EPSON

SCARA ROBOT

LS-B series

MAINTENANCE MANUAL

Rev.3 EM221R5166F

SCARA ROBOT

LS-B series Maintenance Manual

Rev.3

FOREWORD

Thank you for purchasing our robot products.
This manual contains the information necessary for the correct use of the manipulator.
Please carefully read this manual and other related manuals before installing the robot system.
Keep this manual handy for easy access at all times.

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 safety 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 LS-B series Manipulators can be used with the following combinations of Controllers and software.

LS3-B series
- Controller : RC90-B
- Software : LS3-B: EPSON RC+ 7.0 Ver.7.4.4 or later
  LS3-B401S-V1*: EPSON RC+ 7.0 Ver.7.5.1B or later
  * LS3-B401S-V1 is high speed model manipulator of LS3-B401S This manual describes information on LS3-B401S-V1 which is different from LS3-B401S.

LS6-B series
- Controller : RC90-B
- Software : LS6-B: EPSON RC+ 7.0 Ver.7.4.3 or later
  LS6-B602S-V1*: EPSON RC+ 7.0 Ver.7.5.0 R3 or later
  * LS6-B602S-V1 is high speed model manipulator of LS6-B602S. This manual describes information on LS6-B602S-V1 which is different from LS6-B602S.

LS10-B series
- Controller : RC90-B
- Software : EPSON RC+ 7.0 Ver.7.4.2 or later

LS20-B series
- Controller : RC90-B
- Software : EPSON RC+ 7.0 Ver.7.4.5 or later

Turning ON/OFF Controller

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

Shape of Motors

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

Setting by Using Software

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

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.

Pictures in this Manual

Pictures and illustrations of the manipulator in this manual may differ from using manipulator depending on the shipment date and the specifications.

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

RC90 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

LS-B 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.

RC90 series Maintenance Manual (PDF)
LS-B series Maintenance Manual (PDF) (This book)

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 Manual)

This manual describes general information about program development software.

EPSON RC+ 7.0 SPEL+ Language Reference (PDF Manual)

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

Other Manual (PDF Manual)

Manuals for each option are available.

LS3-B, LS6-B Maintenance

LS10-B Maintenance

LS20-B Maintenance

LS3-B LS6-B 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 routine maintenance.

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

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

 WARNING	■ To shut off power to the robot system, 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	■ 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	LS3-B: Break for arm #3 LS6-B: Break for arm #3 to #4	√	√	√	√	√
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, if 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 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

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.

RC90 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].

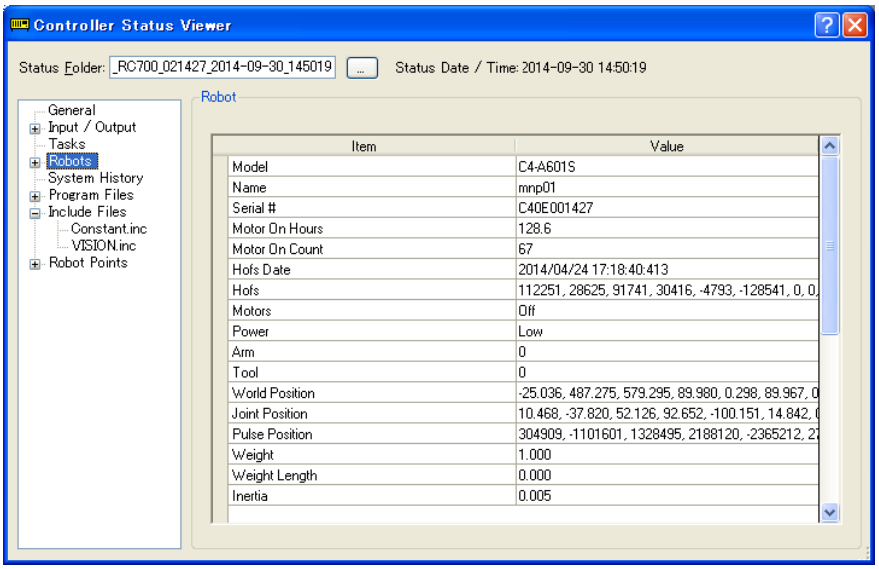
(1) Select EPSON RC+ menu-[Tools]-[Controller] to open the [Controller Tools] dialog.

(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.



For the parts subject to overhaul, refer to *14. 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	■ 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	■ If grease gets into your eyes, mouth, or on your skin, follow the instructions below. If grease gets into your eyes : Flush them thoroughly with clean water, and then see a doctor immediately. If grease gets into your mouth : If swallowed, do not induce vomiting. See a doctor immediately. : If grease just gets into your mouth, wash out your mouth with water thoroughly. If grease gets on your skin : Wash the area thoroughly with soap and water.

	Greasing part	Greasing Interval	Grease	Reference
Joint #1	Reduction gear units	Overhaul timing	SK-1A	*5 Joint #1*
Joint #2			LS3-B: SK-2 LS6-B: SK-1A	*6 Joint #2*
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 usage condition and degree of the load (such as when operated with the maximum motion speed and maximum acceleration / deceleration in continuous operation) applied on the Manipulator.

Joint #3 Ball screw spline unit

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

Normal grease

Discolored grease

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

NOTE

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.
RC90 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	

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 its lower limit in one of the following methods.

- Move the shaft to its lower limit manually while pressing the brake release switch.
- Move the shaft to its lower limit from EPSON RC+ 7.0 [Tools]-[Robot Manager]-[Jog & Teach].

NOTE Make sure that the hand does not interfere with peripheral equipment.

LS3-B: 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 and rotating while the brake release switch is being pressed because the shaft may be lowered by the weight of the end effector.

LS6-B: The brake release switch affects both Joints #3 and #4. When the brake release switch is pressed in emergency mode, the brakes for both Joints #3 and #4 are released. 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.

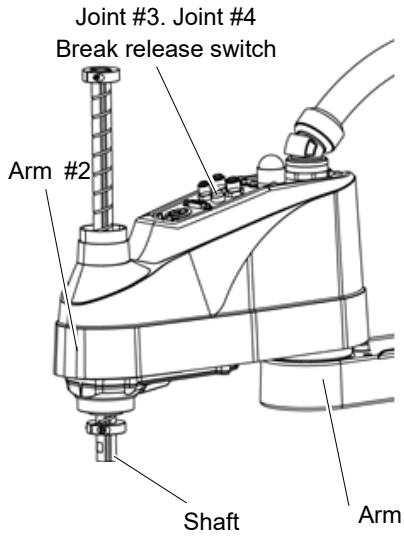
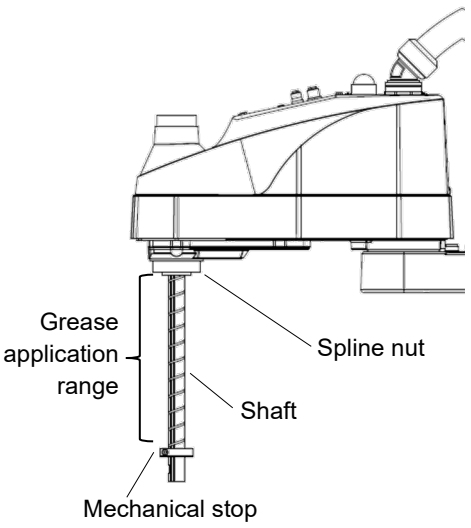


Figure: LS6-B

(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.



(Figure: LS6-B)

(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.


Grease application example

(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.

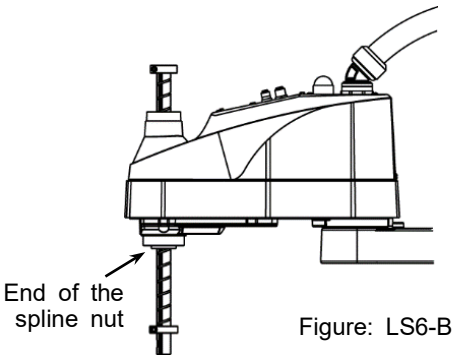


Figure: LS6-B

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.

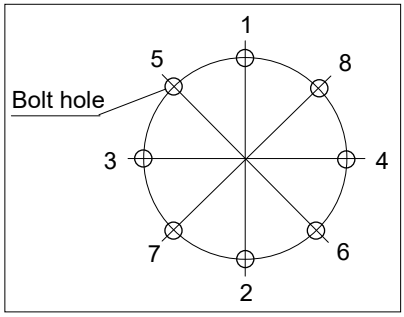
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

Bolt	Tightening Torque
M2.5	1.4 ± 0.1 N·m (14 ± 1 kgf·cm)
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.

Bolt	Tightening Torque
M3	0.7 ± 0.1 N·m (7.1 ± 1 kgf·cm)
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+

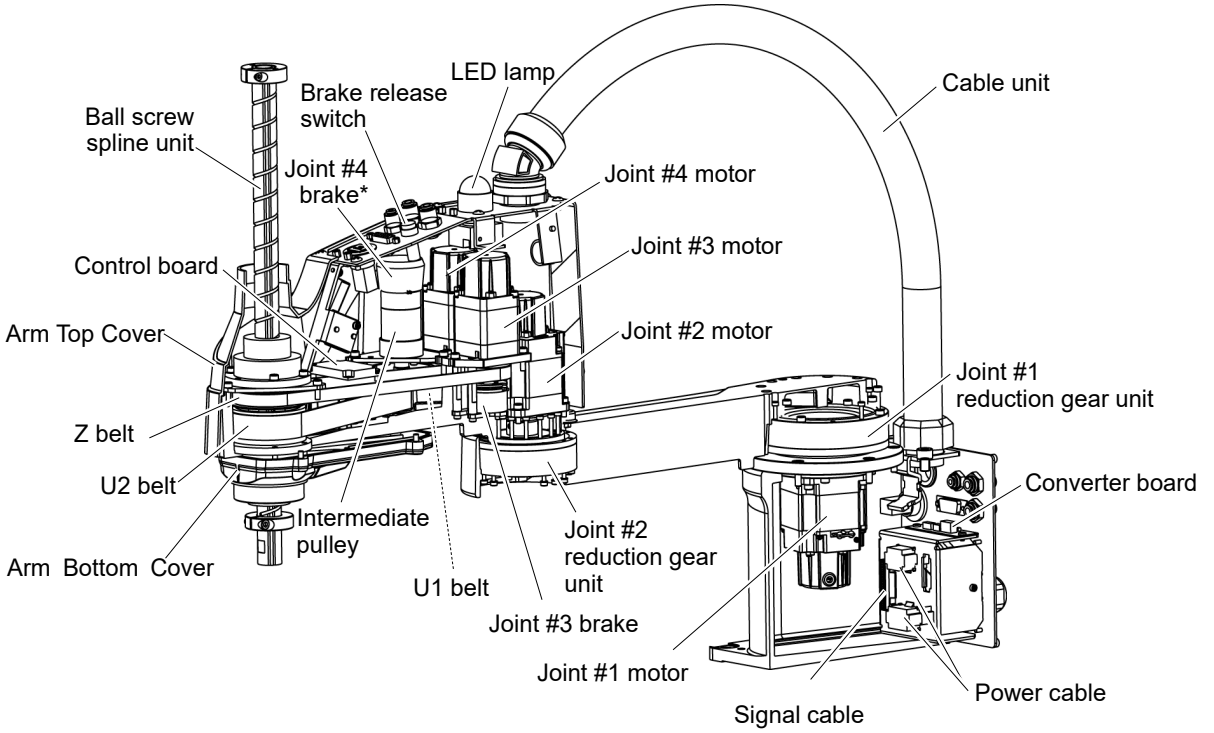
Execute the following command from the [Command Window].

```
>PULSE
```

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

2.6 Layout of Maintenance Parts

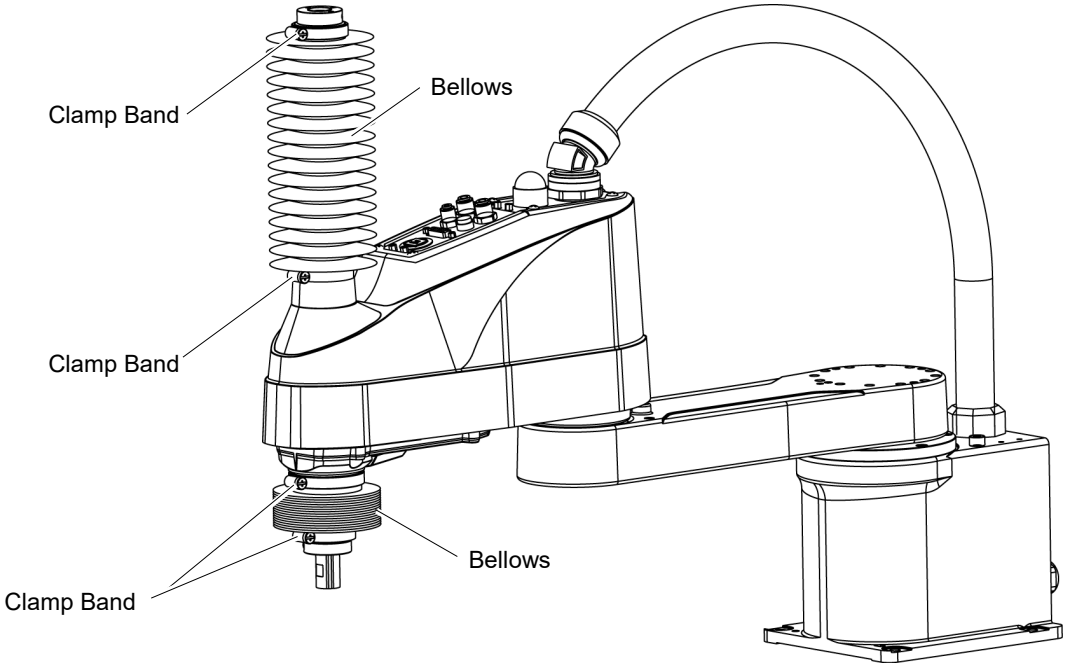
Standard-model



*: Joint #4 brake (LS6-B only)

Cleanroom-model (with optional bellows)

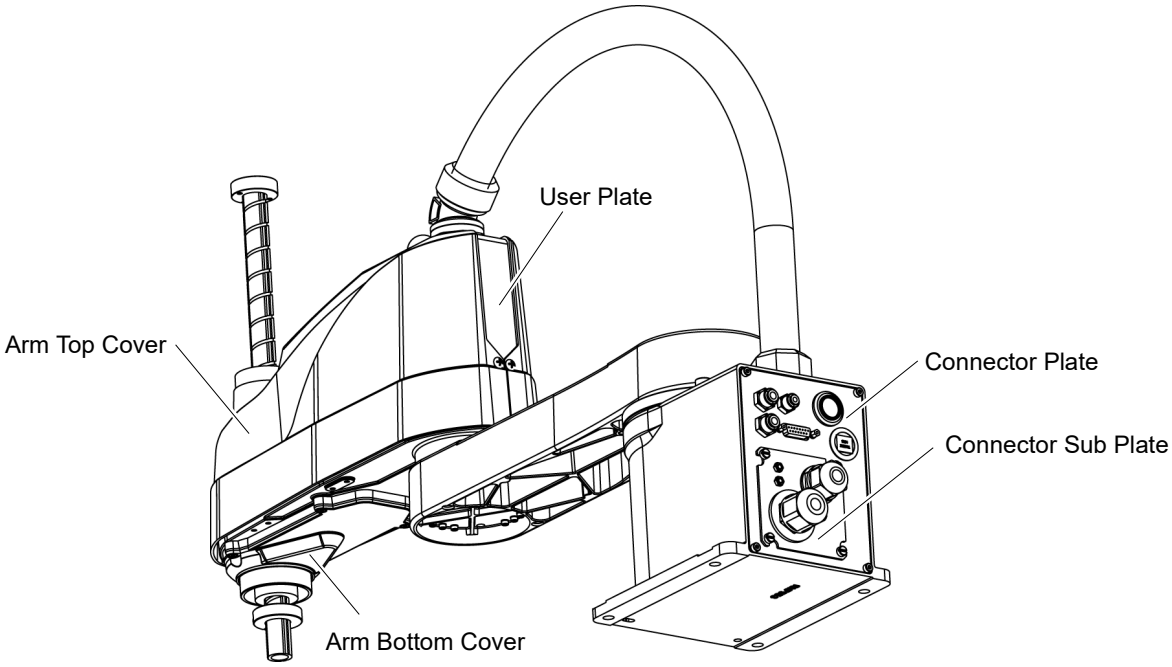
For the Cleanroom-model, the following parts are added to the Standard-model.



3. Covers

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

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. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



3.1 Arm Top Cover

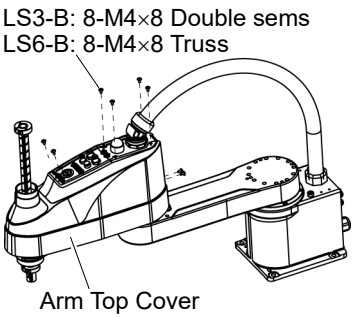
CAUTION	■ Do not remove the arm top cover forcibly. Removing the cover forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.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

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*.

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



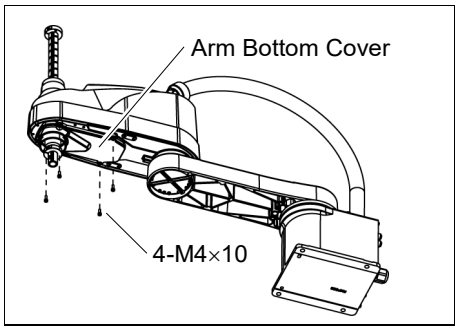
Arm Top Cover Installation

Put the arm top cover to the arm and secure with the Arm Top Cover mounting bolts.
After securing the Arm Top Cover, make sure that the lower limit mechanical stop is not touching the cylindrical part of the Arm Top Cover.

NOTE ☞ When bellows are installed to the manipulator, install the Arm Top Cover and then set the upper bellows. For bellows installation, refer to *9. Bellows*.

3.2 Arm Bottom Cover

Unscrew the Arm Bottom Cover mounting bolts and then remove the cover.



NOTE

Be careful of the end effector. When the end effector is installed, the Arm Bottom Cover may not be removed from the shaft.

When you replace the ball screw spline unit, you need to remove the end effector to remove the Arm Bottom Cover completely.

When you can work (maintenance, inspection) without removing the cover completely, move the shaft to the lower limit and lower the Arm Bottom Cover.

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*.

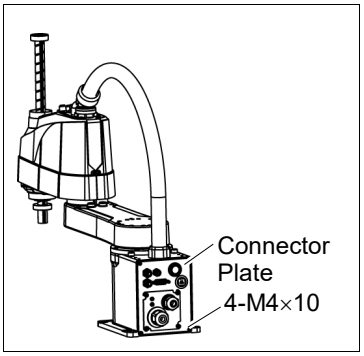
3.3 Connector Plate

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 mounting 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.

NOTE

Unscrew the Connector Plate mounting bolts and remove the plate.

When removing the connector plate, remove it slowly so that the cables will not get damaged.

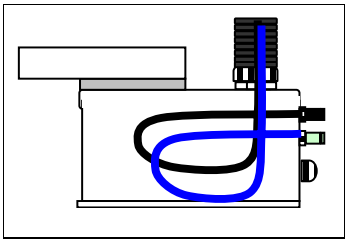


NOTE

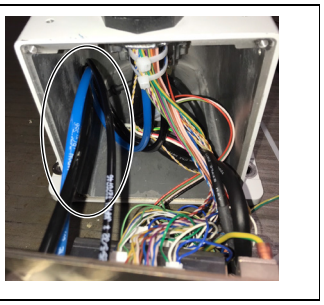
When mounting the Connector Plate, be careful of the following.

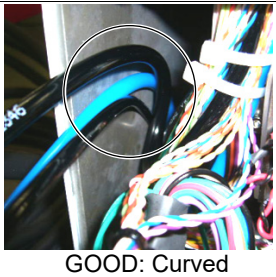
Prevent the air tube from bending sharply inside the manipulator. Also, do not block the air flow.

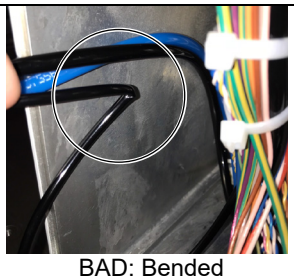
If there is a kink in the air tube, air flow is blocked while the manipulator is operating and may cause a trouble.



Put the air tube along the left side wall as shown in the picture.




GOOD: Curved


BAD: Bended

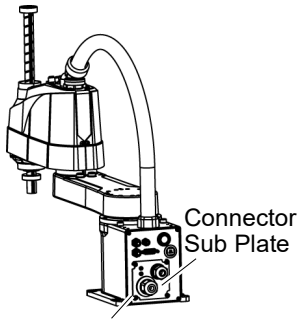
3.4 Connector Sub Plate

CAUTION

- 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 mounting 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.

Refer to
LS-B series Manual – LS3-B LS6-B Manipulator *3.6 Connecting the Cables.*

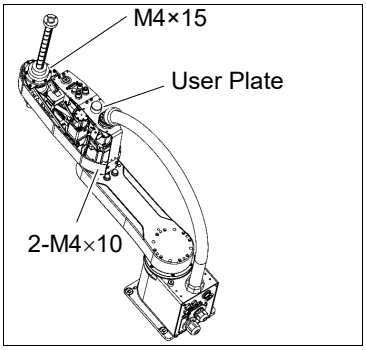


3.5 User Plate

User Plate Removal

(1) Remove the Arm Top Cover.
Refer to *3.1 Arm Top Cover*.

(2) Unscrew the User Plate mounting bolts and remove the plate.



User Plate Installation

(1) Put the User Plate to the arm and secure using the mounting bolts.
(2) Mount the Arm Top Cover.
Refer to *3.1 Arm Top Cover*.

4. Cable

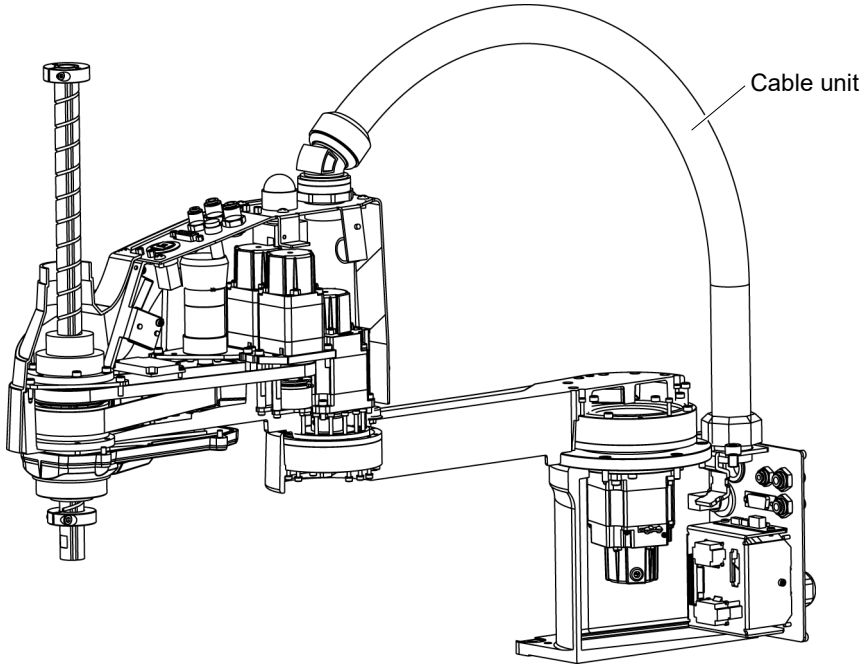
 WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in 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. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

 CAUTION	■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.

4.1 Replacing Cable Unit

NOTE
☞ LS3-B/LS6-B series does not have batteries. Position data is memorized by the motor. When replacing cables, calibration is not necessary.

	Name		Qty.	Note
Maintenance parts	Cable unit		1	LS3-B401* : 2200784 LS6-B502* : 2196931 LS6-B602* : 2196932 LS6-B702* : 2196933
	Cable Protection Sheet		1	Only for LS6-B602S-V1 30×120mm : 1617849 30×150mm : 1622598
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
	Torque wrench		1	
	Nippers		1	For cutting wire tie
Material	Wire tie		-	



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 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. ■ Replace the protection sheet of LS6-B602S-V1 with a new one at the overhaul cycle. If you do not replace the protection sheet, the cable may not be protected by the sheet and may be damaged.

NOTE

LS3-B : 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).

LS6-B : A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

NOTE

LS3-B : The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

LS6-B : The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 Connector Sub Plate from the Connector Plate.

For details, refer to *3.4 Connector Sub Plate*

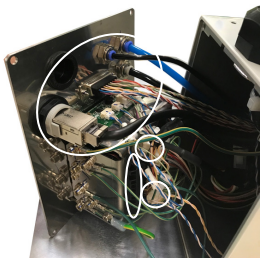
(5) Disconnect M/C cable.

For details, refer to *LS-B series Manual – LS3-B LS6-B Manipulator 3.6 Connecting the Cables - Connect and disconnect M/C cable.*

(6) Remove the Connector Plate.

For details, refer to 3.3 Connector Plate.

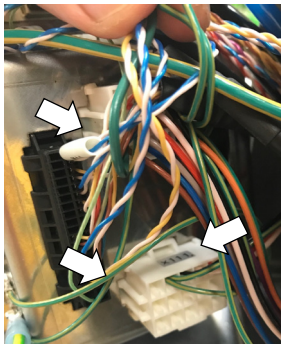
(7) Remove the following that connected to the (inside) of the Connector Plate and Connector Sub Plate.



Air tube
D-sub cable
Ethernet cable (RJ45)
Connectors
: X11, X111, X121, CV11, CV12, CV13

NOTE

For connectors fixed on the mount base, disconnect by holding the clip.



(8) Cut off the two wire ties binding the cables on the base side cable fixing plate.

(9) Remove the seven ground wires that secured on the mount base.

Be careful not to lose the spacer which holding the ground wires.

(10) Cut off the wire tie binding the cables in the Base side.

(11) Remove the Arm Top Cover.

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

(12) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(13) Disconnect 10 connectors on the Arm side.

Connectors: X22, X33,X42, X43, X44, X51, BR, X221, X231, X241

(14) Disconnect the D-sub cable, air tube, and Ethernet cable (RJ45) 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 fittings to pull out the air tube. (ø6×2, ø4×1)
Remember the cable layout for reconnecting the disconnected parts after replacement.

(15) Remove the two ground wires from the User Plate.

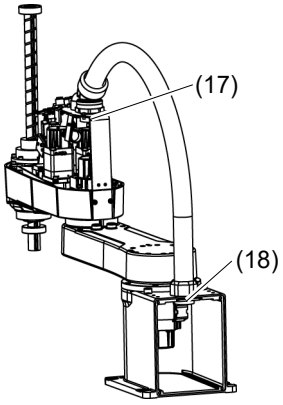
NOTE

Unscrew the cable clamp binding the cables in the Arm side and remove it and protection sheet.

(16) Be careful not to lose the cable clamp, protection sheet, and fixed screws.

(17) The nut secures the cable duct fittings to the User Plate. Rotate the nut to remove it, and pull out the cables from the User Plate.

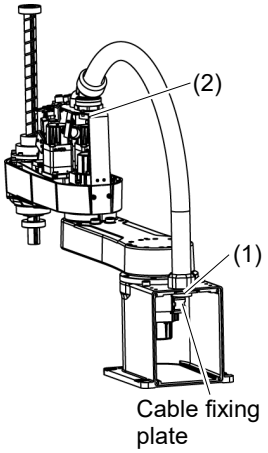
(18) Rotate the cable duct fittings to remove the nut that secures to the Base, and pull out the cables from the Base.



Cable Unit Installation

(1) Pass the new cables through the Base, cable fixing plate, and nut. Then, rotate the fittings to secure the cables.

(2) Pass the cables in the User Plate side through the User Plate and nut and turn the nut to secure the cables.



(3) As with the wire tie cut off at the removal step (8), bind the cables with a new wire tie.

(4) Connect the following to mount base and the Connector Plate.

Air tube, D-sub cable, Ethernet cable (RJ45)
Connectors: X11, X111, X121, CV11, CV12, CV13

(5) Connect the ground wire on the Base side to the mount base.

(6) Connect the air tube, D-sub cable, and Ethernet cable (RJ45) to the User Plate.

(7) Fix the ground wire on the User Plate.

(8) Mount the User Plate.

For the details, refer to *3.5 User Plate*.

(9) Connect the connectors.

Connectors: X22, X33,X42, X43, X44, X51, BR, X221, X231, X241

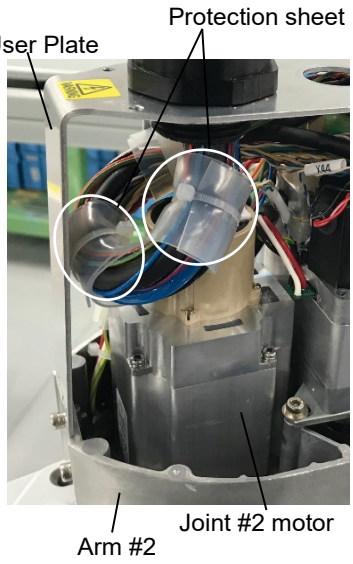
(10) As with the wire tie cut off at the removal step (11), bind the cables with a new wire tie.

Only for LS6-B602S-V1

(10)-1 Wrap the protection sheet around the following locations.

- The part where the cables inside the Manipulator contact the upper part of the joint #2 motor
- The part where the cables inside the Manipulator contact the User Plate

(10)-2 As with the wire tie cut off at the removal step (11), bind the cables with a new wire tie.



NOTE ☞ The protection sheet is provided as a maintenance part. Wrap the sheet around cables without cutting, folding or wrinkles and secure it.

NOTE ☞ When attaching the protection sheet to the cables, secure the end face of the sheet not to rub against the motor cover.

(11) Mount the Connector Plate.

For the details, refer to *3.3 Connector Plate.*

(12) Place and secure the Arm Top Cover without the cables being stuck.

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

Execute the calibration for all joints but the Joint #1.

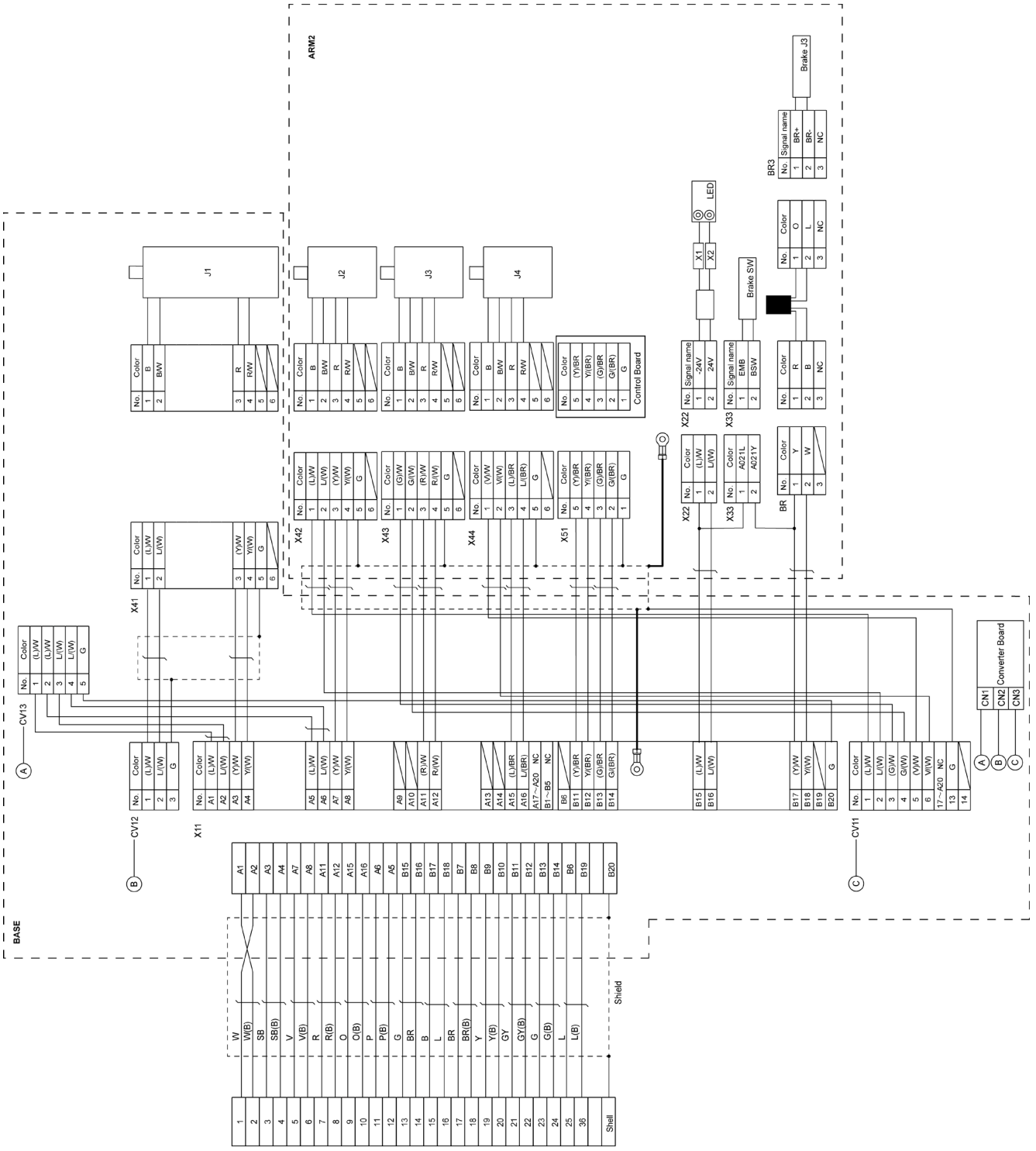
If the connector falls off from the battery board, execute the calibration for all axes.

For details, refer to *13 Calibration*.

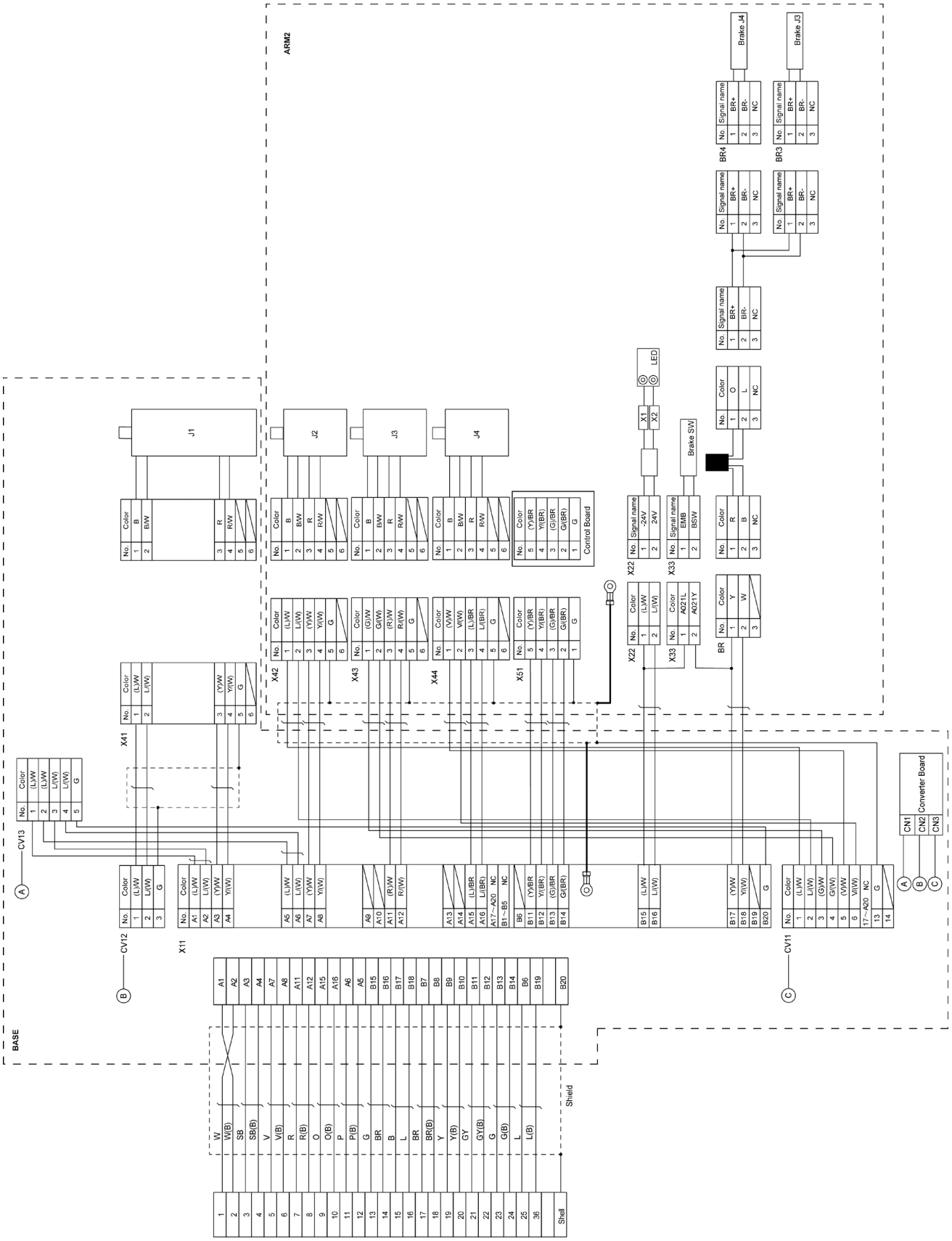
4.2 Wiring Diagrams

4.2.1 Signal Cable

LS3-B

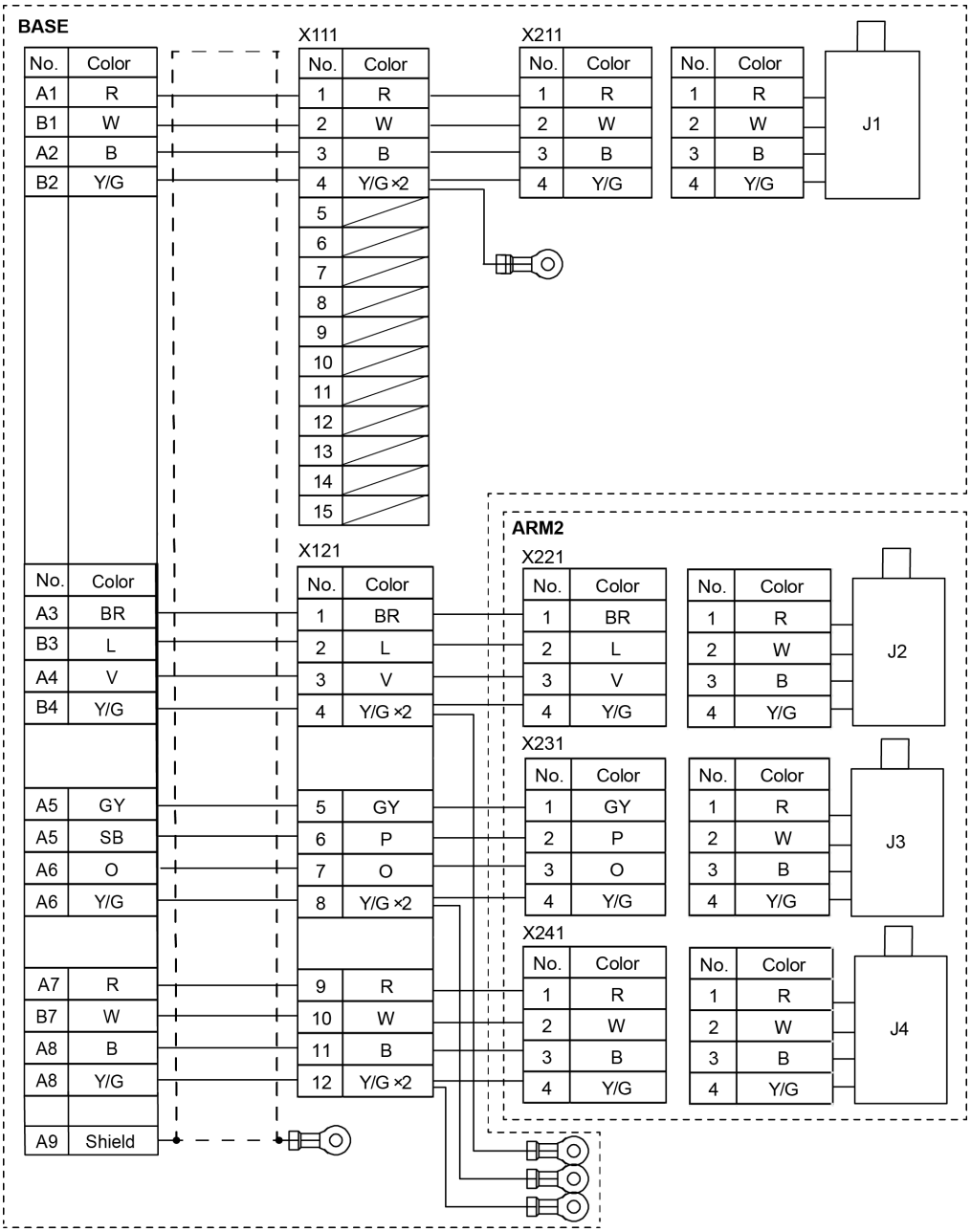


LS6-B


ARM2
BASE
Control Board
Converter Board
CN1
CN2
CN3
Brake J4
Brake J3
Brake SW
LED
J1
J2
J3
J4
X1
X2
X11
X22
X33
X41
X42
X43
X44
X51
BR
BR4
BR3
CV11
CV12
CV13
Shield

4.2.2 Power Cable

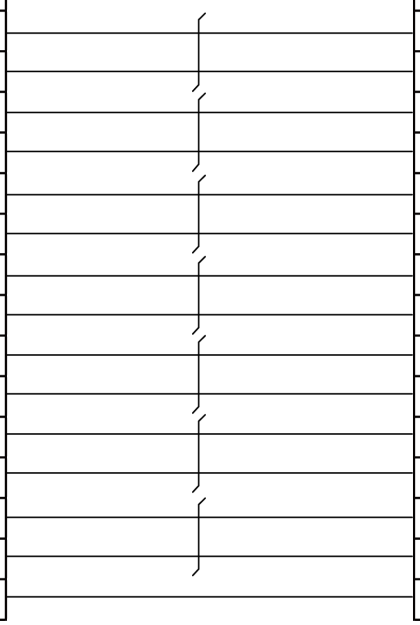
LS3-B/LS6-B



4.2.3 User Cable

LS3-B/LS6-B

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



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

4.2.4 Color of Cables

The following table shows the codes and cable colors indicated in the pin assignments.

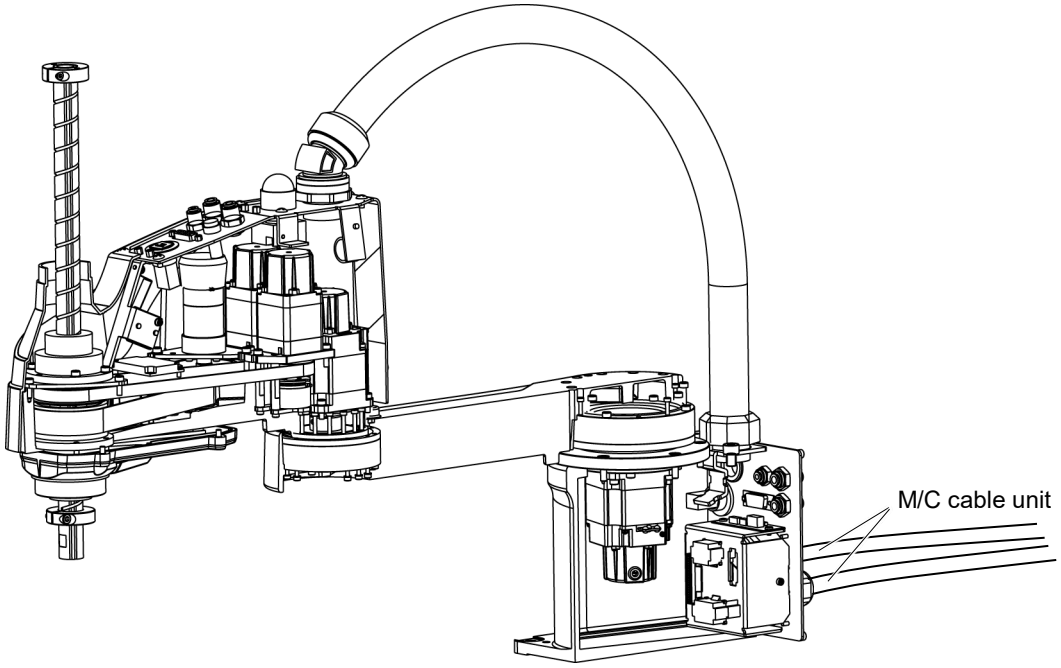
4.2.1 Signal Cable
4.2.2 Power Cable
4.2.3 User Cable

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

4.3 Replacing M/C Cable

NOTE LS3-B/LS6-B series does not have batteries. Position data is memorized by the motor. When replacing cables, calibration is not necessary.

	Name		Qty.	Note
Maintenance parts	M/C cable unit	For fixed wiring	1	3 m: R12NZ9010B 5 m: R12NZ9010C 10 m: R12NZ9010D
		For movable wiring	1	5m: R12NZ90159 10m: R12NZ9015A
Tools	Flathead screwdriver		1	
	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 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.

M/C Cable Removal

(1) Turn OFF the Controller.

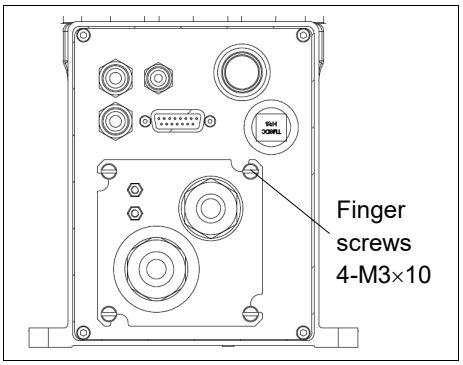
(2) Disconnect the following connectors form the controller.

Power cable connector Signal cable connector

(3) Loosen the screws fixing the plate.

You do not need to remove them completely.

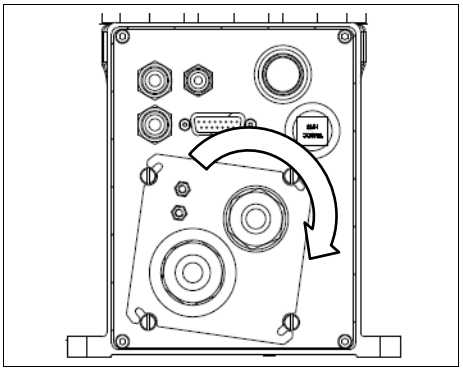
For details, refer to *3.3 Connector Plate*.



NOTE

(4) Slide the plate to remove it from the base.

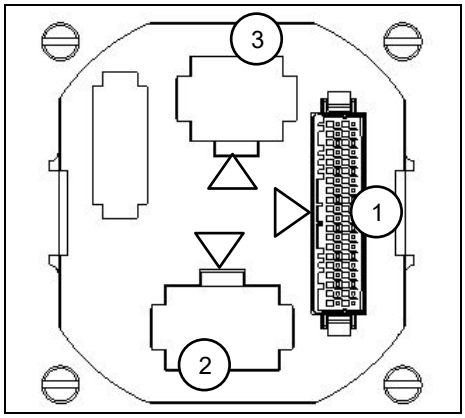
Do not pull the M/C cable unit after removing the plate. M/C cables are connected by the connectors. Doing so may result in disconnection of the cables.



(5) As shown on the right, pull out the cables from the Manipulator.

(6) Disconnect the connectors in the order as shown on the right.

Clips of the connectors are △ positions in the figure.
Push the clip to disconnect the connector.



NOTE

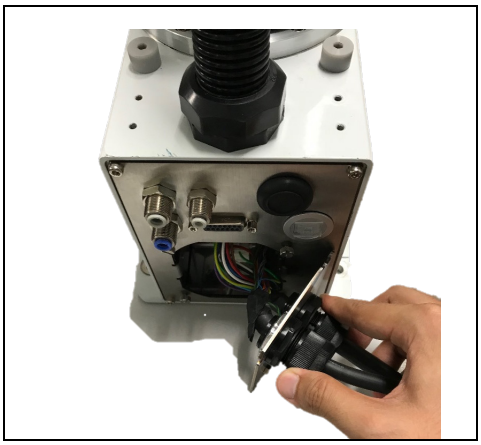
Connector (white) for the power cable is difficult to disconnect for safety purpose.
To disconnect the connector, securely push the clip.
If you cannot disconnect it, push the connector once, and then disconnect it by pushing the clip.

Do not pull the cables. Doing so may result in disconnection.

Do not remove the M/C cable form the plate.

M/C cable Installation

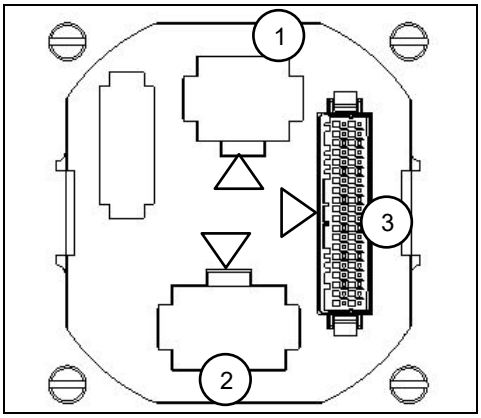
(1) Set the M/C cable as shown on the right.



NOTE

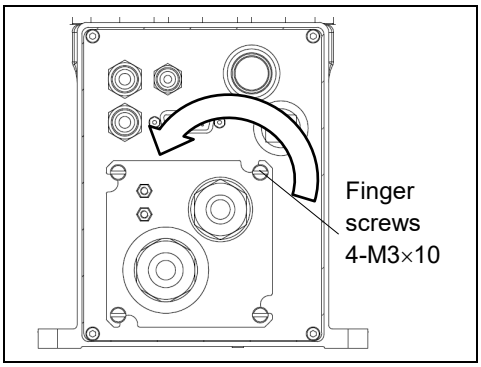
Be careful not to set the plate in wrong direction.

(2) Connect the connectors in the order as shown on the right.



(3) Slide the plate to install it.

Finger screws : 4-M3×10
Tightening torque : 0.6±0.1 N·m



NOTE

Slide the plate until it will be parallel to the base table.

Be careful not to tighten the screws with the cables get caught on the plate.

(4) Connect the following connectors to the controller.

Power cable connector Signal cable connector

(5) Turn ON the Controller.

Direction of the connector sub plate

When installing the plate, be careful for the direction.
Correct direction: When the arrow of warning label of electric shock is the same direction as the illustration on the right.
If the plate is installed in wrong direction, the cables inside the Manipulator will be twisted and may result in disconnection.

Correct: Cables are not twisted

Wrong: Cables are twisted

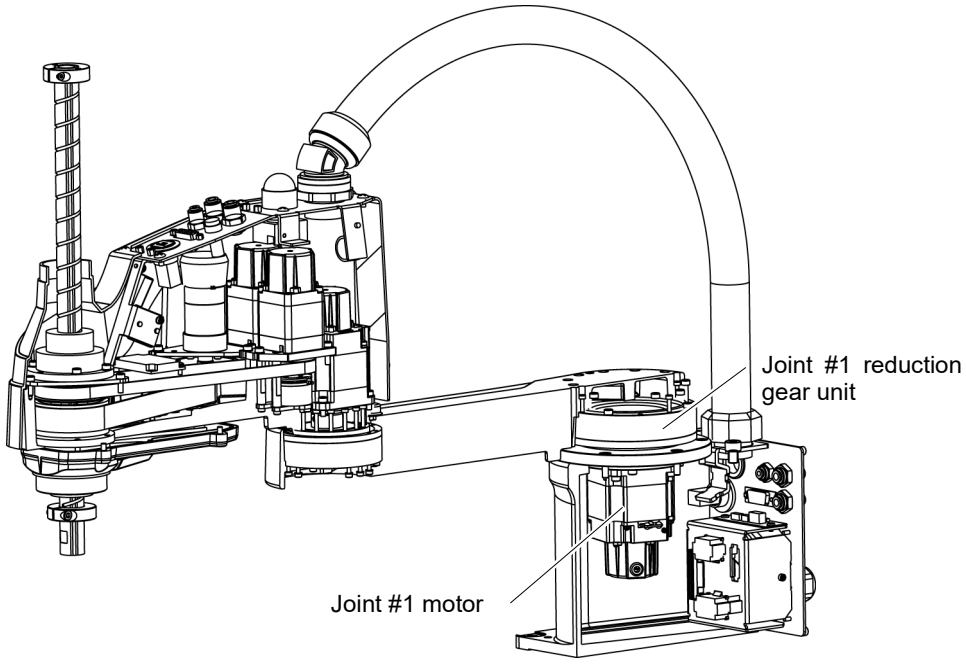
5. Joint #1

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.

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



5.1 Replacing Joint #1 Motor

	Name		Qty.	Note	
Maintenance parts	AC Servo Motor	200 W	1	LS3-B, LS6-B: 2201471 (with oil seal)	
		520 W	1	LS6-B602S-V1: 2215861 (with oil seal)	
	O-ring		1	LS3-B	1213267 (CO0547A)
			1		1520371 (CO0538A)
			1	LS6-B	1213266 (CO0543A)
			1		1520371 (CO0538A)
			1		1510528 (CO0551A)
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw	
		width across flats: 3 mm	1	For M4 screw	
	Torque wrench	width across flats: 4 mm	1	For M5 screw	
	Wiping cloth		1	For wiping grease	
Grease	Grease (SK-1A)		-	-	

Joint #1 motor Removal

(1) Remove the Connector Plate.

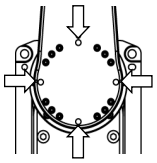
For details, refer to *3.3 Connector Plate*.

(2) Disconnect the connector.

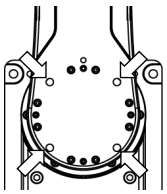
Connectors X41, X211 (Hold the clip to remove.)

(3) Remove the Arm #1 mounting bolt in the Joint #1 side and remove the arm.

LS3-B:
8-M3×32
4-M3×15



LS6-B:
8-M4×40
4-M3×20



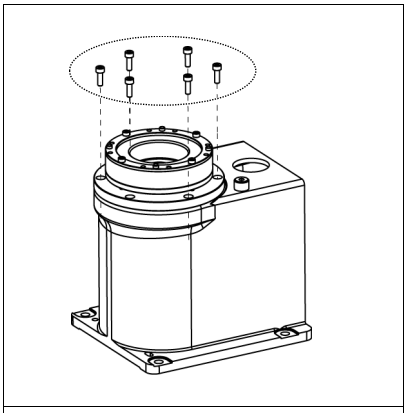
NOTE
Do not remove the bolts indicated by arrows.

NOTE
There is an O-ring between the Joint #1 unit and the arm. Be sure to keep the O-ring.

LS3-B: CO0547A
LS6-B: CO0551A

(4) Remove the screws mounting the Joint #1 flange on the Base.

LS3-B: 8-M4×15
LS6-B: 6-M5×15



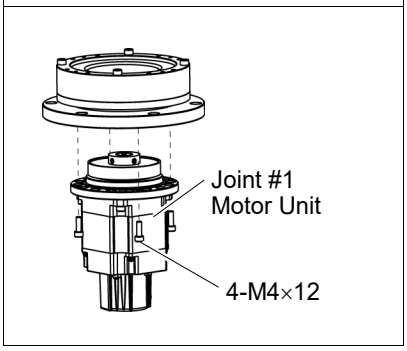
(5) Hold up the Joint #1 unit and remove it from the base.

Be careful not to damage the motor cable by getting it caught on the base.

(6) Loosen the motor mounting screws on the Joint #1 motor flange and remove the motor unit

There is an O-ring in the assembly position of the motor flange and Joint #1 flange.
Be careful not to lose the O-ring.

LS3-B: CO0538A
LS6-B: CO0543A

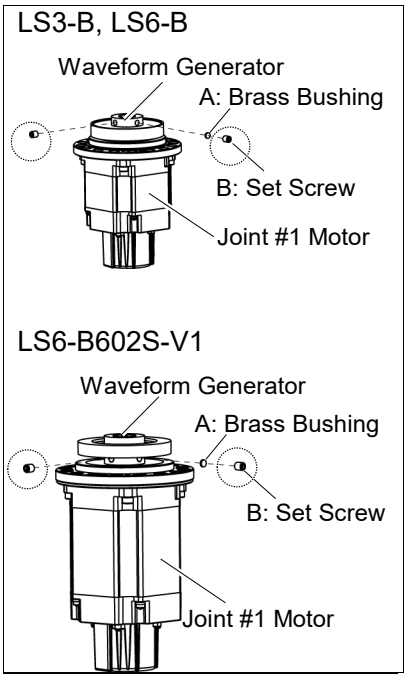


(7) Remove the waveform generator from the Joint #1 motor.

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

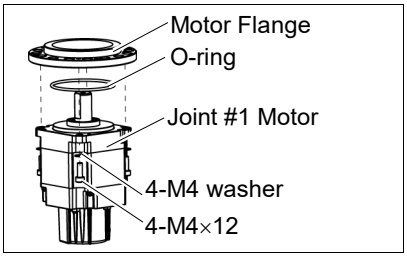
LS3-B:
A: Brass Bushing : M4
B: Set Screw : 2-M4×6

LS6-B, LS6-B602S-V1:
A: Brass Bushing : M5
B: Set Screw : 2-M5×6



(8) For LS6-B only:
Remove the motor mounting screws to remove the motor flange and O-ring (CO0538A).

NOTE LS3-B does not have a motor flange.



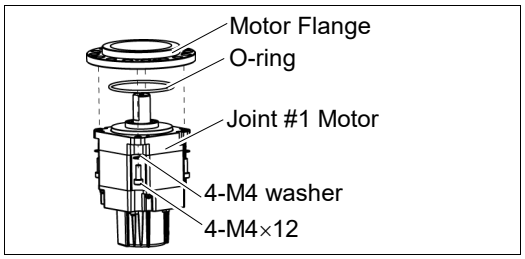
NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #1 motor Installation

(1) For LS6-B only:

Set the O-ring (CO0538A) on the motor mounting surface and mount the motor flange.

NOTE LS3-B does not have a motor flange.



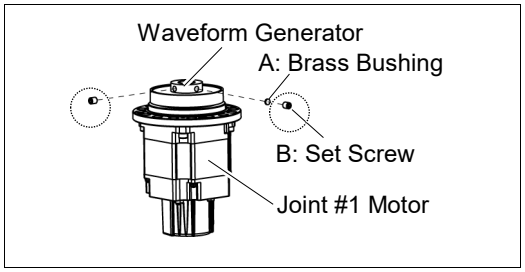
(2) Apply grease (SK-1A) to the between the waveform generator and motor.

Grease volume : LS3-B: 4g
LS3-B401S-V1: 6g
LS6-B: 13 g

Mount the waveform generator on the Joint #1 motor.

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

Tighten one of the set screws vertically on the flat face of the motor shaft. Insert a bushing into the other set screw hole to prevent damage to the motor shaft.



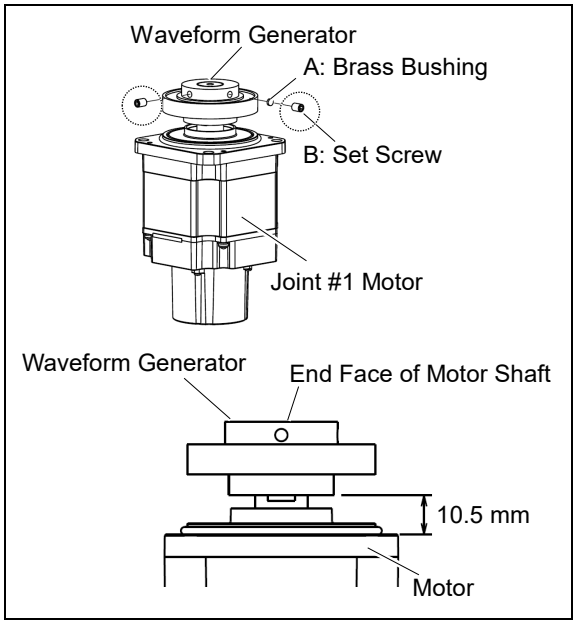
LS3-B
A: Brass Bushing : M4
B: Set Screw : 2-M4×6

LS6-B
A: Brass Bushing : M5
B: Set Screw : 2-M5×6

For LS3-B401S-V1

Joint #1 of LS3-B401S-V1 has a different motor flange and reduction gear unit from the normal LS3-B series.
Secure the motor mounting surface and the lower face of the waveform generator to set to 10.5 mm as shown in the figure.

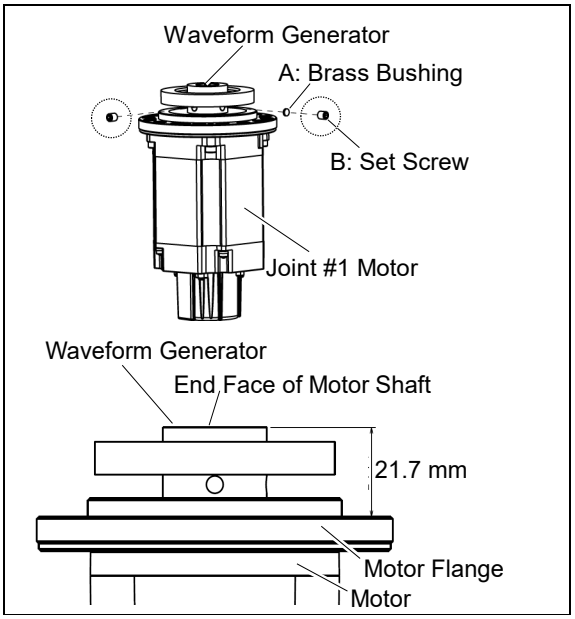
As a guide, make sure that the end face of the motor shaft and the end face of the waveform generator match.



For LS6-B602S-V1

Joint #1 of LS6-B602S-V1 has a different motor and reduction gear unit from the normal LS6-B series. Secure the end face of the motor flange and the end face of the waveform generator to set to 21.7 mm as shown in the figure.

As a guide, make sure that the end face of the motor shaft and the end face of the waveform generator match.



CAUTION

- See the figure 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.
- Joint #1 of LS6-B602S-V1 has a different waveform generator orientation from the normal LS6-B series. When installing Joint #1, be aware of the orientation of the waveform generator.

(3) Set an O-ring on the motor flange and assemble the motor with the Joint #1 flange.

LS3-B: CO0538A
LS6-B: CO0543A

To insert the motor, turn it slowly from side to side by hand and push in.

(4) Mount the Joint #1 unit on the Base.

Secure the Joint #1 motor cables facing toward the back of the Base.

(5) Set the O-ring removed in the removal step (3) into the O-ring groove of the arm.

LS3-B: CO0547A
LS6-B: CO0551A

Then, mount the arm to the Joint #1 unit.

(6) Connect the connectors.

Connectors X41, X211

(7) Mount the Connector Plate.

For details, refer to *3.3 Connector Plate*.

(8) Check if the Joint #1 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #1 moves, the connector for the other joint might be connected to the Joint #1 motor. Check the connector connection.

(9) Execute the calibration for the 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. 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 *14. Maintenance Parts List*.

	Name		Qty.	Note
Maintenance Parts	Reduction Gear Unit		1	LS3-B: 1765520 LS3-B401S-V1: 1879366 LS6-B: 1750570 LS6-B602S-V1: 1765530
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
	Torque wrench		1	
	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)		-	-

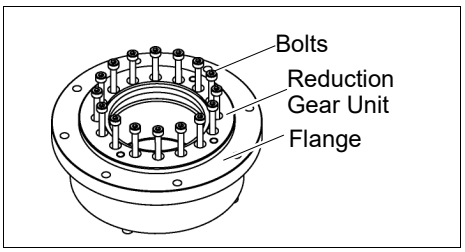
Joint #1 Reduction Gear Unit Removal

(1) Remove the Joint #1 motor unit.

Follow the removal steps in *5.1 Replacing Joint #1 Motor*.

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

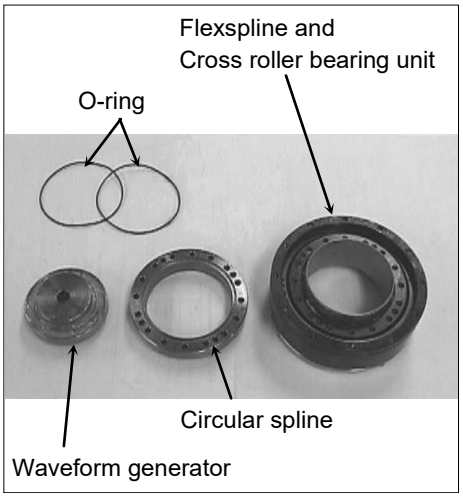
LS3-B: 16-M3×20
LS6-B: 16-M4×25



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.

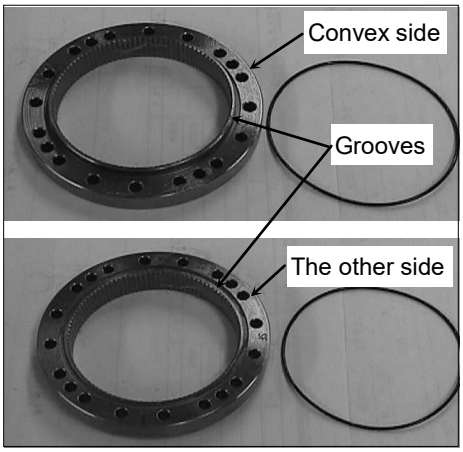


CAUTION

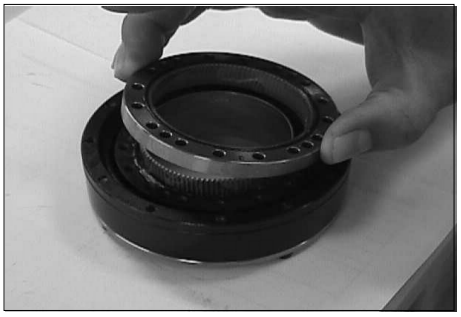
■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

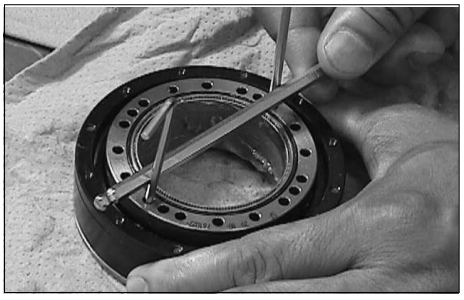
Make sure that the rings do not come out of the grooves.



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

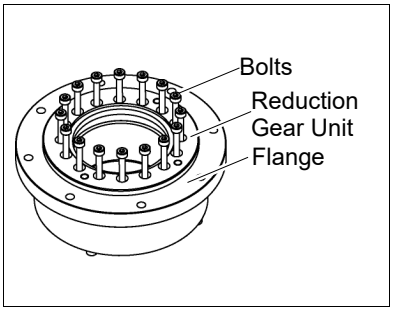


(4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



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

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



Item		Bolt type	Bolts	Tightening torque
Joint #1 reduction gear unit	LS3-B	M3×20	16	2.35 N·m (24 kgf·cm)
	LS6-B	M4×25	16	5.4 N·m (55 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: LS3-B: 19g
LS3-B401S-V1: 20g
LS6-B: 37 g

(7) Mount the Joint #1 motor.

For more details, refer to the installation steps in *5.1 Replacing Joint #1 Motor*.

6. Joint #2

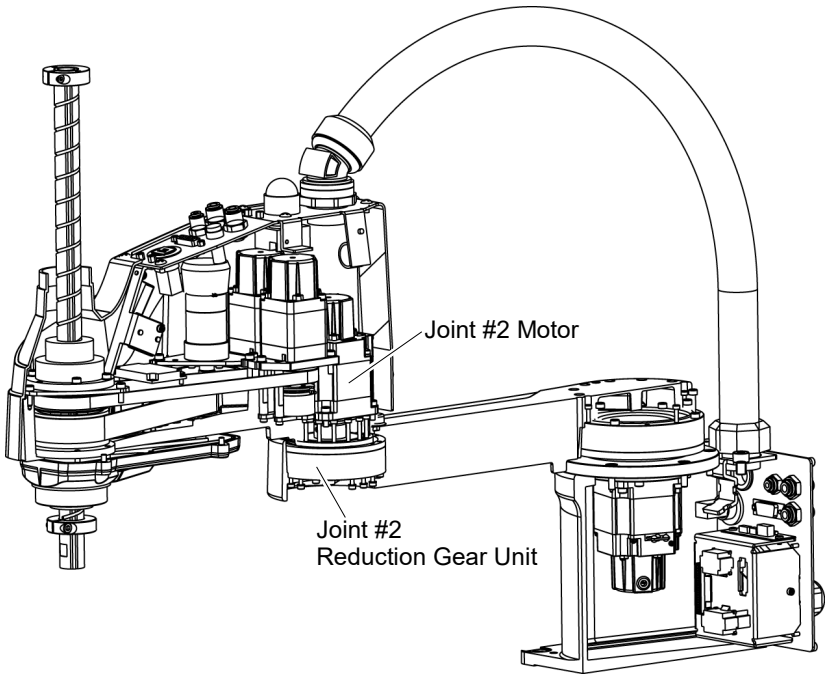
WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in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

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

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

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

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



6.1 Replacing Joint #2 Motor

	Name		Qty.	Note
Maintenance Parts	AC Servo Motor	100 W	1	LS3-B: 2201472
		200 W	1	LS6-B: 2197986 (without oil seal)
		520 W	1	LS6-B602S-V1: 2215862 (without oil seal)
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
	Wiping cloth		1	For wiping grease
Material	Wire tie		-	
Grease	Grease		-	LS3-B: SK-2
			-	LS6-B: SK-1A

NOTE

LS3-B: 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).

LS6-B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective brakes 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.

LS6-B: The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(6) Cut off the wire tie binding the cables.

Do not cut the other wire ties.

(7) Disconnect the connectors.

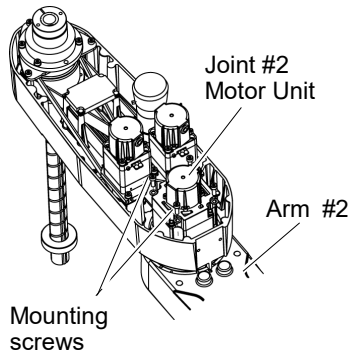
Connectors: X221, X21 (Hold the clip to remove.)

(8) Remove the screws mounting the motor unit and then remove the Joint #2 motor unit from the Arm #2.

