

Industrial Robot: SCARA Robots

G series

MAINTENANCE MANUAL

Rev.3

ENM226R5374F

Original instructions

Industrial Robot: SCARA Robots

G series Maintenance Manual

Rev.3

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FOREWORD

Thank you for purchasing our robot products.

This manual contains the information necessary for the correct use of the robot controller. Please carefully read this manual and other related manuals before installing the robot system.

Keep this manual handy for easy access at all times.

The robot system 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. Please note that the basic performance of the product will not be exhibited if our robot system is used outside of the usage conditions and product specifications described in the manuals.

This manual describes possible dangers and consequences that we can foresee. Be sure to comply with safety precautions on this manual to use our robot system safely and correctly.

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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 Manual Read this manual first

DISPOSAL

When disposing this product, dispose in accordance with the laws and regulations of each country.

Regarding battery disposal

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

For European Union customers only



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.

For Taiwanese customers only



Please separate used 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.

Before Reading This Manual

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

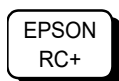
Structure of Control System

The G series Manipulators can be used with the following combinations of Controllers and software.

Controller		Software
Name	Structure	
RC700-A	Control Unit Drive Unit	EPSON RC+ 7.0 Ver.7.1.2 or later

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.

Setting by Using Software



This manual contains setup procedures using the software. Those sections are indicated by the symbol on the left.

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.

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.

Photos and Illustrations Used in This Manual

The appearance of some parts may differ from those on an actual product depending on when it was shipped or the specifications. The procedures themselves, however, are accurate.

Figures in this Manual

The figures of manipulators indicated in this manual are basically Standard-model Manipulator. Unless special instruction is provided, the specifications of Standard-model and Cleanroom-model are the same.

The Manuals of This Product

The following are typical manual types for this product and an outline of the descriptions.

Safety Manual (book, PDF)

This manual contains safety information for all people who handle this product. The manual also describes the process from unpacking to operation and the manual you should look at next.

Read this manual first.

- Safety precautions regarding robot system and residual risk
- Declaration of conformity
- Training
- Flow from unpacking to operation

RC700 series Manual (PDF)

This manual explains the installation of the entire robot system and the specifications and functions of the controller. The manual is primarily intended for people who design robot systems.

- The installation procedure of the robot system (specific details from unpacking to operation)
- Daily inspection of the controller
- Controller specifications and basic functions

G series Manual (PDF)

This manual describes the specifications and functions of the Manipulator. The manual is primarily intended for people who design robot systems.

- Technical information, functions, specifications, etc. required for the Manipulator installation and design
- Daily inspection of the Manipulator

Status Code/Error Code List (PDF)

This manual contains a list of code numbers displayed on the controller and messages displayed in the software message area. The manual is primarily intended for people who design robot systems or do programming.

RC700 series Maintenance Manual (PDF)

G series Maintenance Manual (PDF)

This manual describes the details of maintenance etc. The manual is intended for people who perform maintenance.

- Daily inspection
- Replacement and repair of maintenance parts
- The method of firmware update and controller setting backup etc.

EPSON RC+ 7.0 User's Guide (PDF)

This manual describes general information about program development software.

EPSON RC+ 7.0 SPEL+ Language Reference (PDF)

This manual describes the robot programming language "SPEL+".

Other Manual (PDF)

Manuals for each option are available.

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G1 Maintenance

This volume contains maintenance procedures with safety precautions for Manipulators.

1. Safety Maintenance

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

Only authorized personnel who have taken maintenance training held by the manufacturer or dealer should be allowed to perform the robot maintenance.

 WARNING	<ul style="list-style-type: none"> ■ Do not remove any parts that are not covered in this manual. Follow the maintenance procedure strictly as described in this manual. Improper removal of parts or improper maintenance may not only cause improper function of the robot system but also serious safety problems. ■ Keep away from the Manipulator while the power is ON if you have not taken the training courses. Do not enter the operating area while the power is ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even it seems to be stopped. ■ When you check the operation of the Manipulator after replacing parts, be sure to check it while you are outside of the safeguarded area. Checking the operation of the Manipulator while you are inside of the safeguarded area may cause serious safety problems as the Manipulator may move unexpectedly. ■ Before operating the robot system, make sure that both the Emergency Stop switches and safeguard switch function properly. Operating the robot system when the switches do not function properly is extremely hazardous and may result in serious bodily injury and/or serious damage to the robot system as the switches cannot fulfill their intended functions in an emergency.
 WARNING	<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.
 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. ■ When operating maintenance of manipulator, secure about 50 cm of empty space around the manipulator.

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.

	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						√

h = hour

2.1.2 Inspection Point

Inspection Item

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts/screws.	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
Check looseness of connectors.	External connectors on Manipulator (on the connector plates etc.)	√	√	√	√	√
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 the brake operation	Joint #3	√	√	√	√	√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√

Inspection Method

Inspection Point	Inspection Method
Check looseness or backlash of bolts/screws.	Use a hexagonal wrench to check that the end effector mounting bolts and the Manipulator mounting bolts are not loose. When the bolts are loose, refer to "2.4 Tightening Hexagon Socket Head Bolts" and tighten them to the proper torque.
Check looseness of connectors.	Check that connectors are not loose. When the connectors are loose, reattach it not to come off.
Visually check for external defects. Clean up if necessary.	Check the appearance of the Manipulator and clean up if necessary. Check the appearance of the cable, and if it is scratched, check that there is no cable disconnection.
Check for bends or improper location. Repair or place it properly if necessary.	Check that the safeguard, etc. are located properly. If the location is improper, place it properly.
Check the brake operation	Check that the shaft does not fall when in MOTOR OFF. If the shaft falls when in MOTOR OFF and the brake is not released, contact the supplier. Also, the break is not released even operated release the break, contact the supplier.
Check whether unusual sound or vibration occurs.	Check that there is no unusual sound or vibration when operating. If there is something wrong, contact the supplier.

2.2 Overhaul (Parts Replacement)



CAUTION

- If you do not overhaul properly, it may have a serious impact on safety.
- 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 ambient temperature, 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.

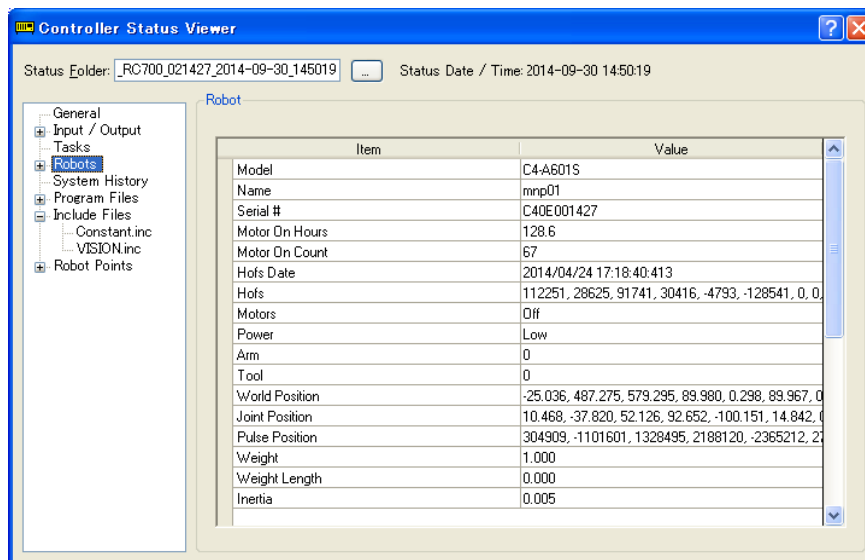
RC700 series Maintenance Manual "6. Alarm"

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 *14. G1 Maintenance Parts List*.


For details of replacement of each part, refer to each 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
Joint #1, Joint #2	Reduction gear units	Overhaul timing	SK-2
Joint #3	Ball screw spline unit	At 100 km of operation (50 km for first greasing)	AFB

Joint #1, 2 reduction gear units

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

However, it may vary depending on ambient temperature, 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.



For 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 EPSON RC+ 7.0.

For details, refer to the following manual.

RC700 series Maintenance Manual "6. Alarm"

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	

Standard-model



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

- (1) Turn ON the Controller.
- (2) Move the shaft to the lower limit by using one of the following methods:
 - Move the shaft to the lower limit manually while pressing the brake release switch.



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.

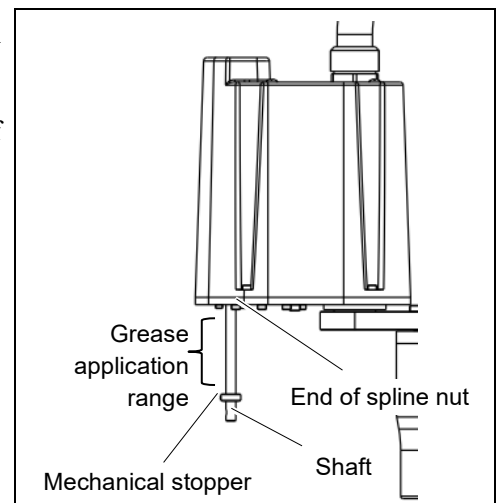
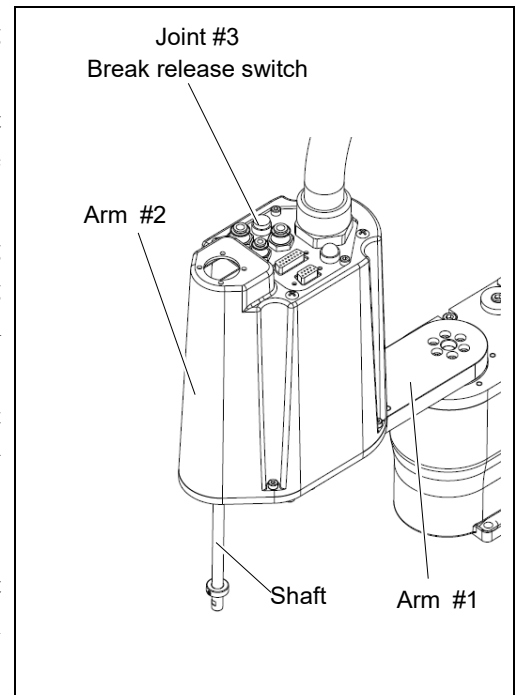
- Move the shaft to the lower limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].



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

- (3) Turn OFF the Controller.
- (4) Wipe off the old grease from the shaft, and then apply new grease to it.

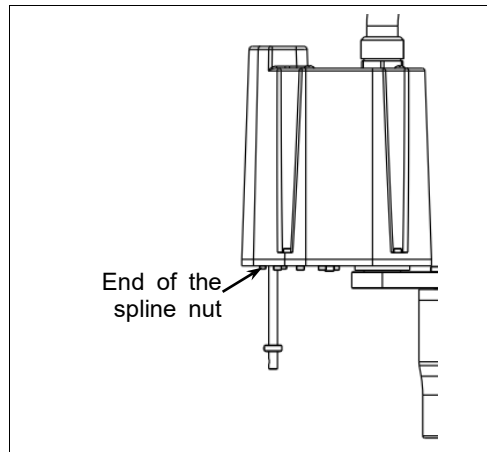
Grease application range is from the end of the spline nut to mechanical stop.




- (5) Apply new grease evenly to the spiral groove of the ball screw spline unit and the vertical groove so that the groove is filled.




- (6) Turn ON the Controller.
- (7) Start the robot manager and move the shaft to the origin position. Be careful not to hit peripheral equipment.
- (8) After moving to the origin position, reciprocate the shaft. The reciprocating operation is a low power mode operation program that performs from the upper limit to the lower limit. Run for about 5 minutes to spread the grease over the shaft.
- (9) Turn OFF the controller.
- (10) Wipe off excess grease on the end of the spline nut and mechanical stop.




Cleanroom-model

NOTE  Dust is emitted when greasing. 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 greasing. Cover the surrounding area such as the end effector and peripheral equipment in case the grease drips.

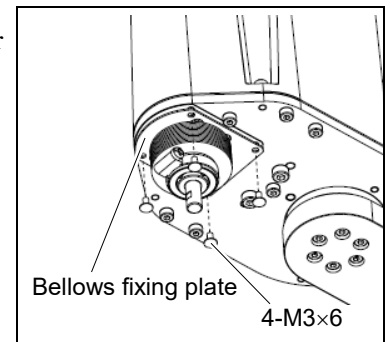
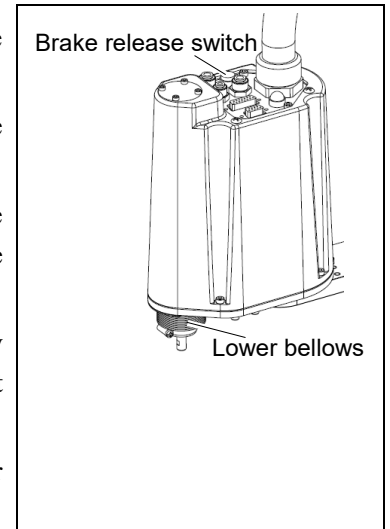
- (1) Turn ON the Controller.
- (2) Move the shaft to the upper limit by using one of the following methods:
 - Move the shaft to the upper limit manually while pressing the brake release switch.

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.

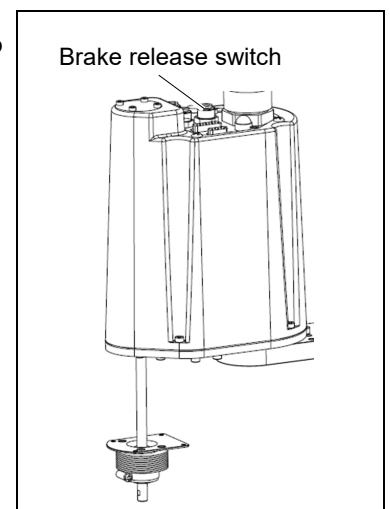
- Move the shaft to the upper limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].

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

- (3) Remove the bellows fixing plate and move the lower bellows downward.

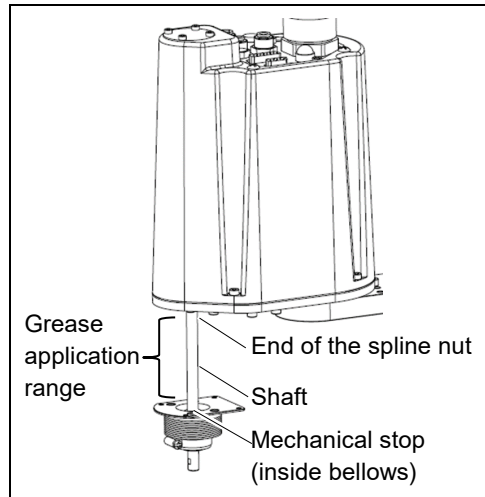


- (4) Move the shaft to the lower limit in the same way as in step (2).



- (5) Turn OFF the Controller.

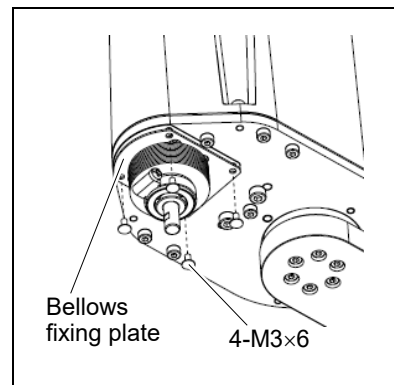
- (6) Wipe off the old grease from the shaft, and then apply new grease to it.
The range to apply grease is from the end of the spline nut to the mechanical stop.



- (7) Apply grease to the spiral groove and vertical groove of the ball screw spline to fill the grooves.



- (8) Turn ON the Controller.
(9) Apply grease to the whole of the shaft.
Move the shaft up and down about 10 times from the upper limit to the lower limit.
When moving the shaft up and down, press and hold the brake release switch on the top of cover.
After moving up and down, wipe off excess grease from the end of the spline nut.



- (10) Move the shaft to the upper limit.
Fit the bellows and the bellows fixing plate to the arm.
(11) After fitting, move the shaft up and down several times and rotate Joint #4. Make sure that the bellows can expand and contract smoothly without any excessive force.
(12) Start Robot Manager and move the shaft to the origin position.
Be sure to prevent the robot hitting any peripheral equipment.
(13) After moving to the origin position, move the shaft up and down. To move up and down, use an operation program to move from the upper limit to the lower limit in low power mode. Run about 5 minutes to spread grease over the shaft.
(14) Turn OFF the Controller.

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.

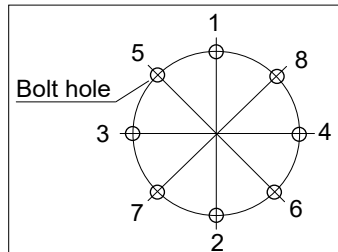
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

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)

Refer below for the set screw.

Set Screw	Tightening Torque
M3	1.5 ± 0.1 N·m (16 ± 1 kgf·cm)
M4	2.4 ± 0.1 N·m (26 ± 1 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.

EPSON
RC+

Execute the following command from the [Command Window].

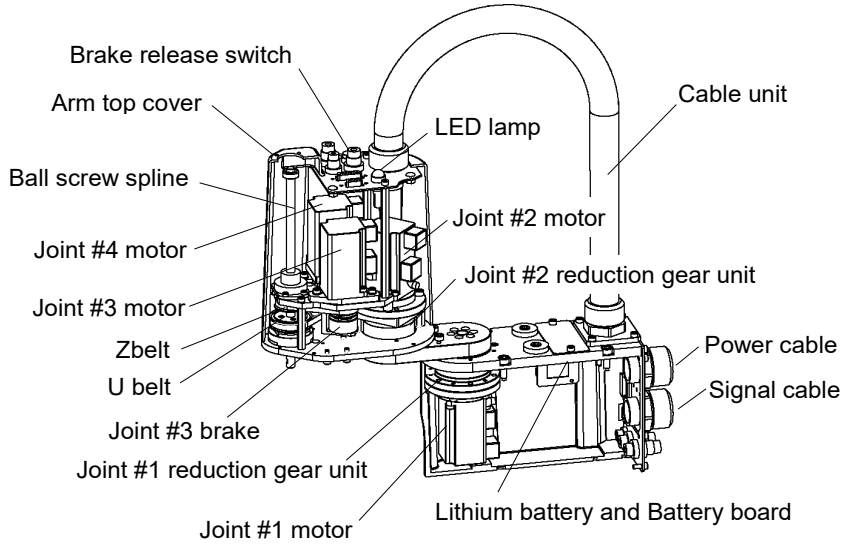
```
>PULSE
```

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

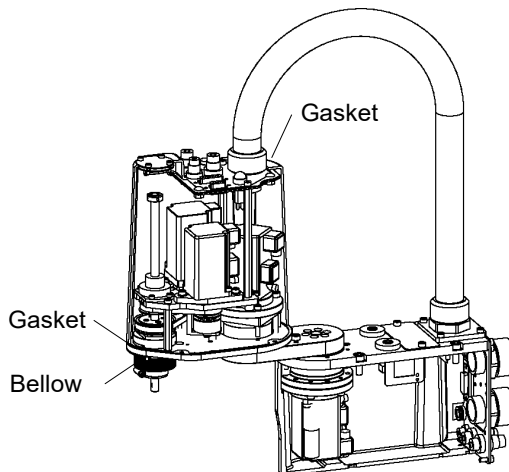
2.6 Layout of Maintenance Parts

2.6.1 4-axis spec

G1-***S: Standard-model

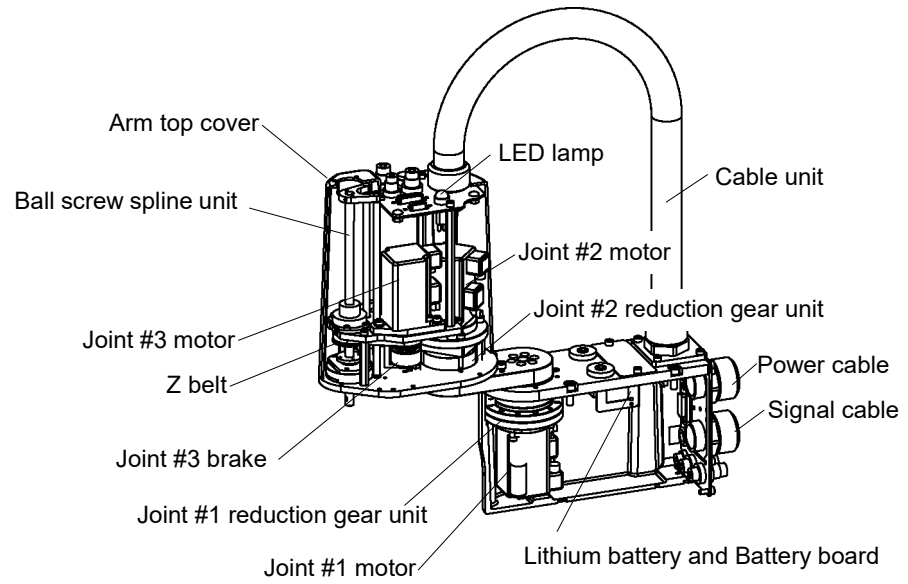


G1-***C: Cleanroom-model

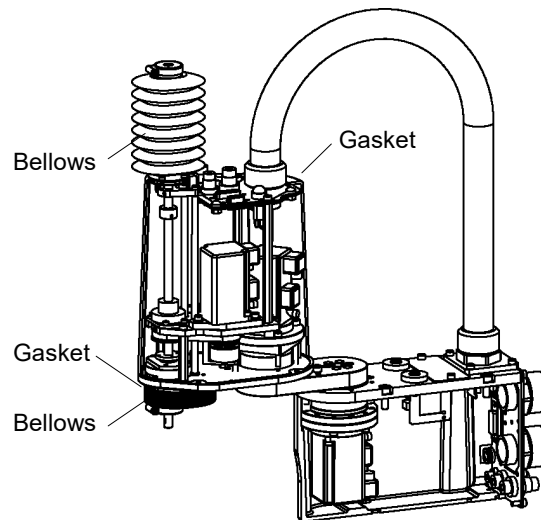


2.6.2 3-axis spec

G1-***SZ: Standard-model




G1-***CZ : Cleanroom-model

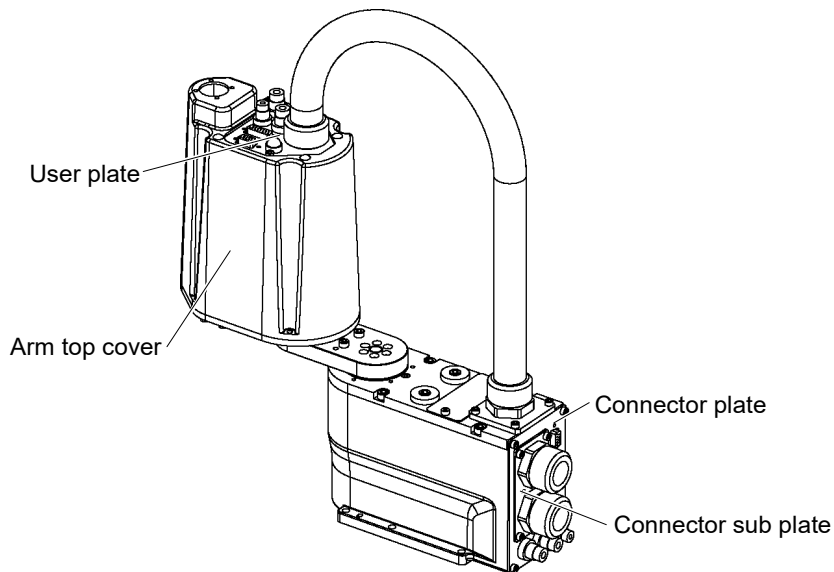


3. Covers

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.
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	Name	Quantity	Note
Maintenance parts	Arm Top Cover	1	
	Arm Top Cover for Cleanroom-model	1	
	Gasket unit	1	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 M4 truss screw Tightening Torque: 0.4 N·m (4.1 kgf·cm)
	Wiping cloth	1	For bellows removal



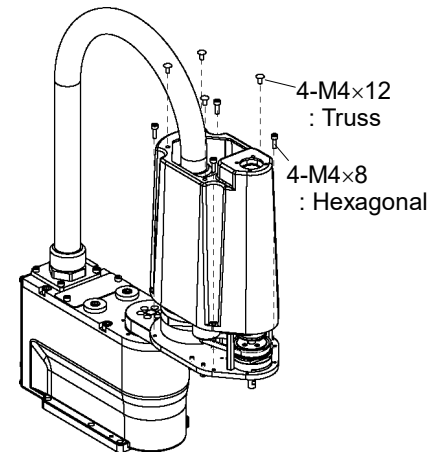
3.1 Arm Top Cover



- Do not remove the arm top cover forcibly. Removing the cover forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
 - When 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.

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

When bellows are installed to the manipulator, remove / install the arm top cover and then remove / install the upper bellows.



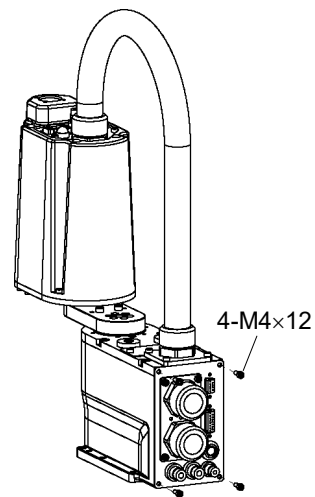
3.2 Connector Plate



CAUTION

- 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.

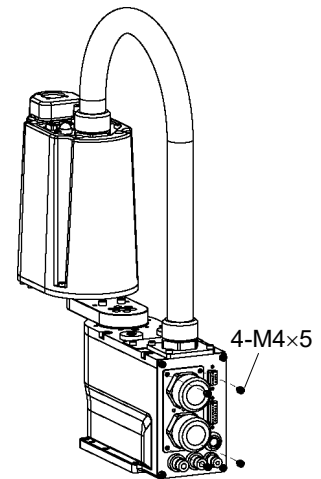


3.3 Connector Sub Plate



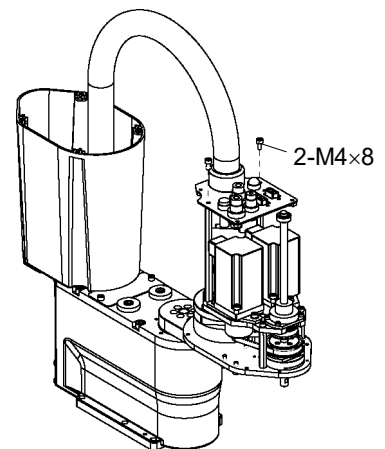
- Do not remove the connector sub plate forcibly. Removing the connector sub plate forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
- When installing the connector sub 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 sub plate. Be sure to place the cables back to their original locations.

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





3.4 User Plate

- (1) Remove the Arm top cover.
For detail, refer to *3.1 Arm top cover*.
- (2) Unscrew the user plate mounting bolts and remove the plate.



4. Cable

 <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.
 <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.

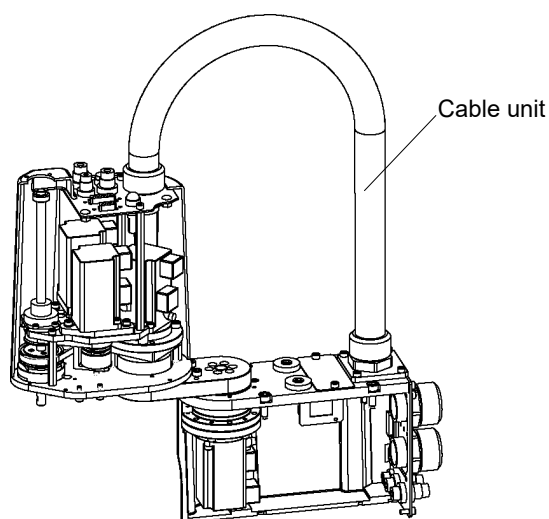
4.1 Replacing Cable Unit

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.

For details of the calibration, refer to 13. *Calibration*.

	Name	Quantity	Note
Maintenance parts	Cable unit	1	
	Battery Unit (Lithium battery)	1	2117879
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 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
	Cross-point screwdriver	1	
	Torque wrench	1	
	Nippers	1	For cutting wire tie
	Alcohol	Proper quantity	For wiping grease
	Wiping cloth	1	For wiping grease





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 *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.

Cable unit
Removal

- (1) Turn ON the Controller and change the motor to OFF status (MOTOR OFF).
- (2) Press and hold the brake release switch to let the shaft down. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released.

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

- (3) Turn OFF the Controller and disconnect the power cable and signal cable connectors from the controller.
- (4) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Connect the spare battery to connector X60C.
 - Use the battery unit as the spare battery.
 - The position data of Joint #2, #3, #4 motor is stored with the battery on base. Connect the spare battery otherwise the Joint #2, #3, #4 position data will be lost.
- (6) Cut off the wire tie binding cables on the arm side.
- (7) Remove the 10 connectors and ground wire on the arm side.

Connector: X21, X22, X31, X32, X33, X41, XB10, X221, X231, X241

- Remember the cable layout so that the cables can be reconnected correctly after replacement.
- (8) Remove the screw securing the user plate and remove the user plate from Arm #2.
For details, refer to *3.4 User Plate*.
 - (9) Remove the connectors of the following from the user plate.

D-sub cable, Air tube, Brake release switch

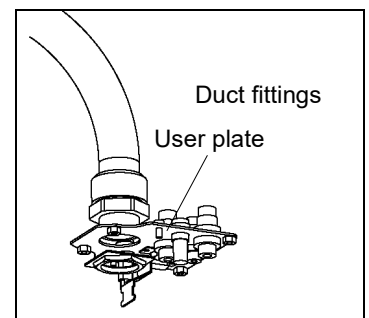


NOTE Be careful not to lose the set screws of D-sub cable because they are so small.

To pull out the air tube, press the ring of fittings. ($\phi 6 \times 2$, $\phi 4 \times 2$)

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

- (10) Remove the duct fitting from the user plate and disconnect the cables.



- (11) Remove the connector plate.
For details, refer to *3.2 Connector Plate*.

(12) Remove the cables from the connector plate.

Air tube, D-sub cable
6 connectors : X10, X20, X30, X111, X121, X131

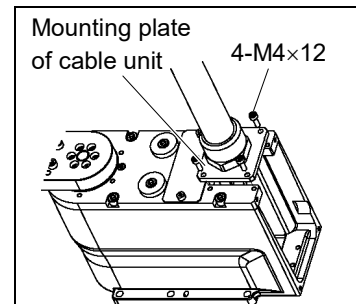


Be sure to keep the connectors of the battery board connected while replacing the cables. Otherwise, you will lose the position data and must execute the calibration again.

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

(13) Remove the ground wire from the base.

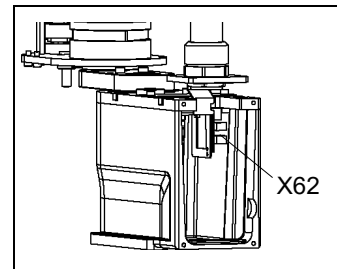
(14) Remove the mounting plate of the cable unit.



(15) Remove the wire tie binding the cables on the base side.

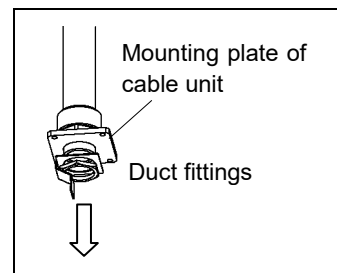
(16) Disconnect the connector X62 from the battery board.
(X62: lower of two connectors)

Be sure to keep the connector X61 (upper one) of the battery board connected. Otherwise, you will lose the position data of the Joint #1 motor and must execute the calibration again. Do not remove the connector X61.



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

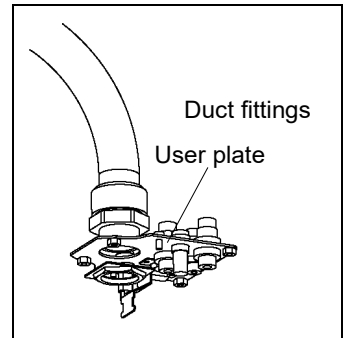
(17) Remove the duct fittings from the mounting plate of the cable unit.



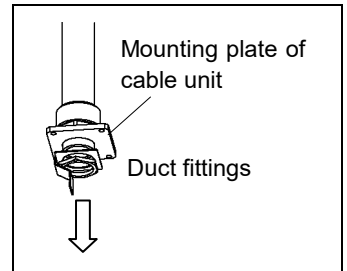
Cable unit
Installation

- (1) Pass the cables through the user plate and secure the duct fittings.

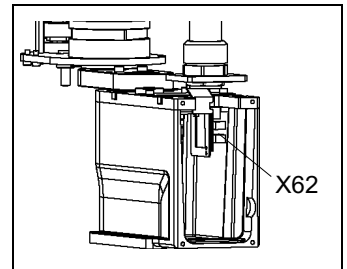
Be careful of the cable support direction.



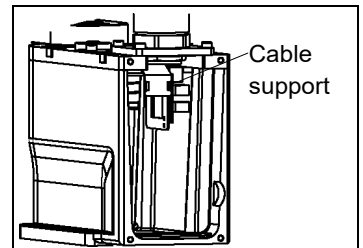
- (2) Mount the air tube, ground wire, and D-sub cable to the user plate.
- (3) Pass the cables through the mounting plate of the cable unit and secure the duct fittings.



- (4) Connect the connector X62 to the battery board.



- (5) Secure the ground wire to the base.
- (6) Re-bundle the wire tie removed in the removal step (16).
- (7) Mount the cable unit to the J1 flange.
Be careful of the cable support direction.



- (8) Mount the following to the inner side of connector plate, connector sub plate.
Air tube, ground wire, D-sub cable
Joint #1 signal cable connector, power cable connector: X10, X111
4 connectors: X20, X30, X121, X131
- (9) Mount the user plate to Arm #2.
For details, refer to 3.4 User Plate.
- (10) Mount the ground wire to Arm #2.
- (11) Connect the connectors on the arm side.
Connectors: X21, X22, X31, X32, X33, X41, XB10, X221, X231, X241
- (12) Remove the spare battery connected to X60C.
- (13) Re-bundle the wire tie removed in the removal step (6).

(14) Mount the connector plate to the base.

For details, refer to *3 3.2 Connector Plate*.

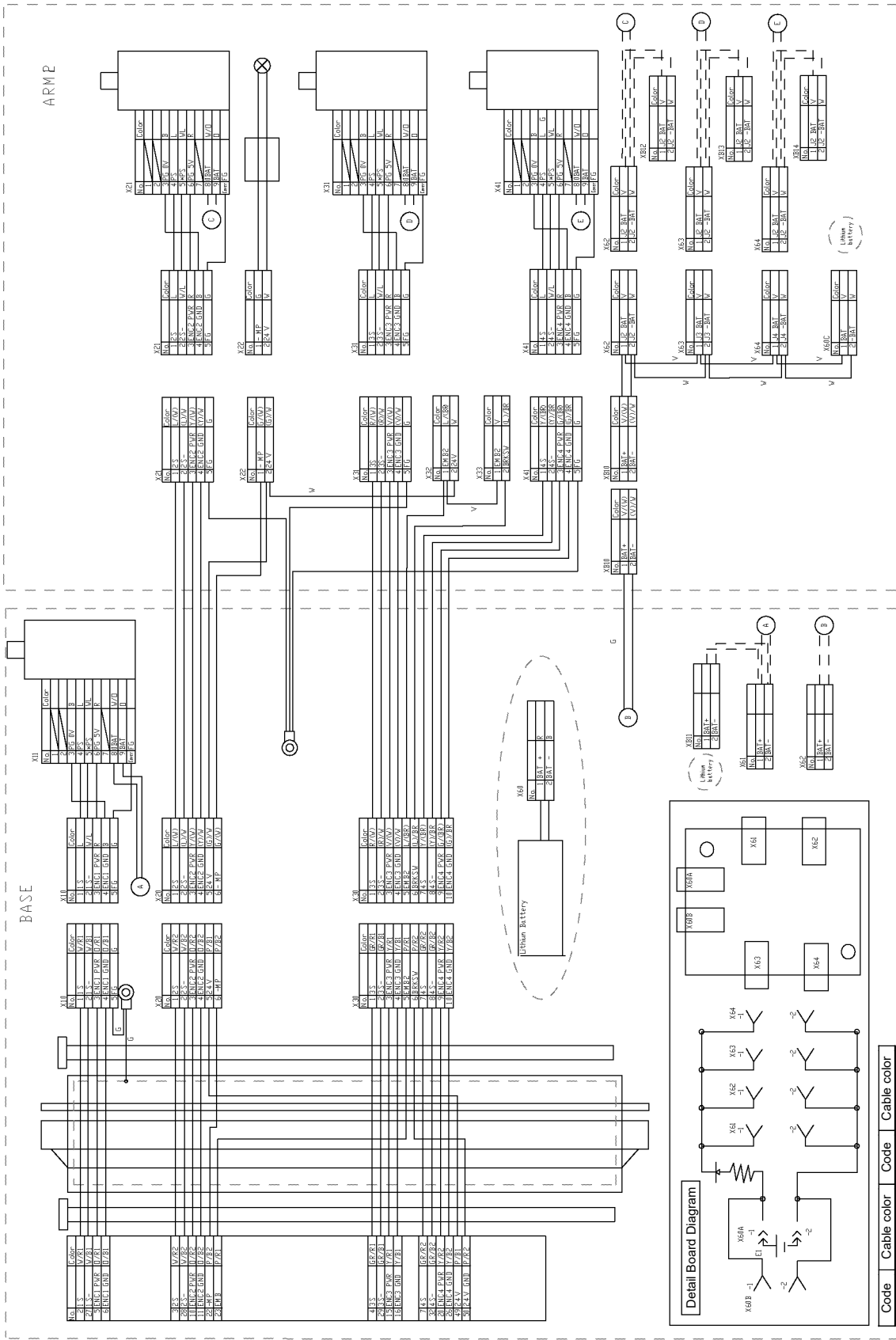
(15) Set the Arm #2 cover without cables caught and secure it.

For details, refer to *3.1 Arm Top Cover*.

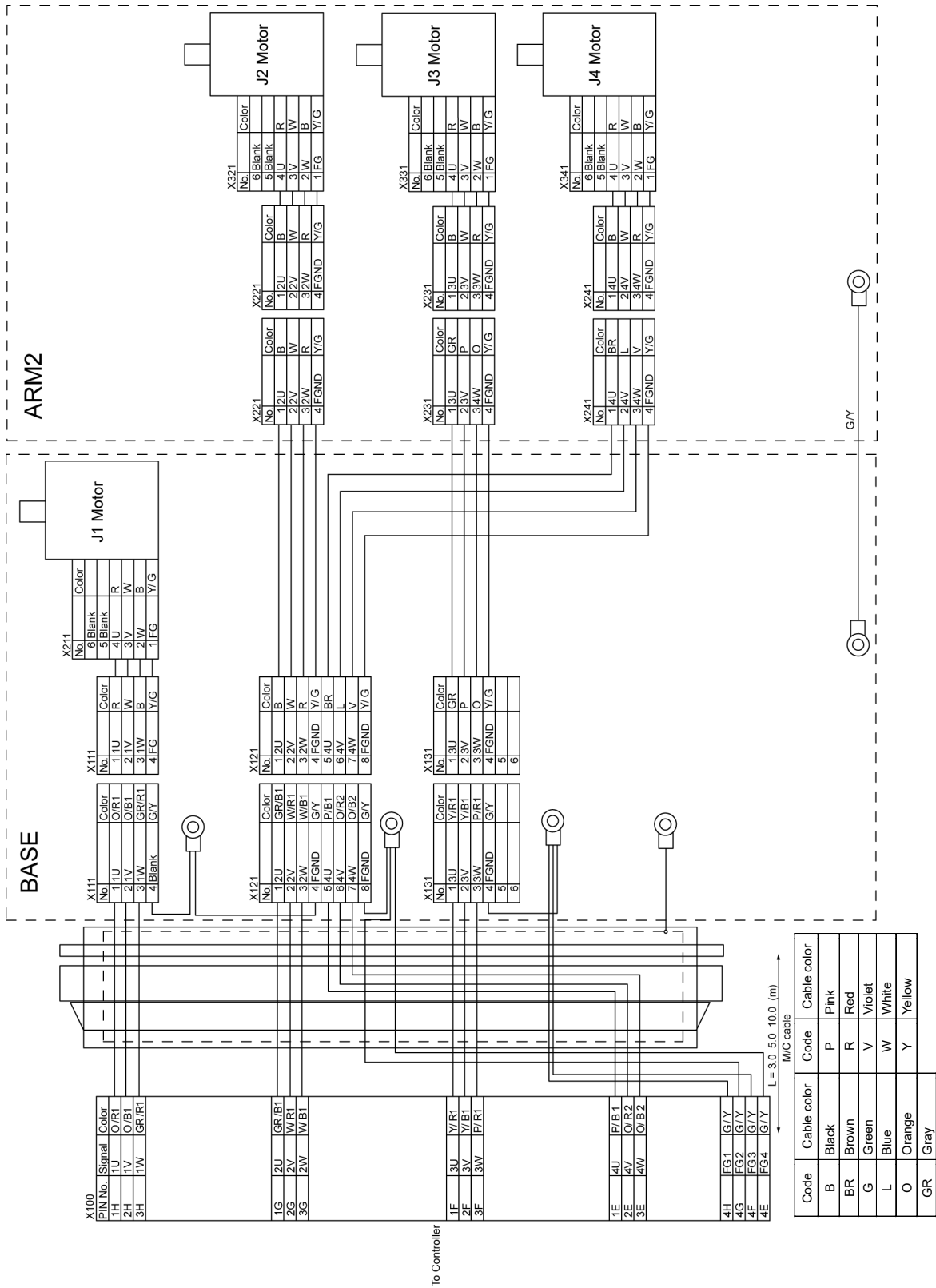
(16) If a connector falls out from the battery board, you must execute the calibration for all axes.

4.2 Wiring Diagrams

4.2.1 Signal Cable



4.2.2 Power Cable



4.2.3 User Cable

D-sub 9pin

No.	Color
1	L/(W)
2	(L)/W
3	Y/(W)
4	(Y)/W
5	G/(W)
6	(G)/W
7	R/(W)
8	(R)/W
9	(V)/W

D-sub 9pin

No.	Color
1	L/(W)
2	(L)/W
3	Y/(W)
4	(Y)/W
5	G/(W)
6	(G)/W
7	R/(W)
8	(R)/W
9	(V)/W

D-sub 15pin

No.	Color
1	L/(W)
2	(L)/W
3	Y/(W)
4	(Y)/W
5	G/(W)
6	(G)/W
7	R/(W)
8	(R)/W
9	V/(W)
10	(V)/W
11	L/(BR)
12	(L)/BR
13	Y/(BR)
14	(Y)/BR
15	G/(BR)

D-sub 15pin

No.	Color
1	L/(W)
2	(L)/W
3	Y/(W)
4	(Y)/W
5	G/(W)
6	(G)/W
7	R/(W)
8	(R)/W
9	V/(W)
10	(V)/W
11	L/(BR)
12	(L)/BR
13	Y/(BR)
14	(Y)/BR
15	G/(BR)

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

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.



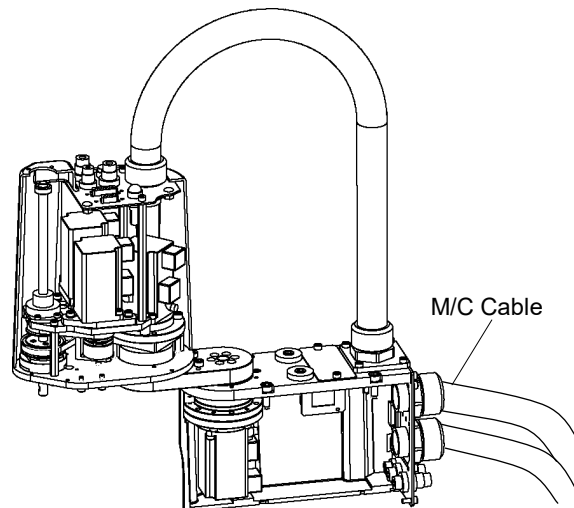
If the connector connected to the battery was disconnected during cable replacement, execute calibration.

For details, refer to *13. Calibration*.

	Name	Quantity	Note
Maintenance parts	M/C Cable	1	Each manipulator model (Refer to <i>14. G1 Maintenance Parts List</i>)
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Torque wrench	1	



- 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 *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 Sub Plate.
For details, refer to *3.3 Connector Sub Plate*.



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

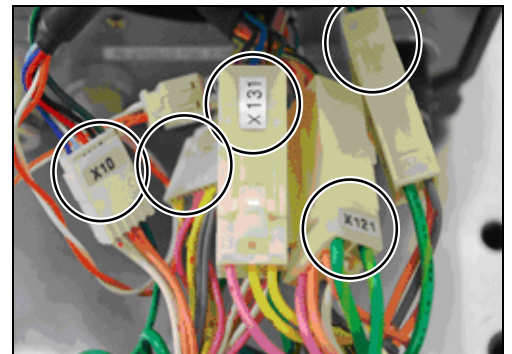
- (4) Disconnect the connectors.
Connector: x10, x20, x30, x111, x121, X131



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



Do not disconnect the battery connector connected with the battery board.
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 Sub Plate.
For details, refer to *3.3 Connector SubPlate*.
- (3) Connect the power cable and signal cable connectors to the controller.
- (4) Turn ON the Controller.
- (5) If the connector falls off from the battery, execute the calibration for All Joint.
For details, refer to *13 Calibration*.

5. Joint #1



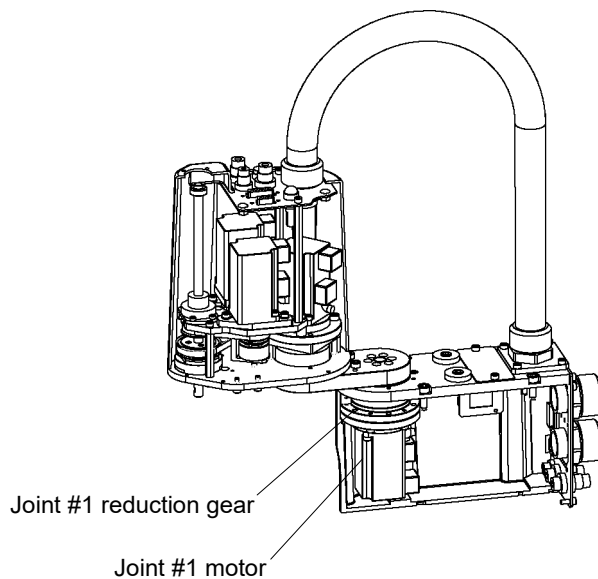
- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric 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 13. *Calibration* to perform the calibration.



5.1 Replacing Joint #1 Motor

	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (50 W)	1	1543776	
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 5 mm	1	For M6 screw
	Torque wrench	1		
Wiping cloth	1	For wiping grease		

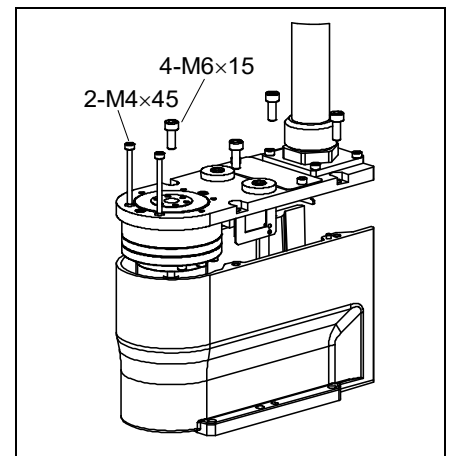
Joint #1 motor Removal (1) Remove Arm #1 from the base. The Arm is fixed by the adhesive.
Put Arm #1 softly on the floor to avoid a shock to the arm.

(2) Remove the connector plate.
For details, refer to 3.4 Connector Plate.

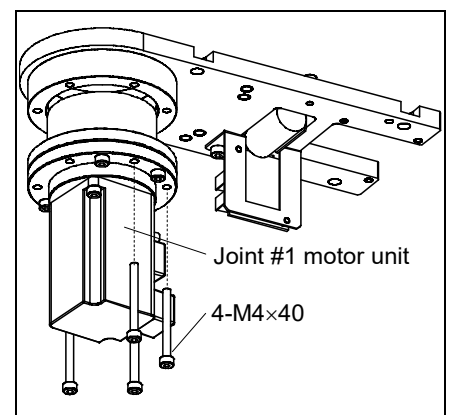
(3) Disconnect the following connectors.
Connectors X111, X10 (Hold the clip to remove.)
Connector X61

(4) Remove the Joint #1 flange with the Joint #1 unit from the base.

The base and Joint #1 flange has been aligned to the assembly position with the positioning pin. Be careful not to lose the positioning pin.

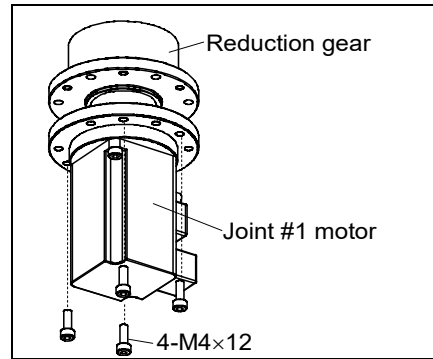


(5) Loosen the screw of motor flange on the Joint #1 flange. Remove the Joint #1 unit.



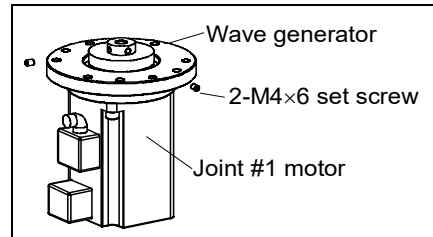
- (6) Loosen the screw fixing the motor flange and reduction gear and remove the motor unit.

There is an O-ring in the assembly position of motor flange and reduction gear. Be careful not to lose the O-ring.

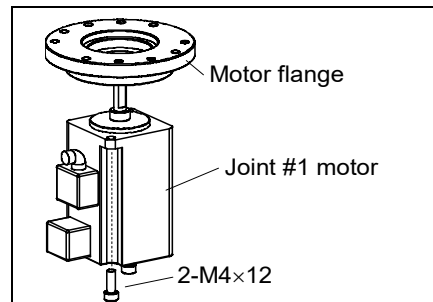


- (7) Remove the wave generator from the Joint #1 motor.

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



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



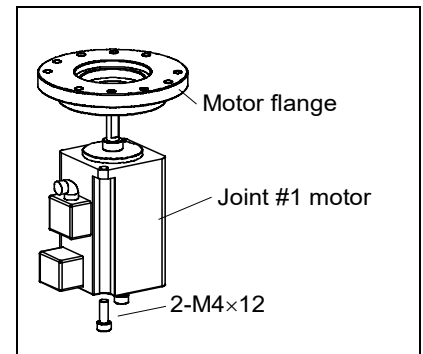
NOTE



When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

Joint #1 motor Installation

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

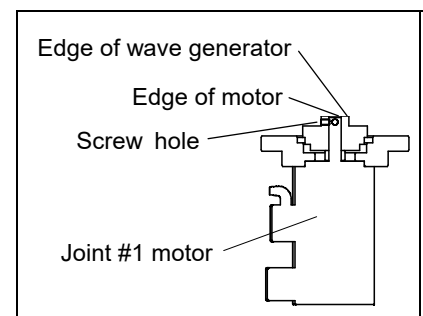


- (2) Mount the waveform generator on the Joint #1 motor.

Press the edge of waveform generator lightly to the edge of spacer on 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.



CAUTION

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

- (3) Insert the O-ring to the groove in the Joint #1 reduction gear unit and assemble the Joint #1 motor unit.

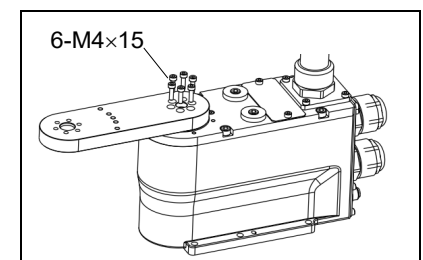
- (4) Mount the Joint #1 flange on the Joint #1 unit.

Make sure that the motor cable faces toward the Joint #1 flange lengthy side.

- (5) Mount the Joint #1 flange to the base.

Apply the adhesive at 8 mm from the end of the screws for fixing the Arm.

The assembly position of the Joint #1 flange and the base has been set by the positioning pin.



- (6) Attach the connectors.

Connector: X110, X10, X61

- (7) Mount the connector plate.

For details, refer to 3.4 Connector Plate.

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

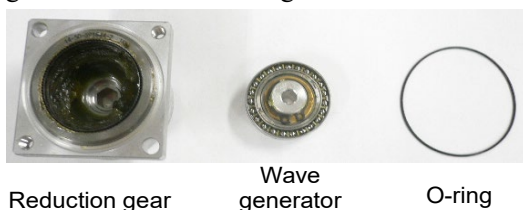
For details refer to 14. Calibration.

5.2 Replacing Joint #1 Reduction Gear Unit

	Name	Quantity	Note	
Maintenance Parts	Reduction Gear Unit	1	1543777	
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 5 mm	1	For M6 screw
	Nippers	1		
	Wiping cloth	1	For wiping grease (motor flange)	
1		For wiping grease (bolt)		
Grease	Grease (SK-2)	4 g		

Removal (1) Follow the steps in *5.1 Replacing Joint #1 Motor*, Removal (1) to (8) and remove the Joint #1 motor unit and waveform generator.

Installation (1) A new reduction gear unit contains the parts shown in the picture.
The grease has been applied to the bearing are of waveform generator. Wipe the grease from the mounting surface.



 CAUTION	<ul style="list-style-type: none"> Never adjust the bolt fixing the reduction gear. If you did, it needs the alignment by the manufacturer.
--------------------	--

(2) Follow the steps in *5.1 Replacing Joint #1 Motor*, Installation (2) to (8).

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.

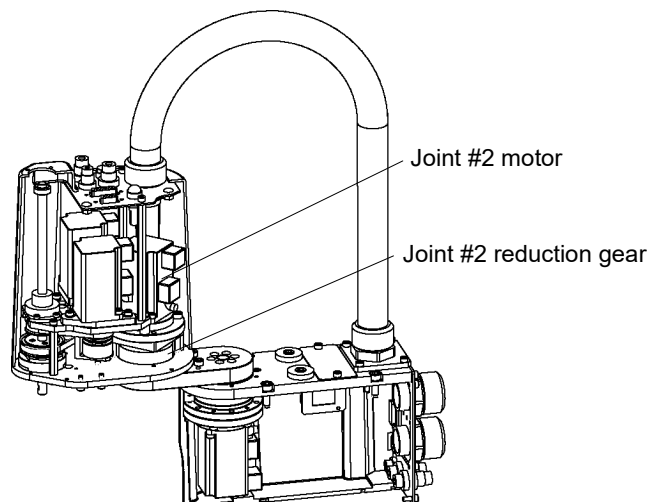


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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 13. *Calibration* to perform the calibration.

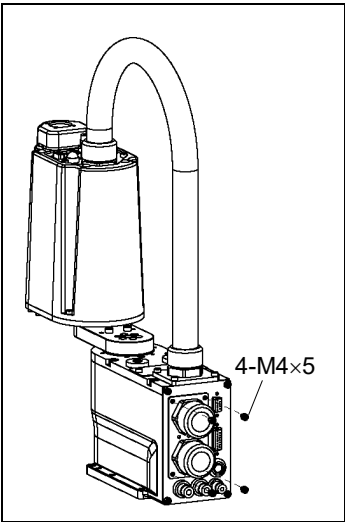


6.1 Replacing Joint #2 Motor

	Name	Quantity	Note	
Maintenance Parts	AC Servo Motor (50W)	1	1533642	
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Cross-point screwdriver	1		
	Nippers	1	For cutting wire tie	
	Wiping cloth	1	For wiping grease	

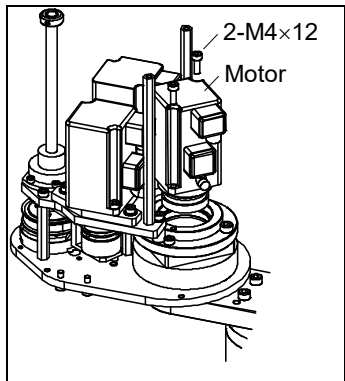
Joint #2 motor Removal

- (1) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (2) Cut off the wire tie binding the Joint #2 motor cables.
- (3) Unscrew the bolts from the user plate and remove the user plate.

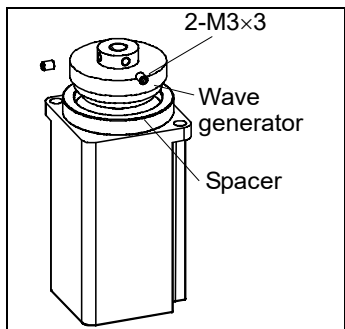


- (4) Disconnect the connectors.
Connectors: X221, X21, X22, XB20 (Hold the clip to remove.)

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



- (6) Remove the wave generator and motor spacer.



NOTE



When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

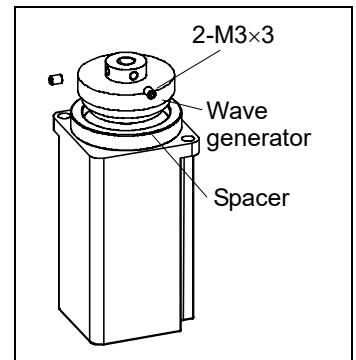
Joint #2 motor Installation

- (1) Mount the motor spacer and wave generator on the Joint #2 motor.

Be sure to fit the edge of the waveform generator to the edge 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.

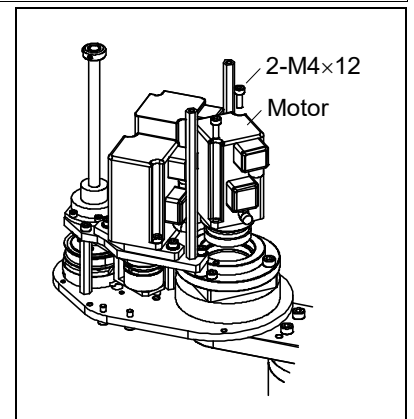


CAUTION

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

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

If it is difficult to mount the motor, push it while moving Arm #2 slowly by hand.



- (3) Connect the connectors.

Connectors: X221, X21, X22, XB20

- (4) Mount the user plate.

Screws: 4- M4x5

- (5) Put the wire tie cut in the removal step (4) to the original position.

Do not allow unnecessary strain on the cables.

- (6) Mount the arm top cover.

For details, refer to 3.1 *Arm Top Cover*.

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

For details refer to 13. *Calibration*.

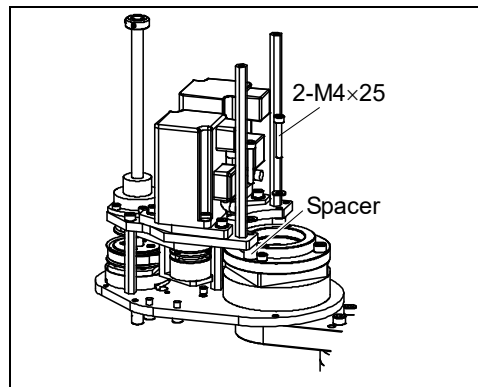
6.2 Replacing Joint #2 Reduction Gear Unit

	Name	Quantity	Note	
Maintenance Parts	Reduction Gear Unit	1	1543778	
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
	Cross-point screwdriver	1		
	Nippers	1		
Wiping cloth	Motor flange	1	For wiping grease	
	Bolt	1	For wiping grease	
Grease	Grease (SK-2)	4 g		

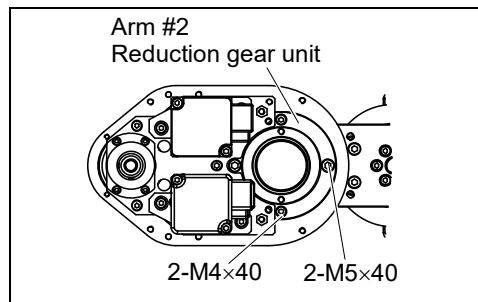
Joint #2
reduction gear
unit
Removal

- (1) Follow the steps in 6.1 Replacing Joint #2 Motor, removal (1) to (7).
Remove the waveform generator from the Joint #2 motor.

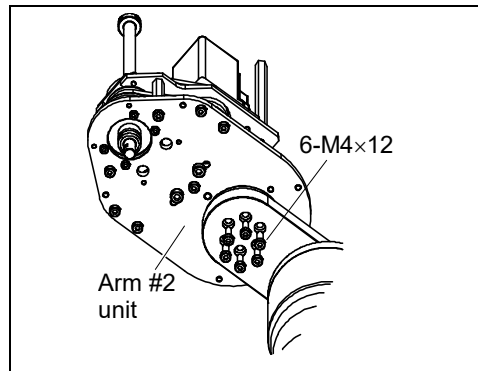
- (2) Remove the Arm #2 spacer.



- (3) Loosen the screw fixing the Joint #2 reduction gear unit and loosely secure.

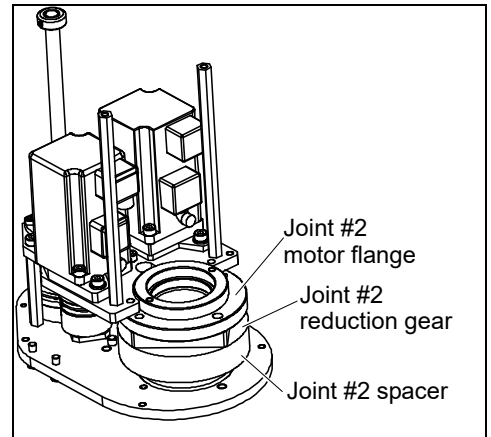


- (4) Remove the Arm #2 unit.



- (5) Remove the screw secured loosely in the step(3) and also remove the Joint #2 motor flange, reduction gear, and Joint #2 spacer.

Hold the Joint #2 spacer upward and pull it out sideways.



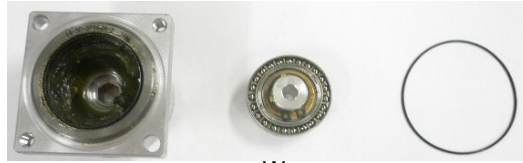


When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

Joint #2
reduction gear
unit
Installation

- (1) A new reduction gear unit contains the parts shown in the picture.

The grease has been applied to the bearing are of waveform generator. Wipe the grease from the mounting surface.

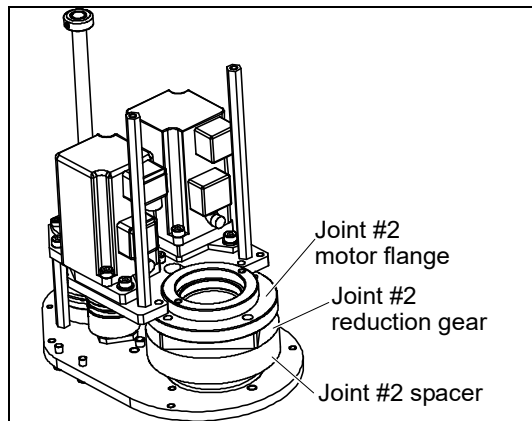


Reduction gear Wave generator O-ring

- (2) Put the O-ring into the groove in the reduction gear top surface.

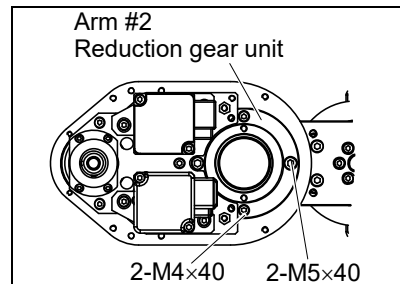
- (3) Mount the Joint #2 motor flange, reduction gear, and Joint #2 spacer.

Hold the Joint #2 spacer and mount by reverse procedure to remove it.

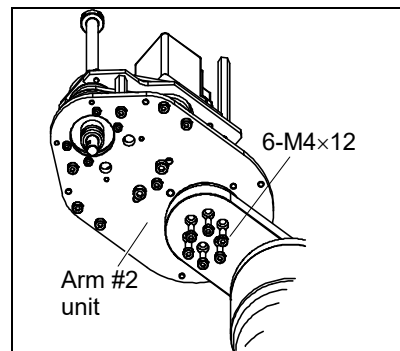


- (4) Loosely secure the Joint #2 reduction gear unit.

Make sure the O-ring between the reduction gear and motor flange has not moved and secure the unit loosely.

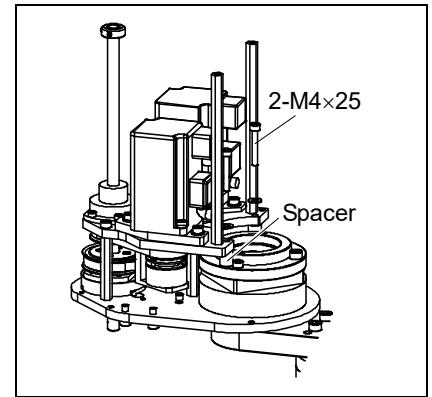


- (5) Mount the Arm #2 unit.



- (6) Tighten the screw secured loosely in the step (4).

- (7) Mount the Arm #2 spacer.



- (8) Follow the steps in
6.1 Replacing Joint #2 Motor, installation step (1) to (7).

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.

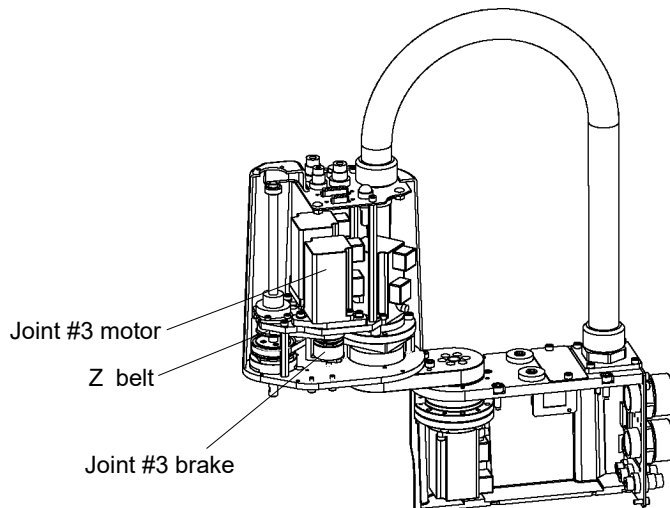


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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 13. *Calibration* to perform the calibration.



7.1 Replacing Joint #3 Motor

	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (50W)	1	1533642	
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 2 mm	1	For M4 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Torque wrench	1		
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 30 N	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	2		

A brake is mounted on the Joint #3 motor 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 (3).

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.

When the brake release switch is pressed, the brake of the Joint #3 is released.

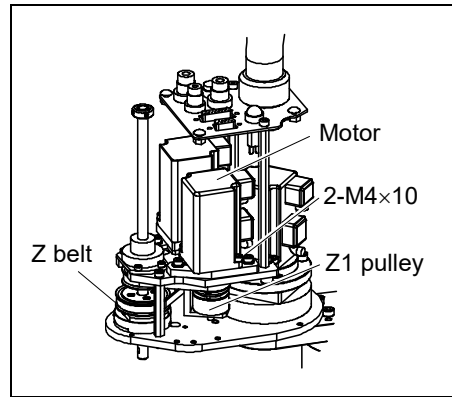
Be careful of the shaft falling while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (6) Disconnect the connectors.
Connectors X231, X31, X32, X33, XB30 (Hold the clip to remove.)
- (7) Remove the user plate.
For details, refer to *3.4 User Plate*.

- (8) Loosen the Z belt.

Loosen two bolts on the Joint #3 motor unit. Slide the Joint #3 motor unit toward the arm end.

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

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

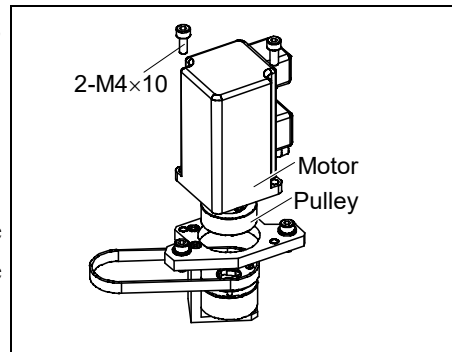


- (10) Remove the Joint #3 motor from the Joint #3 motor unit.

Remove the brake hub and pulley from the Joint #3 motor.

Loosen the screw of pulley and slide the pulley toward the motor and then, loosen the screw of brake hub.

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



NOTE

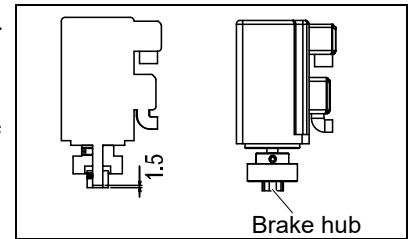


When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

Joint #3 motor Installation

- (1) Mount the brake hub and pulley to the new motor shaft.

Make sure to put a space of 1.5 mm between the edges of the brake hub and motor shaft.



After the brake hub is mounted, press the pulley lightly to the brake hub and secure.

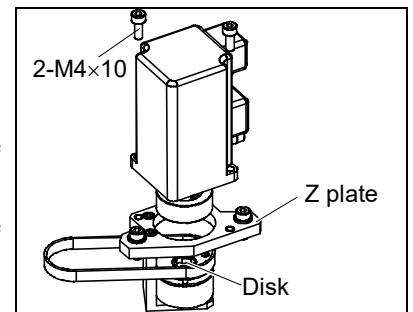
Both of the brake hub and pulley, tighten one of the set screws on the flat face of the motor shaft until the screw just touches the surface.

Insert a bushing into the other set screw hole to prevent damage to the motor shaft. Then, tighten both set screws.

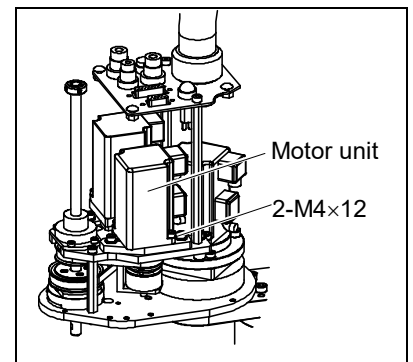
- (2) Mount the Z plate on the Joint #3 motor.

Align the brake disk with the hub and join them.

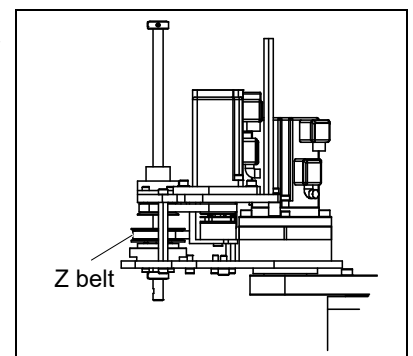
If the brake disk position is not right, turn ON the controller power supply, attach the connector X32, release the brake by pressing the brake release switch, and move the hole to the center by hand.



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



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



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

NOTE



Make sure the motor unit can be moved by hand, and it will not tilt when pulled.

If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

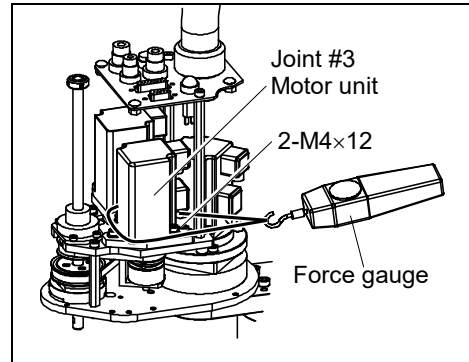
Pass a suitable cord or string around the Joint #3 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension.

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

Z belt tension = 30N (3.0 kgf)

- (7) Connect the connectors.

Connectors: X231, X31, X32, X33, XB30



- (8) Mount the user plate.

For details, refer to *3.4 User Plate*.

- (9) Re-bundle the cables in their original positions with a wire tie removed in step (5).

Do not allow unnecessary strain on the cables.

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

For details, refer to *3.1 Arm Top Cover*.

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

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

7.2 Replacing the Timing Belt

	Name	Quantity	Note	
Maintenance part	Z belt	1	1522129	
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 30 N (3.0 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	2		

A brake is mounted on the Joint #3 motor 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 (3).

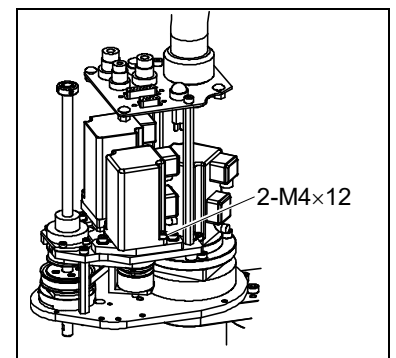
Z belt Removal

- (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.

When the brake release switch is pressed, the brake of the Joint #3 is released.

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

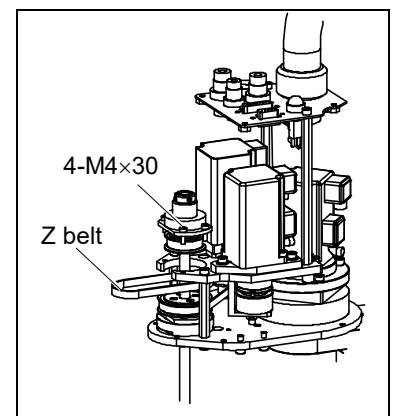
- (3) Turn OFF the Controller.
- (4) Loosen the bolt securing the Joint #3 motor unit.



- (5) Remove the belt from the Z1 pulley and Z2 pulley.

- (6) Remove the Z belt.

Remove the bolts securing the ball screw nut and hold the ball screw nut up to pull out the Z belt upward from the shaft.



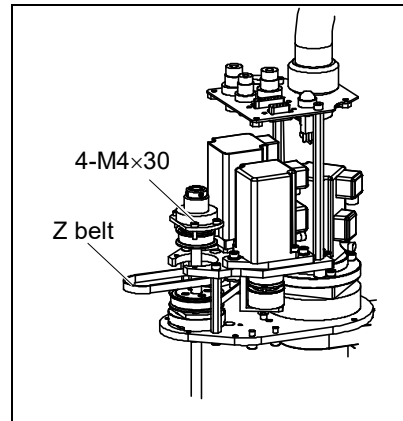
NOTE



When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

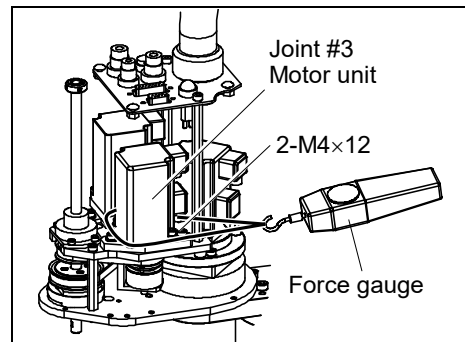
Z belt
Installation

- (1) Pass a new Z belt through the shaft from above, and then place it under the ball screw nut.
- (2) Loosely secure the ball screw nut to Arm #2.
After moving the shaft up and down several times, secure the ball screw nut to Arm #2.



- (3) Place the belt around the Z1 pulley and the Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.
- (4) Apply the proper tension to the Z belt, and then secure the Joint #3 motor unit.

Z belt tension = 30 N (3.0 kgf)



- (5) Perform the calibration of Joint #3.
For details, refer to 13. Calibration.

7.3 Replacing the Brake

	Name	Quantity	Note	
Maintenance parts	Electromagnetic brake	1	1543781	
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 30 N (3.0 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	3		

A brake is mounted on the Joint #3 motor 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 (3).

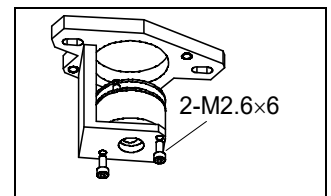
Joint #3 brake Removal

- (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.

When the brake release switch is pressed, the brake of the Joint #3 is released.

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

- (3) Turn OFF the Controller.
- (4) Refer to *7.1 Replacing Joint #3 Motor*, Removal step (4) to (11) and remove the brake hub from the Joint #3 motor.
- (5) Remove the brake from the brake plate.



Joint #3 brake Installation

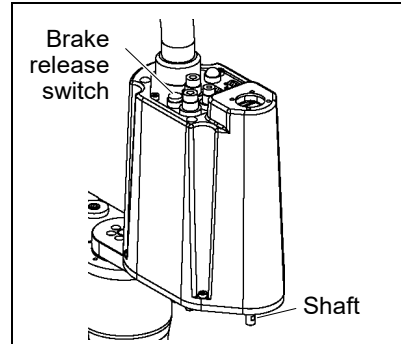
- (1) Mount the brake on the brake plate.
- (2) Refer to *7.1 Replacing Joint #3 Motor*, Installation step (1) to (11) and mount the Joint #2 motor unit to Arm #2 after the brake hub is replaced.
- (3) Perform the calibration of Joint #3.
For details, refer to *13. Calibration*.

7.4 Setting the Mechanical Stop of Joint #3

NOTE This method applies only to the Standard-model Manipulator (G1-***S*). For the Cleanroom-model (G1-***C*), the motion range set with the Joint #3 mechanical stop cannot be changed.

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

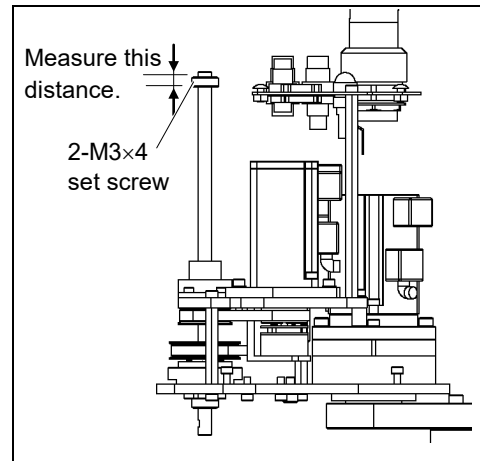
NOTE When you press the brake release switch, the shaft may lower due to the weight of the end effector. Be sure to hold the shaft by hand while pressing the button.



- (3) Turn OFF the Controller.
- (4) Remove the Arm Top Cover.
For details, refer to *G1 manipulator - 3.1 Arm Top Cover*.
- (5) Loosen the lower limit mechanical stop screw. (2-M3×4 set screws)

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

- (6) The upper end of the shaft defines the maximum stroke. Move the lower limit mechanical stop down by the length you want to limit the stroke.
For example, when the lower limit mechanical stop is set at “100 mm” stroke, the lower limit Z coordinate value is “-100”. To change the value to “-80”, move the lower limit mechanical stop down “20 mm”. Use calipers to measure the distance when adjusting the mechanical stop.



- (7) Firmly tighten the lower limit mechanical stop screw (2-M3×4 set screws) not to let it enter the shaft groove.
Recommended tightening torque: 1.5 N·m (16 kgf·cm)
- (8) Mount the Arm top cover to the base.
For details, refer to *G1 manipulator - 3.1 Arm Top Cover*.
- (9) Turn ON the Controller.

- (10) 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.
- (11) Calculate the lower limit pulse value of the pulse range using the formula shown below and set the value.

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

<p>Lower limit of pulse (pulse)</p> $= \text{lower limit Z coordinate value (mm)} / \text{Resolution (mm/pulse)}$

