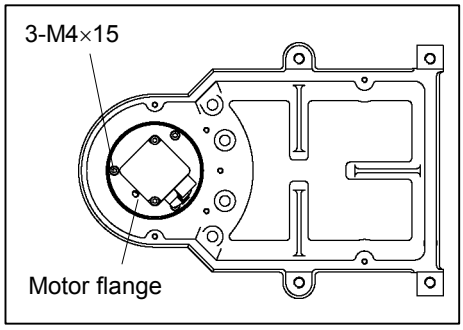
For details on the removal method, refer to *Maintenance: 3.4 Base Connector Box*.

(2) Disconnect the connectors X110 and X11.

To disconnect the X110 connector, pull it out while pushing the projection next to the connector.

(3) 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 upward.



NOTE

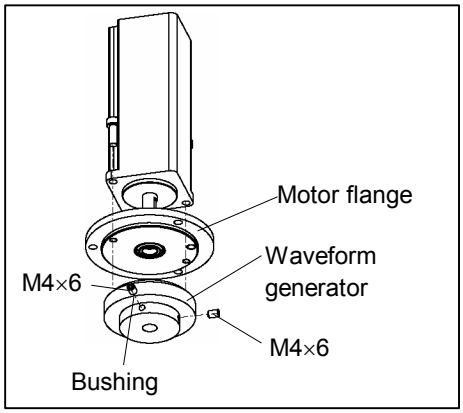
Be careful not to lose the oil seal coated with black rubber.

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

(4) 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.

(5) Remove the motor flange from the Joint #1 motor.

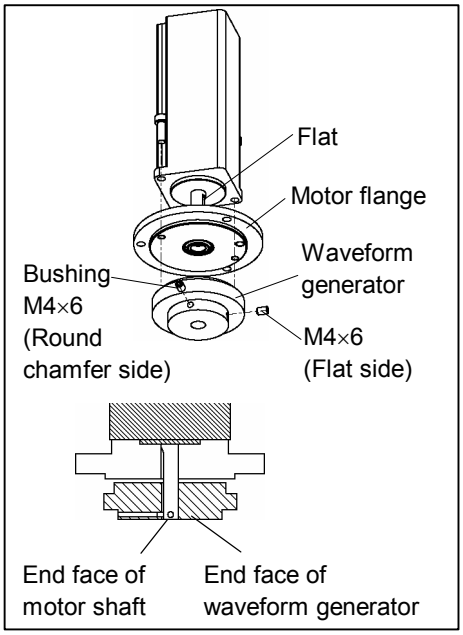


Installation

(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.

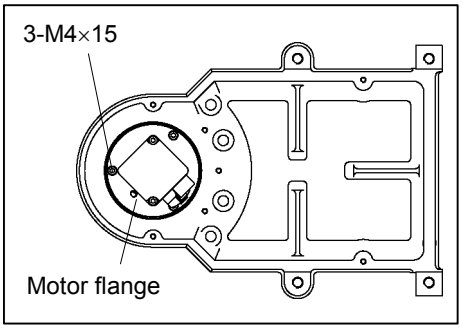


CAUTION

- 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.

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



(4) Connect the connectors X110 and X11.

(5) Install the base connector box.

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

(6) Perform the calibration of Joint #1.

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

5.4 Replacing the Joint #2 Motor

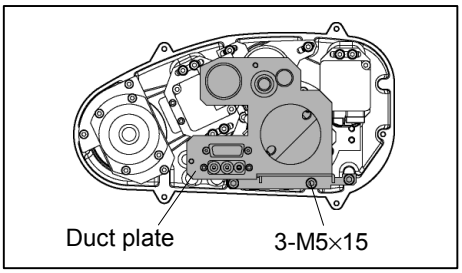
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.



(4) Cut off the wire tie binding motor cables to the Joint #2 motor.

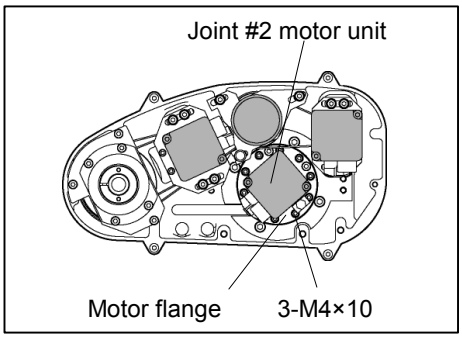
(5) Disconnect the connectors X121 and X21.

To disconnect the X121 connector, pull it out while pushing the projection next to the connector.

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

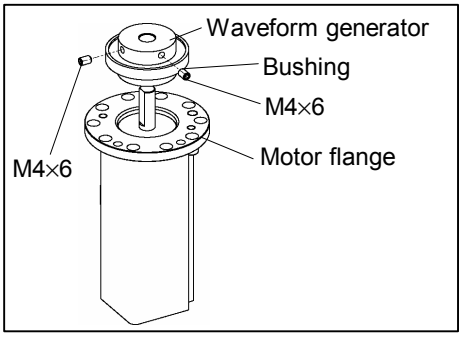
To do so, unscrew the bolts from the Joint #2 motor flange. Then, pull out the motor unit straight and upward.

If the motor cannot be pulled out easily, pull it out while moving Arm #2 slowly by hand.

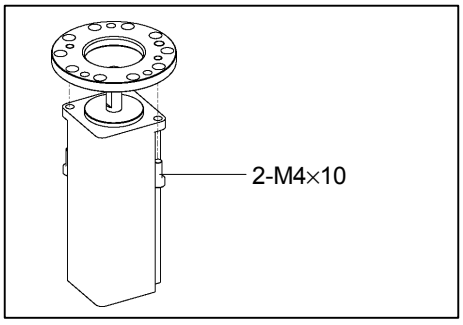


(7) Remove the waveform generator from the Joint #2 motor.

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



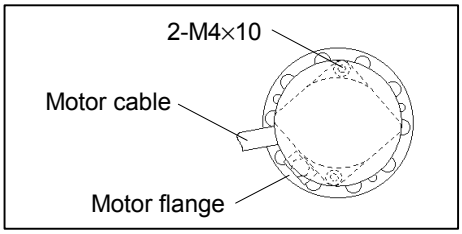
(8) Remove the motor flange from the Joint #2 motor.



Installation

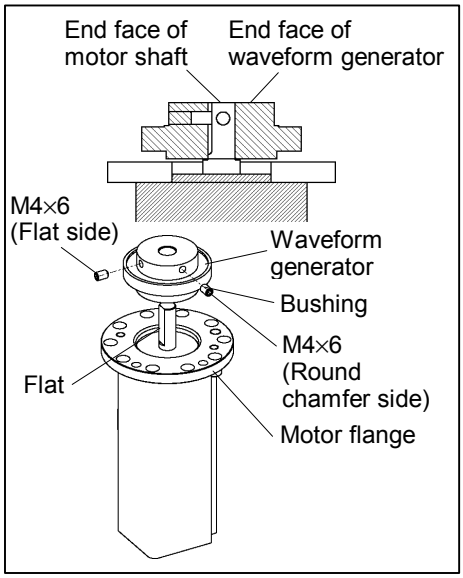
(1) Mount the motor flange on the Joint #2 motor.

The motor cable must be located on the position as shown in the figure on the right.



(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.



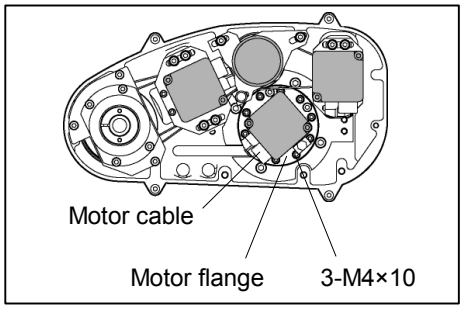
CAUTION

- 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.

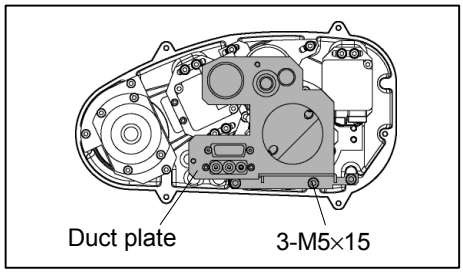
(3) Mount the Joint #2 motor unit on Arm #2.

The motor cable must be located on the position as shown in the figure on the right.

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



(4) Mount the duct plate on Arm #2.



(5) Connect the connectors X121 and X21.

(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 #2.

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

5.5 Replacing the Joint #3 Motor

CAUTION	■ When removing the pulley from the brake, be sure to slide it out perpendicularly from the shaft. Removing the pulley horizontally from the shaft will damage the leaf spring and result in malfunction of the brake.

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.

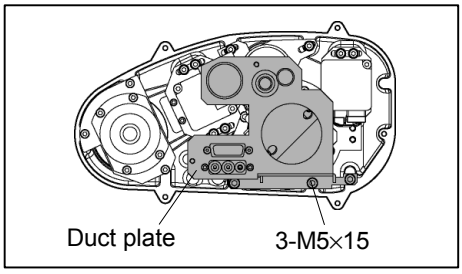
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.



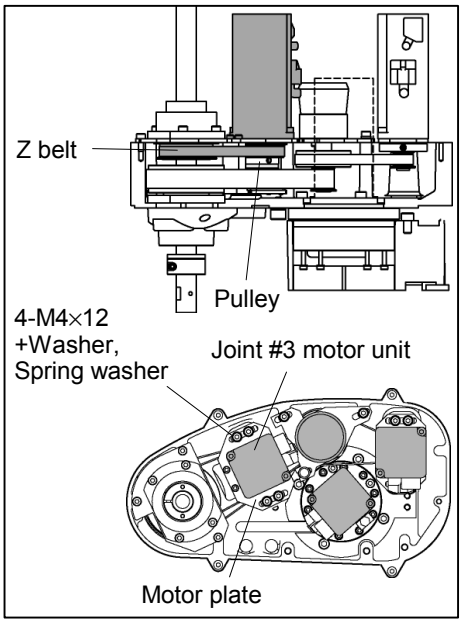
(4) Cut off the wire tie binding motor cables to the Joint #3 motor.

(5) Disconnect the connectors X131, X31, and X32.

To disconnect the X131 connector, pull it out while pushing the projection next to the connector.

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

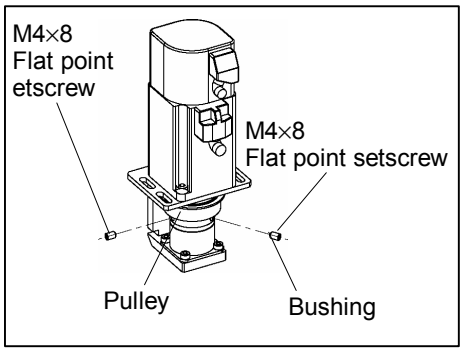
To do so, unscrew the bolts from the Joint #3 motor plate. Then, remove the Z belt from the pulley and pull out the Joint #3 motor unit upward.



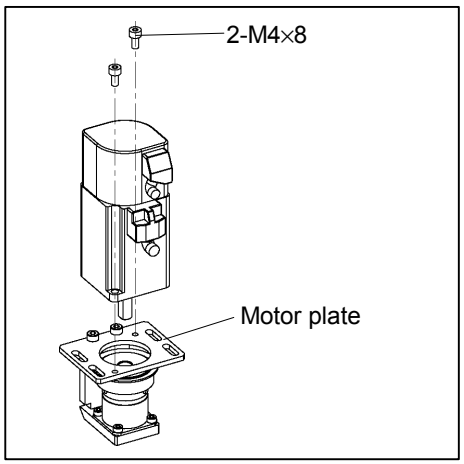
(7) Cut off the wire tie binding the brake cables to the Joint #3 motor.

(8) Unscrew the setscrews from the pulley under the Joint #3 motor.

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

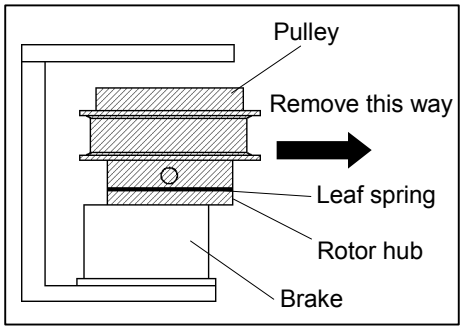


(9) Hold the motor plate and pulley, and then pull the Joint #3 motor upward to remove it.



Installation

(1) Remove the pulley from the brake.



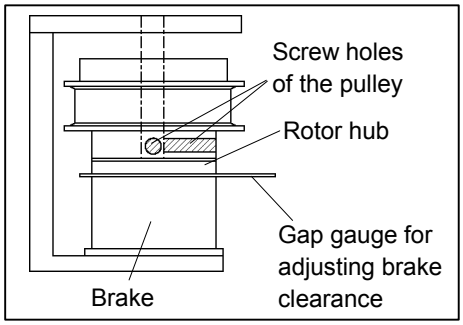
NOTE

The rotor hub is held to the brake by its magnet. When removing the pulley, slide it out perpendicularly from the shaft to prevent damage to the leaf spring on the rotor hub.

(2) For the brake clearance adjustment, hold the gap gauge on the brake, and then mount the pulley over the gauge.

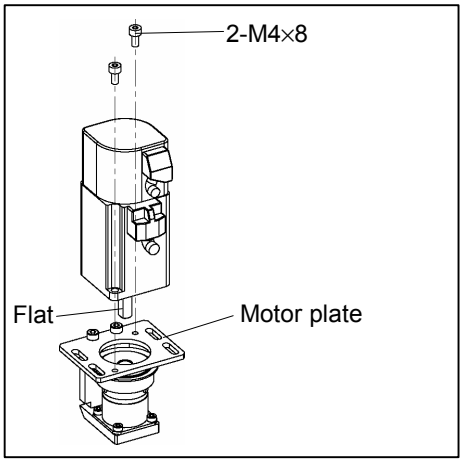
The screw hole of the pulley must be located in the position shown in the figure on the right.

The gap gauge (0.15 mm) is attached to the inside of the arm bottom cover for storage.



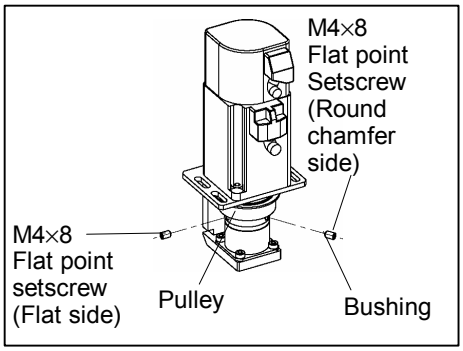
(3) Place the Joint #3 motor on the motor plate.

The motor cables of the Joint #3 motor and the flat face of the motor shaft must be oriented in the direction shown in the figure on the right.



(4) Secure the pulley to the motor shaft of the Joint #3 motor.

To do so, tighten one of the setscrews to 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.



(5) After the pulley is secured, pull out the gap gauge.

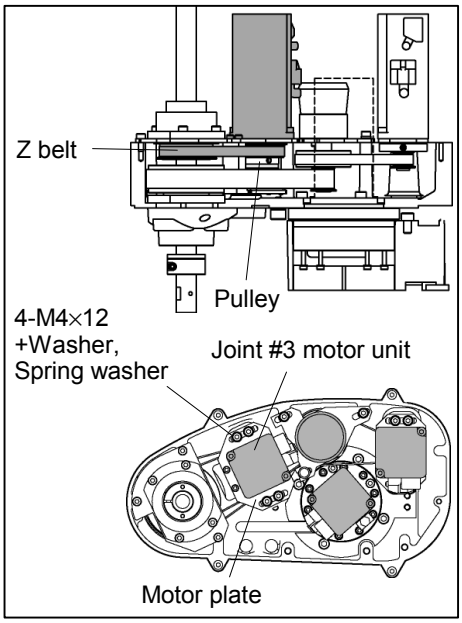
(6) Fasten the brake cables to the Joint #3 motor with a wire tie.

Make sure that the brake cables do not touch the pulleys when installing the Joint #3 motor unit to Arm #2.

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

(8) Place the Z belt around the Z1 and Z2 pulleys.

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



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

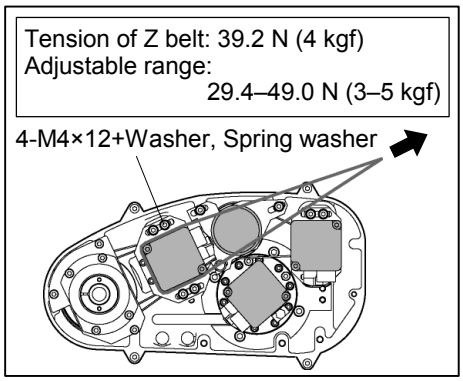
NOTE

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.

(10) 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.



(11) Mount the duct plate on Arm #2.

(12) Connect the connectors X131, X31 and X32.

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

Do not allow unnecessary strain on the cables.

(14) Install the arm top cover.

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

(15) Perform the calibration of Joint #3.

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

5.6 Replacing the Joint #4 Motor

NOTE 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 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.

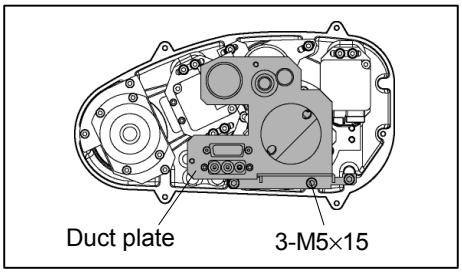
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.