Motor mounting screw
- LS3-B: 2-M4×55+ spacer
- LS6-B: 4-M4×12+ washer
- LS6-B602S-V1: 4-M4×15+ washer

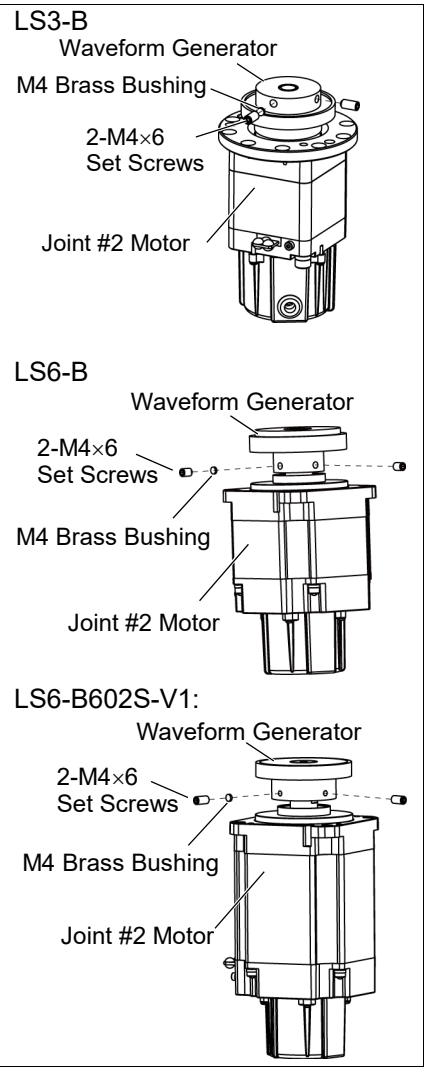
To pull out the motor smoothly, move the Arm #2 slowly by hand while pulling the motor.

NOTE The motor unit has a mounting orientation. When removing the motor unit, make sure the orientation.



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

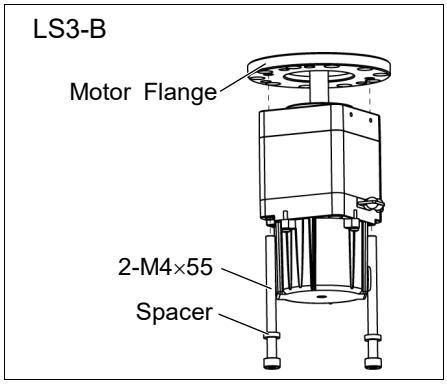
There is a brass bushing in one of the set screw holes. Be sure to keep the bushing.



(10) For LS3-B only

Remove the motor flange from Joint #2.

NOTE
LS6-B does not have a motor flange.



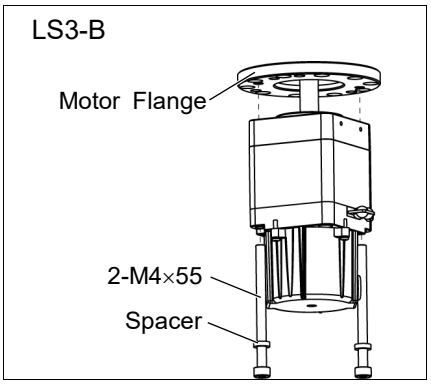
Joint #2 Motor Installation

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

(1) For LS3-B only:

Mount the motor flange on the Joint #2 motor.

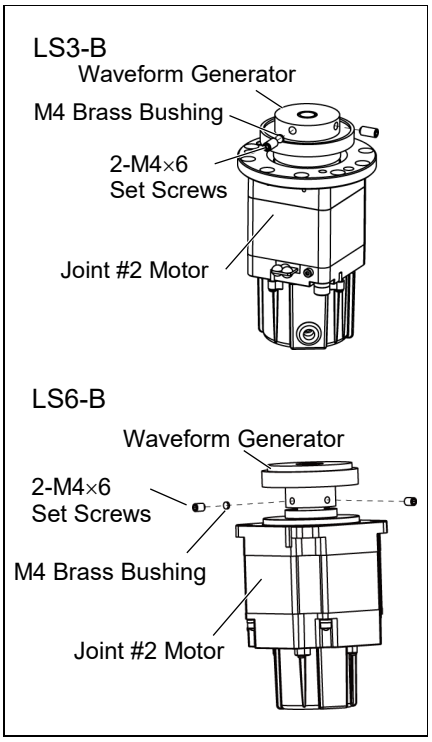
NOTE
LS6-B does not have a motor flange.



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

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

Tighten one of the set screws vertically on the flat face of the motor shaft. Insert a bushing into the other set screw hole to prevent damage to the motor shaft.



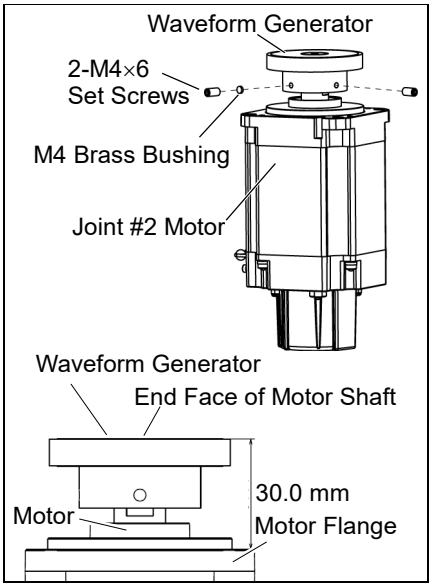
For LS6-B602S-V1

Joint #2 of LS6-B602S-V1 has a different motor and reduction gear unit from the normal LS6-B series.

Secure the end face of the motor flange and the end face of the waveform generator to set to 30.0 mm as shown in the figure.

NOTE

As a guide, make sure that the end face of the motor shaft and the end face of the waveform generator match.



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) Apply grease between the waveform generator and motor flange first. Then, apply to inside the flexspline.

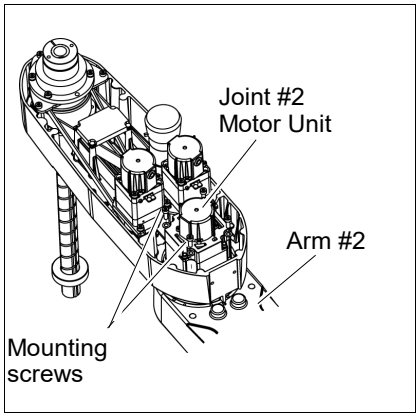
Between the waveform generator and motor flange
Grease volume LS3-B: 4 g (SK-2)
LS6-B: 6 g (SK-1A)

Inside the flexspline
Grease volume LS3-B: 11 g (SK-2)
LS6-B: 16 g (SK-1A)

(4) Mount the Joint #2 motor unit on the Arm #2 in the mounting orientation confirmed in the removal step (8).

To insert the motor, slowly move the Arm #2 by hand and push in.

Motor mounting screw
LS3-B: 2-M4×55+ spacer
LS6-B: 4-M4×12+ washer
LS6-B602S-V1: 4-M4×15+ washer



(5) Mount the User Plate.

For details, refer to *3.5 User Plate*.

(6) Connect the connectors.

Connectors: X221, X21.

(7) Bind the cables with a wire tie in their original positions as before removed in the removal step (6).

Do not allow unnecessary strain on the cables.

(8) Mount the Arm Top Cover.

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

(9) Check if the Joint #2 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #2 moves, the connector for the other joint might be connected to the Joint #2 motor. Check the connector connection.

(10) Execute the calibration for 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. When replacing the reduction gear unit, be sure to always replace the following parts all together as one set.

Waveform generator, Flexspline, Circular spline

For details of the three parts, refer to *14. Maintenance parts list*.

	Name		Qty.	Note
Maintenance parts	Reduction Gear Unit		1	LS3-B: 1587600
				LS6-B: 1750571
				LS6-B602S-V1: 1765520
	O-ring		1	LS3-B: 1213266 (CO0543A)
				LS6-B: 1213267 (CO0547A)
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
	Torque wrench		1	
	Nipper		1	
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Flange)
			1	For wiping grease (Bolt)
	Screw (M3) Length about 20 mm		2	For removing the flexspline
Material	Wire tie		-	
Grease	Grease		-	LS3-B: SK2
			-	LS6-B: SK-1A

NOTE

LS3-B: 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).

LS6-B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS3-B: The brake release switch is applied to both Joint #3.
When the brake release switch is pressed, the respective brake of the Joint #3 is released simultaneously.
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.

LS6-B: The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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.

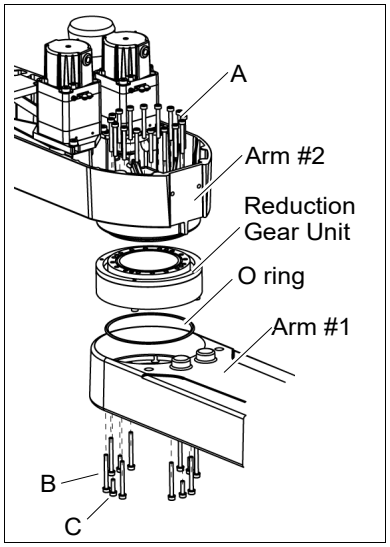
(4) Remove the waveform generator from the Joint #2 motor.

Follow the removal steps in *6.1 Replacing Joint #2 Motor*.

(5) Remove the Arm #2 by removing the screws mounting the Arm #2 on the reduction gear unit.

LS3-B
- A: 10-M3×18
- B: 8-M3×30+8-M3 small washer
- C: 4-M3×15+4-M3 small washer

LS6-B
- A: 16-M3×28
- B: 8-M3×32+8-M3 small washer
- C: 4-M3×12+4-M3 small washer

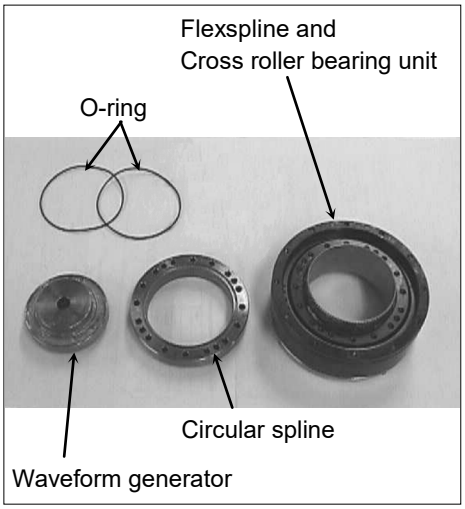


(6) Remove the reduction gear unit from the Arm #1 by removing the screws that mounts the reduction gear unit on the Arm #1.
There is an O-ring between the Arm #1 and the reduction gear unit.
Be careful not to lose the removed O-ring.

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.

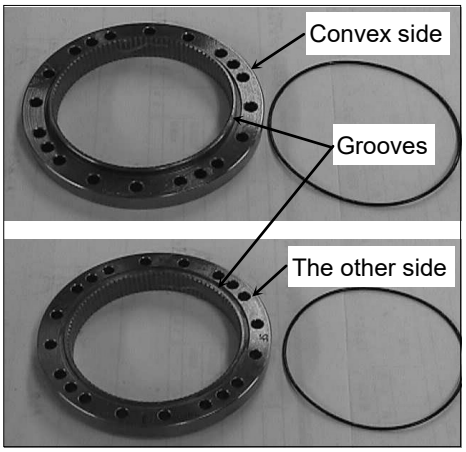
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



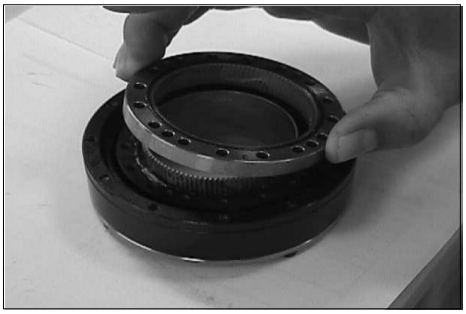
CAUTION	■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

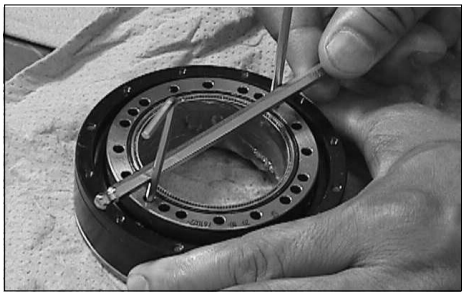
Make sure that the rings do not come out of the grooves.



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



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



(5) Set the O-ring removed in the removal step (6) into the O-ring groove of the Arm #1.

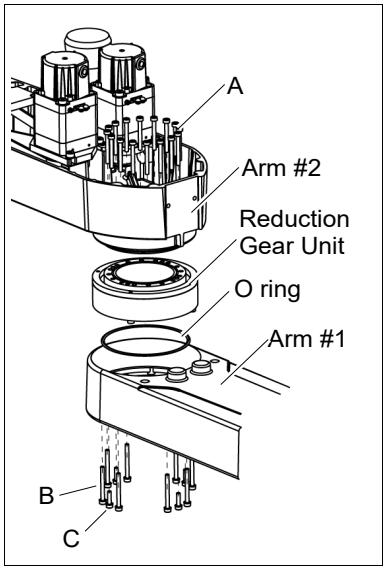
NOTE

If the O-ring is not fit into the groove, please use another O-ring which is prepared as maintenance part.

Install the flexspline on the Arm #1.

LS3-B
- A: 10-M3×18
- B: 8-M3×30+8-M3 small washer
- C: 4-M3×15+4-M3 small washer

LS6-B
- A: 16-M3×28
- B: 8-M3×32+8-M3 small washer
- C: 4-M3×12+4-M3 small washer



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	Tightening torque
Joint #2 reduction gear unit	M3	2.35 N·m (24 kgf·cm)

NOTE

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

(6) Apply grease between the motor flange and waveform generator first. Then, apply to inside the flexspline.

Between the waveform generator and motor flange
Grease volume LS3-B: 4 g (SK-2)
LS6-B: 6 g (SK-1A)

Inside the flexspline
Grease volume LS3-B: 11 g (SK-2)
LS6-B: 16 g (SK-1A)

(7) Set the attached O-ring into the O-ring groove of the circular spline.

Secure the Arm #2 on the circular spline.

(8) Mount and Joint #2 motor.

Follow the installation steps in *6.1 Replacing Joint #2 Motor*.

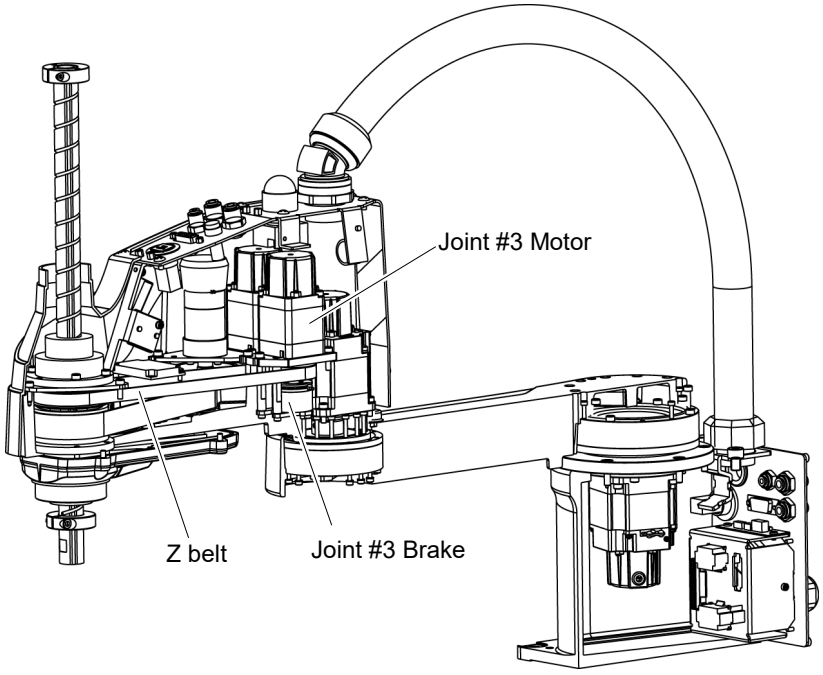
7. Joint #3

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.

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



7.1 Replacing Joint #3 Motor

	Name		Qty.	Note
Maintenance parts	AC Servo Motor	100 W	1	LS3-B, LS6-B: 2201472
		150 W	1	LS6-B602S-V1: 2215863
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench			
	Nippers		1	For cutting wire tie
	Sonic tension meter Force gauge		1	Z: Belt tension (pulling force) 69N (7.0 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		-	

NOTE

LS3B: 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).

LS6B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

LS6-B: When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 binding the Joint #3 motor cables.

Do not cut off the other wire ties that do not relate with removal of the User Plate.

(6) Remove the User Plate.

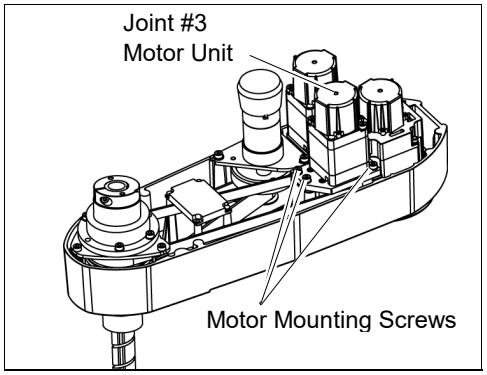
For details, refer to *3.5 User Plate*.

(7) Disconnect the following connectors.

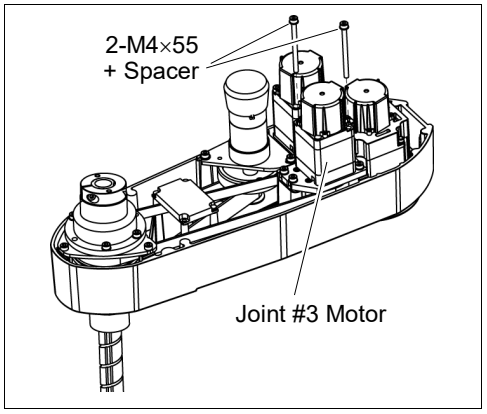
Connectors: X231, X43 (Hold the clip to remove.)

(8) Loosen the screws for the Joint #3 motor unit.

Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer

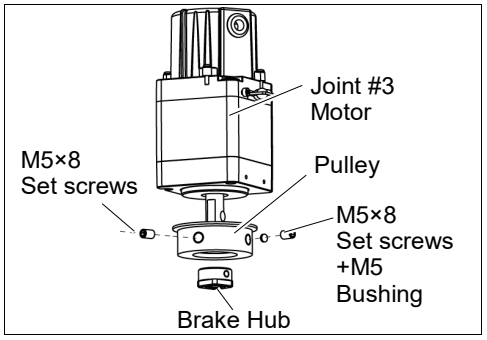


(9) Remove the Joint #3 motor from the Joint #3 motor unit.



(10) Loosen the screws of the pulley and the brake hub. Remove them from the Joint #3 motor.

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

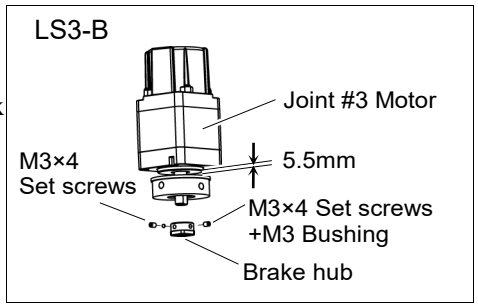


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

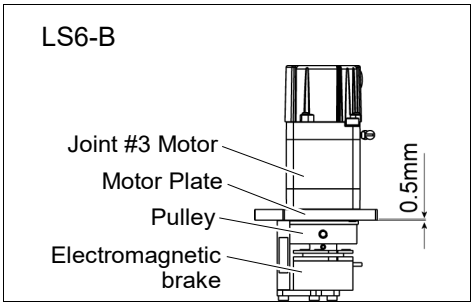
Joint #3 motor Installation

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

LS3-B:
Pass the pulley through the motor shaft. Fix the pulley leaving 5.5 mm space from the motor mounting surface.
Insert the brake hub all the way seated in the pulley and secure it.



LS6-B:
Fix the pulley leaving 0.5 mm space from the motor plate.
Make sure to leave 0.5 mm between the motor plate and the pulley with the motor plate installed. Insert the brake hub all the way seated in the pulley and secure it.

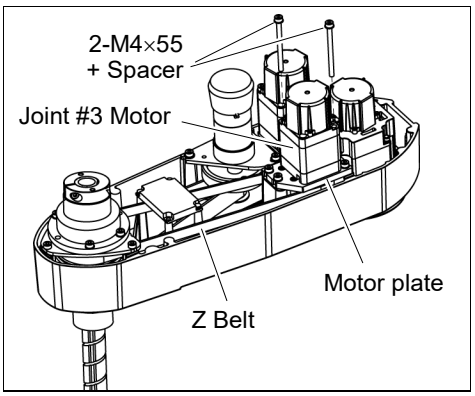


Tighten one of the set screws vertically on the flat face of the motor shaft.
Insert a bushing into the other set screw hole to prevent damage to the motor shaft.

(2) Mount the Joint #3 motor to the motor plate while aligning the hub to the brake disc.

Before aligning the hub, set the motor so that the pulley will be inside of the Z belt.

NOTE Secure the motor cables facing to back of the Arm.



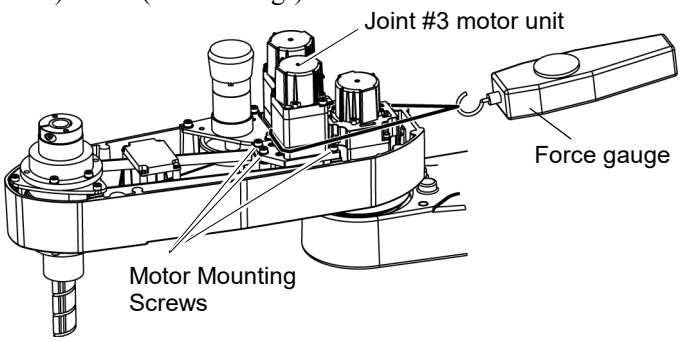
(3) Loosely secure the Joint #3 motor unit to the Arm #2. Make sure that the teeth of the timing belt are engaged with those of the pulley.

NOTE At this point, make sure that the Joint #3 motor unit can be moved by hand, and it will not tilt when pushed by tensioner. If the unit is secured too loose or too tight, the belt will not have the proper tension

(4) Apply the proper tension to the Z belt and 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

Z belt tension: 34.5N (3.5 ± 0.5 kgf)
Axial tension (pulling force): 69 N (7.0 ± 0.5 kgf)



Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer

NOTE To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(5) Connect the connectors.

Connectors: X231, X241, X43, X44, X51

(6) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(7) Bind the cables with a wire tie in their original positions as before removed in the removal 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.*

(9) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for other joint might be connected to the Joint #3 motor. Check the connector connection.

(10) Execute the calibration of Joints #3, #4.
For details, refer to *13. Calibration*.

7.2 Replacing the Timing Belt

	Name		Qty.	Note
Maintenance parts	Z belt		1	LS3-B: 1554773 LS6-B: 1563316
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench		1	
	Cross-point screwdriver (#1)		1	For pan head screw (small)
	Nippers		1	For cutting wire tie
	Sonic tension meter Force gauge		1	Z: Axial tension (pulling force): 69N (7.0 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		-	

NOTE

LS3-B: 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).

LS6-B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

LS6-B: The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 binding the cables.

Cut off the wire tie binding the Joint #3 brake cable.

Do not cut off a wire tie that binds the cables to the User Plate.

(6) Disconnect the following connectors.

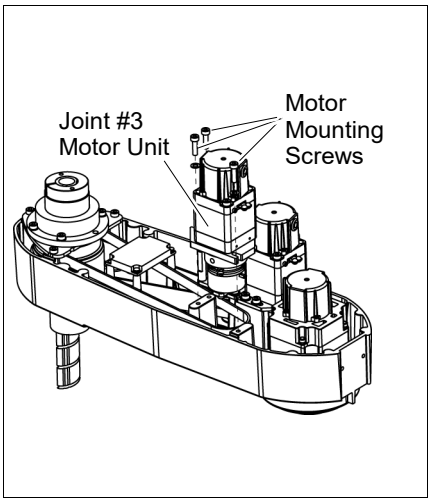
Connectors: X231, X43, X51 (Hold the clip to remove.)

(7) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(8) Remove the screws for the Joint #3 motor unit and pull out the Joint #3 motor unit.

Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer



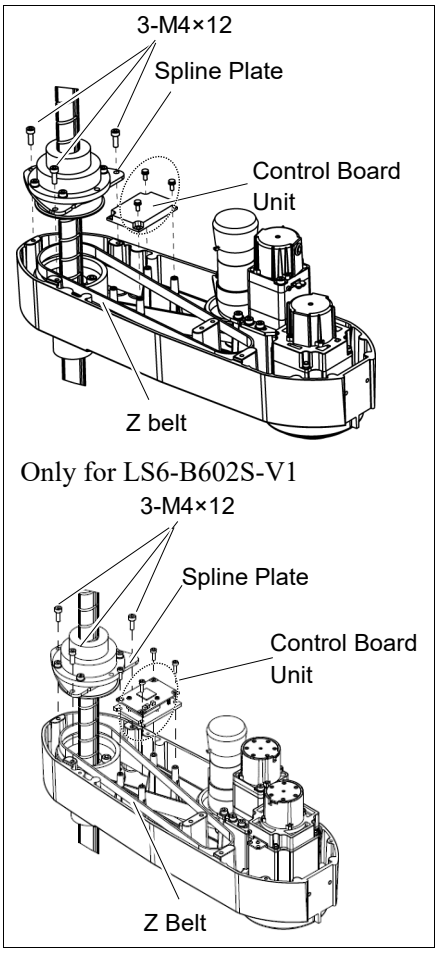
(9) Remove the Joint #3 motor from the motor plate and pull out the Z belt.

The belt is placed around the pulley. To remove the Joint #3 motor, tilt the motor slightly and pull it upward while avoiding the belt.

(10) Unscrew the control board unit mounting screws to remove the control board unit.

LS3-B: 3-M3×8 Pan head screws (Small)
LS6-B: 4-M3×8 Pan head screws (Small)
LS6-B602S-V1:4-M3×10 Hexagon socket head cap bolts

(11) Remove the screws mounting the spline plate. Hold up the spline plate and pull out 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) Pass a new Z belt through the shaft.

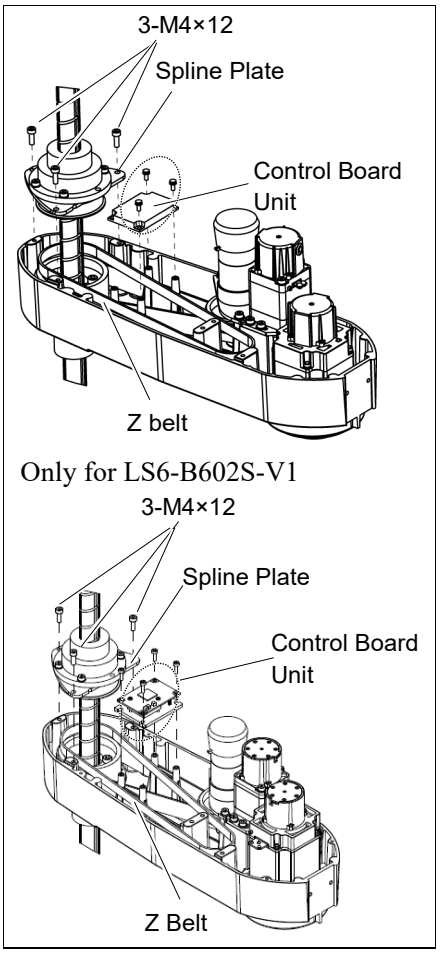
(2) Lower the spline plate with the Z belt placed around the spline plate pulley.

Secure the spline plate with 3 screws.

Loosely secure the spline plate on the Arm #2 and move the shaft up and down several times before firmly secure the spline plate.

(3) Fix the control board unit.

LS3-B: 3-M3×8 Pan head screws (Small)
LS6-B: 4-M3×8 Pan head screws (Small)
LS6-B602S-V1:4-M3×10 Hexagon socket head cap bolts

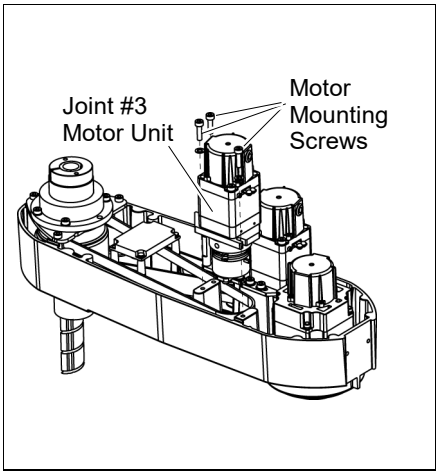


(4) Mount the Joint #3 motor unit back in the arm.

(5) Pass the brake cable and over-excitation power supply through the Z belt.

Place the Z belt around the Z1 pulley and Z2 pulley, with the gear grooves of the belt fitting into grooves of the pulleys completely.

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



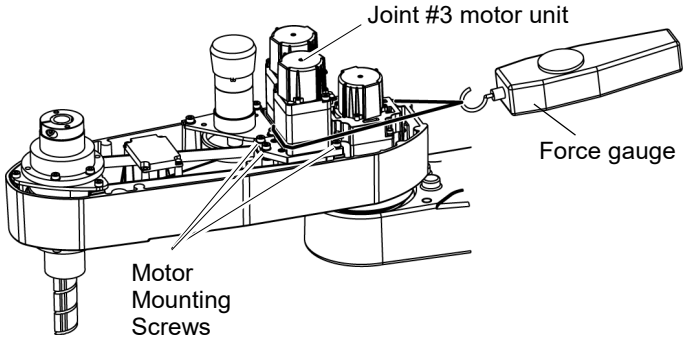
NOTE
Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer

At this point, make sure that the Joint #3 motor unit can be moved by hand, and it will not tilt when pushed by tensioner. 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 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

Z belt tension: 34.5N (3.5 ± 0.5 kgf)
Axial tension (pulling force): 69 N (7.0 ± 0.5 kgf)



Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer

NOTE To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(8) Connect the connectors.

Connectors: X231, X241, X43, X44, X51

(9) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(10) Bind the cables with a wire tie in their original positions as before removed in the removal step (7). Do not allow unnecessary strain on the cables.

(11) Install the Arm Top Cover.
For details, refer to *3.1 Arm Top Cover*.

(12) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for the other joint might be connected to the Joint #3 motor. Check the connector connection.

(13) Execute the calibration of Joint #3.
For details, refer to *13. Calibration*.

7.3 Replacing the Brake

	Name		Qty.	Note
Maintenance parts	Electromagnetic Brake		1	1750573
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
	Sonic tension meter Force gauge		1	Z: Axial tension (pulling force) 69N (7.0 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		-	

NOTE

LS3B: 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).

LS6B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

LS6-B: When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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*.

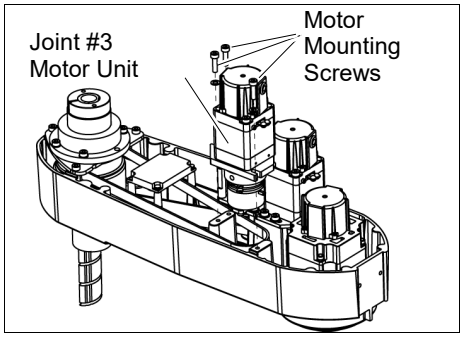
(5) Remove the Joint #3 motor unit.

For details, refer to *7.2 Replacing the Timing Belt*.

Motor mounting screw

LS3-B, LS6-B: 3-M4×15+ washer

LS6-B602S-V1: 3-M4×12+ washer



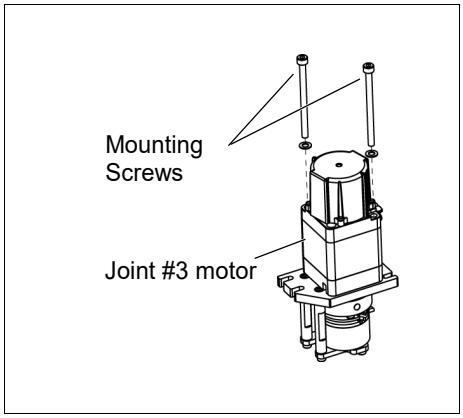
(6) Remove the Joint #3 motor from the Joint #3 motor unit.

The belt is placed around the pulley. To remove the Joint #3 motor, tilt the motor slightly and pull it upward while avoiding the belt.

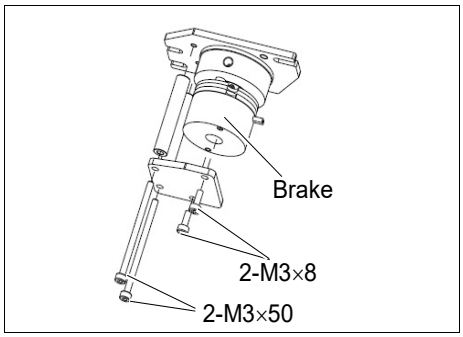
Mounting screw

LS3-B, LS6-B: 2-M4×55+ washer

LS6-B602S-V1: 2-M4×65+ washer

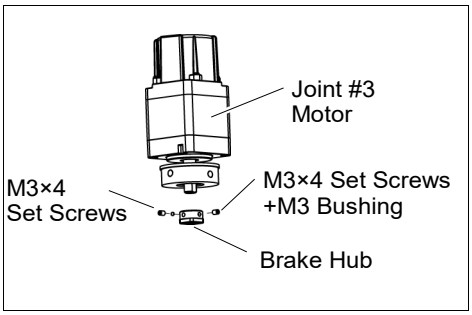


(7) Remove the brake from the brake plate.



(8) Loosen the screws of brake hub and remove it from the pulley of the Joint #3 motor.

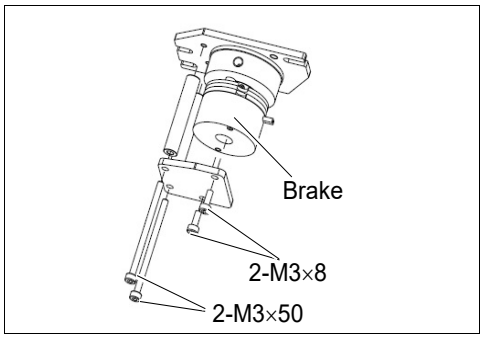
There is a brass bushing in one of the set screw holes. Be sure to keep the bushing.



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.

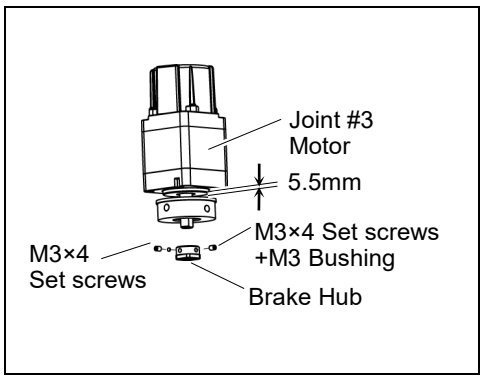


(2) Mount the brake hub to the pulley of the Joint #3 motor.

For LS3-B:

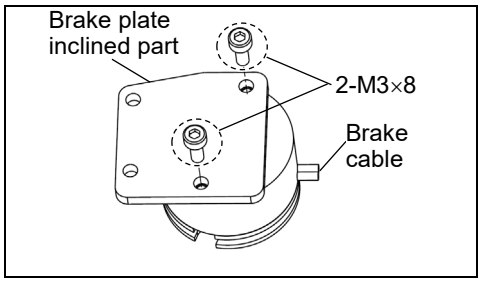
Pass the pulley through the motor shaft. Fix the pulley so that the distance between the motor mounting surface and the pulley upper face is 5.5 mm.

Let the brake hub hit the pulley and fix where it touches the pulley edge face.



For LS6-B602S-V1:

Mount the brake plate inclined part and the brake cable properly not to confuse the directions.

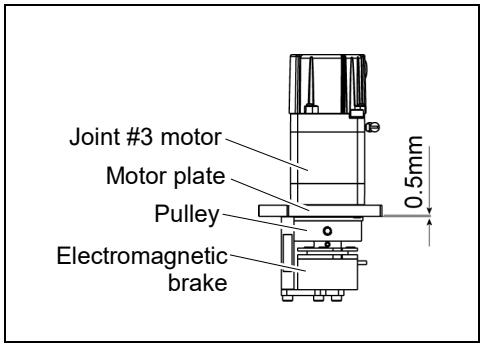


For LS6-B:

Fix the pulley leaving 0.5 mm space from the motor plate.

Make sure to leave 0.5 mm between the motor plate and the pulley with the motor plate installed.

Insert the brake hub all the way seated in the pulley and secure it.

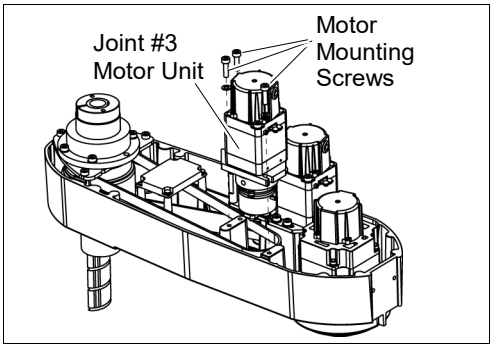


Tighten one of the set screws vertically on the flat face of the motor shaft.
Insert a bushing into the other set screw hole to prevent damage to the motor shaft.

When the brake disc is not aligned, manually adjust the position by following the steps below.

1. Connect the connector BR.
2. Press the brake release switch to release the brake.
3. Adjust the brake disk manually so that the hole is at the center.

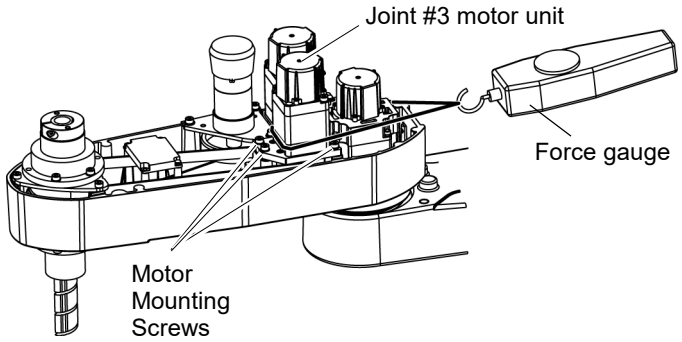
(3) Mount the Joint #3 motor unit back in the Arm #2.



Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer

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

Z belt tension: 34.5N (3.5 ± 0.5 kgf)
Axial tension (pulling force): 69 N (7.0 ± 0.5 kgf)



Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer

For details, refer to the section *7.2 Replacing the Timing Belt*.

NOTE To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(4) Mount the Arm Top Cover.

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

(5) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for other joint might be connected to the Joint #3 motor. Check the connector connection.

(6) Execute the calibration of Joint #3.

For details, refer to *13. Calibration*.

7.4 Checking the Timing Belt Tension (Z Belt)

	Name	Qty.	Note
Tool	Sonic tension meter	1	For details of usage and measurement methods of the tension meter, refer to the instruction manual of the tension meter.

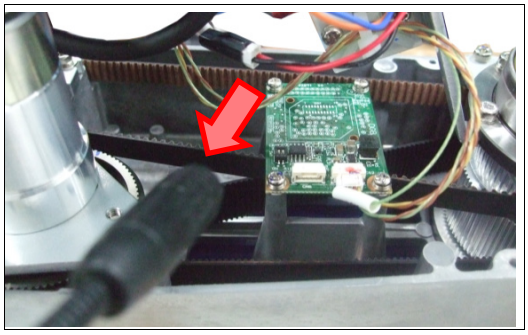
Joint #3 Belt tension check

(1) Enter appropriate setting values to the sonic tension meter.

Model	Belt	Unit mass M [g/ (1 mm width ×1 m length)]	Width W [mm]	Span S [mm]
LS3-B	Z belt	1.9	9	127
LS6-B	Z belt	1.9	10	212

(2) Strum the belt and measure tension.

NOTE Measurement failure may occur if the microphone touches the belt during measurement.



8. Joint #4

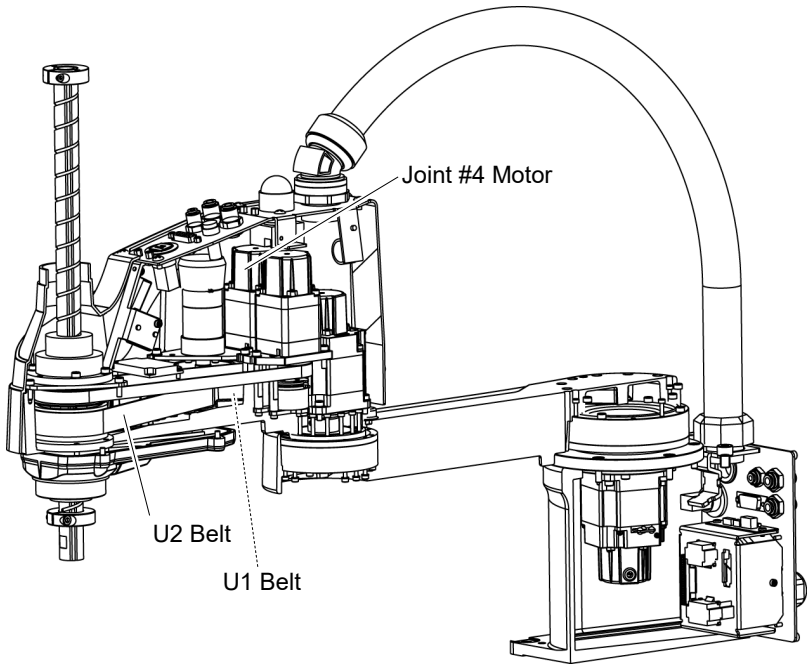
WARNING	■ Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric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

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

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

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

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



8.1 Replacing Joint #4 Motor

	Name		Qty.	Note
Maintenance parts	AC Servo Motor 100 W		1	LS3-B, LS6-B: 2201472
			1	LS6-B602S-V1: 2215864
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	
	Cross-point screwdriver (#1)		1	For pan head screw (small)
	Nippers		1	For cutting wire tie
	Sonic tension meter Force gauge		1	U1: Axial tension (pulling force) LS3-B: 39N (4.0 ± 0.5 kgf) LS6-B: 56N (5.7 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension

CAUTION

- The belt must be installed with proper tension; otherwise the following problems may occur.

  If falling below the lower limit : Jumping of the belt gears (position gap)

  If exceeding the upper limit : Abnormal noise or vibration (oscillation), decline in the life of driving parts

NOTE

LS3-B: 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).

LS6-B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

LS6-B: The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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.

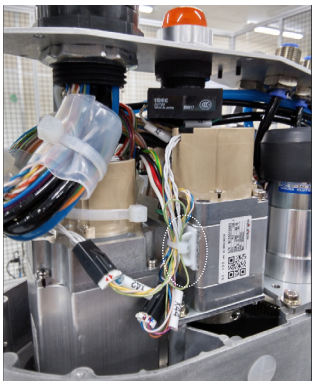
For details, refer to *3.1 Arm Top Cover*.

(5) Cut off the wire tie binding the cables.

At this point, do not cut off a wire tie (in the duct fittings outlet) that binds the cables to the User Plate.

Only for LS6-B602S-V1

Remove the mount base from the motor as shown on the right.



(6) Disconnect the connectors.

Connector X241, X44 (Hold the clip to remove.)

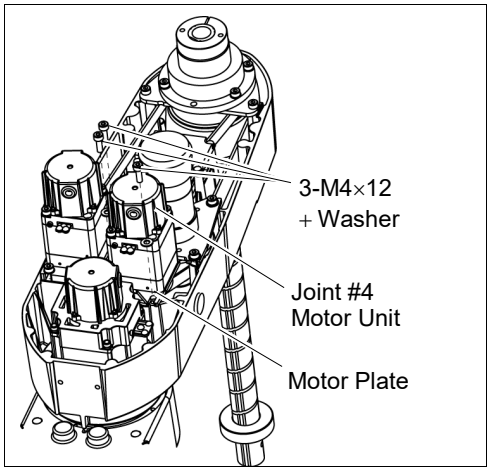
(7) Remove the User Plate.

For details, refer to *3.5 User Plate*.

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

Remove the bolts securing the Joint #4 motor on the motor plate and pull out the motor.

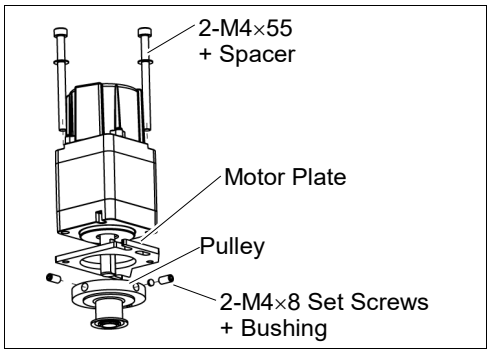
The belt is placed around the pulley. Tilt the motor unit slightly and pull it out.



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

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

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

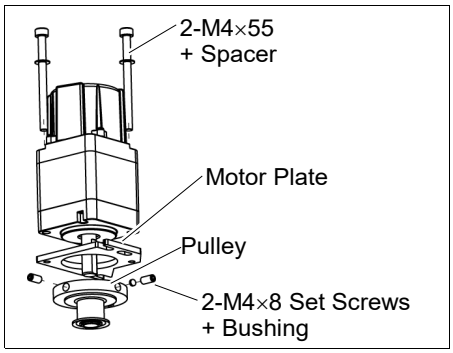


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #4 motor Installation

(1) Mount the motor plate to the Joint #4 motor. At this point, the motor cables must be in the convex shape side of the plate.

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

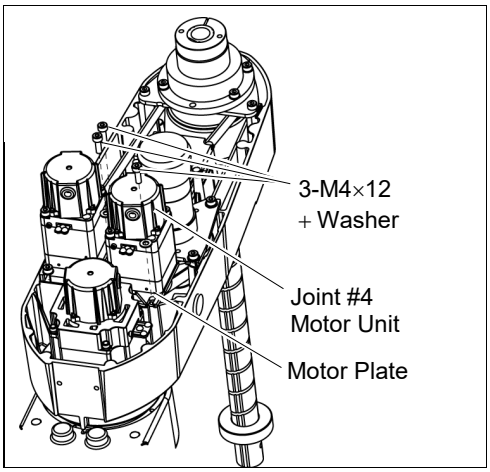


Be sure to fit the end face of the pulley to the end face of the motor shaft.

Be sure to set the one set of the set screws + bushing vertically on the flat face of the motor shaft. Be careful not to damage the motor shaft to tighten the bushing into the other set screw hole.

(3) Place the pulley around the U1 belt and place the Joint #4 motor unit in the upper face of the Arm #2.

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

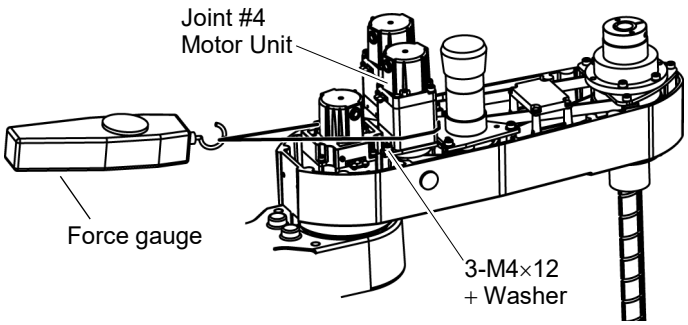
(5) Apply the proper tension to the U1 belt and secure the Joint #4 motor unit.

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.

LS3-B:
U1 belt tension: 19.5N (2.0±0.5 kgf)
Axial tension (pulling force): 39 N (4.0 ± 0.5 kgf)

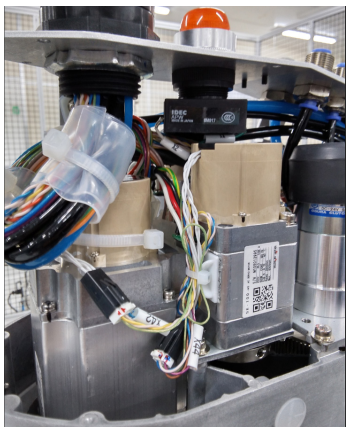
LS6-B:
U1 belt tension: 28N(2.8±0.5kgf)
Axial tension (pulling force): 56 N (5.7 ± 0.5 kgf)



NOTE To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belt)*.

Only for LS6-B602S-V1

Attach the mount base to Joint #4 motor as shown on the right, and secure the cables with a wire tie.



(6) Connect the connectors.
Connectors X241, X44

(7) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(8) Bind the cables with a wire tie in their original positions as before removed in removal 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) Check if the Joint #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #4 moves, the connector for other joint might be connected to the Joint #4 motor. Check the connector connection.

(11) Execute the calibration of Joint #4.
For details on the calibration method, refer to *13. Calibration*.

8.2 Replacing the Timing Belt

	Name		Qty.	Note
Maintenance parts	U1 belt	width 10 mm	1	LS3-B: 1554775
	U2 belt	width 16 mm	1	LS3-B: 1554777
	U1 belt	width 10 mm	1	LS6-B: 1612286
	U2 belt	width 20 mm	1	LS6-B: 1763573
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)		1	For pan head screw (small)
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Force gauge Sonic tension meter		1	LS3-B: Axial tension (pulling force) U1 : 39 N (4.0 ± 0.5 kgf) U2 : 69N (7.0 ± 0.5 kgf) LS6-B: Axial tension (pulling force) U1 : 56 N (5.7 ± 0.5kgf) U2 : 125 N (12.3 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension

CAUTION

■ The belt must be installed with proper tension; otherwise the following problems may occur.

If falling below the lower limit : Jumping of the belt gears (position gap)

If exceeding the upper limit : Abnormal noise or vibration (oscillation), decline in the life of driving parts

NOTE

LS3-B: 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).

LS6-B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

8.2.1 U2 Belt

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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

LS6-B: The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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.

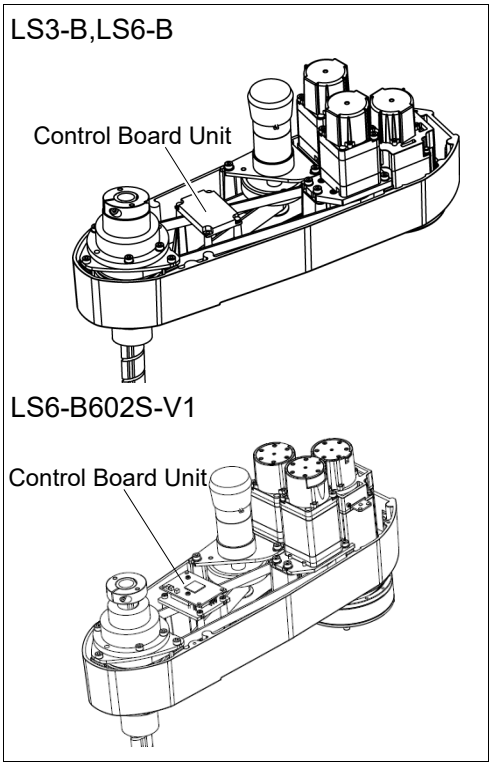
(3) Turn OFF the Controller.

(4) Remove the Arm Top Cover.

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

(5) Remove the control board unit.

LS3-B: 3-M3×8 Pan head screws (Small)
LS6-B: 4-M3×8 Pan head screws (Small)
LS6-B602S-V1: 2-M3×10 Hexagon socket head cap bolts



(6) Cut off the wire tie binding the cables.

Do not cut off the wire tie that binds the cables to the User Plate.

(7) Disconnect the following connectors.

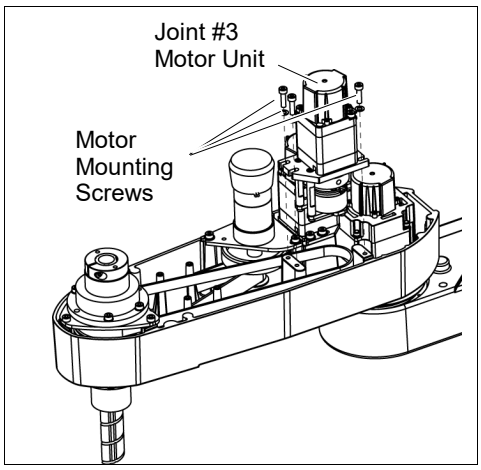
Connectors: X33, X41, X51, X241 (Hold the clip to remove.)
BR4 (Only LS6-B)

(8) Remove the User Plate.

For details, refer to *3.5 User Plate*.

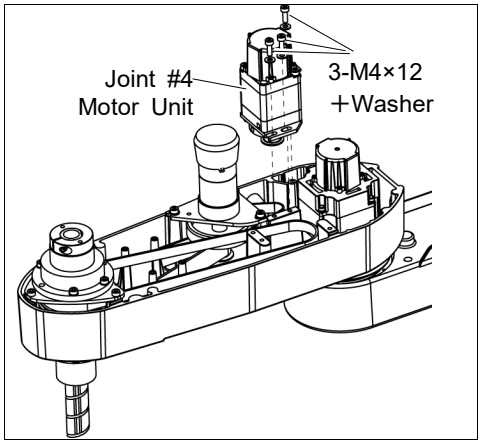
(9) Remove the screws securing the Joint #3 motor unit and pull out the motor unit.

Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer



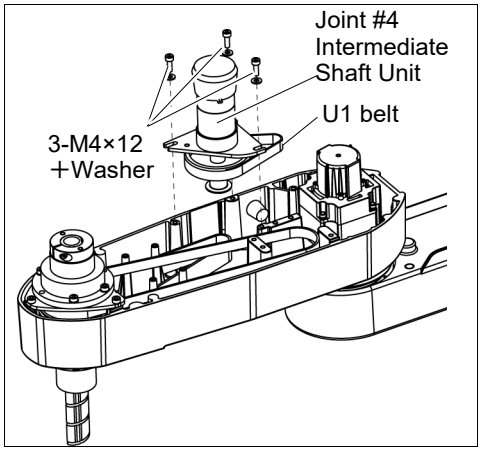
(10) Remove the screws securing the Joint #4 motor unit and pull out the motor unit.

The belt is placed around the pulley. Tilt the motor unit slightly and pull it out.



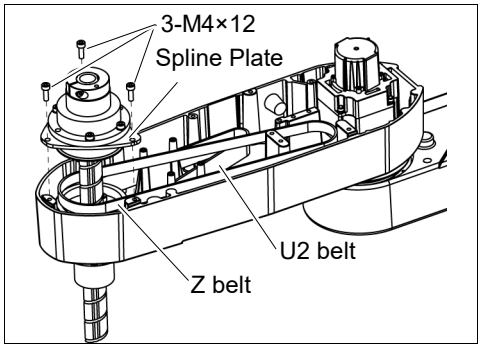
(11) Remove the screws securing the Joint #4 intermediate shaft unit.

Pull out the Joint #4 intermediate shaft unit and U1 belt.



(12) Remove the screws mounting the spline plate.

Hold up the spline plate and pull out the Z belt and U2 belt.



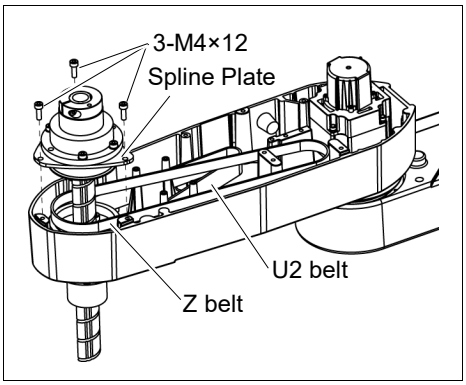
NOTE

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

U2 belt Installation

(1) Hold up the spline plate 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.



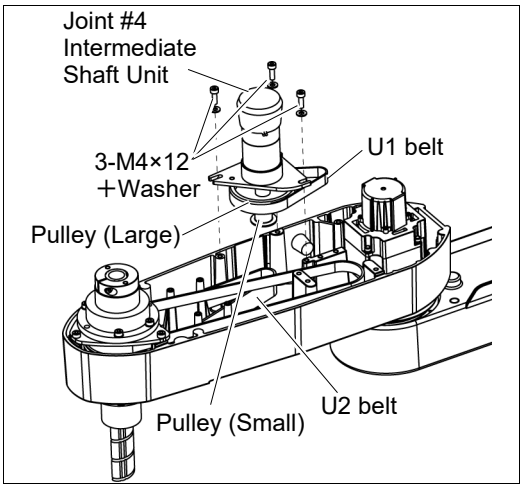
(2) Hold up the spline plate and set the Z belt around the Z2 pulley.

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

(3) Loosely secure the spline plate on the Arm #2 and move the shaft up and down several times before firmly secure the spline plate.

(4) Keeping the U1 belt on the large pulley of the Joint #4 intermediate shaft unit, set the U2 belt in the Arm #2 on the small pulley and put them on the Arm #2 upper surface.

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



(5) Loosely secure the Joint #4 intermediate shaft unit.

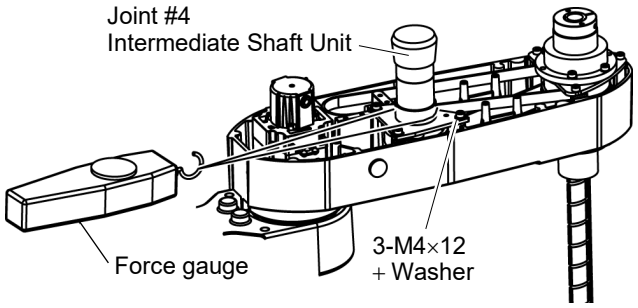
Make sure the unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

LS3-B:
U2 belt tension: 34.5N (3.5±0.25 kgf)
Axial tension (pulling force): 69N (7.0 ± 0.5 kgf)

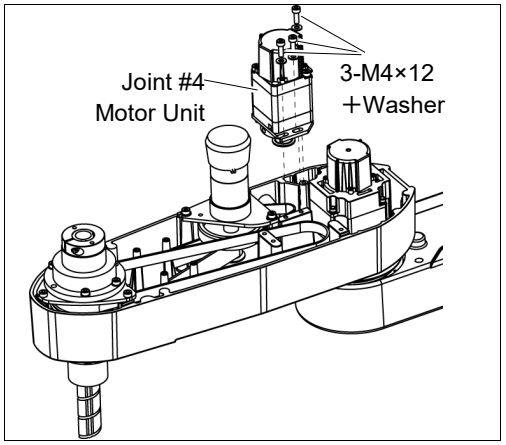
LS6-B:
U2 belt tension: 62.5N (6.3±0.5 kgf)
Axial tension (pulling force): 125N (12.3 ± 0.5 kgf)



NOTE To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

(7) Mount the Joint #4 motor unit on the Arm #2 with the U1 belt around the pulley.

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

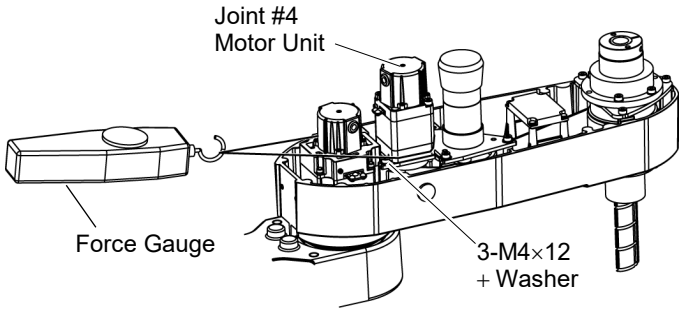
(9) Apply the proper tension to the U1 belt and secure the Joint #4 motor unit.

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 on the right.

LS3-B:
U1 belt tension: 19.5N (2.0±0.5 kgf)
Axial tension (pulling force): 39 N (4.0 ± 0.5 kgf)

LS6-B:
U1 belt tension: 28N(2.8±0.5kgf)
Axial tension (pulling force):56 N (5.7 ± 0.5 kgf)

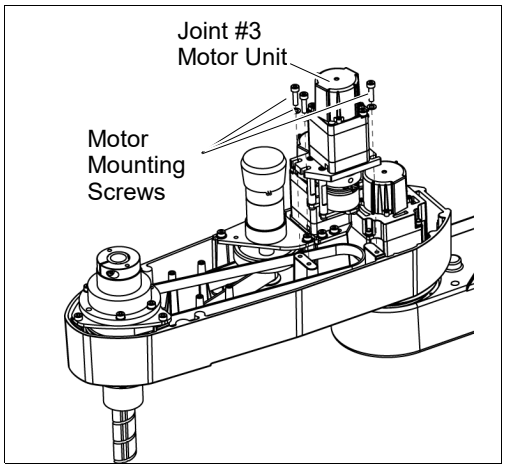


NOTE

To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

(10) Put the Joint #3 motor unit back in the arm.

Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer



(11) Pass the brake cable and over-excitation power supply through the Z belt.

Set the Z belt around the Z1 pulley and Z2 pulley, with the gear grooves of the belt fitting into grooves of the pulleys completely.

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

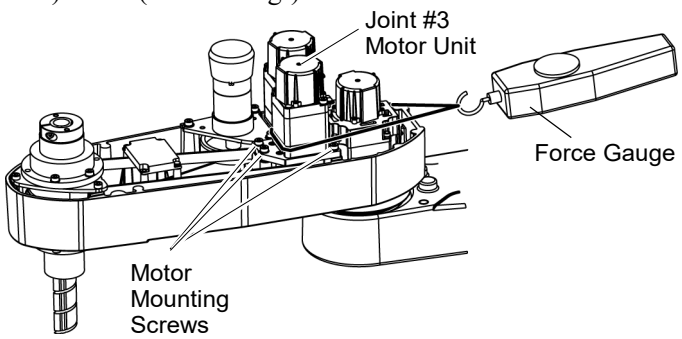
NOTE

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.

(13) Apply the proper tension to the Z belt and 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.

Z belt tension: 34.5 N (3.5 ± 0.5 kgf)
Axial tension (pulling force) :69 N (7.0 ± 0.5 kgf)



Motor mounting screw
LS3-B, LS6-B: 3-M4×15+ washer
LS6-B602S-V1: 3-M4×12+ washer

NOTE
To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(14) Remove the control board unit.

For details, refer to *11.3 Replacing the Control Board*.

(15) Connect the following connectors.

Connectors: X33, X41,X51, X241
BR4 (Only for LS6-B)

(16) Mount the User Plate.

For details, refer to *3.5 User Plate*.

(17) Bind the cables with a wire tie in their original positions as before removed in the removal step (7).

Do not allow unnecessary strain on the cables.

(18) Remove the Arm Top Cover.

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

(19) Check if the Joint #3, #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3, #4 moves, the connector for the other joint might be connected to the Joint#3, #4 motor. Check the connector connection.

(20) Execute the calibration for Joint #3, #4.

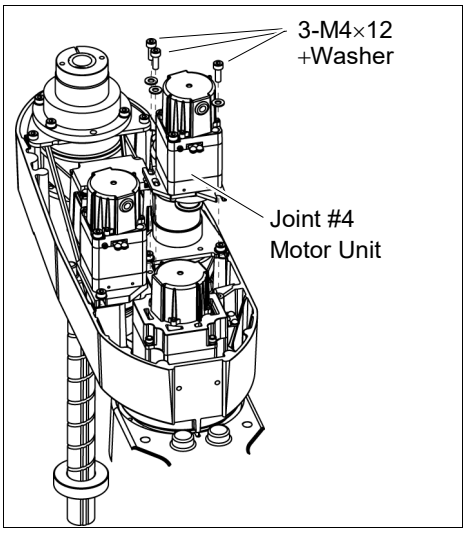
For details on the calibration method, refer to *13. Calibration*.

8.2.2 U1 Belt

U1 belt Removal

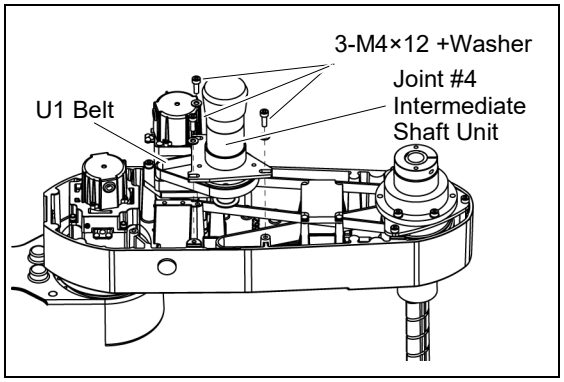
(1) Remove the Joint #4 motor unit.

Follow the removal steps in *8.2.1 U2 Belt*.



(2) Remove the Joint #4 intermediate shaft unit.

Refer to the removal steps in *8.2.1 U2 Belt*.



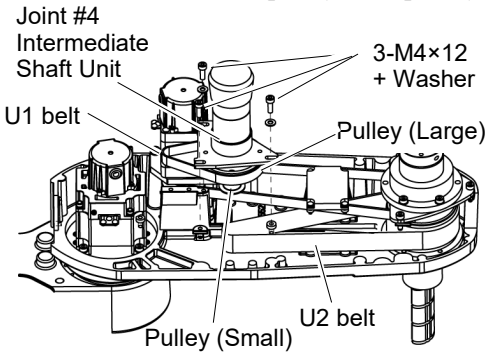
(3) Remove the U1 belt.

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

U1 belt Installation

(1) Keeping the U1 belt on the large pulley of the Joint #4 intermediate shaft unit, set the U2 belt in the Arm #2 on the small pulley and put them on the Arm #2 upper surface.

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



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

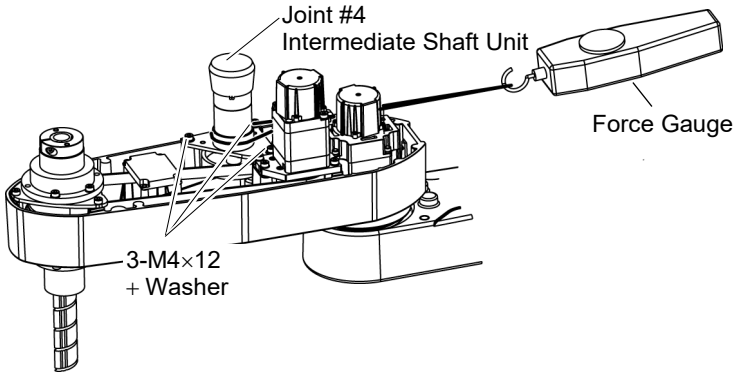
Make sure the motor unit can be moved by hand, and it will not tilt when pulled.
If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

LS3-B:
U2 belt tension: 34.5 N (3.5 ± 0.25kgf)
Axial tension (pulling force): 69N (7.0 ± 0.5 kgf)

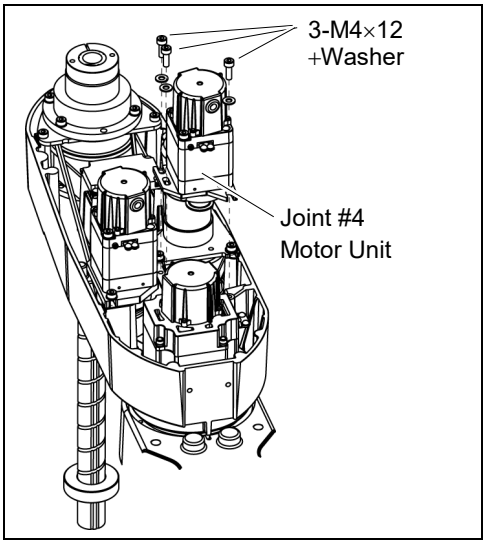
LS6-B:
U2 belt tension: 62.5N (6.3 ± 0.5kgf)
Axial tension (pulling force): 125N (12.3 ± 0.5 kgf)



NOTE ☞ To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

(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.

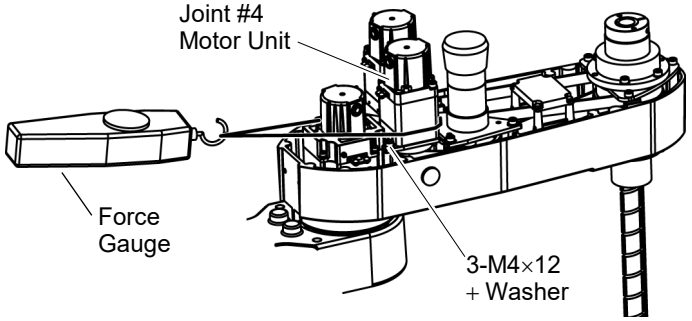


(5) Apply the proper tension to the U1 belt, and then secure the Joint #4 motor unit.

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.

LS3-B:
U1 belt tension: 19.5N (2.0 ± 0.5 kgf)
Axial tension (pulling force): 39 N (4.0 ± 0.5 kgf)

LS6-B:
U1 belt tension: 28N (2.8 ± 0.5kgf)
Axial tension (pulling force): 56 N (5.7 ± 0.5 kgf)



NOTE To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

(6) Connect the connectors.

Connector X241, X41

(7) Bind the cables with a wire tie in their original position as before removed in the removal step (5).

(8) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(9) Install the Arm Top Cover.

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

(10) Check if the Joint #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #4 moves, the connector for the other joint might be connected to the Joint #4 motor. Check the connector connection.

(11) Execute the calibration of Joint #4.

For details, refer to *13. Calibration*.

8.3 Replacing the Brake (for LS6-B series only)

	Name		Qty.	Note
Maintenance parts	Electromagnetic brake		1	1750573
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 2 mm	1	For M2.5 screw
	Nippers		1	For cutting wire tie
Material	Wire tie		1	

NOTE

LS6-B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS6-B: The brake release switch is applied to both Joint #3 and #4. When the brake release switch is pressed, the respective brake 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.

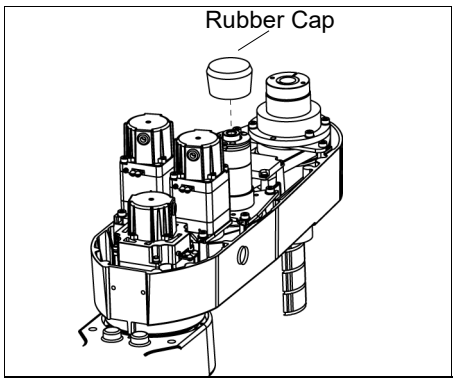
(4) Remove the Arm Top Cover.
For details, refer to *3.1 Arm Top Cover*.

(5) Disconnect the connector.

Connector BR4

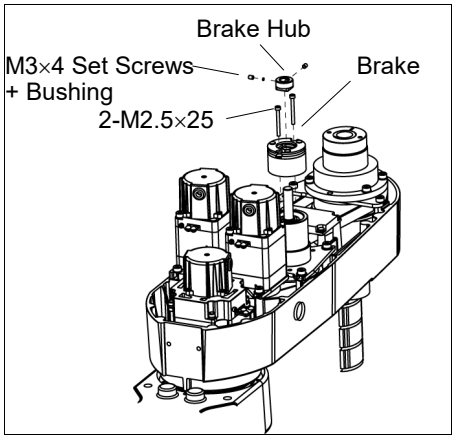
(6) Cut off the wire tie banding brake cables.

