EPSON

SCARA ROBOT

EC series

MANIPULATOR MANUAL

Rev.5 EM019R892F

MANIPULATOR MANUAL EC series Rev.5

SCARA ROBOT

EC series Manipulator manual

Rev.5

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.

TRADEMARKS

Microsoft is a registered trademark and Windows and Windows logo are registered trademarks of the Microsoft Corporation.

Other brand and product names are trademarks or registered trademarks of the respective holders.

NOTICE

- No part of this manual may be copied or reproduced without authorization.
- The content of this manual is subject to change without notice.
- We ask that you please notify us if you should find any errors in this manual or if you have any comments regarding its content.

Please direct any inquiries about the use of this manual to:

EC series manipulator manual

SEIKO EPSON CORPORATION
Sales Engineering Group
TEL : 81-266-24-2004
FAX : 81-266-24-2017

SAFETY PRECAUTIONS

Please carefully read this and other related manuals before and while using the equipment. Keep this manual in a handy location for easy access at all times.

⚠ WARNING	■ This sign indicates that a danger of serious injury or death will exist if these instructions are not followed.
⚠ CAUTION	■ This sign indicates that ignoring these instructions may cause harm to people or physical damage to equipment and facilities.

⚠ WARNING

- The robot system manufacturer/supplier must design and construct robot systems in accordance with the principles described in the *Safety* chapter of the "User's Guide" or "SRC5**/SPEL 95 Introduction Manual" or "User's manual". Please read that manual first.
- This robot has been designed and manufactured strictly for use in a normal indoor environment. Do not use the robot in an environment that exceeds the conditions set forth in the manuals for the manipulator and controller.
- Do not use the robot outside of the usage conditions and product specifications described in the manuals. Doing so will not only adversely affect the life of the product, but may also present a serious safety problem.
- Only trained personnel should be allowed to design, install, operate, perform function testing, and maintain this manipulator and the robot system.
- Trained personnel are those who have taken a robot training course (held by the dealer on a regular basis) or those who have carefully read the manuals and have equivalent knowledge and skill.

FOREWORD

This manual contains information that you need to know to use the EC series manipulator correctly. Please thoroughly read this and other related manuals before using the equipment.

This manipulator can be used with the following EPSON robot controllers:

- EPSON RC+
- SPEL 95 / SRC5**
- SRC-3**

Use the descriptions for the controller used with your manipulator, indicated by the following icons:

RC+	Procedure when using EPSON RC+ Robot Control System.
SPEL 95	Procedure when using SPEL 95 / SRC5** controllers.
300	Procedure when using SRC-3** controllers.

If the manipulator is a Clean model, refer to *Clean Model* and *Clean Model Maintenance*, which provide a summary of differences between the Clean and Standard specifications.

If the manipulator is a Protected model, refer to *Protected Model* and *Protected Model Maintenance*, which provide a summary of differences between the Protected and Standard specifications.

300	An “axis” of manipulator is referred to as a “joint” in this manual.

SERVICE CENTER

Contact the following service center for robot repairs, inspections or adjustments.
Please have the model name, “Serial No.” or “M.CODE”, software version and a description of the problem ready when you call.
If service center information is not indicated here, please contact the supplier office for your region as listed in the following SUPPLIERS section.

SUPPLIERS

Japan & Others **SEIKO EPSON CORPORATION**
Okaya Plant No. 2
1-16-15, Daiei-cho
Okaya-shi, Nagano-ken, 394-0025
Japan

TEL: 81-266-23-0020 (switchboard)
81-266-24-2004 (direct)
FAX: 81-266-24-2017

North & South America **EPSON AMERICA, INC.**
Factory Automation/Robotics
18300 Central Avenue
Carson, CA 90746

TEL: (562) 290-5900
FAX: (562) 290-5999
E-MAIL: info@robots.epson.com

Europe **EPSON DEUTSCHLAND GmbH**
Factory Automation Division
Zuelpicher Str. 6 D-40546 Duesseldorf

TEL: (++) 49 - 211 - 5603 391 (Inside Sales)
FAX: (++) 49 - 211 - 5603 444
E-MAIL: robot.infos@epson.de

TABLE OF CONTENTS

Part 1: Setup & Operation

Part 2: Maintenance

Part 1
Setup & Operation

Part 1 contains information for setup and operation of the EPSON EC Series Manipulator, including:

- Installation
- Safety
- User wiring and pneumatics
- Attaching external devices
- Motion range adjustments
- Specifications

1. Manipulator Part Names

The model name of the EC series Manipulator is specified as follows:

EC 25 1 S

- Option ..... S: Standard model
  C: Clean model *
- Joint #3 stroke..... 1S: 120 mm
  1C: 100 mm
- Arm length ..... 25: 250 mm
  35: 350 mm
- Series name ..... EC

* If the Manipulator is a Clean model, refer to chapter *11. Clean Model*.

Manipulator parts

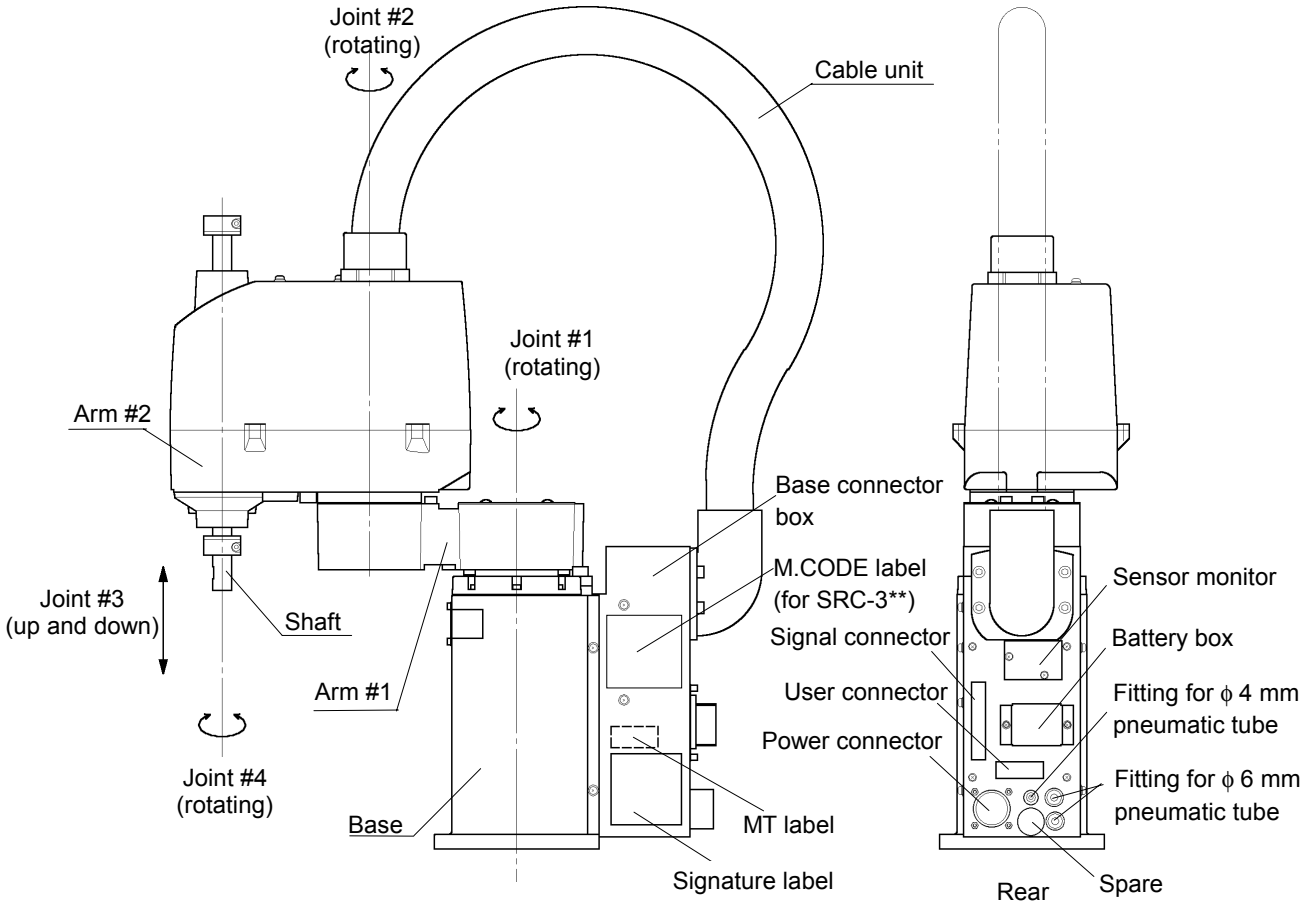


Figure 1. Manipulator

2. Installation Requirements

2.1 Environmental conditions

A suitable environment is necessary for the manipulator to function properly and safely. Please install the robot in a place that meets the following requirements.

Ambient temperature	5 to 40°C (with minimum temperature variation)
Ambient relative humidity	10 to 80% (no condensation)
First transient burst noise	2kV (1μs) max.
Electrostatic noise	6kV max.
Environment	◆ Install indoors. ◆ Place in a well-ventilated area. ◆ Keep away from direct sunlight. ◆ Keep away from dust, oily smoke, salinity, metal powder or other contaminants. ◆ Keep away from flammable or corrosive solvents and gases. ◆ Keep away from water. ◆ Keep away from shocks or vibrations. ◆ Keep away from sources of electric noise. This standard manipulator is not suitable for operation in harsh environment such as painting, etc. Contact the service center or the suppliers for details.

2.2 Installation area

In addition to the space necessary for installing the manipulator, controller and peripheral devices, you will need to have, at a minimum, the following space:

◆ Space for teaching

◆ Space for performing maintenance and inspections

◆ Space for cables

NOTE

The minimum bend radius of the power cable is 130 mm. When you install the manipulator make certain to maintain sufficient distance from obstacles. Leave enough space for other cables also, so that they don't have to be bent at extreme angles.

2.3 Base table

A base table for anchoring the manipulator is not supplied. Users must make or obtain such a table independently. The size and shape of the base table differs depending on the robot's application. For your reference, when designing or obtaining a base table, we have listed some manipulator requirements.

If the controller will be mounted inside the table, please refer to the controller manual, which describes space requirements and environmental conditions.

- M8 steel bolts are used for anchoring the manipulator to the base table. The bolts conform to "ISO898-1 property class 10.9 or 12.9". The locations of these threaded holes for anchoring are shown in Figure 2.

- The base of the manipulator must be bolted securely to the surface of the base table. Using a table with a steel surface is recommended. The steel surface plate should be at least 20 mm thick to reduce vibration. The surface roughness of the steel plate should be 25μm or less.

- The table must not only be able to bear the weight of the manipulator, it must also be able to withstand the dynamic movement of the manipulator when the manipulator is operating at maximum acceleration.

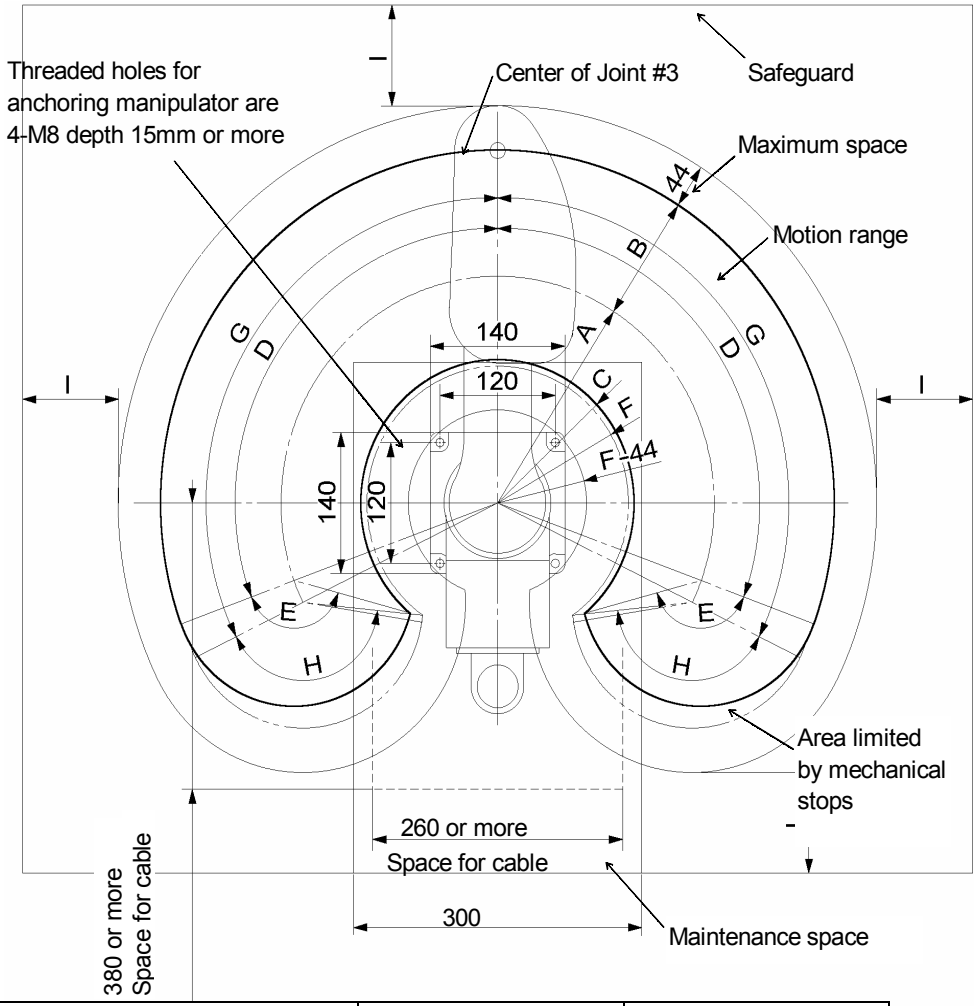
- The table must be anchored to the floor or wall to prevent it from moving.

- The manipulator must be installed horizontally.

- Bolts on the table legs that are used for leveling the table should have a diameter of M16 or more.

- You may want to make holes in the base table through which you can pass cables. (Refer to *7. External Dimensions* for connector dimensions.)

In addition to the table, users are also responsible for creating and installing the safeguard and end effector. Refer to the sections *2.4 Pre-installation safety precautions* and *5. End Effectors*.



Standard range of the manipulator	EC251*	EC351*
A (Arm #1 length)	125 mm	225 mm
B (Arm #2 length)	125 mm	125 mm
C	95.7 mm	142 mm
D (motion range of Joint #1)	90°	110°
E (motion range of Joint #2)	135°	145°
F	89.6 mm	136.2 mm
G (range to the stop of Joint #1)	98°	116°
H (range to the stop of Joint #2)	138°	148°
I (range to the safeguard)	approx. 100 mm *	

* For the case when the safeguard completely prevents a person from touching the robot, such as a transparent acrylic cover, for example. Refer to the chapter *Safety* chapter in the "User's Guide" or "SRC5**/SPEL 95 Induction manual" or "User's Manual" for the actual dimension of "I".

Figure 2. Manipulator installation dimensions [unit: mm]

NOTE ☞ Maximum space in Figure 2 shows the radius of end effector equal to or less than 44 mm. If the radius of the end effector exceeds 44 mm, such as when using a camera or electromagnetic valve, increase the radius to allow proper clearance.

2.4 Pre-installation safety precautions

WARNING

- The manipulator can easily tip over if it is not properly bolted to its mounting surface.

Transporting the manipulator

Transport the manipulator in the delivered condition. After unpacking, to prevent the manipulator from falling, secure the manipulator to a transporter such as a cart or lift, or have it carried by two or more people. (Refer to *3.1 Unpacking*.) If you are using a hoist or a similar apparatus to lift the equipment, make certain that the manipulator is well balanced in the belt.

Be certain to secure the manipulator's arms before transporting it. (Refer to *3.5 Relocating the manipulator*.)

Safeguard design

For safety reasons, it is necessary to equip robot systems with safeguards.

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

SPEL 95 Refer to the *Safety* section of the SRC5** / SPEL 95 Introduction manual.

300 Refer to the *Safety* section of the User's manual for SRC-300/320.

Base table design

- Make certain the base table is sufficiently strong and stable. (Refer to *2.3 Base table*.)

End effector design

- An end effector equipped with a gripper or chuck should hold its object when the power is off. (Refer to *5.1 Attaching an end effector*.)
- The end effector should be within the specified weight and within Joint #4's allowable moment of inertia. (Refer to *5.2 The end effector and acceleration / deceleration*.)

3. Installation

3.1 Unpacking

Contents

Manipulator		
Standard accessories	Power cable	(1)
	Signal cable	(1)
	Connector and clamp hood for user wiring	(2 sets)
	Ball screw spline grease	(70g)

CAUTION

- Transport the manipulator in the delivered condition.
  After unpacking, to prevent the manipulator from falling, secure the manipulator to a transporter such as a cart or lift, or have it carried by two or more people. The manipulator weighs approximately 14kg.
- Be careful not to get hands or fingers caught when holding the manipulator by hand.

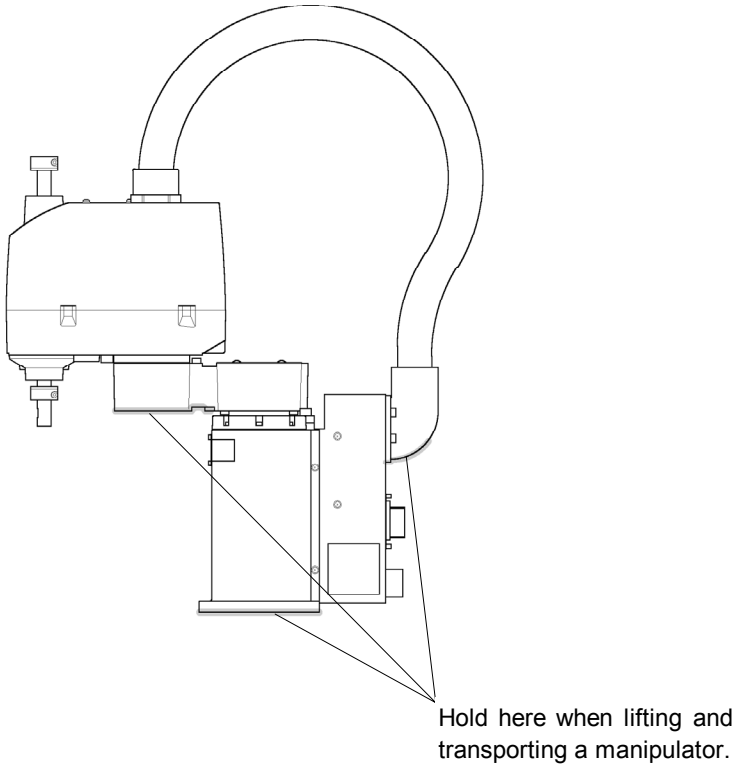


Figure 3. Lifting the manipulator

NOTE

Leave the manipulator's arm secured until you have finished installing.

3.2 Installation method

* If the manipulator is a Clean model, refer to chapter *11. Clean Model*

(1) Anchor the base of the manipulator to the base table using the four steel bolts (with spring washers and plain washers). Use M8 steel bolts that conform to "ISO898-1 property class 10.9 or 12.9".

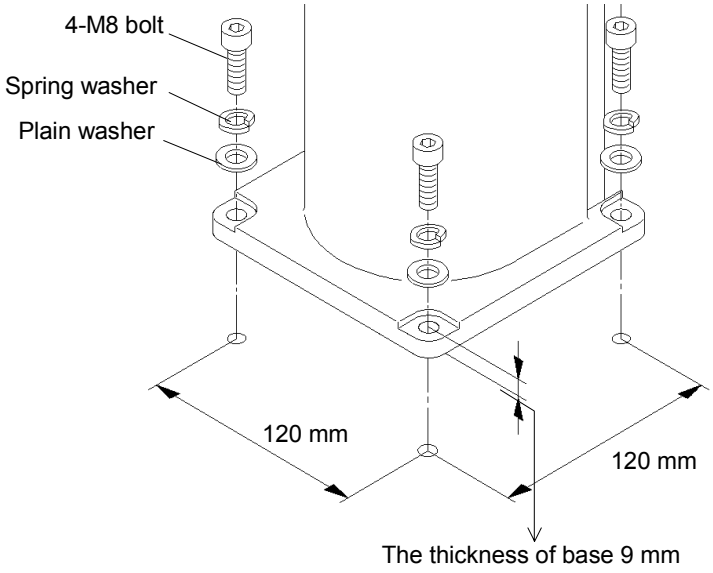


Figure 4. Manipulator installation

(2) Cut off the wire tie-binding Arm #2 and remove the M4 bolt from the bottom of Arm #2.

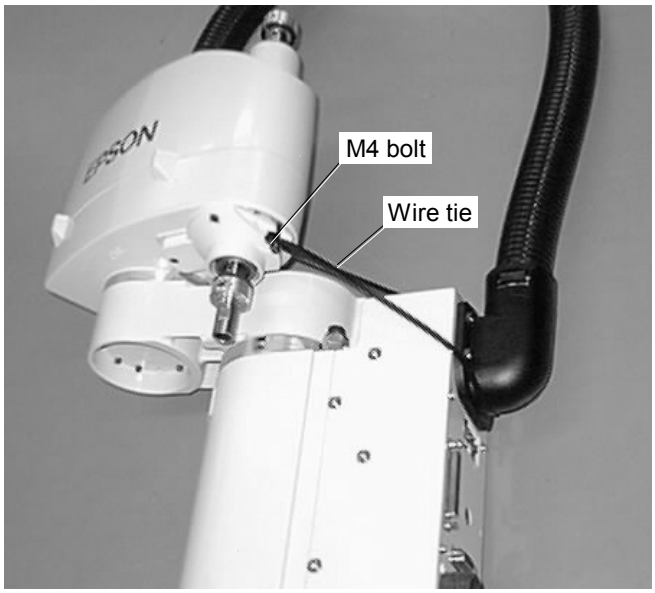


Figure 5. Cut the wire tie

(3) Push Arm #1 slowly in the direction shown by the arrow in Figure 6. After moving the arm, tight the arm-retaining bolt (M8×30) located on the base unit the head of the bolt touches the surface of the base. This bolt must be fully tightened to prevent it from interfering with the motion of Arm #1, limiting the operation area of Joint #1.

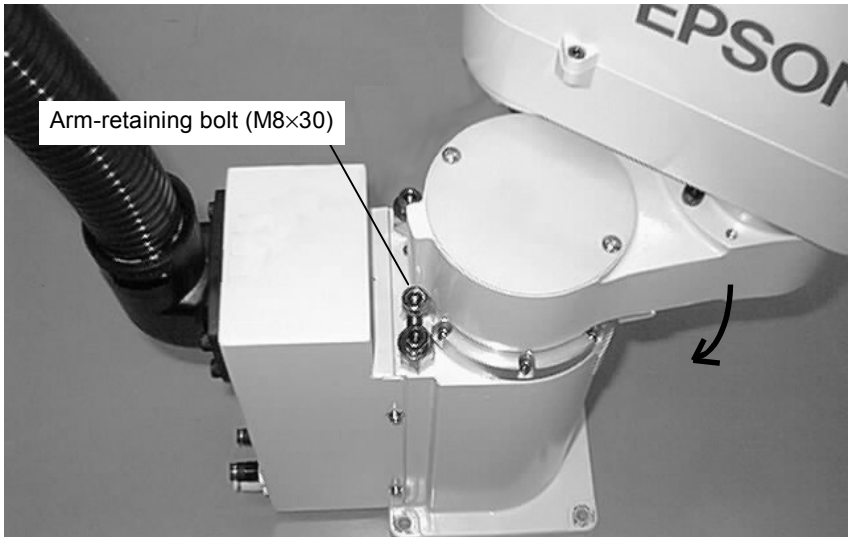


Figure 6. Arm-retaining bolt

NOTE ☞ The arm of the manipulator must be secured to prevent them from moving when transporting. (Refer to *3.5 Relocating the manipulator*.)

3.3 Connecting the cables

Cable connections are shown in Figure 7. The Figure shows the minimum connections necessary for operating the robot. Refer to the controller manual for information on how to connect the cables.

* If the manipulator is a Clean model, connecting with the exhaust system is necessary. For details, refer to chapter *11. Clean Model*.

⚠ WARNING

- For safety, the power supply cable must be connected to a factory power receptacle using the plug provided so it can be easily disconnected. Never connect the cable directly to the factory power supply.
- Be sure to turn OFF the power before connecting/disconnecting the cables. Failure to do so may cause electrical shock and/or malfunction.

⚠ CAUTION

- Plug the manipulator signal cable securely into the jack. Do not damage the signal cable by placing heavy objects on it or by bending it at extreme angles. A damaged signal cable may cause the robot's abnormal operation.

RC+ NOTE

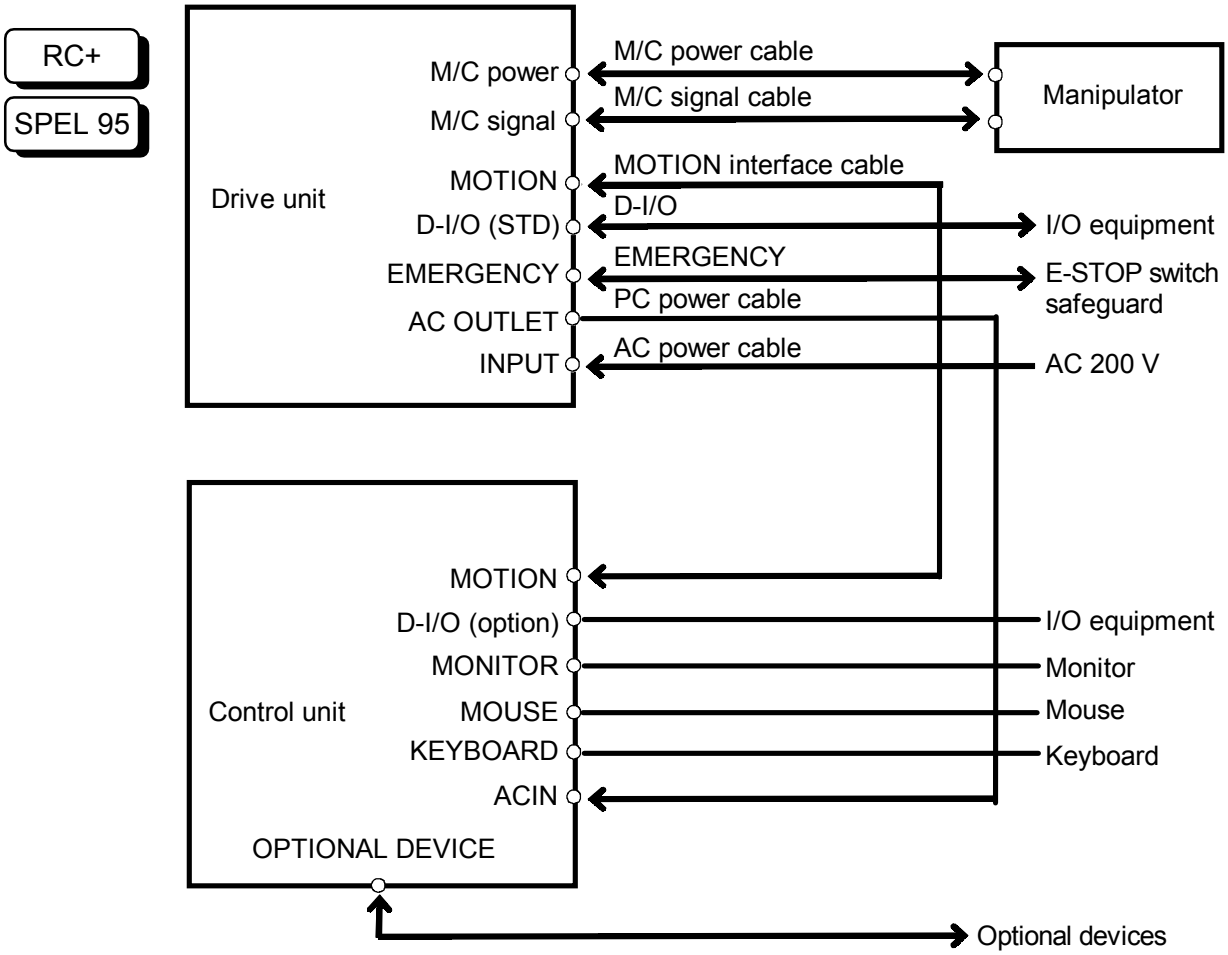
- When connecting the manipulator and Drive Unit cables, make sure the serial number on the Drive Unit matches the serial number on PC Control Unit.

SPEL 95 NOTE

- When connecting the manipulator and Drive Unit cables, make sure the serial number on the Drive Unit matches the serial number on Control Unit.

300 NOTE

- When installing the cables for a manipulator and its corresponding controller, make sure the M.CODEs (matching codes) match. The M.CODE is written on the yellow label of the manipulator base and the controller's rear panel. Also, make sure that the lengths of the power cable and signal cable correspond to the length on the yellow labels mentioned above.



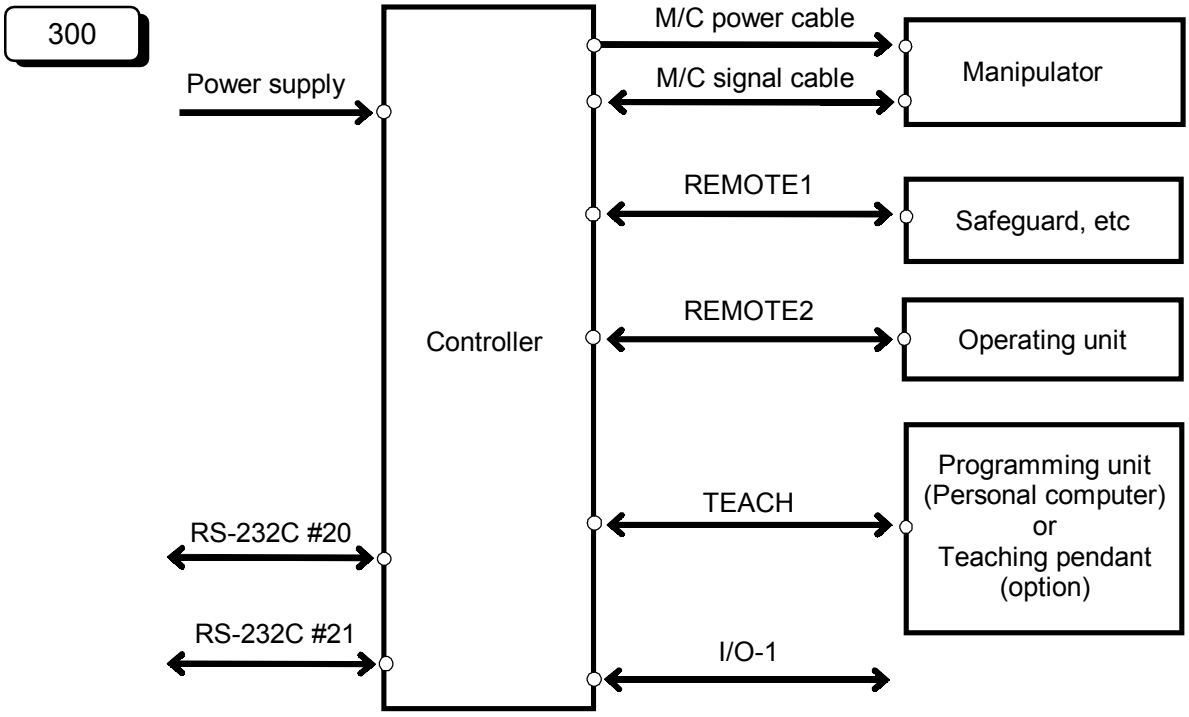


Figure 7. Cable connections

3.4 Safety precautions after installation

⚠ WARNING

- Please carefully read the "*Safety*" chapter of the "User's guide" or "SRC5**/SPEL 95 Introduction Manual" or "User's manual" before operation.
- Do not enter the motion range of the manipulator when the power is ON even if the manipulator seems to be stopped. It is extremely hazardous to put any part of your body in the motion range.
- Be sure to turn OFF power before connecting/disconnecting the cables. Failure to do so may cause electrical shock and/or malfunction.

Safety during operation

- Make sure that no one is inside the safeguarded area when operating the robot.
- If the manipulator moves abnormally during operation, immediately press the emergency stop switch.
- Generally only one person should operate the robot at a time. When, for unavoidable reasons, two or more people operate the robot, they should be certain to tell each other what they are doing and take all necessary safety precautions.
- Only trained personnel should teach and operate the robot and the robot system.
- Teaching operations should be performed only in low power mode.
- The work area should be well lighted (over 750 lx) during teaching operations.

RC+

- If entering the safeguarded area for some reasons during teaching operations, first lock ATTEND mode to ON to prevent another person changing the operating mode. Use the Enable switch when operating in the safeguarded area.

SPEL 95

- Confirm that Jog Pad/Operating Pendant functions normally before operations. If entering the safeguarded area for some reasons during teaching operations, first lock the mode switch of the Jog Pad/Operating Pendant in the ATTEND position. Bring the Jog Pad/Operation Pendant when operating in the safeguarded area to prevent another person changing the operating mode.

300

- If entering the safeguarded area during teaching operations, first lock the mode switch in the TEACH position. If using the optional operating unit, put the mode switch in the TEACH position and bring the key when operating in the safeguard to prevent another person changing the operating mode.

Other safety recommendations

- Perform daily inspections carefully before starting operation.
  (Refer to Part 2: *Maintenance*)

- Perform inspections and maintenance periodically in accordance with the instructions in Part 2: *Maintenance*.

- Joint #3 with an end effector mounted to it, descends under its own weight while the Joint #3 brake release button is pushed. (Refer to *5.1 Attaching an end effector*.)

3.5 Relocating the manipulator

Please follow the procedures below when moving the manipulator to a new location.

NOTE
The arms of the manipulator must be securely secured to prevent them from moving when transporting the manipulator.

(1) Turn OFF the power and unplug the cables.

NOTE
Remove the mechanical stop if using them to limit the motion range of Joint #1 and #2. (Refer to *8.3 Changing the motion range*.)

(2) Gently push Arm #1 in the minus direction (clockwise direction) until the arm-retaining bolt appears.

(3) Unscrew the arm- retaining bolt until the shank length is 15 mm.

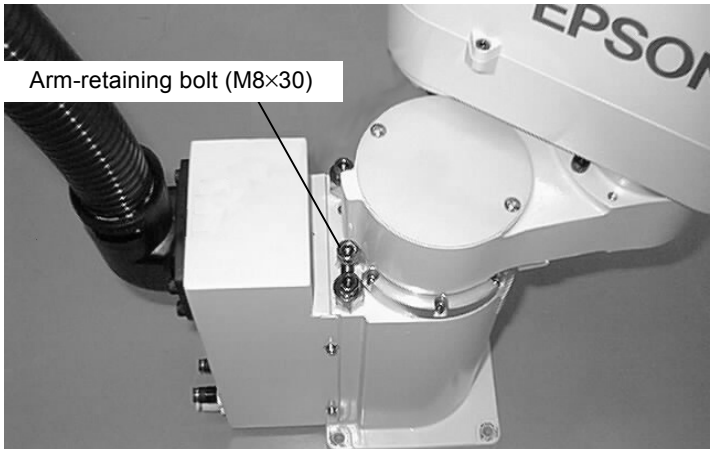


Figure 8. Arm-retaining bolt

(4) Gently push Arm #1 in the plus direction (counterclockwise direction) until it touches the previous bolt.

(5) Gently push Arm #2 in the plus direction (counterclockwise direction) until it touches the mechanical stop.

(6) Immobilize the arm by fastening an M4 screw to the bottom of the end of Arm #2 and then tying down the arm as shown in Figure 5.

(7) To prevent a manipulator from falling, hold Arm #1 with your hand and remove the manipulator from the base table.

⚠ CAUTION

- Transport the manipulator in the delivered condition. After unpacking, to prevent the manipulator from falling, secure the manipulator to a transporter such as a cart or lift. Stabilize the manipulator with your hands when you hoist it so that it does not tip over. To transport, hold Arm #1 by hand and support both the main cable elbow fitting and the underside of the base using two or more people. The manipulator weighs approximately 14kg.
- Be careful not to get hands or fingers caught when holding the manipulator by hand.

4. User Wires and Pneumatic Tubes

Electrical wires and pneumatic tubes have been incorporated into the cable unit for your use.

Electrical wires

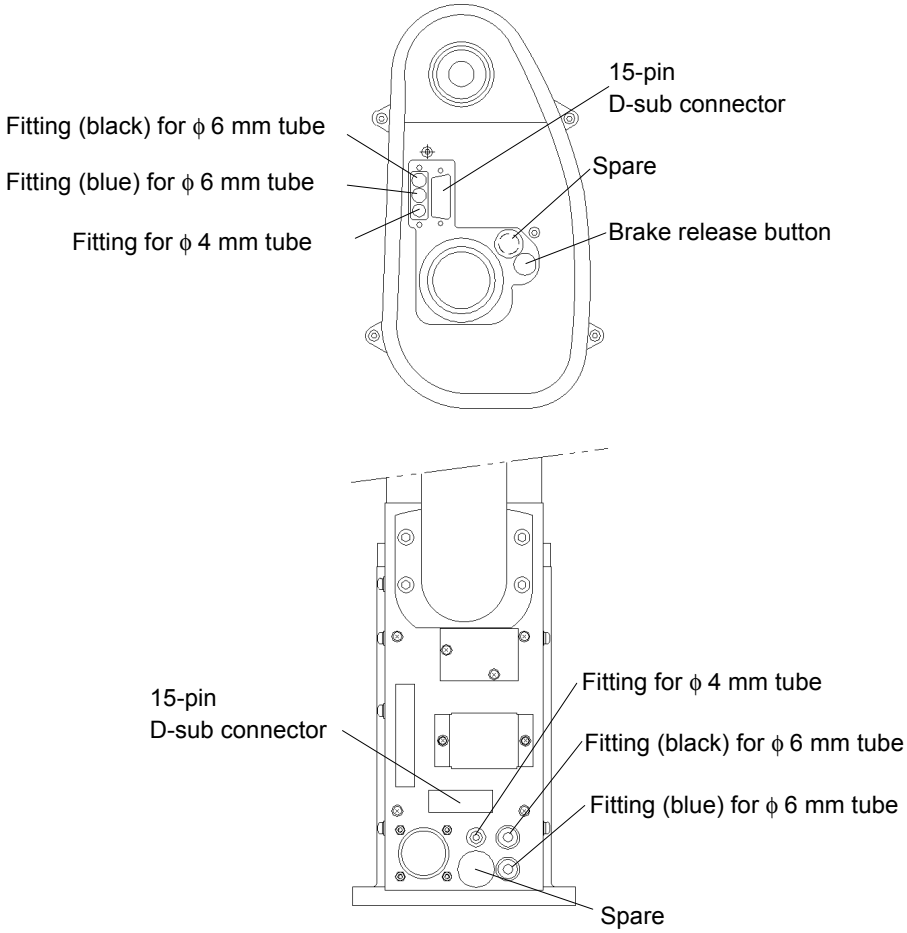
Rated voltage	Allowable current	Number of cables	Nominal sectional area	Outer diameter	Note
AC/DC30 V	1 A	15	0.211 mm^2	ϕ 8.3±0.3 mm	Shielded

Compatible connector :15-pin D-sub connector. Pins with the same number are connected.

Pneumatic tubes

Max. usable pneumatic pressure	Number of pneumatic tubes	Outer diameter × Inner diameter
0.59MPa (6kgf/cm^2)	2	ϕ 6 mm × ϕ 4 mm
	1	ϕ 4 mm × ϕ 2.5 mm

The ends of each pneumatic tube are equipped with fittings for connecting pneumatic tubes having an outer diameter of ϕ 6 mm and ϕ 4 mm.



* If the manipulator is a Clean model, it must be connected to an exhaust system. For details, refer to chapter *11. Clean Model*.

Figure 9. User wires and tubes

5. End Effectors

5.1 Attaching an end effector

Users are responsible for making their own end effector(s). Here, we point out some precautions to adhere to when attaching an end effector.

When you operate the manipulator with an end effector attached, the end effector could touch the main body of the manipulator depending on the outer diameter of the end effector, the size of the work piece or the position of the arms. When you are laying out the system, pay close attention to the interference area of the end effector.

* If the manipulator is a Clean model, refer to chapter *11. Clean Model*.

◆ A detail of the end effector mount is shown in Figure 10. (See Figure 20 in chapter *7. External Dimensions* for overall dimensions.)

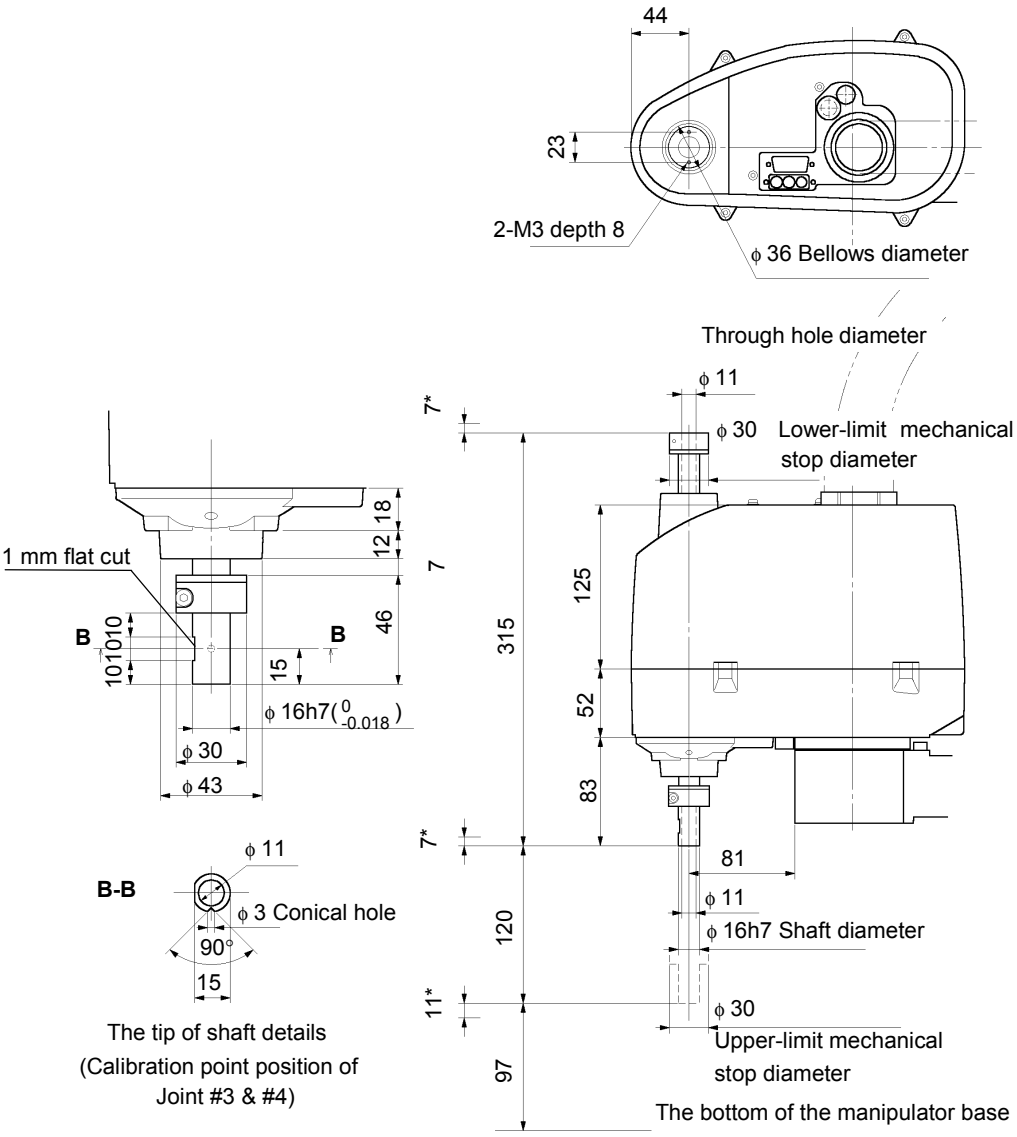


Figure 10. Dimensions around the shaft of Standard model [Unit :mm]

NOTE If the maximum radius of the end effector is over 37mm, the end effector may hit the arm or base of manipulator depending on the motion.

NOTE Do not move the upper-limit mechanical stop that is on the lower side of the shaft.

- Use a split muff coupling with an M4 bolt or larger to attach an end effector to the shaft.
- You can use the flat cut and conical hole on the end of the shaft to orient Joint #4 by tightening a setscrew.
- The electromagnetic brake is applied to Joint #3 when the power is off. Joint #3 cannot be raised or lowered by hand when the brake is engaged. This prevents Joint #3 from descending under the weight of the end effector and striking any peripheral equipment when the power is cut during robot operation or when the power is on but in the MOTOR OFF condition.
  If you want to raise and lower Joint #3 when you are attaching an end effector, turn ON the controller and keep the Joint #3 brake release button pushing. This button is the momentary type which releases the brake only while it is pushed.

NOTE Joint #3 descends under it own weight while you are pushing the Joint #3 brake release button.

Figure 11. Joint #3 brake release button

Wire and tube layout

The Joint #3 shaft has a through-hole to the end effector for supplying air and electricity. The diameter of the through-hole is ϕ 11 mm. The lower limit mechanical stop of Joint #3 has two threaded holes (depth 8 mm) for M3 bolts for tooling. (See Figure 10.)

⚠ WARNING

- If you use an end effector equipped with a gripper or a chuck, set up electrical signals and /or pneumatic in such a way that the gripper does not release its object when the robot is turned OFF.
- All I/O's are set at the factory so that they automatically shut entirely off (0) when the robot is turned OFF, when the emergency stop switch is pressed, or when any of the robot's safety features are activated.

5.2 End effector and acceleration / deceleration

To ensure optimum robot performance, it is important to make certain that the load (weight of the end effector and transported object) and moment of inertia of the load are within the maximum rating for the robot and that Joint #4 does not become eccentric. If the load or moment of inertia exceeds the rating or if the load becomes eccentric, adjust operating acceleration/deceleration and speed in accordance with the explanations below.

Setting WEIGHT parameters

The rated weight capacity is 1kg, and the maximum weight capacity is 3kg. When a load is heavier than the rated weight, you must change the WEIGHT setting.

Weigh both the end effector and the work piece that the end effector will transport.

RC+

Enter their combined total weight into the [Weight:] text box on the WEIGHT tab of the Project | Robot Parameters dialog. (Refer to the chapter *EPSON RC+ GUI* in the EPSON RC+ User's Guide.) You may also execute the WEIGHT command from the EPSON RC+ Monitor Window.

