YAMAHA CARTESIAN ROBOT

YAMAHA
YAMAHA MOTOR CO., LTD.

HXYA SERIES
MXYA SERIES
SXYA SERIES

Owner's Manual

INTRODUCTION

The YAMAHA XYA series robots are cartesian coordinate system assembly robots using AC servomotors, developed based on years of YAMAHA experience and achievements in the automation field as well as efforts to streamline our in-house manufacturing systems. The XYA series consists of a manipulator comprising X and Y axis arms, and a robot controller (MRCA, QRCA or DRCA series). A vertical movement (Z axis) and rotary movement (R axis) at the tip of the manipulator are available as additional functions allowing control of a maximum of 4 axes. The robot can be used for a wide range of assembly applications such as installation and insertion of products, press-fitting of pins and bearings, application of sealant, and packing operations.

This instruction manual describes the safety measures, handling, adjustment and maintenance of XYA series robots for correct, safe and effective use. Be sure to read this manual carefully before installing the robot. Even after you have read this manual, keep it in a safe and convenient place for future reference.
This instruction manual should be used with the robot and considered an integral part of it. When the robot is moved, transferred or sold, ensure that this manual accompanies the robot, and explain to the new user the need to read through this manual.

For details on specific operation and programming of the robot, please refer to the instruction manual for the YAMAHA robot controller (MRCA, QRCA or DRCA series).

NOTE

- We reserve the right to make future product changes that might not be incorporated into this manual.
- We request the customer contact concerning any possible errors, omissions or misprints etc.

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CHAPTER 1

Safety

1 Safety Items

Industrial robots are highly programmable mechanical devices that provide a large degree of freedom for performing various manipulative tasks.
To ensure correct and safe use of YAMAHA industrial robots, FOLLOW THE WARNINGS, CAUTIONS AND ADVICE INCLUDED IN THIS MANUAL; TAKE ANY AND ALL PRECAUTIONS REQUIRED BY GOOD JUDGMENT WHEN USING THE ROBOT AND PERIPHERAL EQUIPMENT. Failure to take necessary safety measures or mishandling due to not following the information in this manual may result in trouble or damage to the robot and injury to personnel (robot operator or service personnel) including fatal accidents.

Warning, cautions or key information are identified in this manual by the following pictogram.

NOTE

A "NOTE" provides key information to make procedures easier or clearer.

CAUTION

A "CAUTION" indicates important safety items that must be followed to avoid damage to the robot or setting data.

WARNING

A "WARNING" indicates the most important safety items that must be observed to avoid injury to the robot operator or service personnel.

This indicates that the operator or any personnel must stand outside the movement area of the manipulator.

It is not possible to detail all safety items within the limited space of this manual. So it is essential that the user has a full knowledge of basic safety rules and also that the operator makes correct judgments on safety procedures during operation. Since the robot is commonly used in conjunction with an automated system, a dangerous situation is more likely to occur from the automated system than from the robot itself. Accordingly, appropriate safety measures must be taken on the part of the system manufacturer according to the individual system. The system manufacturer should provide a proper instruction manual for safe, correct operation and servicing of the system.

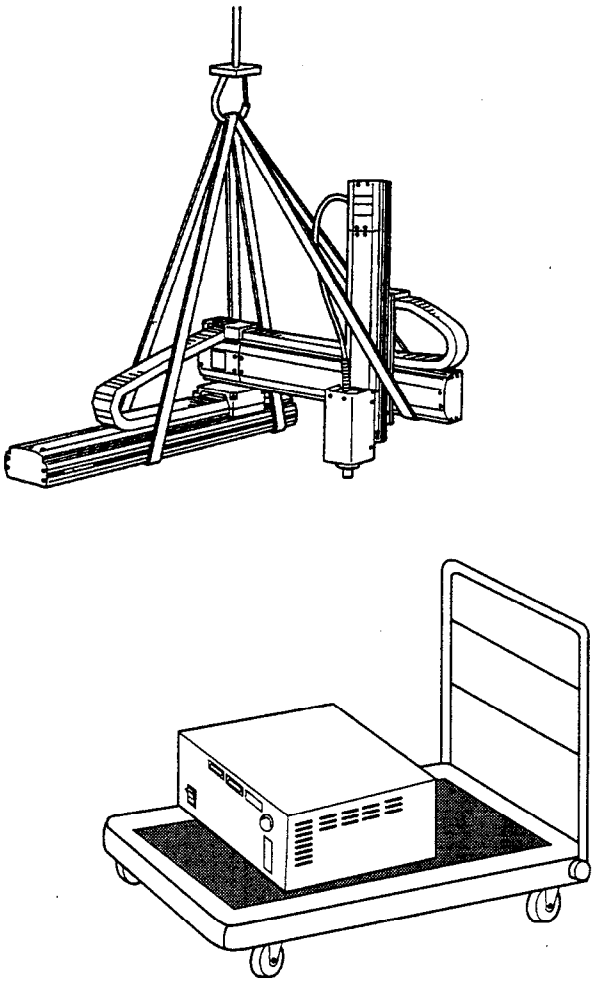
Furthermore, when there are domestic regulations and standards relating to the robot installation and operation not discussed in this manual, the user should have sufficient knowledge of such regulations and must observe them.

2 Safety Measures and Handling Precautions

2-1 Transportation

WARNING

- **Use of a hoist, carrying cart (dolly), or fork-lift is recommended for transporting the robot or controller (hereafter called equipment).**
- **Fasten the equipment securely to avoid injury or damage to the equipment during transportation. Handle the equipment gently in order not to apply any strong vibrations and shocks, while also taking sufficient care relating to the swing and balance of the equipment.**
- **When the equipment is carried by a machine or by transportation requiring a license, then only qualified personnel must handle it. The carrying machine and tools used should be serviced daily.**



Transporting the manipulator and controller with a hoist and carrying cart

2-2 Installation

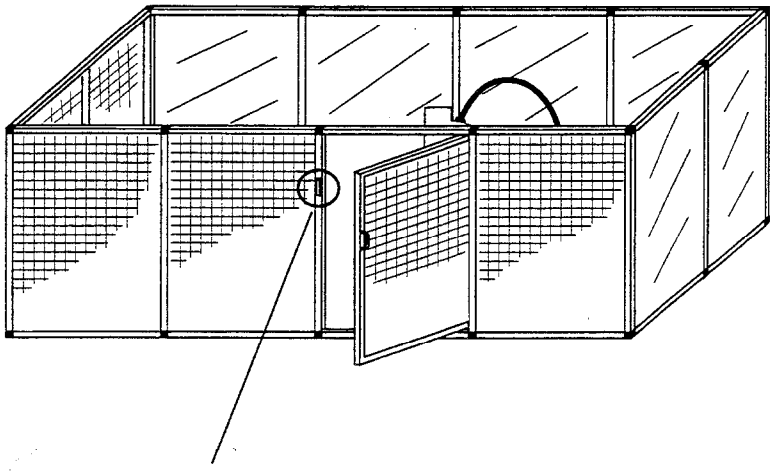
WARNING

- **Install the manipulator on a stable, flat floor. Ensure a space large enough to install, operate and service the manipulator, including an area to set up safe guards such asenclosures.**
- **Before beginning installation, check that the floor surface is clean, and obstacles and dangerous objects have been removed.**
- **The base used to install the manipulator must be rigid and stable enough to handle the manipulator weight and movement during operation. Bolt the base securely in place and also to the manipulator. If the base is not adequately rigid or stable, or is not securely bolted, vibration may occur during operation and degrade the work precision. In the worst case, this may cause the manipulator to fall over.**
- **Avoid installing the robot in locations where ambient temperature and humidity exceed the maximum rating. Fluctuations in the ambient temperature and humidity may cause deterioration of the parts and misoperation of the robot. It is therefore recommended that the robot be used in an air-conditioned room.**
- **Avoid using the robot in environments where oil, water, corrosive gases or metallic powder are generated. These may result in misoperation or short circuits.**
- **IMplement effective shielding if electromagnetic waves (RF) or electrostatic noise is generated near the robot. complete countermeasures against electromagnetic disturbance are not possible with current technology, so avoid using the robot in locations where such disturbances are most likely.**

2-3 System layout

WARNING

- **First of all, lay out the system to ensure that the operator and other personnel can operate or check out the robot in maximum safety.**
- **Safety guards or enclosures must be designed to provide room to adequately enclose the working area of the manipulator. Implement a gate-interlock mechanism for halting manipulator movement if the working area is violated.**
- **arrange The robot controller and programming unit (MPB or DPB) outside the safety guards, so that the operator can press the emergency stop button if any abnormal situation occurs.**
- **Lay out wiring and piping for the robot and peripheral devices neatly, in order to prevent the operator or any other persons from tripping on them. Cables should be connected in an adequate length, so that no excessive load is applied to the connectors by tension on the cables. (For details on connections to the controller, refer to the controller instruction manual.)**



Example of safety guards

2-4 Operation

Safety precautions for the operator

WARNING

- **All persons who are working with the robot must be trained in the safe and correct operation of the system.**
- **After carefully checking the surrounding area for safety, turn on the power to the controller and then use the MPB or DPB to start the manipulator.**
- **Always keep out of the working area (safety guards/ enclosures) while the robot is operating, even during dry run or warm-up operation.**
- **The operator should always be aware of possible manipulator movement and the surrounding area so that the emergency stop button can be pressed if any danger is noticed.**
- **During robot operation, place a conspicuous sign letting everyone know that the robot is in operation.**
- **Before entering the working area of the manipulator for setup or parts replacement, always press the emergency stop button to halt the robot operation. When control of the manipulator is not required, turn off the controller and also the external switch board.**
- **Do not use the robot in an area subject to in flammable gases, gasolines, solvents, etc.**
- **Provide other necessary safety measures according to the individual systems and applications. (For emergency stop and interlock inputs, refer to "Input/Output Interface" in the controller instruction manual.)**

Safety precautions for the robot

CAUTION

- When a new robot is installed, or after a robot has not been used for an extended period, allow a warm-up time of about 10 minutes without a workpiece installed. This will help improve functioning of the sliding parts.
- Do not allow the manipulator to handle a workpiece (including the tool) heavier than the maximum load listed in the catalog or do not change the setting data particularly entered for the robot, otherwise the robot may be damaged.
- There is a limit to the load that can be applied to the R axis. Always observe the specifications listed in this manual. (See 1-2 in Chapter 6.) If the robot exceeds these limits during operation, residual vibrations may occur during positioning and the drive parts may be damaged or the service life shortened.
- If the robot duty is too high, an "overload" or "overheat" error may occur. In this case, set a timer in the programming so as to lengthen the time during which the robot axis is at rest.
- Since YAMAHA robots employ the position control method, they cannot be used in applications which make use of the motor thrust (for example, press-fitting and burr removal). Do not use the robot in this manner.
- Provide other necessary safety measures in accordance with the manipulator tool to be used and the individual application.

2-5 Adjustment and maintenance

WARNING

- **Regular maintenance must be performed by or in the presence of personnel who have participated in the Robot Training Seminar given by YAMAHA or the YAMAHA Sales Representative.**
- **If the adjustment or maintenance procedure calls for operation of the robot, stay out of the working area of the manipulator while it is operating. Do not touch any parts inside the controller. Keep watching the manipulator movement and surrounding area so that the operator can press the emergency stop button if any danger occurs.**
- **When the robot does not need to be operated during adjustment or maintenance, always turn off the controller and the external switch board.**
- **Do not touch the internal parts of the controller for several seconds after the power to the controller has been turned off.**
- **When performing electrical maintenance which does not require manipulator movement, keep the emergency stop button pressed.**
- **Use only the lubricants or grease specified by YAMAHA or the YAMAHA sales representative. Take sufficient care not to allow any foreign matter to contaminate them during adjustment, parts replacement or reassembly.**
- **Drop the supply air pressure to "zero" before disassembling the pneumatic devices.**
- **Do not alter any part of the manipulator or controller. Doing so may result in unsatisfactory specifications or may threaten the safety of the operator.**
- **When adjustment or maintenance is complete, retighten the bolts or screws securely.**
- **During robot adjustment or maintenance, place a sign indicating that the robot is being adjusted or checked, to prevent other persons from inadvertently touching the control keys or switches. Provide a lock on the switch keys or ask someone to keep watch as needed.**

3 Warranty

YAMAHA Motor Co., Ltd. warrants the XYA series robot to be free from defects in material and workmanship. YAMAHA's obligation under this warranty is as follows:

Defective Parts

If any failure should arise in the YAMAHA genuine parts constituting the XYA series robot, due to defects in materials or workmanship, YAMAHA will repair or replace the said parts free of charge.

