

EPSON

EPSON ProSix

S5 series

MANIPULATOR MANUAL

Rev.4

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EPSON ProSix S5 series MANIPULATOR MANUAL Rev. 4

EPSON ProSix

S5 series Manipulator Manual

Rev. 4

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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



MANUFACTURER & SUPPLIER

Japan & Others

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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.

Structure of Control System

S5 series Manipulators can be used with the following combinations of Controllers and software.

Controller		Software
Type	Composition (Hardware)	
RC180	Controller	EPSON RC+ 5.0
RC620	Control Unit Drive Unit	EPSON RC+ 6.0

For details on commands, refer to “EPSON RC+ User’s Guide” or “Online Help”.

Turning ON/OFF Controller

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

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

Please read this manual and other related manuals before installing the robot system or before connecting cables.

Keep this manual handy for easy access at all times.

1.1 Conventions

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


 WARNING	This symbol indicates that a danger of possible serious injury or death exists if the associated instructions are not followed properly.
 WARNING	This symbol indicates that a danger of possible 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, dealer, or local representative company, or those who understand the manuals thoroughly and have the same knowledge and skill level as those who have completed the training courses.

To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the *Installation and Design Precautions* in the *Safety* chapter of the EPSON RC+ User's Guide or the *Safety 1.3 Design Precautions* in the SPEL CT 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 or the <i>Safety</i> part in the SPEL CT User's Guide to understand the safety requirements before designing and/or constructing the robot system. Designing and/or constructing the robot system without understanding the safety requirements is extremely hazardous, and may result in serious bodily injury and/or severe equipment damage to the robot system, and may cause serious safety problems. ■ The Manipulator and the Controller must be used within the environmental conditions described in their respective manuals. This product has been designed and manufactured strictly for use in a normal indoor environment. Using the product in an environment that exceeds the specified environmental conditions may not only shorten the life cycle of the product but may also cause serious safety problems. ■ The robot system must be used within the installation requirements described in the manuals. Using the robot system outside of the installation requirements may not only shorten the life cycle of the product but also cause serious safety problems.
--	---

Further precautions for installation are mentioned 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 EPSON RC+ User's Guide or the <i>Safety 1.1 Safety-related Requirements</i> in the SPEL CT User's Guide before operating the robot system. Operating the robot system without understanding the safety requirements is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system. ■ Do not enter the operating area of the Manipulator while the power to the robot system is turned ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even if it seems to be stopped. ■ Before operating the robot system, make sure that no one is inside the safeguarded area. The robot system can be operated in the mode for teaching even when someone is inside the safeguarded area. The motion of the Manipulator is always in restricted 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 while the robot system is operated. Continuing the operating the robot system 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.

1.4 Emergency Stop

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

However, avoid pressing the Emergency Stop switch unnecessarily while the Manipulator is running normally. Otherwise, the Manipulator may hit the peripheral equipment since the operating trajectory while the robot system stops is different from that in normal operation.

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

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

Free running distance in emergency

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

However, remember that the values vary depending on conditions such as the weight of the end effector and work piece, WEIGHT/SPEED/ACCEL settings, operating pose, etc.

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

Conditions of Measurement

ACCEL Setting	100
SPEED Setting	100
Load [kg]	5
WEIGHT Setting	5

		RC180 / RC620	
		S5-A701**	S5-A901**
Free running time [second]	Arm #1	0.4	
	Arm #2	0.4	
	Arm #3	0.4	
	Arm #4	0.4	
	Arm #5	0.4	
	Arm #6	0.1	
Free running angle [degree]	Arm #1	55	60
	Arm #2	35	40
	Arm #3	30	35
	Arm #4	40	
	Arm #5	50	
	Arm #6	10	

1.5 How to Move Arms the Electromagnetic Brake is Applied to

When the electromagnetic brake is applied to all arms (such as emergency mode), you cannot move any arm by pushing it manually.

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

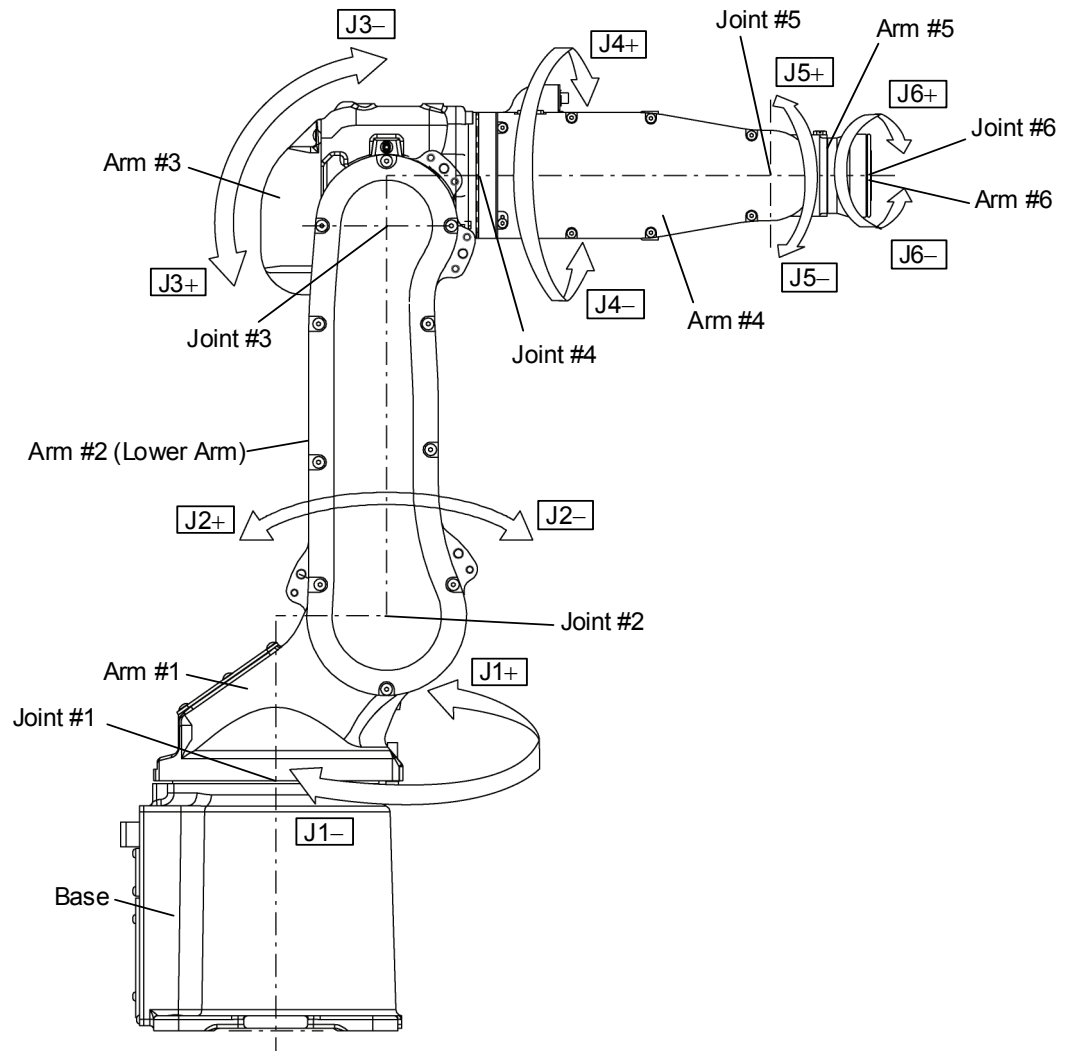
1.5.1 Moving the Arm Using the Brake Release Unit

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

1.5.2 Moving the Arm Using the Software

Follow the method when you can use the software.


Arm Motion




1.5.1 Moving the Arm Using the Brake Release Unit

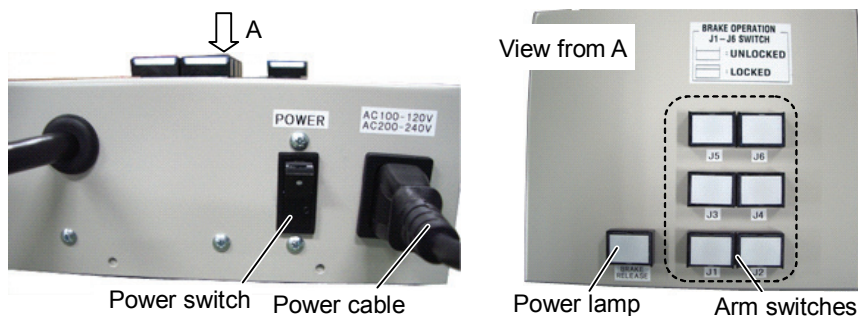
With the electromagnetic brake is ON (such as in Emergency Stop status), you cannot move all arms by hand.

You can move Arms by hand using the brake release unit while the controller power is OFF or right after unpacking.


 WARNING	<ul style="list-style-type: none"> Before connecting/disconnecting the connector of Brake release unit, be sure to check the powers of the controller and break release unit are OFF. Otherwise, it leads to the electrical shock or breakdown.
--	--

 CAUTION	<ul style="list-style-type: none"> Release a brake for each joint one by one. If you need to release some brakes at a time, take a great care. Because when some joints are released at a time, the arms may fall to unintended directions. This is extremely dangerous and may break the manipulator or catch your hand, fingers. Take care of the arm downward motion when the brake is released. While you are pressing the brake release switch, the arm moves downward by its own weight. This is extremely dangerous and may break the manipulator or catch your hand, fingers.
--	---

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, Japan)	100 V specification
Power cable (EU)	200 V specification



Precautions for use

 <p>CAUTION</p>	<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.■ 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.
--	---

NOTE


- When you purchased several S5 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.

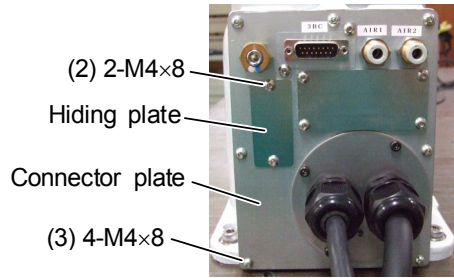
- (1) Turn OFF the controller.

- (2) Remove the hiding plate.

2-M4×10

- (3) Open the connector plate.

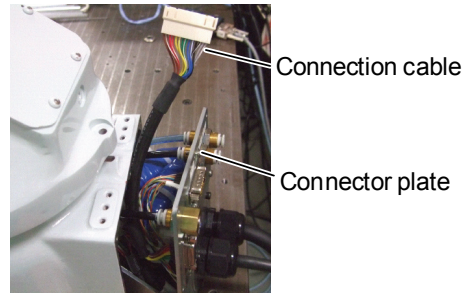
4-M4×10



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

Connect the connection cable to the connector plate.

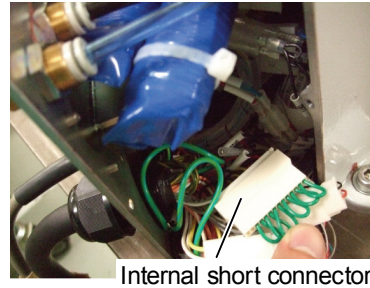
2-M4×10



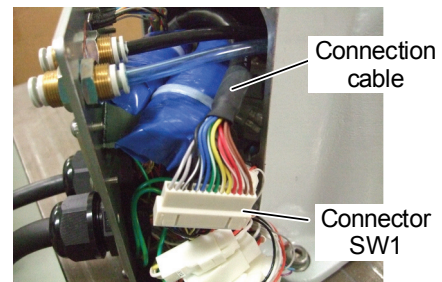
- (5) Take out the connector of internal cable SW1.

- (6) Disconnect the internal short connector.

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



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

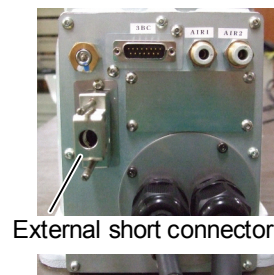


- (8) Mount the connector plate. Be careful not to catch the cables.

4-M4×10

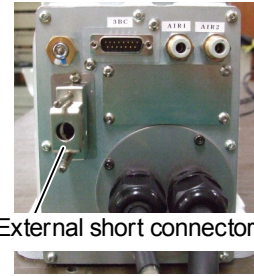
- (9) If the brake release unit is not used, mount the external short connector.

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



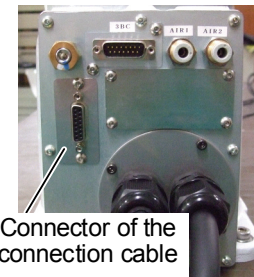
Mount the brake release unit

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



External short connector

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




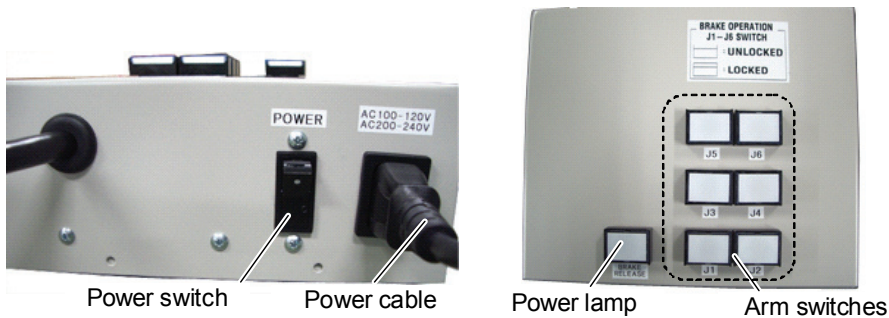
Connector of the connection cable

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 connection cable.
- (4) Connect the external short connector to the connector of connection cable.

How to use the brake release unit


 CAUTION	<ul style="list-style-type: none"> ■ Be careful of the arm downward motion while you release the brakes. The arm will move downward by its own weight while you are pressing a brake release switch. This is extremely dangerous and may break the manipulator or catch your hand, fingers. ■ If the arm you released the brake moves strange or slower than normal, stop the motion promptly and contact us. The brake release unit is possibly broken and if you keep operating the manipulator, it may lead to the brake of the manipulator or you will be caught by the hand or fingers.
--	--




- (1) Mount the brake release unit on the manipulator.
 For the mounting procedure, refer to *Mount the brake release unit* described in the previous page.
- (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 arm switch J1 ~ J6 you want to move and then move the arm.
 Press the switch again, then 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.

When the Manipulator is a Protection-model, be aware of the followings.

 CAUTION	<ul style="list-style-type: none"> ■ Do not leave the brake release unit in special environmental conditions (adverse conditions with dust and oily smoke). The brake release unit does not comply with IP65. Leaving the brake release unit in the special environmental conditions may cause damage to and/or malfunction of the brake release unit.
--	---

1.5.2 Moving the Arm Using the Software

 CAUTION	<ul style="list-style-type: none"> ■ Normally, release the brake of a single joint at a time. Take extra care to release the brakes of two or more joints simultaneously from necessity. 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. If you cannot immediately press the Emergency Stop switch, you have no means to stop the arms urgently when a wrong operation causes the arm to fall. The arm falling may cause equipment damage to and/or malfunction of the Manipulator.
--	--

After releasing the Emergency Stop switch, Execute the following commands.

[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

When the power mode is low, the Manipulator will operate at low speed and low torque. However, comparatively high torque is generated under some circumstances so that the Manipulator can support its own weight. The maximum torque of each joint in the low power status is shown in the following table “Max. Joint Torque in Low Power Status”. Even though the Manipulator is in the low power status, carefully operate the Manipulator since a comparatively high joint torque may be generated. Be careful not to get hands or fingers caught during operations. The Manipulator may also collide with peripheral equipment and it may cause equipment damage to or malfunction of the Manipulator.

Max. Joint Torque in Low Power Status [Unit: N·m]

Joint	#1	#2	#3	#4	#5	#6
S5-A701**	121.80	135.82	56.59	12.72	19.21	8.01
S5-A901**	167.06	169.78	70.74	12.72	19.21	8.01



CAUTION


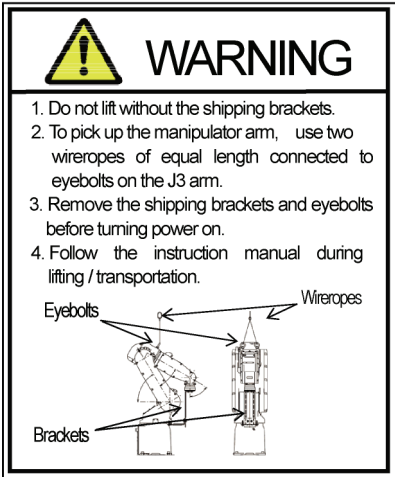



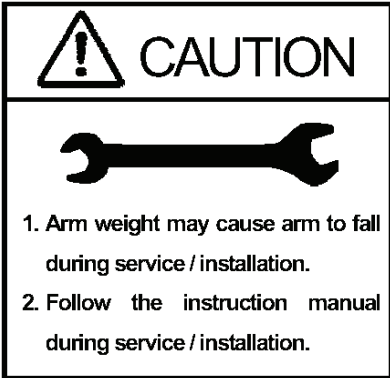

- Carefully operate the Manipulator even though it is in the low power status. A comparatively high joint torque may be generated. The comparatively high joint torque may cause hands and fingers to be caught and/or may cause equipment damage to or malfunction of the Manipulator as it may collide with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

1.7 Manipulator Labels

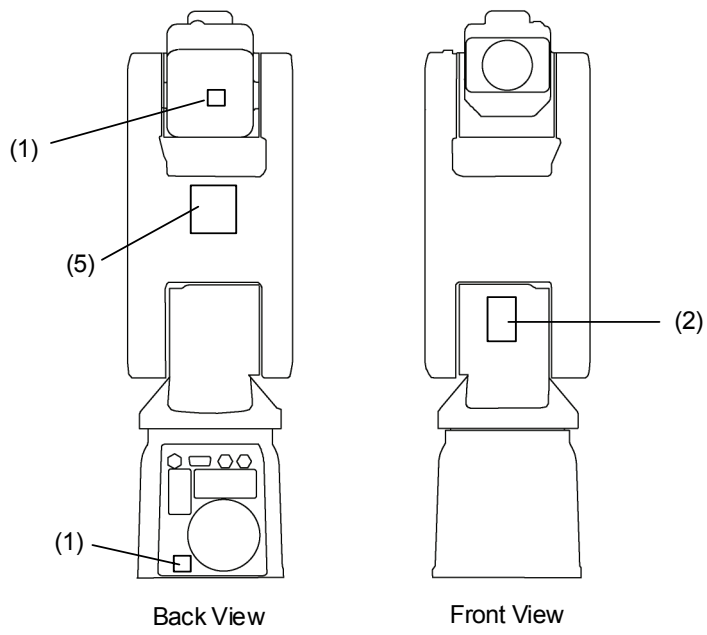
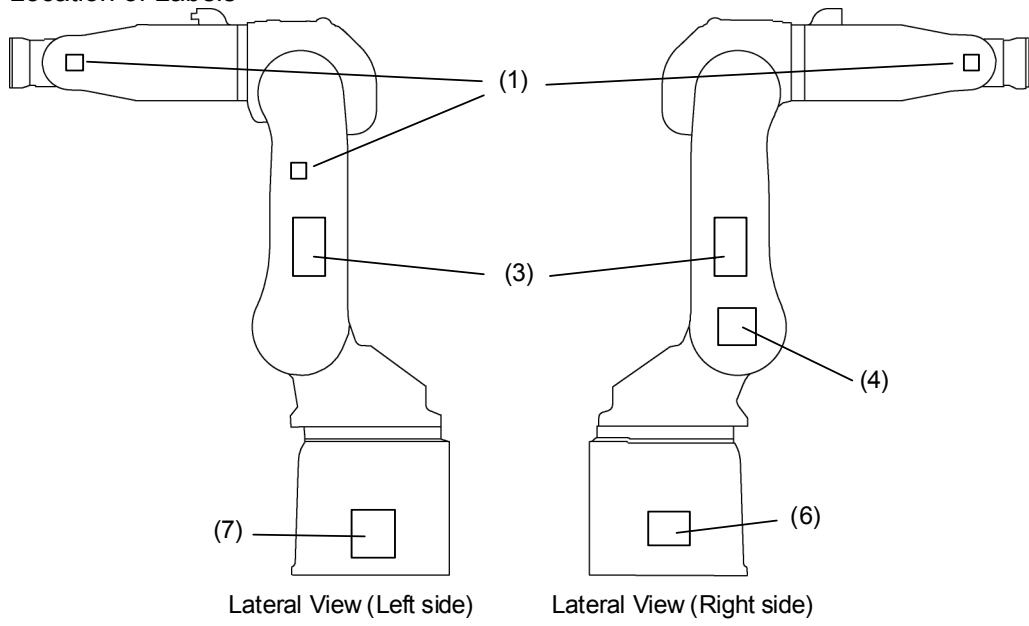
The following labels are attached around the locations of the Manipulator where specific dangers exist.

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:

Location of Labels	Labels	Location of Labels	Labels
(1)	 <p>NOTE: Hazardous voltage exists while the Manipulator is ON. To avoid electric shock, do not touch any internal electric parts.</p>	(5)	
(2)		(6)	
(3)		(7)	<p>MODEL : S5-A701SR SERIAL NO. : 0 0 0 1 MANUFACTURED : 1 0 / 2 0 1 0 WEIGHT : 3 6 k g MOTOR POWER AXIS1 : 400W AXIS2 : 400W AXIS3 : 200W AXIS4 : 50W AXIS5 : 50W AXIS6 : 50W SEIKO EPSON CORPORATION 3-5,OWA 3-CHOME,SUWA-SHI</p>
(4)		(8)	

Location of Labels



2. Specifications

2.1 Features of Manipulators

(1) High-speed and high-accuracy control

S5 Manipulator is controlled at high speed and high accuracy by techniques we have acquired while improving our SCARA robots.

- S5 Manipulator moves at high speed and stops at target points as you desire.
- High-speed and high-accuracy positioning shortens cycle time.
- Maximum operating speed has been improved at the highest level for the small industrial robot industry.
- Residual vibration has been decreased.
- Improved rigidity of the arms reduces vibration and deflection of the Manipulator.
- S5 Manipulator holds position with great stability.

(2) High-accuracy trajectory control

The accuracy of CP trajectory control has been improved so that you can operate the Manipulator with more flexibility while taking advantage of six degrees of freedom.

(3) Available for large payloads

Large allowable moment of inertia has made it possible to support relatively large payloads.

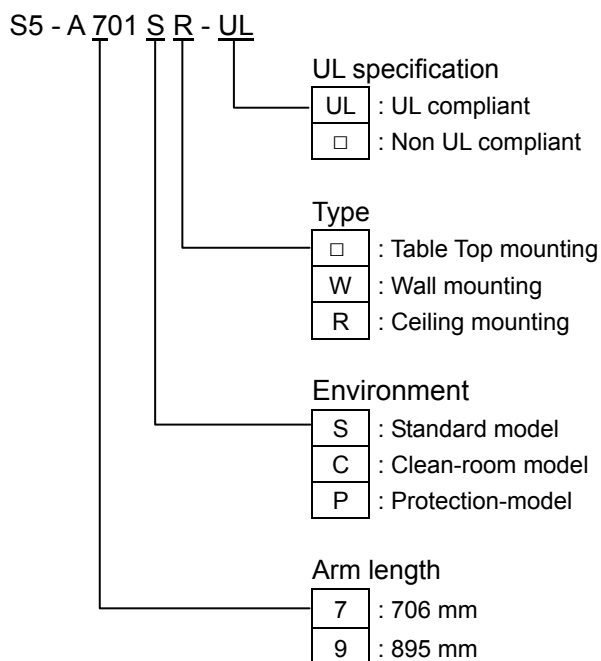
Optimal control for payload by using the WEIGHT and INERTIA commands make handling large payloads more stable.

UL specification (UL1740 Conformance Type)

UL1740 is the Standard for Industrial Robots and Robotic Equipment established by Underwriters Laboratories Inc. (UL). The UL1740 conformance product has a safety mark which shows that Underwriters Laboratories Inc. (UL) has recognized it.

In the United States, the robot system is recommended to be used with the Manipulators and Controller that conform to UL1740 in accordance with ANSI/RIA R15.06.

2.2 Model Number



Environment

Cleanroom-model

Cleanroom-model Manipulator includes additional features that reduce dust emitted by the Manipulator to enable use in clean room environments.

Cleanliness level : Class ISO 3 (ISO14644-1)

In previous criteria;

Clean Class: 10 or its equivalent. Amount of Dust (0.1 μm diameter or larger) in 28317 cm³ (1cft) sample-air around the center of the motion rang: 10 particles or less.)

Exhaust System : Exhaust port diameter:

Inner diameter: ø12 mm / Outer diameter: ø16 mm

Exhaust tube : Polyurethane tube

Outer diameter: ø12 mm (Inner diameter:ø8 mm)
or Inner diameter ø16mm.

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

Protection-model (IP65)

The Protection-model Manipulators operate under adverse conditions with dust and oily smoke.

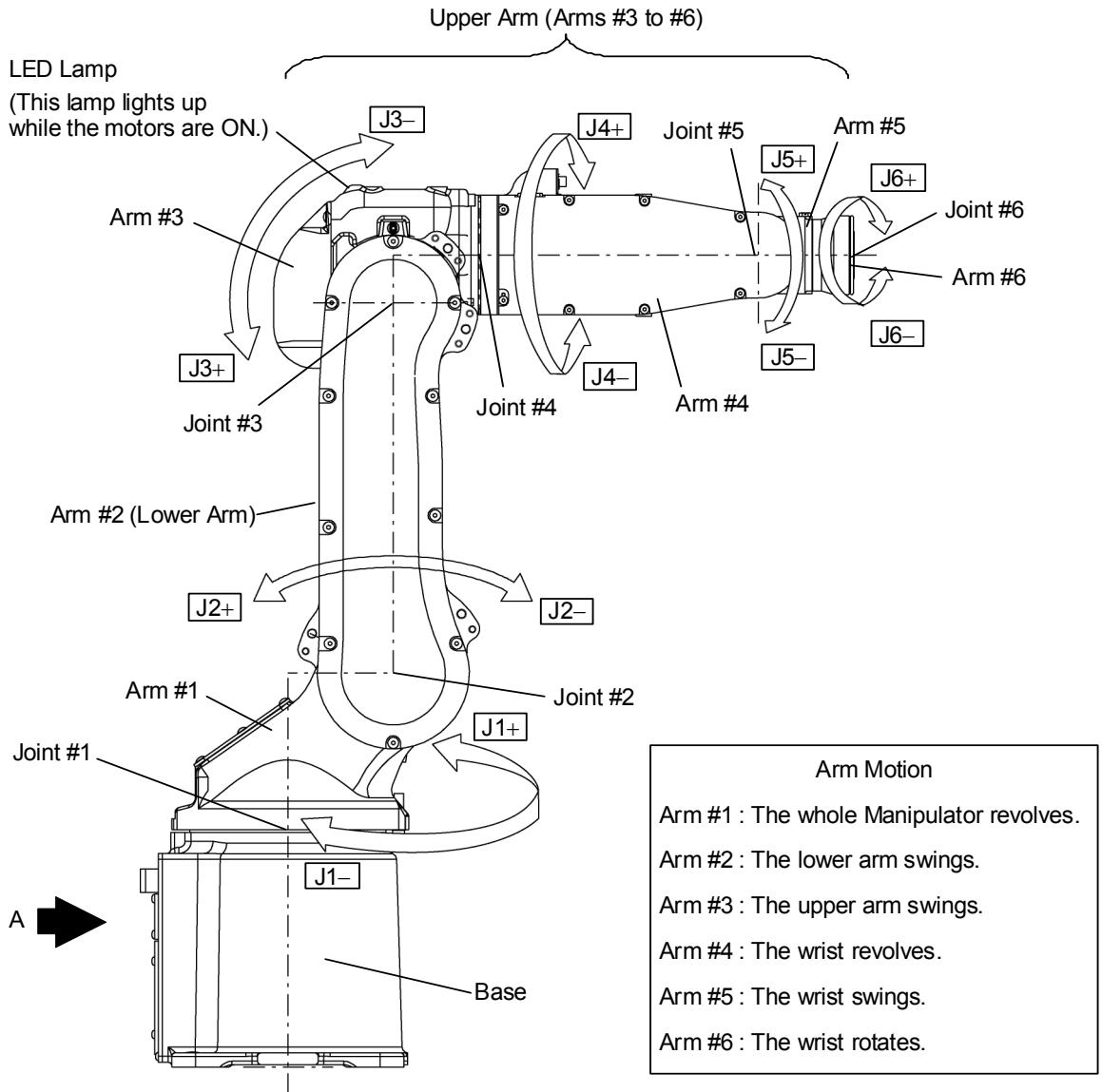
IP (International Protection) for the Protection-model Manipulator indicates International Standard of the protection level against dust and water. (IEC 60529, JIS C0920)

Degree of protection		
IP65	Dust : 6	No ingress of dust.
	Water: 5	Water projected by a nozzle against enclosure from any direction shall have no harmful effects.

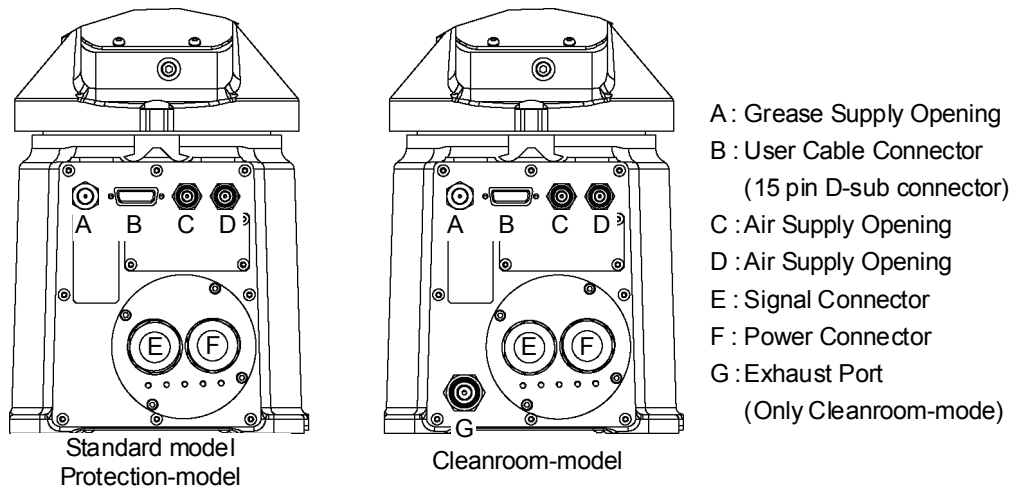
For details on the specifications, refer to *Setup & Operation: 2.4 Specifications*.

2.3 Appearance

Part Names and Motion Range of Each Arm



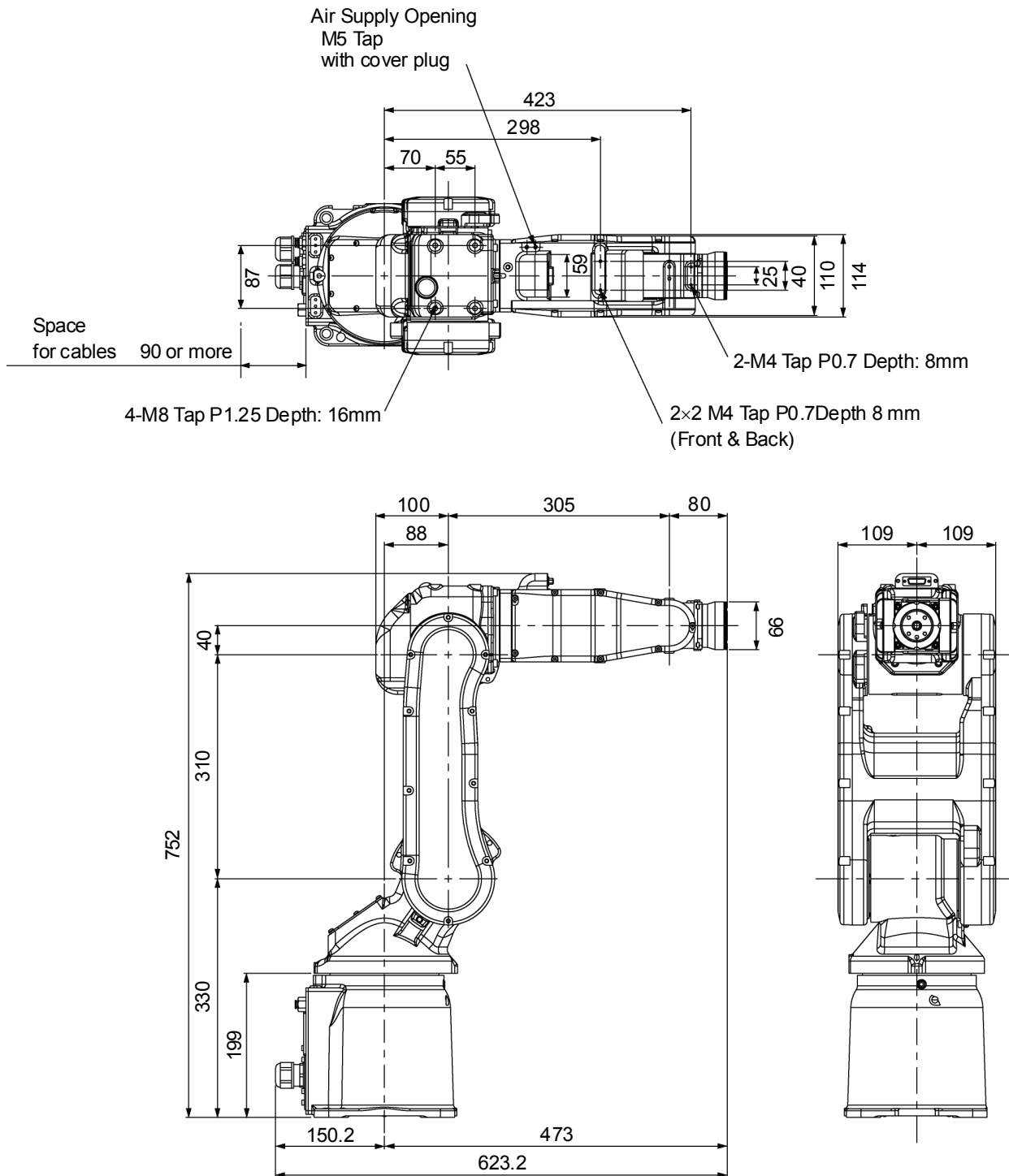
Details of Connector Plate (View A)



Outer Dimensions

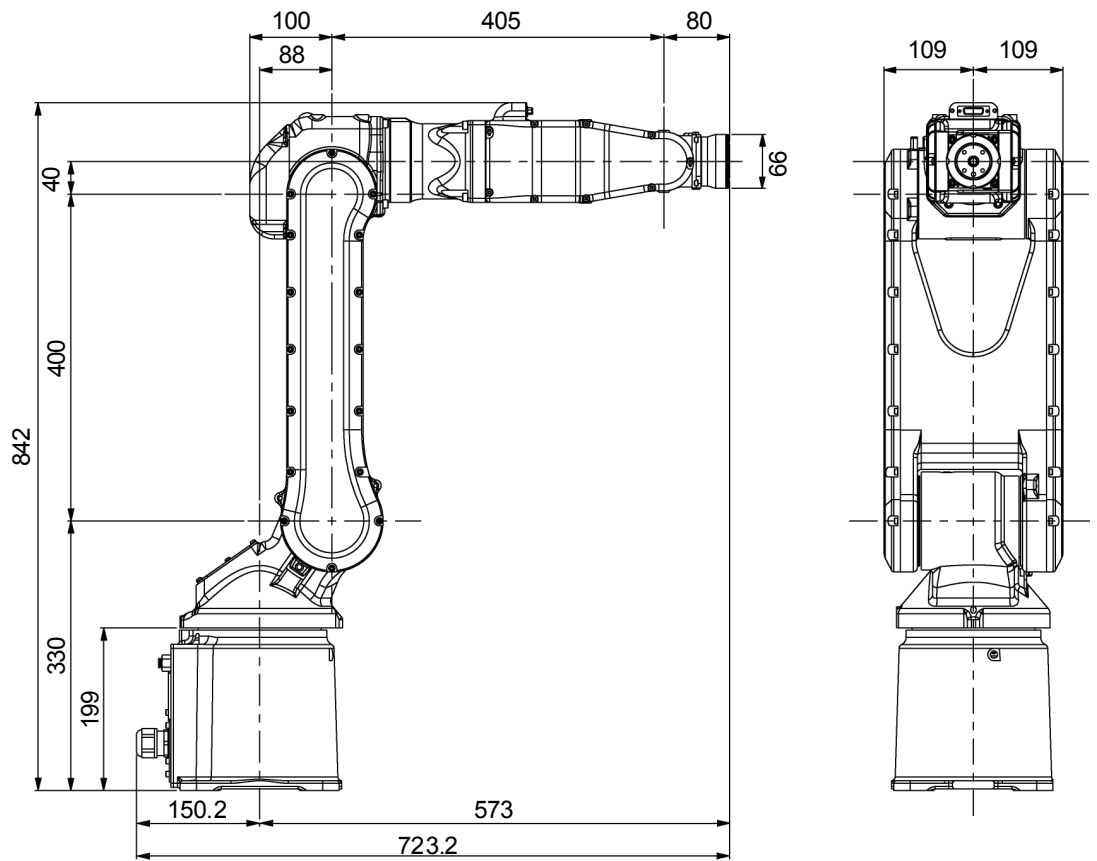
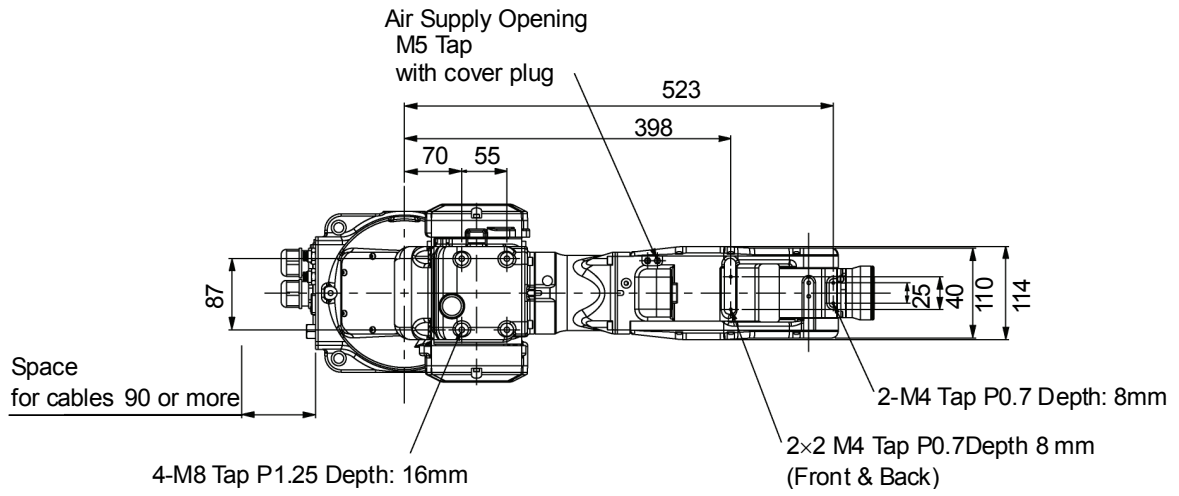
S5-A701**

[Unit: mm]



S5-A901**

[Unit: mm]