(7) Remove the rubber cap.



(8) Remove the brake hub.

(9) Remove the brake.

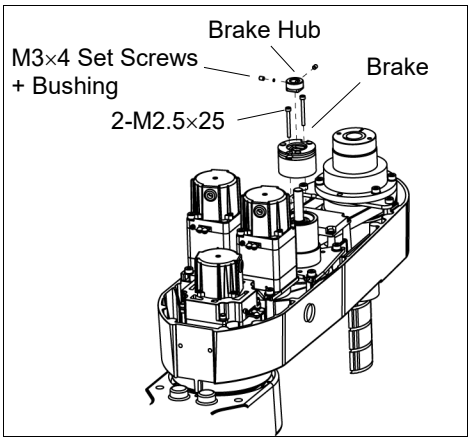


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #4 brake Installation

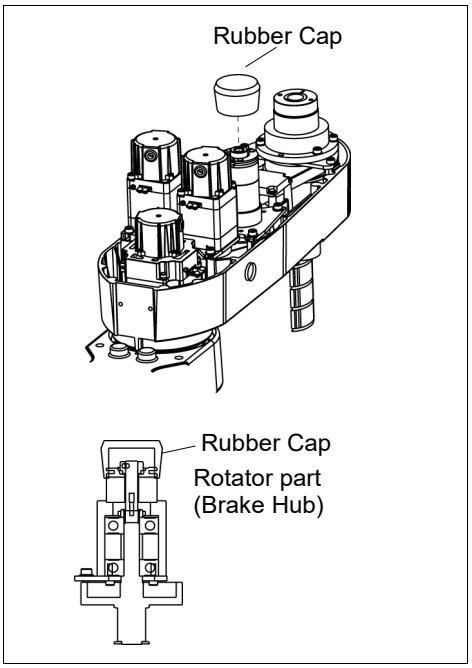
(1) Mount the brake to the Joint #4 intermediate shaft unit.

(2) Mount the brake hub to the Joint #4 intermediate shaft unit.



(3) Mount the rubber cap.

NOTE Insert the rubber cap until the cable part of the brake. If the cables get inside the rubber cap, the cables may be disconnected.



(4) Connect the connector.

Connector BR4

(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*.

8.4 Checking the Timing Belt Tension (U1, U2 Belts)

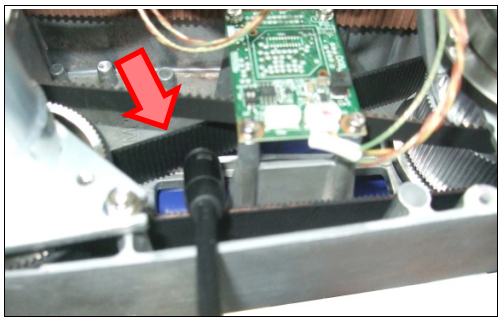
	Name	Qty.	Note
Tool	Sonic tension meter	1	For details of usage and measurement methods of the tension meter, refer to the instruction manual of the tension meter.

Joint #4
Belt tension check

(1) Enter appropriate setting values to the sonic tension meter.

	Belt	Unit mass M [g/ (1 mm width ×1 m length)]	Width W [mm]	Span S [mm]
LS3-B	U1 belt	1.3	10	45
	U2 belt	1.3	16	92
LS6-B	U1 belt	1.3	10	55
	U2 belt	2.6	20	169

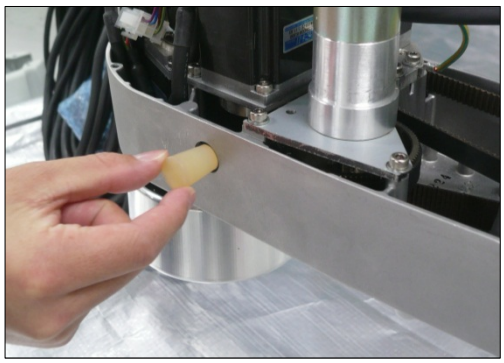
(2) Strum the U2 belt and measure tension.



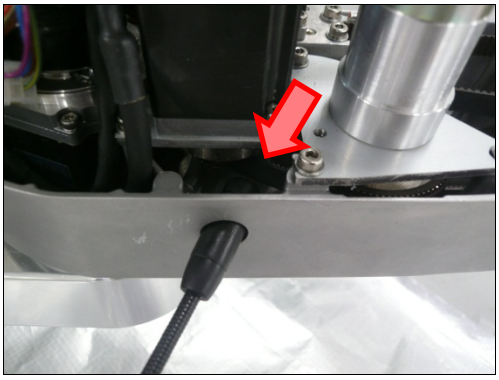
NOTE

Measurement failure may occur if the microphone touches the belt during measurement.

(3) Remove the rubber plug from the hole on the Arm #2.



(4) Strum the U1 belt and measure tension.



NOTE

For LS6-B, insert the microphone of the tension meter to the hole on the Arm to measure tension.

Measurement failure may occur if the microphone touches the belt during measurement.

9. Bellows

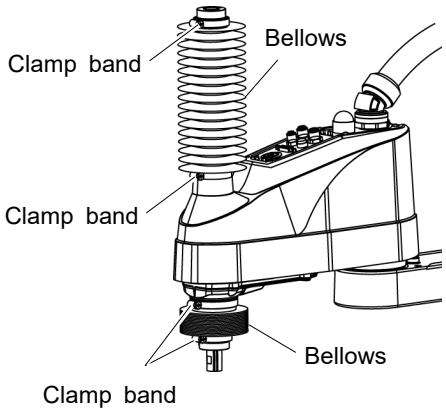
NOTE

The bellows for LS3-B401C are provided in a unit of one piece. The upper and lower bellows have the same shape.

The bellows for LS6-B*02C 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 replacing the bellows.

	Name	Qty.	Note
Maintenance parts	Bellows	1	LS3-B401C: 1513008 LS6-B*02C: 1639708
Tools	Cross-point screwdriver	1	For clamp band removal



Bellows Removal

(1) Remove the cables and tubes from the end effector.

(2) Remove the end effector.

(3) Turn ON the controller. Stop motor excitation. (MOTOR OFF)

(4) Loosen the two clamp bands on the bellows.

(5) Pull out the bellows and clamp bands from 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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

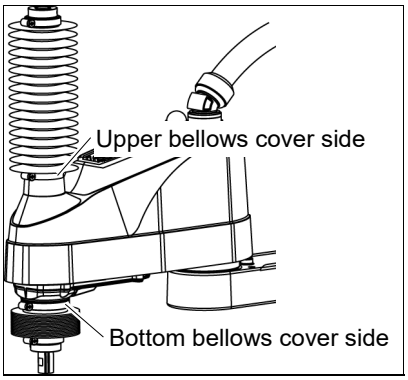
LS6-B: The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #4 are released simultaneously.
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the 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.
Attach the mounting part of the bellows until the end touches the cylindrical part of the cover.

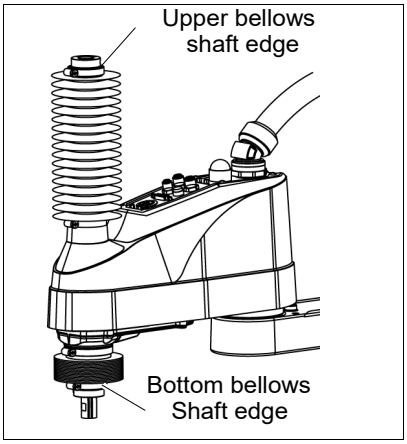
Then, secure them with clamp bands.



(4) Secure the shaft edge side of the bellows.

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

Then, secure them with clamp bands.



(5) When completed the bellows installation, check that the bellows stretch smoothly without any excessive force by moving the shaft up/down by hand and rotating the Joint #4.

(6) Turn OFF the Controller and peripheral equipment.

(7) Attach the end effector.

(8) Connect the cables and tubes to the end effector.

10. Ball Screw Spline Unit Replacement

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.

	Name	Qty.	Note
Maintenance parts	Ball Screw Spline Unit	1	Each manipulator model (Refer to *14. Maintenance parts*)
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 Sonic tension meter	1	Axial tension (pulling force) LS3B: Z : 69 N (7.0 ± 0.5kgf) U1 : 39 N (4.0 ± 0.5 kgf) U2 : 69N (7.0 ± 0.5 kgf) LS6B: Z : 69 N (7.0 ± 0.5kgf) U1 : 56 N (5.7 ± 0.5kgf) U2 : 125 N (12.3 ± 0.5 kgf)
	Suitable cord (Length about 1000 mm)	1	For belt tension
	Wiping cloth	1	For wiping grease (Spline shaft)
Material	Wire tie	-	

NOTE

LS3-B: 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).

LS6-B: A brake is mounted on the motor of Joints #3 and #4 to prevent the shaft from moving down and rotating due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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.

LS3-B: The brake release switch is applied to Joint #3.
When the brake release switch is pressed, the respective 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.

LS6-B: The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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/tubes from the end effector, and remove the end effector.

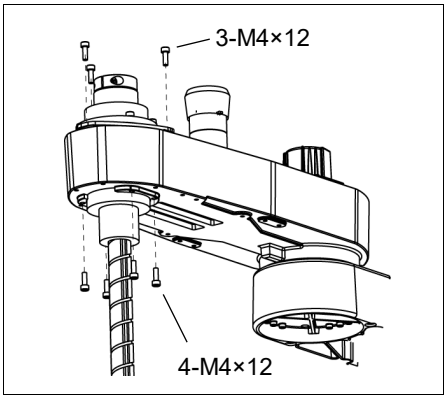
(5) This step is only for Cleanroom-model.
Remove the bellows. For details, refer to *9. Bellows*.

(6) Remove the Arm Top Cover and Arm Bottom Cover.
For details, refer to *3. Covers*.

(7) Remove the following.
Joint # motor unit Joint #4 motor unit Joint #4 intermediate pulley
U1 belt U2 belt Z belt
Follow the U2 belt removal steps in *8.2 Replacing the Timing Belt*.

(8) Remove three screws mounting the spline plate.

(9) Remove four screws mounting the spline nut.



(10) Pull out the following toward the Arm #2 upper side.

Ball screw spline unit Z belt U2 belt

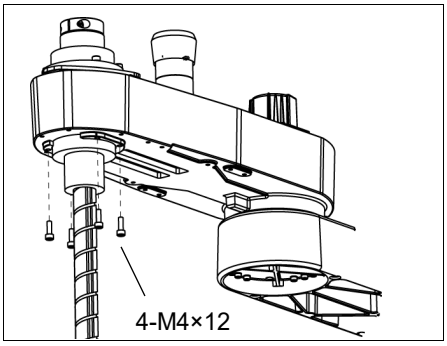
NOTE

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

Ball Screw Spline Unit Installation

(1) Insert a new ball screw spline unit in the Arm #2.

(2) Secure the spline nut from the bottom side of the Arm #2.



(3) Mount the following.

Joint #3 motor unit / Joint #4 motor unit / Joint #4 intermediate pulley / U1 belt / U2 belt / Z belt

Follow the U2 belt installation steps in *8.2 Replacing the Timing Belt*.

(4) Mount the Arm Top Cover and Arm Bottom Cover.

For details, refer to *3. Covers*.

(5) Grease the shaft.

For details, refer to *LS3-B LS6-B Manipulator 2.3 Greasing - Greasing the Ball Screw Spline Unit*.

(6) For the Cleanroom-model, mount the bellows.

For details, refer to *9. Bellows*.

(7) Mount the end effector, cables, and tubes.

(8) Perform the calibration of Joints #3, #4.

For details, refer to *13. Calibration*.

11. Boards

 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.

	Name	Qty.	Note
Maintenance parts	Converter board	1	2196970
	Control board	1	LS3-B, LS6-B: 2198655
		1	LS6-B602S-V1: 2196966
Tools	Nippers	1	For cutting wire tie
	Cross-point screwdriver (#1)	1	
Material	Wire tie	1	For fixing cables

11.1 Replacing the Converter Board

Board which supplies power to the encoder of the motor is mounted inside the base of the manipulator. If the board gets damage, the manipulator will not operate.

Converter board Removal

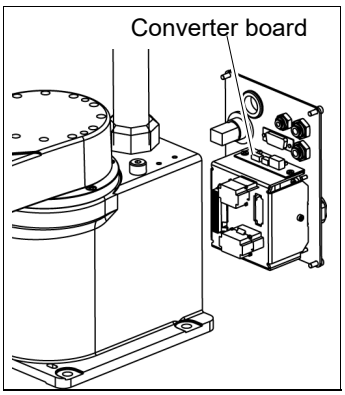
(1) Turn OFF the controller.

(2) Remove the Connector Plate.

For details, refer to *3.3 Connector Plate*.

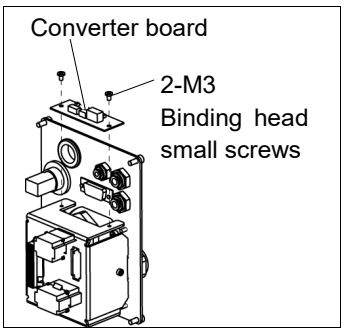
(3) Disconnect the connectors which are connected to the converter board.

Connectors: CV11, CV12, CV13



(4) Remove the converter board from the mount base.

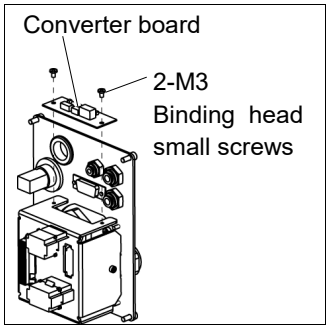
Binding head small screws:
2-M3 (cross-point screwdriver)



Converter board Installation

(1) Mount the converter board on the mount base.

Binding head small screws: (2-M3)



(2) Connect the connectors to the converter board.

Connectors: CV11, CV12, CV13

(3) Mount the Connector Plate.

For details, refer to *3.3 Connector Plate*.

(4) Turn ON the Controller.

(5) Make sure no errors occur in all joints.

11.2 Replacing the Control Board

Control Board Removal

(1) Turn OFF the controller.

(2) Remove the Arm Top Cover.

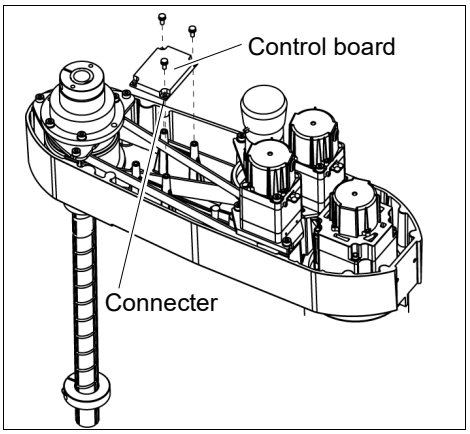
For details, refer to *3.1 Arm Top Cover*.

(3) Disconnect the connector.

Connector: X51

(4) Remove the Control board.

LS3-B: 3-M3×8 Pan head screws (Small)
LS6-B: 4-M3×8 Pan head screws (Small)
LS6-B602S-V1: 2-M2 × 16 Pan head screws (Small)



Control Board Installation

(1) Mount a new Control board.

Be careful of the board direction.
(Check the board direction by the connector position.)

(2) Connect the connector.

Connector: X51

(3) Mount the Arm Top Cover.

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

(4) Turn ON the controller.

12. LED Lamp

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.

	Name	Qty.	Note
Maintenance parts	LED Lamp	1	LS3-B: 2198273 LS6-B: 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*.

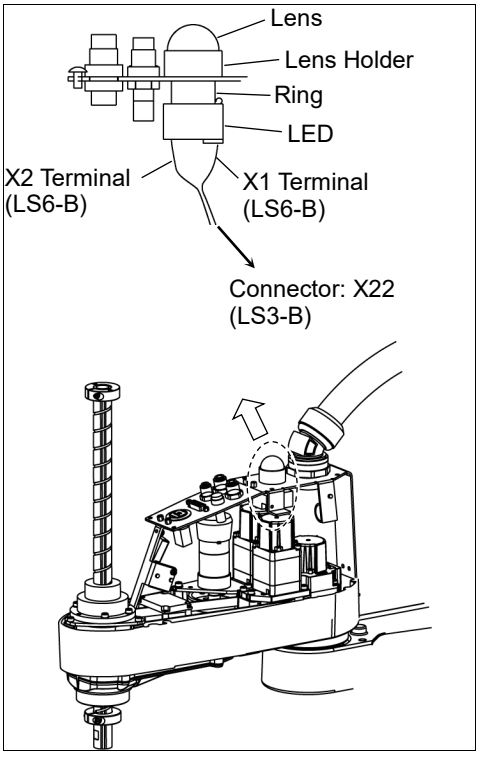
(2) Remove the User Plate.
For details, refer to *3.5 User Plate*.

(3) LS3-B:
Disconnect the connector from LED.
Connector: X22

LS6-B:
Disconnect the X1 and X2 terminals from the LED.

(4) Turn the lens counterclockwise to remove. Then, turn the lens holder counterclockwise to remove.

(5) Remove the LED and ring from the User Plate.



LED Lamp Installation

(1) LS3-B:
Connect the connector to LED.
Connector: X22

LS6-B:
Connect the X1 and X2 terminals to the LED.
Each terminal must be connected to the same terminal number on the LED.

(2) Put the User Plate between the ring and lens holder, and then secure the LED to the cover.

(3) Mount the lens.

(4) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(5) 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.

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

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

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

NOTE

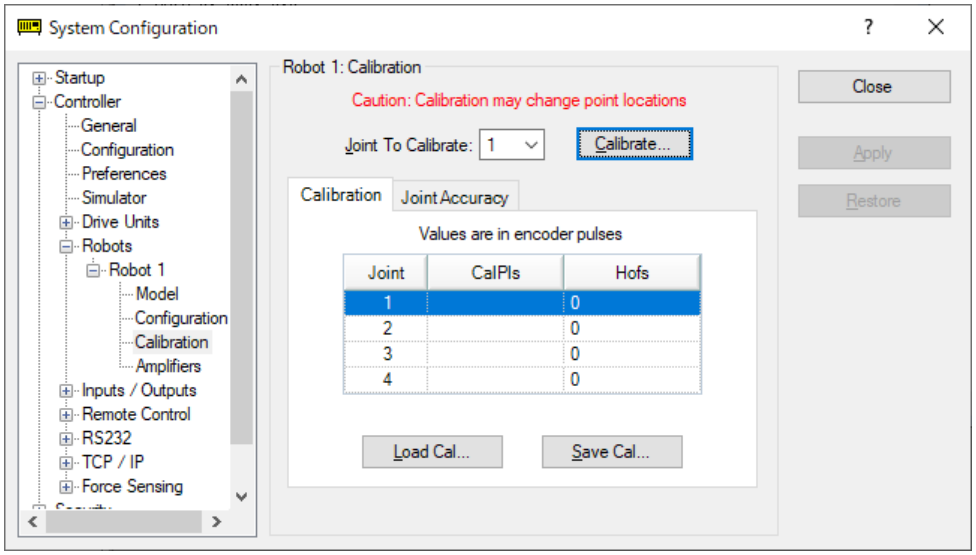
If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *13.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.
The reference point (a point to check the accuracy) needs to be specified for calibration.

(1) Start the calibration wizard.

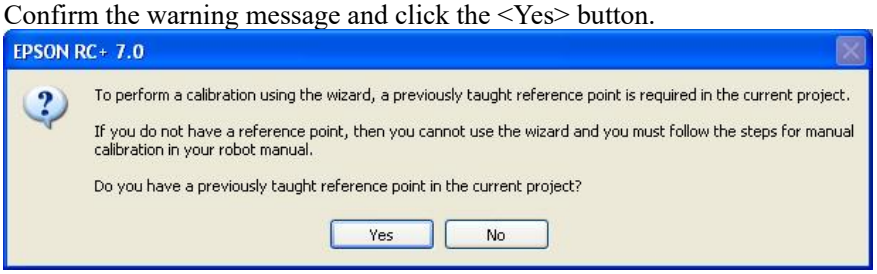
i. Select EPSON RC+ 7.0 menu - [Setup] to display the [System Configuration] dialog.

ii. Select [Robots]-[Robot**] to display [Calibration].

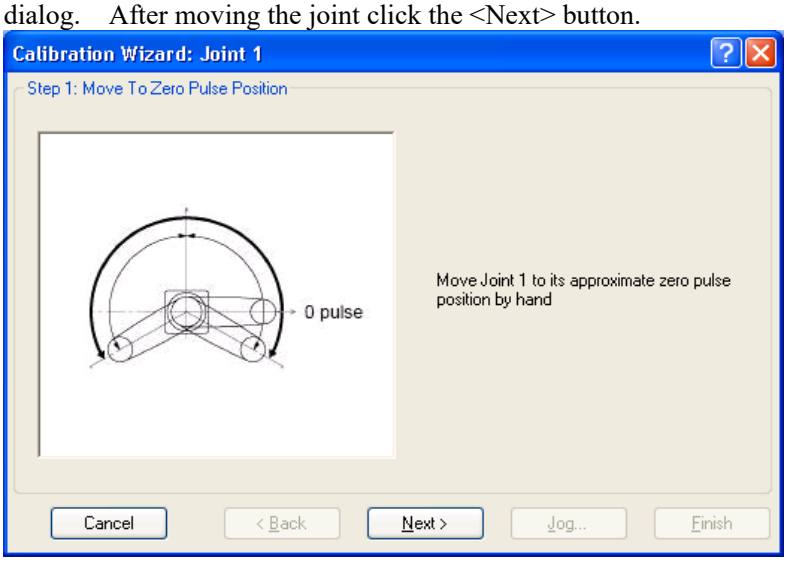
iii. Select the joint and click the <Calibrate…> button.



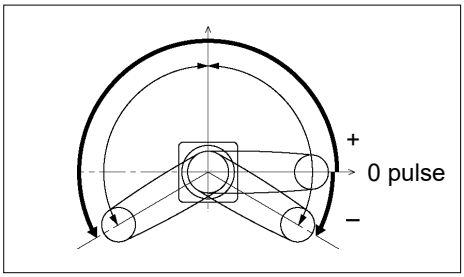
(2) Confirm the warning message and click the <Yes> button.



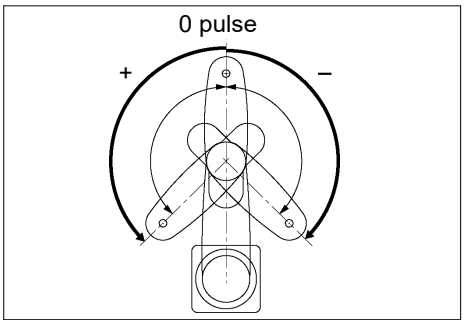
(3) Move the joint to calibrate manually to approximate zero position, as shown in the dialog. After moving the joint click the <Next> button.



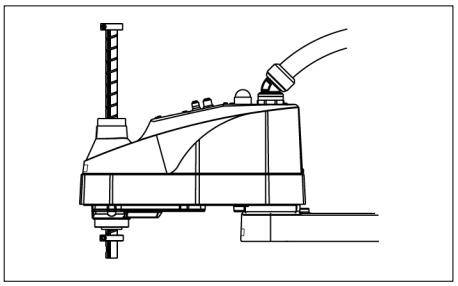
0 pulse position of Joint #1:
position aligned with X-axis in Robot coordinate system



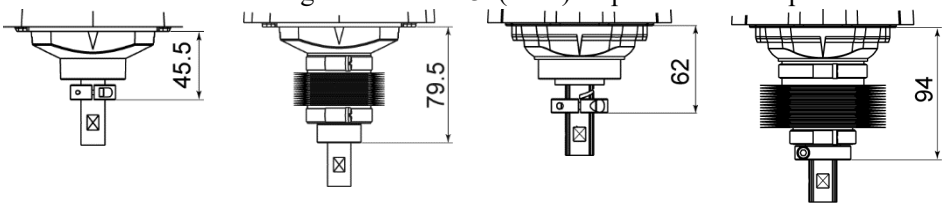
0 pulse position of Joint #2:
position where Arms #1 and #2 are in a straight line
(Regardless of the Joint #1 direction.)



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

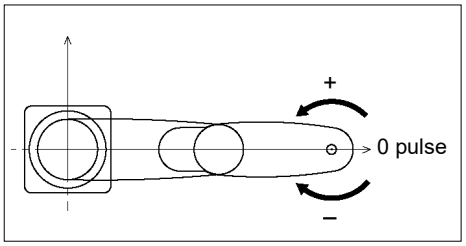


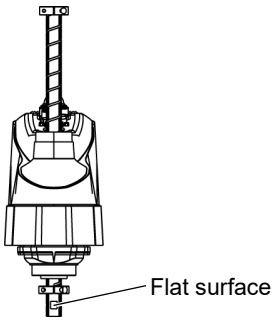
The height of Joint #3 (shaft) depends on manipulator model.



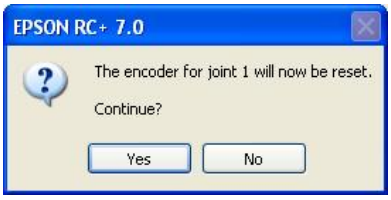
LS3-B401S LS3-B401C LS6-B*02S LS6-B*02C

0 pulse position of Joint #4:
position where the flat surface on the shaft faces toward the tip of Arm #2

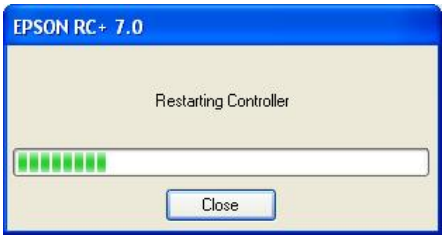




(4) Click the <Yes> button to reset the encoder.

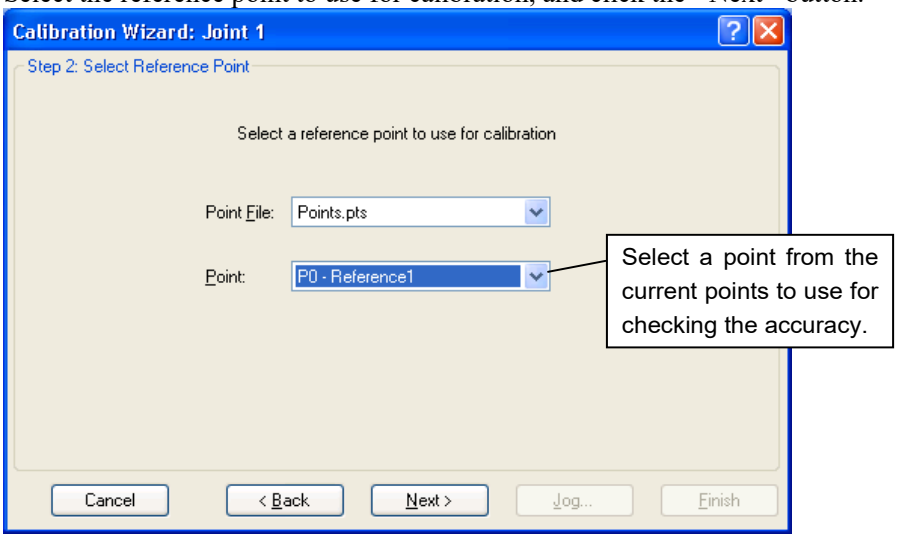


(5) Reboot the Controller.

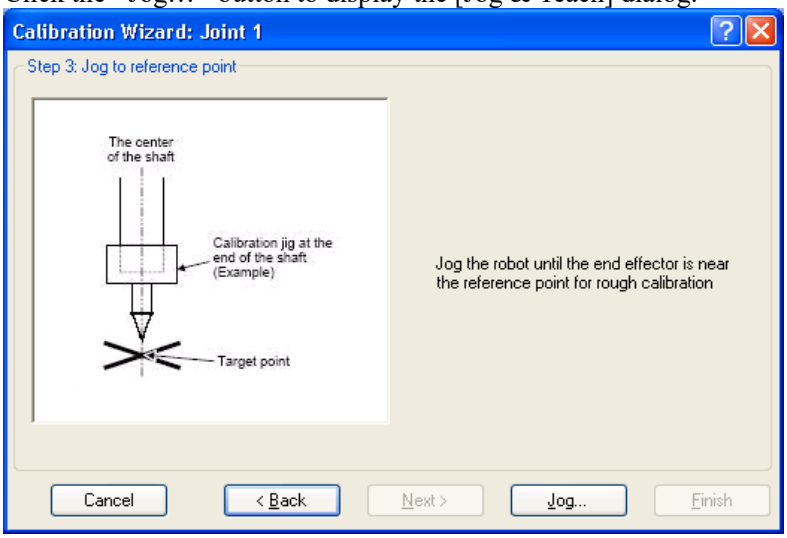


* This window will disappear when the Controller starts up.

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



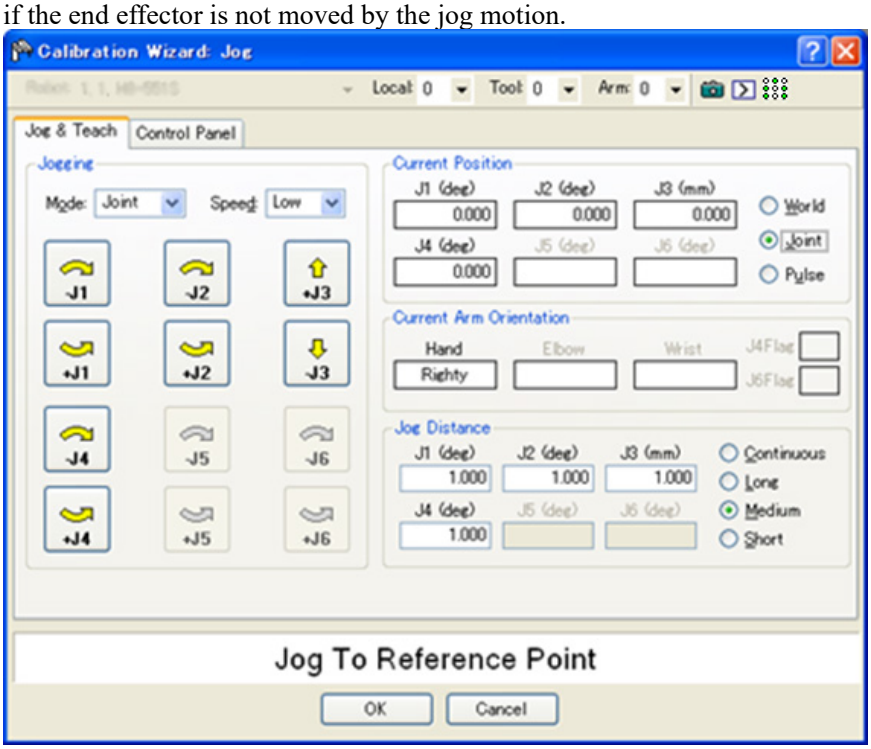
(7) Click the <Jog…> button to display the [Jog & Teach] dialog.



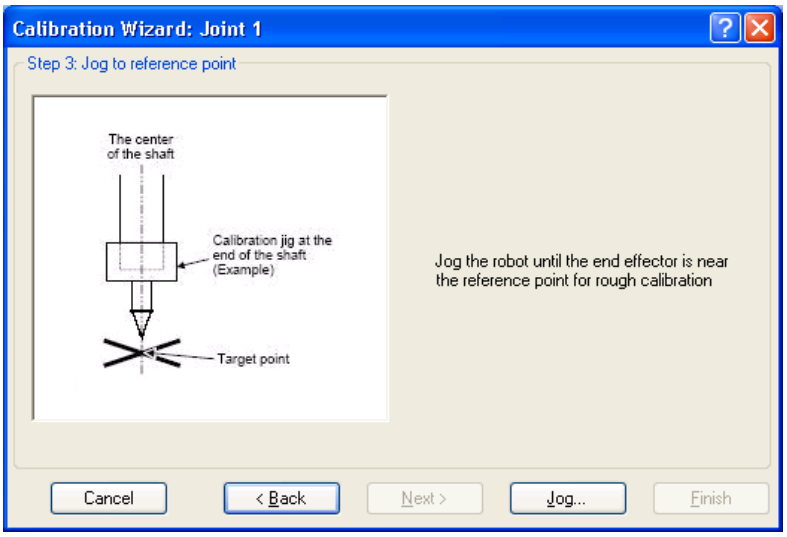
(8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.
Before operating the robot, open the [Control Panel] and click on the <Motor ON> button.

NOTE

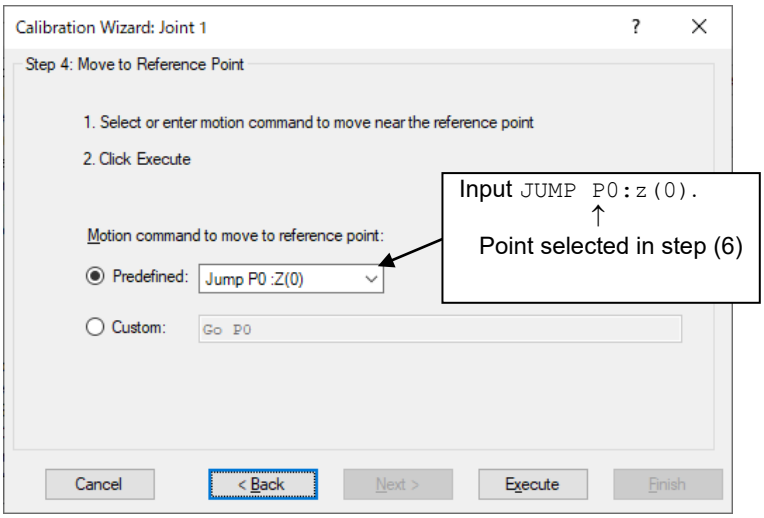

Move the end effector from the zero pulse position to the approximate reference point where rough calibration will be executed at by the jog motion. Position gap may occur if the end effector is not moved by the jog motion.



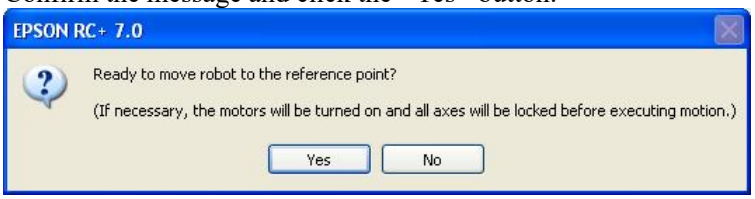
(9) Click the <Next> button.



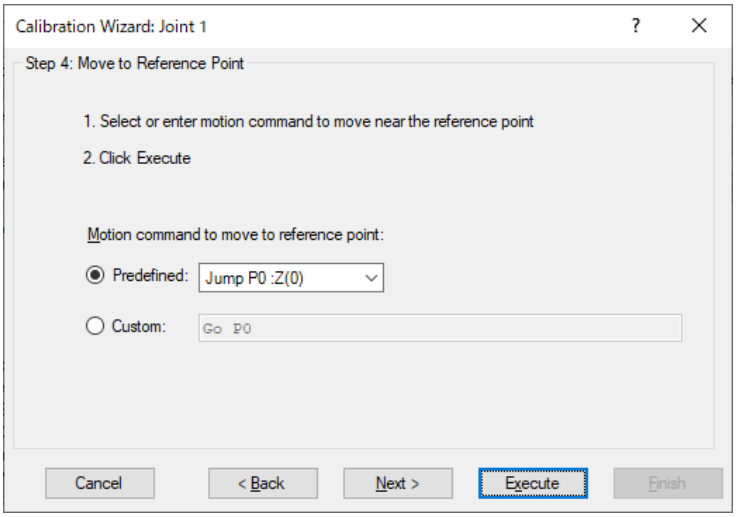
(10) The manipulator moves to the reference point. Click the <Execute> button.



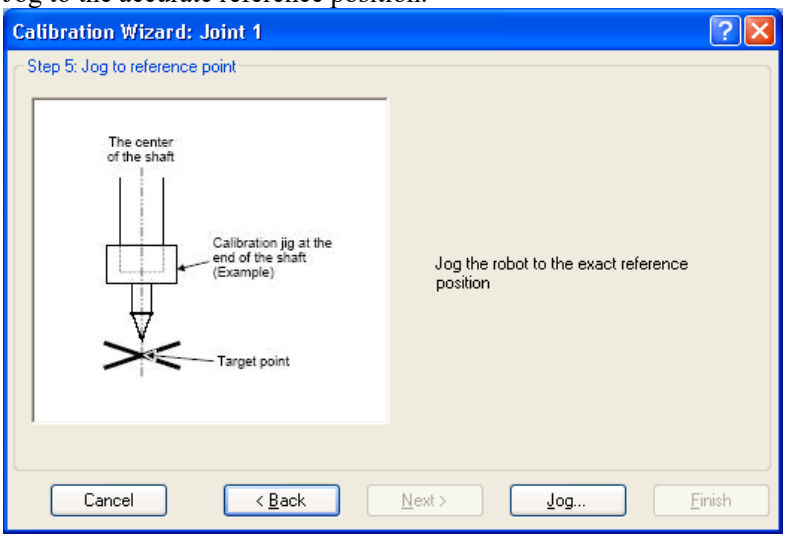
(11) Confirm the message and click the <Yes> button.



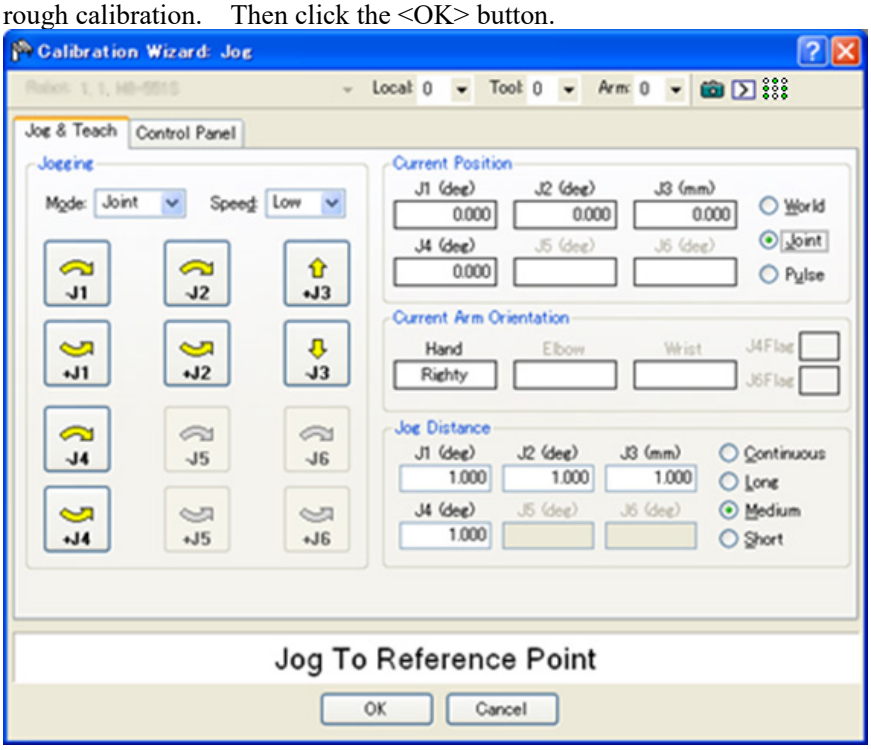
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position.

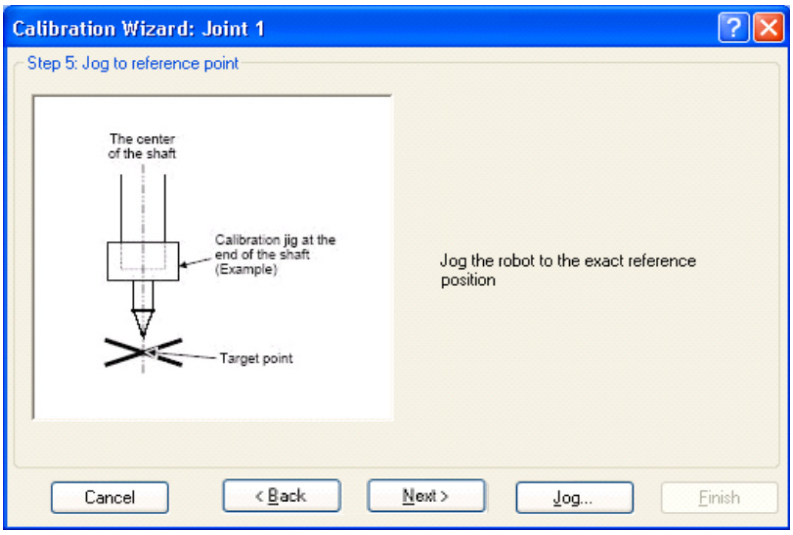


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



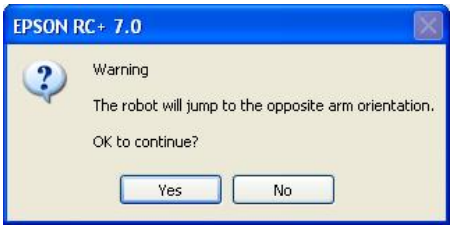
* Position Joint #2 only and move Joint #3 to around 0 pulse.

(15) Click the <Next> button.

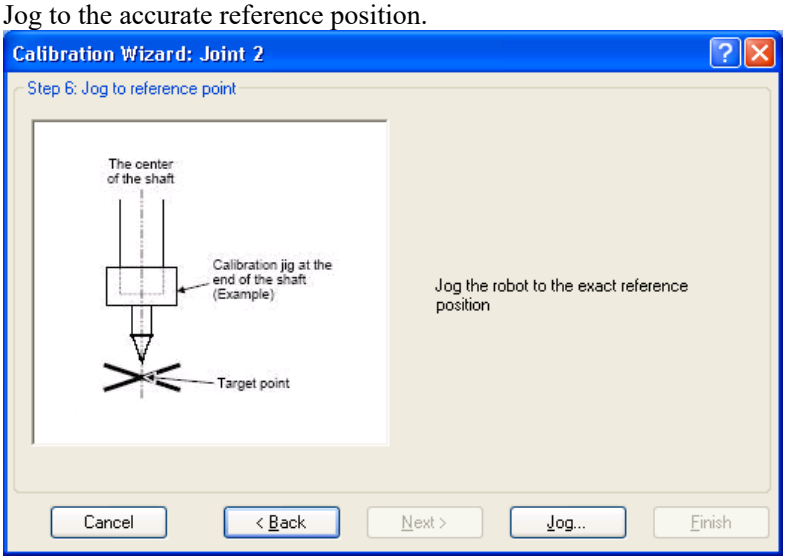


(16) Execute the procedure in "Calibration Using Right / Left Arm Orientations" to accurately calibrate Joint #2.
Go on to the step (17) for the other joints calibration.

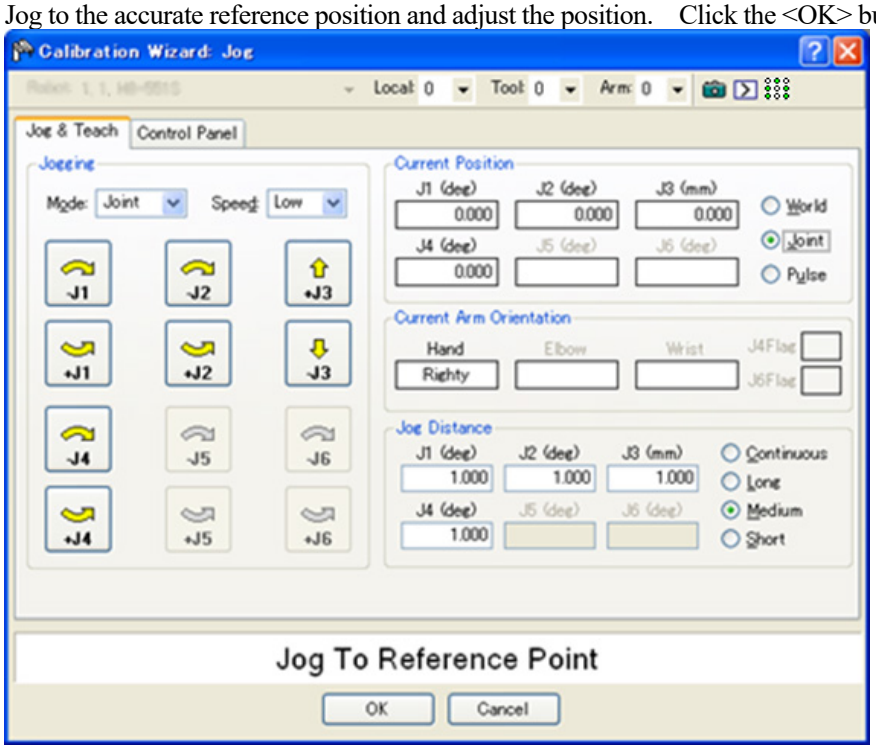
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



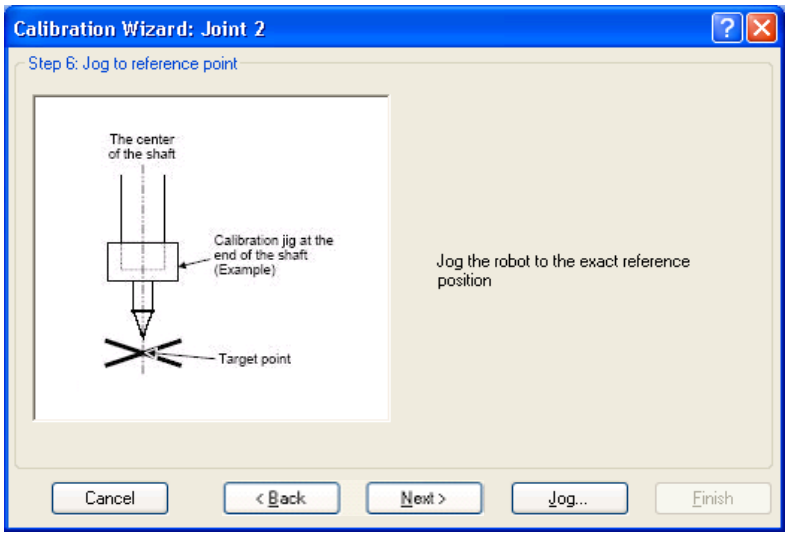
ii. Jog to the accurate reference position.



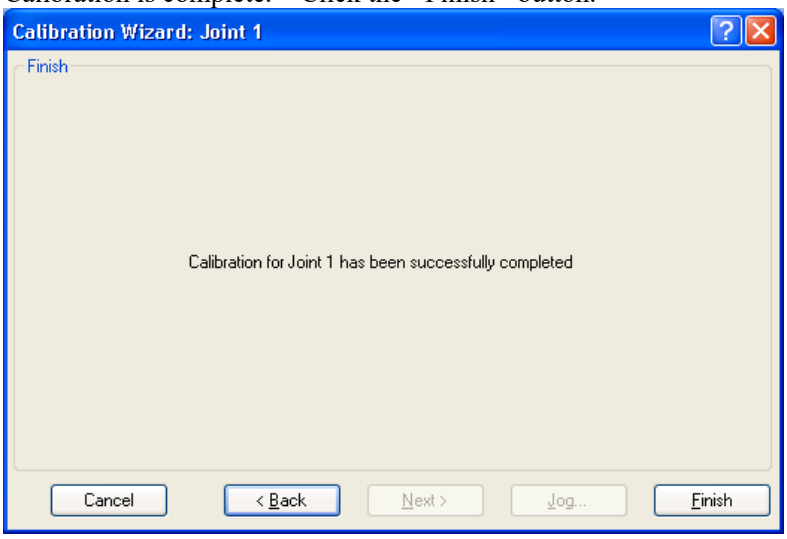
iii. Jog to the accurate reference position and adjust the position. Click the <OK> button.



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.

13.3 Accurate Calibration of Joint #2

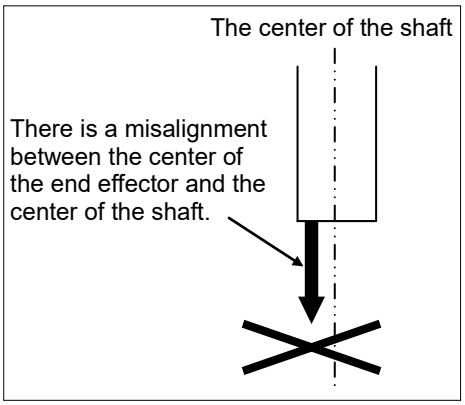
When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.

NOTE

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

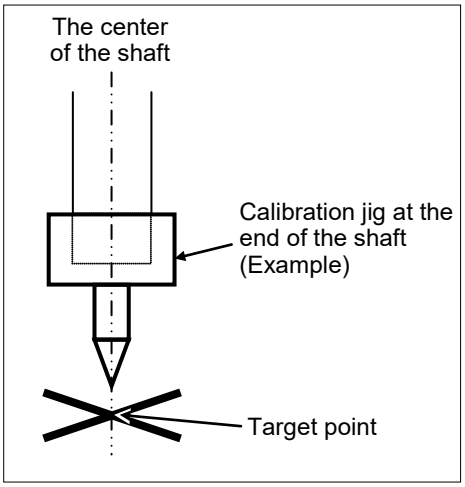
The reference point is the center of the ball screw spline shaft during this calibration.

When there is a misalignment between the center of the end effector and the center of the ball screw spline shaft, remove the end effector and execute 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 executing 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 liner 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 point you can easily verify the accuracy within the work envelop of both right and left arm. Then, check the number of points you want to use.

(2) EPSON RC+ menu-[Tools]-[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 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 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, execute 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

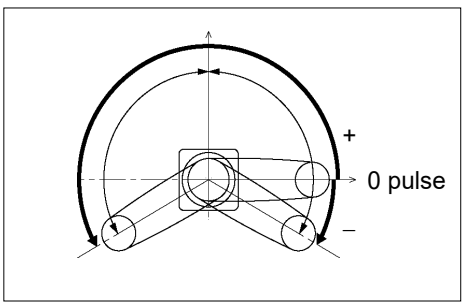
(2)-1 Replace parts as dictated by this manual.
* Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

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

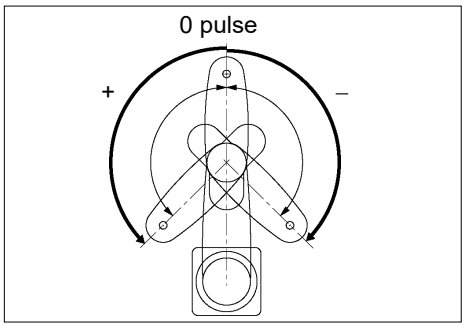
(3)-2 Manually move the joint that needs origin alignment to its approximate 0 pulse position.

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



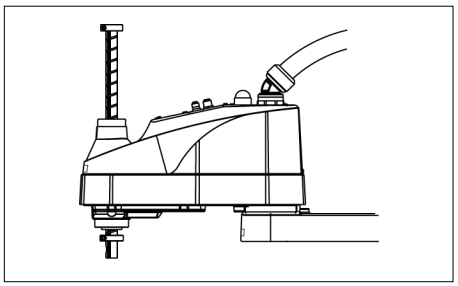
0 pulse position of Joint #2:

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

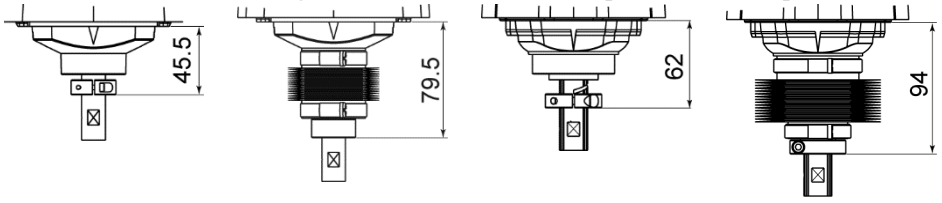


0 pulse position of Joint #3:

upper limit position in motion range



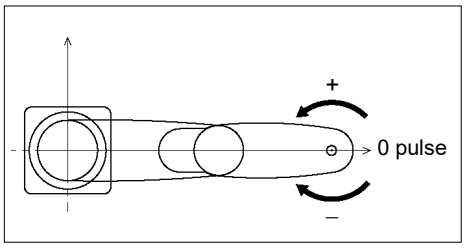
The height of Joint #3 (shaft) depends on manipulator model.

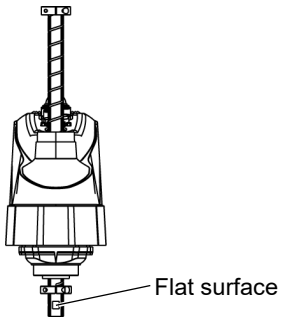


LS3-B401S LS3-B401C LS6-B*02S LS6-B*02C

0 pulse position of Joint #4:

position where the flat surface on the shaft faces toward the tip of Arm #2





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

Select a robot to be calibrated. Input as below in the [Command Window] and execute it.
(This example uses “robot 1”.)

```
> robot 1
```

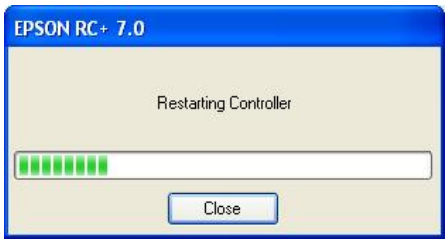
(3)-4 Execute the absolute encoder initialization command.

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

Joint #1: `>EncReset 1`
Joint #2: `>EncReset 2`
Joint #3: `>EncReset 3`
Joint #4: `>EncReset 3, 4`

(3)-5 Reboot the Controller.

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



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

4. Rough Calibration

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

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

* Manipulator does not move.

(4)-2 Execute one of the following commands according to the joint you want to calibrate from the menu-[Tool]-[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 LS3-B

Part Name		Code	Note	Reference	Overhaul *3
Cable Unit	LS3-B401*	2200784		4.1	-
AC Servo Motor	Joint #1	2201471	200 W (with oil seal)	5.1	✓
	Joint #2	2201472	100 W	6.1	✓
	Joint #3	2201472	100 W	7.1	✓
	Joint #4	2201472	100 W	8.1	✓
Reduction Gear Unit *1	Joint #1	1765520		5.2	✓
		1879366	Only for LS3-B401S-V1		
	Joint #2	1587600		6.2	✓
O-ring	Joint #1	1653181	Supplied with Joint #1 reduction gear unit	5.1	-
		1213267	CO0547A		
		1520371	CO0538A		
	Joint #2	1653819	Supplied with Joint #2 reduction gear unit	6.2	-
		1213266	CO0543A		
Timing Belt	Joint #3	1554773	Z	7.2	✓
	Joint #4	1554775	U1	8.2	✓
		1554777	U2		
Electromagnetic brake		1750573	Z	7.3	✓
Brake Release Switch		2117817		-	-
Bellows	LS3-B401C	1513008	*4	9	-
Ball Screw Spline	LS3-B401S	1792117	150 mm	10	✓
	LS3-B401C	1792118	120 mm		
Converter Board		2196970		11.1	-
Control Board		2198655		11.2	-
LED lamp		2198273		12	-
Grease *2	Ball Screw Spline: AFB	-	For purchasing the grease, please contact the supplier of your region.	2.3	-
	Reduction Gear Unit: SK-1A, SK2			5.2, 6.2 6.2	-
Arm Top Cover		1795860	White	3.1	-
Arm Bottom Cover		1769389	Blue	3.1	-
Dust Cover		2014430	For RJ45 connector	-	

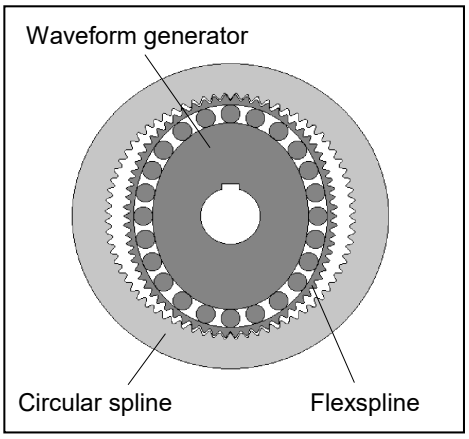
Part Name		Code	Note	Reference	Overhaul *3
M/C Power Cable *5	For fixed wiring	2186054	3 m	4.3	-
		2186055	5 m		
		2186056	10 m		
	For movable wiring	2213020	5 m		
		2213021	10 m		
M/C Signal Cable *5	For fixed wiring	2194703	3 m	4.3	-
		2194704	5 m		
		2194705	10 m		
	For movable wiring	2213018	5 m		
		2213019	10 m		

*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

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.

Splines are greased.　Be careful not to let grease adhere to clothes.

*2 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, SK-2	Harmonic Drive Systems Inc.	https://www.harmonicdrive.net/

*3 Overhaul

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).*

*4 Bellows

The bellows for LS3-B401C are provided in a unit of one piece. The upper and lower bellows have the same shape.

*5 M/C Power Cable, M/C Signal Cable

Select M/C power cable and M/C signal cable with the same specification (For fixed wiring, For movable wiring) and the same length.

If the specification and length are not the same, the robot system may not operate properly.

14.2 LS6-B

Part Name		Code	Note	Reference	Overhaul *3
Cable Unit	LS6-B502*	2196931		4.1	-
	LS6-B602*	2196932			
	LS6-B702*	2196933			
	LS6-B602S-V1	2196932			
Cable Protection Sheet (Only for LS6-B602S-V1)		1617849	30×120mm	4.1	✓
		1622598	30×150mm		
AC Servo Motor	Joint #1	2201471	200 W (with oil seal)	5.1	✓
		2215861	520W (with oil seal) Only for LS6-B602S-V1		
	Joint #2	2197986	200 W (without oil seal)	6.1	✓
		2215862	520W (without oil seal) Only for LS6-B602S-V1		
	Joint #3	2201472	100W	7.1	✓
		2215863	150W Only for LS6-B602S-V1		
	Joint #4	2201472	100W	8.1	✓
		2215864	100W Only for LS6-B602S-V1		
Reduction Gear Unit *1	Joint #1	1750570		5.2	✓
		1765530	Only for LS6-B602S-V1		
	Joint #2	1750571		6.2	✓
		1765520	Only for LS6-B602S-V1		
O-ring	Joint #1	1650901	Supplied with Joint #1 reduction gear unit	5.1	-
		1213266	CO0543A		
		1520371	CO0538A		
		1510528	CO0551A		
	Joint #2	1653181	Supplied with Joint #2 reduction gear unit	6.2	-
		1213267	CO0547A		
Timing Belt	Joint #3	1563316	Z	7.2	✓
	Joint #4	1612286	U1	8.2	✓
		1763573	U2		
Electromagnetic brake		1750573	Z-axis	7.3	✓
		1750573	U-axis	7.4	✓
Brake Release Switch		2117817		-	-
Bellows	LS6-B**2C	1639708	*4	9	-
Ball Screw Spline	LS6-B**2S	1767229	200 mm	10	✓
	LS6-B**2C	1767391	170 mm		
Converter Board		2196970		11.1	-
Control Board		2198655		11.2	-
		2196966	Only for LS6-B602S-V1		
LED lamp		2077258		12	-

Part Name		Code	Note	Reference	Overhaul *3
Grease *2	Ball Screw Spline: AFB	-	For purchasing the grease, please contact the supplier of your region.	2.3	-
	Reduction Gear Unit: SK-1A			5.2, 6.2	-
Arm Cover		1767403	White	3.1	-
Arm Bottom Cover		1763918	Blue	3.1	-
Dust Cover		2014430	For RJ45 connector	-	
M/C Power Cable *5	For fixed wiring	2186054	3 m	4.3	-
		2186055	5 m		
		2186056	10 m		
	For movable wiring	2213020	5 m		
		2213021	10 m		
M/C Signal Cable *5	For fixed wiring	2194703	3 m	4.3	-
		2194704	5 m		
		2194705	10 m		
	For movable wiring	2213018	5 m		
		2213019	10 m		

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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.

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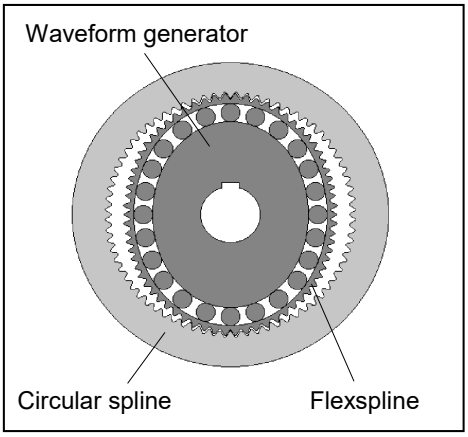

Flexspline

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Circular spline

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*3 Overhaul

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).*

*4 Bellows

The bellows for LS6-B*02C are provided in a unit of two pieces. The shape varies between the upper and lower bellows.

*5 M/C Power Cable, M/C Signal Cable

Select M/C power cable and M/C signal cable with the same specification (For fixed wiring, For movable wiring) and the same length.
If the specification and length are not the same, the robot system may not operate properly.

LS10-B 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 routine maintenance.

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

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

 WARNING	■ To shut off power to the robot system, 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	■ 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	Break for arm #3 to #4	√	√	√	√	√
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, if 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 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

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.
RC90 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].

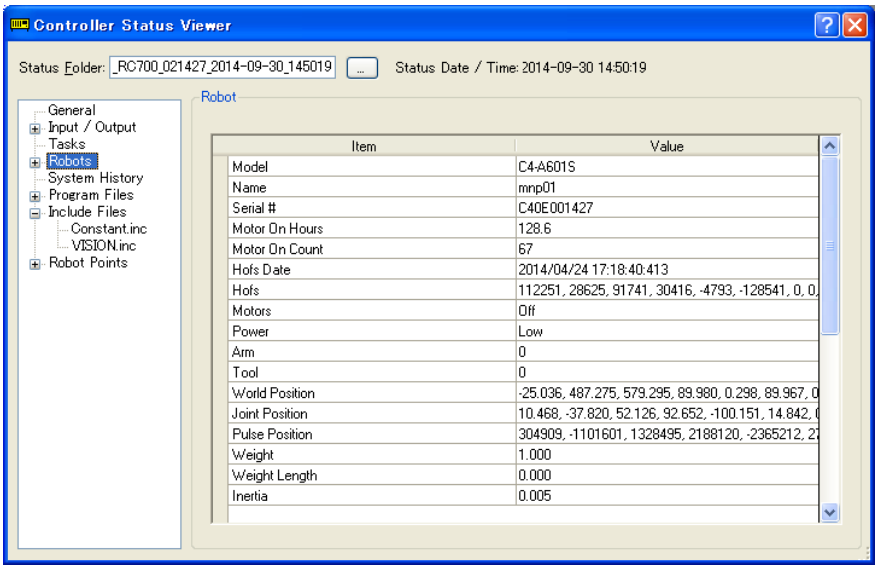
(1) Select EPSON RC+ menu-[Tools]-[Controller] to open the [Controller Tools] dialog.

(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.



For the parts subject to overhaul, refer to *14. 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	■ 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	■ If grease gets into your eyes, mouth, or on your skin, follow the instructions below. If grease gets into your eyes : Flush them thoroughly with clean water, and then see a doctor immediately. If grease gets into your mouth : If swallowed, do not induce vomiting. See a doctor immediately. : If grease just gets into your mouth, wash out your mouth with water thoroughly. If grease gets on your skin : Wash the area thoroughly with soap and water.

	Greasing part	Greasing Interval	Grease	Reference
Joint #1	Reduction gear units	Overhaul timing	SK-1A	*5 Joint #1*
Joint #2			SK-1A	*6 Joint #2*
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 usage condition and degree of the load (such as when operated with the maximum motion speed and maximum acceleration / deceleration in continuous operation) applied on the Manipulator.

Joint #3 Ball screw spline unit

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

Normal grease

Discolored grease

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

NOTE

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.

RC90 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	

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

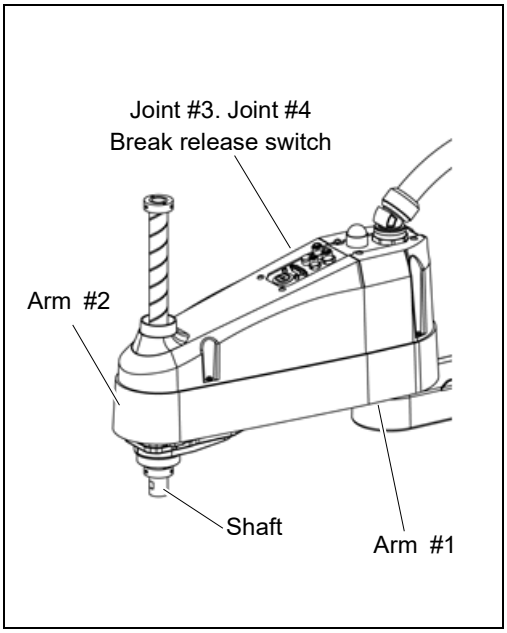
(1) Turn ON the Controller.

(2) Move the shaft to its lower limit in one of the following methods.

- Move the shaft to its lower limit manually while pressing the brake release switch.
- Move the shaft to its lower limit from EPSON RC+ 7.0 [Tools]-[Robot Manager]-[Jog & Teach].

NOTE Make sure that the hand does not interfere with peripheral equipment.

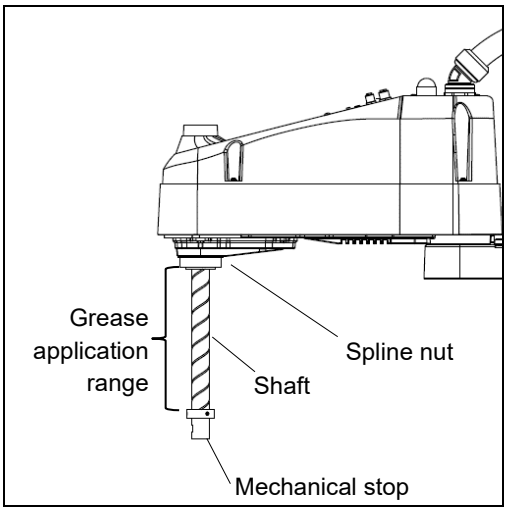
The brake release switch affects both Joints #3 and #4. When the brake release switch is pressed, the brakes for both Joints #3 and #4 are released simultaneously.



(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.

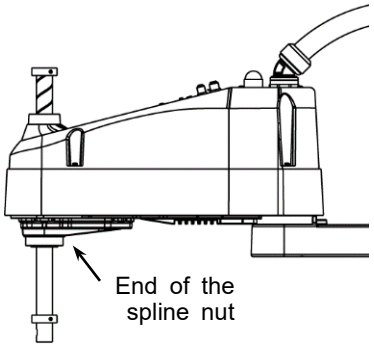
Grease application example

(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.



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.

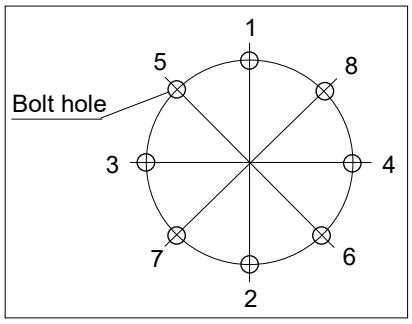
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

Bolt	Tightening Torque
M2.5	1.4 ± 0.1 N·m (14 ± 1 kgf·cm)
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.

Bolt	Tightening Torque
M3	0.7 ± 0.1 N·m (7.1 ± 1 kgf·cm)
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+

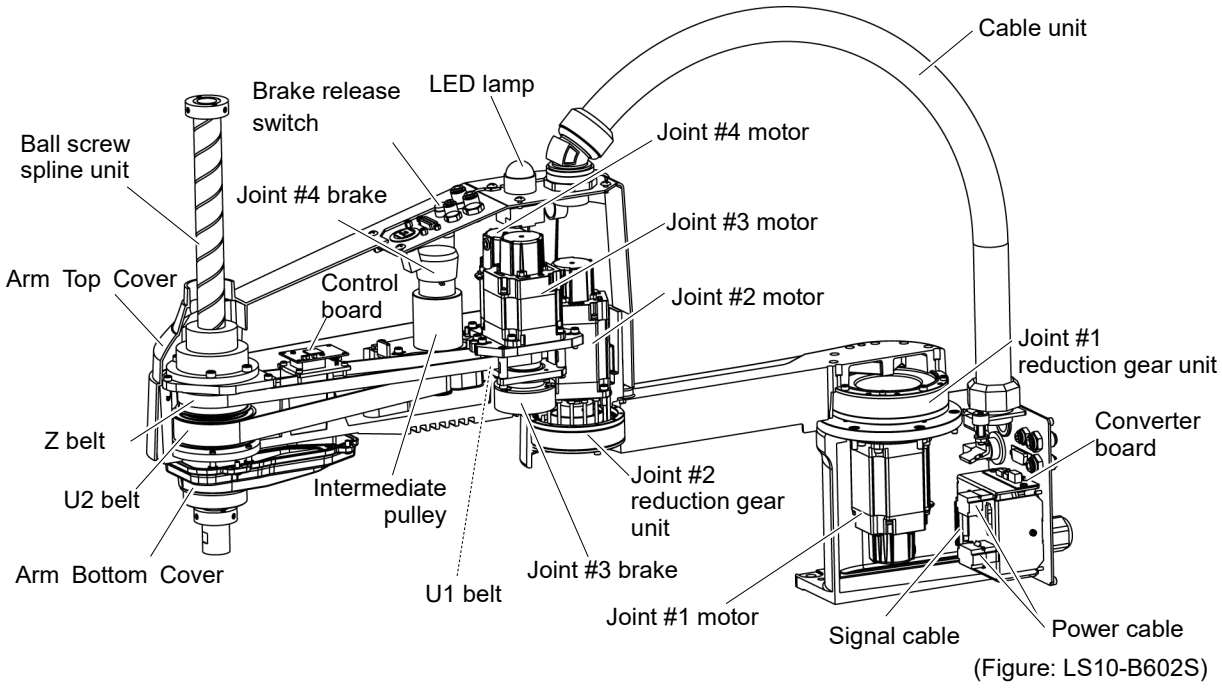
Execute the following command from the [Command Window].

```
>PULSE
```

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

2.6 Layout of Maintenance Parts

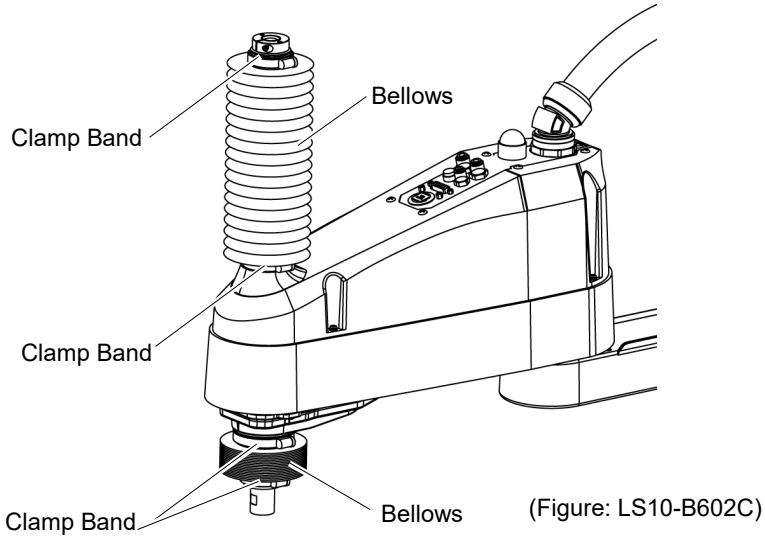
Standard-model



(Figure: LS10-B602S)

Cleanroom-model (with optional bellows)

For the Cleanroom-model, the following parts are added to the Standard-model.