Warranty Period

This warranty is effective for a period of:
(1) one and a half years (18 months) after shipment from Japan, or
(2) one year after installation or
(3) 2,400 hours of actual operation
whichever comes first.

Exceptions to Warranty

This warranty will not apply in the following cases:

- Fatigue arising due to the passage of time, natural wear and tear through operation (natural fading of coated surfaces, deterioration of parts subject to wear)
- Minor natural phenomena which do not effect the capabilities of the robot (signal sound from the controller, rotational sound from the motors, etc.).
- Damage due to fire, earthquakes, storms, floods, snow or any other natural or manmade calamities.
- Modification to the robot not approved by YAMAHA or YAMAHA sales representatives.
- Use of any other than genuine parts and specified lubricant and grease.
- Insufficiency or errors in maintenance and repair.
- Repairs by other than authorized dealers.

"YAMAHA MOTOR CO., LTD. MAKES NO OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. THE WARRANTY SET FORTH ABOVE IS EXCLUSIVE AND IS IN LIEU OF ALL EXPRESSED OR IMPLIED WARRANTIES, INCLUDING WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES ARISING FROM A COURSE OF DEALING OR USAGE OF TRADE. YAMAHA MOTOR CO., LTD. SOLE LIABILITY SHALL BE FOR THE DELIVERY OF THE EQUIPMENT AND YAMAHA MOTOR CO., LTD. SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL DAMAGES (WHETHER ARISING FROM CONTRACT, WARRANTY, NEGLIGENCE OR STRICT LIABILITY). YAMAHA MOTOR CO., LTD. MAKES NO WARRANTY WHATSOEVER IN RESPECT TO ACCESSORIES OR PARTS NOT SUPPLIED BY YAMAHA MOTOR CO., LTD."

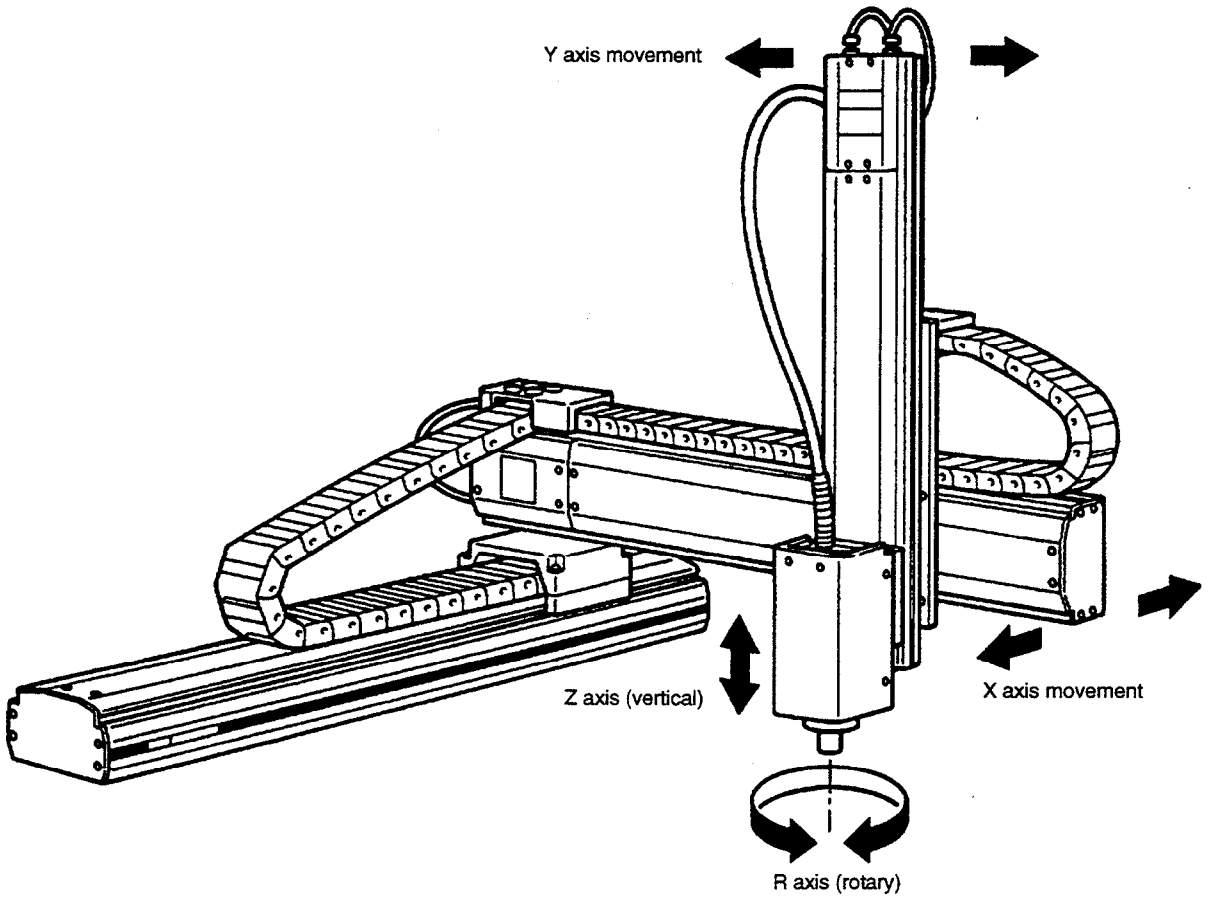
CHAPTER 2

The XYA Series Robot System

1 Manipulator

The XYA series manipulator is composed of the standard X and Y axes (horizontal cartesian slide), and also an optional Z axis (vertical slide) and R axis (rotary).

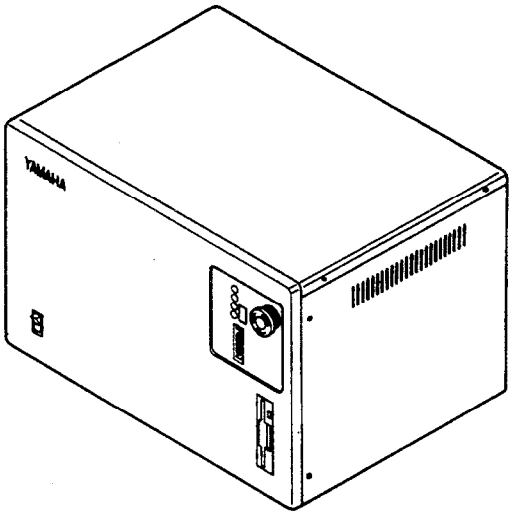
These four axes can operate as shown below. By attaching a work tool at the tip of the Z or R axis, a wide range of tasks can be performed with high precision at high-speed.



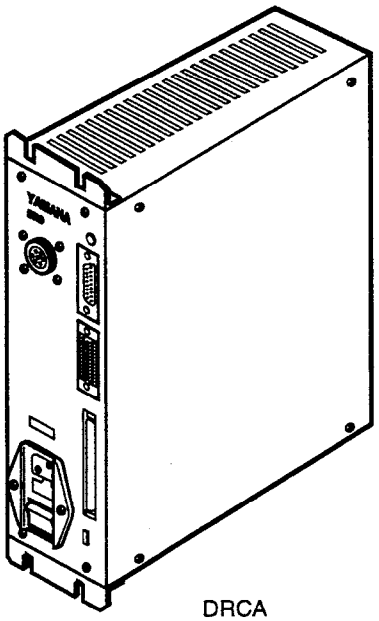
Manipulator movement (with the ZRLA unit)

2 Robot Controller

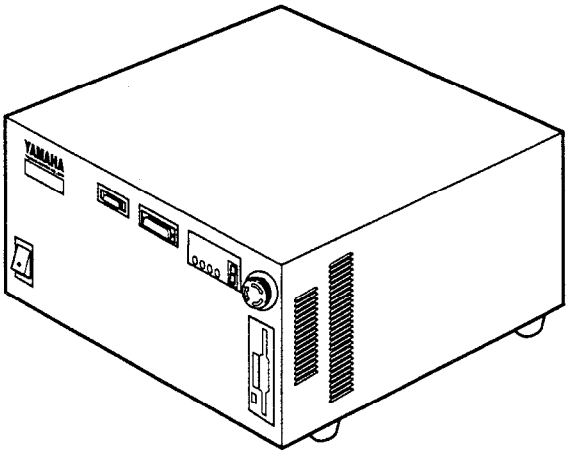
The XYA Robot comes with the MRCA, QRCA or DRCA robot controller according to the order from the user.
Refer to the separate "YAMAHA Robot Controller Instruction Manual" for more details.



MRCA



DRCA



QRCA

Robot controllers

3 Z and R Axes

The standard XYA series is configured with two axes (X and Y), but a maximum of four axes can be used by adding the Z axis and R axis according to the application. The work range can be expanded by attaching various tools to the Z axis or R axis.
To add or exchange the Z axis or R axis, select the appropriate combination from the units shown below. (Note that some models cannot be added or exchanged after delivery.) Refer to the XYA series catalog for more details.

Combination of Z axis and R axis

HXYA

	ZLA	ZRLA	ZHA	ZHRA	ZPHA
Z Axis	AC servo	AC servo	AC servo	AC servo	AC servo
R Axis	-	AC servo	-	AC servo	-
Features	Medium speed	Medium speed	Heavy load	Heavy load	Pole type

MXYA

	ZRMA	ZFA	ZRFA
Z axis	AC servo	AC servo	AC servo
R axis	AC servo	—	AC servo
Features	High speed	Medium load	

SXYA

	ZSA	ZRSA	ZAS	ZFA	ZRFA
Z axis	AC servo	AC servo	Air	AC servo	AC servo
R axis	—	AC servo	—	—	AC servo

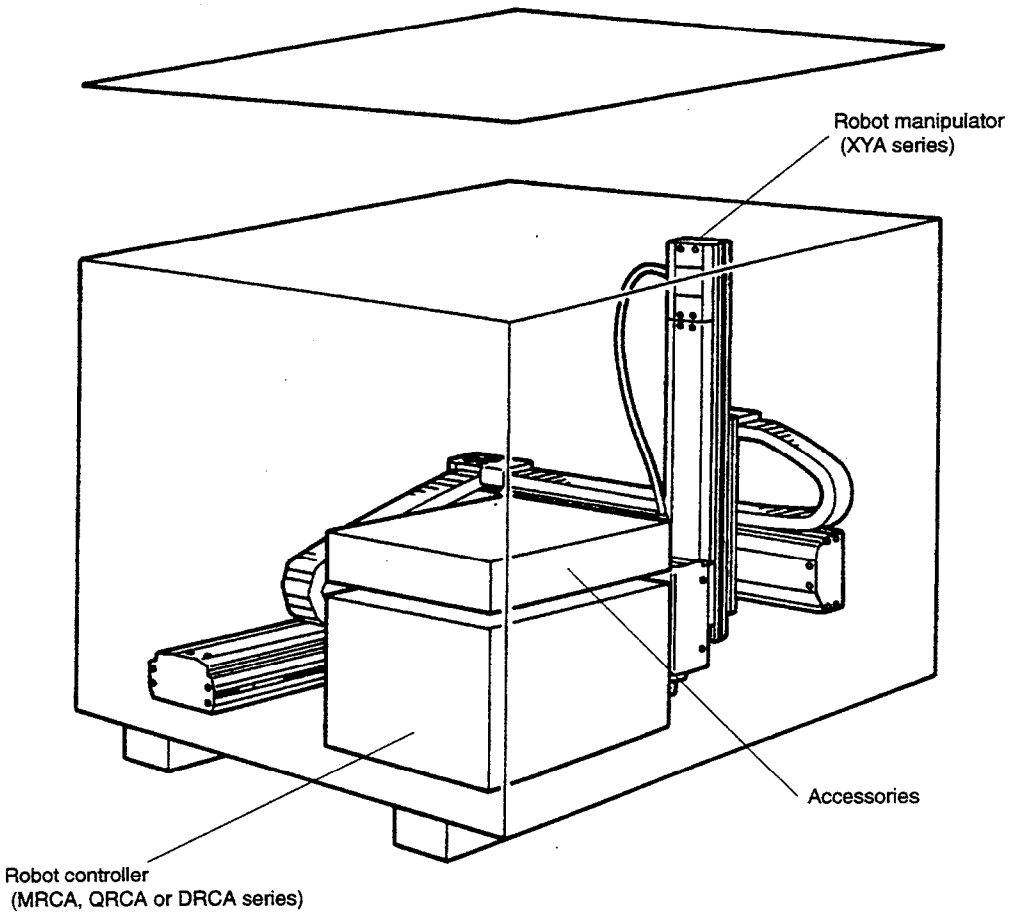
CHAPTER 3

Installation

1 Crate

1-1 Unpacking

The XYA series manipulator is packed with the robot controller (MRCA, QRCA or DRCA series) and accessories, according to the order specifications.
Take sufficient care not to apply shocks to the equipment when unpacking.