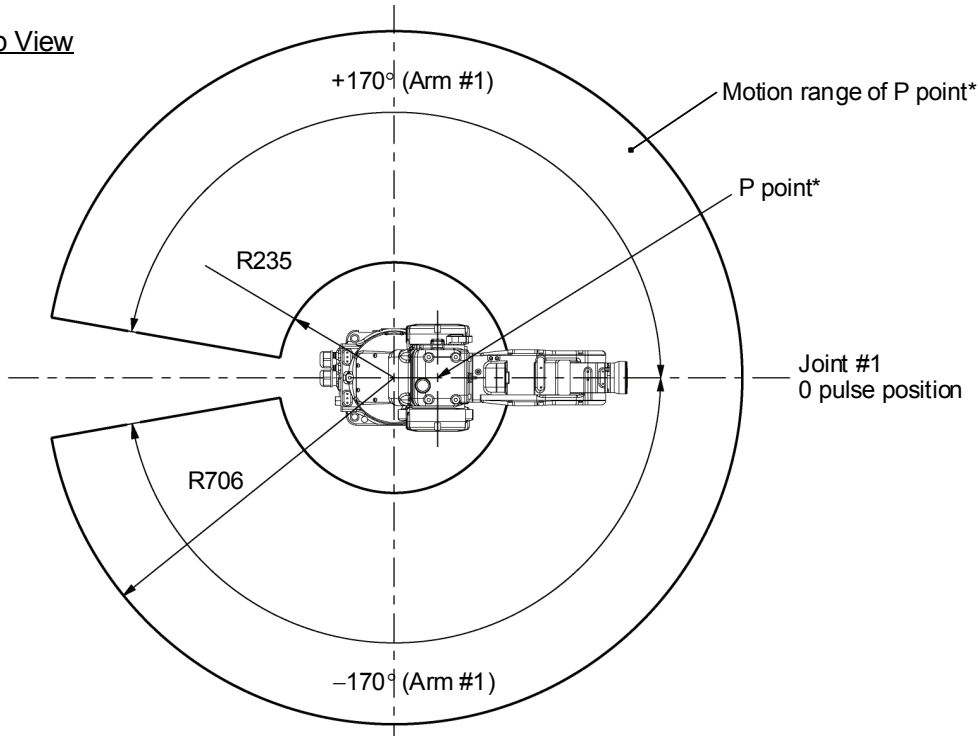


Standard Motion Range

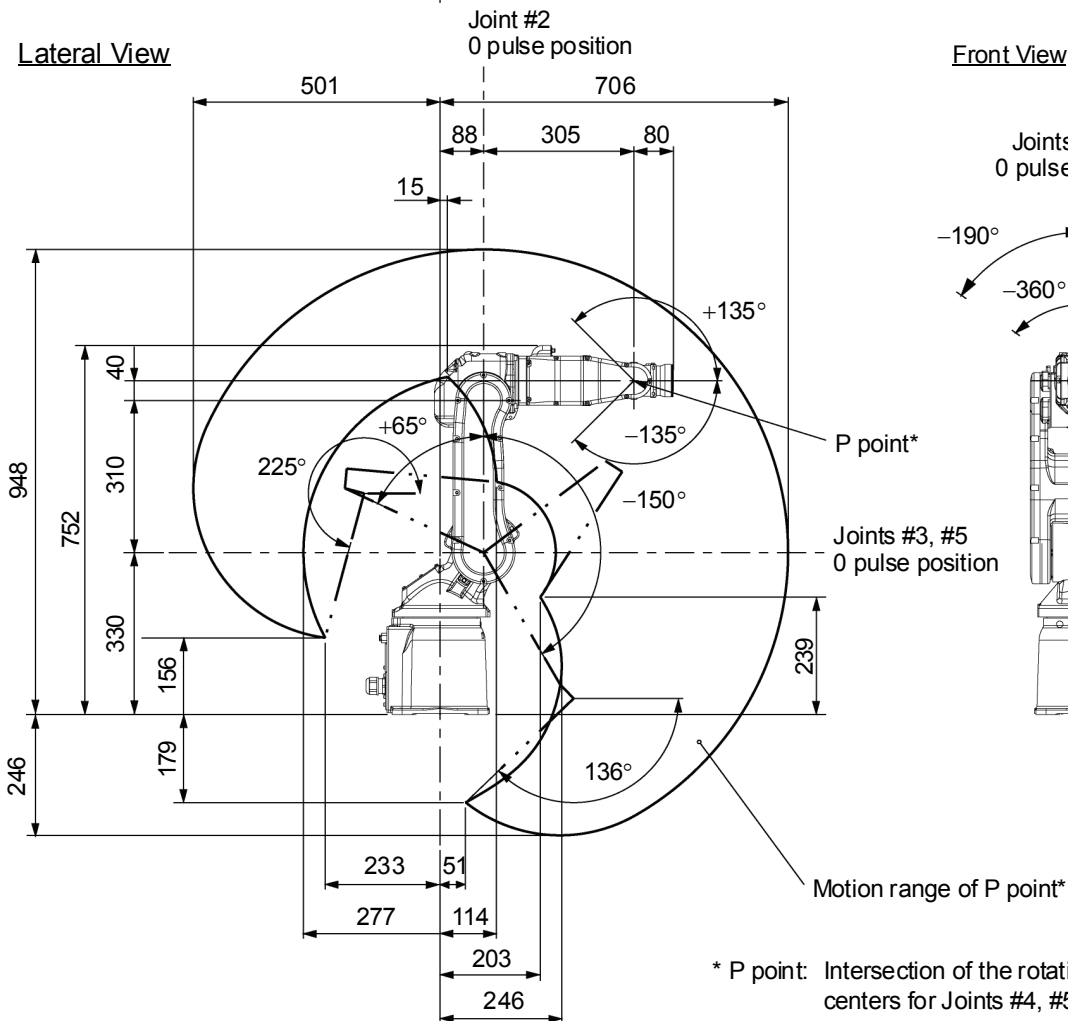
S5-A701**

[Unit: mm] (° = degree)

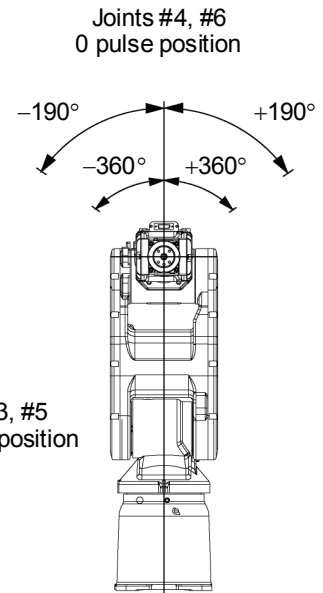
Top View



Lateral View



Front View

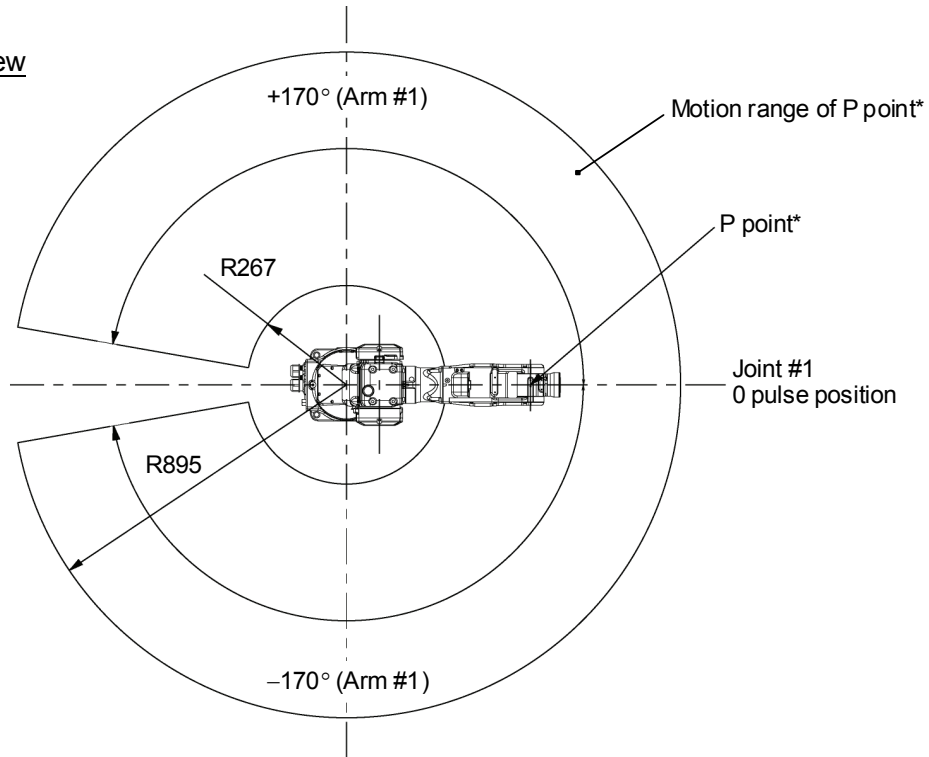


* P point: Intersection of the rotation centers for Joints #4, #5, and #6

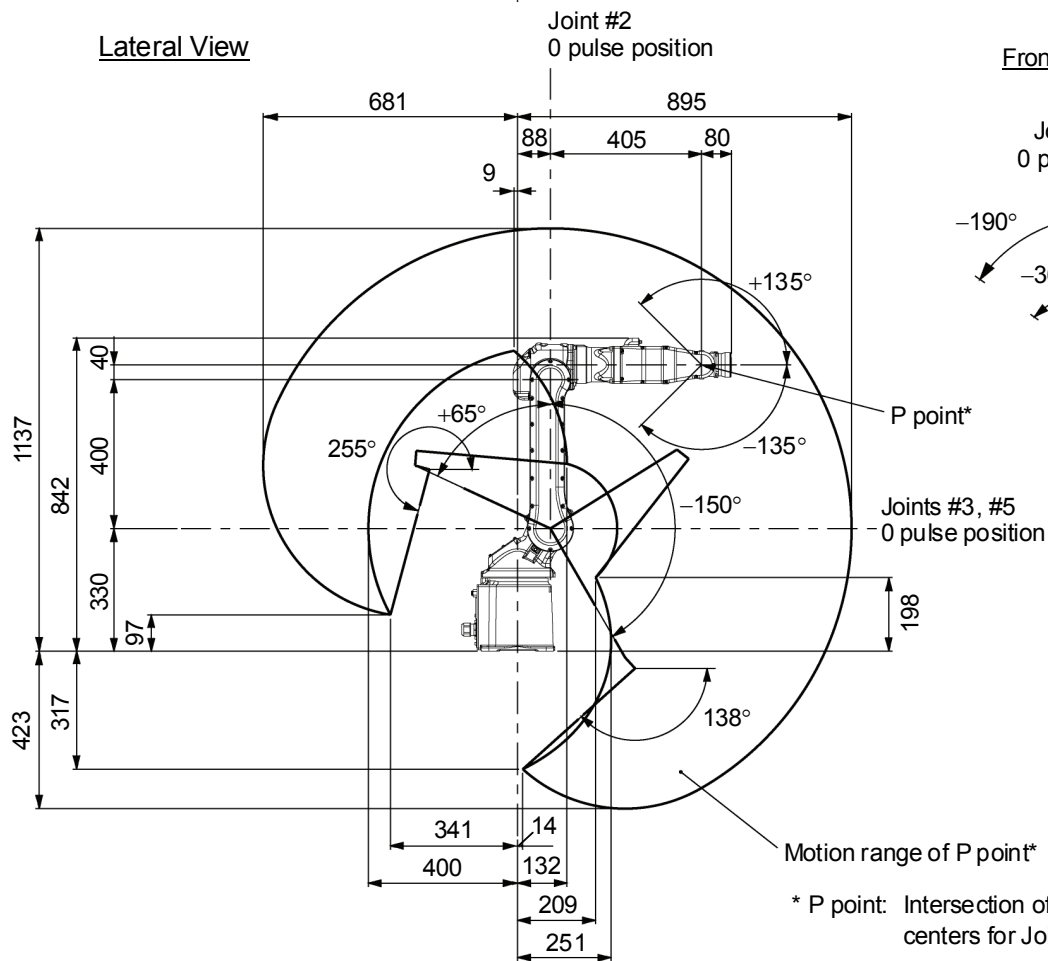
S5-A901**

[Unit: mm] (° = degree)

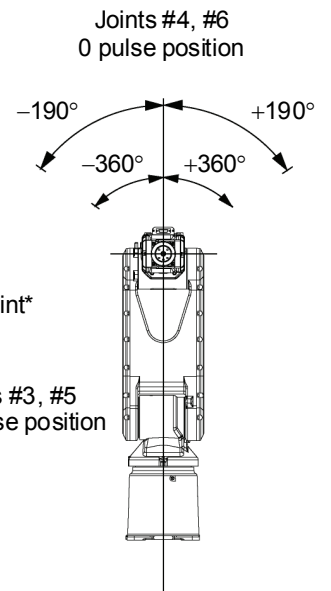
Top View



Lateral View



Front View



* P point: Intersection of the rotation centers for Joints #4, #5, and #6

2.4 Specifications

2.4.1 Specifications Table

Item		Specification					
Model Number		S5-A701S	S5-A701C	S5-A701P	S5-A901S	S5-A901C	S5-9701P
Degree of protection		-	-	IP65	-	-	IP65
Cleanliness level (ISO class)		-	Class 3	-	-	Class 3	-
Weight (not including cables, shipping jigs)		36 kg : 80 lb.			38 kg : 84 lb.		
Driving method		All arms		AC servo motor			
Max. operating speed ^{*1}	Arm #1	6.56 rad/s, 376 deg/s			4.71 rad/s, 270 deg/s		
	Arm #2	6.11 rad/s, 350 deg/s			4.88 rad/s, 280 deg/s		
	Arm #3	6.98 rad/s, 400 deg/s			5.23 rad/s, 300 deg/s		
	Arm #4	7.85 rad/s, 450 deg/s					
	Arm #5	7.85 rad/s, 450 deg/s					
	Arm #6	12.57 rad/s, 720 deg/s					
Repeatability	Arm #1 to #6	±0.02 mm			±0.03 mm		
Max. motion range	Arm #1	±170 deg (Wall mounting: ±30 deg)					
	Arm #2	-150 deg, +65 deg					
	Arm #3	-70 deg, +190 deg			-72 deg, +190 deg		
	Arm #4	±190 deg					
	Arm #5	±135 deg					
	Arm #6	±360 deg					
Max. pulse range	Arm #1	±5920402 pulse (Wall mounting: ±1044777 pulse)			±8120639 pulse (Wall mounting: ±1433054 pulse)		
	Arm #2	+2524350 pulse -5825423 pulse			+3155438 pulse -7281778 pulse		
	Arm #3	+6149057 pulse -2265442 pulse			+7686321 pulse -2912712 pulse		
	Arm #4	±5534152 pulse					
	Arm #5	±3932160 pulse					
	Arm #6	±6553600 pulse					
Resolution	Arm #1	0.00002871 deg/pulse			0.00002093 deg/pulse		
	Arm #2	0.00002574 deg/pulse			0.00002059 deg/pulse		
	Arm #3	0.00003089 deg/pulse			0.00002471 deg/pulse		
	Arm #4	0.00003433 deg/pulse					
	Arm #5	0.00003433 deg/pulse					
	Arm #6	0.00005493 deg/pulse					
Motor power consumption	Arm #1	400 W					
	Arm #2	400 W					
	Arm #3	200 W					
	Arm #4	50 W					
	Arm #5	50 W					
	Arm #6	50 W					
Payload ^{*2}	Rated	2 kg					
	Max.	(with conditions) 5 (7) kg					
Allowable moment	Arm #4	12 N·m (1.22kgf·m)					
	Arm #5	12 N·m (1.22kgf·m)					
	Arm #6	7 N·m (0.71kgf·m)					
Allowable moment of inertia (GD ² /4) ^{*3}	Arm #4	0.3 kg·m ²					
	Arm #5	0.3 kg·m ²					
	Arm #6	0.1 kg·m ²					

Item		Specification
Installed wire for customer use		15 wires : D-sub 15 pin connector
Installed pneumatic tube for customer use		2 pneumatic tubes (ø6 mm), Allowable pressure: 0.49MPa (5kgf/cm ²) (71 psi)
Environmental requirements *4	Ambient Temperature	0 deg.C to 45 deg.C (with minimum temperature variation)
	Ambient relative humidity	20% to 80% (no condensation)
Equivalent continuous A-weighted sound pressure level *5		L _{Aeq} = 80 dB (A) or under
Applicable Controller		RC180, RC620
Default values (Max. setting values)	SPEED	5 (100)
	ACCEL	5, 5 (100, 100)
	SPEEDS	50 (2000)
	ACCELS	200 (25000)
	FINE	10000, 10000, 10000, 10000, 10000, 10000 (65535, 65535, 65535, 65535, 65535, 65535)
	WEIGHT	2, 0
Safety standard		ANSI/RIA R15.06 compliance CE compliance EN775, EN60204-1, EN55011, EN61000-6-2, EN60950

*1 In the case of PTP control

*2 When the setting payload is more than 5 kg and less than or equal to 7 kg, refer to the section “*Restrictions on payload exceeding 5 kg (more than 5 kg and less than or equal to 7 kg)*” in the *Setup & Operation 4.3.1 WEIGHT Setting*.

*3 In the case where 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 environmental requirements, refer to the *Setup & Operation 3.1 Environmental Conditions*.

*5 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

2.4.2 Option Table

S5 series has the following options:

Item	Specification
Brake release unit	Refer to <i>Setup & Operation 1.5.1 Moving the Arm Using the Brake Release Unit</i> .
Camera plate	Call your EPSON Regional Sales Manager for the detail information.
PS compatible plate	
PS installation compatible plate	
Mechanical stops for Arm #1, #2, #3 *	

* If manipulator is equipped with the mechanical stop, it conforms to the safety standard “ANSI/RIA R15.06” and “CE”, but not to “UL1740”.

2.5 How to Set the Model

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



CAUTION

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

NOTE



If an MT label is attached to the rear of a 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.

The method for setting the Manipulator model depends on the software used. 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 necessary for the robot system to function properly and safely. Be sure to install the robot system in an environment that meets the following conditions:

Item	Conditions
Ambient temperature*1	0 deg C to 45 deg C (with minimum temperature variation)
Ambient relative humidity	20% to 80% (no condensation)
First transient burst noise	2 kV or less (Power 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.

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



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

For the Protection-model Manipulator, be sure to install the robot system in an environment that also meets the following conditions:

Item	Conditions
Environment	<ul style="list-style-type: none"> · Install indoors. · Keep away from direct sunlight. · Keep away from salinity or other contaminants. · Keep away from flammable or corrosive solvents (including water)*² and gases. · Keep away from shock or vibration. · Keep away from sources of electric noise. · It can be used under conditions with dust, oily smoke, metal powder or other contaminants.*³

*² The Manipulator body is mainly made of iron and aluminum. It is not rust-proofed. Do not use the Manipulator under conditions where the Manipulator can expose to water or any other corrosive liquid.

*³ Any contaminants that can deteriorate sealing performance of nitrile rubber oil sealing, O-rings, packing seals and liquid gasket should be avoided.

Special Environmental Conditions

The protective seals are attached on the Protection-model Manipulator to prevent dust, water, etc. from the outside. Follow the precautions in use environment described below:


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

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

If your requirements specify that the Manipulator handles food, please consult your distributor to check whether the Manipulator gives damage to the food or not.

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


The controller used with the Protection-model Manipulator does not have protection features for dusty, wet, or oily environment. The controller must be placed in an environment that meets the specified conditions.


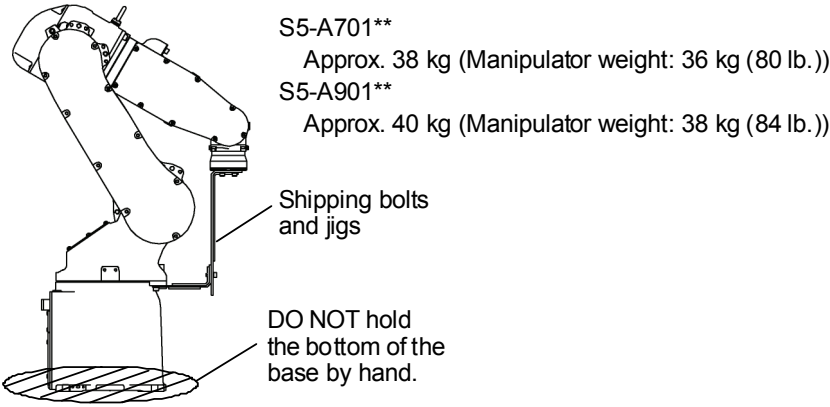
 WARNING	<ul style="list-style-type: none"> ■ Use an earth leakage breaker on the AC power cable of the Controller to avoid the electric shock and circuit breakdown caused by an unexpected water leak. Prepare the earth leakage brake that pertains the controller you are using. For details, refer to the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

 WARNING	<ul style="list-style-type: none"> ■ Only authorized personnel should perform sling work and operate a crane or 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.
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 CAUTION	<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 will fall. ■ Do not remove the wire tie securing the arm until you finish the installation. You may get your hands caught in the Manipulator when the wire tie is removed before completing the installation. ■ To carry the Manipulator, have at least 3 people to work on it and secure the Manipulator to the delivery equipment or hold it by hand. 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 or cut by the grounding electrode. <div style="text-align: center; margin: 10px 0;">  </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.
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Use a crane for transporting the Manipulator during unpacking and relocation.

When using a lifting device other than a crane or forklift for transportation, avoid applying external force to the arms and motors of the Manipulator.

Check that the eyebolts are securely fastened.

The weight of the Manipulator S5-A701** (S5-A901**) is approx. 38 (40) kg including the shipping bolts and jigs (the Manipulator weight: 36 (38) kg (80 (84) lb.)). Use a cable strong enough to withstand the weight.

The attached eyebolts are designed to support the Manipulator weight. Do not use them for anything other than transporting the Manipulator.

Mount the shipping bolts and jigs for transporting the Manipulator.

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

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.

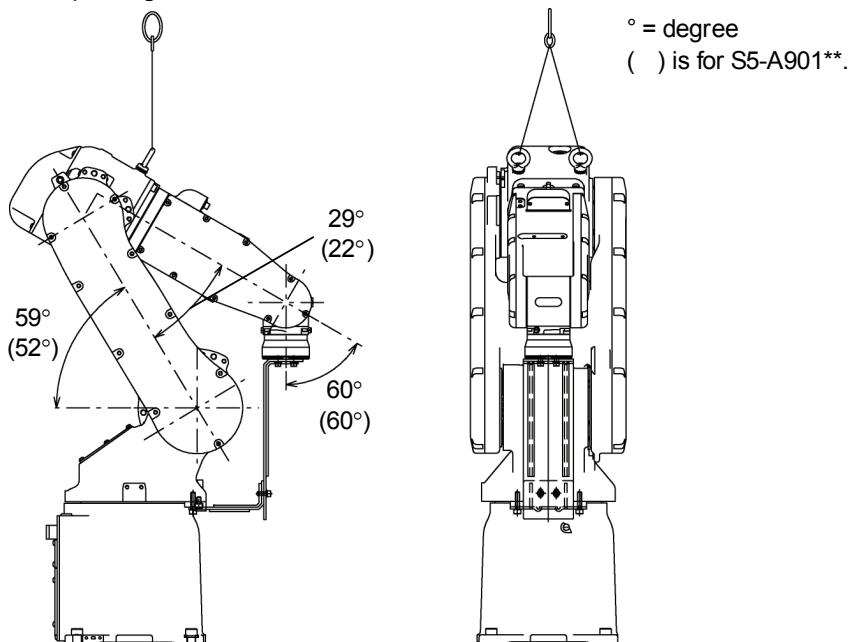
When condensation occurs on the Manipulator during transport or storage, turn ON the power only after the condensation dries.

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.

3.2.1 Using a Crane

To hoist the Manipulator with a crane, secure the Manipulator with shipping bolts and jigs and posture the Manipulator as shown in the figures below (the same posture as shipping). Using a cable threaded through the eyebolts attached to the Manipulator as shown.

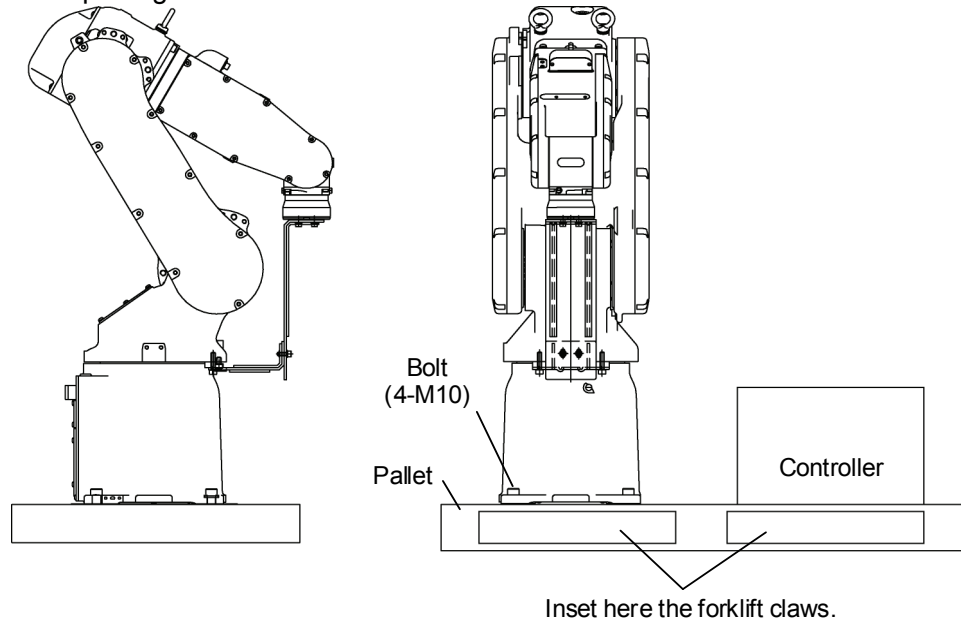
Transporting Posture



3.2.2 Using a Forklift

Position the Manipulator as shown in the figures below (the same posture as shipping) and secure it onto a pallet with shipping bolts and jigs. Insert the forklift claws under the pallet and transport the Manipulator together with the pallet. The pallet must have enough strength to bear the weight of the Manipulator. Transporting of the Manipulator must be performed slowly in order to avoid overturning or slippage.

Transporting Posture

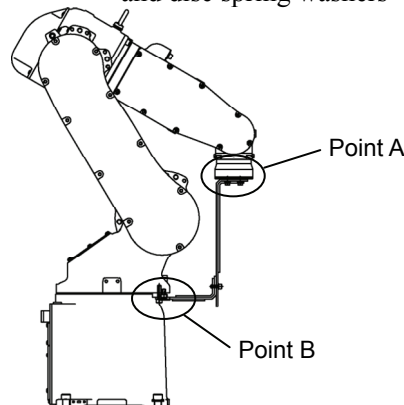


3.2.3 Removing / Attaching the Shipping Bolts and Jigs

The shipping bolts and jigs are attached to the Manipulator as shown the figure below (points A, B) for protecting the Manipulator from various external forces during transportation. The jigs are painted yellow.

Point A : 6-M5×14 hexagon socket head cap bolts with plain washers and disc spring washers

Point B : 2-M6×10 hexagon socket head cap bolts with plain washers and disc spring washers



Removal

- (1) Remove the bolts combining the shipping jigs at the point A.
6-M5×14 hexagon socket head cap bolts with plain washers and disc spring washers
- (2) Remove the bolts securing the shipping jigs at the point B. Then, remove the upper part of the shipping jigs.
2-M6×10 hexagon socket head cap bolts with plain washers and disc spring washers



Before turning on the power, be sure that the shipping bolts and jigs have been removed. The shipping bolts and jigs must then be stored for future use, in the event that the Manipulator must be moved again.

Installation

- (1) Position the Manipulator as show in the figure above.
- (2) Attach the upper part of the shipping jigs to the Manipulator at the point B. Secure it with the bolts.
2-M6×10 hexagon socket head cap bolts with plain washers and disc spring washers
- (3) Secure the shipping jigs at the point A with the bolts.
6-M5×14 hexagon socket head cap bolts with plain washers and disc spring washers

3.2.4 Relocating

Follow the procedures described below when relocating the Manipulator.

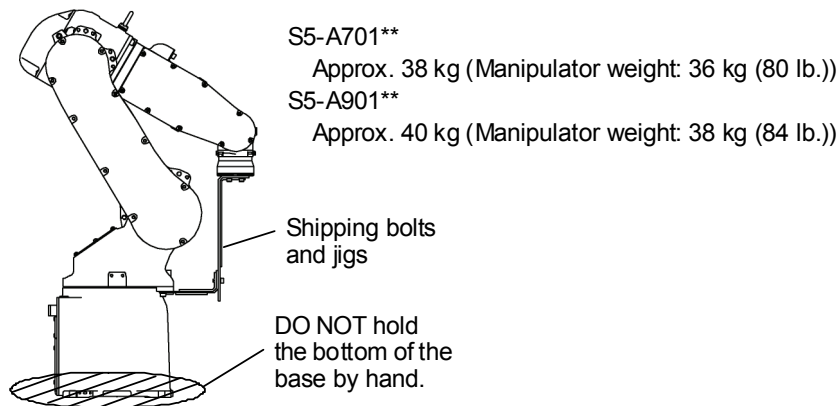
- (1) Turn OFF the power for all devices and unplug the cables.

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 of Arm #1 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 three or more people to carry the Manipulator. 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 or cut by the grounding electrode.



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.

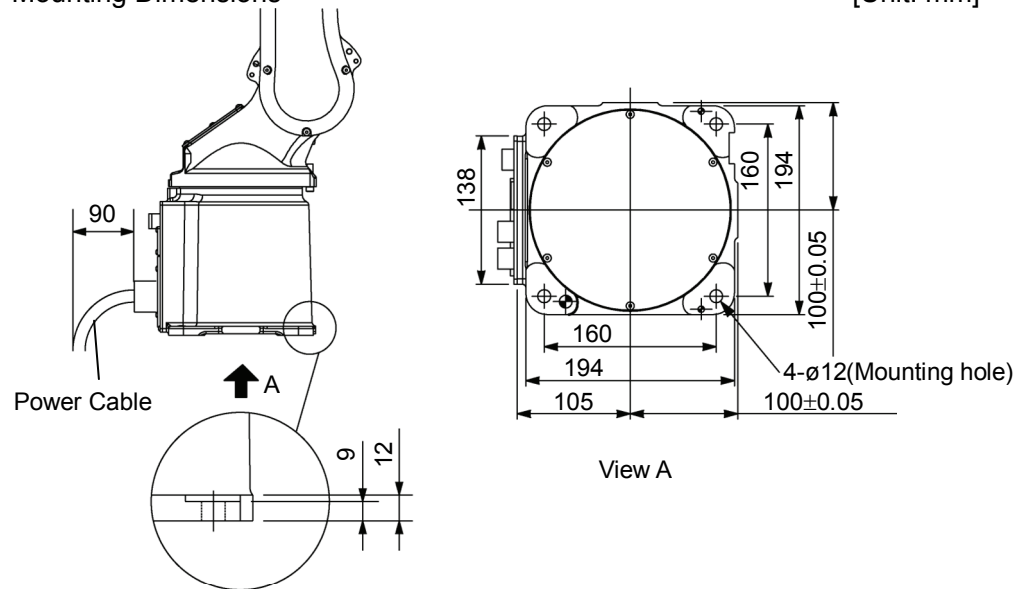
- Space for teaching points
- Space for maintenance and inspections
- Space for cables



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


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 or the <i>Safety 1.3 Design Precautions</i> in the SPEL CT User's Guide. ■ Install the Manipulator at a location with sufficient space so that a tool or a work piece on the end effector does not reach 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 and 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"> ■ Before first turning ON the power, be sure to remove the shipping bolts and jigs from the Manipulator. Turning ON the power while the shipping bolts and jigs are attached may result in equipment damage to the Manipulator. ■ Do not remove the wire tie securing the arm until you finish the installation. You may get your hands caught in the Manipulator when the wire tie is removed before completing the installation. ■ The robot system must be installed to avoid interference with buildings, structures, utilities, other machines and equipment that may create a trapping hazard or pinch points.
--	--

The following sections describe the installation of the Standard Manipulator.

- 3.4.1 Table Top Mounting
- 3.4.2 Floor Mounting

For Cleanroom-model / Protection-model Manipulator, refer to each section.

- 3.4.3 Cleanroom-model
- 3.4.4 Protection-model

3.4.1 Base Table Mounting

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 will differ depending on the use of the robot system. For your reference, we list some basic Manipulator table requirements here.

The base table must not only be able to bear the weight of the Manipulator but also be able to withstand the dynamic movement of the Manipulator when it operates at maximum acceleration. 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:

	S5-A701**	S5-A901**
Max. Horizontal rotating torque	600 N·m	900 N·m
Max. Horizontal reaction force	1000 N	1400 N
Max. Vertical rotating torque	800 N·m	900 N·m
Max. Vertical reaction force	3000 N	3500 N

There are 4 threaded holes for the Manipulator base. Use M10 mounting bolts conforming to the strength, ISO898-1 property class: 12.9. For the dimensions, refer to the *Setup & Operation 3.3 Mounting Dimensions*.

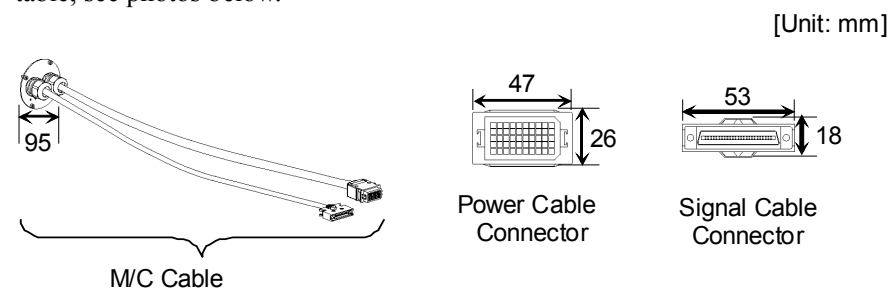
The plate for the Manipulator mounting face should be 30 mm thick or more and made of steel to reduce vibration. The surface roughness of the steel plate should be 25 μm or less.

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

The Manipulator must be installed horizontally.

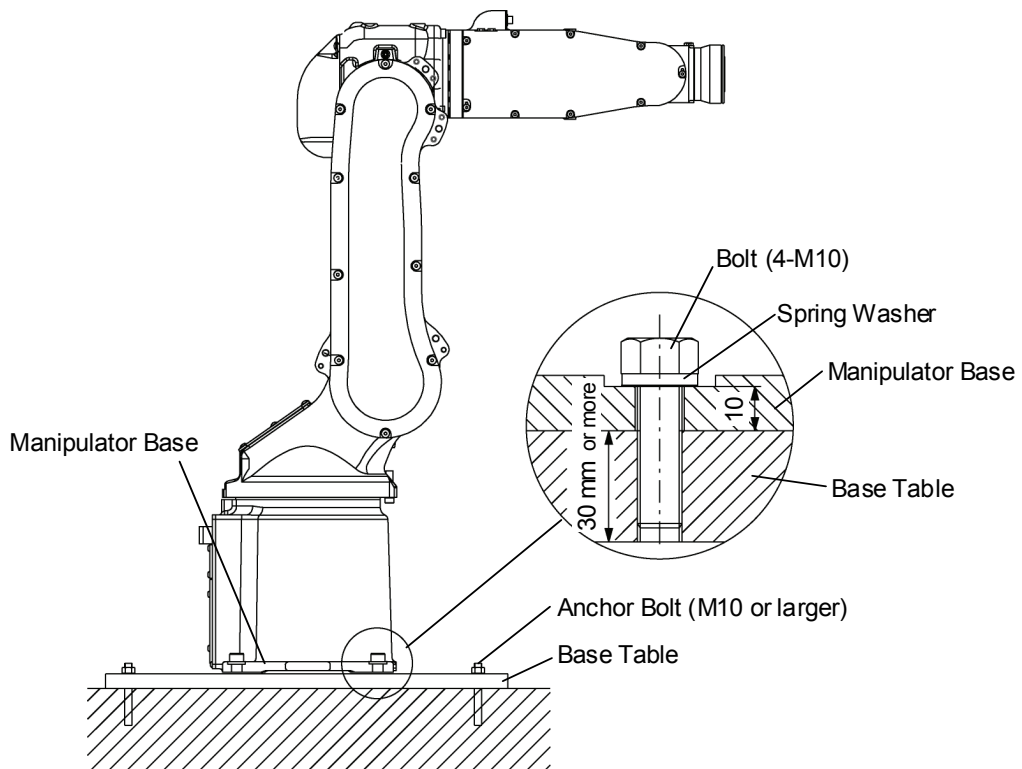
When using a leveler to adjust the height of the base table, use a screw with M16 diameter or more.

If you are making holes for the cables and passing the cables through the holes on the base table, see photos below.



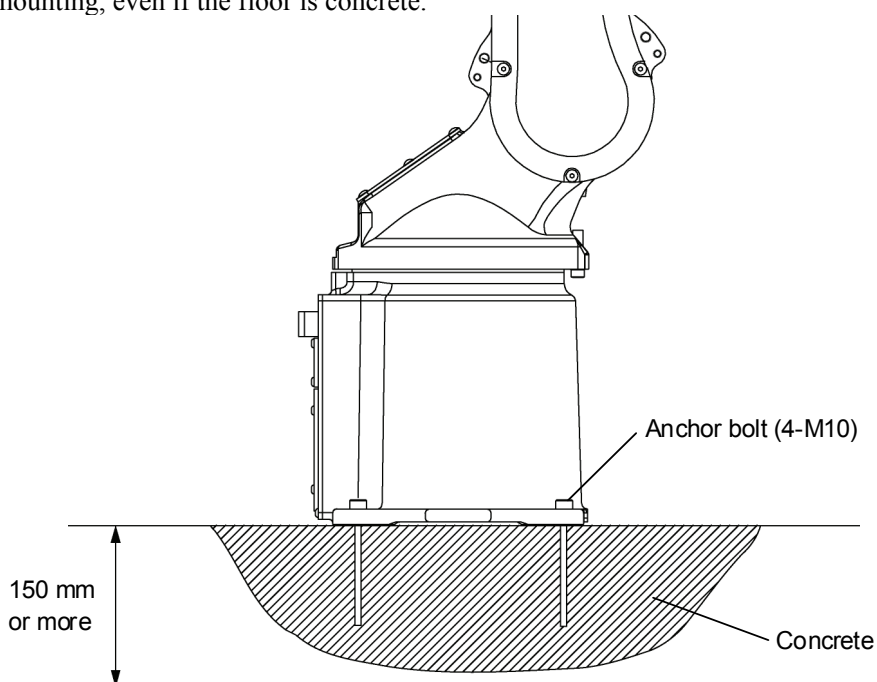
Do not remove the M/C cables from the Manipulator.

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



3.4.2 Floor Mounting

The floor should have enough strength to bear the weight of the Manipulator. Construct a solid foundation with the appropriate thickness to withstand maximum torque and reaction force of the Manipulator (refer to the table in *Setup & Operation 3.4.1 Base Table Mounting*). As a rough standard, when there is a concrete floor with thickness of 150 mm or more, the base of the Manipulator can be secured directly to the floor with M10 anchor bolts. However, before mounting the Manipulator, check that the floor is level and that all cracks, etc. are repaired. Any thickness less than 150 mm is insufficient for mounting, even if the floor is concrete.





3.4.3 Cleanroom-model

For Cleanroom-model Manipulator, the following procedure is necessary before 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) Refer to the installation procedure of each Manipulator model and install the Manipulator.
- (6) Connect an exhaust tube (\varnothing 8 mm) to the exhaust port.


3.4.4 Protection-model

Refer to the installation procedure of each Manipulator model and install the Manipulator. When the Manipulator is a Protection-model, be aware of the followings.

 WARNING	<ul style="list-style-type: none"> ■ Connect the power cable connection and the signal cable connector to the Manipulator immediately after the Manipulator installation. The Manipulator without connecting them may result in electric shock and/or malfunction of the robot system as it cannot ensure IP65.
 CAUTION	<ul style="list-style-type: none"> ■ When operating the Manipulator under special environmental conditions (adverse conditions with dust and oily smoke), do not place the controller in the same condition since the controller does not comply with IP65. Doing so may cause equipment damage to and/or malfunction of the controller.

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.
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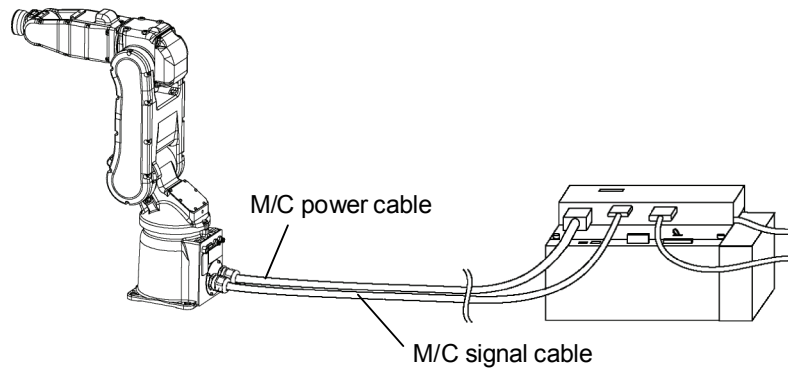
 CAUTION	<ul style="list-style-type: none"> ■ When connecting the Manipulator and the Controller, make sure that the serial numbers on each equipment match. Improper connection between the Manipulator and Controller may not only cause improper function of the robot system but also safety problems. The 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.
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3.5.1 Cable Connections

Cable Connections

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

<Example> Connection of S5 series Manipulator and Robot Controller RC180





Cleanroom-model


When the Manipulator is Cleanroom-model, be aware that it needs an exhaust system.

Protection-model

When the Manipulator is a Protection-model, be aware of the followings.

 WARNING	<ul style="list-style-type: none"> ■ Connect the power cable connection and the signal cable connector to the Manipulator immediately after the Manipulator installation. The Manipulator without connecting them may result in electric shock and/or malfunction of the robot system as it cannot ensure IP65.
 CAUTION	<ul style="list-style-type: none"> ■ When operating the Manipulator under special environmental conditions (adverse conditions with dust and oily smoke), do not place the controller in the same condition since the controller does not comply with IP65. Doing so may cause equipment damage to and/or malfunction of the controller.

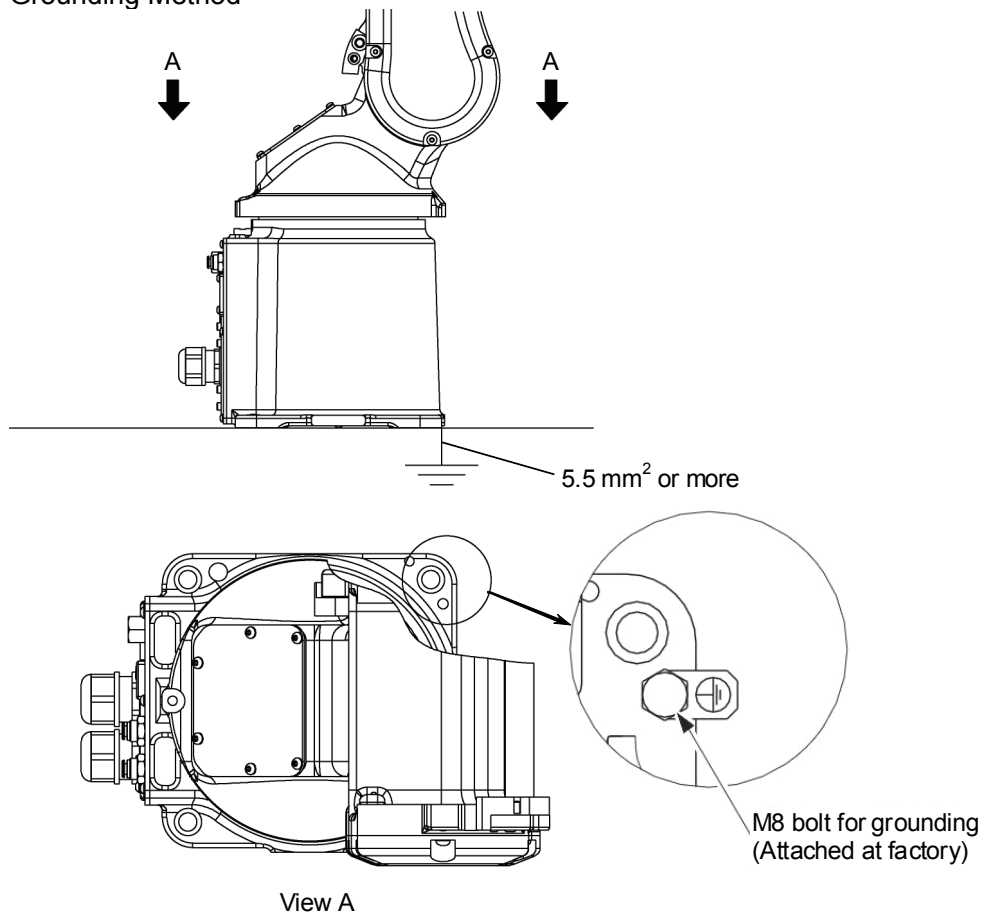
3.5.2 Grounding

 WARNING	<ul style="list-style-type: none"> ■ Ground resistance must be 100 Ω or less. Improper ground resistance may result in fire and/or electric shock. ■ Do not use the ground line for the Manipulator in common with other ground lines or grounding electrodes for other electric power, motor power, welding devices, etc. Using the ground line for the Manipulator in common with other ground lines or grounding electrodes may result in electric shock and/or malfunction of the robot system. ■ When using metal ducts, metallic conduits, or distributing racks for cable, ground in accordance with national and local electric equipment technical standards. Grounding that does not meet the standards may result in electric shock and/or malfunction of the robot system.
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Follow local regulations for grounding. It is recommended that the core size of the grounding wire be 5.5 mm² or more.

