

EPSON

EPSON ProSix

C3 series

MANIPULATOR MANUAL

Rev.9

EM15XR3090F

EPSON ProSix

C3 series Manipulator Manual

Rev. 9

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

Product malfunctions resulting from normal handling or operation will be repaired free of charge during the normal warranty period. (Please ask your Regional Sales Office for warranty period information.)

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

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

Warnings, Cautions, Usage:

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

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NOTICE

No part of this manual may be copied or reproduced without authorization.

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

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

INQUIRIES

Contact the following service center for robot repairs, inspections or adjustments.

If service center information is not indicated below, please contact the supplier office for your region.

Please prepare the following items before you contact us.

- Your controller model and its serial number
- Your manipulator model and its serial number
- Software and its version in your robot system
- A description of the problem

SERVICE CENTER

--

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For Customers in the European Union



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.

Indication by Environment Specification

C3 Manipulators can be classified into four types based on environment specifications. Operations and descriptions may differ due to these differences. The following names are used in this manual.

Classification by Environment Specification		Name
S: Standard model		S/C model
C: Clean room model		
V: Anti-VHP model (Waterproof rating: IP67)		V/P model
P: Waterproof model (Waterproof rating: IP67)		

For details on specifications, refer to *Setup & Operation 2. Specifications*.

Structure of Control System

C3 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
RC620	Control Unit Drive Unit	EPSON RC+ 6.0 Ver. 6.0 or greater

For details on commands, refer to “EPSON RC+ User’s Guide” or “On-line help”.

Standard controllers for the V/P model manipulators are RC180. Please contact us if you use an RC620 controller.

Setting by Software



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

Turning ON/OFF Controller

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

Photos and Illustrations Used in This Manual

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

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Setup & Operation

This volume contains information for setup and operation of the Manipulators.

Please read this volume thoroughly before setting up and operating the Manipulators.

1. Safety

Installation and transportation of the Manipulators 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 harm to people 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, dealers, or local representative companies, 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 EPSON RC+ User's Guide. Designing and/or constructing 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.
--	--

 WARNING	<ul style="list-style-type: none"> ■ 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 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 of the product but also cause serious safety problems.
--	---

Further precautions for installation are described in the chapter *Setup & Operation 3. Environment and Installation*. Please read this chapter carefully to understand safe installation procedures before installing the robots and robotic equipment.

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. 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 status (low speeds and low power) 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 during operation. Continuing the operation while the Manipulator moves abnormally is extremely hazardous and may result in serious bodily injury and/or severe equipment change to the robot system.
--	--

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

 CAUTION	<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. ■ 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 30 degrees for about 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 speed Changing the teach points Changing the end effector load
---	--

1.4 Emergency Stop

If the Manipulator moves abnormally during operation, immediately press the Emergency Stop switch. The motor power will be turned **OFF**, and the arm motion by inertia will be stopped with the electromagnetic brake and dynamic brake.

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

To place the robot system in emergency mode during normal operation, press the Emergency Stop switch while 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 16. 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 2.2.2 Inspection While the Power is ON
(Manipulator is operating)*

*Safety and Installation 5.2.2 Inspection Point - Inspection While the
Power is ON (Manipulator is operating)*

Free running distance in emergency

The Manipulator in operation cannot stop immediately after the Emergency Stop switch is pressed. However, time, angle, and distance of the free running vary by following factors:

Hand weight	WEIGHT Setting	ACCEL Setting
Workpiece weight	SPEED Setting	Posture etc.

Approximate time and distance of the free running are as follow:

Conditions of Measurement

ACCEL Setting	100
SPEED Setting	100
Load [kg]	3
WEIGHT Setting	3

Robot controller		RC180 / RC620	
Brake		Standard J2, J3, J5 with brake	Option All joint with brake
Free running time [sec.]	Arm #1	0.4	
	Arm #2	0.4	
	Arm #3	0.4	
	Arm #4	0.5	0.3
	Arm #5	0.3	
	Arm #6	0.1	
Free running angle [deg.]	Arm #1	85	
	Arm #2	60	
	Arm #3	55	
	Arm #4	55	45
	Arm #5	45	
	Arm #6	10	

1.5 How to Move Arms with the Electromagnetic Brake

There are two methods to release the electromagnetic brake. Follow either method to release the electromagnetic brake and move the arms manually.

1.5.3 Moving the arm using the brake release unit

Follow the method when you just unpack the delivered boxes or when the Controller does not start up yet.

1.5.4 Moving the arm using the software

Follow the method when you can use the software.

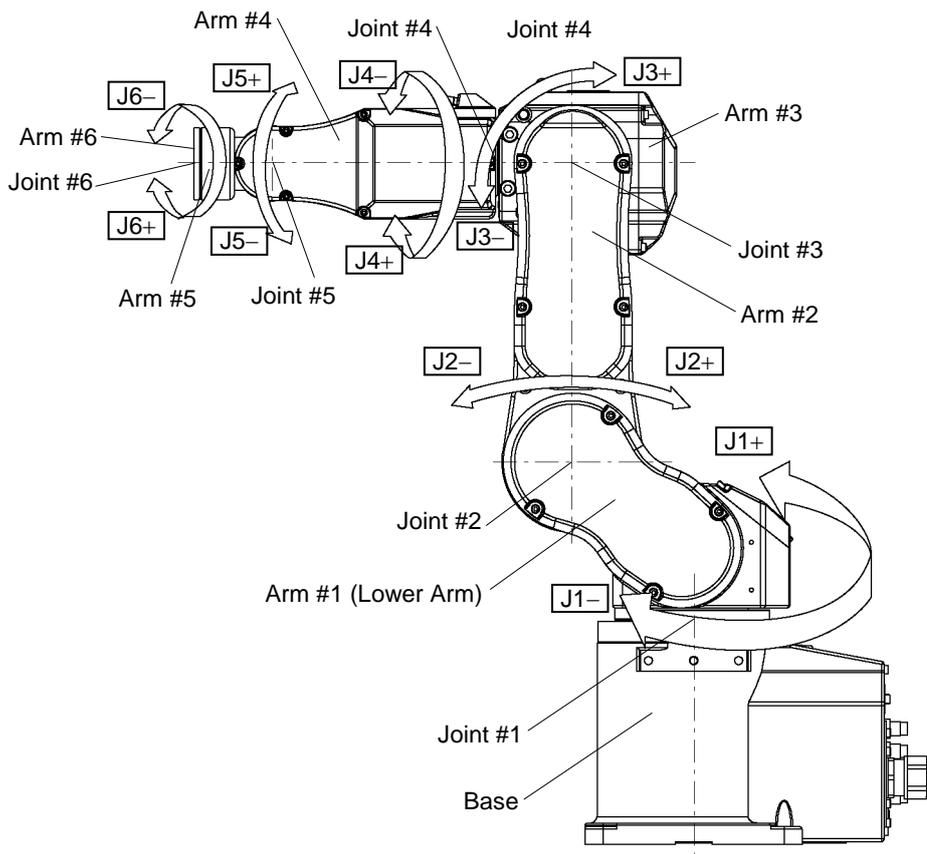
Standard: Brakes on Joints #2, #3, #5

While the electromagnetic brake is ON (such as in emergency mode), you can move Arms #1, #4, #6 by pushing manually.

Option : Brakes on all joints

While the electromagnetic brake is ON (such as in emergency mode), you cannot move any arm by pushing manually.

Arm Motion



1.5.1 Moving the Arm using the brake release unit

The C3 series has the Brake Release Unit as an option.

For details, refer to *Setup & Option: 6 Options*.

1.5.2 Moving the Arm using the software



- Normally, release the brake of joints one by one. Take extra care if you need to release the brakes of two or more joints simultaneously. Releasing the brakes of two or more joints simultaneously may cause hands and fingers to be caught and/or equipment damage to or malfunction of the Manipulator as the arms of the Manipulator may move in unexpected directions.
- Be careful of the arm falling when releasing the brake. While the brake is being released, the Manipulator's arm falls by its own weight. The arm falling may cause hands and fingers to be caught and/or may cause equipment damage to or malfunction of the Manipulator.
- Before releasing the brake, be sure to keep the Emergency Stop switch handy so that you can immediately press the Emergency Stop switch. Otherwise, you cannot immediately stop the arm falling due to an erroneous operation. The arm falling may cause equipment damage to and/or malfunction of the Manipulator.



After releasing the Emergency Stop switch, execute the following command in [Command Window].

```
>Reset
```

```
>Brake Off, [the number (from 1 to 6) corresponding to the arm whose brake will be turned off]
```

Execute the following command to turn on the brake again.

```
>Brake On, [The number (from 1 to 6) corresponding to the arm whose brake will be turned on]
```

1.6 Precaution for Operation in Low Power Status

In the low power status, the Manipulator operates at low speed and low torque. However, comparatively high torque as shown in the table below may be generated to support the Manipulator's own weight.

Carefully operate the Manipulator since it may get your hands or fingers caught during operation. The Manipulator may also collide with peripheral equipment and cause equipment damage to or malfunction of the Manipulator.

Maximum Joint Torque in Low Power Status

[Unit: N·m]

Joint	#1	#2	#3	#4	#5	#6
Joint Torque	102.28	102.28	33.51	10.31	10.31	7.98



- Carefully operate the Manipulator in the low power status. A comparatively high joint torque may be generated. It may cause your hands and fingers caught and/or cause equipment damage to or malfunction of the Manipulator as it may collide with peripheral equipment.

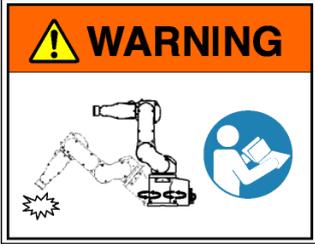
1.7 Manipulator Labels

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

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

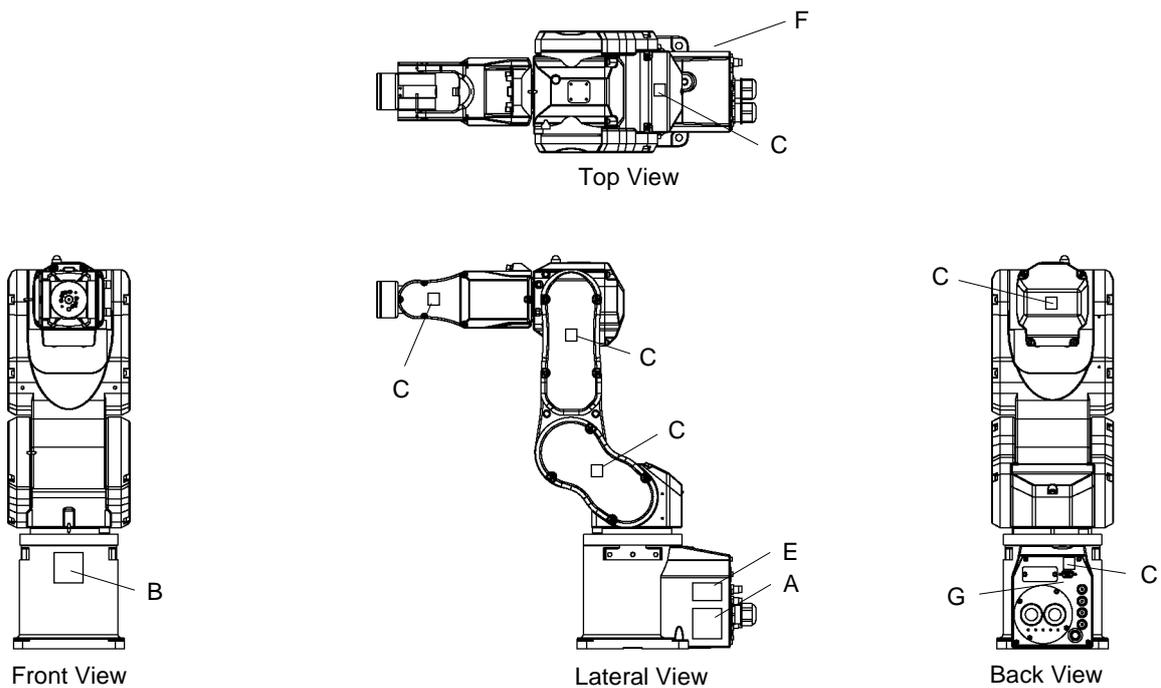
Do not tear, damage, or remove the labels. Use meticulous care when handling those parts or units to which the following labels are attached as well as the nearby areas.

Label types differ according to the specifications.

Location	Label	NOTE
A		To avoid getting hands or fingers caught, fold the Arm and fix it with a belt or a similar tool before removing the base mounting screws.
B		Do not enter the work space when the Manipulator is operating. It is extremely hazardous since the Arm may collide and cause serious safety problems,
C		Do not touch the current-carrying parts inside the Manipulator while the power is ON. It may cause electrical shock.
D		Be careful of the arm falling due to its own weight when pressing the brake release switch. These labels are attached on the optional brake release box
E		UL model Only

Location	Label	NOTE
F	<div style="border: 1px solid black; padding: 5px;"> <p>MODEL : C3-A600S SERIAL NO. : 00001 MANUFACTURED : 07/2009 WEIGHT : 27kg MAX PAYLOAD : 3kg MOTOR POWER AXIS1 : 400W AXIS2 : 400W AXIS3 : 150W AXIS4 : 50W AXIS5 : 50W AXIS6 : 50W SEIKO EPSON CORPORATION 3-5,OWA 3-CHOME,SUWA-SHI NAGANO-KEN,392-8502 JAPAN</p> </div>	
G	<div style="border: 1px solid black; padding: 5px;"> <p>Air pressure max. 0.59Mpa, 86psi</p> </div>	

Location of Labels



C: The label is inside the cover.

A, B, E: Labels are not attached on the Manipulator. Attach the labels to easy-to-see locations outside the system.

2. Specifications

2.1 Features of Manipulators

Speed & Accuracy

Increased productivity by balanced, best-in class fast and accurate operation.

Average cycle time (300 mm) 0.39 second (Speed 100 / Accel 100)

0.37 second (Speed 120 / Accel 120)

Repeatability error ± 0.02 mm

Slim Body

High space efficiency

Manipulator size is only 1/44 of its motion range

Small elbow area (Joint #3) which is half of that of the existing models

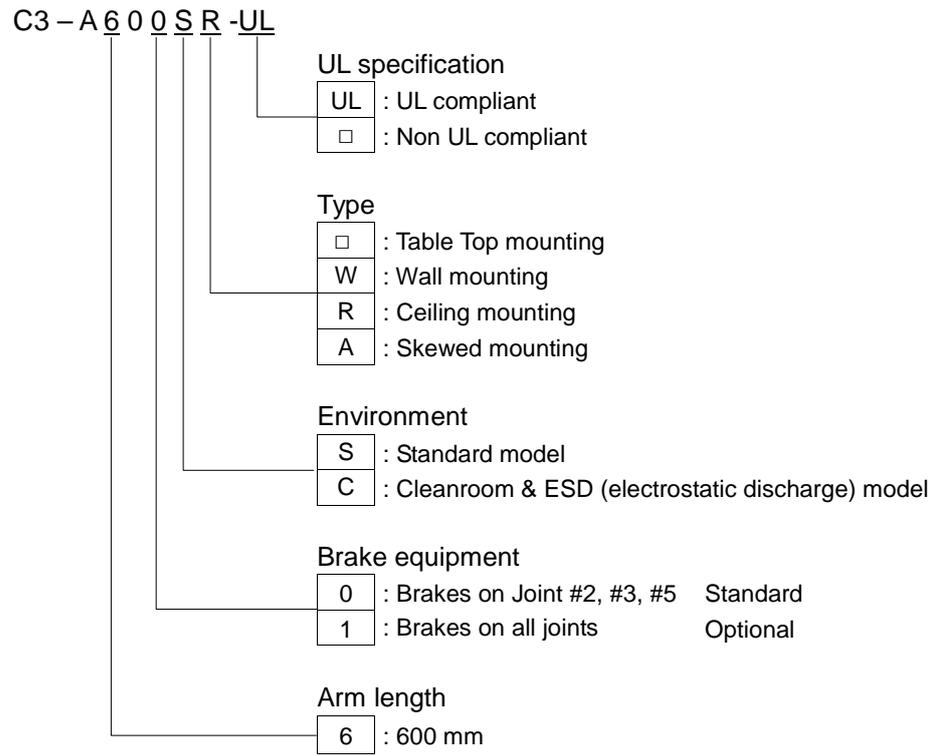
Less interference with peripherals, walls, and ceiling permits more compact installation

Skillful Wrist

Compact wrist (Joint #5) with wide motion range enables smooth movement and the ability to work from many angles

Minimal interference with surroundings improves flexibility in hand design

2.2 Model Number

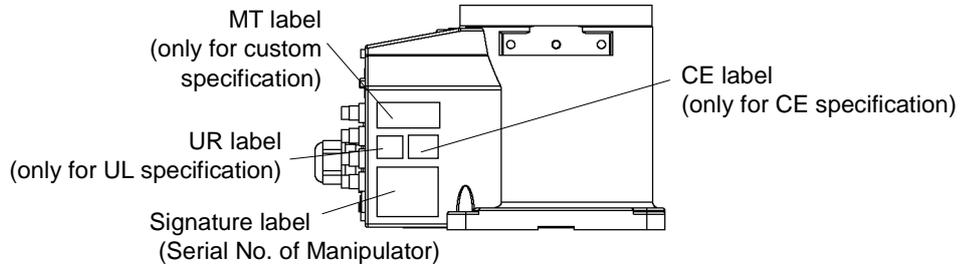
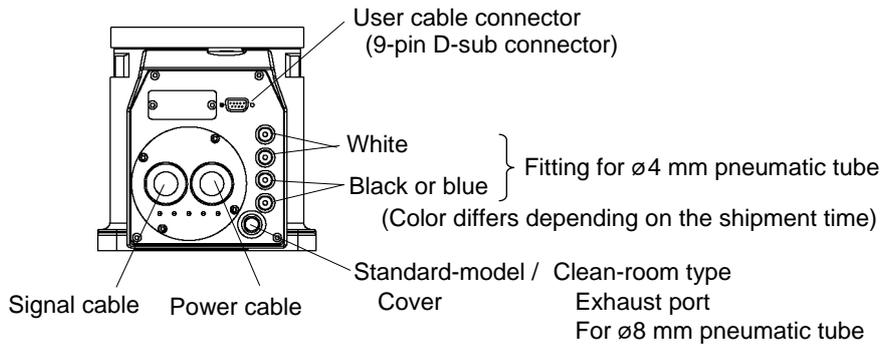
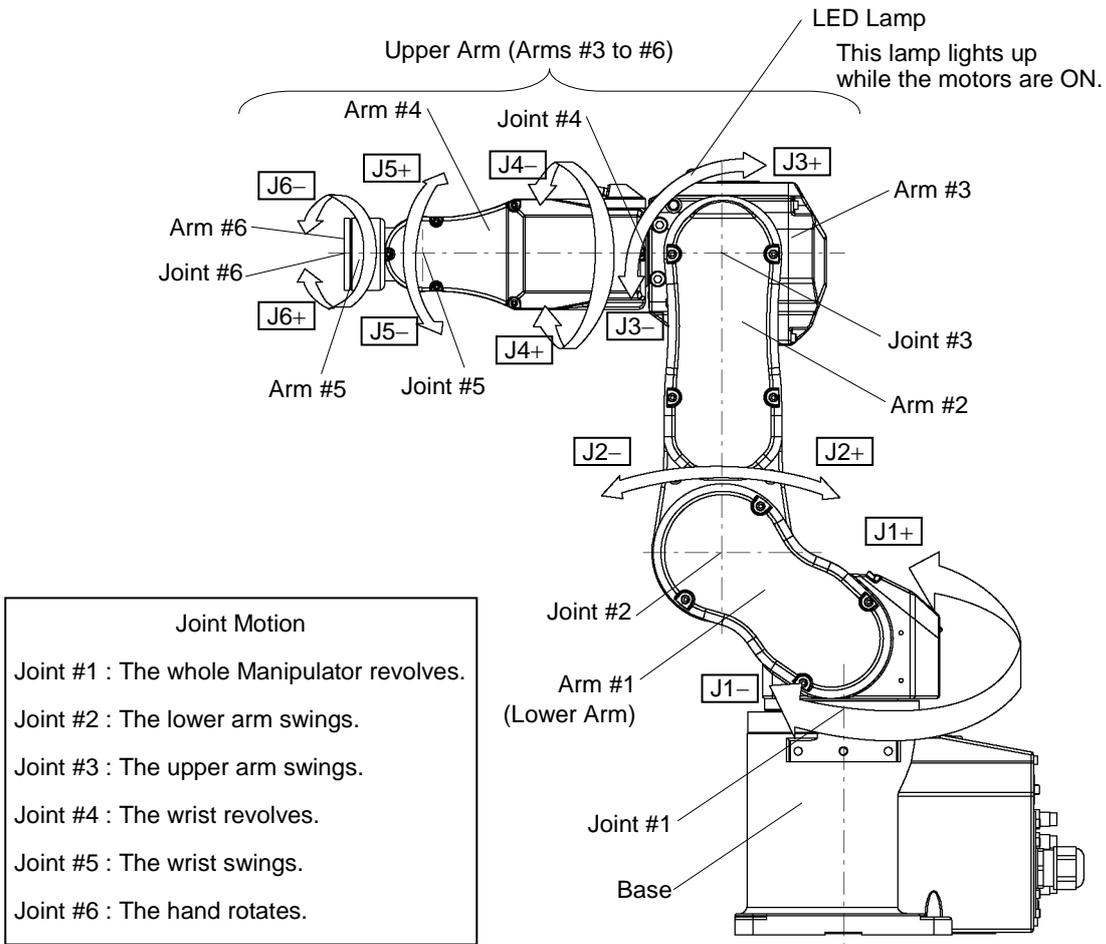


NOTE



For the Wall / Skewed mounting types, brakes are equipped on all joints.

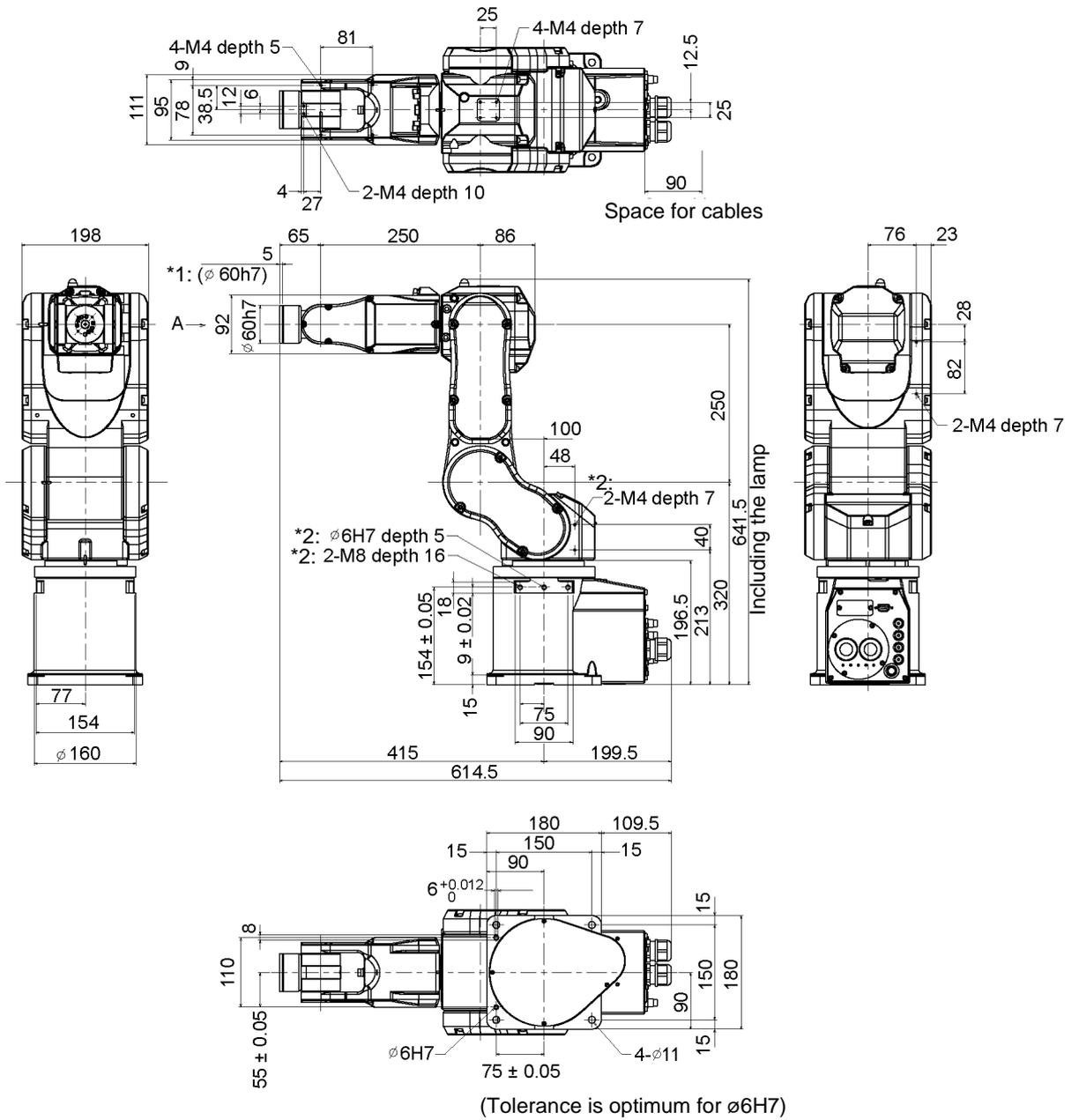
2.3 Part Names and Motion Range of Each Arm



NOTE When the LED lamp is lighting or the controller power is on, the current is being applied to the manipulator. Performing any work with the power ON is extremely hazardous and it may result in electric shock and/or improper function of the robot system. Make sure to turn OFF the controller power before the maintenance work.

2.4 Outer Dimensions

[Unit: mm]

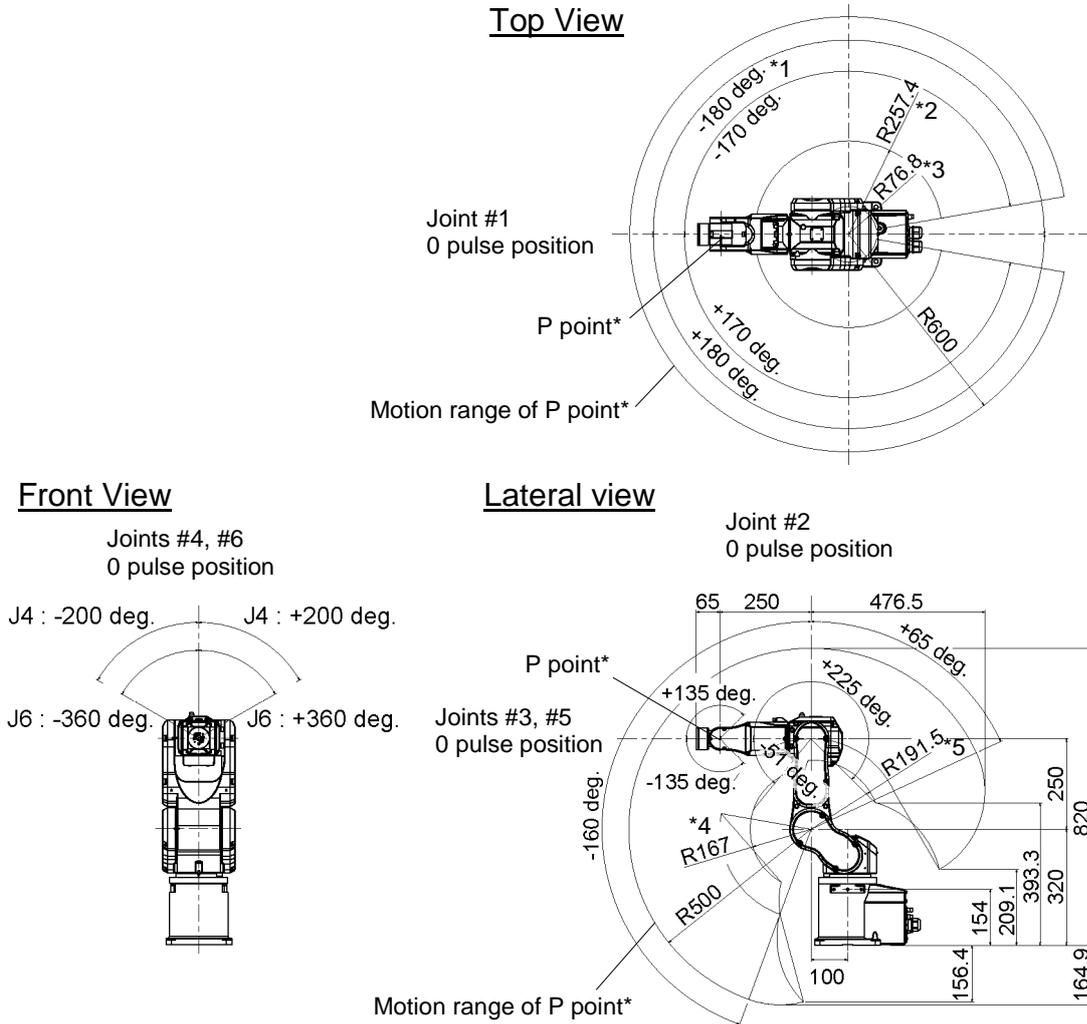


*1: Tolerance in this range

*2: Front and back

2.5 Standard Motion Range

[Unit: mm]



- * P point : Intersection of the rotation centers for Joint #4, #5, and #6
- *1 : Joint #1 without mechanical stop (±180 deg.)
 For the mechanical stop removal procedure, refer to *Setup & Operation: 5.2.1 Motion Range Setting of Arm #1.*
- *2 : P point from top with Joint #3 declining -51 deg. (Joint #1 center – P point center)
- *3 : P point from top with Joint #3 tilting up +225 deg. (Joint #1 center – P point center)
- *4 : P point from lateral with Joint #3 declining -51 deg. (Joint #2 center – P point center)
- *5 : P point from lateral with Joint #3 tilting up +225 deg. (Joint #2 center – P point center)

 CAUTION	<p>Pay attention to the arm pose of the basic arms (Arms #1, #2, and #3) when operating the Manipulator. Arm #5 moves keeping a constant angle regardless of the arm pose. Depending on the arm pose of the basic arms, the wrist may collide with the Manipulator. The collision may cause equipment damage to and/or malfunction of the Manipulator.</p>
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2.6 Specifications

2.6.1 Specifications table

Item		Specification	
Mounting type		Table Top, Ceiling, Skewed mounting	Wall mounting
Weight (not include the weight of cables or shipping jigs)		27 kg (59.5 lb.)	
Driving method	All joints	AC servo motor	
Max. operating speed ^{*1}	Joint #1	450 deg/s	
	Joint #2	450 deg/s	
	Joint #3	514 deg/s	
	Joint #4	553 deg/s	
	Joint #5	553 deg/s	
	Joint #6	720 deg/s	
Repeatability	Joint #1 ~ #6	± 0.02 mm	
Max. motion range	Joint #1	± 170 deg (± 180 deg without the mechanical stop)	± 30 deg
	Joint #2	- 160 deg to + 65 deg	
	Joint #3	- 51 deg to + 225 deg	
	Joint #4	± 200 deg	
	Joint #5	± 135 deg	
	Joint #6	± 360 deg	
Max. pulse range	Joint #1	± 4951609 (± 5242880 without the mechanical stop)	± 873814
	Joint #2	- 4660338 + 1893263	
	Joint #3	- 1299798 + 5734400	
	Joint #4	± 4700057	
	Joint #5	± 3217222	
	Joint #6	± 6553600	
Resolution	Joint #1	0.00000429 deg /pulse	
	Joint #2	0.00000429 deg /pulse	
	Joint #3	0.00000490 deg /pulse	
	Joint #4	0.00000531 deg /pulse	
	Joint #5	0.00000524 deg /pulse	
	Joint #6	0.00000686 deg /pulse	
Motor power consumption	Joint #1	400 W	
	Joint #2	400 W	
	Joint #3	150 W	
	Joint #4	50 W	
	Joint #5	50 W	
	Joint #6	50 W	
Payload ^{*2}	Rated	1 kg	
	Max.	3 kg 5 kg with arm downward positioning	
Allowable moment	Joint #4	4.41 N·m (0.45 kgf·m)	
	Joint #5	4.41 N·m (0.45 kgf·m)	
	Joint #6	2.94 N·m (0.3 kgf·m)	

Item		Specification
Allowable moment of inertia (GD ² /4) *3	Joint #4	0.15 kg·m ²
	Joint #5	0.15 kg·m ²
	Joint #6	0.1 kg·m ²
Installed wire for customer use		9 wires (D-sub)
Installed pneumatic tube for customer use *4		4 pneumatic tubes, Allowable pressure: 0.59Mpa (6 kgf/cm ²) (89 psi)
Environmental requirements *5	Ambient Temperature	5 to 40 deg C
	Ambient relative humidity	20 to 80 % (no condensation)
	Vibration	4.9 m·s ² (0.5 G) or less
Noise level *6		LAeq = 76 dB (A) or under
Environment		Standard / Cleanroom model & ESD *7
Applicable Controller		RC180, RC620
Default values (Max. setting values)	SPEED	5 (100)
	ACCEL *8	5, 5 (120, 120)
	SPEEDS	50 (2000)
	ACCELS	200 (25000)
	FINE	10000, 10000, 10000, 10000, 10000, 10000 (65535, 65535, 65535, 65535, 65535, 65535)
	WEIGHT	1, 0
Safety standard		UL1740 (Third Edition, Dated December 7,2007) ANSI/RIA R15.06-1999 NFPA 79 (2007 Edition) CSA/CAN Z434-03 (February 2003) CE Marking – Machinery Directive, Low Voltage Directive, EMC Directive

- *1 In case of PTP control
- *2 If the payload exceeds the maximum payload, refer to the section “*Restrictions on payload exceeding the maximum payload*” in *Setup & Operation 4.3.1 WEIGHT Setting*.
- *3 If the center of gravity is at the center of each arm. If the center of gravity is not at the center of each arm, set the eccentric quantity using INERTIA command.
- *4 For details of the installed pneumatic tube for customer use, refer to the *Setup & Operation 3.6 User Wires and Pneumatic Tubes*.
- *5 For details of the environmental requirements, refer to the *Setup & Operation 3.1 Environmental Conditions*.
- *6 Conditions of Manipulator at measurement are as follows:
 Operating conditions: Under rated load, 6 arms simultaneous motion, maximum speed, maximum acceleration, and duty 50%.
 Measurement point: 1000 mm apart from the rear of Manipulator

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

A crack or other opening in the base unit can cause loss of negative air pressure in the outer part of the arm, which can cause increased dust emission.

Do not remove the covers.

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)

(Number of particles of 0.1 μ m or larger in a sample air
(28317cm³:1cft) around the center of the motion area = less than 10
particles)

Exhaust System : Fitting for ϕ 8 mm pneumatic tube

Refer to *Setup & Operation: 3.6 User Wires and Pneumatic Tubes.*

60 L/min vacuum

Exhaust tube : Polyurethane tube

Outer diameter: ϕ 8 mm (Inner diameter: ϕ 5 to 6 mm)

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

*8: 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.

2.6.2 Option

C3 series manipulators have the following options.

Camera plate unit

PS compatible plate

Base side angled fittings

Base side fittings

Brake release unit

For details of options, refer to *Setup & Operation: 6. Options.*

2.7 How to Set the Model

The Manipulator for your system has been set before shipment.
Normally, no model setting is necessary.



- 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 an MT label is attached to the side of the Manipulator, the Manipulator has custom specifications. If the Manipulator has custom specifications, the methods for setting the model may differ from those described below. Please contact us with the number on the MT label.

For the method of the Manipulator model setting, refer to the chapter *Robot Configuration* in the EPSON RC+ User's Guide.

3. Environment and Installation

Installation and transportation of robots and robotic equipment shall be performed by qualified personnel and should conform to all national and local codes.

3.1 Environmental Conditions

A suitable environment is essential 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 deg C to 40 deg C
Ambient relative humidity	20 % to 80 % (no condensation)
First transient burst noise	2 kV or less (Power supply wire) 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 shock or vibration. - Keep away from sources of electric noise.

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



When using the Manipulators in inadequate environments that do not meet the above conditions, please contact us.

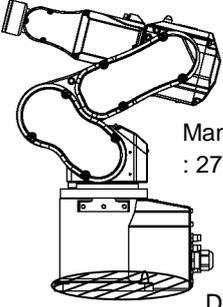
Be sure to transport and store the robot system in environments that meet the following conditions:

Item	Conditions
Ambient temperature	0 to 45 deg C
Ambient relative humidity	20 to 80 %

3.2 Unpacking, Transportation, and Relocation

Using a cart or similar equipment, transport the Manipulator in the same conditions as it was delivered. Observe the following when unpacking the Manipulator.

The installation shall be made by qualified installation personnel and should conform to all national and local codes.

 <p>WARNING</p>	<ul style="list-style-type: none"> Only authorized personnel should perform sling work and operate a crane or 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. Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system as the fall of the Manipulator.
 <p>CAUTION</p>	<ul style="list-style-type: none"> When removing the anchor bolts, support the Manipulator to prevent falling. Removing the anchor bolts without supporting the Manipulator may get hands, fingers, or feet caught as the Manipulator may fall. To carry the Manipulator, secure it to the delivery equipment or have at least 2 people to hold it by hand. Also, do not hold the bottom of the base (the screened parts in the figure). Holding these parts by hand is extremely hazardous and may cause your hands and fingers caught. <div style="text-align: center;">  <p>Manipulator weight : 27 kg (59.5 lb.)</p> <p>DO NOT hold the bottom of the base by hand.</p> </div> <ul style="list-style-type: none"> Avoid excessive vibration or shock during Manipulator transporting. Excessive vibration or shock may cause equipment damage to and/or malfunction of the Manipulator.

During unpacking and relocation, avoid applying external force to the arms and motors 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 condensation occurs on the Manipulator during transport or storage, turn ON the power only after the condensation dries.

When using the Manipulator for the robot system again after long-term storage, perform a test run to verify that the Manipulator works properly. Then, operate the Manipulator thoroughly.

Relocating

Follow the procedures described below when relocating the Manipulator.

- (1) Turn OFF the power for all devices and unplug the power cable connector and signal cable connector from the controller.

Do not unplug the M/C cable (power cable and signal cable) from the manipulator.
(MC cable 3 m: 2 kg)



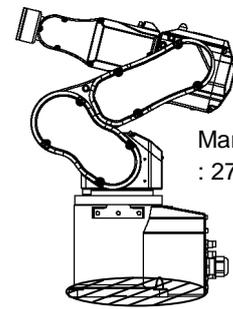
Remove the mechanical stops if using them to limit the motion range.

For details on the motion range, refer to the *Setup & Operation 5.2 Motion Range Setting by Mechanical Stops*.

- (2) Unscrew the anchor bolts. Then, remove the Manipulator from the base table.
- (3) Position the Manipulator as shown in the figure. Then, secure the Manipulator to the delivery equipment or have at least 2 people to carry the Manipulator.

Recommend: Joint #2 +65 deg.
Joint #3 -51 deg.

Do not hold the bottom of the base (the screened parts in the figure). Holding these parts by hand is extremely hazardous and may cause your hands and fingers to be caught.



Manipulator weight
: 27 kg (59.5 lb.)

DO NOT hold
the bottom of the
base by hand.

Using Eyebolt

Check that the eyebolts are securely fastened before carrying the Manipulator.

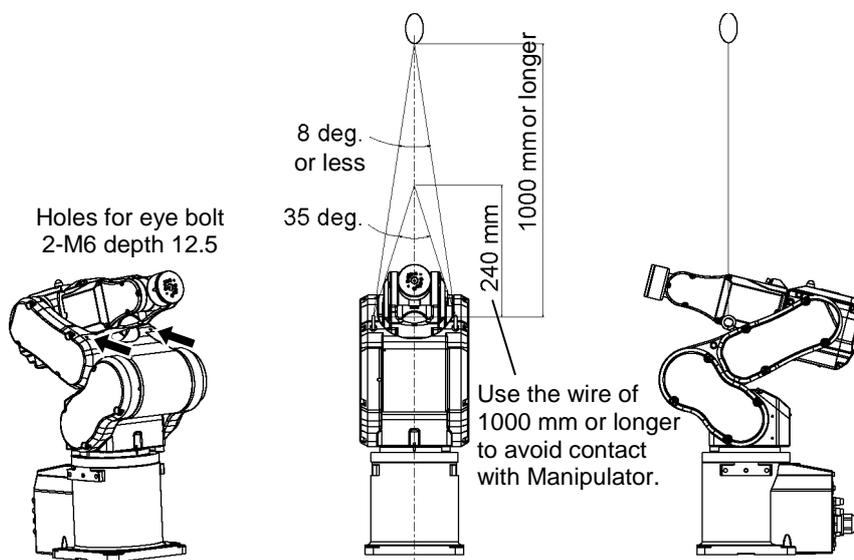
After transporting the Manipulator, remove the eyebolts and keep them for future use.

The eyebolts and wire must be strong enough to withstand the weight (See the figures below).

If you use the eyebolts to lift up the Manipulator, be sure to use the bifilar wire of 1 m long or more to avoid contact with the Arm #4 side cover.

Also, the Manipulator may swing while being lifted up even when using the appropriate length of wire, so be sure to handle it with care.

Take extra care if you use the wire of 240 mm-long or shorter to lift the Manipulator, because the wire is likely to touch the Arm #4 side cover and break the Manipulator.



3.3 Mounting Dimensions

Mounting Area

Be sure to have the following space available in addition to the space for mounting the Manipulator, Controller, and peripheral equipment.

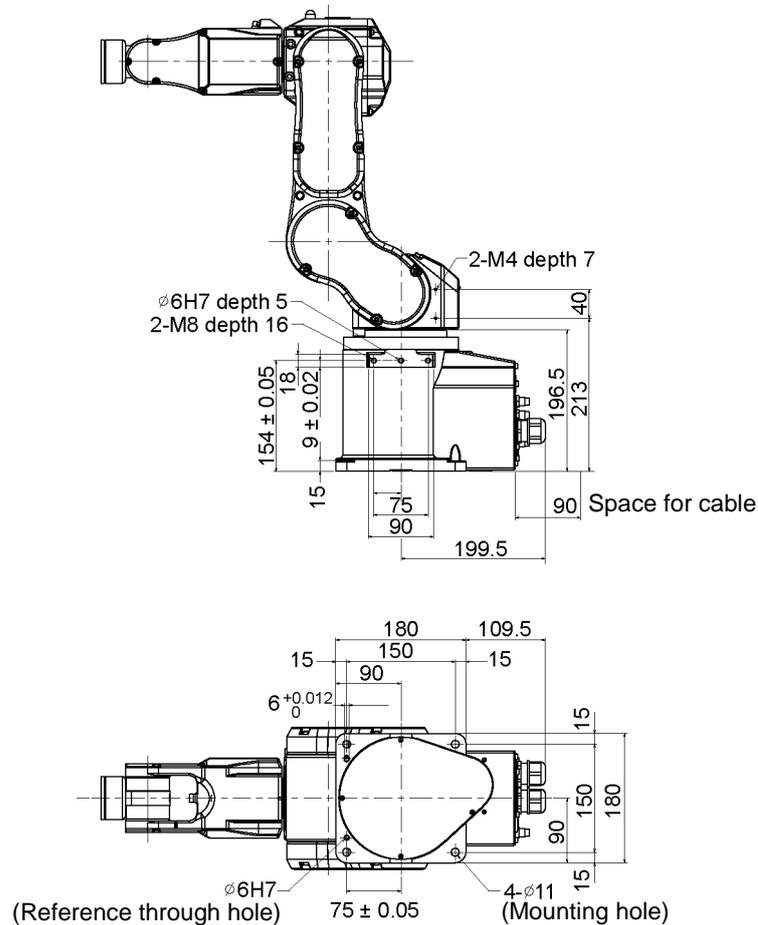
- Space for teaching points
- Space for maintenance and inspections (for installing jigs)
- Space for cables
- Space for mounting holes



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.

Mounting Dimensions

[Unit: mm]



3.4 Installation

The installation shall be made by qualified installation personnel and should conform to all national and local codes.

 WARNING	<ul style="list-style-type: none"> ■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the <i>Installation and Design Precautions</i> in the <i>Safety</i> chapter of the EPSON RC+ User's Guide. ■ Install the Manipulator in a location with sufficient space so that a tool or a work piece does not touch a wall or a safeguard when the Manipulator extends its arm fully while holding a work piece. Installing the Manipulator at a location with insufficient space is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system as a tool or a work piece may collide with a wall or a safeguard. ■ Anchor the Manipulator before turning ON the power to or operating the Manipulator. Turning ON the power to or operating the Manipulator that is not anchored is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system as the Manipulator may fall down. ■ Before installing and operating the Manipulator, make sure that all parts of the Manipulator are in place and have no external defects. Missing or defective parts may cause improper operation of the Manipulator. Improper operation of the Manipulator is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.
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 CAUTION	<ul style="list-style-type: none"> ■ The Manipulator 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.
--	---

Mounting bolt

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

There are four threaded holes for the Manipulator base.

Use M8 mounting bolts conforming to the strength of ISO898-1 property class 12.9.

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 differ depending on the intended use of the robot system. The following is the basic requirements of Manipulator table for your reference.

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. 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. Horizontal rotating torque	500 N·m
Max. Horizontal reaction force	800 N
Max. Vertical rotating torque	600 N·m
Max. Vertical reaction force	2500 N

The plate for the Manipulator mounting face should be 30 mm thick or more and made of steel to reduce vibration.

The surface roughness of the steel plate should be 25 μm or less.

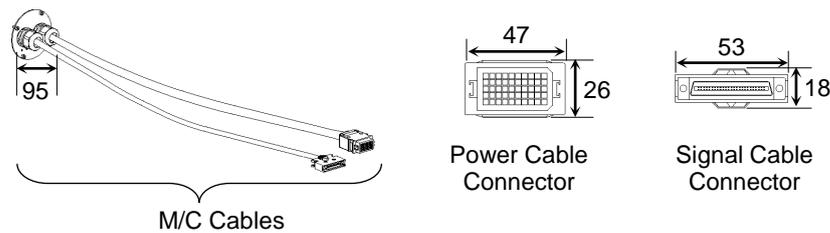
The base table must be secured on the floor to prevent it from moving.

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.

Connector

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



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.

When using the Manipulator in the clean room, follow the steps below before the installation.

- (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) Secure the Manipulator to the base table.

