

EPSON

SCARA ROBOT

RS series

MANIPULATOR MANUAL

Rev.18

EM208R4503F

MANIPULATOR MANUAL

RS series

Rev.18

SCARA ROBOT

RS series Manipulator Manual

Rev.18

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 contact the supplier of your region 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.

TRADEMARKS

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NOTICE

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

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

MANUFACTURER

SEIKO EPSON CORPORATION

CONTACT INFORMATION

Contact information is described in “SUPPLIERS” in the first pages of the following manual:

Robot System Safety and Installation Read this manual first

Regarding battery disposal



The crossed out wheeled bin label that can be found on your product indicates that this product and incorporated batteries should not be disposed of via the normal household waste stream. To prevent possible harm to the environment or human health please separate this product and its batteries from other waste streams to ensure that it can be recycled in an environmentally sound manner. For more details on available collection facilities please contact your local government office or the retailer where you purchased this product. Use of the chemical symbols Pb, Cd or Hg indicates if these metals are used in the battery.

This information only applies to customers in the European Union, according to DIRECTIVE 2006/66/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC and legislation transposing and implementing it into the various national legal systems.

For other countries, please contact your local government to investigate the possibility of recycling your product.

The battery removal/replacement procedure is described in the following manuals:

Controller manual / Manipulator manual (Maintenance section)

Before Reading This Manual

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

Structure of Control System

The RS series 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
Name	Structure	
RC180	Controller	EPSON RC+ 5.0 Ver.5.3 or greater
RC700-A	Control Unit Drive Unit	EPSON RC+ 7.0 Ver.7.1.2 or greater

The motions of the manipulators such as in emergency stops vary depending on the Controllers since they have different control methods. Details are described in the manual.

Turning ON/OFF Controller

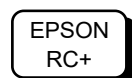
When you see the instruction “Turn ON/OFF the Controller” in this manual, be sure to turn ON/OFF all the hardware components. For the Controller composition, refer to the table above.

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.

Setting by Using Software

This manual contains setting procedures by using software. They are marked with the following icon.



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Setup & Operation

This volume contains information for setup and operation of the RS 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	<p>This symbol indicates that a danger of possible serious injury or death exists if the associated instructions are not followed properly.</p>
 WARNING	<p>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.</p>
 CAUTION	<p>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.</p>

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*.

The following items are safety precautions for design personnel:

 WARNING	<ul style="list-style-type: none">■ Personnel who design and/or construct the robot system with this product must read the <i>Safety</i> chapter in the <i>EPSON RC+ User's Guide</i> 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.■ 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.
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Further precautions for installation are mentioned in the chapter *Setup & Operation: 3. Environments and Installation*. Please read this chapter carefully to understand safe installation procedures before installing the robots and robotic equipment.

1.2.1 Strength of the Ball Screw Spline

If a load exceeding the allowable value is applied to the ball screw spline, it may not work properly due to deformation or breakage of the shaft. If the ball screw spline is applied the load exceeding the allowable value, it is necessary to replace the ball screw spline unit.

The allowable loads differ depending on distance where the load is applied to. For calculating the allowable load, see the calculation formula below.

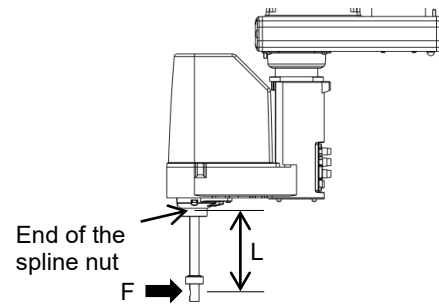
[Allowable bending moment]

$$\text{RS3/RS4: } M=13,000 \text{ N} \cdot \text{mm}$$

Example: If 130 N load is applied
at 100 mm from
the end of the spline nut


[Moment]


$$M=F \cdot L=100 \cdot 130=13,000 \text{ N} \cdot \text{mm}$$



1.3 Operation Safety

The following items are safety precautions for qualified Operator personnel:

 WARNING	<ul style="list-style-type: none"> ■ Please carefully read the <i>Safety-related Requirements</i> in the <i>Safety</i> chapter of the <i>Safety and Installation</i> manual 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	<ul style="list-style-type: none"> ■ To shut off power to the robot system, disconnect 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 disconnect 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 connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting 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.
--	---



- 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.

- Joint #1, #2, and #4:

If the joints are operated repeatedly with the operating angle less than 5 degrees, they may get damaged early because the bearings are likely to cause oil film shortage in such situation. To prevent early breakdown, move the joints larger than 50 degrees for about five to ten times a day.

Joint #3:

If the up-and-down motion of the hand is less than 10 mm, move the joint a half of the maximum stroke for five to ten times a day.

- Vibration (resonance) may occur continuously in low speed Manipulator motion (Speed: approx. 5 to 20%) depending on combination of Arm orientation and end effector load. Oscillation arises from natural oscillation frequency of the Arm and can be controlled by following measures.

Changing Manipulator speed

Changing the teach points

Changing the end effector load

1.4 Emergency Stop

Emergency stop motions of the Manipulators vary due to difference of control methods of the Controllers. See the section for your Controller model.

1.4.1 RC180

If the Manipulator moves abnormally during operation, immediately press the Emergency Stop switch. Stops the power supply to the motor, and the arm stops in the shortest distance with the dynamic brake and mechanical 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. It may also result in short life of the reduction gear unit due to the shock or the electromagnetic brake due to the worn friction plate.

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.

Do not press the Emergency Stop switch unnecessarily while the Manipulator is operating. Pressing the switch during the operation makes the brakes work. This will shorten the life of the brakes due to the worn friction plates.

Normal brake life cycle: About 2 years (when the brakes are used 100 times/day)

Do not turn OFF the Controller while the Manipulator is operating.

If you attempt to stop the Manipulator in emergency situations such as “Safeguard Open”, make sure to stop the Manipulator using the Emergency Stop switch of the Controller.

If the Manipulator is stopped by turning OFF the Controller while it is operating, following problems may occur.

Reduction of the life and damage of the reduction gear unit

Position gap at the joints

In addition, if the Controller was forced to be turned OFF by blackouts and the like while the Manipulator is operating, make sure to check the following points after power restoration.

Whether or not the reduction gear is damaged

Whether or not the joints are in their proper positions

If there is a position gap, perform calibration by referring to the *Maintenance 13. Calibration* in this manual.

Before using the Emergency Stop switch, be aware of the followings.

- The Emergency Stop (E-STOP) switch should be used to stop the Manipulator only in case of emergencies.
- To stop the Manipulator operating the program except in emergency, use Pause (halt) or STOP (program stop) commands.
Pause and STOP commands do not turn OFF the motors. Therefore, the brake does not function.
- For the Safeguard system, do not use the circuit for E-STOP.

For details of the Safeguard system, refer to the following manuals.

*EPSON RC+ User's Guide 2. Safety - Installation and Design Precautions
- Safeguard System
Safety and Installation 2.6 Connection to EMERGENCY Connector*

To check brake problems, refer to the following manuals.

Manipulator Manual Maintenance

*2.1.2 Inspection Point - Inspection While the Power is ON
(Manipulator is operating)*

Safety and Installation

RC180: 5.1.1 Manipulator

- Inspection While the Power is ON (Manipulator is operating)

Free running distance in emergency

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

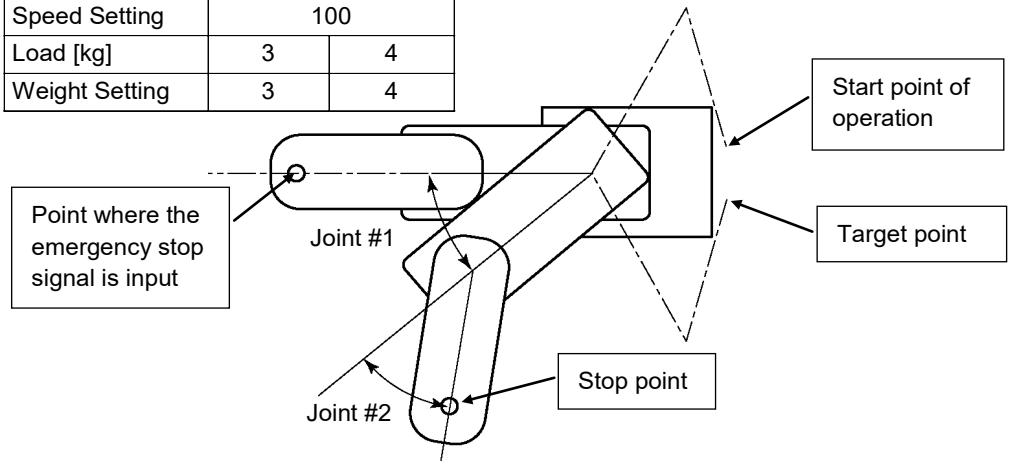
The free running time, angle, and distance of the Manipulator are shown below.

However, remember that the values vary depending on following conditions.

Weight of the end effector Weight of work piece Operating pose
Weight Speed Accel etc.

Conditions for Measurement

	RS3-351*	RS4-551*
Accel Setting	100	
Speed Setting	100	
Load [kg]	3	4
Weight Setting	3	4



		Controller	RC180	
		Manipulator	RS3-351*	RS4-551*
Free running time	Joint #1 + Joint #2 [s]		0.4	0.7
	Joint #3 [s]		0.2	0.4
Free running angle	Joint #1 [deg.]		50	30
	Joint #2 [deg.]		30	50
	Joint #1 + Joint #2 [deg.]		80	80
Free running distance	Joint #3 [mm]		55	75

1.4.2 RC700-A

If the Manipulator moves abnormally during operation, immediately press the Emergency Stop switch. Pressing the Emergency Stop switch immediately changes the manipulator to deceleration motion and stops it at the maximum deceleration speed.

However, avoid pressing the Emergency Stop switch unnecessarily while the Manipulator is running normally. Pressing the Emergency Stop switch locks the brake and it may cause wear on the friction plate of the brake, resulting in the short life of the brake.

Normal brake life cycle: About 2 years (when the brakes are used 100 times/day)

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.

Do not turn OFF the Controller while the Manipulator is operating.

If you attempt to stop the Manipulator in emergency situations such as “Safeguard Open”, make sure to stop the Manipulator using the Emergency Stop switch of the Controller.

If the Manipulator is stopped by turning OFF the Controller while it is operating, following problems may occur.

Reduction of the life and damage of the reduction gear unit

Position gap at the joints

In addition, if the Controller was forced to be turned OFF by blackouts and the like while the Manipulator is operating, make sure to check the following points after power restoration.

Whether or not the reduction gear is damaged

Whether or not the joints are in their proper positions

If there is a position gap, perform calibration by referring to the *Maintenance 13. Calibration* in this manual.

Before using the Emergency Stop switch, be aware of the followings.

- The Emergency Stop (E-STOP) switch should be used to stop the Manipulator only in case of emergencies.
- To stop the Manipulator operating the program except in emergency, use Pause (halt) or STOP (program stop) commands.
Pause and STOP commands do not turn OFF the motors. Therefore, the brake does not function.
- For the Safeguard system, do not use the circuit for E-STOP.

For details of the Safeguard system, refer to the following manuals.

EPSON RC+ User's Guide

*2. Safety - Installation and Design Precautions - Safeguard System
Safety and Installation*

2.6 Connection to EMERGENCY Connector

To check brake problems, refer to the following manuals.

Manipulator Manual Maintenance

2.1.2 Inspection Point - Inspection While the Power is ON
(Manipulator is operating)

Safety and Installation

5.1.1 Manipulator

- Inspection While the Power is ON (Manipulator is operating)

Free running distance in emergency

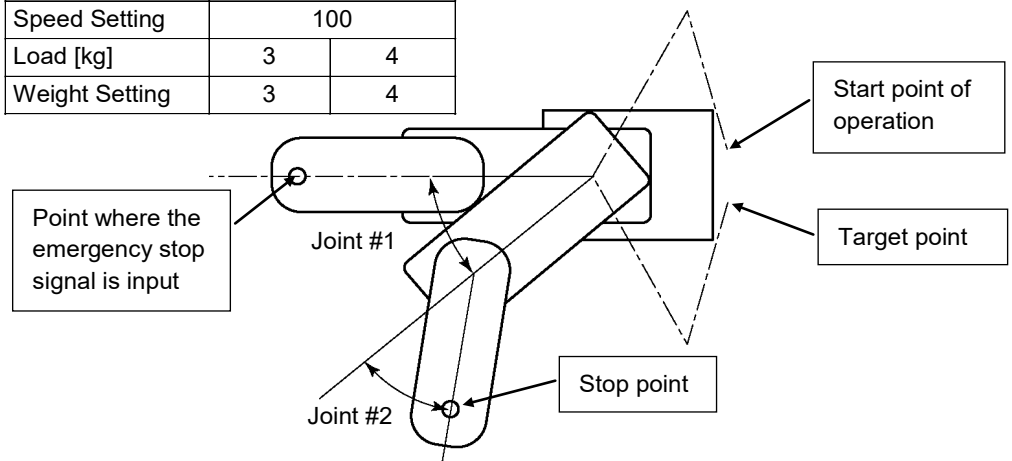
The operating Manipulator cannot stop immediately after the Emergency Stop switch is pressed.

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

Weight of the end effector Weight of work piece Operating pose
Weight Speed Accel etc.

Conditions for Measurement

	RS3-351*	RS4-551*
Accel Setting	100	
Speed Setting	100	
Load [kg]	3	4
Weight Setting	3	4



		Controller	RC700-A	
		Manipulator	RS3-351*	RS4-551*
Free running time	Joint #1 + Joint #2 [s]		0.3	0.7
	Joint #3 [s]		0.2	0.3
Free running angle	Joint #1 [deg.]		50	30
	Joint #2 [deg.]		30	70
	Joint #1 + Joint #2 [deg.]		80	100
Free running distance	Joint #3 [mm]		55	65

1.5 Emergency Movement Without Drive Power

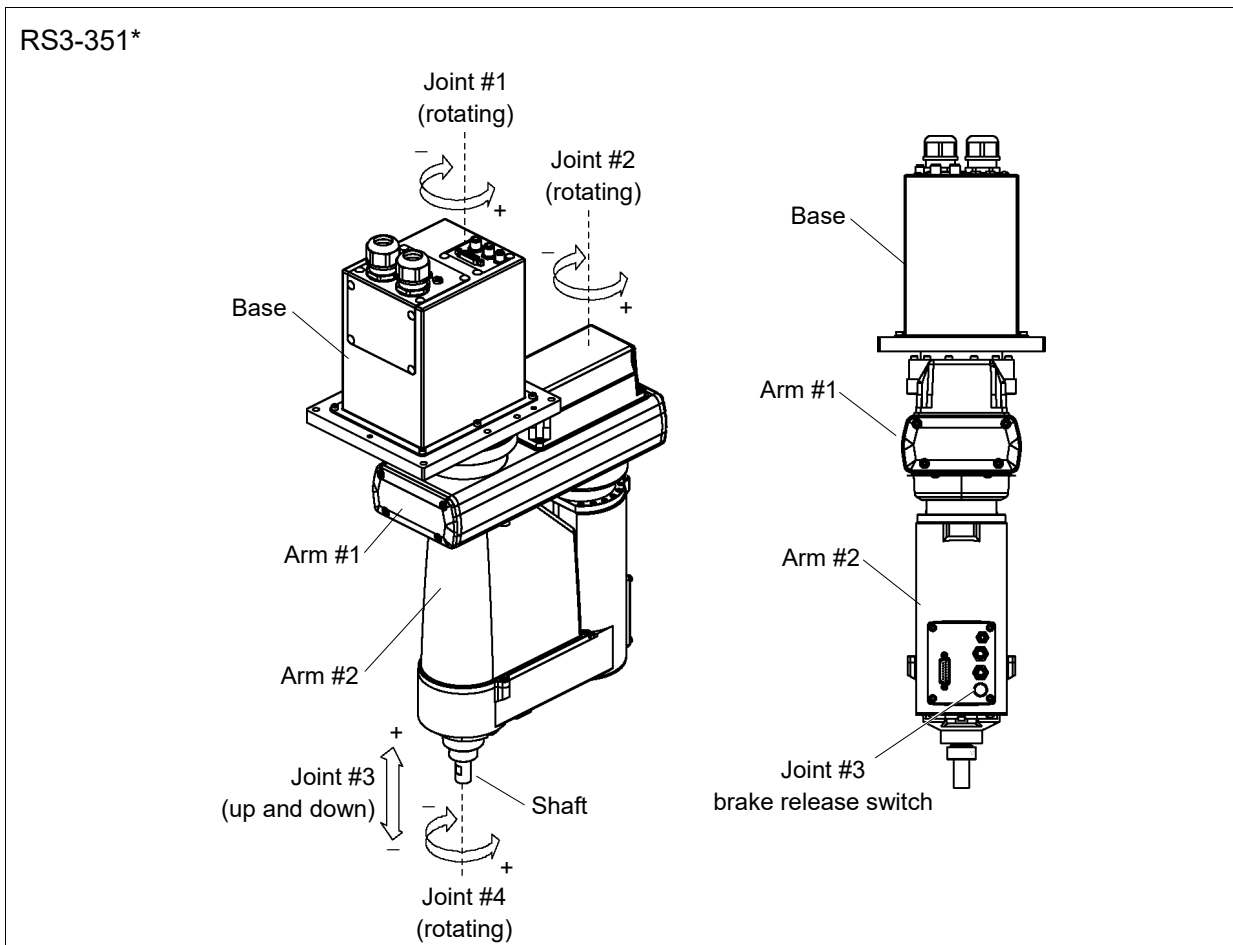
When the system is placed in emergency mode, push the arm or joint of the Manipulator by hand as shown below:

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 until the electromagnetic brake applied to the joint has been released. Move the joint up/down while pressing the brake release switch.

Joint #4 Rotate the shaft by hand.

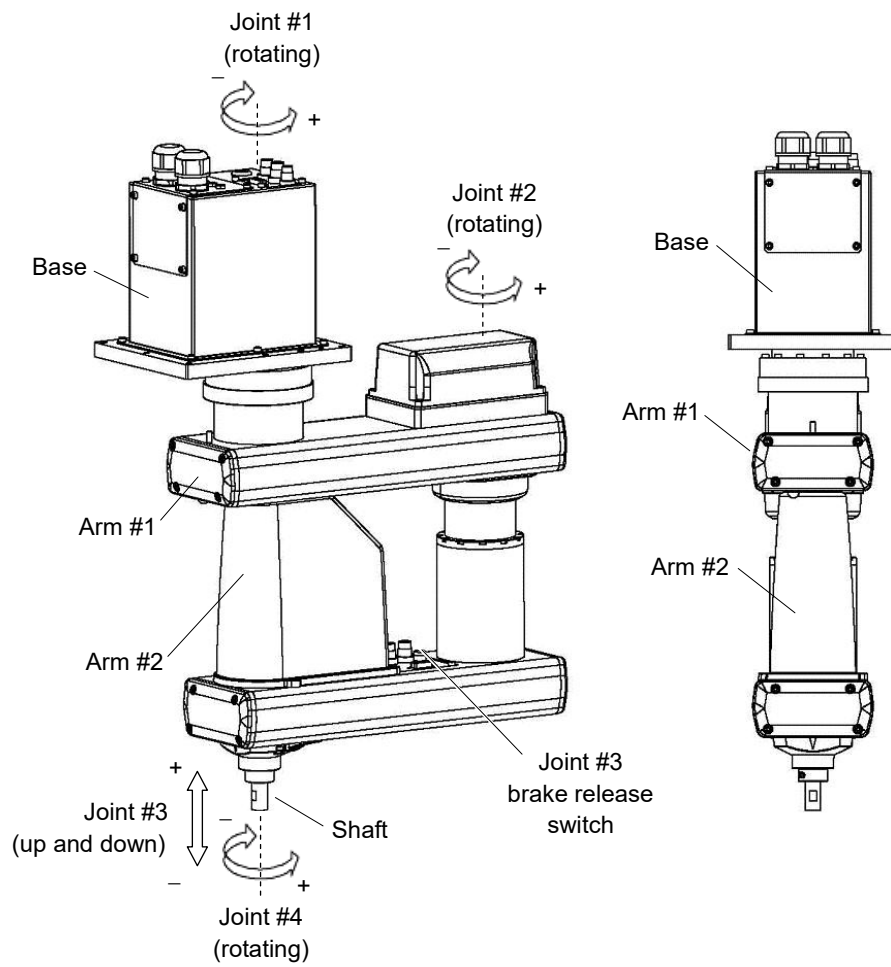



NOTE



Be careful of the shaft while the brake release switch is pressed, because the shaft may be lowered by the weight of an end effector.


RS4-551*



NOTE  Be careful of the shaft while the brake release switch is pressed, because the shaft may be lowered by the weight of an end effector.

1.6 ACCELS Setting for CP Motions

To make the Manipulator move in CP motion, see the following and set ACCELS properly according to the tip load and the Z-axis height.

NOTE Improper setting may cause following problems.
 Reduction of the life and damage of the ball screw spline

Set ACCELS as follows according to the Z-axis height.

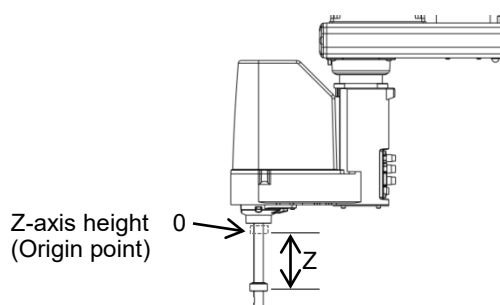
ACCELS setting value by Z-axis position and tip load

RS3

Z position (mm)	Tip load		
	1kg or less	2kg or less	3kg or less
- 0 > Z >= - 50	25000 or less	25000 or less	24000 or less
- 50 > Z >= - 100		24000 or less	16000 or less
- 100 > Z >= - 130		20000 or less	13000 or less

RS4

Z position (mm)	Tip load			
	1kg or less	2kg or less	3kg or less	4kg or less
- 0 > Z >= - 50	25000 or less	25000 or less	24000 or less	17000 or less
-50 > Z >= - 100		24000 or less	16000 or less	12000 or less
- 100 > Z >= - 130		20000 or less	13000 or less	1000 or less



If the Manipulator is operated in CP motion with the wrong set values, make sure to check the following point.

Whether the ball screw spline shaft is deformed or bent




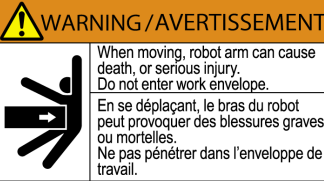


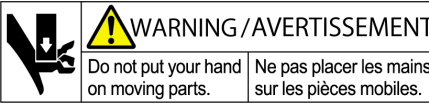
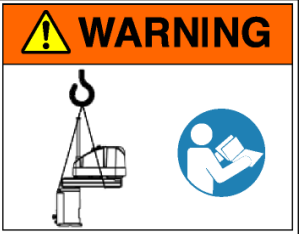

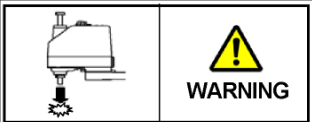

1.7 Warning Labels

The Manipulator has the following warning labels.

The warning labels are attached around the locations where specific dangers exist.

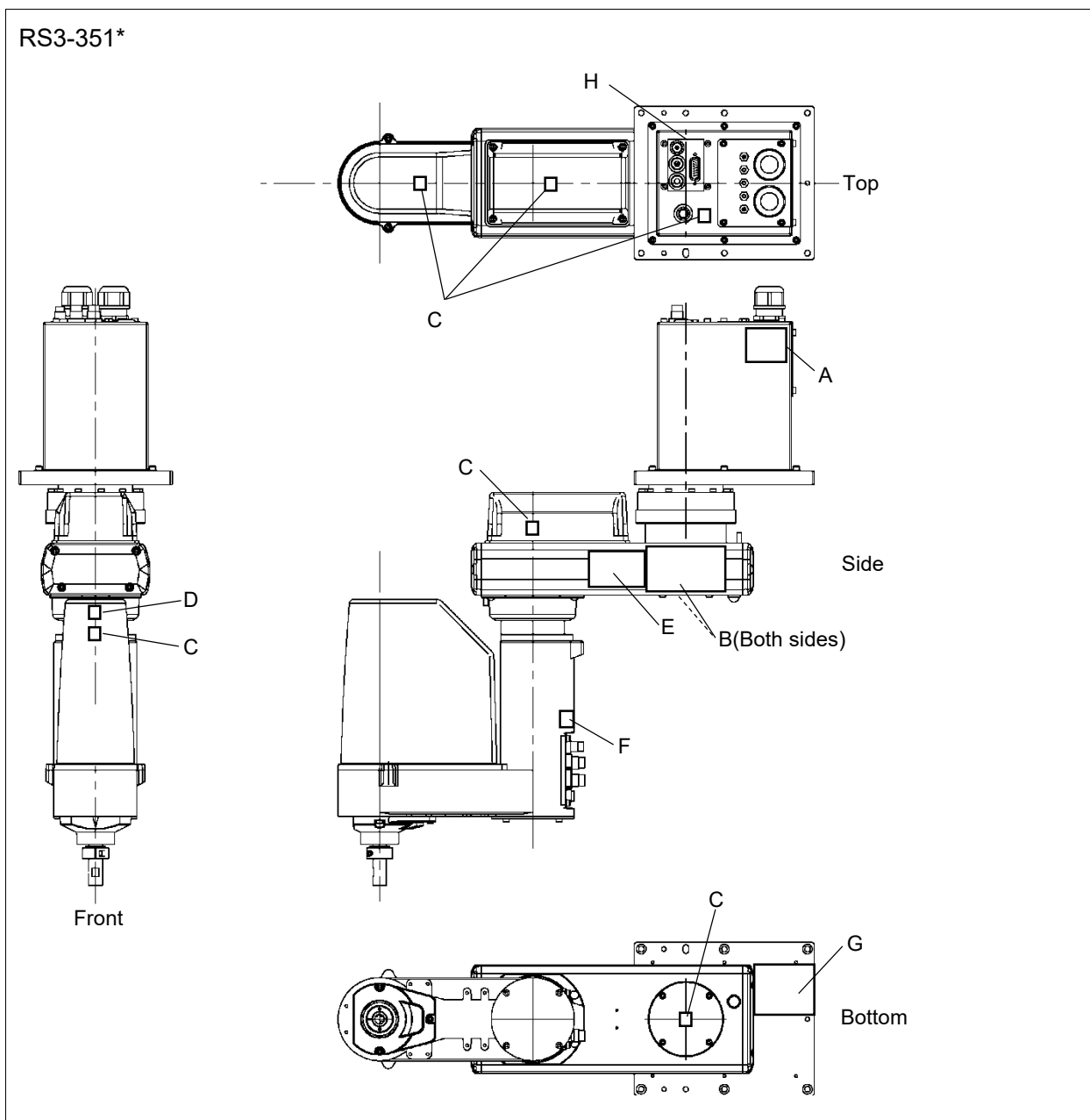
Be sure to comply with descriptions and warnings on the labels to operate and maintain the Manipulator safely.

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

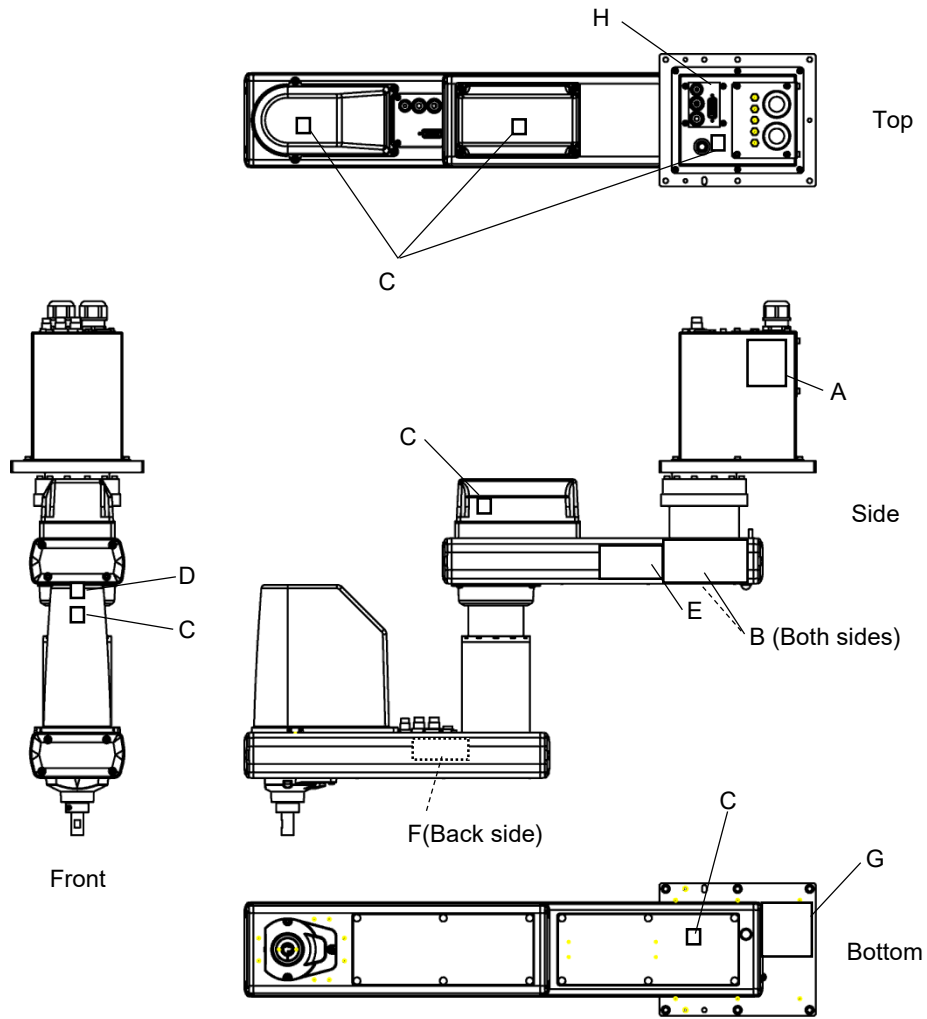
Location	Warning Label	NOTE
A	 	Before loosening the base mounting screws, hold the arm and secure it tightly with a band to prevent hands or fingers from being caught in the Manipulator.
B	 	Do not enter the work space when the Manipulator is operating. It is extremely hazardous since the Arm may collide and cause serious safety problems,
C		Hazardous voltage exists while the Manipulator is ON. To avoid electric shock, do not touch any internal electric parts.
D	 	You can catch your hand or fingers between the shaft and Arm #1 when bringing your hand close to moving parts.
E	 	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. (only UL model.)
F	 	Be careful of the hand falling and rotation while the brake release switch is being pressed.

Location	Label	Location	Label
G	<p>MODEL : RS3-351S SERIALNO. : 00001 MANUFACTURED : 11/2008 WEIGHT : 17kg MAX PAYLOAD : 3kg MOTOR POWER AXIS1 : 400W AXIS2 : 200W AXIS3 : 150W AXIS4 : 100W SEIKO EPSON CORPORATION 3-5,OWA 3-CHOME,SUWA-SHI NAGANO-KEN,392-8502 JAPAN</p>	H	<p>Air pressure max. 0.59Mpa, 86psi</p>

Location of Labels



RS4-551*



2. Specifications

2.1 Features of RS series Manipulators

The RS series Manipulators provides “Operation-oriented layout” with high-performance, high speed, high accuracy, space saving, and flexible installation.

The features of the RS series Manipulators are as follows:

Space Saving

Compactness achieved by using a ductless design

Small body and wide motion range

Ceiling mounting realizes the cylindrical motion range.

- Operation area: approx. 160 % (compared with SCARA robot of same arm length)

- Max. inscribed □: approx. 250 % (compared with SCARA robot of same arm length)

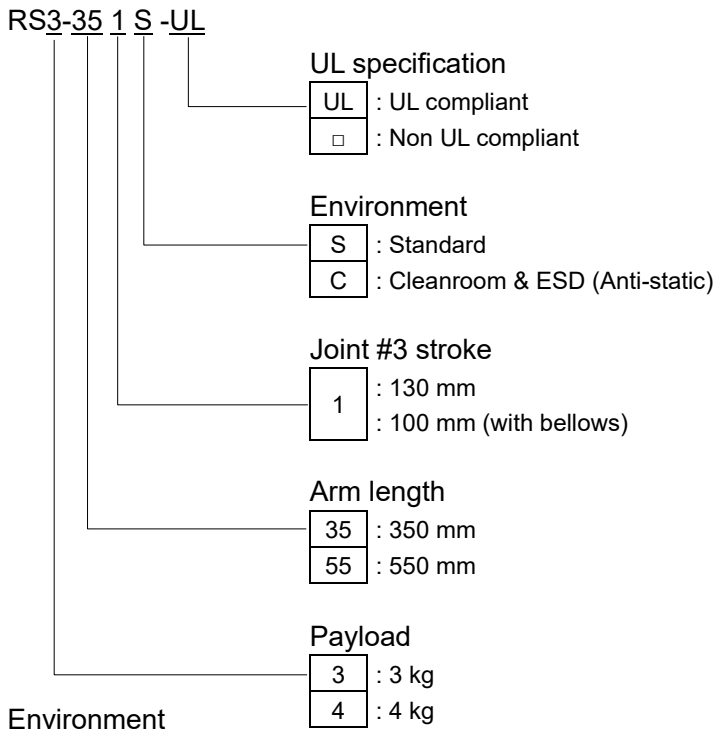
Great flexibility for peripheral equipment installation

Access to ALL directions

Operation efficiency improvement

The shortcut motion with inward movement

2.2 Model Number



Cleanroom-model

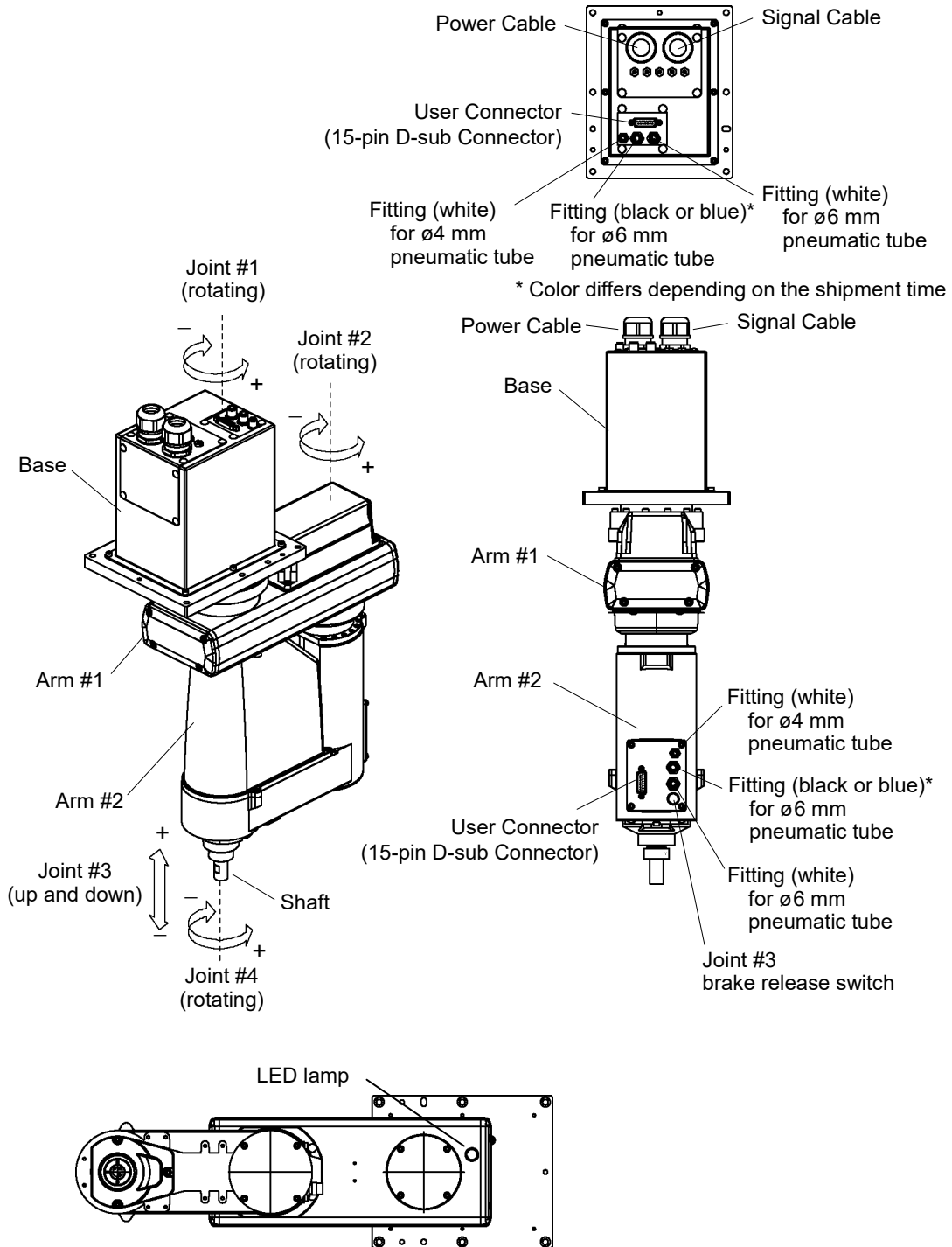
This model has additional features that reduce dust emitted by the Manipulator to enable use in clean room environments.

For details of the specifications, refer to *Setup & Operation: 2.4 Specifications*.

2.3 Part Names and Outer Dimensions

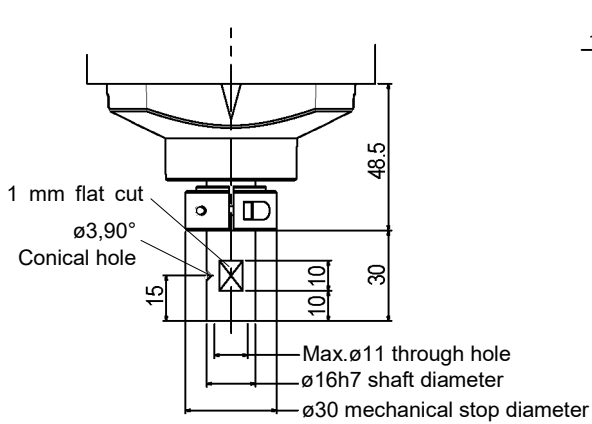
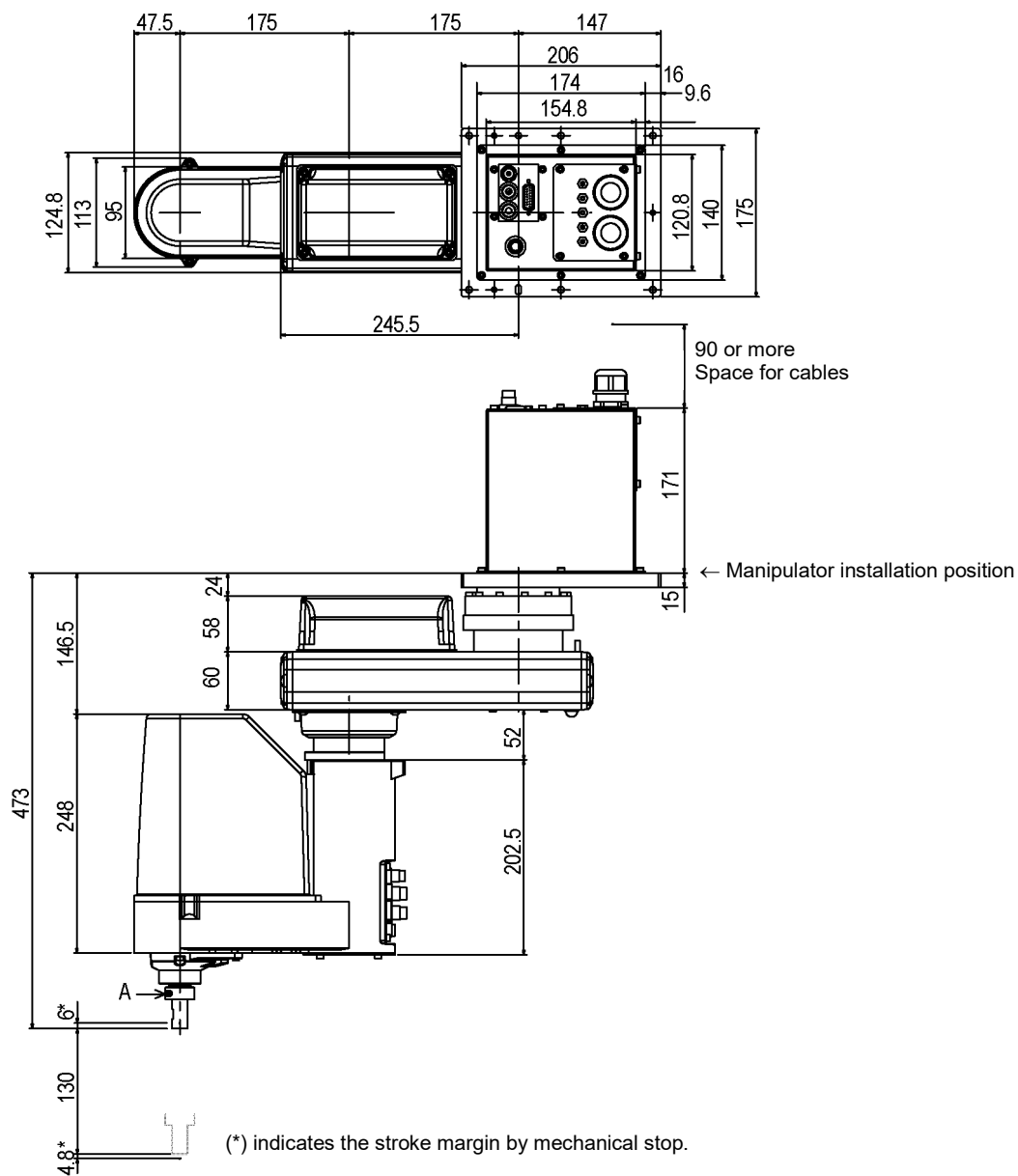
2.3.1 RS3-351*

Standard-model (RS3-351S)

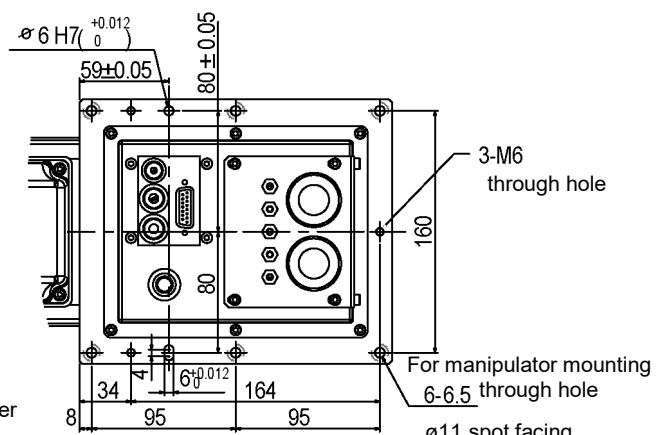


- When the brake release switch is pressed in emergency mode, the Joints #3 brake will be released.
- When the LED lamp is lighting or the controller power is on, the current is being applied to the manipulator. Performing any work with the power ON is extremely hazardous and it may result in electric shock and/or improper function of the robot system. Make sure to turn OFF the controller power before the maintenance work.