SPEL 95

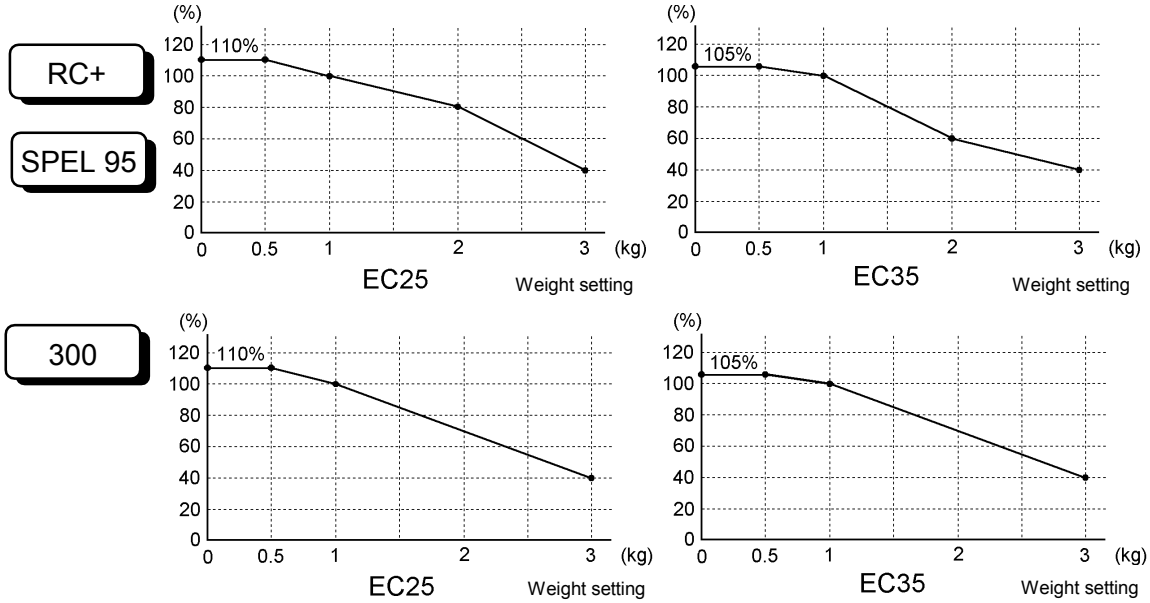
Enter their combined total weight into the [Weight:] text box in the [WEIGHT] panel of the Setup [Robot Parameters] dialog. (Refer to the section *Setting up the Robot Parameters* in chapter 11 of the User's Guide.)

300

Enter their combined total weight as the Hand Weight parameter in the WEIGHT command. (Refer to the Reference manual for details of WEIGHT command.)

Executing this command sets the maximum possible speed and operating acceleration / deceleration speed of the robot automatically in accordance with the WEIGHT parameters.

NOTE ☞ The EC series manipulators are not designed to work with loads exceeding 3kg. The total weight of the end effector and payload must not exceed 3kg. Always set the WEIGHT parameters according to the load; otherwise, the robot cannot fully operate as intended. Setting a value that is smaller than the actual load may cause errors or an excessive vibration. It will also shorten the life of parts and mechanisms.

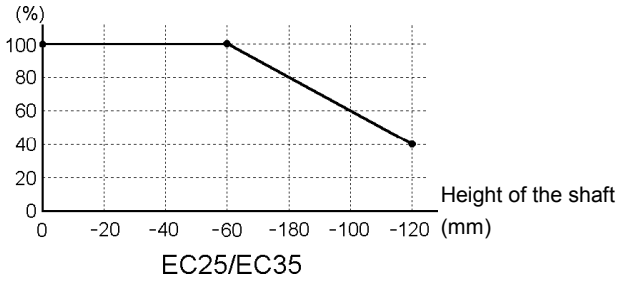


* The percentage in the graph is based on the speed at rated weight (1kg) as 100%.

Figure 12. Automatic acceleration/deceleration setting by WEIGHT

Precautions for auto acceleration / deceleration

◆ When you move the manipulator horizontally with Joint #3 (Z) at a high position, the motion time will be faster. When Joint #3 gets below a certain point (-60mm in figure 13 below), then auto acceleration/deceleration is used to reduce acceleration / deceleration. When the manipulator moves with Joint #3 at a higher position, the motion acceleration/deceleration is faster, but it takes more time to move Joint #3 up and down. Adjust the position of Joint #3 for the robot motion after considering the relations between the current position and the destination position. The upper limit of Joint #3 during horizontal motion is set by the LimZ command.



* The percentage in the graph is based on the acceleration / deceleration at the upper-limited position of Joint #3 as 100%

Figure 13. Automatic acceleration / deceleration vs. Joint #3 position

◆ If you move the manipulator horizontally when the position of Joint #3 is low, it may cause over shoot at the time of final positioning. We recommend that the height of the Joint #3 be as high as possible when you move the manipulator horizontally.

Moment of inertia and the ACCEL setting

When dealing with rotating shafts, you must account for the moment of inertia of a load. There are also ratings and maximum values for allowable moments of inertia. They differ depending on the Weight setting described above. The ratings and maximum moments of inertia are as follows:

W : Weight setting (kg)
I : Allowable moment of inertia ($kg \cdot m^2$)

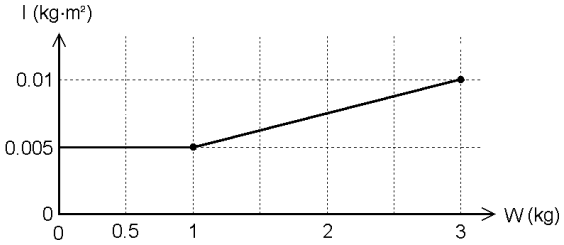


Figure 14. Allowable moment of inertia

When the moment of inertia of the end effector is equal to or less than the rated allowable moment of inertia, you may operate the robot at the maximum acceleration / deceleration speed setting (ACCEL 100, 100).

When the rated allowable moment of inertia is exceeded, lower the acceleration / deceleration speed using the ACCEL command. Using the results of the following formula as a guideline, input the suitable value for the given conditions.

$A = I_0 / I \times 100$ (%)

A : ACCEL value in accordance with the moment of inertia
I_0 : Rated allowable moment of inertia
I : Moment of inertia of the end effector

<Example> For the end effector weighting 1kg and with a moment of inertia of $0.01 kg \cdot m^2$

```
WEIGHT 1
A = 0.005 / 0.01 × 100 = 50%
     ↓
ACCEL 50,50
```

Calculating the moment of inertia

The moment of inertia is defined as "the ratio of the torque applied to a rigid body free to rotate about a given Joint to the angular acceleration produced about that Joint." This value is typically referred to as "the moment of inertia", "inertia", or "GD^2". The following is an example of how to calculate the moment of inertia.

<Example> Consider an end effector and work piece such as those shown in the diagram below. The moment of inertia of the entire load is found using the sum of each of the parts (a) to (c).

Moment of inertia of the whole = Moment of inertia of end effector (a) + Moment of inertia of work piece (b) + Moment of inertia of work piece (c)

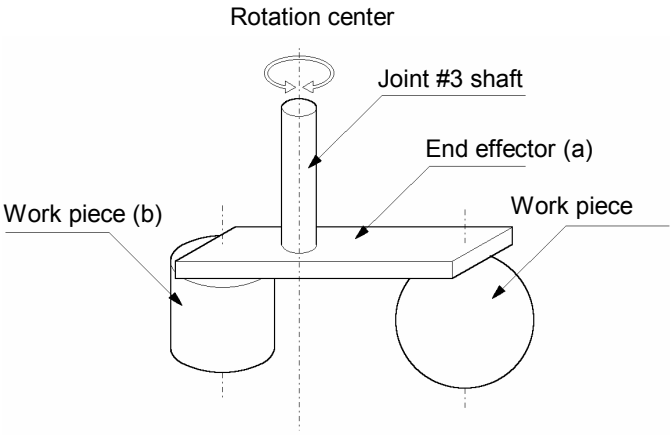


Figure 15. Example of load (end effector carrying work pieces)

The methods for calculating the respective moments of inertia for (a), (b), and (c) are shown below. Using these basic formulas for moment of inertia as a reference, find the moment of inertia for the load as a whole.

(a) Moment of inertia of a rectangular parallelepiped = $m \frac{b^2 + h^2}{12} + m \times L^2$

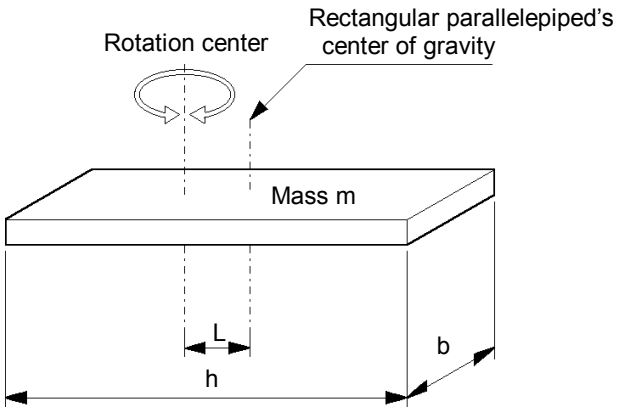


Figure 16 (a). Rectangular parallelepiped

(b) Moment of inertia of cylinder = $m \frac{r^2}{2} + m \times L^2$

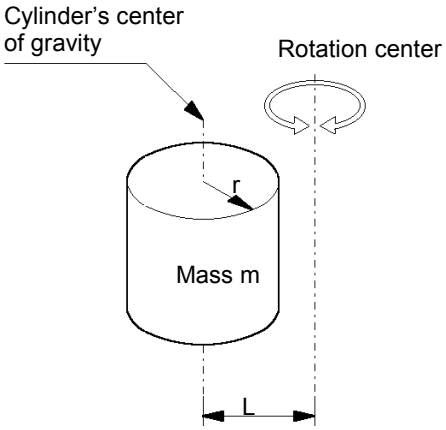


Figure 16 (b). Cylinder

(c) Moment of inertia of a sphere = $m \frac{2}{5} r^2 + m \times L^2$

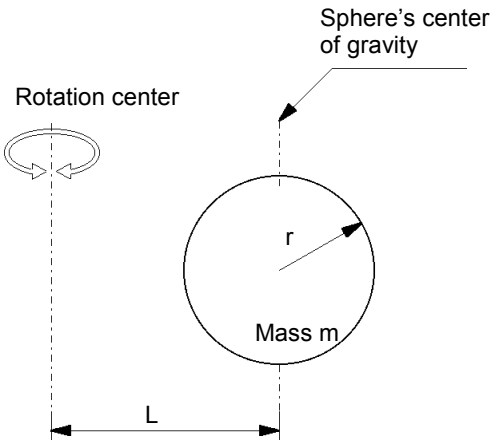


Figure 16 (c). Sphere

Eccentricity of Joint #4

The eccentricity of Joint #4 (rotation center) and the position of a load's center of gravity should not be more than 30 mm.

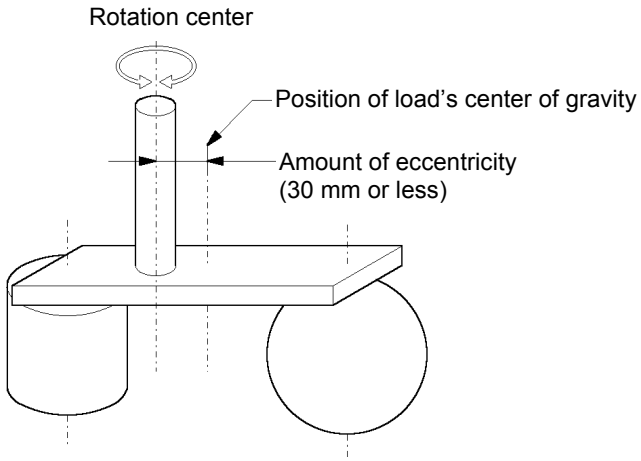


Figure 17. Amount of eccentricity

When the load and joint are eccentric, lower the acceleration/deceleration speed using the ACCEL command. Using the results of the following table and formula as a guideline, use the suitable value for the given conditions.

$A = A_i \times A_h / 100$ (%)

A :ACCEL setting value
A_i :ACCEL setting value according to moment of inertia
A_h :ACCEL % according to amount of eccentricity

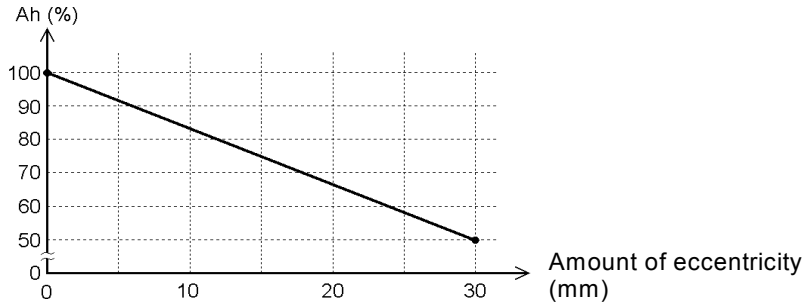


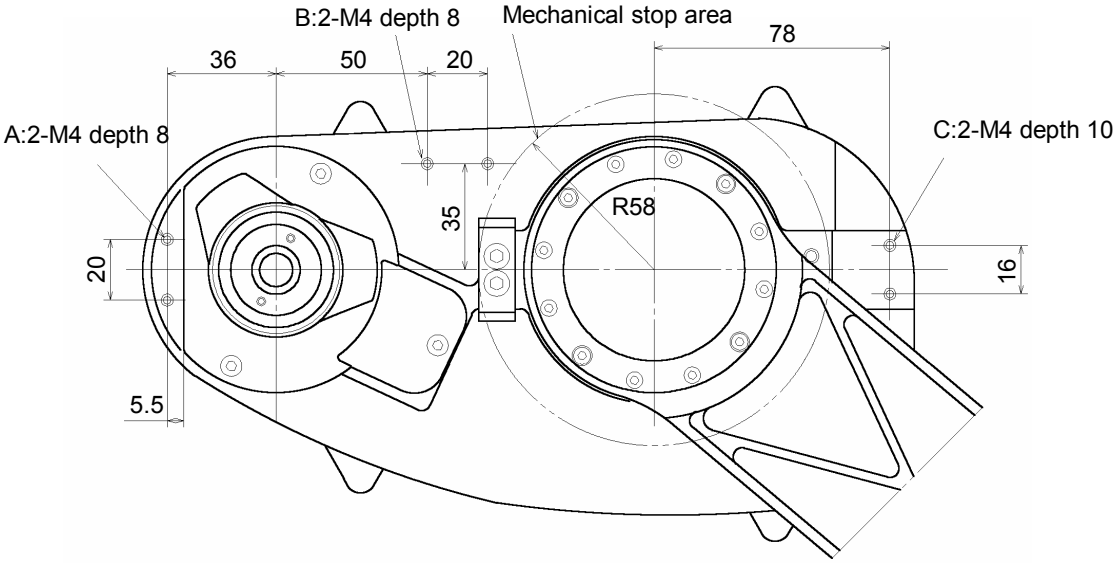
Figure 18. Eccentricity and ACCEL %

<Example> For a 2kg end effector (and work piece) with a moment of inertia of 0.01kg·m^2 and eccentricity of 30 mm:

WEIGHT 2
A_i = 0.075/0.01×100=75 (%)
A_h = 70 (%)
A = 75×70/100=52.5 (%)→ 52 (rounded up)
↓
ACCEL 52,52

6. Attaching a Camera, Valve, and Other Devices

Arm #2 has six threaded holes. Use these holes for attaching cameras, valves, and other equipment.



Height from the base-installed surface

	A	B	C
EC***S	300	302	302
EC***C	301	303	303

Figure 19. Position of threaded holes in Arm #2 (bottom side) [unit: mm]

When you attach a load to the arm, you must consider the WEIGHT parameters as explained in the section 5.2. When you attach a camera or other devices to the shaft, enter the total weight of the end effector, work piece, and the attached device to the parameter. When you attach a camera or other device to the arm, calculate the weight as equivalent weight of Joint #3, and add this to the load weight.

Refer to *5.2 End effector and acceleration / deceleration* for details on the WEIGHT parameters.

Equivalent weight is found using the formula below.

When you attach the equipment near Joint #2 : $W_M = M (L_1)^2 / (L_1+L_2)^2$

When you attach the equipment to the end of Arm #2 : $W_M = M (L_M)^2 / (L_2)^2$

W_M : equivalent weight
M : weight of camera, etc.
L_1 : length of Arm #1
L_2 : length of Arm #2
L_M : distance form rotation center of Joint #2 to center of gravity of camera, etc.

<Example> A 0.5kg camera was attached to the end of the arm (225 mm from the rotation center of Joint #2) of an EC with a load weight of W = 1kg.

$M = 0.5$, $L_2 = 125$, $L_M = 225$

$W_M = 0.5 \times 225^2 / 125^2 = 1.62 \rightarrow 1.7$ (rounded up)

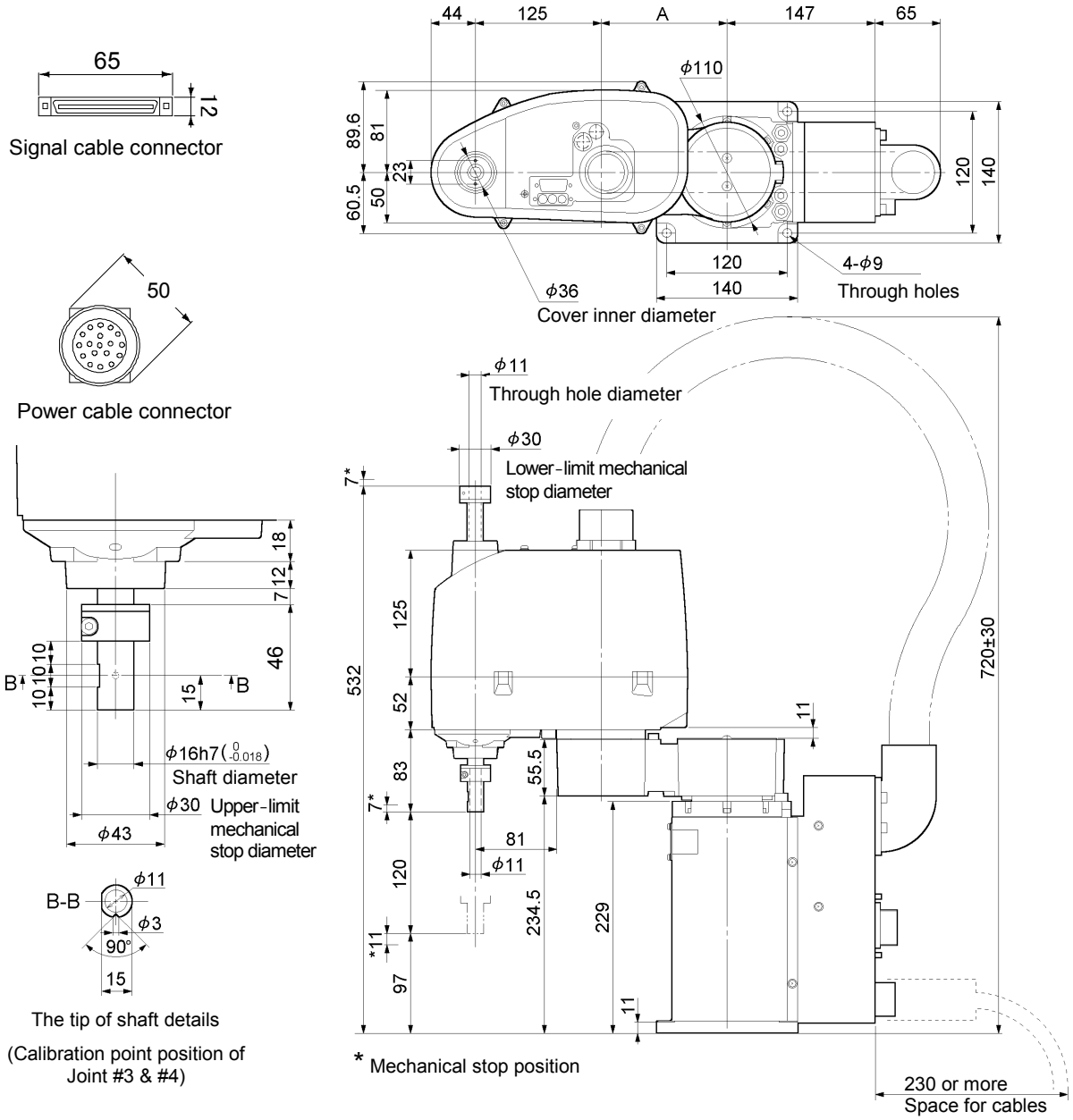
$W + W_M = 1 + 1.7 = 2.7$

Enter 2.7 as the WEIGHT parameter.

7. External Dimensions

EC series

* If the manipulator is a Clean model, refer to chapter *11. Clean Model*.



	EC251S	EC351S
A	125	315

Figure 20. External dimensions of EC**1S [unit : mm]

8. Motion Range and Robot Coordinates

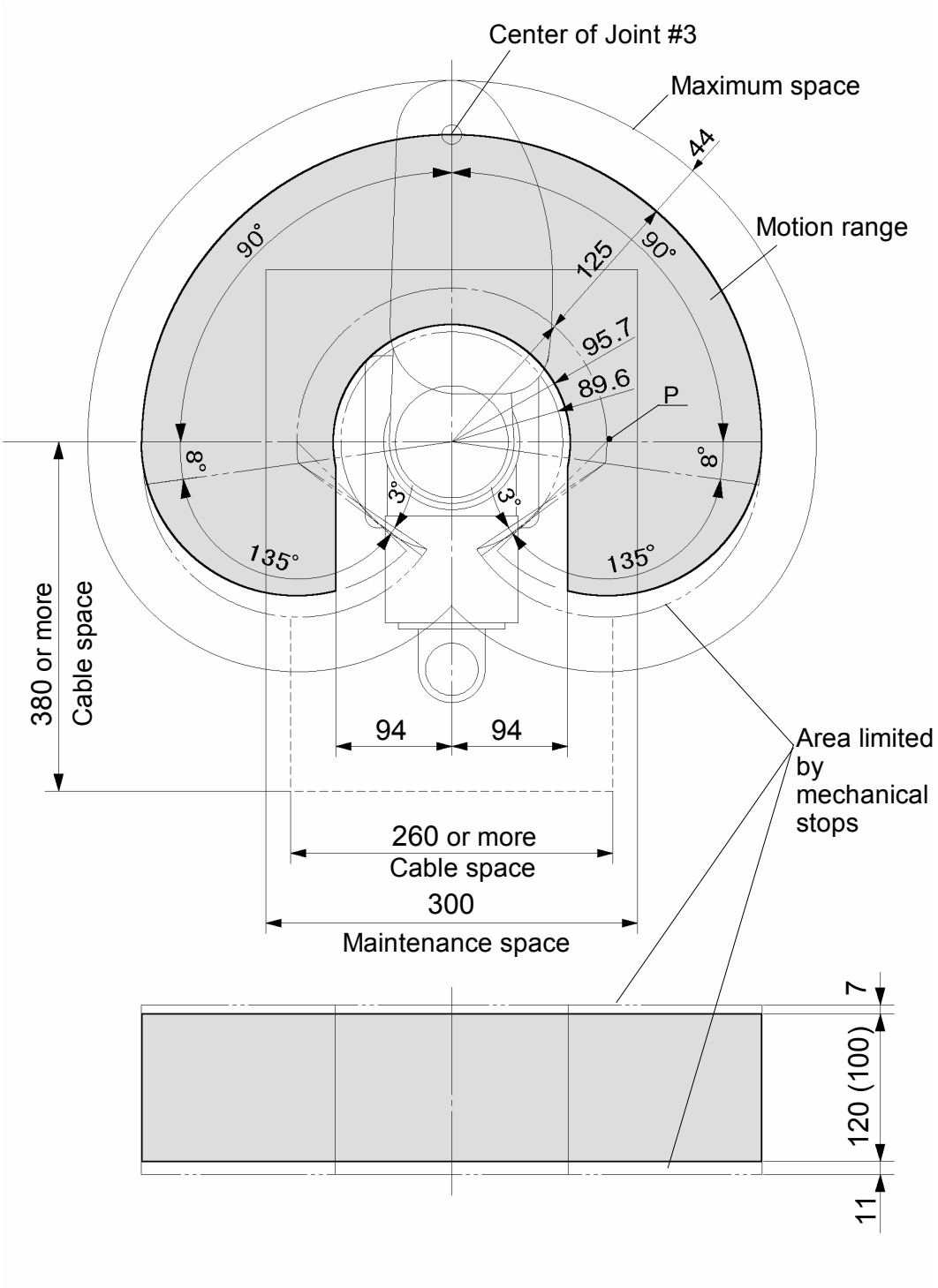
8.1 Standard motion range

The motion range and the robot coordinate system of the EC series manipulator are shown in Figures 21 and 22.
The motion range shown is the standard (maximum) specification. When each axis motor is engaged, the center of Joint #3's lowest point moves in this area.

"Area limited by mechanical stops" is the area where the center of Joint #3's lowest point can be moved when each axis motor is not engaged. The center of Joint #3 cannot move beyond this area mechanically.

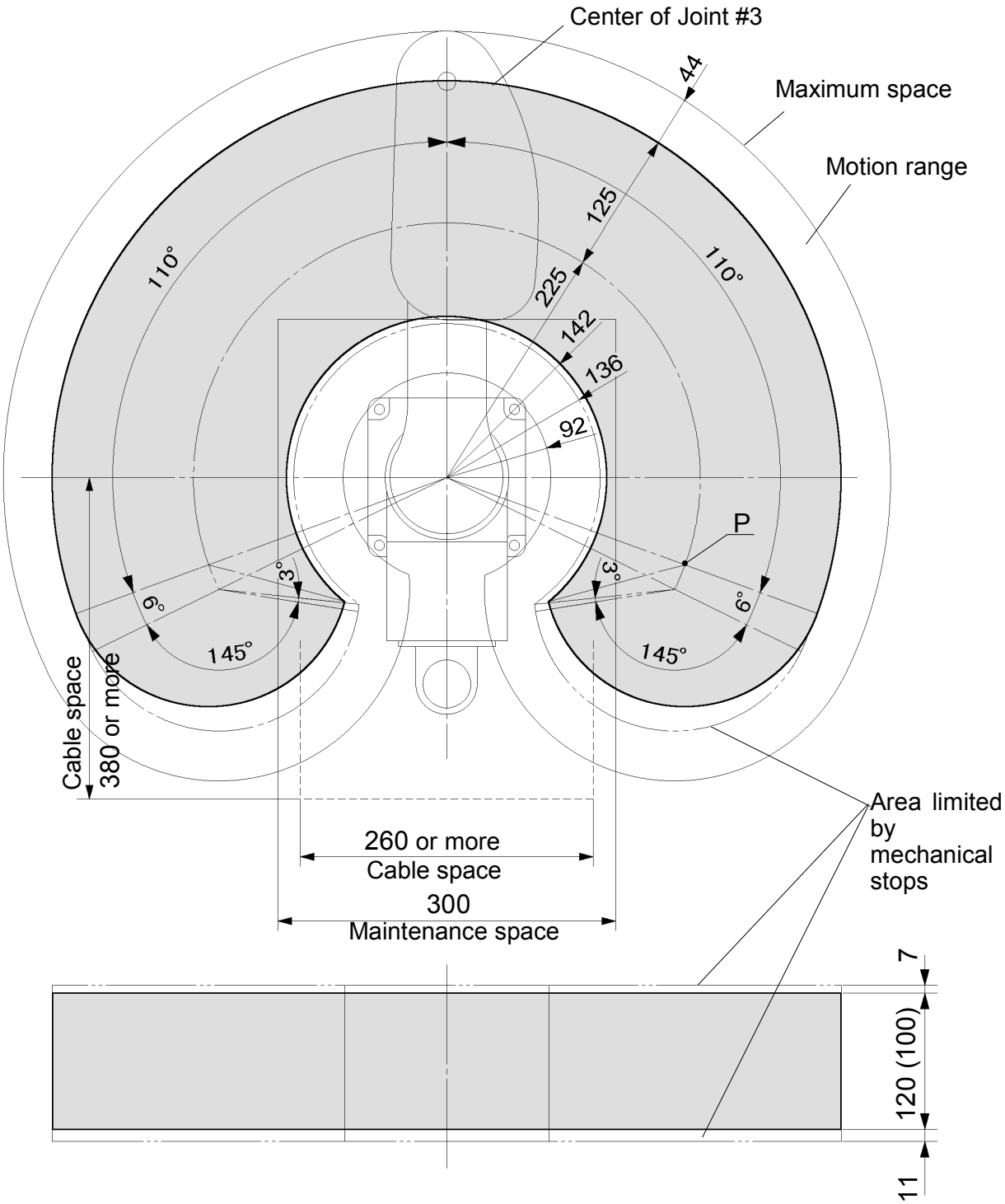
"Maximum space" is the area that contains the farthest reach of the arms. If the maximum radius of the end effector is over 44 mm, then it will extend beyond the maximum space. If this is the case, then the end effector itself dictates the maximum space.

The physical relationship of the manipulator's anchor holes and point P varies from one manipulator to another, but the maximum variance is ±2° referenced to the center of the manipulator base. Take this into account when you lay out your system equipment if you use the outermost circumference of the motion range.



For the Clean model, the Z stroke value is in parentheses ( ).

Figure 21. Motion range of EC251* [unit : mm]



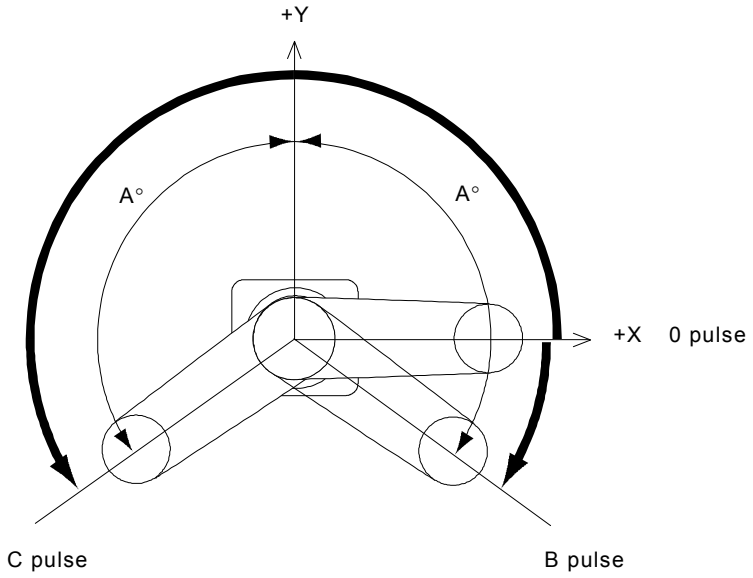
For the Clean model, the Z stroke values is in parentheses ( ).

Figure 22. Motion range of EC351* [unit : mm]

8.2 Pulse range

The manipulator's motion range is controlled by the pulse lower limit and upper limit of each joint. Pulse values are read from the servo motor's encoder output. Here, we show the pulse range of each joint.

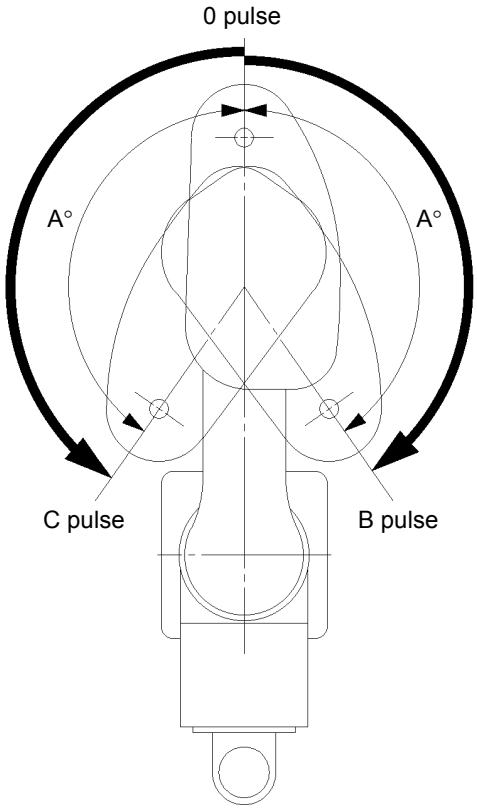
The 0 (zero) pulse position of Joint #1 is the position at which Joint #1 faces in the positive direction of the X-coordinate axis. The pulse value is positive (+) in the counterclockwise direction from the 0 pulse position and negative (-) in the clockwise direction.



	EC251*	EC351*
A°	90°	110°
B pulse	0	-18205
C pulse	+163840	+182045

Figure 23. Pulse range of Joint #1

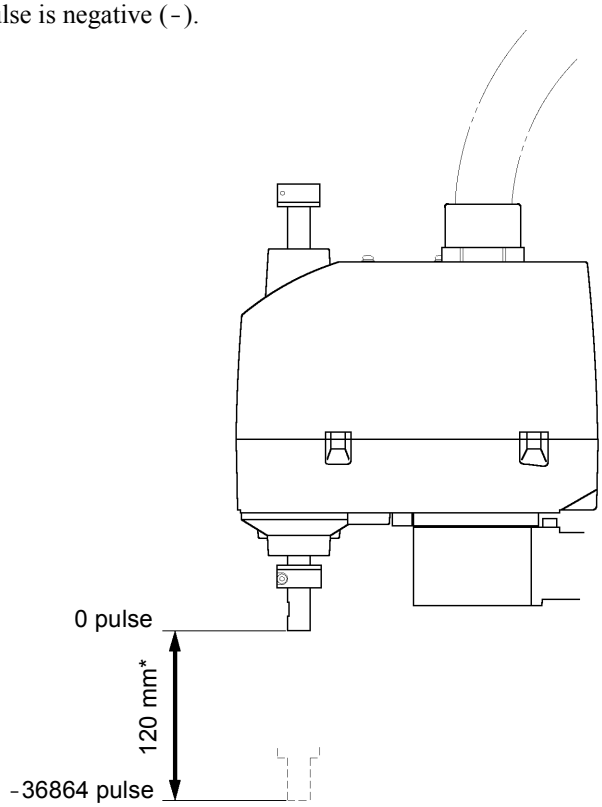
The 0 pulse position of Joint #2 is the position at which Joint #2 is parallel to Joint #1.
A positive (+) pulse value is taken in the counterclockwise direction from the 0 pulse position, and a negative (-) pulse value is taken in the clockwise direction.



	EC251*	EC351*
A°	135°	145°
B pulse	-76800	-82489
C pulse	+76800	+82489

Figure 24. Pulse range of Joint #2

The 0 pulse position of Joint #3 is the upper limit of Joint #3. Joint #3 descends from the 0 pulse position and the pulse is negative (-).



* For the Clean model, the stroke is 100mm (-30720 pulse).

Figure 25. Pulse range of Joint #3

The 0 pulse position of Joint #4 is the position at which the flat cut surface of the Joint #4 shaft faces the positive direction of the X-coordinate axis when Joint #1 and #2 are parallel to the X-coordinate axis. The pulse value is positive (+) in the counterclockwise direction from the 0 pulse position and negative (-) in the clockwise direction.

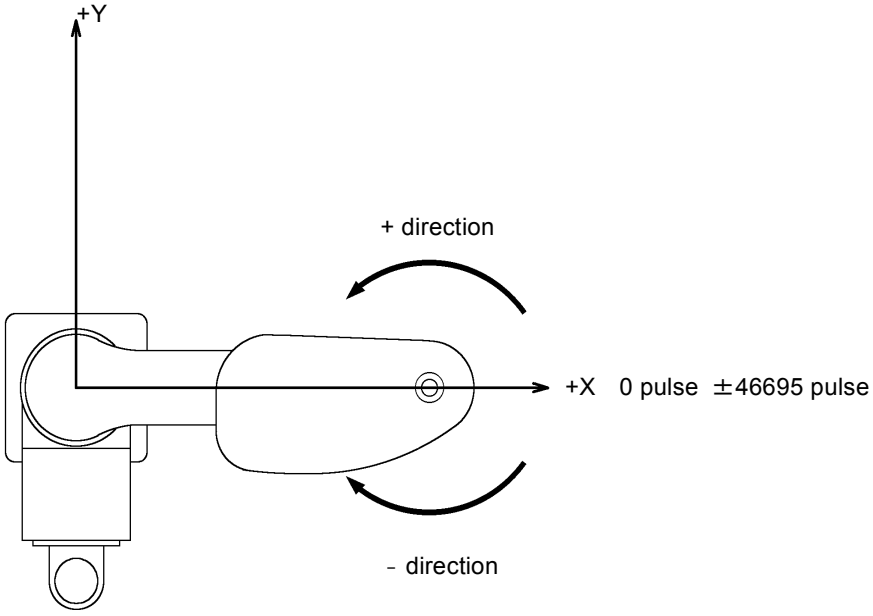


Figure 26. Pulse range of Joint #4

8.3 Changing the Motion Range

⚠ WARNING

■ Both the mechanical stop and the software settings must always be set at the same time when a motion range is being set up.

* The motion range of Joint #3 of clean model manipulator can not be changed with mechanical stops.

The motion range is preset at the factory as explained in *8.1 Standard motion range* in this chapter. This is the manipulator's maximum motion range.
It is possible to change the motion range for reasons of layout efficiency or safety and the like. Make any changes in the motion range in accordance with the following instructions.

Methods of setting the motion range

You can set the motion range by doing any of the following:

(1) Set the pulse range (all Joints).

(2) Set the mechanical stops (Joints #1, #2, and #3).

(3) Set the Cartesian (rectangular) range in the X, Y coordinate system of the robot (Joints #1 and #2).

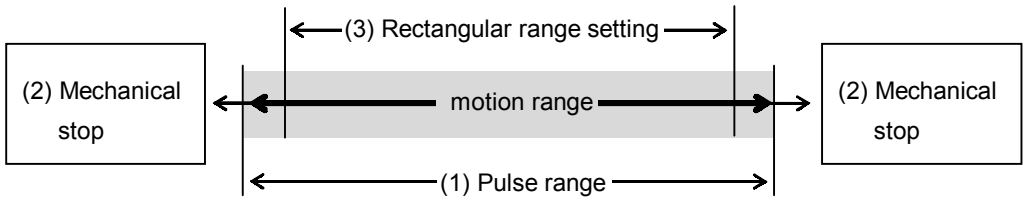


Figure 27. Setting the motion range

(1) Changing motion range using pulse range

Pulses are the basic unit of robot arm operation. Setting the upper and lower limits (pulse range) of these pulse values is the most fundamental in terms of robot control.

RC+

You can set the pulse range by using the RANGE tab in the Project | Robot Parameters dialog. (Refer to the chapter *EPSON RC+ GUI* in the EPSON RC+ User's Guide.) You may also execute the RANGE command from the EPSON RC+ Monitor Window.

SPEL 95

You can set the pulse range by using the [RANGE] panel. (Refer to *Setting the Robot Parameters* in chapter 11 of the User's Guide.)

300

You can set the pulse range by using either the RANGE command or the JRANGE command. Each command has special features, as explained below. Use the command that best fits your application. Refer to the reference manual for details about each command.

RANGE	Sets the pulse ranges for all joints at once.
JRANGE	Sets the pulse ranges for one joint.

The maximum pulse range is shown in *8.2 Pulse range* in this chapter. Always set pulse ranges to the inside of the mechanical stops.
When the robot receives a move command, it first checks whether or not the destination specified by the command is within the pulse range. The robot does not move if the destination is outside the set pulse range. Instead, an error is issued.

(2) Changing motion range using mechanical stops: Joint #1 to #3

Mechanical stops physically limit the absolute area that the manipulator can move. You can change the angle of the stops to the angles shown in the following table.

Joint	Model	Possible area setting using the mechanical stops	
#1	EC***	+0°	-0°
#2	EC251*	+110°	-110°
	EC351*	+120°	-120°
#3	EC***	less than the maximum stroke	

When you change the position of the mechanical stops, you must also input the corresponding pulse range.
The method for changing area settings using the mechanical stops is shown below.

Changing the position of the mechanical stops for Joint #1 and #2

Both Joint #1 and #2 has threaded holes in positions corresponding to the angles for stop settings. You can change the position of the mechanical stops by setting bolts in the appropriate holes. The positions of the mechanical stops are shown below.

RC+

(1) Exit EPSON RC+, shut down the SPEL Runtime Drivers, and turn OFF the Drive Unit.

SPEL 95

(1) Exit SPEL 95, and turn OFF the Drive Unit.

300

(1) Turn OFF the controller.

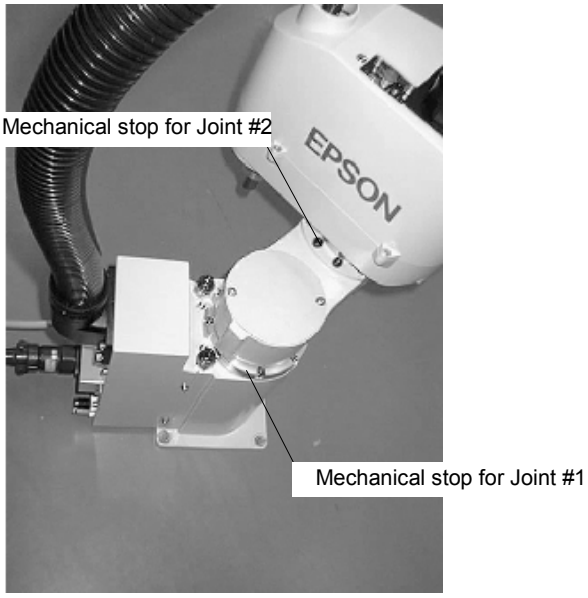


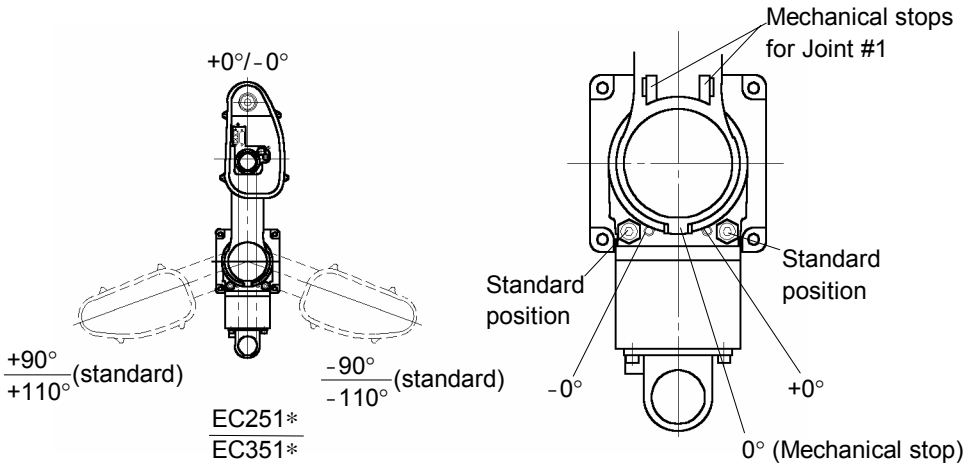
Figure 28. Locations of the mechanical stops

(2) Screw a hexagon socket head cap bolt into each of the holes corresponding to the angle setting.

Joint	Hexagon socket head cap bolt	Number of bolts	Recommended tightening torque
#1	M8×10 fully threaded bolt	1/side	3720N·cm (380kgf·cm)
	Two M10 nuts and a plain washer		
#2	M6×10 fully threaded bolt		1860N·cm (190kgf·cm)

Threaded hole locations corresponding to the angle setting are shown below.

Joint #1



Joint #2

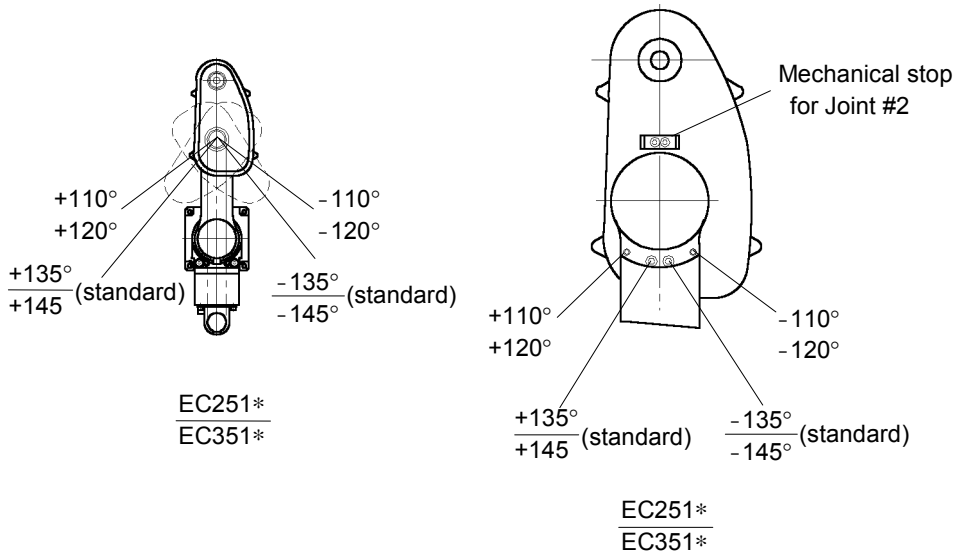


Figure 29. Threaded holes for changing the position of mechanical stops

RC+

(3) Turn ON the Drive Unit, and start EPSON RC+.

SPEL 95

(3) Turn ON the Drive Unit and start SPEL 95.

300

(3) Turn ON the controller.

RC+

(4) Set the pulse range corresponding to the new positions of the mechanical stops using the RANGE tab in the Project | Robot Parameters dialog. (Refer to the chapter *EPSON RC+ GUI* in the EPSON RC+ User's Guide.) You may also execute the RANGE or JRANGE commands from the EPSON RC+ Monitor Window.

SPEL 95

(4) Set the pulse range corresponding to the new positions of the mechanical stops using the [RANGE] panel. (Refer to *Setting the Robot Parameters* in chapter 11 of the User's Guide.

300

(4) Set the pulse range corresponding to the new positions of the mechanical stops using either the RANGE or JRANGE command.

The pulse value corresponding to the angle setting in Figure 29 is described in the tables below.

NOTE

Always set the pulse range to the inside position of the mechanical stops.

Angle setting and Pulse value

Joint #1				
	angle setting	pulse value	angle setting	pulse value
EC251*	+0°	81920	-0°	81920
	+90°	163840	-90°	0
EC351*	+0°	81920	-0°	81920
	+110°	182045	-110°	-18205

Joint #2				
	angle setting	pulse value	angle setting	pulse value
EC251*	+110°	62578	-110°	-62578
	+135°	76800	-135°	-76800
EC351*	+120°	68267	-120°	-68267
	+145°	82489	-145°	-82489

<Example> Joint #1 of EC251S is set from -90° to +0°and Joint #2 is set from -110° to +135°.

