

EPSON

SCARA ROBOT

G3 series

MANIPULATOR MANUAL

Rev.15

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MANIPULATOR MANUAL

G3 series

Rev.15

SCARA ROBOT

G3 series Manipulator Manual

Rev.15

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FOREWORD

Thank you for purchasing our robot products.

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

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

Keep this manual handy for easy access at all times.

WARRANTY

The Manipulator and its optional parts are shipped to our customers only after being subjected to the strictest quality controls, tests, and inspections to certify its compliance with our high performance standards.

Product malfunctions resulting from normal handling or operation will be repaired free of charge during the normal warranty period. (Please contact the supplier of your region for warranty period information.)

However, customers will be charged for repairs in the following cases (even if they occur during the warranty period):

1. Damage or malfunction caused by improper use which is not described in the manual, or careless use.
2. Malfunctions caused by customers' unauthorized disassembly.
3. Damage due to improper adjustments or unauthorized repair attempts.
4. Damage caused by natural disasters such as earthquake, flood, etc.

Warnings, Cautions, Usage:

1. If the Manipulator or associated equipment is used outside of the usage conditions and product specifications described in the manuals, this warranty is void.
2. If you do not follow the WARNINGS and CAUTIONS in this manual, we cannot be responsible for any malfunction or accident, even if the result is injury or death.
3. We cannot foresee all possible dangers and consequences. Therefore, this manual cannot warn the user of all possible hazards.

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

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

MANUFACTURER

SEIKO EPSON CORPORATION

CONTACT INFORMATION

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

Robot System Safety and Installation Read this manual first

Regarding battery disposal



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

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

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

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

Controller manual / Manipulator manual (Maintenance section)

Before Reading This Manual

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

Structure of Control System

The G3 series Manipulators can be used with the following combinations of Controllers and software.

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

Controller		Software
Name	Structure	
RC180	Controller	EPSON RC+ 5.0
RC700-A	Control Unit Drive Unit	EPSON RC+ 7.0 Ver.7.1.2 or later

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

Turning ON/OFF Controller

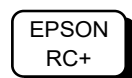
When you see the instruction “Turn ON/OFF the Controller” in this manual, be sure to turn ON/OFF all the hardware components. For the Controller composition, refer to the table above.

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.

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Setup & Operation

This volume contains information for setup and operation of the G3 series Manipulators. Please read this volume thoroughly before setting up and operating the Manipulators.




1. Safety

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

Keep this manual handy for easy access at all times.

1.1 Conventions

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


 WARNING	This symbol indicates that a danger of possible serious injury or death exists if the associated instructions are not followed properly.
 WARNING	This symbol indicates that a danger of possible serious injury or death caused by electric shock exists if the associated instructions are not followed properly.
 CAUTION	This symbol indicates that a danger of possible harm to people or physical damage to equipment and facilities exists if the associated instructions are not followed properly.

1.2 Design and Installation Safety

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

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

The following items are safety precautions for design personnel:

 WARNING	<ul style="list-style-type: none"> ■ Personnel who design and/or construct the robot system with this product must read the <i>Safety</i> chapter in the <i>EPSON RC+ User's Guide</i> to understand the safety requirements before designing and/or constructing the robot system. Designing and/or constructing the robot system without understanding the safety requirements is extremely hazardous, may result in serious bodily injury and/or severe equipment damage to the robot system, and may cause serious safety problems. ■ The Manipulator and the Controller must be used within the environmental conditions described in their respective manuals. This product has been designed and manufactured strictly for use in a normal indoor environment. Using the product in an environment that exceeds the specified environmental conditions may not only shorten the life cycle of the product but may also cause serious safety problems. ■ The robot system must be used within the installation requirements described in the manuals. Using the robot system outside of the installation requirements may not only shorten the life cycle of the product but also cause serious safety problems.
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Further precautions for installation are mentioned in the chapter *Setup & Operation: 3. Environments and Installation*. Please read this chapter carefully to understand safe installation procedures before installing the robots and robotic equipment.

1.2.1 Strength of the Ball Screw Spline

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

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

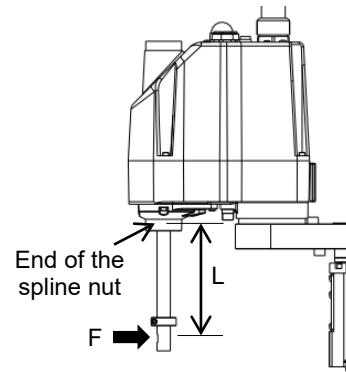
[Allowable bending moment]

$$G3: M=13,000 \text{ Nmm}$$

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


[Moment]


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




1.3 Operation Safety

The following items are safety precautions for qualified Operator personnel:

 WARNING	<ul style="list-style-type: none"> ■ Please carefully read the <i>Safety-related Requirements</i> in the <i>Safety</i> chapter of the <i>Safety and Installation</i> manual before operating the robot system. Operating the robot system without understanding the safety requirements is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system. ■ Do not enter the operating area of the Manipulator while the power to the robot system is turned ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even if it seems to be stopped. ■ Before operating the robot system, make sure that no one is inside the safeguarded area. The robot system can be operated in the mode for teaching even when someone is inside the safeguarded area. The motion of the Manipulator is always in restricted (low speeds and low power) status to secure the safety of an operator. However, operating the robot system while someone is inside the safeguarded area is extremely hazardous and may result in serious safety problems in case that the Manipulator moves unexpectedly. ■ Immediately press the Emergency Stop switch whenever the Manipulator moves abnormally while the robot system is operated.
--	---

 WARNING	<ul style="list-style-type: none"> ■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
--	---

 <p>CAUTION</p>	<ul style="list-style-type: none">■ Whenever possible, only one person should operate the robot system. If it is necessary to operate the robot system with more than one person, ensure that all people involved communicate with each other as to what they are doing and take all necessary safety precautions.■ Joint #1, #2, and #4: If the joints are operated repeatedly with the operating angle less than 5 degrees, they may get damaged early because the bearings are likely to cause oil film shortage in such situation. To prevent early breakdown, move the joints larger than 50 degrees for about five to ten times a day. Joint #3: If the up-and-down motion of the hand is less than 10 mm, move the joint a half of the maximum stroke for five to ten times a day.■ Oscillation (resonance) may occur continuously in low speed Manipulator motion (Speed: approx. 5 to 20%) depending on combination of Arm orientation and end effector load. Oscillation arises from natural oscillation frequency of the Arm and can be controlled by following measures.<ul style="list-style-type: none">Changing Manipulator speedChanging the teach pointsChanging the end effector load
--	---

1.4 Emergency Stop

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

1.4.1 RC180

If the Manipulator moves abnormally during operation, immediately press the Emergency Stop switch. Stops the power supply to the motor, and the arm stops in the shortest distance with the dynamic brake and mechanical brake.

However, avoid pressing the Emergency Stop switch unnecessarily while the Manipulator is running normally. Otherwise, the Manipulator may hit the peripheral equipment since the operating trajectory while the robot system stops is different from that in normal operation. It may also result in short life of the reduction gear unit due to the shock or the electromagnetic brake due to the worn friction plate.

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

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

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

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

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

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

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

Reduction of the life and damage of the reduction gear unit

Position gap at the joints

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

Whether or not the reduction gear is damaged

Whether or not the joints are in their proper positions

If there is a position gap, perform calibration by referring to the *Maintenance 14. Calibration* in this manual.

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

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

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

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

To check brake problems, refer to the following manuals.

Manipulator Manual Maintenance

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

Safety and Installation

RC180: 5.1.1 Manipulator

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

Free running distance in emergency

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

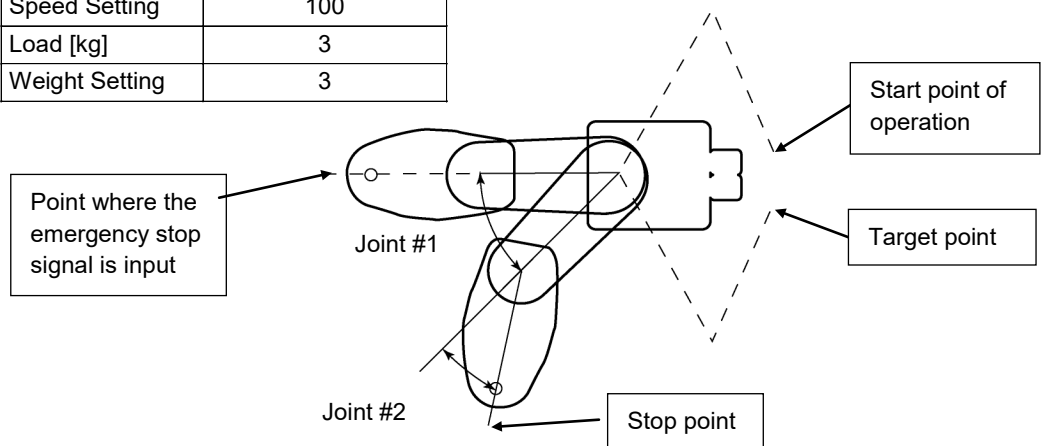
The free running time/angle/distance of the Manipulator are shown below. However, remember that the values vary depending on following conditions.

Weight of the end effector Weight of work piece Operating pose

Weight Speed Accel etc.

Conditions for Measurement

Accel Setting	100
Speed Setting	100
Load [kg]	3
Weight Setting	3



Controller		RC180		
Manipulator		G3-25***	G3-30***	G3-35***
Free running time	Joint #1 + Joint #2 [s]	0.5	0.5	0.5
	Joint #3 [s]	0.5	0.5	0.5
Free running angle	Joint #1 [deg]	35	35	40
	Joint #2 [deg]	50	50	50
	Joint #1 + Joint #2 [deg]	85	85	90
Free running distance	Joint #3 G3-**1** [mm]	95	95	95

1.4.2 RC700-A

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

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

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

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

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

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

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

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

Reduction of the life and damage of the reduction gear unit

Position gap at the joints

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

Whether or not the reduction gear is damaged

Whether or not the joints are in their proper positions

If there is a position gap, perform calibration by referring to the *Maintenance 14. Calibration* in this manual.

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

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

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

EPSON RC+ User's Guide 2. Safety - Installation and Design Precautions
- Safeguard System

Safety and Installation 2.6 Connection to EMERGENCY Connector

To check brake problems, refer to the following manuals.

Manipulator Manual Maintenance

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

Safety and Installation

5.1.1 Manipulator

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

Free running distance in emergency

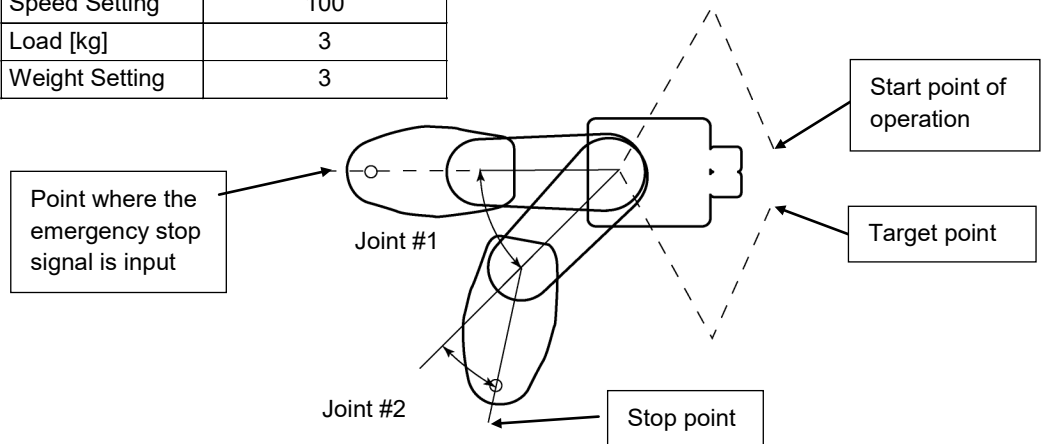
The operating Manipulator cannot stop immediately after the Emergency Stop switch is pressed.

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

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

Conditions for Measurement

Accel Setting	100
Speed Setting	100
Load [kg]	3
Weight Setting	3



Controller		RC700-A		
Manipulator		G3-25***	G3-30***	G3-35***
Free running time	Joint #1 + Joint #2 [s]	0.3	0.2	0.3
	Joint #3 [s]	0.2	0.2	0.2
Free running angle	Joint #1 [deg]	20	20	35
	Joint #2 [deg]	20	20	25
	Joint #1 + Joint #2 [deg]	40	40	60
Free running distance	Joint #3 G3-**1** [mm]	60	60	60

1.5 Emergency Movement Without Drive Power

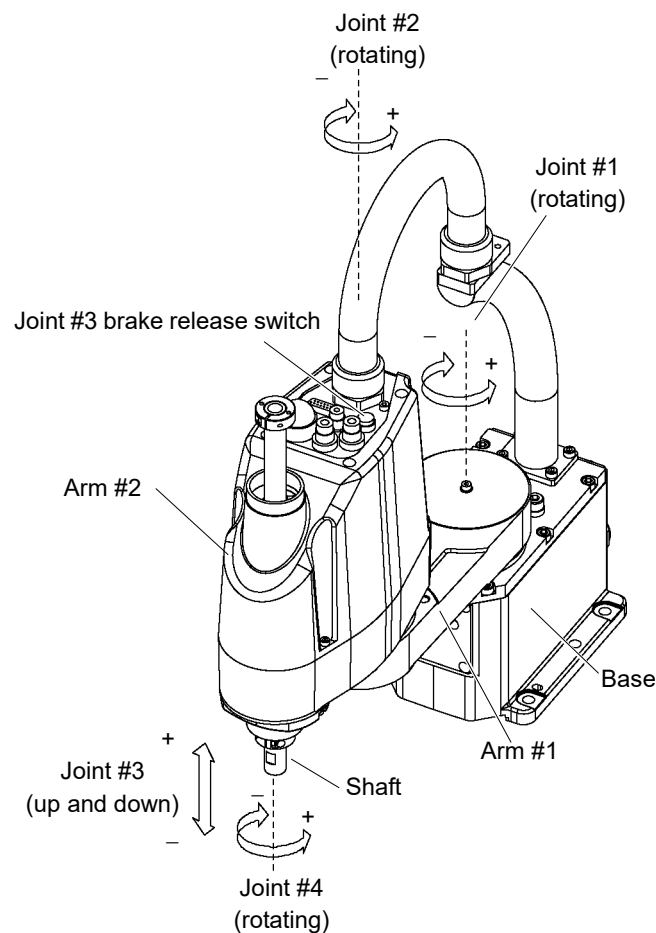
When the system is placed in emergency mode, push the arm or joint of the Manipulator by hand as shown below:

Arm #1 Push the arm by hand.

Arm #2 Push the arm by hand.

Joint #3 The joint cannot be moved up/down by hand until the electromagnetic brake applied to the joint has been released. Move the joint up/down while pressing the brake release switch.

Joint #4 Rotate the shaft by hand.




NOTE


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

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

1.6 ACCELS Setting for CP Motions

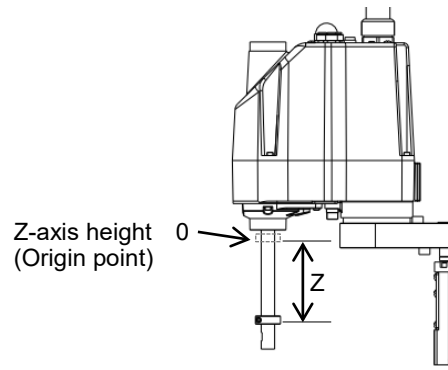
To make the Manipulator move in CP motion, see the following and set ACCELS properly according to the tip load and the Z-axis height.

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

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

ACCELS setting value by Z-axis position and tip load

Z position (mm)	Tip load		
	1kg or less	2kg or less	3kg or less
$0 > Z \geq -50$	25000 or less	25000 or less	24000 or less
$-50 > Z \geq -100$		24000 or less	16000 or less
$-100 > Z \geq -150$		18000 or less	12000 or less



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

Whether the ball screw spline shaft is deformed or bent




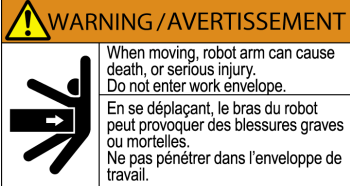


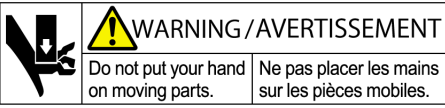





1.7 Warning Labels

The Manipulator has the following warning labels.

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

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

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

Location	Warning Label	NOTE
A	 <div style="border: 1px solid black; padding: 5px; margin-top: 5px;">  WARNING / AVERTISSEMENT Take measures to prevent the manipulator from falling and dropping before removing base mounting bolts. Prendre les mesures nécessaires pour empêcher le manipulateur de tomber avant de démonter les vis de fixation de la base. </div>	<p>Before loosening the base mounting screws, hold the arm and secure it tightly with a band to prevent hands or fingers from being caught in the Manipulator.</p>
B	  <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> When moving, robot arm can cause death, or serious injury. Do not enter work envelope. En se déplaçant, le bras du robot peut provoquer des blessures graves ou mortelles. Ne pas pénétrer dans l'enveloppe de travail. </div>	<p>Be careful to avoid collision.</p>
C		<p>Hazardous voltage exists while the Manipulator is ON. To avoid electric shock, do not touch any internal electric parts.</p>
D	  <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> Do not put your hand on moving parts. Ne pas placer les mains sur les pièces mobiles. </div>	<p>You can catch your hand or fingers between the shaft and cover when bringing your hand close to moving parts. * Manipulators with bellows do not have this label for no danger of your hand or fingers being caught.</p>
E		<p>HOT Be careful not to burn yourself.</p>
F	 <div style="border: 1px solid black; padding: 5px; margin-top: 5px;">  WARNING / AVERTISSEMENT Follow instructions manual during lifting and transportation. Respecter les instructions du manuel d'utilisation pendant le levage et le transport. </div>	<p>Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.</p>
G	 <div style="border: 1px solid black; padding: 5px; margin-top: 5px;">  WARNING / AVERTISSEMENT Hand weight may cause shaft to fall after release of brake. Le poids de la main peut entraîner la chute de l'arbre après la libération du frein. </div>	<p>Be careful of the hand falling or rotating while the brake release switch is being pressed.</p>

Location	Label
H	<p>MODEL : G3-351S</p> <p>SERIAL NO. : 00001</p> <p>MANUFACTURED : 10/2007</p> <p>WEIGHT : 14kg MAX PAYLOAD : 3kg</p> <p>MOTOR POWER</p> <p>AXIS1 : 200W AXIS2 : 150W</p> <p>AXIS3 : 150W AXIS4 : 150W</p> <p>SEIKO EPSON CORPORATION</p> <p>3-5,OWA 3-CHOME,SUWA-SHI</p> <p>NAGANO-KEN,392-8502 JAPAN</p>
I	Air pressure max. 0.59Mpa, 86psi

Common

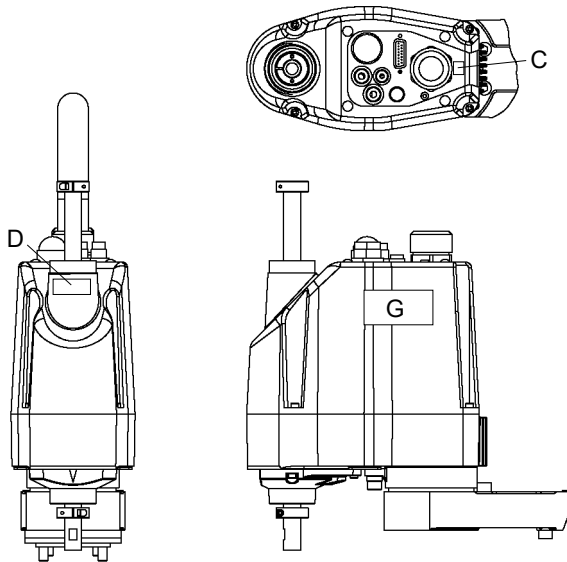
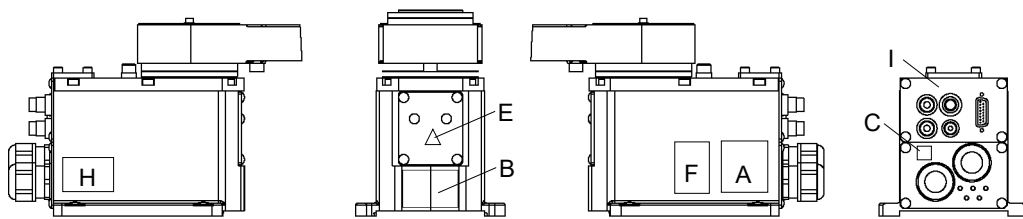
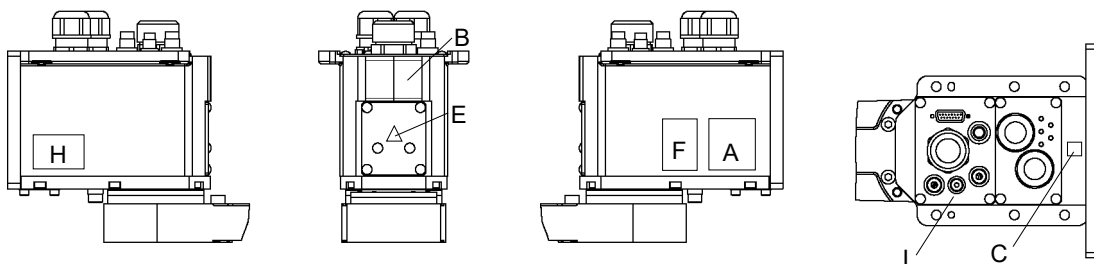


Table Top Mounting



Multiple Mounting



2. Specifications

2.1 Features of G3 series Manipulators

The G3 series Manipulators are high-performance manipulators pursuing high speed, high accuracy, space saving, and high cost-performance.

The features of the G3 series Manipulators are as follows:

Space productivity

Top level of cycle time and positioning accuracy

Minimized body

10 % downsize of overall height, compared to E2C

Extended motion range

The same size of motion range compared with the other brands' one up robots

Extended range in Z direction

Obtain the stroke under the body

Succeeded E2C series advantages

Compatibility with the E2C series Manipulators

The installation procedure and mounting dimensions of end effector for the G3 series are compatible with those for E2C series

* Secure the compatible mounting position with optional parts

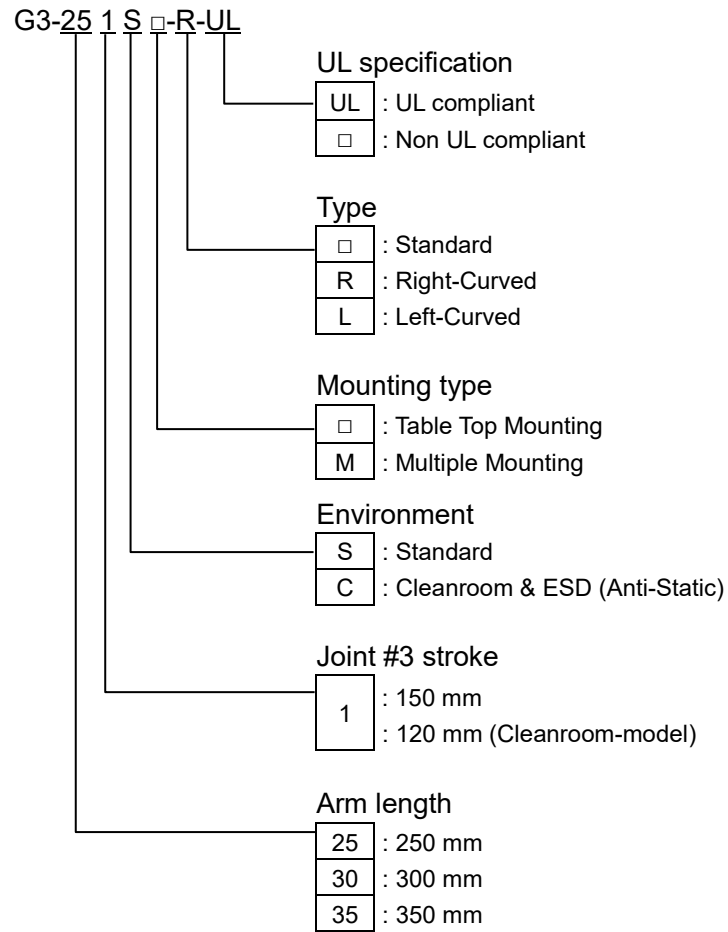
Improved productivity

Increase in number of user wires and pneumatic tubes

Enhanced speed of Joint #1, 2, 3, and 4

Improved cycle time

2.2 Model Number and Model Differences



Environment

Cleanroom-model

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

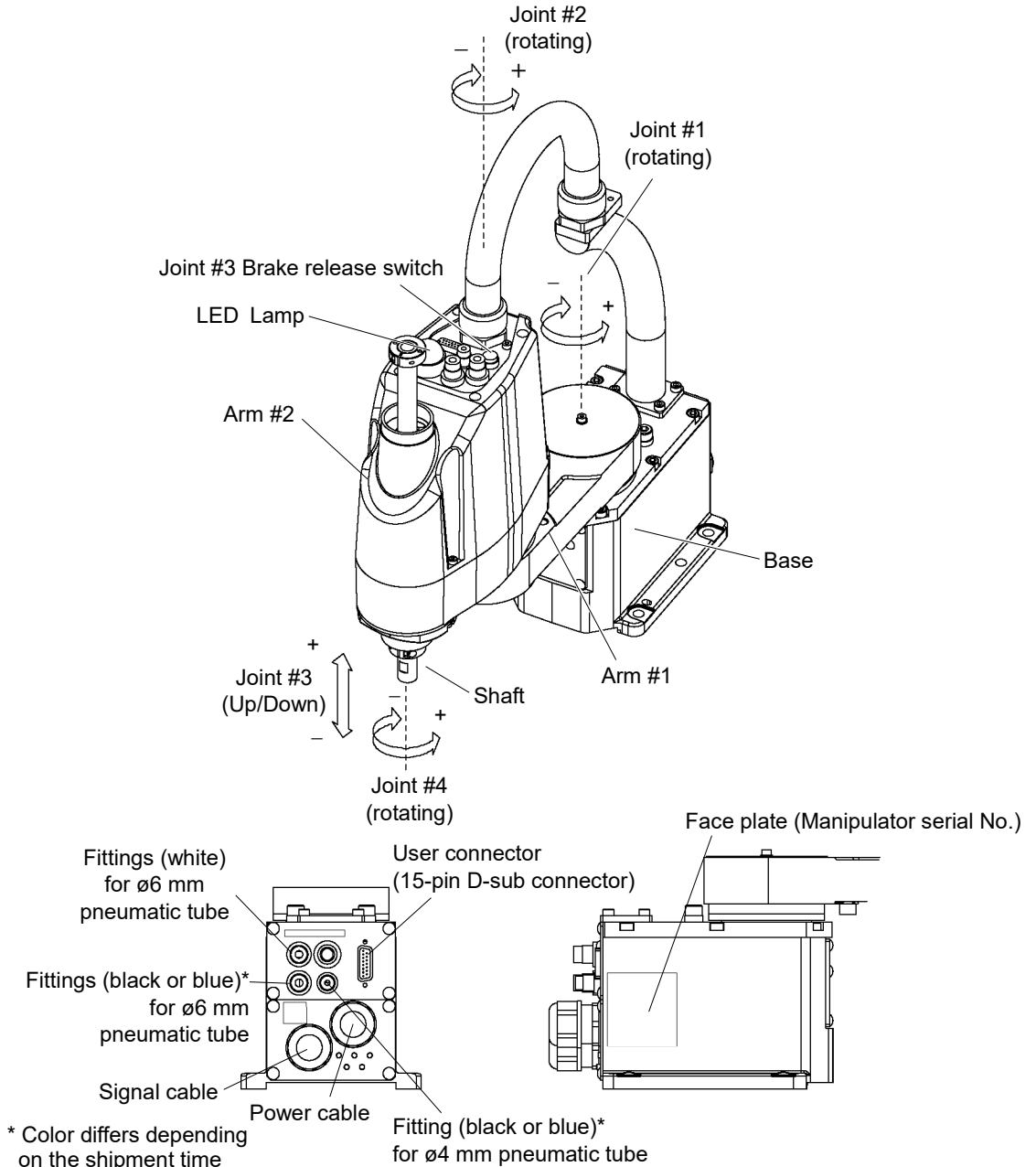
For details on the specifications, refer to *Setup & Operation: 2.4 Specifications*.

Arm length	Arm type	Mounting type	Environment	Joint #3 stroke	Model Number
250 mm	Standard	Table Top Mounting	Standard	150	G3-251S
			Cleanroom	120	G3-251C
300 mm	Standard	Table Top Mounting	Standard	150	G3-301S
			Cleanroom	120	G3-301C
		Multiple Mounting	Standard	150	G3-301SM
			Cleanroom	120	G3-301CM
	Right-Curved	Table Top Mounting	Standard	150	G3-301S-R
			Cleanroom	120	G3-301C-R
	Left-Curved	Table Top Mounting	Standard	150	G3-301S-L
			Cleanroom	120	G3-301C-L
350 mm	Standard	Table Top Mounting	Standard	150	G3-351S
			Cleanroom	120	G3-351C
		Multiple Mounting	Standard	150	G3-351SM
			Cleanroom	120	G3-351CM
	Right-Curved	Table Top Mounting	Standard	150	G3-351S-R
			Cleanroom	120	G3-351C-R
		Multiple Mounting	Standard	150	G3-351SM-R
			Cleanroom	120	G3-351CM-R
	Left-Curved	Table Top Mounting	Standard	150	G3-351S-L
			Cleanroom	120	G3-351C-L
		Multiple Mounting	Standard	150	G3-351SM-L
			Cleanroom	120	G3-351CM-L

2.3 Part Names and Outer Dimensions

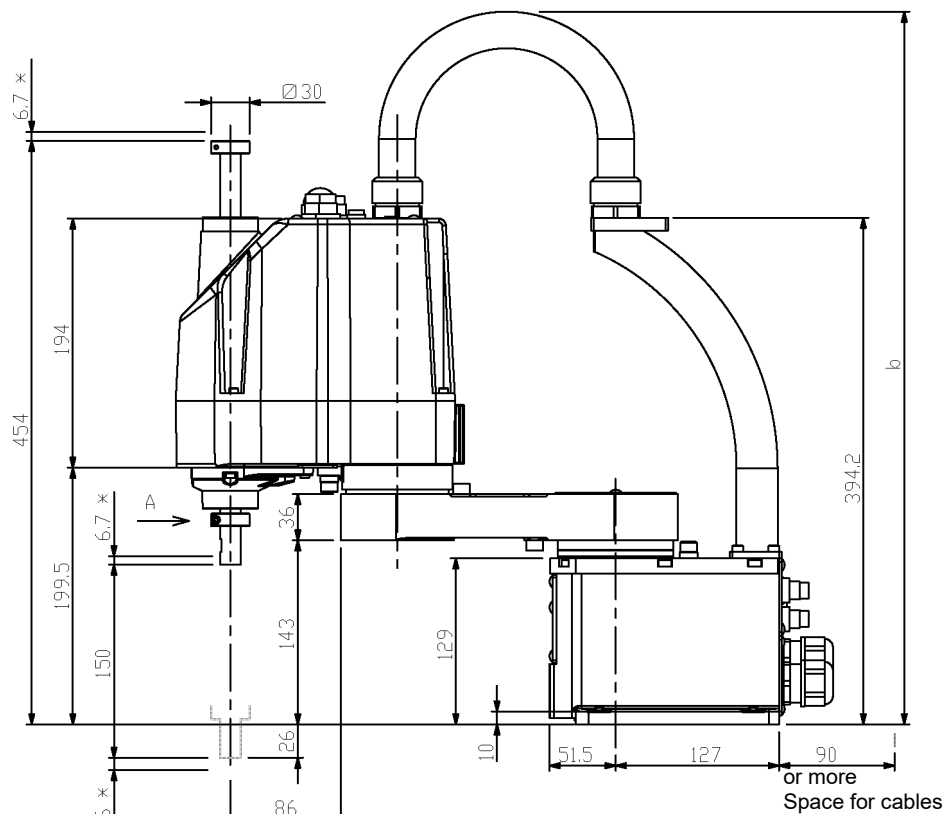
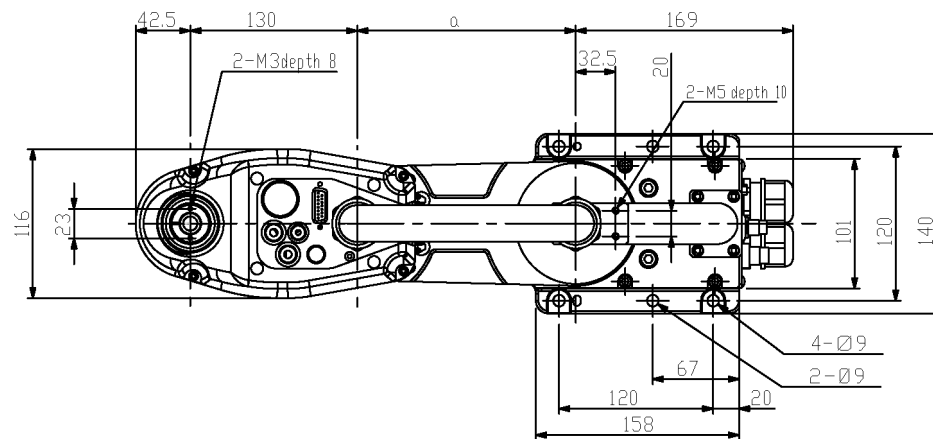
2.3.1 Table Top Mounting

Standard-model G3-**1S



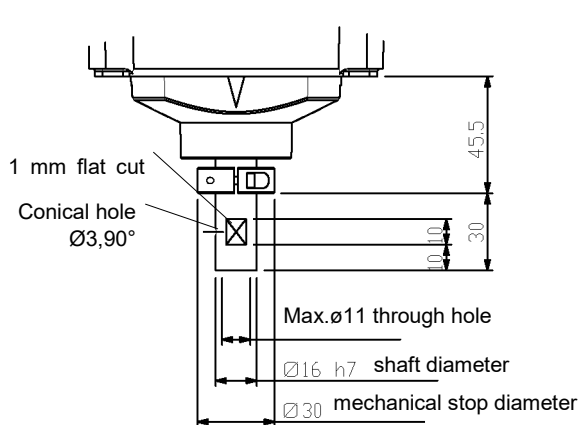
NOTE


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

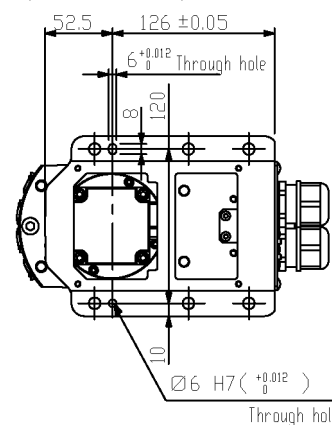


(*) indicates the stroke margin by mechanical stop.

	G3-251S	G3-301S	G3-351S
a	120	170	220
b	Max.545	Max.575	Max.595



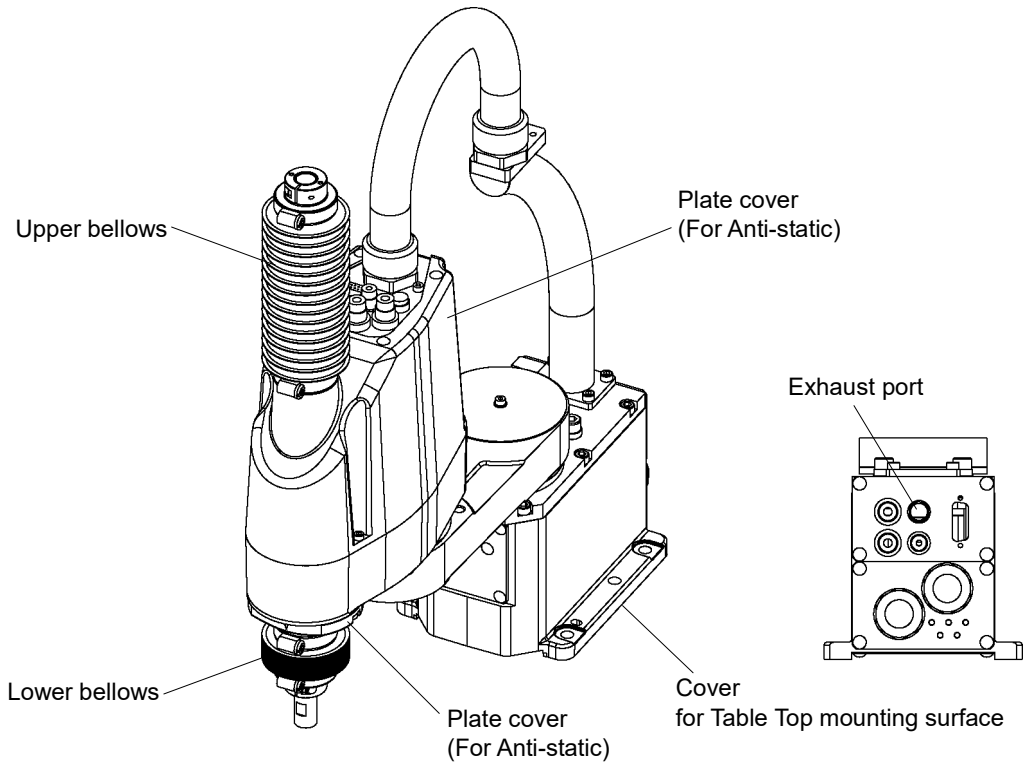
Detail of "A"
(Calibration point position of Joints #3 and #4)

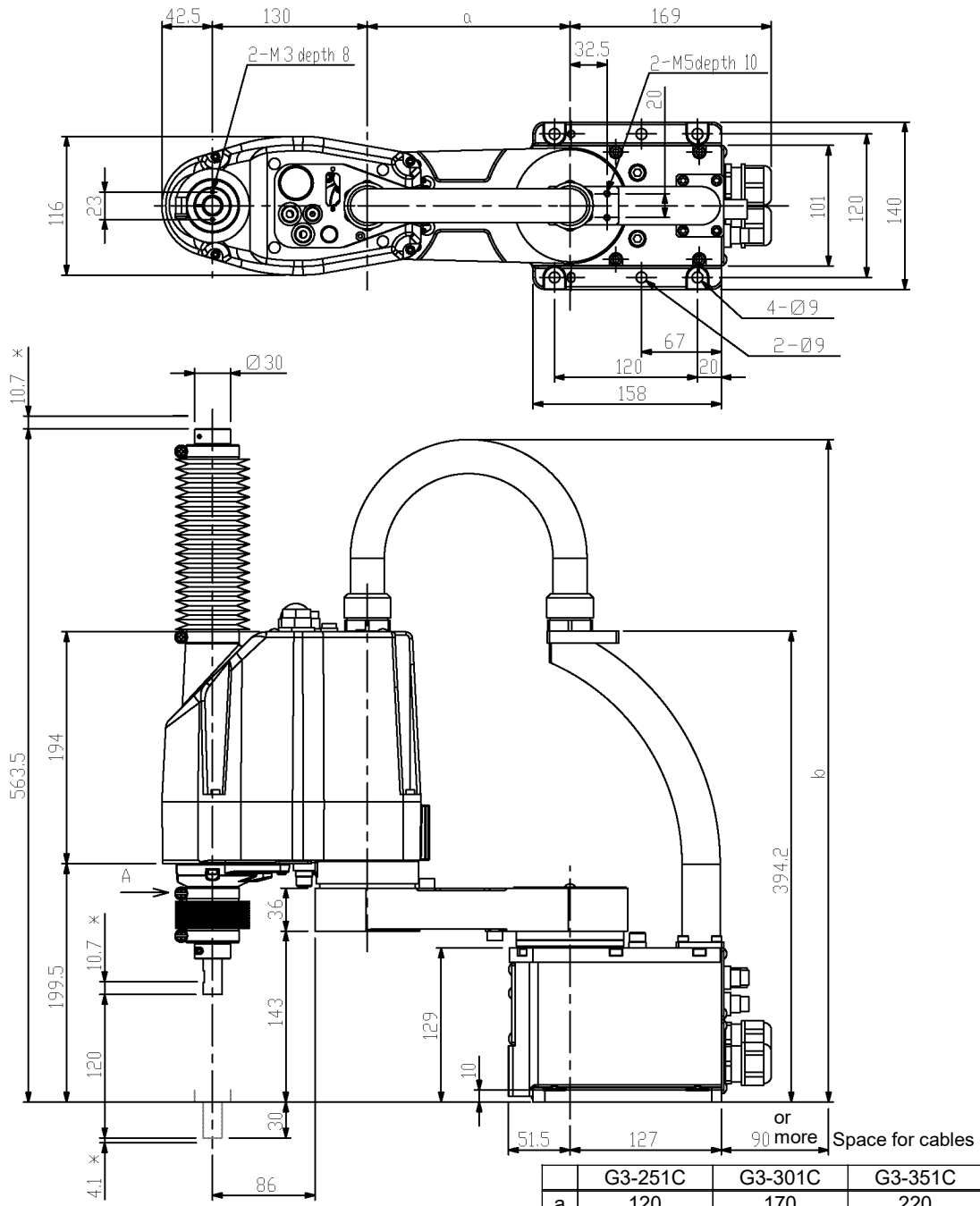


Reference through hole
(View from the bottom of the base)

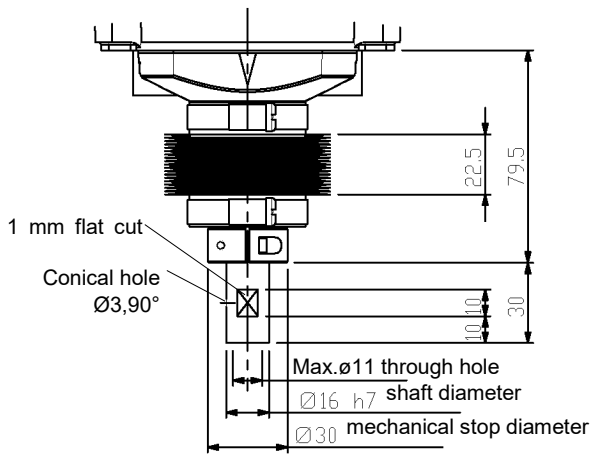
Cleanroom-model: G3-***C

The following figures show the additional parts and specifications for Cleanroom-model (Table Top mounting) when compared with the Standard-model in appearance.



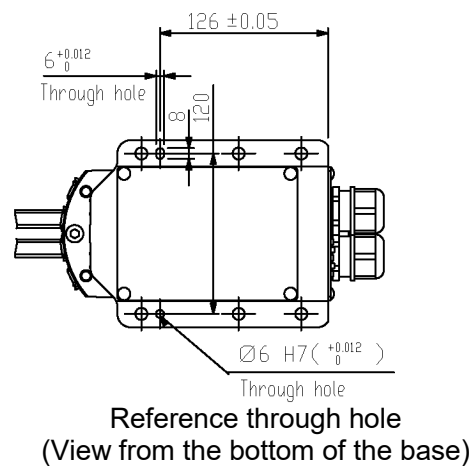


(*) indicates the stroke margin by mechanical stop.