3.5 Connecting the Cables

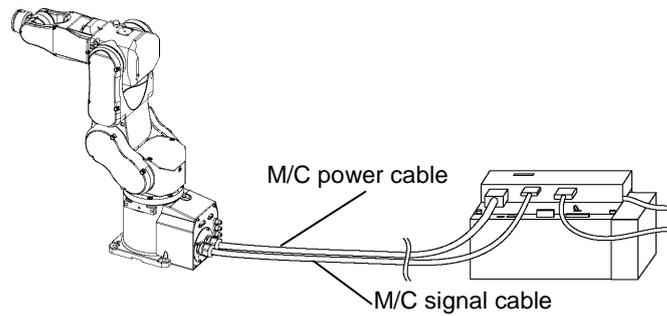
 WARNING	<ul style="list-style-type: none"> ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. To shut off power to the robot system, pull out the power plug from the power source. Performing any work while connecting the AC power cable to a factory power source 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. ■ Before wiring, turn OFF the Controller and related equipment, and then pull up a warning sign (e.g. DO NOT TURN ON THE POWER.). Wiring with the power ON is extremely hazardous and may result in electric shock and/or malfunction 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. ■ When connecting or replacing the brake release unit and the external short connector, turn OFF the power to the Controller and the brake release unit. Inserting and removing the connector while the power is ON may result in electrical shock.
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 CAUTION	<ul style="list-style-type: none"> ■ When connecting the Manipulator and the Controller, make sure that the serial numbers on each equipment match. Improper connection between the Manipulator and Controller may not only cause improper function of the robot system but also safety problems. The connection method varies with the Controller used. For details on the connection, refer to the Controller manual. ■ 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. ■ If the manipulator is operated without connecting the brake release unit and the external short connector, the brakes cannot be released and it may cause damage on them. After using the brake release unit, be sure to connect the external short connector to the Manipulator, or check connection of the connector for the brake release unit.
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Cleanroom-model Manipulator
 For the Cleanroom-model, an exhaust system is necessary. For details, refer to *Setup & Operation: 2.6 Specifications*.

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

Example: C3 series Manipulator and Robot Controller RC180.



3.6 User Wires and Pneumatic Tubes

3.6.1 Wiring and Piping

 CAUTION	<ul style="list-style-type: none"> 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.
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User electrical wires and pneumatic tubes are contained in the cable unit.

Electrical Wires

Rated Voltage	Allowable Current	Wires	Nominal Sectional Area	Outer Diameter	Note
AC/DC30 V	1 A	24	0.211 mm ²	ø8.3±0.3 mm	Shielded

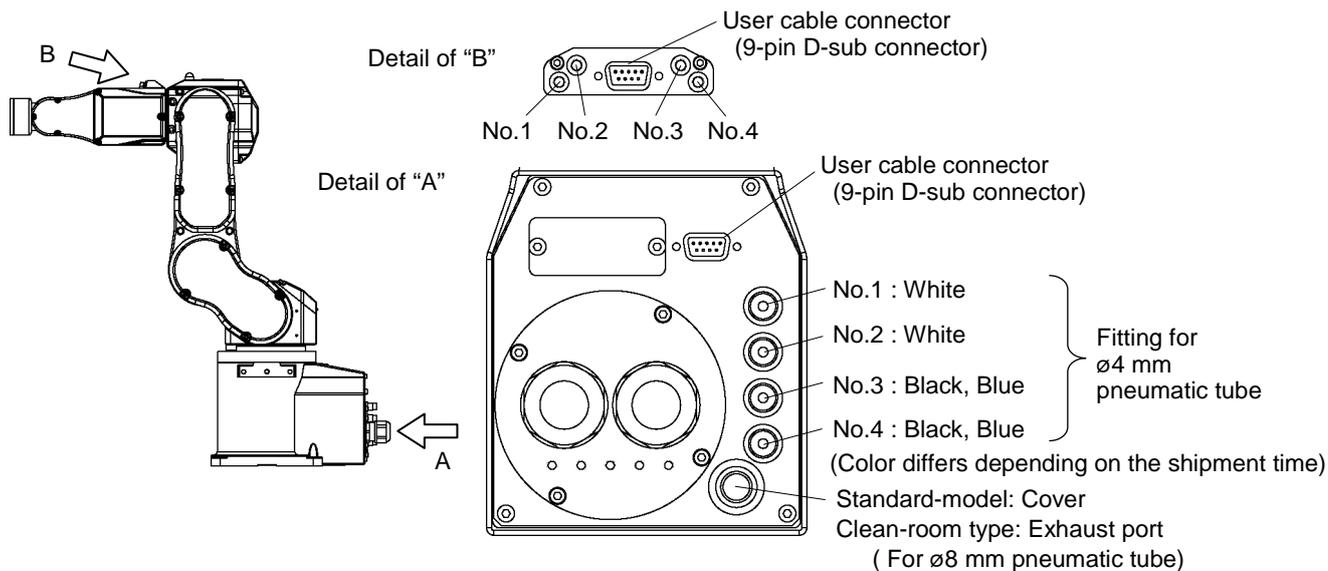
		Maker	Standard
9 pin	Suitable Connector	JAE	DE-9PF-N (Solder type)
	Clamp Hood	JAE	DE-C8-J9-F2-1R (Connector setscrew: #4-40 NC)

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

Pneumatic Tubes

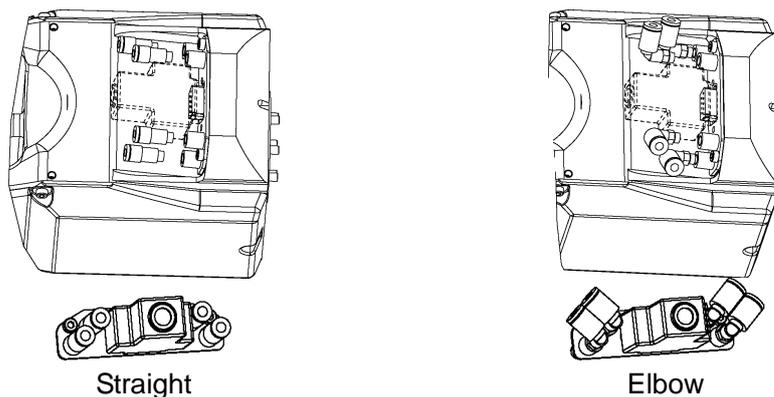
Max. Usable Pneumatic Pressure	Pneumatic Tubes	Outer Diameter x Inner Diameter
0.59 MPa (6 kgf/cm ² : 86 psi)	4	ø4 mm x ø2.5 mm

Tubes with the same number, indicated in details of View A and B, are connected.

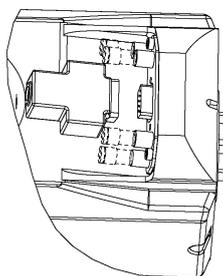


We prepare the part that can be mounted to the position shown in “Detail of B”.

One Touch Fittings Kit (Set of four: M5-ø4 mm one touch fittings for tubes)



User Connector kit (Single: 9 pins D-sub connector)



3.7 Checking the Basic orientation

After parts have been replaced (motors, reduction gear units, belts, etc.), the Manipulator cannot operate properly because a gap exists between the home positions stored in each motor and these stored in the Controller.

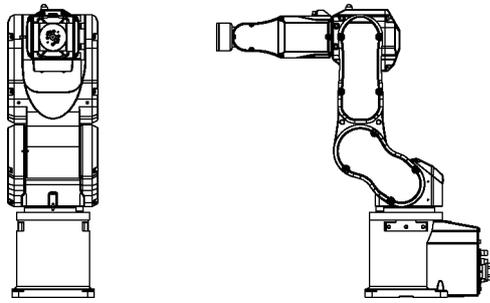
The process to compensate the position gap is called “Calibration”.

At shipment, the Manipulator is set the following basic position as origin.

After all setting is done, go through an origin return and make sure the manipulator moves to the right basic orientation.

To make the manipulator return to origin, select [Tool]-[Robot Manager]-[Control Panel] and click <Home>.

If the gap still exists and the manipulator cannot be in the basic orientation as below after the origin return, refer to *Maintenance 16. Calibration* and calibrate the manipulator.



Basic orientation

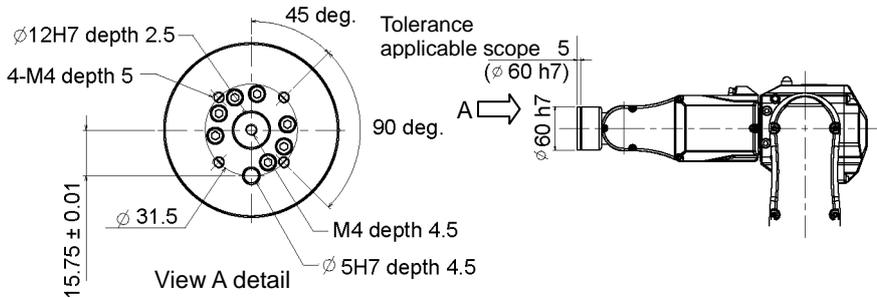
4. End Effectors

4.1 Attaching an End Effector

Create an end effector for your Manipulator. Flange dimensions of the wrist attached to the end of Arm #6 is as below.

 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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Wrist Flange



Arm #6

Attach an end effector to the end of the Arm #6 using the M4 bolts.

Layouts

When you operate the Manipulator with an end effector, the end effector may interfere with the Manipulator body depending on 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 close attention to the interference area of the end effector.

Standard specification (Brakes on Joints #1, #4, #6)

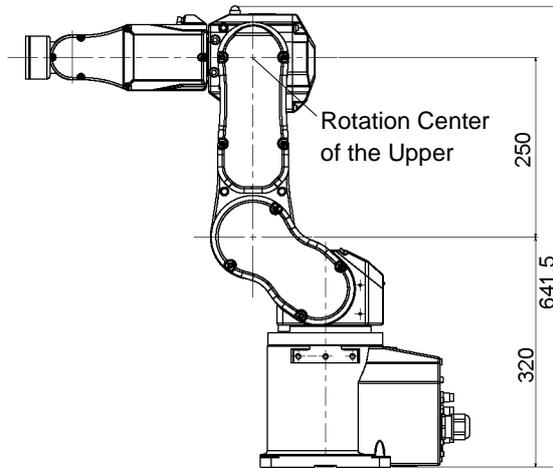
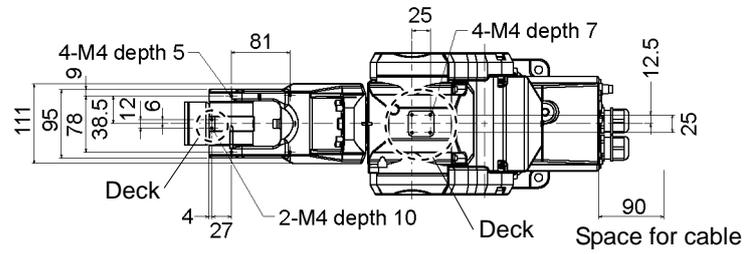
When the end effector is installed, the joint may rotate by the hand weight or inertia in Emergency Stop status. The end effector may interfere with the Manipulator body depending on the diameter of end effector, size of part, or arm position. Be careful about the area of interference of the end effector for the system layout.

Compatibility with PS series

To install the end effector used in the PS series to the C3 series, we provide the optional PS Compatible Plate. For details, refer to *Setup & Operation: 6. Options*.

4.2 Attaching Camera and Valves

Decks are equipped to Arms #3 and #5 to enable the easy installation of air valve.



[Unit: mm]

If the payload exceeds the maximum payload, refer to the section “*Restriction on payload exceeding the maximum payload*” in the *Setup & Operation 4.3.1 WEIGHT Setting*.

To mount the camera, the camera plate unit is necessary.

We provide the optional Camera Plate Unit. For details, refer to *Setup & Operation: 6. Options*.

4.3 WEIGHT and INERTIA Settings

The WEIGHT and INERTIA commands are for setting the load parameters of the Manipulator. These settings optimize the Manipulator motion.

WEIGHT Setting

The WEIGHT command is for setting the load weight. The more the load weight increases, the more the speed and acceleration/deceleration are reduced.

INERTIA Setting

The INERTIA command is for setting the inertia moment and the eccentricity of the load. The more the inertia moment increases, the more the acceleration and deceleration of the Arm #6 are reduced. The more the eccentricity increases, the more the acceleration and deceleration for the Manipulator movement are reduced.

To ensure optimum Manipulator performance, make sure that the load (weight of the end effector and work piece) and inertia moment of the load are within the maximum rating for the Manipulator, and that Arm #6 does not become eccentric.

If the load or the inertia moment exceeds the ratings or if the load becomes eccentric, follow the steps in the *Setup & Operation 4.3.1 WEIGHT Setting* and *4.3.2 INERTIA Setting*, to set parameters.

Setting parameters makes the operation 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 inertia moment of the end effector and work piece is bigger.

The allowable load for C3 series Manipulators is up to 3 (5) kg*.

Due to the limitations shown in the tables below, the moment and the inertia moment should also meet these conditions.

If force is applied to the Manipulator instead of weight, it should not exceed the values shown in the table below.

* If the payload exceeds the maximum payload, refer to the section “*Restriction on payload exceeding the maximum payload*” in the *Setup & Operation 4.3.1 WEIGHT Setting*.

Allowable Load

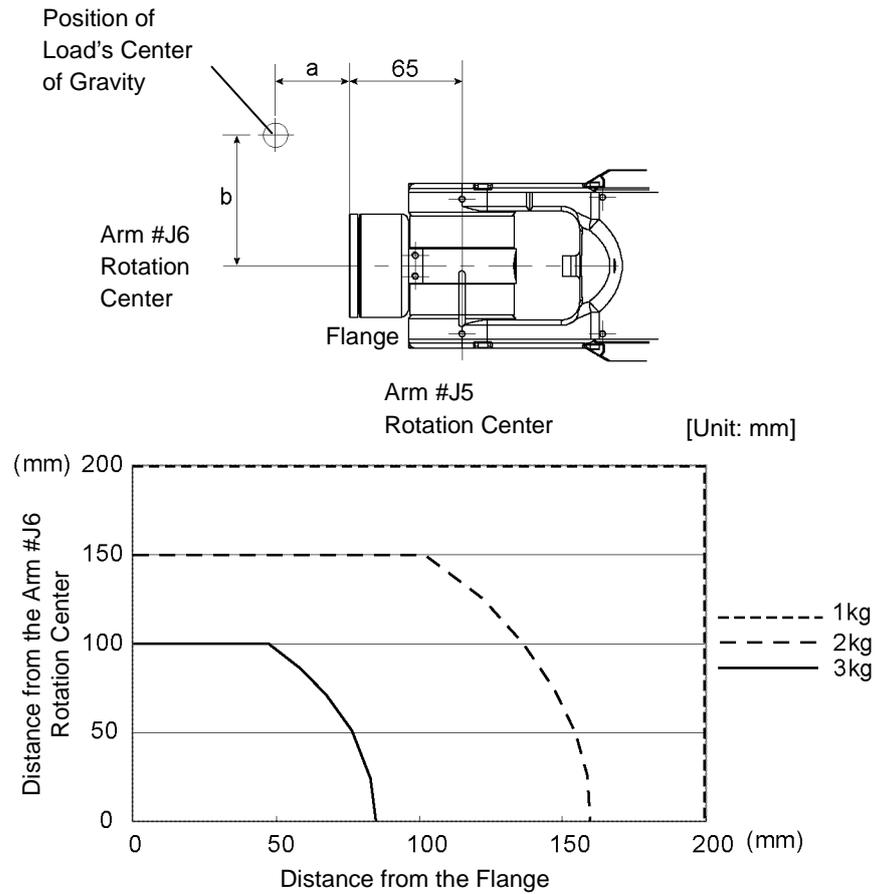
Arm	Allowable Moment *1	GD ² /4 Allowable Moment of Inertia
#4	4.41 N·m (0.45 kgf·m)	0.15 kg·m ²
#5 *2	4.41 N·m (0.45 kgf·m)	0.15 kg·m ²
#6	2.94 N·m (0.3 kgf·m)	0.1 kg·m ²

*1 Torque unit

*2 The allowable load for Arm #5 are calculated as follows:

Distance from the center of Arm #5 rotation (Figure: a + 65 [mm]).

Critical Dimension of Load



When calculating the critical dimension of the load on the Arm #5 using the allowable moment and inertia moment, the calculated value represents a distance from the Arm #5 rotation center, not the distance from the flange. Therefore, to get a value of the critical dimension of the load on Arm #5, subtract 65 (mm) from the calculated distance as shown in the example below.

Example: Calculate the critical dimension of the load on the Arm #5 (c) when a 2.5 kg load is on the Arm #6 rotation center line (b = 0).

$$\begin{aligned} & \text{Allowable Moment of the Arm \#5 (N}\cdot\text{m)} / \text{Load (kg)} \\ & = \text{Distance from the Arm \#5 rotation center (m)} \\ & 4.41 \text{ (N}\cdot\text{m)} / 9.8 / 2.5 \text{ (kg)} = 0.18 \rightarrow 0.18 \text{ (m)} = 180 \text{ (mm)} \end{aligned}$$

$$\begin{aligned} c &= \text{Distance from the Arm \#5 rotation center (mm)} - 65 \text{ (mm)} \\ c &= 180 \text{ (mm)} - 65 \text{ (mm)} = 115 \text{ (mm)} \end{aligned}$$

Moment

A moment is a necessary torque (holding torque) to counteract the gravity affecting the load.

Design an end effector so that the eccentric quantity at the position where the load is attached is within the allowable moment.

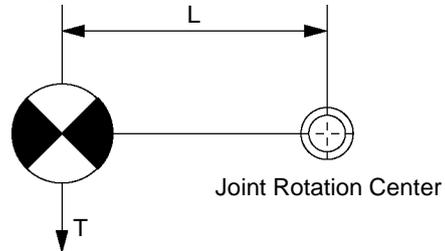
A maximum torque (T) is calculated by the following formula.

$$T = m \text{ (kg)} \times L \text{ (m)} \times g \text{ (m/s}^2\text{)}$$

m: Weight of load (kg)

L: Eccentric quantity of load (m)

g: Gravitational acceleration (m/s²)



Max. Eccentric Quantity of Load

(Distance between the joint rotation center and the load's center of gravity)

Axis	WEIGHT 1 kg	WEIGHT 2 kg	WEIGHT 3 kg
#4	200 mm	200 mm	150 mm
#5	200 mm	200 mm	150 mm
#6	200 mm	150 mm	100 mm

(The maximum eccentric quantity of load is restricted to 200 mm or less.)

4.3.1 WEIGHT setting



CAUTION

- Set the total weight of the end effector and the work piece smaller than the maximum payload.

The C3 Manipulators can operate without limitations on the condition unless and until the load exceeds this maximum payload. When the payload of the Manipulator exceeds the maximum payload, refer to the section “Restrictions on payload exceeding the maximum payload” in the later part of this section for details.

Always set the Weight parameters of the WEIGHT command 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) for C3 Manipulators is as follows:

Rated	Maximum
1 kg	3(5) kg*

When the load exceeds the rating, change the setting of the Weight parameter.

After changing the Weight parameter setting, the maximum acceleration/deceleration and speed of the robot system corresponding to the load is set automatically.

* If the payload exceeds the maximum payload, refer to the section “Restriction on payload exceeding the maximum payload” in the Setup & Operation 4.3.1 WEIGHT Setting.



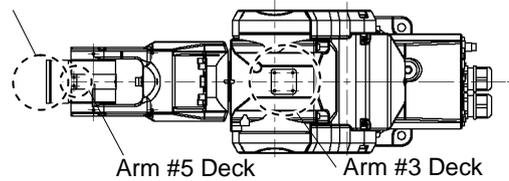
Setting method of Weight parameters

Select [Tools]-[Robot Manager]-[Weight] panel and set the value in [Weight:].
 You may also execute the Weight command from [Command Window].

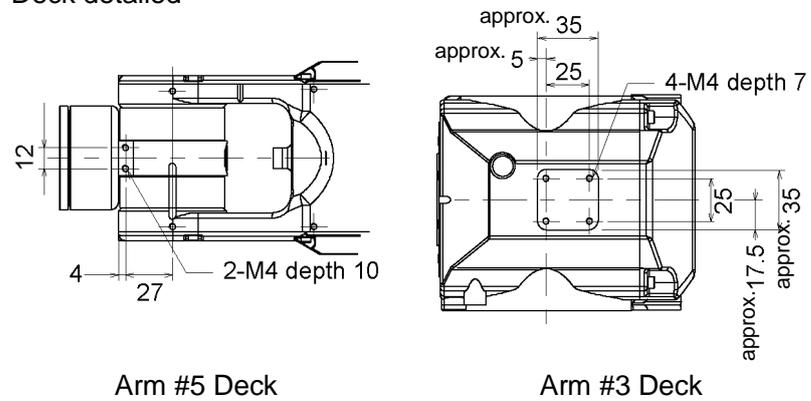
Load on the Manipulator

Mounting location of the load

Load on the fore end of Arm #6



Deck detailed



[Unit: mm]

When you attach the equipment to the decks on the upper arm, convert its weight into equivalent weight assuming that the equipment is attached to the end of the Arm #6. Then, this equivalent weight added to the load will be a Weight parameter.

Calculate the Weight parameter by using the formula below and enter the value.

Weight Parameter Formula

$$\text{Weight parameter} = M_w + W_a + W_b$$

M_w : Load on the fore end of Arm #6 (kg)

W_a : Equivalent weight of the Arm #3 deck (kg)

W_b : Equivalent weight of the Arm #5 deck (kg)

$$W_a = M_a (L_a)^2 / (L)^2$$

$$W_b = M_b (L_b)^2 / (L)^2$$

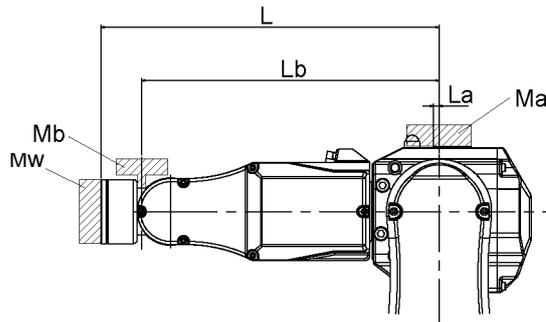
M_a : Weight of the air valve on the Arm #3 deck

M_b : Weight of the camera on the Arm #5 deck

L : Length of the upper arm (315 mm)

L_a : Distance between the Joint #3 and the center of gravity of the air valve on the Arm #3 deck (mm)

L_b : Distance between the Joint #3 and the center of gravity of the camera on the Arm #5 deck (mm)



<Example> The fore end of the Arm #6 is 315 mm (L) away from the Joint #3.

Load on the fore-end of Arm #6 is 1 kg (M_w).

Load on the Arm #3 deck is 1.5 kg (M_a).

The deck is 0 mm (L_a) away from Joint #3.

Load on the Arm #5 deck is 0.5 kg (M_b).

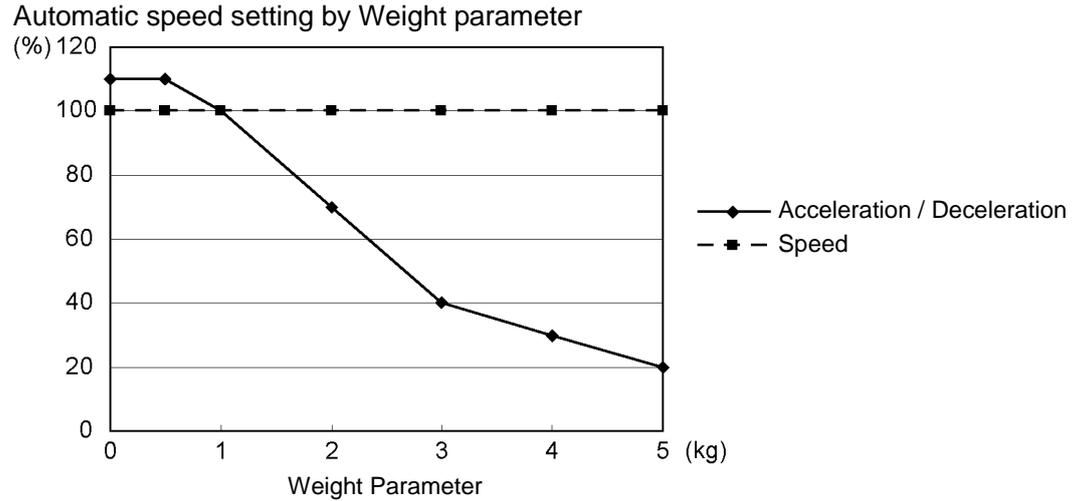
The deck is 280 mm (L_b) away from the Joint #3.

$$W_a = 1.5 \times 0^2 / 315^2 = 0$$

$$W_b = 0.5 \times 280^2 / 315^2 = 0.395 \rightarrow 0.4 (\text{round up})$$

$$M_w + W_a + W_b = 1 + 0 + 0.4 = 1.4$$

Enter "1.4" for the Weight parameter.



- * The percentage in the graph is based on the speed at rated weight (1 kg) as 100%.
- * If the payload exceeds the maximum payload, refer to the section “*Restriction on payload exceeding the maximum payload*” in the *Setup & Operation 4.3.1 WEIGHT Setting*.

Restrictions on payload exceeding the maximum payload

Maximum payload for C3 Manipulators is as follows:

Payload can be increased by restricting the arm posture of the Arm #5 downward.

Max. Payload	Max. Payload with Pose Restriction
3 kg	5 kg

If the load exceeds the maximum payload, use the Arm #5 with a posture angle within the range indicated in the following graph.

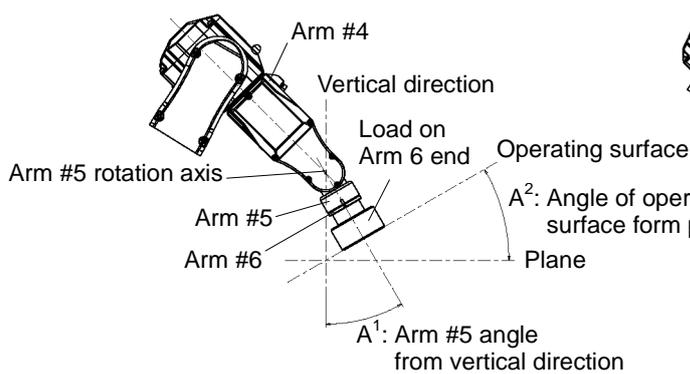
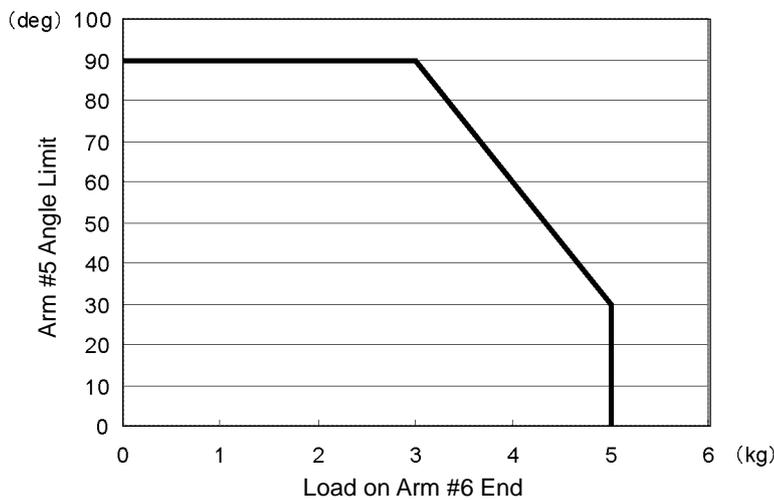
The graph shows the relation of the load weight and Arm #5 angle limit (A^1) measured in vertical direction (direction of gravity). Note that the heavier the load on the Arm #6, the smaller the angle limit becomes.

When the manipulator operates vertically to the operating surface, the limit of the Arm #5 is equivalent to the limit of the operating angle (A^2).

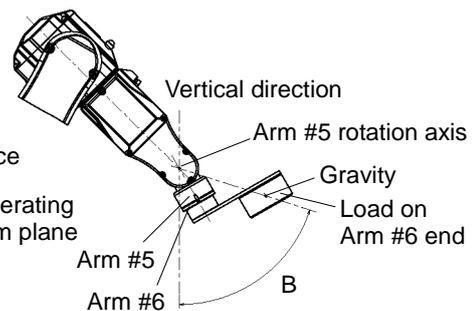
In addition, for the eccentric load, the angle limit is an angle of the line joining the center of the load and the Arm #5 rotation axis with the vertical direction (B).

The eccentric quantity of the load should be within the allowable moment and inertia moment of Arms #4, #5, and #6.

Relation of load weight and Arm #5 angle limit



Relation of Arm #5 angle and operating surface



Angle limit for eccentric load

4.3.2 INERTIA setting

Inertia Moment and the INERTIA Setting

The inertia moment is defined as “the ratio of the torque applied to a rigid body and its resistance to motion”. This value is typically referred to as “the moment of inertia”, “inertia”, or “ GD^2 ”. When the Manipulator operates with objects such as an end effector attached to the Arm #6, the moment of inertia of load must be considered.

 CAUTION	<ul style="list-style-type: none"> ■ The inertia moment of the load (weight of the end effector and work piece) must be $0.1 \text{ kg}\cdot\text{m}^2$ or less. The C3 Manipulators are not designed to work with inertia moment exceeding $0.1 \text{ kg}\cdot\text{m}^2$. Always set the inertia moment (INERTIA) parameter according to the inertia moment. Setting a value that is smaller than the actual inertia moment may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life of parts/mechanisms.
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The acceptable inertia moment of load for C3 Manipulator is $0.1 \text{ kg}\cdot\text{m}^2$ nominal rating and $0.1 \text{ kg}\cdot\text{m}^2$ maximum. When the inertia moment of the load exceeds the rating, change the setting of the inertia moment using the INERTIA command. After the setting has been changed, the maximum acceleration/deceleration speed of Arm #6 responding to “inertia moment” is set automatically.

Inertia moment of load on Arm #6

The inertia moment of the load (weight of the end effector and work piece) on the Arm #6 can be set by the “inertia moment (INERTIA)” parameter of the INERTIA command.

EPSON
RC+

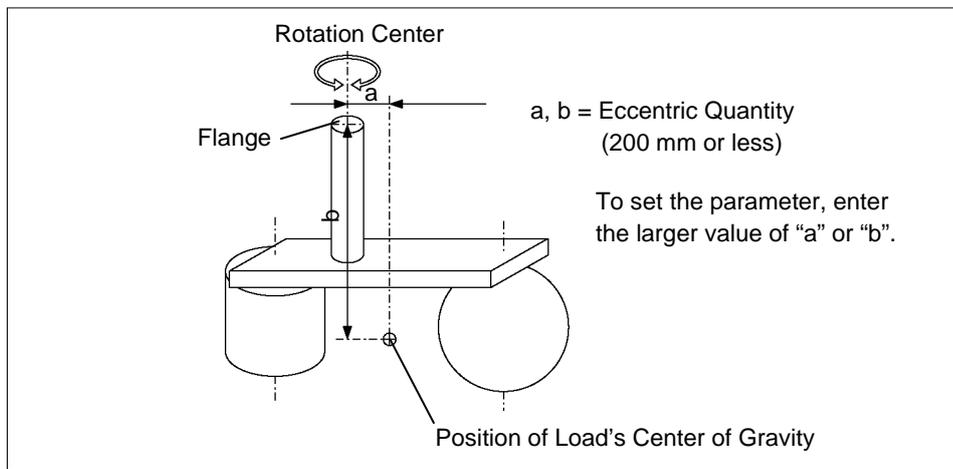
Select [Tools]–[Robot Manager]–[Inertia] panel and enter the value in [Load inertia:].
You may also execute the Inertia command from [Command Window].

Eccentric Quantity and the INERTIA Setting



- The eccentric quantity of the load (weight of the end effector and work piece) must be 200 mm or less. The C3 Manipulators are not designed to work with eccentric quantity exceeding 200 mm. Always set the eccentric quantity parameter according to the eccentric quantity. Setting a value that is smaller than the actual eccentric quantity may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.

The acceptable eccentric quantity of the load for C3 Manipulators is 30 mm at nominal rating and 200 mm at maximum. When the eccentric quantity of the load exceeds the rating, change the setting of eccentric quantity parameter using the INERTIA command. After changing the setting, the maximum acceleration/deceleration speed of Manipulator corresponding to “eccentric quantity” is set automatically.



Eccentric Quantity

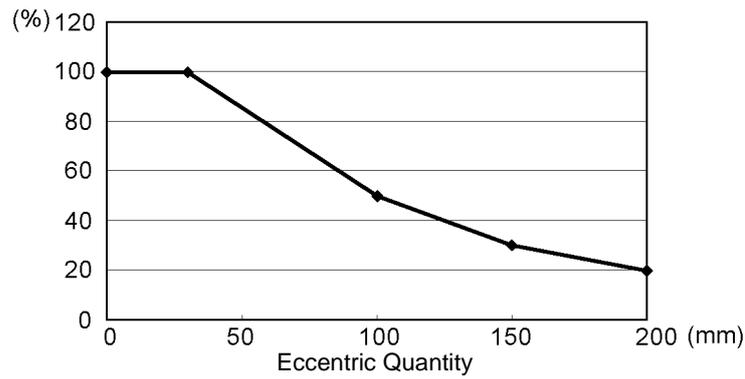
Eccentric quantity of load on Arm #6

The eccentric quantity of the load (weight of the end effector and work piece) on the Arm #6 can be set by the “eccentric quantity” parameter of the INERTIA command. Enter the larger value of either “a” or “b” in the figure above to [Eccentricity].



Select [Tools]–[Robot Manager]-[Inertia] panel and enter the value into [Eccentricity:]. You may also execute the Inertia command from [Command Window].

Automatic acceleration/deceleration setting by INERTIA (eccentric quantity)



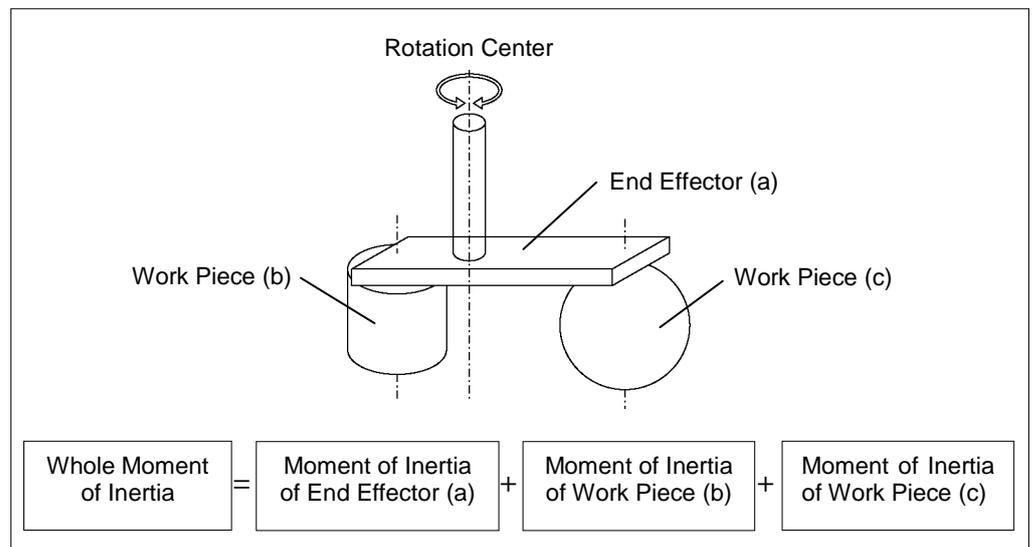
* The percentage in the graph is based on the acceleration/ deceleration at rated eccentricity (30 mm) as 100%.

INERTIA (eccentric quantity) is affected by the load setting. Refer to *Setup & Operation 4.3: WEIGHT and INERTIA Settings* and configure the load setting carefully.

Calculating the Inertia Moment

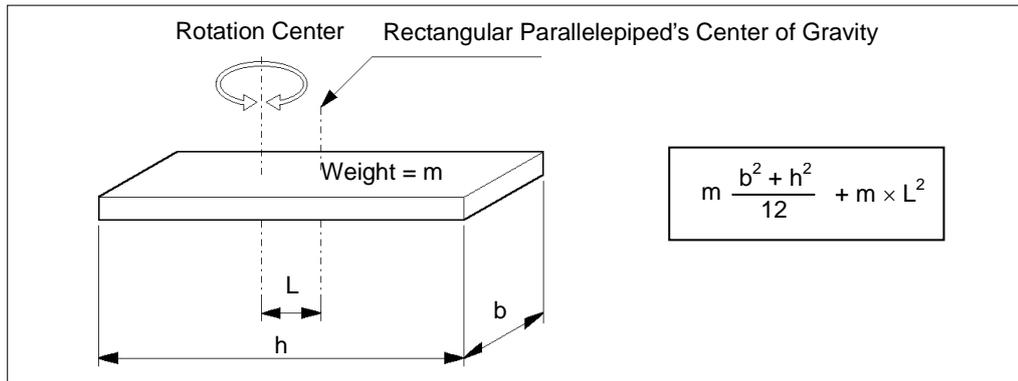
Refer to the following example formulas to calculate the inertia moment of the load (end effector with work piece).

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

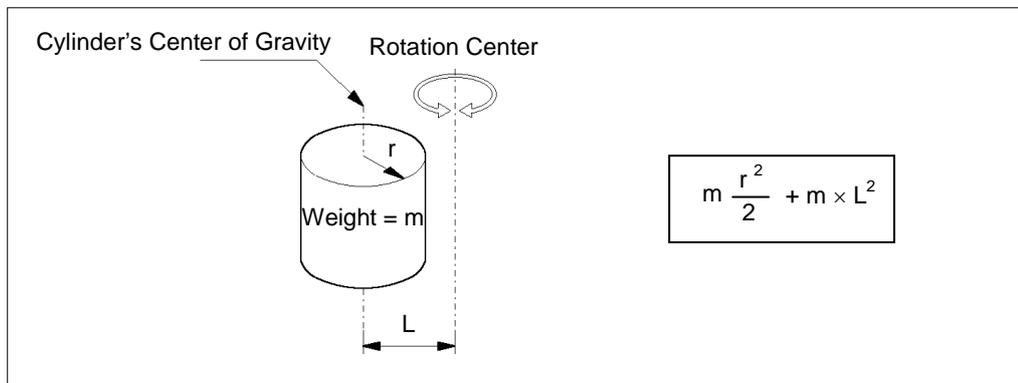


The methods for calculating the inertia moment for (a), (b), and (c) are shown in this and the next page. Figure out the whole inertia moment using the basic formulas below.

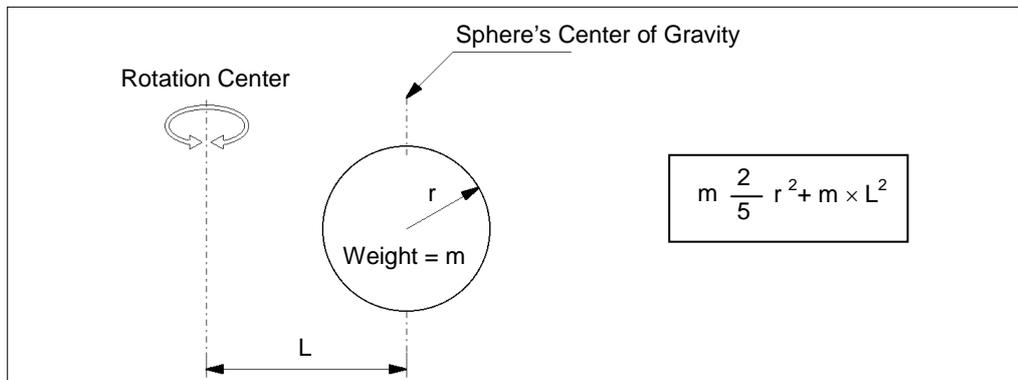
(a) Inertia moment of a rectangular parallelepiped



(b) Inertia moment of a cylinder



(c) Inertia moment of a sphere



4.4 Precautions for Auto Acceleration/Deceleration

The speed and acceleration/deceleration of the Manipulator motion are automatically optimized according to the values of WEIGHT and INERTIA and the Manipulator's postures.

WEIGHT Setting

The speed and acceleration/deceleration of the Manipulator are controlled according to the load weight set by the WEIGHT command.

The more the load weight increases, the more the speed and acceleration/deceleration are reduced to prevent residual vibration.

INERTIA Setting

The acceleration/deceleration of Arm #6 are controlled according to the inertia moment set by the INERTIA command. The acceleration/deceleration of the whole Manipulator are controlled according to the eccentricity set by the INERTIA command. The more the inertia moment and eccentricity of the load increase, the more the acceleration/deceleration are reduced.

Auto Acceleration/Deceleration According to Manipulator's Posture

The acceleration/deceleration are controlled according to the Manipulator's posture. When the Manipulator extends its arms or when the movement of the Manipulator produces vibration frequently, the acceleration/deceleration are reduced.

Set appropriate values for WEIGHT and INERTIA so that the Manipulator operation is optimized.

5. Motion Range

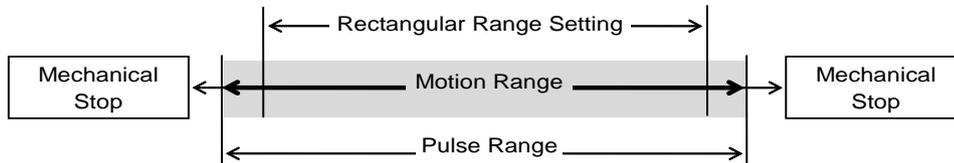


- When limiting the motion range for safety, be sure to set by both the pulse range and mechanical stops. Failure to do so may cause serious safety problems.

The motion range is preset at the factory as describes in the *Setup & Operation 2.5 Standard Motion Range*. This is the maximum motion range of the Manipulator.

Motion range is set by the following three methods:

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



When the motion range is changed due to layout efficiency or safety, follow the descriptions in 5.1 through 5.4 to set the range.

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

Pulses are the basic unit of Manipulator motion. The motion range of the Manipulator is controlled by the pulse range (the lower limit and the upper limit) of each axis.

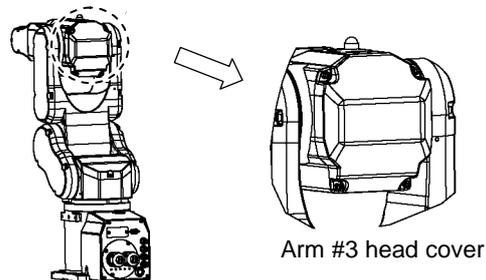
Pulse values are read from the encoder output of the servo motor.

The pulse range should be set within the mechanical stop range.



- Do not set and/or use the Arm #4 with a pulse range exceeding the maximum value.
The Arm #4 does not have a mechanical stop. Using the Arm #4 with a pulse range exceeding the maximum pulse range may cause the inner wiring damaged and/or malfunction to the Manipulator.

Torsion of the inner wiring can be checked by removing the Arm #3 head cover.



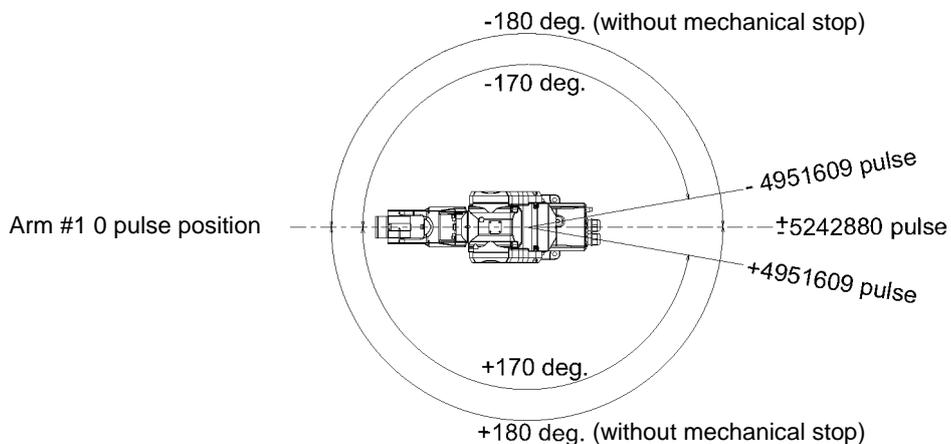
Once the Manipulator receives an operating command, it checks whether the target position specified by the command is within the pulse range before operating. If the target position is out of the set pulse range, an error occurs and the Manipulator does not move.



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

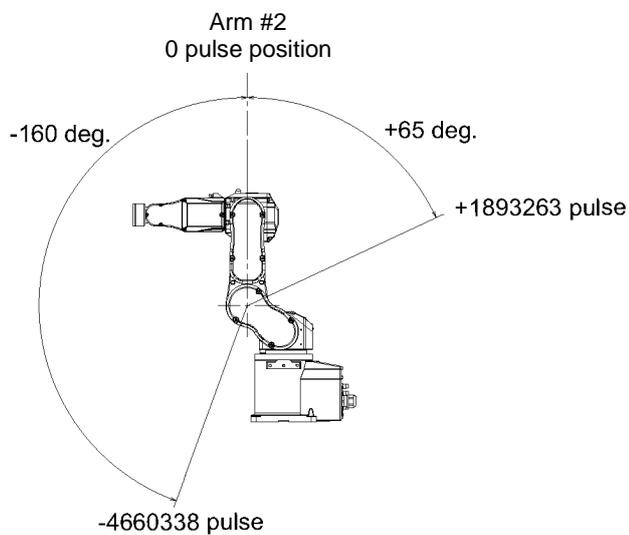
5.1.1 Max. Pulse Range of Arm #1

Pulse values in counterclockwise direction are positive (+) and values in clockwise direction are negative (-).



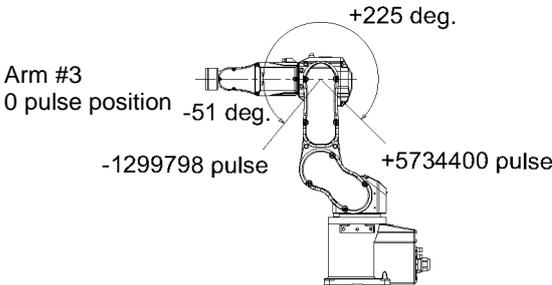
5.1.2 Max. Pulse Range of Arm #2

Pulse values in counterclockwise direction are positive (+) and values in clockwise direction are negative (-).



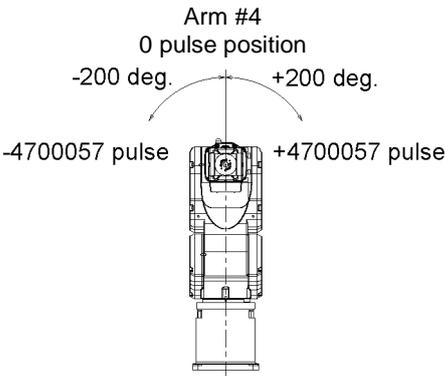
5.1.3 Max. Pulse Range of Arm #3

Pulse values in counterclockwise direction are positive (+) and values in clockwise direction are negative (-).