RC+

```
>JRANGE 1,0,81920          ' Sets the pulse range of Joint #1
>JRANGE 2,-62578,76800     ' Sets the pulse range of Joint #2
>RANGE                     ' Checks the setting using RANGE
0, 81920, -62578, 76800, -36864, 0,-46695, 46695
```

SPEL 95

Select the [RANGE] panel and set the minimum value for Joint #1 to 0 and the maximum value at 81920. Additionally, set the minimum value for Joint #2 at -62578 and the maximum value at 76800.

300

```
>JRANGE 1,0,81920          ' Sets the pulse range of Joint #1
>JRANGE 2,-62578,76800     ' Sets the pulse range of Joint #2
>RANGE                     ' Displays RANGE values
      0   81920
-62578    76800
-36864        0
-46695    46695
```

(5) Check the following:

- Move the arm by hand until it touches the mechanical stop. The arm should not hit any obstructions, such as peripheral equipment.
- Using the PULSE/GO PULSE command, operate the reset joint at slow speed until it reaches the position of the smallest and largest pulse range settings. The arm should not hit the mechanical stops.

<Example in (4)>

Joint #2 of EC251* is set at +110°.

RC+ 300

Open the Monitor Window and execute the commands shown below. (Click the Monitor Window toolbar button.)

```
MOTOR ON
SPEED 5                    ' Sets at slow speed.
PULSE 0,0,0,0              ' Moves to the smallest pulse position
                             of Joint #1.
PULSE 81920,0,0,0          ' Moves to the largest pulse position of
                             Joint #1.
PULSE 40960,-62578,0,0     ' Moves to the smallest pulse position
                             of Joint #2.
PULSE 40960,76800,0,0      ' Moves to the largest pulse position of
                             Joint #2.
```

SPEL 95

Click the <DEBUG> button and enter the commands shown below in the [Command Execution] Window. (Refer to Chapter 3 of the Introduction manual for details on using the [Command Execution] Window.)

```
MOTOR ON
SPEED 5                          ' Sets at slow speed.
GO PULSE(0,0,0,0)                ' Moves to the smallest pulse position of Joint #1.
GO PULSE(81920,0,0,0)            ' Moves to the largest pulse position of Joint #1.
GO PULSE(40960,-62578,0,0)       ' Moves to the smallest pulse position of Joint #2.
GO PULSE(40960,76800,0,0)        ' Moves to the largest pulse position of Joint #2.
```

The PULSE / GO PULSE command moves all joints to the specified positions at the same time. Please specify safe positions after considering motion of not only the joints whose pulse range have been changed, but also other joints. In this example, when you check Joint #2, Joint #1 is moved to the center of it's motion range (pulse value: 40960).

If the arm is touching the mechanical stop or if it has hit the stop and an error has occurred, either change the pulse range to a narrower setting or extend the position of the mechanical stops within limits.

Changing the position of the mechanical stop for Joint #3

* The Joint #3 stroke of a Clean model cannot be changed because the mechanical stop is secured.

RC+
SPEL 95

(1) With the Drive Unit ON and the motors OFF (using the MOTOR OFF command), push the Joint #3 brake release button.

300

(1) With the controller ON and the motors OFF (using the MOTOR OFF command), push the Joint #3 brake release button.

NOTE

When you push the brake release button, Joint #3 may descend under the weight of the end effector, so be sure to support the shaft when you push the button.

Joint #3 can be moved up and down while you are holding down the brake release button. Push the shaft all the way up to the upper limit.

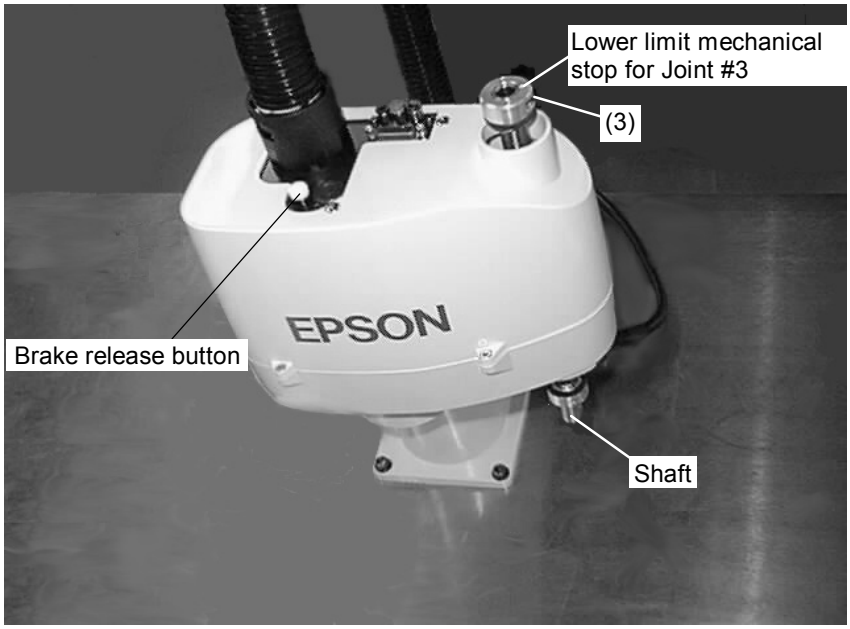


Figure 30. Mechanical stop for Joint #3

RC+

(2) Exit EPSON RC+, shut down the SPEL Runtime Drivers, and turn OFF the Drive Unit.

SPEL 95

(2) Exit SPEL 95, and turn OFF the Drive Unit.

300

(2) Turn OFF the controller.

(3) The lower-limit mechanical stop is a split muff coupling fastened to the top of the shaft. Loosen the coupling's M3×10 bolt. (See Figure 30.)

NOTE

Joint #3 has mechanical stops above and below, but only the lower-limit stop position can be changed. Do not move the upper-limit mechanical stop, as it also functions as part of the calibration point detector.

(4) The upper end of the shaft defines the maximum stroke. So when you want to limit the stroke, lower the lower-limit mechanical stop by the length you want to limit the stroke. As an example, let's say that the lower-limit mechanical stop is set at the standard 120 mm, making the lower-limit Z coordinate －120 mm. If you want to make the lower-limit Z coordinate －100 mm, you must lower the lower-limit mechanical stop by 20 mm. Use calipers to measure the distance when you lower the stop.

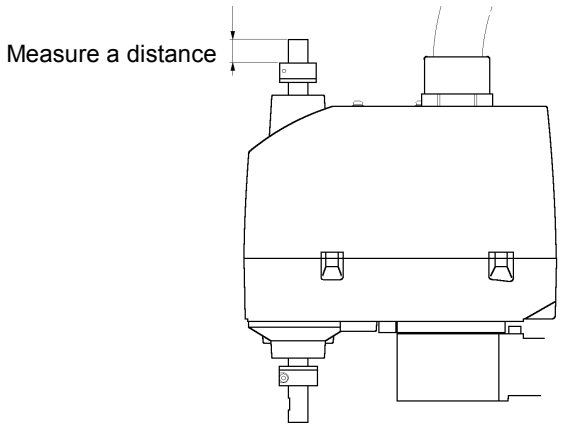


Figure 31. Changing the position of the mechanical stop for Joint #3

(5) Firmly tighten the bolt of the split muff coupling once it is in the appropriate position. Recommended tightening torque is 245N·cm (25kgf·cm).

RC+

(6) Turn ON the Drive Unit and start EPSON RC+.

SPEL 95

(6) Turn ON the Drive Unit and start SPEL 95.

300

(6) Turn ON the controller.

(7) Move the shaft to the lowest position by hand while pushing the brake release button. Make sure that the shaft is not too high for the operation points.

(8) Calculate the lower-limit pulse of the pulse range using the following formula (The lower limit Z coordinate is negative, so always make certain that the result of calculations is negative.)

Lower limit of pulse = lower limit Z axis value / 16 × 4096 × 1.2

<Example>

The stroke is 120 mm. You lower the mechanical stop by 20 mm and change the lower limit Z coordinate to －100 mm.

(－100) / 16 × 4096 × 1.2 = －30720

(9) Set the pulse range. The upper-limit pulse is 0.
<Example in (8)>

```
> JRANGE 3,-30720,0
```

(10) Move Joint #3 slowly using the PULSE/GO PULSE command to the position of the lower-limit value of the pulse range. If the mechanical stop is being hit, or if it is hit and an error occurs, either narrow the pulse range just enough to eliminate interface, or widen the position of the mechanical stop. The typical clearance for the mechanical stop at the lower-limit pulse position is approximately 11 mm.

<Example in (8)>
Click the <debug> button and input the following at [Command Execution] window.

```
MOTOR ON                ' Turns ON the motor
SPEED 5                 ' Sets on slow speed
PULSE 0,0,-30720,0      ' Moves to lower limit-pulse position of axis #3.
                          In the example, all pulses other than that of axis
                          #3 are 0. You should substitute these zeroes
                          with a pulse for a position in which there is no
                          interference even when you lower axis #3.
```

(11) If you need a clear view, open the arm cover and look from the side. Refer to chapter *2. Opening the Covers* in Part 2: Maintenance for instructions.

(3) Changing the range using X, Y limits

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

WARNING

- This setting applies only to the software, so it does not change the physical range. The maximum physical range is based on the positions of the mechanical stops.

RC+

Set the X Y range by using the XYLIM tab in the Project | Robot Parameters dialog. (Refer to the chapter EPSON RC+ GUI in the EPSON RC+ User's Guide.) You may also execute the XYLIM command from the EPSON RC+ Monitor Window.

For only EC251*, at the factory shipping, it is set as follows:

coordinate	lower limits [mm]	upper limits [mm]	Refer to
X	-94	94	Figure 21 in this chapter
Y	-250	0	

For example:

```
> XYLIM -94,94,-250,0
```

SPEL 95

Set the X Y range by using the [XYLIM] panel. For details on the [XYLIM] panel, refer to Chapter 11, section *Setting the Robot Parameters* in the User's Guide.

For only EC251*, at the factory shipping, it is set as follows:

coordinate	lower limits [mm]	upper limits [mm]	Refer to
X	-94	94	Figure 21 in this chapter
Y	-250	0	

For example:

```
> XYLIM -94,94,-250,0
```

300

Refer to the User's manual for SRC-300/320 *11. Set up, Set the robot parameter* in the SPEL Command Reference.

For EC251*, at the factory shipping, it is set as follows:

```
XYLIM -94,94,-250,0
```

(Refer to Figure 21 in this chapter.)

NOTE

If you need to change this setting for the EC251*, you must be careful because the end effector may hit the rear side of the manipulator, depending on the motion.

9. Emergency Stop

If the manipulator moves abnormally during operation, immediately press the emergency stop switch.

By pressing the emergency stop switch, the motor power is cut and the dynamic brake activates and stops the rotation of motor as inertia.

However, you should not press the emergency stop switch during normal operation unnecessarily. The braking distance depends on timing to activate the emergency stop switch and motion speed, but robot arm may overrun the stop position under servo-control and may collide with peripheral equipment.

We recommend pressing the emergency stop switch when the arm is not moving, when you want to prevent the robot from being operated.

(Refer to the Controller manual for more details of the emergency stop switch.)

10. Specifications

* If the manipulator is a Clean model, also refer to the section *11.5 Additional Specifications* in chapter *11. Clean Model*.

EC series

Model		EC251*	EC351*
Arm length	Arm #1+#2	125 + 125 mm	225 + 125 mm
Weight		14kg	
Driving method	All joints	AC servo motor	
Max. operation speed *1	Joint #1+#2 Joint #3 Joint #4	2650 mm/s 1000 mm/s 2368 °/s	3239 mm/s 1000 mm/s 2368 °/s
Repeatability	Joint #1+#2 Joint #3 Joint #4	±0.01 mm ±0.01 mm ±0.03 °	±0.015 mm ±0.01 mm ±0.03 °
Max. motion range *2 Value in ( ) for Clean model	Joint #1 Joint #2 Joint #3 Joint #4	±90 ° ±135 ° 120 mm (100 mm) ±360 °	±110 ° ±145 ° 120 mm (100 mm) ±360 °
Max. pulse range Value in ( ) for Clean model	Joint #1 Joint #2 Joint #3 Joint #4	0 to +163840 ±76800 -36864 (-30720) to 0 ±46695	-18205 to +182045 ±82489 -36864 (-30720) to 0 ±46695
Resolution	Joint #1 Joint #2 Joint #3 Joint #4	0.0010986 °/pulse 0.0017578 °/pulse 0.0032552 mm/pulse 0.0077097 °/ pulse	
Motor power consumption	Joint #1 Joint #2 Joint #3 Joint #4	100 W 100 W 100 W 50 W	
Payload	rated / max.	1kg /3kg	
Joint #4 allowable moment of inertia *3	rated / max.	With rated payload (1kg) : 0.005kg·m^2 / 0.01kg·m^2	
Diameter of the shaft / through hole		ϕ 16 (h7) mm / ϕ 11 mm	
Joint #3 down force		100 N (10.2kgf)	
Installed wire for customer use		15 wires (15 -pin D-sub connector)	
Installed pneumatic tube for customer use		ϕ 6 mm, 2 pneumatic tubes ϕ 4 mm, 1 pneumatic tube Allowable pressure: 0.59MPa (6kgf/cm^2)	
Environmental requirements		Temperature: 5 to 40 °C (No drastic change is allowed.) Humidity: 10 to 80 % (No condensation is allowed.)	
Equivalent continuous A-weighted sound pressure level *4		L_{Aeq} = 66.3 dB (A) or less	
Applicable controller		EPSON RC+, SRC5**(SPEL 95), SRC-3**	
Default values	SPEED ACCEL SPEEDS ACCELS FINE WEIGHT	5 10, 10 50 200 10, 10, 10, 10 1, 125	

*1 : When using PTP motion. For CP motion, the maximum operation speed on the horizontal plane is 1120 mm/sec.

2 : Base backside is excluded from the maximum working area in EC251.

*3 : When the center of gravity is at the center of Joint #4. If the center of gravity is not at the center of Joint #4, speed and acceleration must be reduced.

*4 : Operation conditions of manipulator at measurement:

Under the rated load, 4-Joint simultaneous motion, maximum speed, maximum acceleration, duty 50%.

Measurement point:

At the front of manipulator, 100 mm apart from the motion range, 50 mm above the base-installed surface.

Model settings

RC+

When setting the manipulator model using the EPSON RC+ system, select the manipulator model from the Setup | System Configuration | Robots tab. Refer to the chapter *Robot Configuration* in the EPSON RC+ User's Guide.

SPEL 95

When setting the manipulator model using the SRC5** controller, select the model with the [Basic Settings] panel that is displayed when [Setup] - [Robot Manipulator Settings] is executed. Refer to Chapter 11 in the User's Guide for the section *Setting the Robot Paramters.*

300

Manipulator models used with the SRC-3** controllers are pre-set by DIP switch SD1 on the MPU board in the controller. Be sure not to change DIP switch settings. Also, if an MT label is attached, the manipulator has custom specifications, and settings may differ from those described above. When making an inquiry, please note the custom specifications number on the MT label.

Model name	DIP switch SD1 (model select switch) setting					
	bit 3	bit 4	bit 5	bit 6	bit 7	bit 8
EC251S	-	ON	-	ON	ON	-
EC351S	-	-	ON	ON	ON	-
EC251C	ON	ON	-	ON	ON	-
EC351C	ON	-	ON	ON	ON	-

11. Clean Model

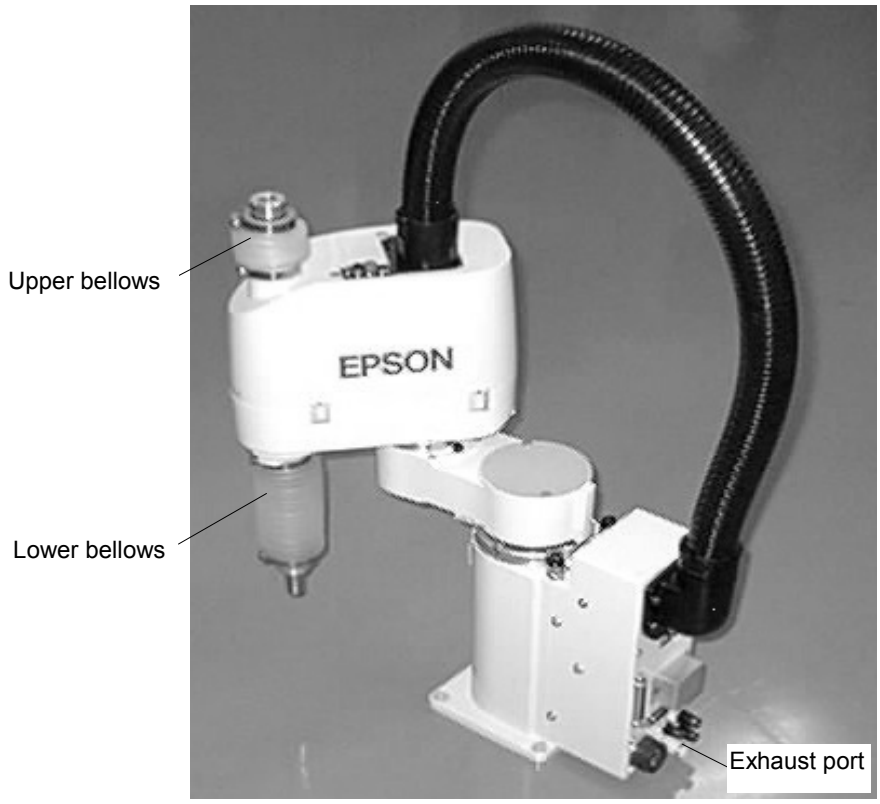
The Clean model for the EC series includes extra features that reduce dust emitted by the manipulator to enable use in clean room environments (see NOTE). This chapter describes the differences between the Standard and Clean models for the EC series.

NOTE

Clean model requirements specify a maximum of 10 particles (0.13 μm or more in diameter) in 28317 cm^3 (1cft) sample-air around the center of the motion range.

11.1 Manipulator part names

For basic information on manipulator part names, refer to chapter *1. Manipulator Part Names*.
The following parts for the Clean model are in addition to the standard manipulator.



11.2 Installation method

Chapter *3. Installation* contains instructions and safety precautions on unpacking and installing the manipulator.

(1) After unpacking the manipulator outside of the clean room, use bolts to fasten it down so that it will not tip over.

(2) Before installing the manipulator in the clean room, make sure it has been cleaned. It's preferable to wipe off the dust with a little alcohol or distilled water on lint-free cloth.

(3) Transport the manipulator to the clean room and install it.

(4) Connect the exhaust tube to the exhaust port. (Refer to the next section.)

11.3 Exhaust System

The Clean model requires the following type of exhaust system to prevent emission of dust particles from the manipulator.

The gap between the exhaust port and the exhaust tube must be sealed with vinyl tape so that the junction is airtight.

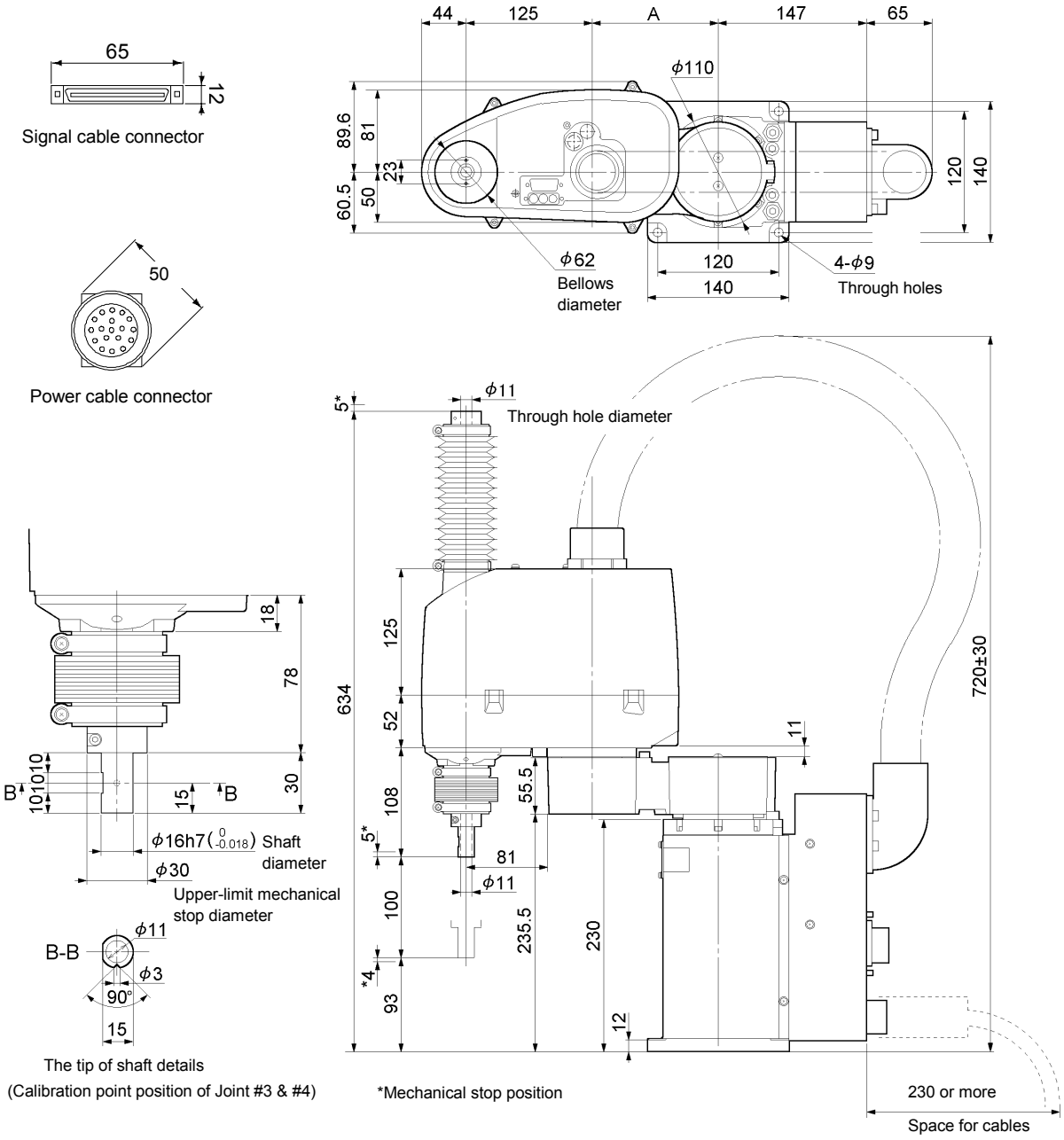
Exhaust tube	Polyethylene tube with outer diameter ϕ 8 mm
Recommended exhaust flow rate	Approximately 1000cm^3/s (Normal)

NOTE ☞ If the exhaust flow is not sufficient, dust particle emission may exceed the specified maximum level.

NOTE ☞ The exhaust system draws air from this Clean model manipulator's base interior and arm cover interior. A crack or other opening in the base unit can cause loss of negative air pressure in the outer part of the arm, which can cause increased dust emission. Therefore, do not remove the maintenance cover on the front of the base, the acrylic cover on the back of the base, or the sealing tape on the connector.

11.4 External dimensions

Clean model for EC series [unit : mm]



	EC251C	ES351C
A	125	225

11.5 Additional specifications

For standard specifications, refer to chapter *10. Specifications*.

Model	EC**1C
Cleanliness level	Maximum of 10 particles (0.13 μm or more in diameter) in 28317 cm^3 (1cft) sample-air located near the center of the work area.
Exhaust tube	Polyethylene tube with outer diameter ϕ8 mm
Recommended exhaust flow rate	Approximately 1000cm^3/s (Normal)

Part 2
Maintenance

Part 2 contains maintenance information for the EC Series Manipulator, including instructions for:

- Maintenance schedules
- Connection diagrams
- How to replace parts
- Calibration
- Parts list

Maintenance Safety Precautions

Please read this manual and other relevant manuals carefully before performing any routine maintenance. Keep this manual in a handy location for easy access at all times.

⚠ WARNING

- Only trained personnel should be allowed to operate, test, and maintain this robot and the robot system. Trained personnel are those who are certified trainees of company sponsored training courses (held on a regular basis) or those who have carefully read the manuals and have equivalent knowledge and skill.
- When you perform maintenance work or inspection of the robot, be sure to use the specified locking procedure for each robot system before starting work.
- When connecting or disconnecting the cables between the manipulator and the controller, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock or malfunction.
- After replacing parts, do not test the manipulator within the safeguarded area.
- Before operation, make sure that emergency stop switches and safeguard switch function properly.

⚠ CAUTION

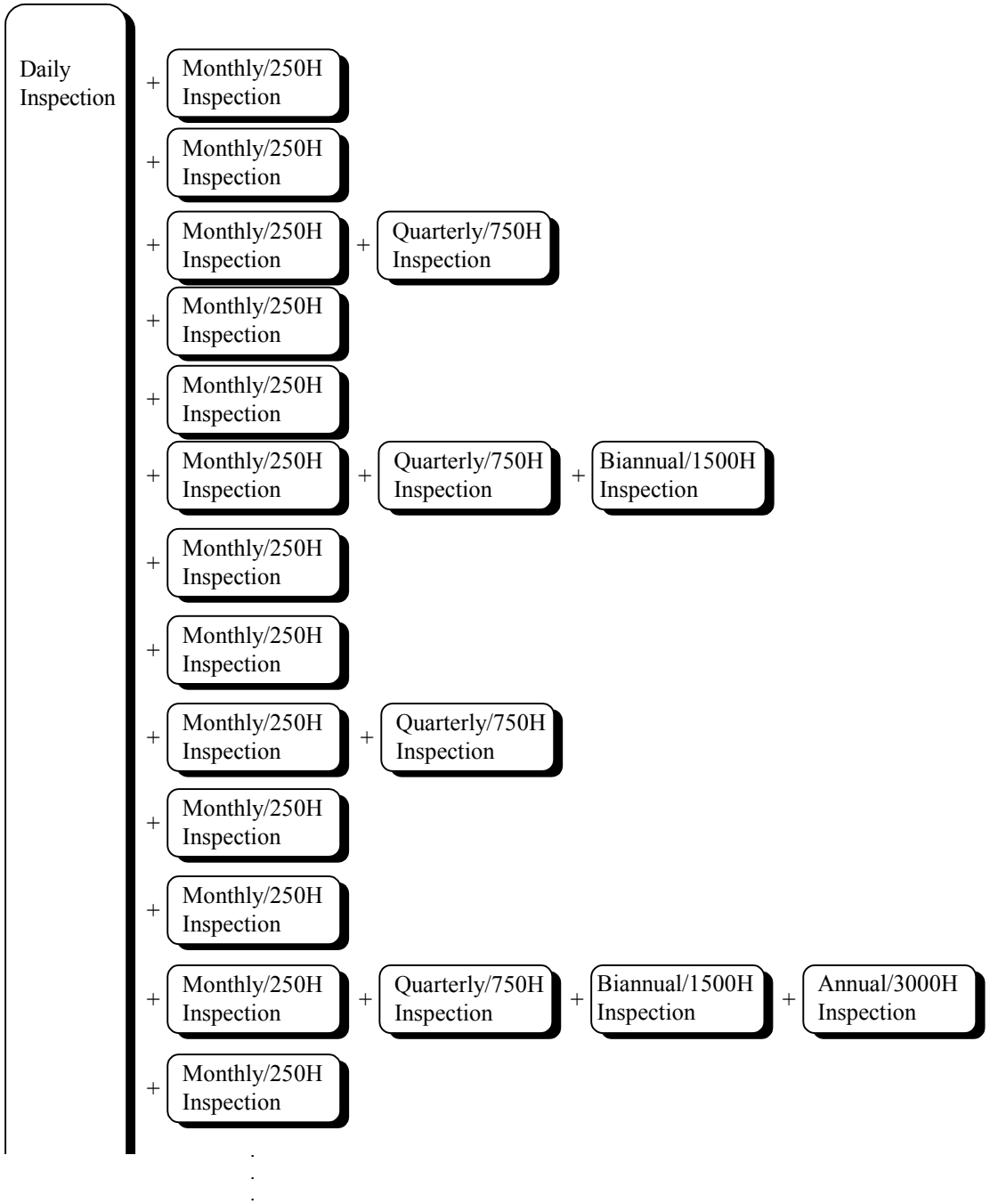
- Please make sure the cables are connected properly. Also, avoid putting heavy objects on the cables, bending the cables at extreme angles, or otherwise damaging the cables. If the cables are damaged, the robot may function abnormally in a dangerous manner.
- Do not remove any parts or units that have no removal procedures in this manual. Do not perform maintenance that is not specified in this manual.

1. General Maintenance

Proper inspection steps are essential to preventing trouble and maintaining safety. This section describes maintenance inspection schedule and procedures. Be sure to perform inspection and maintenance as described in this chapter.

1.1 Maintenance Inspection Schedule

Inspection procedures are divided into five stages: daily, monthly, quarterly, biannually, and annually. However, if the robot is operated for 250 hours or longer per month, the inspection schedule is different. In this case, each step of inspection should be added every 250 hours, 750 hours, 1500 hours, and 3000 hours operation.



1.2 Inspections

Inspection while the power is OFF (Be sure to turn OFF the power)

Inspection item	Point of inspection	Daily	Monthly	Quarterly	Biannual	Annual
Grease condition	Refer to the next page					
Check looseness of bolts/screws and tighten them if necessary. (Follow the torque values in the table on the next page to tighten them.)	End effector installing bolts	○	○	○	○	○
	Manipulator installing bolts	○	○	○	○	○
	Each arm locking bolts	○	○	○	○	○
	Bolts and screws around shaft					○
	Bolts and screws which secure motors, reduction gears etc.					○
Check looseness of connectors. If looseness is found, plug it in securely, or tighten.	External connectors on manipulator (on the base connector plate)	○	○	○	○	○
	Manipulator cable unit		○	○	○	○
Visually check for external defect. Clean if necessary.	External appearance of manipulator	○	○	○	○	○
	External cables		○	○	○	○
Check a bend or improper position. Repair or place it properly.	Safeguard etc.	○	○	○	○	○
Check tension of timing belts. Tighten it if necessary.	Inside Arm #2				○	○

Inspection while the power is ON, or while manipulator is moving

Inspection item	Point of inspection	Daily	Monthly	Quarterly	Biannual	Annual
Check motion range	Motion range of each joint					○
Check disconnection by swinging cables.	External cables (including cable unit)				○	○
Check backlash by pushing arms during MOTOR ON condition.	Each arm					○
Check if any malfunctions occur or not; such as strange sound and vibration during robot operation.	Whole	○	○	○	○	○
Measure repeatability by gauge.	Repeatability					○

1.3 Lubrication

For this manipulator, reduction gears and ball screw spline shaft are used.
These parts require lubrication or replacing grease periodically. If lubrication is not done properly, and the manipulator is operated with insufficient grease, sliding parts will be damaged and the efficiency of the manipulator will be reduced. Once these parts are damaged, a lot of time and money will be required for repairs.

Only use the grease types specified in the following table.

Position	Joint #1	Joint #2	Joint #3
Greasing part	Reduction gear unit (SHF20)	Reduction gear unit (SHF17)	Ball screw spline shaft
Greasing interval	When replacing motor *		First time: after 50 km operation 2nd or more: after 100 km operation
Grease type	SK-1A	SK-2	AFB grease
Refer to:	*6.Replacing the Reduction Gear Units.*		The section *Greasing the Ball Screw Spline Unit* of *9. Replacing the Ball Screw Spline Unit*. If the manipulator is a Clean model, refer to chapter *12. Clean Model Maintenance*.

* It is not necessary to change grease of the reduction gear periodically under normal condition, if the grease has been changed when replacing motor. However, in a case of severe working condition, (such as high duty, high speed, large loading, etc.) change grease every 10,000 hours.

1.4 Tightening Torque of Bolts

Hexagon socket head cap bolts are used where mechanical strength is required in the manipulator. At the time of the construction, these bolts are fastened at the tightening torques shown in the following table.
When additional tightening is necessary after inspection and when parts replacement is necessary, tighten the bolts with a torque wrench.

Bolts	Tightening torque
M3	245 N·cm (25 kgf·cm)
M4	490 N·cm (50 kgf·cm)
M5	980 N·cm (100 kgf·cm)
M6	1760 N·cm (180 kgf·cm)
M8	3720 N·cm (380 kgf·cm)
M10	7350 N·cm (750 kgf·cm)
M12	12740 N·cm(1300 kgf·cm)

1.5 Matching mechanical and electrical origins

After replacing motors or reduction gears, the mechanical origin position does not match the electrical origin position. Calibration is required to match these origin positions. Refer to *11. Calibration*.

You need to record pulse values for a specific position for calibration.
Before replacing parts, move the manipulator to the point which you can check precision easily, then execute PULSE/WHERE command and record the pulse values displayed.

RC+

```
>PULSE
PULSE  [J1 value] pls  [J2 value] pls [J3 value] pls [J4 value] pls
```

SPEL 95

Click the <DEBUG> button and input them to the [Command Execution] window as follows.

(Refer to the User's Guide for details of [Command Execution] window.)

```
>WHERE
```

`pulse` 1:[Joint #1 pulse value] 2:[Joint #2 pulse value] 3:[Joint #3 pulse value]

4:[Joint #4 pulse value]

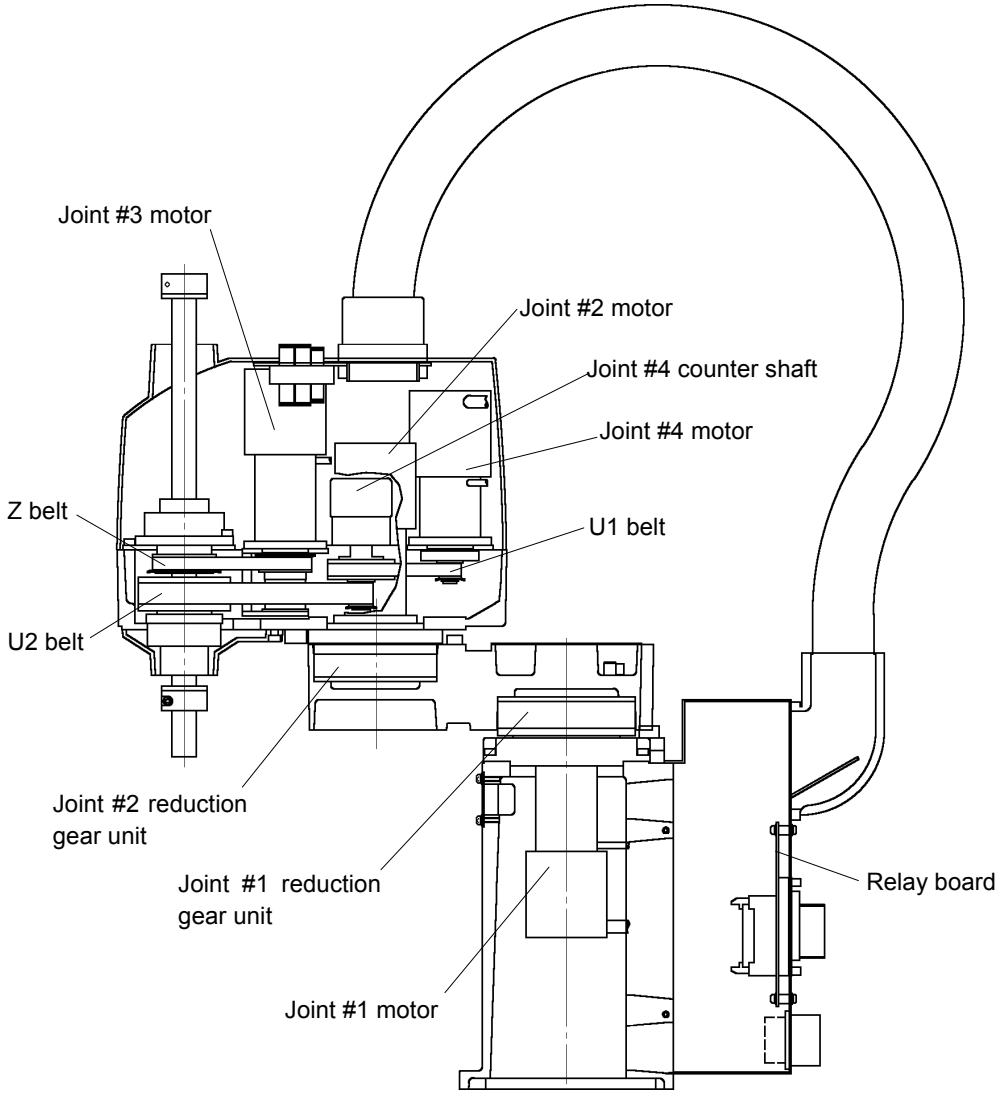
300

```
>PULSE
```

[Joint #1 pulse value] [Joint #2 pulse value]
[Joint #3 pulse value] [Joint #4 pulse value]

1.6 Internal Layout

The outline and name of internal configuration are shown below.

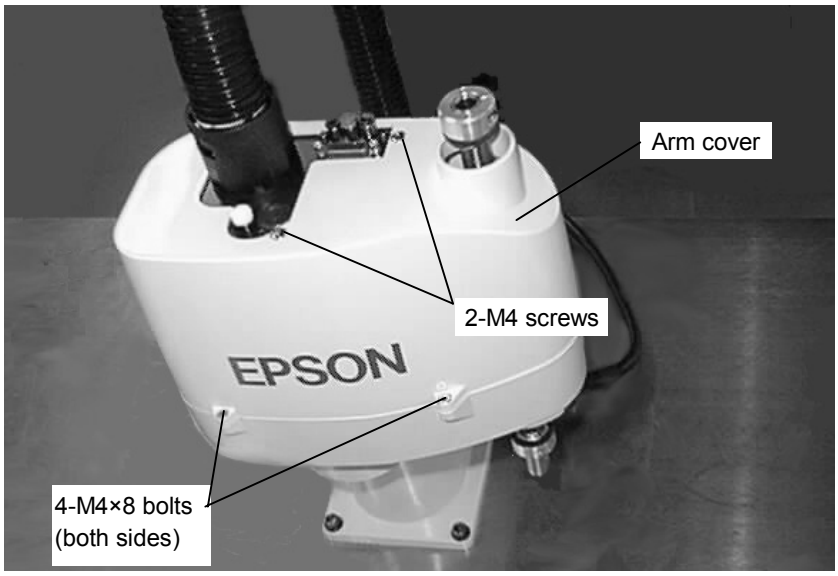


2. Opening the Covers

The methods for removing the various covers that are related to the maintenance of each part are explained here.

2.1 Arm Cover

The arm cover can be pulled upward after the four bolts (M4×8) and two M4 screws are removed.
It cannot be removed completely, because the cable unit is connected with the arm through the cover, but normal maintenance is possible.

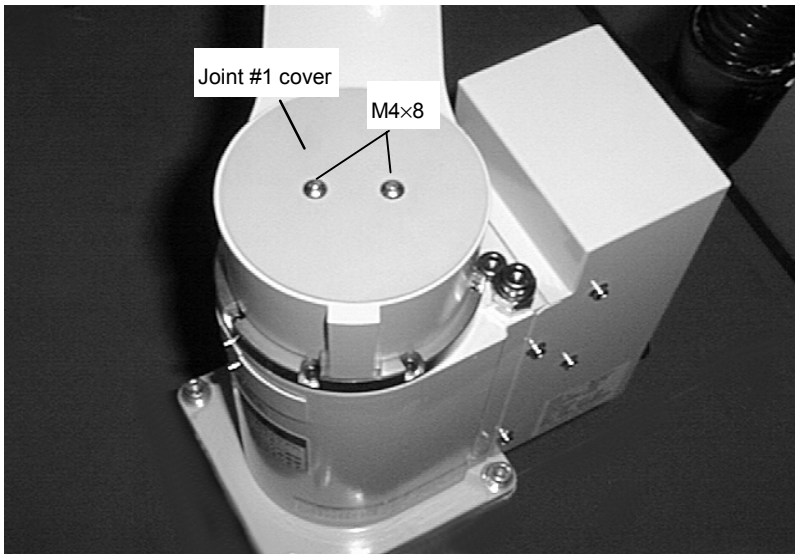


Be careful not to pinch cables when installing the cover. Do not bend these cables forcibly and push them into the cover. This can cause damage or disconnection.
Observe the cable locations during cover removal and wire the cables in their original locations during reassembly.

When you remove the arm cover completely, remove one end of the cable unit. (Refer to *3. Replacing the Cable Unit*.)

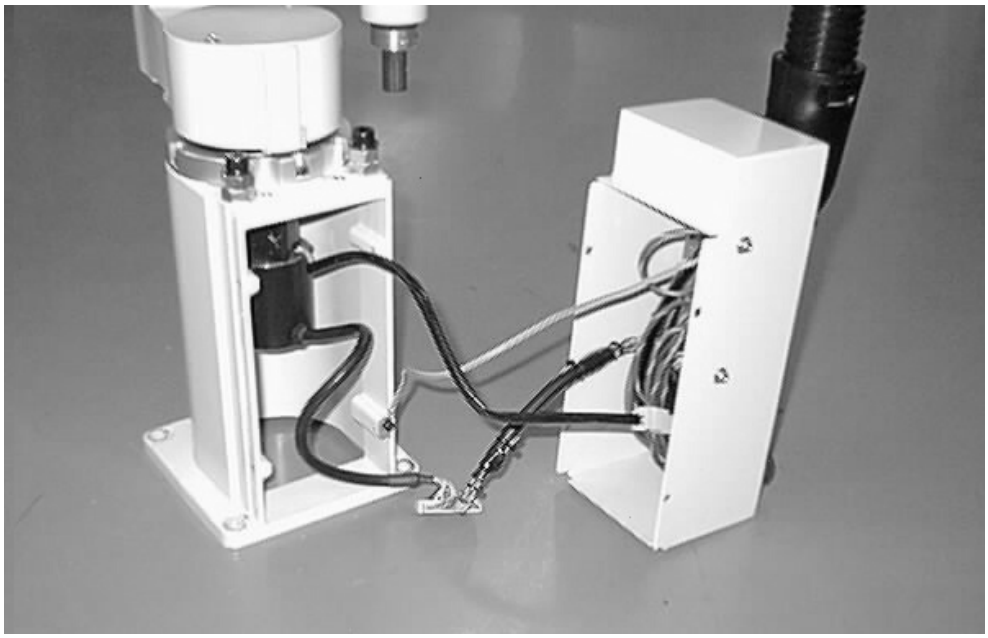
2.2 Joint #1 Cover

The Joint #1 cover can be removed after the two mounting bolts (M4×8) are removed.



2.3 Base Connector Box

The base connector box is fastened to the side of manipulator base with four bolts (M4×8). The base connector box is separated from the base when these bolts are removed. However, the base connector box is internally connected to connectors and ground wires. Be careful not to pull the base connector box forcibly.



3. Replacing the Cable Unit

⚠ WARNING

- When connecting or disconnecting the cables, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in a robot malfunction.
- When replacing the cable unit, remove the cable (the power cable, signal cable, and user's wiring and piping) connected to the manipulator before replacing the cable unit.

NOTE

As a preparation before turning OFF the power, keep the manipulator ON for more than 30 minutes. This is necessary to change so in order to charge the super-capacitor of each motor for retaining the position data.

The charged motor can retain the position data for about 2 hours when its cable is disconnected. (Motors whose serial number start with "0" can retain the data for about 2 days.)

When the power is supplied to each motor from the lithium battery on the signal relay board via signal connector, the position data of the motor will be retained after the main power is turned OFF. However, when the signal connector is removed, the position data will only be retained by the super-capacitor.

The position data cannot be retained beyond the time duration mentioned above after which it will be lost. If this happens, errors will occur when the power is turned ON.

RC+	: Error 5016
SPEL 95(SRC5**)	: Error 5016
SRC-3**	: Error 195

In this case, calibration is necessary.

When exchanging the cable unit, it is necessary to reconnect the connectors inside the arm upper cover and base. In doing so, refer to the wiring schematics in this chapter so that the connectors will be properly reconnected. Also, when reinstalling the replaced cables into the cover, carefully treat the cables, remembering how they were inside the cover before replacement, so that they will not be bent forcibly or pinched. If the cables are bent forcibly or pinched when reinstalling the cover, it may cause cable disconnection or such failures.

NOTE

For the details of each connector and its connection, refer to *4. Connector Pin Assignments*.

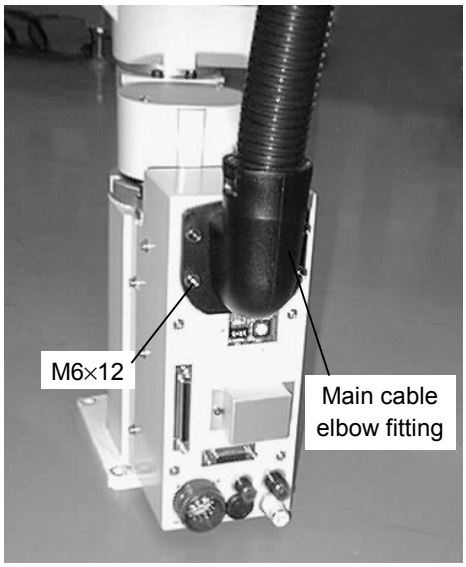
3.1 Cable Unit Replacement Procedure

Removal

(1) Turn OFF the PC Control Unit / Control Unit / Controller power.

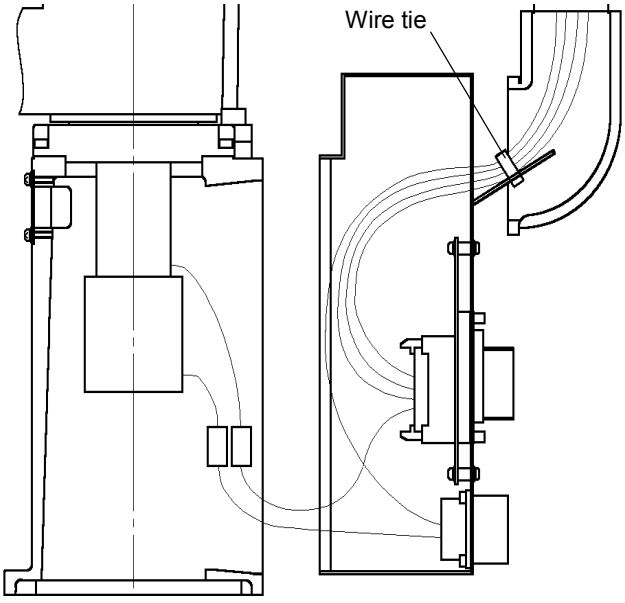
(2) Disconnect all the connectors and tubes from the base connector box located at the back of the manipulator.

(3) Remove the four mounting bolts (M6×12) from the main cable elbow fitting.