Packing state

WARNING

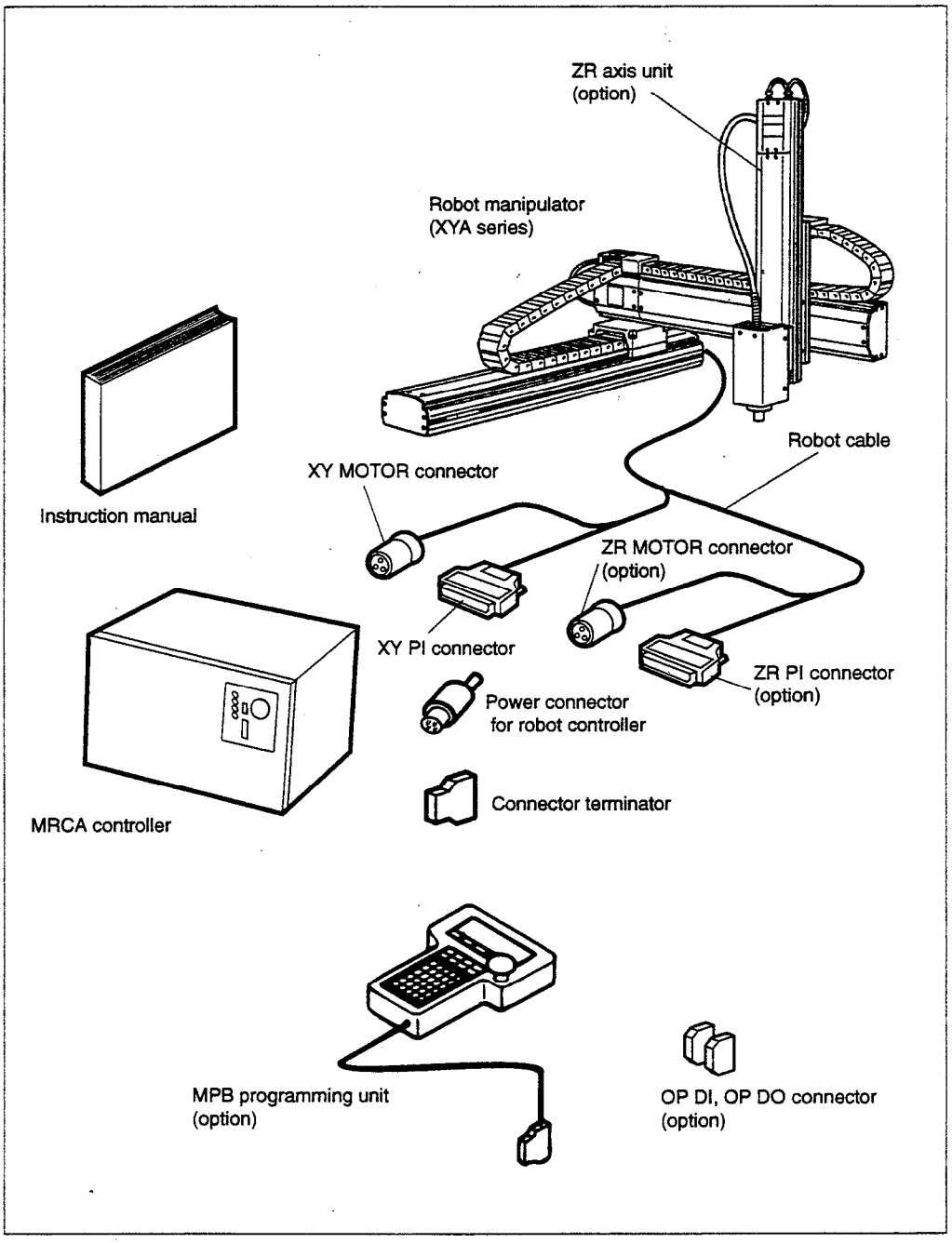
The robot manipulator and controller are rather heavy. Take sufficient care not to drop them during unpacking as this may damage to the equipment or result in personal injury.

1-2 Checking the product

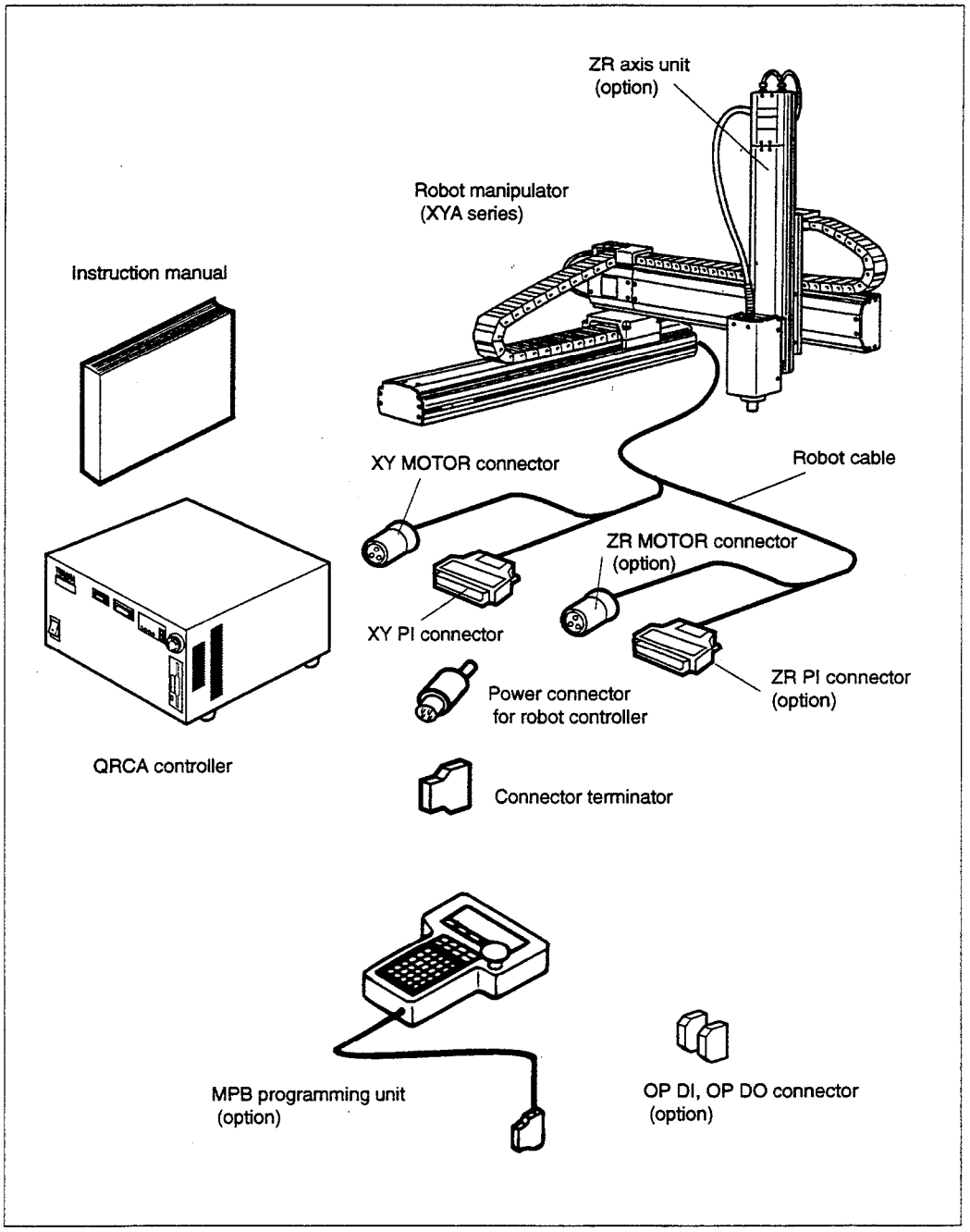
After unpacking, check the product configuration and conditions.
The following configurations are typical examples, so please check that the product is as specified in your order.

CAUTION

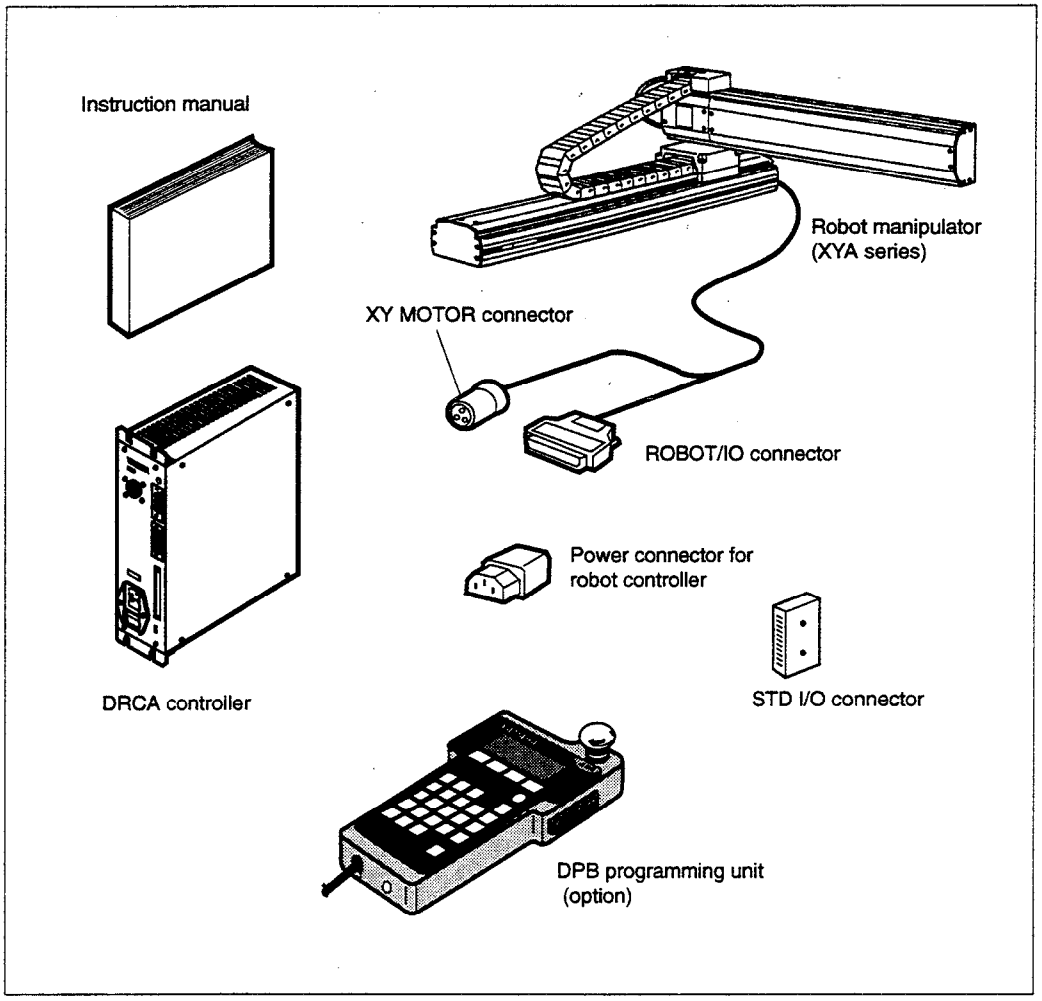
If there is any damage due to transportation or insufficient parts, please notify your YAMAHA sales representative immediately.