Standard-model (RS3-351S)



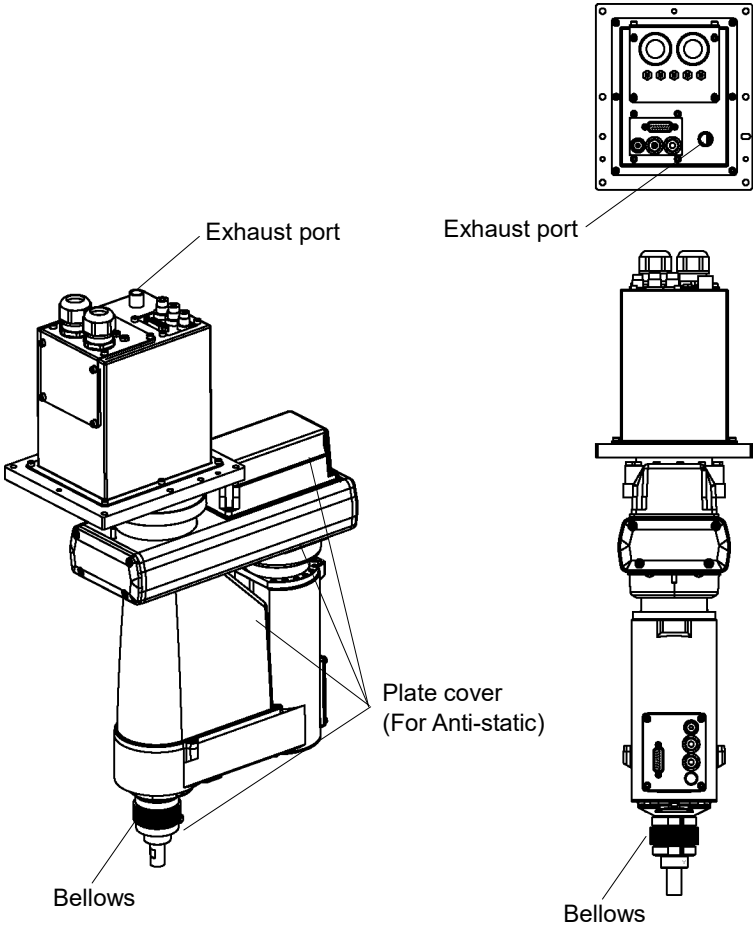
Enlarged view from A
(Original orientation of Joint #3, #4)



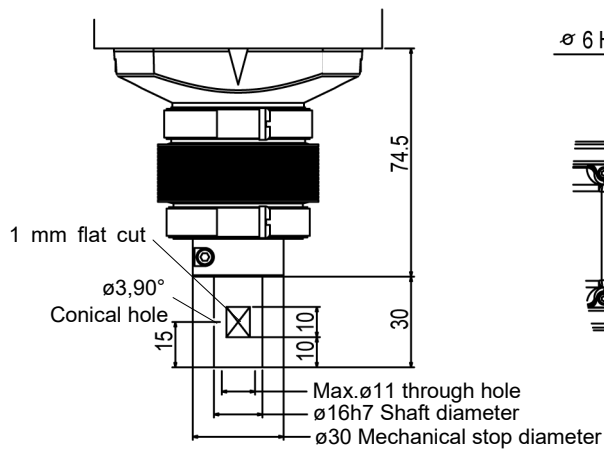
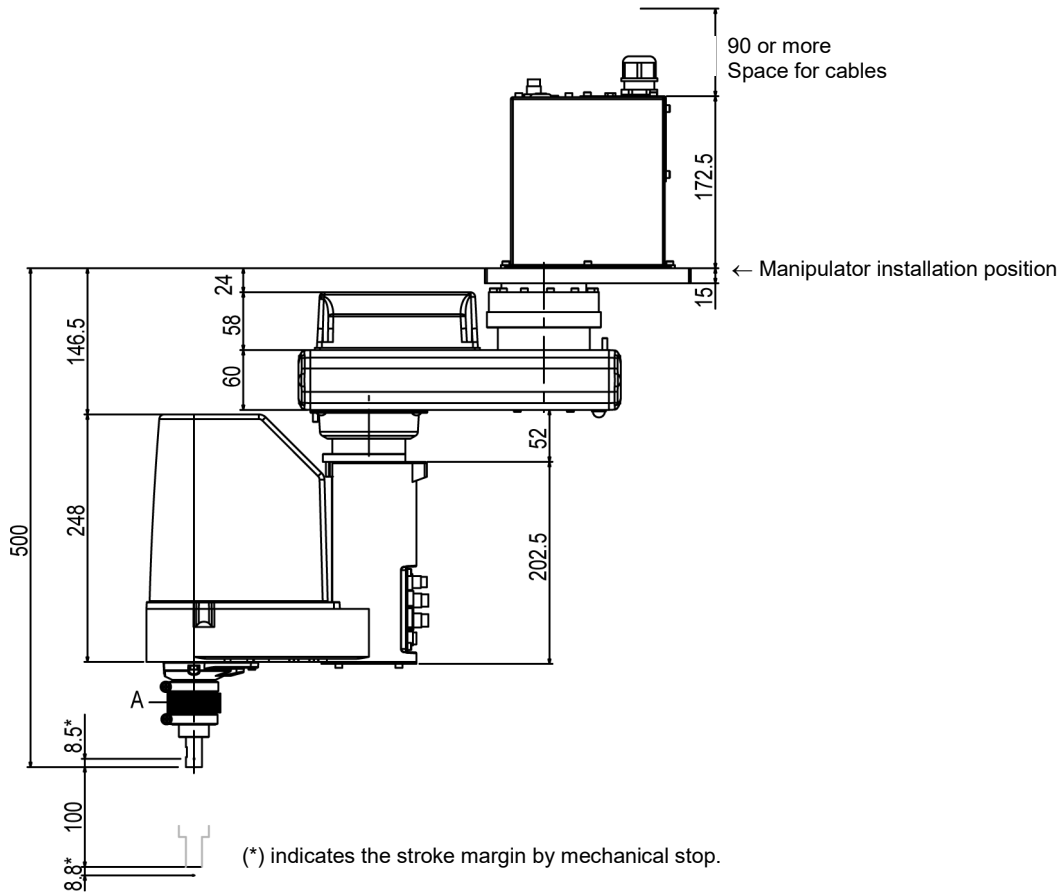
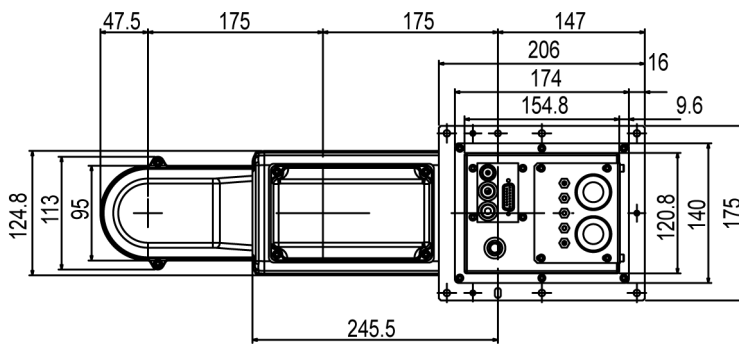
Reference through hole
(View from the top of the base)

Cleanroom-model (RS3-351C)

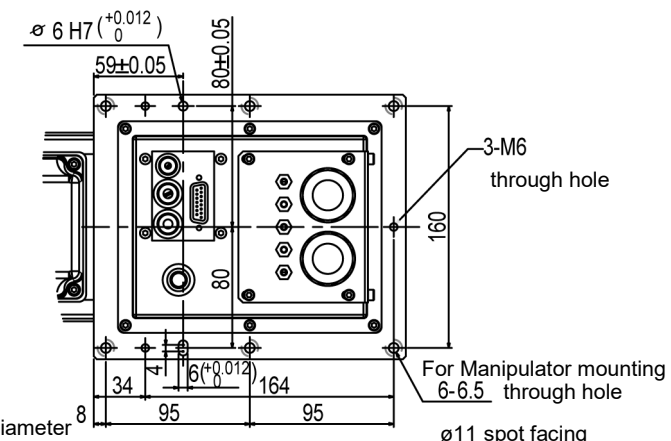
The following figures show the special parts for Cleanroom-model (Table Top mounting). These parts are different in appearance from Standard-model.



Cleanroom-model (RS3-351C)



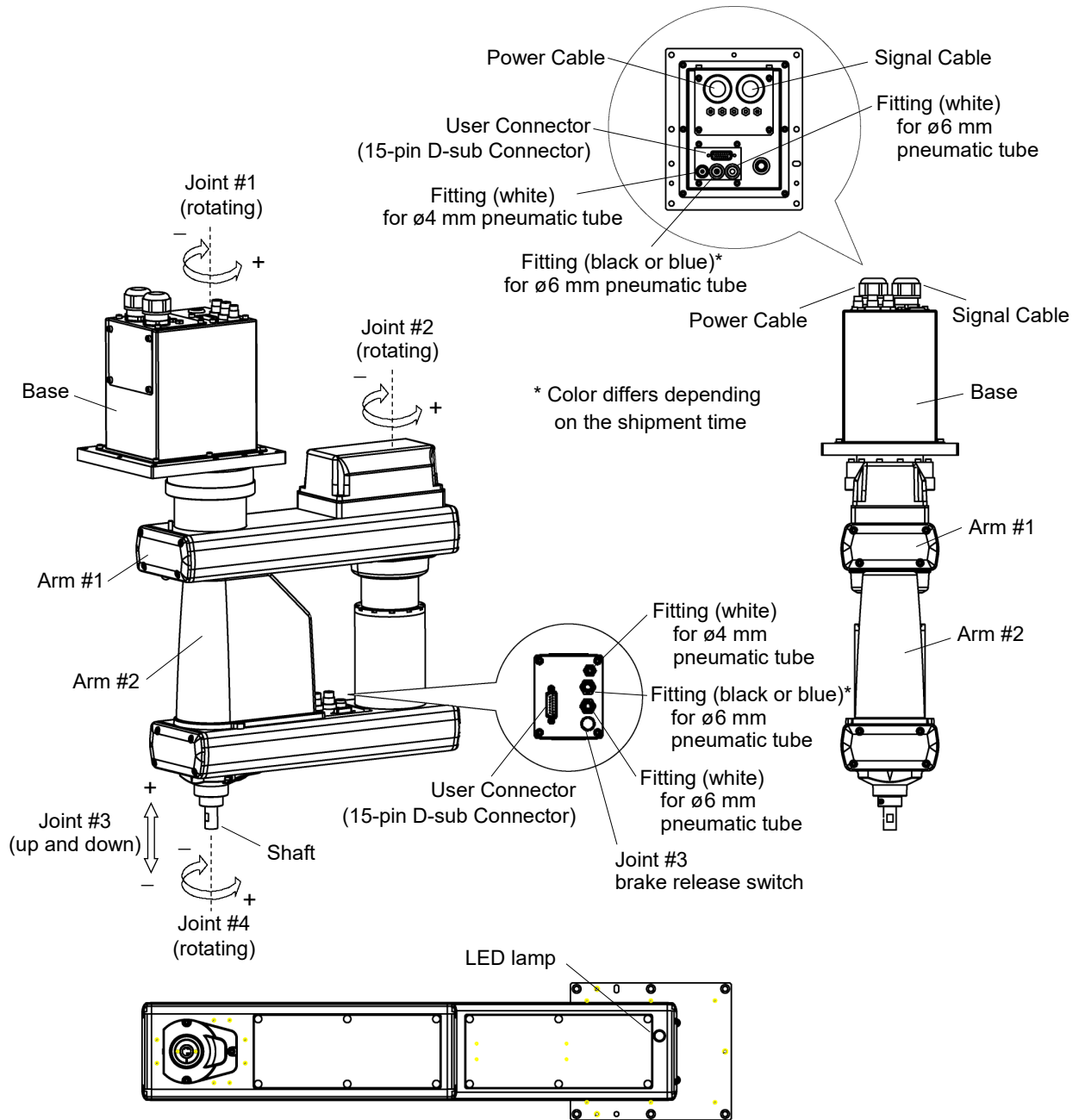
Enlarged view from A
 (Original orientation of Joint #3, #4)



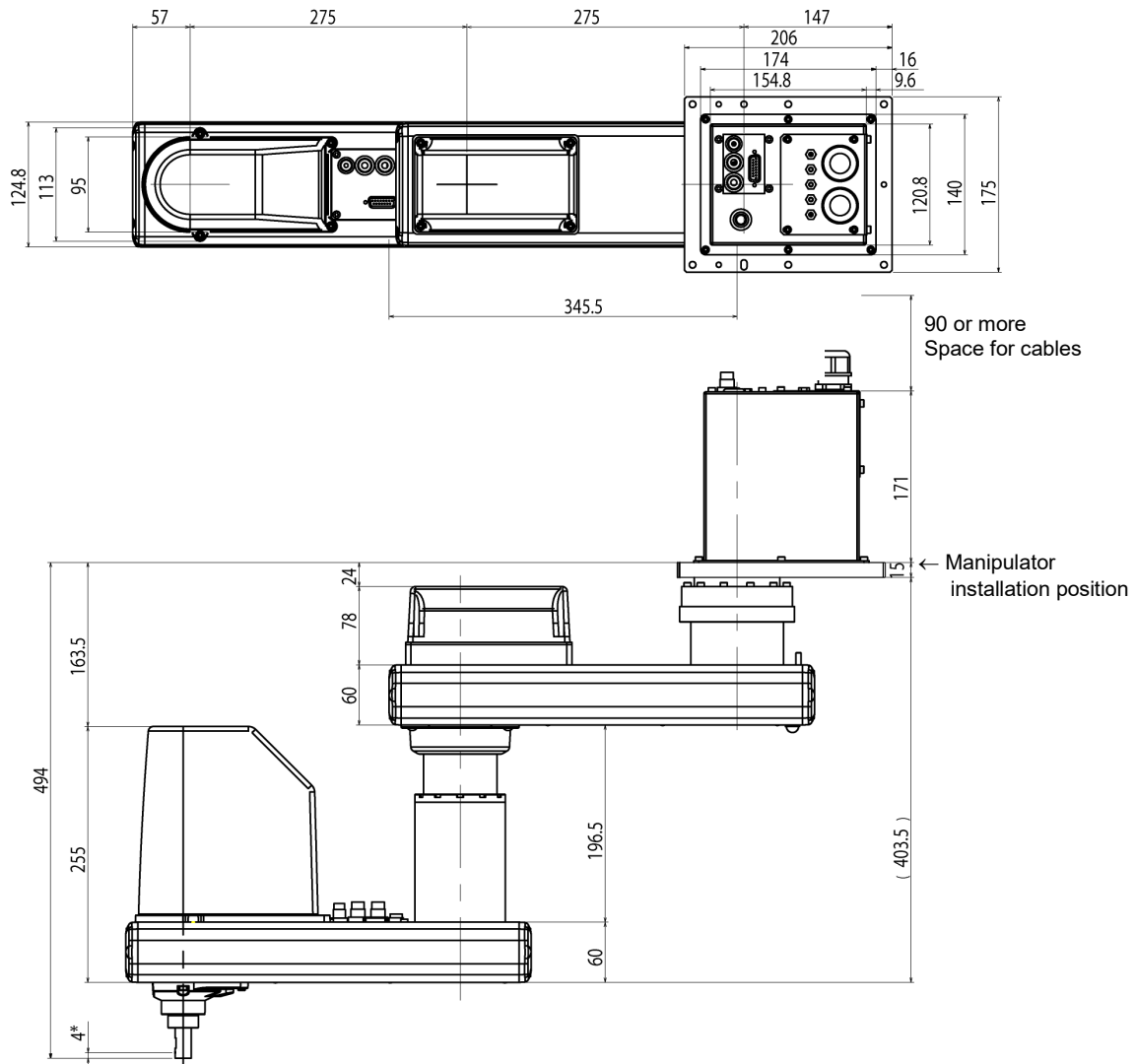
Reference through hole
 (View from the top of the base)

2.3.2 RS4-551*

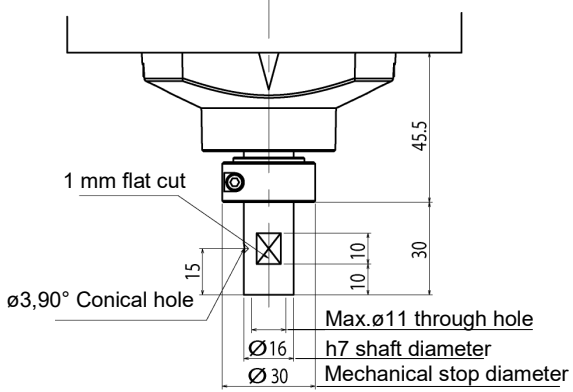
Standard-model (RS4-551S)



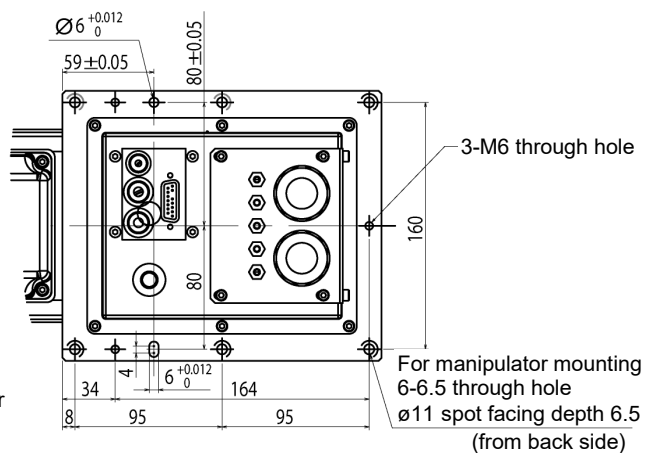
Standard-model (RS4-551S)



4*
1.8* 130
(* indicates the stroke margin by mechanical stop.



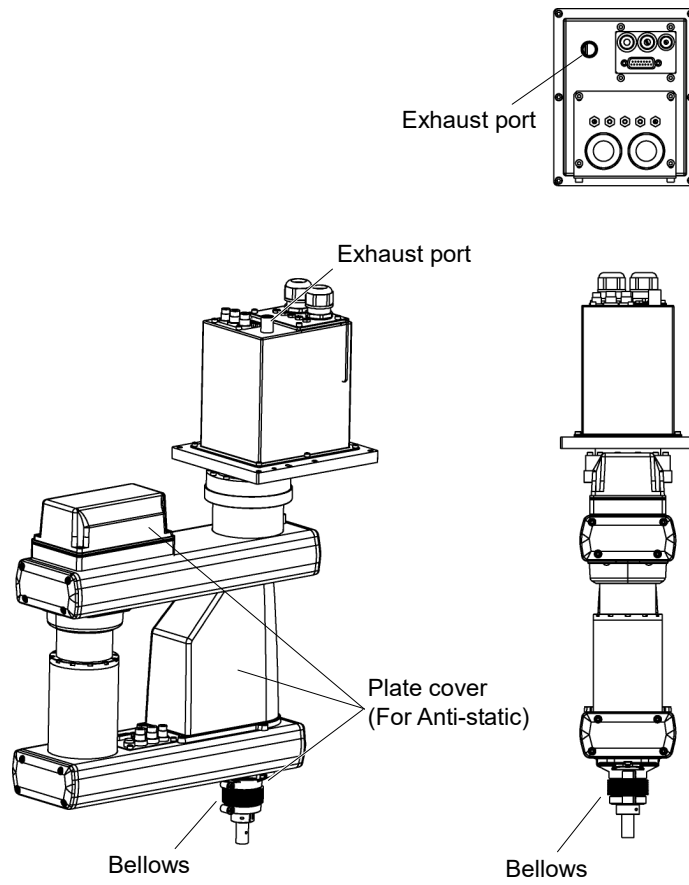
Enlarged view from A
(Original orientation of Joint #3, #4)



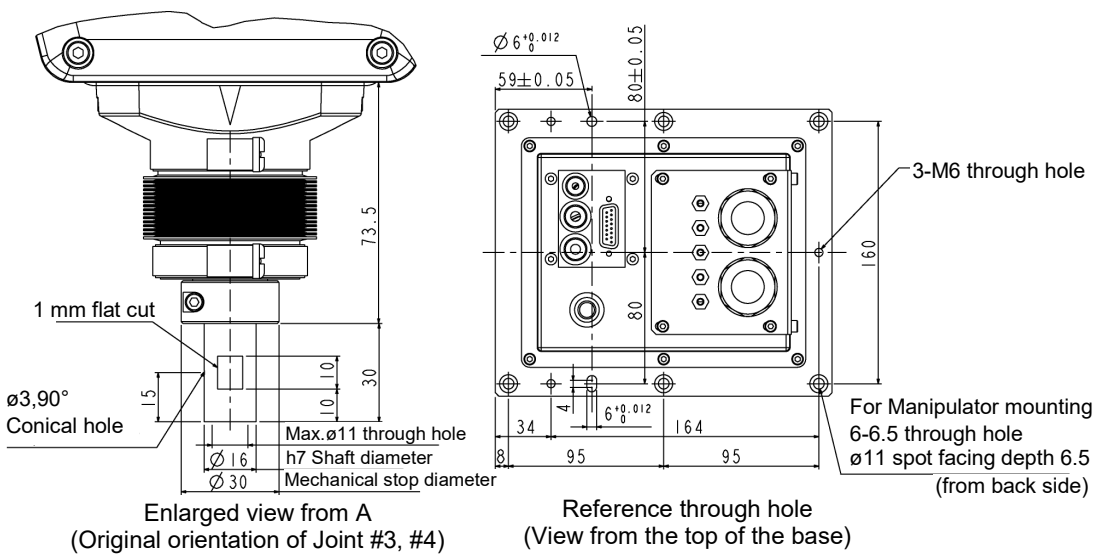
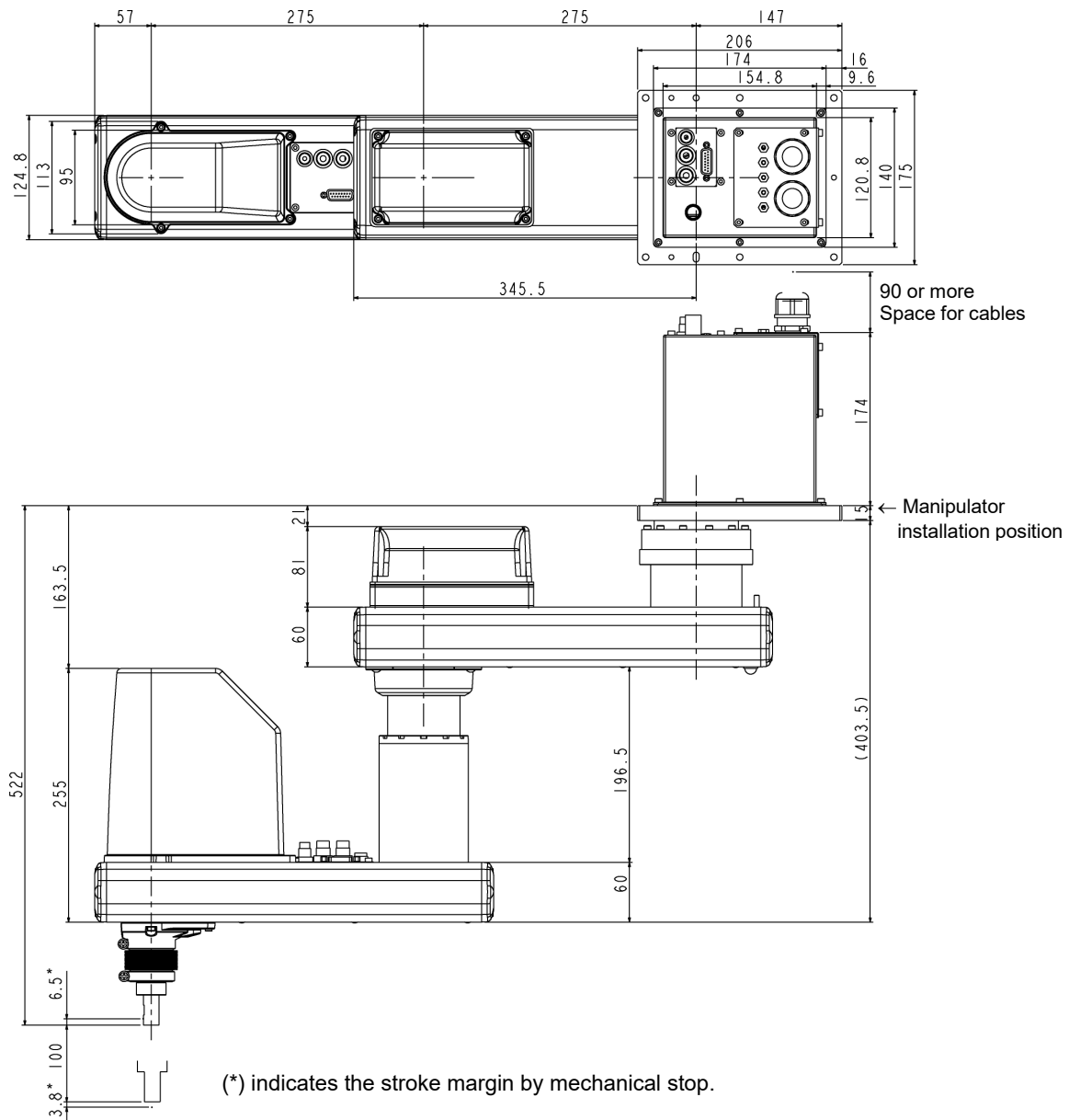
Reference through hole
(View from the top of the base)

Cleanroom-model (RS4-551C)

The following figures show the special parts for Cleanroom-model.
These parts are different in appearance from Standard-model.



Cleanroom-model (RS4-551C)



2.4 Specifications

Item		RS3-351*	RS4-551*
Arm length	Arm #1, #2	350 mm	550 mm
	Arm #1	175 mm	275 mm
	Arm #2	175 mm	275 mm
Max. operating speed *1	Joints #1, #2	6237 mm/s	7400 mm/s
	Joints # 3	1100 mm/s	
	Joint #4	2600 deg/s	
Repeatability	Joints #1, #2	± 0.01 mm	± 0.015 mm
	Joints # 3	± 0.01 mm	
	Joint #4	± 0.01 deg	
Payload (Load)	Rated	1 kg	
	Max.	3 kg	4 kg
Joint #4 allowable moment of inertia *2	Rated	0.005 kg·m ²	
	Max.	0.05 kg·m ²	
Max. motion range	Joint #1	± 225 deg	
	Joint #2	± 225 deg	
	Joint #3	RS*-**1S: 130 mm RS*-**1C: 100 mm	
	Joint #4	± 720 deg	
Max. pulse range (pulse)	Joint #1	- 2560000 to + 5973334 pulse	-4096000 ~ + 9557334 pulse
	Joint #2	± 4177920 pulse	
	Joint #3	RS*-**1S: - 1479112 pulse to 0 pulse RS*-**1C: - 1137778 pulse to 0 pulse	
	Joint #4	± 3145728 pulse	
Resolution	Joint #1	0.0000527 deg/pulse	
	Joint #2	0.0000538 deg/pulse	
	Joint #3	0.0000879 mm/pulse	
	Joint #4	0.000229 deg/pulse	
Hand diameter	Mounting	ø 16 mm	
	Hollow	ø 11 mm	
Mounting hole		6-M6	
Weight (cables not included) (Common to Standard & Cleanroom-model)		17 kg: 38 lb	19 kg: 42 lb
Driving method		AC servo motor	
Motor rated capacity	Joint #1	400 W	
	Joint #2	200 W	400 W
	Joint #3	150 W	
	Joint #4	100 W	
Option	Environment	Cleanroom & ESD *3	
Joint #3 down force		150 N	
Installed wire for customer use		15 wires: D-sub, 15 pin connectors	
Installed pneumatic tube for customer use		2 pneumatic tubes (ø 6 mm): 0.59 MPa (6 kgf/cm ² : 86 psi)	
		1 pneumatic tube (ø 4 mm): 0.59 MPa (6 kgf/cm ² : 86 psi)	
Environmental requirements	Ambient temperature	5 to 40°C (with minimum temperature variation)	
	Ambient relative humidity	10 to 80% RH (no condensation)	
Noise level *4		LAeq = 65 dB (A) or under	
Applicable Controller *5		RC180, RC700-A	

Item		RS3-351*	RS4-551*
Assignable Value () Default values	SPEED	1 to (5) to100	
	ACCEL *6	1 to (10) to 120	
	SPEEDS	1 to (50) to 2000	
	ACCELS	1 to (200) to 25000	
	FINE	0 to (10000) to 65535	
	WEIGHT	0,175 to (1,175) to 3,175	0,275 to (1,275) to 4,275
Safety standard		CE Marking: EMC Directive, Machinery Directive KC Marking / KCs Marking UL standards (In case of UL specification): UL1740 ANSI/RIA R15.06 NFPA 79	

*1: In the case of PTP command. Maximum operating speed for CP command is 2000 mm/s on horizontal plane.

*2: In the case where the center of gravity is at the center of Joint #4.
 If the center of gravity is not at the center of Joint #4, set the parameter using Inertia command.

*3: The exhaust system in the Cleanroom-model Manipulator draws air from the base interior and arm cover interior together.

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.

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.

Cleanliness level: Class ISO 3 (ISO14644-1)

Exhaust System: Exhaust port diameter : Inner diameter: ϕ 12 mm / Outer diameter: ϕ 16 mm

Exhaust tube : Polyurethane tube

Outer diameter: ϕ 12 mm (Inner diameter: ϕ 8 mm)

or Inner diameter ϕ 16mm or larger

Recommended exhaust flow rate: approx. 1000 cm³/s (Normal)

ESD specification uses resin materials with antistatic treatment. This model controls adhesion of dust due to electrification.

*4: Conditions of Manipulator during measurement as follows:

Operating conditions : Under rated load, 4-joints simultaneous motion, maximum speed, maximum acceleration/deceleration, and duty 50%.

Measurement point : Rear of the Manipulator, 1000 mm apart from the motion range, 50 mm above the base-installed surface.

*5: For delivery up until January 2017, there are systems in combination of RS series and RC620.

*6: In general use, Accel setting 100 is the optimum setting that maintains the balance of acceleration and vibration when positioning. Although values larger than 100 can be set to Accel, it is recommended to minimize the use of large values to necessary motions since operating the manipulator continuously with the large Accel setting may shorten the product life remarkably.

2.5 How to Set the Model

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



- 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 the custom specifications number (MT***) is described on MODEL of the signature label (S/N label), the Manipulator has custom specifications. (A label with only the custom specifications number may be attached depending on shipment time.)

The custom specifications may require a different configuration procedure; check the custom specifications number (MT***) and contact the supplier of your region when necessary.

The Manipulator model can be set from software.

Refer to the chapter *Robot Configuration* in the *EPSON RC+ 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 an environment that meets the following conditions:

Item	Conditions
Ambient temperature *1	5 to 40°C (with minimum temperature variation)
Ambient relative humidity	10 to 80% (no condensation)
First transient burst noise	1 kV or less (Signal wire)
Electrostatic noise	4 kV or less
Environment	<ul style="list-style-type: none"> · 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



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

*1 The ambient temperature conditions are for the Manipulators only. For the Controller the Manipulators are connected to, refer to the Controller manual.

Special Environmental Conditions

The surface of the Manipulator has general oil resistance. However, if your requirements specify that the Manipulator must withstand certain kinds of oil, please contact the supplier of your region.

Rapid change in temperature and humidity can cause condensation inside the Manipulator. If your requirements specify that the Manipulator handles food, please contact the supplier of your region to check whether the Manipulator will damage the food or not.

The Manipulator cannot be used in corrosive environments where acid or alkaline is used. In a salty environment where the rust is likely to gather, the Manipulator is susceptible to rust.

 WARNING	<ul style="list-style-type: none"> ■ Use an earth leakage breaker on the AC power cable of the Controller to avoid electric shock and circuit breakdown caused by short circuit. Prepare the earth leakage breaker that pertains the Controller you are using. For details, refer to the Controller manual.
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 CAUTION	<ul style="list-style-type: none"> ■ When cleaning the Manipulator, do not rub it strongly with alcohol or benzene. It may lose luster on the coated face.
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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/deceleration. 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	: 500 Nm
Max. Horizontal reaction force	: 1200 N (RS3-351*)
	: 1400 N (RS4-551*)
Max. Vertical reaction force	: 1100 N

The threaded holes required for mounting the Manipulator base are M6. Use mounting bolts with specifications conforming to ISO898-1 property class: 10.9 or 12.9.

For dimensions, refer to *Setup & Operation: 3.3 Mounting Dimensions*.

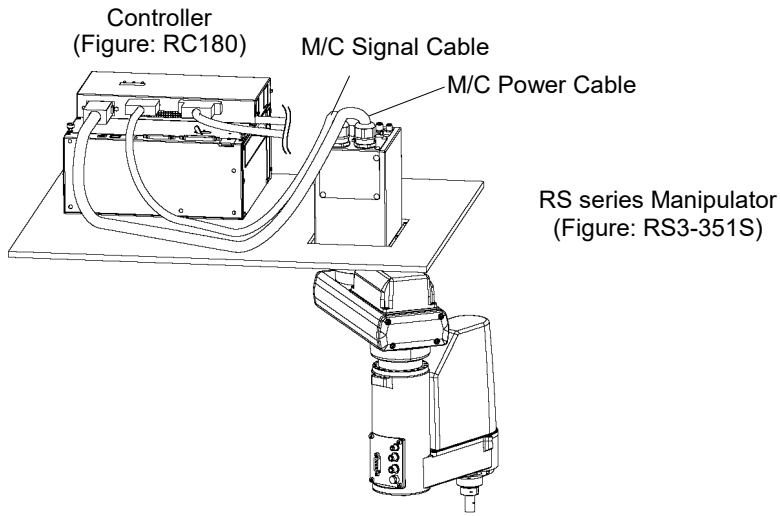
The plate for the Manipulator mounting face should be 20 mm thick or more and made of steel to reduce vibration. The surface roughness of the steel plate should be 25 μm or less.

The table must be secured on the floor or wall to prevent it from moving.

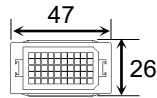
The Manipulator must be installed horizontally.

When using a leveler to adjust the height of the base table, use a screw with M16 diameter or more.

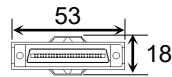
If you are passing cables through the holes on the base table, see the figures below.



RC180, RC620

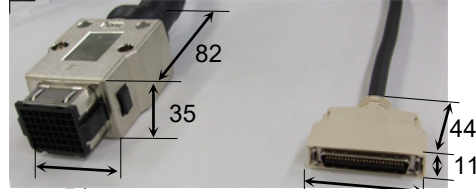


Power Cable Connector



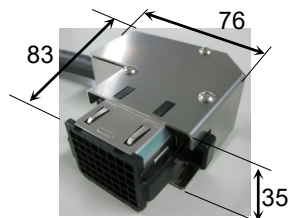
Signal Cable Connector

RC700-A



Power Cable Connector (Straight)

Signal Cable Connector




Power Cable Connector (L-shaped)

Do not remove the M/C cables from the Manipulator.

The M/C cables are installed to the Manipulator body and cannot be removed. Never try to remove the M/C cables.

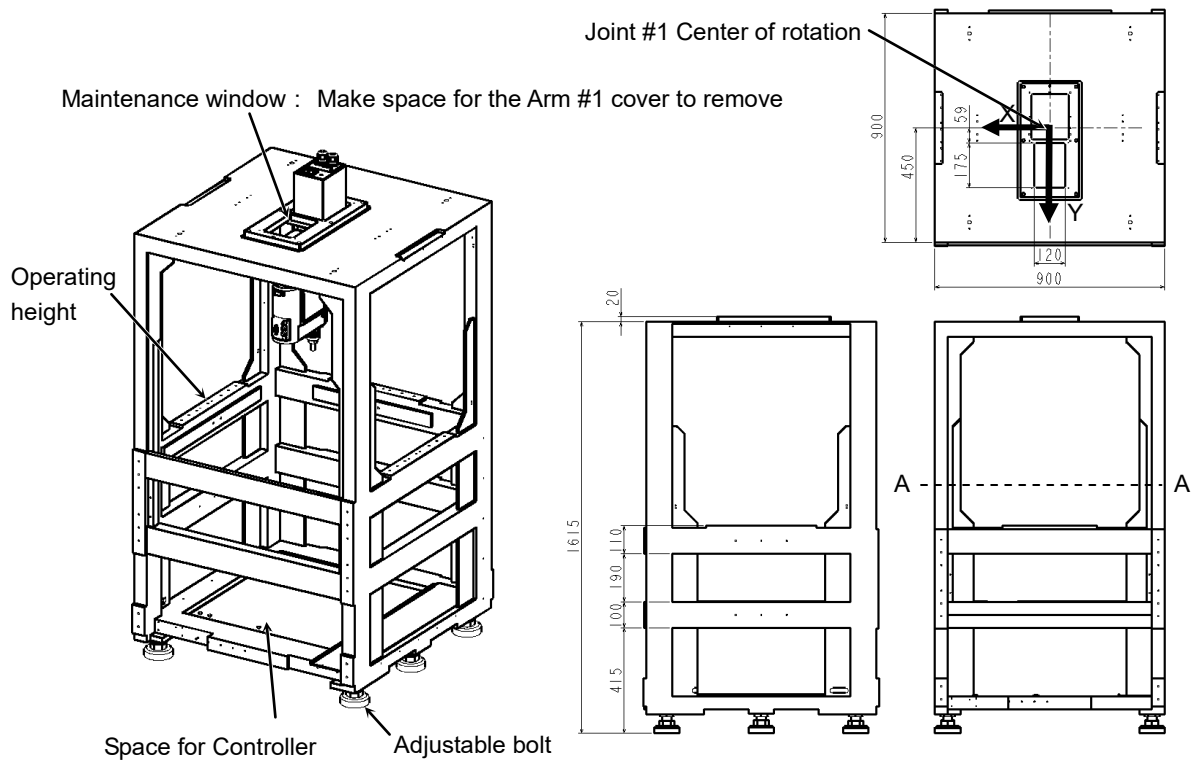
In case that the base table has no maintenance window, it needs to remove the Manipulator from the base table for the maintenance. When designing the base table, consider this point.

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

 WARNING	<p>■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the EPSON RC+ User's Guide.</p>
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Base Table – Design Example

The following is an example for designing the base table of RS3 Manipulator. During the operation of RS3 in the maximum acceleration/deceleration speed, the base table must be steady enough to prevent the vibration from transmitting to RS3.



Wight of table	: approx. 300 kg
Material for the frame	: Iron pipe: □ 100 × 50 mm 3.2 mm thick
Adjustable bolt	: M36
Geometrical moment of inertia	: $I_x = 1.2 \times 10^9 \text{ mm}^4$
(A-A)	$I_y = 1.2 \times 10^9 \text{ mm}^4$

- Set low aspect ratio of the base table height and width
- Put center of gravity lower position by installing the Controller on the bottom of the base table.
- Reinforce the open part with joist or similar material to minimize the part.
- The condition depends on the table height, width, the position of joist, and the center of gravity.

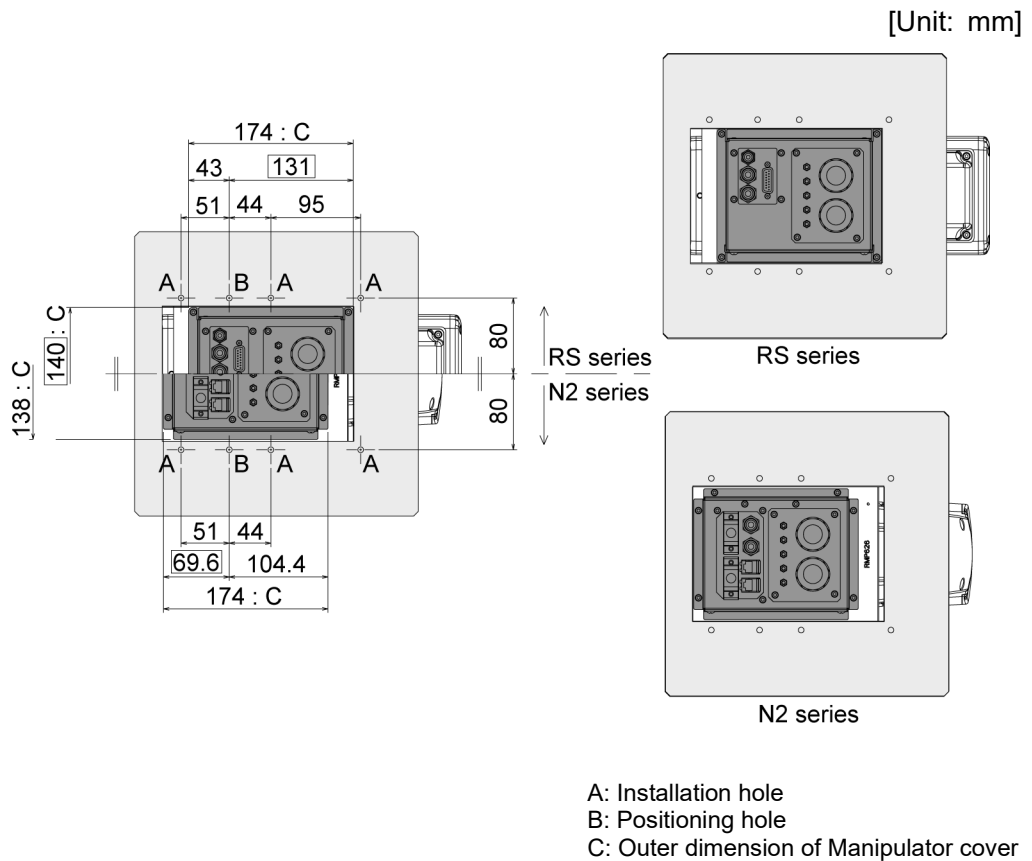
Example of space for Manipulator base

The following is an example of space for the Manipulator base to install both RS and N2 series manipulators.

Design the base table as below considering not interfering with the positioning holes and the installation holes.

Length: 140 mm or more

Width: 131 mm or more from the reference hole, or
69.6 mm or more from the reference hole



3.3 Mounting Dimensions

The maximum space described in figures shows that the radius of the end effector is 50 mm or less. If the radius of the end effector exceeds 50 mm, define the radius as the distance to the outer edge of maximum space.

If a camera or electromagnetic valve extends outside of the arm, set the maximum range including the space that they may reach.

Be sure to allow for the following extra spaces in addition to the space required for mounting the Manipulator, Controller, and peripheral equipment.

Space for teaching

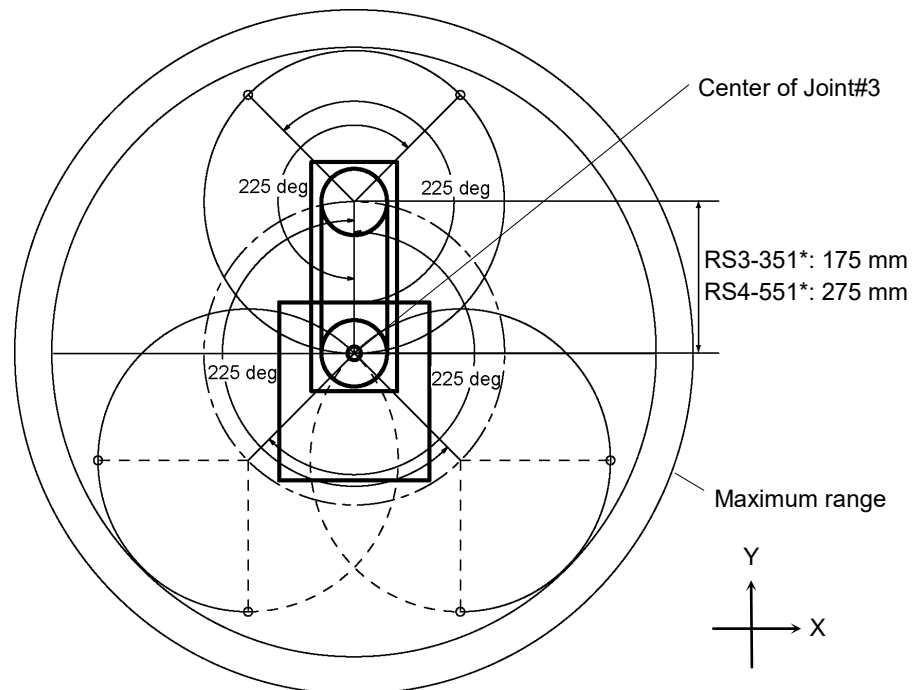
Space for maintenance and inspection

Ensure a space to open the cover for maintenance.

Space for cables

The minimum bend radius of the power cable is 90 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.


Ensure distance to the safeguard from the maximum motion range is more than 50 mm.


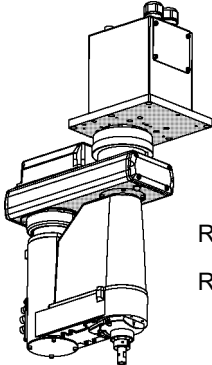


	RS3-351*	RS4-551*
Arm #1 Length	175 mm	275 mm
Arm #2 Length	175 mm	275 mm
Joint #1 Motion range	± 225 degree	
Joint #2 Motion range	± 225 degree	


3.4 Unpacking and Transportation

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


 WARNING	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 transport 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 and bottom of the base) by hand. When holding the bottom of the base by hand, be very careful not to get your hands or fingers caught. <div style="text-align: center;">  </div> <p style="text-align: right;"> RS3-351* : approx. 17 kg : 38 lb. RS4-551* : approx. 19 kg : 42 lb. </p> <ul style="list-style-type: none"> 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.
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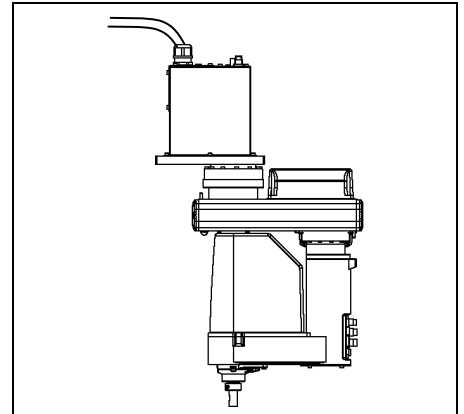
3.5 Installation

 CAUTION	<ul style="list-style-type: none"> ■ The robot system must be installed to avoid interference with buildings, structures, utilities, other machines and equipment that may create a trapping hazard or pinch points. ■ Vibration (resonance) may occur during operation depending on rigidity of the installation table. If the oscillation occurs, improve rigidity of the table or change the speed or acceleration and deceleration settings.
--	--

3.5.1 Standard-model

 CAUTION	<ul style="list-style-type: none"> ■ Install the Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. RS3-351*: approx. 17 kg : 38 lb. (except cables) RS4-551* : approx. 19 kg : 42 lb. (except cables) ■ When installing the Manipulator to the ceiling, support the Manipulator, and then secure the anchor bolts. Removing the support without securing the anchor bolts properly is extremely hazardous and may result in fall of the Manipulator.
--	--

- (1) Unpack the Manipulator with retaining the arm posture.