Directly connect the ground line to the Manipulator as shown in the figure below.

Grounding Method



3.6 Setting the Basic Pose for Calibration

After certain parts have been replaced (motors, reduction gear unit, belts, etc.), a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller. It is necessary to match these origins after replacing the parts. The process of aligning the two origins is called “Calibration”.

Before performing the calibration, a specific point must be set as “reference point”, and also the pose data (point data) on the reference point (hereinafter referred to as the “basic pose”) must be recorded. This must be carried out as soon as the robot system is installed. Follow the procedure below to record pulses of the basic pose.

For EPSON RC+, a coordinate point including the arm pose is defined as “point”. The data is called “point data”.

How to set the reference points for calibration

(1) Decide the reference points.

The reference points should be two or more around the points (poses) where your Manipulator moves frequently. Also, Arms #2, #3, and #5 should not form a straight line at these reference points (the Manipulator should not stretch completely). Be sure that the Manipulator moves to the reference points without problems.

(2) Attach the calibration jigs to the reference points.

Attach your end effector or the calibration jigs described in the section *Maintenance 12.3 Calibration Jig* to the Manipulator.

(3) Move the Manipulator to the reference points and set the basic pose as the point data.

Refer to the following manual for how to move the Manipulator.

EPSON RC+ 5.0 / EPSON RC+ 6.0

: *EPSON RC+ User's Guide* -

5.11.1 Robot Manager Command Tools: Robot Manager:

Jog and Teach Page

(4) Place tram marks on the Manipulator so that you can reproduce each joint position to create the set basic pose.

You should place tram marks on the Manipulator if the Manipulator cannot move to the 0 pulse positions.

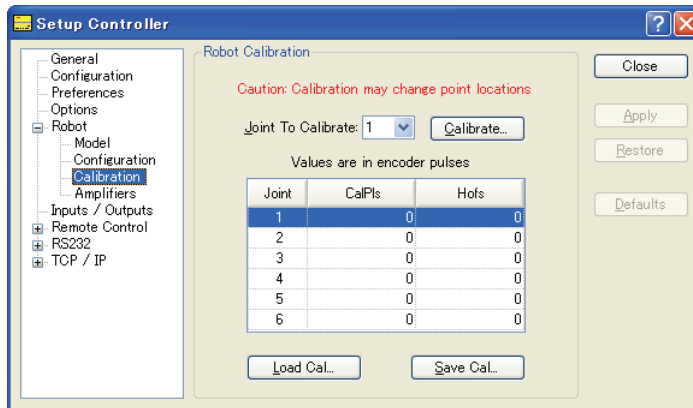
- (5) Display the origin data that are currently stored in the Controller and record them.
 (The origin data are not used in this calibration procedure. However, record the origin data in case of calibration failure.)

EPSON RC+ 5.0 (RC180)

Select menu-[Setup]-[Controller] to display the [Setup Controller] dialog.
 Select [Robot]-[Calibration] and “Hofs” values are indicated.

EPSON RC+ 6.0 (RC620)

Select menu-[Setup]-[System Configuration]-[Robot]-[Robot**]-[Calibration].




To save the “Hofs” value to a file, click the <Save> button.

- (6) Remove the calibration jigs.

When using the jigs explained in the *Maintenance 12.3 Calibration Jig*, remove the jig attached to the end effector after setting the reference points and basic pose. You can leave the other jigs attached. If you remove the jigs, attach them to the same positions for next calibration.

3.7 User Wires and Pneumatic Tubes

 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	Note
AC/DC30 V	3.1 A	15	0.2 mm ²	Shielded

	Manufacture	Standard	
Suitable Connector	JST	Wrist	
		JAZ-15S-3 (D-sub) *JST*	(On the Manipulator side)
		JAZ-15P-3 (D-sub) *JST*	(On the other side)
		Base	
		JAZ-15P-3 (D-sub) *JST*	(On the Manipulator side)
		JAZ-15S-3 (D-sub) *JST*	(On the other side)


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

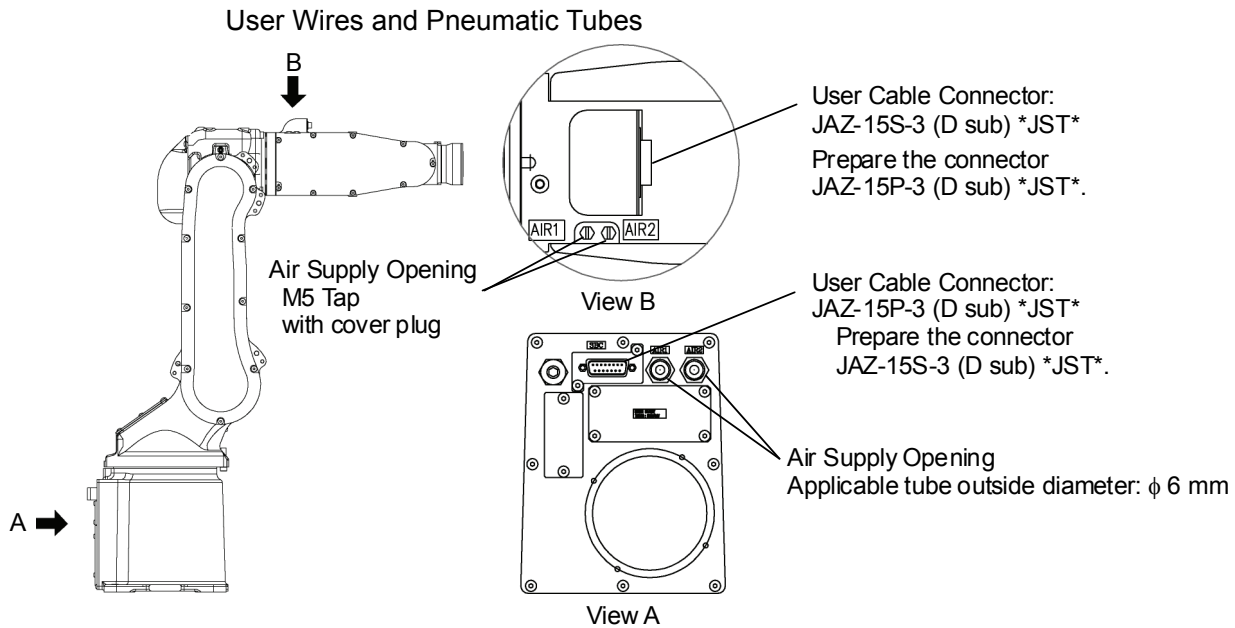
Pneumatic Tubes

Max. Usable Pneumatic Pressure	Pneumatic Tubes	Outer Diameter × Inner Diameter
0.49 MPa (5 kgf/cm ²) (71 psi)	2	ø 6 mm × ø 4 mm

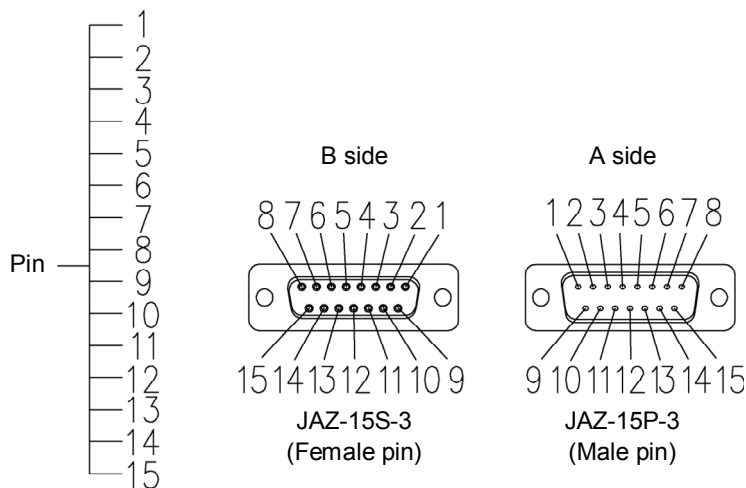
Fittings for ø 6 mm (outer diameter) pneumatic tubes are supplied on the both ends of the pneumatic tubes.

When the Manipulator is a Protection-model, be aware of the followings.

 CAUTION	<ul style="list-style-type: none"> Be sure to use IP65 compliant wires and tubes when using the Manipulator under special environmental conditions (adverse condition with dust and oily smoke). Using unprotected wires and tubes may cause equipment damage to and/or malfunction of the Manipulator as proper operation of the Manipulator under the conditions is no more guaranteed. Be sure to attach the cap on the user cable connector when not using the connector. Using the Manipulator without the cap may cause equipment damage to and/or malfunction of the Manipulator as dust or oily smoke gets into the connector.
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Numbers of Pins in Use



The same pin number (1-15) of two connectors is connected in the lead line of single 0.2 mm².

When the Manipulator is a Protection-model, be aware of the followings.


 CAUTION	<ul style="list-style-type: none"> Be sure to attach the cap on the user cable connector when not using the connector. Using the Manipulator without the cap may cause equipment damage to and/or malfunction of the Manipulator as dust or oily smoke gets into the connector.
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4. End Effectors

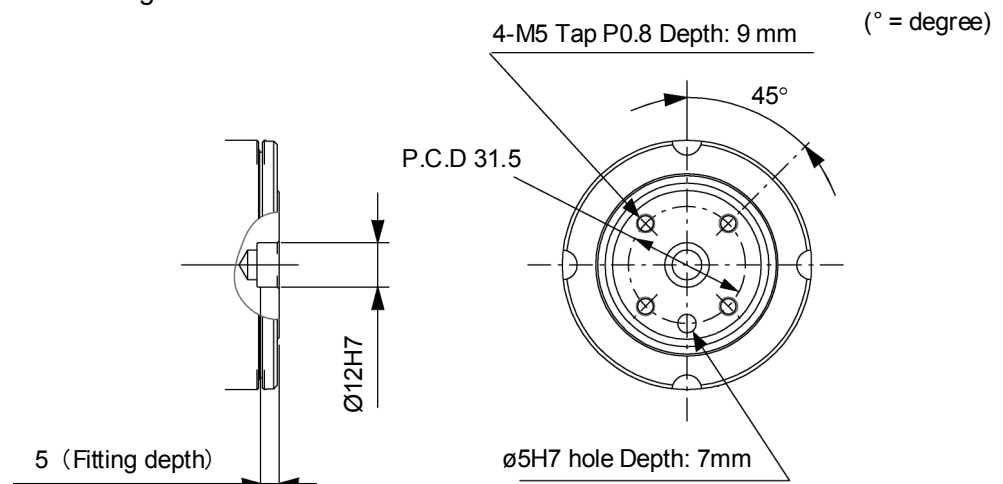
4.1 Attaching an End Effector

Create an end effector for your Manipulator that will attach to Arm #6. Before attaching the end effector to the end of Arm #6, observe these guidelines.

The wrist flange dimensions are shown in the following figure. In order to see the tram marks, it is recommended that the attachment be mounted inside the fitting. Fitting depth of inside and outside fittings must be 5 mm or less.

 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



Wash off anti-corrosive paint (solid yellow paint) on the wrist flange surface with thinner or light oil before mounting the end effector.

Arm #6

Attach an end effector to the end of the Arm #6 using an M5 bolt.

Layouts

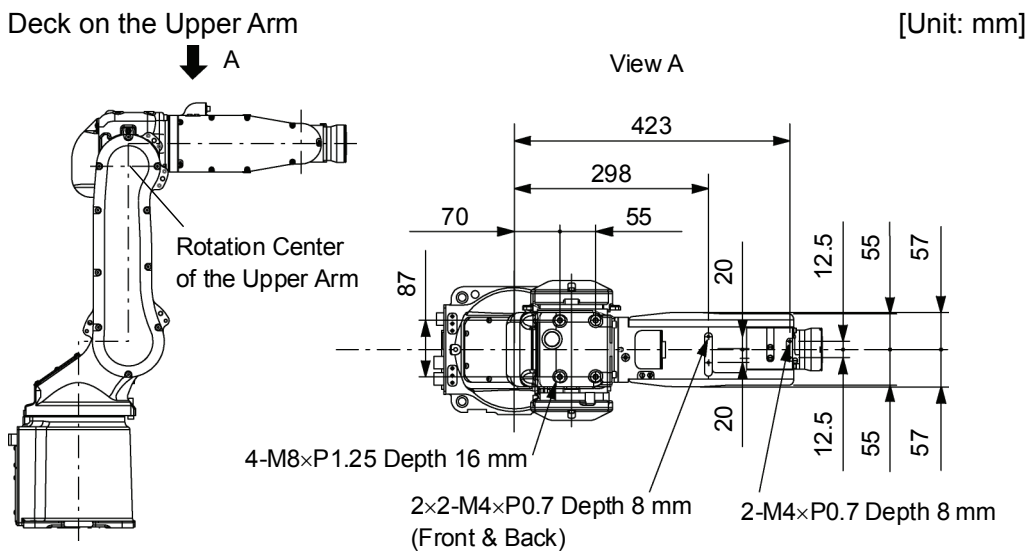
When you operate the Manipulator with an end effector, the end effector may interfere with the Manipulator because of the outer diameter of the end effector, the size of the work piece, or the position of the arms. When designing your system layout, pay close attention to the interference area of the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

4.2 Attaching Valves

There are two decks on the upper arm called “upper arm rear deck” and “upper arm center deck” as shown in the figures below to mount peripheral equipment such as valves.

When the weight on the fore-end of Arm #6 is 5 kg or less, the available weight on the deck is 6 kg or less including the weight on Arm #6. For example, when the weight on Arm #6 is 5 kg, the remaining 1 kg is available weight on the deck.

For details of the payload exceeding 5 kg, refer to the section *Setup & Operation 4.3.1 WEIGHT Setting - “Restriction on payload exceeding 5 kg (more than 5 kg and less than or equal to 7 kg)”*.



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 for the Manipulator movement are reduced.

INERTIA Setting

The INERTIA command is for setting the moment of inertia and the eccentricity of the load. The more the moment of inertia 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, it is important to make sure that the load (weight of the end effector and work piece) and moment of inertia of the load are within the maximum rating for the Manipulator, and that Arm #6 does not become eccentric.

If the load or moment of inertia exceed 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 moment of inertia of the end effector and work piece is bigger.

The allowable weight for S5 series Manipulators is up to 5 kg (7 kg*). However, the moment and the moment of inertia should also be considered due to limitations for these factors.

If force is applied to the Manipulator instead of the weight, force on the Arms #4, #5, and #6 should be within the values shown in the table “Allowable Moment and Moment of Inertia for S5 series Manipulators”.

- * When the load of the Manipulator is more than 5 kg and less than or equal to 7 kg, refer to the section *Setup & Operation 4.3.1 WEIGHT Setting - “Restriction on payload exceeding 5 kg (more than 5 kg and less than or equal to 7 kg)”*.

Allowable Moment and Moment of Inertia for S5 series Manipulators

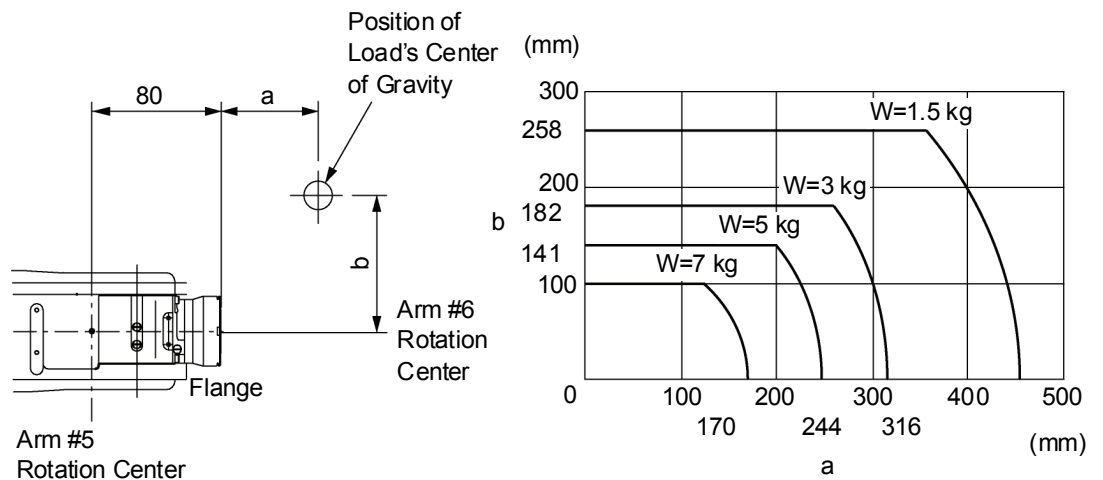
Arm	Allowable Moment N·m (kgf·m) ^{*1}	GD ² /4 Allowable Moment of Inertia (kg·m ²)
#4	12 (1.22)	0.3
#5	12 (1.22) ^{*2}	0.3 ^{*2}
#6	7 (0.71)	0.1

*1 Gravitational unit

*2 The allowable moment and allowable moment of inertia of Arm #5 are calculated by the distance from the Arm #5 rotation center (a + 80 mm). (Refer to the figure in the “Critical Location of the Load on S5 series Manipulators”).

The following figure shows the critical location of the load on the S5 series Manipulators.

Critical Location of the Load on S5 series Manipulators



a: Distance from the Flange
 b: Distance from the Arm #6 Rotation Center

When calculating the critical location of the load on the Arm #5 using the allowable moment and allowable moment of inertia, 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 location of the load on Arm #5, subtract 80 (mm) from the calculated distance from the Arm #5 rotation center as shown the example below.

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

$$\begin{aligned} \text{Allowable Moment of the Arm \#5 (N}\cdot\text{m)} / \text{Load (kg)} \\ &= \text{Distance from the Arm \#5 rotation center (m)} \\ 12 \text{ (N}\cdot\text{m)} / 9.8 / 5 \text{ (kg)} &= 0.2448 \rightarrow 0.295 \text{ (round down) (m)} = 244 \text{ (mm)} \\ \\ c \text{ (mm)} &= \text{Distance from the Arm \#5 rotation center (mm)} - 80 \text{ (mm)} \\ c &= 244 \text{ (mm)} - 80 \text{ (mm)} = 164 \text{ (mm)} \end{aligned}$$

Moment

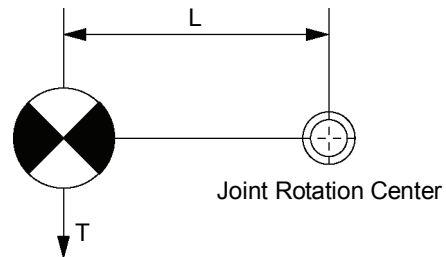
A moment is a necessary torque (holding torque) to counteract the gravity affecting the load.

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)




Maximum eccentric quantities of load for S5 series Manipulators are shown in the following table.

Max. Eccentric Quantity of Load for S5 series Manipulators

Axis	Max. Eccentric Quantity of Load (mm) (Distance between the joint rotation center and the load's center of gravity)			
	WEIGHT 1.5 kg	WEIGHT 3 kg	WEIGHT 5 kg	WEIGHT 7 kg
#5	447 mm	316 mm	244 mm	174 mm
#6	258 mm	183 mm	141 mm	101 mm

4.3.1 WEIGHT Setting

 CAUTION	<ul style="list-style-type: none"> ■ Set the total weight of the end effector and the work piece to 5 kg or less. The S5 series Manipulators can operate without limitations on the condition that the load of the Manipulator should be 5 kg or less. When the payload of the Manipulator is more than 5 kg and less than or equal to 7 kg, refer to the section “<i>Restrictions on payload exceeding 5 kg (more than 5 kg and less than or equal to 7 kg)</i>” 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.
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The acceptable weight capacity (end effector and work piece) for S5 series Manipulators is 2 kg nominal rating and 5 (7*) kg maximum. When the load (weight of the end effector and work piece) exceeds the rating, change the setting of the Weight parameter.

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

* When the payload of the Manipulator is more than 5 kg and less than or equal to 7 kg, refer to the section “*Restrictions on payload exceeding 5 kg (more than 5 kg and less than or equal to 7 kg)*” in the later part of this section for details.

Setting method of Weight parameters

From EPSON RC+-[Tools]-[Robot Manager], enter into the [Weight:] text box on the [Weight] panel.

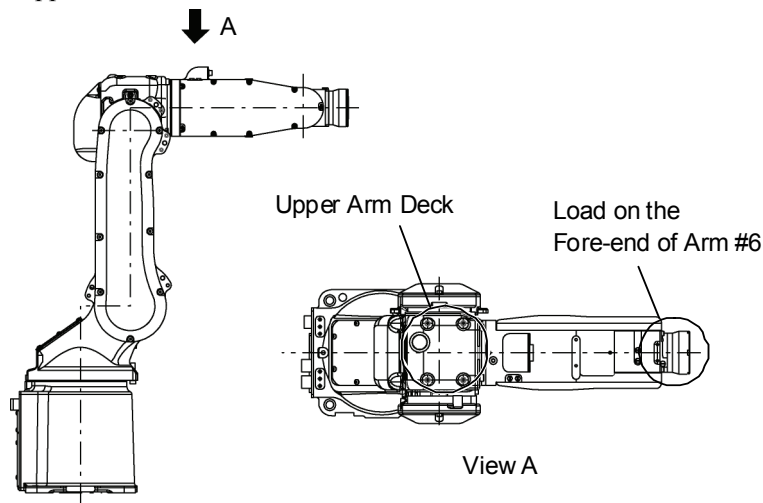
You may also execute the Weight command from [Command Window].

Load on the Manipulators

The Manipulator can load valves or any other devices onto the following two points.

A point on the fore-end of the Arm #6

Upper arm deck



When you attach the equipment to the deck 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 following the formula below and enter the value.

Weight Parameter Formula

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

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

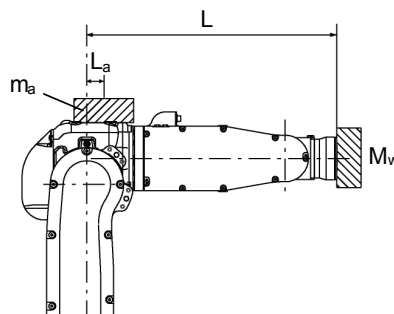
W_a : Equivalent weight of the upper arm deck (kg)

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

m_a : Weight of the equipment on the upper arm deck

L : Length of the upper arm (mm)

L_a : Distance between the Joint #3 and the center of gravity of the equipment on the upper arm deck (mm)



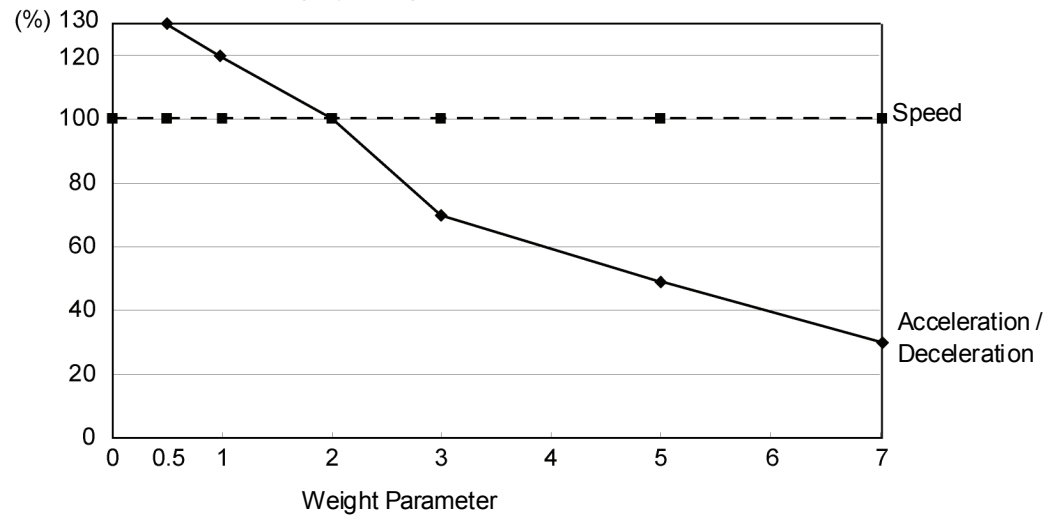
<Example> The fore-end of Arm #6 is 385 mm (L) away from the Joint #3.
 Load on the fore-end of Arm #6 is 1 kg (M_w).
 Load on the upper arm deck is 1.5 kg (m_a).
 The deck is 60 mm (L_a) away from Joint #3.

$$W_a = 1.5 \times 60^2 / 385^2 = 0.036 \rightarrow 0.04 \text{ (round up)}$$

$$M_w + W_a = 1 + 0.04 = 1.04$$

Enter “1.04” for the Weight parameter.

Automatic speed setting by Weight parameter



- * The percentage in the graph is based on the speed at rated weight (2 kg) as 100%.
- * When the payload of the Manipulator is more than 5 kg and less than or equal to 7 kg, refer to the section “Restrictions on payload exceeding 5 kg (more than 5 kg and less than or equal to 7 kg)” in the later part of this section for details.

Restrictions on payload exceeding 5 kg (more than 5 kg and less than or equal to 7 kg)

Although the maximum payload of the S5 series Manipulator is 5 kg, you can increase the payload up to 7 kg when you restrict the arm pose range of Arm #5 as shown below.

When the payload exceeds 5 kg, the arm pose of Arm #5 should be within the restricted angle range shown in the following graph.

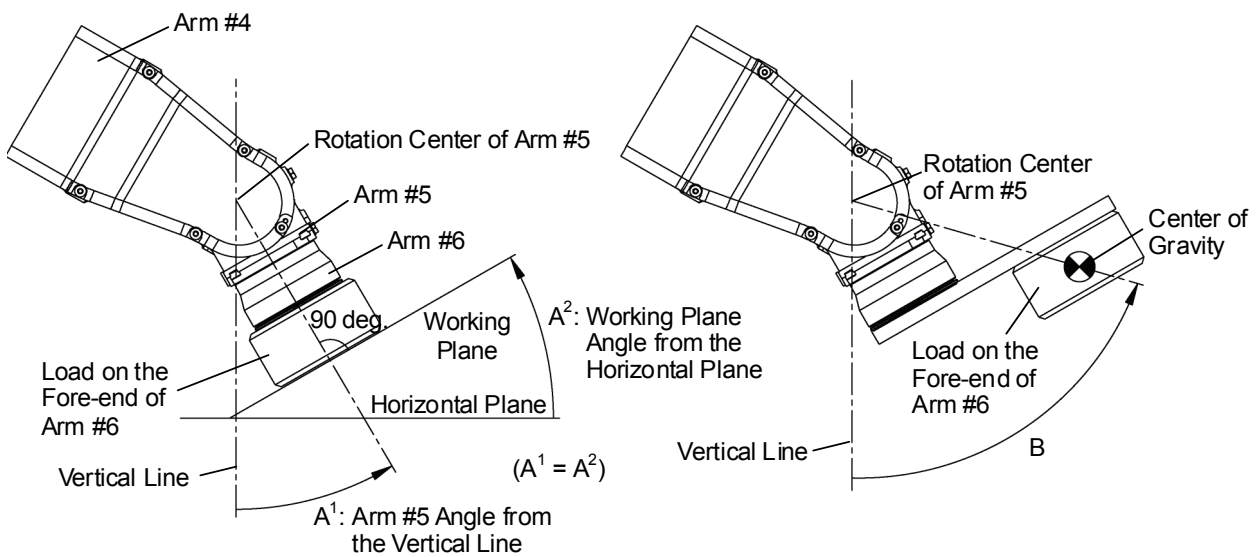
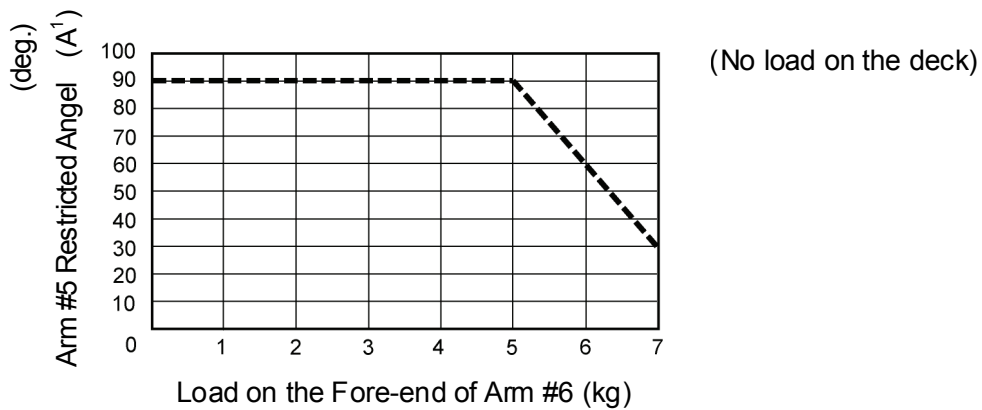
The graph shows the relation between the load and the Arm #5 restricted angel (A^1) measured vertically (in the direction of gravitational effect). The more the load on the fore-end of Arm #6 increases, the more the restricted angle range narrows.

When the Manipulator operating direction is vertical to the working plane, the arm pose restriction of the Arm #5 is equivalent to the tilt restriction of working plane (A^2).

In the case of eccentric load, the restricted angle is an angle (B) forming with a vertical line and a straight line passing through the center of gravity of load and the rotation center of Arm #5.

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

Relation between load and Arm #5 restricted angle




Relation between Arm #5 Angle and Working Plane Angle

Restricted Angle for Eccentric Angle

4.3.2 INERTIA Setting

Moment of Inertia and the INERTIA Setting

The moment of inertia is defined as “the ratio of the torque applied to a rigid body and its resistance to motion”. This value is typically referred to as “the moment of inertia”, “inertia”, or “ 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 moment of inertia of load (weight of the end effector and work piece) must be $0.1 \text{ kg}\cdot\text{m}^2$ or less. The S5 series Manipulators are not designed to work with moment of inertia exceeding $0.1 \text{ kg}\cdot\text{m}^2$. Always set the moment of inertia (INERTIA) parameter according to the moment of inertia. Setting a value that is smaller than the actual moment of inertia may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.
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The acceptable moment of inertia of load in S5 series Manipulator is $0.1 \text{ kg}\cdot\text{m}^2$ nominal rating and $0.1 \text{ kg}\cdot\text{m}^2$ maximum. When the moment of inertia of load exceeds the rating, change the setting of the moment of inertia using the INERTIA command. After the setting has been changed, the maximum acceleration/deceleration speed of Arm #6 responding to “moment of inertia” is set automatically.

Moment of inertia of load on Arm #6

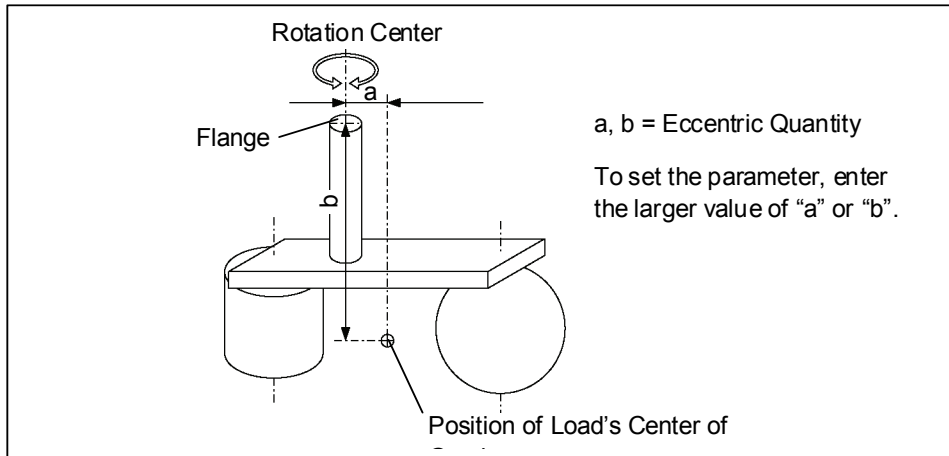
The moment of inertia of load (weight of the end effector and work piece) on Arm #6 can be set by the “moment of inertia (INERTIA)” parameter of the INERTIA command.

From EPSON RC+[Tools]-[Robot Manager], enter into the [Load inertia:] text box on the [Inertia] panel.

You may also execute the Inertia command from [Command Window].

Eccentric Quantity and the INERTIA Setting

The acceptable eccentric quantity of load in S5 series Manipulators is 50 mm nominal rating. When the eccentric quantity of load exceeds the rating, change the setting of eccentric quantity parameter using the INERTIA command. After the setting has been changed, the maximum acceleration/deceleration speed of Manipulator corresponding to “eccentric quantity” is set automatically.



Eccentric Quantity

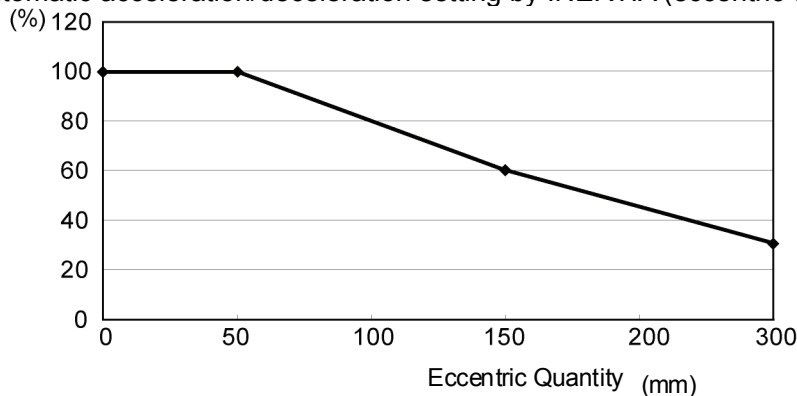
Eccentric quantity of load on Arm #6

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

From EPSON RC+-[Tools]-[Robot Manager], enter into the [Eccentricity:] text box on the [Inertia] panel.

You may also execute the Inertia command from [Command Window].

Automatic acceleration/deceleration setting by INERTIA (eccentric quantity)

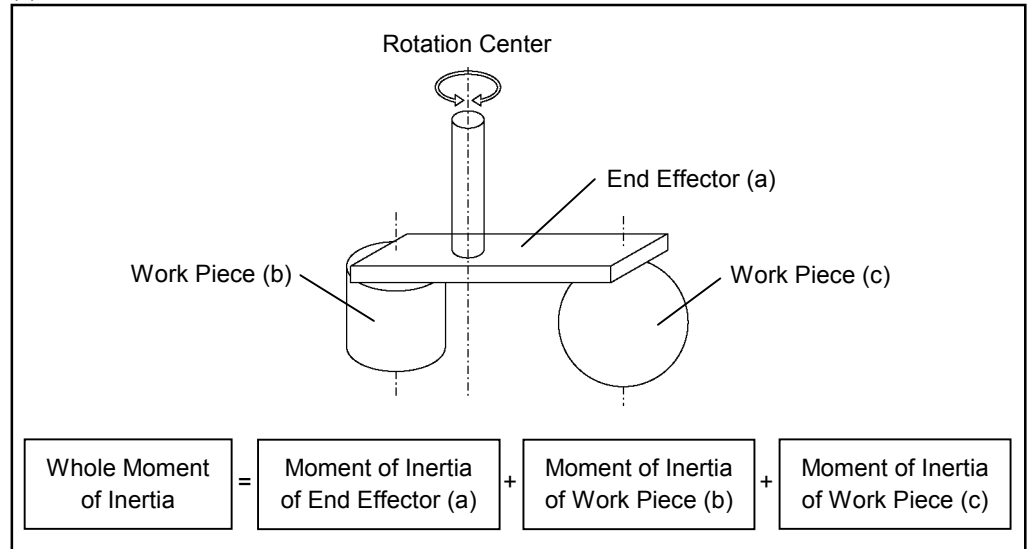


* The percentage in the graph is based on the acceleration/ deceleration at rated eccentricity (50 mm) as 100%.

Calculating the Moment of Inertia

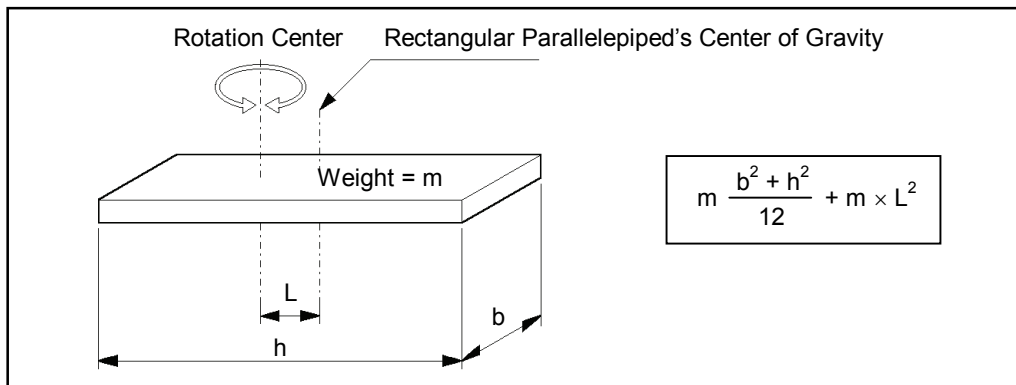
Refer to the following examples of formulas to calculate the moment of inertia of load (end effector with work piece).

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

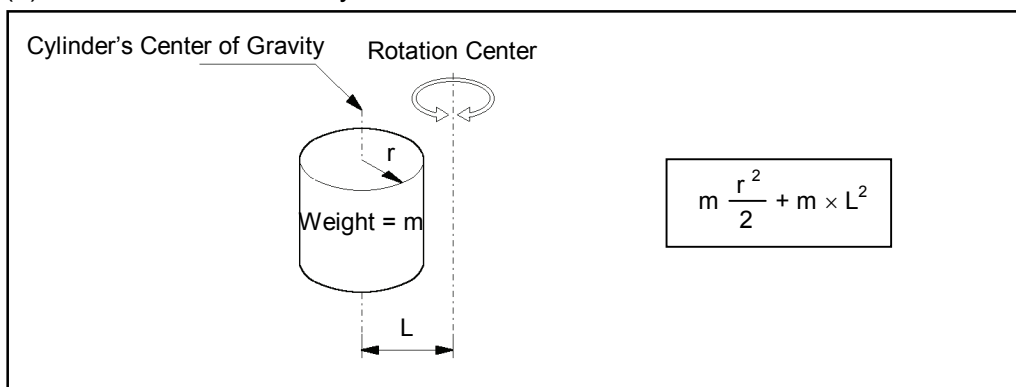


The methods for calculating the moment of inertia for (a), (b), and (c) are shown on this page or the next page. Find the whole moment of inertia using the basic formulas on the next page.

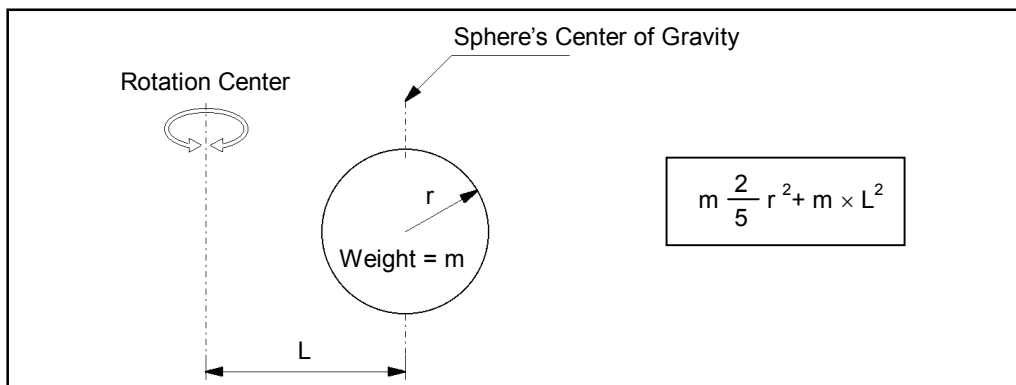
(a) Moment of inertia of a rectangular parallelepiped



(b) Moment of inertia of a cylinder



(c) Moment of inertia of a sphere



4.4 Precautions for Auto Acceleration/Deceleration

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 moment of inertia 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 moment of inertia 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



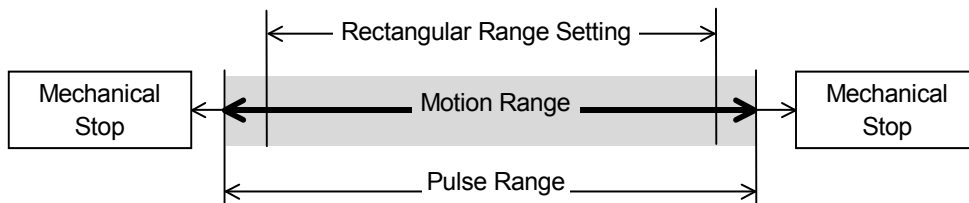
WARNING

- When setting up the motion range for safety, both the pulse range and mechanical stops must always be set at the same time. Failure to set both of them together may cause serious safety problems.