Example in combination with the MRCA controller



Example in combination with the QRCA controller



Example in combination with the DRCA controller

2 Installation

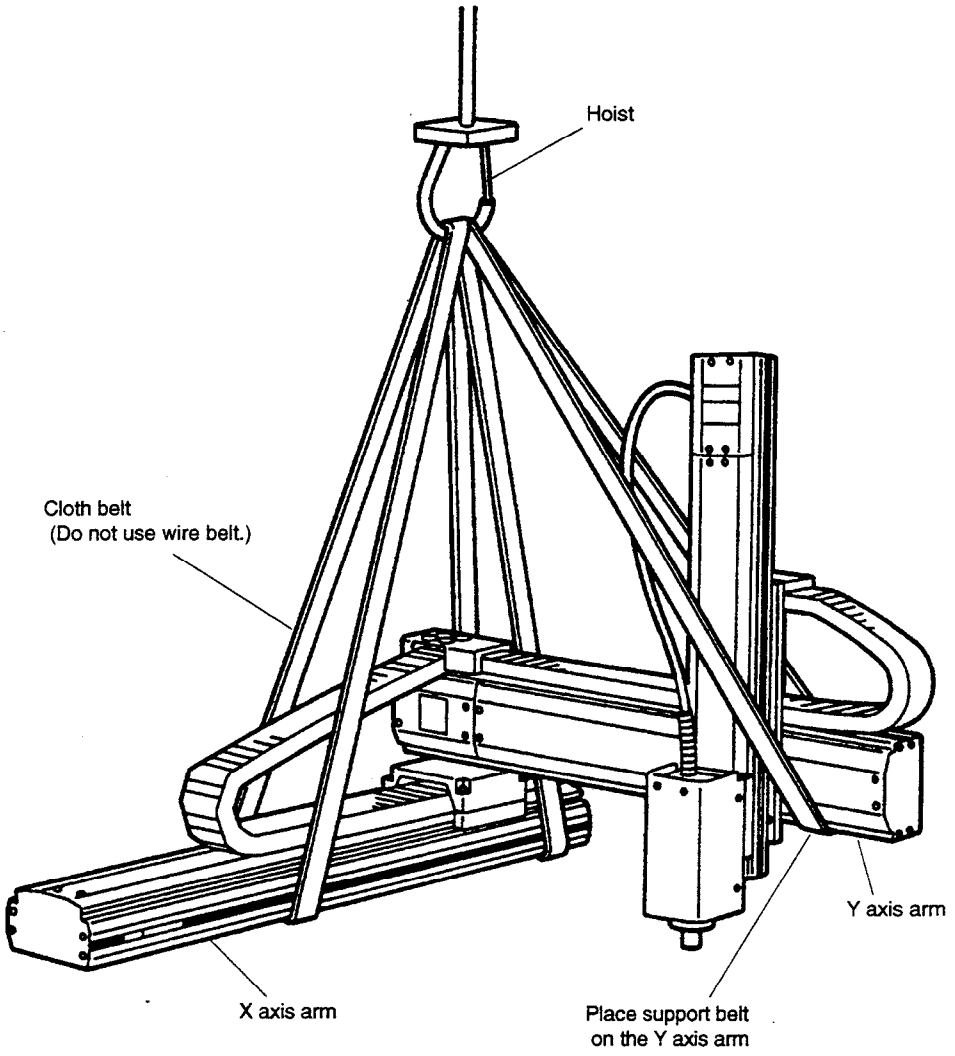
To install the robot correctly and safely, please follow the safety items described in "2-1 Transportation" and "2-2 Installation" in Chapter 1.

2-1 Transportation of the robot

Use of a hoist is recommended for transporting the robot manipulator. (See the figure below.)

WARNING

Place a support belt on the Y axis arm to balance the manipulator when using a hoist.
The carrying capacity of the hoist and the strength of the cloth belt must be sufficient to handle the manipulator weight.



Transporting the manipulator with a hoist

2-2 Installation base

1) Prepare a sufficiently rigid and stable installation base, taking the robot weight (including tool) and workpiece into account, because a large reaction force will be applied to the base while the robot is operating.

WARNING

If the installation base is not sufficiently rigid and stable, vibration may occur (resonance) during operation, causing a detrimental effect on the manipulator work.

2) The parallelism of the installation base surface must be machined within a precision of ±0.05mm/500mm.

3) If there is a gap between the manipulator and the base surface, place a shim of a proper thickness between them, so that no stress is applied to the manipulator frame.

CAUTION

The manipulator positioning may decrease if the installation surface precision is insufficient.

4) Avoid installing the manipulator on the base with less bolts than specified or bolts at one end of the manipulator. Otherwise vibration or degradation of positioning accuracy in the manipulator may occur.

2-3 Installing the manipulator

To install the manipulator correctly and safely, follow the procedure and safety items below.

1 **Tap holes into the surface of the base on which the manipulator is installed.**
Refer to the XYA series catalog for the tap dimension and position.

2 **Anchor the base in place.**
Securely bolt the base so that vibration will not occur during operation of the manipulator. (This step may be performed after the manipulator has been installed on the base, depending on the installation site or base configuration.)

3 **Quietly place the manipulator in position on the base, by using a hoist.**

4 **Remove the host belt from the X axis.**
At this point, the support belt should be still placed on the Y axis to keep the Y axis level.

5 **Loosen the screws on the top cover of the X axis, and remove the top cover. (HXYA, MXYA)**
Since the SXYA series should be bolted from bottom, it is not necessary to remove the cover.

6 **Secure the manipulator on the base, using the hex socket head bolts.**
Bolt diameter and tightening torque
HXYA .... M8, 230 to 350kgf-cm
MXYA.... M8, 230 to 350kgf-cm
SXYA ..... M6, 100 to 130kgf-cm

7 **Remove the remaining hoist belt from the Y axis, and put away the hoist.**

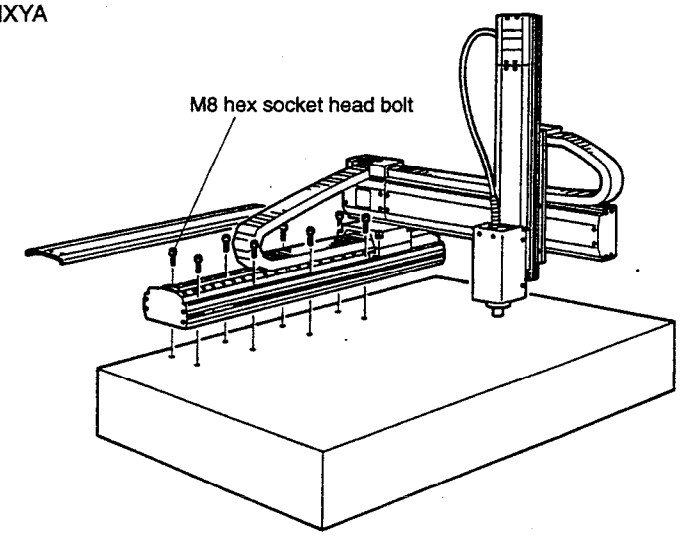
WARNING

- **Take sufficient care not to pinch your fingers when removing the hoist belt from the X axis.**
- **Securely tighten the hex socket head bolt to the correct torque. If the bolt is not tightened correctly, the manipulator may cause positioning errors or even fall over during operation, causing a serious accident.**

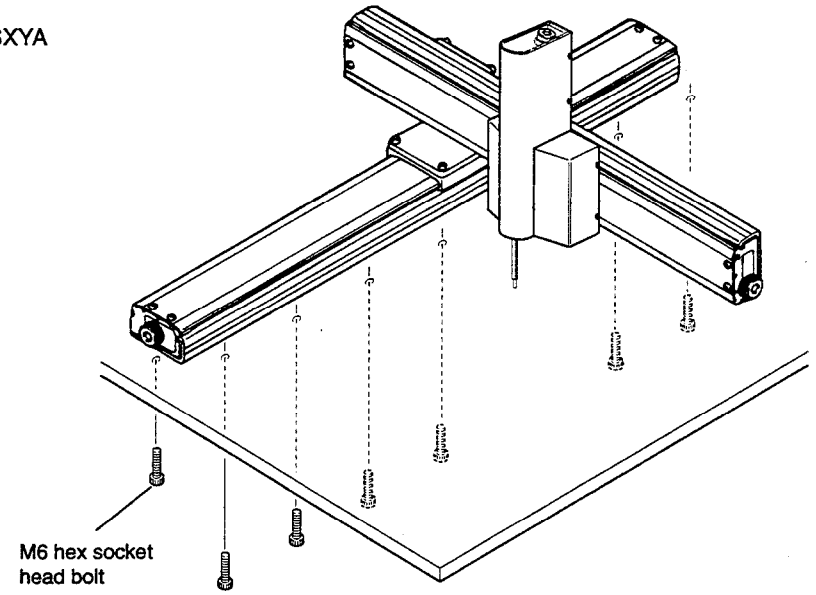
CAUTION

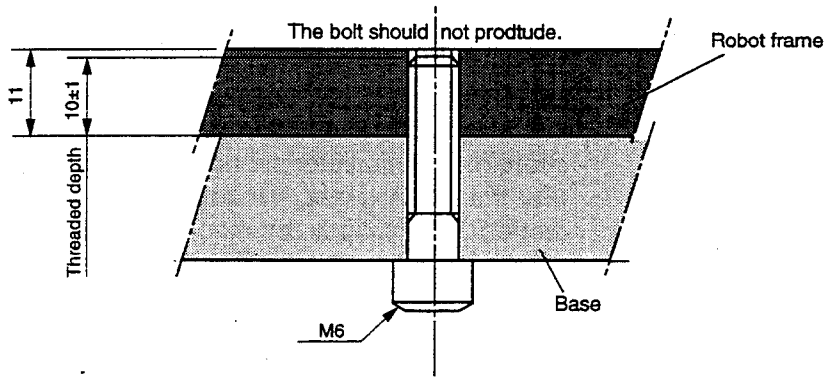
- Use hex socket head bolts which are at least 10mm longer than the thickness of the bottom plate of the manipulator. If too short, the manipulator cannot be bolted securely on the base. (For the SXYA series, the bolts should not protrude inside the frame.) The manipulator should be bolted using all the holes provided on the bottom of the manipulator.
- The manipulator frame is made of aluminum, so be careful not to deform the threads when tightening the bolt.

HXYA/MXYA



SXYA





Installing the manipulator on the base

3 Robot Cable Connection

The robot cable is connected beforehand to the rear end of the manipulator (X axis) by Caplex fasteners. Correctly install the connectors at the other end of the robot cable to the rear panel of the robot controller.
For details on connections to the robot controller, refer to the instruction manual for the YAMAHA robot controller (MRCA, QRCA or DRCA series).