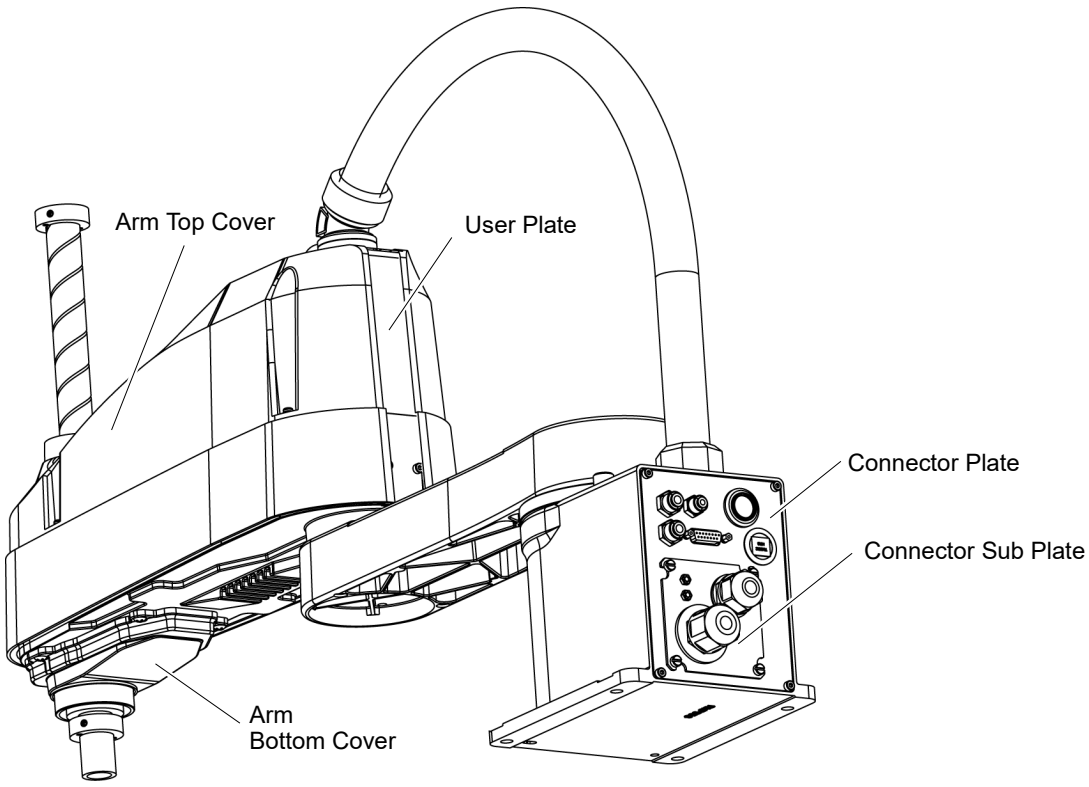


(Figure: LS10-B602C)

3. Covers

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

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. ■ 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.



(Figure: LS10-B702S)

3.1 Arm Top Cover

CAUTION

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

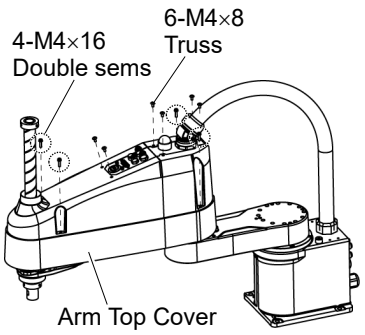
Arm Top Cover Removal

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*.

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



Arm Top Cover Installation

Put the arm top cover to the arm and secure with the Arm Top Cover mounting bolts.
After securing the Arm Top Cover, make sure that the lower limit mechanical stop is not touching the cylindrical part of the Arm Top Cover.

NOTE

When bellows are installed to the manipulator, install the Arm Top Cover and then set the upper bellows. For bellows installation, refer to *9. Bellows*.

3.2 Arm Bottom Cover

Unscrew the Arm Bottom Cover mounting bolts and then remove the cover.

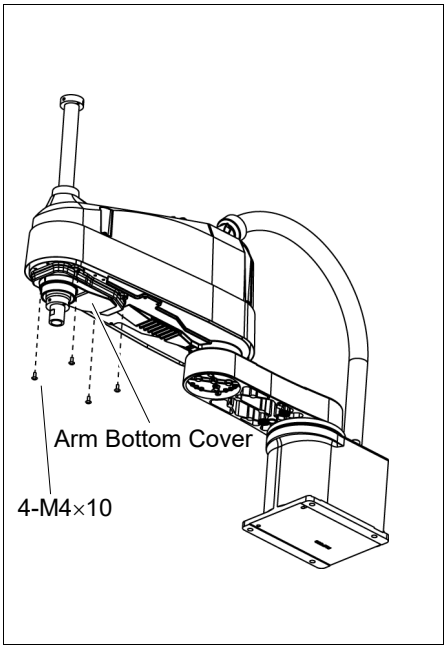
NOTE

Be careful of the end effector. When the end effector is installed, the Arm Bottom Cover may not be removed from the shaft.

When you replace the ball screw spline unit, you need to remove the end effector to remove the Arm Bottom Cover completely.

When you can work (maintenance, inspection) without removing the cover completely, move the shaft to the lower limit and lower the Arm Bottom Cover.

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*.

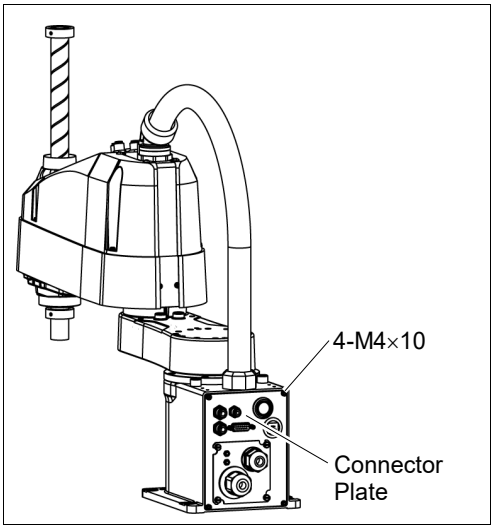


3.3 Connector Plate

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 mounting 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.

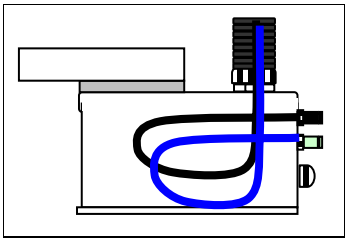


NOTE

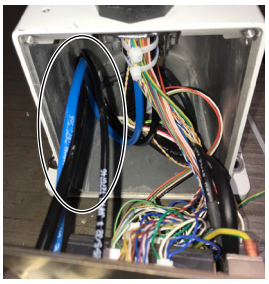
When mounting the Connector Plate, be careful of the following.

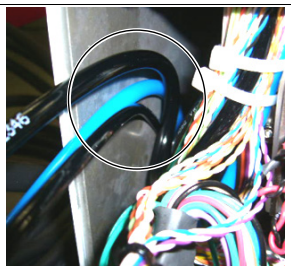
Prevent the air tube from bending sharply inside the manipulator. Also, do not block the air flow.

If there is a kink in the air tube, air flow is blocked while the manipulator is operating and may cause a trouble.

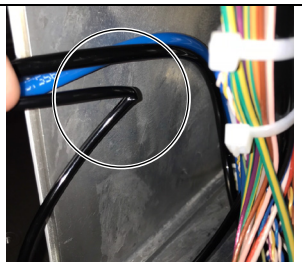


Put the air tube along the left side wall as shown in the picture.





GOOD: Curved



BAD: Bended

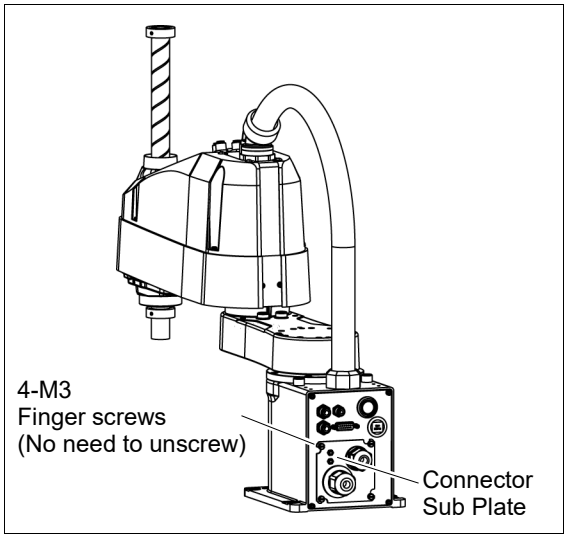
3.4 Connector Sub Plate

CAUTION

- 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 mounting 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.

Refer to
LS-B series Manual – LS10-B Manipulator 3.6 Connecting the Cables.

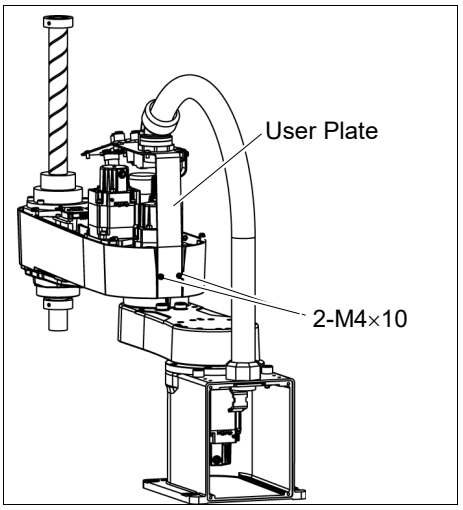


3.5 User Plate

User Plate Removal

(1) Remove the Arm Top Cover.
Refer to *3.1 Arm Top Cover*.

(2) Unscrew the User Plate mounting bolts and remove the plate.



User Plate Installation

(1) Put the User Plate to the arm and secure using the mounting bolts.
(2) Mount the Arm Top Cover.
Refer to *3.1 Arm Top Cover*.

4. Cable

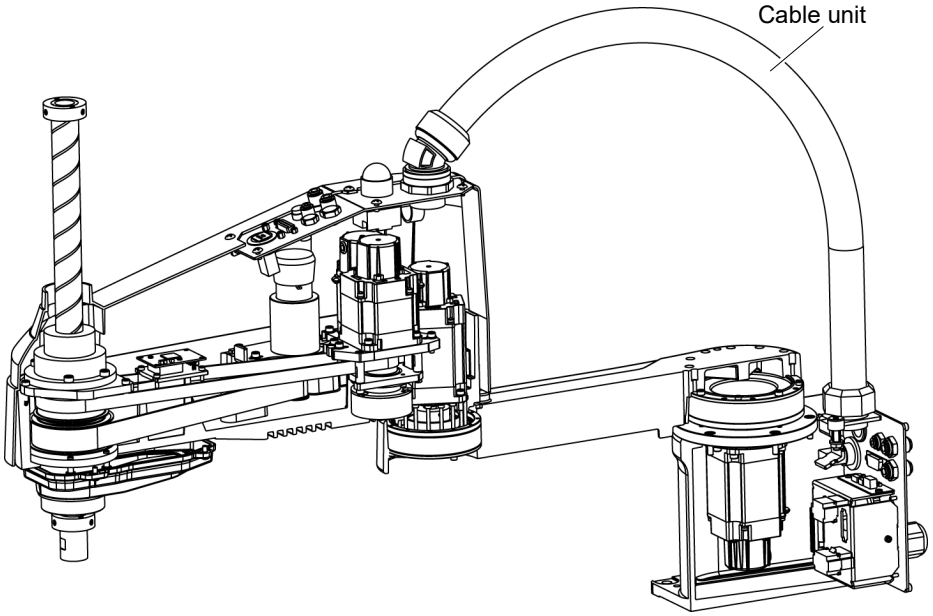
 WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in 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. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

 CAUTION	■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.

4.1 Replacing Cable Unit

NOTE LS10-B series manipulator does not have batteries. Position data is memorized by the motor. When replacing cables, calibration is not necessary.

	Name		Qty.	Note
Maintenance parts	Cable unit		1	LS10-B60** : 2196931 LS10-B70** : 2196932 LS10-B80** : 2196933
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
	Torque wrench		1	
	Nippers		1	For cutting wire tie
Material	Wire tie		-	



(Figure: LS10-B602S)

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 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.

NOTE

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

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

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.

NOTE

The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 Connector Sub Plate from the Connector Plate.

For details, refer to *3.4 Connector Sub Plate*

(5) Disconnect M/C cable.

For details, refer to *LS-B series Manual -LS10-B Manipulator 3.6 Connecting the Cables - Connect and disconnect M/C cable.*

(6) Remove the Connector Plate.

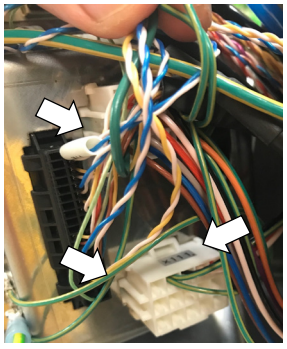
For details, refer to 3.3 Connector Plate.

(7) Remove the following that connected to the (inside) of the Connector Plate and Connector Sub Plate.

Air tube
D-sub cable
Ethernet cable (RJ45)
Connectors
: X11, X111, X121, CV11, CV12, CV13

NOTE

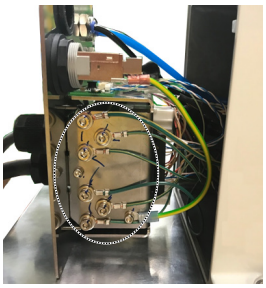
For connectors fixed on the mount base, disconnect by holding the clip.



(8) Cut off the two wire ties binding the cables on the base side cable fixing plate.

(9) Remove the seven ground wires that secured on the mount base.

Be careful not to lose the spacer which holding the ground wires.



(10) Cut off the wire tie binding the cables in the Base side.

(11) Remove the Arm Top Cover.

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

(12) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(13) Disconnect 10 connectors on the Arm side.

Connectors: X22, X33,X42, X43, X44, X51, BR, X221, X231, X241

(14) Disconnect two connectors inside the Base.

Connectors: X41, X211

(15) Disconnect the D-sub cable, air tube, and Ethernet cable (RJ45) 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 fittings to pull out the air tube. (ø6×2, ø4×1)
Remember the cable layout for reconnecting the disconnected parts after replacement.

(16) Remove the two ground wires from the User Plate.

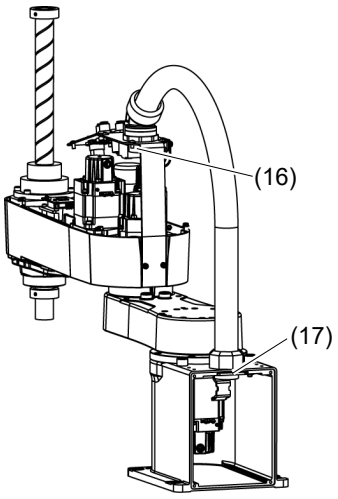
NOTE

Unscrew the cable clamp binding the cables in the Arm side and remove it and protection sheet.

(17) Be careful not to lose the cable clamp, protection sheet, and fixed screws.

(18) The nut secures the cable duct fittings to the User Plate. Rotate the nut to remove it, and pull out the cables from the User Plate.

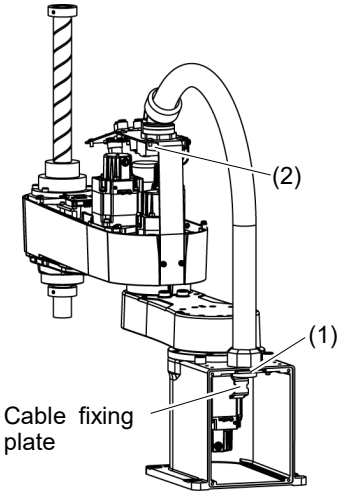
(19) Rotate the cable duct fittings to remove the nut that secures to the Base, and pull out the cables from the Base.



Cable Unit Installation

(1) Pass the new cables through the Base, cable fixing plate, and nut. Then, rotate the fittings to secure the cables.

(2) Pass the cables in the User Plate side through the User Plate and nut and turn the nut to secure the cables.



(3) As with the wire tie cut off at the removal step (8), bind the cables with a new wire tie.

(4) Connect two connectors inside the Base.

Connectors: X41, X211

(5) Connect the following to mount base and the Connector Plate.

Air tube, D-sub cable, Ethernet cable (RJ45)
Connectors: X11, X111, X121, CV11, CV12, CV13

(6) Connect the ground wire on the Base side to the mount base.

(7) Connect the air tube, D-sub cable, and Ethernet cable (RJ45) to the User Plate.

(8) Fix the ground wire on the User Plate.

(9) Mount the User Plate.

For the details, refer to *3.5 User Plate*.

(10) Connect the connectors.

Connectors: X22, X33,X42, X43, X44, X51, BR, X221, X231, X241

(11) As with the wire tie cut off at the removal step (15), bind the cables with a new wire tie.

(12) Mount the Connector Plate.

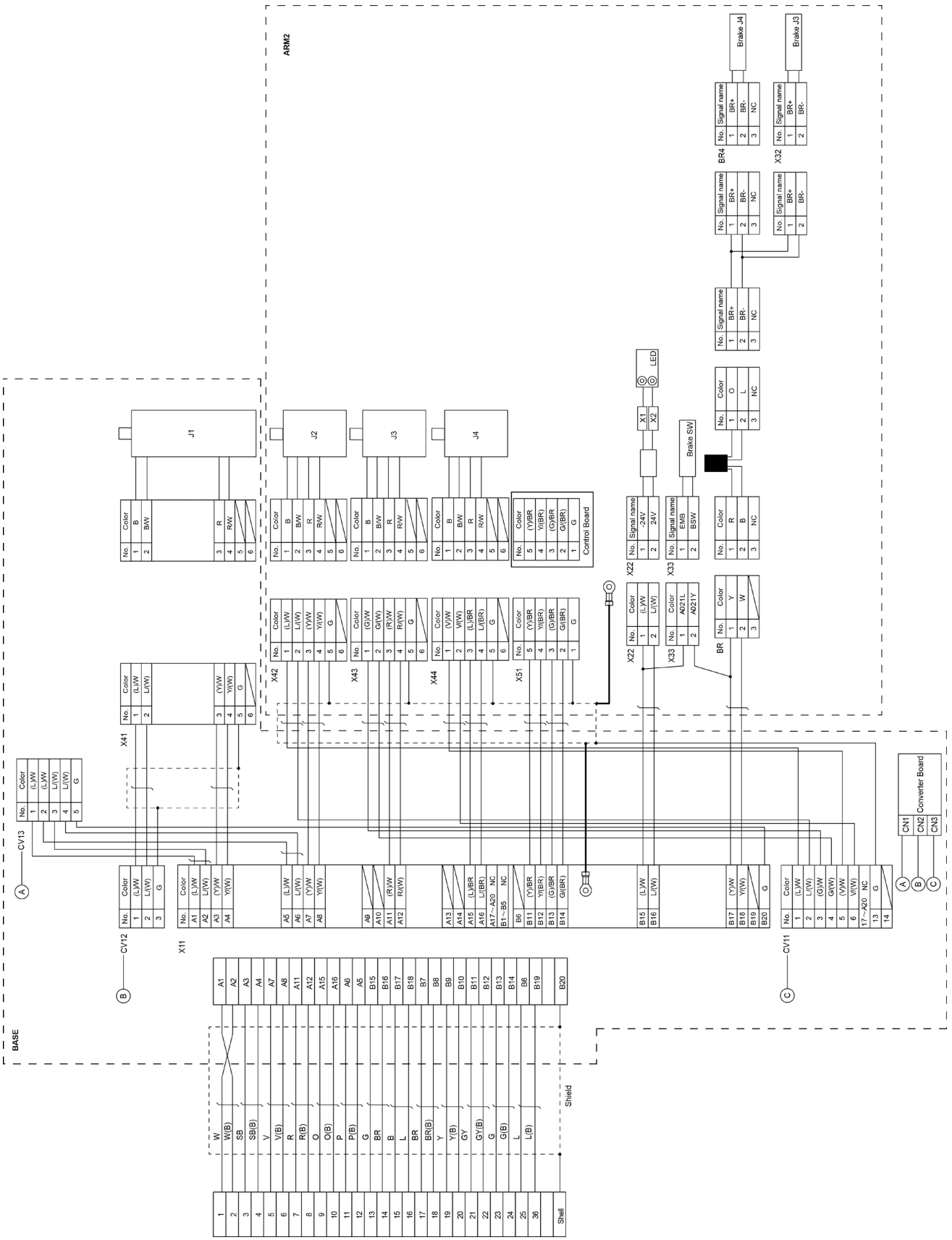
For the details, refer to *3.3 Connector Plate.*

(13) Place and secure the Arm Top Cover without the cables being stuck.

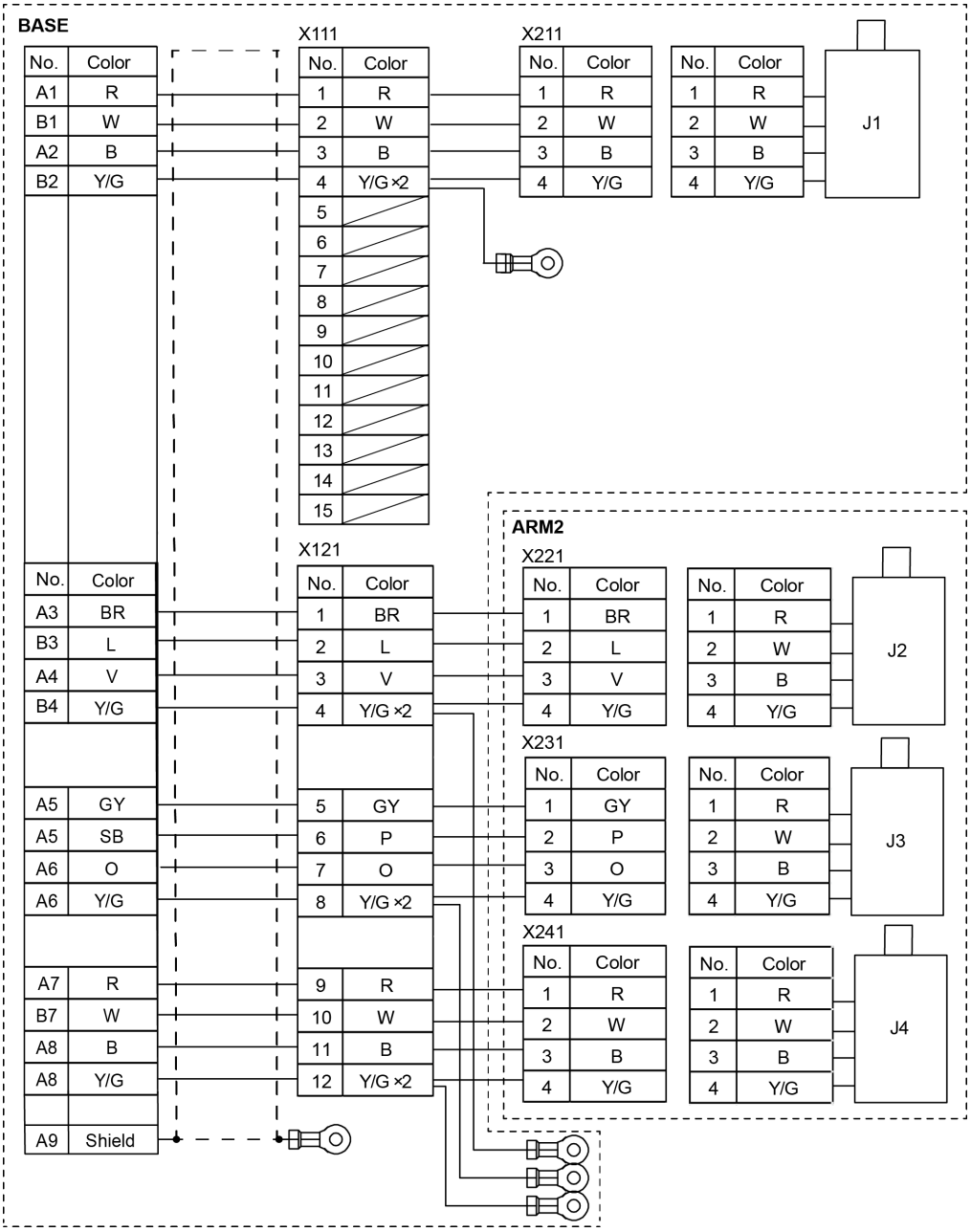
For details, refer to *3.1 Arm Top Cover*.

4.2 Wiring Diagrams

4.2.1 Signal Cable

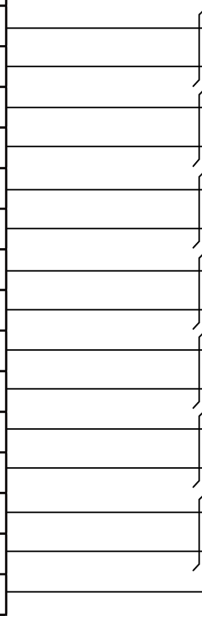


4.2.2 Power Cable



4.2.3 User Cable

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



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

4.2.4 Color of Cables

The following table shows the codes and cable colors indicated in the pin assignments.

4.2.1 Signal Cable

4.2.2 Power Cable

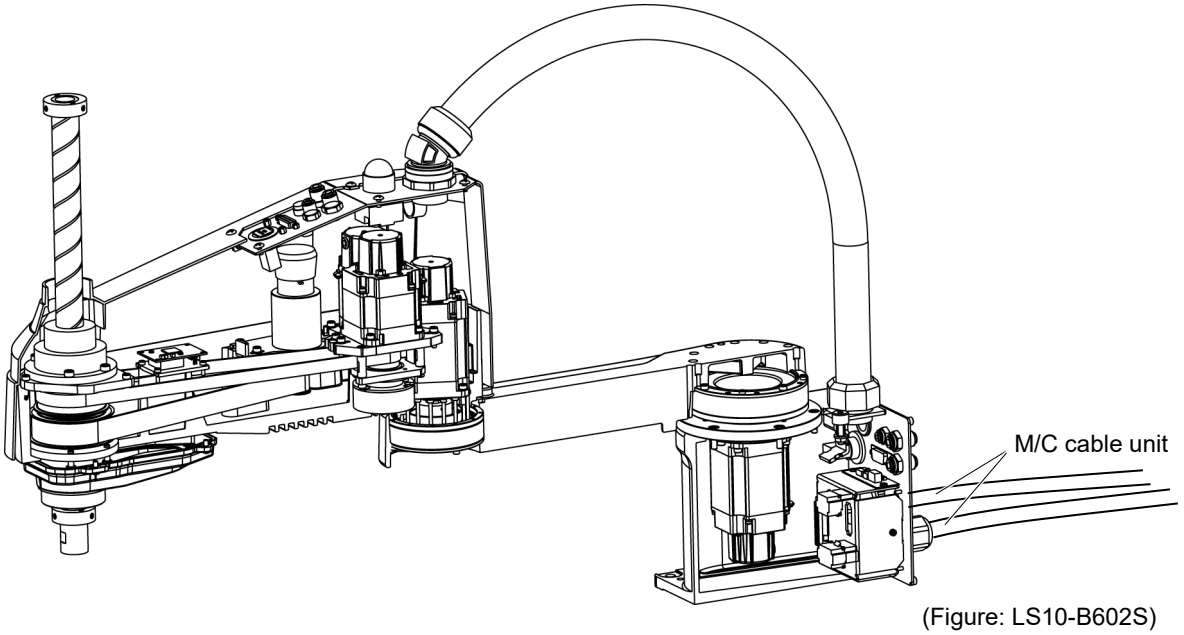
4.2.3 User Cable

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

4.3 Replacing M/C Cable

NOTE LS10-B series manipulator does not have batteries. Position data is memorized by the motor. When replacing cables, calibration is not necessary.

	Name		Qty.	Note
Maintenance parts	M/C cable unit	For fixed wiring	1	3 m: R12NZ9010B 5 m: R12NZ9010C 10 m: R12NZ9010D
		For movable wiring	1	5 m: R12NZ90159 10 m: R12NZ9015A
Tools	Flathead screwdriver		1	
	Torque wrench		1	



(Figure: LS10-B602S)

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 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.

CAUTION	■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.

M/C Cable Removal

(1) Turn OFF the Controller.

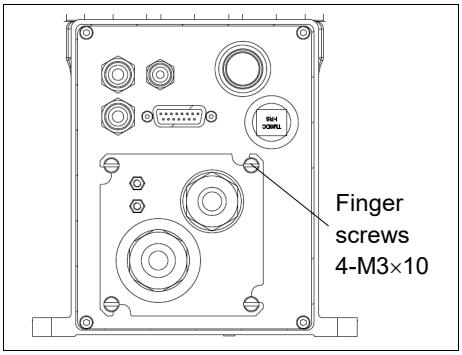
(2) Disconnect the following connectors form the controller.

Power cable connector Signal cable connector

(3) Loosen the screws fixing the plate.

You do not need to remove them completely.

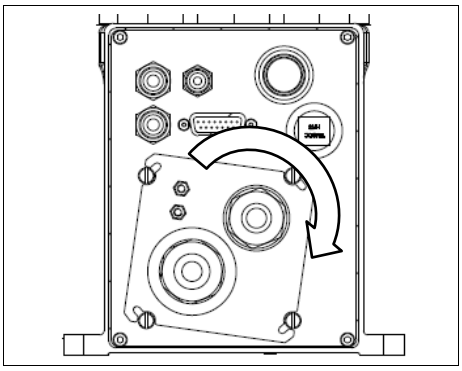
For details, refer to *3.3 Connector Plate*.



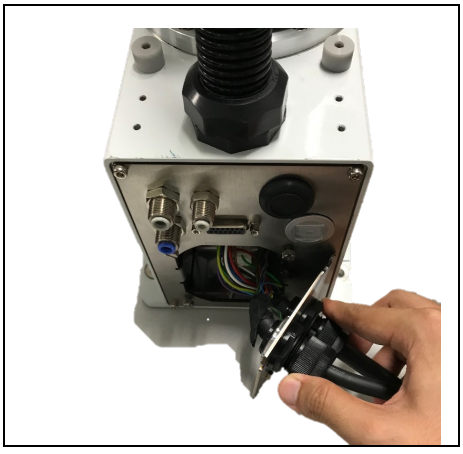
NOTE

(4) Slide the plate to remove it from the base.

Do not pull the M/C cable after removing the plate. M/C cables are connected by the connectors. Doing so may result in disconnection of the cables.

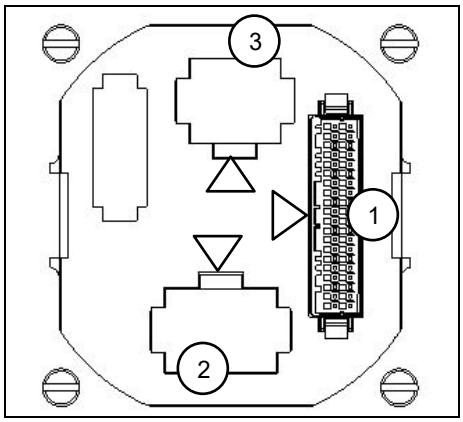


(5) As shown on the right, pull out the cables from the Manipulator.



(6) Disconnect the connectors in the order as shown on the right.

Clips of the connectors are△ positions in the figure.
Push the clip to disconnect the connector.



NOTE

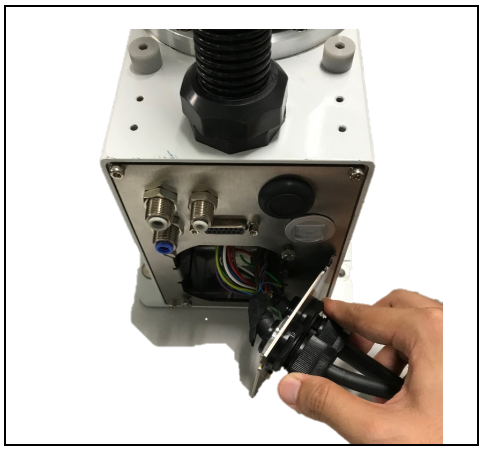
Connector (white) for the power cable is difficult to disconnect for safety purpose.
To disconnect the connector, securely push the clip.
If you cannot disconnect it, push the connector once, and then disconnect it by pushing the clip.

Do not pull the cables. Doing so may result in disconnection.

Do not remove the M/C cable form the plate.

M/C cable Installation

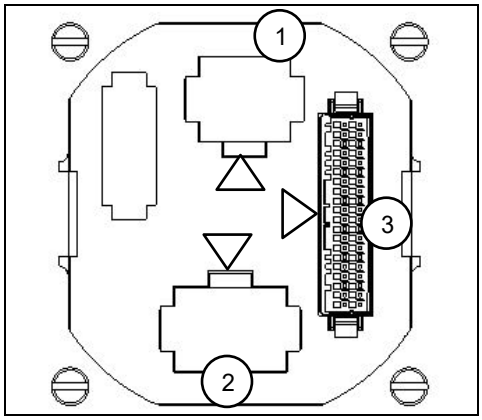
(1) Set the M/C cable as shown on the right.



NOTE

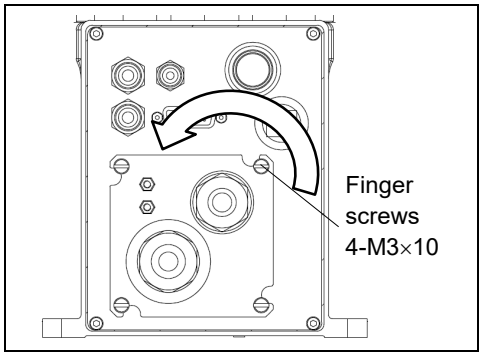
Be careful not to set the plate in wrong direction.

(2) Connect the connectors in the order as shown on the right.



(3) Slide the plate to install it.

Finger screws : 4-M3×10
Tightening torque : 0.6±0.1 N·m



NOTE

Slide the plate until it will be parallel to the base table.

Be careful not to tighten the screws with the cables get caught on the plate.

(4) Connect the following connectors to the controller.

Power cable connector Signal cable connector

(5) Turn ON the Controller.

Direction of the connector sub plate

When installing the plate, be careful for the direction.
Correct direction: When the arrow of warning label of electric shock is the same direction as the illustration on the right.
If the plate is installed in wrong direction, the cables inside the Manipulator will be twisted and may result in disconnection.

Correct: Cables are not twisted

Wrong: Cables are twisted

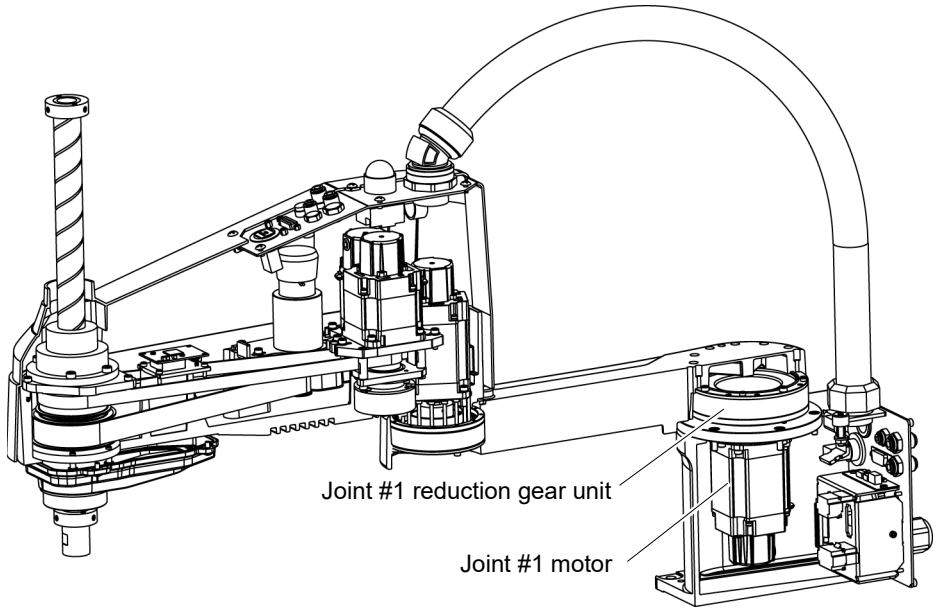
5. Joint #1

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.

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



5.1 Replacing Joint #1 Motor

	Name		Qty.	Note
Maintenance parts	AC Servo Motor 520W		1	2197984 (with oil seal)
	O-ring		1	1213266 (CO0543A)
			1	1520371 (CO0538A)
			1	1510528 (CO0551A)
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	
	Wiping cloth		1	For wiping grease
Grease	Grease (SK-1A)		-	-

Joint #1 motor Removal

(1) Remove the Connector Plate.

For details, refer to *3.3 Connector Plate*.

(2) Disconnect the connector.

Connectors: X41, X211 (Hold the clip to remove.)

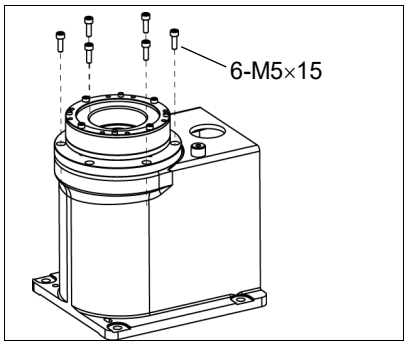
(3) Remove the Arm #1 mounting bolt in the Joint #1 side and remove the arm.

There is an O-ring (CO0551A) between the Joint #1 unit and the arm. Be sure to keep the O-ring.

(4) Remove the screws mounting the Joint #1 flange on the Base.

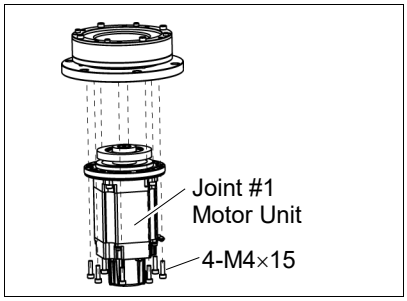
(5) Hold up the Joint #1 unit and remove it from the base.

Be careful not to damage the motor cable by getting it caught on the base.



(6) Loosen the motor mounting screws on the Joint #1 motor flange and remove the motor unit

There is an O-ring in the assembly position of the motor flange and Joint #1 flange.
Be careful not to lose the O-ring.

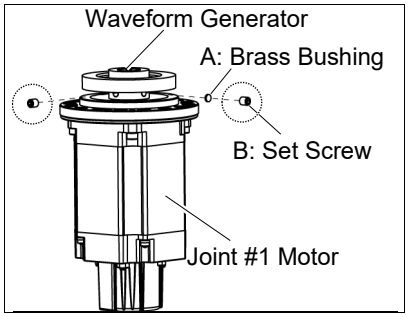


(7) Remove the waveform generator from the Joint #1 motor.

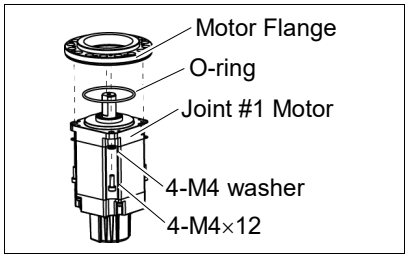
There is a brass bushing in one of the set screw holes. Be careful not to lose the bushing.

A: Brass Bushing : M5

B: Set Screw : 2-M5×6



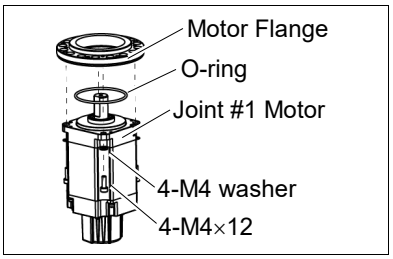
(8) Remove the motor mounting screws to remove the motor flange and O-ring (CO0538A).



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

Joint #1 motor Installation

(1) Set the O-ring (CO0538A) on the motor mounting surface and mount the motor flange.



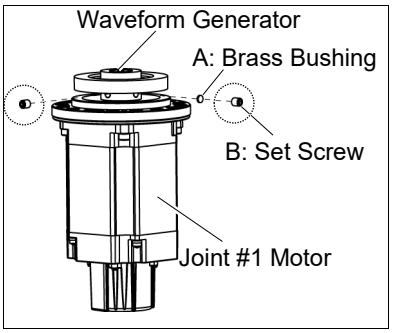
(2) Apply grease (SK-1A) to the between the waveform generator and motor.

Grease volume : 13 g

Mount the waveform generator on the Joint #1 motor.

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

Tighten one of the set screws vertically on the flat face of the motor shaft. Insert a bushing into the other set screw hole to prevent damage to the motor shaft.



A: Brass Bushing : M5

B: Set Screw : 2-M5×6

CAUTION

■ See the figure 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) Set an O-ring (CO0538A) on the motor flange and assemble the motor with the Joint #1 flange.

To insert the motor, turn it slowly from side to side by hand and push in.

(4) Mount the Joint #1 unit on the Base.

Secure the Joint #1 motor cables facing toward the back of the Base.

(5) Set the O-ring (CO0538A) removed in the removal step (3) into the O-ring groove of the arm. Then, mount the arm to the Joint #1 unit.

(6) Connect the connectors.

Connectors: X41, X211

(7) Mount the Connector Plate.

For details, refer to *3.3 Connector Plate*.

(8) Check if the Joint #1 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #1 moves, the connector for the other joint might be connected to the Joint #1 motor. Check the connector connection.

(9) Execute the calibration for the 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. 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 *14. Maintenance Parts List*.

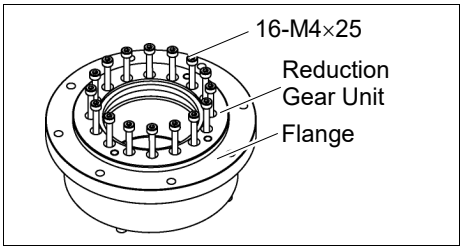
	Name		Qty.	Note
Maintenance Parts	Reduction Gear Unit		1	1765530
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench		1	
	Nippers		1	
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Flange)
			1	For wiping grease (Bolt)
	Screw (M4)		2	About 20 mm in length For flexspline removal
Grease	Grease (SK-1A)		-	-

Joint #1 Reduction Gear Unit Removal

(1) Remove the Joint #1 motor unit.

Follow the removal steps in *5.1 Replacing Joint #1 Motor*.

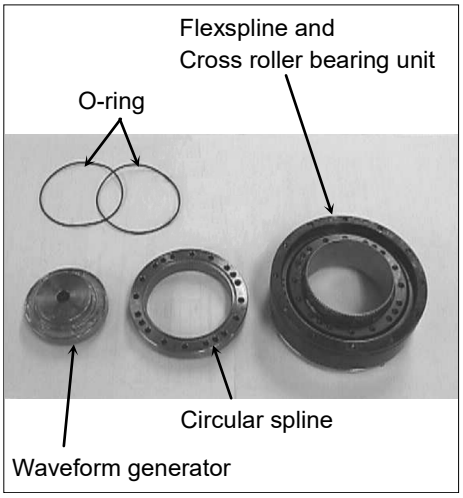
(2) Remove the reduction gear unit from the Joint #1 flange.



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.

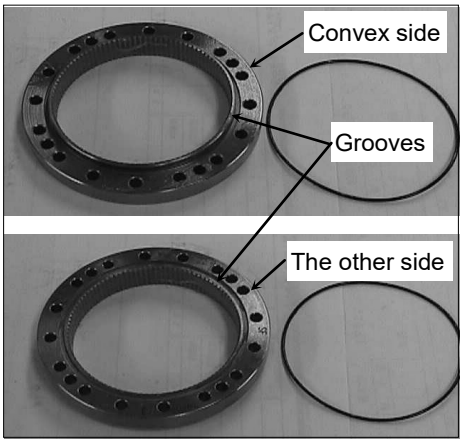
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



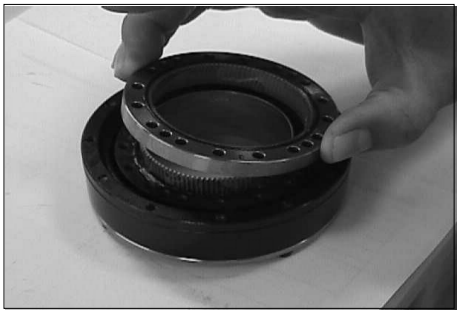
CAUTION	■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

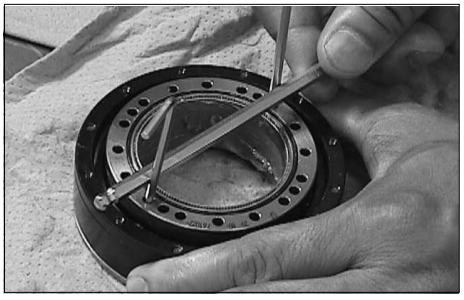
Make sure that the rings do not come out of the grooves.



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

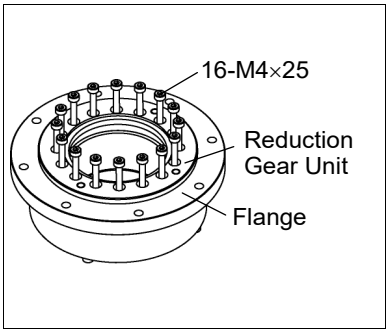


(4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



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

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



Item	Bolt type	Bolts	Tightening torque
Joint #1 reduction gear unit	M4×25	16	5.4 N·m (55 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 : 37 g

(7) Mount the Joint #1 motor.

Follow the installation steps in *5.1 Replacing Joint #1 Motor*.

6. Joint #2

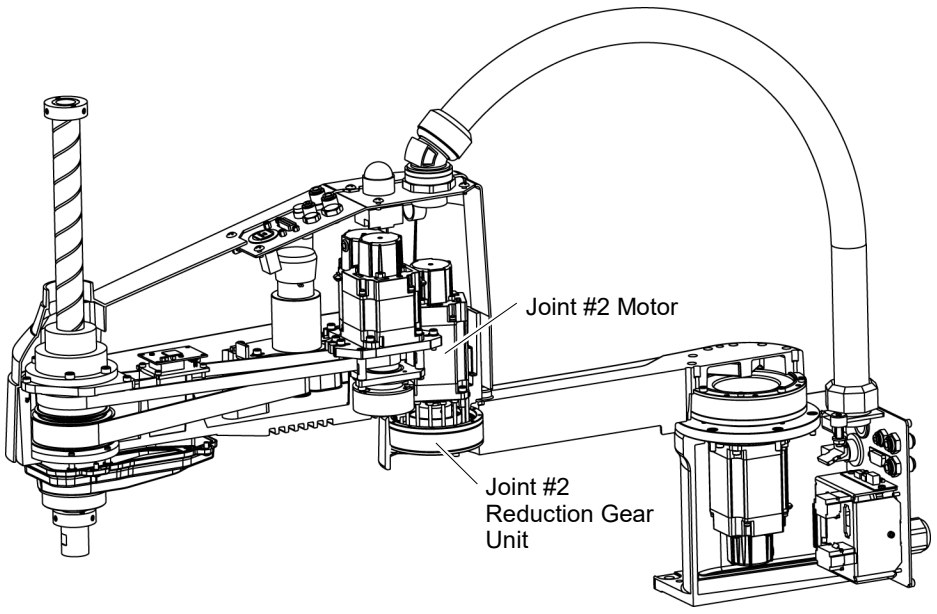
WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in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

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



6.1 Replacing Joint #2 Motor

	Name		Qty.	Note
Maintenance Parts	AC Servo Motor	520 W	1	2197985 (without oil seal)
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
	Wiping cloth		1	For wiping grease
Material	Wire tie		-	
Grease	Grease	SK-1A	-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(6) Cut off the wire tie binding the cables.

Do not cut the other wire ties.

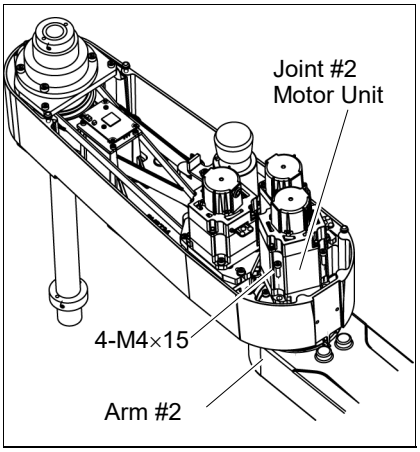
(7) Disconnect the connectors.

Connectors: X221, X42 (Hold the clip to remove.)

(8) Remove the screws mounting the motor unit and then remove the Joint #2 motor unit from the Arm #2.

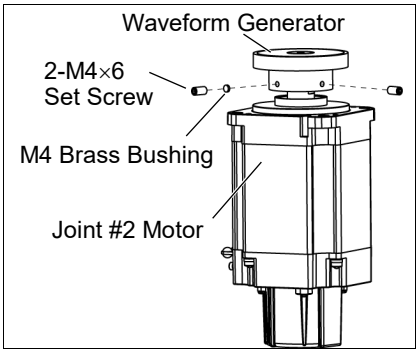
Motor mounting screw 4-M4×15

To pull out the motor smoothly, move the Arm #2 slowly by hand while pulling the motor.



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

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



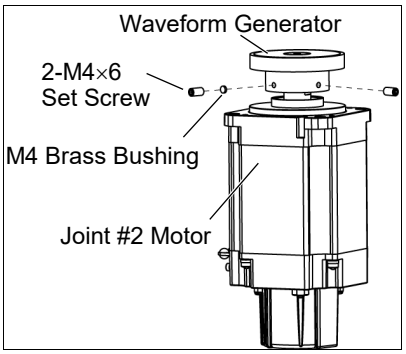
NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #2 Motor Installation

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

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

Tighten one of the set screws vertically on the flat face of the motor shaft. Insert a bushing into the other set screw hole to prevent damage to the motor shaft.



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.

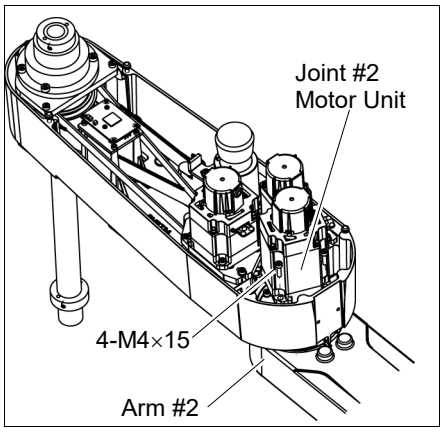
(2) Apply grease between the waveform generator and motor flange.

Grease volume 6 g (SK-1A)

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

To insert the motor, slowly move the Arm #2 by hand and push in.

Motor mounting screw 4-M4×15



(4) Mount the User Plate.

For details, refer to *3.5 User Plate*.

(5) Connect the connectors.

Connectors: X221, X42.

(6) Bind the cables with a wire tie in their original positions as before removed in the removal step (6).

Do not allow unnecessary strain on the cables.

(7) Mount the Arm Top Cover.

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

(8) Check if the Joint #2 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #2 moves, the connector for the other joint might be connected to the Joint #2 motor. Check the connector connection.

(9) Execute the calibration for 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. When replacing the reduction gear unit, be sure to always replace the following parts all together as one set.

Waveform generator, Flexspline, Circular spline

For details of the three parts, refer to *14. Maintenance parts list*.

	Name		Qty.	Note
Maintenance parts	Reduction Gear Unit		1	1765520
	O-ring		1	1213267 (CO0547A)
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
	Torque wrench		1	
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Flange)
			1	For wiping grease (Bolt)
	Screw (M3) Length about 20 mm		2	For removing the flexspline
Material	Wire tie		-	
Grease	Grease	SK-1A	-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 waveform generator from the Joint #2 motor.

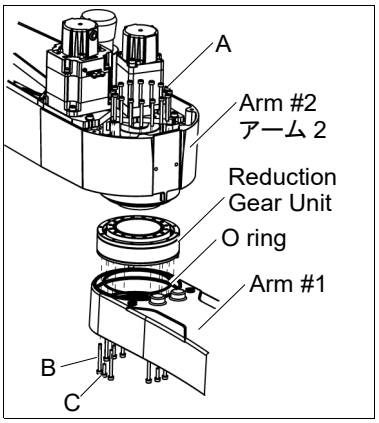
Follow the removal steps in *6.1 Replacing Joint #2 Motor*.

(5) Remove the Arm #2 by removing the screws mounting the Arm #2 on the reduction gear unit.

A: 16-M3×28

B: 8-M3×32+8-M3 small washer

C: 4-M3×12+4-M3 small washer

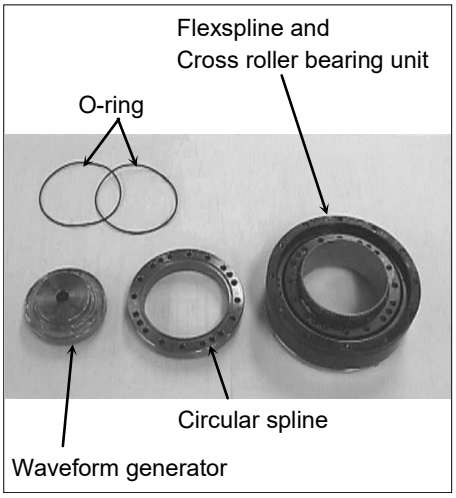


(6) Remove the reduction gear unit from the Arm #1 by removing the screws that mounts the reduction gear unit on the Arm #1.
There is an O-ring between the Arm #1 and the reduction gear unit.
Be careful not to lose the removed O-ring.

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.

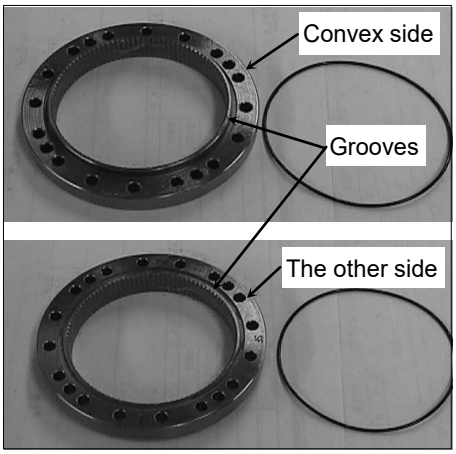
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



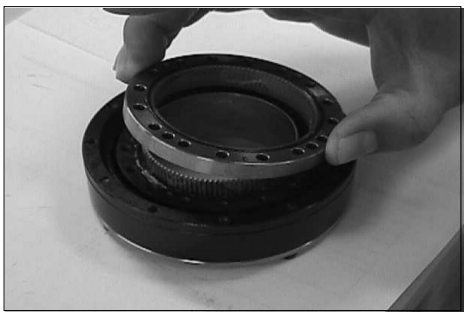
CAUTION	■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

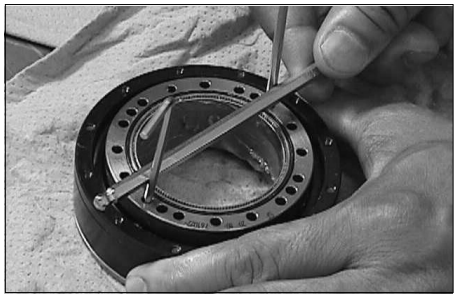
Make sure that the rings do not come out of the grooves.



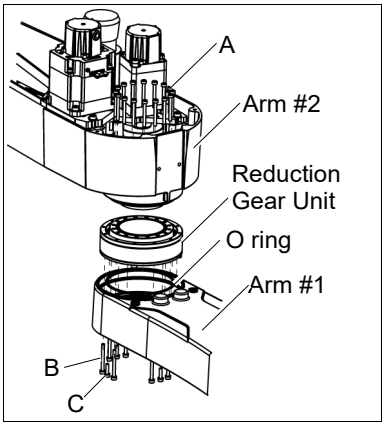
(3) Face the convex side of the circular spline down, and then fit it into the flexspline.



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



(5) Set the O-ring removed in the removal step (6) into the O-ring groove of the Arm #1.



NOTE

If the O-ring is not fit into the groove, please use another O-ring which is prepared as maintenance part.

Install the flexspline on the Arm #1.

A: 16-M3×28

B: 8-M3×32+8-M3 small washer

C: 4-M3×12+4-M3 small washer

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	Tightening torque
Joint #2 reduction gear unit	M3	2.35 N·m (24 kgf·cm)

NOTE

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

(6) Apply grease between the motor flange and waveform generator and next inside the flexspline.

Between the motor flange and waveform generator:

Grease volume 6 g (SK-1A)

Inside the flexspline:

Grease volume 16 g (SK-1A)

(7) Set the attached O-ring into the O-ring groove of the circular spline.

Secure the Arm #2 on the circular spline.

(8) Mount and Joint #2 motor.

Follow the installation steps in *6.1 Replacing Joint #2 Motor*.

7. Joint #3

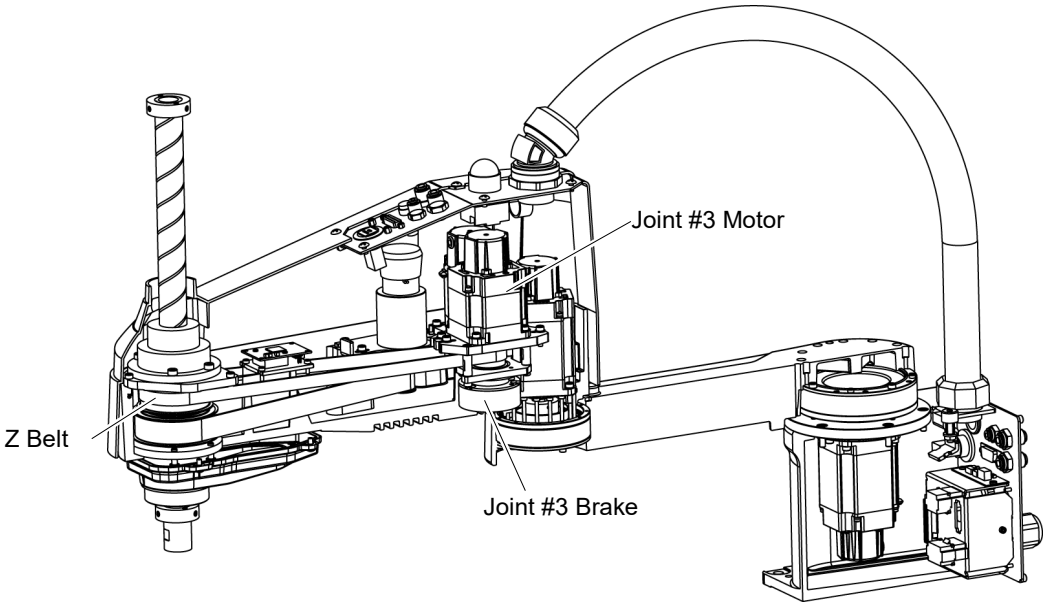
WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in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

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



7.1 Replacing Joint #3 Motor

	Name		Qty.	Note
Maintenance parts	AC Servo Motor 200W		1	2197986
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 4 mm	1	For M5 screw
	Spanner	width across flats: 7 mm		For M4 bolt, M4 nut
	Torque wrench			
	Nippers		1	For cutting wire tie
	Sonic tension meter		1	Z: Belt tension 69N (7.0 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 binding the Joint #3 motor cables.

Do not cut off the other wire ties that do not relate with removal of the User Plate.

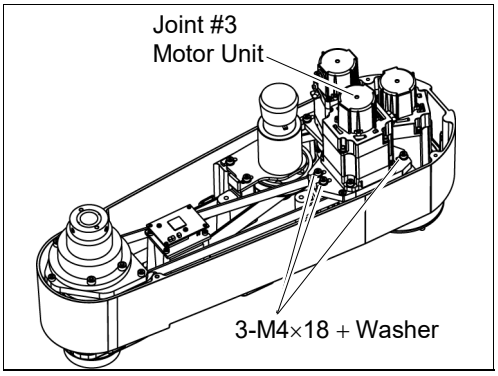
(6) Remove the User Plate.

For details, refer to *3.5 User Plate*.

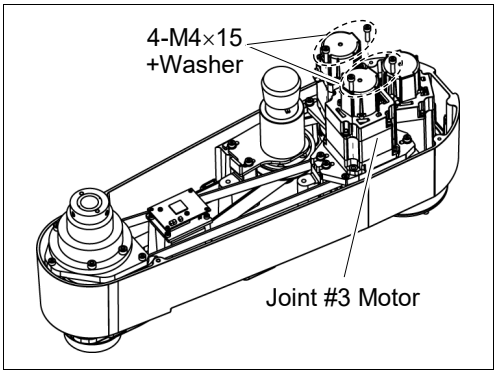
(7) Disconnect the following connectors.

Connectors: X231, X32, X43 (Hold the clip to remove.)

(8) Loosen the bolts for the Joint #3 motor unit.

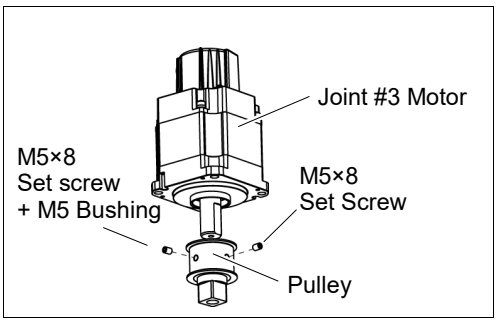


(9) Remove the Joint #3 motor from the Joint #3 motor unit.



(10) Loosen the screws of the pulley remove it from the Joint #3 motor.

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

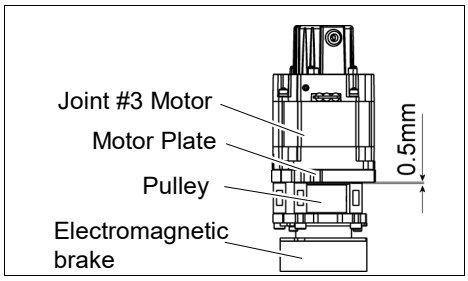


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #3 motor Installation

(1) Mount the pulley to the Joint #3 motor.

Insert the pulley where its end face touches the motor shaft end face and secure by set screws.

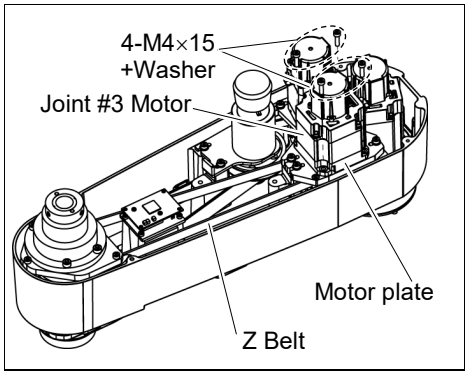


Tighten one of the set screws vertically on the flat face of the motor shaft.
Insert a bushing into the other set screw hole to prevent damage to the motor shaft.

(2) Mount the Joint #3 motor to the motor plate while aligning the hub to the brake disc.

Before aligning the hub, set the motor so that the pulley will be inside of the Z belt.

NOTE Secure the motor cables facing to back of the Arm.



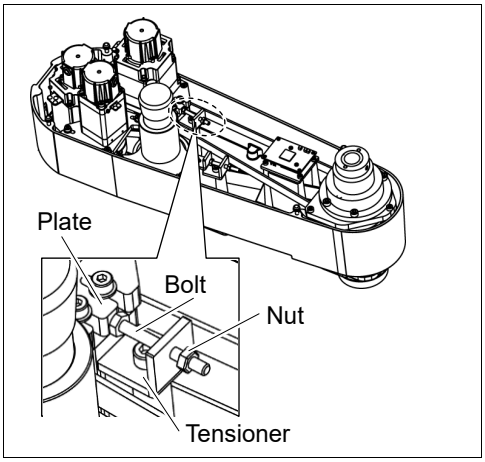
(3) Loosely secure the Joint #3 motor unit to the Arm #2. Make sure that the teeth of the timing belt are engaged with those of the pulley.

NOTE At this point, make sure that the Joint #3 motor unit can be moved by hand, and it will not tilt when pushed by tensioner. If the unit is secured too loose or too tight, the belt will not have the proper tension

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

Install the tensioner in front of the Joint #3 motor unit. Rotate the hexagonal bolt of the tensioner and push the plate to apply the specified tension.

Z belt tension
69 N (7.0 ± 0.5 kgf)



(4)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit.
(4)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.
(4)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.
(4)-4 Repeat the steps (4)-1 through (4)-3 until you get appropriate tension.
(4)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

NOTE
To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(5) Connect the connectors.

Connectors: X231, X241, X32, X43, X44, X51

(6) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(7) Bind the cables with a wire tie in their original positions as before removed in the removal 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.*

(9) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for other joint might be connected to the Joint #3 motor. Check the connector connection.

(10) Execute the calibration of Joints #3, #4.
For details, refer to *13. Calibration*.

7.2 Replacing the Timing Belt

	Name		Qty.	Note
Maintenance parts	Z belt		1	1758946
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Sonic tension meter		1	Z: Belt tension 69N (7.0 ± 0.5 kgf)
Material	Wire tie		-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 binding the cables.

Cut off the wire tie binding the Joint #3 brake cable.

Do not cut off a wire tie that binds the cables to the User Plate.

(6) Disconnect the following connectors.

Connectors: BR4, X231, X43, X51 (Hold the clip to remove.)

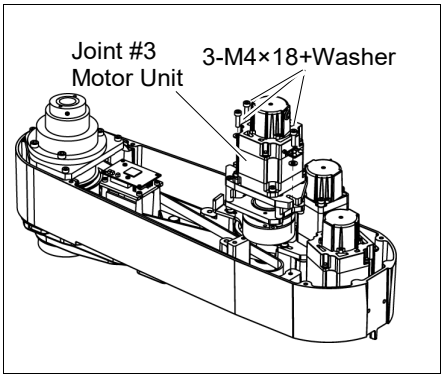
(7) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(8) Remove the screws for the Joint #3 motor unit and pull out the Joint #3 motor unit.

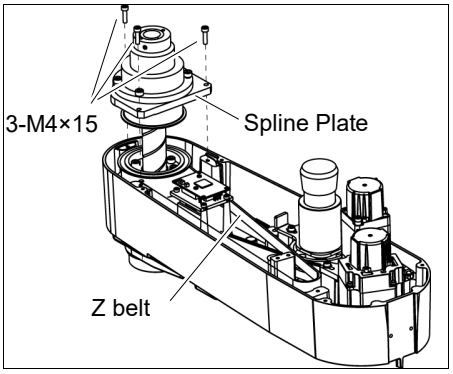
(9) Remove the Joint #3 motor from the motor plate and pull out the Z belt.

The belt is placed around the pulley. To remove the Joint #3 motor, tilt the motor slightly and pull it upward while avoiding the belt.



(10) Remove the screws for the spline plate.

Holding the spline plate upward, pull out the Z belt.



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

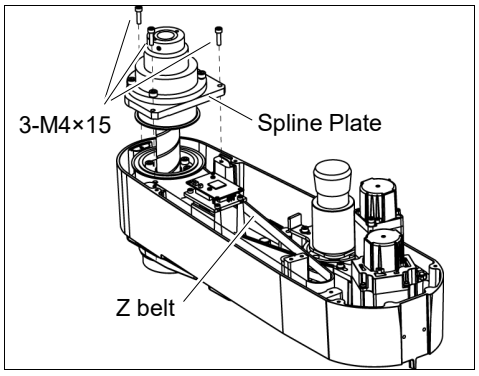
Z belt Installation

(1) Pass a new Z belt through the shaft.

(2) Lower the spline plate with the Z belt placed around the spline plate pulley.

Secure the spline plate with 3 screws.

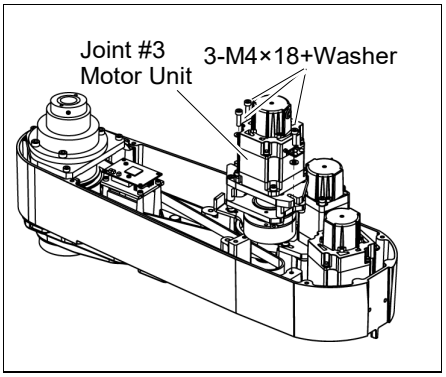
Loosely secure the spline plate on the Arm #2 and move the shaft up and down several times before firmly secure the spline plate.



(3) Mount the Joint #3 motor unit back in the arm.

(4) Pass the brake cable and over-excitation power supply through the Z belt.

Place the Z belt around the Z1 pulley and Z2 pulley, with the gear grooves of the belt fitting into grooves of the pulleys completely.



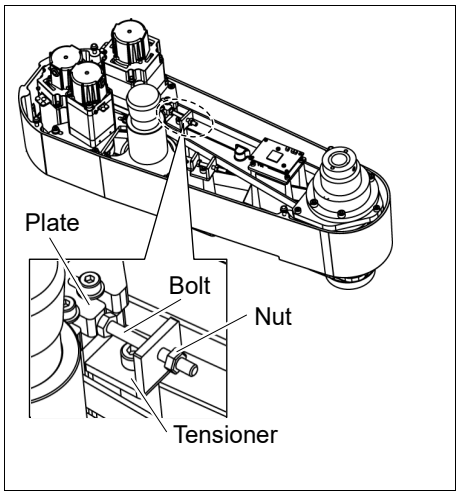
(5) Loosely secure the Joint #3 motor unit to the Arm #2.

NOTE At this point, make sure that the Joint #3 motor unit can be moved by hand, and it will not tilt when pushed by tensioner. 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.

Install the tensioner in front of the Joint #3 motor unit. Rotate the hexagonal bolt of the tensioner and push the plate to apply the specified tension.

Z belt tension
69 N (7.0 ± 0.5 kgf)



(6)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit.
(6)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.
(6)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.
(6)-4 Repeat the steps (6)-1 through (6)-3 until you get appropriate tension.
(6)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

NOTE To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(7) Connect the connectors.

Connectors: BR4, X231, X241, X32, X43, X44, X51

(8) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(9) Bind the cables with a wire tie in their original positions as before removed in the removal step (7). Do not allow unnecessary strain on the cables.