The motion range is preset at the factory as explained in the section “Standard Motion Range” in the *Setup & Operation 2.3 Appearance*. This is the maximum motion range of the Manipulator.

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

1. Setting by pulse range (for all 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 to 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 between the pulse lower limit and upper limit of each axis.

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

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

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

5.1.1 Max. Pulse Range of Arm #1

5.1.2 Max. Pulse Range of Arm #2

5.1.3 Max. Pulse Range of Arm #3

5.1.4 Max. Pulse Range of Arm #4

5.1.5 Max. Pulse Range of Arm #5

5.1.6 Max. Pulse Range of Arm #6



CAUTION

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



NOTE

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

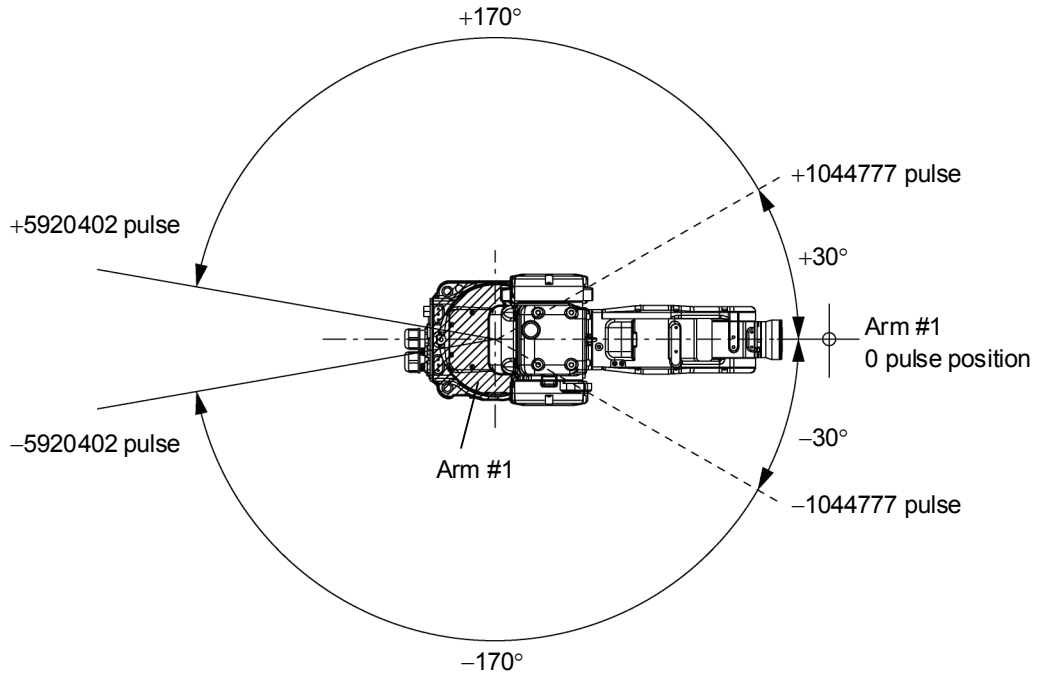
The pulse range can be set from EPSON RC+-[Tools]-[Robot manager]-[Range] panel.

You may also execute the Range command from the [Command Window].

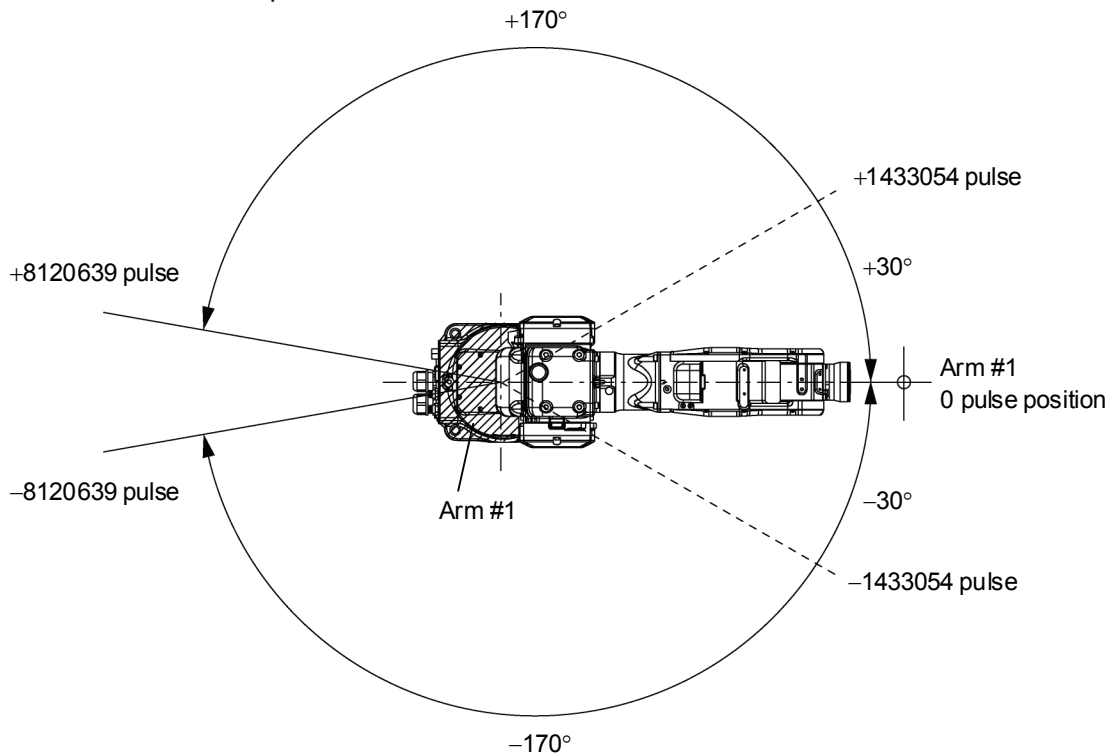
5.1.1 Max. Pulse Range of Arm #1

The 0 pulse position for Arm #1 is shown in the figure below. Counterclockwise pulse values are positive (+) and clockwise pulse values are negative (-).

S5-A701** Top View



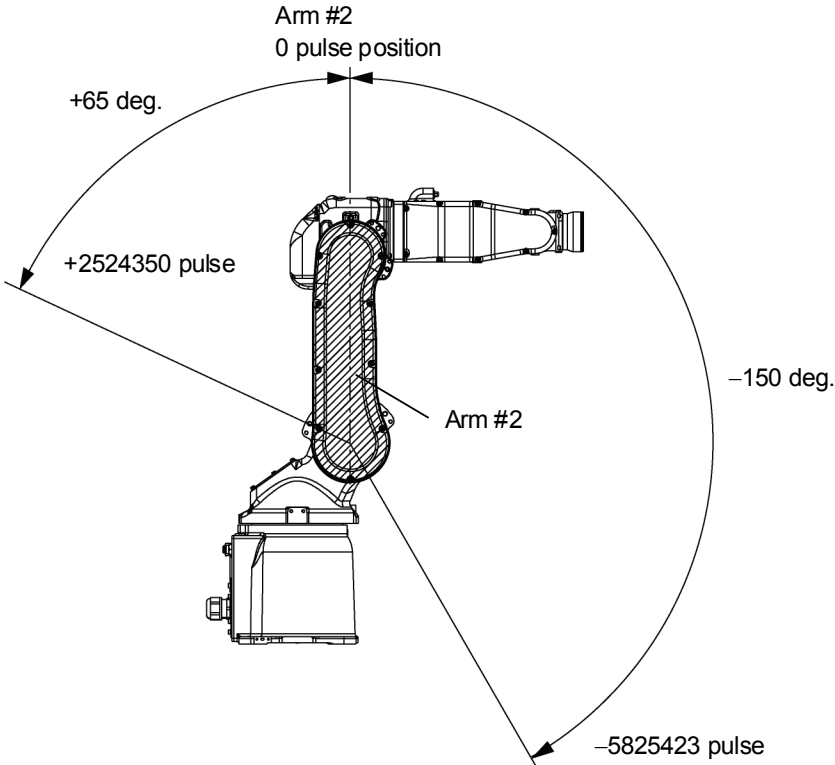
S5-A901** Top View



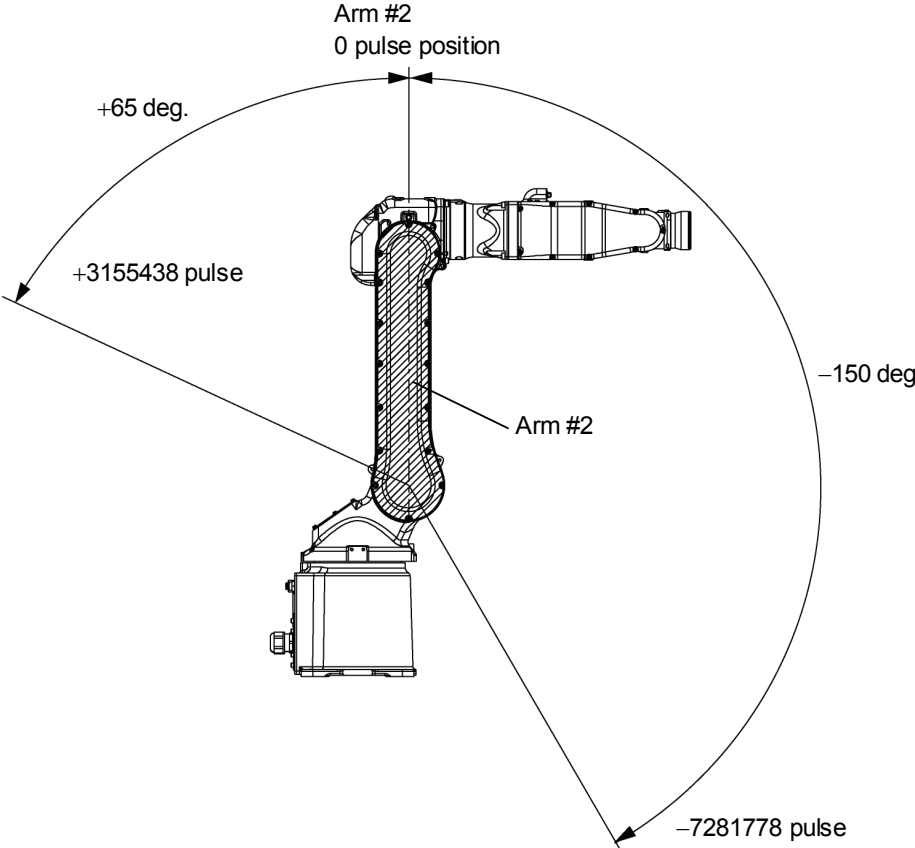
5.1.2 Max. Pulse Range of Arm #2

The 0 pulse position for Arm #2 is shown in the figure below. Counterclockwise pulse values are positive (+) and clockwise pulse values are negative (-).

S5-A701** Lateral View



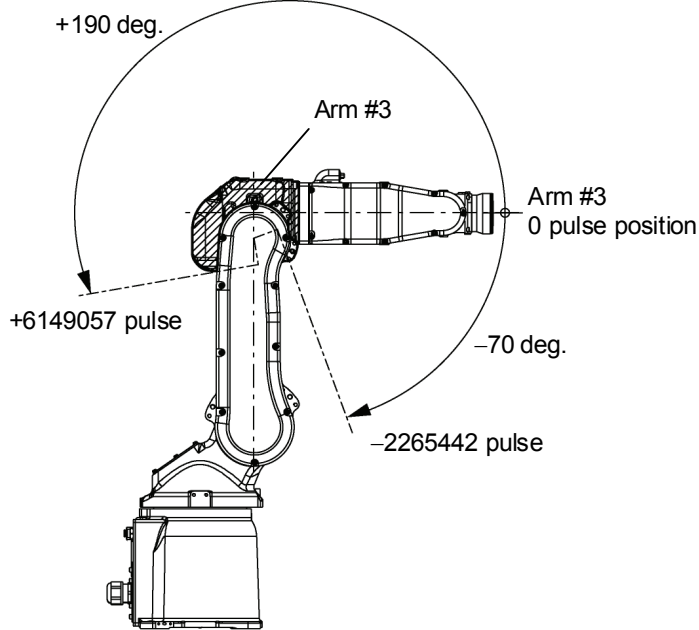
S5-A901** Lateral View



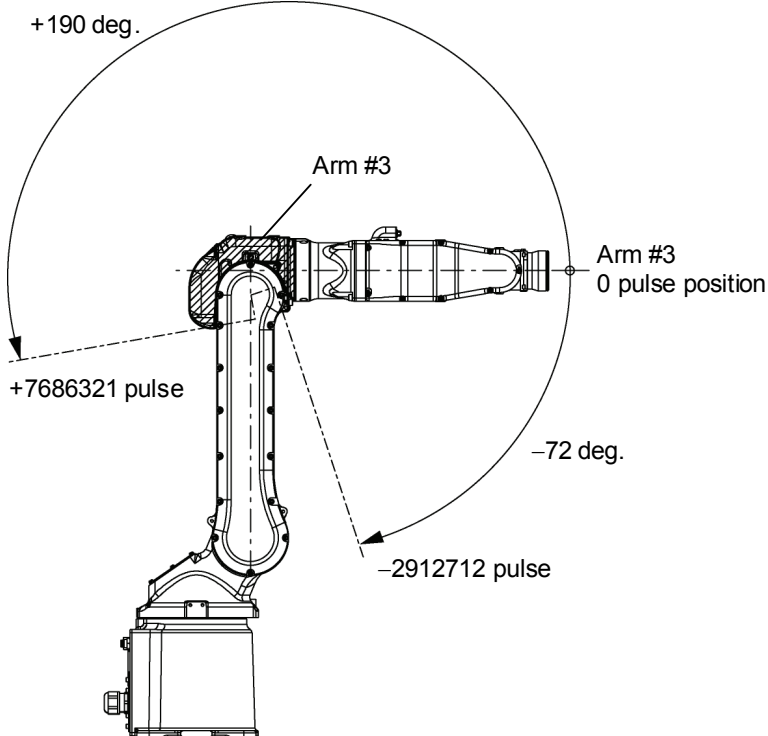
5.1.3 Max. Pulse Range of Arm #3

The 0 pulse position for Arm #3 is shown in the figure below. Counterclockwise pulse values are positive (+) and clockwise pulse values are negative (-).

S5-A701** Lateral View

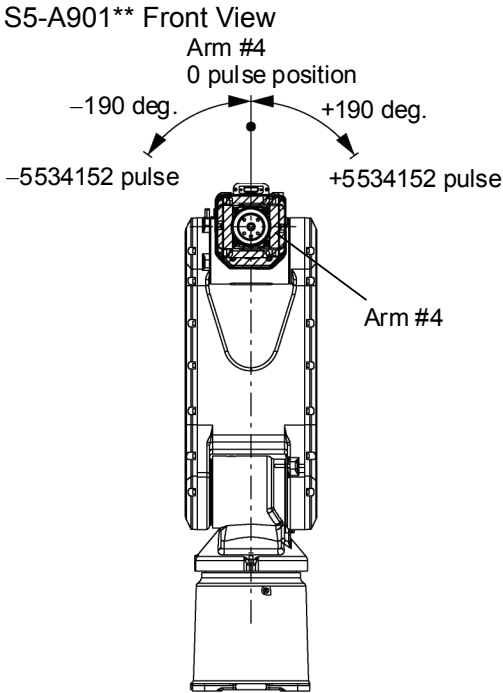
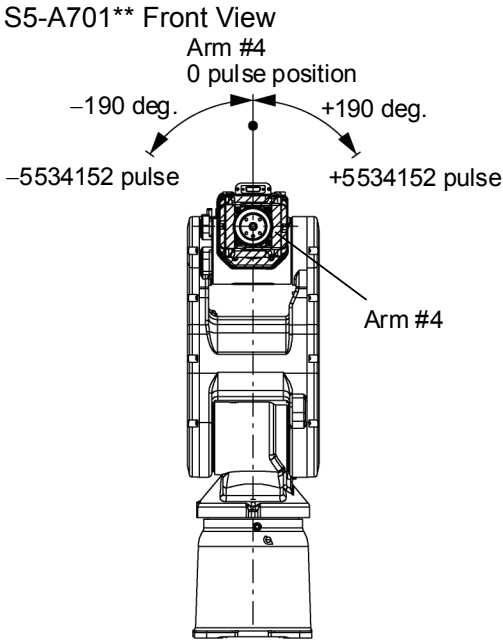



S5-A901** Lateral View



5.1.4 Max. Pulse Range of Arm #4

The 0 pulse position for Arm #4 is shown in the figure below. Clockwise pulse values are positive (+) and counterclockwise pulse values are negative (-).

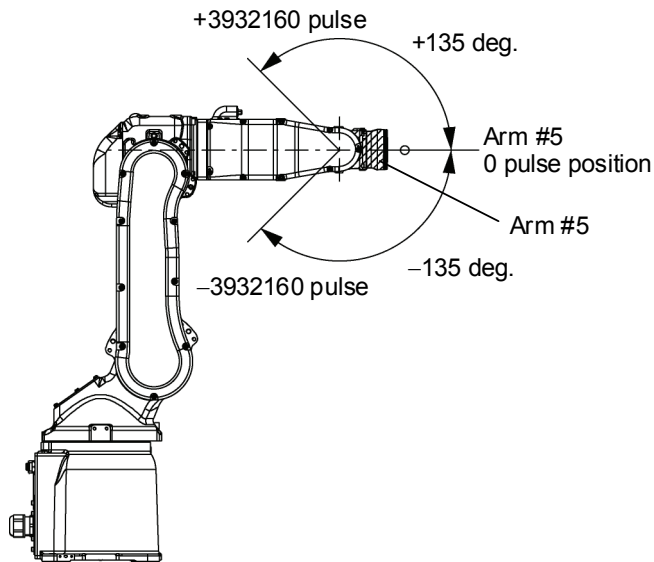


 <p>CAUTION</p>	<ul style="list-style-type: none">Do not set and/or use the Arm #4 with pulse range beyond the maximum value. The Arm #4 does not have a mechanical stop. The used of Arm #4 in motion exceeding the maximum pulse range may cause inner wiring damage to and/or malfunction of the Manipulator.
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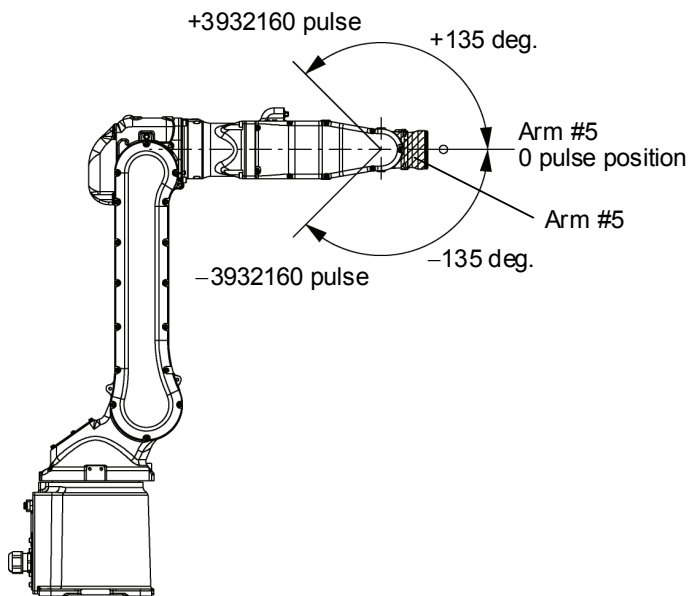
5.1.5 Max. Pulse Range of Arm #5

The 0 pulse position for Arm #5 is shown in the figure below. Counterclockwise pulse values are positive (+) and clockwise pulse values are negative (-).

S5-A701** Lateral View



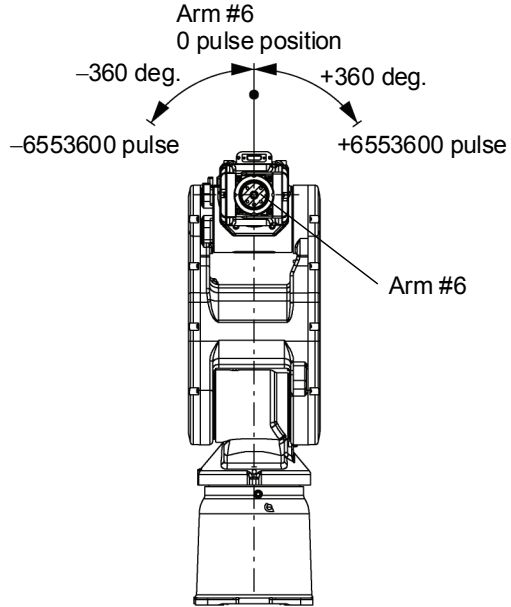
S5-A901** Lateral View



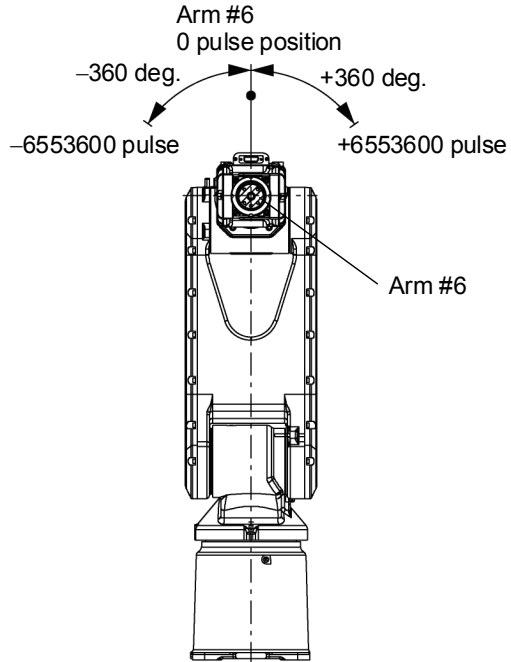
5.1.6 Max. Pulse Range of Arm #6

The 0 pulse position for Arm #6 is shown in the figure below. Clockwise pulse values are positive (+) and counterclockwise pulse values are negative (-).

S5-A701** Front View



S5-A901** Front View



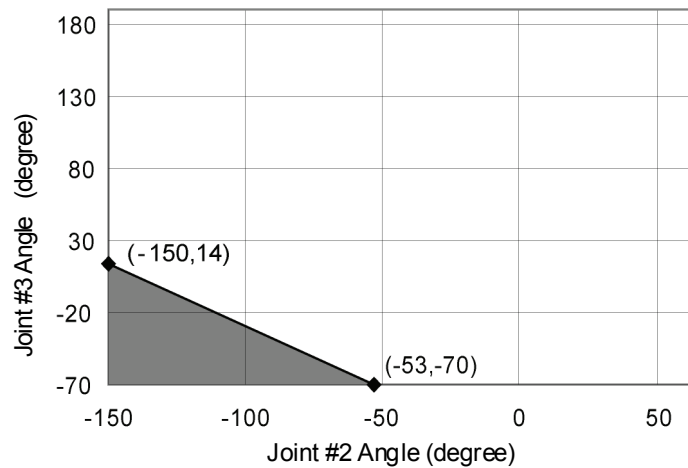
5.2 Restriction of Manipulator Operation by Joint Angle Combination

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 #2, #3, and #4.

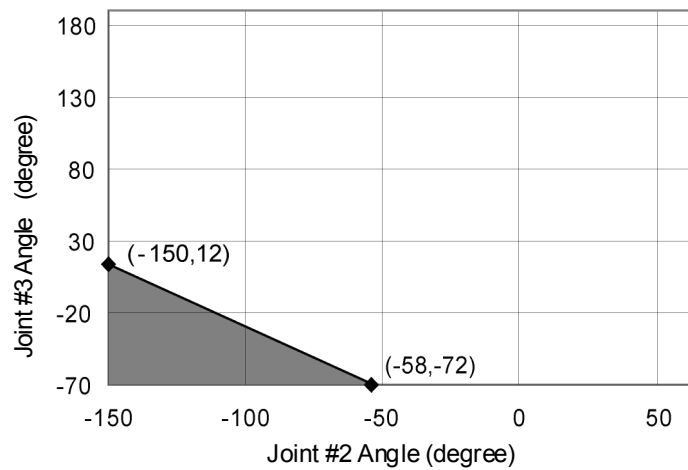
The Manipulator operation is restricted and the Manipulator stops when the joint angles of the Arm are within the gray areas in the following figure.

Combination of Joint #2 and #3

S5-A701**

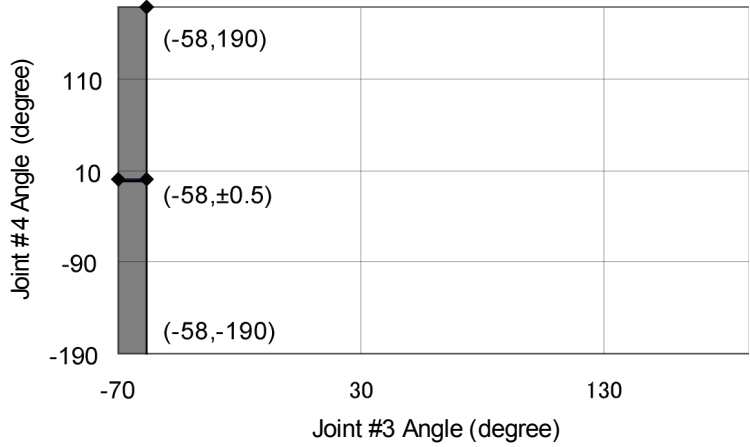


S5-A901**

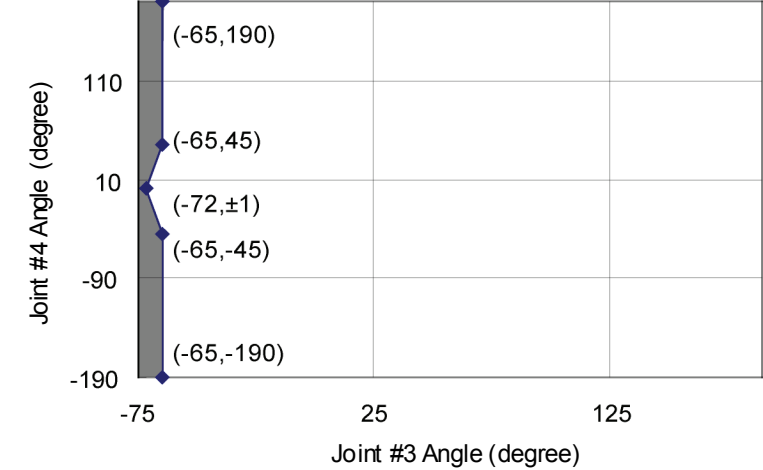


Combination of Joint #3 and #4

S5-A701**



S5-A901**



The restriction to Manipulator operation is enabled:

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

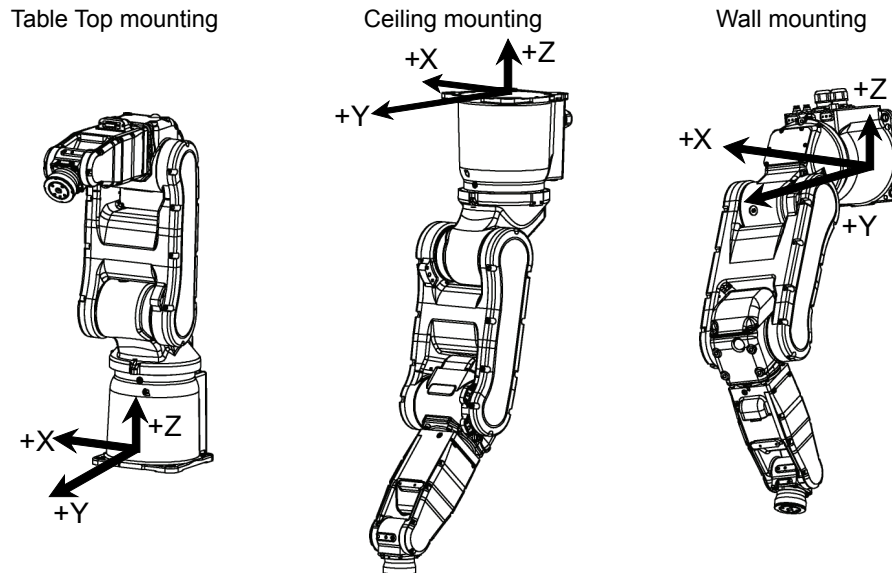
The restriction to the Manipulator operation is disabled:

- 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.

5.3 Coordinate System

The origin point is located where the Manipulator base intersects with the rotation axis of Joint #1.

For details on the coordinate system, refer to the software manual.



5.4 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 is that you can set the upper and lower limits of the X and Y coordinates.

The limited Manipulator operation area and 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 from EPSON RC+-[Tools]-[Robot manager]-[XYZ Limits] panel. You may also execute the XYLim command from the [Command Window].

Maintenance


This volume contains maintenance procedures with safety precautions for Manipulators.


1. Safety Maintenance

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

Only authorized personnel who have taken the safety training should be allowed to maintain the robot system. The safety training is the program for the industrial robot operator that follows the laws and regulations of each nation.

The personnel who have taken the safety training acquire knowledge of industrial robots (operations, teaching, etc.), knowledge of inspections, and knowledge of related rules/regulations. Only personnel who have completed the robot system-training and maintenance-training classes held by the manufacturer, dealer, or locally-incorporated company should be allowed to maintain the robot system.

 <p>WARNING</p>	<ul style="list-style-type: none"> ■ Do not remove any parts that are not covered in this manual. Follow the maintenance procedure strictly as described in this manual. Improper removal of parts or improper maintenance may not only cause improper function of the robot system but also serious safety problems. ■ Keep away from the Manipulator while the power is ON if you have not taken the training courses. Do not enter the operating area while the power is ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even though 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 switches function properly. Operating the robot system when the switches do not function properly is extremely hazardous and may result in serious bodily injury and/or serious damage to the robot system as the switches cannot fulfill their intended functions in an emergency.
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 <p>WARNING</p>	<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. ■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
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CAUTION

- Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems.
 - Never put alcohol, liquid gasket, or adhesive close to fire.
 - Use alcohol, liquid gasket, or adhesive while ventilating the room.
 - Wear protective gear including a mask, protective goggles, and oil-resistant gloves.
 - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water.
 - If alcohol, liquid gasket, 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.

2. Periodic Inspection

Performing the inspection steps properly is essential to preventing trouble and maintaining safety. This section describes the schedule for maintenance inspections and the procedures.

Be sure to perform the maintenance inspections in accordance with the schedule.

2.1 Schedule for Maintenance Inspections

Inspection tasks are divided into five stages: daily, 4 months, 24 months, 48 months, and 96 months. Move up the regular checks when the Manipulator has been used for the following amount of time.

Inspection	Interval between Inspections	Accumulated Operating Time
Daily	Inspect every day.	
4-month	4 months	1000 hours
24-month	24 months	6000 hours
48-month	48 months	12000 hours
96-month	96 months	24000 hours

2.2 Inspection Tasks

Inspection Tasks	Inspection	Method	Inspection and Maintenance	Related Details
Tram mark	Daily	Visual	Check for tram mark misalignment or damage at the home position.	-
Motion range and Manipulator	Daily	Visual	Clean the area of motion range for each joint if dust or spatter is present. Check for damage and outside cracks.	-
Base plate mounting bolts	4-month	Spanner, Wrench	Tighten loose bolts. Replace if necessary.	-
Cover mounting screws	4-month	Screw-driver, Wrench	Tighten loose screws. Replace if necessary.	-
Base connectors	4-month	Manual	Check for loose connectors.	-
Joint #5, Joint #6 timing belts	48-month	Manual	Check for proper belt tension and wear.	8.2
Cable unit ^{*1}	48-month	Visual, Multimeter	Check for conduction between the main connector of base and intermediate connector. ^{*2} Check for wear of protective spring. ^{*2}	9
Battery unit	-	-	Replace the battery unit when an error warning that low battery status is occurring at startup of the software or every three years.	10
Joint #1 reduction gear unit	24-month	Grease gun	Check for malfunction (Replace if necessary). Perform grease replenishment ^{*3}	2.3.1
Joint #2 reduction gear unit	24-month	Grease gun	Check for malfunction (Replace if necessary). Perform grease replenishment ^{*3}	2.3.2
Joint #3 reduction gear unit	24-month	Grease gun	Check for malfunction (Replace if necessary). Perform grease replenishment ^{*3}	2.3.3
Joint #4 reduction gear unit	24-month	Grease gun	Check for malfunction (Replace if necessary). Perform grease replenishment ^{*3}	2.3.4
Joint #5 reduction gear unit	24-month	Grease gun	Check for malfunction (Replace if necessary). Perform grease replenishment ^{*3}	2.3.5
Joint #6 reduction gear unit	24-month	Grease gun	Check for malfunction (Replace if necessary). Perform grease replenishment ^{*3}	2.3.6

*1 Replace the cable unit every 24000 hours. Refer to the *Maintenance: 9. Cable Unit* for details.

*2 When checking for conduction with a multimeter, connect the battery (for backing up motor encoder) to the BAT and OBT connectors, which are encoder connectors for maintenance, on the motor side. Then, disconnect the encoder connector on the cable unit side from the motor. If you disconnect the encoder connector on the cable unit side from the motor before connecting the battery to the BAT and OBT connectors, the arm position data will be lost and the arm will need to be calibrated again.

*3 Replenish grease every 6000 hours. Refer to the *Maintenance 2.3 Grease Replenishment* for details.




When the Manipulator is a Protection-model, be check of the followings.

Inspection Tasks	Inspection	Method	Inspection and Maintenance	Related Details
Arm #1 - #4 Oil Seals	Daily	Visual	Keep the oil seals clean removing any dust such as metal powders.	-
Drain plug Drain cover	4-month	Screw-driver, Wrench	Remove the condensation if it presents in manipulator. *4	2.5

*4 When the manipulator is used in the environment where rapid changes in temperature and humidity occur, perform the inspection more often than specified above.

2.3 Grease Replenishment

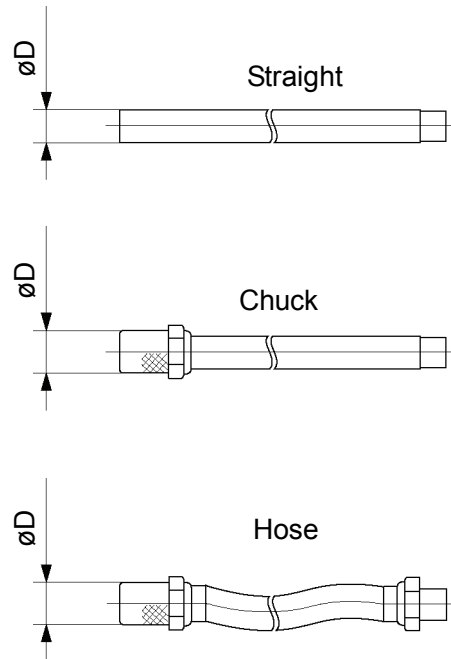
The reduction gear units need greasing at intervals of 6000 hours of operation time. Use only the grease specified.

 WARNING	<ul style="list-style-type: none"> ■ Move out of the safeguarded area before operating the Manipulator for run-in during grease replenishment. Operating the Manipulator while someone is inside of the safeguarded area is extremely hazardous and may cause serious safety problems.
 WARNING	<ul style="list-style-type: none"> ■ After the run-in, be sure to turn OFF the controller and related equipment, and then pull out the power plug from the power source. Then, continue the grease replenishment. Performing any grease procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
 CAUTION	<ul style="list-style-type: none"> ■ Ensure that there is sufficient grease in the Manipulator. Operating the Manipulator with insufficient grease will damage sliding parts and/or result in insufficient function of the Manipulator. Once the parts are damaged, a lot of time and money will be required for the repairs. ■ 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. <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. <ul style="list-style-type: none"> 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.

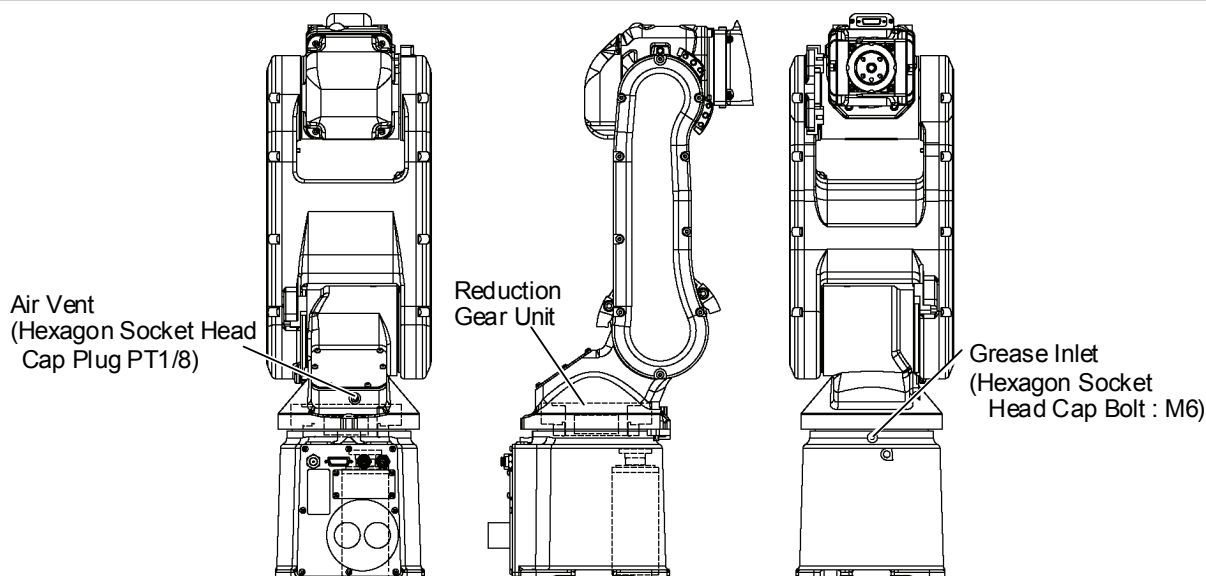
Grease Gun Lubrication Nozzle Shape

Use a commercially available grease gun.

We recommend the use of a grease gun with a nozzle shaped like that shown in the figure below and an outer diameter ($\varnothing D$) 13 mm or less.



2.3.1 Joint #1 Reduction Gear Unit



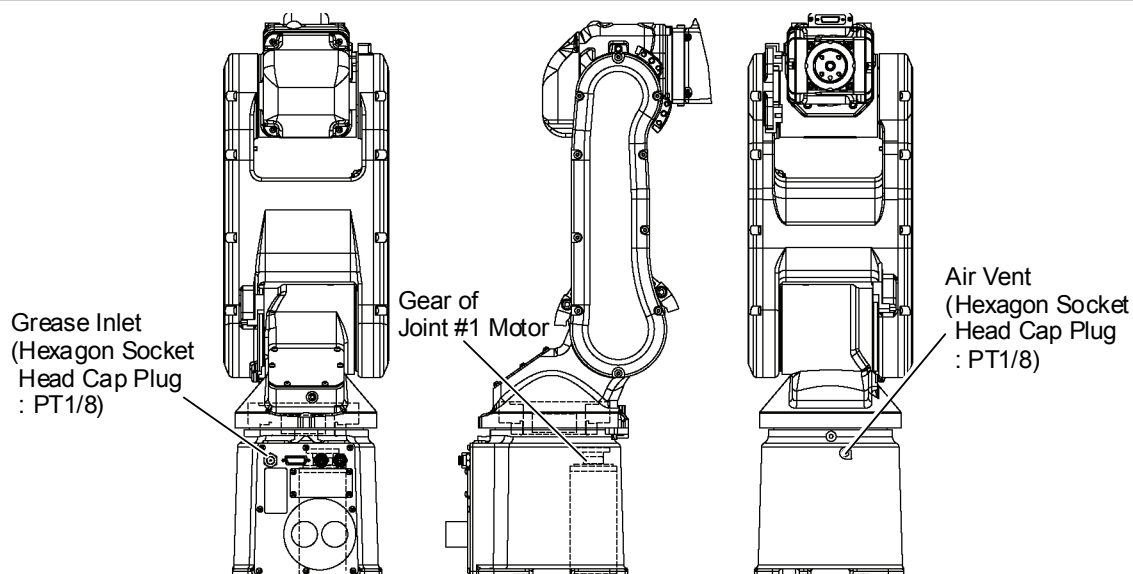
	Name	Quantity	Note	
Maintenance Parts	Grease for reduction gear	25 g	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201

- (1) Remove the bolt from the grease inlet.
Hexagon socket head cap bolt: M6
- (2) Attach a grease nipple to the grease inlet.
(The grease nipple is supplied with the Manipulator.)
Grease nipple: A-MT6×1
- (3) Remove the plug from the air vent.
Hexagon socket head cap plug: PT1/8

NOTE Be sure to remove the plug from the air vent. When grease is being added while the plug is in the air vent, the internal pressure increases. Increasing internal pressure may cause malfunction of the robot system.


- (4) Pump grease into the reduction gear unit from the grease inlet using a grease gun.
Grease : Grease for reduction gear (SK-1A)
Quantity : 25 g
- (5) Operate the Manipulator at low power mode speed for one hour to run-in the grease.
- (6) Wipe off excess grease exhausted from the air vent with wiping cloth.
- (7) Attach the plug to the air vent.
Hexagon socket head cap plug: PT1/8 (Apply liquid gasket.)
- (8) Remove the grease nipple from the grease inlet.
Grease nipple: A-MT6×1
- (9) Attach the bolt to the grease inlet.
Hexagon socket head cap bolt: M6 (Apply liquid gasket.)