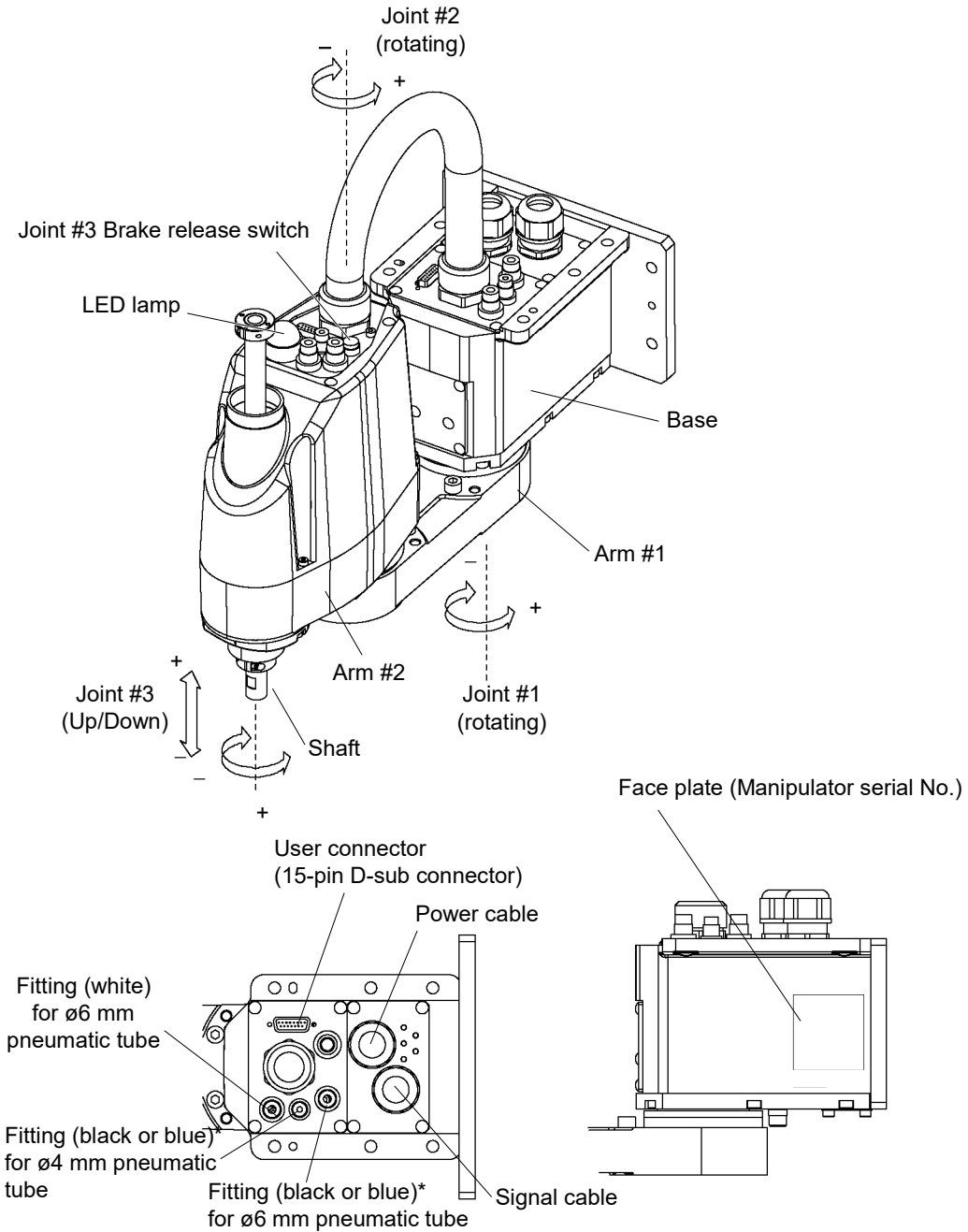
Detail of "A"

(Calibration point position of Joints #3 and #4)



2.3.2 Multiple Mounting

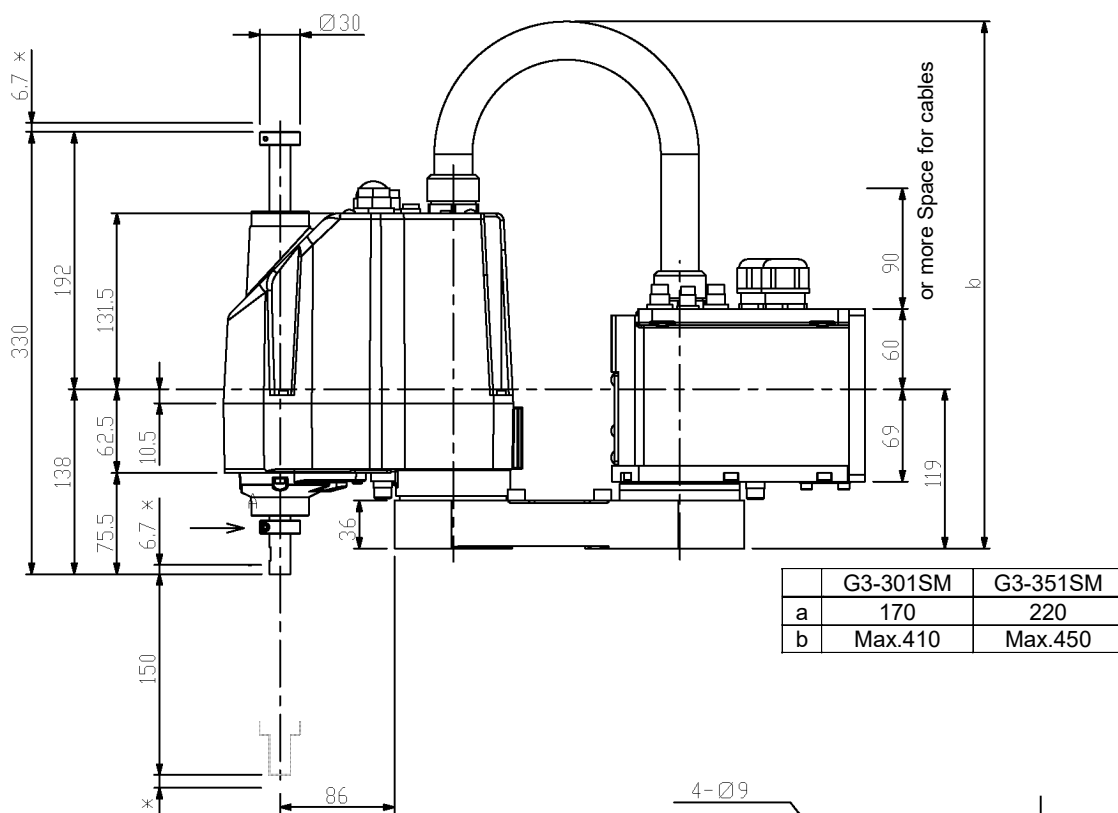
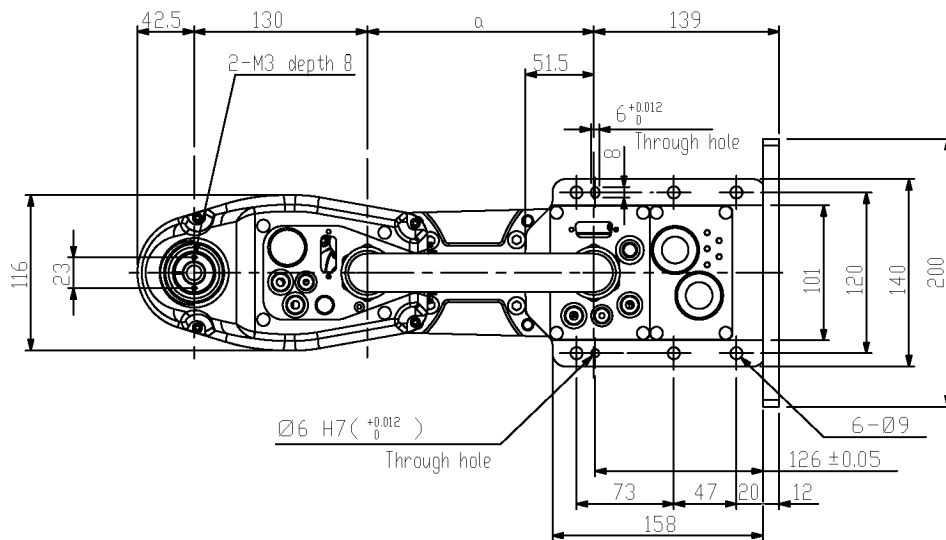
Standard-model: G3-**1SM



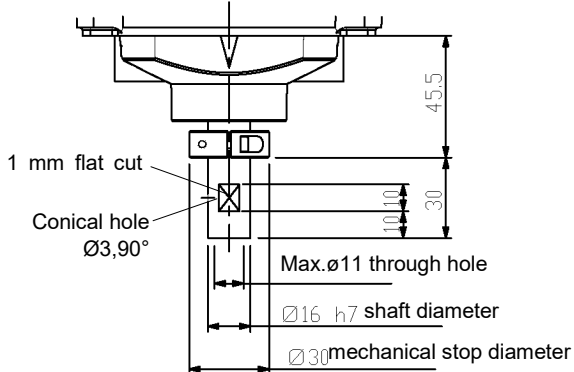
* Color differs depending on the shipment time

NOTE 

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

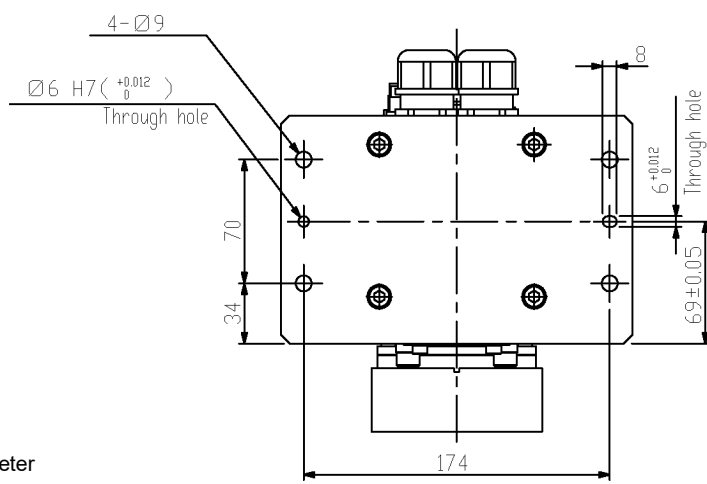


(*) indicates the stroke margin by mechanical stop.



Detail of "A"

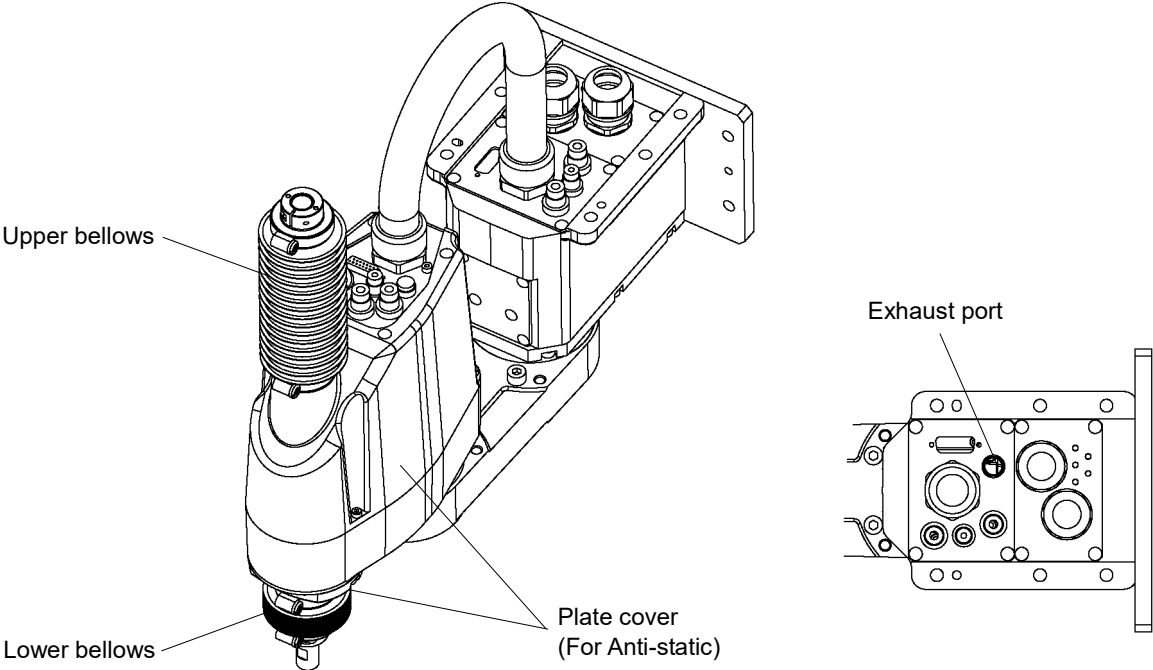
(Calibration point position of Joints #3 and #4)

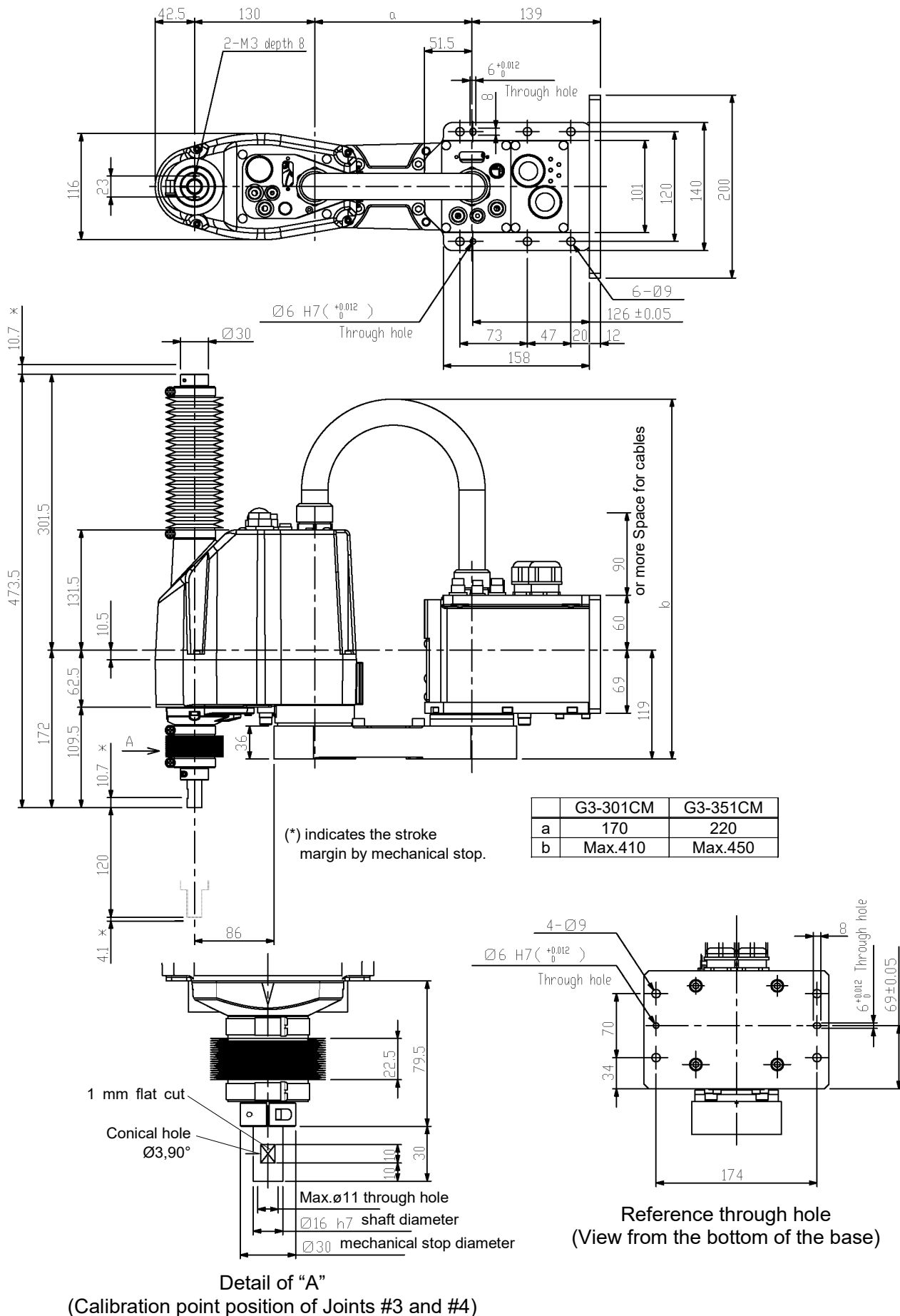


Reference through hole
(View from the bottom of the base)

Cleanroom-model: G3-**1CM

The following figures show the additional parts and specifications for Cleanroom-model (Multiple Mounting) when compared with the Standard-model in appearance.





2.4 Specifications

Item		G3 series Manipulator		
Arm length	Arm #1, #2	250 mm	300 mm	350 mm
	Arm #1	120 mm	170 mm	220 mm
	Arm #2	130 mm	130 mm	130 mm
Max. operating speed *1	Joints #1, #2	3550 mm/s	3950 mm/s	4350 mm/s
	Joint #3	1100 mm/s		
	Joint #4	3000 deg/s		
Repeatability	Joints #1, #2	± 0.008 mm	± 0.01 mm	± 0.01 mm
	Joint #3	± 0.01 mm		
	Joint #4	± 0.005 deg		
Payload (Load)	Rated	1 kg		
	Max.	3 kg		
Joint #4 allowable moment of inertia *2	Rated	0.005 kg·m ²		
	Max.	0.05 kg·m ²		
Resolution	Joints #1	0.0000343323 deg/pulse		
	Joint #2	0.0000549316 deg/pulse		
	Joint #3	0.0000878906 mm/pulse		
	Joint #4	0.000240928 deg/pulse		
Hand	Shaft diameter	ø 16 mm		
	Through hole	ø 11mm		
Mounting hole	Table top mounting	120 × 120 mm (4-M8)		
	Multiple mounting	Wall mounting : 174 × 70 mm (4-M8) Ceiling mounting : 120 × 120 mm (4-M8) / custom specification		
Weight (cables not included)		14 kg : 31 lb.		
Driving method	All joints	AC servo motor		
Motor rated capacity	Joint #1	200 W		
	Joint #2	150 W		
	Joint #3	150 W		
	Joint #4	150 W		
Option	Installation method	-	Multiple Mounting	
	Installation environment	Cleanroom & ESD *3		
Joint #3 down force		150 N		
Installed wire for customer use		15 (15 pin: D-sub) 15 cores		
Installed pneumatic tube for customer use		2 pneumatic tubes (ø6 mm) : 0.59 MPa (6 kgf/cm ² : 86 psi)		
		1 pneumatic tubes (ø4 mm) : 0.59 MPa (6 kgf/cm ² : 86 psi)		
Environmental requirements	Ambient Temp.	5 to 40°C (with minimum temperature variation)		
	Ambient relative humidity	10 to 80% (no condensation)		
Noise level *4		L _{Aeq} = 70 dB (A) or under		
Applicable Controller *5		RC180, RC700-A		
Assignable Value () Default values	SPEED	1 to (5) to 100		
	ACCEL *6	1 to (10) to 120		
	SPEEDS	1 to (50) to 2000		
	ACCELS	1 to (200) to 25000		
	FINE	0 to (10000) to 65535		
	WEIGHT	0,130 to (1,130) 3,130		
Safety standard		CE Marking EMC Directive, Machinery Directive KC Marking, KCs Marking UL standards (In case of UL specification) UL1740 ANSI/RIA R15.06 NFPA 79		

Setup & Operation 2. Specifications

Max. motion range (deg) (mm) / Max. pulse range (pulse)

Standard-model, Table Top Mounting

Item		G3-251S	G3-301S-*	G3-351S-*		
Max. motion range (deg), (mm)	Straight	Joint #1	± 140			
		Joint #2	± 141	± 142		
	Curved	Joint #1	Right hand	-	- 125 to 150	- 110 to 165
			Left hand	-	- 150 to 125	- 165 to 110
		Joint #2	Right hand	-	- 135 to 150	- 120 to 165
			Left hand	-	- 150 to 135	- 165 to 120
	Common	Joint #3	150 mm			
		Joint #4	± 360			
Max. pulse range (pulse)	Straight	Joint #1	- 1456356 to 6699236			
		Joint #2	± 2566827	± 2585032		
	Curved	Joint #1	Right hand	-	- 1019449 to 6990507	- 582543 to 7427414
			Left hand	-	- 1747627 to 6262329	- 2184534 to 5825423
		Joint #2	Right hand	-	- 2457600 to 2730667	- 2184534 to 3003734
			Left hand	-	- 2730667 to 2457600	- 3003734 to 2184534
	Common	Joint #3	-1706667 to 0			
		Joint #4	± 1494221			

Standard-model / Multiple Mounting

Item		G3-301SM	G3-351SM-*		
Max. motion range (deg), (mm)	Straight	Joint #1	± 115	± 120	
		Joint #2	± 135	± 142	
	Curved	Joint #1	Right hand	-	- 105 to 130
			Left hand	-	- 130 to 105
		Joint #2	Right hand	-	- 120 to 160
			Left hand	-	- 160 to 120
	Common	Joint #3	150 mm		
		Joint #4	± 360		
Max. pulse range (pulse)	Straight	Joint #1	- 728178 to 5971058	- 873814 to 6116694	
		Joint #2	± 2457600	± 2585032	
	Curved	Joint #1	Right hand	-	- 436907 to 6407965
			Left hand	-	- 1165085 to 5679787
		Joint #2	Right hand	-	- 2184534 to 2912712
			Left hand	-	- 2912712 to 2184534
	Common	Joint #3	-1706667 to 0		
		Joint #4	± 1494221		

Cleanroom-model, Table Top Mounting

Item		G3-251C	G3-301C-*	G3-351C-*		
Max. motion range (deg), (mm)	Straight	Joint #1	± 140			
		Joint #2	± 137	± 141	± 142	
	Curved	Joint #1	Right hand	-	- 125 to 150	- 110 to 165
			Left hand	-	- 150 to 125	- 165 to 110
		Joint #2	Right hand	-	- 135 to 145	- 120 to 160
			Left hand	-	- 145 to 135	- 160 to 120
	Common	Joint #3	120 mm			
		Joint #4	± 360			
Max. pulse range (pulse)	Straight	Joint #1	- 1456356 to 6699236			
		Joint #2	± 2494009	± 2566827	± 2585032	
	Curved	Joint #1	Right hand	-	- 1019449 to 6990507	- 582543 to 7427414
			Left hand	-	- 1747627 to 6262329	- 2184534 to 5825423
		Joint #2	Right hand	-	- 2457600 to 2639645	- 2184534 to 2912712
			Left hand	-	- 2639645 to 2457600	- 2912712 to 2184534
	Common	Joint #3	- 1365334 to 0			
		Joint #4	± 1494221			

Cleanroom-model, Multiple Mounting

Item		G3-301CM	G3-351CM-*		
Max. motion range (deg), (mm)	Straight	Joint #1	± 115	± 120	
		Joint #2	± 135	± 142	
	Curved	Joint #1	Right hand	-	- 105 to 130
			Left hand	-	- 130 to 105
		Joint #2	Right hand	-	- 120 to 150
			Left hand	-	- 150 to 120
	Common	Joint #3	120 mm		
		Joint #4	± 360		
Max. pulse range (pulse)	Straight	Joint #1	- 728178 to 5971058	- 873814 to 6116694	
		Joint #2	± 2457600	± 2585032	
	Curved	Joint #1	Right hand	-	- 436907 to 6407965
			Left hand	-	- 1165085 to 5679787
		Joint #2	Right hand	-	- 2184534 to 2730667
			Left hand	-	- 2730667 to 2187534
	Common	Joint #3	-1365334 to 0		
		Joint #4	± 1494221		

- *1: In the case of PTP command.
Maximum operating speed for CP command is 2000 mm/s on horizontal plane.
- *2: In the case where the center of gravity is at the center of Joint #4.
If the center of gravity is not at the center of Joint #4, set the parameter using Inertia command.
- *3: The exhaust system in the Cleanroom-model Manipulator draws air from the base interior and arm cover interior together.
A crack or other opening in the base unit can cause loss of negative air pressure in the outer part of the arm, which can cause increased dust emission.
Do not remove the maintenance cover on the front of the base.
Seal the exhaust port and the exhaust tube with vinyl tape so that the joint is airtight.
If the exhaust flow is not sufficient, dust particle emission may exceed the specified maximum level.
Cleanliness level : Class ISO 3 (ISO14644-1)
Exhaust System : Exhaust port diameter : Inner diameter: $\phi 12$ mm / Outer diameter: $\phi 16$ mm
Exhaust tube : Polyurethane tube
Outer diameter: $\phi 12$ mm (Inner diameter: $\phi 8$ mm) or
Inner diameter $\phi 16$ mm or larger
Recommended exhaust flow rate : approx. 1000 cm³/s (Normal)
ESD specification uses resin materials with antistatic treatment. This model controls adhesion of dust due to electrification.
- *4: Conditions of Manipulator during measurement as follows:
Operating conditions : Under rated load, 4-joints simultaneous motion, maximum speed, maximum acceleration/deceleration, and duty 50%.
Measurement point : Rear of the Manipulator, 1000 mm apart from the motion range, 50 mm above the base-installed surface.
- *5: For delivery up until January 2017, there are systems in combination of G series and RC620.
- *6: In general use, Accel setting 100 is the optimum setting that maintains the balance of acceleration and vibration when positioning. Although values larger than 100 can be set to Accel, it is recommended to minimize the use of large values to necessary motions since operating the manipulator continuously with the large Accel setting may shorten the product life remarkably.

2.5 How to Set the Model

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



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



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

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

The Manipulator model can be set from software.

Refer to the chapter *Robot Configuration* in the *EPSON RC+ User's Guide*.

3. Environments and Installation

3.1 Environmental Conditions

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

Item	Conditions
Ambient temperature *	5 to 40°C (with minimum temperature variation)
Ambient relative humidity	10 to 80% (no condensation)
First transient burst noise	1 kV or less (Signal wire)
Electrostatic noise	4 kV or less
Environment	<ul style="list-style-type: none"> - Install indoors. - Keep away from direct sunlight. - Keep away from dust, oily smoke, salinity, metal powder or other contaminants. - Keep away from flammable or corrosive solvents and gases. - Keep away from water. - Keep away from shocks or vibrations. - Keep away from sources of electric noise.



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

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

Special Environmental Conditions

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

Rapid change in temperature and humidity can cause condensation inside the Manipulator.

If your requirements specify that the Manipulator handles food, please contact the supplier of your region to check whether the Manipulator will damage the food or not.

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

 WARNING	<ul style="list-style-type: none"> ■ Use an earth leakage breaker on the AC power cable of the Controller to avoid electric shock and circuit breakdown caused by short circuit. Prepare the earth leakage breaker that pertains the Controller you are using. For details, refer to the Controller manual.
-------------	--

 CAUTION	<ul style="list-style-type: none"> ■ When cleaning the Manipulator, do not rub it strongly with alcohol or benzene. It may lose luster on the coated face.
-------------	---

3.2 Base Table

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

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

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

- Max. Reaction torque on the horizontal plate : 300 Nm
- Max. Horizontal reaction force : 2000 N
- Max. Vertical reaction force : 1000 N

The threaded holes required for mounting the Manipulator base are M8. Use mounting bolts with specifications conforming to ISO898-1 property class: 10.9 or 12.9. For dimensions, refer to *Setup & Operation: 3.3 Mounting Dimensions*.

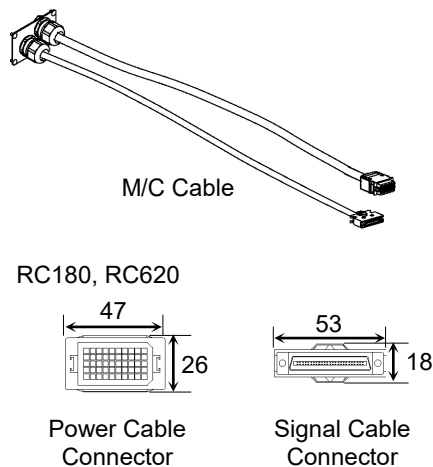
The plate for the Manipulator mounting face should be 20 mm thick or more and made of steel to reduce vibration. The surface roughness of the steel plate should be 25 μm or less.

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

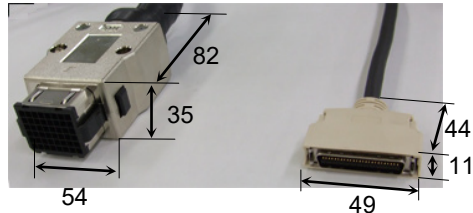
The Manipulator must be installed horizontally.

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

If you are passing cables through the holes on the base table, see the figures below.
[unit: mm]

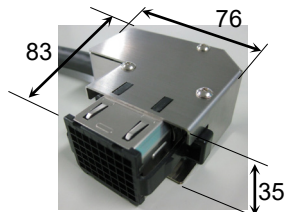


RC700-A



Power Cable Connector (Straight)

Signal Cable Connector



Power Cable Connector (L-shaped)

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



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



WARNING

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

3.3 Mounting Dimensions

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

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

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

Space for teaching

Space for maintenance and inspection

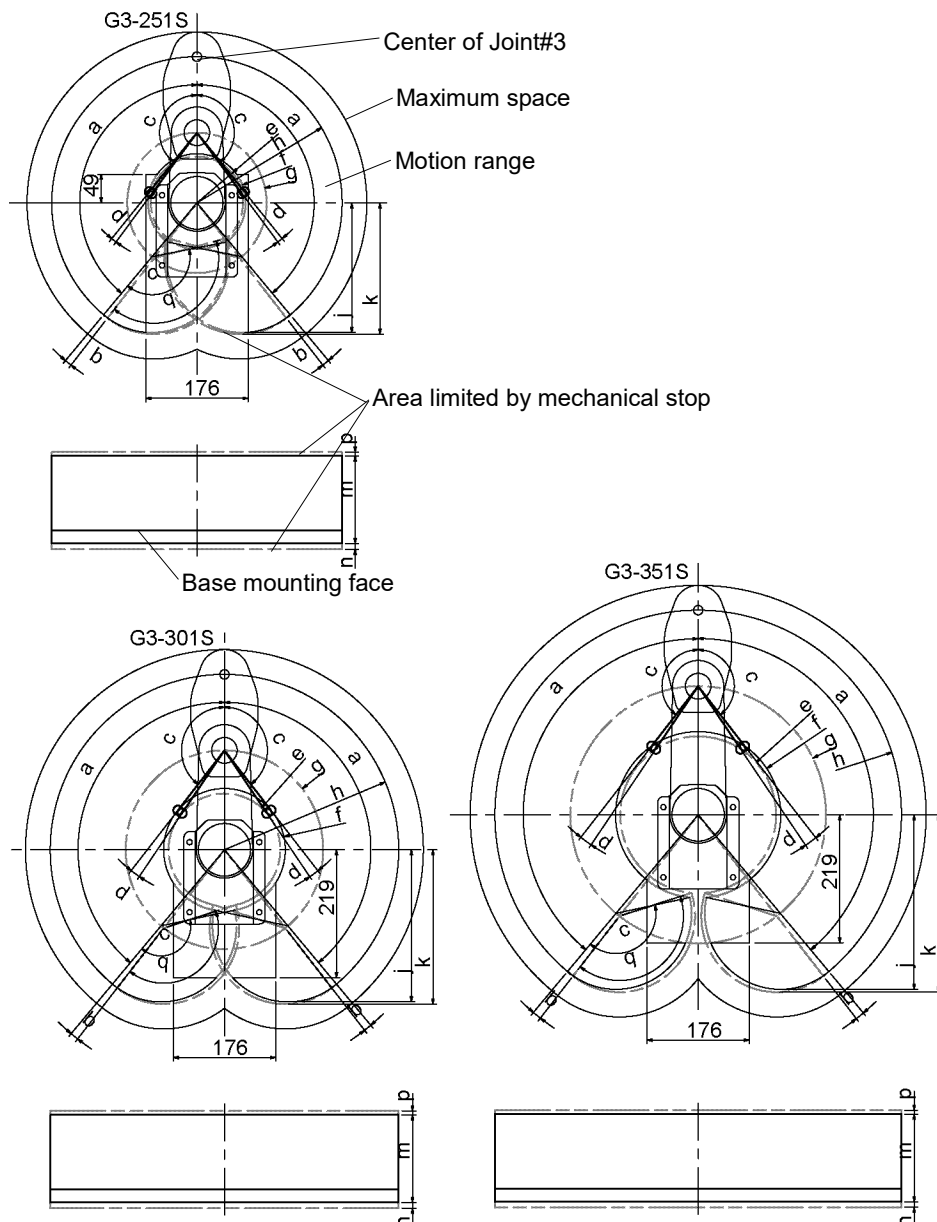
(Ensure a space to open the rear side cover and the maintenance cover for maintenance.)

Space for cables

The minimum bend radius of the power cable is 90 mm. When installing the cable, be sure to maintain sufficient distance from obstacles. In addition, leave enough space for other cables so that they are not bent forcibly.

Ensure distance to the safeguard from the maximum motion range is more than 100 mm.

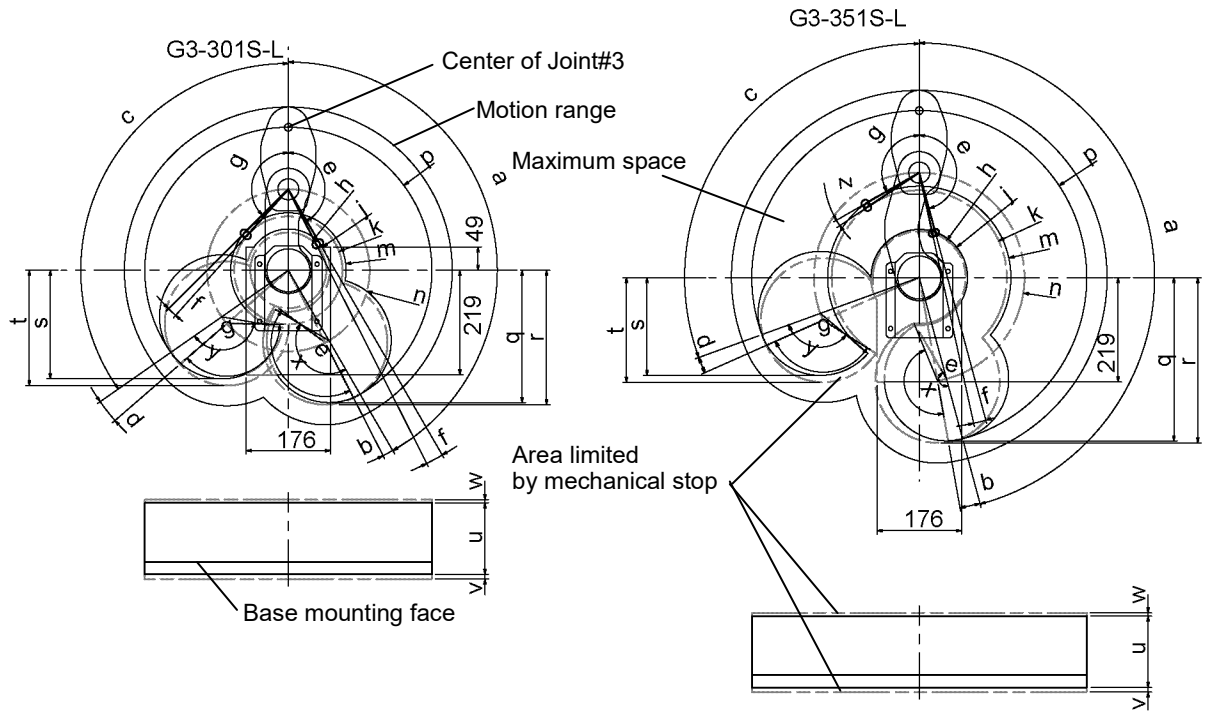
3.3.1 Table Top Mounting – Straight Arm



	a	b	c	d	e	f	g	h	j	k	q	m	n	p
G3-251S	140°	2°	141°	2.3°	79.3	84.0	120	250	221.9	224.5	143.3°	150	9.6	6.7
G3-251C			137°	6.3°		92.0						120	4.1	10.7
G3-301S			142°	3.8°	96.2	104.8	170	300	260.2	263.9	145.8°	150	9.6	6.7
G3-301C			141°	4.8°		107.1						120	4.1	10.7
G3-351S			142°	3.8°	134.2	142.3	220	350	298.5	303.3		150	9.6	6.7
G3-351C			142°	3.8°		146.6						120	4.1	10.7

g	Length of Arm #1 (mm)	b	Joint #1 angle to hit mechanical stop (degree)
h-g	Length of Arm #2 (mm)	d	Joint #2 angle to hit mechanical stop (degree)
m	Stroke of Joint #3 (mm)	n	Joint #3 range to hit lower mechanical stop (mm)
f	Motion range	p	Joint #3 range to hit upper mechanical stop (mm)
a	Motion range of Joint #1 (degree)	j	Range from center of axis to back end (mm)
c	Motion range of Joint #2 (degree)	k	Range from center of axis to back end after moved to mechanical stop (mm)
e	Mechanical stop area	q	Joint #2 motion range + angle to hit mechanical stop (degree)

3.3.2 Table Top Mounting – Left-Curved Arm

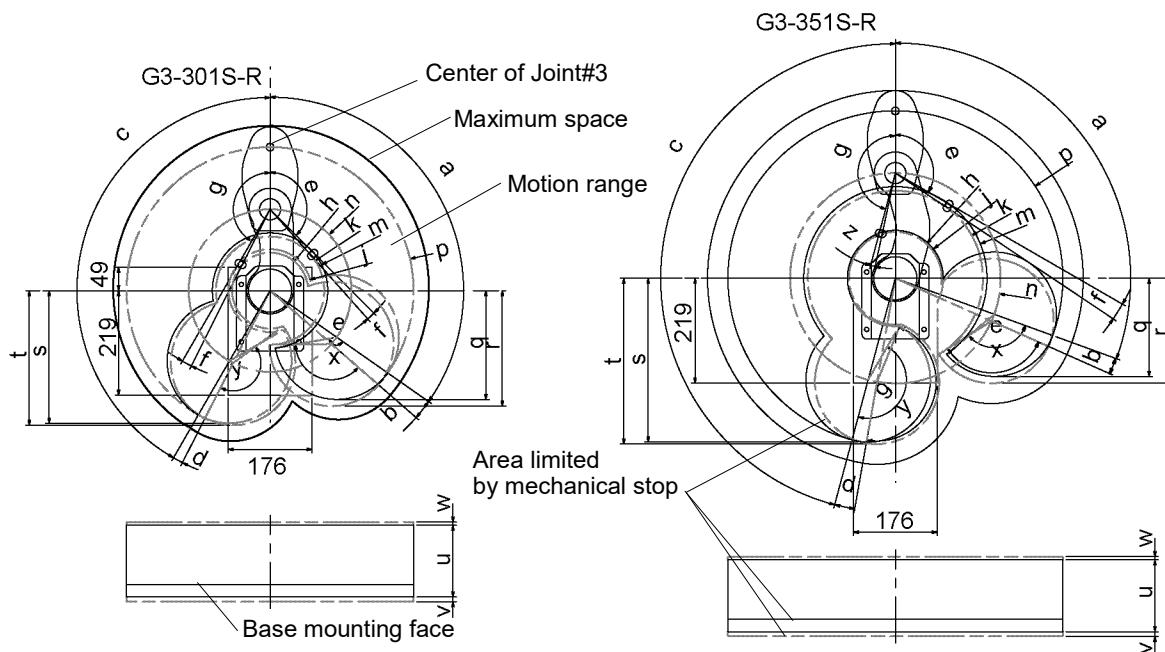


	a	b	c	d	e	f	g	h	j	k	m	n	p	q
G3-301S-L	150°	3°	125°	6°	150°	3.3°	135°	79.5	86.8	113.2	120.7	170	300	277.2
G3-301C-L					145°	8.3°								
G3-351S-L	165°	5°	110°	4°	165°	2.8°	120°	97.0	100.3	183.0	191.6	220	350	342.5
G3-351C-L					160°	7.8°			107.5	184.2				

	r	s	t	u	v	w	x	y	z
G3-301S-L	281.4	227.5	241.5	150	9.6	6.7	153.3°	138.3°	—
G3-301C-L	288.7	201.8	227.5	120	4.1	10.7			3.8°
G3-351S-L	346.6	205.2	219.4	150	9.6	6.7	167.8°	123.8°	3.8°
G3-351C-L			222.9	120	4.1	10.7			

n	Length of Arm #1 (mm)	b, d	Joint #1 angle to hit mechanical stop (degree)
p-n	Length of Arm #2 (mm)	f, z	Joint #2 angle to hit mechanical stop (degree)
u	Stroke of Joint #3 (mm)	v	Joint #3 range to hit lower mechanical stop (mm)
m, j	Motion range	w	Joint #3 range to hit upper mechanical stop (mm)
a, c	Motion range of Joint #1 (degree)	q, s	Range from center of axis to back end (mm)
e, g	Motion range of Joint #2 (degree)	r, t	Range from center of axis to back end after moved to mechanical stop (mm)
h, k	Mechanical stop area	x, y	Joint #2 motion range + angle to hit mechanical stop (degree)

3.3.3 Table Top Mounting – Right-Curved Arm

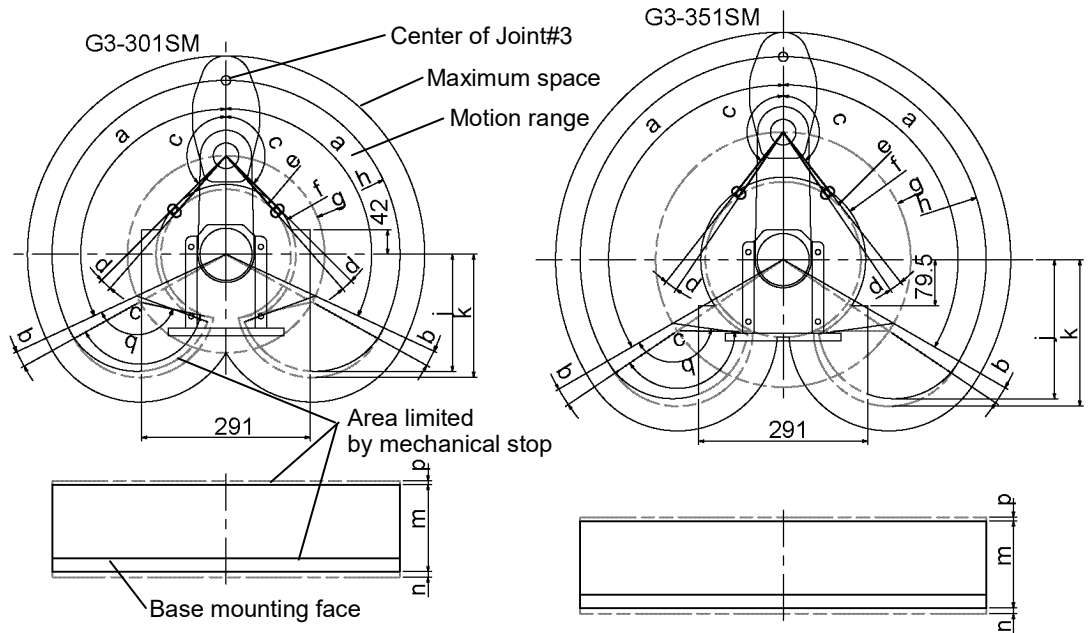


	a	b	c	d	e	f	g	h	j	k	m
G3-301S-R	125°	6°	150°	3°	135°	3.3°	150°	79.5	86.8	113.2	120.7
G3-301C-R							145°				
G3-351S-R	110°	4°	165°	5°	120°	3.8°	165°	97.0	100.3	183.0	191.6
G3-351C-R							160°				

	n	p	q	r	s	t	u	v	w	x	y	z
G3-301S-R	170	300	227.5	241.5	277.2	281.4	150	9.6	6.7	138.3°	153.3°	—
G3-301C-R			201.8	227.5		288.7	120	4.1	10.7			8.3°
G3-351S-R	220	350	205.2	219.4	342.5	346.6	150	9.6	6.7	123.8°	167.8°	2.8°
G3-351C-R			222.9	222.9		120	4.1	10.7	7.8°			

n	Length of Arm #1 (mm)	b, d	Joint #1 angle to hit mechanical stop (degree)
p-n	Length of Arm #2 (mm)	f, z	Joint #2 angle to hit mechanical stop (degree)
u	Stroke of Joint #3 (mm)	v	Joint #3 range to hit lower mechanical stop (mm)
m, j	Motion range	w	Joint #3 range to hit upper mechanical stop (mm)
a, c	Motion range of Joint #1 (degree)	q, s	Range from center of axis to back end (mm)
e, g	Motion range of Joint #2 (degree)	r, t	Range from center of axis to back end after moved to mechanical stop (mm)
h, k	Mechanical stop area	x, y	Joint #2 motion range + angle to hit mechanical stop (degree)

3.3.4 Multiple Mounting – Straight Arm

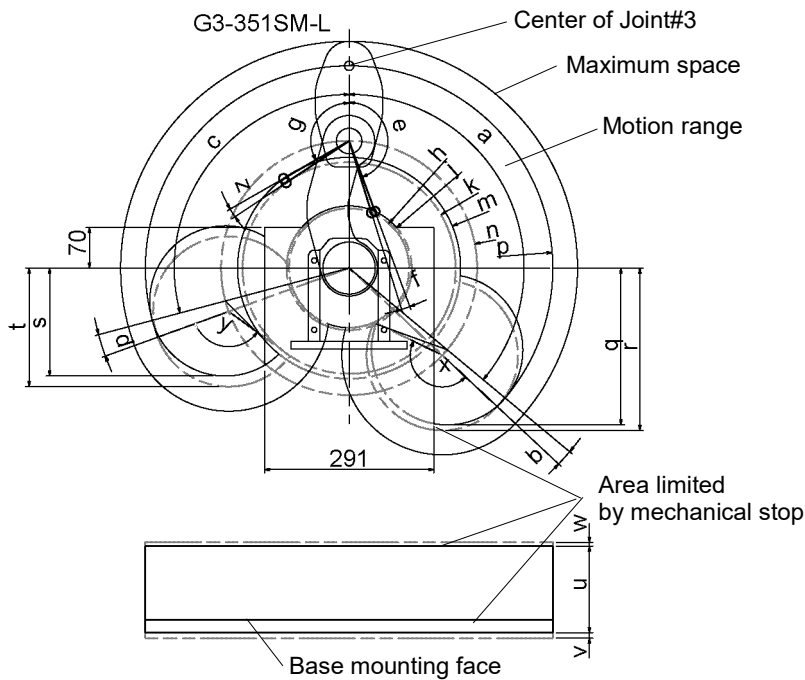


	a	b	c	d	e	f	g	h	j	k	q
G3-301SM/CM	115°	4°	135°	3.8°	112.0	120.7	170	300	201.8	212.4	138.8°
G3-351SM/CM	120°		142°		134.2	142.3	220	350	240.0	253.0	145.8°

	m	n	p
G3-301SM	150	9.6	6.7
G3-301CM	120	4.1	10.7
G3-351SM	150	9.6	6.7
G3-351CM	120	4.1	10.7

g	Length of Arm #1 (mm)	b	Joint #1 angle to hit mechanical stop (degree)
h-g	Length of Arm #2 (mm)	d	Joint #2 angle to hit mechanical stop (degree)
m	Stroke of Joint #3 (mm)	n	Joint #3 range to hit lower mechanical stop (mm)
f	Motion range	p	Joint #3 range to hit upper mechanical stop (mm)
a	Motion range of Joint #1 (degree)	j	Range from center of axis to back end (mm)
c	Motion range of Joint #2 (degree)	k	Range from center of axis to back end after moved to mechanical stop (mm)
e	Mechanical stop area	q	Joint #2 motion range + angle to hit mechanical stop (degree)

3.3.5 Multiple Mounting – Left-Curved Arm



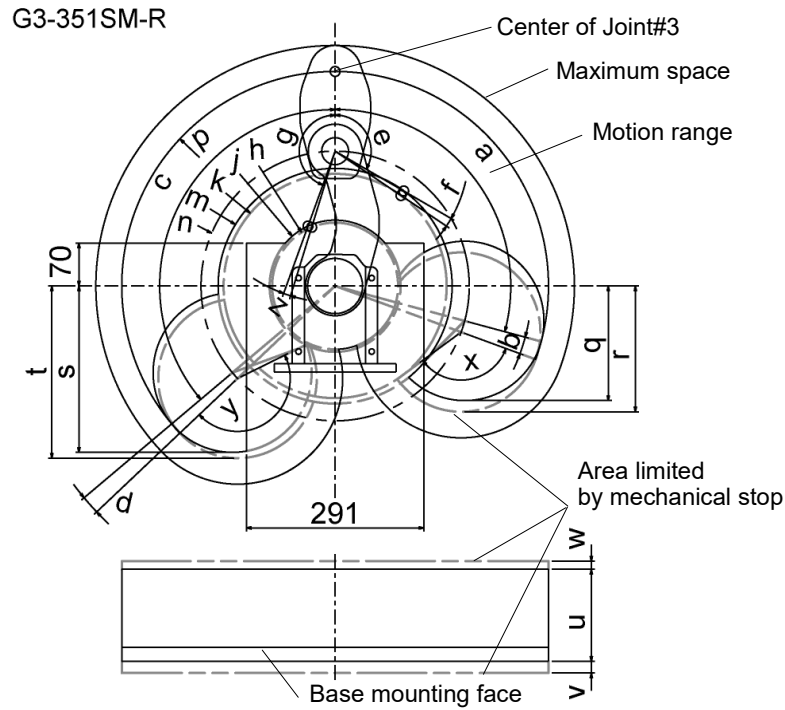
	a	b	c	d	e	f	g	h	j	k	m
G3-351SM-L	130°	3.3°	105°	5°	160°	2.8°	120°	103.3	107.5	183.0	191.9
G3-351CM-L		2°			150°	12.8°			125.6		

	n	p	q	r	s	t	x	y	z
G3-351SM-L	220	350	271.4	280.8	186.9	205.2	162.8°	123.8°	3.8°
G3-351CM-L				277.2					

	u	v	w
G3-351SM-L	150	9.6	6.7
G3-351CM-L	120	4.1	10.7

n	Length of Arm #1 (mm)	b, d	Joint #1 angle to hit mechanical stop (degree)
p-n	Length of Arm #2 (mm)	f, z	Joint #2 angle to hit mechanical stop (degree)
u	Stroke of Joint #3 (mm)	v	Joint #3 range to hit lower mechanical stop (mm)
m, j	Motion range	w	Joint #3 range to hit upper mechanical stop (mm)
a, c	Motion range of Joint #1 (degree)	q, s	Range from center of axis to back end (mm)
e, g	Motion range of Joint #2 (degree)	r, t	Range from center of axis to back end after moved to mechanical stop (mm)
h, k	Mechanical stop area	x, y	Joint #2 motion range + angle to hit mechanical stop (degree)

3.3.6 Multiple Mounting – Right-Curved Arm



	a	b	c	d	e	f	g	h	j	k	m
G3-351SM-R	105°	5°	130°	3.3°	120°	3.8°	160°	103.3	107.5	183.0	191.9
G3-351CM-R				2°			150°		125.6		

	n	p	q	r	s	t	x	y	z
G3-351SM-R	220	350	186.9	205.2	271.4	280.8	123.8°	162.8°	2.8°
G3-351CM-R						277.2			12.8°

	u	v	w
G3-351SM-R	150	9.6	6.7
G3-351CM-R	120	4.1	10.7

n	Length of Arm #1 (mm)	b, d	Joint #1 angle to hit mechanical stop (degree)
p-n	Length of Arm #2 (mm)	f, z	Joint #2 angle to hit mechanical stop (degree)
u	Stroke of Joint #3 (mm)	v	Joint #3 range to hit lower mechanical stop (mm)
m, j	Motion range	w	Joint #3 range to hit upper mechanical stop (mm)
a, c	Motion range of Joint #1 (degree)	q, s	Range from center of axis to back end (mm)
e, g	Motion range of Joint #2 (degree)	r, t	Range from center of axis to back end after moved to mechanical stop (mm)
h, k	Mechanical stop area	x, y	Joint #2 motion range + angle to hit mechanical stop (degree)

3.4 Unpacking and Transportation

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



WARNING

- Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.