(10) Install the Arm Top Cover.
For details, refer to *3.1 Arm Top Cover*.

(11) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for the other joint might be connected to the Joint #3 motor. Check the connector connection.

(12) Execute the calibration of Joint #3.
For details, refer to *13. Calibration*.

7.3 Replacing the Brake

	Name		Qty.	Note
Maintenance parts	Electromagnetic Brake		1	1499588
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
	Sonic tension meter		1	Z: Belt tension 69N (7.0 ± 0.5 kgf)
Material	Wire tie		-	

NOTE

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

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

Joint #3 brake Removal

(1) Turn ON the Controller.

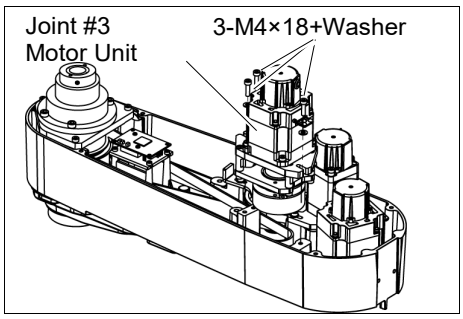
(2) Push down the shaft to its lower limit while pressing the brake release switch.
Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

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

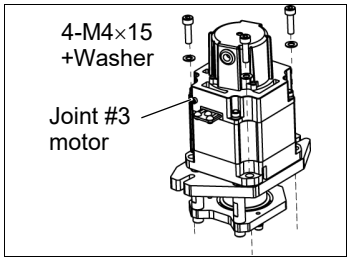
(4) Remove the Arm Top Cover.
For details, refer to *3.1 Arm Top Cover*.

(5) Remove the Joint #3 motor unit.
For details, refer to *7.2 Replacing the Timing Belt*.

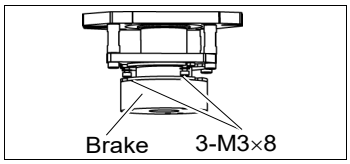


(6) Remove the Joint #3 motor from the Joint #3 motor unit.

The belt is placed around the pulley. To remove the Joint #3 motor, tilt the motor slightly and pull it upward while avoiding the belt.

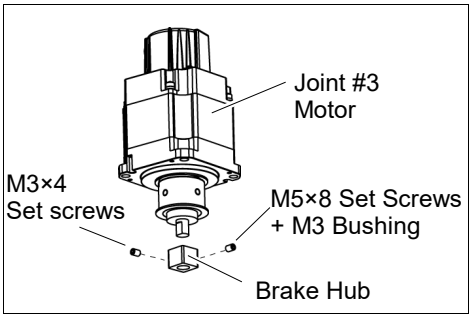


(7) Remove the brake from the brake plate.



(8) Loosen the screws of brake hub and remove it from the pulley of the Joint #3 motor.

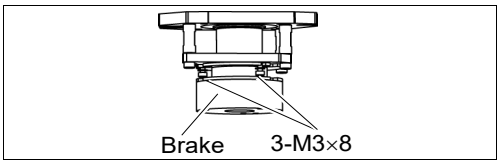
There is a brass bushing in one of the set screw holes. Be sure to keep the bushing.



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

Joint #3 brake Installation

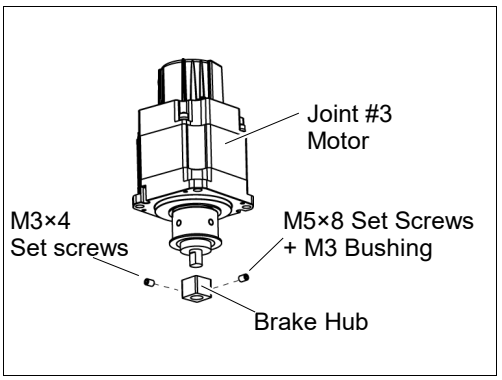
(1) Mount the brake to the brake plate.



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

Insert the brake hub and secure it when it touches the pulley.

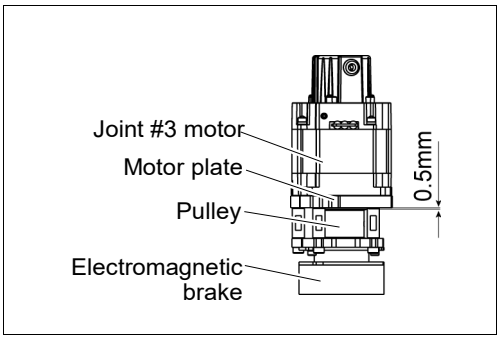
Tighten one of the set screws vertically on the flat face of the motor shaft.
Insert a bushing into the other set screw hole to prevent damage to the motor shaft.



(3) Mount the Joint #3 motor to the motor plate while aligning the hub to the brake disc.

Before aligning the hub, set the motor so that the pulley will be inside of the Z belt.

Be sure to fix the motor cable so that it faces opposite side of the brake support.



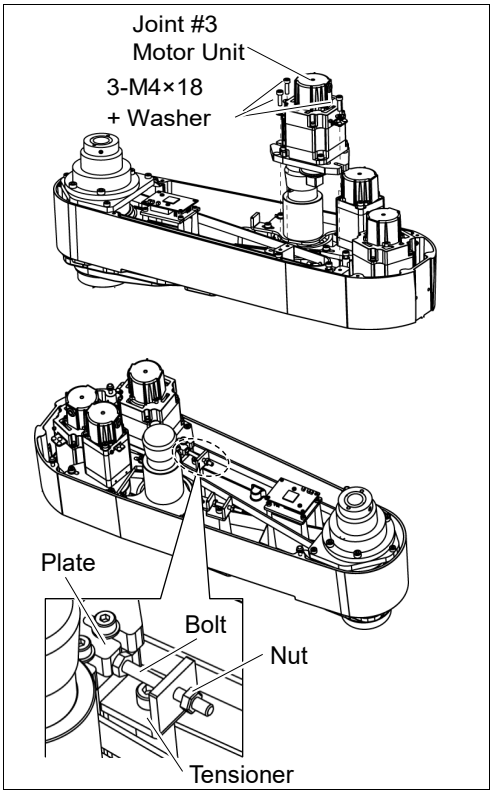
When the brake disc is not aligned, manually adjust the position by following the steps below.

1. Connect the connector X32.
2. Press the brake release switch to release the brake.
3. Adjust the brake disk manually so that the hole is at the center.

(4) Mount the Joint #3 motor unit back in the Arm #2.

For details, refer to the section *7.2 Replacing the Timing Belt*.

Z belt tension
69 N (7.0 ± 0.5 kgf)



(4)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit.
(4)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.
(4)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.
(4)-4 Repeat the steps (4)-1 through (4)-3 until you get appropriate tension.
(4)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

NOTE To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(5) Mount the Arm Top Cover.

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

(6) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for other joint might be connected to the Joint #3 motor. Check the connector connection.

(7) Execute the calibration of Joint #3.

For details, refer to *13. Calibration*.

7.4 Checking the Timing Belt Tension (Z Belt)

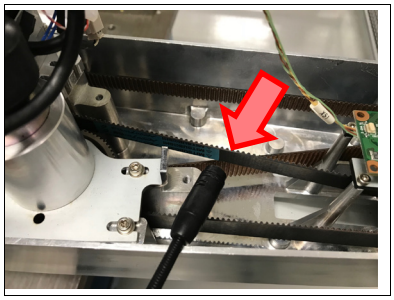
	Name	Qty.	Note
Tool	Sonic tension meter	1	For details of usage and measurement methods of the tension meter, refer to the instruction manual of the tension meter.

Joint #3
Belt tension check

(1) Enter appropriate setting values to the sonic tension meter.

Model	Belt	Unit mass M [g/ (1 mm width ×1 m length)]	Width W [mm]	Span S [mm]
LS10-B	Z belt	2.5	17	303

(2) Strum the belt and measure tension.



NOTE Measurement failure may occur if the microphone touches the belt during measurement.

8. Joint #4

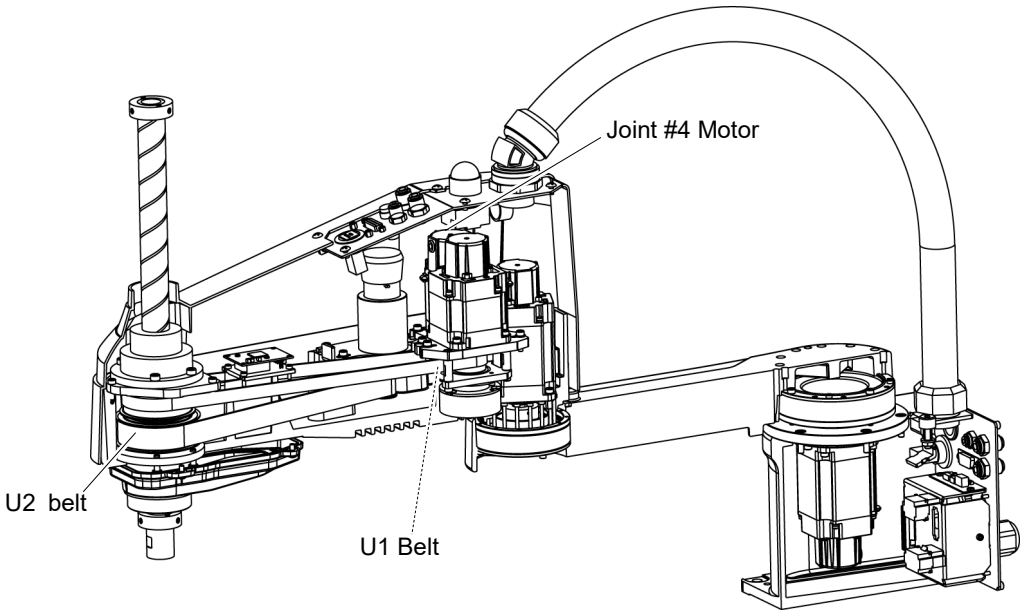
WARNING	■ Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric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

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



8.1 Replacing Joint #4 Motor

	Name		Qty.	Note
Maintenance parts	AC Servo Motor 150 W		1	2197987
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	U1: Axial tension (pulling force) 114N (11.6 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension

CAUTION

■ The belt must be installed with proper tension; otherwise the following problems may occur.

If falling below the lower limit : Jumping of the belt gears (position gap)

If exceeding the upper limit : Abnormal noise or vibration (oscillation), decline in the life of driving parts

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 binding the cables.

At this point, do not cut off a wire tie (in the duct fittings outlet) that binds the cables to the User Plate.

(6) Disconnect the connectors.

Connectors: BR4, X241, X44 (Hold the clip to remove.)

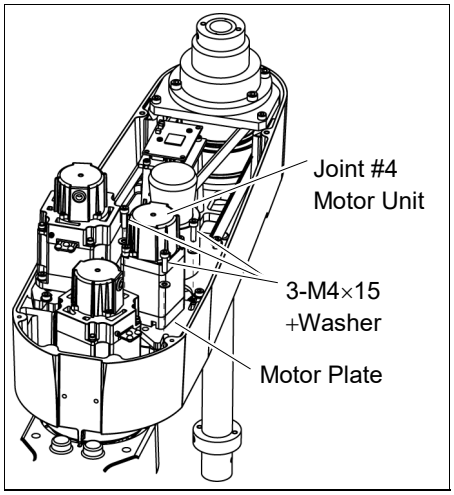
(7) Remove the User Plate.

For details, refer to *3.5 User Plate*.

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

Remove the bolts securing the Joint #4 motor on the motor plate and pull out the motor.

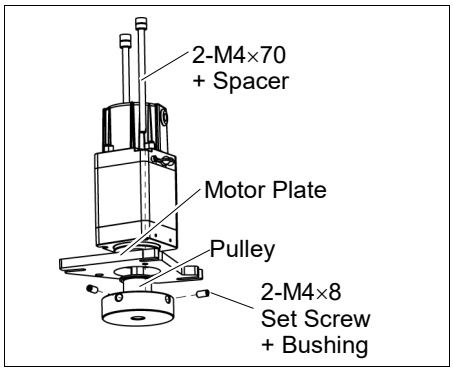
The belt is placed around the pulley. Tilt the motor unit slightly and pull it out.



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

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

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

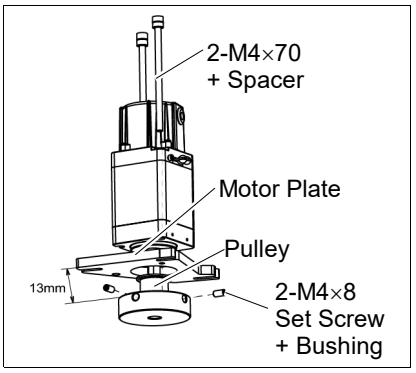


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #4 motor Installation

(1) Mount the motor plate to the Joint #4 motor.
At this point, the motor cables must be in the convex shape side of the plate.

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

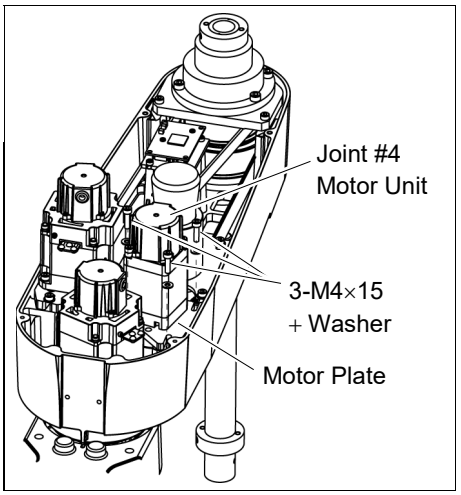


Install so that the gap between the motor plate and the pulley is 13 mm.

Be sure to set the one set of the set screws + bushing vertically on the flat face of the motor shaft. Be careful not to damage the the motor shaft to tighten the bushing into the other set screw hole.

(3) Place the pulley around the U1 belt and place the Joint #4 motor unit in the upper face of the Arm #2.

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



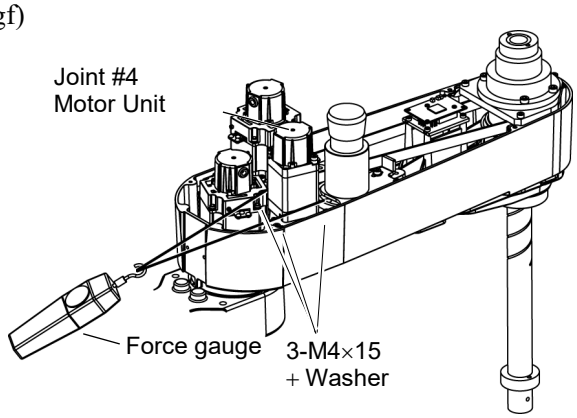
NOTE Make sure the motor unit can be moved by hand, and it will not tilt when pulled.
If the unit is secured too loose or too tight, the belt will not have the proper tension.
Make sure the gear grooves of the belt are fit into those of the pulleys completely.

(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.

U1 axial tension (pulling force): 114 N (11.6 ± 0.5 kgf)
U1 belt tension: 58 N (5.9 ± 0.5 kgf)



NOTE ☞ To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belt)*.

(6) Connect the connectors.
Connectors: BR4, X241, X44

(7) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(8) Bind the cables with a wire tie in their original positions as before removed in removal 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) Check if the Joint #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #4 moves, the connector for other joint might be connected to the Joint #4 motor. Check the connector connection.

(11) Execute the calibration of Joint #4.
For details on the calibration method, refer to *13. Calibration*.

8.2 Replacing the Timing Belt

	Name		Qty.	Note
Maintenance parts	U1 belt	width 10 mm	1	1757386
	U2 belt	width 21 mm	1	1757387
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Spanner	width across flats: 7 mm	1	
	Cross-point screwdriver		1	For cross-recessed head screws
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Force gauge		1	U1: Axial tension (pulling force) 114 N (11.6 ± 0.5 kgf)
	Sonic tension meter		1	U2: Tension (belt tension) 102 N (10.4 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension

CAUTION

- The belt must be installed with proper tension; otherwise the following problems may occur.

  If falling below the lower limit : Jumping of the belt gears (position gap)

  If exceeding the upper limit : Abnormal noise or vibration (oscillation), decline in the life of driving parts

NOTE

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

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

8.2.1 U2 Belt

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.

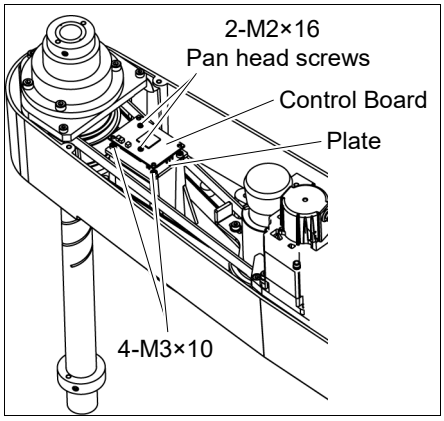
The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #4 are released simultaneously.
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft 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) Remove the control board and the plate.



(6) Cut off the wire tie binding the cables.

Do not cut off the wire tie that binds the cables to the User Plate.

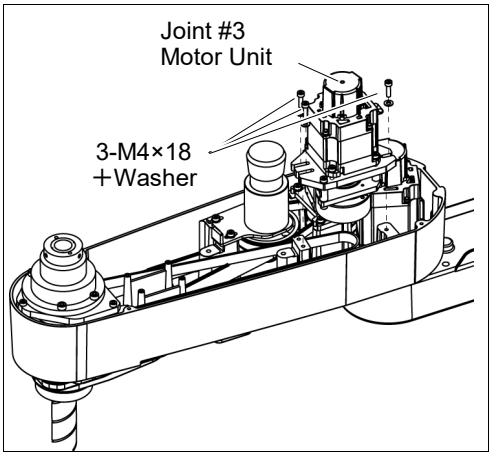
(7) Disconnect the following connectors.

Connectors: BR4, X32, X43, X44, X51, X231, X241 (Hold the clip to remove.)

(8) Remove the User Plate.

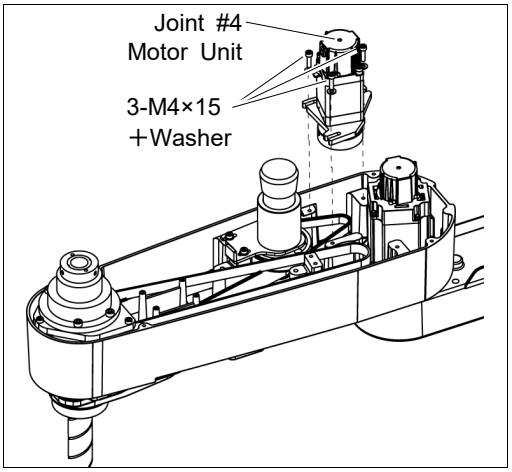
For details, refer to *3.5 User Plate*.

(9) Remove the screws securing the Joint #3 motor unit and pull out the motor unit.



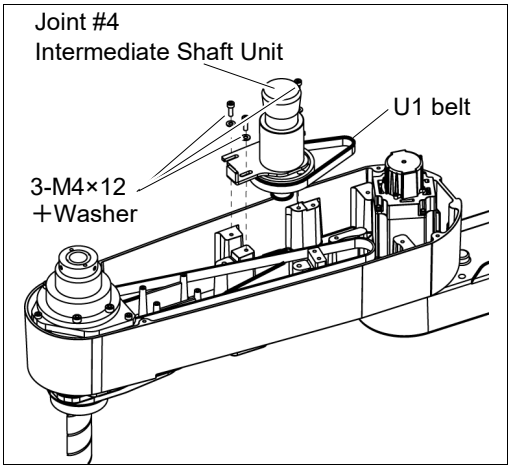
(10) Remove the screws securing the Joint #4 motor unit and pull out the motor unit.

The belt is placed around the pulley. Tilt the motor unit slightly and pull it out.



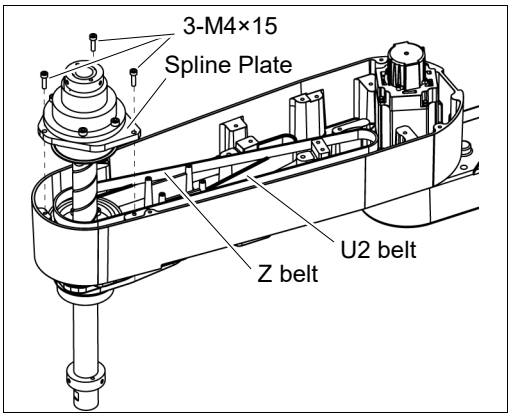
(11) Remove the screws securing the Joint #4 intermediate shaft unit.

Pull out the Joint #4 intermediate shaft unit and U1 belt.



(12) Remove the screws mounting the spline plate.

Hold up the spline plate and pull out the Z belt and U2 belt.

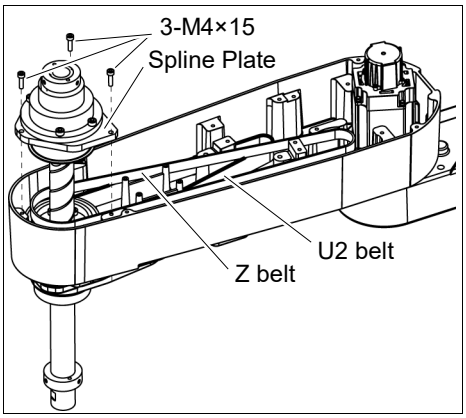


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

U2 belt Installation

(1) Hold up the spline plate 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.



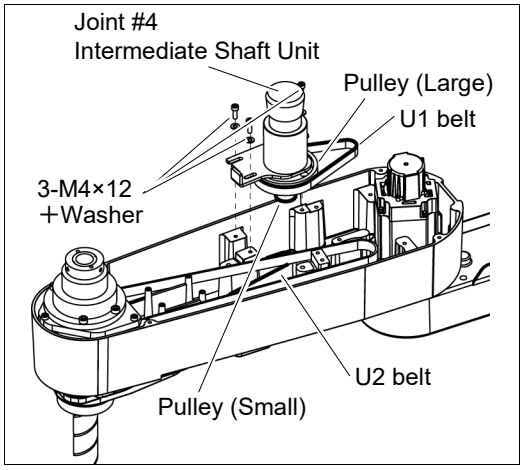
(2) Hold up the spline plate and set the Z belt around the Z2 pulley.

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

(3) Loosely secure the spline plate on the Arm #2 and move the shaft up and down several times before firmly secure the spline plate.

(4) Keeping the U1 belt on the large pulley of the Joint #4 intermediate shaft unit, set the U2 belt in the Arm #2 on the small pulley and put them on the Arm #2 upper surface.

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



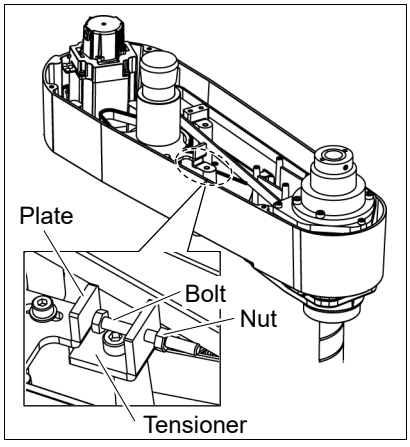
(5) Loosely secure the Joint #4 intermediate shaft unit.

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

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

Install the tensioner in front of the Joint #4 motor unit. Rotate the hexagonal bolt of the tensioner and push the plate to apply the specified tension.

U2 belt tension: 102 N (10.4 ± 0.75 kgf)



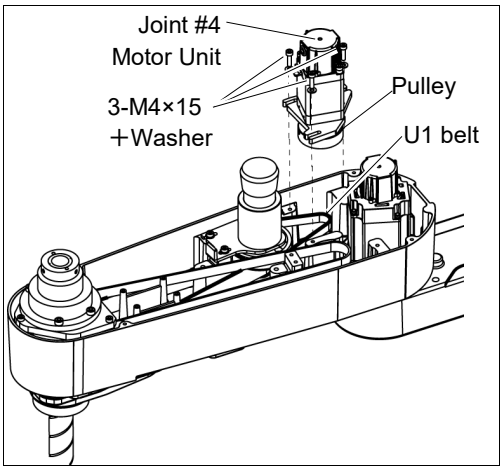
(6)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit.
(6)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.
(6)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.
(6)-4 Repeat the steps (6)-1 through (6)-3 until you get appropriate tension.
(6)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

NOTE

To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

(7) Mount the Joint #4 motor unit on the Arm #2 with the U1 belt around the pulley.

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



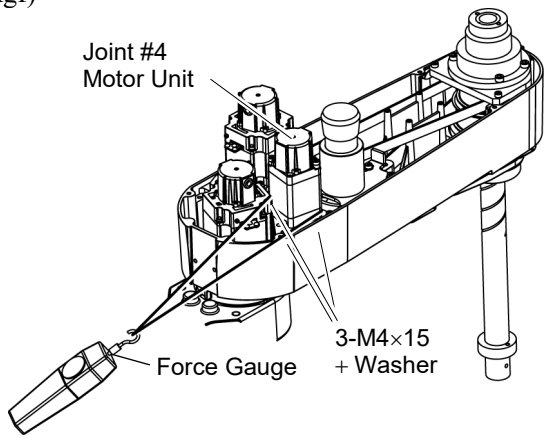
Make sure the motor unit can be moved by hand, and it will not tilt when pulled.
If the unit is secured too loose or too tight, the belt will not have the proper tension.

(9) 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 on the right.

U1 axial tension (pulling force): 114 N (11.6 ± 0.5 kgf)
U1 belt tension: 58 N (5.9 ± 0.5 kgf)



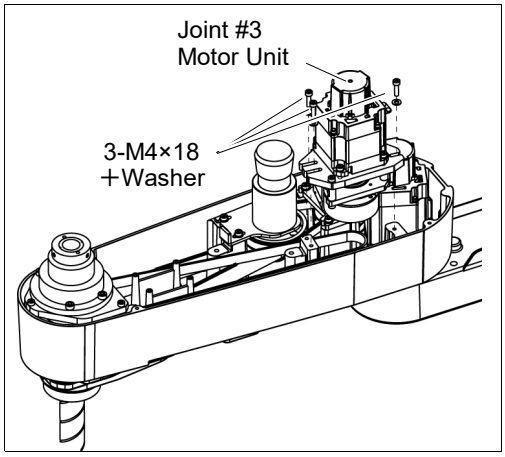
NOTE

To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

(10) Put the Joint #3 motor unit back in the arm.

(11) Pass the brake cable and special power supply through the Z belt.

Set the Z belt around the Z1 pulley and Z2 pulley, with the gear grooves of the belt fitting into grooves of the pulleys completely.



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

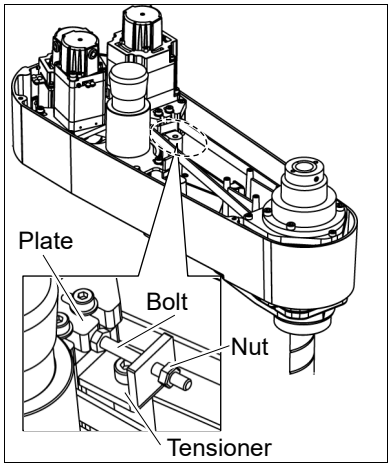
NOTE Make sure the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

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

Install the tensioner in front of the Joint #3 motor unit. Rotate the hexagonal bolt of the tensioner and push the plate to apply the specified tension.

For details, refer to *7.2 Replacing the Timing Belt.*

Z belt tension:
69 N (7.0 ± 0.5 kgf)



(13)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit.
(13)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.
(13)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.
(13)-4 Repeat the steps (13)-1 through (13)-3 until you get appropriate tension.
(13)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

NOTE To check belt tension with the tension meter, refer to *7.4 Checking the Timing Belt Tension (Z Belt)*.

(14) Remove the control board and the plate.

For details, refer to *11.3 Replacing the Control Board.*

(15) Connect the following connectors.

Connectors: BR4, X32, X43, X44, X51, X231, X241

(16) Mount the User Plate.

For details, refer to *3.5 User Plate*.

(17) Bind the cables with a wire tie in their original positions as before removed in the removal step (7).

Do not allow unnecessary strain on the cables.

(18) Remove the Arm Top Cover.

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

(19) Check if the Joint #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #4 moves, the connector for other joint might be connected to the Joint #4 motor. Check the connector connection.

(20) Execute the calibration for Joint #3.

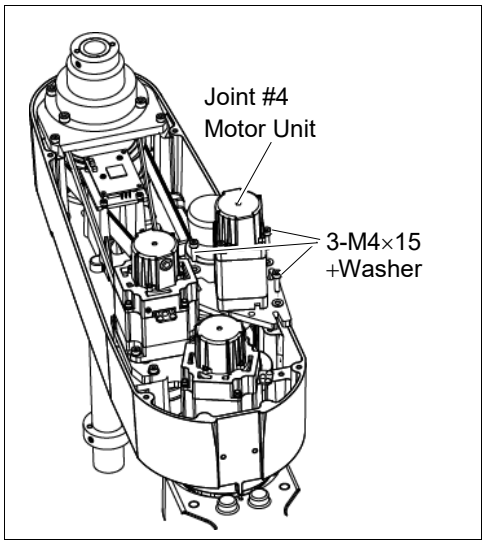
For details on the calibration method, refer to *13. Calibration*.

8.2.2 U1 Belt

U1 belt Removal

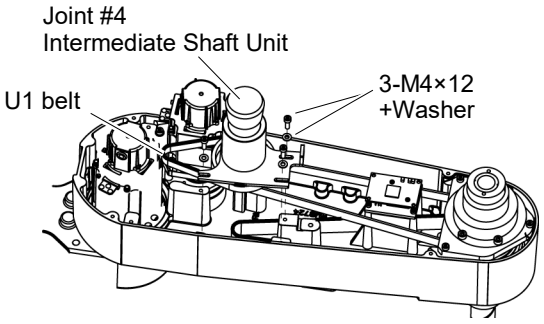
(1) Remove the Joint #4 motor unit.

Follow the removal steps in *8.2.1 U2 Belt*.



(2) Remove the Joint #4 intermediate shaft unit.

Refer to the removal steps in *8.2.1 U2 Belt*.



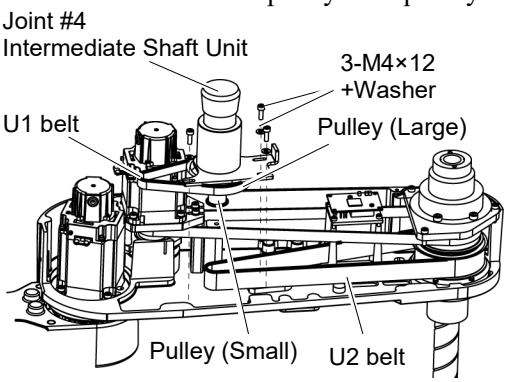
(3) Remove the U1 belt.

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

U1 belt Installation

(1) Keeping the U1 belt on the large pulley of the Joint #4 intermediate shaft unit, set the U2 belt in the Arm #2 on the small pulley and put them on the Arm #2 upper surface.

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



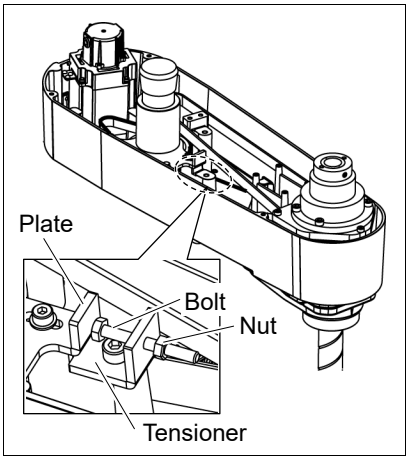
(2) Loosely secure the Joint #4 intermediate shaft unit.

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

Install the tensioner in front of the Joint #4 motor unit. Rotate the hexagonal bolt of the tensioner and push the plate to apply the specified tension.

U2 belt tension: 102 N (10.4 ± 0.5 kgf)

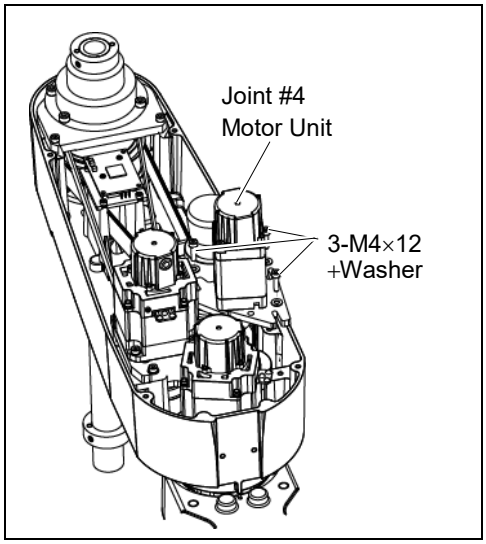


(3)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit.
(3)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.
(3)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.
(3)-4 Repeat the steps (3)-1 through (3)-3 until you get appropriate tension.
(3)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

NOTE To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

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

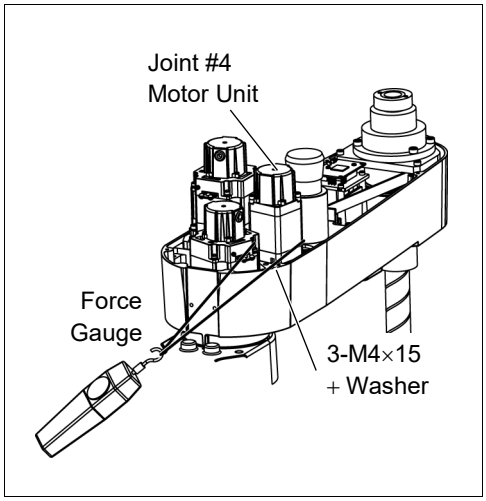
Make sure the motor unit can be moved by hand, and it will not tilt when pulled.
If the unit is secured too loose or too tight, the belt will not have the proper tension.



(5) Apply the proper tension to the 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.

U1 axial tension (pulling force):
114 N (11.6 ± 0.5 kgf)
U1 belt tension
58 N (5.9 ± 0.5 kgf)



NOTE To check belt tension with the tension meter, refer to *8.4 Checking the Timing Belt Tension (U1, U2 Belts)*.

(6) Connect the connectors.

Connectors: BR4, X241, X44

(7) Bind the cables with a wire tie in their original position as before removed in the removal step (5).

(8) Remove the User Plate.

For details, refer to *3.5 User Plate*.

(9) Install the Arm Top Cover.

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

(10) Check if the Joint #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #4 moves, the connector for other joint might be connected to the Joint #4 motor. Check the connector connection.

(11) Execute the calibration of Joint #4.

For details, refer to *13. Calibration*.

8.3 Replacing the Brake

	Name		Qty.	Note
Maintenance parts	Electromagnetic brake		1	1750573
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 2 mm	1	For M2.5 screw
	Nippers		1	For cutting wire tie
Material	Wire tie		1	

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

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

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 Joint #3 and #4. When the brake release switch is pressed, the respective brake 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.

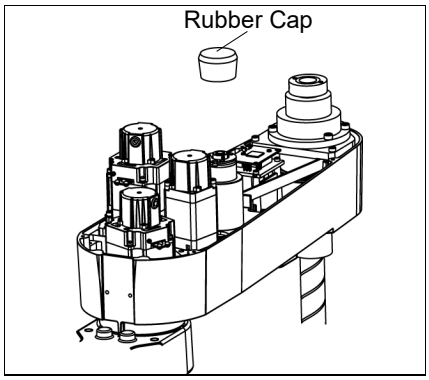
(4) Remove the Arm Top Cover.
For details, refer to *3.1 Arm Top Cover*.

(5) Disconnect the connector.

Connector BR4

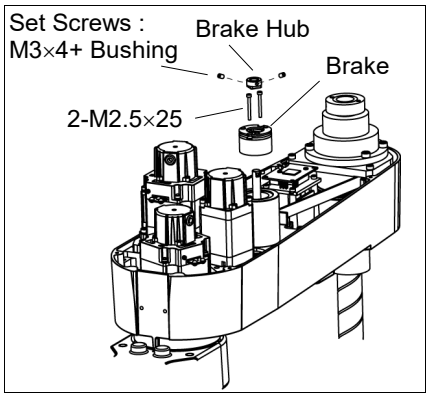
(6) Cut off the wire tie banding brake cables.

(7) Remove the rubber cap.



(8) Remove the brake hub.

(9) Remove the brake.

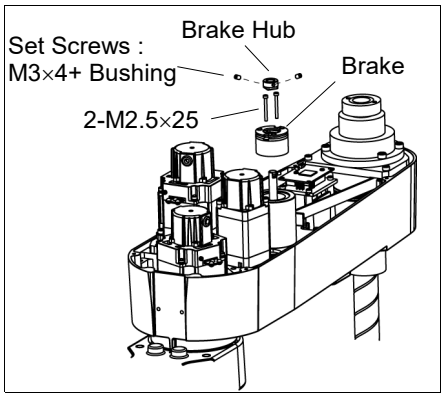


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #4 brake Installation

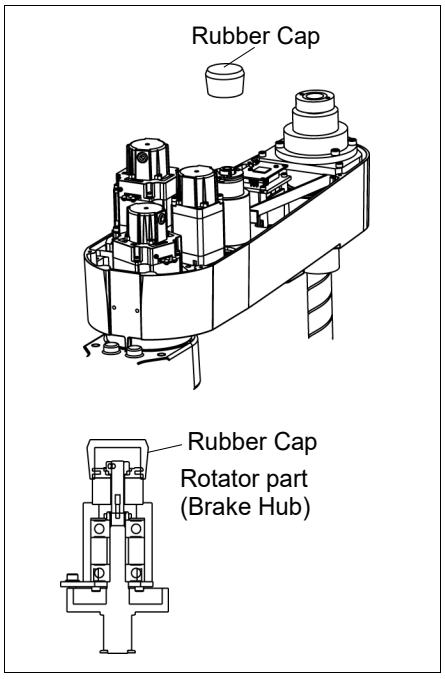
(1) Mount the brake to the Joint #4 intermediate shaft unit.

(2) Mount the brake hub to the Joint #4 intermediate shaft unit.



(3) Mount the rubber cap.

Insert the rubber cap until the cable part of the brake. If the cables get inside the rubber cap, the cables may be disconnected.



(4) Connect the connector.

Connector: BR4

(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*.

8.4 Checking the Timing Belt Tension (U1, U2 Belts)

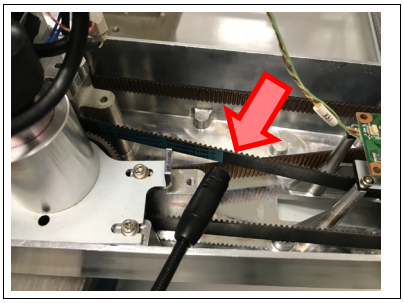
	Name	Qty.	Note
Tool	Sonic tension meter	1	For details of usage and measurement methods of the tension meter, refer to the instruction manual of the tension meter.

Joint #4
Belt tension check

(1) Enter appropriate setting values to the sonic tension meter.

Belt	Unit mass M [g/ (1 mm width ×1 m length)]	Width W [mm]	Span S [mm]
U1 belt	2.5	10	70
U2 belt	2.5	21	250

(2) Strum the belt and measure tension.



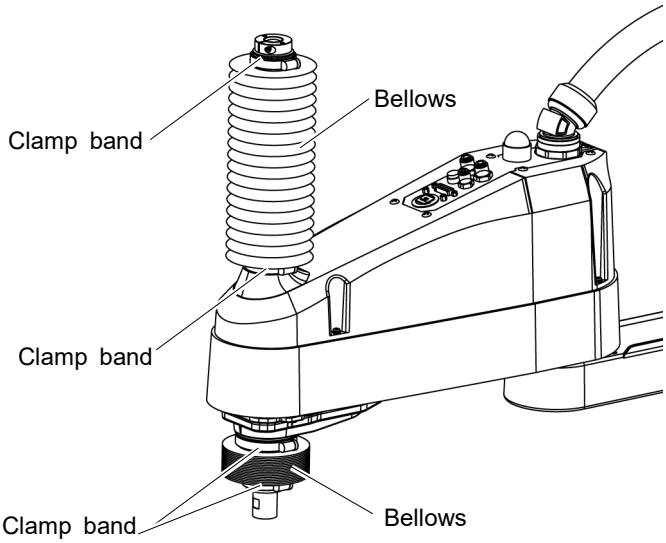
NOTE
Measurement failure may occur if the microphone touches the belt during measurement.

9. Bellows

NOTE The bellows for LS10-B***C 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 replacing the bellows.

	Name	Qty.	Note
Maintenance parts	Bellows	1	170 mm: 1765523 270 mm: 1765524
Tools	Cross-point screwdriver	1	For clamp band removal



Bellows Removal

(1) Remove the cables and tubes from the end effector.

(2) Remove the end effector.

(3) Turn ON the controller. Stop motor excitation. (MOTOR OFF)

(4) Loosen the two clamp bands on the bellows.

(5) Pull out the bellows and clamp bands from 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.

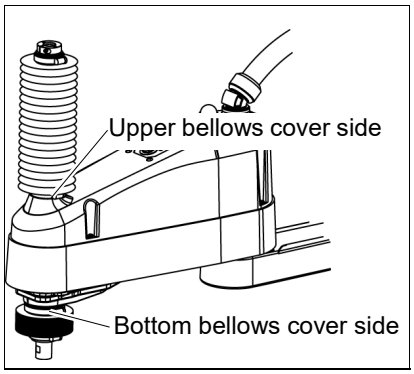
The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #4 are released simultaneously.
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft 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.
Attach the mounting part of the bellows until the end touches the cylindrical part of the cover.

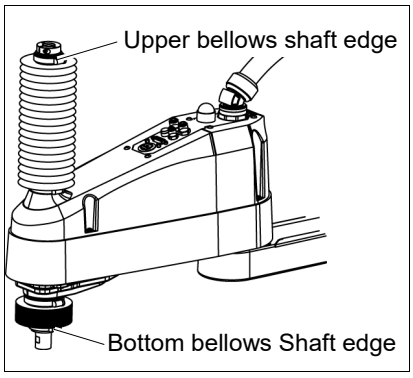
Then, secure them with clamp bands.



(4) Secure the shaft edge side of the bellows.

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

Then, secure them with clamp bands.



(5) When completed the bellows installation, check that the bellows stretch smoothly without any excessive force by moving the shaft up/down by hand and rotating the Joint #4.

(6) Turn OFF the Controller and peripheral equipment.

(7) Attach the end effector.

(8) Connect the cables and tubes to the end effector.

10. Ball Screw Spline Unit Replacement

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.

	Name		Qty.	Note
Maintenance parts	Ball Screw Spline Unit		1	Each manipulator model (Refer to *14. Maintenance parts*)
Grease	For Ball Screw Spline Unit (AFB grease)		Proper quantity	
Tools	Hexagonal wrench	(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
	Cross-point screwdriver		1	Only for Cleanroom-model
	Force gauge		1	Axial tension (pulling force): 114 N (11.6 ± 0.5 kgf)
	Suitable cord (Length about 1000 mm)		1	For belt tension
	Wiping cloth		1	For wiping grease (Spline shaft)
Material	Wire tie		-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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/tubes from the end effector, and remove the end effector.

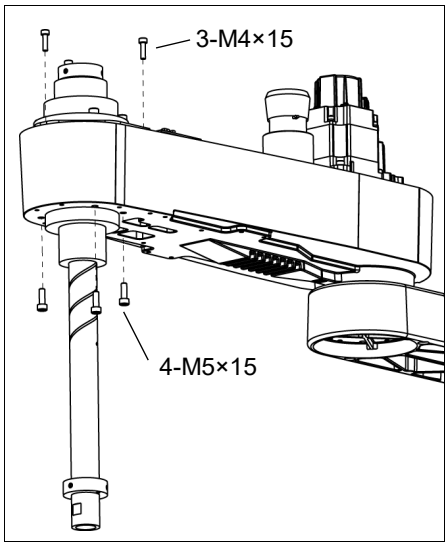
(5) This step is only for Cleanroom-model.
Remove the bellows. For details, refer to *9. Bellows*.

(6) Remove the Arm Top Cover and Arm Bottom Cover.
For details, refer to *3. Covers*.

(7) Remove the following.
Joint # motor unit Joint #4 motor unit Joint #4 intermediate pulley
U1 belt U2 belt Z belt
Follow the U2 belt removal steps in *8.2 Replacing the Timing Belt*.

(8) Remove three screws mounting the spline plate.

(9) Remove four screws mounting the spline nut.



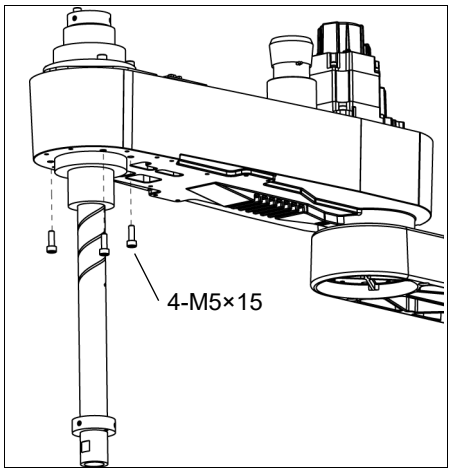
(10) Pull out the following toward the Arm #2 upper side.
Ball screw spline unit Z belt U2 belt

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

Ball Screw Spline Unit Installation

(1) Insert a new ball screw spline unit in the Arm #2.

(2) Secure the spline nut from the bottom side of the Arm #2.



(3) Mount the following.

Joint #3 motor unit / Joint #4 motor unit / Joint #4 intermediate pulley / U1 belt / U2 belt / Z belt

Follow the U2 belt installation steps in *Maintenance: 8.2 Replacing the Timing Belt*.

(4) Mount the Arm Top Cover and Arm Bottom Cover.

For details, refer to *3. Covers*.

(5) Grease the shaft.

For details, refer to *LS10-B Manipulator -2.3 Greasing - Greasing the Ball Screw Spline Unit.*

(6) For the Cleanroom-model, mount the bellows.

For details, refer to *9. Bellows*.

(7) Mount the end effector, cables, and tubes.

(8) Perform the calibration of Joints #3, #4.

For details, refer to *13. Calibration*.

11. Boards

 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.

	Name	Qty.	Note
Maintenance parts	Converter board	1	2196970
	Control board	1	2196966
Tools	Nippers	1	For cutting wire tie
	Cross-point screwdriver (#1)	1	
Material	Wire tie	1	For fixing cables

11.1 Replacing the Converter Board

Board which supplies power to the encoder of the motor is mounted inside the base of the manipulator. If the board gets damage, the manipulator will not operate.

Converter board Removal

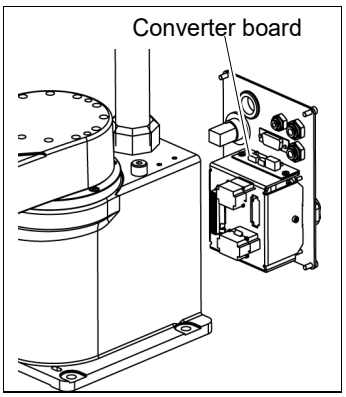
(1) Turn OFF the controller.

(2) Remove the Connector Plate.

For details, refer to *3.3 Connector Plate*.

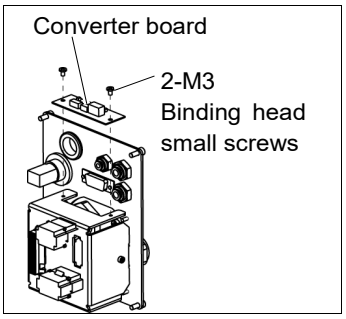
(3) Disconnect the connectors which are connected to the converter board.

Connectors: CV11, CV12, CV13



(4) Remove the converter board from the mount base.

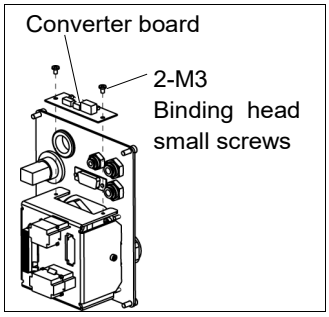
Binding head small screws:
2-M3 (cross-point screwdriver)



Converter board Installation

(1) Mount the converter board on the mount base.

Binding head small screws: (2-M3)



(2) Connect the connectors to the converter board.

Connectors: CV11, CV12, CV13

(3) Mount the Connector Plate.

For details, refer to *3.3 Connector Plate*.

(4) Turn ON the Controller.

(5) Make sure no errors occur in all joints.

11.2 Replacing the Control Board

Control Board Removal

(1) Turn OFF the controller.

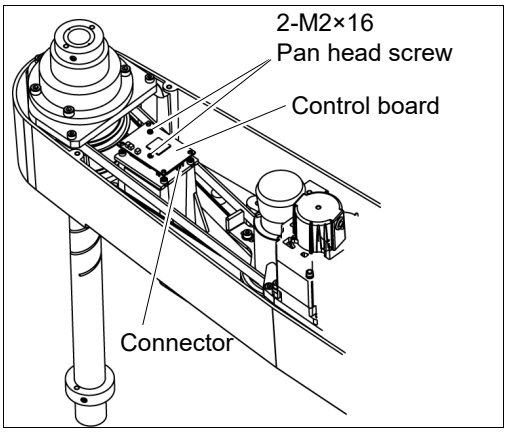
(2) Remove the Arm Top Cover.

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

(3) Disconnect the connector.

Connector: X51

(4) Remove the Control board.



Control Board Installation

(1) Mount a new Control board.

Be careful of the board direction.
(Check the board direction by the connector position.)

(2) Connect the connector.

Connector: X51

(3) Mount the Arm Top Cover.

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

(4) Turn ON the controller.

12. LED Lamp

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.

	Name	Qty.	Note
Maintenance parts	LED Lamp	1	2077258
Tools	Cross-point screwdriver	1	For wire removal
	Nippers	1	
Material	Wire tie	1	

LED Lamp Removal

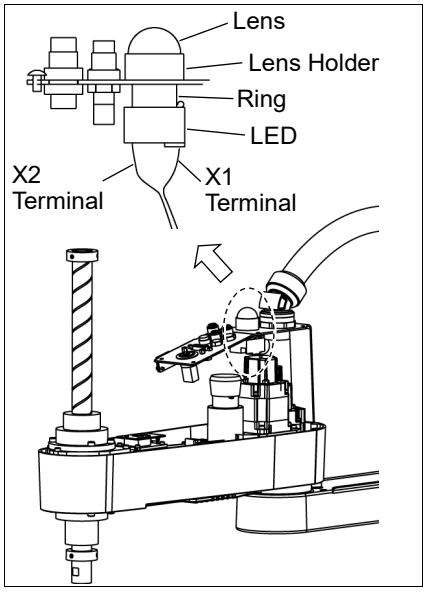
(1) Remove the Arm Top Cover.
For details, refer to *3.1 Arm Top Cover*.

(2) Remove the User Plate.
For details, refer to *3.5 User Plate*.

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

(4) Turn the lens counterclockwise to remove. Then, turn the lens holder counterclockwise to remove.

(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 the same terminal number on the LED.

(2) Put the User Plate between the ring and lens holder, and then secure the LED to the cover.

(3) Mount the lens.

(4) Mount the User Plate.
For details, refer to *3.5 User Plate*.

(5) 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.

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

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

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

NOTE

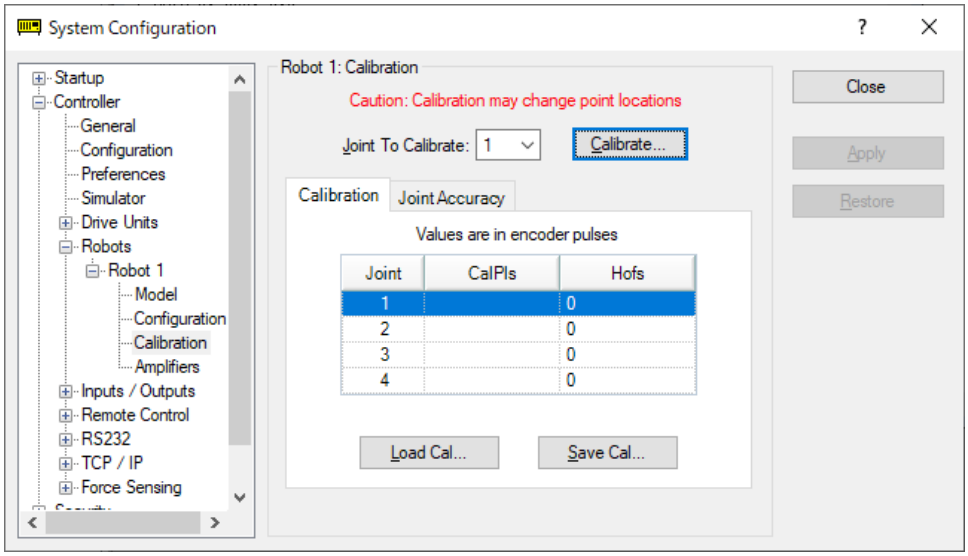
If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *13.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.
The reference point (a point to check the accuracy) needs to be specified for calibration.

(1) Start the calibration wizard.

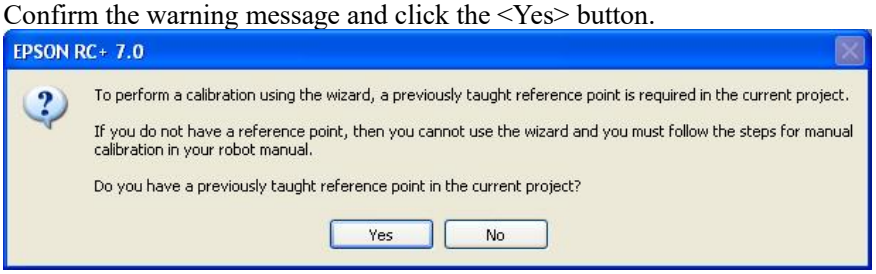
i. Select EPSON RC+ 7.0 menu - [Setup] to display the [System Configuration] dialog.

ii. Select [Robots]-[Robot**] to display [Calibration].

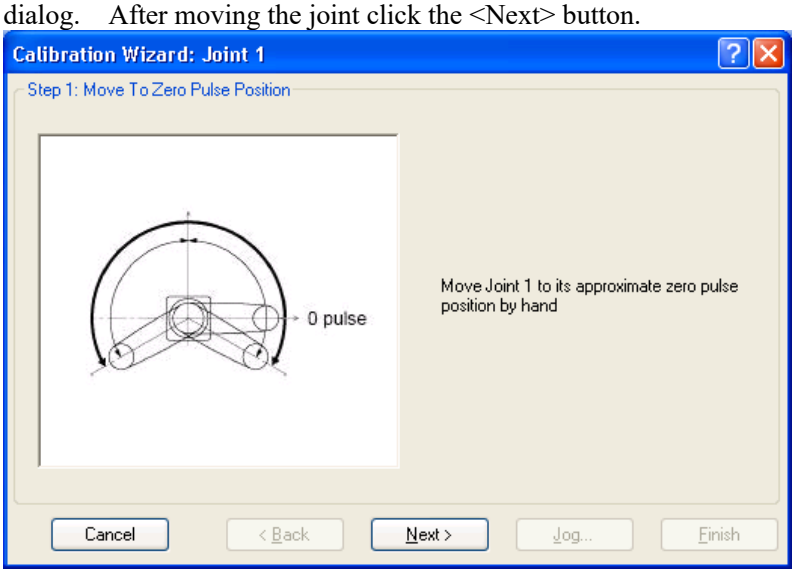
iii. Select the joint and click the <Calibrate…> button.



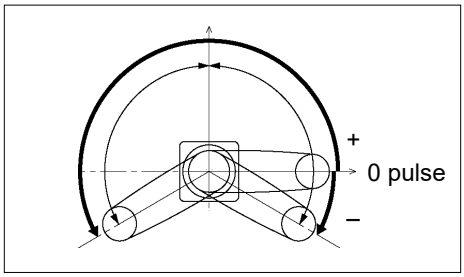
(2) Confirm the warning message and click the <Yes> button.



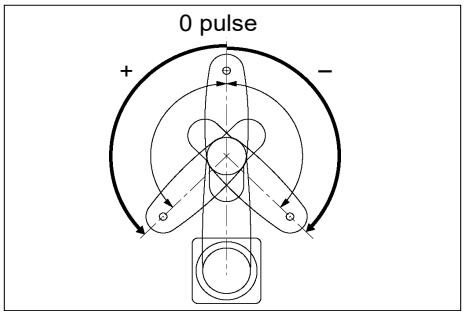
(3) Move the joint to calibrate manually to approximate zero position, as shown in the dialog. After moving the joint click the <Next> button.



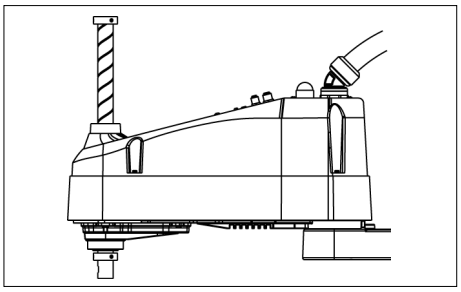
0 pulse position of Joint #1:
position aligned with X-axis in Robot coordinate system



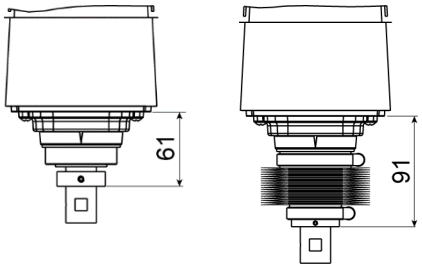
0 pulse position of Joint #2:
position where Arms #1 and #2 are in a straight line
(Regardless of the Joint #1 direction.)



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

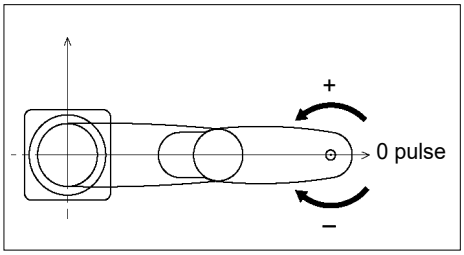


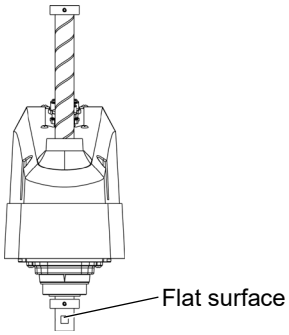
The height of Joint #3 depends on manipulator model.



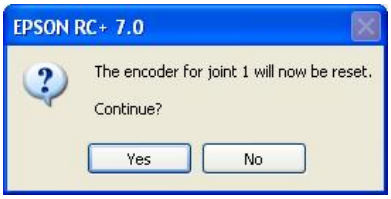
Standard model Cleranroom model

0 pulse position of Joint #4:
position where the flat surface on the shaft faces toward the tip of Arm #2





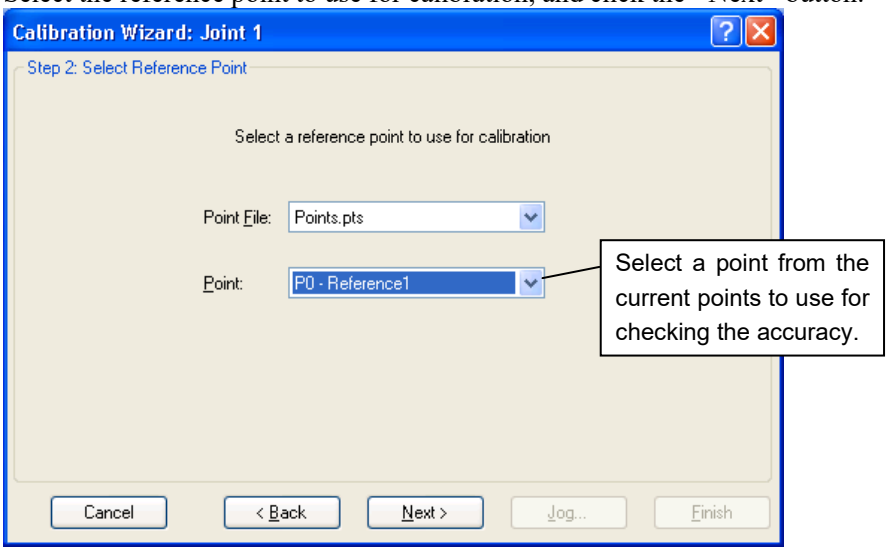
(4) Click the <Yes> button to reset the encoder.



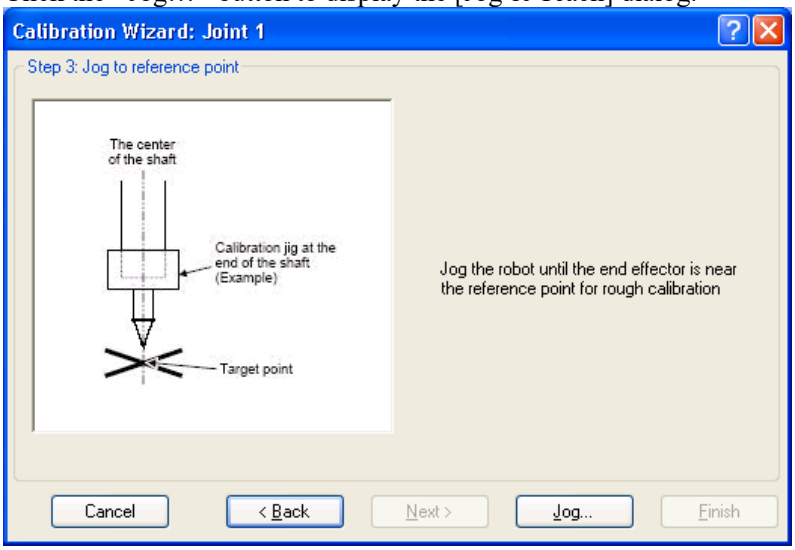
(5) Reboot the Controller.

* This window will disappear when the Controller starts up.

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



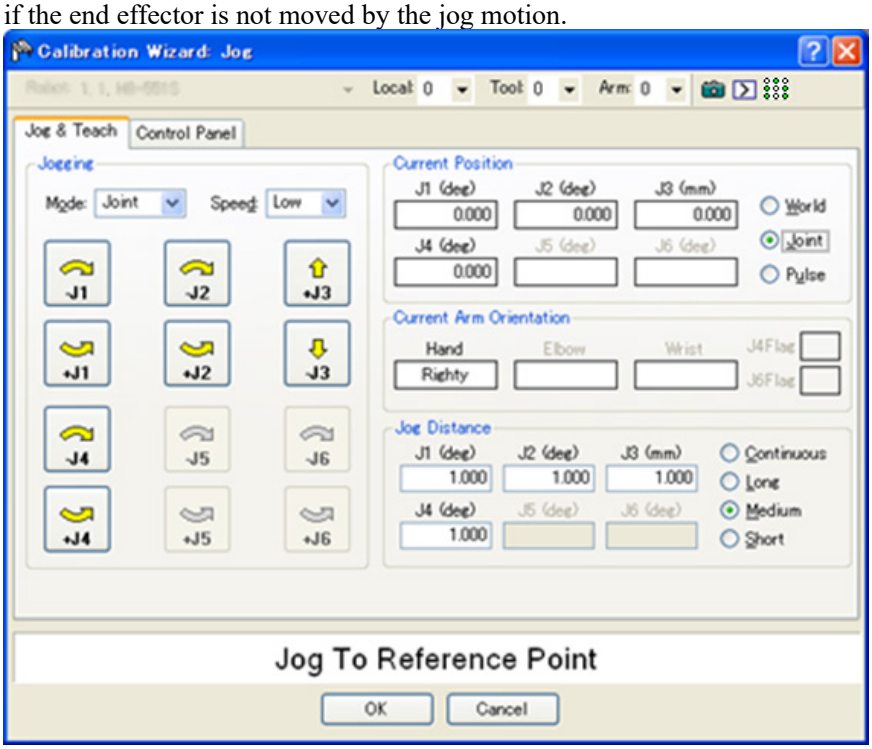
(7) Click the <Jog…> button to display the [Jog & Teach] dialog.



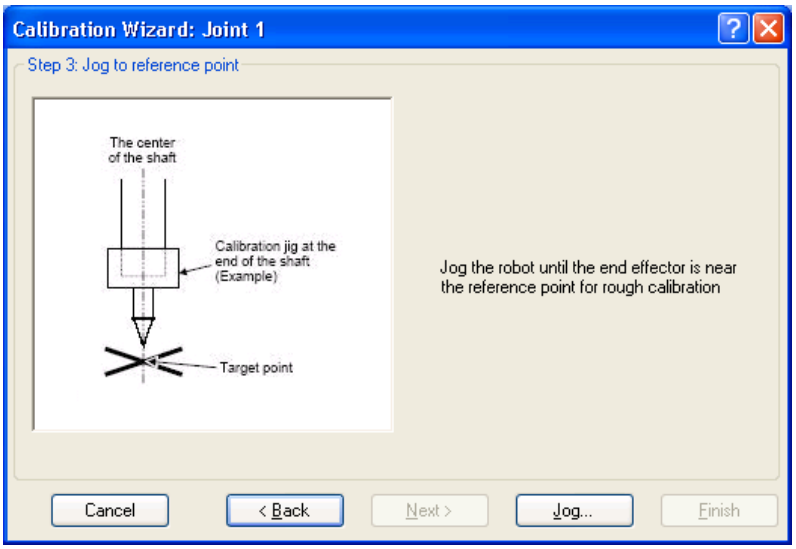
(8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.
Before operating the robot, open the [Control Panel] and click on the <Motor ON> button.

NOTE

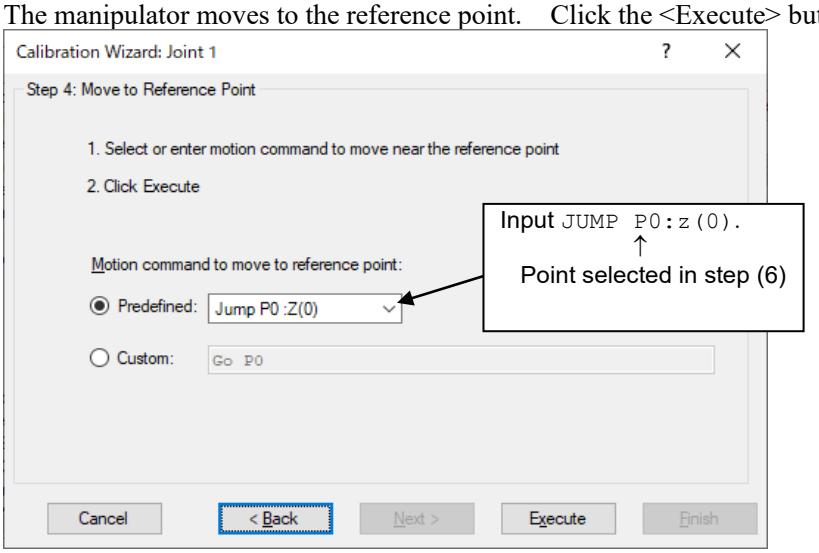
Move the end effector from the zero pulse position to the approximate reference point where rough calibration will be executed at by the jog motion. Position gap may occur if the end effector is not moved by the jog motion.



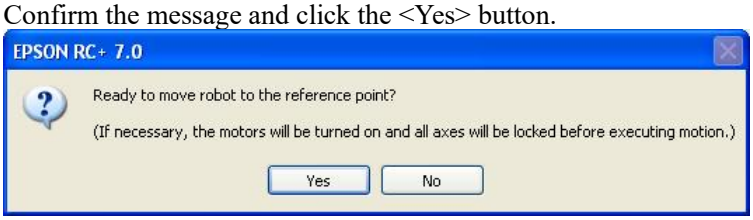
(9) Click the <Next> button.



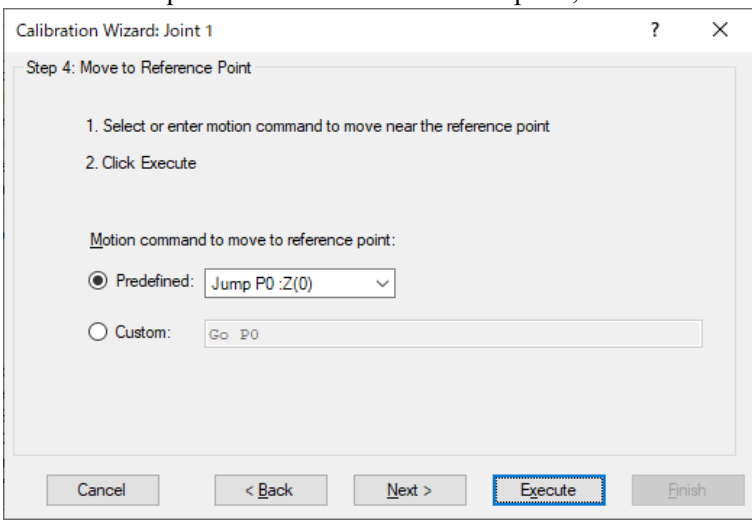
(10) The manipulator moves to the reference point. Click the <Execute> button.



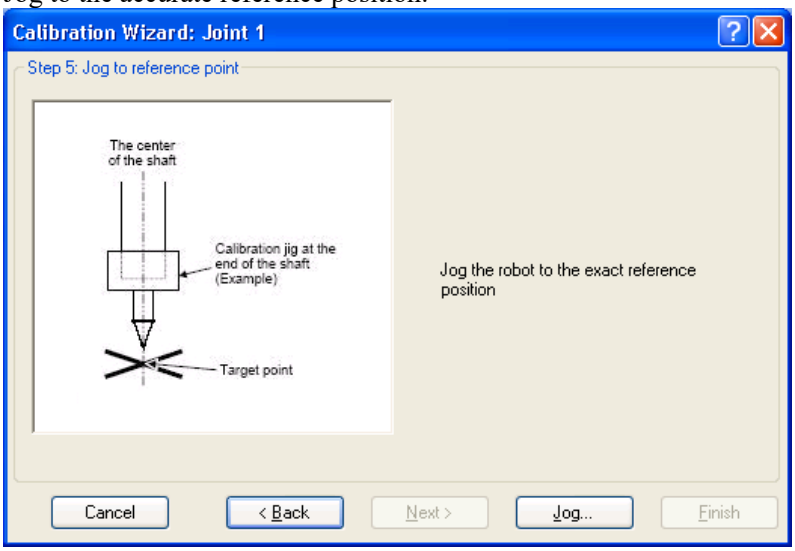
(11) Confirm the message and click the <Yes> button.