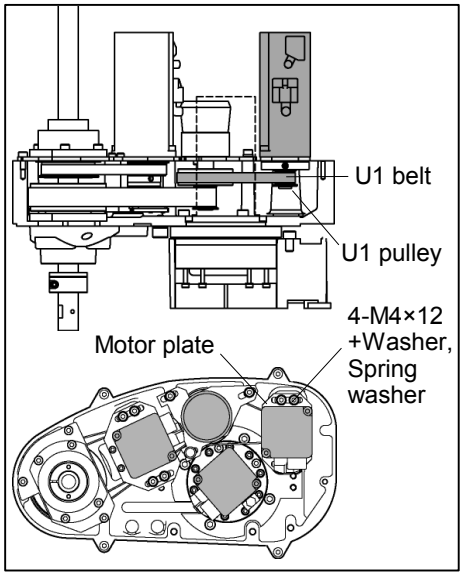
(4) Cut off the wire tie binding the motor cables to the Joint #4 motor.

(5) Disconnect connectors X141 and X41.

To disconnect the X141 connector, pull it out while pushing the projection next to the connector.

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

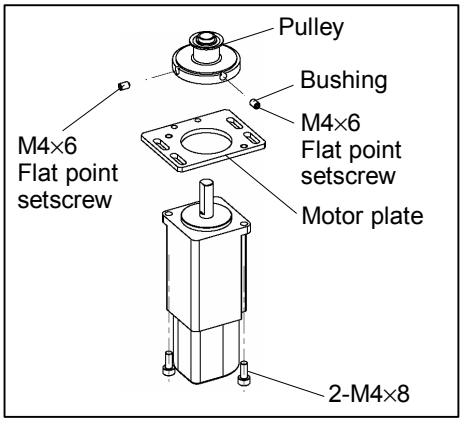
To do so, unscrew the bolts from the Joint #4 motor plate. Then, remove the U1 belt from the pulley and pull it out upward.



(7) Remove the pulley from the Joint #4 motor.

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

(8) Remove the motor plate from the Joint #4 motor.



Installation

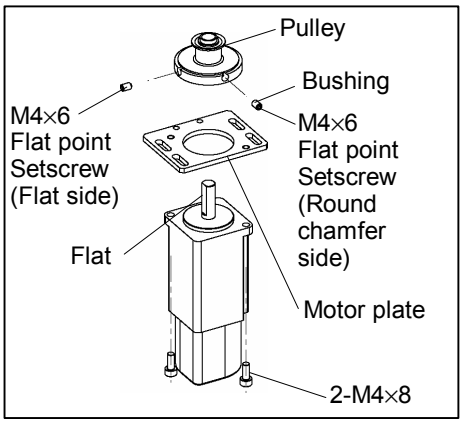
(1) Mount the motor plate on the Joint #4 motor.

(2) Mount the pulley on the Joint #4 motor.

Be sure to fit the end face of the motor shaft to the end face of the pulley. 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.

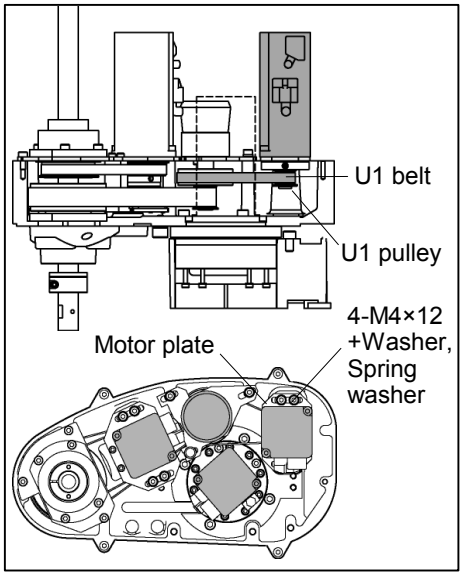
(3) Place the Joint #4 motor unit back on Arm #2.

The Joint #4 motor cable must be located on the left side when it faces toward the end of Arm #2.



(4) Place the U1 belt around the large U2 pulley and the U1 pulley.

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



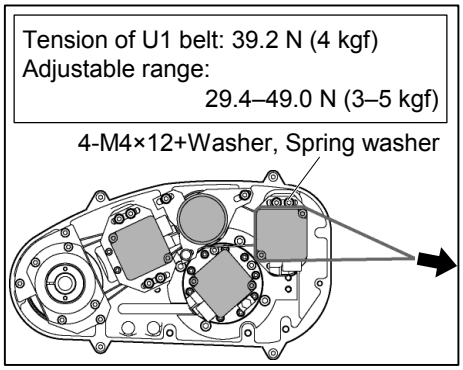
(5) Loosely secure the Joint #4 motor unit to Arm #2.

NOTE

Loosely secure the Joint #4 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 U1 belt, and secure the Joint #4 motor unit.

To do so, pass a suitable cord or string around the Joint #4 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.



(7) Mount the duct plate on Arm #2.

(8) Connect the connectors X141 and X41.

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

Do not allow unnecessary strain on the cables.

(10) Install the arm top cover.

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

(11) Perform the calibration of Joint #4.

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

6. Replacing the Reduction Gear Units

 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.

 CAUTION	■ 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.

NOTE

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 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.

The M3 bolt on the reduction gear unit needs to be tightened with 294 N·cm (30 kgf·cm) torque to give the bolt higher support ability although it normally needs to be tightened with 245 N·cm (25 kgf·cm) torque. If the tightening torque is specified, fasten the bolt with the specified torque.

6.1 Types of Reduction Gear Units

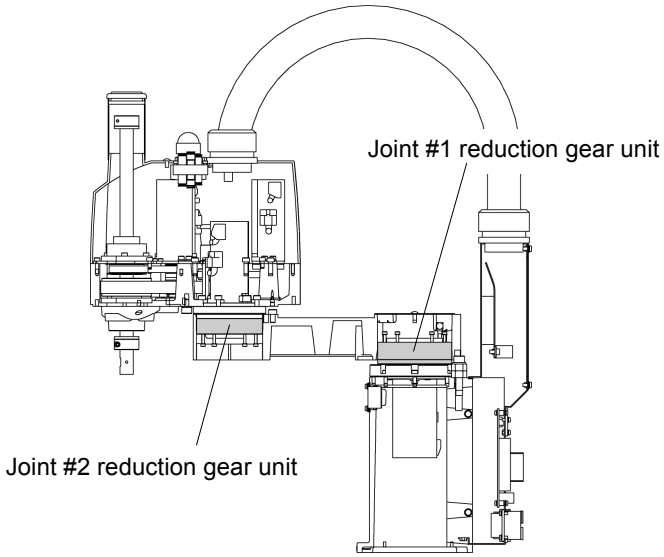
The types of the reduction gear units used in E2C series Manipulators are shown in the table below.

When ordering a reduction gear unit for replacement, check the series of Manipulator and the working joint. Then, specify the code from the table below.

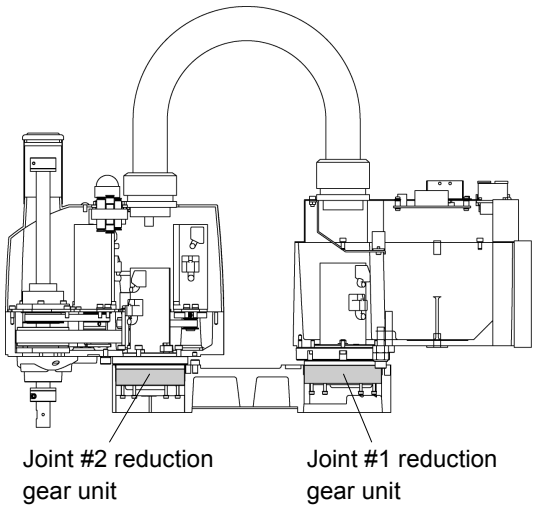
Item	Series	Working Joint	Code	Note
Reduction gear unit	E2C	#1	R13ZA00101000	SHF-20-80
		#2	R13ZA00101100	SHF-17-50

6.2 Location of Reduction Gear Units

S, C type



SM, CM type



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

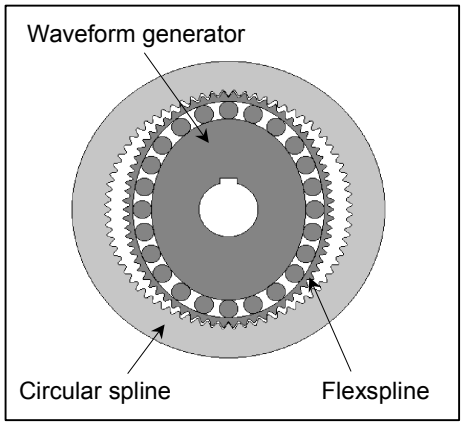
This waveform generator consists of an ellipsoidal cam with ball bearings on its outer circumference.
The inner ring of bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.

(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

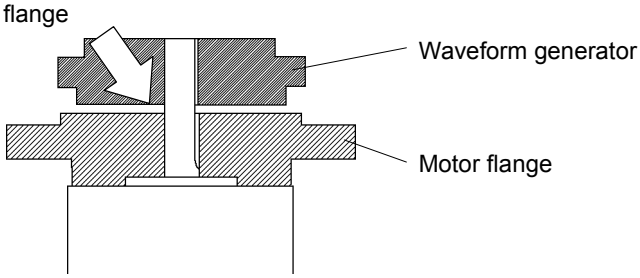
Grease for the Joint #1 reduction gear unit is different from that for the Joint #2 reduction gear unit. Be sure to use the proper grease.
While greasing the reduction gear units, be careful not to contain any foreign substances in the grease. The adequate quantity of the grease is specified as follows:

Series	Reduction gear unit	Color of Grease	Grease quantity		Code	Note
			Flexspline	Between the waveform generator and motor flange		
E2C	Joint #1	Yellow	12 g	4 g	R13ZA00330100	SK-1A
	Joint #2	Green	8 g	3 g	R13ZA00330400	SK-2

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

The procedure for replacing the Joint #1 reduction gear unit varies with the Manipulator used.

6.5.1 S, C Type Manipulators

Removal

(1) Remove the power cable and signal cable from the base connector box (outside).

(2) Remove the Joint #1 cover.

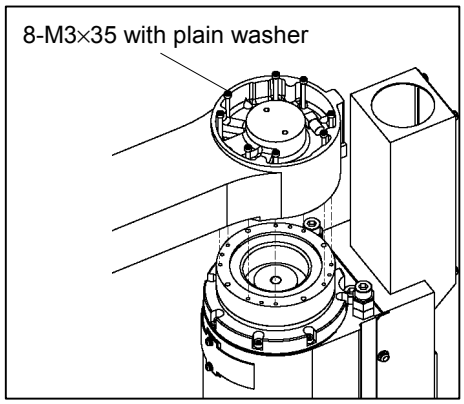
For details on the removal method, refer to *Maintenance: 3.3 Joint #1 Cover*.

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 may result in fall of the arm, bodily injury, and/or malfunction of the robot system.

(3) Remove Arm #1 from the base.

To do so, support the 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.

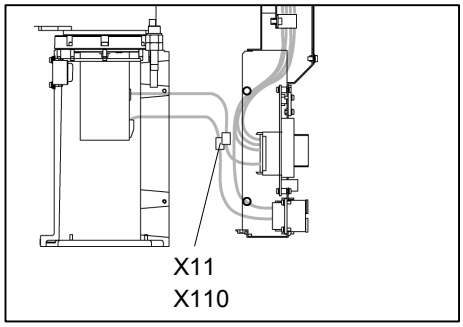


(4) Remove the base connector box.

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

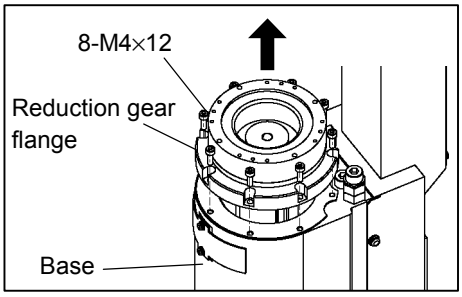
(5) Disconnect the connectors X110 and X11.

To disconnect the X110 connector, pull it out while pushing the projection next to the connector.



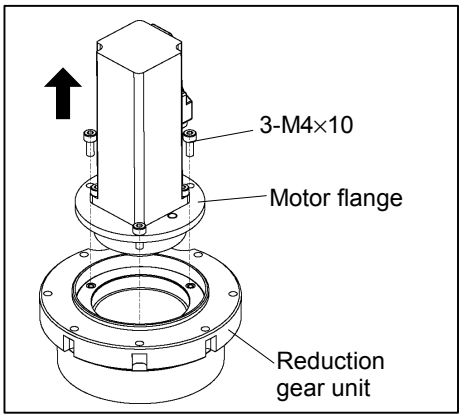
(6) Remove the Joint #1 reduction gear unit from the base.

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

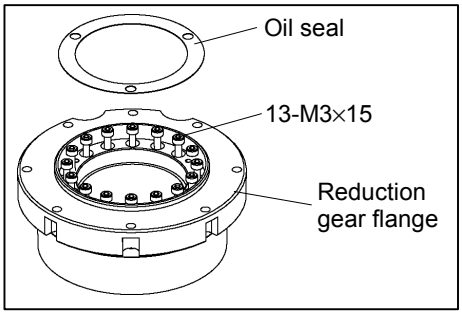


(7) Remove the Joint #1 motor unit from the Joint #1 reduction gear unit.

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

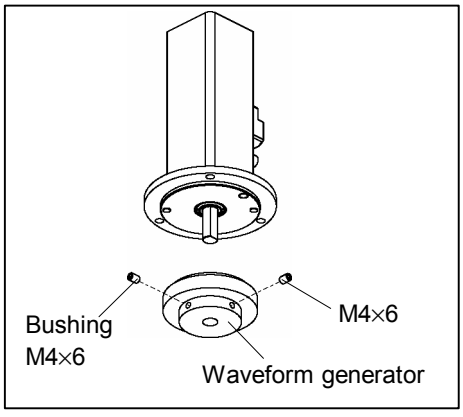


(8) Detach the oil seal from the Joint #1 reduction gear, and then remove the reduction gear flange.



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

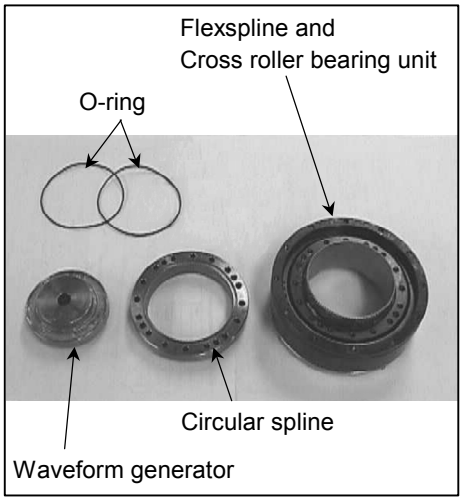
There is a brass bushing in one of the setscrew holes. Be careful not to lose it.



Installation

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

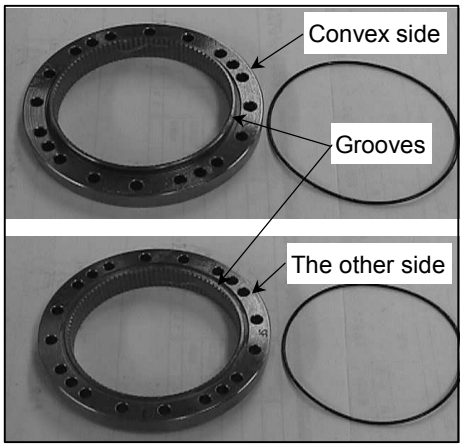
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



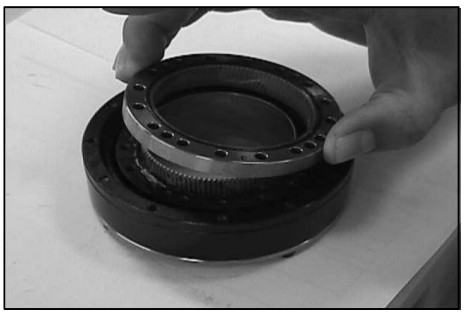
CAUTION	■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

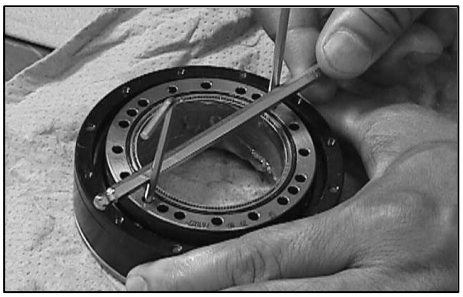
Make sure that the rings do not come out of the grooves.