2.3.2 Joint #1 Gear



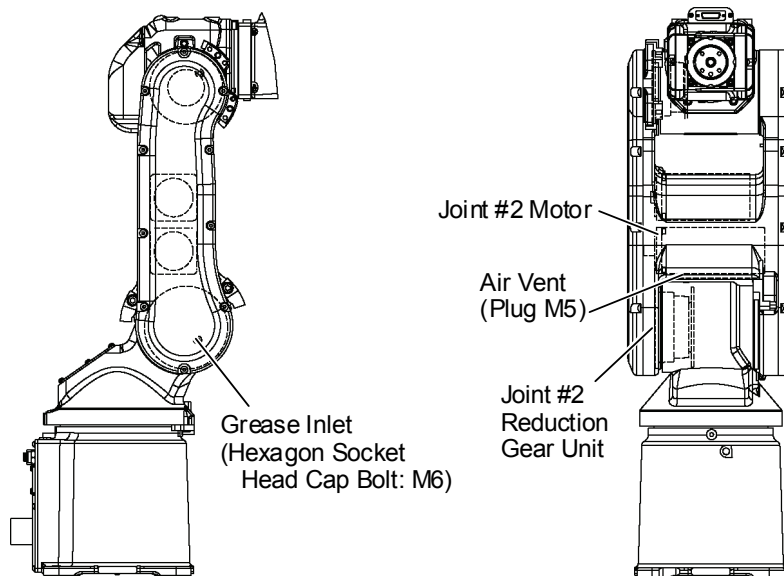
	Name	Quantity	Note	
Maintenance Parts	Grease for reduction gear	25 g	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201

- (1) Remove the plug from the grease inlet.
Hexagon socket head cap plug: PT1/8
- (2) Attach a grease nipple to the grease inlet.
(The grease nipple is supplied with the Manipulator.)
Grease nipple: A-MT6×1
- (3) Remove the plug from the air vent.
Hexagon socket head cap plug: PT1/8

NOTE  Be sure to remove the plug from the air vent. When grease is being added while the plug is in the air vent, the internal pressure increases. Increasing internal pressure may cause malfunction of the robot system.

- (4) Pump grease into the reduction gear unit from the grease inlet using a grease gun.
Grease : Grease for reduction gear (SK-1A)
Quantity : 25 g
- (5) Operate the Manipulator at low power mode speed for one hour to run-in the grease.
- (6) Wipe off excess grease exhausted from the air vent with wiping cloth.
- (7) Attach the plug to the air vent.
Hexagon socket head cap plug: PT1/8 (Apply liquid gasket.)
- (8) Remove the grease nipple from the grease inlet.
Grease nipple: A-MT6×1
- (9) Attach the bolt to the grease inlet.
Hexagon socket head cap bolt: M6 (Apply liquid gasket.)

2.3.3 Joint #2 Reduction Gear Unit



	Name	Quantity	Note	
Maintenance Parts	Grease for reduction gear	30 g	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201

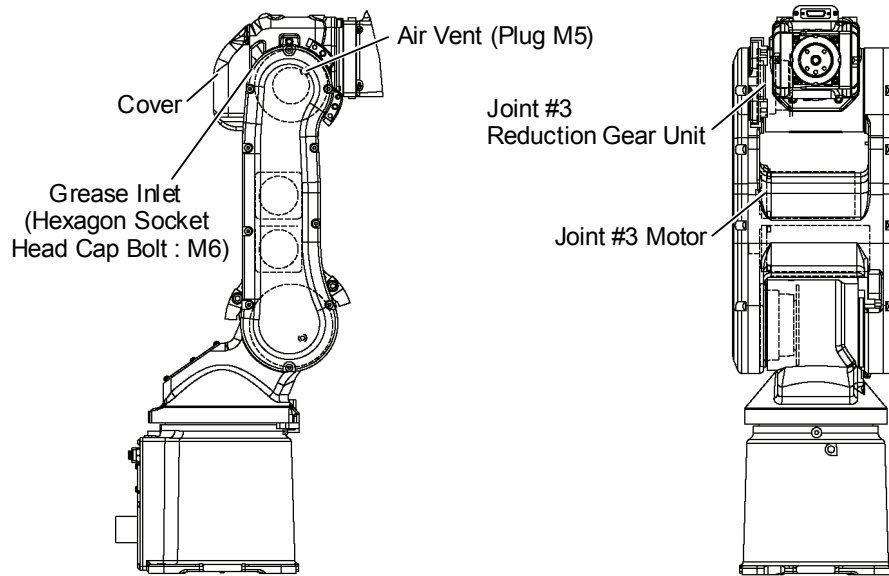
- (1) Remove the bolt from the grease inlet.
Hexagon socket head cap bolt: M6
- (2) Attach a grease nipple to the grease inlet.
(The grease nipple is supplied with the Manipulator.)
Grease nipple: A-MT6×1
- (3) Remove the plug from the air vent.
Plug: LP-M5



Be sure to remove the plug from the air vent. When grease is being added while the plug is in the air vent, grease will go inside the motor and may cause malfunction of the robot system.

- (4) Pump grease into the reduction gear unit from the grease inlet using a grease gun.
Grease : Grease for reduction gear (SK-1A)
Quantity : 30 g
- (5) Operate the Manipulator at low power mode speed for one hour to run-in the grease.
- (6) Wipe off excess grease exhausted from the air vent with wiping cloth.
- (7) Attach the plug to the air vent.
Plug: LP-M5 (Apply liquid gasket.)
- (8) Remove the grease nipple from the grease inlet.
Grease nipple: A-MT6×1
- (9) Attach the bolt to the grease inlet.
Hexagon socket head cap bolt: M6 (Apply liquid gasket.)

2.3.4 Joint #3 Reduction Gear Unit



	Name	Quantity	Note	
Maintenance Parts	Grease for reduction gear	20 g	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201

- (1) Remove the bolt from the grease inlet.

Hexagon socket head cap bolt: M6

- (2) Attach a grease nipple to the grease inlet.
(The grease nipple is supplied with the Manipulator.)

Grease nipple: A-MT6×1

- (3) Remove the plug from the air vent.

Plug: LP-M5

NOTE Be sure to remove the plug from the air vent. When grease is being added while the plug is in the air vent, grease will go inside the motor and may cause malfunction of the robot system.

- (4) Pump grease into the reduction gear unit from the grease inlet using a grease gun.

Grease : Grease for reduction gear (SK-1A)

Quantity : 20 g

- (5) Operate the Manipulator at low power mode speed for one hour to run-in the grease.

- (6) Wipe off excess grease exhausted from the air vent with wiping cloth.

- (7) Attach the plug to the air vent.

Plug: LP-M5 (Apply liquid gasket.)

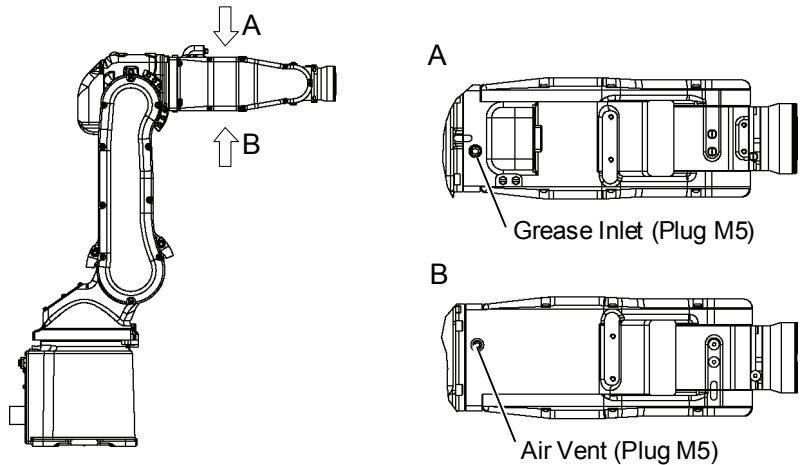
- (8) Remove the grease nipple from the grease inlet.

Grease nipple: A-MT6×1

- (9) Attach the bolt to the grease inlet.

Hexagon socket head cap bolt: M6 (Apply liquid gasket.)

2.3.5 Joint #4 Reduction Gear Unit



	Name	Quantity	Note	
Maintenance Parts	Grease for reduction gear	7 g	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201

(1) Remove the bolts and then remove the Arm #4 Cover.
For details, refer to *Maintenance: 3.4 Arm #4 Cover*.

(2) Remove the plug from the air vent.
Plug: LP-M5

NOTE Be sure to remove the plug from the air vent. When grease is being added while the plug is in the air vent, the internal pressure increases. Increasing internal pressure may cause malfunction of the robot system.

(3) Remove the plug from the grease inlet.
Plug: LP-M5

(4) Attach a grease nipple to the grease inlet.
(The grease nipple is supplied with the Manipulator.)
Grease nipple: M5

(5) Pump grease into the reduction gear unit from the grease inlet using a grease gun.
Grease : Grease for reduction gear (SK-1A)
Quantity : 7 g

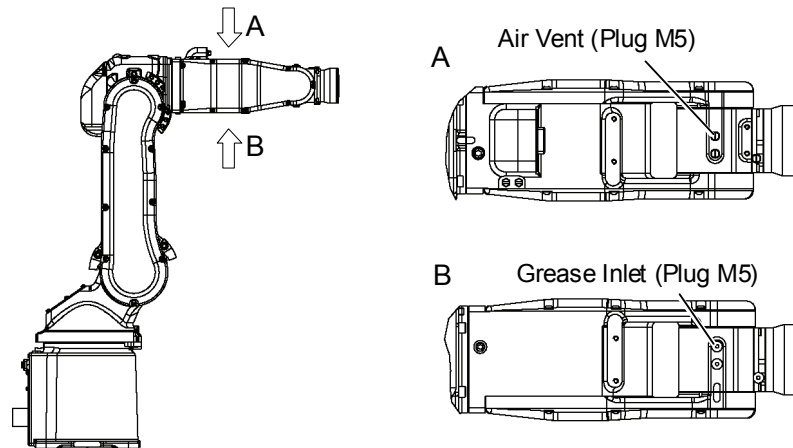
(6) Operate the Manipulator at low power mode speed for one hour to run-in the grease.
(7) Wipe off excess grease exhausted from the air vent with wiping cloth.

(8) Attach the plug to the air vent.
Plug: LP-M5 (Apply liquid gasket.)

(9) Mount the Arm #4 Cover. For details, refer to *Maintenance: 3.4 Arm #4 Cover*.

NOTE When mounting the cover, apply liquid grease on the contact surface with the arm.
Liquid gasket: 1206C


2.3.6 Joint #5 Reduction Gear Unit



	Name	Quantity	Note	
Maintenance Parts	Grease for reduction gear	5 g	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201

- (1) Remove the plug from the air vent.

Plug: LP-M5

NOTE  Be sure to remove the plug from the air vent. When grease is being added while the plug is in the air vent, the internal pressure increases. Increasing internal pressure may cause malfunction of the robot system.

- (2) Remove the plug from the grease inlet.

Plug: LP-M5

- (3) Attach a grease nipple to the grease inlet.
(The grease nipple is supplied with the Manipulator.)

Grease nipple: M5

- (4) Pump grease into the reduction gear unit from the grease inlet using a grease gun.

Grease : Grease for reduction gear (SK-1A)

Quantity : 5 g

- (5) Operate the Manipulator at low power mode speed for one hour to run-in the grease.

- (6) Wipe off excess grease exhausted from the air vent with wiping cloth.

- (7) Attach the plug to the air vent.

Plug: LP-M5 (Apply liquid gasket.)

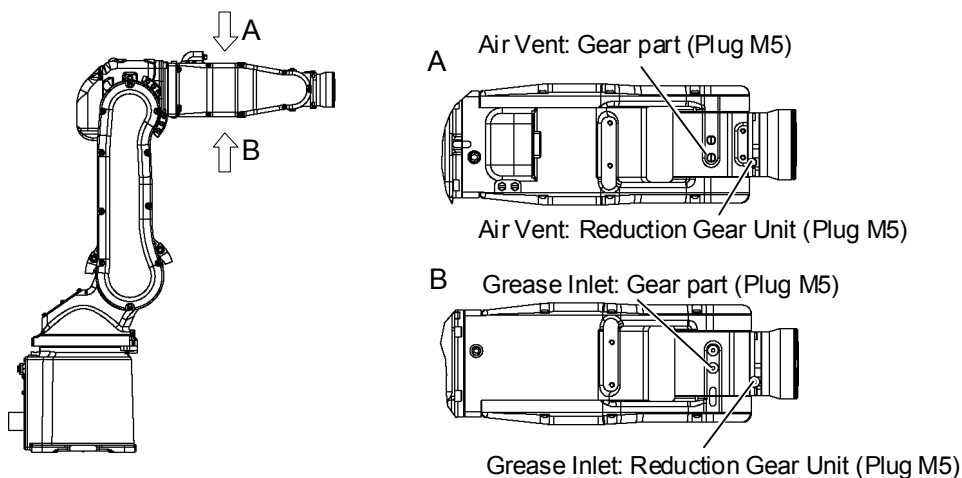
- (8) Remove the grease nipple from the grease inlet.

Grease nipple: M5

- (9) Attach the bolt to the grease inlet.

Plug: LP-M5 (Apply liquid gasket.)

2.3.7 Joint #6 Reduction Gear Unit



	Name	Quantity	Note	
Maintenance Parts	Grease for reduction gear	5 g	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201

- (1) Remove the plug from the grease inlet.


Plug: LP-M5

- (2) Attach a grease nipple to the grease inlet.
(The grease nipple is supplied with the Manipulator.)

Grease nipple: M5

- (3) Remove the plug from the air vent.

Plug: LP-M5

NOTE  Be sure to remove the plug from the air vent. When grease is being added while the plug is in the air vent, the internal pressure increases. Increasing internal pressure may cause malfunction of the robot system.

- (4) Pump grease into the reduction gear unit from the grease inlet using a grease gun.

Grease : Grease for reduction gear (SK-1A)

Quantity : 5 g

- (5) Operate the Manipulator at low power mode speed for one hour to run-in the grease.

- (6) Wipe off excess grease exhausted from the air vent with wiping cloth.

- (7) Attach the plug to the air vent.

Plug: LP-M5 (Apply liquid gasket.)

- (8) Remove the grease nipple from the grease inlet.

Grease nipple: M5

- (9) Attach the bolt to the grease inlet.

Plug: LP-M5 (Apply liquid gasket.)

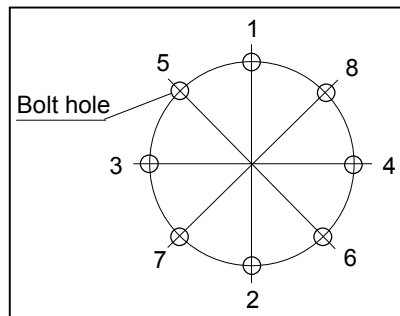
2.4 Tightening Hexagon Socket Head Cap Bolts

Hexagon socket head cap bolts are used where mechanical strength is required. These bolts are fastened with the tightening torques shown in the following table.

When it is necessary to refasten these bolts during 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	245 N·cm	(25 kgf·cm)
M4	490 N·cm	(50 kgf·cm)
M5	980 N·cm	(100 kgf·cm)
M6	1,760 N·cm	(180 kgf·cm)
M8	3,720 N·cm	(380 kgf·cm)
M10	7,350 N·cm	(750 kgf·cm)
M12	12,740 N·cm	(1,300 kgf·cm)

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




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

2.5 Removing Condensation (Only protection-model)

For protection-model manipulators, condensation water should be drained.

	Name	Quantity	Note
Maintenance Parts	Liquid gasket (1206C)	Proper quantity	R13B031201
	Gasket	1	R13B031275 For replacement

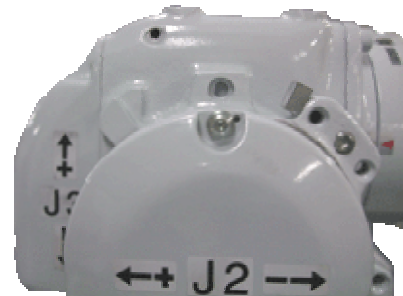
- (1) Remove the bolt. Detach the drain cover and the gasket of the No.1 drain vent.

NOTE  Replace the gasket with a new one if it is damaged.



- (2) Remove the drain plug of the No.2 drain vent.

Drain plug: PT1/8



- (3) Incline the Arm #3 slightly toward the No.2 drain vent side.

- (4) Drain the condensation water.



- (5) Put the gasket between the drain cover and arm, and then secure the cover of the No.1 drain vent with the bolt.


Bolt: Apply liquid gasket.


- (6) Attach the plug to the No.2 drain vent.

Drain plug: PT1/8 (Apply liquid gasket.)

3. Covers

The common procedure for removing the covers for maintenance are described in this chapter.

 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 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. ■ 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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 CAUTION	<ul style="list-style-type: none"> ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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.
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3.1 Arm #1 Cover

Remove the bolts and then remove the Arm #1 Cover.

- Tool : Hexagonal wrench (width across flats: 3 mm)
- Button bolt : 6-M4×10
- Tightening torque : 1.4 N·m (0.14 kg·m)



For cleanroom-model:

A gasket (R13B031270) is attached.

Removal

Remove the gasket with the cover.

Installation

Attach the gasket between the cover and manipulator.



NOTE



You can't reuse the gasket. Be sure to use a new gasket.

For protection-model:

Liquid gasket (R13B031201) is applied.

Removal

Remove caked-on liquid gasket residue with a scraper or similar tool.

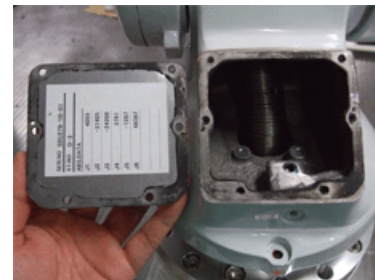
Installation

Apply liquid gasket on the contact surfaces of the cover and manipulator.

NOTE



Wipe off any excess liquid gasket with a wiping cloth treated with alcohol.




3.2 Arm #2 Cover

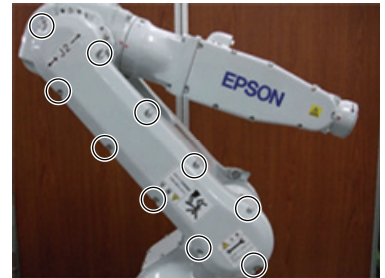
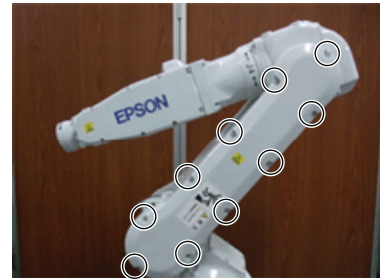
Remove the bolts and then remove the Arm #2 Cover.

Tool : Hexagonal wrench (width across flats: 4 mm)

Button bolt : 20-M5×10 (with washer)

Tightening torque : 2.8 N·m (0.29 kg·m)

NOTE  There is one cover on each side. Remove the cover(s) as required in maintenance work.



For cleanroom-model:

A gasket is attached.

S5-A701C* : R13B031271


S5-A901C* : R13B031272

Removal

Remove the gasket with the cover.

Installation

Attach the gasket between the cover and manipulator.

NOTE  You can't reuse the gasket. Be sure to use a new gasket.



For protection-model:


Liquid gasket (R13B031201) is applied.

Removal

Remove caked-on liquid gasket residue with a scraper or similar tool.

Installation

Apply liquid gasket on the contact surfaces of the cover and manipulator.

NOTE  Wipe off any excess liquid gasket with a wiping cloth treated with alcohol.



3.3 Arm #3 Cover

Remove the bolts and then remove the Arm #3 Cover.

- Tool : Hexagonal wrench (width across flats: 3 mm)
- Button bolt : 4-M4×10 (with washer)
- Tightening torque : 1.4 N·m (0.14 kg·m)

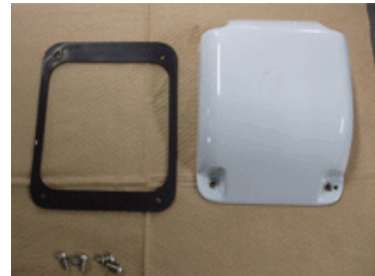


For cleanroom-model:

A gasket (R13B031273) is attached.

Removal

Remove the gasket with the cover.



Installation

Attach the gasket between the cover and manipulator.



You can't reuse the gasket. Be sure to use a new gasket.

For protection-model:

Liquid gasket (R13B031201) is applied.

Removal

Remove caked-on liquid gasket residue with a scraper or similar tool.



Installation

Apply liquid gasket on the contact surfaces of the cover and manipulator.



Wipe off any excess liquid gasket with a wiping cloth treated with alcohol.


3.4 Arm #4 Cover

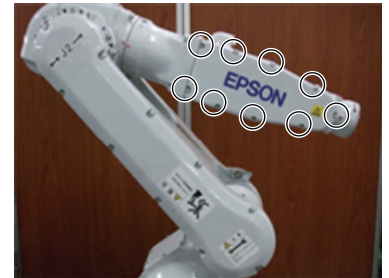
Remove the bolts and then remove the Arm #4 Cover.

Tool : Hexagonal wrench (width across flats: 3 mm)

Button bolt : 18-M4×10 (with washer)

Tightening torque : 1.4 N·m (0.14 kg·m)

NOTE  There is one cover on each side. Remove the cover(s) as required in maintenance work.



For cleanroom-model:

A gasket (R13B031274) is attached.


Removal

Remove the gasket with the cover.



Installation

Attach the gasket between the cover and manipulator.

NOTE  You can't reuse the gasket. Be sure to use a new gasket.

For protection-model:

Liquid gasket (R13B031201) is applied.


Removal

Remove caked-on liquid gasket residue with a scraper or similar tool.




Installation


Apply liquid gasket on the contact surfaces of the cover and manipulator.


NOTE  Wipe off any excess liquid gasket with a wiping cloth treated with alcohol.


4. Joint #1

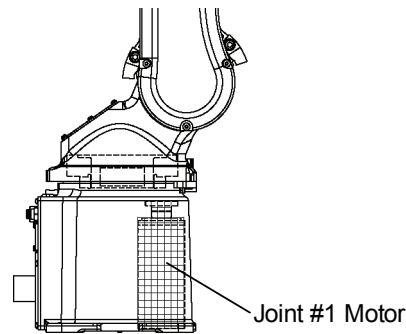
4.1 Replacing the Joint #1 Motor

 <p>WARNING</p>	<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.■ 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.
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 <p>CAUTION</p>	<ul style="list-style-type: none">■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle 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.■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems.<ul style="list-style-type: none">- Never put alcohol, liquid gasket, or adhesive close to fire.- Use alcohol, liquid gasket, or adhesive while ventilating the room.- Wear protective gear including a mask, protective goggles, and oil-resistant gloves.- If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water.- If alcohol, liquid gasket, 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.
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 CAUTION	<ul style="list-style-type: none"> ■ 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. <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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NOTE  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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



	Name	Quantity	Note	
Maintenance Parts	AC servo motor	1	400 W	R13B000626
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201
	Adhesive	Proper quantity	Loctite 242	R13B031701
Material	Wire tie	-		

Joint #1 Motor Removal

- (1) Remove the manipulator installation bolts and put the manipulator on its side.



Before removing the installation bolts, position the manipulator to make sure you can put the manipulator back in the installation position. If the manipulator installation position changes after the motor replacement, you need to adjust the points already taught.

- (2) Remove the bolts and remove the bottom cover.

Button bolt: 6-M4×10

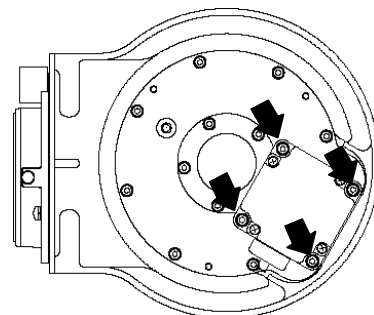
- (3) Connect the backup battery to the Joint #1 motor cables.

- (4) Remove the Joint #1 motor cables from the cables inside the manipulator.

- (5) Remove the hexagon socket head cap bolts.

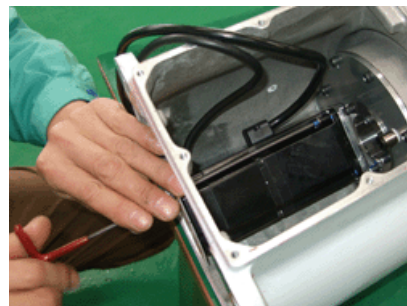
a: 2-M4×25 (with disc spring)

b: 2-M4×14 (with disc spring)



- (6) Remove the Joint #1 motor with the motor plate.

Use the hexagon socket head cap bolts as a removal tap.



- (7) Remove the Joint #1 input gear from the Joint #1 motor.

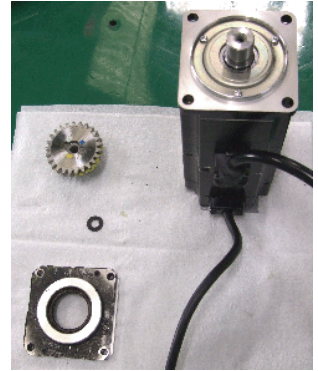
Hexagon socket head cap bolt
: 1-M5×16 (with disc spring)




- Hold the Joint #1 input gear as shown in the picture while removing the bolt to prevent the gear from turning.
- There is a gasket between the Joint #1 input gear and the motor shaft. Be sure to keep the gasket.



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



- (9) Remove caked-on liquid gasket residue with a scraper or similar tool.

NOTE  Double-check the bolts to make sure that you have not forgotten to tighten any of them.

Joint # Motor Installation

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

Hexagon socket head cap bolt
: 2-M4×14 (with disc spring, M4 washer)

Tightening torque: 2.8 N·m (0.29 kgf·m)

NOTE 

- Be careful of direction of the Joint #1 motor plate.
- Be careful not to damage the oil seal in the Joint #1 motor plate.

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

- (3) Mount the Joint #1 input gear.

Hexagon socket head cap bolt
: 1-M5×16 (with disc spring 2H-5)
Apply the liquid gasket.

Tightening torque: 10 N·m (1.02 kgf·m)

NOTE 

- Hold the Joint #1 input gear as shown in the picture while removing the bolt to prevent the gear from turning.
- Wipe excess adhesive from other parts of the motor with a wiping cloth treated with alcohol.

- (4) Apply the liquid gasket on surfaces of the Joint #1 motor plate and the Base.

Apply the grease for the reduction gear on the Joint #1 input gear.

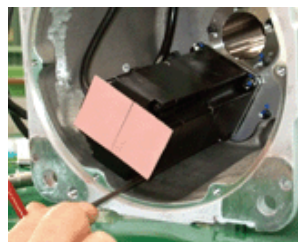
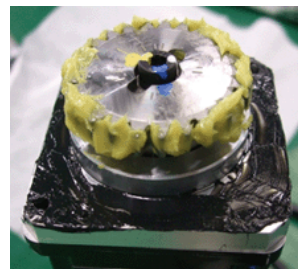
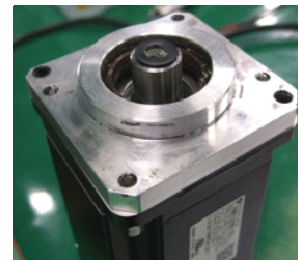
Grease: SK-1A

- (5) Mount the Joint #1 motor on the Base.

Hexagon socket head cap bolt
: 2-M4×25 (with disc spring 2H-4, M4 washer)
Apply the liquid gasket.


Tightening torque: 2.8 N·m (0.29 kgf·m)


- (6) Connect the Joint #1 motor cables with the cables inside the manipulator.



- (7) Remove the backup battery.
- (8) Mount the Bottom Cover.
 - Button bolt : 6-M4×10
 - Tightening torque : 1.4 N·m (0.14 kgf·m)
- (9) Put the manipulator in the installation position.

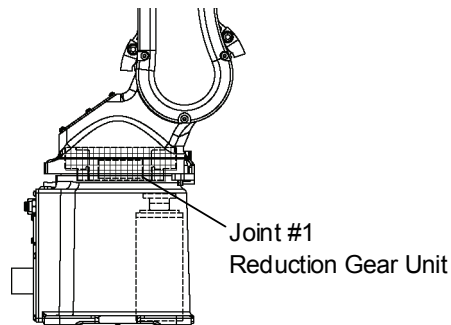
4.2 Replacing the Joint #1 Reduction Gear Unit

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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. <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. <ul style="list-style-type: none"> 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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- 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: 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.
- A reduction gear unit consists of the three parts described below. When replacing the reduction gear unit, be sure to always replace the waveform generator, flexspline, and circular spline all together as one set. For the structure details of the reduction gear, refer to *Maintenance: 13. Maintenance Parts List*.

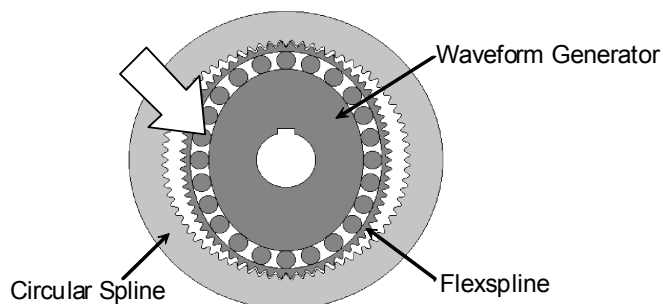


4.2.1 Greasing the Reduction Gear Unit


 CAUTION	<ul style="list-style-type: none"> ■ 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. <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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When greasing the reduction gear unit, use only the grease specified for the reduction gear unit. While greasing the reduction gear unit, be careful not to allow any foreign substances in the grease.

Location for applying grease on the waveform generator



4.2.2 Replacing the Reduction Gear Unit


 CAUTION	<ul style="list-style-type: none"> Use at least three people when removing the upper structure (Arms #1 to #6). One should support the upper arm and the others should hold Arm #1 up. The upper structure is so heavy that attempting this task requires a large force.
--	---

NOTE  When replacing the reduction gear unit, the bearings should be replaced together.

	Name	Quantity	Note	
Maintenance Parts	Reduction gear unit	1	S5-A701** S5-A901**	R13B010030 R13B010031
	Bearing	1	6810VV*NS7* 6811LLU	R13B030803 R13B030804
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Grease for oil seal	Proper quantity	MP-1	R13B030306
	Liquid gasket	Proper quantity	1206C	R13B031201
Material	Wire tie	-		

- Joint #1 (1) Turn OFF the Controller.
 Reduction Gear Unit (2) Remove the cables from inside the manipulator.
 Removal For details, refer to *Maintenance: 9.1 Replacing the Cable Unit*.

- (3) Remove the Joint #1 motor.
 For details, refer to *Maintenance: 4.1 Replacing the Joint #1 Motor*.

 CAUTION	<ul style="list-style-type: none"> Use at least three people when removing the upper structure (Arms #1 to #6). One should support the upper arm and the others should hold Arm #1 up. The upper structure is so heavy that attempting this task requires a large force.
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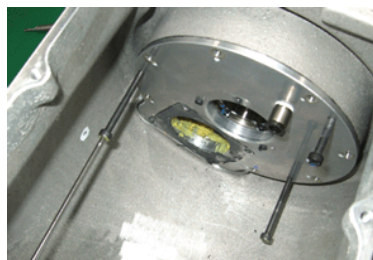
- (4) Remove the shaft from the Base.

GT-SA bolt : 4-M4×12
 Removal tap : M3



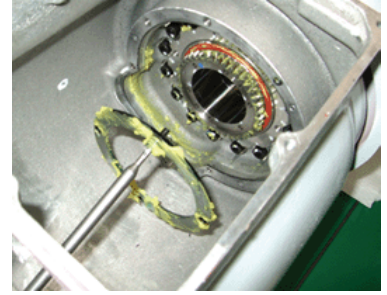
- (5) Remove the flange from the Base.

GT-SA bolt : 7-M4×16
 Removal tap : M4



- (6) Remove the GT-SA bolts and then remove the bearing holder.

GT-SA bolt: 4-M4×10



- (7) Remove the Joint #1 output gear.

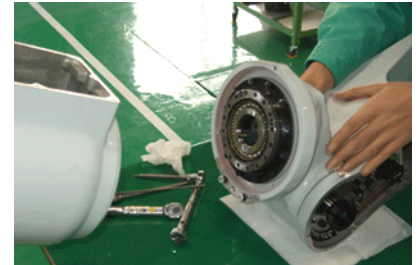
Hexagon socket head cap bolt
: 6-M3×30 (with disc spring)



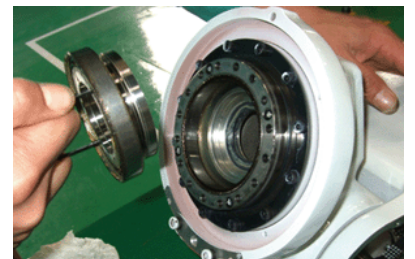
- (8) Detach the Base and Arm #1.

Hexagon socket head cap bolt
: 16-M5×30 (with disc spring)

If the Base and Arm #1 are not easily detached,
tap the corner of the Base using a plastic
hammer or similar tool.

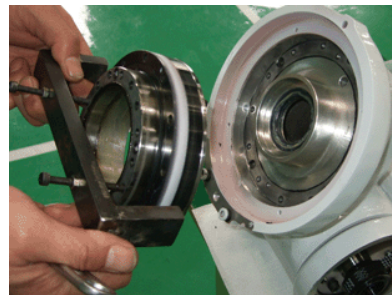
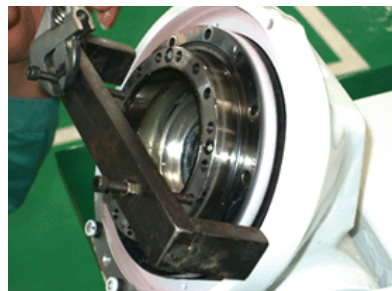


- (9) Remove the waveform generator and bearing
from the Arm #1.



- (10) Remove the circular spline and flexspline from the Arm #1.

Hexagon socket head cap bolt
: 12-M5×40 (with disc spring)



- (11) Remove the bearing from the waveform generator using a hand press or similar tool.



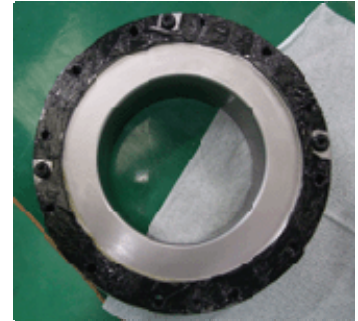
- (12) Remove the bearing from the Joint #1 output gear.
- (13) Remove the oil seal from the Arm #1.
- (14) Remove caked-on liquid gasket residue with a scraper or similar tool.
- (15) Repair scratches incurred during tap use with a sharpening stone or similar tool.



Double-check the bolts to make sure that you have not forgotten to tighten any of them.

Joint #1
Reduction Gear
Unit
Installation

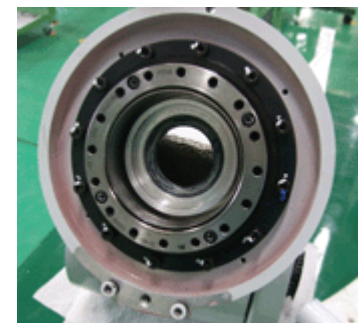
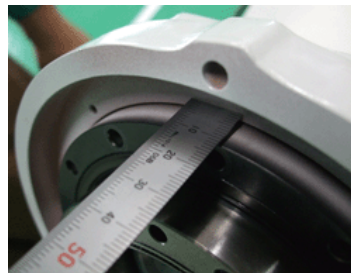
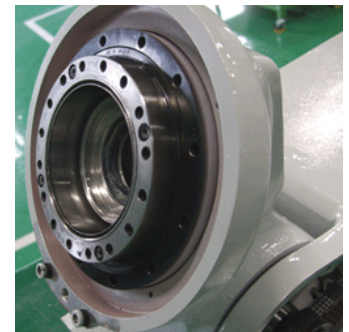
- (1) Apply liquid gasket to contact surfaces of the circular spline, flexspline, and Arm #1.



- (2) Mount the circular spline, flexspline on the Arm #1.

Hexagon socket head cap bolt
: 12-M5×40 (with disc spring 2H-5)

Tightening torque
: 8.4 N·m (0.86 kgf·m)



- (3) Press the bearing into the waveform generator using a hand press or similar tool.

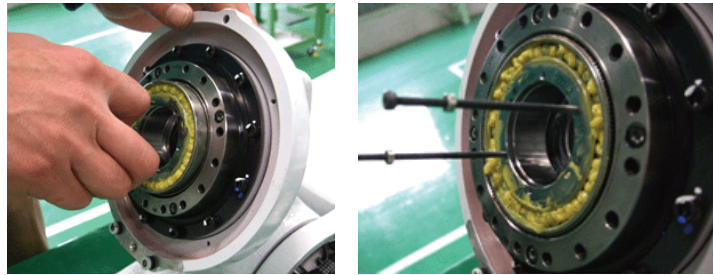


- (4) Apply grease on the bearing of the waveform generator.

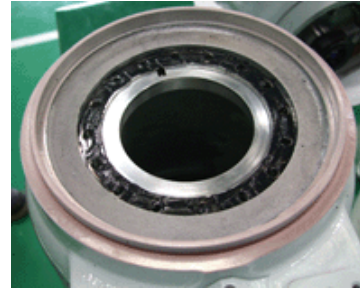
Grease for reduction gear: SK-1A



- (5) Insert the waveform generator into the circular spline and flexspline.



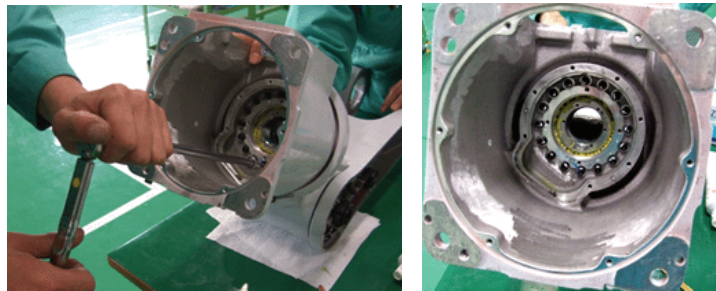
- (6) Apply liquid gasket to contact surfaces of the circular spline and flexspline of the Base.



- (7) Mount the circular spline and flexspline to the Base.
Press the bearing into the Joint #1 output gear.



Put a seal side of the bearing to the gear side (Base side), and the other side to the Arm # side.

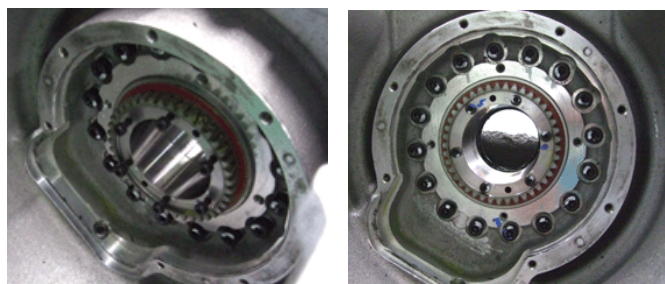


- (8) Mount the spacer to the Joint #1 output gear.



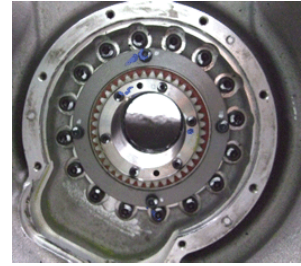
- (9) Mount the Joint #1 output gear to the Base.

Hexagon socket head cap bolt : 6-M3×30 (with disc spring 2H-3)
Tightening torque : 2.25 N·m (0.23 kgf·m)



(10) Mount the bearing holder.

GT-SA bolt : 4-M4×10
Tightening torque : 2.8 N·m (0.29 kgf·m)



(11) Apply grease for reduction gear around the Joint #1 output gear.

Grease for reduction gear: SK-1A



(12) Apply liquid gasket on the flange surface where it joins with the Base.



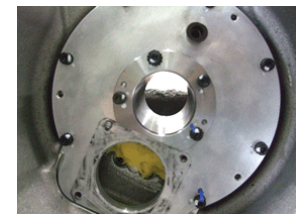
(13) Mount the flange on the Base.


GT-SA bolt : 7-M4×16
Tightening torque : 2.8 N·m (0.29 kgf·m)



(14) Mount the shaft to on the flange.

GT-SA bolt : 4-M4×12
Apply liquid gasket.
Tightening torque : 2.8 N·m (0.29 kgf·m)



NOTE  -Apply grease for the oil seal on the contact surfaces of the O-ring and oil seal.

Grease: MP-1

-Treat the O-ring and oil seal with extra care and prevent from curing up.



(15) Mount the Joint #1 motor.


For details, refer to *Maintenance: 4.1 Replacing the Joint #1 Motor.*


(16) Mount the cables inside the manipulator.


For details, refer to *Maintenance: 9.1 Replacing the Cable Unit.*

5. Joint #2

5.1 Replacing the Joint #2 Motor

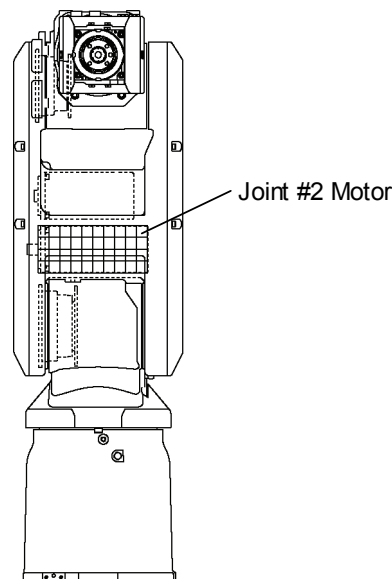
 WARNING	<ul style="list-style-type: none"> ■ Before performing any replacement procedure, turn OFF the Controller and related equipment, and then pull out the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle 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. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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.
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 CAUTION	<ul style="list-style-type: none"> ■ 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. <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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NOTE - 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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



 WARNING	<ul style="list-style-type: none"> ■ Always use at least two people when removing the motor unit. Remove the motor unit while one person is supporting the upper structure (Arms #2 to #6). The upper structure folds inward at Joint #2 as soon as the motor unit is removed and the brake is released. Failure to properly support the upper structure may result in serious bodily injury and/or severe equipment damage.
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Maintenance 5. Joint #2 (Replacing the Motor)

	Name	Quantity	Note	
Maintenance Parts	AC servo motor	1	400W	R13B000626
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201
	Adhesive	Proper quantity	Loctite 242	R13B031701
Material	Wire tie	-		


NOTE




We recommend folding the upper structure (Arms #2 to #6) toward the stop side before starting the replacement.