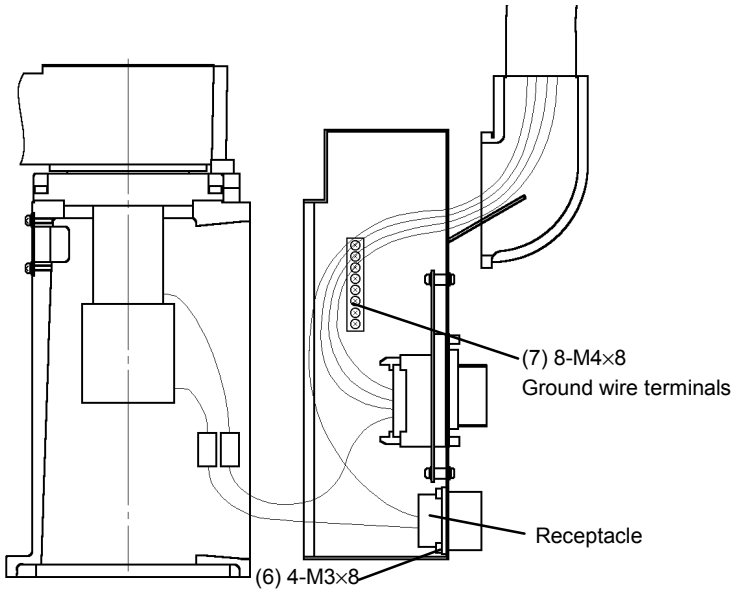


(4) Remove the mounting bolts from the base connector box. Pull the box forward (refer to *2. Opening the Covers*). Be careful not to pull the base connector box forcibly since the strain on the cables may cause wire disconnection. Also, close remember the approximate cable arrangement so that the cables can be reconnected similarly during replacement.

(5) Cut off the wire tie inside the main cable elbow fitting.



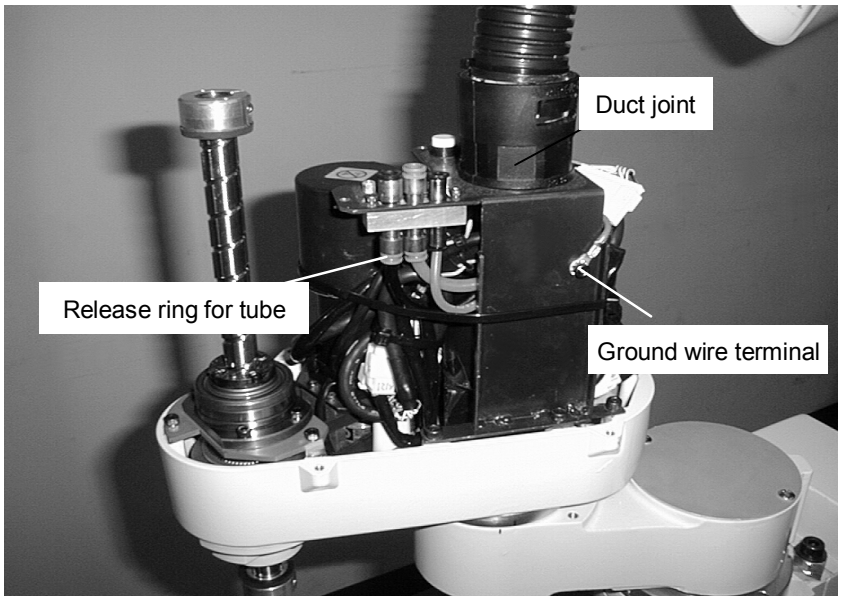
(6) Remove the base connector box from the receptacle. Remove the four mounting bolts (M3×8) from the receptacle and receptacle itself.



(7) Disconnect the ground wires and pneumatic tubes from the base connector box. Each pneumatic tube can be pulled out of its fitting by first pushing the fitting release ring. The ground wire terminals are fastened with bolts (8-M4×8).

(8) Open the arm cover (refer to *2. Opening the Covers*). Remember the approximate cable arrangement so that the cables can be reconnected similarly after the unit is replaced

(9) Using either a spanner (double side 51mm wide) or pair of pliers, loosen the duct joint.

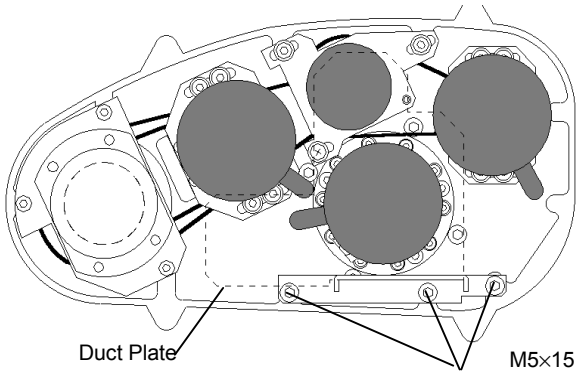


(10) Disconnect the ground wires and pneumatic tubes off the duct plate. To disconnect each pneumatic tube, pull it out by first pushing the fitting release ring. The ground wire terminals are secured by bolts (M4×8).

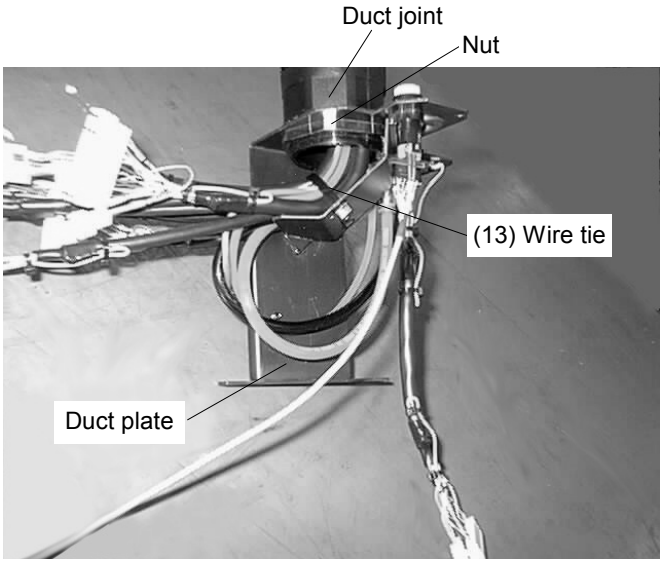
(11) Referring to the wiring schematics in this chapter, disconnect the connectors from the base and arm. To disconnect the power connector, pull it out while pushing the presser tongue next to the connector number on the motor side.

NOTE ☞ For manipulators whose serial number start with "1," their motors must be connected to the signal relay board of the new cable unit within 2 hours. Otherwise, the motor will lose position data and it will be necessary to calibrate again.

(12) Remove the duct plate from the arm (3-M4×8 bolts).



(13) Cut off the wire tie binding cables to the duct plate.



(14) Remove the joint from the nut. Pull the cables out of the duct plate and nut. The nut is prevented from rotating by the back of the duct plate.

(15) If there are any wire ties binding the cables, cut them off. Remove the cable unit.

Installation

(1) Pass the cables of the new cable unit through the duct plate and nut. Fasten the duct joint to the duct plate.

(2) Pass the cables through the base connector box and fasten the main cable elbow fitting using four bolts (M6×12).

(3) Referring to the wiring schematics in the following pages, then connect the connectors properly.

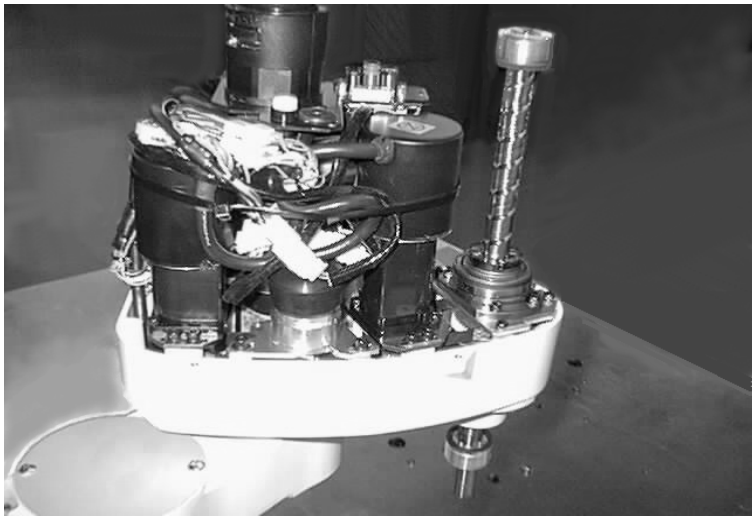
> **⚠ CAUTION**
>
> ■ Connect the signal cable securely. Do not put anything heavy on the signal cable or bend it too much. This may damage the signal cable and cause the robot to malfunction.

(4) Referring to the section *Wiring Schematic 1* in this chapter, connect the ground wires and pneumatic tubes properly.

(5) Mount the receptacle on the base connector box using four bolts (M4×8).

(6) Fasten the cables with wire ties as they were before the unit replacement. The following must be paid attention to when binding the cables with a wire tie:

- The cables must not touch the pulley, timing belt or other movable parts or areas.
- Do not pinch the cables when closing the cover.
- Do not unneccessary the cables. The cables must be arranged so that they will not be forcibly bent. Unnecessary strain on the cables may cause wire disconnection inside.
- The cables inside the duct must be long enough so that they will not be pulled during operation.



(7) Attach the duct plate to the arm using three bolts (M4×8).

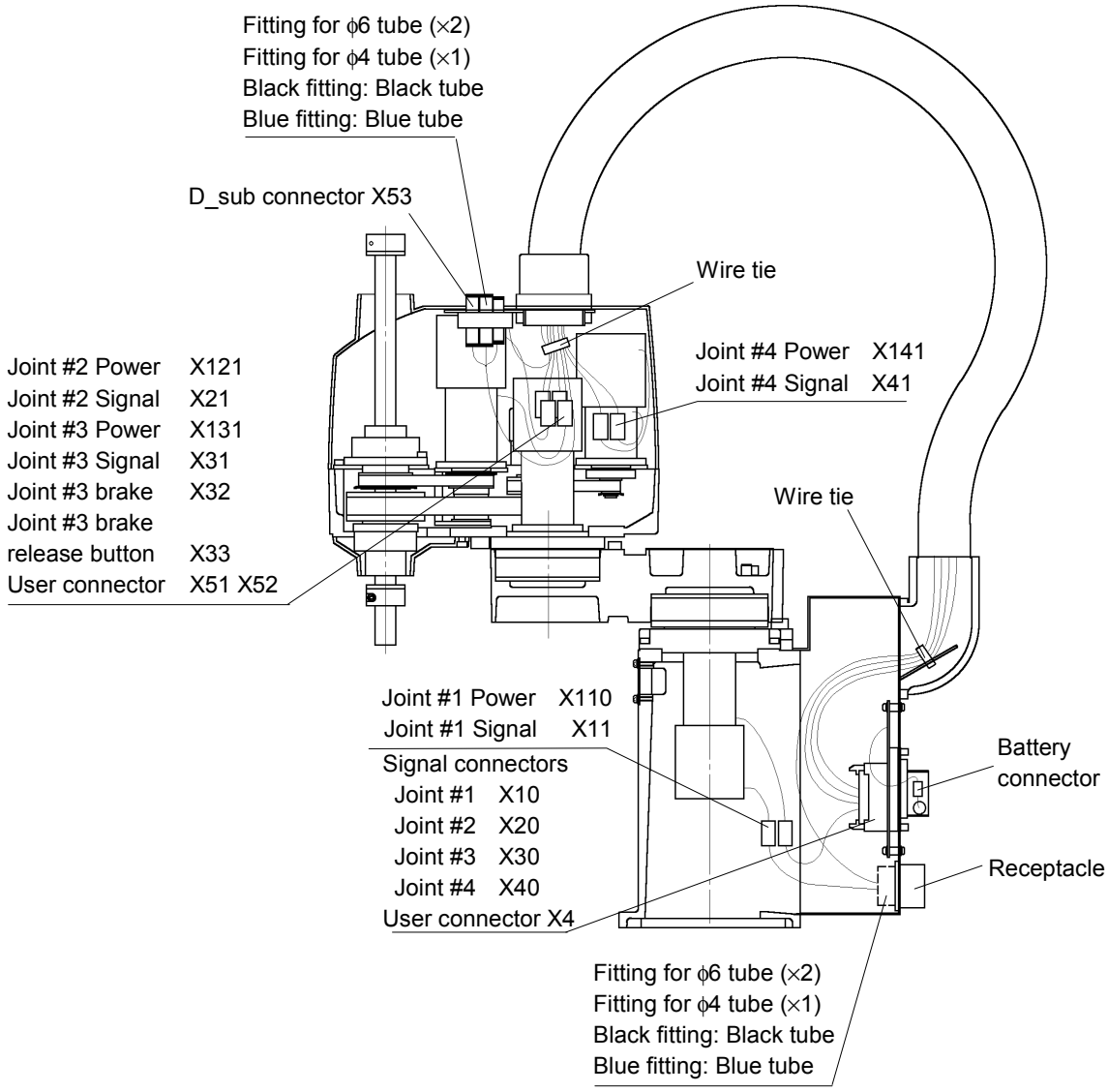
(8) Fasten the duct joint using a spanner (double side 51mm wide) or a pair of pliers.

(9) Place the base connector box back to where it was and fasten it.

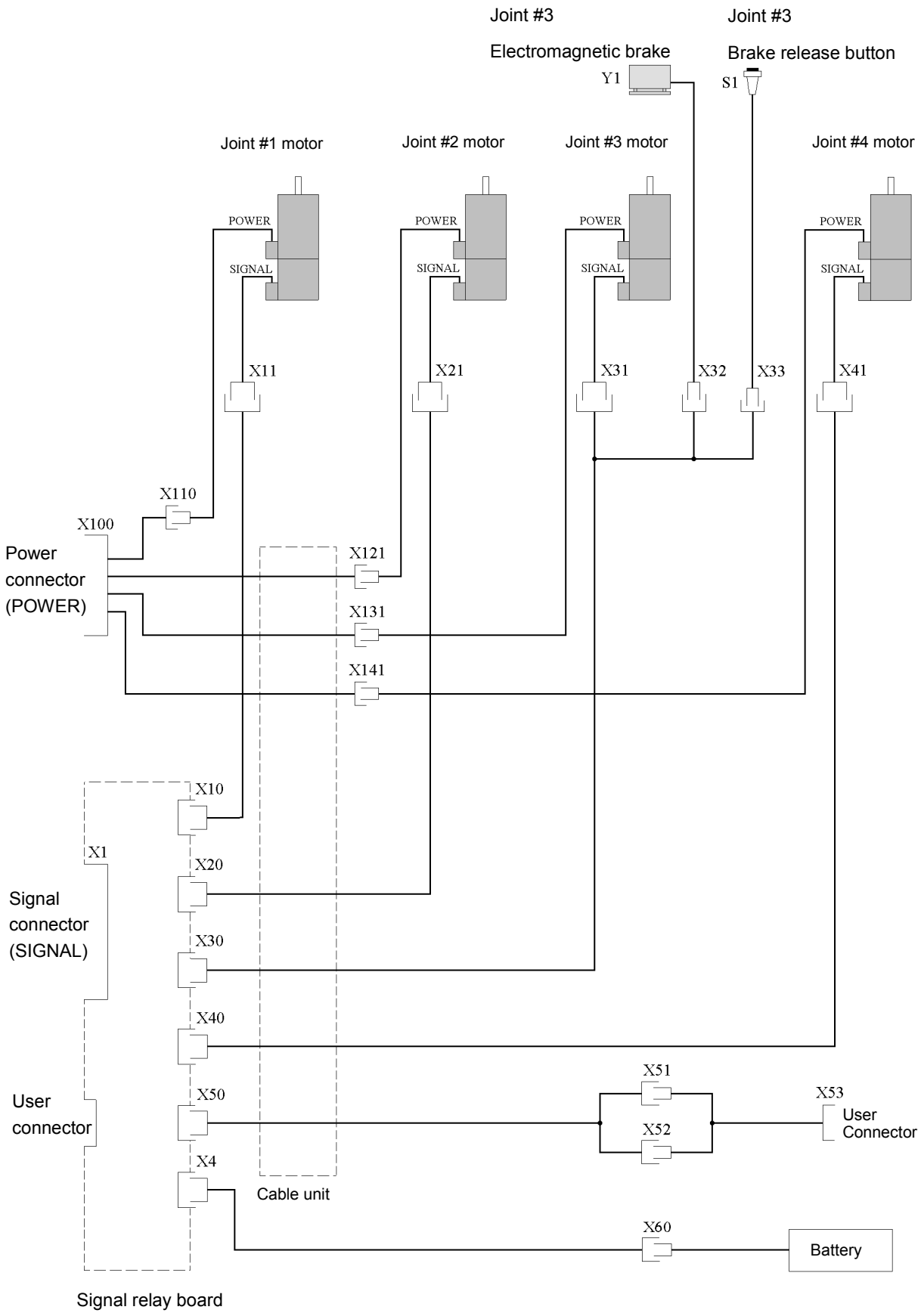
(10) Reinstall the arm cover to complete the reassembly.

3.2 Wiring Schematic 1

To remove the cable unit, remove the connectors in the arm cover and base connector box. These connectors are connected as shown in the figure below. For more information, refer to the next page and the wiring list in *4. Connector Pin Assignments*.



3.3 Wiring Schematic 2



4. Connector Pin Assignments

X10 Signal connector

No.		Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	1A	BLU/(WHT)	X11-1
2B	$1\overline{A}$	WHT/(BLU)	X11-2
3A	1B	YLW/(WHT)	X11-3
3B	$1\overline{B}$	WHT/(YLW)	X11-4
4A	1Z	GRN/(WHT)	X11-5
4B	$1\overline{Z}$	WHT/(GRN)	X11-6
5A	1S *	RED/(WHT)	X11-7
5B	$1\overline{S}$ *	WHT/(RED)	X11-8
6A	ENC+5V	PPL/(WHT)	X11-12
6B	EGND	WHT/(PPL)	X11-13
7A	BAT+	BLU/(BRN)	X11-9
7B	BAT-	BRN/(BLU)	X11-10
8A	RES	YLW/(BRN)	X11-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	N.C.		
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	N.C.		
12B	N.C.		
13A	N.C.		
13B	N.C.		

X11 Motor signal connector

No.		Line color	Connect to
1	$1\overline{A}$	BLU/(WHT)	Joint #1 motor encoder (SIGNAL)
2	1A	WHT/(BLU)	
3	$1\overline{B}$	YLW/(WHT)	
4	1B	WHT/(YLW)	
5	$1\overline{Z}$	GRN/(WHT)	
6	1Z	WHT/(GRN)	
7	$1\overline{S}$ *	RED/(WHT)	
8	1S *	WHT/(RED)	
9	BAT+	BLU/(BRN)	
10	BAT-	BRN/(BLU)	
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

* Motor for used on manipulators whose Serial number starts with “1” does not have S-channel signal.

X20 Signal connector

No.		Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	2A	BLU/(WHT)	X21-1
2B	$2\overline{A}$	WHT/(BLU)	X21-2
3A	2B	YLW/(WHT)	X21-3
3B	$2\overline{B}$	WHT/(YLW)	X21-4
4A	2Z	GRN/(WHT)	X21-5
4B	$2\overline{Z}$	WHT/(GRN)	X21-6
5A	2S *	RED/(WHT)	X21-7
5B	$2\overline{S}$ *	WHT/(RED)	X21-8
6A	ENC+5V	PPL/(WHT)	X21-12
6B	EGND	WHT/(PPL)	X21-13
7A	BAT+	BLU/(BRN)	X21-9
7B	BAT-	BRN/(BLU)	X21-10
8A	RES	YLW/(BRN)	X21-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	N.C.		
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	N.C.		
12B	N.C.		
13A	N.C.		
13B	N.C.		

X21 Motor signal connector

No.		Line color	Connect to
1	2A	BLU/(WHT)	Joint #2 motor encoder (SIGNAL)
2	$2\overline{A}$	WHT/(BLU)	
3	2B	YLW/(WHT)	
4	$2\overline{B}$	WHT/(YLW)	
5	2Z	GRN/(WHT)	
6	$2\overline{Z}$	WHT/(GRN)	
7	2S *	RED/(WHT)	
8	$2\overline{S}$ *	WHT/(RED)	
9	BAT+	BLU/(BRN)	
10	BAT-	BRN/(BLU)	
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

* Motor for the manipulators whose Serial number starts with “1” does not have S-channel signal.

X30 Signal connector

No.		Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	3A	BLU/(WHT)	X31-1
2B	3$\overline{A}$	WHT/(BLU)	X31-2
3A	3B	YLW/(WHT)	X31-3
3B	3$\overline{B}$	WHT/(YLW)	X31-4
4A	3Z	GRN/(WHT)	X31-5
4B	3$\overline{Z}$	WHT/(GRN)	X31-6
5A	3S *	RED/(WHT)	X31-7
5B	3$\overline{S}$ *	WHT/(RED)	X31-8
6A	ENC+5V	PPL/(WHT)	X31-12
6B	EGND	WHT/(PPL)	X31-13
7A	BAT+	BLU/(BRN)	X31-9
7B	BAT-	BRN/(BLU)	X31-10
8A	RES	YLW/(BRN)	X31-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	BRK.SW	BRN/(YLW)	X33-2
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	$\overline{EMB2}$	GRN/(BRN)	X31-2
12B	+24V	BRN/(GRN)	X32-2
13A	N.C.		
13B	N.C.		

X31 Motor signal connector

No.		Line color	Connect to
1	3A	BLU/(WHT)	Joint #3 motor encoder (SIGNAL)
2	3$\overline{A}$	WHT/(BLU)	
3	3B	YLW/(WHT)	
4	3$\overline{B}$	WHT/(YLW)	
5	3Z	GRN/(WHT)	
6	3$\overline{Z}$	WHT/(GRN)	
7	3S *	RED/(WHT)	
8	3$\overline{S}$ *	WHT/(RED)	
9	BAT+	BLU/(BRN)	
10	BAT-	BRN/(BLU)	
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

X32 brake connector

No.		Line color	Connect to
1	$\overline{EMB2}$	GRN/(BRN)	Joint #3 brake (Y1)
2	+24V	BRN/(GRN)	

X33 brake SW connector

No.		Line color	Connect to
1	$\overline{EMB2}$	GRN	Joint #3 brake release button (S1)
2	BRK.SW	BRN/(YLW)	

* Motor for the manipulators whose Serial number starts with “1” does not have S-channel signal.

X40 Signal connector

No.		Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	4A	BLU/(WHT)	X41-1
2B	$4\overline{A}$	WHT/(BLU)	X41-2
3A	4B	YLW/(WHT)	X41-3
3B	$4\overline{B}$	WHT/(YLW)	X41-4
4A	4Z	GRN/(WHT)	X41-5
4B	$4\overline{Z}$	WHT/(GRN)	X41-6
5A	4S *	RED/(WHT)	X41-7
5B	$4\overline{S}$ *	WHT/(RED)	X41-8
6A	ENC+5V	PPL/(WHT)	X41-12
6B	EGND	WHT/(PPL)	X41-13
7A	BAT+	BLU/(BRN)	X41-9
7B	BAT-	BRN/(BLU)	X41-10
8A	RES	YLW/(BRN)	X41-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	N.C.		
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	N.C.		
12B	N.C.		
13A	N.C.		
13B	N.C.		

X41 Motor signal connector

No.		Line color	Connect to
1	4A	BLU/(WHT)	Joint #4 motor encoder (SIGNAL)
2	$4\overline{A}$	WHT/(BLU)	
3	4B	YLW/(WHT)	
4	$4\overline{B}$	WHT/(YLW)	
5	4Z	GRN/(WHT)	
6	$4\overline{Z}$	WHT/(GRN)	
7	4S *	RED/(WHT)	
8	$4\overline{S}$ *	WHT/(RED)	
9	BAT+	BLU/(BRN)	
10	BAT-	BRN/(BLU)	
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

* Motor for the manipulators whose Serial number starts with “1” does not have S-channel signal.

X50 Signal connector

No.		Line color	Connect to
1A		BLU/(WHT)	X51-1
1B		WHT/(BLU)	X51-2
2A		YLW/(WHT)	X51-3
2B		WHT/(YLW)	X51-4
3A		GRN/(WHT)	X51-5
3B		WHT/(GRN)	X51-6
4A		RED/(WHT)	X51-7
4B		WHT/(RED)	X51-8
5A		PPL/(WHT)	X51-9
5B		WHT/(PPL)	X51-10
6A		BLU/(BRN)	X52-1
6B		BRN/(BLU)	X52-2
7A		YLW/(BRN)	X52-3
7B		BRN/(YLW)	X52-4
8A		GRN/(BRN)	X52-5
8B		GRN	shield

X51 Signal connector

No.		Line color	Connect to
1		BLU/(WHT)	X53-1
2		WHT/(BLU)	X53-2
3		YLW/(WHT)	X53-3
4		WHT/(YLW)	X53-4
5		GRN/(WHT)	X53-5
6		WHT/(GRN)	X53-6
7		RED/(WHT)	X53-7
8		WHT/(RED)	X53-8
9		PPL/(WHT)	X53-9
10		WHT/(PPL)	X53-10

X52 Signal connector

No.		Line color	Connect to
1		BLU/(BRN)	X53-11
2		BRN/(BLU)	X53-12
3		YLW/(BRN)	X53-13
4		BRN/(YLW)	X53-14
5		GRN/(BRN)	X53-15
6		GRN	shield

X60 Battery connector

No.		Line color	Connect to
1		ORANGE	X60 battery (RED)
2		WHITE	X60 battery (BRK)

X4 connector

No.		Line color	Connect to
1		ORANGE	X60-1
2		WHITE	X60-2

X100 Receptacle

No.		Line color	Connect to
1	1U	BLK	X110-1
3	1V	WHT	X110-2
6	1W	RED	X110-3
10	2U	BLK	X121-1
14	2V	WHT	X121-2
16	2W	RED	X121-3
15	3U	BLK	X131-1
13	3V	WHT	X131-2
9	3W	RED	X131-3
4	4U	BLK	X141-1
2	4V	WHT	X141-2
7	4W	RED	X141-3
5	FGND	GRN	
17	FGND	GRN/YLW	
8	N.C.		
12	N.C.		
11	N.C.		

X110 Motor power connector

No.		Line color	Connect to
1	1U	BLK	Joint #1 motor (POWER)
2	1V	WHT	
3	1W	RED	
4	FGND	GRN/YLW	

X121 Motor power connector

No.		Line color	Connect to
1	2U	BLK	Joint #2 motor (POWER)
2	2V	WHT	
3	2W	RED	
4	FGND	GRN/YLW	

X131 Motor power connector

No.		Line color	Connect to
1	3U	BLK	Joint #3 motor (POWER)
2	3V	WHT	
3	3W	RED	
4	FGND	GRN/YLW	

X141 Motor power connector

No.		Line color	Connect to
1	4U	BLK	Joint #4 motor (POWER)
2	4V	WHT	
3	4W	RED	
4	FGND	GRN/YLW	

5. Replacing the Motors

WARNING

- Only trained personnel should be allowed to maintain this unit.
- When replacing the motors, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock or malfunction.

CAUTION

- Be careful not to apply an excessive shock to the motor shaft when replacing a motor. This may shorten the life of the motor and encoder. This also may destroy them.
- Never disassemble the motor and encoder. If you do, a position shift will occur. The motor and encoder cannot be used again in this case.

NOTE

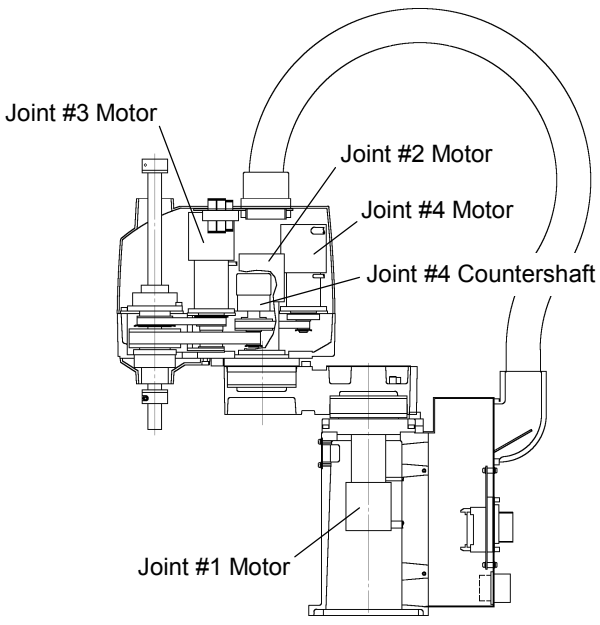
The origin position changes when the motor is replaced. As a result, the previous teach points will change. After motor replacement, adjust the origin point as described in chapter *11. Calibration*.

Motor Types

Specify the Z code when ordering a replacement motor.

Description	Series	Joint	Specification	Serial number	Old code	New code
AC servo motor	EC	#1	100W-ABS	0****	ZA000622	R13ZA00062200
				1****	ZA000627	R13ZA00062700
		#2, 3	100W-ABS	0****	ZA000613	R13ZA00061300
				1****	ZA000624	R13ZA00062400
		#4	50W-ABS	0****	ZA000612	R13ZA00061200
				1****	ZA000623	R13ZA00062300

Motor Locations

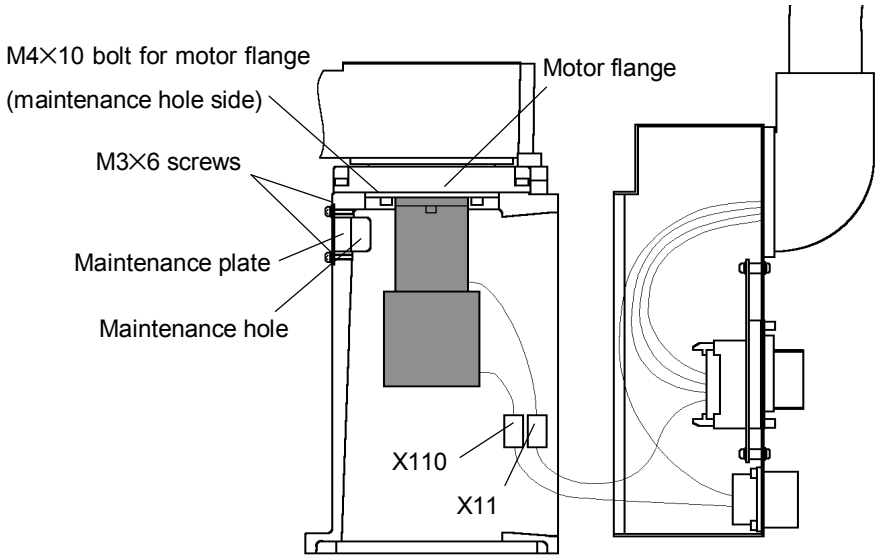


5.1 Replacing the Joint #1 Motor

Removal : Joint #1

(1) Open the base connector box. (Refer to *2. Opening the Covers*.)

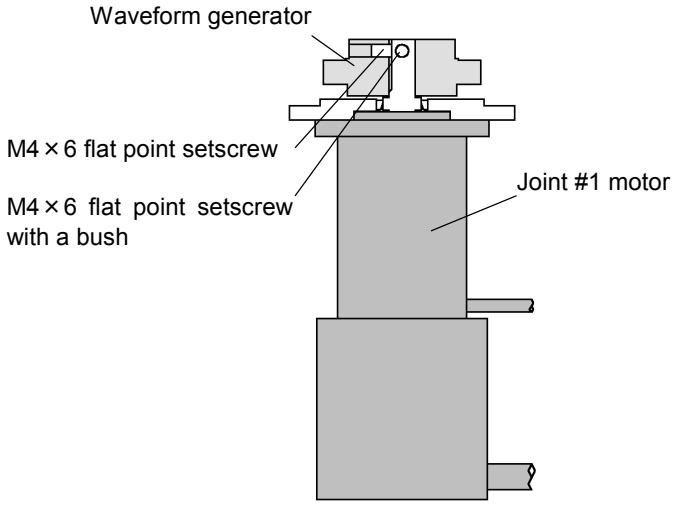
(2) Remove the maintenance plate and open the maintenance hole (2-M3×6 screws).



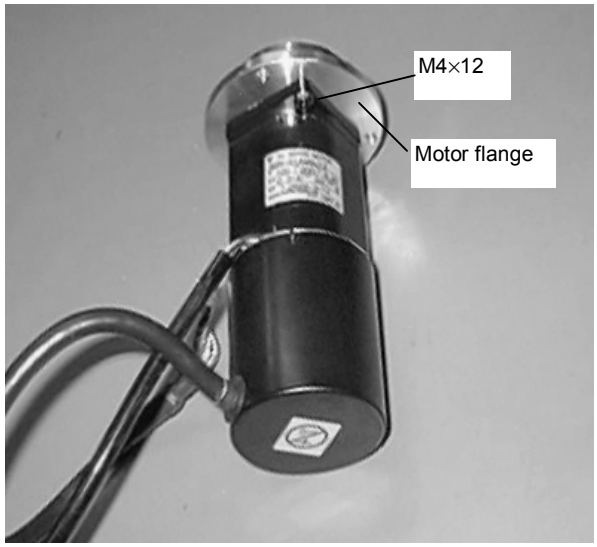
(3) Disconnect the connectors (X110 and X11). To disconnect X110, pull it out while pushing the presser tongue next to the connector number on the motor side.

(4) Remove the three motor mounting bolts (M4×10) and pull the motor downward. Insert a hexagon head wrench through the maintenance hole and remove the bolt at the maintenance hole side. If it is difficult to extract the motor, try it while moving Arm #1 slightly.

(5) Using a hexagon head wrench in the screw holes of the waveform generator, remove the two flat point setscrews (M4×6). Remove the waveform generator from the motor. One of the setscrews has a brass bush which must not be lost.



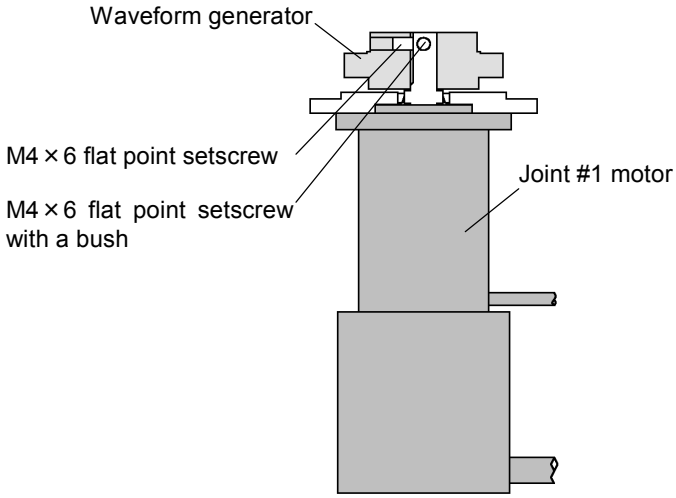
(6) Remove the two bolts (M4×12) from the motor and remove the motor flange.



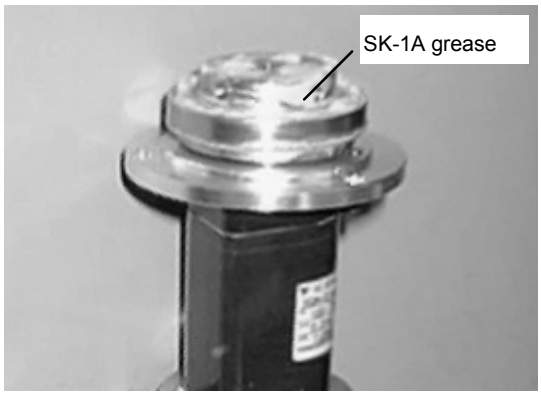
Installation : Joint #1

(1) Attach a new Joint #1 motor to the motor flange so that the motor cable turns to the direction of the figure and secure it with two bolts (M4×12).

(2) Mount the waveform generator to the motor shaft. Match the end face of the waveform generator to the end face of the motor shaft. There are two flat point setscrews (M4×6). One of the setscrew should touch the flat side of the motor shaft perpendicularly. Insert a bush in the other setscrew hole and fasten it carefully not to scratch the motor shaft.



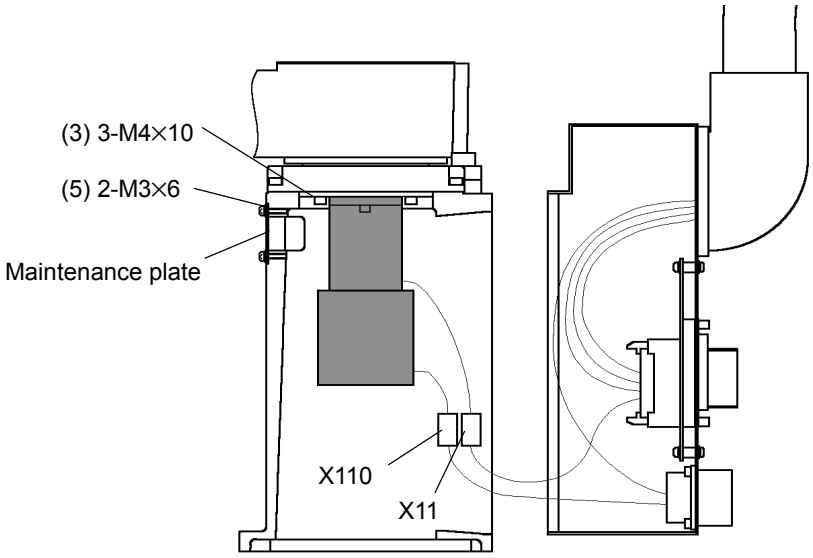
NOTE When the waveform generator of Joint #1 needs to be greased, please make sure to use SK-1A, a grease specifically for the Joint #1 reduction gear.



(3) Install the motor flange in the manipulator base with three bolts (M4×10) so that the motor cable faces the base connector box. If the wave form generator does not fit into the arm easily. If this is the case, move Arm #1 slowly by hand while pushing the waveform generator into place. It should slip in easily. Insert a hexagon head wrench from maintenance hole and tighten the bolt at maintenance hole side.

(4) Connect the connectors, X110 and X11.

(5) Install the maintenance plate with two M3×6 screws.



(6) Install the base connector box. (Refer to chapter *2. Opening the Covers*.)

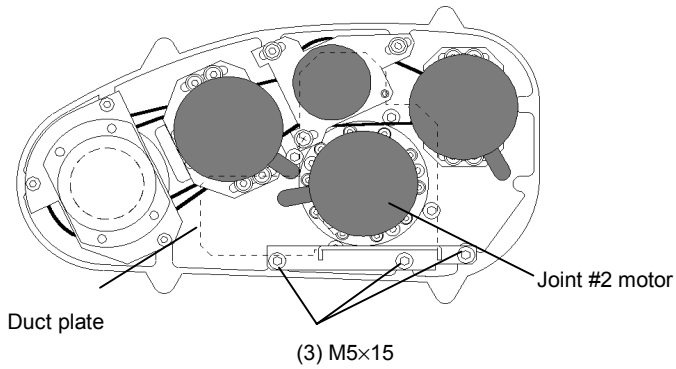
(7) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #1. Refer to chapter *11. Calibration*.

5.2 Replacing the Joint #2 Motor

Removal : Joint #2

(1) Open the arm cover. (Refer to chapter *2. Opening the Covers*.)

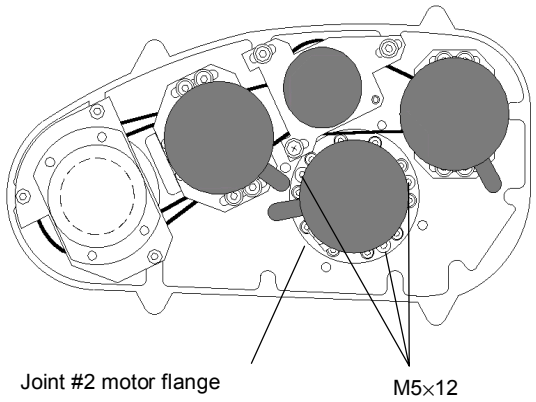
(2) Cut off the wire tie which holds the Joint #2 motor cables.



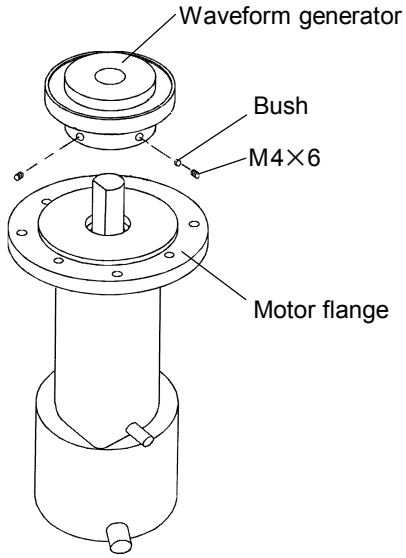
(3) Remove the mounting bolts (3-M5×15) from the duct plate.

(4) Disconnect the connectors, X121 and X21. To disconnect X121, pull it out while pushing the presser tongue next to the connector number on the motor side.

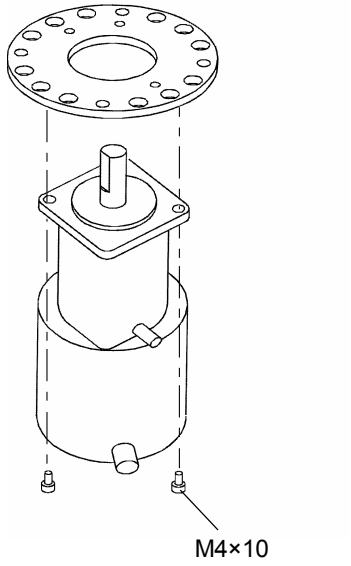
(5) Remove the three mounting bolts (M5×12) from the motor flange and pull the motor unit upward. If it is difficult to extract the motor, try it while moving Arm #2 slightly. In this case, the waveform generator attached to the motor shaft is also extracted simultaneously.



(6) Using a hexagon head wrench in the screw holes of the waveform generator, remove the two flat point setscrews (M4×6). Remove the waveform generator from the motor. One of the setscrew holes has a brass bush inside which must not be lost.

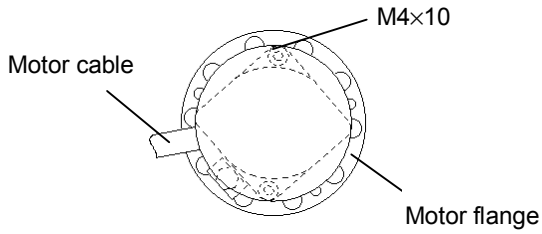


(7) Remove the bolts (2-M4×10) from the motor and remove the motor flange.

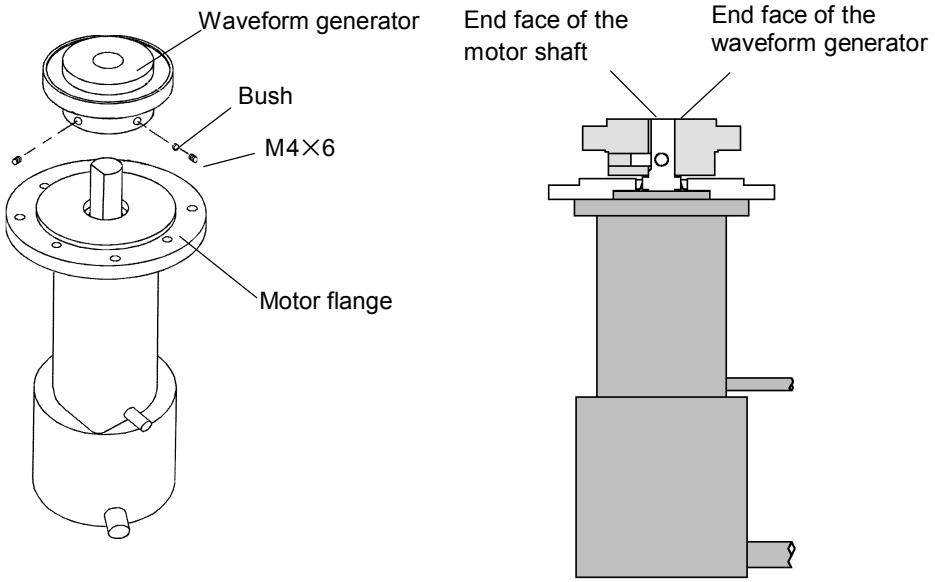


Installation : Joint #2

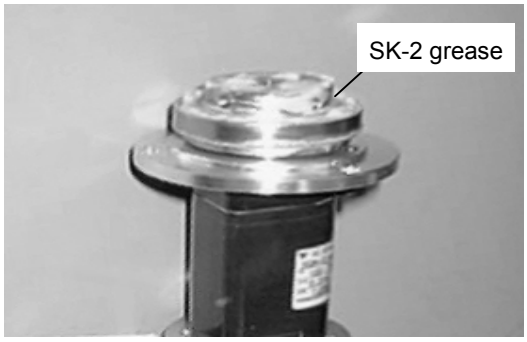
(1) Attach a new Joint #2 motor to the motor flange so that the motor cable turns to the direction of the figure and secure it with two bolts (M4×10).



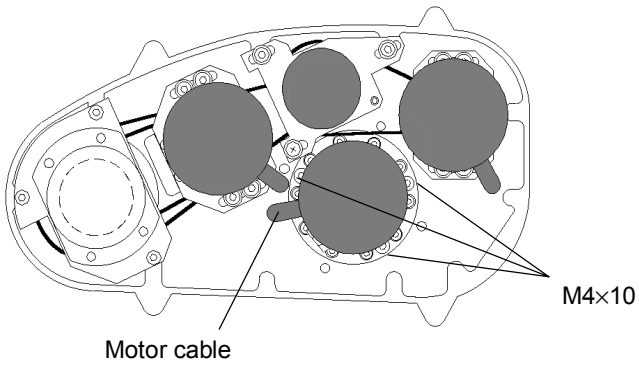
(2) Mount the waveform generator to the motor shaft. Match the end face of the waveform generator to the end face of the motor shaft. There are two flat point setscrews (M4×6). One of the setscrews should touch the flat side of the motor shaft perpendicularly. Insert a bush in the other setscrew holes and tighten the screw. Do not over tighten to avoid damage to the motor shaft.



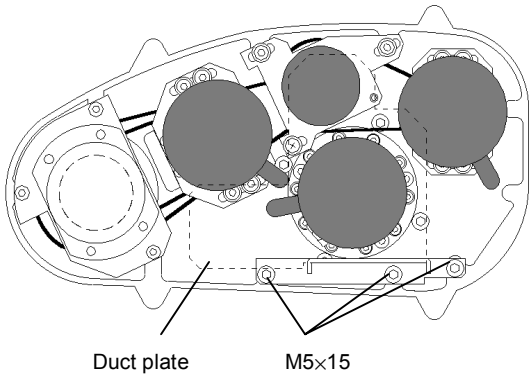
NOTE ☞ When the waveform generator of Joint #2 needs to be greased, please make sure to use SK-2, a grease specifically for the Joint #2 reduction gear.