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

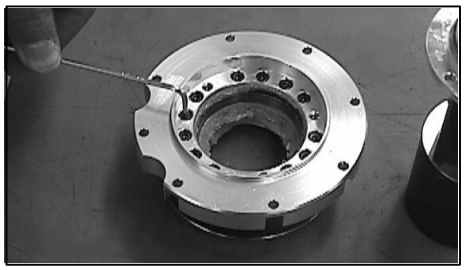


(4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



(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 unit of E2C	M3×15	13	294 N·cm (30 kgf·cm)

NOTE

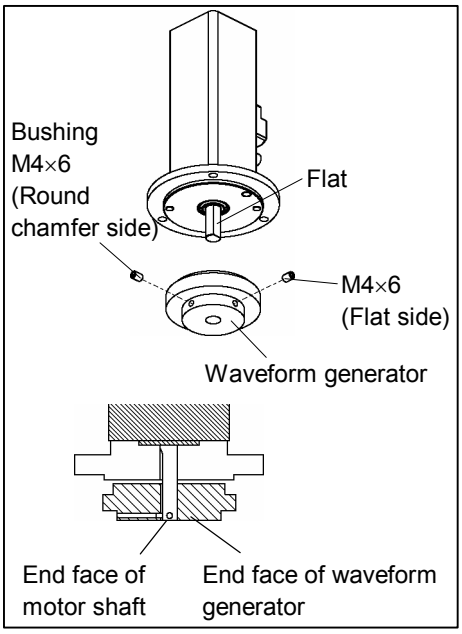
Be careful not to apply too much force since it may damage the parts.

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

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*. (The grease for the Joint #1 reduction gear unit is different from that for the Joint #2 reduction gear unit.)

(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.

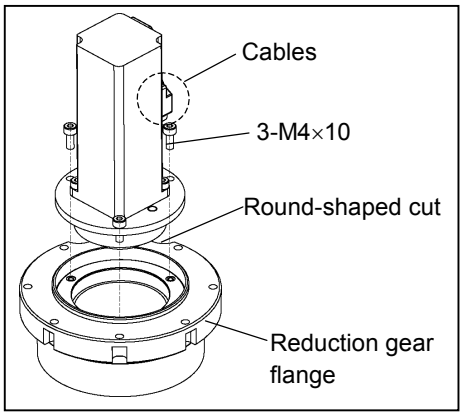


CAUTION

■ 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.

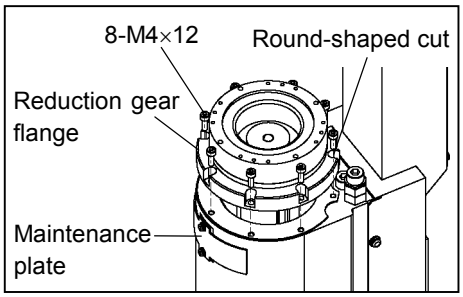
(8) Mount the Joint #1 motor unit on the Joint #1 reduction gear unit.

Make sure that the motor cables face toward the round-shaped cut on the reduction gear flange as shown in the figure on the right.



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

The round-shaped cut on the reduction gear flange must be in the position as shown in the figure on the right.



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: Yellow) inside the flexspline.

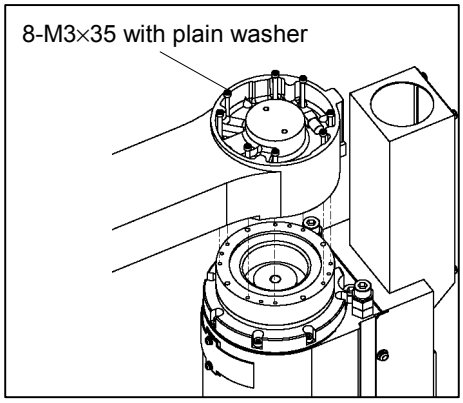
For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*. (The grease for the Joint #1 reduction gear unit is different from that for the Joint #2 reduction gear unit.)

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 may result in fall of the arm, bodily injury, and/or malfunction of the robot system.

(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.

Tightening torque: 294 N·cm (30 kgf·cm)



(12) Connect the connectors X110 and X11.

(13) Install the base connector box.

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

(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 box (outside).

(16) Perform the calibration of Joint #1.

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

6.5.2 SM, CM Type Manipulators

Removal

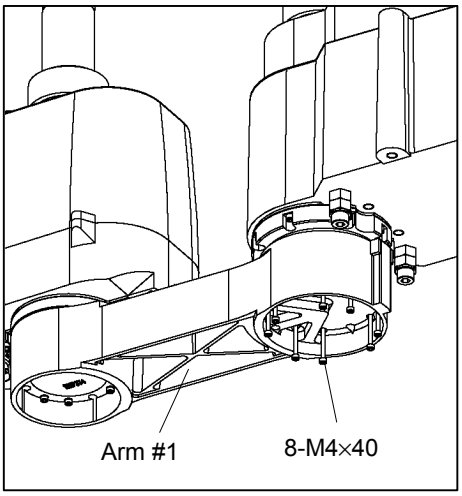
(1) Remove the power cable and signal cable from the base connector box (outside).

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 may result in fall of the arm, bodily injury, and/or malfunction of the robot system.

(2) Remove Arm #1 from the base.

To do so, support the 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.

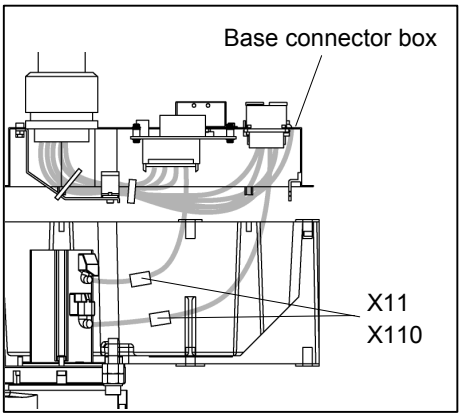


(3) Remove the base connector box.

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

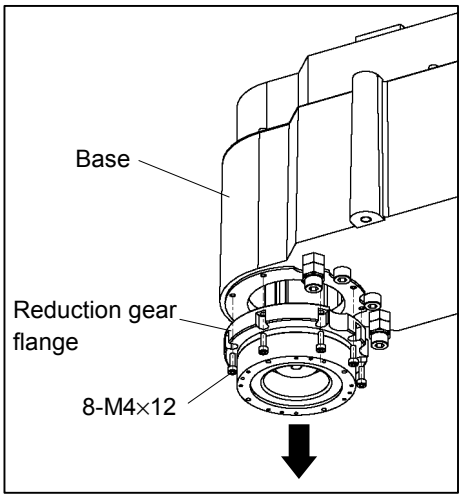
(4) Disconnect the connectors X110 and X11.

To disconnect the X110 connector, pull it out while pushing the projection next to the connector.



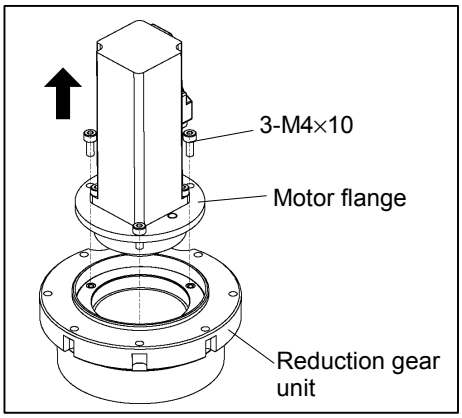
(5) Remove the Joint #1 reduction gear unit from the base.

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

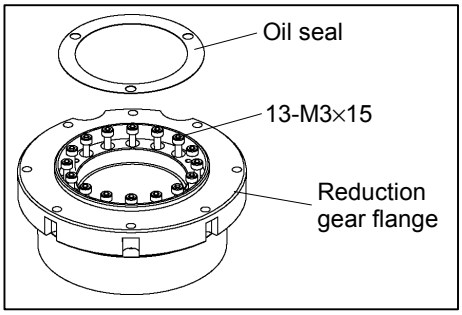


(6) Remove the Joint #1 motor unit from the Joint #1 reduction gear unit.

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

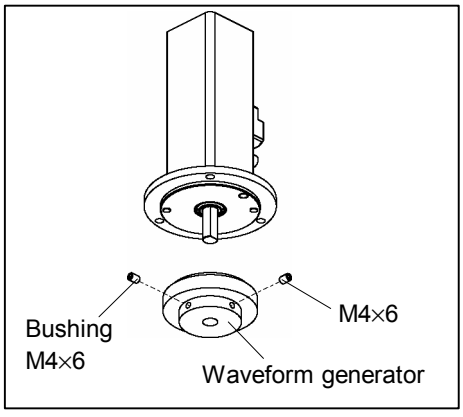


(7) Detach the oil seal from the Joint #1 reduction gear, and then remove the reduction gear flange.



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

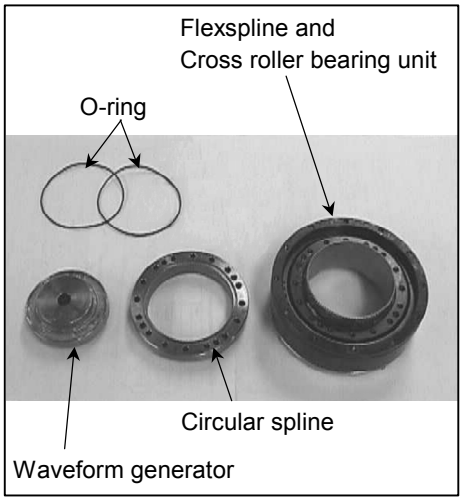
There is a brass bushing in one of the setscrew holes. Be careful not to lose it.



Installation

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

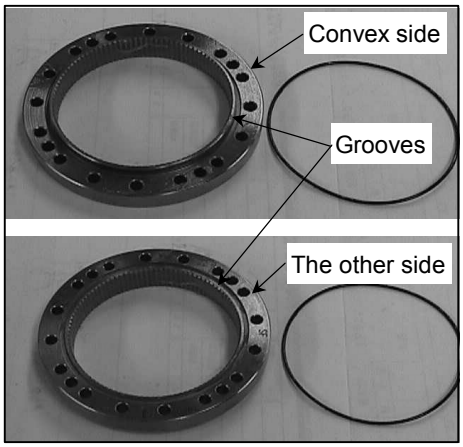
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



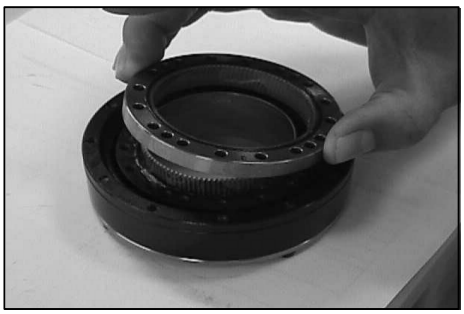
CAUTION	■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

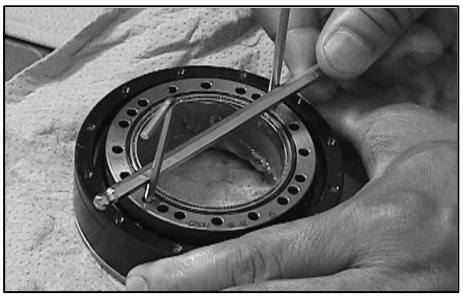
Make sure that the rings do not come out of the grooves.



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

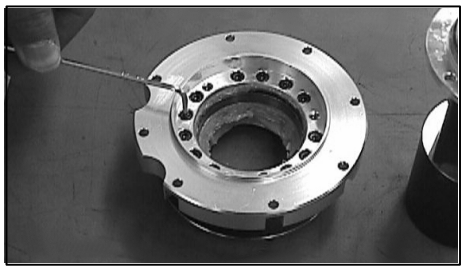


(4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



(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 unit of E2C	M3×15	13	294 N·cm (30 kgf·cm)

NOTE

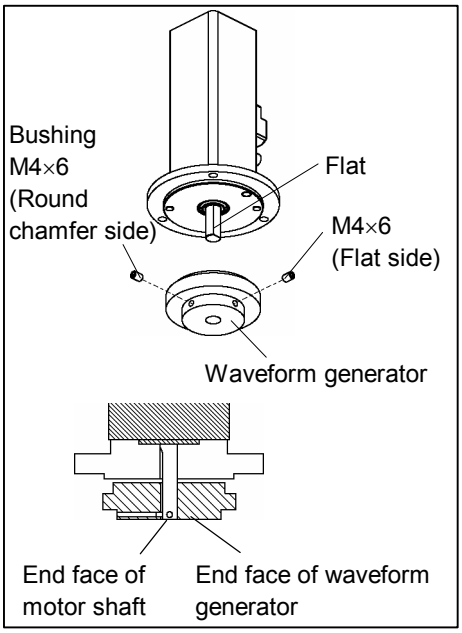
Be careful not to apply too much force since it may damage the parts.

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

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*. (The grease for the Joint #1 reduction gear unit is different from that for the Joint #2 reduction gear unit.)

(7) Mount the waveform generator to 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.

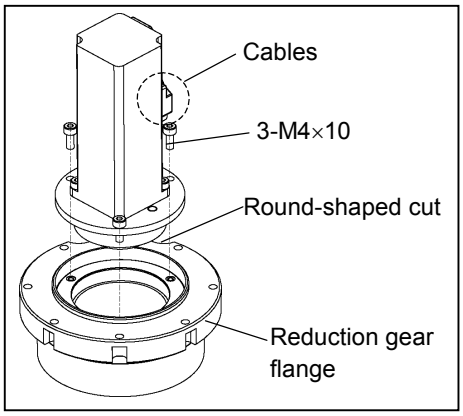


CAUTION

- 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.

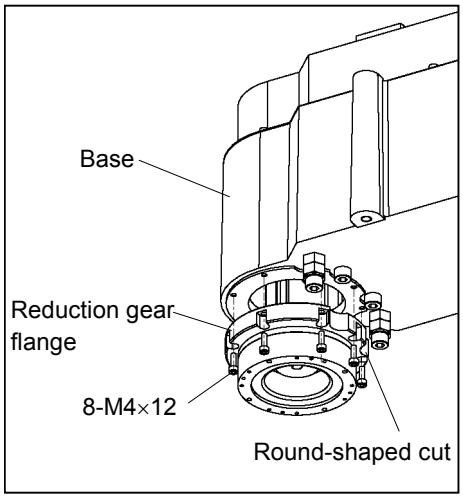
(8) Mount the Joint #1 motor unit on the Joint #1 reduction gear unit.

Make sure that the motor cables face toward the round-shaped cut on the reduction gear flange as shown in the figure on the right.



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

The round-shaped cut on the reduction gear flange must be in the position as shown in the figure on the right.



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: Yellow) inside the flexspline.

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*. (The grease for the Joint #1 reduction gear unit is different from that for the Joint #2 reduction gear unit.)

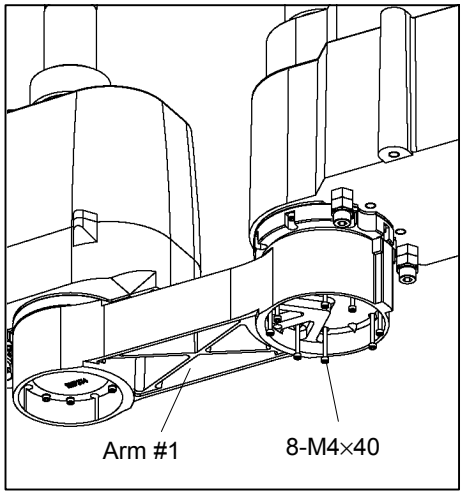
CAUTION	■ When removing or installing the arm, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting may result in fall of the arm, bodily injury, and/or malfunction of the robot system.

(11) For the prevention of grease leakage, put an O-ring on the joint area between Arm #1 and the Joint #1 reduction gear unit.

To do so, install an O-ring in the groove of the clamp face on the Arm #1 side.

(12) 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.



(13) Connect the connectors X110 and X11.

(14) Install the base connector box.

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

(15) Connect the power cable and signal cable to the base connector box (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

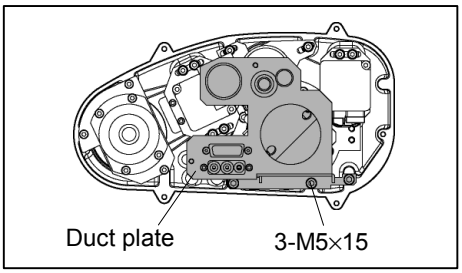
(1) Remove the power cable and signal cable from the base connector box (outside).

(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 binding the duct plate, motor, and cables together.

(4) Remove the duct plate.



(5) Cut off the wire tie binding cables to the Joint #2 motor.

(6) Disconnect the connectors X121 and X21.

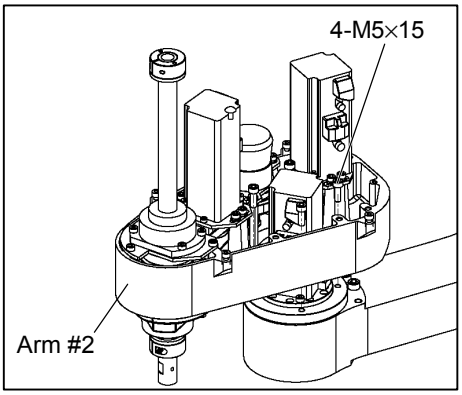
To disconnect the X121 connector, pull it out while pushing the projection next to the connector.

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 may result in fall of the arm, bodily injury, and/or malfunction of the robot system.

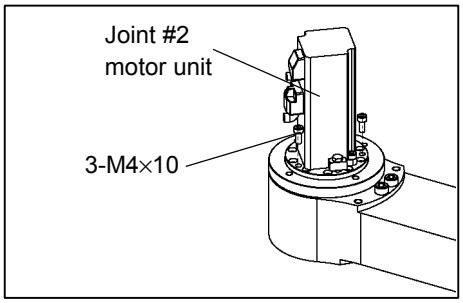
(7) Remove Arm #2 from Arm #1.

To do so, support the 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.