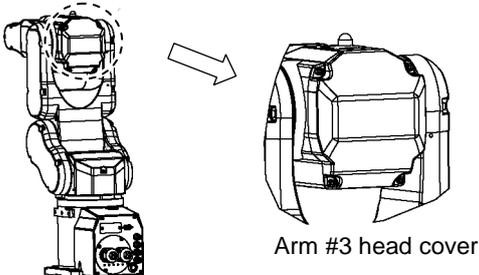
5.1.4 Max. Pulse Range of Arm #4

From the angle of arm end, clockwise pulse values are positive (+) and counterclockwise pulse values are negative (-).



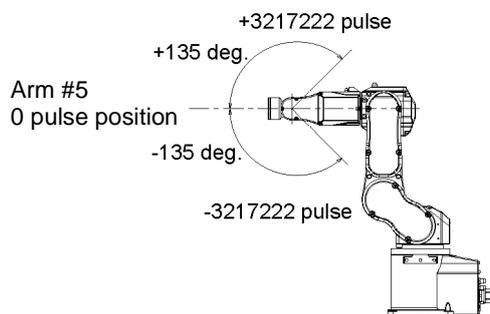
 <p>CAUTION</p>	<ul style="list-style-type: none">Do not set and/or use the Arm #4 with a pulse range exceeding the maximum value. <p>The Arm #4 does not have a mechanical stop. Using the Arm #4 with a pulse range exceeding the maximum pulse range may cause the inner wiring damaged and/or malfunction to the Manipulator.</p>
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Torsion of the inner wiring can be checked by removing the Arm #3 head cover.



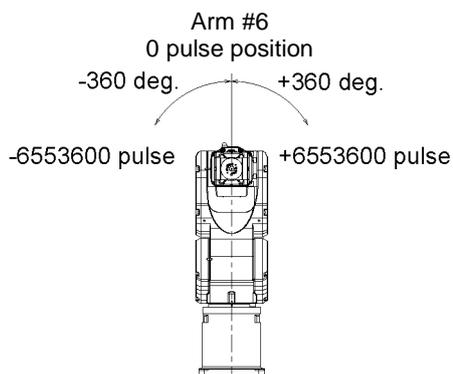
5.1.5 Max. Pulse Range of Arm #5

Pulse values in counterclockwise direction are positive (+) and values in clockwise direction are negative (-).



5.1.6 Max. Pulse Range of Arm #6

From the angle of arm end, clockwise pulse values are positive (+) and counterclockwise pulse values are negative (-).



5.2 Motion Range Setting by Mechanical Stops

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

Be sure to turn OFF the Controller in advance.

Bolts are not provided, arrange for them by yourself.

Use bolts conforming to the strength specified by ISO-898-1, property class: 12.9.

Specify the pulse range again after changing the position of the mechanical stop.

For details on the pulse range setting, refer to the *Setup & Operation 5.1 Motion Range Setting by Pulse Range (for All Arms)*.

Be sure to set the pulse range not to exceed the setting angles of the mechanical stop.

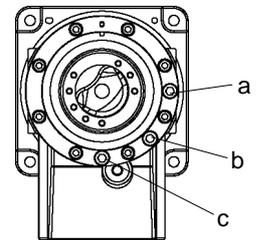
5.2.1 Motion Range Setting of Arm #1

Install the bolt to the threaded hole corresponding to the angle you want to set.

Normally a mechanical stop is equipped at [b].

[a] and [c] limit the one side of motion range.

Remove the bolts when the motion range of the Arm #1 is set to ± 180 deg.



M8×15 hexagon socket head cap bolt

Tightening torque 37.2 N·m (380 kgf·cm)

	a	b		c
Angle (deg.)	-125	± 170	± 180	+125
Pulse (pulse)	-3640889	± 4951609	± 5242880	-3640889
Bolt	Applied	Applied (Normal)	Not applied	Applied

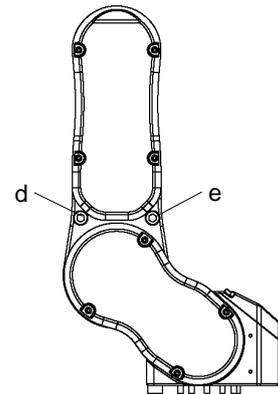
5.2.2 Motion Range Setting of Arm #2

There are threaded holes corresponding to each angle on the Manipulator.

Normally there is no mechanical stop equipped.
(-160 deg. - +65 deg.)

[d] and [e] limit the one side of motion range.

M10x15 hexagon socket head cap bolt
Tightening torque 73.5 N·m (750 kgf·cm)



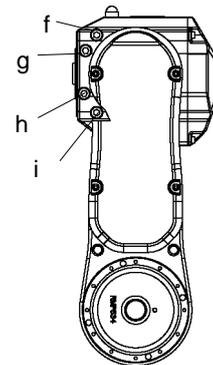
	d	e	-	-
Angle (deg.)	-143	+48	-160	+65
Pulse (pulse)	-4165177	+1398102	-4660338	+1893263
Bolt	Applied	Applied	Not applied (Normal)	Not applied (Normal)

5.2.3 Motion Range Setting of Arm #3

There are threaded holes corresponding to each angle on the Manipulator.

Normally mechanical stops are equipped to [g] and [h].
(+225 deg. - -51 deg.)

M8x12 hexagon socket head cap bolt
Tightening torque 37.2 N·m (380 kgf·cm)



	f	i	g	h
Angle (deg.)	+201	-27	+225	-51
Pulse (pulse)	+5122731	-688128	+5734400	-1299798
Bolt	Applied	Applied	Applied (Normal)	Applied (Normal)

5.3 Restriction of Manipulator Operation by Joint Angle Combination

To prevent the arms of the Manipulator from interfering each other, the Manipulator operation is restricted in the specified motion range according to the joint angle combination of the Arm #1, #2, and #3.

The Manipulator operation is restricted and the Manipulator stops when the joint angles of the Arm are within the gray areas in the following figure.

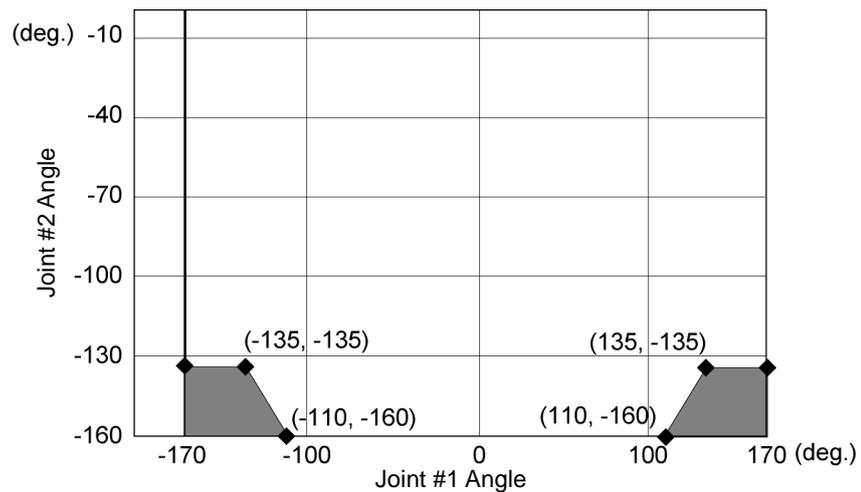
The restriction to Manipulator operation is enabled:

- During CP motion command execution
- When you attempt to execute the motion command for moving the Manipulator to a target point (or pose) in the specified motion range.

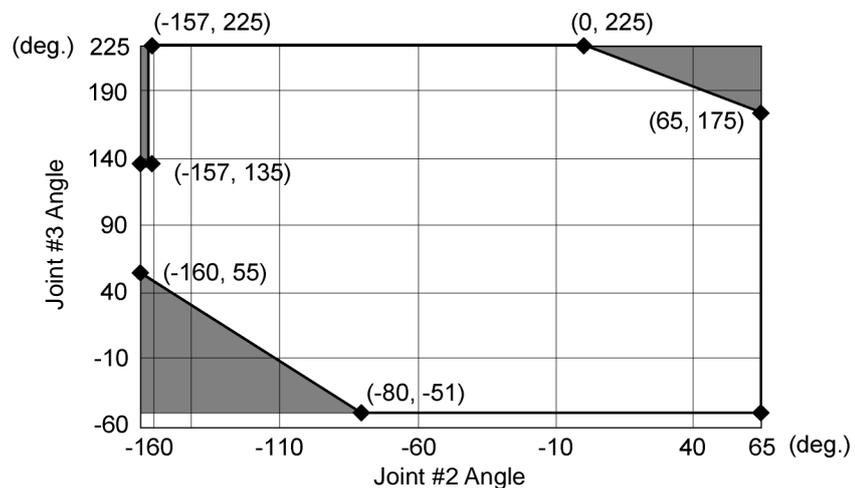
The restriction to the Manipulator operation is disabled:

- The Arms of the Manipulator momentarily go through the specified motion range during the PTP motion command execution even though the joint angles of the Arms are in the gray areas of the figures above.

Combination of Joint #1 and #2

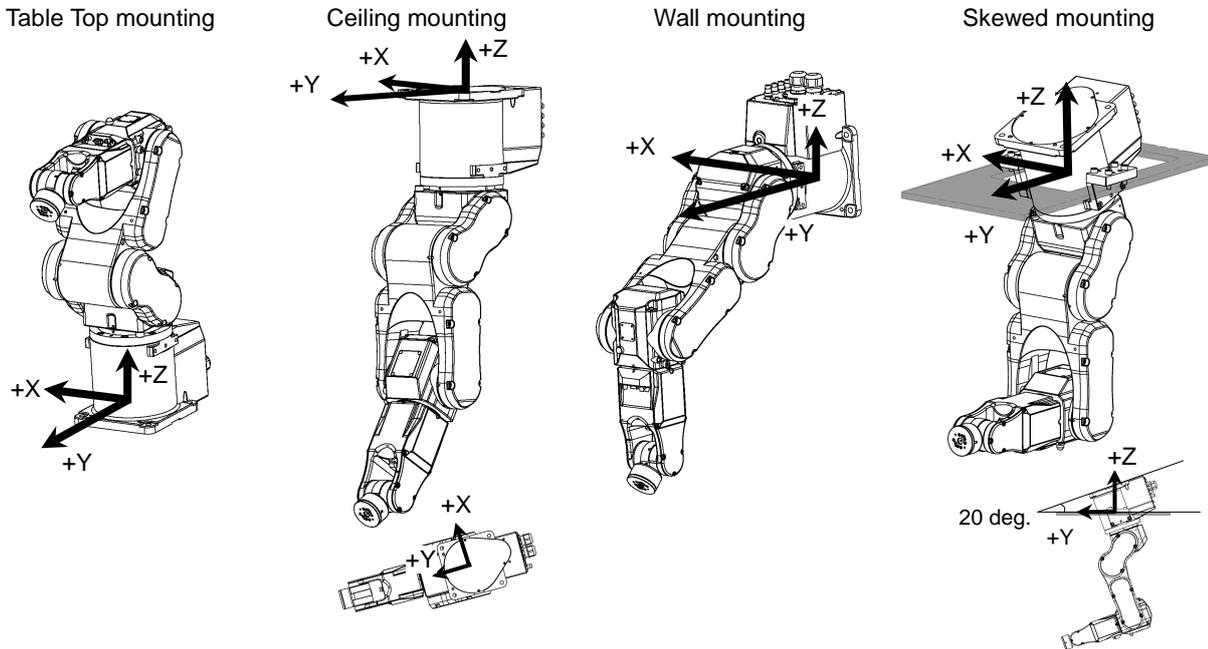


Combination of Joint #2 and #3



5.4 Coordinate System

The origin point is where the Manipulator base intersects with the rotation axis of Joint #1. For details on the coordinate system, refer to the *EPSON RC+ Users Guide manual*.



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

The Cartesian (rectangular) range in the XY coordinate system of the Manipulator is specified by the limited Manipulator operation area and the XYLIM setting.

The limited Manipulator operation area is defined so that the end effector does not interfere with the rear side of the Manipulator. The XYLIM setting that you can determine the upper and lower limits of the X and Y coordinates.

The limited Manipulator operation area and the XYLIM setting apply only to the software. Therefore, these settings do not change the physical range. The maximum physical range is based on the position of the mechanical stops.

These settings are disabled during a joint jogging operation. Therefore, be careful not to allow the end effector to collide with the Manipulator or peripheral equipment.

The method for changing the XYLIM setting varies with the software used.



Set the XYLIM setting in [Tools]-[Robot manager]-[XYZ Limits] panel. You may also execute the XYLIM command from the [Command Window].

6. Options

C3 series manipulators have the following options.

- 6.1 Brake Release Unit
- 6.2 Camera Mounting Plate
- 6.3 PS Compatible Plate
- 6.4 Base Side Angled Fittings
- 6.5 Base Side Fittings

6.1 Brake Release Unit

With the electromagnetic brake is ON (such as in Emergency Stop status), you cannot move the Arms #2, #3, and #5 by hand. If all joints have brakes, all arms don't move. You can move the Arms by hand using the brake release unit while the controller power is OFF or right after unpacking.

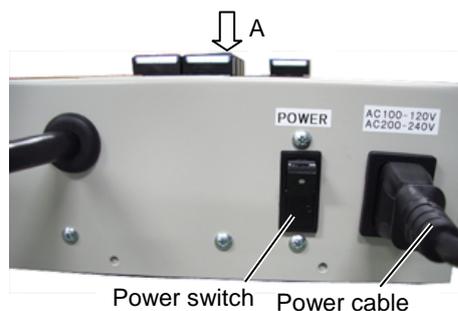


- Before connecting/disconnecting the connector of the Brake release unit, be sure to turn OFF the powers of the controller and brake release unit. Otherwise, it leads to the electrical shock or breakdown.

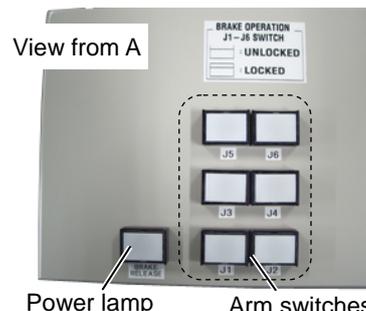


- Normally, release the brake of joints one by one. Take extra care if you need to release the brakes of two or more joints simultaneously. Releasing the brakes of two or more joints simultaneously may cause hands and fingers to be caught and/or equipment damage to or malfunction of the Manipulator as the arms of the Manipulator may move in unexpected directions.
- Be careful of the arm falling when releasing the brake. While the brake is being released, the Manipulator's arm falls by its own weight. The arm falling may cause hands and fingers to be caught and/or may cause equipment damage to or malfunction of the Manipulator.

Width	180 mm
Depth	150 mm
Height	87 mm
Weight (Cables are not included.)	1.7 kg
Cable to the Manipulator	2 m
Power cable length	2 m
Power cable (US)	100 V specification
Power cable (EU)	200 V specification



Power switch Power cable



Power lamp Arm switches

Precautions for use

C3 Rev.9

 CAUTION	<ul style="list-style-type: none"> ■ After the brake release unit is disconnected, be sure to connect the external short connector. Otherwise, you cannot release the brakes. If the manipulator is operated without connecting the brake release unit and the external short connector, the brakes cannot be released and it may cause damage on them. After using the brake release unit, be sure to connect the external short connector to the Manipulator, or check connection of the connector for the brake release unit. ■ Keep the external short connector. Otherwise you cannot release the brakes. ■ If you turn ON the brake release unit while the brake release switch is being pressed, an unintended arm may move downward. Before turning ON the brake release unit, make sure that the brake release switch is not pressed. ■ If you turn ON the brake release unit without the connector, it may lead to the short for the male pin used in the connector. Before turning ON the brake release unit, make sure that the connector is connected.
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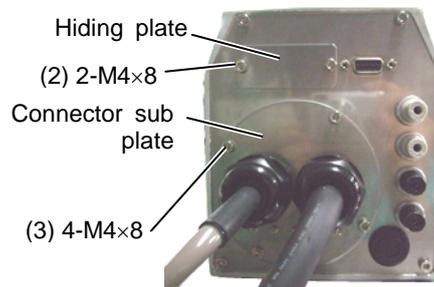


- When you purchased several C3 series manipulators and use the brake release unit in the manipulator without the connection cable, you need to change the connection cable inside the manipulator.
To skip this switching work, purchase the cable set for the brake release unit.
If you purchased the manipulator and connection cable together, the cable has been installed to the manipulator before shipment.
For additional external short connector or connection cable, please contact us.

How to connect the connection cable

If you purchased the manipulator and connection cable together, the cable has been installed to the manipulator before shipment. This procedure is not necessary.

- (1) Turn OFF the controller.
- (2) Remove the hiding plate.



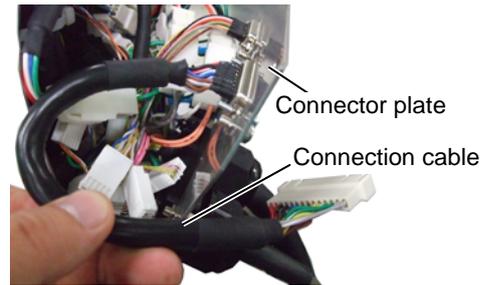
- (3) Open the connector plate.

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

- (4) Pass the cable through the hole below the hiding plate from the outside.

Connect the connection cable to the connector plate.

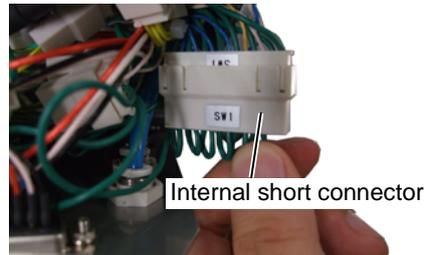
2-M4×8



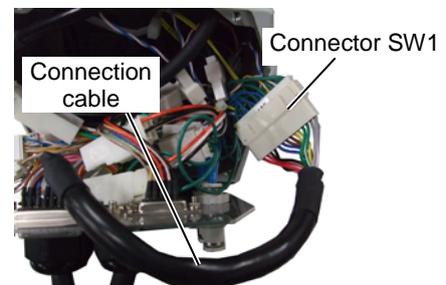
- (5) Take out the connector (SW1) of the internal cable.

- (6) Disconnect the internal short connector.

Keep the short connector to the inside of base or somewhere not to lose.



- (7) Connect the connector (SW1) of the connection cable and the internal cable.

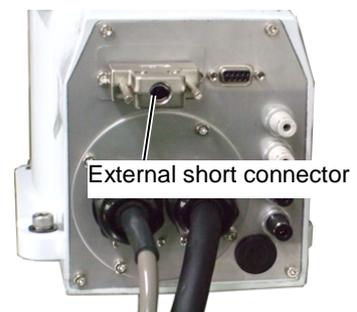


- (8) Mount the connector plate. Be careful not to catch the cables.

4-M4×8

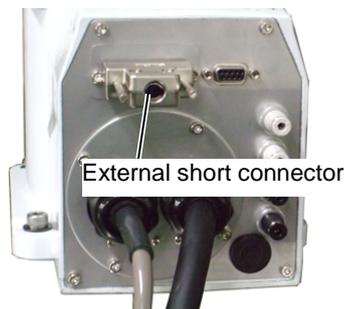
- (9) If the brake release unit is not used, mount the external short connector.

To prevent the external short connector from falling off, secure it with the two screws included with the connector.

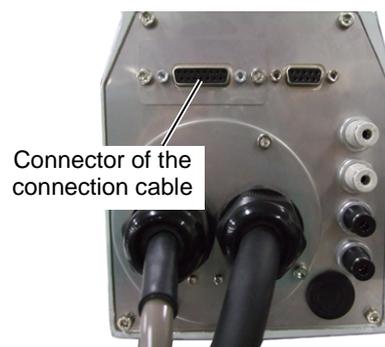


Mount the brake release unit

- (1) Turn OFF the controller.
- (2) Remove the external short connector.



- (3) Connect the brake release unit to the connector of the connection cable.



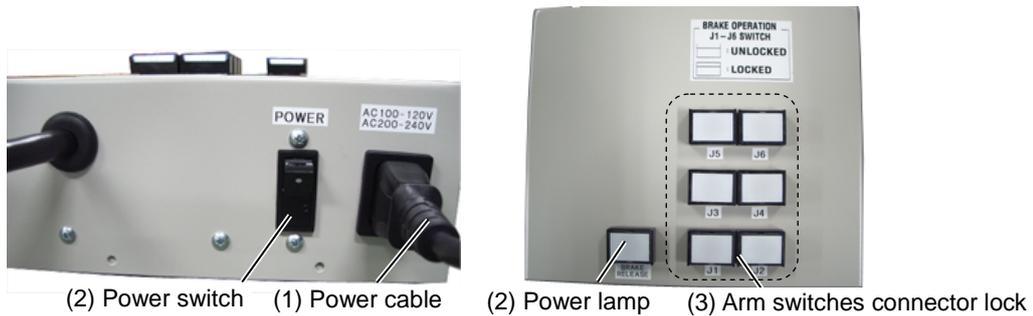
Remove the brake release unit

- (1) Turn OFF the brake release unit.
- (2) Remove the power cable of the brake release unit.
- (3) Disconnect the brake release unit from the connector of the connection cable.
- (4) Connect the external short connector to the connector of the connection cable.

How to use the brake release unit



- Be careful of the arm falling when releasing the brake. While the brake is being released, the Manipulator's arm falls by its own weight. The arm falling may cause hands and fingers to be caught and/or may cause equipment damage to or malfunction of the Manipulator.
- If the arm you released its brake moves awkwardly or faster than usual, stop the operation promptly and contact us. The brake release unit may be broken. If you keep operating the manipulator, it may lead to the breakdown of the manipulator or you may get your hand or fingers caught.



- (1) Disconnect the external short connector.
- (2) Plug the power cable into the brake release unit.
- (3) Plug the power cable into the power supply plug.
- (4) Turn ON the brake release unit.
When the brake release unit is enabled, the power lamp lights up.
- (5) Press the switch of the arm (J1 to J6) you want to move and then move the arm.
Press the switch again. The brake will be released.
The brake will be enabled by pressing the switch once again.

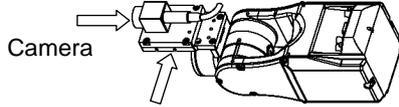


NOTE Move the arm the brake is released by two persons or more (one presses the switch and one moves the arm). The arm can be very heavy and needs the significant force to move.

6.2 Camera Plate Unit

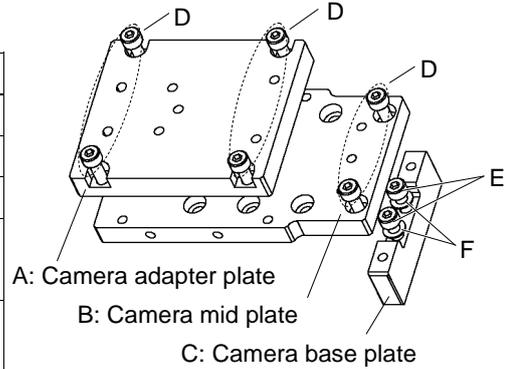
To mount a camera to the C3 series manipulator, you need to mount the camera plate unit first.

Appearance of arm end with camera



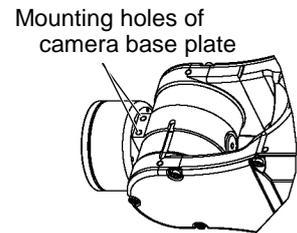
Camera plate unit

Parts included		unit
A	Camera adapter plate	1
B	Camera mid plate	1
C	Camera base plate	1
D	Hexagon socket head screws M4×12	6
E	hexagon socket head screws M4×20	2
F	Plain washer for M4 (small washer)	2



To mount the camera plate unit

- (1) Mount the camera base plate to the manipulator.
2-M4 × 20 + Plain washer for M4 (small washer)
- (2) Mount the camera mid plate to the base plate.
2-M4 × 12



NOTE The motion range and dimension of the manipulator with the camera installed may vary depending on the mounting hole of camera mid plate. The details are described in the table below.

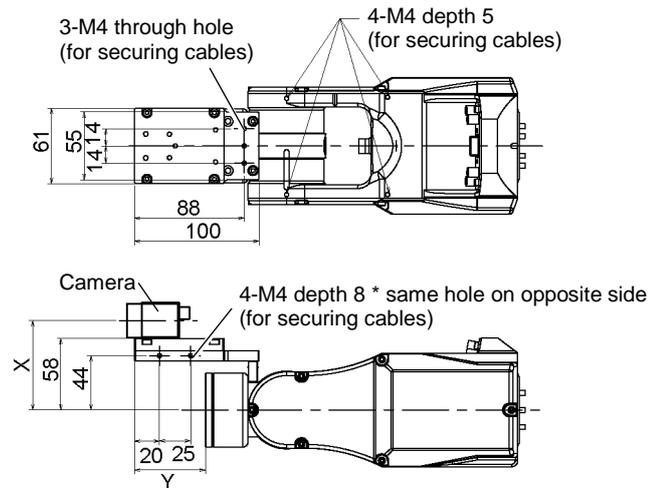
- (3) Mount the camera to the camera adapter plate.

NOTE According to the camera, the available mounting hole of adapter plate will be different. The details are described below.

- (4) Mount the camera adapter plate and camera to the camera mid plate.
4-M4 × 12
- (5) Secure the cables at the position where they do not interfere with the manipulator motion.

NOTE When securing the cables, check if the cables bend radius is big enough and the cables are not rubbing against each other while the manipulator moves. Otherwise, the cables will be disconnected.

Dimension of the camera plate unit

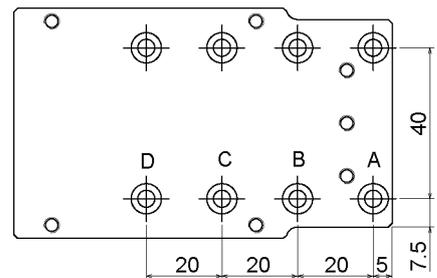


Dimensions X and Y will change depending on the position of camera mid plate and camera size. Refer to the table below for the values.

Camera mid plate

The camera mid plate uses the mounting holes A to D.

By using the different mounting holes, it can be mounted to the camera base plate in the different four positions.



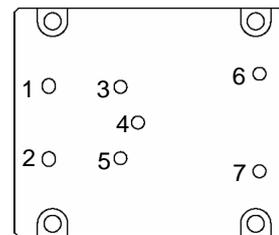
Camera adapter plate

Each camera uses the different mounting holes.

Sony XC-ES30, HR50, HR70 : 1, 2, 4

Matrox Iris : 1, 2, 3, 5

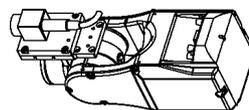
JAI (Pulnix) CV-A1 : 6, 7



Mounting example



Using the mounting hole A



Using the mounting hole C

E.g.) Camera: XC-ES30

Camera and Joint #5 motion range (reference values)

The Joint #5 motion range varies depending on the mounting position of camera mid plate and the camera you are using.

The table below shows the motion range (reference values) based on the available cameras for this option and the mounting positions of the camera mid plate. The values in the table may vary depending on how to secure the cables.

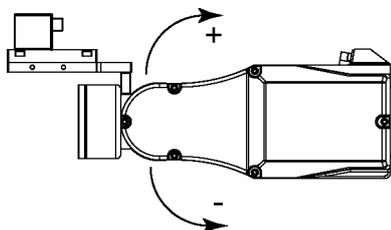
By changing the Y position, you can extend the distance from the end effector mounting surface to the camera. Also, you can attach the larger end effector. However, be careful about the Joint #5 motion range that will be limited in this case.

(° = degree)

	A	B	C	D	X
JAI (Pulnix) CV-A1	-135° to +60°	-135° to +50°	-135° to +35°	-135° to +25°	72.5 mm
Sony XC-ES30, HR50, HR70					
Matrox Iris	-135° to +45°	-135° to +30°	-135° to +15°	-135° to +10°	83 mm

	A	B	C	D
Y	57 mm	37 mm	17 mm	7 mm

Direction of the Joint #5 motion

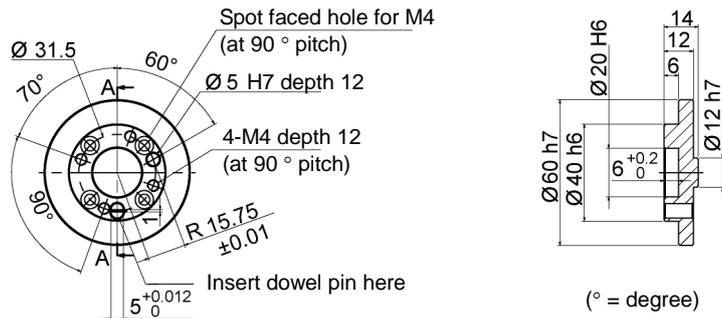


6.3 PS Compatible Plate

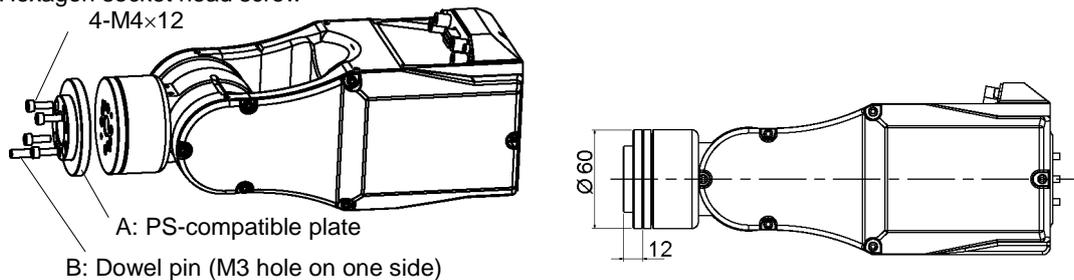
Using the PS compatible plate, you can mount the end effector used in the PS series to the C3 series.

Parts included		Unit
A	PS compatible plate	1
B	Dowel pin (M3 hole on one side)	1
C	Hexagon socket head screw M4×12	4

Dimensions of PS-compatible plate



C: Hexagon socket head screw
4-M4×12



To mount the PS compatible plate

- Align the hole on the arm end flange ($\phi 12H7$) to the projection on the PS compatible plate ($\phi 12h7$).
- Insert the dowel pin from the PS compatible plate side and position the arm and PS compatible plate. One side of the dowel pin has the M3 screw hole and you can adjust the depth using M3.



NOTE If you move the Manipulator with the dowel pin inserted, the dowel pin will fall out. To move the Manipulator with the dowel pin inserted, you need to secure the dowel pin with glue.

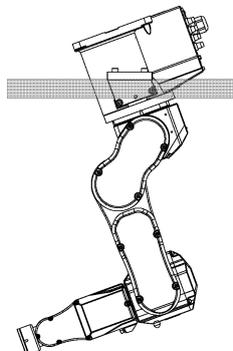
- Secure the PS compatible plate with 4 hexagon socket head screws.

4-M4 × 12

6.4 Base Side Angled Fittings

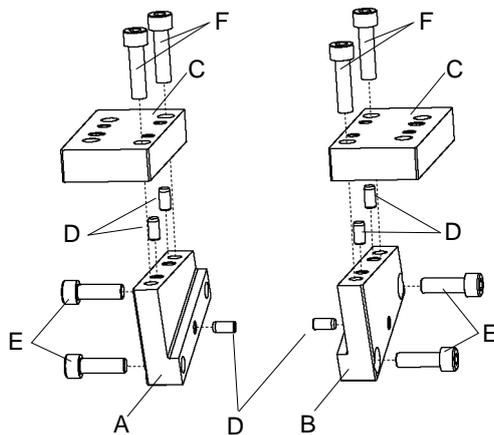
By using the base side angled fittings to the C3 series manipulator base, you can mount the manipulator in skewed position. The motion range expands with this mounting type compared to the normal ceiling mounting.

Mounting image using the base side angled fittings



For details of the mounting and precautions, refer to *Setup & Operation: 3. Environment and Installation*.

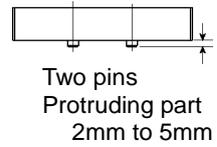
Parts included		Qty.
A	Base side angled plate (Left side)	1
B	Base side angled plate (Right side)	1
C	Base side plate (for Skewed mounting type)	2
D	Pin	6
E	Hexagon socket head screw M8 × 25	4
F	Hexagon socket head screw M8 × 30	4



To mount the base side angled fittings

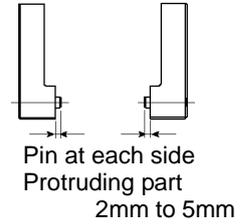
- (1) Drive pins to the base side plate (for Skewed mounting type).

Protruding part of pins is approx. 2 to 5 mm.



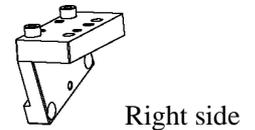
- (2) Drive pins to the base side angled plate (left & right sides).

Protruding part of pins is approx. 2 to 5 mm.



- (3) Create a base side angled fittings.

Fit the pins of the plate for Skewed mounting type in the step (1) with the holes on the plate in the step (2) and secure with the screws.

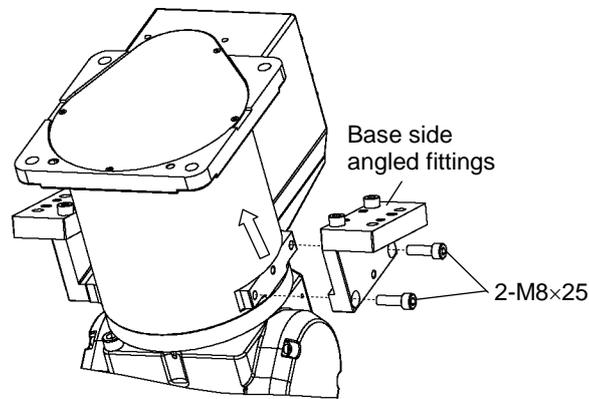


Hexagon socket head screw M8 × 30

- (4) Mount the base side angled fittings to the both sides of manipulator base.

Fit the pins drove in the step (2) with the holes on the base. Secure the fittings by pressing it to the indicated direction in the figure below.

Left & Right side Hexagon socket heat screw 2- M8 × 25

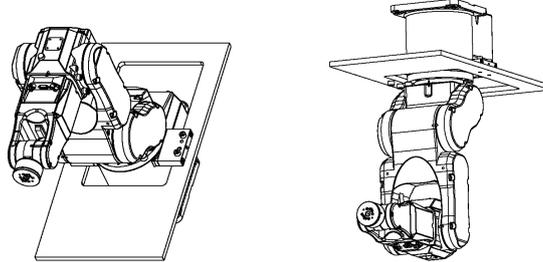


NOTE The shape of the base side angled fittings is asymmetry. Be sure to mount the fittings in correct direction. Otherwise, the motion range of Arm #2 is limited in the backside.

6.5 Base Side Fittings

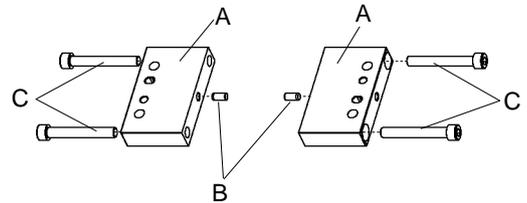
Using the base side fittings to the C3 manipulator base, you can mount the manipulator in the place where limits the mounting height or use the open room for the base.

Mounting image using the base side fittings



For the information on how to mount and precautions, refer to *Setup & Operation: 3. Environment and Installation*.

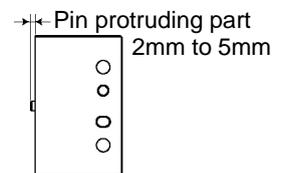
Parts included		Qty.
A	Base side plate	2
B	Pin	2
C	Hexagon socket head screw M8 × 60	4



To mount the base side plate

- (1) Drive the pins to the base side plate.

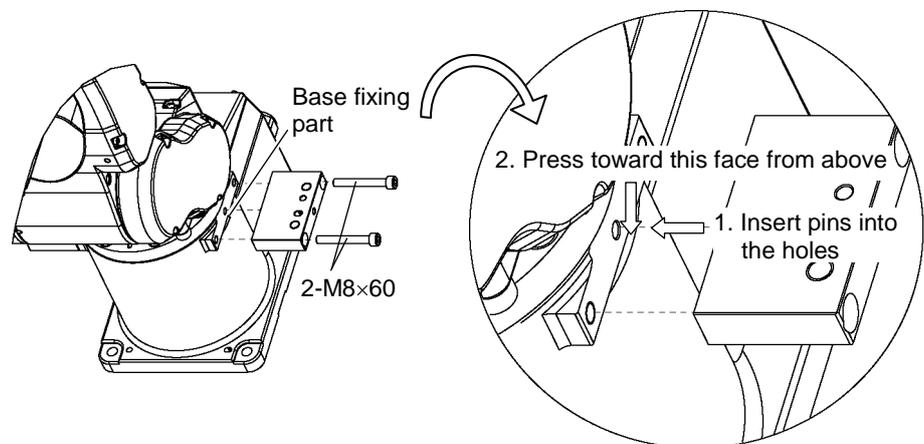
Protruding part of pins is approx. 2 to 5 mm.



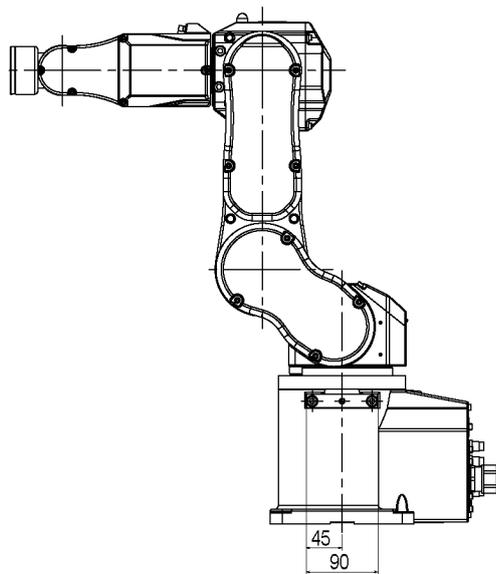
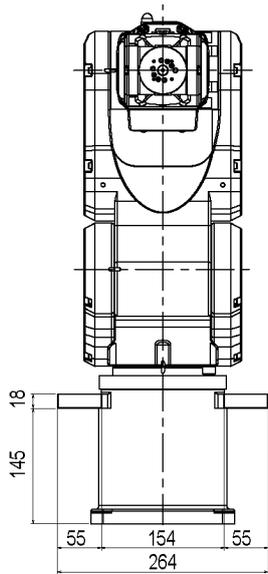
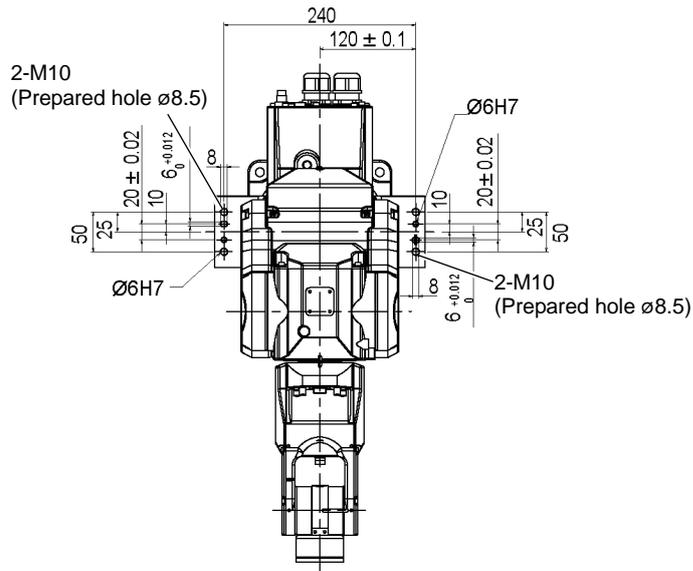
- (2) Mount the base side plate with the pins driven to the both sides of the base.

Fit the pins with the holes and secure the base side plate by pressing it from above to the base fixing part.

(With the steps above, the both surfaces of base side fittings can be stable.)



Dimension of the manipulator with the base side fittings



Installation example

Screws

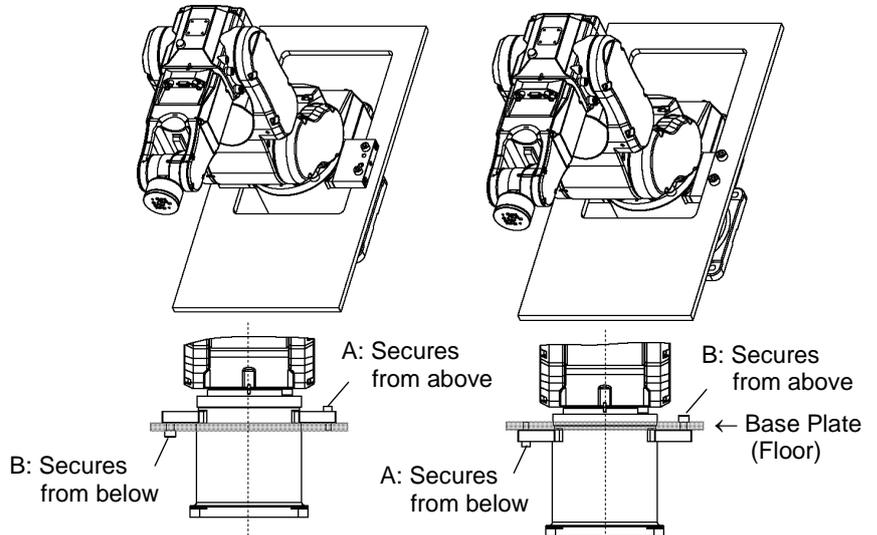
	Size	Recommended length
A	M8	30 mm or more
B	M10	15 mm + Base Plate or more

NOTE  The base side plate has a M10 screw hole. You can secure the plate with a M10 screw or a M8 screw by using a prepared screw hole of $\phi 8.5$ to make a M8 screw hole on the mounting surface.

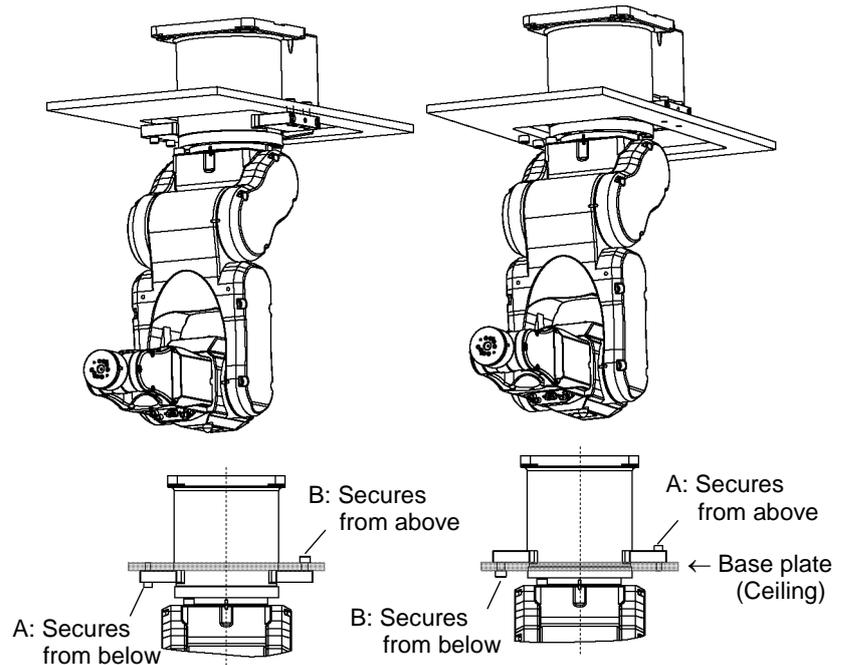
NOTE  A: Securing from above
To secure from above, use the screw A in the table above.

When you install the manipulator for practical use, you need to insert the screws in the right/left side from the same direction (above or below).

Table Top mounting



Ceiling mounting



Maintenance

This volume contains maintenance procedures with safety precautions for C3 series Manipulators.

1. Safety Maintenance

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

Only authorized personnel who have taken 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, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- When connecting or replacing the brake release unit and the external short connector, turn OFF the power to the Controller and the brake release unit. Inserting and removing the connector while the power is ON may result in electrical shock.

 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. ■ If the manipulator is operated without connecting the brake release unit and the external short connector, the brakes cannot be released and it may cause damage on them. After using the brake release unit, be sure to connect the external short connector to the Manipulator, or check connection of the connector for the brake release unit.
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2. General Maintenance

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

2.1 Schedule for Maintenance Inspection

Inspection points are divided into five stages: daily, monthly, quarterly, biannual, and annual. The inspection points are added every stage.

If the Manipulator is operated for 250 hours or longer per month, the inspection points must be added every 250 hours, 750 hours, 1500 hours, and 3000 hours operation.

	Inspection Point				
	Daily inspection	Monthly inspection	Quarterly inspection	Biannual inspection	Annual inspection
1 month (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) ⋮		⋮	√ ⋮	⋮	⋮

h = hour

2.2 Inspection Point

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

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts/screws. Tighten them if necessary. (For the tightening torque, refer to <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.	Base Inside of Arms #1, 2, 3, 4				√	√
Grease conditions	Refer to <i>Maintenance: 2.3 Greasing.</i>					
Battery	—	Replace the battery when an error warning the low battery status occurs at the software startup, or every 1.5 years.				
Check either the external short connector or the brake release unit connector is connected.	The external short connector on the back side of the Manipulator, or the brake release unit connector.	√	√	√	√	√

* Check for airtightness

Inspection intervals differ depending on environment of use. For inspection procedures, please contact us.

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

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check motion range	Each joint					√
Move the cables back and forth lightly to check whether the cables are disconnected.	External cables (including cable unit of the Manipulator)				√	√
Push each arm in MOTOR ON status to check whether backlash exists.	Each arm					√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√
Measure the accuracy repeatedly by a dial gauge.	Whole					√
When brake release unit is installed: Connect the brake release unit and check the sound of the electromagnetic brake with the brake released. If there is no sound, replace the brake. When brake release unit is not installed: Execute Brake off command (brake off, joint #) from the command window of the EPSON RC+ while the motors are OFF, and then check the sound of the electromagnetic brake. If there is no sound, replace the brake.	Brake	√	√	√	√	√

2.3 Greasing

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

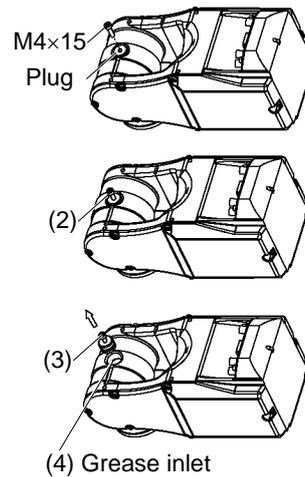
 CAUTION	<ul style="list-style-type: none"> ■ Keep enough grease in the Manipulator. Operating the Manipulator with insufficient grease will cause the noise or damage sliding parts and/or result in insufficient function of the Manipulator. Once the parts are damaged, a lot of time and money will be required for the repairs. ■ 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 : Flush them thoroughly with clean water, and then see a doctor immediately. If grease gets into your mouth : If swallowed, do not induce vomiting. See a doctor immediately. : If grease just gets into your mouth, wash out your mouth with water thoroughly. If grease gets on your skin : Wash the area thoroughly with soap and water.
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	Greasing part	Greasing Interval	Grease	Greasing method
Joint #1, 2, 3, 4	Reduction gear units	10,000 hours or 2 years, whichever comes first	SK-1A	Refer to <i>Maintenance: 5.2, 6.2, 7.2, 8.2 Replacing the Reduction Gear Unit</i>
Joint #6	Bevel gear	Once a year (every 8000 hours)	SK-2	Follow the steps below.