Joint #2 Motor Removal


- (1) Remove the Arm #2 Cover.
For details, refer to the *Maintenance 3.2 Arm #2 Cover*.
- (2) Connect the backup battery to the Joint #2 motor cable.
- (3) Remove the Joint #2 motor cable from inside the manipulator.
- (4) Remove the Joint #2 motor and the motor plate from the Arm #2.
GT-SA bolt: 2-M4×16 (with M4 washer)
- (5) Remove the Joint #2 motor plate from the Joint #2 motor.
Hexagon socket head cap bolt: 3-M4×16 (with disc spring 2H-4, M4 washer)
- (6) Remove the Joint #2 input pulley from the Joint #2 motor.
Hexagon socket head cap bolt: 1-M4×18 (with disc spring 2H-4)

NOTE  Double-check the bolts to make sure that you have not forgotten to tighten any of them.

- Joint #2 Motor Installation
- (1) Mount the Joint #2 input pulley to the Joint #2 motor.
 Hexagon socket head cap bolt : 1-M5×16 (with disc spring 2H-5)
 Apply adhesive.
 Tightening torque : 6.0 N·m (0.62 kgf·m)

NOTE  Hold the Joint #2 input pulley by using its grooves while tightening the bolt to prevent the motor from turning.

- (2) Mount the motor plate to the Joint #2 motor.
 Hexagon socket head cap bolt : 3-M4×16 (with disc spring 2H-4, M4 washer)
 Tightening torque : 2.8 N·m (0.29 kgf·m)
- (3) Place the timing belt around the Joint #2 input pulley and mount the Joint #2 motor to the Arm #2.
 GT-SA bolt : 2-M4×16 (with M4 washer)
 Tightening torque : 2.8 N·m (0.29 kgf·m)

NOTE  - Make sure the Arm #2 touches the radiation sheet on the motor side surface. It is necessary for the heat radiation of the motor.


- Adjust the belt tension.


For details, refer to *Maintenance: 5.3 Replacing the Joint #2 Timing Belt*.

- (4) Attach two cables of the Joint #2 motor (power system, signal system) to the cables inside the manipulator.
- (5) Remove the backup battery from the Joint #2 motor.
- (6) Mount the Arm #2 Cover.

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

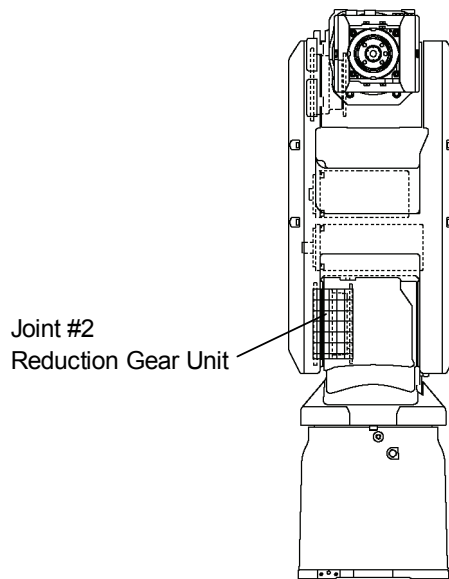
5.2 Replacing the Joint #2 Reduction Gear Unit

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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. <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. <ul style="list-style-type: none"> 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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- NOTE
- 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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.
 - A reduction gear unit consists of the three parts described below. When replacing the reduction gear unit, be sure to always replace the waveform generator, flexspline, and circular spline all together as one set. For the structure details of the reduction gear, refer to *Maintenance: 13. Maintenance Parts List*.

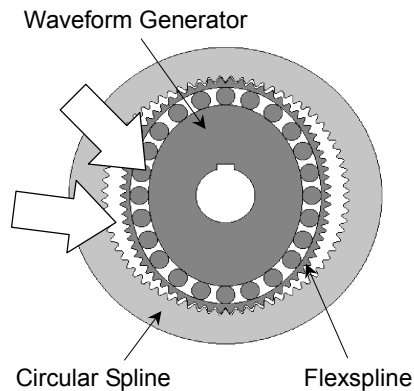


5.2.1 Greasing the Reduction Gear Unit


 <p>CAUTION</p>	<ul style="list-style-type: none">■ 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.<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.<ul style="list-style-type: none">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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When greasing the reduction gear unit, use only the grease specified for the reduction gear unit. While greasing the reduction gear unit, be careful not to allow any foreign substances in the grease.

Location for applying grease on the teeth of flexspline and circular spline and the waveform generator




5.2.2 Replacing the Reduction Gear Unit

 WARNING	<ul style="list-style-type: none"> Always use at least two people when removing the motor unit. Remove the motor unit while one person is supporting the upper structure (Arms #2 to #6). The upper structure folds inward at Joint #2 as soon as the motor unit is removed and the brake is released. Failure to properly support the upper structure may result in serious bodily injury and/or severe equipment damage.
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NOTE  When replacing the reduction gear unit, the bearings should be replaced together.

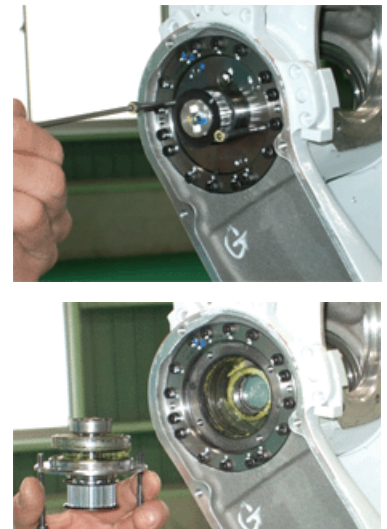
	Name	Quantity	Note	
Maintenance Parts	Reduction gear unit	1	S5-A701**	R13B010032
			S5-A901**	R13B010033
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201
	Bearing	1	6000ZZ	R13B030805
			6916DDU	R13B030806
6913ZZ			R13B030807	
Material	Wire tie	-		

NOTE  - We recommend folding the upper structure (Arms #2 to #6) to the stop side before the replacement.
 - Structure of the reduction gear unit for the Joint #2 and Joint #3 are almost same. The replacement procedure below uses pictures of Joint #3.

Joint #2
Reduction Gear
Unit
Removal

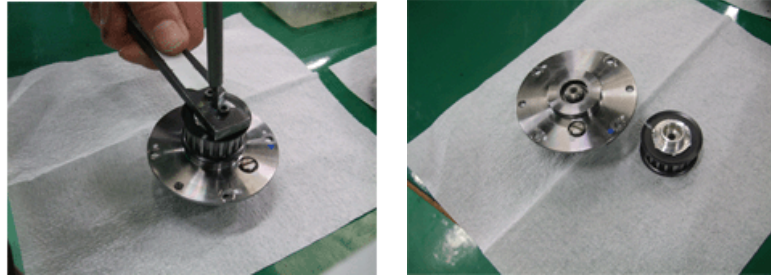
- Connect the backup battery to the motors of Joint #2, #3, #4, #5, and #6.
- Remove the cables from inside the manipulator.
For details, refer to *Maintenance: 9.1 Replacing the Cable Unit*.
- Remove the Joint #2 motor unit from the manipulator.
For details, refer to *Maintenance: 5.1 Replacing the Joint #2 Motor*.
- Remove the following:
 - Joint #2 output pulley
 - Waveform generator
 - Housing
 - Bearing
 - GT-SA bolt: 4-M4×10

NOTE  As shown in the picture, use a removal tap to remove.



- (5) From the waveform generator, remove the Joint #2 output pulley.

Hexagon socket head cap bolt: 1-M5×20 (with disc spring 2H-5)



- (6) From the waveform generator, remove the housing.



- (7) From the housing, remove the bearing.

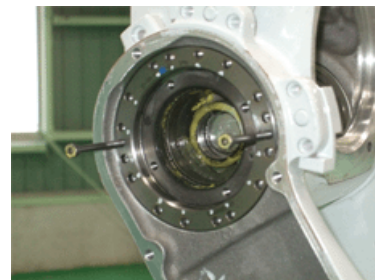


- (8) From the waveform generator, remove the bearing.




- (9) Remove the circular spline from the Arm #2.

Hexagon socket head cap bolt
: 29-M4×12 (with disc spring 2H-4)



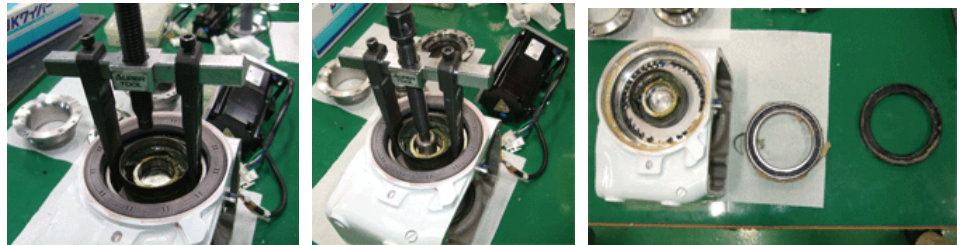
(10) Remove the housing from the Arm #2.

GT-SA bolt: 6-M4×10

NOTE  When the housing is removed, the Arm #1 and Arm #2 are detached. Therefore, hold the Arm #2 while removing the housing.

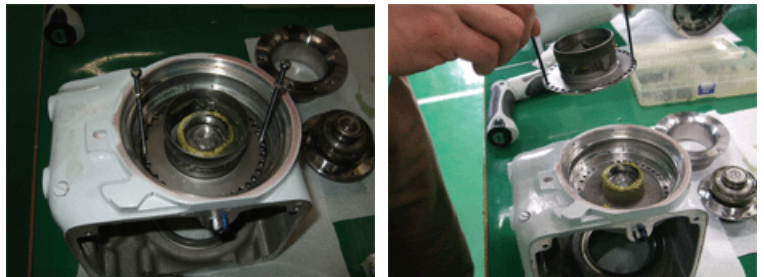


(11) Remove the bearing and oil seal from the Arm #1.




(12) Remove the flexspline from the Arm #1.

Hexagon socket head cap bolt: 30-M4×16 (with disc spring 2H-4)

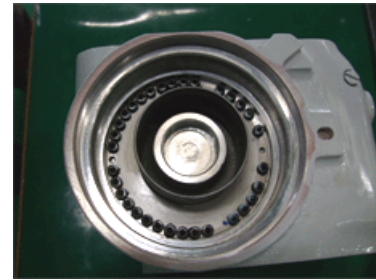


(13) Remove caked-on liquid gasket residue with a scraper or similar tool.


(14) Repair scratches incurred during tap use with a sharpening stone or similar tool.

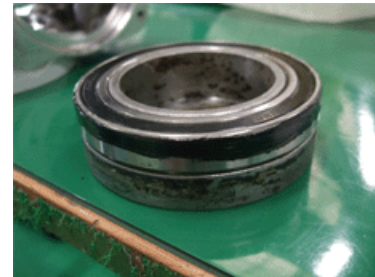
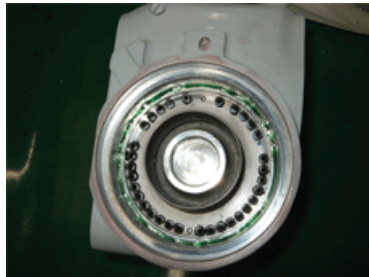
NOTE  Double-check the bolts to make sure that you have not forgotten to tighten any of them.

- Joint #2
Reduction Gear
Unit
Installation
- (1) Mount the flexspline to the Arm #1.
Hexagon socket head cap bolt
: 30-M4×16 (with disc spring 2H-4)
Apply liquid gasket.
Tightening torque
: 2.8 N·m (0.29 kgf·m)



- (2) Press the bearing into the Arm #1.
Apply adhesive to the contact surface with the Arm #2.
Apply liquid gasket to the outer periphery of the bearing.

NOTE  - Spread flat the adhesive and liquid gasket using a spatula.
- Be careful to keep the liquid gasket out of the bearing.



- (3) Apply grease to the inside and lip of the oil seal.

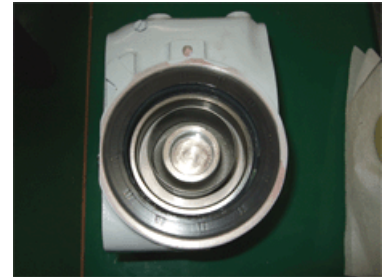
Grease: MP-1



- (4) Press the oil seal into the Arm #1.

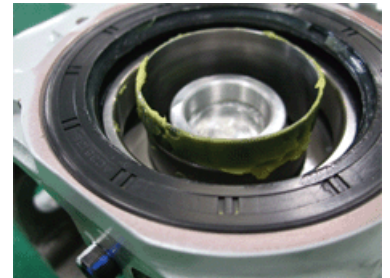


- NOTE
- Before mounting the oil seal, wipe off any liquid gasket on the Arm #1.
 - The height of the oil seal surface and Arm #1 surface should be the same.

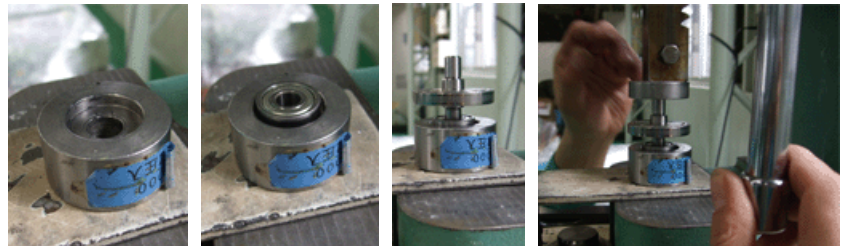


- (5) Apply grease for the reduction gear unit on the teeth of the flexspline.

Grease for reduction gear unit : SK-1A



- (6) Press bearing into the waveform generator.



- (7) Apply liquid gasket to the inside of the bearing.



- (8) Press the bearing into the waveform generator.



(9) Apply liquid gasket to the inside of the housing.



(10) Press the waveform generator into the housing.



(11) Mount the Joint #2 output pulley to the waveform generator.

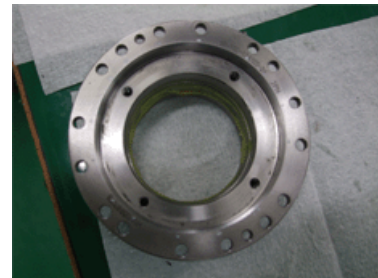
Hexagon socket head cap bolt
: 1-M5×20 (with disc spring 2H-5)

Tightening torque
: 10 N·m (1.02 kgf·m)



(12) Apply grease for the reduction gear unit to the teeth of circular spline.

Grease for reduction gear unit : SK-1A

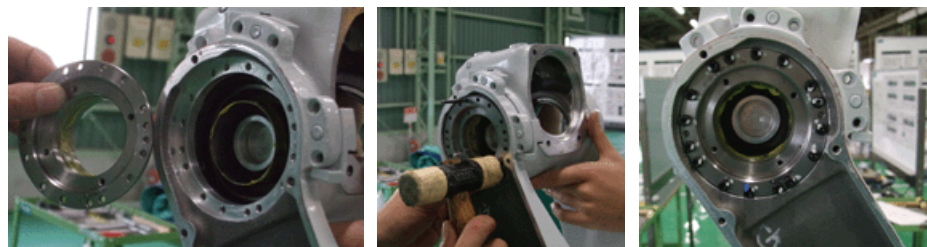


(13) Insert the bearing into the opposite side of the Arm #1's reduction gear unit mounting surface.

(14) Pass the circular spline through the Arm #1 and Arm #2 and joint the arms.

Hexagon socket head cap bolt : 29-M4×12 (with disc spring 2H-4)

Tightening torque : 2.8 N·m (0.29 kgf·m)



(15) Insert the housing into the Arm #2 and bearing.

GT-SA bolt : 6-M4×10

Tightening torque : 2.8 N·m (0.29 kgf·m)

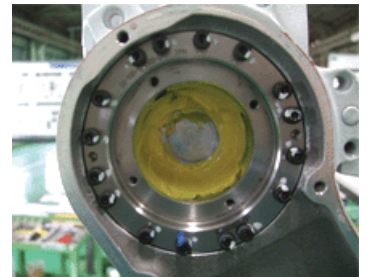


If the housing is not easily inserted, tap the housing using a plastic hammer or similar tool.



(16) Apply 5 mm-thick grease to the inner periphery of the flexspline.

Grease for reduction gear unit: SK-1A



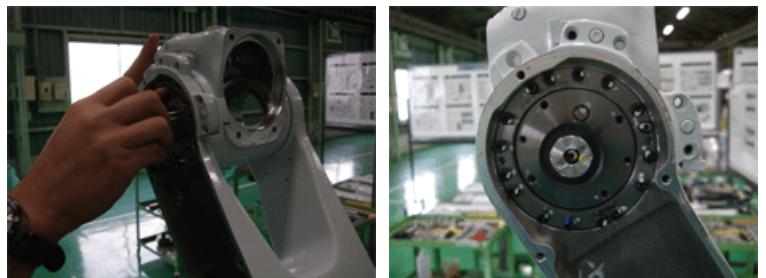
(17) Apply grease to the bearing of waveform generator.

Grease for the reduction gear unit: SK-1A

(18) Apply liquid gasket to the surfaces of the housing (with the waveform generator mounted) and circular spline.



(19) Mount the housing and circular spline.




(20) Mount the Joint #2 motor unit to the manipulator.


For details, refer to *Maintenance: 5.1 Replacing the Joint #2 Motor.*

(21) Mount the cables to inside of the manipulator.

For details, refer to *Maintenance: 9.1 Replacing the Cable Unit.*

5.3 Replacing the Joint #2 Timing Belt

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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.
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NOTE


- After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positionig 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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.
- Replacement procedure of the timing belt for the Joint #2 and Joint #3 are almost same. The following replacement procedure uses pictures of Joint #3.

	Name	Quantity	Note
Maintenance Part	Timing belt	1	R13B030228

Joint #2
Timing belt
Removal

- (1) Remove the Arm #2 Cover.
For details, refer to *Maintenance: 3.2 Arm #2 Cover*.
- (2) Remove the bolts of the motor plate and then remove the timing belt from the pulley.
GT-SA bolt : 2-M4×16 (with M4 washer)

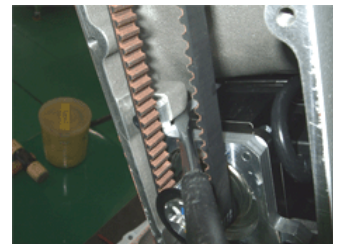


NOTE When the timing belt is removed, the manipulator will lose its posture. Therefore, hold the Arm #2 to prevent it from turning while replacing the belt.



Joint #2
Timing belt
Installation

- (1) Set the timing belt on the pulley and loosely secure the motor plate with the bolts.
GT-SA bolt : 2-M4×16 (with M4 washer)
- (2) Apply the specified tension to the timing belt and secure the motor plate firmly.
Tightening torque : 2.8 N·m (0.29 kgf·m)
Belt tension : 57.9 ~ 77.5 N (5.9 ~7.9 kgf)




- (3) Check the belt tension.





- (4) Mount the Arm #2 Cover.
For details, refer to *Maintenance: 3.2 Arm #2 Cover*.


6. Joint #3

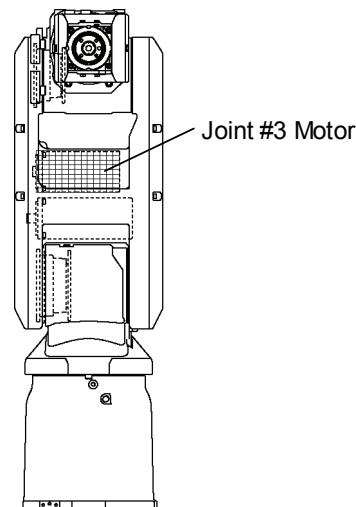
6.1 Replacing the Joint #3 Motor


 <p>WARNING</p>	<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.■ 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.
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 <p>CAUTION</p>	<ul style="list-style-type: none">■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle 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.■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems.<ul style="list-style-type: none">- Never put alcohol, liquid gasket, or adhesive close to fire.- Use alcohol, liquid gasket, or adhesive while ventilating the room.- Wear protective gear including a mask, protective goggles, and oil-resistant gloves.- If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water.- If alcohol, liquid gasket, 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.
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 CAUTION	<ul style="list-style-type: none"> ■ 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. <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. <ul style="list-style-type: none"> 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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NOTE  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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



 WARNING	<ul style="list-style-type: none"> ■ Always use at least two people when removing the motor unit. Remove the motor unit while one person is supporting the upper structure (Arms #3 to #6). The upper structure folds inward at Joint #3 as soon as the motor unit is removed and the brake is released. Failure to properly support the upper structure may result in serious bodily injury and/or severe equipment damage.
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Maintenance 6. Joint #3 (Replacing the Motor)


	Name	Quantity	Note	
Maintenance Parts	AC servo motor	1	200W	R13B000627
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201
	Adhesive	Proper quantity	Loctite 242	R13B031701
Material	Wire tie	-		

NOTE  We recommend folding the upper structure (Arms #3 to #6) to the stop side before the replacement.

Joint #3 Motor Removal


- (1) Remove the Arm #2 Cover.
For details, refer to the *Maintenance 3.2 Arm #2 Cover*.
- (2) Connect the backup battery to the Joint #3 motor cable.
- (3) Remove the Joint #3 motor cable from inside of the manipulator.
- (4) Remove the Joint #3 motor and the Joint #3 motor plate from the Arm #2.
GT-SA bolt: 2-M4×16 (with M4 washer)
- (5) Remove the Joint #3 motor plate from the Joint #3 motor.
Hexagon socket head cap bolt: 3-M4×16 (with disc spring 2H-4, M4 washer)
- (6) Remove the Joint #3 input pulley from the Joint #3 motor.
Hexagon socket head cap bolt: 1-M4×18 (with disc spring 2H-4)

 WARNING	<ul style="list-style-type: none"> ■ Always use at least two people when removing the motor unit. Remove the motor unit while one person is supporting the upper structure (Arms #3 to #6). The upper structure folds inward at Joint #3 as soon as the motor unit is removed and the brake is released. Failure to properly support the upper structure may result in serious bodily injury and/or severe equipment damage.
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 NOTE Double-check the bolts to make sure that you have not forgotten to tighten any of them.

Joint #3 Motor Installation

- (1) Mount the Joint #3 input pulley to the Joint #3 motor.
 - Hexagon socket head cap bolt : 1-M4×18 (with disc spring 2H-4, M4 washer)
 - Apply adhesive.
 - Tightening torque : 2.8 N·m (0.29 kgf·m)


 NOTE When tightening the bolts using the hexagonal wrench, use the grooves of the Joint #3 input pulley to prevent the motor from turning.


- (2) Mount the motor plate to the Joint #3 motor.
 - Hexagon socket head cap bolt : 3-M4×16 (with disc spring 2H-4, M4 washer)
 - Tightening torque : 2.8 N·m (0.29 kgf·m)
- (3) Place the Joint #3 timing belt around the Joint #3 input pulley and mount the Joint #3 motor to the Arm #2.
 - GT-SA bolt : 2-M4×16 (with M4 washer)
 - Tightening torque : 2.8 N·m (0.29 kgf·m)

 NOTE - Make sure the Arm #2 touches the radiation sheet on the motor side surface. It is necessary for the heat radiation of the motor.
 - Adjust the belt tension.
 For details, refer to *Maintenance: 6.3 Replacing the Joint #3 Timing Belt*.

- (4) Attach two cables of the Joint #3 motor (power system, signal system) to the cables inside the manipulator.
- (5) Remove the backup battery from the Joint #3 motor.
- (6) Mount the Arm #3 Cover.
 For details, refer to the *Maintenance 3.3 Arm #3 Cover*.

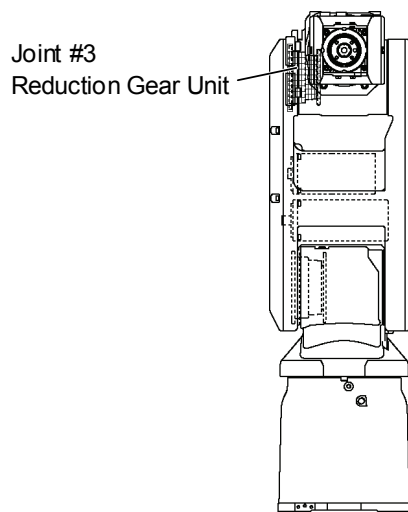
6.2 Replacing the Joint #3 Reduction Gear Unit

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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. <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. <ul style="list-style-type: none"> 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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- 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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.
- A reduction gear unit consists of the three parts described below. When replacing the reduction gear unit, be sure to always replace the waveform generator, flexspline, and circular spline all together as one set. For the structure details of the reduction gear, refer to *Maintenance: 13. Maintenance Parts List*.



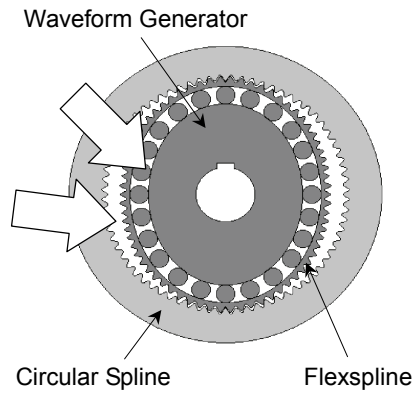
6.2.1 Greasing the Reduction Gear Unit

 CAUTION	<ul style="list-style-type: none"> ■ 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. <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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When greasing the reduction gear unit, use only the grease specified for the reduction gear unit.


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

Location for applying grease on the teeth of flexspline and circular spline and the waveform generator




6.2.2 Replacing the Reduction Gear Unit

 WARNING	<ul style="list-style-type: none"> Always use at least two people when removing the motor unit. Remove the motor unit while one person is supporting the upper structure (Arms #3 to #6). The upper structure folds inward at Joint #3 as soon as the motor unit is removed and the brake is released. Failure to properly support the upper structure may result in serious bodily injury and/or severe equipment damage.
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NOTE  When replacing the reduction gear unit, the bearings should be replaced together.

	Name	Quantity	Note	
Maintenance Parts	Reduction gear unit	1	S5-A701**	R13B010034
			S5-A901**	R13B010035
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201
	Adhesive	Proper quantity	Loctite 242	R13B031701
	Bearing		1	6913ZZ
1			6000ZZ	R13B030805
1			6913DDU	R13B030808
Material	Wire tie	-		

NOTE  We recommend folding the upper structure (Arms #3 to #6) to the stop side before the replacement.

Joint #3
Reduction Gear
Unit
Removal

- Remove the Joint #3 motor unit from the Manipulator.
For details, refer to *Maintenance 6.1 Replacing the Joint #3 Motor*.
- Remove the following:
Joint #3 output pulley / Waveform generator / Housing / Bearing
GT-SA bolt: 4-M4×10

NOTE  As shown in the picture, use a removal tap to remove.



- From the waveform generator, remove the Joint #3 output pulley.

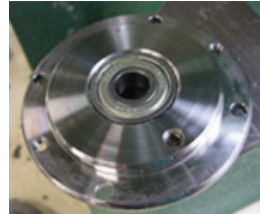


Maintenance 6. Joint #3 (Replacing the Reduction Gear Unit)

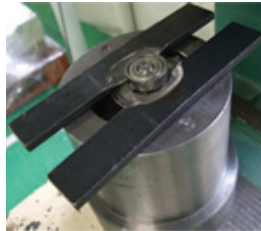
- (4) From the waveform generator, remove the housing



- (5) From the housing, remove the bearing.



- (6) From the waveform generator, remove the bearing.




- (7) Remove the circular spline from the Arm #2.

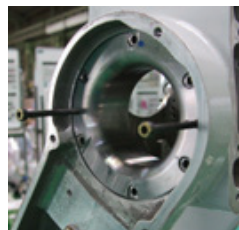
Hexagon socket head cap bolt: 6-M4×12



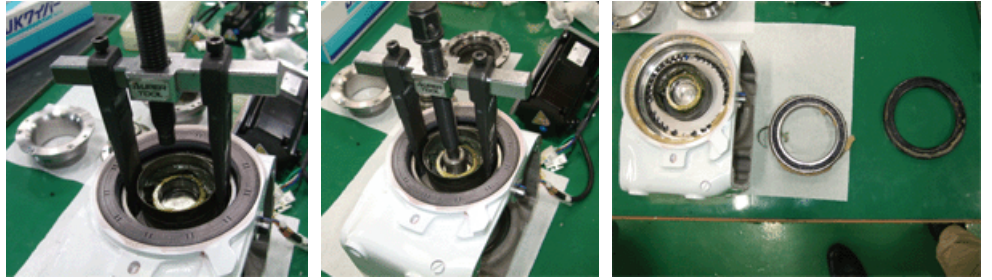
- (8) Remove the housing from the Arm #2.

GT-SA bolt: 6-M4×10

NOTE  When the housing is removed, the Arm #1 and Arm #2 are detached. Make sure to hold the Arm #2 while removing the housing.

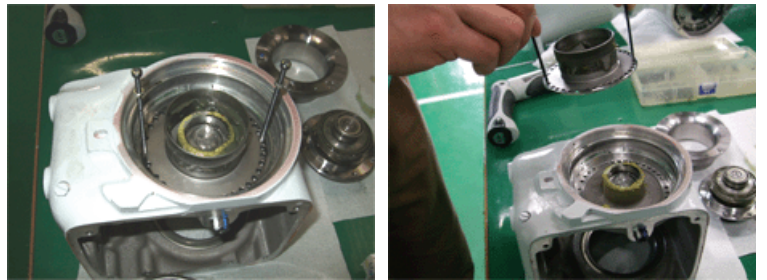


- (9) Remove the bearing and oil seal from the Arm #3.




- (10) Remove the flexspline from the Arm #3.

Hexagon socket head cap bolt: 32-M3×10 (with disc spring 2H-3)



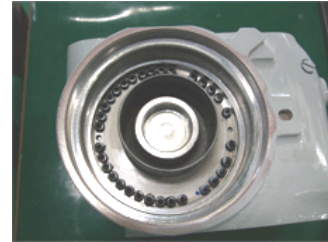
- (11) Remove caked-on liquid gasket residue with a scraper or similar tool.

- (12) Repair scratches incurred during tap use with a sharpening stone or similar tool.


NOTE  Double-check the bolts to make sure that you have not forgotten to tighten any of them.

Joint #3
Reduction Gear
Unit
Installation

- (1) Mount the flexspline to the Arm #3.
Hexagon socket head cap bolt:
32-M3×10 (with disc spring 2H-3)
Apply liquid gasket.
Tightening torque : 1.4 N·m (0.15 kgf·m)



- (2) Press the bearing into the Arm #3.
Apply adhesive to the contact surface with the Arm #3.
Apply liquid gasket to the outer periphery of the bearing.


NOTE  - Spread flat the adhesive and liquid gasket using a spatula.
- Be careful to keep the liquid gasket out of the bearing.



- (3) Apply grease to the inside and lip of the oil seal.
Grease: MP-1



- (4) Press the oil seal into the Arm #3.

NOTE  - Before mounting the oil seal, wipe off any liquid gasket on the Arm #3.
- The height of the oil seal surface and Arm #1 surface should be the same.

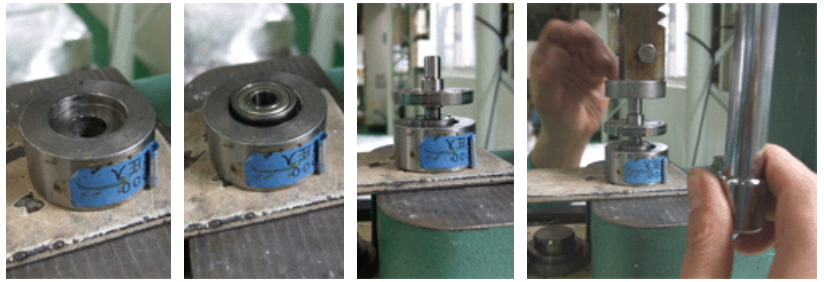


- (5) Apply grease for the reduction gear unit on the teeth of the flexspline.

Grease for reduction gear unit: SK-1A



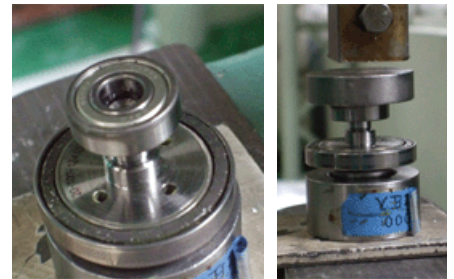
- (6) Press the bearing into the waveform generator.



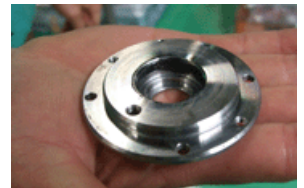
- (7) Apply liquid gasket to inside of the bearing.



- (8) Press the bearing into the waveform generator.



- (9) Apply liquid gasket to inside of the housing.



- (10) Press the waveform generator into the housing.



- (11) Mount the Joint #3 output pulley to the waveform generator.

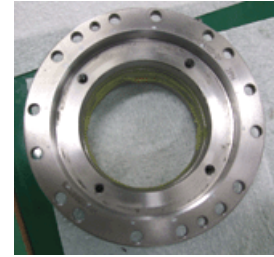
Hexagon socket head cap bolt : 1-M4×18 (with disc spring 2H-4)

Tightening torque : 4.8 N·m (0.49 kgf·m)



- (12) Apply grease on teeth of the circular spline.

Grease for reduction gear unit: SK-1A

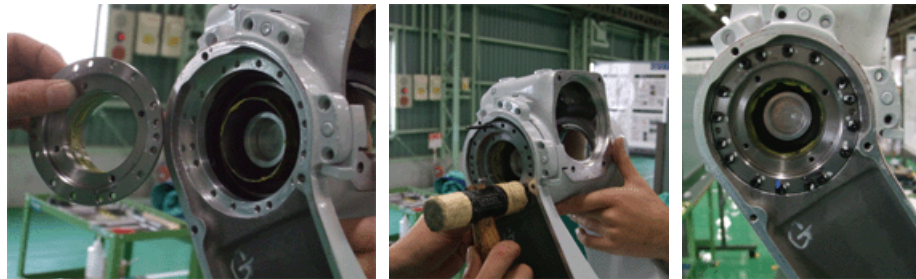


- (13) Insert the bearing into the opposite side of the Arm #3's reduction gear unit mounting surface.

- (14) Pass the circular spline through the Arm #2 and Arm #3 and joint the arms.

Hexagon socket head cap bolt: 16-M4×12


Tightening torque : 2.8 N·m (0.29 kgf·m)

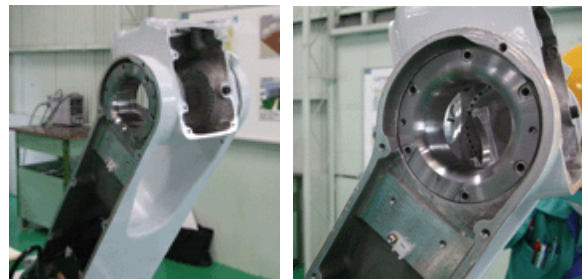


- (15) Insert the housing into the Arm #2 and bearing.

GT-SA bolt : 6-M4×10

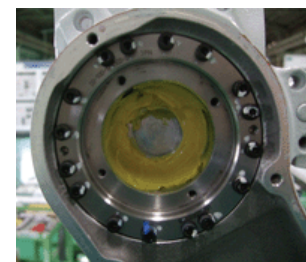
Tightening torque : 2.8 N·m (0.29 kgf·m)

NOTE  If the housing is not easily inserted, tap the housing using a plastic hammer or similar tool.



- (16) Apply 5 mm-thick grease for the reduction gear unit to the inner periphery of the flexspline.

Grease for reduction gear unit: SK-1A



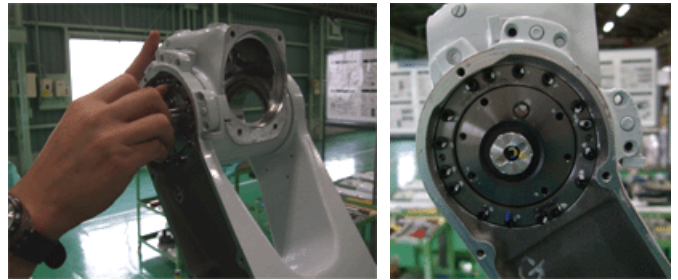
- (17) Apply grease to the bearing of waveform generator.

Grease for reduction gear unit: SK-1A

- (18) Apply liquid gasket to the surfaces of the housing (with the waveform generator mounted) and circular spline.



(19) Mount the housing and circular spline.




(20) Mount the Joint #3 motor unit to the manipulator.

For details, refer to *Maintenance: 6.1 Replacing the Joint #3 Motor*.

(21) Mount the cables to inside of the manipulator.


For details, refer to *Maintenance: 9.1 Replacing the Cable Unit*.

6.3 Replacing the Joint #3 Timing Belt



WARNING

- 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.



CAUTION

- Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems.
 - Never put alcohol, liquid gasket, or adhesive close to fire.
 - Use alcohol, liquid gasket, or adhesive while ventilating the room.
 - Wear protective gear including a mask, protective goggles, and oil-resistant gloves.
 - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water.
 - If alcohol, liquid gasket, 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.

NOTE - After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positionig 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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

	Name	Quantity	Note				
Maintenance Part	Timing belt	1	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border-right: 1px dashed black; padding: 2px;">S5-A701**</td> <td style="padding: 2px;">R13B030229</td> </tr> <tr> <td style="border-right: 1px dashed black; padding: 2px;">S5-A901**</td> <td style="padding: 2px;">R13B030230</td> </tr> </table>	S5-A701**	R13B030229	S5-A901**	R13B030230
S5-A701**	R13B030229						
S5-A901**	R13B030230						

Joint #3
Timing belt
Removal

- (1) Remove the Arm #2 Cover.
For details, refer to *Maintenance: 3.2 Arm #2 Cover*.
- (2) Remove the bolts of the motor plate and then remove the timing belt from the pulley.
GT-SA bolt : 2-M4×16 (with M4 washer)



NOTE
When the timing belt is removed, the manipulator will lose its posture. Therefore, hold the Arm #3 to prevent it from turning while replacing the belt.



Joint #3
Timing belt
Installation

- (1) Set the timing belt on the pulley and loosely secure the motor plate with the bolts.
GT-SA bolt : 2-M4×16 (with M4 washer)
- (2) Apply the specified tension to the timing belt and secure the motor plate firmly.
Tightening torque : 2.8 N·m (0.29 kgf·m)
Belt tension : 57.9 ~ 77.5 N (5.9 ~ 7.9 kgf)




- (3) Check the belt tension.




- (4) Mount the Arm #2 Cover.
For details, refer to *Maintenance: 3.2 Arm #2 Cover*.

7. Joint #4

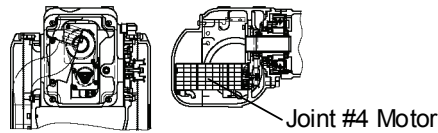
7.1 Replacing the Joint #4 Motor

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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. <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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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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



	Name	Quantity		Note
Maintenance Parts	AC servo motor	1	50W	R13B000628
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201
	Adhesive	Proper quantity	Loctite 242	R13B031701
Material	Wire tie	-		

Joint #4 Motor Removal (1) Remove the Arm #3 Cover.

For details, refer to *Maintenance 3.3 Arm #3 Cover*.

(2) Remove the LED lamp.



(3) Remove the bolts that secure the supporting plate and then pull out the lead line from the manipulator.

GT-SA bolt: 2-M4×10



(4) Connect the backup battery to the Joint #4 motor cable.


(5) Remove the Joint #4 motor cables from the cables inside the manipulator.

(6) Remove the bolts and then remove the Joint #4 motor.


GT-SA bolt : 2-M3×12 (with M3 washer

(7) Remove the bolts and then remove the pulley.


Hexagon socket head cap bolt : M3×12 (with disc spring 2H-3)

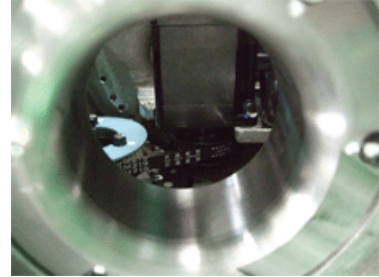
NOTE
 Double-check the bolts to make sure that you have not forgotten to tighten any of them.

- Joint #4 Motor Installation**
- (1) Mount the pulley to the Joint #4 motor.
Hexagon socket head cap bolt: M3×12 (with disc spring 2H-3)
Apply adhesive.
Tightening torque: 2.25 N·m (0.25 kg·m)

NOTE
 When tightening the bolts using the hexagonal wrench, use the grooves of the pulley to prevent the motor from turning.

- (2) Set the belt around the pulley and mount the Joint #3 motor to the Arm #3.
GT-SA bolt : 2-M3×12 (with M3 washer)
Tightening torque : 1.4 N·m (0.14 kg·m)

NOTE
 From the Arm #3 side surface, confirm that the timing belt is properly set on the pulley.

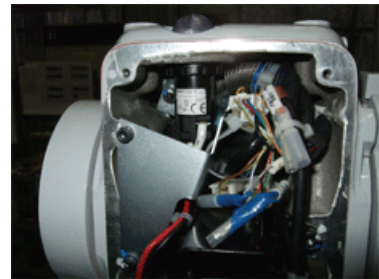
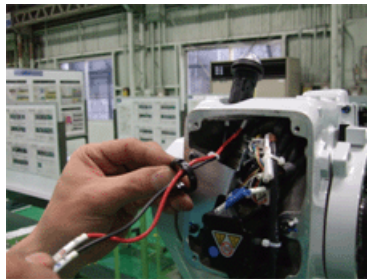


- (3) Mount the Joint #4 motor cable to the lead line.
- (4) Remove the backup battery.
- (5) Mount the supporting plate on the Arm #3.

GT-SA bolt : 2-M4×10
Tightening torque : 2.8 N·m (0.28 kg·m)




- (6) Mount the LED lamp.




- (7) Mount the Arm #3 Cover.

For details, refer to *Maintenance 3.3 Arm #3 Cover*.

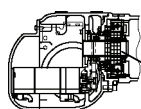
7.2 Replacing the Joint #4 Reduction Gear Unit

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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. <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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- 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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.
- A reduction gear unit consists of the three parts described below. When replacing the reduction gear unit, be sure to always replace the waveform generator, flexspline, and circular spline all together as one set. For the structure details of the reduction gear, refer to *Maintenance: 13. Maintenance Parts List*.