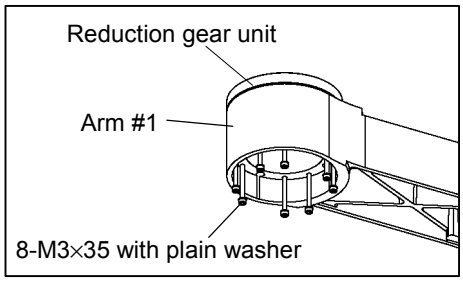


(8) Remove the Joint #2 motor unit from Arm #1.



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

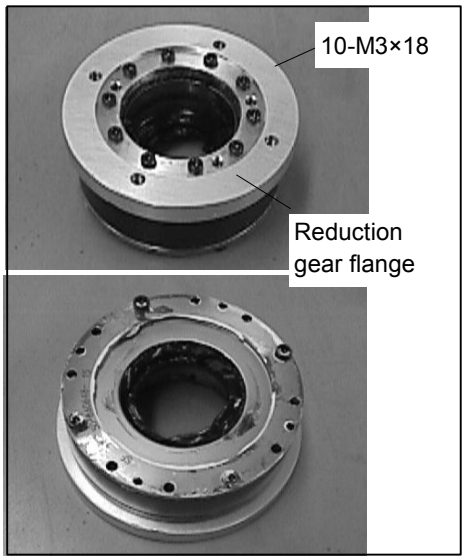
To do so, unscrew the mounting bolts for the reduction gear unit on the lower side of Arm #1. Then, pull out the reduction gear unit upward to remove it.



NOTE

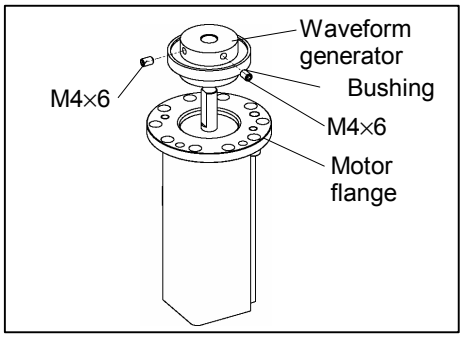
For the prevention of grease leakage, an O-ring is used on the joint area between Arm #1 and the Joint #2 reduction gear unit. Do not lose the O-ring when removing it.

(10) Remove the reduction gear flange from the Joint #2 reduction gear.



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

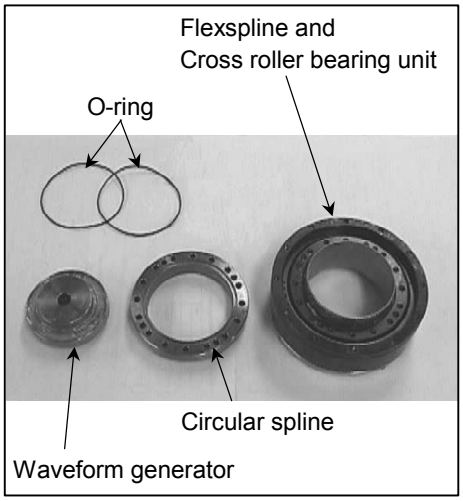
There is a brass bushing in one of the setscrew holes. Be careful not to lose it.



Installation

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

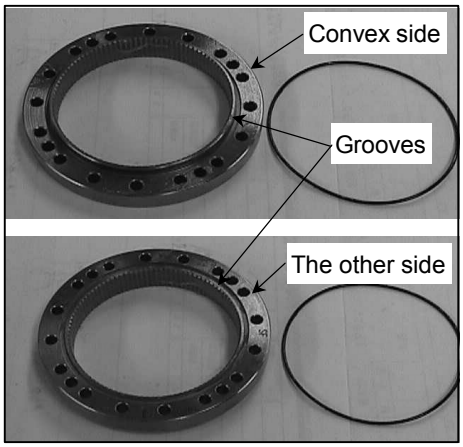
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



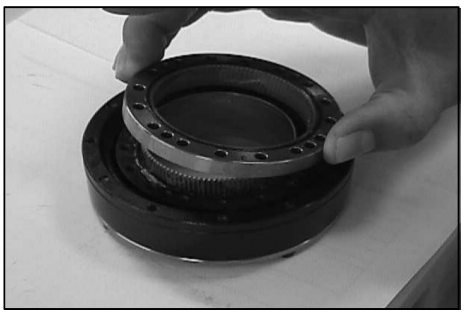
CAUTION	■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

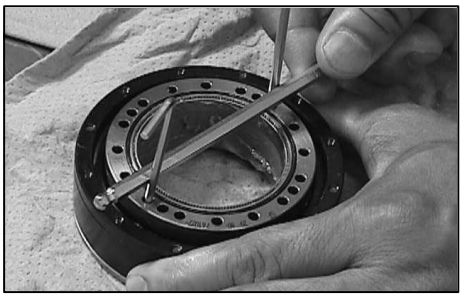
Make sure that the rings do not come out of the grooves.



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

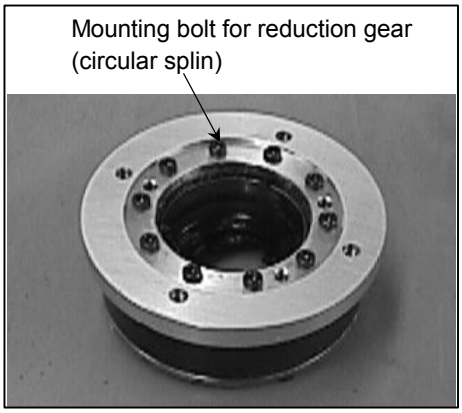


(4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



(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 of E2C	M3×18	10	294 N·cm (30 kgf·cm)

NOTE

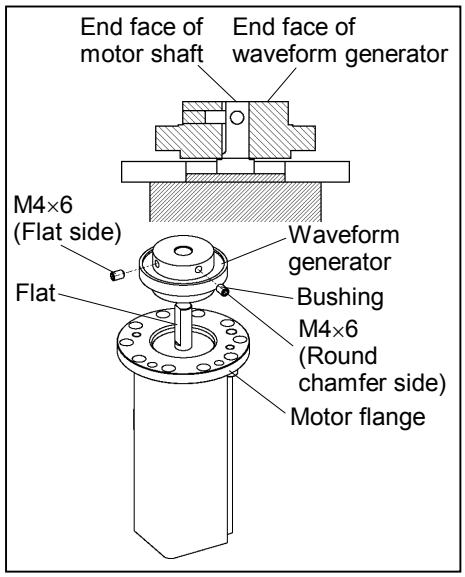
Be careful not to apply too much force since it may damage the parts.

(6) Apply grease (SK-2: Green) between the waveform generator and motor flange.

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*. (The grease for the Joint #2 reduction gear unit is different from that for the Joint #1 reduction gear unit.)

(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.

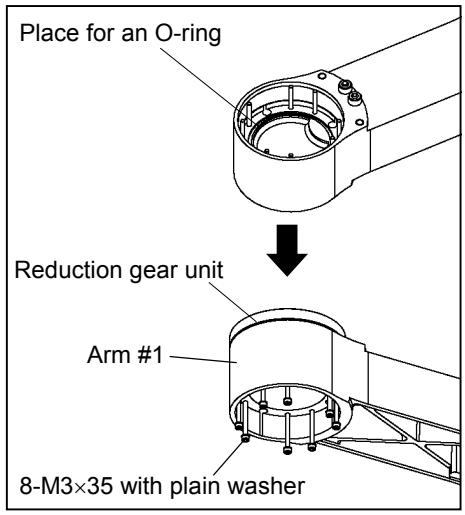


CAUTION

- 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 an O-ring on the joint area between Arm #1 and the Joint #2 reduction gear unit.

To do so, install an O-ring in the groove of the clamp face on the Arm #1 side as shown in the figure on the right.



(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.

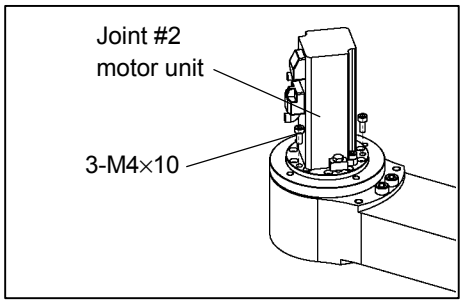
Tightening torque: 294 N·cm (30 kgf·cm)

(10) Apply grease (SK-2: Green) inside the flexspline.

For details on the grease quantity, refer to *Maintenance: 6.4 Greasing the Reduction Gear Units*. (The grease for the Joint #2 reduction gear unit is different from that for the Joint #1 reduction gear unit.)

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

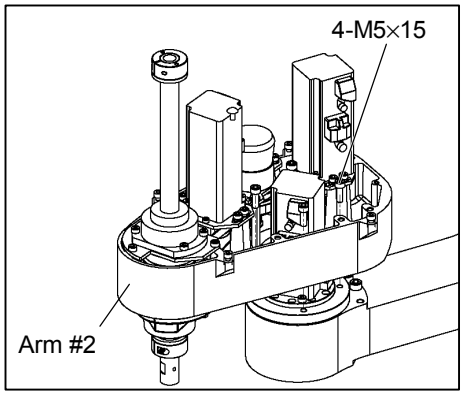
Make sure that the motor cables face toward the direction as shown in the figure on the right.



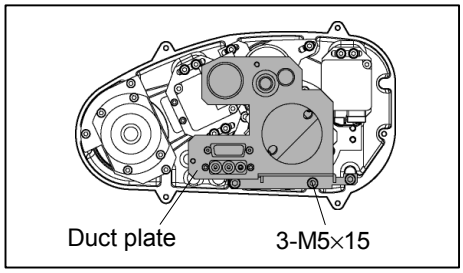
CAUTION	■ When removing or installing the arm, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting may result in fall of the arm, bodily injury, and/or malfunction of the robot system.

(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) Mount the duct plate on Arm #2.



(14) Connect the connectors X121 and X21.

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

Do not allow unnecessary strain on the cables.

(16) Install the arm top cover.

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

(17) Connect the power cable and signal cable to the base connector box (outside).

(18) Perform the calibration of Joint #2.

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

7. Replacing the Brake

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.

CAUTION	■ When removing the pulley from the brake, be sure to slide it out perpendicularly from the shaft. Removing the pulley horizontally from the shaft will damage the leaf spring and result in malfunction of the brake.

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, 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 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.

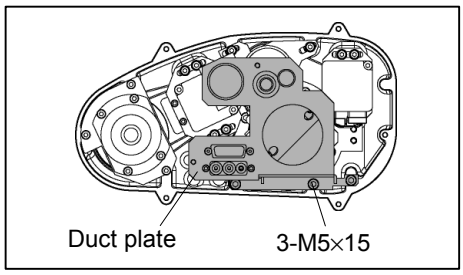
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.



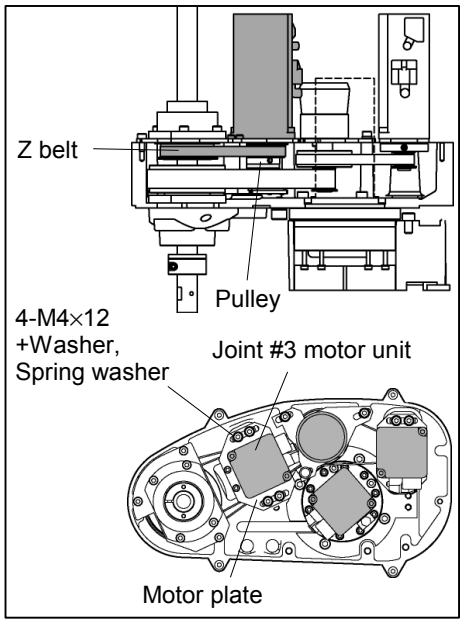
(4) Cut off the wire tie binding the motor cables to the Joint #3 motor.

(5) Disconnect the connectors X131, X31, and X32.

To disconnect the X131 connector, pull it out while pushing the projection next to the connector.

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

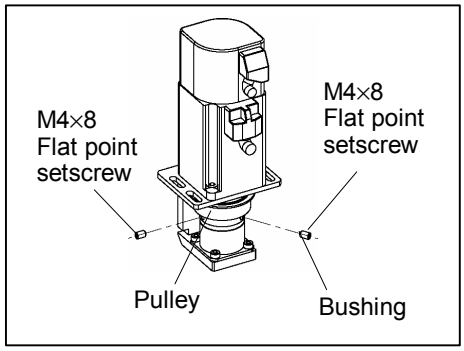
To do so, unscrew the bolts from the Joint #3 motor plate. Then, remove the Z belt from the pulley and pull it out upward.



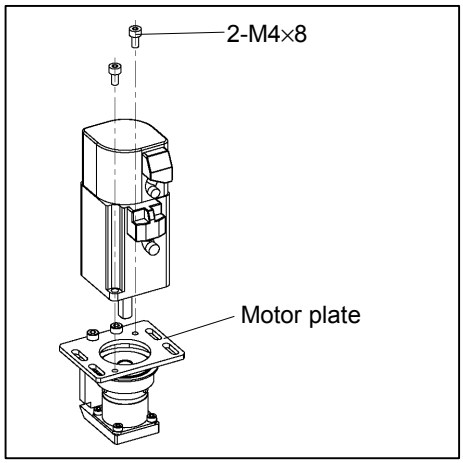
(7) Cut off the wire tie binding brake cables to the Joint #3 motor.

(8) Unscrew the setscrews from the pulley under the Joint #3 motor.

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



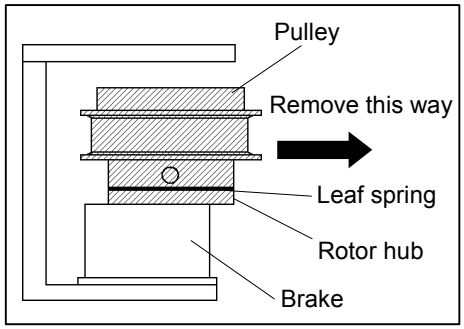
(9) Hold the motor plate and pulley, and then pull the Joint #3 motor upward to remove it.



(10) Remove the pulley from the brake.

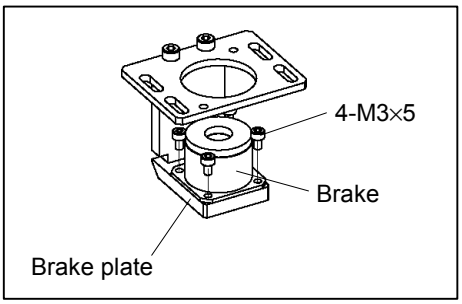
NOTE

The rotor hub is held to the brake by its magnet. When removing the pulley, slide it out perpendicularly from the shaft to prevent damage to the leaf spring on the rotor hub.

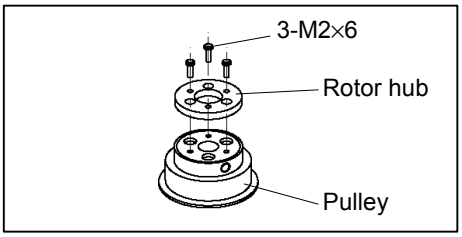


(11) Cut off the wire tie binding the brake cables to the brake plate.

(12) Remove the brake from the brake plate.

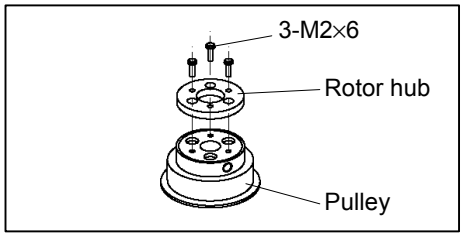


(13) Remove the rotor hub from the pulley.

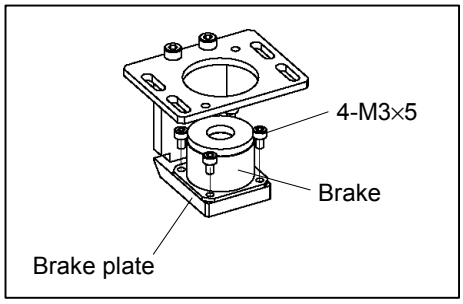


Installation

(1) Mount the rotor hub on the pulley.



(2) Mount the brake to the brake plate.

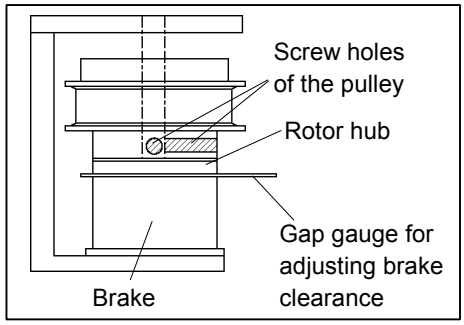


(3) Fasten the brake cables to the brake plate with a wire tie so that they do not touch the pulley.

(4) For the brake clearance adjustment, hold the gap gauge on the brake, and then mount the pulley over the gauge.

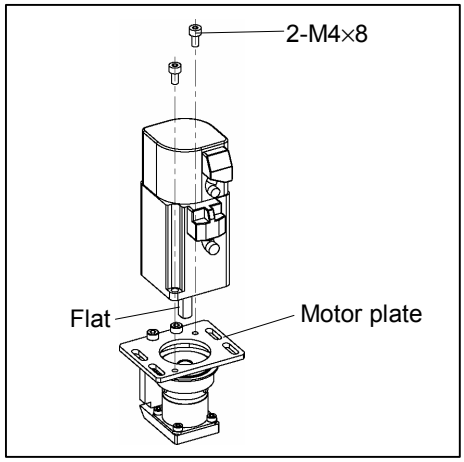
The screw hole of the pulley must be located in the position shown in the figure on the right.