(3) Fasten the Joint #2 motor unit in Arm #2 with the three bolts (M4×10). The waveform generator does not fit into the arm easily. If this is the case, move Arm #2 slowly by hand while pushing the waveform generator into place. It should slip in easily.

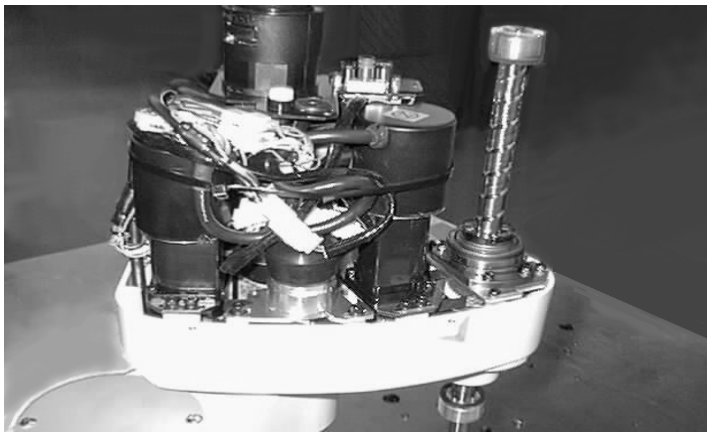


(4) Install the duct plate (3-M5×15).



(5) Connect the connectors, X121 and X21.

(6) Fasten the cables with wire ties as before. Do not allow unnecessary strain on the cables.



(7) Install the arm cover. (Refer to chapter *2. Opening the Covers*).

(8) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #2. Refer to chapter *11. Calibration*.

5.3 Replacing the Joint #3 Motor

⚠ CAUTION

■ A brake is provided for the Joint #3 motor.
If the motor is replaced, it is necessary to adjust the brake, but be careful not to stretch the board spring of the brake. When removing the rotor hub from the body of the brake, don't pull in the joint direction. Always remove it from the side.

NOTE

A brake is provided for the Joint #3 motor to prevent the end effector from moving down due to its own weight when the power is turned OFF or the motor is turned OFF. This brake will not work while the Joint #3 motor is being replaced. Therefore, lower Joint #3 to its lower limit in advance. Joint #3 operates while the Joint #3 brake release button is being pushed with the power turned ON (See Figure 11 in the chapter *End Effectors* in Part 1.) Lower Joint #3, taking care that the end effector does not strike against peripheral equipment. Turn OFF the power before replacing the Joint #3 motor.

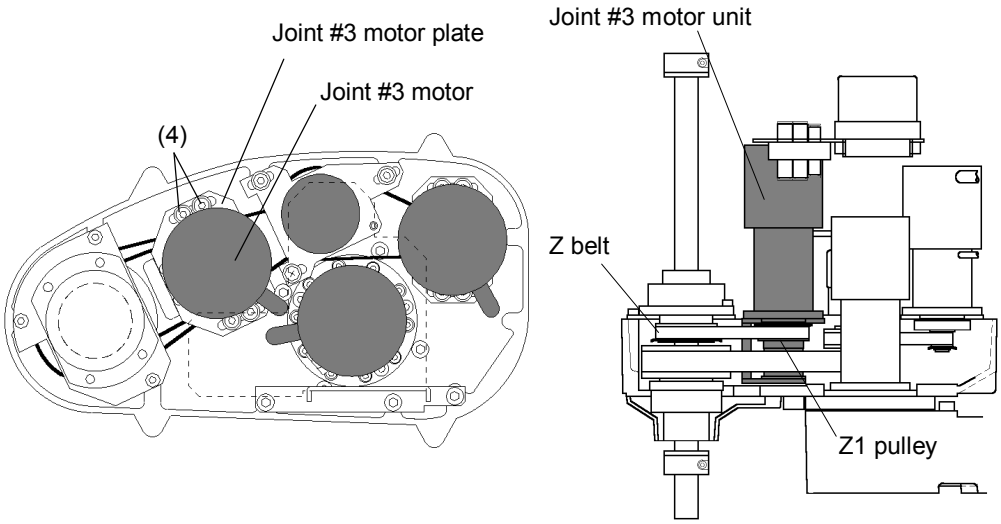
Removal : Joint #3

(1) Open the arm cover. (Refer to chapter *2. Opening the Covers*.)

(2) Cut off the wire tie, which fastens the Joint #3 motor and cables.

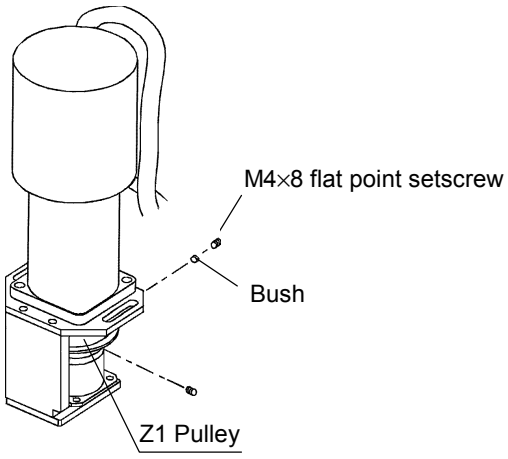
(3) Disconnect the connectors, X131, X31, and X32. To disconnect X131, pull it out while pushing the presser tongue next to the connector number on the motor side.

(4) Remove the four bolts (M4×12) from the motor plate and remove the Z1 pulley from the Z belt. Pull the Joint #3 motor unit upward.

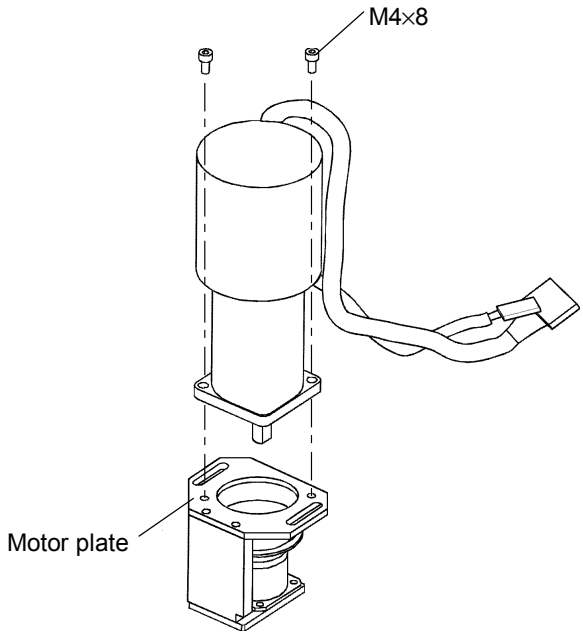


(5) Cut off the wire tie which fastens the brake cable to the motor.

(6) Using a hexagon head wrench in the screw holes of the pulley, remove the two flat point setscrews (M4×8) that secure the Z1 pulley to the motor shaft. One of the setscrews has a brass bush inside which must not be lost.

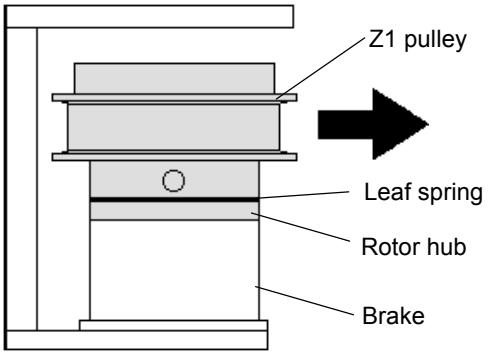


(7) Remove the two bolts (M4×8) from the motor and pull the motor upward.

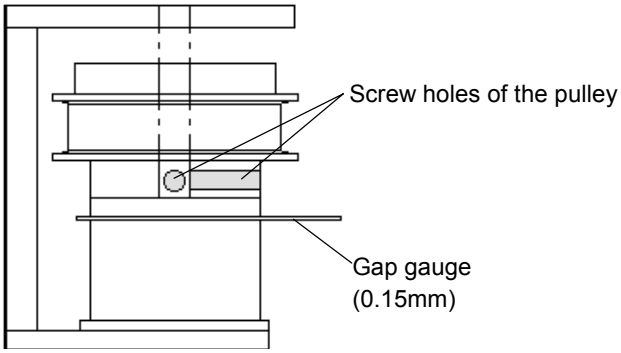


Installation : Joint #3

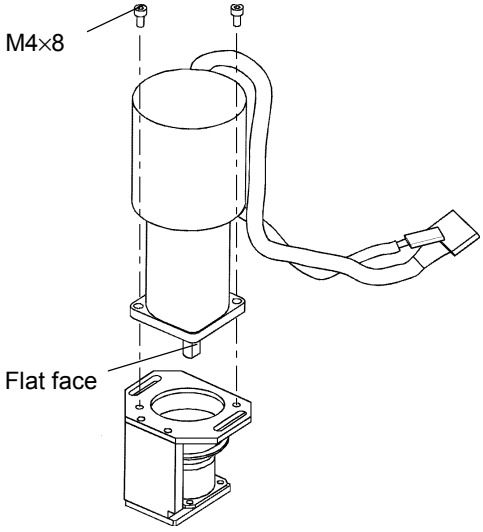
(1) Slide the pulley and rotor hub horizontally to remove them from the brake so as not to cause damage to the leaf spring. The rotor hub, which is screwed on the pulley, is attracted to the brake magnet. If you force it to separate, the leaf spring will stretch.



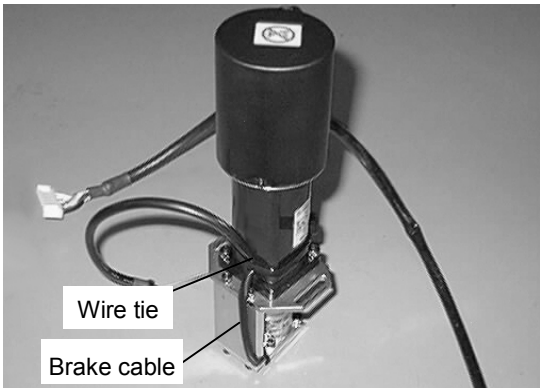
(2) Insert the gap gauge (0.15 mm) (which is mounted in the arm cover between the brake and rotor hub), and set the pulley on the brake. At this time, the screw holes of the pulley are in the position shown in the figure below.



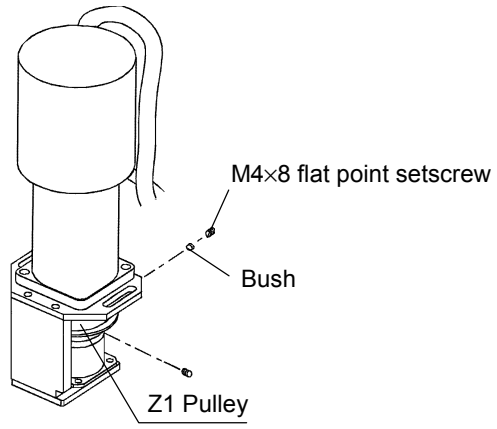
(3) Place the new Joint #3 motor on the motor plate so that the motor cables turn to the direction of the figure and fasten it with two bolts (M4×8). The direction of the motor shaft flat face should face one of the screw holes of the pulley.



(4) Secure the brake cables to the motor with a wire tie to prevent interference with the pulley.

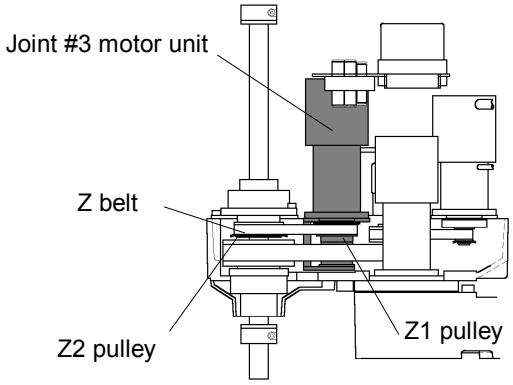


(5) Secure the pulley to the motor shaft with two flat point setscrews (M4×8). One of them should touch the flat face of the motor shaft perpendicularly. Insert a bush on the other setscrew hole, them insert the setscrew and tighten it carefully to avoid damage to the motor shaft.

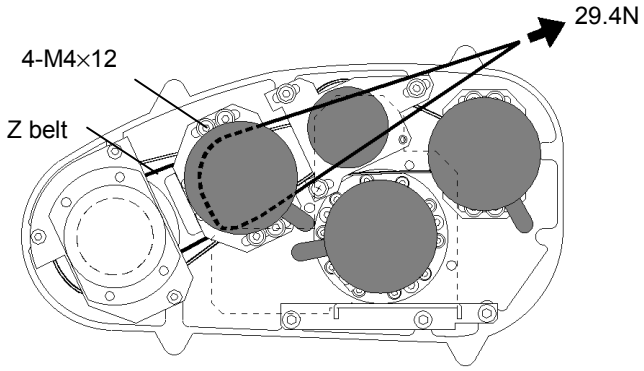


(6) After the pulley is secured, pull out the gap gauge.

(7) Put the Joint #3 motor unit in the arm and place the Z belt around the Z1 and Z2 pulleys. Ensure that the gear grooves of the belt and pulleys engage properly. Be careful not to slip off the Z belt from the pulleys when maintaining proper interval between the pulleys. Fasten the Joint #3 motor plate for the time being using four bolts (M4×10).

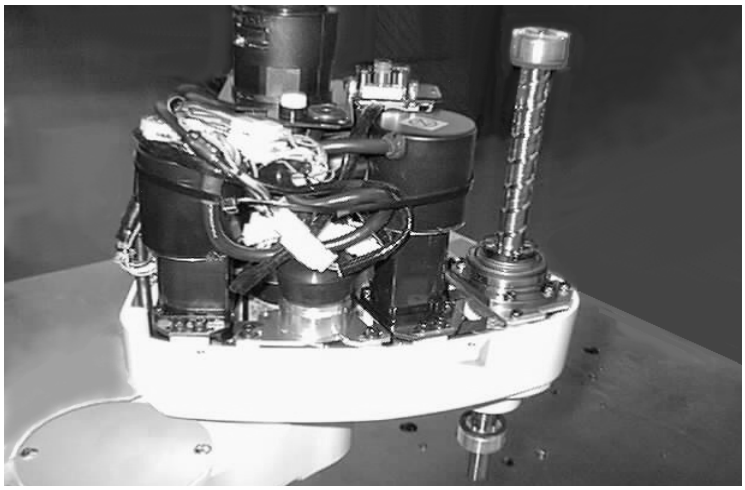


(8) Pass a suitable cord or string around the Joint #3 motor near its mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (7) and pull the cord using a force gauge or similar tool. Fasten the Joint #3 motor plate securely where the Z belt is pulled at 29.4N (3kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(9) Connect the connectors, X131, X31 and X32.

(10) Fasten the cables with wire ties again. Do not allow unnecessary strain on the cables.



(11) Install the arm cover (Refer to chapter *2. Opening the Covers*).

(12) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #3. Refer to chapter *11. Calibration*.

5.4 Replacing the Joint #4 Motor

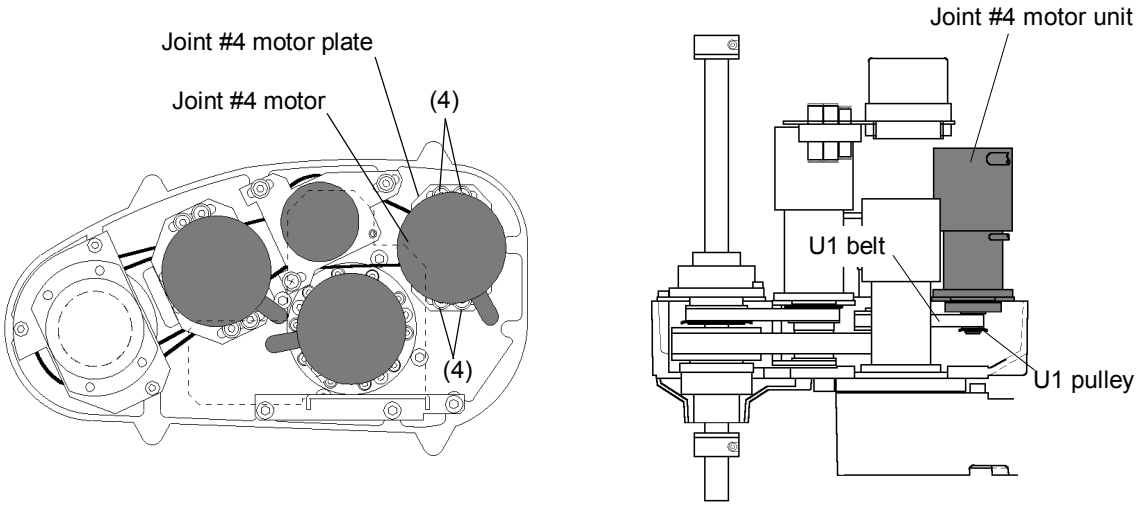
Removal : Joint #4

(1) Open the arm cover. (Refer to chapter *2. Opening the Covers*.)

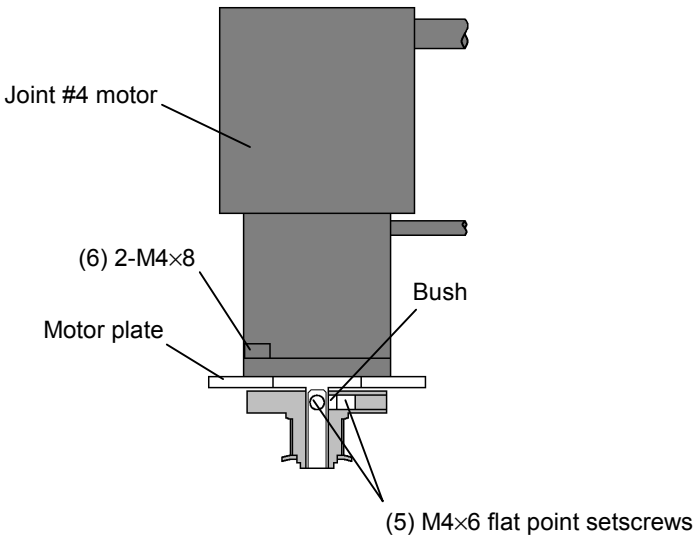
(2) Cut off the wire ties which bind the Joint #4 motor and cables.

(3) Disconnect connectors, X141 and X41. To disconnect X141, pull it out while pushing the presser tongue next to the connector number on the motor side.

(4) Remove the four bolts (M4×12) from the motor plate. And remove the pulley from the U1 belt. Pull the Joint #4 motor unit upward.



(5) Using a hexagon head wrench in the screw holes of the U1 pulley, remove the two flat point setscrews (M4×8) that secure the pulley to the motor shaft. Remove the pulley from the motor. One of the setscrew holes has a brass bushing which must not be lost.

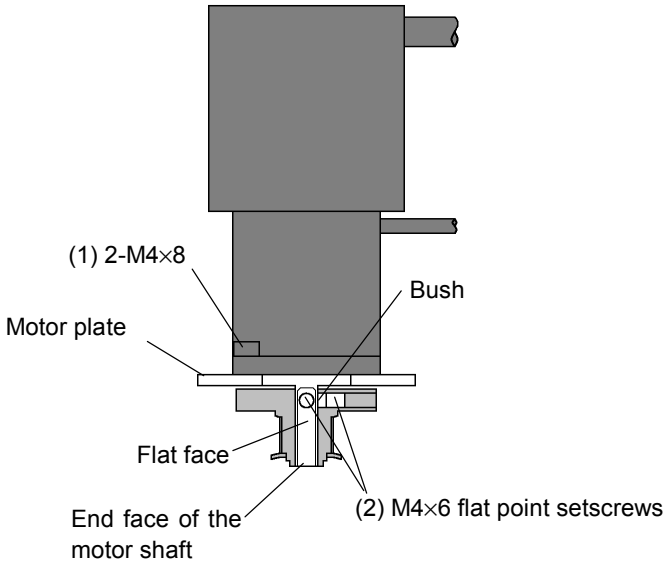


(6) Remove the two bolts (M4×8) from the motor and remove the motor plate.

Installation : Joint #4

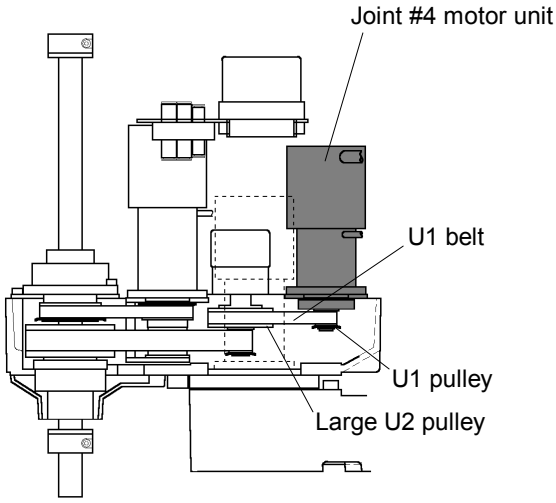
(1) Attach the new motor onto the motor plate with two bolts (M4×8).

(2) Secure the pulley to the motor shaft. Match the end face of the pulley to the end face of the motor shaft. There are two flat point setscrews (M4×8). One of the setscrews should touch the flat side of the motor shaft perpendicularly. Insert a bush in the other setscrew and tighten the screw. Do not over tighten to avoid damage to the motor shaft.



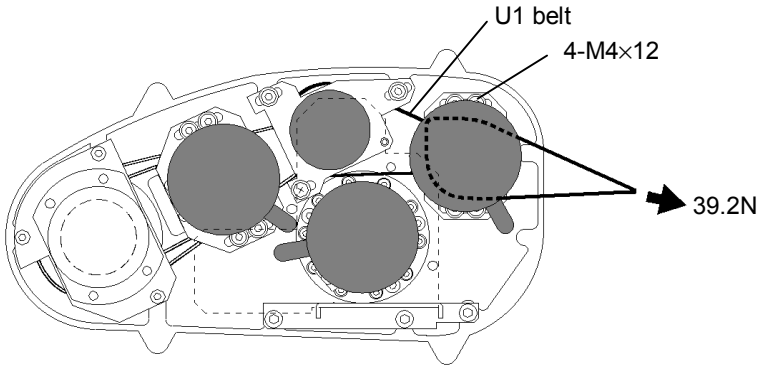
(3) Place the Joint #4 motor unit in Arm #2. The motor cables should be facing Joint #3.

(4) Fit the U1 belt around the large U2 and U1 pulleys. Ensure that the gear grooves of the belt and pulleys engage properly. Be careful not to slip the belts from the pulleys while maintaining proper interval between the units.



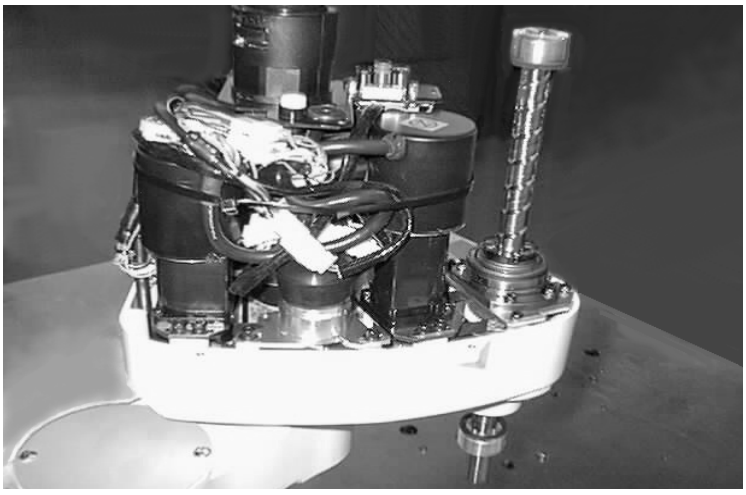
(5) Loosely fasten the Joint #4 motor plate using four bolts (M4×12).

(6) Pass a suitable cord or string around the Joint #4 motor near its mounting plate. Loosen the bolts for the Joint #4 motor plate fastened in the step (5) and pull the string using a force gauge or similar tool. Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(7) Connect the connectors, X141 and X41.

(8) Fasten the cables with wire ties again. Do not allow unnecessary strain on the cables.



(9) Install the arm cover. (Refer to chapter *2. Opening the Covers*.)

(10) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #4. Refer to chapter *11. Calibration*.

6. Replacing the Reduction Gear Units

⚠ WARNING

- Only trained personnel should be allowed to maintain this unit.
- When replacing the reduction gear units, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock or malfunction.

⚠ CAUTION

- Be careful not to apply an excessive shock to the motor shaft when replacing a reduction gear unit. This may shorten the life of the motor and encoder. This may also destroy them.

NOTE ☞ When replacing a reduction gear unit, be sure to always replace the waveform generator, fleck spline and circular spline all together as one set.

NOTE ☞ To grease the reduction gear unit, use the grease shown in the table below. Do not mix with other grease.

		Joint #1 reduction gear	Joint #2 reduction gear
Grease	Name	SK-1A	SK-2
	Z-code	ZA003301	ZA003304
	Color	Yellow	Green
	Adequate quantity	approx. 16g	approx. 10g

NOTE ☞ When replacing the Joint #2 reduction gear unit, prepare the liquid gasket (refer to the maintenance parts list at the end of this manual).

NOTE ☞ The mechanical origin position and teach points change when the motor or reduction gear is replaced. Whenever the reduction gear unit is replaced, be sure to calibrate the manipulator. Refer to chapter *11. Calibration*.

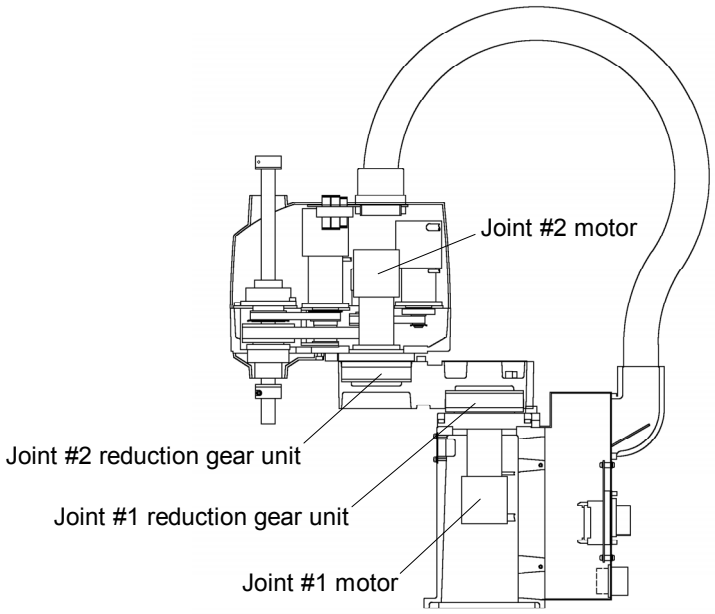
NOTE ☞ The tightening torque of a typical M3 bolt is 245N·cm. (Refer to section *1.4 Tightening Torque of Bolts*.) However, some bolts in the reduction gear units should be fastened using a higher torque at 294N·cm (30kgf·cm). Follow the instructions for tightening torque.

Types of reduction gear units

The types of reduction gear units used in the EC series manipulators are listed below. Specify the manipulator series and relevant joint when ordering a reduction gear unit for replacement.

Description	Series	Joint	Specification	Old code	New code
Reduction gear unit	EC	#1	SHF-20-80	ZA001010	R13ZA00101000
		#2	SHF-17-50	ZA001011	R13ZA00101100

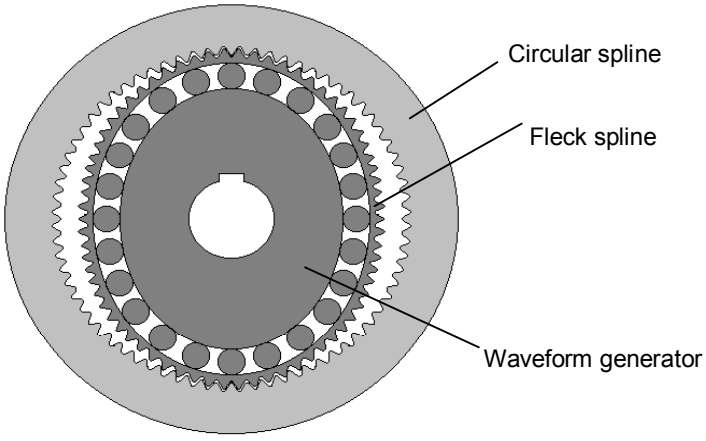
Location of reduction gear units



Structure of reduction gear unit

The reduction gear unit consists of the following three parts:

1. Waveform generator
   An ellipsoid cam with ball bearings around the outer circumference. The inner ring of the bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.
2. Fleck spline
   A thin, elastic, cup-shaped metal body with gear teeth around the outer circumference of the opening.
3. Circular spline
   A rigid, ring-shaped body with gear teeth on the inner circumference. The circular spline has twice as many teeth as the fleck spline but at identical pitch.

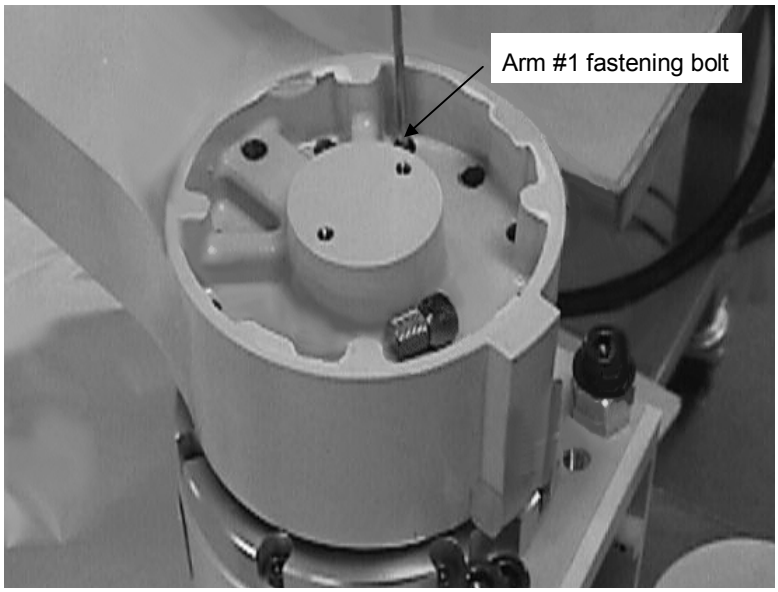


6.1 Replacing the Joint #1 Reduction Gear Unit

Removal Joint #1

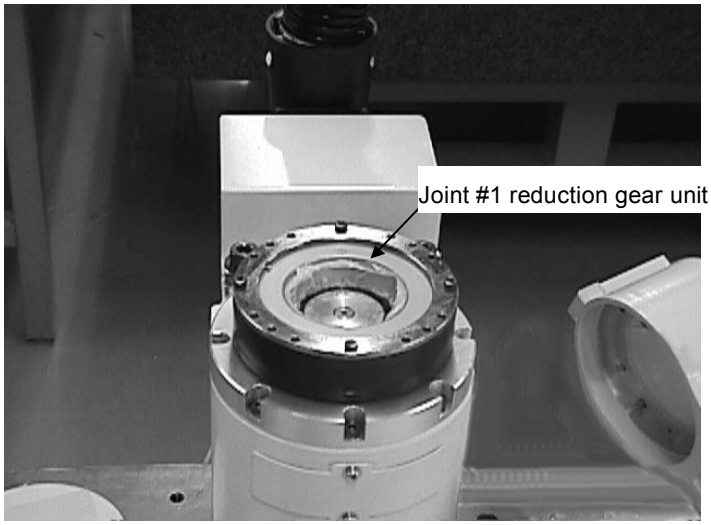
(1) Remove the two screws (M4×8) from the Joint #1 cover to open the cover. (Refer to *2. Opening the Covers*.)

(2) Support the arm with at least one person. While the arm is being supported, have another person unscrew the eight fastening bolts (M3×35 with plain washer) and remove Arm #1.



CAUTION

■ When removing or installing Arm #1, there must be two or more people to work on it so that at least one of them can support the arm while others remove the bolts and so on. The arm will drop immediately when the fastening bolts are removed. This is highly dangerous. Also, it may cause damage or malfunction if the arm is dropped or hit at this time.

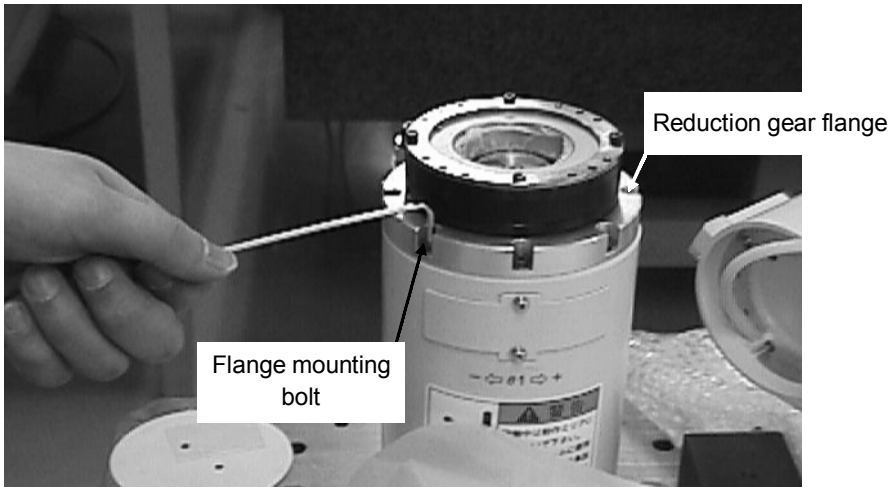


Place the arm gently on the floor.

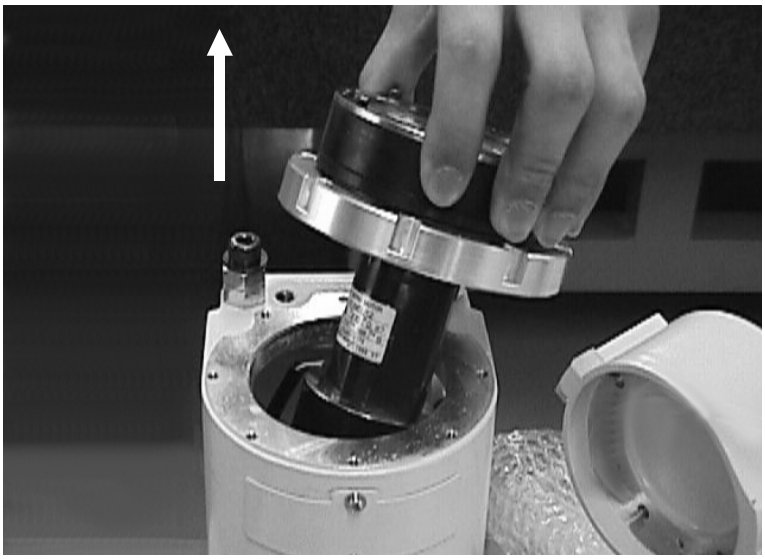
(3) Remove the power cable and signal cable from the base connector box.

(4) Open the base connector box (refer to chapter *2. Opening the Covers*) and disconnect the signal connector X11 and power connector X110. To disconnect X110, pull it out while pushing the presser tongue next to the connector number on the motor side.

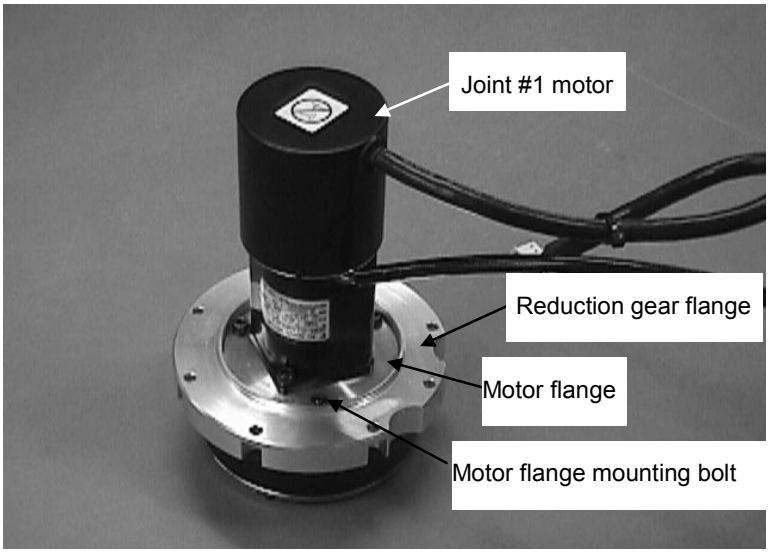
(5) Remove the eight mounting bolts (M4×12) from the reduction gear flange.

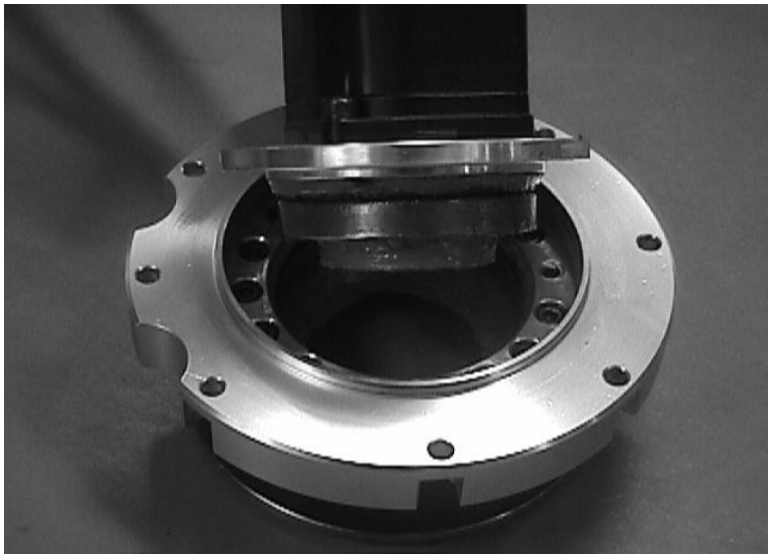


(6) Lift up the reduction gear unit.

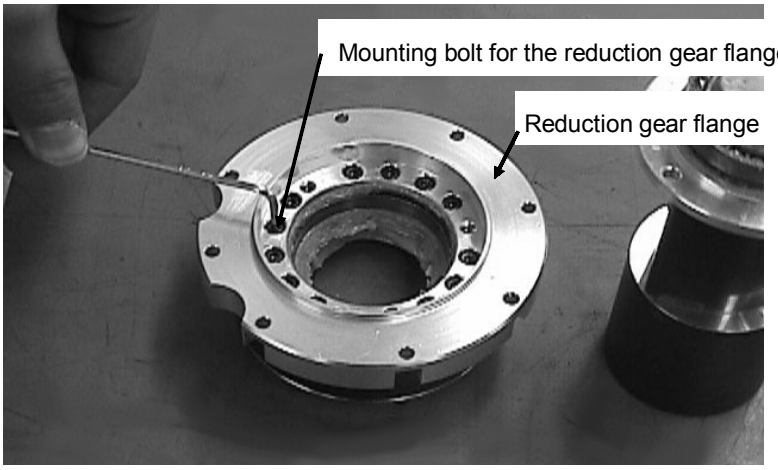


(7) Remove the three mounting bolts (M4×10) from the motor flange and pull the motor out of the reduction gear flange.

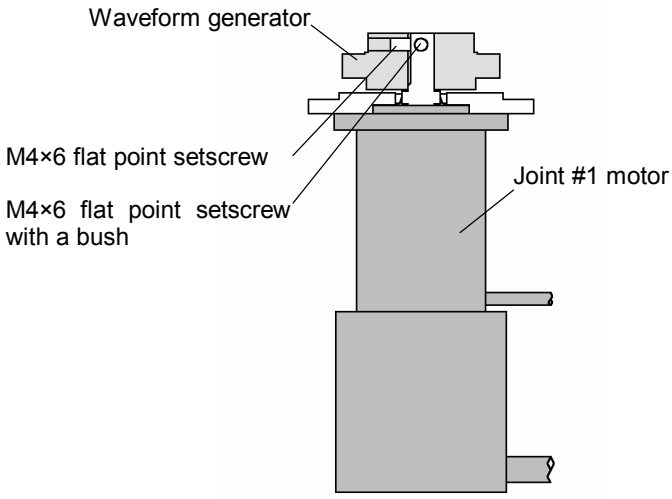




(8) Remove the thirteen mounting bolts (M3×15) from the reduction gear and remove the reduction gear flange.

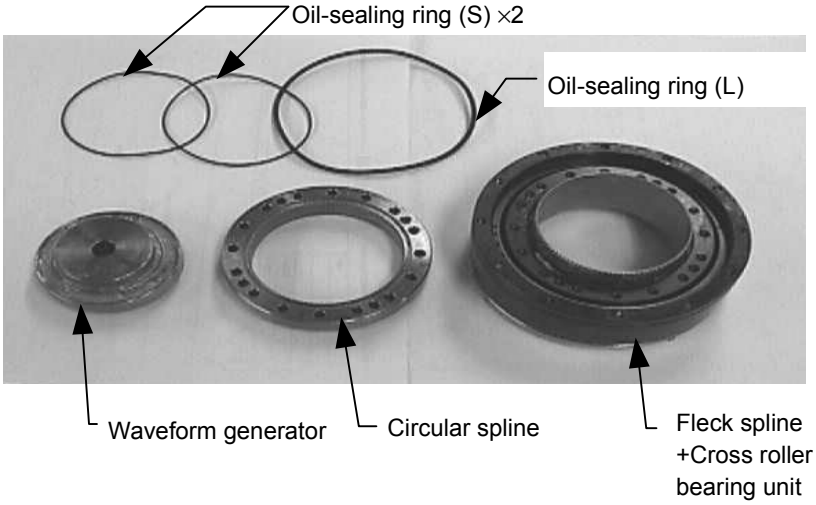


(9) Using a hexagon head wrench in the screw holes of the waveform generator, remove the two flat point setscrews (M4×6). Remove the waveform generator from the motor. One of the setscrew holes has a brass bush inside which must not be lost.



Installation : Joint #1

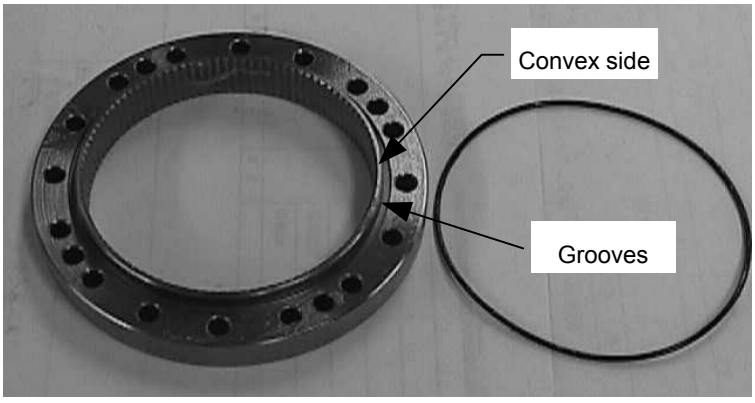
(1) A new reduction gear unit contains the parts shown below when it is unpacked. However, the oil-sealing ring (L) will not be used here. The circular spline and fleck spline (at the gear grooves) are greased as well as the waveform generator (at the bearings). Wipe off excess grease from the mounting surface.

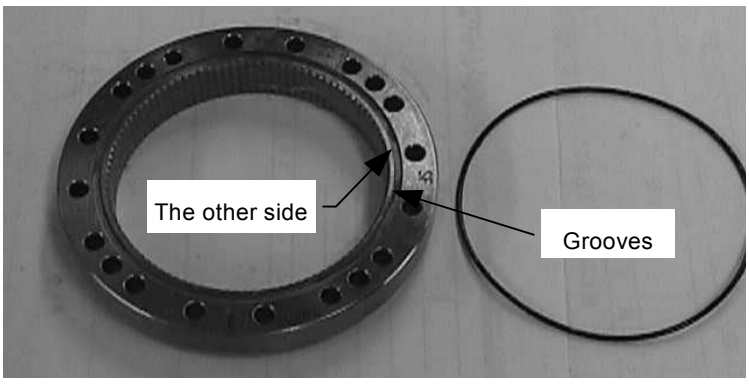


NOTE

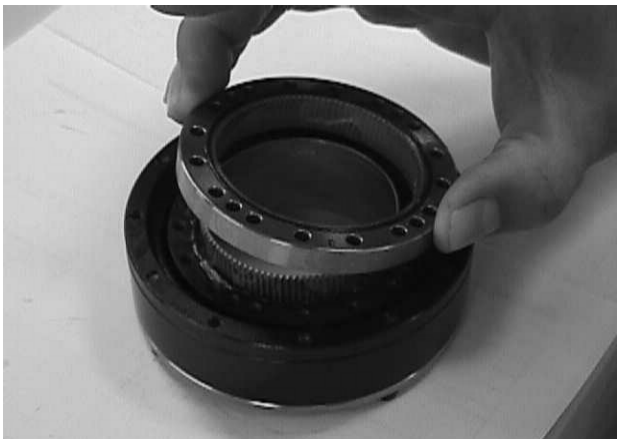
Never touch (to loosen or tighten) the bolts holding the fleck spline and cross roller bearing unit together. If the bolts are moved, the fleck spline and cross roller bearing unit must be readjusted at the suppliers since they are centered when attached together.

(2) Fit the oil-sealing rings (S) into the grooves on both sides of the new circular spline. Be sure that the rings will not come out of the grooves.





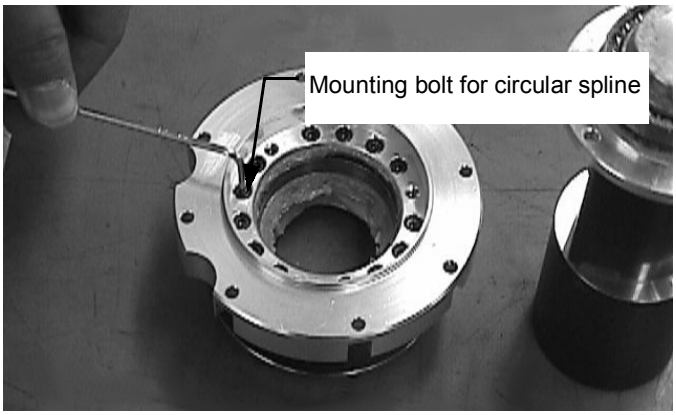
(3) Fit the circular spline (with the convex side facing down) into the fleck spline.