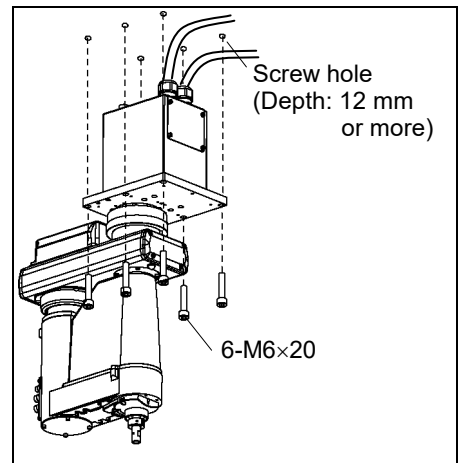
- (2) Secure the base to the wall with 6 bolts.



NOTE Intensity of the bolts should be equivalent to ISO898-1 Property Class 10.9 or 12.9.

Tightening torque:
13.0 N·cm (133 kgf·cm)



- (3) Remove the fixing jig for transport.



3.5.2 Cleanroom-model

- (1) Unpack the Manipulator outside of the clean room.
- (2) Secure the Manipulator to delivery equipment such as a pallet with bolts so that the Manipulator does not fall over.
- (3) Wipe off the dust on the Manipulator with a little alcohol or distilled water on a lint-free cloth.
- (4) Transport the Manipulator into the cleanroom.
- (5) Refer to the installation procedure of each Manipulator model and install the Manipulator.
- (6) Connect an exhaust tube to the exhaust port.

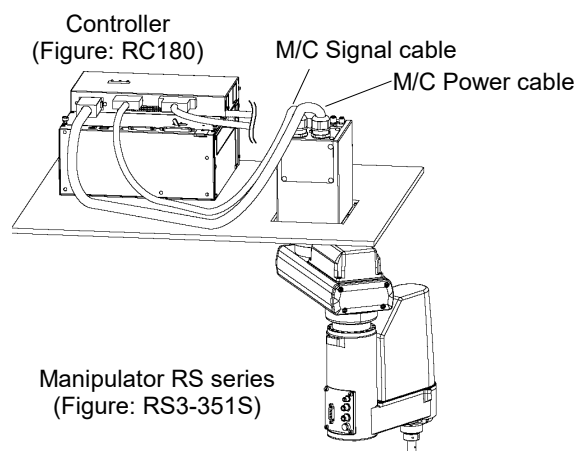
3.6 Connecting the Cables

 WARNING	<ul style="list-style-type: none"> ■ To shut off power to the robot system, disconnect 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 disconnect 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. ■ Grounding the manipulator is done by connecting with the controller. Ensure that the controller is grounded and the cables are correctly connected. If the ground wire is improperly connected to ground, it may result in the fire or electric shock.
 CAUTION	<ul style="list-style-type: none"> ■ When connecting the Manipulator to 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 <i>Controller manual</i>. If the Manipulator G series, E2 series or RS series is connected to the Controller for the 6-axis, it may result in malfunction of the Manipulator.


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

Cable Connections

Connect the power connector and signal connector of the M/C cables to the Controller.



3.7 User Wires and Pneumatic Tubes

 CAUTION	<p>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.</p>
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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
15 pin	Suitable Connector	JAE	DA-15PF-N (Solder type)
	Clamp Hood	JAE	DA-C8-J10-F2-1R (Connector setscrew: #4-40 NC)

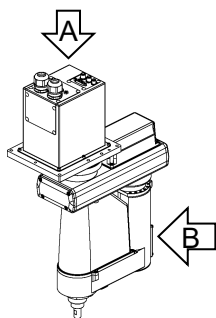
Pins with the same number, indicated on the connectors on both ends of the cables, are connected.

Pneumatic Tubes

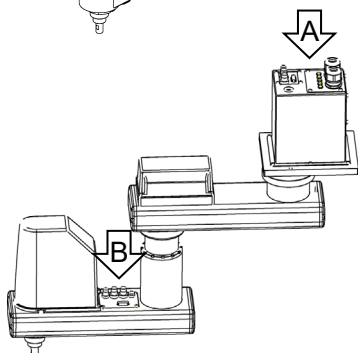
Max. Usable Pneumatic Pressure	Pneumatic Tubes	Outer Diameter × Inner Diameter
0.59 MPa (6 kgf/cm ² : 86 psi)	2	ø6 mm × ø4 mm
	1	ø4 mm × ø2.5 mm

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

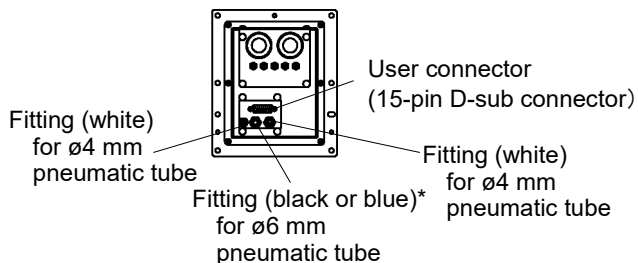
RS3-351*



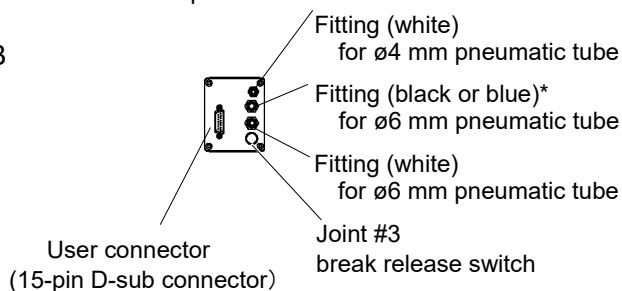
RS4-551*



A



B



* Color differs depending on the shipment time

NOTE



The Joint #4 (rotating) motion range is ±720 degrees. Be careful not to let the wires/tubes caught in the end effector.


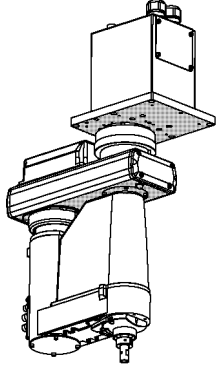
3.8 Relocation and Storage

3.8.1 Precautions for Relocation and Storage

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

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

 WARNING	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 support may result in a fall of the Manipulator, and then get hands, fingers, or feet caught. To transport 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 and bottom of the base) by hand. When holding the bottom of the base by hand, be very careful not to get your hands or fingers caught. <div style="text-align: right; margin-top: 20px;">  <p>RS3-351* : approx. 17 kg : 38 lb. RS4-551* : approx. 19 kg : 42 lb.</p> </div> <ul style="list-style-type: none"> 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 a robot system again after long-term storage, perform a test run to verify that it works properly, and then operate it thoroughly.


Transport and store the Manipulator in the range of -25°C to $+55^{\circ}\text{C}$.

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 Relocation procedure


 <p>WARNING</p>	<ul style="list-style-type: none">■ Install or relocate the Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. RS3-351* : approx. 17 kg: 38 lb. RS4-551* : approx. 19 kg: 42 lb.■ When removing the Manipulator from the ceiling, 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.
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- (1) Turn OFF the power on all devices and unplug the cables.
- (2) Hold the bottom of Arm #1 by hand to unscrew the anchor bolts. Then, remove the Manipulator.

4. Setting of End Effectors

4.1 Attaching an End Effector

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

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

Shaft

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

Brake release switch

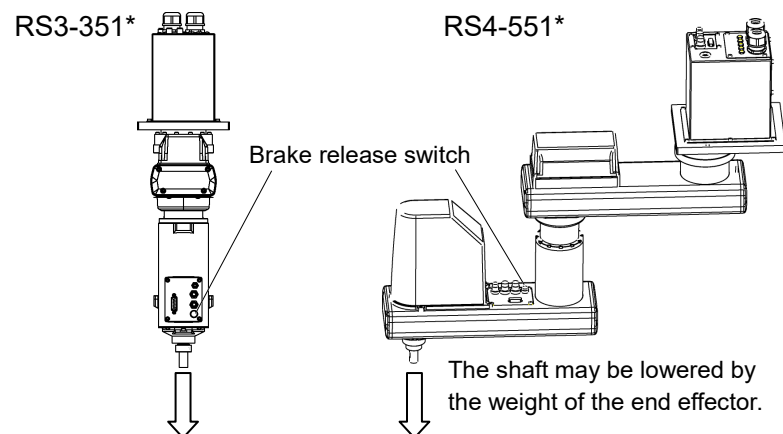
- Joint #3 cannot be moved up/down by hand because the electromagnetic brake is applied while power to the robot system is turned OFF.

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 though the power is turned ON.

When attaching an end effector, turn ON the Controller. Move Joint #3 up/down while pressing the brake release switch.

This button switch is a momentary-type; the brake is released only while the button switch is being pressed.

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

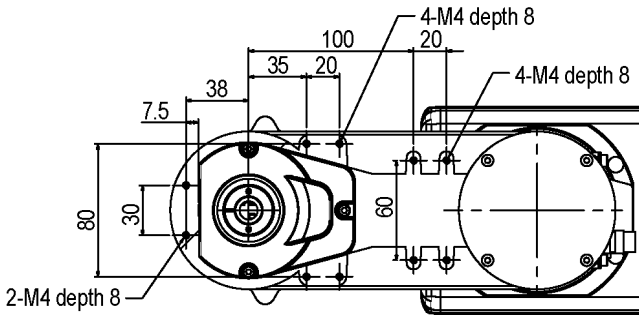


4.2 Attaching Cameras and Air valves

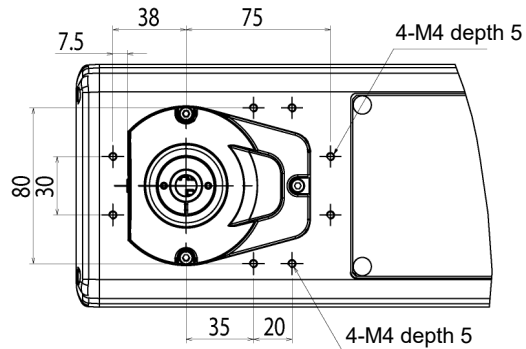


Arm #2 has threaded holes as shown in the figure below. Use these holes for attaching cameras, air valves, and other equipment. [Unit : mm]

RS3-351*



RS4-551*



- When cameras and air valves are attached, it can limit the motion range by wires and pneumatic tubes. Take extra care when designing and attaching.
- The Joint #4 (rotating) motion range is ± 720 degrees. Be careful not to let the wires/tubes caught in the end effector.

4.3 Weight and Inertia Settings

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

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

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

4.3.1 Weight Setting

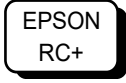
 CAUTION	<p>■ The total weight of the end effector and the work piece must not exceed RS3-351*: 3 kg, RS4-551*: 4 kg. The RS series Manipulators are not designed to work with loads exceeding RS3-351*: 3 kg, RS4-551*: 4 kg. Always set the Weight parameters according to the load. Setting a value that is smaller than the actual load may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.</p>
-------------	--

The acceptable weight capacity (end effector and work piece) in RS series is 1 kg at the default rating and RS3-351*: 3 kg, RS4-551*: 4 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 at PTP motion 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.



Enter a value into the [Load inertia:] text box on the [Inertia] panel ([Tools]-[Robot Manager]). (You may also execute the Inertia command from the [Command Window].)

Load on the Arm

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

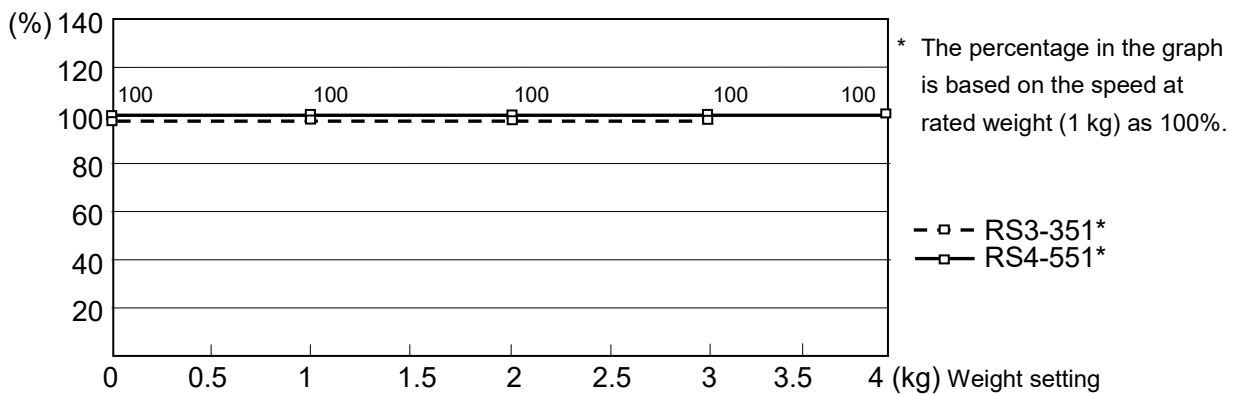
Equivalent Weight Formula

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

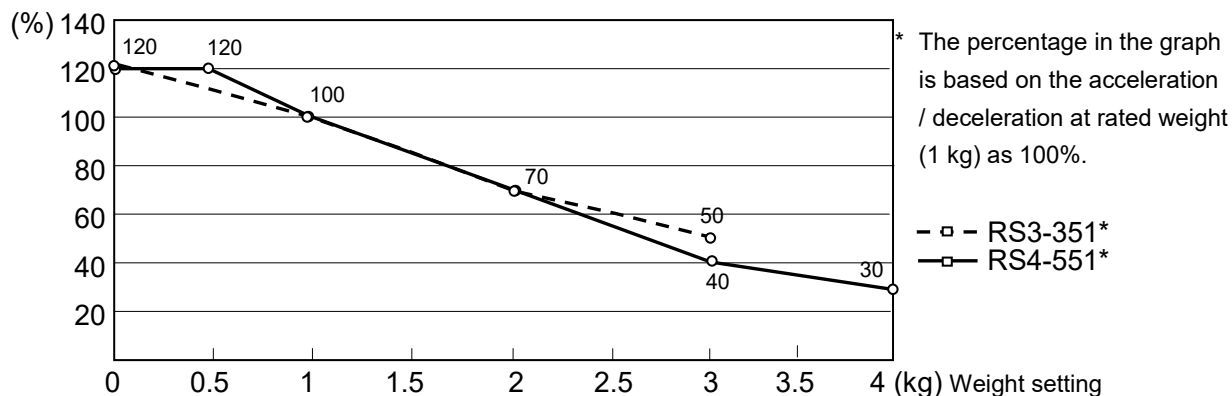
<Example> A “0.5 kg” camera is attached to the end of the RS series arm (250 mm away from the rotation center of Joint #2) with a load weight of “1 kg”.

$M = 0.5$
 $L_2 = 175$
 $L_M = 250$
 $W_M = 0.5 \times 250^2 / 175^2 = 1.02 \rightarrow 1.1$ (round up)
 $W + W_M = 1 + 1.1 = 2.1$
 Enter “2.1” for the Weight Parameter.

Automatic speed setting by Weight




Automatic acceleration/deceleration setting by Weight



4.3.2 Inertia Setting

Moment of Inertia and the Inertia Setting

The moment of inertia is defined as “the ratio of the torque applied to a rigid body and its resistance to motion”. This value is typically referred to as “the moment of inertia”, “inertia”, or “GD²”. When the Manipulator operates with additional objects (such as an end effector) attached to the shaft, the moment of inertia of load must be considered.

 CAUTION	<ul style="list-style-type: none"> ■ The moment of inertia of the load (weight of the end effector and work piece) must be 0.05 kg·m² or less. The RS series Manipulators are not designed to work with a moment of inertia exceeding 0.05 kg·m². Always set the moment of inertia parameter to the correct 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.
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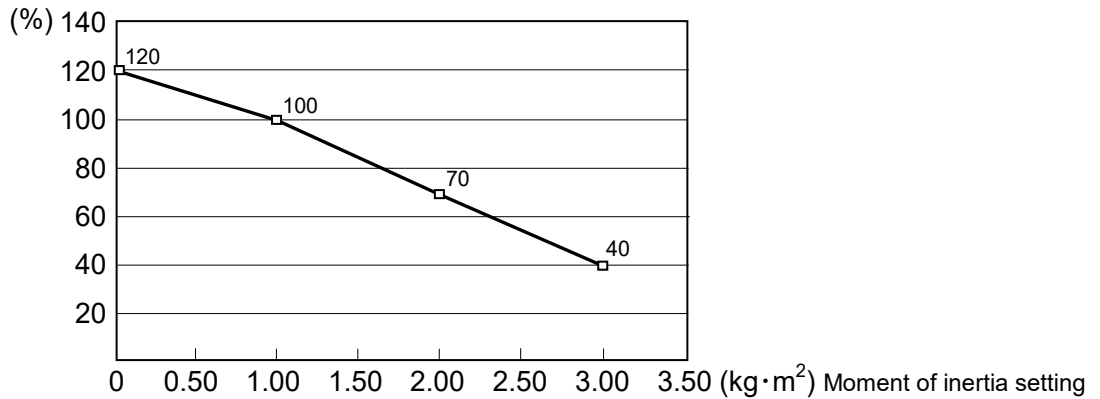
The acceptable moment of inertia of load for a RS series Manipulator is 0.005 kg·m² at the default rating and 0.05 kg·m² at the maximum. When the moment of inertia of the load exceeds the rating, change the setting of the moment of inertia parameter of the Inertia command. After the setting is changed, the maximum acceleration/deceleration speed of Joint #4 at PTP motion corresponding to the “moment of inertia” value is set automatically.

Moment of inertia of load on the shaft


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

EPSON RC+	Enter a value into the [Load inertia:] text box on the [Inertia] panel ([Tools]-[Robot Manager]). (You may also execute the Inertia command from the [Command Window].)
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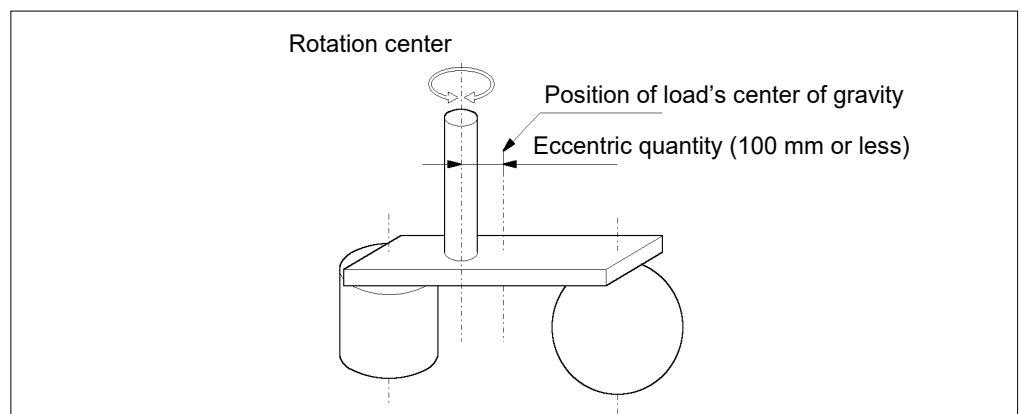
Automatic acceleration/deceleration setting of Joint #4 by Inertia (moment of inertia)



Eccentric Quantity and the Inertia Setting

 CAUTION	<ul style="list-style-type: none"> The eccentric quantity of load (weight of the end effector and work piece) must be 100 mm or less. The RS 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 RS series is 0 mm at the default 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 the Manipulator at PTP motion corresponding to the “eccentric quantity” is set automatically.

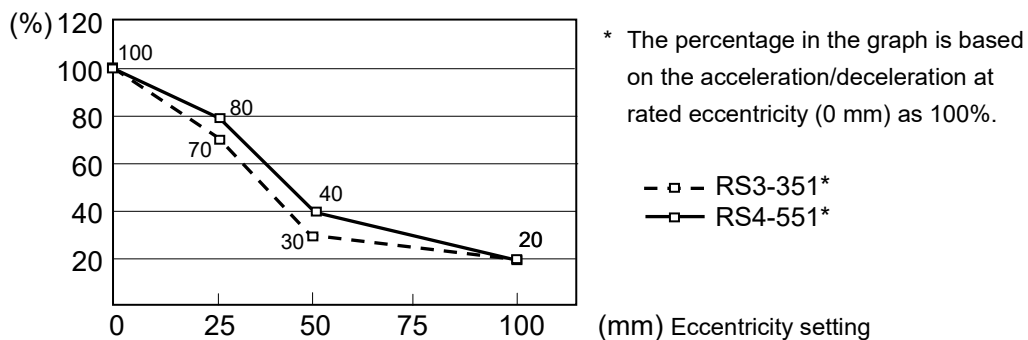


Eccentric quantity of load on the shaft

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

EPSON RC+ Enter a value into the [Eccentricity:] text box on the [Inertia] panel ([Tools] - [Robot Manager]). (You may also execute the Inertia command from the [Command Window].)

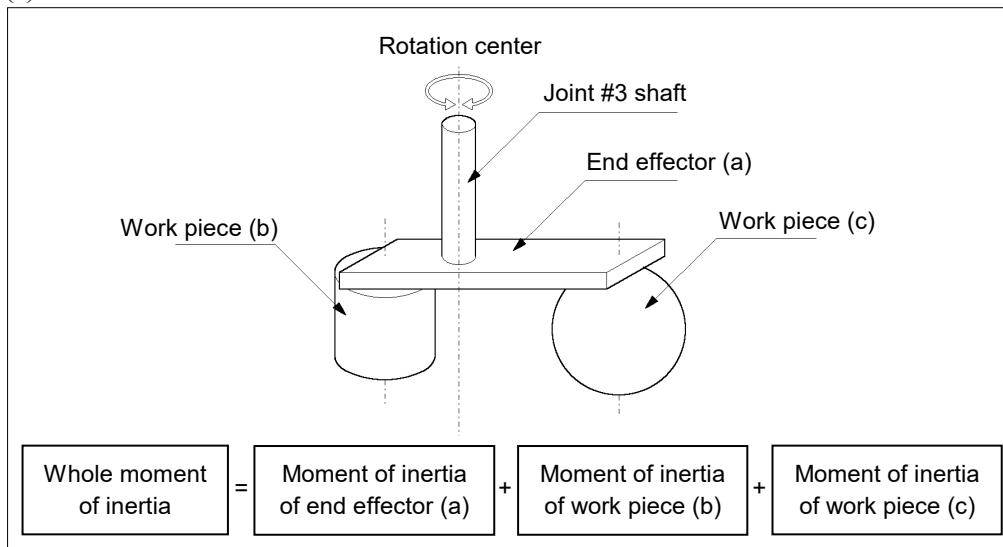
Automatic acceleration/deceleration setting by Inertia (eccentric quantity)



Calculating the Moment of Inertia

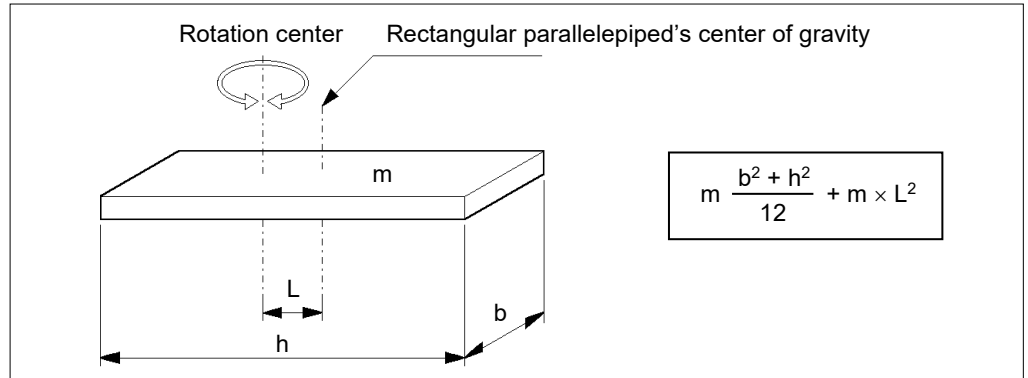
Refer to the following examples of formulas to calculate the moment of inertia of load (end effector with work piece).

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

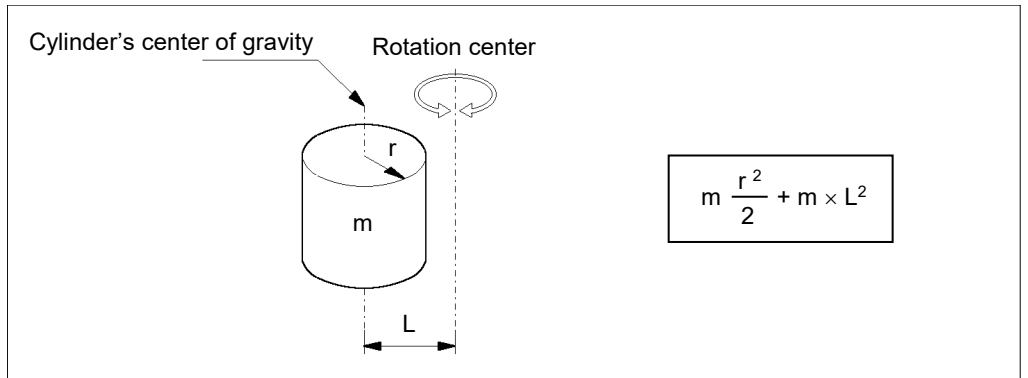


The methods for calculating the moment of inertia for (a), (b), and (c) are shown below. Calculate the total moment of inertia using the basic formulas.

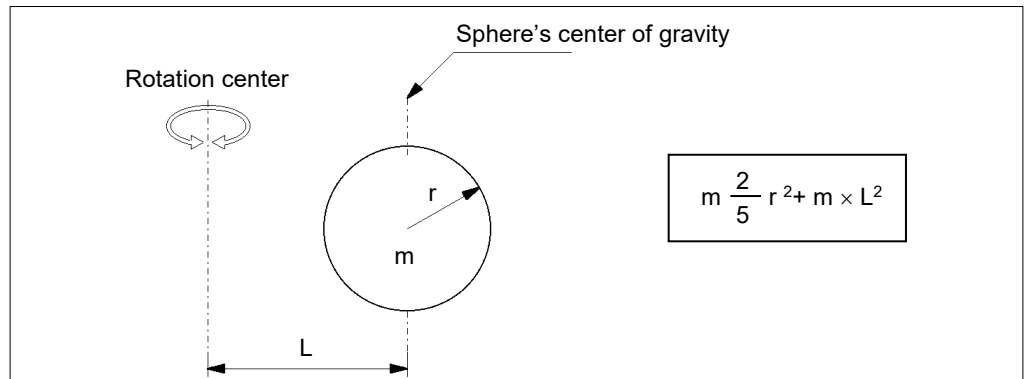
(a) Moment of inertia of a rectangular parallelepiped



(b) Moment of inertia of a cylinder



(c) Moment of inertia of a sphere



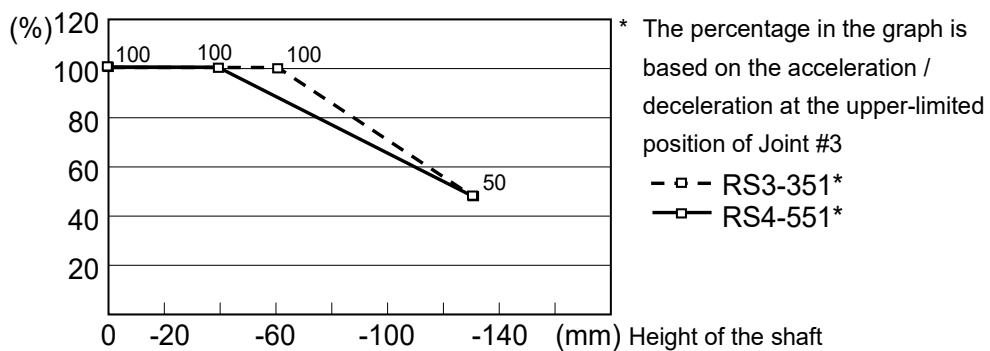
4.4 Precautions for Auto Acceleration/Deceleration of Joint #3

When you move the Manipulator in horizontal PTP motion with Joint #3 (Z) at a high position, the motion time will be faster.

When Joint #3 gets below a certain point, then auto acceleration/deceleration is used to reduce acceleration/deceleration. (Refer to the figure below.) The higher the position of the shaft is, the faster the motion acceleration/deceleration is. However, it takes more time to move Joint #3 up and down. Adjust the position of Joint #3 for the Manipulator motion after considering the relation between the current position and the destination position.

The upper limit of Joint #3 during horizontal motion using Jump command can be set by the LimZ command.

Automatic acceleration/deceleration vs. Joint #3 position



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

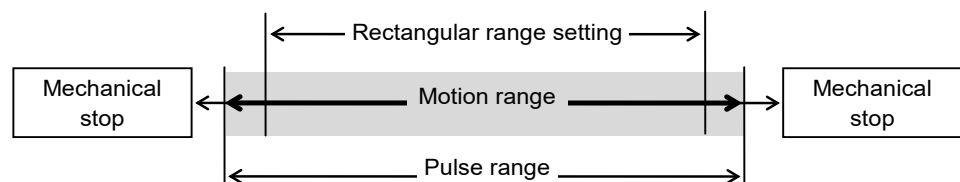


- When setting up the motion range for safety, both the pulse range and mechanical stops must always be set at the same time.

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 #3)
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

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.

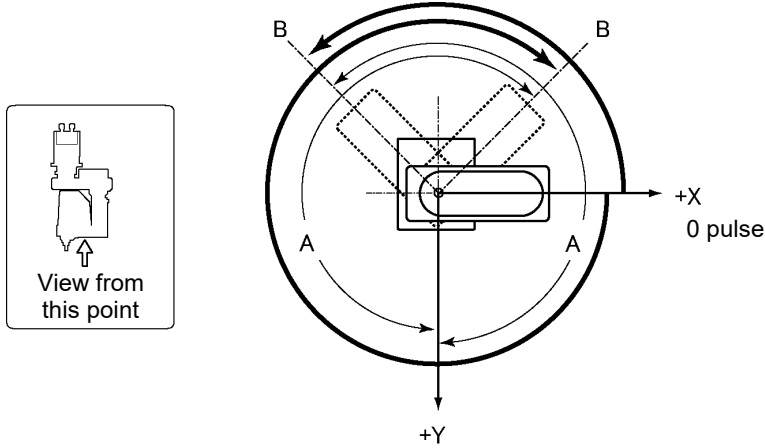
EPSON
RC+

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

5.1.1 Max. Pulse Range of Joint #1

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

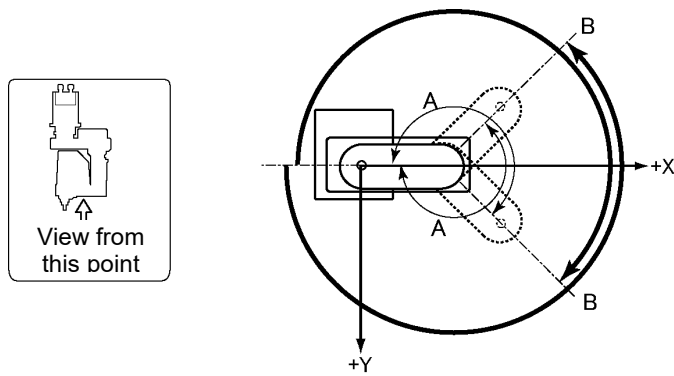
When the 0 pulse is a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).



- A : Max. motion range : $\pm 225^\circ$
- B : Max. pulse range : $- 2560000$ to $+5973334$ pulse (RS3-351*)
 $- 4096000$ to $+ 9557334$ pulse (RS4-551*)

5.1.2 Max. Pulse Range of Joint #2

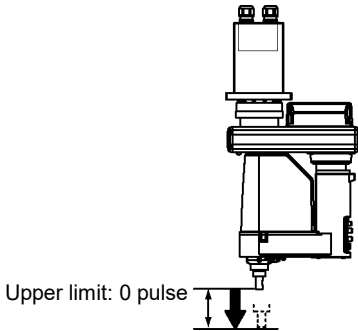
The 0 (zero) pulse position of Joint #2 is where Arm #2 overlaps straight with Arm #1 as shown in the figure below. With the 0 pulse as a starting point, the counterclockwise pulse value is defined as the positive (+) and the clockwise pulse value is defined as the negative (-).



- A : Max. motion range : $\pm 225^\circ$
- B : Max. pulse range : $- 4177920$ to $+ 4177920$ pulse

5.1.3 Max. Pulse Range of Joint #3

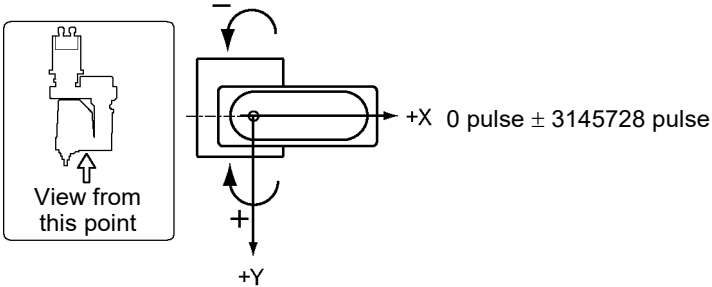
The 0 (zero) pulse position of Joint #3 is the position where the shaft is at its upper limit. The pulse value is always negative because Joint #3 always moves lower than the 0 pulse position.



Type	Joint #3 stroke	Lower limit pulse value
RS3-351S/RS4-551S	130 mm	- 1479112 pulse
RS3-351C/RS4-551C	100 mm	- 1137778 pulse

5.1.4 Max. Pulse Range of Joint #4

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

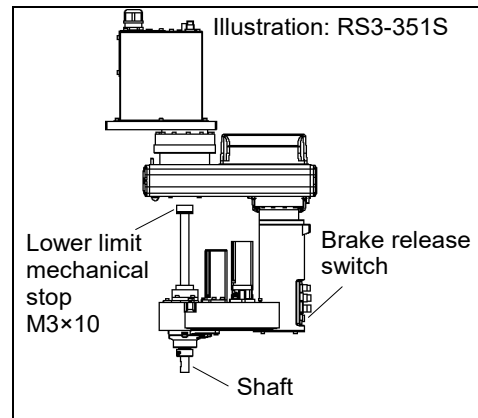


5.2 Motion Range Setting by Joint #3 Mechanical Stops

- (1) Turn ON the Controller and turn OFF the motors using the Motor OFF command.
- (2) Remove the Arm #2 cover (4-M4×10).
- (3) Push up the shaft while pressing the brake release switch.



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

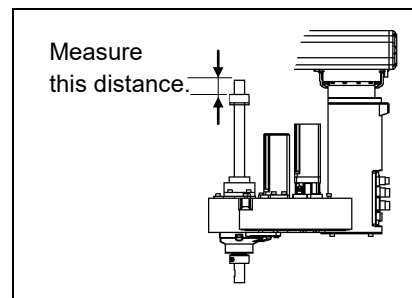


- (4) Turn OFF the Controller.
- (5) Loosen the lower limit mechanical stop screw (M3×10).



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

- (6) The upper end of the shaft defines the maximum stroke. Move the lower limit mechanical stop down by the length you want to limit the stroke. For example, when the lower limit mechanical stop is at “130 mm” stroke, the lower limit Z coordinate value is “-130”. To change the value to “-100”, move the lower limit mechanical stop down “30 mm”. Use calipers to measure the distance when adjusting the mechanical stop.



- (7) Firmly tighten two lower limit mechanical stop screws (M3×10).
Recommended tightening torque: 2.45 N·m (25 kgf·cm)
- (8) Turn ON the Controller.
- (9) Move Joint #3 to its lower limit while pressing the brake release switch, and then check the lower limit position. Do not lower the mechanical stop too far. Otherwise, the joint may not reach a target position.

- (10) 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.

<p>Lower limit of pulse (pulse) = lower limit Z coordinate value (mm) / Resolution (mm/pulse)</p>

** For the Joint #3 resolution,

refer to the section *Setup & Operation 2.4 Specifications*.

EPSON
RC+

Execute the following command from the [Command Window]. Enter the calculated value in X.

```
>JRANGE 3, X, 0 'Sets the pulse range of Joint #3
```

- (11) Use the Pulse command (Go Pulse command), and move Joint #3 to the lower limit position of the pulse range at low speed.

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.

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.

EPSON
RC+

Execute the following commands from the [Command Window]. Enter the value calculated in Step (10) in X.

```
>MOTOR ON 'Turns ON the motor
```

```
>SPEED 5 'Sets low speed
```

```
>PULSE 0, 0, X, 0 'Moves to the lower limit-pulse position of Joint #3.
```

(In this example, all pulses except those for Joint #3 are “0”. Substitute these “0s” with the other pulse values specifying a position where there is no interference even when lowering Joint #3.)

5.3 Setting the Cartesian (Rectangular) Range in the XY Coordinate System of the Manipulator (for Joints #1 and #2)

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

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

EPSON
RC+

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

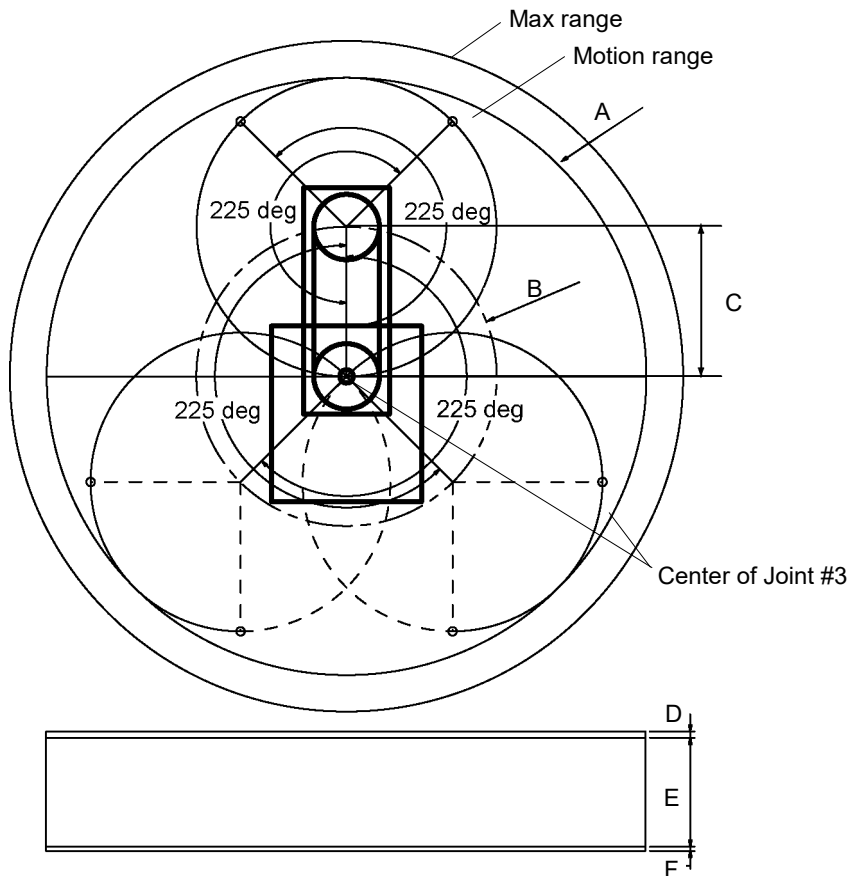
(You may also execute the XYLim command from the [Command Window].)

5.4 Standard Motion Range

The following “motion range” diagrams show 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 areas 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.



	RS3-351S	RS3-351C	RS4-551S	RS4-551C	
A	R350		R550		
B	R175		R275		
C	175 mm		275 mm		Arm#1, Arm#2 length
D	4	6.5	6	8.5	Joint #3 range to hit upper mechanical stop
E	130	100	130	100	Joint #3 stroke
F	1.8	3.8	4.8	7.8	Joint #3 range to hit lower mechanical stop

Maintenance

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

1. Safety Maintenance

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

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

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

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

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

When removing the arm from the Manipulator, for such as replacing the reduction gear unit, it must be done by two or more personnel.


For removing the Arm #1 cover, in case that the maintenance window is not installed to the base table, it needs to remove the Manipulator from the base table. Removing the Manipulator must be done by two or more personnel.




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



- To shut off power to the robot system, disconnect 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.

 WARNING	<ul style="list-style-type: none"> Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect 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	<ul style="list-style-type: none"> 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.
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2. General Maintenance

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

2.1 Maintenance Inspection

2.1.1 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.

h = hour

	Inspection Point					
	Daily inspection	Monthly inspection	Quarterly inspection	Biannual inspection	Annual inspection	Overhaul (replacement)
1 month (250 h)	Inspect every day	√				
2 months (500 h)		√				
3 months (750 h)		√	√			
4 months (1000 h)		√				
5 months (1250 h)		√				
6 months (1500 h)		√	√	√		
7 months (1750 h)		√				
8 months (2000 h)		√				
9 months (2250 h)		√	√			
10 months (2500 h)		√				
11 months (2750 h)		√				
12 months (3000 h)		√	√	√	√	
13 months (3250 h)		√				
⋮	⋮	⋮	⋮	⋮	⋮	⋮
20000 h						√

2.1.2 Inspection Point

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

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts, screws. Tighten them if necessary. (For the tightening torque, refer to <i>Maintenance: 2.4 Tightening Hexagon Socket Head Cap Bolts.</i>)	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
	Each arm locking bolts	√	√	√	√	√
	Bolts, screws around shaft					√
	Bolts, screws securing motors, reduction gear units, etc.					√
Check looseness of connectors. If the connectors are loosen, push it securely or tighten.	External connectors on Manipulator (on the connector plates etc.)	√	√	√	√	√
	Manipulator cable unit		√	√	√	√
Visually check for external defects. Clean up if necessary.	External appearance of Manipulator	√	√	√	√	√
	External cables		√	√	√	√
Check for bends or improper location. Repair or place it properly if necessary.	Safeguard etc.	√	√	√	√	√
Check tension of timing belts. Tighten it if necessary.	Inside of Arm #2				√	√
Grease conditions	Refer to <i>Maintenance: 2.3 Greasing.</i>					
Battery	Refer to <i>Maintenance: 11 Lithium Battery.</i>					

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					√
Turn ON and OFF the brake release switch and check the sound of the electromagnetic brake. If there is no sound, replace the brake.	Brake	√	√	√	√	√

2.2 Overhaul (Parts Replacement)



CAUTION

- Overhaul timing is based on an assumption that all joints are operated for equal distance. If a particular joint has a high duty or high load, it is recommended to overhaul all joints (as many as possible) before exceeding 20,000 operation hours with the joint as a basis.

The parts for the manipulator joints may cause accuracy decline or malfunction due to deterioration of the manipulator resulting from long term use. In order to use the manipulator for a long term, it is recommended to overhaul the parts (parts replacement).

The time between overhauls is 20,000 operation hours of the Manipulator as a rough indication.

However, it may vary depending on usage condition and degree of the load (such as when operated with the maximum motion speed and maximum acceleration / deceleration in continuous operation) applied on the Manipulator.



NOTE For the EPSON RC+ 7.0 Ver. 7.2.x or later (firmware Ver.7.2.x.x or later), the recommended replacement time for the parts subject to maintenance (motors, reduction gear units, and timing belts) can be checked in the [Maintenance] dialog box of the EPSON RC+ 7.0.

For details, refer to the following manual.

Robot Controller RC700 / RC700-A Maintenance 6. Alarm



NOTE For the EPSON RC+ 5.0 Ver. 5.4.7 or later (firmware Ver.1.16.4.x or 1.24.4.x or later), the recommended replacement time for the parts subject to maintenance (motors, reduction gear units, and timing belts) can be checked in the [Maintenance] dialog box of the EPSON RC+ 5.0.