CAUTION

- Using a cart or similar equipment, transport the Manipulator in the same manner as it was delivered.
- After removing the bolts securing the Manipulator to the delivery equipment, the Manipulator can fall. Be careful not to get hands or fingers caught.
- The arm is secured with a wire tie. Leave the wire tie secured until you finish the installation so as not to get hands or fingers caught.
- To carry the Manipulator, have two or more people to work on it and secure the Manipulator to the delivery equipment or hold the areas indicated in gray in the figure (bottom of Arm #1 and bottom of the base) by hand. When holding the bottom of the base by hand, be very careful not to get your hands or fingers caught.

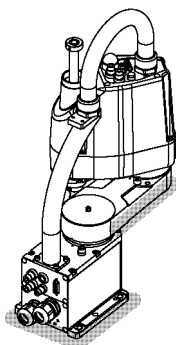
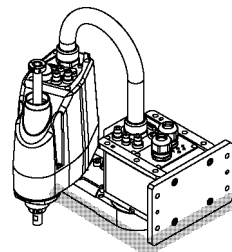


Table Top Mounting

- G3-251* : approx. 14 kg: 31 lb.
- G3-301* : approx. 14 kg: 31 lb.
- G3-351* : approx. 14 kg: 31 lb.




Multiple Mounting

- G3-301*M : approx. 14 kg: 31 lb.
- G3-351*M : approx. 14 kg: 31 lb.

- Stabilize the Manipulator with your hands when hoisting it.
- When transporting the Manipulator for a long distance, secure it to the delivery equipment directly so that the Manipulator never falls. If necessary, pack the Manipulator in the same style as it was delivered.

3.5 Installation Procedure

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

The following sections describe the installation of the Standard Manipulator.


3.5.1 Table Top Mounting

3.5.2 Multiple Mounting

For Cleanroom-model manipulator, refer to this section;

3.5.3 Cleanroom-model

3.5.1 Table Top Mounting

 CAUTION	<ul style="list-style-type: none"> ■ Install the Table Top Mounting Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. G3-251* : approx. 14 kg: 31 lb. G3-301* : approx. 14 kg: 31 lb. G3-351* : approx. 14 kg: 31 lb.
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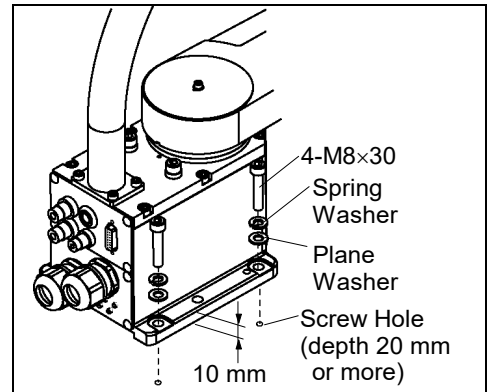
Standard-model

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

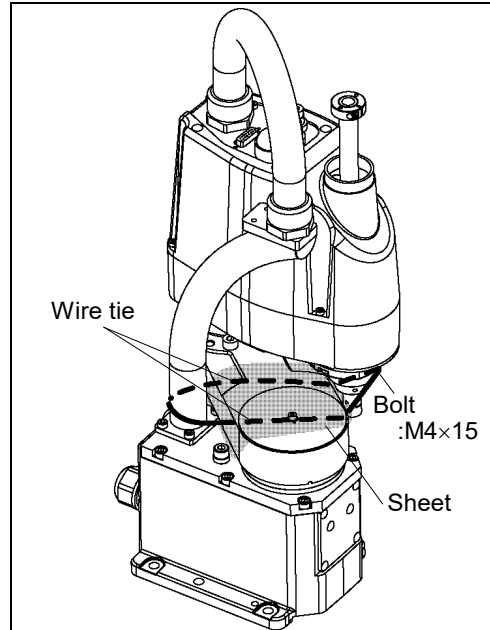


Use bolts with specifications conforming to ISO898-1 Property Class: 10.9 or 12.9.


Tightening torque:
32.0 N·m (326 kgf·cm)




- (2) Using nippers, cut off the wire tie binding the shaft and arm retaining bracket on the base.
- (3) Remove the bolts securing the wire ties removed in step (2).
- (4) Remove the fixing jig for transport.

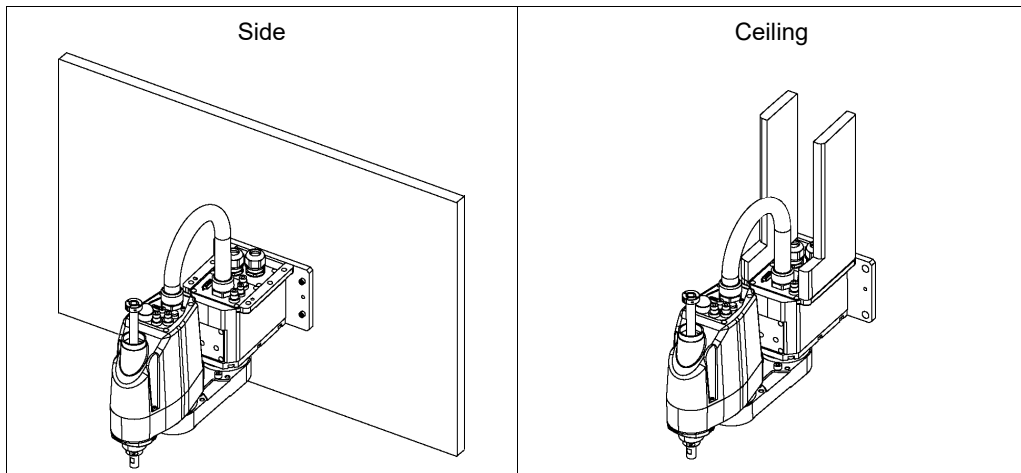


3.5.2 Multiple Mounting

 WARNING	<ul style="list-style-type: none"> ■ Install the Multiple Mounting Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. G3-301*M : approx. 14 kg: 31 lb. G3-351*M : approx. 14 kg: 31 lb. ■ When installing the Manipulator to the wall, support the Manipulator, and then secure the anchor bolts. Removing the support without securing the anchor bolts properly is extremely hazardous and may result in fall of the Manipulator.
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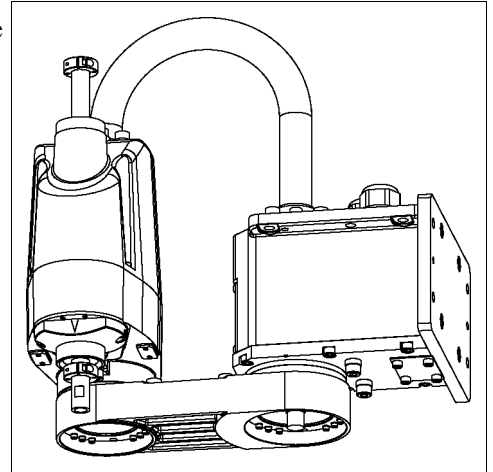
NOTE  Design and make the base table for anchoring the Multiple Mounting Manipulators so that it does not touch any cable connected to the base connector plate and duct.

The recommended installation patterns are as follows:



Standard-model

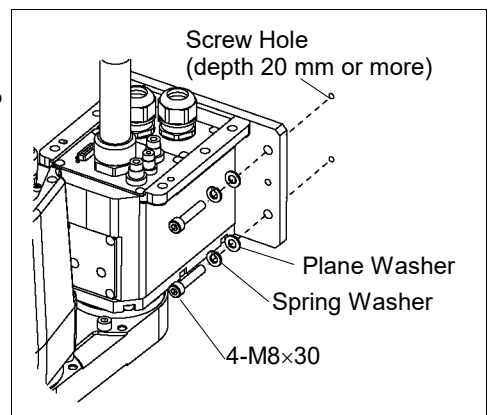
- (1) Unpack the manipulator with retaining the arm posture.



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

Tightening torque:
32.0 N·m (326 kgf·cm)

- (3) Remove the fixing jig for transport.




3.5.3 Cleanroom-model


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




■ When operating the Manipulator under special environmental conditions (adverse conditions with dust and oily smoke), do not place the controller in the same condition since the controller does not comply with IP54 / IP65. Doing so may cause equipment damage to and/or malfunction of the controller.

3.6 Connecting the Cables

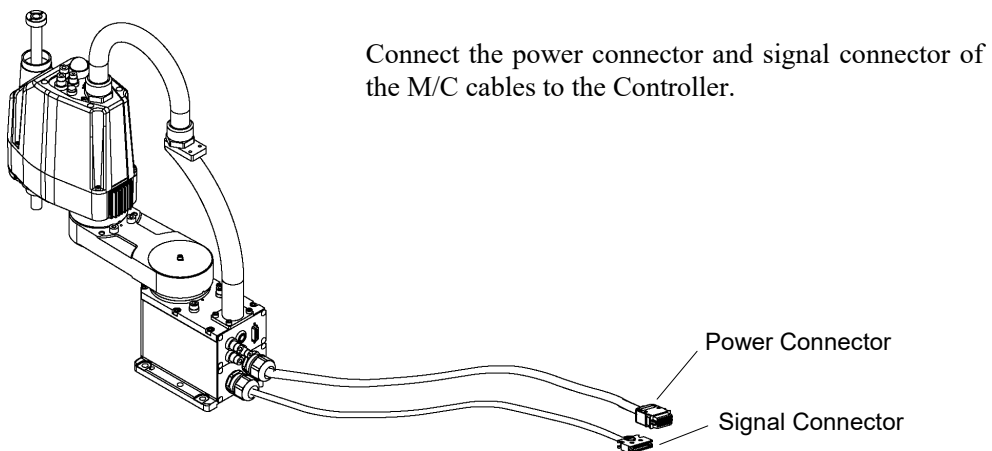
 WARNING	<ul style="list-style-type: none"> ■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. ■ Grounding the manipulator is done by connecting with the controller. Ensure that the controller is grounded and the cables are correctly connected. If the ground wire is improperly connected to ground, it may result in the fire or electric shock.
--	---

 CAUTION	<ul style="list-style-type: none"> ■ When connecting the Manipulator to the Controller, make sure that the serial numbers on each equipment match. Improper connection between the Manipulator and Controller may not only cause improper function of the robot system but also serious safety problems. The connection method varies with the Controller used. For details on the connection, refer to the <i>Controller manual</i>. If the G series Manipulator is connected to the Controller for the 6-axis robot, it may result in malfunction of the Manipulator.
--	--


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

 CAUTION	<ul style="list-style-type: none"> ■ When operating the Manipulator under special environmental conditions (adverse conditions with dust and oily smoke), do not place the controller in the same condition since the controller does not comply with IP54 / IP65. Doing so may cause equipment damage to and/or malfunction of the controller.
--	--

Cable Connections



3.7 User Wires and Pneumatic Tubes

 CAUTION	<p>■ Only authorized or certified personnel should be allowed to perform wiring. Wiring by unauthorized or uncertified personnel may result in bodily injury and/or malfunction of the robot system.</p>
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User electrical wires and pneumatic tubes are contained in the cable unit.

Electrical Wires

Rated Voltage	Allowable Current	Wires	Nominal Sectional Area	Note
AC/DC30 V	1 A	15	0.211 mm ²	Twist pair

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

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

Pneumatic Tubes

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

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

* Color differs depending on the shipment time

Common Parts

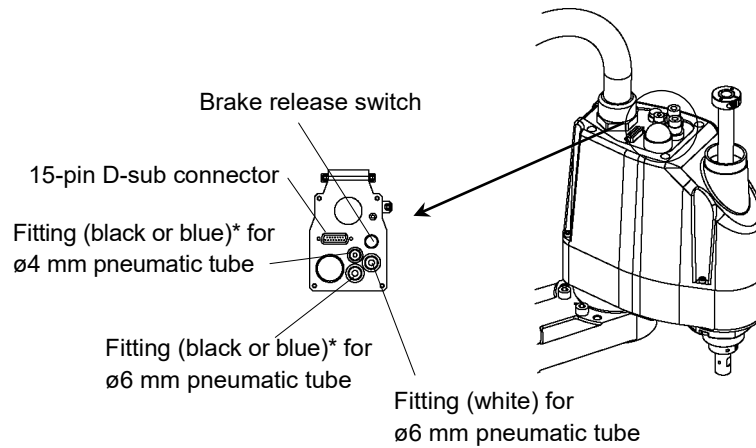
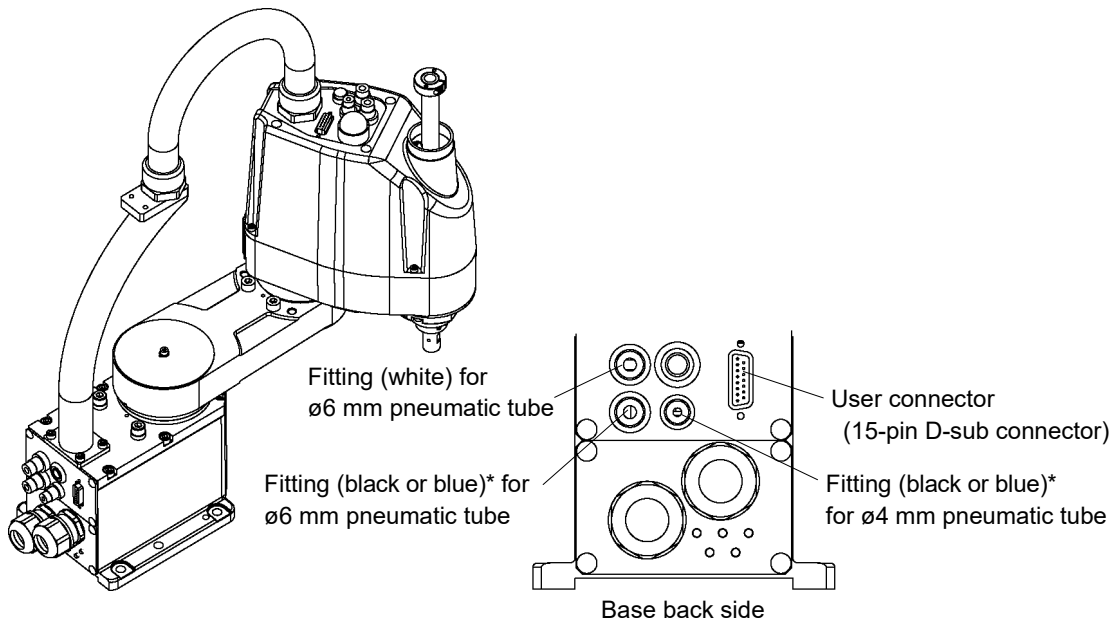
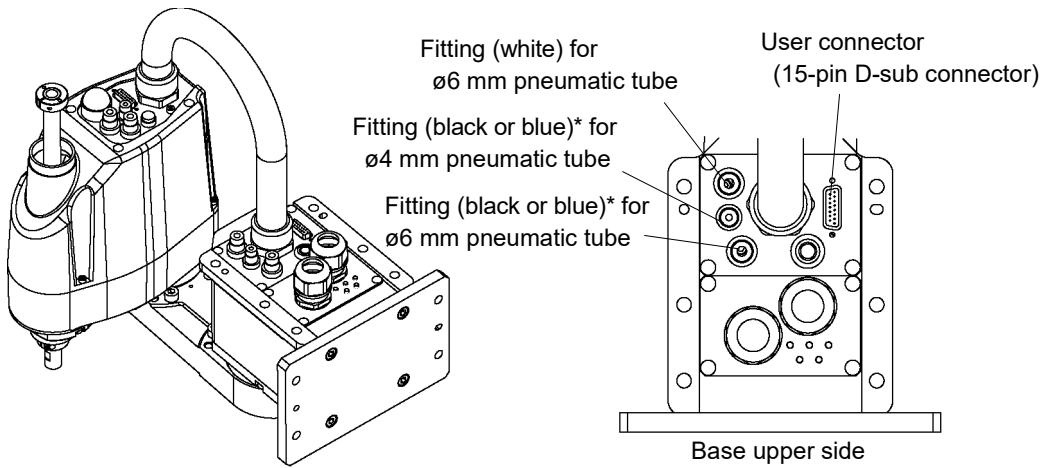


Table Top Mounting



Multiple Mounting





3.8 Relocation and Storage

3.8.1 Precautions for Relocation and Storage

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

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

 WARNING	<ul style="list-style-type: none"> ■ Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.
---	--

 CAUTION	<ul style="list-style-type: none"> ■ Before relocating the Manipulator, fold the arm and secure it tightly with a wire tie to prevent hands or fingers from being caught in the Manipulator. ■ When removing the anchor bolts, support the Manipulator to prevent falling. Removing the anchor bolts without support may result in a fall of the Manipulator, and then get hands, fingers, or feet caught. ■ To carry the Manipulator, have two or more people to work on it and secure the Manipulator to the delivery equipment or hold the bottom of Arm #1, the bottom of the main cable fitting, and the bottom of the base by hand. When holding the bottom of the base by hand, be very careful not to get hands or fingers caught. ■ Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in fall of the Manipulator.
---	--

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

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

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


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

Humidity within 10% to 90% is recommended.


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

Do not shock or shake the Manipulator during transport.

3.8.2 Table Top Mounting

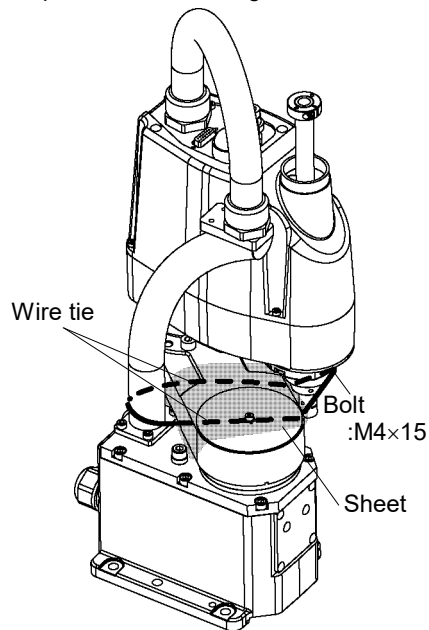
 CAUTION	<p>■ Install or relocate the Table Top Mounting Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator.</p> <p>G3-251* : approx. 14 kg: 31 lb. G3-301* : approx. 14 kg: 31 lb. G3-351* : approx. 14 kg: 31 lb.</p>
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- (1) Turn OFF the power on all devices and unplug the cables.

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


- (2) Cover the arm with a sheet so that the arm will not be damaged.
 Tie the lower end of the shaft and arm, and the base and arm together with the wire tie.
 Be careful not to tie them too tight. Otherwise, the shaft may bend.

Example of Arm Retaining Posture



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

3.8.3 Multiple Mounting

 WARNING	<ul style="list-style-type: none"> ■ Install or relocate the Multiple Mounting Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. G3-301*M : approx. 14 kg: 31 lb. G3-351*M : approx. 14 kg: 31 lb. ■ When removing the Manipulator from the wall, support the Manipulator, and then remove the anchor bolts. Removing the anchor bolts without supporting is extremely hazardous and may result in fall of the Manipulator.
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- (1) Turn OFF the power on all devices and unplug the cables.

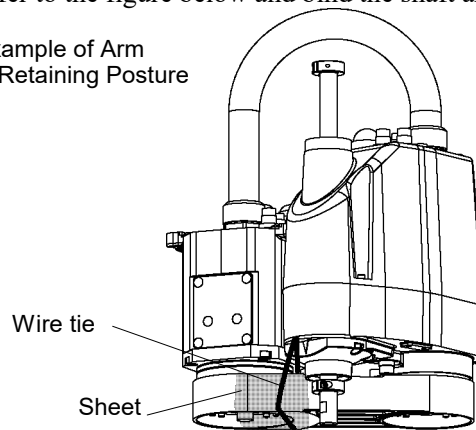
NOTE



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

- (2) Cover the arm with a sheet so that the arm will not be damaged. Refer to the figure below and bind the shaft and arm retaining bracket on the base.

Example of Arm Retaining Posture




- (3) Hold the bottom of Arm #1 by hand to unscrew the anchor bolts. Then, remove the Manipulator from the wall.

4. Setting of End Effectors

4.1 Attaching an End Effector

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

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

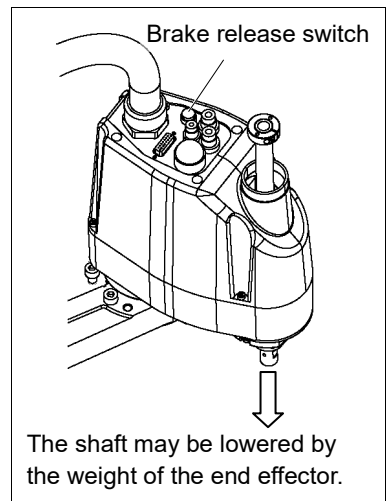
- Attach an end effector to the lower end of the shaft.
For the shaft dimensions, and the overall dimensions of the Manipulator, refer to *Setup & Operation: 2. Specifications*.
- Do not move the upper limit mechanical stop on the lower side of the shaft. Otherwise, when “Jump motion” is performed, the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

Brake release switch

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

This prevents the shaft from hitting peripheral equipment in the case that the shaft is lowered by the weight of the end effector when the power is disconnected during operation, or when the motor is turned OFF even though the power is turned ON.

To move Joint #3 up/down while attaching an end effector, turn ON the Controller and press the brake release switch.



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

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

Layouts

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

4.2 Attaching Cameras and Valves

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

Common Dimensions

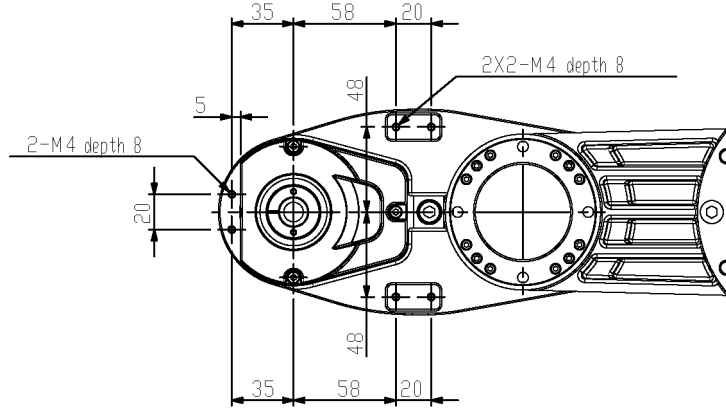
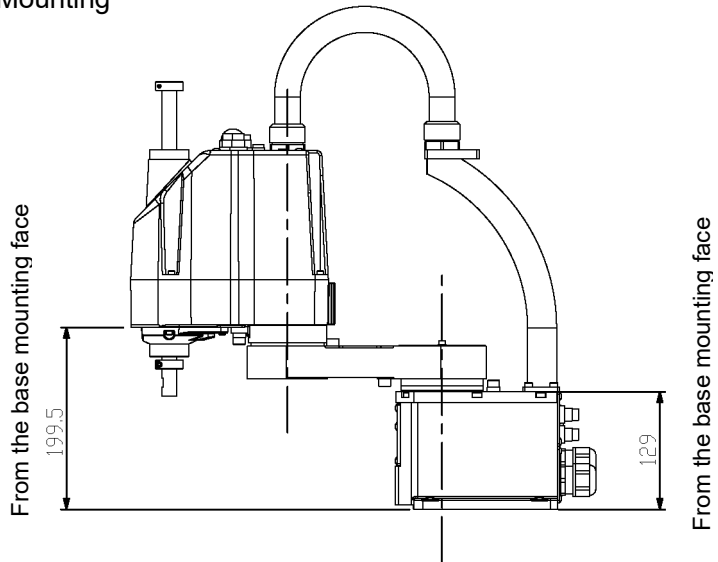
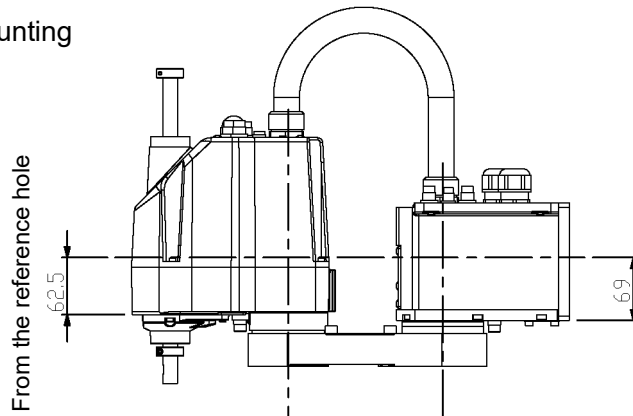


Table Top Mounting



Multiple Mounting




4.3 Weight and Inertia Settings

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

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

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

4.3.1 Weight Setting

 CAUTION	<ul style="list-style-type: none"> The total weight of the end effector and the work piece must not exceed 3 kg. The G3 series Manipulators are not designed to work with loads exceeding 3 kg. Always set the Weight parameters according to the load. Setting a value that is smaller than the actual load may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.
--	---

The acceptable weight capacity (end effector and work piece) in G3 series is 1 kg at the default rating and 3 kg at the maximum. When the load (weight of the end effector and work piece) exceeds the rating, change the setting of Weight parameter.

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

Load on the Shaft

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



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

Load on the Arm

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

Equivalent Weight Formula

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

<Example> A “1 kg” camera is attached to the end of the G3 series arm (180 mm away from the rotation center of Joint #2) with a load weight of “1 kg”.

$$M=1$$

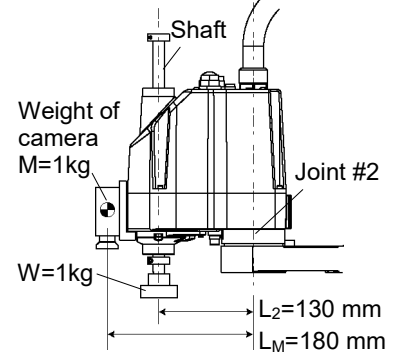
$$L_2=130$$

$$L_M=180$$

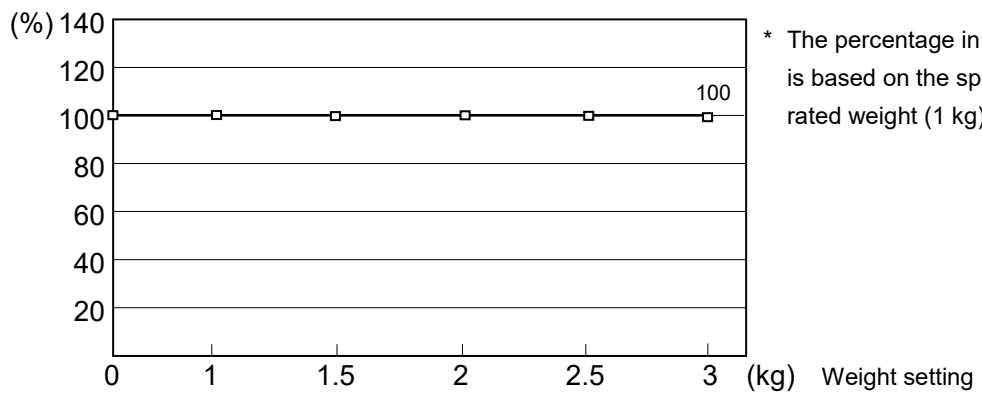
$$W_M=1 \times 180^2 / 130^2 = 1.917 \Rightarrow 2 \text{ (round up)}$$

$$W+W_M=1+2=3$$

Enter “3” for the Weight Parameter.

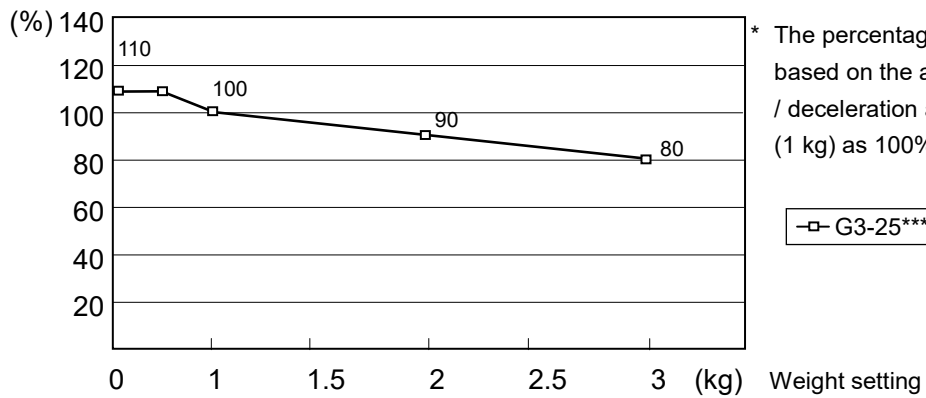


Automatic speed setting by Weight



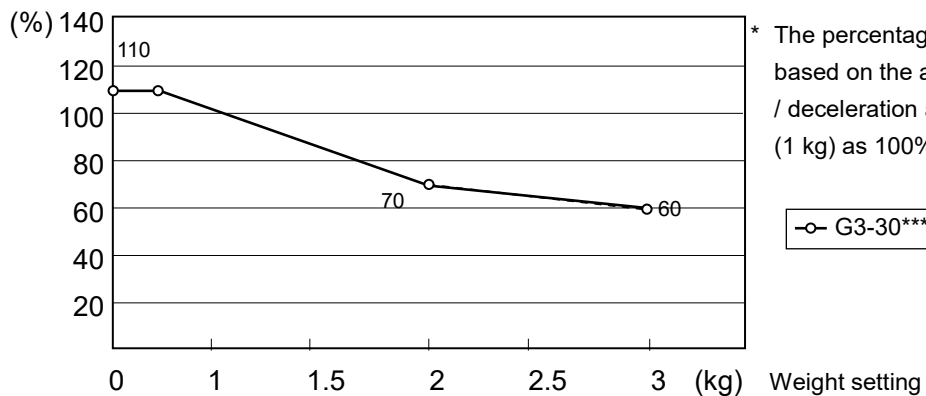
* The percentage in the graph is based on the speed at rated weight (1 kg) as 100%.

Automatic acceleration/deceleration setting by Weight



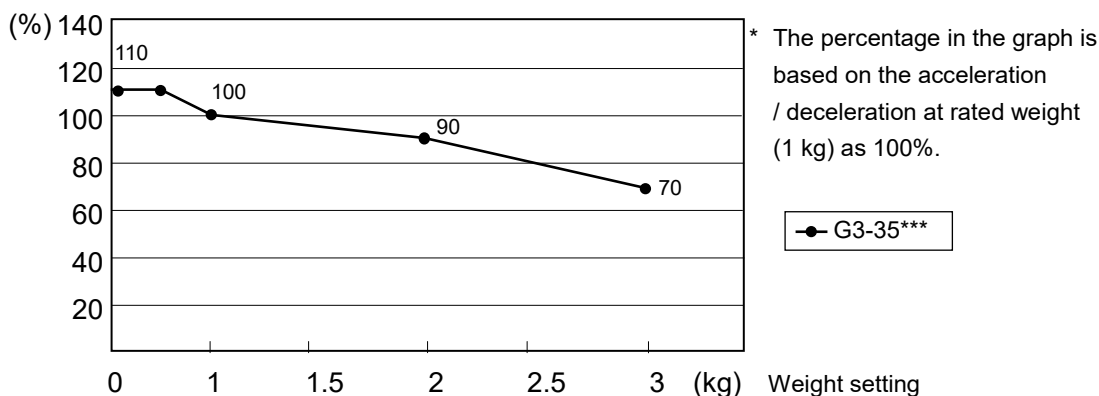
* The percentage in the graph is based on the acceleration / deceleration at rated weight (1 kg) as 100%.

—□— G3-25***



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


—○— G3-30***



4.3.2 Inertia Setting

Moment of Inertia and the Inertia Setting

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



CAUTION

- The moment of inertia of the load (weight of the end effector and work piece) must be 0.05 kg·m² or less. The G3 series Manipulators are not designed to work with a moment of inertia exceeding 0.05 kg·m². Always set the moment of inertia parameter to the correct moment of inertia. Setting a value that is smaller than the actual moment of inertia may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.

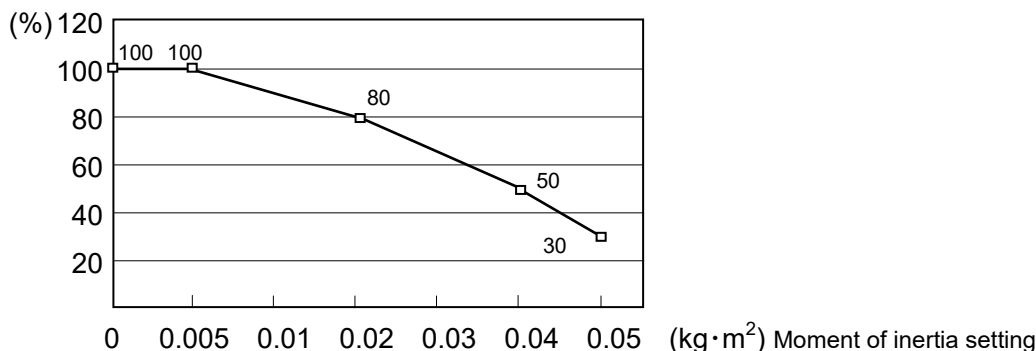
The acceptable moment of inertia of load for a G3 series Manipulator is 0.005 kg·m² at the default rating and 0.05 kg·m² at the maximum. When the moment of inertia of the load exceeds the rating, change the setting of the moment of inertia parameter of the Inertia command. After the setting is changed, the maximum acceleration/deceleration speed of Joint #4 at PTP motion corresponding to the “moment of inertia” value is set automatically.

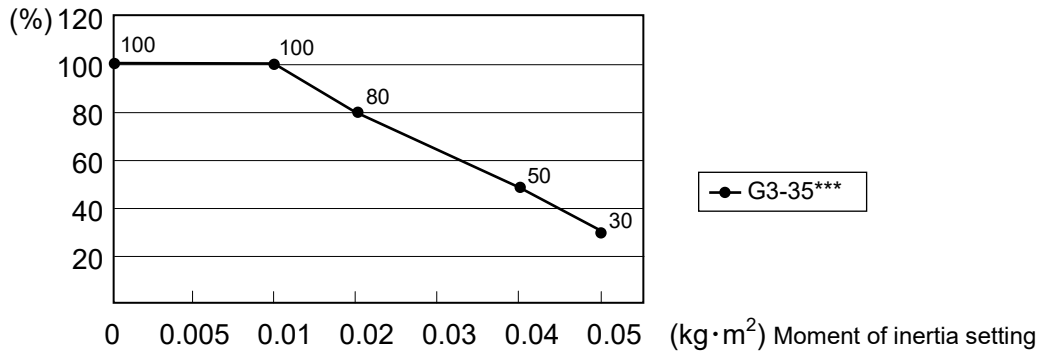
Moment of inertia of load on the shaft

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


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

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

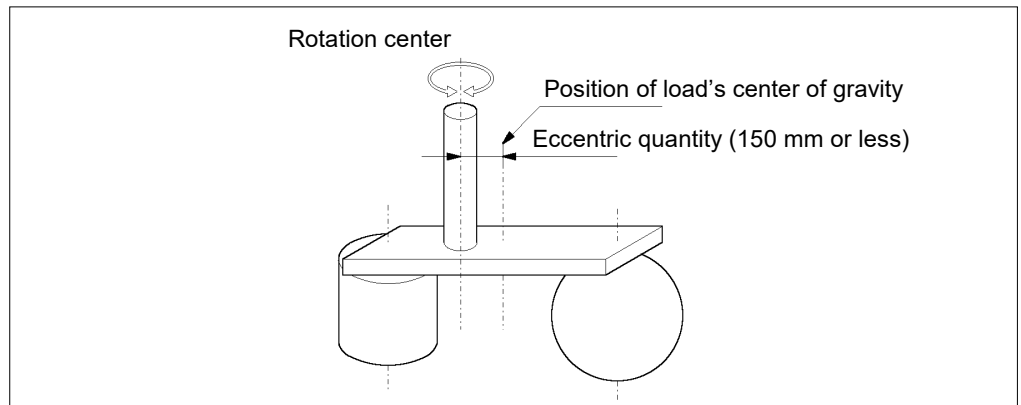




Eccentric Quantity and the Inertia Setting

 CAUTION	<ul style="list-style-type: none"> The eccentric quantity of load (weight of the end effector and work piece) must be 150 mm or less. The G3 series Manipulators are not designed to work with eccentric quantity exceeding 150 mm. Always set the eccentric quantity parameter according to the eccentric quantity. Setting a value that is smaller than the actual eccentric quantity may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.
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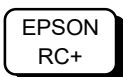
The acceptable eccentric quantity of load in G3 series is 0 mm at the default rating and 150 mm at the maximum. When the eccentric quantity of load exceeds the rating, change the setting of eccentric quantity parameter of Inertia command. After the setting is changed, the maximum acceleration/deceleration speed of the Manipulator at PTP motion corresponding to the “eccentric quantity” is set automatically.



Eccentric Quantity

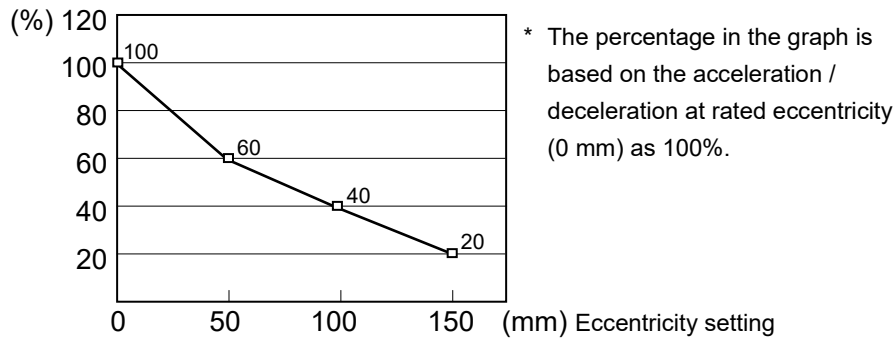
Eccentric quantity of load on the shaft

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



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

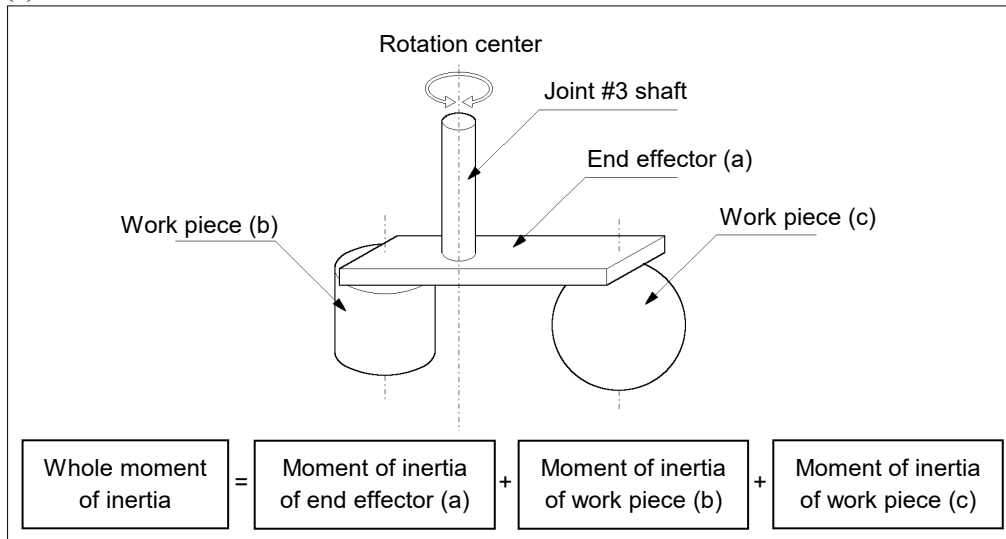
Automatic acceleration/deceleration setting by Inertia (eccentric quantity)



Calculating the Moment of Inertia

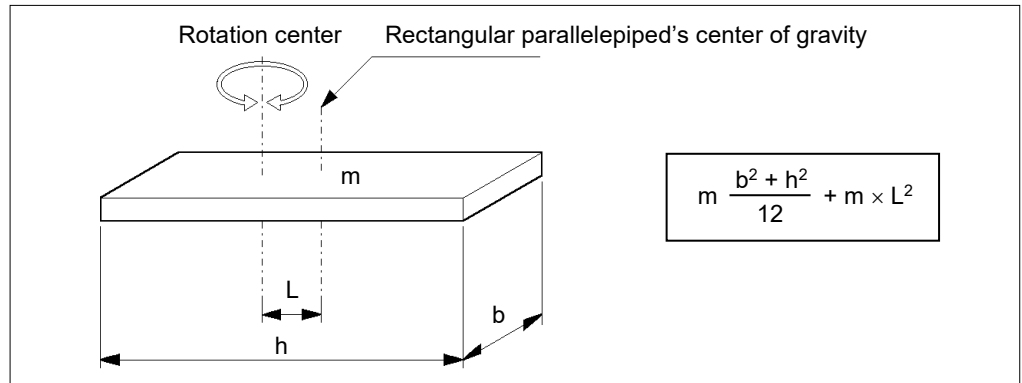
Refer to the following examples of formulas to calculate the moment of inertia of load (end effector with work piece).