The gap gauge (0.15 mm) is attached to the inside of the arm bottom cover for storage.



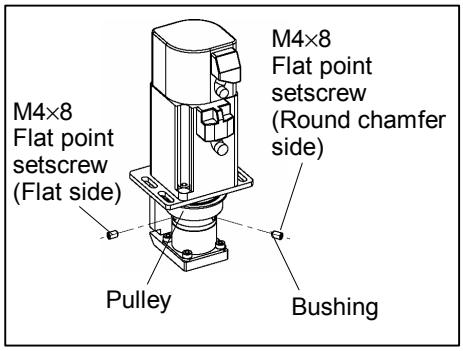
(5) Place the Joint #3 motor on the motor plate.

The motor cables of the Joint #3 motor and the flat face of the motor shaft must be oriented in the direction shown in the figure on the right.



(6) Secure the pulley to the motor shaft of the Joint #3 motor.

To do so, tighten one of the setscrews to 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.



(7) After the pulley is secured, pull out the gap gauge.

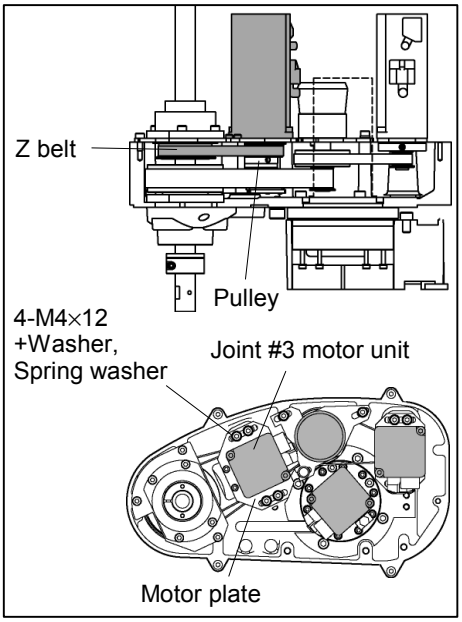
(8) Fasten the brake cables to the Joint #3 motor with a wire tie.

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

Make sure that the brake cables do not touch the pulley when installing the Joint #3 motor unit to Arm #2.

(10) Place the Z belt around the Z1 pulley and Z2 pulley.

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



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

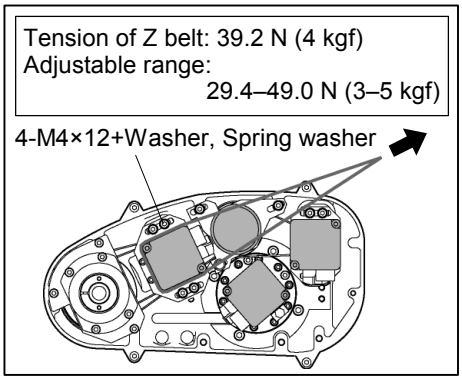
NOTE

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.

(12) 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.



(13) Mount the duct plate on Arm #2.

(14) Connect the connectors X131, X31 and X32.

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

Do not allow unnecessary strain on the cables.

(16) Install the arm top cover.

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

(17) Perform the calibration of Joint #3.

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

8. Replacing the Timing Belts

 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

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

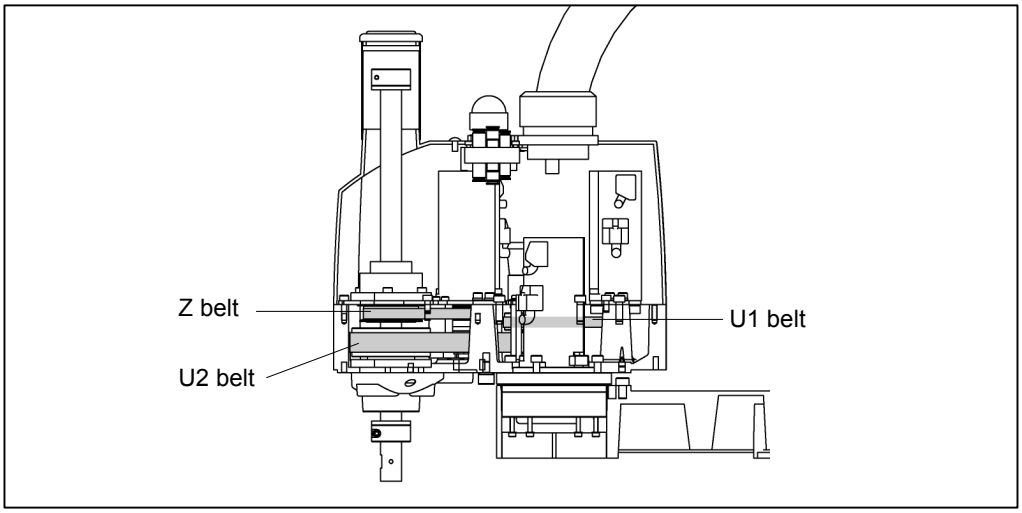
Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

8.1 Types of Timing Belts

The types of the timing belts used in the E2C 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, check the working joint and the timing belt. Then, specify the code from the table below.

Working Joint	Timing belt	Code	Note
#3	Z belt	R13ZA00322000	252-2GT-8 (cir: 252 mm)
#4	U1 belt	R13ZA00322100	224-2GT-8-T434N1 (cir: 224 mm)
	U2 belt	R13ZA00322200	366-2GT-15-T434N1 (cir: 366 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.

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.

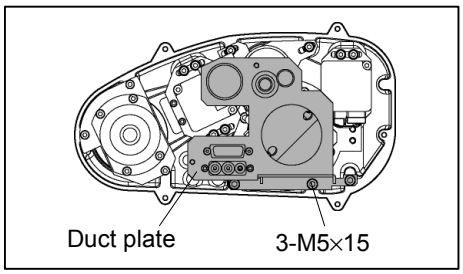
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.



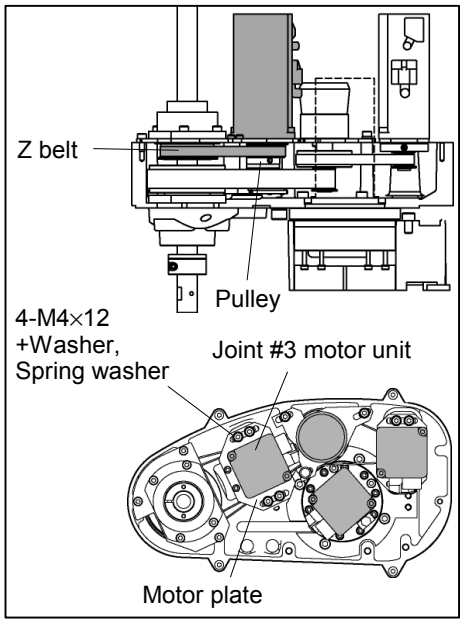
(4) Cut off the wire tie binding the motor cables to the Joint #3 motor.

(5) Disconnect the connectors X131, X31, and X32.

To disconnect the X131 connector, pull it out while pushing the projection next to the connector.

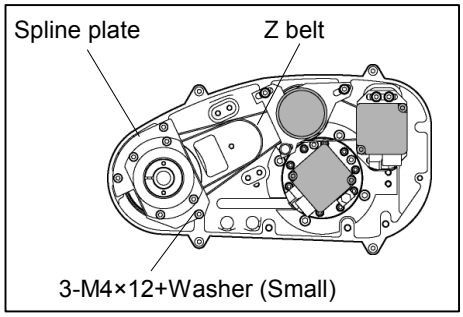
(6) Remove the Joint #3 motor unit from Arm #2.

To do so, unscrew the bolts from the Joint #3 motor plate. Then, remove the Z belt from the pulley and pull 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.

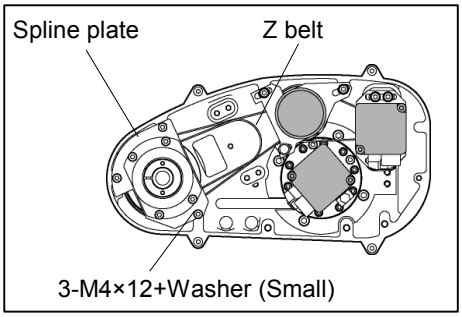


Installation

(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.

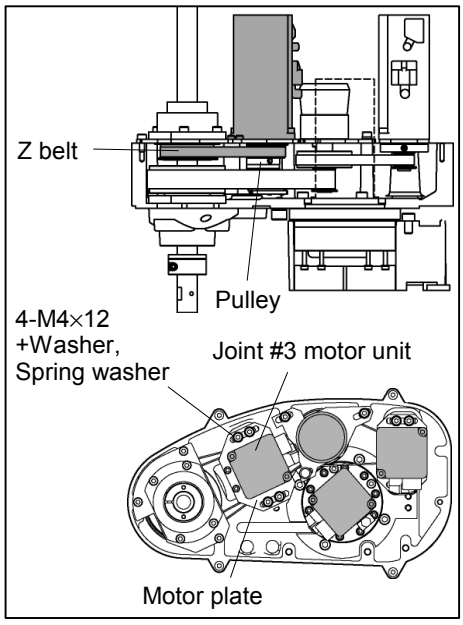
After moving the shaft up and down several times, secure the spline plate to Arm #2.



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

(4) Place the Z belt around the Z1 and Z2 pulleys.

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



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

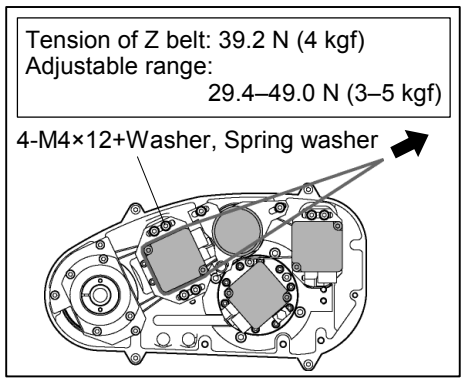
NOTE

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) Mount the duct plate on Arm #2.

(8) Connect the connectors X131, X31 and X32.

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

Do not allow unnecessary strain on the cables.

(10) Install the arm top cover.

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

(11) Perform the calibration of Joint #3.

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

8.4 Replacing the U1 Belt

NOTE 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:

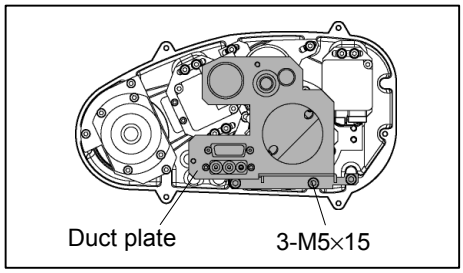
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.

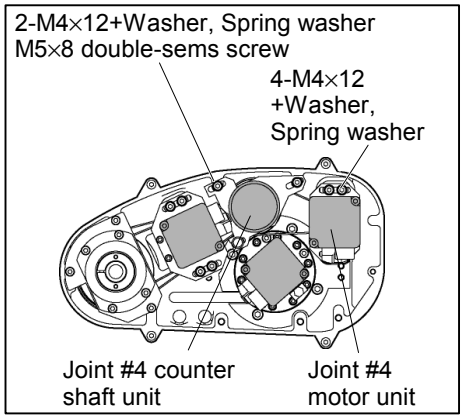


(4) Loosen the bolts securing the Joint #4 motor unit.

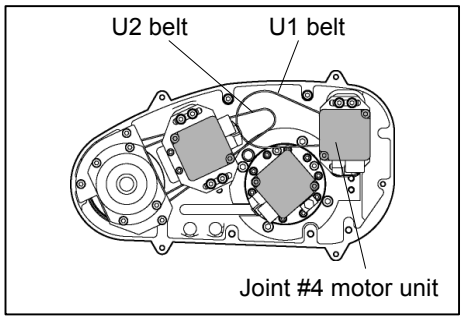
If there is a wire tie securing cables to the Joint #4 motor, cut off it.

(5) Remove the Joint #4 counter shaft unit.

To do so, unscrew the bolts securing the Joint #4 counter shaft unit.
Move the Joint #4 motor unit to the shaft side and remove the Joint #4 counter shaft unit from the U1 and U2 belts.



(6) Remove the U1 belt from the U1 pulley.

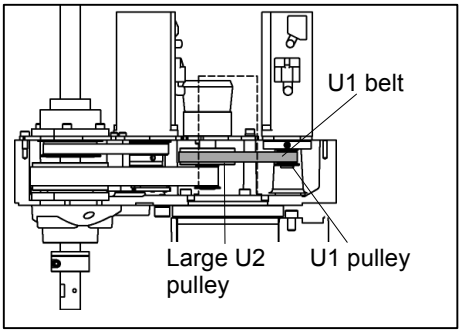


Installation

(1) Place the Joint #4 counter shaft unit back on Arm #2.

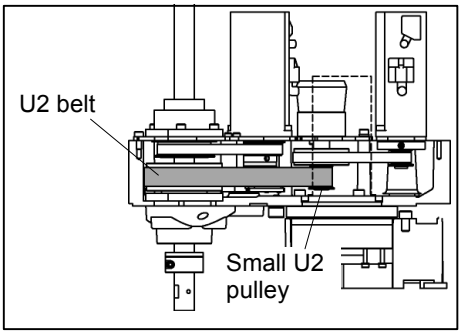
(2) Place a new U1 belt around the U1 and large U2 pulleys (upward).

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



(3) Place the U2 belt around the small U2 pulley (downward).

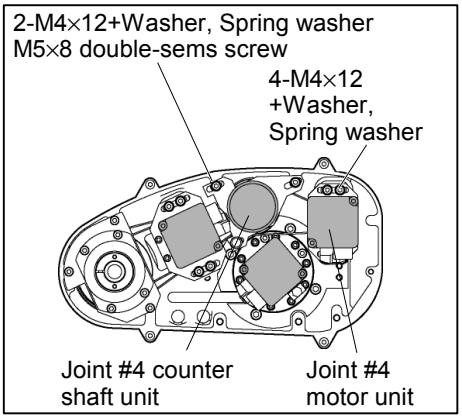
Make sure that the gear teeth of the belt mesh with the pulley completely.



(4) Loosely secure the Joint #4 counter shaft unit and motor unit to Arm #2 in the following order:

Joint #4 counter shaft unit
↓
Joint #4 motor unit

Be careful not to move the engagement between the gear teeth of the belt and the pulleys.

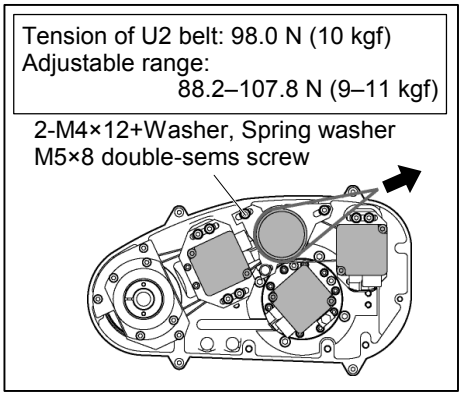


NOTE

Loosely secure the units to Arm #2 so that the motor units can be moved by hand, and they will not tilt when pulled. If the units are secured too loose or too tight, the belts will not have the proper tension.

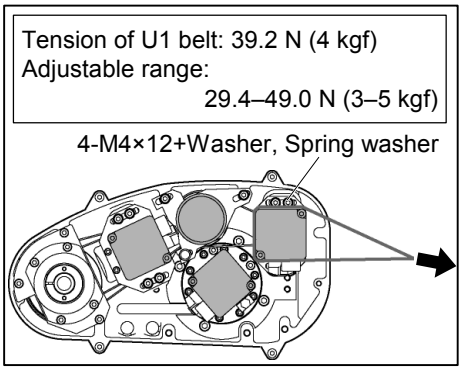
(5) Apply the proper tension to the U2 belt, and then secure the Joint #4 counter shaft unit.

To do so, pass a suitable cord or string around the Joint #4 counter shaft 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.



(6) Apply the proper tension to the U1 belt, and then secure the Joint #4 motor unit.

To do so, pass a suitable cord or string around the Joint #4 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.



(7) Mount the duct plate on Arm #2.

(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 Joints #3 and #4.

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

8.5 Replacing the U2 Belt

NOTE

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:

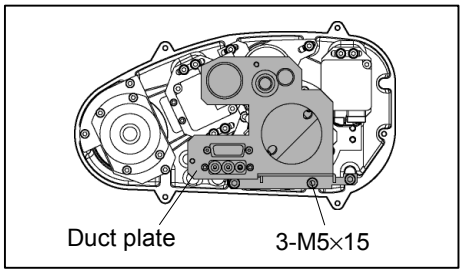
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.



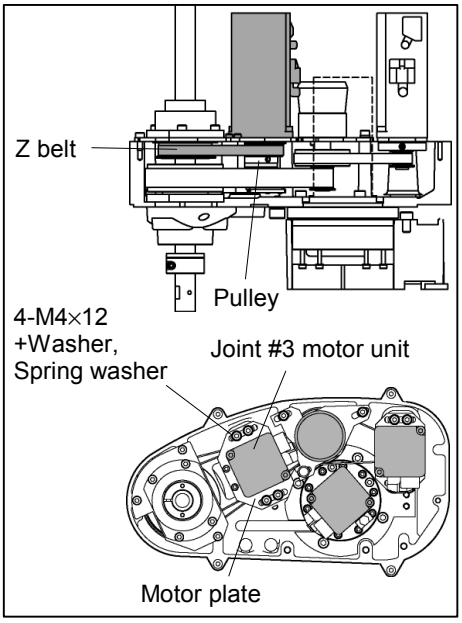
(4) Cut off the wire tie binding the motor cables to the Joint #3 motor.