For details, refer to the following manual.

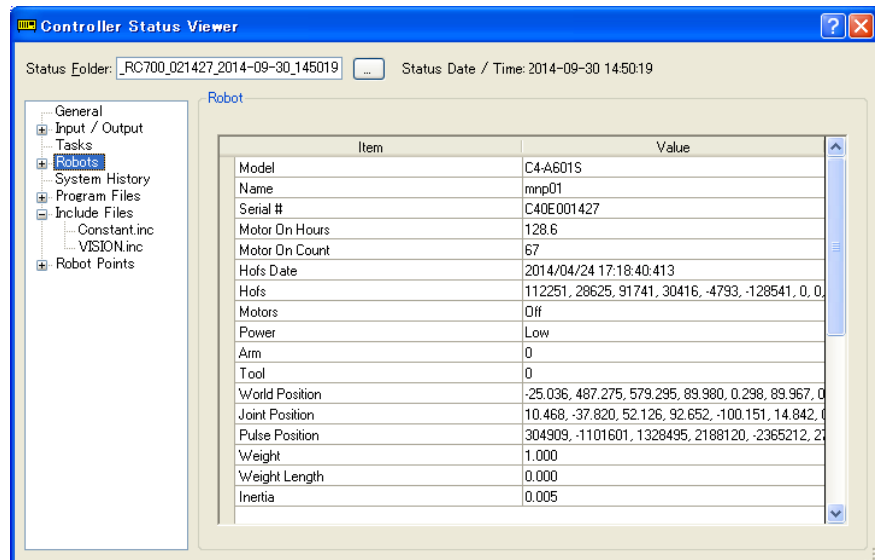
Robot Controller RC180 "Appendix. Alarm"

Note:

The recommended replacement time for the maintenance parts is when it reaches the L10 life (time until 10% failure probability). In the [Maintenance] dialog box, the L10 life is displayed as 100%.

The manipulator operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours].

- (1) Select EPSON RC+ menu-[Tools]-[Controller] to open the [Controller Tools] dialog.
- (2) Click the <View Controller Status> button to open the [Browse For Folder] dialog.
- (3) Select the folder where the information is stored.
- (4) Click <OK> to view the [Controller Status Viewer] dialog.
- (5) Select [Robot] from the tree menu on the left side (Dialog image: EPSON RC+ 7.0)




For the parts subject to overhaul, refer to *Maintenance 14. Maintenance Parts List*.


For details of replacement of each part, refer to the *Maintenance* section.

Please contact the supplier of your region for further information.

2.3 Greasing

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

 CAUTION	<ul style="list-style-type: none"> ■ 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.
--	--

 CAUTION	<ul style="list-style-type: none"> ■ If grease gets into your eyes, mouth, or on your skin, follow the instructions below. <ul style="list-style-type: none"> If grease gets into your eyes <ul style="list-style-type: none"> : Flush them thoroughly with clean water, and then see a doctor immediately. If grease gets into your mouth <ul style="list-style-type: none"> : 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 <ul style="list-style-type: none"> : Wash the area thoroughly with soap and water.
--	--

	Greasing part	Greasing Interval	Grease	Refer to <i>Maintenance</i> :
Joint #1 Joint #2	Reduction gear units	Overhaul timing	SK-1A	<i>5.2 Replacing the Joint #1 Reduction Gear Unit</i> <i>6.2 Replacing the Joint #2 Reduction Gear Unit</i>
Joint #3	Ball screw spline unit	At 100 km of operation (50 km for first greasing)	AFB	<i>10.1 Greasing the Ball Screw Spline Unit</i>

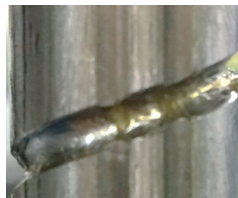
Joint #1, 2 reduction gear units

As a rough indication, perform greasing at the same timing as overhaul.

However, it may vary depending on usage condition and degree of the load (such as when operated with the maximum motion speed and maximum acceleration / deceleration in continuous operation) applied on the Manipulator.

Joint #3 Ball screw spline unit

The recommended greasing interval is at 100 km of operation. However, greasing timing also can be checked from the grease condition. Perform greasing if the grease is discolored or becomes dry.




Normal grease




Discolored grease

Perform greasing at 50 km of operation for the first time of greasing.

 NOTE For the EPSON RC+ 7.0 Ver. 7.2.x or later (firmware Ver.7.2.x.x or later), the recommended replacement time for the grease on the ball screw spline unit can be checked in the [Maintenance] dialog box of the EPSON RC+ 7.0.

For details, refer to the following manual.

Robot Controller RC700 / RC700-A Maintenance 6. Alarm

 NOTE For the EPSON RC+ 5.0 Ver. 5.4.7 or later (firmware Ver.1.16.4.x or 1.24.4.x or later), the recommended replacement time for the grease can be checked in the [Maintenance] dialog box of the EPSON RC+ 5.0.

For details, refer to the following manual.

Robot Controller RC180 "Appendix. Alarm"

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.

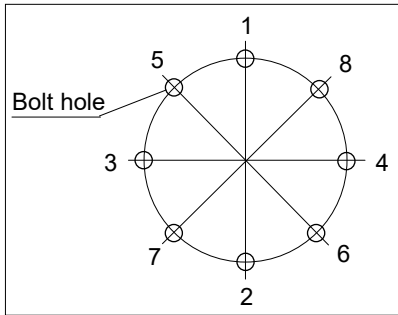
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

Bolt	Tightening Torque
M3	2.0 ± 0.1 N·m (21 ± 1 kgf·cm)
M4	4.0 ± 0.2 N·m (41 ± 2 kgf·cm)
M5	8.0 ± 0.4 N·m (82 ± 4 kgf·cm)
M6	13.0 ± 0.6 N·m (133 ± 6 kgf·cm)
M8	32.0 ± 1.6 N·m (326 ± 16 kgf·cm)
M10	58.0 ± 2.9 N·m (590 ± 30 kgf·cm)
M12	100.0 ± 5.0 N·m (1,020 ± 51 kgf·cm)

Refer below for the set screw.

Set Screw	Tightening Torque
M4	2.4 ± 0.1 N·m (26 ± 1 kgf·cm)
M5	3.9 ± 0.2 N·m (40 ± 2 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.

For calibration, the pulse values for a specific position must be recorded in advance. Before replacing parts, select easy point (pose) data from the registered point data to check the accuracy. Then, follow the steps below to display the pulse values and record them.

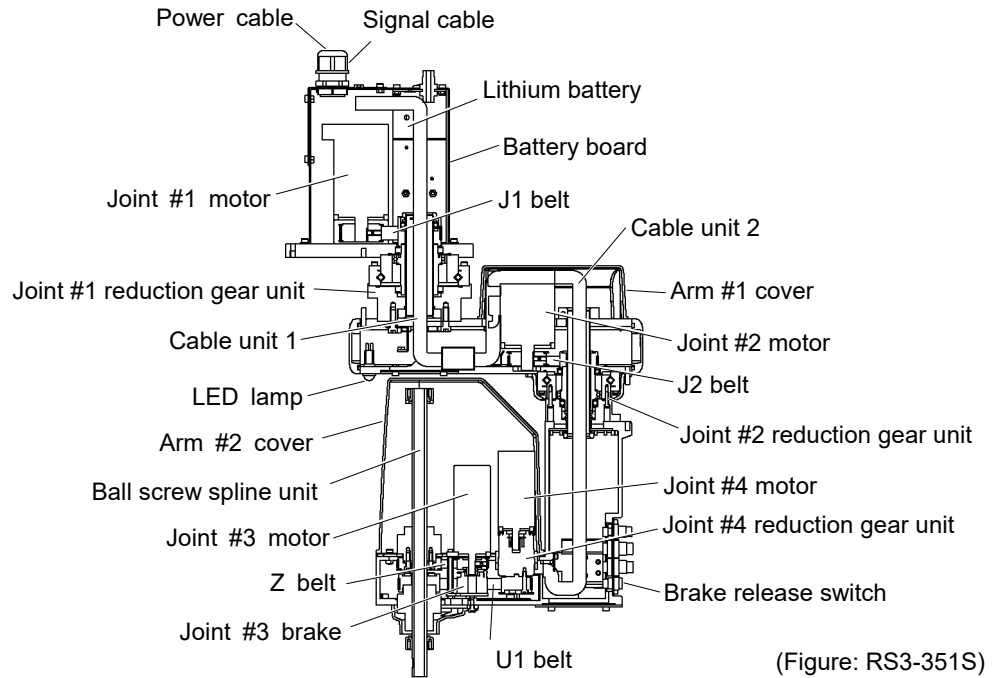


Execute the following command from the [Command Window].

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

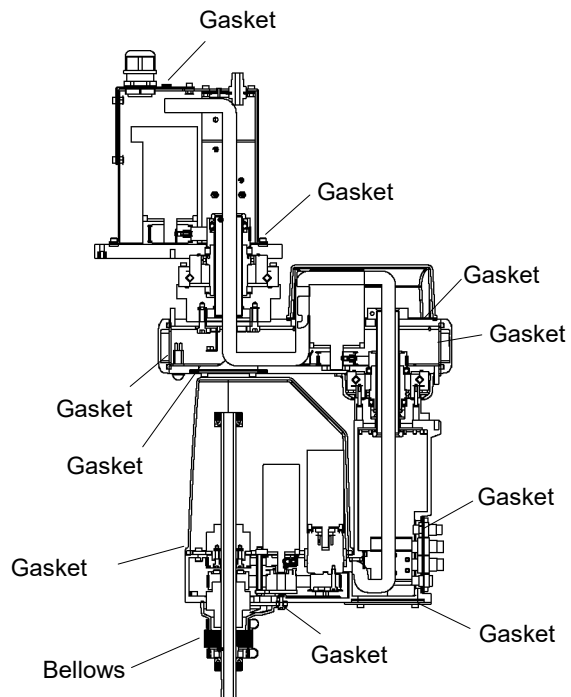
2.6 Layout of Maintenance Parts

Standard-model



(Figure: RS3-351S)


Cleanroom-model



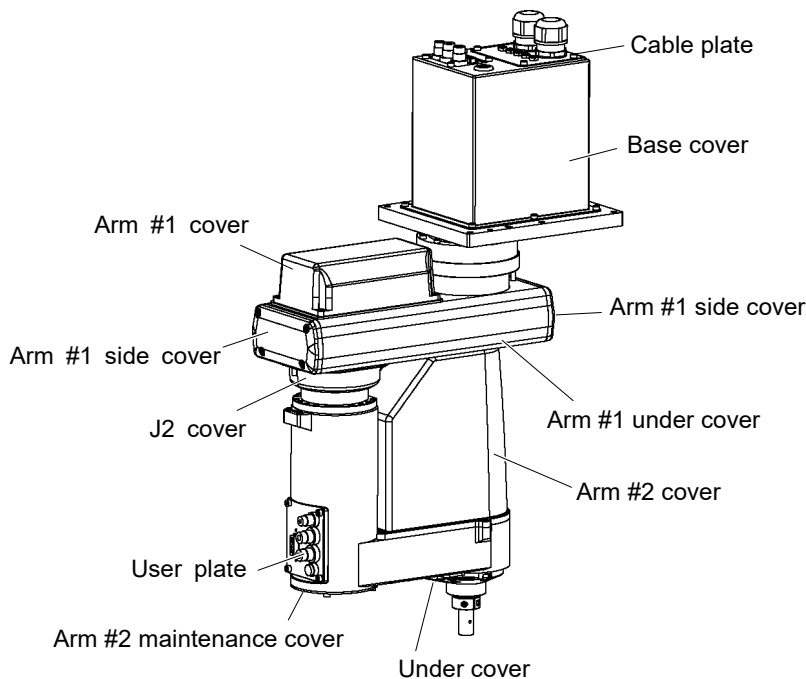
(Figure: RS3-351C)

3. Covers

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

 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting 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, disconnect 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 disconnect 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.
--	---

	Name	Quantity	Note
Maintenance parts	Gasket unit	1	1514477 (RS3-351C) 1548345 (RS4-551C) Only for Cleanroom-model
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw Tightening torque: 0.9 N·m (9.2 kgf·cm)
	Cross-point screwdriver	1	For bellows removal (Only for Cleanroom-model) For M4 truss Tightening torque: 0.9 N·m (9.2 kgf·cm)



3.1 Arm #1

The following covers are mounted to Arm #1.

Arm #1 cover	× 1
Arm #1 under cover	× 1
J2 cover	× 2
Arm #1 side cover	× 2

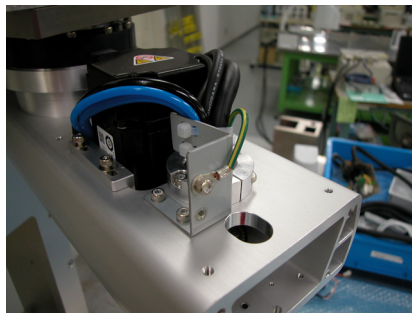
Remove the bolt (or screw) securing the cover to remove the cover.



CAUTION

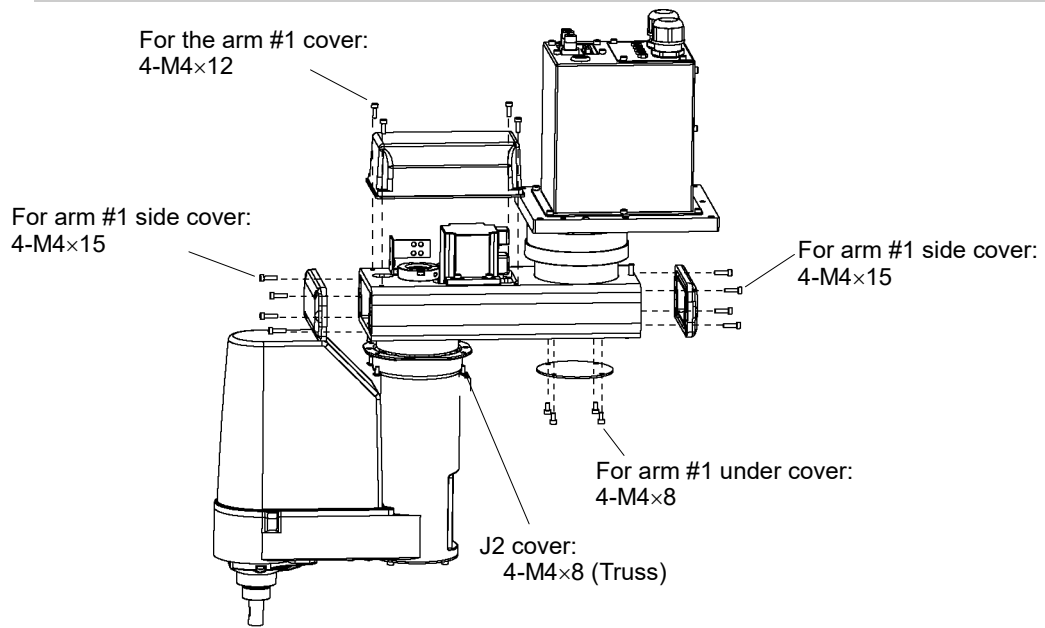
- When mounting the cover, do not allow the cables to interfere with the cover mounting or bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure that cause the electric shock and/or improper function 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.

When mounting Arm #1 cover, be sure to check the air tubes and cables are secured as in the figure below. Be careful not to squash the air tubes and cables with the cover.

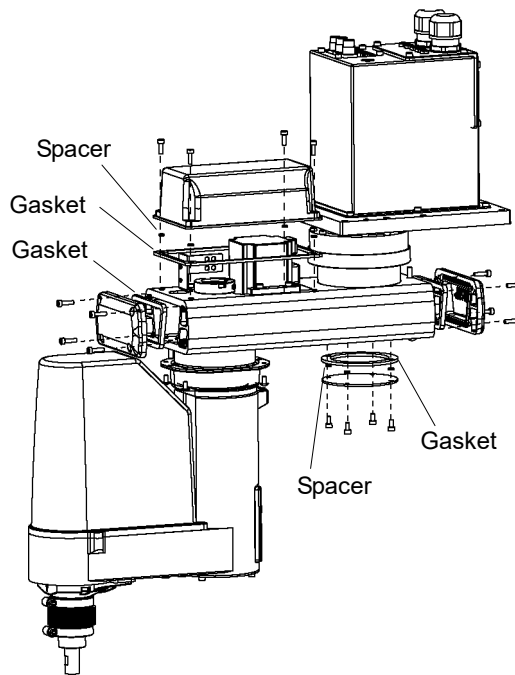


If the maintenance window is not designed in the base table, the Arm #1 cover cannot be removed. It needs to remove the Manipulator from the base table for the maintenance work. Be sure to remove the Manipulator from the base table by two or more personnel. For details, refer to *Setup & Operation 3. Environments and Installation*.

3.1.1 Standard-model



3.1.2 Cleanroom-model



Gaskets and spacers are installed to Cleanroom-model.

3.2 Arm #2

3.2.1 Arm #2 Cover



CAUTION

- When mounting 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.

Arm Top Cover Removal (1) Move the Arm #2 to the 180 degree.

Removal

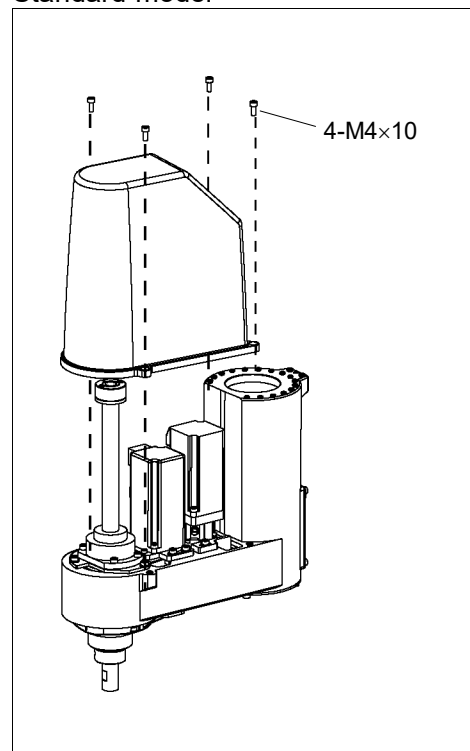
For the arm position, refer to the figure in *Maintenance 3.1 Arm #1*.

(2) Remove the Arm #1 side cover on the Joint #2 side.

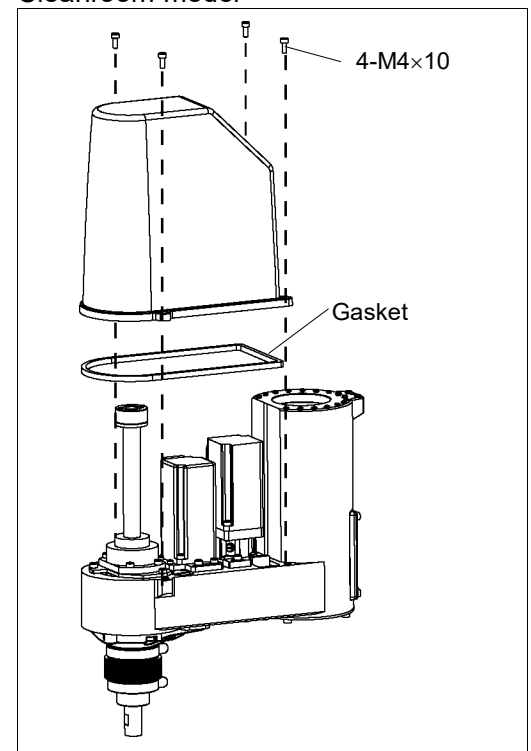
For details, refer to *Maintenance 3.1 Arm #1*.

(3) Remove the Arm #2 cover mounting bolt and hold the cover up.

Standard-model



Cleanroom-model



Arm Top Cover Installation

(1) Set the arm top cover to the arm and secure with the mounting bolts.

Gaskets are installed to the Cleanroom-model.

(2) Mount the Arm #1 side cover.

For details, refer to *Maintenance 3.1 Arm #1*.

3.2.2 Under Cover

Unscrew the under cover mounting bolts, and then pull the cover downward to remove it.



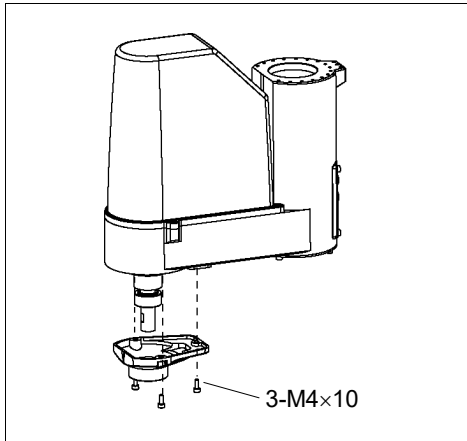
The under cover may not be removed from the shaft because the end effector is installed. If it is necessary to remove the cover completely (for replacement of the ball screw spline unit etc.), remove the end effector.

When the ball screw spline unit need to be replaced, remove the end effector and remove the under cover completely.

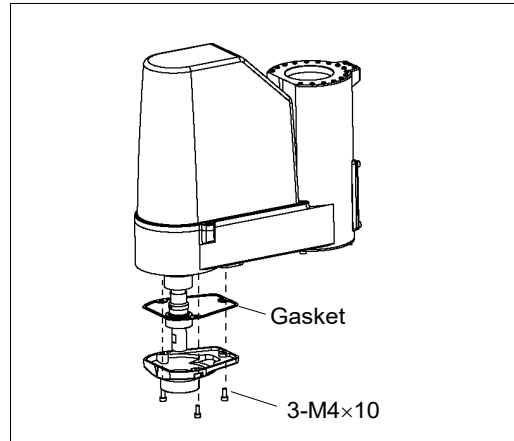
If it is not necessary to remove the cover completely, move the shaft to the lower limit, and lower the under cover. Then, perform maintenance or inspection.

When bellows are installed to the manipulator, remove or pull down the lower bellows and then remove the under cover. For bellows removal, refer to *Maintenance 9. Bellows*.

Standard-model



Cleanroom-model

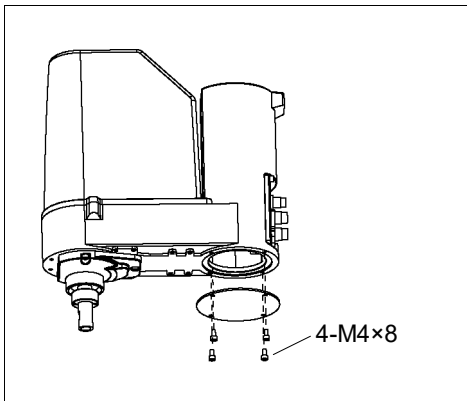


A gasket is installed to Cleanroom-model.

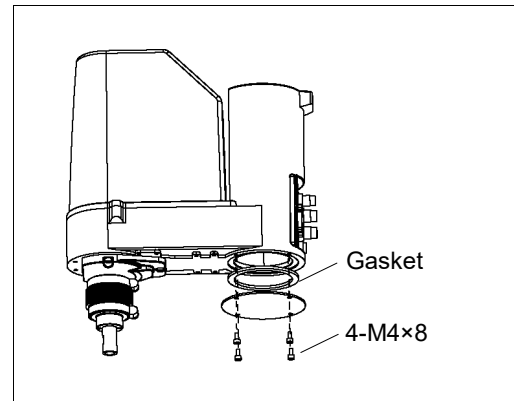
3.2.3 Arm #2 Maintenance Cover

Unscrew the bolts securing the Arm #2 maintenance cover, and then pull the cover downward to remove it.

Standard-model



Cleanroom-model



Gasket is installed to the Cleanroom-model.

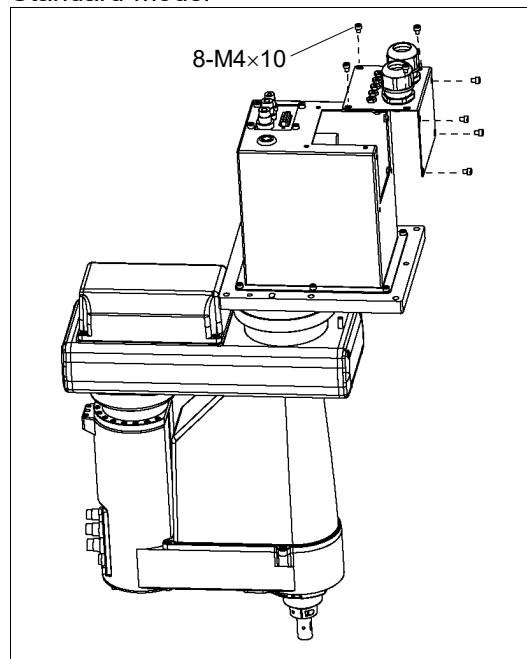
3.3 Connector Plate



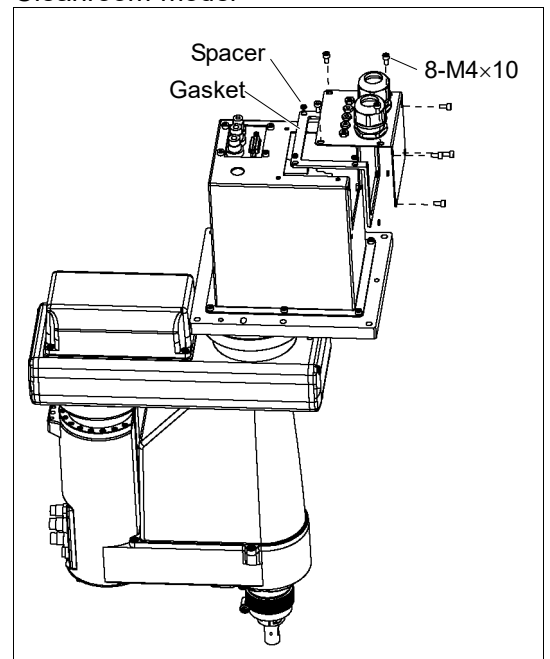
- Do not remove the connector plate forcibly. Removing the connector plate forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot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

Unscrew the connector plate mounting bolts and remove the plate.

Standard-model



Cleanroom-model



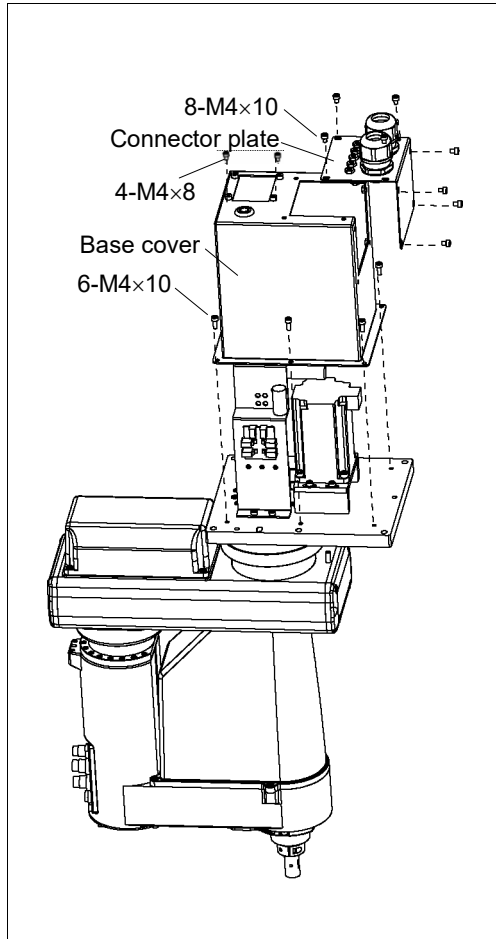
A gasket and spacer are installed to Cleanroom-model.

3.4 Base Cover

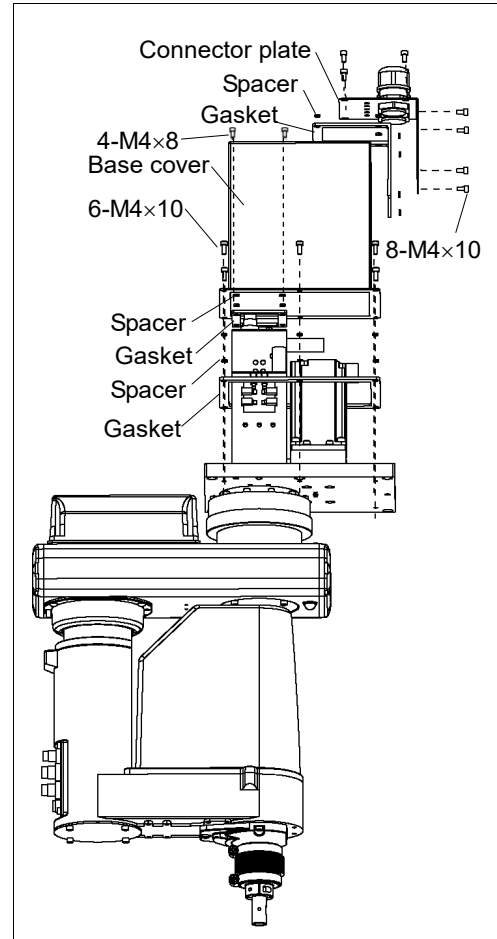
Before removing the base cover, remove the connector plate and disconnect the connectors.

Unscrew the bolts securing the base cover to remove the base cover.

Standard-model



Cleanroom-model

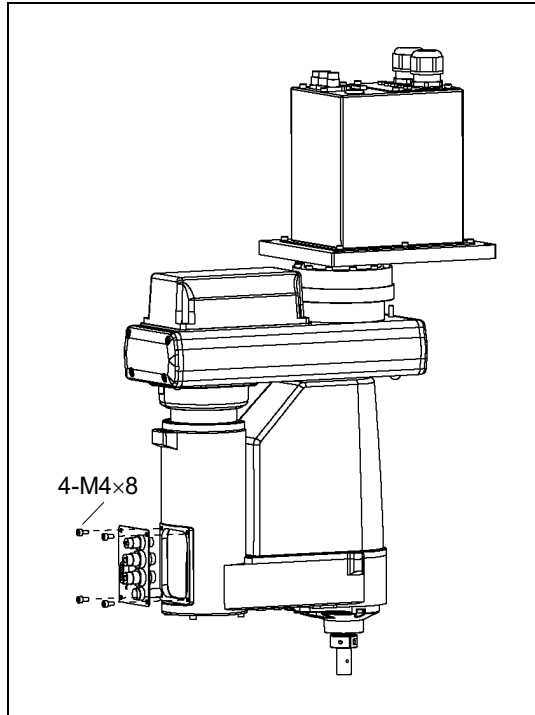


Gaskets and spacers are installed to the Cleanroom-model.

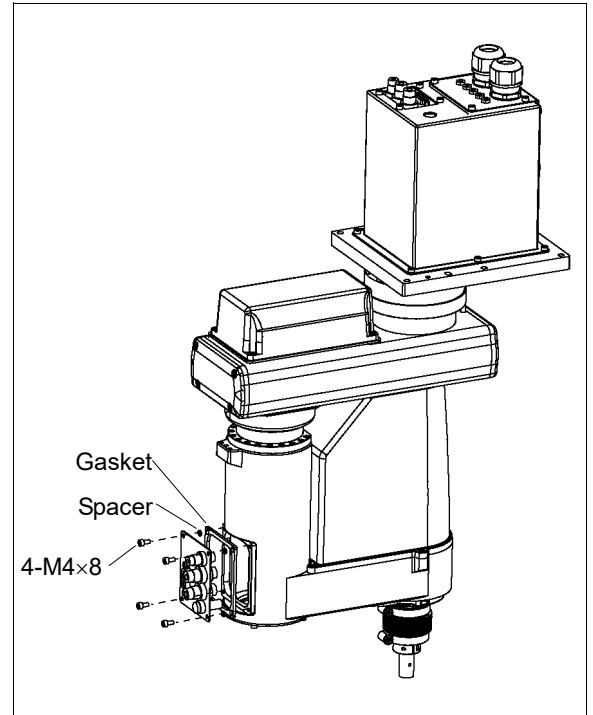
3.5 User Plate

Unscrew the user plate mounting bolts and remove the plate.

Standard-model





Cleanroom-model



A gasket and spacer are installed to Cleanroom-model.

4. Cable Unit

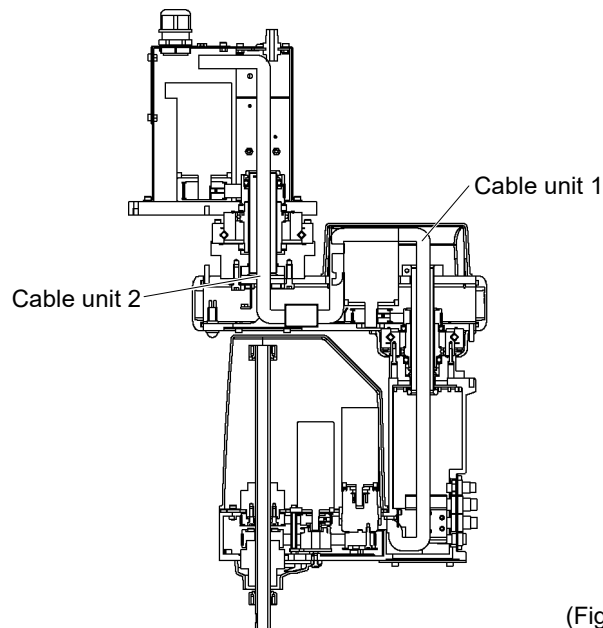
 <p>WARNING</p>	<ul style="list-style-type: none">■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.■ To shut off power to the robot system, disconnect 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 disconnect 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.■ Be sure to remove the Manipulator with two or more people. The Manipulator weight is as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. RS-351S : Approx. 17kg : 38lb.■ When installing the Manipulator to the ceiling, support the Manipulator, and then secure the anchor bolts. Removing the support without securing the anchor bolts properly is extremely hazardous and may result in fall of the Manipulator.
 <p>CAUTION</p>	<ul style="list-style-type: none">■ 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 Replacing Cable Unit


Since the power is supplied to each motor from the lithium battery installed on the battery board via the battery connector, the position data will not be lost when the Controller is turned OFF. When the battery connectors are disconnected, the position data will be lost, and EPSON RC+ will display an error when the Controller is turned ON.

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

	Name	Quantity	Note
Maintenance parts	Cable unit	1	Each manipulator model (Refer to Maintenance: 14. Maintenance parts)
	Battery Unit (Lithium battery)	3	2117879
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Hexagonal wrench (width across flats: 4 mm)	1	For M5 screw
	Hexagonal wrench (width across flats: 5 mm)	1	For M6 screw
	Spanner (width across flats: 5 mm)	1	For D-sub connector removal
	Nut screwdriver (width across flats: 5 mm)	1	For D-sub connector removal
	Nippers	1	For cutting wire tie
	Alcohol	Proper quantity	For wiping grease
	Wiping cloth	1	For wiping grease
Material	Wire tie	20	
Grease	Grease for cable (GPL-224)	10 g	

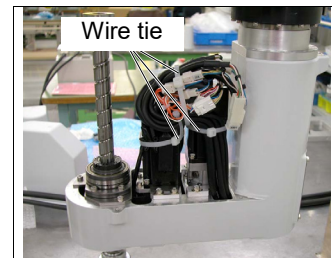


(Figure: RS3-351S)

 CAUTION	<ul style="list-style-type: none"> ■ 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 <i>Maintenance: 4.2 Wiring Diagrams</i>. ■ When mounting 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.
--	--

Cable unit
Removal

- (1) Turn OFF the Controller.
- (2) Disconnect the power cable and signal cable connectors from the controller.
- (3) Remove the Arm #2 cover.
For details, refer to *Maintenance 3.2 Arm #2*.
- (4) Cut off the wire ties bundling cables.



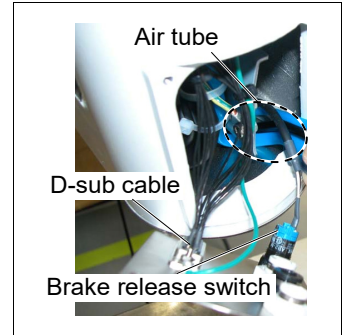
- (5) Connect the spare batteries to connector XB13, XB14 (in Arm #2 side).
- The position of motors of Joints #3 and #4 are stored by the battery in the base.
Connect the batteries to prevent the position data from losing.
- (6) Disconnect the connectors.
Connectors X31, X32, X33, X41, XB33, XB34, X331, X341
- (7) Remove the user plate, and it draws it out forward.
For details, refer to *Maintenance 3.5 User Plate*.

- (8) Disconnect the air tubes, ground wire, connector of the D-sub cable (XU11, XU21), and connector of the brake release switch from the user plate.

Press the ring on the fitting and pull out the air tube.
($\phi 6 \times 2$, $\phi 4 \times 1$)



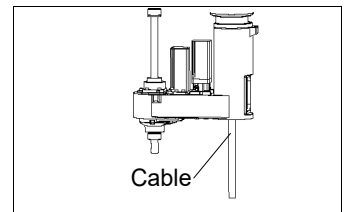
NOTE Be sure to remember the cable location to connect them to the original position.



- (9) Remove the ground wire from the cable mounting jig.
Cut off two wire ties bundling the cables.

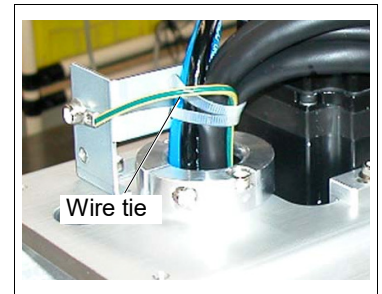
- (10) Remove the Arm #2 maintenance cover.
For details, refer to *Maintenance 3.2 Arm #2*.

- (11) Draw out the cables connected to the motor side forward in order of size with the thinnest one first.



- (12) Remove the Arm #1 cover.
For details, refer to *Maintenance: 3.1 Arm #1*.

- (13) Cut off two wire ties bundling the cables.
(14) Disconnect the ground wire.



- (15) Pull out the tubes and cables upward in order of size with the thinnest one first.
(Be careful about the connectors not to be caught.)

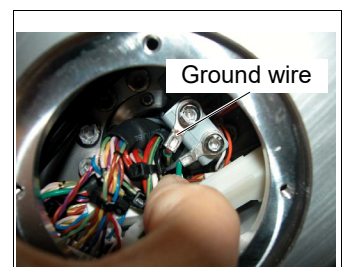
- (16) Remove the Arm #1 side cover and Arm #1 under cover.
For details, refer to *Maintenance 3.1 Arm #1*.

- (17) Connect the spare batteries to connector XB12 (in Arm #2 side).
- The position of motor of Joint #2 is stored by the battery in the base.
Connect the batteries to prevent the position data from losing.

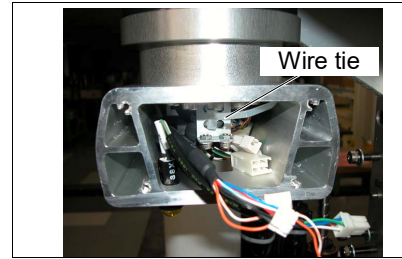
- (18) Push the cables and tubes drawn out before and disconnect the connectors from the hole of the under cover.

- (19) Disconnect the connectors except the battery connector.
Connectors X21, X22, X23, X30, XB22, XB23,
X221, X231, XU10, XU20

- (20) Remove the ground wire.



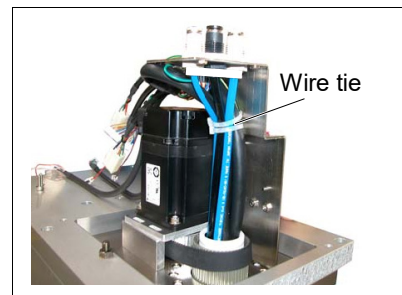
- (21) Cut off two wire ties bundling the cables
Pull out the cable unit 2.



- (22) Remove the Connector plate.
For details, refer to *Maintenance: 3.3 Connector plate*.
- (23) Remove the Base cover.
For details, refer to *Maintenance 3.4 Base cover*.

- (24) Remove the D-sub connector from the plate securing the cables.

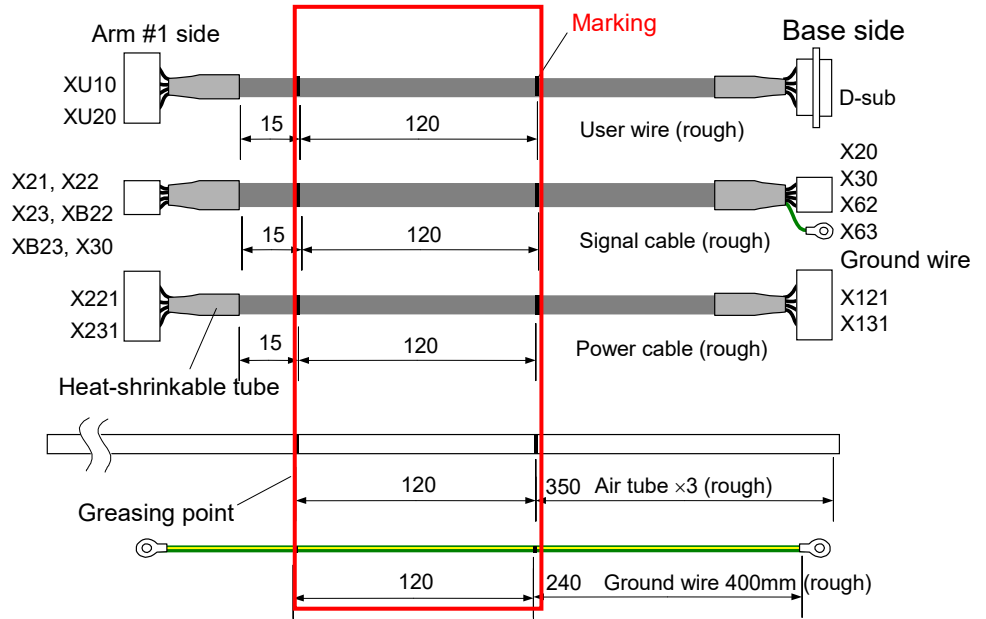
- (25) Remove three air tubes.
Cut off two wire ties bundling the cables.



- (26) Pull out the cable unit 2 and air tubes.
(Be careful about the connector not to be caught.)

Cable unit Installation

- (1) Mark the position of the cable unit 1 using a permanent marker.



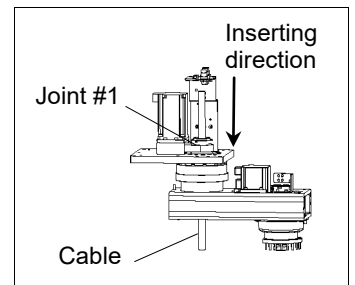
- (2) Cover both ends of the cables with plastic bags.
(The photo shows the one end covered with plastic bags.)

The plastic bags prevent grease adhesion to the ends of connectors/air tubes during the cable drawing.



- (3) Insert the cables to the Joint #1 from the base side. Be careful about the cable direction.
Refer to the connector label in Step (1).

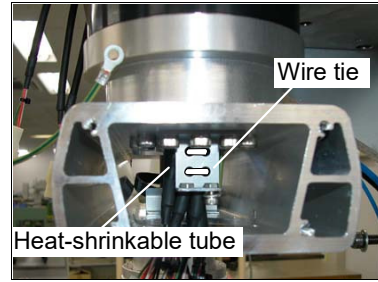
Insert the connectors in order of size with the largest one first, and then, the air tube and ground wire.
To prevent the cables and tube from falling off, pull them out from the bottom side temporarily and apply grease (GPL-224) to the marked point.
For the greasing point, refer to Step (1).



- (4) Put two wire ties to the cable mounting jig in Arm #1.

Secure cables, tube, and ground wire loosely.

Secure the bottom of the tube and ground wire where the grease (GPL-224) is applied.



- (5) Connect the connectors to the battery board of the base side.

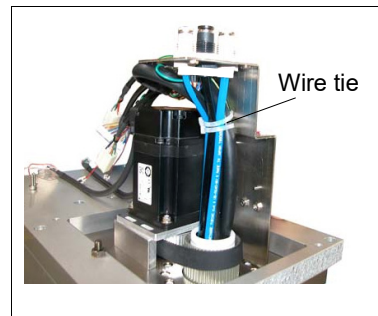
Connectors X62, X63

- (6) Draw out the connectors of Arm #1 side (X21, X22, XB22, X221) forward in the arm.

- (7) Connect the D-sub cable and air tubes connected to the J1 cable plate (inner side).