** For the Joint #3 resolution,
refer to *Appendix A: 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
```

- (12) Using the Pulse command (Go Pulse command), 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.)

8. Joint #4

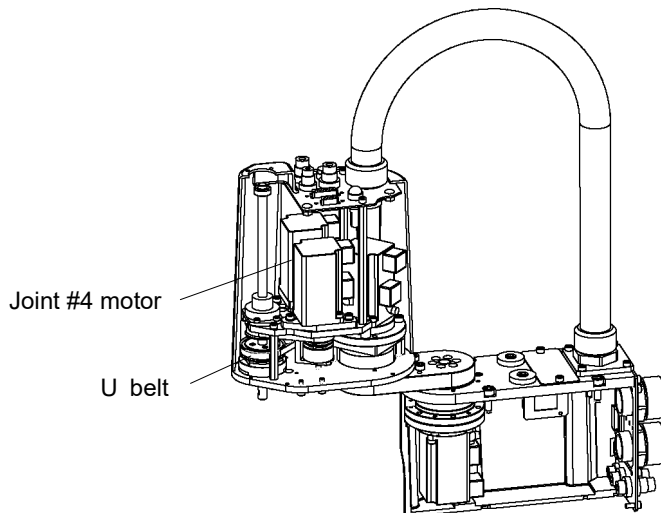
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move 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.
--	---

 CAUTION	<ul style="list-style-type: none"> ■ 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 *13. Calibration* to perform the calibration.



8.1 Replacing Joint #4 Motor

	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (50 W)	1	1533642	
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Cross-point screwdriver	1		
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 30 N (3.0 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	

A brake is mounted on the Joint #3 motor 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 (3).

Joint #4 motor Removal

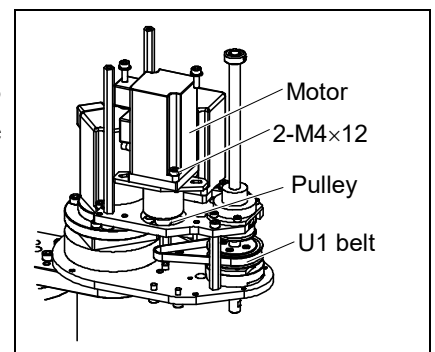
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

When the brake release switch is pressed, the brake of the Joint #3 is released.

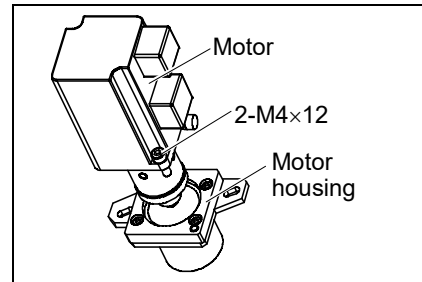
Be careful of the shaft falling while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #4 motor.
- (6) Disconnect the connectors.
Connectors: X241, X41, X64 (Hold the clip to remove.)
- (7) Remove the user plate.
For details, refer to *3.4 User Plate*.
- (8) Remove the Joint #4 motor unit from Arm #2.

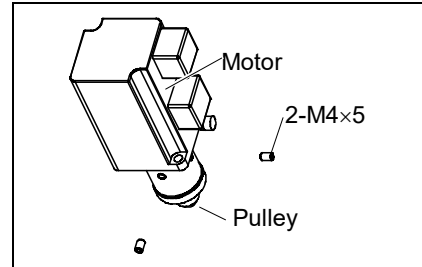
Unscrew the bolts securing the Joint #4 motor to the motor plate. Remove the U1 belt from the pulley. Pull the motor unit upward to remove.



- (9) Remove the motor from the Joint #4 motor housing.



- (10) Remove the pulley from the Joint #4 motor.
There is a brass bushing in one of the set screw holes. Be careful not to lose it.





When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

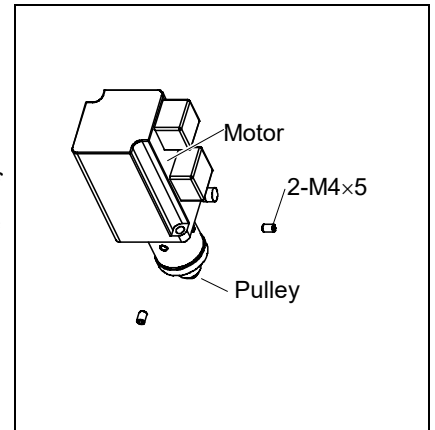
Joint #4 motor Installation

- (1) Mount the pulley to the new Joint #4 motor.

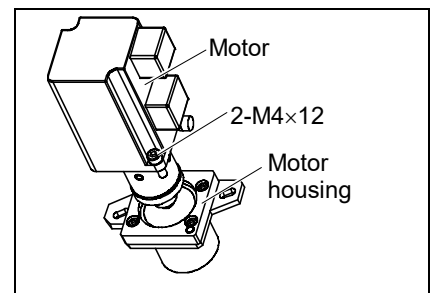
Be sure to fit the edge of the pulley to the edge of the motor shaft.

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

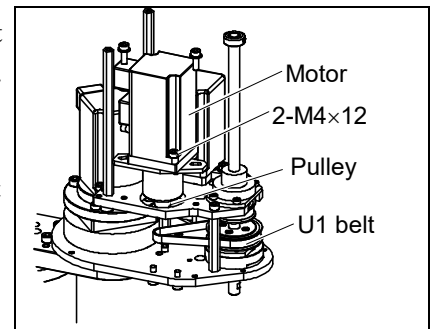
Insert a bushing into the other set screw hole to prevent damage to the motor shaft. Then, tighten both set screws.



- (2) Mount the housing to the Joint #4 motor.



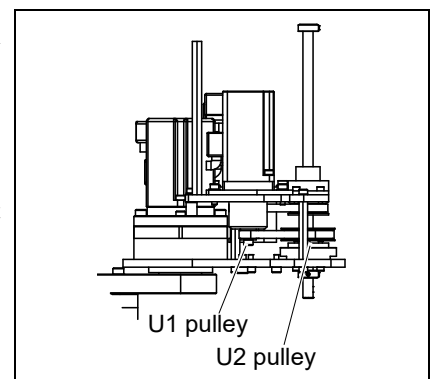
- (3) Place the Joint #4 motor unit in the arm so that the motor cable faces toward the back of the arm.
- (4) Place the belt around the U1 pulley and the U2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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



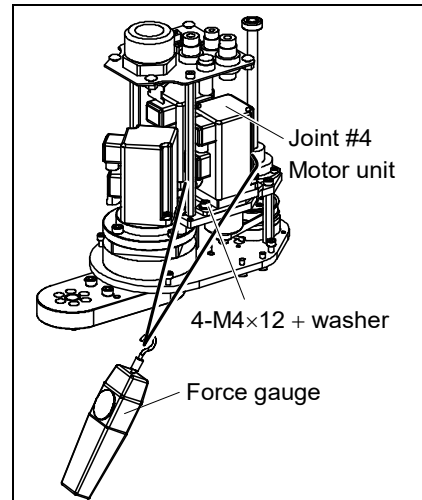
Make sure the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



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

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

U belt tension = 30N (3.0 kgf)



- (7) Connect the connectors.
Connectors: X241, X41, X64
- (8) Mount the user plate.
For details, refer to *3.4 User Plate*.
- (9) Re-bundle the cables in their original positions with a wire tie removed in step (5).
Do not allow unnecessary strain on the cables.
- (10) Install the arm top cover and the arm bottom cover.
For details, refer to *3.1 Arm Top Cover*.
- (11) Perform the calibration of Joint #4.
For details on the calibration method, refer to *13. Calibration*.

8.2 Replacing the Timing Belt

	Name		Quantity	Note
Maintenance parts	U belt		1	1522134
	Z belt		1	1522129
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Cross-point screwdriver		1	
	Nippers		1	For cutting wire tie
	Force gauge		1	Belt tension: 30 N (3.0 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension

A brake is mounted on the Joint #3 motor 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 (3).

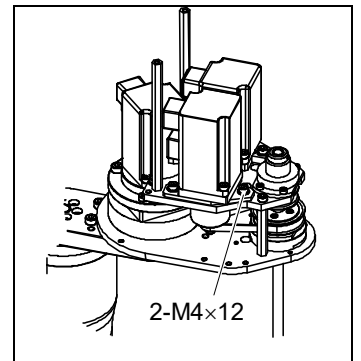
U belt Removal

- (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.

When the brake release switch is pressed, the brake of the Joint #3 is released.

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

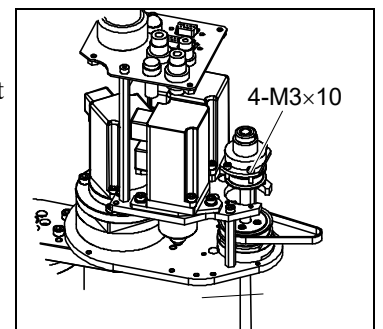
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to
3.1 Arm Top Cover.
- (5) Loosen the bolts securing the Joint #4 motor unit.
- (6) Remove the U belt from the U1 pulley.



- (7) Remove the Z belt.
For details, refer to *7.2 Replacing the Timing Belt*, Z belt Removal step (4) to (6).

- (8) Remove the U belt.

Hold the ball screw nut up and pull out the U belt upward from the shaft.





When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

U belt Installation

(1) Pass a new U belt through the shaft from above, and then pass a new Z belt too. Place them under the ball screw nut.

(2) Loosely secure the ball screw nut to Arm #2.

After moving the shaft up and down several times, secure the ball screw nut to Arm #2.

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

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

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

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

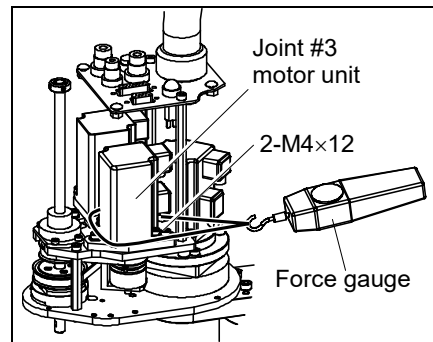


Loosely secure the units to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the units are secured too loose or too tight, the belt will not have the proper tension.

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

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

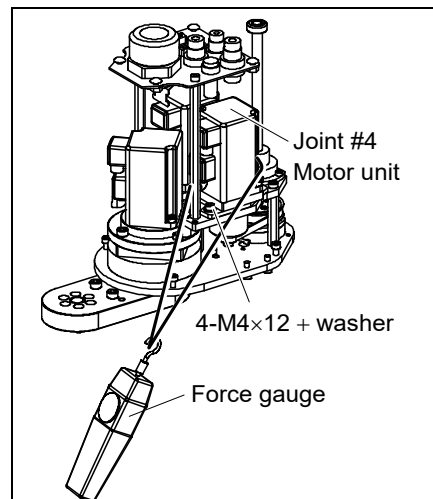
Z belt tension = 30N (3.0 kgf)



(7) 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 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension.

U belt tension = 30N (3.0 kgf)



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

For details, refer to 3.1 Arm Top Cover.

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

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

9. Bellows

NOTE



The bellows for 4-axis spec are provided in a unit of one piece.

The bellows for 3-axis spec are provided in a unit of two pieces.

The shape varies between the upper and lower bellows.

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

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

	Name	Quantity	Note
Maintenance parts	Bellows	1	For each manipulator model (Refer to <i>14.G1 Maintenance Parts List.</i>)
Tools	Cross-point screwdriver	1	
Gasket	Liquid gasket 1206C	1	

9.1 Replacing the Bellows (4-axis spec)

Bellows

(1) Stop motor excitation. (MOTOR OFF)

Removal

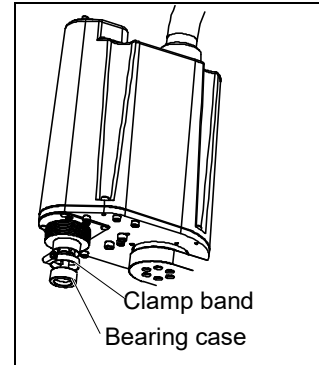
(4-axis spec)

(2) Remove the end effector.

(3) Remove the wires and tubes from the end effector.

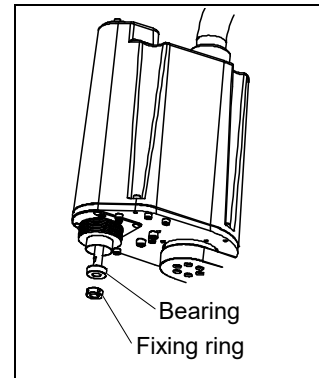
(4) Loosen the two clamp bands on bellows.

(5) Remove the bearing case.



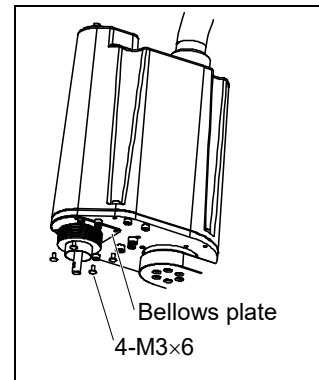
(6) Loosen the set screw of fixing ring.

Remove the fixing ring and bearing.



(7) Remove the bellows and the plate securing the bellows.

(8) Pull out the bellows from the bellows plate.



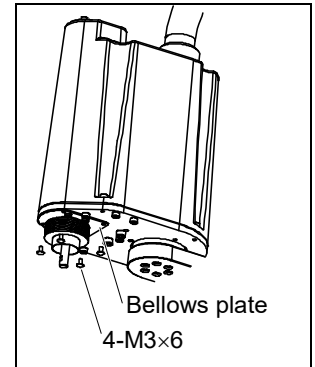
NOTE



When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

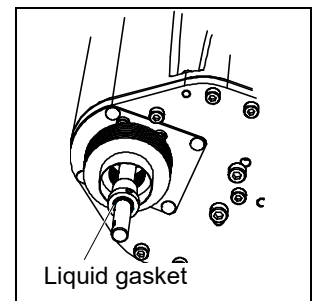
Bellows
Installation
(4-axis spec)

- (1) Press the brake release switch and move the shaft to the point 10 mm~20 mm down from the upper limit.
- (2) Insert the flat part of bellows into the bellows plate.
- (3) Mount the bellows and bellows plate on the arm.



- (4) Wipe off the old liquid gasket from the upper limit mechanical stop, and then apply new liquid gasket to it lightly.

Apply the liquid gasket to the whole bottom surface of the mechanical stop.



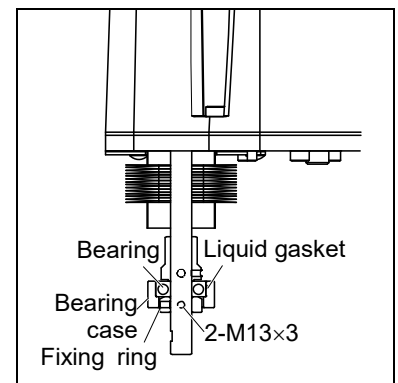
- (5) Insert the bearing and fixing ring from below the shaft and secure the bearing fixing ring by pressing it upward.

When securing the fixing ring, make sure the set screw does not touch the spline groove.

- (6) Wipe off the old liquid gasket from the inside surface of bearing case, and then apply new liquid gasket to it lightly.

Insert it into the shaft from below.

Apply the liquid gasket to the whole inside surface of the bearing case.

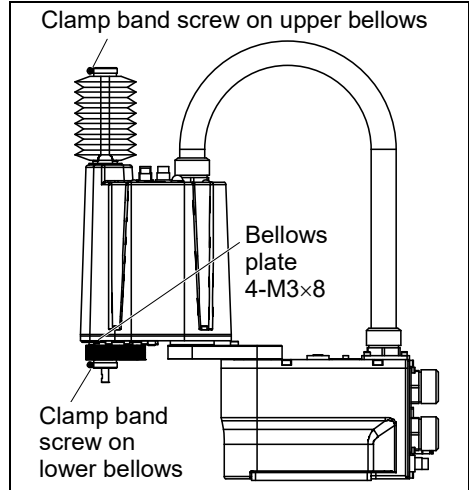


- (7) Insert the bellows lower part into the bearing case and secure with the clamp band.

9.2 Replacing the Bellows (3-axis spec)

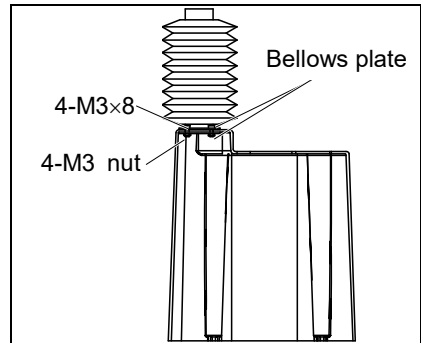
Bellows Removal (3-axis spec)

- (1) Stop motor excitation. (MOTOR OFF)
- (2) Remove the end effector.
- (3) Detach the wires/tubes from the end effector.
- (4) Loosen the two clamp bands on each bellows.
- (5) Remove the plate securing the lower bellows.
- (6) Pull out the lower bellows, bellows plate, and clamp band from the shaft.



- (7) Pull out the lower bellows from the bellows plate.
- (8) Press the brake release switch and move the shaft to its lower limit.
- (9) Remove the arm top cover.
For details, refer to 3. Covers.

- (10) Remove the plate securing the upper bellows.
Remove the set screw from inside of the arm top cover while pressing the nut.



- (11) Pull out the upper bellows from the bellows plate.

NOTE

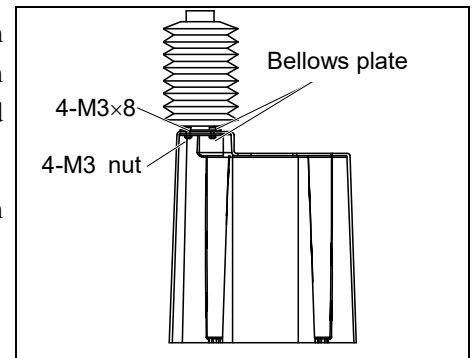


When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

**Bellows
Installation
(3-axis spec)**

- (1) Pass the flat part of the upper bellows through the bellows plate and put the bellows and arm top cover between two bellows plate and secure them.

Press the nut and remove the set screw from inside of the arm top cover.



- (2) Mount the arm top cover.
For details, refer to 3. Covers.

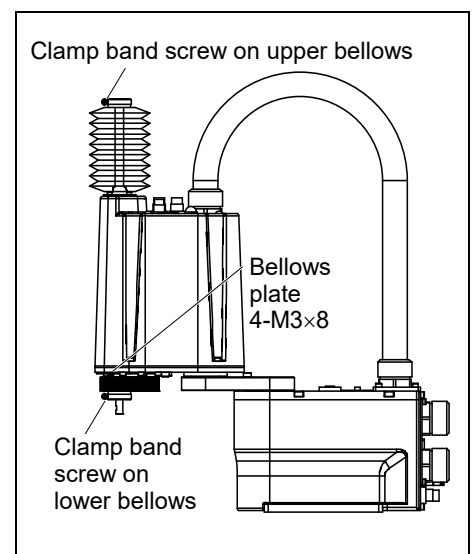
- (3) Pass the flat part of the lower bellows through the bellows plate and put the bellows between the bellows plate and Arm #2 bottom surface and secure it.

- (4) Secure the cylinder side of two bellows with clamp bands.


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


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

Press the brake release switch and move the shaft up/down.



10. Ball Screw Spline Unit

 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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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 *13. Calibration* to perform the calibration.

A brake is mounted on the Joint #3 motor 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 (3).

	Name	Quantity	Note
Maintenance parts	Ball Screw Spline Unit	1	Each manipulator model (Refer to <i>14. G1 Maintenance parts list</i>)
Grease	For Ball Screw Spline Unit (AFB grease)	Proper quantity	
Gasket	Liquid gasket 1206C	Proper quantity	
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Torque wrench	1	
	Nippers	1	For cutting wire tie
	Force gauge	1	Belt tension 30 N (3.0 kgf)
	Suitable cord (Length about 1000 mm)	1	For belt tension
	Wiping cloth	1	For wiping grease (Spline shaft)

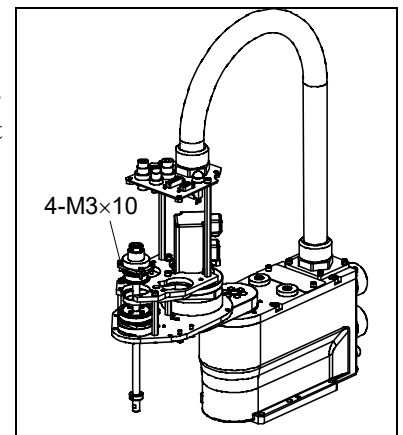
10.1 Replacing the ball screw spline unit (4-axis spec)

Ball screw spline unit Removal (4-axis spec)

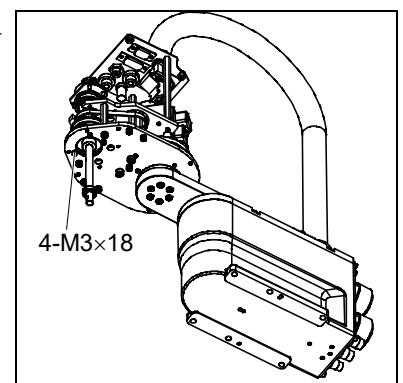
- (1) Turn ON the controller power.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

Be careful of the shaft falling while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Turn OFF the controller power.
- (4) Detach the wires/tubes from the end effector, and remove the end effector.
- (5) This step is only for Cleanroom-model.
Remove the bellows.
For details, refer to 9. *Bellows*.
- (6) Remove the arm top cover.
For details, refer to 3. *Covers*.
- (7) Remove the Joint #3 motor unit.
For details, refer to 7.1 *Replacing Joint #3 Motor*.
- (8) Remove the Joint #4 motor unit from Arm #2.
For details, refer to 8.1 *Replacing Joint #4 Motor*.
- (9) Remove the U belt and Z belt.

Remove the bolts securing the ball screw nut. Hold the ball screw nut up and remove the U belt and Z belt from the shaft by pulling them up.



- (10) Remove the nut mounting screws of the ball screw spline shaft on the lower part of Arm #2.



- (11) Pull out the ball screw spline unit from Arm #2.

Remove the ball screw nut from the Arm #2 bottom plate and pull out the ball screw spline unit toward the cutout of the Arm #2 upper plate (front).

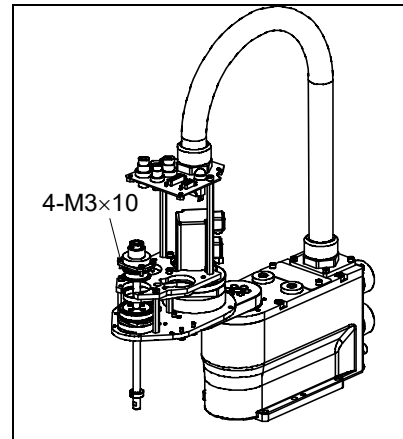


When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

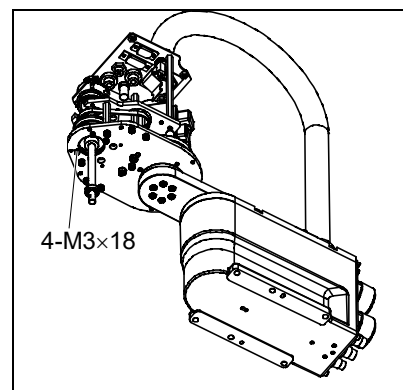
Ball screw spline unit
 Installation
 (4-axis spec)

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

Attach the spacer to the lower part of spline unit and align two holes in the spacer and in the Arm #2 bottom plate.

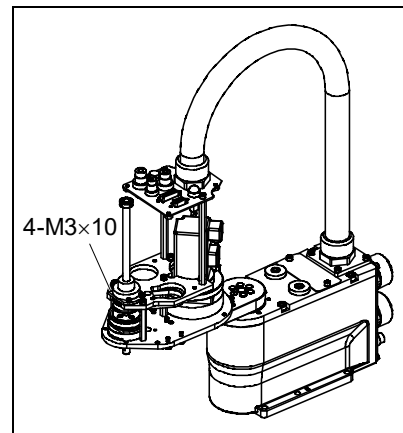


- (2) Secure the nut mounting screws of the ball screw spline shaft on lower side of Arm #2.



- (3) Loosely secure the ball screw nut to Arm #2.

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



- (4) Mount the Joint #3 motor unit.
 For details, refer to 7.1 Replacing Joint #3 Motor.
- (5) Mount the Joint #4 motor unit.
 For details, refer to 8.1 Replacing Joint #4 Motor.
- (6) If the position of the lower limit mechanical stop was changed for area limit, secure it to the proper position.
- (7) Grease the shaft.
 For details, refer to 10.1. Greasing the Ball Screw Spline Unit.
- (8) Mount the arm top cover.
 For details, refer to 3. Covers.

(9) Turn OFF the controller power and peripheral equipment.

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

Install the bellows.

For details, refer to *9. Bellows*.

(11) Mount the end effector, and connect wires and tubes to the end effector.

(12) Perform the calibration for the Joints #3 and #4.

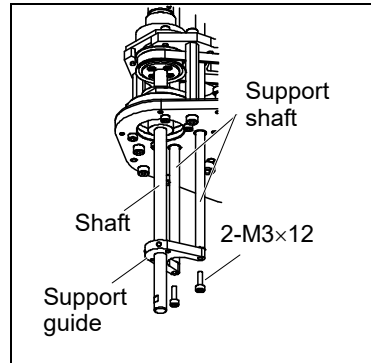
For details, refer to *13. Calibration*.

10.2 Replacing the ball screw spline unit (3-axis spec)

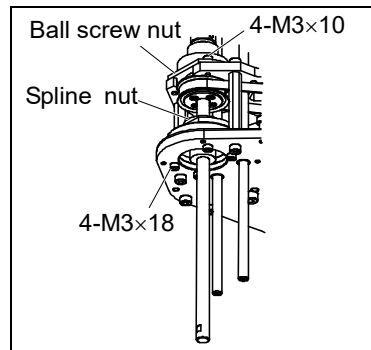
Ball screw spline unit Removal (3-axis spec)

- (1) This step is only for Cleanroom-model.
Loosen the screw of bellows fixing ring and pull it out to the lower shaft.
For details, refer to 9.2 *Replacing the Bellows (3-axis spec)*, removal step (1) to (8).
- (2) Remove the arm top cover and Joint #3 motor unit.
For details, refer to 10.2.1 *Replacing the ball screw spline unit (4-axis spec)*, removal step (1) to (7).

- (3) Remove the screw securing the upper side of support shaft.
- (4) Loosen the screw securing the lower support guide to the shaft. Pull out the support guide and support shaft downward.



- (5) Remove the screw securing the ball screw nut and spline nut.



- (6) Pull out the U belt and ball screw spline unit from Arm #2.
For details, refer to 10.2.1 *Replacing the ball screw spline unit (4-axis spec)*, removal step (9) to (11).

NOTE



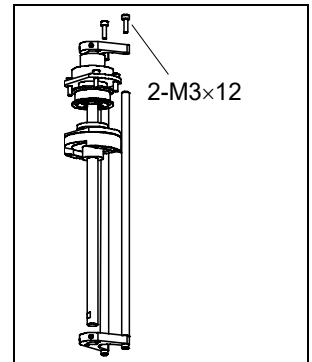
When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

Ball screw
spline unit
Installation
(3-axis spec)

- (1) Remove the screw securing the upper side of support shaft and loosen the screw securing the lower support guide.

Remove the lower support guide and support shaft from the new ball screw spline shaft.

Make sure the spline nut will not fall out from the shaft.



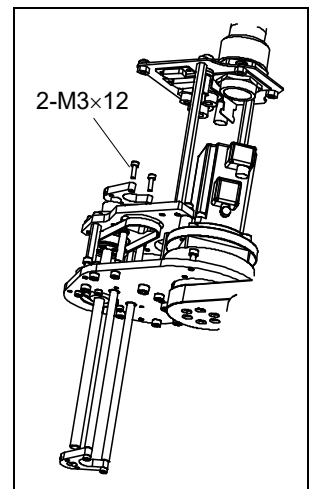
- (2) Mount the ball screw spline unit from which the support shaft and lower support guide have been removed.

For details, refer to 10.2.1 Replacing the ball screw spline unit (4-axis spec), installation step (1) to (4).

The U belt is not equipped for 3-axis spec.

- (3) Mount the support shaft and lower support guide removed in the step (1) through below Arm #2.

When inserting the support shaft into the arm, pass the support shaft near the Joint #4 motor unit through the U belt.

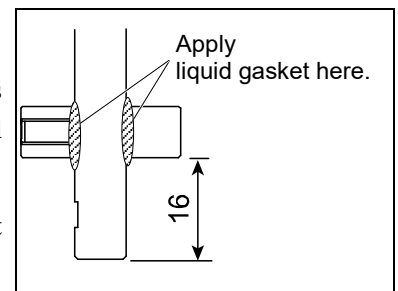


Loosely secure the upper side of support shaft to the upper support guide. After moving the shaft up and down several times, secure the set screw on the upper side of shaft, and then secure the set screw of the lower support guide.

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

Apply the liquid gasket to the inside of bellows fixing ring and insert it from below the shaft and secure it.

When securing the bellows fixing ring, make sure it does not touch the spline groove.



- (5) Mount the Joint #3 motor unit.

For details, refer to 7.1 Replacing Joint #3 Motor.

- (6) Grease the shaft.

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

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

Install the bellows.

For details, refer to 9. Bellows.



- (8) Mount the arm top cover.

For details, refer to 3. Covers.

- (9) Turn OFF the controller power and peripheral equipment.

- (10) Mount the end effector, and connect wires and tubes to the end effector.
- (11) Perform the calibration for the Joints #3 and #4.
For details, refer to *13. Calibration*.

11. Lithium Battery

 <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.
 <p>WARNING</p>	<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. <ul style="list-style-type: none"> <Improper Handling> <ul style="list-style-type: none"> • Battery Charge • Disassembly • Incorrect Installation • Exposing to Fire • Forced Discharge • Deformation by Pressure • Short-circuit (Polarity; Positive/Negative) • Heating (85°C or more) • Soldering the terminal of the lithium battery directly ■ When disposing of the battery, consult with the professional disposal services or comply with the local regulation. Spent battery or not, make sure the terminal is insulated. If the terminal contacts with the other metals, it is extremely hazardous, may result in heat generation, leakage, explosion, or inflammation, and may cause serious safety problems.

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.

RC700 series Maintenance Manual 6. 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 14. G1 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 (No Lithium battery)	1	2126750
Tools	Nippers	1	For cutting wire tie
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw (For replacing battery board)
Material	Wire tie	2	For fixing battery unit (battery)
		2	For fixing cable

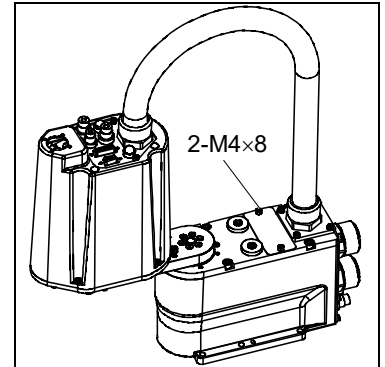
11.1 Replacing the Battery Unit (Lithium Battery)

- Battery unit (lithium battery) Removal
- (1) Turn OFF the controller power.
 - (2) Remove the screw securing the battery plate.

- (3) Lift the battery plate upward.



The lithium battery is fixed to the under the battery plate.



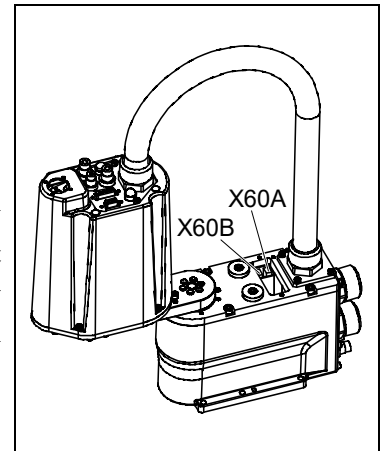
- (4) Connect the connector of the new lithium battery to the battery board.

Use 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 one, the robot will lose the origin position data and the calibration must be executed again.

Except when the Power-Low warning is appearing.



- (5) Cut off the wire tie binding the lithium battery to the battery plate and remove the lithium battery.



When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

- Battery unit (lithium battery) Installation
- (1) Mount the new lithium battery to the battery plate using wire tie.
 - (2) Mount the battery plate to the base.

- (3) Turn ON the controller power.
- (4) 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).

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

For details, refer to 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.

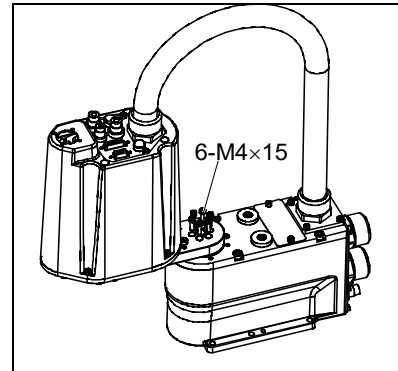
The process of aligning the two origins is called “Calibration”.

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

Battery board Removal

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

Place the removed Arm #1 on the floor without giving any shock.



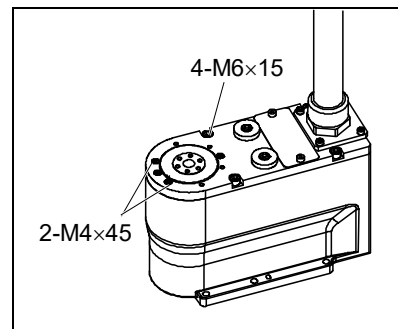
- (2) Remove the connector plate.

For details, refer to 3.2 *Connector Plate*.

- (3) Remove the Joint #1 flange by removing the whole Joint #1 unit.

The base and Joint #1 flange are aligned by the positioning pin.

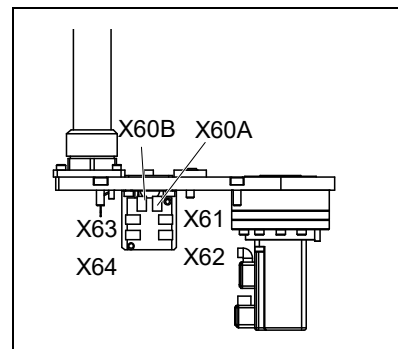
Be sure to keep the positioning pin.



- (4) Disconnect the connectors X61, X62, X63, and X64 connected to the battery board.

- (5) Loosen the screws securing the battery board and remove the battery board.

- (6) Disconnect the connector X60 (Lithium battery) connected to X60A or X60B.



NOTE



When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

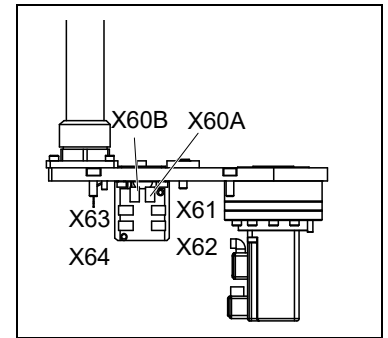
Battery board Installation

- (1) Mount the new battery board and connect the connector X60 to X60A or X60B.

Secure the board with screws.

- (2) Connect the connectors.

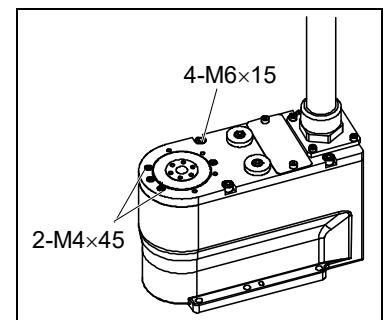
Connectors: X61, X62, X63, X64



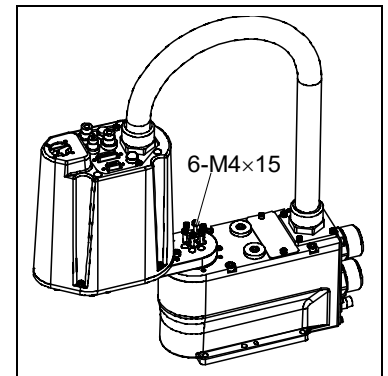
- (3) Mount the Joint #1 flange on the base.

When mounting the base and Joint #1 flange, their positions are determined by the positioning pin.

Be careful not to catch cables when mounting the flange.



- (4) Mount the Arm #1 on the base.




- (5) Mount the connector plate.

For details, refer to 3.2 Connector Plate.

- (6) Perform the calibration of all joints.

For details, refer to 13. Calibration.

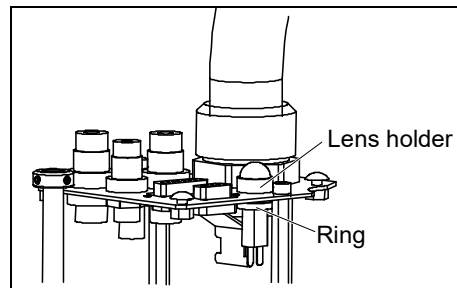
12. LED Lamp

	<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	2125880
Tools	Cross-point screwdriver	1	For removing wire
	Nippers	1	
Material	Wire tie	1	

LED Lamp Removal

- (1) Turn OFF the controller power.
- (2) Remove the arm top cover.
For details, refer to 3. Covers.
- (3) Disconnect the connector.
Connector: X22
- (4) Remove the lens and lens holder.
Turn them counterclockwise to remove.
- (5) Remove the LED and ring from the user plate.
To remove the ring, turn it counterclockwise.



LED Lamp Installation

- (1) Mount the LED on the user plate.
- (2) Put the arm top cover between the ring and lens holder, and then secure the LED to the user plate.
- (3) Mount the lens. Connect the connector.
Connector: X22.
- (4) Mount the arm top cover.
For details, refer to 3. Covers.

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.

13.2 Calibration Procedure

EPSON RC+ has a wizard for calibration.

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

The same calibration procedure is used for each joint.

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 *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.



If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *13.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.

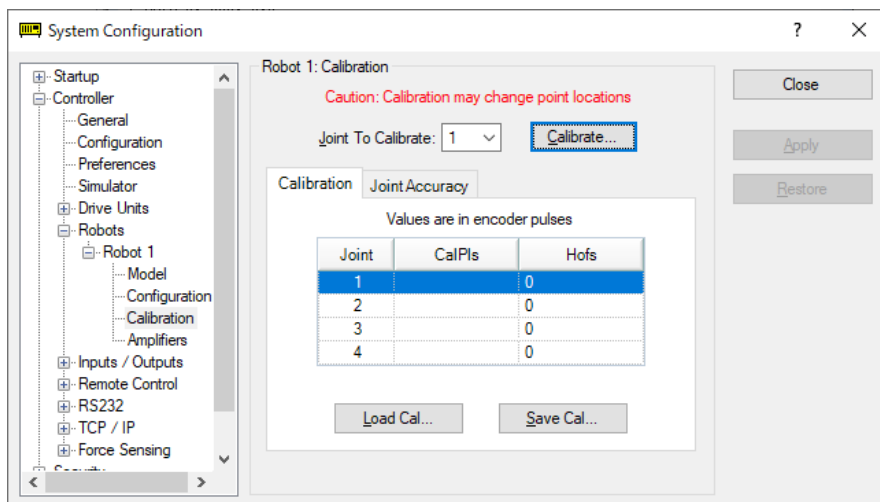
The reference point (a point to check the accuracy) needs to be specified for calibration.

- (1) Start the calibration wizard.
 - i. Select EPSON RC+ menu-[Setup]-[System Configuration].
 - ii. Select the [Robot]-[Robot**]-[Calibration].

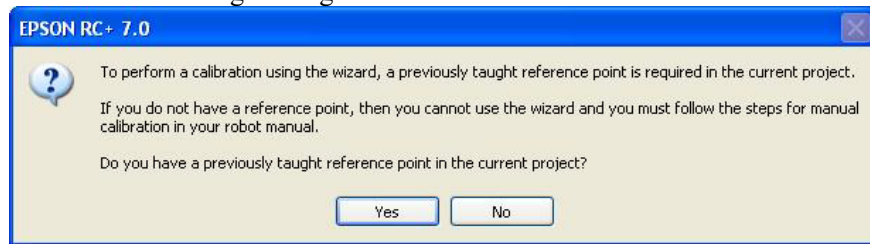


Only selected robot can be calibrated.

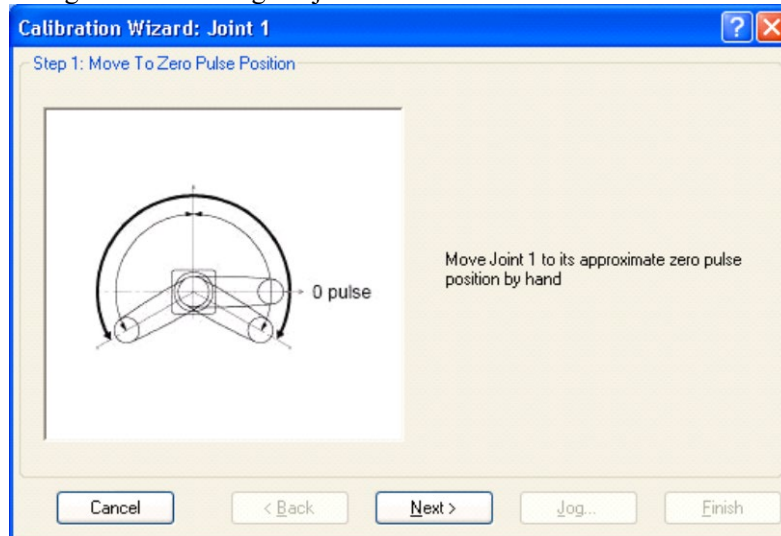
- iii. Select the joint and click the <Calibrate...> button.



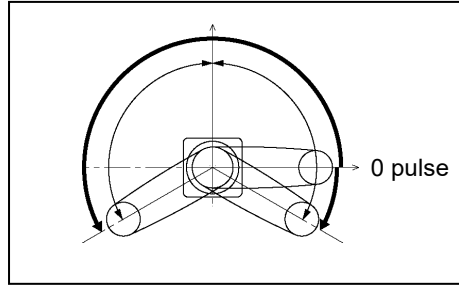
- (2) Confirm the warning message and click the <Yes> button.



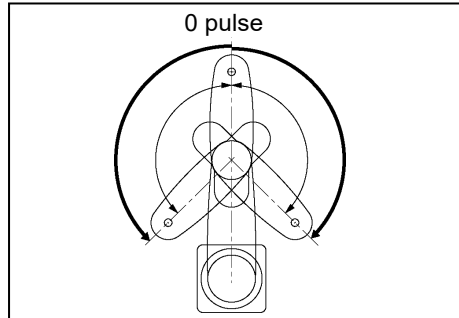
- (3) Move the joint to calibrate manually to approximate 0 pulse position, as shown in the dialog. After moving the joint click the <Next> button.



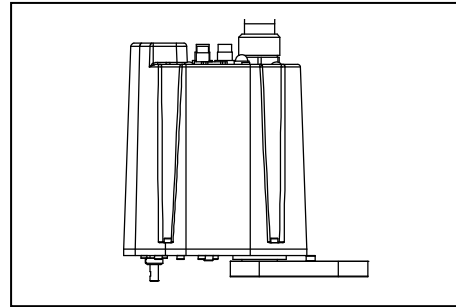
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



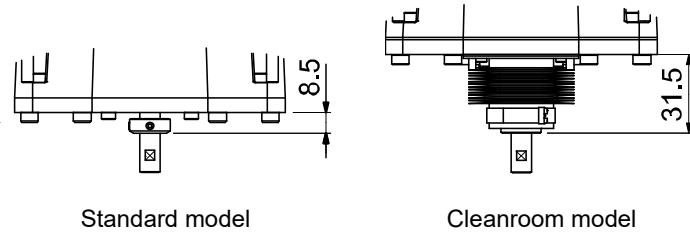
0 pulse position of Joint #2:
position where Arms #1 and #2
are in a straight line
(Regardless of the Joint #1
direction.)



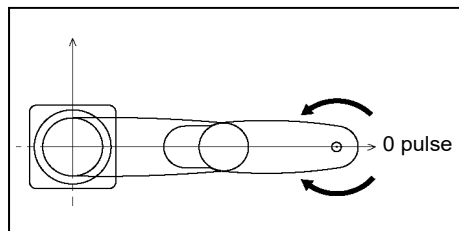
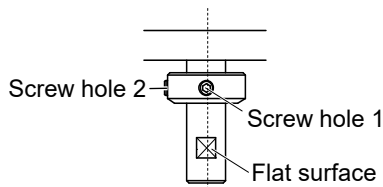
0 pulse position of Joint #3:
upper limit position in motion
range



The height of Joint #3 depends on manipulator model.



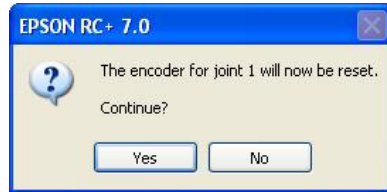
0 pulse position of Joint #4:
position where the flat surface
(or screw hole 1) on the shaft
faces toward the tip of Arm #2



Screw hole 1 and flat surface are located
in the center of the shaft.

Screw hole 1 and 2 are located at right
angles to one another.

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



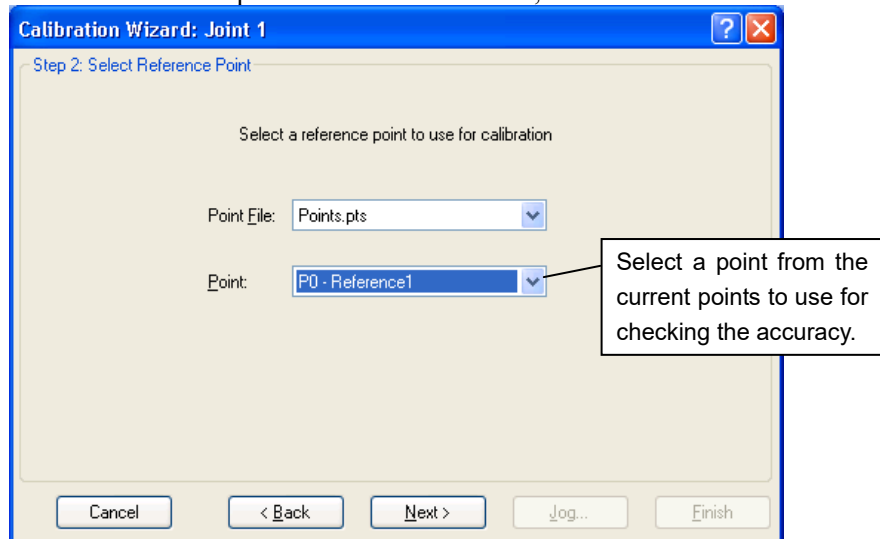
* This window will disappear when the Controller starts up.

- (5) Reboot the Controller.

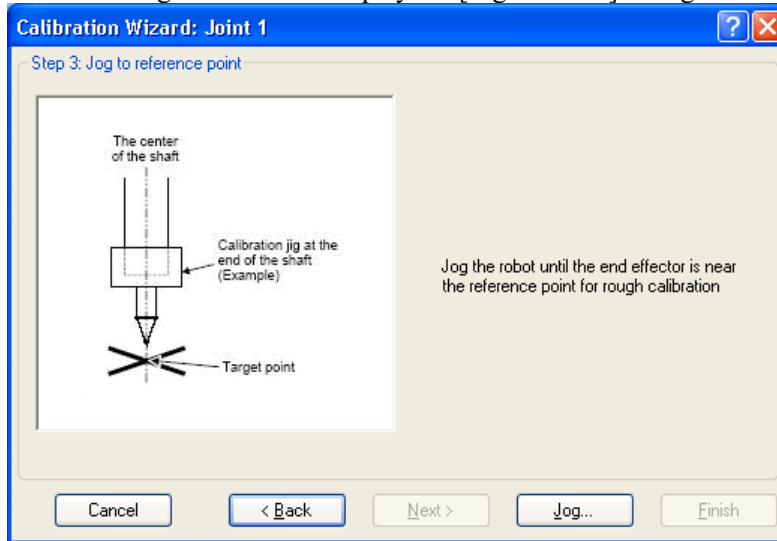


* This window will disappear when the Controller starts up.

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

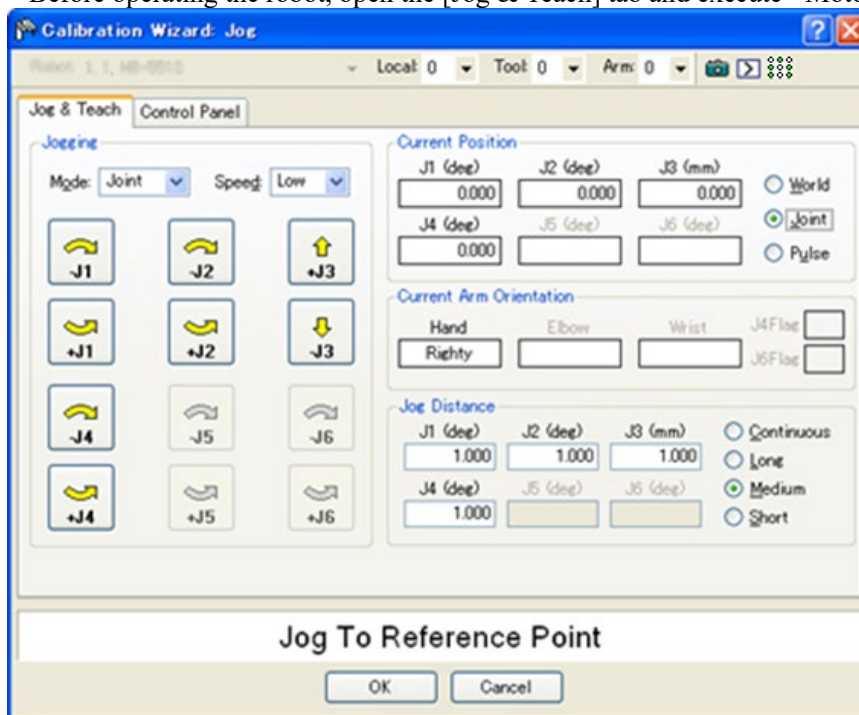


- (7) Click the <Jog...> button to display the [Jog & Teach] dialog.

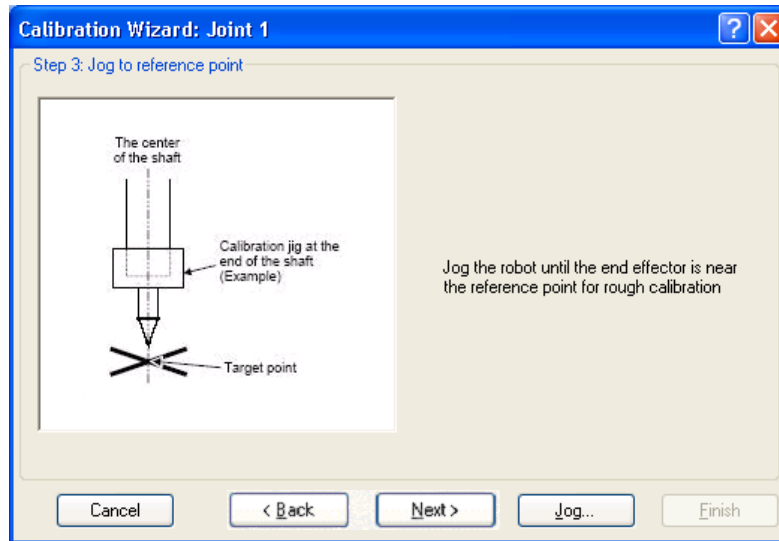


- (8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.

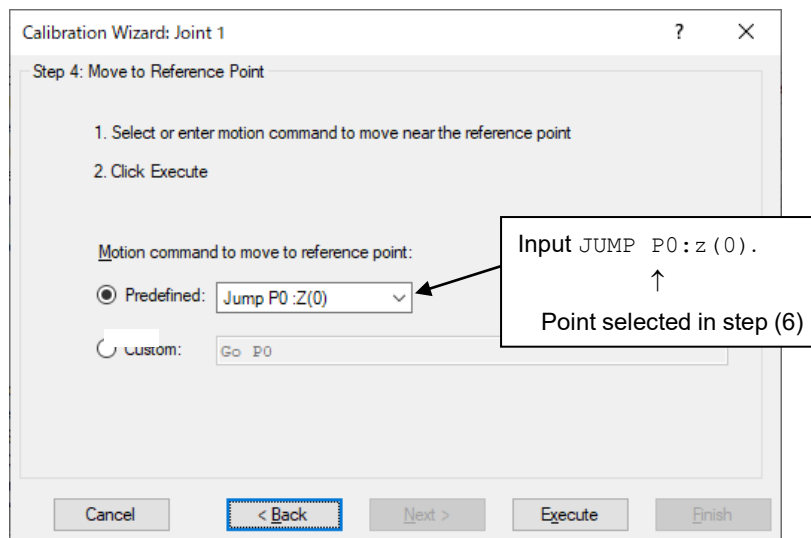
* Before operating the robot, open the [Jog & Teach] tab and execute <Motor ON>.



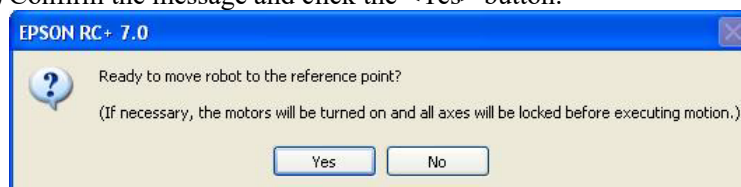
(9) Click the <Next> button.



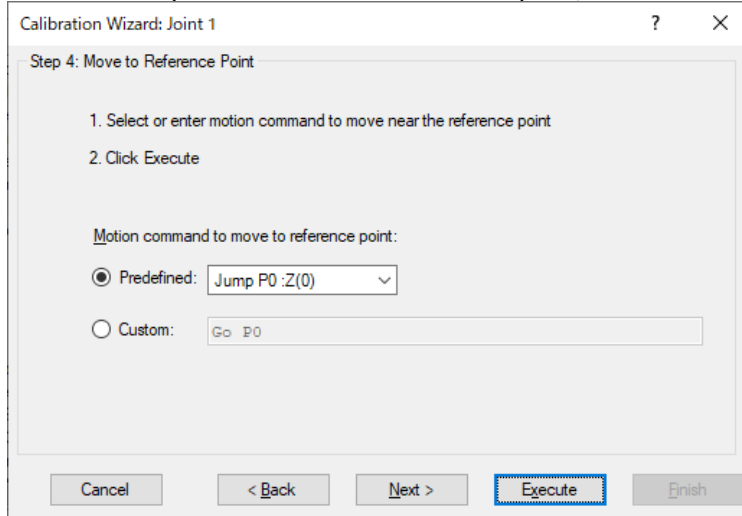
(10) The manipulator moves to the reference point. Click the <Execute> button.



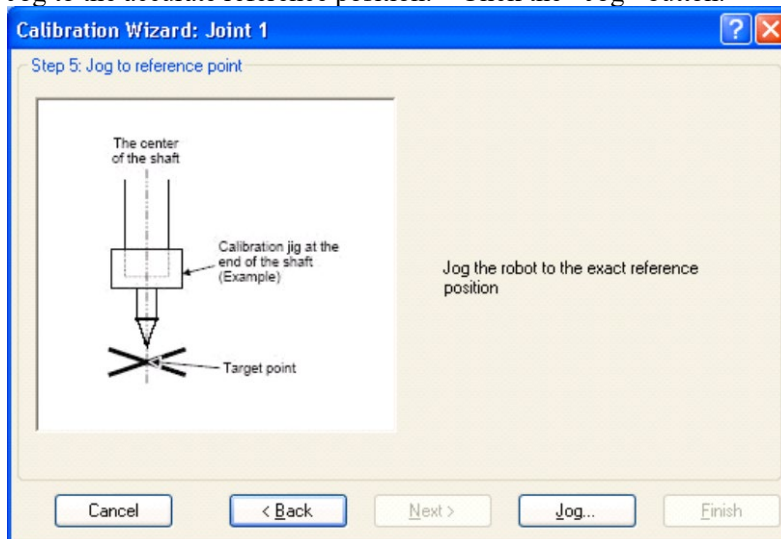
(11) Confirm the message and click the <Yes> button.



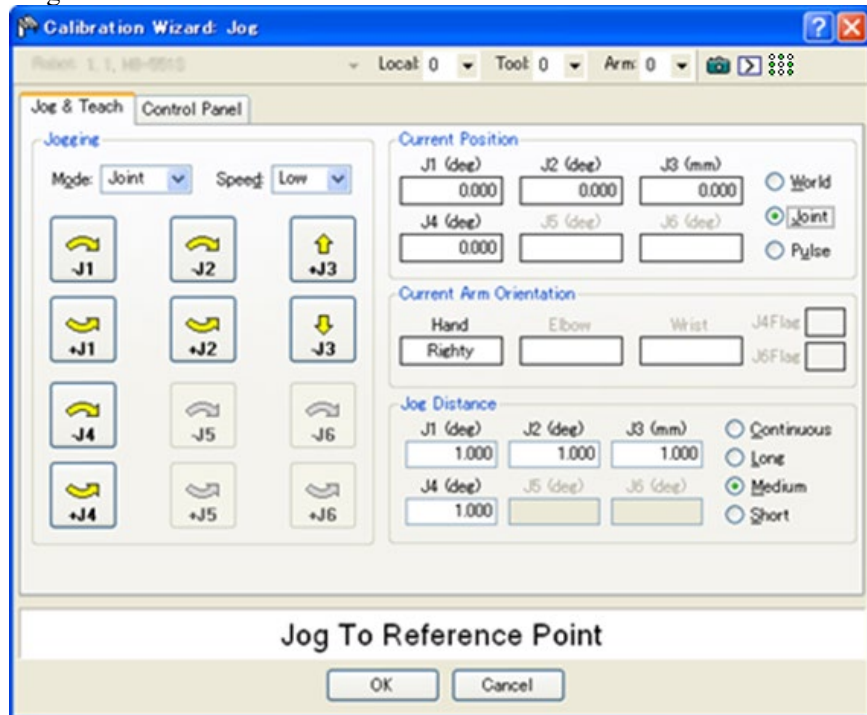
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position. Click the <Jog> button.

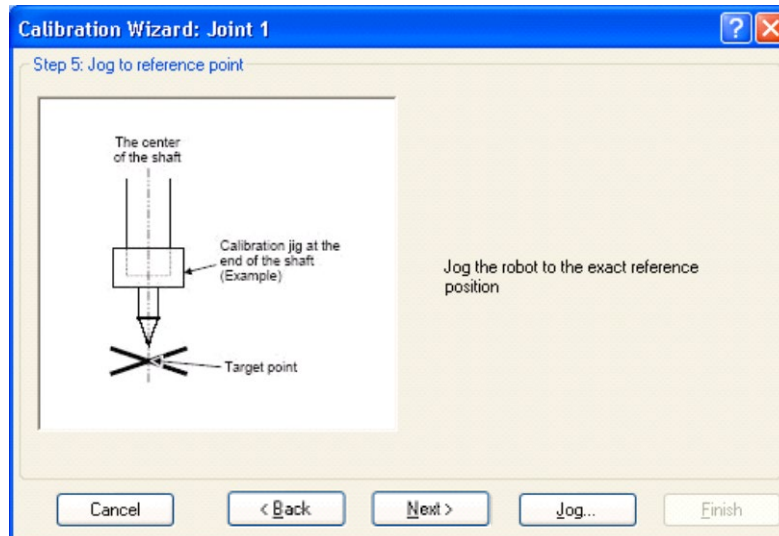


- (14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



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

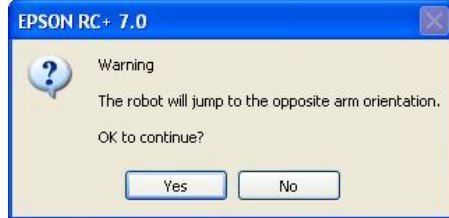
- (15) Click the <Next> button.



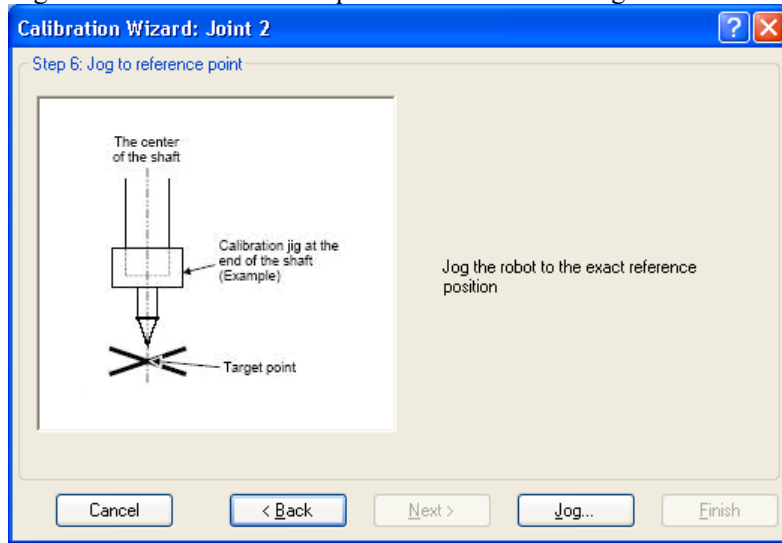
(16) Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2 only.

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

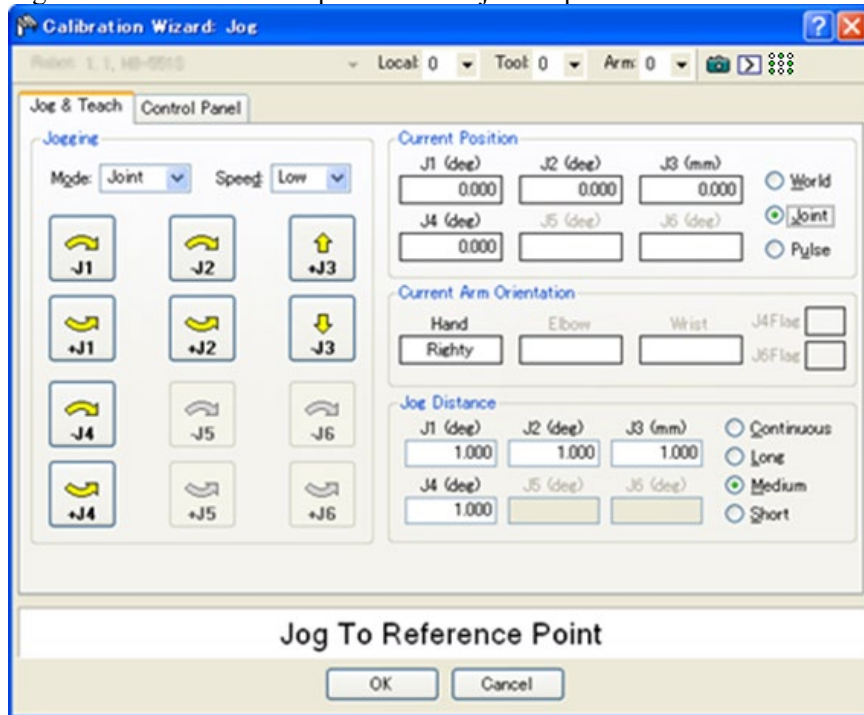
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



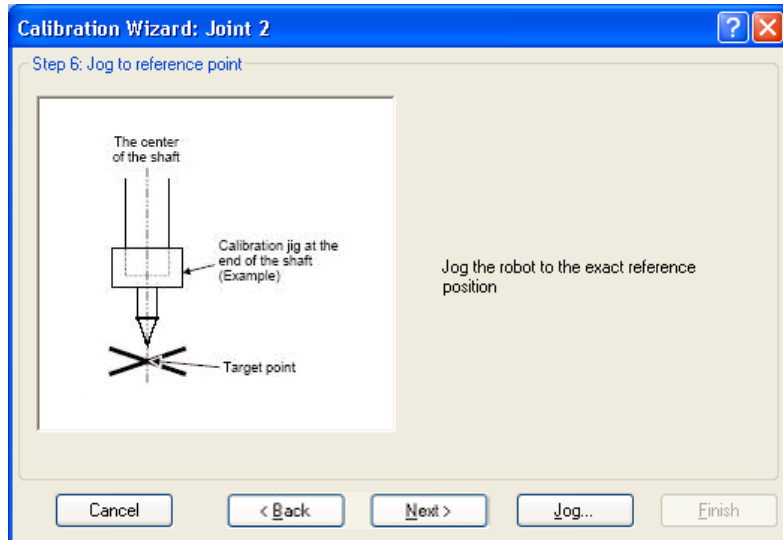
ii. Jog to the accurate reference position. Click the <Jog> button.



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.



(18) Move the manipulator to other points and check if it can move without problems. Teach points where appropriate.

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.



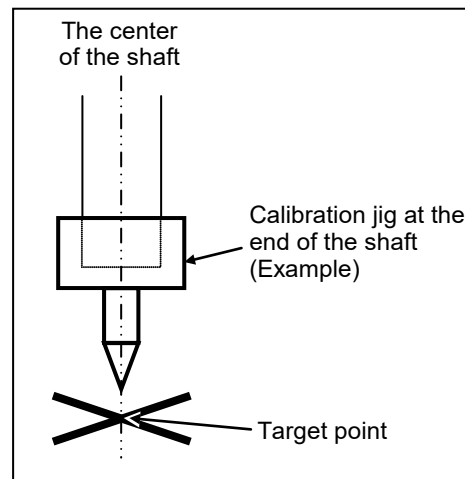
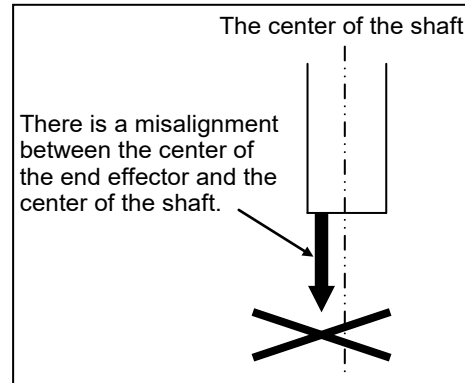
IF the calibration of Joint #2 is performed in *13.2 Calibration Procedure*, configure “Calibration Using Right / Left Arm Orientations” by the wizard.

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

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

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

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



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

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

- Teaching the working point by entering the coordinate values (MDI teaching)
- Switching the arm orientation between right and left at a given point
- Using the 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. And then check the number of pose (point) you want to use.
- (2) Open the Tools menu | Robot Manager | Control Panel and click the MOTOR ON.
- (3) Click the <Free All> button in the [Control Panel] to free all joints. 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 point is now called P1.
Specify the point number "1" and click the <Teach> button in the [Jog & Teach].
- (6) Click the <Lock All> button in the [Control Panel] to lock all joints.
- (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 rightly to lefty
Z is the maximum position
```


* If there is interference on the way from right to lefty, click the <Free All> button 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 Hof's 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 rightly arm orientation. Then, make sure the manipulator move to the correct position.

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


* If there is any interference on the way from lefty to rightly, click the <Free All> button in the [Control Panel] and change the arm orientation to rightly 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 *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.

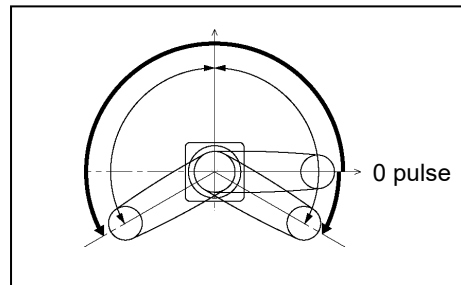
Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

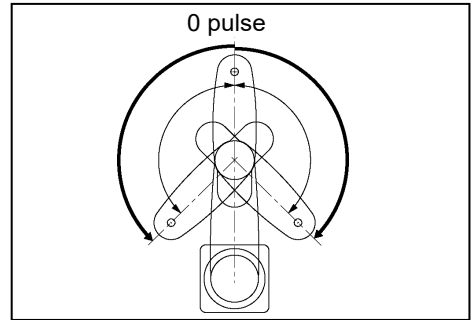
(3)-1 Turn ON the Controller when all joints are in the motion range.

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

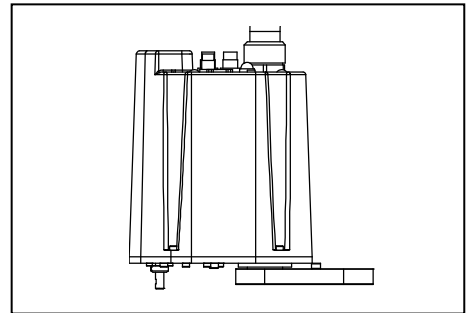
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



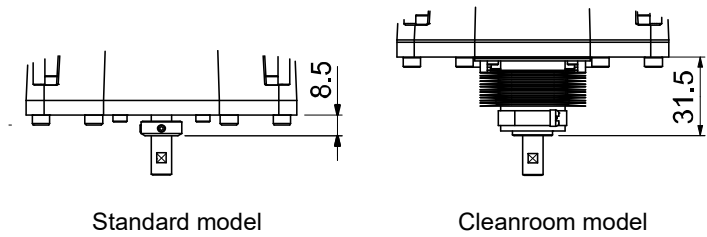
0 pulse position of Joint #2:
 position where Arms #1 and #2
 are in a straight line
 (Regardless of the Joint #1
 direction.)



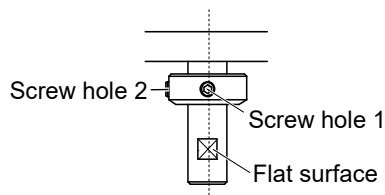
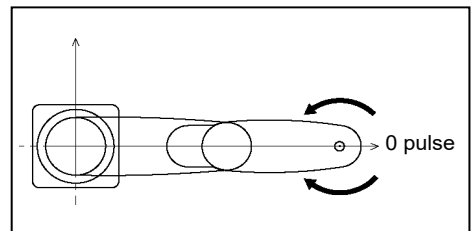
0 pulse position of Joint #3:
 upper limit position in motion
 range



The height of Joint #3 depends on manipulator model.



0 pulse position of Joint #4:
 position where the flat surface
 (or screw hole 1) on the shaft
 faces toward the tip of Arm #2



Screw hole 1 and flat surface are located
 in the center of the shaft.

Screw hole 1 and 2 are located at right
 angles to one another.

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

Select the robot to be calibrated. Input as below in the [Command
 Window] and execute.

(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 in the [Control Panel] to free all joints. 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	Overhaul *1
AC Servo Motor	Joint #1	1543776	R13B000621	50 W	5.1	✓
	Joint #2	1533642	R13B000619		6.1	✓
	Joint #3				7.1	✓
	Joint #4				8.1	✓
Reduction Gear Unit	Joint #1	1543777	R13B010026		5.2	✓
	Joint #2	1543778	R13B010027		6.2	✓
Electromagnetic Brake	Z axis	1543781	R13B030507		7.3	✓
Timing Belt	Joint #3	1522129	R13B030226	Z: width 6 mm, length 196 mm	7.2	✓
	Joint #4	1522134	R13B030227	U: width 6 mm, length 190 mm	8.2	✓
Cable Unit	175 mm	—	R13B020039		4.1	
	225 mm	—	R13B020040		4.1	
M/C Cable		R12NZ9002L	R12B020446	3 m	For RC180	4.3
		R12NZ900KG	—		For RC700-A, Straight	
		R12NZ900KK	—		For RC700-A, L-shaped	
		R12NZ9007K	R12B020447	5 m	For RC180	
		R12NZ900KH	—		For RC700-A, Straight	
		R12NZ900KL	—		For RC700-A, L-shaped	
		R12NZ9002M	R12B020448	10 m	For RC180	
		R12NZ900KJ	—		For RC700-A, Straight	
		R12NZ900KM	—		For RC700-A, L-shaped	
		R12NZ900XP	—	15 m	For RC700-A, Straight	
		R12NZ900XR	—		For RC700-A, L-shaped	
		R12NZ900XQ	—	20 m	For RC700-A, Straight	
	R12NZ900XT	—	For RC700-A, L-shaped			
Battery Board		2126750	R13B041203	No lithium battery Installed in Base	11.2	
Battery Unit		2117879	R13ZA006003 00	Lithium battery for replacement ER17330V (TOSHIBA)	11.1	
O-ring	Joint #1	1523421	R13B031251	For Joint #1 motor flange	5.1	
	Joint #2	1543780	R13B031252	For Joint #2 motor flange	6.1	

Part Name			Code	Note	Reference	Overhaul *1
Brake Release Switch		2117817	R13Z7026401 00		-	
LED Lamp		2125880	R13B030004		12	
Grease *2	AFB (Ball Screw Spline)	—	—	For purchasing grease, liquid gasket, and adhesive please contact the supplier of your region.	2.3	
	SK-2 (Reduction Gear Unit)	—	—		2.3	
	GPL-224 (Cable)	—	—		-	
Liquid gasket 1206C *2	—	—	10.2			
LOCTITE242 *2	—	—	5.1			

*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 2.2 *Overhaul (Parts Replacement)*.

*2 Regarding purchase of grease, liquid gasket, and adhesive

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase grease required for maintenance from the manufacturers listed in the table below as of April 2015. Regarding purchase of 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.	https://www.thk.com/
Harmonic Grease SK-2	Harmonic Drive Systems Inc.	https://www.harmonicdrive.net/
Krytox®GPL-224	Chemours	https://www.chemours.com/en/brands-and-products
1206C	ThreeBond Co.,Ltd	https://www.threebond.com

14.2 Parts by Environment Model

14.2.1 S: Standard-model

Part Name		Code	Old code	Note	Reference	Overhaul *1
Ball Screw Spline	4-axis spec	1543779	R13B010224		10.2.1	✓
	3-axis spec	1545312	R13B010226		10.2.2	✓
Arm Cover		1546243	R13B030441	White	3.1	

*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 2.2 *Overhaul (Parts Replacement)*.

14.2.2 C: Cleanroom-model

Part Name		Code	Old code	Note	Reference	Overhaul *1
Ball Screw Spline	4-axis spec	1545310	R13B010225		10.2.1	✓
	3-axis spec	1545314	R13B010227		10.2.2	✓
Arm Cover		1546245	R13B030442	Plating	3.1	
Bellows	4-axis spec	1522136	R13B030706	*2	9.1	
	3-axis spec	1545340	R13B030707	*3	9.2	
Gasket Unit		1545346	R13B031253		-	

*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 2.2 *Overhaul (Parts Replacement)*.

*2 The bellows for 4-axis spec are provided in a unit of one piece.

*3 The bellows for 3-axis spec are provided in a unit of two pieces.

The shape varies between the upper and lower bellows.




G3 Maintenance

This volume contains maintenance procedures with safety precautions for Manipulators.

1. Safety Maintenance

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

Only authorized personnel who have taken maintenance training held by the manufacturer or dealer should be allowed to perform the robot maintenance.

 <p>WARNING</p>	<ul style="list-style-type: none"> ■ 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.
 <p>WARNING</p>	<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.
 <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. ■ When operating maintenance of manipulator, secure about 50 cm of empty space around the manipulator.

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.

	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						√

h = hour

2.1.2 Inspection Point

Inspection Item

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts/screws.	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
Check looseness of connectors.	External connectors on Manipulator (on the connector plates etc.)	√	√	√	√	√
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 the brake operation	Joint #3	√	√	√	√	√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√

Inspection Method

Inspection Point	Inspection Method
Check looseness or backlash of bolts/screws.	Use a hexagonal wrench to check that the end effector mounting bolts and the Manipulator mounting bolts are not loose. When the bolts are loose, refer to “2.4 Tightening Hexagon Socket Head Bolts” and tighten them to the proper torque.
Check looseness of connectors.	Check that connectors are not loose. When the connectors are loose, reattach it not to come off.
Visually check for external defects. Clean up if necessary.	Check the appearance of the Manipulator and clean up if necessary. Check the appearance of the cable, and if it is scratched, check that there is no cable disconnection.
Check for bends or improper location. Repair or place it properly if necessary.	Check that the safeguard, etc. are located properly. If the location is improper, place it properly.
Check the brake operation	Check that the shaft does not fall when in MOTOR OFF. If the shaft falls when in MOTOR OFF and the brake is not released, contact the supplier. Also, the break is not released even operated release the break, contact the supplier.
Check whether unusual sound or vibration occurs.	Check that there is no unusual sound or vibration when operating. If there is something wrong, contact the supplier.

2.2 Overhaul (Parts Replacement)



CAUTION

- If you do not overhaul properly, it may have a serious impact on safety.
- 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 ambient temperature, 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.

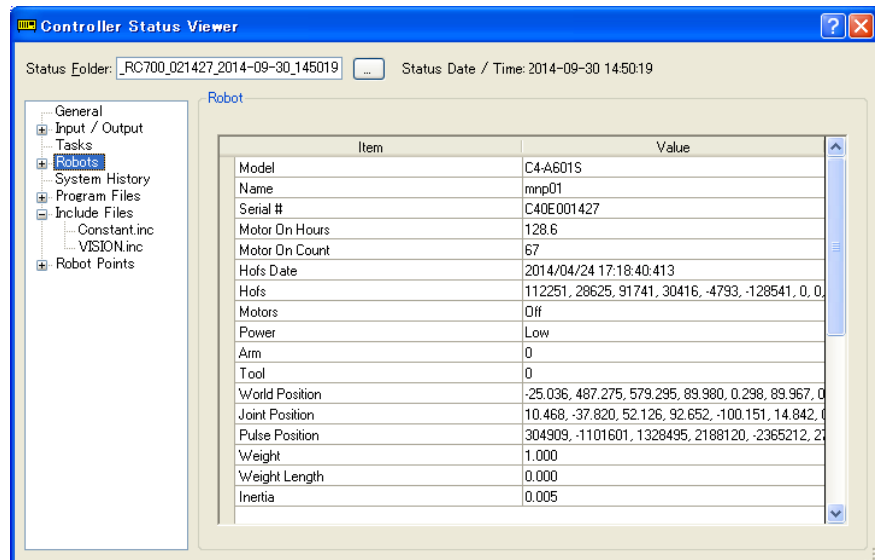
RC700 series Maintenance Manual 6. Alarm

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 15. *G3 Maintenance Parts List*.


For details of replacement of each part, refer to each 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	Reference
Joint #1 Joint #2	Reduction gear units	Overhaul timing	SK-1A	5.2 Replacing the Joint #1 Reduction Gear Unit 6.2 Replacing the Joint #2 Reduction Gear Unit
Joint #3	Ball screw spline unit	At 100 km of operation (50 km for first greasing)	AFB	Greasing the Ball Screw Spline Unit

Joint #1, 2 reduction gear units

As a rough indication, perform greasing at the same timing as overhaul. However, it may vary depending on ambient temperature, 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.



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.

RC700 series Maintenance Manual 6. Alarm


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	


Standard-model

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

- (1) Turn ON the Controller.
- (2) Move the shaft to the lower limit by using one of the following methods:
 - Move the shaft to the lower limit manually while pressing the brake release switch.

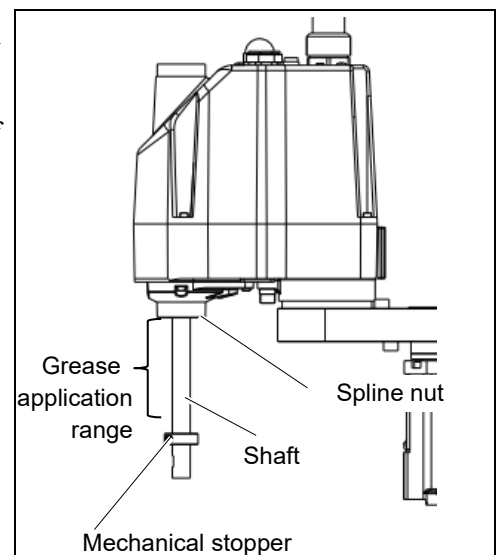
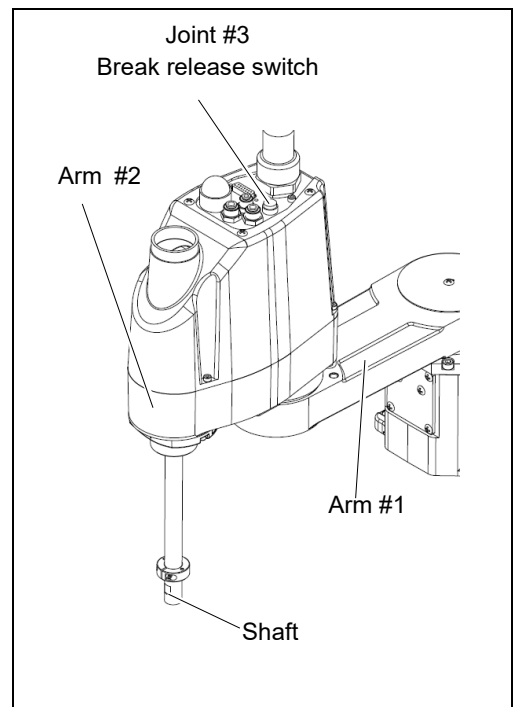
NOTE
 Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of the end effector.

- Move the shaft to the lower limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].

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

- (3) Turn OFF the Controller.
- (4) Wipe off the old grease from the shaft, and then apply new grease to it.

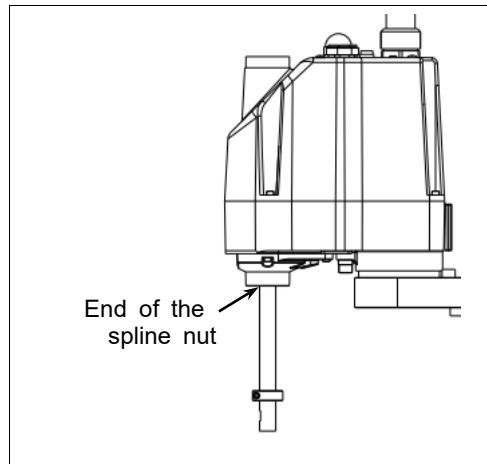
Grease application range is from the end of the spline nut to mechanical stop.



- (5) Apply new grease evenly to the spiral groove of the ball screw spline unit and the vertical groove so that the groove is filled.



- (6) Turn ON the Controller.
- (7) Start the robot manager and move the shaft to the origin position. Be careful not to hit peripheral equipment.
- (8) After moving to the origin position, reciprocate the shaft. The reciprocating operation is a low power mode operation program that performs from the upper limit to the lower limit. Run for about 5 minutes to spread the grease over the shaft.
- (9) Turn OFF the controller.
- (10) Wipe off excess grease on the end of the spline nut and mechanical stop.



Cleanroom-model



Dust is emitted when greasing. 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 greasing. Cover the surrounding area such as the end effector and peripheral equipment in case the grease drips.

- (1) Turn ON the Controller.
- (2) Move the shaft to the upper limit by using one of the following methods:
 - Move the shaft to the upper limit manually while pressing the brake release switch.



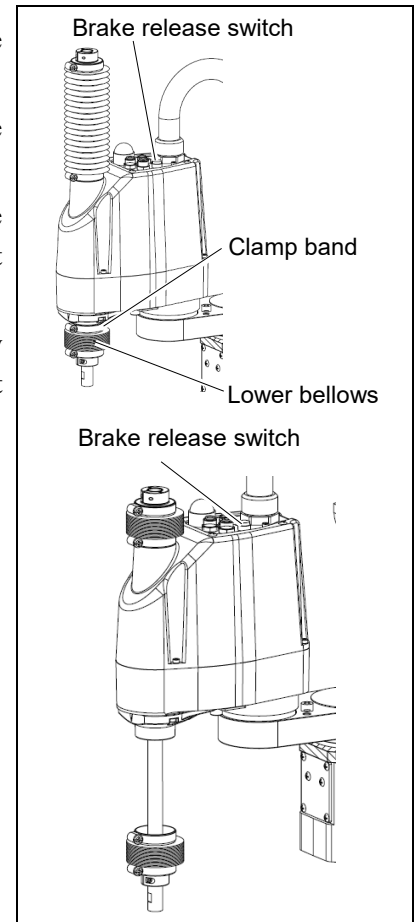
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of the end effector.

- Move the shaft to the upper limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].

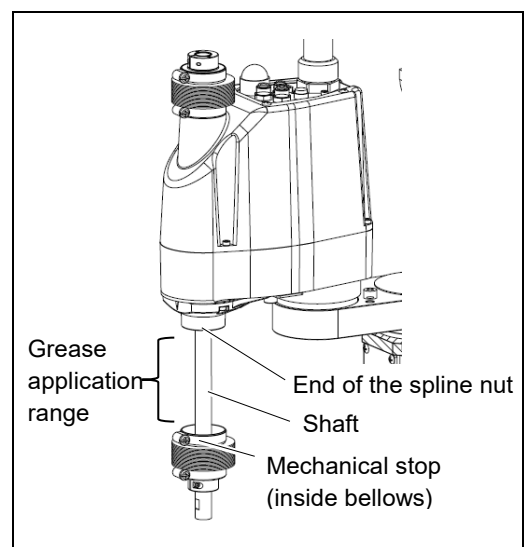


Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

- (3) Loosen the clamp band on the top of the lower bellows, and then move the lower bellows downward.
- (4) Move the shaft to the lower limit in the same way as in step (2).



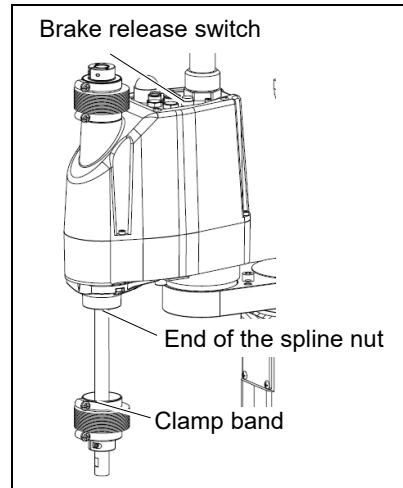
- (5) Turn OFF the Controller.
- (6) Wipe off the old grease from the shaft, and then apply new grease to it.
The range to apply grease is from the end of the spline nut to the mechanical stop.



- (7) Apply grease to the spiral groove and vertical groove of the ball screw spline to fill the grooves.



- (8) Turn ON the Controller.
- (9) Apply grease to the whole of the shaft.
Move the shaft up and down about 10 times from the upper limit to the lower limit.
When moving the shaft up and down, press and hold the brake release switch on the top of cover.
After moving up and down, wipe off excess grease from the end of the spline nut.



- (10) Fix the lower bellows.
Move the shaft to the upper limit.
Insert the bellows mounted part until it touches the cylinder part of the cover.
Fix with the clamp band.
- (11) After fitting, move the shaft up and down several times and rotate Joint #4. Make sure that the bellows can expand and contract smoothly without any excessive force.
- (12) Start Robot Manager and move the shaft to the origin position.
Be sure to prevent hitting any peripheral equipment.
- (13) After moving to the origin position, move the shaft up and down. To move up and down, use an operation program to move from the upper limit to the lower limit in low power mode. Run about 5 minutes to spread grease over the shaft.
- (14) Turn OFF the Controller.

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.

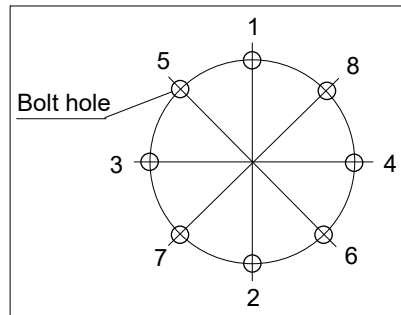
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

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.

**EPSON
RC+**

Execute the following command from the [Command Window].