(5) Disconnect the connectors X131, X31, and X32.

To disconnect the X131 connector, pull it out while pushing the projection next to the connector.

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

To do so, unscrew the bolts from the Joint #3 motor plate. Then, remove the Z belt from the pulley and pull the Joint #3 motor unit upward to remove it.

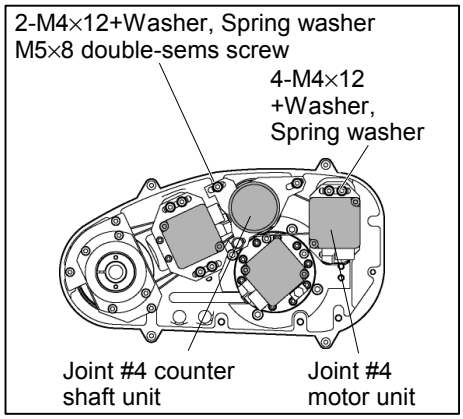


(7) Loosen the bolts securing the Joint #4 motor unit.

If there is a wire tie securing cables to the Joint #4 motor, cut off it.

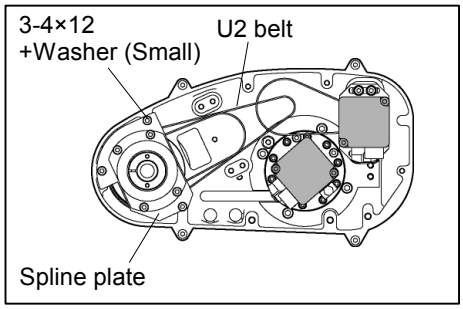
(8) Remove the Joint #4 counter shaft unit.

To do so, unscrew the bolts securing the Joint #4 counter shaft unit.
Move the Joint #4 motor unit to the shaft side and remove the Joint #4 counter shaft unit from the U1 and U2 belts.



(9) Remove the U2 belt.

To do so, unscrew the bolts securing the spline plate. Then, lift the spline plate and pull the U2 belt out of the shaft.

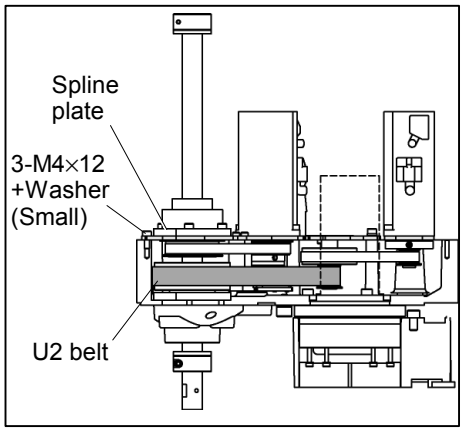


Installation

(1) Pass a new U2 belt through the shaft from above. Then, place it under the spline plate.

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

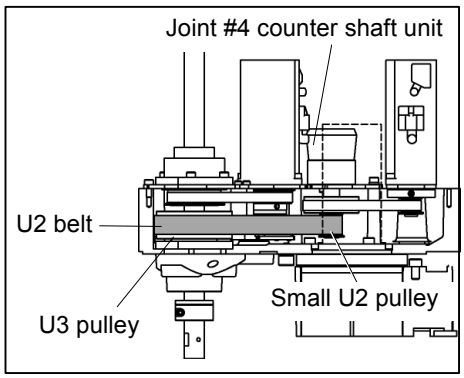
After moving the shaft up and down several times, secure the spline plate to Arm #2.



(3) Place the Joint #4 counter shaft unit back on Arm #2.

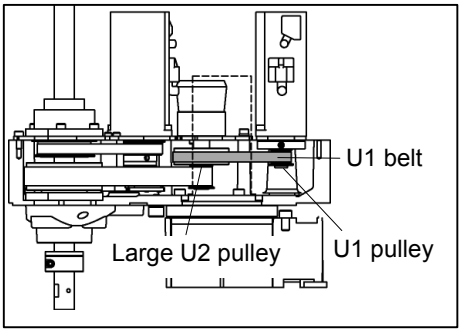
(4) Place the U2 belt around the U3 and small U2 pulleys.

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



(5) Place the U1 belt around the U1 and large U2 pulleys.

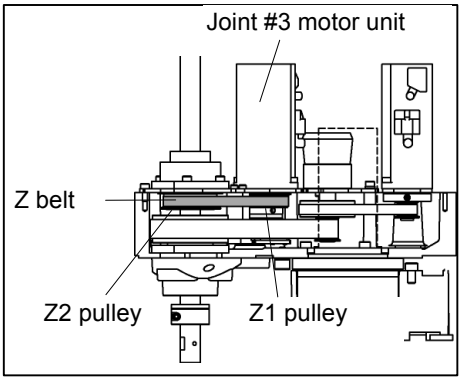
Make sure that the gear teeth of the belt mesh with the pulleys completely.



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

(7) Place the Z belt around the Z1 and Z2 pulleys.

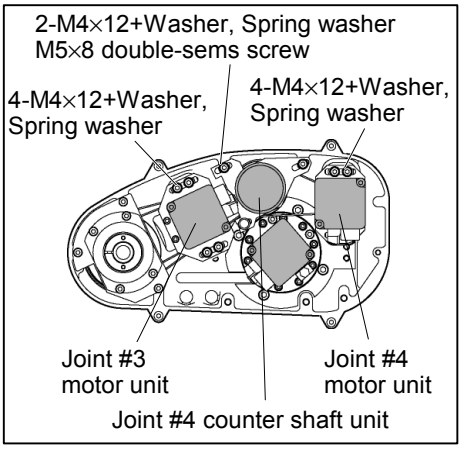
Make sure that the gear teeth of the belt mesh with the pulleys completely.



(8) Loosely secure the Joint #3 motor unit, Joint #4 counter shaft unit, and Joint #4 motor unit to Arm #2 in the following order:

Joint #3 motor unit
↓
Joint #4 counter shaft unit
↓
Joint #4 motor unit

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

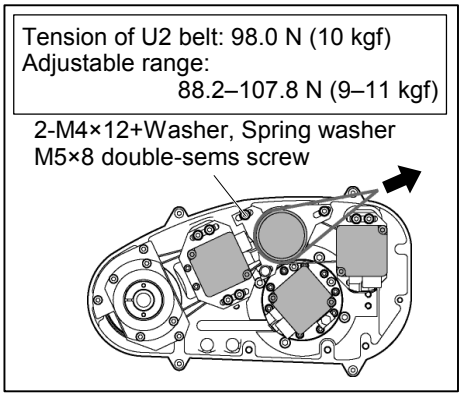


NOTE

Loosely secure the units to Arm #2 so that the motor units can be moved by hand, and they will not tilt when pulled. If the units are secured too loose or too tight, the belts will not have the proper tension.

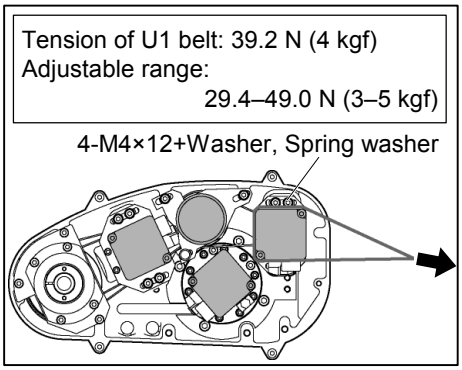
(9) Apply the proper tension to the U2 belt, and then secure the Joint #4 counter shaft unit.

To do so, pass a suitable cord or string around the Joint #4 counter shaft 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.



(10) Apply the proper tension to the U1 belt, and then secure the Joint #4 motor unit.

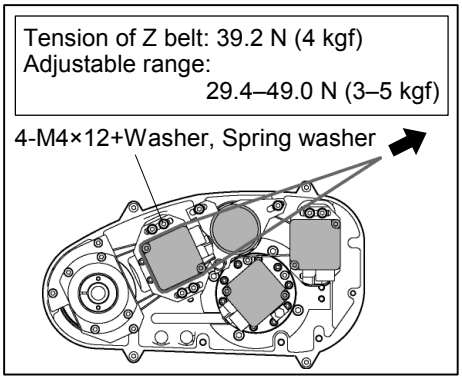
To do so, pass a suitable cord or string around the Joint #4 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



(11) 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.



(12) Mount the duct plate on Arm #2.

(13) Connect the connectors X131, X31 and X32.

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

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

9. Replacing the Bellows (C, CM Types)

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.

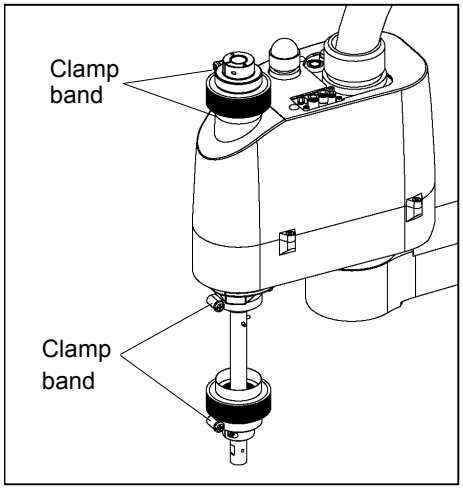
Removal

(1) Detach the wires/tubes from the end effector, and remove the end effector.

(2) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)

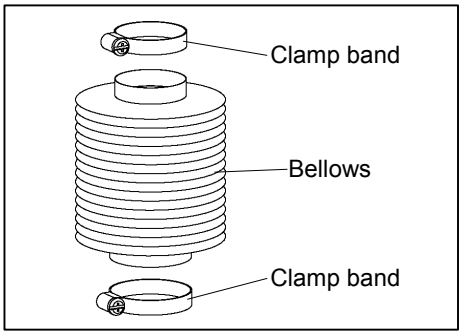
(3) Loosen the two clamp bands on each bellows.

(4) Pull the bellows, bearing cases (blue), and clamp bands out of the shaft.



Installation

(1) Attaching the bearing cases (blue) and clamp bands to each new bellows.



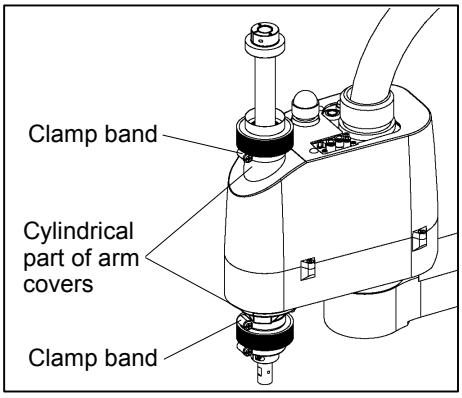
The bellows has two joints:
The larger joint must be attached to the cover side.
The smaller joint must be attached to the end face side of the shaft.
Be careful not to misplace the clamp bands and bearing cases.

(2) Pass the bellows through the shaft 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.

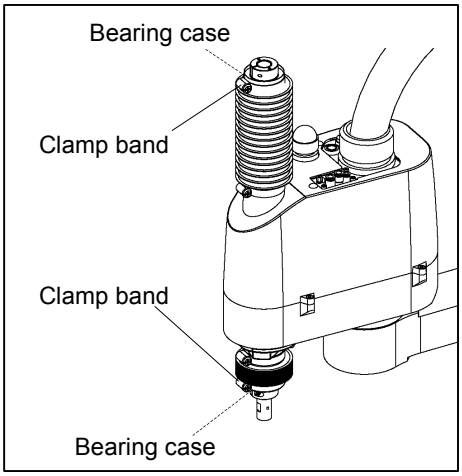
To move the shaft up/down, press and hold the Joint #3 brake release button.

(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 covers by 10 mm or more, and then fasten them with clamp bands.
The screw on each clamp band must be oriented toward the end of the arm.

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



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

The screw on each clamp band must be oriented toward the end of the arm.

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

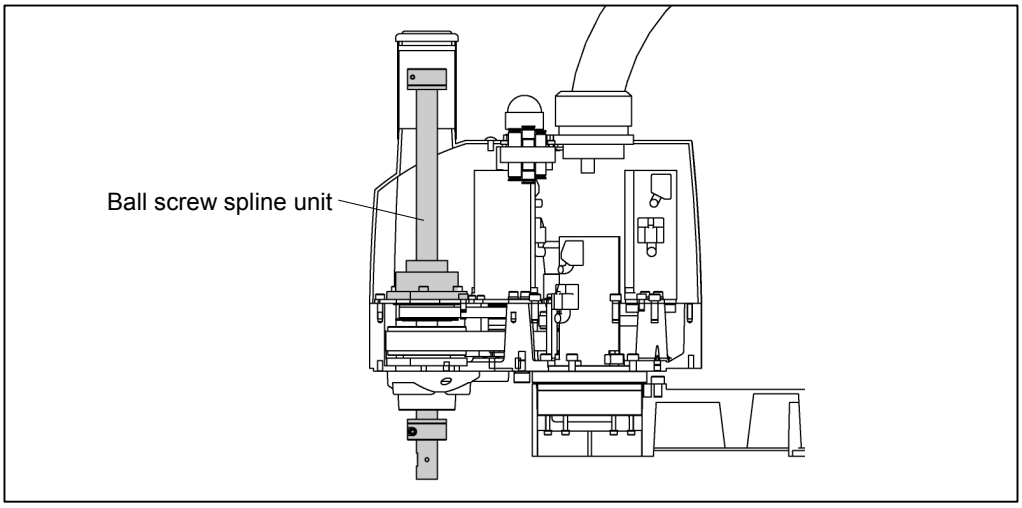
Refer to *Maintenance: 14. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

10.1 Type of Ball Screw Spline Unit

The type of the ball screw spline unit used in the E2C series Manipulators is 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
E2C**1S E2C351SM	120 mm	Ball screw spline unit for Z120	R13ZA00121000	BNS1616AE-315LC5
E2C**1C E2C351CM	100 mm	Cleanroom-model: Ball screw spline unit for Z100	R13ZA00121300	BNS1616AE-315LC5/CL

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.

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 the end effector.

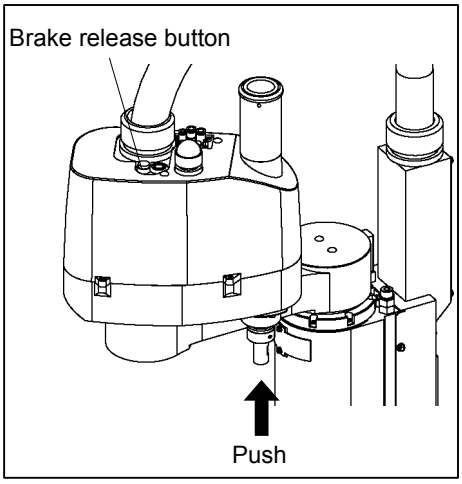
10.3.1 S, SM Type Manipulators

Cover the surrounding 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 pushing the Joint #3 brake release button.



(4) Turn OFF the Controller.

(5) Remove the arm top cover and lift it. (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 pushing the Joint #3 brake release button.

(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 pushing the Joint #3 brake release button 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 C, CM Type Manipulators

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 or CM 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 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)

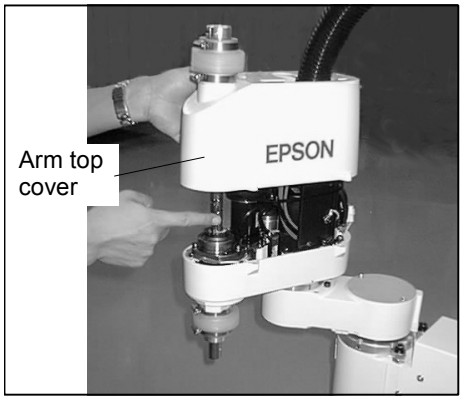
(2) Move the arm to a position where Joint #3 can be moved in full stroke.

(3) Move the shaft to its upper limit manually while pushing the Joint #3 brake release button.

(4) Turn OFF the Controller.

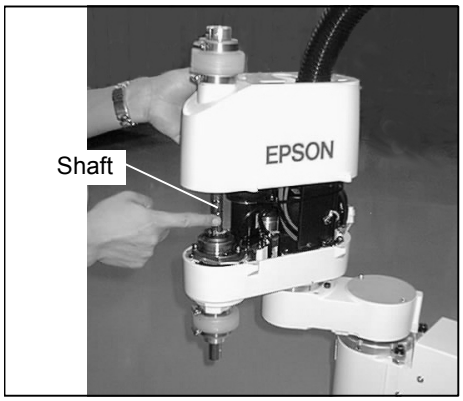
(5) Remove the arm top cover and lift it.

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.

Directly fill the grooves on the shaft inside the bellows with grease by hand.
Wipe off excess grease from the shaft.

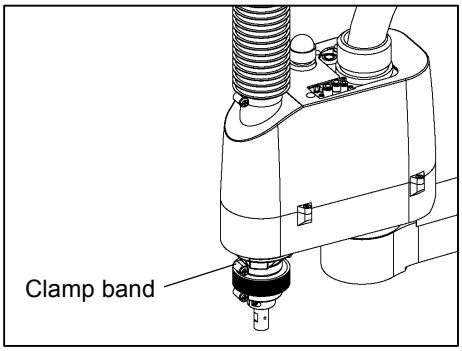


(7) Install the arm top cover.