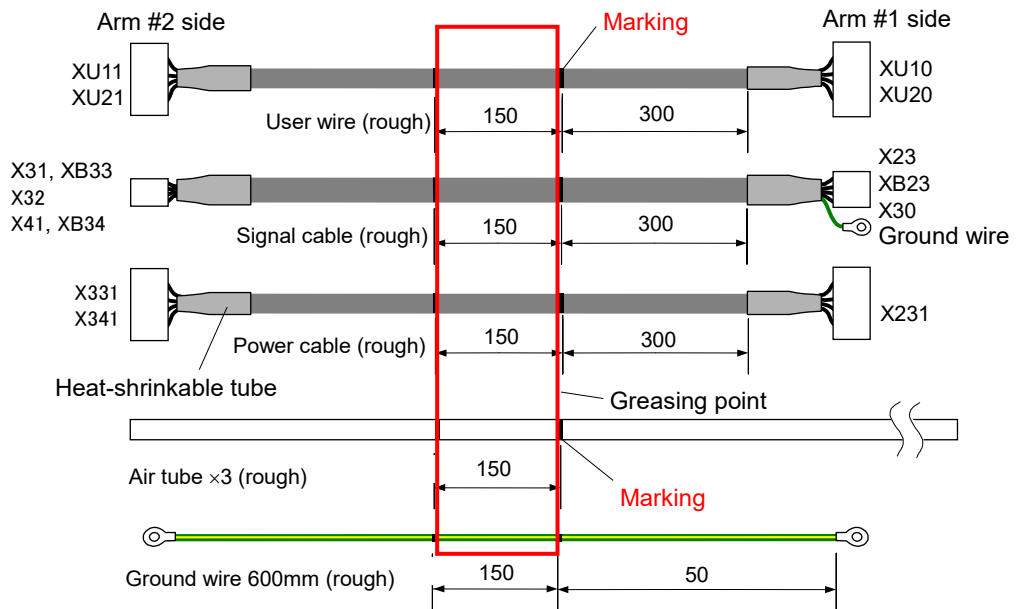
- (8) Push the wires, tubes, and ground wire downward and secure them to the cable mounting plate with the wire tie.

When bundling the cables, untangle the cables and put Arm #1 to the position of 90 degree (end of the arm faces to the other side to the J1 motor.)



- (9) Install the ground wire.

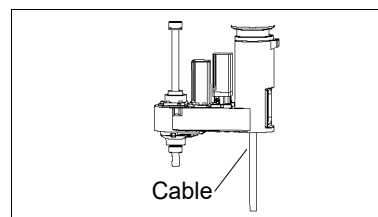
- (10) Mark the position of the cable unit 2 using a permanent marker.



- (11) Insert the cables to the Arm #1.

Be careful about the cable direction.

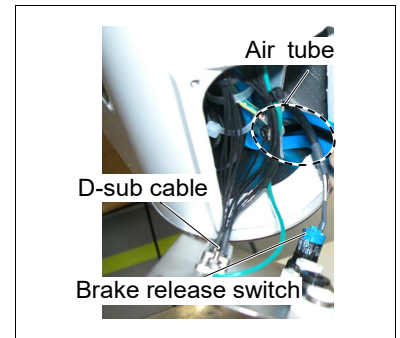
Refer to the connector label in Step (1).



- (12) Secure the cables with the wire tie.

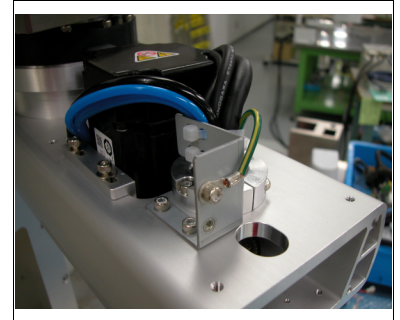
The wire tie should be a little away from the greasing part of the cables.

Untangle the cables and bundle them at the position of calibration point of Arm #2 (where Arm #1 overlaps with Arm #2).



- (13) Connect the ground wire.

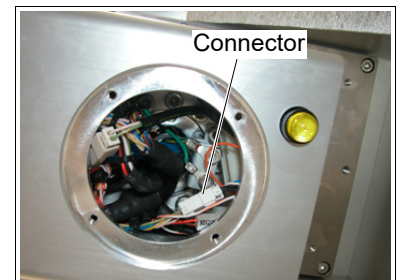
- (14) Secure the air tubes and cables to both sides of the motor.



- (15) Connect the ground wire.

- (16) Connect the connectors.

Connectors X21, X22, X23, X30, XB22, XB23, X221, X231, XU10, XU20.

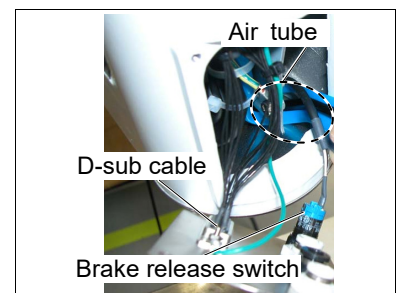


- (17) Remove the spare battery from XB12.

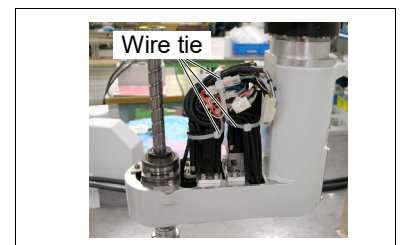
- (18) Secure the cables with the wire tie.

- (19) Install the ground wire to the connector plate.

- (20) Connect the D-sub cable connectors (XU11, XU21) and air tubes connected to the inner side of connector plate.



- (21) Put the cable unit 2 to the wire hole of Arm #2 and bundle the cables with the wire tie.



- (22) Connect the connectors.

Connectors X31, X32, X33, X41, XB33, XB34, X331, X341.

For details, refer to *Maintenance 4.2 Wiring Diagrams*.

- (23) Remove the spare batteries from XB13 and XB14.

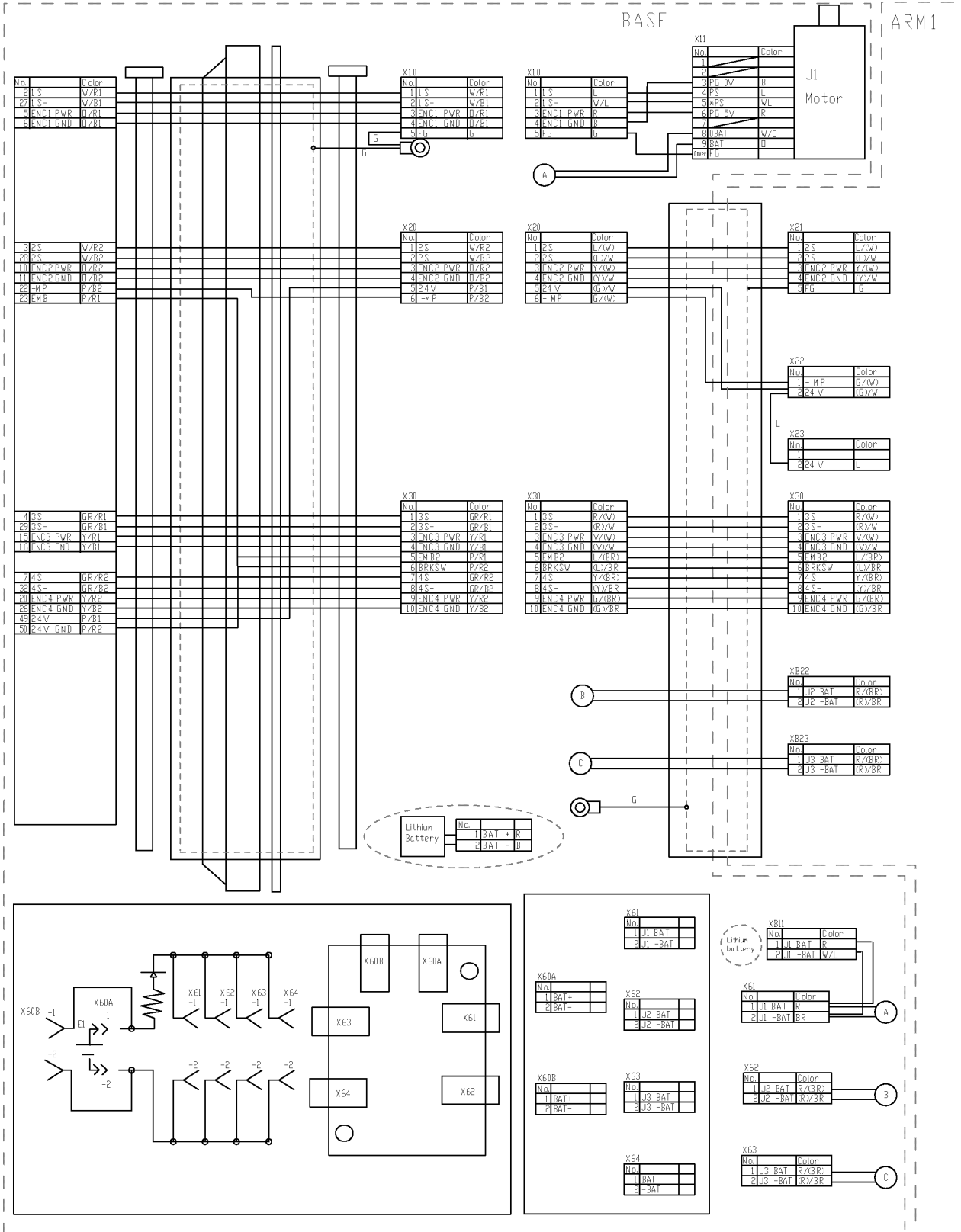
- (24) Mount the user plate to the Arm #2 cover.
For details, refer to *Maintenance 3.5 User Plate*.
- (25) Set and secure the Arm #2 cover and Arm #2 maintenance cover without the cables being stuck.
For details, refer to *Maintenance 3.2 Arm #2*.
- (26) Mount the Arm #1 cover, Arm #1 side cover, and Arm #1 under cover.
For details, refer to *Maintenance 3.1 Arm #1*.
- (27) Install the Base cover.
For details, refer to *Maintenance 3.4 Base Cover*.
- (28) Connect the connector and install the connector plate.
For details, refer to *Maintenance 3.3 Connector Plate*.
- (29) Perform the calibration of all axis.

4.2 Wiring Diagrams

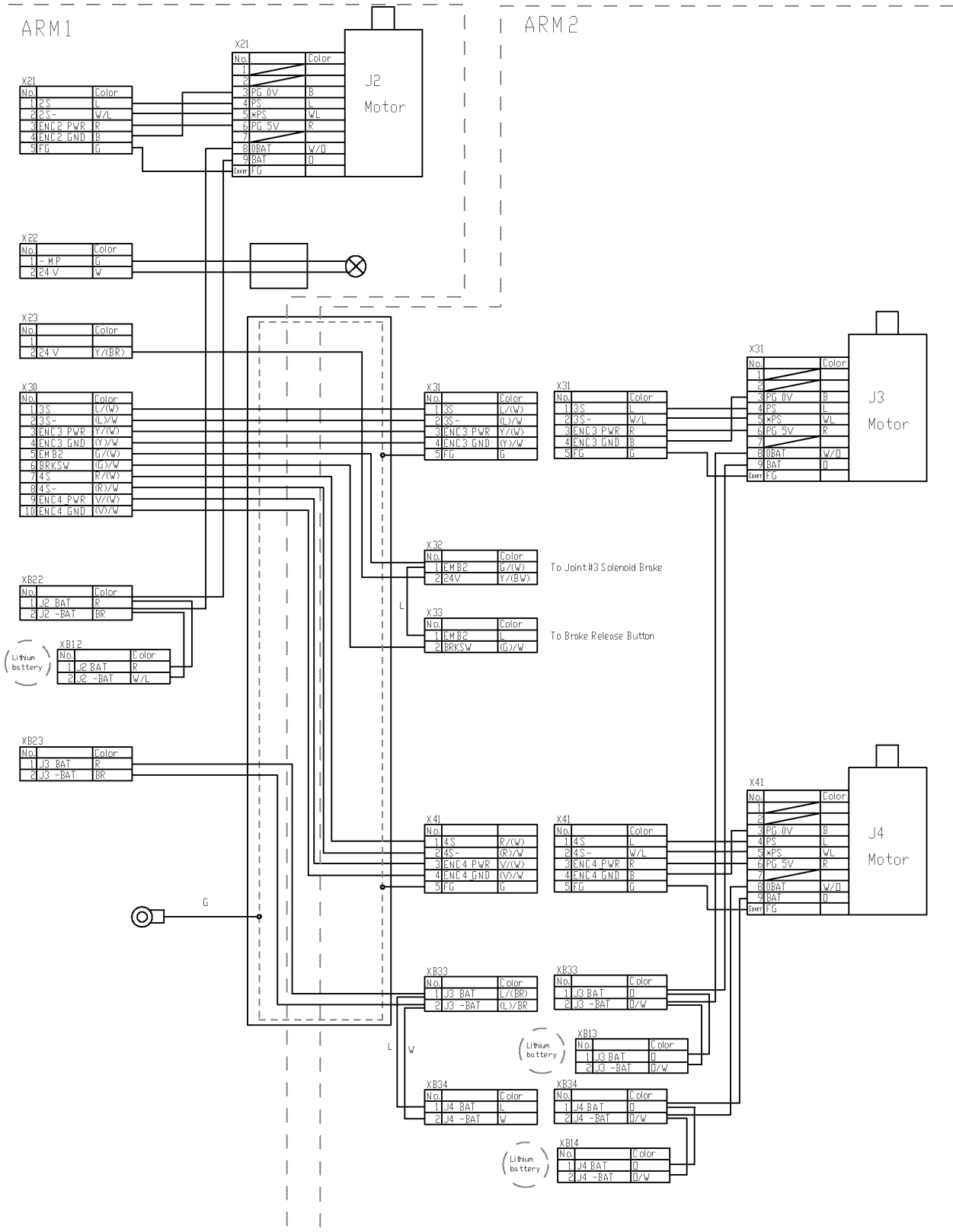
4.2.1 Signal Cable

For the colors and symbols of the cables, refer to *Maintenance 4.2.2 Power Cable*.

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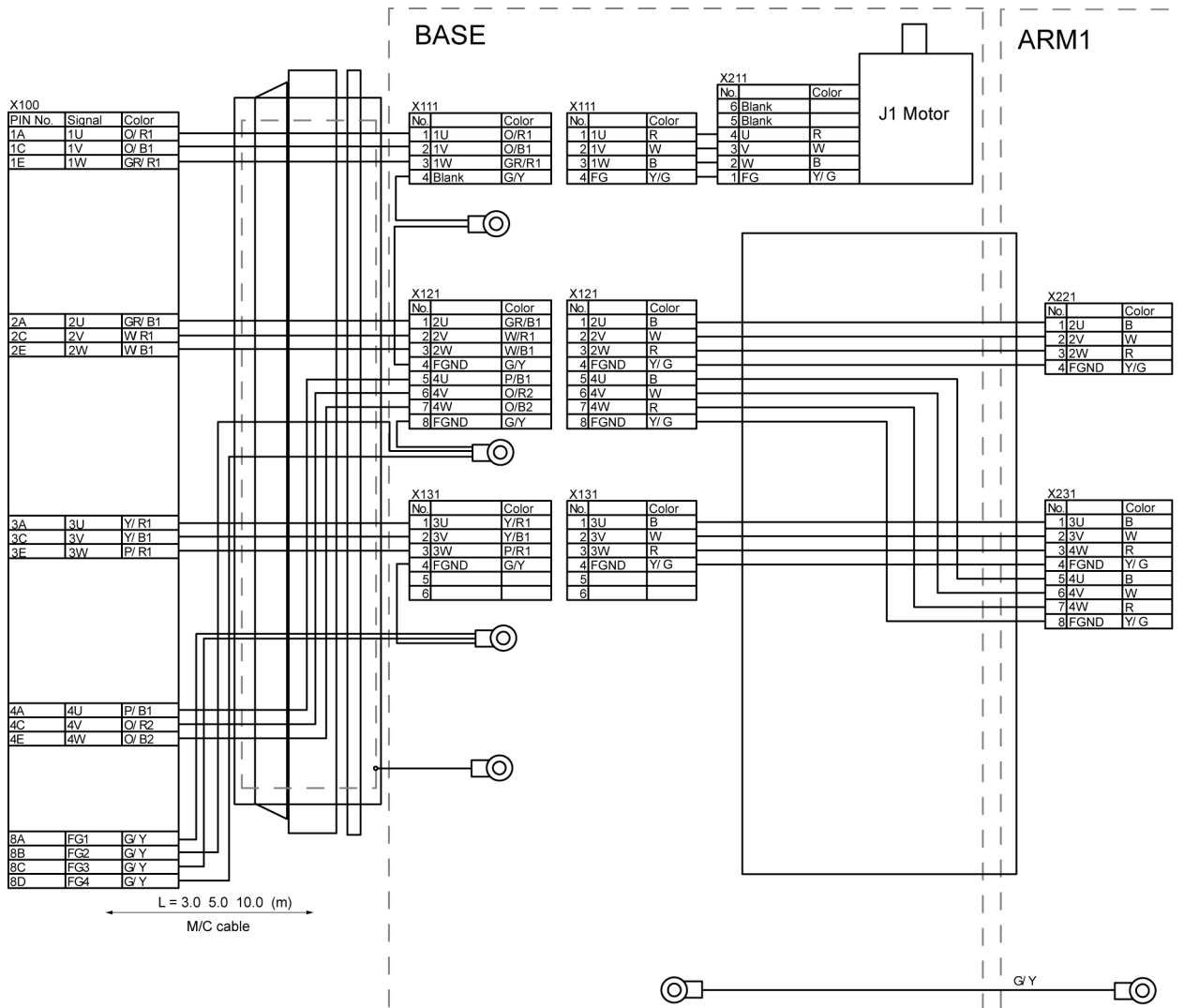
Continued from the previous page



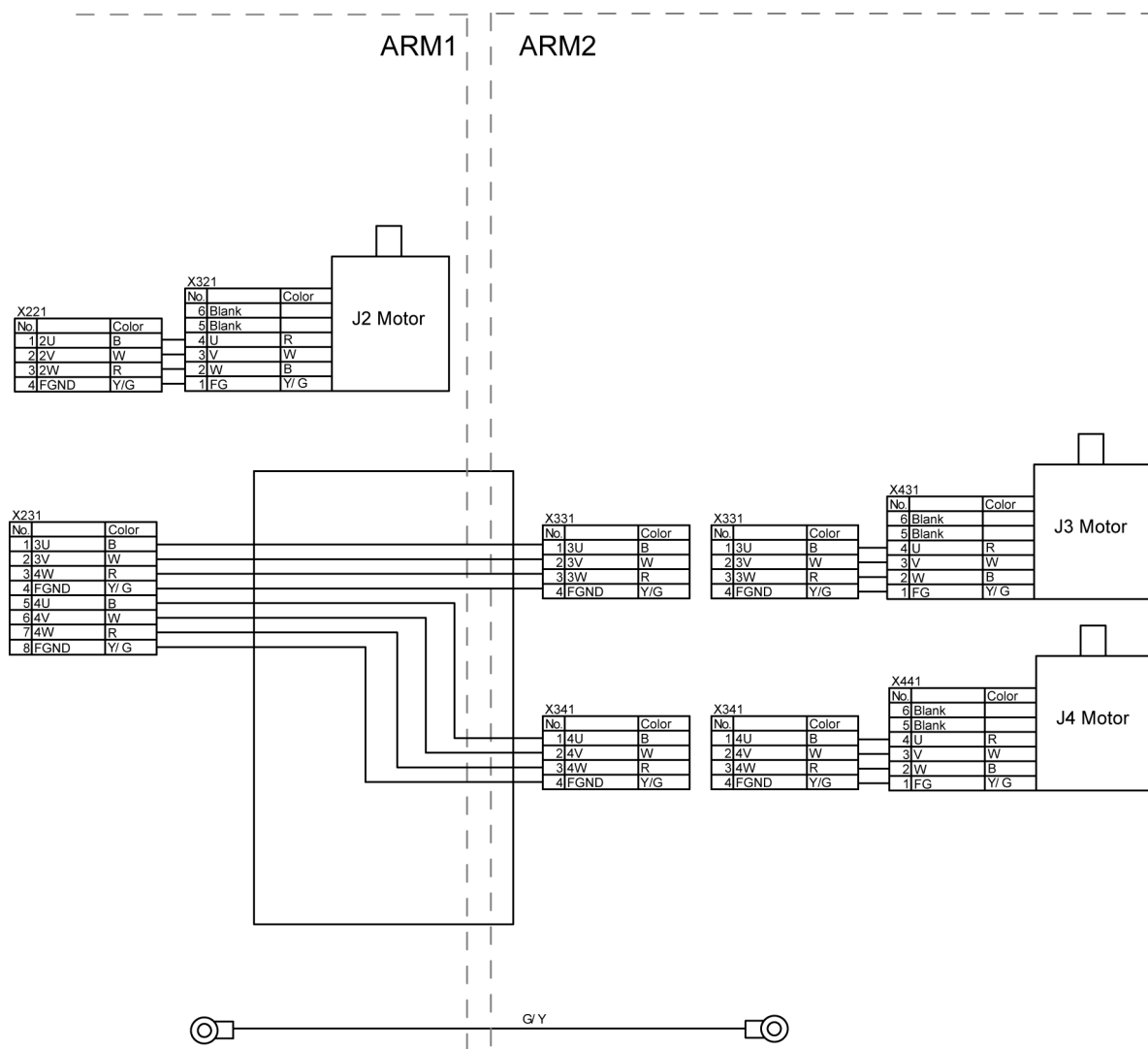
4.2.2 Power Cable

RC180

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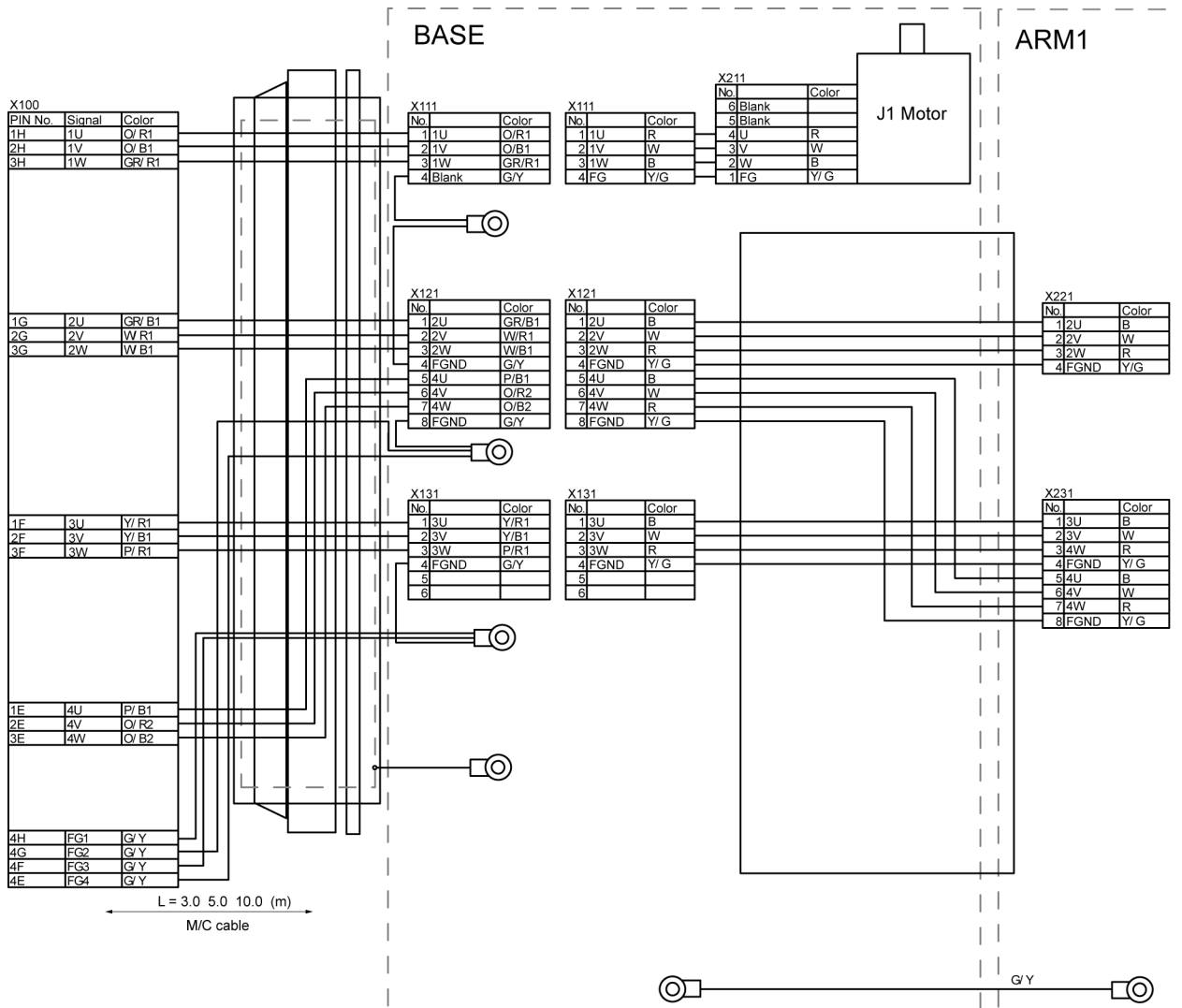


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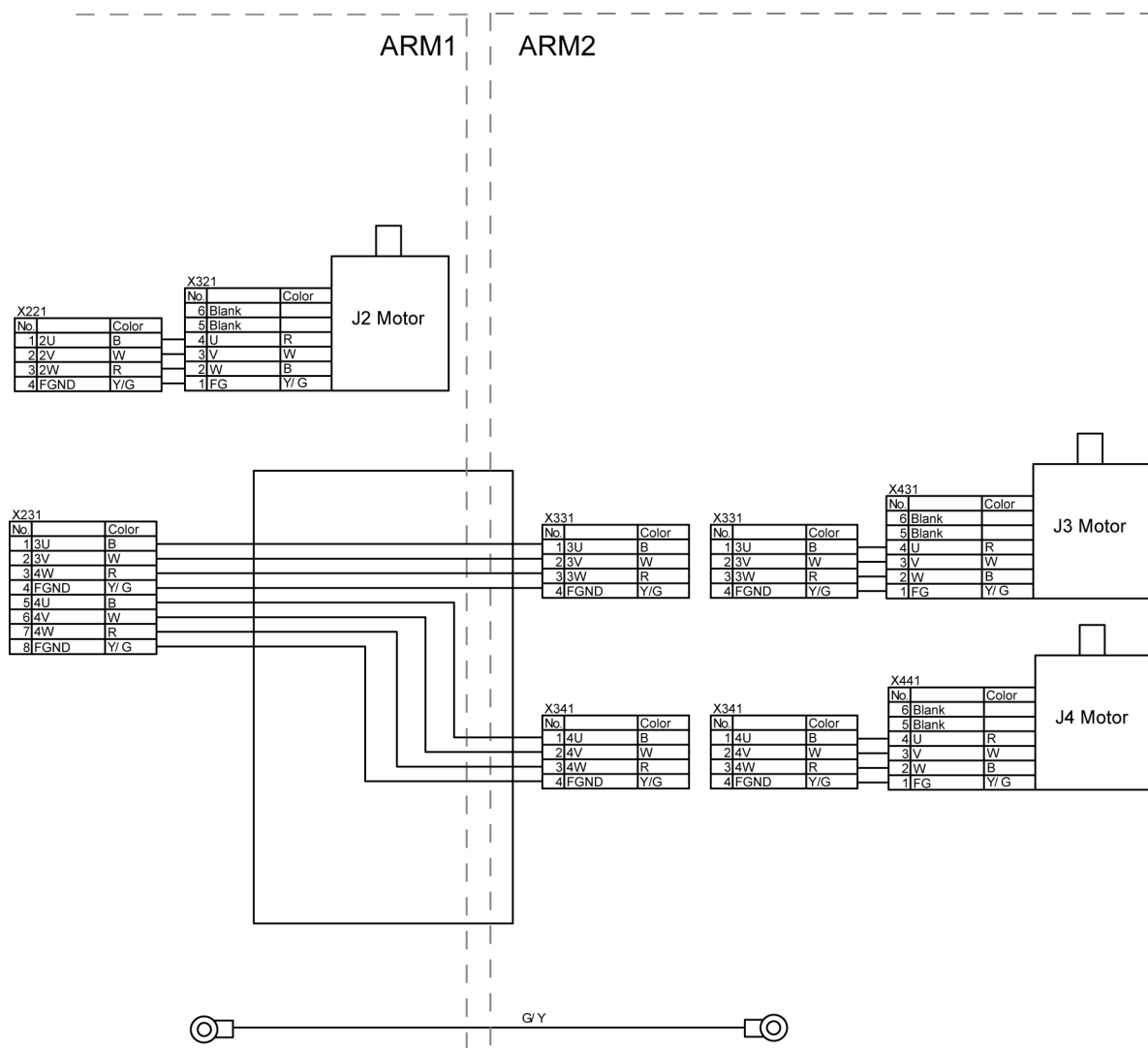
RC700-A, RC700DU-A

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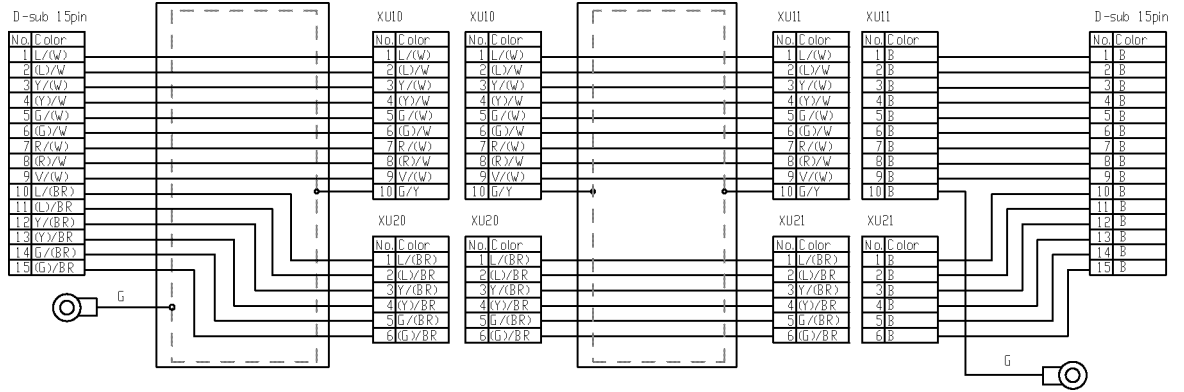


Code	Cable color	Code	Cable color
B	Black	P	Pink
BR	Brown	R	Red
G	Green	V	Violet
L	Blue	W	White
O	Orange	Y	Yellow

Continued from the previous page



4.2.3 User Cable




Code	Cable color	Code	Cable color
B	Black	R	Red
BR	Brown	V	Violet
G	Green	W	White
L	Blue	Y	Yellow

The following table shows the types of the cable unit.


Environment	Code	Note
S	R13B020028	
C	R13B020029	Waterproof connector : D-sub

4.3 Replacing M/C Cable

Since the power is supplied to each motor from the lithium battery installed on the battery board via the battery connector, the position data will not be lost when the Controller is turned OFF. When the battery connectors are disconnected, the position data will be lost, and EPSON RC+ will display an error when the Controller is turned ON.

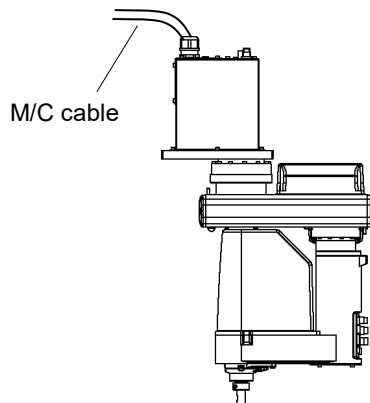
NOTE  If the connector connected to the battery was disconnected during cable replacement, execute calibration.
For details, refer to *Maintenance: 13. Calibration*.

	Name	Quantity	Note
Maintenance parts	M/C Cable	1	Each manipulator model (Refer to <i>Maintenance: 14. Maintenance parts</i>)
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Torque wrench	1	



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: 4.2 Wiring Diagrams*.
- When mounting 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.



M/C Cable
Removal

- (1) Turn OFF the Controller.
- (2) Disconnect the power cable and signal cable connectors from the controller.
- (3) Remove the Connector Plate.

For details, refer to *Maintenance: 3.3 Connector Plate*.

NOTE



Do not pull the Connector plate forcibly.
The M/C cables are still attached to the plate.

- (4) Disconnect the connectors.
Connector: X10, X20, X30, X111, X121, X131

NOTE

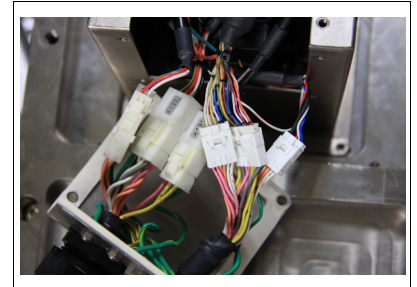


Each connector has a unique number.
Each connector has a different shape.

NOTE



Do not disconnect the battery connectors (X61, X62, X63). Otherwise, the calibration must be executed.

M/C Cable
Installation

- (1) Connect new M/C cable connectors to those of the Cable Unit.
(Connect to the connectors of the Cable Unit with the same number.)
- (2) Mount the Connector Plate.
For details, refer to *Maintenance: 3.3 Connector Plate*.
- (3) Connect the power cable and signal cable connectors to the controller.
- (4) Turn ON the Controller.
- (5) If the connectors (X61, X62, X63) fall off from the battery, execute the calibration for Joint #1.
For details, refer to *Maintenance: 13 Calibration*.

5. Joint #1



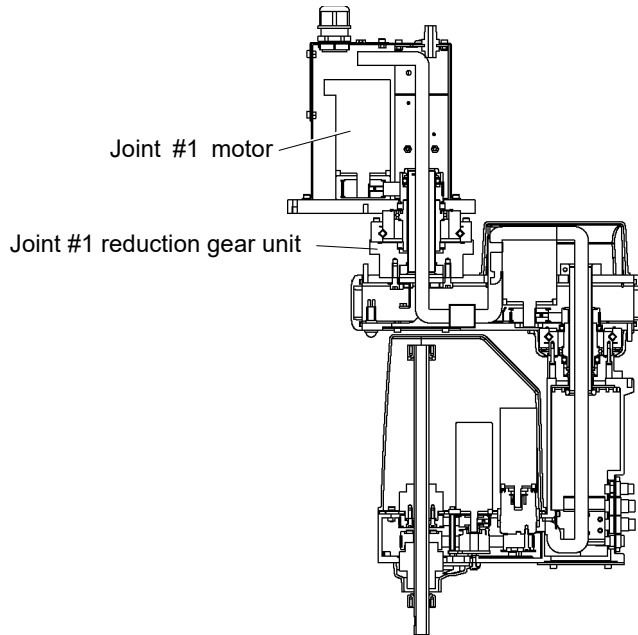
- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, disconnect 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 disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

Refer to *Maintenance: 13. Calibration* to perform the calibration.



(Figure : RS3-351S)

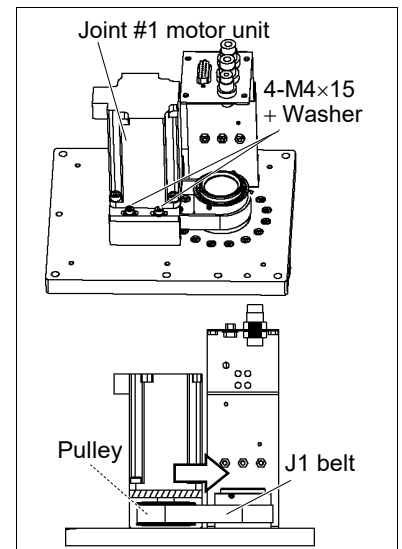
5.1 Replacing Joint #1 Motor

	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (400 W)	1	1514468	
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw, M3 screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench (M4)	1		
	Force gauge	1	Belt tension 150 N (15.3 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
	Wiping cloth	1	For wiping grease	
Grease	Grease (SK-1A)	13 g		

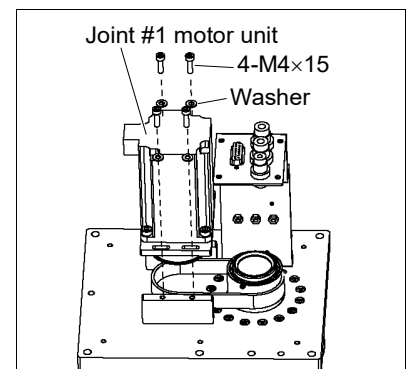
Joint #1 motor Removal

- (1) Turn ON the Controller.
- (2) Move the Manipulator Joint #1 to the origin.
- (3) Turn OFF the Controller.
- (4) Remove the connector plate.
For details, refer to *Maintenance: 3.3 Connector Plate*.
- (5) Disconnect the following connectors.
Connectors X10, X20, X30, X111, X121, X131 (Hold the clip to remove.)
Connector X61
- (6) Remove the base cover.
For details, refer to *Maintenance: 3.4 Base Cover*.
- (7) Loosen the J1 belt.

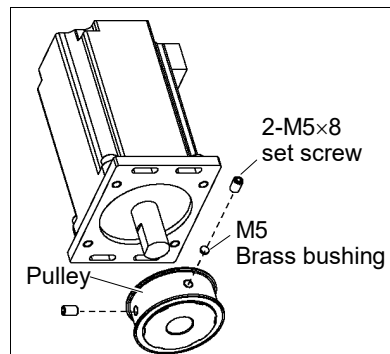
Loosen four bolts on the Joint #1 motor unit.
Slide the Joint #1 motor unit toward the Joint #1 side.



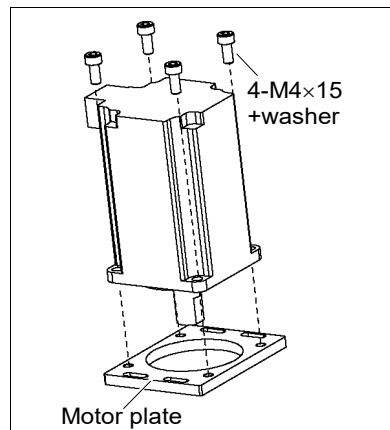
- (8) Remove the Joint #1 motor unit from the base.
Unscrew the bolts securing the Joint #1 motor plate and pull it upward to remove.



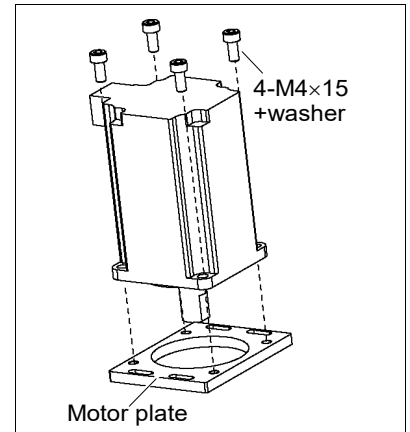
(9) Remove the pulley from the Joint #1 motor.



(10) Remove the motor plate from the Joint #1 motor.



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



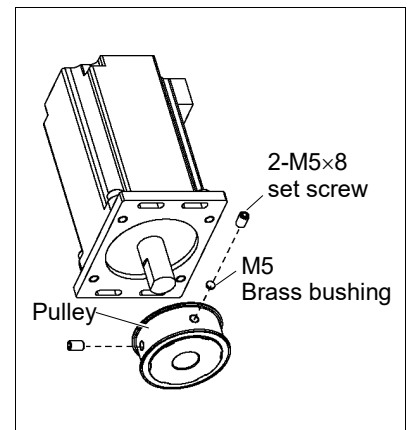
(2) Mount the pulley to the Joint #1 motor.

Fit the end face of the pulley with the end face of the motor shaft.

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

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

Then, tighten both set screws.



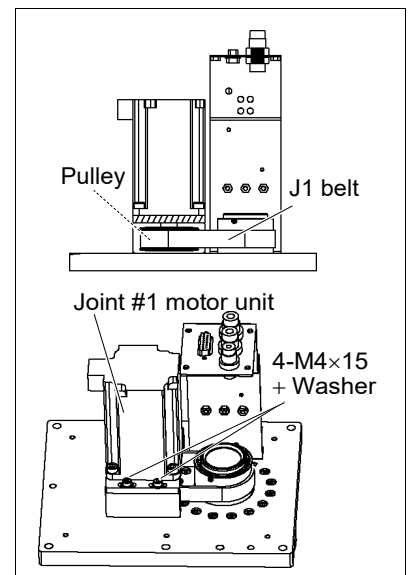
(3) Place the J1 belt around the pulley of the Joint #1 motor unit to secure the unit loosely.



Make sure that the gear grooves of the belt are fit into those of the pulleys completely.

Put the motor cable facing toward the other side of Joint #1.

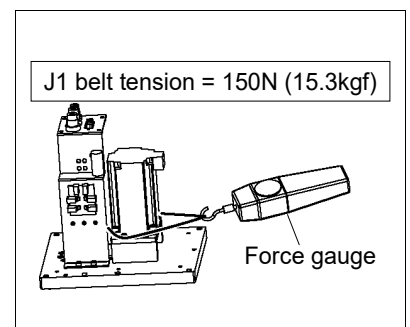
When securing the motor unit, make sure the unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



(4) Apply the proper tension to the J1 belt and secure the Joint #1 motor unit.

To do so, pass a suitable cord or string around the Joint #1 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.



- (5) Connect the connector to the battery board

Connector X61

- (6) Mount the base cover.

For the details, refer to *Maintenance: 3.4 Base Cover*.

- (7) Connect the following connectors.

Connectors X10, X20, X30, X111, X121, X131

- (8) Mount the connector plate.


For details, refer to *Maintenance: 3.3 Connector Plate*.

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

For details refer to *Maintenance: 13. Calibration*.

5.2 Replacing Joint #1 Reduction Gear Unit

	Name	Quantity	Note	
Maintenance Parts	Reduction Gear Unit	1	1514470 (RS3-351*) 1547165 (RS4-551*)	
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M2 screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 5 mm	1	For M6 screw
	Torque wrench	M4	1	
		M6	1	
	Nippers		1	
	Spatula		1	For applying grease
	Force gauge		1	Belt tension 150 N (15.3 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Wiping cloth		1	For wiping grease (Flange)	
		1	For wiping grease (Bolt)	
Material	Wire tie	4		
Grease	Grease (SK-1A)	40 g		

 WARNING	<ul style="list-style-type: none"> ■ When removing the Manipulator from the base table, the Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. RS3-351S : approx. 17 kg: 38 lb. RS4-551* : approx. 19 kg: 42 lb. ■ When removing the Manipulator from the base table, 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.
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Joint #1 reduction gear unit Removal

- (1) Remove the Manipulator from the base table.

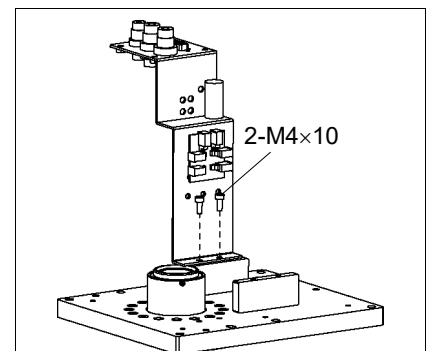
To remove the Manipulator, please observe the WARNING above.

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

Execute the removal steps from (1) to (5) in *Maintenance: 5.1 Replacing Joint #1 Motor*.

- (3) Remove the air tube, D-sub cable, ground wire on the J1 cable plate. Cut off the wire tie.

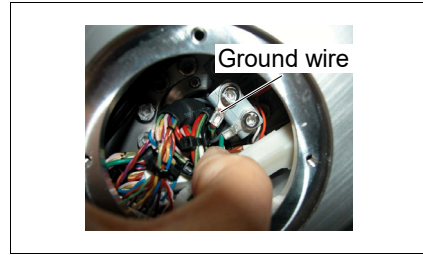
- (4) Remove the J1 cable plate.



- (5) Remove the Arm #1 under cover.

For details, refer to *Maintenance: 3.1 Arm #1*.

- (6) Remove the ground wire and connectors in the Joint #1 side of Arm #1.



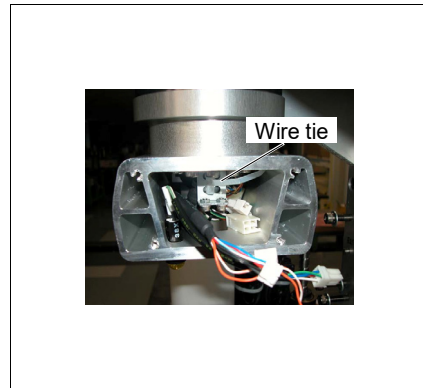
- (7) Cut off two wire tie bundling the cables.