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

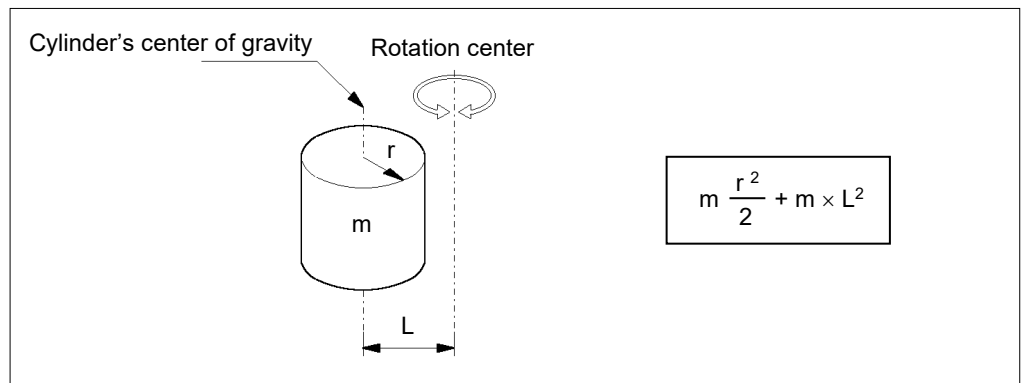


The methods for calculating the moment of inertia for (a), (b), and (c) are shown below. Calculate the total moment of inertia using the basic formulas.

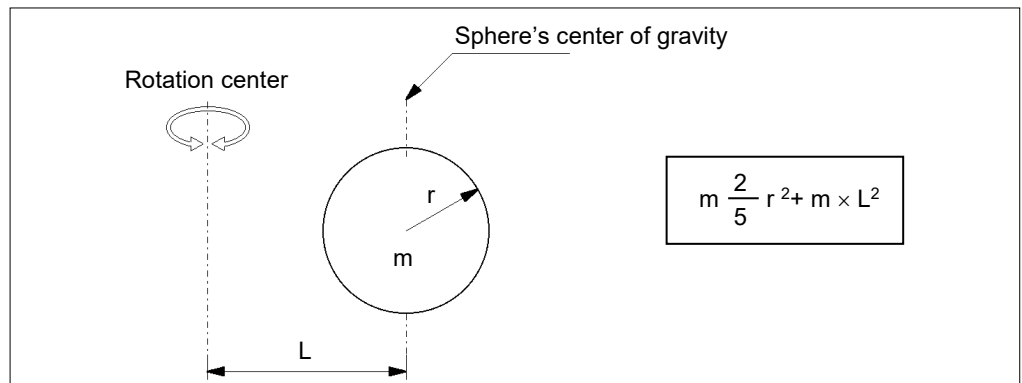
(a) Moment of inertia of a rectangular parallelepiped



(b) Moment of inertia of a cylinder



(c) Moment of inertia of a sphere



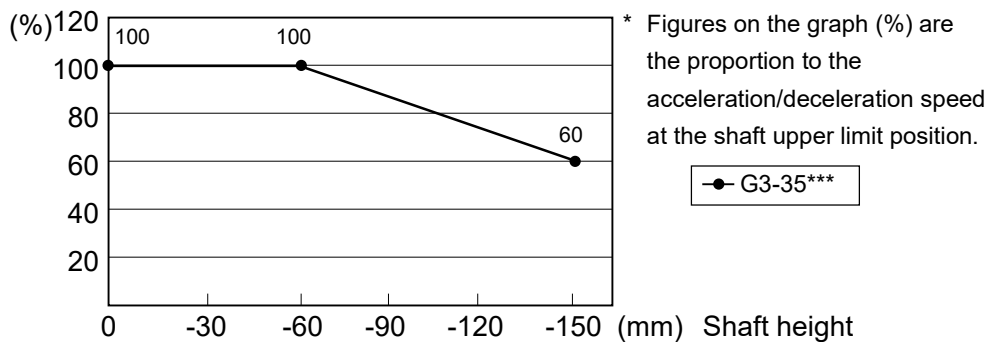
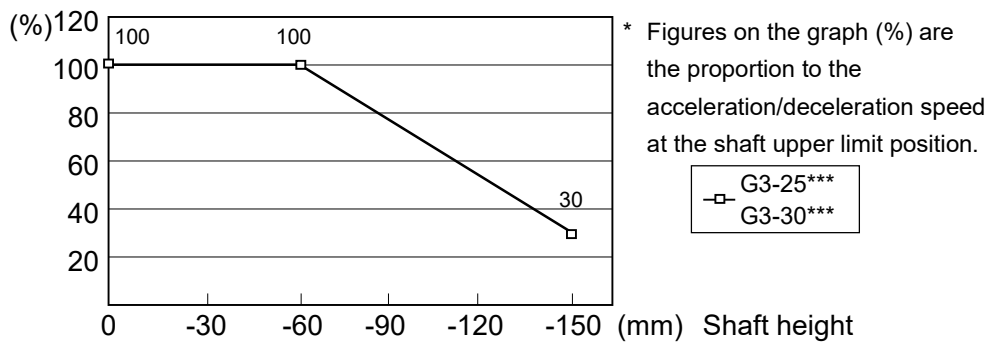
4.4 Precautions for Auto Acceleration/Deceleration of Joint #3

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

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

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

Automatic acceleration/deceleration vs. Joint #3 position



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

5. Motion Range

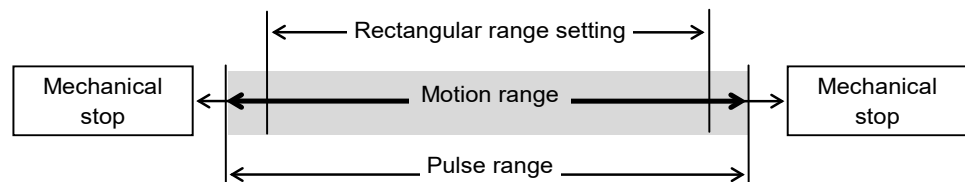


- When setting up the motion range for safety, both the pulse range and mechanical stops must always be set at the same time.

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

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

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



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

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

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

For the maximum pulse range, refer to the following sections.

The pulse range must be set inside of the mechanical stop range.

5.1.1 Max. Pulse Range of Joint #1

5.1.2 Max. Pulse Range of Joint #2

5.1.3 Max. Pulse Range of Joint #3

5.1.4 Max. Pulse Range of Joint #4.



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



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

5.1.1 Max. Pulse Range of Joint #1

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

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

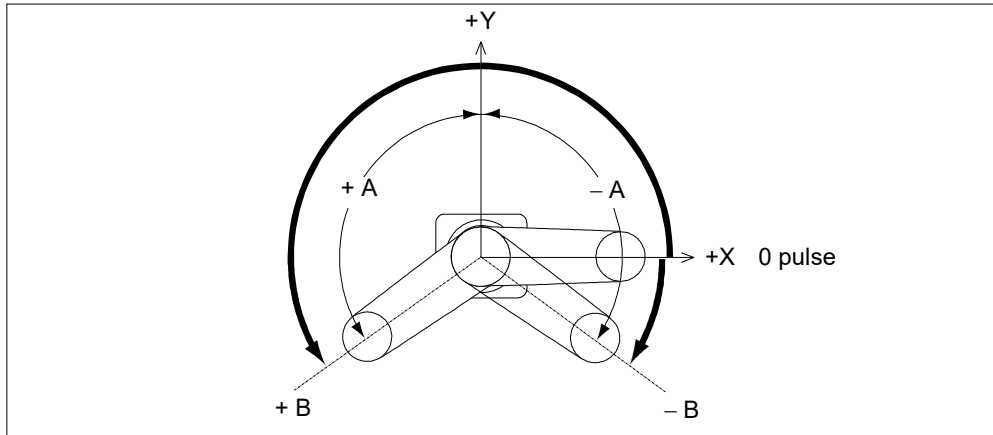


Table Top Mounting

	Arm	Standard	-R	-L
A Max. Motion Range (deg)	25	±140	-	-
	30		-125 to 150	-150 to 125
	35		-110 to 165	-165 to 110
B Max. Pulse Range (pulse)	25	-1456356 to 6699236	-	-
	30		-1019449 to 6990507	-1747627 to 6262329
	35		-582542 to 7427413	-2184533 ~ 5825422

Multiple Mounting

	Arm	Standard	-R	-L
A Max. Motion Range (deg)	30	±115	-	-
	35	±120	-105 to 130	-130 to 105
B Max. Pulse Range (pulse)	30	-728178 to 5971058	-	-
	35	-873813 to 6116693	-436907 to 6407965	-1165085 to 5679787

5.1.2 Max. Pulse Range of Joint #2

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

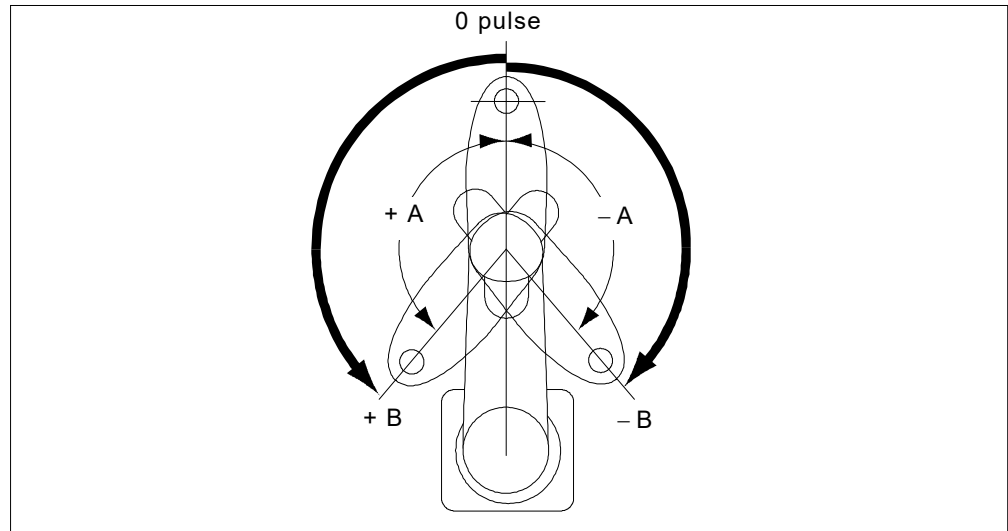


Table Top Mounting (S: Standard-model, C: Cleanroom-model)

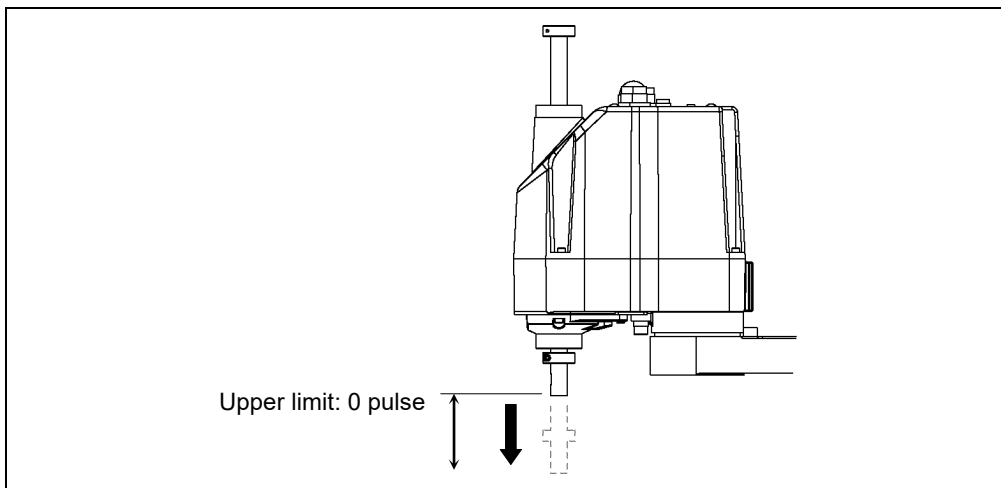
	Arm	Standard	-R	-L
A Max. Motion Range (deg)	25	±141 ±137	-	-
	30	±142 ±141	-135 to 150 -135 to 145	-150 to 135 -145 to 135
	35	±142	-120 to 165 -120 to 160	-165 to 120 -160 to 120
B Max. Pulse Range (pulse)	25	-2566827 to 2566827 -2494009 to 2494009	-	-
	30	-2585031 to 2585031 -2494009 to 2494009	-2457600 to 2730667 -2457600 to 2639645	-2730667 to 2457600 -2639645 to 2457600
	35	-2585031 to 2585031	-2184533 to 3003733 -2184533 to 2912711	-3003733 to 2184533 -2912711 to 2184533

Table Top Mounting (S: Standard-model, C: Cleanroom-model)

	Arm	Standard	-R	-L
A Max. Motion Range (deg)	30	±135	-	-
	35	±142	-120 to 160 -120 to 150	-160 to 120 -150 to 120
B Max. Pulse Range (pulse)	30	-2457600 to 2457600	-	-
	35	-2585031 to 2585031	-2184533 to 2912711 -2184533 to 2730667	-2912711 to 2184533 -2730667 to 2184533

5.1.3 Max. Pulse Range of Joint #3

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



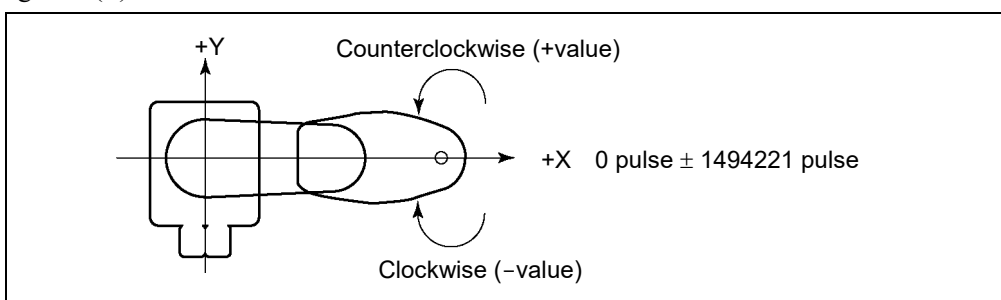
Model	Joint #3 Stroke	Lower Limit Pulse
G3-**1S*	150 mm	-1706667
G3-**1C* (Cleanroom-model)	120 mm	-1365334



NOTE For the Cleanroom-model (G3-**1C*), the motion range set with the Joint #3 mechanical stop cannot be changed.

5.1.4 Max. Pulse Range of Joint #4

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



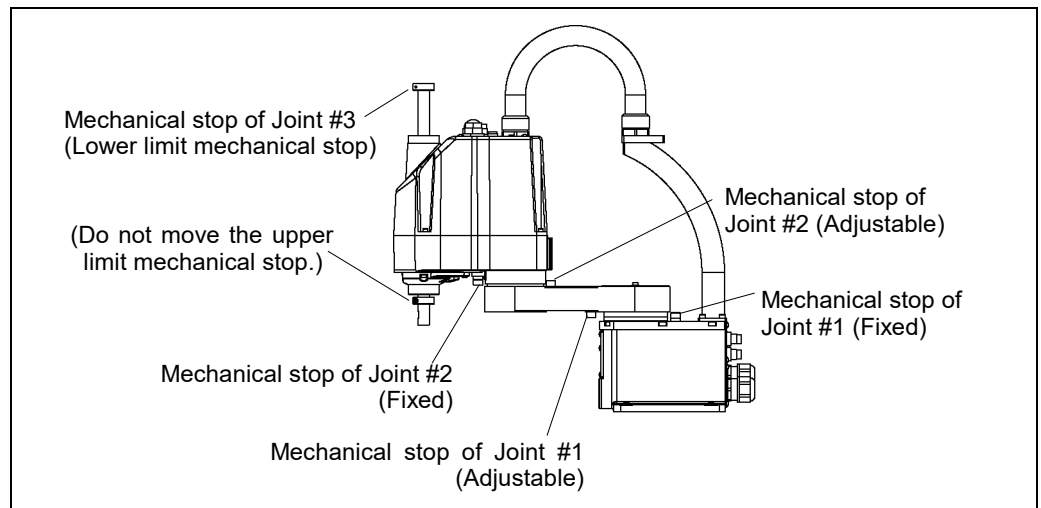
5.2 Motion Range Setting by Mechanical Stops

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

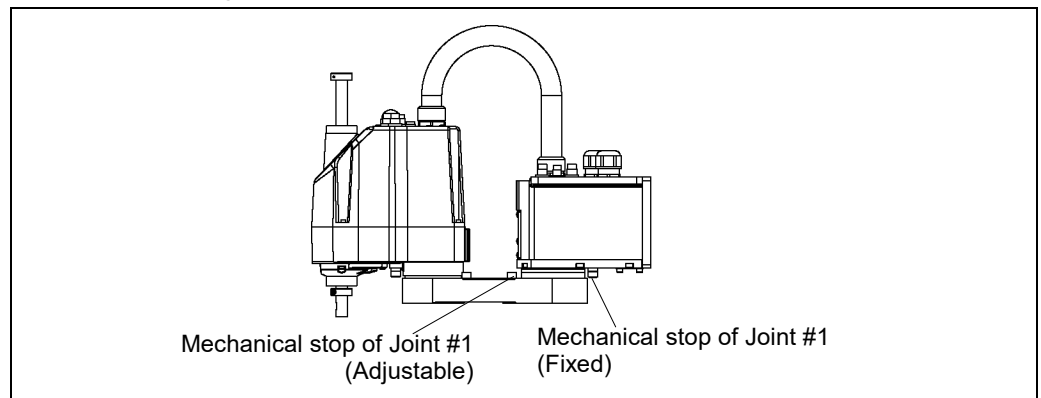
Both Joints #1 and #2 have threaded holes in the positions corresponding to the angle for the mechanical stop settings. Install the bolts in the holes corresponding to the angle that you want to set.

Joints #3 can be set to any length less than the maximum stroke.

Table Top Mounting



Multiple Mounting



* The different mechanical stop positions from Table Top mounting are indicated for Multiple mounting.

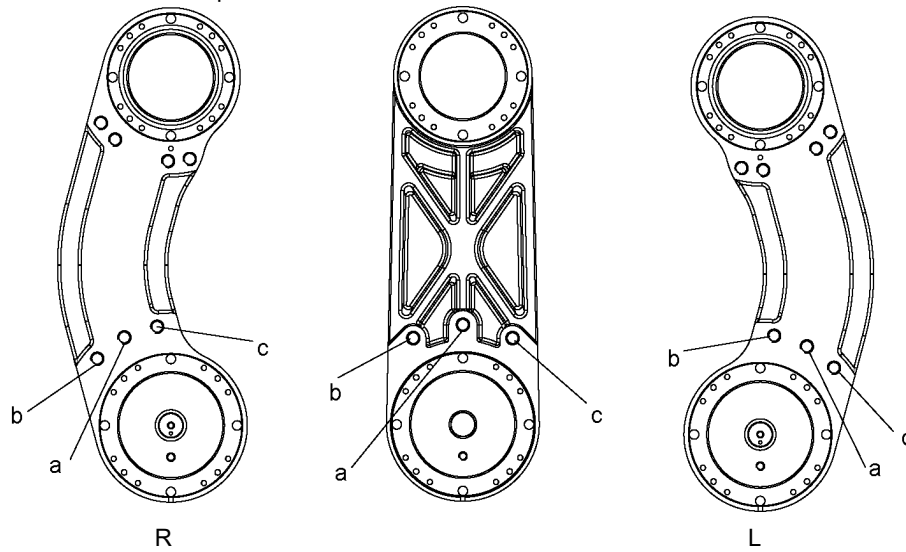
5.2.1 Setting the Mechanical Stops of Joints #1 and #2

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

Install the bolts for the mechanical stop of Joint #1 (adjustable) to the following position.

- | | |
|--------------------|-------------------|
| Table Top mounting | : Arm bottom side |
| Multiple mounting | : Arm top side |

Joint #1 Mechanical Stops



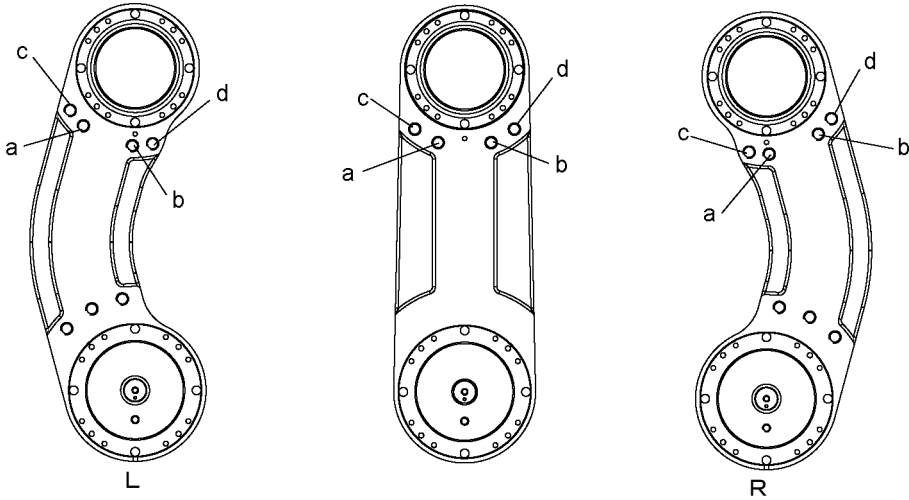
Views from the bottom of Arm #1

Model	Arm	a	b	c
G3-**1S/C	250	±140°	-110°	+110°
	300	±140°	-110°	+110°
	350	±140°	-110°	+110°
G3-**1S/C-R	300	-125° to +150°	-105°	+130°
	350	-110° to +165°	-90°	+145°
G3-**1S/C-L	300	-150° to +125°	-130°	+105°
	350	-165° to +110°	-145°	+90°
G3-**1SM/CM	300	±115°	-100°	+100°
	350	±120°	-105°	+105°
G3-351SM/CM-R	350	-105° to +130°	-95°	+120°
G3-351SM/CM-L	350	-130° to +105°	-120°	+95°

Setting Angle	+90°	+95°	+100°	+105°	+110°	+115°	+120°
Pulse Value	5242880	5388516	5534151	5679787	5825423	5971058	6116694
Setting Angle	+125°	+130°	+140°	+145°	+150°	+165°	
Pulse Value	6262329	6407965	6699236	6844872	6990507	7427414	
Setting Angle	-90°	-95°	-100°	-105°	-110°	-115	-120°
Pulse Value	0	-145636	-291271	-436907	-582542	-728178	-873813
Setting Angle	-125°	-130°	-140°	-145°	-150°	+165°	
Pulse Value	-1019449	-1165085	-1456356	-1601991	-1747627	-2184533	

(°: degree)

Joint #2 Mechanical Stops



Views from the top of Arm #1

Model	Arm	a	b	c	d
G3-**1S/C	250	+141°	-141°	+120°	-120°
	300	+142°	-142°	+120°	-120°
	350	+142°	-142°	+120°	-120°
G3-**1S/C-R	300	+150°	-135°	+130°	-115°
	350	+165°	-120°	+145°	-100°
G3-**1S/C-L	300	+135°	-150°	+115°	-130°
	350	+120°	-165°	+100°	-145°
G3-**1SM/CM	300	+135°	-135°	+115°	-115°
	350	+142°	-142°	+120°	-120°
G3-351SM/CM-R	350	+160°	-120°	+150°	-110°
G3-351SM/CM-L	350	+120°	-160°	+110°	-150°

Setting Angle	+100°	+110°	+115°	+120°	+130°	+135°
Pulse Value	1820444	2002488	2093511	2184533	2366577	2457600
Setting Angle	+141°	+142°	+145°	+150°	+160°	+165°
Pulse Value	2566826	2585031	2639644	2730666	2912711	3003733
Setting Angle	-100°	-100°	-115°	-120°	-130°	-135°
Pulse Value	-1820444	-2002488	-2093511	-2184533	-2366577	-2457600
Setting Angle	-141°	-142°	-145°	-150°	-160°	-165°
Pulse Value	-2566826	-2585031	-2639644	-2730666	-2912711	-3003733

(°: degree)



In case of Multiple Mounting, it is impossible to limit the operating range completely. Because it may hit the wall within the setting range of mechanical stops.

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

Joint	Hexagon socket head cap bolt (fully threaded)	The number of bolts	Recommended tightening torque
1	M8 × 10	1 bolt / one side	37.2 N·m (380 kgf·cm)

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

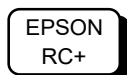


Be sure to set the pulse range inside the positions of the mechanical stop range.

Example: Using G3-251S*

The angle of Joint #1 is set from -110 degrees to +110 degrees.

The angle of Joint #2 is set from -120 degrees to +120 degrees.



Execute the following commands from the [Command Window].

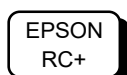
```
>JRANGE 1, -582542, 5825423 ' the pulse range of Joint #1
>JRANGE 2, -2184533, 2184533 ' Sets the pulse range of Joint #2
>RANGE ' Checks the setting using Range
-582542, 5825423, -2184533, 2184533, -1706667
, 0, -1494221, 1494221
```

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

Example: Using G3-251S*

The angle of Joint #1 is set from -110 degrees to +110 degrees.

The angle of Joint #2 is set from -120 degrees to +120 degrees.



Execute the following commands from the [Command Window].

```
>MOTOR ON 'Turns ON the motor
>POWER LOW 'Enters low-power mode
>SPEED 5 'Sets at low speeds
>PULSE -582542, 0, 0, 0 'Moves to the min. pulse position of Joint #1
>PULSE 5825423, 0, 0, 0 'Moves to the max. pulse position of Joint #1
>PULSE 2621440, - 2184533, 0, 0 'Moves to the min. pulse position of Joint #2
>PULSE 2621440, 2184533, 0, 0 'Moves to the max. pulse position of Joint #2
```

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

In this example, Joint #1 is moved to the center of its motion range (pulse value: 2621440) when checking Joint #2.

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

5.2.2 Setting the Mechanical Stop of Joint #3

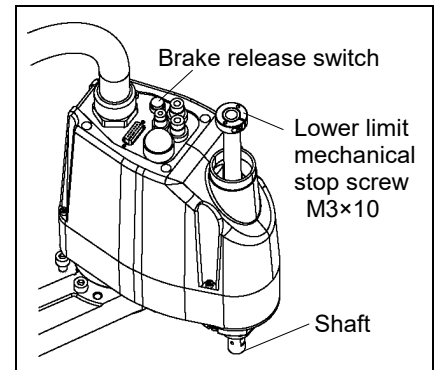


This method applies only to the Standard-model Manipulator (G3-**1S*) / Multiple Mounting Manipulator (G3-**1SM).

For the Cleanroom-model (G3-**1C*), the motion range set with the Joint #3 mechanical stop cannot be changed.

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

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



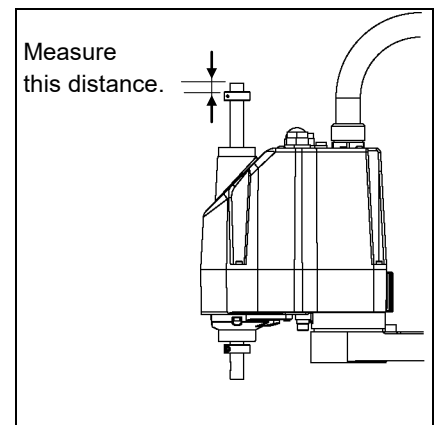
When you press the brake release switch, the shaft may lower due to the weight of the end effector. Be sure to hold the shaft by hand while pressing the button.

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



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

- (5) The upper end of the shaft defines the maximum stroke. Move the lower limit mechanical stop down by the length you want to limit the stroke. For example, when the lower limit mechanical stop is set at “150 mm” stroke, the lower limit Z coordinate value is “-150”. To change the value to “-130”, move the lower limit mechanical stop down “20 mm”. Use calipers to measure the distance when adjusting the mechanical stop.



- (6) Firmly tighten the lower limit mechanical stop screw (M3×10) not to let it enter the shaft groove.
Recommended tightening torque: 2.45 N·m (25 kgf·cm)
- (7) Turn ON the Controller.

- (8) Move Joint #3 to its lower limit while pressing the brake release switch, and then check the lower limit position. Do not lower the mechanical stop too far. Otherwise, the joint may not reach a target position.
- (9) Calculate the lower limit pulse value of the pulse range using the formula shown below and set the value.

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

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

** For the Joint #3 resolution,
 refer to the section *Setup & Operation 2.4 Specifications*.



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

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

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



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



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

```
>MOTOR ON ' Turns ON the motor
>SPEED 5 ' Sets low speed
>PULSE 0, 0, X, 0 ' Moves to the lower limit-pulse position of Joint #3.
```

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

5.3 Setting the Cartesian (Rectangular) Range in the XY Coordinate System of the Manipulator

(Joints #1 and #2)

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

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

EPSON
RC+

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

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

5.4 Standard Motion Range

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

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

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

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

For the motion area figures, refer to *Setup & Operation 3.3 Mounting Dimensions*.

Maintenance

This volume contains maintenance procedures with safety precautions for G3 series Manipulators.

1. Safety Maintenance

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

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

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

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


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



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



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

 CAUTION	<ul style="list-style-type: none"> Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
---	---

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 While the Power is OFF (Manipulator is not operating)

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts/screws. Tighten them if necessary. (For the tightening torque, refer to <i>Maintenance: 2.4 Tightening Hexagon Socket Head Cap Bolts.</i>)	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
	Each arm locking bolts	√	√	√	√	√
	Bolts/screws around shaft					√
	Bolts/screws securing motors, reduction gear units, etc.					√
Check looseness of connectors. If the connectors are loosen, push it securely or tighten.	External connectors on Manipulator (on the connector plates etc.)	√	√	√	√	√
	Manipulator cable unit		√	√	√	√
Visually check for external defects. Clean up if necessary.	External appearance of Manipulator	√	√	√	√	√
	External cables		√	√	√	√
Check for bends or improper location. Repair or place it properly if necessary.	Safeguard etc.	√	√	√	√	√
Check tension of timing belts. Tighten it if necessary.	Inside of Arm #2				√	√
Grease conditions	Refer to <i>Maintenance: 2.3 Greasing.</i>					
Battery	Refer to <i>Maintenance: 12 Lithium Battery.</i>					

Inspection While the Power is ON (Manipulator is operating)

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check motion range	Each joint					√
Move the cables back and forth lightly to check whether the cables are disconnected.	External cables (including cable unit of the Manipulator)				√	√
Push each arm in MOTOR ON status to check whether backlash exists.	Each arm					√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√
Measure the accuracy repeatedly by a gauge.	Whole					√
Turn ON and OFF the Brake Release switch and check the sound of the electromagnetic brake. If there is no sound, replace the brake.	Brake	√	√	√	√	√

2.2 Overhaul (Parts Replacement)



CAUTION

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

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

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

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

NOTE



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

For details, refer to the following manual.

Robot Controller RC700 / RC700-A Maintenance 6. Alarm

NOTE



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

For details, refer to the following manual.

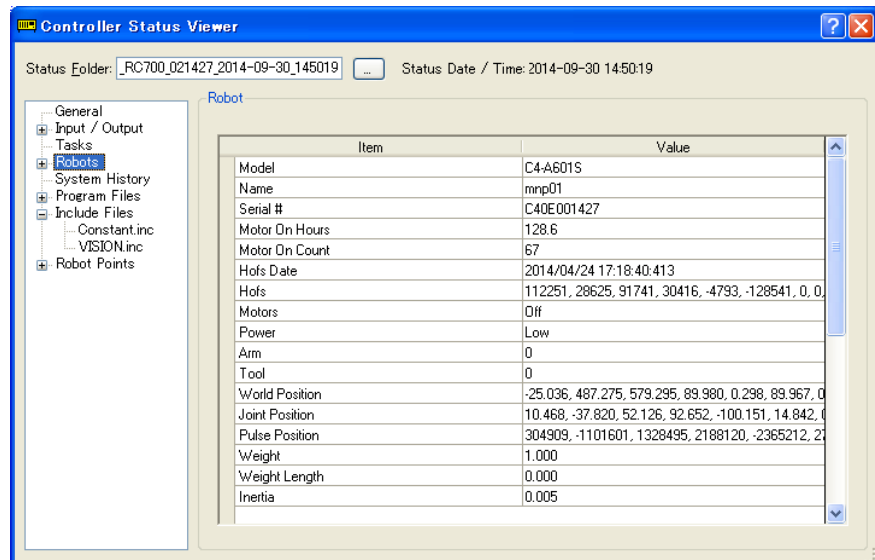
Robot Controller RC180 "Appendix. Alarm"

Note:

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

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

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




For the parts subject to overhaul, refer to *Maintenance 15. Maintenance Parts List*.


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

Please contact the supplier of your region for further information.

2.3 Greasing

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

 CAUTION	<ul style="list-style-type: none"> ■ Keep enough grease in the Manipulator. Operating the Manipulator with insufficient grease will damage sliding parts and/or result in insufficient function of the Manipulator. Once the parts are damaged, a lot of time and money will be required for the repairs.
--	--

 CAUTION	<ul style="list-style-type: none"> ■ If grease gets into your eyes, mouth, or on your skin, follow the instructions below. <ul style="list-style-type: none"> If grease gets into your eyes <ul style="list-style-type: none"> : Flush them thoroughly with clean water, and then see a doctor immediately. If grease gets into your mouth <ul style="list-style-type: none"> : If swallowed, do not induce vomiting. See a doctor immediately. : If grease just gets into your mouth, wash out your mouth with water thoroughly. If grease gets on your skin <ul style="list-style-type: none"> : Wash the area thoroughly with soap and water.
--	--

	Greasing part	Greasing Interval	Grease	Refer to <i>Maintenance</i> :
Joint #1 Joint #2	Reduction gear units	Overhaul timing	SK-1A	5.2 <i>Replacing the Joint #1 Reduction Gear Unit</i> 6.2 <i>Replacing the Joint #2 Reduction Gear Unit</i>
Joint #3	Ball screw spline unit	At 100 km of operation (50 km for first greasing)	AFB	11.1 <i>Greasing the Ball Screw Spline Unit</i>

Joint #1, 2 reduction gear units

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

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

Joint #3 Ball screw spline unit


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



Normal grease


Discolored grease

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

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

For details, refer to the following manual.

Robot Controller RC700 / RC700-A Maintenance 6. Alarm

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

For details, refer to the following manual.

Robot Controller RC180 "Appendix. Alarm"

2.4 Tightening Hexagon Socket Head Cap Bolts

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

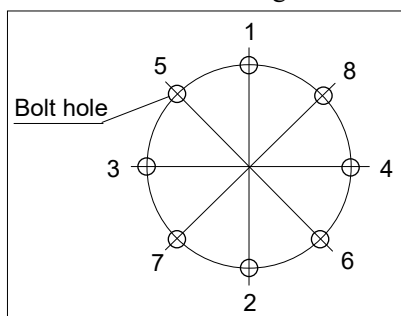
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

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

Refer below for the set screw.

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

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



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

2.5 Matching Origins

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

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

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

**EPSON
RC+**

Execute the following command from the [Command Window].

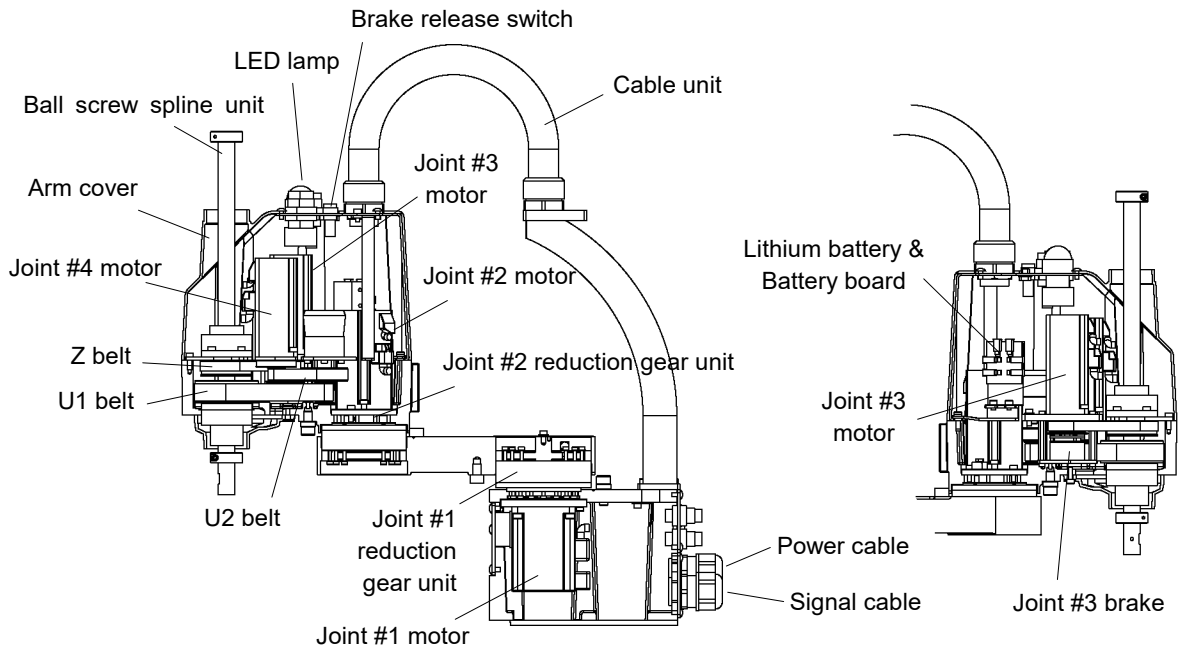
>PULSE

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

2.6 Layout of Maintenance Parts

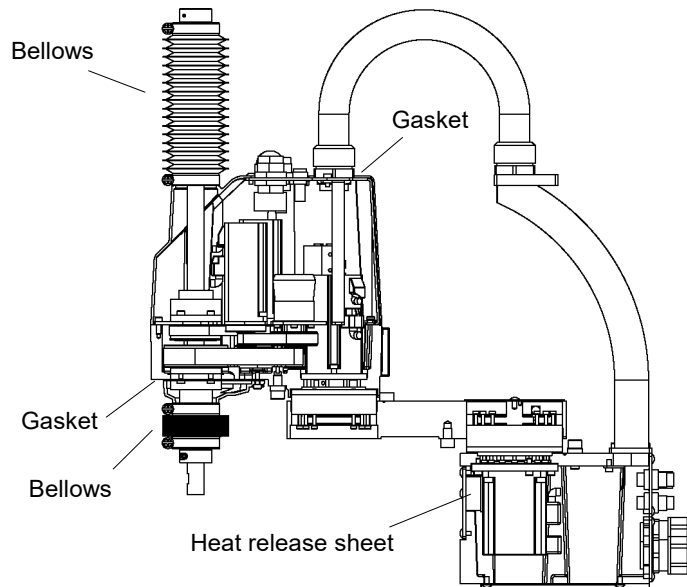
2.6.1 Table Top Mounting

G3-**1S : Standard-model



(Figure: G3-301S)

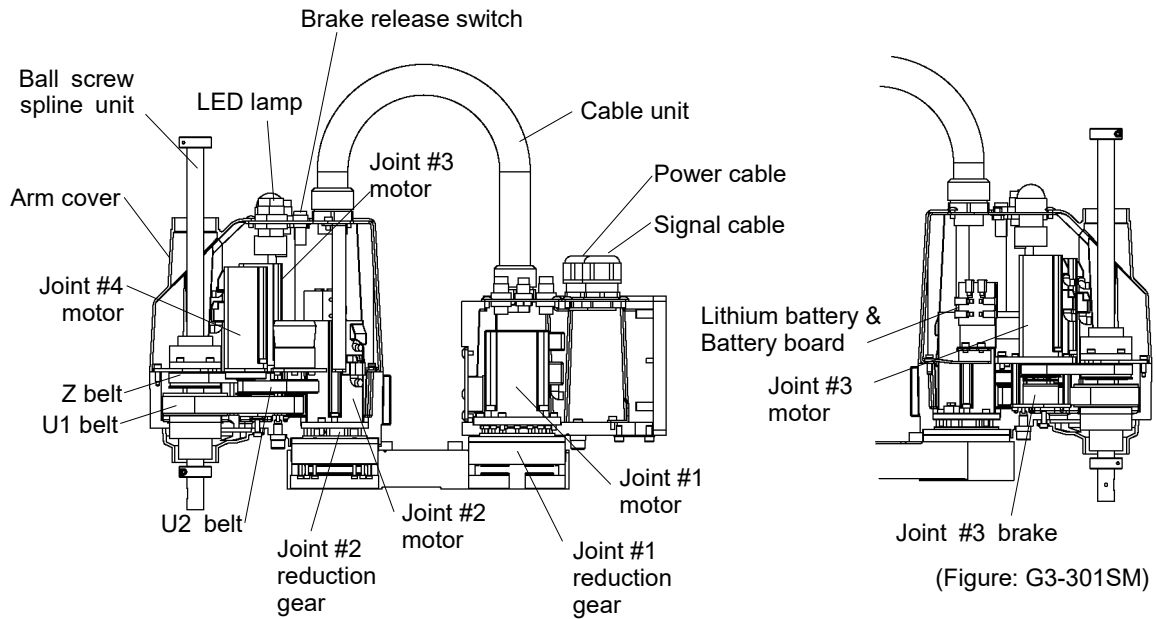
G3-**1C : Cleanroom-model (with bellows)



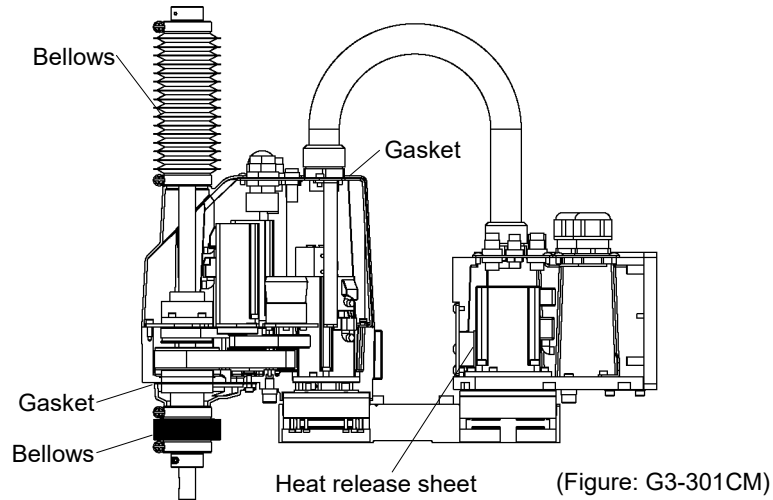
(Figure: G3-301C)

2.6.2 Multiple Mounting

G3-**1SM : Standard-model




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



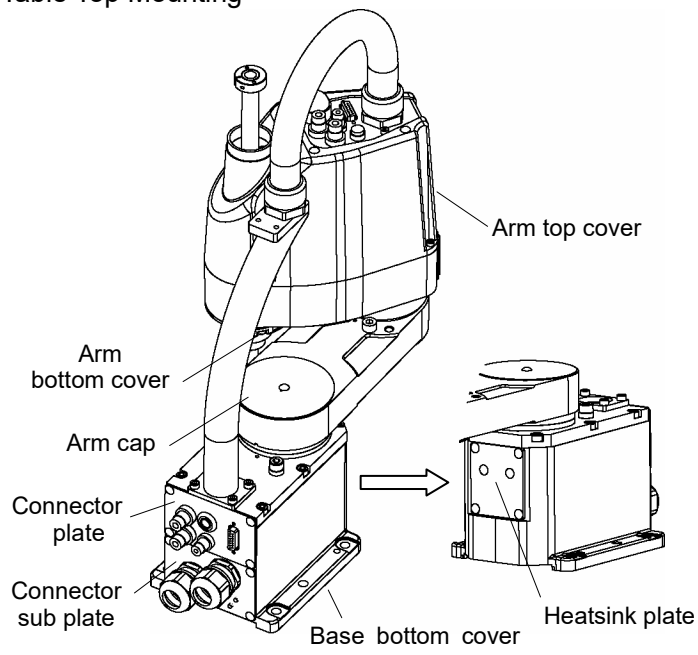
3. Covers

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

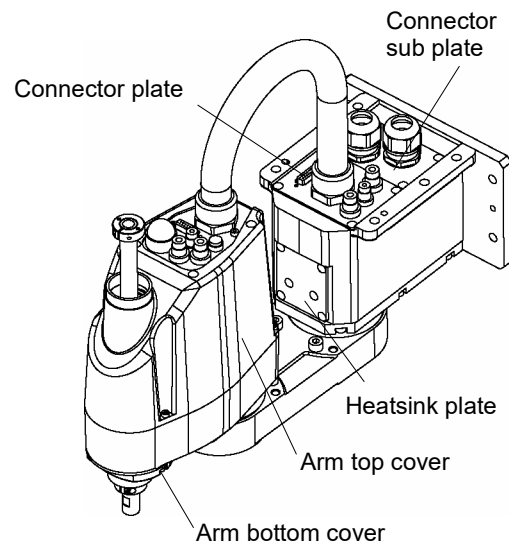
 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system. ■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
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	Name	Quantity	Note
Maintenance parts	Under cover gasket	1	R13B031226 Only for Cleanroom-model
Tools	Silicon adhesive (for the gasket on the Connector Plate)	1	R13B031227 Only for Cleanroom-model
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw Tightening Torque: 0.9 N·m (9.2 kgf·cm)
	Torque wrench	1	
	Cross-point screwdriver	1	For M4 truss screw Tightening torque: 0.4 N·m (4.1 kgf·cm) For bellows removal (Only for Cleanroom-model)
	Wiping cloth	1	For wiping adhesive

Table Top Mounting



Multiple Mounting



3.1 Arm Top Cover




- 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 (1) Turn ON the Controller.