Greasing Joint #6 bevel gear

	Name	Quantity	Note
Grease	Grease for reduction gear unit (SK-2)	Proper quantity	
Tools	Screw M4×15 (length: 15 mm or more)	1	For unplugging
	Wiping cloth	1	For wiping grease

- (1) Secure Arm #5 in the direction you can unplug easily.
- (2) Insert the screw into the screw part of plug. M4 depth 5.
Screw : M4 length 15 mm or more (easy-to-unplug)
- (3) Hold the screw inserted in the step (2) and unplug.
- (4) Apply the grease.
Grease amount : 2 g
- (5) Insert the plug unplugged in the step (3) to the original position.
To prevent the grease leaking or unplugging, be sure to insert the plug all the way seated.
- (6) Pull out the screw inserted in the step (2).



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 “bolt” hereinafter.) These bolts are fastened with the tightening torques shown in the following table.

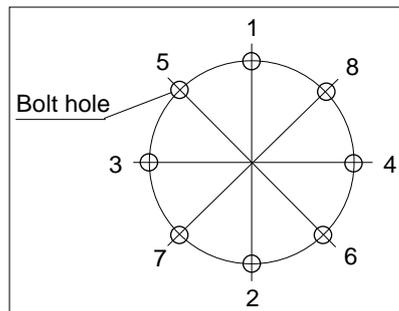
When it is required to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

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 ($1,020 \pm 51$ kgf·cm)

Refer below for the set screw.

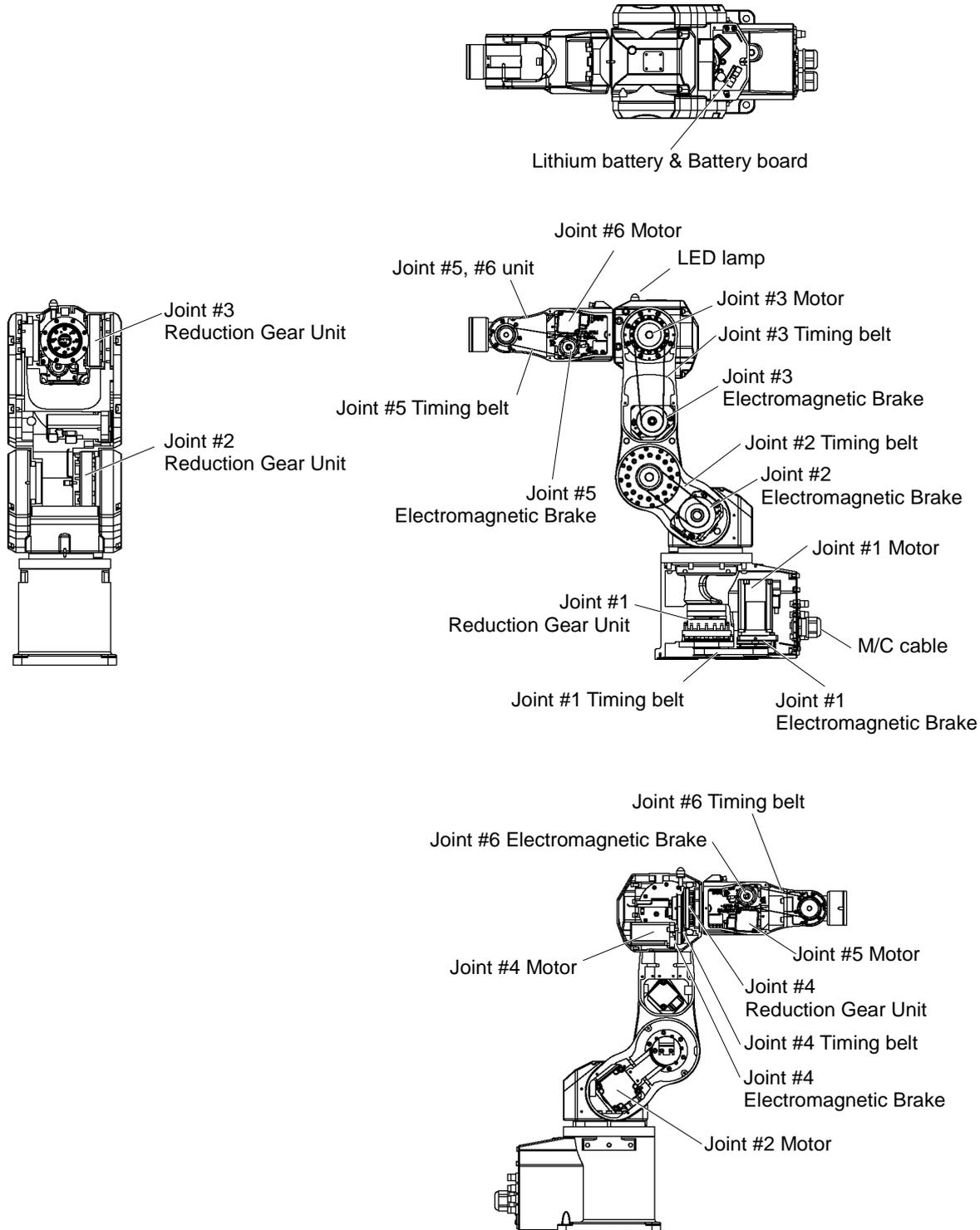
Set Screw	Tightening Torque
M4	2.4 ± 0.1 N·m (26 ± 1 kgf·cm)
M5	3.9 ± 0.2 N·m (40 ± 2 kgf·cm)

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 to fasten the bolts 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 Layout of Maintenance Parts

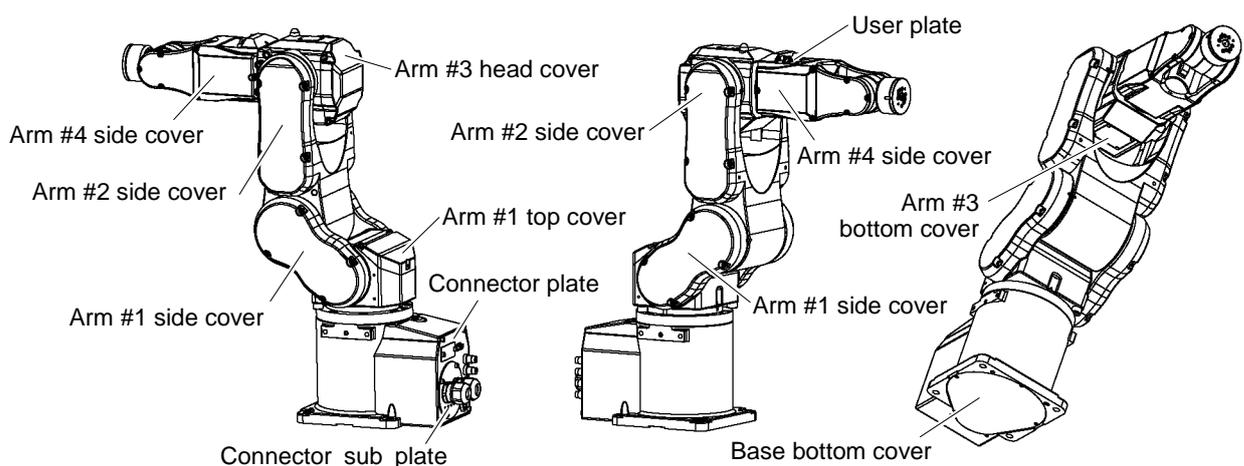


3. Covers

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

 WARNING	<ul style="list-style-type: none"> ■ Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system. ■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
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	Name	Quantity	Note
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Cross-point screwdriver	1	

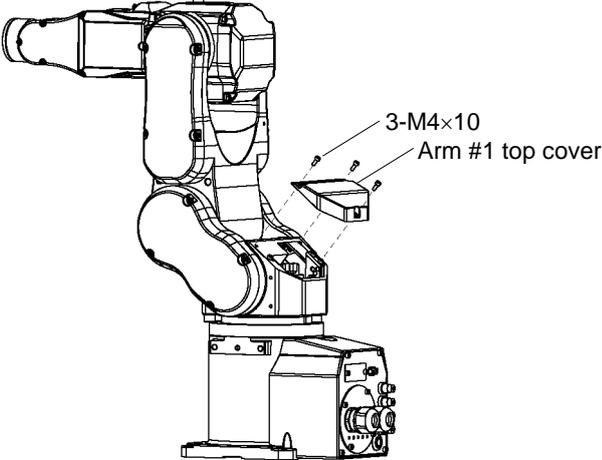


3.1 Arm #1 Top Cover



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

Unscrew the cover mounting bolts and remove the cover.

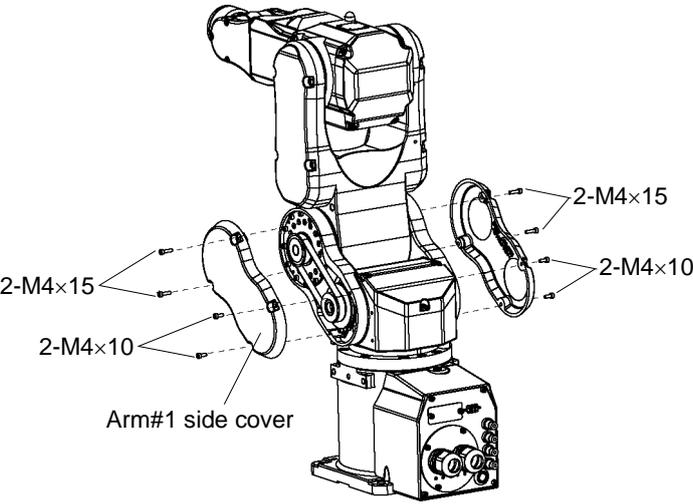


3.2 Arm #1 Side Cover



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

Unscrew the cover mounting bolts and remove the cover.

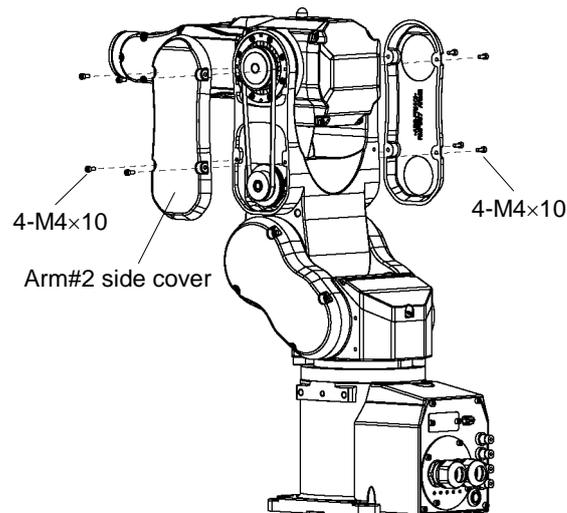


3.3 Arm#2 Side Cover



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

Unscrew the cover mounting bolts and remove the cover.

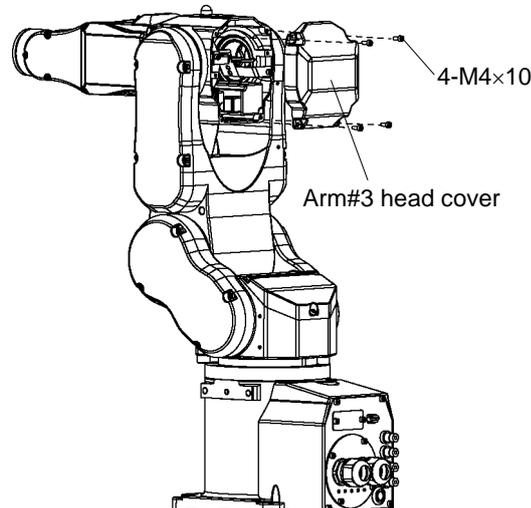


3.4 Arm#3 Head Cover



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

Unscrew the cover mounting bolts and remove the cover.

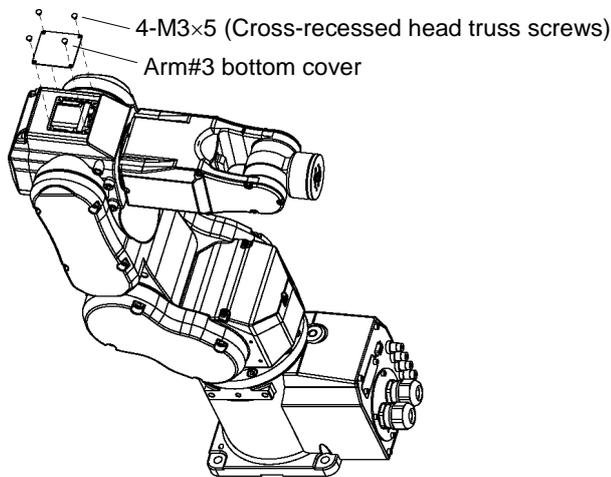


3.5 Arm #3 Bottom Cover



- 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.

Move the arm so that you can remove the Arm #3 bottom cover.
Remove the screws (cross-recessed head truss screws) securing the cover and remove the cover.

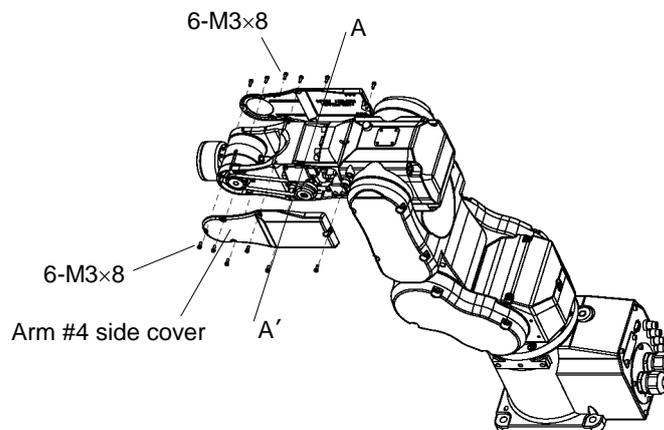


3.6 Arm#4 side cover

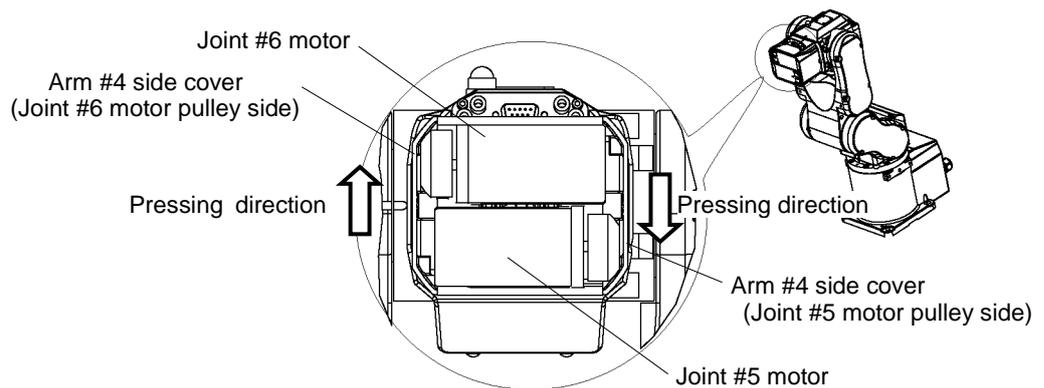


- When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection,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

Unscrew the cover mounting bolts and remove the cover.



To improve the manipulator performance, clearances of the Arm #4 side cover, the Joint #5 motor pulley, and the Joint #6 motor pulley have become smaller. To avoid the interference of covers and pulleys, attach the Arm #4 side cover.



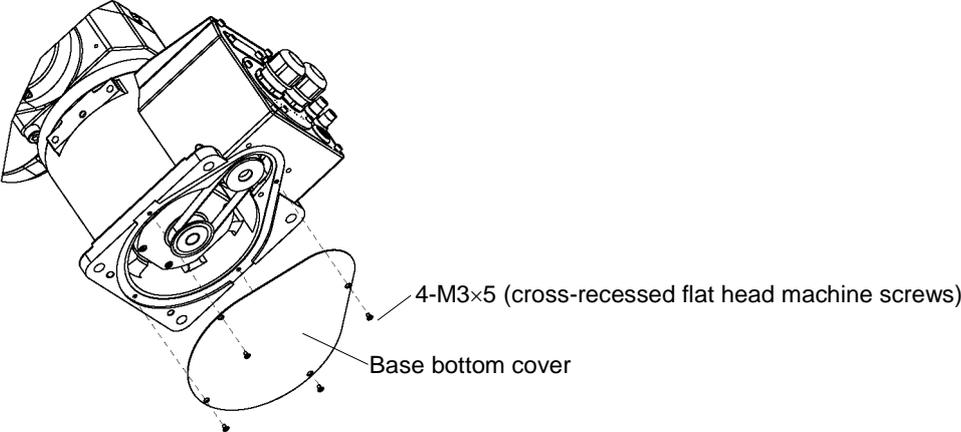
A - A' Cross section detail

3.7 Base Bottom Cover

 <p>CAUTION</p>	<ul style="list-style-type: none">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.
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Remove the screws (cross-recessed flat head machine screws) securing the cover and remove the cover.

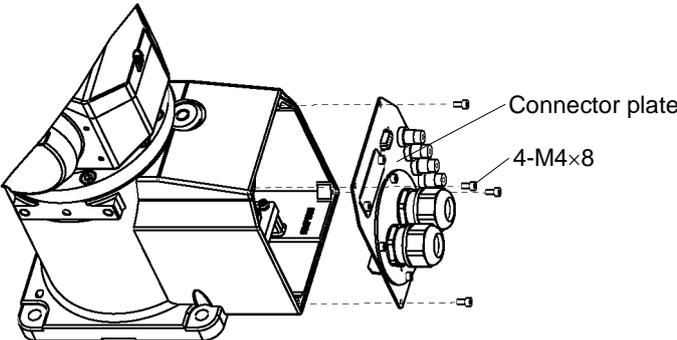
If you use the other screws than the screws indicated here, the screw head will protrude from the base surface and it will make it difficult to mount the manipulator firmly. We recommend using our attached screws or equivalent ones.



3.8 Connector Plate

 <p>CAUTION</p>	<ul style="list-style-type: none">Do not remove the connector plate forcibly. Removing the connector plate forcibly may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.When installing the connector plate, be careful not to allow the cables to interfere with the plate mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. When routing the cables, observe the cable locations after removing the connector plate. Be sure to place the cables back to their original locations.
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Unscrew the connector plate mounting bolts and remove the connector plate.

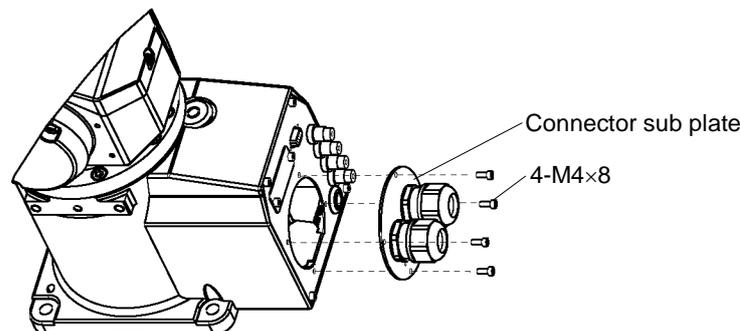


3.9 Connector Sub Plate



- 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 connector sub plate.

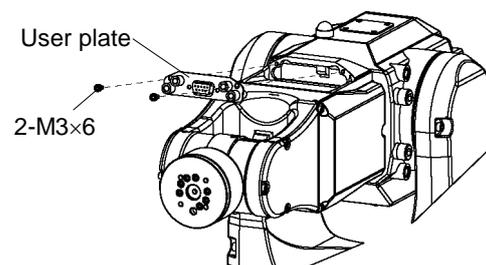


3.10 User Plate



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

Unscrew the user plate mounting bolts and remove the user plate.



4. Cable Unit

4.1 Replacing the Cable Unit



- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Do not insert or pull out the motor connectors while the power to the robot system is turned ON. Inserting or pulling out the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. To shut off power to the robot system, pull out the power plug from the power source. Performing any work while connecting the AC power cable to a factory power source is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
- When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations.



CAUTION

- When disconnecting the connectors during the replacement of the cable unit, be sure to reconnect the connectors to their proper positions.
Improper connection of the connectors may result in improper function of the robot system.
For details on the connections, refer to the *Maintenance 10.3 Connector Pin Assignments*.
- Carefully use alcohol and adhesive following respective instructions and also instructions below. Otherwise, it may cause a fire and/or safety problems.
 - Never put alcohol or adhesive close to fire.
 - Use alcohol or adhesive while ventilating the room.
 - Wear protective gear including a mask, protective goggles, and oil-resistant gloves.
 - If alcohol or adhesive gets on your skin, wash the area thoroughly with soap and water.
 - If alcohol or adhesive gets into your eyes or mouth, flush your eyes or wash out your mouth with clean water thoroughly, and then see a doctor immediately.
- Wear protective gear including a mask, protective goggles, and oil-resistant gloves during grease up. If grease gets into your eyes, mouth, or on your skin, follow the instructions below.
 - If grease gets into your eyes : Flush them thoroughly with clean water, and then see a doctor immediately.
 - If grease gets into your mouth : If swallowed, do not induce vomiting. See a doctor immediately.
If grease just gets into your mouth, wash out your mouth with water thoroughly.
 - If grease gets on your skin : Wash the area thoroughly with soap and water.

	Name	Quantity	Note
Maintenance Parts	Cable unit	1	R13B020036
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Box wrench (width across flats: 5 mm)	1	For D-Sub connector
	Long nose pliers	1	For removing air connector
	Nippers	1	
	Cross-point screwdriver	1	
	Brush	1	For applying grease
	Force gauge	1	For belt tension
Material	Alcohol	Proper quantity	
	Wire tie (AB100)	18	
	Wire tie (AB150)	11	
	Wire tie (AB250)	3	
Grease	GPL-224	Proper quantity	

Removal: Cable Unit

- (1) Move the manipulator to the origin (0 pulse position).
- (2) Turn OFF the controller power.
- (3) Remove the following covers and plates.

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

Arm #4 side cover (Both sides)	User plate
Arm #3 head cover	Arm #3 bottom cover
Arm #2 side cover (Both sides)	Arm #1 side cover (Both sides)
Arm #1 center cover	Connector plate

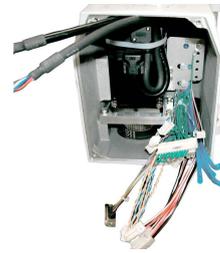
When removing the user plate and connector plate, remove the parts below together.

- D-sub 9-pin connector
- Air tube × 4

- (4) Disconnect the connectors inside the base.

Connector:

X010, X020, X030, X040, X050, X060,
LEDA, (BR010, BR011), BR020, BR030,
BR040, BT1, X11, X12, X13, X14, X15, X16



- (5) Cut off the wire ties which bind the cables inside the Arm #3.

Remove the battery board inside the Arm #1 and disconnect the following connectors from the battery board.

Connector:

X61, X62, X63, X64



- (6) Remove the wire ties binding the cables.

Disconnect the connector of inside the Arm #3.

Connector:

X71, X72, X041, X051, X061,
LEDB, (BR041), BR051,(BR061),
BT4, BT5, BT6, X141, X151, X161

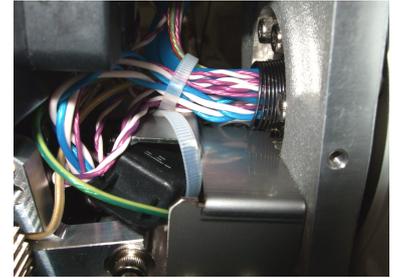


- (7) Disconnect the connector from the motors of Joint #2 and #3.

Connector: X021, X121, BR021, X031, X131, BT3, BR031

- (8) Remove the following parts from the Arm #4.

Arm #4 cable fixing plate (2-M4×8)
Ground wire (M4×5)



- (9) Cut off four wire ties of the Arm #4 cable fixing plate.

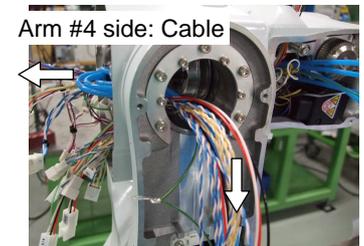
- For binding the cables
- For fixing the coil plate
- For binding the special power supply
- For fixing the special power supply plate

- (10) Remove the following parts from the Arm #3.

Arm #3 cable fixing plate (2-M4×5)
Ground wire × 2 (2-M4×5)

- (11) Cut off the five wire ties of the Arm #3 cable fixing plate.

- (12) Pull out the air tube and the ground wires removed in (8) toward the Arm #3.



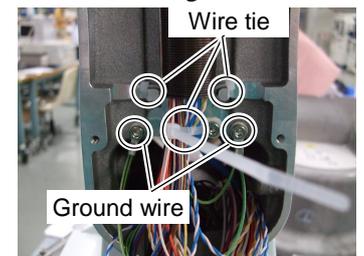
Pull out the following cables toward the Arm #4.

Joint #5 motor cable, brake cable
Joint #6 motor cable, brake cable
Cable for installed wire for customer use
(X71, X72, X051, X061, X151, X161,
BR051, (BR061), BT5, BT6)

When pulling out the cables, carefully treat cables and connectors to prevent damage to them.

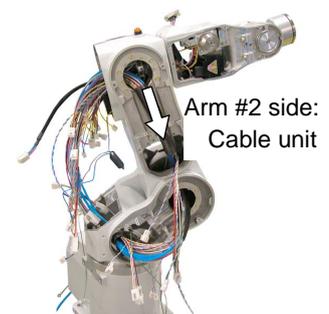
Pull out the cables in the order of connector size, from smallest to largest.

- (13) Cut off the three wire ties of the Arm #2 and disconnect two ground wires (2-M4×5).



- (14) Pull out the cable unit of the Arm #3 toward the Arm #2.

Carefully treat cables and connectors to prevent damage to them.



- (15) Remove the Arm #2 cable fixing plate (2-M4×8).

It is not necessary to remove the fixing bolts completely.

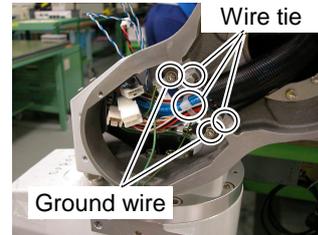
Remaining the bolts in Arm #2 makes it easy to mount the cable unit.

Pull out the cables toward Arm #1.



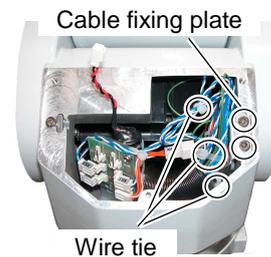
- (16) Cut off three wire ties of the Arm #1.

Disconnect two ground wires (2-M4×5).



- (17) Remove the Arm #1 cable fixing plate (2-M4×5).

- (18) Cut off three wire ties of the Arm #1 cable fixing plate.



- (19) Remove the following parts.

Base cable fixing plate (2-M4×8)
Ground wire (M4×5)

- (20) Cut off three wire ties of the base cable fixing plate.

Pull out the cables in the base side toward the Arm #1.

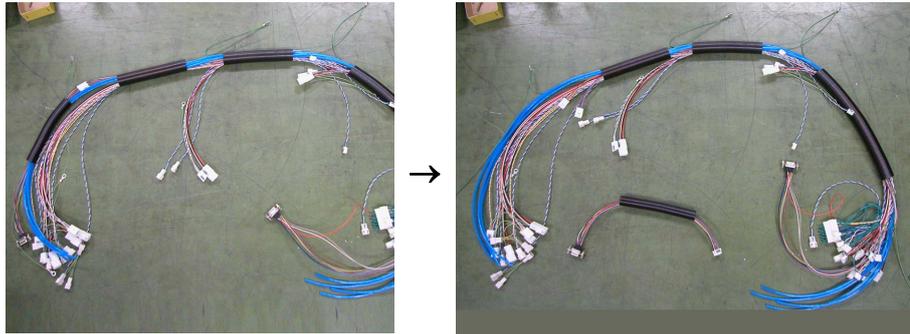


- (21) Pull out the cable unit from the base.



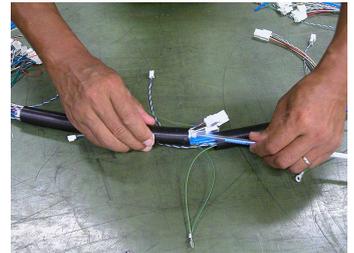
Installation: Cable Unit

- (1) Separate the cable unit.



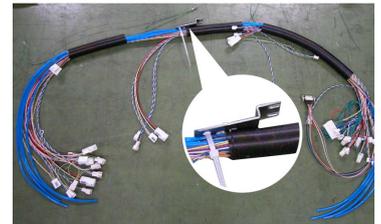
- (2) Apply grease inside of the cable protection spring
(GPL-224 : 4 g)

Small-diameter spring : 0.5 g
 Spring (Length: 130 mm) : 1 g × 2
 Spring (Length: 230 mm) : 1.5 g

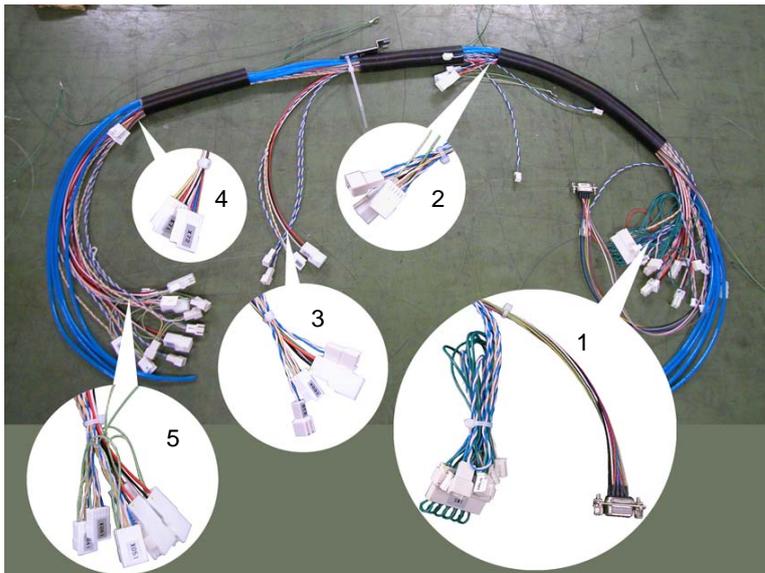


- (3) Secure the Arm #2 cable fixing plate and the cable unit.

Plate and spring : Wire tie AB100
 Cable unit and plate : Wire tie AB150



- (4) Prepare to mount the cable unit to the manipulator.
 Bind the cables. Be careful not to bind the ground wires together.
 (Wire tie: AB100 × 6)

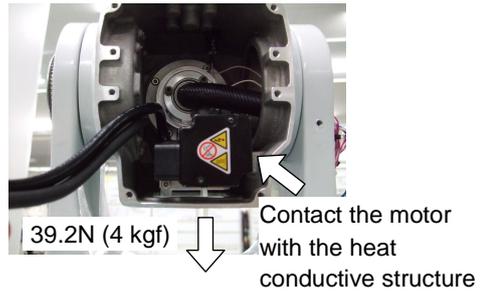


1. Connector
SW1, BR010, BR011, BR020, BR030, BR040, LEDA
2. Connector
X121, X021, BR021
3. Connector
X131, X031, BR031, BT3
4. Connector
X71, X72
5. Connector
X141, X151, X101, X041, X051, X061

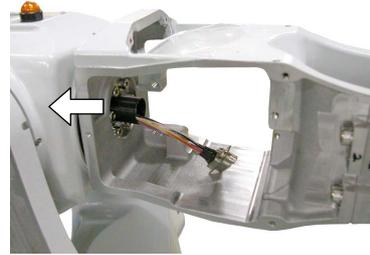
(5) Put the timing belt on the Joint #4 motor unit and temporarily joint on the Arm #3.

(6) Put a ring made by a wire tie on the Joint #4 motor plate. Pull the ring with the force gauge and fix the Joint #4 motor plate.

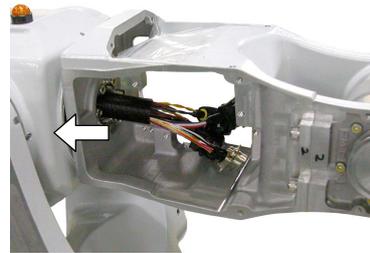
- Belt tension: 39.2N : 4kgf
- Screw: 2-M4×15
- Washer: 2-M4



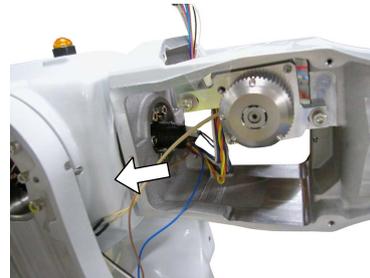
(7) Insert the cable protection spring (small diameter) and the user cable in the direction indicated in the right picture from the Arm #4 side.



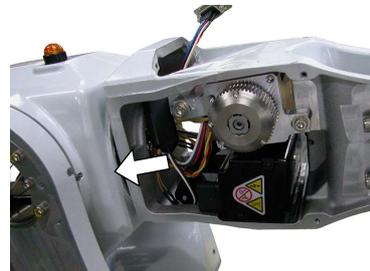
(8) Insert the motor cables for the Joint #5 and #6 (power cable and signal cable) in the direction indicated in the right picture from the Arm #4 side. Insert the cable with a larger connector first.



(9) For the manipulator with all axes brakes: Insert the Joint #6 brake cable toward the direction indicated in the right picture into the cable protection spring and secure the Joint #6 motor unit to the Arm #4. (2-M4×15, 2-M4 washer)



(10) Insert the Joint #5 brake cable into the cable protection spring toward the direction indicated in the right picture. Loosely secure the Joint #5 motor unit to the opposite side from the Arm #4. (2-M4×15, 2-M4 washer)

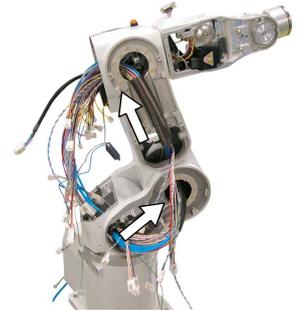


- (11) Insert the following connectors into the base side.

Signal cable: X010, X020, X030, X040,
LED-A, X050, X060
Power cable: X12, X13, X14, X15, X16



- (12) Insert the cable unit into the Arm #2 and then the Arm #3.



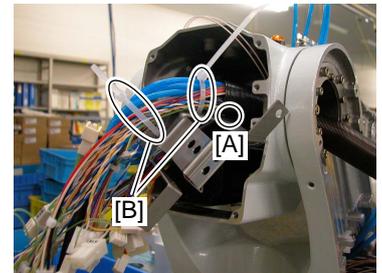
- (13) Pass the air tube and ground wire of the cable unit through the cable protection spring (Small diameter) and take them out from the Arm #4.



- (14) Secure the Arm #3 cables.
Loosely bind the cables so that you can adjust their location afterward.

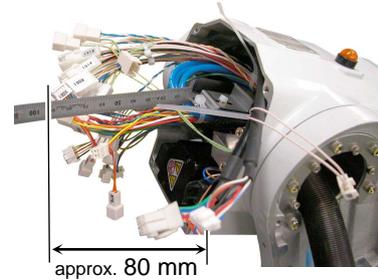
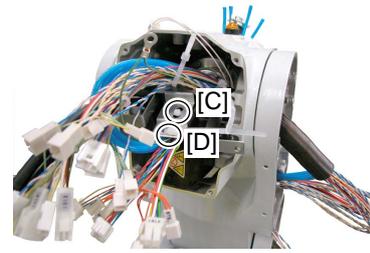
[A] Bind three coils of the cable protection spring in the Arm #2 side (130 mm) to the Arm #3 cable fixing plate. (AB100)

[B] Loosely bind the cables using two wire ties (AB150).



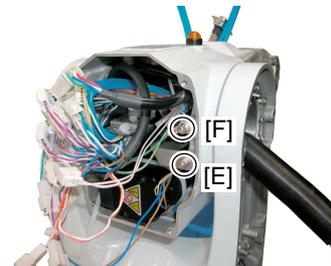
[C] Bind three cable protection springs (Small diameter) to the Arm #3 cable fixing plate. (AB100)

[D] Loosely bind the cables sticking out from the Arm #4. (AB150)



[E] Secure the Arm #3 cable fixing plate to the Arm #3. (2-M4×5)

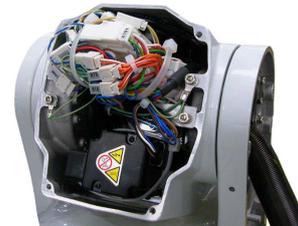
[F] Secure two ground wires (2-M4×5).



Connect the connectors.

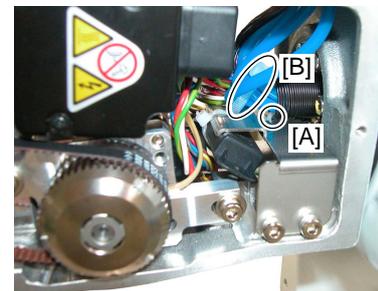
Connector: X71, X72, X041, X051, X061, LEDB, (BR041), BR051, (BR061), BT4, BT5, BT6, X141, X151, X161

Bind the cables using two wire ties. (AB200)



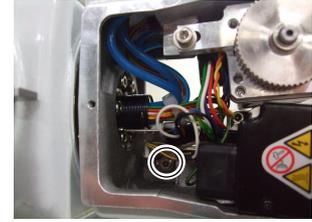
(15) [A] Bind three cable protection springs (Small diameter) to the Arm #4 cable fixing plate. (AB100)

[B] Loosely bind the cables. (AB150)



(16) Secure the Arm #4 cable fixing plate to the Arm #4. (2-M4×10)

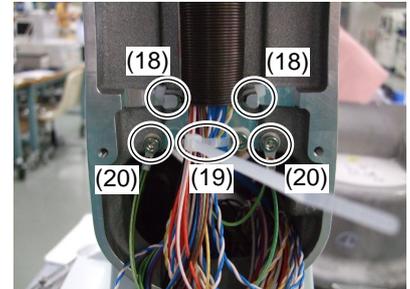
- (17) Secure the ground wire to the Arm #4.
Secure the brake special power supply to the Arm #4 cable protection plate. (2-AB150)



- (18) Secure the cable protection spring (130 mm) to Arm #2. (2-AB100)

- (19) Loosely secure the cables to the cable binder. (AB150)

To avoid the cables from scratching against the spring, put the cables up by 3 mm and secure them.

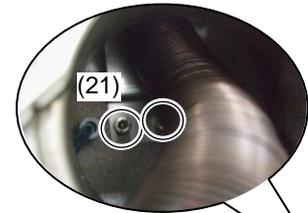


- (20) Secure two ground wires to the Arm #2. (2-M4x5)
Connect the connector of the Joint #3 motor.

- (21) Secure the Arm #2 cable fixing plate to the Arm #2. (2-M4x8)

Bind the wire ties loosely bound previously.

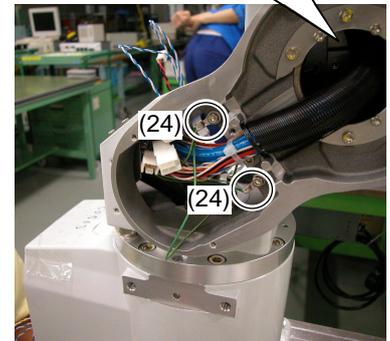
- (22) Secure the cable protection spring (150 mm) to the Arm #1. (2-AB100)



- (23) Loosely secure the cables to the cable binder. (AB150)

- (24) Secure two ground wires to the Arm #1. (2-M4x5)

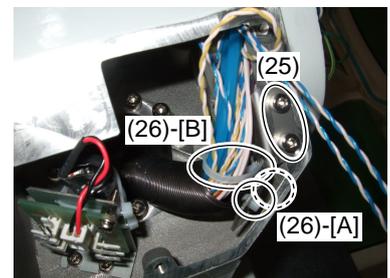
- (25) Secure the Arm #1 cable fixing plate to the Arm #1. (2-M4x5)



- (26) [A] Bind three coils of cable protection spring (230 mm) to the base cable fixing plate. (2 points: 2-AB100)

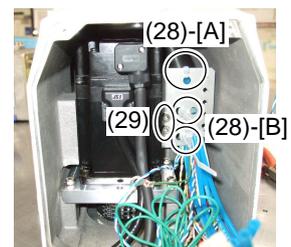
[B] Loosely secure the cables. (AB150)

- (27) Connect the connector of the Joint #2 motor.



- (28) [A] Bind three coils of cable protection spring (230 mm) to the base cable fixing plate. (AB100)

[B] Loosely secure the cables. (2 points: 2-AB150)



- (29) Secure the base cable fixing plate to the base. (2-M4×8)

To avoid the cables from scratching against the spring, put the cables up by 3 mm and secure them.

- (30) Secure the ground wires to the base cable fixing plate. (M4×5)

Secure the battery board to the Arm #1.

Cut off the air tube at approx. 70 mm from the manipulator.

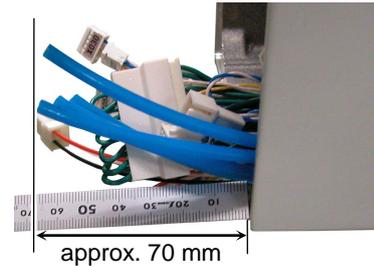


- (31) Adjust the length of whole cable unit and connect the all connectors below.

Connector:

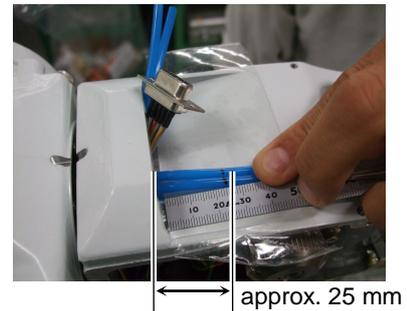
X010, X020, X030, X040, X050, X060,
LEDA, (BR010, BR011), BR020, BR030,
BR040

BT1, X11, X12, X13, X14, X15, X16,
X61, X62, X63, X64, X021, X121,
BR021, X031, X131, BT3, BR031



- (32) Bind the wire ties loosely bound previously.

- (33) Pull the air tube lightly and cut at 25 mm.



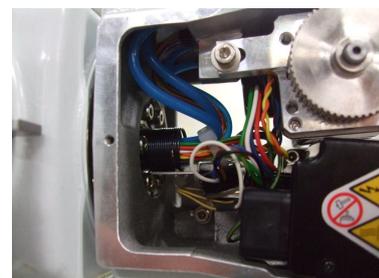
- (34) Secure the D-sub connector to the user plate and secure four air tubes.

Be careful of the direction of the user plate.

- (35) Secure the user plate to the Arm #4. (2-M3×6)



Check if there are any bended air tubes inside the Arm #4.



- (36) Apply tension to the Joint #5 motor unit and secure it.

For details, refer to *Maintenance: 9.1 Joint #5 – Replacing the Motor*, Installation step (4) to (8).

- (37) Apply tension to the Joint #6 motor unit and secure it.

For details, refer to *Maintenance: 10.1.1 Joint #6 motor (without electromagnetic brake)*, Installation step (4) to (8).

- (38) Mount the following covers and plates.

Arm #4 side cover (Both sides)	
Arm #3 head cover	Arm #3 bottom cover
Arm #2 side cover (Both sides)	Arm #1 side cover (Both sides)
Arm #1 center cover	Connector plate

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

- (39) Perform the calibration.

For details, refer to *Maintenance: 16. Calibration*.

Base bottom

Removal (1) Remove the cover at the bottom of the base and remove the following connectors inside.

Connector:

X010, X020, X030, X040, X050, X060,
BR010, BR011, BR020, BR030, BR040, BT1, BT1A, (BT1B*)
X11, X12, X13, X14, X15, X16

* BT1B is for the battery replacement. (a spare cable of BT1A)

The battery is connected to BT1A at shipment. Nothing is connected to BT1B.

(2) Remove the cover on the back of the base and remove the cable fixing plate.

(3) Pull out the cables.

Installation

(1) Pass the cables to the bottom of the base.

Pulling the cables forcibly may break the cables. Do not pull the cables.

(2) Install the cable fixing plate to the base.

(3) Connect the connectors and install the cover.

Connector:

X010, X020, X030, X040, X050, X060,
BR010, BR011, BR020, BR030, BR040, BT1, BT1A, (BT1B*)
X11, X12, X13, X14, X15, X16

* BT1B is for the battery replacement. (a spare cable of BT1A)

If the battery is connected to BT1A, it is not necessary to connect to the connector to BT1B.

User Connector

Removal (1) Remove the user connector (circular).

(2) Remove the following connectors from the Arm #3.

Connector: X71, X72

(3) Pull out the user connector.

Installation

(1) Insert the cables to the arm.