Pull out the Cable unit 1 (except air tubes) from the base side.

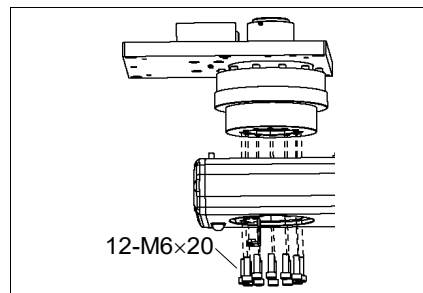
When pulling out the cables, first, pull out the air tubes from the Arm #1 side (the other side to the cables).

And pull out from smaller connectors in order from the base side.

Do not try to pull out the cables forcibly. Otherwise, connectors may be stuck, disconnected, or connector pins may fall off.

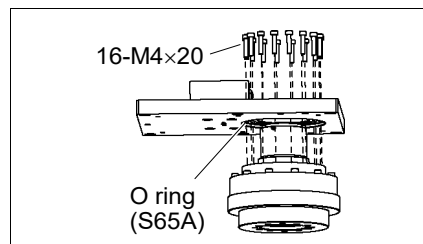


- (8) Remove the Arm #1.



- (9) Remove the reduction gear unit from the base.

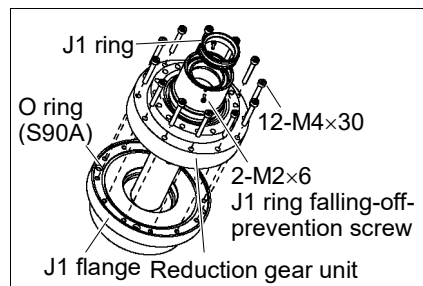
Be sure to keep the O ring (S65A).



- (10) Remove the J1 ring falling-off-prevention screws and remove the J1 ring.

- (11) Remove the J1 flange (with Metallic pipe).

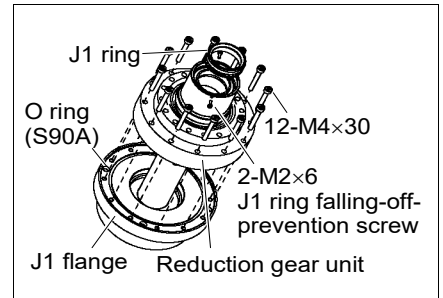
Be sure to keep the O ring (S90A).



Joint #1
reduction gear
unit
Installation

- (1) Unpack the new reduction gear unit.
- (2) Set the O ring to the O ring (S90A) groove in the J1 flange.
- (3) Set the hole on the reduction gear and the tap hole on the J1 flange.

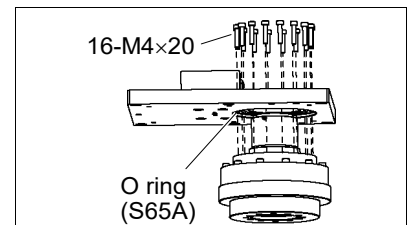
Loosely secure all bolts in a crisscross pattern so that the bolts will be secured evenly. Then, using a torque wrench, tighten each bolt securely in a crisscross pattern at the torque specified in the table below.



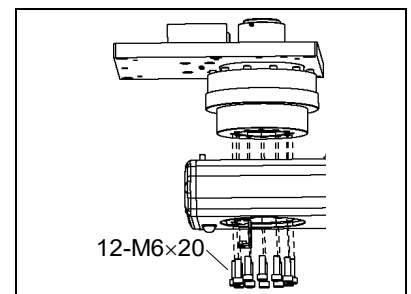
- (4) Set the J1 ring and secure the J1 ring falling-off-prevention screws.

Item	Bolt type	Number of bolts	Tightening torque
Joint #1 reduction gear unit	M4x30	12	6.0 N·m (61.2 kgf·cm)
	M6x15	8	22.0 N·m (224.3 kgf·cm)

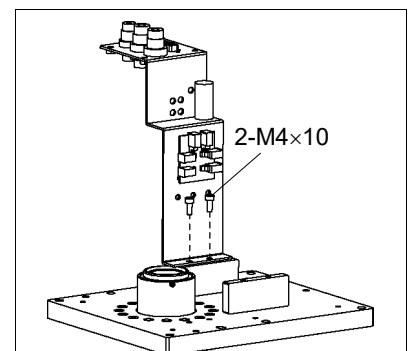
- (5) Set the O ring to the O ring (S65A) groove in the Base.
- (6) Mount the reduction gear unit to the base.
Be sure to keep the O ring.



- (7) Mount the Arm #1.



- (8) Mount the Joint #1 cable plate.



- (9) Insert the cable unit to the Arm #1.

Follow the steps in *Maintenance: 4.1 Cable Unit - Installation (1) - (9)*.

- (10) Secure the Joint #1 motor and mount the cover.

Follow the steps in *Maintenance: 5.1 Replacing Joint #1 Motor - Installation (4) - (8)*.

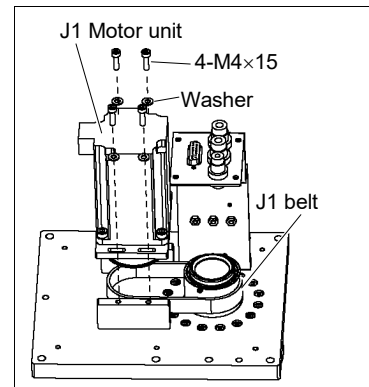
- (11) Mount the Manipulator to the base table.

5.3 Replacing J1 Belt

J1 belt
Removal

- (1) Remove the J1 motor unit.
Follow the steps in *Maintenance: 5.1 Replacing Joint #1 Motor - Removal (1) - (8)*.

- (2) Remove the J1 belt.



J1 belt
Installation

- (1) Mount the J1 belt to the pulley of the Joint #1 side.
- (2) Mount the J1 motor unit.

Follow the steps in
Maintenance: 5.1 Replacing Joint #1 Motor - Installation (3) - (9).

6. Joint #2



- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting 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, disconnect 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 disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



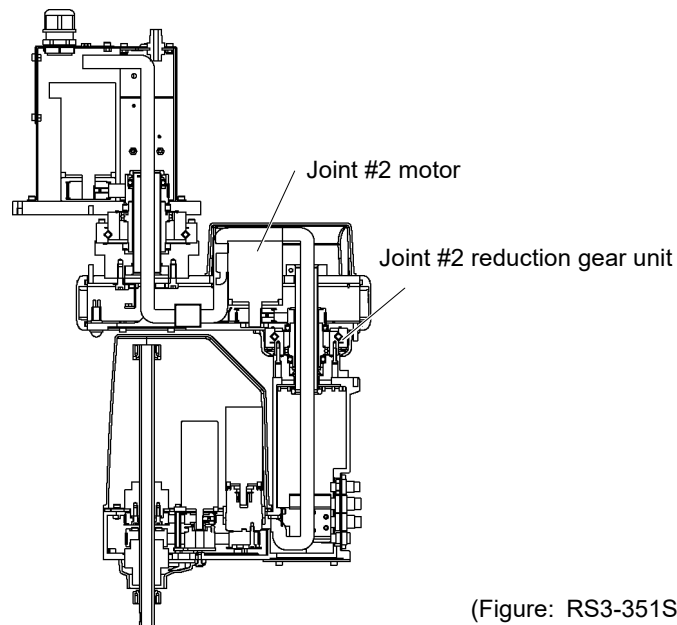
- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

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

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

Refer to *Maintenance: 13. Calibration* to perform the calibration.

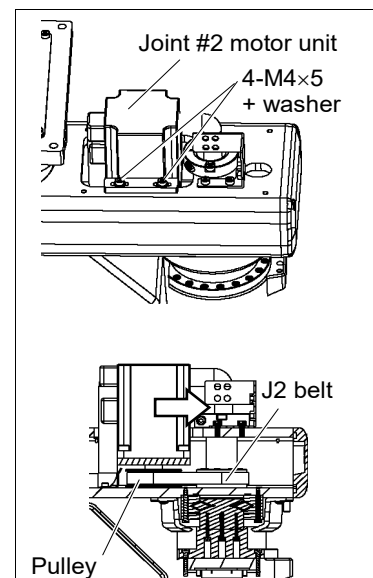


(Figure: RS3-351S)

6.1 Replacing Joint #2 Motor

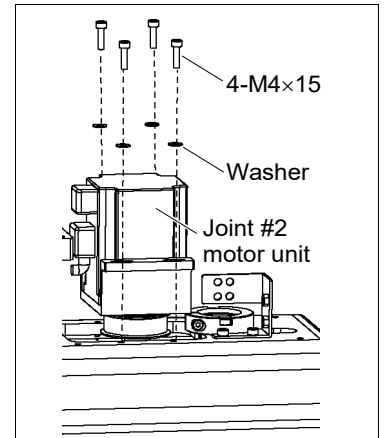
	Name	Quantity	Note
Maintenance Parts	AC Servo Motor	200 W (RS3-351*)	1 1514451
		400 W (RS4-551*)	1 1514468
Tools	Hexagonal wrench	width across flats: 2.5 mm	1 For M5 set screw
		width across flats: 3 mm	1 For M4 screw
		width across flats: 4 mm	1 For M5 screw
	Nippers	1	For cutting wire tie
	Force gauge	1	Belt tension 100 N (10.2 kgf)
	Suitable cord (Length about 800 mm)	1	For belt tension
	Wiping cloth	1	For wiping grease
Material	Wire tie	4	
Grease	Grease (SK-1A)	6 g	

- Joint #2 motor Removal**
- (1) Remove the Arm #1 cover.
For details, refer to *Maintenance: 3.1 Arm #1*.
 - (2) Remove the Arm #1 under cover.
For details, refer to *Maintenance: 3.1 Arm #1*.
 - (3) Disconnect the following connectors.
Connectors X21, X221, XB22 (Hold the clip to remove.)
 - (4) Loosen the J2 belt.
Loosen four bolts securing the Joint #2 motor unit.
Slide the Joint #2 motor unit toward the Joint #2 side.

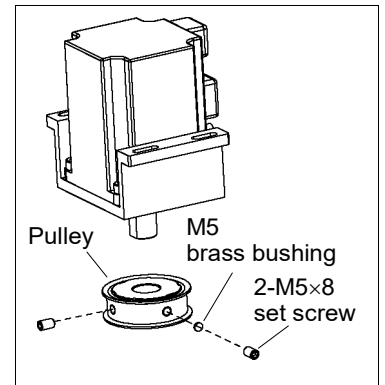


- (5) Remove the Joint #2 motor unit from the Arm #1.

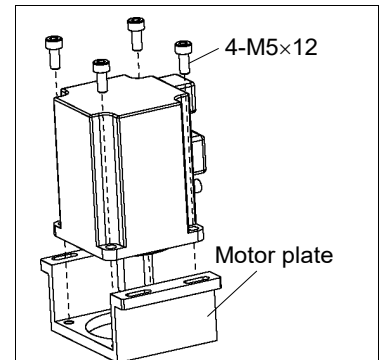
Unscrew the bolts securing the Joint #2 motor plate and pull the plate upward to remove.



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

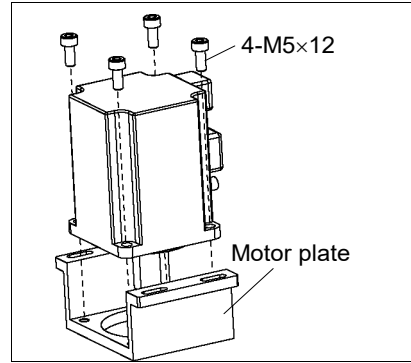


- (7) Remove the motor plate from the Joint #2 motor.



Joint #2 motor Installation

(1) Mount the motor plate to the Joint #2 motor.



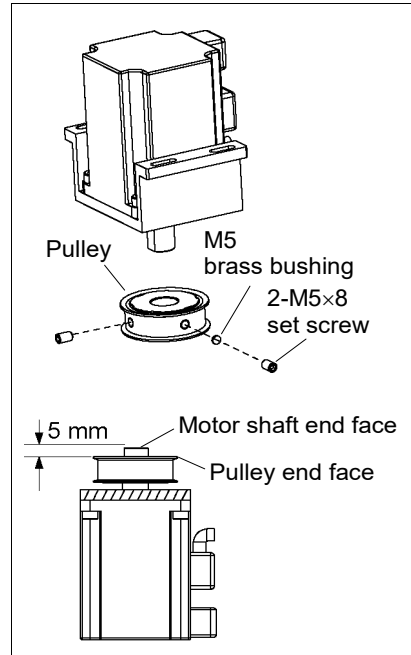
(2) Mount the pulley to the Joint #2 motor.

Secure the pulley to the distance of 5 mm from the end of the motor shaft.

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

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

Then, tighten both set screws.



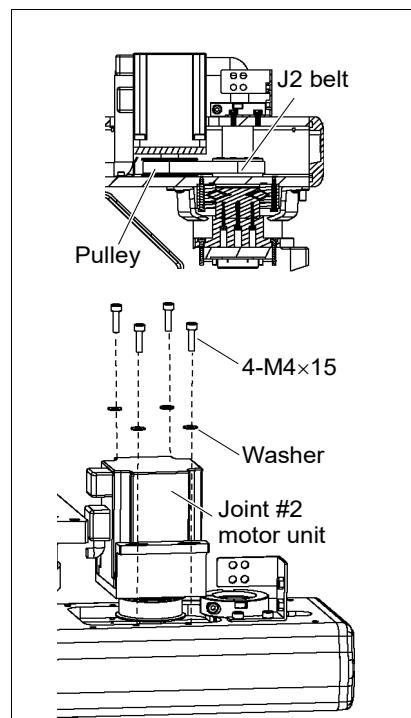
(3) Set the J2 belt around the pulley of the Joint #2 motor unit and secure the unit loosely.



Make sure the gear grooves of the belt are fit into those of the pulleys completely.

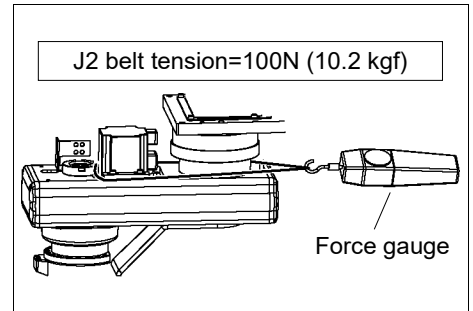
Set the motor cable facing toward the other side to J2 axis.

When securing the unit, make sure that the motor unit can move 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.



- (4) Apply the proper tension to J2 belt and secure the Joint #2 motor unit.

To do so, pass a suitable cord or string around the Joint #2 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.



- (5) Insert the cables to Arm #1.
- (6) Connect the connectors.

Connectors X21, X221, XB22

- (7) Mount the Arm #1 cover.

For details, refer to *Maintenance: 3.1 Arm #1*.

- (8) Mount the Arm #1 under cover.

For details, refer to *Maintenance: 3.1 Arm #1*.

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

For details refer to *Maintenance: 13. Calibration*.

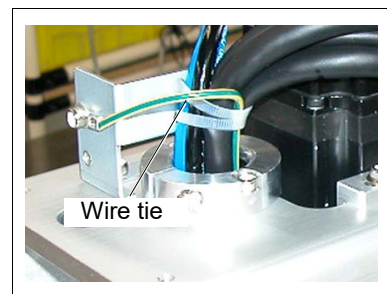
6.2 Replacing Joint #2 Reduction Gear Unit

	Name	Quantity	Note	
Maintenance parts	Reduction Gear Unit	1	1514471	
Tools	Hexagonal wrench	width across flats: 2 mm	1	
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	
		width across flats: 4 mm	1	For M5 screw
	Torque wrench	M3	1	
		M5	1	
	Nipper		1	
	Spatula		1	For applying grease
	Force gauge		1	Belt tension 100 N (10.2 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Wiping cloth		1	For wiping grease (Flange)	
		1	For wiping grease (Bolt)	
Material	Wire tie	4		
Grease	Grease (SK-1A)	12 g		

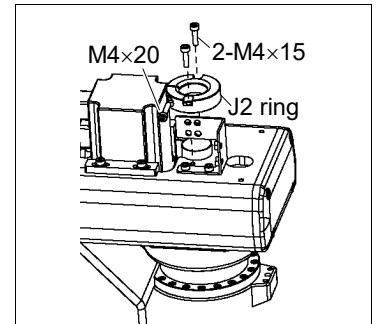
Joint #2 reduction gear unit Removal

- (1) Remove the Arm #1 cover.
For details, refer to *Maintenance: 3.1 Arm #1*.
- (2) Remove the Arm #1 under cover.
For details, refer to *Maintenance: 3.1 Arm #1*.
- (3) Disconnect the connectors:
Connectors X30, X23, XB23, X231, XU10, XU20 (Hold the clip to remove.)
- (4) Put the cables over the J2.
- (5) Cut off two wire ties bundling the cables.
- (6) Disconnect the ground wire.
- (7) Remove the user plate.
For details, refer to *Maintenance: 3.5 User plate*.
- (8) Remove the air tubes from the user plate. Press the ring of fittings of the air tube to pull it out ($\phi 6 \times 2$, $\phi 4 \times 1$).

Be sure to remember the cable location to connect them to the original position.
- (9) Pull out the air tubes from the upper side of Joint #2.



- (10) Remove the J2 ring.



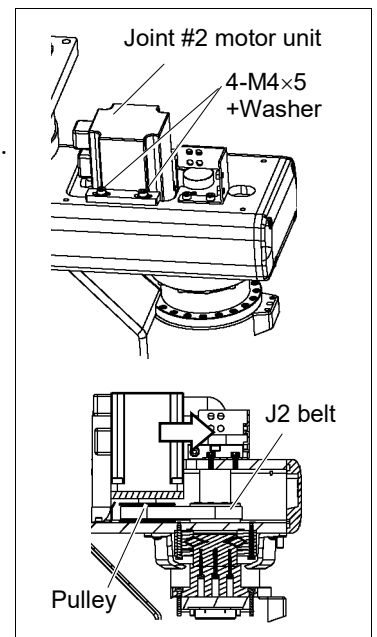
- (11) Remove the J2 cover.

For details, refer to *Maintenance: 3.1 Arm #1*.

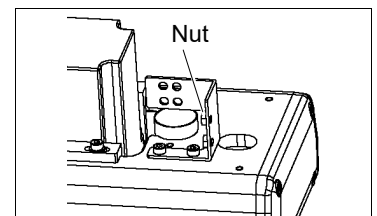
- (12) Loosen the J2 belt.

Unscrew four bolts securing the Joint #2 motor unit.

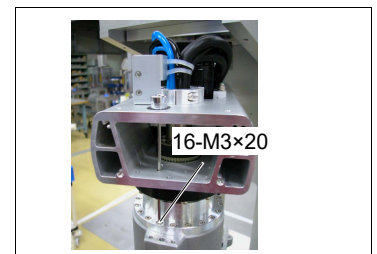
Slide the Joint #2 motor unit toward the Joint #2 side.



- (13) Remove the screws secured with nuts.



- (14) Use the holes and rotate the Arm #2 to remove the screws.



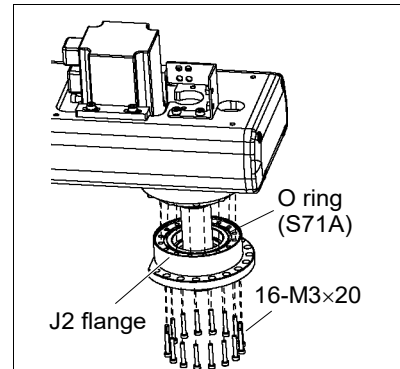
- (15) Pull out the cables (except air tube) to downward from Joint #1.

Pull out cables in order of size (smaller cables first).

Do not try to pull out the cables forcibly. Otherwise, connectors may be stuck, disconnected, or connector pins may fall off.

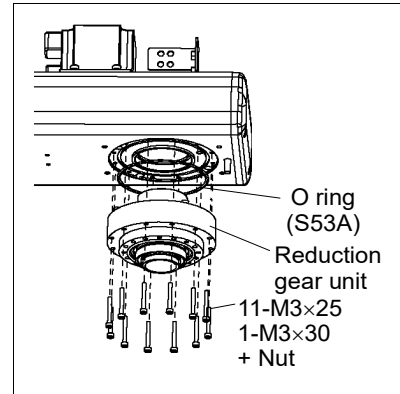
(16) Remove the J2 flange.

Be sure to keep the O ring (S71A).



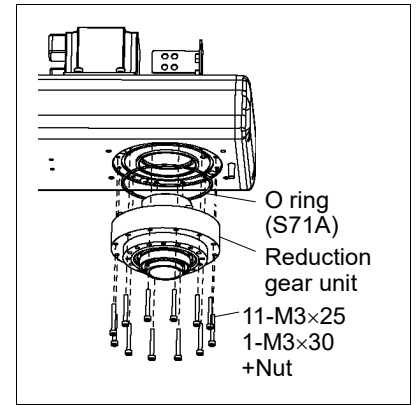
(17) Remove the reduction gear unit.

Be sure to keep the O ring (S53A).



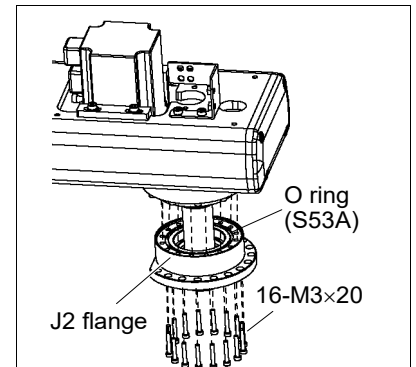
Joint #2
reduction gear
unit
Installation

- (1) Unpack the new reduction gear unit.
Apply the grease on the gear.
- (2) Set the O ring to the O ring (S71A) groove under the Arm.
- (3) Secure the reduction gear unit to the Arm #1.
Be sure to keep the O ring.

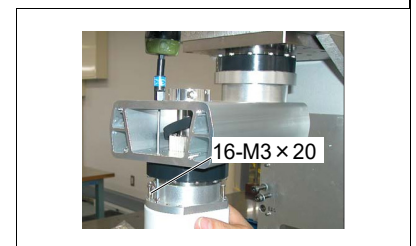


Item	Bolt type	Number of bolts	Tightening torque
Joint #2 reduction gear unit	M3×25	11	3.0 N·m (30.5 kgf)
	M3×30	1	
	M3×20	16	

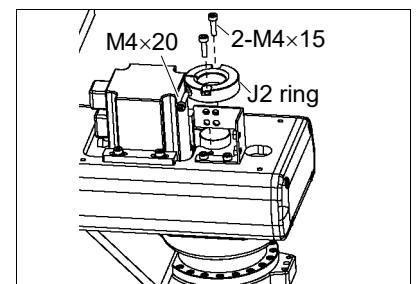
- (4) Set the O ring (S53A) to the O ring groove in the J2 flange.
- (5) Mount the J2 flange.
Be sure to keep the O ring.



- (6) Insert the cables to the Arm.
- (7) Mount the Arm #2.



- (8) Mount J2 ring.
- (9) Insert the air tube to Arm #2 upper side.
Put the cables from above.

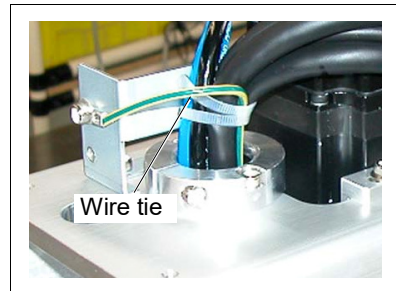


- (10) Connect the air tube to the user plate and mount the user plate.

For details, refer to *Maintenance: 3.5 User Plate*.

(11) Secure the cables with wire tie and connect the ground wire.

(12) Along both sides of the motor, insert the cables and tube in the Arm #1.



(13) Connect the connector.

(14) Mount the Arm #1 under cover and J2 cover.

For details, refer to *Maintenance: 3.1 Arm #1*.

(15) Secure the Joint #2 motor and mount the cover.

Follow the steps in *Maintenance: 6.1 Replacing Joint #2 Motor - Installation (4) - (8)*.

6.3 Replacing J2 Belt

J2 belt Removal

- (1) Remove the Joint #2 motor unit.
Follow the steps in *Maintenance: 6.1 Replacing Joint #2 Motor- Removal (1) - (5)*.
- (2) Pull out the cables.
Follow the steps in *Maintenance: 6.2 Replacing Joint #2 Reduction Gear Unit - Removal (2) - (10)*.
- (3) Push the metal pipe for the cable.
- (4) Remove the J2 belt.

J2 belt Installation

- (1) Mount the J2 belt.
- (2) Pull out the pipe for cables to the upper part of the arm.
Follow the steps in *Maintenance: 6.2 Replacing Joint #2 Reduction Gear Unit - Installation (8) - (10)*.
- (3) Install the Joint #2 motor unit.
Follow the steps in *Maintenance: 6.1 Replacing Joint #2 Motor - Installation (3) - (6)*.
- (4) Follow the steps in *Maintenance: 6.2 Replacing Joint #2 Reduction Gear Unit - Installation (11) - (13)*.
- (5) Follow the steps in *Maintenance: 6.1 Replacing Joint #2 Motor - Installation (7) - (9)*.

7. Joint #3



- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting 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, disconnect 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 disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

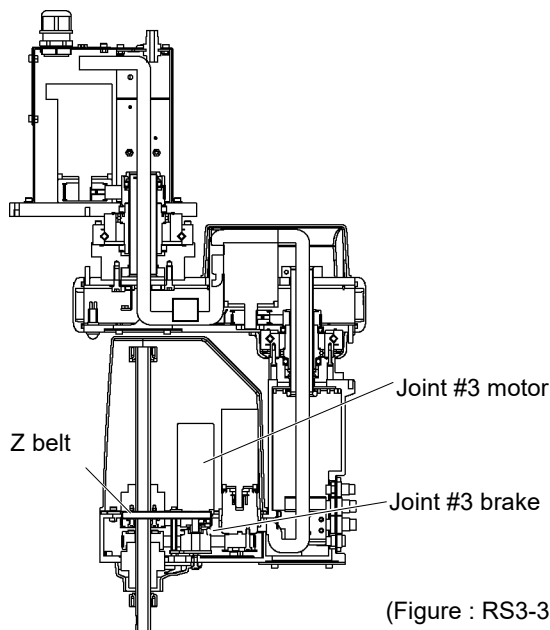


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

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

Refer to *Maintenance: 13. Calibration* to perform the calibration.



(Figure : RS3-351S)

7.1 Replacing Joint #3 Motor

	Name		Quantity	Note
Maintenance parts	AC Servo Motor	150W	1	1514453
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Torque wrench	M5	1	
	Nippers		1	For cutting wire tie
	Force gauge		1	Belt tension 75 N (7.7 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		4	

A brake is mounted on Joints #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 removal steps from (1) to (4).

Joint #3 motor Removal

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

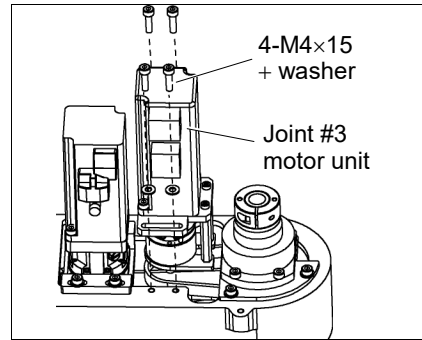
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Turn the Arm #2 to the 180 degree position.
- (4) Turn OFF the Controller.
- (5) Remove the Arm #1 side cover of the Joint #2 side.
For details, refer to *Maintenance: 3.1 Arm #1 Covers*.
- (6) Remove the Arm #2 cover.
For details, refer to *Maintenance: 3.2 Arm #2 Covers*.
- (7) Cut off the wire tie bundling the motor cables to the Joint #3 motor.

Remember the cable layout so that the cables can be reconnected correctly after replacement.
- (8) Disconnect the following connectors.
Connectors X331, X31, X32 (Hold the clip to remove.)
Connector XB33

- (9) Loosen the Z belt.

Loosen four bolts on the Joint #3 motor unit.

Slide the Joint #3 motor unit to the end of the arm.

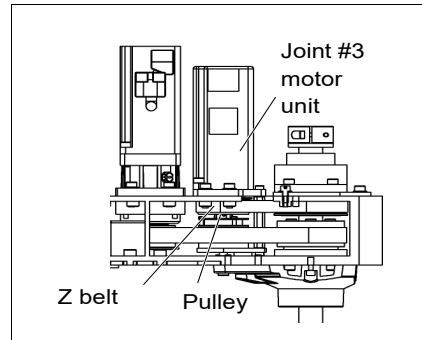


- (10) Remove the Joint #3 motor unit from Arm #2.

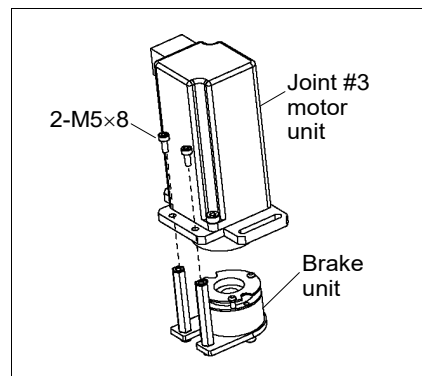
Unscrew the bolts securing the Joint #3 motor unit.

Remove the Z pulley from the Z belt.

Pull the Joint #3 motor unit upward to remove.



- (11) Remove the brake unit from the Joint #3 motor unit.

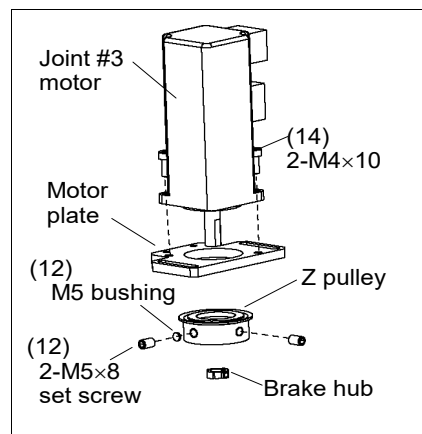


- (12) Unscrew the screws securing the pulley to the Joint #3 motor. Press the pulley toward the plate.

Remove the brake hub.

Remove the pulley and motor plate.

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



Joint #3 motor Installation

- (1) Mount the motor plate to the Joint #3 motor.
(Be careful of the mounting direction.)

Screw: 2-M4×10

Tightening torque: 3.5 N·m (35.7 kgf·cm)

- (2) Insert the pulley and brake hub into the motor shaft. Then, tighten both at a distance of 1 mm from the shaft.

- (3) Secure the pulley to the position touching the hub.

Put the one of the set screws and the flatly chamfered surface of motor shaft to touch vertically.

Insert the bushing into the other screw.

Secure the bushing to prevent damage from the motor shaft.

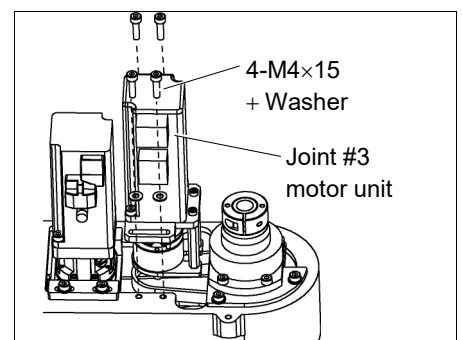
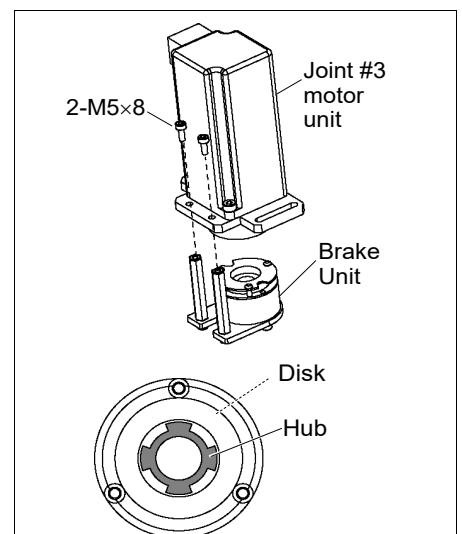
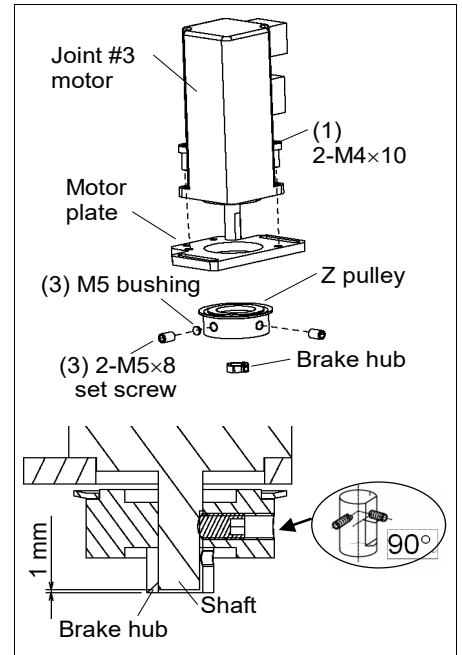
- (4) Install the brake to the Joint #3 motor.

Align the position of the disk on the brake and the hub.

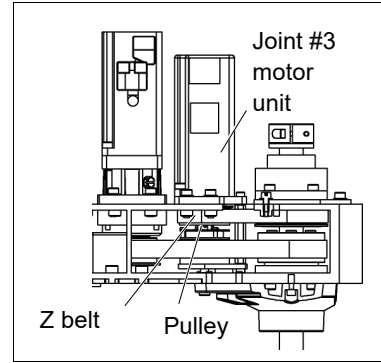
When the brake disk is not aligned, connect the connector X32. Press the brake release switch and release the brake to manually adjust the position.

- (5) Put the Joint # 3 motor unit in the arm.


Motor cable must face to the right side of the arm.



- (6) Place the Z belt around the Z pulley so that the gear grooves of the belt are fit into those of the pulley completely.



- (7) 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.

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

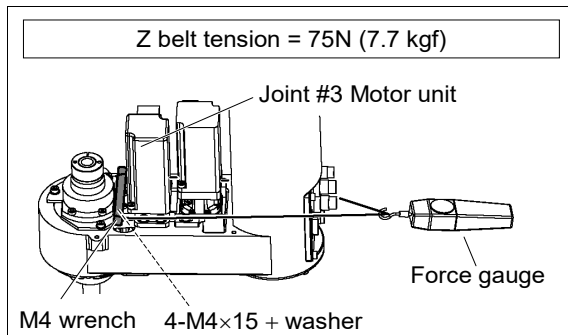
Hexagonal wrench (Stubby type) makes it easier to tighten / remove screws.

Put the M4 wrench to the Joint #3 motor unit, near its mounting plate.

And pass a suitable cord or string around the motor unit.

Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure.

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



- (9) Connect the following connectors.

Connectors X331, X31, X32, XB33

- (10) Re-bundle the cables in their original positions with a wire tie removed in step (7).

Do not allow unnecessary strain on the cables.

- (11) Install the Arm #2 cover.

For details, refer to *Maintenance: 3.2 Arm #2*.

- (12) Install the Arm #1 side cove.

For details, refer to *Maintenance: 3.1 Arm #1*.

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

For details on the calibration method, refer to *Maintenance: 13. Calibration*.

7.2 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance parts	Z belt (width 9 mm)	1	1510526
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Nippers	1	For cutting wire tie
	Force gauge	1	Belt tension 75 N (7.7 kgf)
	Suitable cord (Length about 800 mm)	1	For belt tension
Material	Wire tie	2	

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 removal steps.

Z belt Removal

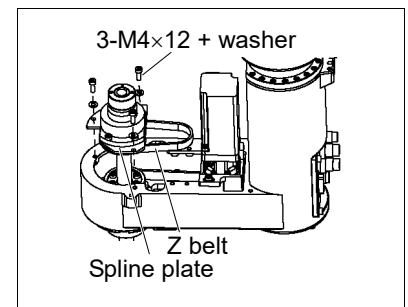
- (1) Remove the Joint #3 motor.

Follow the steps in *Maintenance: 7.1 Replacing Joint #3 Motor - Removal (1) - (10)*.

- (2) Remove the Z belt.

Remove the bolts securing the spline plate.

Hold up the spline plate and pull out the Z belt upward.



Z belt Installation

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

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

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

- (3) Set the Joint #3 motor unit in the arm so that motor cable faces toward the right side of arm.

Secure the Joint #3 motor unit and mount the cover.

Follow the steps in *Maintenance 7.1 Replacing Joint #3 Motor - Installation (5) - (13)*.

7.3 Replacing the Brake

	Name	Quantity	Note	
Maintenance parts	Electromagnetic brake	1	1497639	
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 75 N (7.7 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	3		

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).

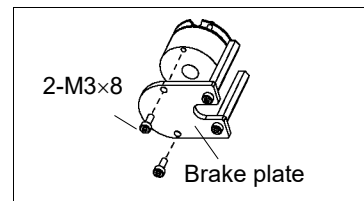
Note that the brake will not work during the replacement procedure.

Move the shaft down to its lower limit before the replacement procedure following the removal steps.

Electromagnetic Brake Removal (1) Remove the Joint #3 motor.

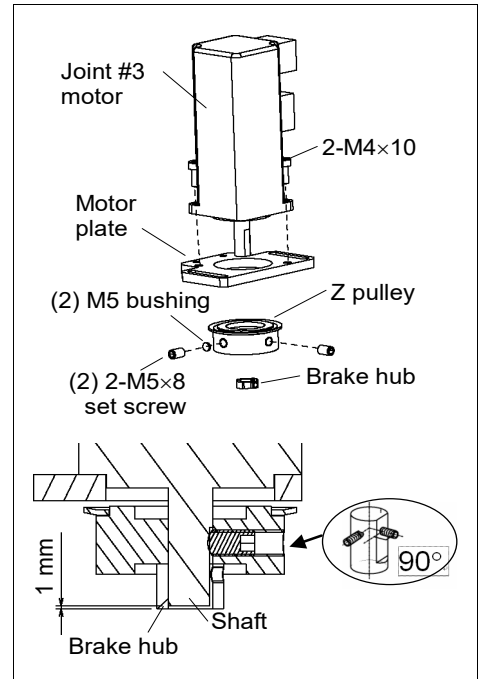
Follow the steps in *Maintenance: 7.1 Replacing Joint #3 Motor - Removal (1) - (13)*.

(2) Remove the brake from the brake plate.

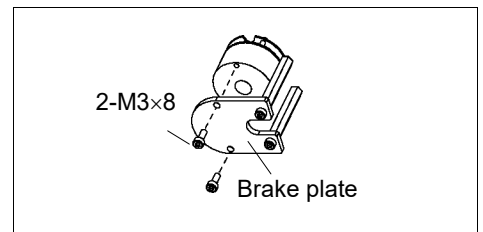


Electromagnetic Brake Installation

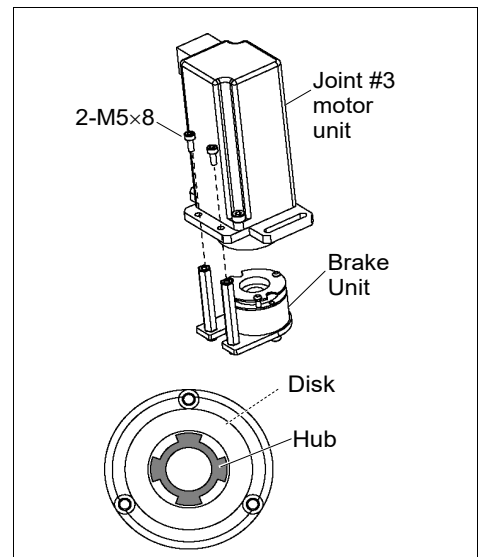
- (1) Mount the brake hub to the motor shaft.
Secure the hub to the distance of 1 mm from the shaft.
- (2) Secure the pulley so that it touches the hub.
Put one of the set screws and the flatly chamfered surface of the motor shaft to touch vertically.
Insert the bushing into the other screw to prevent the damage from the motor shaft.



- (3) Install the electromagnetic brake to the brake plate.



- (4) Install the brake to the Joint #3 motor.
Align the position of the disk on the brake and the hub.
When the brake disk is not aligned, connect the connector X32. Press the brake release switch and release the brake to manually adjust the position.



- (5) Secure the Joint #3 motor unit and mount the cover.
Follow the steps in *Maintenance 7.1 Replacing Joint #3 Motor - Installation (5) - (13)*.

8. Joint #4



- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting 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, disconnect 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 disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

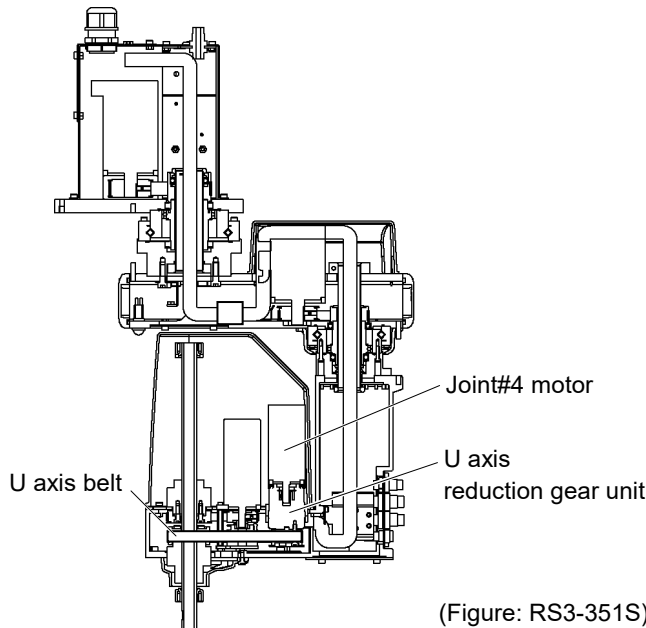


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

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

Refer to *Maintenance: 13. Calibration* to perform the calibration.



8.1 Replacing Joint #4 Motor

	Name		Quantity	Note
Maintenance parts	AC Servo Motor (100W)		1	1514469
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 3 mm	1	For M4 screw
	Nippers		1	For cutting wire tie
	Force gauge		1	Belt tension 120 N (12.2kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension

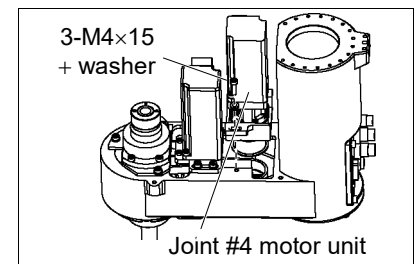
A brake is mounted on the motor of Joint #3 to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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 removal steps (1) - (4).

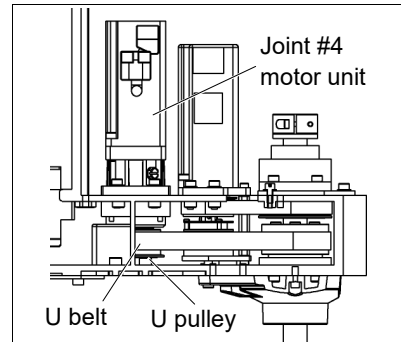
Joint #4 Motor Removal

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Move Arm #2 to the position of 180 degree.
- (4) Turn OFF the Controller.
- (5) Remove the Arm #1 side cover in the Joint #2 side.
For details, refer to *Maintenance: 3.1 Arm #1*.
- (6) Remove the Arm #2 cover.
For details, refer to *Maintenance: 3.2 Arm #2*.
- (7) Cut off the wire tie used for binding the motor cables to the Joint #4 motor.
Remember the cable location to connect them to the original position.
- (8) Remove the following connectors:
Connector X341, X41 (Hold the clip to remove.)
Connector XB34
- (9) Remove the U belt.
Remove four bolts securing the Joint #4 motor unit.
Slide the motor unit toward the end of arm.



- (10) First, remove the bolts securing the Joint #4 motor unit.

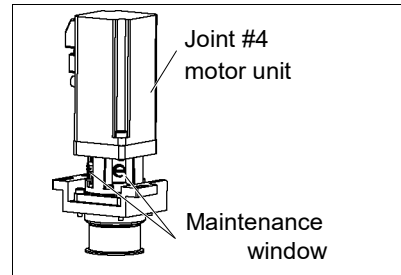
Next, remove the U pulley from the U belt and pull out the motor unit to remove.



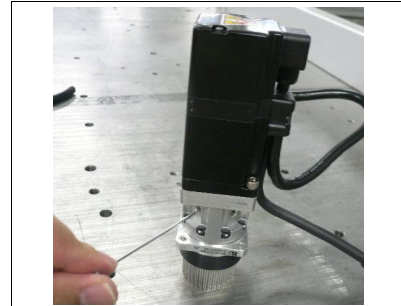
- (11) Open the maintenance windows of the Joint #4 reduction gear unit.