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

Lower Part of the Shaft

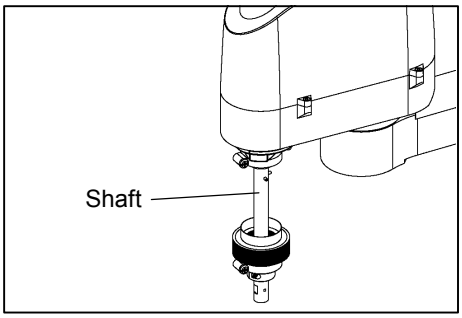
(8) Loosen the clamp band on the bellows, and then move the bellows downward.



(9) Turn ON the Controller.

(10) Move the shaft to its lower limit manually while pushing the Joint #3 brake release button.

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

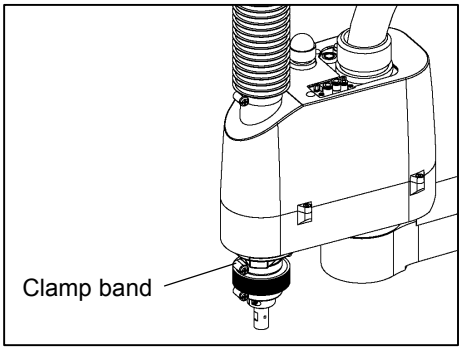


Directly fill the grooves on the shaft inside the bellows with grease by hand.
Wipe off excess grease from the shaft.

(12) Move the shaft up and down several times while pushing the Joint #3 brake release button to smooth out the grease on the shaft. Wipe off excess grease from the shaft.

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

(13) 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.

The screw on each clamp band must be oriented toward the end of the arm.

When mounting the lower bellows, move the shaft up to its upper limit.

To move the shaft up/down, push and hold the Joint #3 brake release button.

10.4 Replacing the Ball Screw Spline Unit

Removal

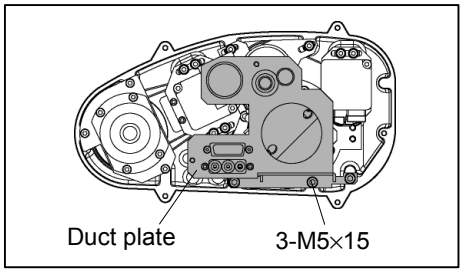
(1) Detach the wires/tubes from the end effector, and remove the end effector and bellows.

(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) Cut off the wire tie binding the duct plate, motor, and cables together.

(4) Remove the duct plate.



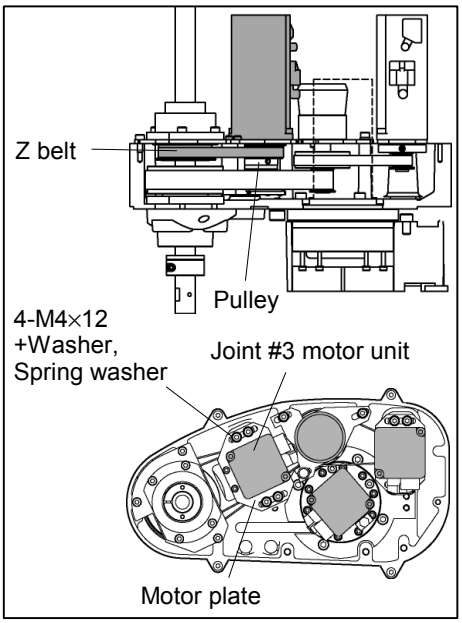
(5) Cut off the wire tie binding the motor cables to the Joint #3 motor.

(6) Disconnect the connectors X131, X31, and X32.

To disconnect the X131 connector, pull it out while pushing the projection next to the connector.

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

To do so, unscrew the bolts from the Joint #3 motor plate. Then, remove the Z belt from the pulley and pull the Joint #3 motor unit upward to remove it.

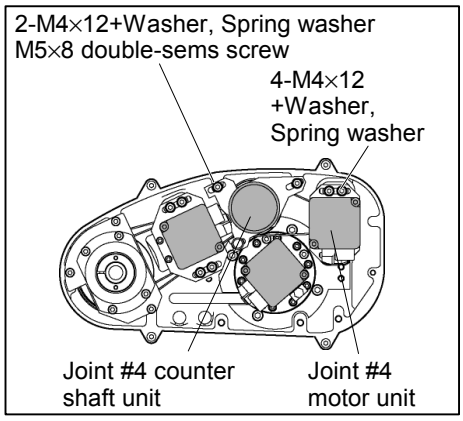


(8) Loosen the bolts securing the Joint #4 motor unit.

If there is a wire tie securing cables to the Joint #4 motor, cut off it.

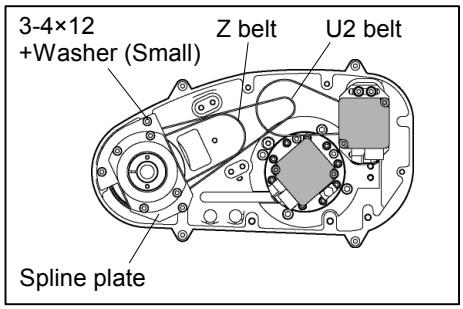
(9) Remove the Joint #4 counter shaft unit.

To do so, unscrew the bolts securing the Joint #4 counter shaft unit.
Move the Joint #4 motor unit to the shaft side and remove the Joint #4 counter shaft unit from the U1 and U2 belts.

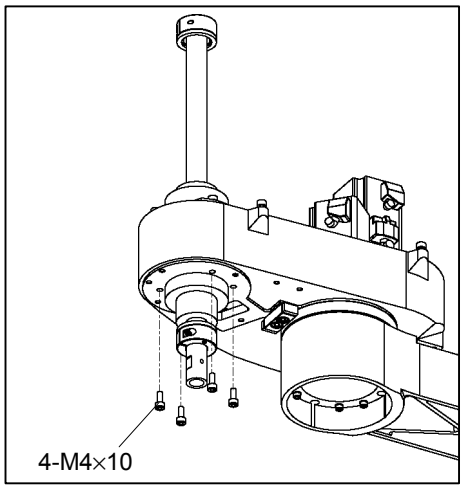


(10) Remove both the U2 and Z belts.

To do so, unscrew the bolts from the spline plate. Then, lift the spline plate and pull the belts upward.



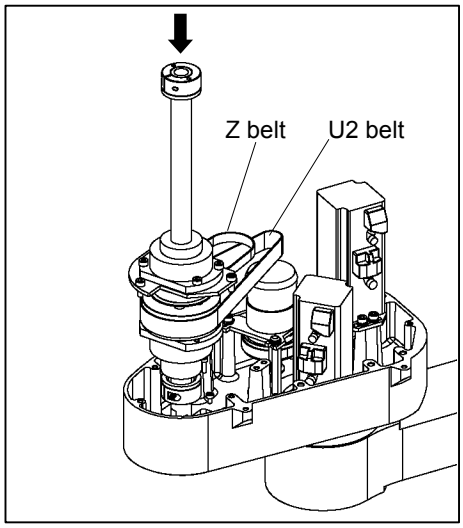
(11) Remove the screws for the ball screw spline shaft from the bottom of Arm #2.



(12) Pull the ball screw spline unit out of Arm #2.

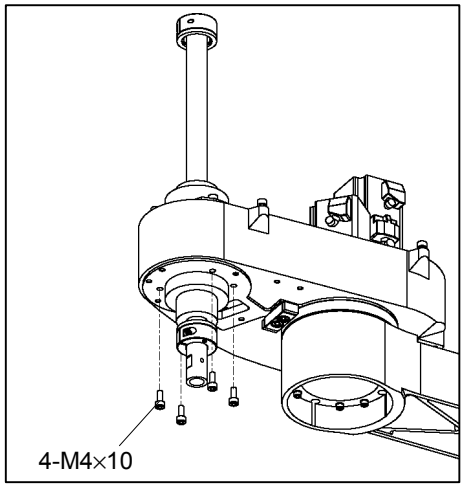
Installation

(1) Fit the U2 and Z belts onto the shaft, and then place the ball screw spline unit into the Arm #2.



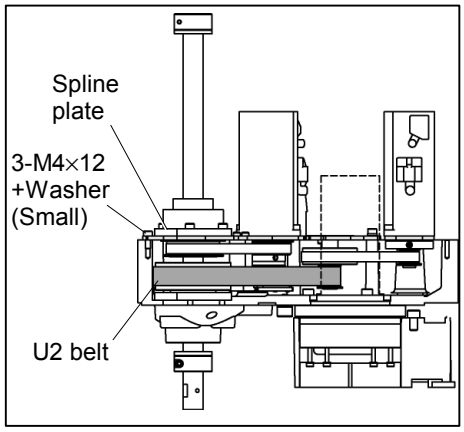
(2) Tighten the screws for the ball screw spline shaft to the bottom of Arm #2.

Be careful not to allow the timing belt pinched between the nut and Arm #2.



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

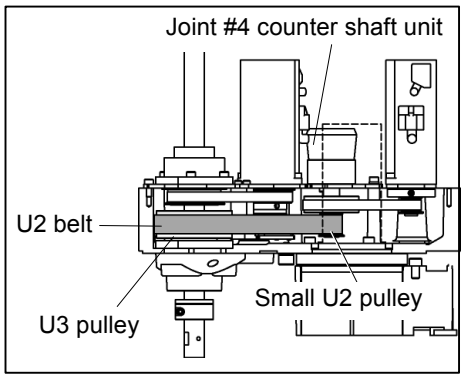
After moving the shaft up and down several times, secure the spline plate to Arm #2.



(4) Place the Joint #4 counter shaft unit back on Arm #2.

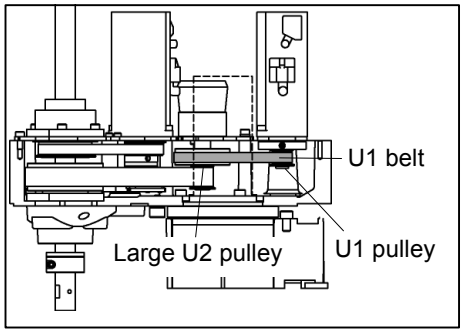
(5) Place the U2 belt around the U3 and small U2 pulleys (downward).

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



(6) Place the U1 belt around the U1 and large U2 pulleys (upward).

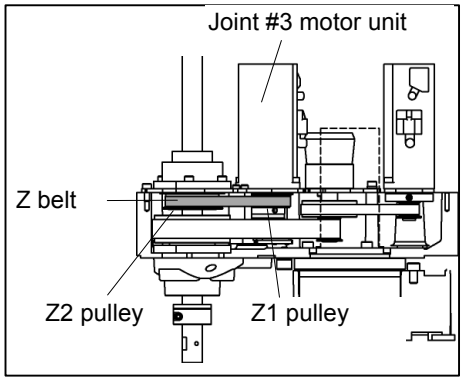
Make sure that the gear teeth of the belt mesh with the pulleys completely.



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

(8) Place the Z belt around the Z1 and Z2 pulleys.

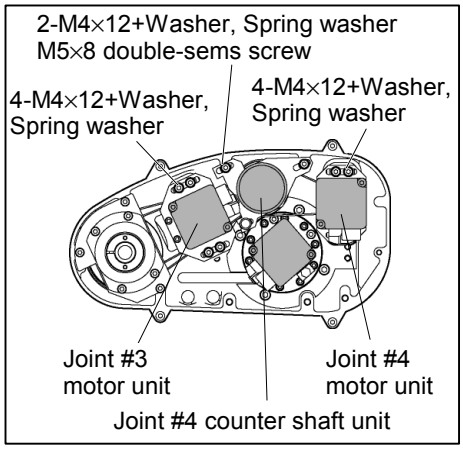
Make sure that the gear teeth of the belt mesh with the pulleys completely.



(9) Loosely secure the Joint #3 motor unit, Joint #4 counter shaft unit, and Joint #4 motor unit to Arm #2 in the following order:

Joint #3 motor unit
↓
Joint #4 counter shaft unit
↓
Joint #4 motor unit

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

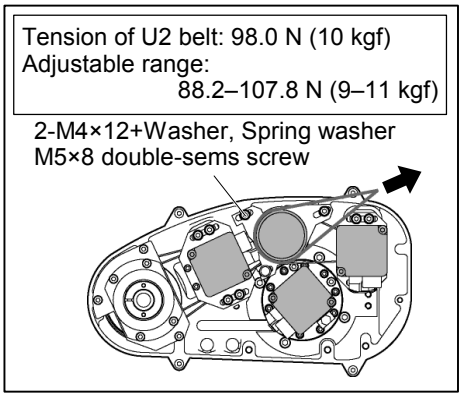


NOTE

Loosely secure the units to Arm #2 so that the motor units can be moved by hand, and they will not tilt when pulled. If the units are secured too loose or too tight, the belts will not have the proper tension.

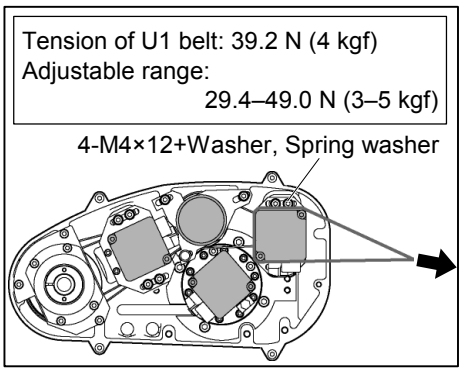
(10) Apply the proper tension to the U2 belt, and then secure the Joint #4 counter shaft unit.

To do so, pass a suitable cord or string around the Joint #4 counter shaft 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.



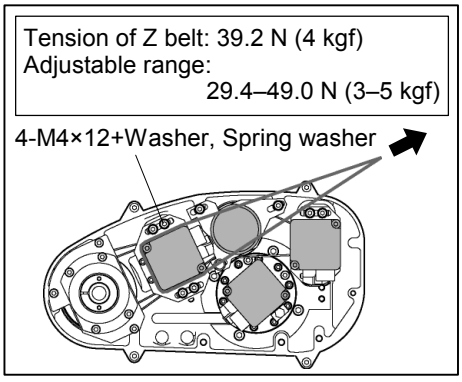
(11) Apply the proper tension to the U1 belt, and then secure the Joint #4 motor unit.

To do so, pass a suitable cord or string around the Joint #4 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.



(12) 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.



(13) Mount the duct plate on Arm #2.

(14) Connect the connectors X131, X31 and X32.

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

Do not allow unnecessary strain on the cables.

(16) 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.

(17) Install the arm top cover and arm bottom cover.

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

(18) Grease the shaft.

For details on the greasing method, refer to *Maintenance: 10.3. Greasing the Ball Screw Spline Unit*.

(19) Turn OFF the Controller and peripheral equipment. Install the end effector and bellows, and connect wires and tubes to the end effector.

(20) 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

 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.

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 keeps the position data.
The super-capacitor is mounted on each motor. The charged motors can keep the 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 the 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

The replacement procedure for the signal relay board varies with the Manipulator used.

11.2.1 S, C Type Manipulators

Removal

(1) Disconnect all the connectors and tubes from the base connector box (outside).

(2) Remove the base connector box.

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

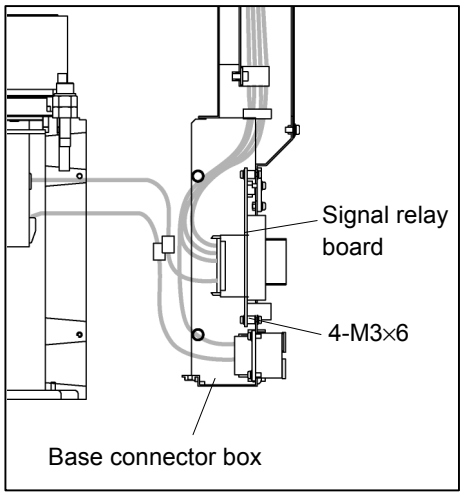
(3) Disconnect the connectors (X10, X20, X30, X40, X50, and X4) from the signal relay board.

To do so, open up the top and bottom clips of the connectors.

NOTE Connect motors and the signal relay board with a new cable unit within 2 hours after the connectors are removed. When 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 the calibration will be required again.

(4) Remove the signal relay board from the base connector box.

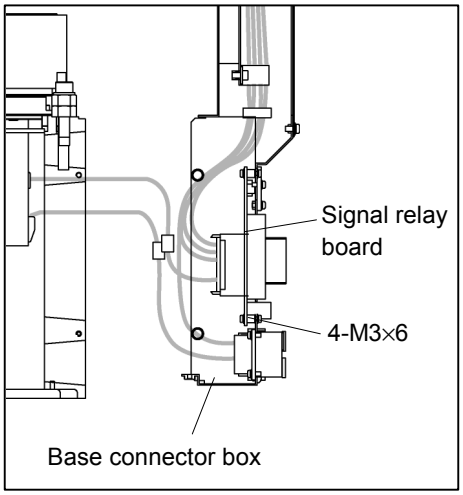
The signal relay board is secured from the outside of the base connector box.



Installation

(1) Install a new signal relay board to the base connector box.

Secure the board from the outside of the box.



(2) Connect the connectors (X10, X20, X30, X40, X50, and X4) to the signal relay board.

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.

(3) Install the base connector box.

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

(4) Connect the connectors and tubes to the base connector box (outside).

(5) Turn ON the Controller.

(6) Check if the Manipulator moves to points (pose) correctly.