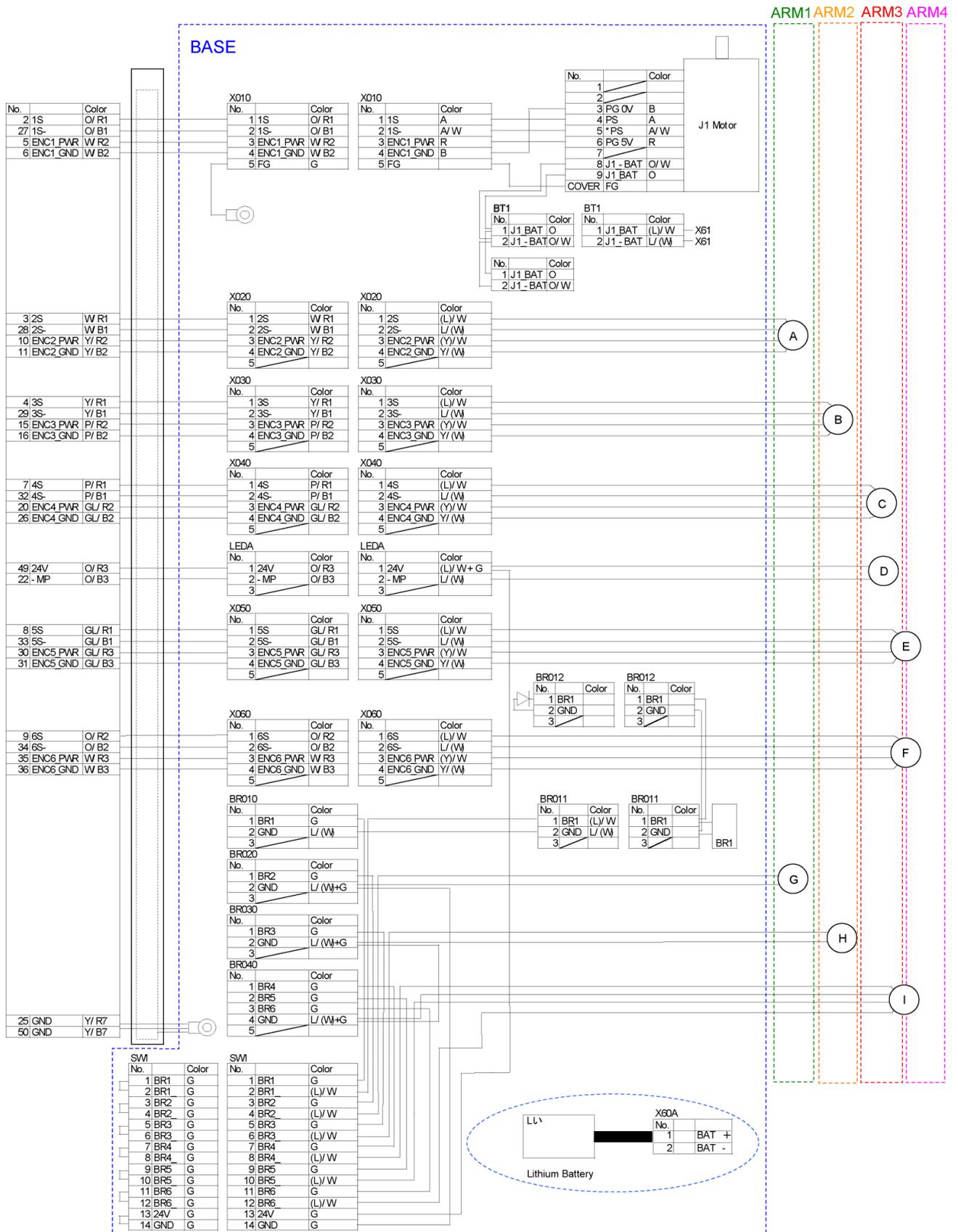
(2) Connect the following connector.

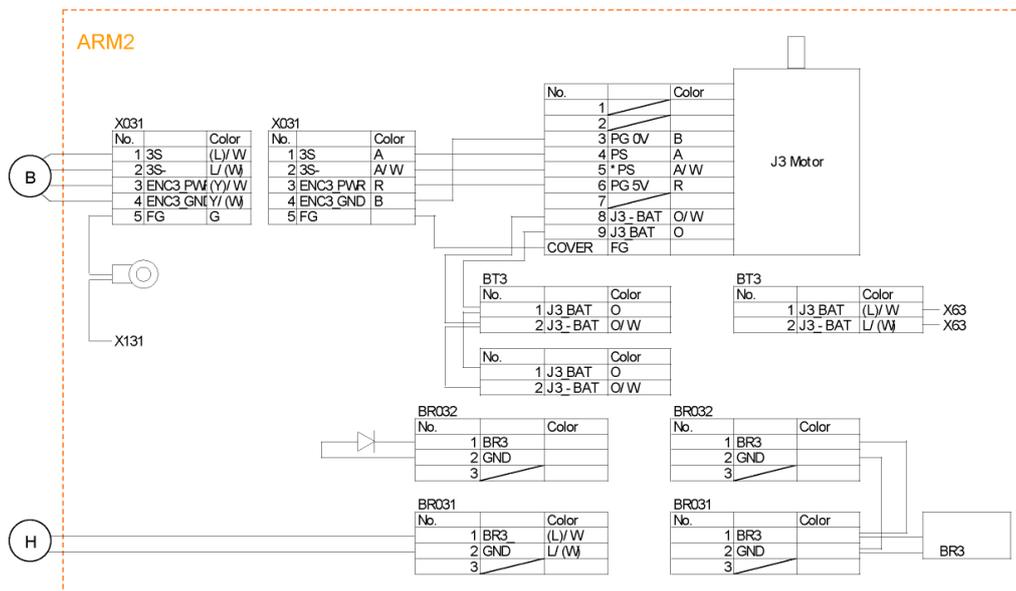
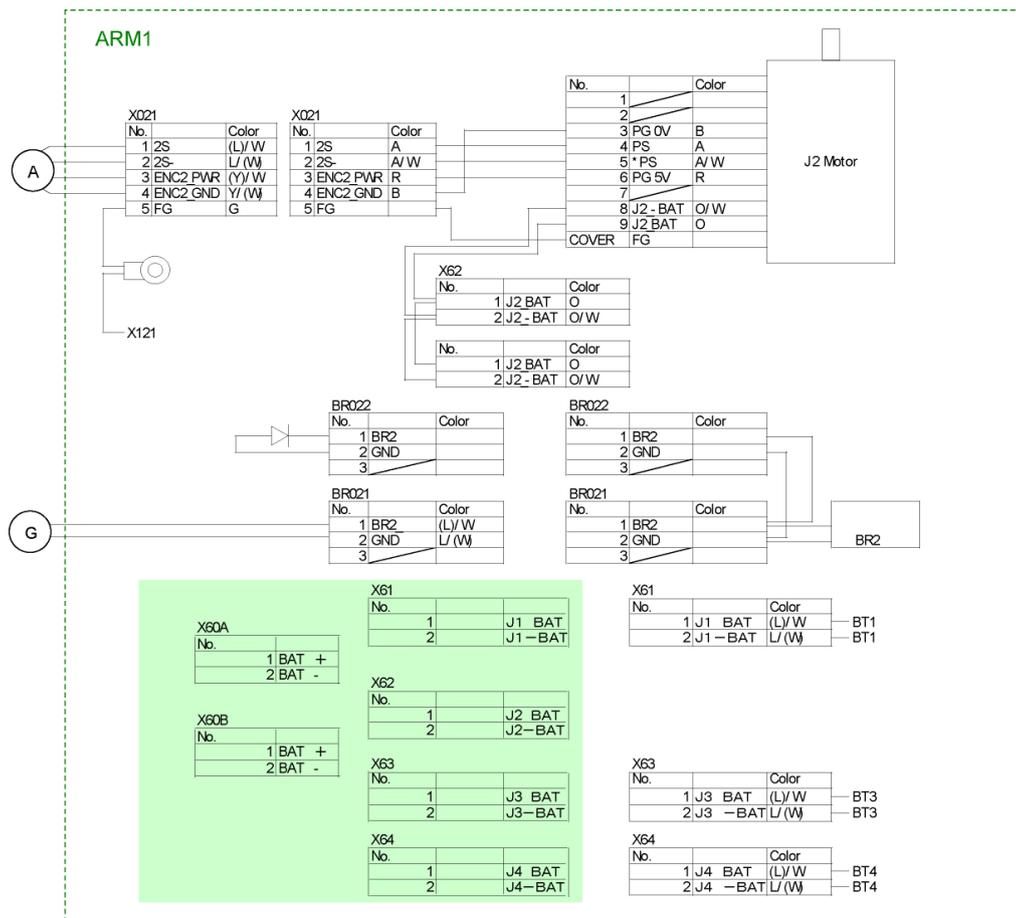
Connector: X71, X72

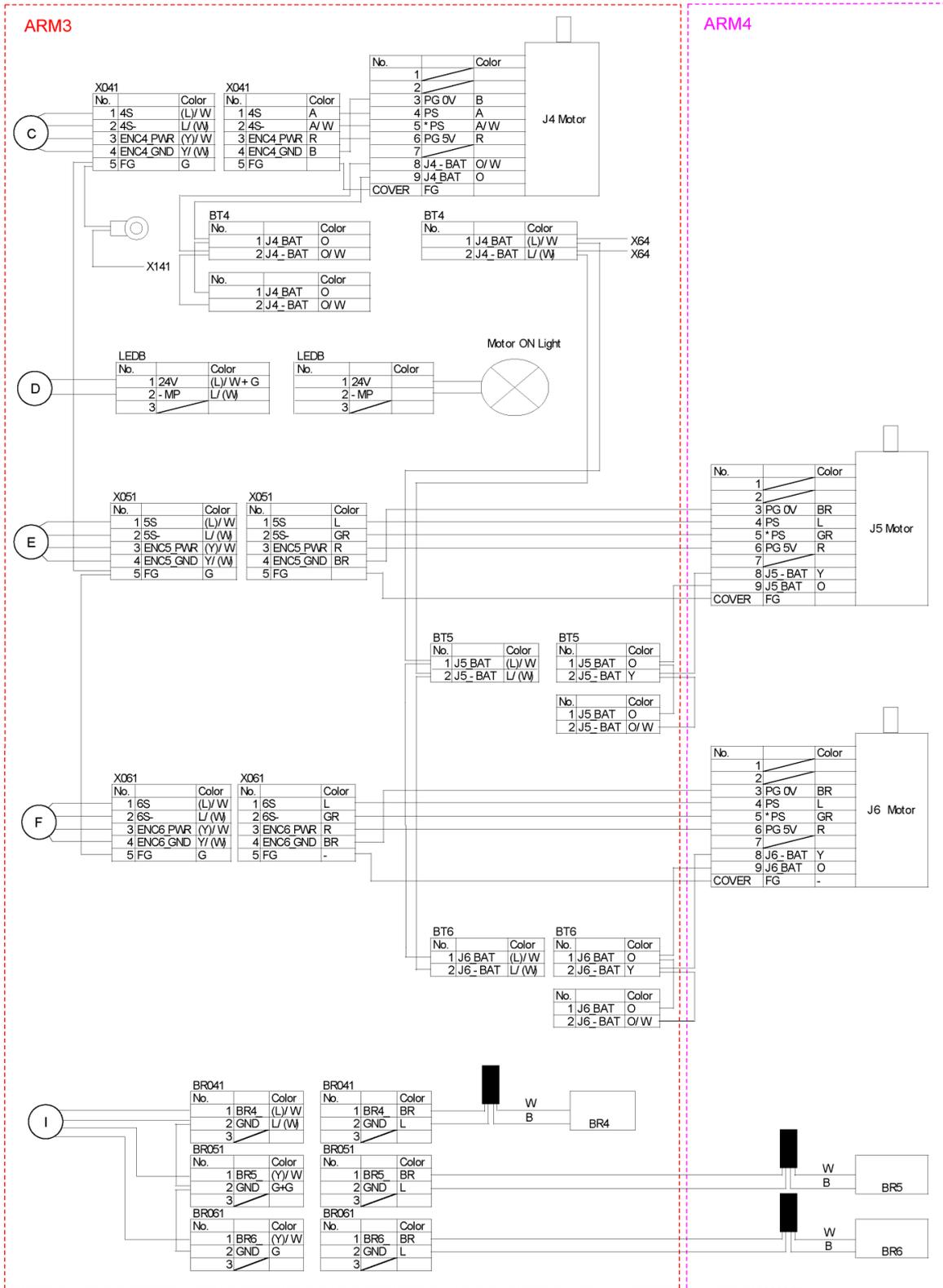
(3) Secure the user connector.

4.2 Connector Pin Assignments

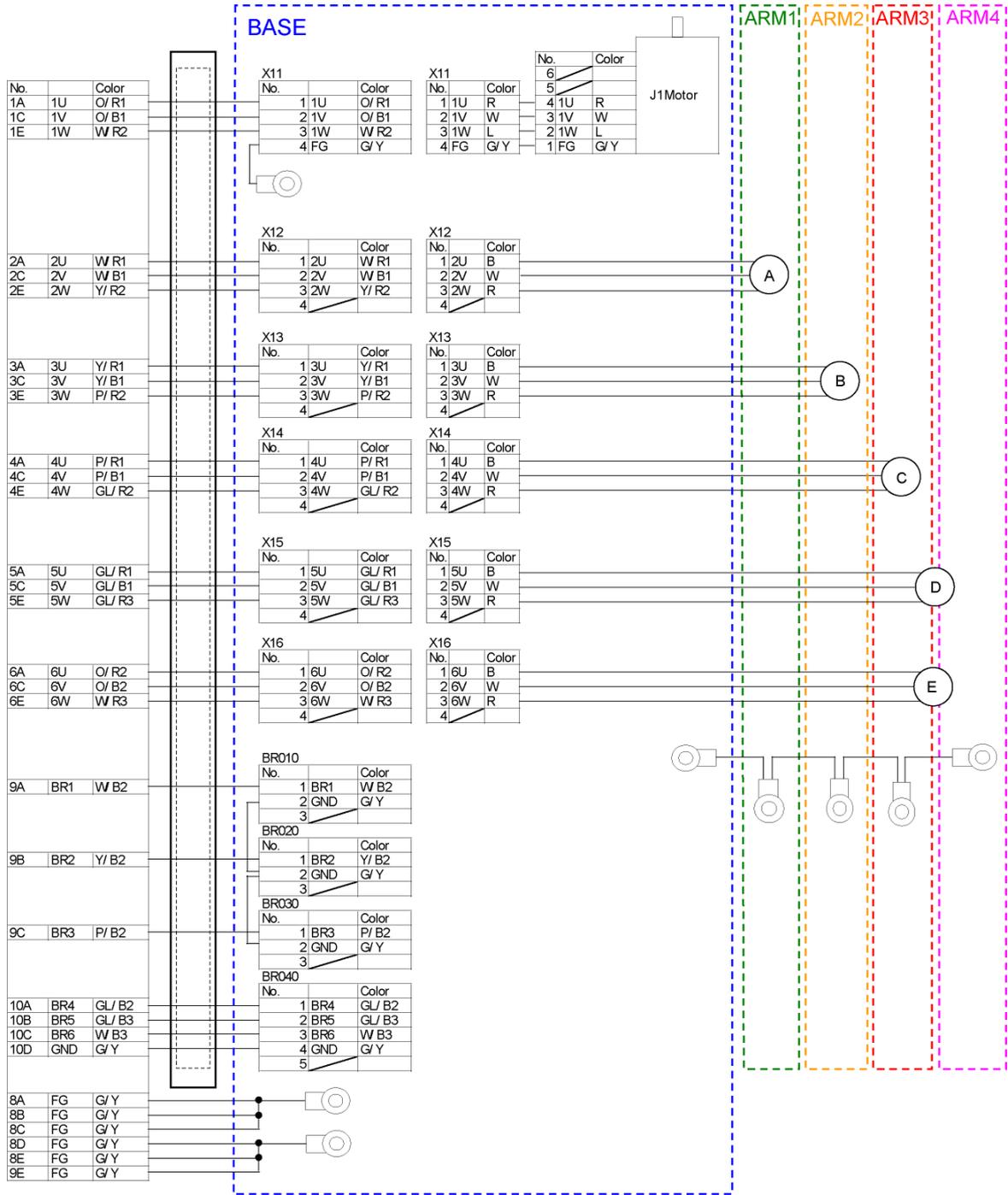
4.2.1 Signal Cable

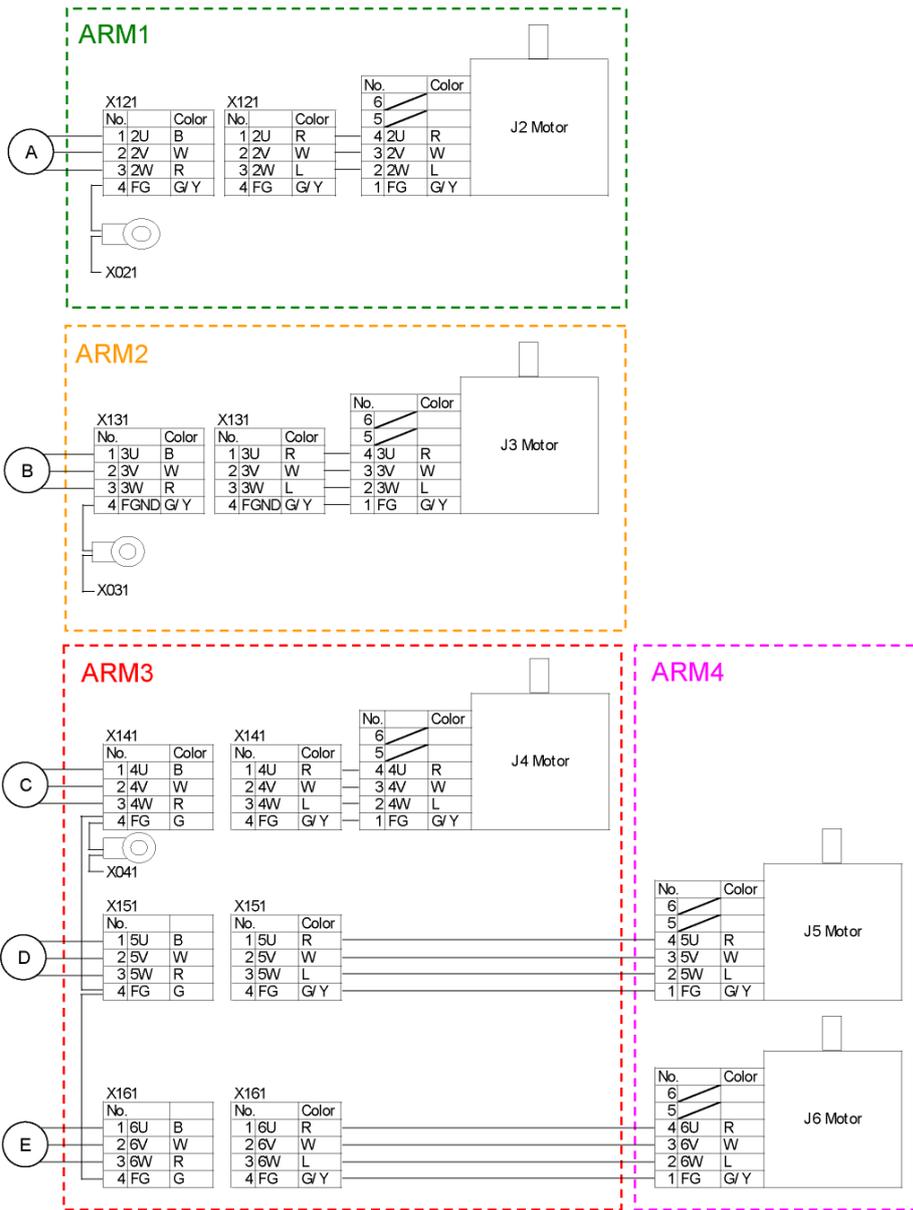






4.2.2 Power Cable





4.2.3 User Cable



4.2.4 Color of Cables

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

- 4.2.1 Signal Cable
- 4.2.2 Power Cable
- 4.2.3 User Cable

Code	Cable color
B	Black
W	White
R	Red
G	Green
Y	Yellow
BR	Brown
L	Blue
V	Violet
A	Azure
O	Orange
GL	Gray

5. Arm #1



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



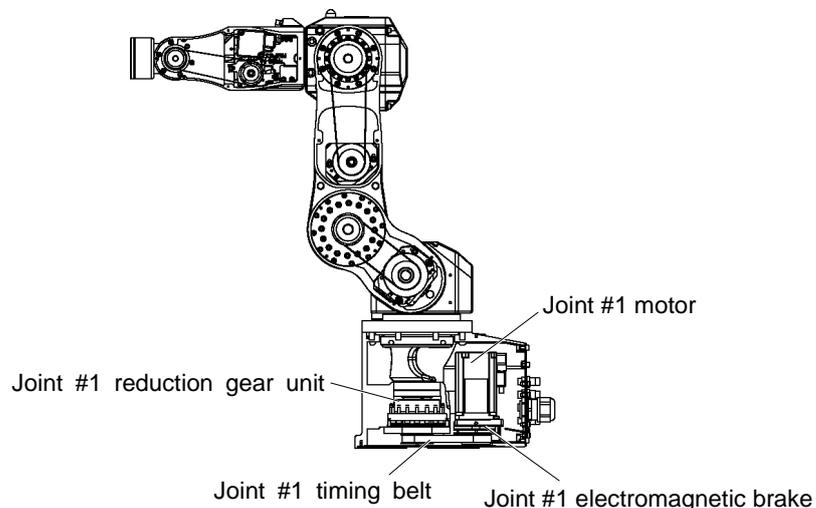
- Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder 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 16. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



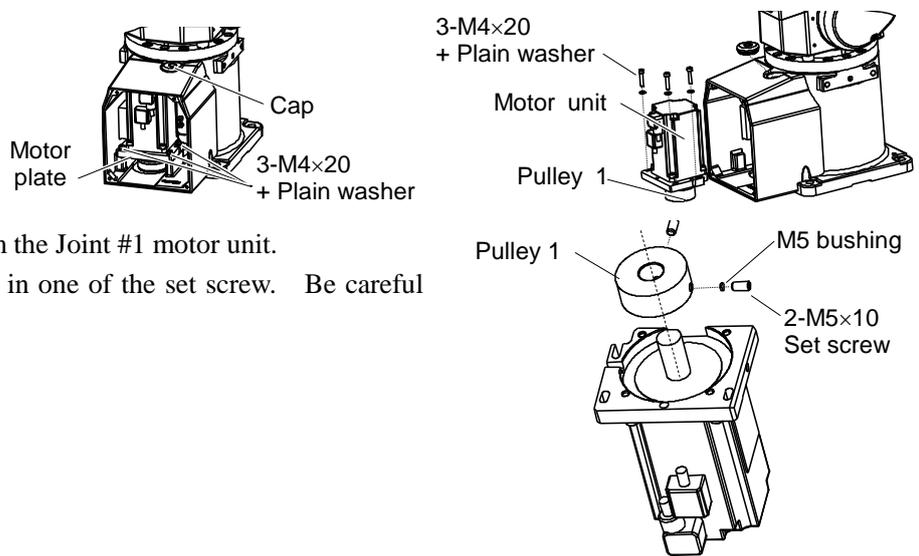
5.1 Replacing the Motor

	Name	Quantity	Note
Maintenance Parts	AC servo motor 400 W	1	R13B000616
	Heat dissipating sheet	1	R13B031905
	Noise reduction diode	1	R13B020301
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M5 set screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Hexagonal wrench (width across flats: 4 mm)	1	For M5 screw
	Cross-point screwdriver	1	For motor connector
	Force gauge	1	For belt tension

5.1.1 Joint #1 motor (without electromagnetic brake)

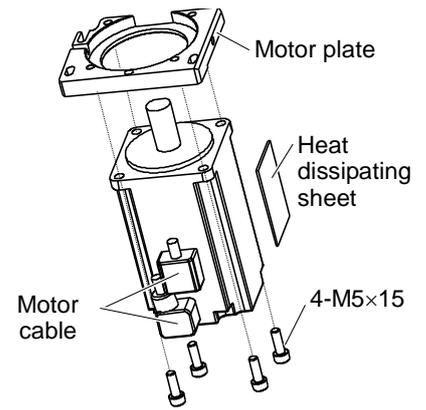
Removal: Joint #1 motor (without electromagnetic brake)

1. Turn ON the controller.
2. Remove the connector plate.
For details, refer to *Maintenance: 3. Covers*.
3. Disconnect the connectors.
Connector: X11, X010 (Hold the claw to remove.)
Connector: BT1
4. Remove the Joint #1 motor unit from the base.
To remove the screw fixed to the rear of the motor unit, put a hexagonal wrench through the hole after removing the cap.



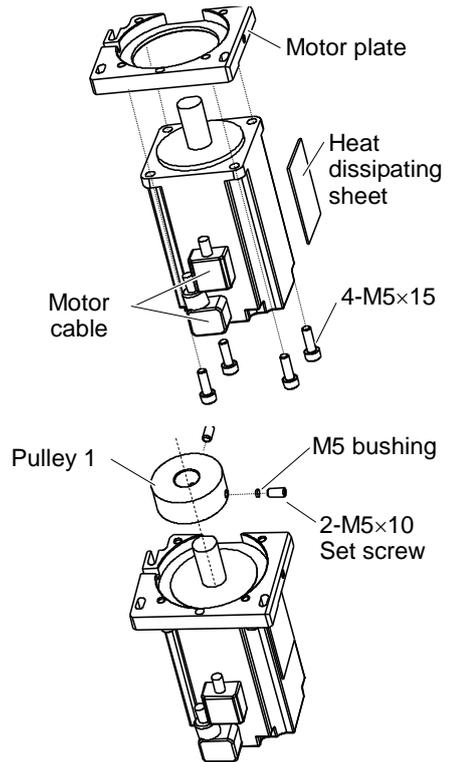
5. Remove the pulley 1 from the Joint #1 motor unit.
There is a brass bushing in one of the set screw. Be careful not to lose it.

6. Remove the motor plate from the Joint #1 motor.
7. Remove the heat dissipating attached to the Joint #1 motor.
The sheet is very soft, be careful not to break.
8. Remove the motor cable from the Joint #1 motor.

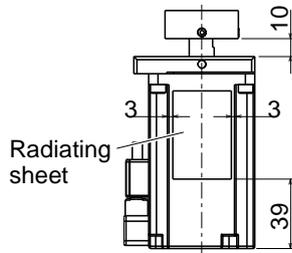


Installation: Joint #1 motor (without electromagnetic brake)

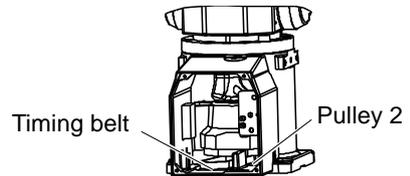
1. Mount the motor cable to the Joint #1 motor.
2. Mount the motor plate to the Joint #1 motor.
Be careful of the direction of the motor plate.
(See the figure.)



3. Mount the pulley 1 to the Joint #1 motor.
Put a space of 10 mm between the pulley 1 and the motor plate.
Use the bushing to the hole that is fixed with the round face of the motor shaft.

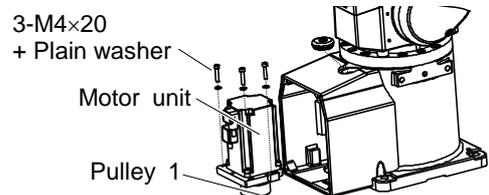


4. Attach the heat dissipating sheet to the Joint #1 motor.
5. Place the Joint #1 timing belt around the Joint #1 pulley 2 in the Joint #1 side.



6. Pass the pulley 1 of the Joint #1 motor unit to the Joint #1 timing belt and loosely secure it to the base.

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

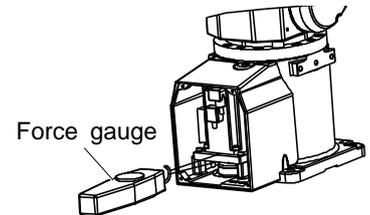
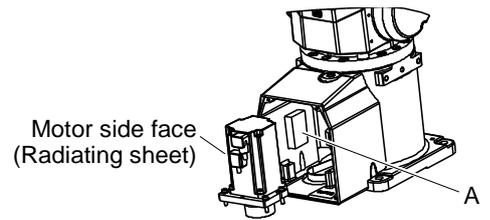


When securing the motor unit loosely, make sure the motor unit can be moved by hand, and it does not tilt when being pulled. If the unit is secured too loose or too tight, the belt will not have proper tension.

7. Apply proper tension to the Joint #1 motor unit to secure it.

Pass a suitable cord or string (insulation lock) to the screw. Then, pull the cord using a force gauge or a similar tool to apply specified tension. At this point, apply tension by pressing toward the “A” surface in the figure and secure the motor unit.

Joint #1 timing belt tension: $78.4 \text{ N} \pm 9.8 \text{ N}$ (8 kgf \pm 1 kgf)



8. Connect the following connectors.
Connectors: X11, X010, BT1
9. Mount the connector plate.
For details, refer to *Maintenance: 3. Covers.*
10. Perform the calibration for the Joint #1.
For details, refer to *Maintenance: 16. Calibration.*

5.1.2 Joint #1 motor (with electromagnetic brake)

Removal: Joint #1 motor (with electromagnetic brake)

1. Remove the Joint #1 motor unit.

For details, refer to *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake)*, Removal step (1) to (4).

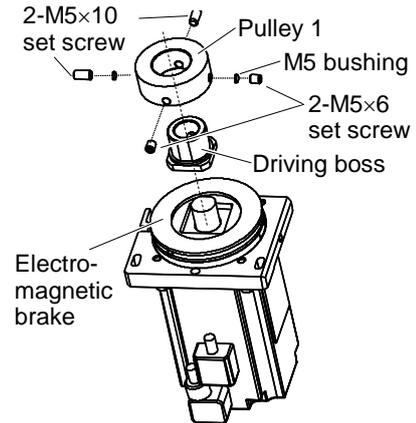
When disconnecting the connectors, disconnect the following together.

Connector: BR011

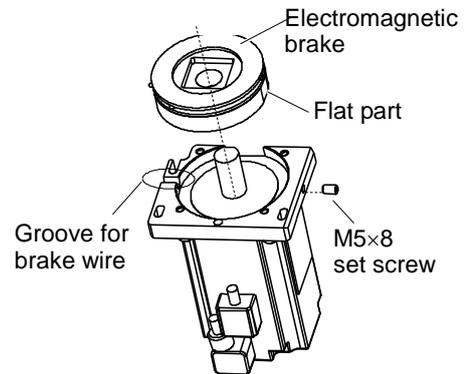
Be careful not to lose the noise reduction diode.

2. Remove the Joint #1 pulley 1 and driving boss from the Joint #1 motor unit.

There is a brass bushing in one of the set screws fixing the driving boss and pulley 1. Be careful not to lose it.



3. Remove the electromagnetic brake.



4. Remove the Joint #1 motor.

For details, refer to *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake)*, Removal step (6) to (8).

Installation: Joint #1 motor (with electromagnetic brake)

1. Assemble the motor.

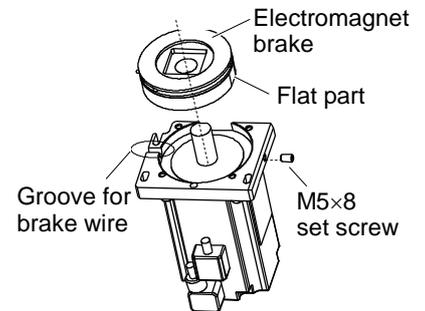
For the detail, refer to the *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake) – Installation step (1) to (2)*.

2. Mount the Joint #1 electromagnetic brake to the Joint #1 motor unit.

Align the position of brake wire with the groove in motor plate. Then, put the flat part of brake to the side of set screw and secure the brake.

Set screw: M5 × 8

Tightening torque: 1.4 N·m



Be careful not to catch the brake wire in the motor plate and cut it off.

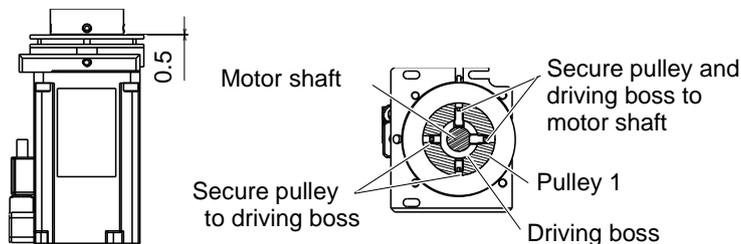
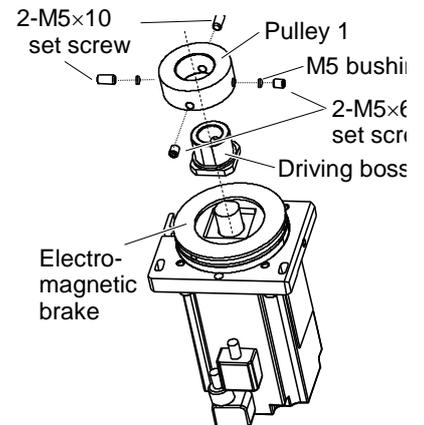
Press the brake toward the motor plate and tighten the set screw.

3. Mount the noise dissipative diode to the wire of electromagnetic brake.

Connector: BR011

4. Mount the driving boss and pulley 1 to the Joint #1 motor unit.

Align the edges of driving boss and pulley 1. Put a space of 0.5 mm between the pulley 1 and electromagnetic brake. See the figure for the position of set screws.



5. Mount the Joint #1 motor unit.

For details, refer to *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake)*, Installation step (4) to (10).

5.2 Replacing the Reduction Gear Unit

A reduction gear unit consists of the following three parts. Also, two additional parts are included as accessories. When replacing the reduction gear unit, be sure to replace these parts all together as a set.

Reduction gear unit: Wave generator, Flexspline, Circular spline

Accessory: Spacer, Grip ring

For details, refer to *Maintenance: 17. Maintenance Parts List*.

It is recommended replacing the O-ring when replacing the reduction gear unit.

	Name	Quantity	Note
Maintenance Parts	Joint #1 reduction gear unit	1	R13B010011
	Joint #1 O-ring	1	R13B031223
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M5 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Hexagonal wrench (width across flats: 5 mm)	1	For M6 screw
	Force gauge	1	For belt tension adjustment
	Wiping cloth	2	For wiping grease
Grease	SK-1A	-	

Removal: Joint #1 reduction gear unit

1. Turn OFF the controller.
2. Turn the Manipulator laterally.

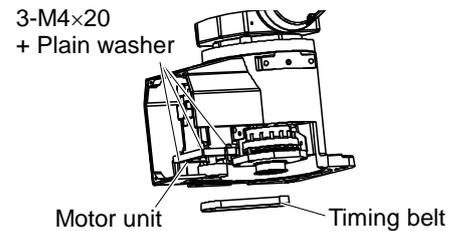


- When turning the Manipulator laterally, there must be two or more people to work on it so that at least one of them can support the arm while the others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot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

3. Remove the connector plate and the base bottom cover.

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

4. Loosen the set screws of the Joint #1 motor unit and remove the Joint #1 timing belt.

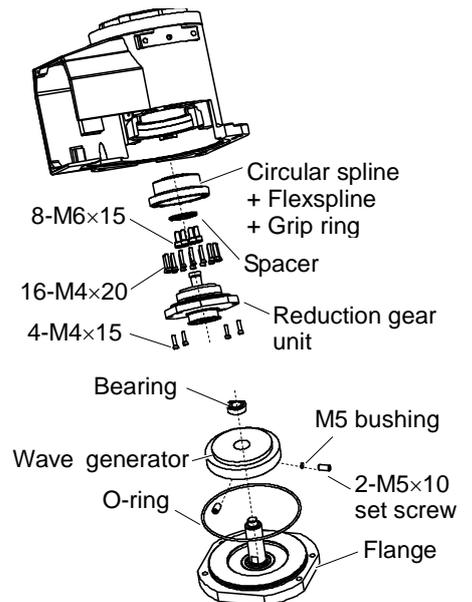


5. Remove the Joint #1 reduction gear unit from the base while wiping grease from the parts.

6. Remove the following parts from the Arm #2.

Circular spline
Grip ring
Flexspline
Spacer

Wipe grease from the parts while removing them.



7. Remove the wave generator from the Joint #1 reduction gear unit.

At this point, remove the bearing together. Be careful not to lose the bearing which is necessary in the later procedure.

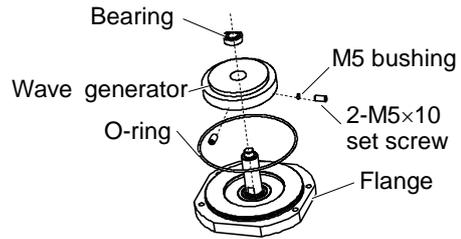
There is a brass bushing in one of the set screws. Be careful not to lose it.

8. Remove the O-ring.

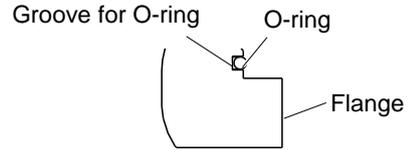
9. Wipe grease using a cloth or similar material if it is attached to the base.

Installation: Joint #1 reduction gear unit

1. Mount the wave generator and bearing to the Joint #1 reduction gear unit.



2. Put the O-ring into the groove on the flange. Carefully assemble these parts to avoid damaging the O-ring. (Otherwise the grease may leak.)



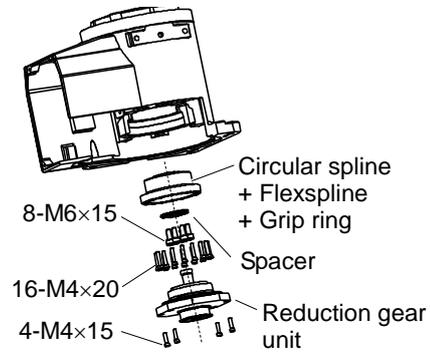
3. Apply grease (SK-1A) to the bearing area of the wave generator.

4. Mount the following parts to the base.

- Circular spline
- Grip ring
- Flexspline
- Spacer

Note that screw tightening torque is different from the normal torque.

- 16-M4x20 : Tightening torque 6.0 N·m
- 8-M6x15 : Tightening torque 22.0 N·m



5. Apply grease (SK-1A) to the inside of the flexspline.

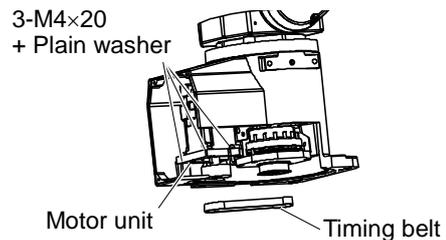
Grease volume: 40 g

6. Mount the Joint #1 reduction gear unit to the base.

7. Place the Joint #1 timing belt around the Joint #1 pulley 1 and pulley 2.

Place the timing belt to the pulley 2 first.

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



8. Loosely secure the Joint #1 motor unit.

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

9. Mount the Joint #1 motor unit.

For details, refer to *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake)*, Installation step (7) to (10).

5.3 Replacing the Timing Belt

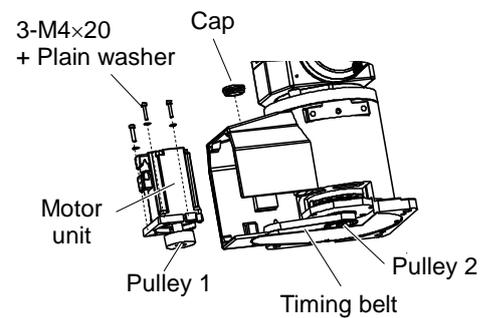
	Name	Quantity	Note
Maintenance Part	Joint #1 Timing belt	1	R13B030220
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment Belt tension: 8 kgf·cm

Removal: Joint #1 timing belt

1. Remove the Joint #1 motor unit.

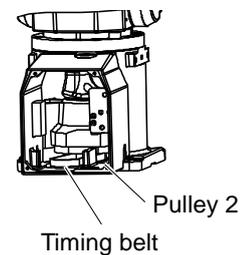
For details, refer to *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake)*, Removal step (1) to (4).

2. Remove the Joint #1 timing belt.



Installation: Joint #1 timing belt

1. Place the Joint #1 timing belt around the Joint #1 pulley 2.



2. Mount the Joint #1 motor unit.

For details, refer to *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake)*, Installation step (6) to (10).

5.4 Replacing the Electromagnetic Brake

	Name	Quantity	Note
Maintenance Parts	Joint #1 electromagnetic brake	1	R13B030504
	Noise dissipative diode	1	R13B020301
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M5 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment

Removal: Joint #1 electromagnetic brake

1. Remove the Joint #1 electromagnetic brake from the Joint #1 motor unit.

For details, refer to *Maintenance: 5.1.2 Joint #1 motor (with electromagnetic brake)*, Removal step (1) to (3).

Installation: Joint #1 electromagnetic brake

1. Assemble the Joint #1 motor unit.

For details, refer to *Maintenance: 5.1.2 Joint #1 motor (with electromagnetic brake)*, Installation step (2) to (4).

2. Mount the Joint #1 motor unit.

For details, refer to *Maintenance: 5.1.1 Joint #1 motor (without electromagnetic brake)*, Installation step (5) to (10).

6. Arm #2



- Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.



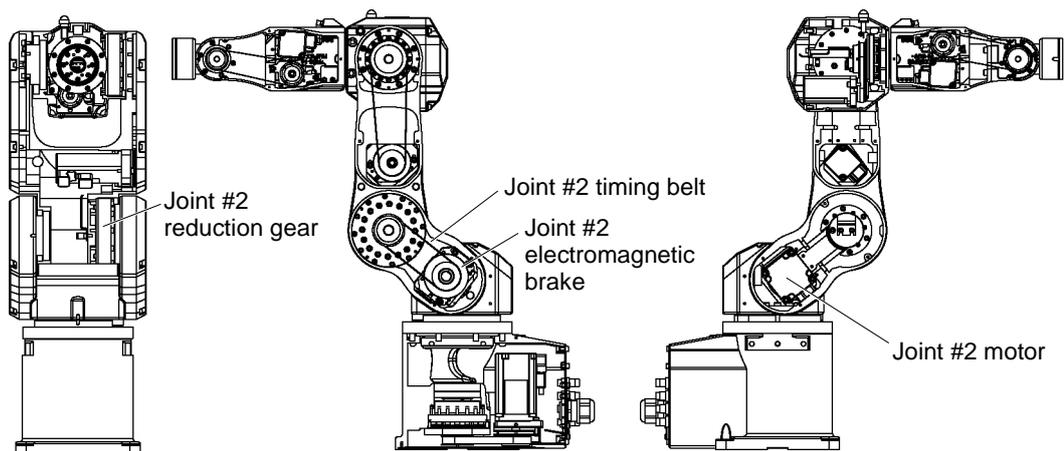
- Be careful not to apply excessive shock to the motor shaft during replacement. The shock may shorten the life of the motors and encoder and/or damage them.
- Never disassemble the motor and the encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder 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 16. Calibration* and perform the calibration after the parts replacement.



6.1 Replacing the Motor

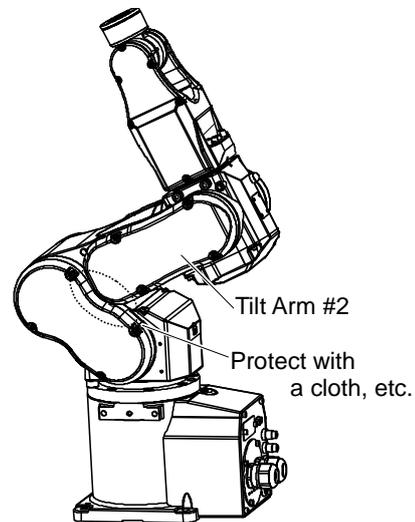
	Name	Quantity	Note
Maintenance Parts	AC servo motor 400 W	1	R13B000616
	Heat dissipating sheet	1	R13B031905
	Noise reduction diode	1	R13B020301
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M5 set screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Hexagonal wrench (width across flats: 4 mm)	1	For M5 screw
	Cross-point screwdriver	1	For motor connector
	Cloth	1	For pressing arm
	Force gauge	1	For belt tension adjustment

The brake is mounted on the Joint #2 to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. However, the brake does not work during replacement.

To replace the Joint #2 motor, tilt the Arm #2 and press it toward the Arm #1. (See the step (2).) When pressing the arm, put a cloth or a similar material between the arms to avoid each arm from contacting. This also protects the arm surfaces and coatings.

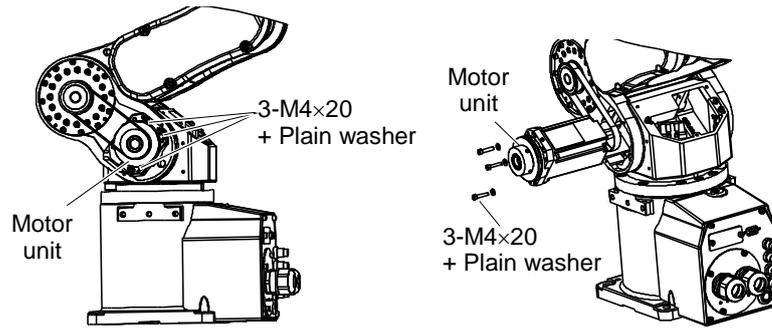
Removal : Joint #2 motor

1. Remove the Arm #1 cover and the Arm #1 side cover.
For details, refer to *Maintenance 3. Covers*.
2. Turn ON the controller power.
3. Tilt Arm #2.
Put a cloth between Arm #1 and Arm #2 so that two arms do not touch each other.



4. Turn OFF the controller power.
5. Disconnect the connectors.
Connector: X121, X021 (Hold the claw to remove.)
Connector: X62, BR021

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



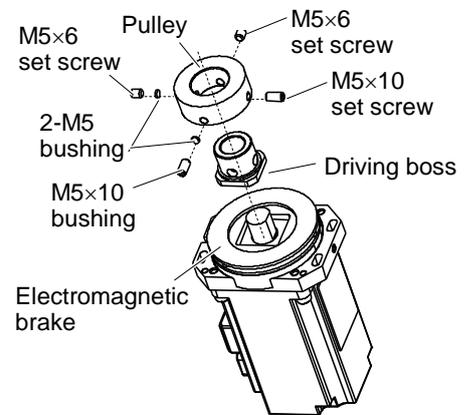
- Disconnect the connector.

Connector: BR022 (for the noise dissipative diode)

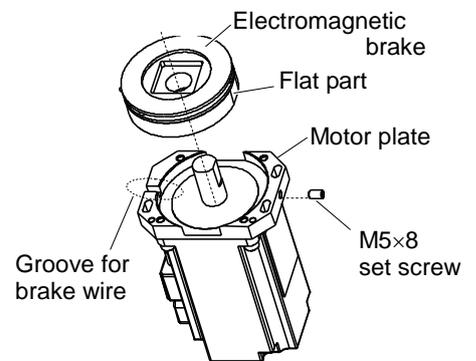
Be careful not to lose the noise dissipative diode.

- Remove the Joint #2 pulley 1 and driving boss from the Joint #2 motor unit.

There is a brass bushing in one of the set screw fixing the driving boss and pulley. Be careful not to lose it.



- Remove the Joint #2 electromagnetic brake.

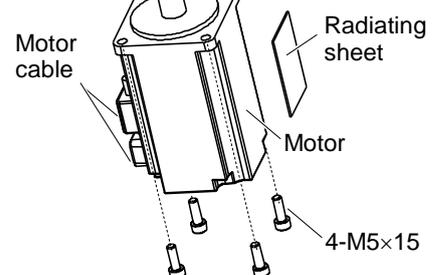


- Remove the motor plate from the Joint #2 motor.



- Remove the radiating sheet attached to the Joint #2 motor side.

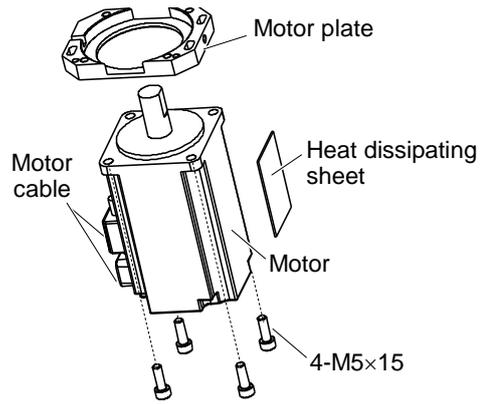
The sheet is very soft, be careful not to break.