Remove the set screw.

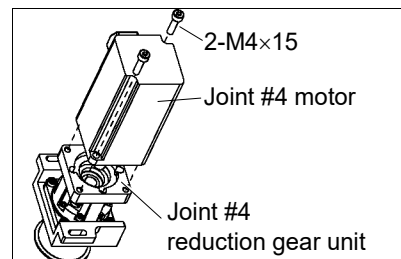
Rotate the pulley until the screws fit into the holes.



Remove two set screws.



- (12) Remove the Joint #4 motor.



If the motor cannot be removed easily, put a washer between the motor and reduction gear and use the motor mounting screws to press the motor equally from the reduction gear side to remove the motor.

(Use two diagonal holes from the motor mounting holes. See the photo.)



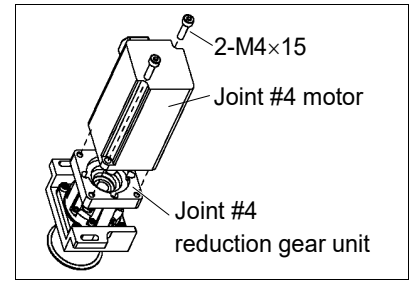
Joint #4 Motor Installation

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

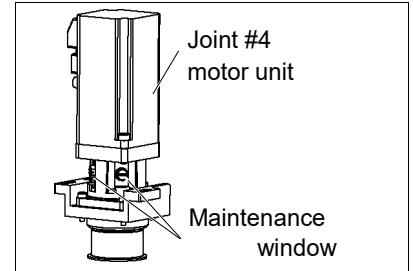
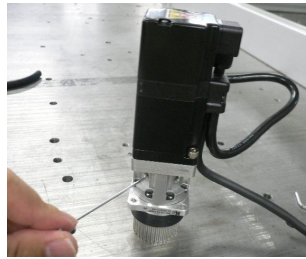
Align the flat face of the shaft with the hole of the maintenance window.

Screw: 2-M4 × 15

Tightening torque: 3.5 N·m (35.7 kgf·cm)

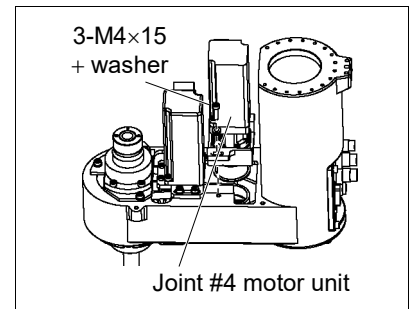


- (2) Align the maintenance holes and screws position by turning the pulley and secure with the set screws.

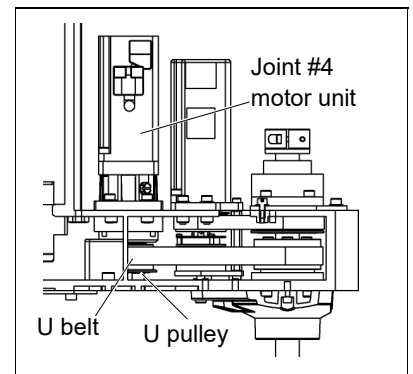


Close the maintenance windows.

- (3) Place the Joint #4 motor unit in the arm so that the motor cable faces toward the right side of arm.



- (4) Place the U belt around the U pulley so that the gear grooves of the belt are fit into those of the pulley completely.

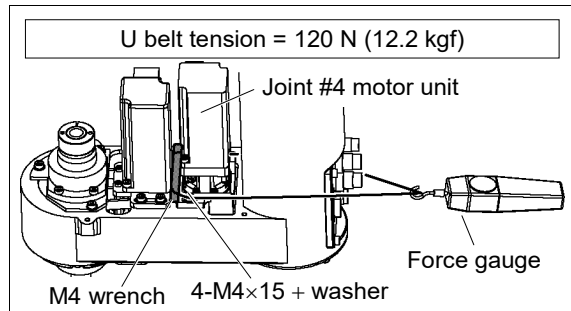


- (5) Loosely secure the Joint #4 motor unit to Arm #2.



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) Put M4 wrench to the Joint #4 motor unit near its mounting plate.
And pass a suitable cord or string around the motor unit.
Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure.



- (7) Connect the connectors X341, X41, XB34
- (8) Re-bundle the cables in their original positions with a wire tie removed in step (7).
Do not allow unnecessary strain on the cables.
- (9) Install the Arm #2 cover.
For details, refer to *Maintenance: 3.2 Arm #2*.
- (10) Install the Arm #1 side cover.
For details, refer to *Maintenance: 3.1 Arm #1*.
Perform the calibration of Joint #4.
For details on the calibration method, refer to *Maintenance: 13. Calibration*.

8.2 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance parts	U belt (width 12 mm)	1	1510527
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	Belt tension : 75 N (7.6 kgf), 120 N (12.2 kgf)
	Nippers	1	For cutting wire tie
	Suitable cord (Length about 800 mm)	1	For belt tension
Material	Wire tie	2	

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 removal steps (1) - (4).

U belt Removal

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

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

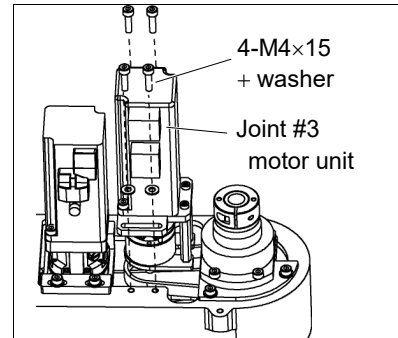
- (3) Move Arm #2 to the position of 180 degree.
- (4) Turn OFF the Controller.
- (5) Remove the Arm #1 side cover.
For details, refer to *Maintenance: 3.1 Arm #1*.
- (6) Remove the Arm #2 cover.
For details, refer to *Maintenance: 3.2 Arm #2*.
- (7) Cut off the wire tie used for binding the motor cables to the Joint #3, #4 motor.
Remember the cable location to connect them to the original position.
- (8) Remove the following connectors:

Connector X331, X31, X32, X341, X41 (Hold the clip to remove.)

Connector XB33, XB34

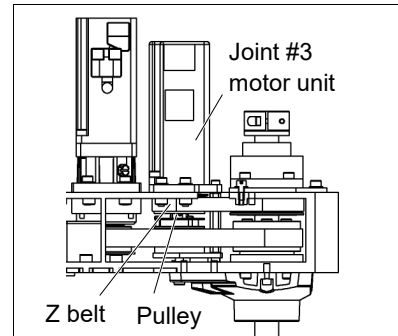
- (9) Loosen the Z belt.

Loosen four bolts securing the Joint #3 motor unit.
Slide the motor unit toward the end of arm.



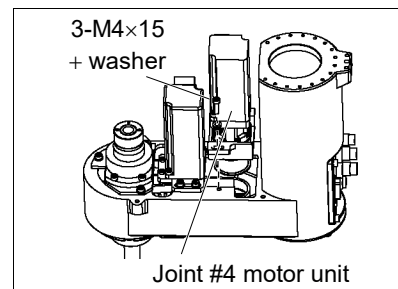
- (10) Remove the Joint #3 motor unit from Arm #2.

Remove the bolts securing the Joint #3 motor unit.
Remove the Z1 pulley from the Z belt.
Pull out the motor unit to remove.



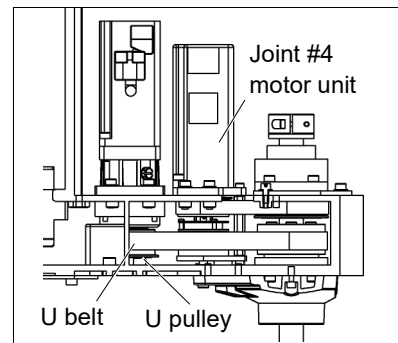
- (11) Loosen the U belt.

Loosen the four bolts securing the Joint #4 motor unit.
Slide the Joint #4 motor unit toward the end of arm.



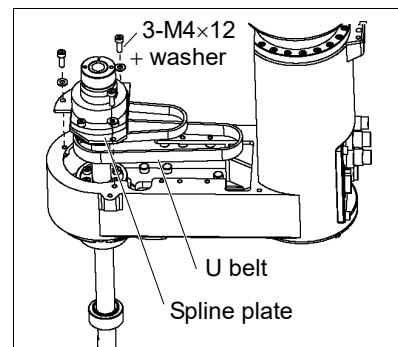
- (12) Remove the Joint #4 motor unit from Arm #2.

First, remove the bolts securing the Joint #4 motor unit.
Next, remove the U pulley from the U belt.
Pull out the Joint #4 motor unit to remove.



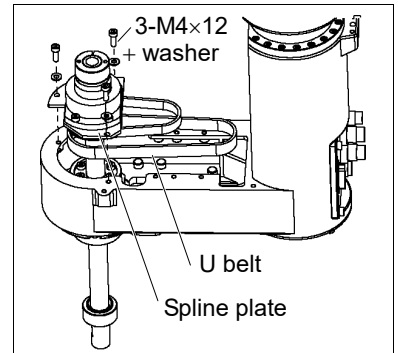
- (13) Remove the belt.

Remove the bolts securing the spline plate.
Hold up the spline plate and pull the U belt upward from the shaft.



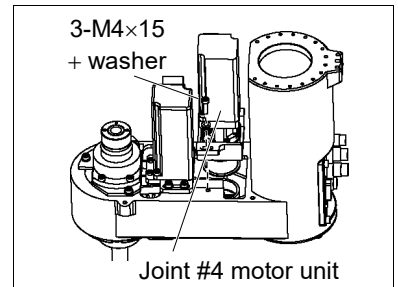
U belt
Installation

(1) Pass the U belt through the shaft and under the spline plate.



(2) Loosely secure the Spline plate to Arm #2.
Move the shaft up/down several times and secure it.

(3) Set the Joint #4 motor unit to Arm #2 so that the motor cables face to the right side of arm.



(4) Place the U belt around the U pulley so that the gear grooves of the belt are fit into those of the pulley completely.

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

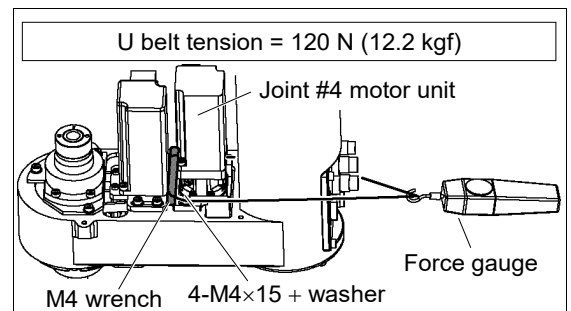


NOTE Check that the motor unit can be moved by hand, and it will not tilt when pulled. If the units are secured too loose or too tight, the belt will not have the proper tension.

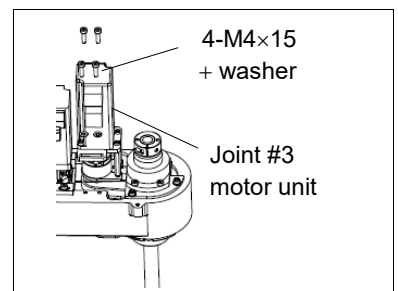
(6) Apply the proper tension to the U belt, and then secure the Joint #4 motor unit.

To do so, pass a suitable cord or string around the Joint #4 intermediate shaft unit near its mounting plate.

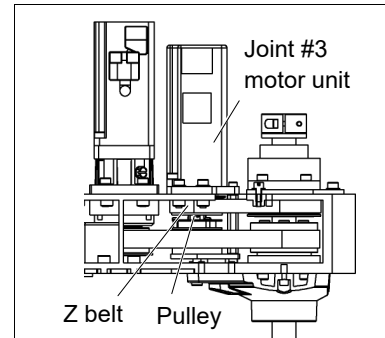
Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure.



(7) Set the Joint #3 motor unit to Arm #2 so that the motor cables face to the right side of arm.



- (8) Place the Z belt around the Z pulley so that the gear grooves of the belt are fit into those of the pulley completely.



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

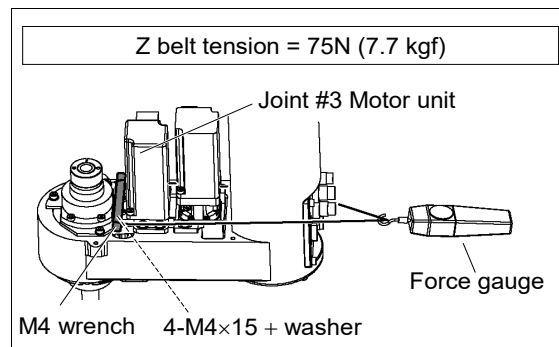


NOTE Check that the motor unit can be moved by hand, and it will not tilt when pulled. If the units are secured too loose or too tight, the belt will not have the proper tension.

- (10) 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 #4 intermediate 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.

Make sure the brake cable not to touch the pulley.



- (11) Connect the connectors.

Connector X331, X31, X32, X341, X41, XB33, XB34

- (12) Re-bundle the cables in their original positions with a wire tie removed in step (7).

Do not allow unnecessary strain on the cables.

- (13) Install the Arm #2 cover.

For details, refer to *Maintenance: 3.2 Arm #2*.

- (14) Install the Arm #1 side cover.

For details, refer to *Maintenance: 3.1 Arm #1*.

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

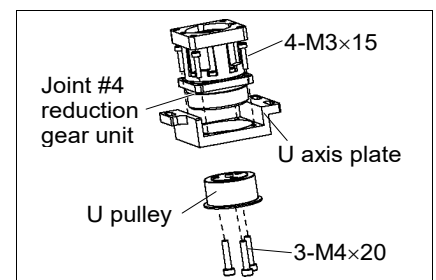
For details on the calibration method, refer to *Maintenance: 13. Calibration*.

8.3 Replacing the Reduction Gear Unit

	Name	Quantity	Note	
Maintenance parts	Reduction Gear Unit	1	1510322	
Tools	Hexagonal wrench	width across flats: 1.3 mm	1	For M2.5 set screw
		width across flats: 2 mm	1	For M2.5 screw
	Nippers	1	For cutting wire tie	
Material	Wire tie	1		

Joint #4 reduction gear unit Removal

- Remove the Joint #4 motor unit from Arm #2 and remove the motor.
Follow the steps in *Maintenance: 8.1 Replacing Joint #4 Motor – Removal (1)-(12)*.
- Remove the reduction gear unit.
Remove the U pulley, and remove the Joint #4 reduction gear unit from U axis plate.



Joint #4 reduction gear unit Installation

- Mount the reduction gear unit.
At this point, the maintenance window hole should come to the front of the Arm (the side with no cutout to U axis plate).
- Mount the reduction gear unit to the Joint #4 motor and secure to Arm #2.
Follow the steps in *Maintenance: 8.1 Replacing Joint #4 Motor – Installation (1)-(12)*.

9. Bellows



NOTE The bellows are provided in a unit of one piece.
 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.

	Name	Quantity	Note
Maintenance parts	Bellows (100 mm)	1	1510547
Tools	Cross-point screwdriver	1	For clamp band removal
Material	Liquid gasket	1	

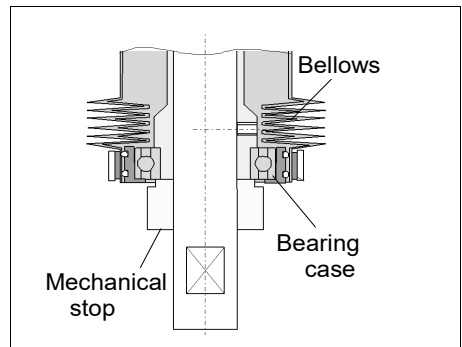
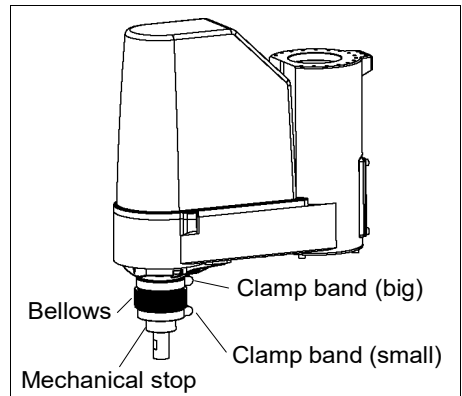
Bellows Removal

- (1) Remove the end effector.
- (2) Remove the wires and tubes from the end effector.
- (3) Turn ON the controller. Stop motor excitation. (MOTOR OFF)
- (4) Remove the mechanical stop.

- (5) Loosen the cramp band securing above and below the bellows.

- (6) Push up the bellows, and remove the bearing case and the baring from the shaft.

- (7) Pull the bellows, rubber sheet and clamp band from the shaft.



Bellows Installation

- (1) To attach the bellows, move the shaft to its upper limit.

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

Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

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

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

- (3) Secure the cover side of the 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.

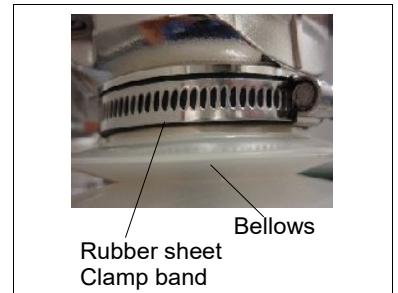
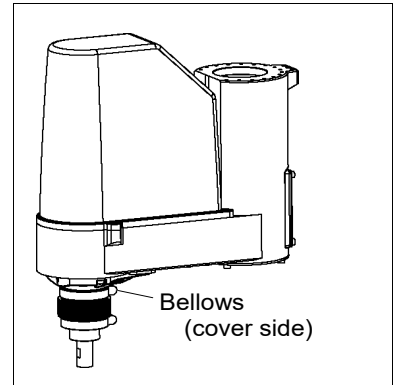
Be careful not to misplace the clamp bands. The clamp band has two sizes; small and large.

Attach the mounting part of the bellows until the end touches the cylindrical part of the cover.

Attach the rubber sheet. Be sure to attach the rubber sheet so that no space is made between the bias cut.



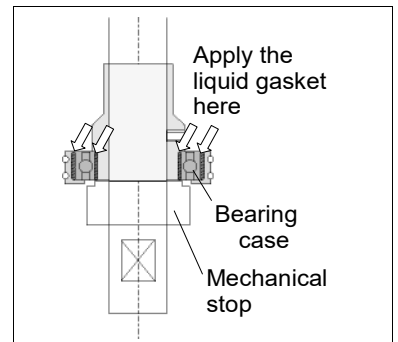
Then, secure them with clamp bands.



- (4) Apply the liquid gasket uniformly.
 - Mating point of the bearing inner race
 - Inside of the bearing base

- (5) Mount the bearing and the bearing case.

- (6) Mount the mechanical stop.



- (7) Secure the end face side of the bellows to the shaft.

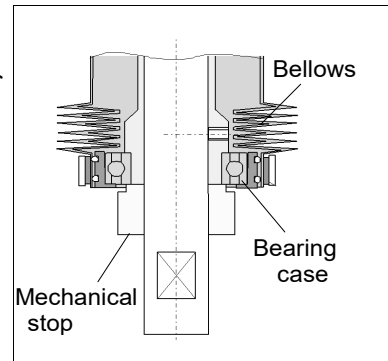
Cover the bearing case (black) on the end face of the shaft with the bellows mounting part.

Attach the rubber sheet. Be sure to attach the rubber sheet so that no space is made between the bias cut.





Then, secure them with clamp bands.

- (8) 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.
- (9) Turn OFF the Controller and peripheral equipment.
- (10) Attach the end effector.
- (11) Connect the wires and tubes to the end effector.




10. Ball Screw Spline Unit

	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting 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, disconnect 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 disconnect 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.
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NOTE  After parts have been replaced (motors, reduction gear units, brakes, timing belts, ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller. After replacing the parts, it is necessary to match these origins. The process of aligning the two origins is called “Calibration”. Refer to *Maintenance: 13. Calibration* to perform the calibration.

10.1 Greasing the Ball Screw Spline Unit

	Name	Quantity	Note
Grease	For Ball Screw Spline Unit (AFB grease)	Proper quantity	
Tools	Wiping cloth	1	For wiping grease (Spline shaft)
	Cross-point screwdriver	1	For clamp band removal Only for Cleanroom-model

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

10.1.1 Standard-model (S type)

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

- (1) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)
- (2) Move the Arm #2 to the position of 180 degree.
- (3) Move the shaft to its upper limit manually while pressing the brake release switch.
- (4) Remove the Arm #1 side cover.

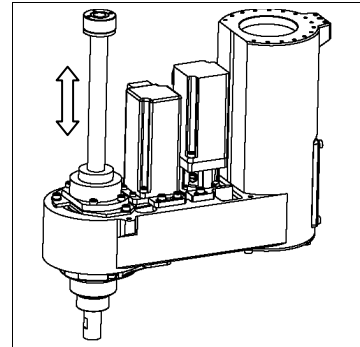
For details, refer to *Maintenance: 3.1 Arm #1*.

- (5) Remove the Arm #2 cover.

For details, refer to *Maintenance: 3.2 Arm #2*.

- (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) Move the shaft to its lower limit manually while pressing the brake release switch.
- (8) Wipe off the old grease from the lower part of the shaft, and 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.
- (9) Move the shaft up and down several times while pressing the brake release switch to smooth out the grease on the shaft. Wipe off excess grease from the shaft.

When wiping off the excess grease from the upper part of shaft, turn OFF the Controller and remove the Arm #2 cover.

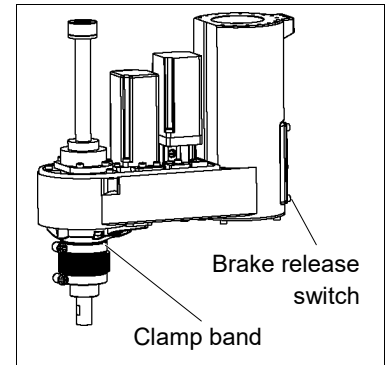
For details, refer to *Maintenance: 3.2 Arm #2*.

10.1.2 Cleanroom-model / Protected-model (C / D with bellows / P type)

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

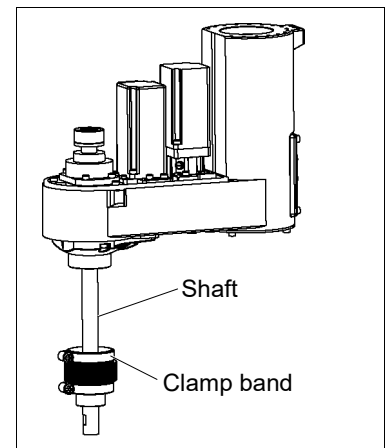
- (1) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)
- (2) Move the Arm #2 to the position of 180 degree.
- (3) Move the shaft to its upper limit manually while pressing the brake release switch.
- (4) Wipe off the old grease from the upper part of the shaft, and apply new grease to it.

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



- (5) Move the shaft to its lower limit manually while pressing the brake release switch.
- (6) Loosen the clamp band on the bellows, and then move the bellows downward.
- (7) 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.



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

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

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

Attach the mounting part of the bellows until it touches the cylindrical part of the cover.



Then, secure them with clamp bands.

10.2 Replacing the Ball Screw Spline Unit

	Name	Quantity	Note
Maintenance parts	Ball Screw Spline Unit	1	Standard-model: 1514472
			Cleanroom-model: 1514473
Grease	For Ball Screw Spline Unit (AFB grease)	Proper quantity	
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Nippers	1	For cutting wire tie
	Force gauge	1	Belt tension 75N (7.6 kgf) / 120 N (12.2 kgf)
	Suitable cord (Length about 1000 mm)	1	For belt tension
	Wiping cloth	1	For wiping grease (Spline shaft)
Material	Wire tie	2	

Ball screw spline unit Removal

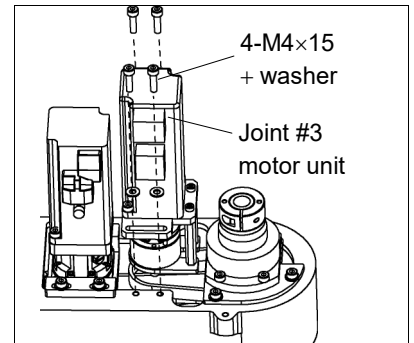
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Move Arm #2 to the position of 180 degree.
- (4) Turn OFF the Controller.
- (5) Detach the wires/tubes from the end effector, and remove the end effector.
- (6) This step is only for Cleanroom-model.
Remove the bellows. For details, refer to *Maintenance: 9. Bellows*.
- (7) Remove the Arm #1 side cover and Arm #2 cover.
For details, refer to *Maintenance: 3. Covers*.
- (8) Cut off the wire tie banding motor cables to the motors of Joints #3, #4.

Be sure to remember the cable layout to connect the cables to the original position.
- (9) Disconnect the following connectors.
Connectors X331, X31, X32, X341, X41 (Hold the clip to remove.)
Connector XB33, XB34

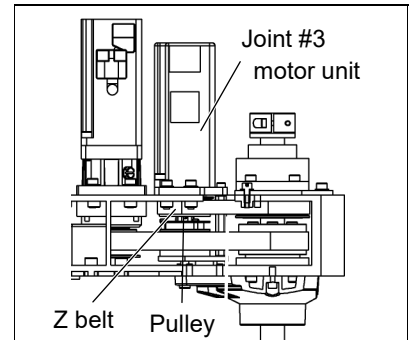
(10) Loosen the Z belt.

Loosen four bolts securing the Joint #3 motor.
Slide the Joint #3 motor unit toward the arm end.



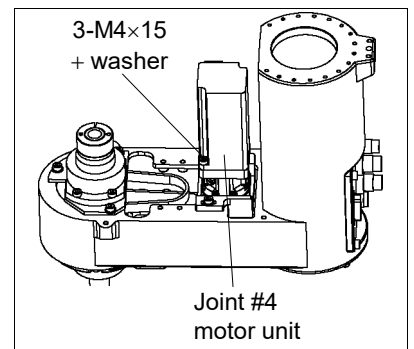
(11) Remove the Joint #3 motor unit from Arm #2.

Remove the bolts securing the Joint #3 motor.
Remove the pulley from the Z belt and pull out the Joint #3 motor unit.



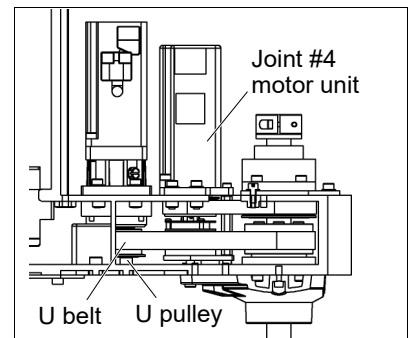
(12) Loosen the U belt.

Loosen four bolts securing the Joint #4 motor.
Slide the Joint #4 motor unit toward the arm end.



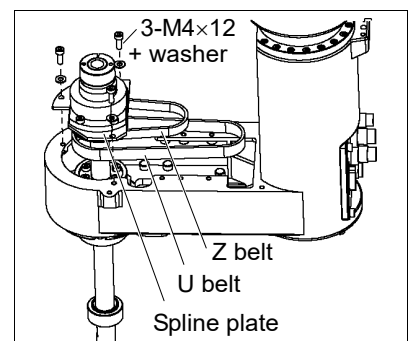
(13) Remove the Joint #4 motor unit from Arm #2.

First, remove the bolts securing the Joint #4 motor.
Next, remove the U pulley from the U belt and pull out the Joint #4 motor unit.



(14) Remove the U belt and Z belt.

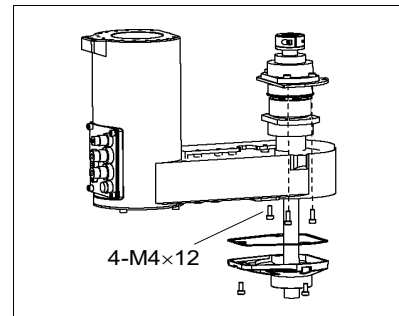
Remove the bolts securing the spline plate.
Hold the spline plate upward and pull the U belt and Z belt out of the shaft.



(15) Remove the under cover.

For details, refer to *Maintenance: 3.2.Arm #2*.

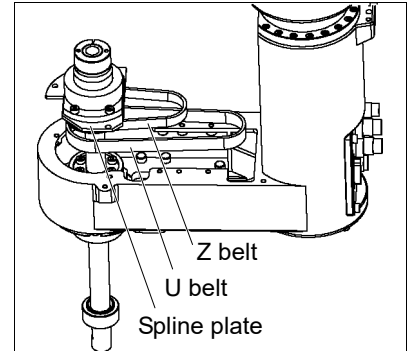
(16) Remove the nut mounting screws of the ball screw spline shaft on the underside of Arm #2.



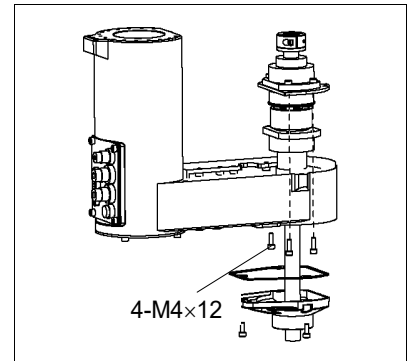
(17) Pull the ball screw spline unit out of Arm #2.

Ball screw spline unit
Installation

- (1) Pass the U belt and Z belt through the shaft and mount the ball screw spline unit to Arm #2.

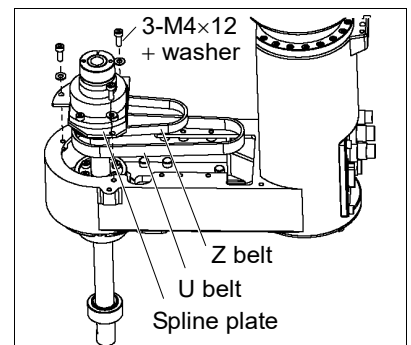


- (2) Secure the nut mounting screws of the ball screw spline shaft on lower side of Arm #2.
Be sure to keep the timing belt from being stuck between the nut and Arm #2.



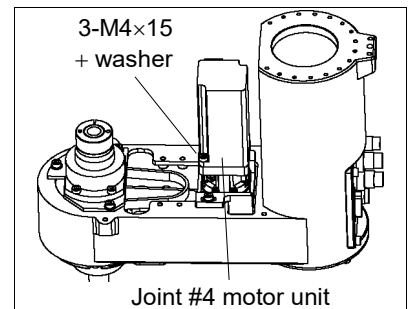
- (3) Secure the under cover.
For details, refer to *Maintenance: 3.2.Arm #2*.

- (4) Loosely secure the spline plate to Arm #2.
Secure the spline plate to Arm #2 after moving the shaft up and down several times.



- (5) Place the Joint #4 motor unit back to Arm #2.

- (6) Set the U belt around the U pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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



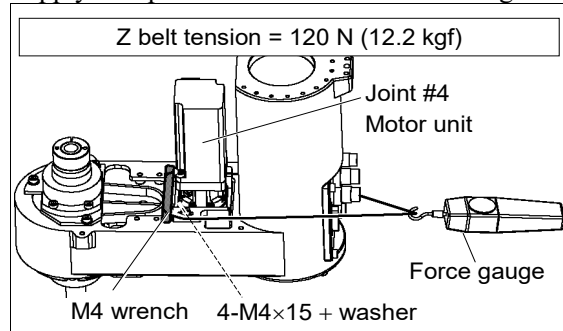
NOTE Check that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

- (8) Apply the proper tension to the U belt, and then secure the Joint #4 motor unit.

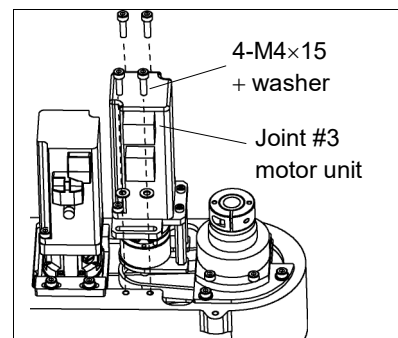
Hexagonal wrench (Stubby type) makes it easier to tighten / remove the screws.

Put M4 wrench to the Joint #4 motor unit near its mounting plate.

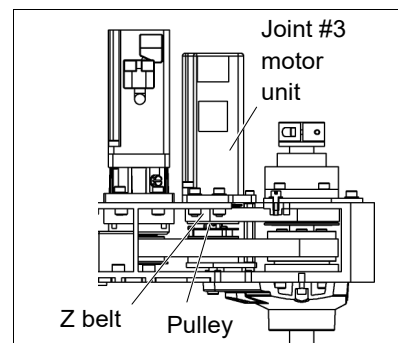
Pass a suitable cord or string around the Joint #4 motor unit. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure.



- (9) Place the Joint #3 motor unit back to Arm #2 so that the motor cable faces toward the right side of arm.



- (10) Put the Z belt around the Z pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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

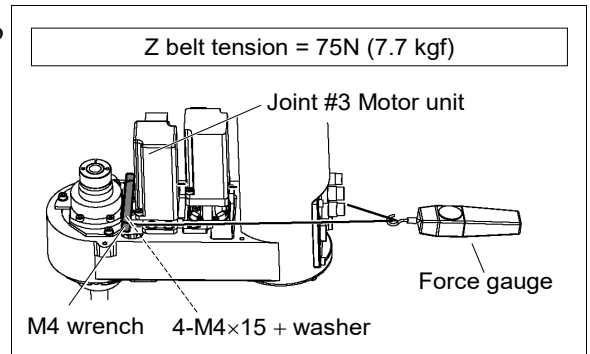


Check that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

- (12) Apply the proper tension to the U 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.

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



- (13) Connect the following connectors;

Connector X331, X31, X32, X341, X41

Connector XB33, XB34

- (14) Re-bundle the cables in their original positions with a wire tie removed in Removal step (8).

Do not allow unnecessary strain on the cables.

- (15) If the position of the lower limit mechanical stop was changed for area limit, secure it to the proper position.

- (16) Grease the shaft.

For details, refer to *Maintenance: 10.1. Greasing the Ball Screw Spline Unit*.

- (17) Install the Arm #2 cover and Arm #1 side cover.

For details, refer to *Maintenance: 3. Covers*.

- (18) Turn OFF the Controller and peripheral equipment.

- (19) Install the end effector, and connect wires and tubes to the end effector.


- (20) This step is only for Cleanroom-model.


Install the bellows. For details, refer to *Maintenance: 9. Bellows*.

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

For details, refer to *Maintenance: 13. Calibration*.


11. Lithium Battery

 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting 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, disconnect 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 disconnect 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.
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 WARNING	<ul style="list-style-type: none"> ■ 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. <table style="margin-left: 20px; border: none;"> <tr> <td style="padding-right: 20px;"><Improper Handling></td> <td>• Forced Discharge</td> </tr> <tr> <td>• Battery Charge</td> <td>• Deformation by Pressure</td> </tr> <tr> <td>• Disassembly</td> <td>• Short-circuit (Polarity; Positive/Negative)</td> </tr> <tr> <td>• Incorrect Installation</td> <td>• Heating (85°C or more)</td> </tr> <tr> <td>• Exposing to Fire</td> <td>• Soldering the terminal of the lithium battery directly</td> </tr> </table> ■ When disposing of the battery, consult with the professional disposal services or comply with the local regulation. Spent battery or not, make sure the battery terminal is insulated. If the terminal contacts with the other metals, it may short and result in heat generation, leakage, explosion, or inflammation. 	<Improper Handling>	• Forced Discharge	• Battery Charge	• Deformation by Pressure	• Disassembly	• Short-circuit (Polarity; Positive/Negative)	• Incorrect Installation	• Heating (85°C or more)	• Exposing to Fire	• Soldering the terminal of the lithium battery directly
<Improper Handling>	• Forced Discharge										
• Battery Charge	• Deformation by Pressure										
• Disassembly	• Short-circuit (Polarity; Positive/Negative)										
• Incorrect Installation	• Heating (85°C or more)										
• Exposing to Fire	• Soldering the terminal of the lithium battery directly										


In case of the low lithium battery power, the error to warn the voltage reduction occurs at the Controller startup (the software startup). All position data will be lost and you will need to calibrate all joints.

The life span of the lithium battery varies depending on the energizing hours and installation environment of the Controller. It is about 3 years as a rough guide (when the Controller is connected to power for 8 hours a day). When the Controller is not connected to power, the battery consumption will significantly increase compared to when the Controller is energized. If warnings of voltage reduction occur, replace the lithium metal battery even if it has not reached the above product life.

NOTE
 For the EPSON RC+ 7.0 Ver. 7.2.x or later (firmware Ver.7.2.x.x or later), the recommended replacement time for the battery can be checked in the [Maintenance] dialog box of the EPSON RC+ 7.0.

For details, refer to the following manual.

Robot Controller RC700 / RC700-A Maintenance 6. Alarm

NOTE
 For the EPSON RC+ 5.0 Ver. 5.4.7 or later (firmware Ver.1.16.4.x or 1.24.4.x or later), the recommended replacement time for the battery can be checked in the [Maintenance] dialog box of the EPSON RC+ 5.0.

For details, refer to the following manual.

Robot Controller RC180 "Appendix. Alarm"

The battery may run out if it passes the recommended replacement time.

If no warnings of voltage reduction occur, the calibration for all joints is not necessary. You need to perform calibration if the position moves from the originals after replaced the battery.

Always use the lithium battery and battery board designated by us.

(Refer to *Maintenance: 14. Maintenance Parts List.*)

Be careful of the battery polarity to connect it correctly.

	Name	Quantity	Note
Maintenance parts	Battery unit (Lithium battery)	1	2117879
	Battery board	1	2126750
Tools	Nippers	1	For cutting wire tie
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
Material	Wire tie	1	For fixing battery unit (battery)
		2	For fixing cable

11.1 Replacing the Battery Unit (Lithium Battery)

Battery unit (lithium battery) Removal

- (1) Turn OFF the Controller.
- (2) Remove the connector plate and base cover.

For details, refer to *Maintenance: 3.3 Connector Plate and 3.4 Base Cover*.

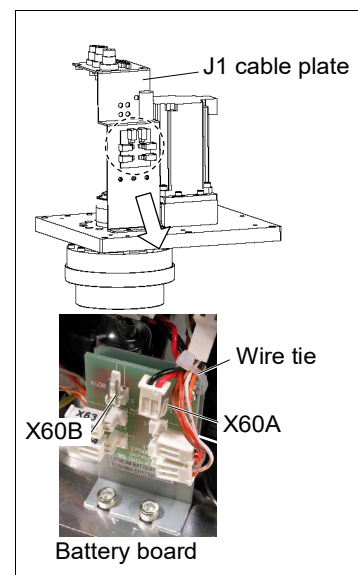
- (3) Connect the connectors of the new lithium battery to the battery board.

User the unused connector of the two connectors X60A, X60B on the upper part of the battery board.

Be sure to connect the connector of the new battery before disconnecting the old battery. If the current battery is disconnected before connecting the new battery, the robot will lose the home position data and the calibration must be executed again.

- (4) Cut off the wire tie banding the cables of lithium battery.

- (5) Cut off the wire tie banding the lithium battery, Remove the battery.



Battery unit (lithium battery) Installation

- (1) Mount the new lithium battery to the battery board.

- (2) Fix the cable of lithium battery and connector cable connecting to battery board with wire tie. Refer to the procedure (3).

- (3) Mount the base cover and connector plate.

For details, refer to *Maintenance: 3.3 Connector Plate and 3.4 Base Cover*.

- (4) Turn ON the Controller.

- (5) Check if the Manipulator moves to points (poses) correctly.

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

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

For details, refer to *Maintenance: 13. Calibration*.

11.2 Replacing the Battery Board

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

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

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

Refer to *Maintenance: 13. Calibration* to perform the calibration.

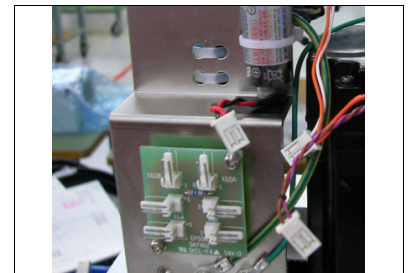
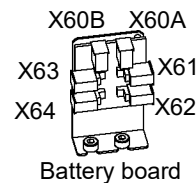
Battery board Removal

- (1) Turn OFF the Controller.
- (2) Remove the connector plate and base cover.

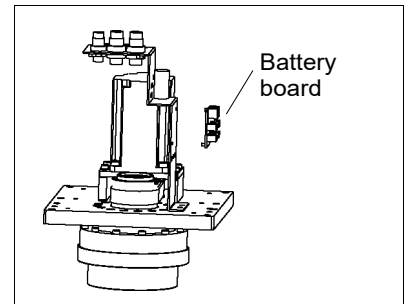
For details, refer to *Maintenance: 3.3 Connector Plate* and *3.4 Base Cover*.

- (3) Disconnect the following connectors from the battery board.

Connectors
X60, X61, X62,
X63, X64



- (4) Loosen the screws securing the battery board and remove the battery board.
- (5) Cut the wire tie securing the battery and remove the battery.

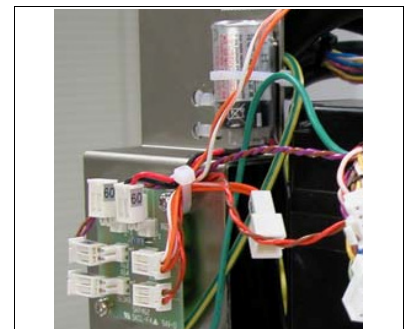
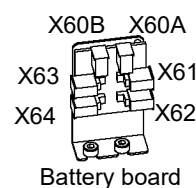


Battery board Installation

- (1) Mount the new battery board and secure it with screws.


- (2) Connect the following connectors to the battery board.

Connectors
X60, X61, X62,
X63, X64



- (3) Mount the battery to Arm #1 cable plate and secure it.
- (4) Mount the base cover and connector plate.
For details, refer to *Maintenance: 3.3 Connector Plate* and *3.4 Base Cover*.
- (5) Turn ON the Controller.
- (6) Perform the calibration of all joints.
For details, refer to *Maintenance: 13. Calibration*.

12. LED Lamp

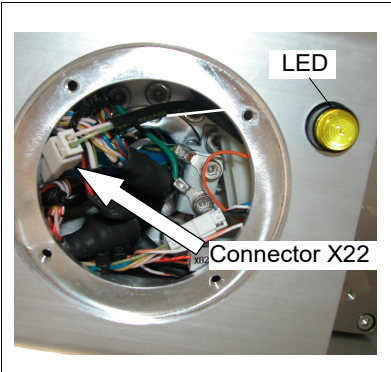
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system. ■ To shut off power to the robot system, disconnect 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 disconnect 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.
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	Name	Quantity	Note
Maintenance parts	LED Lamp	1	1661726
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw

LED Lamp Removal

- (1) Remove the Arm #1 under cover.
 For details, refer to *Maintenance: 3.1 Arm #1 Cover*.

- (2) Disconnect the connector X22 from the LED.
- (3) Remove the LED. Turn it counterclockwise to remove.



LED Lamp Installation

- (1) Pass the cable through the LED mounting hole and connect the following connector.
 Connector X22

- (2) Secure the LED to the Arm #1.
- (3) Mount the Arm #1 under cover.

For details, refer to *Maintenance: 3.1 Arm #1 Cover*.

13. Calibration

13.1 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 EPSON RC+ User's Guide: *2.4 Installation and Design Precautions*.
- 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. Select EPSON RC+ menu-[Tools]-[Command Window] to use the command window.

The information above is omitted in the calibration procedure.

Jog Motion

The process to set the jog motion is included in the [Jog & Teach] page of the Robot Manager. Select EPSON RC+ menu-[Tools]-[Robot Manager] and select the [Jog & Teach] tab to use the [Jog & Teach] page.

The page above is indicated as [Jog & Teach] in the calibration procedure.

When the procedure is different for each type of software, see your software type.



13.2 Calibration Procedure

EPSON RC+ has a wizard for calibration.

This section indicates the calibration using the calibration wizard of EPSON RC+.

EPSON RC+ 5.0

You can also calibrate with option TP1 in TEACH mode. For details, refer to RC170/RC180 option Teach pendant *TP1 manual, Operation: 2.7 Calibrating Origin: E2 Series / G Series / RS series*.

The same calibration procedure is used for each joint.

The follow the steps below are calibration using Joint #1. Follow the steps below to calibrate other joints.

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately. Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2. For details, refer to *Maintenance: 13.3 Accurate Calibration of Joint #2*.

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.