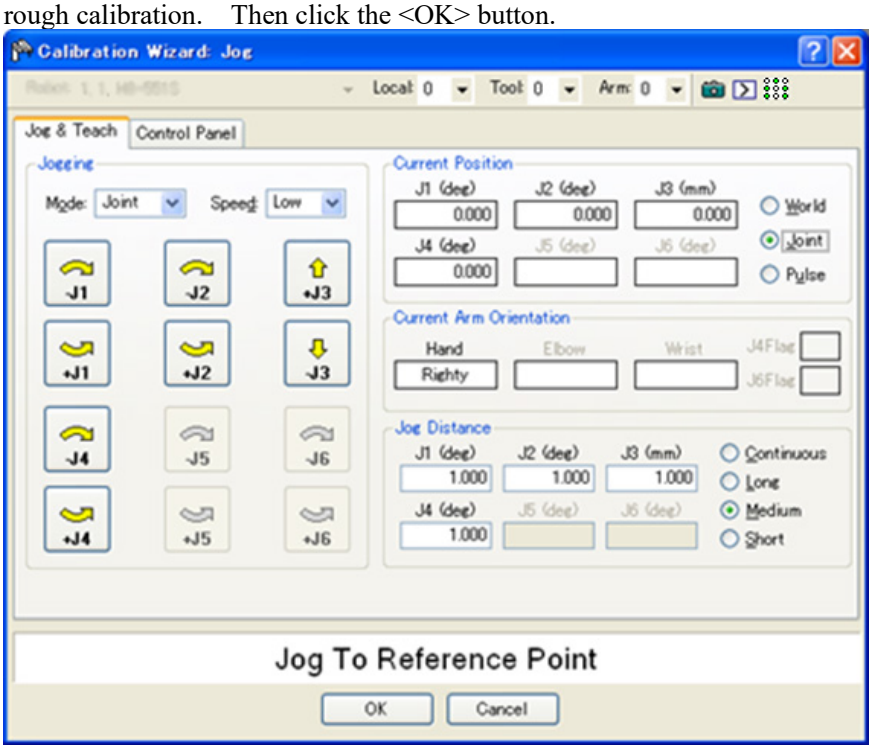
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position.

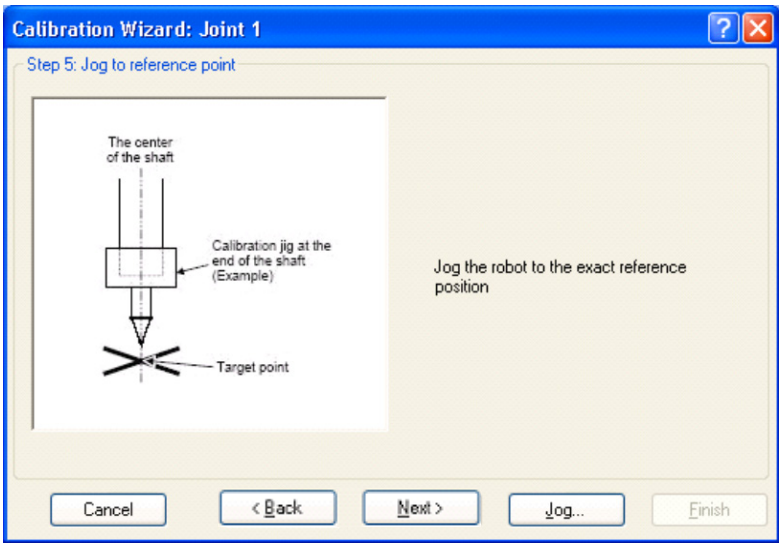


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



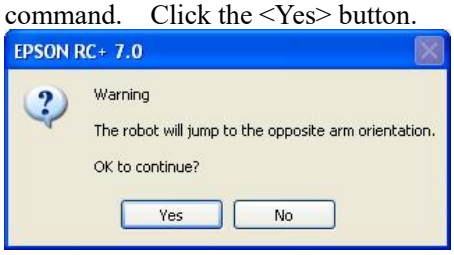
* Position Joint #2 only and move Joint #3 to around 0 pulse.

(15) Click the <Next> button.

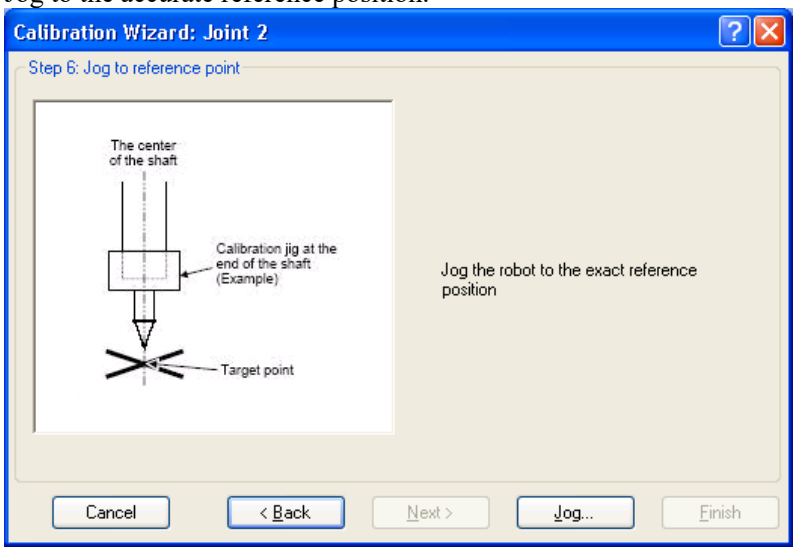


(16) Execute the procedure in "Calibration Using Right / Left Arm Orientations" to accurately calibrate Joint #2.
Go on to the step (17) for the other joints calibration.

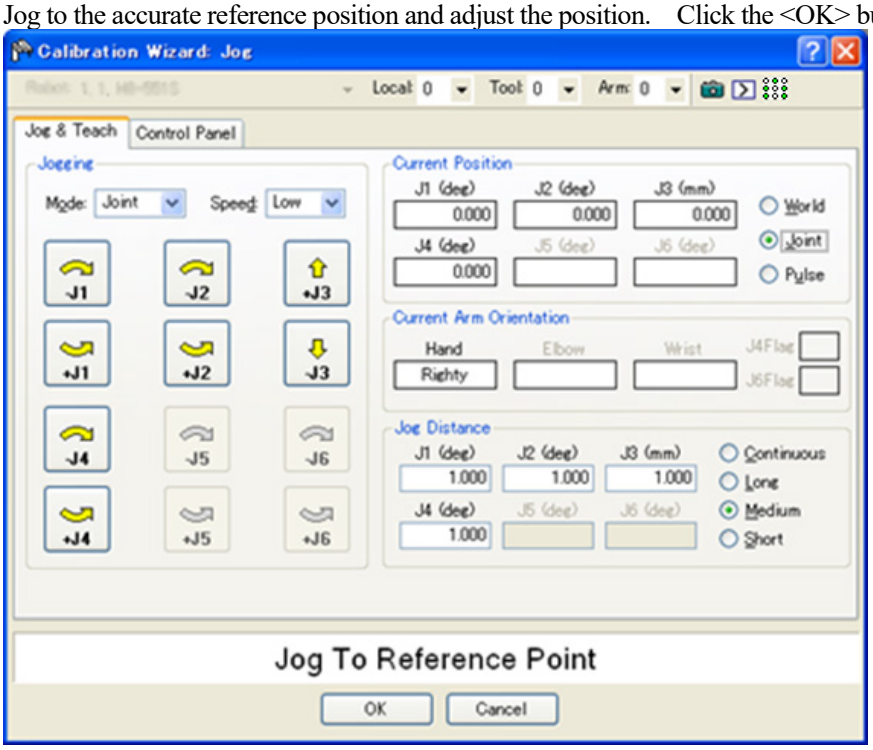
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



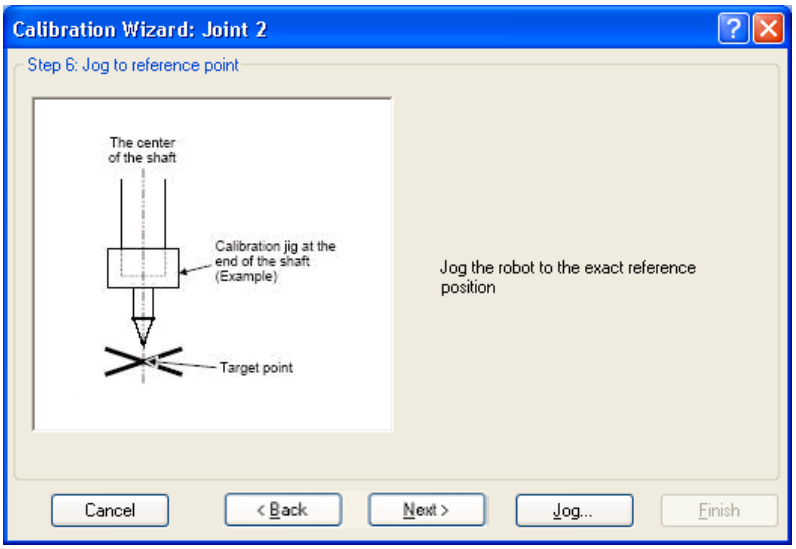
ii. Jog to the accurate reference position.



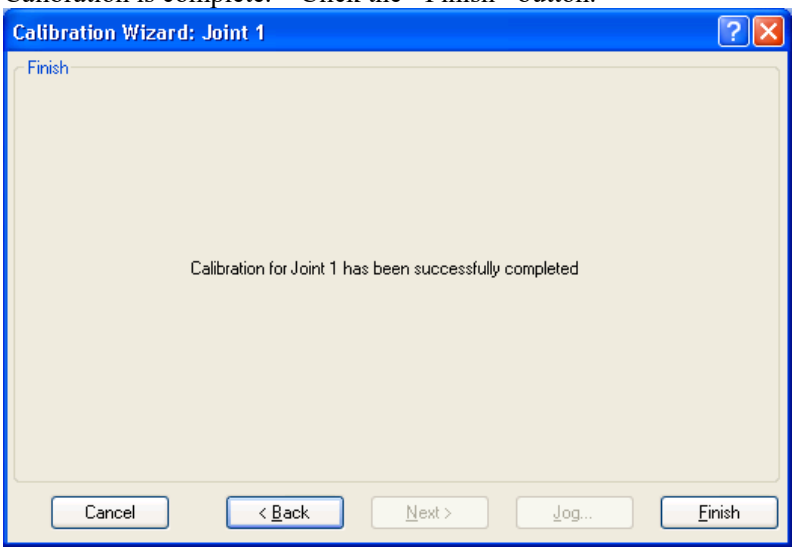
iii. Jog to the accurate reference position and adjust the position. Click the <OK> button.



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.

13.3 Accurate Calibration of Joint #2

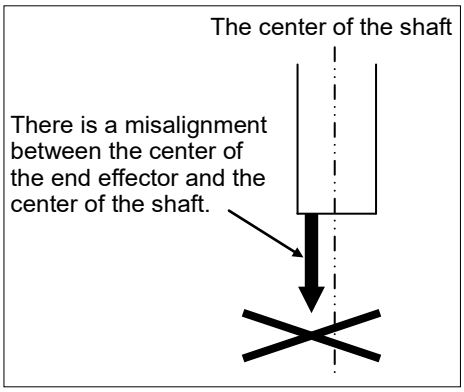
When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.

NOTE

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

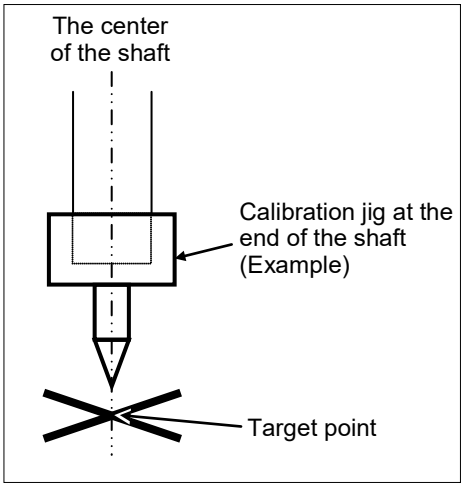
The reference point is the center of the ball screw spline shaft during this calibration.

When there is a misalignment between the center of the end effector and the center of the ball screw spline shaft, remove the end effector and execute 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 executing 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 liner 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 point you can easily verify the accuracy within the work envelop of both right and left arm. Then, check the number of points you want to use.

(2) EPSON RC+ menu-[Tools]-[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 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 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, execute 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

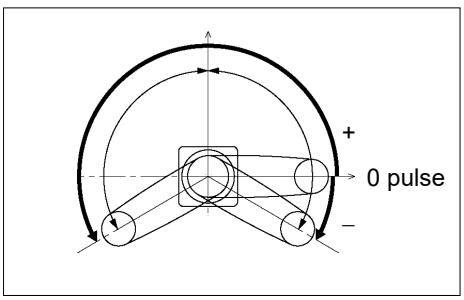
(2)-1 Replace parts as dictated by this manual.
* Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

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

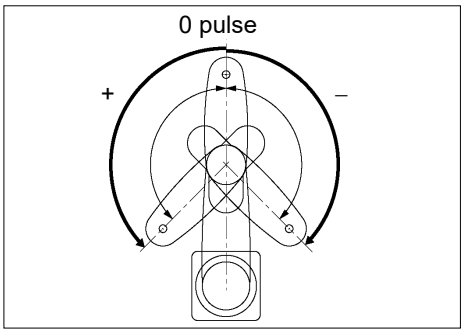
(3)-2 Manually move the joint that needs origin alignment to its approximate 0 pulse position.

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



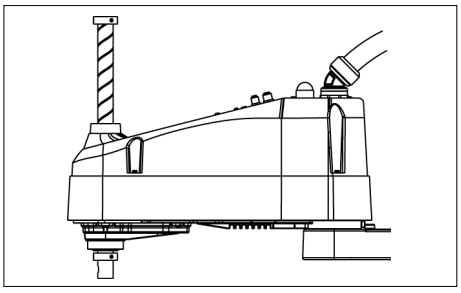
0 pulse position of Joint #2:

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

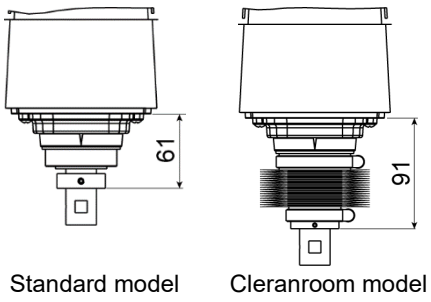


0 pulse position of Joint #3:

upper limit position in motion range

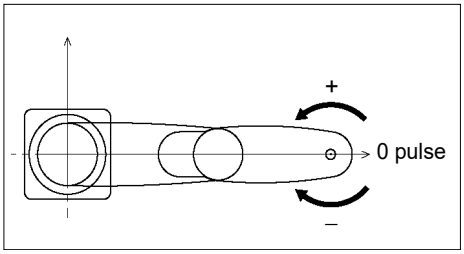


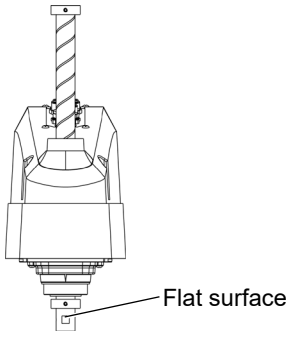
The height of Joint #3 depends on manipulator model.



0 pulse position of Joint #4:

position where the flat surface on the shaft faces toward the tip of Arm #2





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

Select a robot to be calibrated. Input as below in the [Command Window] and execute it.
(This example uses “robot 1”.)

```
> robot 1
```

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

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

Joint #1: `>EncReset 1`
Joint #2: `>EncReset 2`
Joint #3: `>EncReset 3`
Joint #4: `>EncReset 3, 4`

(3)-5 Reboot the Controller.

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

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

4. Rough Calibration

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

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

* Manipulator does not move.

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

Part Name		Code	Note	Reference	Overhaul *3
Cable Unit	600 mm	2196931		4.1	-
	700 mm	2196932			
	800 mm	2196933			
AC Servo Motor	Joint #1	2197984	520 W (with oil seal)	5.1	✓
	Joint #2	2197985	520 W (without oil seal)	6.1	✓
	Joint #3	2197986	200 W	7.1	✓
	Joint #4	2197987	150 W	8.1	✓
Reduction Gear Unit *1	Joint #1	1765530		5.2	✓
	Joint #2	1765520		6.2	✓
O-ring	Joint #1	1650901	Supplied with Joint #1 reduction gear unit	5.1	-
		1213266	CO0543A		
		1520371	CO0538A		
		1510528	CO0551A		
	Joint #2	1653181	Supplied with Joint #2 reduction gear unit	6.2	-
		1213267	CO0547A		
Timing Belt	Joint #3	1758946	Z	7.2	✓
	Joint #4	1757386	U1	8.2	✓
		1757387	U2		
Electromagnetic brake		1499588	Z-axis (Brake only)	7.3	✓
		1750573	U-axis (Brake + Power)	7.4	✓
Brake Release Switch		2117817		-	-
Bellows	LS10-B**2C	1765523	*4	9	-
	LS10-B**3C	1765524	*4	9	-
Ball Screw Spline	LS10-B**2S	1765521	200 mm	10	✓
	LS10-B**3S	1765522	300 mm		
	LS10-B**2C	1765528	170 mm		
	LS10-B**3C	1765529	270 mm		
Converter Board		2196970		11.1	-
Control Board		2196966		11.2	-
LED lamp		2077258		12	-
Grease *2	Ball Screw Spline: AFB	-	For purchasing grease, and adhesive, please the supplier of your region.	2.3	-
	Reduction Gear Unit: SK-1A			5.2, 6.2	-
Arm Top Cover		1802514	White	3.1	-
Arm Bottom Cover		1759511	Blue	3.2	-

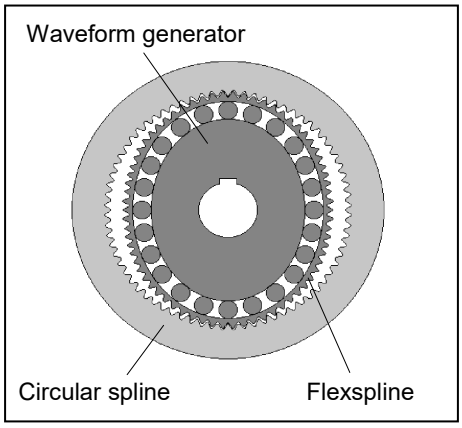
Part Name		Code	Note	Reference	Overhaul *3
Dust Cover		2014430	For RJ45 connector	-	-
Mechanical stopper		1759366	1	-	-
M/C Power Cable　*5	For fixed wiring	2186054	3 m	4.3	-
		2186055	5 m		
		2186056	10 m		
	For movable wiring	2213020	5 m		
		2213021	10 m		
M/C Signal Cable　*5	For fixed wiring	2194703	3 m	4.3	-
		2194704	5 m		
		2194705	10 m		
	For movable wiring	2213018	5 m		
		2213019	10 m		

*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

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.

Splines are greased.　Be careful not to let grease adhere to clothes.

*2 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 suppliers 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/

*3 Overhaul

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).*

*4 Bellows

The bellows for LS10-B**C are provided in a unit of two pieces.　The shape varies between the upper and lower bellows.

*5 M/C Power Cable, M/C Signal Cable

Select M/C power cable and M/C signal cable with the same specification (For fixed wiring, For movable wiring) and the same length.
If the specification and length are not the same, the robot system may not operate properly.

LS20-B 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 routine maintenance.

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

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

 WARNING	■ To shut off power to the robot system, 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	■ 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	Break for arm #3 to #4	√	√	√	√	√
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, if 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 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

Recommended replacement time for the parts subject to maintenance (motors, reduction gear units, and timing belts) can be checked in the [Maintenance] dialog box box of the EPSON RC+ 7.0.

For details, refer to the following manual.
RC90 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 box, the L10 life is displayed as 100%.

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

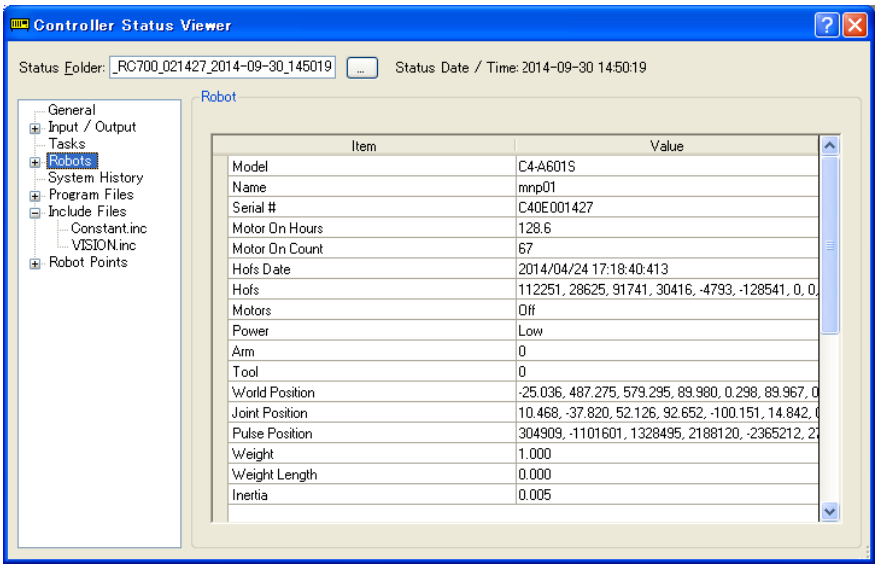
(1) Select EPSON RC+ menu-[Tools]-[Controller] to open the [Controller Tools] dialog box.

(2) Click the <View Controller Status> button to open the [Browse For Folder] dialog box.

(3) Select the folder where the information is stored.

(4) Click <OK> to view the [Controller Status Viewer] dialog box.

(5) Select [Robot] from the tree menu on the left side.



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

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

	Greasing part	Greasing Interval	Grease	Reference
Joint #1	Reduction gear units	Overhaul timing	SK-1A	*5. Joint #1*
Joint #2			SK-1A	*6. Joint #2*
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 usage condition and degree of the load (such as when operated with the maximum motion speed and maximum acceleration / deceleration in continuous operation) applied on the Manipulator.

Joint #3 Ball screw spline unit

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

Normal grease

Discolored grease

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

NOTE

Recommended replacement time for the grease on the ball screw spline unit can be checked in the [Maintenance] dialog box box of the EPSON RC+ 7.0.
For details, refer to the following manual.

RC90 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	

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

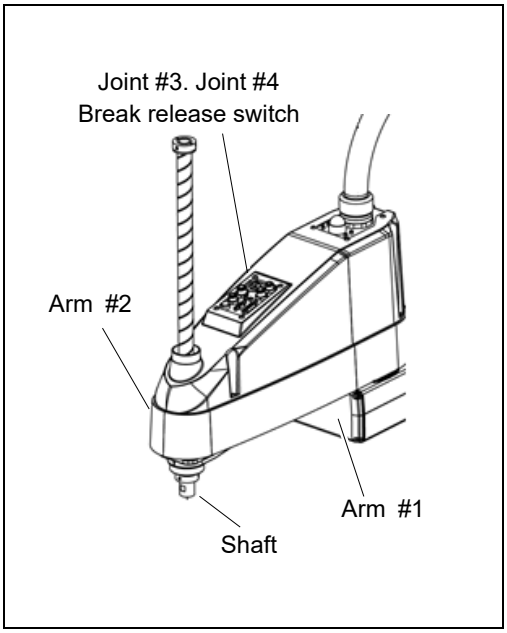
(1) Turn ON the Controller.

(2) Move the shaft to its lower limit in one of the following methods.

- Move the shaft to its lower limit manually while pressing the brake release switch.
- Move the shaft to its lower limit from EPSON RC+ 7.0 [Tools]-[Robot Manager]-[Jog & Teach].

NOTE Make sure that the hand does not interfere with peripheral equipment.

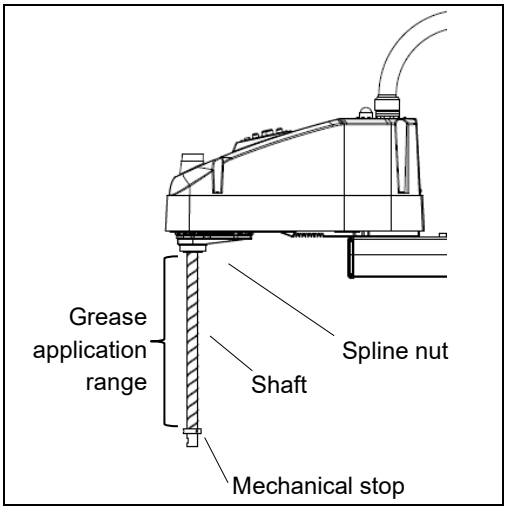
The brake release switch affects both Joints #3 and #4. When the brake release switch is pressed, the brakes for both Joints #3 and #4 are released simultaneously.



(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.

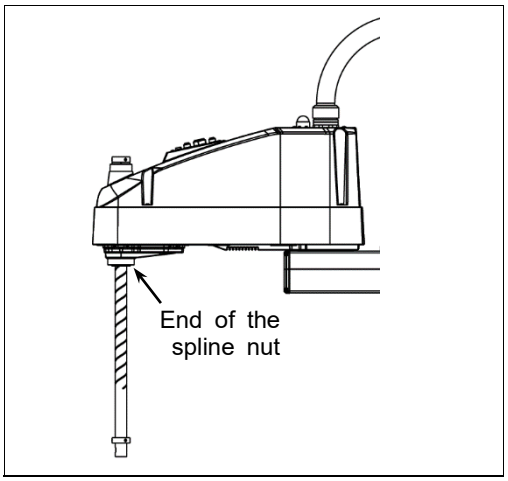
Grease application example

(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.



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.

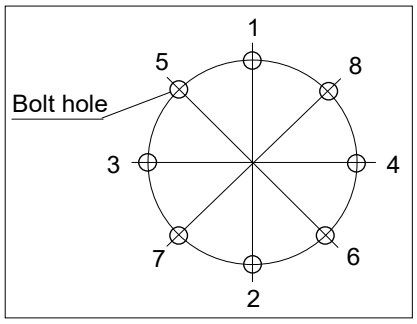
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

Bolt	Tightening Torque
M2.5	1.4 ± 0.1 N·m (14 ± 1 kgf·cm)
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.

Bolt	Tightening Torque
M3	0.7 ± 0.1 N·m (7.1 ± 1 kgf·cm)
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+

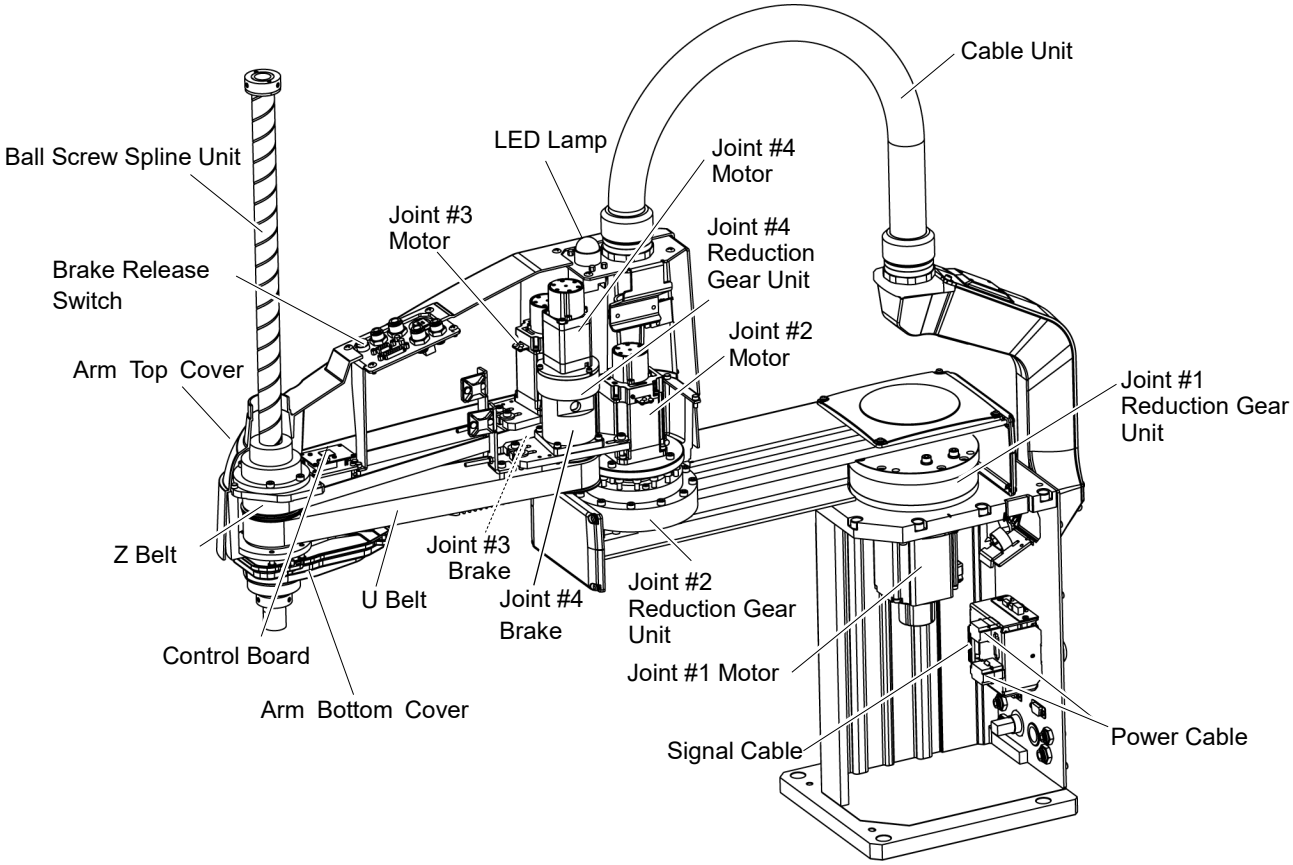
Execute the following command from the [Command Window].

```
>PULSE
```

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

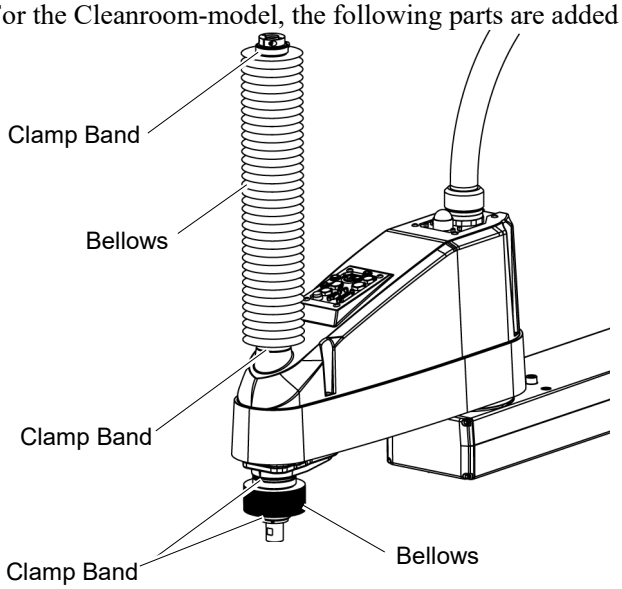
2.6 Layout of Maintenance Parts

Standard-model



Cleanroom-model (with optional bellows)

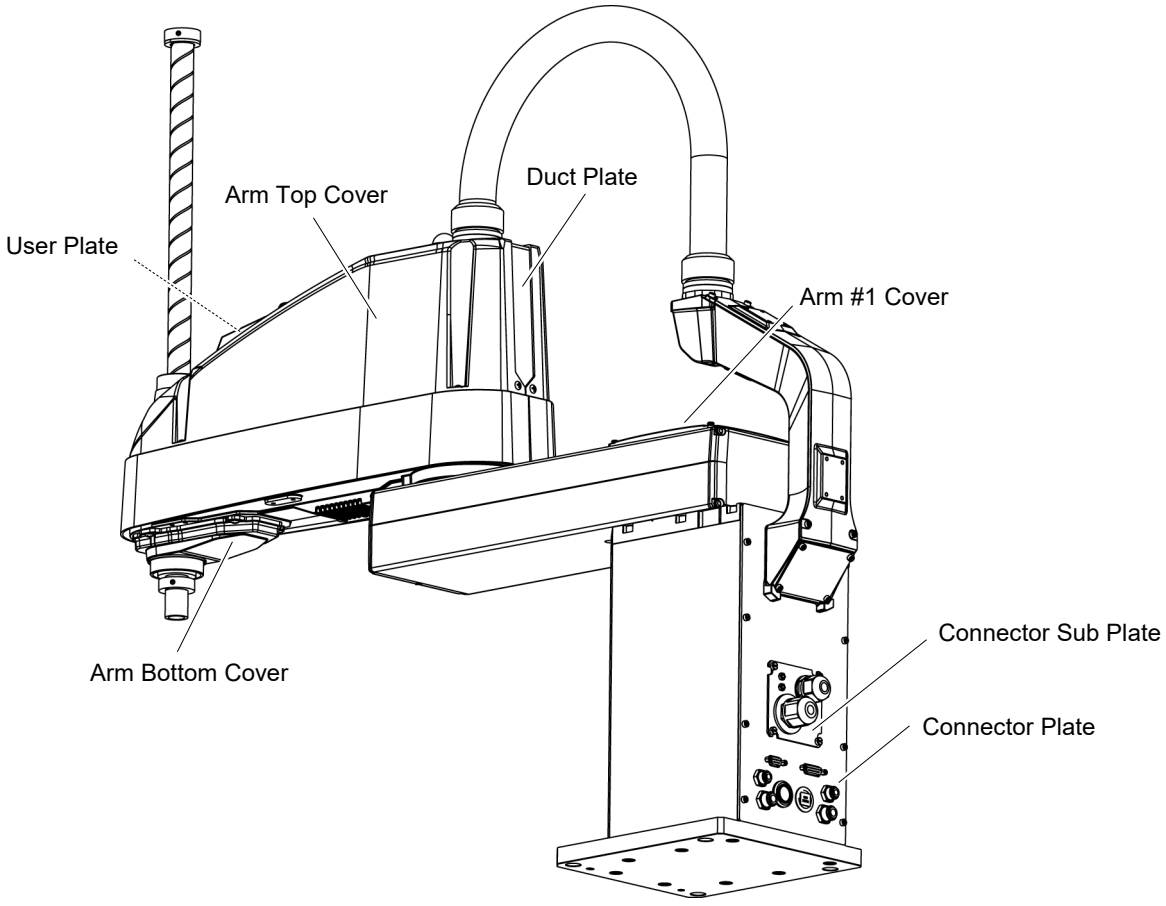
For the Cleanroom-model, the following parts are added to the Standard-model.



3. Covers

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

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. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



3.1 Arm Top Cover

CAUTION

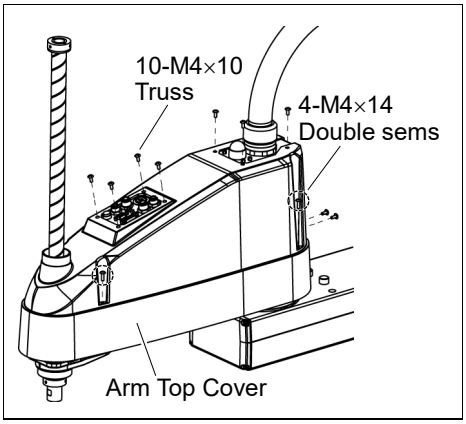
- Do not remove the arm top cover forcibly. Removing the cover forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
-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

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*.

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



Arm Top Cover Installation

Put the arm top cover to the arm and secure with the Arm Top Cover mounting bolts.
After securing the Arm Top Cover, make sure that the lower limit mechanical stop is not touching the cylindrical part of the Arm Top Cover.

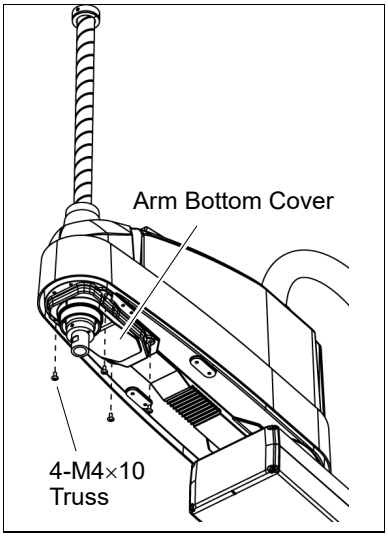
Tightening torque: 0.45 N·m

NOTE When bellows are installed to the manipulator, install the Arm Top Cover and then set the upper bellows. For bellows installation, refer to *9. Bellows*.

3.2 Arm Bottom Cover

Unscrew the Arm Bottom Cover mounting bolts and then remove the cover.

Tightening torque: 0.45 N·m



NOTE

Be careful of the end effector. When the end effector is installed, the Arm Bottom Cover may not be removed from the shaft.

When you replace the ball screw spline unit, you need to remove the end effector to remove the Arm Bottom Cover completely.

When you can work (maintenance, inspection) without removing the cover completely, move the shaft to the lower limit and lower the Arm Bottom Cover.

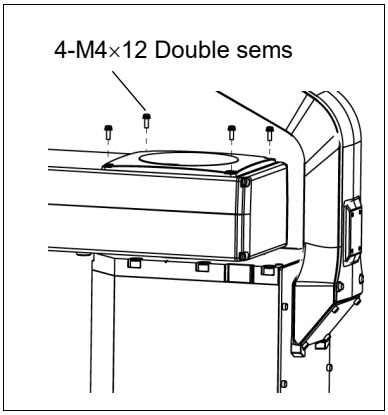
NOTE

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*.

3.3 Arm #1 Cover

Unscrew the Arm #1 cover mounting bolts and remove the cover.

Tightening torque: 0.45 N·m

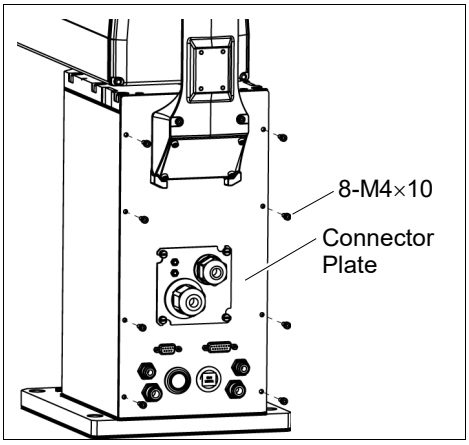


3.4 Connector Plate

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 mounting 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.

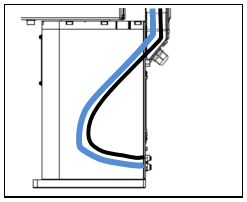


When mounting the Connector Plate, be careful of the following.

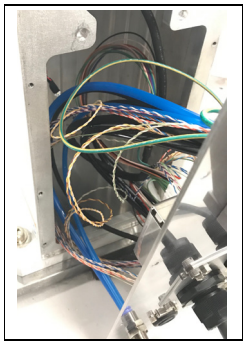
NOTE

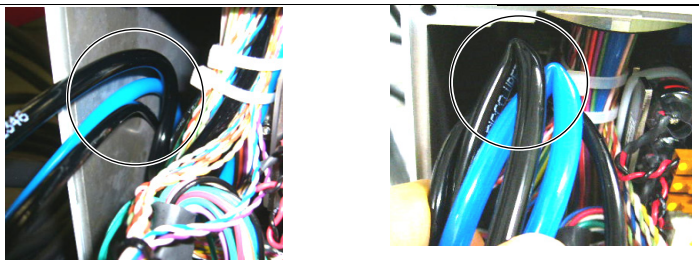
Prevent the air tube from bending sharply inside the manipulator. Also, do not block the air flow.

If there is a kink in the air tube, air flow is blocked while the manipulator is operating and may cause a trouble.



Put the air tubes along the wall as shown in the picture.





GOOD: Curved BAD: Bended

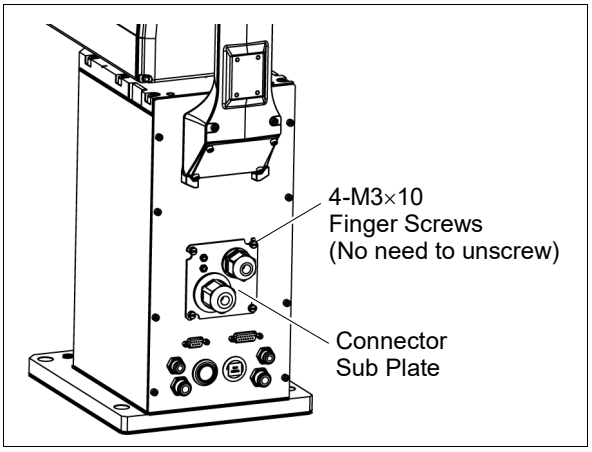
3.5 Connector Sub Plate

CAUTION

- 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 mounting 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.

Refer to
LS-B series Manual – LS20-B Manipulator 3.6 Connecting the Cables.

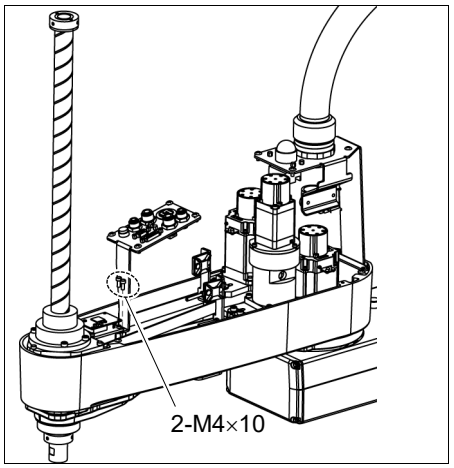


3.6 User Plate

User Plate Removal

(1) Remove the Arm Top Cover.
Refer to *3.1 Arm Top Cover*.

(2) Unscrew the User Plate mounting bolts and remove the plate.



User Plate Installation

(1) Put the User Plate to the arm and secure using the mounting bolts.

(2) Mount the Arm Top Cover.

Refer to *3.1 Arm Top Cover*.

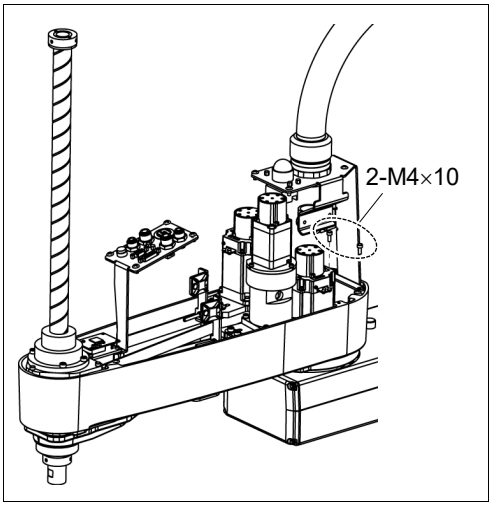
3.7 Duct Plate

Duct Plate Removal

(1) Remove the Arm Top Cover.

Refer to *3.1 Arm Top Cover*.

(2) Unscrew the Duct Plate mounting bolts and remove the plate.



Duct Plate Installation

(1) Put the Duct Plate to the arm and secure using the mounting bolts.

(2) Mount the Arm Top Cover.

Refer to *3.1 Arm Top Cover*.

4. Cable

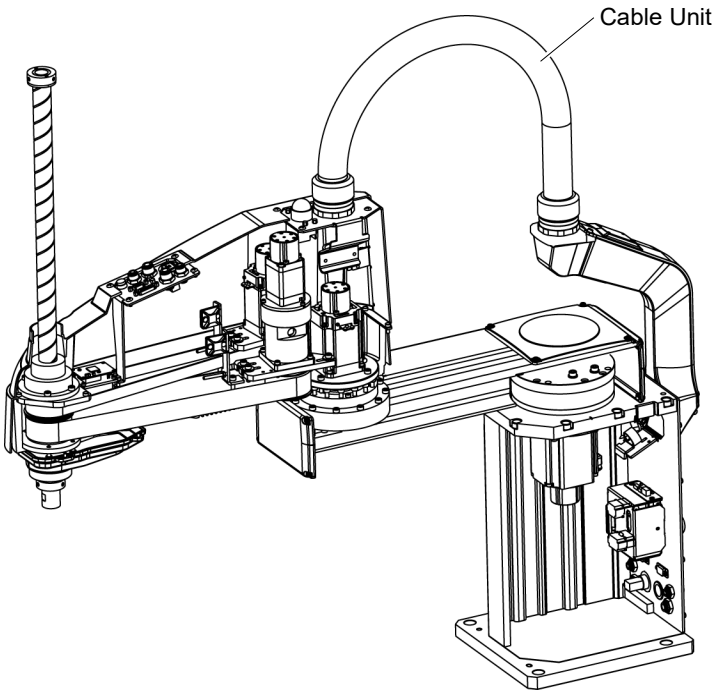
 WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in 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. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

 CAUTION	■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.

4.1 Replacing Cable Unit

NOTE LS20-B series manipulator does not have batteries. Position data is memorized by the motor. When replacing cables, calibration is not necessary.

	Name		Qty.	Note
Maintenance parts	Cable unit		1	LS20-B804*: 2202239 LS20-BA04*: 2202240
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
	Torque wrench		1	
	Nippers		1	For cutting wire tie
Material	Wire tie		-	



CAUTION	■ If the connectors have been disconnected during the replacement of the cable unit, be sure to reconnect the following 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 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.

NOTE

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

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

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.

NOTE

The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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 Connector Sub Plate from the Connector Plate.

For details, refer to *3.5 Connector Sub Plate*

(5) Disconnect M/C cable.

For details, refer to *LS-B series Manual – LS20-B Manipulator 3.6 Connecting the Cables - Connect and disconnect M/C cable.*

(6) Remove the Connector Plate.

For details, refer to *3.4 Connector Plate.*

(7) Remove the following that connected to the (inside) of the Connector Plate and Connector Sub Plate.

Pneumatic tube
D-sub cable
Ethernet cable (RJ45)
Connectors: X11, X111, X121, CV11, CV12, CV13

NOTE
For connectors fixed on the mount base, disconnect by holding the clip.
Be careful not to lose the spacer which holding the ground wires.

(8) Cut off the two wire ties binding the cables on the base side cable fixing plate.

NOTE
Remember the cable layout for reconnecting the disconnected parts after replacement.

(9) Disconnect two connectors inside the Base.

Connectors: X41, X211

(10) Remove the Arm Top Cover.

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

(11) Remove the User Plate.

For details, refer to *3.6 User Plate*.

(12) Disconnect 11 connectors on the Arm side.

Connectors: X22, X33,X42, X43, X44, X51, BR3, BR4, X221, X231, X241

(13) Disconnect the D-sub cable, pneumatic tube, and Ethernet cable (RJ45) 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 fittings to pull out the pneumatic tube. (ø6×2, ø8×1)
Remember the cable layout for reconnecting the disconnected parts after replacement.

(14) Remove the two ground wires from Joint #3 Plate and Duct Plate.

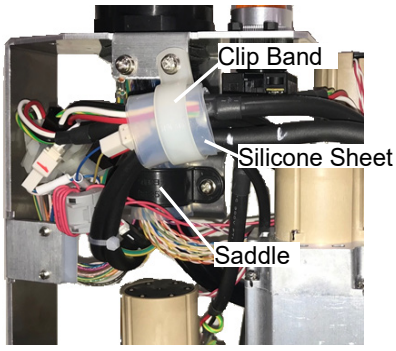
(15) Cut off the wire tie binding the cables in the Arm side.

NOTE
Remove the following parts:
Clip band, saddle

Removed parts will be used again.
Be careful not to lose them.

Cables are wrapped in a silicon sheet for protection. The sheet will be reused when installing the cable unit.
Be careful not to lose it.

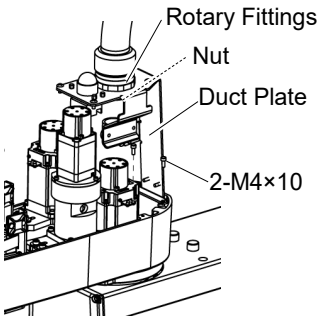
Arm #2 side



(16) Remove the nut of the rotary fitting.

Remove the rotary fitting from the Duct Plate.

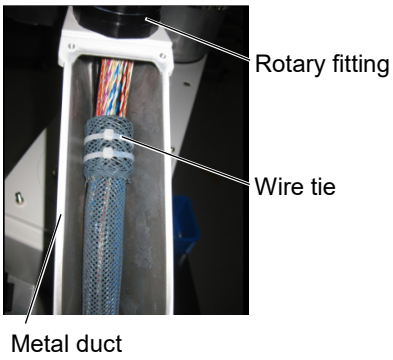
Disconnect the cables from the Duct Plate.

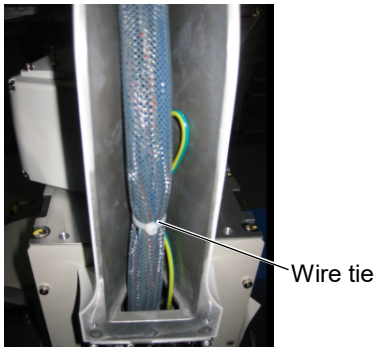


(17) Remove the rotary fitting from the metal duct.

The rotary fitting is directly screwed in the metal duct. Loosen the screws to remove the fitting.

Cut off the wire tie fixing the cables, and then disconnect the cables from the metal duct.





Cable Unit Installation

(1) Pass the new cables through the Cable Duct Unit. Then, rotate the fittings to secure the cables.

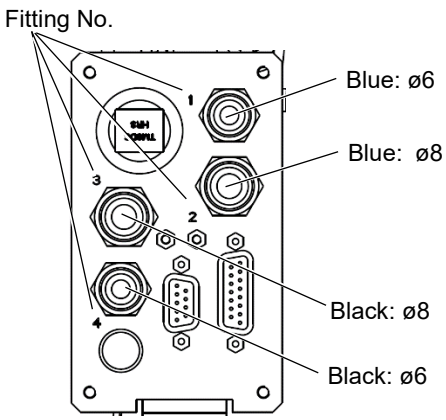
(2) Pass the cables in the Duct Plate side through the Duct Plate and nut and turn the fittings to secure the cables.

(3) Connect the following parts to the Connector Plate.

Pneumatic tube, D-sub cable, Ethernet cable (RJ45), ground wire (×7)

NOTE All fittings of LS20-B series manipulators are white. See the table below for connection of pneumatic tube to fittings.

Fitting No.	Pneumatic tube (Color / Outer Diameter)
1	Blue / ø6
2	Blue / ø8
3	Black / ø8
4	Black / ø6



(4) Connect two connectors on the Base side.

Connectors: X41, X211

(5) Bind the cables with a new wire tie as before in the removal step (8).

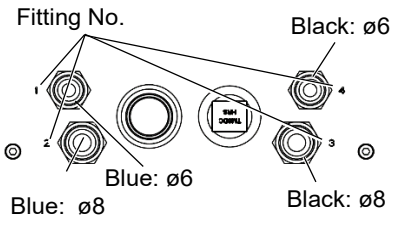
NOTE Fix the short flexible tube shipped with the cable unit with the wire tie at the upper side of the metal duct.

(6) Connect the following parts to the User Plate.

Pneumatic tube, D-sub cable, Ethernet cable (RJ45)

NOTE All fittings of LS20-B series manipulators are white. See the table below for connection of pneumatic tube to fittings.

Fitting No.	Pneumatic tube (Color / Outer Diameter)
1	Blue / ø6
2	Blue / ø8
3	Black / ø8
4	Black / ø6



(7) Mount the User Plate.

For the details, refer to *3.6 User Plate*.

(8) Connect the following connectors.

Connectors: X22, X33,X42, X43, X44, X51, BR3, BR4, X221, X231, X241

(9) Mount two ground wires in the Arm side to the Joint #3 Motor Plate and Duct Plate.

(10) As with the wire tie cut off at the removal step (14), bind the cables with a new wire tie.

Wrap the cables in the silicon sheet for protection.

Bind the cables with the clip band and the saddle.

(11) Mount the Connector Plate.

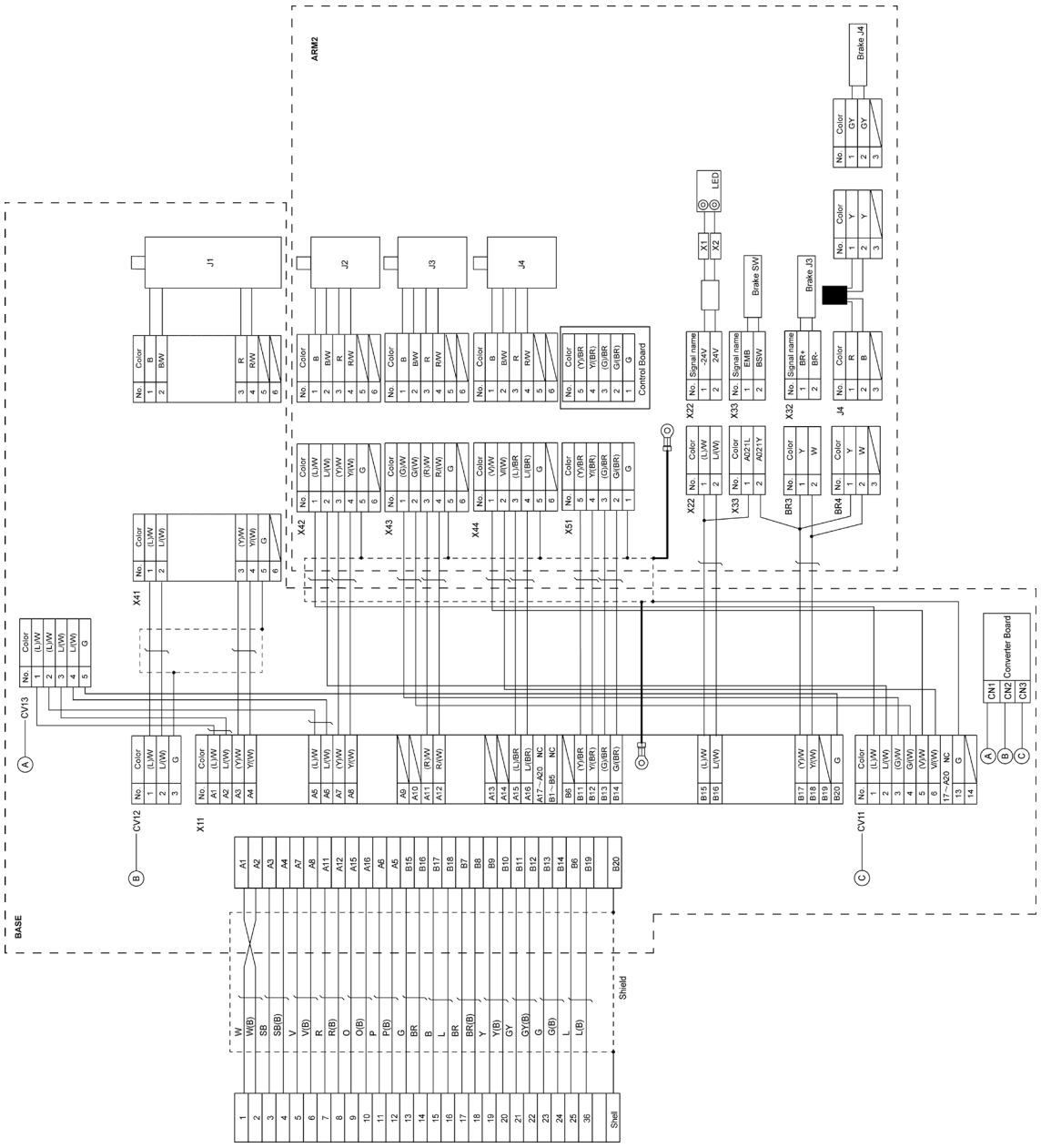
For the details, refer to *3.4 Connector Plate.*

(12) Place and secure the Arm Top Cover without the cables being stuck.

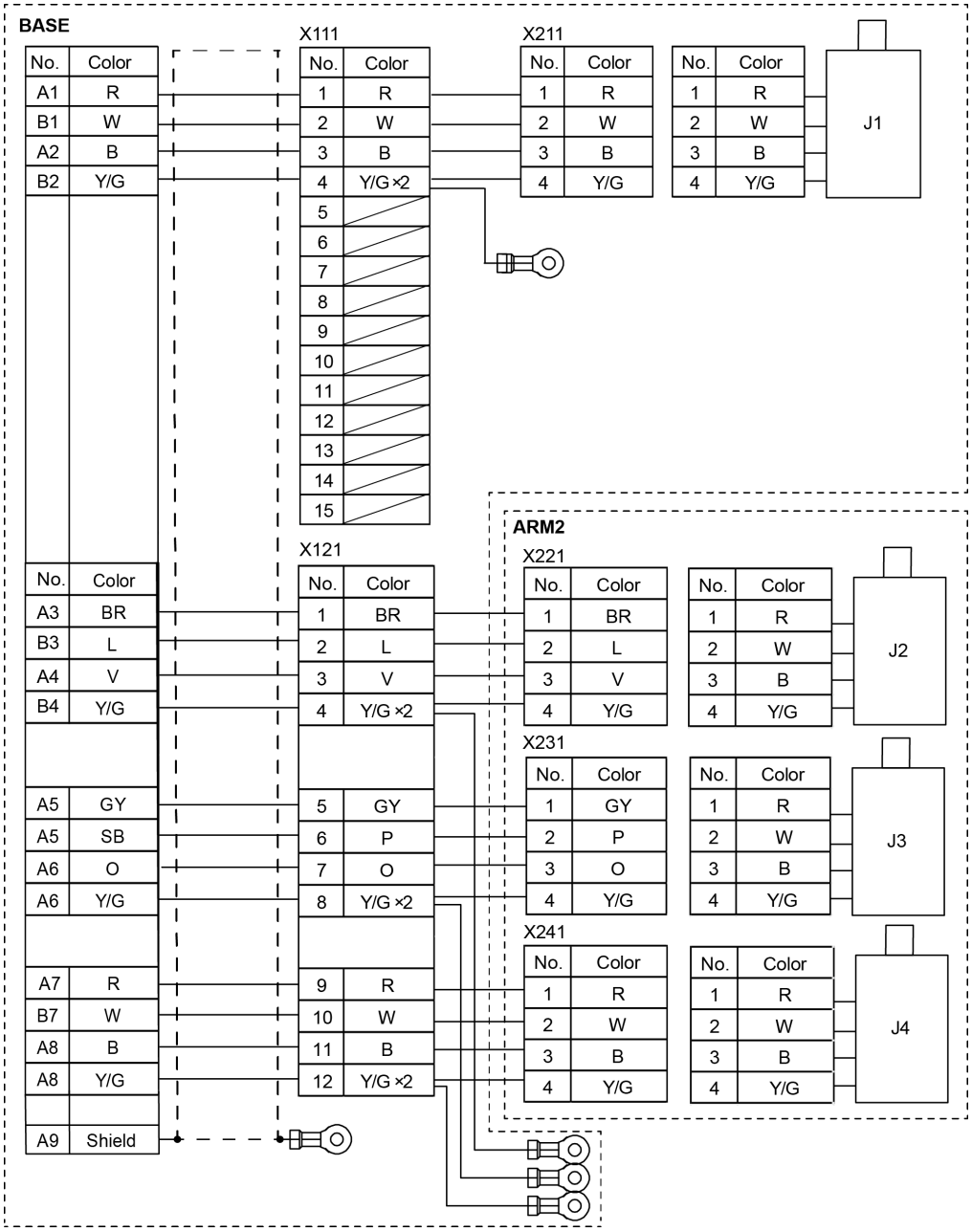
For details, refer to *3.1 Arm Top Cover*.

4.2 Wiring Diagrams

4.2.1 Signal Cable



4.2.2 Power Cable



4.2.3 User Cable

D-sub 9pin

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	G	⟷	9	G

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	⟷	15	G

The following table shows the types of User cable.

Model name	Model type	Code
LS20-B804*	Standard, Cleanroom	2202239
LS20-BA04*	Standard, Cleanroom	2202240

4.2.4 Color of Cables

The following table shows the codes and cable colors indicated in the pin assignments.

4.2.1 Signal Cable

4.2.2 Power Cable

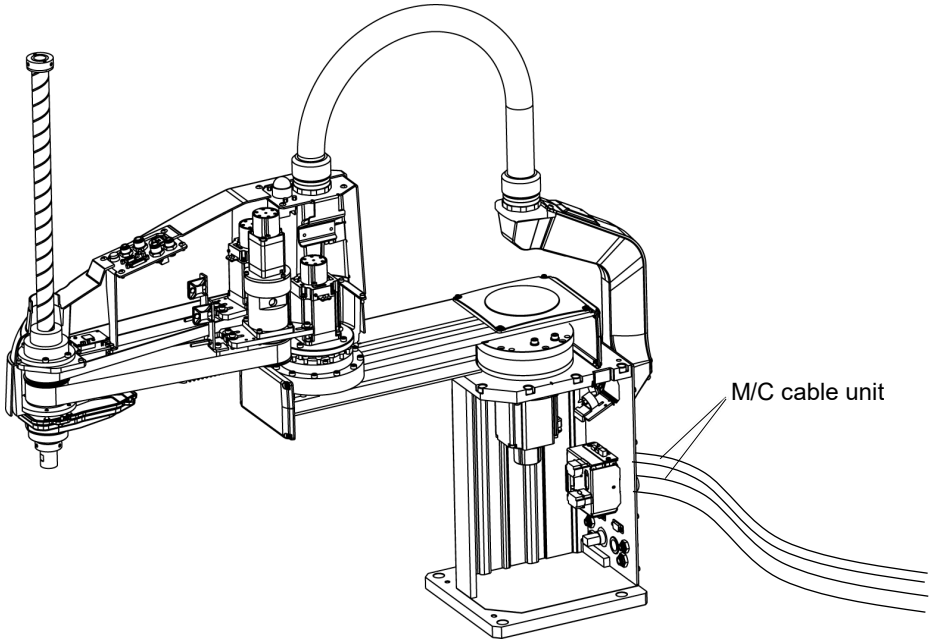
4.2.3 User Cable

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

4.3 Replacing M/C Cable

NOTE
LS20-B series manipulator does not have batteries. Position data is memorized by the motor. When replacing cables, calibration is not necessary.

	Name		Qty.	Note
Maintenance parts	M/C cable unit	For fixed wiring	1	3 m: R12NZ9010B 5 m: R12NZ9010C 10 m: R12NZ9010D
		For movable wiring	1	5 m: R12NZ90159 10 m: R12NZ9015A
Tool	Flathead screwdriver		1	
	Torque wrench		1	



CAUTION

- If the connectors have been disconnected during the replacement of the cable unit, be sure to reconnect the following 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 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.

M/C Cable Removal

(1) Turn OFF the Controller.

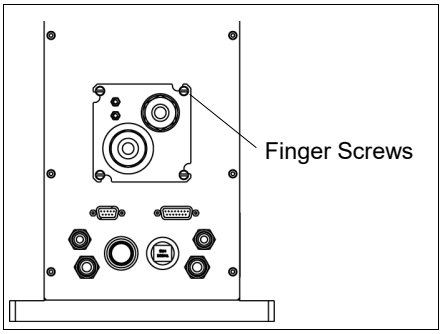
(2) Disconnect the following connectors form the controller.

Power cable connector Signal cable connector

(3) Loosen the screws fixing the plate.

You do not need to remove them completely.

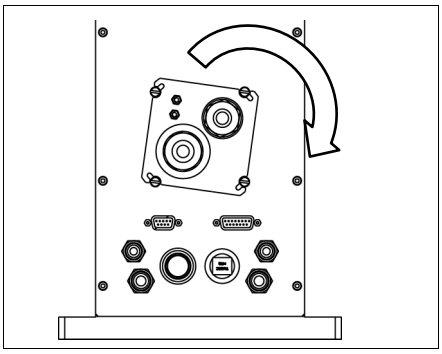
For details, refer to
Maintenance: 3.3 Connector Plate.



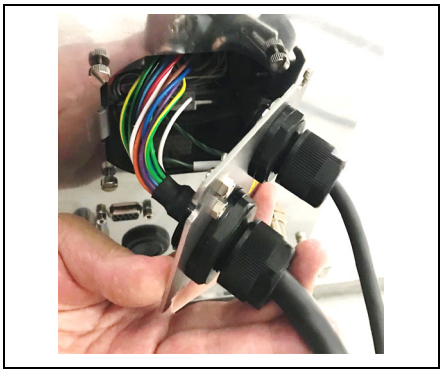
(4) Slide the plate to remove it from the base.

NOTE

Do not pull the M/C cable after removing the plate. M/C cables are connected by the connectors. Doing so may result in disconnection of the cables.

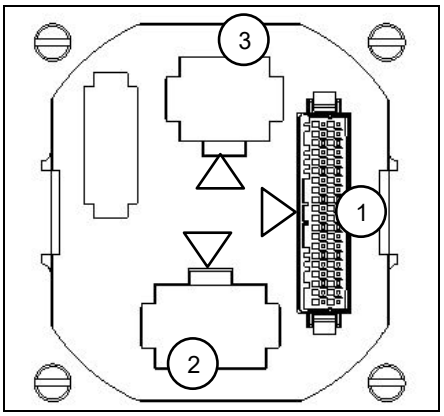


(5) As shown on the right, pull out the cables from the Manipulator.



(6) Disconnect the following connectors in the order as shown on the right.

Clips of the connectors are △ positions in the figure.
Push the clip to disconnect the connector.



NOTE

Connector (white) for the power cable is difficult to disconnect for safety purpose.

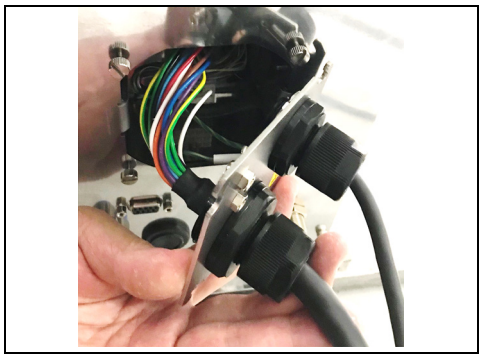
To disconnect the connector, securely push the clip.
If you cannot disconnect it, push the connector once, and then disconnect it by pushing the clip.

Do not pull the cables. Doing so may result in disconnection.

Do not remove the M/C cable form the plate.

M/C cable Installation

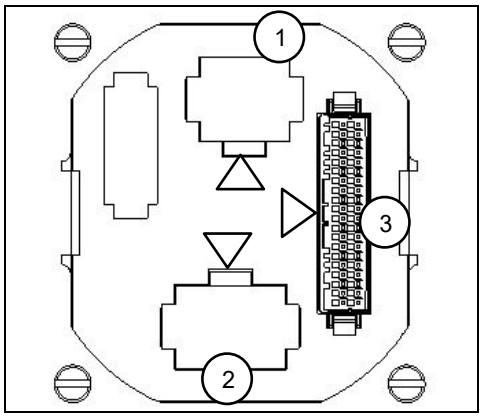
(1) Set the M/C cable as shown on the right.



NOTE

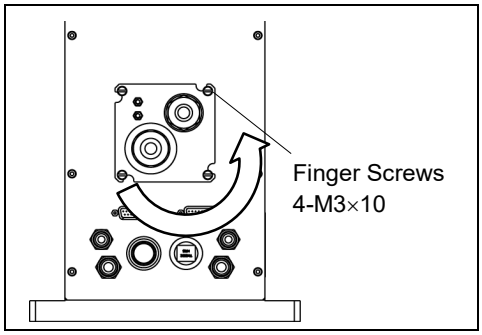
Be careful with the direction of the plate.

(2) Connect the following connectors in the order as shown on the right.



(3) Slide the plate to install it.

Finger screws : 4-M3×10
Tightening torque : 0.6±0.1 N·m



NOTE

Slide the plate until it will be parallel to the base table.

Be careful not to tighten the screws with the cables get caught on the plate.

(4) Connect the following connectors to the controller.

Power cable connector Signal cable connector

(5) Turn ON the Controller.

Direction of the connector sub plate

When installing the plate, be careful for the direction.
Correct direction: When the arrow of warning label of electric shock is the same direction as the illustration on the right.
If the plate is installed in wrong direction, the cables inside the Manipulator will be twisted and may result in disconnection.

Correct: Cables are not twisted

Wrong: Cables are twisted

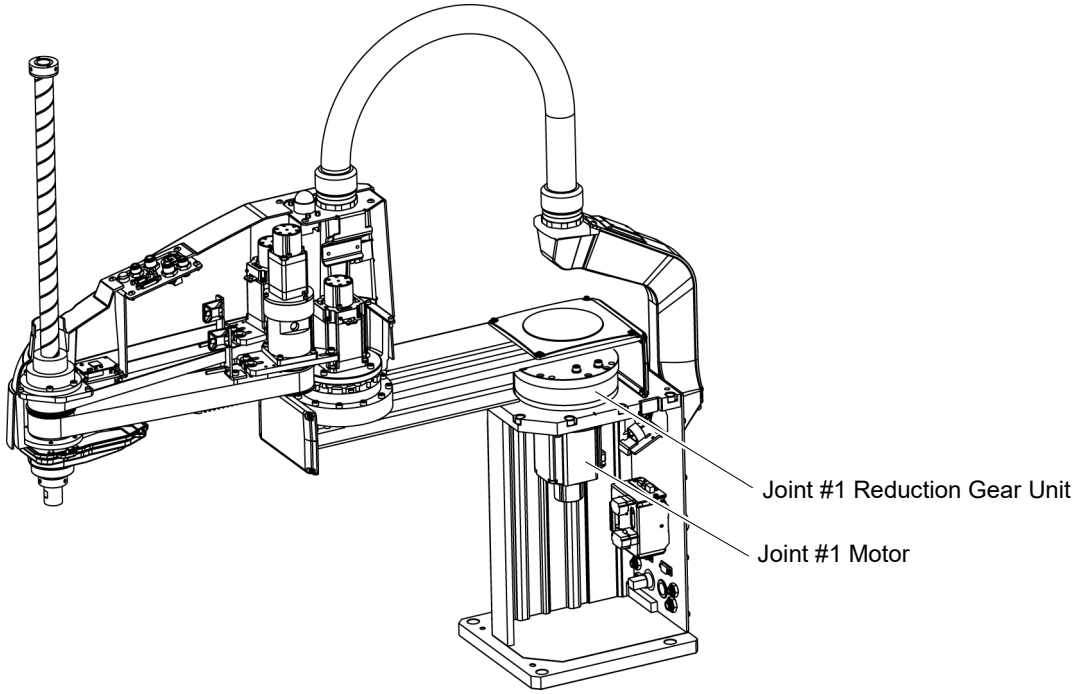
5. Joint #1

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.