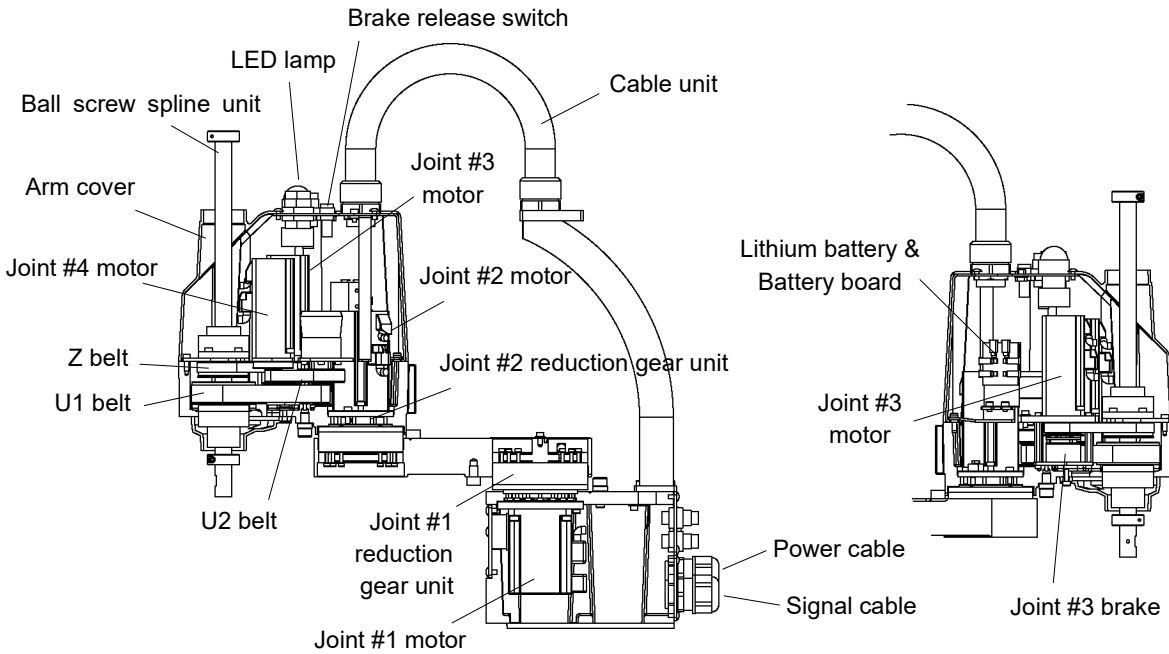
```
>PULSE
```

```
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

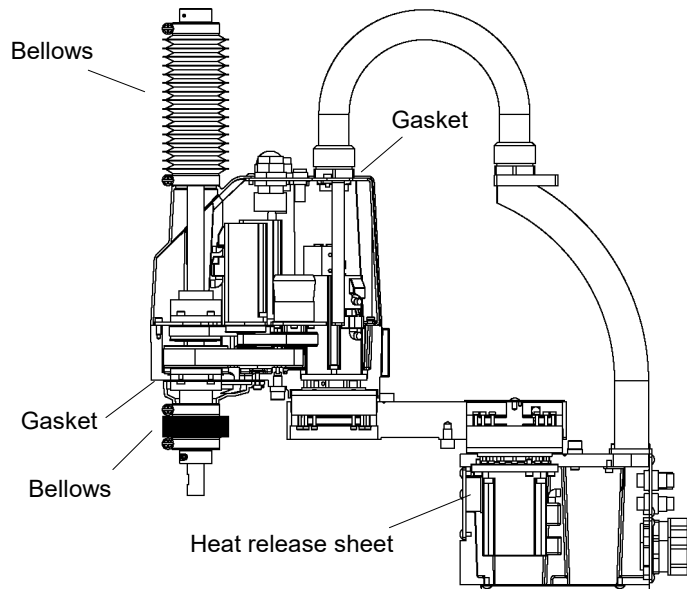
2.6.1 Table Top Mounting

G3-**1S : Standard-model



(Figure: G3-301S)

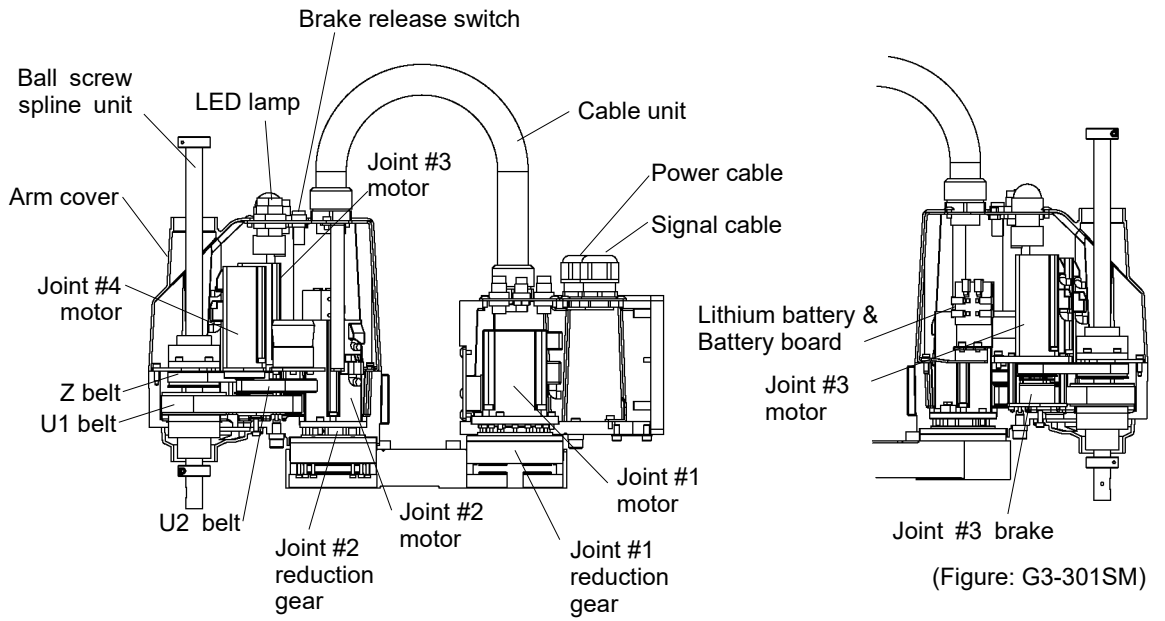
G3-**1C : Cleanroom-model (with bellows)



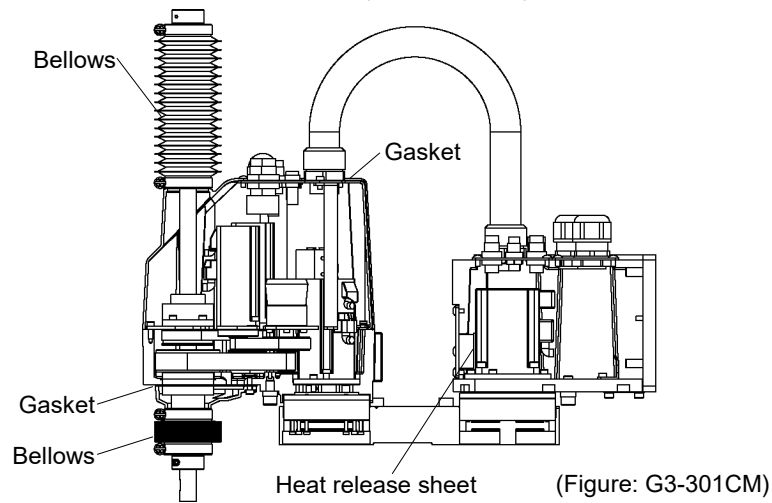
(Figure: G3-301C)

2.6.2 Multiple Mounting

G3-**1SM : Standard-model




G3-**1CM : Cleanroom-model (with bellows)



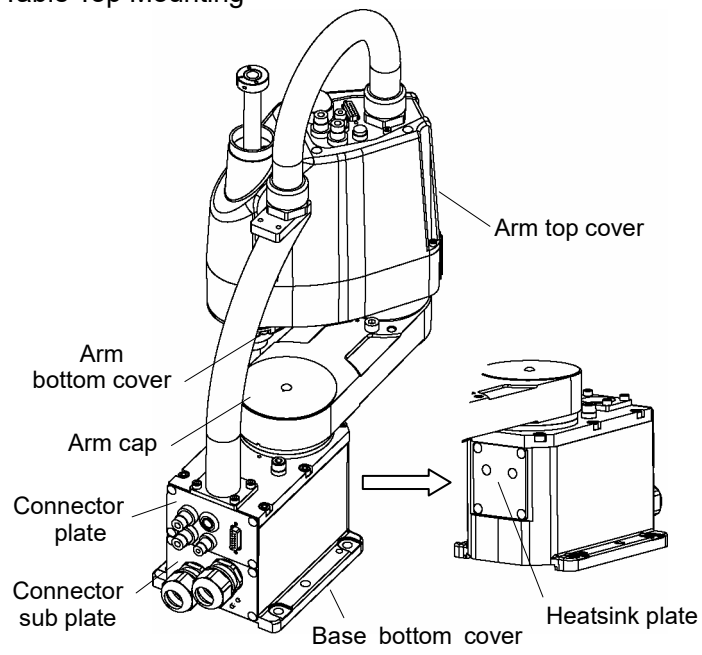
3. Covers

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

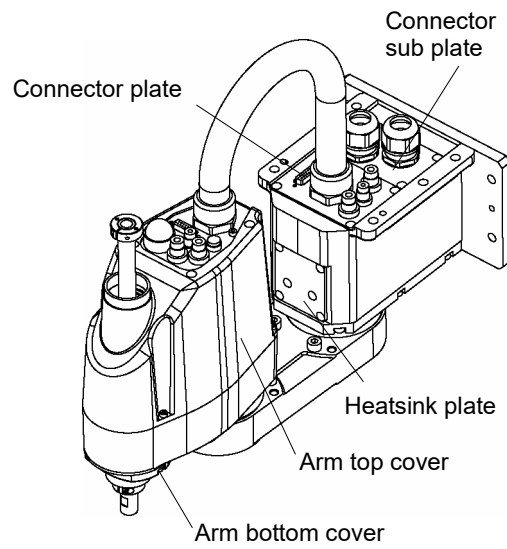
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move 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	Under cover gasket	1	1514467 Only for Cleanroom-model
	User Plate gasket	1	
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw Tightening Torque: 0.9 N·m (9.2 kgf·cm)
	Torque wrench	1	
	Cross-point screwdriver	1	For M4 truss screw Tightening torque: 0.4 N·m (4.1 kgf·cm) For bellows removal (Only for Cleanroom-model)
	Wiping cloth	1	For wiping adhesive


Table Top Mounting



Multiple Mounting




3.1 Arm Top Cover

 CAUTION	<ul style="list-style-type: none"> ■ Do not remove the arm top cover forcibly. Removing the cover forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. ■ When 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. <p>When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations.</p>
--	---

Arm Top Cover (1) Turn ON the Controller.


Removal

- (2) Press and hold the brake release switch to let the shaft down. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

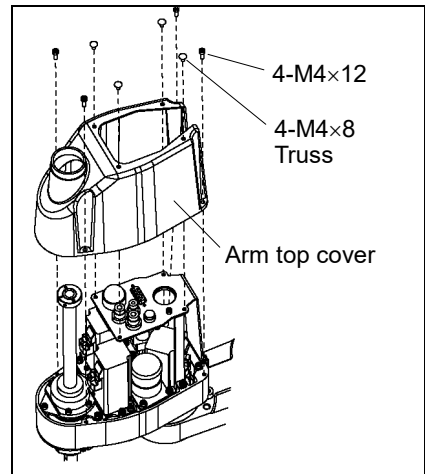
NOTE  The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

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

- (3) Turn OFF the Controller.
- (4) Unscrew the arm top cover mounting bolts, and then lift the cover.

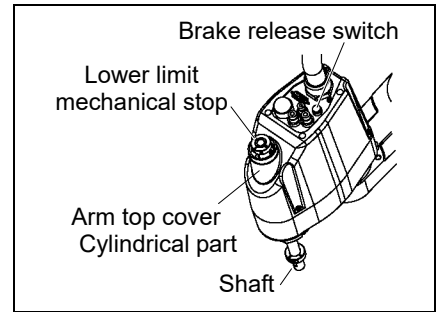
NOTE  When bellows are installed to the manipulator, remove the upper bellows and then remove the arm top cover. For bellows removal, refer to *10. Bellows*.

Be careful for user wires and tubes when removing the cover.



- Arm Top Cover Installation (1) Set the arm top cover to the arm and secure with the arm top cover mounting bolts.

After mounting the arm top cover, make sure that the lower limit mechanical stop does not touch the cylindrical part of the arm top cover.



- (2) When bellows are installed to the manipulator, install the arm top cover and then install the upper bellows.

For bellows installation, refer to 10. Bellows.

3.2 Arm Bottom Cover

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

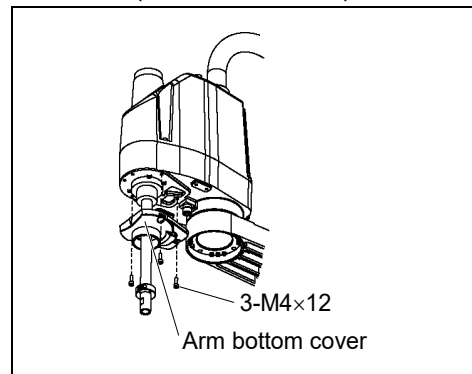


The arm bottom cover may not be removed from the shaft because the end effector is installed. If it is necessary to remove the cover completely (for replacement of the ball screw spline unit etc.), remove the end effector.

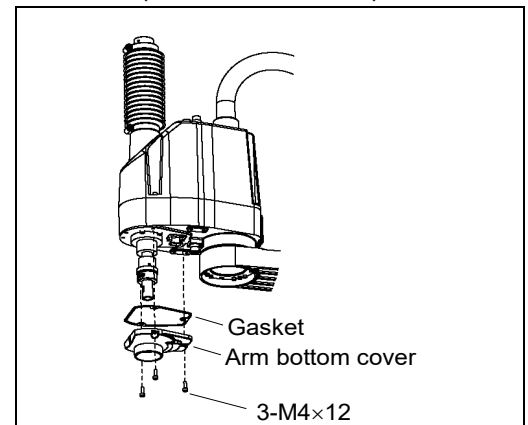
If it is not necessary to remove the cover completely, move the shaft to the lower limit, and lower the arm bottom cover. Then, perform maintenance or inspection.

When bellows are installed to the manipulator, remove or pull down the lower bellows and then remove the arm bottom cover. For bellows removal, refer to 10. Bellows.

G3-**1S* (Standard-model)



G3-**1C* (Cleanroom-model)

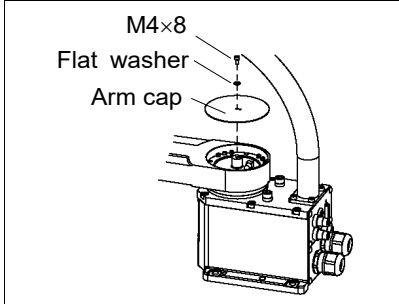


A gasket is installed to G3-**1C* (Cleanroom-model).

3.3 Arm Cap

Unscrew the arm cap mounting bolts and remove the cover.
 Arm cap is not installed to the Multiple Mounting Manipulators.

G3-**1 Table Top Mounting



3.4 Connector Plate

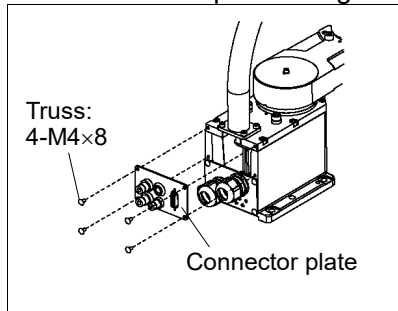


CAUTION

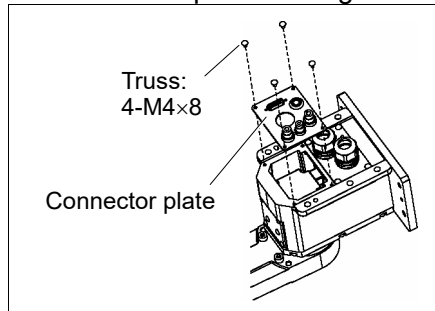
- Do not remove the connector plate forcibly. Removing the connector plate forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot 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.

G3-**1* Table Top Mounting



G3-**1*M Multiple Mounting



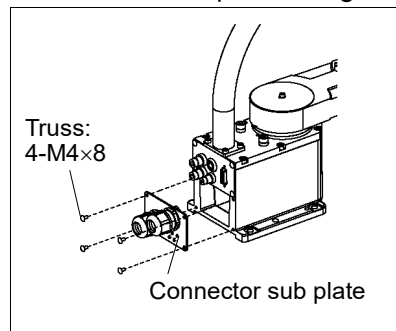
3.5 Connector Sub Plate



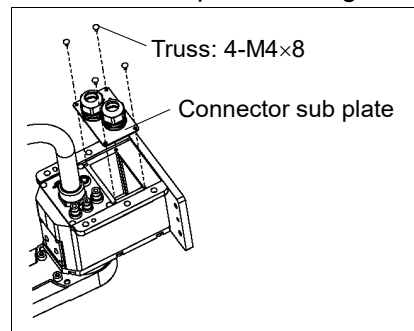
- Do not remove the connector sub plate forcibly. Removing the connector sub plate forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
- When installing the connector sub 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 sub plate. Be sure to place the cables back to their original locations.

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

G3-**1* Table Top Mounting



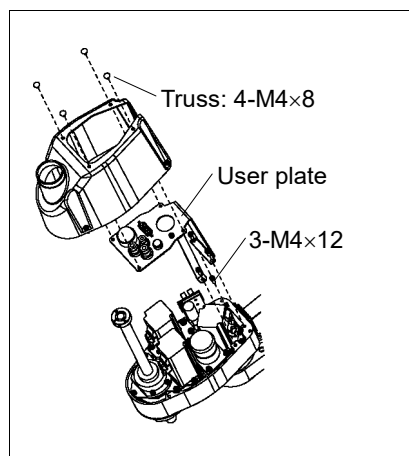
G3-**1*M Multiple Mounting



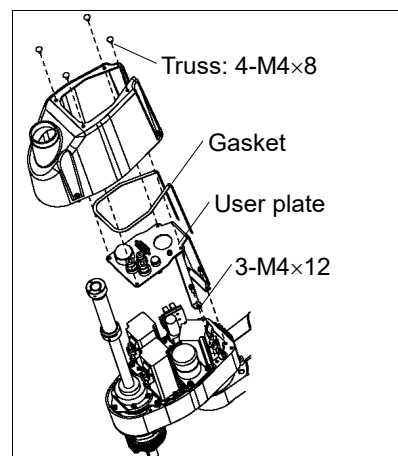
3.6 User Plate

Unscrew the user plate mounting bolts and remove the plate.

G3-**1S* Standard-model



G3-**1C* Cleanroom-model

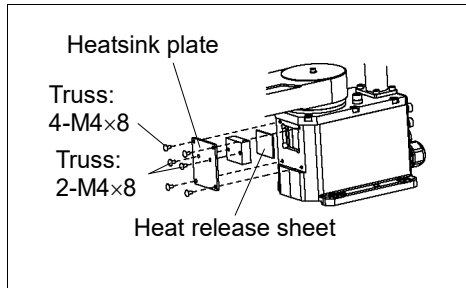


A gasket is installed to G3-**1C* (Cleanroom-model).

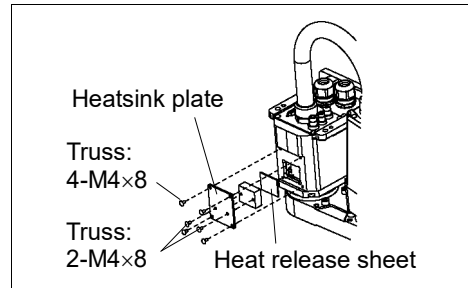
3.7 Heatsink Plate

Unscrew the heatsink plate mounting bolts to remove the plate.

G3-**1* Table Top Mounting



G3-**1*M Multiple Mounting



Be careful of the Heat release sheet at the side of the Motor, and be sure to keep it.

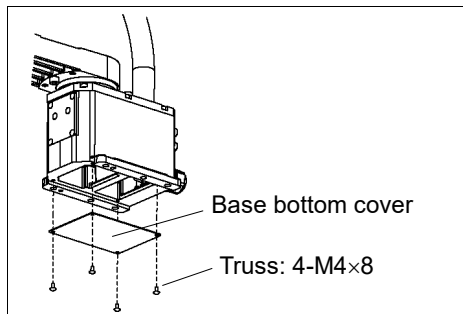


Be careful when you mount the Heatsink plate without the Heat release sheet, it may cause the malfunction or break by the heat from the Motor.

3.8 Base Bottom Cover

Unscrew the base bottom cover mounting bolts and remove the cover.

G3-**1C* Cleanroom-model



A base bottom cover is not installed to G3-**1S* (Standard-model).

4. Cable



- 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 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.

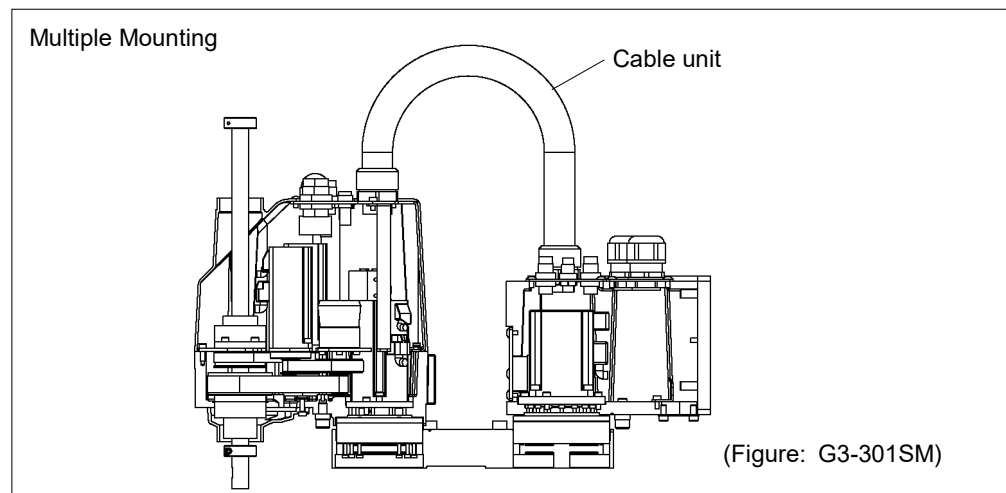
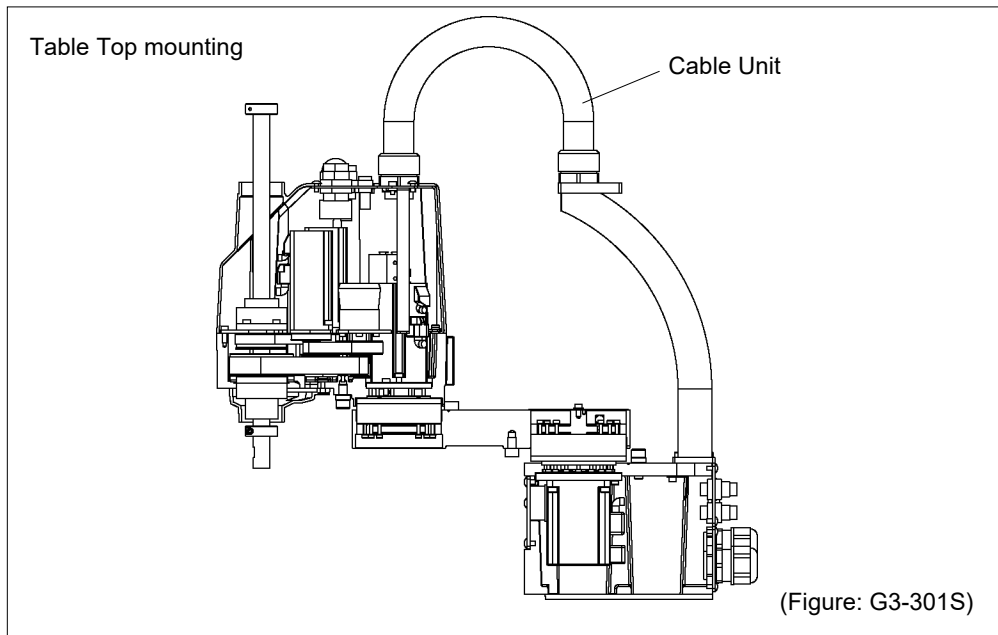
4.1 Replacing Cable Unit


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.

For details of the Calibration, refer to *14. Calibration*.

	Name		Quantity	Note	
Maintenance parts	Cable unit		1	Each manipulator model (Refer to <i>15. G3Maintenance parts</i>)	
	Battery Unit (Lithium battery)		1	2117879	
Tools	Hexagonal wrench	width across flats: 3 mm	1	For M4 screw	
		width across flats: 4 mm	1	For M5 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
	Torque wrench			1	
	Nippers		1	For cutting wire tie	
Material	Wire tie		9		



 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>4.2 Wiring Diagrams</i>. ■ When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations. ■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
---	---

Cable unit Removal

- (1) Turn ON the Controller and change the motor to OFF status (MOTOR OFF).
- (2) Press and hold the brake release switch to let the shaft down. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.
The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.
Be careful of the shaft while the brake release switch is being pushed because it may be lowered by the weight of an end effector.
- (3) Turn OFF the Controller and disconnect the power cable and signal cable connectors from the controller.
- (4) Remove the connector plate.
For details, refer to *3.4 Connector Plate*.
- (5) Remove the connector sub plate.
For details, refer to *3.5 Connector Sub Plate*.
- (6) Connect the spare battery to the spare battery connector (XB11) of Joint #1 signal cable.

NOTE



- Use the battery unit as the spare battery.
- The position of Joint #1 motor is stored with the battery on Arm #2/
Connect the spare battery otherwise the Joint #1 position data will be lost.

- (7) Disconnect the air tubes, ground wire, D-sub cable, and seven connectors (X10, X20, X30, X111, X121, X131, XB10) connected to the connector plate and connector sub plate (inner side).

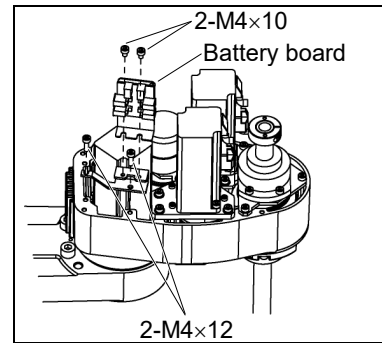
NOTE



- Be sure to keep the connectors of the battery board connected at cables replacement. Otherwise, the motor will lose position data and the calibration must be executed again.
- Remember the cable layout so that the cables can be reconnected correctly after replacement.

- (8) Cut off one wire tie binding Base side cables.
- (9) Remove the arm top cover.
For details, refer to 3.1 Arm Top Cover.
- (10) Remove the Battery board.
- (11) Loosen the mounting screws for the User plate and remove the plate from the Arm #2.

At this point, the ground is removed with the plate.



- (12) Disconnect 11 connectors on the Arm side.

Connectors X21, X22, X31, X32, X33, X41, X42, X61, X221, X231, X241

NOTE X61 is connected to the battery board.



Be sure to keep the connectors of the battery board connected at cables replacement. Otherwise, the Joint #2, #3, and #4 motors will lose position data and the calibration must be executed again.

- (13) Disconnect the D-sub cable, air tubes, and connector of the brake release switch from the user plate.

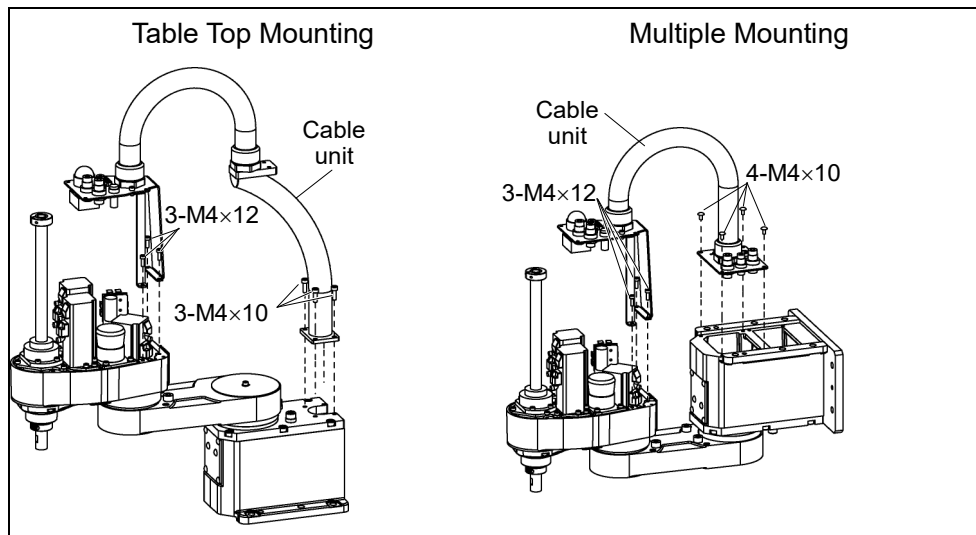


NOTE Mounting screws for the D-sub cable are very small. Be sure to keep the screws.

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

Be sure to observe the connection for connecting the disconnected parts after replacement.

- (14) Remove the mounting screws for the cable unit and remove the unit from the Manipulator.

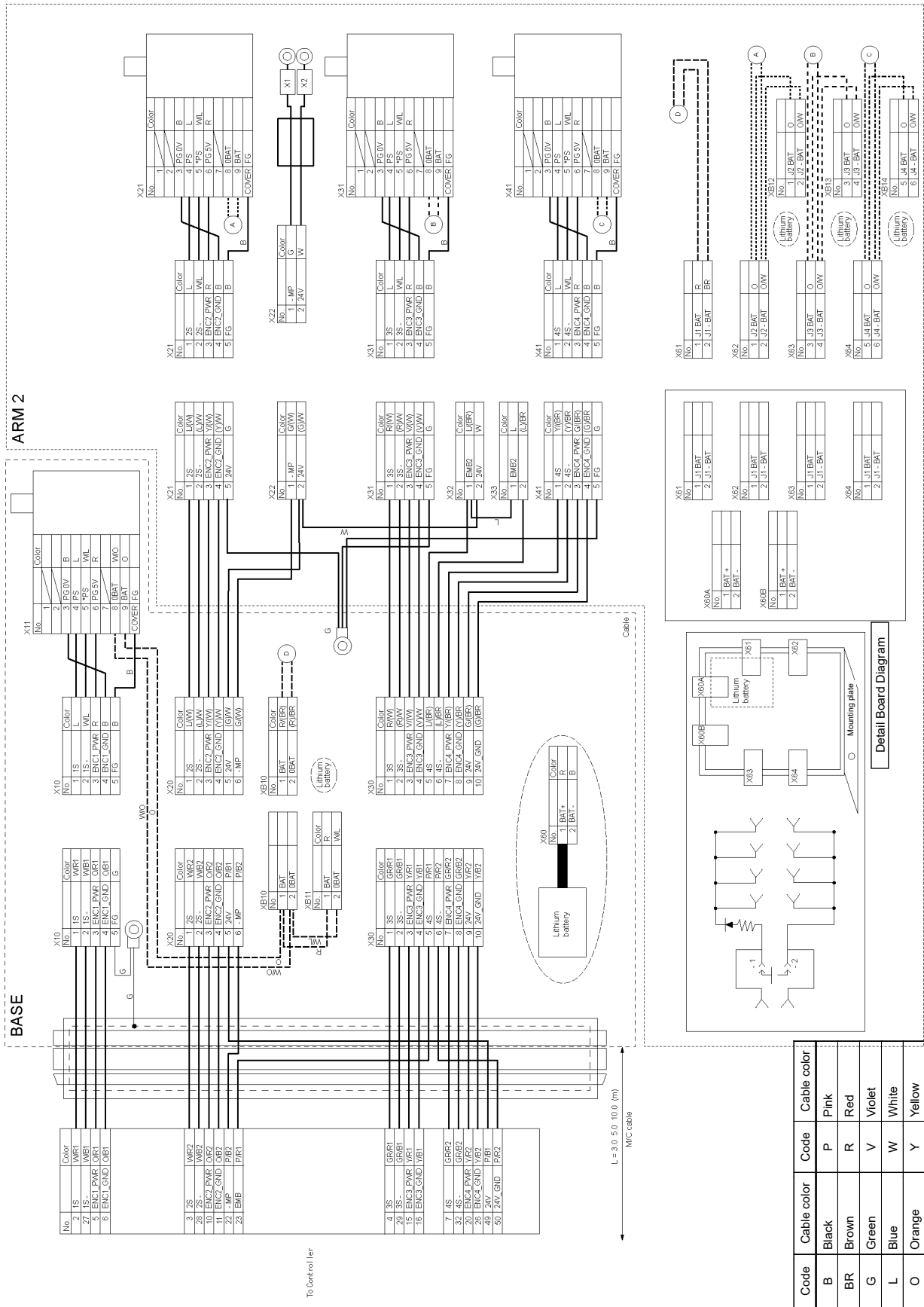


**Cable unit
Installation**

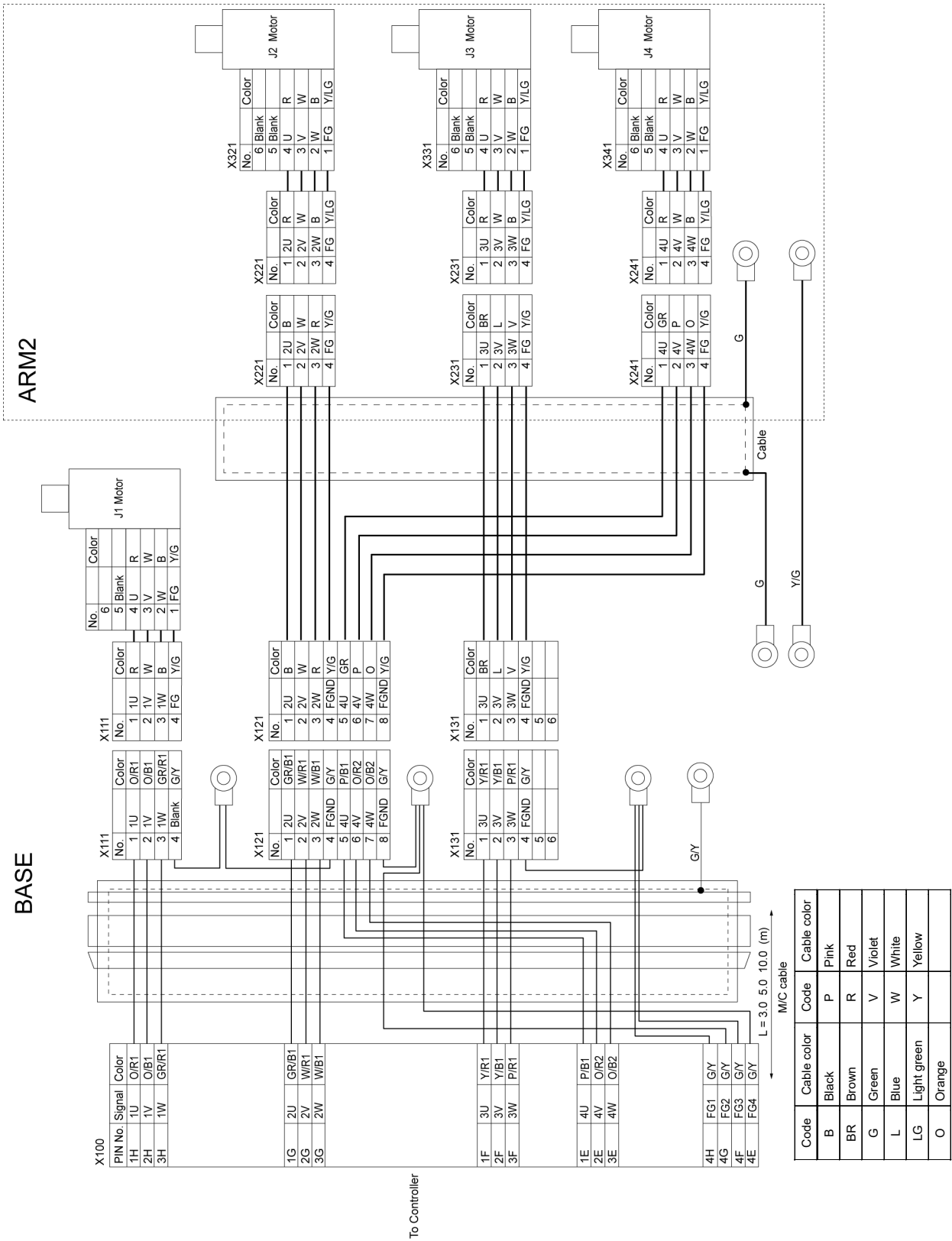
- (1) Mount the cable unit to the Manipulator.
- (2) Connect the following to inner connector plate and connector sub plate.
Air tube // Ground wire // D-sub cable
Joint #1 Signal cable connector and Power cable connector
4 connectors (X20, X30, X121, X131)
- (3) Connect Joint #1 Signal cable connector and XB10.
- (4) Bundle the wire tie removed in *Removal Step (8)*.
- (5) Mount the user plate to the Arm #2.
At this point, mount the ground together.
- (6) Connect the connectors:
Connectors X21, X22, X31, X32, X33, X41, X61, X221, X231, X241
- (7) Mount the battery board to the Arm #2.
- (8) Remove the spare battery from XB11.
- (9) Mount the connector plate to the base.
For the details, refer to *3.4 Connector Plate*.
- (10) Mount the connector sub plate to the base.
For details, refer to *3.5 Connector Sub Plate*.
- (11) Set and secure the Arm #2 cover without the cables being stuck.
For details, refer to *3.1 Arm Top Cover*.
- (12) When the connector falls off from the battery board, execute the calibration of all axes.
For details, refer to *14 Calibration*.

4.2 Wiring Diagrams

4.2.1 Signal Cable



4.2.2 Power Cable



4.2.3 User Cable

D-sub 15pin

No.	Color
1	L/(W)
2	(L)/W
3	Y/(W)
4	(Y)/W
5	G/(W)
6	(G)/W
7	R/(W)
8	(R)/W
9	V/(W)
10	(V)/W
11	L/(BR)
12	(L)/BR
13	Y/(BR)
14	(Y)/BR
15	G/(BR)

D-sub 15pin

No.	Color
1	L/(W)
2	(L)/W
3	Y/(W)
4	(Y)/W
5	G/(W)
6	(G)/W
7	R/(W)
8	(R)/W
9	V/(W)
10	(V)/W
11	L/(BR)
12	(L)/BR
13	Y/(BR)
14	(Y)/BR
15	G/(BR)

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 use cable.

Mounting type	Arm length	Code
S, C (Table Top Mounting)	250 mm	1514457
	300 mm	1514458
	350 mm	1514459
SM, CM (Multiple Mounting)	300 mm	1514460
	350 mm	1514461

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.



If the connector connected to the battery was disconnected during cable replacement, execute calibration.

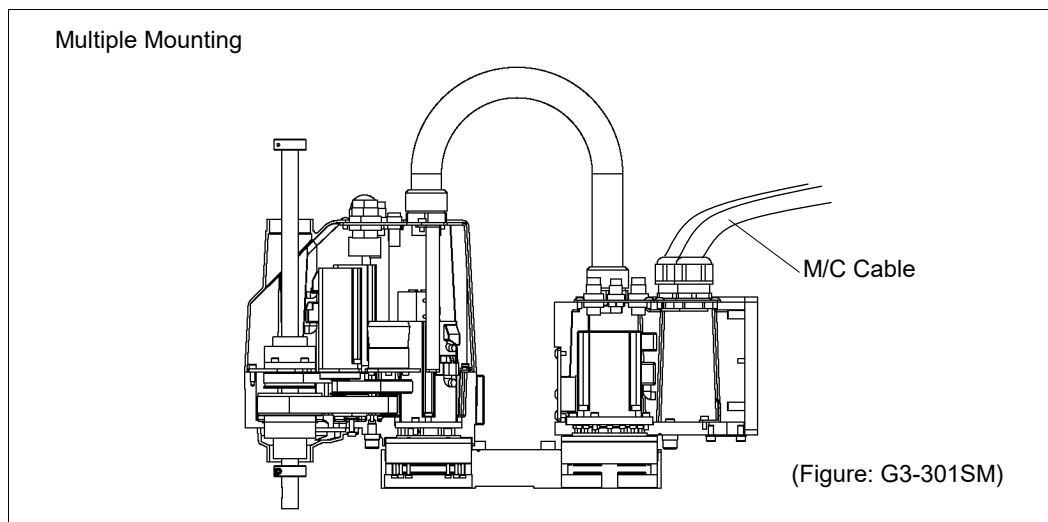
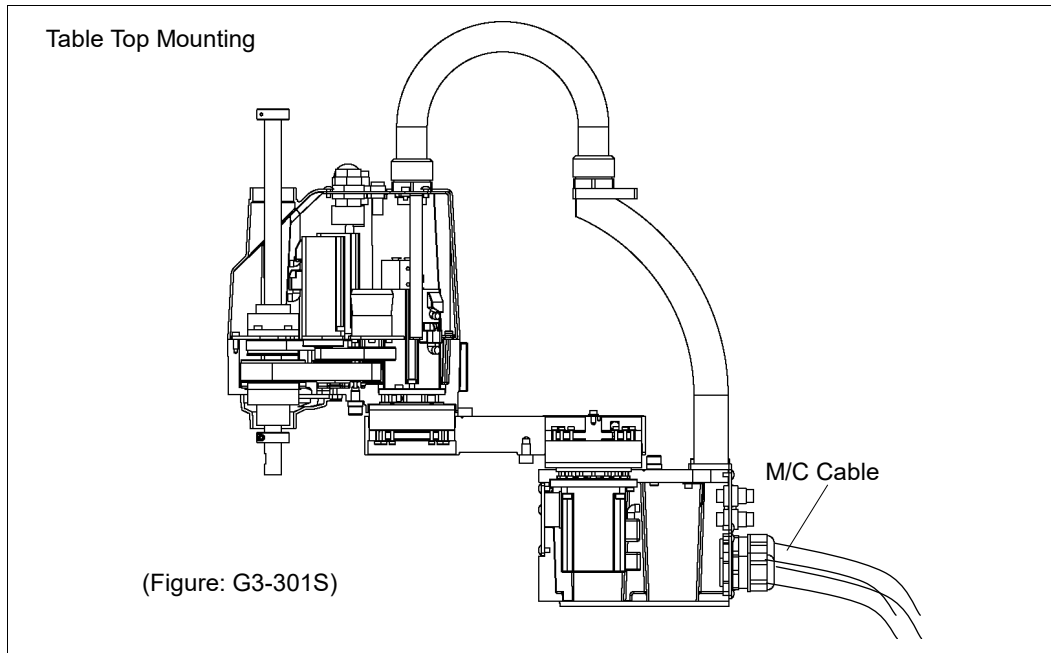
For details, refer to *14. Calibration*.

	Name	Quantity	Note
Maintenance parts	M/C Cable	1	Each manipulator model (Refer to <i>15. G3 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 *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 Sub Plate.
For details, refer to *3.5 Connector Sub Plate*.



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

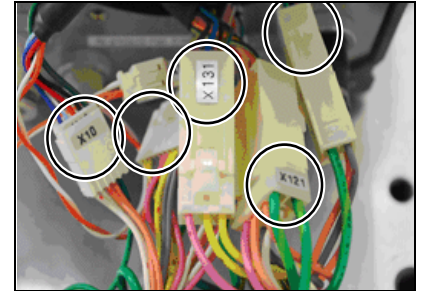
- (4) Disconnect the connectors.
Connector: x10, x20, x30, x111, x121, X131



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



Do not disconnect the battery connector (XB10).
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 Sub Plate.
For details, refer to *3.5 Connector SubPlate*.
- (3) Connect the power cable and signal cable connectors to the controller.
- (4) Turn ON the Controller.
- (5) If the connector (XB10) falls off from the battery, execute the calibration for Joint #1.
For details, refer to *14 Calibration*.

5. Joint #1



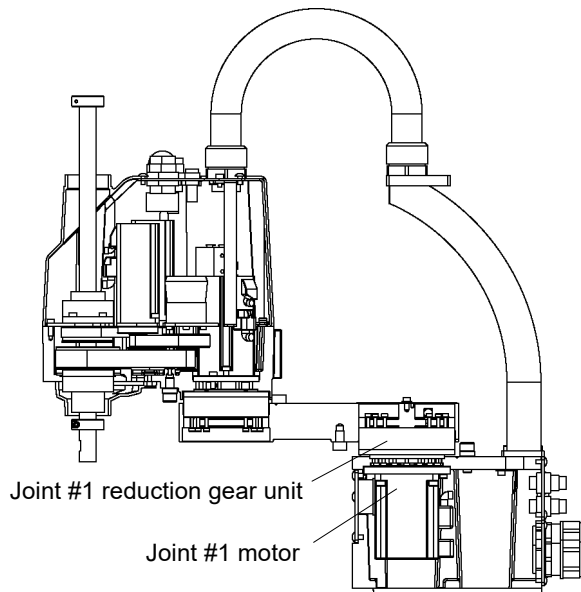
- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric 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”.

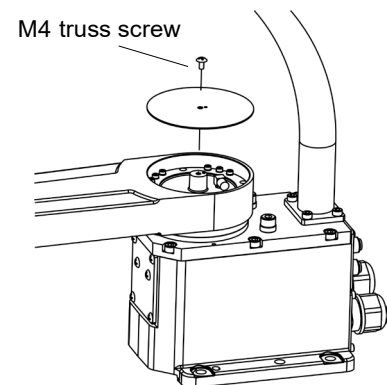
Refer to 14. *Calibration* to perform the calibration.



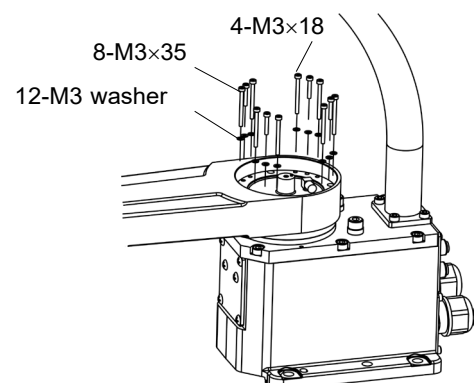
5.1 Replacing Joint #1 Motor

	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (200 W)	1	1514451	
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 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
		width across flats: 5 mm	1	For M6 screw
	Torque wrench	1		
	Wiping cloth	1	For wiping grease	
Grease	Grease (SK-1A)	4 g		

- Joint #1 motor Removal
- (1) Remove the connector plate.
For details, refer to *3.4 Connector Plate*.
 - (2) Remove the connector sub plate.
For details, refer to *3.5 Connector Sub Plate*.
 - (3) Disconnect the following connectors.
Connectors X111, X10 (Hold the clip to remove.)
Connector XB10
 - (4) Remove the heatsink plate.
For details, refer to *3.7 Heatsink Plate*.
 - (5) Remove the heat release sheet from the Motor.
 - (6) Remove the lid mounted to Arm #1.



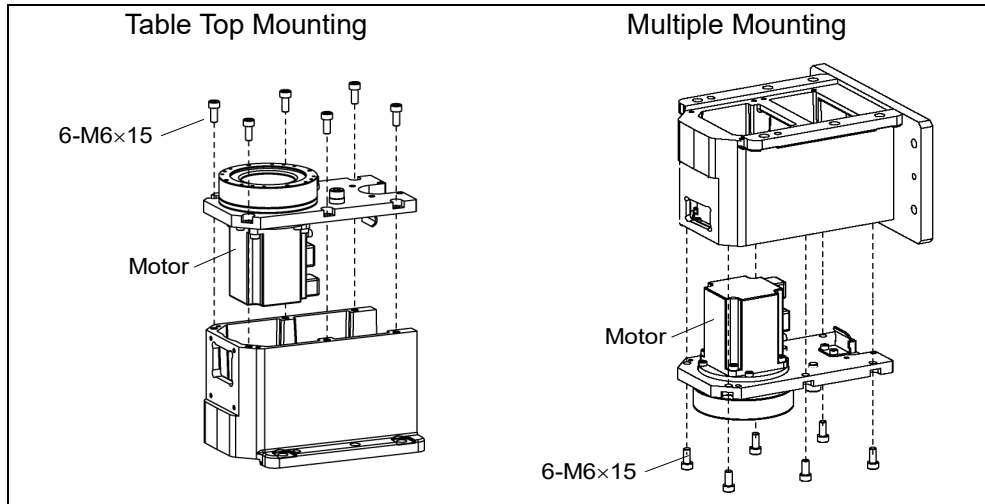
- (7) Remove the screws which secure Arm #1 and Joint #1 reduction gear unit.



- (8) Unscrew and remove the bolts from Joint #1 flange mounting on the base.

Mounting positions of the base and Joint #1 flange are determined by the positioning pin.

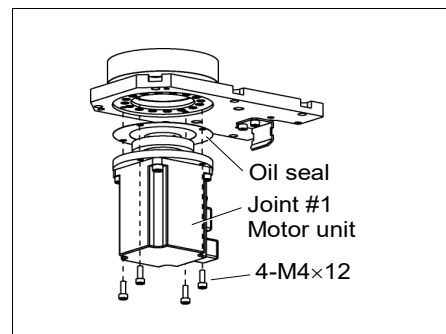
Be sure to keep the positioning pin.



- (9) Unscrew the bolts from Joint #1 Motor flange and remove the motor unit

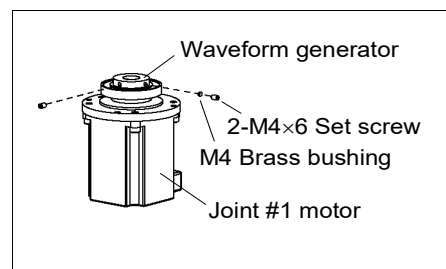
There is an oil seal (soft metal) in the assembly position of the motor flange and Joint #1 flange.

Be sure to keep the oil seal.

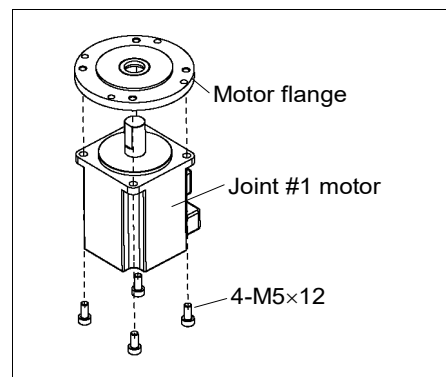


- (10) Remove the waveform generator from the Joint #1 motor.

There is a brass bushing in one of the set screw holes. Be sure to keep the bushing.



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

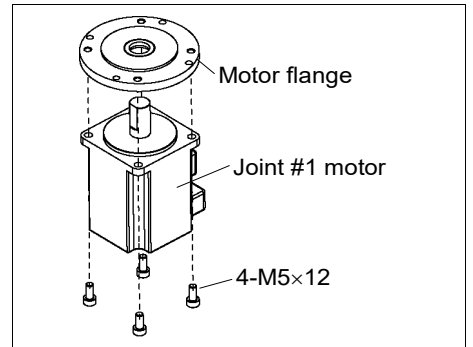




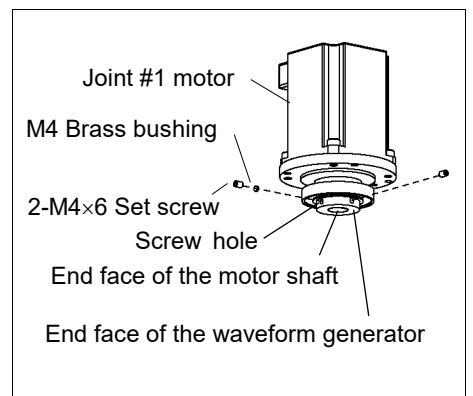
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #1 motor Installation

- (1) Mount the motor flange on the Joint #1 motor.
- (2) Apply grease (SK-1A) to the between the waveform generator and motor flange.
Grease volume 4 g



- (3) Mount the waveform generator on the Joint #1 motor.
Be sure to fit the end face of the waveform generator to the end face of the motor shaft. Tighten one of the 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.

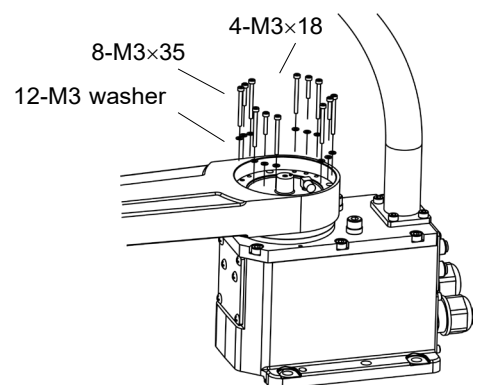


- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

- (4) Mount the motor unit to the Joint #1 flange.
Mount the oil seal (soft metal) hole to the mounting hole.

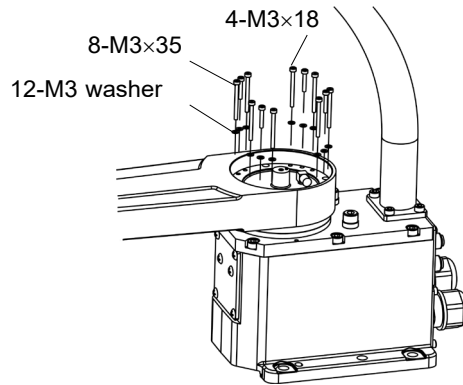
The motor cable must face the connector plate side.
If it is difficult to mount the motor, push it while moving Arm #1 slowly by hand.
- (5) Secure the screws for tightening Arm #1 and Joint #1 reduction gear unit.

Mount the lid of Arm #1.



- (6) Mount the Joint #1 flange to the base.

Mounting positions of the Joint #1 flange and base are determined by the positioning pin.



- (7) Connect the connectors.
Connectors: X110, X10, XB10
- (8) Mount the connector sub plate.
For the details, refer to 3.5 *Connector Sub Plate*.
- (9) Mount the connector plate.
For details, refer to 3.4 *Connector Plate*.
- (10) Mount the heatsink plate.
For details, refer to 3.7 *Heatsink Plate*.
- (11) Perform the calibration of Joint #1.
For details refer to 14. *Calibration*.

5.2 Replacing Joint #1 Reduction Gear Unit

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

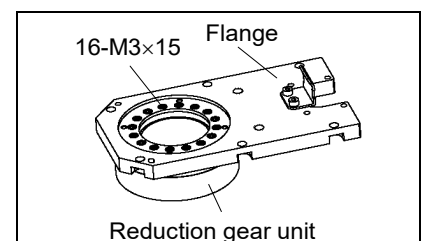
Waveform generator / Flexspline / Circular spline

For details of the reduction gear unit, refer to 15. *G3 Maintenance parts list*.

	Name	Quantity	Note	
Maintenance Parts	Reduction Gear Unit	1	1856653	
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 5 mm	1	For M6 screw
	Torque wrench	M4	1	Tightening torque: 6.0 N·m (61.2 kgf·cm)
		M6	1	Tightening torque: 22.0 N· m (224.3 kgf·cm)
	Nippers	1		
	Spatula	1	For apply grease	
	Wiping cloth	1	For wiping grease (Flange)	
		1	For wiping grease (Bolt)	
Screw (M4)	2	About 20 mm in length For flexspline removal		
Grease	Grease (SK-1A)	16 g		

Joint #1
reduction gear
unit
Removal

- (1) Remove the Joint #1 motor unit.
Refer to the removal steps (1) to (7) in 5.1 *Replacing Joint #1 Motor*.
- (2) Remove the Reduction gear unit from the Joint #1 flange.



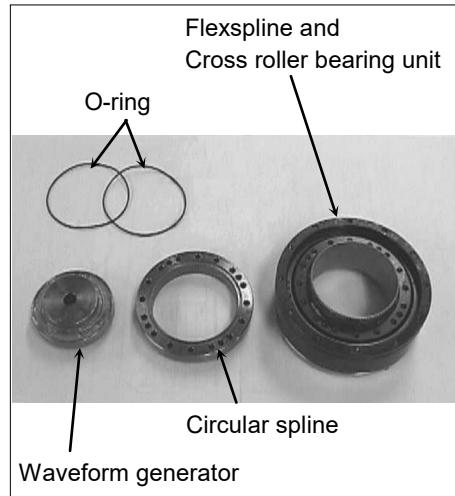


When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #1
 reduction gear
 unit
 Installation

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

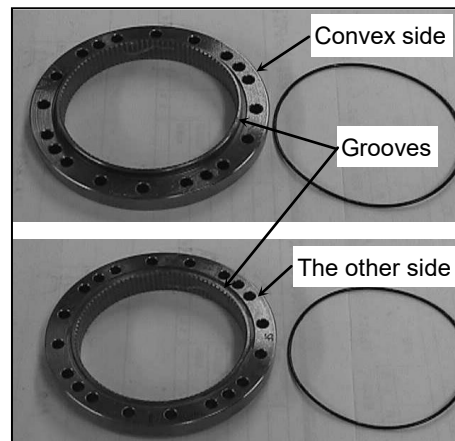
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



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

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

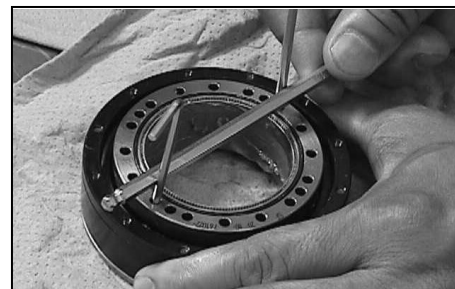
Make sure that the rings do not come out of the grooves.



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

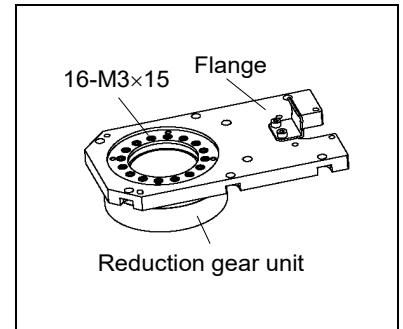


- (4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



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

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



Item	Bolt type	Number of bolts	Tightening torque
Joint #1 reduction gear unit	M3x15	16	3.0 N·m (30.6 kgf·cm)

NOTE




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


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

Grease volume 12 g

- (7) Execute the installation steps (2) to (10) in *5.1 Replacing Joint #1 Motor*.

6. Joint #2

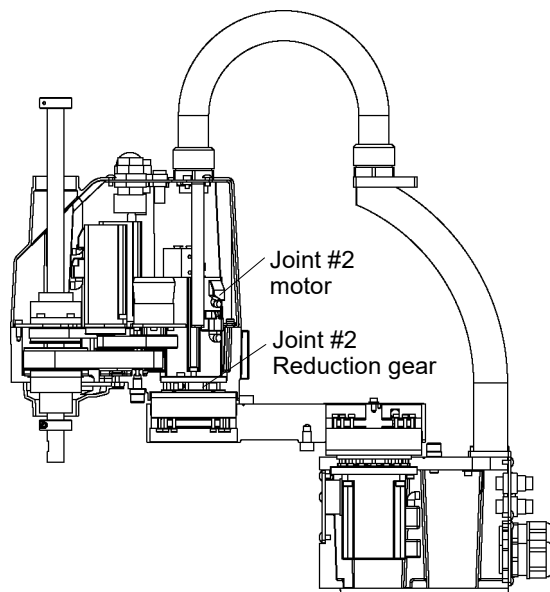
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move 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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 CAUTION	<ul style="list-style-type: none"> ■ 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 14. *Calibration* to perform the calibration.



6.1 Replacing Joint #2 Motor

	Name	Quantity	Note	
Maintenance Parts	AC Servo Motor (150W)	1	1514453	
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Wiping cloth		1	For wiping grease
Material	Wire tie	4		
Grease	Grease (SK-2)	3 g		

Joint #2 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.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for the Joint #3 is released simultaneously.

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

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Remove the battery board.
- (6) Remove the user plate.
- (7) Cut off the wire tie used for binding the cables connected to the user cable.
- (8) Cut off the wire tie used for binding the motor cables to the Joint #2 motor.
- (9) Disconnect the following connectors.

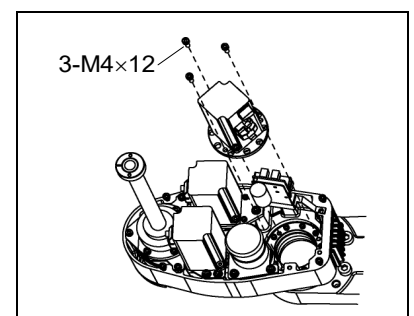
Connectors X221, X21 (Hold the clip to remove.)

Connector X62

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

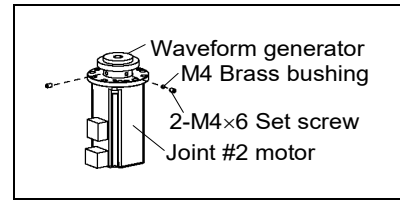
If the motor cannot be removed easily, pull it out while moving Arm #2 slowly by hand.

Also, the motor flange touches the intermediate pulley and you cannot pull the motor straight upward. Therefore, tip the motor and pull it avoiding the intermediate pulley.

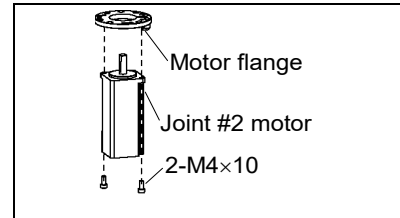


- (11) Remove the waveform generator from the Joint #2 motor.

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



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



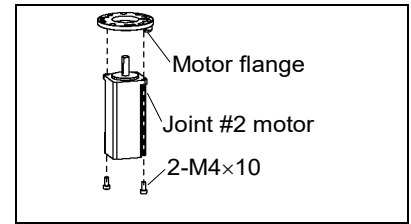
NOTE



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

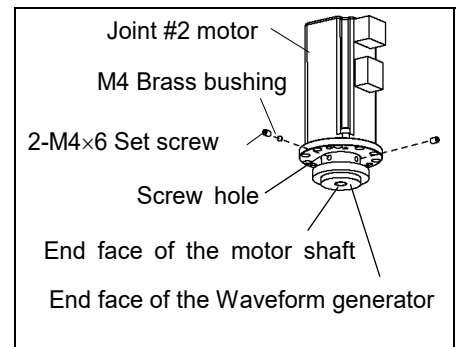
Joint #2 motor Installation

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



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

Be sure to fit the end face of the waveform generator to the end face of the motor shaft. Tighten one of the set screws on the flat face of the motor shaft until the screw touches vertically the surface. Insert a bushing into the other set screw hole without damage to the motor shaft.



Then, tighten both set screws.

- (3) Apply grease (SK-2) to the between the waveform generator and motor flange.

Grease volume 3 g

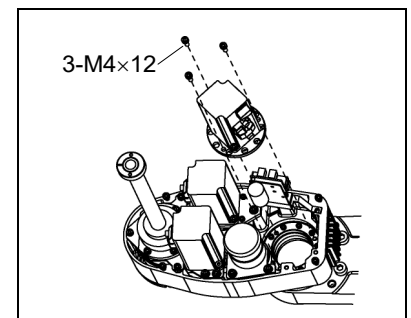


- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

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

The motor flange touches the intermediate pulley and you cannot insert the motor straight on the arm. Therefore, tip the motor and insert it avoiding the intermediate pulley.

Also, if it is difficult to insert the motor, push it while moving Arm #2 slowly by hand.



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

Do not allow unnecessary strain on the cables.

- (6) Mount the user plate to Arm #2.

- (7) Mount the battery board to Arm #2.

- (8) Connect the connectors.

Connectors X221, X21

- (9) Connect the backup cable connector X62 to the battery board.

Band the cables with a wire tie to prevent the back up cable connectors to fall out by mistake.

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

Do not allow unnecessary strain on the cables.

- (11) Mount the arm top cover.

For details, refer to *3.1 Arm Top Cover*.

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

For details refer to *14. Calibration*.

6.2 Replacing Joint #2 Reduction Gear Unit

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

Waveform generator / Flexspline / Circular spline

For details of the reduction gear unit, refer to 15. *G3 Maintenance parts list*.

	Name	Quantity	Note	
Maintenance parts	Reduction Gear Unit	1	1856070	
	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	
	Torque wrench (M3)	1	Tightening torque : 3.0 N·m (30.6 kgf·cm)	
	Spatula	1	For apply grease	
	Wiping cloth		1	For wiping grease (Flange)
		1	For wiping grease (Bolt)	
Screw (M3)	2	For flexspline removal		
Material	Wire tie	4		
Grease	Grease (SK-2)	11 g		

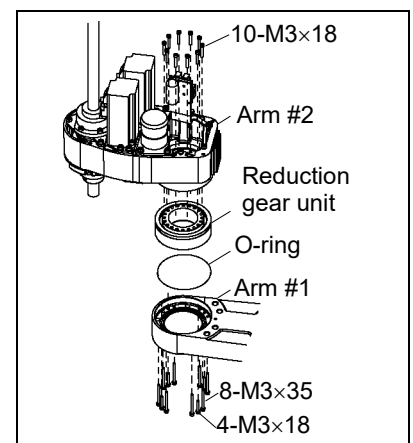
Joint #2 reduction gear unit Removal

- Turn ON the Controller.
- 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.

The brake release switch affects only Joints #3. When the brake release switch is pressed, the brake of the Joints #3 is released simultaneously.

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

- Turn OFF the Controller.
- Execute steps from (1) to (11) in 6.1 *Replacing Joint #2 Motor* and remove the waveform generator from the Joint #2 motor.
- Remove the mounting screws for the Arm #2 and remove the reduction gear unit from the Arm #1.



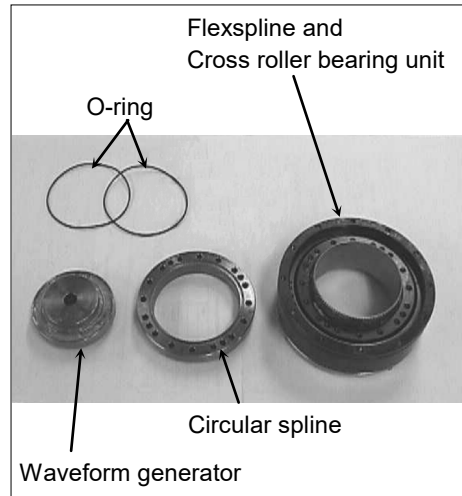


When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

Joint #2
 reduction gear
 unit
 Installation

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

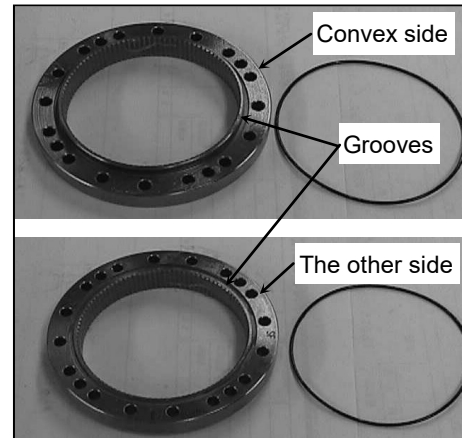
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



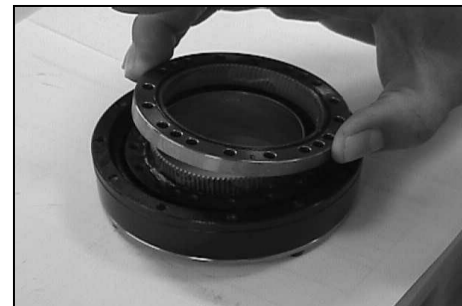
- Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

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



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

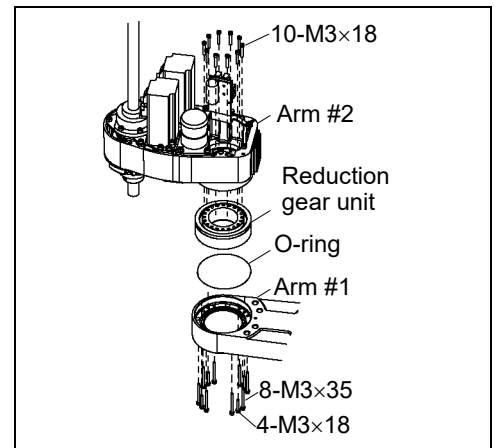


- (4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



- (5) Mount the circular spline to Arm #2.

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.



Item	Bolt type	Number of bolts	Tightening torque
Joint #2 reduction gear unit	M3×18	10	3.0 N·m (30.6 kgf·cm)

NOTE



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

- (6) Apply grease (SK-2) inside the flexspline.

Grease volume 8 g


- (7) Install the O ring to the Arm #1.


- (8) Install and secure the flexspline.

Slide the Arm #2 to the right/left to adjust the holes position.

- (9) Execute installation steps (2) to (12) in *6.1 Replacing Joint #2 Motor*.

7. Joint #3

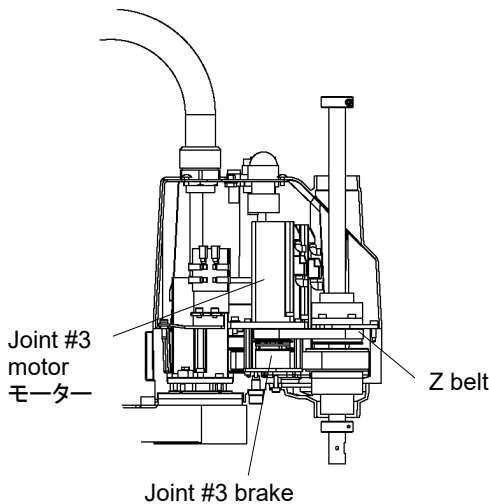
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move 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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 CAUTION	<ul style="list-style-type: none"> ■ 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 14. *Calibration* to perform the calibration.



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 M4 set screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench	1		
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 74 N (7.5 ± 0.5 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	2		

A brake is mounted on the Joints #3 motor to prevent the shaft from lowering 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 (3).

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.

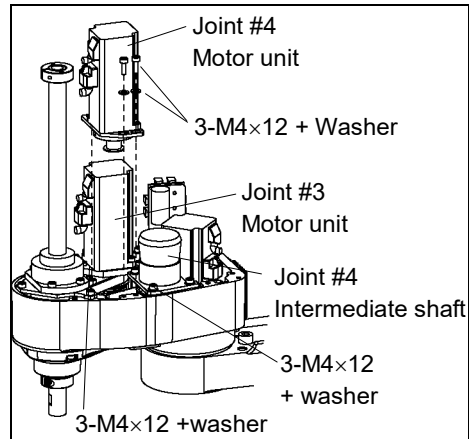
The brake release switch affects only Joints #3. When the brake release switch is pressed, the brake for Joints #3 is released simultaneously.

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

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.
- (5) Remove the battery board.
Be careful not to pull the connector when removing the battery board.
- (6) Cut off the wire tie used for bundling the power cables and signal cables of motor.
- (7) Remove the user plate.
- (8) Cut off the wire tie used for bundling the motor cables with the Joint #3 motor.
- (9) Disconnect the following connectors.
Connectors X231, X241, X31, X32, X41 (Hold the clip to remove.)
Connector X63, X64 (Backup cable connector of Joint #3 and #4)

(10) Loosen bolts of the Joint #4 motor unit.

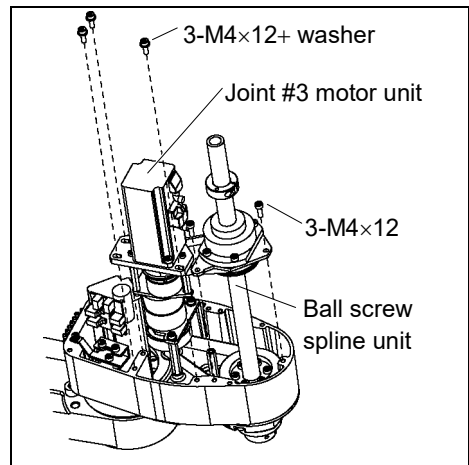
Pull the Joint #4 motor unit upward to remove.



(11) Unscrew the bolts securing the Joint #3 motor unit.

(12) Unscrew the screws securing the ball screw spline unit on the upper part of Arm #2.

(13) Hold up the upper rotator part of ball screw spline unit and the Joint #3 motor unit together.

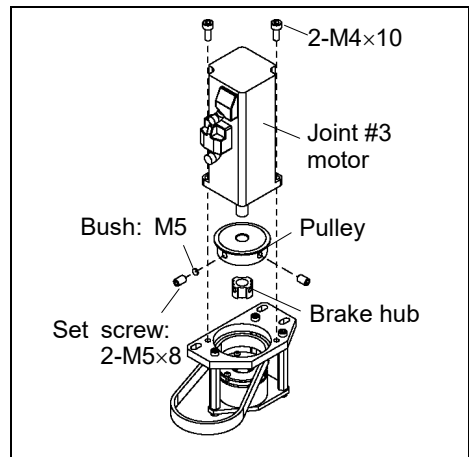


(14) Hold the Joint #3 motor up. Pass the Z belt through the upper rotator part of ball screw spline and remove the belt.

(15) Remove the Joint #3 motor from the Joint #3 motor unit.

(16) Remove the pulley and brake hub from the Joint #3 motor.

There is a brass bushing in one of the set screw holes. Be sure to keep them.



NOTE



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

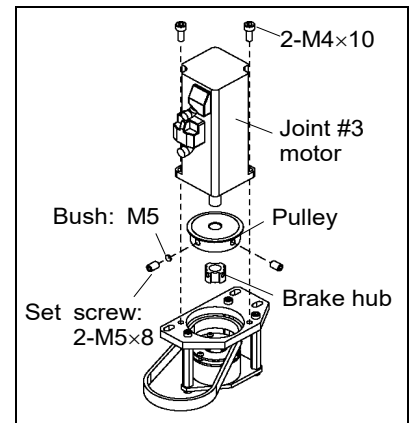
Joint #3 motor Installation

- (1) Mount the pulley and brake hub to the Joint #3 motor.

Insert the brake hub until it touches the end face of motor shaft and secure the hub.

Be sure to fit the end face of the pulley to the brake hub.

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.

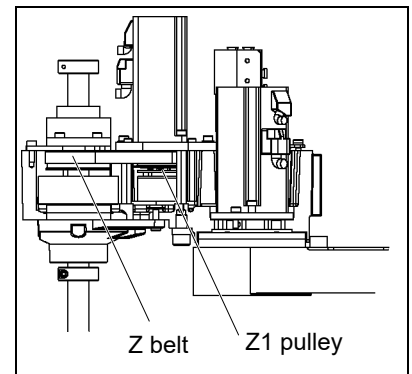
- (2) Mount the Z plate to the Joint #3 motor.
Screw : 4-M4x10
- (3) Pass the Z belt of Joint #3 motor unit through the ball screw spline.
Place the belt around the pulley.

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

- (4) Move the Joint #3 motor unit and spline upper rotator part downwards together and put them on the Arm #2 upper side.

Be sure to keep the belt on the pulley.

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



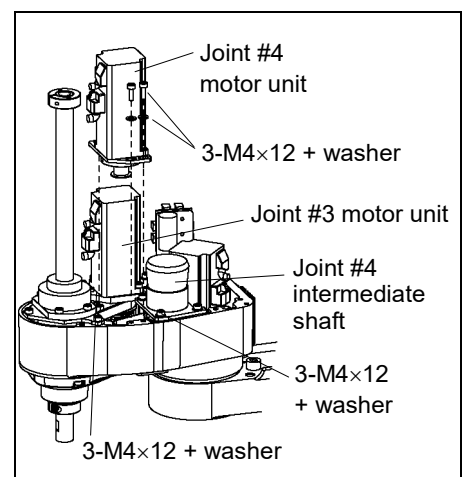
NOTE



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

- (6) Place the U1 belt around the pulley.

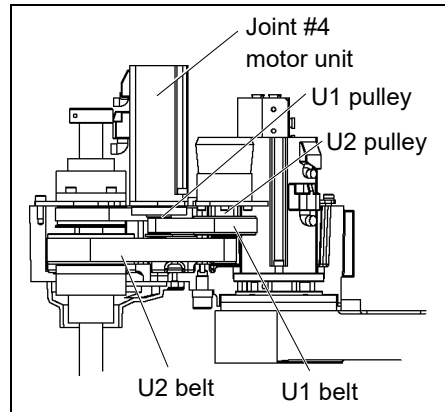
Place the Joint #4 motor unit on the Arm #2 upper side.



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

Check that the motor unit can be moved by hand, and it will not tilt when pulled.

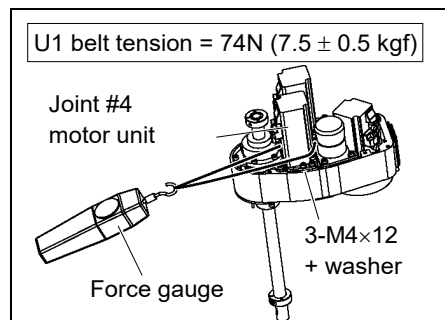
If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (8) Secure the spline upper rotator part on the Arm #2 upper side with screws.
- (9) Rotate and move up/down the ball screw spline shaft.

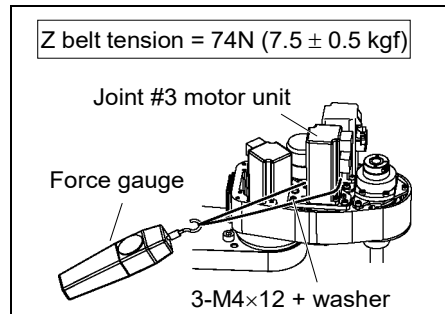
- (10) Apply the proper tension to the U1 belt, and secure the Joint #4 motor unit.

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



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

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



- (12) Connect the connectors.
Connectors: X231, X241, X31, X41
- (13) Re-bundle the cables in their original positions with the wire tie removed in the Removal step (8).
Do not allow unnecessary strain on the cables.
- (14) Connect the backup connectors for Joint #3 and #4 (X63, X64) to the battery board.
Bundle the backup cable with wire tie to prevent the cable connector to fall off by mistake.
- (15) Mount the user plate and ground wire to Arm #2.
- (16) Mount the battery board to the Arm #2.
- (17) Install the arm top cover and the arm bottom cover.
For details, refer to 3. Covers.
- (18) Perform the calibration of Joint #3 and #4.
For details, refer to 14. Calibration.

7.2 Replacing the Timing Belt

	Name		Quantity	Note
Maintenance parts	Z belt	width 9 mm	1	1510625
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Nippers		1	For cutting wire tie
	Force gauge		1	Belt tension 74N (7.5 ± 0.5 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 from (1) to (3).

Z belt Removal

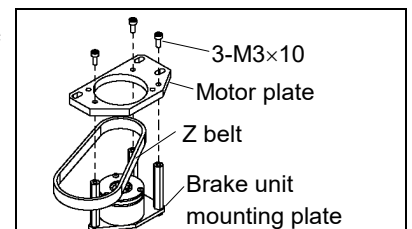
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

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

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.
- (5) Remove motors of the Joint #3 and #4.
For details, refer to steps from (1) to (17) in 7.1 *Replacing Joint #3 Motor*.

- (6) Remove the brake unit mounting plate from the motor blade.
- (7) Remove the Z belt.

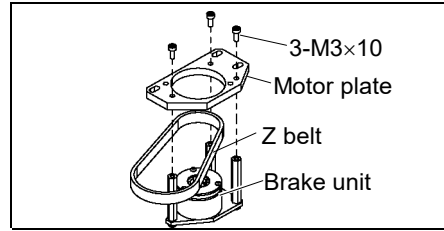


NOTE

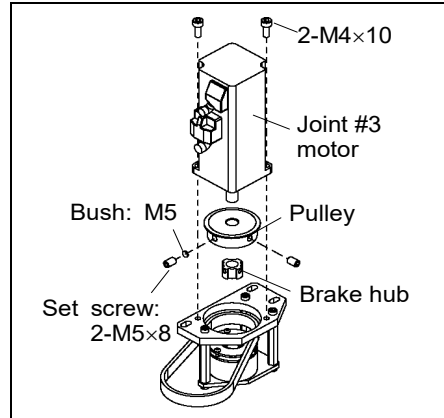

When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

Z belt
 Installation

- (1) Place a new Z belt around the brake unit, and then mount it to the motor plate.

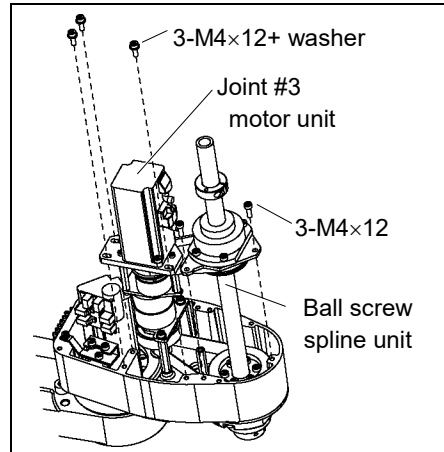


- (2) Mount the Joint #3 motor unit.



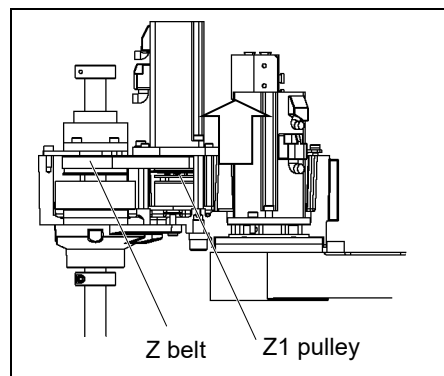
- (3) Place the Z belt of Joint #3 motor unit around the ball screw spline unit and the pulley.

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




- (4) Put the Joint #3 motor unit and the spline upper rotator parts downwards and place them on the Arm #2 upper surface.

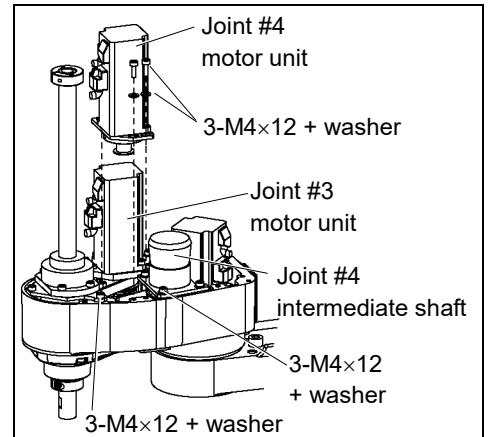
Be sure to keep the belt on the pulley.



- (5) Secure the Joint #3 motor unit to Arm #2 so that the open side faces toward the end of the arm.

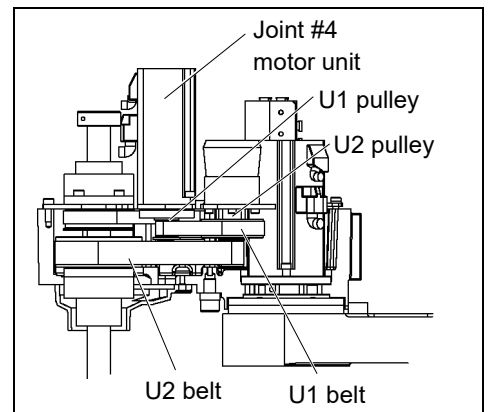
NOTE  Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

- (6) Put the pulley to the U2 belt and place the Joint #4 motor unit on the Arm #2 surface.
Make sure the motor cables face to the end of the arm.



- (7) Loosely secure the Joint #4 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.

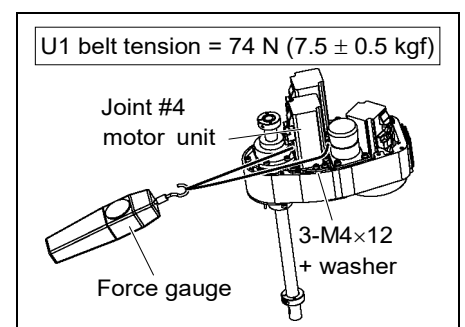


- (8) Loosely secure the spline plate to Arm #2.

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

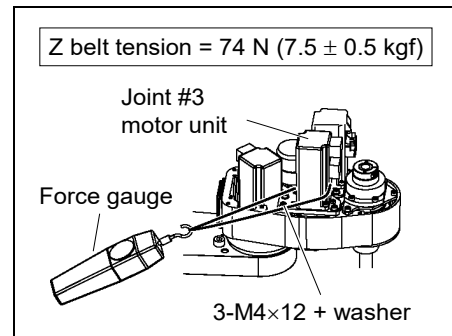
- (9) Apply the proper tension to the U1 belt, and then secure the Joint #4 motor unit.

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



- (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 #3 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



- (11) Connect the connectors.

Connectors: X231, X241, X31, X32, X41

- (12) Connect the backup connectors for Joint #3 and #4 (X63, X64) to the battery board.

Bundle the backup cable with wire tie to prevent the cable connector to fall off by mistake.

- (13) Re-bundle the cables in their original positions with a wire tie removed in step (5).

Do not allow unnecessary strain on the cables.

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

For details, refer to 3. *Covers*.

- (15) Perform the calibration of Joint #3 and #4.

For details, refer to 14. *Calibration*.

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
	Torque wrench	1		
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 74N (7.5 ± 0.5 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	3		

A brake is mounted on the Joint #3 motor 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.

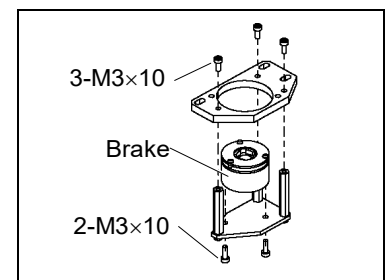
Move the shaft down to its lower limit before the replacement procedure following the removal steps from (1) to (3).

Joint #3 brake 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.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. Covers.
- (5) Remove the Joint #3 motor.
For details, refer to 7.1 Replacing Joint #3 Motor - Joint #3 motor removal step (1) to (17).
- (6) Remove the brake from the brake plate.
- (7) Remove the brake hub from the Joint #3 motor.



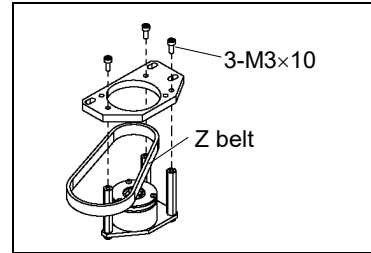
NOTE



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #3 brake Installation

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

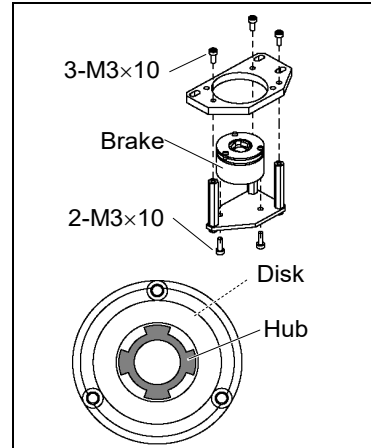


- (2) Mount the brake hub to the Joint #3 motor.

- (3) Mount the motor unit to the Z plate.

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.



- (4) Mount the Joint #3 motor unit to Arm #2 so that the open side faces toward the end of the arm.

For the brake hub mounting procedure, refer to the section *7.1 Replacing Joint #3 Motor - Joint #3 motor installation - Step (3) - (19)*.

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

For details, refer to *3. Covers*.

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

For details, refer to *14. Calibration*.

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.

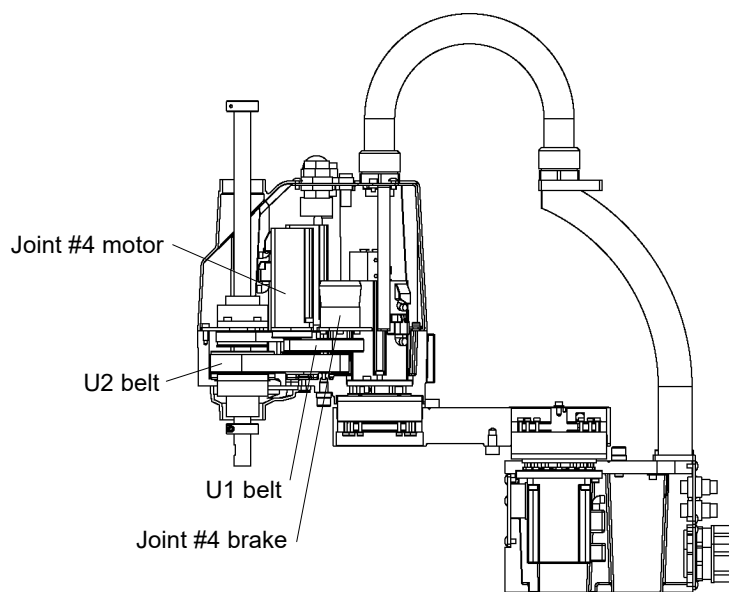


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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 *14. Calibration* to perform the calibration.



8.1 Replacing Joint #4 Motor

	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (150 W)	1	1514453	
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench	1		
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 74 N (7.5 ± 0.5 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	

A brake is mounted on the Joints #3 motor to prevent the shaft from lowering 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 (3).

**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.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

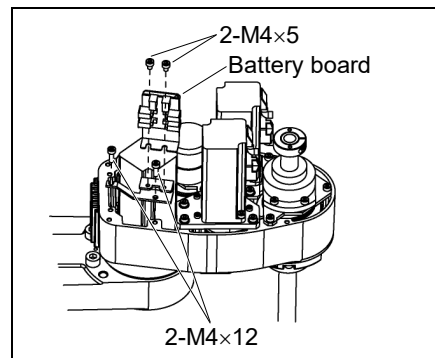
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. Covers.

- (5) Remove the battery board from Arm #2.

Be careful of the connector not to fall off when removing the battery board.

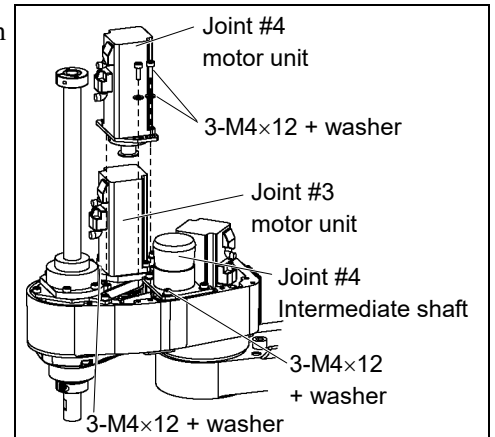
If the connector falls off, the joints other than Joint #4 need the calibration.



- (6) Remove the user plate and ground wire secured on Arm #2.
- (7) Cut off a wire tie used for bundling the motor cables and signal cables.
- (8) Disconnect the following connectors.
Connectors X241, X41 (Hold the clip to remove.)
Connector X64 (for backup cable connector of Joint #4)

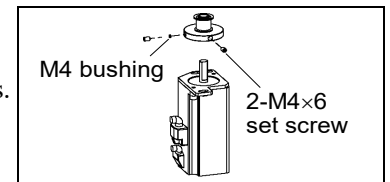
- (9) Remove the Joint #4 motor unit from Arm #2.

Unscrew the bolts securing the Joint #4 motor unit to the Motor plate. Pull the motor unit upward to remove.



- (10) Remove the pulley from the Joint #4 motor.

There is a brass bushing in one of the set screw holes. Be sure to keep them.



- (11) Remove the motor plate from the Joint #4 motor.

Screw: 2-M4x8

NOTE



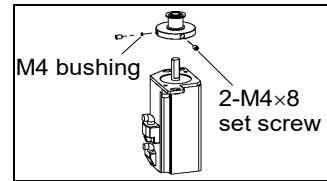
When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

Joint #4 motor Installation

- (1) Mount the motor plate to the Joint #4 motor.
Screw: 2-M4×8

- (2) Secure the pulley to the new Joint #4 motor.

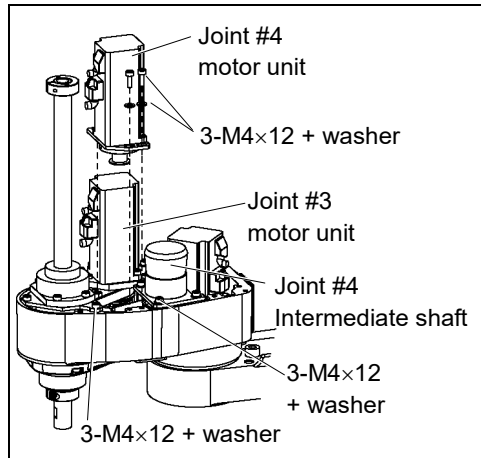
Be sure to fit the end face of the pulley to the end face of the motor shaft.



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 pulley around the U2 belt and place the Joint #4 motor unit in the arm so that the motor cable faces toward the Arm #2 head.



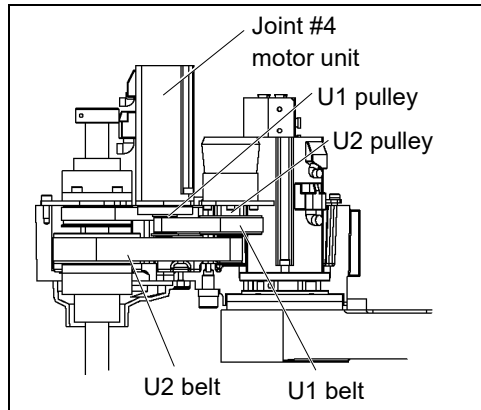
- (4) Loosely secure the Joint #4 motor unit to Arm #2.

NOTE



Make sure 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.

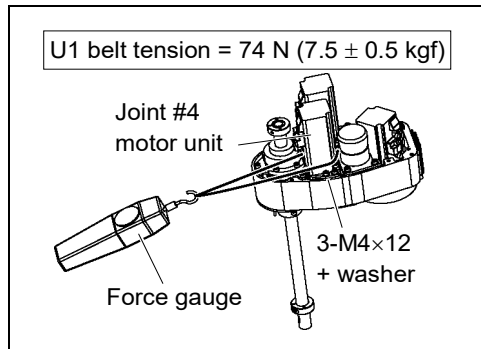
Also, check the gear grooves of the belt are fit into those of the pulleys completely.



- (5) Apply the proper tension to the U1 belt and secure the Joint #4 motor unit.

Pass a suitable cord or string around the Joint #4 motor unit near its mounting plate.

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



- (6) Connect the connectors.

Connectors: X241, X41, X42

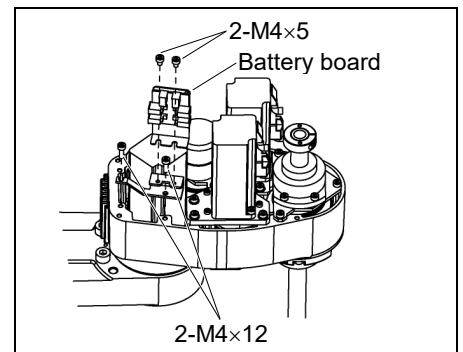
- (7) Connect the backup cable of Joint #4: X64.

Bundle the cables with the wire tie to prevent the backup connector from falling off by mistake.

- (8) Mount the battery board to Arm #2.



The screws on the rear side secure both the battery board and the user plate. Set these screws when mounting the user plate.



- (9) Mount the user plate and ground wire to Arm #2.

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

Do not allow unnecessary strain on the cables.

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

For details, refer to 3. *Covers*.

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

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

8.2 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance parts	U1 belt (width 10 mm)	1	1510626
	U2 belt (width 16 mm)	1	1510627
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Spanner (width across flats: 7 mm)	1	
	Torque wrench	1	
	Force gauge	1	Belt tension 98N (10 kgf) / 74N (7.5kgf)
	Nippers	1	For cutting wire tie
	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 lowering 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 from (1) to (3).

U2 belt Removal

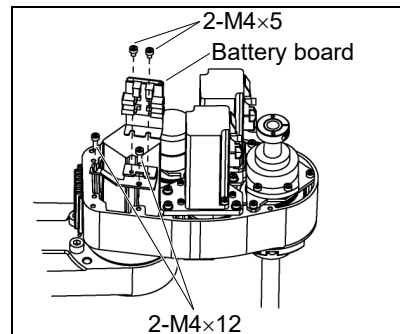
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

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

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.

- (5) Remove the battery board and mounting metal jig.
- (6) Remove the user plate and ground wire secured on Arm #2.
- (7) Cut off a wire tie bundling the motor cables and signal cables.

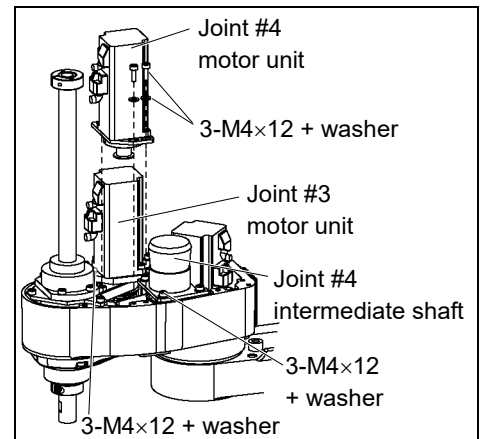


- (8) Disconnect the following connectors.
Connectors X231, X241, X31, X32, X41 (Hold the clip to remove.)
Connector X63, X64 (for backup cable connector of Joint #3 and 4)

(9) Loosen the bolts securing the Joint #4 motor unit and pull the motor unit upwards.

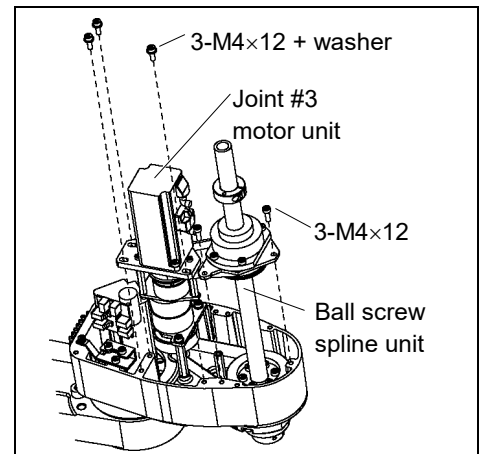
(10) Remove the screws securing the ball screw spline on the surface of Arm #2.

(11) Remove the screws on the Joint #3 motor unit.



(12) Hold the upper rotator part of ball screw spline and Joint #3 motor up together.

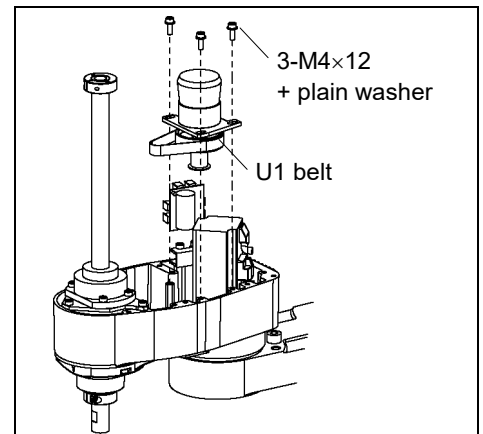
(13) Pass the belt through the upper rotator part of spline and hold the Joint #3 motor up and remove the belt.



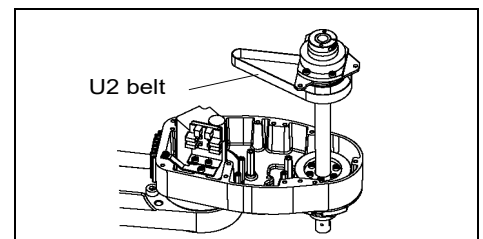
(14) Remove the screws securing the Joint #4 intermediate shaft unit.

Pull the Joint #4 intermediate shaft unit upwards.

(15) Remove the U1 belt.



(16) Keep the spline upper rotator part up and remove the U2 belt.





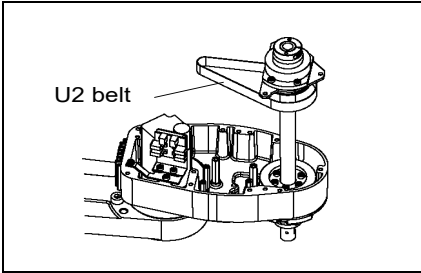
When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

U2 belt Installation

- (1) Hold the spline upper rotator part and set the U2 belt around the U3 pulley.



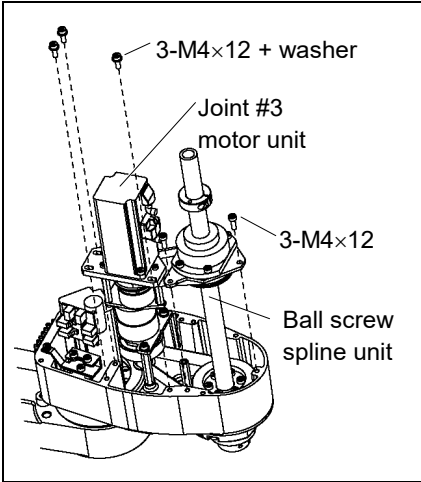
Make sure the gear grooves of the belt are fit into those of the pulleys completely.



- (2) Pass the Z belt through the ball screw spline of Joint #3 motor unit and set the belt around the pulley.

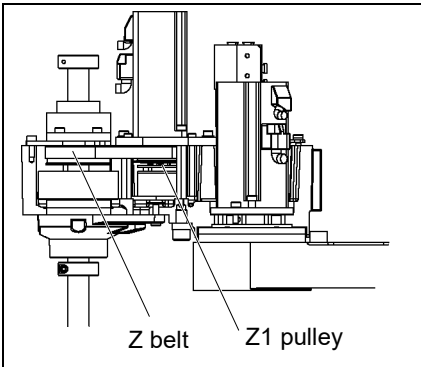


Make sure the gear grooves of the belt are fit into those of the pulleys completely.



- (3) Place the Joint # motor unit and spline rotator part on the Arm #2 top surface.

Make sure the belt stays on the pulley.



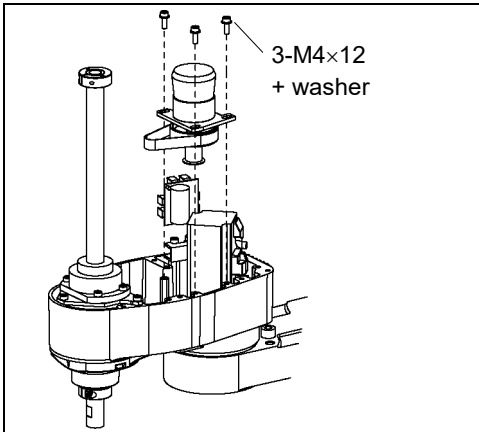
- (4) Loosely secure the Joint #3 motor unit to Arm #2.

Make sure 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.

- (5) Place the U1 belt in Arm #2 around the small pulley and put it on the Arm #2 top surface.

At this point, keep the U2 belt on the large pulley of Joint #4 intermediate unit.

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



- (6) Loosely secure the Joint #4 intermediate unit with screws.

Make sure 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.

- (7) Place the Joint#4 motor unit around the U1 belt. Put the Joint #4 motor unit on the Arm #2 top surface.

Put the Joint #4 motor cable toward the end of Arm #2.

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

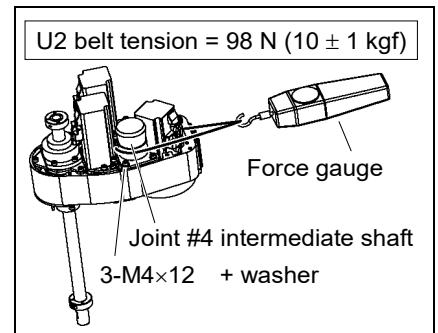
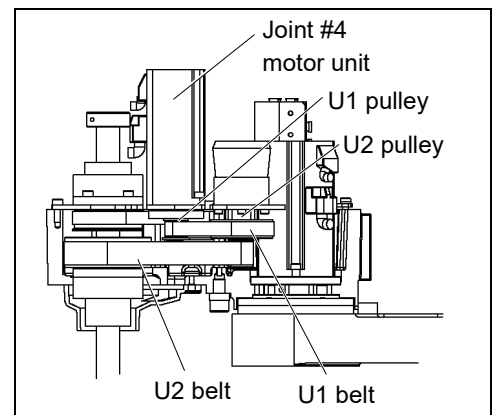
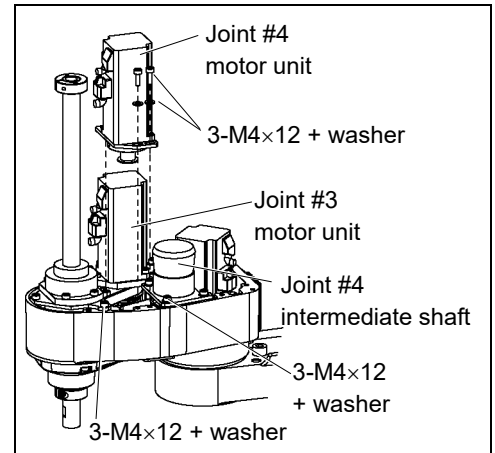
Make sure the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

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

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

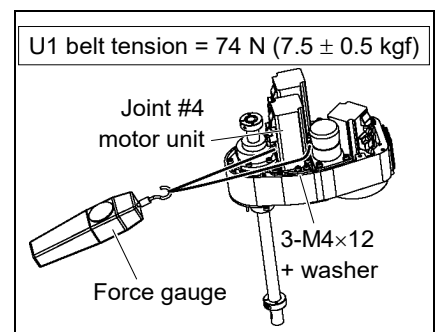
To do so, pass a suitable cord or string around the Joint #4 intermediate shaft unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



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

Pass a suitable cord or string around the Joint #4 motor unit near its mounting plate.

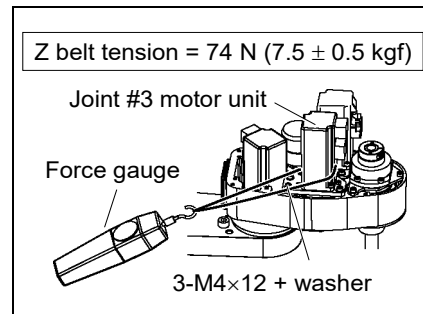
Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



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

Pass a suitable cord or string around the Joint #3 motor unit near its mounting plate.

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



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

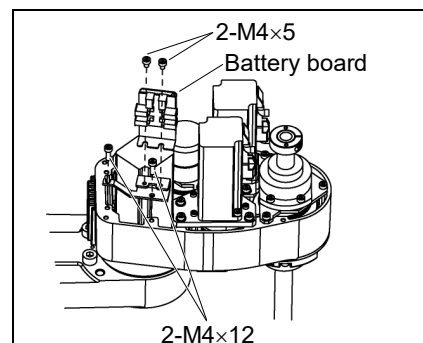
- (14) Connect the following connectors.

Connector X231, X241, X31, X32, and X41

- (15) Connect the backup connectors of Joint #3 and #4 (X63, X64) to the battery board.

Bundle the cables with wire tie to prevent the backup cable connectors from falling off by mistake.

- (16) Mount the battery board to Arm #2.



- (17) Mount the user plate and ground wire to Arm #2.

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

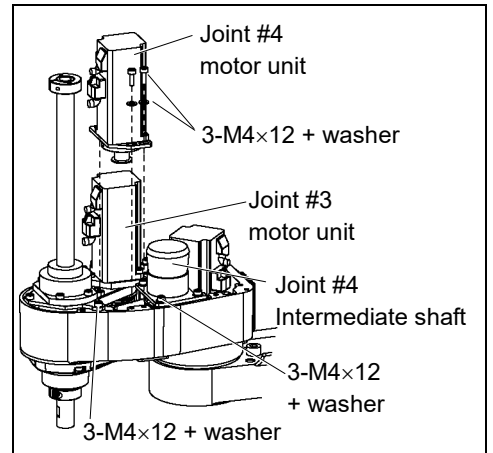
For details, refer to 3. *Covers*.

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

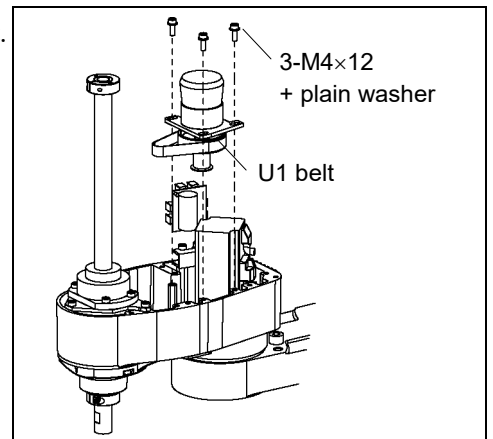
For details on the calibration method, refer to 14. *Calibration*.

U1 belt
Removal

- (1) Remove the Joint #4 motor with referring to the procedure of *Joint #4 motor Removal (1) to (9)*.



- (2) Remove the Joint #4 intermediate shaft unit.
- (3) Remove the U1 belt.



NOTE


When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

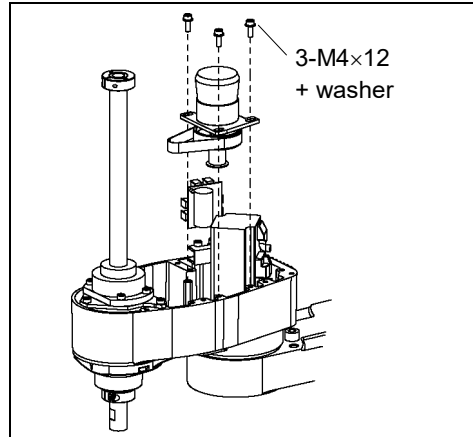
U1 belt
 Installation

- (1) Place the U2 belt in Arm #2 around the small pulley and put it on the Arm #2.

At this point, keep the U1 belt on the large pulley of Joint #4 intermediate unit.

NOTE


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

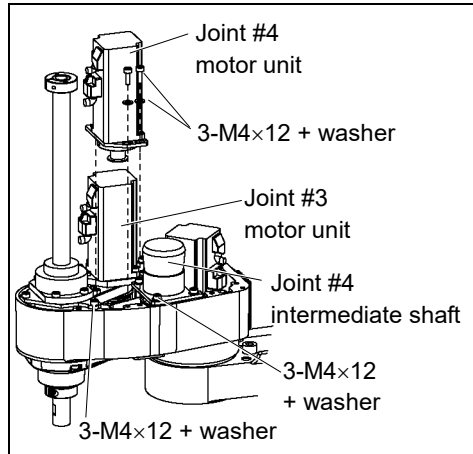


- (2) Loosely secure the Joint #4 intermediate unit.

Make sure 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.

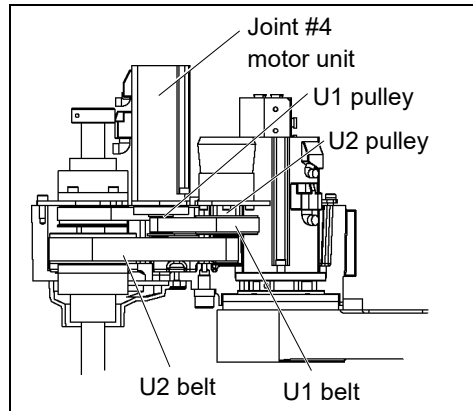
- (3) Place the pulley in the U1 belt and put the Joint #4 motor unit to Arm #2.

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



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

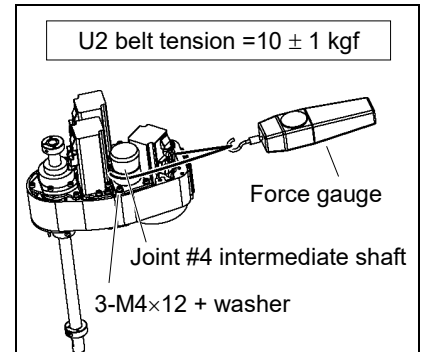
Make sure the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



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

Pass a suitable cord or string around the Joint #4 intermediate unit near its mounting plate.

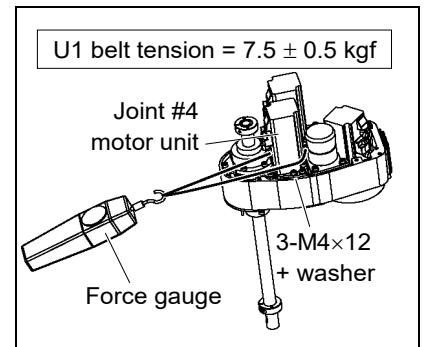
Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



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

Pass a suitable cord or string around the Joint #4 motor unit near its mounting plate.

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



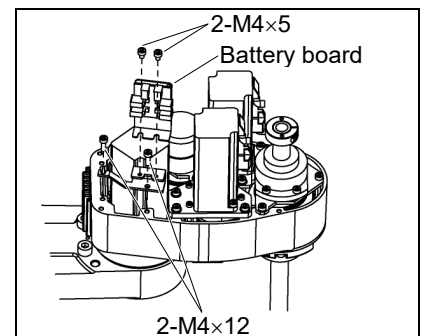
- (7) Connect the connector.

Connector: X241, X41

- (8) Re-bundle the cables in their original positions with a wire tie removed in step (9).
- (9) Connect the backup connectors of Joint #4, X64 to the battery board.


Bundle the cables with wire tie to prevent the backup cable connectors from falling off by mistake.


- (10) Mount the battery board to Arm #2.



- (11) Mount the user plate and ground wire to Arm #2.
- (12) Install the arm top cover and arm bottom cover.
For details, refer to 3. Covers.
- (13) Perform the calibration of Joint #4.
For details, refer to 14. Calibration.

9. Replacing Arm #1

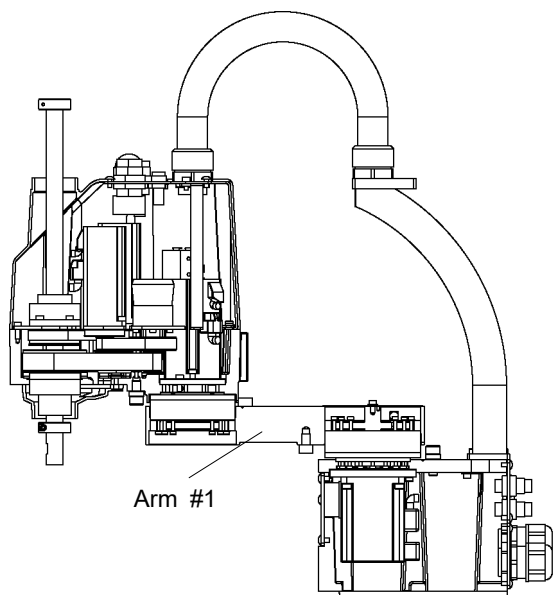
 WARNING	<ul style="list-style-type: none">■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move 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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 CAUTION	<ul style="list-style-type: none">■ 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 14. *Calibration* to perform the calibration.



		Name	Quantity	Notes		
Maintenance parts	Table Top Mounting	Standard arm	250 mm	1	Arm #1_25ST	R12B031914
			300 mm	1	Arm #1_30ST	R12B031915
			350 mm	1	Arm #1_35ST	R12B031916
		Curved arm	300 mm	1	Arm #1_30B	R12B031917
			350 mm	1	Arm #1_35B	R12B031918
	Multiple Mounting	Standard arm	300 mm	1	Arm #1_M_30ST	R12B031919
			350 mm	1	Arm #1_M_35ST	R12B031920
		Curved arm	350 mm	1	Arm #1_M_35B	R12B031921
Tools		Hexagonal wrench (width across flats: 2.5 mm)		1	For screw M3	
		Torque wrench		1		
		Flathead screwdriver		1		

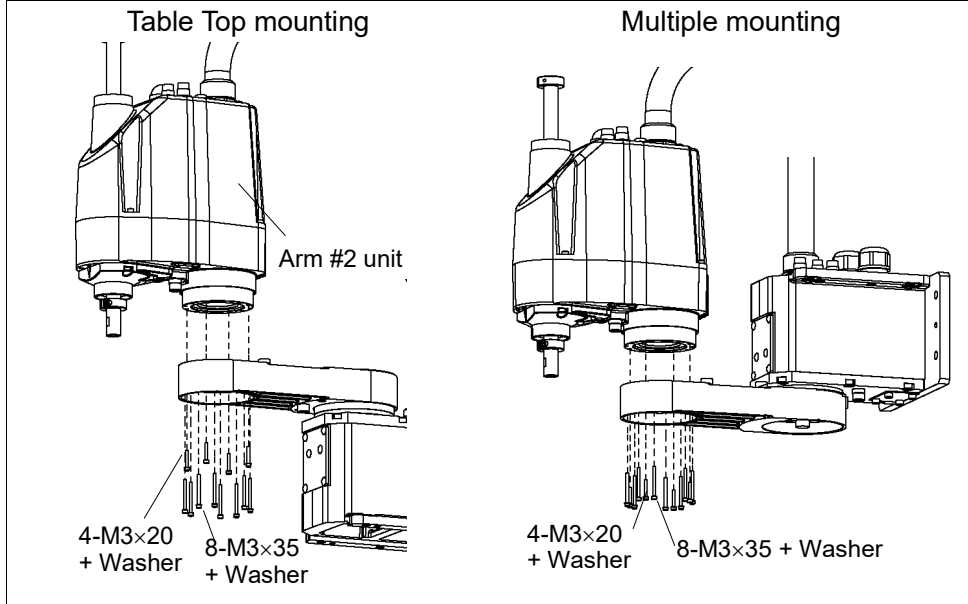
When changes the arm length, it requires the other cable unit for the new arm length.

Right / Left-curved arm have the shared maintenance parts.

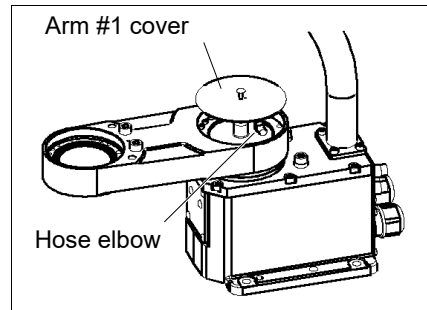
 CAUTION	<ul style="list-style-type: none"> ■ Replacing Arm #1 should be done by two persons. There are dangers of main parts to fall or get damage.
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Arm #1
Removal

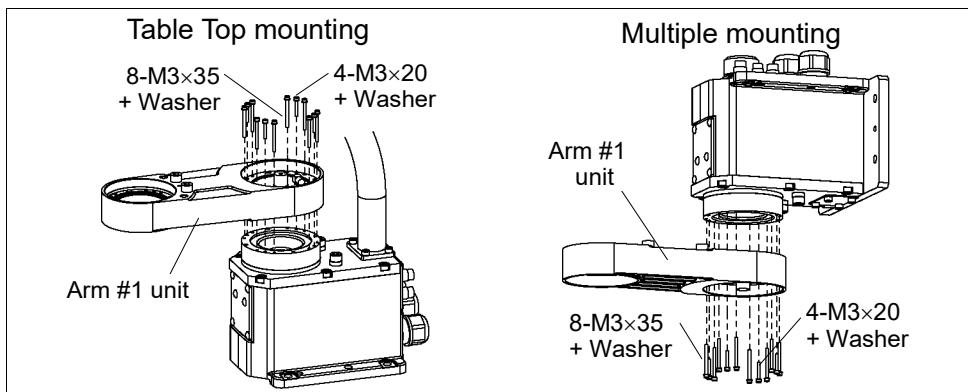
- (1) Remove the arm cap.
For details, refer to 3.3 Arm Cap.
- (2) Remove the harmonic mounting screws on the Joint #2 side and remove the Arm #2 unit.
This procedure should be done with an assistant. The assistant supports the Arm #2 unit.
Do not allow unnecessary strain on the cables.
For Multiple mounting, removal direction of Joint “1 and #2 is the same. In this procedure, remove the only screws on the left side of figure.



- (3) Remove the O ring on the part where Arm #2 was mounted.
- (4) Remove the Arm #1 covet and hose elbow.
These parts are not attached for the Multiple mounting Manipulators.



- (5) Remove the harmonic mounting screws on the Joint #1 side and remove the Arm #1 unit.
In case of Multiple mounting type, Arm #1 falls without mounting screws. Support Arm #1 when removing the screws. Remove the O ring which is attached to the Joint #1 mounting part.



NOTE



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Arm #1
Installation

- (1) Prepare the spare Arm #1 and mount the mechanical stop.

Base side	Table Top	M8×10	1 unit	(Bottom surface, Center, 1 point)
	Multiple	M8×10	2 units	(Top surface, Center, 2 points)
Arm #2 side		M8×10	2 units	(Top surface, Center, 2 points)

- (2) Insert the base side of Arm #1 to the harmonic drive of the base.

In case of Multiple mounting type,

Insert the O ring into the chase in the Joint #1 mounting surface of Arm #1 before mounting the arm.

Apply a small amount of grease for the reduction gear to the O ring.

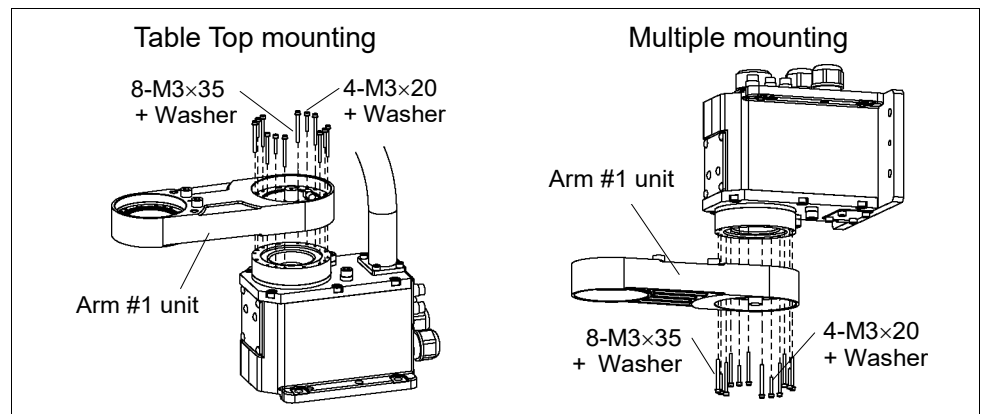
Fit with the space for the screws head of harmonic drive on Arm #1 side.

- (3) Put washer on screws and mount the Arm #1 unit with specified torque.

M3 tightening torque: 3.0 N·m (30.6 kgf·cm)

Use 35 mm screws to all side and the middle one in each side is 20 mm.

Do not use the screws of different length. Otherwise, it causes a malfunction.



- (4) There is an O ring groove in the Arm #2 mounting part on Arm #1 side. Insert an O ring in the groove.

Apply a small amount of grease on the O ring.

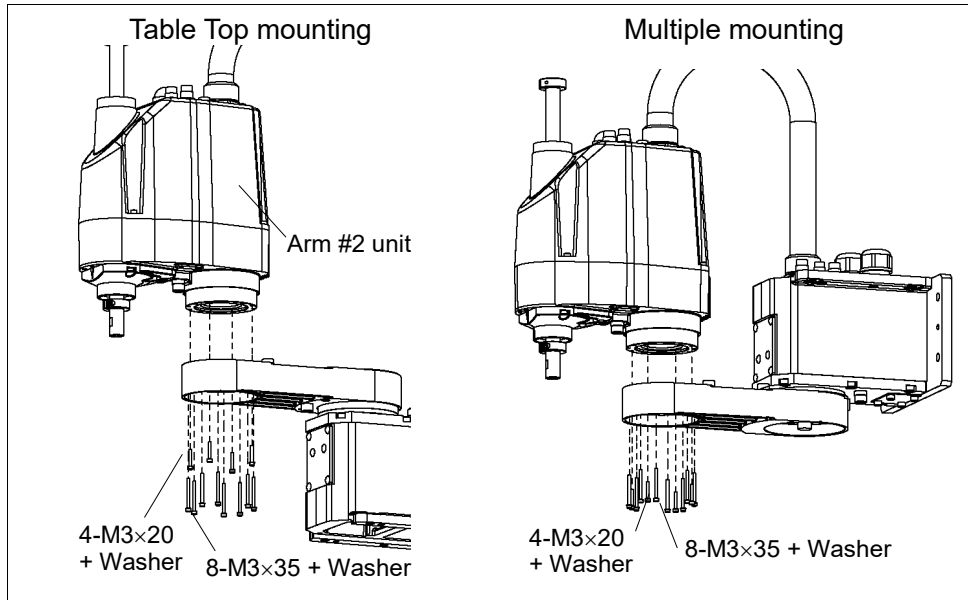
- (5) Insert the Arm #2 side on Arm #1 to the harmonic drive of Arm #2.

Fit with the space for the screws head of harmonic drive on Arm #2 side.

- (6) Put washer on screws and mount the Arm #1 unit with specified torque.
 M3 tightening torque: 3.0 N·m (30.6 kgf·cm)

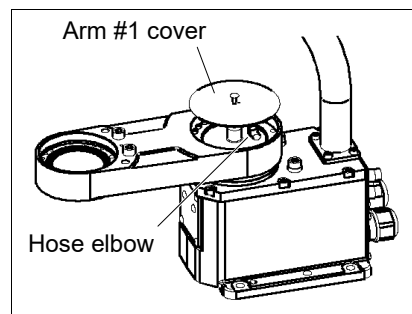
Use 35 mm screws to all side and the middle one in each side is 20 mm.

Do not use screws of different length. It causes a malfunction.



- (7) Mount the hose elbow and Arm #1 cover.

These parts are not attached to the Multiple mounting Manipulators.



- (8) Put the $\theta 2$ movement direction label to the end of Arm #1, in Arm #2 side.



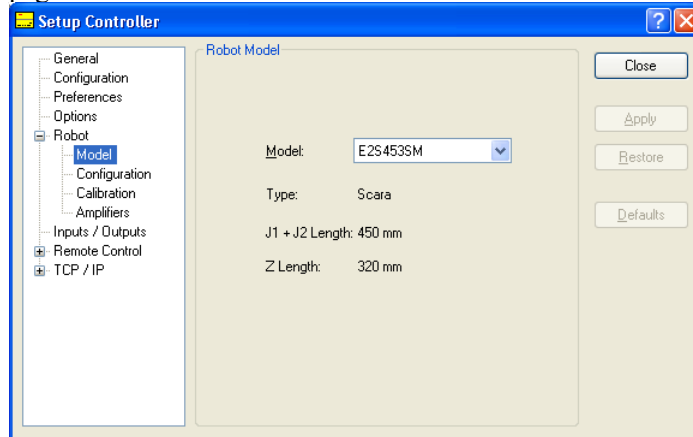
CAUTION

- After replacing the arm, do not fail to change the robot model in the software. If the model is different, it may cause a robot to malfunction. Also, the robot may collide with the mechanical stop and break it.

(9) Change the robot model.

(9)-1 From the Setup Menu, select Controller.

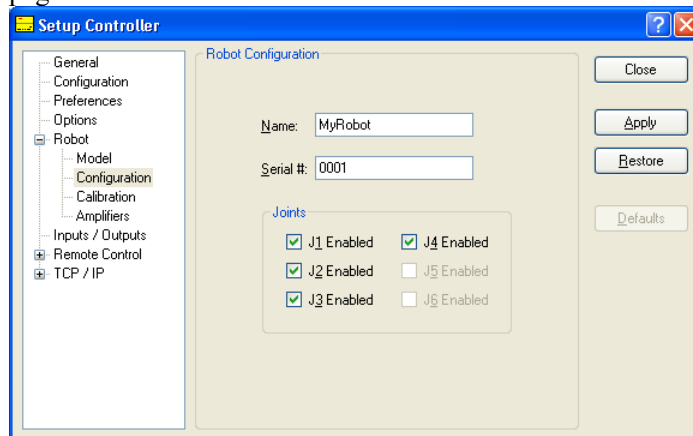
(9)-2 Click on the Robot folder in the tree on the left side to open the Robot Model page.



(9)-3 Select the model for your robot from the Model dropdown list. Only robot models that can be used with the amplifiers currently in the controller are listed. When using Dry Run, all robot models are shown in the list.

(9)-4 Click the **Apply** button to save settings.

(9)-5 Click on Robot Configuration in the tree to open the Robot Configuration page.

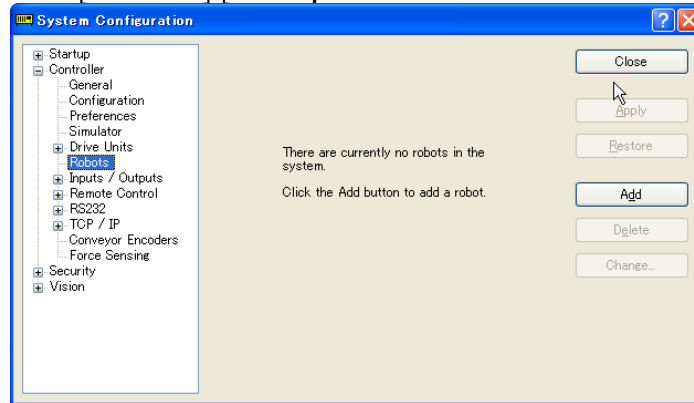


(9)-6 Type in a name for the new robot and enter the serial number from the robot's nameplate. Any serial number can be used, but it is recommended that you use the number that is stamped on the robot.

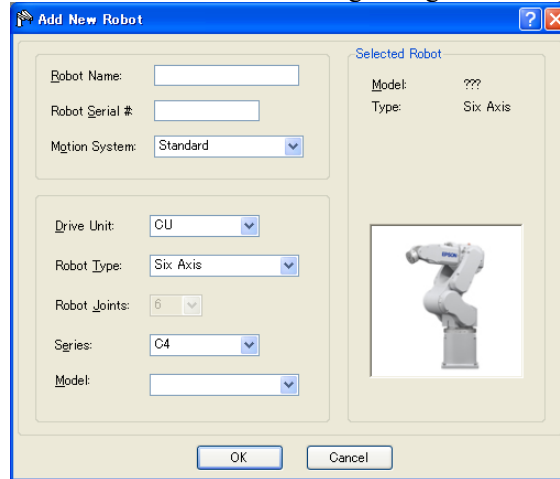
(9)-7 Click **Apply** to save settings.

(9)-1 From the Setup Menu, select System Configuration.

(9)-2 Click [Controller]-[Robots] in the tree on the left.



(9)-3 Click <Add> and the following dialog box will appear.



(9)-4 Type in a name for the new manipulator and enter the serial number on the manipulator’s nameplate. Any serial number can be used, but it is recommended that you use the number that is stamped on the manipulator.

(9)-5 Select a motion system to use from the [Motion System] dropdown list. If there are no other motion systems installed, then “Standard” will already be selected.

(9)-6 Select a Drive Unit for your manipulator from the [Drive Unit] dropdown list.

(9)-7 Select a manipulator type from the [Robot type] box.

(9)-8 Select a manipulator series from the [Series] dropdown list.

(9)-9 Select a manipulator model from the [Model] dropdown list.

After you select a manipulator model, all manipulators available for the type of motor driver currently installed in the controller will be displayed. If you use [Dry run], all robots selected in step 9 will be shown.

(9)-10 Click <OK> and the controller will be rebooted.

(10) Perform the calibration of Joint #1, #2.

For details, refer to 14. Calibration.

10. Bellows

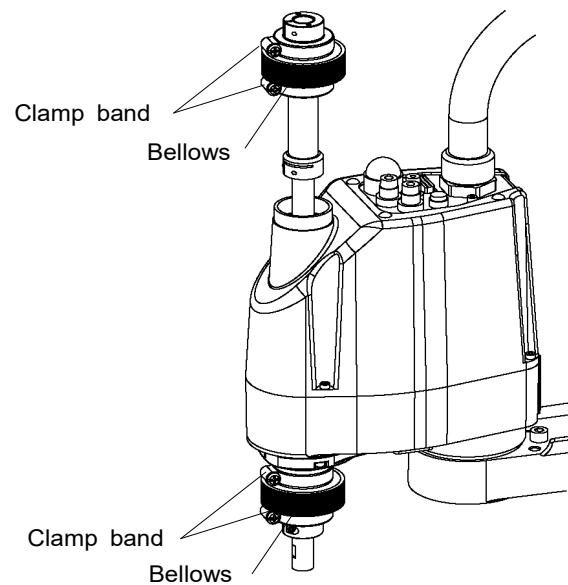


The bellows are provided in a unit of one piece. The upper and lower bellows have the same shape.

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	120 mm	1	1513008
Tools	Cross-point screwdriver		1	For clamp band removal



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) Loosen the two clamp bands on each bellows.
- (5) Pull the bellows and clamp bands out of the shaft.

**Bellows
Installation**

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

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

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

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

Be careful of the shaft 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.

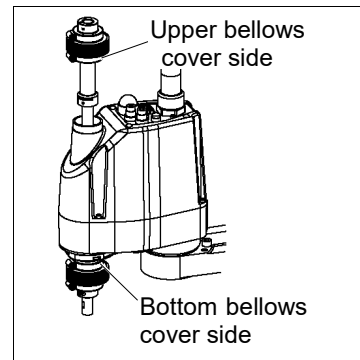
The bellows has two joints:

The larger joint must be attached to the cover side.

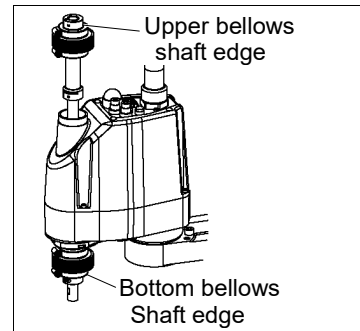
The smaller joint must be attached to the end face side of the shaft.

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

Then, secure them with clamp bands.



- (4) 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.
Then, secure them with clamp bands.



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

11. Ball Screw Spline Unit



- 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.



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 *14. Calibration* to perform the calibration.

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 (3).

	Name	Quantity	Note
Maintenance parts	Ball Screw Spline Unit	1	Each manipulator model (Refer to <i>15. G3 Maintenance parts</i>)
Grease	For Ball Screw Spline Unit (AFB grease)	Proper quantity	
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Torque wrench	1	
	Nippers	1	For cutting wire tie
	Cross-point screwdriver	1	Only for Cleanroom-model
	Force gauge	1	Belt tension 98 N (10 kgf) / 74 N (7.5 kgf)
	Suitable cord (Length about 1000 mm)	1	For belt tension
	Wiping cloth	1	For wiping grease (Spline shaft)
Material	Wire tie	2	

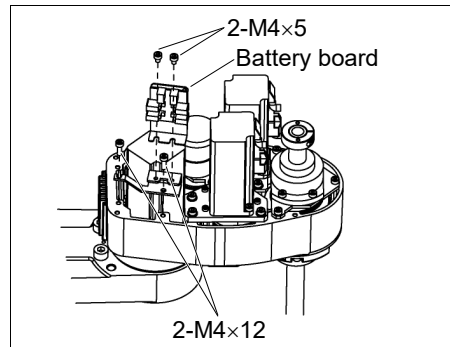
Ball screw spline unit Removal

- (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.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

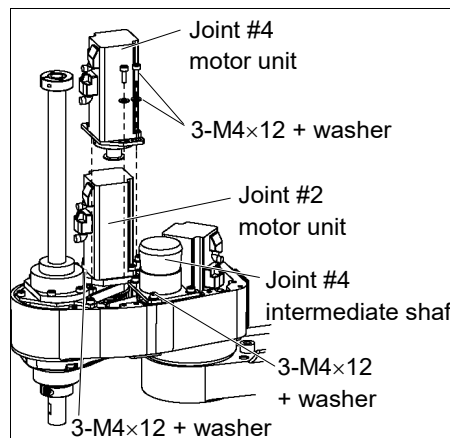
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Detach the wires/tubes from the end effector, and remove the end effector.
- (5) This step is only for Cleanroom-model (C with bellows option).
Remove the bellows. For details, refer to 10. Bellows.
- (6) Remove the arm top cover and arm bottom cover.
For details, refer to 3. Covers.
- (7) Remove the battery board from Arm #2.



- (8) Remove the user plate and grounding wire from Arm #2.
- (9) Disconnect the following connectors.
Connectors X231, X31, X341, X41 (Hold the clip to remove.)
Connector X32
Connector X63, X64 (Backup cable connector for Joint #3, #4)

- (10) Remove the motor unit by pulling it up.
Remove the bolts securing the Joint #4 motor unit.
- (11) Remove the screws securing the ball screw spline of Arm #3 surface.

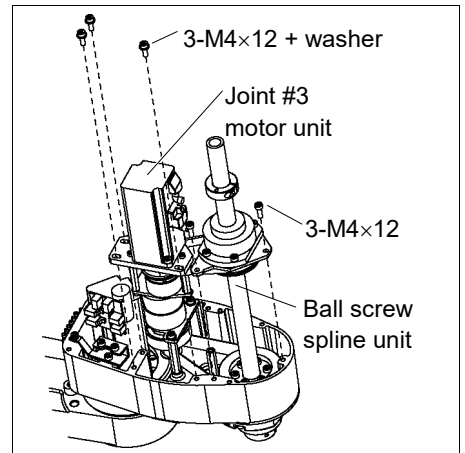


(12) Remove the screws securing the Joint #3 motor unit.

(13) Hold the rotator part of ball screw spline and Joint #3 motor up together.

(14) Hold the Joint #3 motor up.

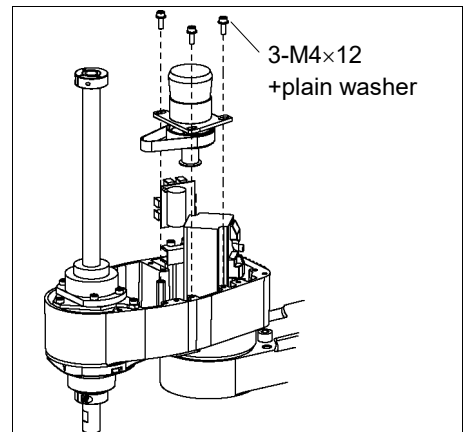
Remove the belt by passing through the spline rotator part.



(15) Remove the screws securing the Joint #4 intermediate unit.

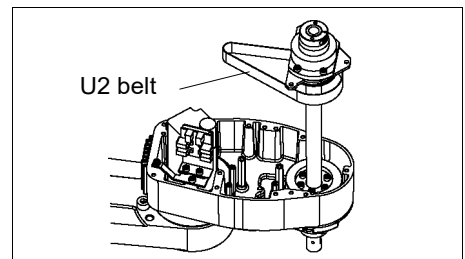
Remove the unit by pulling it up.

(16) Remove the U1 belt.

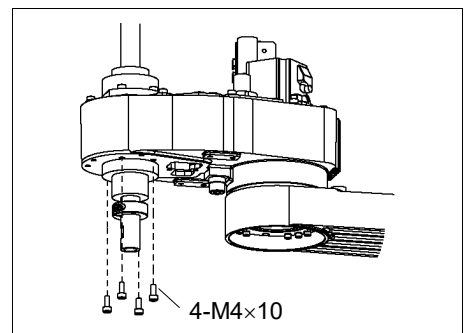


(17) Hold the spline upper rotator part.

Remove the U2 belt.



(18) Remove the mounting screws of the ball screw spline shaft on the lower part of Arm #2.



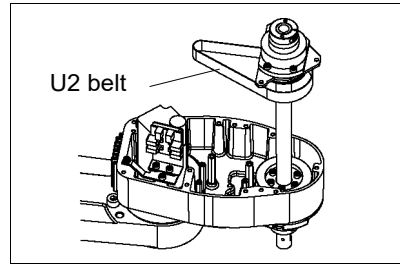
(19) Remove the ball screw spline unit by pulling it upward from Arm #2.



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

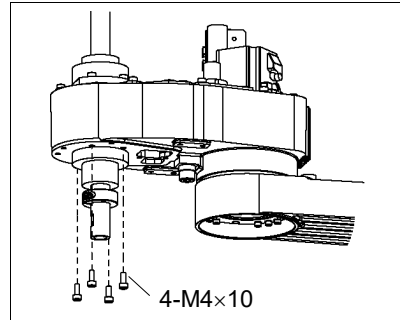
Ball screw spline unit Installation

- (1) Pass the U2 belt through the ball screw spline unit and U3 pulley and insert the belt to Arm #2 from above.



- (2) Secure the ball screw spline shaft on lower side of Arm #2.

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



- (3) Mount the ball screw spline unit.
For the procedure, refer to *8. Arm #4 – 8.2 Replacing the Timing Belt – U2 belt installation*.
- (4) Grease the shaft.
For details, refer to *11.1. Greasing the Ball Screw Spline Unit*.
- (5) Install the arm top cover and arm bottom cover.
For details, refer to *3. Covers*.
- (6) Turn OFF the Controller and peripheral equipment.
- (7) Install the end effector, and connect wires and tubes.
- (8) This step is only for Cleanroom-model. Install the bellows.
For details, refer to *10. Bellows*.
- (9) Perform the calibration of Joints #3 and #4.
For details, refer to *14. Calibration*.

12. Lithium Battery



WARNING

- 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.



WARNING

- Use meticulous care when handling the lithium battery. Improper handling of the lithium battery as mentioned below is extremely hazardous, may result in heat generation, leakage, explosion, or inflammation, and may cause serious safety problems.
<Improper Handling>
 - Battery Charge
 - Disassembly
 - Incorrect Installation
 - Exposing to Fire
 - Forced Discharge
 - Deformation by Pressure
 - Short-circuit (Polarity; Positive/Negative)
 - Heating (85°C or more)
 - Soldering the terminal of the lithium battery directly
- 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.

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.

RC700 series Maintenance Manual 6. 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 15. *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	2120180
Tools	Nippers	1	For cutting wire tie
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
Material	Wire tie	2	For fixing battery unit (battery)
		2	For fixing cable

12.1 Replacing the Battery Unit (Lithium Battery)

Battery unit (lithium battery) Removal

- (1) Turn OFF 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.

The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.

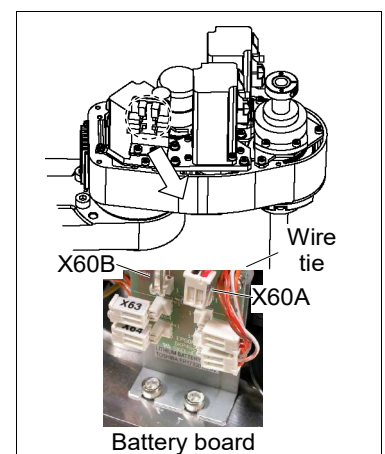
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.

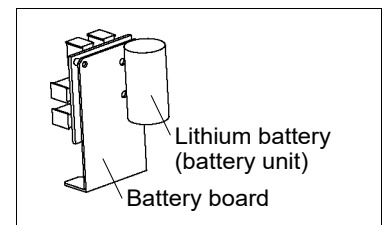
- (4) Connect the connector of the new lithium battery (battery unit) to the battery board.

Use 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 one, the robot will lose the origin position data and the calibration must be executed again.

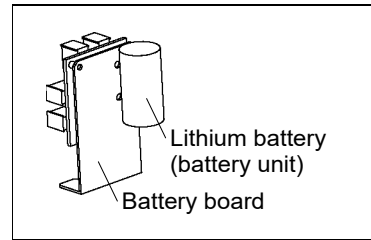


- (5) Cut off the wire tie banding the lithium battery and remove the lithium battery.
- (6) Cut off the wire tie banding the lithium battery, Remove the battery.



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 *Removal step (4)*.
- (3) Mount the arm top cover.
For details, refer to *3.1 Arm Top 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 *14. Calibration*.

12.2 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.

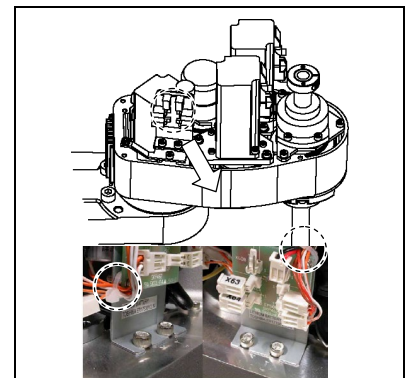
The process of aligning the two origins is called “Calibration”.

Refer to *14. Calibration* to perform the calibration.

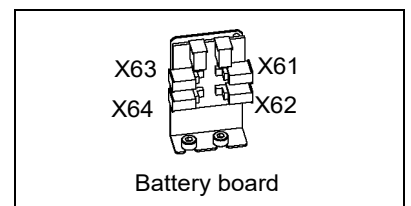
Battery board Removal

- (1) Turn OFF 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.
The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

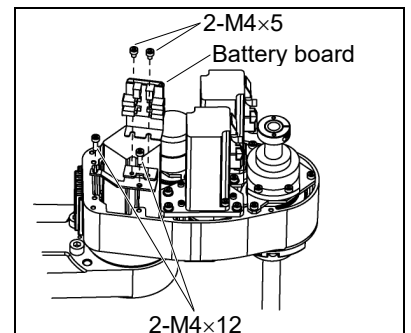
- (3) Remove the arm top cover.
For details, refer to
3.1 Arm Top Cover.
- (4) Disconnect the wiring tie connecting the connector cable.



- (5) Disconnect the connectors X61, X62, X63, and X64 from the battery board.



- (6) Loosen the screws securing the battery board and remove the battery board.



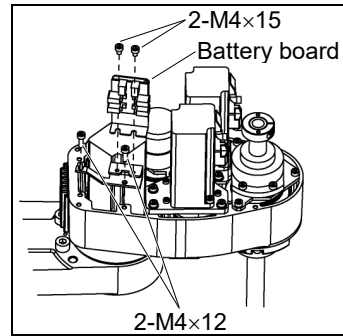
NOTE



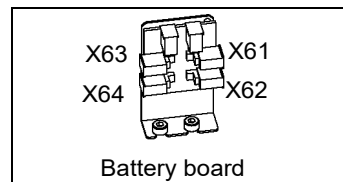
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Battery board Installation

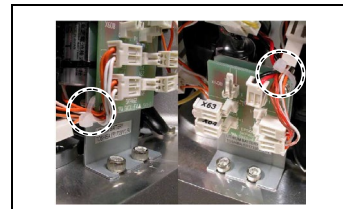
- (1) Mount the new battery board and secure it with screws.



- (2) Connect the connectors.
Connectors: X61, X62, X63, X64



- (3) Fix the connector cable with wiring tie.
Refer to *Removal step (4)*.



- (4) Mount the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Turn ON the Controller.
- (6) Perform the calibration of all joints.
For details, refer to *14. Calibration*.

13. LED Lamp

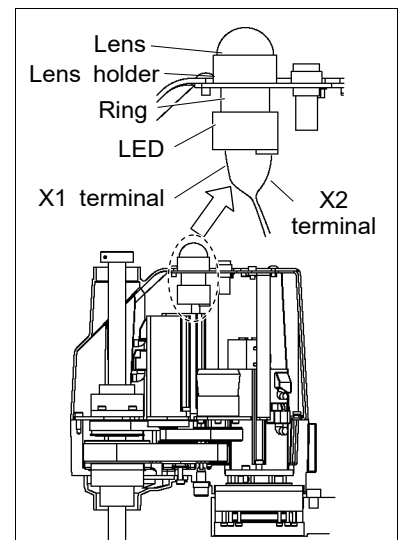


- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric 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.

	Name	Quantity	Note
Maintenance parts	LED Lamp	1	2077258
Tools	Cross-point screwdriver	1	For wire removal
	Nippers	1	
Material	Wire tie	1	

LED Lamp Removal

- (1) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (2) Remove the user plate from the Arm #2 cover.
- (3) Disconnect the X1 and X2 terminals from the LED.
- (4) Turn the lens counterclockwise to remove it. Then, turn the lens holder counterclockwise to remove it.
- (5) Remove the LED and ring from the user plate.



LED Lamp Installation

- (1) Connect the X1 and X2 terminals to the LED.
Each terminal must be connected to its terminal number on the LED.
- (2) Put the user plate between the ring and lens holder, and then mount the LED on the arm top cover.
- (3) Install the lens to the lens holder.
- (4) Mount the user plate to Arm #2.
- (5) Install the arm top cover.
For details, refer to *3.1 Arm Top Cover*.

14. Calibration


14.1 About Calibration

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

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

The process of aligning the two origins is called “Calibration”. Note that calibration is not the same as teaching*.

*: “Teaching” means to teach the Controller coordinate points (including poses) anywhere in the operating area of the Manipulator.

 WARNING	<ul style="list-style-type: none"> ■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to EPSON RC+ User’s Guide: <i>2.4 Installation and Design Precautions</i>. ■ 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.
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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 calibration procedure is different for each type of software, see your software type.

14.2 Calibration Procedure

EPSON RC+ has a wizard for calibration.

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

The same calibration procedure is used for each joint.

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 *14.3 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.



If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *14.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.

The reference point (a point to check the accuracy) needs to be specified for calibration.

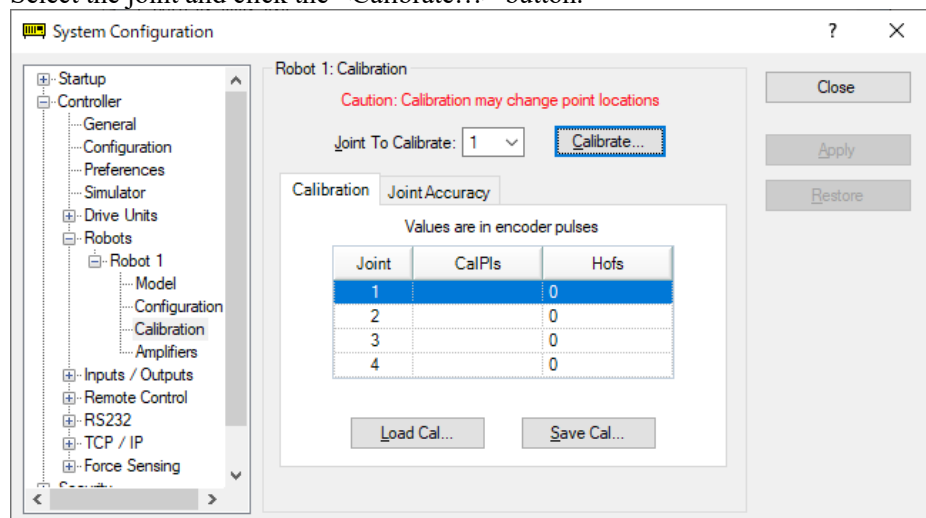
(1) Start the calibration wizard.

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

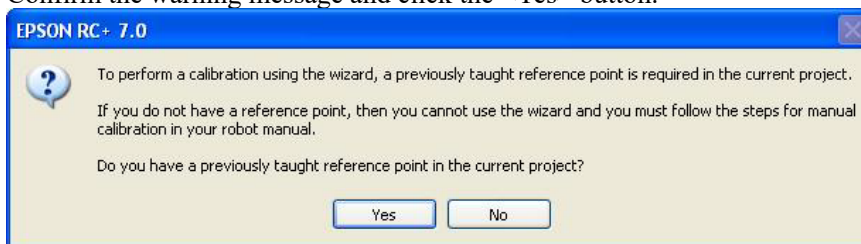


Only selected robot can be calibrated.

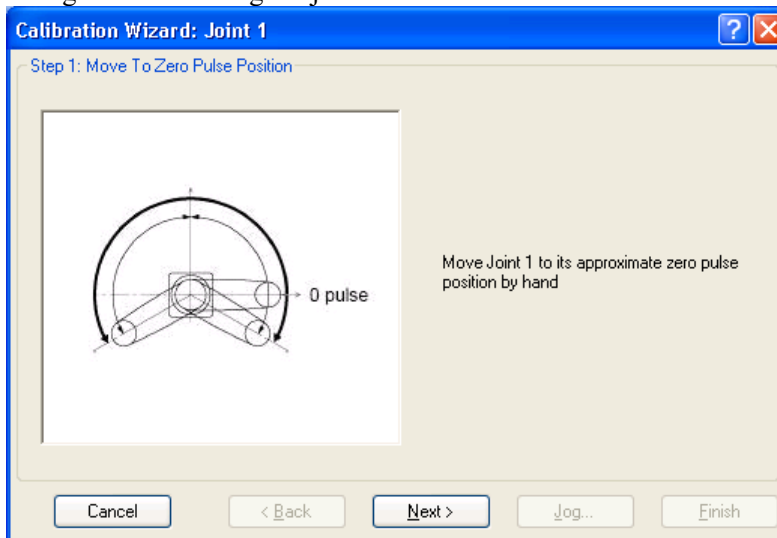
iii. Select the joint and click the <Calibrate...> button.



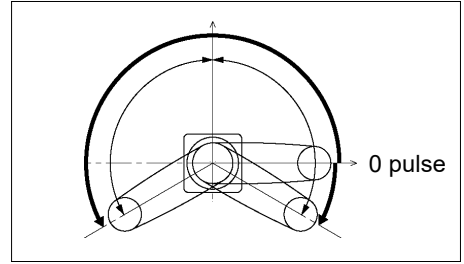
- (2) Confirm the warning message and click the <Yes> button.



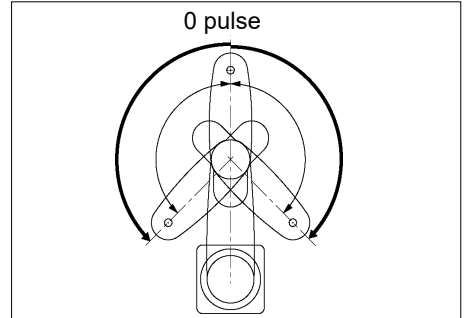
- (3) Move the joint to calibrate manually to approximate 0 pulse position, as shown in the dialog. After moving the joint click the <Next> button.



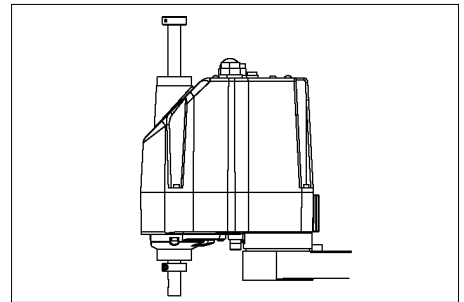
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



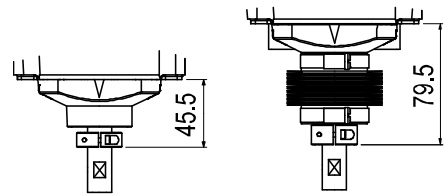
0 pulse position of Joint #2:
position where Arms #1
and #2 are in a straight line
(Regardless of the Joint #1
direction.)



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



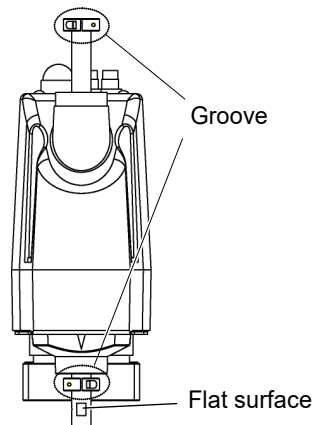
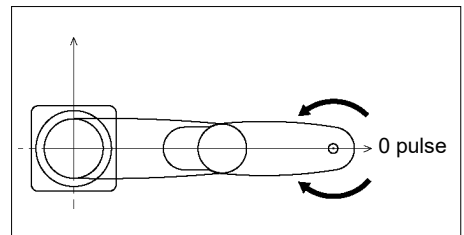
The height of Joint #3
depends on manipulator
model.



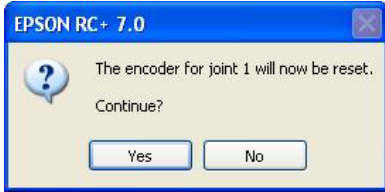
Standard model

Cleanroom model

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



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



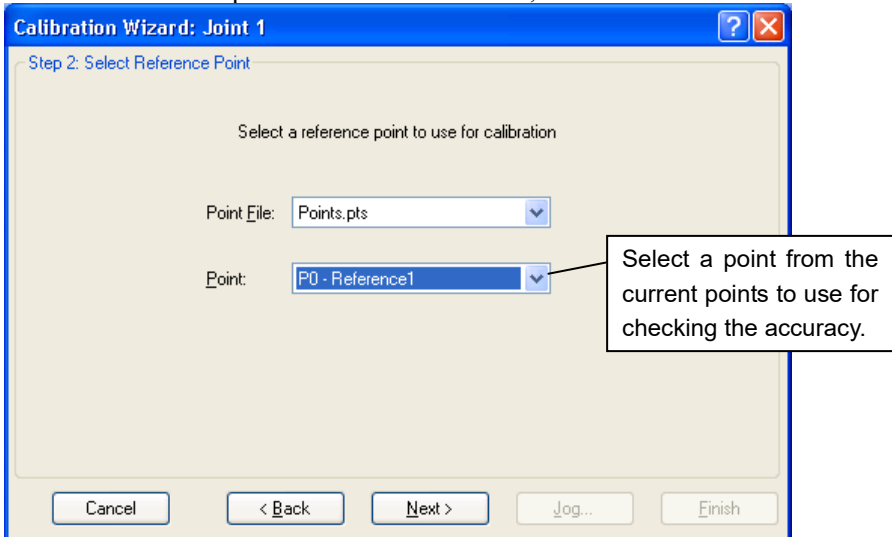
* This window will disappear when the Controller starts up.

- (5) Reboot the Controller.

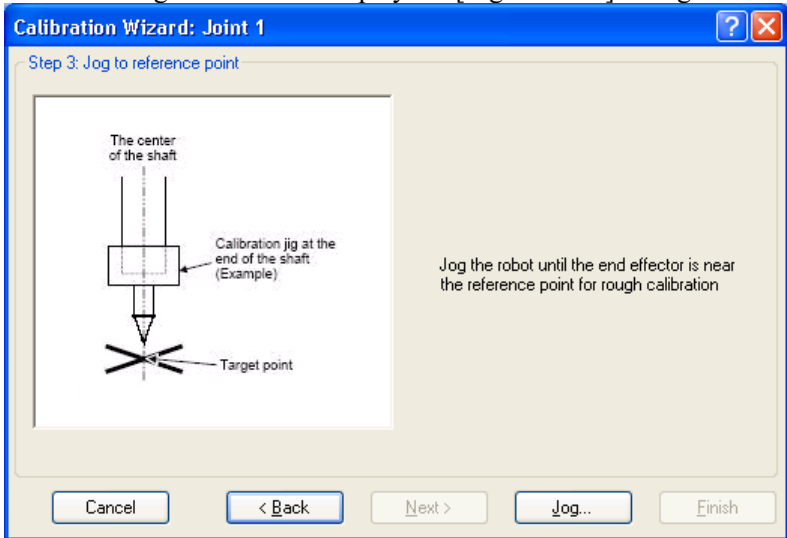


* This window will disappear when the Controller starts up.

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

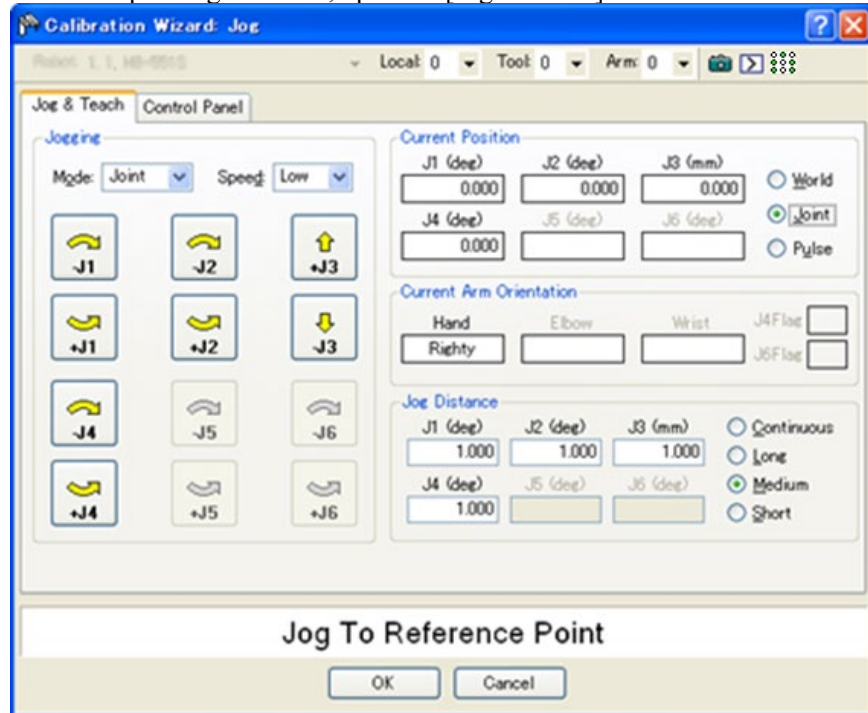


- (7) Click the <Jog...> button to display the [Jog & Teach] dialog.

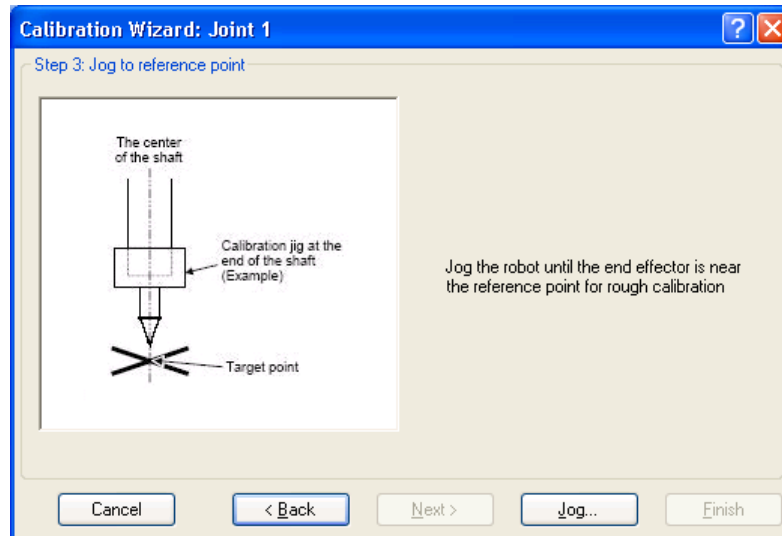


- (8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.

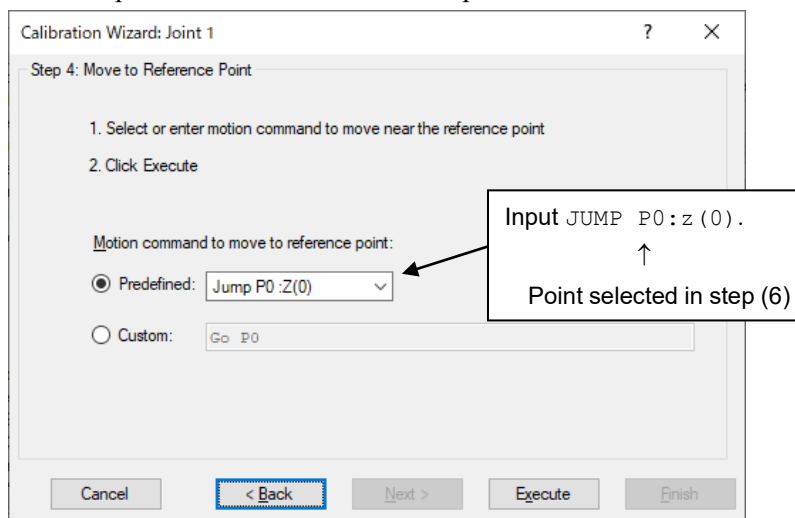
* Before operating the robot, open the [Jog & Teach] tab and execute <Motor ON>.



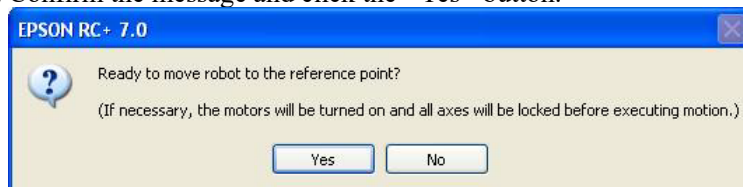
- (9) Click the <Next> button.



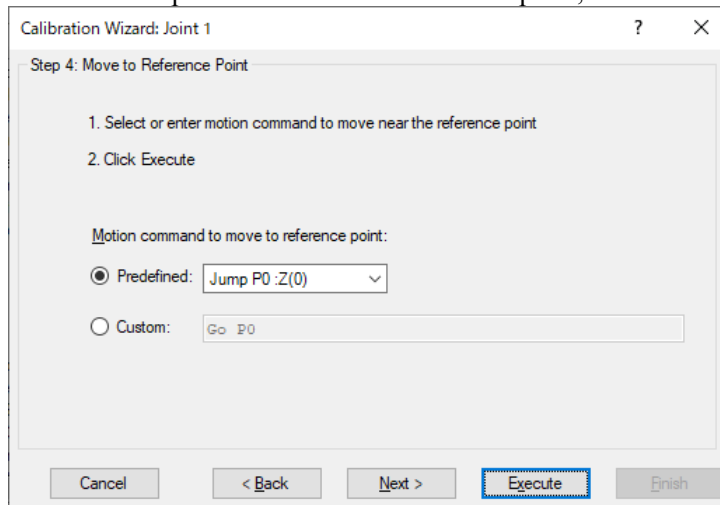
(10) The manipulator moves to the reference point. Click the <Execute> button.



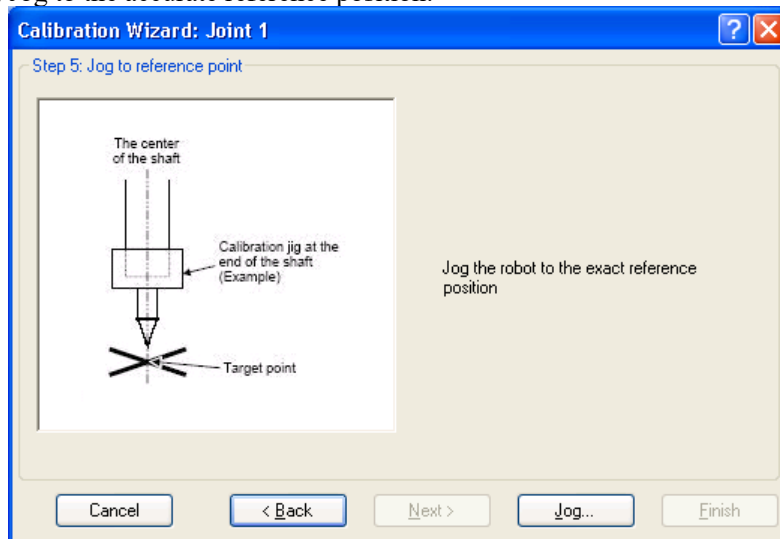
(11) Confirm the message and click the <Yes> button.



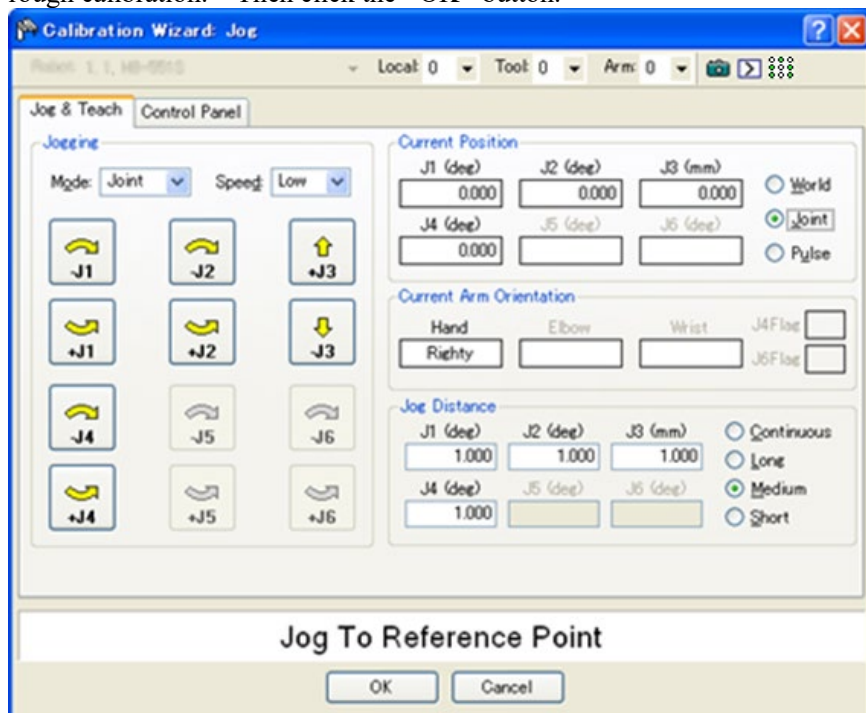
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position.

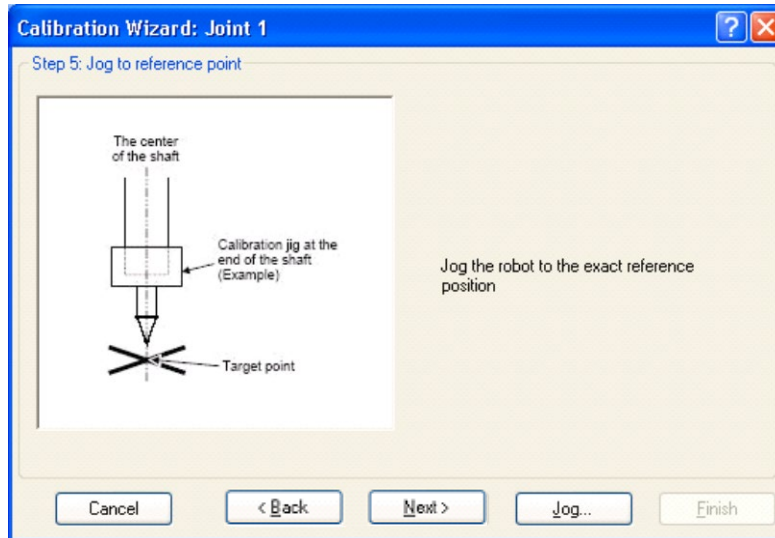


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



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

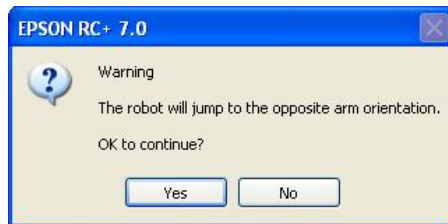
(15) Click the <Next> button.



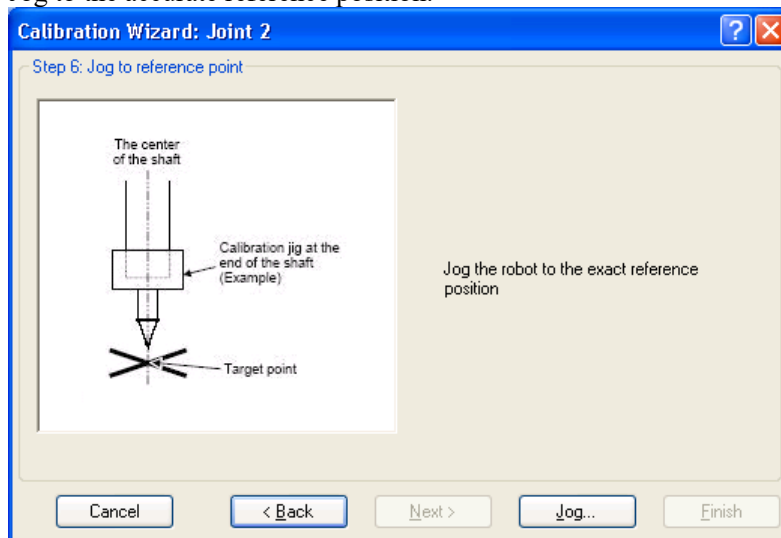
(16) Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2.

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

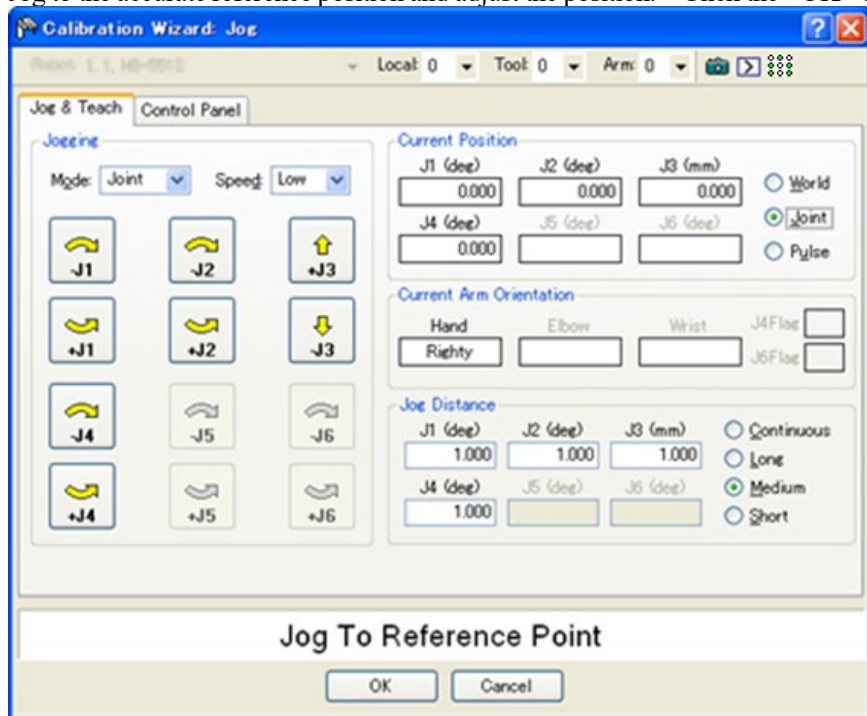
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



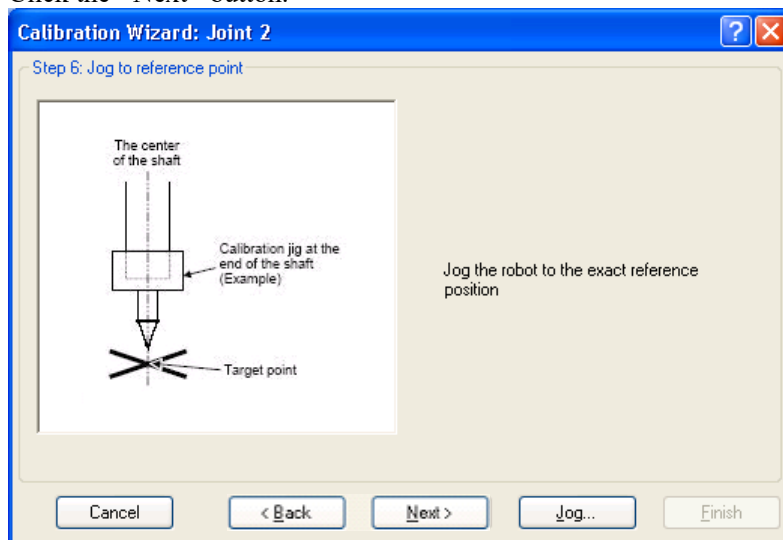
ii. Jog to the accurate reference position.



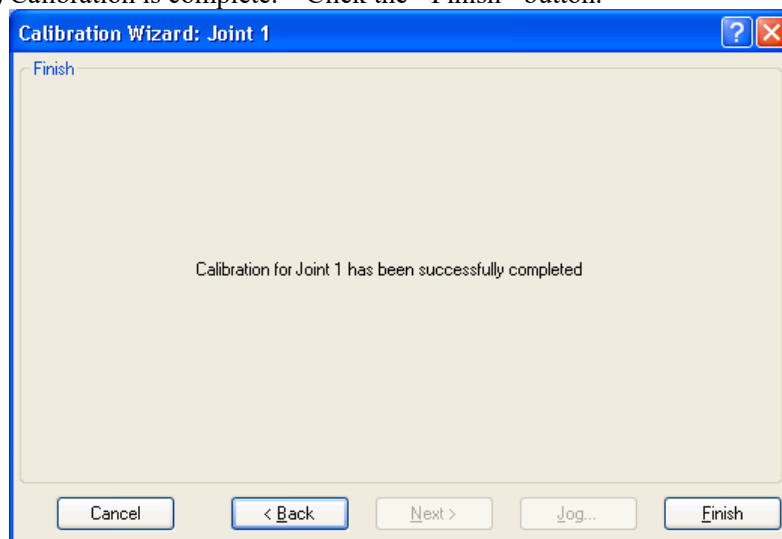
iii. Jog to the accurate reference position and adjust the position. Click the <OK> button.



iv. Click the <Next> button.



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



(18) Move the manipulator to other points and check if it can move without problems.
Teach points where appropriate.

14.3 Accurate Calibration of Joint #2

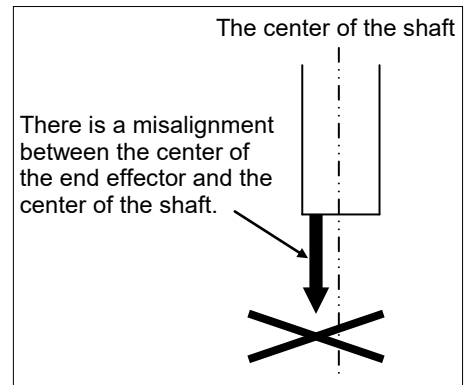
When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.



IF the calibration of Joint #2 is performed in *14.2 Calibration Procedure*, configure “Calibration Using Right / Left Arm Orientations” by the wizard.

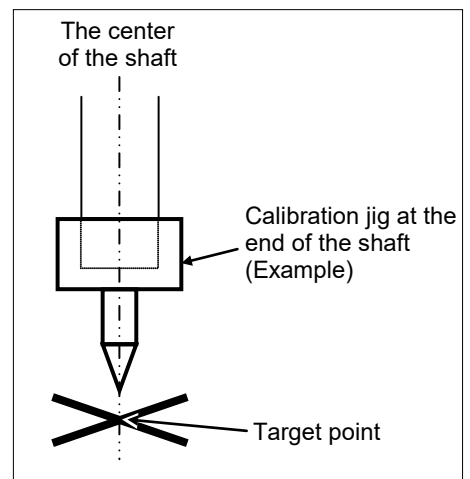
The reference point is the center of the ball screw spline shaft during this calibration.

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



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

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



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

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

- Teaching the working point by entering the coordinate values (MDI teaching)
- Switching the arm orientation between right and left at a given point
- Using the 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 the Tools menu | Robot Manager | Control Panel and click the MOTOR ON.
- (3) Click the <Free All> button in the [Control Panel] to free all joints. Now, you can move arms by hands.
- (4) Move the arms to the position of point data for calibration in righty arm orientation.
- (5) From the current position, teach any point data number unused.
This point is now called P1.

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

- (6) Click the <Lock All> button in the [Control Panel] to lock all joints.
- (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> button 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> button 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.

14.4 Calibration Procedure without using Calibration Wizard



This section indicates the calibration without using the calibration wizard of EPSON RC+. For details of calibration using the calibration wizard, refer to *14.2 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 *14.3 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.



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.

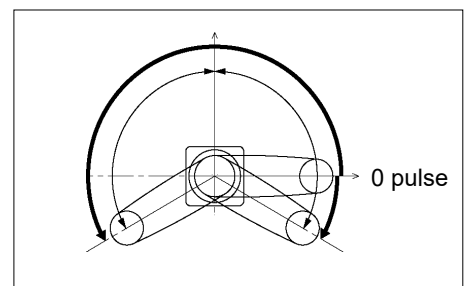
* Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

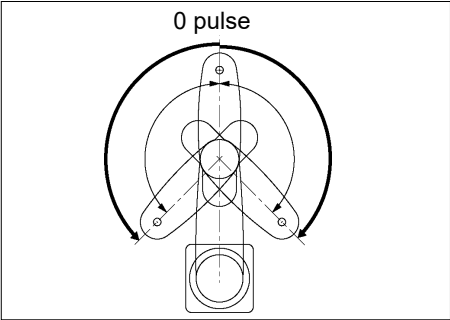
(3)-1 Turn ON the Controller when all joints are in the motion range.

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

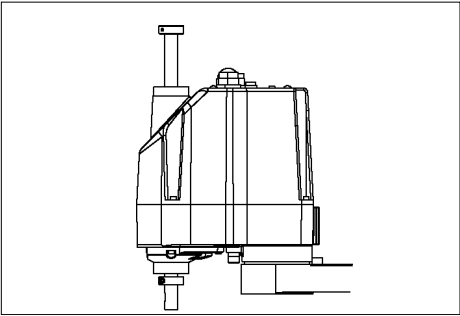
0 pulse position of Joint #1:
 position aligned with X-axis in
 Robot coordinate system



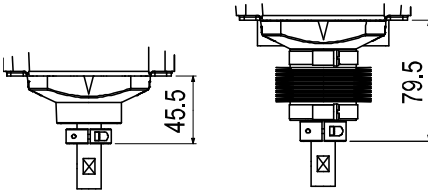
0 pulse position of Joint #2:
 position where Arms #1 and #2 are in a straight line
 (Regardless of the Joint #1 direction.)



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

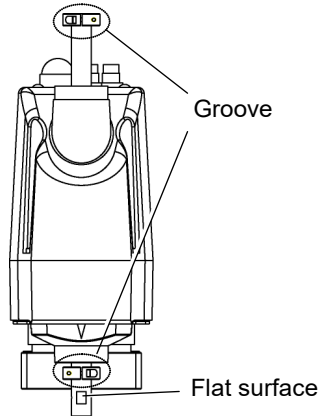
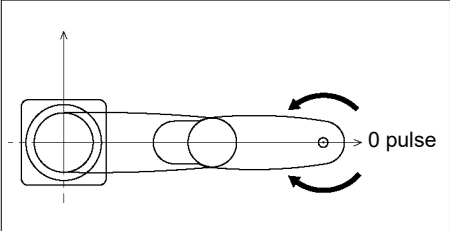


The height of Joint #3 depends on manipulator model.



Standard model Cleanroom model

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



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

Select the robot to be calibrated. Input as below in the [Command Window] and execute.
 (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 in the [Control Panel] to free all joints. 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.

15. G3 Maintenance Parts List

15.1 Common Parts

Part Name		Code	Old Code	Note	Reference	Overhaul *1
Cable Unit	S C	250 mm	1514457	R13B020023	4.1	
		300 mm	1514458	R13B020024		
		350 mm	1514459	R13B020025		
	SM CM	300 mm	1514460	R13B020026	4.1	
		350 mm	1514461	R13B020027		
M/C Cable	3 m	For RC180	R12NZ9002C	R12B020431	4.3	
		For RC700-A Straight	R12NZ900KA	-		
		For RC700-A, L-shaped	R12NZ900KD	-		
	5 m	For RC180	R12NZ9002D	R12B020432		
		For RC700-A, Straight	R12NZ900KB	-		
		For RC700-A, L-shaped	R12NZ900KE	-		
	10 m	For RC180	R12NZ9002E	R12B020433		
		For RC700-A, Straight	R12NZ900KC	-		
		For RC700-A, L-shaped	R12NZ900KF	-		
	15 m	For RC700-A, Straight	R12NZ900XU	—		
		For RC700-A, L-shaped	R12NZ900XW	—		
	20 m	For RC700-A, Straight	R12NZ900XV	—		
For RC700-A, L-shaped		R12NZ900XX	—			
AC Servo Motor	Joint #1	1514451	R13B000614	200 W	5.1	✓
	Joint #2 / #3 / #4	1514453	R13B000615	150 W	6.1, 7.1, 8.1	✓
Reduction Gear Unit	Joint #1	1856653	R13B010016		5.2	✓
	Joint #2	1856070	R13B010017		6.2	✓
Electromag netic Brake	Z axis	1497639	R13B030501		7.3	✓
Timing Belt	Joint #3	1510625	R13B030213	Z	7.2	✓
	Joint #4	1510626	R13B030214	U1	8.2	✓
		1510627	R13B030215	U2	8.2	✓
O-ring	Joint #1	1653181	R13A0307002 00		5.2	
	Joint #2	1653819	R13A0307001 00		6.2	

Part Name		Code	Old Code	Note	Reference	Overhaul *1
	Joint #1	1213267	R13A0312007 00	O-ring20 For Multiple layout mounting only.	-	
	Joint #2	1213266	R13A0312006 00	O-ring17	6.2	
Brake Release Switch		2117817	R13Z7026401 00		-	
Oil seal (soft metal)		1510206	R13B031233		5.1	
Battery Board		2120180	R13B041202	With lithium battery Installed in Arm #2 ER17330V (TOSHIBA)	12.2	
Battery Unit		2117879	R13ZA006003 00	Lithium battery for replacement ER17330V (TOSHIBA)	4.1, 12.1	
LED Lamp		2077258	R13A0300002 00		13	
Grease *2	For Ball Screw Spline : AFB		-	-	For purchasing the grease, please contact the supplier of your region.	2.3
	For Reduction Gear Unit	SK-1A	-	-		2.3
		SK-2	-	-		2.3

*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 2.2 *Overhaul (Parts Replacement)*.

*2 Regarding purchase of grease

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase grease required for maintenance from the manufacturers listed in the table below as of April 2015. Regarding purchase of grease, please contact the following manufacturers. If there is anything unclear, please contact supplier of your region.

Product name	Manufacturer	URL
THK AFB-LF Grease	THK CO., LTD.	https://www.thk.com/
Harmonic Grease SK-1A Harmonic Grease SK-2	Harmonic Drive Systems Inc.	https://www.harmonicdrive.net/

15.2 Parts by Environment Model

15.2.1 S: Standard-model

Part Name		Code	Old Code	Note	Reference	Overhaul *1
Ball Screw Spline	150 mm	1514454	R13B010220		11.1.1	✓
Arm Cover		1514465	R13B030421	White	3.1	

*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 2.2 *Overhaul (Parts Replacement)*.

15.2.2 C: Cleanroom-model

Part Name		Code	Old Code	Note	Reference	Overhaul *1
Ball Screw Spline	120 mm	1514455	R13B010221		11.1.2	✓
Arm Cover		1514466	R13B030422	Plating	3.1	
Bellows		1513008	R13B030704	*2	10	
Gasket Unit		1514467	R13B031234		3	

*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 2.2 *Overhaul (Parts Replacement)*.

*2 Common with LS3 series.

The bellows are provided in a unit of one piece. The upper and lower bellows have the same shape.




G6 Maintenance

This volume contains maintenance procedures with safety precautions for Manipulators.

1. Safety Maintenance

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

Only authorized personnel who have taken maintenance training held by the manufacturer or dealer should be allowed to perform the robot maintenance.

 WARNING	<ul style="list-style-type: none"> ■ Do not remove any parts that are not covered in this manual. Follow the maintenance procedure strictly as described in this manual. Improper removal of parts or improper maintenance may not only cause improper function of the robot system but also serious safety problems. ■ Keep away from the Manipulator while the power is ON if you have not taken the training courses. Do not enter the operating area while the power is ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even it seems to be stopped. ■ When you check the operation of the Manipulator after replacing parts, be sure to check it while you are outside of the safeguarded area. Checking the operation of the Manipulator while you are inside of the safeguarded area may cause serious safety problems as the Manipulator may move unexpectedly. ■ Before operating the robot system, make sure that both the Emergency Stop switches and safeguard switch function properly. Operating the robot system when the switches do not function properly is extremely hazardous and may result in serious bodily injury and/or serious damage to the robot system as the switches cannot fulfill their intended functions in an emergency.
 WARNING	<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.
 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. ■ When operating maintenance of manipulator, secure about 50 cm of empty space around the manipulator.

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.

	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						√

h = hour

2.1.2 Inspection Point

Inspection Item

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts/screws.	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
Check looseness of connectors.	External connectors on Manipulator (on the connector plates etc.)	√	√	√	√	√
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 the brake operation	Joint #3	√	√	√	√	√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√

Inspection Method

Inspection Point	Inspection Method
Check looseness or backlash of bolts/screws.	Use a hexagonal wrench to check that the end effector mounting bolts and the Manipulator mounting bolts are not loose. When the bolts are loose, refer to "2.4 Tightening Hexagon Socket Head Bolts" and tighten them to the proper torque.
Check looseness of connectors.	Check that connectors are not loose. When the connectors are loose, reattach it not to come off.
Visually check for external defects. Clean up if necessary.	Check the appearance of the Manipulator and clean up if necessary. Check the appearance of the cable, and if it is scratched, check that there is no cable disconnection.
Check for bends or improper location. Repair or place it properly if necessary.	Check that the safeguard, etc. are located properly. If the location is improper, place it properly.
Check the brake operation	Check that the shaft does not fall when in MOTOR OFF. If the shaft falls when in MOTOR OFF and the brake is not released, contact the supplier. Also, the break is not released even operated release the break, contact the supplier.
Check whether unusual sound or vibration occurs.	Check that there is no unusual sound or vibration when operating. If there is something wrong, contact the supplier.

2.2 Overhaul (Parts Replacement)



CAUTION

- If you do not overhaul properly, it may have a serious impact on safety.
- 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 ambient temperature, 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.

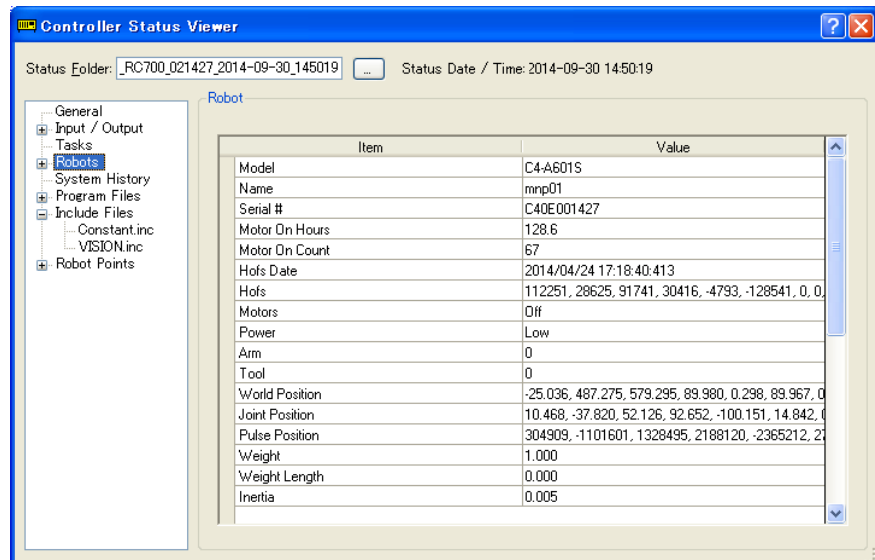
RC700 series Maintenance Manual 6. Alarm

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 *4. G6 Maintenance Parts List*.


For details of replacement of each part, refer to each 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	Reference
Joint #1 Joint #2	Reduction gear units	Overhaul timing	SK-1A	5.2 Replacing the Joint #1 Reduction Gear Unit 6.2 Replacing the Joint #2 Reduction Gear Unit
Joint #3	Ball screw spline unit	At 100 km of operation (50 km for first greasing)	AFB	Greasing the Ball Screw Spline Unit

Joint #1, 2 reduction gear units

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

However, it may vary depending on ambient temperature, 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.



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.

RC700 series Maintenance Manual 6. Alarm


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	


Standard-model

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

- (1) Turn ON the Controller.
- (2) Move the shaft to the lower limit by using one of the following methods:
 - Move the shaft to the lower limit manually while pressing the brake release switch.

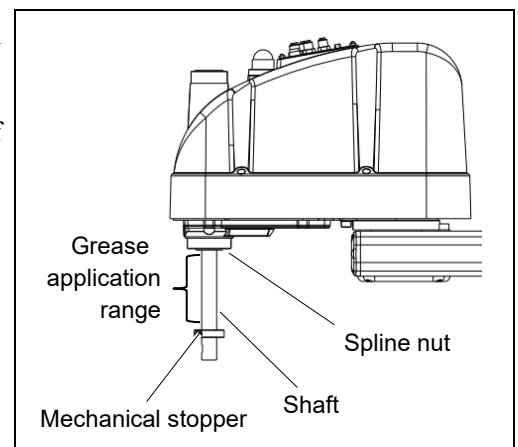
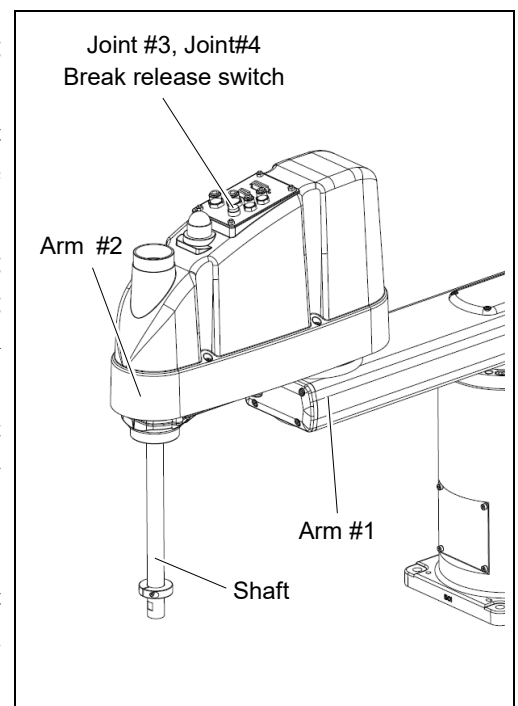
NOTE  Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of the end effector.

- Move the shaft to the lower limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].

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

- (3) Turn OFF the Controller.
- (4) Wipe off the old grease from the shaft, and then apply new grease to it.

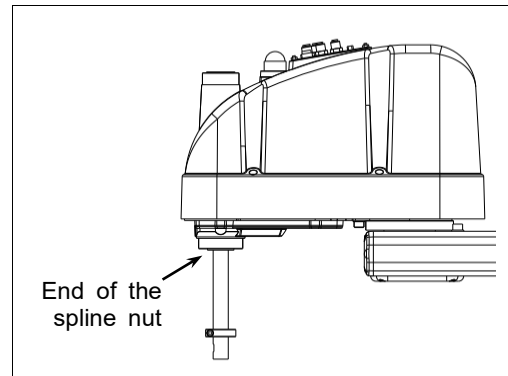
Grease application range is from the end of the spline nut to mechanical stop.



- (5) Apply new grease evenly to the spiral groove of the ball screw spline unit and the vertical groove so that the groove is filled.



- (6) Turn ON the Controller.
- (7) Start the robot manager and move the shaft to the origin position. Be careful not to hit peripheral equipment.
- (8) After moving to the origin position, reciprocate the shaft. The reciprocating operation is a low power mode operation program that performs from the upper limit to the lower limit. Run for about 5 minutes to spread the grease over the shaft.
- (9) Turn OFF the controller.



Cleanroom-model

NOTE



Dust is emitted when greasing. 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 greasing. Cover the surrounding area such as the end effector and peripheral equipment in case the grease drips.

- (1) Turn ON the Controller.
- (2) Move the shaft to the upper limit by using one of the following methods:
 - Move the shaft to the upper limit manually while pressing the brake release switch.

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.

- Move the shaft to the upper limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].

NOTE

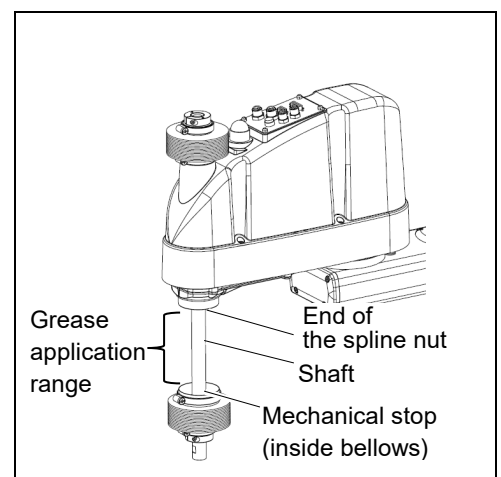
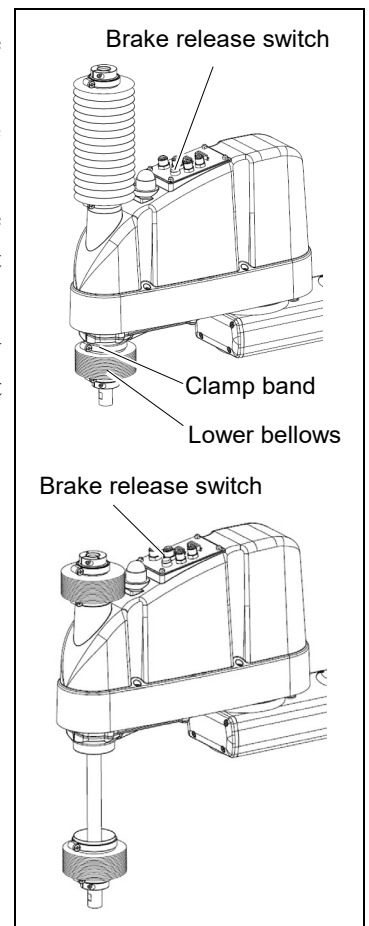


Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

- (3) Loosen the clamp band on the top of the lower bellows, and then move the lower bellows downward.
- (4) Move the shaft to the lower limit in the same way as in step (2).

- (5) Turn OFF the Controller.
- (6) Wipe off the old grease from the shaft, and then apply new grease to it.

The range to apply grease is from the end of the spline nut to the mechanical stop.



- (7) Apply grease to the spiral groove and vertical groove of the ball screw spline to fill the grooves.



- (8) Turn ON the Controller.

- (9) Apply grease to the whole of the shaft.

Move the shaft up and down about 10 times from the upper limit to the lower limit.

When moving the shaft up and down, press and hold the brake release switch on the top of cover.

After moving up and down, wipe off excess grease from the end of the spline nut.

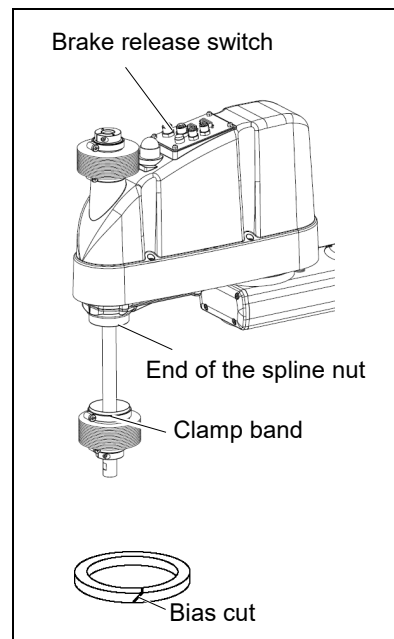
- (10) Fix the lower bellows.

Move the shaft to the upper limit.

Insert the bellows mounted part until it touches the cylinder part of the cover.

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

Fix with the clamp band.



- (11) After fitting, move the shaft up and down several times and rotate Joint #4. Make sure that the bellows can expand and contract smoothly without any excessive force.

- (12) Start Robot Manager and move the shaft to the origin position.

Be sure to prevent hitting any peripheral equipment.

- (13) After moving to the origin position, move the shaft up and down. To move up and down, use an operation program to move from the upper limit to the lower limit in low power mode. Run about 5 minutes to spread grease over the shaft.

- (14) Turn OFF the Controller.

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.

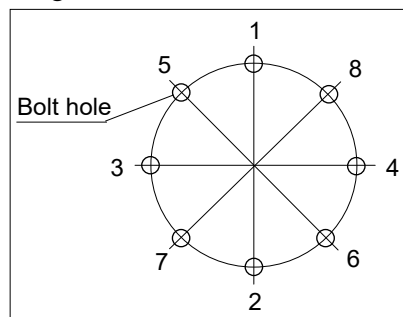
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

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)

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.

**EPSON
RC+**

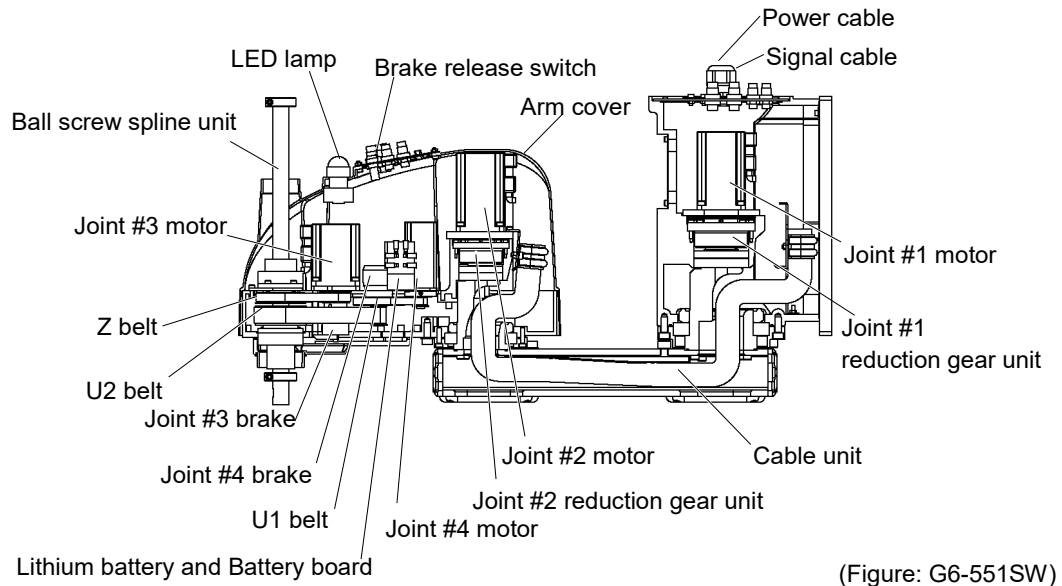
Execute the following command from the [Command Window].