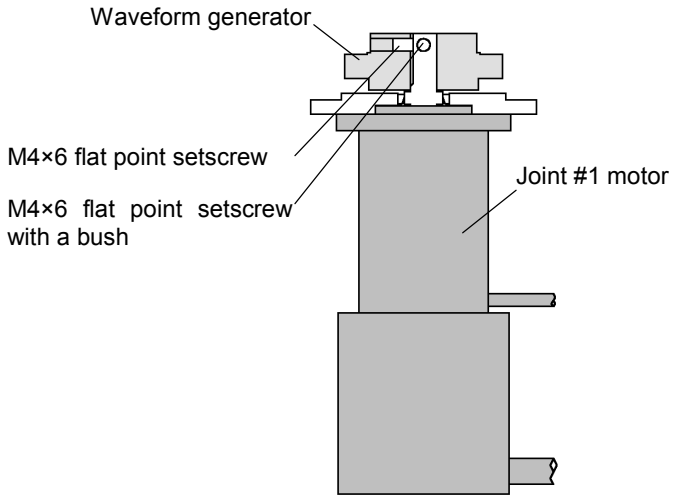
(4) As shown below, match the screw holes on the inner ring unit (of the cross roller bearing unit) and the through holes of the circular spline.

(5) Place the reduction gear flange onto the circular spline. First, using a hexagon wrench, position the thirteen (13) bolts. Loosely fasten each bolt in a crisscross pattern so that the bolts will be fastened evenly. When the bolts are positioned, tighten each bolt securely at the torque specified in the table below using a torque wrench. Tighten each bolt in a crisscross pattern. Be careful not to apply too much force since it may damage the parts.

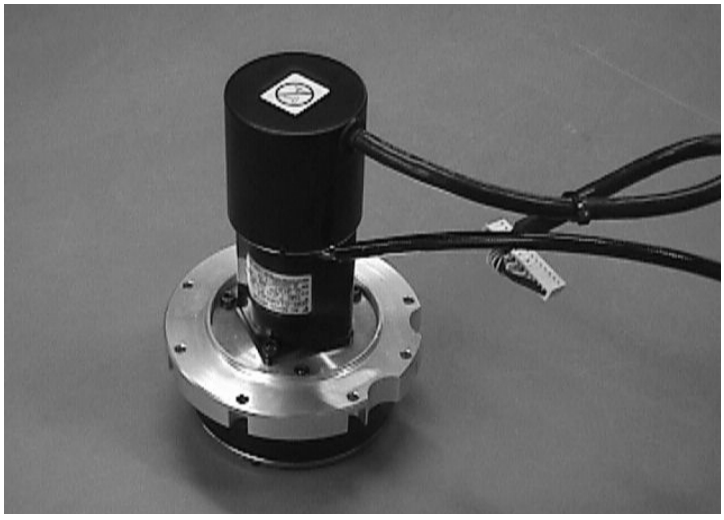
Joint #1 circular spline	Bolts	Tightening torque of the bolts
	13-M3×15	294N·cm (30kgf·cm)



(6) Secure the waveform generator to the motor shaft. Match the end face of the waveform generator to the end face of the motor shaft. There are two flat point setscrews (M4×6). One of them should touch the flat face in the motor shaft perpendicularly. Insert a bush to the other setscrew hole and tighten the screw carefully to avoid damage to the motor shaft.



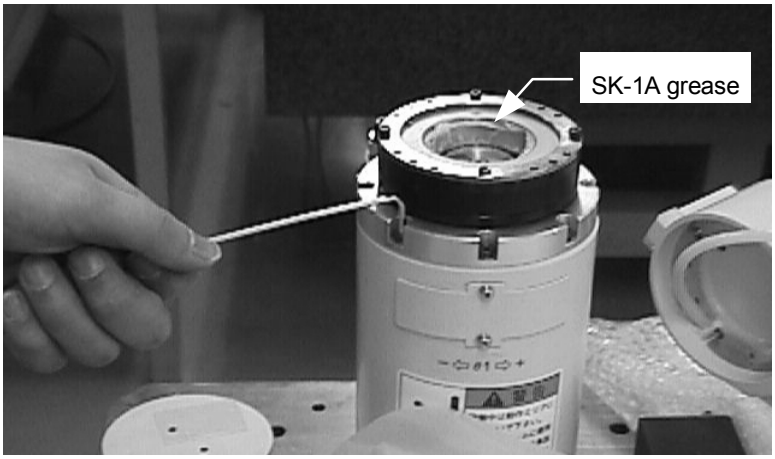
(7) Secure the motor unit to the reduction gear so that the motor cables are placed to above the round cuttings of the flange described below and secure the motor unit with three bolts (M4×10).



(8) Mount the reduction gear flange to the manipulator base and secure it with eight bolts (M4×12). Be sure that the round cuttings of the reduction gear flange are directed to the rear side.

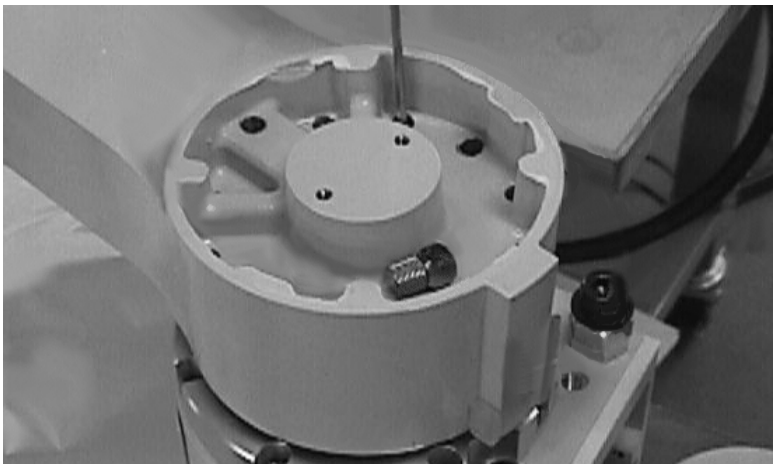
NOTE

Never touch (to loosen or tighten) the four bolts on the top surface shown in the picture below. If the bolts are moved, the fleck spline and cross roller bearing unit must be readjusted at the suppliers since they are centered when attached together.



(9) As illustrated above, grease inside the reduction gear unit. (SK-1A: 16g)

(10) Secure Arm #1. Support the arm with at least one person. While the arm is being supported, have another person fasten the eight bolts (M3×35 with plain washer) to attach Arm #1. Be careful not to drop or hit the arm.



(11) Connect the signal connector X11 and power connector X110 of Joint #1. Then, attach the base connector box back on. (Refer to chapter *2. Opening the Covers*.)

(12) Connect the power cable and signal cable to the base connector box.

(13) Attach the Joint #1 cover by fastening it with two bolts (M4×8).

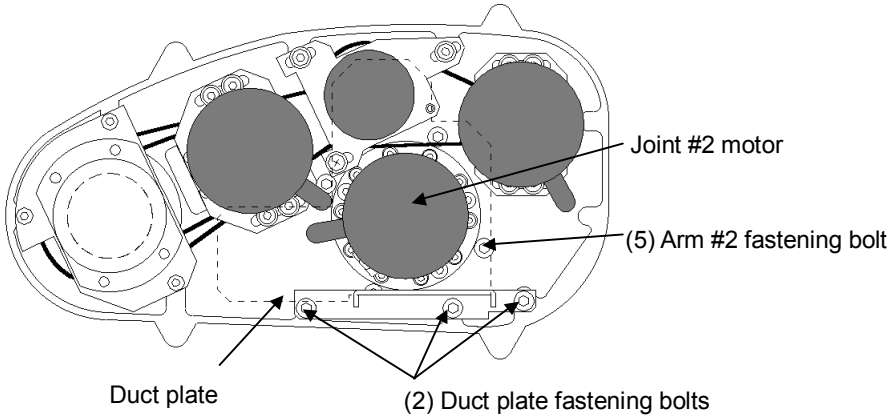
(14) The mechanical origin position and teach points change when the reduction gear unit is replaced. Be sure to calibrate Joint #1. Refer to chapter *11. Calibration*.

6.2 Replacing the Joint #2 Reduction Gear Unit

Removal :Joint #2

(1) Open the arm cover. (Refer to chapter *2. Opening the Covers*.)

(2) Remove the duct plate from Arm #2 by unscrewing three bolts (M5×15).



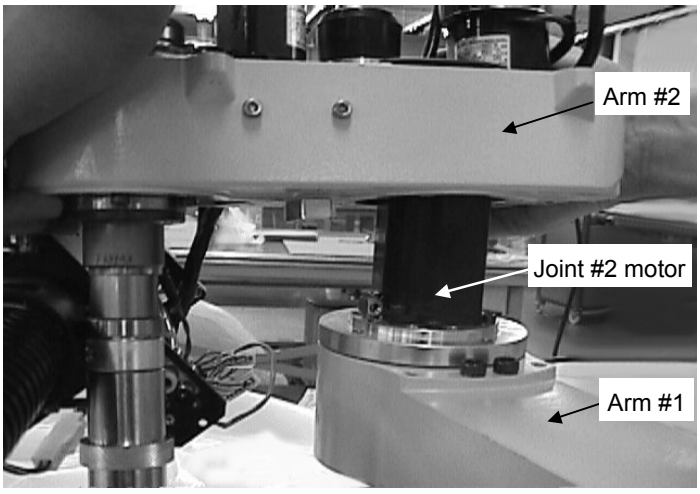
(3) Cut off the wire ties which bind the Joint #2 motor and cables.

(4) Disconnect the signal connector X21 and power connector X121 from the Joint #2 motor. To disconnect X121, pull it out while pushing the presser tongue next to the connector number on the motor side.

(5) Support Arm #2 with at least one person. While the arm is being supported, have another person unscrew the four fastening bolts (M5×15) and remove Arm #2.

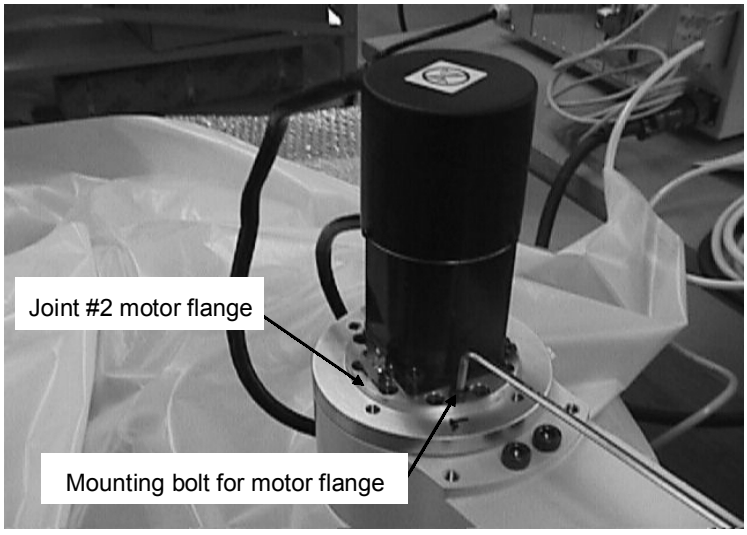
⚠ CAUTION

- When removing or installing Arm #2, there must be two or more people to work on it so that at least one of them can support the arm while others remove the bolts and so on. The arm will drop, immediately when right away as soon as the fastening bolts are removed. This is highly dangerous. Also, it may cause damage or malfunction if the arm is dropped or hit at this time.

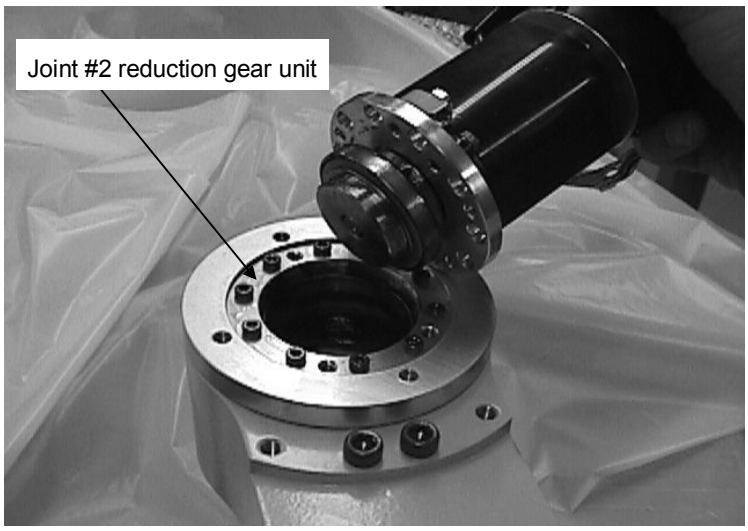


Place the removed arm gently on the floor.

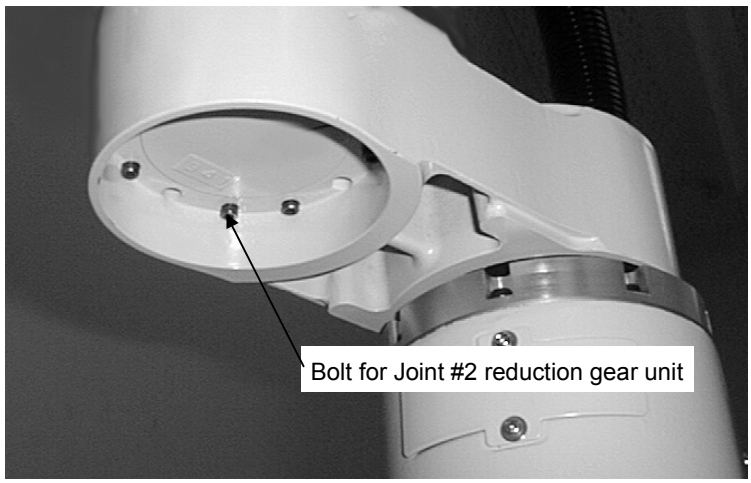
(6) Remove the three mounting bolts (M4×10) from the Joint #2 motor flange.



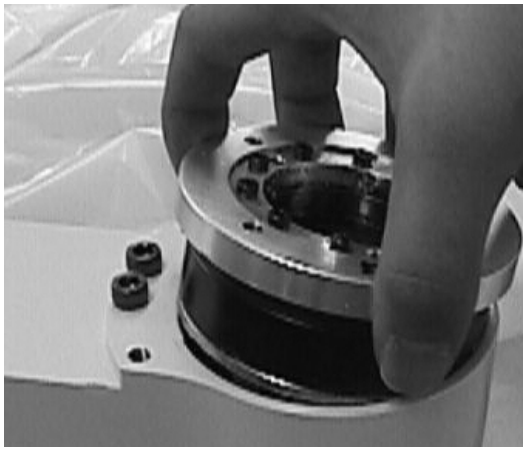
(7) Remove the Joint #2 motor unit.



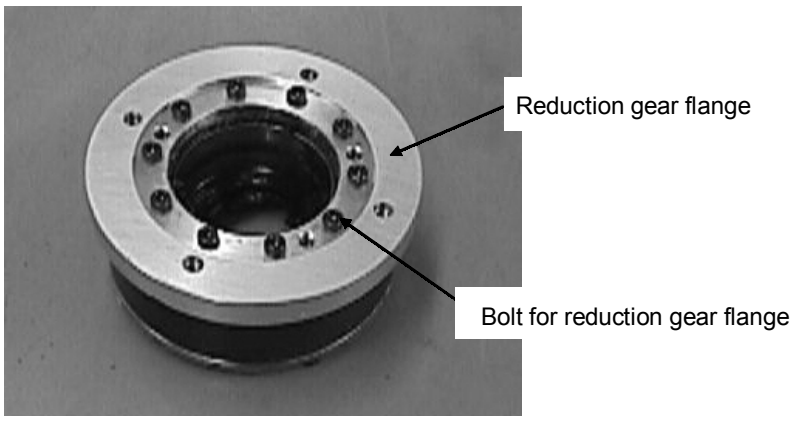
(8) Remove the eight bolts (M3×35 with plain washer) from the Joint #2 reduction gear unit at the bottom of Arm #1.

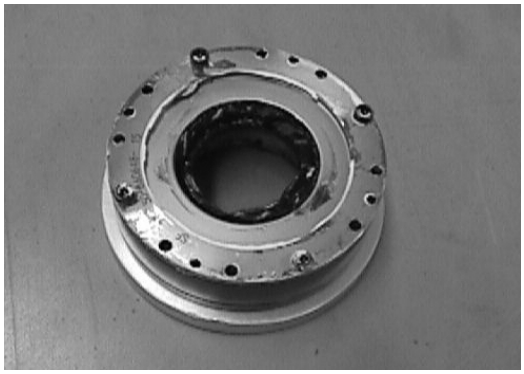


(9) Remove the reduction gear unit from Arm #1. If the unit does not come out easily because of the liquid gasket on the junction surface to prevent grease from leaking, use a flat screwdriver between the flange and the arm.

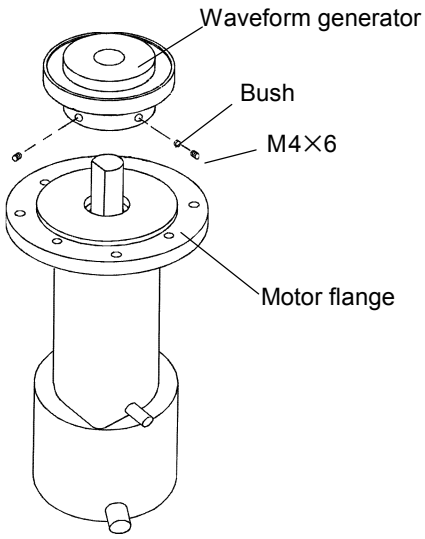


(10) Remove the ten mounting bolts (M3×18) from the reduction gear and remove the reduction gear flange.



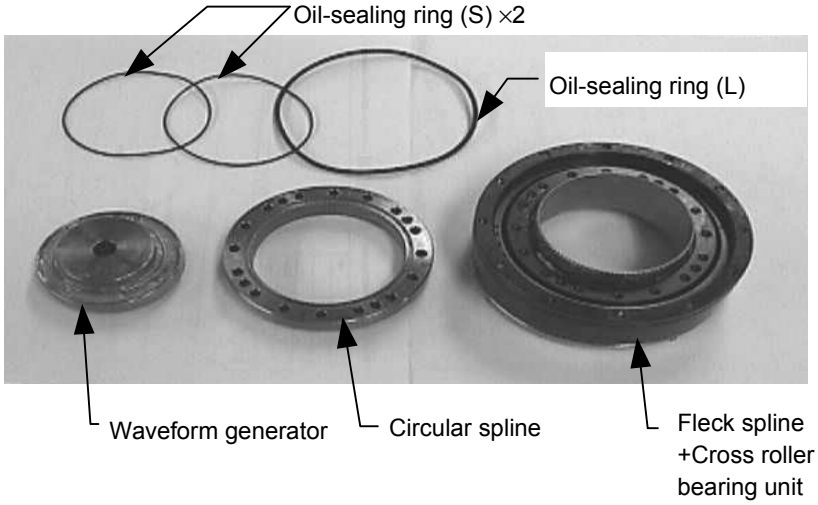


(11) Using a hexagon head wrench in the screw holes of the waveform generator, remove the two flat point setscrews (M4×6). Remove the waveform generator from the motor. One of the setscrew holes has a brass bush inside which must not be lost.



Installation : Joint #2

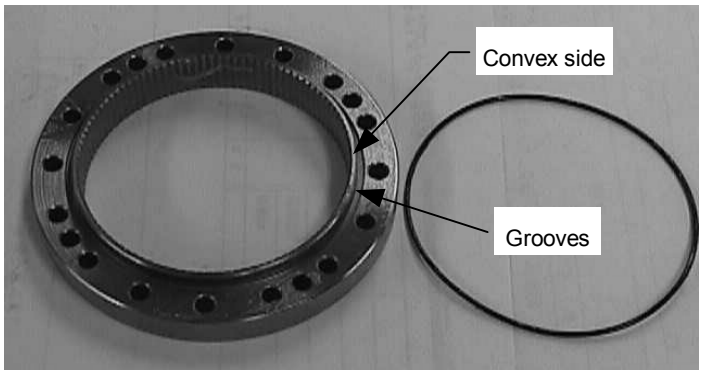
(1) A new reduction gear unit contains the parts shown below when it is unpacked. However, the oil-sealing ring (L) will not be used here. The circular spline and fleck spline (at the gear grooves) are greased as well as the waveform generator (at the bearings). Wipe off excess grease from the mounting surface.

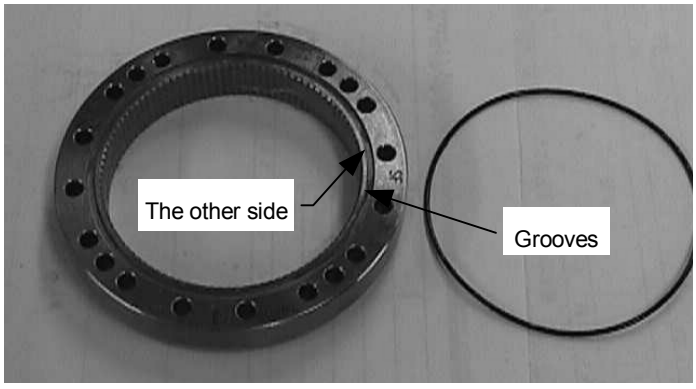


NOTE

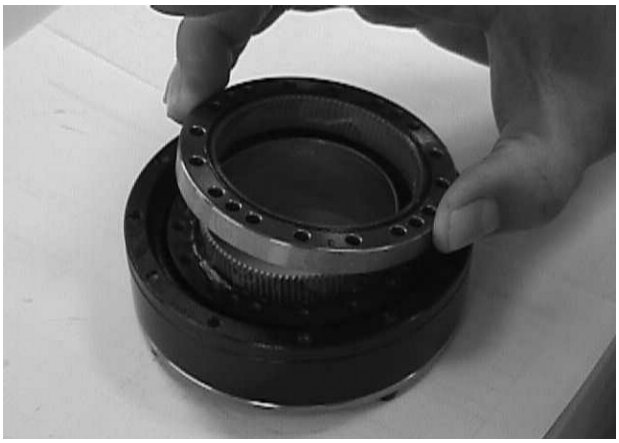
Never touch (to loosen or tighten) the bolts holding the fleck spline and cross roller bearing unit together. If the bolts are moved, the fleck spline and cross roller bearing unit must be readjusted at the suppliers since they are centered when attached together.

(2) Fit the oil-sealing rings (S) into the grooves on both sides of the new circular spline. Be sure that the rings will not come out of the grooves.





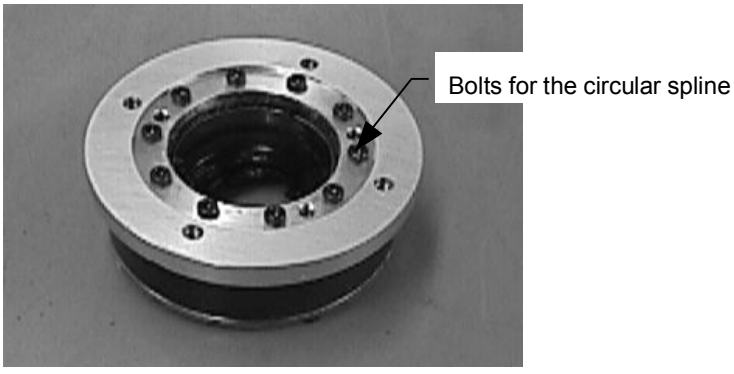
(3) Fit the circular spline (with the convex side facing down) into the fleck spline.



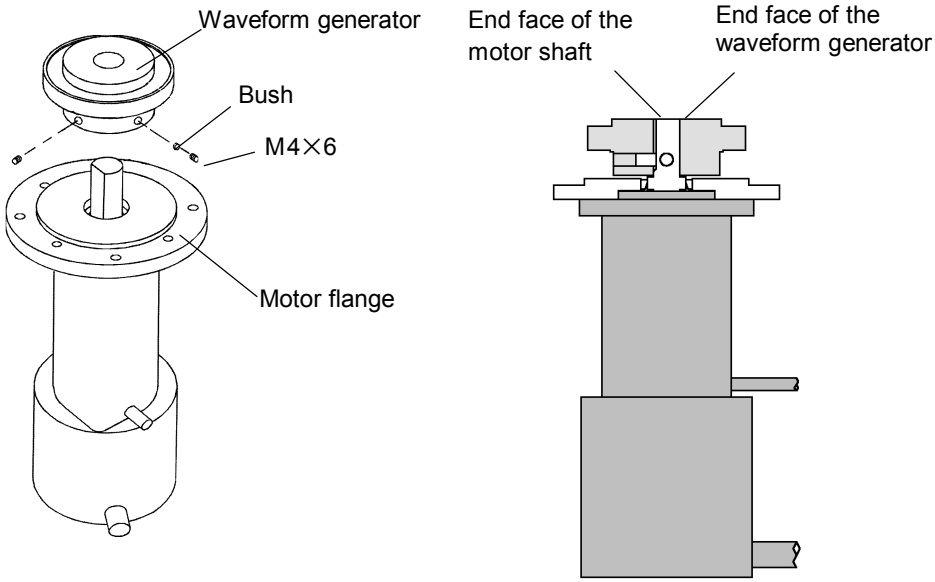
(4) As shown below, match the screw holes on the inner ring unit (of the cross roller bearing unit) and the through holes of the circular spline.

(5) Place the reduction gear flange onto the circular spline. First, using a hexagon wrench, position the ten (10) bolts. Loosely fasten each bolt in a crisscross pattern so that the bolts will be fastened evenly. When the bolts are positioned, tighten each bolt securely at the torque specified in the table below using a torque wrench. Tighten each bolt in a crisscross pattern. Be careful not to apply too much force since it may damage the parts.

	Bolts	Tightening torque of the bolts
Joint #2 circular spline	10-M3×18	294N·cm (30kgf·cm)

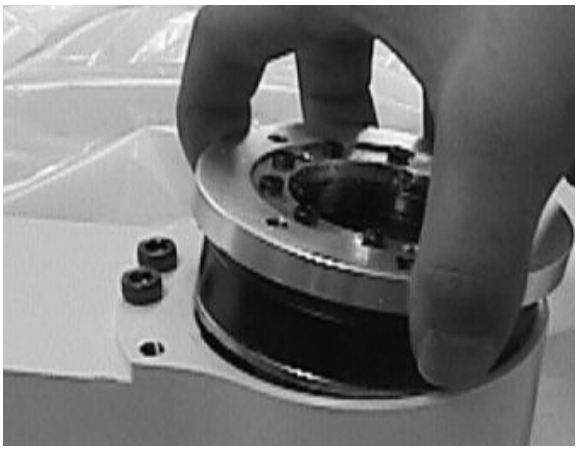


(6) Mount the waveform generator to the motor shaft. Match the end face of the waveform generator to the end face of the motor shaft. There are two flat point setscrews (M4×6). One of them should touch the flat face in the motor shaft perpendicularly. Insert a bush to the other setscrew hole and fasten so as not to scratch the motor shaft.



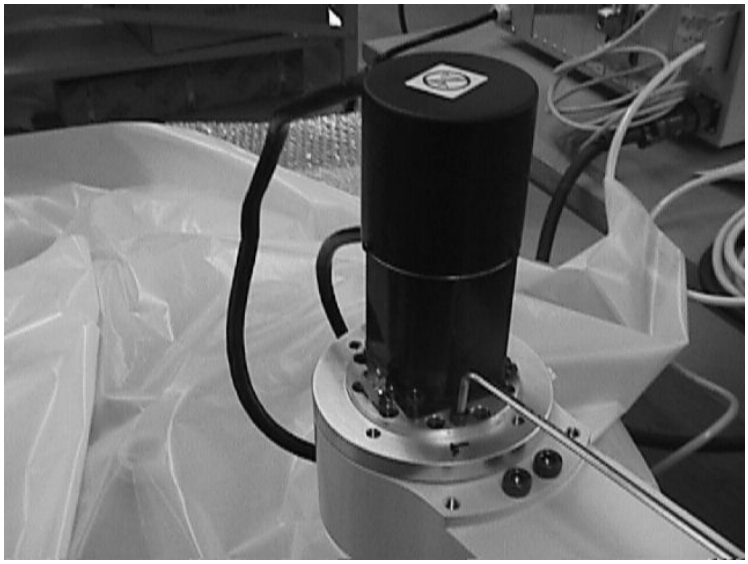
(7) Remove the old liquid gasket and apply the new liquid gasket again on the junction surface of the reduction gear unit.

(8) Place the Joint #2 reduction gear unit back inside Arm #1 and secure it with the eight bolts (M3×35 with plain washer) at 294N·cm (30kgf·cm).

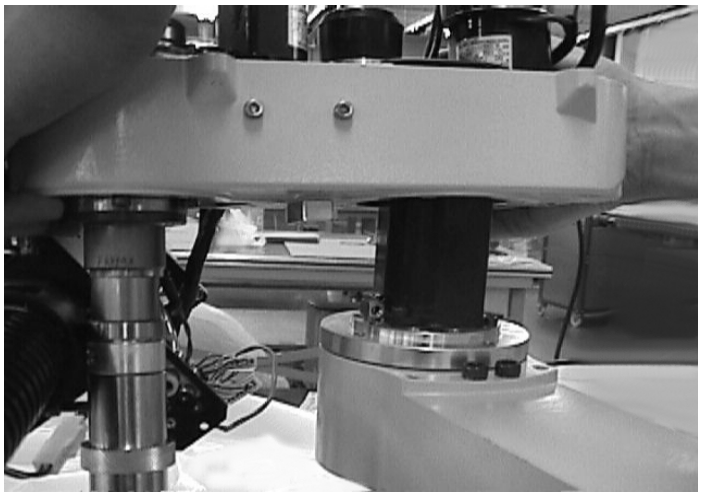


(9) As shown below, grease inside the reduction gear unit (SK-2: 10g) and attach the motor unit inside Joint #2.

(10) Secure the motor flange with three bolts (M4×10) so that the motor cable will come to the position shown in the picture below.



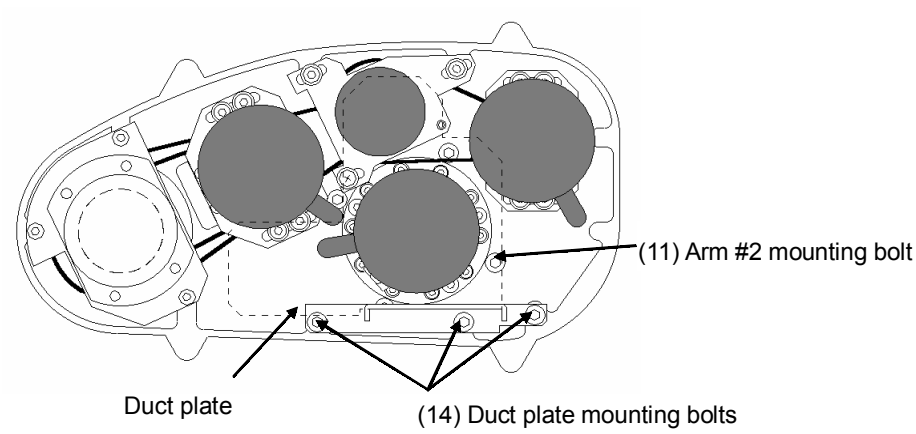
(11) Secure Arm #2. Support the arm with at least one person. While the arm is being supported, have another person fasten the four bolts (M5×15) to attach Arm #2. Be careful not to drop or hit the arm.



(12) Connect the connectors, X121 and X21 of the Joint #2 motor.

(13) Fasten the motor cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(14) Place the duct plate on and secure it with three bolts (M4×8).



(15) Attach the arm cover. (Refer to chapter *2. Opening the Covers*).

(16) The mechanical origin position and teach points change when the reduction gear unit is replaced. Be sure to calibrate the Joint #2. Refer to chapter *11. Calibration*.

7. Replacing the Brake

⚠ WARNING

- Only trained personnel should be allowed to maintain this unit.
- When replacing the brake, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock and malfunction.

⚠ CAUTION

- When replacing the brake, be careful not to extend the leaf spring on the rotor hub of the brake. When removing the rotor hub from the brake, slide it horizontally toward the shaft.

NOTE

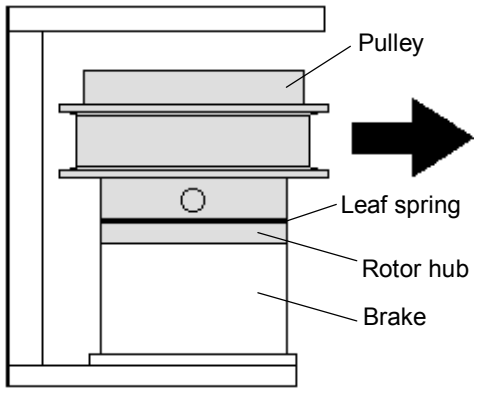
The brake on Joint #3, which normally prevents the end effector from dropping under its own weight when either the power or the motor itself is turned OFF, is rendered inoperable while the brake is being replaced.

Joint #3 moves while the brake release button is held down while the power is ON (refer to the Figure 11 in Part 1 of this manual). Lower Joint #3 carefully to prevent it from striking against nearby equipment. The power should be OFF while replacing the brake.

Removal

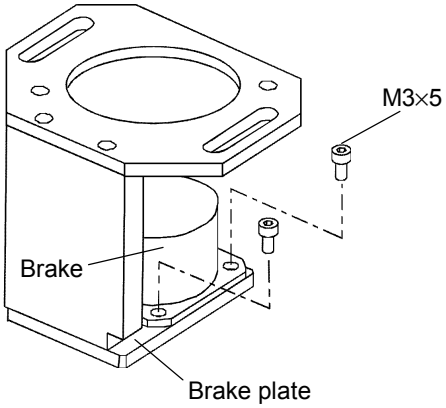
(1) Remove the Joint #3 motor as described in chapter *5. Replacing the Motors*, steps (1) through (7).

(2) To adjust a gap, remove a pulley from the brake. Rotor hub which is screwed on the pulley, is attracted to the brake magnet. If you force it to separate, the leaf spring will stretch. To prevent the leaf spring from stretching, remove the pulley by sliding it out from the side as shown by the arrow in the figure below.

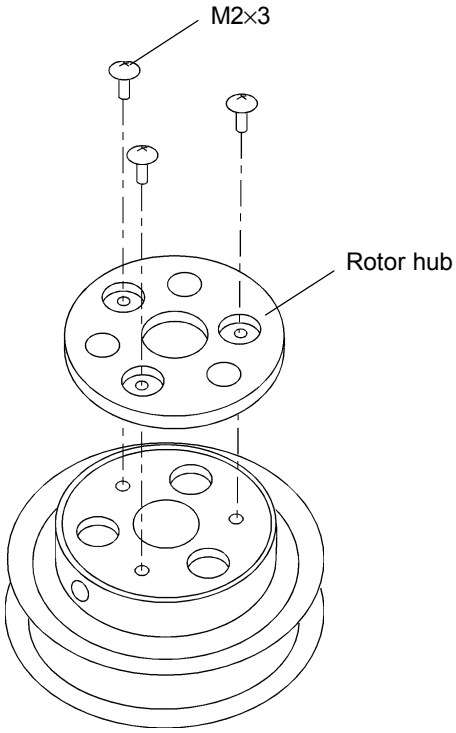


(3) Cut off the wire tie that fastens the brake cables to the brake plate.

(4) Remove the four bolts (M3×5) from the brake and remove the brake from the brake plate.



(5) Remove the rotor hub from the end of the pulley. (3-M2×3 machine screw)



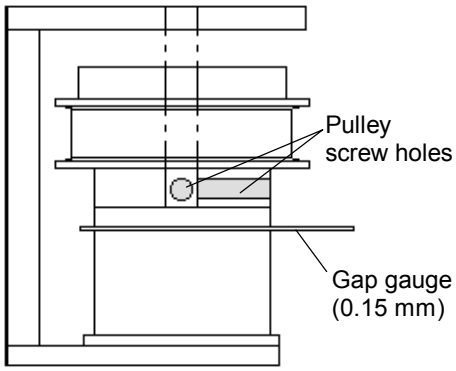
Installation

(1) Fasten the rotor hub to the end of the pulley securely with three M2×3 machine screws.

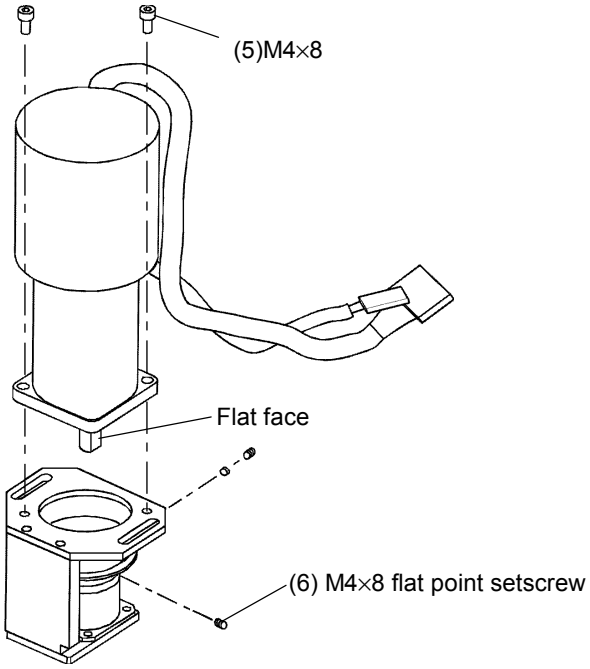
(2) Fasten the replacement brake to the brake plate with four M3×5 bolts.

(3) Fasten the brake cables to the brake plate with a wire tie to prevent interference with the pulley.

(4) Put a gap gauge (0.15 mm) which was pasted inside the arm cover between the brake and rotor hub. Then, set the pulley on the brake. At this time, the positions of the pulley setscrew holes are as shown in the figure below.



(5) Place the new motor to the motor plate so that the motor cables turn to the direction of the figure below and fasten it with two bolts. (M4×8) Remember the position of the motor cable. The direction of the motor shaft flat face should face one of the screw holes of the pulley.

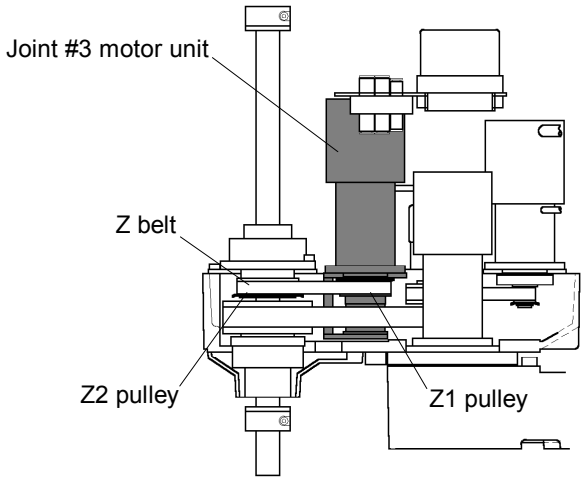


(6) Tighten two M4×8 flat point setscrews to secure the pulley. One of the screws should contact the flat face of the motor shaft at a right angle. Fit the bush onto the other screw and tighten, making sure that it does not scratch the motor shaft.

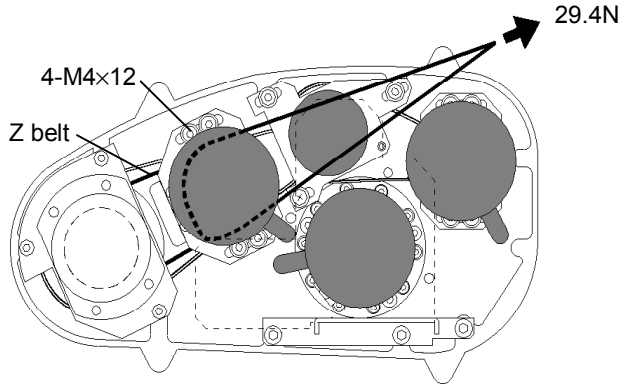
(7) After the pulley is secured, pull out the gap gauge.

(8) Place the Joint #3 motor unit in the arm. The motor cables should be facing Joint #2.

(9) Fit the Z belt around the Z1 and Z2 pulleys. Ensure that the gear grooves of the belt and pulleys engage properly. Be careful not to slip the Z belt from the pulleys while maintaining proper interval between the pulleys. Fasten the Joint #3 motor plate for the time being using four bolts (M4×10).



(10) Pass a suitable cord or string around the Joint #3 motor near its mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (9) and pull the cord using a force gauge or similar tool. Fasten the Joint #3 motor plate securely where the Z belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(11) Connect the connectors, X131, X31 and X32.

(12) Fasten the cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(13) Install the arm cover. (Refer to chapter *2. Opening the Covers*.)

(14) The mechanical origin position and teach points change when the brake and motor are replaced. Be sure to calibrate Joint #3. (Refer to chapter *11. Calibration*.)

8. Replacing the Timing Belts

⚠ WARNING

- Only trained personnel should be allowed to maintain this part. Trained personnel are those who have taken a robot training course held by the dealer or those who have carefully read the manuals and have equivalent knowledge and skill.
- When replacing the timing belts, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock or malfunction.

NOTE

The brake on the Joint #3 motor, which normally prevents the end effector from dropping under its own weight when either the power or the motor itself is turned OFF, is rendered inoperable while the timing belt is being replaced.
Joint #3 moves if the brake release button (see figure 11 in the chapter *End Effectors* in Part 1) is held down while the power is ON. Lower Joint #3 carefully to prevent it from colliding with nearby equipment. The power should be OFF while replacing the timing belt.

NOTE

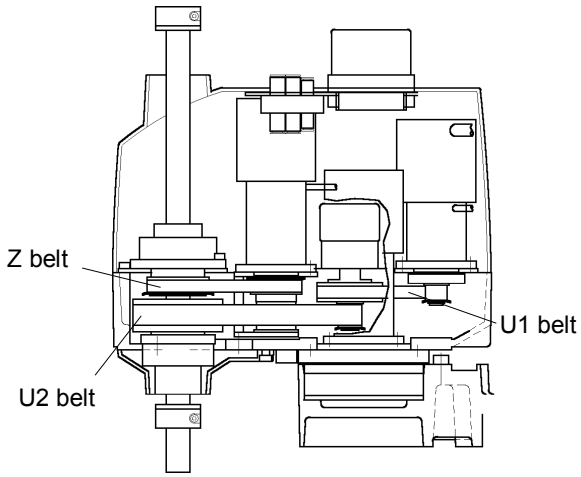
Once the timing belt is removed or replaced, the origin position changes. As a result, the teach points you have been using will also deviate from their original positions. In order to use the original teach points, you must calibrate the origin position.
You need to choose one point from among the currently held teach points. The accuracy of the selected point should be easy to check. Adjust the origin point as described in chapter *11. Calibration*.

Types of timing belts

There is one type of timing belt used for Joint #3 and two for Joint #4. Specify the manipulator type name and corresponding joint name when ordering a replacement timing belt.

Joint	Name	Specification	Perimeter	Old code	New code
#3	Z belt	252-2GT-6	252 mm	ZA003220	R13ZA00322000
#4	U1 belt	224-2GT-8-T434N1	224 mm	ZA003221	R13ZA00322100
	U2 belt	366-2GT-15-T434N1	366 mm	ZA003222	R13ZA00322200

Locations of timing belts

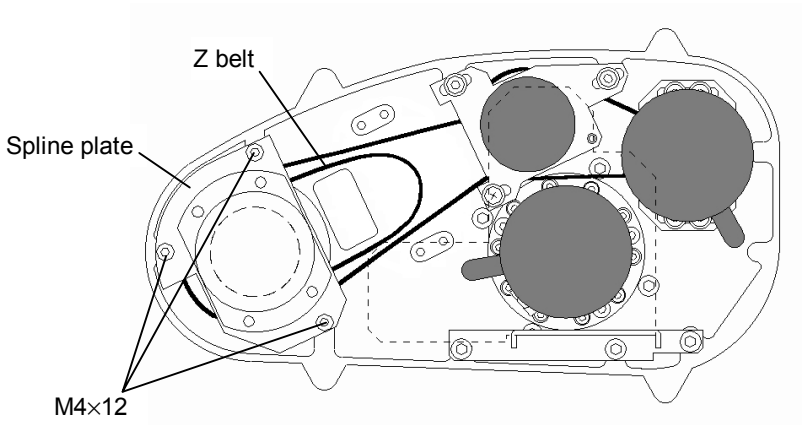


8.1 Replacing the Z belt

Removal : Zbelt

(1) Remove the Joint #3 motor unit as described in "*5. Replacing the Motors : Joint #3*" (1) through (4).

(2) Remove the bolts (3-M4×12) from the spline plate.

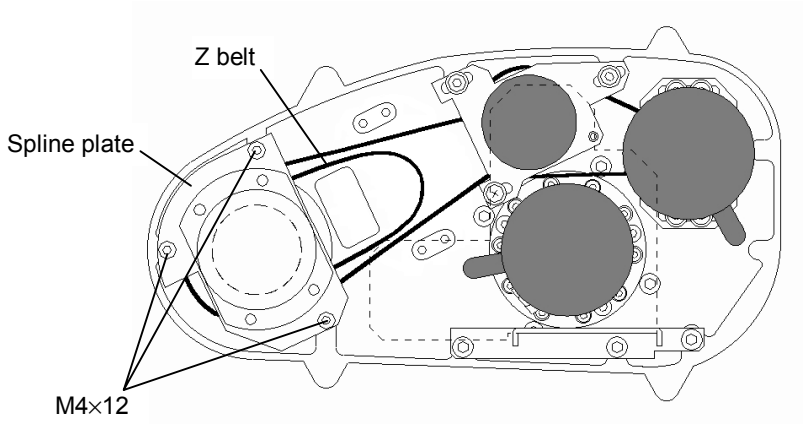


(3) Lift the spline plate and draw the Z belt up, make it through under the spline plate, and pull the Z belt upward.

Installation : Z belt

(1) Place the new Z belt on the shaft from above, and lift the spline plate to allow the belt to be positioned under it.

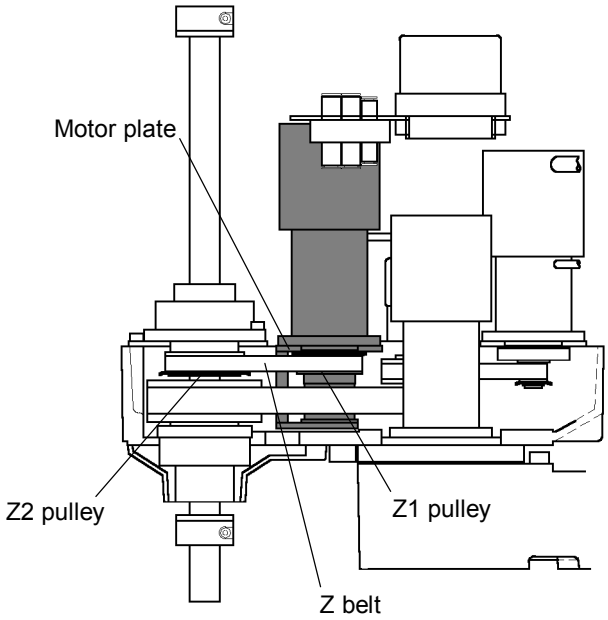
(2) Fasten the spline plate (with the belt attached on the spline plate pulley) on the arm.