- Remove the motor cable from the Joint #2 motor.

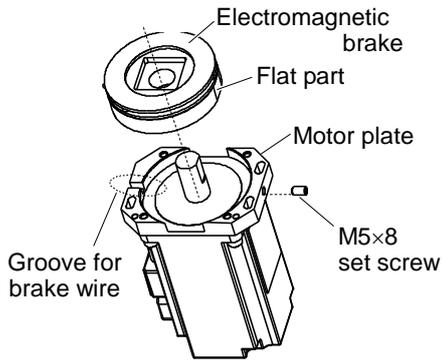
Installation: Joint #2 motor

1. Mount the motor cable to the Joint #2 motor.
2. Mount the motor plate to the Joint #2 motor.
Be careful of the direction of the motor plate. (See the figure.)



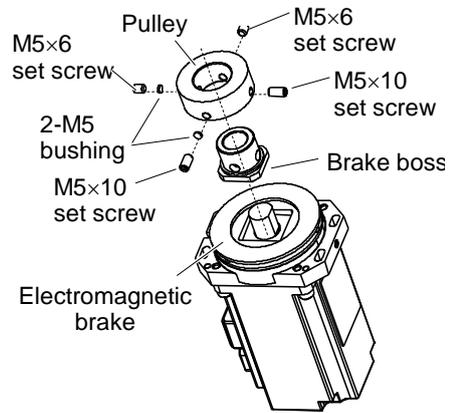
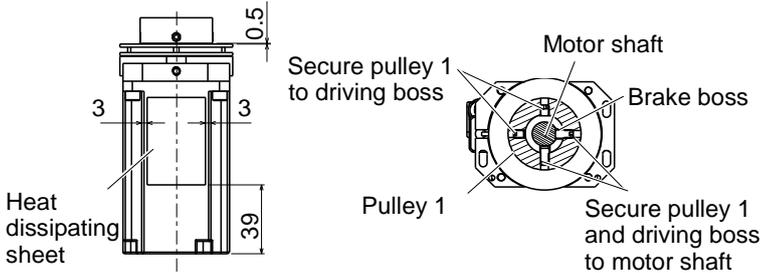
3. Mount the Joint #2 electromagnetic brake to the Joint #2 motor unit.
Align the position of the brake wire with the groove on the motor plate. Then, put the flat part of the brake to the side of the set screw and secure the brake. Be careful not to catch the brake wire in the motor plate and cut it off.

Press the brake toward the motor plate and tighten the set screw.

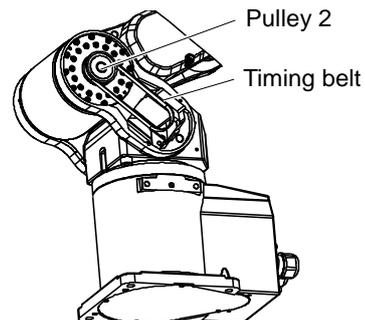


4. Mount the noise dissipative diode to the wire of the electromagnetic brake.
Connector: BR022

5. Mount the brake boss and pulley 1 to the Joint #2 motor unit.
Align the edges of the brake boss and pulley 1. Put a space of 0.5 mm between the pulley 1 and the electromagnetic brake. See the figure for the position of the set screws.



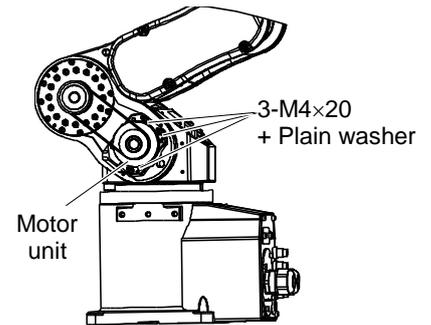
6. Mount the heat dissipating sheet.
7. Place the Joint #2 timing belt around the Joint #2 pulley 2.



8. Pass the pulley 1 of the Joint #2 motor unit to the Joint #2 timing belt and loosely secure it to the Arm #1.

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

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

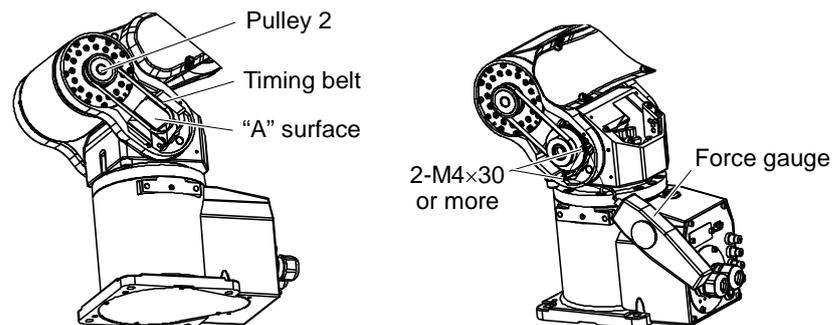


9. Apply proper tension to the Joint #2 motor unit to secure it.
Mount a screw of M4×30 or longer (recommended) to the motor plate.

Pass a suitable cord or string (insulation lock) to the screw. Then, pull the cord using a force gauge or a similar tool to apply specified tension. At this point, apply tension by pressing toward the “A” surface in the figure and secure the motor unit.

Joint #2 timing belt tension: $78.4 \text{ N} \pm 9.8 \text{ N}$ (8 kgf \pm 1 kgf)

Make sure to remove the screw mounted for applying tension.



10. Connect the following connectors.
Connectors: X121, X021, X62, BR021
11. Mount the Arm #1 cover and the Arm #1 side cover.
For details, refer to *Maintenance: 3. Covers*.
12. Perform the calibration.
For details, refer to *Maintenance: 16. Calibration*.

6.2 Replacing the Reduction Gear Unit

A reduction gear unit consists of the following three parts. Also, two additional parts are included as accessories. When replacing the reduction gear unit, be sure to replace these parts all together as a set.

Reduction gear unit: Wave generator, Flexspline (CRB combined), Circular spline

Accessory: O-ring × 2

For details, refer to *Maintenance: 17. Maintenance Parts List*.

It is recommended replacing the O-ring (for Joint #2) when replacing the reduction gear unit.

	Name	Quantity	Note
Maintenance Parts	Joint #2 reduction gear unit	1	R13B010021
	Joint #2 O-ring	1	R13B031242
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3, M5 screws
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment
	Wiping cloth	2	For wiping grease
Grease	SK-1A	-	

Removal: Joint #2 reduction gear

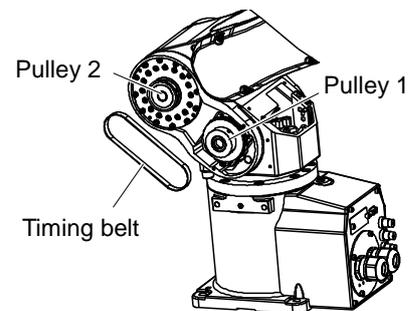
1. Remove the following covers.

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

- Arm #1 cover
- Arm #1 side cover
- Arm #2 side cover
- Arm #3 head cover

2. Remove the Joint #2 timing belt.

For details, refer to *Maintenance: 6.3 Replacing the Timing Belt*, Removal step (1) to (4).



3. Remove the cable unit.

For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*, step (6) to (17).

4. Turn the Manipulator laterally.

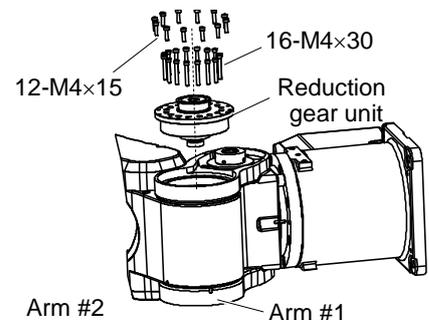
 CAUTION	<ul style="list-style-type: none"> ■ When turning the Manipulator laterally, there must be two or more people to work on it so that at least one of them can support the arm while the others are removing the bolts. Removing the bolts without supporting the arm may result in the arm falling, bodily injury, and/or malfunction of the robot system.
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5. Turn the Arm #3 to the opposite side and remove the Joint #2 reduction gear unit from the Arm #1.

At this point, Arms #2 to #6 (head of #6) come off.

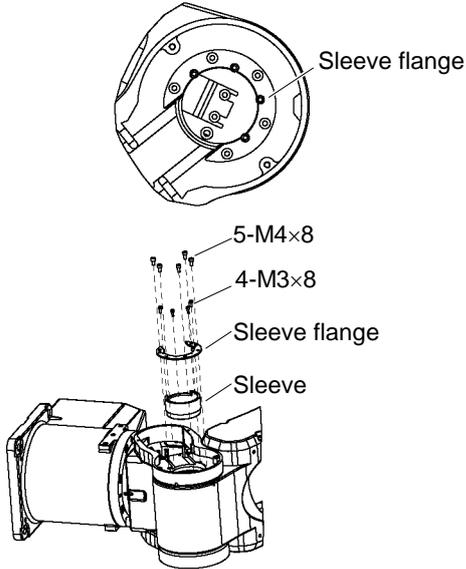
Do not work on it alone. Have at least two workers so that one can support the arms while the other worker(s) are removing the reduction gear unit.

Wipe the grease on the parts while removing them.

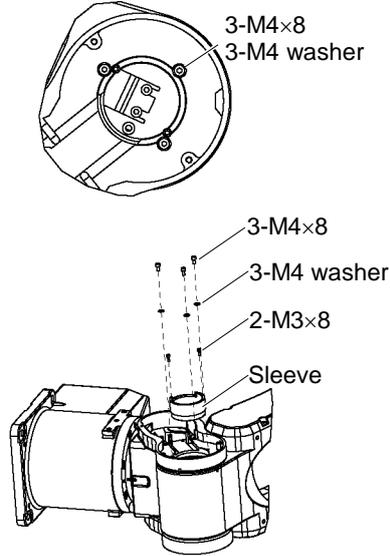


6. Remove the Joint #2 sleeve and the sleeve flange.
 There are following two methods to fix the sleeve.

A: using the sleeve flange

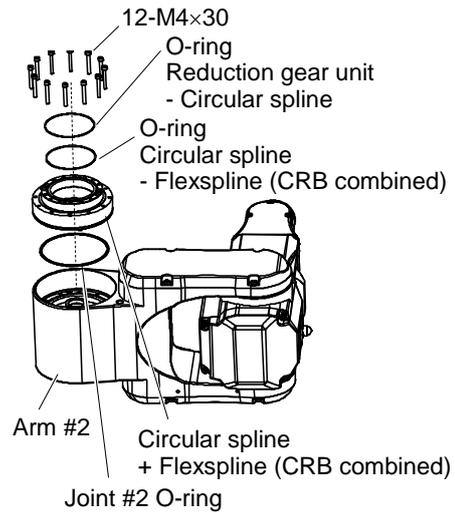


B: using screws

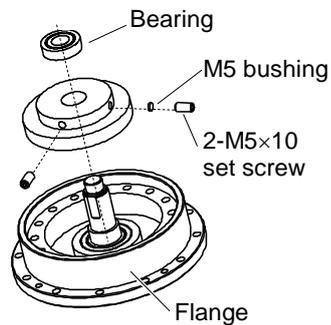


7. Remove the following parts from the Arm #2.
 Circular spline
 Flexspline (CRB combined)
 Joint #2 O-ring
 O-ring (between the reduction gear unit and the circular spline)

Wipe the grease on the parts while removing them.



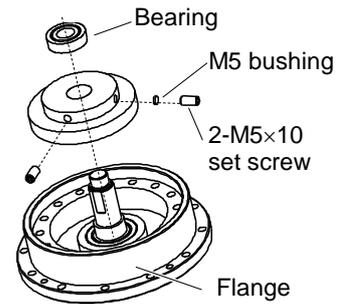
8. Remove the wave generator from the Joint #2 reduction gear unit.
 At this point, remove the bearing together. Be careful not to lose the bearing which is necessary afterward.
 There is a brass bushing in one of the set screws.
 Be careful not to lose it.



9. Wipe grease using a cloth or a similar material if it is attached to the Arm #1, #2, flange, etc.

Installation: Joint #2 reduction gear

1. Mount the wave generator and the bearing to the Joint #2 reduction gear unit.
2. Apply grease (SK-1A) to the bearing area of the wave generator.
3. Mount the Joint #2 O-ring to Arm #2.



4. Mount the following parts to the Arm #2.

- Flexspline (CRB combined)
- Circular spline
- O-ring ×2 (Accessory)

Apply grease to fill the inside gear groove of the circular spline.

Grease: SK-1A

Put a O-ring to:

- Between the circular spline and the flexspline (CRB combined)
 - Between the circular spline and the reduction gear unit
- Screw: 12-M4×30 Tightening torque: 5.0 N·m

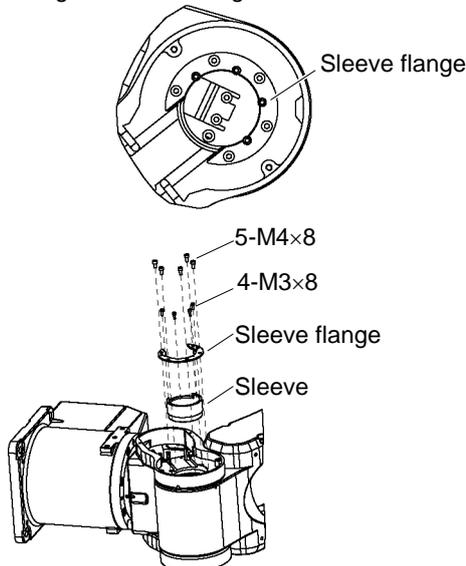
5. Apply grease (SK-1A) to the inside of the flexspline.

Grease volume: 30 g

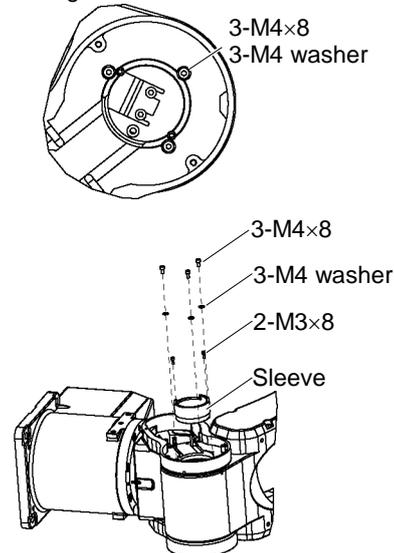
6. Mount the Joint #2 sleeve and the sleeve flange.

There are following two methods to fix the sleeve.

A: using the sleeve flange



B: using screws



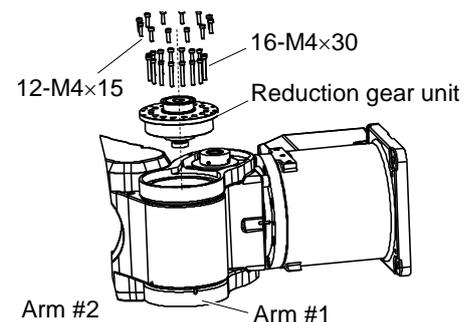
7. Join the Arm #2 and the Arm #1 and mount the Joint #2 reduction gear unit.

Screw: 16-M4×30 Tightening torque: 5.0 N·m

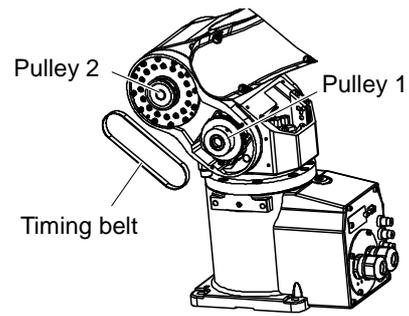
Screw: 12-M4×15 Tightening torque: 5.0 N·m

8. Mount the cable unit.

For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*, Installation step (12) to (14).



9. Place the Joint #2 timing belt around the Joint #2 pulley 2 and pulley 1.
10. Apply tension to the Joint #2 motor unit to secure it.
For details, refer to *Maintenance: 6.1 Replacing the Motor*, Installation step (9) to (12).
11. Mount the covers.
For details, refer to *Maintenance: 3. Covers*.

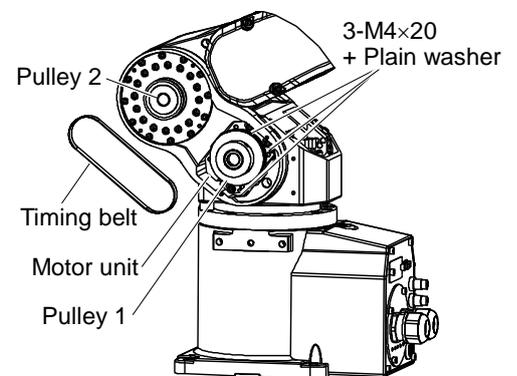


6.3 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance Part	Joint #2 Timing belt	1	R13B030221
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 set screw
	Cloth	1	For pressing arm
	Force gauge	1	For belt tension adjustment

Removal: Joint #2 timing belt

1. Follow *Maintenance: 6.1 Replacing the Motor*, Removal step (1) to (3).
2. Remove the Arm #1 side cover.
For details, refer to *Maintenance: 3. Covers*.
3. Loosen the set screw of Joint #2 motor unit.
4. Remove the Joint #2 timing belt.
First, remove the timing belt from pulley 1 and then from the pulley 2.



Installation: Joint #2 timing belt

1. Place the Joint #2 timing belt around the Joint #2 pulley 1 and pulley 2.
Put the timing belt to pulley 2 first.
2. Secure the Joint #2 motor unit.
For details, refer to *Maintenance: 6.1 Replacing the Motor*, Installation step (9) to (12).

6.4 Replacing the Electromagnetic Brake

	Name	Quantity	Note
Maintenance Parts	Joint #2 electromagnetic brake	1	R13B030504
	Noise dissipative diode	1	R13B020301
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M5 set screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Cloth	1	For pressing arm
	Force gauge	1	For belt tension adjustment

Removal: Joint #2 electromagnetic brake

Remove the Joint #2 electromagnetic brake.

For details, refer to *Maintenance: 6.1 Replacing the Motor*, Removal step (1) to (9).

Installation: Joint #2 electromagnetic brake

Assemble the Joint #2 electromagnetic brake and mount the motor unit.

For details, refer to *Maintenance: 6.1 Replacing the Motor*, Installation step (3) to (12).

7. Arm #3



- Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.



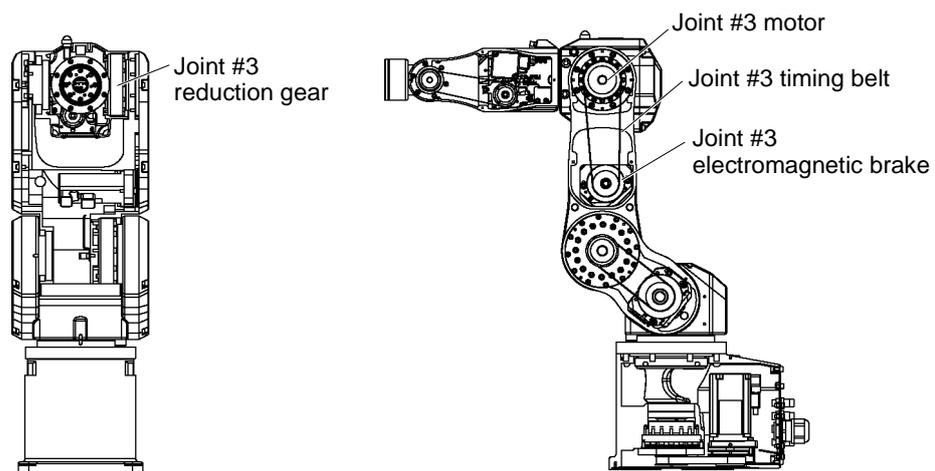
- Be careful not to apply excessive shock to the motor shaft during replacement. The shock may shorten the life of the motors and encoder and/or damage them.
- Never disassemble the motor and the encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder 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 16. Calibration* and perform the calibration after the parts replacement.



7.1 Replacing the Motor

	Name	Quantity	Note
Maintenance Parts	AC servo motor 150W	1	R13B000618
	Noise reduction diode	1	R13B020301
Tools	Hexagonal wrench (width across flats: 2 mm)	1	For M4 set screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Cross-point screwdriver	1	For motor connector
	Cloth	1	For pressing arm
	Force gauge	1	For belt tension adjustment

The brake is mounted on the Joint #3 to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. However, the brake does not work during replacement.

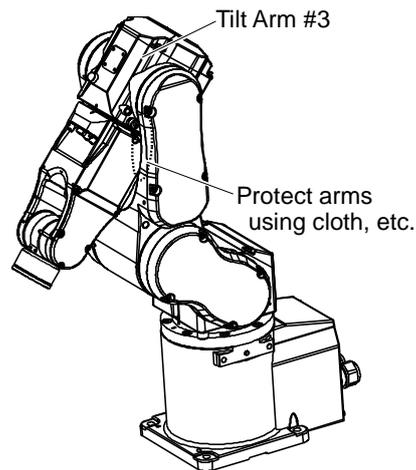
To replace the Joint #3 motor, tilt the Arm #3 and press it toward the Arm #2. (See the step (2).)

When pressing the arm, put a cloth or a similar material between the arms to avoid each arm from contacting. This also protects the arm surfaces and coatings.

Removal: Joint #3 motor

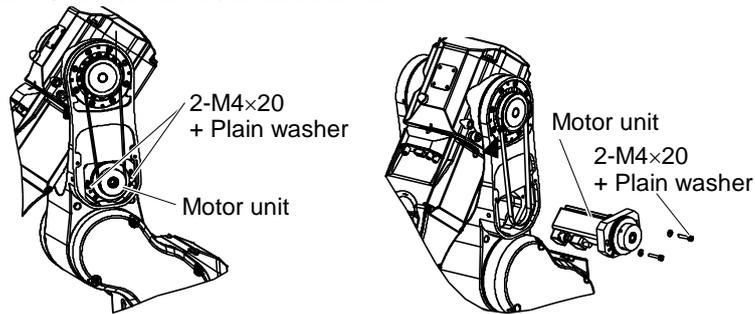
1. Turn ON the controller.

2. Tilt the Arm #3.
Put a cloth between the Arm #3 and the Arm #2 so that two arms do not touch each other.



3. Turn OFF the controller.
4. Remove the Arm #2 side cover.
For details, refer to *Maintenance: 3. Covers*.
5. Disconnect the connectors.
Connector: X131, X031 (Hold the claw to remove.)
Connector: BT3, BR031

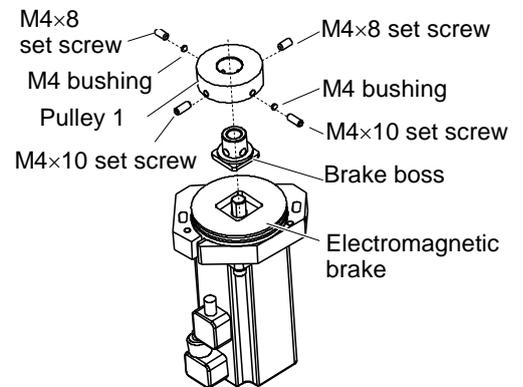
6. Remove the Joint #3 motor unit from the Arm #2.



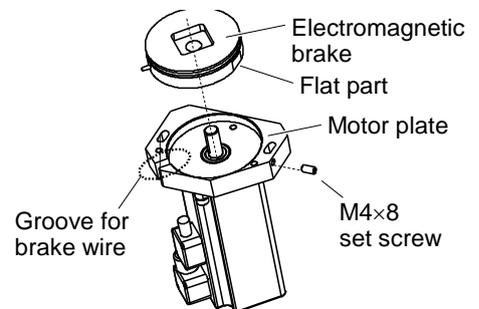
7. Disconnect the connector.

Connector: BR032 (for the noise dissipative diode)
Be careful not to lose the noise dissipative diode.

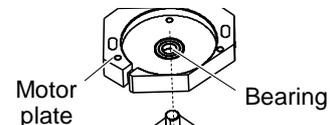
8. Remove the Joint #3 pulley 1 and the brake boss from the Joint #3 motor unit.
There is a brass bushing in one of the set screw fixing the brake boss and pulley.
Be careful not to lose it.



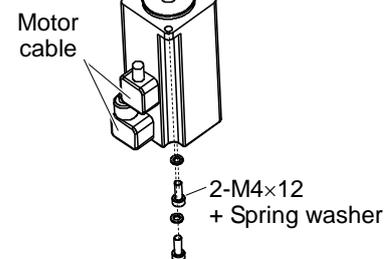
9. Remove the Joint #3 electromagnetic brake.



10. Remove the motor plate from the Joint #3 motor.
Be careful not to lose the bearing inside the motor plate.

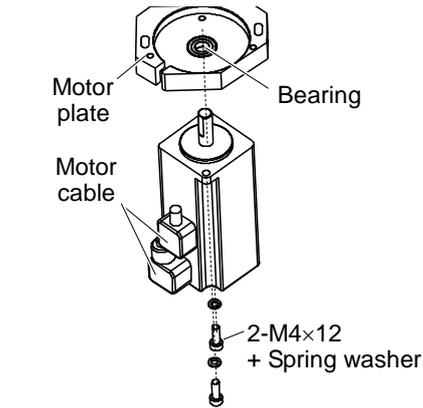


11. Remove the motor cable from the Joint #3 motor.



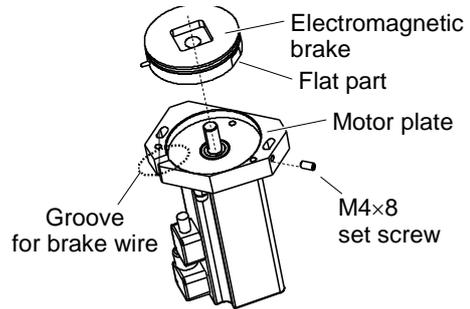
Installation: Joint #3 motor

1. Mount the motor cable to the Joint #3 motor.
2. Mount the motor plate to the Joint #2 motor.
Be careful of the direction of the motor plate.
(See the figure.)



3. Mount the Joint #3 electromagnetic brake to the Joint #3 motor unit.

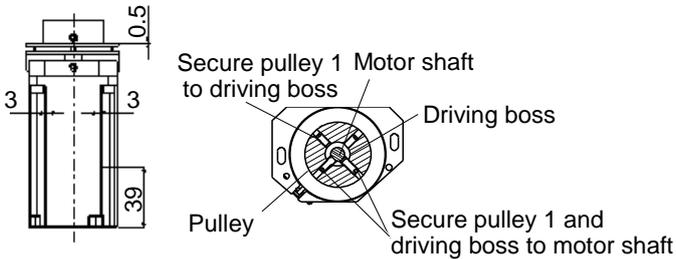
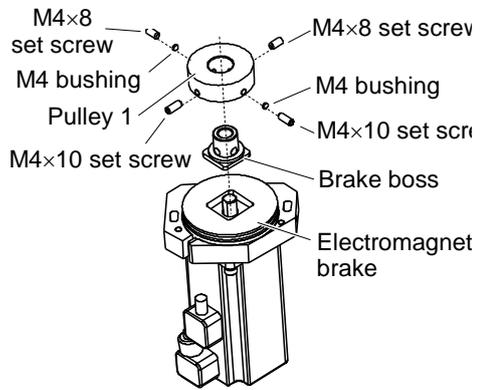
Align the position of the brake wire with the groove on the motor plate. Then, put the flat part of the brake to the side of the set screw and secure the brake. Be careful not to catch the brake wire in the motor plate and cut it off.



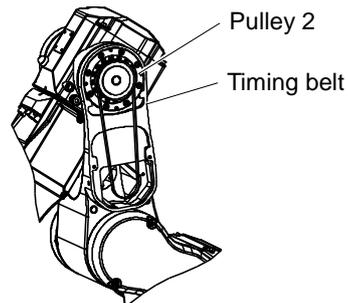
Press the brake toward the motor plate and tighten the set screw.

4. Mount the noise dissipative diode to the wire of electromagnetic brake.
Connector: BR032

5. Mount the brake boss and pulley 1 to the Joint #3 motor unit.
Align the edges of brake boss and pulley 1. Put a space of 0.5 mm between the pulley 1 and electromagnetic brake.
See the figure for the position of set screws.

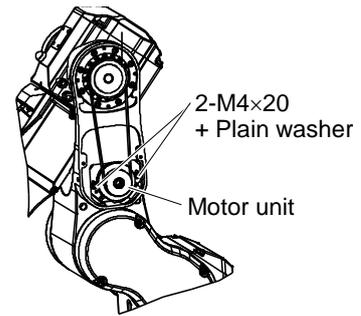


6. Mount the motor unit to the Arm 2.
7. Place the Joint #3 timing belt around the Joint #3 pulley 2.



8. Pass the pulley 1 of the Joint #3 motor unit to the Joint #3 timing belt and loosely secure it to the Arm #2. Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.

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



9. Apply proper tension to the Joint #3 motor unit to secure it.

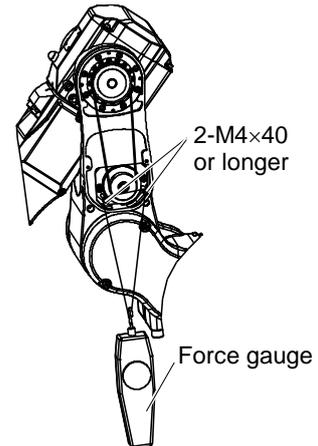
Mount a screw of M4 × 40 or longer (recommended) to the motor plate.

Pass a suitable cord or string (insulation lock) to the screw. Then, pull the cord using a force gauge or a similar tool to apply specified tension.

Joint #3 timing belt tension:

$$68.6 \text{ N} \pm 9.8 \text{ N} (7 \text{ kgf} \pm 1 \text{ kgf})$$

Make sure to remove the screw for belt tension.



10. Connect the following connectors.

Connectors: X131, X031, BT3, BR021

11. Bind the cables as before removing the motor unit.

12. Mount the Arm #2 side cover.

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

13. Perform the calibration.

For details, refer to *Maintenance: 16. Calibration*.

7.2 Replacing the Reduction Gear Unit

A reduction gear unit consists of the following three parts. Also, two additional parts are included as accessories. When replacing the reduction gear unit, be sure to replace 5 parts all together as a set.

Reduction gear unit: Wave generator, Flexspline (CRB combined), Circular spline

Accessory: O-ring × 2

For details, refer to *Maintenance: 17. Maintenance Parts List*.

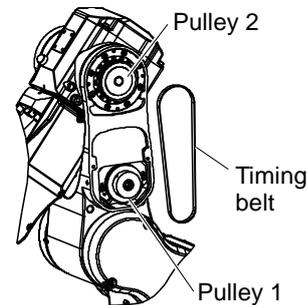
It is recommended replacing the O-ring (for Joint #3) when replacing the reduction gear unit.

Maintenance Parts and Tools

	Name	Quantity	Note
Maintenance Parts	Joint #3 reduction gear	1	R13B010022
	Joint #3 O-ring	1	R13B031243
Tools	Hexagonal wrench (width across flats: 2 mm)	1	For M4 set screws
	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment
	Wiping cloth	2	For wiping grease
Grease	SK-1A	-	

Removal: Joint #3 reduction gear

- Remove the Joint #3 timing belt.
For details, refer to *Maintenance: 7.3 Joint #3 - Replacing the Timing Belt*, Removal step (1) to (3).

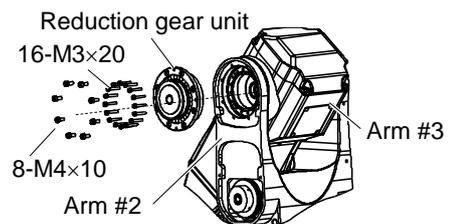


- Remove the following parts:
 - Arm #3 head cover
 - Arm #4 cover
 - User plate
 - Air tube

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

- Remove the cable unit.
For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*, Removal step (6) to (15).

- Remove the Joint #3 reduction gear unit from the Arm #3.
Note that Arms #3 to #6 (head of #6) come off when replacing the reduction gear unit. Do not work on this step alone. Have at least two workers so that the one of them can support the arms while the other(s) are removing the reduction gear unit.

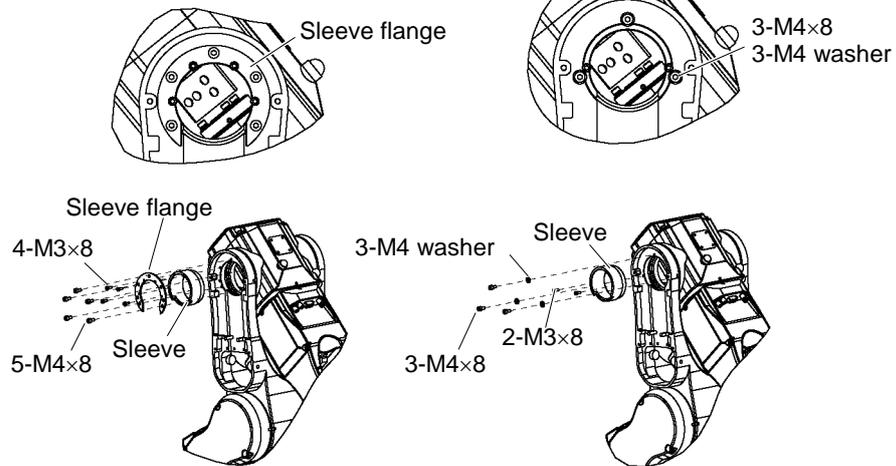


Wipe grease from the parts while removing them.

5. Remove the Joint #3 sleeve and the sleeve flange.
There are following two methods to fix the sleeve.

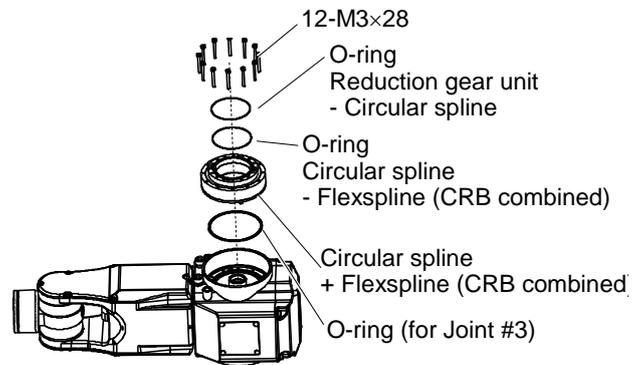
A: using the sleeve flange

B: using screws



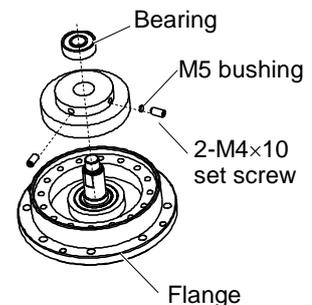
6. Remove the following parts from the Arm #2.
Circular spline
Flexspline
Joint #2 O-ring
O-ring (between reduction gear unit and circular spline)

Wipe grease from the parts while removing them.



7. Remove the wave generator from the Joint #3 reduction gear unit.
At this point, remove the bearing together. Be careful not to lose the bearing since it is necessary for the later procedure.

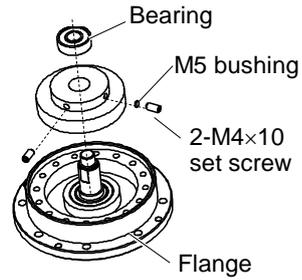
There is a brass bushing in one of the set screws.
Be careful not to lose it.



8. Wipe grease using a cloth or a similar material if it is attached to the following parts
Arm #2
Arm #3
Flange, etc.

Installation: Joint #3 reduction gear

1. Mount the wave generator and the bearing to the Joint #3 reduction gear unit.
2. Apply grease (SK-1A) to the bearing area of the wave generator.
3. Mount the Joint #3 O-ring to the Arm #3.
4. Mount the following parts to the Arm #3.
Flexspline (CRB combined)
Circular spline O-ring ×2 (Accessory)

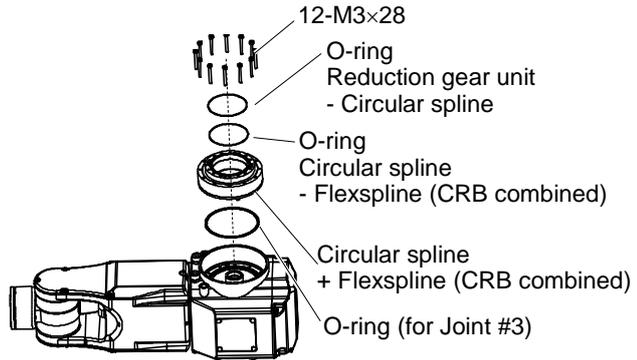


Put a O-ring to:

- Between circular spline and Flexspline (CRB combined)
- Between circular spline and Reduction gear unit

Bolt: 12-M3x28

Tightening torque: 2.5 N·m

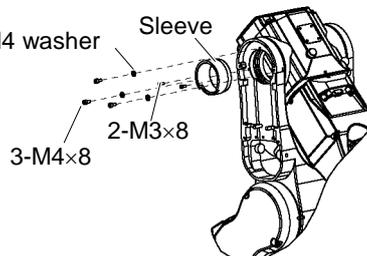
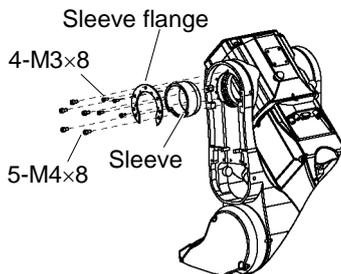
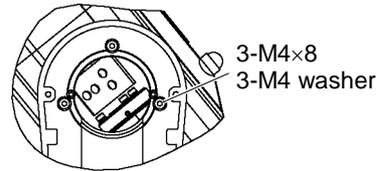


5. Apply grease (SK-1A) to the inside of flexspline.
Grease volume: 20 g

6. Mount the Joint #3 sleeve and the sleeve flange.
There are following two methods to fix the sleeve.

A: using the sleeve flange

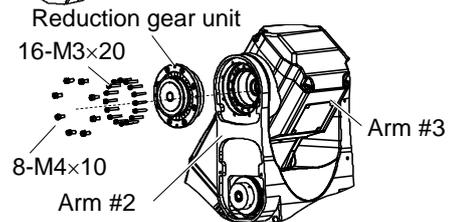
B: using screws



7. Join the Arm #3 and the Arm #2 and mount the Joint #3 reduction gear unit.

Bolt: 16-M3x20 Tightening torque: 3.0 N·m

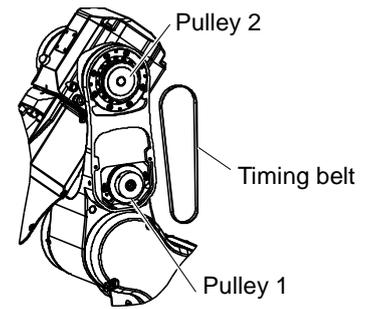
Bolt: 8-M4x10 Tightening torque: 5.0 N·m



8. Mount the cable unit.

For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*, Installation step (12) to (14).

9. Place the Joint #3 timing belt around the Joint #3 pulley 2 and pulley 1.
10. Apply tension to the Joint #3 motor unit to secure it.
For details, refer to *Maintenance: 7.1 Joint #3 – Replacing the Motor*, Installation step (8) to (11).
11. Mount the Arm #3 head cover and the Arm #4 cover.
For details, refer to *Maintenance:3.Covers*

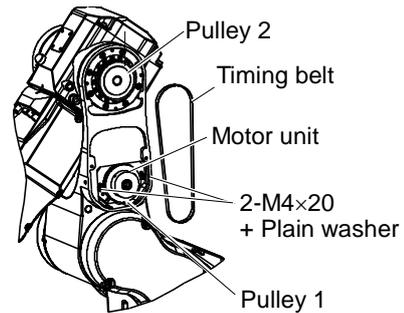


7.3 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance Part	Joint #3 Timing belt	1	R13B030222
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Cloth	1	For pressing arm
	Force gauge	1	For belt tension adjustment

Removal: Joint #3 Timing belt

1. Follow the *Maintenance: 7.1 Replacing the Motor*, Removal step (1) to (4).
2. Loosen the set screw of the Joint #3 motor unit.
3. Remove the Joint #3 timing belt.
First, remove the timing belt from pulley 1 and then from the pulley 2.



Installation: Joint #3 Timing belt

1. Place the Joint #3 timing belt around the Joint #3 pulley 1 and pulley 2.
Place the timing belt to pulley 2 first.
2. Secure the Joint #3 motor unit.
For details, refer to *Maintenance: 7.1 Replacing the Motor*, Installation step (9) to (12).

7.4 Replacing the Electromagnetic Brake

	Name	Quantity	Note
Maintenance Parts	Joint #3 electromagnetic brake	1	R13B030505
	Noise dissipative diode	1	R13B020301
Tools	Hexagonal wrench (width across flats: 2 mm)	1	For M4 set screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Cloth	1	For pressing arm
	Force gauge	1	For belt tension adjustment

Removal: Joint #3 electromagnetic brake

Remove the Joint #3 electromagnetic brake.

For details, refer to *Maintenance: 7.1 Replacing the Motor*, Removal step (1) to (9).

Installation: Joint #3 electromagnetic brake

Assemble the Joint #2 electromagnetic brake and mount the motor unit.

For details, refer to *Maintenance: 7.1 Replacing the Motor*, Installation step (3) to (11).

8. Arm #4

 WARNING	<ul style="list-style-type: none">■ Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system.■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. <p>Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.</p>
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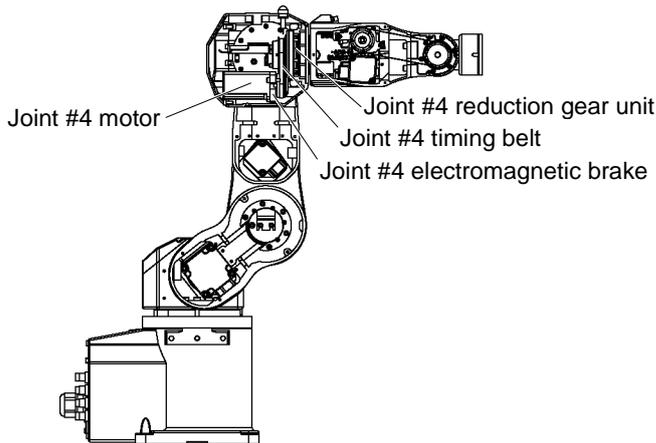
 CAUTION	<ul style="list-style-type: none">■ Be careful not to apply excessive shock to the motor shaft during replacement. The shock may shorten the life of the motors and encoder and/or damage them.■ Never disassemble the motor and the encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again.
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After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder 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 16. Calibration* and perform the calibration after the parts replacement.



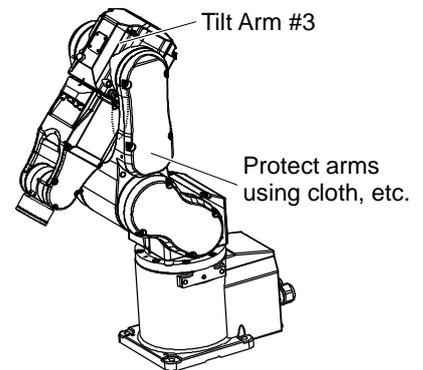
8.1 Replacing the Motor

	Name	Qty.	Note
Maintenance Parts	AC servo motor 50W	1	R13B000619
Tools	Hexagonal wrench (width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Flat blade screwdriver	1	For motor connector
	Force gauge	1	For belt tension adjustment

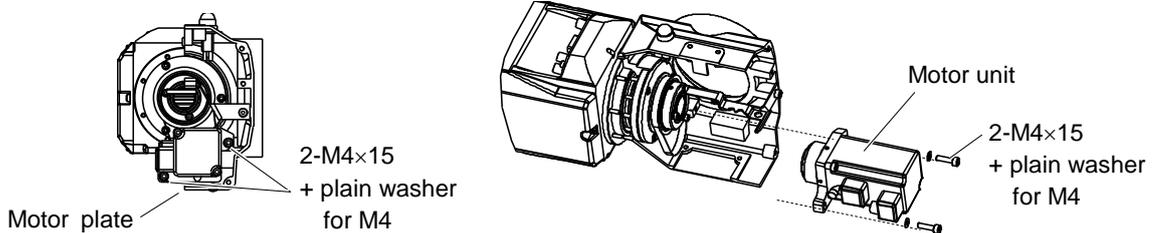
8.1.1 Joint #4 motor (without electromagnetic brake)

Removal: Joint #4 motor (without electromagnetic brake)

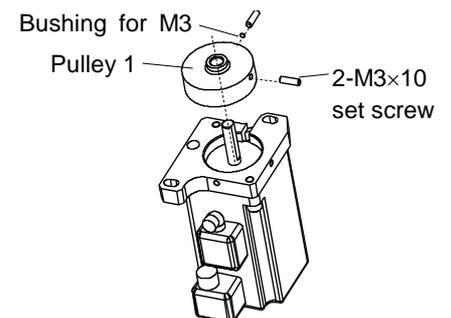
1. Turn OFF the controller.
2. Remove the Arm #3 head cover and the Arm #3 bottom cover.
For the details, refer to *Maintenance: 3. Covers*.
3. Remove the following connectors.
Connector: X141, X041 (Hold the claw to remove.)
Connector: BT4



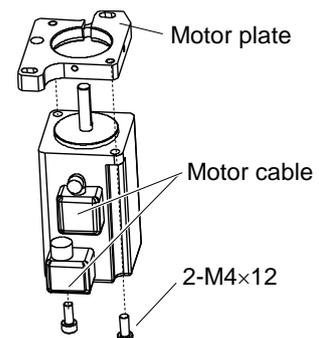
4. Remove the Joint #4 motor unit from the Arm #3.



5. Remove the Joint #4 pulley from the Joint #4 motor unit.
There is a brass bushing in one of the set screws fixing the pulley 1.
Be careful not to lose it.