```
>PULSE
```

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

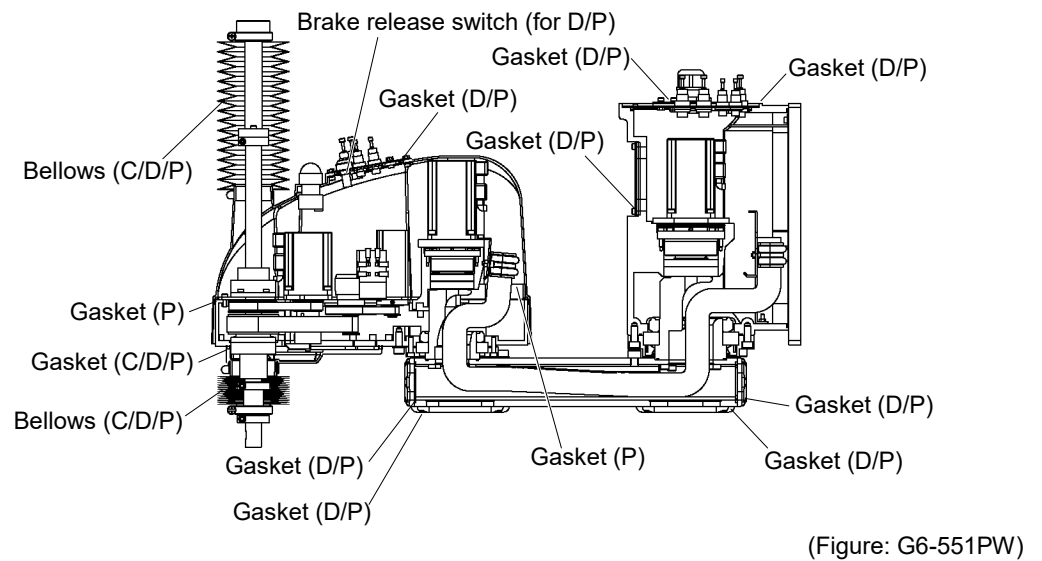

2.6.2 Wall Mounting type

G6-***SW : Standard-model



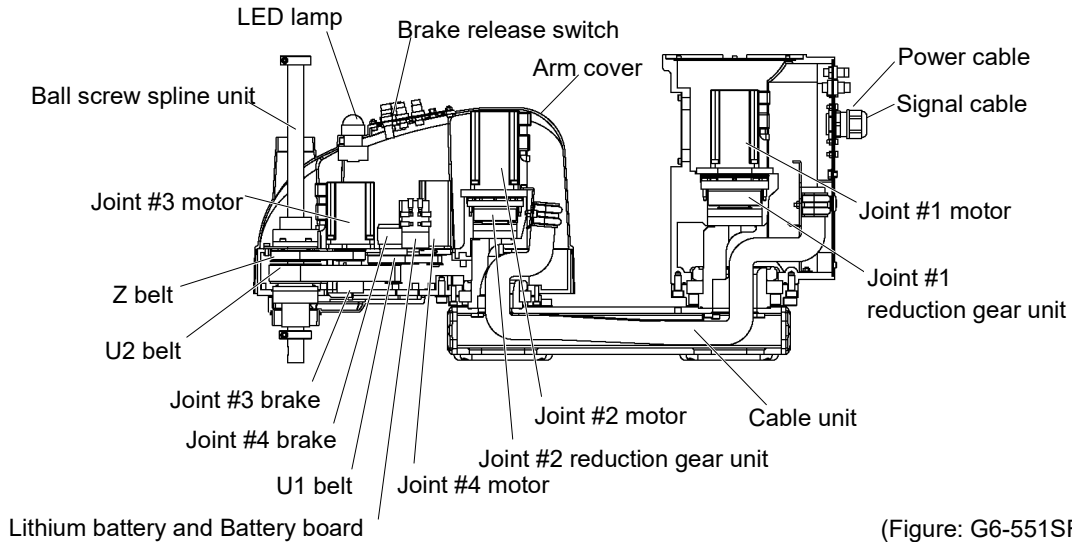
G6-***CW : Cleanroom-model

G6-***DW, PW : Protected-model (D: With bellows option)



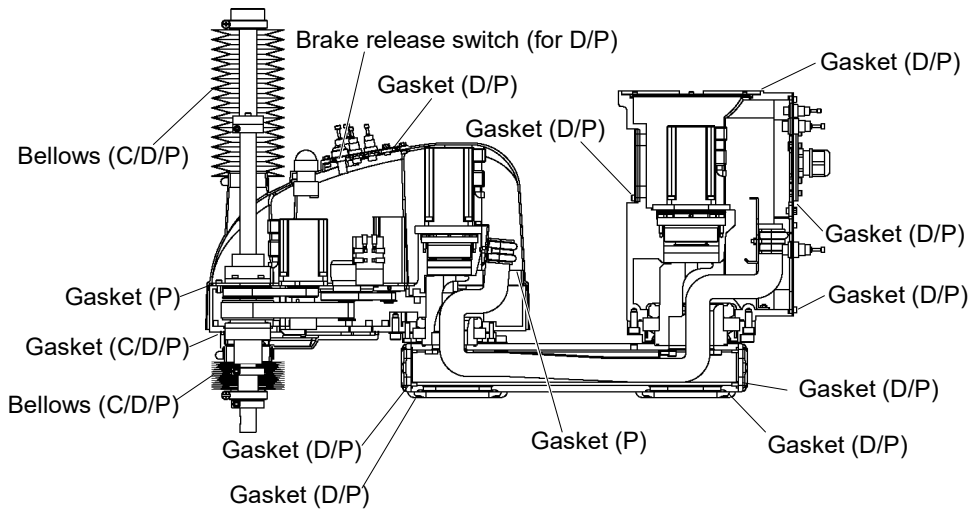
2.6.3 Ceiling Mounting type

G6-***SR : Standard-model




G6-***CR : Cleanroom-model

G6-***DR, PR : Protected-model (D: With bellows option)

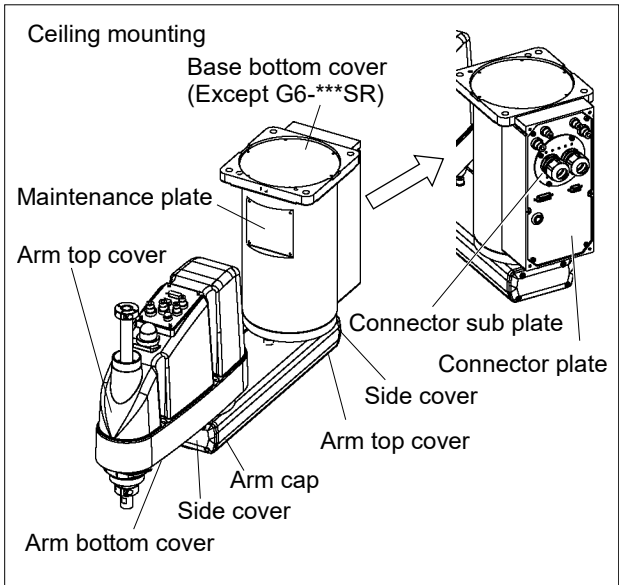
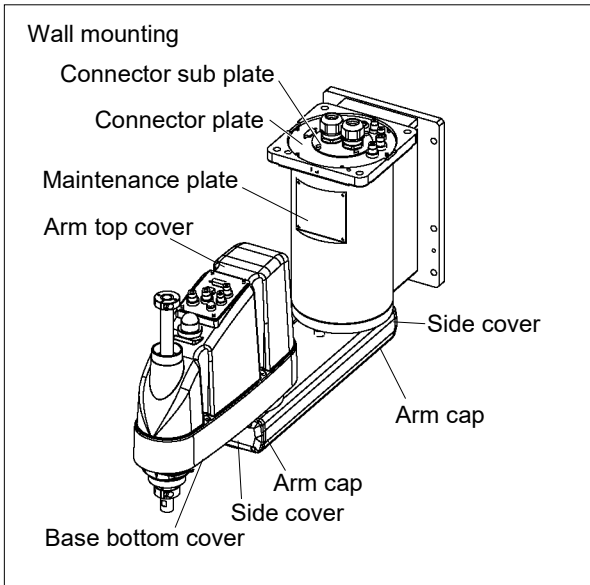
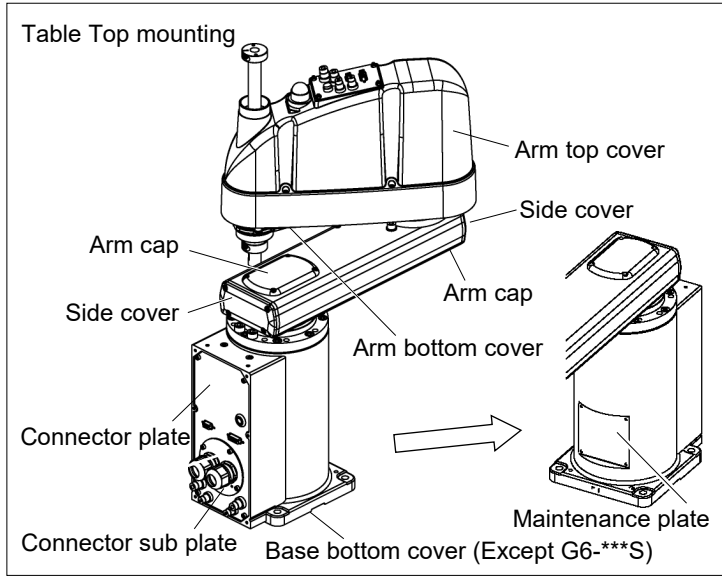


3. Covers


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

 <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.
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	Name	Quantity	Note
Maintenance parts	Gasket unit	1	1497643 Only for Cleanroom-model and Protected-model
	Arm #2 Gasket	1	1497644 Only for Cleanroom-model and Protected-model
	Silicon adhesive (for the gasket on the Connector Plate)	1	Only for Table top mounting and Ceiling mounting/ Protected-model
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw Only for Wall mounting / Cleanroom-model and Protected-model
	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 and Protected-model
	Wiping cloth	1	For wiping adhesive




3.1 Arm Top Cover

 CAUTION	<ul style="list-style-type: none"> ■ Do not remove the arm top cover forcibly. Removing the cover forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. ■ When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. <p>When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations.</p>
---	---

Arm Top Cover (1) Turn ON the Controller.


Removal

- (2) Press and hold the brake release switch to let the shaft down. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

NOTE  The brake release switch affects both Joints #3 and #4. When the brake release switch is pressed, the brakes for both Joints #3 and #4 are released simultaneously. (Joint #4 brake is installed to G6-**3** only.)

Be careful of the shaft falling or rotation while the brake release switch is being pushed because it may be lowered by the weight of an end effector.

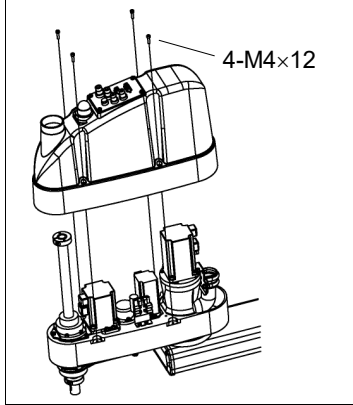
- (3) Turn OFF the Controller.
- (4) Unscrew the arm top cover mounting bolts, and then lift the cover.

NOTE  When bellows are installed to the manipulator, remove the upper bellows and then remove the arm top cover. For bellows removal, refer to 9. *Bellows*.

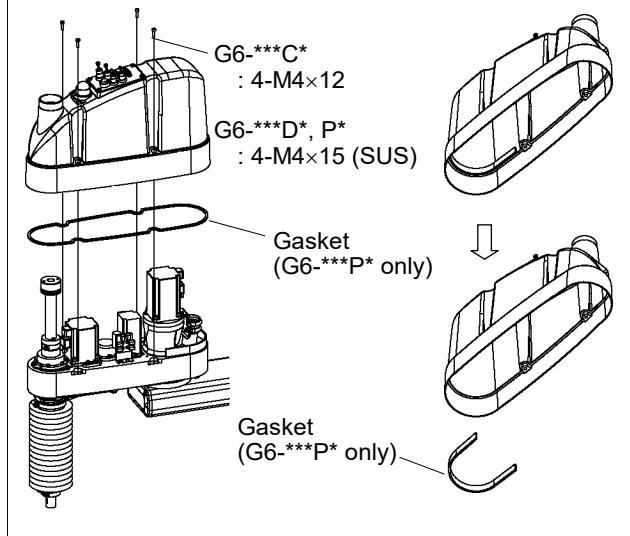
The cover cannot be removed completely because user wires and tubes are connected. However, you can continue regular maintenance.

LED lamp and the cable of the brake release switch are located between the main part and the cover. Do not pull the cable strong or the connector may be damaged.

G6-***S* (Standard-model)



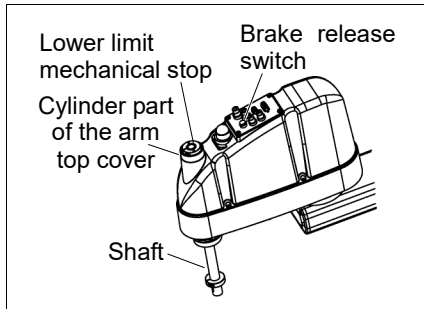
G6-***C* (Cleanroom-model),
G6-***D*, P* (Protected-model)



Gaskets are installed only to G6-***P*.

Arm Top Cover Installation (1) Set the arm top cover to the arm and secure with the arm top cover mounting bolts.

After mounting the arm top cover, make sure that the lower limit mechanical stop does not touch the cylindrical part of the arm top cover.



When bellows are installed to the manipulator, install the arm top cover and then install the upper bellows. For bellows installation, refer to 9. Bellows.

3.2 Arm Bottom Cover

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



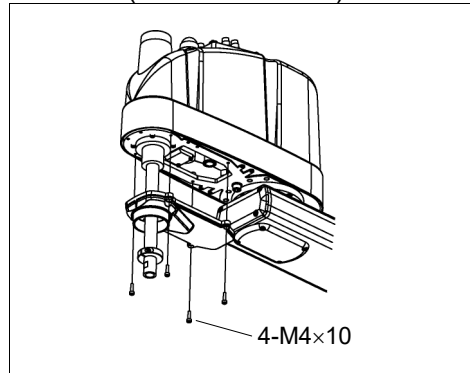
The arm bottom cover may not be removed from the shaft because the end effector is installed.

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

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

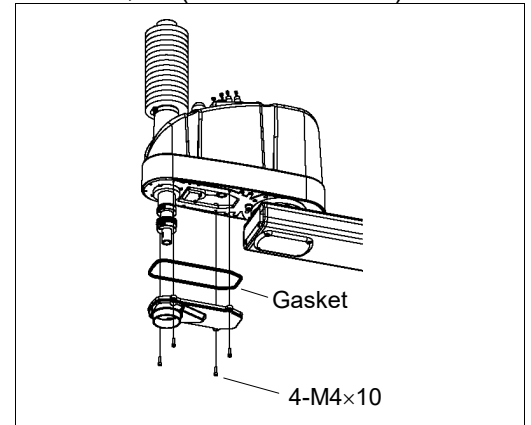
When bellows are installed to the manipulator, remove or pull down the lower bellows and then remove the arm bottom cover. For bellows removal, refer to 9. *Bellows*.

G6-***S* (Standard-model)



G6-***C* (Cleanroom-model)

G6-***D*, P* (Protected-model)



A gasket is installed to G6-***C* (Cleanroom-model) and G6-***D*, P* (Protected-model).

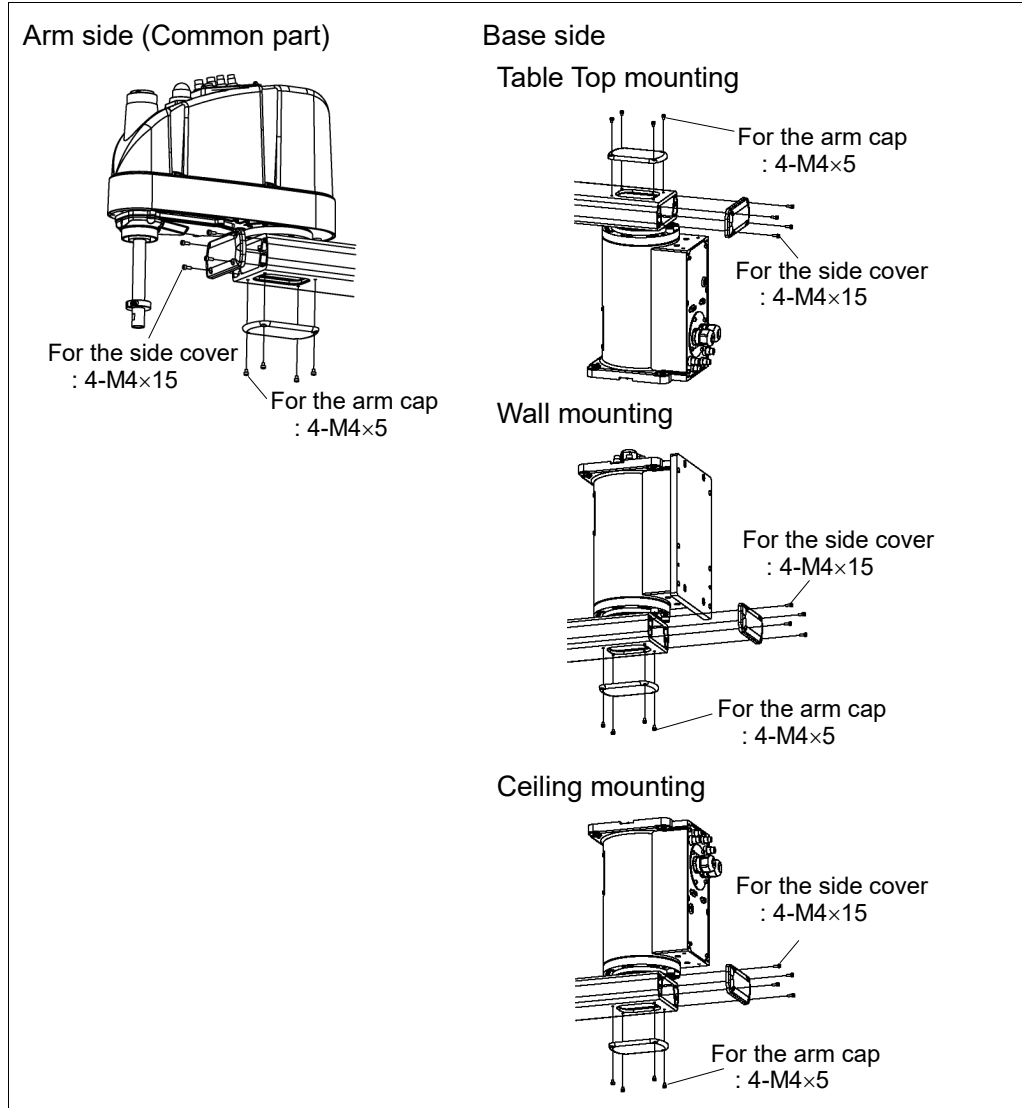
3.3 Arm #1 Cover

There are two sets of Arm #1 covers.

- Arm caps
- Side covers

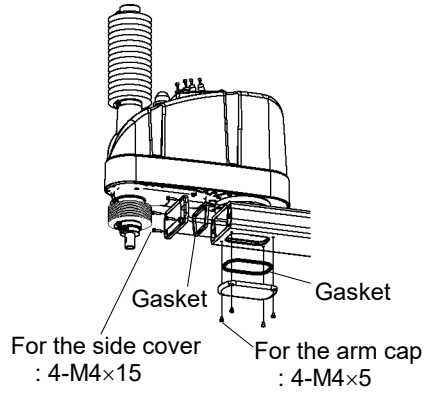
Unscrew the bolts mounting the covers and the caps to remove them.

3.3.1 G6-***S* (Standard-model), G6-***C* (Cleanroom-model)



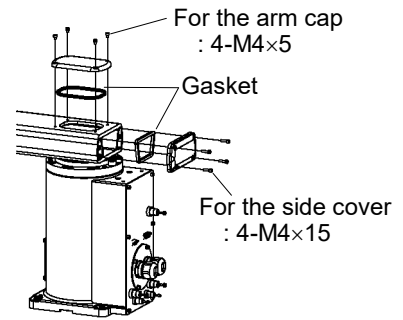
3.3.2 G6-***D*/P* (Protected-model)

Arm side (Common part)

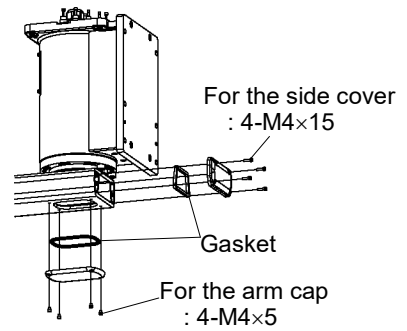


Base side

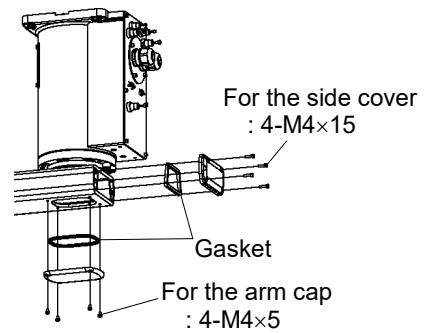
Table Top mounting



Wall mounting



Ceiling mounting



Gaskets are installed to G6-***D*, P* (Protected-model).

3.4 Connector Plate



CAUTION

- 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.

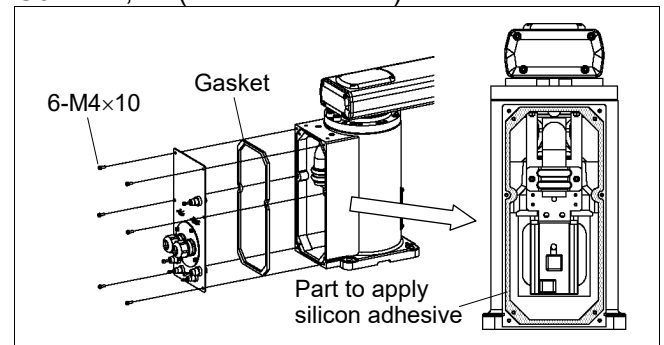
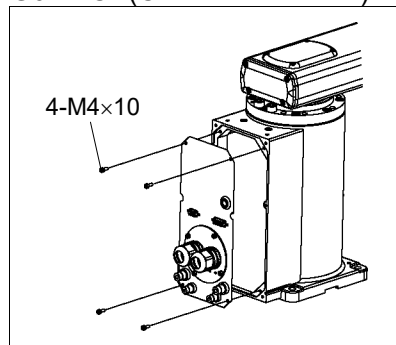
Unscrew the connector plate mounting bolts and remove the plate.

G6-***S* (Standard-model)

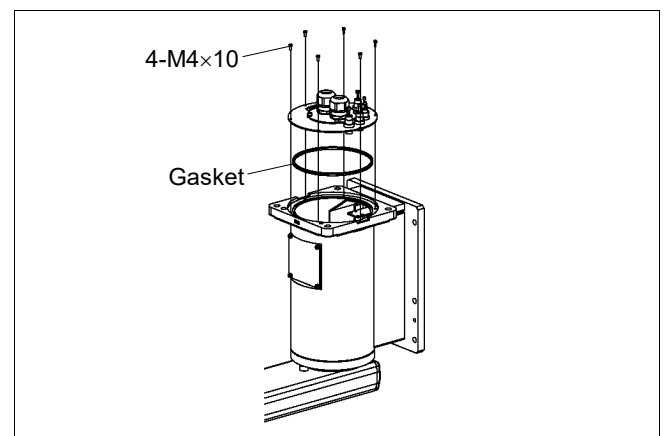
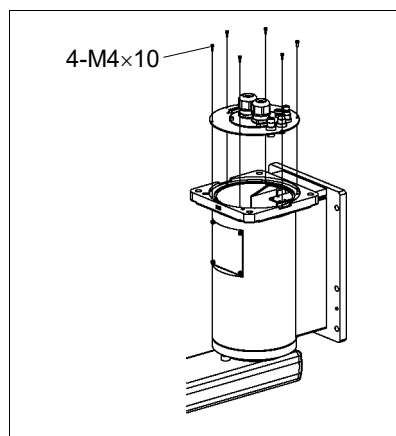
G6-***C* (Cleanroom-model)

G6-***D*, P* (Protected-model)

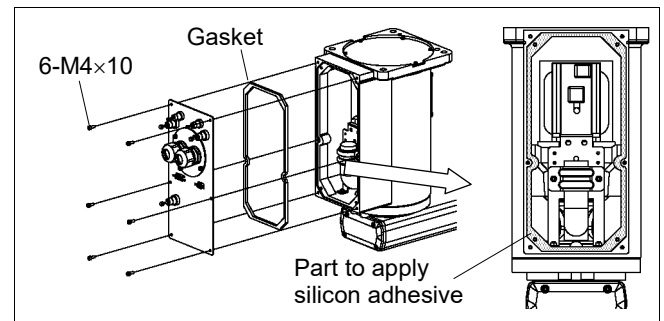
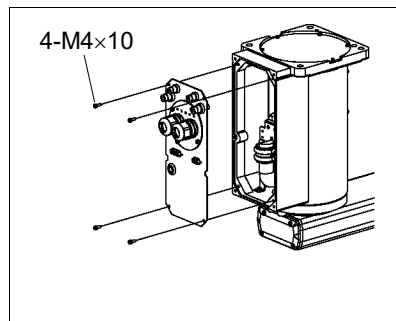
Table
Top
mounting



Wall
mounting



Ceiling
mounting



A gasket is installed to G6-***D*, P* (Protected-model).

NOTE

When installing the gasket to Table Top mounting (G6-***D, P) or ceiling mounting (G6-***DR, PR), apply silicon adhesive to the gasket installing part on the base side (shaded part in the photo).

3.5 Connector Sub Plate



- Do not remove the connector sub plate forcibly. Removing the connector sub 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 sub 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 sub plate. Be sure to place the cables back to their original locations.

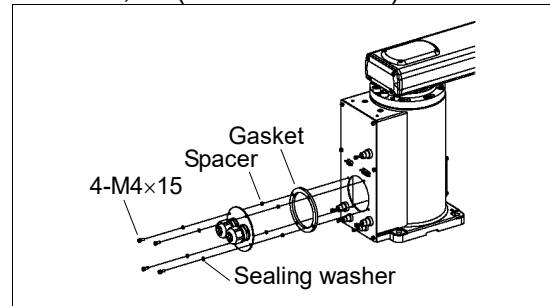
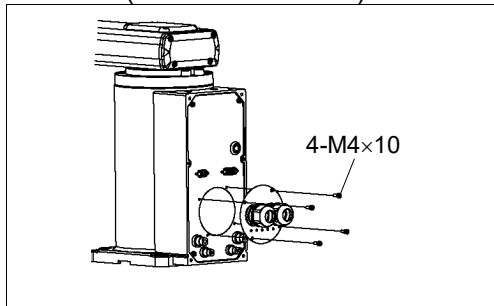
Unscrew the connector sub plate mounting bolts and remove the plate.

G6-***S* (Standard-model)

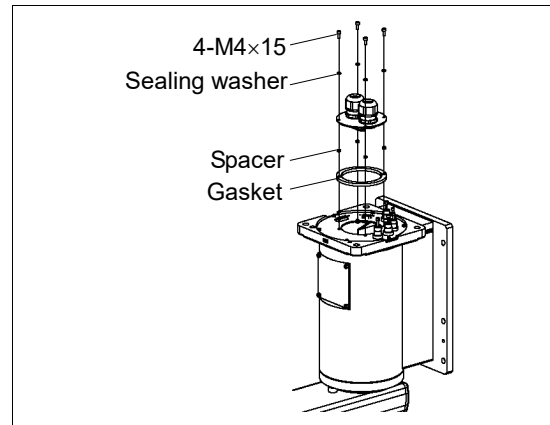
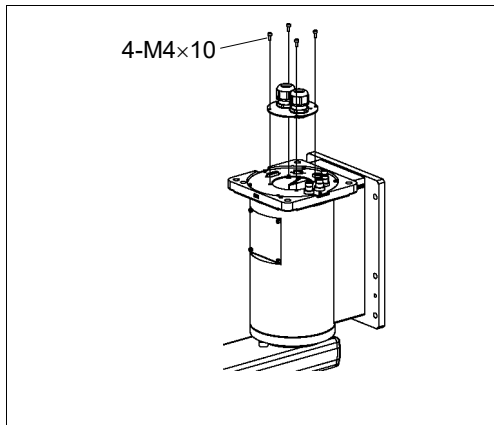
G6-***C* (Cleanroom-model)

G6-***D*, P* (Protected-model)

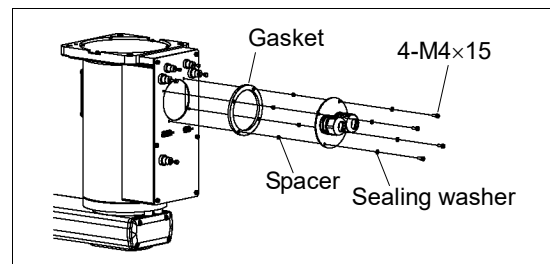
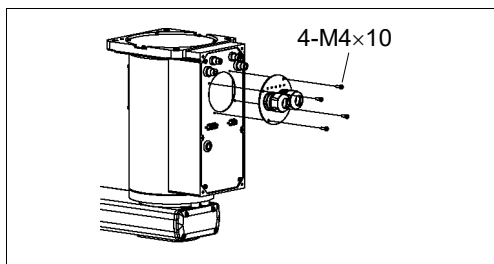
Table Top mounting



Wall mounting



Ceiling mounting



A gasket, spacers, and sealing washers are installed to G6-***D*, P* (Protected-model).

3.6 User Plate

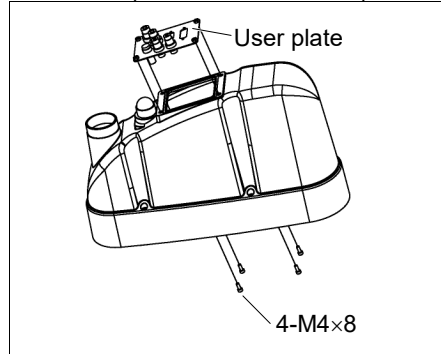
Unscrew the user plate mounting bolts and remove the plate.



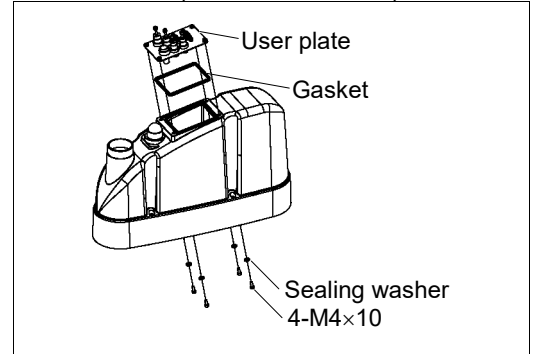
Do not remove the nut by force. The nut for the user plate is combined with the user plate. And if you try to remove the nut, it will damage the user plate.

G6-***S* (Standard-model)

G6-***C* (Cleanroom-model)



G6-***D*, P* (Protected-model)



A gasket and sealing washers are installed to G6-***D*, P* (Protected-model).

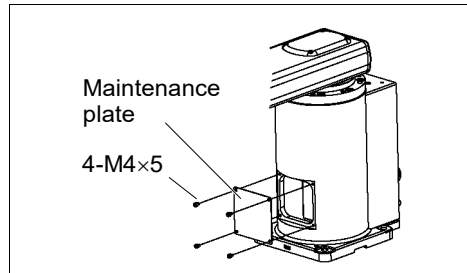
3.7 Maintenance Plate

Unscrew the maintenance plate mounting bolts and remove the plate.

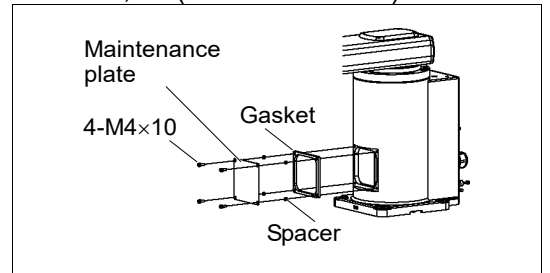
G6-***S* (Standard-model)

G6-***C* (Cleanroom-model)

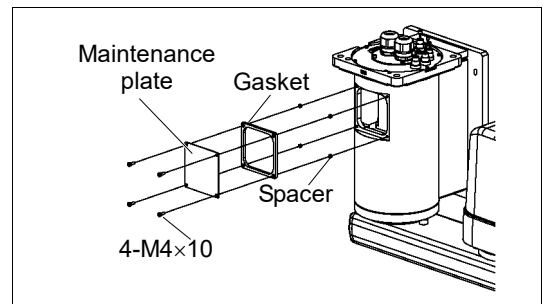
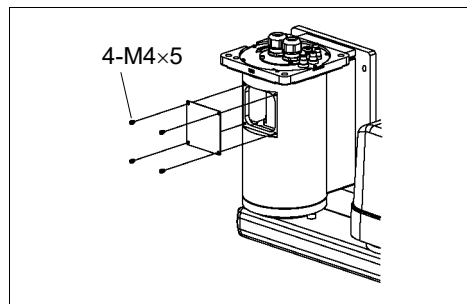
Table Top mounting



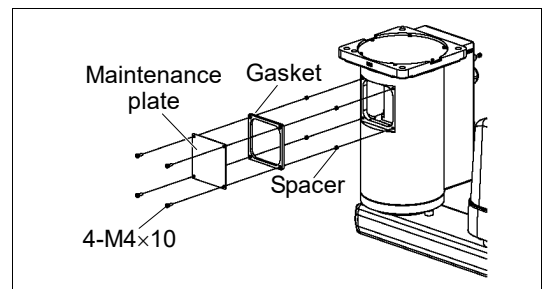
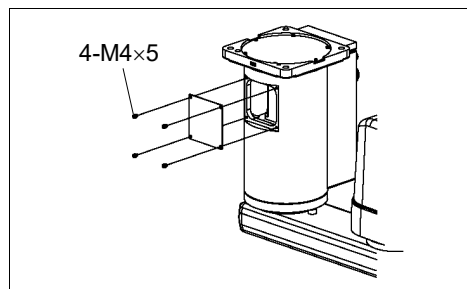
G6-***D*, P* (Protected-model)



Wall mounting



Ceiling mounting

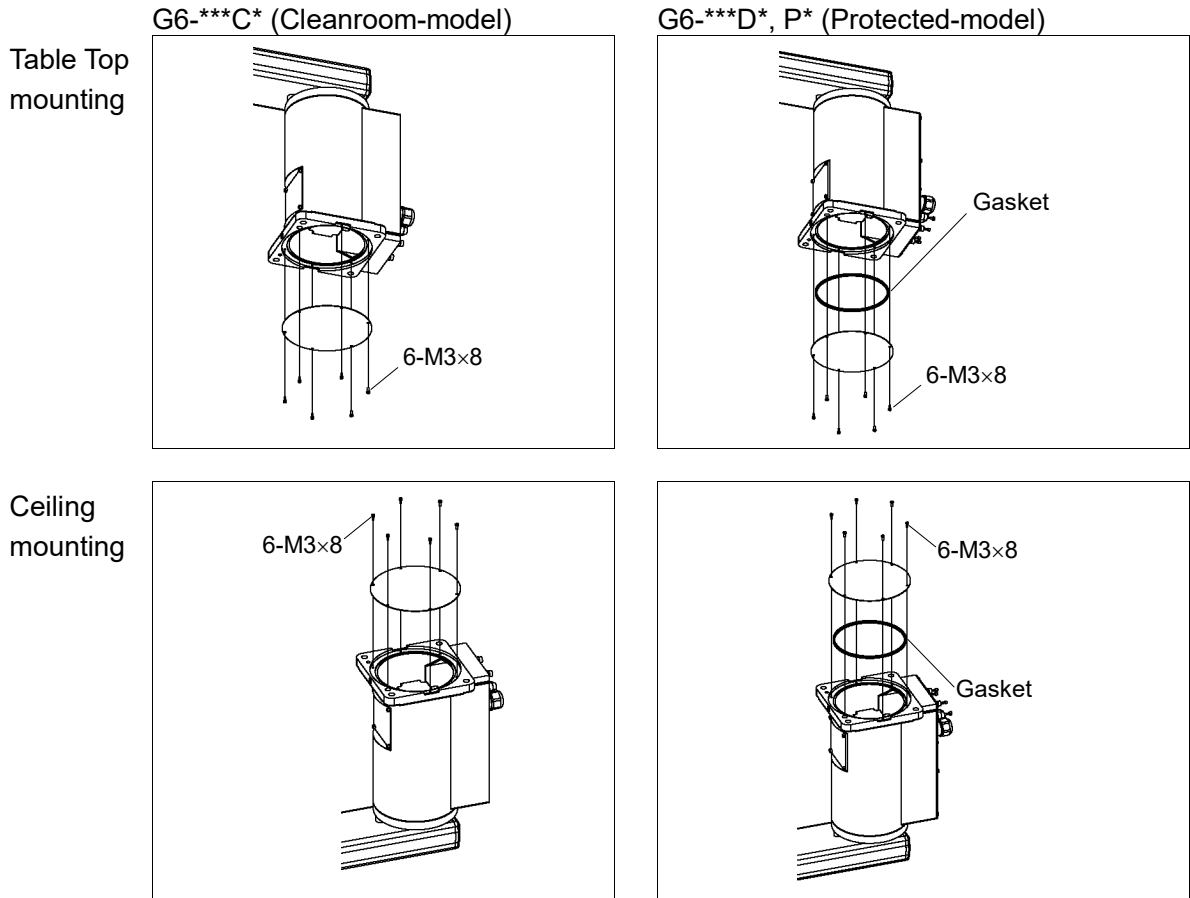


A gasket and spacers are installed to G6-***D*, P* (Protected-model).

3.8 Base Bottom Cover

The base bottom cover is removed only when replacing the gasket unit.

Unscrew the base bottom cover mounting bolts and remove the cover.



NOTE


A gasket is installed to G6-***D*, P* (Protected-model).

A base bottom cover is not installed to G6-***S* (Standard-model).

4. Cable



- 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 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.

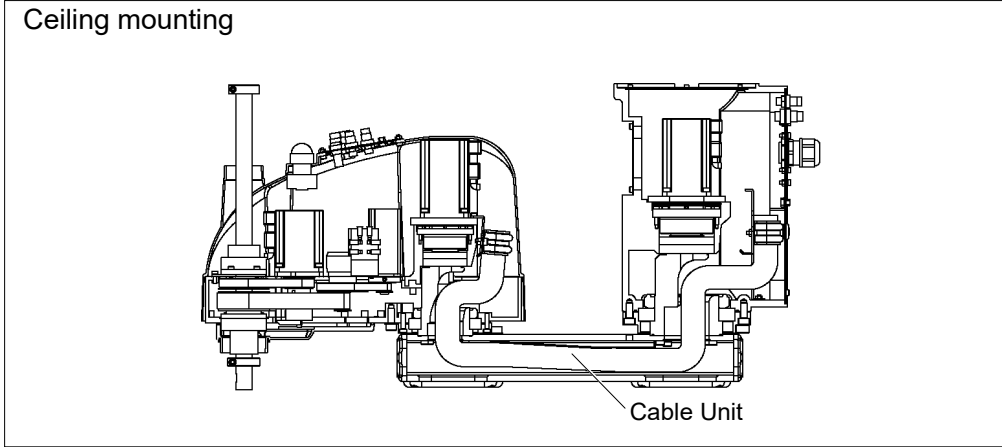
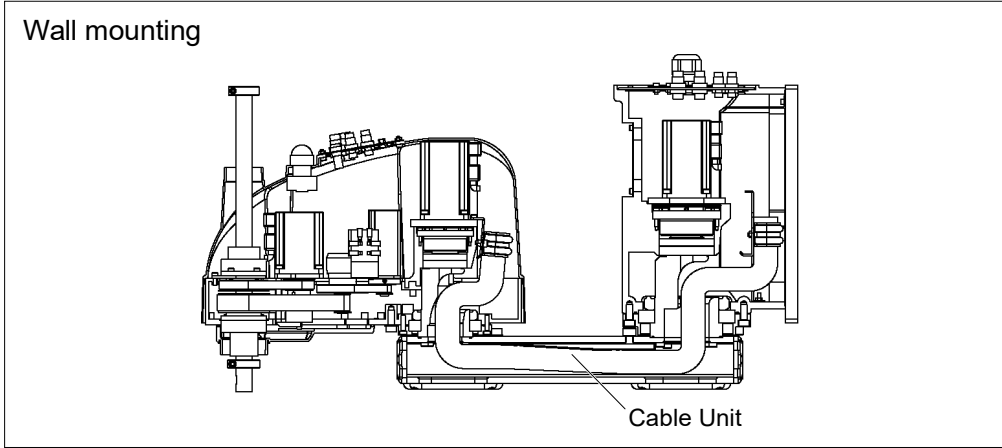
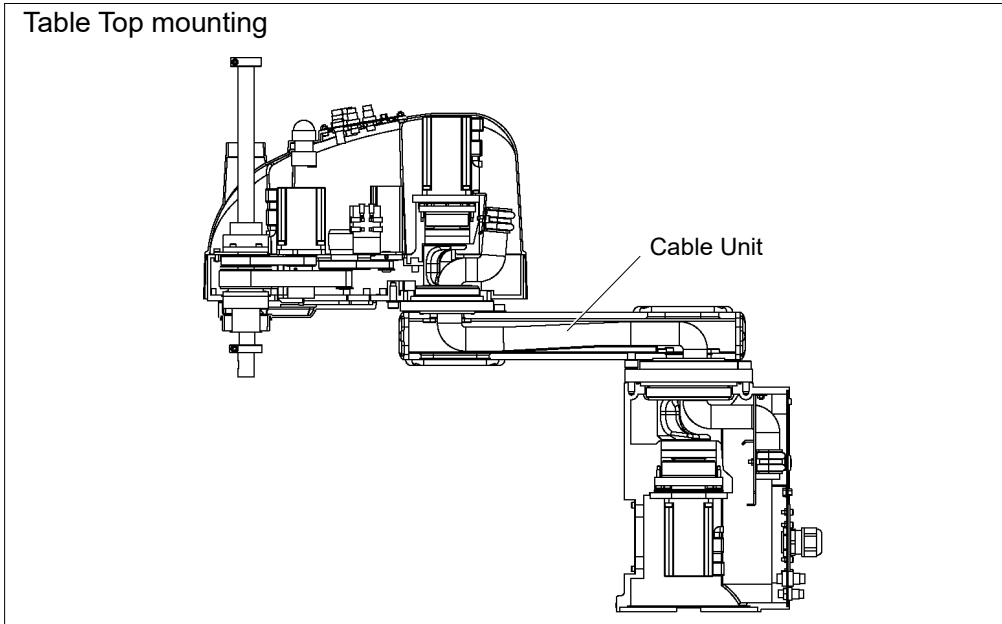
4.1 Replacing Cable Unit


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.

For details of the calibration, refer to 13. *Calibration*.

	Name		Quantity	Note
Maintenance parts	Cable unit		1	Each manipulator model (Refer to 14. G6 Maintenance parts)
	Battery Unit (Lithium battery)		1	2117879
Tools	Hexagonal wrench	width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
		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		9	
Grease	Grease for cable (GPL-224)			



 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>4.2 Wiring Diagrams</i>. ■ When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations. ■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
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Cable unit
Removal

- (1) Turn ON the Controller and change the motor to OFF status (MOTOR OFF).
- (2) Press and hold the brake release switch to let the shaft down. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch affects both Joints #3 and #4. When the brake release switch is pressed, the brakes for both Joints #3 and #4 are released simultaneously. (Joint #4 brake is installed to G6-**3** only.)

Be careful of the shaft falling or rotation while the brake release switch is being pushed because it may be lowered by the weight of an end effector.
- (3) Turn OFF the Controller and disconnect the power cable and signal cable connectors from the controller.
- (4) Remove the connector plate.
For details, refer to *3.4 Connector Plate*.
- (5) Connect the spare battery to connector XB11.
 - The position data of Joint #1 motor is stored with the battery on Arm #2. Connect the spare battery otherwise the Joint #1 position data will be lost.
- (6) Disconnect the connectors, air tubes, ground wire, D-sub cable, and seven connectors (X10, X20, X30, X111, X121, X131, XB10) connected to the connector plate (inner side).

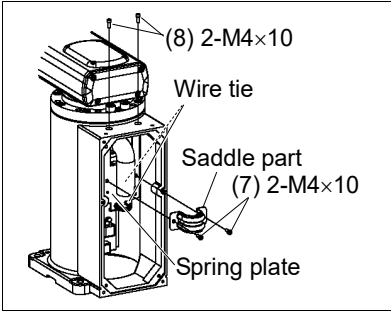


- Remember the cable layout so that the cables can be reconnected correctly after replacement.

- (7) The procedure of step (7) differs by mounting types.
Follow the corresponding procedure.

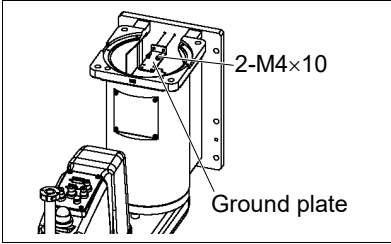
When using Table Top mounting type or Ceiling mounting type

- (7)-1 Remove the saddle part mounting cables inside the base.
- (7)-2 Remove the spring plate.
- (7)-3 Cut off the two wire ties binding cables.

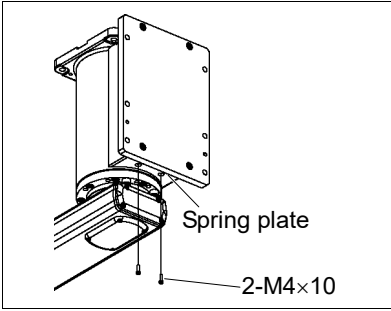


When using Wall mounting type

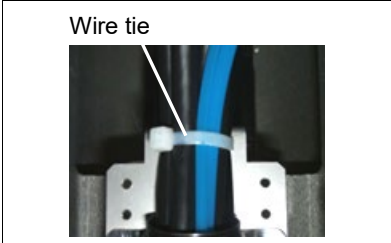
- (7)-1 Remove the ground plate.



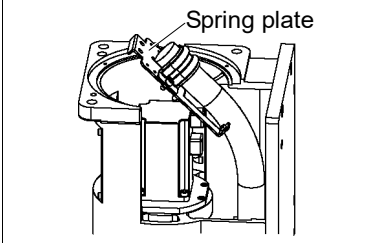
- (7)-2 Remove the spring plate.



- (7)-3 Cut the wire tie banding the cables.

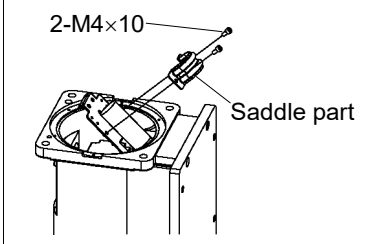


- (7)-4 Pull out the spring plate.



- (7)-5 Remove the saddle part mounting the cables.

- (7)-6 Cut the wire tie banding the spring.



(8) Remove the arm caps and side covers on Arm #1.
For details, refer to 3.3 Arm #1 Cover.

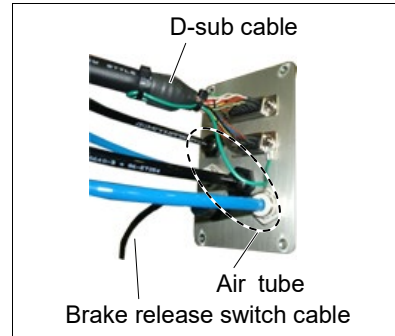
(9) Remove the arm top cover.
For details, refer to 3.1 Arm Top Cover.

(10) Remove the user plate.
For details of user plate removal, refer to 3.6 User Plate.

(11) Disconnect the D-sub cable, air tubes, and connector of the brake release switch from the user plate.

Mounting screws for the D-sub cable are very small. Be sure to keep the screws.

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

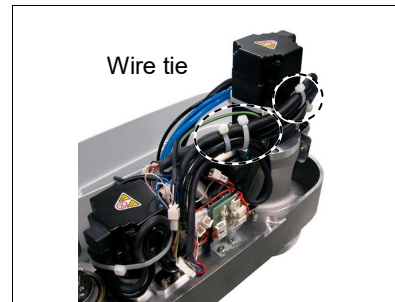


NOTE Be sure to observe the connection for connecting the disconnected parts after replacement.

(12) Cut off the wire tie binding cables on the Arm #2 side.

(13) Remove the 11 connectors on the Arm side.

X21, X22, X31, X32, X33, X41, X42, X61, X221, X231, X241

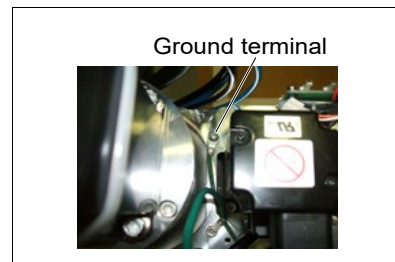


NOTE Be sure to keep the connectors excluding X61 of the battery board connected at cables replacement. Otherwise, the motor will lose position data and the calibration must be executed again.

(14) Remove the ground terminals mounted to Arm #2.

NOTE Record the connection terminal and the connection point before disconnect the ground terminal.

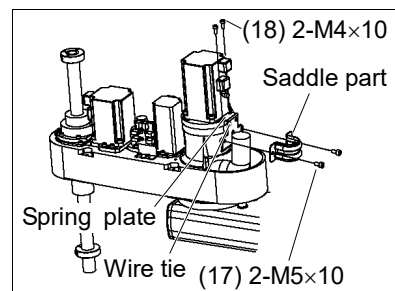
G6-***S*, C*: 2 terminals
G6-***D*, P*: 3 terminals



(15) Remove the saddle part mounting cables inside Arm #2.

(16) Remove the spring plate.

(17) Cut off the wire ties binding cable and fixing spring.



(18) Disconnect the Base side cables from Arm #1.

Table Top mounting

: Disconnect from the upper part of Arm #1

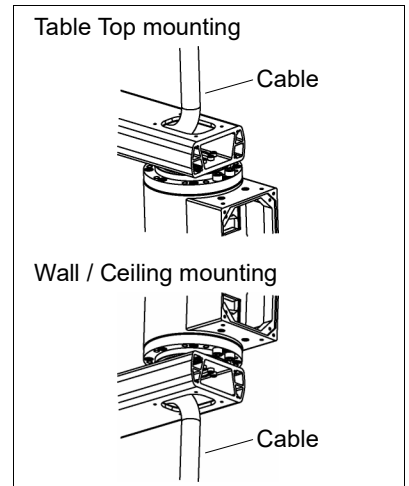
Wall mounting, Ceiling mounting

: Disconnect from the lower part of Arm #1

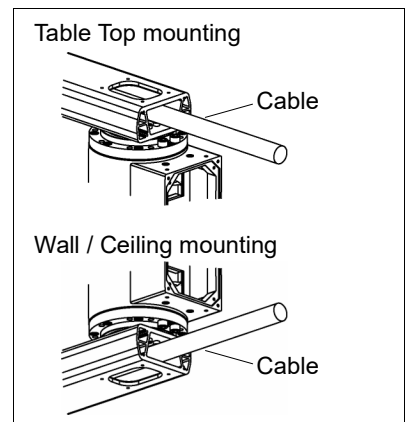


When disconnecting the cables, first, disconnect the air tubes. Then, disconnect from the smaller connectors in order.

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



(19) Disconnect the cables that were disconnected from Arm #1 in step (18) to the side of Arm #1.

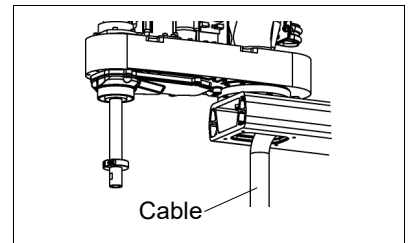


(20) Disconnect the Arm #2 side cables from the lower part of Arm #1.

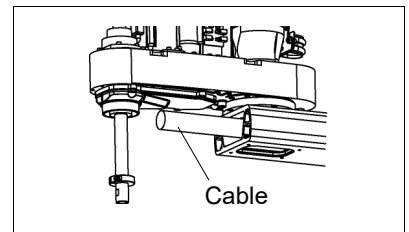


When disconnecting the cables, first, disconnect the air tubes. Then, disconnect from the smaller connectors in order.

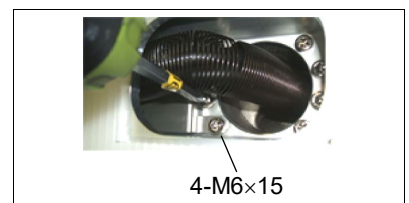
Do not try to disconnect the cables forcibly. Otherwise, connectors may be stuck, disconnected, or connector pins may fall off.



(21) Disconnect the cables that were disconnected to the lower part of Arm #1 in step (20) to the side of Arm #1.



(22) Remove the Arm #1 four mounting bolts on the spring plate side.



(23) Disconnect the cables to the base side.

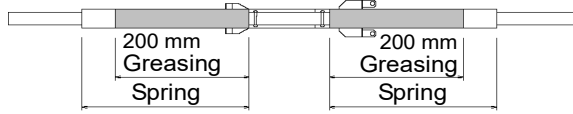


When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

Cable unit
Installation

- (1) Apply grease (GPL-224) to the cables.

Grease volume: 5 g each (10 g in total)



Applying positions

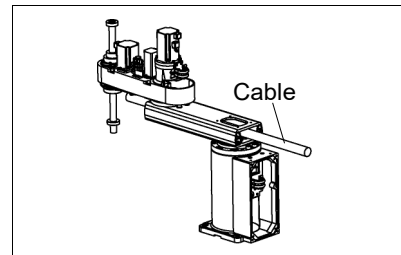
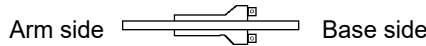
- Each cable inside the spring
- Air tube
- Periphery of spring (shaded part)

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

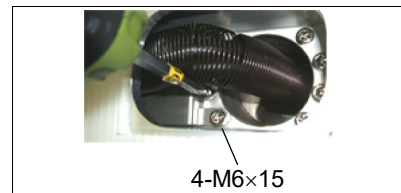
The plastic bags prevent grease adhesion to the ends of connectors and air tubes during the cable drawing.



- (3) Connect the cables to Arm #1 in the proper direction.

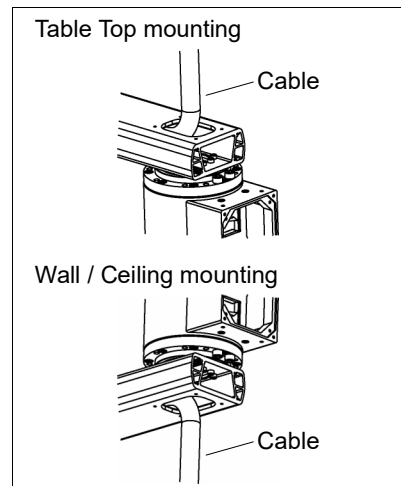


- (4) Set the mounting holes of the spring plate to the base side and mount the spring plate to Arm #1.



- (5) When using Table Top mounting, disconnect the base side cables to the upper part of Arm #1 and pull the cables into the base.

When using Wall mounting or Ceiling mounting, disconnect the base side cables to the lower part of Arm #1 and pull the cables into the base.

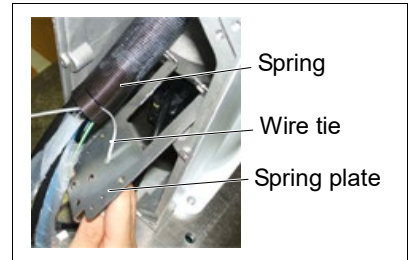


(6) The procedure of step (6) differs by mounting types.

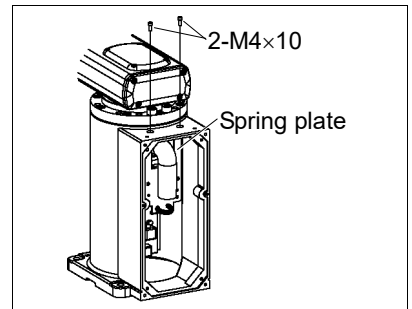
Follow the corresponding procedure.

When using Table Top mounting type or Ceiling mounting type

(6)-1 Mount the spring for cable protection to the spring plate with a wire tie.



(6)-2 Mount the spring plate to the base.

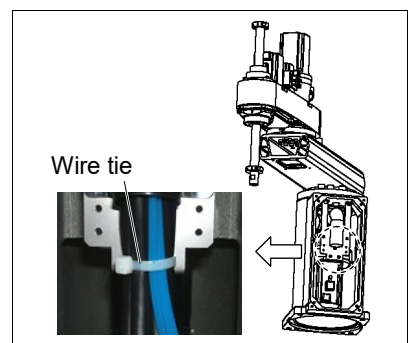


(6)-3 Move Arm #1 to the right or left until the arm touches the mechanical stop to make allowance.

Then, band the cables and air tubes with a wire tie.

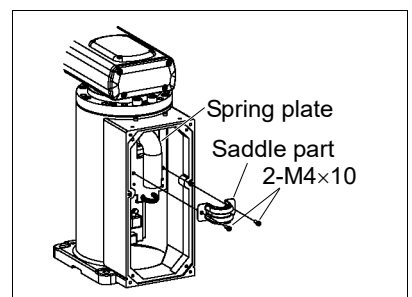


NOTE If you band the cables and tubes without allowance, the cables are pulled and may be disconnected during the robot operation. Make sure to make allowance.



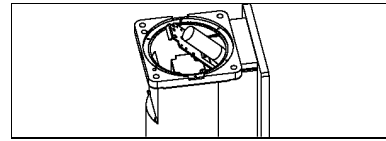
(6)-4 Remove the plastic bags on the base side applied in step (2).

(6)-5 Mount the saddle part to the spring plate.

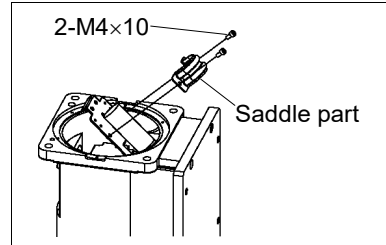


When using Wall mounting type

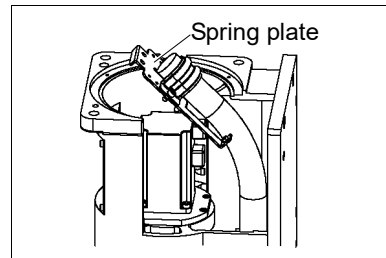
(6)-1 Pull out the spring and mount it to the spring plate with a wire tie.



(6)-2 Mount the saddle part to mount the cables.



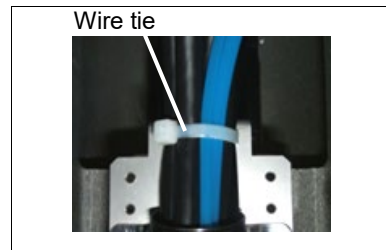
(6)-3 Loosely band the cables with a wire tie. Be sure to keep the wire tie loose enough so that the cables move.



(6)-4 Move Arm #1 to the right or left until the arm touches the mechanical stop to make allowance. Then, band the cables and air tubes with a wire tie.

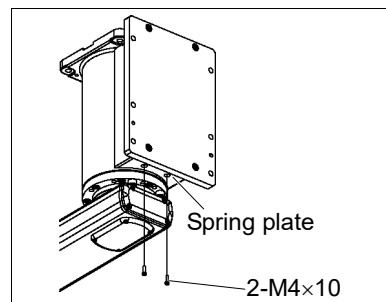
NOTE


If you band the cables and tubes without allowance, the cables are pulled and may be disconnected during the robot operation. Make sure to make allowance.

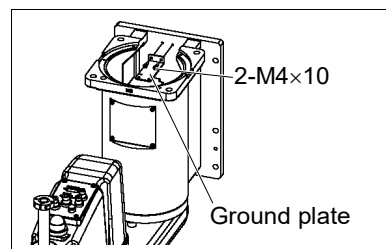


(6)-5 Remove the plastic bags on the base side applied in step (2).

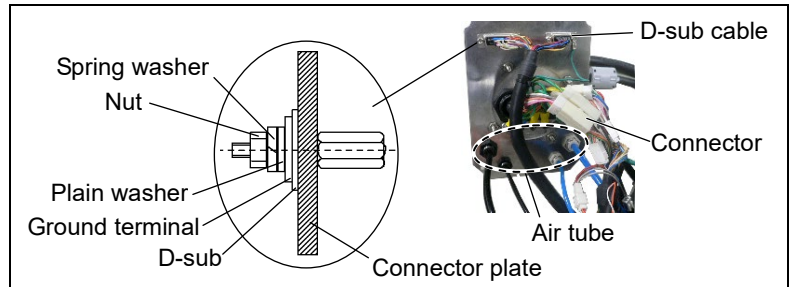
(6)-6 Mount the spring plate.



(6)-7 Mount the ground plate.

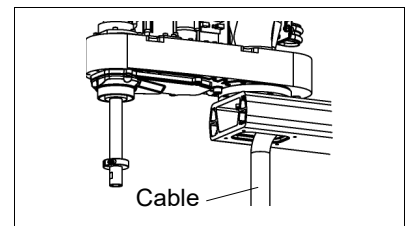


- (7) Connect the connectors, air tubes, D-sub cable, and connectors to the connector plate (inner side).

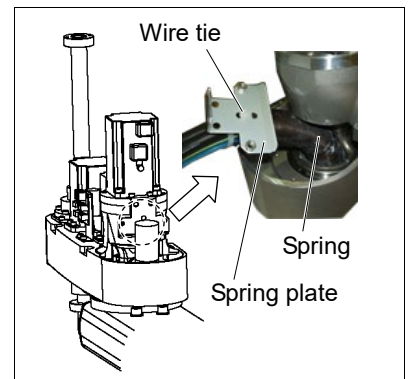


- (8) Loosely mount the connector plate with two screws (M4).
For details, refer to 3.4 Connector Plate.

- (9) Disconnect the Arm #2 side cables to the lower part of Arm #1 and pull the cables into Arm #2.



- (10) Mount the spring for cable protection to the spring plate with a wire tie.
Secure the spring plate to Arm 2.

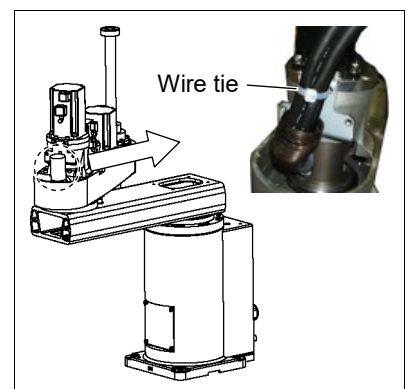


- (11) Move Arm #2 until the arm touches the mechanical stop to make allowance.

Then, band the cables and air tubes with a wire tie.

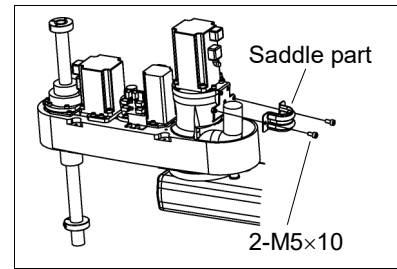


If you band the cables and tubes without allowance, the cables are pulled and may be disconnected during the robot operation. Make sure to make allowance.



- (12) Remove the plastic bags on the Arm side applied in step (2).

(13) Mount the saddle part to the spring plate.

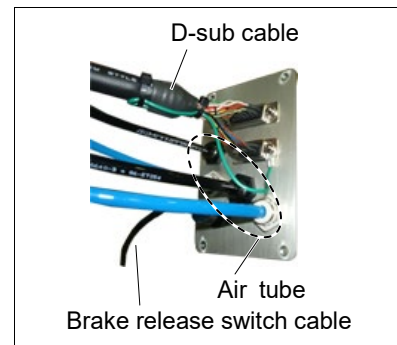


(14) Connect the connectors and the ground wire.

For details, refer to 4.2 *Wiring Diagrams*.

(15) Bind the excess cables with a wire tie.

(16) Connect the D-sub cable, air tubes, and connector of the brake release switch cable to the user plate.



(17) Mount the user plate to the Arm #2 cover.

For details of user plate installation, refer to 3.6 *User Plate*.


(18) Set and secure the Arm #2 cover without the cables being stuck.

For details, refer to 3.1 *Arm Top Cover*.

(19) Mount the arm caps and side covers for Arm #1.

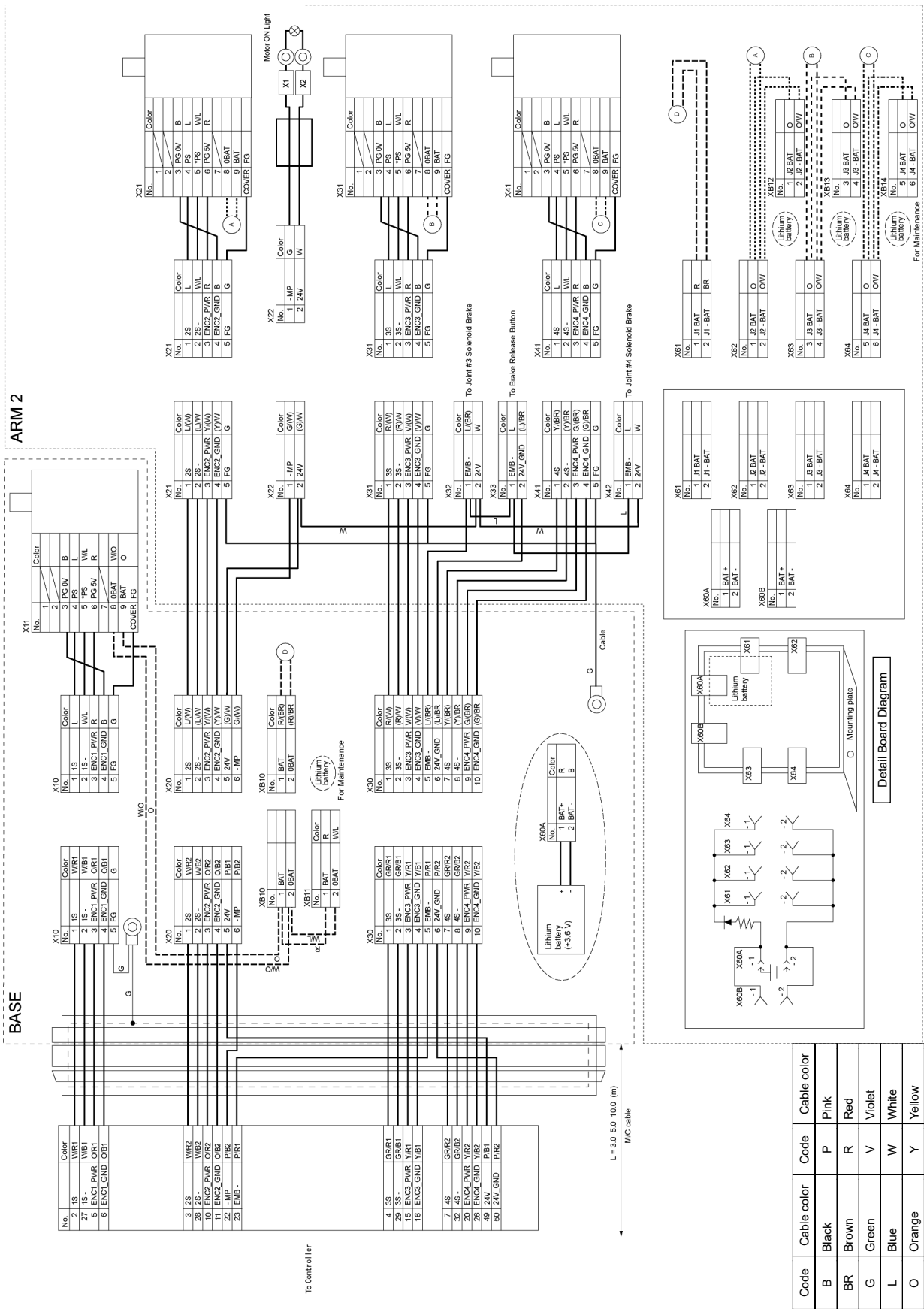
For details, refer to 3.3 *Arm #1 Cover*.

(20) Remove the connector plate mounted loosely in the step (8) and remove the spare battery in the XB11. Then, mount the connector plate.

NOTE  In this replacement method, calibration is not needed. However, perform the calibration if it is required.

4.2 Wiring Diagrams

4.2.1 Signal Cable



4.2.3 User Cable

J-sub 9pin		D-sub 9pin	
No.	Color	No.	Color
1	R/(BR)	1	R/(BR)
2	(R)/BR	2	(R)/BR
3	V/(BR)	3	V/(BR)
4	(V)/BR	4	(V)/BR
5	L(B)	5	L(B)
6	(L)/B	6	(L)/B
7	Y(B)	7	Y(B)
8	(Y)/B	8	(Y)/B
9	(G)/BR	9	(G)/BR

J-sub 15pin		D-sub 15pin	
No.	Color	No.	Color
1	L(W)	1	L(W)
2	(L)/W	2	(L)/W
3	Y(W)	3	Y(W)
4	(Y)/W	4	(Y)/W
5	G(W)	5	G(W)
6	(G)/W	6	(G)/W
7	R(W)	7	R(W)
8	(R)/W	8	(R)/W
9	V(W)	9	V(W)
10	(V)/W	10	(V)/W
11	L(BR)	11	L(BR)
12	(L)/BR	12	(L)/BR
13	Y(BR)	13	Y(BR)
14	(Y)/BR	14	(Y)/BR
15	G(BR)	15	G(BR)



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 use cable.

Environment	Arm length	Code	Note
S, C	450 mm	1497631	
	550 mm	1497632	
	650 mm	1497633	
P, D	450 mm	1497634	Waterproof connector
	550 mm	1497635	
	650 mm	1497636	

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.



If the connector connected to the battery was disconnected during cable replacement, execute calibration.

For details, refer to *13. Calibration*.

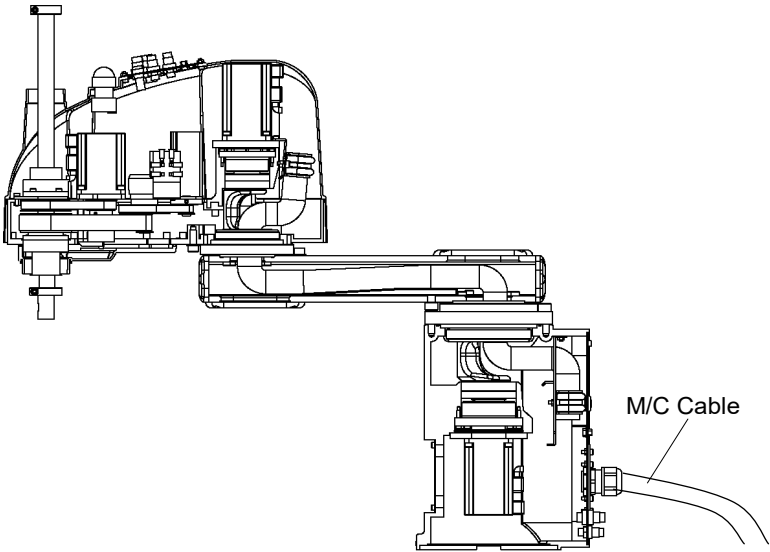
	Name	Quantity	Note
Maintenance parts	M/C Cable	1	Each manipulator model (Refer to: <i>14. G6 Maintenance parts</i>)
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Torque wrench	1	



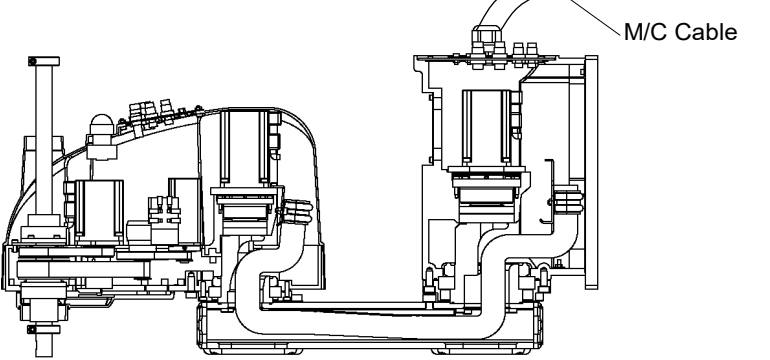
CAUTION

- 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 *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.

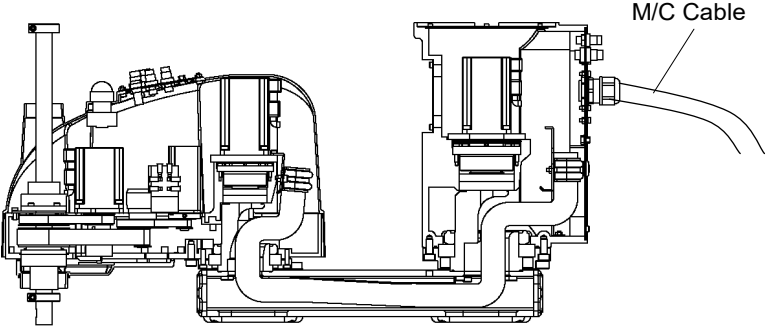
Table Top mounting



Wall mounting



Ceiling mounting



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 Sub Plate.
For details, refer to *3.5 Connector Sub Plate*.



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

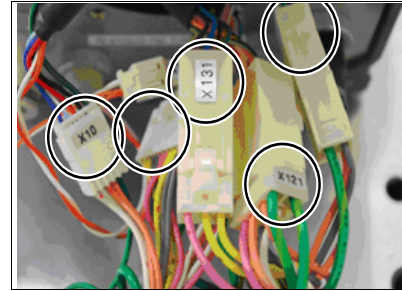
- (4) Disconnect the connectors.
Connector: X10, X20, X30, X111, X121, X131



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



NOTE Do not disconnect the battery connector (XB10).
Otherwise, the calibration must be executed.



M/C Cable
Installation

- (5) Connect new M/C cable connectors to those of the Cable Unit.
(Connect to the connectors of the Cable Unit with the same number.)
- (6) Mount the Connector Sub Plate.
For details, refer to *3.5 Connector SubPlate*.
- (7) Connect the power cable and signal cable connectors to the controller.
- (8) Turn ON the Controller.
- (9) If the connector (XB10) falls off from the battery, execute the calibration for Joint #1.
For details, refer to *13 Calibration*.

5. Joint #1



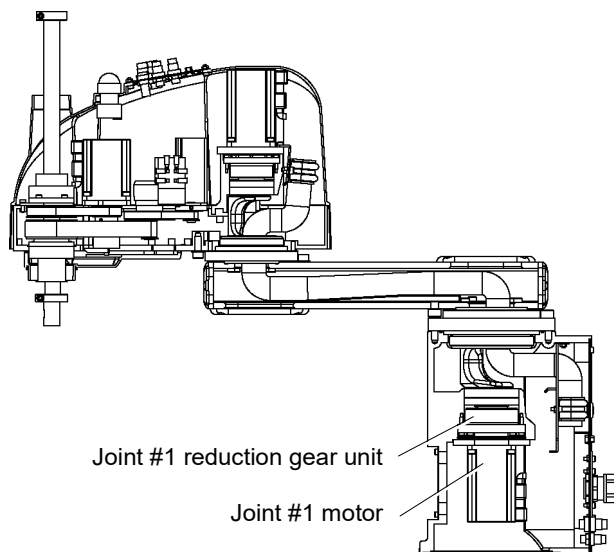
- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric 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 13. *Calibration* to perform the calibration.



5.1 Replacing Joint #1 Motor

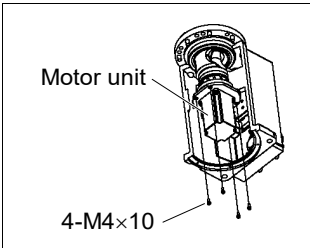
	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (400 W)	1	1497624	
			1514468 (For S/N:1**** or later)	
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw, M3 screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Wiping cloth	1	For wiping grease	
Grease	Grease (SK-1A)	13 g		

Joint #1 motor Removal

- (1) Remove the connector plate.
For details, refer to 3.4 Connector Plate.
- (2) Disconnect the following connectors.
Connectors X111, X10 (Hold the clip to remove.)
Connector XB10
- (3) Remove the maintenance plate.
For details, refer to 3.7 Maintenance Plate.
- (4) Remove the spring plate.
For the details, refer to 4.1 Replacing Cable Unit - Cable unit Removal Step (7)-2 for Table mounting, Ceiling mounting.

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

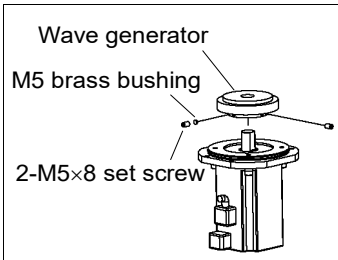
To do so, unscrew the bolts from the Joint #1 motor flange. Then, pull out the motor straight and downward. To unscrew the two bolts on the maintenance hole side, insert a hexagonal wrench through the maintenance hole.



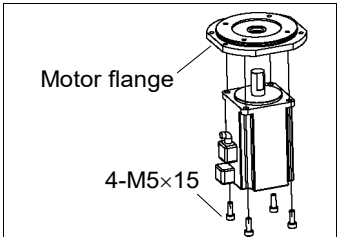
If the motor cannot be pulled out easily, pull it out while moving Arm #1 slowly by hand.

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

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



Remove the motor flange from the Joint #1 motor.

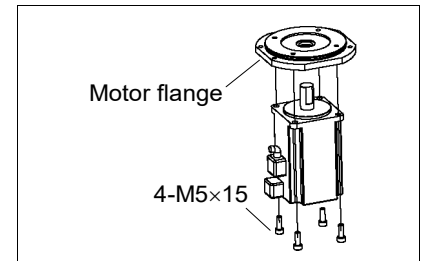




When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

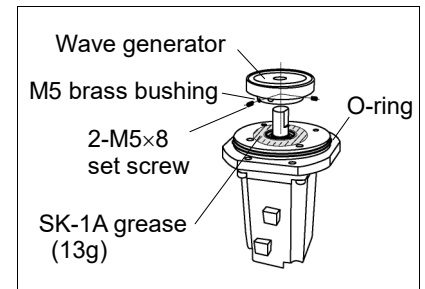
Joint #1 motor Installation

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



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

Apply grease without touching the motor axis. Be sure to fit the end face of the waveform generator to 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.



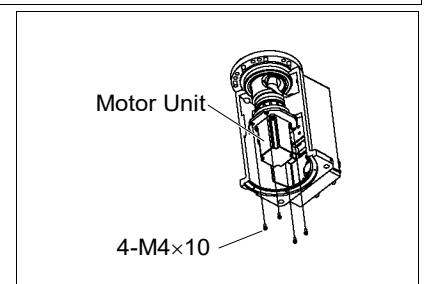
- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

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

Be sure to fit the O-ring properly.

The motor cable must face the connector plate side.

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



- (4) Connect the connectors.
Connectors X111, X10, XB10
- (5) Mount the spring plate.
For the details, refer to 4.1 Replacing Cable Unit - Cable unit Installation Step (6)-2 for Table mounting, Ceiling mounting.
- (6) Mount the connector plate.
For details, refer to 3.4 Connector Plate.
- (7) Mount the maintenance plate.
For details, refer to 3.7 Maintenance Plate.
- (8) Perform the calibration of Joint #1.
For details refer to 13. Calibration.

5.2 Replacing Joint #1 Reduction Gear Unit

A reduction gear unit consists of the following three parts and two attached parts. At replacing the reduction gear unit, be sure to always replace them all together as one set.

Reduction gear unit : Waveform generator, Flexspline, Circular spline

Attachment : Spacer, Grip ring

For details of the reduction gear unit, refer to 14. *Maintenance parts list.*

	Name		Quantity	Note
Maintenance Parts	Reduction Gear Unit		1	1480755
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	
		width across flats: 5 mm	1	For M6 screw
	Torque wrench	M4	1	Tightening torque 6.0 N·m (61.2 kgf·cm)
		M6	1	Tightening torque 22.0 N·m (224.3 kgf·cm)
	Nippers		1	
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Flange)
			1	For wiping grease (Bolt)
Screw (M4)		2	About 20mm in length For flexspline removal	
Grease	Grease (SK-1A)	40 g		

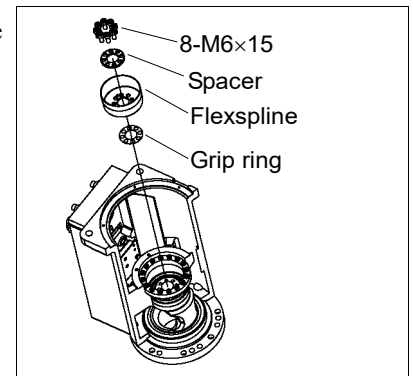
Joint #1
reduction gear
unit
Removal

- (1) Execute the removal steps from (1) to (5) in *5.1 Replacing Joint #1 Motor* and remove the waveform generator.
- (2) Remove the arm cap on the base side.
For details, refer to *3.3 Arm #1 Cover*.
- (3) Turn the Manipulator laterally.

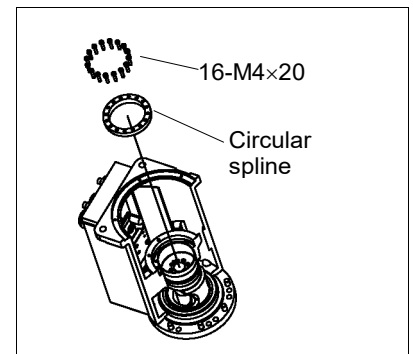


- When turning the Manipulator laterally, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot system.

- (4) Use the extracting M4 screws and remove the flexspline and the grip ring.
Be sure to keep the spacer.



- (5) Remove the circular spline from the base.

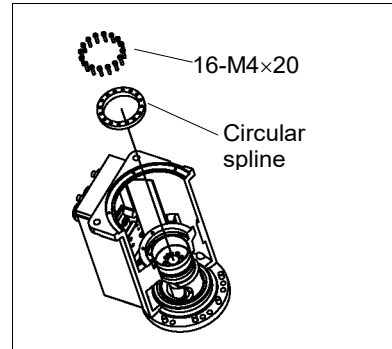


Joint #1
reduction gear
unit
Installation

- (1) A new reduction gear unit contains the parts shown in the picture on the right when it is unpacked.
- Apply grease (SK-1A) to the waveform generator and flexspline so that the gear surface is filled with grease.

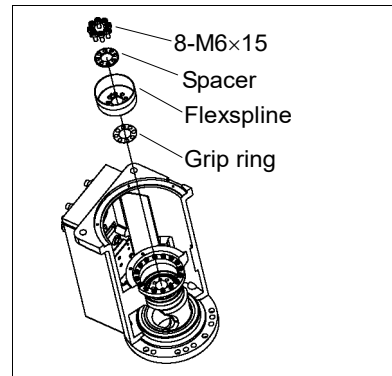


- (2) Set the hole on the circular spline and the tap hole on the base.
- Loosely secure all bolts in a crisscross pattern so that the bolts will be secured evenly. Then, using a torque wrench, tighten each bolt securely in a crisscross pattern at the torque specified in the table below.

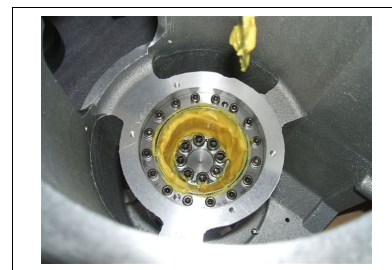


Item	Bolt type	Number of bolts	Tightening torque
Joint #1 reduction gear unit	M4x20	16	6.0 N·m (61.2 kgf·cm)
	M6x15	8	22.0 N·m (224.3 kgf·cm)

- (3) Set the grip ring by aligning it with the tap hole.
- Set the flexspline by aligning it with the tap hole.
- Align the position of the air vent of the spacer.



- (4) Apply grease (SK-1A) inside the flexspline.
- Grease volume 27 g



- (5) Apply grease (SK-1A) to the bearing part of the waveform generator.
- (6) Execute steps from (2) to (3) in 5.1 Replacing Joint #1 Motor.
- (7) Turn and secure the Manipulator to the mounting position.
- (8) Execute steps from (4) to (7) in 5.1 Replacing Joint #1 Motor.

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.

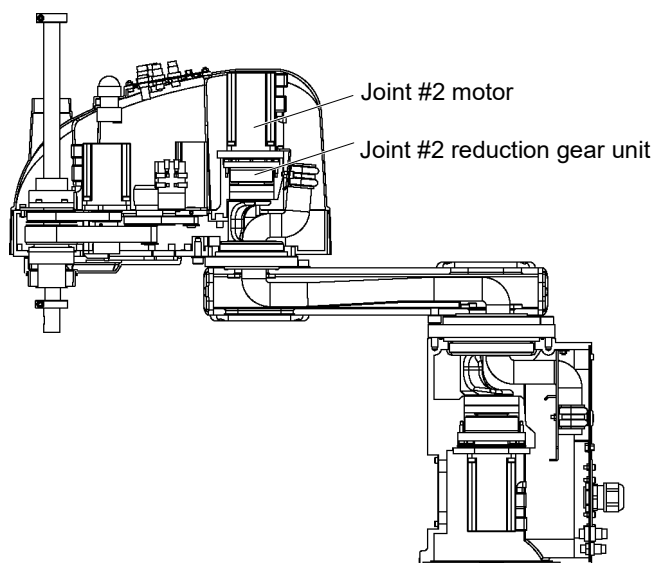


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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 *13. Calibration* to perform the calibration.



6.1 Replacing Joint #2 Motor

	Name	Quantity	Note	
Maintenance Parts	AC Servo Motor (400W)	1	1497624	
			1514468 (For S/N: 1**** or later)	
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 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	
	Wiping cloth	1	For wiping grease	
Material	Wire tie	4		
Grease	Grease (SK-1A)	6 g		

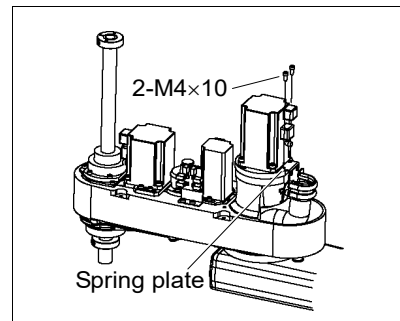
Joint #2 motor Removal

- (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.

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (Joint #4 brake is installed to G6-*** only.)

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.

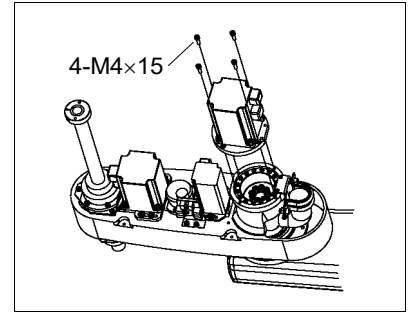
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover.
For details, refer to 3.1 Arm Top Cover.
- (5) Disconnect the connectors X22, X33 connected to the arm top cover.
- (6) Cut off the wire tie used for binding the motor cables to the Joint #2 motor.
- (7) Disconnect the connectors.
Connectors X221, X21 (Hold the clip to remove.)
Connector X62
- (8) Remove the spring plate.



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

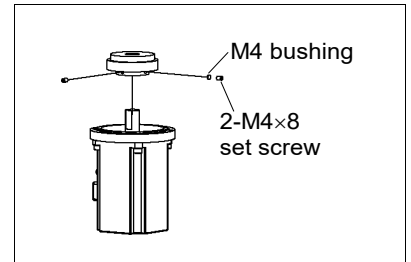
To do so, unscrew the bolts from the Joint #2 motor flange. Pull the Joint #2 motor unit upward to remove.

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

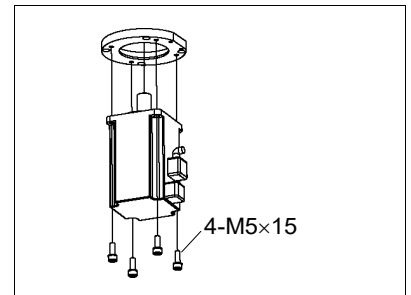


- (10) Remove the wave generator from the Joint #2 motor.

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



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

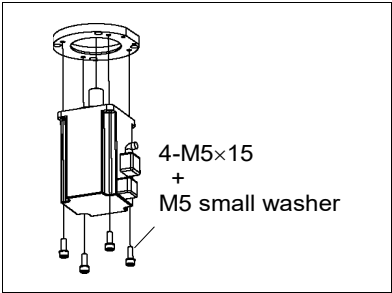




When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

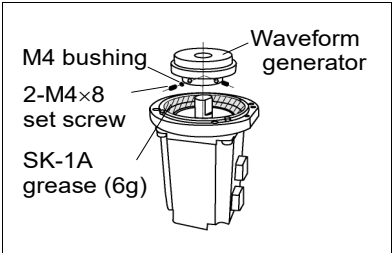
Joint #2 motor Installation

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



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

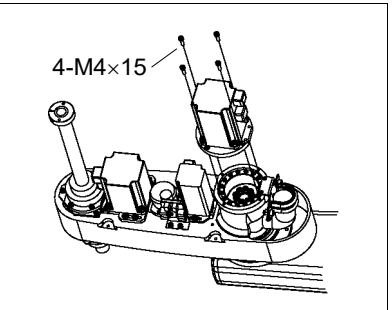
Apply grease without touching the motor axis. Be sure to fit the end face of the waveform generator to the end face of the motor shaft. Tighten one of the set screws on the flat face of the motor shaft until the screw just touches the surface. Insert a bushing into the other set screw hole to prevent damage to the motor shaft. Then, tighten both set screws.



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

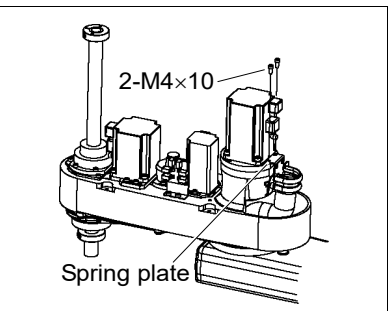
- (3) Mount the Joint #2 motor unit on Arm #2.

If it is difficult to mount the motor, push it while moving Arm #2 slowly by hand.



- (4) Mount the spring plate.
- (5) Connect the connectors X221, X21, and X62.
- (6) Re-bundle the cables in their original positions with a wire tie removed in the removal procedure step (6).

Do not allow unnecessary strain on the cables.



- (7) Make sure that the connectors X22 and X33 are connected.
- (8) Mount the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (9) Perform the calibration of Joint #2.
For details refer to *13. Calibration*.

6.2 Replacing Joint #2 Reduction Gear Unit

A reduction gear unit consists of the following three parts and two attached parts.

At replacing the reduction gear unit, be sure to always replace them all together as one set.

Reduction gear unit : Waveform generator, Flexspline, Circular spline

Attachment : Spacer, Grip ring

For details of the reduction gear unit, refer to 14. *Maintenance parts list*.

	Name		Quantity	Note
Maintenance parts	Reduction Gear Unit		1	1480756
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	Tightening torque 3.0 N·m (30.5 kgf·cm)
		M5	1	Tightening torque 12.0 N·m (122.3 kgf·cm)
	Nippers		1	
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Flange)
			1	For wiping grease (Bolt)
Screw (M3)		2	For flexspline removal	
Material	Wire tie		4	
Grease	Grease (SK-1A)		21 g	

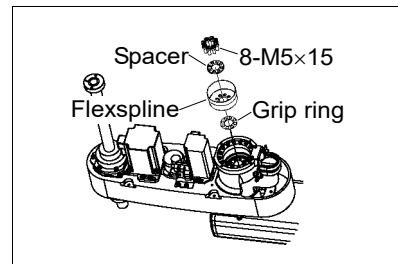
Joint #2
reduction gear
unit
Removal

- (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.

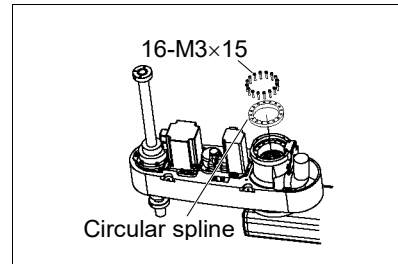
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (Joint #4 brake is installed to G6-*** only.)

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 OFF the Controller.
- (4) Execute steps from (1) to (10) in 6.1 Replacing Joint #2 Motor and remove the waveform generator from the Joint #2 motor.
- (5) Use the extracting M3 screws and remove the flexspline and grip ring from Arm #2.



- (6) Remove the circular spline from Arm #2.



Joint #2
reduction gear
unit
Installation

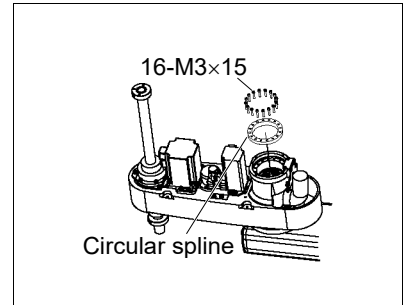
- (1) A new reduction gear unit contains the parts shown in the picture on the right when it is unpacked.



Apply grease (SK-1A) to the waveform generator and flexspline so that the gear surface is filled with grease.

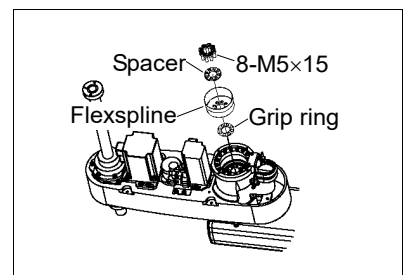
- (2) Set the hole on the circular spline and the tap hole on the base.

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.



Item	Bolt type	Number of bolts	Tightening torque
Joint #2 reduction gear unit	M3×15	16	3.0 N·m (30.5 kgf·cm)
	M5×15	8	12.0 N·m (122.3 kgf·cm)

- (3) Set the grip ring by aligning it with the tap hole.
Set the flexspline by aligning it with the tap hole.
Align the tap hole and mount the flexspline.
Align the position of the air vent of the spacer.
If it is difficult to align the position, move Arm #2 from side to side.




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


Grease volume 15 g



- (5) Apply grease (SK-1A) to the bearing part of the waveform generator.
(6) Execute steps from (2) to (9) in 6.1 Replacing Joint #2 Motor:

7. Joint #3

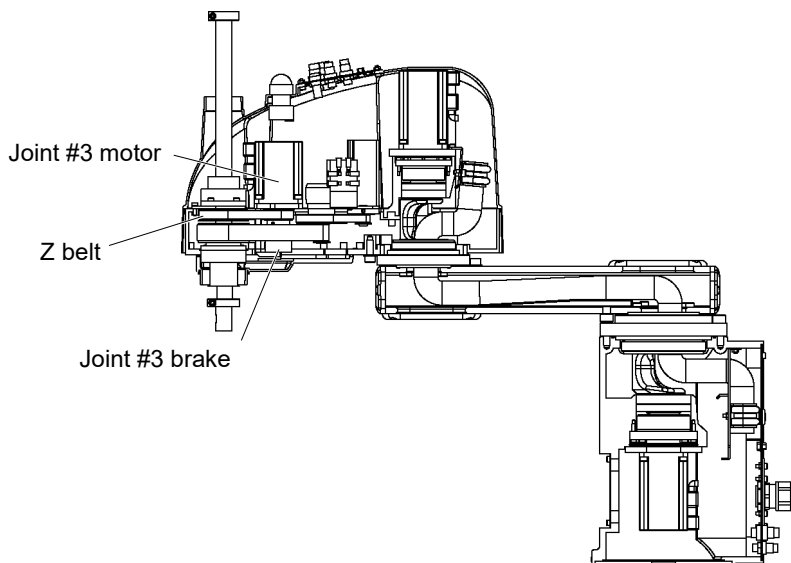
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move 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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 CAUTION	<ul style="list-style-type: none"> ■ 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.
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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 13. *Calibration* to perform the calibration.



7.1 Replacing Joint #3 Motor

	Name		Quantity	Note
Maintenance parts	AC Servo Motor (200W)		1	1497625
				1514451 (For S/N: 1**** or later)
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	Tightening torque 7.0 N·m (71.3 kgf·cm)
	Nippers		1	For cutting wire tie
	Force gauge		1	Belt tension 80 N (8.2 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		2	

A brake is mounted on the motor of Joints #3 and #4 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). (The brake for Joint #4 is only installed to G6-***3**.)

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 (3).

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.

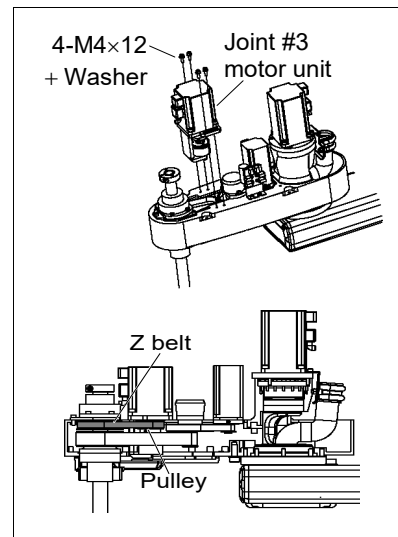
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

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 OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. Covers.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (6) Disconnect the following connectors.
Connectors X231, X31 (Hold the clip to remove.)
Connector X63

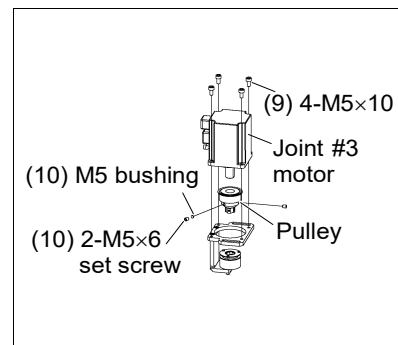
- (7) Loosen the Z belt.
Loosen four bolts on the Joint #3 motor unit. Slide the Joint #3 motor unit to the end of the arm.

- (8) Remove the Joint #3 motor unit from Arm #2.
Unscrew the bolts securing the Joint #3 motor unit. Remove the Z1 pulley from the Z belt. Pull the Joint #3 motor unit upward to remove.



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

- (10) Remove the pulley from the Joint #3 motor.
There is a brass bushing in one of the set screw holes. Be careful not to lose it.





When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

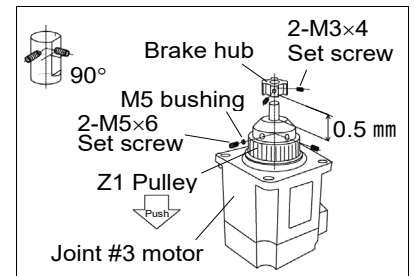
Joint #3 motor Installation

- (1) Secure the pulley to the new motor shaft.

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

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

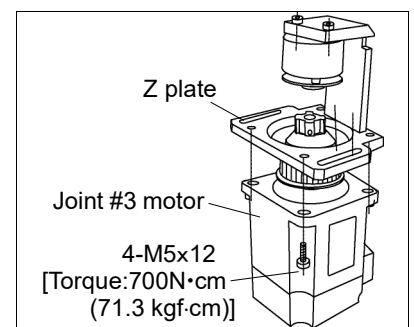
Insert a bushing into the other set screw hole to prevent damage to the motor shaft. Then, tighten both set screws.



- (2) Mount the Z plate to the Joint #3 motor.

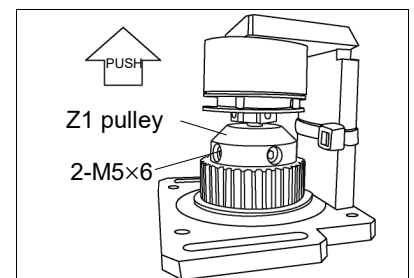
Screw : 4-M5x12

Tightening torque : 7.0 N·m (71.3 kgf·cm)



- (3) Loosen the screws securing the pulley.

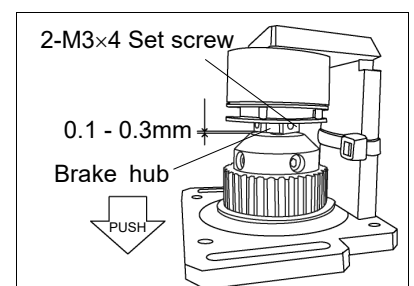
Push up the pulley to the brake and tighten the screw.



- (4) Loosen the screws securing the hub.

Push down the hub to the pulley side.

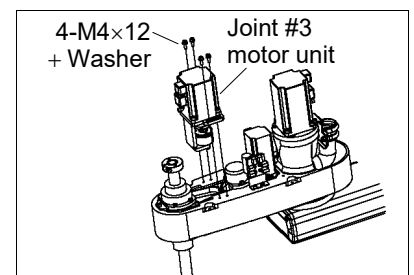
Tighten the screws with the space 0.1 - 0.3 mm between.



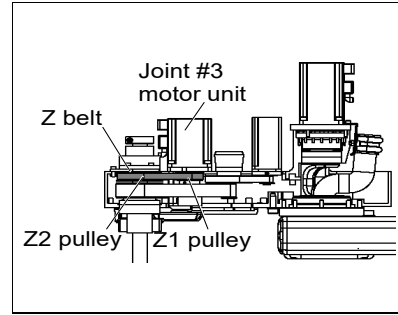
If the hub is secured with the space larger than 0.3 mm, the brake hub may interfere with the movable plate. This may grind the movable plate and cause metal powder.

- (5) Place the Joint #3 motor unit in the arm so that the motor cable faces toward the front of the arm.


Make sure that the rotor hub on the end face of the pulley is completely set in the fitting on the brake friction plate.



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

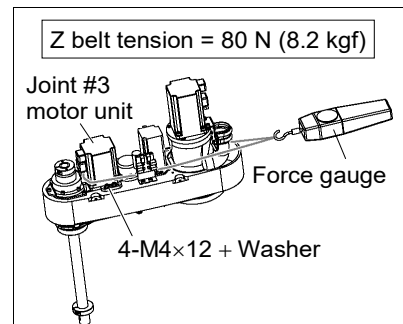


- (7) Loosely secure the Joint #3 motor unit to Arm #2.

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.

At this point, be careful of the battery board.
 To remove the battery board, take out the set screws with cables connected.
 Hexagonal wrench (Stubby type) makes it easier to tighten / remove screws.



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

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

- (9) Connect the connectors.
 Connectors X231, X31, X63
- (10) Re-bundle the cables in their original positions with a wire tie removed in step (5).
 Do not allow unnecessary strain on the cables.
- (11) Install the arm top cover and the arm bottom cover.
 For details, refer to 3. *Covers*.
- (12) Perform the calibration of Joint #3.
 For details on the calibration method, refer to 13. *Calibration*.

7.2 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance parts	Z belt (width 10 mm)	1	1480849
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Nippers	1	For cutting wire tie
	Force gauge	1	Belt tension 80 N (8.2 kgf)
	Suitable cord (Length about 800 mm)	1	For belt tension
Material	Wire tie	2	

A brake is mounted on the motor of Joints #3 and #4 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). (The brake for Joint #4 is only installed to G6-***.)

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 from (1) to (3).

Z belt
Removal

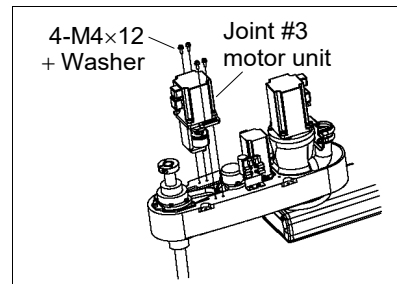
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes for Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

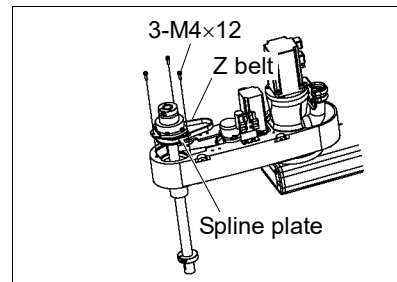
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (6) Disconnect the following connectors.
Connectors X231, X31 (Hold the clip to remove.)
Connector X32, X63

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



- (8) Remove the Z belt.
Remove the bolts securing the spline plate and pull out the spline plate upward to remove it.



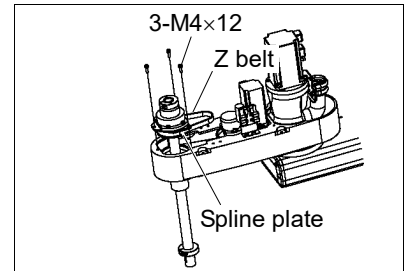
NOTE



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Z belt
Installation

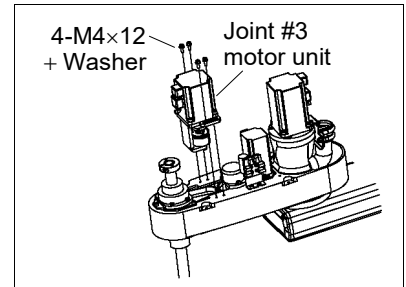
- (1) Pass a new Z belt through the shaft from above, and then place it under the spline plate.



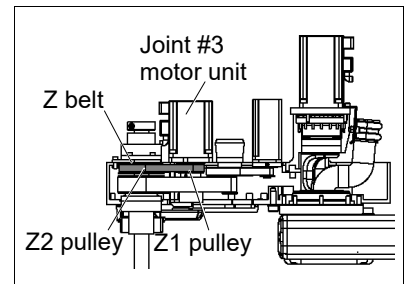
- (2) Loosely secure the spline plate to Arm #2.

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 back of the arm.



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



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

NOTE

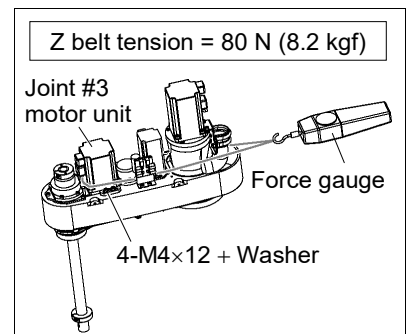


Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

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

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



- (7) Connect the connectors.

Connectors X231, X31, X32, X63

- (8) Re-bundle the cables in their original positions with a wire tie removed in step (5). Do not allow unnecessary strain on the cables.

- (9) Install the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.

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

For details, refer to 13. *Calibration*.

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 80 N (8.2 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	3		

A brake is mounted on the motor of Joints #3 and #4 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). (The brake for Joint #4 is only installed to G6-****3****.)

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 from (1) to (3).

Joint #3 brake Removal

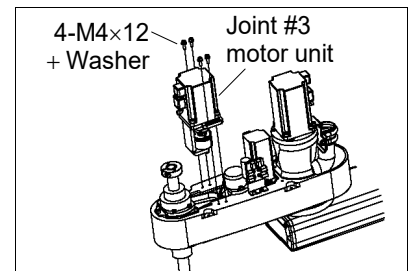
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes for Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

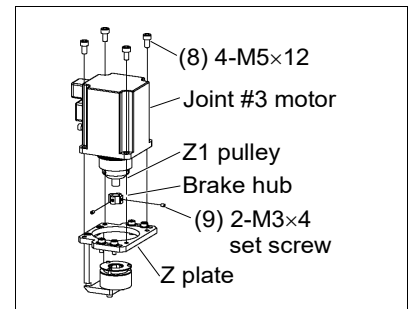
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. Covers.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (6) Disconnect the following connectors.
Connectors X231, X31 (Hold the clip to remove.)
Connector X32, X63

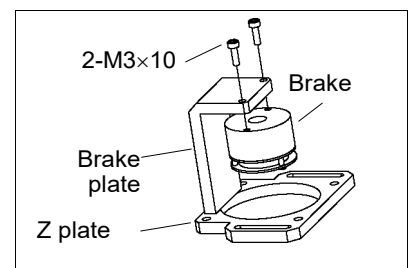
- (7) Remove the Joint #3 motor unit from Arm #2.



- (8) Remove the Joint #3 motor from the Z plate.
- (9) Remove the brake hub from the Z1 pulley.



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

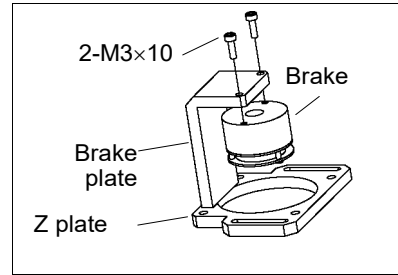




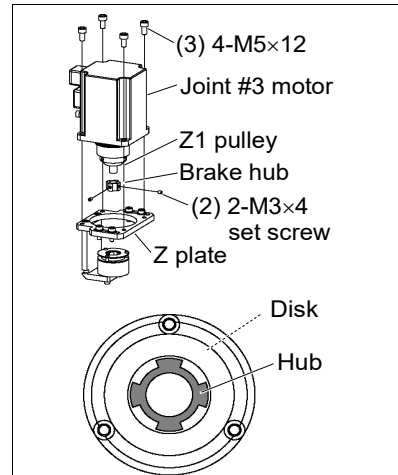
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #3 brake Installation

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

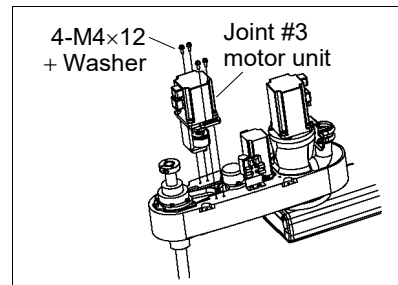


- (2) Mount the brake hub to the Z1 pulley.
For the brake hub mounting procedure, refer to the section *7.1 Replacing Joint #3 Motor - Joint #3 motor installation - Step (1) - (4)*.



- (3) Mount the motor unit to the Z plate.
Align the position of the disk on the brake and the hub.
When the brake disk is not aligned, turn ON the Controller and connect the connector X32. Press the brake release switch and release the brake to manually adjust the position.

- (4) Mount the Joint #3 motor unit to Arm #2 so that the open side faces toward the end of the arm.



- (5) Connect the connectors.
Connectors X231, X31, X32, X63
- (6) Re-bundle the cables in their original positions with a wire tie removed in step (5).
Do not allow unnecessary strain on the cables.
- (7) Install the arm top cover and the arm bottom cover.
For details, refer to *3. Covers*.
- (8) Perform the calibration of Joint #3.
For details, refer to *13. Calibration*.

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.

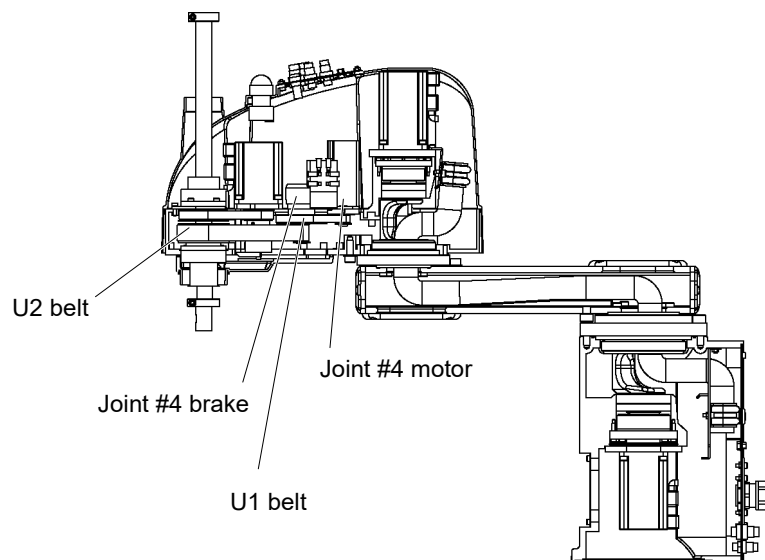


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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 13. *Calibration* to perform the calibration.



8.1 Replacing Joint #4 Motor

	Name		Quantity	Note
Maintenance parts	AC Servo Motor (100 W)		1	1497626
				1514469 (For S/N:1**** or later)
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 70 N (7.1 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension

A brake is mounted on the motor of Joints #3 and #4 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). (The brake for Joint #4 is only installed to G6-***.)

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 (3).

Joint #4 motor Removal

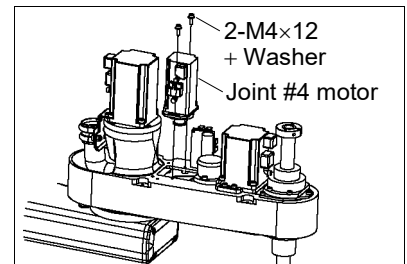
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment. The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***)**.)
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 OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #4 motor.
- (6) Disconnect the following connectors. (X42: G6-***)** only)
Connectors X241, X41 (Hold the clip to remove.)
Connector X42, X64

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

NOTE Be careful not to break the battery board.

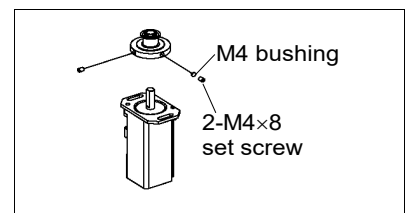


Unscrew the bolts securing the Joint #4 motor unit to the Motor plate. Remove the U1 belt from the pulley. Pull the Joint #4 motor unit upward to remove.

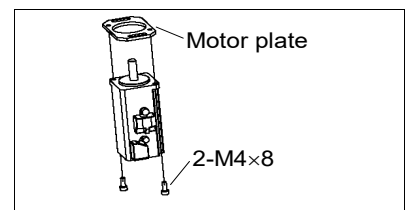


- (8) Remove the pulley from the Joint #4 motor.

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



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

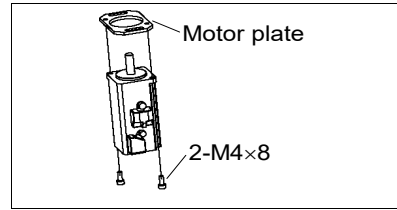




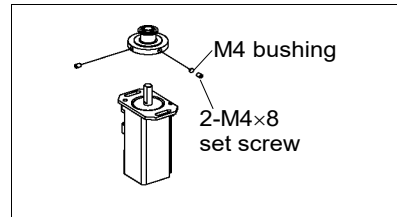
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #4 motor Installation

- (1) Mount the motor plate to the Joint #4 motor.



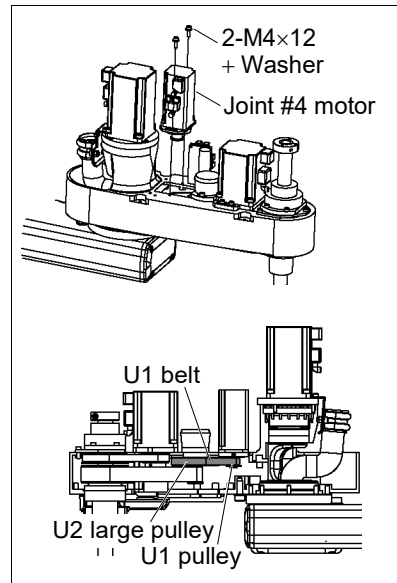
- (2) Secure the pulley to the new Joint #4 motor.
Be sure to fit the end face of the pulley to the end face of the motor shaft.



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.

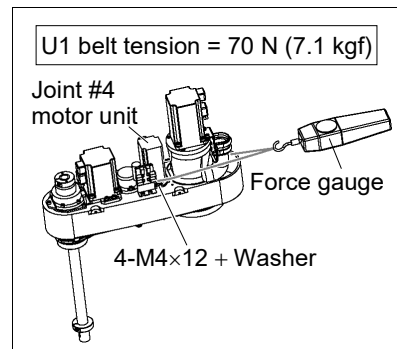
- (3) Place the Joint #4 motor unit in the arm so that the motor cable faces toward the left of the arm.
- (4) Place the U1 belt around the U1 pulley and the U2 large pulley (upper side) so that the gear grooves of the belt are fit into those of the pulleys completely.
- (5) Loosely secure the Joint #4 motor unit to Arm #2.



Loosely secure the Joint #4 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

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



- (7) Connect the connectors.
Connectors X241, X41, X42, and X64. (X42:G6-*** only)
- (8) Re-bundle the cables in their original positions with a wire tie removed in step (5).
Do not allow unnecessary strain on the cables.
- (9) Install the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.
- (10) Perform the calibration of Joint #4.
For details on the calibration method, refer to 13. *Calibration*.

8.2 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance parts	U1 belt (width 9 mm)	1	1480850
	U2 belt (width 20 mm)	1	1480851