Removal


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

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

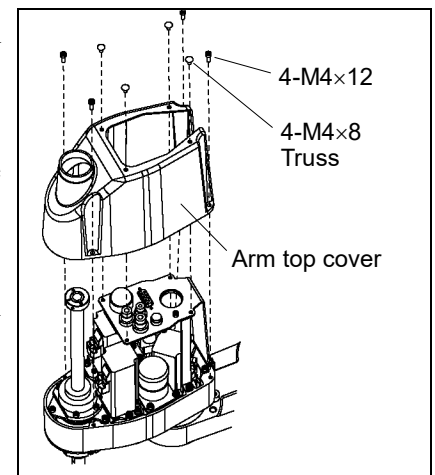
Be careful of the shaft while the brake release switch is being pushed because it may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.

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

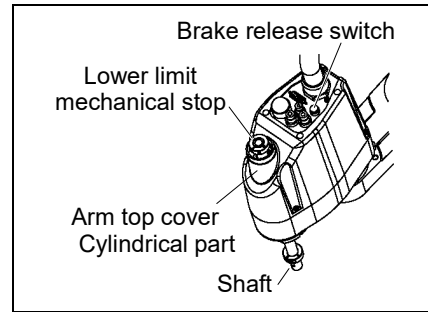
NOTE  When bellows are installed to the manipulator, remove the upper bellows and then remove the arm top cover. For bellows removal, refer to *Maintenance 10. Bellows*.

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



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

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



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

For bellows installation, refer to *Maintenance10. Bellows*.

3.2 Arm Bottom Cover

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

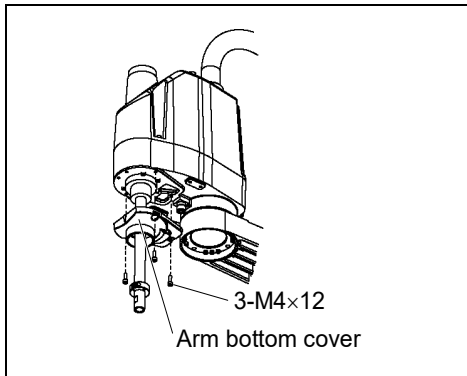


NOTE The arm bottom cover may not be removed from the shaft because the end effector is installed. If it is necessary to remove the cover completely (for replacement of the ball screw spline unit etc.), remove the end effector.

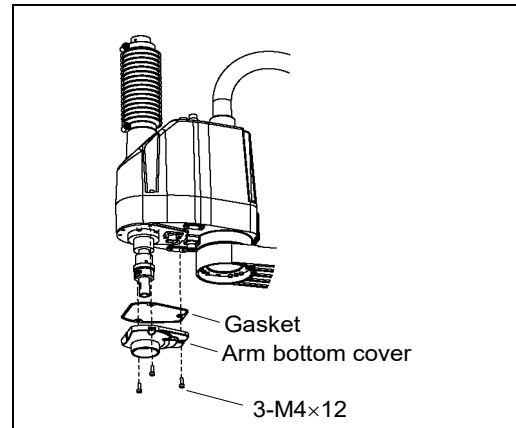
If it is not necessary to remove the cover completely, move the shaft to the lower limit, and lower the arm bottom cover. Then, perform maintenance or inspection.

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

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



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



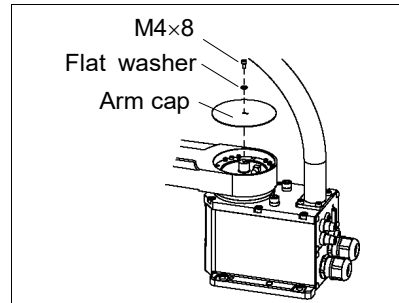
A gasket is installed to G3-**1C* (Cleanroom-model).

3.3 Arm Cap

Unscrew the arm cap mounting bolts and remove the cover.

Arm cap is not installed to the Multiple Mounting Manipulators.

G3-**1 Table Top Mounting



3.4 Connector Plate



CAUTION

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

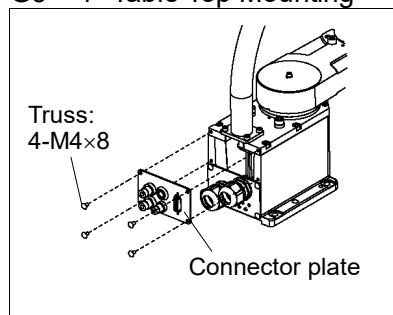
- When installing the connector plate, be careful not to allow the cables to interfere with the plate mounting and do not bend these cables forcibly to push them into the cover.

Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.

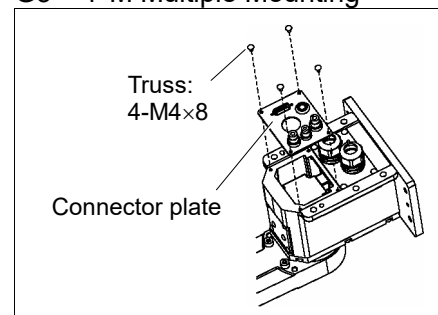
When routing the cables, observe the cable locations after removing the connector plate. Be sure to place the cables back to their original locations.

Unscrew the connector plate mounting bolts and remove the plate.

G3-**1* Table Top Mounting



G3-**1*M Multiple Mounting



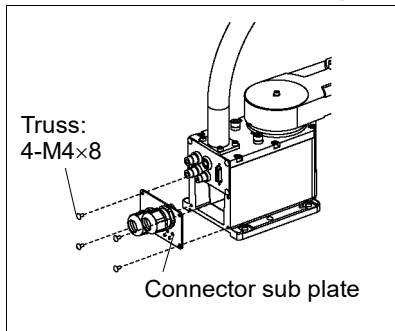
3.5 Connector Sub Plate



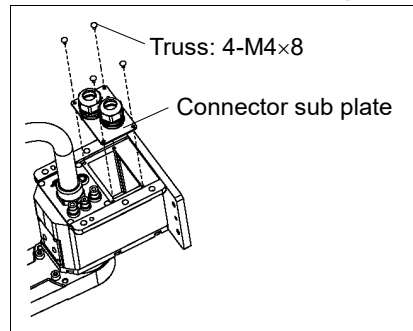
- Do not remove the connector sub plate forcibly. Removing the connector sub plate forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of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

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

G3-**1* Table Top Mounting



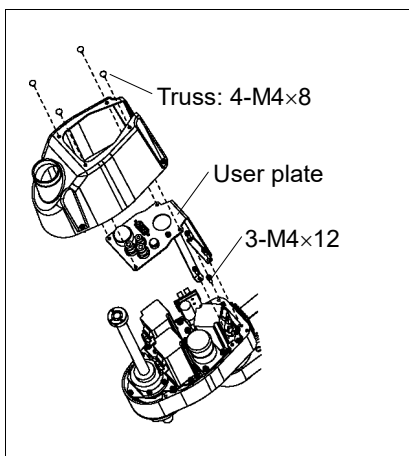
G3-**1*M Multiple Mounting



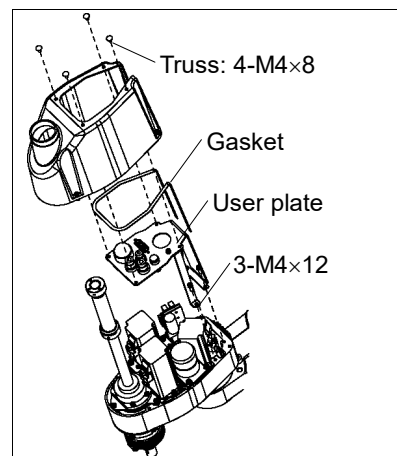
3.6 User Plate

Unscrew the user plate mounting bolts and remove the plate.

G3-**1S* Standard-model



G3-**1C* Cleanroom-model

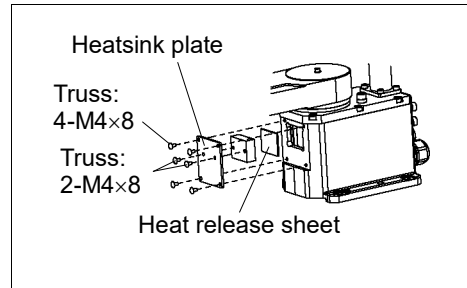


A gasket is installed to G3-**1C* (Cleanroom-model).

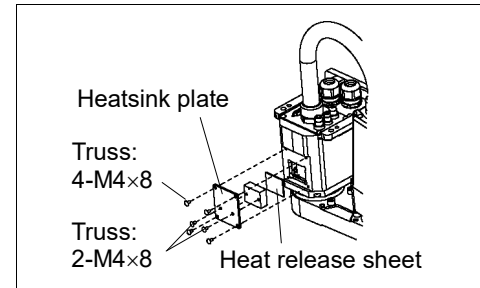
3.7 Heatsink Plate

Unscrew the heatsink plate mounting bolts to remove the plate.

G3-**1* Table Top Mounting



G3-**1*M Multiple Mounting



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

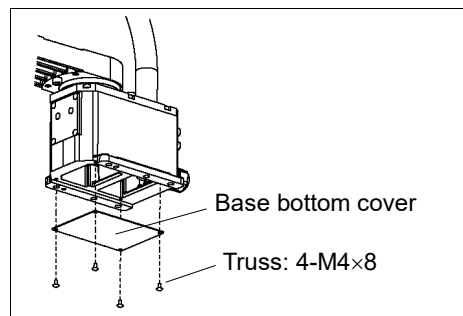


Be careful when you mount the Heatsink plate without the Heat release sheet, it may cause the malfunction or break by the heat from the Motor.

3.8 Base Bottom Cover


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


G3-**1C* Cleanroom-model



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

4. Cable

 WARNING	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system. ■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
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 CAUTION	<ul style="list-style-type: none"> ■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
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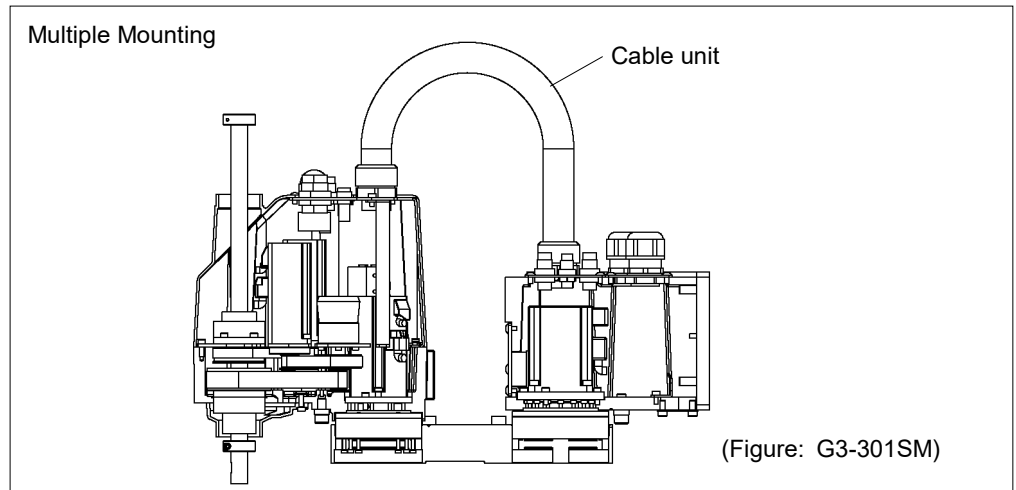
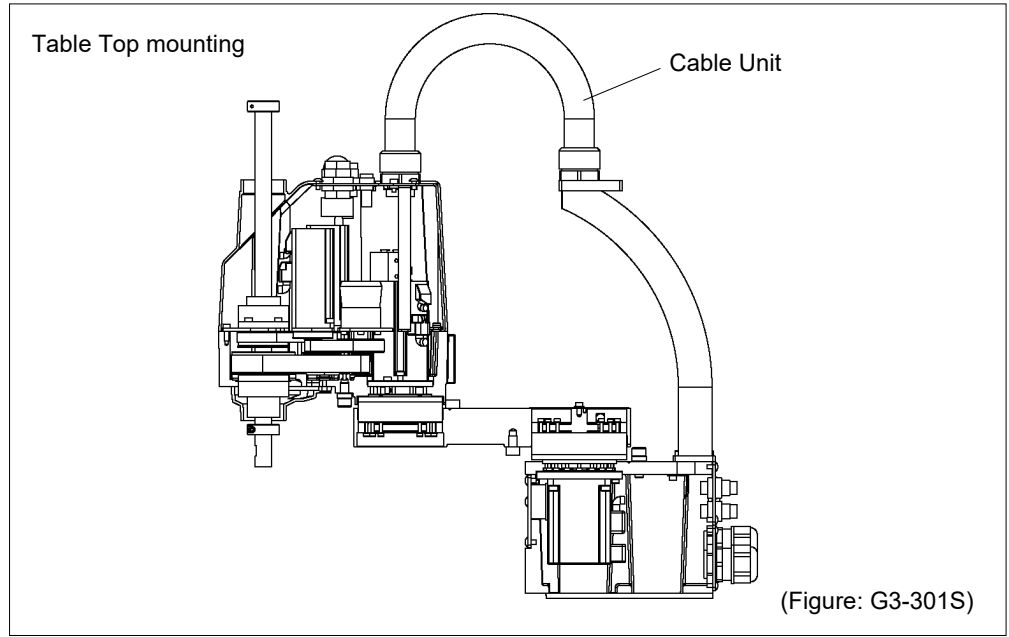
4.1 Replacing Cable Unit


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

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

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

	Name	Quantity	Note	
Maintenance parts	Cable unit	1	Each manipulator model <i>(Refer to Maintenance: 15. Maintenance parts)</i>	
	Battery Unit (Lithium battery)	1	2117879	
Tools	Hexagonal wrench	width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Spanner	width across flats: 5 mm	1	For D-sub connector removal
	Nut screwdriver	width across flats: 5 mm	1	For D-sub connector removal
	Torque wrench		1	
	Nippers		1	For cutting wire tie
Material	Wire tie	9		



 CAUTION	<ul style="list-style-type: none"> ■ If the connectors have been disconnected during the replacement of the cable unit, be sure to reconnect the connectors to their proper positions. Refer to the block diagrams. Improper connection of the connectors may result in improper function of the robot system. For details on the connections, refer to <i>Maintenance: 4.2 Wiring Diagrams</i>. ■ When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations. ■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
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Cable unit
Removal

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

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

Be careful of the shaft while the brake release switch is being pushed because it may be lowered by the weight of an end effector.
- (3) Turn OFF the Controller and disconnect the power cable and signal cable connectors from the controller.
- (4) Remove the connector plate.
For details, refer to *Maintenance: 3.4 Connector Plate*.
- (5) Remove the connector sub plate.
For details, refer to *Maintenance: 3.5 Connector Sub Plate*.
- (6) Connect the spare battery to the spare battery connector (XB11) of Joint #1 signal cable.



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

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

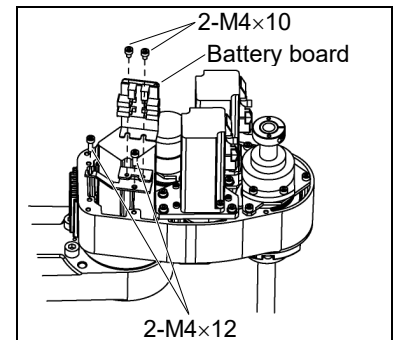


- NOTE
- Be sure to keep the connectors of the battery board connected at cables replacement. Otherwise, the motor will lose position data and the calibration must be executed again.
 - Remember the cable layout so that the cables can be reconnected correctly after replacement.

- (8) Cut off one wire tie binding Base side cables.
- (9) Remove the arm top cover.
For details, refer to *Maintenance: 3.1 Arm Top Cover*.
- (10) Remove the Battery board.

- (11) Loosen the mounting screws for the User plate and remove the plate from the Arm #2.

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



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

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



X61 is connected to the battery board.

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

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

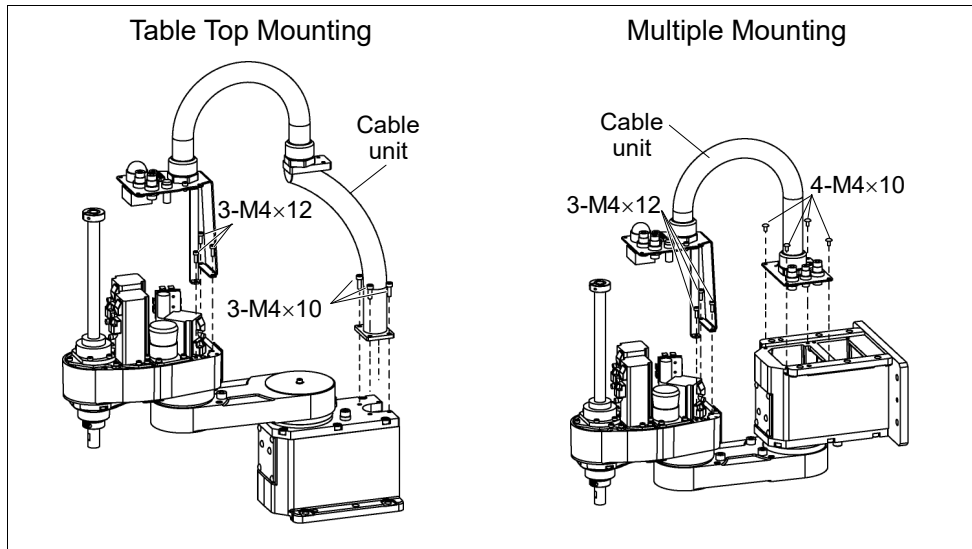


Mounting screws for the D-sub cable are very small. Be sure to keep the screws.

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

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

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

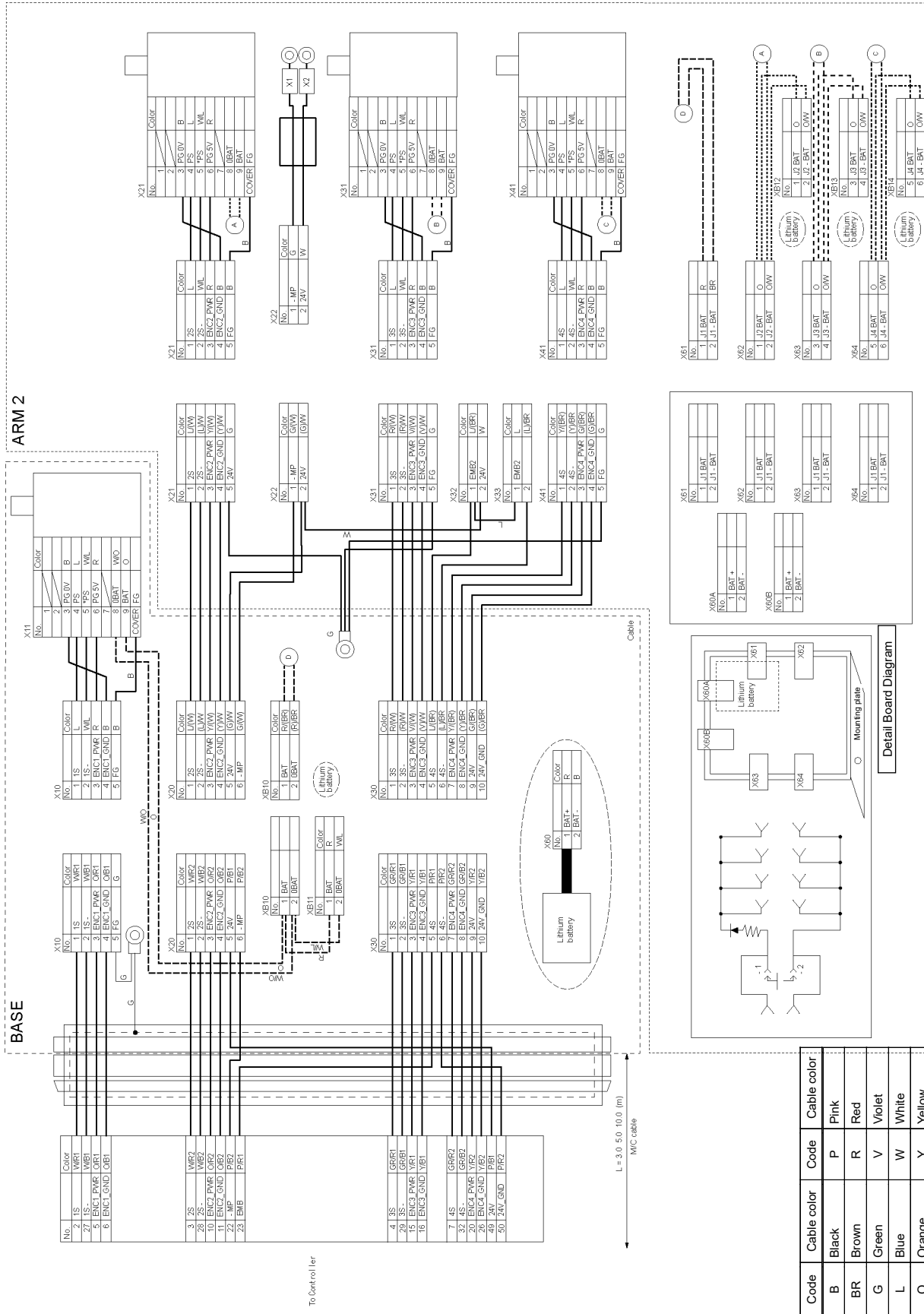


**Cable unit
Installation**

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

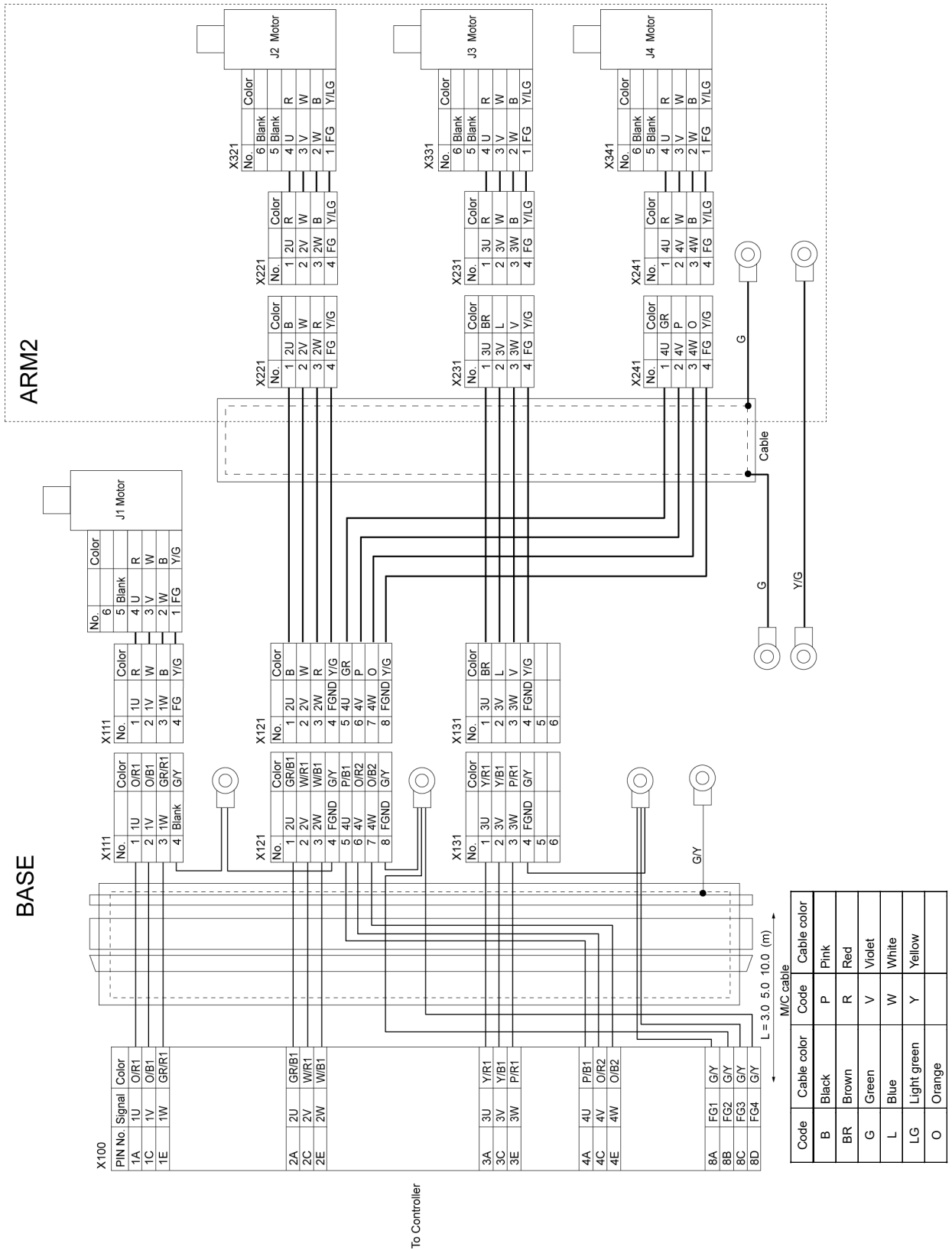
4.2 Wiring Diagrams

4.2.1 Signal Cable

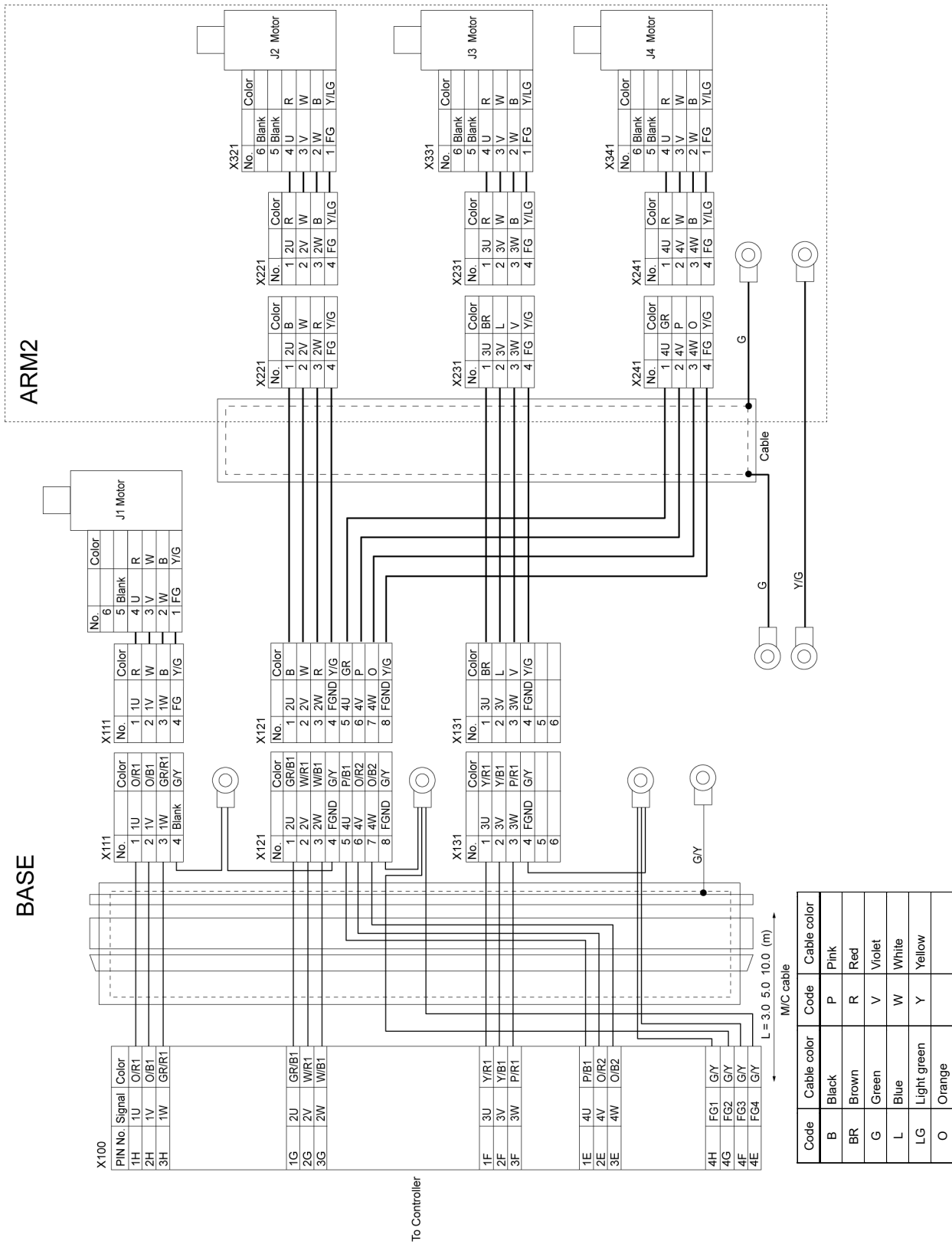


4.2.2 Power Cable

RC180



RC700-A, RC700DU-A



4.2.3 User Cable

D-sub 15pin

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

D-sub 15pin

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

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

The following table shows the types of the use cable.

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

4.3 Replacing M/C Cable

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



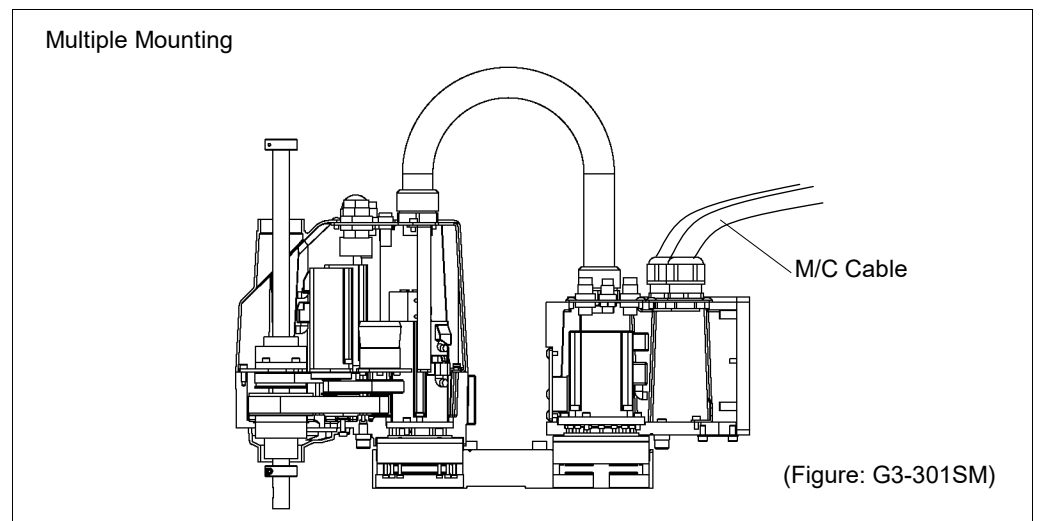
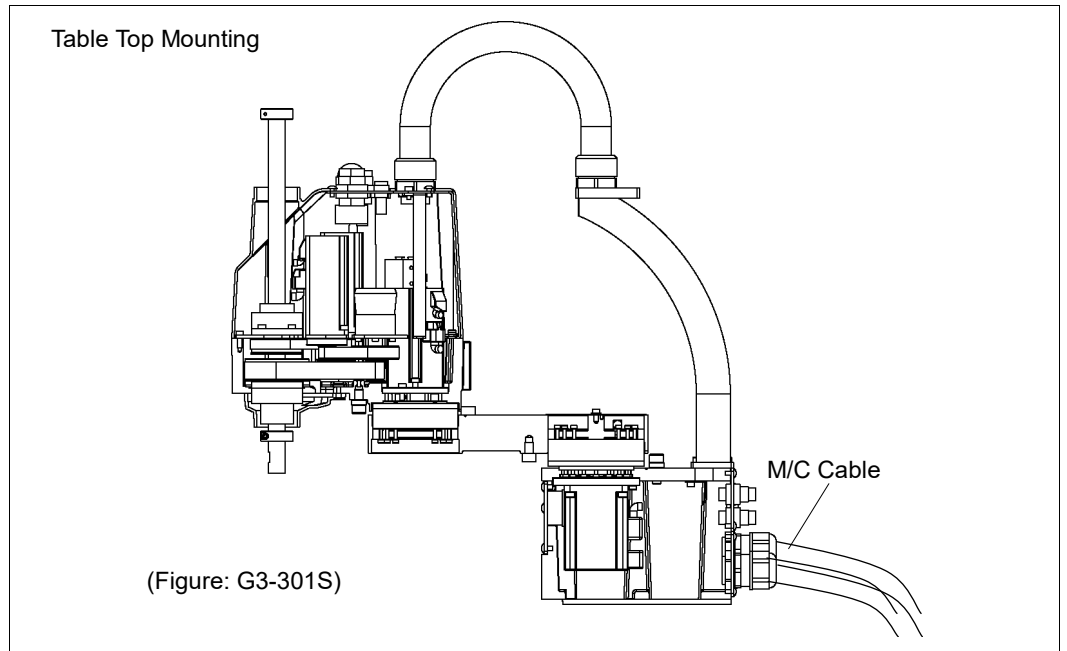
If the connector connected to the battery was disconnected during cable replacement, execute calibration.

For details, refer to *Maintenance: 14. Calibration*.

	Name	Quantity	Note
Maintenance parts	M/C Cable	1	Each manipulator model (Refer to <i>Maintenance: 15. Maintenance parts</i>)
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Torque wrench	1	



- If the connectors have been disconnected during the replacement of the cable unit, be sure to reconnect the connectors to their proper positions. Refer to the block diagrams.
Improper connection of the connectors may result in improper function of the robot system.
For details on the connections, refer to *Maintenance: 4.2 Wiring Diagrams*.
- When mounting the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations.
- Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.



M/C Cable
Removal

- (1) Turn OFF the Controller.
- (2) Disconnect the power cable and signal cable connectors from the controller.
- (3) Remove the Connector Sub Plate.
For details, refer to *Maintenance: 3.5 Connector Sub Plate*.



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

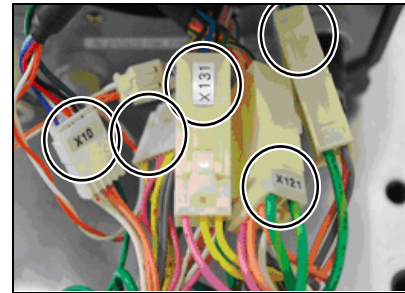
- (4) Disconnect the connectors.
Connector: x10, x20, x30, x111, x121, X131



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



NOTE
Do not disconnect the battery connector (XB10).
Otherwise, the calibration must be executed.



M/C Cable
Installation

- (1) Connect new M/C cable connectors to those of the Cable Unit.
(Connect to the connectors of the Cable Unit with the same number.)
- (2) Mount the Connector Sub Plate.
For details, refer to *Maintenance: 3.5 Connector SubPlate*.
- (3) Connect the power cable and signal cable connectors to the controller.
- (4) Turn ON the Controller.
- (5) If the connector (XB10) falls off from the battery, execute the calibration for Joint #1.
For details, refer to *Maintenance: 14 Calibration*.

5. Joint #1



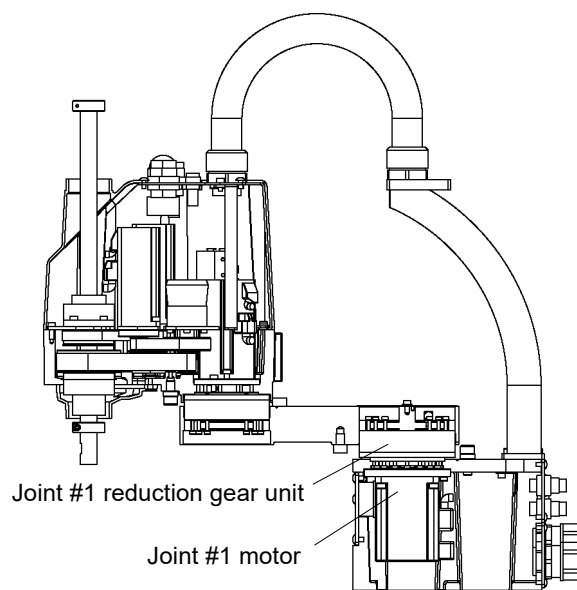
- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric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



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

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

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



5.1 Replacing Joint #1 Motor

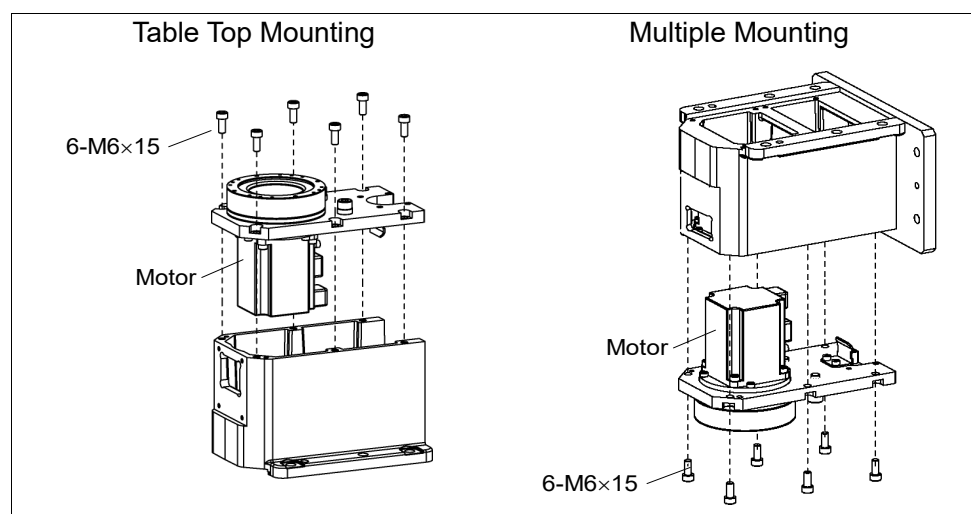
	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (200 W)	1	1514451	
Tools	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
		width across flats: 5 mm	1	For M6 screw
	Torque wrench	1		
	Wiping cloth	1	For wiping grease	
Grease	Grease (SK-1A)	4 g		

Joint #1 motor Removal

- (1) Remove the connector plate.
For details, refer to *Maintenance: 3.4 Connector Plate*.
- (2) Remove the connector sub plate.
For details, refer to *Maintenance: 3.5 Connector Sub Plate*.
- (3) Disconnect the following connectors.
Connectors X111, X10 (Hold the clip to remove.)
Connector XB10
- (4) Remove the heatsink plate.
For details, refer to *Maintenance: 3.7 Heatsink Plate*.
- (5) Remove the heat release sheet from the Motor.
- (6) Unscrew and remove the bolts from Joint #1 flange mounting on the base.

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

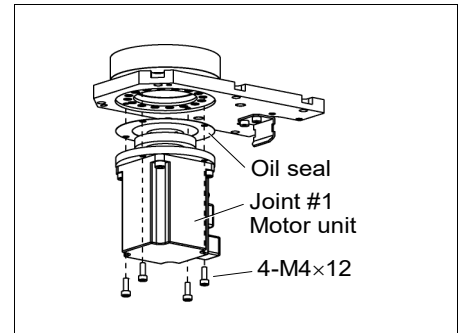
Be sure to keep the positioning pin.



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

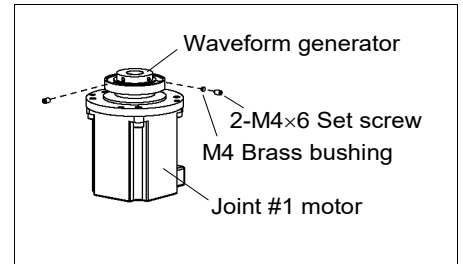
There is an oil seal (soft metal) in the assembly position of the motor flange and Joint #1 flange.

Be sure to keep the oil seal.

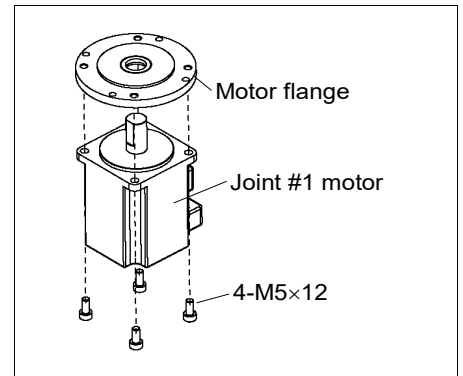


- (8) Remove the waveform generator from the Joint #1 motor.

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



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



Joint #1 motor
Installation

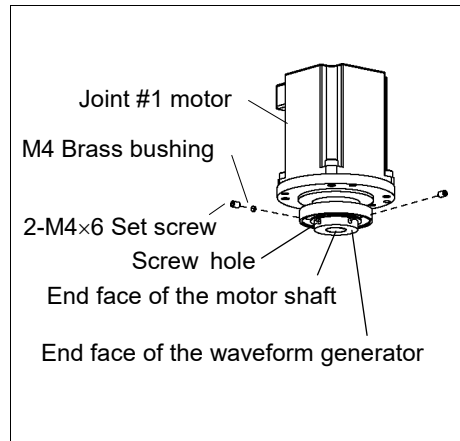
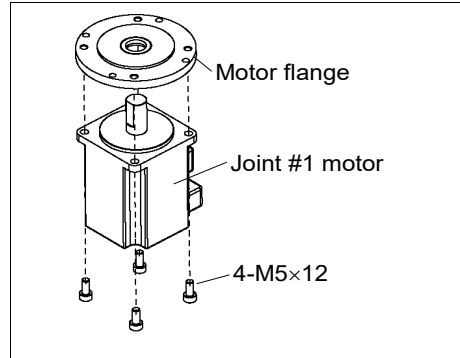
(1) Mount the motor flange on the Joint #1 motor.

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

Grease volume 4 g

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

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



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

(4) Mount the motor unit to the Joint #1 flange.

Mount the oil seal (soft metal) hole to the mounting hole.

The motor cable must face the connector plate side.

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

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

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

(6) Connect the connectors.

Connectors: X110, X10, XB10

(7) Mount the connector sub plate.

For the details, refer to *Maintenance: 3.5 Connector Sub Plate*.

(8) Mount the connector plate.

For details, refer to *Maintenance: 3.4 Connector Plate*.

(9) Mount the heatsink plate.

For details, refer to *Maintenance: 3.7 Heatsink Plate*.

(10) Perform the calibration of Joint #1.

For details refer to *Maintenance: 14. Calibration*.

5.2 Replacing Joint #1 Reduction Gear Unit

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

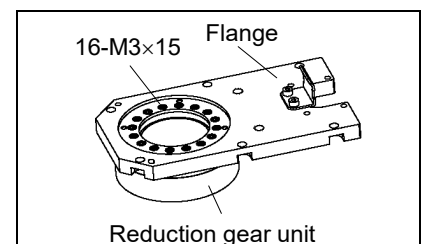
Waveform generator / Flexspline / Circular spline

For details of the reduction gear unit, refer to *Maintenance: 14. Maintenance parts list*.

	Name	Quantity	Note	
Maintenance Parts	Reduction Gear Unit	1	1649160	
Tools	Hexagonal wrench	width across flats: 2 mm	1 For M4 set screw	
		width across flats: 2.5 mm	1 For M3 screw	
		width across flats: 3 mm	1 For M4 screw	
		width across flats: 5 mm	1 For M6 screw	
	Torque wrench	M4	1	Tightening torque: 6.0 N·m (61.2 kgf·cm)
		M6	1	Tightening torque: 22.0 N·m (224.3 kgf·cm)
	Nippers	1		
	Spatula	1	For apply grease	
	Wiping cloth	1	For wiping grease (Flange)	
		1	For wiping grease (Bolt)	
Screw (M4)	2	About 20 mm in length For flexspline removal		
Grease	Grease (SK-1A)	16 g		

Joint #1
reduction gear
unit
Removal

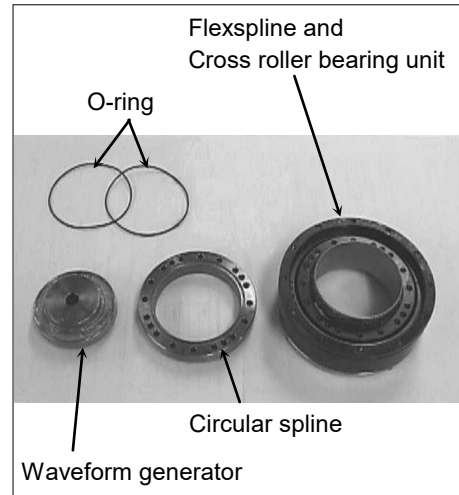
- (1) Remove the Joint #1 motor unit.
Refer to the removal steps (1) to (7) in *Maintenance: 5.1 Replacing Joint #1 Motor*.
- (2) Remove the Reduction gear unit from the Joint #1 flange.



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.