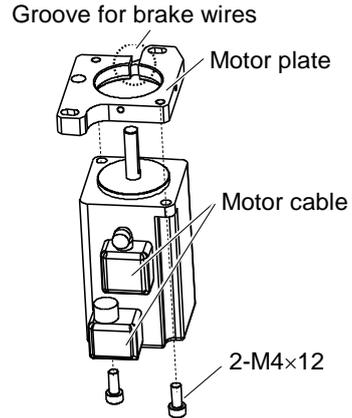


6. Remove the Joint #4 motor from the Joint #4 motor plate.
7. Remove the motor cable of the Joint #4 motor.

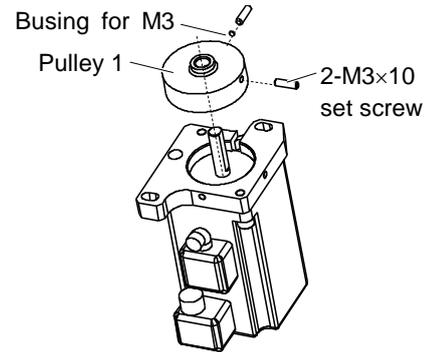
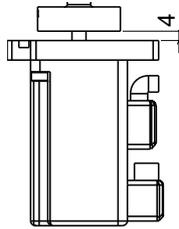


Installation: Joint #4 motor (without electromagnetic brake)

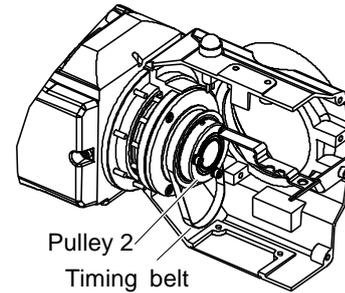
1. Connect the motor cable to the Joint #4 motor.
2. Mount the motor plate to the Joint #4 motor.
The groove of the motor plate should be in the opposite side to the motor cable.



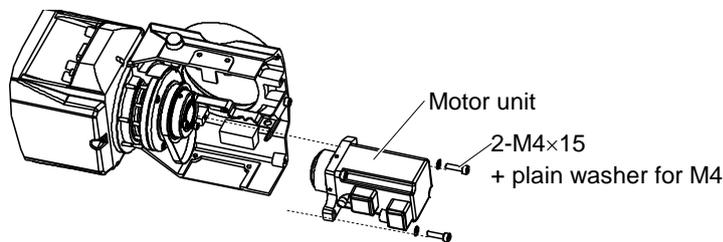
3. Mount the Joint #4 pulley 1 to the Joint #4 motor unit.
The space between the motor and the pulley is 4mm.



4. Place the Joint #4 timing belt around the Joint #4 pulley 2.

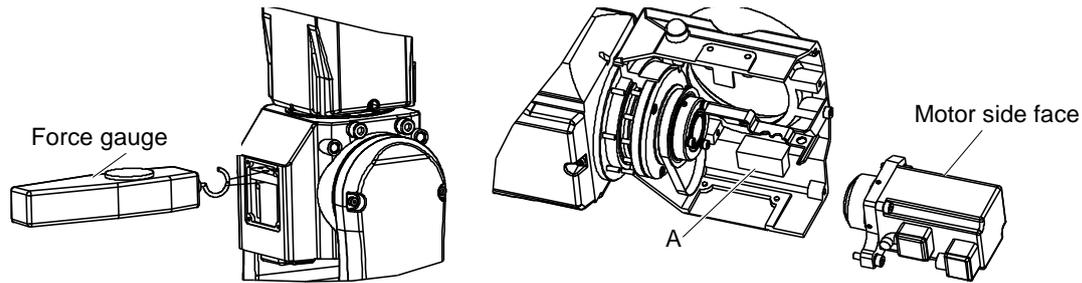


5. Pass the Joint #4 motor unit through the Joint #4 timing belt and loosely secure it to the Arm #3.
Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.
When securing the motor unit loosely, make sure that the motor unit can be moved by hand, and it does not tilt when being pulled. If the unit is secured too loose or too tight, the belt will not have the proper tension.



6. Apply proper tension to the timing belt, and then secure the Joint #4 motor unit.
Turn ON the controller and move the Arm #3 to the position where you can apply tension easily.
Turn OFF the controller.
Pass a suitable cord or string (insulation lock) around the motor plate drilled hole. Then, pull the cord using a force gauge or a similar tool to apply specified tension.
At this point, press the motor cable fixing side and the other side to the “A” surface of the Arm #3 and apply tension to secure the motor unit.

Joint #4 timing belt tension = $39.2N \pm 9.8N$



7. Connect the following
Connectors: X141, X041, BT4.
8. Mount the Arm #3 head cover and Arm #3 bottom cover.
For details, refer to *Maintenance: 3. Covers*.
9. Perform the calibration for Joint #4.
For details, refer to *Maintenance: 16. Calibration*.

8.1.2 Joint #4 motor (with electromagnetic brake)

Removal: Joint #4 motor (with electromagnetic brake)

1. Remove the Joint #4 motor unit.

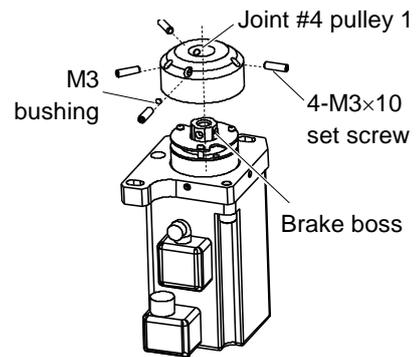
For details, refer to *Maintenance: 8.1.1 Joint #4 motor (without electromagnetic brake)*, Removal step (1) to (4).

2. Remove the connector BR041.

3. Remove the Joint #4 pulley 1 and the brake boss from the Joint #4 motor unit.

There is a brass bushing in one of the set screws fixing the brake boss.

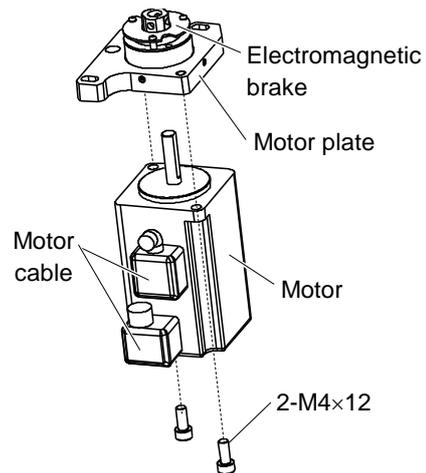
Be careful not to lose it.



4. Remove the motor plate from the Joint #4 motor.

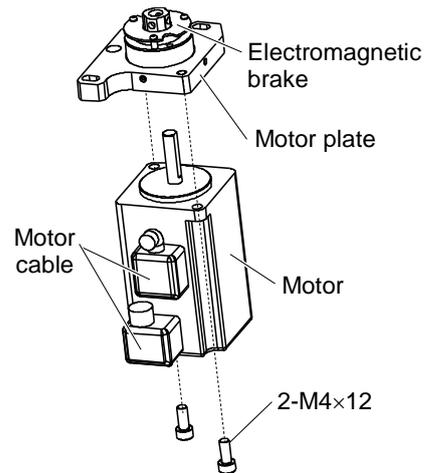
Be careful of the electromagnetic brake on the motor plate.

5. Remove the motor cable from the Joint #4 motor.

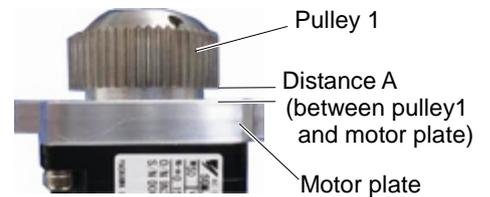


Installation: Joint #4 motor (with electromagnetic brake)

1. Mount the motor cable to the Joint #4 motor.
2. Mount the motor plate to the Joint #4 motor.
Be careful of the direction of motor plate installation.
(See the figure on right side.)



3. Mount the driving boss to the pulley 1, and mount the brake boss and pulley 1 to the Joint #4 motor unit.
Press the pulley 1 to the very end and measure the Distance A (between the pulley 1 and motor plate).



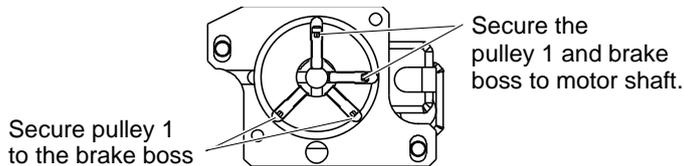
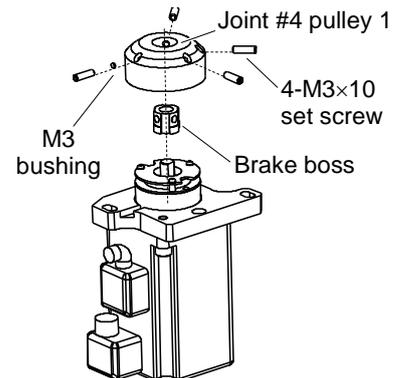
If the Distance A is less than 2.5 mm:

Secure the pulley with the Distance A of 2.5 mm.

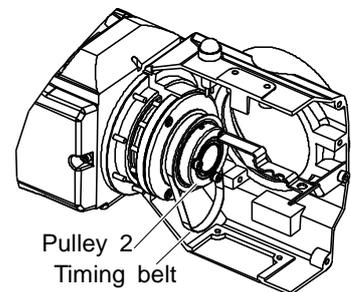
If the Distance A is more than 2.5 mm:

Secure the pulley after putting more 0.5 mm space from the position you measured the Distance A.

See the figure for the position of set screws.



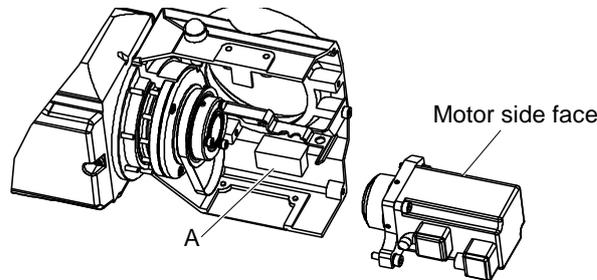
4. Place the Joint #4 timing belt around the Joint #4 pulley 2.



5. Pass the pulley 1 of the Joint #4 motor unit through the Joint #4 timing belt and loosely secure it to the Arm #3.

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

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



6. Apply proper tension to the Joint #4 motor unit, and then secure the unit by pressing to the motor side face and “A” surface.

Pass a suitable cord or string (insulation lock) around the motor plate drilled hole. Then, pull the cord using a force gauge or a similar tool to apply specified tension.

Belt tension: $39.2\text{N} \pm 9.8\text{N}$ ($4\text{ kgf} \pm 1\text{ kgf}$)

7. Connect the following connectors.

Connector : X141, X041, BT4, BR041

8. Mount the Arm #3 head cover and the Arm #3 bottom cover.

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

9. Perform the calibration.

For details, refer to *Maintenance: 16. Calibration*.

8.2 Replacing the Reduction Gear Unit

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder 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 16. Calibration* and perform the calibration after the parts replacement.

8.2.1 Structure of the Reduction Gear Unit

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

For details on the reduction gear unit, refer to *Maintenance: 17. Maintenance Parts List*.

It is recommended replacing the O-ring (for Joint #4) together when replacing the reduction gear unit.

8.2.2 How to Grease the Reduction Gear Unit



- Wear protective gear including a mask, protective goggles, and oil-resistant gloves during grease up. If grease gets into your eyes, mouth, or on your skin, follow the instructions below.

If grease gets into your eyes : Flush them thoroughly with clean water, and then see a doctor immediately.

If grease gets into your mouth : If swallowed, do not induce vomiting. See a doctor immediately.

If grease just gets into your mouth, wash out your mouth with water thoroughly.

If grease gets on your skin : Wash the area thoroughly with soap and water.

When greasing the reduction gear unit, use only specified grease for the reduction gear unit.

While greasing the reduction gear unit, be careful not to allow any foreign substances in grease.

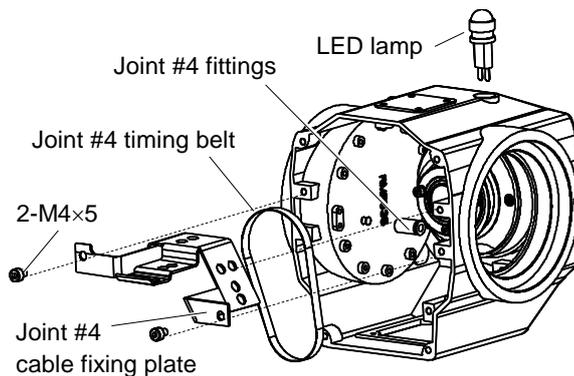
8.2.3 How to Replace the Reduction Gear Unit

	Name	Quantity	Note
Maintenance Parts	Joint #4 reduction gear unit	1	R13B010023
	O-ring	1	R13B031244
Tools	Hexagonal wrench (width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment
	Sharpening stone	1	For repairing removal tap
	Wiping cloth	1	For wiping liquid gasket For wiping adhesive
Grease	SK-1A	-	

Removal: Joint #4 reduction gear unit

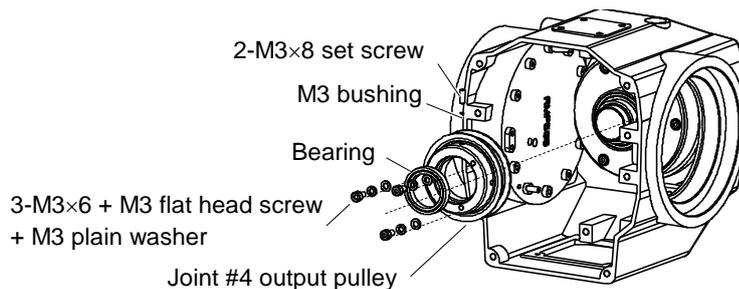
- Remove the Joint #4 motor unit from the Arm #3.
For details, refer to *Maintenance: 8.1.1 Joint #4 motor (without electromagnetic brake)*, Removal step (2) to (4).
(The removal step of the Joint #4 motor unit is common to the model that has brakes on all axes.)

- Remove the cable unit.
- Remove the Joint #4 cable fixing plate.
(2-M4×5)



- Remove the Joint #4 timing belt.
- Remove the Joint #4 fittings.
- Remove the LED lamp.

- Remove the Joint #4 output pulley. (2-M3×8 set screw, with bushing.)
When removing the Joint #4 output pulley, also remove the bearing.
(3-M3×6 + flat head screw for M3 + washer for M3)
Be careful not to lose the bearing which is necessary in later procedure.
There is a brass bushing in one of the set screws. Be careful not to lose it.

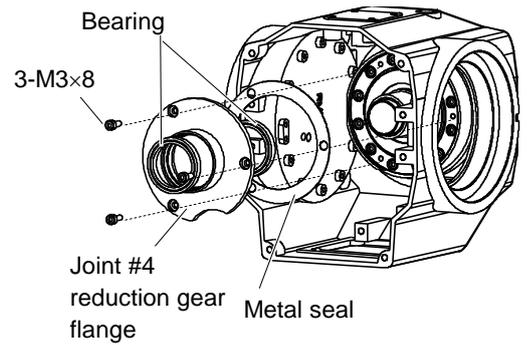


8. Remove the Joint #4 reduction gear unit's flange.
(3-M3×8)

When removing the flange, remove the two bearings and the metal seal together.

Be careful not to lose the metal seal which is necessary in later procedures.

When removing the parts, grease is attached to the Joint #4 reduction gear unit's flange, etc. Wipe grease during the replacement.



9. Remove the wave generator from the Joint #4 reduction gear unit.

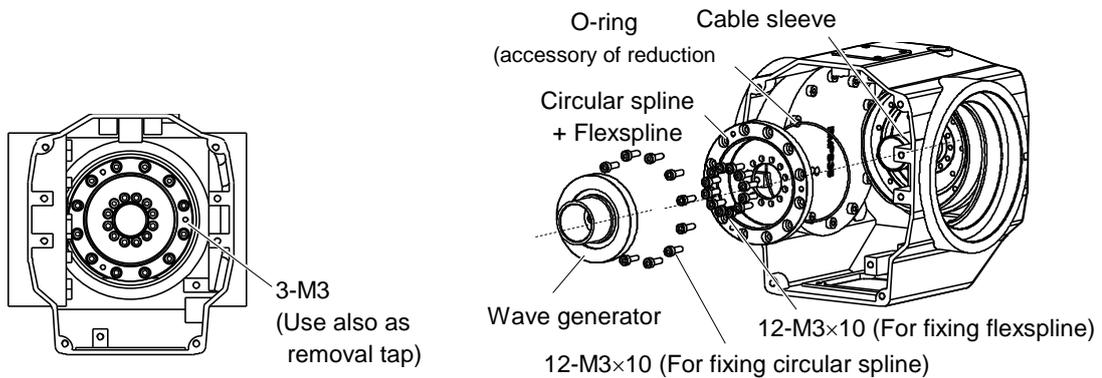
10. Remove the circular spline. (12-M3×10, removal tap 3-M3)

If you have any cracks while using the removal taps, repair them using a sharpening stone.

11. Remove the flexspline. (12-M3×10)

12. Remove the O-ring.

13. Wipe grease using a cloth if it is attached to the Arm #4, etc.



Installation: Joint #4 reduction gear unit

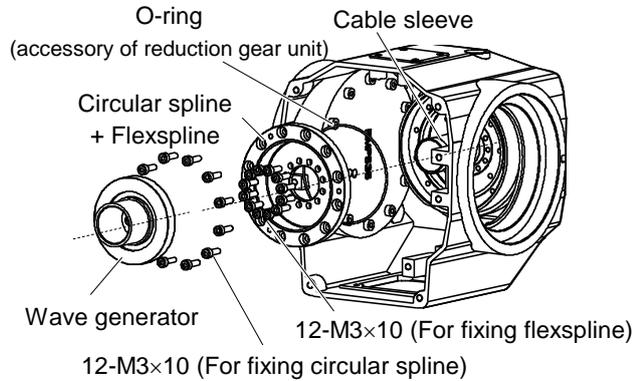
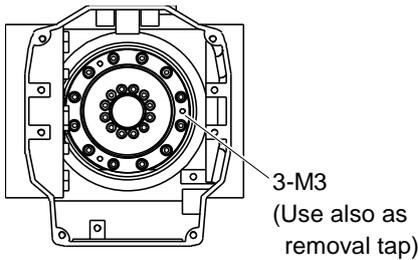
NOTE



When tightening the bolts, please double-check that the every bolt is surely tightened.

1. Apply grease (SK-1A) to the following points:
 - Both sides of the gears of the flexspline and the circular spline
 - Wave generator (to the level that it covers the ball bearing.)
2. Mount the O-ring to the Arm #4.
3. Turn the face of the circular spline (stamp) to the front and mount it to the Arm #4.
 12-M3×10 Tightening torque: 2.5 N·m
 Be careful of the mounting angle of the M3 screw holes which affect the mounting angle of the Joint #4 reduction gear unit flange. (See the figure below.)

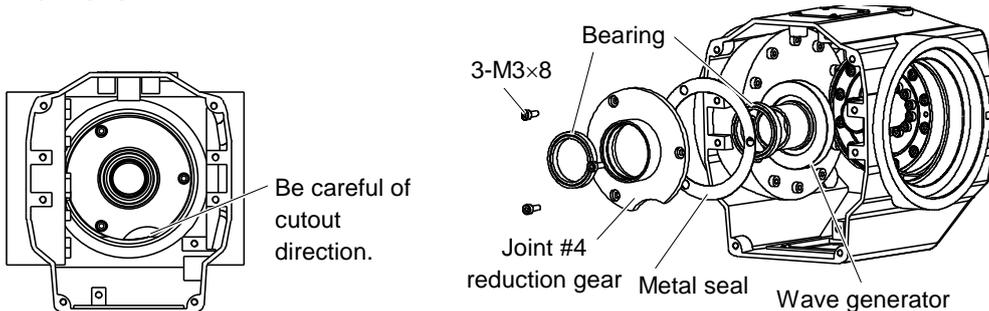
4. Mount the flexspline. (12-M3×10).
 Tightening torque: 3.0 N·m
 Make sure that the cable sleeve is attached while mounting the flexspline for the centering.



5. Apply grease to the inside of the flexspline (SK-1A).
 Grease volume: 10 g

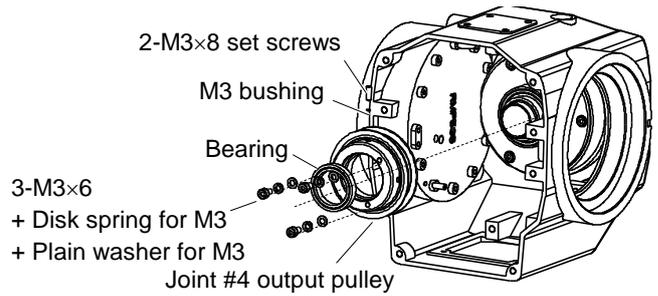


6. Mount the bearing to the wave generator and mount it to the flexspline.
7. Mount the metal seal.
8. Mount the bearing to the Joint #4 reduction gear unit's flange and loosely secure it to the circular spline.
 Be careful of the direction of the cutout in the Joint #4 reduction gear flange.
 Screw: 3-M3×8



9. Mount the Joint #4 output pulley.
Set screw: 2-M3×8 with bushing

10. Mount the bearing.
Screw: 3-M3×6
+ Disk spring for M3 + Plain washer for M3



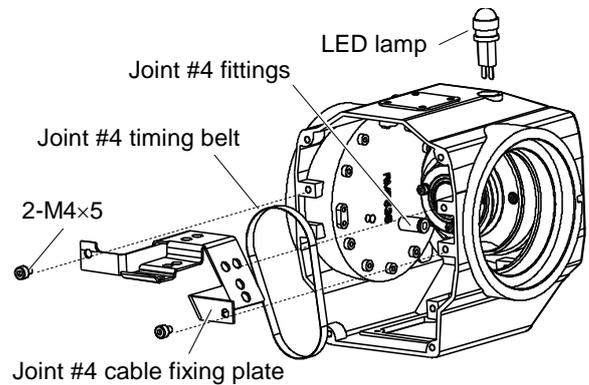
11. Tighten three set screws of the Joint #4 reduction gear unit's flange.

12. Mount the Joint #3 reduction gear unit.

For details, refer to *Maintenance: 7.2 Joint #3 - Replacing the Reduction Gear Unit*, Installation step (6) to (10).

13. Mount the LED lamp.

14. Mount the Joint #4 fittings.



15. Mount the Joint #4 motor unit.

Without electromagnetic brake:

For details, refer to *Maintenance: 8.1.1 Joint #4 motor (without electromagnetic brake)*, Installation step (4) to (8).

For the model with brakes on all axes:

For details, refer to *Maintenance: 8.1.2 Joint #4 motor (with electromagnetic brake)*, Installation step (4) to (8).

16. Perform the calibration for the Joint #4.

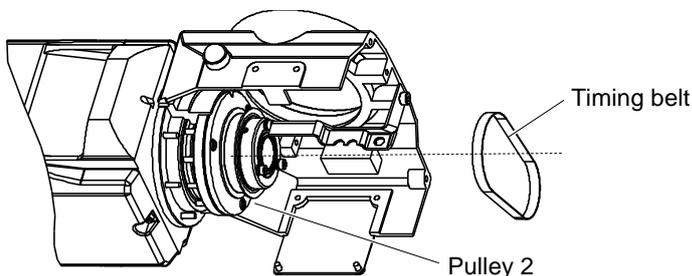
For details, refer to *Maintenance: 16. Calibration*.

8.3 Replacing the Timing Belt

	Name	Quantity	Note
Maintenance Part	Joint #4 Timing belt	1	R13B030223
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 set screw
	Force gauge	1	For belt tension adjustment

Removal: Joint #4 Timing belt

1. Remove the Joint #4 motor unit.
For details, refer to *Maintenance 8.1.1 Joint #4 motor (without electromagnetic brake)*, Removal step (1) to (4).
2. Remove the Joint #4 timing belt.



Installation: Joint #4 Timing belt

1. Place the Joint #4 timing belt around the Joint #4 pulley 2.
2. Mount the Joint #4 motor unit.
For details, refer to *Maintenance 8.1.1 Joint #4 motor (without electromagnetic brake)*, Installation step (5) to (9).

8.4 Replacing the Electromagnetic Brake

	Name	Quantity	Note
Maintenance Parts	Joint #4 Electromagnetic brake	1	R13B030506
Tools	Hexagonal wrench (width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment

Removal: Joint #4 Electromagnetic brake

- Follow the steps in *Maintenance 8.1.2 Joint #4 motor (with electromagnetic brake)*, Removal step (1) to (2).
- Remove the Joint #4 electromagnetic brake from the Joint #4 motor unit.

Installation: Joint #4 Electromagnetic brake

- Mount the Joint #4 electromagnetic brake to the Joint #4 motor unit.

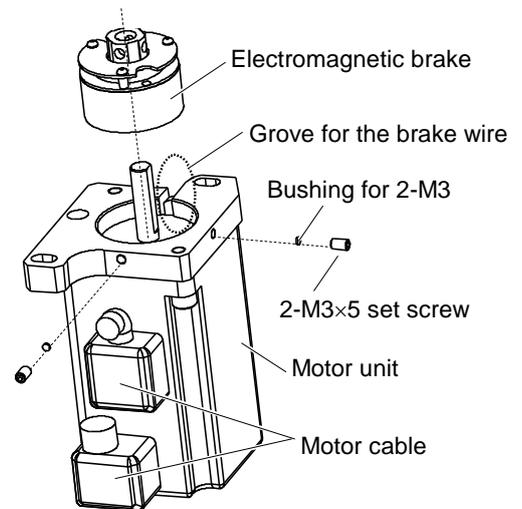
Align the positions of the electromagnetic brake wire and the groove on the motor plate.

Then, press the electromagnetic brake to the very end and secure it.

Tightening torque M3: 0.7 N·m

- Assemble the motor unit and mount it.

For details, refer to *Maintenance 8.1.2 Joint #4 motor (with electromagnetic brake)*, Installation step (3) to (9).



9. Arm #5

 WARNING	<ul style="list-style-type: none"> ■ Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system. ■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.
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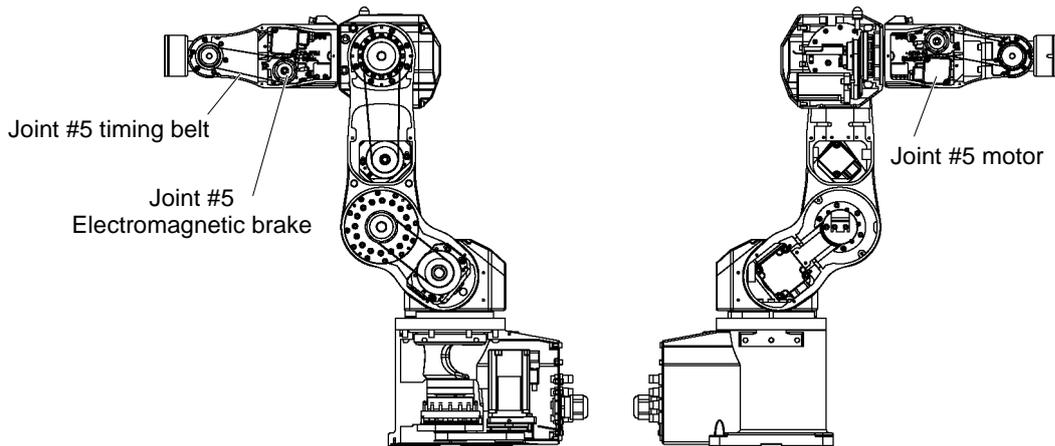
 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement. The shock may shorten the life of the motors and encoder and/or damage them. ■ Never disassemble the motor and the encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again.
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After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder 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 16. Calibration* and perform the calibration after the parts replacement.



9.1 Replacing the Motor

	Name	Quantity	Note
Maintenance Part	AC servo motor 50 W	1	R13B000620
Tools	Hexagonal wrench (width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Cross-point screwdriver	1	For motor connector
	Force gauge	1	For belt tension adjustment

The brake is mounted on the Joint #5 to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. However, the brake does not work during replacement.

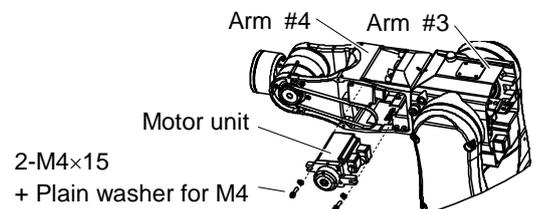
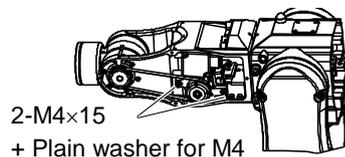
The following is steps of the motor replacement. Use the original motor cables (power cable, signal cable).

When replacing the motor cables, pull the cables out from the Arm #3 cylinder.

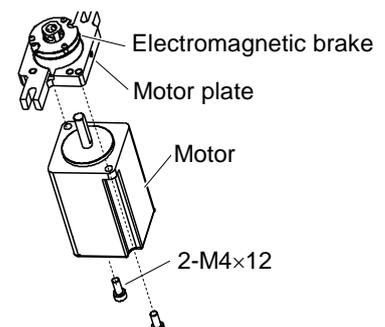
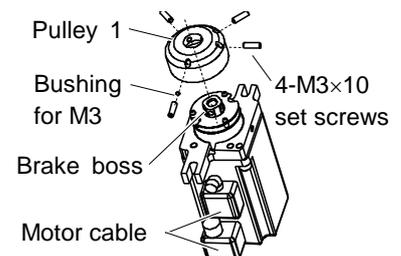
For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*.

Removal: Joint #5 motor

1. Turn ON the controller.
2. Remove the Arm #4 side cover.
For details, refer to *Maintenance: 3. Covers*.
3. Remove the Joint #5 motor unit from the Arm #4.

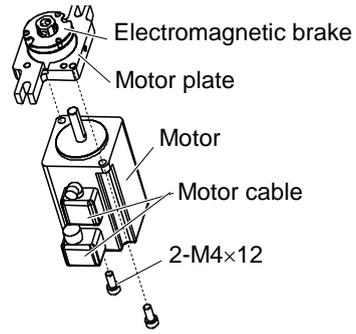


4. Remove the motor cable from the Joint #5 motor.
Keep the brake cable connected.
5. Remove the Joint #5 pulley 1 and the brake boss from the Joint #5 motor unit.
There is a brass bushing in one of the set screws fixing the pulley 1 and the motor shaft.
Be careful not to lose it.
6. Remove the motor plate from the Joint #5 motor.
Be careful of the electromagnetic brake on the motor plate.

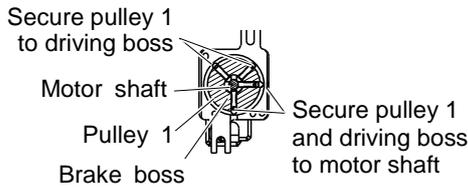
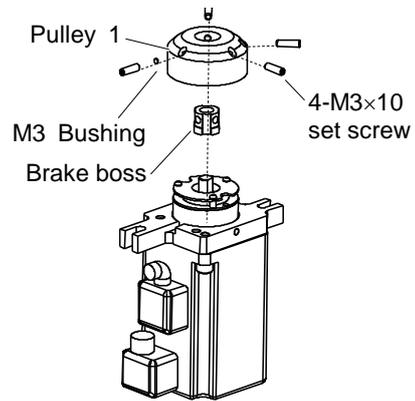
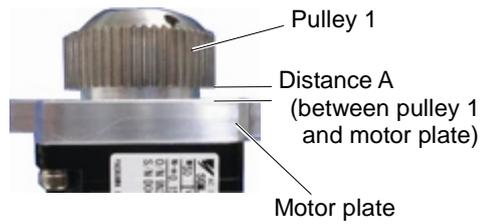


Installation: Joint #5 motor

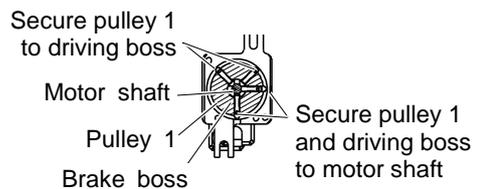
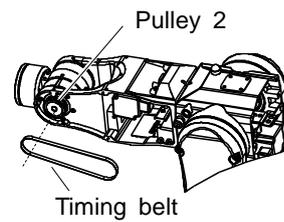
1. Mount the motor cable to the Joint #5 motor.
2. Mount the motor plate to the Joint #5 motor.
Be careful of the direction of the motor plate.



3. Mount the brake boss to the pulley 1, and mount the boss and pulley 1 to the Joint #5 motor shaft.
Press the pulley 1 to the very end and measure the Distance A (between the pulley 1 and motor plate).
If the Distance A is less than 2.5 mm:
 Secure the pulley with the Distance A of 2.5 mm.
If the Distance A is more than 2.5 mm:
 Secure the pulley after putting more 0.5 mm space from the position you measured the Distance A.
See the figure for the position of set screws.

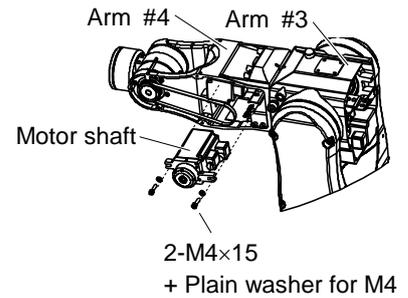


4. Insert the Joint #5 motor into the Arm #4.
Be careful not to scratch or catch the cable.
5. Place the Joint #5 timing belt around the Joint #5 pulley 2.



6. Pass the pulley 1 of the Joint #5 motor unit to the Joint #5 timing belt and loosely secure it to the Arm #4.
Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.

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

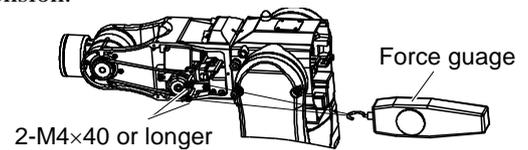


7. Apply proper tension to the Joint #5 motor unit to secure it.
Mount screws of M4x40 or longer (recommended) to the motor plate.

Pass a suitable cord or string (insulation lock) to the screw. Then, pull the cord using a force gauge or a similar tool to apply specified tension.

Joint #5 timing belt tension: $39.2 \text{ N} \pm 9.8 \text{ N}$ (4 kgf \pm 1 kgf)

Make sure to remove the screws mounted for applying tension.



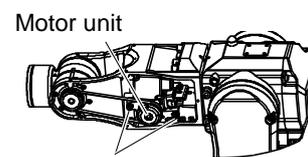
8. Mount the Arm #4 side cover.
For details, refer to *Maintenance: 3. Covers*.
9. Perform the calibration.
For details, refer to *Maintenance: 16. Calibration*.

9.2 Replacing the Timing Belt

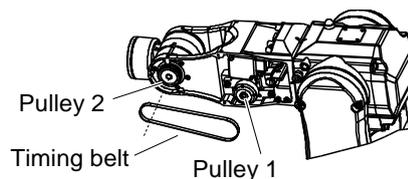
	Name	Quantity	Note
Maintenance Part	Joint #5 Timing belt	1	R13B030224
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment

Removal: Joint #5 Timing belt

1. Turn ON the controller.
2. Remove the Arm #4 side cover.
For details, refer to *Maintenance: 3. Covers*.
3. Loosen the set screws of the Joint #5 motor unit.



4. Remove the Joint #5 timing belt.



Installation Joint #5 Timing belt

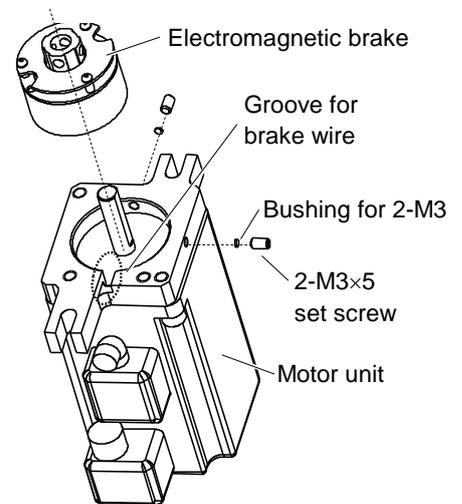
1. Place the Joint #5 timing belt around the Joint #5 pulley 1 and pulley 2.
2. Secure the Joint #5 motor unit.
For details, refer to *Maintenance: 9.1 Joint #5 – Replacing the Motor*, Installation step (6) to (10).

9.3 Replacing the Electromagnetic Brake

	Name	Quantity	Note
Maintenance Parts	Joint #5 electromagnetic brake	1	R13B030506
Tools	Hexagonal wrench (width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment

Removal: Joint #5 electromagnetic brake

1. Follow the *Maintenance: 9.1 Joint #5 – Replacing the Motor*, Removal step (1) to (6).
2. Remove the Joint #5 electromagnetic brake from the Joint #5 motor unit.



Installation: Joint #5 electromagnetic brake

1. Mount the Joint #5 electromagnetic brake to the Joint #5 motor unit.
Align the wire of electromagnetic brake and the groove on the motor plate.
Press the electromagnetic brake into the very end and secure it.
Tightening torque M3: 0.7 N·m
2. Assemble and mount the motor unit.
For details, refer to *Maintenance: 9.1 Joint #5 – Replacing the Motor*, Installation step (3) to (10).

10. Arm #6

 WARNING	<ul style="list-style-type: none"> ■ Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system. ■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.
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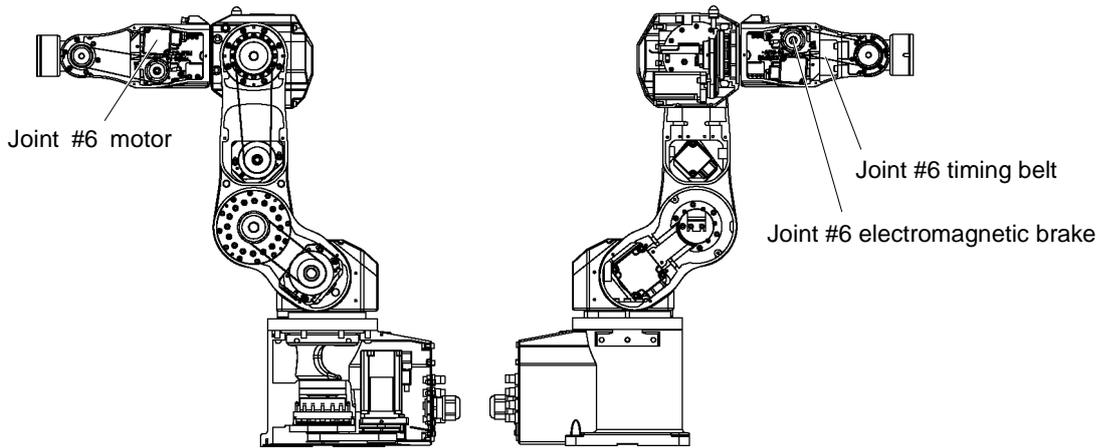
 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement. The shock may shorten the life of the motors and encoder and/or damage them. ■ Never disassemble the motor and the encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again.
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After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder 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 16. Calibration* and perform the calibration after the parts replacement.



10.1 Replacing the Motor

Maintenance Part and Tools

	Name	Quantity	Note
Maintenance Part	AC servo motor 50 W	1	R13B000620
Tools	Hexagonal wrench (width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Cross-point screwdriver	1	For motor connector
	Force gauge	1	For belt tension adjustment

The brake is mounted on the Joint #6 to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. However, the brake does not work during replacement.

The following is steps of the motor replacement. Use the original motor cables (power cable, signal cable).

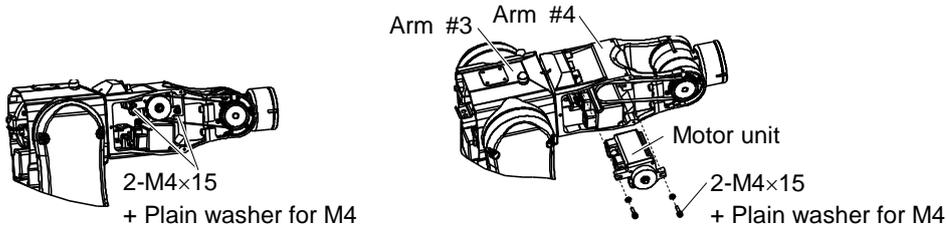
When replacing the motor cables, pull the cables out from the Arm #3 cylinder.

For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*.

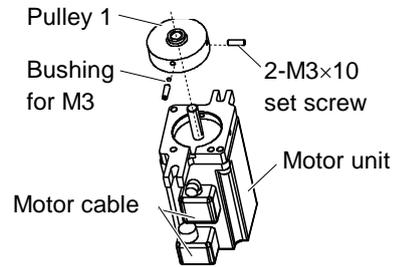
10.1.1 Joint #6 motor (without electromagnetic brake)

Removal: Joint #6 motor (without electromagnetic brake)

1. Turn OFF the controller.
2. Remove the Arm #4 side cover.
For the details, refer to *Maintenance: 3. Covers*.
3. Remove the Joint #6 motor unit from Arm #4.

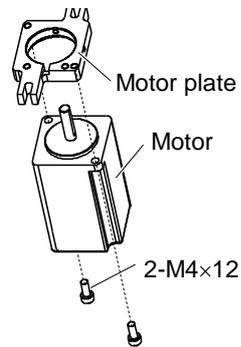


4. Remove the motor cable from the Joint #5 motor.
Keep the brake cable connected.



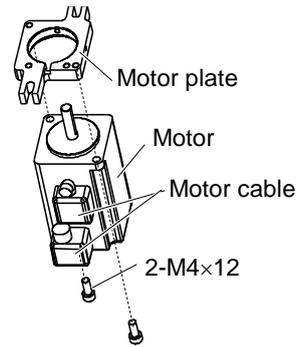
5. Remove the pulley 1 of the Joint #6 from the Joint #6 motor unit.

6. Remove the motor plate from the Joint #6 motor.

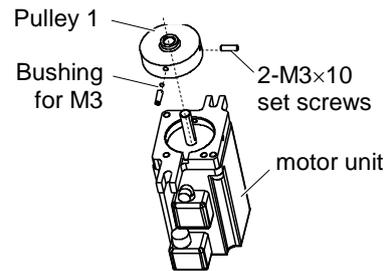
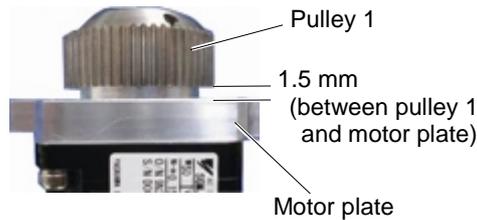


Installation: Joint #6 motor (without electromagnetic brake)

1. Connect the motor cable to the Joint #6 motor.
2. Mount the motor plate to the Joint #6 motor.
Be careful of the direction of motor plate. (See figure on the right side.)

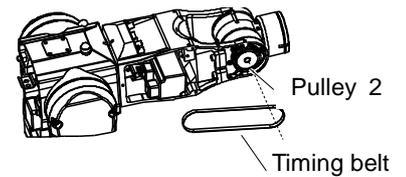


3. Mount the pulley 1 to the Joint #6 motor unit.

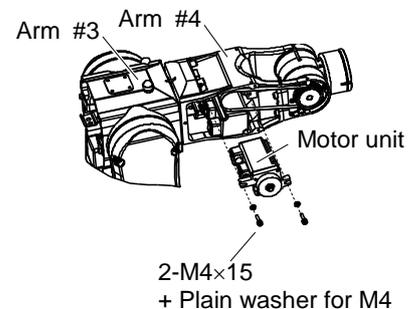


4. Insert the Joint #6 motor unit to the Arm #4. Be careful not to scratch or catch cables.

5. Place the Joint #6 timing belt around the Joint #6 pulley 2.



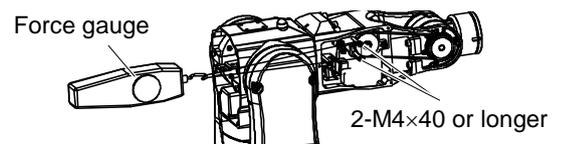
6. Pass the pulley 1 of the Joint #6 motor unit through the Joint #6 timing belt and loosely secure it to the Arm #4.
Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.
When securing the motor unit loosely, make sure that the motor unit can be moved by hand, and it does not tilt when being pulled.
If the unit is secured too loose or too tight, the belt will not have proper tension.



7. Apply proper tension to the Joint #6 motor unit to secure it.
Mount screws of M4x40 or longer (recommended) to the motor plate.

Pass a suitable cord or string (insulation lock) around the screw. Then, pull the cord using a force gauge or a similar tool to apply specified tension.

Joint #6 timing belt tension
= 39.2 N ± 9.8 N (4 kgf ± 1 kgf)



8. Mount the Arm #4 side cover.
For details, refer to *Maintenance: 3. Covers.*
9. Perform the calibration.
For details, refer to *Maintenance: 16. Calibration.*

10.1.2 Joint #6 motor (with electromagnetic brake)

Removal: Joint #6 motor (with electromagnetic brake)

1. Remove the Joint #6 motor unit.

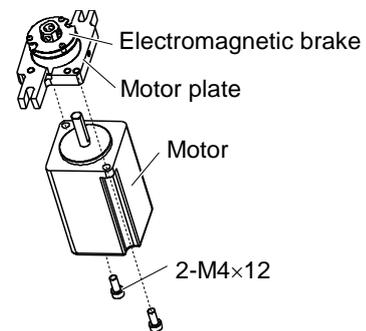
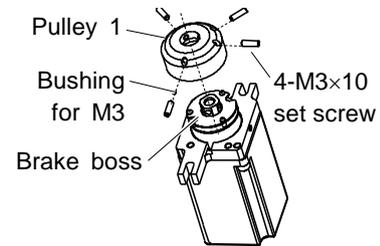
For details, refer to *Maintenance: 10.1.1 Joint #6 motor (without electromagnetic brake)*, Removal step (1) to (4).

2. Remove the Joint #6 pulley 1 and the brake boss from the Joint #6 motor unit.

There is a brass bushing in one of the set screws fixing the pulley 1 and the motor shaft.

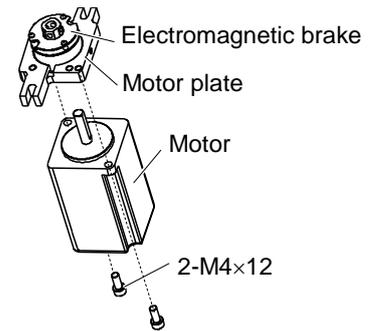
Be careful not to lose it.

3. Remove the motor plate from the Joint #6 motor.
4. Remove the motor cable from the Joint #6 motor.

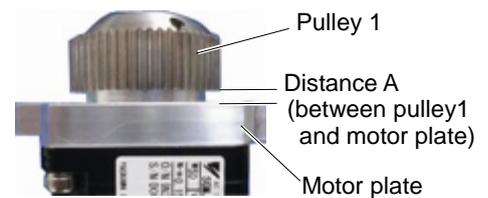


Installation: Joint #6 motor (with electromagnetic brake)

1. Mount the motor cable to the Joint #6 motor.
2. Mount the motor plate to the Joint #6 motor.
Be careful of the direction of the motor plate.
(See the figure on the right side.)



3. Mount the brake boss to the pulley 1, and mount the brake boss and pulley 1 to the Joint #6 motor shaft.
Press the pulley 1 to the very end and measure the Distance A (between the pulley 1 and the motor plate).