CAUTION

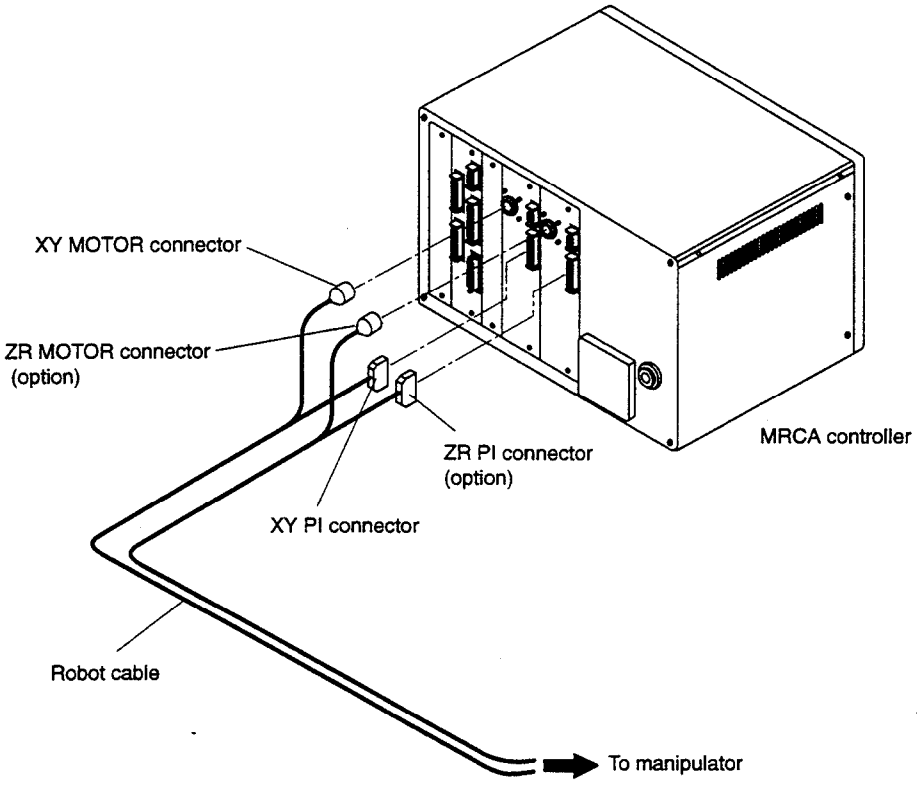
Check that there are no bends or breaks in the connector pins and that the cables are not damaged before connecting the cables.

3-1 Connecting the MRCA controller

Make correct connections to the MRCA controller according to the table below.

Robot Cable	MRCA
XY MOTOR	MOTOR (Driver Unit 1)
XY PI	PI (Driver Unit 1)
ZR MOTOR (Option)	MOTOR (Driver Unit 2)
ZR PI (Option)	PI (Driver Unit 2)

Note: These connections apply to the main robot.
Refer to the controller instruction manual for more details.



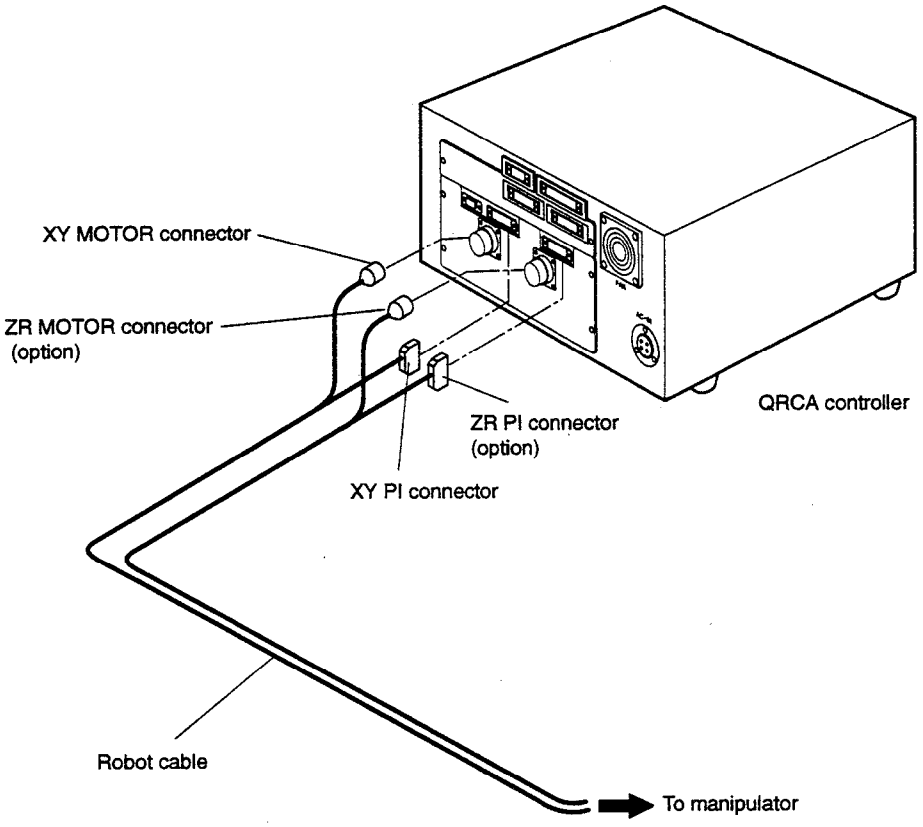
Connecting the MRCA controller

3-2 Connecting the QRCA controller

Make correct connections to the QRCA controller according to the table below.

Robot Cable	QRCA
XY MOTOR	MOTOR 1
XY PI	PI 1
ZR MOTOR (Option)	MOTOR 2
ZR PI (Option)	PI 2

Note: These connections apply to the main robot.
Refer to the controller instruction manual for more details.



Connecting the QRCA controller

CAUTION

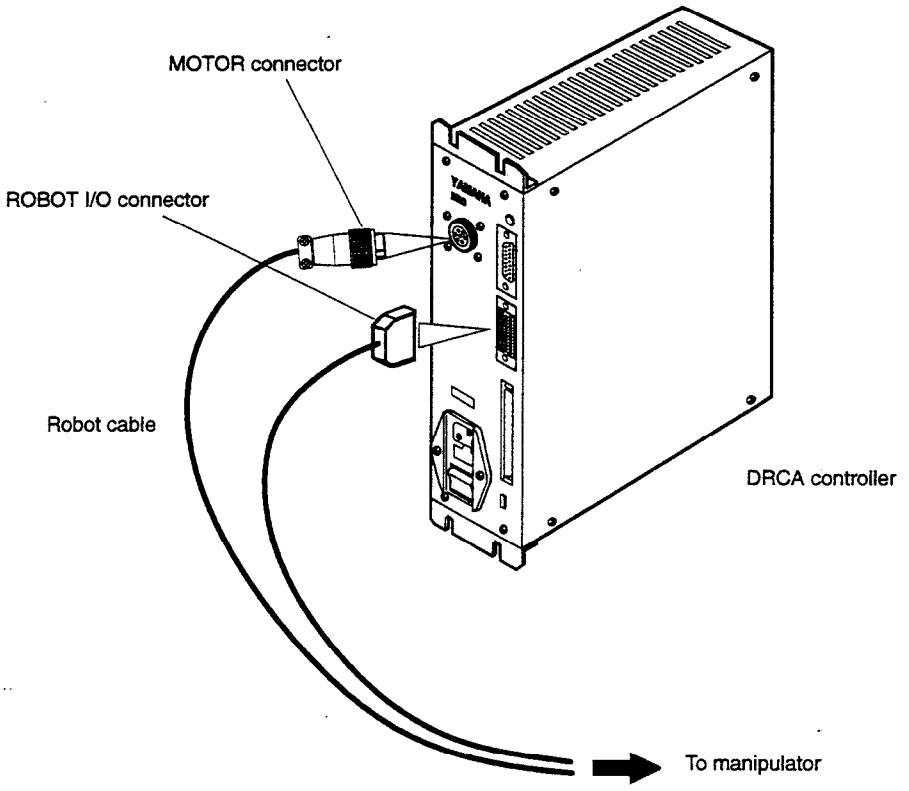
For the QRCA and MRCA controllers, the MOTOR connectors and PI connectors used for the XY axes and ZR axes have an identical shape. Do not confuse the XY and ZR robot cable connectors when making connections.

3-3 Connecting the DRCA controller

Make correct connections to the DRCA controller according to the table below.

Robot Cable	DRCA
MOTOR	MOTOR
ROBOT I/O	ROBOT I/O

Note: Refer to the controller instruction manual for more details.



Connecting the DRCA controller

WARNING

- **The robot cable is the most important cable for controlling the robot. If the connector installation is inadequate or if there are contact failures in the pins, the robot may malfunction. Recheck that each connector is securely installed before turning on the power to the controller.**
- **Lay out the cables so that they do not obstruct the movement of the manipulator and operator. No excessive load should be applied to the connectors due to stress or tension on the cables.**

CHAPTER 4

Adjustments

1 Outline

The YAMAHA robots are completely adjusted at the factory before shipment. It is not necessary to make any adjustment including the origin adjustment as long as you use the robot under normal conditions. However, when the operating conditions are changed and adjustment of the robot becomes necessary, follow the procedure described in this chapter.

WARNING

- **Read and understand the contents of this chapter before attempting to adjust the robot. Be sure to observe the safety items explained in "2-5 Adjustment and maintenance" in Chapter 1.**
- **Place a conspicuous sign indicating that the robot is being adjusted, in order to keep any person not involved with the adjustment from inadvertently touching the control keys or switches. Provide locks on the switch keys or ask someone to keep a watch as needed.**
- **Always turn off the power to the control unit before making any adjust-ments within the manipulator working area.**

1-1 Clearance between the origin sensor and dog

The origin position is set at the encoder "0" phase immediately after the origin sensor has detected the dog (refer to 2-2 in this chapter for more details). It is advisable that you have the following items in mind when adjusting the origin and machine reference.

1) The clearance (space) between the origin sensor and the dog of each axis should be as follows:

   X axis: 0.5 to 2mm.
   Y axis: 0.5 to 2mm.
   Z axis: 0.5 to 2mm.
   R axis: 0.2 to 1mm.

2) The origin sensors used are normally closed a 24V type switches.

   Each origin sensor has an LED display (red) which is normally lit and turns off when the dog is detected. After the clearance has been adjusted, it is possible to check whether the origin sensor reliably detects the dog by using this LED display.

WARNING

Before you check the origin sensor LED display, always press the emergency stop button and then turn on the robot controller.

2 Origin and Machine Reference Adjustments

2-1 Return-to-origin movement

Return-to-origin can be performed by either of the following procedures.

For MRCA and QRCA controllers:

Press the F3 key (ORG) of the MPB or input an origin return signal (DI14) in manual mode. (Refer to the instruction manual for the MRCA or QRCA controller for details.)

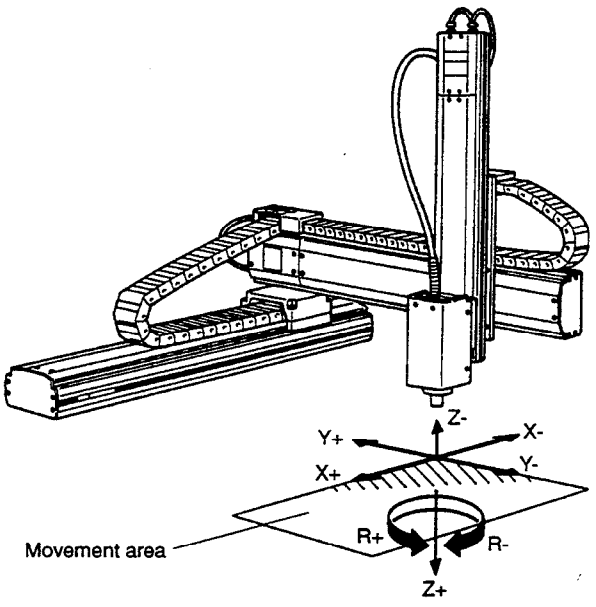
For DRCA controller:

Press the F1 (ORG) key of the DPB in manual mode.

When return-to-origin is instructed, the robot will normally move in the minus direction at a low speed. Origin return is complete when the origin sensor of each axis detects the dog.