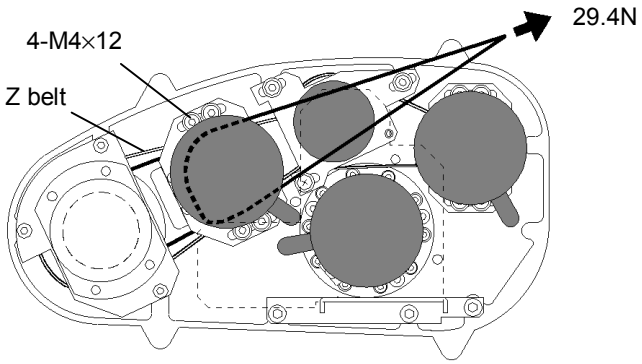
(3) Fasten the spline plate with three M4×12 bolts.

(4) Place the Joint #3 motor unit in the arm. The motor cables should be facing Joint #2.

(5) Place the Z belt around the Z1 and Z2 pulleys. Ensure that the gear grooves of the belt and pulleys engage properly. Be careful not to slip the Z belt from the pulleys while maintaining proper interval between the pulleys. Fasten the Joint #3 motor plate for the time being using four bolts (M4×12).



(6) Pass a suitable cord or string around the Joint #3 motor near ith mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (5) and pull the cord using force gauge or similar tool. Fasten the Joint #3 motor plate securely where the Z belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(7) Connect the connectors, X131, X31, and X32. Fasten the cables with wire ties as in their original points. Do not allow unnecessary strain on the cables.

(8) Install the arm cover. (Refer to chapter *2. Opening the Covers*.)

(9) The mechanical origin position and teach points change when the timing belt is replaced. Be sure to calibrate Joint #3 as described in *11. Calibration*.

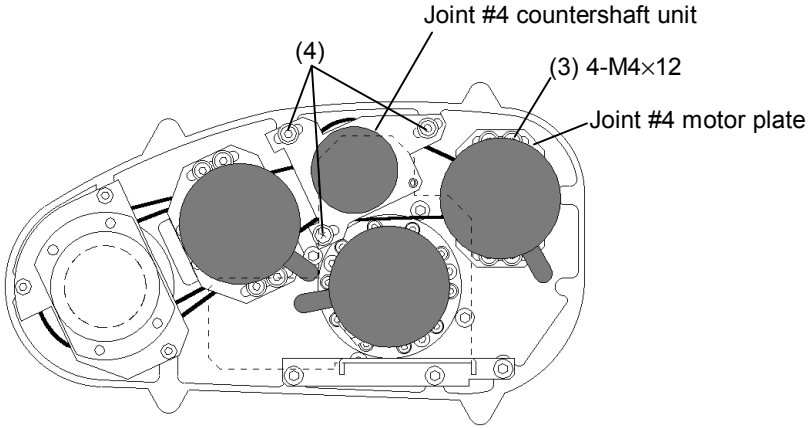
8.2 Replacing the U1 Belt

Removal : U1 belt

(1) Open the arm cover. (Refer to chapter *2. Opening the Covers*.)

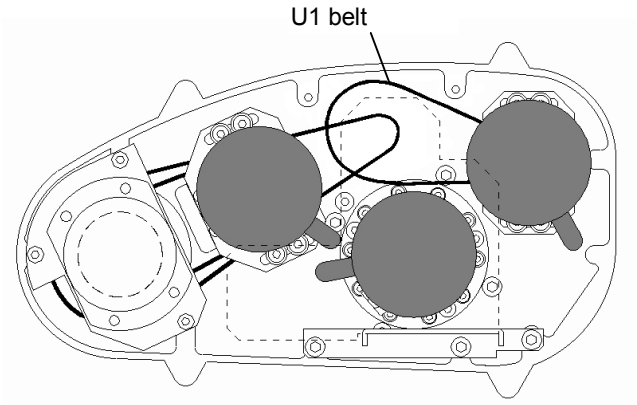
(2) Cut off the wire ties which bind the Joint #4 motor and cables.

(3) Loosen the four bolts (M4×12) holding the Joint #4 motor plate.



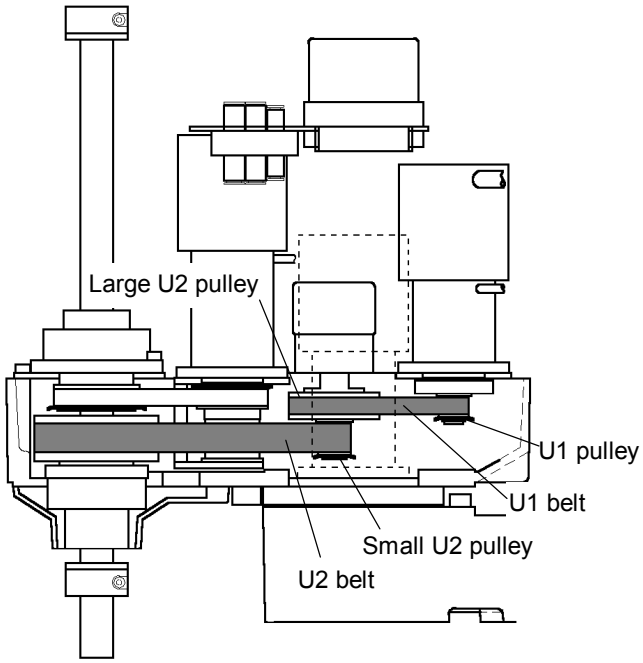
(4) Loosen the three bolts (2-M4×12 bolts and M5×8 screw) holding the Joint #4 countershaft unit.

(5) Remove the U1 belt.

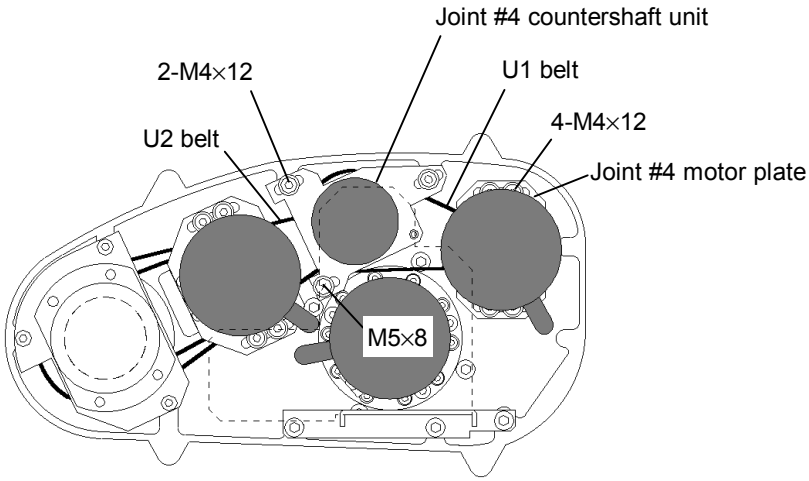


Installation : U1 belt

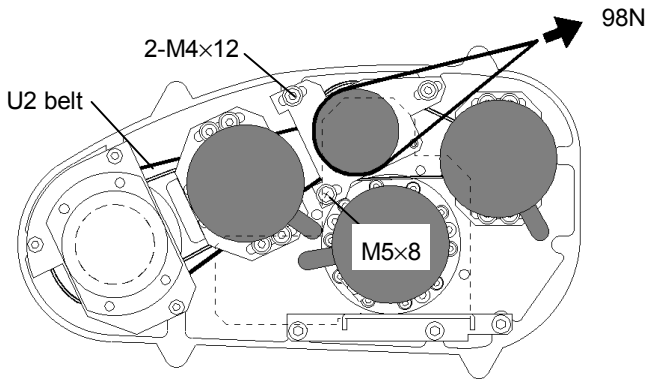
(1) Fit the new U1 belt and U2 belt around the pulleys as shown below. Ensure that the gear grooves of the belts and pulleys engage properly.



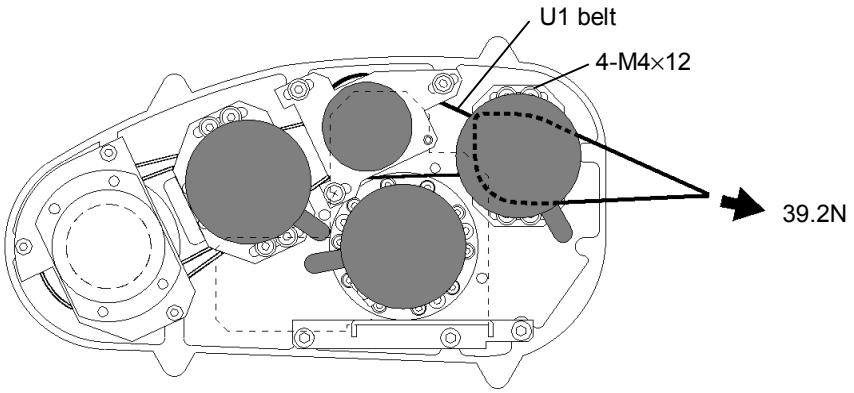
(2) Position the Joint #4 countershaft unit and Joint #4 motor plate on the arm. Be careful not to slip the belts from the pulleys while maintaining proper interval between the units. Mount them loosely for the time being using the following bolts: 2-M4×12 and M5×8 screw for the Joint #4 countershaft unit; 4-M4×10 for the Joint #4 motor plate.



(3) Pass a suitable cord or string around the Joint #4 countershaft near its countershaft plate. Loosen the bolts for the Joint #4 countershaft plate fastened in the step (2) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 countershaft securely where the U2 belt is pulled at 98N (10kgf). Adjust in the range of 89N - 107N (9kgf - 11kgf).



(4) Pass a suitable cord or string around the Joint #4 motor near its mounting plate. Loosen the bolts for the Joint #4 motor plate fastened in the step (2) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(5) Fasten the cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(6) Install the arm cover. (Refer to chapter *2. Opening the Covers*.)

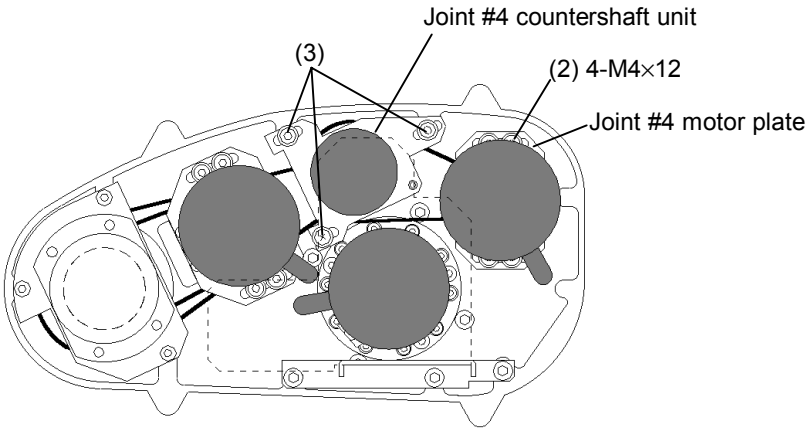
(7) The mechanical origin position and teach points change when the timing belt is replaced. After the U1 belt replacement, calibrate Joint #3 and Joint #4 as described in *11. Calibration*.

8.3 Replacing the U2 Belt

Removal : U2 belt

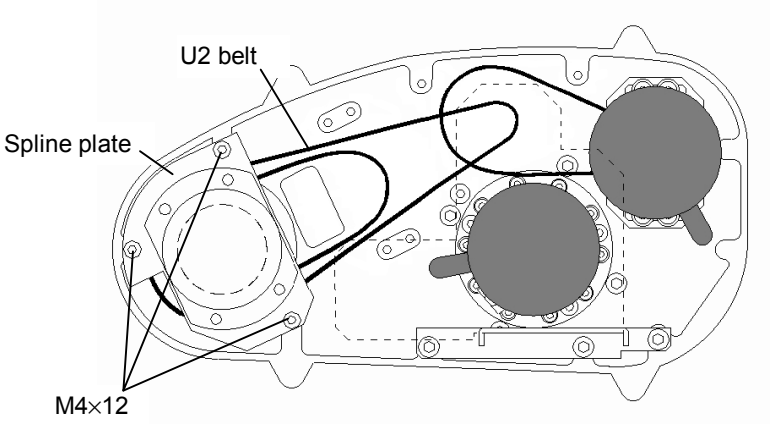
(1) Remove the Joint #3 motor unit as described in *5.3 Replacing the Joint #3 Motor*, steps (1) through (4).

(2) Loosen the four bolts (M4×12) holding the Joint #4 motor plate.



(3) Loosen the three bolts (2-M4×12 bolts and M5×8 screw) holding the Joint #4 countershaft unit and remove the unit.

(4) Remove the bolts (3-M4×12) from the spline plate to lift the spline plate, and pull the U2 belt out of the shaft upward.

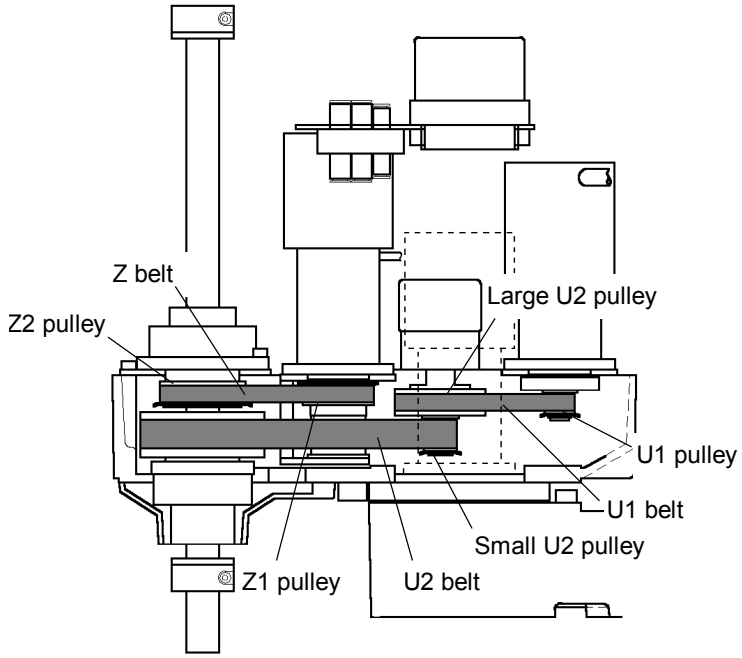


Installation : U2 belt

(1) Pass the new U2 belt through the shaft from above, and lift the spline plate to make U2 belt through.

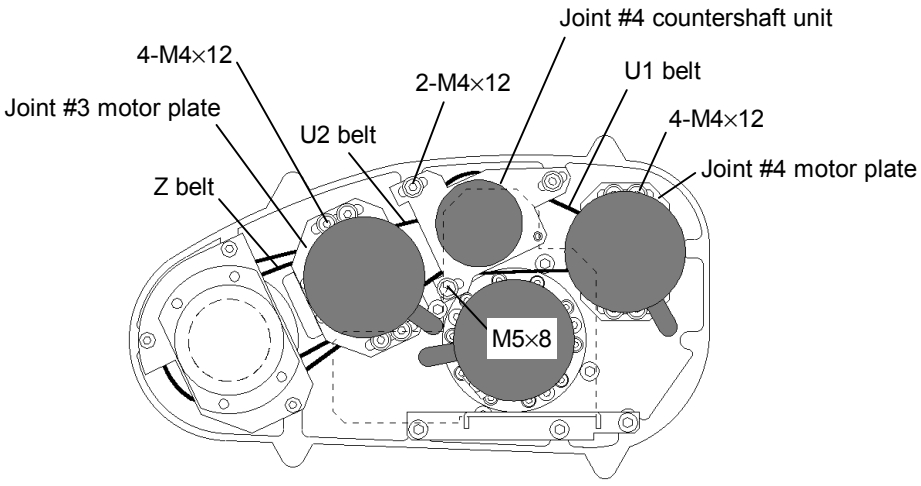
(2) Place the Joint #3 motor unit in the arm. The motor cables should be facing Joint #2.

(3) Fit the new U2 belt around the U3 and the small U2 pulleys. And, fit the Z belt around the Z2 and the Z1 pulleys. Ensure that the gear grooves of the belts and pulleys engage properly.

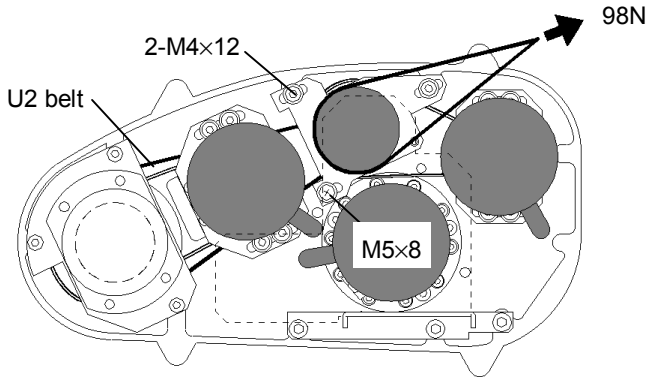


(4) Secure the spline plate with three bolts (M4×12).

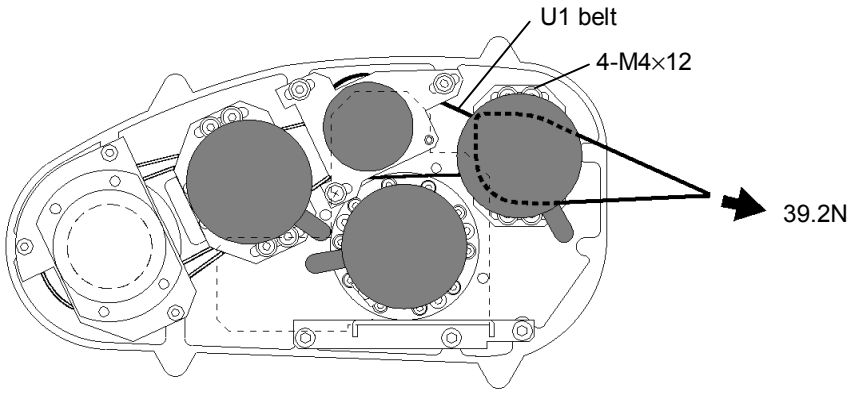
(5) Position the Joint #3 motor plate, Joint #4 countershaft unit and Joint #4 motor plate on the arm. Be careful not to slip the belts from the pulleys while maintaining proper interval between the units. Secure them loosely for the time being using the following bolts: 4-M4×12 for the Joint #3 motor plate; 2-M4×12 and M5×8 screw for the Joint #4 countershaft unit; 4-M4×12 for the Joint #4 motor plate.



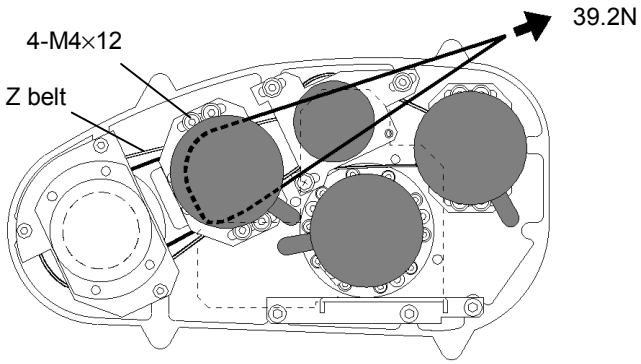
(6) Pass a suitable cord or string around the Joint #4 countershaft near its countershaft plate. Loosen the bolts for the Joint #4 countershaft plate fastened in the step (5) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 countershaft securely where the U2 belt is pulled at 98N (10kgf). Adjust in the range of 89N - 107N (9kgf - 11kgf).



(7) Pass a suitable cord or string around the Joint #4 motor near its mounting plate. Loosen the bolts for the Joint #4 motor plate fastened in the step (5) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(8) Pass a suitable cord or string around the Joint #3 motor near its mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (5) and pull the cord using a force gauge or similar tool. Fasten the Joint #3 motor plate securely where the Z belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(9) Connect the connectors, X131, X31, and X32.

(10) Fasten the cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(11) Install the arm cover. (Refer to chapter *2. Opening the Covers*.)

(12) The mechanical origin position and teach points change when the timing belt is replaced. After the U2 belt replacement, calibrate Joint #3 and Joint #4 as described in *11. Calibration*.

9. Replacing the Ball Screw Spline Unit

⚠ WARNING

- Only trained personnel should be allowed to maintain this unit. Trained personnel are those who have taken a robot training course held by the dealer or those who have carefully read the manuals and have equivalent knowledge and skill.
- When replacing this unit, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock or malfunction.

NOTE

When the motor and timing belts are removed while replacing the ball screw spline unit, the mechanical origin position and teach points change. (The mechanical origin position is offset from the position saved in the Control Unit's memory.) The operation to offset the mechanical origin is called calibration.

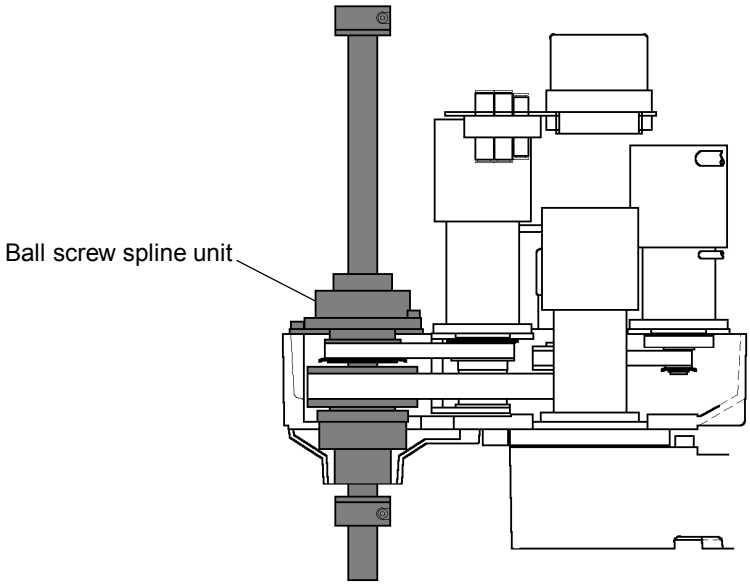
For calibration, the most suitable point to check the calibration accuracy must be selected from the set teach points. Refer to chapter *11. Calibration*, which details the calibration procedure.

Types of ball screw spline units

There are two types of ball screw spline units. Specify the manipulator series and relevant stroke of Joint #3 when ordering a ball screw spline unit for replacement.

Name	Stroke of Joint #3	Specification	Old code	New code
Ball screw spline unit for EC**1S	120 mm	BNS1616AE-315LC5	ZA001210	R13ZA00121000
Ball screw spline unit for EC**1C	100 mm	BNS1616AE-315LC5/CL	ZA001213	R13ZA00121300

Location of the ball screw spline unit



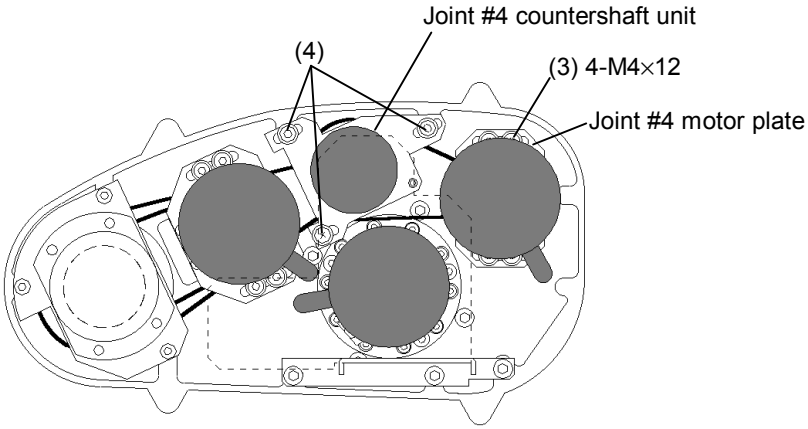
9.1 Replacing the Ball Screw Spline Unit

Removal

(1) Remove the end effector from the shaft.
*If the manipulator is a Clean model, remove the bellows. Refer to the "*12. Clean Model*".

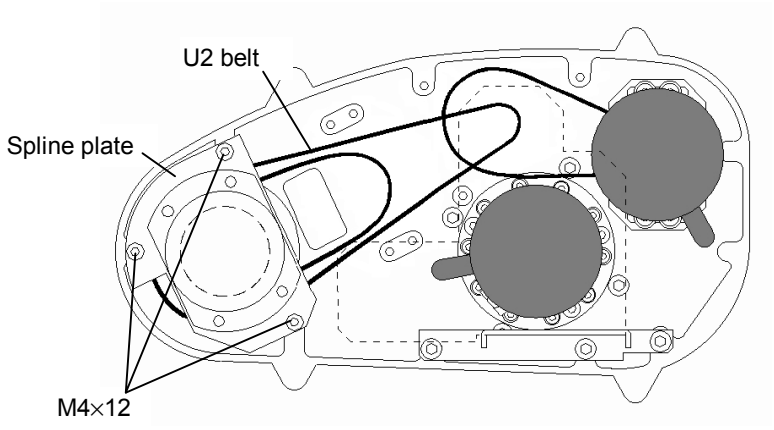
(2) Remove the Joint #3 motor unit (refer to the removal step (1) through (4) in *5.3 Replacing the Joint #3 Motor*).

(3) Loosen the four bolts (M4×12) holding the Joint #4 motor plate.

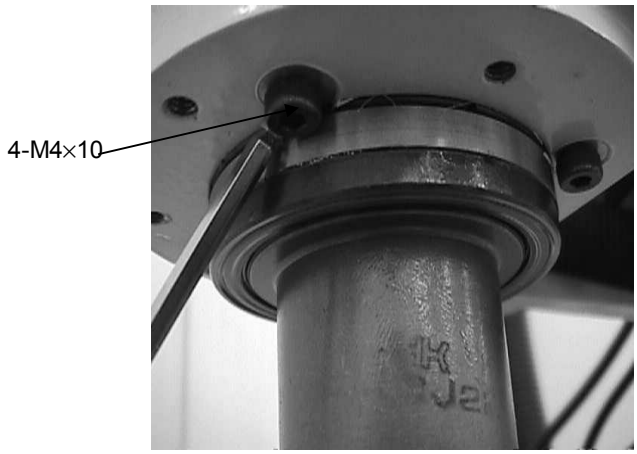


(4) Loosen the three bolts (2-M4×12 bolts and M5×8 screw) holding the Joint #4 countershaft unit.

(5) Remove the bolts (3-M4×12) from the spline plate to lift the spline plate, and pull the U2 belt out of the shaft upward.

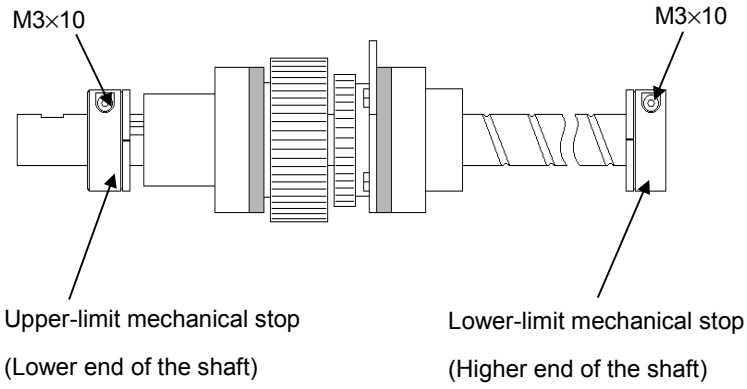


(6) Remove the four bolts (M4×10) from the ball screw spline shaft which is under Arm #2.



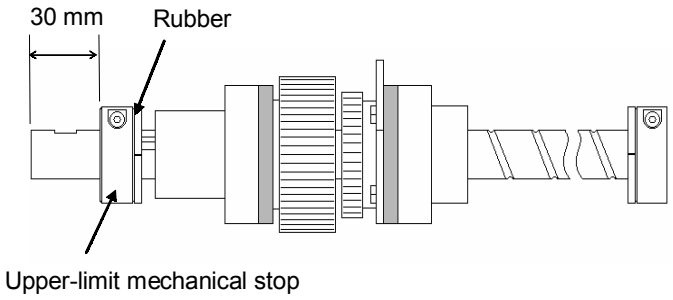
(7) Pull up the ball screw spline unit and remove it from Arm #2.

(8) Remove the upper-limit and lower-limit stops from the removed ball screw spline unit. To do so, loosen the bolt (M3×10) at each stop and pull the stops out of the shaft.

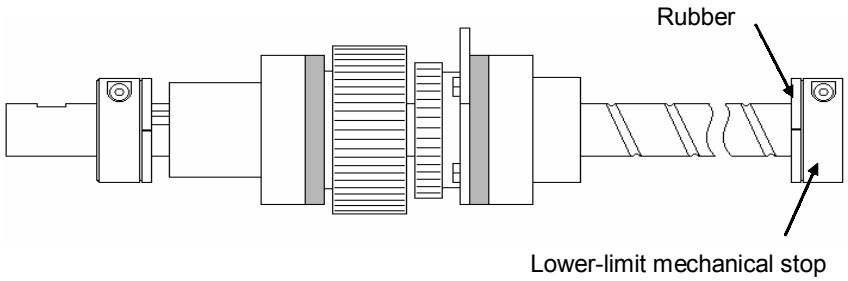


Installation

(1) Install the upper-limit mechanical stop at the lower end of the new ball screw spline unit's shaft. The mechanical stop should be pierced into the shaft from the rubber side first. When it is pierced into the shaft by 30mm (see illustration below), secure it with a bolt (M3×10). When fastening the bolt, apply 245N·cm (25kgf·cm) torque to it.

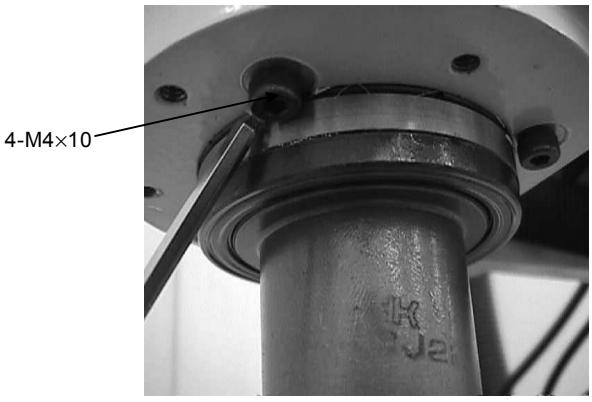


(2) Install the lower-limit mechanical stop at the higher end of the shaft. Have the stop pierced from the rubber side first into the shaft, level the end surfaces of the shaft and stop, and fasten with the bolt (M3×10). When fastening the bolt, apply 245N·cm (25kgf·cm) of torque. If the lower-end stop is positioned elsewhere to limit the motion area/range, fasten it at the proper position to that limit (refer to chapter *8. Motion Range and Robot Coordinates* in Part 1).

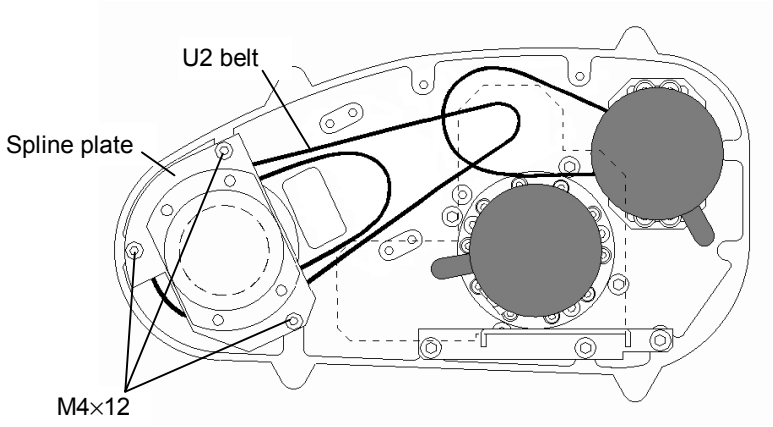


(3) Fit the U2 and Z belts into the shaft. Place the ball screw spline unit inside the arm.

(4) Fasten the four bolts (M4×10) at the ball screw spline unit under the arm. Beware so that the timing belts will not be pinched between the nut and arm.



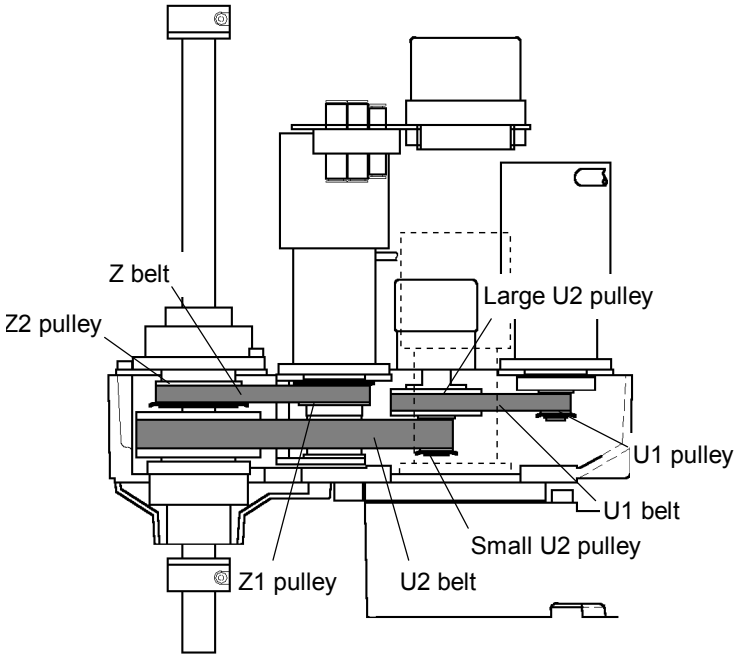
(5) For the time being, loosely fasten three bolts (M4×12) on the spline plate.



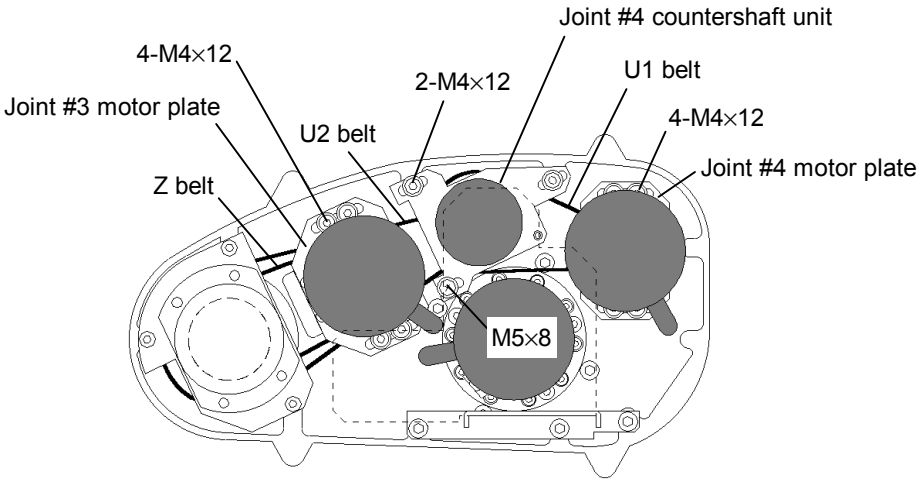
(6) Move the shaft up and down several times and fasten the bolts at the spline plate (loosely fastened before) securely.

(7) Place the Joint #3 motor unit and the Joint #4 countershaft unit in the arm. The Joint #3 motor cables should be facing Joint #2.

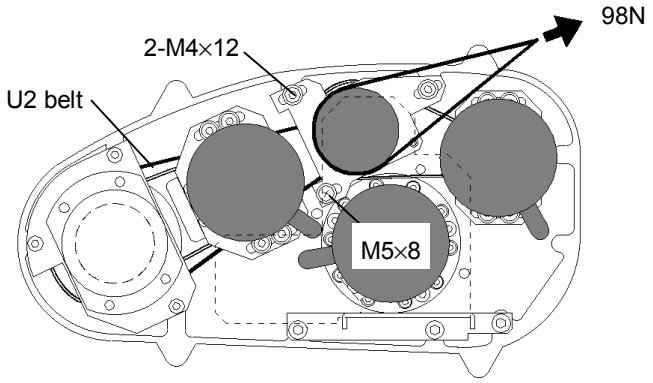
(8) Fit the belts around the pulleys as shown below. Ensure that the gear grooves of the belts and pulleys are engaging properly.



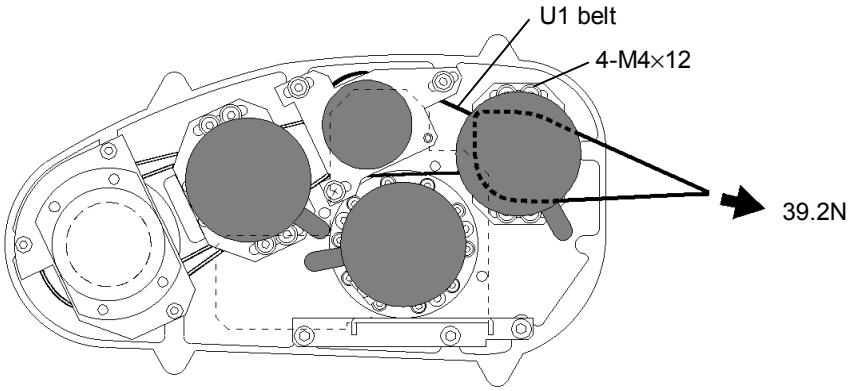
(9) Position the Joint #3 motor plate, Joint #4 countershaft unit and Joint #4 motor plate on the arm. Be careful not to slip the belts from the pulleys while maintaining proper interval between the units. Mount them loosely for the time being using the following bolts: 4-M4×12 for the Joint #3 motor plate; 2-M4×12 and M5×8 screw for the Joint #4 countershaft unit; 4-M4×12 for the Joint #4 motor plate.



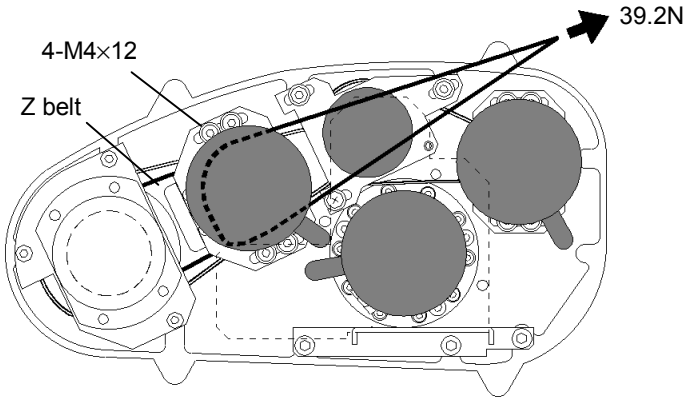
(10) Pass a suitable cord or string around the Joint #4 countershaft near its countershaft plate. Loosen the bolts for the Joint #4 countershaft plate fastened in the step (9) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 countershaft securely where the U2 belt is pulled at 98N (10kgf). Adjust in the range of 89N - 107N (9kgf - 11kgf).



(11) Pass a suitable cord or string around the Joint #4 motor near its motor mounting plate. Loosen the bolts for the Joint #4 motor plate fastened in the step (9) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(12) Pass a suitable cord or string around the Joint #3 motor near its motor mounting plate. Loosen the bolts for the joint #3 motor plate fastened in the step (9) and pull the cord using a force gauge or similar tool. Fasten the Joint #3 motor plate securely where the Z belt is pulled at 39.2N (4kgf). Adjust in the range of 30N - 49N (3kgf - 5kgf).



(13) Connect the connectors, X131, X31, and X32. Fasten the cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(14) Install the arm cover. (Refer to chapter *2. Opening the Covers*.)

(15) Grease the shaft (refer to *9.2 Greasing the Ball Screw Spline Unit* on the following page).

(16) Install the end effector.

(17) The mechanical origin position and teach points change when the timing belts are replaced. Calibrate Joint #3 and Joint #4. Refer to chapter *11. Calibration*.

9.2 Greasing the Ball Screw Spline Unit

When greasing the ball screw spline unit, follow the procedure on this page.

*If the manipulator is a Clean Model, refer to “12. Clean Model”.

RC+

SPEL 95

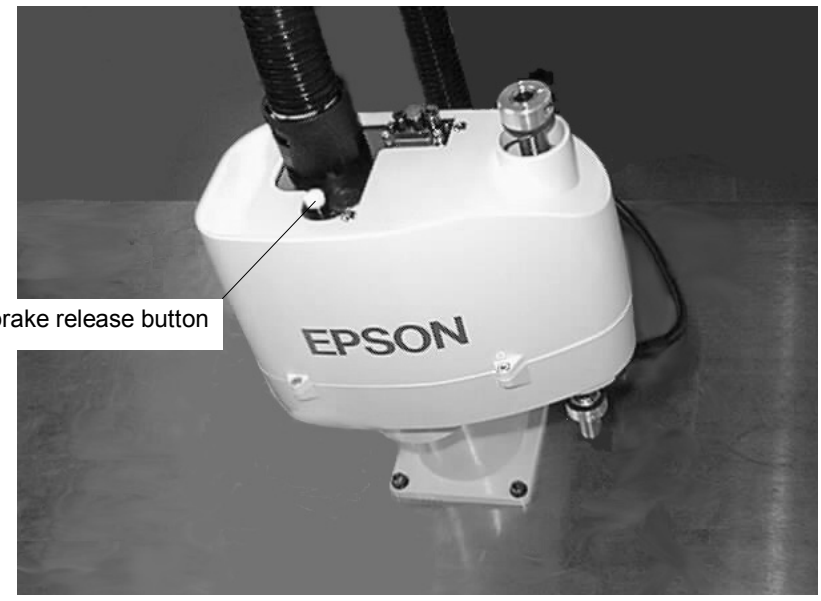
(1) Disengage the motors from servo control using the motor <OFF> button on the [Robot control] panel and keep the Drive Unit power ON.

300

(1) Disengage the motors by the MOTOR OFF command while keeping the Controller power ON.

(2) Move the arm to a position where Joint #3 can be moved in full stroke. If necessary, cover the surrounding area so that grease will not damage the end effector and peripheral equipment, etc.

(3) Push the Joint #3 brake release button. Joint #3 can be moved while this button is pushed. Push down the shaft to the lower limit.



(4) Fill the grooves on the lower end of this shaft with grease.

(5) Pull up the shaft to the highest position while pushing the brake release button.

(6) Fill the grooves on the upper end of this shaft with grease.

(7) Move the shaft up and down several times to smooth out the grease on the shaft. Wipe off the excess grease.

10. Replacing the Signal Relay Board

WARNING

- Only trained personnel should be allowed to maintain this board
- When replacing this board, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock or malfunction.

NOTE

Before turning OFF the power, keep the manipulator ON for more than 30 minutes. It is necessary to do so in order to charge the super-capacitor of each motor for retaining the position data.

The charged motor can retain the position data for about 2 hours in case its cable is disconnected. (Motors for whose serial number starts with "0" can retain the data for about 2 days.)

The position data cannot be retained beyond the time duration mentioned above after which it will be lost. If this happens, Error 195/5016 will occur when the power is turned ON. In this case, all the joints need to be calibrated all over again. (Refer to chapter *11. Calibration*.)

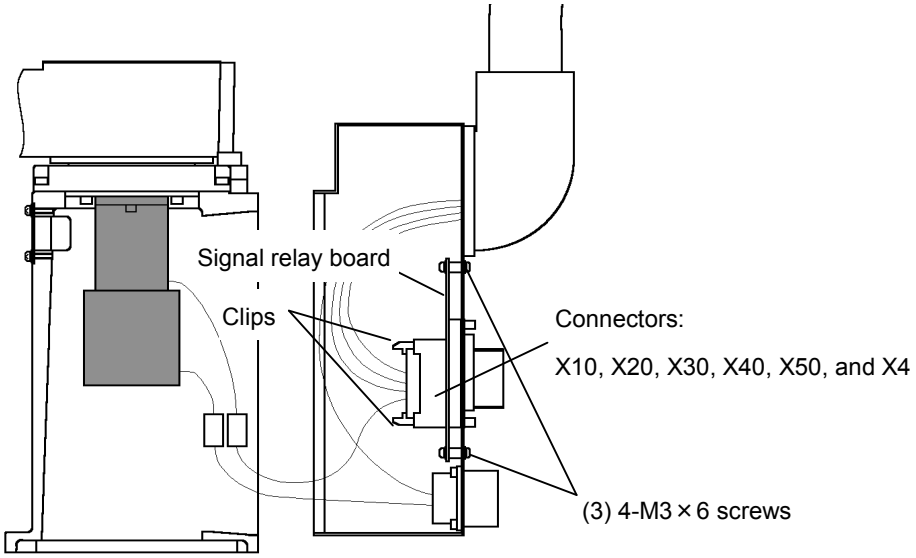
10.1 Replacing the Signal Relay Board

Removal

(1) Disconnect cables from the base connector box. Pull the base connector box forward. (Refer to chapter *2. Opening the Covers*.)

(2) Remove all connectors from the signal relay board. Open the top and bottom clips and pull off connectors, X10, X20, X30, X40, X50, and X4.

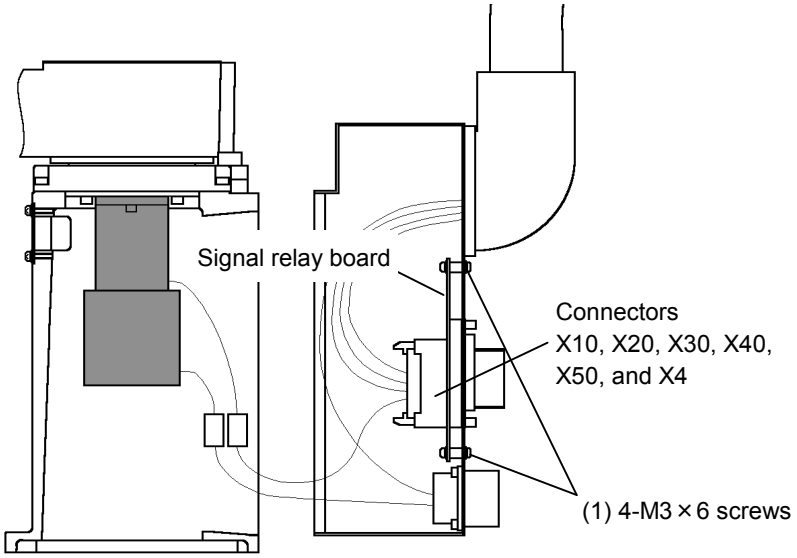
NOTE ☞ For manipulators whose Serial number starts with "1", their motors must be connected to the signal relay board of the new cable unit within 2 hours. Otherwise, the motors will lose position data and it will be necessary to calibrate again.



(3) Remove the four screws (M3×6) from the signal relay board on the base connector box and remove the relay board.

Installation

(1) Install the new signal relay board onto the base connector box with four M3×6 screws.



(2) Securely connect the connectors X10, X20, X30, X40, X50 and X4.