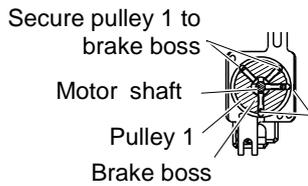
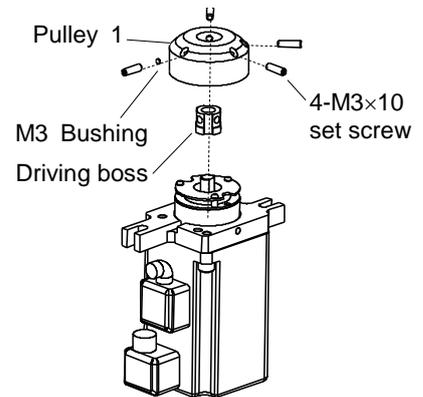
If the Distance A is less than 2.5 mm:

Secure the pulley with the Distance A of 2.5 mm.

If the Distance A is more than 2.5 mm:

Secure the pulley after putting more 0.5 mm space from the position you measured the Distance A.

See the figure for the position of set screws.



Secure pulley 1 and brake boss to the motor shaft

4. Assemble and mount the Joint #6 motor unit.

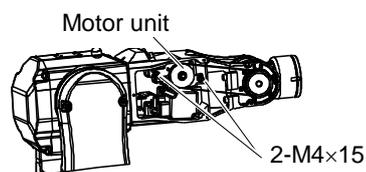
For details, refer to *Maintenance: 10.1.1 Joint #6 motor (without electromagnetic brake)*, Installation step (4) to (10).

10.2 Replacing the Timing Belt

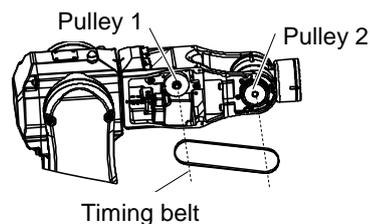
	Name	Quantity	Note
Maintenance Part	Joint #6 timing belt	1	R13B030225
Tools	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench(width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment

Removal: Joint #6 timing belt

1. Turn OFF the controller.
2. Remove the Arm #4 side cover.
For details, refer to *Maintenance: 3. Covers*.
3. Loosen the set screws of the Joint #6 motor unit.



4. Remove the Joint #4 timing belt.



Installation: Joint #6 timing belt

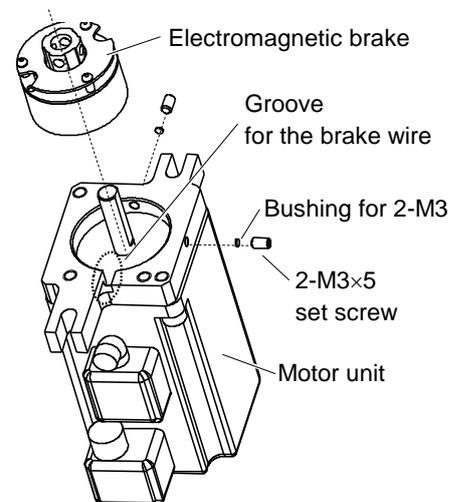
1. Place the Joint #6 timing belt around the Joint #6 pulley 1 and pulley 2.
2. Secure the Joint #6 motor unit.
For details, refer to *Maintenance 10.1.1 Joint #6 motor (without electromagnetic brake)*, Installation step (6) to (10).

10.3 Replacing the Electromagnetic Brake

	Name	Quantity	Note
Maintenance Part	Joint #6 Electromagnetic brake	1	R13B030506
Tools	Hexagonal wrench (width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment

Removal: Joint #6 Electromagnetic brake

- Follow the steps in *Maintenance 10.1.2 Joint #6 motor (with electromagnetic brake)*, Removal step (1) to (2).
- Remove the Joint #6 electromagnetic brake from the Joint #6 motor unit.



Installation: Joint #6 Electromagnetic brake

- Mount the Joint #6 electromagnetic brake to the Joint #6 motor unit.
Align the positions of the electromagnetic brake wire and the groove on the motor plate. Then, secure the electromagnetic brake.
Press the electromagnetic brake into the very end and secure it.
Tightening torque M3: 0.7 N·m
- Assemble the motor unit and mount it.
For details, refer to *Maintenance 10.1.2 Joint #6 motor (with electromagnetic brake)*, Installation step (3) to (4).

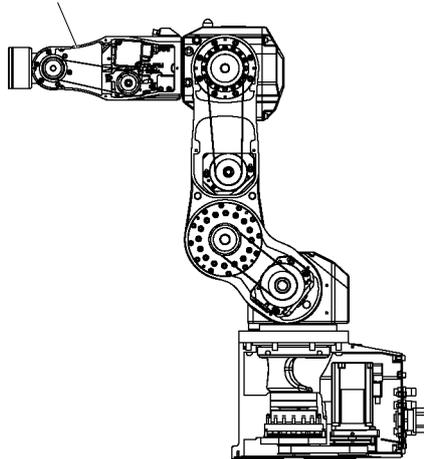
11. Replacing the Joint #5 and #6 Unit

 WARNING	<ul style="list-style-type: none"> ■ Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system. ■ To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement. The shock may shorten the life of the motors and encoder and/or damage them. ■ Never disassemble the motor and the encoder. Disassembled motor and encoder will cause a positional gap and cannot be used again.
--	--

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a mismatch exists between the origin stored in each motor encoder 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 16. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

Joint #5 and #6 Unit

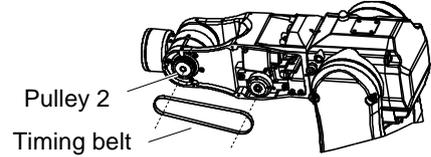


	Name	Quantity	Note
Maintenance Parts	Joint #5 and #6 Unit	1	R13B080202
	O-ring (Arm #3 - #4)	1	R13B031245
Tools	Hexagonal wrench (Width across flats: 1.5 mm)	1	For M3 set screw
	Hexagonal wrench (Width across flats: 2.5 mm)	1	For M3 screw
	Hexagonal wrench (Width across flats: 3 mm)	1	For M4 screw
	Force gauge	1	For belt tension adjustment

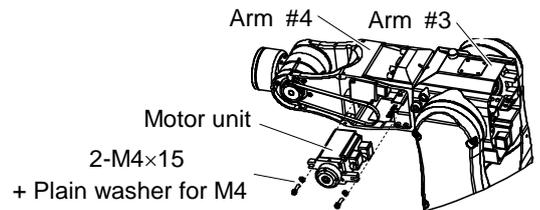
Removal: Joint #5 and #6 Unit

1. Turn OFF the controller.
2. Remove the Arm #3 head cover and the Arm #4 side cover.
For the details, refer to *Maintenance: 3. Covers*.

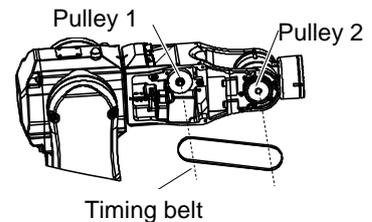
3. Remove the Joint #5 timing belt.



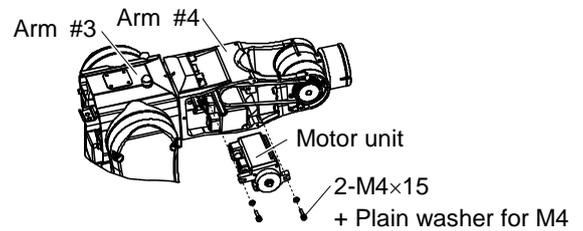
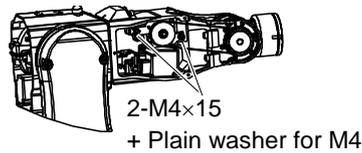
4. Remove the Joint #5 motor unit.



5. Remove the Joint #6 timing belt.



6. Remove the Joint #6 motor unit.



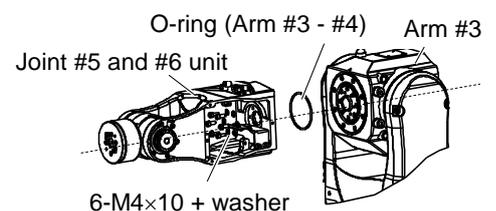
7. Remove the following connectors. Open the Arm #3 head cover to get the connectors.
Connector: X151, X051, X161, X061 (Hold claws to remove.)
Connector: BT5, BT6
Connector: BR051, BR061 (Optional when all axes have brakes.)

8. Disconnect cables and tubes from the user plate.
For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*.

9. Pull out the brake cables and motor cables of the Joint #5 and #6 from the Arm #3 cylinder.
For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*.

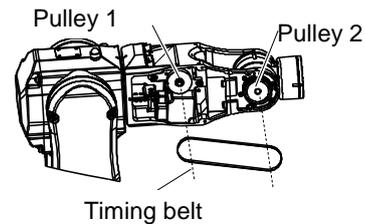
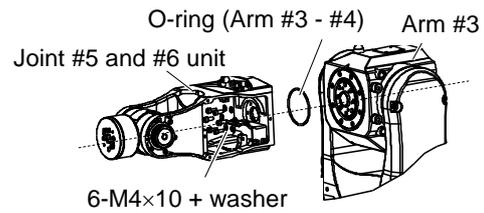
10. Remove the Joint #5 and #6 unit from the Arm #3.

11. Remove the O-ring (Arm #3 - #4).

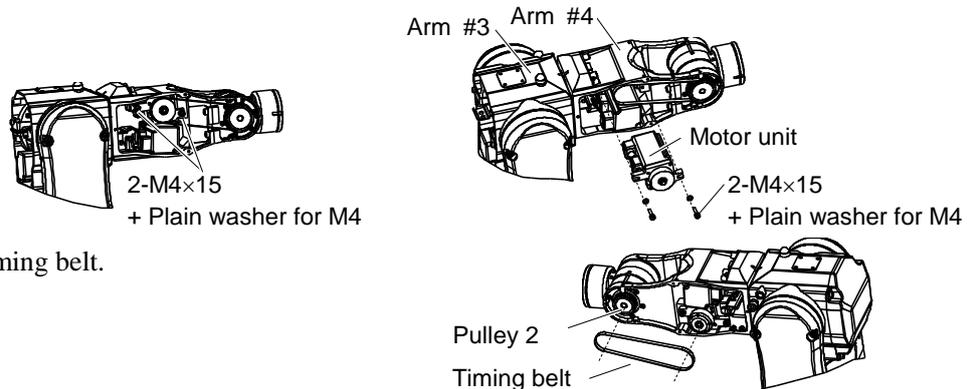


Installation: Joint #5 and #6 Unit

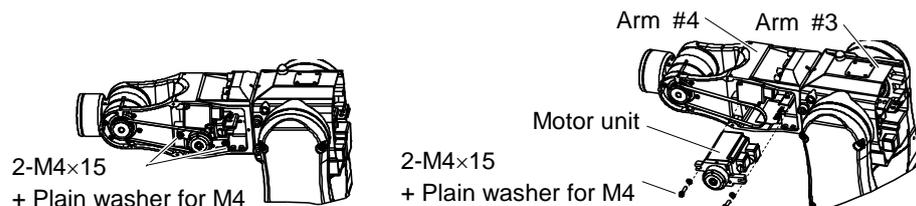
1. Mount the O-ring (Arm #3 - #4).
When replacing the Joint #5 and #6 unit, replace the O-ring as well.
2. Mount the Joint #5 and #6 unit to the Arm #3.
Put the cables through the spring.
3. Place the Joint #6 timing belt around the Joint #6 pulley 2.



4. Pass the pulley 1 of the Joint #6 motor unit through the Joint #6 timing belt and loosely secure it to the Arm #4.
Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.
When securing the motor unit loosely, make sure that the motor unit can be moved by hand, and it does not tilt when being pulled. If the unit is secured too loose or too tight, the belt will not have proper tension.



5. Mount the Joint #5 timing belt.
6. Pass the pulley 1 of the Joint #5 motor unit through the Joint #5 timing belt and loosely secure it to the Arm #4.
Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.
When securing the motor unit loosely, make sure that the motor unit can be moved by hand, and it does not tilt when being pulled. If the unit is secured too loose or too tight, the belt will not have proper tension.



7. Pass the brake cables of the Joint #5 and #6 through the Arm #3.
For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*.

8. Connect the following connectors.

Connector: X151, X051, BT5, X161, X061, BT6

Connector: BR051, BR061 (Optional when all axes have brakes.)

9. Connect the wires and tubes to the user plate.

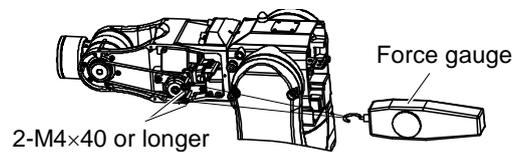
For details, refer to *Maintenance: 4.1 Replacing the Cable Unit*.

10. Apply proper tension to the Joint #5 motor unit to secure the Joint #6 motor unit.

Mount screws of M4×40 or longer (recommended) to the motor plate.

Pass a suitable cord or string (insulation lock) around the screws. Then, pull the cord using a force gauge or a similar tool to apply specified tension.

Joint #5 timing belt tension = $39.2 \text{ N} \pm 9.8 \text{ N}$ (4 kgf \pm 1 kgf)

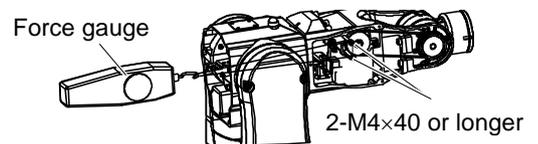


11. Apply proper tension to the Joint #6 motor unit to secure it.

Mount screws of M4×40 or longer (recommended) to the motor plate.

Pass a suitable cord or string (insulation lock) around the screws. Then, pull the cord using a force gauge or a similar tool to apply specified tension.

Joint #6 timing belt tension = $39.2 \text{ N} \pm 9.8 \text{ N}$ (4 kgf \pm 1 kgf)



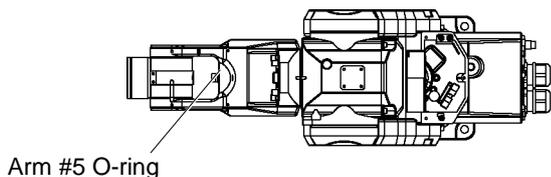
12. Mount the Arm #3 head cover and the Arm #4 side cover.

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

13. Perform the calibration.

For details, refer to *Maintenance: 16. Calibration*.

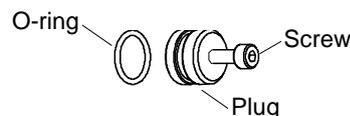
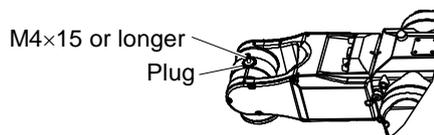
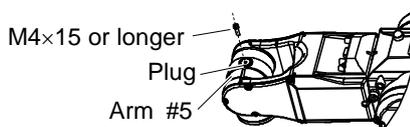
12. Replacing the Arm #5 O-Ring



	Name	Quantity	Note
Maintenance Part	Arm #5 O-ring	1	R13B031245

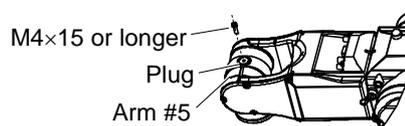
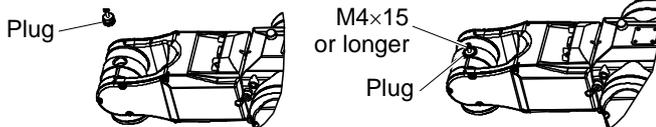
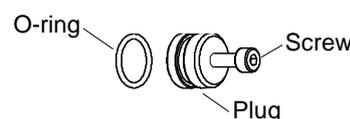
Removal: Arm #5 O-ring

1. Turn OFF the controller.
2. Turn the Arm #5 to the direction you can easily pull out the plug.
3. Turn ON the controller.
4. Insert a screw into the plug.
5. Hold the screw inserted and remove the plug from the Arm #5.
6. Remove the O-ring from the plug.



Installation: Arm #5 O-ring

1. Mount the O-ring.
2. Insert the plug into Arm #5 to the very end.
3. Remove the screw.
If you move the arm with the screw mounted, it may contact with the manipulator body. Make sure to remove the screw.



13. Replacing the Battery Unit



WARNING

- Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.



WARNING

- Take meticulous care when handling the lithium battery. Improper handling of the lithium battery as mentioned below is extremely hazardous and may result in heat generation, leakage, explosion, or inflammation. It also may cause serious safety problems.
<Improper Handling>

Attempting to charge	Deforming by pressure
Disassembling	Short-circuit (Polarity; Positive/Negative)
Connecting batteries improperly	Heating (85°C or more)
Exposing to fire	Soldering the terminal of the lithium battery directly
Forcing discharge	
- When disposing the battery, consult with the professional disposal services or comply with the local regulation.
Make sure that the battery terminal is insulated, even for a used battery. If the terminal contacts with the other metals, it may short and result in heat generation, leakage, explosion, or inflammation.

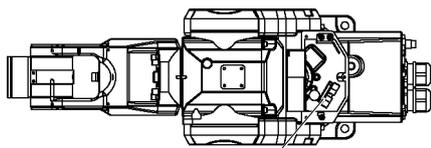
In case of the low lithium battery power, the error to warn the voltage reduction occurs at the Controller startup (the software startup). All position data will be lost and you will need to calibrate all joints.

The life span of the lithium battery is 1.5 years. Even if the Manipulator is constantly connected to power, you need to replace the battery every 1.5 years.

If no warnings of voltage reduction occur, the calibration for all joints is not necessary. However, 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.

Be careful of the battery polarity to connect it correctly.



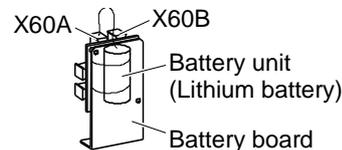
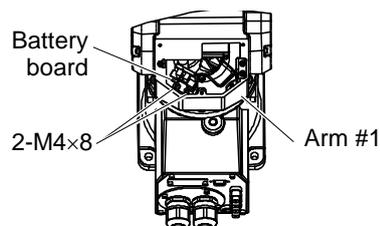
Lithium battery & Battery board

	Name	Quantity	Note
Maintenance Parts	Battery unit (Lithium battery)	1	R13ZA00600300
	Battery board	1	R13B041202
Tools	Nippers	1	
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw

13.1 Replacing the Battery Unit (Lithium Battery)

Removal: Battery unit (Lithium battery)

1. Turn OFF the controller.
2. Remove the Arm #1 cover.
For details, refer to *Maintenance: 3. Covers*.
3. Pull out the battery board from the Arm #1.
Carefully pull out the battery board; otherwise the connectors will be disconnected.
Be careful of the cables length.
4. Connect the connector of the new lithium battery to the battery board.
Use the connector available of 2 connectors (X60A, X60B) on the upper side of the battery board.



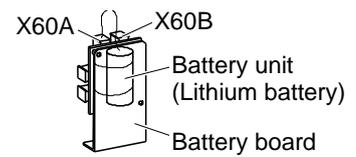
Always connect the new battery unit before disconnecting the old battery unit.

Otherwise, all position data for each arm will be lost and you will need to calibrate again (ENCRESET).

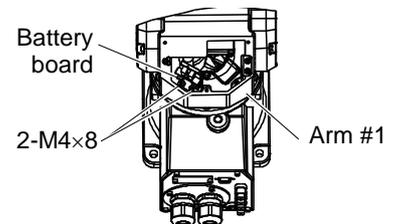
5. Cut off the wire tie fixing the cable of old battery unit.
6. Cut off the wire tie fixing the battery unit to remove it.

Installation: Battery unit (Lithium battery)

1. Mont the new battery unit to the battery board.
2. Referring to the Removal step (4), bind the lithium battery cable and the connector cable connected to the battery board with the wire tie.
3. Mount the battery board to the Arm #1.



4. Mount the Arm #1 cover.
For details, refer to *Maintenance: 3. Covers*.
5. Turn ON the controller.
6. Check the arm positions and orientations.
Move the arms to some points (pose) of the currently registered points.
7. If any position and orientation were changed from the originals, perform the calibration for all joints and axes.
For details, refer to *Maintenance: 16. Calibration*.



13.2 Replacing the Battery Board

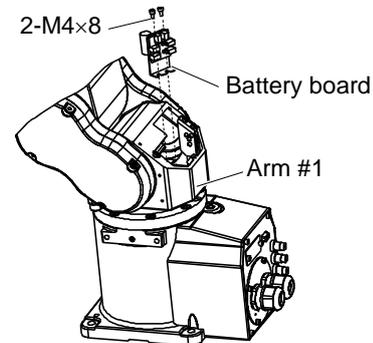
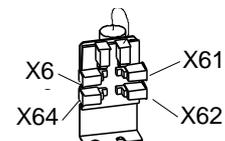
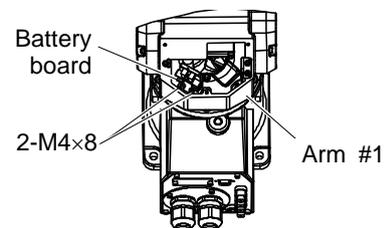
After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder and its corresponding origin stored in the Controller.

After replacing the parts, it is necessary to match these origins. The process of aligning the two origins is called “Calibration”.

Refer to *Maintenance 16. Calibration* and perform the calibration after the parts replacement.

Removal: Battery Board

1. Turn OFF the controller.
2. Remove the Arm #1 cover.
For details, refer to *Maintenance: 3. Covers*.
3. Pull out the battery board from Arm #1.
Carefully pull out the battery board, otherwise the connectors will be disconnected.
Be careful of the cables length.
4. Disconnect the connectors from the battery board.
Connector: X61, X62, X63, X64
5. Remove the battery board from the connectors.



Installation: Battery Board

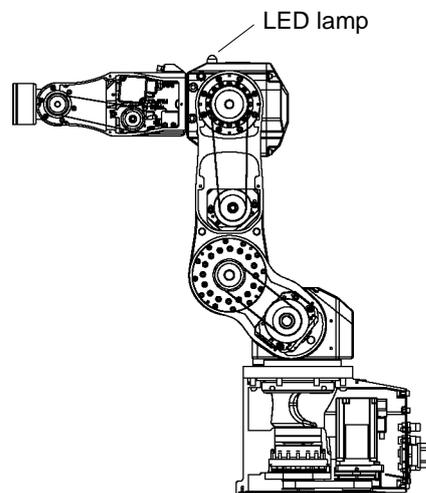
1. Connect the following connectors to the new battery board.
Connector: X61, X62, X63, X64
2. Mount the new battery board to the Arm #1 and secure it with the screws.
3. Mount the Arm #1 cover.
For details, refer to *Maintenance: 3. Covers*.
4. Turn ON the controller.
5. Perform the calibration.
For details, refer to *Maintenance: 16. Calibration*.

14. Replacing the LED Lamp



WARNING

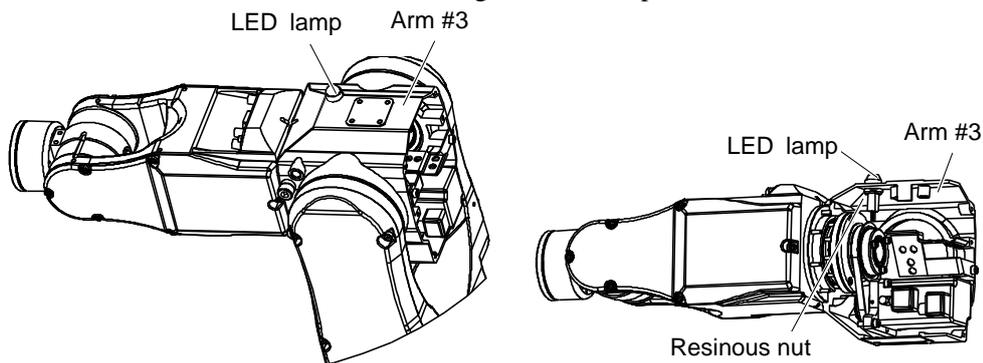
- Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.



	Name	Quantity	Note
Maintenance Part	LED lamp	1	R13B030005
Tools	Nippers	1	
	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw

Removal: LED lamp

1. Turn OFF the controller.
2. Remove the Arm #3 head cover.
For details, refer to *Maintenance: 3. Covers*.
3. Disconnect the connector from the LED lamp.
Connector: LEDB
When the Arm #3 head cover is opened, this connector comes out.
4. Remove the LED lamp from the Arm #3.
Turn the resin nut inside the Arm #3 fixing the LED lamp in a counterclockwise direction.



Installation: LED lamp

1. Attach the LED lamp to the Arm #3.
Detach the resin nut from the LED lamp and pass the lamp through the Arm #3.
Turn the nut clockwise from the inside of the Arm #3 and pinch it in the Arm #3 to secure it.
2. Attach the following connector.
Connector: LEDB
3. Attach the Arm #3 head cover.
For details, refer to *Maintenance 3. Covers*.

15. Replacing the M/C Cable

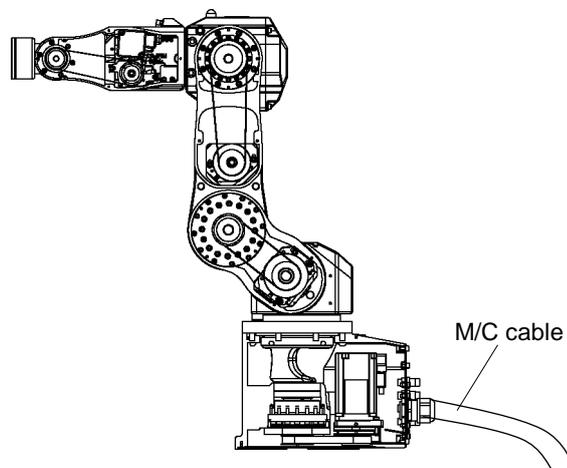
Each battery is provided electricity by the battery for backup. Therefore, position data is held even after turning OFF the controller. The position data will be lost when the cable connector connected to the battery is disconnected. And the EPSON RC+ will display the error message of encoder alarm occurrence when the controller is turned ON.



- Do not remove or install the motor connectors while the power is ON. It is extremely hazardous since the Manipulator may move abnormally. Also, operating the Manipulator with the power ON may result in electrical shock and/or malfunction of the robot system.
- To shut off power to the robot system, pull out the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Be sure to turn OFF the controller and relevant equipment and disconnect the power plugs before starting replacement. Operating the Manipulator with the power ON is extremely hazardous and may result in electrical shock and/or malfunction of the robot system.



- When the connectors are disconnected at the cable replacement, refer to the wiring diagram and reconnect the cables correctly. Improper wiring may cause system malfunction. For details of wiring for each connector, refer to *Maintenance 4.2 Connector Pin Assignment*.
- When installing the cover, make sure not to get the cables caught or bend them forcibly. Doing so may damage the cables and cause connection failure, resulting in system malfunction or electrical shock. When moving the cables, check their positions after removing the cover, and be sure to restore them to reasonable positions.
- Connect the cables securely. Do not put heavy objects on the cables, bend the cables extremely, pull them forcibly, or get them caught. Doing so may damage the cables and cause connection failure, resulting in system malfunction or electrical shock.



NOTE
Make sure to calibrate after the cable replacement
For details, refer to *Maintenance 16. Calibration*.

Maintenance 15. M/C Cable

	Name	Quantity	Note
Maintenance Parts	M/C cable (3 m)	1	R12B020440
	M/C cable (5 m)	1	R12B020441
	M/C cable (10 m)	1	R12B020442
Tool	Hexagonal wrench (width across flats: 3 mm)	1	For M4 screw

Removal: M/C cable

1. Turn OFF the controller.
2. Remove the following connectors from the controller.
 - Power cable connector
 - Signal cable connector
3. Remove the connector sub plate.
 - For details, refer to *Maintenance 3. Covers*.

 NOTE Do not pull the sub plate forcibly.

Do not remove the M/C cable from the connector sub plate.

4. Remove the following connectors.
 - Connector: X010, X011, X020, X12, X30, X13, X040, X14, X050, LEDA, BR010, BR020, BR030, BR040

 NOTE Connector number is indicated on each connector. Shapes of the connector differ from each other.

Do not remove the battery connector (BT1*). Otherwise, you will need the calibration.

Installation: M/C cable

1. Connect the new M/C cable connectors to those of the cable unit.
 - Connect the same numbers.
2. Mount the connector sub plate to the connector plate.
 - For details, refer to *Maintenance 3. Covers*.
3. Connect the following connectors to the controller.
 - Power cable connector
 - Signal cable connector
4. Turn ON the controller.
5. Check the arm motion if the position and orientation have not changed.
 - Move the arms to some points (poses) of currently registered points (poses).
6. If the battery connector (BT1*) is disconnected, calibrate the Joint #1.
 - For details, refer to *Maintenance 16. Calibration*.
7. If the position and orientation have been changed from the originals, calibrate all joints and axes.
 - For details, refer to *Maintenance 16. Calibration*.

16. Calibration

16.1 Overview

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder and its corresponding origin stored in the Controller.

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

The process of aligning the two origins is called “Calibration”. Note that calibration is not the same as teaching*.

* “Teaching” means to teach the Controller coordinate points (including poses) anywhere in the operating area of the Manipulator.



WARNING

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

In EPSON RC+, a coordinate point including the arm pose is defined as “point”. The data is called “point data”.

There are two methods to move the Manipulator during calibration.

- Releasing the electromagnetic brake and moving the arms manually
For details, refer to the *Setup & Operation 1.5 How to Move Arms with the Electromagnetic Brake*.
- Moving the Manipulator using Jog & Teach.

Moving the Manipulator while releasing the electromagnetic brake involves risk as described below. It is recommended to move the Manipulator using Jog & Teach.



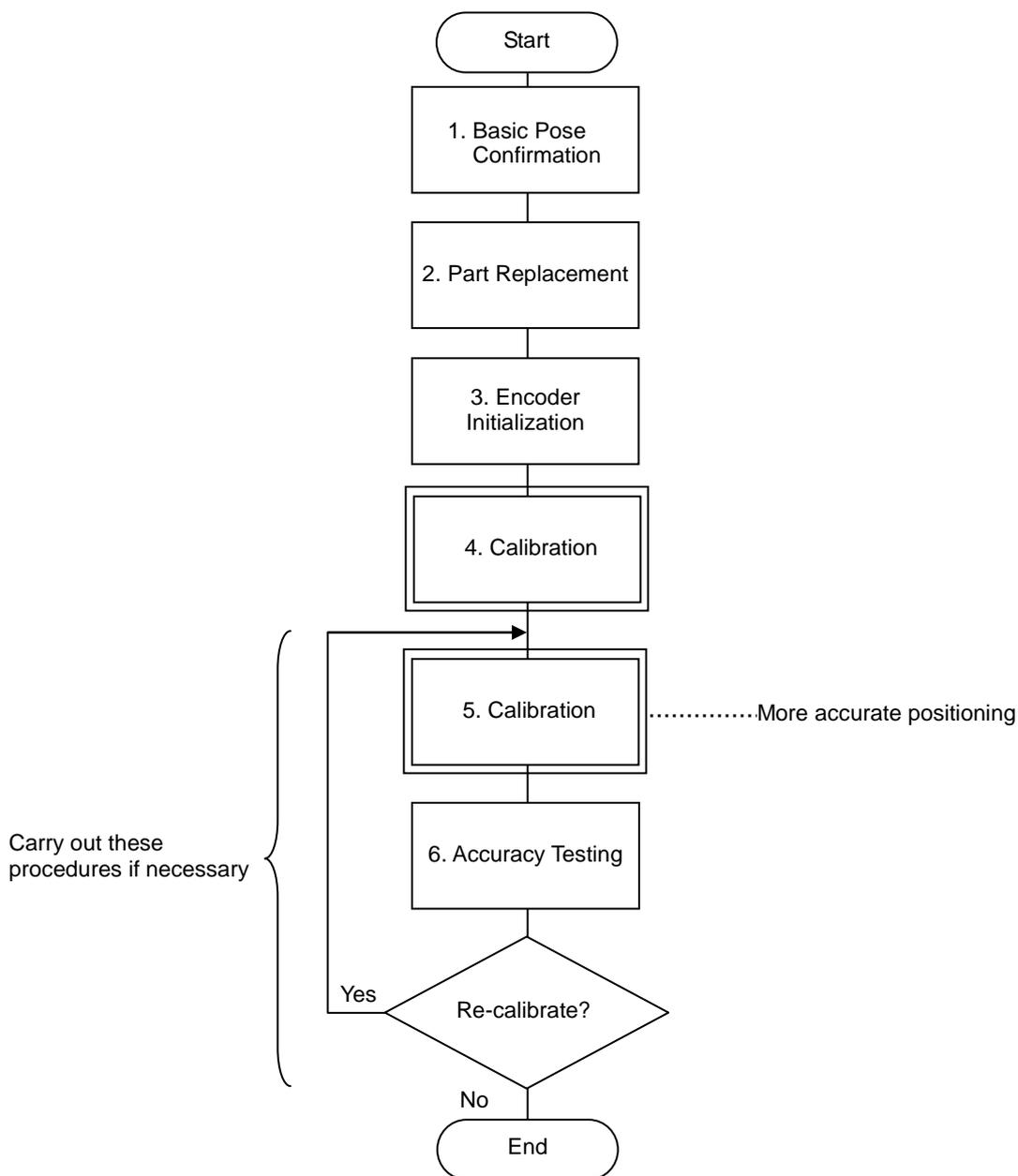
CAUTION

- Normally, release the brake of joints one by one. Take extra care if you need to release the brakes of two or more joints simultaneously. Releasing the brakes of two or more joints simultaneously may cause hands and fingers to be caught and/or equipment damage to or malfunction of the Manipulator as the arms of the Manipulator may move in unexpected directions.
- Be careful of the arm falling when releasing the brake. While the brake is being released, the Manipulator's arm falls by its own weight. The arm falling may cause hands and fingers to be caught and/or may cause equipment damage to or malfunction of the Manipulator.

For details on Jog & Teach, refer to *EPSON RC+ User's Guide*
 5.11.1 Robot Manager Command Tools: Robot Manager: Jog and Teach Page

- NOTE  - For details about the basic pose, refer to *Setup & Operation 3.7 Checking the Basic orientation*.
- Whenever possible, calibrate the origin one joint at a time. (Also, replace parts one joint at a time whenever possible.) If you calibrate the origins for multiple joints simultaneously, it will be more difficult to verify their origins and obtain the origin correct positions.
- However, joint #5 cannot be calibrated alone due to the structure of the Manipulator. Make sure you calibrate joint #5 and #6 at the same time.

Calibration Flowchart



16.2 Calibration Procedure

Command Input

Command execution is required in some calibration procedures.

Select the EPSON RC+ menu-[Tools]-[Command Window].

This step is omitted in the calibration procedures.

Jog Motion

Setting of the jog motion is required in some calibration procedures.

Select EPSON RC+ menu-[Tools]-[Robot Manager] and select the [Jog & Teach] page.

The panel, window, and page above are indicated as [Jog & Teach] in the calibration procedures.

Follow steps 1 to 6 to calibrate the Manipulator.

1. Basic Pose Confirmation

Pose data (Point data) prior to the part replacement (motors, reduction gear unit, or belt) is necessary for the calibration.

Verify the recorded pulse values of the basic pose obtained in the *Setup & Operation 3.7 Checking the Basic orientation*.

2. Part Replacement

Replace parts as instructed in this manual. Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

Turn ON the controller while all joints are in the motion range.

The error message, "Encoder alarm has occurred. Check robot battery. EPSON RC+ must be restarted.", will be displayed.

Initialize the encoder at the current position and reset the error.

Initialize the encoder using one of the following procedures.

Execute the following command at the [Monitor Window].

EPSON
RC+

>Encreset [The joint number (1 to 6) of the encoder to be reset]

Select EPSON RC+ menu-[Tools]-[Controller], then click <Restart Controller>.

After resetting the error, the motor encoder of the joint whose parts have been replaced will be initialized. Set the jog mode to “Joint” in [Jog & Teach] and operate the Manipulator in jog motion to match the home position marks (0 pulse position) of the joint accurately.

When the joint cannot move to the home position, operate the Manipulator to match the tram mark placed in *Setup & Operation 3.7 Checking the Basic orientation* as accurate as possible.

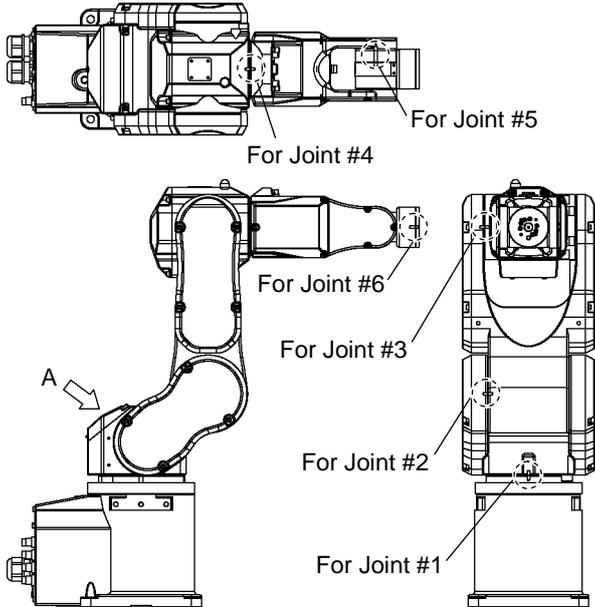
Initialize the encoder when the joint matches the home position or the tram mark. For the encoder initialization, refer to the procedure indicated above.



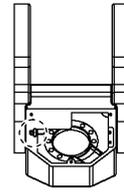
When the origin of the Joint #5 is calibrated, the Joint #6 will be out of position. (Due to the structure of the Manipulator, any offset in the position of the Joint #5 affects the Joint #6.) Calibrate the origin of the Joint #6 together when calibrating the Joint #5.

4. Calibration

Position of grooves for calibration



Position of calibration key



Detail of A
(Arm #1 center cover is removed)

The key is secured to the inside of the Arm #1 center cover using M4 screw. Be sure to put the key back to the original position after use.

4-1 Prepare the calibration key.

One calibration key is secured inside the Arm #1 center cover using M4 screw. Be careful not to lose the screw.

4-2 Move the arm you want to calibrate to the position of the calibration groove.



Select menu-[Tool]-[Robot Manager]-[Jog & Teach] panel to move the Manipulator. If an error occurs after replacing the motor and you cannot use the [Jog & Teach] panel or “Brake OFF, *” does not work (* is an axis number to calibrate.), go through the steps (4) and (5) now.

Then, [Jog & Teach] panel and “Brake OFF, *” will be available. Move the arm you want to calibrate to the position of the calibration groove and go on to the step 4-3.

4-3 Set the calibration key to the calibration groove (the grooves for Joints #1 to #6).

At this point, if the key cannot be set completely, the arm(s) is not in the origin.

Move the arm until the key can be set completely.

The key will be broken if you move any arm with the key in the groove. Do not move arm(s) once its position is fixed.

4-4 Reset the encoder.

EPSON
RC+

Execute one of the following commands to reset the encoder of the joint you want to calibrate from the menu-[Tool]-[Command Window].

```
Joint #1 >Encreset 1
Joint #2 >Encreset 2
Joint #3 >Encreset 3
Joint #4 >Encreset 4
Joint #5 >Encreset 5, 6
Joint #6 >Encreset 6
```

4-5 Reboot the controller.

EPSON
RC+

Click EPSON RC+ menu-[Tool]-[Controller]-<Reset Controller>.

4-6 Input the command in the Command window and execute it.

EPSON
RC+

Execute the following command to reset the encoder of the joint you want to calibrate from the menu-[Tool]-[Command Window].

```
>calpls 0,0,0,0,0,0
* Manipulator does not move.
```

4-7 Perform the calibration.

EPSON
RC+

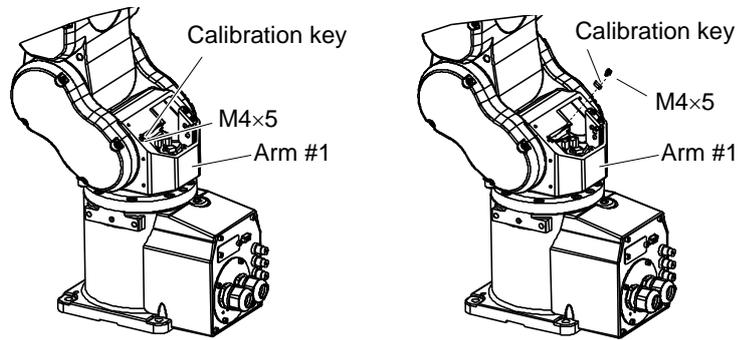
Execute the following command to reset the encoder of the joint you want to calibrate from the menu-[Tool]-[Command Window].

```
Joint #1 >calib 1
Joint #2 >calib 2
Joint #3 >calib 3
Joint #4 >calib 4
Joint #5 >calib 5,6
Joint #6 >calib 6
```

Move the arm to several points to check if the arm moves to the original positions properly. Teach points if fine adjustment is necessary.

4-8 All joints are calibrated.

Put the calibration key back to the original position in the Arm #1 and secure it with the screw.



4-9 Mount the Arm #1 cover.

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

5. Calibration (More accurate positioning)



Move the Manipulator to the selected point data by jogging in [Jog & Teach].

Move the joint* which is not calibrated to the specified point by motion command.

*When the Joint #5 is being calibrated, move the Joints #1 - #4 to the home positions.

For example, when the selected point data is "P1", execute "Motor On" in [Control Panel] and execute "Go P1" in [Jog & Teach].

Position the calibrating joint* to the selected point data position accurately by jog command.

* When the Joint #5 is being calibrated, move the Joint #5 and #6 to the home positions.

Select the "Joint" jog mode from [Jog & Teach] to operate in the jog motion.

To perform the calibration, enter the pulse values of the selected point data.

When "P1" is selected, enter the values as follows.

```
>Calpls Ppls(P1,1), Ppls(P1,2), Ppls(P1,3), Ppls(P1,4),
Ppls (P1,5), Ppls(P1,6)
```

Perform the calibration. Input one of the following commands according to the joint being calibrated.

```
Joint #1 :>Calib 1
Joint #2 :>Calib 2
Joint #3 :>Calib 3
Joint #4 :>Calib 4
Joint #5 :>Calib 5,6
Joint #6 :>Calib 6
```

6. Accuracy Testing

Move the Manipulator to a different pose (point) to verify whether it moves back to the original position. If accuracy is inadequate, it is necessary to re-calibrate the origin using a different pose (point). You must set the pose (point) again if the Manipulator does not move back to the original position after re-calibration.

17. Maintenance Parts List

17.1 Standard

Part Name		Code	Note	Reference in Maintenance
Motor	Joint #1, #2	R13B000616	400 W	5.1, 6.1
	Joint #3	R13B000618	150 W	7.1
	Joint #4	R13B000619	50 W	8.1
	Joint #5, #6	R13B000620	50 W	9.1, 10.1
Reduction Gear Unit *	Joint #1	R13B010011		5.2
	Joint #2	R13B010021		6.2
	Joint #3	R13B010022		7.2
	Joint #4	R13B010023		8.2
Electromagnetic Brake	Joint #2 (Joint #1 **)	R13B030504		6.4 (5.4**)
	Joint #3	R13B030505		7.4
	Joint #5 (Joint #4, #6 **)	R13B030506		9.3 (8.4, 10.3**)
Timing Belt	Joint #1	R13B030220	Width 10 mm	5.3
	Joint #2	R13B030221	Width 10 mm	6.3
	Joint #3	R13B030222	Width 7 mm	7.3
	Joint #4	R13B030223	Width 6 mm	8.3
	Joint #5	R13B030224	Width 6 mm	9.2
	Joint #6	R13B030225	Width 6 mm	10.2
Battery Unit (Spare lithium battery)		R13ZA00600300	Lithium battery: ER17330V (TOSHIBA)	13.1
Seal	Joint #4	R13A031200100		8.2
Grease **	Joints #1 to #4 SK-1A	-	For purchasing grease, please contact the sales company in your region.	2.3
	Bevel gear SK-2	-		2.3
	Cable GPL-224	-		4.1
Cable Unit		R13B020036	Internal cable	4.1
Noise Reduction Diode	Joint #2, #3 (Joint #1 ***)	R13B020301		(5.1**), 6.1, 7.1
Heat Dissipating Sheet	Joint #1, #2	R13B031905		5.1, 6.1
O ring	Joint #1	R13B031223		5.2
	Joint #2	R13B031242		6.2
	Joint #3	R13B031243		7.2
	Joint #4	R13B031244		8.2
	Arm #3, #4	R13B031245		11

Part Name		Code	Note	Reference in Maintenance
	Arm #5	R13B031247		12
Joint #5, #6 Unit		R13B080202		11
Battery Board (Lithium battery is supplied)		R13B041202	Lithium battery: ER17330V (TOSHIBA)	13.2
LED Lamp		R13B030005		14
M/C Cable		R12B020440	3 m	15
		R12B020441	5 m	
		R12B020442	10 m	

* Reduction Gear Unit: A reduction gear unit consists of the following three parts.

When replacing the reduction gear unit, replace the following parts all together as a set.

Waveform generator

The waveform generator consists of an ellipsoidal cam and ball bearings on outer circumference.

The inner ring of the bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.

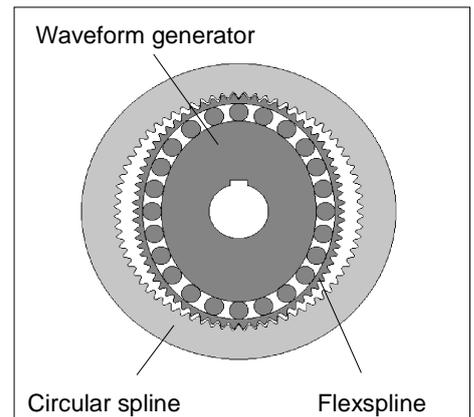
Flexspline

A thin, elastic, cup-shaped metal body with gear teeth around the outer circumference of the opening.

Circular spline

A rigid, ring-shaped body with gear teeth on the inner circumference.

The circular spline has two more teeth than the flexspline does.



The splines are greased. Be sure to keep the grease from being attaching to the clothes.

*** Regarding purchase of grease

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase grease required for maintenance from the manufacturers listed in the table below as of April 2015.

Regarding purchase of grease, please contact the following manufacturers. If there is anything unclear, please contact our suppliers.

Product name	Manufacturer	URL
Harmonic Grease SK-1A Harmonic Grease SK-2	Harmonic Drive Systems Inc.	http://www.harmonicdrive.net/
Krytox®GPL-224	DuPont	http://www2.dupont.com/Our_Company/en_US/worldwide/us_country.html

*** Option: Brakes are equipped to all joints.

17.2 Option

Part Name	Code	Note	Reference in Setup & Operation
Brake Release Unit (with cable and short connector)	R12B120805	For Europe	6.1
	R12B120806	For U.S. & Japan	
Brake Release Unit (Main unit only)	R12B120803	For Europe	
	R12B120804	For U.S. & Japan	
Camera Plate Unit	R12B031922		6.2
PS Compatible Plate	R12B031923		6.3
Base Side Angled Fitting	R12B031924		6.4
Base Side Fitting	R12B031925		6.5