CAUTION

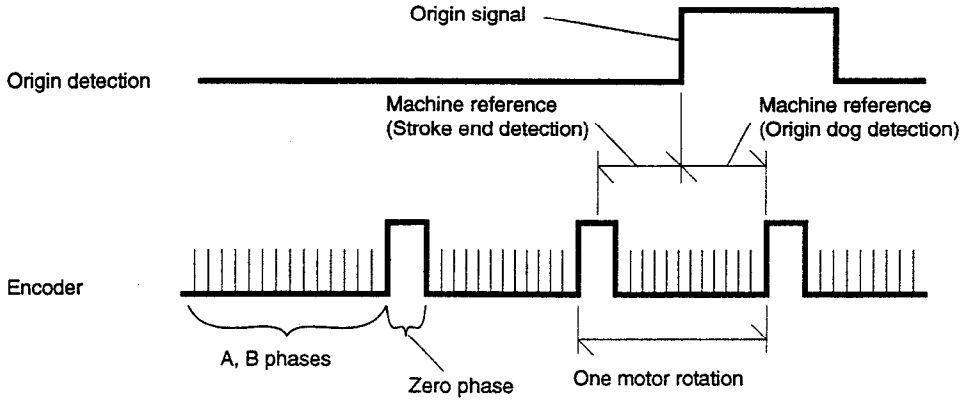
- The order in which each axis returns to the origin differs depending on the controller parameter setting. The initial state when equipped with the ZR axis is as follows:
  Z axis → X axis → Y axis → R axis
  The X axis and Y axis order can be changed with parameter "ORGN". (Refer to the instruction manual for the MRCA or QRCA controller for details.)
- All axes must be at a position that is plus (positive) with respect to origin before starting return-to-origin.



Return-to-origin direction for each axis (standard specifications)

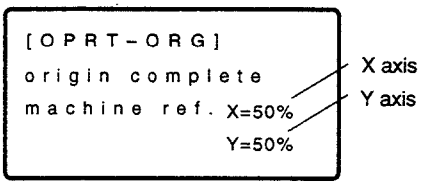
2-2 Machine reference

The origin position is set at the encoder "0" pulse immediately after the origin sensor has detected the dog (or immediately before the stroke end is detected as the origin signal).
When return-to-origin is performed, there will be a difference in distance between the position where the origin sensor detects the dog and the point at which the next encoder "0" pulse is received. This is called the machine reference (see the figure below) and is usually expressed as a percent, with 100% being equal to one full turn of the motor. The optional MTB or DPB is required to confirm the machine reference. It is displayed on the LCD screen of the programming unit (MPB or DPB) when return-to-origin is complete.

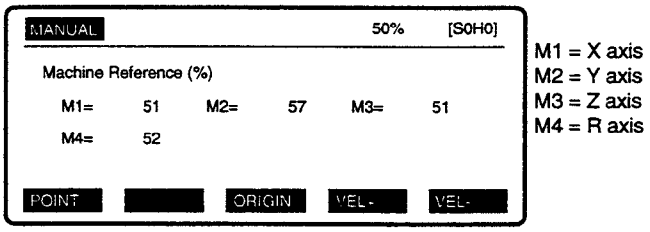


Machine reference

DPB



MPB



Machine reference display

CAUTION

In order to preserve the repeatability of a robot movement, the machine reference for each axis must be adjusted within tolerance. (This is adjusted prior to shipment.) When the origin position is changed, always readjust the machine reference. Refer to 2-3 to 2-6 in this chapter for adjustment procedures.

Tolerance for machine reference: 40% to 60%

2-3 Adjusting the XY axis origin and machine reference

2-3-1 HXYLA (X axis)

The standard origin of this axis is at the position shown below. (However, the robot has been shipped with the origin at any position due to customer order.) When the origin position needs to be changed after the robot has been delivered, follow the procedure below, including the machine reference adjustment. When you are adjusting only the machine reference, proceed from Step [11].

CAUTION

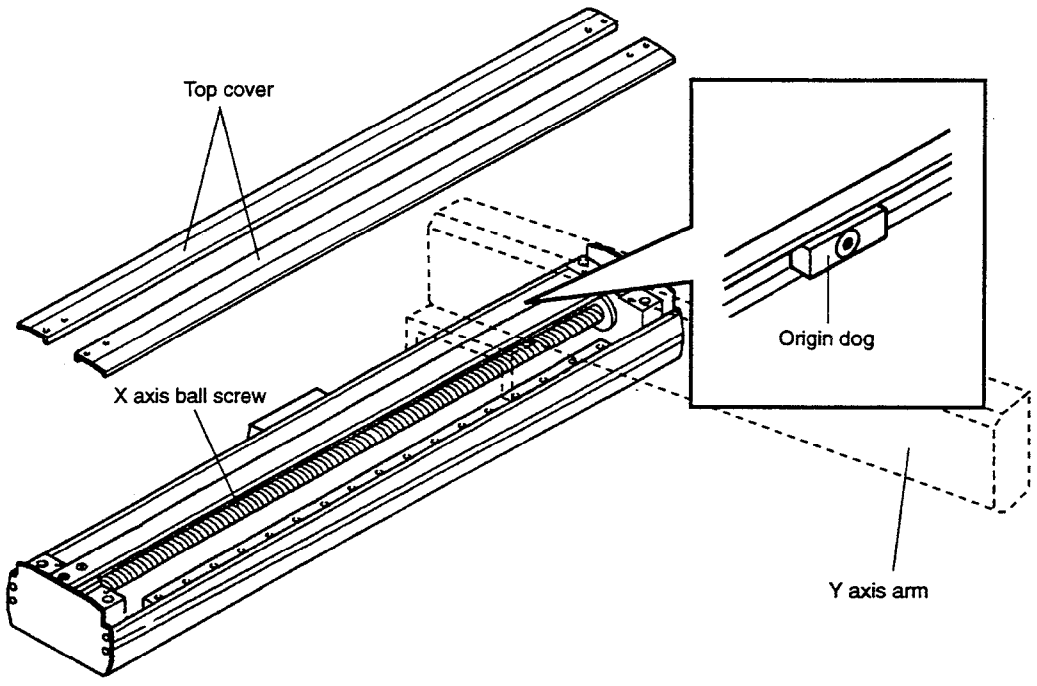
Always readjust the parameter setting for the return-to-origin direction and the machine reference when the origin position has been changed.

[1] **Stand outside the movement area of the manipulator, and then turn on the controller.**
Ensure safety for surrounding area before turning on the controller.

[2] **Perform return-to-origin and check the current origin position.**
Refer to 2-1 in this chapter for performing return-to-origin.

[3] **Turn off the controller.**

[4] **Loosen the screws of the top covers of the X axis, and remove the covers.**
A "T" slot is seen along the inner frame of the X axis, and the origin dog is attached to it. The origin dog is hidden below the slide plate at the return-to-origin position. Move the slide plate by hand so that the origin sensor is easily accessible.



Interior of X axis and origin dog (standard origin position)

5 Loosen the screw securing the origin dog.
Loosen the screw slightly (do not remove) to allow the dog to slide along the slot.

6 Move the dog to the desired position and retighten the screw to secure the dog.

7 Stand outside the movement area of the manipulator, and then turn on the controller.

8 Change the parameter setting for the return-to-origin direction as necessary.
When you have set the origin on the position side, you must change this parameter setting. Refer to the robot controller manual for details.

9 Perform return-to-origin, then check the X axis origin position and also the machine reference displayed on the programming unit.
When the machine reference is within the tolerance range (40 to 60%), the X axis origin adjustment is complete. If it is outside the tolerance range, adjust with the procedure below.

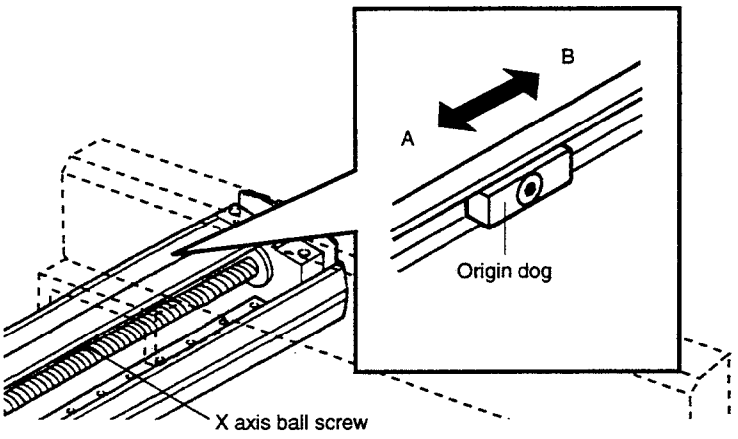
10 Turn off the controller.

11 Loosen the screw of the origin dog.

12 Slide the dog slightly (10mm maximum) to adjust the machine reference as follows:
When the machine reference < 40%: slide in direction A.
When the machine reference > 60%: slide in direction B.

NOTE

- *When the return-to-origin direction is opposite the standard specification, slide the origin dog in the reverse of the A-B directions.*
- *A 2mm movement of the origin dog equals 10% of the machine reference. Do not move the origin dog more than 10mm, because rotating it too far may cause the origin to shift.*



Adjusting the X axis machine reference

13 Retighten the screw of the origin dog.

14 Stand outside the movement area of the manipulator, and then turn on the controller.

15 Perform return-to-origin and check the machine reference.
When the machine reference is within the tolerance range (40 to 60%), adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 11.

16 After the adjustment is complete, reattach the X axis top covers.

2-3-2 HXYLA (Y axis), HXYA (X, Y axes), MXYA (X axis)

The standard origin position of these axes is on the motor side. (However, the robot has been shipped with the origin position opposite the motor side according to the customer order.) When the origin position needs to be changed after the robot has been delivered, use the following procedures, including adjustment of the machine reference.
When you are adjusting only the machine reference, proceed from Step [11].

CAUTION

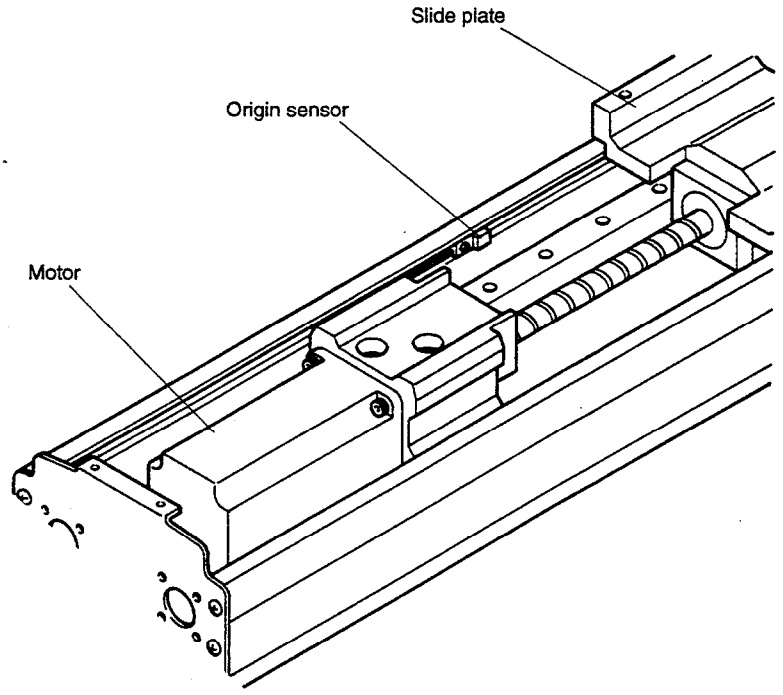
Always readjust the parameter setting for the return-to-origin direction and the machine reference when the origin position has been changed.

[1] **Stand outside the movement area of the manipulator, and then turn on the controller.**
Ensure safety for surrounding area before turning on the controller.

[2] **Perform return-to-origin and check the current origin position.**
Refer to 2-1 in this chapter for performing return-to-origin.

[3] **Turn off the controller.**

[4] **Loosen the screws of the cover and remove the cover.**
A "T" slot is seen along the inner frame of the axis, and the origin sensor is attached to it. The origin sensor is hidden below the slide plate at the return-to-origin position. Move the slide plate by hand so that the origin sensor is easily accessible.