> **⚠ CAUTION**
>
> ■ Be sure to connect the signal connectors correctly and securely. Do not bend the cables sharply or damage them in any way. Abnormal signals may cause the malfunction of the robot to deviate dangerously from normal operation.

(3) Mount the base connector box on the back of the manipulator. (Refer to chapter *2. Opening the Covers*.)

(4) Connect the cables to the base connector box.

(5) Turn ON the Drive Unit / Controller power and test it with a few teach points to make sure that the teach positions have not been offset. When you have confirmed that the position data has been retained, replacement is complated. If there is any position found to be offset, calibrate the manipulator by referring to *11. Calibration.*

10.2 Replacing the Lithium Battery

When the lithium battery power is low, an error will occur when EPSON RC+ / SPEL 95(SRC5**) / SRC-3** starts to warn the user about the low battery status. When this happens, the position data of the motors will be lost and all joints need to be calibrated all over again. (refer to chapter *11. Calibration.*)

The life of the lithium battery is 3 years. Even if the manipulator is constantly connected to power, it is necessary to replace the lithium battery every 3 years.

NOTE

The manipulator must be connected to power for more than 30 minutes before the lithium battery is to be replaced.

Each motor's super-capacitor must be charged to retain position data in memory. The motor can retain position data for about 2 hours after being disconnected from the battery on the signal relay board. (The motors for those manipulators whose serial number starts with "0" can retain position data for about 2 days.) If the motor is disconnected from the battery for more than the above hold-time, the position data will be lost and errors will occur when software is started.

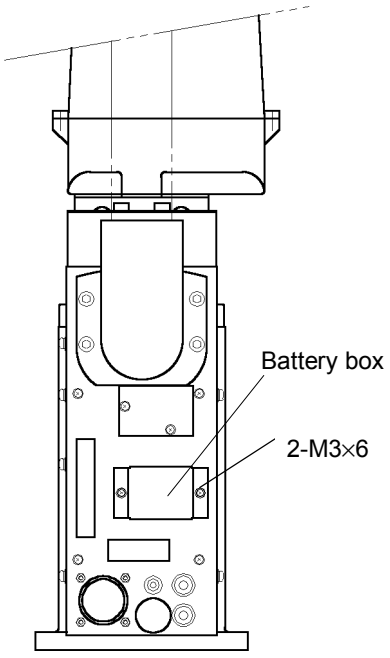
RC+	: Error 5016
SPEL 95(SRC5**)	: Error 5016
SRC-3**	: Error 195

When this happens, all the joints must be recalibrated (refer to chapter *11. Calibration*).

Removal

(1) Disconnect the cables from the base connector box.

(2) Remove the two screws (M3×6) from the battery box.



(3) Disconnect X60 connector of the battery unit.

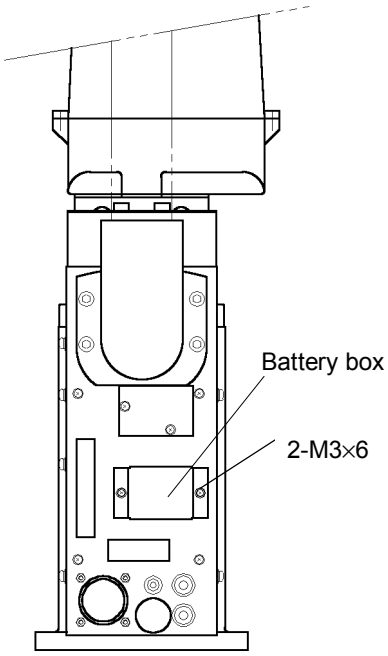
(4) Cut off the wire ties securing the lithium battery unit to remove it.

Installation

(1) Connect the X60 connector of the new battery unit.

(2) Secure the battery unit to the battery box with the wire ties.

(3) Using two screws (M3×6), install the battery box onto the base connector box.



(4) Connect the cables to the base connector box.

(6) Turn ON the Drive Unit/Controller power and test it with a few teach points to make sure that the teach positions have not been offset. When you have confirmed that position data has been retained properly, battery replacement is complete. If there is any position found to be incorrect, calibrate the manipulator by referring to chapter *11. Calibration*.

11. Calibration

The electrical and mechanical origins for each joint motor must be calibrated to ensure proper operation of the robot. The origin position changes when motors are replaced or belts are adjusted, and the previously used teach points are lost.
The process of realigning the origin position is called “origin calibration”.

This chapter includes calibration instructions for three different controller types, designated by the following icons:

RC+	Procedure when using EPSON RC+ Robot Control System.
SPEL 95	Procedure when using SPEL 95 / SRC5** controllers.
300	Procedure when using SRC-3** controllers.

Refer to section in this chapter that pertains to the controller you are using.

11.1 Calibration for EPSON RC+ Controller

Refer to the EPSON RC+ on-line help for details of commands used in this section.

NOTE

During the following steps, you may have to open the safeguard to gain access to the manipulator, depending on the system setup. With the safeguard open, the manipulator motors will turn OFF unless attend mode is ON. When executing Monitor Window commands, attend mode must be OFF.

Common procedure for calibration

RC+

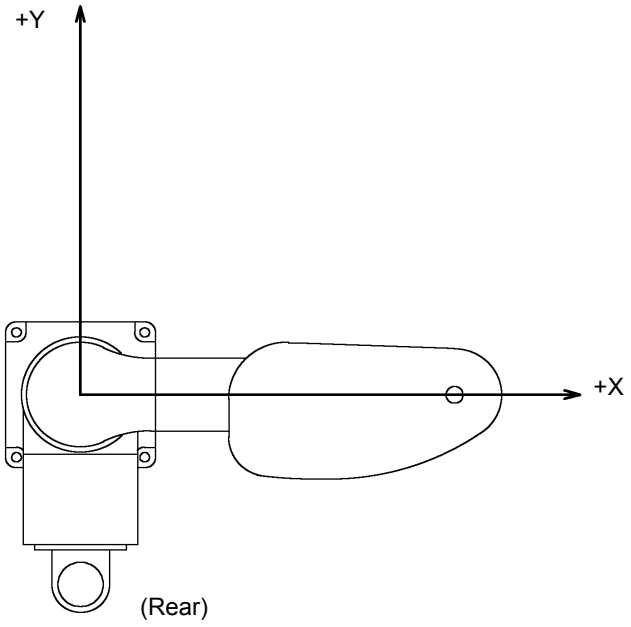
For EC series manipulators, calibration steps (1) to (10) are the same for all four joints.

(1) Turn ON the power of the RC520 Drive Unit and RC520 PC Control Unit after moving all joints to within motion range. Check if an error occurs. If an error does not occur, proceed to next step.

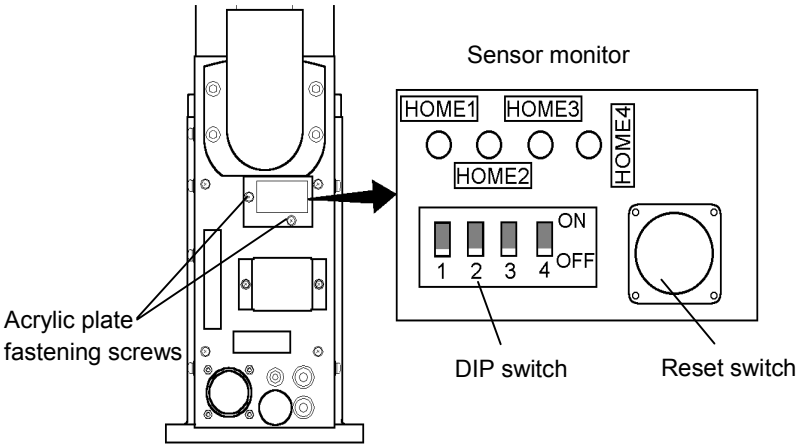
Error F-5001 occurs when the capacitor in the motor encoder is insufficiently charged because, for example, the motor is new. To change the capacitor, leave the power ON for 3 or more minutes.

(2) Manually move joints to be calibrated into approximately the 0 pulse position.

Joint #1 : 0 pulse position : aligned with X-axis in robot coordinate system (see the figure below).
Joint #2 : 0 pulse position : parallel with Arm #1 (i.e., straight) regardless of Joint #1 direction.
Joint #3 : 0 pulse position : uppermost position in working area.
Joint #4 : 0 pulse position : flat surface on the shaft facing in the top of Arm #2 direction.



(3) Open the acrylic plate on the sensor monitor on the base connector box.



(4) Set the DIP switch bits corresponding to the joints to be calibrated to the ON position.

(5) Hold down the reset switch for at least one second.

(6) Right click on the SPEL Runtime Drivers system tray icon and select Restart SPEL Drivers. Open the [Robot Control Panel] dialog and click the Motor <ON> button. Error F-5136 will be displayed. Click the <RESET> button. The error should clear.

(7) Return all DIP switch bits to the OFF position.

(8) Close the acrylic plate on the sensor monitor.

(9) Visually determine the current position, and enter that as the 0 pulse position using the CALPLS command.

```
> CALPLS 0,0,0,0
```

(10) Execute CALIB commands for the joints requiring point alignment.

<Example>

```
> CALIB 1                          ' Calibrate Joint #1.
```

From this point forward, the method used for Joint #3 differs from that used with Joint #1, #2 and #4. To continue, refer to the corresponding section below.

NOTE ☞ Joint #3 should be calibrated before other joints. Joint #3 can interfere with the calibration of other joints if it is too low.

Calibrating Joint #3

RC+

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) Select a current teach point, which is easy to verify for accuracy, and move the robot to that point using servo control. Because of the error due to origin offset, the same position will not be obtained. Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Joint #1 motor: ±4.5°
One revolution of the Joint #2 motor: ±7.2°
One revolution of the Joint #3 motor: ±13.4 mm
One revolution of the Joint #4 motor: ±31.6°

We will use P1 in these steps. Move Joint #3 above this point using the JUMP command.

<Example>
```
> JUMP P1:Z(0)                ' Set Joint #3 high to prevent interference with surrounding machinery.
```

(12) Display the coordinates of this position with the PLIST command and note the [C] value.

<Example>
```
> PLIST 1
P1 = [A], [B], [C], [D] /0
```

(13) Calculate the number of Joint #3 pulses at this point from the coordinate value that was noted in step (11). Multiply [C] by the Joint #3 resolution (307.2 pulse/mm) and round off after the decimal point. This value is called [E].

`[E] = [C] × 307.2` (Round E off after the decimal point)

(14) Substitute the [E] value using the CALPLS command and input. [E] is always negative.

```
> CALPLS 0,0,[E],0
```

(15) Using the Jog & Teach dialog, jog Joint #3 to the original position.

(16) Execute the CALIB command for Joint #3.

```
> CALIB 3
```

(17) Display the number of pulses at this position using the PULSE command and check that it matches the value of [E] obtained in step (13) above.

```
<Example>
>PULSE
PULSE: [a] pls [b] pls [c] pls [d] pls
```

(18) Move to another teach point and check the position.

Calibrating Joint #1, #2, and #4

RC+

Joint #1, #2 and #4 are all calibrated by the same method. Calibrating two or more joints at the same time can affect accuracy. For best accuracy, calibrate each joint one at a time.

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) For each joint, select a current teach point that is easy to verify for accuracy, and move the robot to that point using servo control. Because of the error due to origin offset, the same position will not be obtained. Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Joint #1 motor: ±4.5°

One revolution of the Joint #2 motor: ±7.2°

One revolution of the Joint #4 motor: ±31.6°

We will use P1 in these steps. Move Joint #3 above this point using the JUMP command.

<Example>

```
> JUMP P1:Z(0)                    ' Set Joint #3 high to prevent interference with
                                    surrounding machinery.
```

(12) Display the number of pulses at this position using the PULSE command and note the four values.

<Example>

```
> PULSE
PULSE 16000 pls 10000 pls     0 pls    -10 pls
```

(13) Enter the numbers noted in step (12) using the CALPLS command.

<Example>

```
> CALPLS 16000,10000,0,-10
```

(14) Use the SFREE command to free the joint being calibrated and Joint #3.

<Example>

```
> SFREE 1,3                       ' Joints #1 and #3 can now be moved manually.
```

(15) Manually move the joint to be calibrated, and determine the proper original position. When moving Joint #3, move while pushing the Joint #3 break release button.

(16) Execute the CALIB command for the Joint to be calibrated.

<Example>

```
> CALIB 1                         ' Joint #1 is calibrated.
```

(17) Display the number of pulses in this position using the PULSE command and check that they match the values obtained in step (12) on previous page.

<Example>

```
>PULSE
PULSE: 16000  pls 10000 pls     0  pls   -10  pls.
```

(18) Restore servo control to the calibrated joint with the SLOCK command.

<Example>

```
>SLOCK 1,3                          ' Joints #1 and #3 is under servo control.
```

(19) Move to another teach point and check the position.

Accurate calibration of Joint #2

RC+

For accurate calibration of Joint #2, calculation of robot working point coordinates is most important in the following cases.

- Entering coordinate values to register the teach point. (MDI teaching)
- Switching the arm orientation between right and left at a given point.
- Using the PALLET command.
- During CP control (such as linear or circular interpolation).
- Using the LOCAL command.
- For statements using relative coordinates < Example, `P1+X100` >.

If the methods above require accuracy of Joint #2, then calibrate for both right and left arm orientations. Note that this method cannot be used if Joint #4 has excessive run-out.

(1) Display HOFS values using the HOFS command and note the [A], [B], [C], and [D] values.

<Example>

```
>HOFS
[A], [B], [C], [D]            ' HOFS values for Joint #1 - #4.
```

(2) Select a point for teaching that is within the region accessible to both right and left arm and is easy to verify for accuracy. Define P1 using the following statement.

<Example>

```
> P1=P*
```

(3) Display the number of pulses at the P1 position using the PULSE command. Note the Joint #2 value [F1].

<Example>

```
> PULSE
PULSE: [E] pls [F1] pls [G] pls [H] pls
```

(4) Switch positioning of left and right orientation and move to the same point.

<Example>
```
> MOTOR ON
> JUMP P1:Z(0)/L          ' To change from right to left orientation.
                          ' (Use /R at end of statement for left to right)
> SFREE                   ' All joints can now be moved manually.
```

(5) The position in left orientation mode is different from the position in right orientation mode. This gap must be adjusted manually after lowering Joint #3 to P1 position. In order to lower Joint #3 to P1, push Joint #3 down while pushing the brake release button. Then execute SLOCK.

```
> SLOCK                   ' All joints are under servo control.
```

(6) Display the number of pulses at the P1 position again using PULSE, and note the Joint #2 value [F2].

<Example>
```
>PULSE
PULSE: [E] pls [F2] pls [G] pls [H] pls
```

(7) Calculate the new HOFS value from the values that were noted: add the left and right pulse numbers [F1] and [F2], then add to [B] in step (1) on previous page, and take the mid-way value. Incorporate + and - signs in the calculation. The new HOFS value is called [I].

```
> I = B + (F1 + F2) / 2
```

(8) Substitute [I] in the HOFS command and execute. For other joint values, use the values that were noted in step (1) above.

```
> HOFS [A], [I], [C], [D]
```

(9) Move to another teach point and confirm the position.

11.2 Calibration for SPEL 95 / SRC5** Controller

Refer to the on-line help of SPEL 95 for details of commands used in this section.

Common procedure for calibration

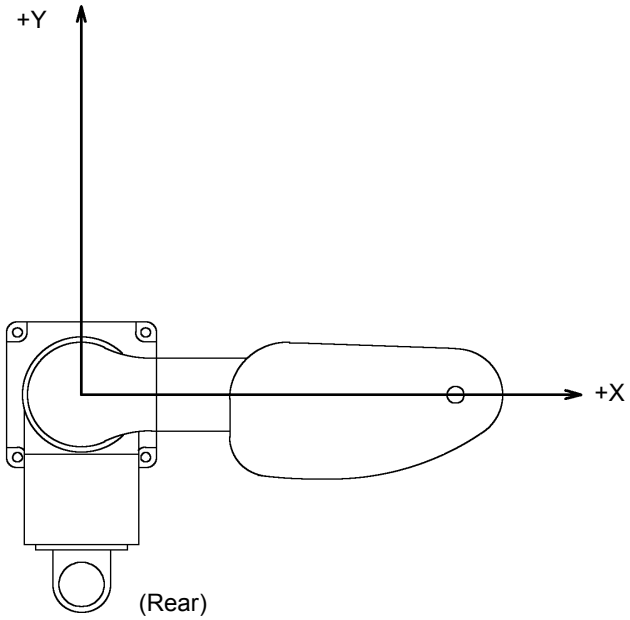
SPEL 95

For the EC series manipulators, calibration steps (1) to (10) are the same for all four joints.

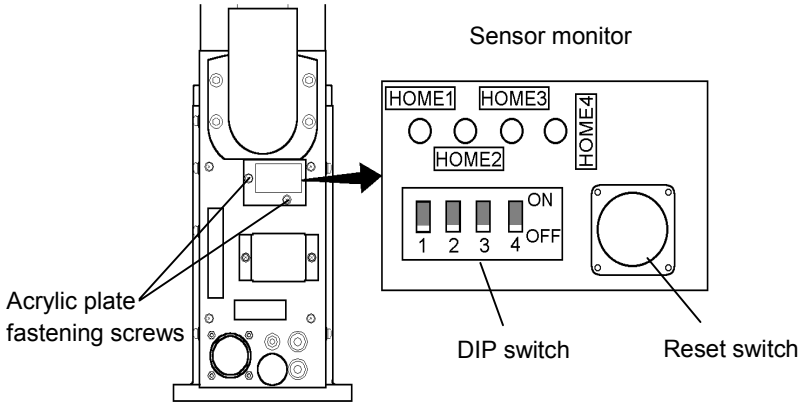
(1) Turn ON the power of the robot after moving all joints into the motion range. Confirm that an error occurs. If an error does not occur, proceed to next step.
Error F-5001 occurs when the capacitor in the motor encoder is insufficiently charged because, for example, the motor is new. To change the capacitor, leave the power ON for 3 or more minutes. (The error display does not change.)

(2) Manually move joints to be calibrated into approximately the 0 pulse position.

Joint #1 : 0 pulse position :	aligned with X-axis in robot coordinate system (see the figure below).
Joint #2 : 0 pulse position :	parallel with Arm #1 (i.e., straight) regardless of Joint #1 direction.
Joint #3 : 0 pulse position :	uppermost position in working area.
Joint #4 : 0 pulse position :	flat surface on the shaft facing in the top of Arm #2 direction.



(3) Open the acrylic plate on the sensor monitor on the base connector box.



(4) Set the DIP switch bits corresponding to the joints to be calibrated to the ON position.

(5) Hold down the reset switch for at least one second.
(The error display does not change.)

(6) Exit SPEL 95, and then start it again. Open the [Robot Control Panel] dialog and click the Motor <ON> button. Error F-5136 will be displayed. Click the <RESET> button. The error should clear.

(7) Return all DIP switch bits to the OFF position.

(8) Close the acrylic plate on the sensor monitor.

(9) Visually determine the current position, and enter that as the 0 pulse position with the CALPLS command

```
> CALPLS 0,0,0,0
```

(10) Execute the CALIB command for the joints requiring point alignment.

<Example>

```
>CALIB 1                          ' Calibrate Joint #1.
```

From this point forward, the method used for Joint #3 differs from that used with Joint #1, #2, and #4. To continue, refer to the corresponding section below.

Calibrating Joint #3

SPEL 95

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

NOTE

Joint #3 should be calibrated before other joints. Joint #3 can interfere with the calibration of other joints if it is too low.

(11) Select a current teach point, which is easy to verify for accuracy, and move the robot to that point using servo control.

Because of the error due to origin offset, the same position will not be obtained.
Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Joint #1 motor: ±4.5°
One revolution of the Joint #2 motor: ±7.2°
One revolution of the Joint #3 motor: ±13.4 mm
One revolution of the Joint #4 motor: ±31.6°

We will use P1 in these steps. Move Joint #3 above this point using the JUMP command.

<Example>

```
>JUMP P1:Z(0)                    'Set Joint #3 high to prevent interference with
                                  surrounding machinery.
```

(12) Display the coordinates of this position with the PLIST command and note the [C] value.

<Example>

```
>PLIST 1
P1=[A],[B],[C],[D]
```

(13) Calculate the number of Joint #3 pulses at this point from the coordinate value which was noted in step (12). Multiply [C] by the Joint #3 resolution (307.2 pulse/mm) and round off after the decimal point. This value is called [E].

[E] = [C] × 307.2 (Round E off after the decimal point)

(14) Substitute the [E] value using the CALPLS command and input. [E] is always negative.

```
>CALPLS 0,0,[E],0
```

(15) Move Joint #3 with the jog key and determine the proper original position.

(16) Execute the CALIB command for Joint #3.

```
>CALIB 3
```

(17) Display the number of pulses at this position using the WHERE command and check that it matches the value of [E] obtained in step (13) above.

<Example>
```
>WHERE
Pulse 1:[a] 2:[b] 3:[c] 4:[d]        ' Joints #1 - #4 pulses.
```

(18) Move to another teach point and check the position.

Calibrating Joint #1, #2, and #4

SPEL 95

Joint #1, #2, and #4 are all calibrated by the same method. Calibrating two or more joints at the same time can affect accuracy. For best accuracy, calibrate each joint one at a time.

First, perform steps (1) to (10) in the Common procedure for calibration section.

(11) For each joint, select a current teach point that is easy to verify for accuracy, and move the robot to that point using servo control. Because of the error due to origin offset, the same position will not be obtained. Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Joint #1 motor: ±4.5°
One revolution of the Joint #2 motor: ±7.2°
One revolution of the Joint #4 motor: ±31.6°

We will use P1 in these steps. Move Joint #3 above this point using the JUMP command.

<Example>
```
> JUMP P1:Z(0)          ' Set Joint #3 high to prevent interference with
                          surrounding machinery.
```

(12) Display the number of pulses at this position using the WHERE command and note the four values.

<Example>
```
> WHERE
pulse 1:16000  2:10000  3:0  4:-10     ' Joints #1 - #4 pulses.
```

(13) Enter the numbers noted in step (12) using the CALPLS command.

<Example>
```
>CALPLS 16000,10000,0,-10
```

(14) Use the SFREE command to free the joint being calibrated and Joint #3.

<Example>
```
> SFREE 1,3                  ' Joints #1 and #3 can now be moved manually.
```

(15) Manually move the joint to be calibrated, and determine the proper original position. When moving Joint #3, move while pushing the Joint #3 break release button.

(16) Execute the CALIB command for the joint to be calibrated.

<Example>
```
>CALIB 1                    ' Joint #1 is calibrated.
```

(17) Display the number of pulses at this position using the WHERE command and check that they match the values obtained in step (12) above.

<Example>
```
>WHERE
 Pulse 1:16000  2:10000  3:0  4:-10   'Joints #1 - #4 pulses.
```

(18) Use the SLOCK command to put the free joints back under servo control.

<Example>
```
>SLOCK 1,3          ' Joints #1 and #3 are now under servo control
```

(19) Move to another teach point and check the position.

Accurate calibration of Joint #2

SPEL 95

For accurate calibration of Joint #2, calculation of robot working point coordinates is most important in the following cases.

- Entering coordinate values to register working point for teaching. (MDI teaching)
- Switching the arm mode between right and left at a given point.
- Using the PALLET command.
- During CP control (such as liner or circular interpolation).
- Using the LOCAL command.
- For statements using relative coordinates < Example, `P1+X100` >.

If the above methods do not obtain the required accuracy of Joint #2, calibrate for both right and left arm orientations. Note that this method cannot be used in the event of run-out due to rotation of Joint #4.

(1) Display HOFS values using the HOFS command and note the [A], [B], [C], and [D] values.

<Example>
```
>HOFS
[A]   [B]                  ' HOFS values for Joints #1 and #2.
[C]   [D]                  ' HOFS values for Joints #3 and #4.
```

(2) Select a point for teaching that is within the region accessible to both right and left orientation and is easy to verify for accuracy. Define P1 using the following statement.

<Example>
```
>P1=P*
```

(3) Display the number of pulses at the P1 position using the WHERE command. Note the Joint #2 value [F1].

<Example>
```
> WHERE
Pulse 1:[E] 2:[F1] 3:[G] 4:[H]          ' Joints #1 - #4 pulses.
```

(4) Switch positioning of left and right orientation and move to the same point.

<Example>
```
> MOTOR ON
> JUMP P1:Z(0)/L          ' To change from right to left orientation.
                          ' (/R at end of statement for left to right)
> SFREE                   ' All joints can now be moved manually.
```

(5) The position in left orientation mode is different from the position in right orientation mode. This gap must be adjusted manually after lowering Joint #3 to P1 position. In order to lower Joint #3 to P1, push Joint #3 down while pushing the brake release button. Then execute SLOCK.

```
> SLOCK                   ' All joints are under servo control.
```

(6) Display the number of pulses at the P1 position again using WHERE, and note the Joint #2 value [F2].

<Example>
```
> WHERE
Pulse 1:[E] 2:[F2] 3:[G] 4:[H]      ' Joints #1 - #4 pulses.
```

(7) Calculate the new HOFS value from the values that were noted: add the left and right pulse numbers [F1] and [F2], add to [B] in step (1) above, and take the mid-way value. Incorporate + and - signs in the calculation. The new HOFS value is called [I].

```
> I = B + (F1 + F2) / 2
```

(8) Substitute [I] using the HOFS command and input. For other joint values, use the values that were noted in step (1) on previous page.

```
> HOFS [A],[I],[C],[D]
```

(9) Move to another teach point and confirm the position.

11.3 Calibration for SRC-3** Controllers

Refer to the SPEL for Windows online help for details on the commands used in this section.

Common procedure for calibration

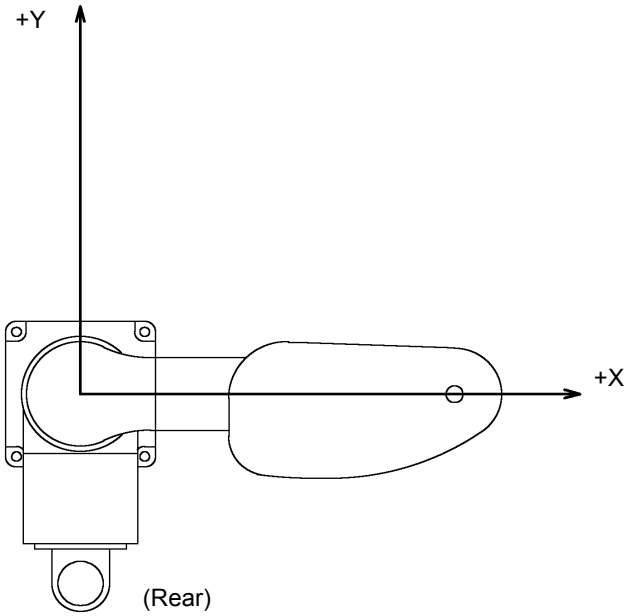
300

For the EC series manipulators, calibration steps (1) to (10) are the same for all four axes.

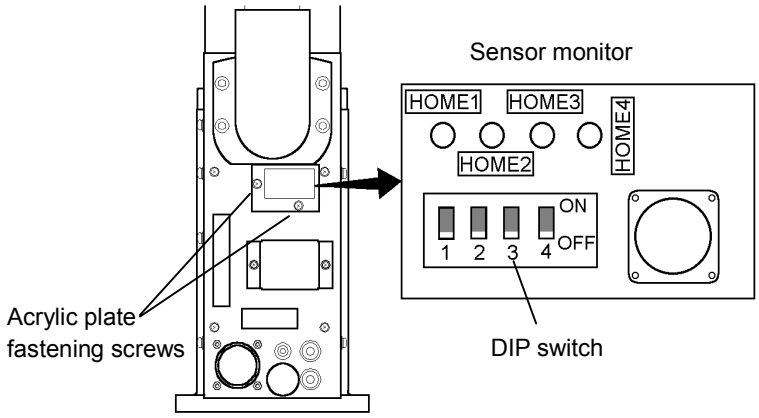
(1) Turn ON the power of the controller after moving all axes into the motion range. Confirm that an error occurs. If an error does not occur, proceed to next step.
Error 195 occurs when the capacitor in the motor encoder is insufficiently charged because, for example, the motor is new. To change the capacitor, leave the power ON for 3 or more minutes.

(2) Manually move axes to be calibrated into approximately the 0 pulse position.

Joint #1 : 0 pulse position	:	aligned with X-axis in robot coordinate system (see the figure below).
Joint #2 : 0 pulse position	:	parallel with Arm #1 (i.e., straight) regardless of Axis #1 direction.
Joint #3 : 0 pulse position	:	uppermost position in working area.
Joint #4 : 0 pulse position	:	flat surface on shaft tip facing in the top of Arm #2 direction.



(3) Open the acrylic plate on the sensor monitor on the base connector box.



(4) Set the DIP switch bits corresponding to the axes to be calibrated to the ON position.

(5) Hold down the reset switch for at least one second. (The error display does not change.)

(6) Turn the controller power OFF and ON again. Error 165 will be displayed. Repeat power cycle. The error should clear.

(7) Return all DIP switch bits to the OFF position.

(8) Close the acrylic plate on the sensor monitor.

(9) Visually determine the current position, and enter that as the 0 pulse position with the CALPLS command.

```
> CALPLS 0,0,0,0
```

(10) Execute CALIB commands for axes requiring point alignment.
<Example>

```
>CALIB 1                    ' Calibrate Axis #1.
```

From this point forward, the method used for the Axis #3 differs from that used with Axis #1, #2, and #4.

NOTE ☞ The Axis #3 should be calibrated before other axes. The Axis #3 can interfere with the calibration of other axes if it is too low.

Calibrating Axis #3

300

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) Select a current teach point, which is easy to verify for accuracy, and move the robot to that point using servo control. Because of the error due to origin offset, the same position will not be obtained. Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Axis #1 motor: ±4.5°
One revolution of the Axis #2 motor: ±7.2°
One revolution of the Axis #3 motor: ±13.4 mm
One revolution of the Axis #4 motor: ±31.6°

We will use P1 in these steps. Move Axis #3 above this point using the JUMP command.
<Example>

```
> JUMP P1:Z0                    ' Set the Axis #3 high to prevent interference
                                  with surrounding machinery.
```

(12) Display the coordinates of this position with the PLIST command and note the [C] value.

<Example>

```
> PLIST 1
P1 = [A], [B], [C], [D] /0
```

(13) Calculate the number of Axis #3 pulses at this point from the value which was noted in step (12). Multiply the [C] by Axis #3 resolution (307.2 pulse/mm) and round off after the decimal point. This value is called [E].

`[E] = [C] × 307.2` (Round E off after the decimal point)

(14) Substitute the [E] value using the CALPLS command and execute. [E] is always negative.

```
> CALPLS 0,0,[E],0
```

(15) Move Axis #3 with the jog key and determine the proper original position.

(16) Execute the CALIB command for Axis #3.

```
>CALIB 3
```

(17) Display the number of pulses at this position using the PULSE command and check that it matches the value of `[E]` obtained in step (13) on previous page.

<Example>

```
> PULSE
[a]   [b]                     ' Axes #1and #2 pulses.
[c]   [d]                     ' Axes #3 and #4 pulses.
```

(18) Move to another teach point and check the position.

Calibrating Axes #1, #2, and #4

300

Axes #1, #2 and #4 are all calibrated by the same method. Calibrating two or more axes at the same time can affect accuracy. For best accuracy, calibrate each axis one at a time.

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) For each Axis, select a current teach point that is easy to verify for accuracy, and move to that point. Because of the error due to origin offset, the same position will not be obtained. Although the error is less than one revolution of the motors, care should be taken to avoid interference with surrounding machinery.

One revolution of the Axis #1 motor: ±4.5°
One revolution of the Axis #2 motor: ±7.2°
One revolution of the Axis #4 motor: ±31.6°

We will use P1 in these steps. Move Axis #3 above this point using the JUMP command.

<Example>

```
> JUMP P1:Z0                    ' Set Axis #3 high (Z0) to prevent interference
                                  with surrounding machinery.
```

(12) Display the number of pulses in this position using the PULSE command and note the four values.

<Example>

```
> PULSE
16000  10000                    ' Axes #1 and #2 pulses.
   0    -10                     ' Axes #3 and #4 pulses.
```

(13) Enter the numbers which were noted in step (12) using the CALPLS command.

<Example>

```
> CALPLS 16000,10000,0,-10
```

(14) Use the SFREE command to free the axis to being calibrated and Axis #3.

<Example>

```
> SFREE 1,3                     ' Axes #1 and #3 can now be moved manually.
```

(15) Manually move the axis to be calibrated, and determine the proper original position. When moving Axis #3, move while pushing the brake release button for Axis #3.

(16) Execute the CALIB command for the axis to be calibrated.

<Example>

```
> CALIB 1                       ' Axis #1 is calibrated.
```

(17) Display the number of pulses in this position using the PULSE command and check that they match the values obtained in step (12) above.

<Example>
```
> PULSE
16000   10000                ' Axes #1 and #2 pulses.
    0     -10                ' Axes #3 and #4 pulses.
```

(18) Use the SLOCK command to put the free axes back under servo control.

<Example>
```
>SLOCK 1,3                   ' Axes #1 and #3 are under servo control.
```

(20) Move to another teach point and check the position.

Accurate calibration of Axis #2

For accurate calibration of Axis #2, calculation of robot working point coordinates is most important in the following cases.

- Entering coordinate values to teach a point.
- Switching the arm orientation between right and left at a given point.
- Using the PALET command.
- During CP control (such as liner or circular interpolation).
- Using the LOCAL command.
- For statements using relative coordinates. < Example, `P1+X100` >

If the methods above require accuracy of Axis #2, then calibrate for both right and left arm orientations. Note that this method cannot be used if Axis #4 has excessive run-out.

(1) Display HOFS values using the HOFS command and note values [A], [B], [C], and [D].

<Example>
```
> HOFS
[A]  [B]                    ' HOFS values for Axes #1 and #2.
[C]  [D]                    ' HOFS values for Axes #3 and #4.
```

(2) Select a point for teaching that is within the region accessible to both right and left arm and is easy to verify for accuracy. Carry out teaching and call the point P1.

<Example>
```
> P1=P*
```

(3) Display the number of pulses at the P1 position using the PULSE command. Note the Axis #2 value `[F1]`.

<Example>
```
> PULSE
[E]  [F1]                   ' Axes #1 and #2 pulses.
[G]  [H]                    ' Axes #3 and #4 pulses.
```

(4) Switch the arm mode from right to left and move to the same point.

<Example>
```
> MOTOR ON
>JUMP P1:Z0/L          ' To change from right to left arm.
                       ' (/R at end of statement for left to right)
> SFREE                ' All axes can now be moved manually.
```

(5) The position with left arm mode is different from the position with right arm mode. This gap must be adjusted manually after lowering Axis #3 to the P1 position. In order to lower Axis #3 to P1, push Axis #3 down while pushing the brake release button.

```
> SLOCK                ' All axes are under servo control.
```

(6) Display the number of pulses at the P1 position again using PULSE, and note the axis #2 value [F2].

<Example>
```
> PULSE
[E]  [F2]              ' Axes #1 and #2 pulses.
[G]  [H]               ' Axes #3 and #4 pulses.
```

(7) Calculate the new HOFS value from the values which ware noted previously: add the left and right pulse values [F1] and [F2], add to [B] in step (1) on previous page, and take the mid-way value. Incorporate + and - signs in the calculation. The new HOFS value is called [I].

```
> I = B + (F1 + F2) / 2
```

(8) Substitute [I] using the HOFS command and execute. For other axis values, use the values that were noted in step (1) above.

```
>HOFS [A], [I], [C], [D]
```

(9) Move to another teach point and confirm the position.

12. Clean Model Maintenance

The Clean model for the EC series includes additional features that reduce dust emitted by the manipulator to enable use in clean room environments (see NOTE). This chapter describes the differences between the EC series Standard and Clean models.

NOTE Clean model requirements specify a maximum of 10 particles (0.13 μm or more in diameter) in 28317 cm^3 (1cft) sample-air around the center of the motion range.

12.1 Greasing the Ball Screw Spline Unit

For basic information about the ball screw spline unit, refer to chapter *9. Replacing the Ball Screw Spline Unit*.
Follow the standard specifications concerning the type of grease to use and the areas to be greased. Note that the bellows must be removed before greasing the shaft.

NOTE Removing the bellows to enable greasing emits a large amount of dust. Therefore, take the unit to an outer room such as the room in front of the clean room's entrance, or set up a dust emission prevention device before removing the bellows in the clean room.

NOTE When greasing, do not allow any grease to get on the outside of the bellows. Grease may drip. Cover peripheral units with a sheet if necessary.

RC+ SPEL 95

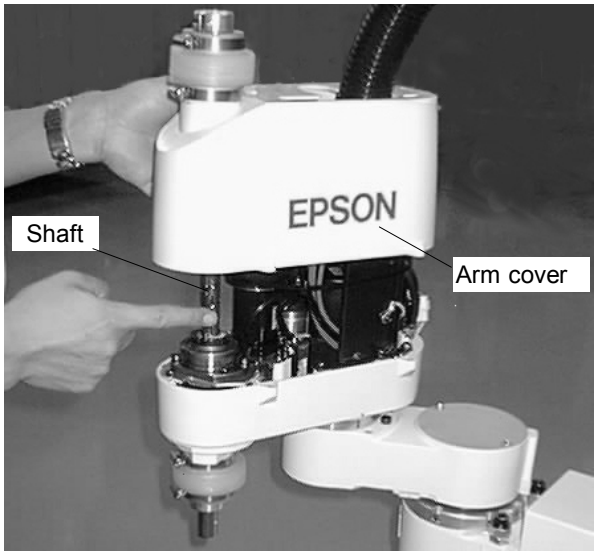
(1) Disengage the motors by the motor <OFF> button while keeping the Drive Unit power ON.

300

(1) Disengage the motors by the motor <OFF> button while keeping the Controller power ON.

(2) Joint #3 can be moved up and down while pushing the brake release button. Push the shaft all the way up to the upper limit.

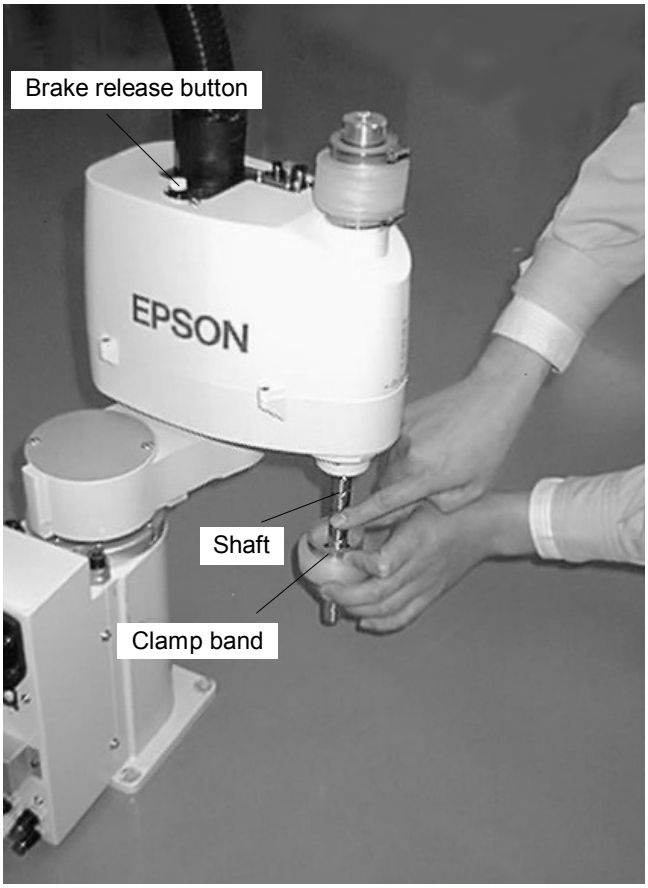
(3) Open the arm cover to lift up the cover. (Refer to chapter *2. Opening the Covers*.)



(4) Fill the groove of the ball screw spline shaft with grease. Apply it directly by hand. Wipe off excess grease from the shaft.

(5) Push the shaft all the way down to the lower limit while pushing the brake release button.

(6) Remove the lower bellows, use a screwdriver to loosen the clamp band at the top of the lower bellows, and then slide the lower bellows downward.



(7) Fill the groove of the ball screw spline shaft in the lower bellows with grease by hand. Wipe off excess grease from the shaft.

(8) Move the shaft up and down several times to spread grease all over the shaft while pushing the brake release button. Wipe off excess grease from the shaft.

(9) Reattach the arm cover. (Refer to chapter *2. Opening the Covers*.)

(10) Reattach the lower bellows, lift the top of the bellows until it covers at least 10 mm of the cylindrical part of the arm cover, then turn the clamp band screws to fasten it.

12.2 Replacing the Bellows

If the bellows should become damaged, follow the steps described below for replacing them. The replacement method is the same for both the upper and lower bellows.

NOTE

Removing the bellows to enable greasing emits a large amount of dust. Therefore, take the unit to an outer room, such as the room in front of the clean room's entrance, or set up a dust emission prevention device before removing the bellows in the clean room.

RC+ SPEL 95

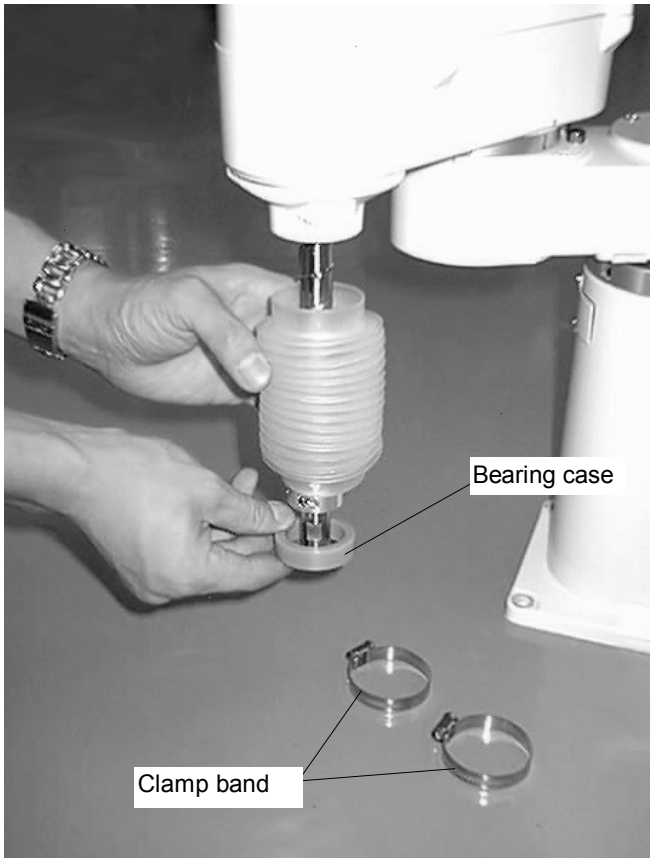
(1) Disengage the motors using the motor <OFF> button while keeping the Drive Unit power ON.

300

(1) Disengage the motors by the MOTOR OFF command while keeping the Controller power ON.

(2) Using a screwdriver, loosen the screw of the clamp band that secures the upper bellows and lower bellows. (See the greasing diagram on the previous section.)

(3) Remove the bellows from the cover, and then slide the bellows toward the end of shaft.



(4) Remove the bearing case from the old bellows. The bearing case's larger hole fits onto the cover side and its smaller hole fits onto the shaft side.

(5) Attach the bearing case on the new bellows.

(6) Slide the wide end of the bellows over the shaft first. The wide end of the bellows should be slid past the cover by at least 10 mm, over which the clamp should be fastened.

(7) Attach the blue plastic casing on the shaft where the bellows are to be secured and bring the bellows over so that the bellows are covering the base of the shaft before fastening the bellow's end with the clamp band. Fasten the screw of the clamp band on the arm tip side.

You may want to adjust the position of Joint #3 relative to Arm #2 to facilitate easier mounting of the bellows. Joint #3 can be moved up and down manually while pushing the brake release button.

(8) After attaching the bellows, push and hold the brake release button on the top of the cover and manually raise and lower Joint #3, rotate Joint #4, and make sure that the bellows can expand and contact smoothly, without requiring excessive force.

13. Maintenance Parts List

13.1 Maintenance Parts for All Models

(S/N : Serial Number)

Name			New code	Old code	NOTE
AC servo motor	Joint #1	S/N: 0*****	R13ZA00062200	ZA000622	100W-ABS
		S/N: 1*****	R13ZA00062700	ZA000627	
	Joint #2	S/N: 0*****	R13ZA00061300	ZA000613	
		S/N: 1*****	R13ZA00062400	ZA000624	
	Joint #3	S/N: 0*****	R13ZA00061300	ZA000613	
		S/N: 1*****	R13ZA00062400	ZA000624	
	Joint #4	S/N: 0*****	R13ZA00061200	ZA000612	50W-ABS
		S/N: 1*****	R13ZA00062300	ZA000623	
Reduction gear unit	Joint #1		R13ZA00101000	ZA001010	SHF-17-50
	Joint #2		R13ZA00101100	ZA001011	SHF-17-50
Cable unit	EC251*		R13ZA00204600	ZA002046	MPI11100600
	EC351*		R13ZA00204700	ZA002047	MPI11100500
Power cable			R13ZA00200200	ZA002002	3 m the standard
Signal cable			R13ZA00200300	ZA002003	3 m the standard
Z belt			R13ZA00322000	ZA003220	252-2GT-8
U1 belt			R13ZA00322100	ZA003221	224-2GT-8-T434N1
U2 belt			R13ZA00322200	ZA003222	366-2GT-15-T434N1
U2 pulley			R13ZA003B0200	ZA003B02	MMEC000-15-**
Signal relay board			R13ZA00450400	ZA004504	SKP337-1
Battery Unit			R13ZA00600300	ZA006003	E97-035-**
Brake	Joint #3		R13ZA00350100	ZA003501	ERS-135L
Brake release switch	Joint #3		R13Z702640100	Z7026401	AB2M-M1W
Grease	Ball screw spline shaft		R13ZA00330200	ZA003302	AFB grease (400 g)
	Joint #1 reduction gear		R13ZA00330100	ZA003301	SK-1A (500 g)
	Joint #2 reduction gear		R13ZA00330400	ZA003304	SK-2 (500 g)
Liquid gasket			R13ZA00371000	ZA003710	RTV

13.2 Maintenance Parts for Standard-model

Name	New code	Old code	Specification	NOTE
Ball screw spline unit	R13ZA00121000	ZA001210	BNS1616AE-315LC5	For Standard model

13.3 Maintenance Parts for Clean-model

Name	New code	Old code	Specification	NOTE
Ball screw spline unit	R13ZA00121300	ZA001213	BNS1616AE-315LC5/CL	For Clean model, without bellows
Round bellows	R13ZA00370600	ZA003706	ϕ62－ϕ34×st.100	2 bellows