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	Belt tension : 70 N (7.1 kgf) 80 N (8.2 kgf) 130 N (13.2 kgf)
	Nippers	1	For cutting wire tie
	Suitable cord (Length about 800 mm)	1	For belt tension

A brake is mounted on the motor of Joints #3 and #4 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). (The brake for Joint #4 is only installed to G6-***3**.)

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 from (1) to (3).

U1 belt
Removal

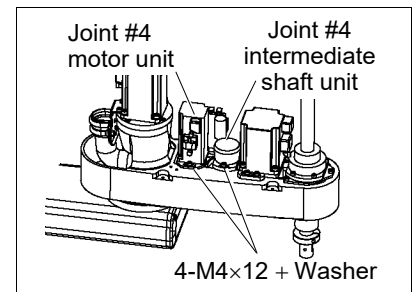
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes for Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

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.

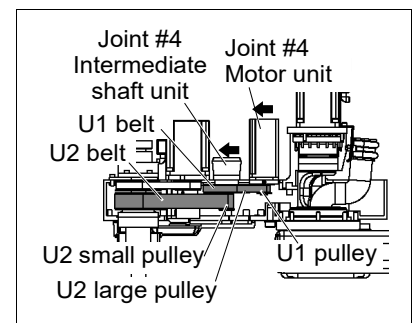
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.

- (5) Loosen the bolts securing the Joint #4 motor unit.
- (6) Loosen the bolts securing the Joint #4 intermediate shaft unit.



- (7) Remove the U2 belt from the U2 small pulley and remove the U1 belt from the U1 pulley and U2 large pulley.

Put the Joint #4 motor unit and the Joint #4 intermediate shaft unit to the shaft side and remove the belt from the pulley.

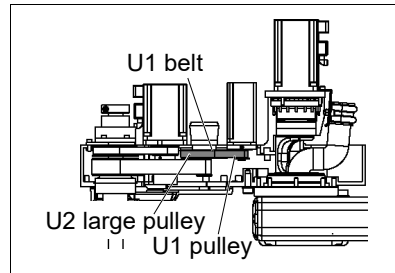




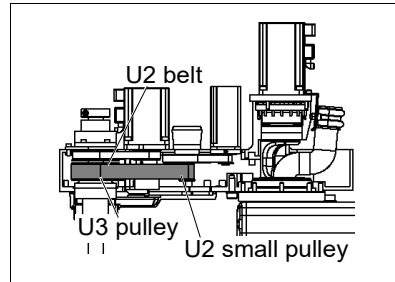
When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

U1 belt
Installation

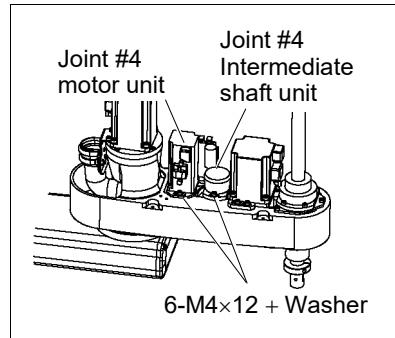
- (1) Set the U1 belt around the U1 pulley and U2 large pulley (upper side) so that the gear grooves of the belt are fit into those of the pulleys completely.



- (2) Set the U2 belt around the U3 pulley and U2 small pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



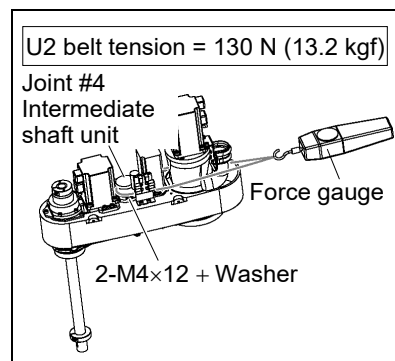
- (3) Loosely secure the Joint #4 intermediate shaft unit, Joint #4 motor unit to Arm #2 in this order. Make sure that the gear grooves of the belt are fit into those of the pulleys completely.



Loosely secure the units to Arm #2 so 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.

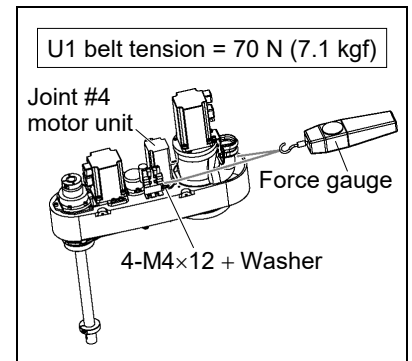
- (4) Apply the proper tension to the U2 belt, and then secure the Joint #4 intermediate shaft unit.

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.



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

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



- (6) Install the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.
- (7) Perform the calibration of Joint #3.
For details on the calibration method, refer to 13. *Calibration*.

U2 belt
Removal

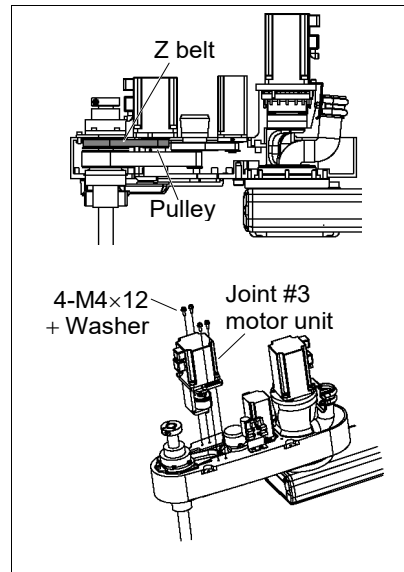
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes for Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

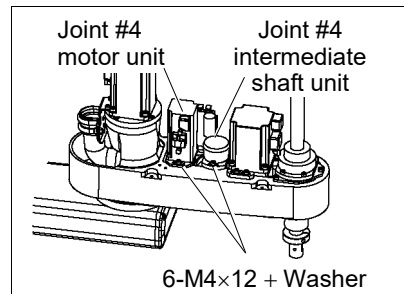
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. Covers.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (6) Disconnect the following connectors.
Connectors X231, X31 (Hold the clip to remove.)
Connector X63, X32

- (7) Remove the Joint #3 motor unit from Arm #2.
Remove the bolts securing the Joint #3 motor plate. Remove the Z belt from the pulley. Pull the Joint #3 motor unit upward to remove.

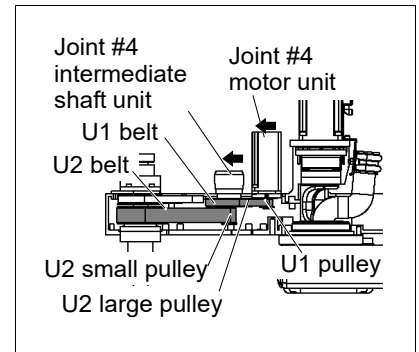


- (8) Loosen the bolts securing the Joint #4 motor unit.
- (9) Loosen the bolts securing the Joint #4 intermediate shaft unit.



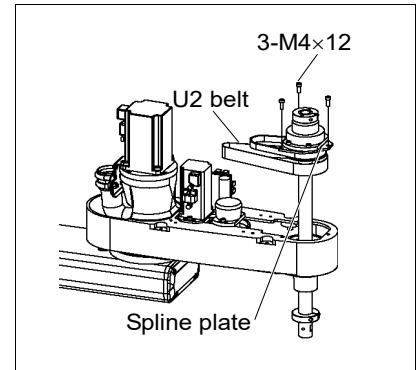
- (10) Remove the U2 belt from the U2 small pulley and remove the U1 belt from the U1 pulley and U2 large pulley.

Put the Joint #4 motor unit and the Joint #4 intermediate shaft unit to the shaft side and remove the belt from the pulley.



- (11) Remove the U2 belt.

Remove the bolts securing the spline plate. Hold the spline plate up and remove the U2 belt from the shaft by pulling them up.

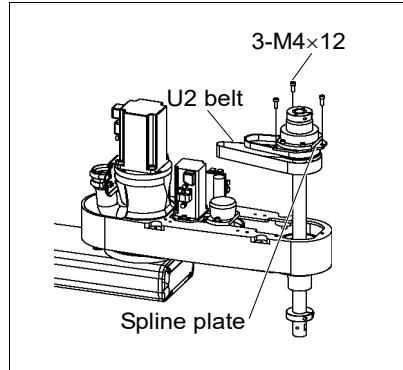




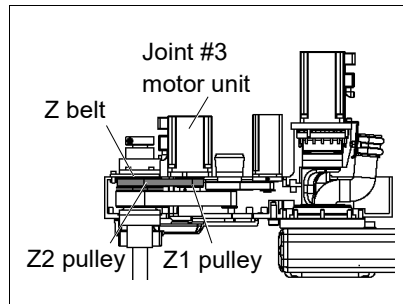
When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

U2 belt Installation

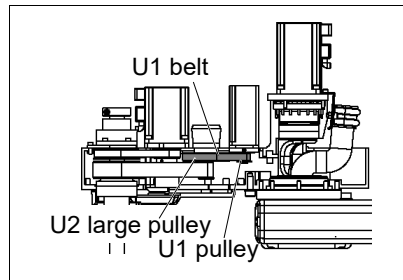
- (1) Pass the U2 belt through the shaft and mount the ball screw spline unit to Arm #2.
- (2) Loosely secure the spline plate to Arm #2.
After moving the shaft up and down several times, secure the spline plate to Arm #2.



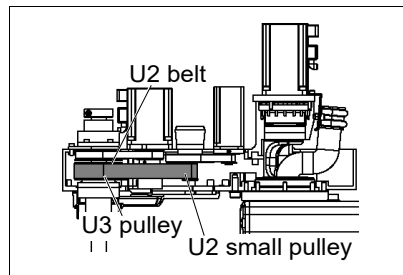
- (3) Place the Joint #3 motor unit back to Arm #2.
- (4) Set the Z belt around the Z1 pulley and Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



- (5) Set the U1 belt around the U1 pulley and U2 large pulley (upper side) so that the gear grooves of the belt are fit into those of the pulleys completely.

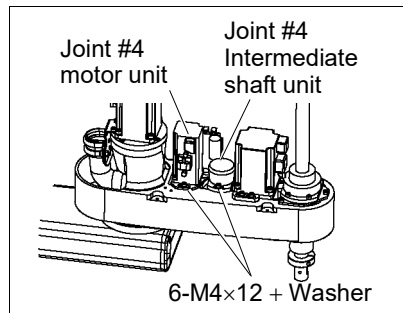


- (6) Set the U2 belt around the U3 pulley and U2 small pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



- (7) Loosely secure the Joint #3 motor unit, Joint #4 intermediate shaft unit, Joint #4 motor unit to Arm #2 in this order.

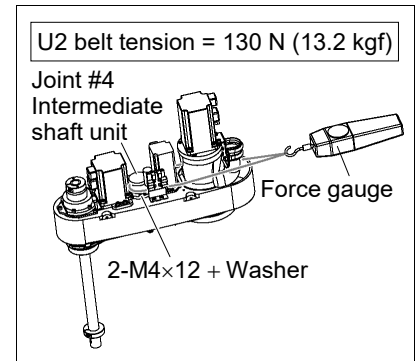
Make sure that the gear grooves of the belt are fit into those of the pulleys completely.



Loosely secure the units to Arm #2 so 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.

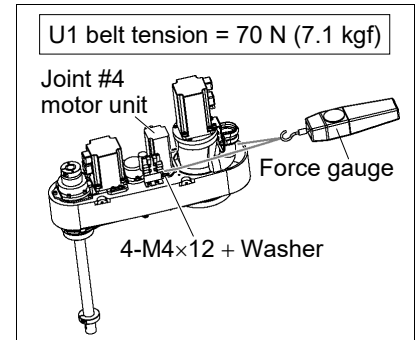
- (8) Apply the proper tension to the U2 belt, and then secure the Joint #4 intermediate shaft unit.

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.



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

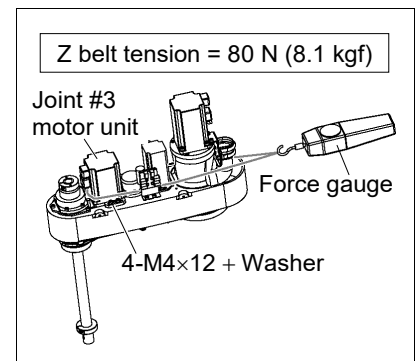
To do so, pass a suitable cord or string around the Joint #4 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



- (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 #3 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.

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



- (11) Connect the connectors.

Connectors X231, X31, X32, X63.

- (12) Re-bundle the cables in their original positions with a wire tie removed in step (5).

Do not allow unnecessary strain on the cables.

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

For details, refer to 3. *Covers*.

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

For details, refer to 13. *Calibration*.

8.3 Replacing the Brake

	Name	Quantity	Note	
Maintenance parts	Electromagnetic brake	1	1497640	
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		

The brake for U axis is installed to G6-***3**.

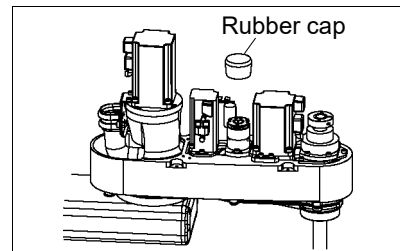
A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF). (The brake for Joint #4 is only installed to G6-***3**.)

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

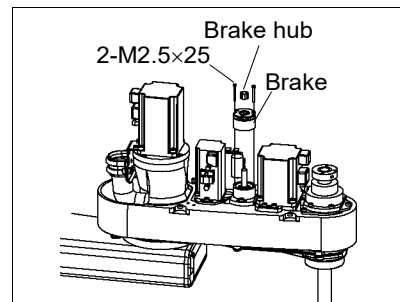
Move the shaft down to its lower limit before the replacement procedure following the removal steps from (1) to (3).

Joint #4 brake 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.
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes for Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)
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 OFF the Controller.
- (4) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Disconnect the connector.
Connector X42
- (6) Cut off the wire tie banding brake cables.
- (7) Remove the rubber cap.



- (8) Remove the brake hub.
- (9) Remove the brake.



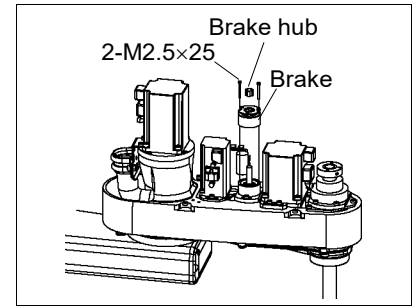
NOTE



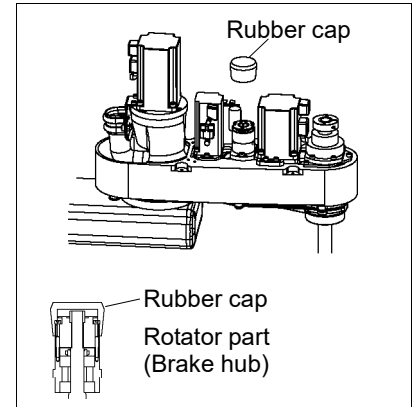
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #4 brake Installation

- (1) Mount the brake to the Joint #4 intermediate shaft unit.
- (2) Mount the brake hub to the Joint #4 intermediate shaft unit.



- (3) Mount the rubber cap.
Insert 9 mm to the brake.
If the cap is inserted 10 mm or more, the rotation part touches the rubber cap and may result in malfunctions.



- (4) Connect the connector.
Connector X42
- (5) Re-bundle the cables in their original positions with a wire tie removed in step (6).
Do not allow unnecessary strain on the cables.
- (6) Install the arm top cover.
For details, refer to *3.1 Arm Top Cover*.

9. Bellows



The bellows are provided in a unit of two pieces. The shape varies between the upper and lower bellows.

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

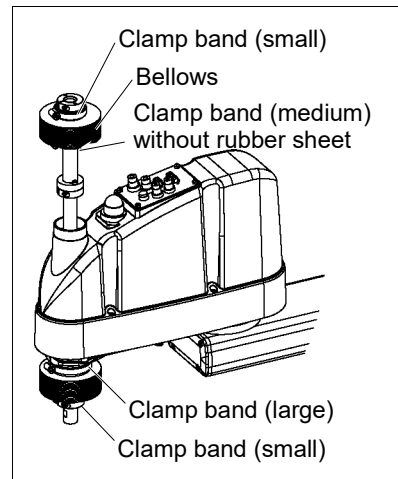
Take the Manipulator to an outer room such as the room in front of the clean room’s entrance, or take the necessary countermeasures to prevent dust emission before removing the bellows.

	Name		Quantity	Note
Maintenance parts	Bellows	150 mm	1	1497641
		300 mm		1497642
Tools	Cross-point screwdriver		1	For clamp band removal

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) Loosen the two clamp bands on each bellows.
- (5) Pull the bellows, rubber sheet, and clamp bands out of the shaft.

(The rubber sheet is not used for the upper bellows.)



Bellows Installation

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

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

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

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

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.

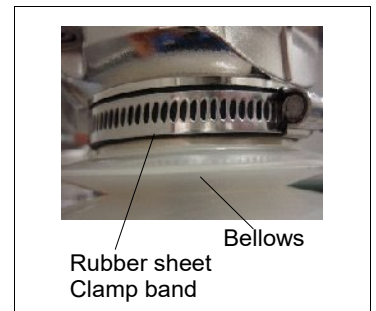
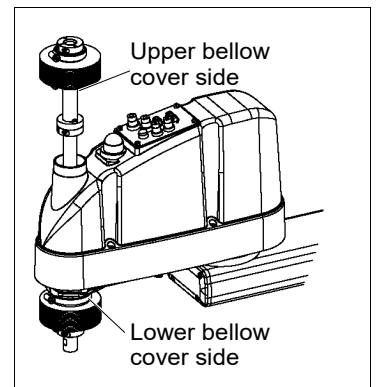
Be careful not to misplace the clamp bands. The clamp band has three sizes; small, medium, and large.

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. (No rubber sheet for the upper bellows cover side)



Then, secure them with clamp bands.



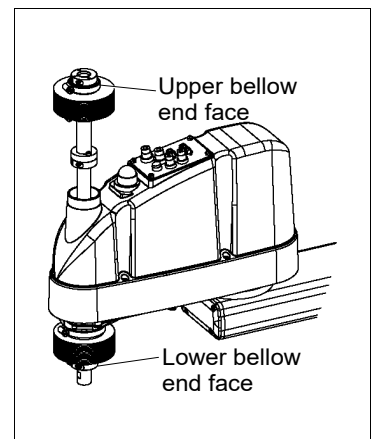
- (4) Secure the end face side of the bellows to the shaft.

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.



- (5) After completing the attachment of the bellows, move the shaft up/down by hand several times and rotate Joint #4. Make sure that the bellows can expand and contract smoothly without any excessive force.

- (6) Turn OFF the Controller and peripheral equipment.
- (7) Attach the end effector.
- (8) Connect the wires and tubes to the end effector.

10. Ball Screw Spline Unit



WARNING

- 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.

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 13. *Calibration* to perform the calibration.

A brake is mounted on the motor of Joints #3 and #4 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). (The brake for Joint #4 is only installed to G6-**3**.)

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 (3).

	Name	Quantity	Note
Maintenance parts	Ball Screw Spline Unit	1	Each manipulator model (Refer to 14. <i>G6 Maintenance Parts</i>)
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 70 N (8.2 kgf), 80 N (8.1 kgf), 130 N (13.2 kgf)
	Suitable cord (Length about 1000 mm)	1	For belt tension
	Wiping cloth	1	For wiping grease
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.

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

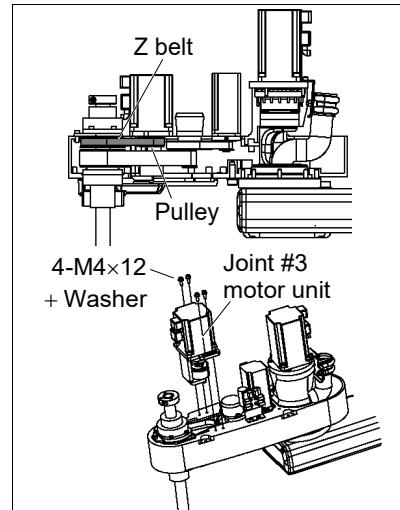
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Detach the wires/tubes from the end effector, and remove the end effector.
- (5) This step is only for Cleanroom-model and Protected-model (C, D with bellows option, P).

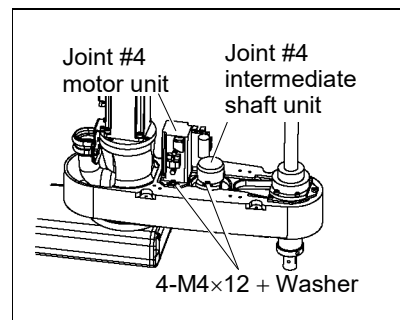
Remove the bellows. For details, refer to 9. *Bellows*.

- (6) Remove the arm top cover and arm bottom cover.
For details, refer to 3. *Covers*.
- (7) Cut off the wire tie banding motor cables to the Joint #3 motor.
- (8) Disconnect the connectors.
Connectors X231, X31 (Hold the clip to remove.)
Connector X32

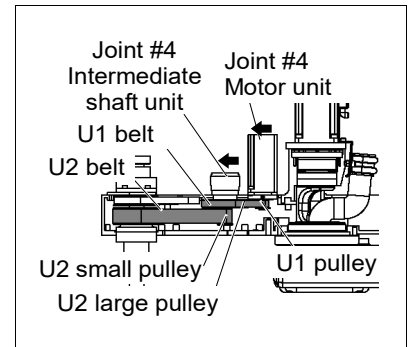
- (9) Remove the Joint #3 motor from Arm #2.
Remove the bolts securing the Joint #3 motor plate. Remove the Z belt from the pulley. Remove the motor by pulling it up.



- (10) Loosen the bolts securing the Joint #4 motor unit.
- (11) Loosen the bolts securing the Joint #4 intermediate shaft unit.



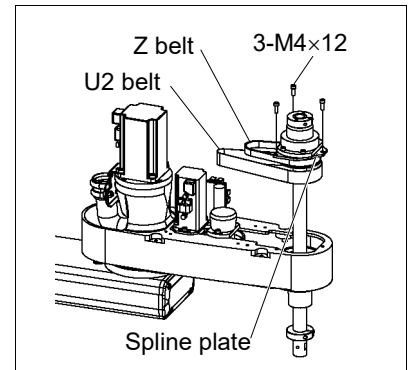
(12) Remove the U2 belt from the U2 small pulley and remove the U1 belt from the U1 pulley and U2 large pulley.



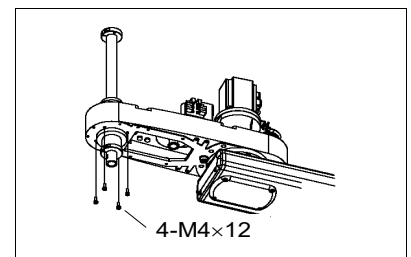
(13) Put the Joint #4 motor unit and the Joint #4 intermediate shaft unit to the shaft side and remove the belt from the pulley.

(14) Remove the U2 belt and Z belt.

Remove the bolts securing the spline plate. Hold the spline plate up and remove the U2 belt and Z belt from the shaft by pulling them up.



(15) Remove the nut mounting screws of the ball screw spline shaft on the lower part of Arm #2.



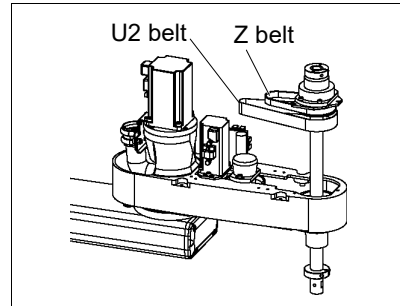
(16) Pull out the ball screw spline unit from Arm #2.



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

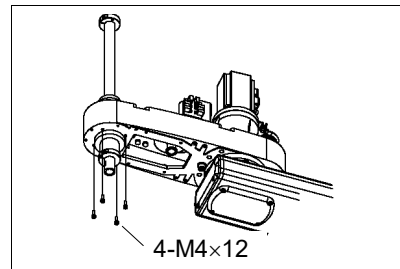
Ball screw spline unit Installation

- (1) Pass the U2 belt and Z belt through the shaft and mount the ball screw spline unit to Arm #2.



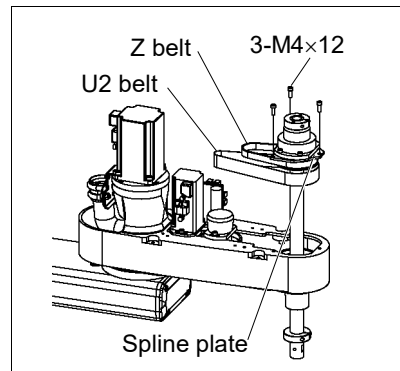
- (2) Secure the nut mounting screws of the ball screw spline shaft on lower side of Arm #2.

Be sure to keep the timing belt from being stuck between the nut and Arm #2.



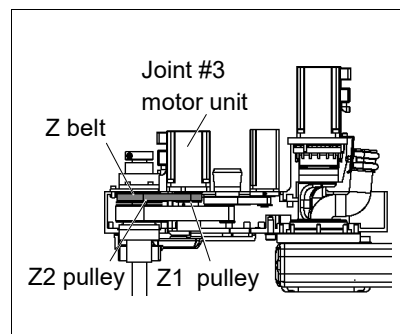
- (3) Loosely secure the spline plate to Arm #2.

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

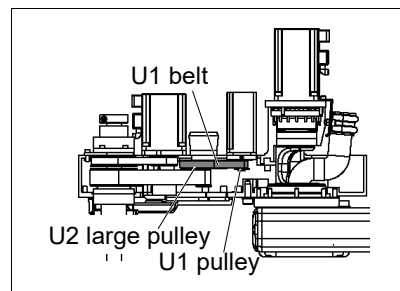


- (4) Place the Joint #3 motor unit back to Arm #2.

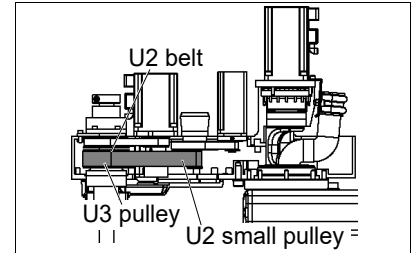
- (5) Set the Z belt around the Z1 pulley and Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



- (6) Set the U1 belt around the U1 pulley and U2 large pulley (upper side) so that the gear grooves of the belt are fit into those of the pulleys completely.

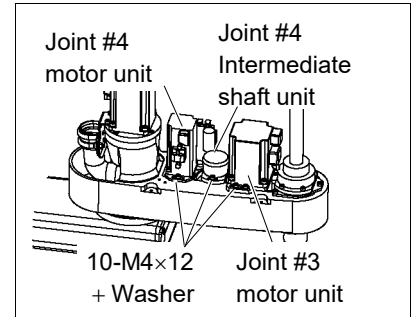



- (7) Set the U2 belt around the U3 pulley and U2 small pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



- (8) Loosely secure the Joint #3 motor unit, Joint #4 intermediate shaft unit, Joint #4 motor unit to Arm #2 in this order.

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

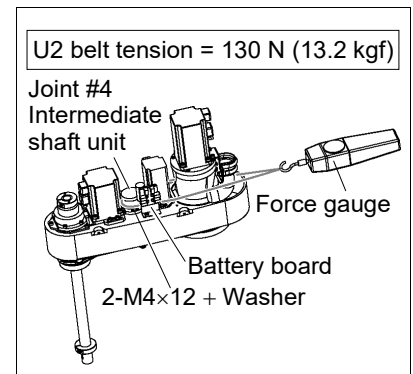


NOTE  Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

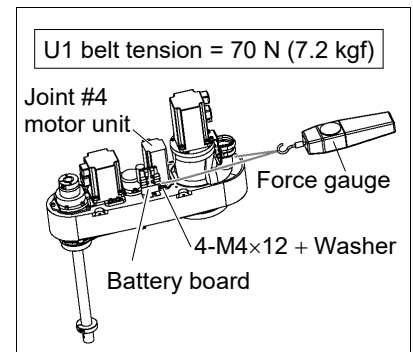
To do so, pass a suitable cord or string around the Joint #4 intermediate shaft unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.

If the string is touching the battery board, remove mounting screw for the battery board to put it aside.



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

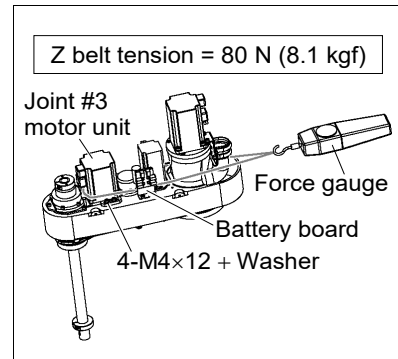
To do so, pass a suitable cord or string around the Joint #4 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



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

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

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



- (12) Connect the connectors.

Connectors X231, X31, and X32

- (13) Re-bundle the cables in their original positions with a wire tie removed in step (4).

Do not allow unnecessary strain on the cables.

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

- (15) Grease the shaft.

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

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

For details, refer to 3. *Covers.*

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

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

- (19) This step is only for Cleanroom-model and Protected-model (C, D with bellows option, P).



Install the bellows.

For details, refer to 9. *Bellows.*

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

For details, refer to 13. *Calibration.*

11. Lithium Battery

 <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.
 <p>CAUTION</p>	<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. <ul style="list-style-type: none"> <Improper Handling> <ul style="list-style-type: none"> • Battery Charge • Disassembly • Incorrect Installation • Exposing to Fire • Forced Discharge • Deformation by Pressure • Short-circuit (Polarity; Positive/Negative) • Heating (85°C or more) • Soldering the terminal of the lithium battery directly ■ When disposing of the battery, consult with the professional disposal services or comply with the local regulation. <p>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.</p>

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.

RC700 series Maintenance Manual 6. 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 14. G6 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	2120180
Tools	Nippers	1	For cutting wire tie
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
Material	Wire tie	2	For fixing battery unit (battery)
			For fixing cable

11.1 Replacing the Battery Unit (Lithium Battery)

Battery unit (lithium battery) Removal

- (1) Turn OFF 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.

The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

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) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.

- (4) Connect the connector of the new lithium battery to the battery board.

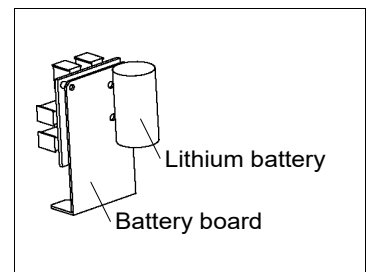
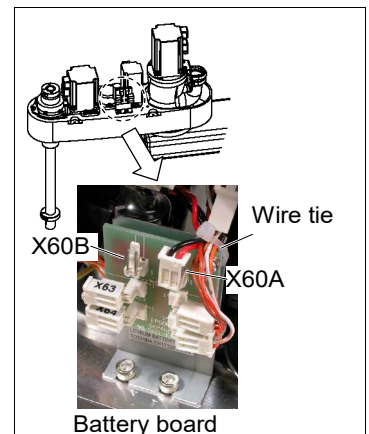
Use the unused connector of the two connectors X60A, X60B on the upper part of the battery board.

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 one, the robot will lose the origin position data and the calibration must be executed again.



NOTE Except when the Power-Low warning is appearing.

- (5) Cut off the wire tie banding the lithium battery and remove the lithium battery.
- (6) 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 (4).

- (3) Mount the arm top cover.
For details, refer to *3.1 Arm Top 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 *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 *13. Calibration* to perform the calibration.

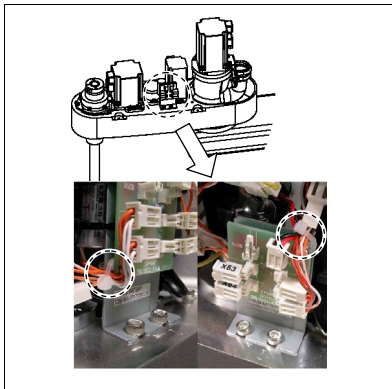
Battery board Removal

- (1) Turn OFF 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.

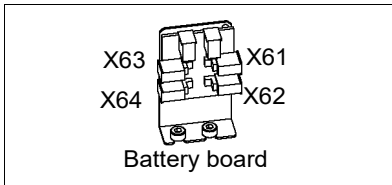
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously. (The brake for Joint #4 is only installed to G6-***3**.)

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.

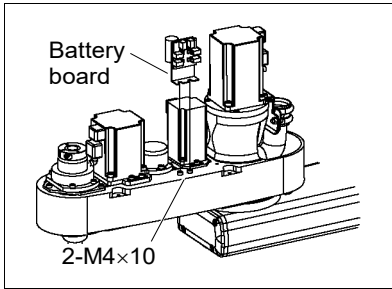
- (3) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (4) Disconnect the wiring tie connecting the connector cable.



- (5) Disconnect the connectors X61, X62, X63, and X64 connected to the battery board.



- (6) Loosen the screws securing the battery board and remove the battery board.



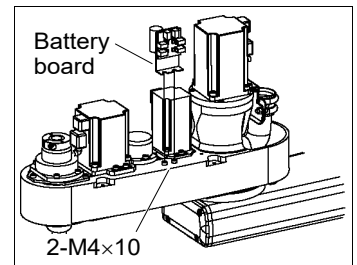
NOTE



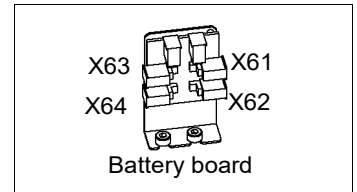
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Battery board Installation

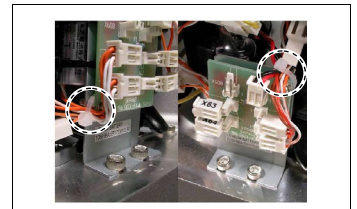
- (1) Mount the new battery board and secure it with screws.



- (2) Connect the connectors.
Connectors X61, X62, X63, X64




- (3) Fix the connector cable with wiring tie. Refer to procedure (4).



- (4) Mount the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Turn ON the Controller.
- (6) Perform the calibration of all joints.
For details, refer to *13. Calibration*.

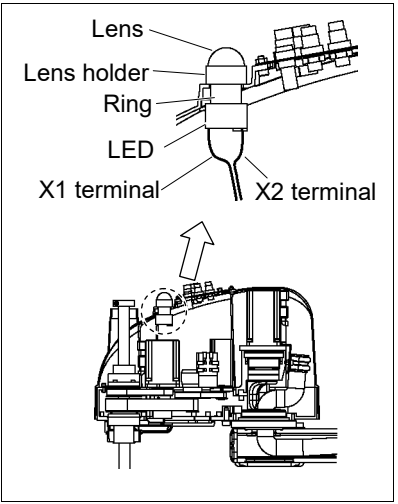
12. LED Lamp

 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	2077258
Tools	Cross-point screwdriver	1	For wire removal
	Nippers	1	
Material	Wire tie	1	

LED Lamp Removal

- (1) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (2) Disconnect the X1 and X2 terminals from the LED.
- (3) Turn the lens counterclockwise to remove it. Then, turn the lens holder counterclockwise to remove it.
- (4) Remove the LED from the arm top cover.



LED Lamp Installation

- (1) Connect the X1 and X2 terminals to the LED.
Each terminal must be connected to its terminal number on the LED.
- (2) Put the arm top cover between the ring and lens holder, and then mount the LED on the arm top cover.
- (3) Install the lens to the lens holder.
- (4) Install the arm top cover.
For details, refer to *3.1 Arm Top 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: *2.3 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 calibration 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+.

The same calibration procedure is used for each joint.

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 *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.



If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *13.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.

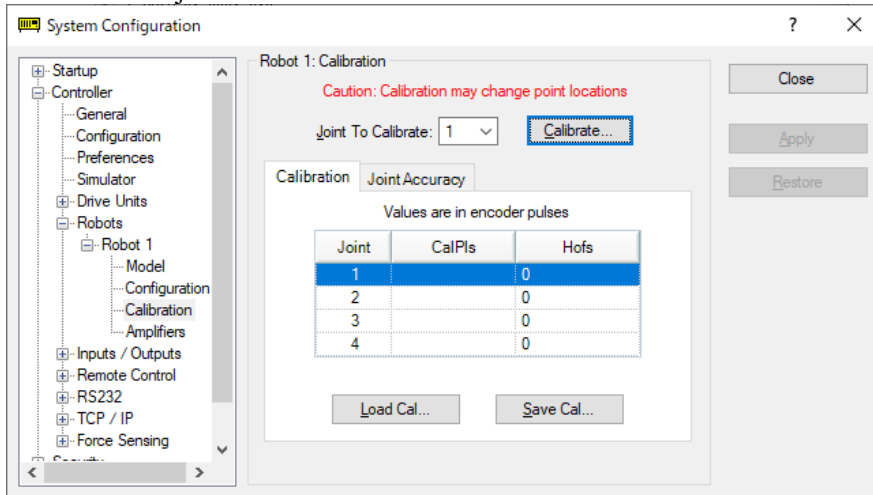
The reference point (a point to check the accuracy) needs to be specified for calibration.

- (1) Start the calibration wizard.
 - i. Select EPSON RC+ menu-[Setup]-[System Configuration].
 - ii. Select the [Robot]-[Robot**]-[Calibration].

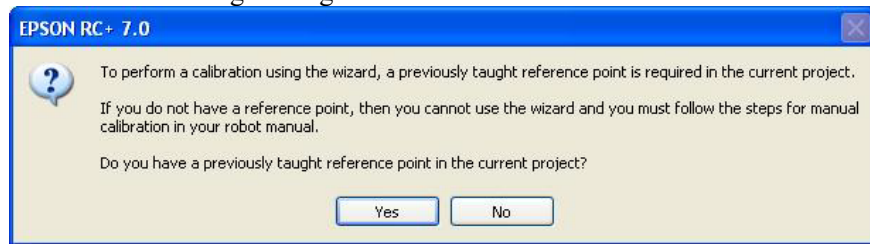


Only selected robot can be calibrated.

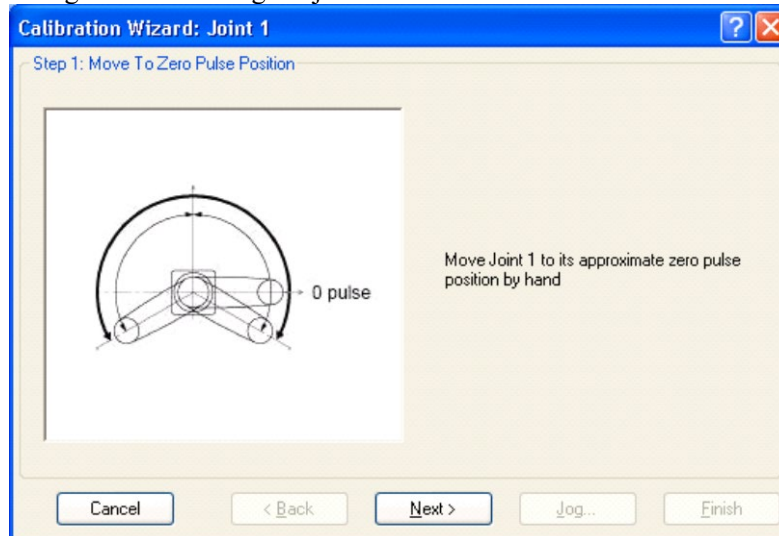
- iii. Select the joint and click the <Calibrate...> button.



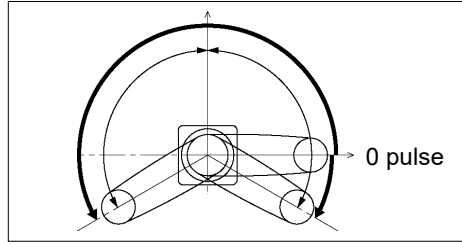
- (2) Confirm the warning message and click the <Yes> button.



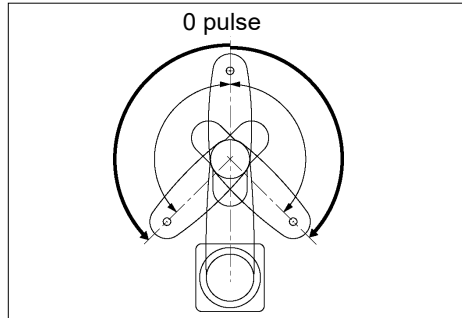
- (3) Move the joint to calibrate manually to approximate 0 pulse position, as shown in the dialog. After moving the joint click the <Next> button.



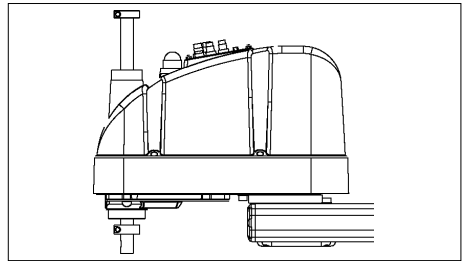
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



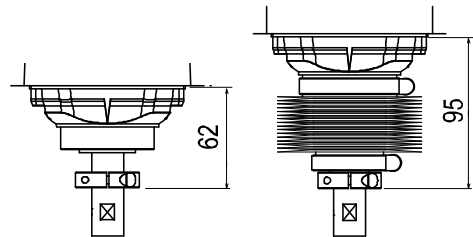
0 pulse position of Joint #2:
position where Arms #1 and #2
are in a straight line
(Regardless of the Joint #1
direction.)



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



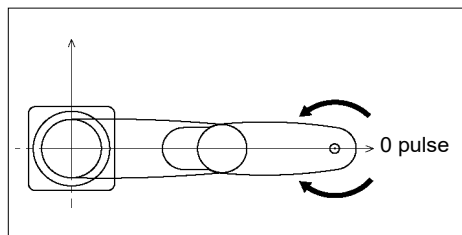
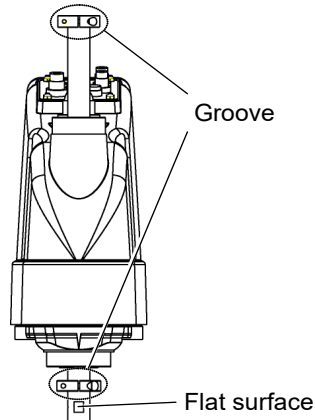
The height of Joint #3 depends
on manipulator model.



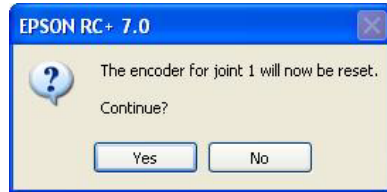
Standard model

Cleanroom model,
Protected model
with bellows option

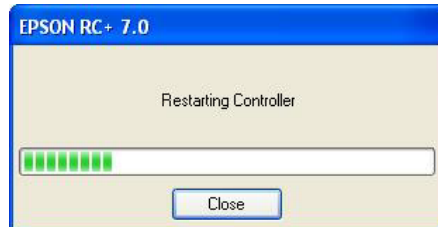
0 pulse position of Joint #4:
position where the flat surface
(or groove in the up/down
mechanical stop) on the shaft
faces toward the tip of Arm #2



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

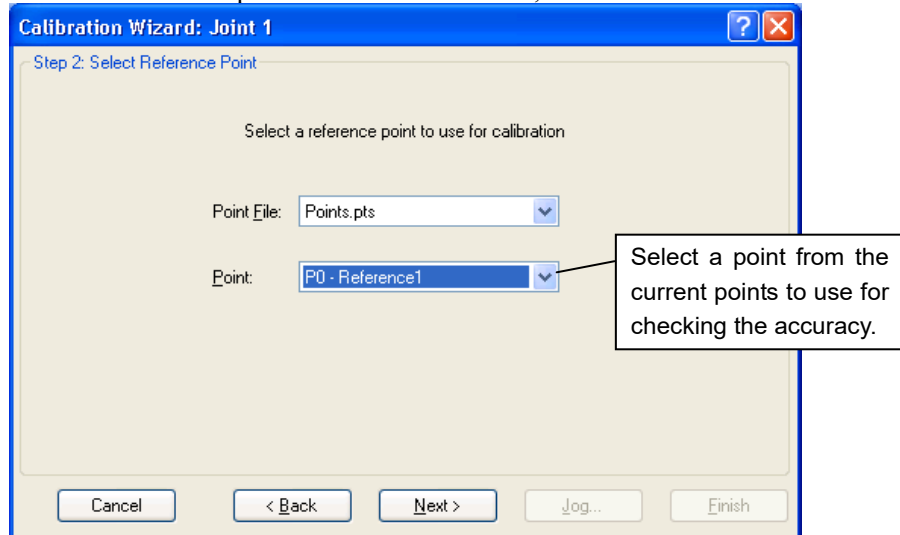


- (5) Reboot the Controller.

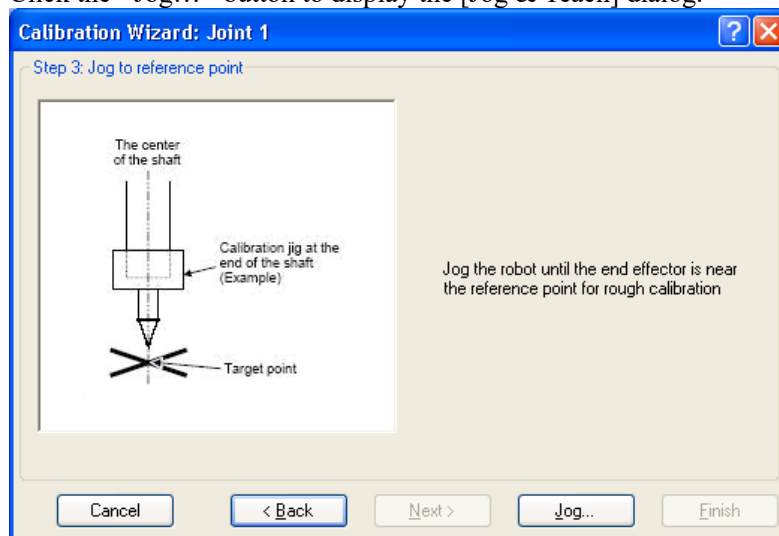


* This window will disappear when the Controller starts up.

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

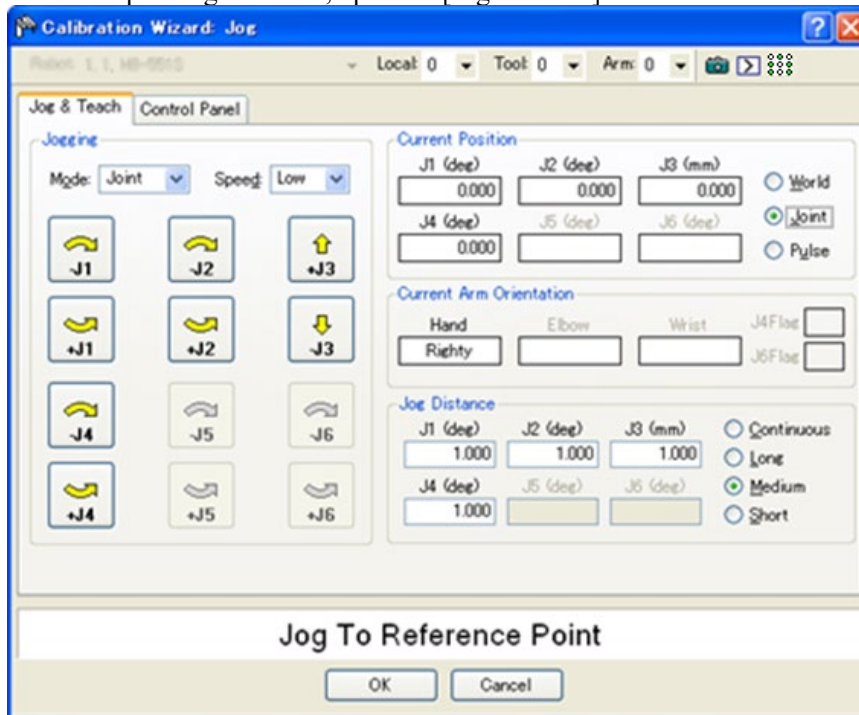


- (7) Click the <Jog...> button to display the [Jog & Teach] dialog.

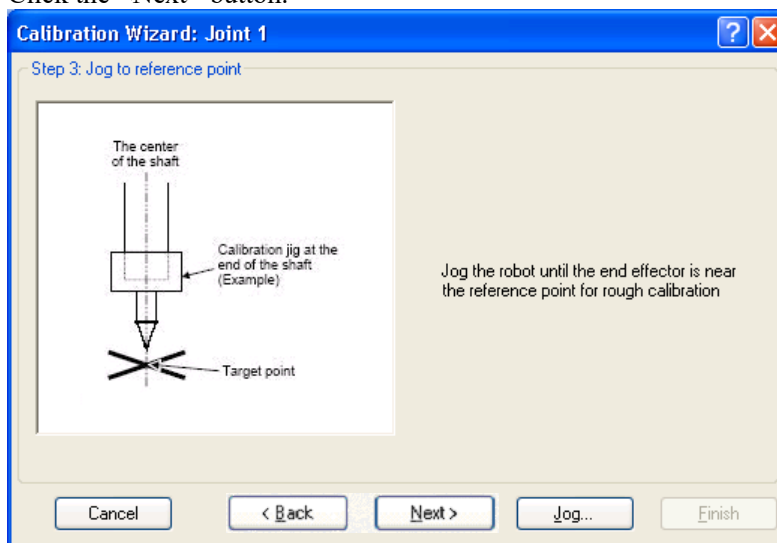


- (8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.

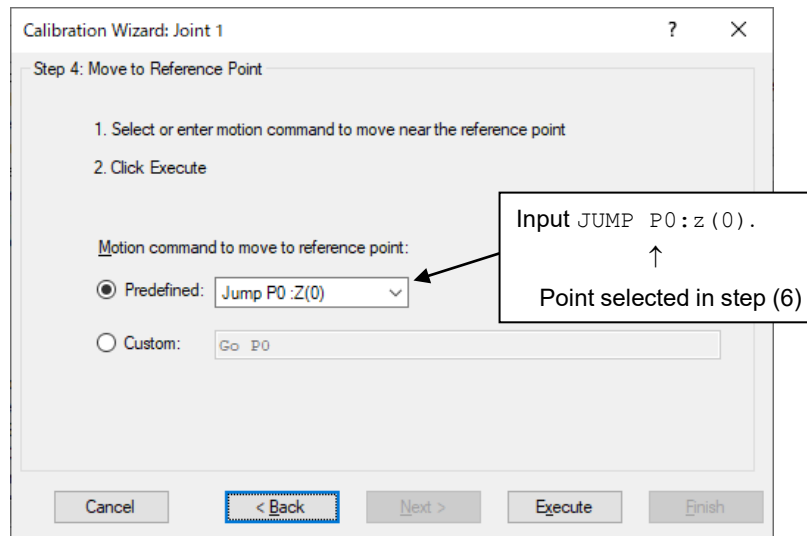
* Before operating the robot, open the [Jog & Teach] tab and execute <Motor ON>.



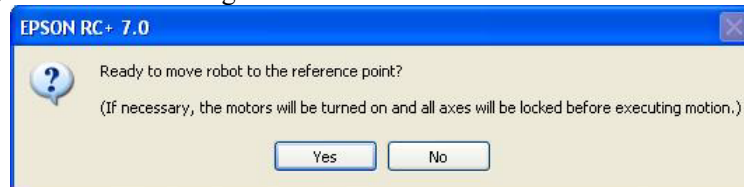
- (9) Click the <Next> button.



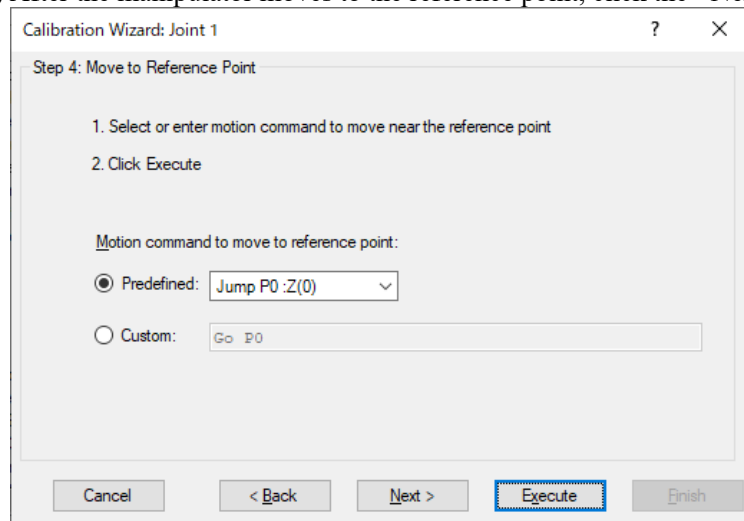
(10) The manipulator moves to the reference point. Click the <Execute> button.



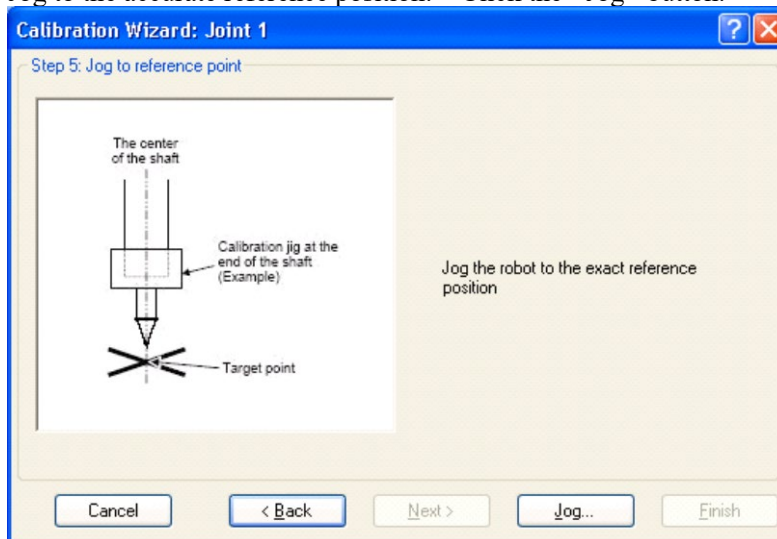
(11) Confirm the message and click the <Yes> button.



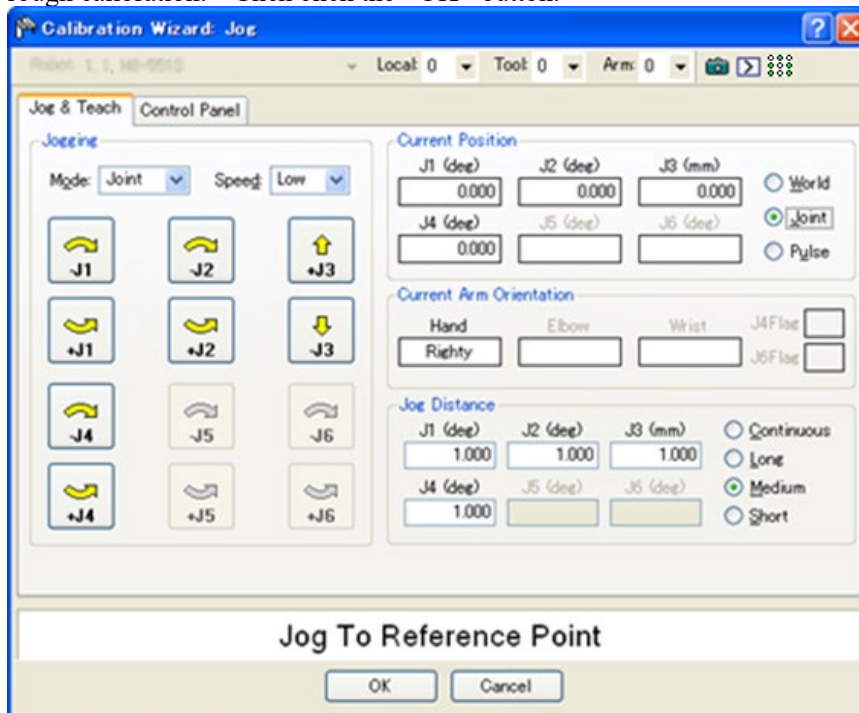
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position. Click the <Jog> button.

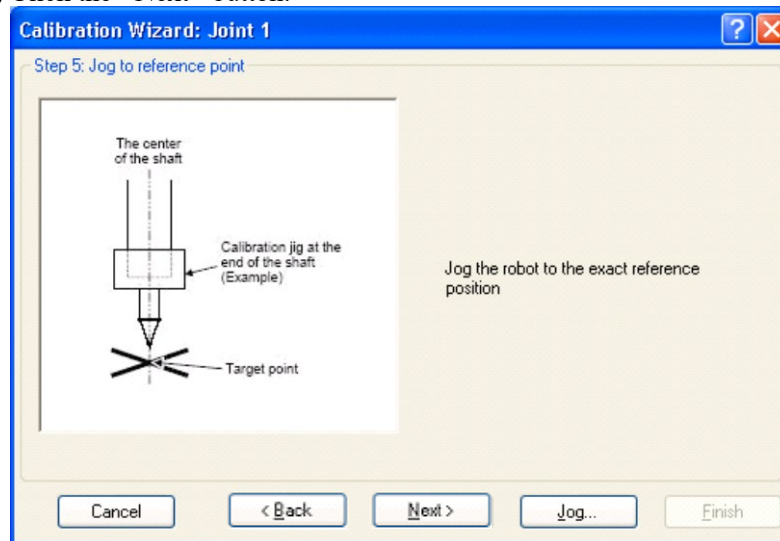


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



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

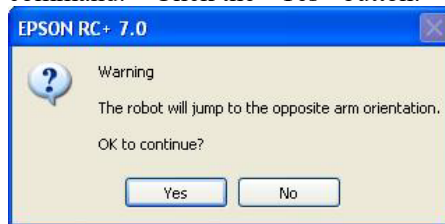
(15) Click the <Next> button.



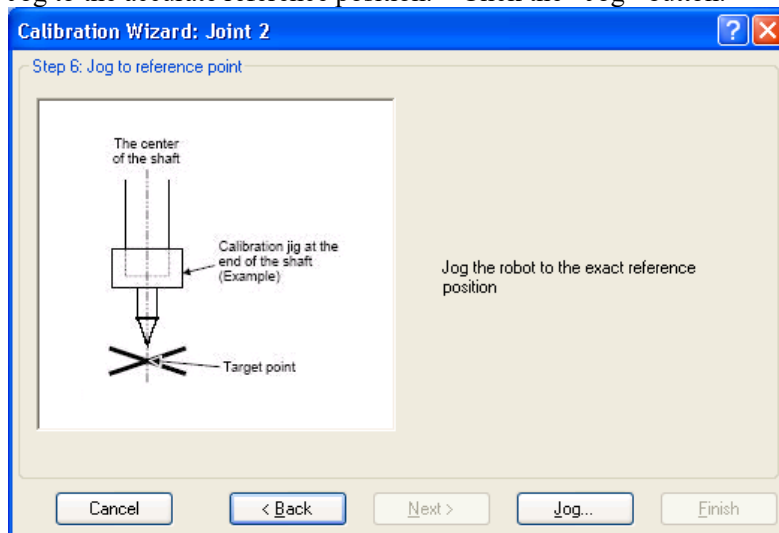
(16) Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2 only.

Go on to the step (19) for the other joints calibration.

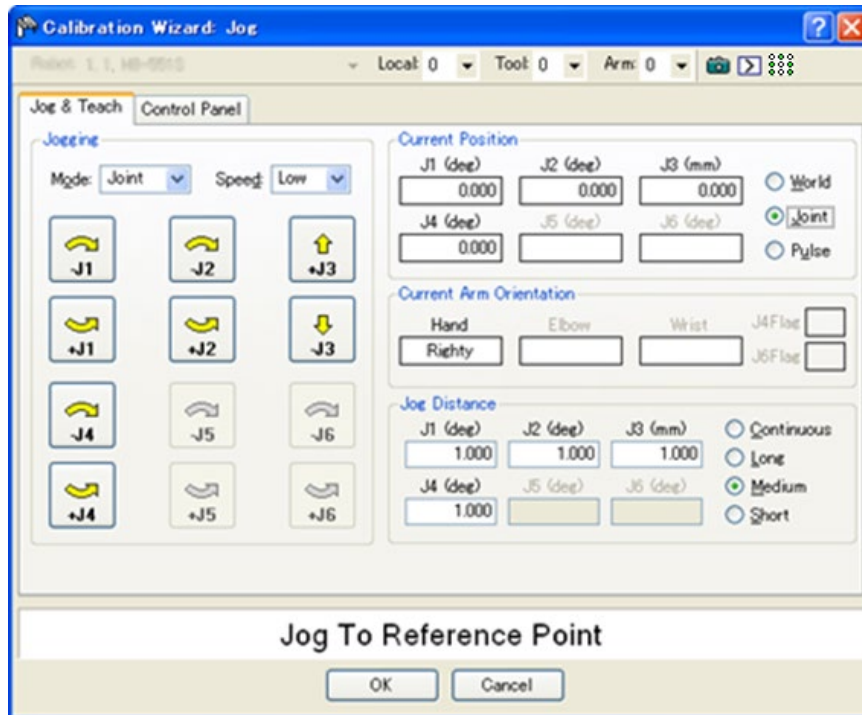
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



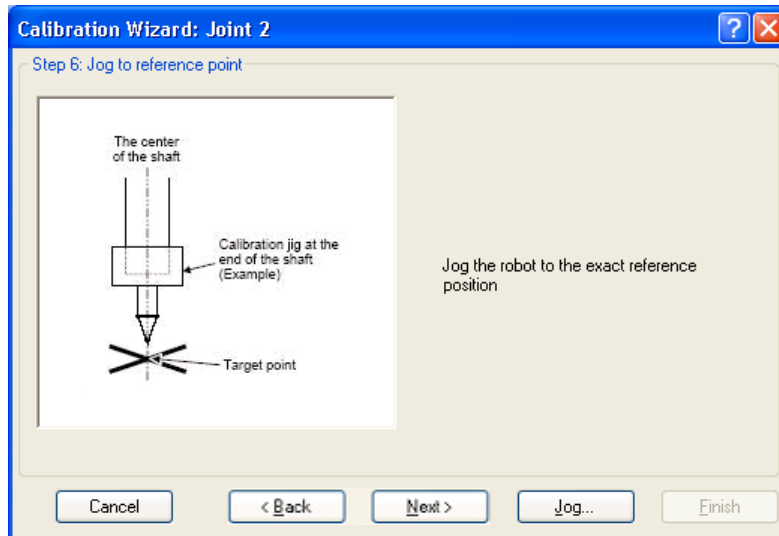
ii. Jog to the accurate reference position. Click the <Jog> button.



- 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.



(18) Move the manipulator to other points and check if it can move without problems.
Teach points where appropriate.

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.

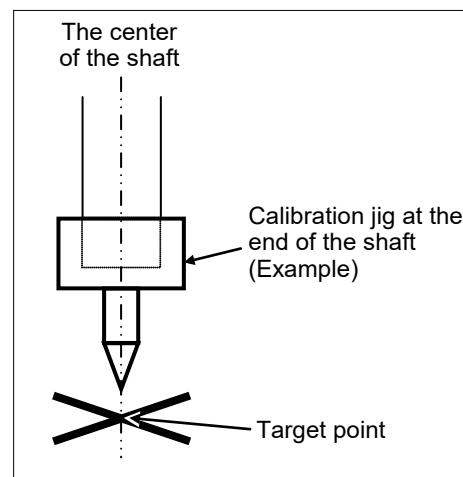
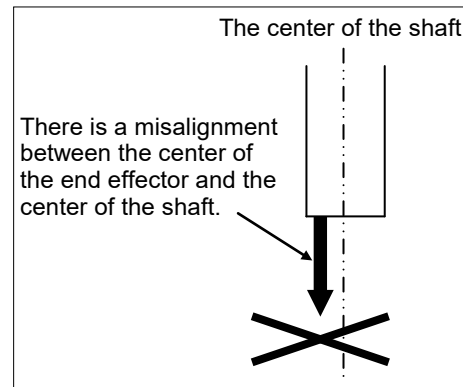
NOTE IF the calibration of Joint #2 is performed in *13.2 Calibration Procedure*, configure “Calibration Using Right / Left Arm Orientations” by the wizard.

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

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

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

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



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

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

- Teaching the working point by entering the coordinate values (MDI teaching)
- Switching the arm orientation between right and left at a given point
- Using the 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 the Tools menu | Robot Manager | Control Panel and click the MOTOR ON.
- (3) Click the <Free All> button in the [Control Panel] to free all joints. Now, you can move arms by hands.
- (4) Move the arms to the position of point data for calibration in righty arm orientation.
- (5) From the current position, teach any point data number unused.
This point is now called P1.
Specify the point number "1" and click the <Teach> button in the [Jog & Teach].
- (6) Click the <Lock All> button in the [Control Panel] to lock all joints.
- (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> button 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 point is now called P2.

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

- (9) Input the new Hof's value.

>Hofs Hof's (1), Hof's (2) + (Ppls (P1, 2) + Ppls (P2, 2)) /
2, Hof's (3), Hof's (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 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> button 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 *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.

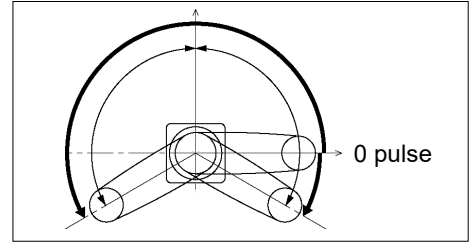
* Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

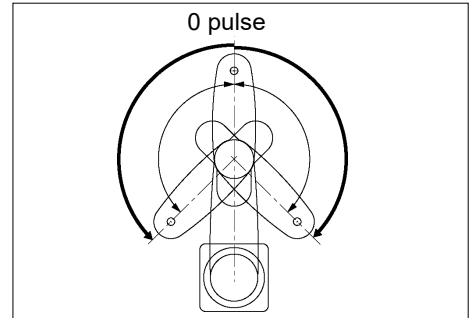
(3)-1 Turn ON the Controller when all joints are in the motion range.

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

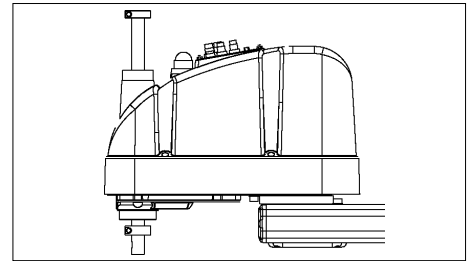
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



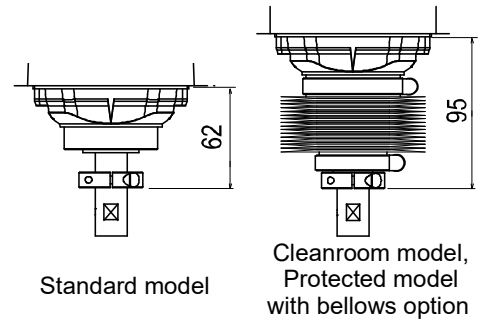
0 pulse position of Joint #2:
position where Arms #1 and #2
are in a straight line
(Regardless of the Joint #1
direction.)



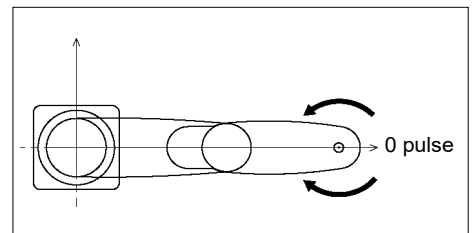
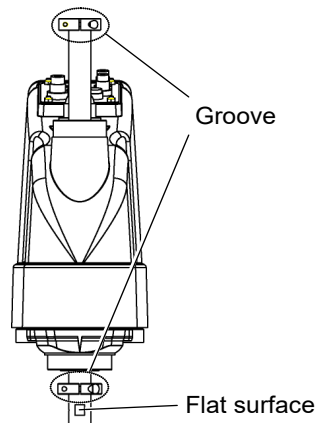
0 pulse position of Joint #3:
upper limit position in motion
range



The height of Joint #3 depends
on manipulator model.



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



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

Select the robot to be calibrated. Input as below in the [Command Window] and execute.

(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 in the [Control Panel] to free all joints. 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. G6 Maintenance Parts List

14.1 Common Parts

Part Name		Code	Old Code	Note	Reference	Overhaul *4
AC Servo Motor	Joint #1, 2	1497624	R13B000607	400 W	5.1, 6.1	✓
		1514468	R13B000616	400 W (For S/N: 1**** or later)		
	Joint #3	1497625	R13B000608	200 W	7.1	✓
		1514451	R13B000614	200 W (For S/N: 1**** or later)		
	Joint #4	1497626	R13B000609	100 W	8.1	✓
		1514469	R13B000617	100 W (For S/N: 1**** or later)		
Reduction Gear Unit **	Joint #1	1480755	R13B010011		5.2	✓
	Joint #2	1480756	R13B010012		6.2	✓
Electromagnetic Brake	Z axis	1497639	R13B030501		7.3	✓
	U axis	1497640	R13B030502	For G6-***3** (Z: 300, 330 mm) *1	8.3	✓
Timing Belt	Joint #3	1480849	R13B030206	Z : width 10 mm	7.2	✓
	Joint #4	1480850	R13B030207	U1 : width 9 mm	8.2	✓
		1480851	R13B030208	U2 : width 20 mm		
Battery Board		2120180	R13B041202	With lithium battery Installed in Arm #2 ER17330V (TOSHIBA)	11.2	
Battery Unit		2117879	R13ZA00600300	Lithium battery for replacement*3 ER17330V (TOSHIBA)	11.1	
O-ring		1480857	R13B031223	For Motor flange of Joint #1	5.1	
LED Lamp		2077258	R13A030000200	*2	12	
Grease *5	AFB (Ball Screw Spline)	-	-	For purchasing the grease, please contact the supplier of your region.	2.3	
	SK-1A (Reduction Gear Unit)	-	-		2.3	
	GPL-224 (Cable)	-	-		4	

*1 G6-***1** (Z: 150, 180 mm) do not have U axis Electromagnetic Brake.

*2 Common with E2 series

*3 Common with E2C

*4 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 2.2 Overhaul (Parts Replacement).

*5 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.	https://www.thk.com/
Harmonic Grease SK-1A	Harmonic Drive Systems Inc.	https://www.harmonicdrive.net/
Krytox®GPL-224	Chemours	https://www.chemours.com/en/brands-and-products

** Reduction Gear Unit

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

Waveform generator

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

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

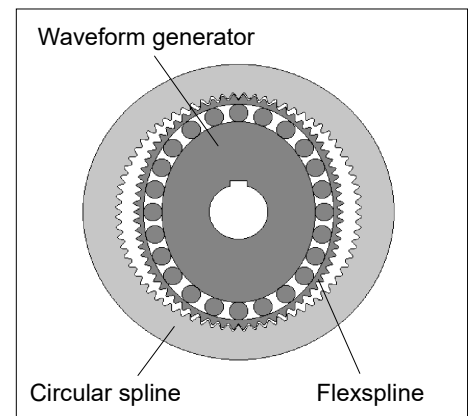
Flexspline

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

Circular spline

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

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



The splines are greased. Be sure to keep the grease from being attaching to the clothes.

14.2 Parts by Environment Model

(S: Standard-model C: Cleanroom-model D, P: Protected-model)

Part Name			Code	Old Code	Note	Reference	Overhaul *5		
Ball Screw Spline	S, D(without bellows)	180 mm	1495142	R13B010202		10.1.1	✓		
		330 mm	1495143	R13B010203					
	C	150 mm	1497627	R13B010204		10.1.2	✓		
		300 mm	1497628	R13B010205					
	P, D with bellows option	150 mm	1497629	R13B010206					
		300 mm	1497630	R13B010207					
Cable Unit	S, C	450 mm	1497631	R13B020012	Inner wiring cable			4	
		550 mm	1497632	R13B020013					
		650 mm	1497633	R13B020014					
	P, D	450 mm	1497634	R13B020015					
		550 mm	1497635	R13B020016					
		650 mm	1497636	R13B020017					
M/C Cable	S, C	3 m	For RC180	R12NZ90026	R12B020425	*4	4.3		
			For RC700-A, Straight	R12NZ900JX	—				
			For RC700-A, L-shaped	R12NZ900K1	—				
		5 m	For RC180	R12NZ90027	R12B020426				
			For RC700-A, Straight	R12NZ900JY	—				
			For RC700-A, L-shaped	R12NZ900K2	—				
		10 m	For RC180	R12NZ90028	R12B020427				
			For RC700-A, Straight	R12NZ900JZ	—				
			For RC700-A, L-shaped	R12NZ900K3	—				
		15 m	For RC700-A, Straight	R12NZ900X Y	—				
			For RC700-A, L-shaped	R12NZ900Y1	—				
		20 m	For RC700-A, Straight	R12NZ900X Z	—				
			For RC700-A, L-shaped	R12NZ900Y2	—				

Part Name			Code	Old Code	Note	Reference	Overhaul *5
M/C Cable	D, P	3 m	For RC180	R12NZ90029	R12B020428	*4	4.3
			For RC700-A, Straight	R12NZ900K4	—		
			For RC700-A, L-shaped	R12NZ900K7	—		
		5 m	For RC180	R12NZ9002A	R12B020429		
			For RC700-A, Straight	R12NZ900K5	—		
			For RC700-A, L-shaped	R12NZ900K8	—		
		10 m	For RC180	R12NZ9002B	R12B020430		
			For RC700-A, Straight	R12NZ900K6	—		
			For RC700-A, L-shaped	R12NZ900K9	—		
		15 m	For RC700-A, Straight	R12NZ900Y3	—		
			For RC700-A, L-shaped	R12NZ900Y5	—		
		20 m	For RC700-A, Straight	R12NZ900Y4	—		
For RC700-A, L-shaped	R12NZ900Y6		—				
Arm Cover	S, D		1497637	R13B030402	White	3.1, 3.2	
	C, P		1497638	R13B030406	Plating		
Bellows	C, P, D with bellows option	150 mm	1497641	R13B030701	*4 *6	9	
		300 mm	1497642	R13B030702	*6		
Gasket Unit	D, P		1497643	R13B031226		2.6	
Arm Gasket #2	P		1497644	R13B031227		-	
Brake Release Switch	S, C		2117817	R13Z7026401 00	*2	-	
	D, P		1497647	R13B060902	*4	-	

*1 G6-***1** (Z: 150, 180 mm) do not have U axis Electromagnetic Brake.

*2 Common with E2 series

*3 Common with E2C

*4 Common with G10/G20 series

*5 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 2.2 *Overhaul (Parts Replacement)*.

*6 The bellows are provided in a unit of two pieces. The shape varies between the upper and lower bellows.


G10 G20 Maintenance


This volume contains maintenance procedures with safety precautions for Manipulators.


1. Safety Maintenance

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

Only authorized personnel who have taken maintenance training held by the manufacturer or dealer should be allowed to perform the robot maintenance.

 WARNING	<ul style="list-style-type: none"> ■ 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.
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 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.
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 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. ■ When operating maintenance of manipulator, secure about 50 cm of empty space around the manipulator.
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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.

	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					√	

h = hour

2.1.2 Inspection Point

Inspection Item

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts/screws.	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
Check looseness of connectors.	External connectors on Manipulator (on the connector plates etc.)	√	√	√	√	√
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 the brake operation	Joint #3	√	√	√	√	√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√

Inspection Method

Inspection Point	Inspection Method
Check looseness or backlash of bolts/screws.	Use a hexagonal wrench to check that the end effector mounting bolts and the Manipulator mounting bolts are not loose. When the bolts are loose, refer to "2.4 Tightening Hexagon Socket Head Bolts" and tighten them to the proper torque.
Check looseness of connectors.	Check that connectors are not loose. When the connectors are loose, reattach it not to come off.
Visually check for external defects. Clean up if necessary.	Check the appearance of the Manipulator and clean up if necessary. Check the appearance of the cable, and if it is scratched, check that there is no cable disconnection.
Check for bends or improper location. Repair or place it properly if necessary.	Check that the safeguard, etc. are located properly. If the location is improper, place it properly.
Check the brake operation	Check that the shaft does not fall when in MOTOR OFF. If the shaft falls when in MOTOR OFF and the brake is not released, contact the supplier. Also, the break is not released even operated release the break, contact the supplier.
Check whether unusual sound or vibration occurs.	Check that there is no unusual sound or vibration when operating. If there is something wrong, contact the supplier.

2.2 Overhaul (Parts Replacement)



CAUTION

- If you do not overhaul properly, it may have a serious impact on safety.
- 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 ambient temperature, 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.

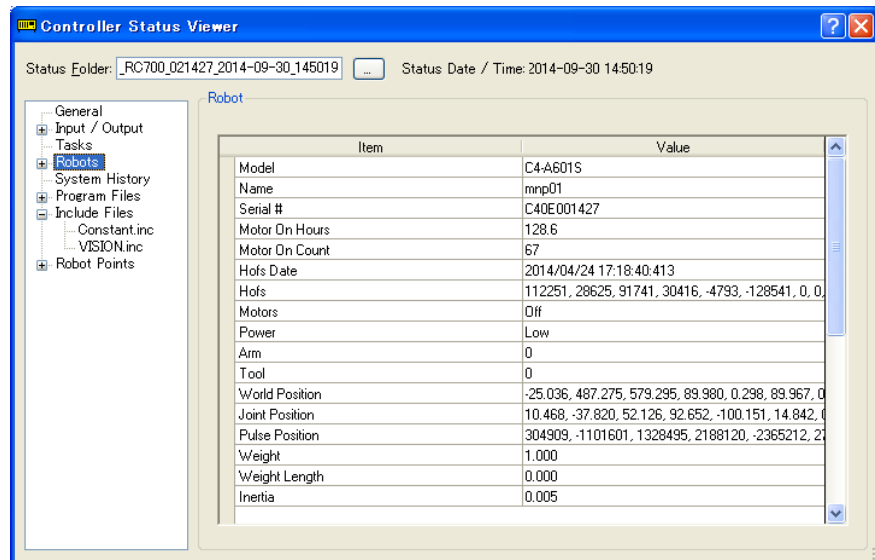
RC700 series Maintenance Manual 6. Alarm

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 15. *G10 G20 Maintenance Parts List*.


For details of replacement of each part, refer to each 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.
--	--

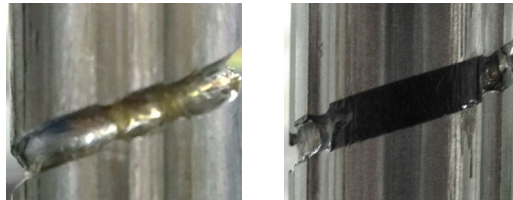
	Greasing part	Greasing Interval	Grease	Reference
Joint #1	Reduction gear units	Overhaul timing	SK-1A	5.2 Replacing the Joint #1 Reduction Gear Unit
Joint #2				6.2 Replacing the Joint #2 Reduction Gear Unit
Joint #3	Ball screw spline unit	At 100 km of operation (50 km for first greasing)	AFB	Greasing the Ball Screw Spline Unit
Joint #4	Backlash-less gear	In Joint #3 greasing	AFB	G10 only

Joint #1, 2 reduction gear units

As a rough indication, perform greasing at the same timing as overhaul. However, it may vary depending on ambient temperature, 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.



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.

RC700 series Maintenance Manual 6. Alarm

2.3.1 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	

Standard-model



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

- (1) Turn ON the Controller.
- (2) Move the shaft to the lower limit by using one of the following methods:
 - Move the shaft to the lower limit manually while pressing the brake release switch.



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.

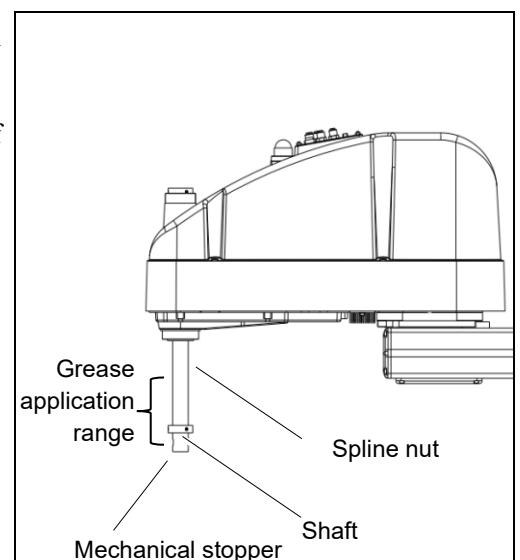
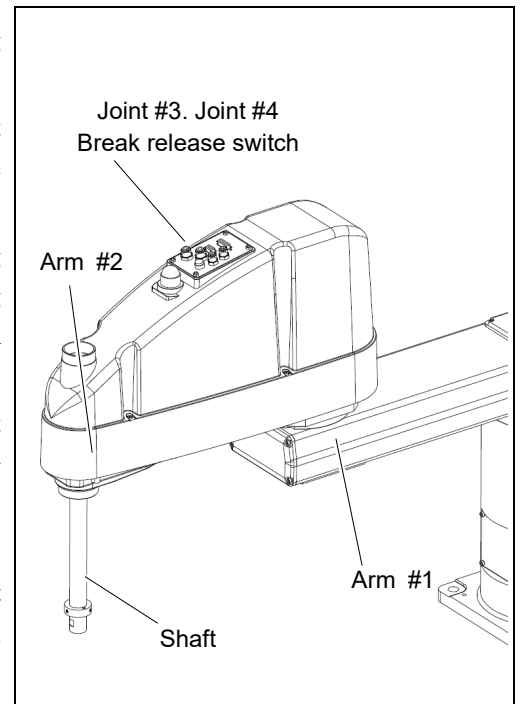
- Move the shaft to the lower limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].



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

- (3) Turn OFF the Controller.
- (4) Wipe off the old grease from the shaft, and then apply new grease to it.

Grease application range is from the end of the spline nut to mechanical stop.

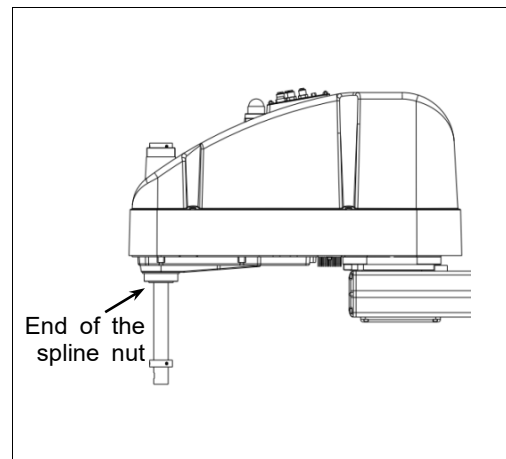


- (5) Apply new grease evenly to the spiral groove of the ball screw spline unit and the vertical groove so that the groove is filled.




- (6) Turn ON the Controller.
- (7) Start the robot manager and move the shaft to the origin position. Be careful not to hit peripheral equipment.
- (8) After moving to the origin position, reciprocate the shaft. The reciprocating operation is a low power mode operation program that performs from the upper limit to the lower limit. Run for about 5 minutes to spread the grease over the shaft.


- (9) Turn OFF the controller.
- (10) Wipe off excess grease on the end of the spline nut and mechanical stop.




Cleanroom-model

NOTE  Dust is emitted when greasing. 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 greasing. Cover the surrounding area such as the end effector and peripheral equipment in case the grease drips.

- (1) Turn ON the Controller.
- (2) Move the shaft to the upper limit by using one of the following methods:
 - Move the shaft to the upper limit manually while pressing the brake release switch.

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.

- Move the shaft to the upper limit manually while by selecting EPSON RC+ 7.0 menu - [Tools] - [Robot Manager] - [Jog & Teach].

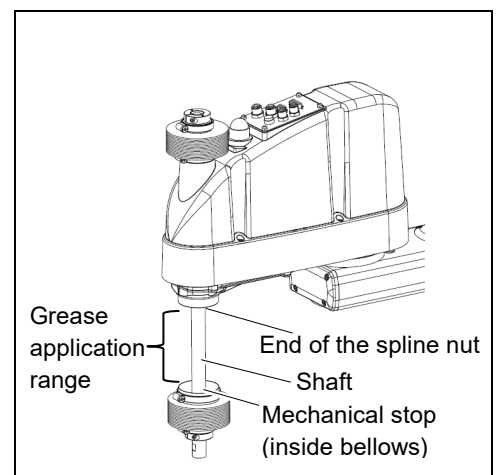
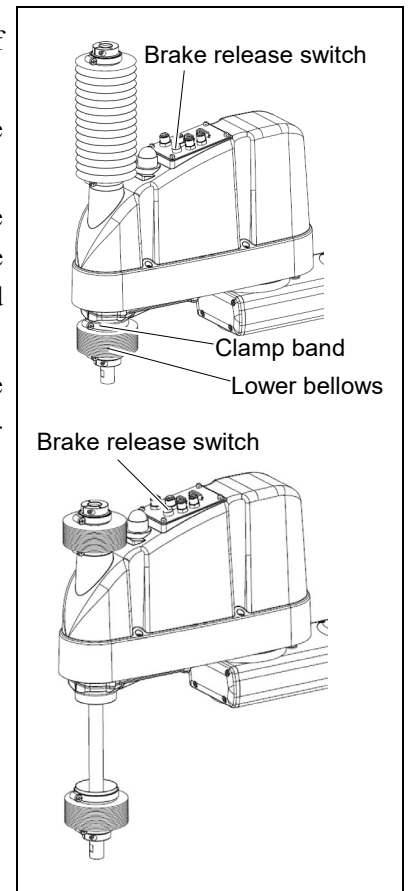
NOTE  Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

- (3) Loosen the clamp band on the top of the lower bellows, and then move the lower bellows downward.
- (4) Move the shaft to the lower limit in the same way as in step (2).

- (5) Turn OFF the Controller.

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

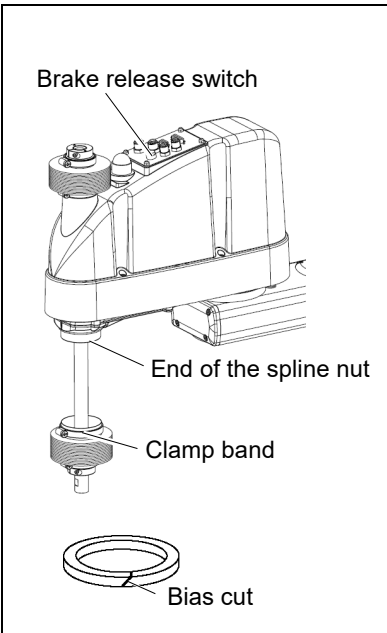
The range to apply grease is from the end of the spline nut to the mechanical stop.



- (7) Apply grease to the spiral groove and vertical groove of the ball screw spline to fill the grooves.



- (8) Turn ON the Controller.
- (9) Apply grease to the whole of the shaft.
Move the shaft up and down about 10 times from the upper limit to the lower limit.
When moving the shaft up and down, press and hold the brake release switch on the top of cover.
After moving up and down, wipe off excess grease from the end of the spline nut.



- (10) Fix the lower bellows.
Move the shaft to the upper limit.
Insert the bellows mounted part until it touches the cylinder part of the cover.
Fit the rubber sheet. Be sure to fit the rubber sheet so that no space is made between the bias cut.
Fix with the clamp band.

- (11) After fitting, move the shaft up and down several times and rotate Joint #4. Make sure that the bellows can expand and contract smoothly without any excessive force.
- (12) Start Robot Manager and move the shaft to the origin position.
Be sure to prevent hitting any peripheral equipment.
- (13) After moving to the origin position, move the shaft up and down. To move up and down, use an operation program to move from the upper limit to the lower limit in low power mode. Run about 5 minutes to spread grease over the shaft.
- (14) Turn OFF the Controller.

2.3.2 Greasing Joint #4 Backlash-less gear (G10 only)

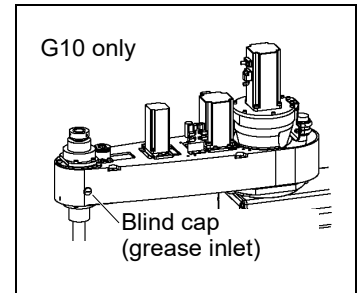
	Name	Quantity	Note
Maintenance Parts	For Ball Screw spline (AFB grease)	Proper quantity	
Tools	Flat blade screwdriver	1	
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Grease gun (or Plastic syringe)	10 to 20g	
	Wiping cloth	1	For wiping grease

- (1) Remove the arm top cover.

For details, refer to
3.1 Arm Top Cover.

- (2) Remove the blind cap.
- (3) Apply grease with a grease gun or a plastic syringe (without needle).

Put 10 to 20 g of grease into the plastic syringe and apply 5 g to the backlash-less gear, so as to fill in the gear grooves.



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.

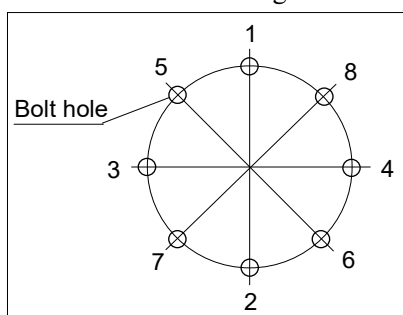
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

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.

EPSON
RC+

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

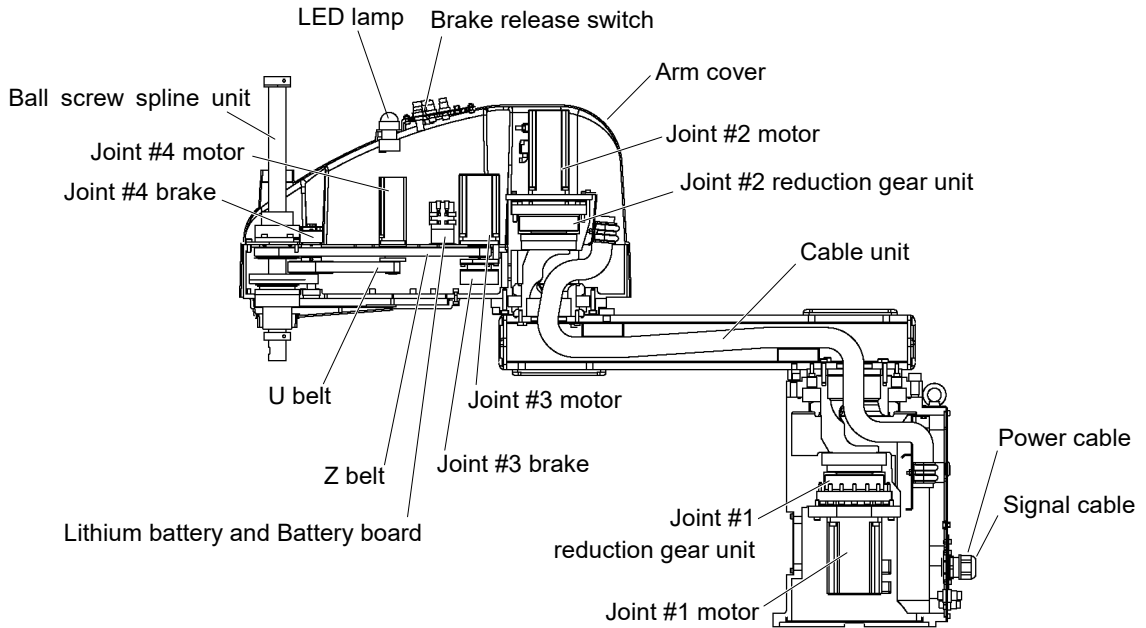
G10-65*** manipulator of S/N: 1**** or later is different from other models in its maintenance parts position.

For the detail, refer to 2.6.4 G10-65***: For S/N: 1**** or later.

2.6.1 Table Top Mounting type

G10

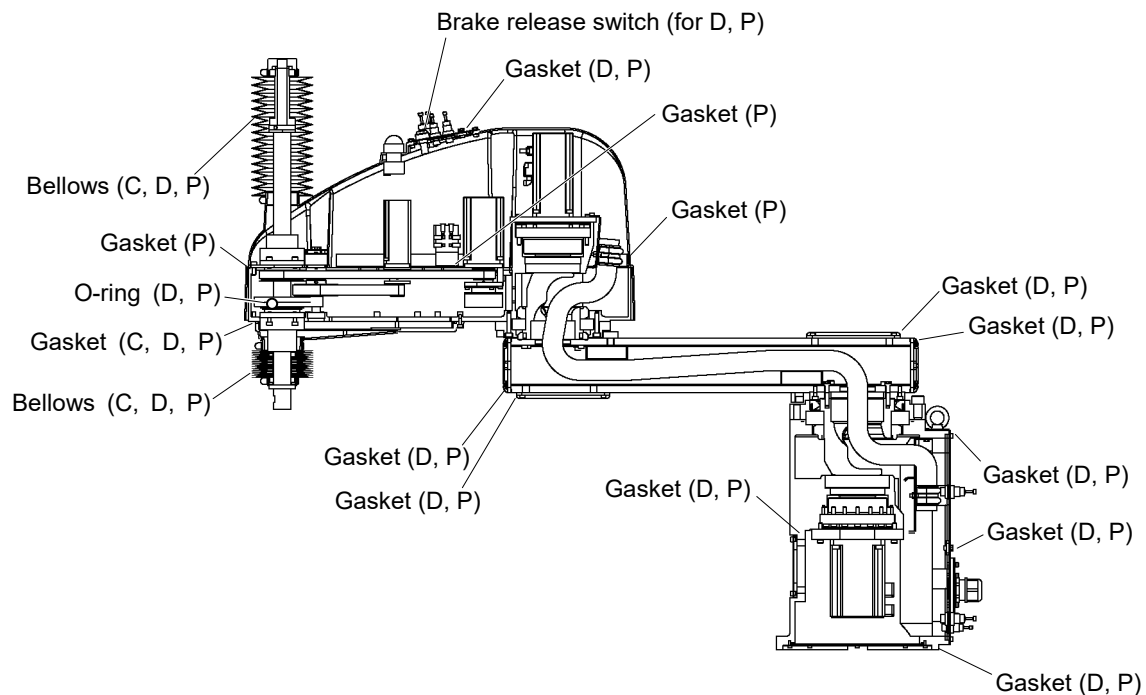
G10-***S : Standard-model



(Figure: G10-851S)

G10-***C : Cleanroom-model

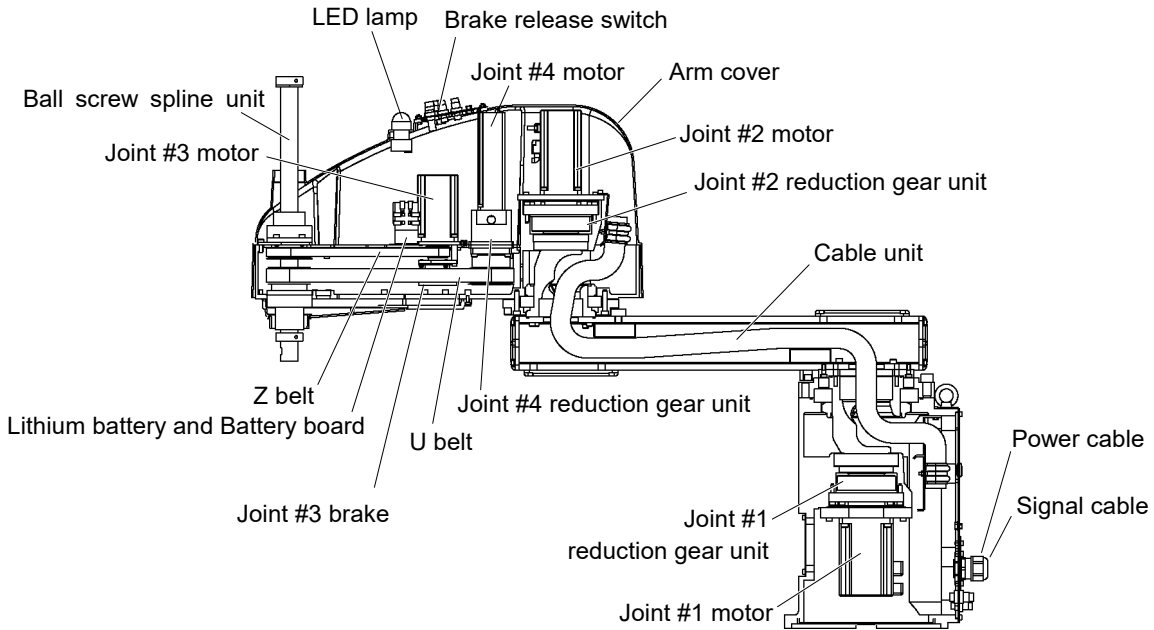
G10-***D, P : Protected-model (D: With bellows option)



(Figure: G10-851P)

G20

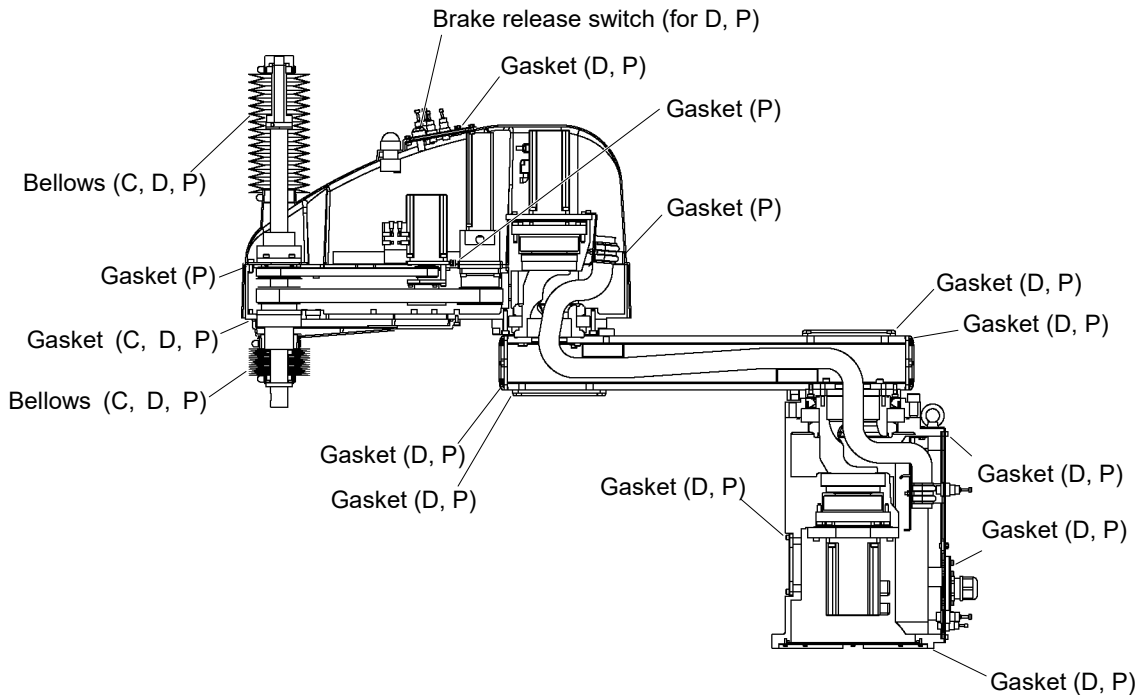
G20-***S : Standard-model



(Figure: G20-851S)

G20-***C : Cleanroom-model

G20-***D, P : Protected-model (D: With bellows option)

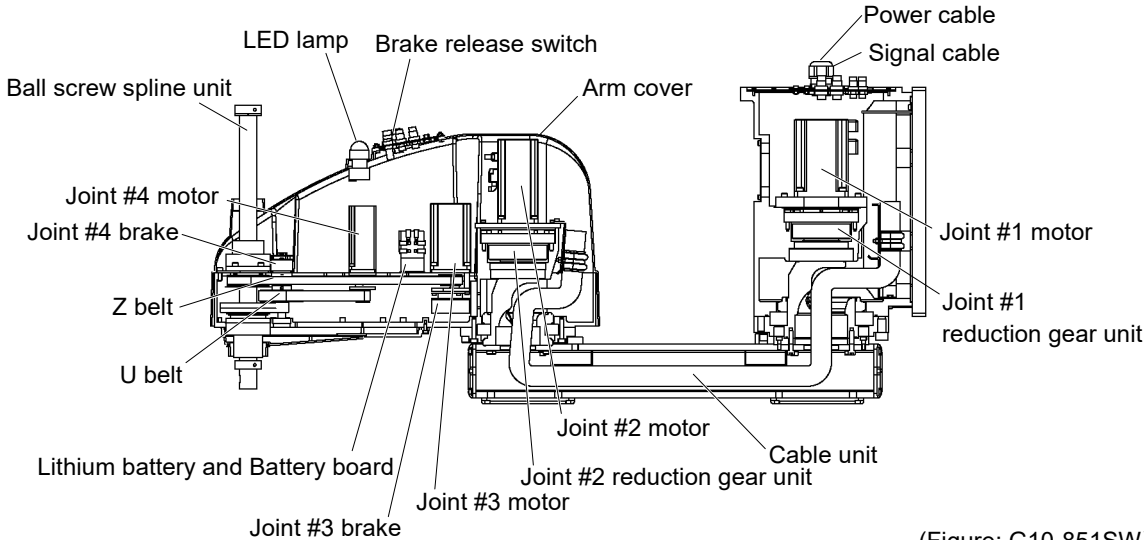


(Figure: G20-851P)

2.6.2 Wall Mounting type

G10

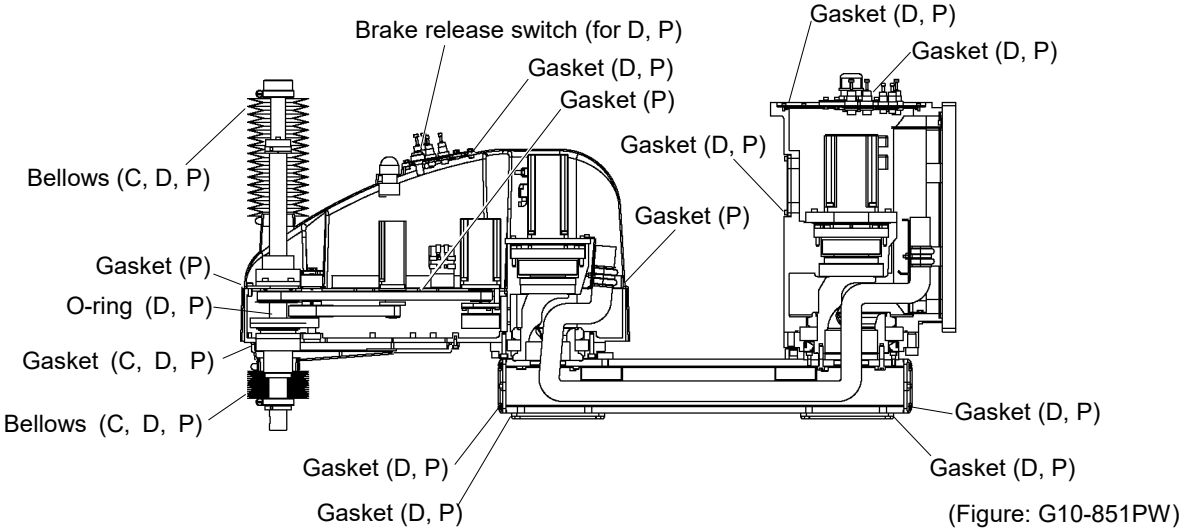
G10-***SW : Standard-model



(Figure: G10-851SW)

G10-***CW : Cleanroom-model

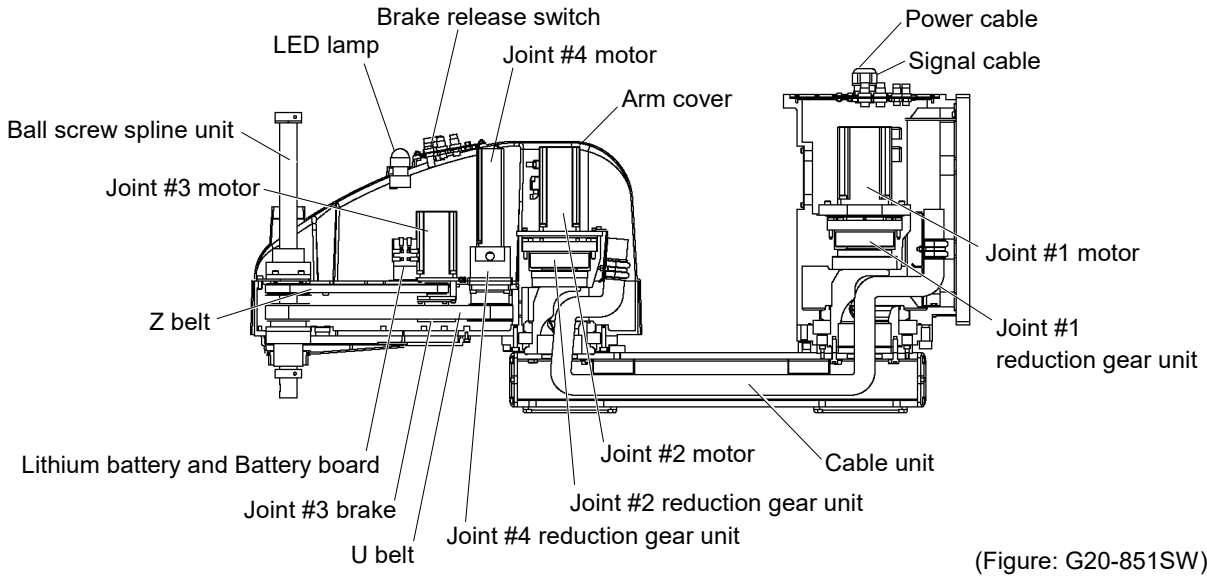
G10-***DW, PW : Protected-model (D: With bellows option)



(Figure: G10-851PW)

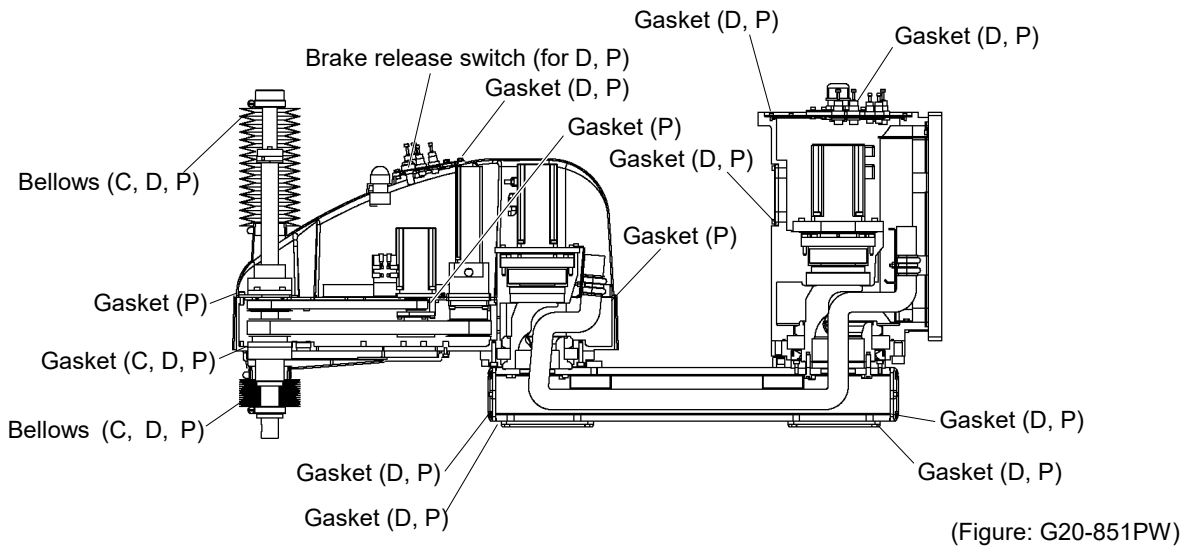
G20

G20-***SW : Standard-model



G20-***CW : Cleanroom-model

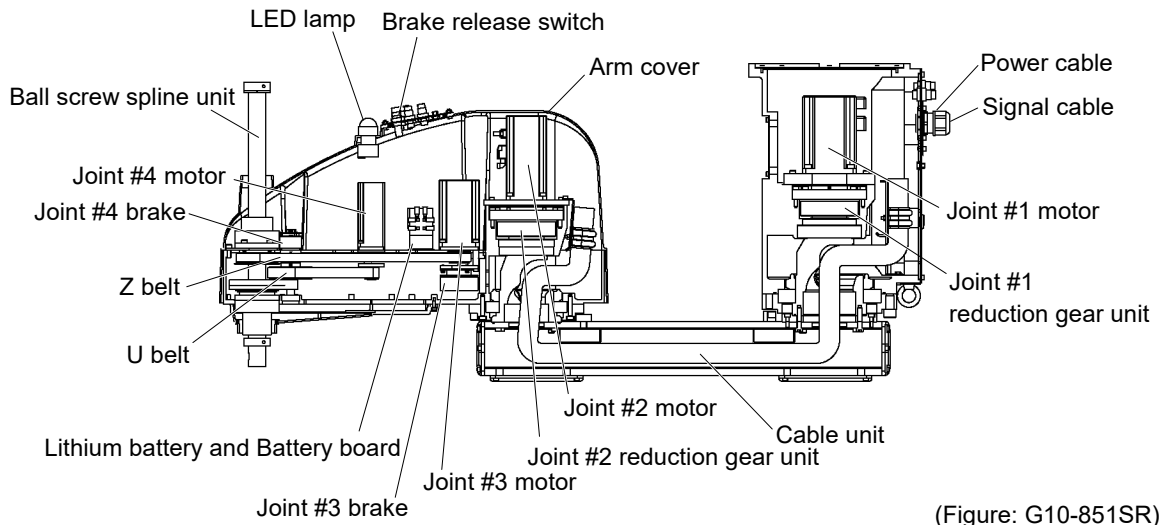
G20-***DW, PW : Protected-model (D: With bellows option)



2.6.3 Ceiling Mounting type

G10

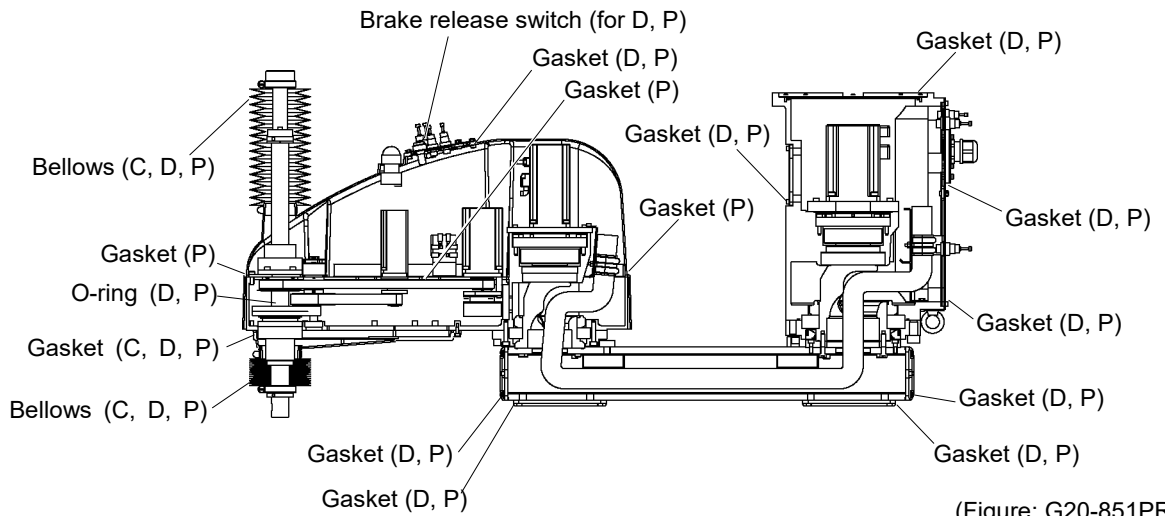
G10-***SR : Standard-model



(Figure: G10-851SR)

G10-***CR : Cleanroom-model

G10-***DR, PR : Protected-model (D: With bellows option)

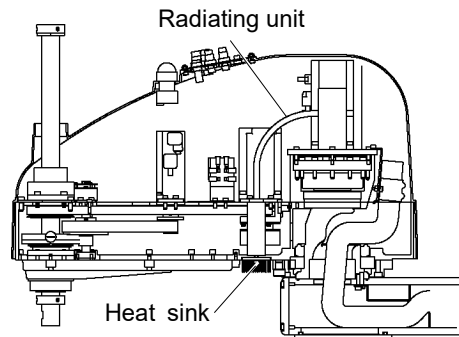


(Figure: G20-851PR)

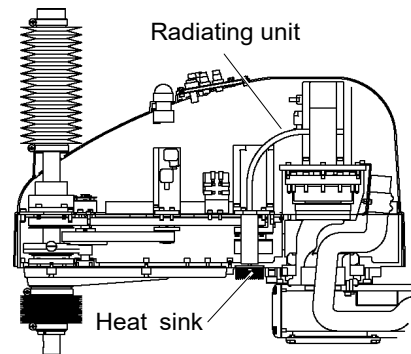
2.6.4 G10-65*: For S/N: 1**** or later**

The following maintenance parts have been added for G10-65*** manipulator of S/N: 1**** or later.

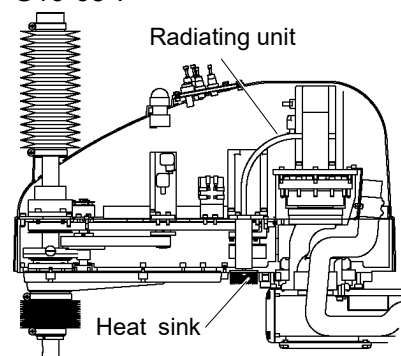
Standard model G10-65*S*



Cleanroom model G10-65*C*




Protection model G10-65*P*

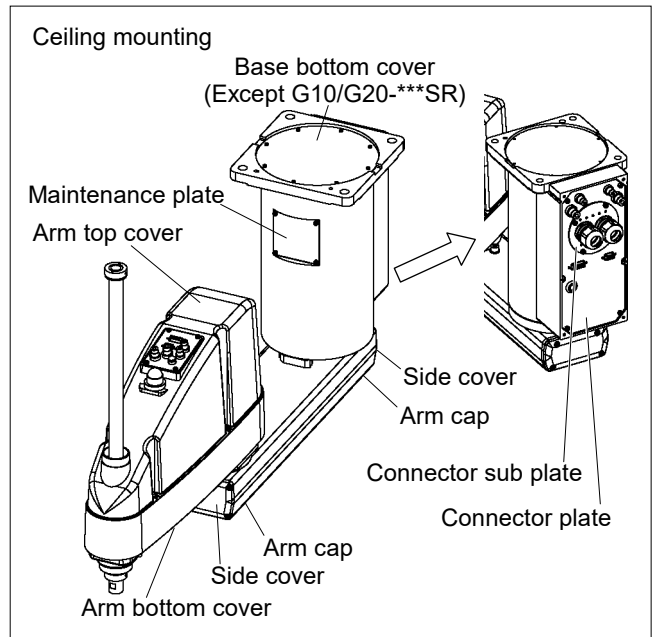
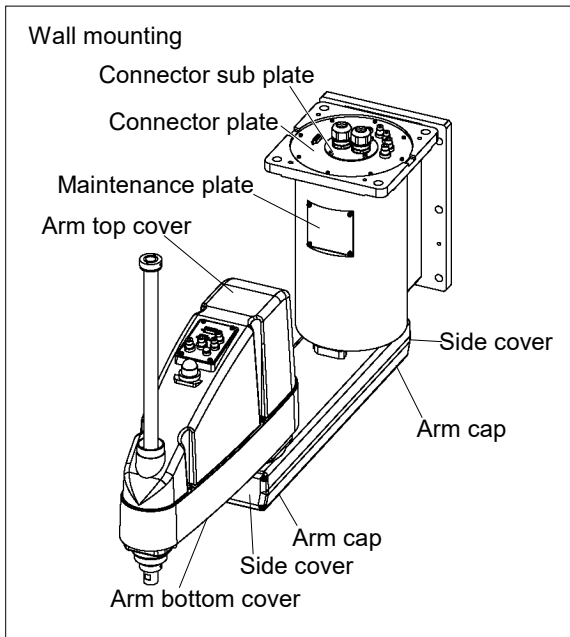
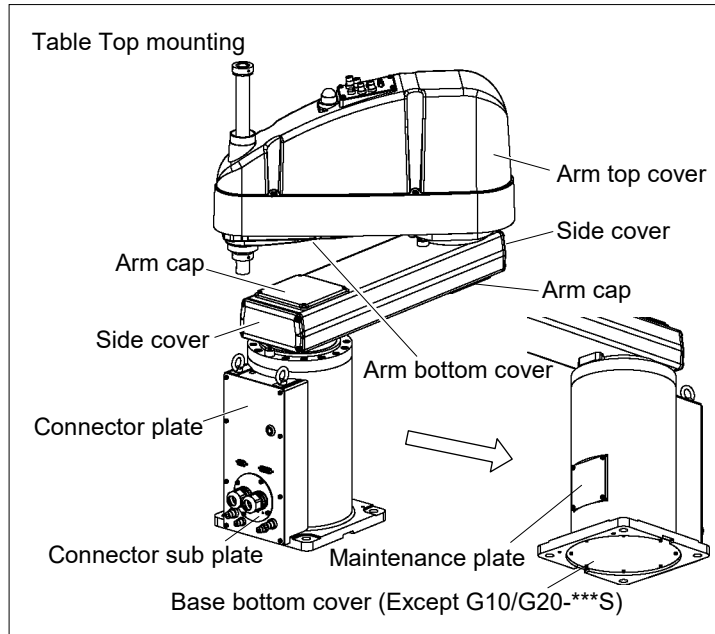


3. Covers


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	1499592 Only for Cleanroom-model and Protected-model
	Arm #2 Gasket	1	1499593 Only for Cleanroom-model and Protected-model
	Silicon adhesive (for the gasket on the Connector Plate)	1	Only for Table top mounting and Ceiling mounting / Protected-model
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw Only for Wall mounting / Protected-model
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw Tightening Torque: 0.9 N·m (9.2 kgf·cm) Only for Cleanroom-model and Protected-model
	Cross-point screwdriver	1	For bellows removal Only for Cleanroom-model and Protected-model
	Wiping cloth	1	For wiping adhesive




3.1 Arm Top Cover

 CAUTION	<ul style="list-style-type: none"> ■ Do not remove the arm top cover forcibly. Removing the cover forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. ■ When 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) Turn ON the Controller.
- (2) Press and hold the brake release switch to let the shaft down. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

NOTE  The brake release switch affects both Joints #3 and #4. When the brake release switch is pressed, the brakes for both Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling or rotation while the brake release switch is being pushed because it may be lowered by the weight of an end effector.

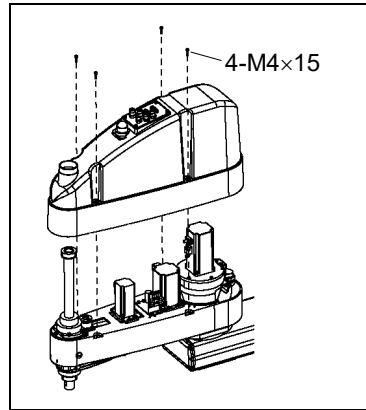
- (3) Turn OFF the Controller.
- (4) Unscrew the arm top cover mounting bolts, and then lift the cover.

NOTE  When bellows are installed to the manipulator, remove the upper bellows and then remove the arm top cover. For bellows removal, refer to 9. *Bellows*.

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

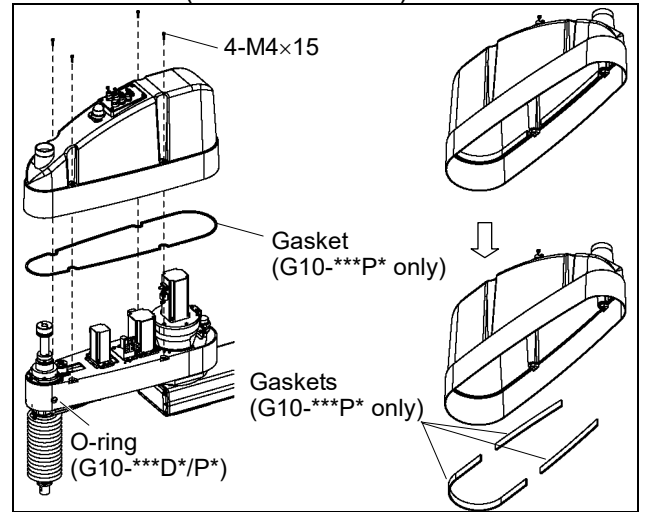
LED lamp and the cable of the brake release switch are located between the main part and the cover. Do not pull the cable strong or the connector may be damaged.

G10-***S* (Standard-model)



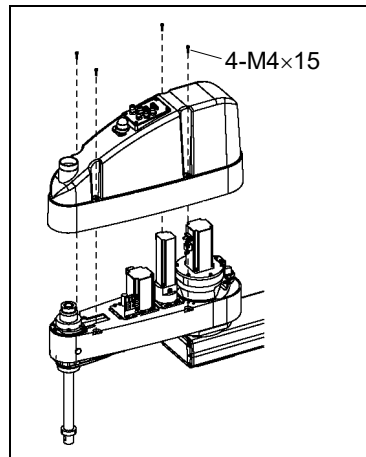
G10-***C* (Cleanroom-model)

G10-***D*/P* (Protected-model)



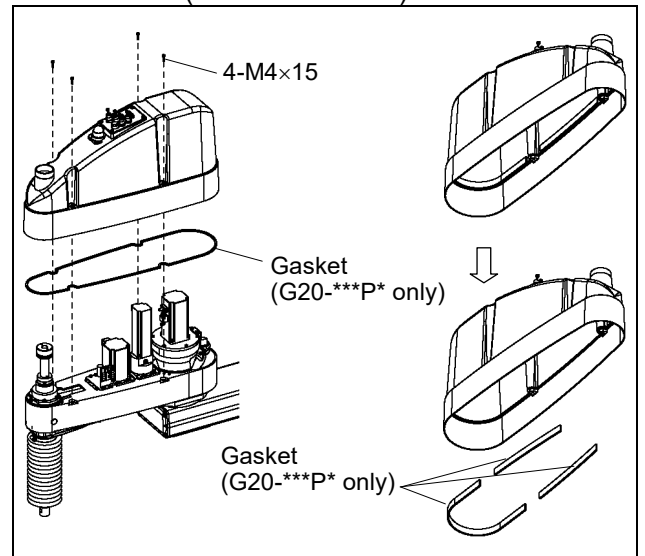
Gaskets are installed to G10-***P*.
O-ring is installed to G10-***D*, P*.

G20-***S* (Standard-model)



G20-***C* (Cleanroom-model)

G20-***D*/P* (Protected-model)

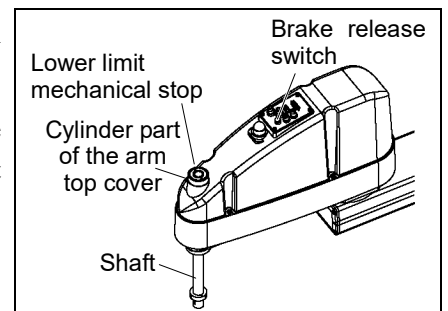


Gaskets are installed to G20-***P*.

Arm Top Cover Installation

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