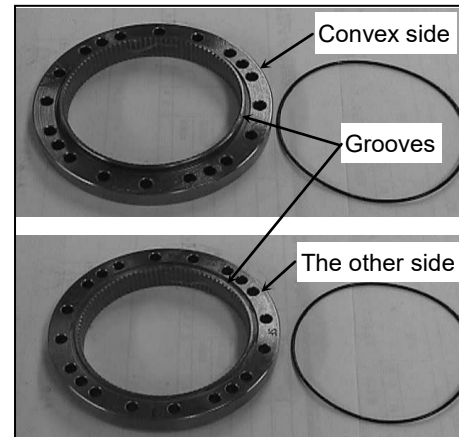
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



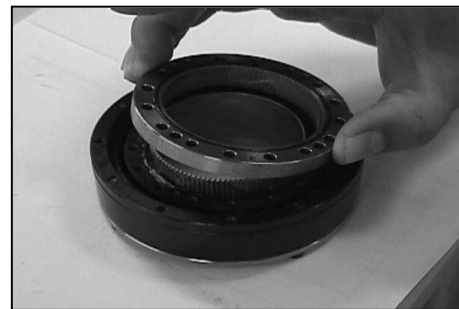
- Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

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



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

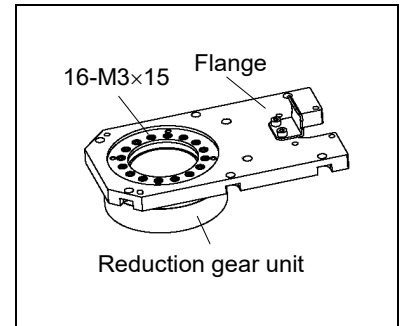


- (4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



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

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



Item	Bolt type	Number of bolts	Tightening torque
Joint #1 reduction gear unit	M3×15	16	3.0 N·m (30.6 kgf·cm)



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

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

Grease volume 12 g

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

6. Joint #2



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

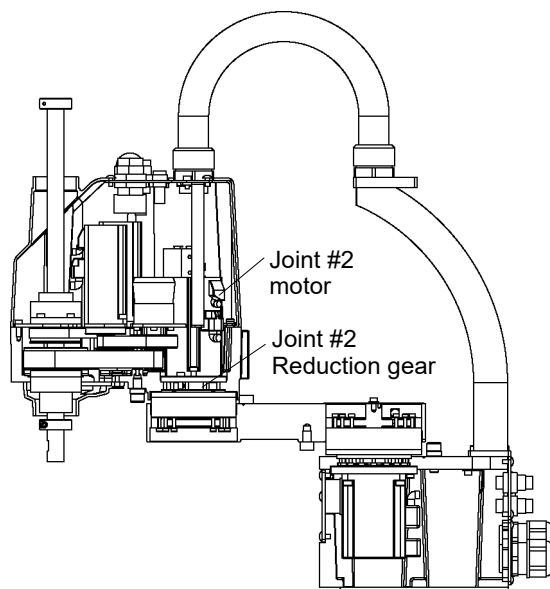


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

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

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



6.1 Replacing Joint #2 Motor

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

Joint #2 motor Removal

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

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

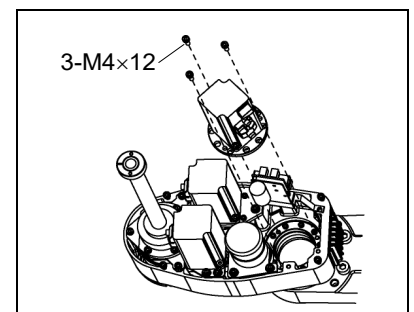
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover.
For details, refer to *Maintenance: 3.1 Arm Top Cover*.
- (5) Remove the battery board.
- (6) Remove the user plate.
- (7) Cut off the wire tie used for binding the cables connected to the user cable.
- (8) Cut off the wire tie used for binding the motor cables to the Joint #2 motor.
- (9) Disconnect the following connectors.
Connectors X221, X21 (Hold the clip to remove.)
Connector X62

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

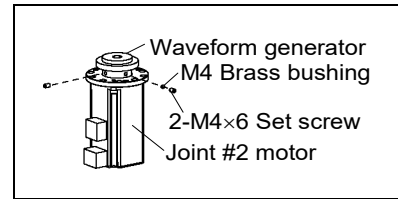
If the motor cannot be removed easily, pull it out while moving Arm #2 slowly by hand.

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

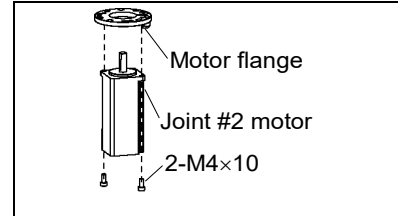


- (11) Remove the waveform generator from the Joint #2 motor.

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

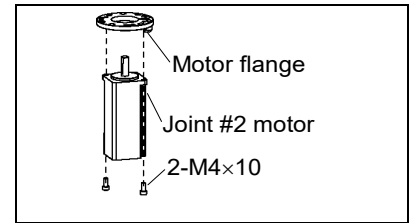


- (12) Remove the motor flange from the Joint #2 motor.



Joint #2 motor
Installation

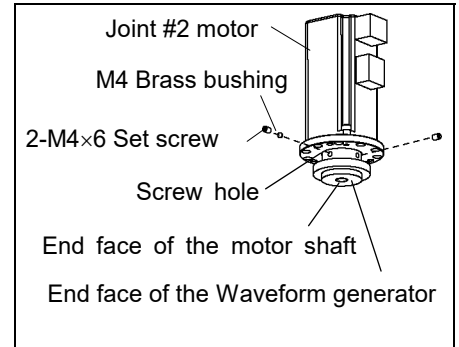
- (1) Mount the motor flange on the Joint #2 motor.



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

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

Then, tighten both set screws.



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

Grease volume 3 g

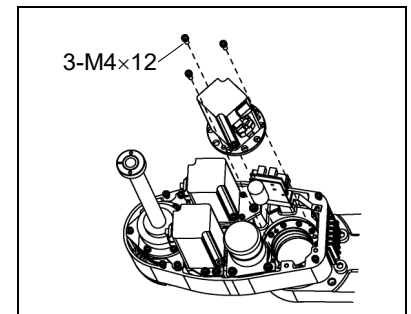


- See the figures above for the orientation of the waveform generator. Be sure to install the waveform generator properly. Improper installation of the waveform generator will result in improper function of the Manipulator.

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

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

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



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

Do not allow unnecessary strain on the cables.

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

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

- (8) Connect the connectors.

Connectors X221, X21

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

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

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

Do not allow unnecessary strain on the cables.

- (11) Mount the arm top cover.

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

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

For details refer to *Maintenance: 14. Calibration*.

6.2 Replacing Joint #2 Reduction Gear Unit

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

Waveform generator / Flexspline / Circular spline

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

	Name	Quantity	Note	
Maintenance parts	Reduction Gear Unit	1	1661086	
	Hexagonal wrench	width across flats: 2 mm	1	For M4 set screw
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	
	Torque wrench (M3)	1	Tightening torque : 3.0 N·m (30.6 kgf·cm)	
	Spatula	1	For apply grease	
	Wiping cloth		1	For wiping grease (Flange)
		1	For wiping grease (Bolt)	
Screw (M3)	2	For flexspline removal		
Material	Wire tie	4		
Grease	Grease (SK-2)	11 g		

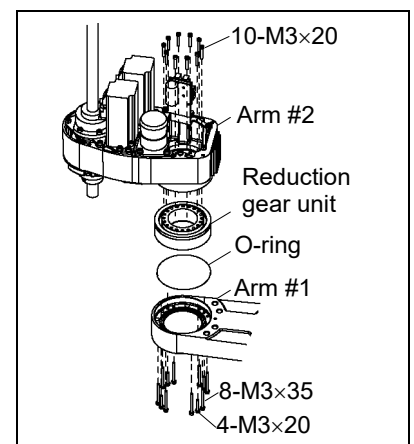
Joint #2 reduction gear unit Removal

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

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

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

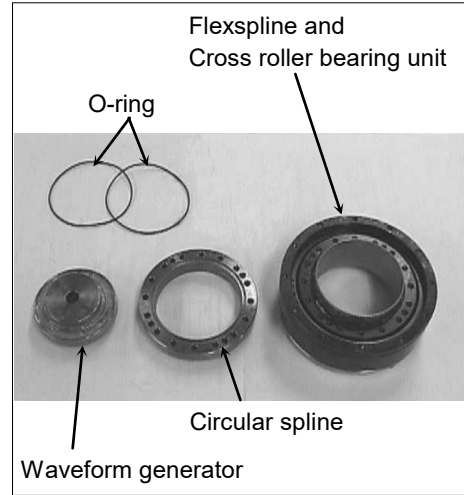
- Turn OFF the Controller.
- Execute steps from (1) to (11) in *Maintenance: 6.1 Replacing Joint #2 Motor* and remove the waveform generator from the Joint #2 motor.
- Remove the mounting screws for the Arm #2 and remove the reduction gear unit from the Arm #1.



Joint #2
reduction gear
unit
Installation

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

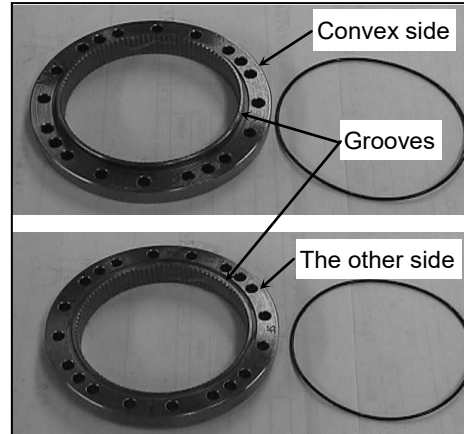
The gear grooves of the flexspline, circular spline, and the bearings of the waveform generator have been greased. Wipe off excess grease from the mounting surface.



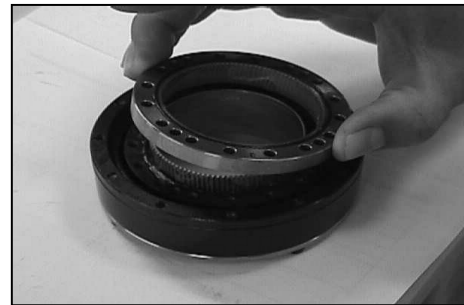
- Never adjust (loosen or tighten) the mounting bolts between the flexspline and cross roller bearing unit. If the mounting bolts are adjusted, the flexspline and cross roller bearing unit must be aligned by the maker of the reduction gear unit.

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

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



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

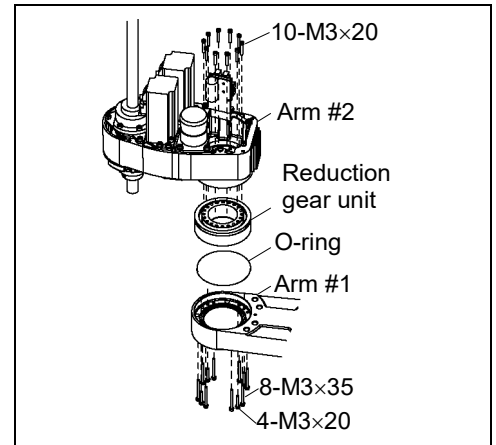


- (4) Match the screw holes on the inner ring of the cross roller bearing unit and the through holes of the circular spline.



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

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



Item	Bolt type	Number of bolts	Tightening torque
Joint #2 reduction gear unit	M3x20	10	3.0 N·m (30.6 kgf·cm)

NOTE



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

- (6) Apply grease (SK-2) inside the flexspline.
Grease volume 8 g
- (7) Install the O ring to the Arm #1.
- (8) Install and secure the flexspline.
Slide the Arm #2 to the right/left to adjust the holes position.
- (9) Execute installation steps (2) to (12) in *Maintenance: 6.1 Replacing Joint #2 Motor*.

7. Joint #3



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

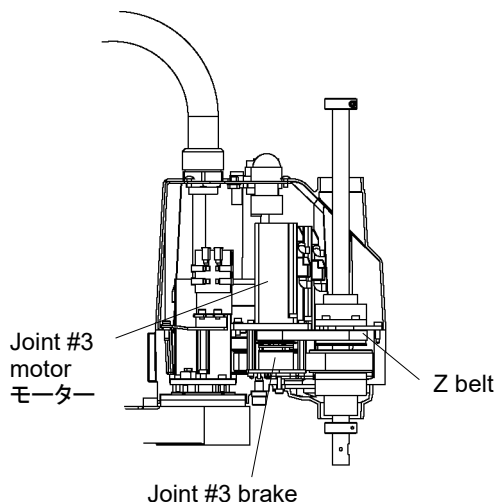


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

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

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



7.1 Replacing Joint #3 Motor

	Name	Quantity	Note	
Maintenance parts	AC Servo Motor (150W)	1	1514453	
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M4 set screw
		width across flats: 3 mm	1	For M4 screw
	Torque wrench	1		
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 74 N (7.5 ± 0.5 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	2		

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

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

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

Joint #3 motor Removal

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

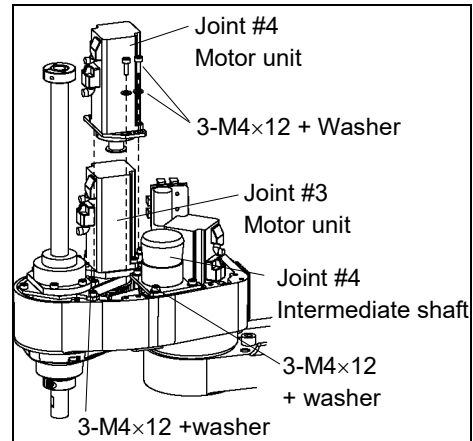
The brake release switch affects only Joints #3. When the brake release switch is pressed, the brake for Joints #3 is released simultaneously.

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

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

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

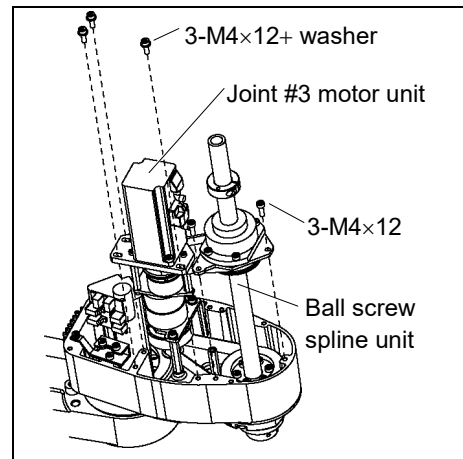
Pull the Joint #4 motor unit upward to remove.



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

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

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

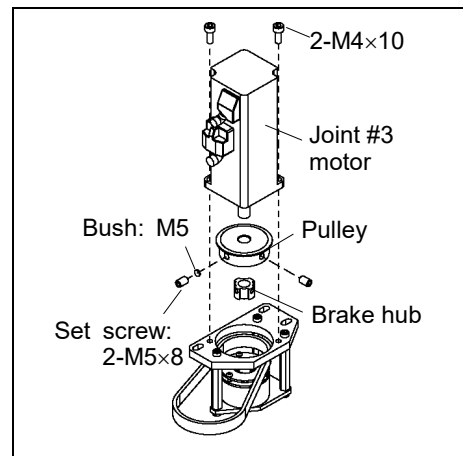


- (14) Hold the Joint #3 motor up. Pass the Z belt through the upper rotator part of ball screw spline and remove the belt.

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

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

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



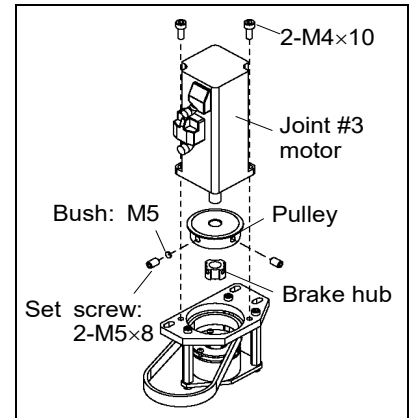
Joint #3 motor Installation

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

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

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

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



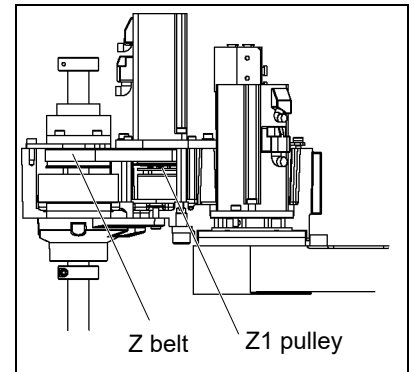
Insert a bushing into the other set screw hole to prevent damage to the motor shaft.

- (2) Mount the Z plate to the Joint #3 motor.
Screw : 4-M4x10

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

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

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



Be sure to keep the belt on the pulley.

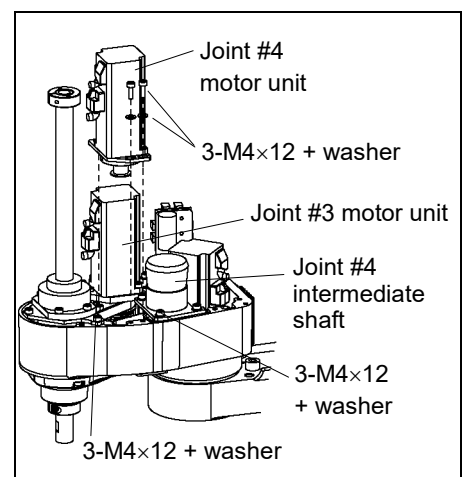
- (5) Loosely secure the Joint #3 motor unit to Arm #2.



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

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

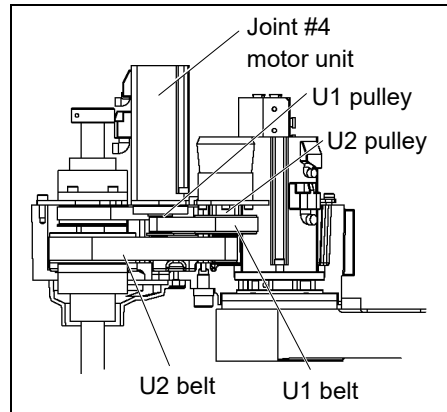
Place the Joint #4 motor unit on the Arm #2 upper side.



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

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

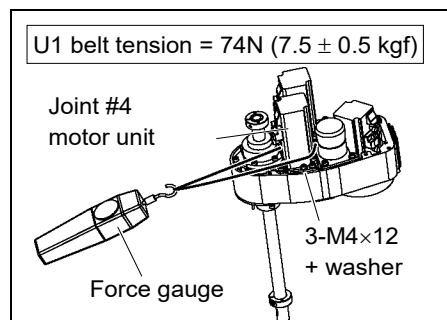
If the unit is secured too loose or too tight, the belt will not have the proper tension.



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

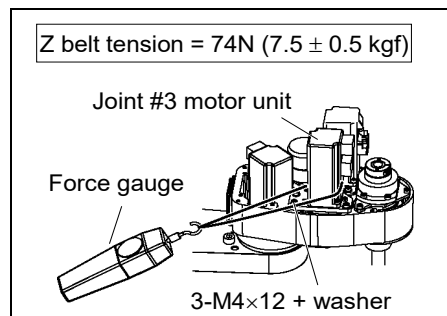
- (10) Apply the proper tension to the U1 belt, and secure the Joint #4 motor unit.

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



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

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



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

7.2 Replacing the Timing Belt

	Name		Quantity	Note
Maintenance parts	Z belt	width 9 mm	1	1510625
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
	Nippers		1	For cutting wire tie
	Force gauge		1	Belt tension 74N (7.5 ± 0.5 kgf)
	Suitable cord (Length about 800 mm)		1	For belt tension
Material	Wire tie		2	

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

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

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

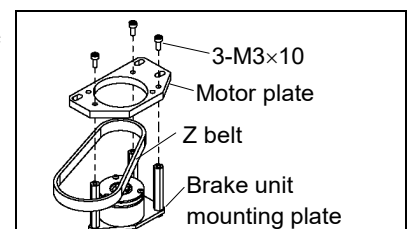
Z belt Removal

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

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

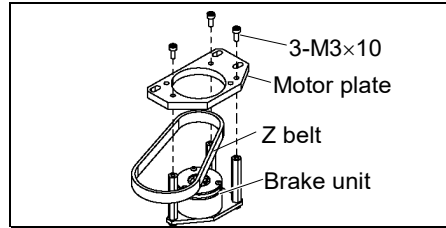
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to *Maintenance: 3. Covers*.
- (5) Remove motors of the Joint #3 and #4.
For details, refer to steps from (1) to (17) in *Maintenance: 7.1 Replacing Joint #3 Motor*.
- (6) Remove the brake unit mounting plate from the motor blade.
- (7) Remove the Z belt.

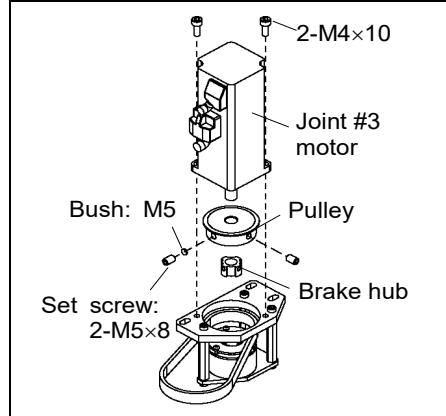


Z belt
Installation

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

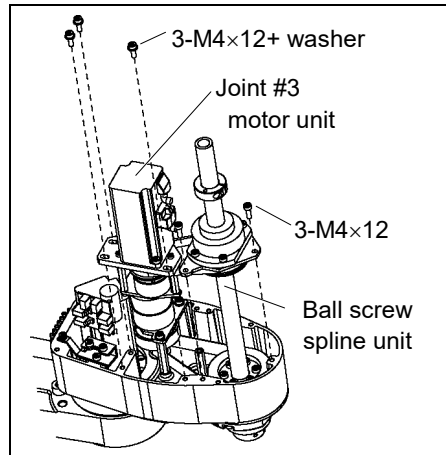


- (2) Mount the Joint #3 motor unit.



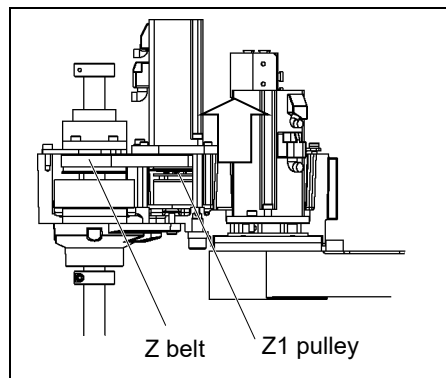
- (3) Place the Z belt of Joint #3 motor unit around the ball screw spline unit and the pulley.

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




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

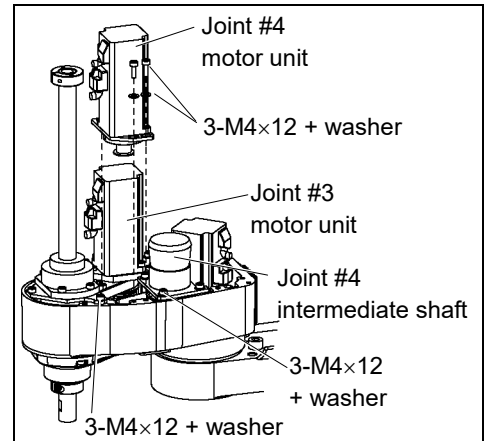
Be sure to keep the belt on the pulley.



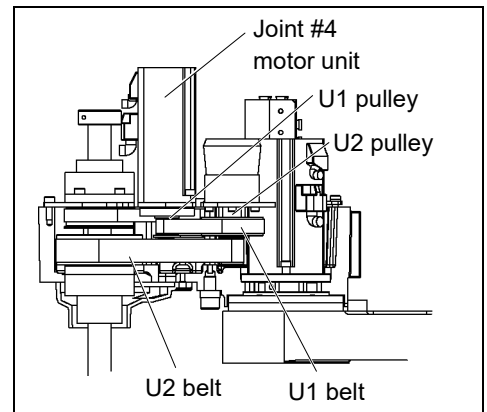
- (5) Secure the Joint #3 motor unit to Arm #2 so that the open side faces toward the end of the arm.

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

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



- (7) Loosely secure the Joint #4 motor unit to Arm #2.
Check that the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.

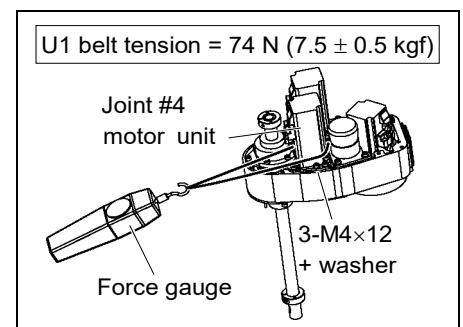


- (8) Loosely secure the spline plate to Arm #2.

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

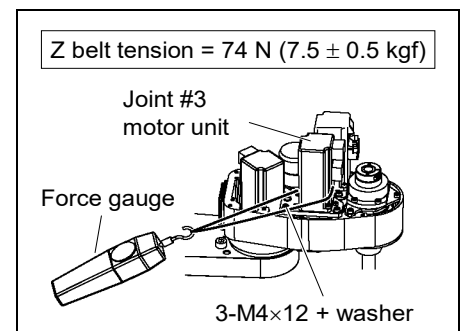
- (9) Apply the proper tension to the U1 belt, and then secure the Joint #4 motor unit.

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



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

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



- (11) Connect the connectors.

Connectors: X231, X241, X31, X32, X41

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

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

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

Do not allow unnecessary strain on the cables.

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

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

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

For details, refer to *Maintenance: 14. Calibration*.

7.3 Replacing the Brake

	Name	Quantity	Note	
Maintenance parts	Electromagnetic brake	1	1497639	
Tools	Hexagonal wrench	width across flats: 1.5 mm	1	For M3 set screw
		width across flats: 2.5 mm	1	For M3 screw
		width across flats: 3 mm	1	For M4 screw
		width across flats: 4 mm	1	For M5 screw
	Torque wrench	1		
	Nippers	1	For cutting wire tie	
	Force gauge	1	Belt tension 74N (7.5 ± 0.5 kgf)	
	Suitable cord (Length about 800 mm)	1	For belt tension	
Material	Wire tie	3		

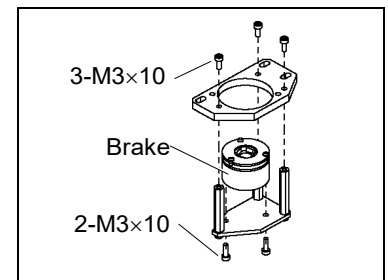
A brake is mounted on the Joint #3 motor to prevent the shaft from moving down due to the weight of the end effector while the power to the Controller is OFF or while the motor is in OFF status (MOTOR OFF).

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

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

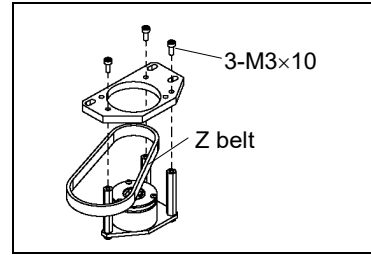
Joint #3 brake Removal

- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.
The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to *Maintenance: 3. Covers*.
- (5) Remove the Joint #3 motor.
For details, refer to *Maintenance: 7.1 Replacing Joint #3 Motor - Joint #3 motor removal step (1) to (17)*.
- (6) Remove the brake from the brake plate.
- (7) Remove the brake hub from the Joint #3 motor.



Joint #3 brake
Installation

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

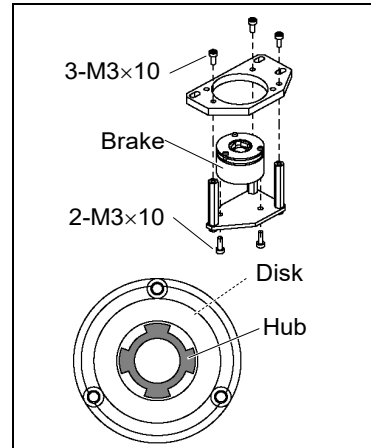


- (2) Mount the brake hub to the Joint #3 motor.

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

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

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



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

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

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

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

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

For details, refer to *Maintenance: 14. Calibration*.

8. Joint #4



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

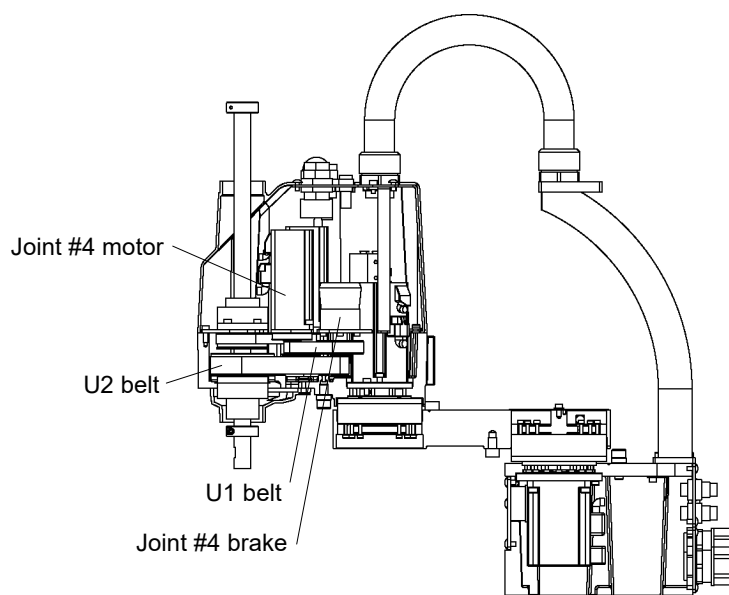


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

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

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



8.1 Replacing Joint #4 Motor

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

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

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

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

Joint #4 motor Removal

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

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

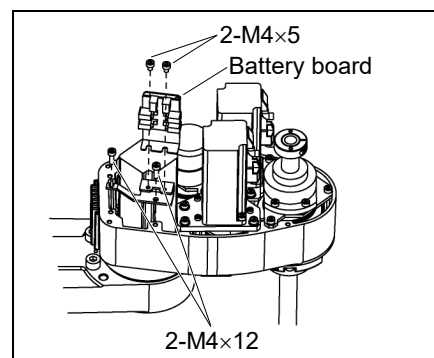
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

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

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

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

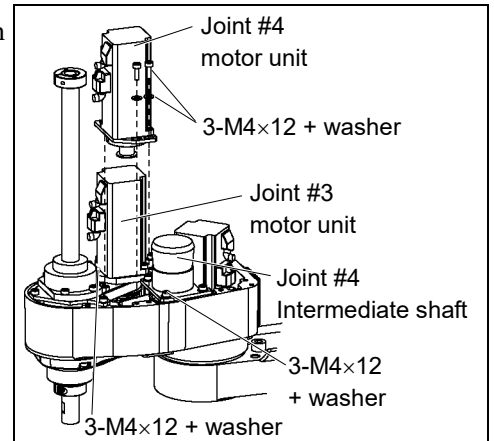
If the connector falls off, the joints other than Joint #4 need the calibration.



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

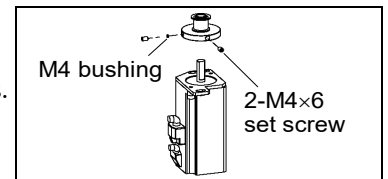
- (9) Remove the Joint #4 motor unit from Arm #2.

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



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

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



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

Screw: 2-M4x8

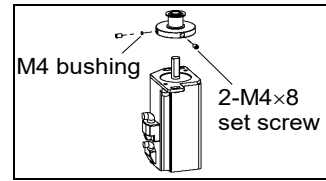
Joint #4 motor Installation

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

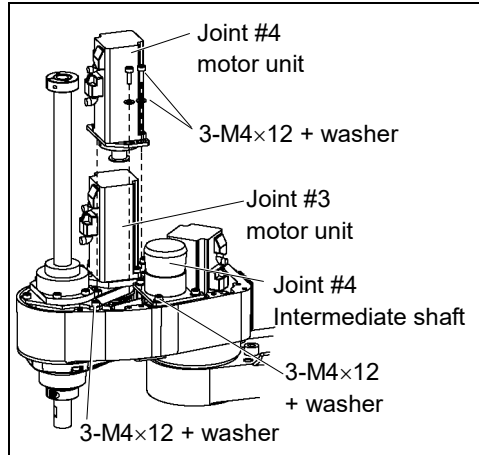
Be sure to fit the end face of the pulley to the end face of the motor shaft.

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

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



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

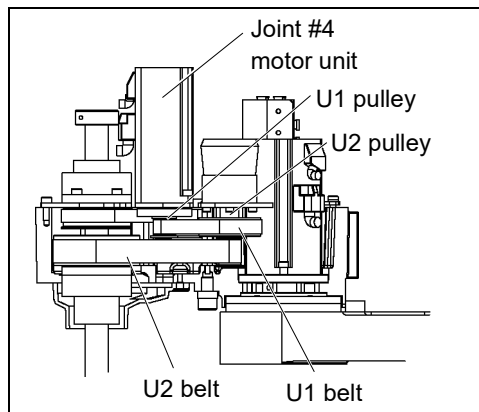


- (4) Loosely secure the Joint #4 motor unit to Arm #2.

NOTE

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

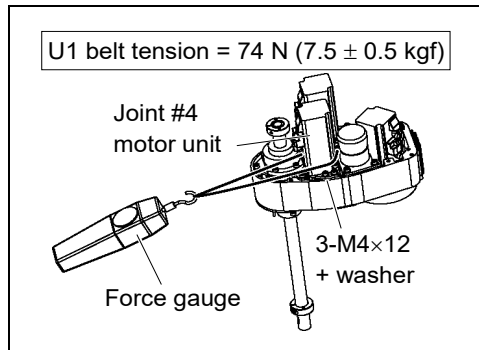
Also, check the gear grooves of the belt are fit into those of the pulleys completely.



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

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

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



- (6) Connect the connectors.
Connectors: X241, X41, X42

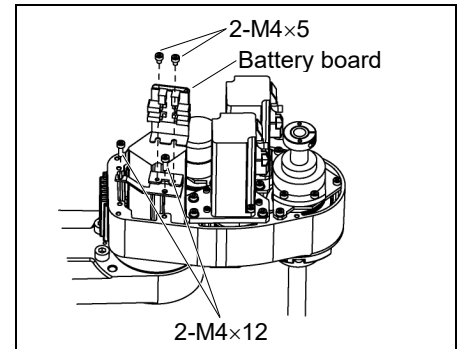
- (7) Connect the backup cable of Joint #4: X64.

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

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



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



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

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

Do not allow unnecessary strain on the cables.

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

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

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

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

8.2 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance parts	U1 belt (width 10 mm)	1	1510626
	U2 belt (width 16 mm)	1	1510627
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Spanner (width across flats: 7 mm)	1	
	Torque wrench	1	
	Force gauge	1	Belt tension 98N (10 kgf) / 74N (7.5kgf)
	Nippers	1	For cutting wire tie
	Suitable cord (Length about 800 mm)	1	For belt tension

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

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

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

U2 belt Removal

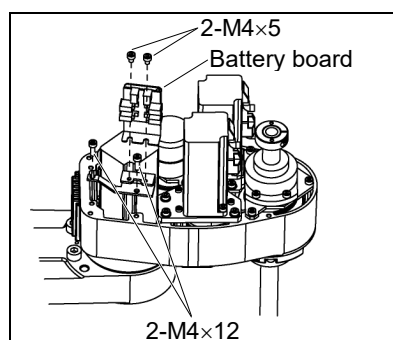
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

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

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

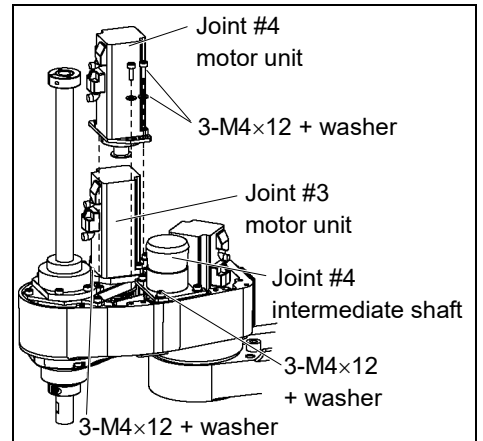
- (3) Turn OFF the Controller.
- (4) Remove the arm top cover and the arm bottom cover.
For details, refer to *Maintenance: 3. Covers*.

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



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

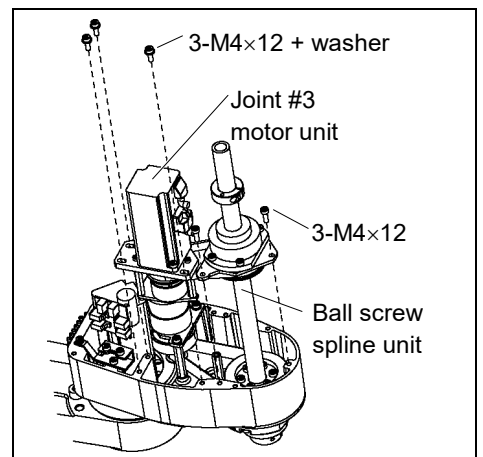
- (9) Loosen the bolts securing the Joint #4 motor unit and pull the motor unit upwards.



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

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

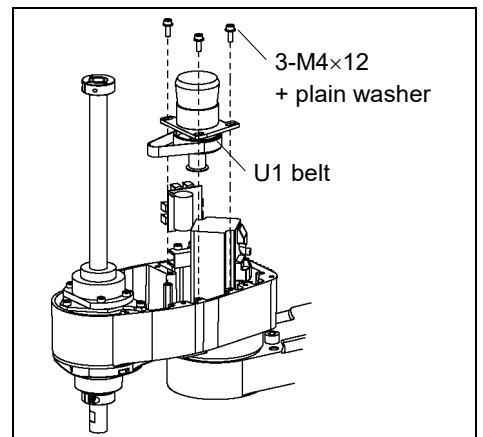
- (12) Hold the upper rotator part of ball screw spline and Joint #3 motor up together.



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

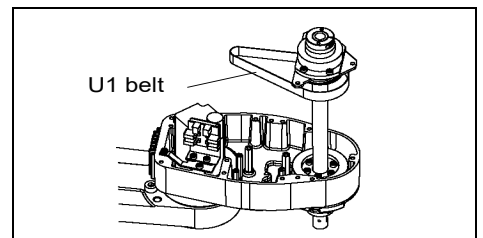
- (14) Remove the screws securing the Joint #4 intermediate shaft unit.

Pull the Joint #4 intermediate shaft unit upwards.




- (15) Remove the U1 belt.

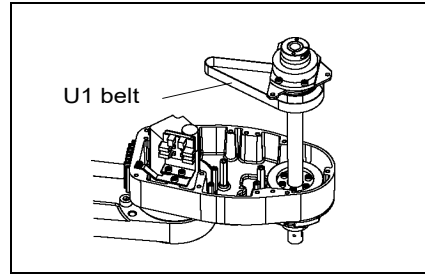
- (16) Keep the spline upper rotator part up and remove the U1 belt.




U2 belt
Installation

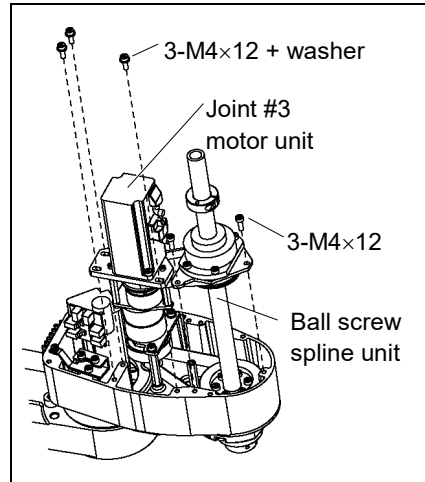
- (1) Hold the spline upper rotator part and set the U1 belt around the U1 pulley.

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



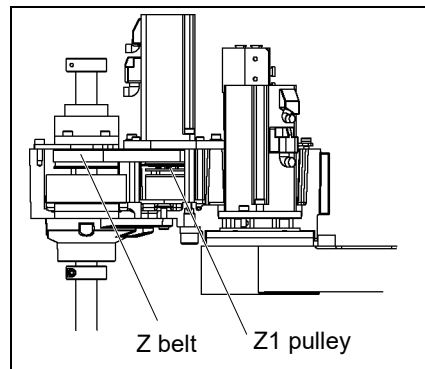
- (2) Pass the Z belt through the ball screw spline of Joint #3 motor unit and set the belt around the pulley.

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



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

Make sure the belt stays on the pulley.



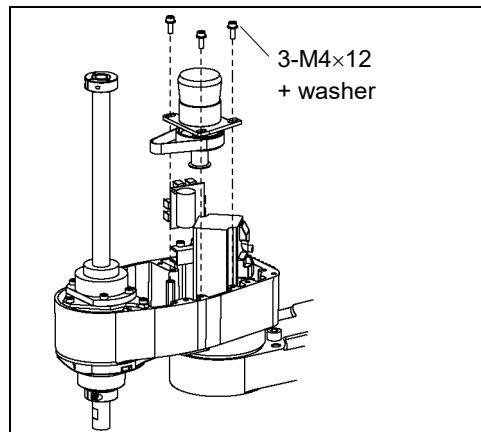
- (4) Loosely secure the Joint #3 motor unit to Arm #2.

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

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

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

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

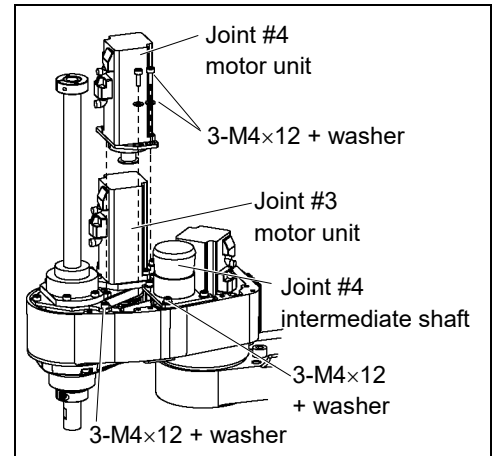


- (6) Loosely secure the Joint #4 intermediate unit with screws.

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

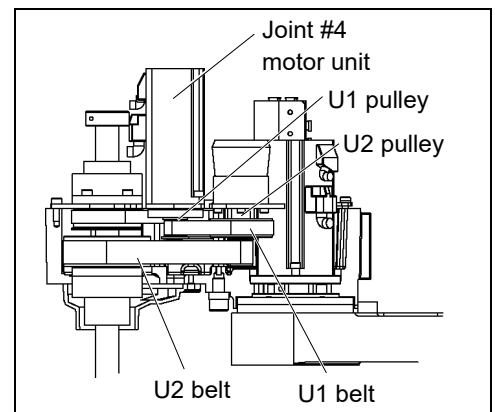
- (7) Place the Joint#4 motor unit around the U1 belt. Put the Joint #4 motor unit on the Arm #2 top surface.

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



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

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

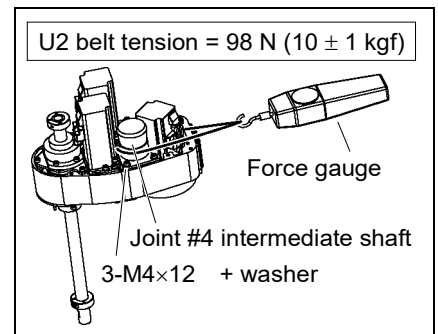


- (9) Loosely secure the spline plate to Arm #2.

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

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

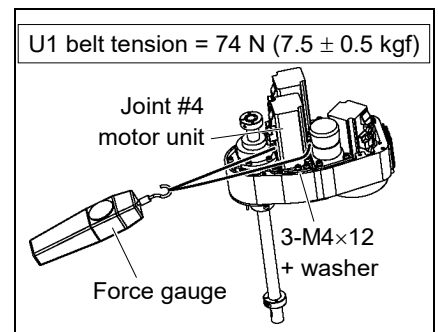
To do so, pass a suitable cord or string around the Joint #4 intermediate shaft unit near its mounting plate. Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



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

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

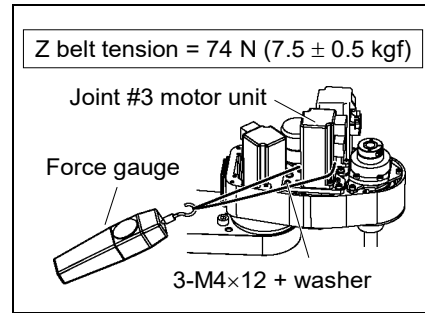
Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



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

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

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



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

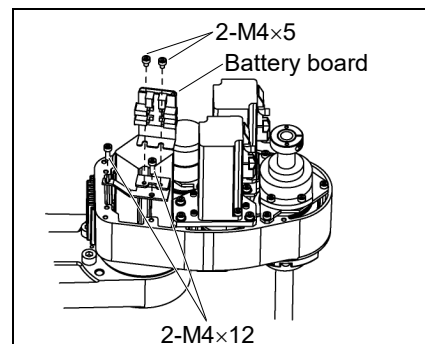
- (14) Connect the following connectors.

Connector X231, X241, X31, X32, and X41

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

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

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



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

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

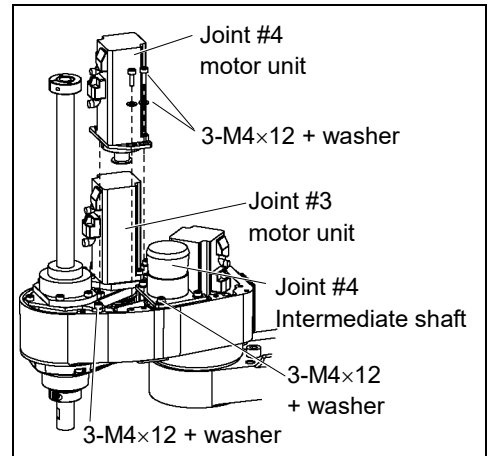
For details, refer to *Maintenance: 3. Covers*.