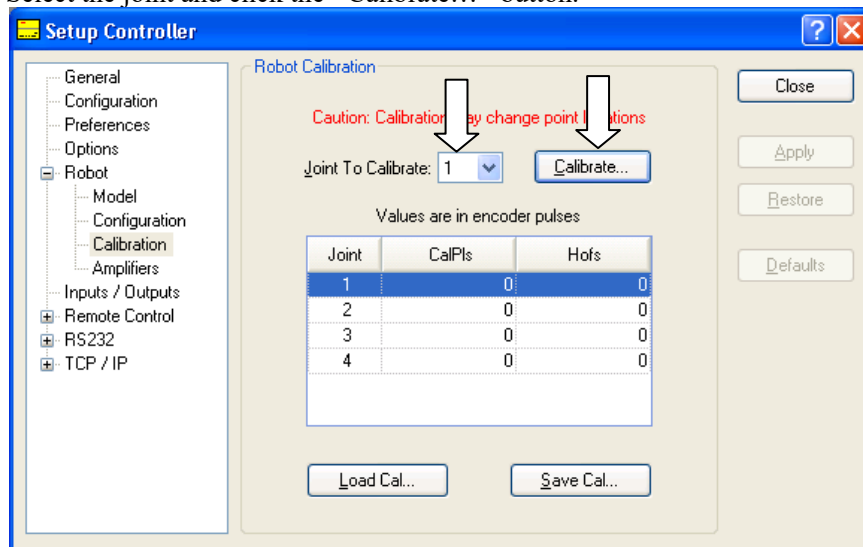
NOTE


The reference point (a point to identify the position of the manipulator) needs to be specified for calibration.

(1) Start the calibration wizard.

EPSON RC+ 5.0

- i. Select EPSON RC+ menu-[Setup]-[Controller] to display the [Controller] dialog.
- ii. Select [Robot]-[Calibration] to display [Robot Calibration].
- iii. Select the joint and click the <Calibrate...> button.



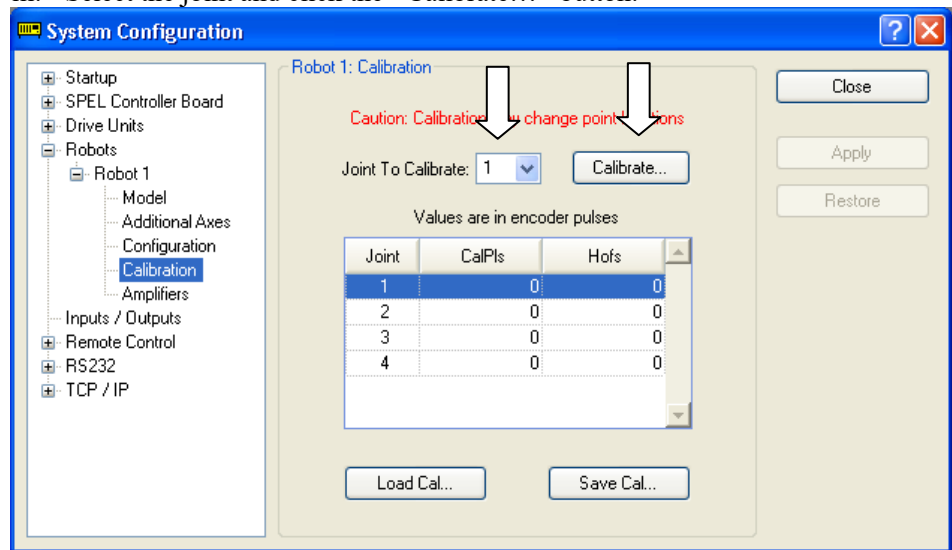
EPSON RC+ 7.0

- i. Select EPSON RC+ menu-[Setup]-[System Configuration].
- ii. Select the [Robot]-[Robot**]-[Calibration].

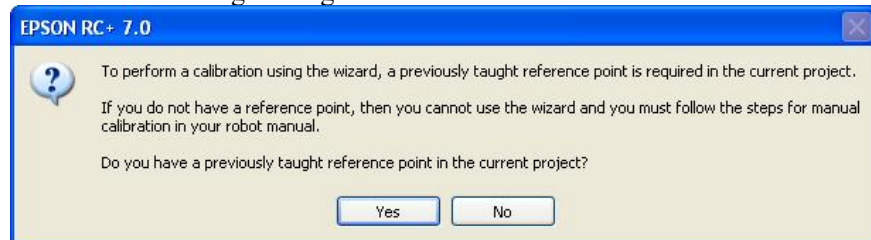
NOTE


Only selected robot can be calibrated.

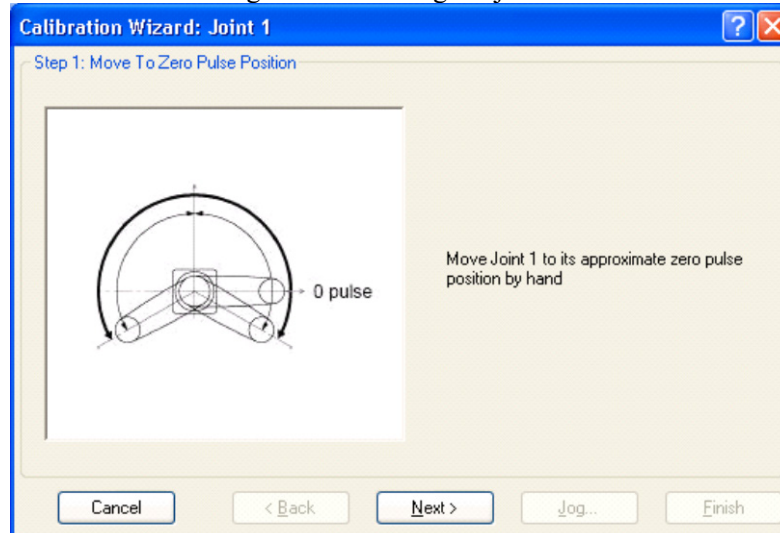
iii. Select the joint and click the <Calibrate...> button.



(2) Confirm the warning message and click the <Yes> button.

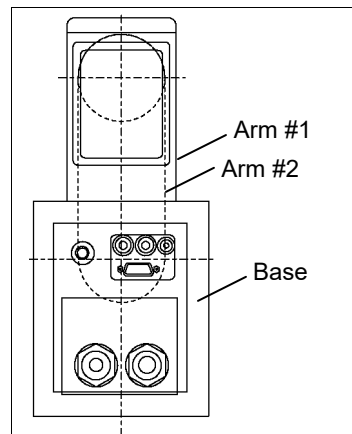


(3) Move the joint to calibrate manually to approximate zero position (Joint #1: 90 deg.), as shown in the dialog. After moving the joint click the <Next> button.

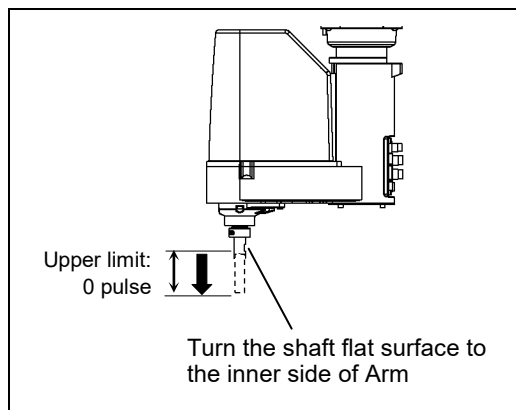
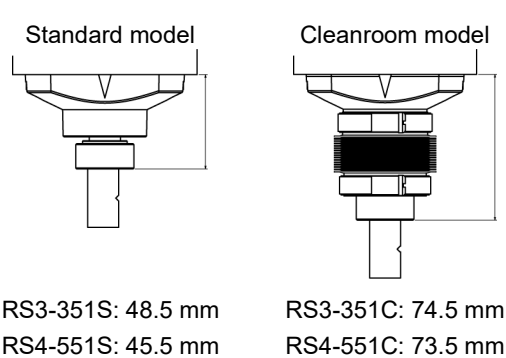


90 deg. position of Joint #1:
 position aligned with Y-axis in Robot coordinate system

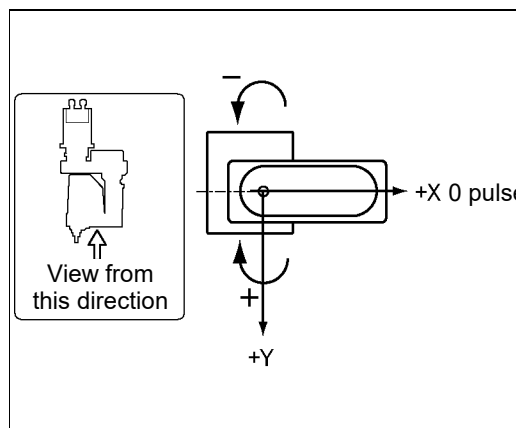
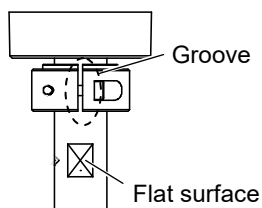
0 pulse position of Joint #2:
 position where Arm #2 is inner side of Arm #1
 (Regardless of the Joint #1 direction)



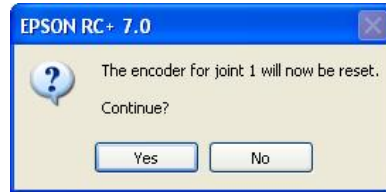
0 pulse position of Joint #3:
 upper limit position in motion range
 The height of Joint #3 depends on manipulator model.



0 pulse position of Joint #4:
 position where the flat surface (or groove in mechanical stop) on the shaft faces toward the inside of Arm #2



- (4) Click the <Yes> button to reset the encoder.



- (5) Reboot the Controller.

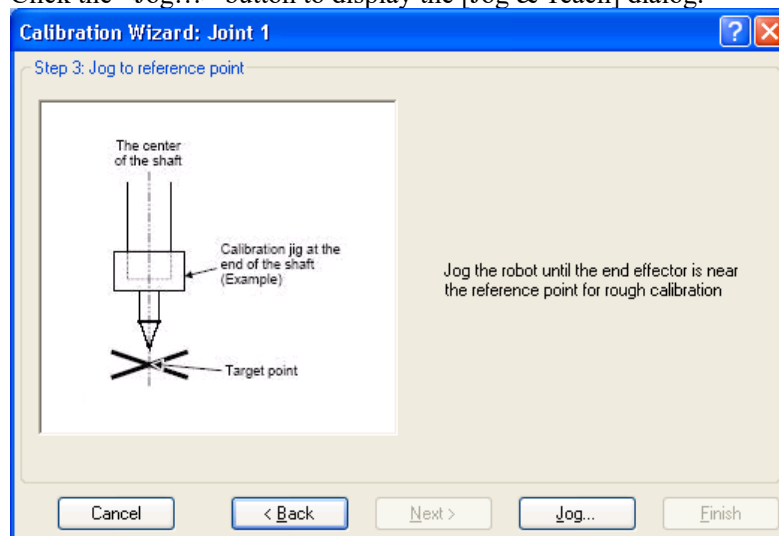


* This window will disappear when the Controller starts up.

- (6) Select the reference point to use for calibration, and click the <Next> button.

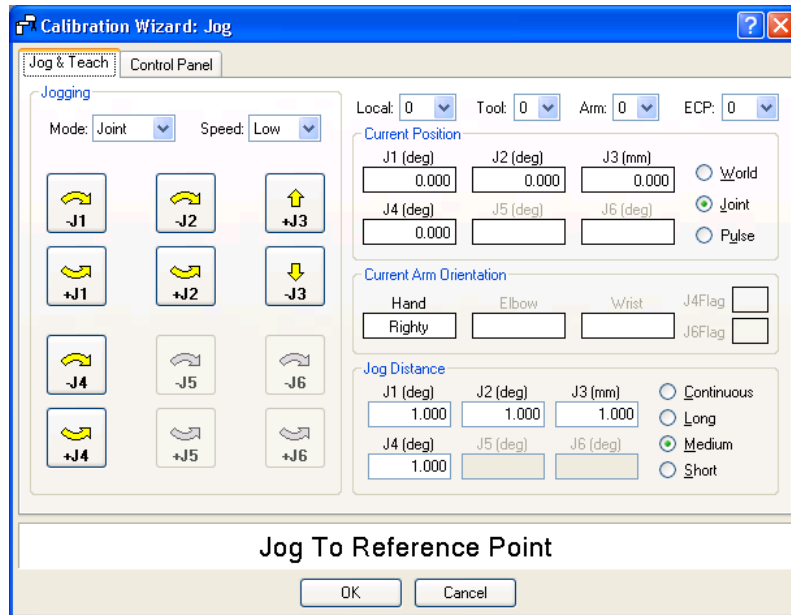


- (7) Click the <Jog...> button to display the [Jog & Teach] dialog.

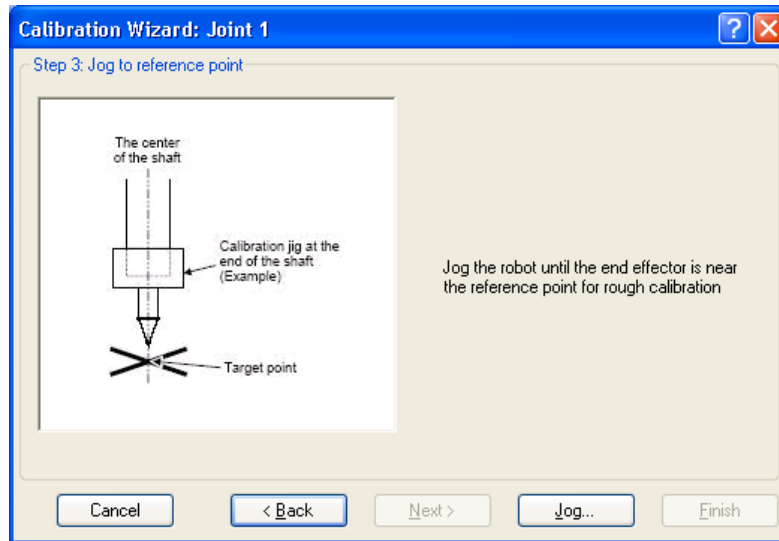


- (8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration.

Then click the <OK> button.

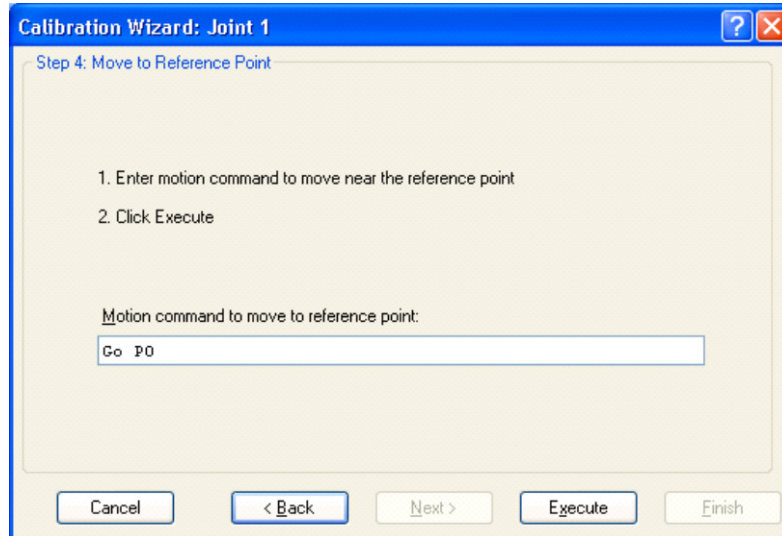


- (9) Click the <Next> button.

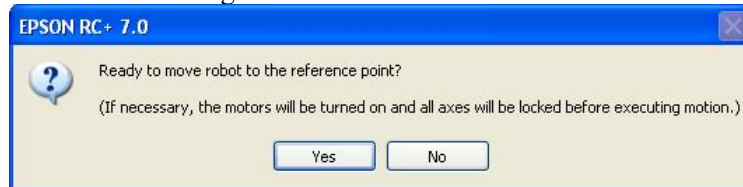


(10) The manipulator moves to the reference point.

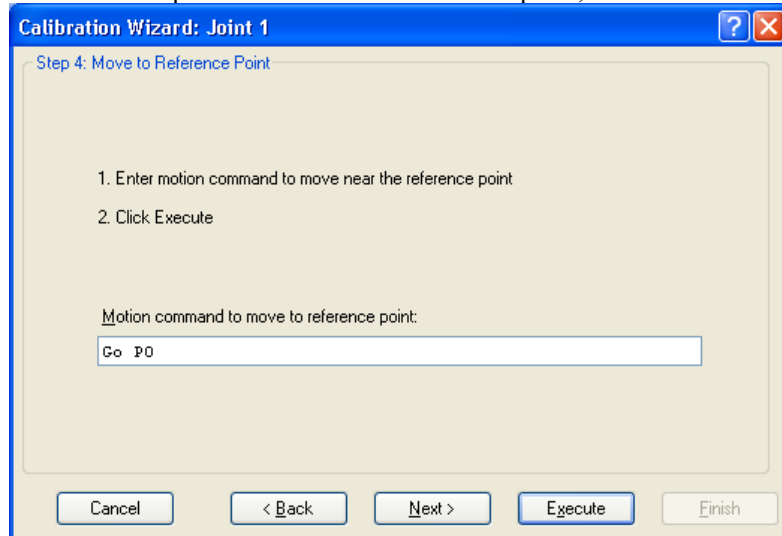
Click the <Execute> button.



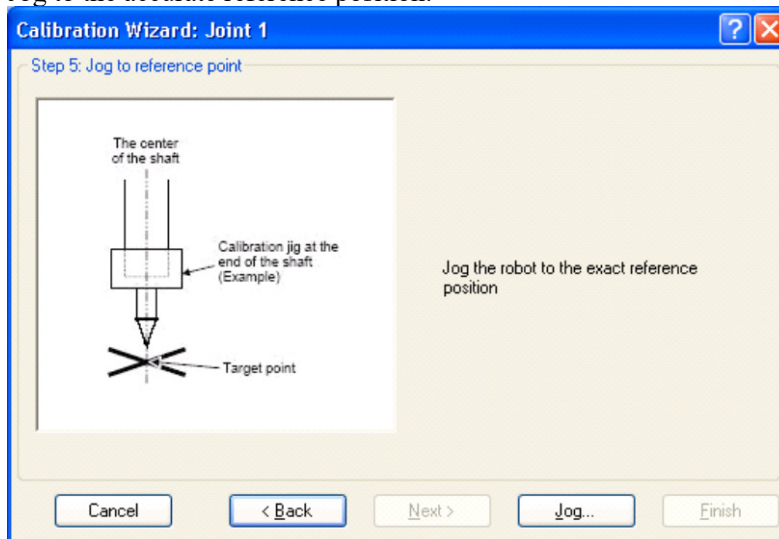
(11) Confirm the message and click the <Yes> button.



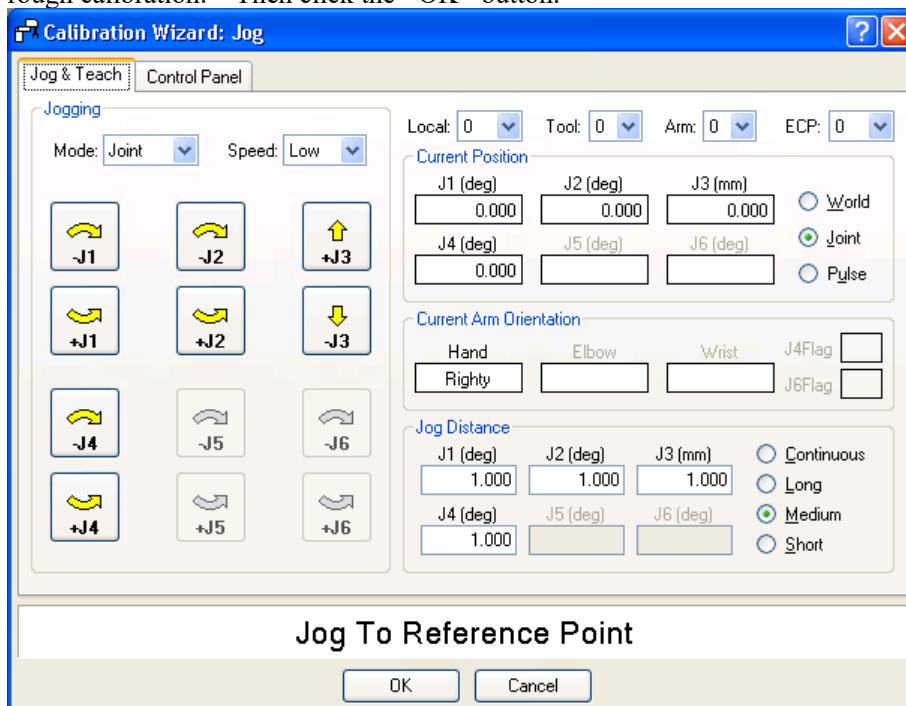
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position.

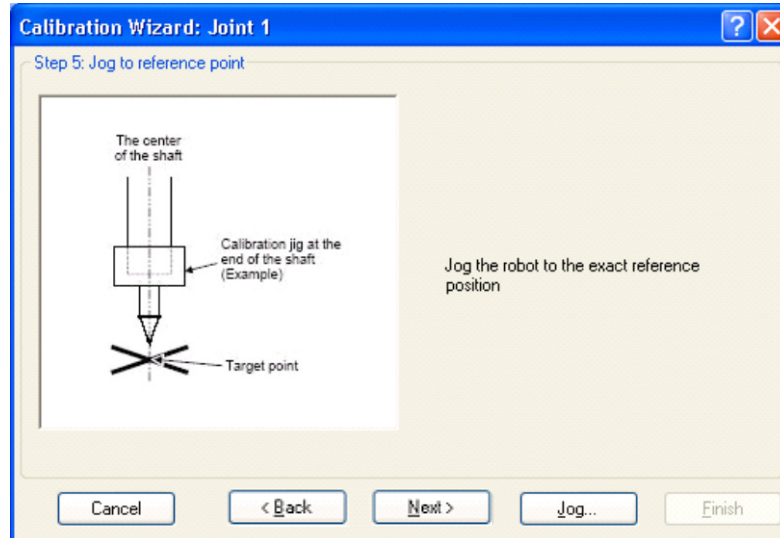


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



* Position Joint #2 only and move Joint #3 to around 0 pulse.

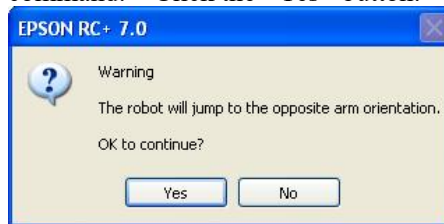
(15) Click the <Next> button.



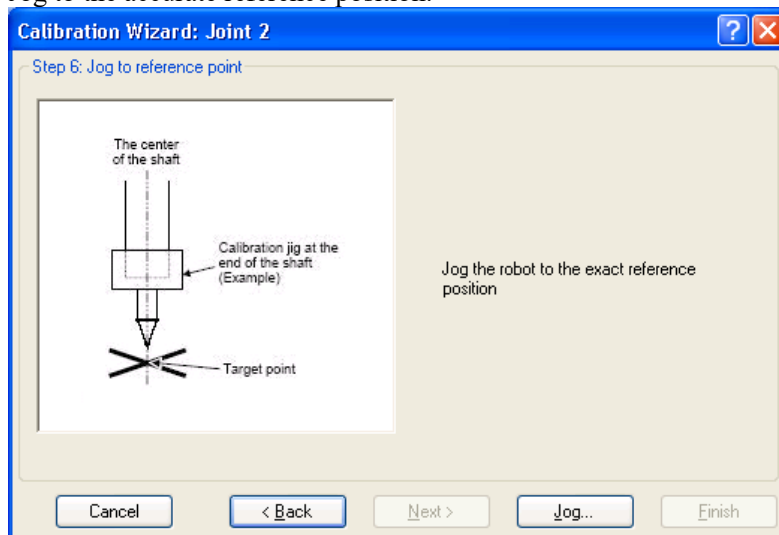
(16) Execute the procedures in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2.

Go on to the step (17) for the other joints calibration.

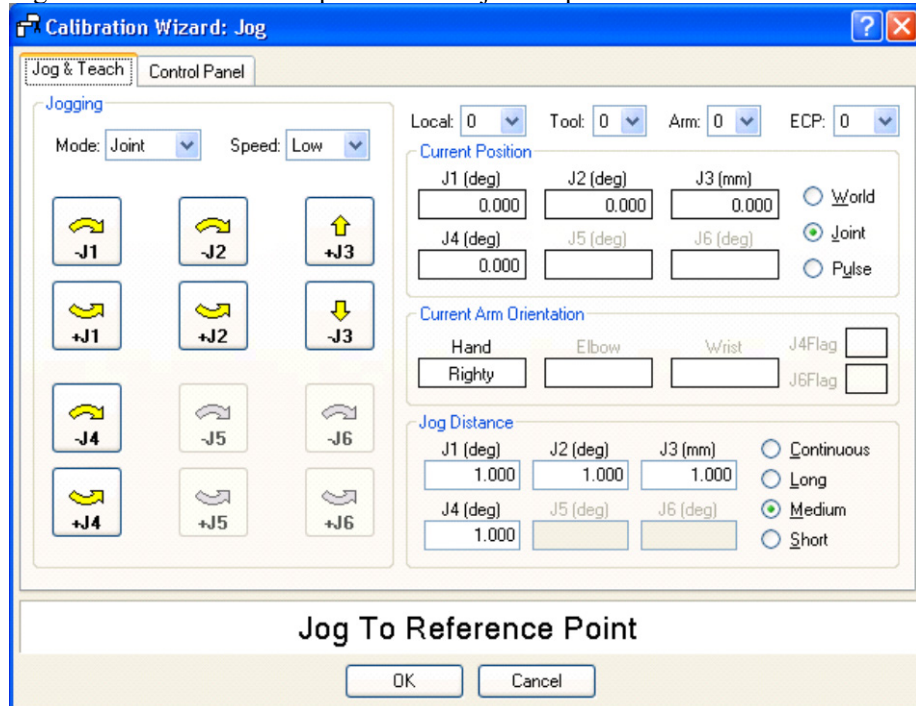
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



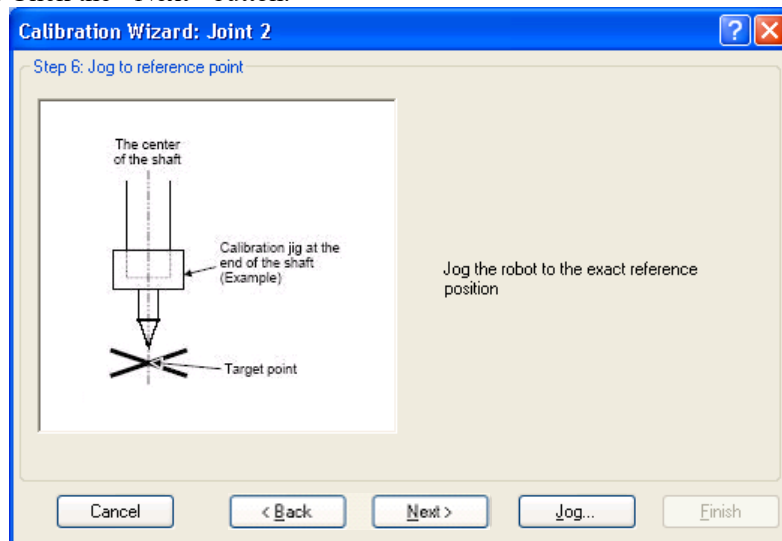
ii. Jog to the accurate reference position.



iii. Jog to the accurate reference position and adjust the position. Click the <OK> button.



iv. Click the <Next> button.



(17) Calibration is complete. Click the <Finish> button.



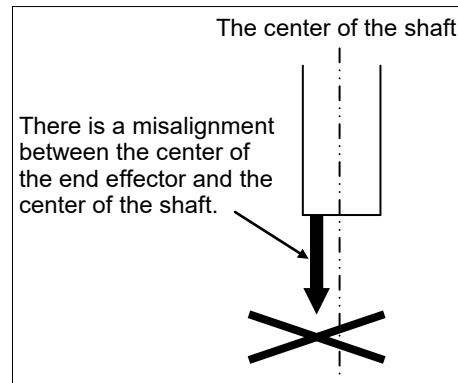
13.3 Accurate Calibration of Joint #2

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.

NOTE If the accuracy of Joint #2 is not obtained through the steps in the section *13.2 Calibration Procedure*, follow the steps below “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2.

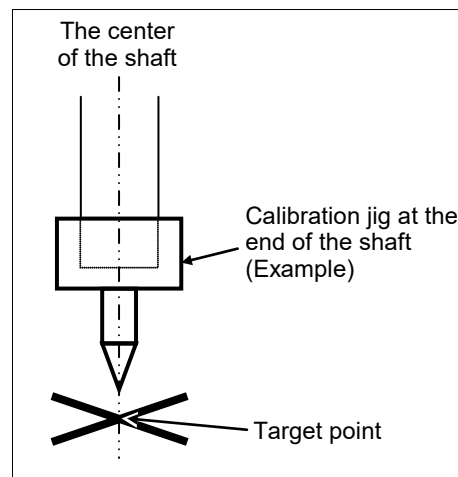
The reference point is the center of the ball screw spline shaft during this calibration.

When there is a misalignment between the center of the end effector and the center of the ball screw spline shaft, remove the end effector and perform the calibration of the shaft.



Make a calibration jig as shown in the right figure and attach it on the end of the shaft to make the center of the shaft clear.

Decide a target point and mark a cross (X) on it so that you can easily verify the center of the shaft after switching the arm pose between right and left.



After removing the end effector and performing the calibration, install the end effector and move the Manipulator to the teaching point to verify whether there is a positional gap. If there is a positional gap, fine-tune the installation position of the end effector and teach the point again.

Coordinates for the working point requires calculation in the following cases:

- Teaching the working point by entering the coordinate values (MDI teaching)
- Switching the arm orientation between right and left at a given point
- Using the Pallet command
- Executing CP control (such as linear or circular interpolation)
- Using the Local command
- Pose data specified with relative coordinates <Example: P1+X(100) >
- Vision Guide camera calibrations

Calibration Using Right / Left Arm Orientations

- (1) Check the point data for calibration

Use a pose (point) you can easily verify the accuracy within the work envelop of both right and left arm. Then, check the number of pose (point) you want to use.

- (2) Open [Tools menu]-[Robot Manager]-[Control Panel] and turn ON the motor.
- (3) Click the <Free All> button to free all joints from servo control. Now, you can move arms by hands.
- (4) Move the arms to the position of point data for calibration in rightly arm orientation.
- (5) From the current position, teach any point data number unused.
This pose (point) is now called P1.

Specify the point number “1” and click the <Teach> button in the [Jog & Teach].

- (6) Click the Lock All in the [Control Panel] to lock all joints under servo control.
- (7) Switch to the lefty arm orientation. Then, move the arm to the same point.

>Jump P1/L:Z(0) ' Change the arm orientation from righty to lefty
Z is the maximum position

* If there is interference on the way from right to lefty, click the Free All in the [Control Panel] and change the arm orientation to lefty by hands. Then, go to the step (6), (7).

- (8) The joints are slightly out of position.

Adjust the gap with the -Z in the Jogging group in the [Jog & Teach]. Then, teach another point data number unused. This pose (point) is now called P2.

Specify point number “P2” and click the <Teach> button in [Jog & Teach].

- (9) Input the new HofS value.

>HofS HofS (1), HofS (2) + (Ppls (P1,2) + Ppls (P2,2)) / 2,
HofS (3), HofS (4)

- (10) From the current lefty arm orientation (the position in the step (8)), teach the point data number used in the step (8). This pose (point) is called P2.

Specify point number “P2” and click the <Teach> button in [Jog & Teach].

- (11) Switch to the righty arm orientation. Then, make sure the manipulator move to the correct position.


>Jump P2/R ' Change the arm orientation from lefty to righty

* If there is any interference on the way from lefty to righty, click the Free All in the [Control Panel] and change the arm orientation to righty by hands. Then, go to the step (6), (11).

- (12) Move the manipulator to other point data and make sure it moves to the correct position. Teach some more points if required.


* Delete the two points taught for the Joint #2 calibration.

13.4 Calibration Procedure without using Calibration Wizard

NOTE  This section indicates the calibration without using the calibration wizard of EPSON RC+. For details of calibration using the calibration wizard, refer to *13.2 Calibration Procedure*.

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately. Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2. For details, refer to *Maintenance: 13.3 Accurate Calibration of Joint #2*.

You cannot calibrate Joint #4 alone because of the structure of the Manipulator. When calibrating Joint #4, you must calibrate Joint #3 and #4 at the same time.

NOTE  The reference point (a point to identify the position of the manipulator) needs to be specified for calibration.

Follow steps 1 to 6 described below in order to calibrate the origin.

1. Basic Pose Confirmation

(1)-1 After the part replacement, perform the calibration using the point data currently registered.

Confirm the point data number (P*) to reconstruct the correct manipulator position.

* Point data before the parts replacement (motor, reduction gear, belt, etc.) is necessary for the calibration.

2. Part Replacement

(2)-1 Replace parts as dictated by this manual.

Be careful not to injure yourself or damage parts during part replacement.

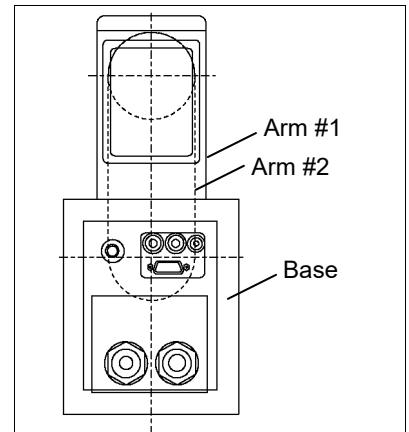
3. Encoder Initialization

(3)-1 Turn ON the Controller when all joints are in the motion range.

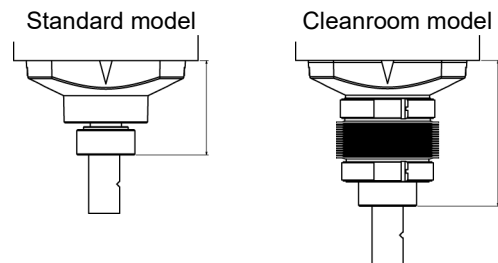
(3)-2 Manually move the joint that needs origin alignment to its approximate 0 pulse position.

90 deg. position of Joint #1:
 position aligned with Y-axis in Robot coordinate system

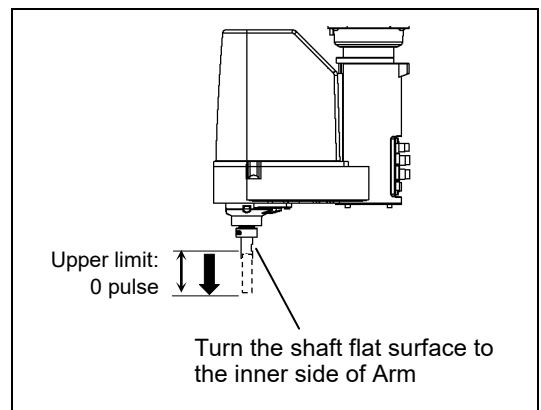
0 pulse position of Joint #2:
 position where Arm #2 is inner side of Arm #1
 (Regardless of the Joint #1 direction)



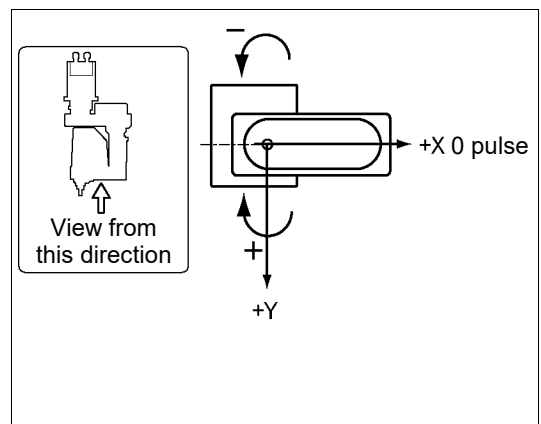
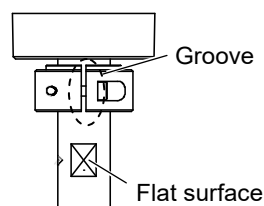
0 pulse position of Joint #3:
 upper limit position in motion range
 The height of Joint #3 depends on manipulator model.



RS3-351S: 48.5 mm	RS3-351C: 74.5 mm
RS4-551S: 45.5 mm	RS4-551C: 73.5 mm



0 pulse position of Joint #4:
 position where the flat surface (or groove in mechanical stop) on the shaft faces toward the inside of Arm #2



(3)-3 Connect EPSON RC+ to the Controller.

EPSON RC+ 7.0 Select a robot to be calibrated. Input as below in the [Command Window] and execute it.

(This example uses “robot 1”.)

```
> robot 1
```

(3)-4 Execute the absolute encoder initialization command.

Input one of the following commands to [Command Window] according to the joint being calibrated.

Joint #1: >EncReset 1

Joint #2: >EncReset 2

Joint #3: >EncReset 3

Joint #4: >EncReset 3, 4

(3)-5 Reboot the Controller.

Select EPSON RC+ menu-[Tools]-[Controller] and click the <Reset Controller> button.



* This window will be disappeared when the Controller starts up.

4. Rough Calibration

(4)-1 Execute the following command from the menu-[Tools]-[Command Window].

```
>calpls 0,0,0,0
```

* Manipulator does not move.

(4)-2 Execute one of the following commands according to the joint you want to calibrate from the menu-[Tools]-[Command Window].

Joint #1 >calib 1

Joint #2 >calib 2

Joint #3 >calib 3

Joint #4 >calib 3, 4

5. Calibration (Accurate Positioning)

(5)-1 Turn ON the motors from the EPSON RC+ menu -[Tools] -[Robot Manager]-[Control Panel].

(5)-2 Click the <Free All> button to free all joints from servo control. Now, you can move arms by hands.

(5)-3 Move the Manipulator by hand to a rough position/posture of the calibration point data.

- (5)-4 Create the data from the calibration point data.

Enter and execute the following command in [Command Window].

(In this example, P1 is used as the calibration point data.)

```
> Calpls Ppls(P1,1), Ppls(P1,2), Ppls(P1,3), Ppls(P1,4)
```

- (5)-5 Move the joint to the specified point using a motion command.

For example, when the specified point data is "P1",

execute "Jump P1:Z(0)" from [Jog & Teach].

* The joint NOT being calibrated moves to the original position.

- (5)-6 Accurately align the joint* being calibrated to the specified point using jog commands.

* You must move Joint #3 and #4 to the position when calibrating Joint #4.

Select the jog mode [Joint] from [Jog & Teach] to execute the jog motion.

- (5)-7 Execute the calibration.

Enter and execute one of the following commands in [Command Window] according to the joint being calibrated.

```
Joint #1: >Calib 1
```

```
Joint #2: >Calib 2
```

```
Joint #3: >Calib 3
```

```
Joint #4: >Calib 3, 4
```

6. Accuracy Testing

- (6)-1 Move the Manipulator to another point to confirm that it moves to the same position. If it does not move to the same position, re-calibrate using another point. You must set the point again if reproducibility cannot be assured through calibration.

14. Maintenance Parts List

14.1 Common Parts

Part Name		Code	Old Code	Note	Reference Maintenance	Overhaul*
AC Servo Motor	Joint #1	1514468	R13B000616	400 W	5.1	✓
	Joint #2	1514451	R13B000614	200 W / RS3-351*	6.1	✓
		1514468	R13B000616	400 W / RS4-551*		
	Joint #3	1514453	R13B000615	150 W	7.1	✓
Joint #4	1514469	R13B000617	100 W	8.1	✓	
Reduction Gear Unit	Joint #1	1514470	R13B010018	RS3-351*	5.2	✓
		1547165	R13B010029	RS4-551*		
	Joint #2	1514471	R13B010019		6.2	✓
	Joint #4	1510322	R13B010020		8.3	✓
Electromagnetic Brake	Joint #3	1497639	R13B030501		7.3	✓
Timing Belt	Joint #1	1510524	R13B030216	Width 15 mm Length 270 mm	5.3	✓
	Joint #2	1510525	R13B030217	Width 10 mm Length 246 mm	6.3	✓
	Joint #3	1510526	R13B030218	Width 9 mm Length 246 mm	7.2	✓
	Joint #4	1510527	R13B030219	Width 12 mm Length 339 mm	8.2	✓
Battery Board		2126750	R13B041203	No lithium battery Installed in Base	11.2	
Battery Unit		2117879	R13ZA00600 300	Spare lithium battery ER17330V (TOSHIBA)	11.1	
O-ring	Joint #1	1213269	R13B031206	S90A	5.2	
		1510529	R13B031236	S65A		
		1510530	R13B031237	S30A		
	Joint #2	1213267	R13A031200 700	S71A	6.2	
		1510531	R13B031238	S53A		
Grease **	AFB (Ball Screw Spline)	—	—		2.3	
	SK-1A (Reduction Gear Unit)	—	—	For purchasing the grease, please contact the supplier of your region.	2.3	
	GPL-224 (Cable)	—	—		2.3	
Oil seal unit (Arm #2)		1514476	R13B031239			

Part Name		Code	Old Code	Note	Reference Maintenance	Overhaul*	
M/C cable	3 m	For RC180	R12NZ9007C	R12B020434	(For RC620)	3.4	
		For RC700-A, Straight	R12NZ900KN	—			
		For RC700-A, L-shaped	R12NZ900KR	—			
	5 m	For RC180	R12NZ9002F	R12B020435	(For RC620)		
		For RC700-A, Straight	R12NZ900KP	—			
		For RC700-A, L-shaped	R12NZ900KT	—			
	10 m	For RC180	R12NZ9002G	R12B020436	(For RC620)		
		For RC700-A, Straight	R12NZ900KQ	—			
		For RC700-A, L-shaped	R12NZ900KU	—			
	15 m	For RC700-A, Straight	R12NZ900Y7	—			
		For RC700-A, L-shaped	R12NZ900Y9	—			
	20 m	For RC700-A, Straight	R12NZ900Y8	—			
For RC700-A, L-shaped		R12NZ900YA	—				
LED Lamp		1661726	R13B030004		12		
Brake Release Switch		2117817	R13Z702640100		—		

* As a rough indication, perform the overhaul (parts replacement) before reaching 20,000 operation hours of the Manipulator. The operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours].

For details, refer to Maintenance 2.2 Overhaul (Parts Replacement).

** Regarding purchase of grease

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase the grease required for maintenance from the manufacturers listed in the table below as of April 2015. Regarding purchase of the grease, please contact the following manufacturers. If there is anything unclear, please contact the supplier of your region.

Product name	Manufacturer	URL
THK AFB-LF Grease	THK CO., LTD.	http://www.thk.com/
Harmonic Grease SK-1A	Harmonic Drive Systems Inc.	http://www.harmonicdrive.net/
Krytox®GPL-224	DuPont	http://www2.dupont.com/Our_Company/en_US/worldwide/us_country.html

14.2 Parts by Environment Model

14.2.1 S: Standard-model

Part Name	Code	Old Code	Note	Reference: Maintenance	Overhaul *
Ball Screw Spline	1514472	R13B010222		10.2	✓
Cable Unit	1514474	R13B020028	RS3-351*	4	
	1547166	R13B020054	RS4-551*		
Arm #2 Cover	1509821	R13B030425		3.2.1	

* As a rough indication, perform the overhaul (parts replacement) before reaching 20,000 operation hours of the Manipulator. The operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours].

For details, refer to *Maintenance 2.2 Overhaul (Parts Replacement)*.

14.2.2 C: Cleanroom-model

Part Name	Code	Old Code	Note	Reference: Maintenance	Overhaul *
Ball Screw Spline	1514473	R13B010223		10.2	✓
Cable Unit	1514475	R13B020029	RS3-351*	4	
	1548346	R13B020055	RS4-551*		
Arm #2 Cover	1509828	R13B030426		3.2.1	
Bellows	1510547	R13B030705	**	9	
Gasket Unit	1514477	R13B031240	RS3-351*	3	
	1548345	R13B031254	RS4-551*		
Liquid gasket KE3497W ***	—	—	For purchasing the liquid gasket, please contact the supplier of your region.	9	

* As a rough indication, perform the overhaul (parts replacement) before reaching 20,000 operation hours of the Manipulator. The operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours].

For details, refer to *Maintenance 2.2 Overhaul (Parts Replacement)*.

** The bellows are provided in a unit of one piece.

*** Regarding purchase of liquid gasket

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase liquid gasket required for maintenance from the manufacturers listed in the table below as of April 2015. Regarding purchase of liquid gasket, please contact the following manufacturers. If there is anything unclear, please contact our suppliers.

Product name	Manufacturer	URL
KE-3497-W	Shin-Etsu Chemical Co., Ltd.	http://www.shinetsusilicone-global.com/