Location of origin sensor (standard origin position)

5 **Loosen the screw securing the origin sensor.**
Loosen the screw slightly (do not remove) to allow the origin sensor to slide along the slot.

6 **Move the origin sensor to the desired position and retighten the screw to secure the origin sensor.**

CAUTION
The origin sensor cable has a length equal to the axis length, to allow for changing the origin position. When the origin sensor is moved, fit the cable into the "T" slot so that the cable slack does not come out in the frame.

7 **Stand outside the movement area of the manipulator, and then turn on the controller.**

8 **Change the parameter setting for the return-to-origin direction as necessary.**
When you have set the origin on the position side, you must change this parameter setting. Refer to the robot controller instruction manual for details.

9 **Perform return-to-origin, then check the origin position and also the machine reference displayed on the programming unit.**
When the machine reference is within the tolerance range (40 to 60%), the origin adjustment is complete. If it is outside the tolerance range, adjust with the procedure below.

10 **Turn off the controller.**

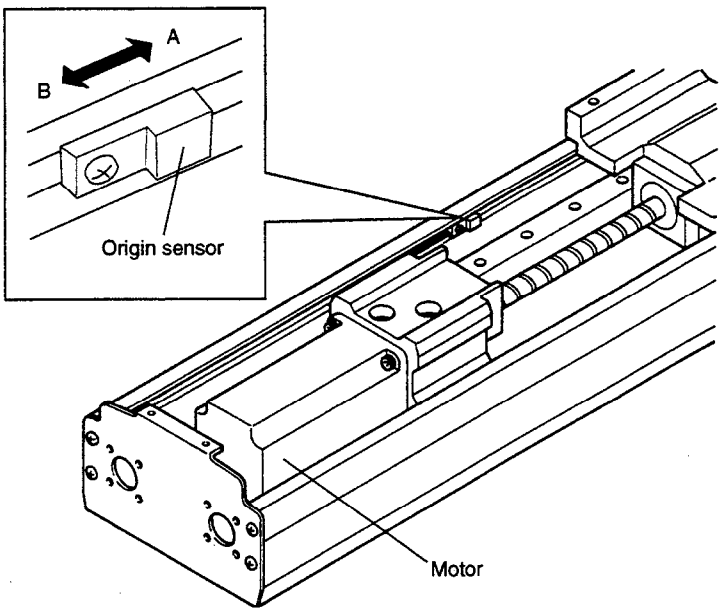
11 **Loosen the screw of the origin sensor.**

12 **Slight the origin sensor slightly (10mm maximum) to adjust the machine reference as follows:**
When the machine reference < 40%: slide in direction A.
When the machine reference > 60%: slide in direction B.

13 Slight the origin sensor slightly (10mm maximum) to adjust the machine reference as follows:
When the machine reference < 40%: slide in direction A.
When the machine reference > 60%: slide in direction B.

NOTE

- *When the return-to-origin direction is opposite the standard specification, slide the origin sensor in the reverse of the A-B directions.*
- *A 2mm movement of the origin dog equals 10% of the machine reference. Do not slide the origin dog more than 10mm, because sliding it too far may cause the origin to shift.*



Adjusting the machine reference (standard origin position)

13 Retighten the screw of the origin sensor.

14 Stand outside the movement area of the manipulator, and then turn on the controller.

15 Perform return-to-origin and check the machine reference.
When the machine reference is within the tolerance range (40 to 60%), adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 11.

16 After the adjustment is complete, reattach the X axis top covers.

2-3-3 MXYA (Y axis), SXYA (X axis)

The standard origin position of these axes is on the motor side. (However, the robot has been shipped with the origin position opposite the motor side due to customer order.) When the machine reference needs to be adjusted, use the following procedures.

CAUTION

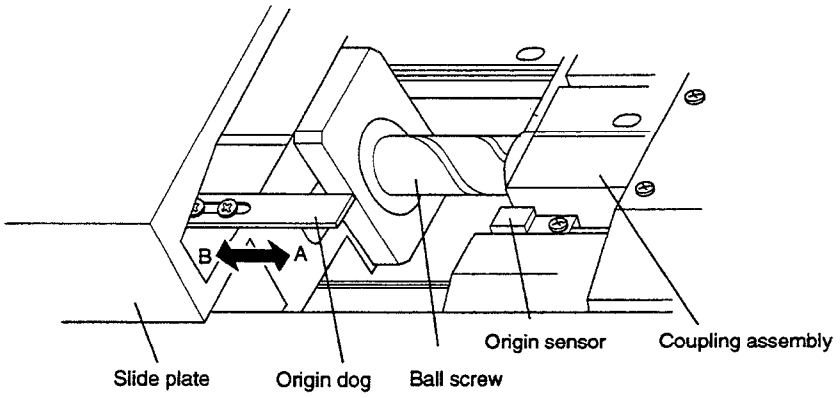
Always readjust the parameter setting for the return-to-origin direction and the machine reference when the origin position has been changed.

1 **Stand outside the movement area of the manipulator, and then turn on the controller.**
Ensure safety for surrounding area before turning on the controller.

2 **Perform return-to-origin and check the machine reference.**
Refer to 2-1 in this chapter for performing return-to-origin.
When the machine reference is within the tolerance range (40 to 60%), there is no need for adjustment. If outside the tolerance range, adjust with the procedure below.

3 **Turn off the controller.**

4 **Loosen the screws of the cover and remove the cover.**
The origin sensor is located on the coupling assembly. The origin dog is attached to the slide plate.



Origin sensor and origin dog

5 Loosen the screws securing the origin dog and slide it (10mm maximum) to adjust the machine reference as follows:
When the machine reference < 40%: slide in direction B
When the machine reference > 60%: slide in direction A

NOTE

- *When the origin is opposite the standard position (opposite the motor side), slide the origin dog in the reverse of the A-B directions.*
- *A 2mm movement of the origin dog equals 10% of the machine reference. Do not slide the origin dog more than 10mm, because sliding it too far may cause the origin to shift.*

6 Retighten the screws of the origin dog.

7 Stand outside the movement area of the manipulator, and then turn on the controller.

8 Perform return-to-origin and check the machine reference.
When the machine reference is within the tolerance range (40 to 60%), adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 5.

9 After the adjustment is complete, reattach the cover.

2-3-4 SXYA (Y axis)

The origin of this axis is detected when the axis travels against the stroke end. The standard origin position is on the motor side, but the robot has been shipped with the origin position opposite the motor side due to customer order. After the robot has been delivered, the origin position can be changed by changing the controller's parameter setting. In this case, the machine reference must be readjusted. Use the following procedure for adjustment.

[1] Stand outside the movement area of the manipulator, and then turn on the controller.
Ensure safety for surrounding area before turning on the controller.

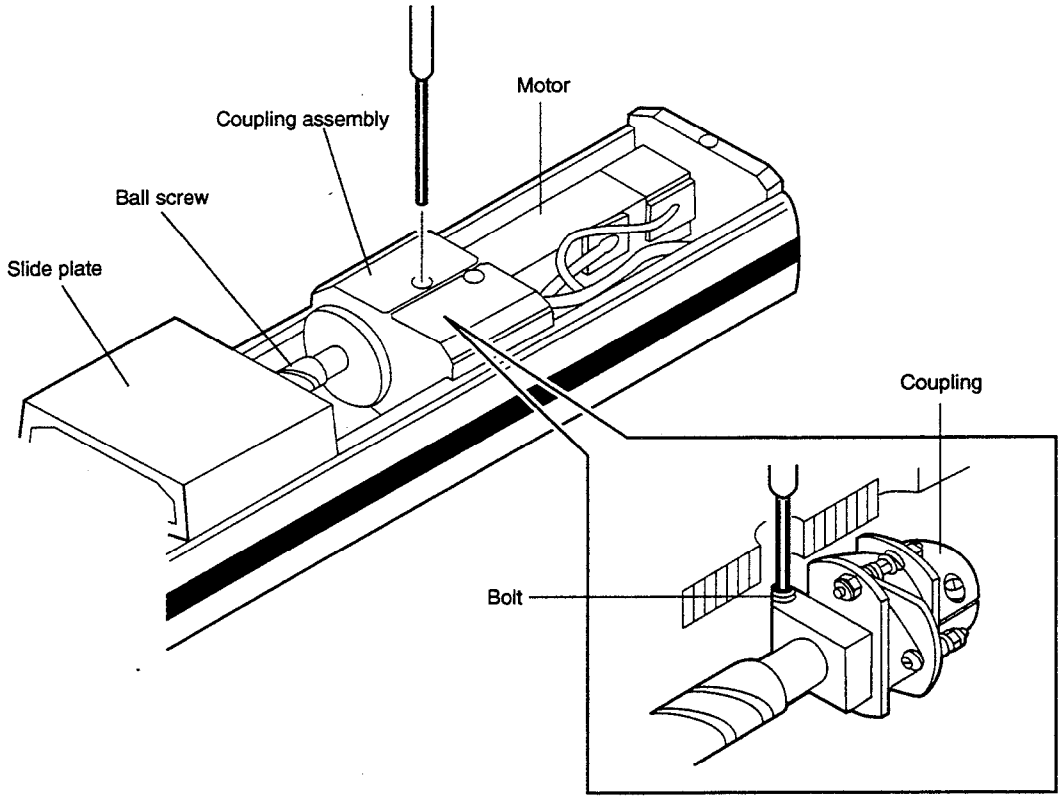
[2] Perform return-to-origin and check the machine reference.
Refer to 2-1 in this chapter for performing return-to-origin.
When the machine reference is within the tolerance range (40 to 60%), there is no need for adjustment. If outside the tolerance range, adjust with the procedure below.

[3] Turn off the controller.

[4] Loosen the screws of the Y axis cover and remove the cover.
The coupling assembly that links the motor shaft to the ball screw can be seen.

[5] Align the bolt securing the coupling on the ball screw side with the hole of the coupling assembly (ball screw side).
Move the Y axis slide plate by hand so that the bolt can be seen through the hole on the ball screw side.

[6] Using the 2.5mm hex wrench, loosen the bolt aligned with the hole.

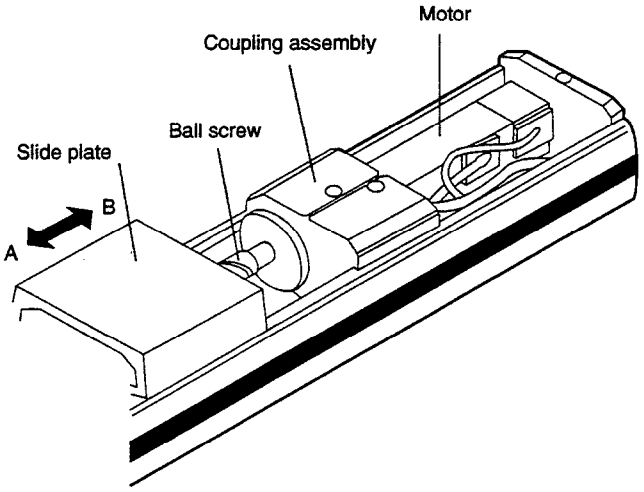


Interior of Y axis and coupling

7 Move the Y axis slide plate by hand (10mm maximum) to adjust the machine reference as follows:
When the machine reference < 40%: move in direction A
When the machine reference > 60%: move in direction B

NOTE

- *For robots with the origin position setting opposite the motor side, move the slide plate in the reverse of the A-B directions.*
- *A 2mm movement of the slide plate equals 10% of the machine reference. Be careful not to allow the motor shaft to turn at this point.*



Adjusting the machine reference

8 Retighten the bolt to secure the coupling.

9 Stand outside the movement area of the manipulator, and then turn on the controller.

10 Perform return-to-origin and check the machine reference.
When the machine reference is within the tolerance range (40 to 60%), the adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 6.