Joint #4 Reduction Gear Unit

7.2.1 Greasing the Reduction Gear Unit

 CAUTION	<ul style="list-style-type: none"> ■ 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. <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. <ul style="list-style-type: none"> 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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When greasing the reduction gear unit, use only the grease specified for the reduction gear unit.

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

Location for applying grease

- Teeth of the Joint #4 flexspline and the circular spline
- Waveform generator
- Between the waveform generator and the motor plate of the Joint #4 reduction gear

7.2.2 Replacing the Reduction Gear Unit

NOTE  When replacing the reduction gear unit, the bearings should be replaced together.

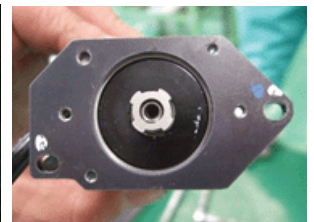
	Name	Quantity		Note
Maintenance Parts	Reduction gear unit	1		R13B010036
	Grease for reduction gear	Proper quantity	SK-1A	R13ZA00330100
	Liquid gasket	Proper quantity	1206C	R13B031201
	Adhesive	Proper quantity	Loctite 242	R13B031701
	Bearing		1	6806ZZ
		1	6808ZZ*NS7	R13B030809
Material	Wire tie	-		

Joint #4
Reduction Gear
Unit
Removal

- (1) Pull out the lead line toward the Arm #2 side.
For details, refer to *Maintenance 9.1 Replacing the Cable Unit*.



- (2) Remove the bolts and then remove the pipe.
GT-SA bolt : 2-M3×12



- (3) Remove the bolts and then remove the Joint #4 motor.
GT-SA bolt: : 2-M3×12 (with M3 washer)

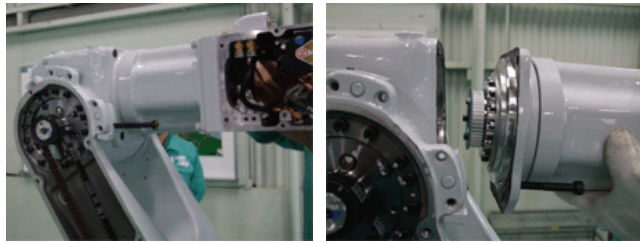


- (4) Remove the belt from the pulley.



- (5) Remove the bolts and then remove the wrist from the Arm #3.

Hexagon socket head cap bolt : 4-M6×16 (with disc spring 2H-6)

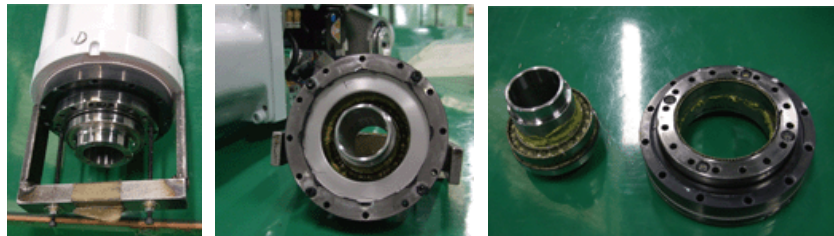


- (6) Remove the bolts and then remove the pulley and washer from waveform generator.

GT-SA bolt : 3-M3×10

- (7) Remove the bolts and then remove the Joint #4 reduction gear unit using the removal tap.

Hexagon socket head cap bolt : 16-M3×20 (with disc spring 2H-3)



- (8) Remove the bearing from the housing.



- (9) Remove the bearing from the waveform generator.




- (10) Remove caked-on liquid gasket residue with a scraper or similar tool.

- (11) Repair scratches incurred during tap use with a sharpening stone or similar tool.

- (12) Remove the flexspline cap from the flexspline.

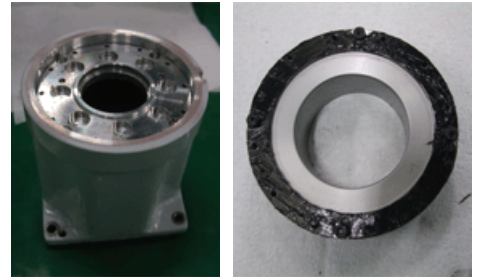


NOTE  Double-check the bolts to make sure that you have not forgotten to tighten any of them.

**Joint #4
Reduction Gear
Unit
Installation**

- (1) Apply liquid gasket to contact surfaces of the circular spline, flexspline, and spacer.

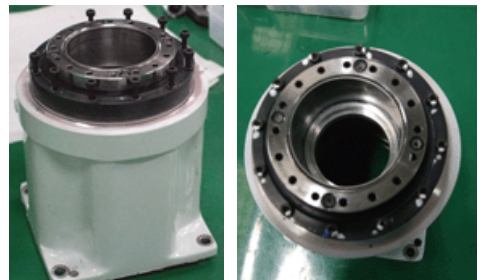
Liquid gasket (1206C)



- (2) Mount the circular spline and flexspline to the spacer.

Hexagon socket head cap bolt
: 12-M3×30 (with disc spring 2H-3)
Apply liquid gasket (1206C).

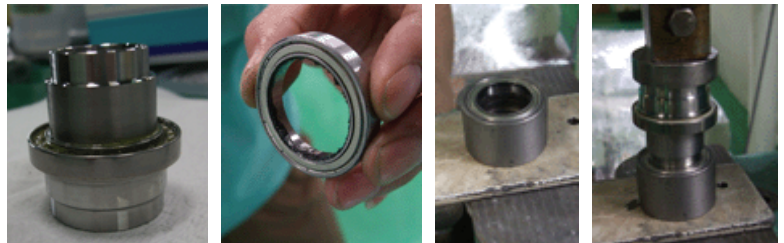
Tightening torque : 1.4 N·m (0.14 kgf·m)



- (3) Apply liquid gasket to inner periphery of the bearing.
Press the bearing into the waveform generator.

Bearing : 6806ZZ

Liquid gasket : 1206C



- (4) Apply liquid gasket to the inner periphery of the bearing.
Press the bearing into the waveform generator.

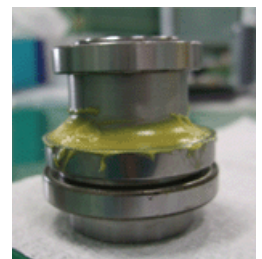
Bearing : 6808ZZ*NS7*

Liquid gasket : 1206C



- (5) Apply the grease for the reduction gear to the bearing of the waveform generator.

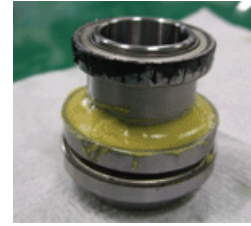
Grease for reduction gear: SK-1A (Approx. 2 g)



- (6) Apply liquid gasket to outer periphery of the bearing.

Bearing : 6806ZZ

Liquid gasket : 1206C



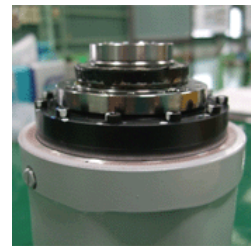
- (7) Insert the circular spline and flexspline into the waveform generator.



- (8) Apply liquid gasket to outer periphery of the bearing.

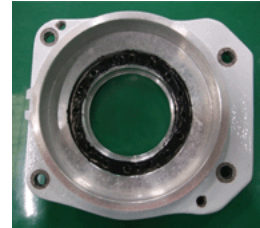
Bearing : 6808ZZ*NS7*

Liquid gasket : 1206C



- (9) Apply liquid gasket to contact surfaces of the housing, circular spline, and flexspline.

Liquid gasket: 1206C



- (10) Mount the housing to the circular spline and flexspline.

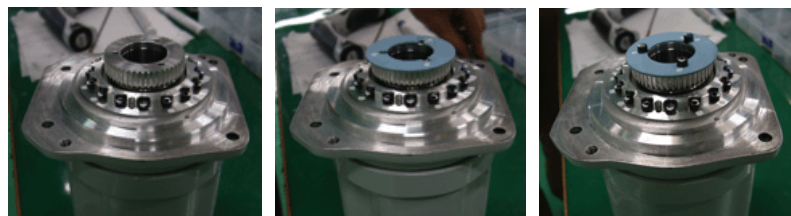
Hexagon socket head cap bolt: 16-M3×20 (with disc spring 2H-3)

Tightening torque: 1.4 N·m (0.14 kgf·m)

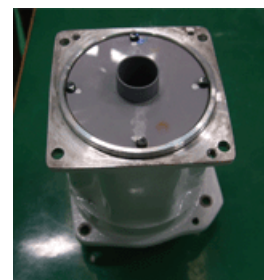
- (11) Mount the pulley and washer to the waveform generator.

GT-SA bolt : 3-M3×10

Tightening torque : 1.4 N·m (0.14 kgf·m)

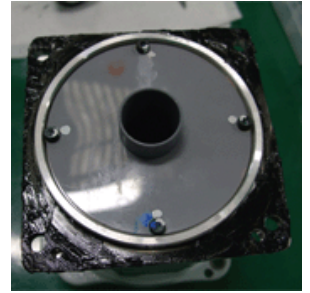


- (12) Mount the pipe to the spacer.



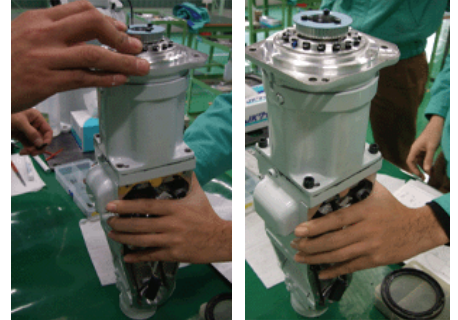
- (13) Apply liquid gasket to contact surfaces of the spacer and Wrist Unit.

Liquid gasket: 1206C



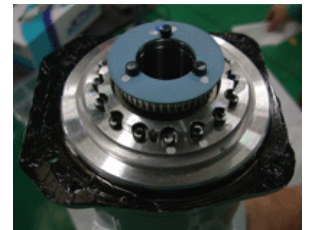
- (14) Mount the spacer to the Wrist Unit.

Hexagon socket head cap bolt
: 4-M6×16 (with disc spring 2H-6)
Tightening torque: 10 N·m (1.02 kgf·m)



- (15) Apply liquid gasket to the contact surfaces of the spacer and Arm #3.

Liquid gasket: 1206C



- (16) Mount the spacer to the Arm #3.

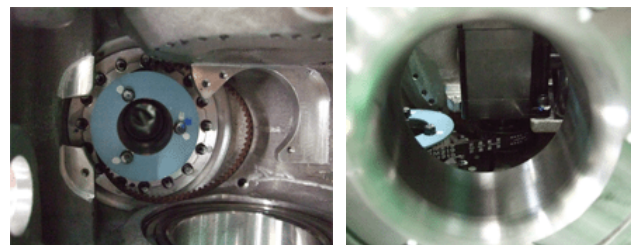
Hexagon socket head cap bolt
: 4-M6×16 (with disc spring 2H-6)
Tightening torque: 10 N·m (1.02 kgf·m)



- (17) Set the belt around the belt and mount the Joint #4 motor to the Arm #3.

GT-SA bolt : 2-M3×12 (with M3 washer)
Tightening torque : 1.4 N·m (0.14 kgf·m)

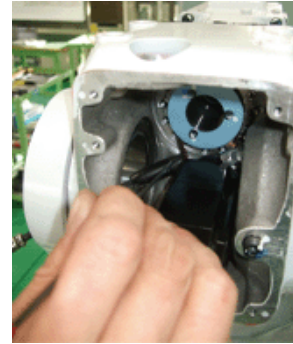
From the Arm #3 side surface, confirm that the timing belt is properly set on the pulley.



Maintenance 7. Joint #4 (Replacing the Reduction Gear Unit)

- (18) Confirm that the specified tension is applied to the belt.

Belt tension: 19.6 ~ 26.5 N (2.0 ~ 2.7 kgf)



- (19) Mount the pipe to the Arm #3.

GT-SA bolt : 2-M3×12

Tightening torque : 1.4 N·m (0.14 kgf·m)

NOTE




Be careful of the pipe direction. (See the photo.)




- (20) Mount the lead line.

For details, refer to *Maintenance 9.1 Replacing the Cable Unit*.

7.3 Replacing the Joint #4 Timing Belt

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle 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. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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.
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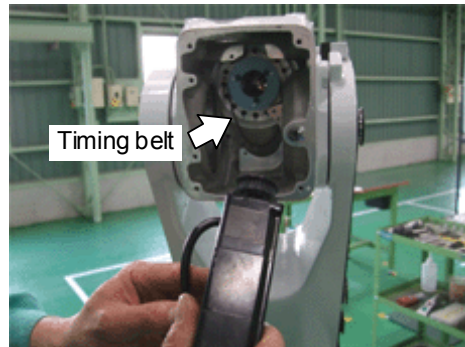
After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a mismatch exists between the origin stored in each motor encoder and its corresponding origin stored in the Controller. After replacing the parts, it is necessary to match these origins. The process of aligning the two origins is called “Calibration”. Refer to *Maintenance 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.

	Name	Quantity	Note
Maintenance Part	Timing belt	1	R13B030231

Joint #4
Timing belt
Removal

- (1) Remove the Arm #3 Cover.
For details, refer to *Maintenance: 3.3 Arm #3 Cover*.
- (2) Remove the timing belt.

Follow the removal steps (1) to (4) in *Maintenance: 7.2.2 Replacing the Joint #4 Reduction Gear Unit*.





Joint #4
Timing belt
Installation

- (1) Mount the timing belt.
Follow the installation steps (17) to (21) in *Maintenance: 7.2.2 Replacing the Joint #4 Reduction Gear Unit*.
- (2) Mount the Arm #3 Cover.
For details, refer to *Maintenance: 3.3 Arm #3 Cover*.

8. Joint #5 & Joint #6

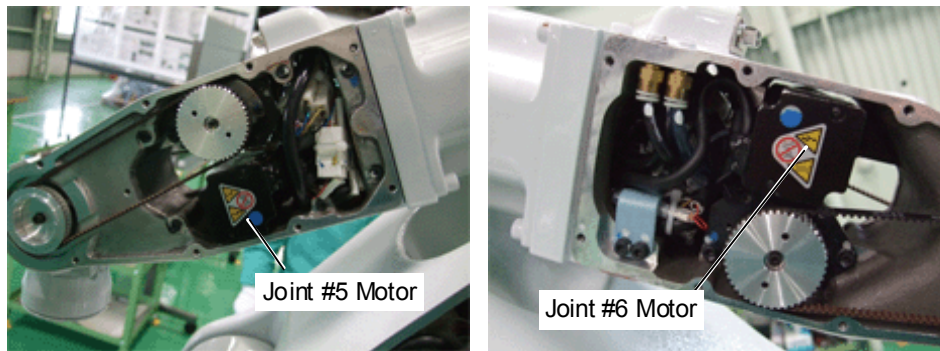
8.1 Replacing the Joint #5 & Joint #6 Motor

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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.
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NOTE 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 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



	Name	Quantity	Note
Maintenance Parts	AC servo motor	1	50W Common for Joint #5, Joint #6
	Adhesive	Proper quantity	Loctite 242
Material	Wire tie	-	

 WARNING	<ul style="list-style-type: none"> Lower the Arm #5 and Arm #6 before replacing the Joint #5 motor. Removing the motor will disengage the brake, which may cause the Manipulator to fall and may result in serious bodily injury and/or severe equipment damage.
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Joint #5 & #6
Motor
Removal

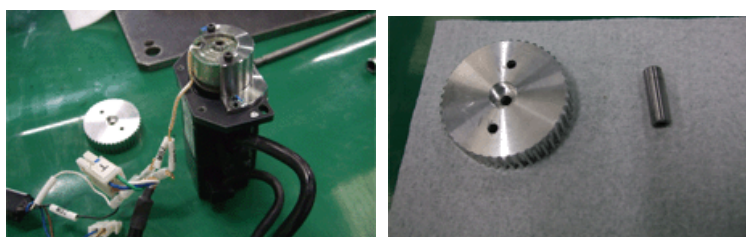
- Remove the Arm #4 Cover.
For details, refer to *Maintenance 3.4 Arm #4 Cover*.
- Connect the backup battery to the motor cable.
- Remove the motor cable from the lead line.
- Remove the bolts and then remove the motor plate and motor from the Arm #4.

GT-SA bolt : 2-M4×16 (with M4 washer)



- Remove the bolts and then remove the pulley and shaft.

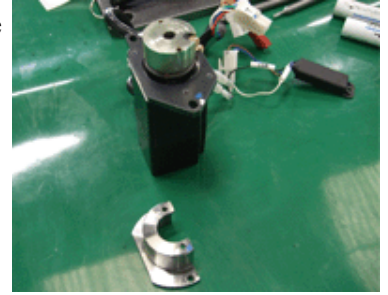
Hexagon socket head cap bolt : M3×30 (with disc spring 2H-3)



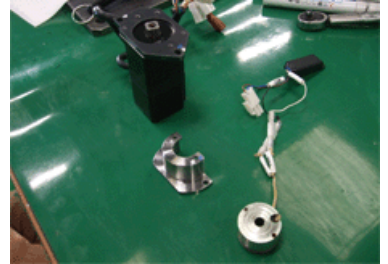
- (6) Remove the two types of bolts and then remove the bracket.

Hexagon socket head cap bolt : 2-M2.6×5

GT-SA bolt : 2-M3×12

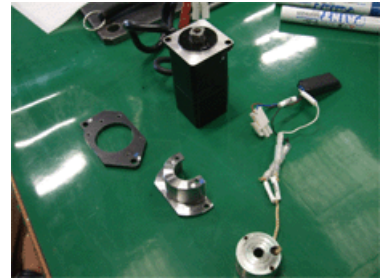


- (7) Remove the electromagnetic brake.



- (8) Remove the bolts and then remove the motor plate.


GT-SA bolt: 2-M3×12 (with M3 washer)



- (9) Remove the set screws and then remove the rotor hub.

Hexagon socket head cap set screw: 2-M2



NOTE  Double-check the bolts to make sure that you have not forgotten to tighten any of them.


Joint #5 & #6 (1) Mount the rotor hub to the motor shaft.

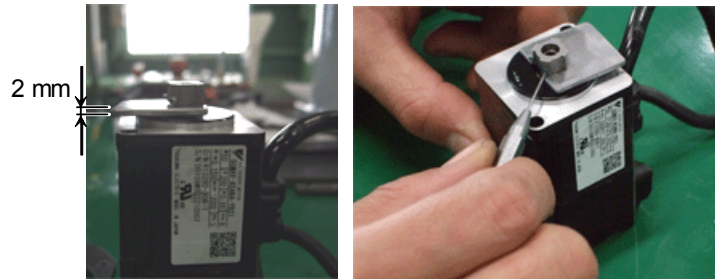
Motor Installation

Hexagon socket head cap set screw : 2-M2

Apply adhesive.

Tightening torque : 0.3 N·m (0.03 kgf·m)

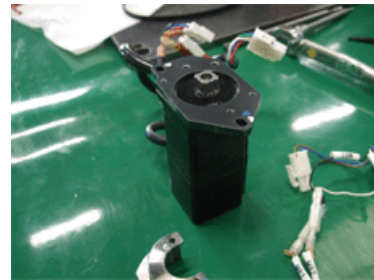
NOTE  Use a spacer or similar tool to secure the rotor hub at 2 mm from the motor edge surface.



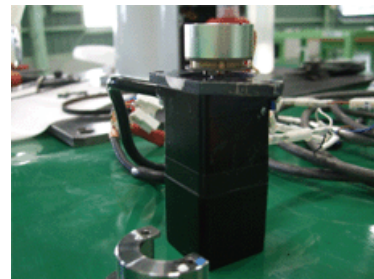
(2) Mount the motor plate to the motor.

GT-SA bolt : 2-M3×12 (with M3 washer)

Tightening torque : 1.4 N·m (0.14 kgf·m)



(3) Insert the electromagnetic brake into the rotor hub.



(4) Mount the bracket using the brake centering jig.

Hexagon socket head cap bolt

: 2-M2.6×5

Tightening torque

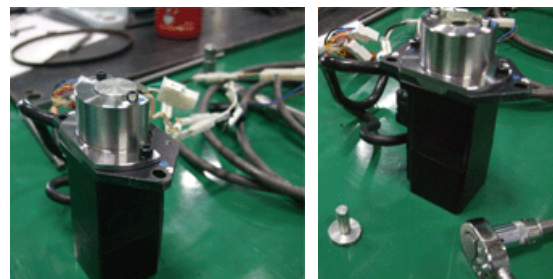
: 0.3 N·m (0.03 kgf·m)

GT-SA bolt

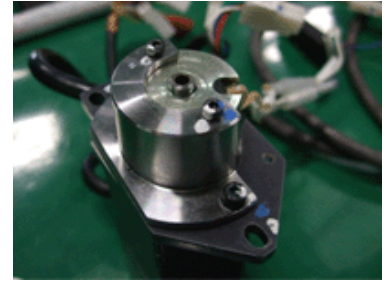
: 2-M3×12

Tightening torque

: 1.4 N·m (0.14 kgf·m)



- (5) Insert the shaft to center of the electromagnetic brake.



- (6) Mount the pulley and then secure the brake cable with a wire tie.

Hexagon socket head cap bolt: M3×30 (with disc spring 2H-3)

Apply adhesive.

Tightening torque: 2.25 N·m (0.23 kgf·m)

- (7) Mount the motor plate and motor to the Arm #4.

GT-SA bolt: 2-M4×16 (with M4 washer)

- (8) Set the timing belt on the pulley and adjust the belt tension.

For details, refer to *Maintenance: 8.2 Replacing the Joint #5 & Joint #6 Timing Belt*.


- (9) Connect the motor cable to the lead line.


- (10) Remove the backup battery.


- (11) Mount the Arm #4 Cover.

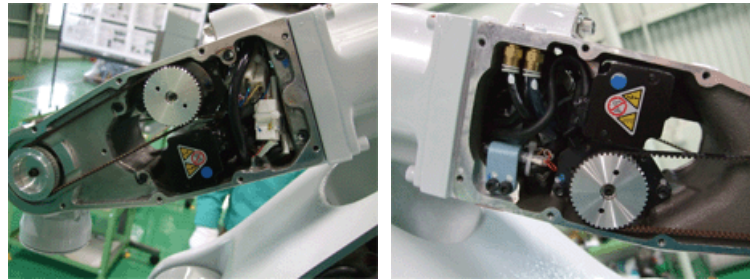
For details, refer to *Maintenance: 3.4 Arm #4 Cover*.

8.2 Replacing the Joint #5 & Joint #6 Timing Belt

 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. ■ 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.
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 CAUTION	<ul style="list-style-type: none"> ■ Be careful not to apply excessive shock to the motor shaft during replacement procedures. The shock may shorten the life cycle of the motors and encoder and/or damage them. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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.
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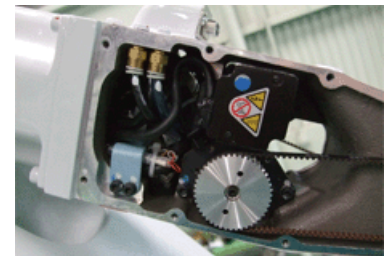
NOTE  After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a mismatch exists between the origin stored in each motor encoder and its corresponding origin stored in the Controller. After replacing the parts, it is necessary to match these origins. The process of aligning the two origins is called “Calibration”. Refer to *Maintenance 12. Calibration* and follow the steps that pertain to the software you are using to perform the calibration.



	Name	Quantity	Note
Maintenance Part	Timing belt	1	R13B030232

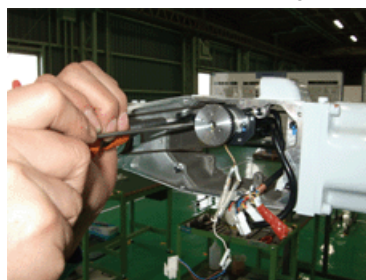
**Joint #5 & #6
Timing Belt
Removal**

- (1) Remove the Arm #4 Cover.
For details, refer to the *Maintenance 3.4 Arm #4 Cover*.
- (2) Remove the bolts of the motor plate.
Pull the motor unit so that it is leaning towards you and remove the timing belt from the pulley.
GT-SA bolt: 2-M4×16 (with M4 washer)



**Joint #5 & #6
Timing Belt
Installation**

- (1) Insert the motor unit to its original position in the Manipulator.
- (2) Set the timing belt on the pulley and loosely fasten the motor plate with the bolts.
GT-SA bolt: 2-M4×16 (with M4 washer)
- (3) Apply the specified tension to the timing belt and firmly fasten the motor plate.
Tightening torque : 2.8 N·m (0.29 kgf·m)
Belt tension : 19.6 ~ 26.5 N (2.0 ~2.7 kgf)




- (4) Check the belt tension.




- (5) Mount the Arm #4 Cover.
For details, refer to the *Maintenance 3.4 Arm #4 Cover*.


9. Cable Unit

 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. ■ 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.
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9.1 Replacing the Cable Unit

If the power and signal connectors are unplugged without connecting the backup battery for the motor encoder, the motor position data will be lost and the calibration must be executed again. Connect a battery to the battery port on each motor when replacing cables.

 WARNING	<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. ■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
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 <p>CAUTION</p>	<ul style="list-style-type: none"> ■ 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 <i>Maintenance 9.2 Connector Pin Assignments</i>. ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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. <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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	Name	Quantity	Note	
Maintenance Parts	Cable unit	1	S5-A701** :	R13B020056
			S5-A901** :	R13B020057
	Backup battery for motor encoder *	6	For Joint #1, #2, #3, #4, #5, #6	R13B060006
Material	Wire tie	-		

* The backup battery for the motor encoder is only used for retaining the motor position data during maintenance (cable replacement, etc.). It is not used for the Manipulator itself.

Cable Unit Removal

- (1) Return the Manipulator to the origin position (0 pulse position).
- (2) Remove the covers listed below.
 - Arm #1 Cover Arm #2 Cover Arm #3 Cover
 - Arm #4 Cover Base Connector Plate

Refer to the *Maintenance 3. Covers* for details on removing covers.



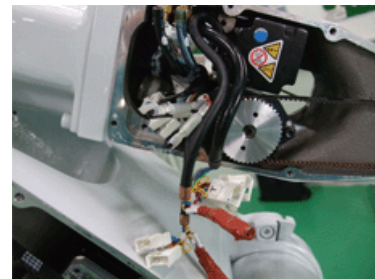
- (3) Cut the wire ties that bind six connector packs (power system, signal system) of the motors of the Joints #1, #2, #3, #4, #5, and #6.
- (4) Connect the motor encoder backup battery for the Joint #1, #2, #3, #4, #5, and #6 motor to the each motor.



NOTE If you unplug the power cable and signal cable without connecting the backup batteries for the motor encoders, the position data in motors will be lost and the arms will need to be calibrated again.

- (5) Remove the connectors of the power cable and signal cable.
 - Connector: For Joint #5 (B), For Joint #6 (T)

- (6) Remove the air hose and equipped cable connector.
 - Connector: 3BC, 4BC



- (7) Remove the connectors of the power cable and signal cable.
 - Connector: For Joint #4 (R)

- (8) Cut off all wire ties that secure the lead line inside the Arm #3.

- (9) Remove the LED.



- (10) Remove the supporting plate.

Hexagon socket head cap bolt : 2-M4×10



- (11) Remove the saddle.

Hexagon socket head cap bolt

: M5×8 (with disc spring 2H-5, M5 washer)



- (12) Cut off the wire ties and pull out the lead line toward the Arm #3.

To pull out the lead line smoothly, bind the connectors with a tape as shown in the picture below.



- (13) Remove the connectors of power cable and signal cable.

Connector: For Joint #2 (L), For Joint #3 (U)

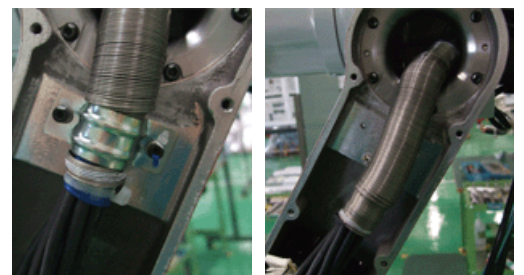
- (14) Cut off all wire ties that secure the lead line inside the Arm #2.

- (15) Remove the saddle.

Hexagon socket head cap bolt

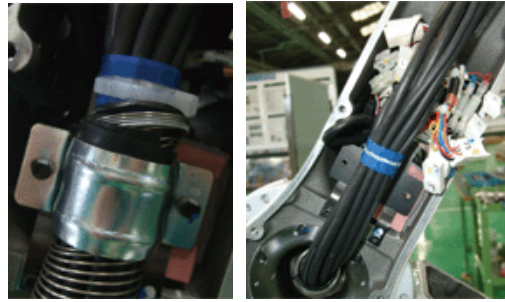
: 2-M4×8

(with disc spring 2H-4, M4 washer)



(16) Remove the saddle.

Hexagon socket head cap bolt
: 2-M4×6
(with disc spring 2H-4, M4 washer,
and rubber plate)



(17) Pull out the lead line toward the Arm #2.

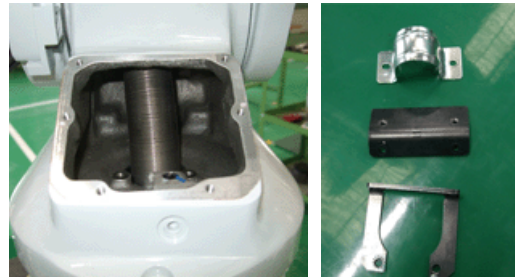
(18) Remove the supporting plate.

GT-SA bolt : 2-M4×12



(19) Remove the saddle.

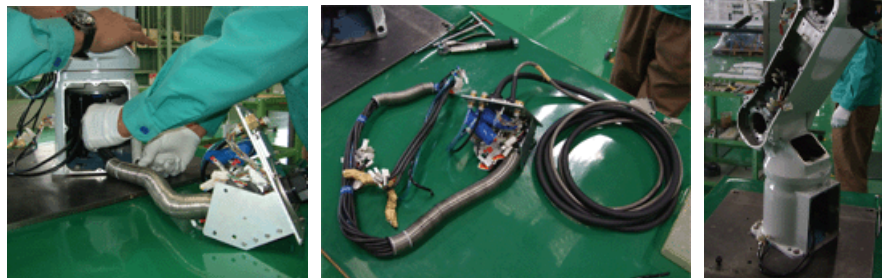
GT-SA bolt : 2-M5×10
(with M5 washer)




(20) Remove the connectors of power cable and signal cable.

Connector: For Joint #1 (S)

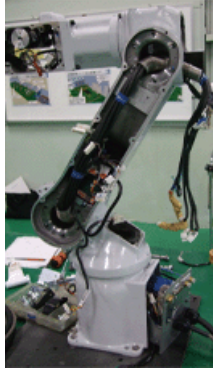
(21) Pull out the lead line by pulling the connector plate.



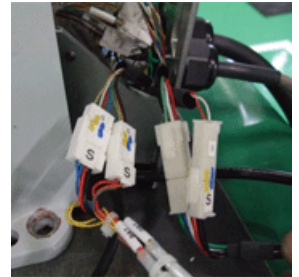
NOTE  Double-check the bolts to make sure that you have not forgotten to tighten any of them.

Cable Unit Installation

- (1) Pass the lead line (with the connector plate attached) through the back of the Base and Arm #1 to Arm #4.




- (2) Connect the Joint #1 motor connector to the lead line.
Remove the backup battery.



- (3) Press the lead line into the Base and mount the Connector Plate.

Hexagon socket button head bolt : 8-M4×10
Tightening torque : 1.4 N·m (0.14 kgf·m)

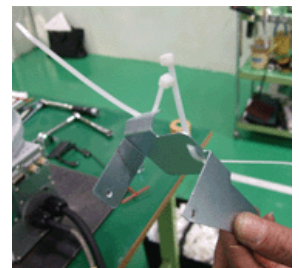


NOTE  Be careful not to catch the cables between the Base and the Connector Plate.

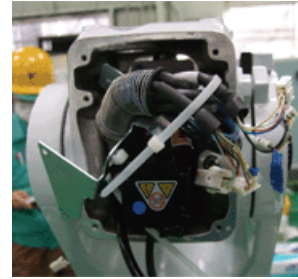
- (4) Put the lead line around the Arm #3 as shown in the picture.



- (5) Pass a wire tie through the supporting plate.



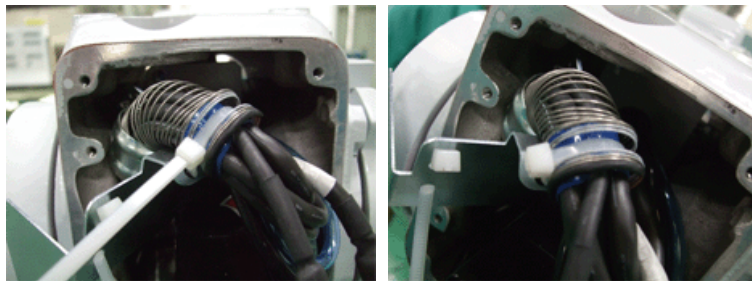
- (6) Secure the wire tie as shown in the picture.



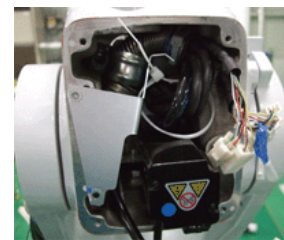
- (7) Mount the saddle to the supporting plate.
GT-SA bolt : M4×10
Tightening torque : 2.8 N·m (0.29 kgf·m)



- (8) Secure the cables to the supporting plate as shown in the picture.



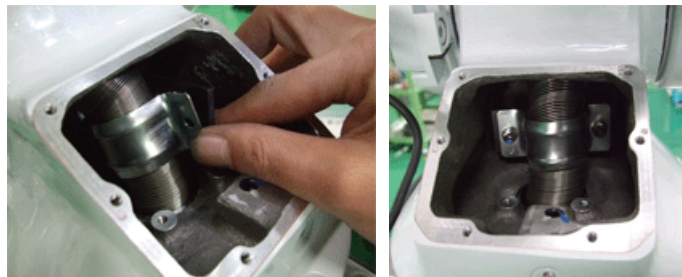
- (9) Loosely secure the cables in the Arm #3 with a wire tie.



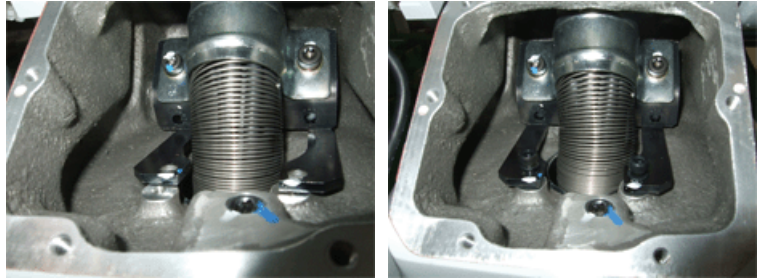
- (10) Secure the supporting plate to the Arm #3.
GT-SA bolt : 2-M4×10
Tightening torque : 2.8 N·m (0.29 kgf·m)



- (11) Mount the saddle to the spring (some winds from the end) of the lead line.



(12) Mount the supporting plate inside the Arm #1.



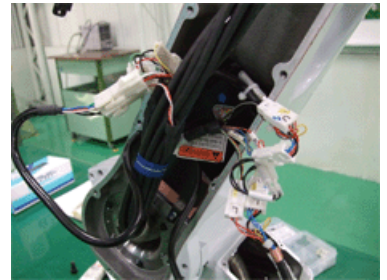
(13) Secure the supporting plate and saddle.



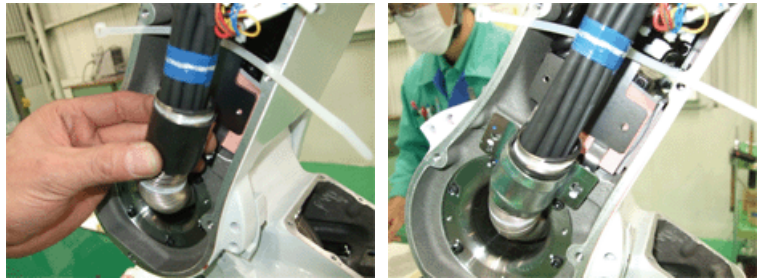
(14) Connect the connector to the lead line.

Remove the backup battery.

Connector: For Joint #2 (L), For Joint #3 (U)



(15) Mount the rubber plate and saddle to the spring (some winds from the end) of the lead line.



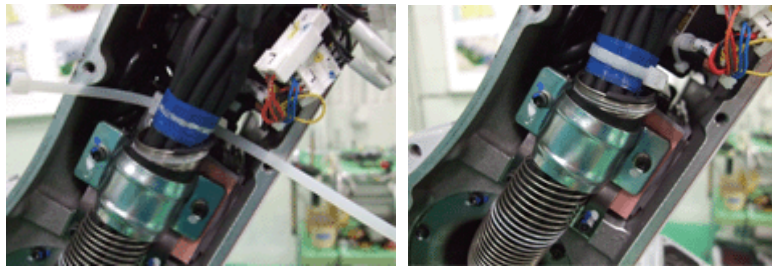
(16) Secure the saddle to the Arm #2.

Hexagon socket head cap bolt
: 2-M4×6
(with disc spring 2H-4, M4 washer)

Tightening torque
: 2.8 N·m (0.29 kgf·m)

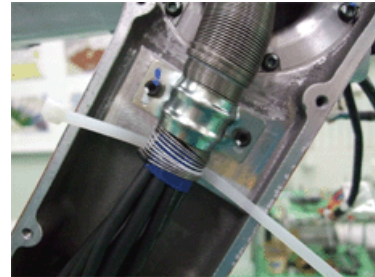


(17) Set a wire tie in the area marked in white.



(18) Mount another saddle to the spring (some winds from the end) of the Arm #3 side.

Hexagon socket head cap bolt
: 2-M4×8
(with disc spring 2H-4, M4 washer)
Tightening torque: 2.8 N·m (0.29 kgf·m)

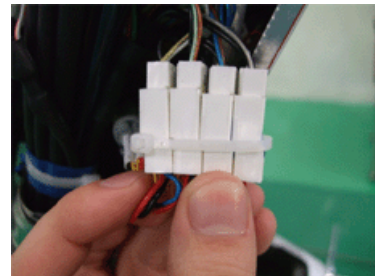


(19) Set a wire tie in the area marked in white.



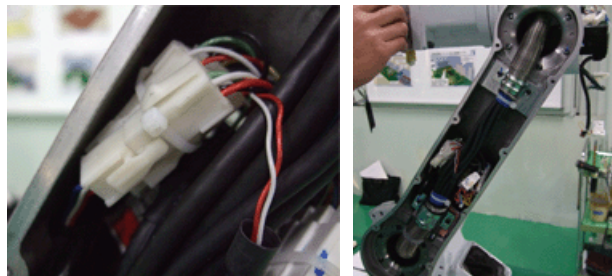
(20) Bind the signal connectors with a wire tie as shown in the picture.

Connector: For Joint #2 (L), For Joint #3 (U)

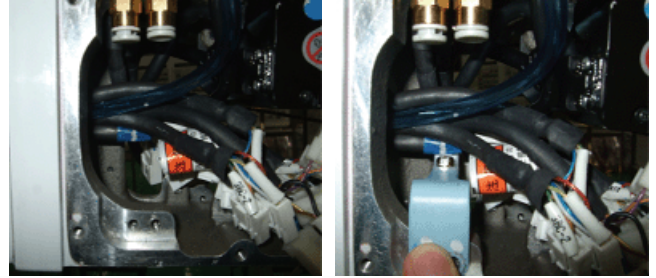


(21) Bind the power connectors with a wire tie as shown in the picture.

Connector: For Joint #2 (L), For Joint #3 (U)



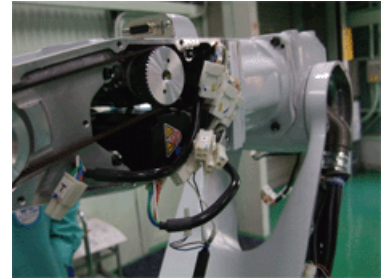
- (22) Put the cable in the position in the Arm #4 as shown in the picture below, with the white marking on the cable as the guide.



- (23) Connect the connector to the lead line.

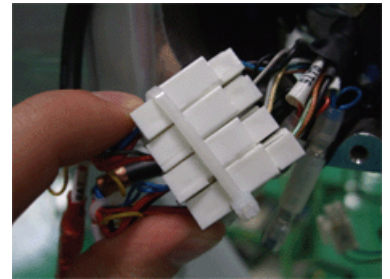
Remove the backup battery.

Connector: For Joint #5 (B), For Joint #6 (T)



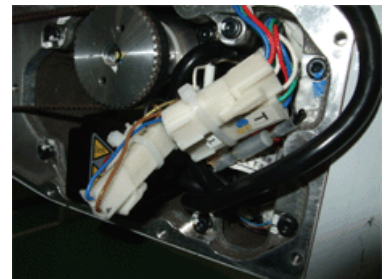
- (24) Bind the signal connectors with a wire tie as shown in the picture.

Connector: For Joint #5 (B), For Joint #6 (T)



- (25) Bind the power connectors with a wire tie as shown in the picture.

Connector: For Joint #5 (B), For Joint #6 (T)



- (26) Put the connector of the signal cable in the position shown in the picture.

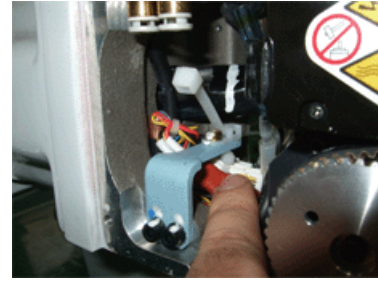


- (27) Pass the wire tie through the cable fixing plate.

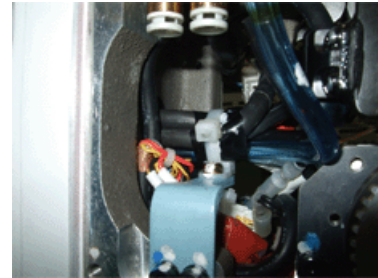


- (28) Secure the cable fixing plate to the Arm #4.