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



5.1 Replacing Joint #1 Motor

	Name		Qty.	Note
Maintenance parts	AC Servo Motor (750W)		1	2202238
	O-ring		1	1618361
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: 5 mm	1	For M6 screw
		width across flats: 6 mm	1	For M8 screw
	Cross-point screwdriver (#2)		1	For M4 screw
	Torque wrench		1	
	Wiping cloth		1	For wiping grease
Maintenance parts	Grease (SK-1A)		-	-

Joint #1 motor Removal

(1) Remove the Connector Plate.

For details, refer to *3.4 Connector Plate*.

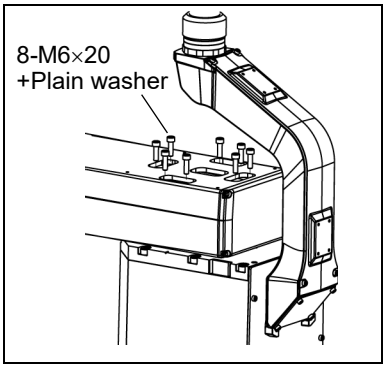
(2) Disconnect the connector.

Connectors: X41, X211 (Hold the clip to remove.)

(3) Remove the Arm #1 cover.

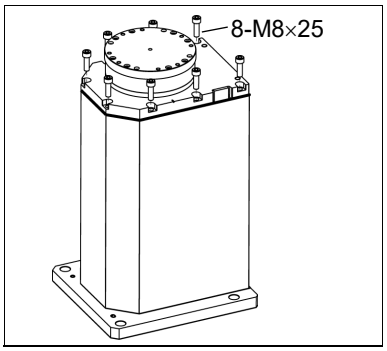
For details, refer to *3.3 Arm #1 cover*.

(4) Remove the Arm #1 mounting bolt on the Joint #1 side and remove the Arm 1.



(5) Remove the screws mounting the Top Plate on the Base.

(6) Hold up the Joint #1 unit and remove from the Base.

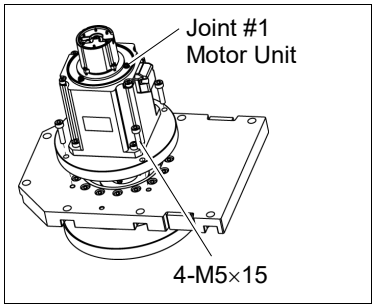


NOTE

The Joint #1 motor can be replaced while the Arm #1 and the Top plate are mounted. Refer to the next page for replacement steps.

(7) Loosen the motor mounting screws on the motor flange and remove the motor unit

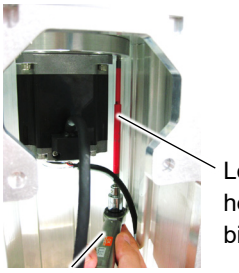
There is an O-ring between Top Plate and the motor flange. Be sure to keep the O-ring.

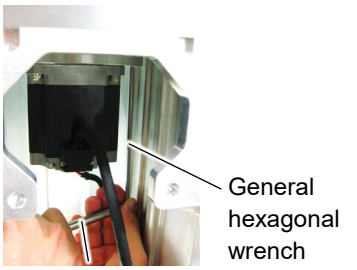


NOTE

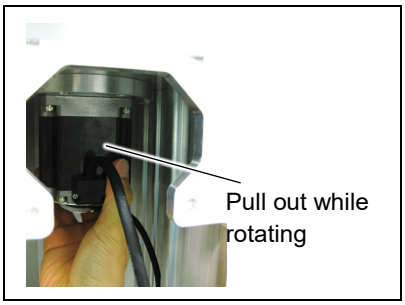
The motor can be removed while the Arm #1 and the Top plate are mounted.

When removing the motor with the Top plate mounted, use the torque wrench with the long hexagonal bit, or lengthen the general hexagonal wrench by using the metal pipe to loosen the screws.



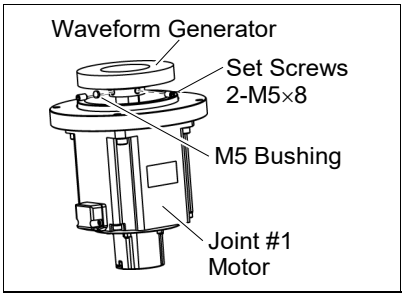


After loosening the screws, rotate the motor to pull out. If the motor is hard to pull out, pull the motor while rotating the Arm #1 slowly.

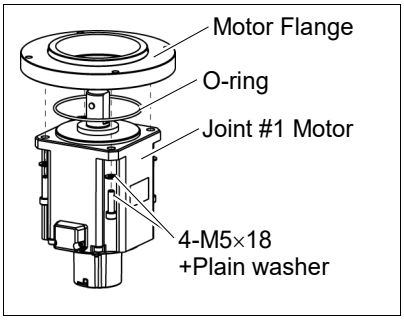


(8) Remove the waveform generator from the Joint #1 motor.

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



(9) Remove the motor mounting screws, and then remove the motor flange and O-ring.

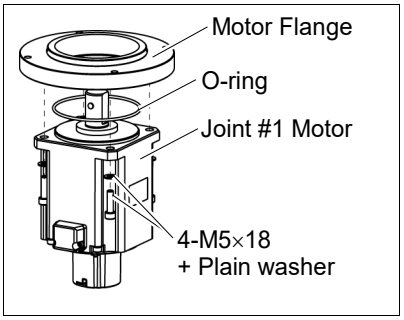


NOTE

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

Joint #1 motor Installation

(1) Put the O-ring on the motor mounting surface and mount the motor flange.

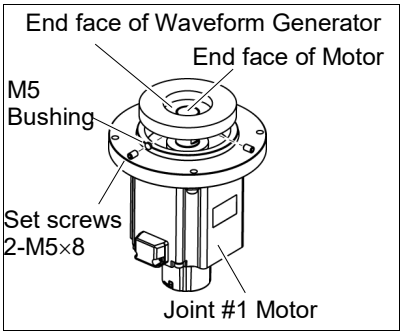


(2) Apply grease (SK-1A) to the between the waveform generator and motor.

Grease volume : 6 g

Mount the waveform generator on the Joint #1 motor. Be sure to align the end face of the waveform generator to the end face of the motor shaft.

Tighten one of the set screws vertically on the flat face of the motor shaft. Insert a bushing into the other set screw hole to prevent damage to the motor shaft.

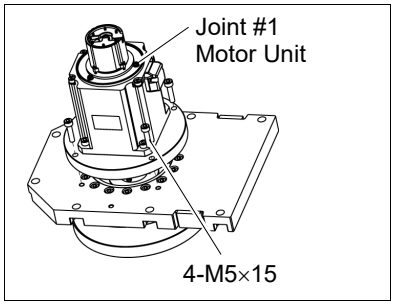


CAUTION

- See the figure 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.

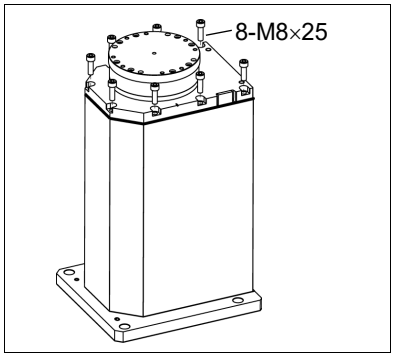
(3) Set an O-ring on the motor flange and assemble the Top Plate.

To insert the motor, turn it slowly from side to side by hand and push in.

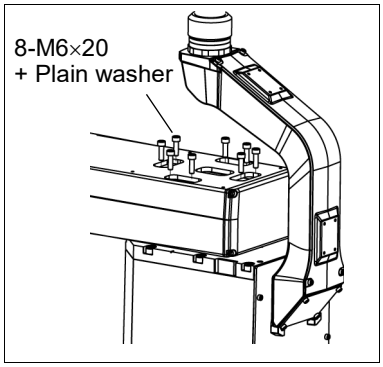


(4) Mount the Joint #1 unit on the Base.

Secure the Joint #1 motor cables facing toward the back of the Base.



(5) Mount the Arm #1 to the Joint #1 unit.



Tightening torque: 18 N·m

NOTE

Operating the Manipulator with improper tightening torque may cause positioning gap and damage on the screw and screw hole.

(6) Mount the cover to the Arm #1.

For details, refer to *3.3 Arm #1 Cover*.

(7) Connect the following connectors.

Connectors: X41, X211

(8) Mount the Connector Plate.

For details, refer to *3.4 Connector Plate*.

(9) Check if the Joint #1 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #1 moves, the connector for the other joint might be connected to the Joint #1 motor. Check the connector connection.

(10) Execute the calibration for the 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. 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 *14. Maintenance Parts List*.

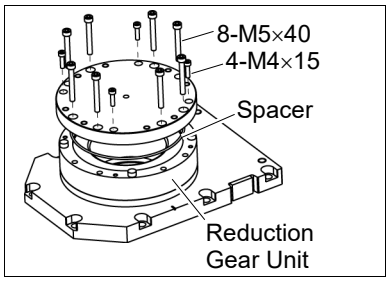
	Name		Qty.	Note
Maintenance Part	Joint #1 Reduction Gear Unit		1	1646483
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
		width across flats: 5 mm	1	For M6 screw
		width across flats: 6 mm	1	For M8 screw
		width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 3 mm	1	For M4 screw
	Cross-point screwdriver (#2)		1	For M4 screw
	Torque wrench		1	
	Nippers		1	
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Motor Flange)
			1	For wiping grease (Bolt)
Grease	Grease (SK-1A)		-	-

Joint #1 Reduction Gear Unit Removal

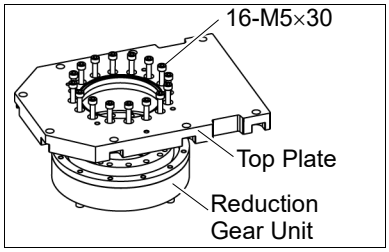
(1) Remove the Joint #1 motor unit.

Follow the removal steps in *5.1 Replacing Joint #1 Motor*.

(2) Remove the spacer from the reduction gear unit.



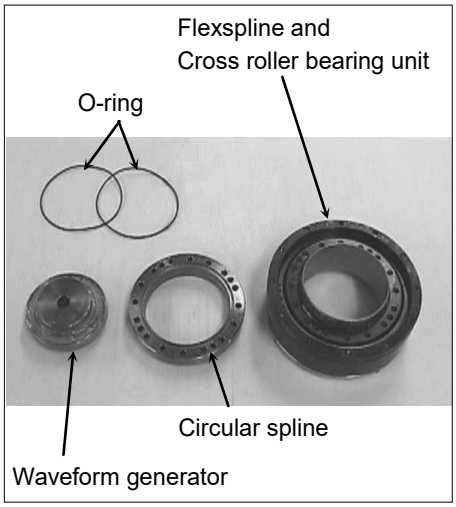
(3) Remove the reduction gear unit from the Top Plate.



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.

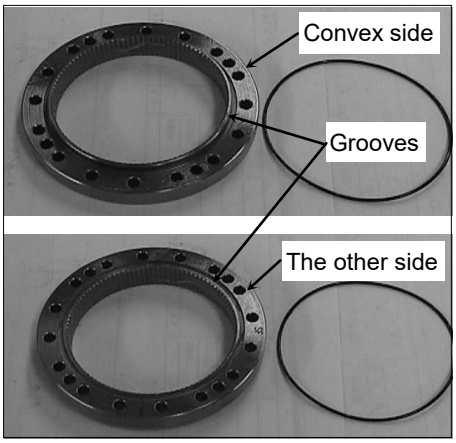
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



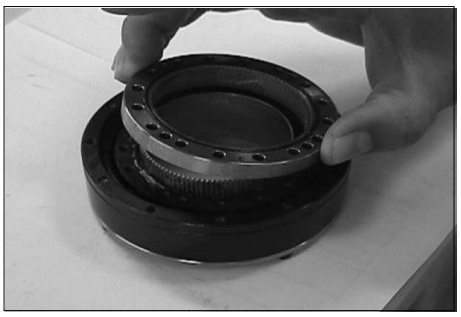
CAUTION	■ Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

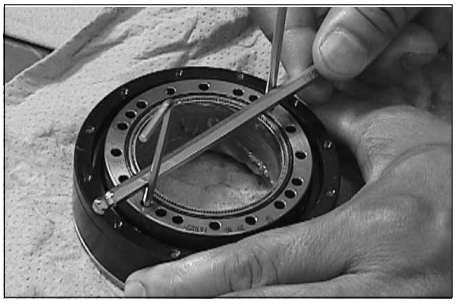
Make sure that the rings do not come out of the grooves.



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



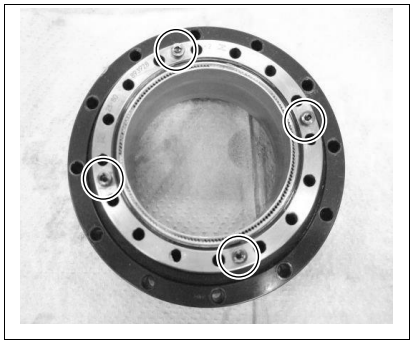
(4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



(5) Secure the cross roller bearing to the circular spline.

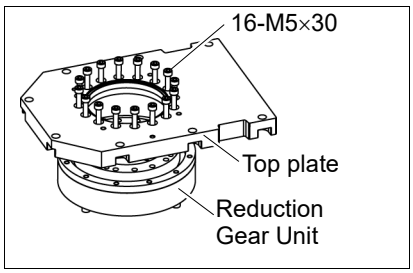
4-M4×20

Tightening torque: 4.0 N·m (40.8 kgf·cm)



(6) Secure the Top Plate 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	Bolts	Tightening torque
Joint #1 reduction gear unit	M5×30	16	10.0 N·m (102 kgf·cm)

NOTE

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

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

Grease volume : 80 g

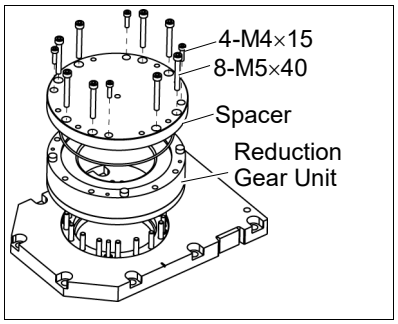
(8) Mount the spacer to the reduction gear unit.

Hexagon socket head cap bolts: 4-M4×15

Tightening torque: 5.5 N·m (56.1 kgf·cm)

Hexagon socket head cap bolts: 8-M5×40

Tightening torque: 10.0 N·m (102 kgf·cm)



(9) Mount the Joint #1 motor.

Follow the installation steps in *5.1 Replacing Joint #1 Motor*.

6. Joint #2

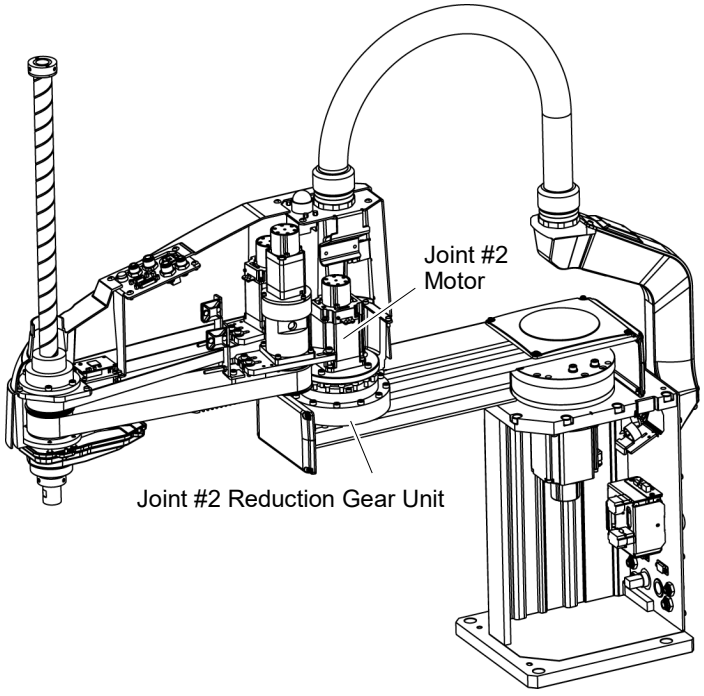
WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in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

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



6.1 Replacing Joint #2 Motor

	Name		Qty.	Note
Maintenance Parts	AC Servo Motor (520 W)		1	2197985
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M5 set screw
		width across flats: 4 mm	1	For M5 screw
	Cross-point screwdriver (#2)		1	For M4 screw
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Wiping cloth		1	For wiping grease
Material	Wire tie		-	
Grease	Grease (SK-1A)		-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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*.

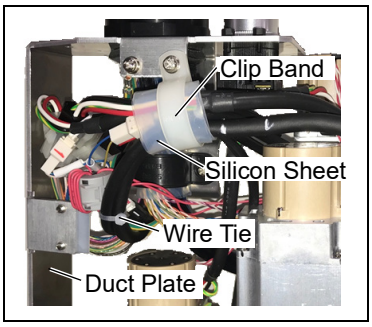
(5) Remove the User Plate and Duct Plate.

For details, refer to *3 Covers*.

(6) Remove the Clip Band and Sheet binding the motor cables.

The Clip Band and sheet will be reused when installing the cable unit. Be careful not to lose them.

Do not cut the wire tie (in the duct fittings outlet) that binds the cables to the duct plate.

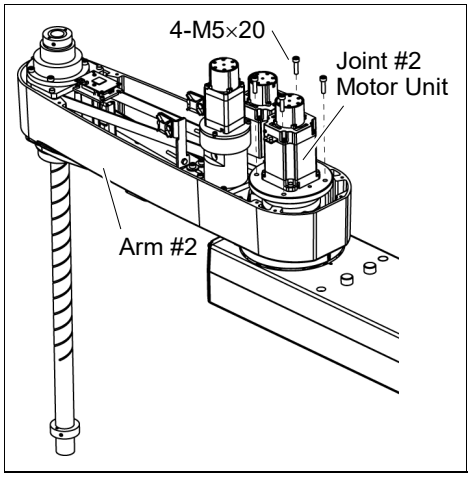


(7) Disconnect the following connectors.

Connectors: X221, X42 (Hold the clip to remove.)

(8) Remove the screws mounting the motor unit and then remove the Joint #2 motor unit from the Arm #2.

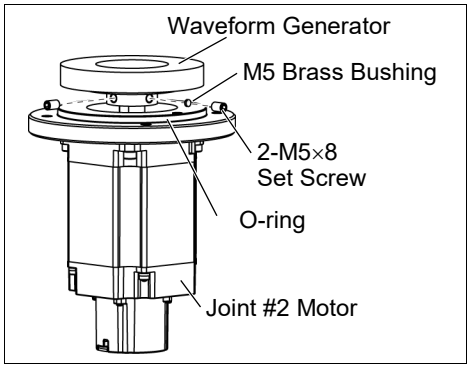
To pull out the motor smoothly, move the Arm #2 slowly by hand while pulling the motor.



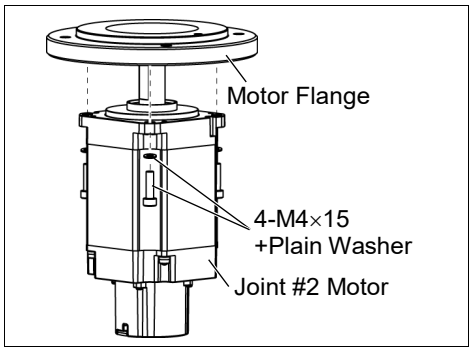
(9) Remove the waveform generator from the Joint #2 motor.

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

The O ring will be used again.
Be careful not to lose it.



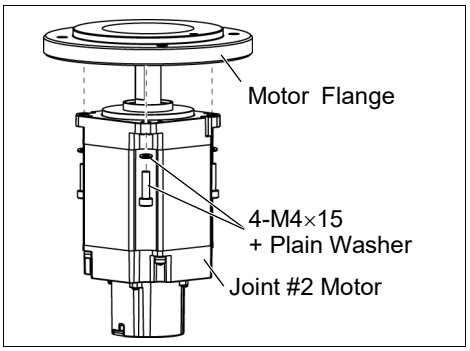
(10) Remove the motor flange from the Joint #2 motor.



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

Joint #2 Motor Installation

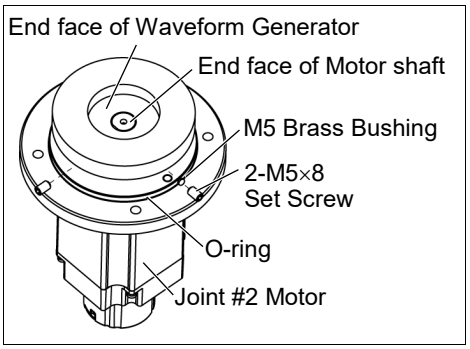
(1) Mount the motor flange on the Joint #2 motor.



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

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

Tighten one of the set screws vertically on the flat face of the motor shaft. Insert a bushing into the other set screw hole to prevent damage to the motor shaft.



CAUTION

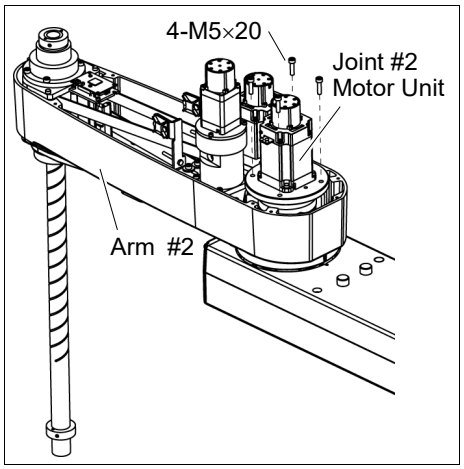
■ See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

(3) Apply grease between the waveform generator and motor flange.

Grease volume: 38 g (SK-1A)

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

To insert the motor, slowly move the Arm #2 by hand and push in.



(5) Mount the User Plate and Duct Plate.

For details, refer to *3. Covers*.

(6) Connect the following connectors.

Connectors: X221, X42

(7) Install the clip band removed in the removal step (6), bind the cables, and then fix them.

Do not allow unnecessary strain on the cables.

(8) Mount the Arm Top Cover.

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

(9) Check if the Joint #2 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #2 moves, the connector for the other joint might be connected to the Joint #2 motor. Check the connector connection.

(10) Execute the calibration for 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. When replacing the reduction gear unit, be sure to always replace the following parts all together as one set.

Waveform generator, Flexspline, Circular spline

For details of the three parts, refer to *14. Maintenance parts list*.

	Name		Qty.	Note
Maintenance parts	Reduction Gear Unit		1	1798349
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
	Cross-point screwdriver (#2)			For M4 screw
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Spatula		1	For apply grease
	Wiping cloth		1	For wiping grease (Motor Flange)
			1	For wiping grease (Bolt)
Material	Wire tie		-	
Grease	Grease (SK-1A)		-	

NOTE

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

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

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.

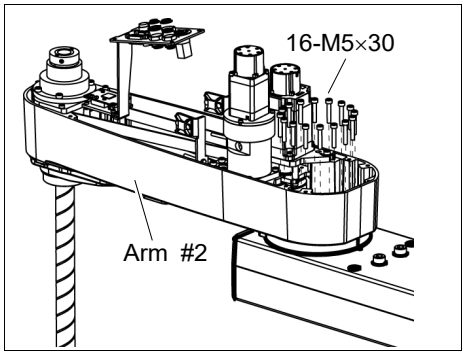
The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #4 are released simultaneously.
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft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

(3) Turn OFF the Controller.

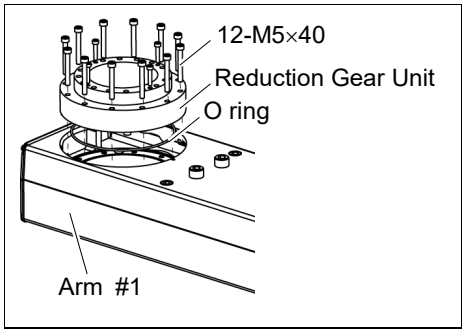
(4) Remove the waveform generator from the Joint #2 motor.

Follow the removal steps in *6.1 Replacing Joint #2 Motor*.

(5) Remove the Arm #2 mounting screws to remove it from the reduction gear unit.



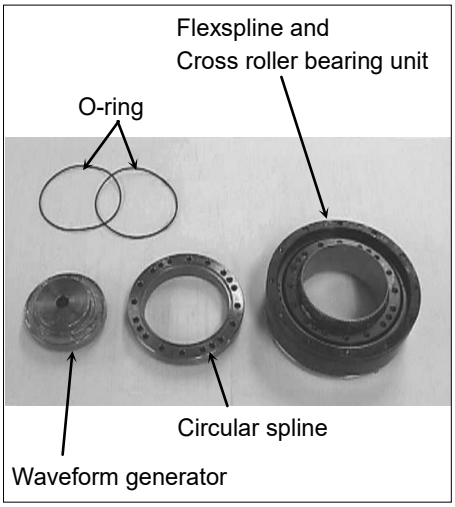
(6) Remove the reduction gear unit from the Arm #1 by removing the screws that mounts the reduction gear unit on the Arm #1.
There is an O-ring between the Arm #1 and the reduction gear unit.
Be careful not to lose the removed O-ring.



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.

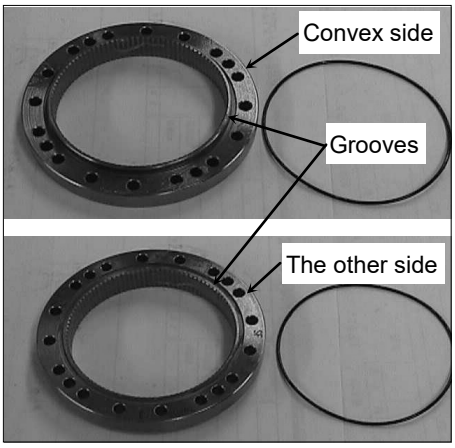
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



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

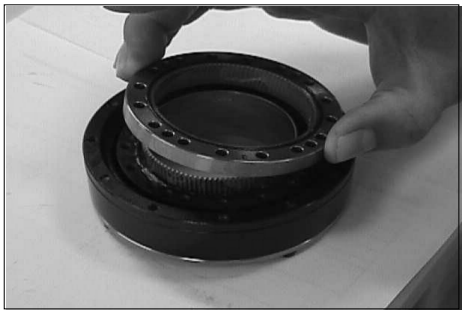
(2) Fit the O-rings into the grooves on both sides of the new circular spline.

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



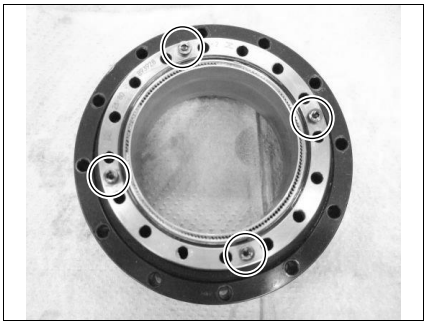
(3) Face the convex side of the circular spline down, and then fit it into the flexspline.

If it is difficult to fit in, rotate the circular spline a little bit and change the position.



(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 cross roller bearing to the circular spline.



4-M4×20

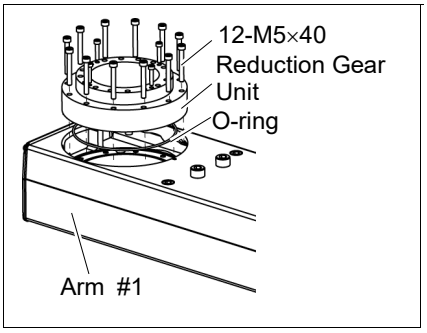
Tightening torque: 4.0 N·m (40.8 kgf·cm)

(6) Set the O-ring removed in the removal step (6) into the O-ring groove of the Arm #1.

Install the reduction gear unit on the Arm #1.

Hexagon socket head cap bolts: 12-M5×40

Tightening torque: 10.0 N·m (102 kgf·cm)



NOTE

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 above.

(6) Apply grease between the motor flange and waveform generator and next inside the flexspline.

Between the motor flange and waveform generator:

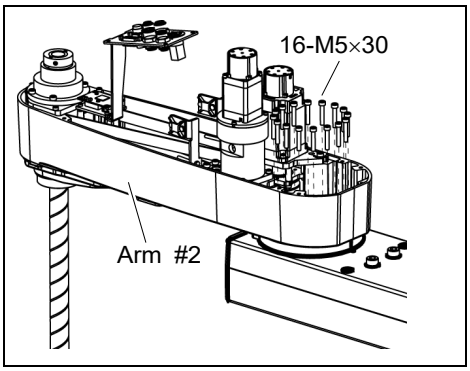
Grease volume: 38 g (SK-1A)

Inside the flexspline:

Grease volume: 90 g (SK-1A)

(7) Set the attached O-ring into the O-ring groove of the circular spline.

Secure the Arm #2 on the reduction gear unit.



(8) Mount and Joint #2 motor.

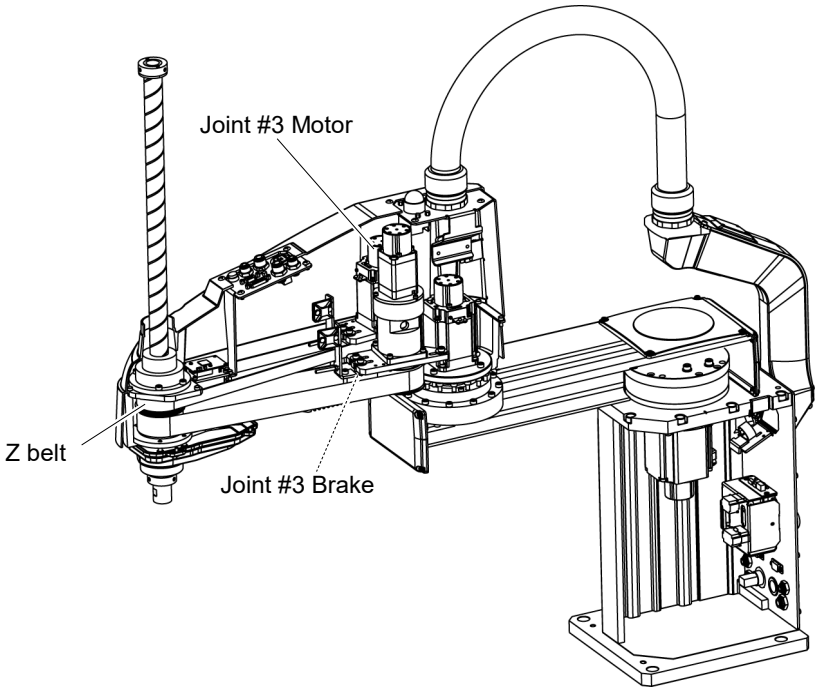
Follow the installation steps in *6.1 Replacing Joint #2 Motor*.

7. Joint #3

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.

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



7.1 Replacing Joint #3 Motor

	Name		Qty.	Note
Maintenance part	AC Servo Motor 520W		1	2197985
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
	Spanner	width across flats: 7 mm		For M4 bolt, M4 nut
	Cross-point screwdriver (#2)			For M3, M4 screw
	Torque wrench			
	Nippers		1	For cutting wire tie
	Sonic tension meter		1	Z: Belt tension 93N (9.5 ± 0.75 kgf)
Material	Wire tie		-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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.

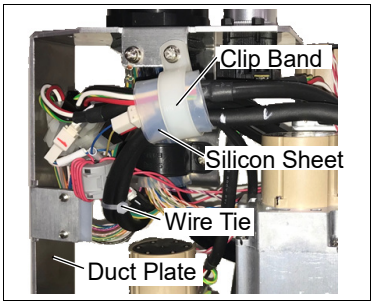
(4) Remove the Arm Top Cover.

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

(5) Remove the Clip Band and Sheet binding the motor cables.

Removed parts will be used again. Be careful not to lose them.

Do not cut the wire tie (in the duct fittings outlet) that binds the cables to the duct plate.



(6) Remove the User Plate and the Duct Plate.

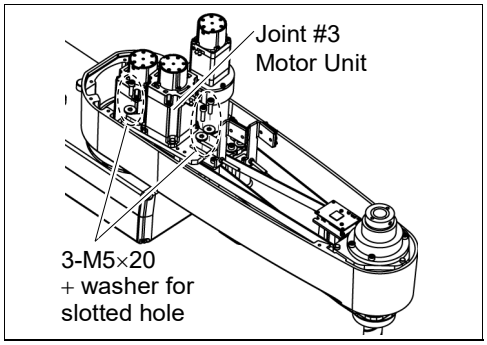
For details, refer to *3. Covers.*

(7) Disconnect the following connectors.

Connectors: X231, X43 (Hold the clip to remove.)

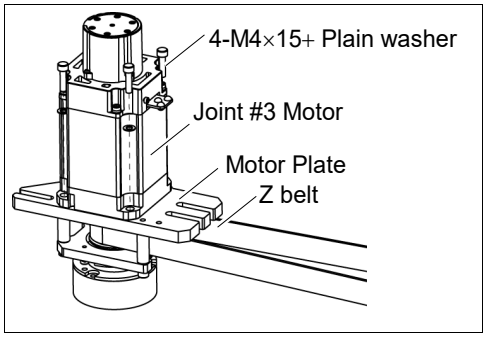
(8) Remove the bolts fixing the Joint #3 motor unit.

The washers for slotted holes will be used again when installing the Z belt.
Be careful not to lose them.



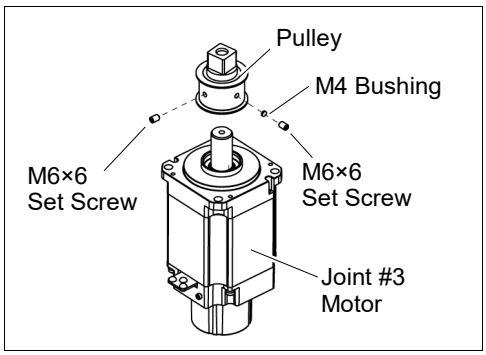
(9) Remove the Joint #3 motor from the Motor Plate.

The belt is placed around the pulley.
To remove the Joint #3 motor, tilt the motor slightly and pull it upward while avoiding the belt.



(10) Loosen the screws of the pulley remove it from the Joint #3 motor.

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

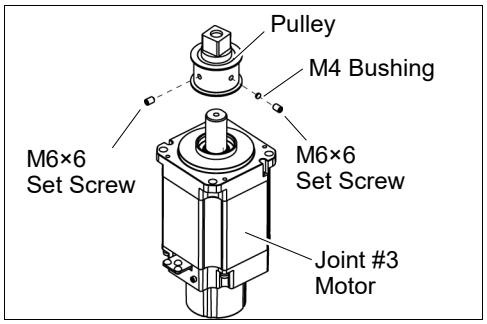


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #3 motor Installation

(1) Mount the pulley to the Joint #3 motor.

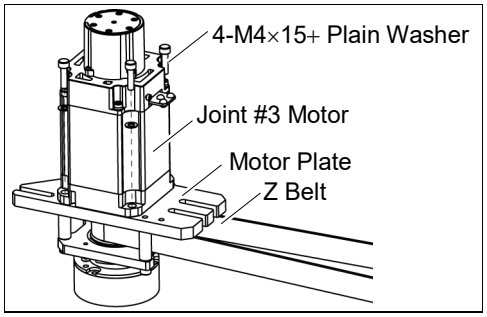
Secure the pulley where the pulley end face touches the motor shaft end face.



Tighten one of the set screws vertically on the flat face of the motor shaft.
Insert a bushing into the other set screw hole to prevent damage to the motor shaft.

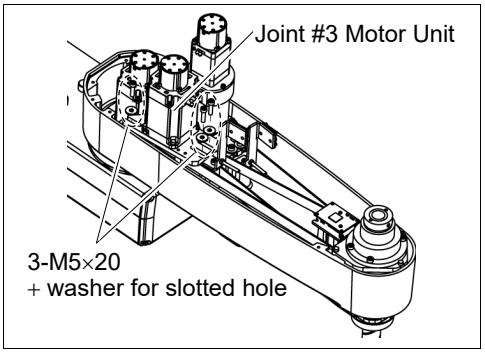
(2) Mount the Joint #3 motor to the motor plate while aligning the hub to the brake disc.

Before aligning the hub, set the motor so that the pulley will be inside of the Z belt.



(3) Loosely secure the Joint #3 motor unit to the Arm #2. Make sure that the teeth of the timing belt are engaged with those of the pulley.

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

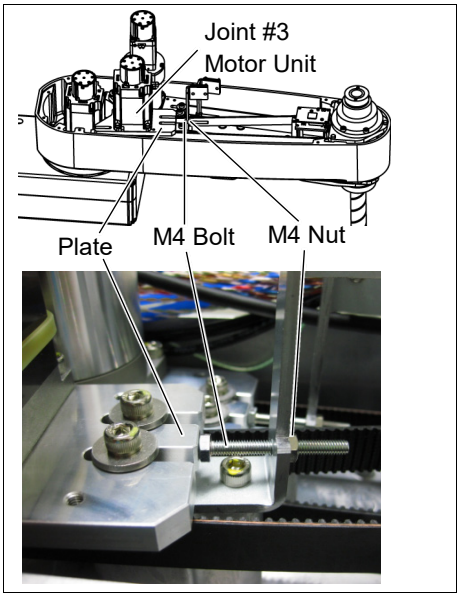


If the unit is tilted, the belt will not have the proper tension.

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

Z belt tension
: 93N (9.5 ± 0.75 kgf)

Axial tension (if being pulled): 186N



NOTE
To apply tension to the Joint #3 motor unit, use the bolt at the front.

(4)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit slowly.

(4)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.

(4)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.

(4)-4 Repeat the steps (4)-1 through (4)-3 until you get appropriate tension.

(4)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

(5) Mount the User Plate and the Duct Plate.

For details, refer to *3. Covers*.

(6) Connect the following connectors.

Connectors: X231, X43

(7) Install the clip band removed in the removal step (5), bind the cables, and then fix them.

Do not allow unnecessary strain on the cables.

(8) Install the Arm Top Cover.

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

(9) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for other joint might be connected to the Joint #3 motor. Check the connector connection.

(10) Execute the calibration of Joints #3, #4.

For details, refer to *13. Calibration*.

7.2 Replacing the Timing Belt

	Name		Qty.	Note
Maintenance part	Z belt		1	1618727
Tools	Hexagonal wrench	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 (#2)		1	For M3, M4 screw
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Sonic tension meter		1	Z: Belt tension 93N (9.5 ± 0.75 kgf)
Material	Wire tie		-	For binding cables

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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.

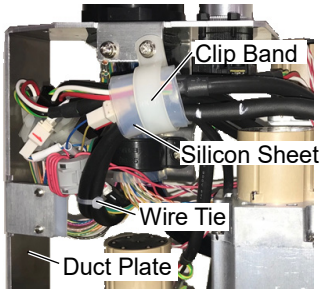
For details, refer to *3.1 Arm Top Cover*.

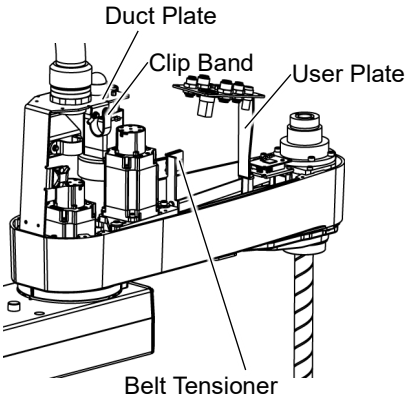
(5) Remove the clip band and sheet bundling the motor cables.

Cut off the wire tie fixing the cables to the belt tensioner.

Do not cut the wire tie (in the duct fittings outlet) that binds the cables to the duct plate.

Removed parts will be used again. Be careful not to lose them.





(6) Disconnect the following connectors.

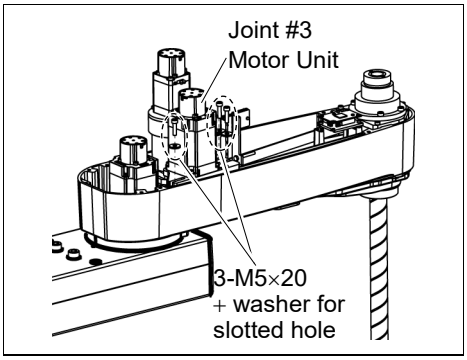
Connectors: X231, X43 (Hold the clip to remove.)

(7) Remove the User Plate and Duct Plate.

For details, refer to *3. Covers*.

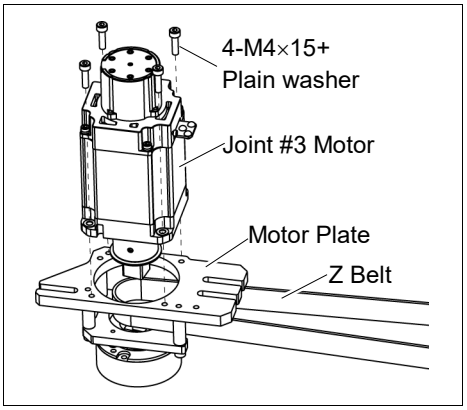
(8) Remove the screws for the Joint #3 motor unit and pull out the Joint #3 motor unit.

The washers for slotted holes will be used again when installing the Z belt. Be careful not to lose them.



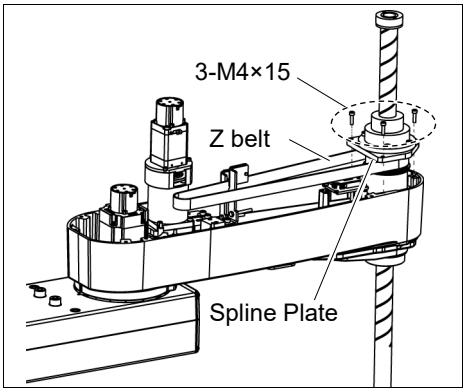
(9) Remove the Joint #3 motor from the motor plate and pull out the Z belt.

The belt is placed around the pulley. To remove the Joint #3 motor, tilt the motor slightly and pull it upward while avoiding the belt.



(10) Remove the screws for the spline plate.

Holding the spline plate upward, pull out the Z belt.



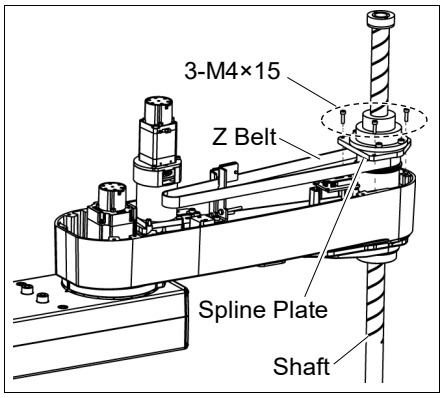
NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Z belt Installation

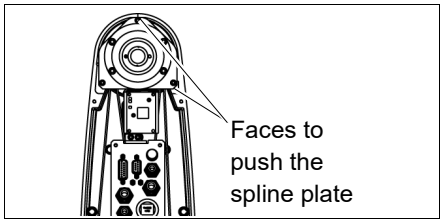
(1) Pass a new Z belt through the shaft.

(2) Lower the spline plate with the Z belt placed around the spline plate pulley.

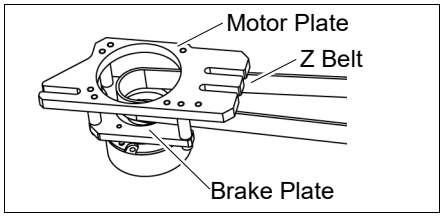
Secure the spline plate with 3 screws.



NOTE Loosely tighten screws temporarily so that the spline plate can be moved by hand. Tighten the spline plate with the screws while pushing the front side of the Arm #2 and the right side face.

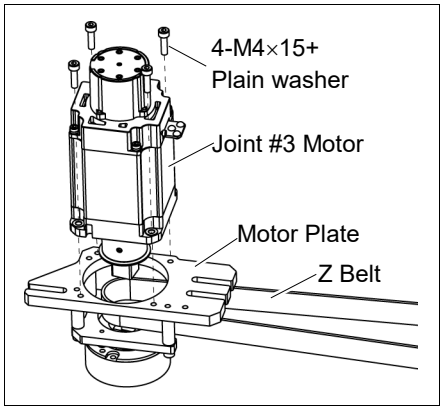


(3) Pass the Z belt between the motor plate of the Joint #3 motor unit and the brake plate.



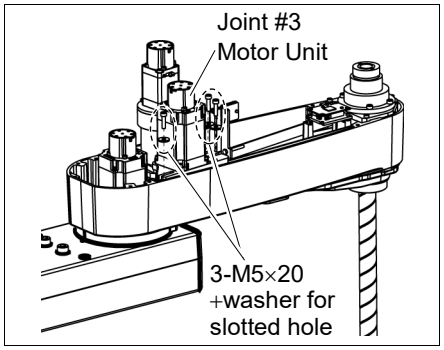
(4) Mount the Joint #3 motor to the motor plate while aligning the hub to the brake disc.

Install the motor so that the pulley will be inside of the Z belt.



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

Make sure that the teeth of the timing belt are engaged with those of the pulley.



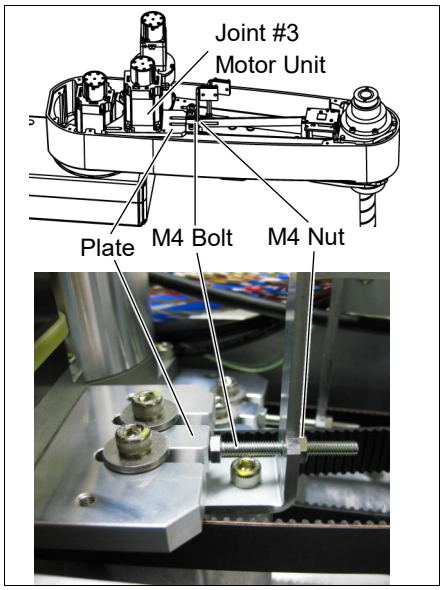
NOTE

At this point, make sure that the Joint #3 motor unit can be moved by hand, and it will not tilt when pulled. If the unit is tilted, 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.

Z belt tension
: 93N (9.5 ± 0.75 kgf)

Axial tension (if being pulled): 186N



NOTE

To apply tension to the Joint #3 motor unit, use the bolt at the front of the plate.

(6)-1 Loosen the nut and turn the bolt. Push in the Joint #3 motor unit slowly.

(6)-2 After fixing the Joint #3 motor unit, turn the bolt to leave from the plate.

(6)-3 Check the tension using the sonic tension meter.
For details, refer to *7.4 Checking the Timing Belt Tension*.

(6)-4 Repeat the steps (6)-1 through (6)-3 until you get appropriate tension.

(6)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

(7) Connect the following connectors.

Connectors: X231, X43

(8) Mount the User Plate and the Duct Plate.

For details, refer to *3. Covers*.

(9) Bind the cables with new wire ties at their original positions as before in the removal step (5). Bind the cables with the clip band. Do not allow unnecessary strain on the cables.

(10) Install the Arm Top Cover.

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

(11) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for the other joint might be connected to the Joint #3 motor. Check the connector connection.

(12) Execute the calibration of Joint #3.

For details, refer to *13. Calibration*.

7.3 Replacing the Brake

	Name		Qty.	Note
Maintenance parts	Electromagnetic Brake		1	1499588
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
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Sonic tension meter		1	Z: Belt tension 93N (9.5 ± 0.75 kgf)
Material	Wire tie		-	For binding cables

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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.

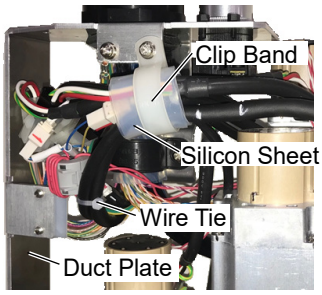
(4) Remove the Arm Top Cover.
For details, refer to *3.1 Arm Top Cover*.

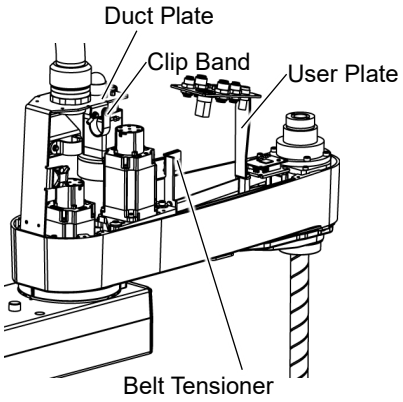
(5) Remove the clip band and sheet bundling the motor cables.

Cut off the wire tie fixing the cables to the belt tensioner.

Do not cut the wire tie (in the duct fittings outlet) that binds the cables to the duct plate.

Removed parts will be used again. Be careful not to lose them.



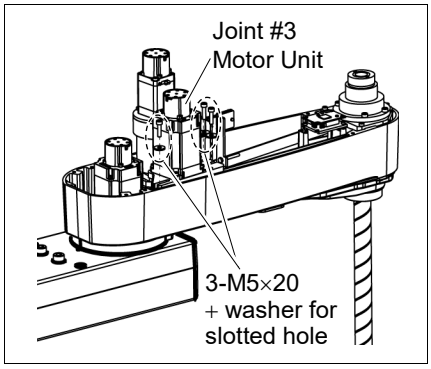


(6) Disconnect the following connectors.

Connectors: X231, X43, BR3

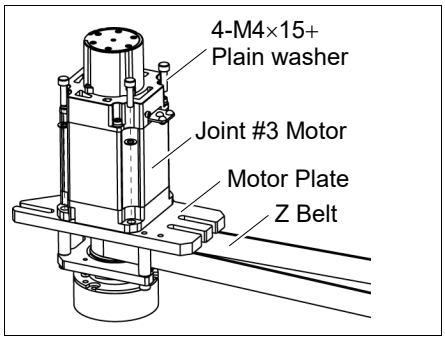
(7) Remove the bolts fixing the Joint #3 motor unit.

The washers for slotted holes will be used again when installing the Z belt. Be careful not to lose them.

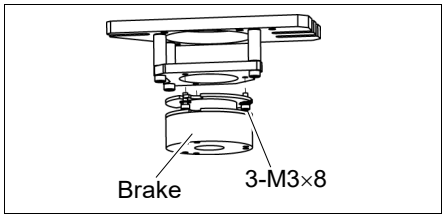


(8) Remove the Joint #3 motor from the motor plate.

The Z belt is placed around the pulley.
To remove the Joint #3 motor, tilt the motor slightly and pull it upward while avoiding the belt.

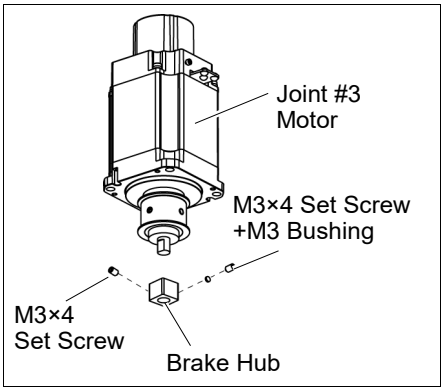


(9) Remove the brake from the brake plate.



(10) Loosen the screws of the brake hub and remove the brake hub from the pulley shaft of the Joint #3 motor unit.

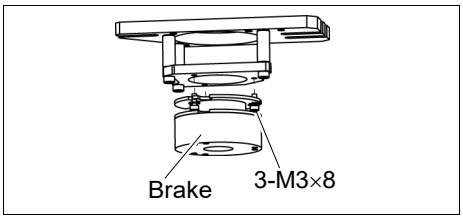
There is a brass bushing on one of the set screws. Be careful not to lose it.



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

Joint #3 brake Installation

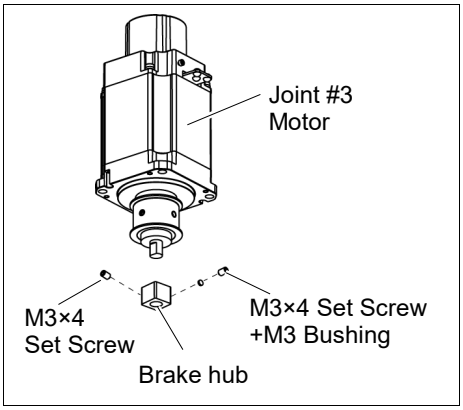
(1) Mount the brake to the brake plate.



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

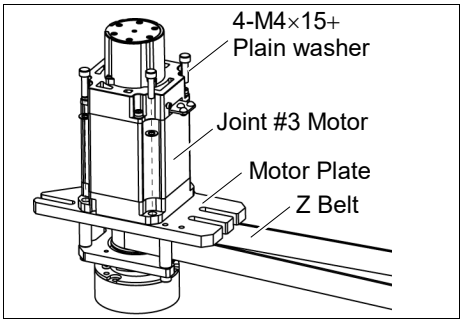
Fix the brake hub while aligning it to the end face of the pulley.

Tighten one of the set screws vertically on the flat face of the motor shaft.
Insert a bushing into the other set screw hole to prevent damage to the motor shaft.



(3) Mount the Joint #3 motor to the motor plate while aligning the hub to the brake disc.

Before aligning the hub, set the motor so that the pulley will be inside of the Z belt.

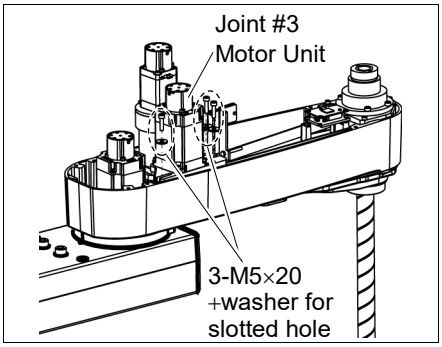


When the brake disc is not aligned, manually adjust the position by following the steps below.

1. Connect the connector BR3.
2. Press the brake release switch to release the brake.
3. Adjust the brake disc manually so that the hole is at the center.

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

For details, refer to the installation steps in *7.2 Replacing the Timing Belt*.



(5) Mount the User Plate and the Duct Plate.

For details, refer to *3. Covers*.

(6) Connect the following connectors.

Connectors: X231, X43, BR3

(7) Mount the Arm Top Cover.

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

(8) Check if the Joint #3 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #3 moves, the connector for other joint might be connected to the Joint #3 motor. Check the connector connection.

(9) Execute the calibration of Joint #3.

For details, refer to *13. Calibration*.

7.4 Checking the Timing Belt Tension (Z Belt)

	Name	Qty.	Note
Tool	Sonic tension meter	1	For details of usage and measurement methods of the tension meter, refer to the instruction manual of the tension meter.

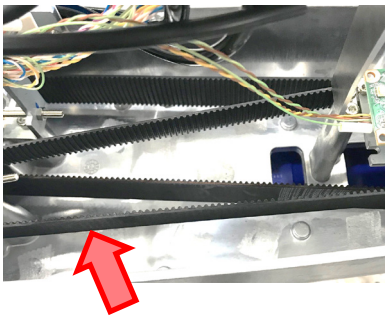
Joint #3
Belt tension check

(1) Enter appropriate setting values to the sonic tension meter.

Model	Belt	Unit mass M [g/ (1 mm width ×1 m length)]	Width W [mm]	Span S [mm]
LS20-B	Z belt	2.5	17	367

(2) Strum the belt and measure tension.

NOTE
Measurement failure may occur if the microphone touches the belt during measurement.



8. Joint #4

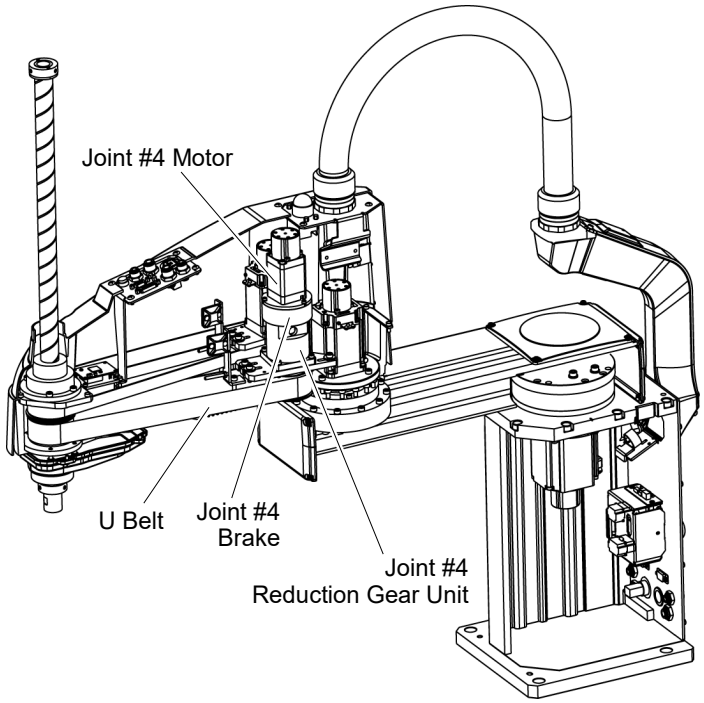
WARNING	■ Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric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

CAUTION	■ Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. 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 execute the calibration.



8.1 Replacing Joint #4 Motor

	Name		Qty.	Note
Maintenance part	AC Servo Motor 150 W		1	1646520
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		For M5 screw
	Spanner	width across flats: 7 mm	1	For M4 bolt, M4 nut
	Cross-point screwdriver (#2)		1	For M4 screw
	Torque wrench		1	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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.

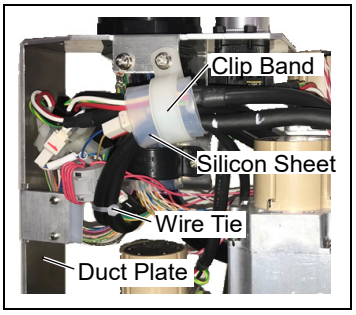
(4) Remove the Arm Top Cover.

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

(5) Remove the clip band and sheet binding the motor cables.

Removed parts will be used again. Be careful not to lose them.

At this point, do not cut the wire tie (in the duct fittings outlet) that binds the cables to the duct plate.



(6) Remove the User Plate and Duct Plate.

For details, refer to *3. Covers*.

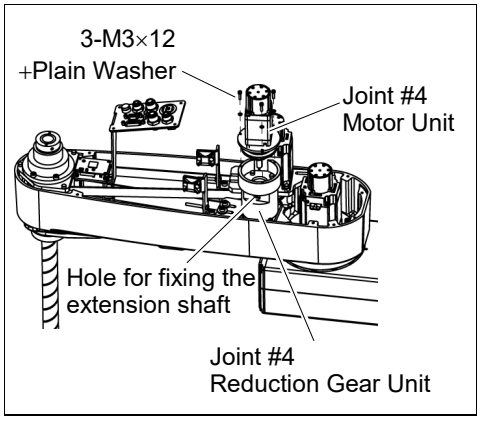
(7) Disconnect the following connectors.

Connectors: X241, X41, BR4 (Hold the clip to remove.)

(8) Remove the screws mounting Joint #4 motor unit on the reduction gear unit.

(9) Remove the cover of the hole for fixing the extension shaft on the side of the reduction gear, and loosen the screws.

If the screw position does not match, turn the motor slightly and move until the screw fixing the extension shaft can be seen.



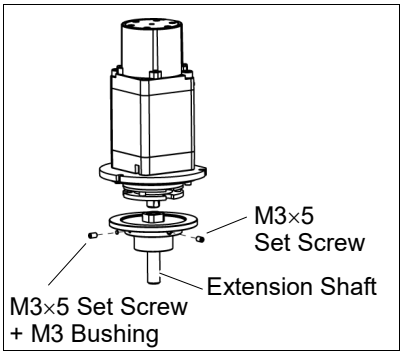
(10) Remove Joint #4 motor unit from the reduction gear unit.

(11) Mount the cover of the hole for fixing the extension shaft on the side of reduction gear unit.

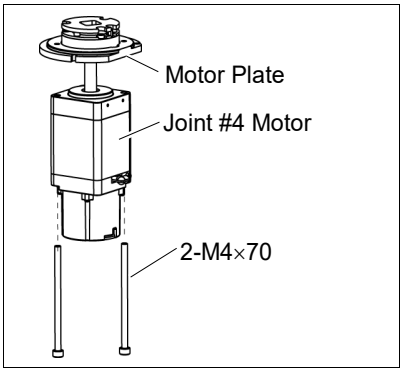
(12) Pull the motor unit upward to remove.

(13) Loosen the set screws tightening the extension shaft and remove the shaft from the Joint #4 motor unit.

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



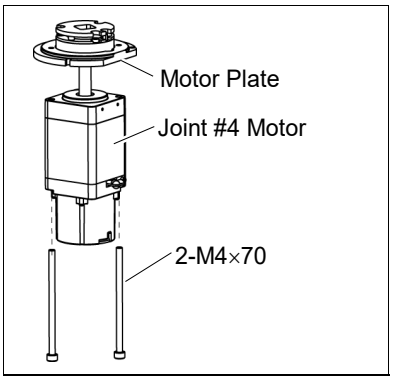
(14) Remove the Joint #4 motor from the motor plate.



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

Joint #4 motor Installation

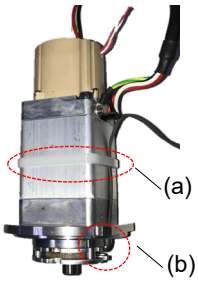
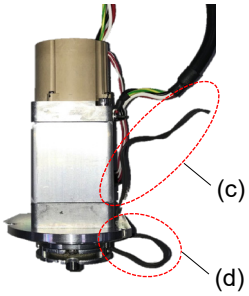
(1) Mount the Joint #4 motor on the motor plate.



NOTE Before you mount the motor, make sure that the brake harness passes through a gap of the motor plate.

NOTE When mounting the motor, be careful not to catch the brake harness in the space between the motor plate and Joint #4 motor.

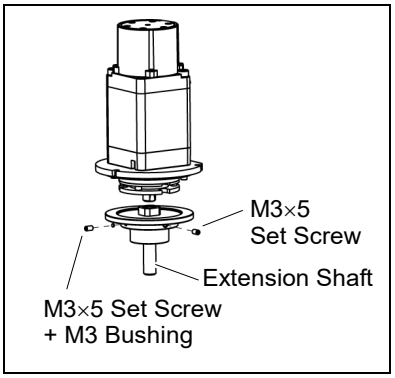
After the motor is mounted, bind the brake harness with a wire tie and fix it on the motor.

Correct Example	Wrong Example
	
(a) The brake harness is fixed to the motor with the attached wire tie. (b) The brake harness is not come out.	(c) The brake harness is not fixed to the motor. (d) The brake harness is come out.

(2) Mount the extension shaft on the Joint #4 motor unit while aligning the hub of the extension shaft to the brake disc.

Tighten one of the set screws vertically on the flat face of the extension shaft.

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



NOTE When the brake disc is not aligned, manually adjust the position by following the steps below.

1. Connect the connector: BR4.
2. Press the brake release switch to release the brake.
3. Manually adjust the brake disc so that the hole will be at the center.

(3) Insert the extension shaft to the reduction gear unit.

Make sure that Joint #4 motor cable is sideways when looking from the front side of Arm #2.

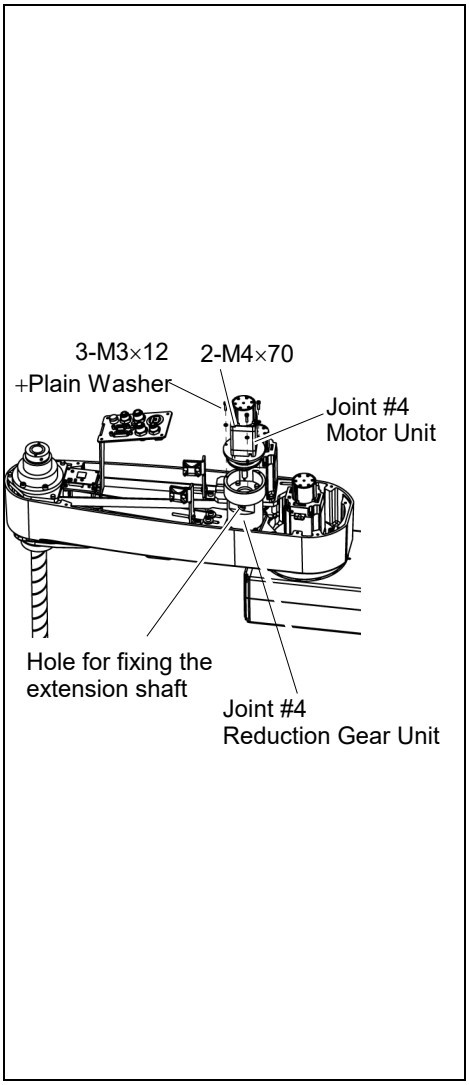
After inserting the extension shaft, loosely secure the motor plate on the Joint #4 motor unit with bolts (M3×12), and loosen the motor fixing bolts (M4×70) to secure the motor loosely.

NOTE

At this point, make sure that the motor unit can be moved by hand, and it will not tilt when pulled.

Before fixing it to the reduction gear unit, make sure to rotate Joint #4 reduction unit two or three times from the output side by turning shaft or belt.

Remove the cover of the hole for fixing the extension shaft, and then tighten the bolts to fix the extension shaft on the reduction gear unit.



(4) Tighten the bolts on the loosely secured motor plate and the motor to fix Joint #4 motor unit on the reduction gear unit.

(5) Mount the cover of the hole for fixing the extension shaft.

(6) Connect the following connectors.

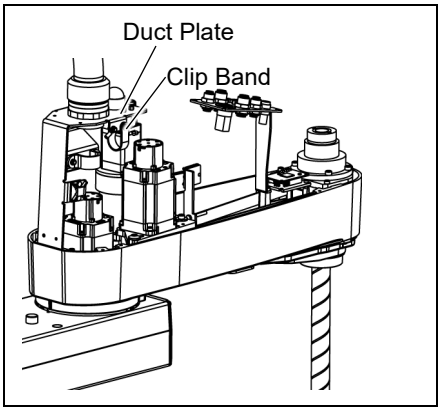
Connectors: BR4, X241, X41

(7) Mount the User Plate and the Duct Plate.

For details, refer to *3. Covers*.

(8) Install the clip band removed in the removal step (5), bind the cables, and then fix them.

Do not bend or pull the cables forcibly to allow unnecessary strain on the cables.



(9) Mount the Arm Top Cover.

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

(10) Check if the Joint #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #4 moves, the connector for other joint might be connected to the Joint #4 motor. Check the connector connection.

(11) Execute the calibration of Joint #4.

For details, refer to *13. Calibration*.

8.2 Replacing the Timing Belt

	Name		Qty.	Note
Maintenance part	U belt (width 30 mm)		1	1618729
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: 7 mm	1	
	Cross-point screwdriver (#2)		1	For M3, M4 screws
	Torque wrench		1	
	Nippers		1	For cutting wire tie
	Sonic tension meter		1	Z: Tension 206 N (21.0 ± 0.75 kgf)
Material	Wire tie		-	For binding cables

NOTE

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

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

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.

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

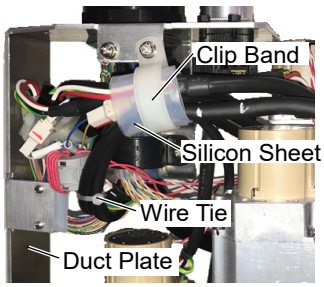
For details, refer to *3.1 Arm Top Cover*.

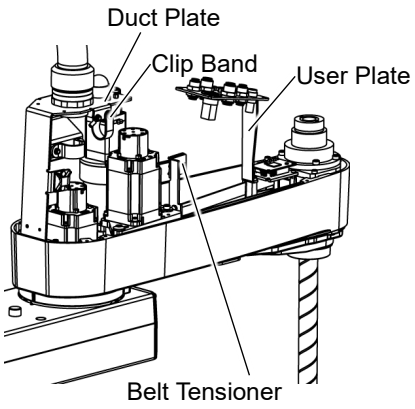
(5) Remove the clip band and sheet bundling the motor cables.

Cut off the wire tie fixing the cables to the belt tensioner.

Do not cut the wire tie (in the duct fittings outlet) that binds the cables to the duct plate.

Removed parts will be used again. Be careful not to lose them.





(6) Disconnect the following connectors.

Connectors: X231, X241, X43, X44, X51, BR3, BR4
(Hold the clip to remove.)

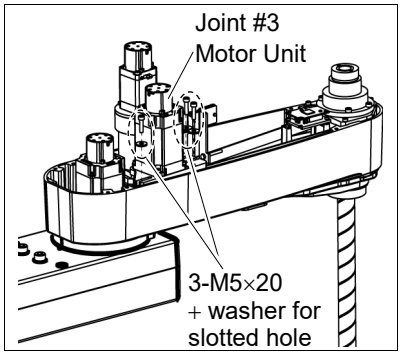
(7) Remove the User Plate and the Duct Plate.

For details, refer to *3. Covers*.

(8) Remove the screws mounting the Joint #3 motor unit.

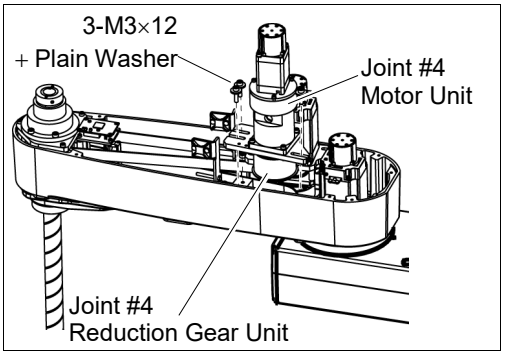
Remove the Joint #3 motor from the motor plate and pull out the Z belt.

For details, refer to *7.2. Timing Belt*.



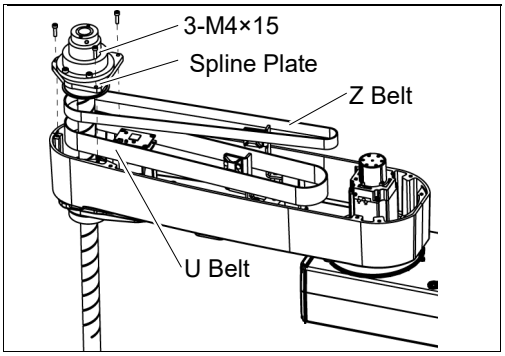
(9) Remove the screws mounting the Joint #4 motor unit.

Pull the Joint #4 motor unit upward.



(10) Remove the screws mounting the spline plate.

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

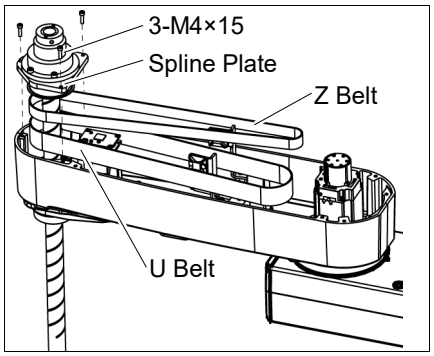


NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

U belt Installation

(1) Hold up the spline plate and set the U belt around the pulley.

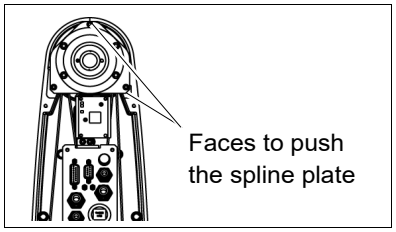
Make sure the gear grooves of the belt are fit into those of the pulleys completely.