After mounting the arm top cover, make sure that the lower limit mechanical stop does not touch the cylindrical part of the arm top cover.



When bellows are installed to the manipulator, install the arm top cover and then install the upper bellows. For bellows installation, refer to 9. *Bellows*.

3.2 Arm Bottom Cover

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



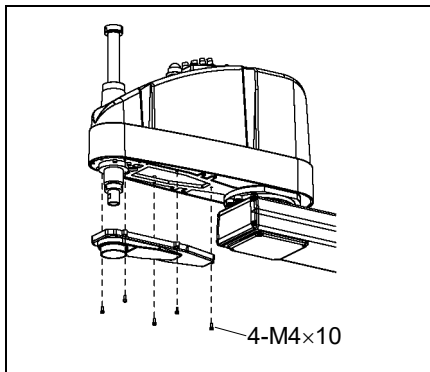
The arm bottom cover may not be removed from the shaft because the end effector is installed.

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

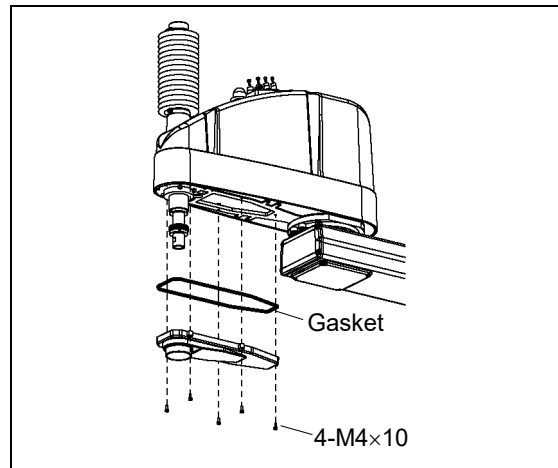
If it is not necessary to remove the cover completely, move the shaft to the lower limit, and lower the arm bottom cover. Then, perform maintenance or inspection.

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

G10/G20-***S* (Standard-model)



G10/G20-***C* (Cleanroom-model)
G10/G20-***D*, P* (Protected-model)



A gasket is installed to G10/G20-***C* (Cleanroom-model) and G10/G20-***D*/P* (Protected-model).

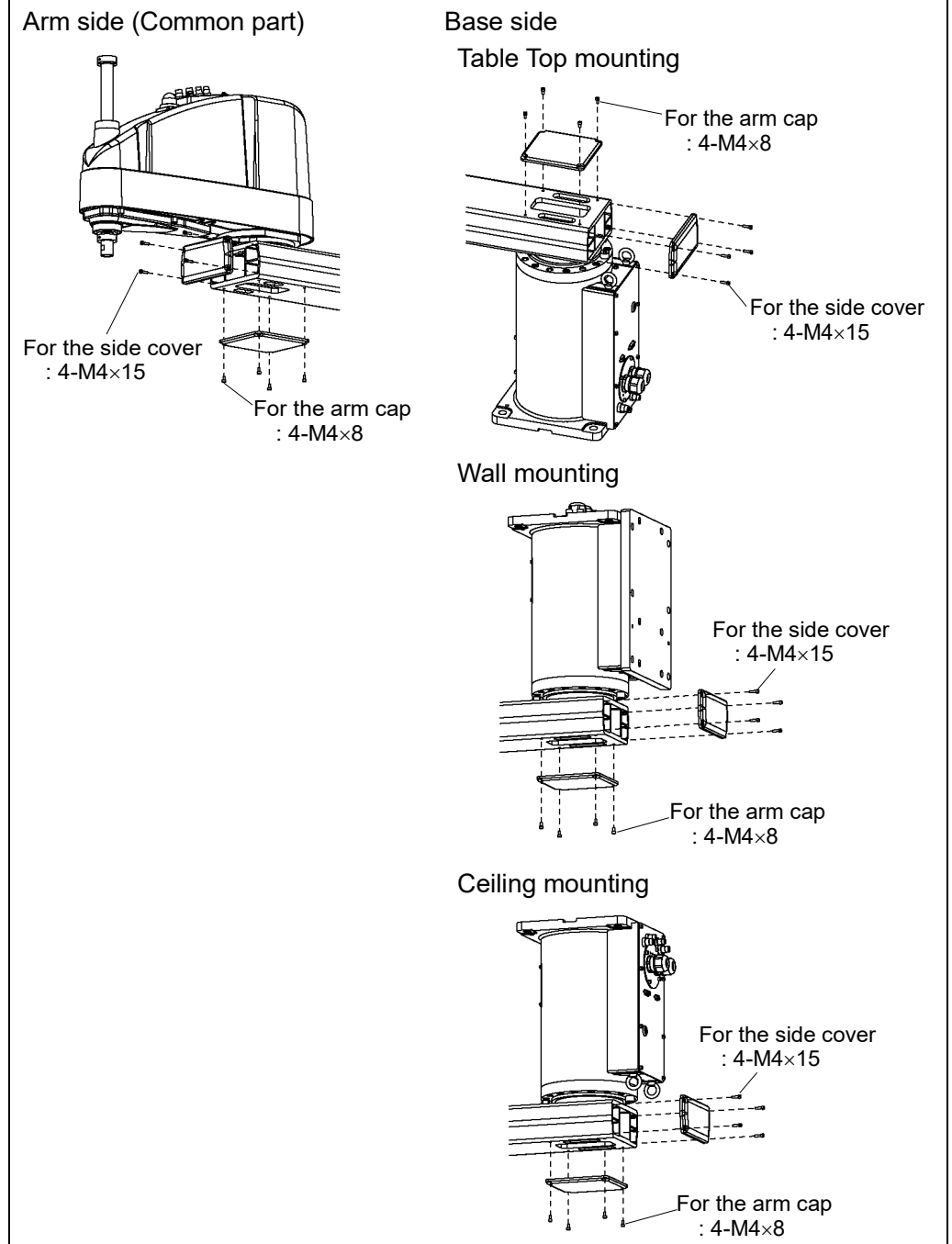
3.3 Arm #1 Cover

There are two sets of Arm #1 covers.

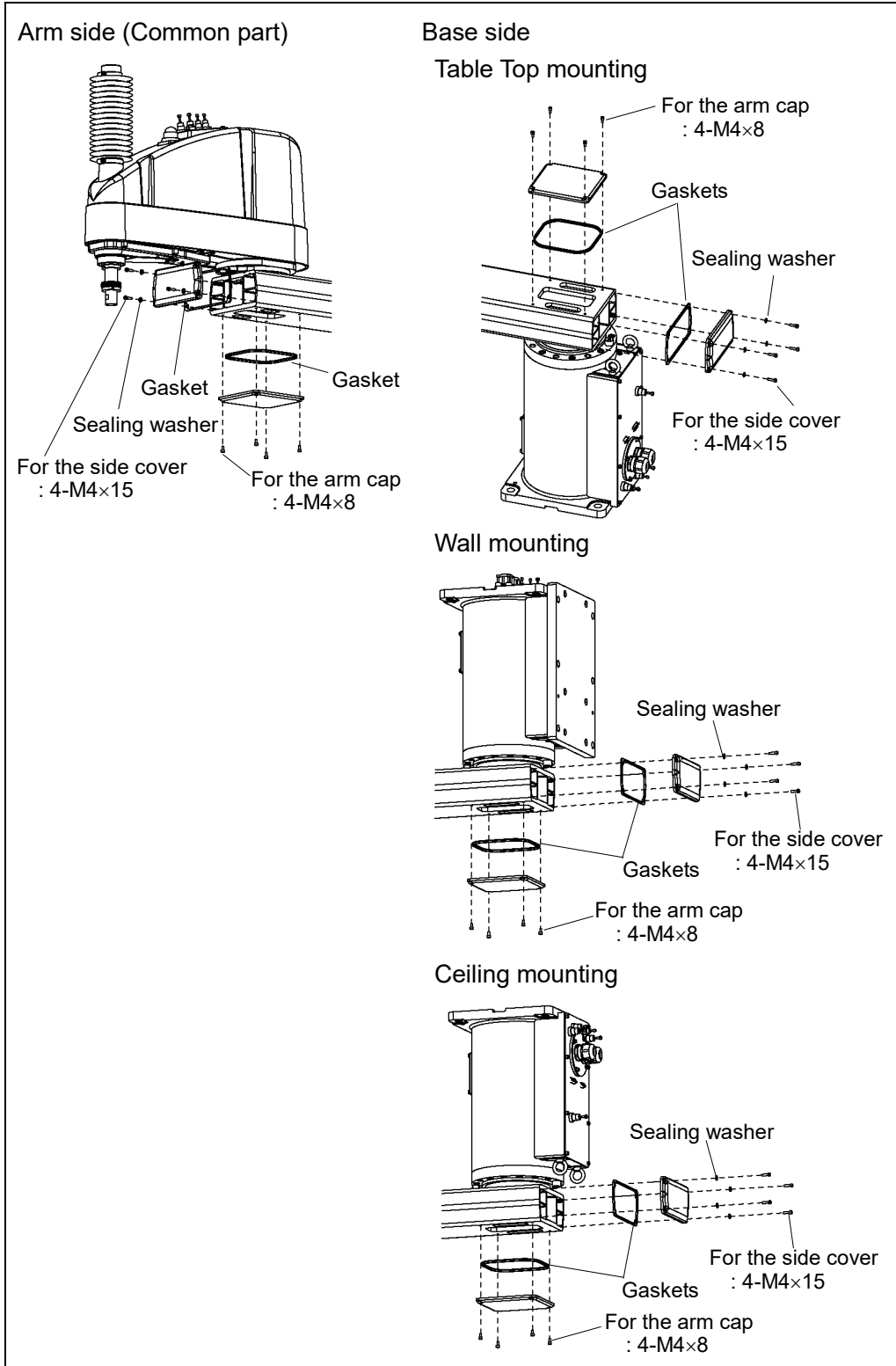
- Arm caps
- Side covers

Unscrew the bolts mounting the covers and the caps to remove them.

3.3.1 G10/G20-***S* (Standard-model), G10/G20-***C* (Cleanroom-model)




3.3.2 G10/G20-***D*, P* (Protected-model)



Gaskets and sealing washers are installed to G10/G20-***D*, P* (Protected-model).

3.4 Connector Plate

 CAUTION	<ul style="list-style-type: none"> 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.
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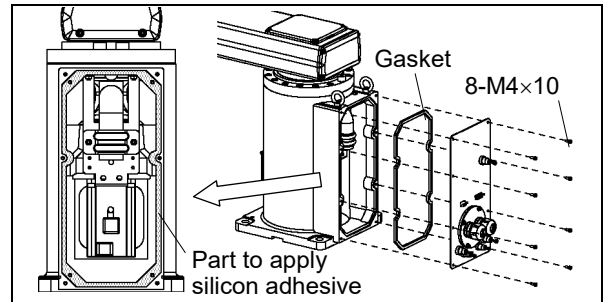
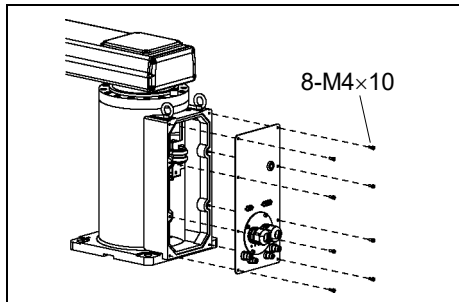
Unscrew the connector plate mounting bolts and remove the plate.

G10/G20-***S* (Standard-model)

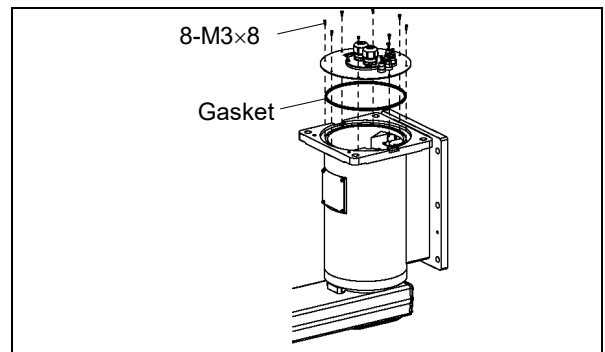
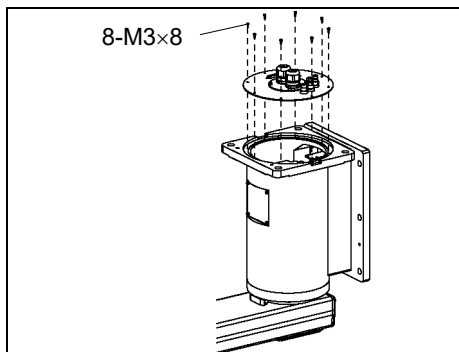
G10/G20-***C* (Cleanroom-model)

G10/G20-***D*, P* (Protected-model)

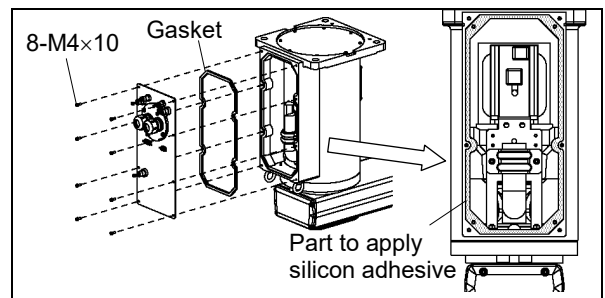
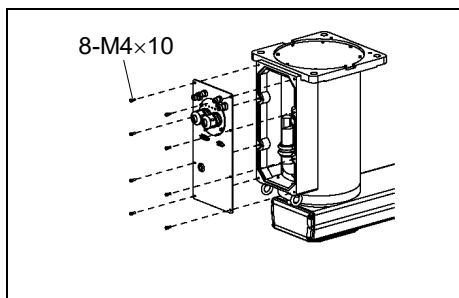
Table Top
mounting



Wall
mounting



Ceiling
mounting



A gasket is installed to G10/G20-***D*, P* (Protected-model).

NOTE


When installing the gasket to Table Top mounting (G10/G20-***D, P) or Ceiling mounting (G10/G20-***DR, PR), apply silicon adhesive to the gasket installing part on the base side (shaded part in the photo).

3.5 Connector Sub Plate



- Do not remove the connector sub plate forcibly. Removing the connector sub 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 sub 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 sub plate. Be sure to place the cables back to their original locations.

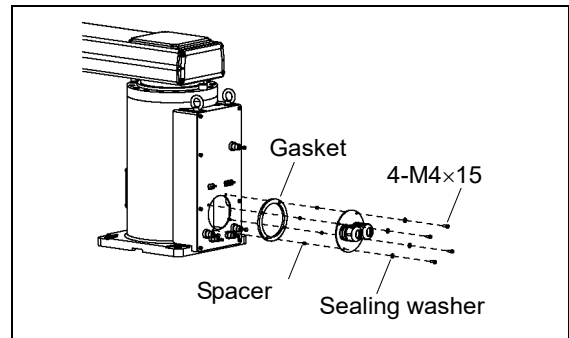
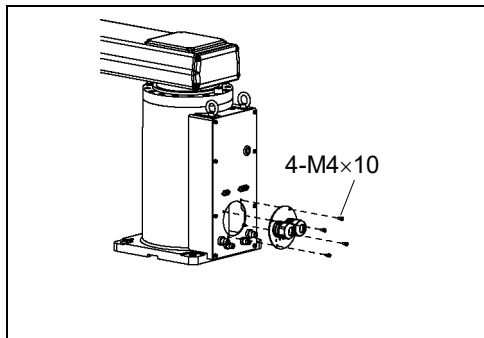
Unscrew the connector sub plate mounting bolts and remove the plate.

G10/G20-***S* (Standard-model)

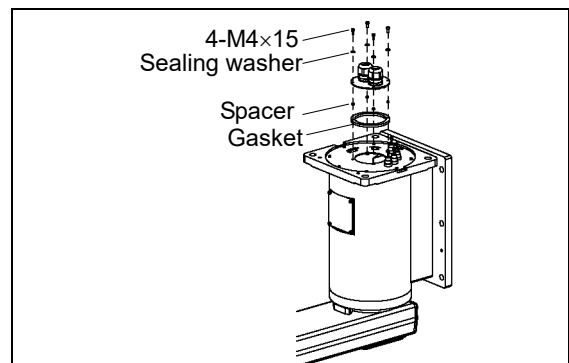
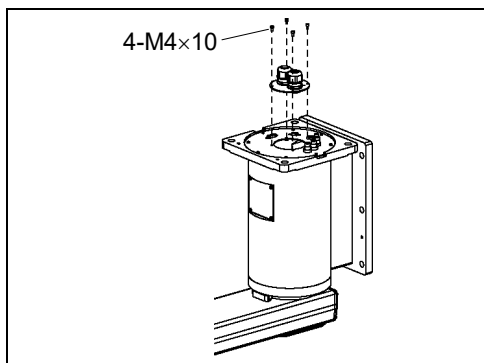
G10/G20-***C* (Cleanroom-model)

G10/G20-***D*, P* (Protected-model)

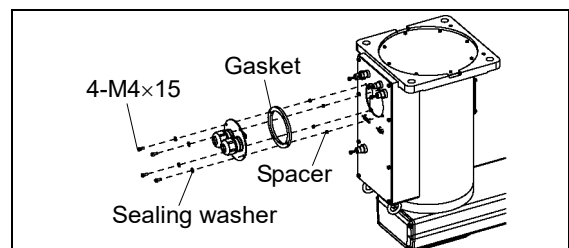
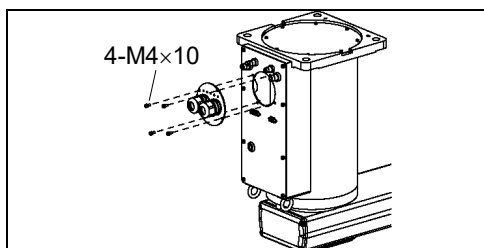
Table Top mounting



Wall mounting



Ceiling mounting



A gasket, spacers, and sealing washers are installed to G10/G20-***D*, P* (Protected - model).

3.6 User Plate

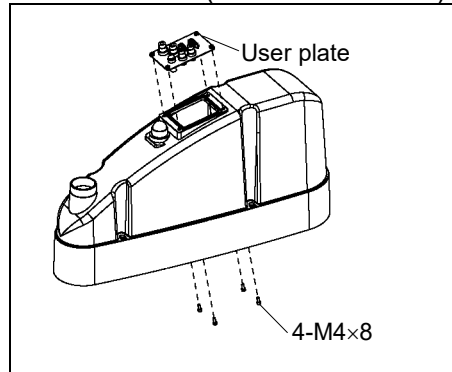
Unscrew the user plate mounting bolts and remove the plate.



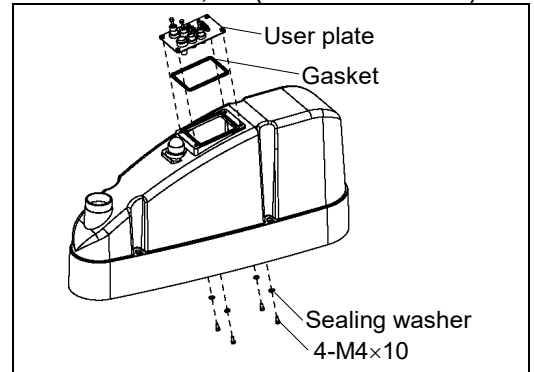
Do not remove the nut by force. The nut for the user plate is combined with the user plate. And if you try to remove the nut, it will damage the user plate.

G10/G20-***S* (Standard-model)

G10/G20-***C* (Cleanroom-model)



G10/G20-***D*, P* (Protected-model)



A gasket and sealing washers are installed to G10/G20-***D*, P* (Protected-model).

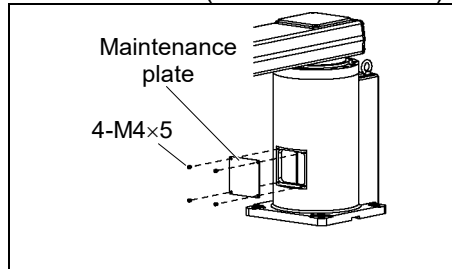
3.7 Maintenance Plate

Unscrew the maintenance plate mounting bolts and remove the plate.

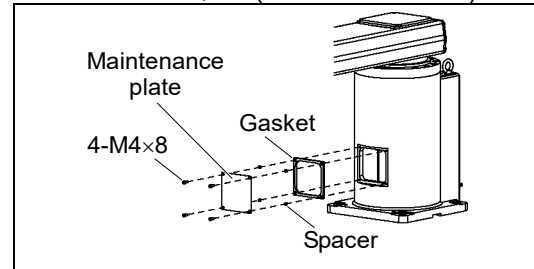
G10/G20-***S* (Standard-model)

G10/G20-***C* (Cleanroom-model)

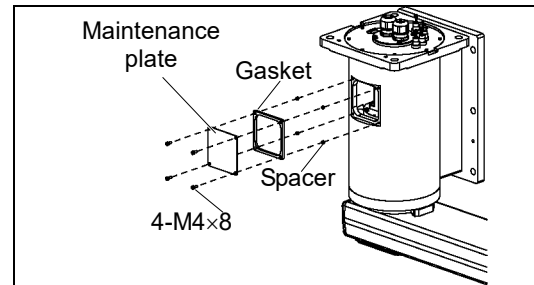
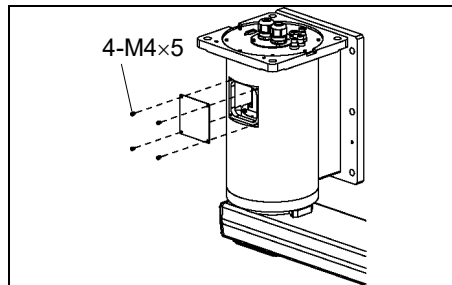
Table Top mounting



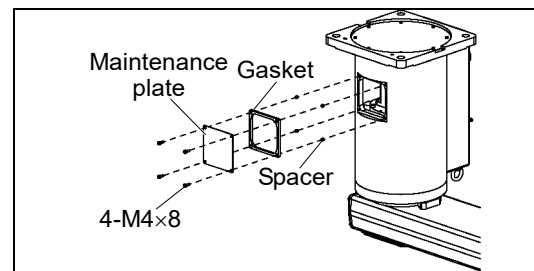
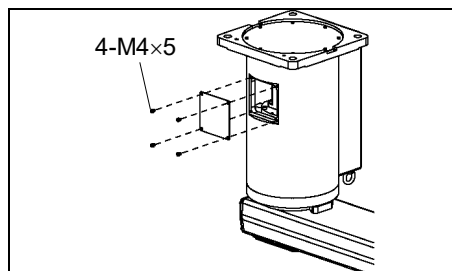
G10/G20-***D*, P* (Protected-model)



Wall mounting



Ceiling mounting



A gasket and spacers are installed to G10/G20-***D*, P* (Protected-model).

3.8 Base Bottom Cover

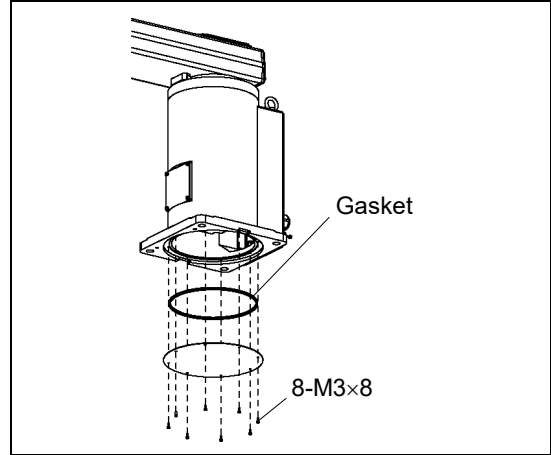
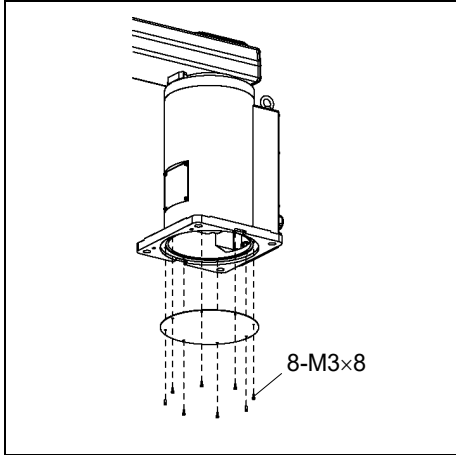
The base bottom cover is removed only when replacing the gasket unit.

Unscrew the base bottom cover mounting bolts and remove the cover.

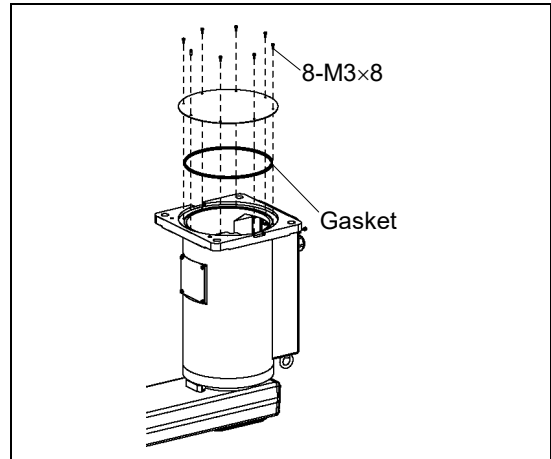
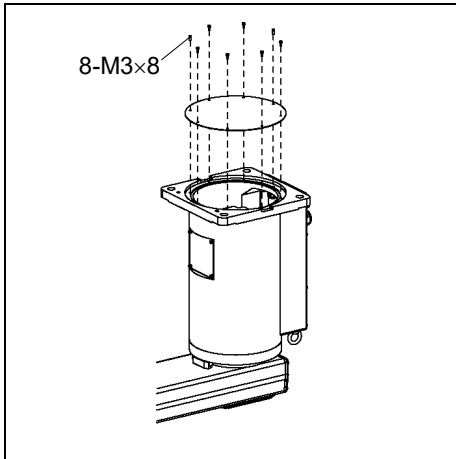
G10/G20-***C* (Cleanroom-model)

G10/G20-***D*, P* (Protected-model)

Table Top
mounting



Ceiling
mounting





NOTE



A gasket is installed to G10/G20-***D*, P* (Protected-model).

A base bottom cover is not installed to G10/G20-***S* (Standard-model).

4. Cable

 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.
 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.

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.

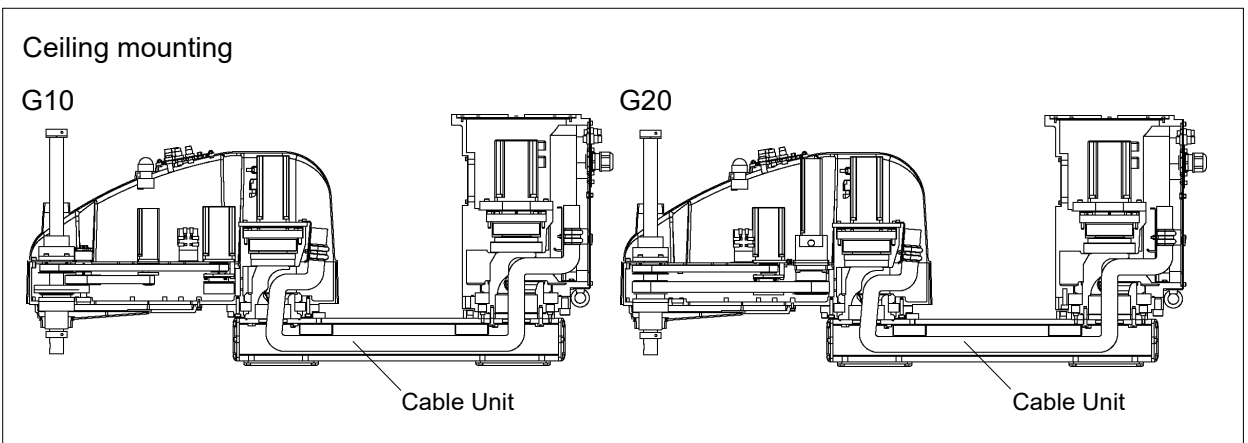
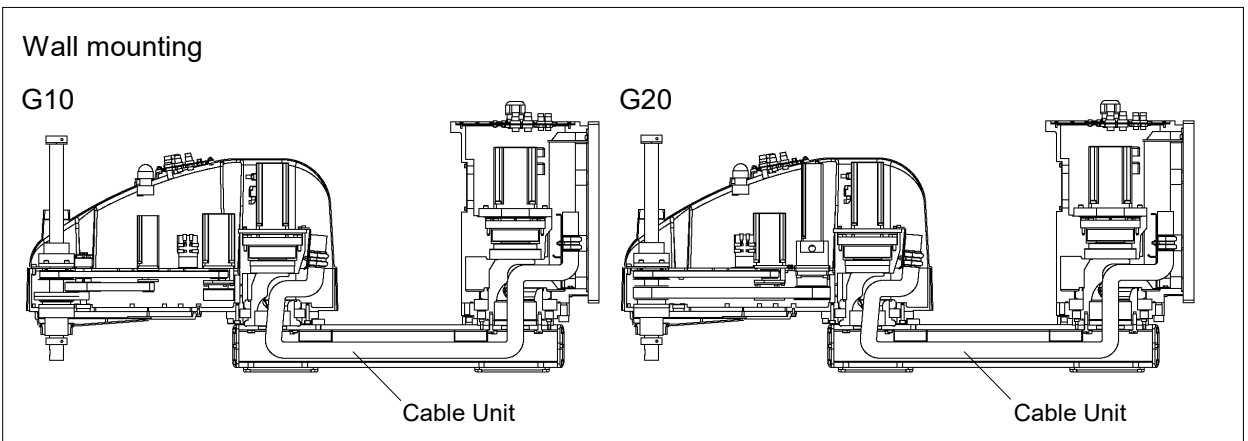
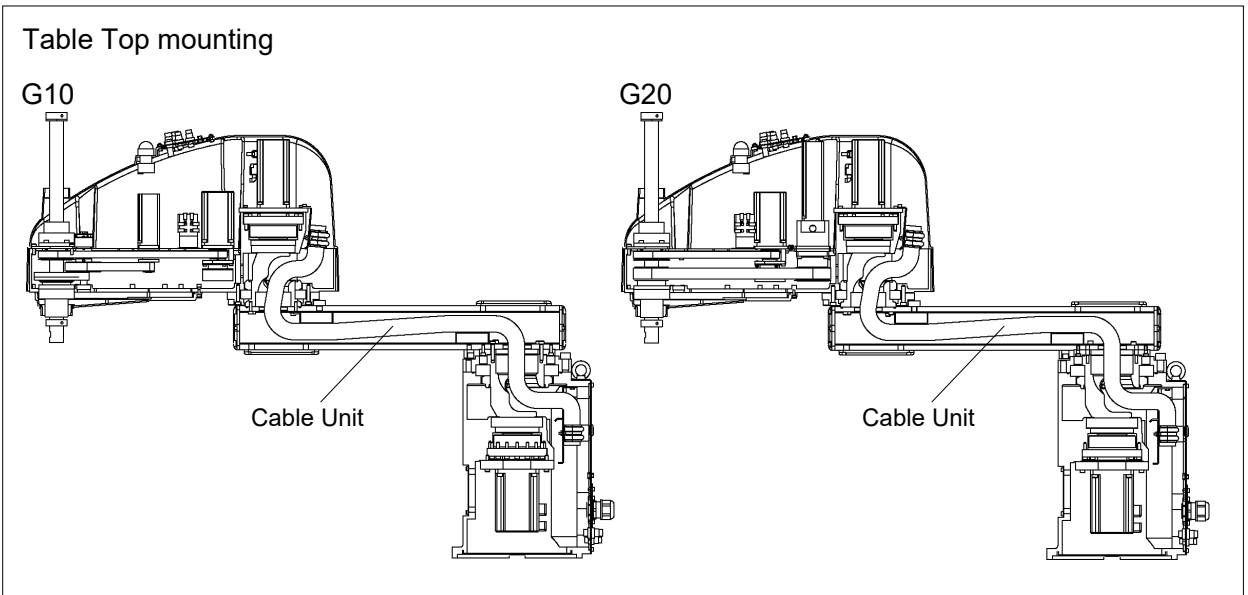
If the error occurs, execute the calibration of all joints and axes.

For details of the calibration, refer to *14. Calibration*.

	Name		Quantity	Note
Maintenance parts	Cable unit		1	Each manipulator model (Refer to <i>15. Maintenance parts</i>)
	Battery Unit (Lithium battery)		1	2117879
Tools	Hexagonal wrench	width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
		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		8	
Grease	Grease for cable (GPL-224)		10 g	

NOTE G10-65*** manipulator of S/N: 1**** or later is different from other models in its form.

 For the detail, refer to 2.6.4 G10-65***: For S/N: 1**** or later.





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 *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.


Cable unit
Removal

- (1) Turn ON the Controller and change the motor to OFF status (MOTOR OFF).
- (2) Press and hold the brake release switch to let the shaft down. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.


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

Be careful of the shaft falling or rotation while the brake release switch is being pushed because it may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller and disconnect the power cable and signal cable connectors from the controller.
- (4) Remove the connector plate.
For details, refer to 3.4 Connector Plate.
- (5) Connect the spare battery to connector XB11.

NOTE  - The position data of Joint #1 motor is stored with the battery on Arm #2. Connect the spare battery otherwise the Joint #1 position data will be lost.

- (6) Disconnect the air tubes, ground wire, D-sub cable, and seven connectors (X10, X20, X30, X111, X121, X131, XB10) connected to the connector plate (inner side).

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

- (7) The procedure of step (7) differs by mounting types.

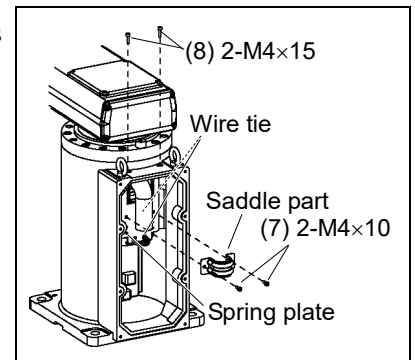
Follow the corresponding procedure.

When using Table Top mounting type or Ceiling mounting type

(7)-1 Remove the saddle part mounting cables inside the base.

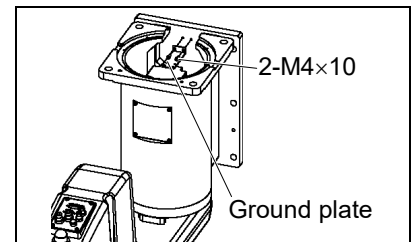
(7)-2 Remove the spring plate.

(7)-3 Cut off the two wire ties binding cables.

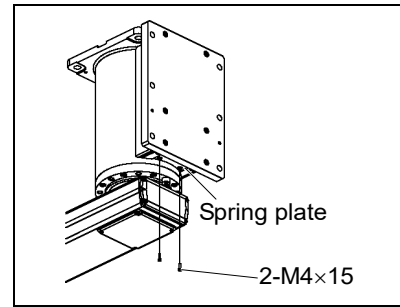


When using Wall mounting type

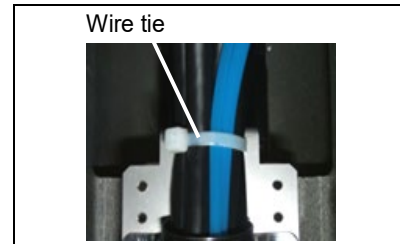
(7)-1 Remove the ground plate.



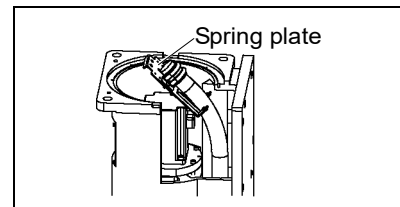
(7)-2 Remove the spring plate.



(7)-3 Cut the wire tie banding the cables.

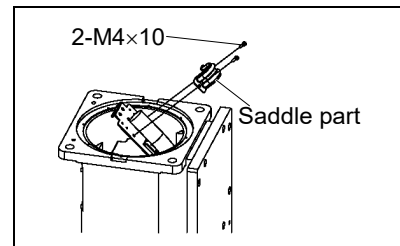


(7)-4 Pull out the spring plate.



(7)-5 Remove the saddle part mounting the cables.

(7)-6 Cut the wire tie banding the spring.



(8) Remove the arm caps and side covers on Arm #1.
For details, refer to 3.3 Arm #1 Cover.

(9) Remove the arm top cover.
For details, refer to 3.1 Arm Top Cover.

(10) Remove the user plate.
For details of user plate removal, refer to 3.6 User Plate.

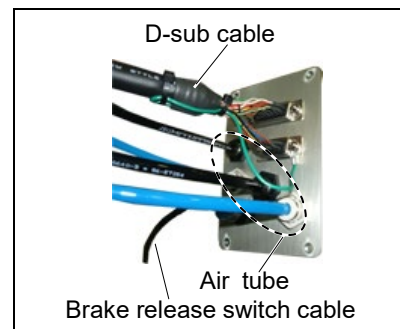
(11) Disconnect the D-sub cable, air tubes, and connector of the brake release switch from the user plate.



NOTE Mounting screws for the D-sub cable are very small. Be sure to keep the screws.

Press the ring on the fitting and pull out the air tube. (ø6×2, ø4×2)

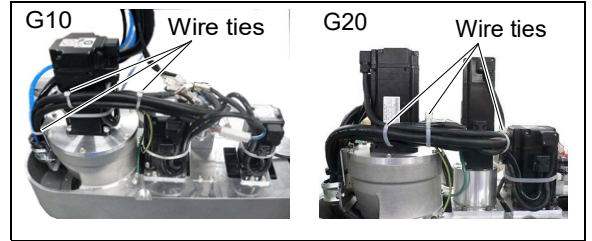
Be sure to observe the connection for connecting the disconnected parts after replacement.



(12) Cut off the wire tie binding cables on the Arm #2 side.

(13) Remove the 11 connectors on the Arm side.

X21, X22, X31, X32, X33, X41, X42, X61, X221, X231, X241



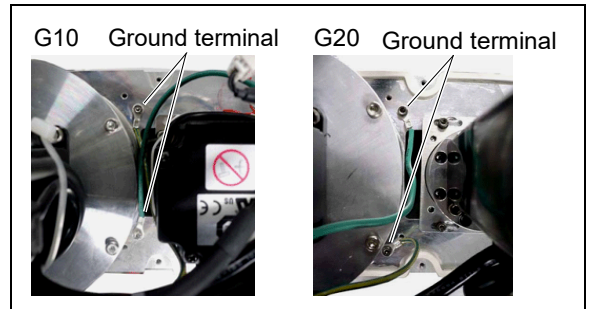
NOTE Be sure to keep the connectors excluding X61 of the battery board connected at cables replacement. Otherwise, the motor will lose position data and the calibration must be executed again

(14) Remove the ground terminals mounted to Arm #2.



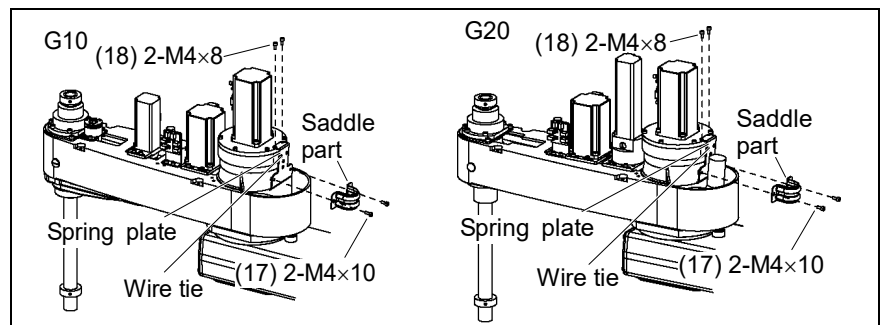
NOTE Record the connection terminal and the connection point before disconnect the ground terminal.

G10/G20-***S*/C*: 3 terminals
G10/G20-***D*/P*: 3 terminals



(15) Remove the saddle part mounting cables inside Arm #2.

(16) Remove the spring plate.



(17) Cut off the two wire tie binding cables.

(18) Disconnect the Base side cables from Arm #1.

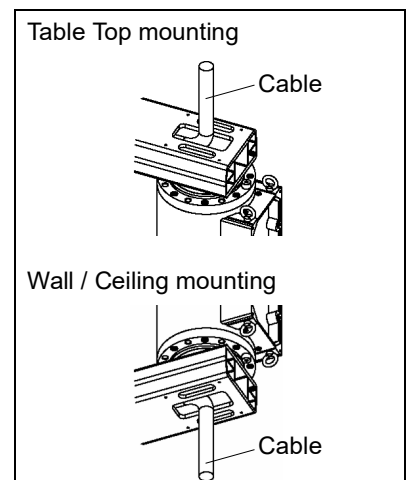
Table Top mounting
: Disconnect from the upper part of Arm #1

Wall mounting / Ceiling mounting
: Disconnect from the lower part of Arm #1

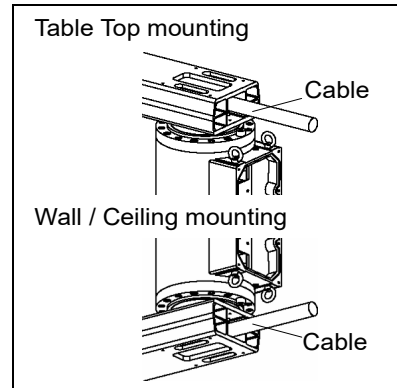


NOTE When disconnecting the cables, first, disconnect the air tubes. Then, disconnect from the smaller connectors in order.

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



(19) Disconnect the cables that were disconnected from Arm #1 in step (18) to the side of Arm #1.

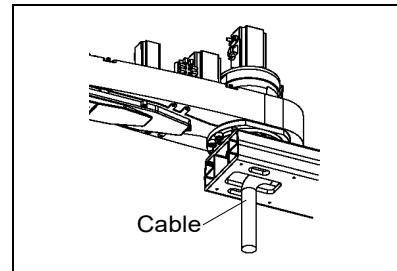


(20) Disconnect the Arm #2 side cables from the lower part of Arm #1.

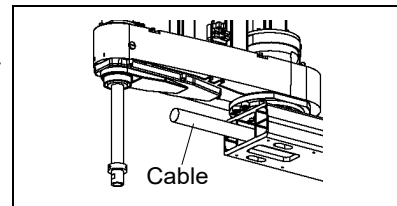


NOTE When disconnecting the cables, first, disconnect the air tubes. Then, disconnect from the smaller connectors in order.

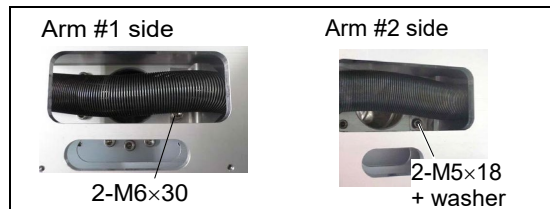
Do not try to disconnect the cables forcibly. Otherwise, connectors may be stuck, disconnected, or connector pins may fall off.



(21) Disconnect the cables that were disconnected to the lower part of Arm #1 in step (20) to the side of Arm #1.



(22) Remove the spring plate mounting bolts on both the Arm #1 side and the Arm #2 side.



(23) Disconnect the cables to the base side.

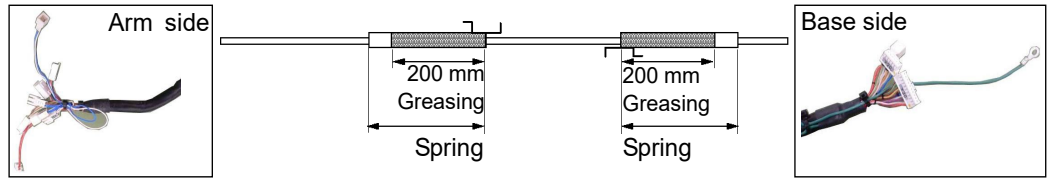
NOTE


When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Cable unit
Installation

- Apply grease (GPL-224) to the cables.
Grease volume: 5 g each (10 g in total)

Applying positions
 Each cable inside the spring
 Air tube
 Periphery of spring (shaded part)




Connector
 X221,231,241
 X21,22,31,32,33
 X41,42
 X61

Connector
 X121,131
 X20,30
 XB10

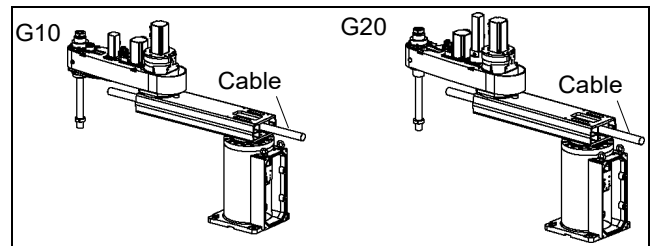
- Cover both ends of the cables with plastic bags.
 (The photo shows one end covered with plastic bags)



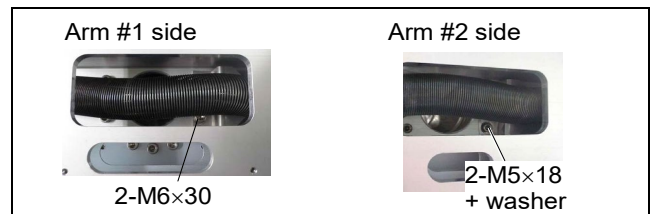
NOTE
 The plastic bags prevent grease adhesion to the ends of connectors and air tubes while drawing the cables.



- Refer to step (1) and insert the cables to Arm #1 in the proper direction.

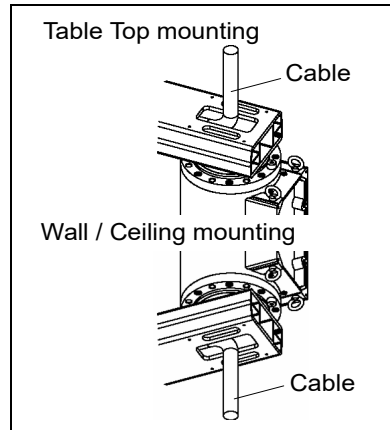


- Set the mounting holes of the spring plate to the base side and mount the spring plate to Arm #1.



- (5) When using Table Top mounting, disconnect the base side cables to the upper part of Arm #1 and pull the cables into the base.

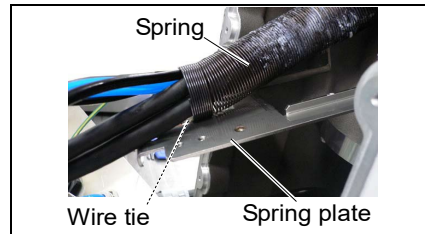
When using Wall mounting or Ceiling mounting, disconnect the base side cables to the lower part of Arm #1 and pull the cables into the base.



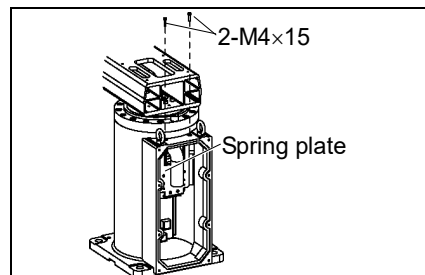
- (6) The procedure of step (6) differs by mounting types. Follow the corresponding procedure.

When using Table Top mounting type or Ceiling mounting type


- (6)-1 Mount the spring for cable protection to the spring plate with a wire tie.

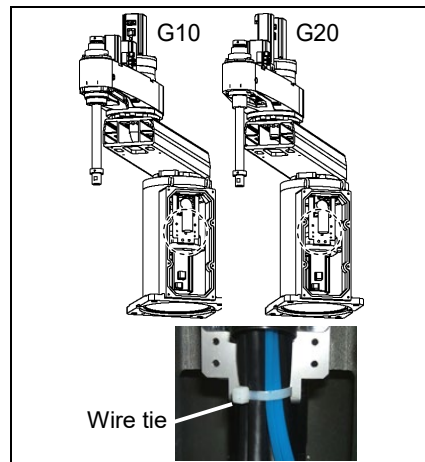


- (6)-2 Mount the spring plate to the base.



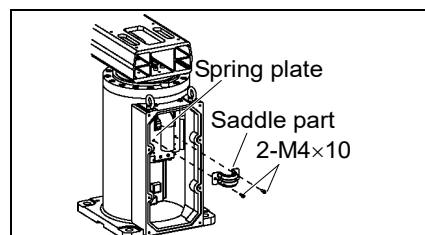
- (6)-3 Move Arm #1 to the right or left until the arm touches the mechanical stop to make allowance. Then, band the cables and air tubes with a wire tie.

NOTE  If you band the cables and tubes without allowance, the cables are pulled and may be disconnected during the robot operation. Make sure to make allowance.



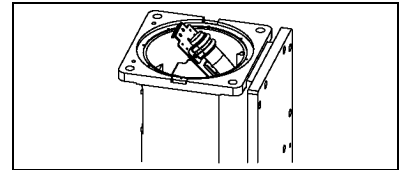
- (6)-4 Remove the plastic bags on the base side applied in step (2).

- (6)-5 Mount the saddle part to the spring plate.

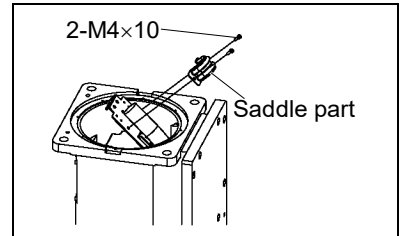


When using Wall mounting type

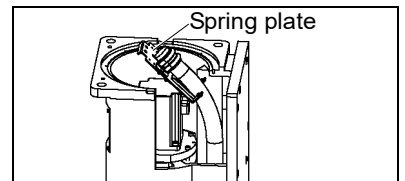
(6)-1 Pull out the spring and mount it to the spring plate with a wire tie.



(6)-2 Mount the saddle part to mount the cables.



(6)-3 Loosely band the cables with a wire tie. Be sure to keep the wire tie loose enough so that the cables move.

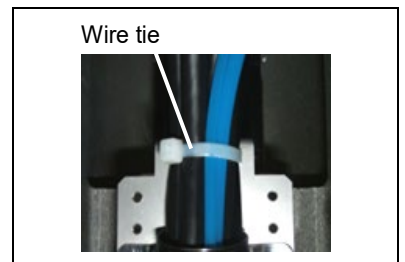


(6)-4 Move Arm #1 to the right or left until the arm touches the mechanical stop to make allowance.

Then, band the cables and air tubes with a wire tie.

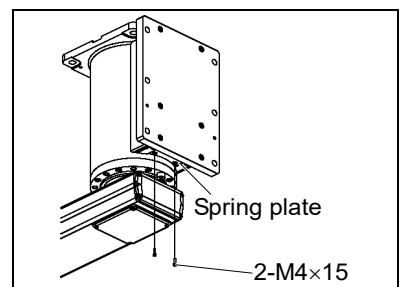
NOTE


If you band the cables and tubes without allowance, the cables are pulled and may be disconnected during the robot operation. Make sure to make allowance.

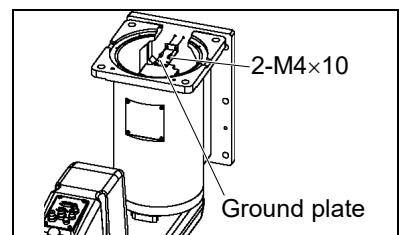


(6)-5 Remove the plastic bags on the base side applied in step (2).

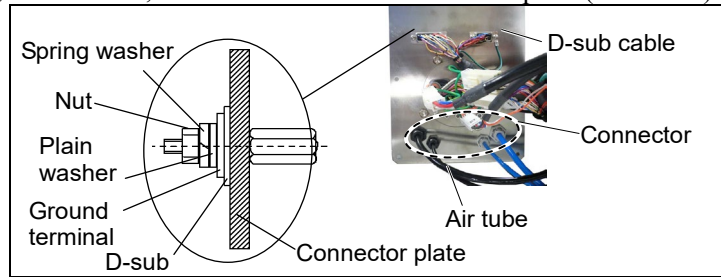
(6)-6 Mount the spring plate.



(6)-7 Mount the ground plate.



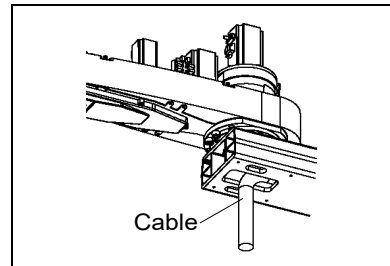
- (7) Connect the air tubes, D-sub cable, and connectors to the connector plate (inner side).



- (8) Loosely mount the connector plate with 2 screws (M4).

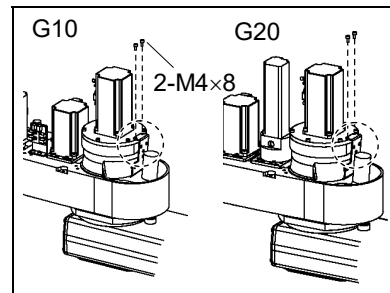
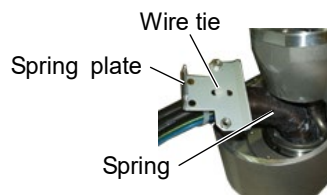
For details, refer to 3.4 Connector Plate.

- (9) Disconnect the Arm #2 side cables to the lower part of Arm #1 and pull the cables into Arm #2.



- (10) Mount the spring for cable protection to the spring plate with a wire tie.

Secure the spring plate to Arm #2.

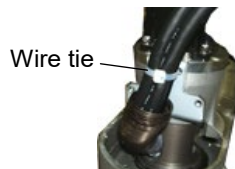
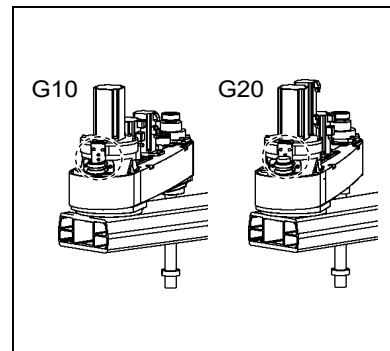


- (11) Move Arm #2 until the arm touches the mechanical stop to make allowance (push the cables toward the spring by approx. 20 mm).

Then, band the cables and air tubes with a wire tie.

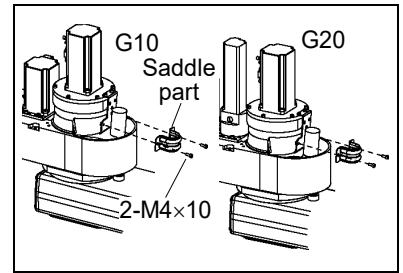


NOTE If you band the cables and tubes without allowance, the cables are pulled and may be disconnected during the robot operation. Make sure to make allowance.



- (12) Remove the plastic bags on the Arm side applied in step (2).

- (13) Mount the saddle part to the spring plate.



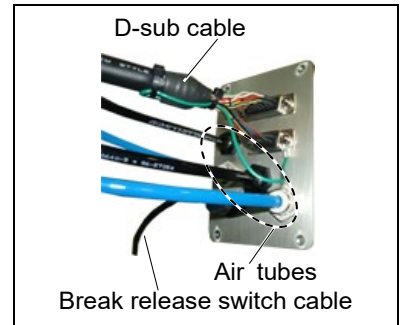
- (14) Connect the connectors and the ground wire.

For details, refer to *4.2 Wiring Diagrams*.

- (15) Bind the excess cables with a wire tie.

- (16) Connect the D-sub cable, air tubes, and connector of the brake release switch cable to the user plate.

To secure the ground wire, tighten it with the terminal of D-sub cable.



- (17) Mount the user plate to the Arm #2 cover.

For details of user plate installation, refer to *3.6 User Plate*.

- (18) Set and secure the Arm #2 cover without the cables being stuck.

For details, refer to *3.1 Arm Top Cover*.

- (19) Mount the arm caps and side covers for Arm #1.

For details, refer to *3.3 Arm #1 Cover*.

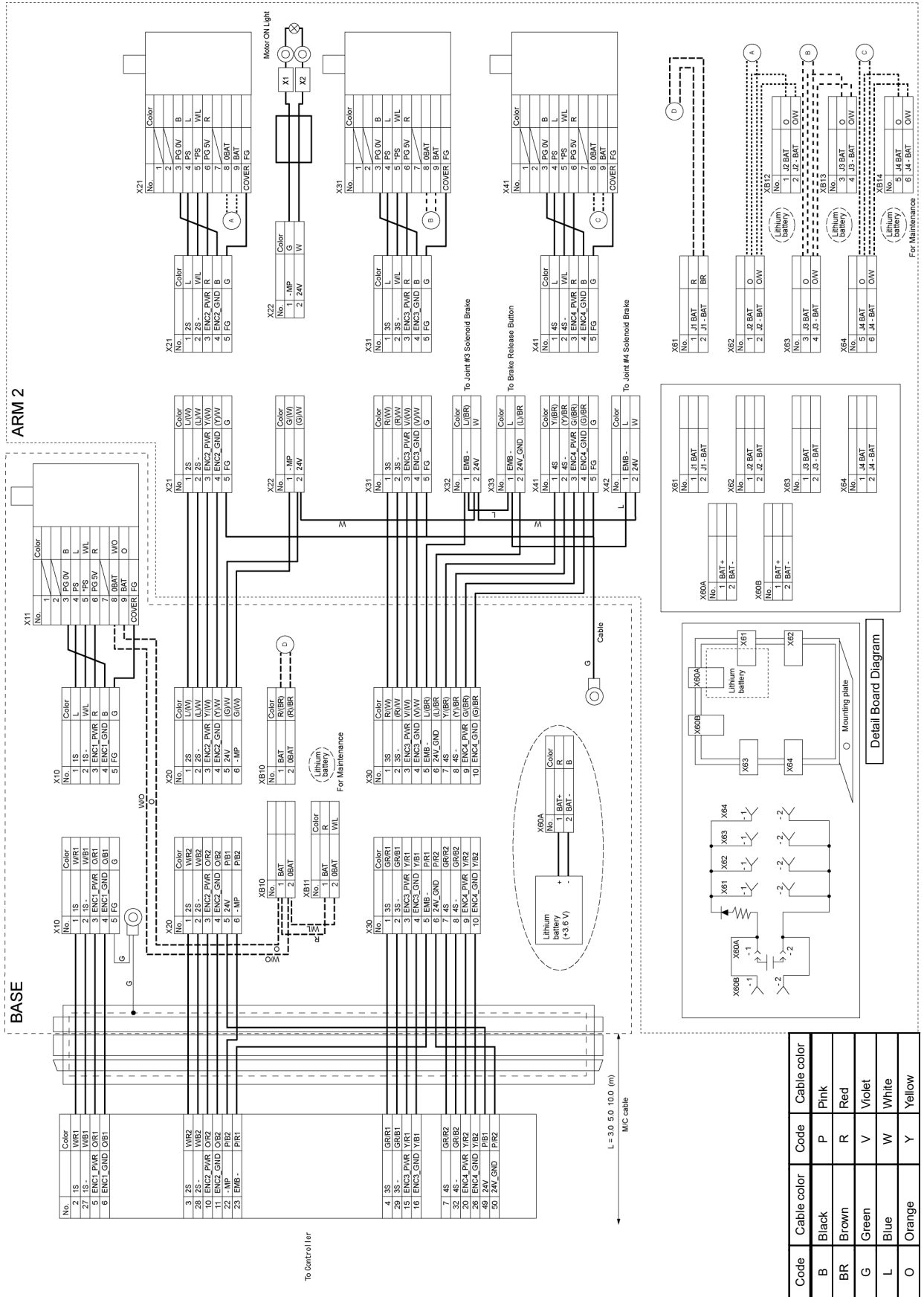
- (20) Remove the connector plate mounted loosely in the step (8) and remove the spare battery in the XB11. Then, mount the connector plate.



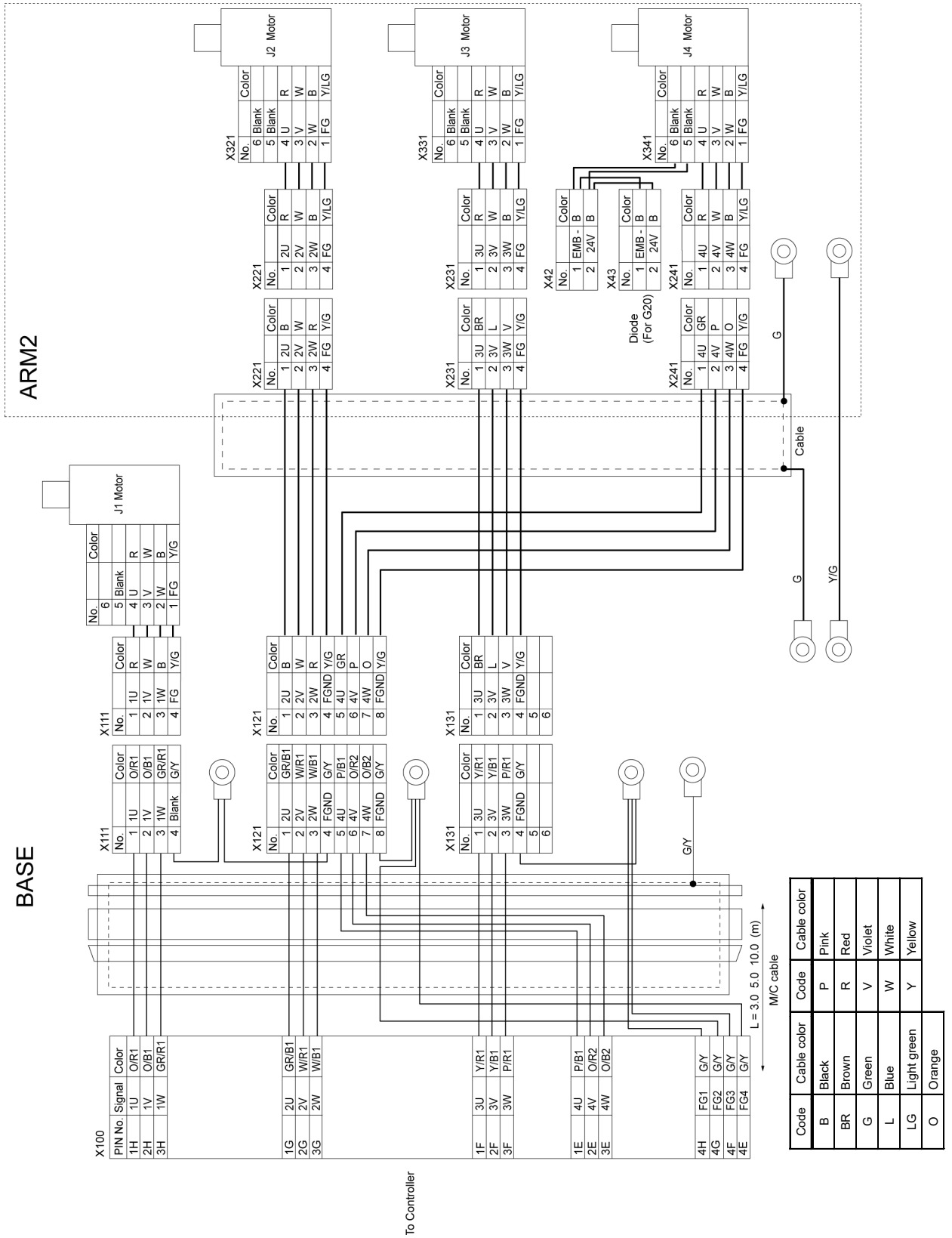
NOTE In this replacement method, calibration is not needed.
However, perform the calibration if it is required.

4.2 Wiring Diagrams

4.2.1 Signal Cable



4.2.2 Power Cable



4.2.3 User Cable

D-sub 9pin		D-sub 9pin	
No.	Color	No.	Color
1	R/(BR)	1	R/(BR)
2	(R)/BR	2	(R)/BR
3	V/(BR)	3	V/(BR)
4	(V)/BR	4	(V)/BR
5	L/(B)	5	L/(B)
6	(L)/B	6	(L)/B
7	Y/(B)	7	Y/(B)
8	(Y)/B	8	(Y)/B
9	(G)/BR	9	(G)/BR

D-sub 15pin		D-sub 15pin	
No.	Color	No.	Color
1	L/(W)	1	L/(W)
2	(L)/W	2	(L)/W
3	Y/(W)	3	Y/(W)
4	(Y)/W	4	(Y)/W
5	G/(W)	5	G/(W)
6	(G)/W	6	(G)/W
7	R/(W)	7	R/(W)
8	(R)/W	8	(R)/W
9	V/(W)	9	V/(W)
10	(V)/W	10	(V)/W
11	L/(BR)	11	L/(BR)
12	(L)/BR	12	(L)/BR
13	Y/(BR)	13	Y/(BR)
14	(Y)/BR	14	(Y)/BR
15	G/(BR)	15	G/(BR)

Y/G

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 use cable.

Environment	Arm length	Code	Note
S/C	650 mm	1563046	
	850 mm	1499531	
	1000 mm	1499532	
P/D	650 mm	1563047	Waterproof connector
	850 mm	1499533	
	1000 mm	1499534	

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.



If the connector connected to the battery was disconnected during cable replacement, execute calibration.

For details, refer to *14. Calibration*.

	Name	Quantity	Note
Maintenance parts	M/C Cable	1	Each manipulator model (Refer to <i>15. Maintenance parts</i>)
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Torque wrench	1	

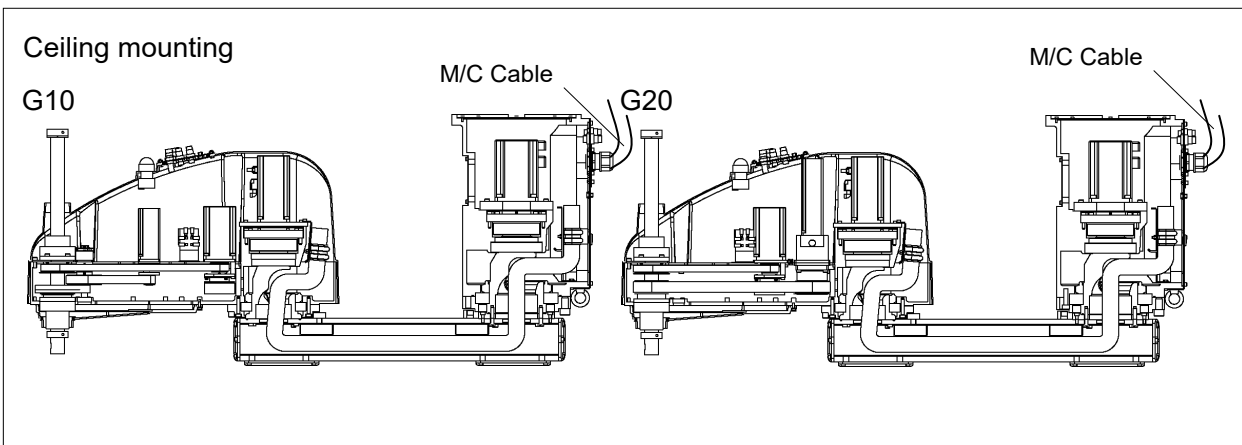
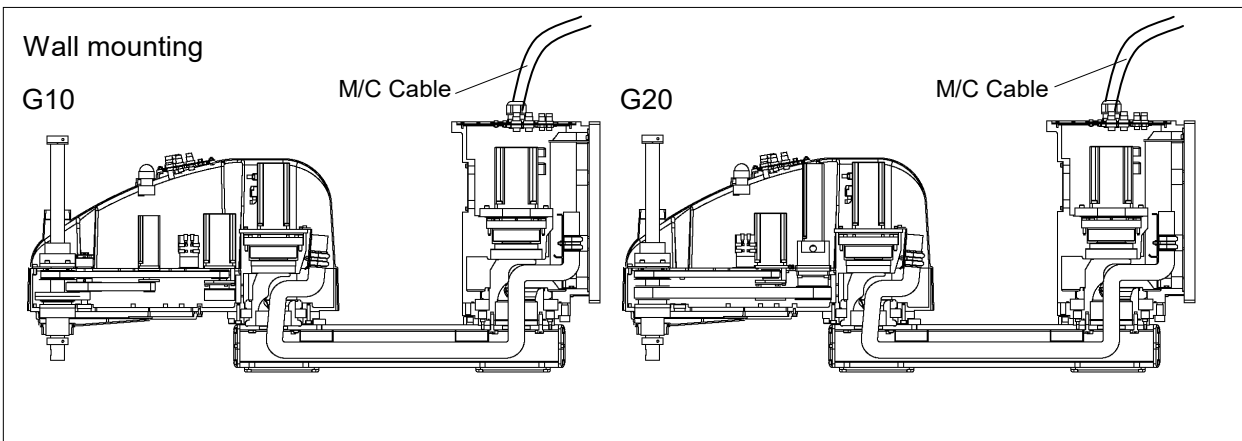
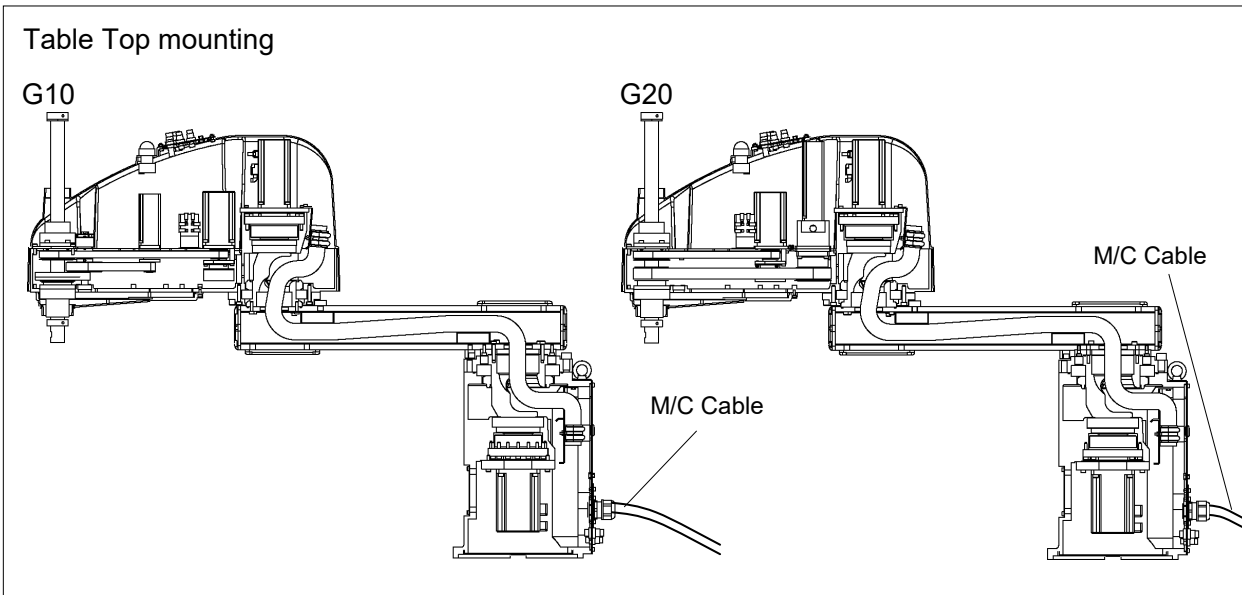


- If the connectors have been disconnected during the replacement of the cable unit, be sure to reconnect the connectors to their proper positions. Refer to the block diagrams.
Improper connection of the connectors may result in improper function of the robot system.
For details on the connections, refer to *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.

NOTE G10-65*** manipulator of S/N: 1**** or later is different from other models in its form.



For the detail, refer to 2.6.4 G10-65***: For S/N: 1**** or later.



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 Sub Plate.
For details, refer to *3.5 Connector Sub Plate*.



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

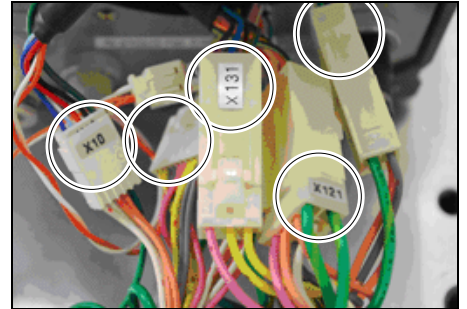
- (4) Disconnect the connectors.
Connector: x10, x20, x30, x111, x121, X131



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




Do not disconnect the battery connector (XB10).
Otherwise, the calibration must be executed.




M/C Cable Installation

- (5) Connect new M/C cable connectors to those of the Cable Unit.
(Connect to the connectors of the Cable Unit with the same number.)
- (6) Mount the Connector Sub Plate.
For details, refer to *3.5 Connector SubPlate*.
- (7) Connect the power cable and signal cable connectors to the controller.
- (8) Turn ON the Controller.
- (9) If the connector (XB10) falls off from the battery, execute the calibration for Joint #1.
For details, refer to *14 Calibration*.

5. Joint #1

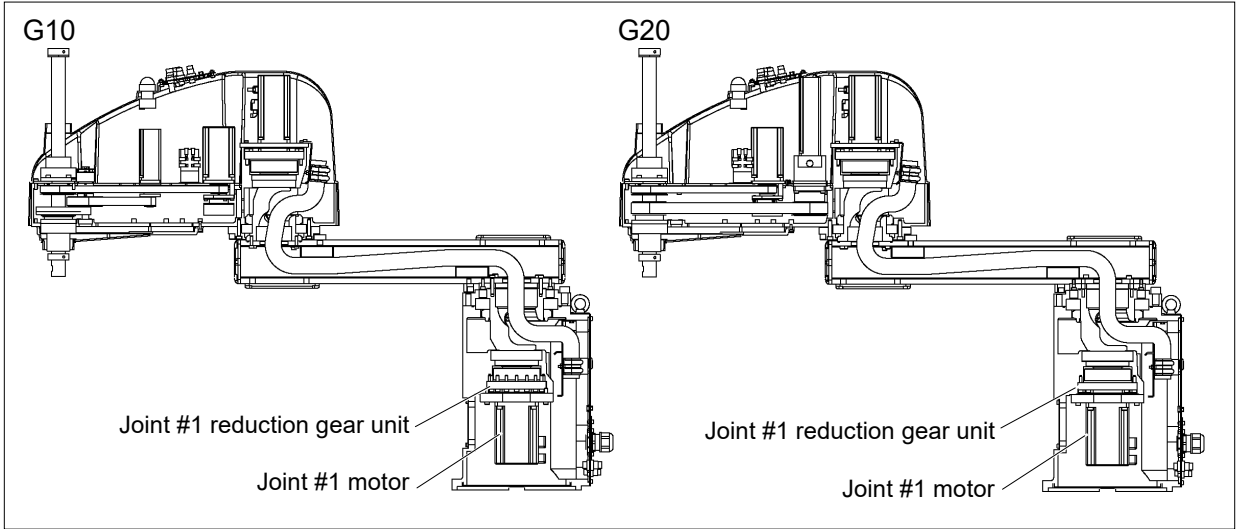
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move 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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 CAUTION	<ul style="list-style-type: none"> ■ 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.
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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 14. Calibration to perform the calibration.

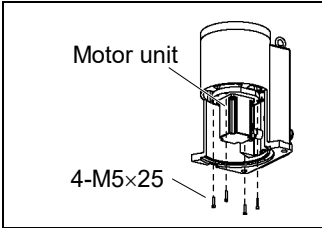
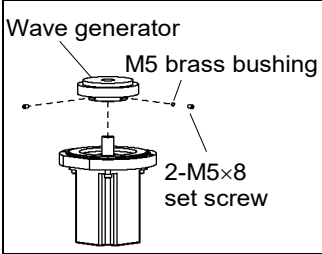
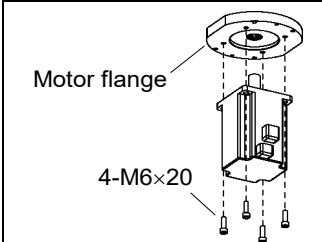
NOTE G10-65** manipulator of S/N: 1**** or later is different from other models in its form. For the detail, refer to 2.6.4 G10-65***: For S/N: 1**** or later.



5.1 Replacing Joint #1 Motor

	Name	Quantity	Note
Maintenance parts	AC Servo Motor (750 W)	1	1499527
			1546181 (For S/N: 1**** or later)
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
		width across flats: 5 mm	1 For M6 screw
	Wiping cloth	1	For wiping grease
Grease	Grease (SK-1A)	28 g	

Joint #1 motor Removal

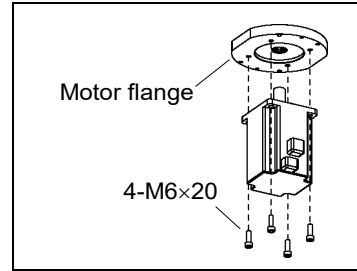
- (1) Remove the connector plate.
For details, refer to *3.4 Connector Plate*.
- (2) Disconnect the following connectors.
Connectors X111, X10 (Hold the clip to remove.)
Connector XB10
- (3) Remove the maintenance plate.
For details, refer to *3.7 Maintenance Plate*.
- (4) Remove the spring plate.
For the details, refer to *4.1 Replacing Cable Unit - Cable unit Removal Step (7)-2* for Table mounting, Ceiling mounting.
- (5) Remove the Joint #1 motor unit from the base. To do so, unscrew the bolts from the Joint #1 motor flange. Then, pull out the motor straight and downward. To unscrew the two bolts on the maintenance hole side, insert a hexagonal wrench through the maintenance hole. If the motor cannot be pulled out easily, pull it out while moving Arm #1 slowly by hand.
 
- (6) Remove the wave generator from the Joint #1 motor.
There is a brass bushing in one of the set screw holes. Be careful not to lose it.
 
- (7) Remove the motor flange from the Joint #1 motor.
 



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #1 motor Installation

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



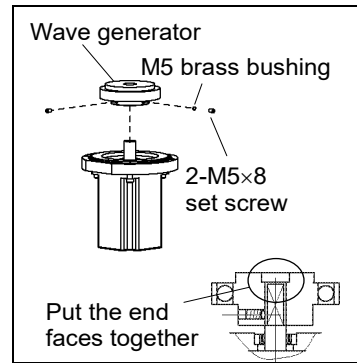
- (2) Apply grease around the motor shaft.

Grease volume: 28 g



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

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



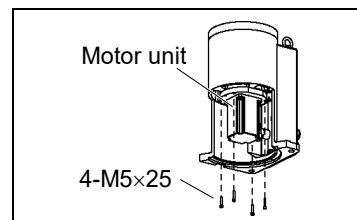
■ See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

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

Be sure to fit the O-ring properly.

The motor cable must face the connector plate side.

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



- (5) Connect the connectors X111, X10, and XB10.

- (6) Mount the spring plate.

For the details, refer to *4.1 Replacing Cable Unit - Cable unit Installation Step (6)-2* for Table mounting, Ceiling mounting.

- (7) Mount the connector plate.

For details, refer to *3.4 Connector Plate*.

- (8) Mount the maintenance plate.

For details, refer to *3.7 Maintenance Plate*.

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

For details refer to *14. Calibration*.

5.2 Replacing Joint #1 Reduction Gear Unit

A reduction gear unit consists of the following three parts and two attached parts. At replacing the reduction gear unit, be sure to always replace them all together as one set.


Reduction gear unit : Waveform generator, Flexspline, Circular spline

Attachment : Spacer, Grip ring

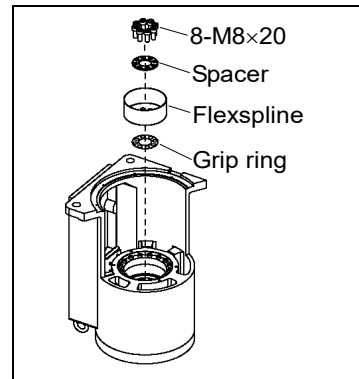
For details of the reduction gear unit, refer to 15. *G10/G20 Maintenance parts list*.

	Name		Quantity	Note
Maintenance Parts	Reduction Gear Unit		1	1489327
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 4 mm	1	For M5 screw
		width across flats: 6 mm	1	For M8 screw
	Torque wrench	M5	1	Tightening torque 10.0 N·m (101.9 kgf·cm)
		M8	1	Tightening torque 30.0 N·cm (305.9 kgf·cm)
	Nippers		1	
	Spatula		1	For applying grease
	Wiping cloth		1	For wiping grease (Flange)
			1	For wiping grease (Bolt)
Screw (M5)		2	About 20mm in length For removing flexspline	
Materials	ROCTITE 241		Proper quantity	For locking screw
Grease	Grease (SK-1A)		71 g	

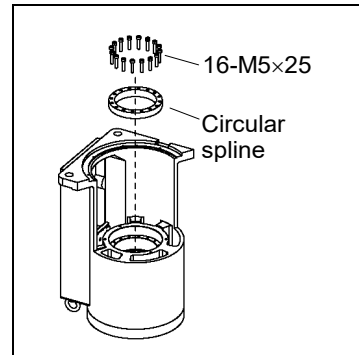
- Joint #1
reduction gear
unit
Removal
- (1) Execute the removal steps from (1) to (5) in *5.1 Replacing Joint #1 Motor* and remove the waveform generator.
 - (2) Remove the arm cap on the base side.
For details, refer to *3.3 Arm #1 Cover*.
 - (3) Turn the Manipulator laterally.

 CAUTION	<p>■ When turning the Manipulator laterally, there must be two or more people to work on it so that at least one of them can support the arm while others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot system.</p>
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- (4) Use the extracting M5 screws and remove the spacer, flexspline and the grip ring.



- (5) Remove the circular spline from the base.



NOTE



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #1
reduction gear
unit
Installation

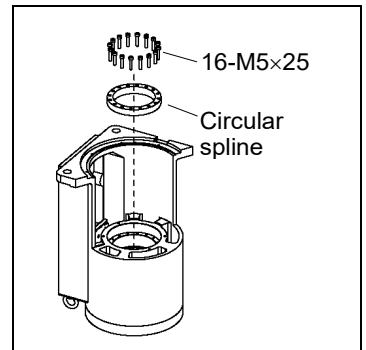
- (1) A new reduction gear unit contains the parts shown in the picture on the right when it is unpacked.



- (2) Apply LOCTITE 241 on the screws.
Set the hole on the circular spline and the tap hole on the base.

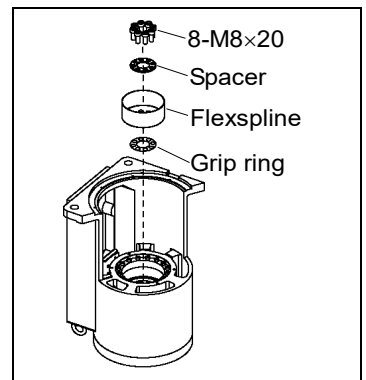
Apply grease (SK-1A) on the gear side of the circular spline.

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.



Item	Bolt type	Number of bolts	Tightening torque
Joint #1 reduction gear unit	M5×25	16	10.0 N·m(101.9 kgf·cm)
	M8×20	8	30.0 N·m(305.9 kgf·cm)

- (3) Apply LOCTITE 241 on the screws.
Set the grip ring by aligning it with the tap hole.
Apply grease (SK-1A) on the gear side of the flexspline.
Set the flexspline by aligning it with the tap hole.
Align the position of the air vent of the spacer and secure the flexspline.





- (4) Apply grease (SK-1A) inside the flexspline.
Grease volume: 43 g



- (5) Apply grease to the bearing part of the waveform generator.
(6) Execute steps from (2) to (4) in *5.1 Replacing Joint #1 Motor*.
(7) Turn and secure the Manipulator to the mounting position.
(8) Execute steps from (5) to (7) in *5.1 Replacing Joint #1 Motor*.

6. Joint #2

 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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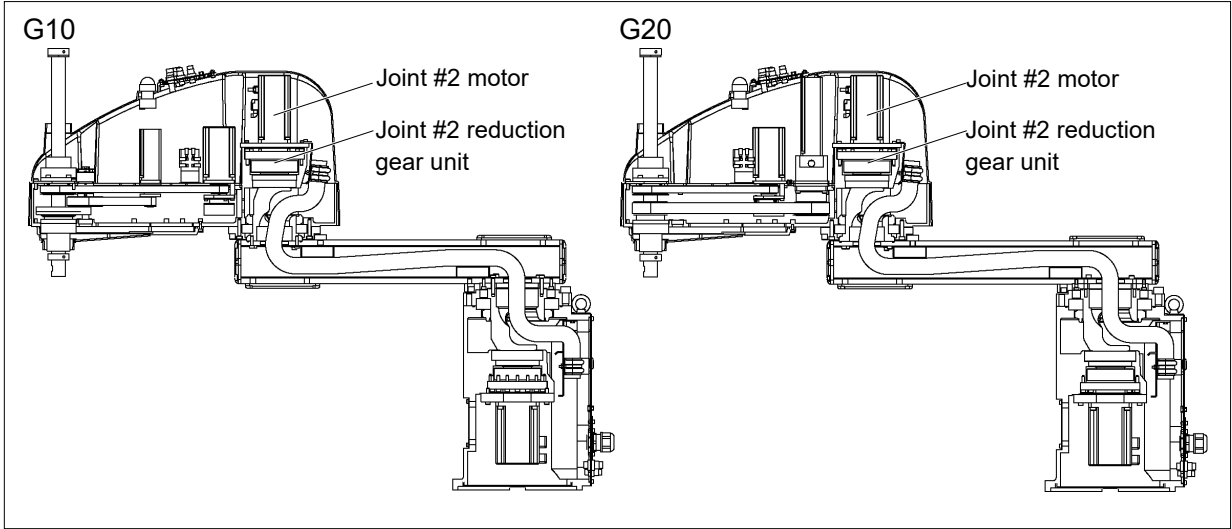
 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.
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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 14. Calibration to perform the calibration.

NOTE G10-65*** manipulator of S/N: 1**** or later is different from other models in its form. For the detail, refer to 2.6.4 G10-65***: For S/N: 1**** or later.



6.1 Replacing Joint #2 Motor

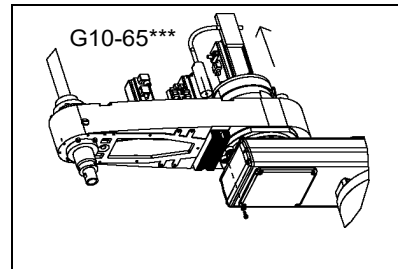
	Name		Quantity	Note
Maintenance Parts	AC Servo Motor (600W)		1	1499528
				1546180 (For S/N: 1**** or later)
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Nippers		1	For cutting wire tie
	Spatula		1	For grease up
	Wiping cloth		1	For wiping grease
Material	Wire tie		3	
Grease	Grease (SK-1A)		28 g	

Joint #2 motor
Removal

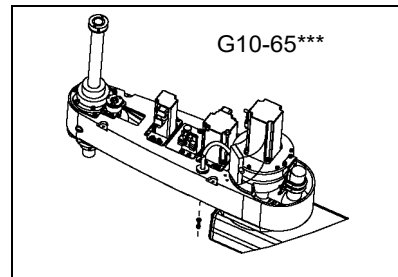
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch.
Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.
- Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover.
For details, refer to 3.1 Arm Top Cover.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #2 motor.
- (6) Disconnect the following connectors.
Connectors X221, X21 (Hold the clip to remove.)
Connector X62

(7) This step is for the Radiating Unit:

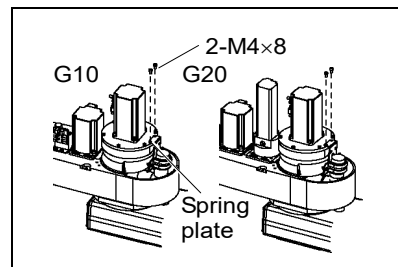
- (7)-1 Remove the mounting bolt of the heat sink (Hexagon socket head cap bolt (fully threaded)) mounted on the radiating unit side beneath the arm.
The radiating unit side is the right side from the arm forefront.



- (7)-2 Remove the insulation lock that secures the plate of radiating unit and rotate the radiating unit.
At this point, be sure to keep the plate mounted.



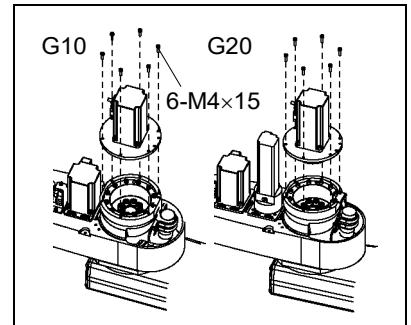
(8) Remove the spring plate.



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

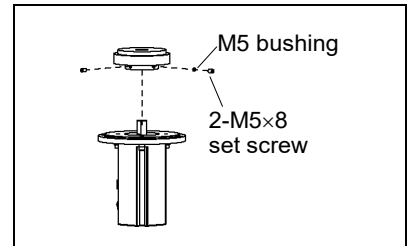
To do so, unscrew the bolts from the Joint #2 motor flange. Pull the Joint #2 motor unit upward to remove.

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

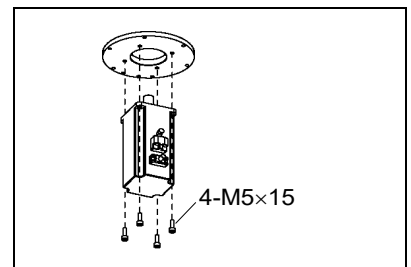


- (10) Remove the wave generator from the Joint #2 motor.

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



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

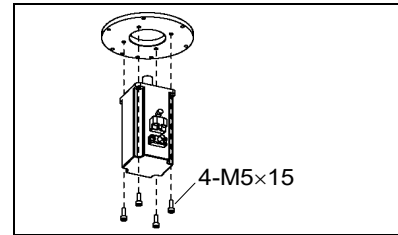




When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

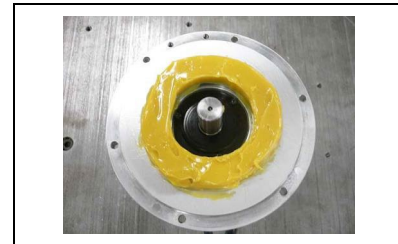
Joint #2 motor Installation

- (1) Mount the motor flange on the Joint #2 motor.
Set the spring plate mounting hole of the motor flange in the counter direction to the motor cable.



- (2) Apply grease around the motor shaft.

Grease volume: 28 g

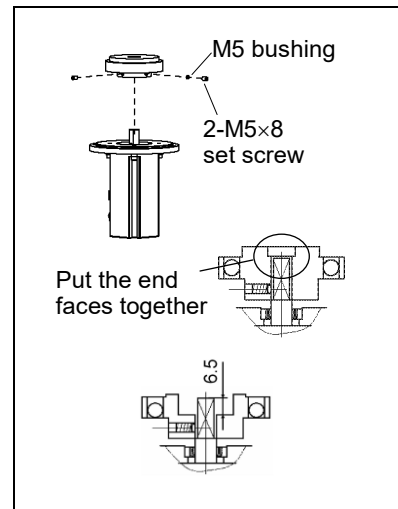


- (3) Mount the waveform generator on the Joint #2 motor.

Be sure to fit the waveform generator edge to the motor shaft edge. 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.

For G10 series manipulator of S/N: 1**** or later:

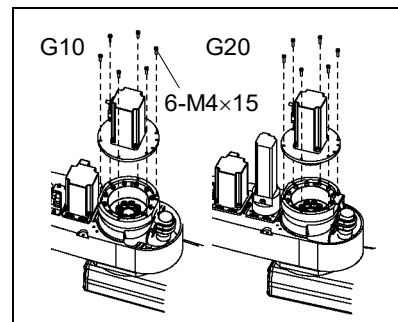
Put a space of 6.5 mm or less between the waveform generator edge and the motor shaft edge.



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

- (4) Mount the Joint #2 motor unit on Arm #2.
If it is difficult to mount the motor, push it while moving Arm #2 slowly by hand.

At this point, be careful about the direction of the spring plate mounting hole of the motor flange.



- (5) This step is for the Radiating Unit.

Mount the radiating unit to the motor using insulation lock tie. Then, secure the mounting bolt of head sink pipe beneath the arm. To do so, be careful not to move the plate. For details, refer to *13. Radiating Unit*.

- (6) Mount the spring plate.
- (7) Connect the connectors X221, X21, and X62.
- (8) Re-bundle the cables in their original positions with a wire tie removed in the removal procedure step (5).

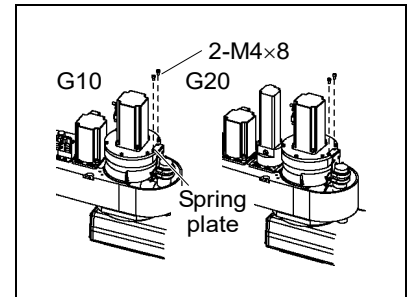
Do not allow unnecessary strain on the cables.

- (9) Mount the arm top cover.

For details, refer to *3.1 Arm Top Cover*.

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

For details, refer to *14. Calibration*.



6.2 Replacing Joint #2 Reduction Gear Unit

A reduction gear unit consists of the following three parts and one attached parts. At replacing the reduction gear unit, be sure to always replace them all together as one set.

Reduction gear unit : Waveform generator, Flexspline, Circular spline

Attachment : Spacer

For details of the reduction gear unit, refer to 15. *G10/G20 Maintenance parts list*.

	Name		Qty.	Note
Maintenance parts	Reduction Gear Unit		1	1489326 1525071 (For G10-65***/G10-85***): S/N: 1**** or later)
	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 4 mm	1	For M5 screw
		width across flats: 6 mm	1	For M8 screw
	Torque wrench	M5	1	Tightening torque 10.0 N·m (102 kgf·cm)
		M8	1	Tightening torque 30.0 N·m (306 kgf·cm)
	Nippers		1	
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Flange)
			1	For wiping grease (Bolt)
Screw (M5)		2	Length about 20 mm For flexspline removal	
Material	Wire tie		3	
Grease	Grease (SK-1A)		71 g	

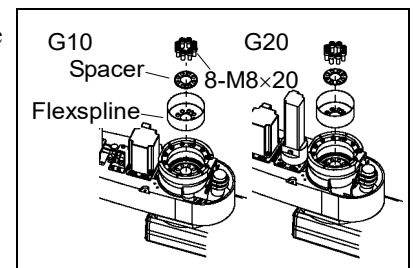
Joint #2
reduction gear
unit
Removal

- (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.

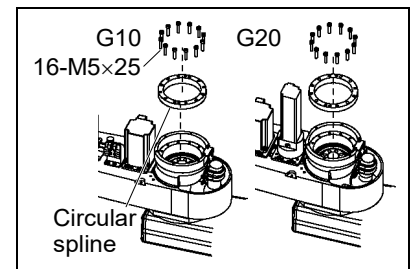
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

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

- (3) Turn OFF the Controller.
- (4) Execute steps from (1) to (9) in *6.1 Replacing Joint #2 Motor* and remove the waveform generator from the Joint #2 motor.
- (5) Use the extracting M5 screws and remove the flexspline from Arm #2.



- (6) Remove the circular spline from Arm #2.



Joint #2
reduction gear
unit
Installation

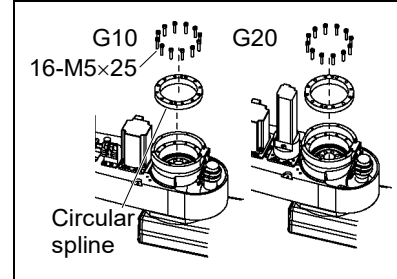
- (1) A new reduction gear unit contains the parts shown in the picture on the right when it is unpacked.



- (2) Set the hole on the circular spline and the tap hole on the base.

Apply grease (SK-1A) on the gear side of the circular spline.

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.



Item	Bolt type	Number of bolts	Tightening torque
Joint #2 reduction gear unit	M5x25	16	10.0 N·m (102 kgf·cm)
	M8x20	8	30.0 N·m (306 kgf·cm)

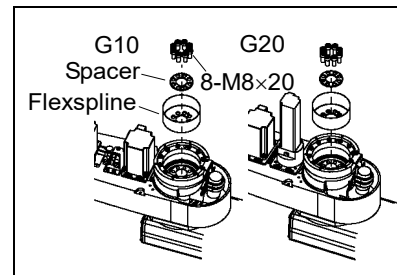
- (3) Apply grease (SK-1A) on the flexspline teeth.

Set the flexspline by aligning it with the tap hole.

Aligning the tap hole and mount the flexspline.

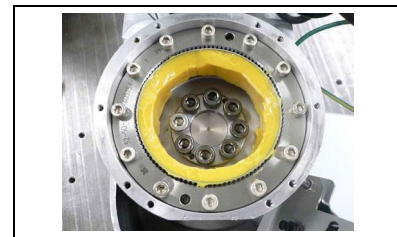
Align the position of the air vent of the spacer.

If it is difficult to align the position, move Arm #2 from side to side.



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

Grease volume 43 g



- (5) Apply grease to the bearing part of the waveform generator.

- (6) Execute steps from (2) to (9) in 6.1 Replacing Joint #2 Motor.

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.

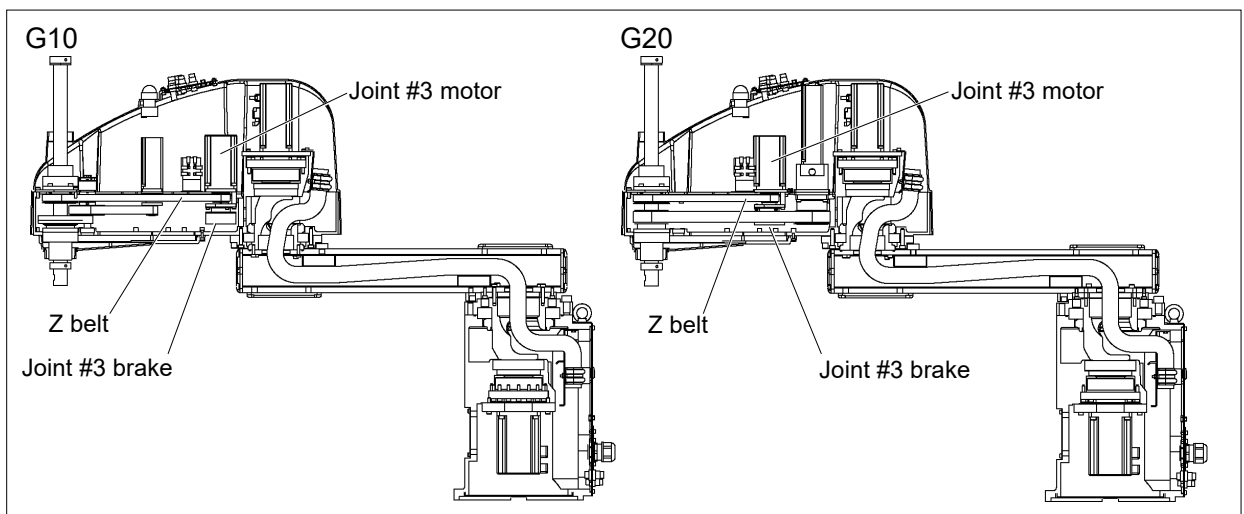
The process of aligning the two origins is called “Calibration”.

Refer to *14. Calibration* to perform the calibration.



G10-65*** manipulator of S/N: 1**** or later is different from other models in its form.

For the detail, refer to *2.6.4 G10-65***: For S/N: 1**** or later.*



7.1 Replacing Joint #3 Motor

	Name		Quantity	Note
Maintenance parts	AC Servo Motor (400W)		1	1497624
				1514468 (For S/N: 1**** or later)
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 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 130 N (13.3 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
	Wiping cloth		1	For wiping grease
Material	Wire tie		1	

A brake is mounted on the motor of Joints #3 and #4 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 (3).

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.

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

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

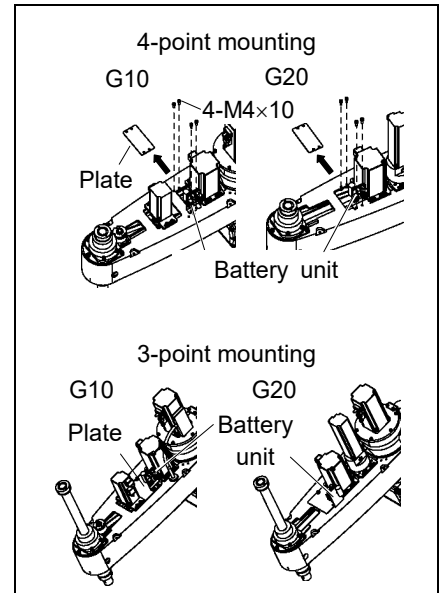
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to 3. Covers.
- (5) Cut off the wire tie used for binding the motor cables to the Joint #3 motor.
- (6) Disconnect the following connectors.
Connectors X231, X31 (Hold the clip to remove.)
Connector X63

- (7) When you use the plate of 4-point mounting, remove the plate.

When removing the battery unit mounting bolts, be sure to keep the connectors connected to the battery unit.

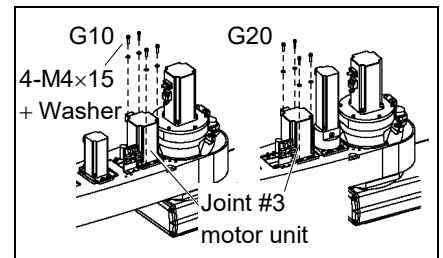
If connectors of the battery unity are disconnected, you need to perform calibration again.

When you use the plate of 3-point mounting, loosen the mounting bolts.

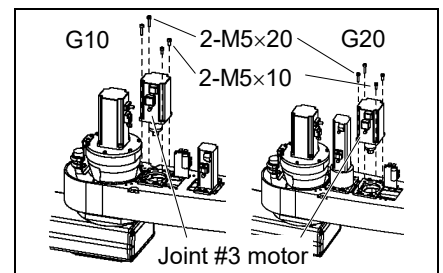


- (8) Loosen the Z belt.

Loosen four bolts on the Joint #3 motor unit. Slide the Joint #3 motor unit to the end of the arm.

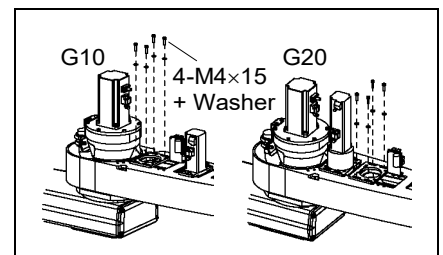


- (9) Remove the motor from the Joint #3 motor unit.



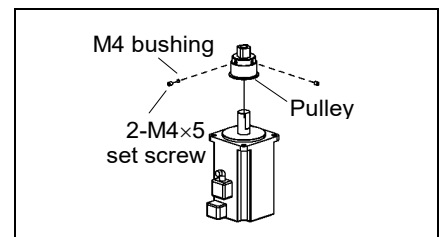
- (10) Remove the brake unit mounting bolts from the Joint #3 motor unit.

Leave the brake unit mounted on Arm #2.



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

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





When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

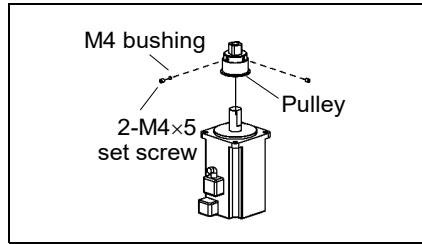
Joint #3 motor Installation

- (1) Secure the pulley to the new motor shaft.

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

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

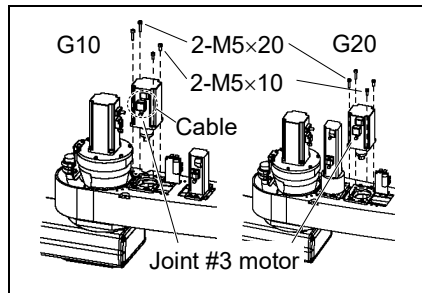
Insert a bushing into the other set screw hole to prevent damage to the motor shaft. Then, tighten both set screws.



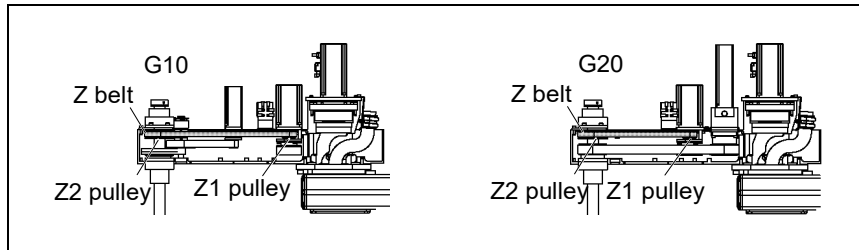
- (2) Align the brake disk to the hub and mount the Joint #3 motor to the plate.

Be sure to pass the motor through the belt.

Place the Joint #3 motor to the plate so that the motor cable faces toward the left from the end of Arm #2.



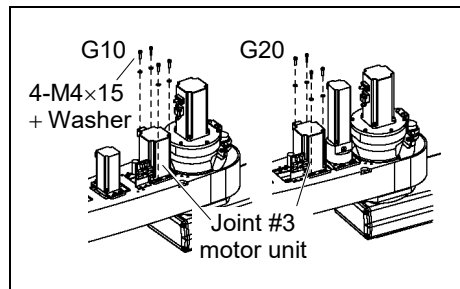
- (3) Place the Z belt around the Z1 pulley and the Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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



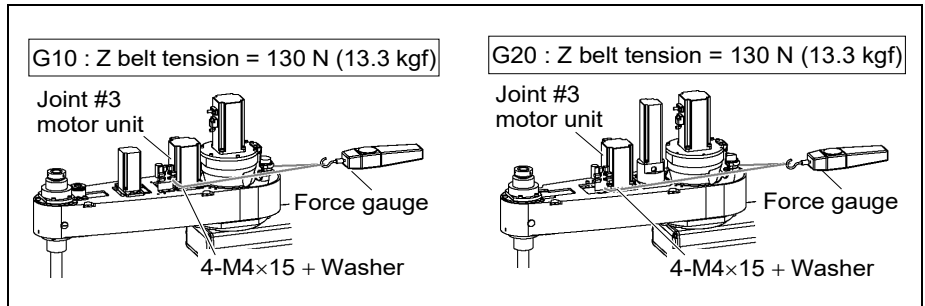
Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



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

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

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



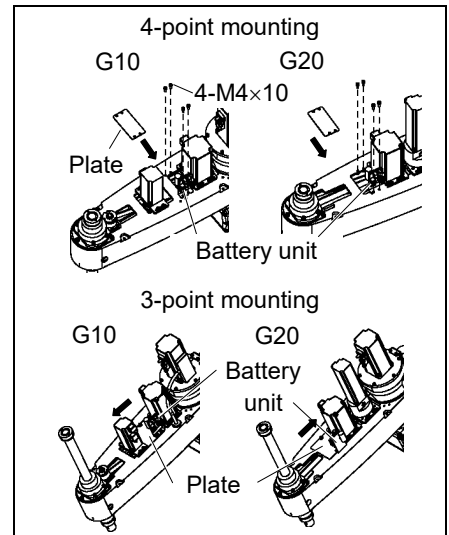
- (6) When you use the plate of 4-point mounting, mount the plate.

When you use the plate of 3-point mounting, mount the plate with pressing it to the motor side*.

- * G10 series: Joint #4 motor side
- G20 series: Joint #3 motor side



When mounting the battery unit mounting bolts, be sure to keep the connectors connected to the battery unit. If connectors of the battery unit are disconnected, you need to perform calibration again.



- (7) Connect the connectors X231, X31, and X63.
- (8) Re-bundle the cables in their original positions with a wire tie removed in step (5).

Do not allow unnecessary strain on the cables.

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

For details, refer to 3. *Covers*.

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

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

7.2 Replacing the Timing Belt

The length and the replacement procedure of the timing belts for G10 series and G20 series are different.

	Name		Quantity	Note
Maintenance parts	Z belt	G10 : width 12 mm	1	1489329
		G20 : width 12 mm	1	1493781
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 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 160 N (16.3 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
	Wiping cloth		1	For wiping grease
Material	Wire tie		2	

7.2.1 Replacing the Timing Belt : G10

A brake is mounted on the motor of Joints #3 and #4 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.

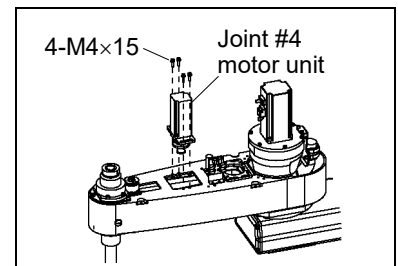
Z belt
Removal : G10

- (1) Execute the removal steps from (1) to (10) in *7.1 Replacing Joint #3 Motor* to remove the Joint #3 motor.

Do not remove the brake unit from Arm #2.

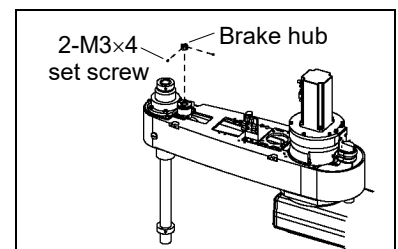
- (2) Remove the Joint #4 motor unit from Arm #2.

Pull out the U belt from the U1 pulley to remove it.



- (3) Remove the brake hub.

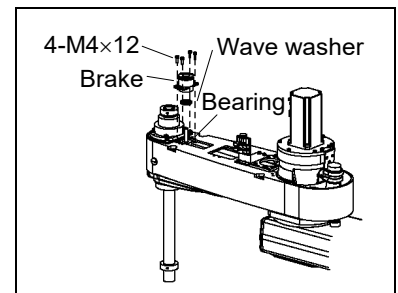
Loosen the two set screws and pull out the brake hub.



- (4) Remove the brake.

There is a wave washer between the housing and the bearing. Be careful not to lose it.

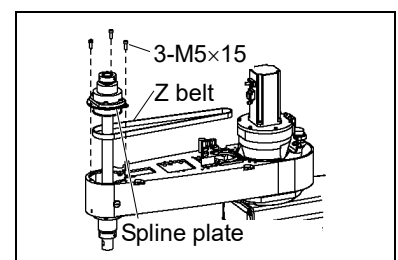
The gear for Z axis is a backlash-less gear. Be sure to keep the gear and pinion engage.



If the gear is out of joint, refer to step (7) in *Ball Screw Spline Unit Installation of 10.2.1 Replacing the Ball Screw Spline Unit: G10* to engage the gear.

- (5) Remove the Z belt.

Remove the bolts securing the spline plate. Hold the spline plate and pull out the Z belt from the shaft upwards.



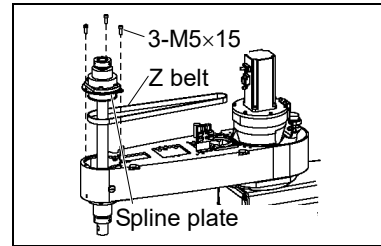


When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

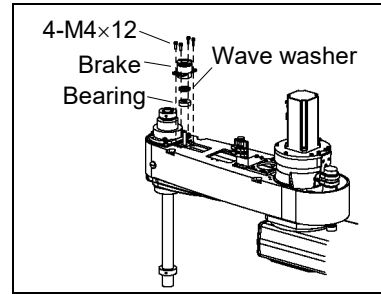
**Z belt
Installation : G10**

- (1) Pass a new Z belt through the shaft from above, and then place it under the spline plate.
- (2) Pass the belt through Arm #2.
- (3) Loosely secure the spline plate to Arm #2.
After moving the shaft up and down several times, secure the spline plate to Arm #2.
- (4) Mount the brake to the Joint #4 intermediate pulley unit.

When mounting the brake, be sure to keep the wave washer from being stuck.



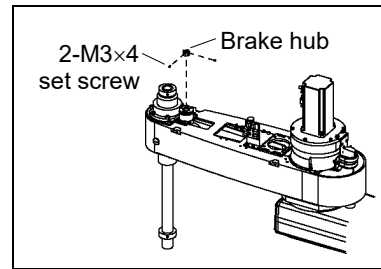
- (5) Secure the brake hub with the two set screws.



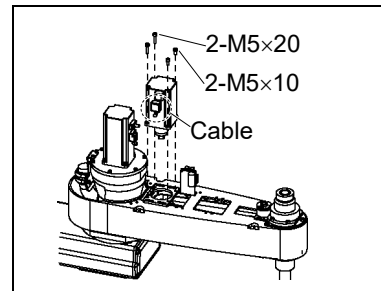
- (6) Align the brake disk to the hub and mount the Joint #3 motor to the plate.

Be sure to pass the motor through the belt.

Place the Joint #3 motor to the plate so that the motor cable faces toward the left from the end of Arm #2.

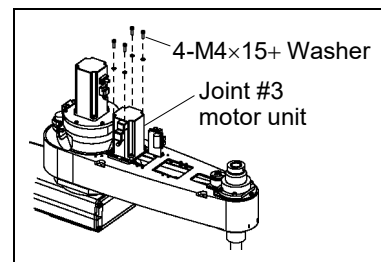
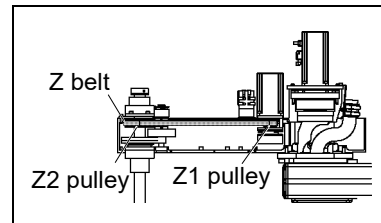


- (7) Place the Z belt around the Z1 pulley and the Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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

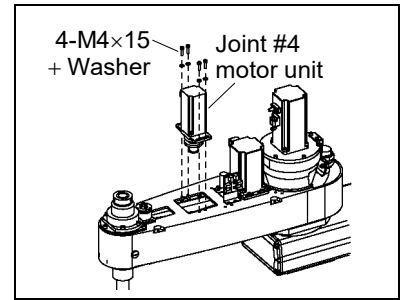
NOTE Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



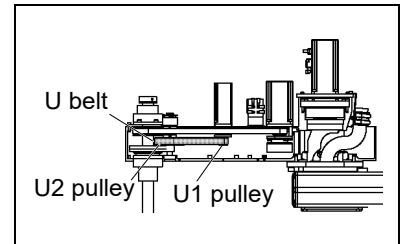
- (9) Set the Joint #4 motor unit in Arm #2.

Place the Joint #4 motor unit in Arm #2 so that the motor cable faces toward the left from the end of the arm.

The screws are not secured in this step.



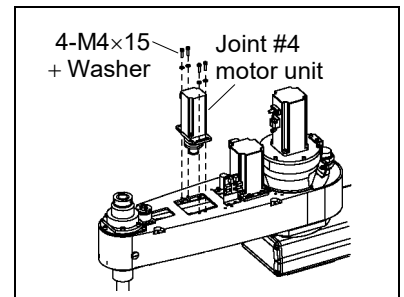
- (10) Place the U belt around the U1 pulley and the U2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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

NOTE

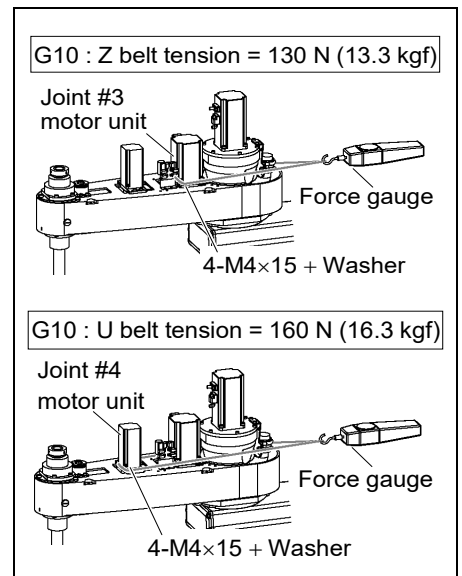

Loosely secure the Joint #4 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (12) Apply the proper tension to the Z belt and U belt, and then secure the Joint #3 motor unit and Joint #4 motor unit.

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

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

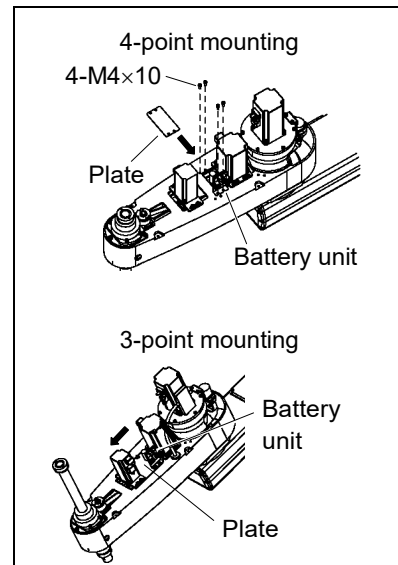


- (13) When you use the plate of 4-point mounting, mount the plate.

When you use the plate of 3-point mounting, mount the plate pressing it to the Joint #4 motor side.

When mounting the battery unit, be sure to keep the connectors connected to the battery unit.

If connectors of the battery unit are disconnected, you need to perform calibration again.



- (14) Re-bundle the cables in their original positions with a wire tie removed in the removal procedure. Do not allow unnecessary strain on the cables.
- (15) Install the arm top cover and the arm bottom cover.
For details, refer to 3. *Covers*.
- (16) Perform the calibration of Joint #3.
For details, refer to 14. *Calibration*.

7.2.2 Replacing the Timing Belt : G20

A brake is mounted on the motor of Joints #3 and #4 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.

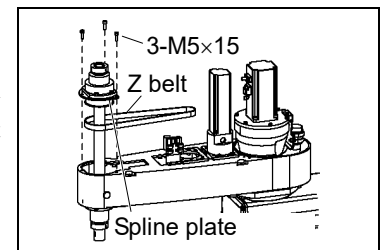
Z belt
Removal : G20

- (1) Execute the removal steps from (1) to (10) in *7.1 Replacing Joint #3 Motor* to remove the Joint #3 motor.

Do not remove the brake unit from Arm #2.

- (2) Remove the Z belt.

Remove the bolts securing the spline plate. Hold the spline plate and pull out the Z belt from the shaft upwards.



Z belt
Installation : G20

- (1) Pass a new Z belt through the shaft from above, and then place it under the spline plate.
- (2) Pass the belt through Arm #2.
- (3) Loosely secure the spline plate to Arm #2.
After moving the shaft up and down several times, secure the spline plate to Arm #2.
- (4) Execute steps from (2) to (10) in *7.1 Replacing Joint #3*.

7.3 Replacing the Brake

	Name		Quantity	Note
Maintenance parts	Electromagnetic brake	G10	1	1499588
		G20	-	-
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
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		3	

A brake is mounted on the motor of Joints #3 and #4 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).

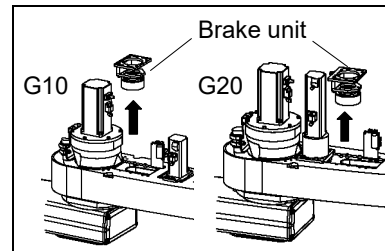
Note that the brake will not work during the replacement procedure.

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

Joint #3 brake Removal

- (1) Execute the removal steps from (1) to (10) in 7.1 Replacing Joint #3 Motor to remove the Joint #3 motor.

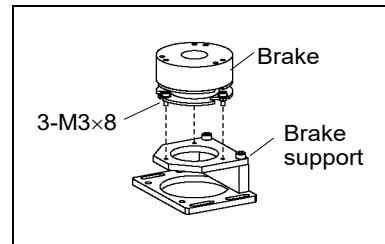
- (2) Remove the brake unit from Arm #2.



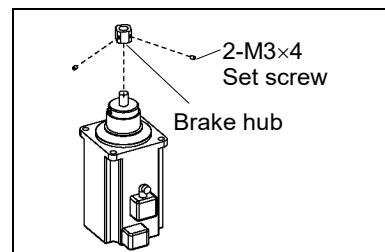
- (3) Disconnect the connector.

Connector X32

- (4) Remove the brake from the brake support.



- (5) Remove the brake hub from the Z1 pulley.



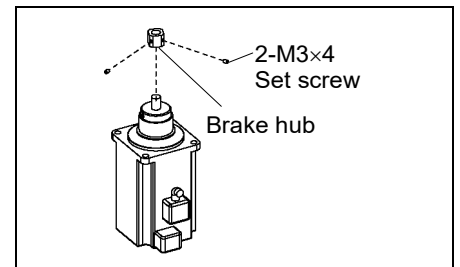
NOTE



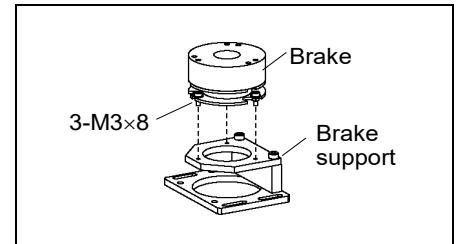
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #3 brake
Installation

- (1) Mount the brake hub to the Z1 pulley.



- (2) Mount the brake support to the brake.

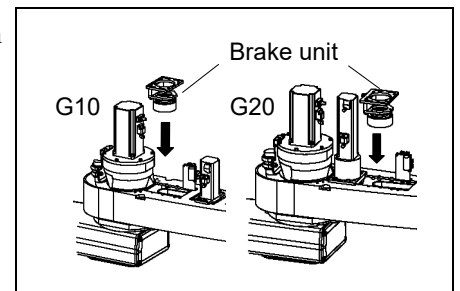


- (3) Mount back the Joint #3 brake unit to Arm #2.

The screws are not secured in this step.


- (4) Connect the connector.


Connector X32



- (5) Execute steps from (2) to (10) in *7.1 Replacing Joint #3*.

8. Joint #4

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

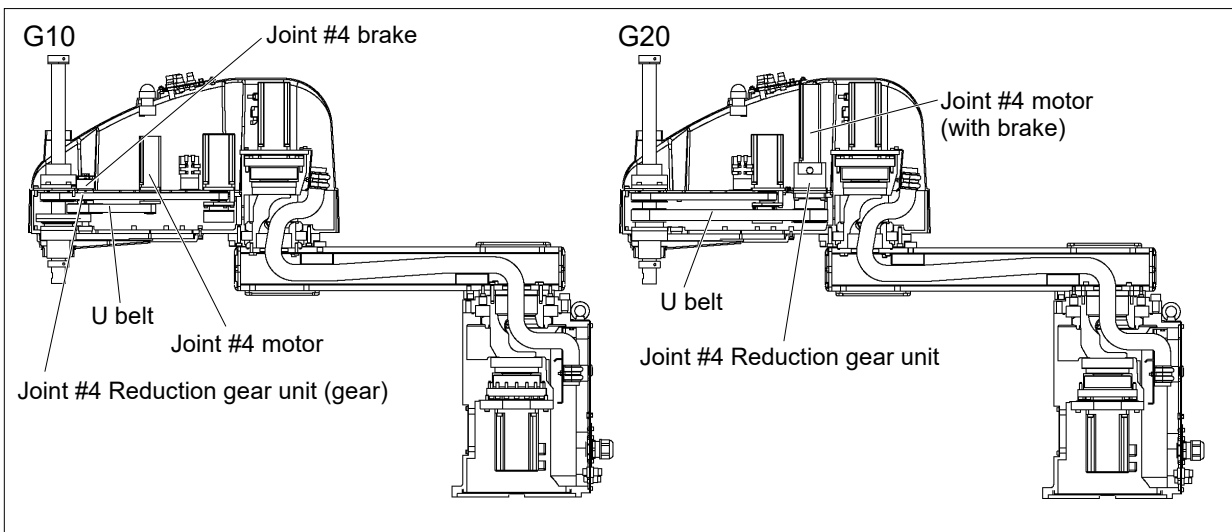
The process of aligning the two origins is called “Calibration”.

Refer to 14. *Calibration* to perform the calibration.

NOTE



G10-65*** manipulator of S/N: 1**** or later is different from other models in its form. For the detail, refer to 2.6.4 *G10-65***: For S/N: 1**** or later.*



8.1 Replacing Joint #4 Motor

The shape and the replacement procedure of the Joint #4 AC servo motor for G10 series and G20 series are different.

	Name		Quantity	Note		
Maintenance parts	AC Servo Motor	150W	G10	1	1499529 1533638 (For S/N: 1**** or later)	
		150W with brake	G20	1	1499530 1546182 (For S/N: 1*** or later)	
	Tools	Hexagonal wrench	width across flats: 1.5 mm	G20	1	For M3 set screw
			width across flats: 2 mm		1	For M4 set screw
width across flats: 2.5 mm			G20	1	For M3 screw	
width across flats: 3 mm				1	For M4 screw	
	Nipper			1	For cutting wire tie	
	Force gauge		G10	1	Belt tension 160 N (16.3 kgf)	
			G20	1	Belt tension 200 N (20.3 kgf)	
	Scale		G20	1	Ring mounting height 16.5 mm	
	Suitable cord (Length about 800 mm)			1	For belt tension	
Material	Wire tie			1		

8.1.1 Replacing the Joint #4 Motor: G10

A brake is mounted on the motor of Joints #3 and #4 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.

Joint #4 motor
Removal: G10