GT-SA bolt : 2-M4×12
Tightening torque : 2.8 N·m (0.29 kgf·m)




- (29) Set a wire tie in the area marked in white.

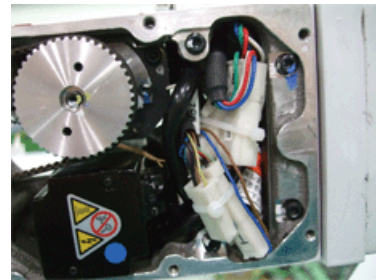


- (30) Mount two air hoses to the Arm #4.

Air Hose: A – Black, B – Blue

NOTE  Make sure to mount the air hoses in the right position. Otherwise, the air lines change inside the manipulator and the equipment such as the hand cannot function normally.

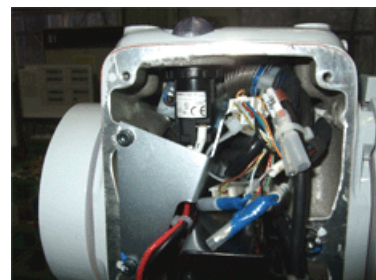
- (31) Press the power connectors into the Arm #4.



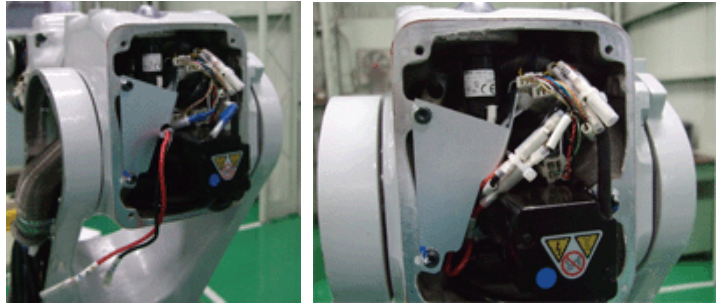
- (32) Connect the connector to the lead line. Remove the backup battery.

Connector: For Joint #4 (R)

- (33) Mount the LED lamp to the Arm #3.



(34) Mount the connector of the LED lamp to the lead line.



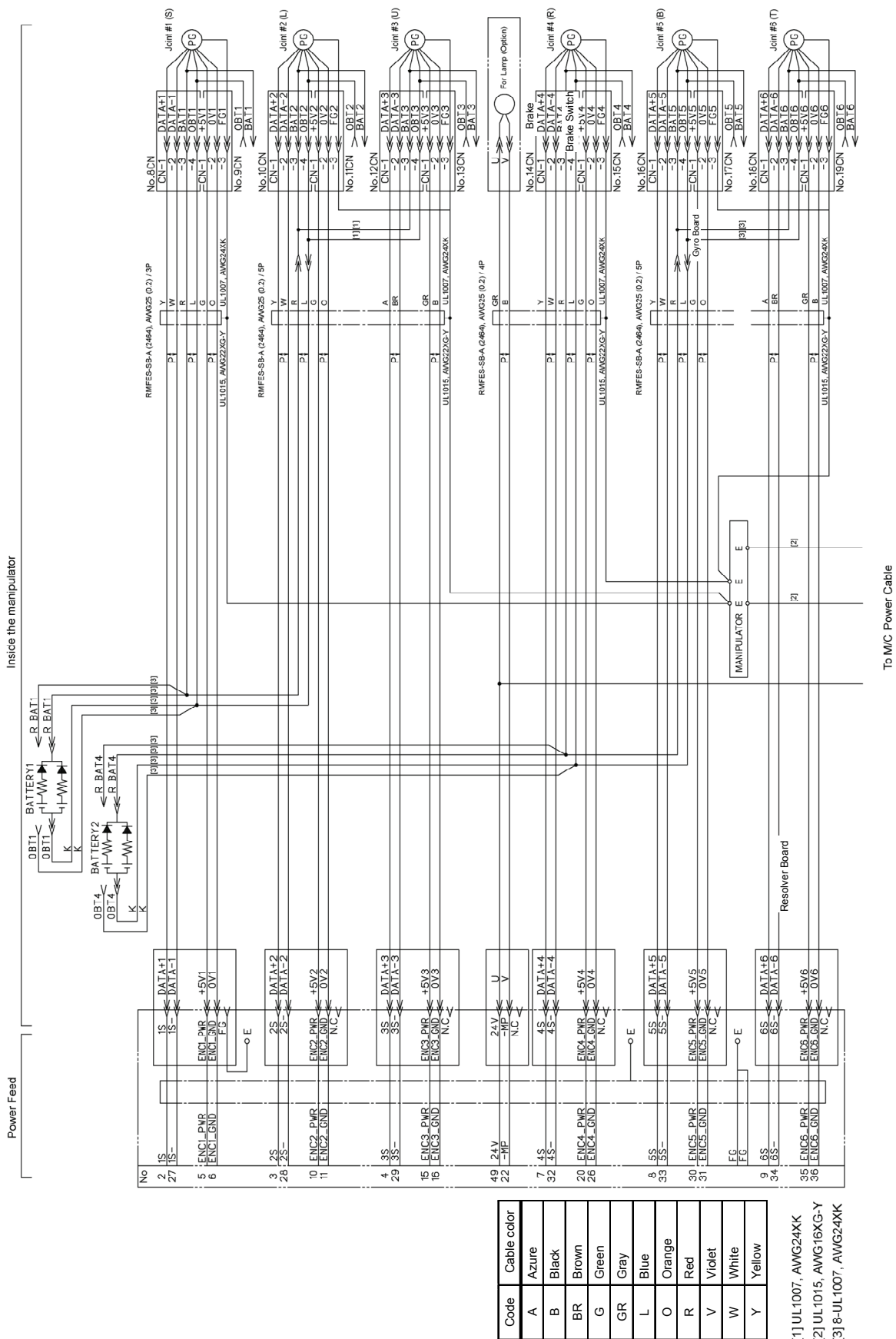
(35) Remove the following covers:

- Arm #1 Cover Arm #2 Cover Arm #3 Cover
- Arm #4 Cover Base Connector Plate

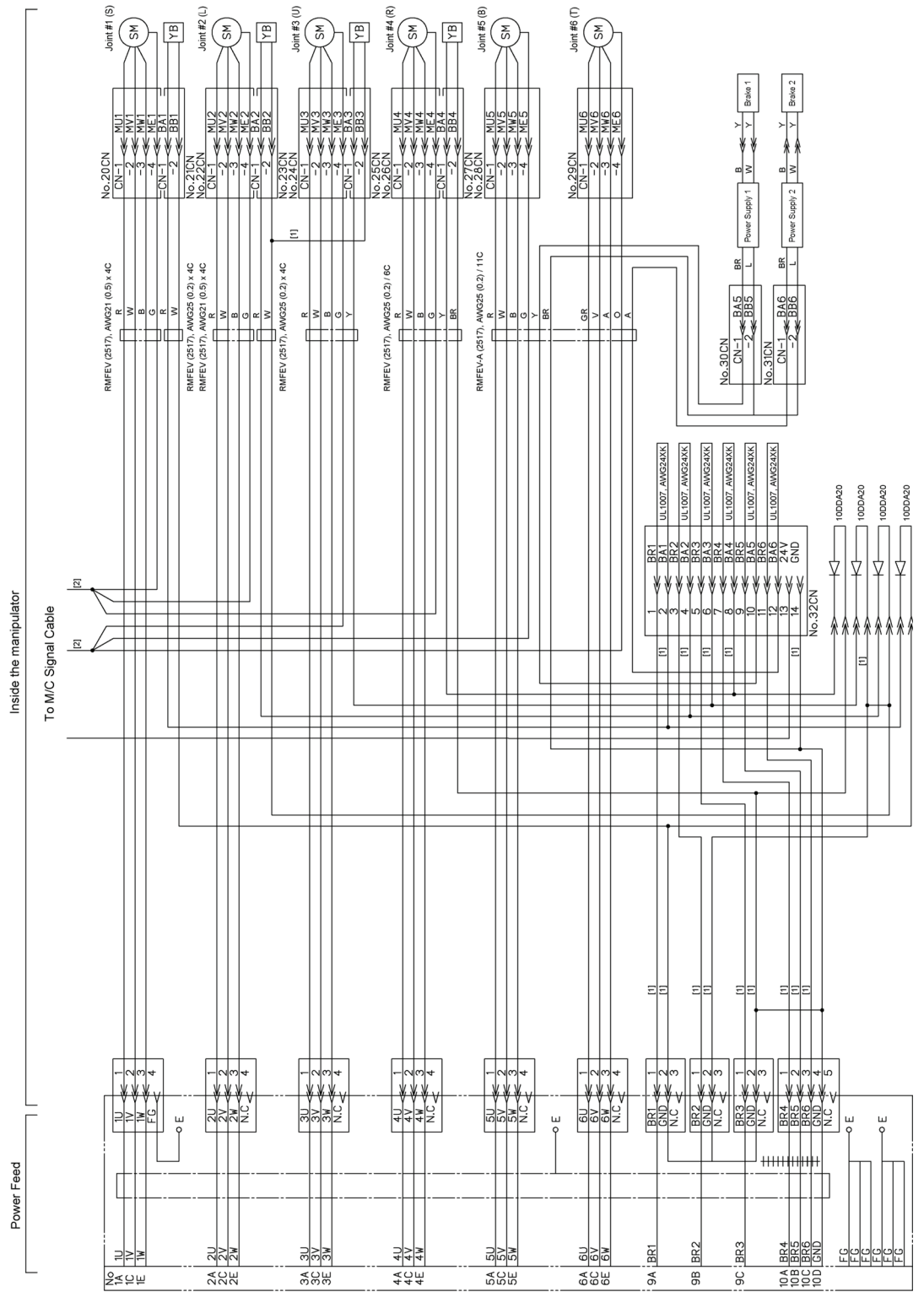
For details, refer to *Maintenance: 3. Covers*.

9.2 Wiring Diagrams

9.2.1 Signal Cable



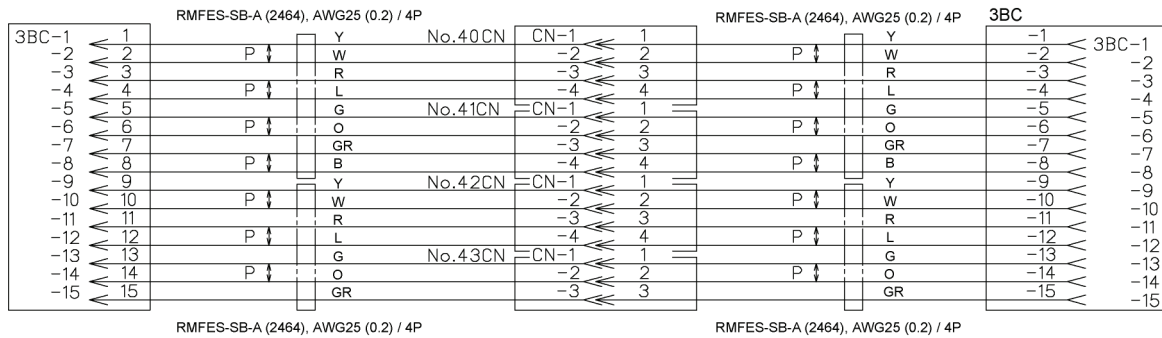
9.2.2 Power Cable



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


1) UL1007, AWG24XK
2) UL1015, AWG18XG-Y


9.2.3 User Cable



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

10. Battery Unit (Lithium Battery)

 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. ■ 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.
--	---

 CAUTION	<ul style="list-style-type: none"> ■ Use meticulous care when handling the lithium battery. Improper handling of the lithium battery as mentioned below is extremely hazardous, may result in heat generation, leakage, explosion, or inflammation, and may cause serious safety problems. <table style="width: 100%; border: none;"> <tr> <td colspan="2" style="padding-left: 20px;"><Improper Handling></td> </tr> <tr> <td style="padding-left: 40px;">Attempting to charge</td> <td style="padding-left: 40px;">Deforming by pressure</td> </tr> <tr> <td style="padding-left: 40px;">Disassembling</td> <td style="padding-left: 40px;">Short-circuit (Polarity; Positive/Negative)</td> </tr> <tr> <td style="padding-left: 40px;">Connecting batteries improperly</td> <td style="padding-left: 40px;">Heating (100°C or more)</td> </tr> <tr> <td style="padding-left: 40px;">Exposing to fire</td> <td style="padding-left: 40px;">Soldering the terminal of the lithium battery directly</td> </tr> <tr> <td style="padding-left: 40px;">Forcing discharge</td> <td></td> </tr> </table>	<Improper Handling>		Attempting to charge	Deforming by pressure	Disassembling	Short-circuit (Polarity; Positive/Negative)	Connecting batteries improperly	Heating (100°C or more)	Exposing to fire	Soldering the terminal of the lithium battery directly	Forcing discharge	
<Improper Handling>													
Attempting to charge	Deforming by pressure												
Disassembling	Short-circuit (Polarity; Positive/Negative)												
Connecting batteries improperly	Heating (100°C or more)												
Exposing to fire	Soldering the terminal of the lithium battery directly												
Forcing discharge													

The life span of the lithium battery is three years. Even if the Manipulator is constantly connected to power, the lithium battery needs to be replaced every three years.

10.1 Precautions of the Data

NOTE



- Always connect the new battery unit before disconnecting the old battery unit. If you disconnect the old battery unit before connecting the new one, all position data for each arm will be lost and you will need to execute the recovery procedure. Refer to *10.3 Data Recovery Procedure* to recover the data.

When battery replacement is executed in the properly, the recovery procedure is not required.

If the position data has been lost because the low lithium battery power

The following error that warns the voltage reduction appears at starting the Controller (starting up the software). After replacing the battery unit, recover the position data using the procedures described in 10.3. *Data Recovery Procedure*.

EPSON RC+ 5.0 / EPSON RC+ 6.0

: Error 5016 [Power supply failure of the absolute encoder.] occurs.

When the motor or gears are removed from the robot for parts replacement

You cannot recover by 10.3. *Data Recovery Procedure*. For calibration after parts replacement, refer to Maintenance 12. *Calibration*.

10.2 Replacing the Battery Unit

	Name	Quantity	Note
Maintenance Parts	Battery unit	1	R13B060005
	Liquid Gasket	Proper quantity	R13B031201

Battery Unit Removal

- (1) Turn OFF the power for the Controller.
- (2) Remove the connector plate.
Button bolt: 8-M4×10
- (3) Remove the grease supply tube for the Joint #1 reduction gear unit.



- (4) Pull out the connectors.
Connector: OBT1, OBT4



- (5) Cut off the wire tie binding the battery unit.
Pull out the battery unit.



Battery Unit Installation

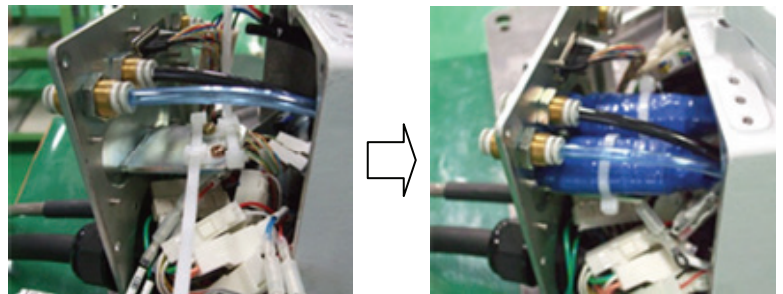
- (6) Two connectors are paralleled, so make sure to connect a new battery unit to another available connector.



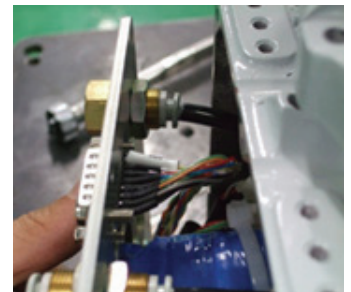
- NOTE
- Make sure to connect a new battery unit before disconnecting the old battery unit. If you disconnect the old battery unit without connecting new one, all position data for each arm will be lost and all arms need to be calibrated again.
 - Make sure to use our specified battery unit (Code: R13B060005).



- (7) As shown in the picture, use wire ties to secure the battery unit.



- (8) Mount the grease supply tube for the Joint #1 reduction gear unit.



- (9) Mount the connector plate.

Button bolt : 8-M4×10

Apply liquid gasket.

Tightening torque : 1.4 N·m (0.14 kgf·m)


10.3 Data Recovery

In this section, there are steps to execute some commands. The dialogs and startup procedures used in the following sections depend on which software you are using. Please follow the instructions for the software you are using.

EPSON RC+ 5.0 / EPSON RC+ 6.0

: Select menu-[Tools]-[Command Window] to display [Command] window.

- (1) Turn ON the Controller with all joints in the motion range.
- (2) Reset the encoder.
- (3) Execute the following command.
 > EncReset 1, 2, 3, 4, 5, 6
- (4) Select menu-[Tools]-[Controller] and click the <Reset Controller> button to restart the Controller.
- (5) Move the robot to the origin position (0 pulse position).
 Release the electromagnetic brake and move the arms manually, or set the jog mode to “Joint” from the [Jog & Teach] and operate the Manipulator in jog motion to match the home position of the joint accurately.
 Make sure to match the home position of the joint as accurate as possible visually.

 CAUTION	<ul style="list-style-type: none"> ■ The Arm #4 does not have a mechanical stop. The used of Arm #4 in motion exceeding the maximum pulse range may cause inner wiring damage to and/or malfunction of the Manipulator.
---	--

- (6) Reset the encoder again by the procedure in step (2).
- (7) Restart.

EPSON RC+ 5.0 / EPSON RC+ 6.0

: Select menu-[Tools]-[Controller] and click the <Reset Controller> button to restart the Controller.

- (8) Execute the following command to move to 0 pulse position.
 > Go Pulse(0, 0, 0, 0, 0, 0)
- (9) Be sure to check that all joints have moved to their home positions (0 pulse position).
 If no differences are found, recovery is complete.
 Joint(s) that did not move to the proper home position will be out of position in multiples of degrees shown in the following table.

S5

Joint	#1	#2	#3	#4	#5	#6
Difference	3.76 deg.	3.37 deg	4.05 deg	4.5 deg	4.5 deg	7.2 deg

S5L

Joint	#1	#2	#3	#4	#5	#6
Difference	2.74 deg	2.7 deg	3.24 deg	4.5 deg	4.5 deg	7.2 deg

Specify the joint that is out of the home position and the direction of the difference, then change the Hofs values as follows.

Joint #1 out of home position in + direction

> Hofs Hofs (1) - 131072, Hofs (2), Hofs (3), Hofs (4), Hofs (5), Hofs (6)

Joint #1 out of home position in - direction

> Hofs Hofs (1) + 131072, Hofs (2), Hofs (3), Hofs (4), Hofs (5), Hofs (6)

Joint #2 out of home position in + direction

> Hofs Hofs (1), Hofs (2) - 131072, Hofs (3), Hofs (4), Hofs (5), Hofs (6)

Joint #2 out of home position in - direction

> Hofs Hofs (1), Hofs (2) + 131072, Hofs (3), Hofs (4), Hofs (5), Hofs (6)

:
:
:

Joint #6 out of home position in + direction

> Hofs Hofs (1), Hofs (2), Hofs (3), Hofs (4), Hofs (5), Hofs (6) - 131072

Joint #6 out of home position in - direction

> Hofs Hofs (1), Hofs (2), Hofs (3), Hofs (4), Hofs (5), Hofs (6) + 131072

(10) Move to 0 pulse position again.

> Go Pulse (0, 0, 0, 0, 0, 0)

(11) Be sure to check that all joints have moved to their home positions (0 pulse position).


If no differences are found, recovery is complete.


Otherwise, repeat step (7) and (8) until no differences are found.

Now, the recovery of the home position is complete.

When you change the Hofs values, make sure to write down the new Hofs values.

11. Replacing the LED Lamp

 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. ■ 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.
--	---

 CAUTION	<ul style="list-style-type: none"> ■ Carefully use alcohol, liquid gasket, and adhesive following respective instructions and also instructions below. Careless use of alcohol, liquid gasket, or adhesive may cause a fire and/or safety problems. <ul style="list-style-type: none"> - Never put alcohol, liquid gasket, or adhesive close to fire. - Use alcohol, liquid gasket, or adhesive while ventilating the room. - Wear protective gear including a mask, protective goggles, and oil-resistant gloves. - If alcohol, liquid gasket, or adhesive gets on your skin, wash the area thoroughly with soap and water. - If alcohol, liquid gasket, 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.
--	---

	Name	Quantity	Note
Maintenance Parts	LED lamp	1	R13B030006

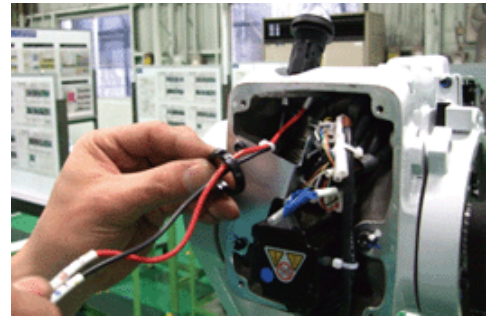
Removal

- (1) Remove the Arm #3 Cover.

For details, refer to the *Maintenance 3.3 Arm #3 Cover*.

- (2) Remove the LED lamp connectors from inside of the manipulator.

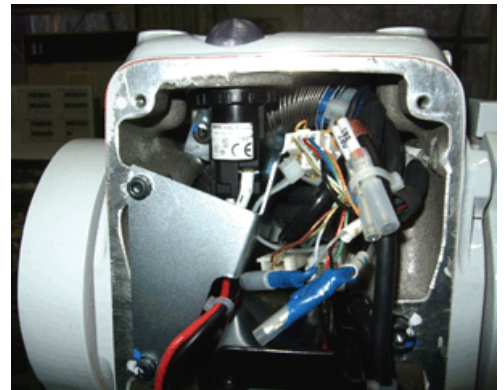
- (3) Loosen the nut and remove the LED lamp.



Installation

- (1) Mount the LED lamp and fasten it with the nut.

(Adjust the LED lamp so that the CE label is in the front side.)



- (2) Mount the LED lamp connector.

- (3) Mount the Arm #3 Cover.

For details, refer to the *Maintenance 3.3 Arm #3 Cover*.

For protection-model



NOTE When the Manipulator is a protection-model, liquid gasket (R13B031201) was applied on the LED mounting surface.

Removal

The LED lamp is secured with liquid gasket. There is a risk that the LED lamp gets broken in removal. Replace the LED lamp with great caution.

Installation

Before installing the LED lamp, apply liquid gasket on the contact surfaces of the LED lamp and Arm #3.

Wipe excess liquid gasket with a wiping cloth treated with alcohol.


12. Calibration

12.1 Overview

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 (correct) these origins.

The process of aligning the two origins is called “Calibration”. The calibration is not the same as teaching*.

* “Teaching” means to teach the Controller coordinate points (including poses) anywhere in the operating area of the Manipulator.


 WARNING	<ul style="list-style-type: none"> ■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the <i>Installation and Design Precautions</i> in the <i>Safety</i> 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.
--	---

For 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 the Electromagnetic Brake is Applied to*.
- Moving the Manipulator in the Jog & Teach mode.
 For details, refer to *EPSON RC+ 5.0 User’s Guide - 5.11.1 Robot Manager Command Tools: Robot Manager: Jog and Teach Page*.

Normally move the Manipulator in the Jog & Teach mode since moving the Manipulator while releasing the electromagnetic brake involves risk.

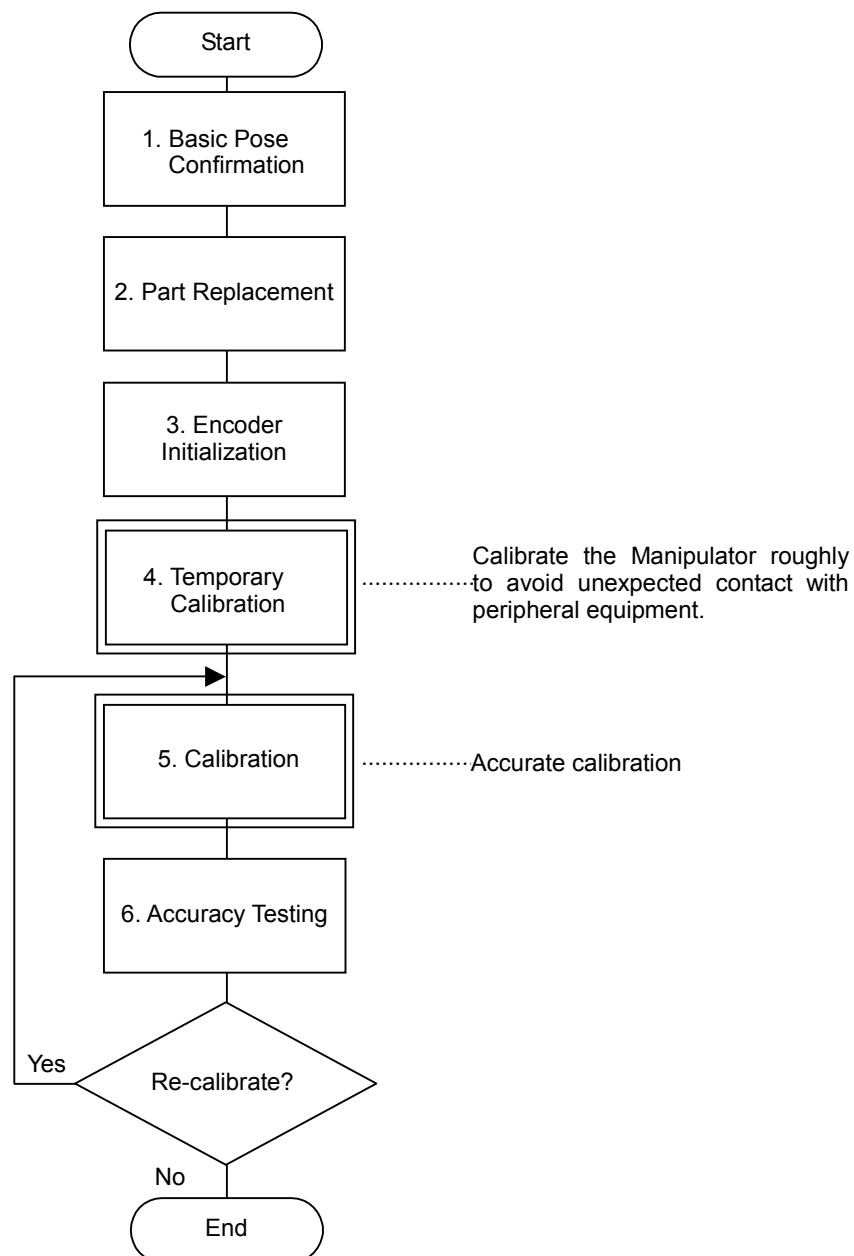
 CAUTION	<ul style="list-style-type: none"> ■ Normally, release the brake of a single joint at a time. Take extra care to release the brakes of two or more joints simultaneously from necessity. Releasing the brakes of two or more joints simultaneously may cause hands and fingers to be caught, serious bodily injury and/or severe equipment damage to 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 release switch is pressed, 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.
--	---

NOTE



- For details about the basic pose, refer to the *Setup & Operation 3.6 Setting the Basic Pose for Calibration*.
- Whenever possible, calibrate the origin one joint at a time. (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 positions. However, joint #5 cannot be calibrated alone according to the structure of the Manipulator. Make sure you calibrate joint #6 at the same time.

Calibration Flowchart



12.2 Calibration Procedure

Command Input

Calibration procedures include command execution.

Select the EPSON RC+ menu-[Tools]-[Command Window].

The information above is omitted in the calibration procedure.

Jog Motion

The process to set the jog motion is included in the calibration procedures.

Select the 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 procedure.

Follow steps 1 to 7 described below in order to calibrate the origin.

1. Basic Pose Confirmation

Verify the recorded pulse values of the basic pose obtained in the *Setup & Operation 3.6 Setting the Basic Pose for Calibration*.

2. Part Replacement

Replace parts as dictated by this manual. Be careful not to injure yourself or damage parts during part replacement.

3. Encoder Initialization

Turn ON the Controller when all joints are in the motion range.

The message “Encoder alarm has occurred. Check robot battery. EPSON RC+ must be restarted.” is 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].

>Encreset [The joint number (1 to 6) corresponding to the encoder will be reset]


Select the EPSON RC+ menu-[Tools]-[Maintenance], then click the [Restart Controller] button.

After resetting the error, the motor encoder of the parts replaced joint is initialized. Set the jog mode to “Joint” from the [Jog & Teach] and operate the Manipulator in jog motion to match the home position of the joint accurately.


When the joint does not move to the home position, operate the Manipulator to match the tram mark placed in *Setup & Operation 3.6 Setting the Basic Pose for Calibration* as accurate as possible.

Initialize the joint encoder when the joint matches the home position or the tram mark.

For the encoder initialization, refer to the procedure indicated above.

- NOTE  - When the origin of Joint #5 is calibrated, Joint #6 will be out of position. (Due to the structure of the Manipulator, any offset in the position of Joint #5 affects Joint #6.)
Calibrate the origin of Joint #6 at the same time when calibrating Joint #6.

4. Rough Calibration

- NOTE  Calibrate the origin of Joint #5 at the same time when calibrating Joint #6.

Select either the points of the basic pose you previously set in the *Setup & Operation 3.6 Setting the Basic Pose for Calibration* or the currently registered point data that makes it easy to verify the accuracy of the joint whose origin you want to calibrate. Move the Manipulator to the selected point while avoiding interference with peripheral equipment.

To perform temporary calibration, input the pulse value of the specified point data. For example, when the specified point data is "P1," execute the following command.

```
> Calpls Ppls (P1, 1) , Ppls (P1, 2) , Ppls (P1, 3) , Ppls (P1, 4) , Ppls  
  (P1, 5) , Ppls (P1, 6)
```

Perform the temporary 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
```

5. Calibration (Accurate Positioning)

Move the joint* being calibrated to the specified point by motion command.

*You must also move Joints #1 - #4 to the position when calibrating Joint #5.

For example, when the specified point data is “P1”, “Motor On” is executed from [Control Panel], and “Go P1” is executed from [Jog & Teach].

Accurately conform the calibrating joint* to the specified point data by jog command.

*You must also move Joint #5 and #6 to the position when calibrating Joint #5.

Select the Joint jog mode from the [Jog & Teach] to execute the jog motion.

Perform the calibration. Input one of the following commands according to the joint being calibrated.

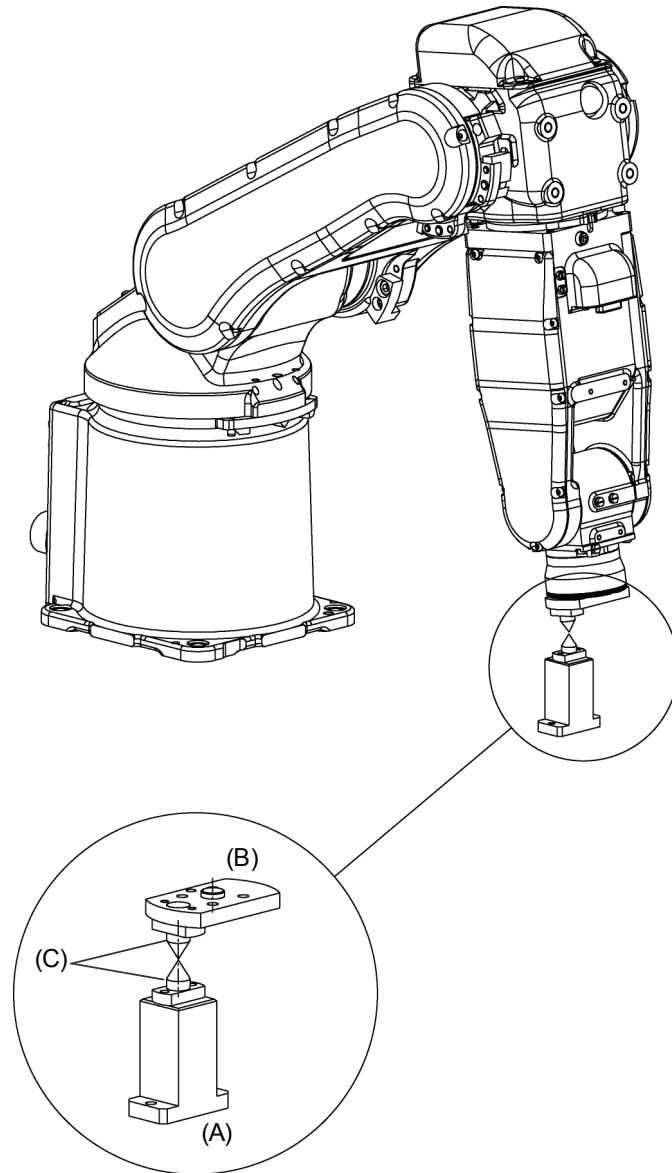
```
Joint #1 :>Calib 1
Joint #2 :>Calib 2
Joint #3 :>Calib 3
Joint #4 :>Calib 4
Joint #5 :>Calib 5, 6
Joint #6 :>Calib 6
```

6. Accuracy Testing

Move the Manipulator into a different point to verify the reproducibility of the position. If accuracy is inadequate, it may be necessary to re-calibrate the origin using a different point. You must set the point again if reproducibility cannot be assured through calibration.

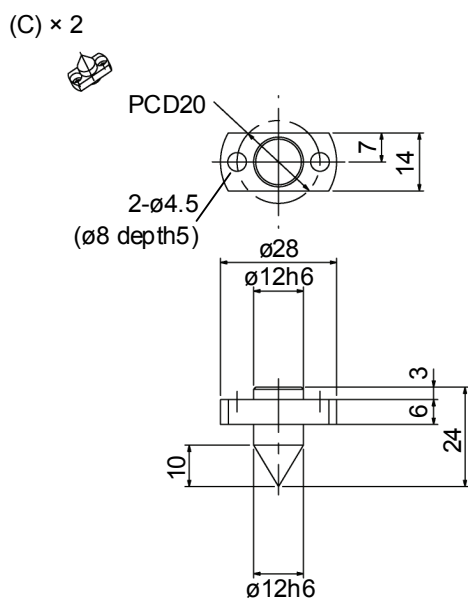
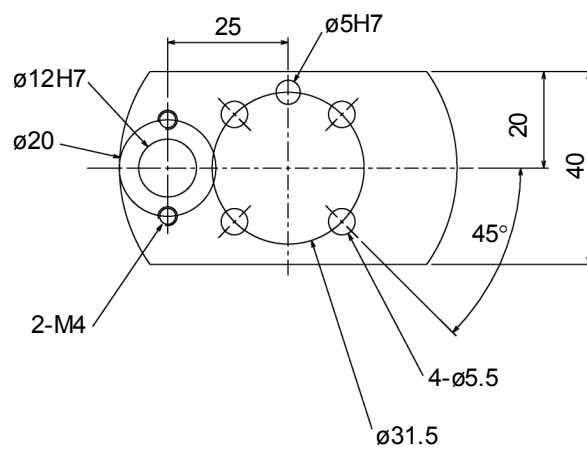
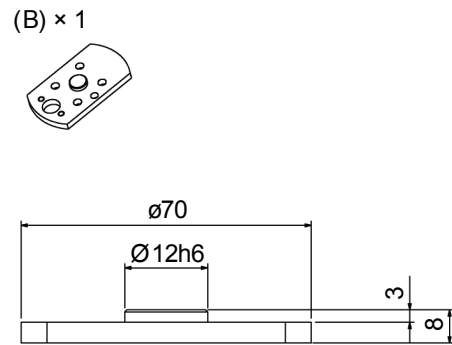
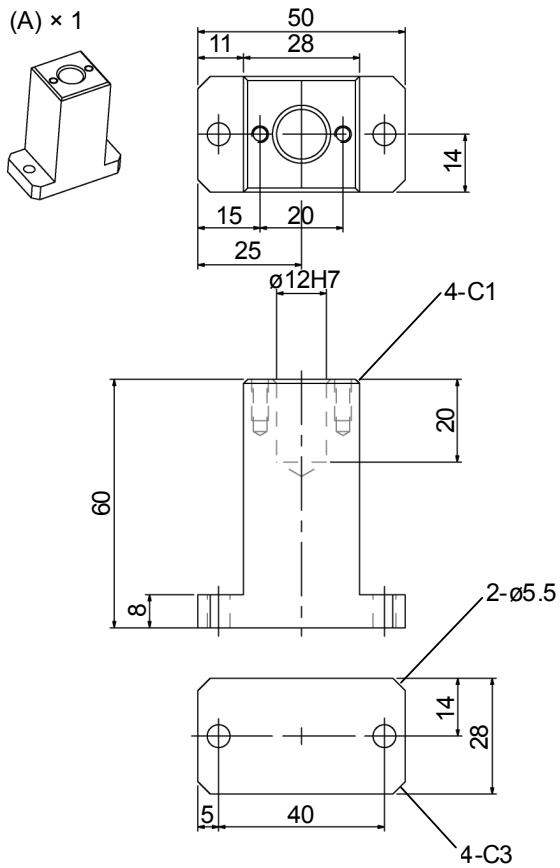
12.3 Calibration Jig

Jigs such as the one described in this section are necessary in order to set the reference points for calibration when installing the Manipulator. (In practice, there are instances where your end effector can be used.)



[Unit: mm]

°: deg.



13. Maintenance Parts List

Be sure to specify the proper codes when ordering maintenance parts.

13.1 Standard

Part Name		Code	Note
AC Servo Motor	For Joints #1, #2	R13B000626	400 W with brake
	For Joint #3	R13B000627	200 W with brake
	For Joint #4	R13B000628	50 W with brake
	For Joints #5, #6	R13B000629	50 W
Reduction Gear Unit *1	For Joint #1	R13B010030	S5-A701**
		R13B010031	S5-A901**
	For Joint #2	R13B010032	S5-A701**
		R13B010033	S5-A901**
	For Joint #3	R13B010034	S5-A701**
		R13B010035	S5-A901**
	For Joint #4	R13B010036	
	For Joint #5	R13B010037	
For Joint #6	R13B010038		
Electromagnetic Brake	For Joints #5, #6	R13B030508	
Timing Belt	For Joint #2	R13B030228	
	For Joint #3	R13B030229	S5-A701**
		R13B030230	S5-A901**
	For Joint #4	R13B030231	
	For Joints #5, #6	R13B030232	
Grease	Reduction gear	For ALL Joints	R13ZA00330100 SK-1A (500 g)
	Base	For Joint #1	R13B030303 Multemp SRL
Liquid Gasket	For ALL Joints	R13B031201	1206C
LED Lamp		R13B030006	
M/C Cable		R12B020440	3 m
		R12B020441	5 m
		R12B020442	10 m
Cable Unit		R13B020056	S5-A701**
		R13B020057	S5-A901**
Battery Unit		R13B060005	Lithium battery ER6V LY (TOSHIBA)

Part Name		Code	Note	
Oil Seal	For motor shafts	For Joint #1	R13B031256	
	For Reduction Gear Unit	For Joint #2	R13B031258 R13B031264	For Cleanroom-model
		For Joint #5	R13B031260 R13B031266	For Cleanroom-model
	For rotator	For Joint #1	R13B031257	
		For Joint #2	R13B031259 R13B031265	For Cleanroom-model
		For Joint #5	R13B031261 R13B031267	For Cleanroom-model
		For Joint #6	R13B031262 R13B031268	For Cleanroom-model
	O-ring	For Joint #1	R13B031255	
		For Joint #6	R13B031263	
	Gasket	Base		R13B031269
			R13B031275	
Arm #1			R13B031270	For Cleanroom-model
Arm #2		S5-A701C*	R13B031271	For Cleanroom-model
		S5-A901C*	R13B031272	For Cleanroom-model
Arm #3			R13B031273	For Cleanroom-model
Arm #4			R13B031274	For Cleanroom-model
Radiating sheet	For Joint #1, #2, #3	R13B031910		
Battery for backing up motor encoder *2		R13B060006	Lithium battery ER6V LY (TOSHIBA)	
Joints #5, #6 Unit (Motor NOT included)		R13B080204	Arm #4 is included	
Brake Release Unit		R12B120803	For Europe	
		R12B120804	For USA and Japan	

***1 Reduction Gear Unit**

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

Waveform generator

This waveform generator consists of an ellipsoidal cam with ball bearings on its outer circumference.

The inner ring of bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.

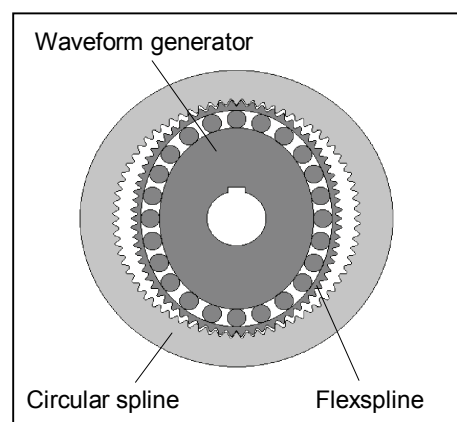
Flexspline

A thin, elastic, cup-shaped metal body with gear teeth around the outer circumference of the opening.

Circular spline

A rigid, ring-shaped body with gear teeth on the inner circumference.

The circular spline has two more teeth than the flexspline does.

***2 Battery for backing up motor encoder**

The battery for backing up a motor encoder is only used for retaining the motor position data during maintenance (cable replacement, etc.). It is not used for the Manipulator itself.

Even storing a battery consumes battery power. When three years have passed since you purchased a spare battery, replace it with a new one or measure the battery voltage before using it.

13.2 Option

Part Name	Code	Note
Brake release unit (with Cable, short connector)	R12B120805	For Europe
	R12B120806	For USA and Japan
Brake release unit	R12B120803	For Europe
	R12B120804	For USA and Japan
Camera Plate	R12B031930	
PS Compatible Plate	R12B031931	
PS Installation Compatible Plate	R12B031932	
Mechanical stop for Arm #1, #2, #3	R12B031933	