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

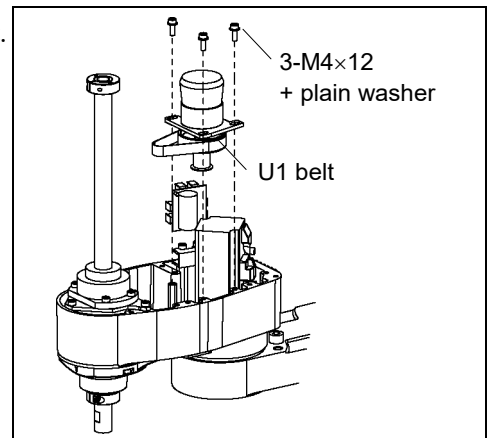
For details on the calibration method, refer to *Maintenance: 14. Calibration*.

U1 belt
Removal

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




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

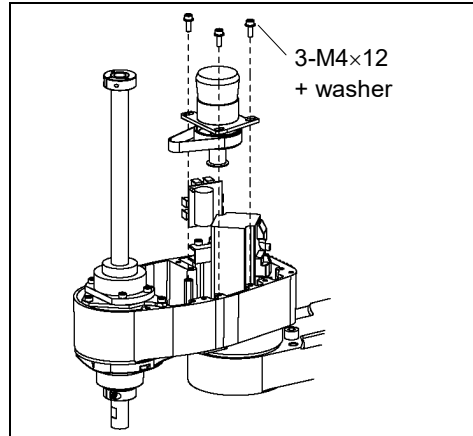


U1 belt Installation

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

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

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

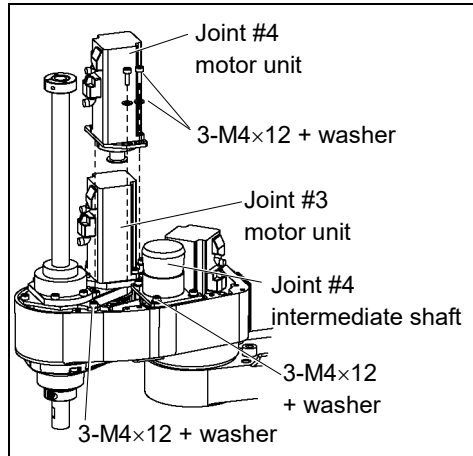


- (2) Loosely secure the Joint #4 intermediate unit.

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

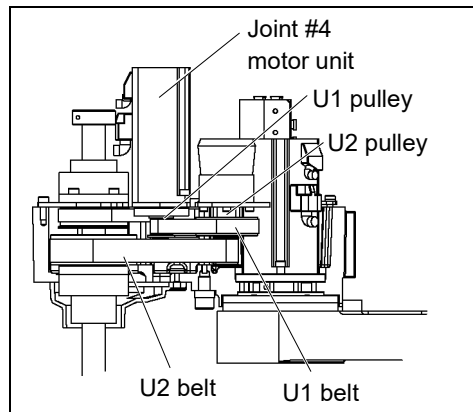
- (3) Place the pulley in the U1 belt and put the Joint #4 motor unit to Arm #2.

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



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

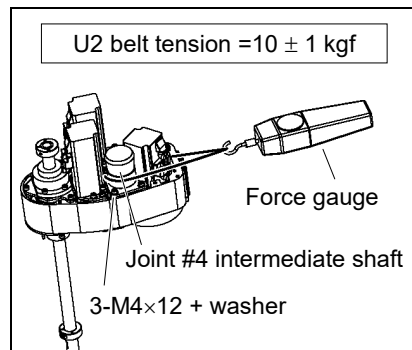
Make sure the motor unit can be moved by hand, and it will not tilt when pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



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

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

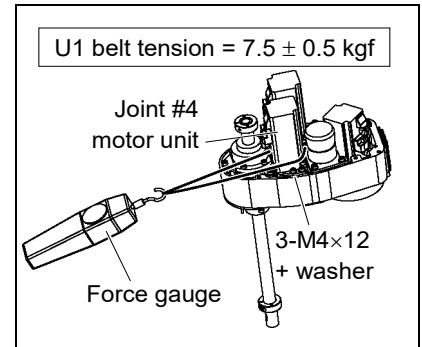
Then, pull the cord using a force gauge or similar tool to apply the specified tension shown in the figure on the right.



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

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

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



- (7) Connect the connector.

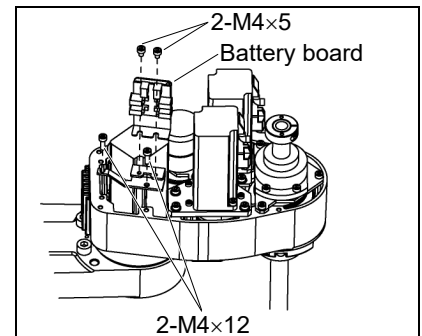
Connector: X241, X41

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

- (9) Connect the backup connectors of Joint #4, X64 to the battery board.

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

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



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

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

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

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

For details, refer to *Maintenance: 14. Calibration*.

9. Replacing Arm #1



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

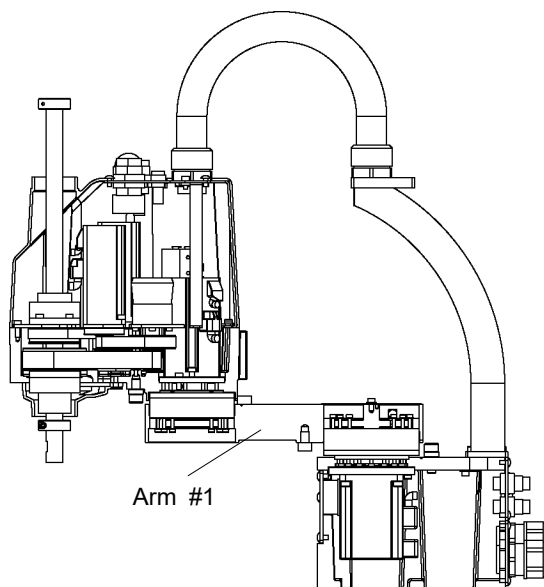


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

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

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


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



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

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

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

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

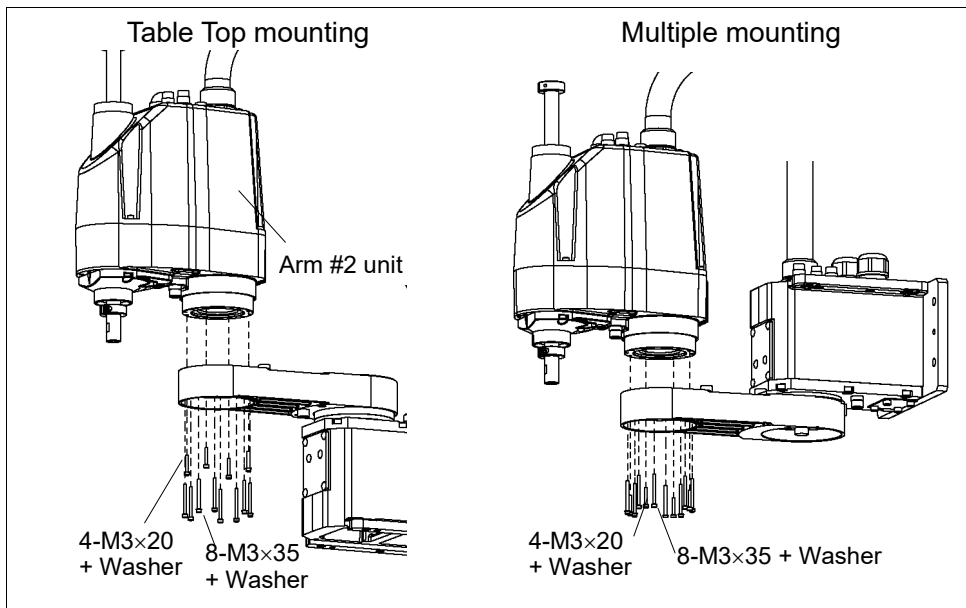
Arm #1
Removal

- (1) Remove the arm cap.
For details, refer to *Maintenance: 3.3 Arm Cap*.
- (2) Remove the harmonic mounting screws on the Joint #2 side and remove the Arm #2 unit.

This procedure should be done with an assistant. The assistant supports the Arm #2 unit.

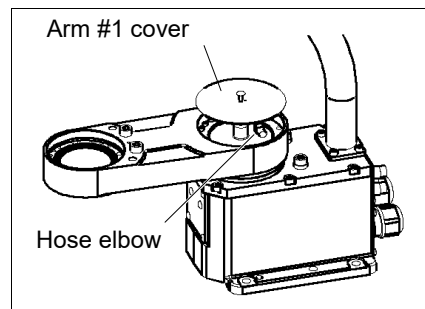
Do not allow unnecessary strain on the cables.

For Multiple mounting, removal direction of Joint "1 and #2 is the same. In this procedure, remove the only screws on the left side of figure.



- (3) Remove the O ring on the part where Arm #2 was mounted.
- (4) Remove the Arm #1 covet and hose elbow.

These parts are not attached for the Multiple mounting Manipulators.

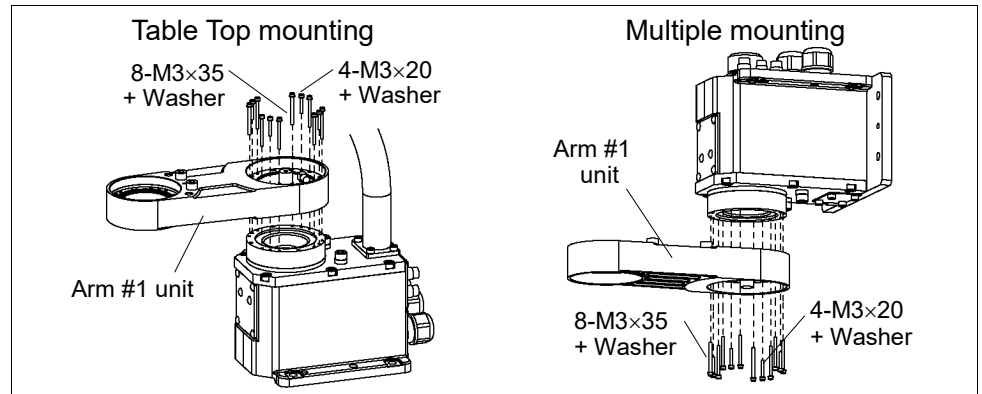


- (5) Remove the harmonic mounting screws on the Joint #1 side and remove the Arm #1 unit.

In case of Multiple mounting type,

Arm #1 falls without mounting screws. Support Arm #1 when removing the screws.

Remove the O ring which is attached to the Joint #1 mounting part.



Arm #1
Installation

- (1) Prepare the spare Arm #1 and mount the mechanical stop.
- | | | | | |
|-------------|-----------|-------|---------|-----------------------------------|
| Base side | Table Top | M8×10 | 1 unit | (Bottom surface, Center, 1 point) |
| | Multiple | M8×10 | 2 units | (Top surface, Center, 2 points) |
| Arm #2 side | | M8×10 | 2 units | (Top surface, Center, 2 points) |

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

In case of Multiple mounting type,

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

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

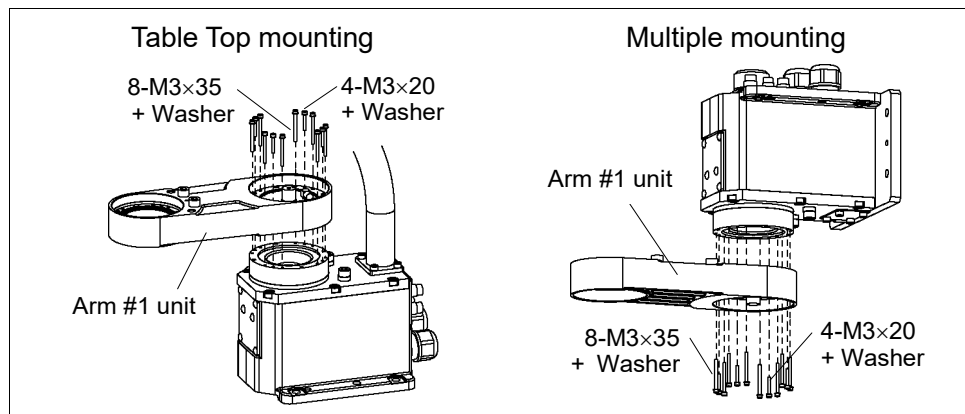
Fit with the space for the screws head of harmonic drive on Arm #1 side.

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

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

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

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



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

Apply a small amount of grease on the O ring.

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

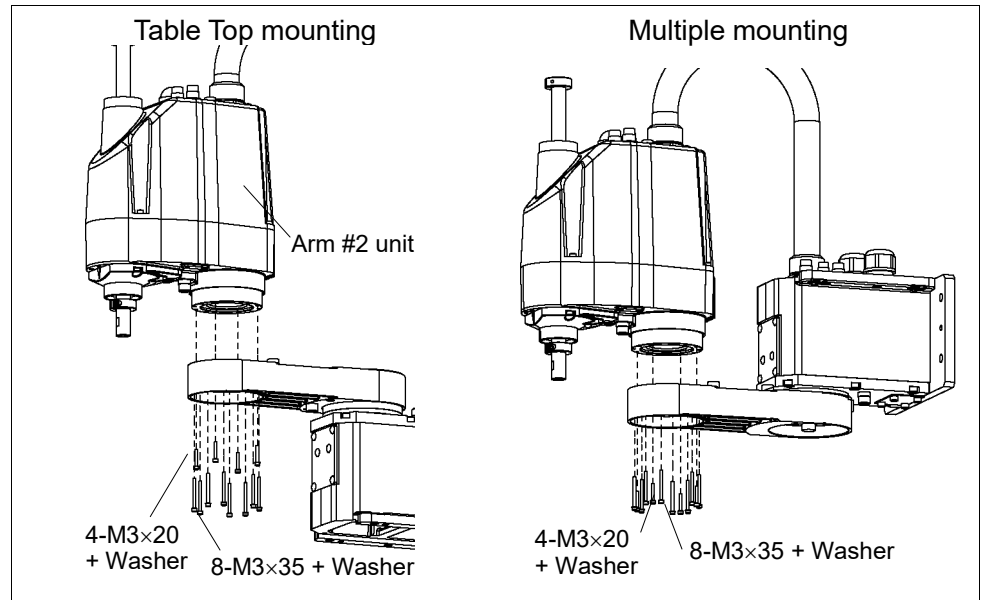
Fit with the space for the screws head of harmonic drive on Arm #2 side.

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

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

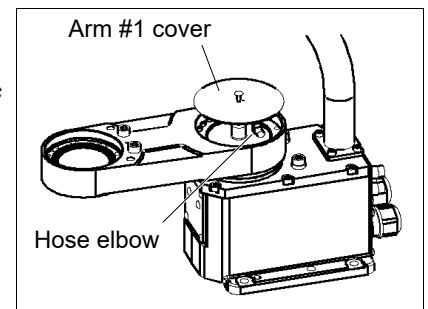
Use 35 mm screws to all side and the middle one in each side is 20 mm.

Do not use screws of different length. It causes a malfunction.



- (7) Mount the hose elbow and Arm #1 cover.

These parts are not attached to the Multiple mounting Manipulators.



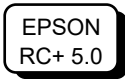
- (8) Put the $\theta 2$ movement direction label to the end of Arm #1, in Arm #2 side.



CAUTION

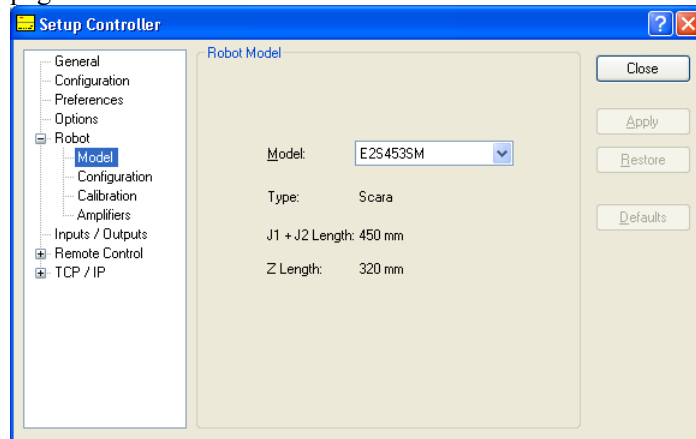
- After replacing the arm, do not fail to change the robot model in the software. If the model is different, it may cause a robot to malfunction. Also, the robot may collide with the mechanical stop and break it.

(9) Change the robot model.



(9)-1 From the Setup Menu, select Controller.

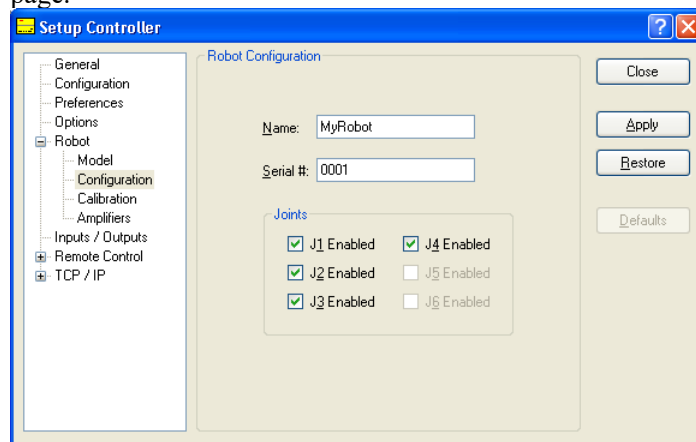
(9)-2 Click on the Robot folder in the tree on the left side to open the Robot Model page.



(9)-3 Select the model for your robot from the Model dropdown list. Only robot models that can be used with the amplifiers currently in the controller are listed. When using Dry Run, all robot models are shown in the list.

(9)-4 Click the **Apply** button to save settings.

(9)-5 Click on Robot Configuration in the tree to open the Robot Configuration page.



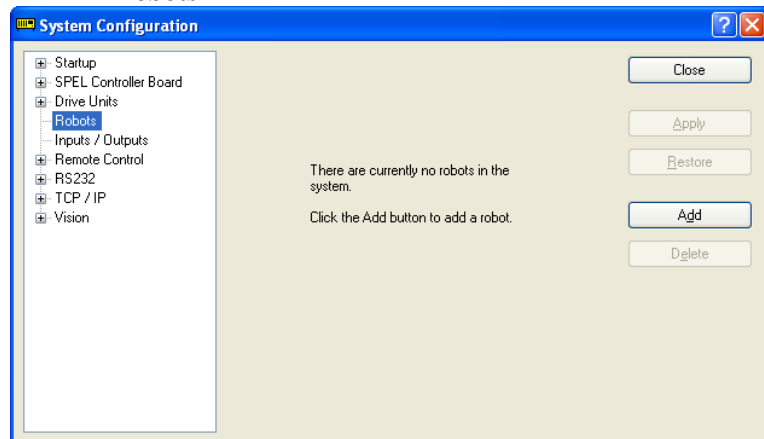
(9)-6 Type in a name for the new robot and enter the serial number from the robot's nameplate. Any serial number can be used, but it is recommended that you use the number that is stamped on the robot.

(9)-7 Click **Apply** to save settings.

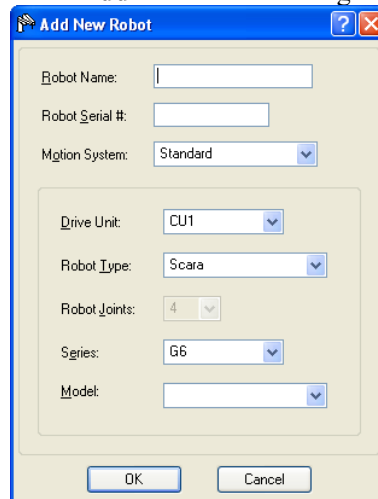
EPSON
RC+ 6.0

(9)-1 From the Setup Menu, select System Configuration.

(9)-2 Click on **Robots** in the tree on the left.



(9)-3 Click **Add** and the next dialog will appear.



(9)-4 Type in a name for the new robot and enter the serial number from the robot's nameplate. Any serial number can be used, but it is recommended that you use the number that is stamped on the robot.

(9)-5 Select a motion system to use from the [Motion System] dropdown list. If there are no other motion systems installed, then "Standard" will already be selected.

(9)-6 Select a Drive Unit for your robot from the [Drive Unit] dropdown list.

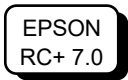
(9)-7 Select a robot type from the [Robot type] box.

(9)-8 Select a robot series from the [Series] dropdown list.

(9)-9 Select a robot model from the [Model] dropdown list.

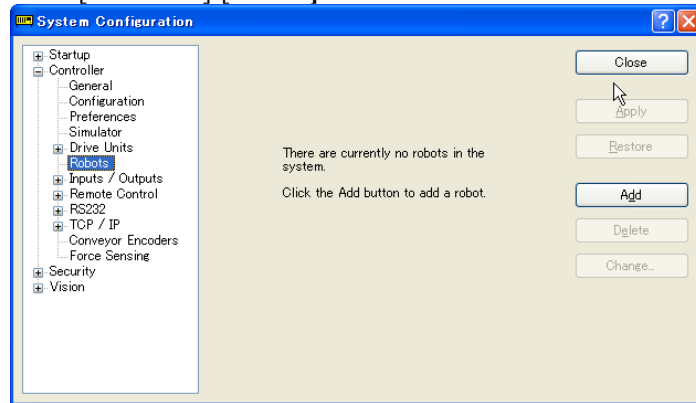
After you select a robot model, all robots available for the type of motor driver currently installed in the controller will be shown. If you use [Dry run], all robots selected in step 8 will be shown.

(9)-10 Click **OK** and the controller will be rebooted.

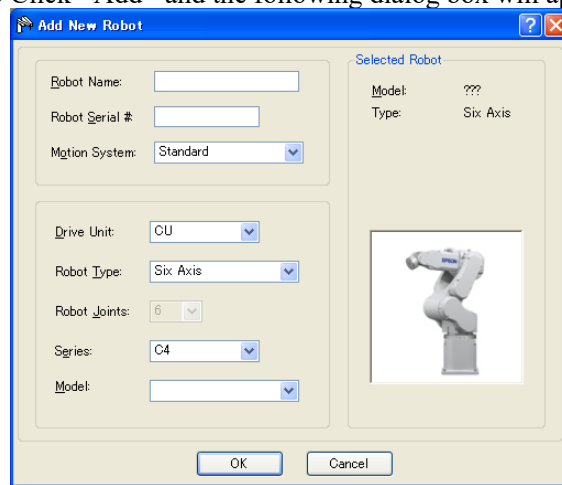


(9)-1 From the Setup Menu, select System Configuration.

(9)-2 Click [Controller]-[Robots] in the tree on the left.



(9)-3 Click <Add> and the following dialog box will appear.



(9)-4 Type in a name for the new manipulator and enter the serial number on the manipulator’s nameplate. Any serial number can be used, but it is recommended that you use the number that is stamped on the manipulator.

(9)-5 Select a motion system to use from the [Motion System] dropdown list. If there are no other motion systems installed, then “Standard” will already be selected.

(9)-6 Select a Drive Unit for your manipulator from the [Drive Unit] dropdown list.

(9)-7 Select a manipulator type from the [Robot type] box.

(9)-8 Select a manipulator series from the [Series] dropdown list.

(9)-9 Select a manipulator model from the [Model] dropdown list.

After you select a manipulator model, all manipulators available for the type of motor driver currently installed in the controller will be displayed. If you use [Dry run], all robots selected in step 9 will be shown.

(9)-10 Click <OK> and the controller will be rebooted.

(10) Perform the calibration of Joint #1, #2.

For details, refer to *Maintenance: 14. Calibration*.

10. Bellows

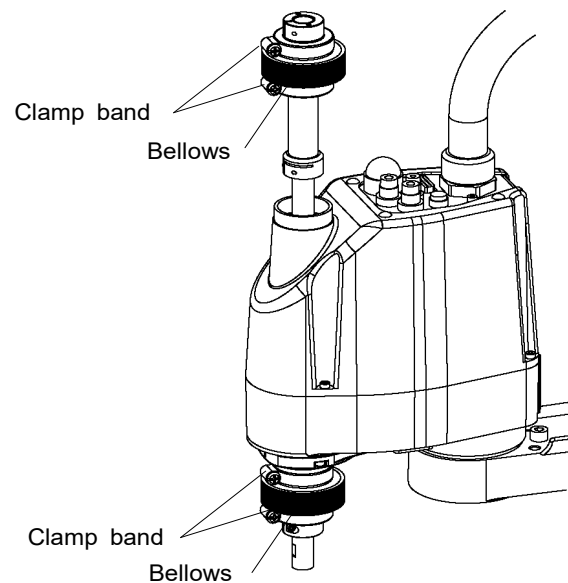


The bellows are provided in a unit of one piece. The upper and lower bellows have the same shape.

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

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

	Name		Quantity	Note
Maintenance parts	Bellows	120 mm	1	1513008
Tools	Cross-point screwdriver		1	For clamp band removal



Bellows Removal

- (1) Remove the end effector.
- (2) Remove the wires and tubes from the end effector.
- (3) Turn ON the controller. Stop motor excitation. (MOTOR OFF)
- (4) Loosen the two clamp bands on each bellows.
- (5) Pull the bellows and clamp bands out of the shaft.

Bellows
Installation

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

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

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

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

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

- (2) Pass the shaft through the bellows from the larger joint.
- (3) Secure the cover side of the bellows.

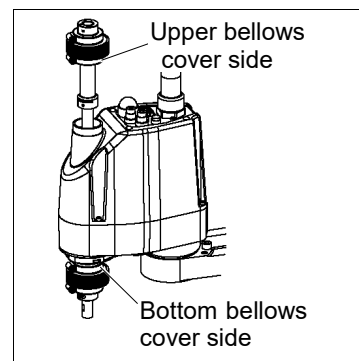
The bellows has two joints:

The larger joint must be attached to the cover side.

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

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

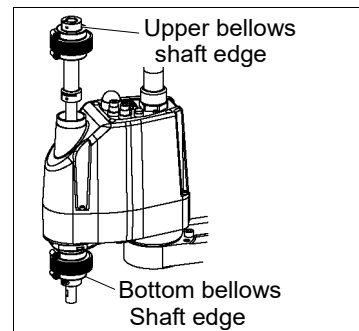
Then, secure them with clamp bands.



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


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


Then, secure them with clamp bands.



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


11. Ball Screw Spline Unit

 <p>WARNING</p>	<ul style="list-style-type: none"> ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system. ■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
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- NOTE**  After parts have been replaced (motors, reduction gear units, brakes, timing belts, ball screw spline unit, etc.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller. After replacing the parts, it is necessary to match these origins. The process of aligning the two origins is called “Calibration”. Refer to *Maintenance: 14. Calibration* to perform the calibration.

11.1 Greasing the Ball Screw Spline Unit

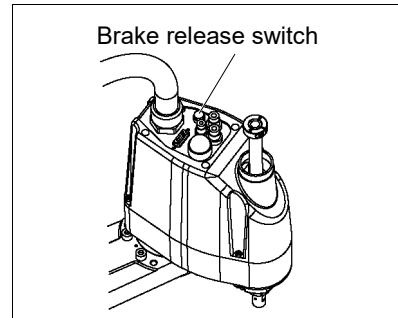
	Name	Quantity	Note
Grease	For Ball Screw Spline Unit (AFB grease)	Proper quantity	
Tools	Wiping cloth	1	For wiping grease (Spline shaft)
	Cross-point screwdriver	1	For clamp band removal Only for Cleanroom-model and Protected-model

- NOTE**  The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously. Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of the end effector.

11.1.1 Standard-model (S type)

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

- (1) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)
- (2) Move the arm to a position where Joint #3 can be moved in full stroke.
- (3) Move the shaft to its upper limit manually while pressing the brake release switch.
- (4) Turn OFF the Controller.
- (5) Wipe off the old grease from the upper part of the shaft, and then apply new grease to it.



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

- (6) Turn ON the Controller.
- (7) Move the shaft to its lower limit by hand while pressing the brake release switch.
- (8) Wipe off the old grease from the lower part of the shaft, and then apply new grease to it.

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

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

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

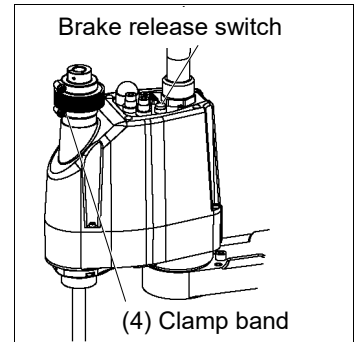
For details, refer to *Maintenance: 3.1 Arm Top Cover*.

11.1.2 Cleanroom-model (C with bellows)

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

Upper Part of the Shaft

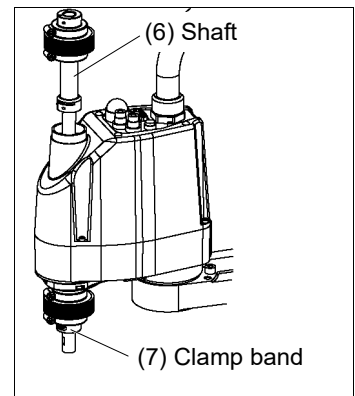
- (1) Turn ON the Controller. Stop motor excitation. (MOTOR OFF)
- (2) Move the arm to a position where Joint #3 can be moved in full stroke.
- (3) Move the shaft to its lower limit manually while pressing the brake release switch.
- (4) Loosen the clamp band under the bellows, and then lift the bellows.
- (5) Move the shaft to its upper limit manually while pressing the brake release switch.



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

Directly fill the grooves on the shaft inside the bellows with grease by hand.

Wipe off excess grease from the shaft.



Lower Part of the Shaft

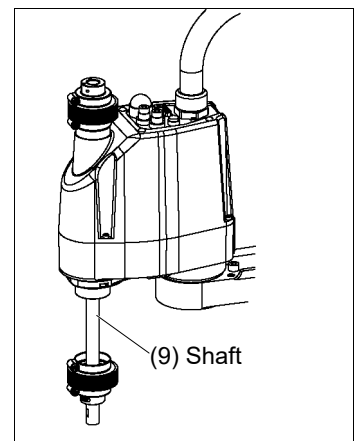
- (7) Loosen the clamp band on the bellows, and then move the bellows downward.
- (8) Move the shaft to its lower limit manually while pressing the brake release switch.

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

Directly fill the grooves on the shaft inside the bellows with grease by hand.

Wipe off excess grease from the shaft.

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



- (11) Secure the bellows.

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.

Attach the mounting part of the bellows until it touches the cylindrical part of the cover. Then, secure them with clamp bands.

11.2 Replacing the Ball Screw Spline Unit

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

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

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

	Name	Quantity	Note
Maintenance parts	Ball Screw Spline Unit	1	Each manipulator model (Refer to <i>Maintenance: 15. Maintenance parts</i>)
Grease	For Ball Screw Spline Unit (AFB grease)	Proper quantity	
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Torque wrench	1	
	Nippers	1	For cutting wire tie
	Cross-point screwdriver	1	Only for Cleanroom-model
	Force gauge	1	Belt tension 98 N (10 kgf) / 74 N (7.5 kgf)
	Suitable cord (Length about 1000 mm)	1	For belt tension
	Wiping cloth	1	For wiping grease (Spline shaft)
Material	Wire tie	2	

Ball screw spline unit Removal

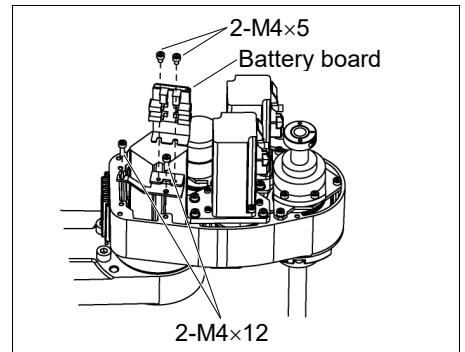
- (1) Turn ON the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.

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

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

- (3) Turn OFF the Controller.
- (4) Detach the wires/tubes from the end effector, and remove the end effector.
- (5) This step is only for Cleanroom-model (C with bellows option).
Remove the bellows. For details, refer to *Maintenance: 10. Bellows*.
- (6) Remove the arm top cover and arm bottom cover.
For details, refer to *Maintenance: 3. Covers*.

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



- (8) Remove the user plate and grounding wire from Arm #2.

- (9) Disconnect the following connectors.

Connectors X231, X31, X341, X41 (Hold the clip to remove.)

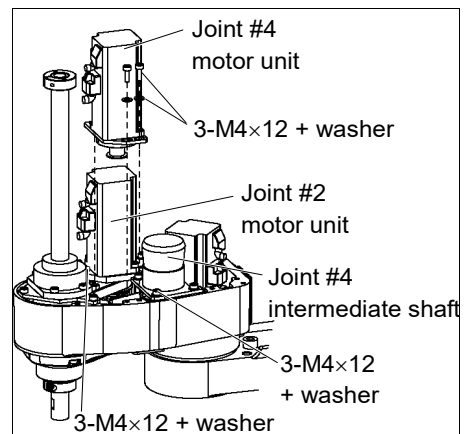
Connector X32

Connector X63, X64 (Backup cable connector for Joint #3, #4)

- (10) Remove the motor unit by pulling it up.

Remove the bolts securing the Joint #4 motor unit.

- (11) Remove the screws securing the ball screw spline of Arm #3 surface.

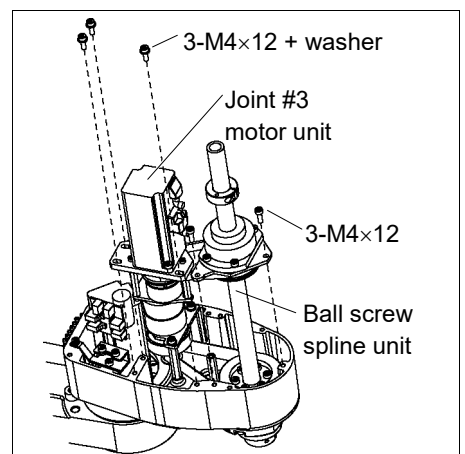


- (12) Remove the screws securing the Joint #3 motor unit.

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

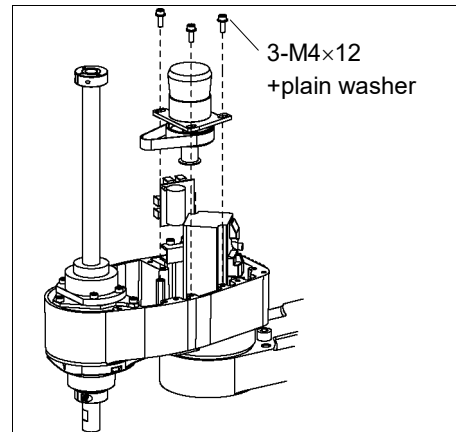
- (14) Hold the Joint #3 motor up.

Remove the belt by passing through the spline rotator part.



- (15) Remove the screws securing the Joint #4 intermediate unit.

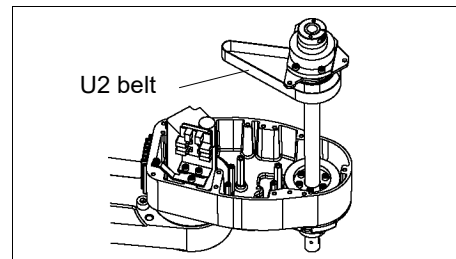
Remove the unit by pulling it up.



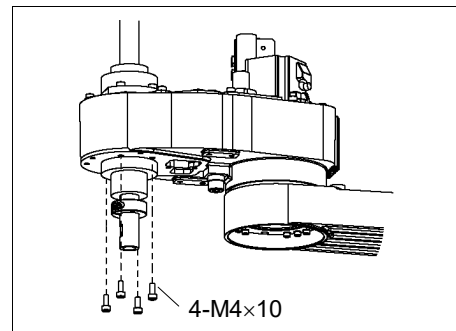
- (16) Remove the U2 belt.

- (17) Hold the spline upper rotator part.

Remove the U2 belt.



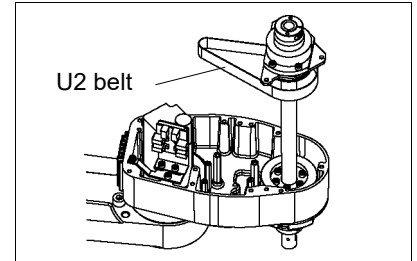
- (18) Remove the mounting screws of the ball screw spline shaft on the lower part of Arm #2.



- (19) Remove the ball screw spline unit by pulling it upward from Arm #2.

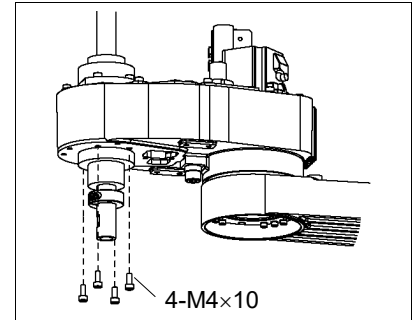
Ball screw
spline unit
Installation

- (1) Pass the U2 belt through the ball screw spline unit and U3 pulley and insert the belt to Arm #2 from above.




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


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



- (3) Mount the ball screw spline unit.
For the procedure, refer to *Maintenance: 8. Arm #4 – 8.2 Replacing the Timing Belt – U2 belt installation.*
- (4) Grease the shaft.
For details, refer to *Maintenance: 11.1. Greasing the Ball Screw Spline Unit.*
- (5) Install the arm top cover and arm bottom cover.
For details, refer to *Maintenance: 3. Covers.*
- (6) Turn OFF the Controller and peripheral equipment.
- (7) Install the end effector, and connect wires and tubes.
- (8) This step is only for Cleanroom-model. Install the bellows.
For details, refer to *Maintenance: 10. Bellows.*
- (9) Perform the calibration of Joints #3 and #4.
For details, refer to *Maintenance: 14. Calibration.*


12. Lithium Battery

 <p>WARNING</p>	<ul style="list-style-type: none">■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
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 <p>WARNING</p>	<ul style="list-style-type: none">■ Use meticulous care when handling the lithium battery. Improper handling of the lithium battery as mentioned below is extremely hazardous, may result in heat generation, leakage, explosion, or inflammation, and may cause serious safety problems. <Improper Handling><ul style="list-style-type: none">- Battery Charge- Deformation by Pressure- Disassembly- Short-circuit (Polarity; Positive/Negative)- Incorrect Installation- Heating (85°C or more)- Exposing to Fire- Soldering the terminal of the lithium battery directly- Forced Discharge■ When disposing of the battery, consult with the professional disposal services or comply with the local regulation. Spent battery or not, make sure the battery terminal is insulated. If the terminal contacts with the other metals, it may short and result in heat generation, leakage, explosion, or inflammation.
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In case of the low lithium battery power, the error to warn the voltage reduction occurs at the Controller startup (the software startup). All position data will be lost and you will need to calibrate all joints.

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

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

For details, refer to the following manual.

Robot Controller RC700 / RC700-A Maintenance 6. Alarm

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

For details, refer to the following manual.

Robot Controller RC180 "Appendix. Alarm"

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

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

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

(Refer to *Maintenance: 15. Maintenance Parts List.*)

Be careful of the battery polarity to connect it correctly.

	Name	Quantity	Note
Maintenance parts	Battery unit (Lithium battery)	1	2117879
	Battery board	1	2120180
Tools	Nippers	1	For cutting wire tie
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
Material	Wire tie	2	For fixing battery unit (battery)
		2	For fixing cable

12.1 Replacing the Battery Unit (Lithium Battery)

Battery unit (lithium battery) Removal

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

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

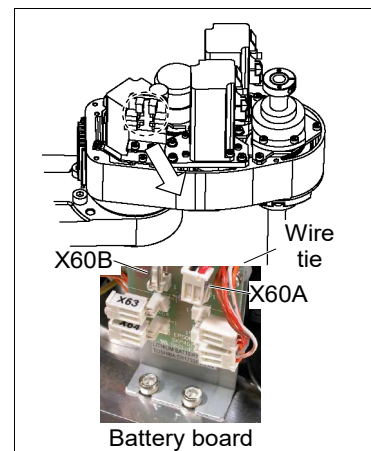
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Remove the arm top cover.
For details, refer to *Maintenance: 3.1 Arm Top Cover*.

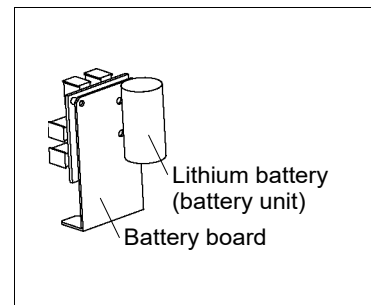
- (4) Connect the connector of the new lithium battery (battery unit) to the battery board.

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

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



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



Battery unit (lithium battery) Installation

- (1) Mount the new lithium battery to the battery board.
- (2) Fix the cable of lithium battery and connector cable connecting to battery board with wire tie. Refer to the *Removal step (4)*.
- (3) Mount the arm top cover.
For details, refer to *Maintenance: 3.1 Arm Top Cover*.
- (4) Turn ON the Controller.
- (5) Check if the Manipulator moves to points (poses) correctly.
To do so, select 2 points (poses) or more from the registered points (poses) and move the Manipulator to the points (poses).
- (6) If the Manipulator does not move to the points (poses) correctly, perform the calibration of all joints and axes.

For details, refer to *Maintenance: 14. Calibration*.

12.2 Replacing the Battery Board

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

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

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

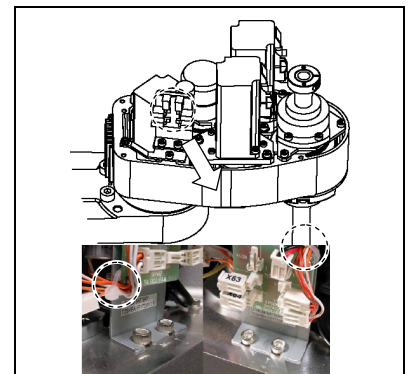
Refer to *Maintenance: 14. Calibration* to perform the calibration.

Battery board Removal

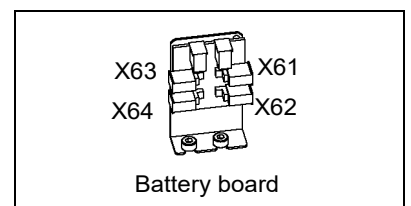
- (1) Turn OFF the Controller.
- (2) Push down the shaft to its lower limit while pressing the brake release switch. Be sure to keep enough space and prevent the end effector hitting any peripheral equipment.
The brake release switch affects only Joint #3. When the brake release switch is pressed, the brake for Joint #3 is released simultaneously.
Be careful of the shaft while the brake release switch is being pressed because the shaft may be lowered by the weight of an end effector.

- (3) Remove the arm top cover.
For details, refer to
Maintenance: 3.1 Arm Top Cover.

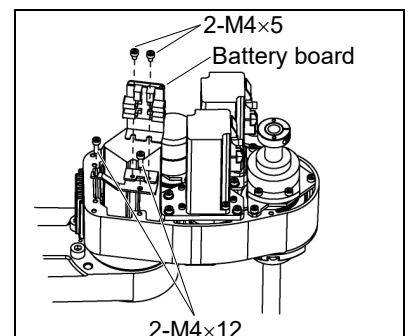
- (4) Disconnect the wiring tie connecting the connector cable.



- (5) Disconnect the connectors X61, X62, X63, and X64 from the battery board.

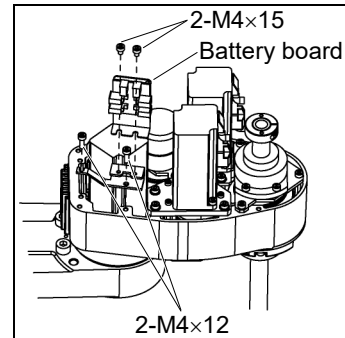


- (6) Loosen the screws securing the battery board and remove the battery board.

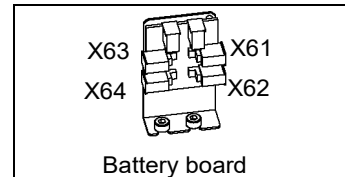


Battery board
Installation

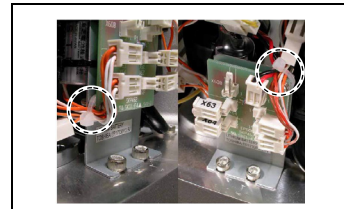
- (1) Mount the new battery board and secure it with screws.



- (2) Connect the connectors.
Connectors: X61, X62, X63, X64



- (3) Fix the connector cable with wiring tie.
Refer to *Removal step (4)*.



- (4) Mount the arm top cover.
For details, refer to *Maintenance: 3.1 Arm Top Cover*.
- (5) Turn ON the Controller.
- (6) Perform the calibration of all joints.
For details, refer to *Maintenance: 14. Calibration*.