- (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.

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


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

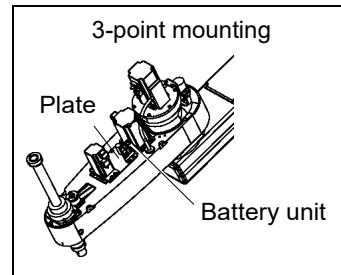
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.

For details, refer to 3. Covers.

- (5) Cut off the wire tie used for binding the motor cables to the Joint #4 motor.
- (6) Disconnect the following connectors.
Connectors X241, X41 (Hold the clip to remove.)
Connector X64

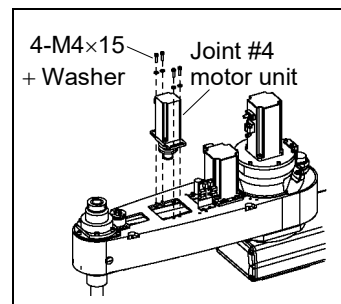
- (7) When you use the plate of 3-point mounting, loosen the plate mounting bolt.

NOTE  Be sure to keep the connectors connected to the battery unit.
If connectors of the battery unit are disconnected, you need to perform calibration again.



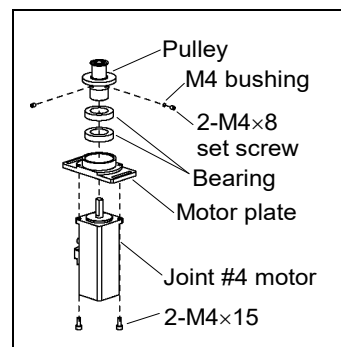
When you use the plate of 4-point mounting, you do not have to loosen the plate mounting bolt.

- (8) Remove the Joint #4 motor unit from Arm #2.
Remove the U belt from the U1 pulley. Pull the Joint #4 motor unit upward to remove.



- (9) Remove the U1 pulley and the motor plate from the Joint #4 motor.

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



NOTE



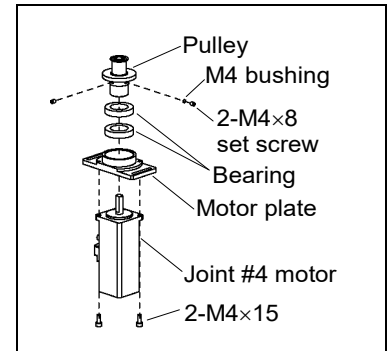
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #4 motor
Installation: G10

- (1) Mount the U1 pulley and the motor plate to the new Joint #4 motor.

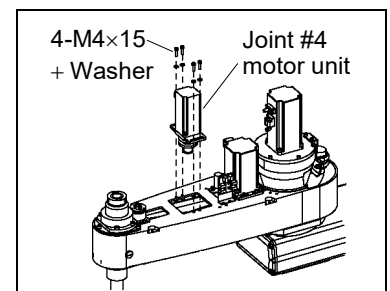
Pull the pulley to the motor side with 50N force to pressurize the bearing while securing the pulley.

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.



- (2) Place the Joint #4 motor unit in the arm so that the motor cable faces toward the left from the end of Arm #2.

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

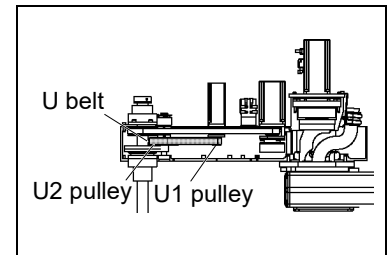


- (4) Loosely secure the Joint #4 motor unit to Arm #2.

NOTE



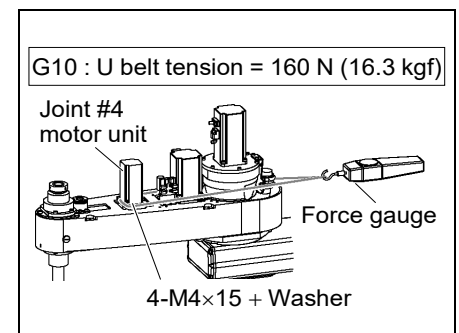
Loosely secure the Joint #4 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (5) 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 motor unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.

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



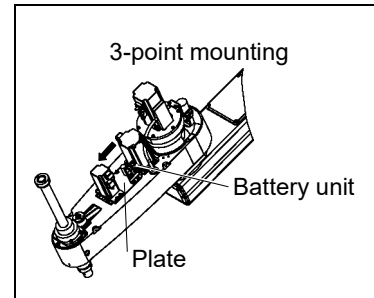
- (6) When you use the plate of 3-point mounting, mount the plate with pressing it to the Joint #4 motor.



Be sure to keep the connectors connected to the battery unit.

If connectors of the battery unity are disconnected, you need to perform calibration again.

When you use the plate of 4-point mounting, you do not have to mount the plate.



- (7) Connect the connectors X241, X41, and X64.
(8) Re-bundle the cables in their original positions with a wire tie removed in step (5).

Do not allow unnecessary strain on the cables.

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

For details, refer to 3. *Covers*.

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

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

8.1.2 Replacing the Joint #4 Motor: G20

A brake is mounted on the motor of Joints #3 and #4 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.

Joint #4 motor
Removal: G20

- (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.

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

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

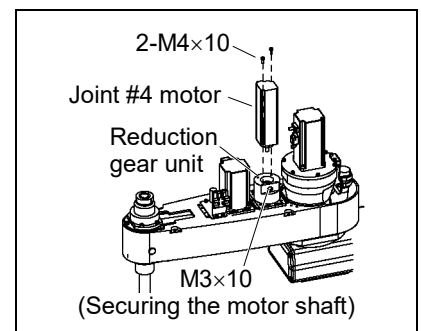
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.

For details, refer to 3. *Covers*.

- (5) Cut off the wire tie used for binding the motor cables to the Joint #4 motor.
- (6) Disconnect the following connectors.
 - Connectors X241, X41 (Hold the clip to remove.)
 - Connector X64

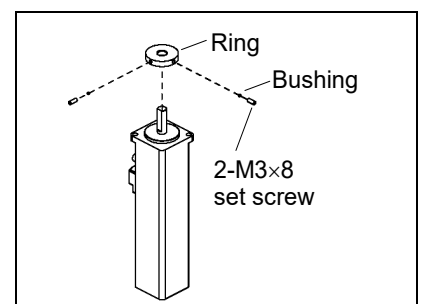
- (7) Remove the Joint #4 motor from the reduction gear unit.

Unscrew the reduction gear unit bolts securing the Joint #4 motor shaft and bolts securing the Joint #4 motor.



- (8) Remove the ring from the Joint #4 motor.

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





When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

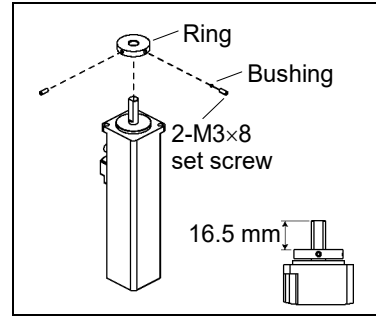
Joint #4 motor
Installation: G20

- (1) Mount the ring to the Joint #4 motor.

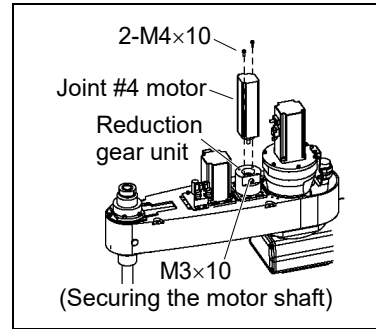
Be sure to fit the end face of the ring 16.5 mm from the end face of the motor shaft.

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.



- (2) Secure the Joint #4 motor to the reduction gear unit so that the Joint #4 motor cable faces toward the left from the end of Arm #2.
- (3) Secure the motor shaft to the reduction gear unit.
- (4) Connect the connectors X241, X41, and X64.



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

Do not allow unnecessary strain on the cables.

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

For details, refer to *3. Covers*.

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

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

8.2 Replacing the Timing Belt

The length and the replacement procedure of the timing belts for G10 series and G20 series are different.

	Name		Quantity	Note	
Maintenance parts	U belt	width 15 mm	G10	1	1489330
		width 20 mm	G20	1	1493784
Tools	Hexagonal wrench	width across flats: 1.5 mm	G10	1	For M3 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: 130N, 160N, 200N (13.3 kgf, 16.3 kgf, 20.4 kgf)
	Suitable cord (Length about 800 mm)			1	For belt tension

8.2.1 Replacing the Timing Belt: G10

A brake is mounted on the motor of Joints #3 and #4 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 (3).

U belt
Removal: G10

- (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.

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

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

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.

For details, refer to 3. Covers.

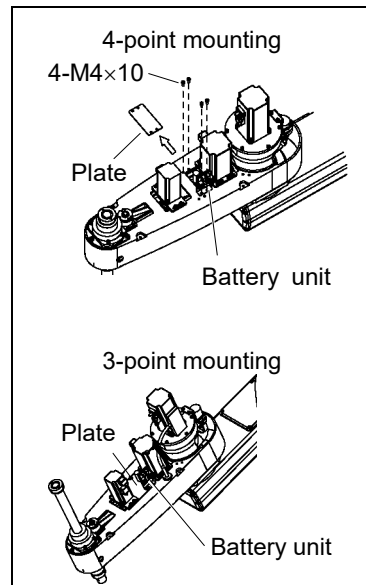
- (5) When you use the plate of 4-point mounting, remove the plate.



When removing the mounting bolt of battery unit, be sure to keep the connectors connected to the battery unit.

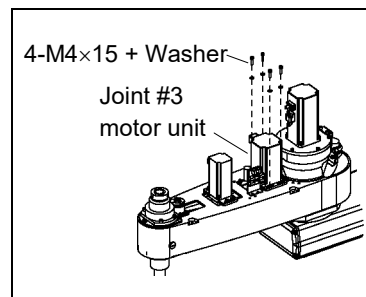
If connectors of the battery unit are disconnected, you need to perform calibration again.

When you use the plate of 3-point mounting, loosen the plate mounting bolt.



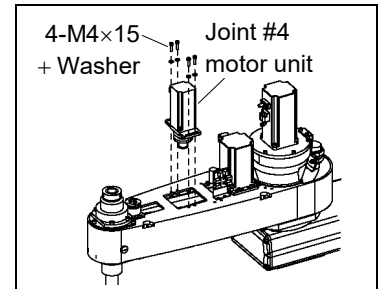
- (6) Loosen the Z belt.

Remove the four bolts securing the Joint #3 motor unit and slide the Joint #3 motor unit to the arm end side.



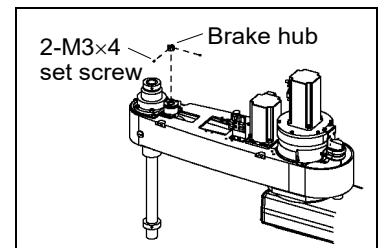
- (7) Remove the Joint #4 motor unit from Arm #2.

Pull out the U belt from the U1 pulley to remove it.



- (8) Remove the brake hub.

Loosen the two set screws and pull out the brake hub.

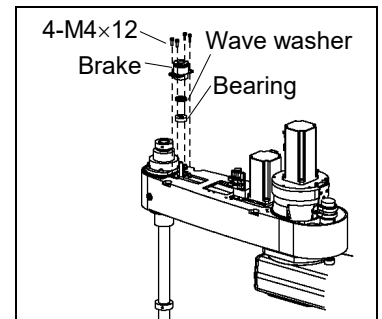


- (9) Remove the brake.

There is a wave washer between the housing and the bearing. Be careful not to lose it.

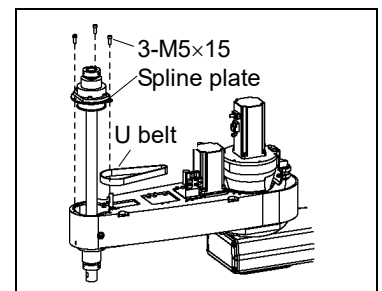
The gear for Z axis is a backlash-less gear. Be sure to keep the gear and pinion engage.

If the gear is out of joint, refer to step (7) in *Ball Screw Spline Unit Installation* of 10.2.1 *Replacing the Ball Screw Spline Unit: G10* to engage the gear.



- (10) Remove the Z belt from the Z pulley and remove the U belt.

Remove the bolts securing the spline plate. Hold the spline plate and pull out the Z belt from the Z pulley upwards to remove the U belt.

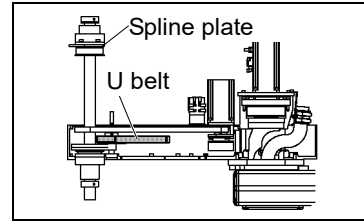


NOTE

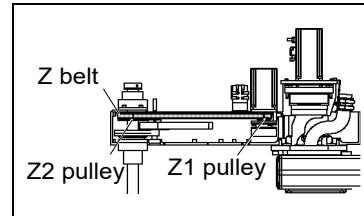

When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

U belt
 Installation: G10

(1) Hold the spline plate and place the U belt around the U2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



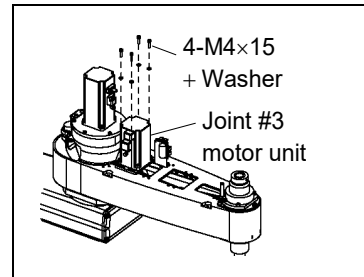
(2) Place the Z belt around the Z1 pulley and the Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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

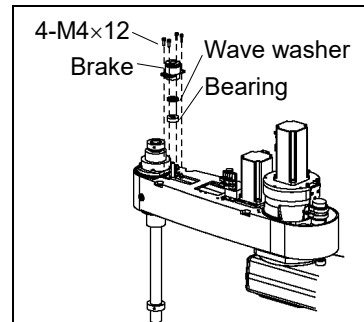
NOTE


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.

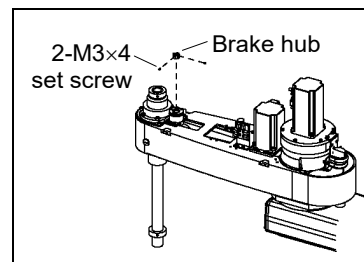


(4) Mount the brake to the Joint #4 intermediate pulley unit.

When mounting the brake, be sure to keep the wave washer from being stuck.



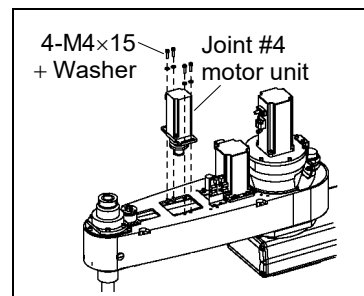
(5) Secure the brake hub with the two set screws.



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

NOTE

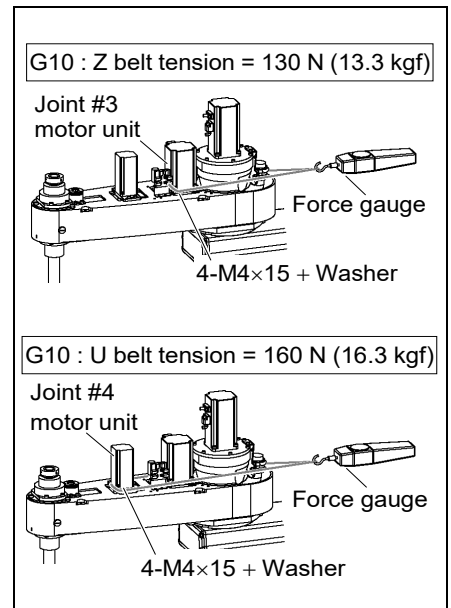

Loosely secure the Joint #4 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (7) Apply the proper tension to the Z belt and U belt, and then secure the Joint #3 motor unit and Joint #4 motor unit.

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

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

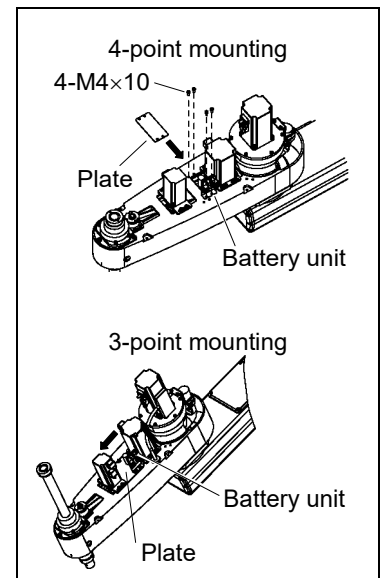


- (8) When you use the plate of 4-point mounting, mount the plate.

When you use the plate of 3-point mounting, mount the plate with pressing it to the Joint #4 motor.



When mounting the battery unit, be sure to keep the connectors connected to the battery unit. If connectors of the battery unit are disconnected, you need to perform calibration again.



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

For details, refer to 3. *Covers*.

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

For details, refer to 14. *Calibration*.

8.2.2 Replacing the Timing Belt: G20

A brake is mounted on the motor of Joints #3 and #4 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.

U belt
Removal: G20

- (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.

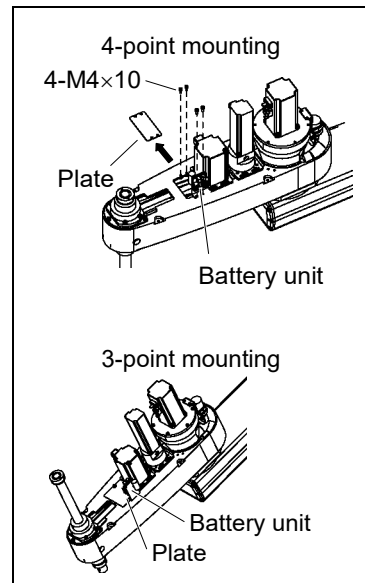
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

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

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.

For details, refer to 3. Covers.

- (5) When you use the plate of 4-point mounting, remove the plate.



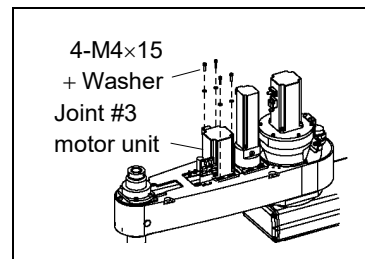
When you use the plate of 3-point mounting, loosen the plate mounting bolts.

Be sure to keep the connectors connected to the battery unit.

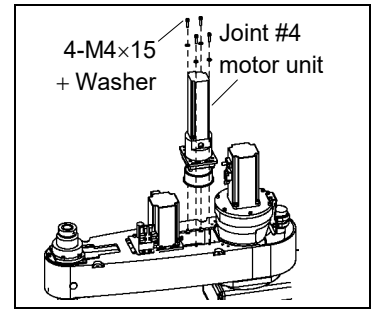
If connectors of the battery unity are disconnected, you need to perform calibration again.

- (6) 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.



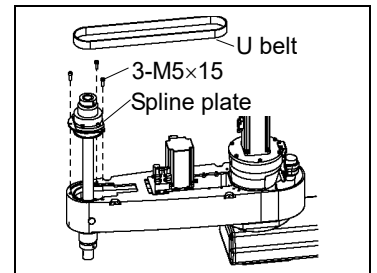
- (7) Remove the Joint #4 motor unit from Arm #2.



- (8) Remove the Z belt from the Z pulley and remove the U belt.

Remove the bolts securing the spline plate.

Hold the spline plate and pull out the Z belt from the Z pulley upwards and remove the U belt.



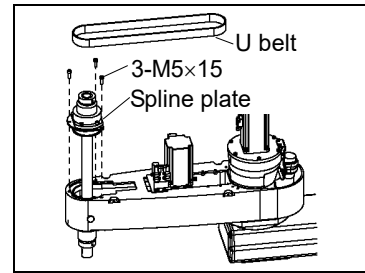
NOTE



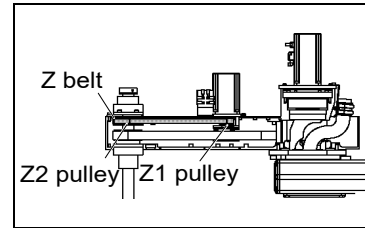
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

U belt
Installation: G20

- (1) Hold the spline plate and place the U belt around the U2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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

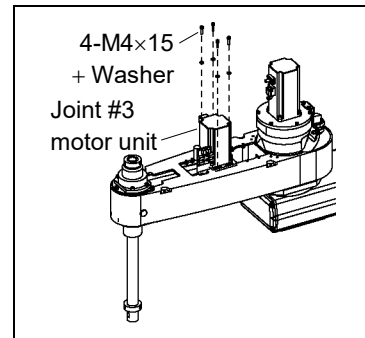


- (3) Loosely secure the Joint #3 motor unit to Arm #2.

NOTE



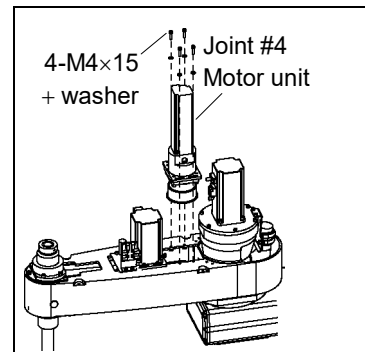
Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (4) Set the Joint #4 motor unit in Arm #2.

Place the Joint #4 motor unit in Arm #2 so that the motor cable faces toward the left from the end of Arm #2.

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

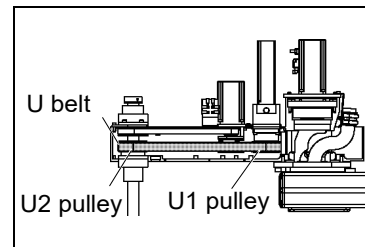


- (6) Loosely secure the Joint #4 motor unit to Arm #2.

NOTE



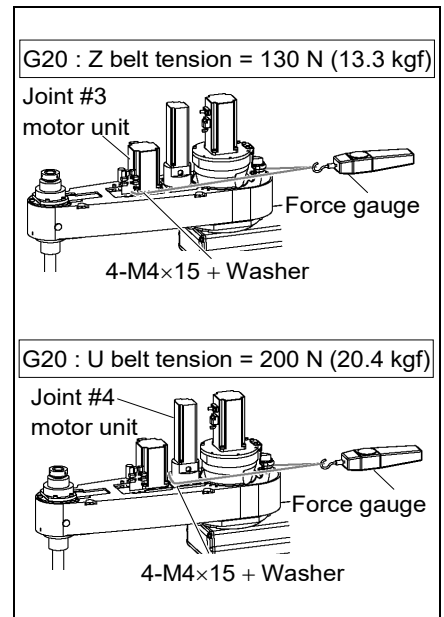
Loosely secure the Joint #4 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (7) Apply the proper tension to the Z belt and U belt, and then secure the Joint #3 motor unit and Joint #4 motor unit.

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

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



How to apply the proper tension to the U belt of G20

There is a bolt on the Z axis plate part to apply tension to the U belt.

(Since it is difficult to apply 200N tension on the U belt only by human power.)

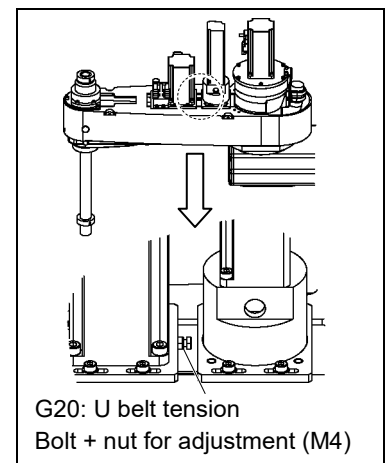
The procedure to apply tension using the bolt is as follows.

We recommend the Tensometer U series from Gates Unitta for measuring the belt tension.

Tensometer setting

Weight 5.25 g/m Width 20 mm Span 297.5 mm

1. Loosen the nut.
Be careful about the motor flange.
It may break with too much power.
2. Screw the bolt and push in the U axis plate.
3. Use the ultrasonic gauge to apply the proper tension to the U axis belt.
4. Secure the U axis unit.
5. Place back the bolt to the position.
Secure the nut.
6. Loosen the nut.



- (8) When you use the plate of 3-point mounting, mount the plate.

When you use the plate of 3-point mounting, mount the plate with pressing it to the Joint #3 motor.



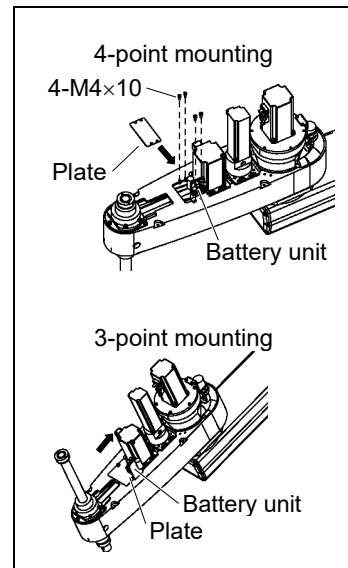
When mounting the battery unit, be sure to keep the connectors connected to the battery unit.
If connectors of the battery unit are disconnected, you need to perform calibration again.

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

For details, refer to *3. Covers*.

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

For details, refer to *14. Calibration*.



8.3 Replacing the Brake

The brake of Joint #4 for G20 series is built in the motor. Replace the motor to change the brake.

	Name		Quantity	Note
Maintenance parts	Electromagnetic brake	G10	1	1497639
		G20	-	-
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 2 mm	1	For M2.5 screw
	Nippers		1	For cutting wire tie
	Force gauge		1	Belt tension 160N (16.3 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		1	

A brake is mounted on the motor of Joints #3 and #4 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 from (1) to (3).

Joint #4 brake
Removal: G10

- (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.

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

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

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Disconnect the connector X42.
- (6) Cut off the wire tie used for binding the brake cables.

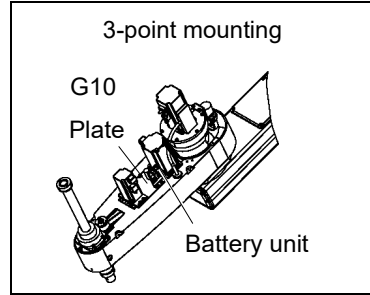
- (7) When you use the plate of 3-point mounting, loosen the plate mounting bolt.



Be sure to keep the connectors connected to the battery unit.

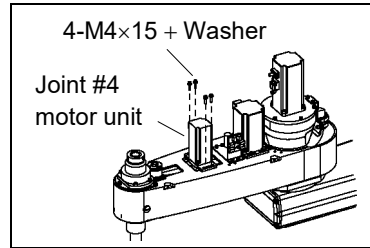
If connectors of the battery unity are disconnected, you need to perform calibration again.

When you use the plate of 4-point mounting, you do not have to loosen the plate mounting bolt.



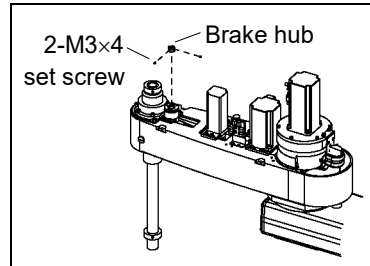
- (8) Loosen the U belt.

Loosen bolts on the Joint #4 motor unit. Slide the Joint #4 motor unit to the end of the arm.

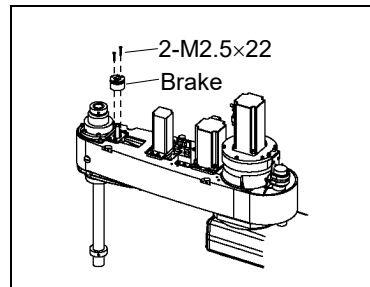


- (9) Remove the brake hub.

Loosen the two set screws and pull out the brake hub.



- (10) Remove the brake.



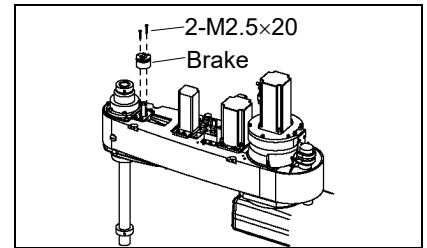
NOTE



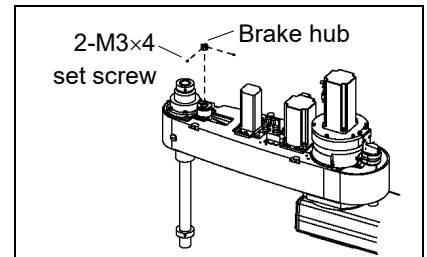
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #4 brake
Installation: G10

- (1) Mount the brake.



- (2) Secure the brake hub with the two set screws.

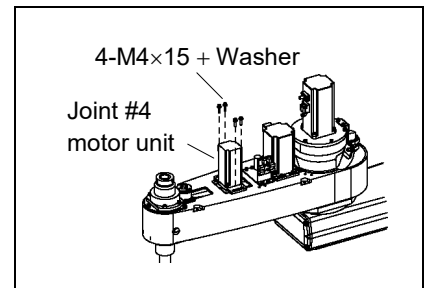


- (3) Loosely secure the Joint #4 motor unit to Arm #2.

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.

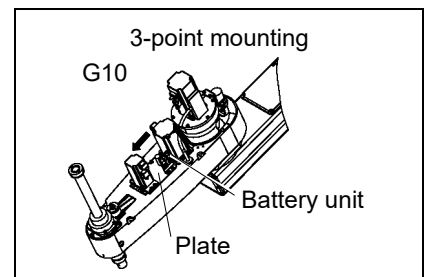


- (4) When you use the plate of 3-point mounting, mount the plate with pressing it to the Joint #4 motor.

NOTE

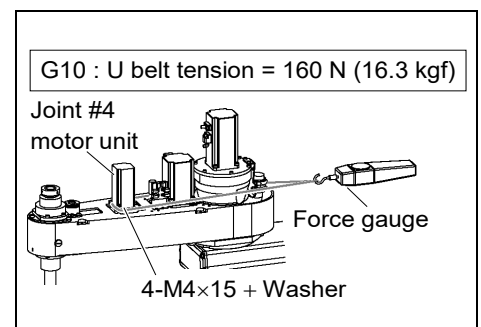


When mounting the battery unit, be sure to keep the connectors connected to the battery unit. If connectors of the battery unit are disconnected, you need to perform calibration again. When you use the plate of 4-point mounting, you do not have to mount the plate.



- (5) 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 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.



- (6) Connect the connectors X42.

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

Do not allow unnecessary strain on the cables.

- (8) Install the arm top cover.

For details, refer to *3.1 Arm Top Cover*.

8.4 Replacing the Reduction Gear Unit

The shape and the replacement procedure of the reduction gear unit for G10 series and G20 series are different.

	Name		Quantity	Note	
Maintenance parts	Reduction Gear Unit		G10	1	1499535
			G20	1	1493783
Tools	Hexagonal wrench	width across flats: 2.5 mm	G10	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 130N, 160N, 200N (13.3 kgf, 16.3 kgf, 20.4 kgf)	

8.4.1 Replacing the Reduction Gear Unit (Gear): G10

A brake is mounted on the motor of Joints #3 and #4 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.

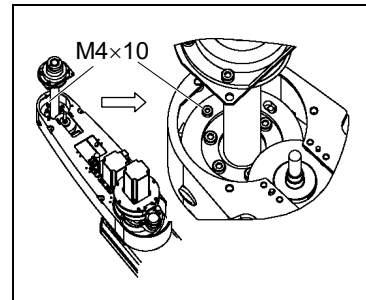
Move the shaft down to its lower limit before the replacement procedure following the removal steps.

Reduction Gear Unit Removal: G10

(1) Refer to the removal steps (1) to (13) in *10.2.1 Replacing the Ball Screw Spline Unit: G10* and remove the U belt.

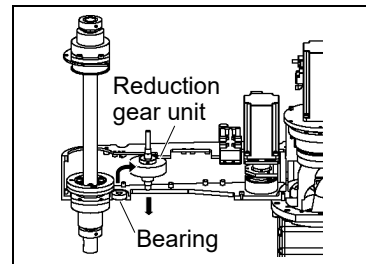
(2) Secure the Z gear.

Before removing the reduction gear unit, secure the Z gear with pressure on the Z gear.



(3) Remove the reduction gear unit.

(4) Remove the bearing.



Reduction Gear Unit Installation: G10

(1) Mount a new bearing.

(2) Mount a new reduction gear unit.

(3) Execute the installation steps (3) to (23) in *10.2.1 Replacing the Ball Screw Spline Unit: G10*.

8.4.2 Replacing the Reduction Gear Unit: G20

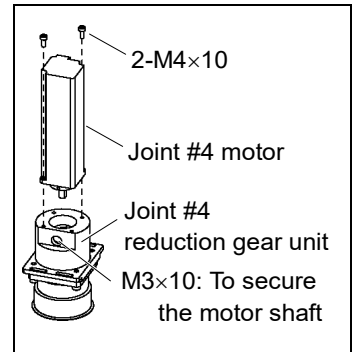
A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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.

Joint #4
Reduction gear
unit
Removal: G20

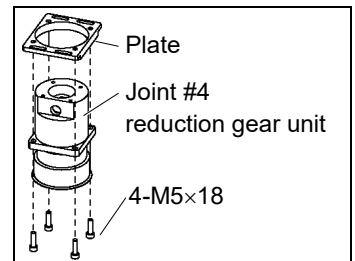
(1) Refer to *the removal steps (1) to (7) in 8.2.2 Replacing the Timing Belt: G20* and remove the Joint #4 motor unit from Arm #2.



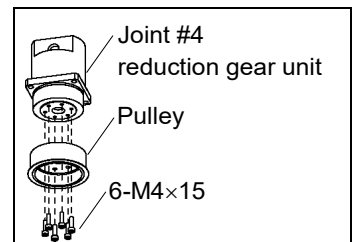
(2) Remove the Joint #4 motor from the reduction gear unit.

Unscrew the bolt of reduction gear unit securing the Joint #4 motor shaft and bolt securing the Joint #4 motor.

(3) Remove the plate.



(4) Remove the U pulley.



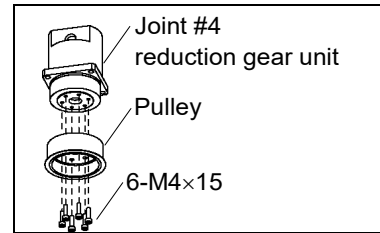
NOTE



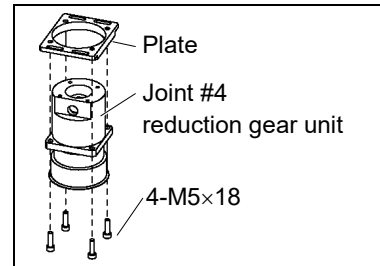
When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

Joint #4
Reduction gear
unit
Installation: G20

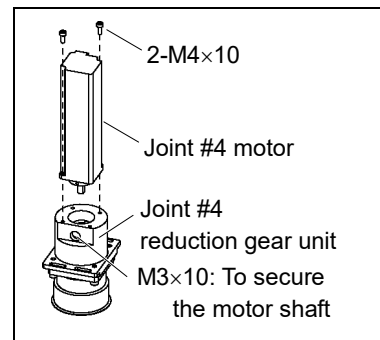
- (1) Mount the U pulley.



- (2) Mount the plate.



- (3) Mount the Joint #4 motor to the reduction gear unit. Secure the blot of the reduction gear unit securing the Joint #4 motor shaft.
- (4) Execute the installation steps (4) to (10) in *8.2.2 Replacing the Timing Belt: G20*.



9. Bellows



NOTE The bellows are provided in a unit of two pieces. The shape varies between the upper and lower bellows.

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

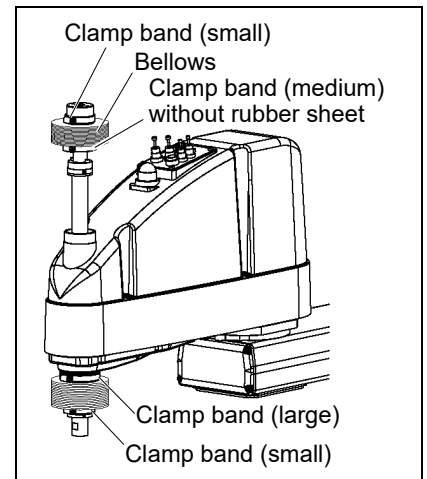
Take the Manipulator to an outer room such as the room in front of the clean room's entrance, or take the necessary countermeasures to prevent dust emission before removing the bellows.

	Name		Quantity	Note
Maintenance parts	Bellows	150 mm	1	1497641
		390 mm		1499591
Tools	Cross-point screwdriver		1	For clamp band removal

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) Loosen the two clamp bands on each bellows.
- (5) Pull the bellows, rubber sheet, and clamp bands out of the shaft.

(The rubber sheet is not used for the upper bellows.)



Bellows Installation

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

To move the shaft up/down, press and hold the brake release switch.
Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

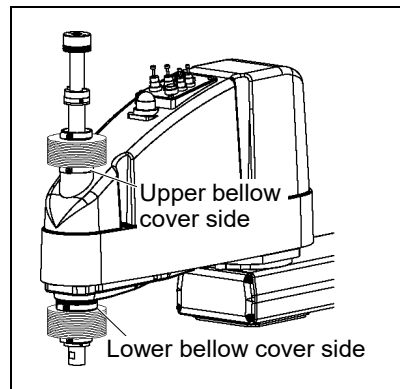
The brake release switch is applied to both Joints #3 and #4. When the brake release switch is pressed, the respective brakes of the Joints #3 and #4 are released simultaneously.

Be careful of the shaft falling and rotating while the brake release 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.

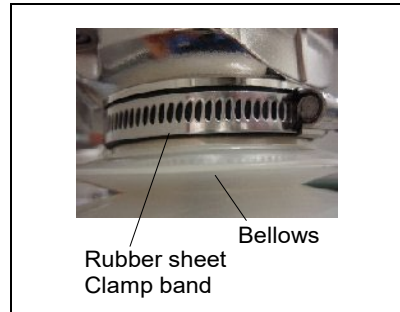
- (3) Secure the cover side of the bellows.

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 three sizes; small, medium, 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. (No rubber sheet for the upper bellows cover side)

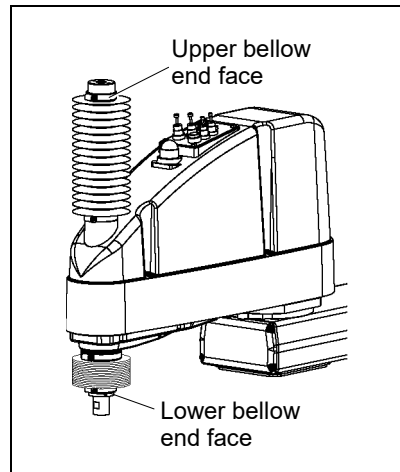


Then, secure them with clamp bands.

- (4) 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.

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

10. Ball Screw Spline Unit

 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.
--	---

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 *14. Calibration* to perform the calibration.

The replacement procedure of the ball screw spline unit for G10 series and G20 series are different.

	Name	Quantity	Note		
Maintenance parts	Ball Screw Spline Unit	1	Each manipulator model (Refer to <i>15. G10 G20 Maintenance parts</i>)		
Grease	For Ball Screw Spline Unit (AFB grease)	Proper quantity			
Tools	Hexagonal wrench	width across flats: 1.5 mm	G10	1	For M3 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
	Cross-point screwdriver			1	Only for Cleanroom-model and Protected-model
	Force gauge			1	G10 Belt tension: 130N, 160N (13.3 kgf, 16.3 kgf) G20 Belt tension: 130N, 200N (13.3 kgf, 20.4 kgf)
	Suitable cord (Length about 1000 mm)			1	For belt tension
Wiping cloth			1	For wiping grease	

10.1 Replacing the Ball Screw Spline Unit: G10

A brake is mounted on the motor of Joints #3 and #4 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 (3).

Ball screw
spline unit
Removal : G10

- (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.

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

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

- (3) Turn OFF the Controller.
- (4) Detach the wires and tubes from the end effector, and remove the end effector.
- (5) This step is only for Cleanroom-model and Protected-model (C, D with bellows option, P).

Remove the bellows.

For details, refer to 9. *Bellows*.

- (6) Remove the arm top cover and arm bottom cover.

For details, refer to 3. *Covers*.

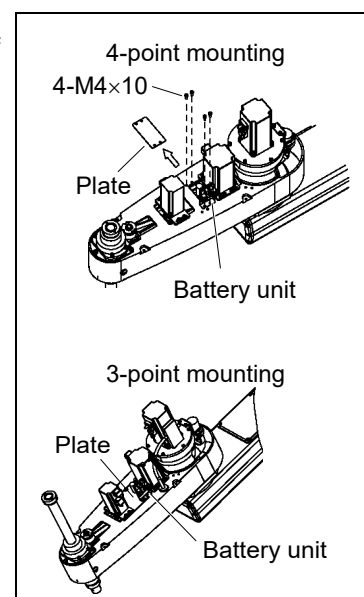
- (7) Cut off the wire tie banding motor cables to the Joint #3 motor and Joint #4 motor.

- (8) When you use the plate of 4-point mounting, remove the plate.

When you use the plate of 3-point mounting, loosen the plate mounting bolt.

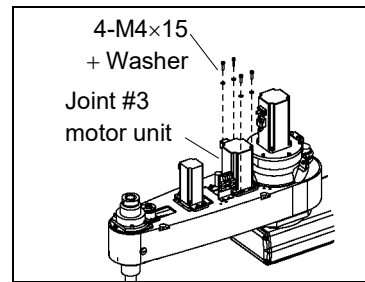


When removing the battery unit mounting bolts, be sure to keep the connectors connected to the battery unit. If connectors of the battery unit are disconnected, you need to perform calibration again.



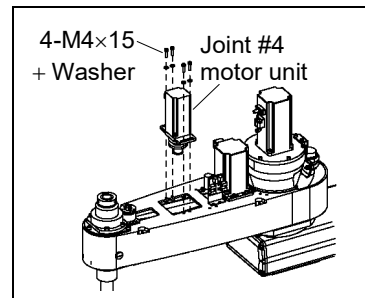
- (9) Loosen the Z belt.

Loosen four bolts on the Joint #3 motor unit. Slide the Joint #3 motor unit to the end of the arm.



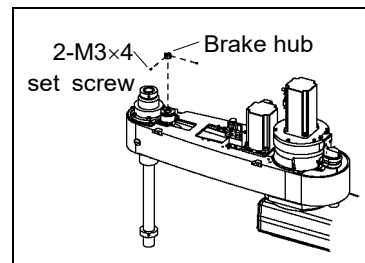
- (10) Remove the Joint #4 motor unit from Arm #2.

Unscrew the bolts securing the Joint #4 motor unit to the motor plate. Remove the U belt from the U1 pulley. Pull the Joint #4 motor unit upward to remove.



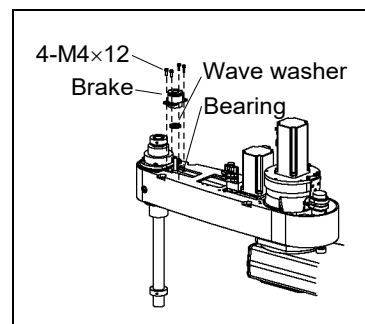
- (11) Remove the brake hub.

Loosen the two set screws and pull out the brake hub.

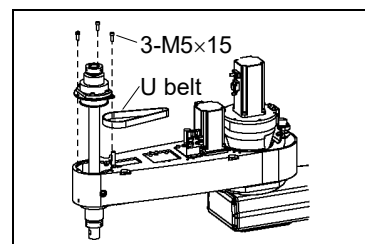


- (12) Remove the brake.

There is a wave washer between the housing and the bearing. Be careful not to lose it.

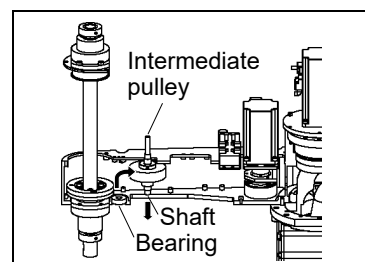


- (13) Remove the U belt.



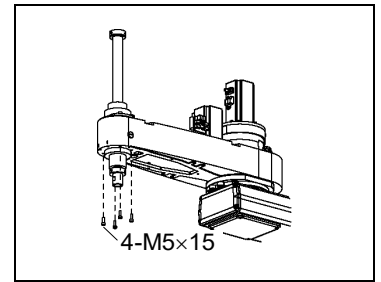
- (14) Remove the Joint #4 intermediate pulley.

Remove the shaft from the bearing and remove the intermediate pulley from the lower side of Arm #2.



(15) Remove the nut mounting screws of the ball screw spline shaft on the lower part of Arm #2.

(16) Pull out the ball screw spline unit from Arm #2.



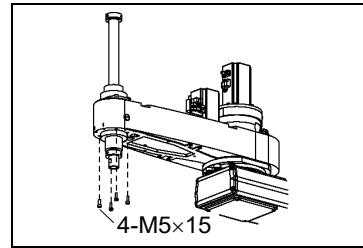


When tightening hexagon socket head cap bolts, refer to the 2.4 Tightening Hexagon Socket Head Cap Bolts.

Ball screw spline unit Installation : G10

- (1) Pass the 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.

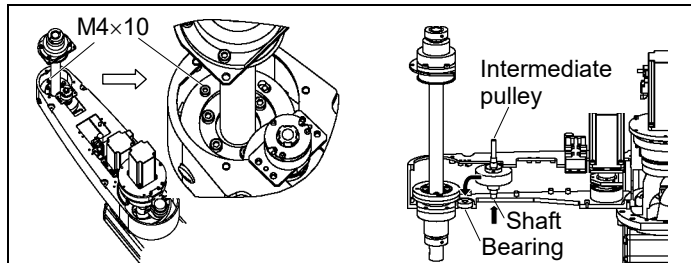
Be sure to keep the timing belt from being stuck between the nut and Arm #2.



- (3) Mount the Joint #4 intermediate pulley.

Place the M4 bolt position of the Z axis gear to the end of the arm.

Insert the intermediate pulley from the lower side of Arm #2 and engage the gear.



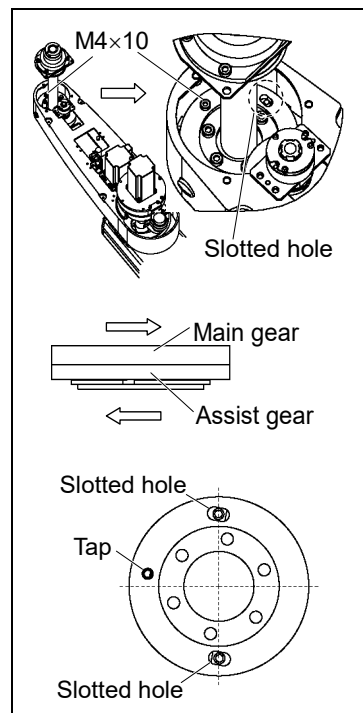
- (4) Remove the bolt of the Z gear.

The gear for Z axis is a backlash-less gear consists of two gears.

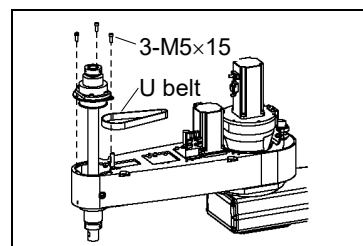
The gear and pinion is pressurized. Be sure to keep the gear and pinion engage.

If the gear is out of joint

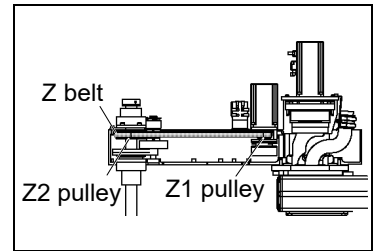
1. Rotate the main gear and the assist gear in the opposite direction and shift one tooth of the gear. (The pin pushes the spring and generates pressure.)
2. Use the tap to mount the M4 bolt.
3. Make sure that the pin position of the main gear is near the center of the slotted hole.



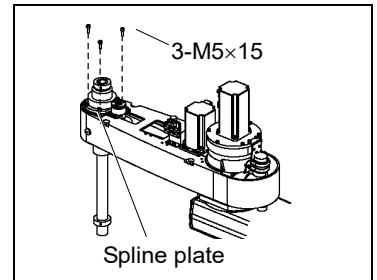
- (5) Hold the spline plate and place the U belt to the U2 pulley.



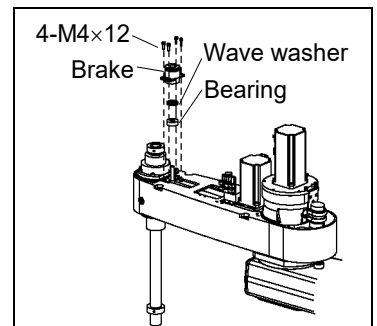
- (6) Set the Z belt around the Z1 pulley and Z2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



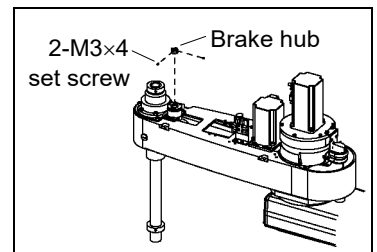
- (7) Loosely secure the spline plate to Arm #2.
After moving the shaft up and down several times, secure the spline plate to Arm #2.



- (8) Mount the brake to the Joint #4 intermediate pulley unit.
When mounting the brake, be sure to keep the wave washer from being stuck.



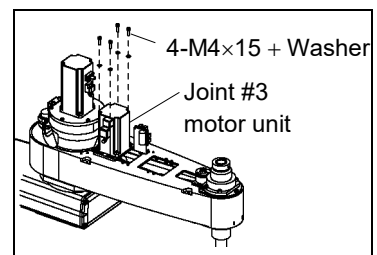
- (9) Secure the brake hub with the two set screws.



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



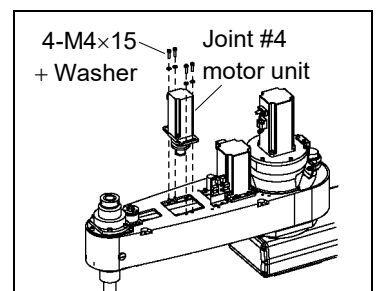
NOTE Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



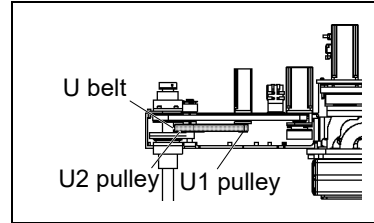
- (11) Set the Joint #4 motor unit in Arm #2.

Place the Joint #4 motor unit in Arm #2 so that the motor cable faces toward the left from the end of the arm.

The screws are not secured in this step.



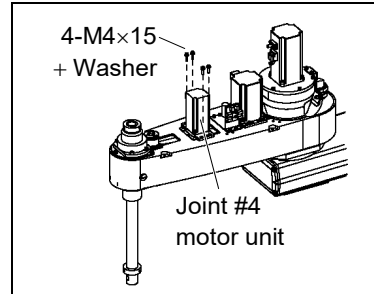
- (12) Place the U belt around the U1 pulley and the U2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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



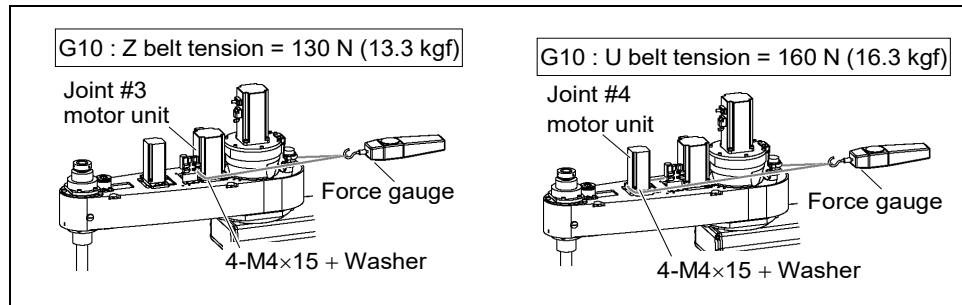
Loosely secure the Joint #4 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (14) Apply the proper tension to the Z belt and U belt, and then secure the Joint #3 motor unit and Joint #4 motor unit.

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

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

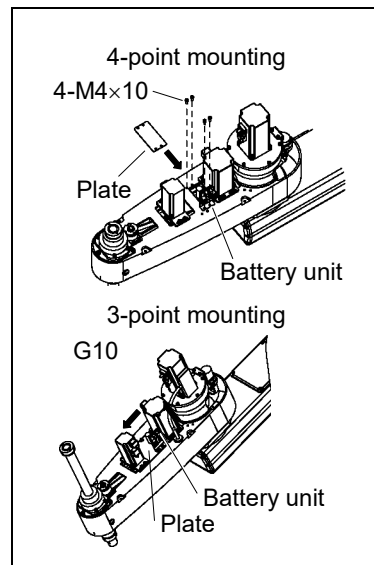


- (15) When you use the plate of 4-point mounting, mount the plate without pressing it to the Joint #4 motor.



When you use the plate of 3-point mounting, mount the plate with pressing it to the motor.

When mounting the battery unit, be sure to keep the connectors connected to the battery unit. If connectors of the battery unit are disconnected, you need to perform calibration again.



- (16) Re-bundle the cables in their original positions with a wire tie removed in the removal procedure. Do not allow unnecessary strain on the cables.
- (17) If the position of the lower limit mechanical stop was changed for area limit, secure it to the proper position.
- (18) Grease the shaft.
For details, refer to *10.1. Greasing the Ball Screw Spline Unit*.
- (19) Install the arm top cover and arm bottom cover.
For details, refer to *3. Covers*.
- (20) Turn OFF the Controller and peripheral equipment.
- (21) Install the end effector, and connect wires and tubes to the end effector.
- (22) This step is only for Cleanroom-model and Protected-model (C / D with bellows option / P).
Install the bellows.
For details, refer to *9. Bellows*.
- (23) Perform the calibration of Joints #3 and #4.
For details, refer to *14. Calibration*.

10.2 Replacing the Ball Screw Spline Unit: G20

A brake is mounted on the motor of Joints #3 and #4 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 (3).

Ball screw
spline unit
Removal : G20

- (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.

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

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

- (3) Turn OFF the Controller.
- (4) Detach the wires and tubes from the end effector, and remove the end effector.
- (5) This step is only for Cleanroom-model and Protected-model (C, D with bellows option, P).
Remove the bellows.

For details, refer to 9. *Bellows*.

- (6) Remove the arm top cover and the bottom cover.

For details, refer to 3. *Covers*.

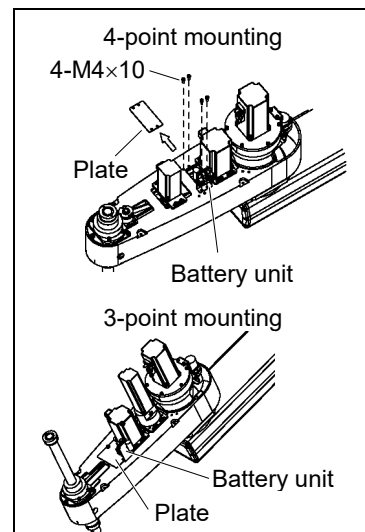
- (7) Cut off the wire tie banding motor cables to the Joint #3 motor and Joint #4 motor.

- (8) When you use the plate of 4-point mounting, remove the plate.

When removing the battery unit mounting bolts, be sure to keep the connectors connected to the battery unit.

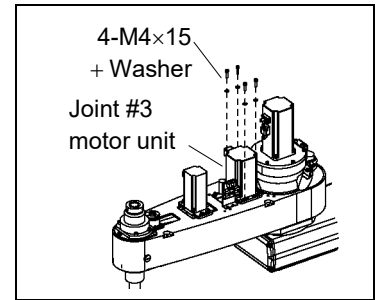
If connectors of the battery unit are disconnected, you need to perform calibration again.

When you use the plate of 3 mounting, loosen the plate mounting bolts.



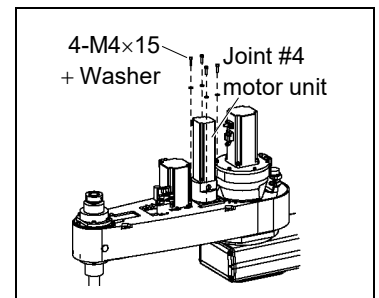
- (9) Loosen the Z belt.

Loosen four bolts on the Joint #3 motor unit. Slide the Joint #3 motor unit to the end of the arm.

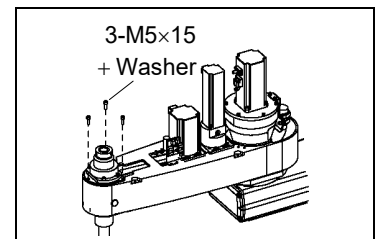


- (10) Loosen the U belt.

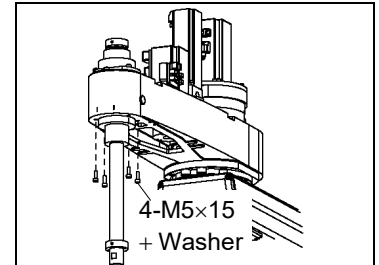
Loosen the bolts mounting the Joint #4 motor unit on the motor plate. Slide the Joint #4 motor unit to the end of the arm.



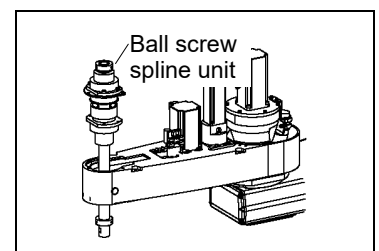
- (11) Remove the nut mounting screws of the ball screw spline shaft on the upper part of Arm #2.



- (12) Remove the nut mounting screws of the ball screw spline shaft on the lower part of Arm #2.



- (13) Pull out the ball screw spline unit from Arm #2.



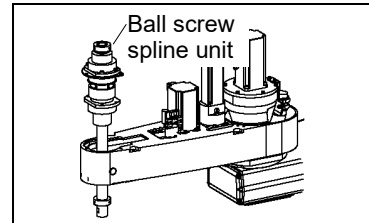
NOTE



When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts*.

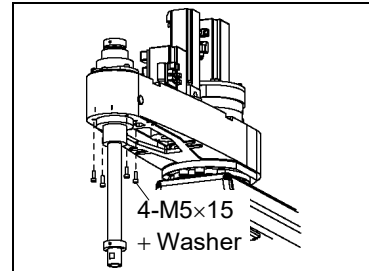
Ball screw spline unit
Installation: G20

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



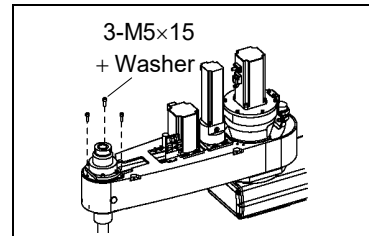
- (2) Secure the nut mounting screws of the ball screw spline shaft on lower side of Arm #2.

Be sure to keep the timing belt from being stuck between the nut and Arm #2.

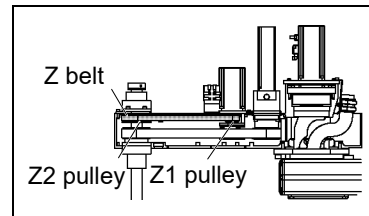


- (3) Loosely secure the spline plate to Arm #2.

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



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

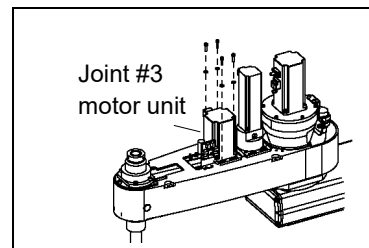


- (5) Loosely secure the Joint #3 motor unit to Arm #2.

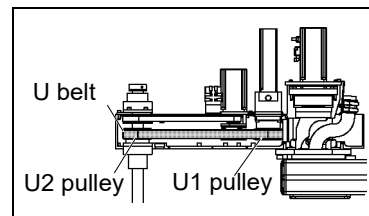
NOTE



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



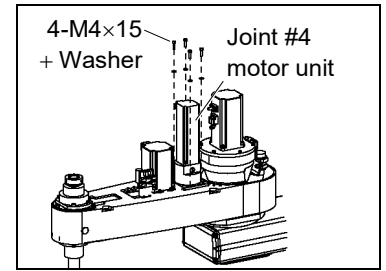
- (6) Place the U belt around the U1 pulley and the U2 pulley so that the gear grooves of the belt are fit into those of the pulleys completely.



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



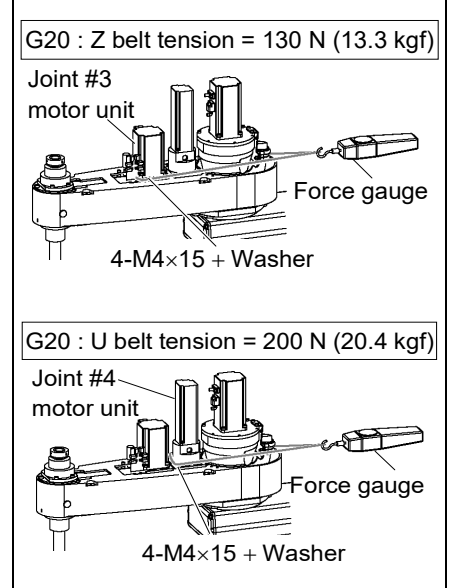
Loosely secure the Joint #3 motor unit to Arm #2 so that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



- (8) Apply the proper tension to the Z belt and U belt, and then secure the Joint #3 motor unit and Joint #4 motor unit.

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

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



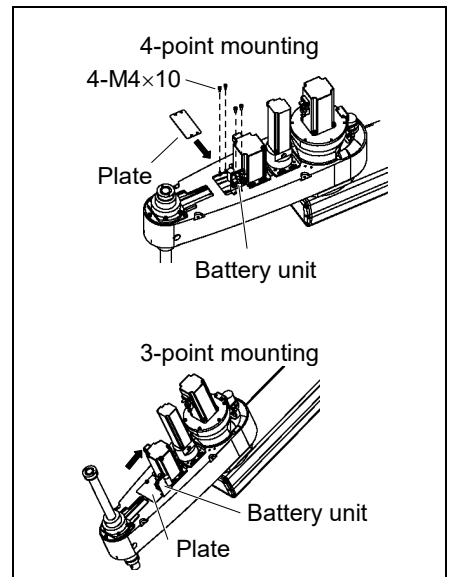
- (9) When you use the plate of 4-point mounting, mount the plate without pressing it to the motor.

When you use the plate of 3-point mounting, mount the plate with pressing it to the motor.



When mounting the battery unit, be sure to keep the connectors connected to the battery unit.

If connectors of the battery unit are disconnected, you need to perform calibration again.



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

Do not allow unnecessary strain on the cables.

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

(12) Grease the shaft.

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

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

For details, refer to *3. Covers*.

(14) Turn OFF the Controller and peripheral equipment.

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

(16) This step is only for Cleanroom-model and Protected-model (C, D with bellows option, P).



Install the bellows.

For details, refer to *9. Bellows*.

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

For details, refer to *14. Calibration*.

11. Lithium Battery

 <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.
 <p>CAUTION</p>	<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. <ul style="list-style-type: none"> <Improper Handling> <ul style="list-style-type: none"> • Battery Charge • Disassembly • Incorrect Installation • Exposing to Fire • Forced Discharge • Deformation by Pressure • Short-circuit (Polarity; Positive/Negative) • Heating (85°C or more) • Soldering the terminal of the lithium battery directly ■ 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.

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.

RC700 series Maintenance Manual 6. 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 15. *G10/G20 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	2120180
Tools	Nippers	1	For cutting wire tie
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw (For Replace Battery board)
Material	Wire tie	2	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) 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.

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

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

- (3) Remove the arm top cover.

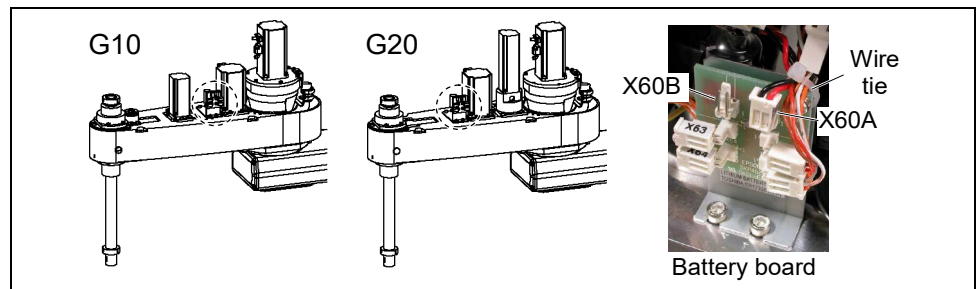
For details, refer to *3.1 Arm Top Cover*.

- (4) Connect the connector of the new lithium battery to the battery board.

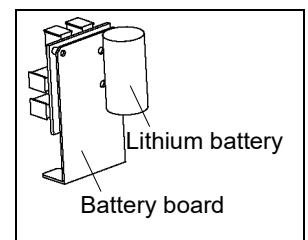
User the unused connector of the two connectors X60A, X60B on the upper part of the battery board.

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 one, the robot will lose the origin position data and the calibration must be executed again.

Except when the Power-Low warning is appearing.



- (5) Cut off the wire tie banding the cables of used lithium battery.
- (6) Cut off the wire tie banding the lithium battery and remove the lithium battery.



Battery unit
(lithium battery)
Installation

- (1) Mount the new lithium battery to the battery board.
- (2) Refer to the Removal step (4) to mount cables of the lithium battery and the connector from the battery board.
- (3) Mount the arm top cover.

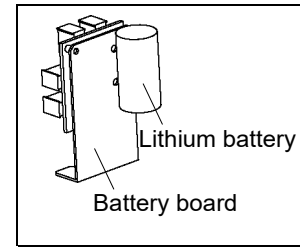
For details, refer to *3.1 Arm Top Cover*.

- (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 *14. 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 *14. Calibration* to perform the calibration.

Battery board Removal

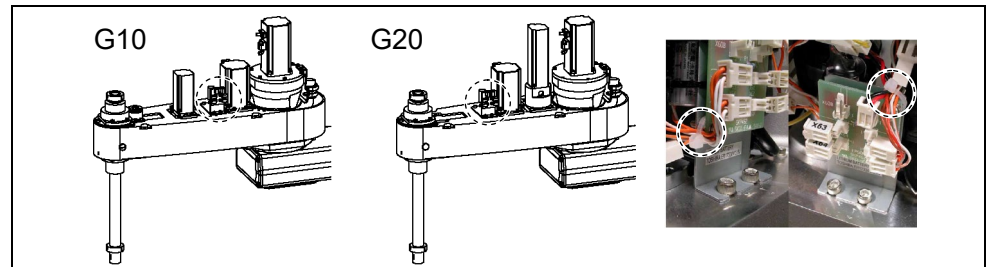
- (1) Turn OFF the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

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

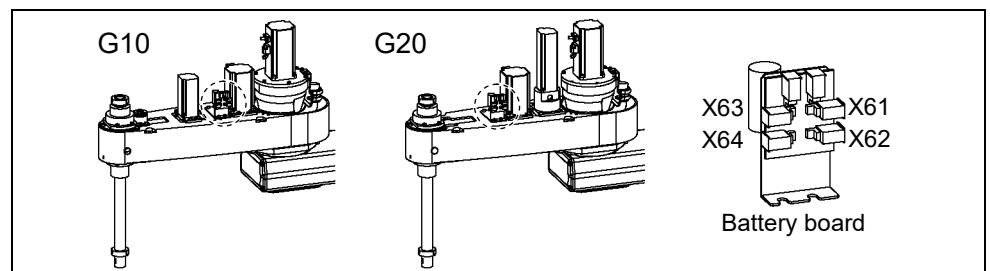
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.

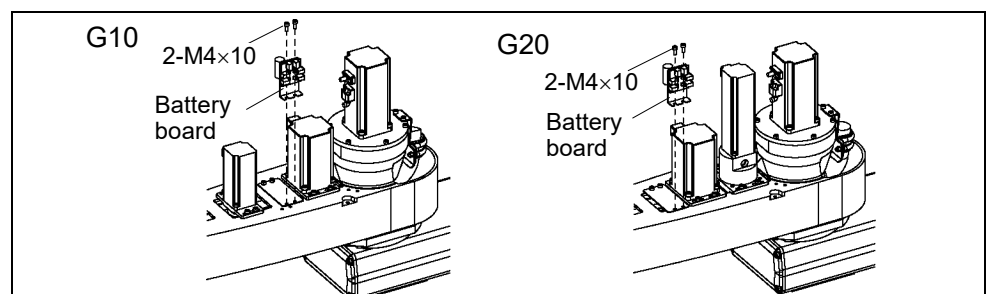
- (4) Cut off the wire tie banding the connector cables.



- (5) Disconnect the connectors X61, X62, X63, and X64 connected to the battery board.

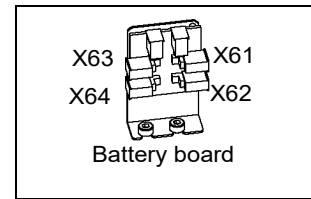


- (6) Loosen the screws securing the battery board and remove the battery board.

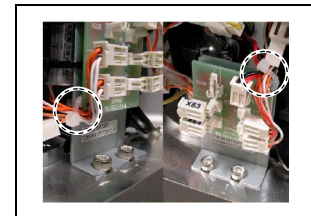


Battery board
Installation

- (1) Mount the new battery board and secure it with screws.
- (2) Connect the connectors X61, X62, X63, and X64.




- (3) Refer to the Removal step (4) to mount the cables of connector with wire tie.



- (4) Mount the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (5) Turn ON the Controller.
- (6) Perform the calibration of all joints.
For details, refer to *14. Calibration*.

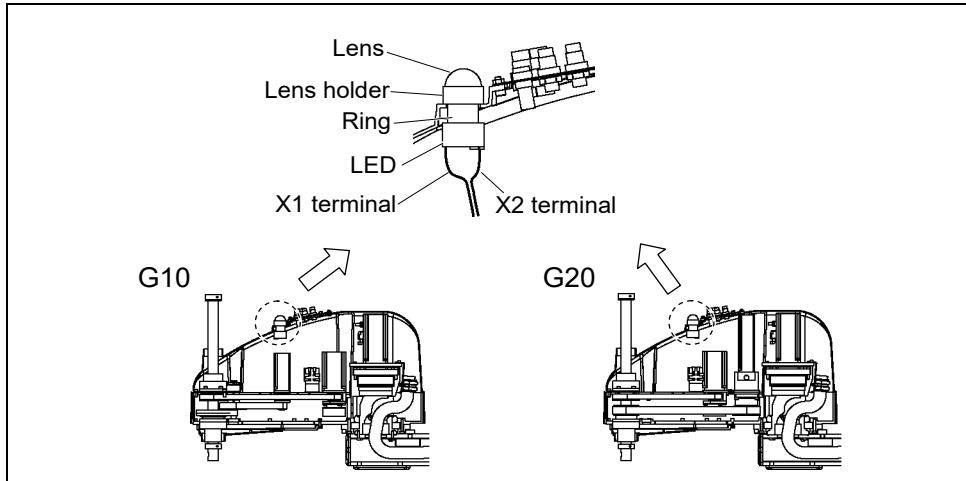
12. LED Lamp

 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.
---	---

	Name	Quantity	Note
Maintenance parts	LED Lamp	1	2077258
Tools	Cross-point screwdriver	1	For wire removal
	Nippers	1	
Material	Wire tie	1	

LED Lamp
Removal


- (1) Remove the arm top cover.
For details, refer to *3.1 Arm Top Cover*.
- (2) Disconnect the X1 and X2 terminals from the LED.
- (3) Turn the lens counterclockwise to remove it. Then, turn the lens holder counterclockwise to remove it.
- (4) Remove the LED from the arm top cover.




LED Lamp
Installation

- (1) Connect the X1 and X2 terminals to the LED.
Each terminal must be connected to its terminal number on the LED.
- (2) Put the arm top cover between the ring and lens holder, and then mount the LED on the arm top cover.
- (3) Install the lens to the lens holder.
- (4) Install the arm top cover.
For details, refer to *3.1 Arm Top Cover*.

13. Radiating Unit

 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. ■ The radiating unit can be very hot after the robot operation. DO NOT touch and wait until it cools down enough to touch for the replacement work.
---	--

NOTE  G10-65*** manipulator of S/N: 1**** or later is different from other models in its form. For the detail, refer to 2.6.4 G10-65***: For S/N: 1**** or later.

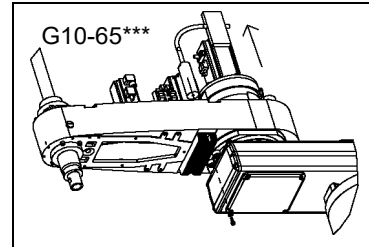
	Name	Quantity	Note
Maintenance parts	Radiating Unit	1	1546193
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screws
	Spanner (width across flats: 20 mm)	1	For mounting pillar
	Nippers	1	For cutting wire tie

Radiating Unit
Removal

- (1) Remove the arm top cover.
For details, refer to 3. *Covers*.
- (2) Remove two insulation lock ties that secure the Joint #2 motor and plate.
- (3) Remove the radiating sheet from to the plate.
- (4) Remove the mounting bolt located in the radiating unit side of heat sink (Hexagon socket head cap bolt (fully threaded)).



The radiating unit side is the right side from the arm forefront.



- (5) Pull out the radiating unit upward.



To do so, be careful not to pull out the plate too from the pipe.



When tightening hexagon socket head cap bolts, refer to the 2.4 *Tightening Hexagon Socket Head Cap Bolts*.

Radiating Unit
Installation

- (1) Insert the radiating unit to the arm from above.
- (2) Apply the radiating sheet to the plate.
Make sure the gray color side of radiating sheet faces to the plate.
To do so, put the plate as upper side as possible.
- (3) Press the plate to the Joint #2 motor and secure the plate and motor using the insulation lock ties in two points (up/down) of the plate.
Be careful not to catch the motor cable.
- (4) Secure the heat sink mounting bolt with the pillar.
Hold the pillar with the spanners to avoid it from rotating.
- (5) Mount the arm top cover.



For details, refer to 3. *Covers*.
During the installation, be sure to keep the plate attached to the pipe.

14. Calibration


14.1 About Calibration

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

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

The process of aligning the two origins is called “Calibration”. Note that calibration is not the same as teaching*.

*: “Teaching” means to teach the Controller coordinate points (including poses) anywhere in the operating area of the Manipulator.

 WARNING	<ul style="list-style-type: none"> ■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to EPSON RC+ User's Guide: <i>2.3 Installation and Design Precautions</i>. ■ 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 calibration procedure is different for each type of software, see your software type.

14.2 Calibration Procedure

EPSON RC+ has a wizard for calibration.

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

The same calibration procedure is used for each joint.

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 *14.3 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.



If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *14.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.

The reference point (a point to check the accuracy) needs to be specified for calibration.

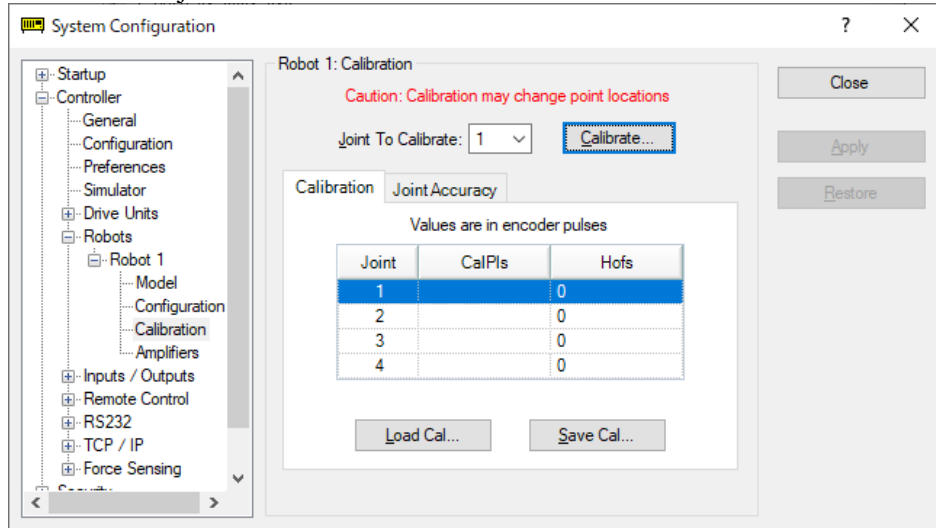
(1) Start the calibration wizard.

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

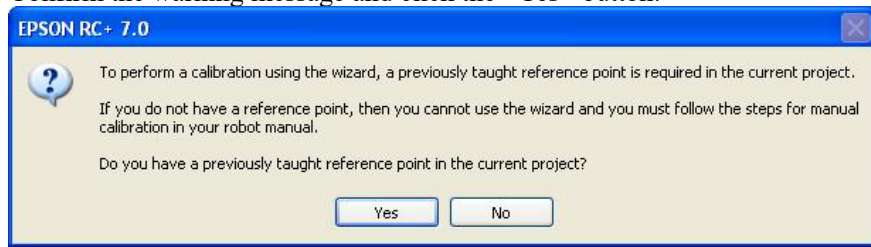


Only selected robot can be calibrated.

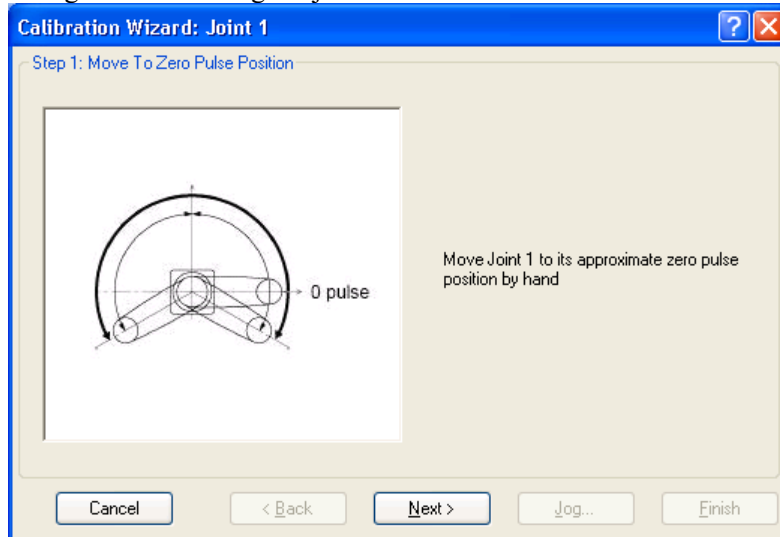
- iii. Select the joint and click the <Calibrate...> button.



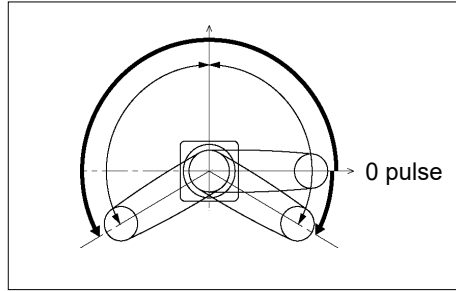
- (2) Confirm the warning message and click the <Yes> button.



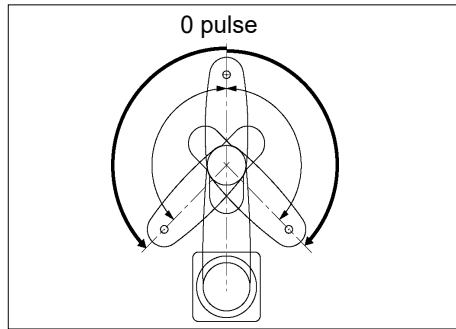
- (3) Move the joint to calibrate manually to approximate 0 pulse position, as shown in the dialog. After moving the joint click the <Next> button.



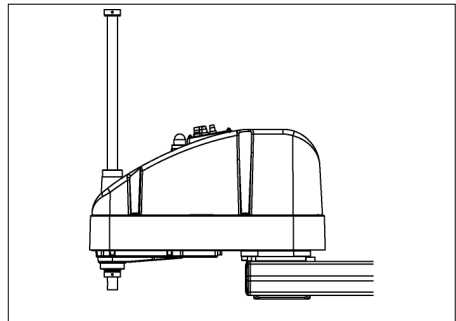
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



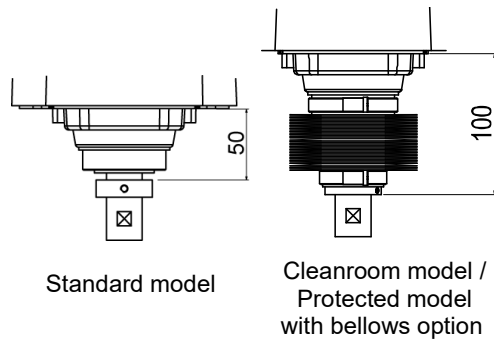
0 pulse position of Joint #2:
position where Arms #1 and #2
are in a straight line
(Regardless of the Joint #1
direction.)



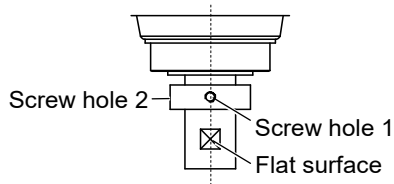
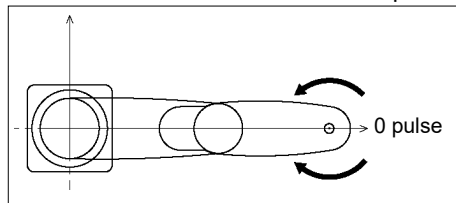
0 pulse position of Joint #3:
upper limit position in motion
range



The height of Joint #3 depends
on manipulator model.



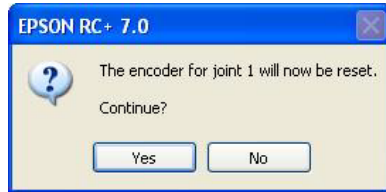
0 pulse position of Joint #4:
position where the flat surface
(or screw hole 1) on the shaft
faces toward the tip of Arm #2



Screw hole 1 and flat surface are located
in the center of the shaft.

Screw hole 1 and 2 are located at right
angles to one another.

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

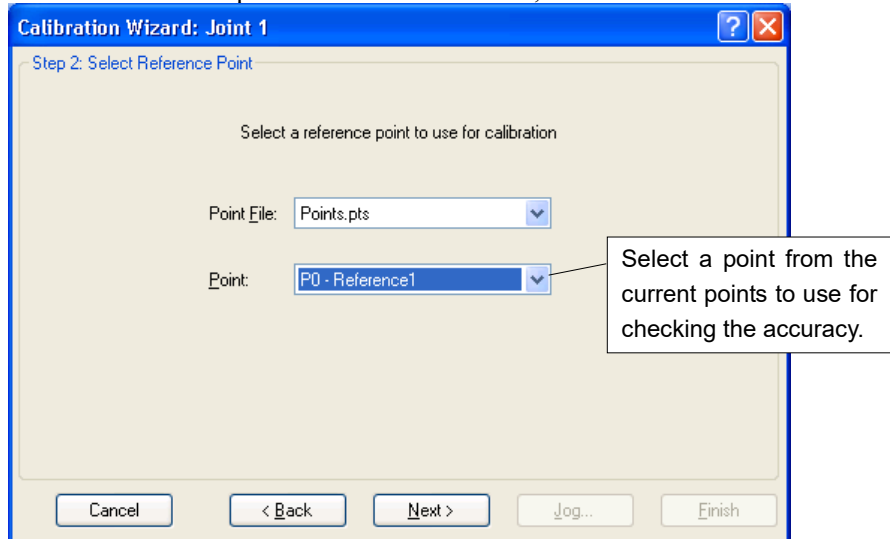


- (5) Reboot the Controller.

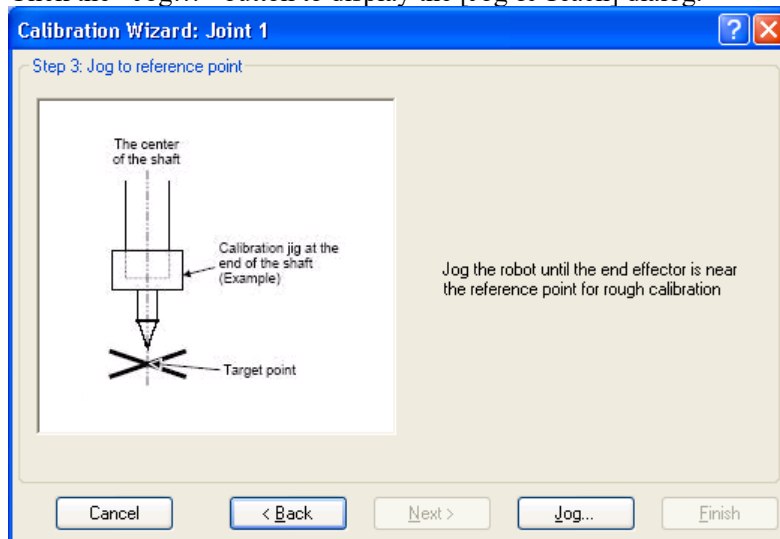


* This window will disappear when the Controller starts up.

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

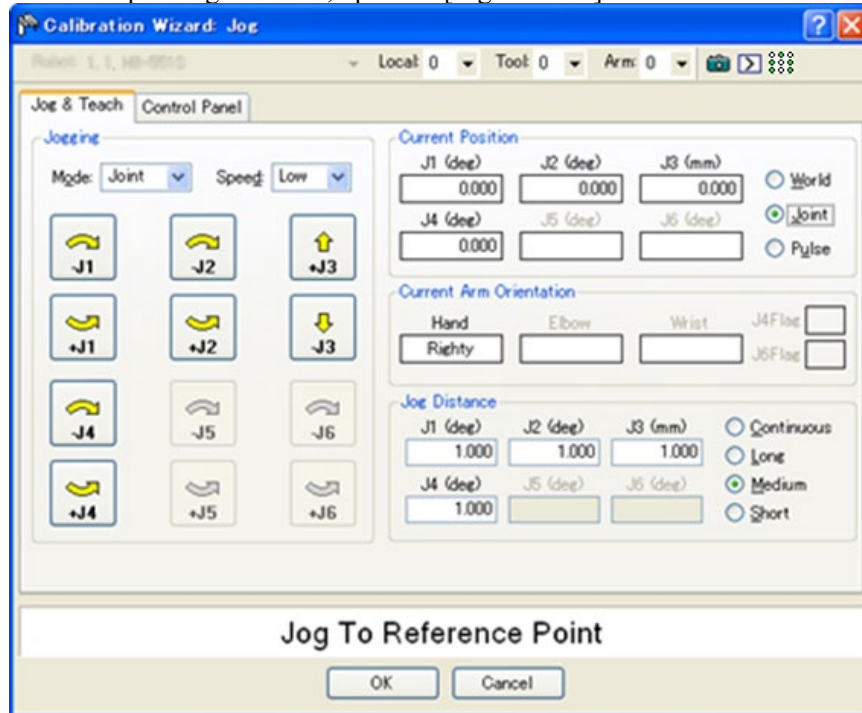


- (7) Click the <Jog...> button to display the [Jog & Teach] dialog.

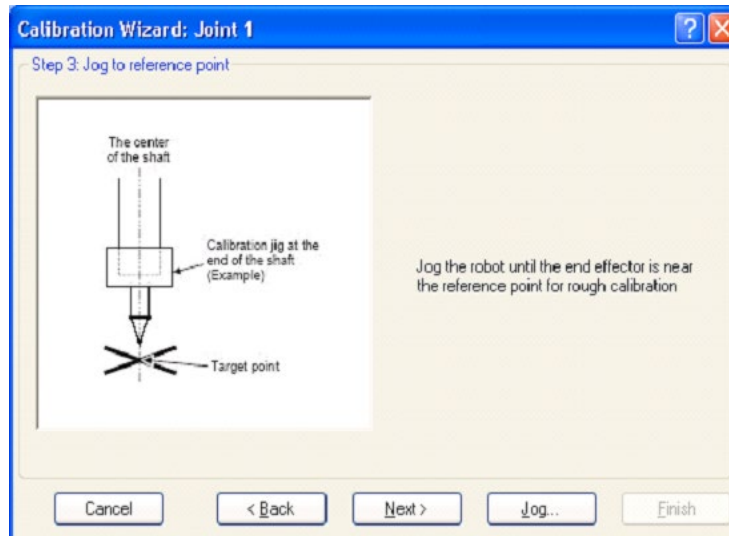


- (8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.

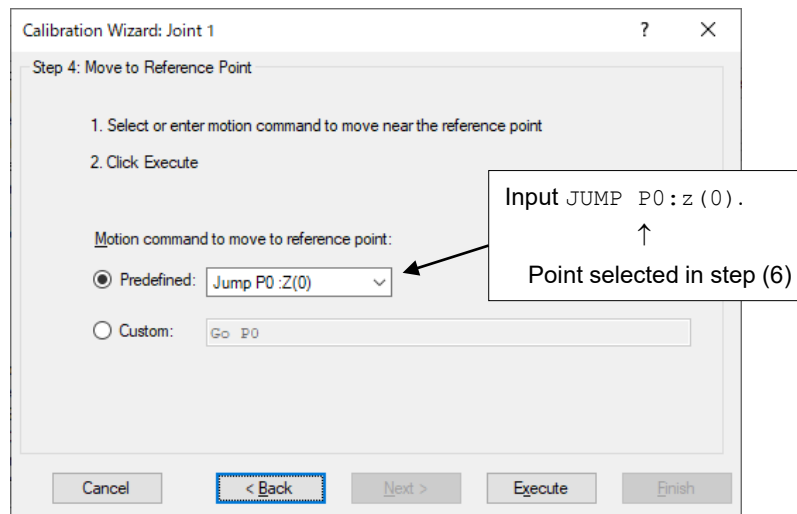
* Before operating the robot, open the [Jog & Teach] tab and execute <Motor ON>.



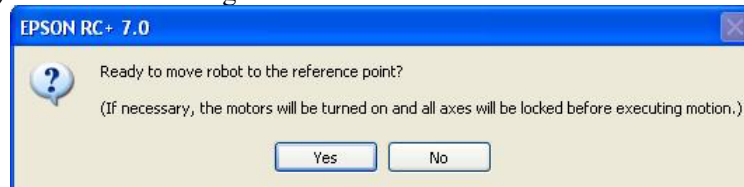
- (9) Click the <Next> button.



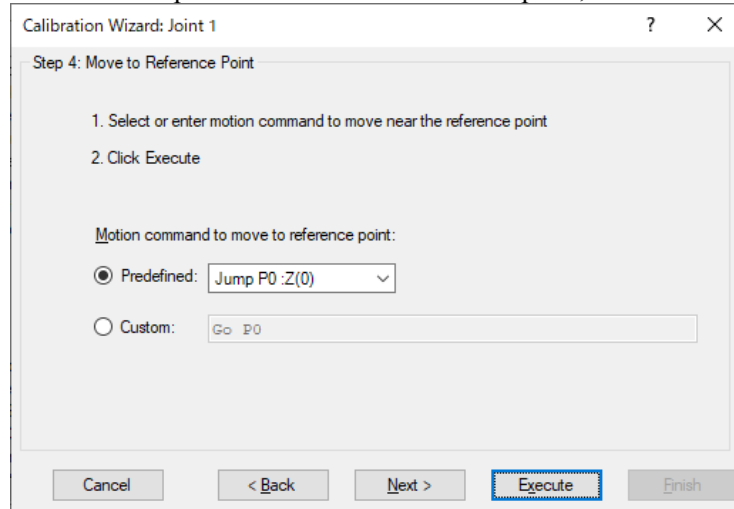
(10) The manipulator moves to the reference point. Click the <Execute> button.



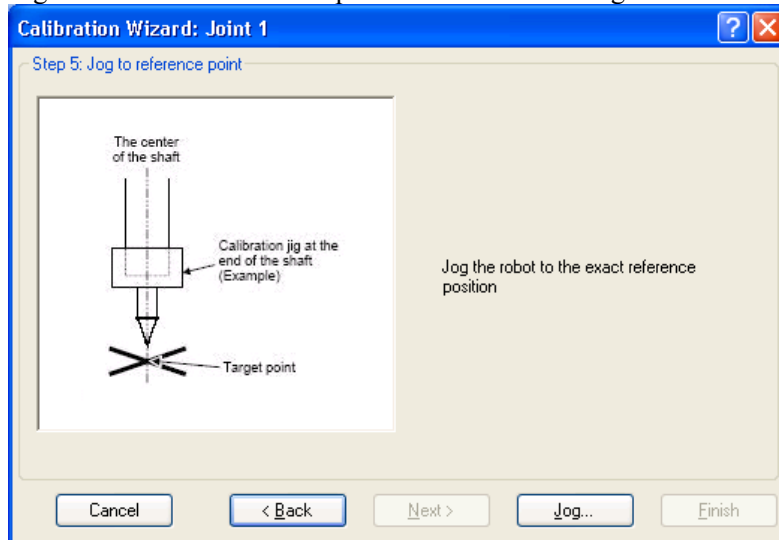
(11) Confirm the message and click the <Yes> button.



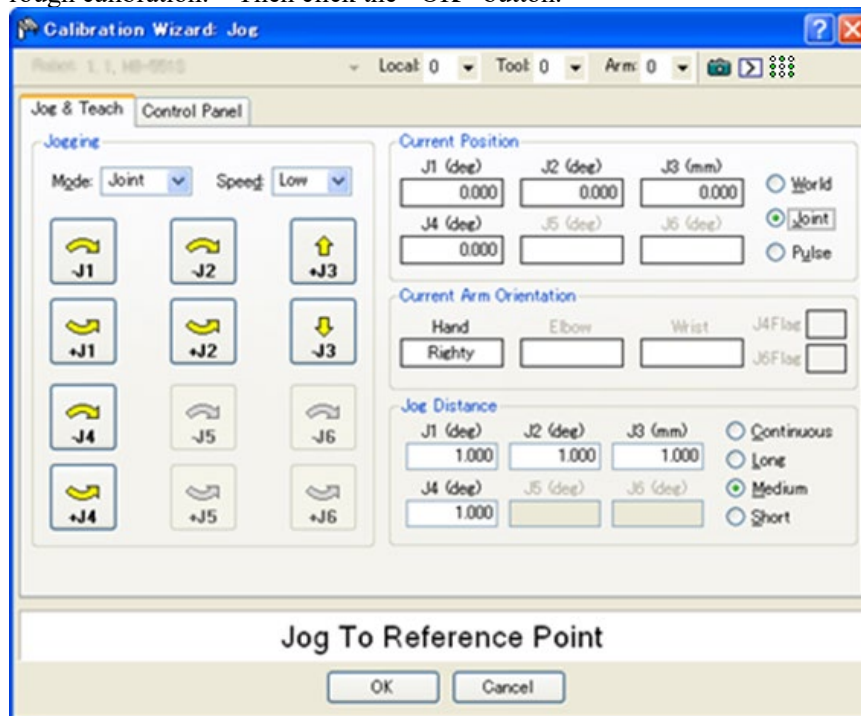
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position. Click the <Jog> button.

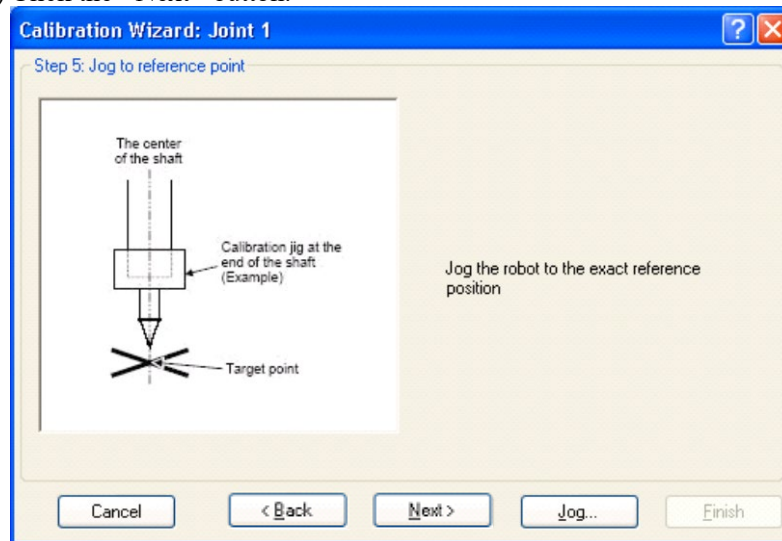


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



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

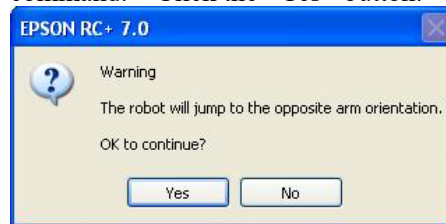
(15) Click the <Next> button.



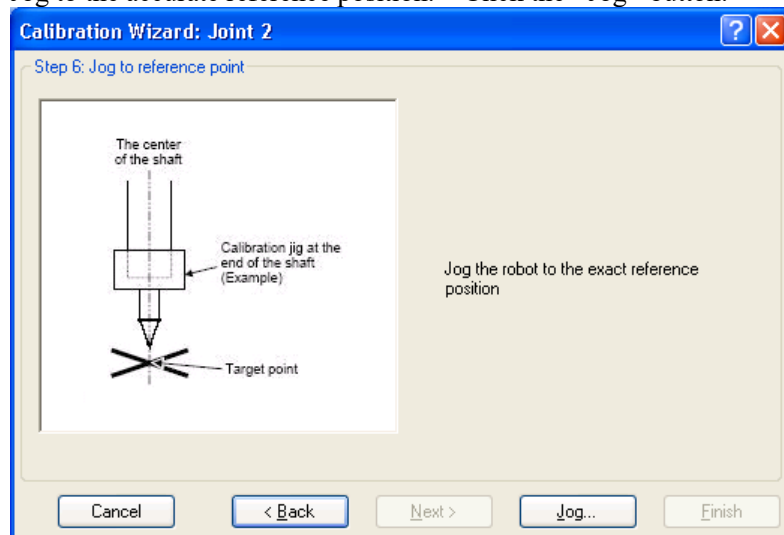
(16) Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2 only.

* Go on to the step (19) for the other joints calibration.

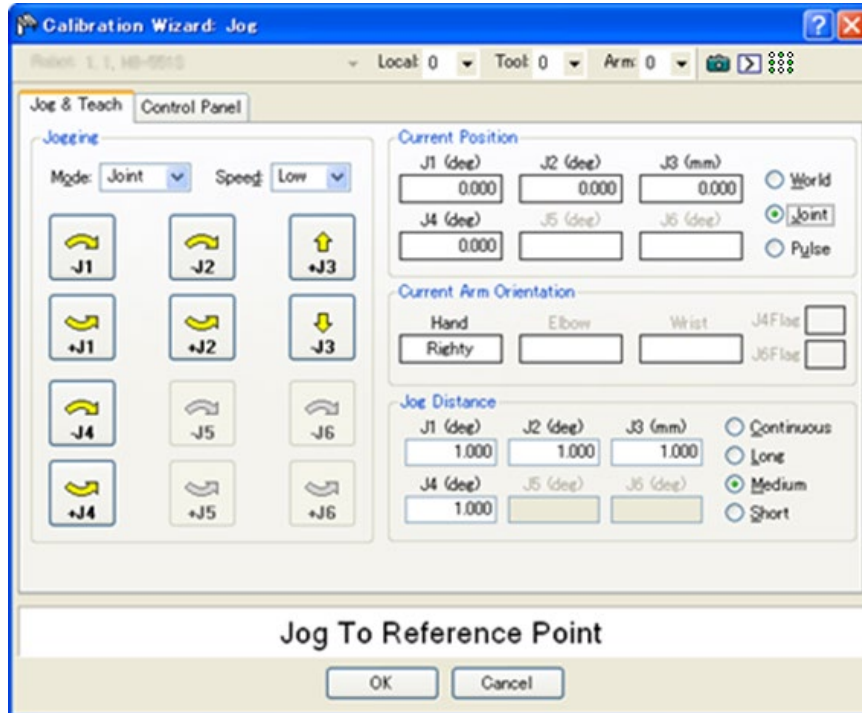
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



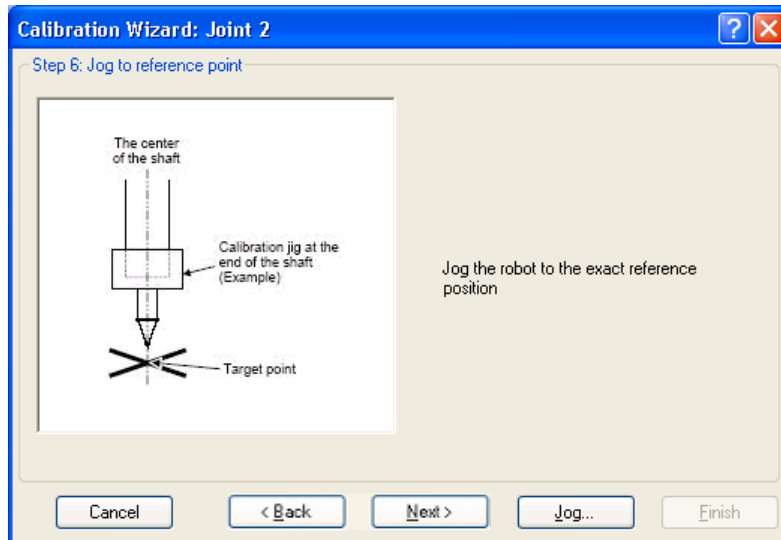
ii. Jog to the accurate reference position. Click the <Jog> button.



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.



(18) Move the manipulator to other points and check if it can move without problems.
Teach points where appropriate.

14.3 Accurate Calibration of Joint #2

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

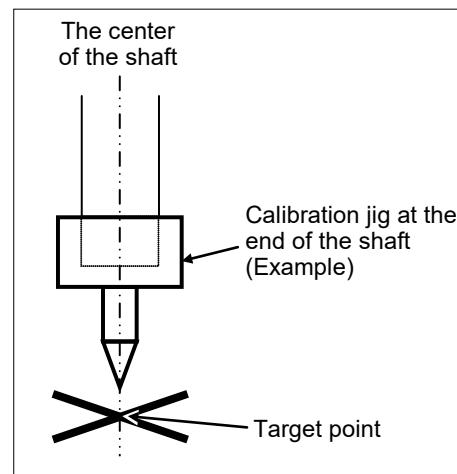
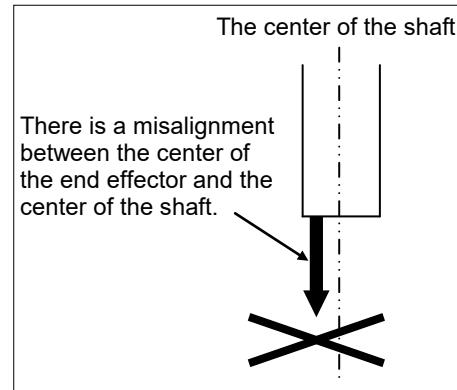
NOTE IF the calibration of Joint #2 is performed in *14.2 Calibration Procedure*, configure “Calibration Using Right / Left Arm Orientations” by the wizard.

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

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

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

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



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

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

- Teaching the working point by entering the coordinate values (MDI teaching)
- Switching the arm orientation between right and left at a given point
- Using the 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 the [Tools] menu - [Robot Manager] - [Control Panel] and click the MOTOR ON.
- (3) Click the <Free All> button in the [Control Panel] to free all joints. 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 point is now called P1.

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

- (6) Click the <Lock All> button in the [Control Panel] to lock all joints.
- (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> button 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 point is now called P2.

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

- (9) Input the new Hof's value.