(2) Hold up the spline plate and set the Z belt around the Z pulley.

Make sure the teeth of the timing belt are engaged with those of the pulley.

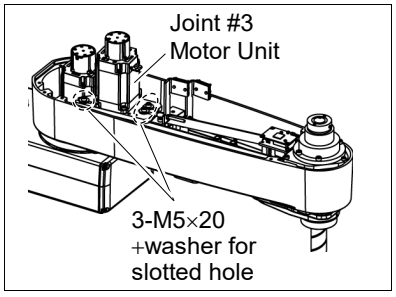
(3) Loosely secure the spline plate on the Arm #2 and move the shaft up and down several times before firmly secure the spline plate.



NOTE Loosely tighten the screws so that the spline plate can be moved by hand. Fix the spline plate with the screws while pushing the front side of the Arm #2 and the right side face.

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

Make sure the teeth of the timing belt are engaged with those of the pulley.



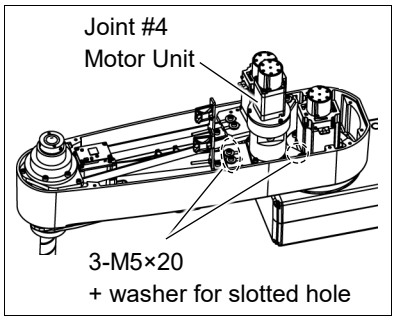
NOTE At this point, make sure that the Joint #3 motor unit can be moved by hand, and it will not tilt when pulled. If the unit is tilted, the belt will not have the proper tension.

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

For details, refer to *7.2 Replacing the Timing Belt.*

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

Make sure the teeth of the timing belt are engaged with those of the pulley.



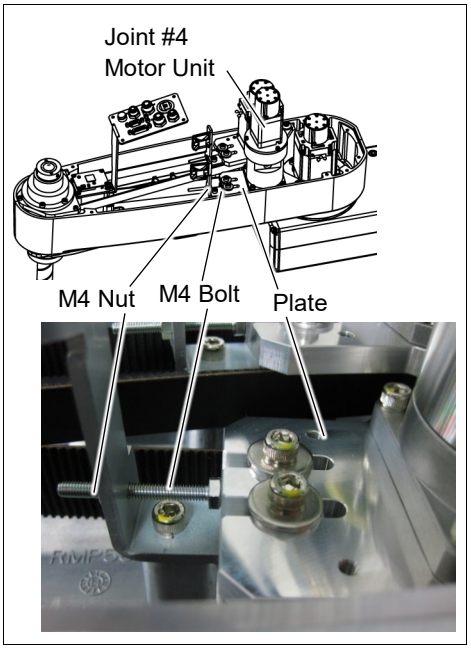
NOTE Make sure that the Joint #4 motor unit can be moved by hand, and it will not tilt when pulled.

If the unit is tilted, the belt will not have the proper tension.

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

U belt tension
: 206 N (21.0 ± 0.75 kgf)
Axial tension (when being pulled): 412 N

NOTE To apply tension to the Joint #4 motor unit, use the bolt at the front of the plate.



(7)-1 Loosen the nut and turn the bolt. Push in the Joint #4 motor unit plate slowly.

(7)-2 After fixing the Joint #4 motor unit, turn the bolt to leave from the plate.

(7)-3 Check the tension using the sonic tension meter.

For details, refer to *8.5 Checking the Timing Belt Tension*.

(7)-4 Repeat the steps (7)-1 through (7)-3 until you get appropriate tension.

(7)-5 After the adjustment, put the bolt back to its original position and fix it with the nut.

(8) Connect the following connectors.

Connectors: X231, X241, X43, X44, X51, BR3, BR4

(9) Mount the User Plate and the Duct Plate.

For details, refer to *3. Covers*.

(10) Bind the cables with new wire ties at their original positions as before in the removal step (5). Bind the cables with the clip band.

Do not allow unnecessary strain on the cables.

(11) Install the Arm Top Cover.

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

(12) Check if the Joints #3, #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MotorON and the following errors are detected,

Error 5041: Motor torque output failure in low power state.

Error 4241: Over speed during low power mode was detected.

or when the joint other than Joints #3, #4 moves, the connector for the other joint might be connected to the Joints #3, #4 motor. Check the connector connection.

(13) Execute the calibration for Joint #3, 4.

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

8.3 Replacing the Brake

	Name		Qty.	Note
Maintenance part	Electromagnetic brake		1	1803965
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
	Spanner	width across flats: 7 mm	2	For M4 bolt, M4 nut
	Cross-point screwdriver (#2)		1	For M4 screw
	Torque wrench		1	

NOTE

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

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

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 Joint #3 and #4. When the brake release switch is pressed, the respective brake 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.

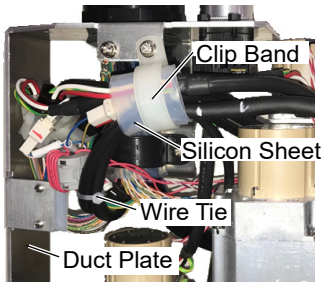
For details, refer to *3.1 Arm Top Cover*.

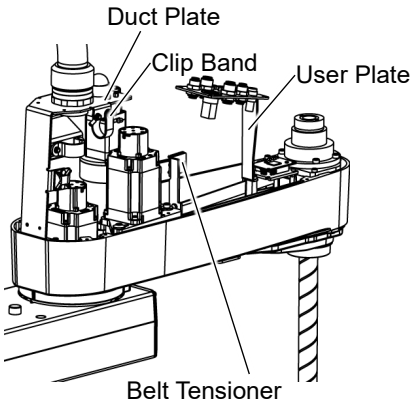
(5) Remove the clip band and sheet bundling the motor cables.

Cut off the wire tie fixing the cables to the belt tensioner.

Do not cut the wire tie (in the duct fittings outlet) that binds the cables to the duct plate.

Removed parts will be used again. Be careful not to lose them.





(6) Remove the Duct Plate.

For details, refer to *3. Covers*.

(7) Disconnect the following connectors.

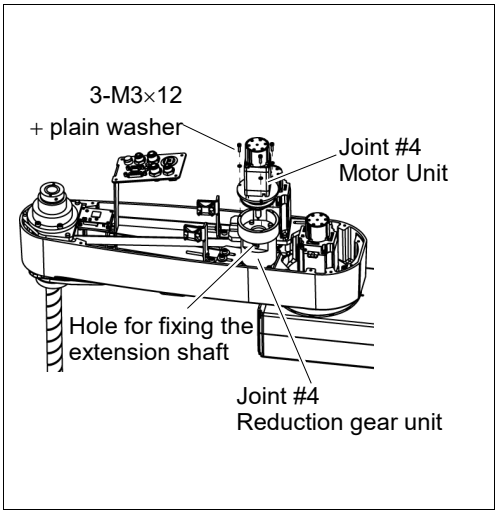
Connectors: X241, X41, BR4 (Hold the clip to remove.)

(8) Remove the screws securing the Joint #4 motor unit on the reduction gear unit.

(9) Remove the cover of the hole for fixing the extension shaft on the side of the reduction gear, and loosen the screws.

If the screw position does not match, turn the motor slightly and move until the screw fixing the extension shaft can be seen.

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

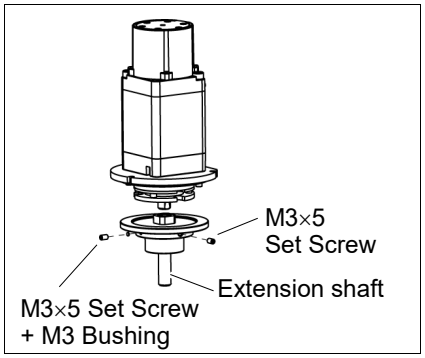


(11) Mount the cover of the hole for fixing the extension shaft on the side of the reduction gear.

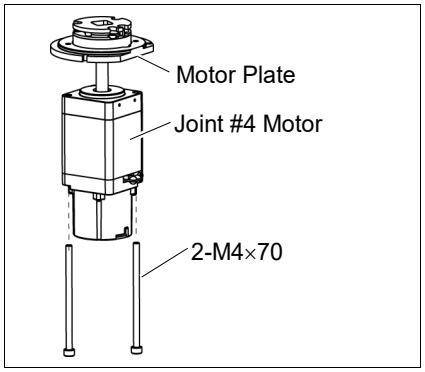
(12) Pull the motor unit upward to remove.

(13) Loosen the set screws tightening the extension shaft and remove the shaft from the Joint #4 motor unit.

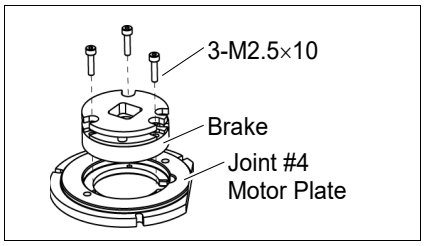
There is a brass bushing in one of the set screw holes. Be sure to keep the bushing.



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



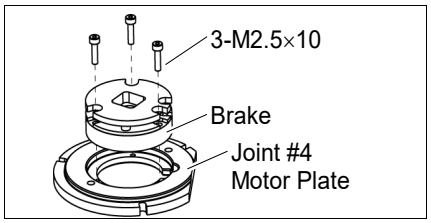
(15) Remove the brake from the motor plate.



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

Joint #4 Brake Installation

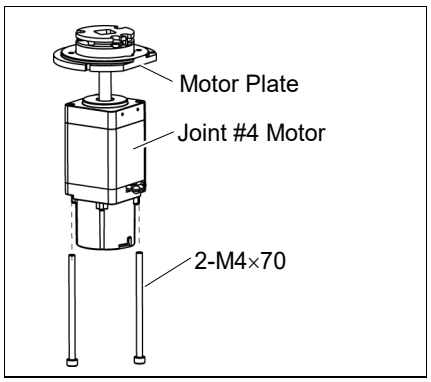
(1) Mount the brake on the motor plate.



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

Before you mount the motor, make sure that the brake harness passes through a gap of the motor plate.
When mounting the motor, be careful not to catch the brake harness in the space between the motor plate and Joint #4 motor.

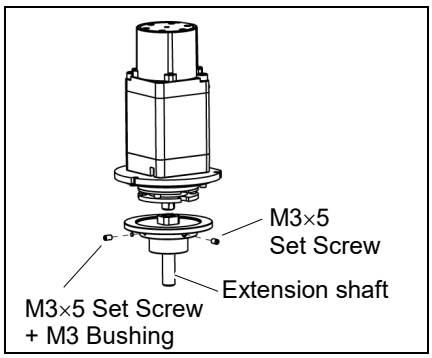
After the motor is mounted, bind the brake harness with a wire tie and fix it on the motor.



(3) Mount the extension shaft on the Joint #4 motor unit while aligning the hub of the extension shaft to the brake disc.

Tighten one of the set screws vertically on the flat face of the extension shaft.

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



NOTE When the brake disc is not aligned, manually adjust the position by following the steps below.

1. Connect the connector: BR4.
2. Press the brake release switch to release the brake.
3. Manually adjust the brake disc so that the hole will be at the center.

(4) Insert the extension shaft to the reduction gear unit.

Make sure that Joint #4 motor cable is sideways when looking from the front side of Arm #2.

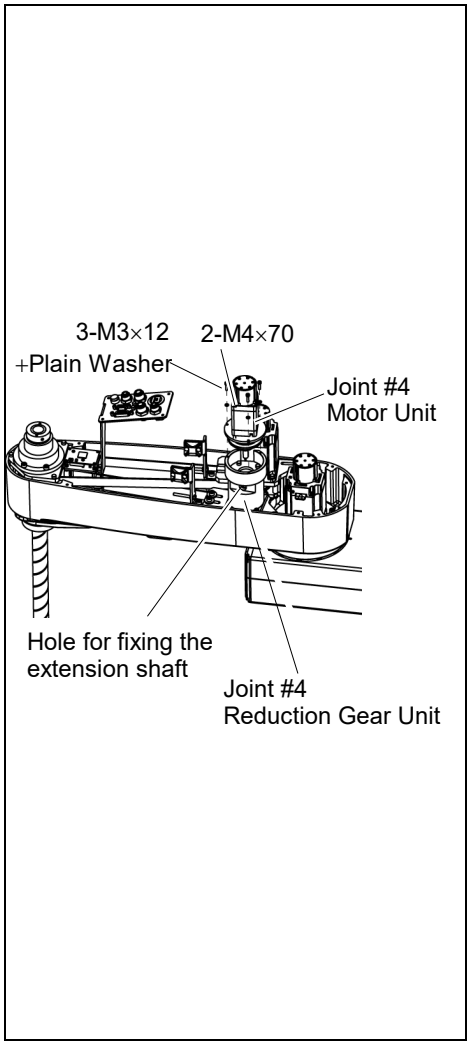
After inserting the extension shaft, loosely secure the motor plate on the Joint #4 motor unit with bolts (M3×12), and loosen the motor fixing bolts (M4×70) to secure the motor loosely.

NOTE

At this point, make sure that the motor unit can be moved by hand, and it will not tilt when pulled.

Before fixing it to the reduction gear unit, make sure to rotate Joint #4 reduction unit two or three times from the output side.

Remove the cover of the hole for fixing the extension shaft, and then tighten the bolts to fix the extension shaft on the reduction gear unit.



(5) Tighten the bolts on the loosely secured motor plate and the motor to fix Joint #4 motor unit on the reduction gear unit.

(6) Mount the cover of the hole for fixing the extension shaft.

(7) Mount the Duct Plate.

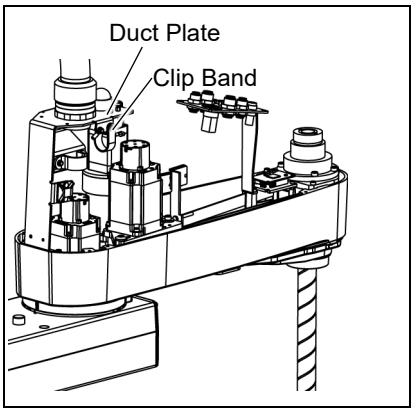
For details, refer to *3. Covers*.

(8) Connect the following connectors.

Connectors: BR4, X241, X41

(9) Install the clip band removed in the removal step (5) and bind the cables to fix.

Do not bend or pull the cables forcibly to allow unnecessary strain on the cables.



(10) Mount the Arm Top Cover.

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

(11) Check if the Joint #4 moves in a Jog motion by operating from EPSON RC+ menu - [Tools]-[Robot Manager]-[Jog & Teach].

If the Manipulator oscillates with MOTOR ON and the following errors are detected,
Error 5041: Motor torque output failure in low power state.
Error 4241: Over speed during low power mode was detected.

or when the joint other than Joint #4 moves, the connector for other joint might be connected to the Joint #4 motor. Check the connector connection.

(12) Execute the calibration of Joint #4.

For details, refer to *13. Calibration*.

8.4 Replacing the Reduction Gear Unit

	Name		Qty.	Note
Maintenance part	Reduction Gear Unit		1	1493783
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: 7 mm	1	For M4 hexagon head bolt and M4 hexagon nut
	Cross-point screwdriver (#2)		1	For M4 screws
	Torque wrench		1	
	Sonic tension meter		1	Refer: Unitta U-508
Material	Wire tie		-	For binding cables

NOTE

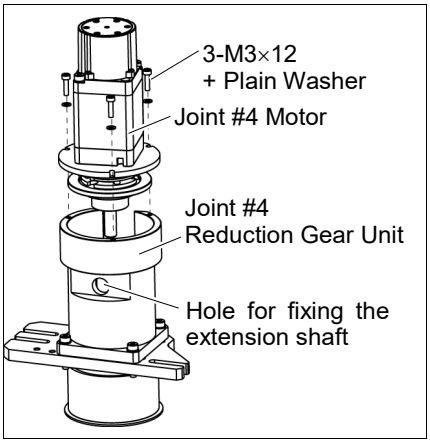
The brakes are mounted on the Joints #3 and #4 to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

Joint #4 Reduction Gear Unit Removal

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

For details, refer to the Installation steps in *8.2 Replacing the Timing Belt*.



(2) Remove the screws mounting Joint #4 motor unit on the reduction gear unit.

Remove the cover of the hole for fixing the extension shaft on the side of the reduction gear, and loosen the screws.

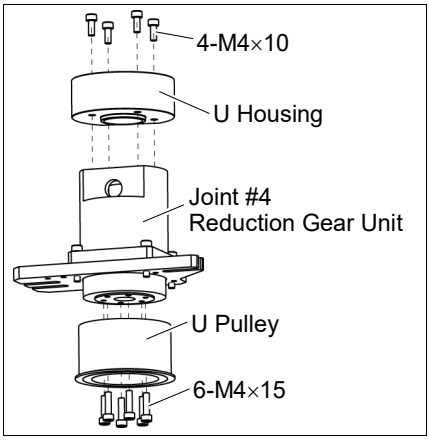
If the screw position does not match, turn the motor slightly and move until the screw fixing the extension shaft can be seen.

Remove Joint #4 motor unit from the reduction gear unit.

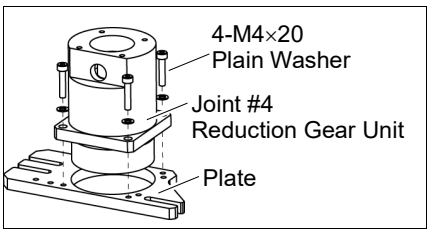
Mount the cover of a hole for fixing the extension shaft on the side of reduction gear unit.

Pull the motor unit upward to remove.

(3) Remove the U pulley and U housing.



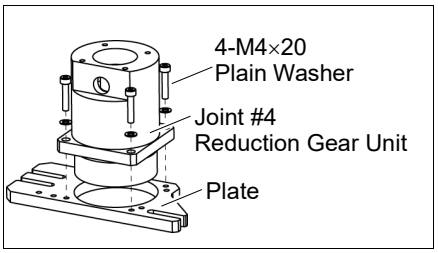
(4) Remove the plate.



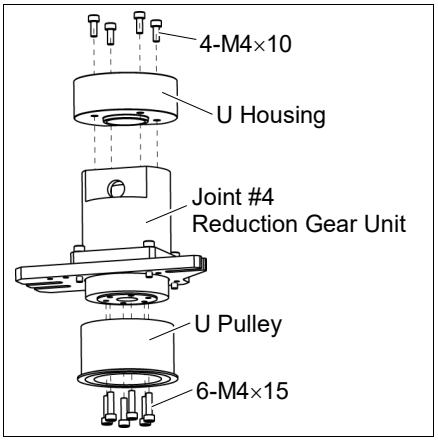
NOTE When tightening hexagon socket head cap bolts, refer to the *2.4 Tightening Hexagon Socket Head Cap Bolts.*

Joint #4 Reduction Gear Unit Installation

(1) Mount the plate on a new reduction gear unit.



(2) Mount the U pulley and the U housing.

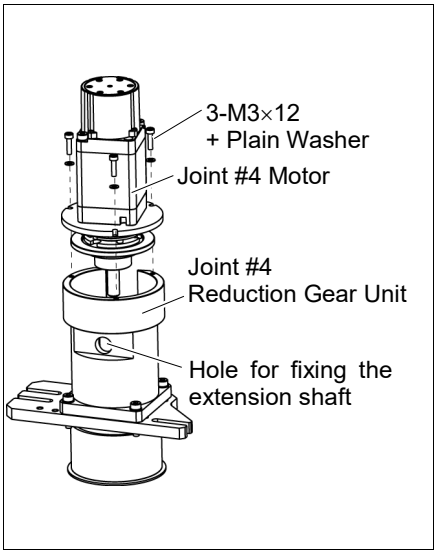


(3) Mount the Joint #4 motor unit on the reduction gear unit.

Insert the extension shaft to the reduction gear unit.

After inserting the extension shaft, loosely secure the motor plate on the Joint #4 motor unit with bolts (M3×12), and loosen the motor fixing bolts (M4×70) to secure the motor loosely.

NOTE At this point, make sure that the motor unit can be moved by hand, and it will not tilt when pulled.



Before fixing it to the reduction gear unit, make sure to rotate Joint #4 reduction unit two or three times from the output side.

Remove the cover of the hole for fixing the extension shaft, and then tighten the bolts to fix the extension shaft on the reduction gear unit.

After fixing the shaft, mount the cover of the hole for fixing the extension shaft.

(4) Tighten the bolts on the loosely secured motor plate and the motor to fix Joint #4 motor unit on the reduction gear unit.

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

For details, refer to *8.2 Replacing the Timing Belt*.

8.5 Checking the Timing Belt Tension (U Belt)

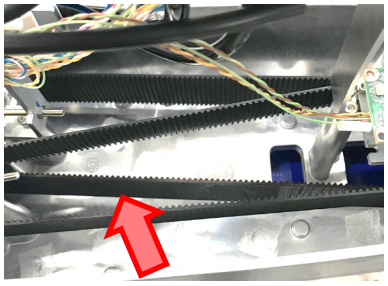
	Name	Qty.	Note
Tool	Sonic tension meter	1	For details on usage and measurement methods of the tension meter, refer to the instruction manual of the tension meter.

Joint #4
Belt tension check

(1) Enter appropriate setting values to the sonic tension meter.

Belt	Unit mass M [g/ (1 mm width×1 m length)]	Width W [mm]	Span S [mm]
U belt	2.5	30	357

(2) Strum the belt and measure tension.



NOTE

Measurement failure may occur if the microphone touches the belt during measurement.

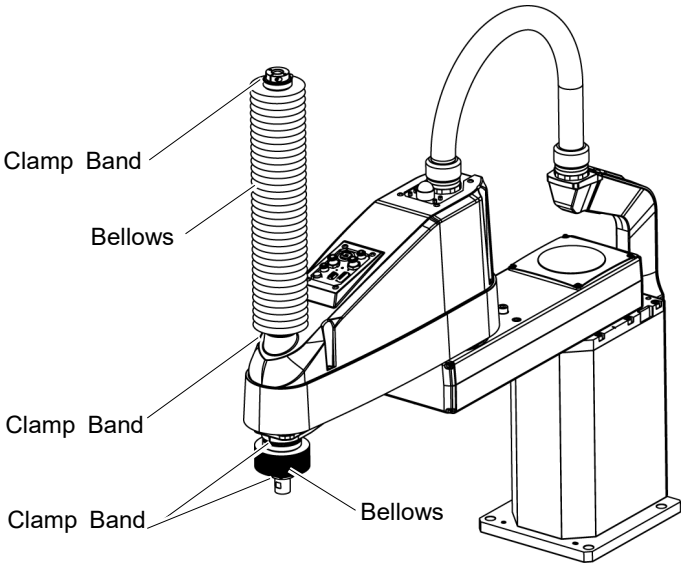
9. Bellows

NOTE


The bellows for LS20-B***C 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 replacing the bellows.

	Name	Qty.	Note
Maintenance part	Bellows	1	1499591
Tool	Cross-point screwdriver	1	For clamp band removal



Bellows Removal

(1) Remove the cables and tubes from the end effector.

(2) Remove the end effector.

(3) Turn ON the controller. Stop motor excitation. (MOTOR OFF)

(4) Loosen the two clamp bands on the bellows.

(5) Pull out the bellows and clamp bands from 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.

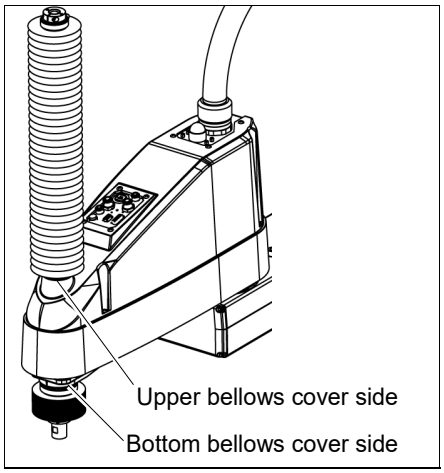
The brake release switch is applied to both Joints #3 and Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #4 are released simultaneously.
Be careful of the shaft falling and rotating while the brake release switch is being pressed because the shaft 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.
Attach the mounting part of the bellows until the end touches the cylindrical part of the cover.

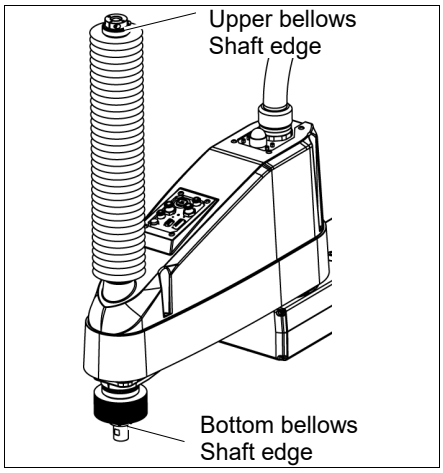
Then, secure them with clamp bands.



(4) Secure the shaft edge side of the bellows.

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

Then, secure them with clamp bands.



(5) When completed the bellows installation, check that the bellows stretch smoothly without any excessive force by moving the shaft up/down by hand and rotating the Joint #4.

(6) Turn OFF the Controller and peripheral equipment.

(7) Attach the end effector.

(8) Connect the cables and tubes to the end effector.

10. Ball Screw Spline Unit Replacement

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.

	Name		Qty.	Note
Maintenance part	Ball Screw Spline Unit		1	1646487: For LS20-B*04S 1646488: For LS20-B*04C
Grease	For Ball Screw Spline Unit (AFB grease)		Proper quantity	
Tools	Hexagonal wrench	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
	Cross-point screwdriver (#2)		1	
	Wiping cloth		1	For wiping grease (Spline shaft)
Material	Wire tie		-	

NOTE

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

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

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 Joint #4.
When the brake release switch is pressed, the respective brakes of the Joint #3 and Joint #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/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 and Arm Bottom Cover.

For details, refer to *3. Covers*.

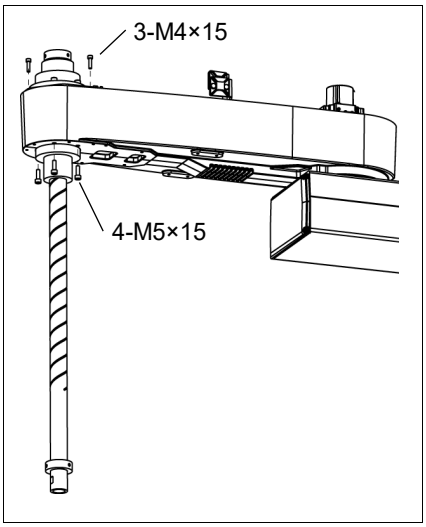
(7) Remove the following parts:

Joint #3 motor unit Joint #4 motor unit

For details, refer to the following manuals:

7.1 Replacing Joint #3 Motor
8.1 Replacing Joint #4 Motor

(8) Remove three screws mounting the spline plate.



(9) Remove four screws mounting the spline nut.

(10) Pull out the following toward the Arm #2 upper side.

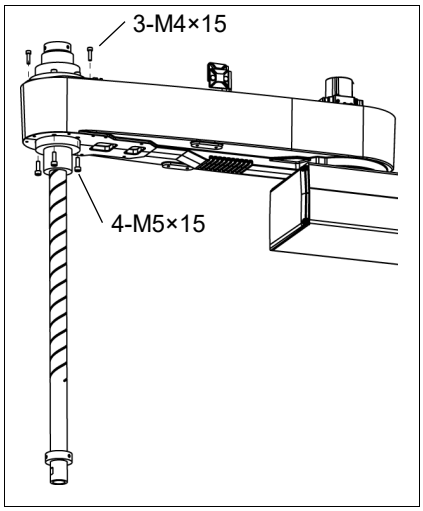
Ball screw spline unit Z belt U belt

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

Ball Screw Spline Unit Installation

(1) Insert a new ball screw spline unit in the Arm #2.

(2) Secure the spline nut from the bottom side of the Arm #2.



(3) Mount the following.

Joint #3 motor unit Joint #4 motor unit U belt Z belt

For details, refer to the following manuals:

7.1 Replacing Joint #3 Motor

8.1 Replacing Joint #4 Motor

(4) Mount the Arm Top Cover and Arm Bottom Cover.

For details, refer to *3. Covers*.

(5) Grease the shaft.

For details, refer to *LS20-B Manipulator- 2.3Greasing Greasing the Ball Screw Spline Unit*.

(6) For the Cleanroom-model, mount the bellows.

For details, refer to *9. Bellows*.

(7) Mount the end effector, cables, and tubes.

(8) Perform the calibration of Joints #3, #4.

For details, refer to *13. Calibration*.

11. Boards

 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.

	Name	Qty.	Note
Maintenance parts	Converter board	1	2196970
	Control board	1	2196966
Tools	Nippers	1	For cutting wire tie
	Cross-point screwdriver (#1)	1	
Material	Wire tie	1	For fixing cables

11.1 Replacing the Converter Board

Board which supplies power to the encoder of the motor is mounted inside the base of the manipulator. If the board gets damage, the manipulator will not operate.

Converter board Removal

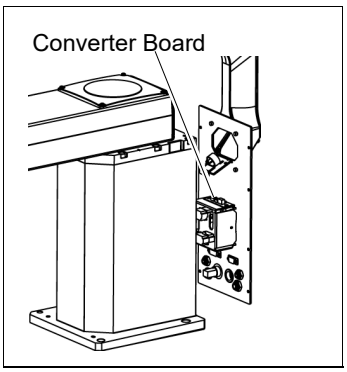
(1) Turn OFF the controller.

(2) Remove the Connector Plate.

For details, refer to *3.4 Connector Plate*.

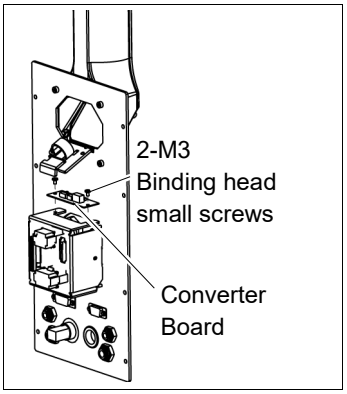
(3) Disconnect the following connectors which are connected to the converter board.

Connectors: CV11, CV12, CV13



(4) Remove the converter board from the mount base.

Binding head small screws:
2-M3 (cross-point screwdriver)



Converter board Installation

(1) Mount the converter board on the mount base.

Binding head small screws: (2-M3)

(2) Connect the following connectors to the converter board.

Connectors: CV11, CV12, CV13

(3) Mount the Connector Plate.

For details, refer to *3.4 Connector Plate*.

(4) Turn ON the Controller.

(5) Make sure no errors occur in all joints.

11.2 Replacing the Control Board

Control Board Removal

(1) Turn OFF the controller.

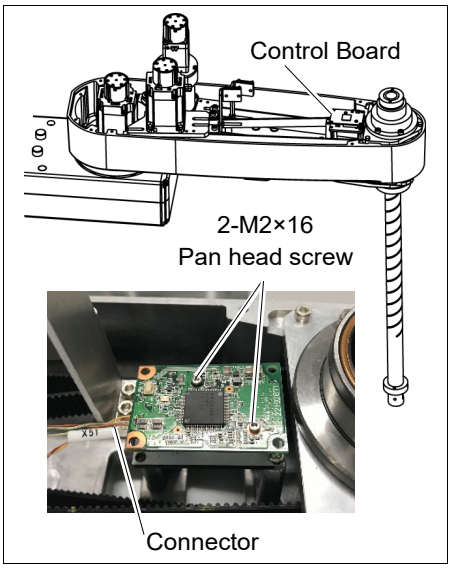
(2) Remove the Arm Top Cover.

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

(3) Disconnect the following connector.

Connector: X51

(4) Remove the Control board.



Control Board Installation

(1) Mount a new Control board.

Be careful of the board direction.
(Check the board direction by the connector position.)

(2) Connect the following connector.

Connector: X51

(3) Mount the Arm Top Cover.

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

(4) Turn ON the controller.

12. LED Lamp

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.

	Name	Qty.	Note
Maintenance parts	LED Lamp	1	2077258
Tools	Cross-point screwdriver	1	For wire removal
	Nippers	1	
Material	Wire tie	1	

LED Lamp Removal

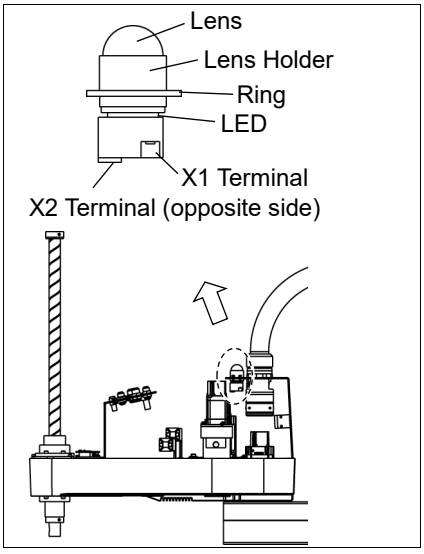
(1) Remove the Arm Top Cover.

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. Then, turn the lens holder counterclockwise to remove.

(4) 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 the same terminal number on the LED.

(2) Put the User Plate between the ring and lens holder, and then secure the LED to the cover.

(3) Mount the lens.

(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.

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

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

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

NOTE

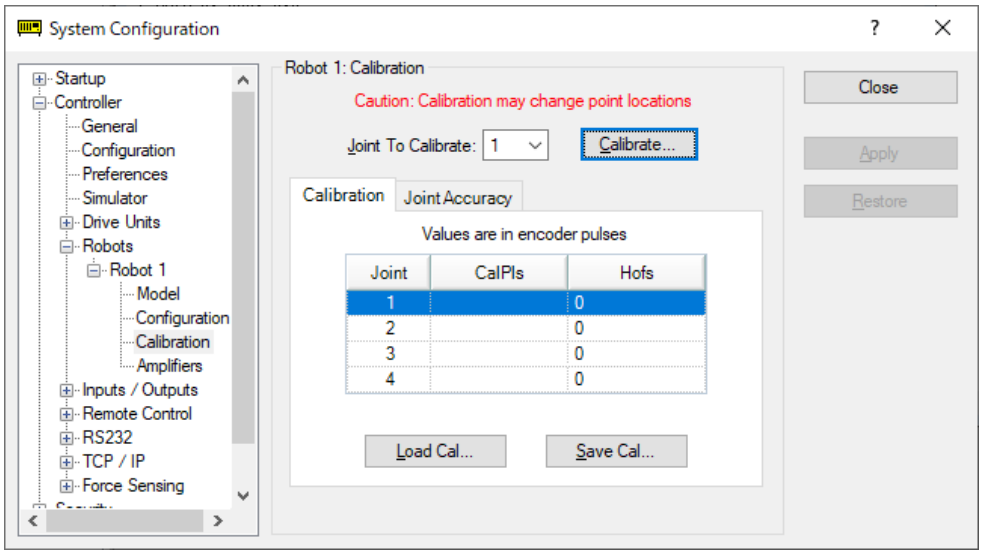
If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *13.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.
The reference point (a point to check the accuracy) needs to be specified for calibration.

(1) Start the calibration wizard.

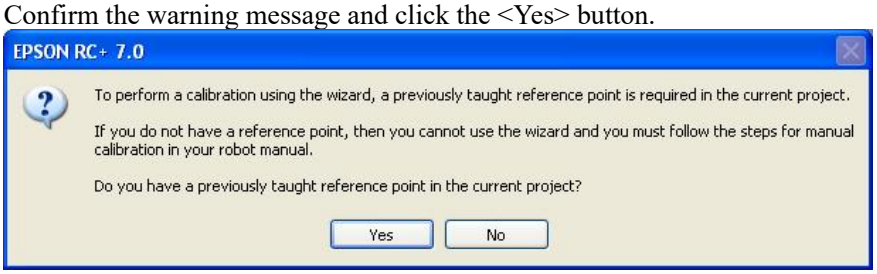
i. Select EPSON RC+ 7.0 menu - [Setup] to display the [System Configuration] dialog.

ii. Select [Robots]-[Robot**] to display [Calibration].

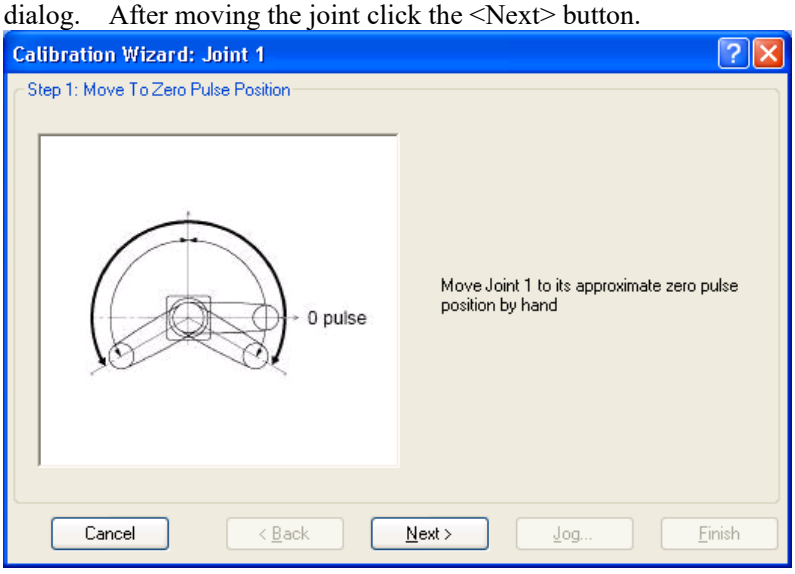
iii. Select the joint and click the <Calibrate…> button.



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

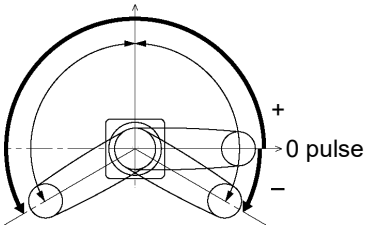


(3) Move the joint to calibrate manually to approximate zero position, as shown in the dialog. After moving the joint click the <Next> button.



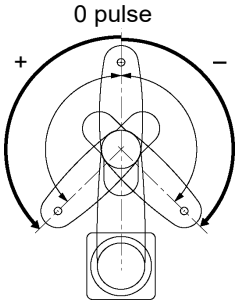
0 pulse position of Joint #1:

position aligned with X-axis in Robot coordinate system



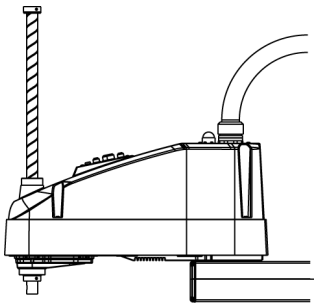
0 pulse position of Joint #2:

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

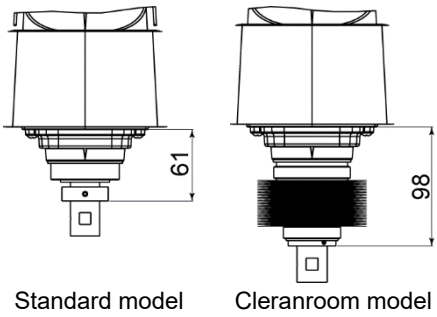


0 pulse position of Joint #3:

upper limit position in motion range

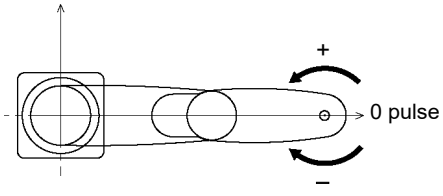


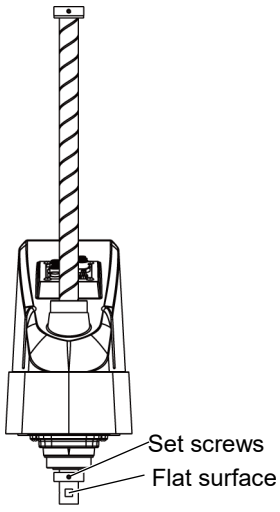
The height of Joint #3 depends on manipulator model.



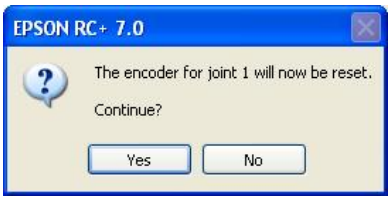
0 pulse position of Joint #4:

position where the flat surface on the shaft (or set screws of the mechanical stop on the bottom) faces toward the tip of Arm #2

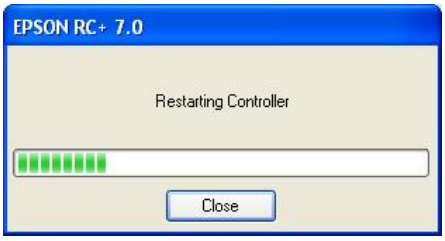




(4) Click the <Yes> button to reset the encoder.

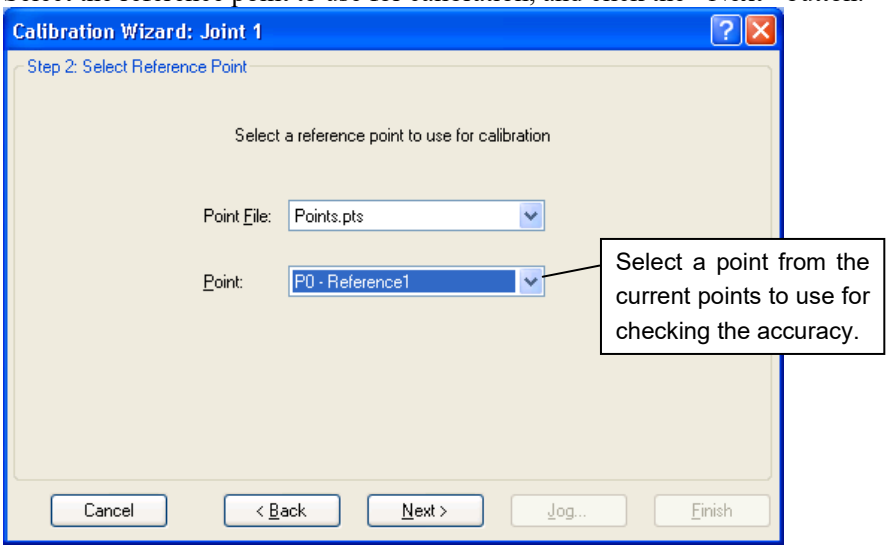


(5) Reboot the Controller.

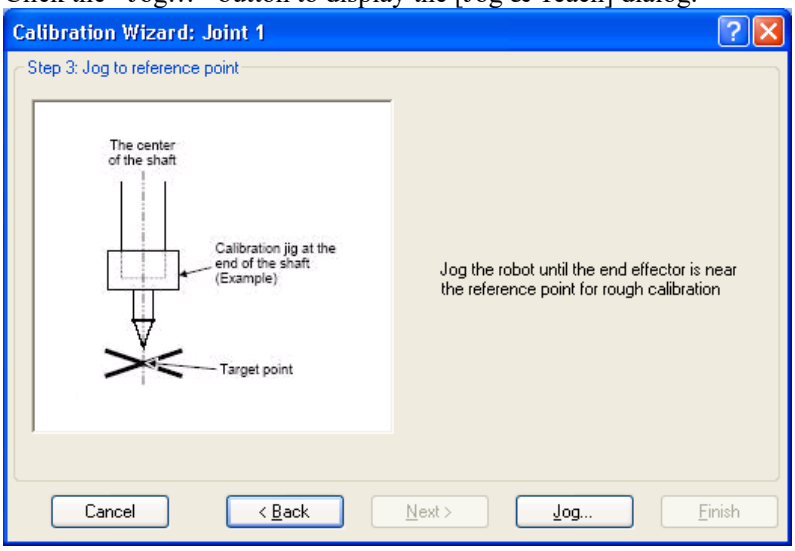


* This window will disappear when the Controller starts up.

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



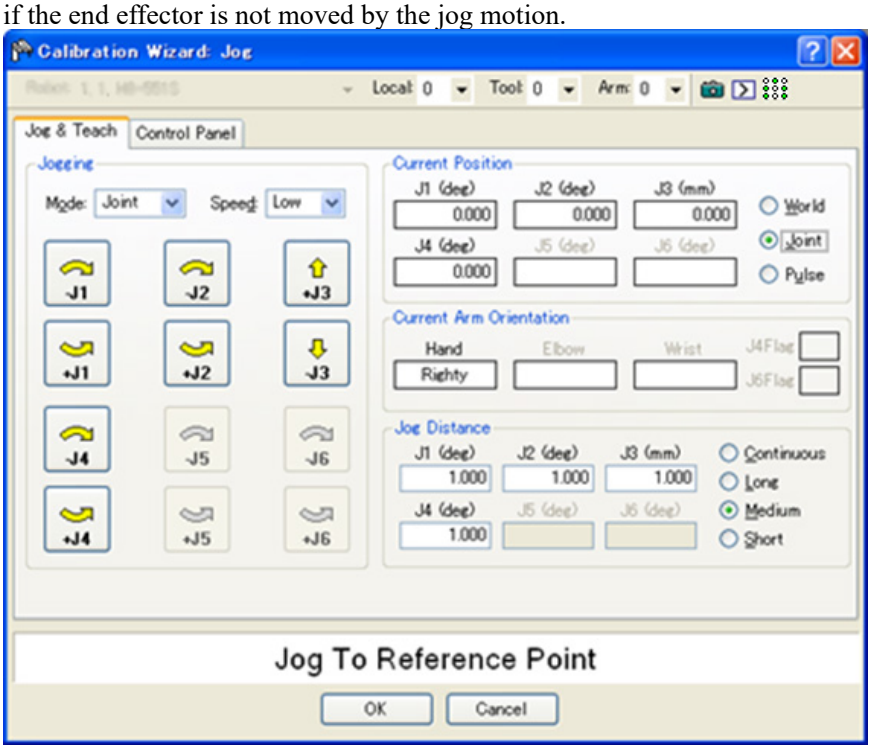
(7) Click the <Jog…> button to display the [Jog & Teach] dialog.



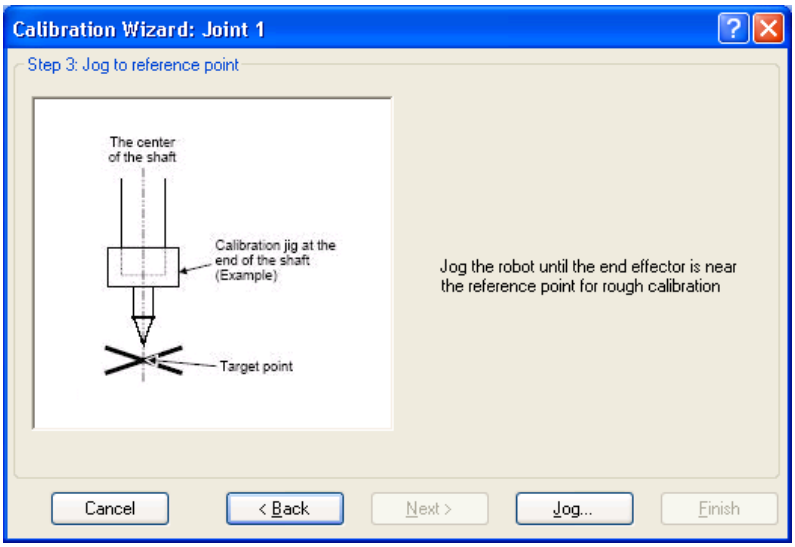
(8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.
Before operating the robot, open the [Control Panel] and click on the <Motor ON> button.

NOTE

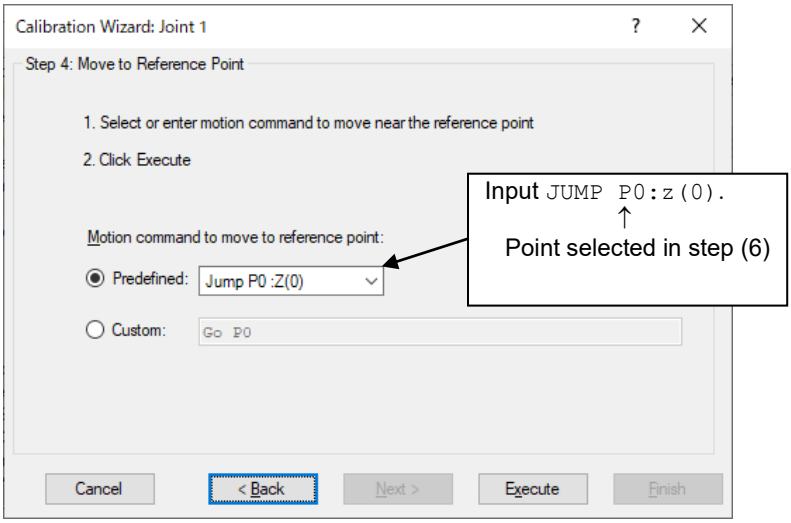

Move the end effector from the zero pulse position to the approximate reference point where rough calibration will be executed at by the jog motion. Position gap may occur if the end effector is not moved by the jog motion.



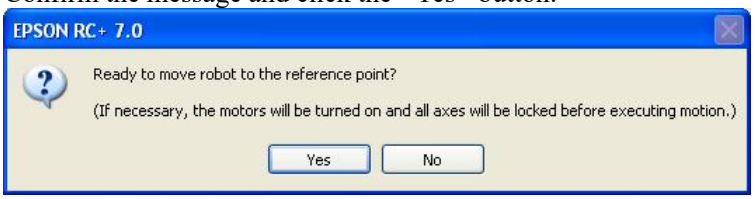
(9) Click the <Next> button.



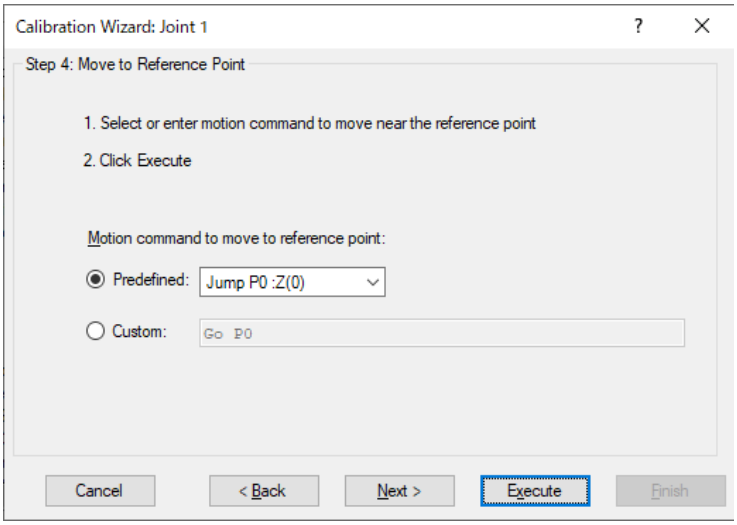
(10) The manipulator moves to the reference point. Click the <Execute> button.



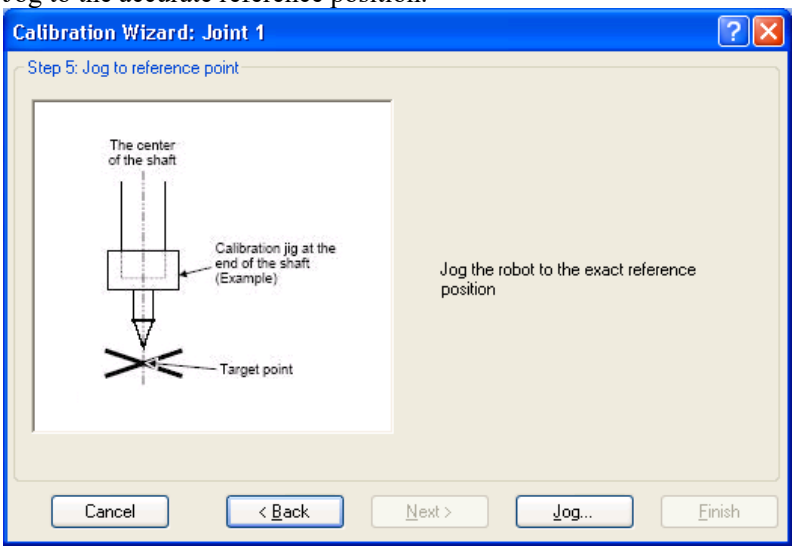
(11) Confirm the message and click the <Yes> button.



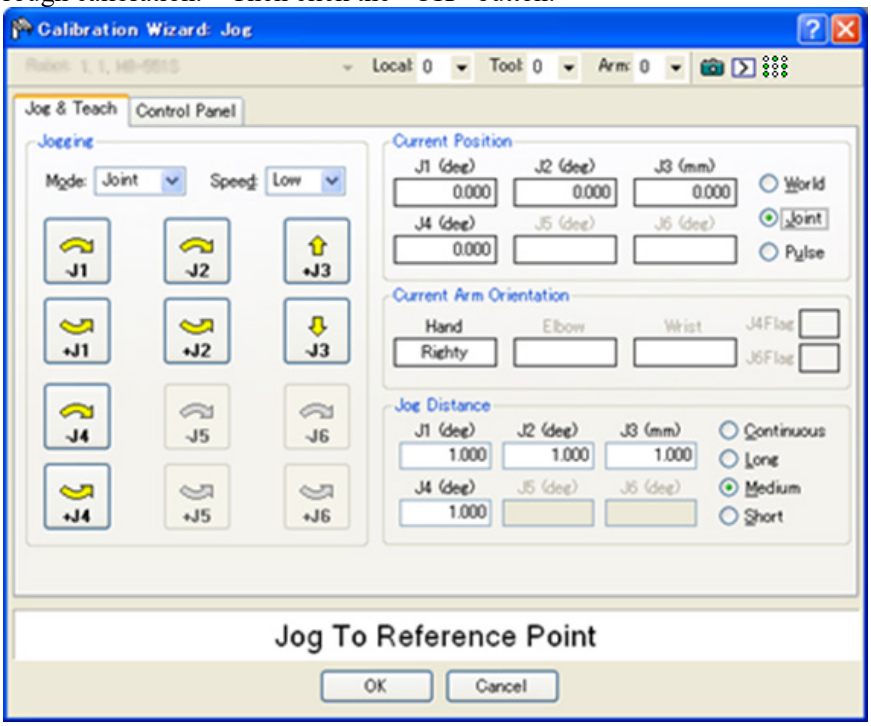
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position.

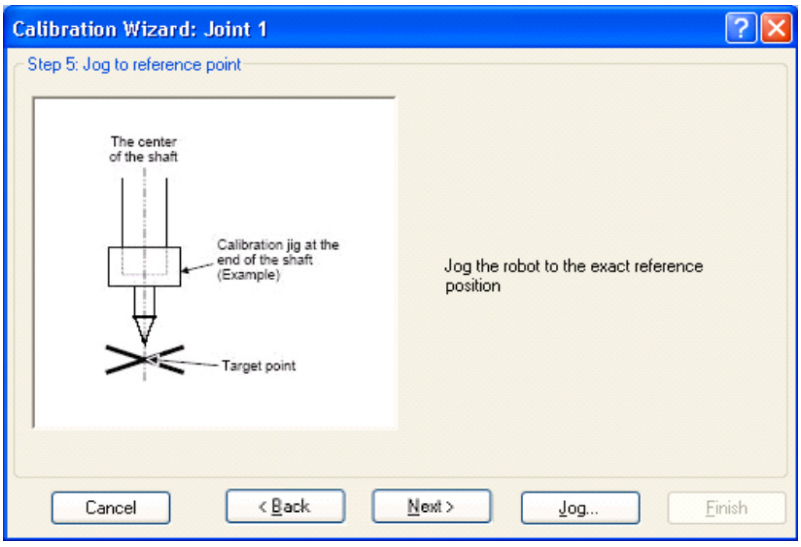


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



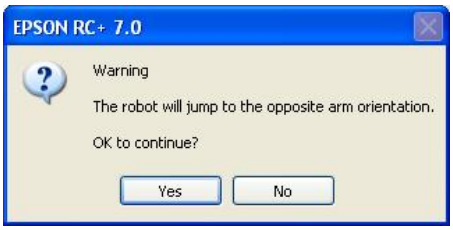
* Position Joint #2 only and move Joint #3 to around 0 pulse.

(15) Click the <Next> button.

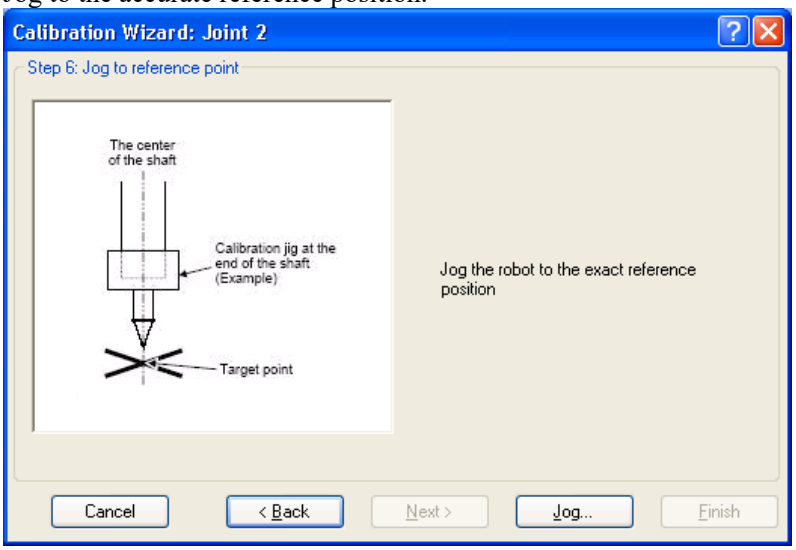


(16) Execute the procedure in "Calibration Using Right / Left Arm Orientations" to accurately calibrate Joint #2.
Go on to the step (17) for the other joints calibration.

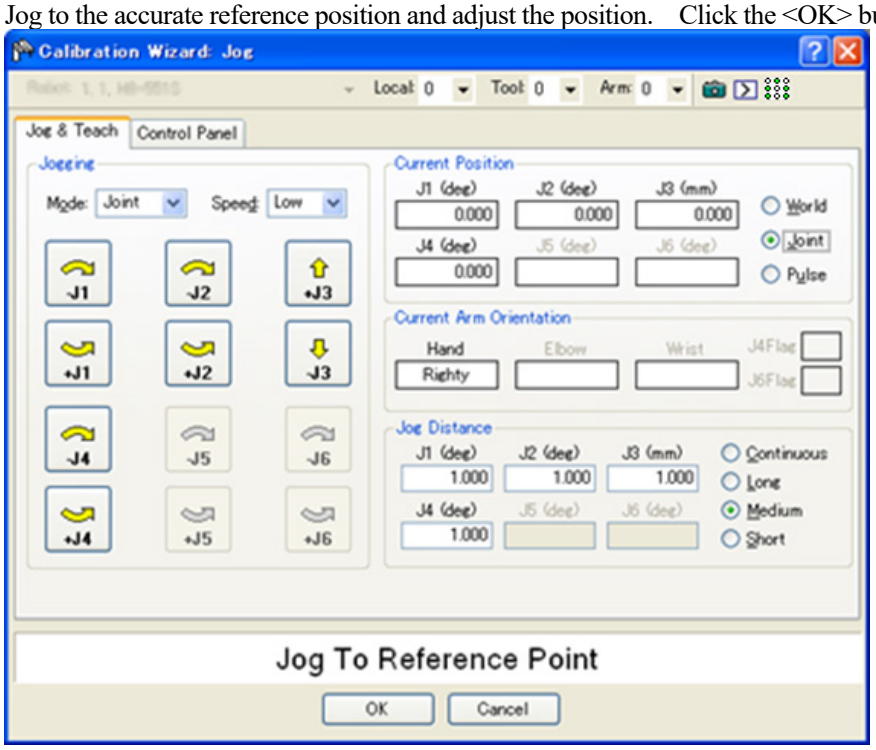
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



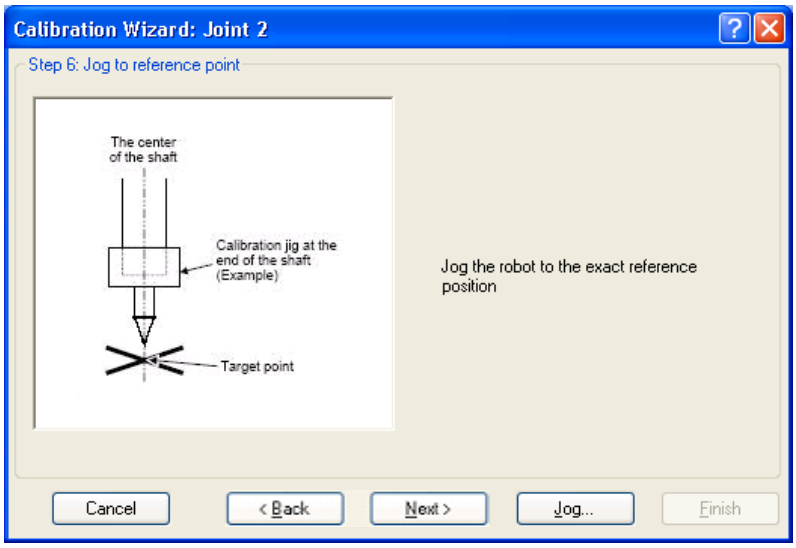
ii. Jog to the accurate reference position.



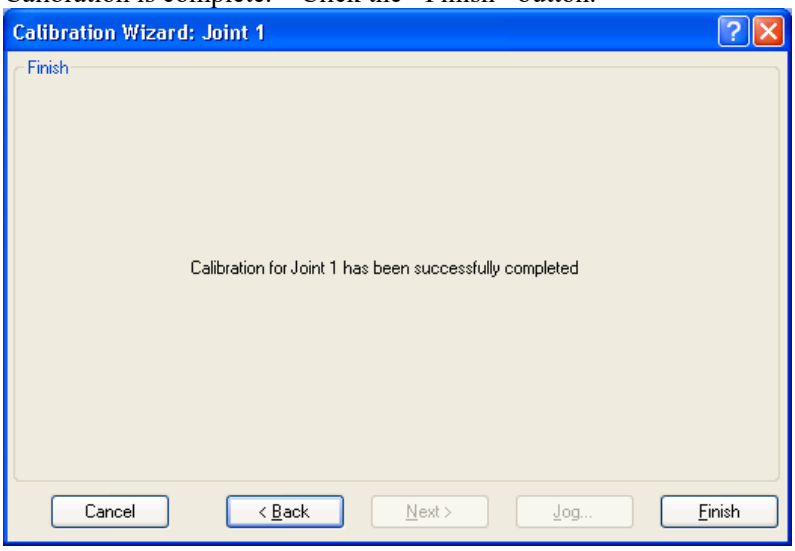
iii. Jog to the accurate reference position and adjust the position. Click the <OK> button.



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.

13.3 Accurate Calibration of Joint #2

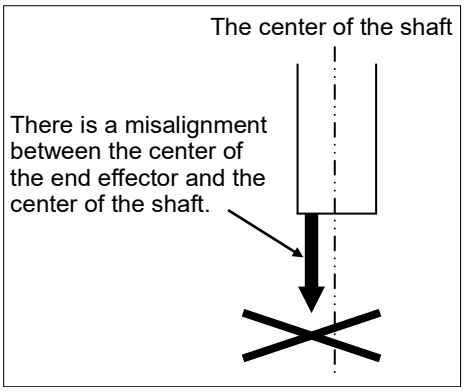
When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.

NOTE

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

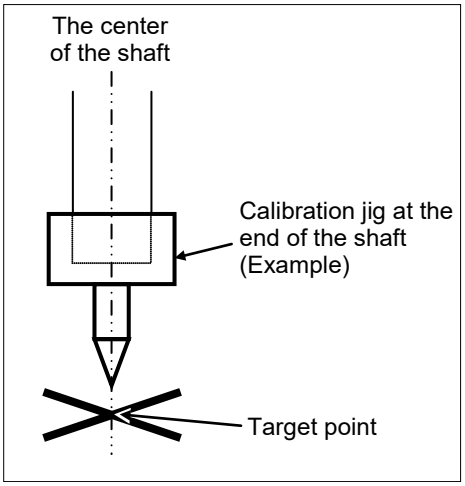
The reference point is the center of the ball screw spline shaft during this calibration.

When there is a misalignment between the center of the end effector and the center of the ball screw spline shaft, remove the end effector and execute 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 executing 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 liner 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 point you can easily verify the accuracy within the work envelop of both right and left arm. Then, check the number of points you want to use.

(2) EPSON RC+ menu-[Tools]-[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 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 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, execute 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.

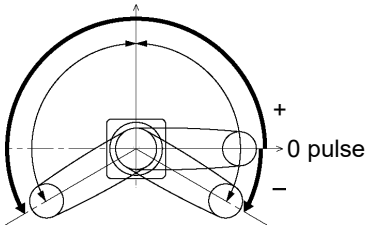
3. Encoder Initialization

   (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.

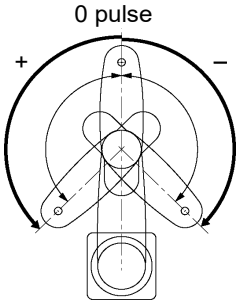
0 pulse position of Joint #1:

position aligned with X-axis in Robot coordinate system



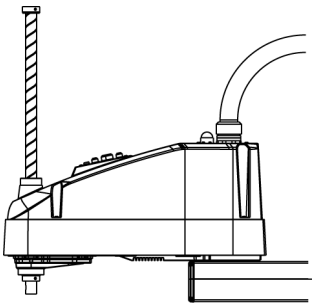
0 pulse position of Joint #2:

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

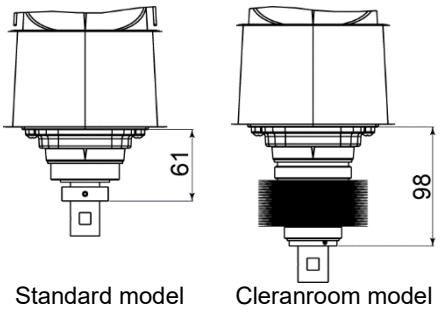


0 pulse position of Joint #3:

upper limit position in motion range

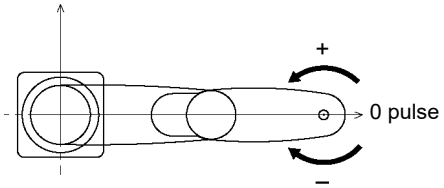


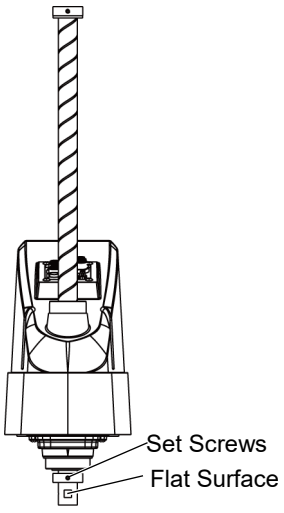
The height of Joint #3 depends on manipulator model.



0 pulse position of Joint #4:

position where the flat surface on the shaft (or set screws of the mechanical stop on the bottom) faces toward the tip of Arm #2





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

Select a robot to be calibrated. Input as below in the [Command Window] and execute it.
(This example uses “robot 1”.)

```
> robot 1
```

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

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

Joint #1: `>EncReset 1`
Joint #2: `>EncReset 2`
Joint #3: `>EncReset 3`
Joint #4: `>EncReset 3, 4`

(3)-5 Reboot the Controller.

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

This window will be disappeared when the Controller starts up.

4. Rough Calibration

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

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

* Manipulator does not move.

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

Part Name		Code	Note	Reference	Overhaul *3
Cable Unit	LS20-B804*	2202239	800 mm	4.1	-
	LS20-BA04*	2202240	1000 mm		
AC Servo Motor	Joint #1	2202238	750 W	5.1	✓
	Joint #2	2197985	520 W	6.1	✓
	Joint #3	2197985	520 W	7.1	✓
	Joint #4	2197987	150 W	8.1	✓
Reduction Gear Unit *1	Joint #1	1646483		5.2	✓
	Joint #2	1798349		6.2	✓
	Joint #4	1493783		8.4	
O-ring	Joint #1	1650902	For reduction gear unit (Joint #1, Joint #2)	5.2	-
		1489339	CO0557		
		1618362	CO0549		
		1618361	CO0546		
	Joint #2	1489339	CO0557	6.2	-
		1618362	CO0549		
Timing Belt	Joint #3	1618727	Z	7.2	✓
	Joint #4	1618729	U	8.2	✓
Electromagnetic brake		1499588	Z-axis	7.3	✓
		1803965	U-axis	7.4	✓
Brake Release Switch		2173869		-	-
Bellows		1499591	*4	9	-
Ball Screw Spline	LS20-B***S	1646487	420 mm	10	✓
	LS20-B***C	1646488	390 mm		
Converter Board		2196970		11.1	-
Control Board		2196966		11.2	-
LED lamp		2077258		12	-
Grease *2	Ball Screw Spline: AFB	-	For purchasing grease, and adhesive, please the supplier of your region.	2.3	-
	Reduction Gear Unit: SK-1A			5.2, 6.2	-
Arm Top Cover		1798943	White	3.1	-
Arm Bottom Cover		1759511	Blue	3.2	-
Dust Cover		2014430	For RJ45 connector	-	

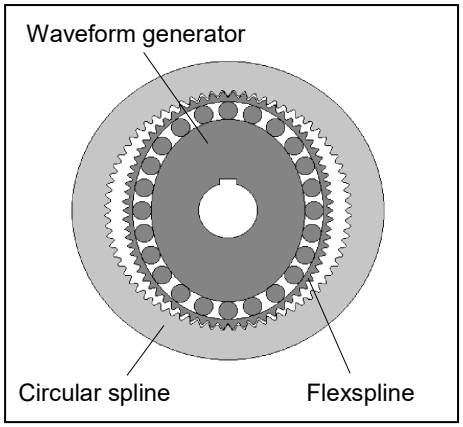
Part Name		Code	Note	Reference	Overhaul *3
M/C Power Cable　*5	For fixed wiring	2186054	3 m	4.3	-
		2186055	5 m		
		2186056	10 m		
	For movable wiring	2213020	5 m		
		2213021	10 m		
M/C Signal Cable　*5	For fixed wiring	2194703	3 m	4.3	-
		2194704	5 m		
		2194705	10 m		
	For movable wiring	2213018	5 m		
		2213019	10 m		

*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

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.

Splines are greased.　Be careful not to let grease adhere to clothes.

*2 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 suppliers 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/

*3 Overhaul

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).*

*4 Bellows

The bellows for LS20-B**C are provided in a unit of two pieces. The shape varies between the upper and lower bellows.

*5 M/C Power Cable, M/C Signal Cable

Select M/C power cable and M/C signal cable with the same specification (For fixed wiring, For movable wiring) and the same length.

If the specification and length are not the same, the robot system may not operate properly.