13. LED Lamp

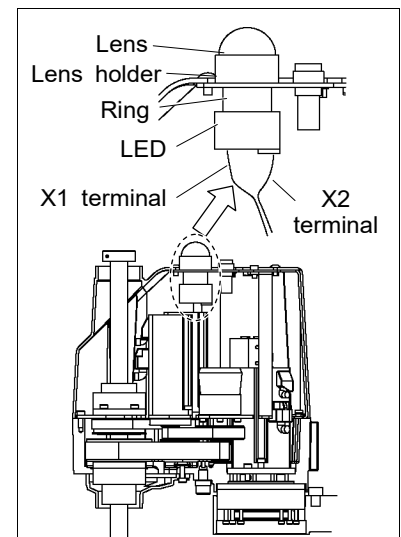


- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric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

	Name	Quantity	Note
Maintenance parts	LED Lamp	1	2077258
Tools	Cross-point screwdriver	1	For wire removal
	Nippers	1	
Material	Wire tie	1	

LED Lamp Removal

- (1) Remove the arm top cover.
For details, refer to *Maintenance: 3.1 Arm Top Cover*.
- (2) Remove the user plate from the Arm #2 cover.
- (3) Disconnect the X1 and X2 terminals from the LED.
- (4) Turn the lens counterclockwise to remove it. Then, turn the lens holder counterclockwise to remove it.
- (5) Remove the LED and ring from the user plate.



LED Lamp Installation

- (1) Connect the X1 and X2 terminals to the LED.
Each terminal must be connected to its terminal number on the LED.
- (2) Put the user plate between the ring and lens holder, and then mount the LED on the arm top cover.
- (3) Install the lens to the lens holder.
- (4) Mount the user plate to Arm #2.
- (5) Install the arm top cover.
For details, refer to *Maintenance: 3.1 Arm Top Cover*.

14. Calibration


14.1 About Calibration

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

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

The process of aligning the two origins is called “Calibration”. Note that calibration is not the same as teaching*.

*: “Teaching” means to teach the Controller coordinate points (including poses) anywhere in the operating area of the Manipulator.

 <p>WARNING</p>	<ul style="list-style-type: none">■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to EPSON RC+ User’s Guide: <i>2.4 Installation and Design Precautions</i>.■ Before operating the robot system, make sure that no one is inside the safeguarded area. The robot system can be operated in the mode for teaching even when someone is inside the safeguarded area. The motion of the Manipulator is always in restricted (low speeds and low power) status to secure the safety of an operator. However, operating the robot system while someone is inside the safeguarded area is extremely hazardous and may result in serious safety problems in case that the Manipulator moves unexpectedly.
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Command Input

Calibration procedures include the process to input commands. Select EPSON RC+ menu-[Tools]-[Command Window] to use the command window.

The information above is omitted in the calibration procedure.

Jog Motion

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

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

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



14.2 Calibration Procedure

EPSON RC+ has a wizard for calibration.

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

EPSON
RC+ 5.0

You can also calibrate with option TP1 in TEACH mode. For details, refer to RC180/RC90 option Teach pendant *TP1 manual, Operation: 2.7 Calibrating Origin: E2 Series / G Series / RS series*.

The same calibration procedure is used for each joint.

The 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: 14.3 Accurate Calibration of Joint #2*.

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

NOTE
☞

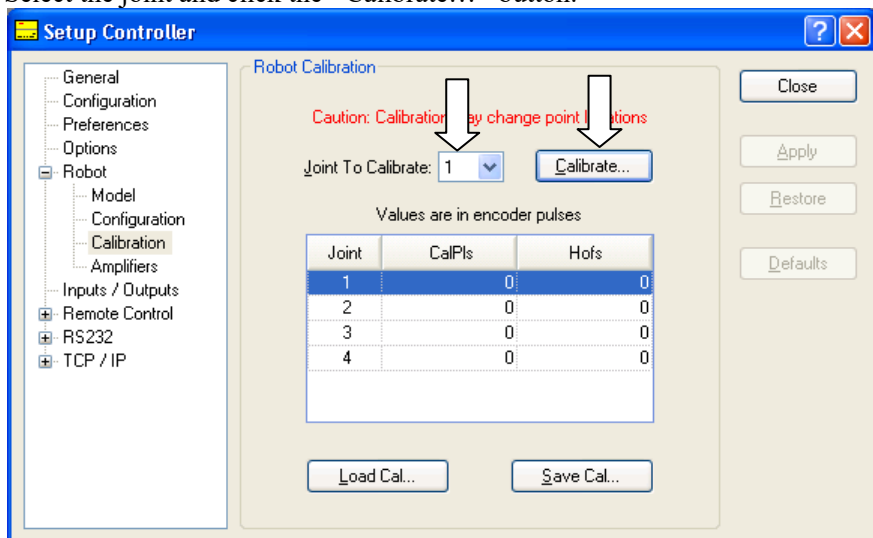
If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *Maintenance: 14.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.

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

(1) Start the calibration wizard.

EPSON
RC+ 5.0

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



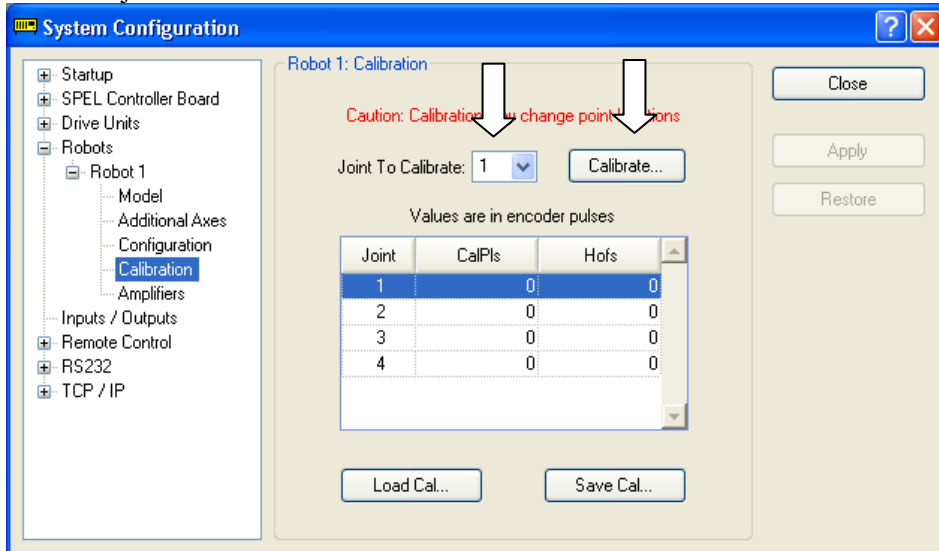
EPSON
RC+ 7.0

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

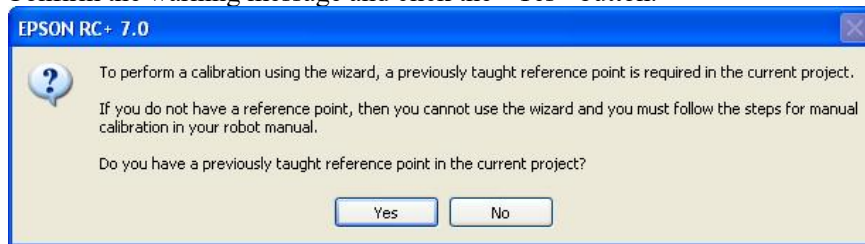


Only selected robot can be calibrated.

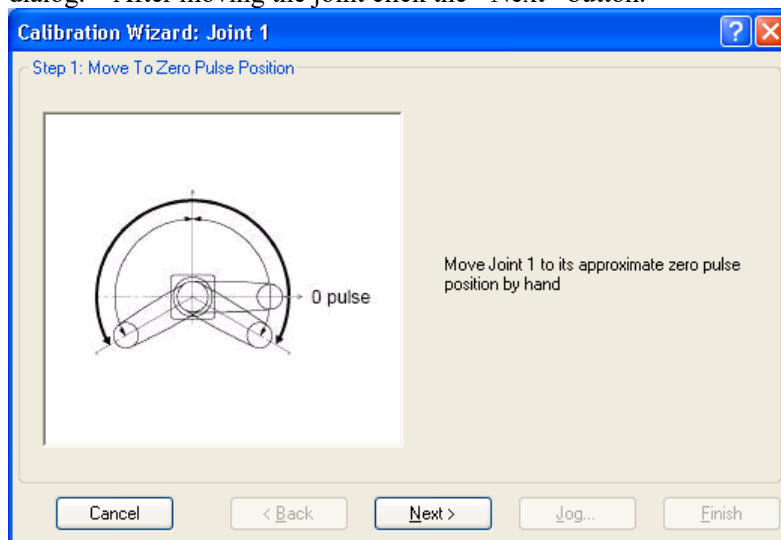
- iii. Select the joint and click the <Calibrate...> button.



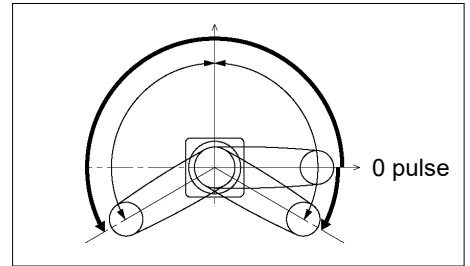
- (2) Confirm the warning message and click the <Yes> button.



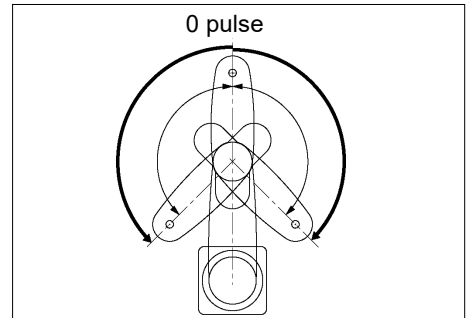
- (3) Move the joint to calibrate manually to approximate 0 pulse position, as shown in the dialog. After moving the joint click the <Next> button.



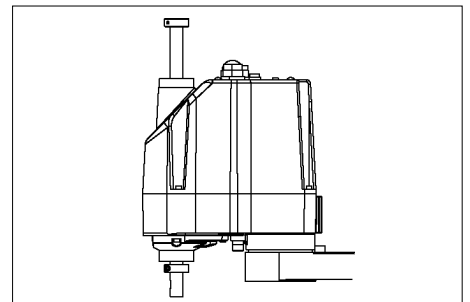
0 pulse position of Joint #1:
position aligned with X-axis in
Robot coordinate system



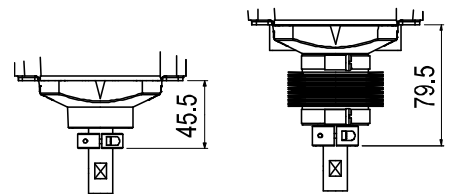
0 pulse position of Joint #2:
position where Arms #1
and #2 are in a straight line
(Regardless of the Joint #1
direction.)



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



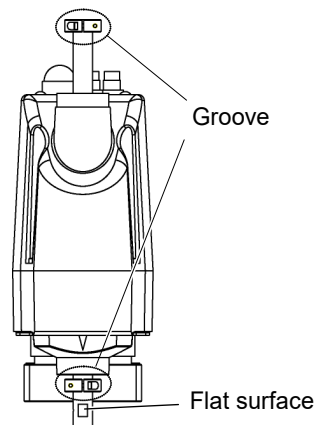
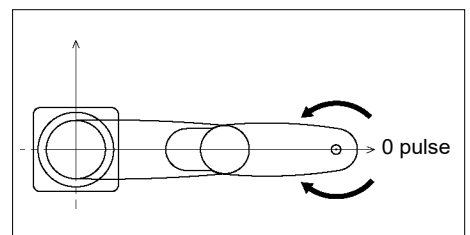
The height of Joint #3
depends on manipulator
model.



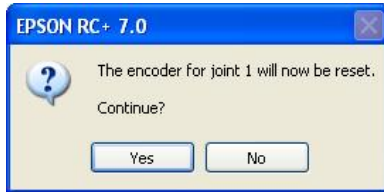
Standard model

Cleanroom model

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



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



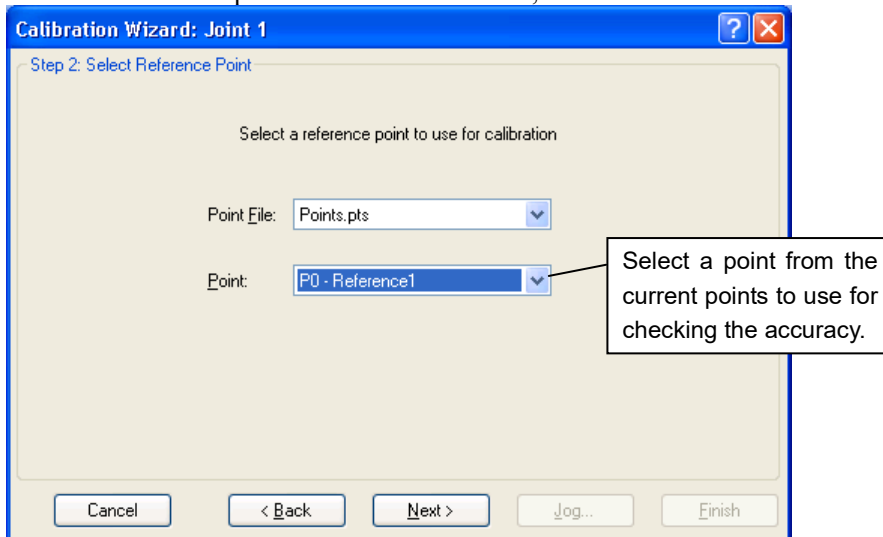
* This window will disappear when the Controller starts up.

- (5) Reboot the Controller.

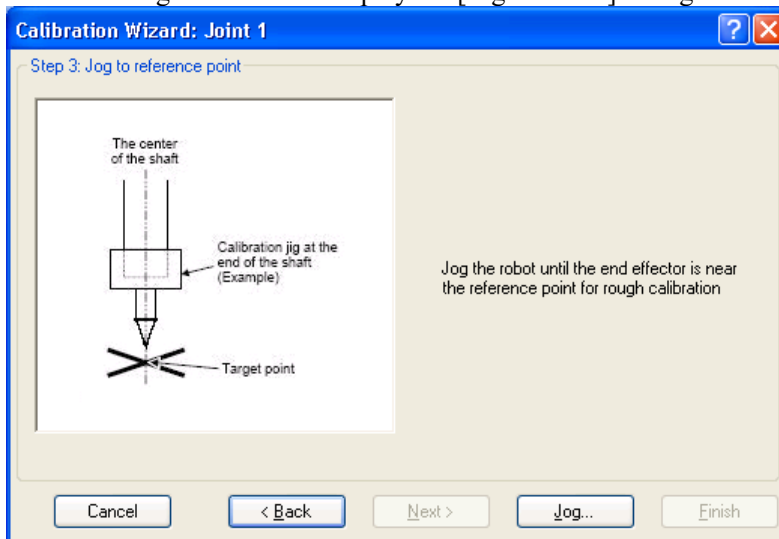


* This window will disappear when the Controller starts up.

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

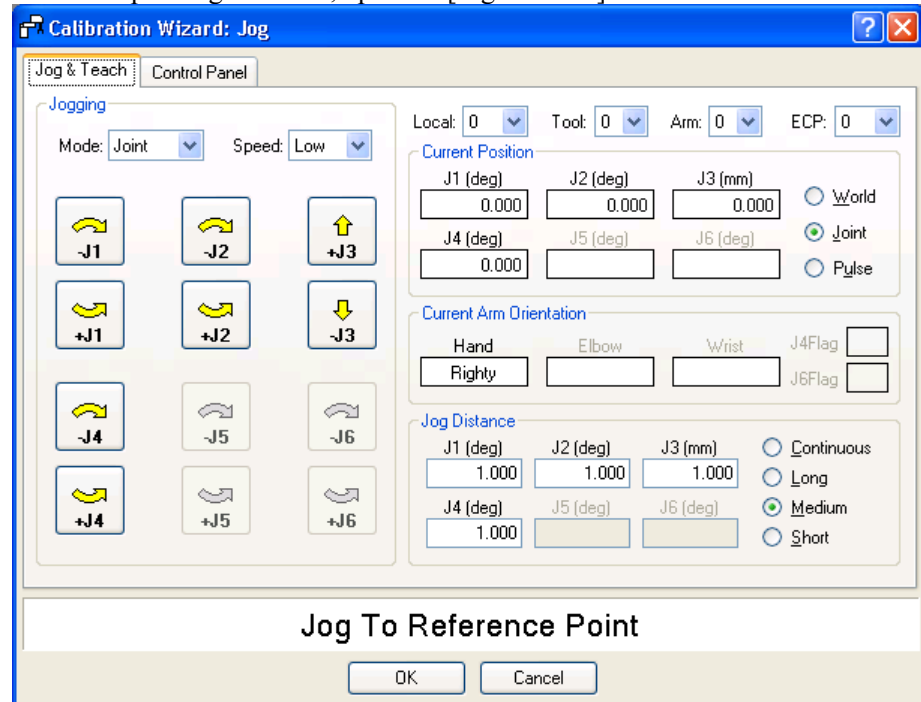


- (7) Click the <Jog...> button to display the [Jog & Teach] dialog.

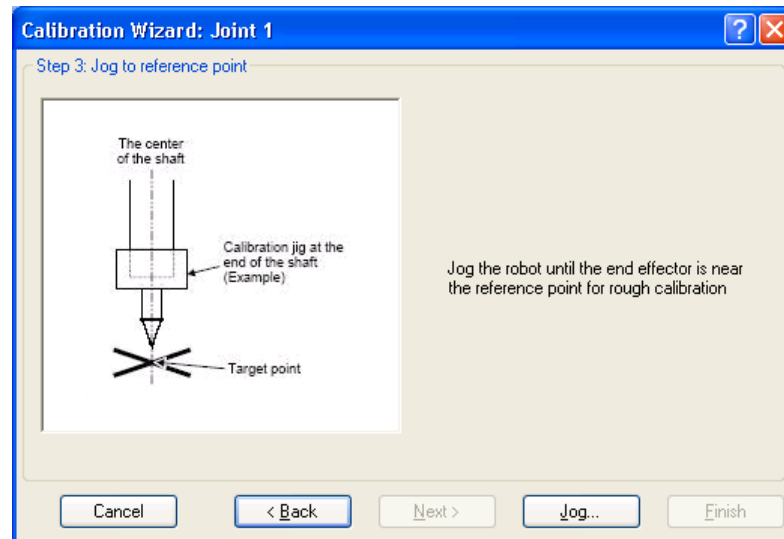


- (8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.

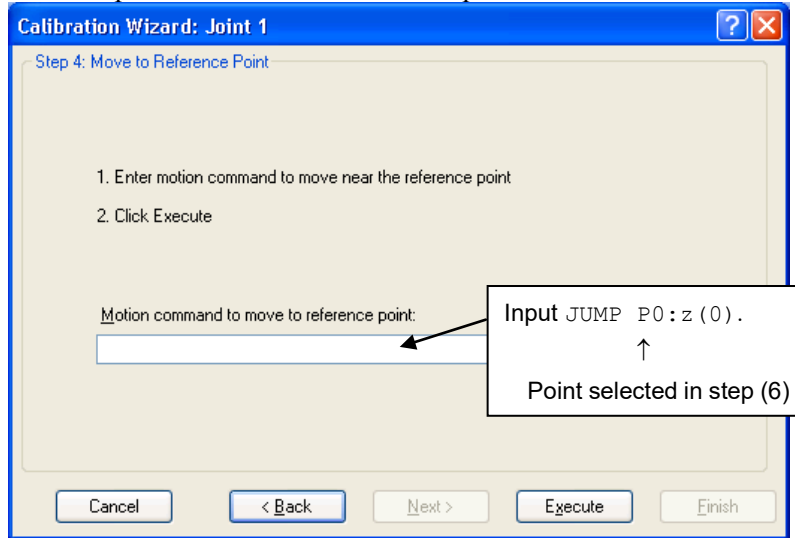
* Before operating the robot, open the [Jog & Teach] tab and execute <Motor ON>.



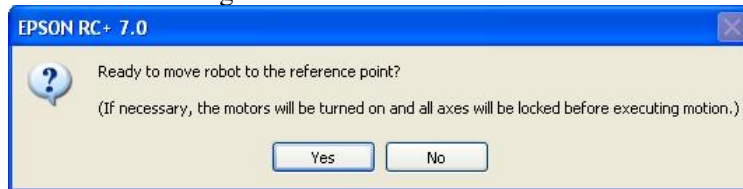
- (9) Click the <Next> button.



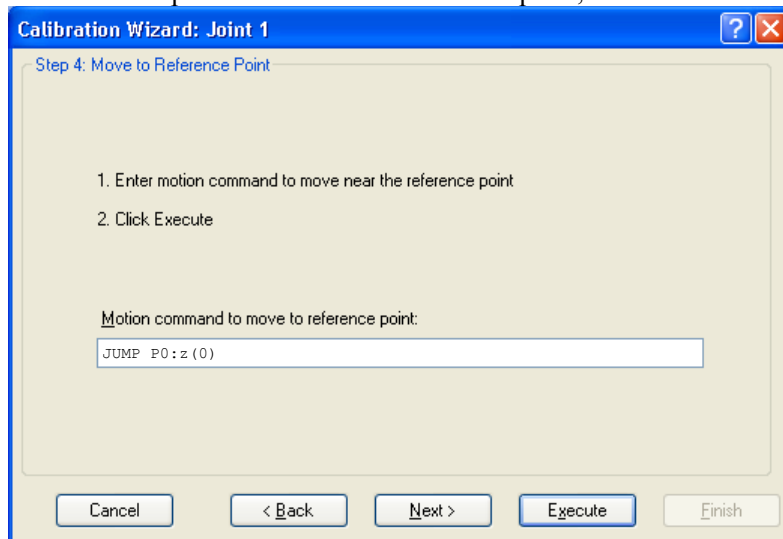
(10) The manipulator moves to the reference point. Click the <Execute> button.



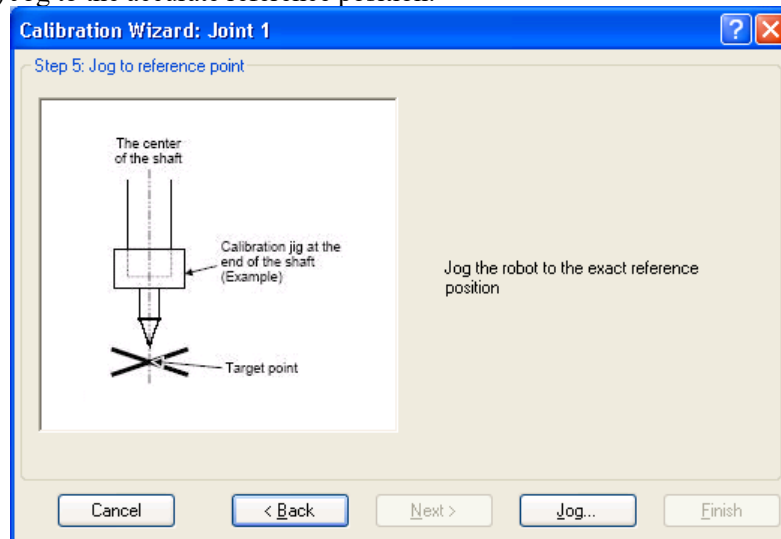
(11) Confirm the message and click the <Yes> button.



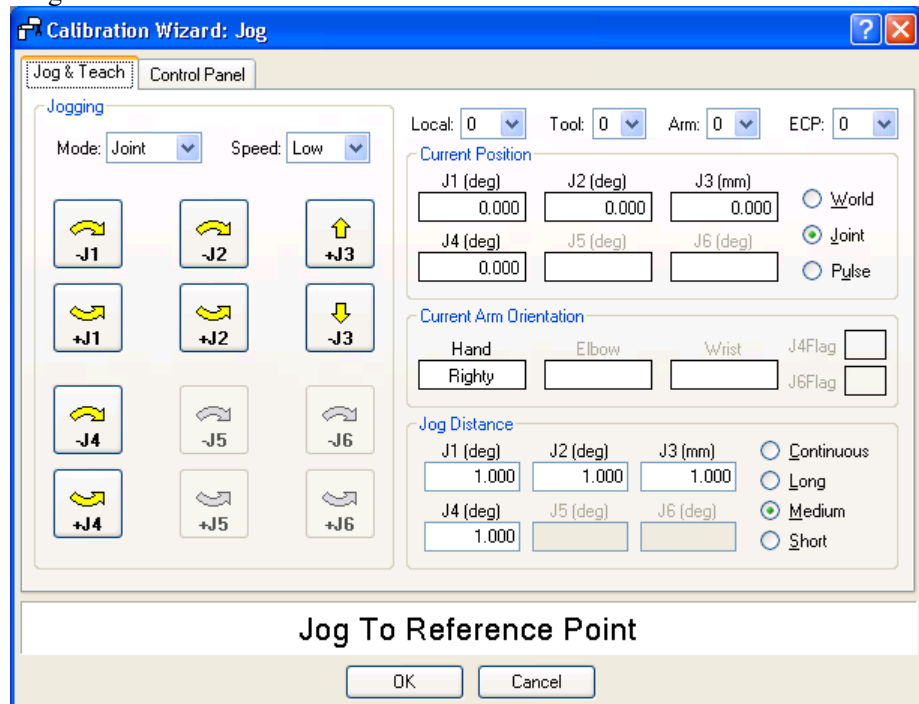
(12) After the manipulator moves to the reference point, click the <Next> button.



(13) Jog to the accurate reference position.

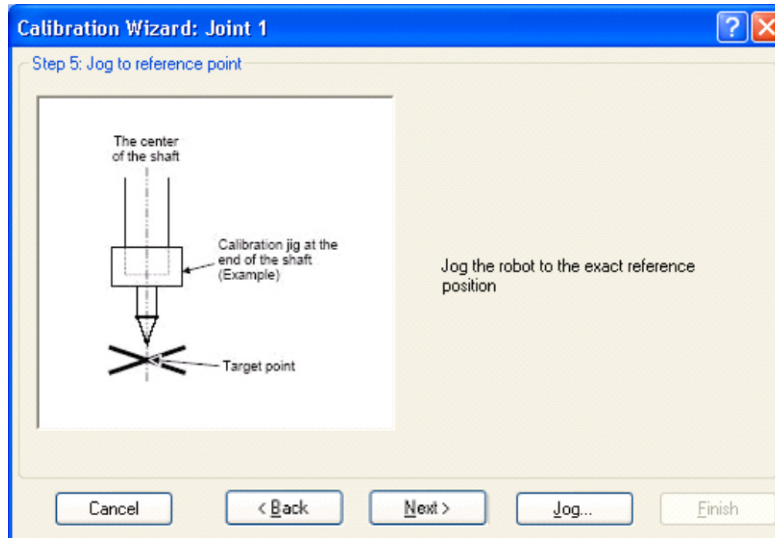


(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration. Then click the <OK> button.



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

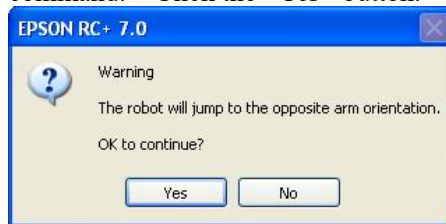
(15) Click the <Next> button.



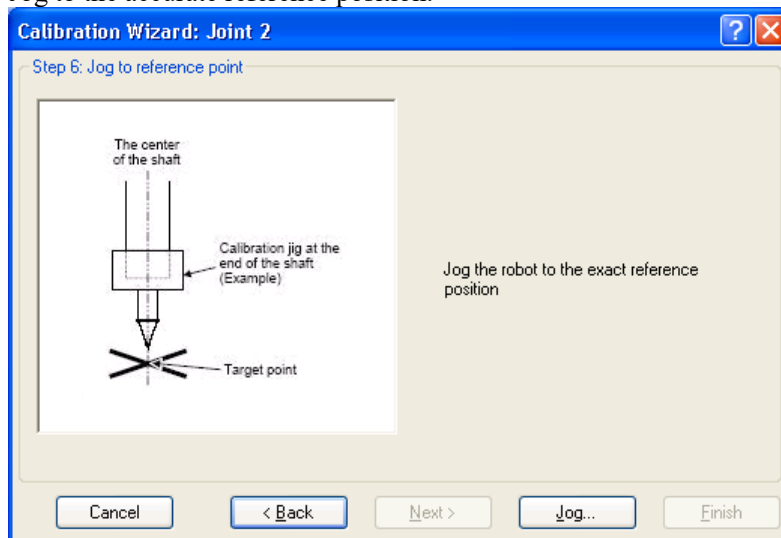
(16) Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2.

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

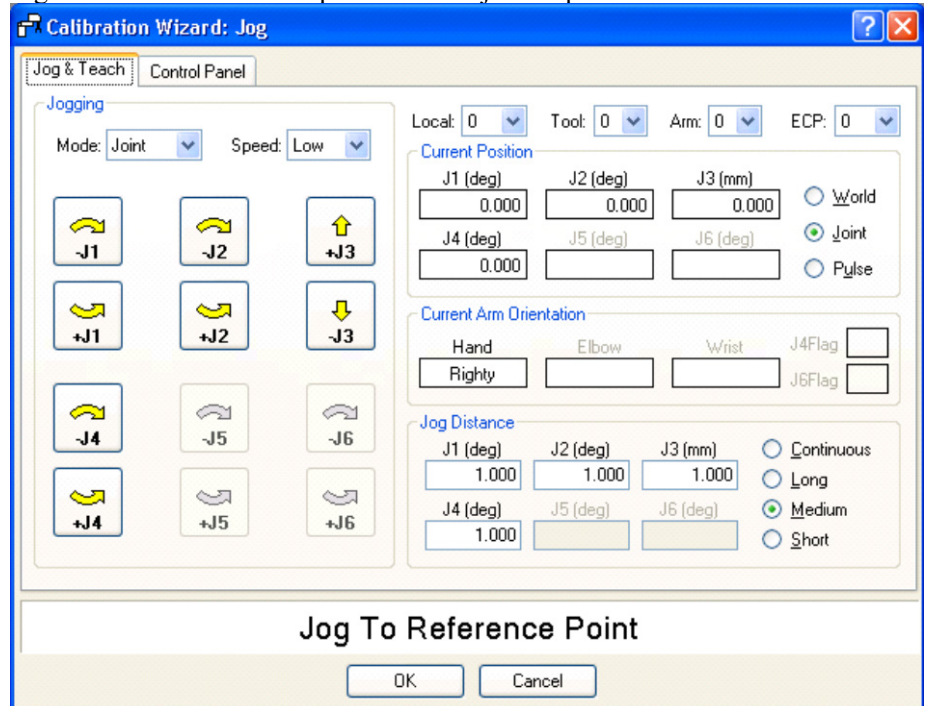
i. Move to another point that has different pose (from righty to lefty) using Jump command. Click the <Yes> button.



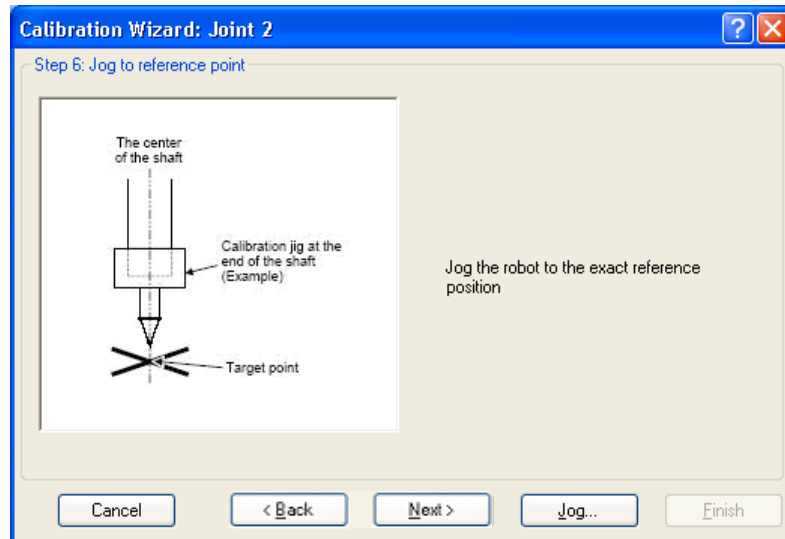
ii. Jog to the accurate reference position.



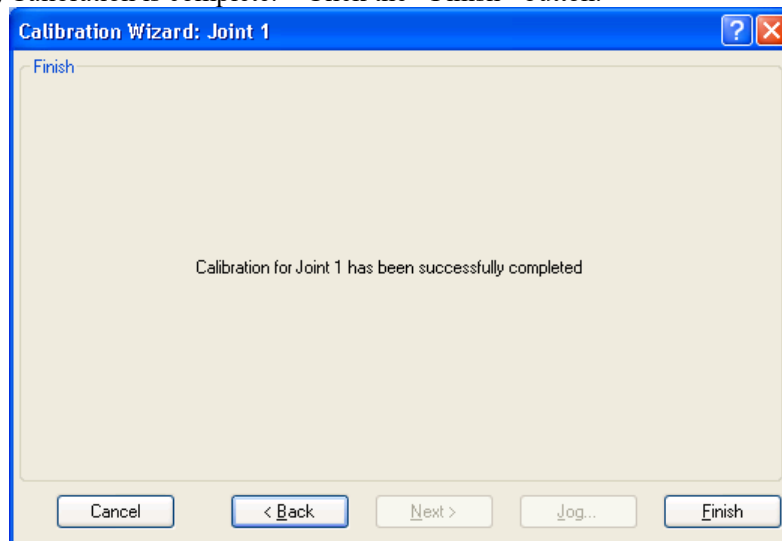
iii. Jog to the accurate reference position and adjust the position. Click the <OK> button.



iv. Click the <Next> button.



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



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

14.3 Accurate Calibration of Joint #2

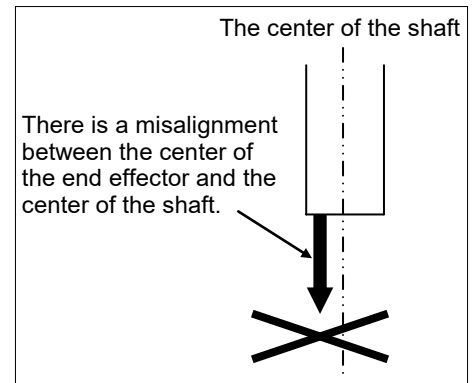
When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.



If the accuracy of Joint #2 is not obtained through the steps in the section *Maintenance: 14.2 Calibration Procedure*, follow the steps below “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2.

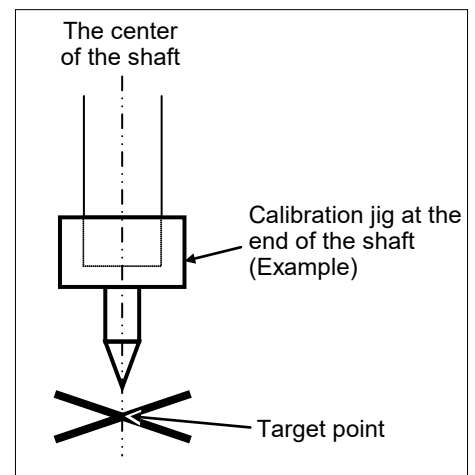
The reference point is the center of the ball screw spline shaft during this calibration.

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



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

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



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

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

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

Calibration Using Right / Left Arm Orientations

- (1) Check the point data for calibration

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

- (2) Open the Tools menu | Robot Manager | Control Panel and click the MOTOR ON.
- (3) Click the <Free All> button to free all joints from servo control. Now, you can move arms by hands.

- (4) Move the arms to the position of point data for calibration in righty arm orientation.

- (5) From the current position, teach any point data number unused.

This pose (point) is now called P1.

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

- (6) Click the Lock All in the [Control Panel] to lock all joints under servo control.

- (7) Switch to the lefty arm orientation. Then, move the arm to the same point.

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

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

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

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

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

- (9) Input the new Hofs value.

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

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

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

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

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

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

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

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

14.4 Calibration Procedure without using Calibration Wizard



This section indicates the calibration without using the calibration wizard of EPSON RC+. For details of calibration using the calibration wizard, refer to *14.2 Calibration Procedure*.

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately. Execute the procedure in “Calibration Using Right / Left Arm Orientations” to accurately calibrate Joint #2. For details, refer to *Maintenance: 14.3 Accurate Calibration of Joint #2*.

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



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

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

1. Basic Pose Confirmation

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

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

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

2. Part Replacement

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

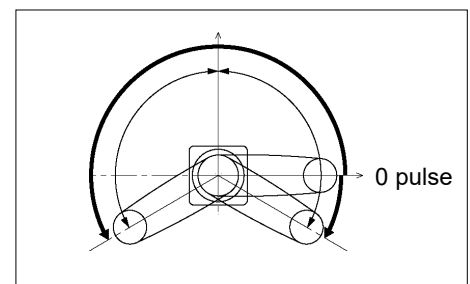
* Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

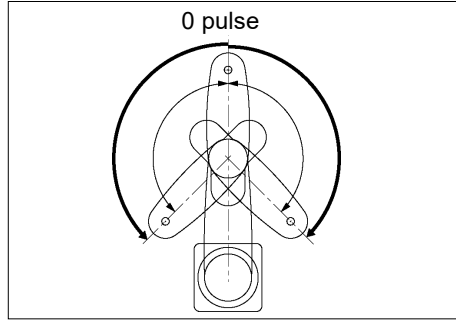
(3)-1 Turn ON the Controller when all joints are in the motion range.

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

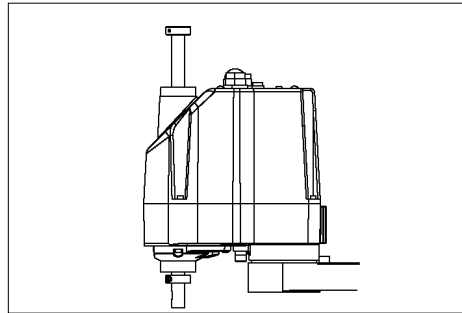
0 pulse position of Joint #1:
 position aligned with X-axis in
 Robot coordinate system



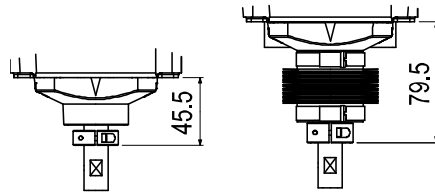
0 pulse position of Joint #2:
 position where Arms #1 and #2 are in a straight line
 (Regardless of the Joint #1 direction.)



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

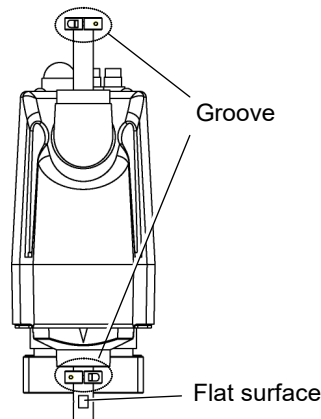
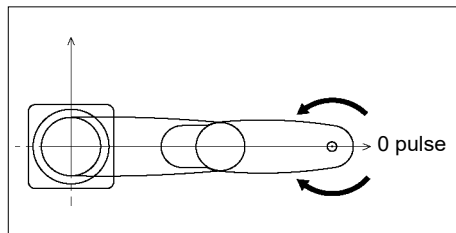


The height of Joint #3 depends on manipulator model.

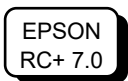


Standard model Cleanroom model

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



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



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

```
> robot 1
```

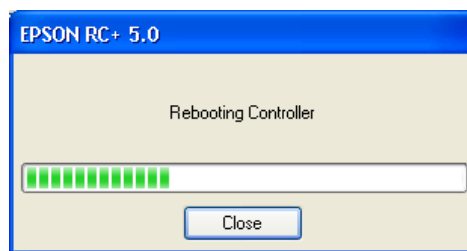
- (3)-4 Execute the absolute encoder initialization command.

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

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

- (3)-5 Reboot the Controller.

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



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

4. Rough Calibration

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

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

* Manipulator does not move.

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

```
Joint #1 >calib 1
Joint #2 >calib 2
Joint #3 >calib 3
Joint #4 >calib 3, 4
```

5. Calibration (Accurate Positioning)

- (5)-1 Turn ON the motors from the EPSON RC+ menu -[Tools]-[Robot Manager]-[Control Panel].
- (5)-2 Click the <Free All> button to free all joints from servo control. Now, you can move arms by hands.
- (5)-3 Move the Manipulator by hand to a rough position/posture of the calibration point data.

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

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

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

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

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

For example, when the specified point data is “P1”,

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

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

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

* You must move Joint #3 and #4 to the position when calibrating Joint #4.

Select the jog mode [Joint] from [Jog & Teach] to execute the jog motion.

(5)-7 Execute the calibration.

Enter and execute one of the following commands in [Command Window] according to the joint being calibrated.

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

6. Accuracy Testing

(6)-1 Move the Manipulator to another point to confirm that it moves to the same position.

If it does not move to the same position, re-calibrate using another point. You must set the point again if reproducibility cannot be assured through calibration.

15. Maintenance Parts List

15.1 Common Parts

Part Name		Code	Old Code	Note	Ref. Maintenance	Overhaul *1
Cable Unit	S C	250 mm	1514457	R13B020023	4.1	
		300 mm	1514458	R13B020024		
		350 mm	1514459	R13B020025		
	SM CM	300 mm	1514460	R13B020026	4.1	
		350 mm	1514461	R13B020027		
M/C Cable	3 m	For RC180	R12NZ9002C	R12B020431	4.3	
		For RC700-A Straight	R12NZ900KA	-		
		For RC700-A, L-shaped	R12NZ900KD	-		
	5 m	For RC180	R12NZ9002D	R12B020432		
		For RC700-A, Straight	R12NZ900KB	-		
		For RC700-A, L-shaped	R12NZ900KE	-		
	10 m	For RC180	R12NZ9002E	R12B020433		
		For RC700-A, Straight	R12NZ900KC	-		
		For RC700-A, L-shaped	R12NZ900KF	-		
	15 m	For RC700-A, Straight	R12NZ900XU	—		
		For RC700-A, L-shaped	R12NZ900XW	—		
	20 m	For RC700-A, Straight	R12NZ900XV	—		
For RC700-A, L-shaped		R12NZ900XX	—			
AC Servo Motor	Joint #1	1514451	R13B000614	200 W	5.1	✓
	Joint #2 / #3 / #4	1514453	R13B000615	150 W	6.1, 7.1, 8.1	✓
Reduction Gear Unit	Joint #1	1649160	R13B010016		5.2	✓
	Joint #2	1661086	R13B010017		6.2	✓
Electromag netic Brake	Z axis	1497639	R13B030501		7.3	✓
Timing Belt	Joint #3	1510625	R13B030213	Z	7.2	✓
	Joint #4	1510626	R13B030214	U1	8.2	✓
		1510627	R13B030215	U2	8.2	✓
O-ring	Joint #1	1653181	R13A0307002 00		5.2	
	Joint #2	1653819	R13A0307001 00		6.2	

Maintenance 15. Maintenance Parts List

Part Name		Code	Old Code	Note	Ref. Maintenance	Overhaul *1
	Joint #1	1213267	R13A031200700	O-ring20 For Multiple layout mounting only.	-	
	Joint #2	1213266	R13A031200600	O-ring17	6.2	
Brake Release Switch		2117817	R13Z702640100		-	
Oil seal (soft metal)		1510206	R13B031233		5.1	
Battery Board		2120180	R13B041202	With lithium battery Installed in Arm #2 ER17330V (TOSHIBA)	12.2	
Battery Unit		2117879	R13ZA00600300	Lithium battery for replacement ER17330V (TOSHIBA)	4.1, 12.1	
LED Lamp		2077258	R13A030000200		13	
Grease *2	For Ball Screw Spline : AFB		-	-	For purchasing the grease, please contact the supplier of your region.	2.3
	For Reduction Gear Unit	SK-1A	-	-		2.3
		SK-2		-		2.3

*1 As a rough indication, perform the overhaul (parts replacement) before reaching 20,000 operation hours of the Manipulator. The operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours]. For details, refer to *Maintenance 2.2 Overhaul (Parts Replacement)*.

*2 Regarding purchase of grease

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase grease required for maintenance from the manufacturers listed in the table below as of April 2015. Regarding purchase of grease, please contact the following manufacturers. If there is anything unclear, please contact supplier of your region.

Product name	Manufacturer	URL
THK AFB-LF Grease	THK CO., LTD.	http://www.thk.com/
Harmonic Grease SK-1A Harmonic Grease SK-2	Harmonic Drive Systems Inc.	http://www.harmonicdrive.net/

15.2 Parts by Environment Model

15.2.1 S: Standard-model

Part Name		Code	Old Code	Note	Reference: Maintenance	Overhaul *1
Ball Screw Spline	150 mm	1514454	R13B010220		11.1.1	✓
Arm Cover		1514465	R13B030421	White	3.1	

*1 As a rough indication, perform the overhaul (parts replacement) before reaching 20,000 operation hours of the Manipulator. The operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours].

For details, refer to *Maintenance 2.2 Overhaul (Parts Replacement)*.

15.2.2 C: Cleanroom-model

Part Name		Code	Old Code	Note	Reference: Maintenance	Overhaul *1
Ball Screw Spline	120 mm	1514455	R13B010221		11.1.2	✓
Arm Cover		1514466	R13B030422	Plating	3.1	
Bellows		1513008	R13B030704	*2	10	
Gasket Unit		1514467	R13B031234		3	

*1 As a rough indication, perform the overhaul (parts replacement) before reaching 20,000 operation hours of the Manipulator. The operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours].

For details, refer to *Maintenance 2.2 Overhaul (Parts Replacement)*.

*2 Common with LS3 series.

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