```
>Hofs Hof's (1), Hof's (2) + (Ppls(P1,2) + Ppls(P2,2)) /
    2, Hof's (3), Hof's (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 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> button 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.

14.4 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 *14.2 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 *14.3 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.

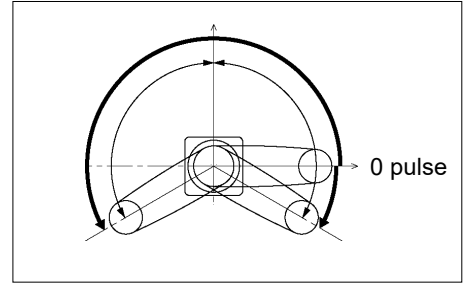
Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

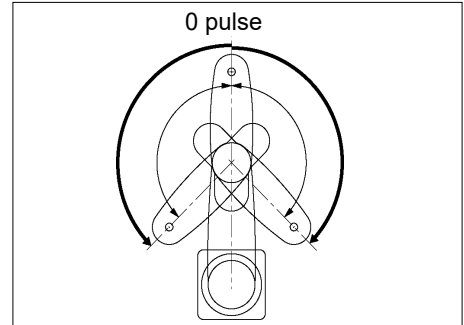
(3)-1 Turn ON the Controller when all joints are in the motion range.

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

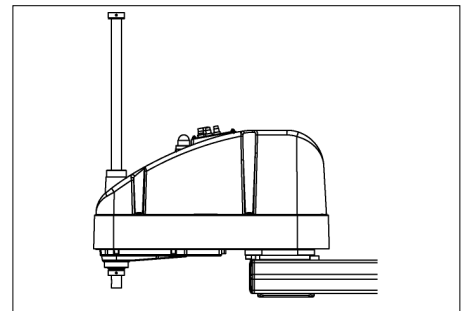
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



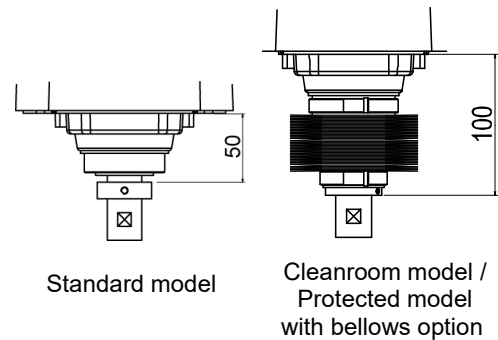
0 pulse position of Joint #2:
position where Arms #1 and #2
are in a straight line
(Regardless of the Joint #1
direction.)



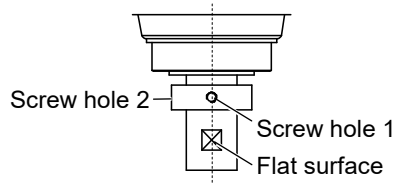
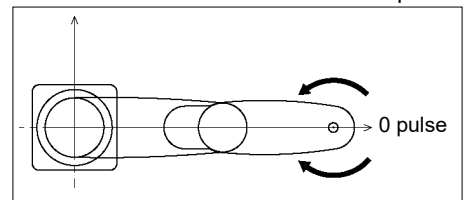
0 pulse position of Joint #3:
upper limit position in motion
range



The height of Joint #3 depends
on manipulator model.



0 pulse position of Joint #4:
position where the flat surface
(or screw hole 1) on the shaft
faces toward the tip of Arm #2



Screw hole 1 and flat surface are located
in the center of the shaft.

Screw hole 1 and 2 are located at right
angles to one another.

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

Select the robot to be calibrated. Input as below in the [Command Window] and execute.

(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

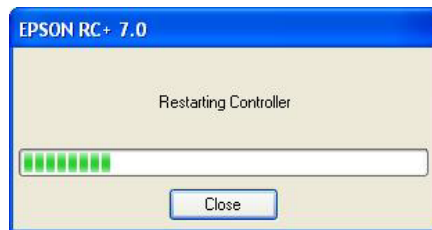
Joint #2: >EncReset 2

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 disappear 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 in the [Control Panel] to free all joints. 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.

15. G10/G20 Maintenance Parts List

15.1 Common Parts

Part Name		Code	Old Code	Note	Reference	Overhaul *4	
AC Servo Motor	Joint #1	1499527	R13B000610	750 W	5.1	✓	
		1546181	R13B000624	750 W (For S/N: 1**** or later)			
	Joint #2	1499528	R13B000611	600 W	6.1	✓	
		1546180	R13B000623	600 W (For S/N: 1**** or later)			
	Joint #3	1497624	R13B000607	400 W	7.1	✓	
		1514468	R13B000616	400 W (For S/N: 1**** or later)			
	Joint #4	G10	1499529	R13B000612	150 W	8.1.1	✓
			1533638	R13B000618	150 W (For S/N: 1**** or later)		
		G20	1499530	R13B000613	150 W with brake	8.1.2	✓
			1546182	R13B000625	150 W with brake (For S/N: 1**** or later)		
Reduction Gear Unit	Joint #1	1489327	R13B010013		5.2	✓	
	Joint #2	1489326	R13B010014		6.2	✓	
	Joint #2	1525071	R13B010028	(For G10-65****/G10-85**** S/N: 1**** or later)			
	Joint #4	G10	1499535	R13B031601		8.4.1	✓
		G20	1493783	R13B010015		8.4.2	✓
Electromagnetic Brake	Z axis	1499588	R13B030503		7.3	✓	
	U axis	1497639	R13B030501	G10 only *1	8.3	✓	
Timing Belt	Joint #3	G10	1489329	R13B030209	Z : width 12 mm	7.2.1	✓
		G20	1493781	R13B030211	Z : width 12 mm	7.2.2	✓
	Joint #4	G10	1489330	R13B030210	U1 : width 15 mm	8.2.1	✓
		G20	1493784	R13B030212	U1 : width 20 mm	8.2.2	✓

*1 Common with G6 series

*4 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 2.2 Overhaul (Parts Replacement).

Part Name	Code	Old Code	Note	Reference
Battery Board	2120180	R13B041202	With lithium battery Installed in Arm #2 ER17330V (TOSHIBA)	11.2
Battery Unit	2117879	R13ZA00600300	Spare lithium battery *2 ER17330V (TOSHIBA)	11.1
O-ring	1489339	R13B031228	For Motor flange of Joint #1	5.1
LED Lamp	2077258	R13A030000200	*3	12
Grease *5	Ball Screw Spline: AFB *3	-	For purchasing the grease, please contact the supplier of your region.	10.1
	Reduction Gear Unit: SK-1A *3	-		2.3
	Cables: GPL-224	-		4.1
Radiating Unit	1546193	R13B031906	For G10-65*** only	13
Heat Sink	1529403	R13B031907		
Radiating Sheet	1529402	R13B031908		

*2 Common with E2C *3 Common with E2 series

*5 Regarding purchase of grease

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase grease required for maintenance from the manufacturers listed in the table below as of April 2015. Regarding purchase of grease, please contact the following manufacturers. If there is anything unclear, please contact our supplier of your region.

Product name	Manufacturer	URL
THK AFB-LF Grease	THK CO., LTD.	https://www.thk.com/
Harmonic Grease SK-1A	Harmonic Drive Systems Inc.	https://www.harmonicdrive.net/
Krytox®GPL-224	Chemours	https://www.chemours.com/en/brands-and-products

Reduction Gear Unit

A reduction gear unit consists of the following three parts (for Joint #1 and Joint #2). When replacing the reduction gear unit, be sure to always replace the waveform generator, flexspline, and circular spline all together as one set.

Waveform generator

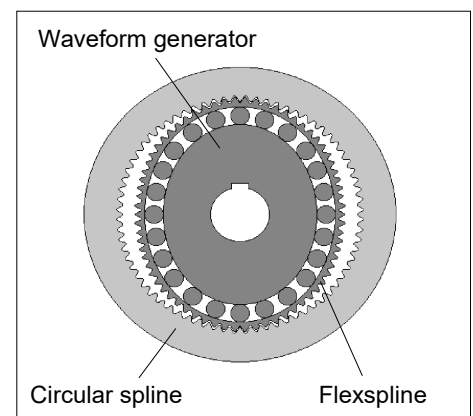
This waveform generator consists of an ellipsoidal cam with ball bearings on its outer circumference. The inner ring of bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.

Flexspline

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

Circular spline

A rigid, ring-shaped body with gear teeth on the inner circumference. The circular spline has two more teeth than the flexspline does.



The splines are greased. Be sure to keep the grease from being attaching to the clothes.

15.2 Parts by Environment Model

(S: Standard-model C: Cleanroom-model D, P: Protected-model)

Part Name			Code	Old Code	Note	Reference	Overhaul *4
Ball Screw Spline	For G10	S, D (without bellows)	180 mm	1499537	R13B010208	10.2.1	✓
			420 mm	1499538	R13B010209		
		C	150 mm	1499575	R13B010210		
			390 mm	1499576	R13B010211		
		P, D with bellows option	150 mm	1499577	R13B010212		
			390 mm	1499578	R13B010213		
	For G20	S, D (without bellows)	180 mm	1499579	R13B010214	10.2.2	✓
			420 mm	1499580	R13B010215		
		C	150 mm	1499584	R13B010216		
			390 mm	1499585	R13B010217		
		P, D with bellows option	150 mm	1499586	R13B010218		
			390 mm	1499587	R13B010219		
Cable Unit	S, C	650 mm	1563046	R13B020033	Inner wiring cable	4	
		850 mm	1499531	R13B020018			
		1000 mm	1499532	R13B020019			
	P, D	650 mm	1563047	R13B020034			
		850 mm	1499533	R13B020020			
		1000 mm	1499534	R13B020021			
M/C Cable	S, C	3 m	For RC180	R12NZ90026	R12B020425	*1	4.3
			For RC700-A, Straight	R12NZ900JX	—		
			For RC700-A, L-shaped	R12NZ900K1	—		
		5 m	For RC180	R12NZ90027	R12B020426		
			For RC700-A, Straight	R12NZ900JY	—		
			For RC700-A, L-shaped	R12NZ900K2	—		
		10 m	For RC180	R12NZ90028	R12B020427		
			For RC700-A, Straight	R12NZ900JZ	—		
			For RC700-A, L-shaped	R12NZ900K3	—		

Part Name			Code	Old Code	Note	Reference	Overhaul *4
M/C Cable	S, C	15 m	For RC700-A, Straight	R12NZ900XY	—	*1	4.3
			For RC700-A, L-shaped	R12NZ900Y1	—		
	20 m	For RC700-A, Straight	R12NZ900XZ	—			
		For RC700-A, L-shaped	R12NZ900Y2	—			
M/C Cable	P, D	3 m	For RC180	R12NZ90029	R12B020428	*1	4.3
			For RC700-A, Straight	R12NZ900K4	—		
			For RC700-A, L-shaped	R12NZ900K7	—		
		5 m	For RC180	R12NZ9002A	R12B020429		
			For RC700-A, Straight	R12NZ900K5	—		
			For RC700-A, L-shaped	R12NZ900K8	—		
		10 m	For RC180	R12NZ9002B	R12B020430		
			For RC700-A, Straight	R12NZ900K6	—		
			For RC700-A, L-shaped	R12NZ900K9	—		
		15 m	For RC700-A, Straight	R12NZ900Y3	—		
			For RC700-A, L-shaped	R12NZ900Y5	—		
		20 m	For RC700-A, Straight	R12NZ900Y4	—		
			For RC700-A, L-shaped	R12NZ900Y6	—		
		Arm Cover	S, D		1499589		
C, P			1499590	R13B030414	Plating		
Bellows	C, P, D with bellows option	150 mm	1497641	R13B030701	*1 *5	9	
		390 mm	1499591	R13B030703	*5		
Gasket Unit	D, P		1499592	R13B031231		2.6	
Arm #2 Gasket	P		1499593	R13B031232		-	
Brake Release Switch	S, C		2117817	R13Z702640 100	*3	-	
	P, D		1497647	R13B060902	*1	-	

*1 Common with G6 series

*3 Common with E2 series

*4 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 2.2 *Overhaul (Parts Replacement)*.

*5 The bellows are provided in a unit of two pieces. The shape varies between the upper and lower bellows.