To do so, select 2 points (pose) or more from the registered points (pose) and move the Manipulator to the points (pose).

(7) If the Manipulator does not move to the points (pose) correctly, perform the calibration of all joints and axes.

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

11.2.2 SM, CM Type Manipulators

Removal

(1) Disconnect all the connectors and tubes from the base connector box (outside).

(2) Remove the base connector box.

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

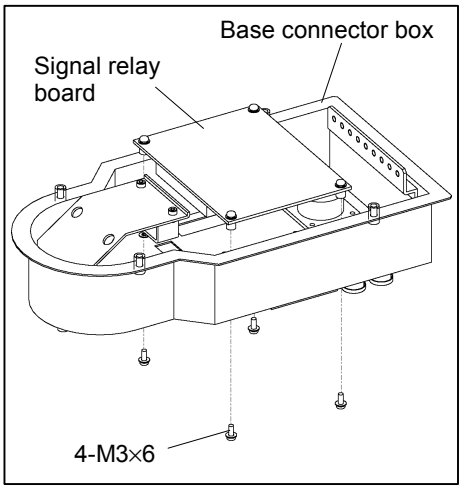
(3) Disconnect the connectors (X10, X20, X30, X40, X50, and X4) from the signal relay board.

To do so, open up the top and bottom clips of the connectors.

NOTE Connect motors and the signal relay board with a new cable unit within 2 hours after the connectors are removed. When 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 the calibration will be required again.

(4) Remove the signal relay board from the base connector box.

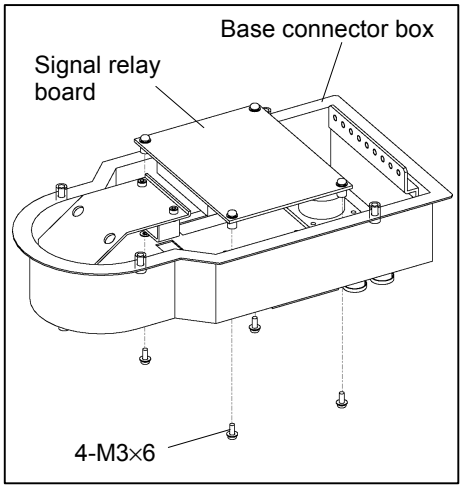
The signal relay board is secured from the outside of the base connector box.



Installation

(1) Install a new signal relay board to the base connector box.

Secure the board from the outside of the box.



(2) Connect the connectors (X10, X20, X30, X40, X50, and X4) to the signal relay board.

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.

(3) Install the base connector box.

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

(4) Connect the connectors and tubes to the base connector box (outside).

(5) Turn ON the Controller.

(6) Check if the Manipulator moves to the points (pose) correctly.

To do so, select 2 points (pose) or more from the registered points (pose) and move the Manipulator to the points (pose).

(7) If the Manipulator does not move to the points (pose) 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

 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.

 CAUTION	■ 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. <Improper Handling> ・Battery Charge ・Deformation by Pressure ・Disassembly ・Short-circuit (Polarity; Positive/Negative) ・Mis-loading ・Heating (100 degrees or more) ・Throwing into Fire ・Soldering (the terminal of the lithium battery directly) ・Enforced Discharge

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 calibrated all over 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-capacitor that keeps the position data.
The super-capacitor is mounted on each motor. The charged motors can keep the 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 the 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.

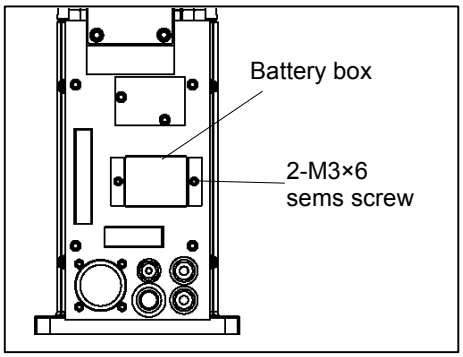
If the error occurs, perform the calibration of all joints and axes. For details on the calibration method, refer to *Maintenance: 14. Calibration*.

12.2 How to Replace the Lithium Battery

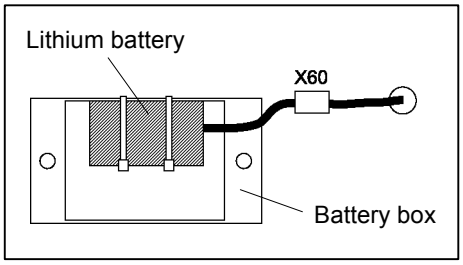
Removal

(1) Disconnect all the connectors and tubes from the base connector box (outside).

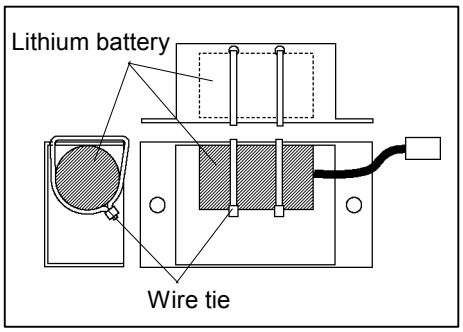
(2) Remove the battery box from the base connector box.



(3) Disconnect the X60 connector from the lithium battery.



(4) Cut off the wire ties securing the lithium battery, and then remove the lithium battery.

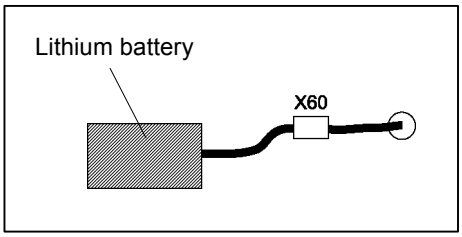


Installation

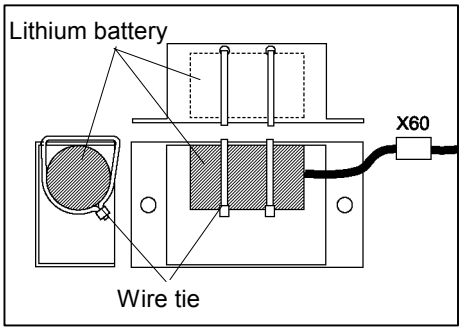
NOTE

Be sure to use the specified “battery unit for signal relay board (Code: R13ZA00600300)”.
Observe polarity (positive/negative) when connecting the lithium battery.

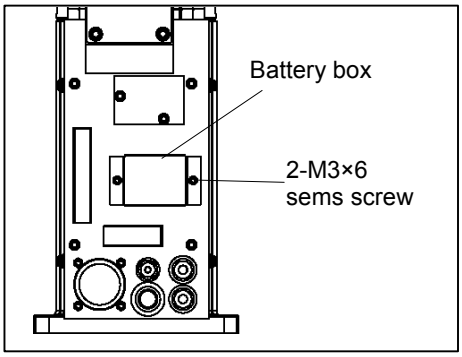
(1) Connect the X60 connector to the new lithium battery.



(2) Secure the lithium battery to the battery box.



(3) Mount the battery box on the base connector box.



(4) Connect the connectors and tubes to the base connector box (outside).

(5) Turn ON the Controller.

(6) Check if the Manipulator moves to points (pose) correctly.

To do so, select 2 points (pose) or more from the registered points (pose) and move the Manipulator to the points (pose).

(7) If the Manipulator does not move to the points (pose) 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

 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.

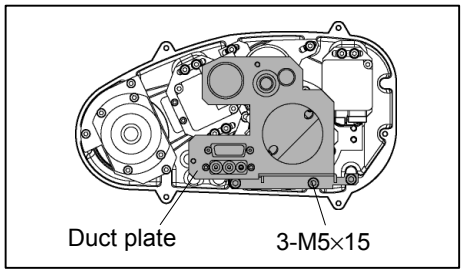
Removal

(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 binding the duct plate, motor, and cables together.

(3) Remove the duct plate.



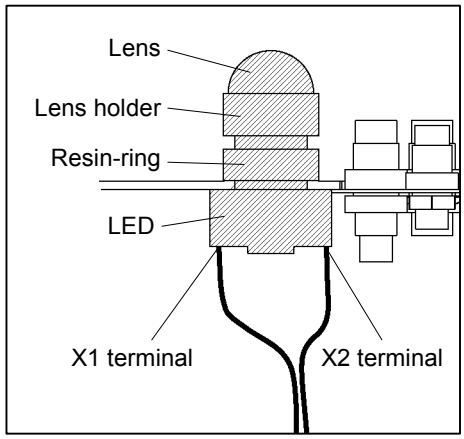
(4) Remove the lens and lens holder.

To remove, turn them right

(5) Remove the LED from the duct plate.

To remove, hold the LED and turn the resin-ring.

(6) Disconnect the X1 and X2 terminals from the LED.



Installation

(1) Connect the X1 and X2 terminals to the LED.

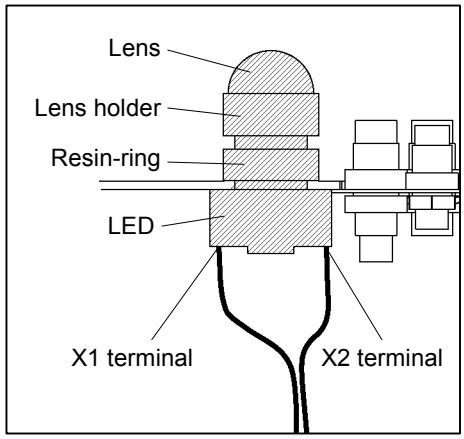
Each terminal must be connected to its terminal number on the LED.

(2) Mount the LED on the duct plate.

To mount, hold the LED and turn the resin-ring.

(3) Install the lens and lens holder to the LED.

Be sure to place the lens on the lens holder.



(4) Mount the duct plate on Arm #2.

(5) Rebind the duct plate, motor, and cables together with a wire tie.

(6) 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.



WARNING

- 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.
- 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.

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

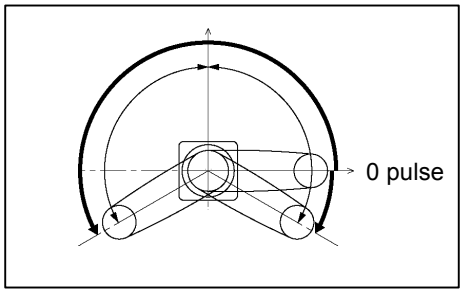
EPSON RC+ : "Encoder alarm has occurred. Check robot battery. EPSON RC+ must be restarted." is displayed

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.)

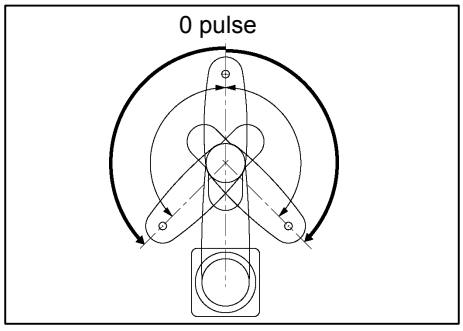
If the error does not occur, go to the next step (3) below.

(3) Manually move the joint that needs origin alignment to its approximate 0 pulse position.

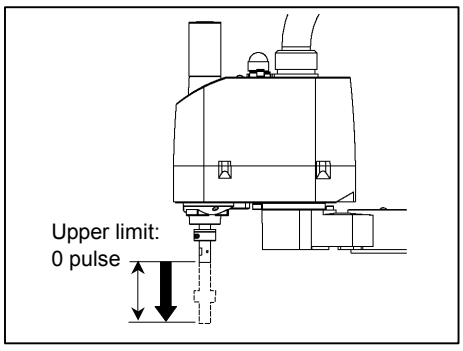
0 pulse position of Joint #1:
position aligned with X-axis in Manipulator coordinate system



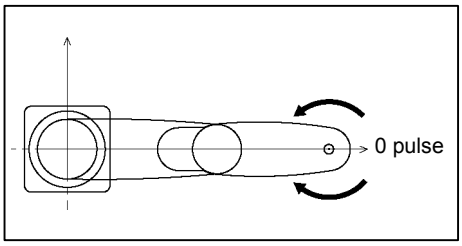
0 pulse position of Joint #2:
position where Arms #1 and #2 are in a straight line
(Regardless of the Joint #1 direction)



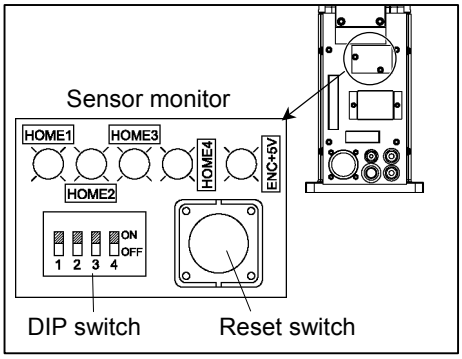
0 pulse position of Joint #3:
upper limit position in motion range



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.

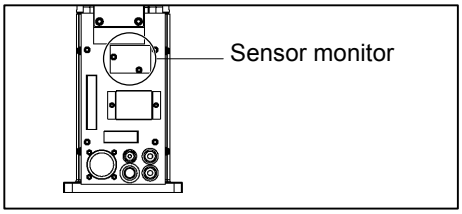


(5) Set the DIP switch corresponding to the joint that needs origin alignment to its ON position. For Joint #4, place both "3" and "4" in their ON positions.

(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.

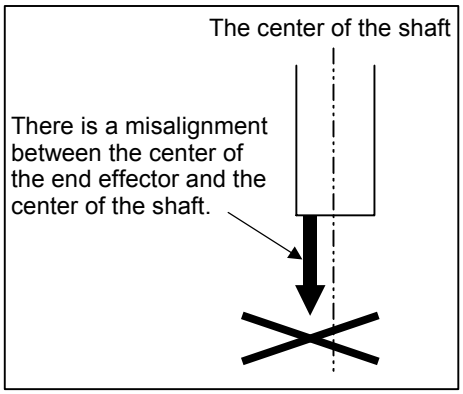
14.3 Accurate Calibration of Joint #2

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.

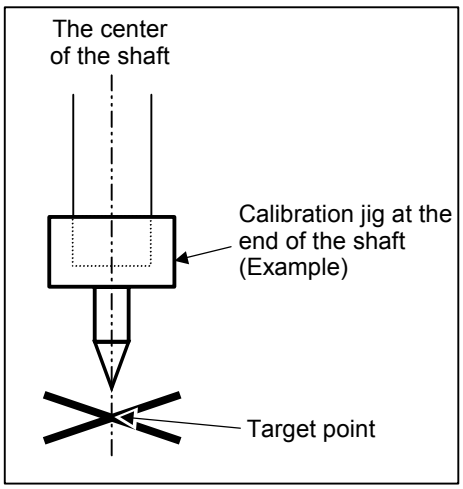
The reference point is the center of the ball screw spline shaft during this calibration.

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 (×) 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 liner 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	R13A000600500	SGM-150 W See “NOTE” below.
	Joint #2, 3, 4	R13A000600300	SGM-150 W See “NOTE” below.
Reduction gear unit	Joint #1	R13ZA00101000	SHF-20-80 ♦
	Joint #2	R13ZA00101100	SHF-17-50 ♦
Cable unit	E2C251S E2C251C E2C351SM E2C351CM	R13A020000300	
	E2C351S E2C351C	R13A020000400	
Brake	Joint #3	R13ZA00350100	ERS-135L ♦
Brake release button	Joint #3	R13Z702640100	AB2M-M1W ♦
Power cable		R13ZA00200200	3 m (standard) ♦
Signal cable		R13ZA00200300	3 m (standard) ♦
Timing Belts	Z belt	R13ZA00322000	252-2GT-8 ♦
	U1 belt	R13ZA00322100	224-2GT-8-T434N1 ♦
	U2 belt	R13ZA00322200	366-2GT-15-T434N1 ♦
Grease	for Ball screw spline shaft	R13ZA00330200	AFB grease (400 g) ♦
	for Joint #1 reduction gear unit	R13ZA00330100	SK-1A (500 g) ♦
	for Joint #2 reduction gear unit	R13ZA00330400	SK-2 (500 g) ♦
Signal relay board		R13ZA00450400	SKP337-1 ♦
Battery unit for signal relay board		R13ZA00600300	Lithium battery (Battery unit) ♦
O-ring (for Reduction gear unit)	for SHF-17	R13A030700100	Joint #2 ♦
	for SHF-20	R13A030700200	Joint #1 ♦
O-ring (for the prevention of grease leakage)	O-ring 17	R13A031200600	
	O-ring 20	R13A031200700	Only for E2C351*M (Multiple Mountings)
LED lamp		R13A030000200	
Oil seal		R13A031200100	SEAL_20

♦: common to E series

NOTE: Apply motor driver module for 200 W to joint #1, 2, 3, and motor driver module for 100 W to joint #4. For codes of the motor driver modules, refer to the *Maintenance Parts List* of the *Controller manual*.

15.2 S, SM Type Manipulators

Part Name		Code	Note
Ball screw spline unit		R13ZA00121000	BNS1616AE-315LC5 for 120 mm stroke ♦
Arm cover with shaft cover (Only for -UL type)	E2C*51S-UL E2C351SM-UL	R13A030400400	for 120 mm stroke

♦: common to E series

15.3 C, CM Type Manipulators

Part Name	Code	Note
Ball screw spline unit	R13ZA00121300	BNS1616AE-315LC5/CL for 100 mm stroke ♦
Bellows (Round-type)	R13A030700500	ø62 – ø34 × st.100 (2 bellows)

♦: common to E series

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