11 After the adjustment is complete, attach the Y axis cover.

2-3-5 SXYA (Bent Y axis)

The origin of this axis is detected when the axis travels against the stroke end. The standard origin position is on the motor side, but the robot has been shipped with the origin position opposite the motor side due to customer order. After the robot has been delivered, the origin position can be changed by changing the controller's parameter setting. In this case, the machine reference must be readjusted. Use the following procedure for adjustment.

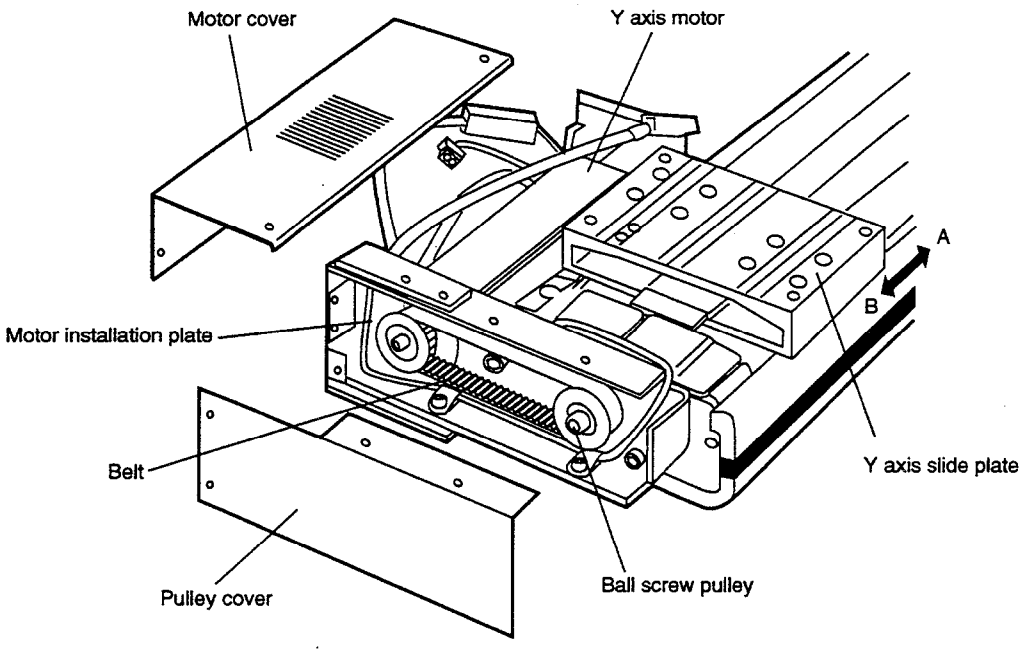
1 Stand outside the movement area of the manipulator, and then turn on the controller.
Ensure safety for surrounding area before turning on the controller.

2 Perform return-to-origin and check the X axis machine reference displayed on the programming unit.
When the machine reference value is within the tolerance range (40 to 60%), there is no need for adjustment. If it is outside the tolerance range, adjust with the procedure below.

3 Turn off the controller.

4 Loosen the screws of the motor and pulley covers and remove these covers.

5 Using the 5mm hex wrench, loosen the bolt securing the ball screw pulley.



Adjusting the axis machine reference

6 Move the Y axis slide plate by hand (10mm maximum) to adjust the machine reference as follows:
When the machine reference < 40%: move in direction A
When the machine reference > 60%: move in direction B

NOTE

- *For robots with the origin position setting opposite the motor side, move the slide plate in the reverse of the A-B directions.*
- *A 2mm movement of the slide plate equals 10% of the machine reference. Be careful not to allow the pulley to turn at this point.*

7 Stand outside the movement area of the manipulator, and then turn on the controller.

8 Perform return-to-origin and check the machine reference.
When the machine reference value is within the tolerance range (40 to 60%), adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 5.

9 After the adjustment is complete, reattach the motor covers.

2-4 Adjusting the Z axis machine reference

2-4-1 ZLA, ZHA

The origin position is set at the upper end of the Z axis stroke and cannot be changed. The machine reference is adjusted to an optimum value before shipment and does not deviate from the tolerance range during normal operation. However, if for some reason the machine reference is outside the tolerance range, use the procedure below for adjustment.

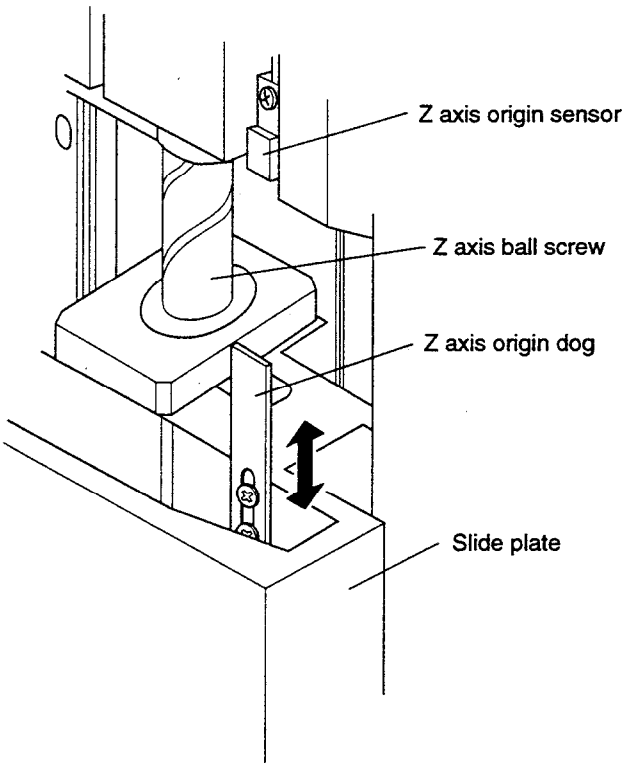
1. **Stand outside the movement area of the manipulator, and then turn on the controller.**
   Ensure safety for surrounding area before turning on the controller.

2. **Perform return-to-origin.**
   Refer to 2-1 in this chapter for performing return-to-origin.

3. **After return-to-origin is complete, check the Z axis machine reference displayed on the programming unit.**
   When the machine reference is within the tolerance range (40 to 60%), there is no need for adjustment. If it is outside the tolerance range, adjust with the procedure below.

4. **Turn off the controller.**

5. **Loosen the screws of the Z axis cover and remove the cover.**
   The Z axis origin sensor is attached to the upper part of the Z axis, and the origin dog to the slide plate.



Adjusting the Z axis machine reference

6 Loosen the screws securing the Z axis origin dog, and move the position to adjust the machine reference as follows:
When the Z axis machine reference < 40%: move upward
When the Z axis machine reference > 60%: move downward

NOTE

Use the following guide to move the origin dog (5mm maximum for the ZLA and 2.5mm maximum for the ZHA).

ZLA: Machine reference is adjusted about 10% for every 1mm movement

ZHA: Machine reference is adjusted about 20% for every 1mm movement

7 Tighten the screws of the origin dog.

8 Stand outside the movement area of the manipulator, and then turn on the controller.

9 Perform return-to-origin and check the Z axis machine reference.
When the machine reference is within the tolerance range (40 to 60%), the Z axis origin adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 6.

10 After the adjustment is complete, reattach the cover of the Z axis.

2-4-2 ZFA

The origin position of this axis is set at the upper end of the stroke and cannot be changed. The machine reference is adjusted to an optimum value before shipment and does not deviate from the tolerance range during normal operation. However, if for some reason the machine reference is outside the tolerance range, adjust with the procedure below.

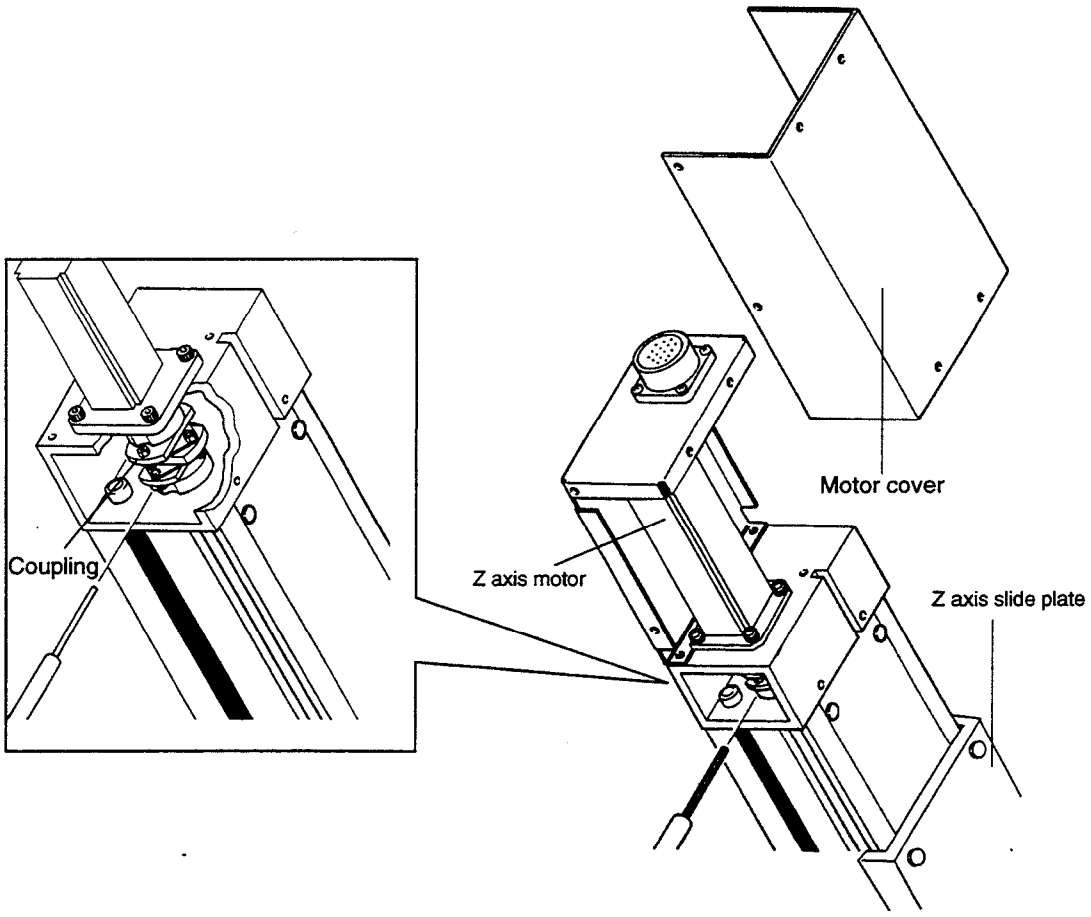
[1] Stand outside the movement area of the manipulator, and then turn on the controller.
Ensure safety for surrounding area before turning on the controller.

[2] Perform return-to-origin.
Refer to 2-1 in this chapter for performing return to origin.

[3] After return-to-origin is complete, check the Z axis machine reference displayed on the programming unit.
When the machine reference is within the tolerance range (40 to 60%), there is no need for adjustment. If it is outside the tolerance range, adjust with the procedure below.

[4] Turn off the controller.

[5] Loosen the screws of the motor cover and remove the motor cover.



Adjusting the Z axis machine reference

6 Using the 2.5mm hex wrench, loosen the bolt securing the coupling on the ball screw side.

7 Move the Z axis slide plate by hand (4mm maximum) to adjust the machine reference as follows:
When the machine reference < 40%: move downward
When the machine reference > 60%: move upward

NOTE

A 1.6mm movement of the slide plate equals 20% of the machine reference. Do not move the slide plate more than 4mm, because moving it too far may cause the origin to shift. Be careful not to allow the pulley to turn at this point.

8 Retighten the bolt to secure the coupling.

9 Stand outside the movement area of the manipulator, and then turn on the controller.

10 Perform return-to-origin and check the machine reference.
When the machine reference is within the tolerance range (40 to 60%), the adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 6.

11 After the adjustment is complete, reattach the motor cover.

2-4-3 ZSA

The origin position of this axis is set at the upper end of the stroke and cannot be changed. The machine reference is adjusted to an optimum value before shipment and does not deviate from the tolerance range during normal operation. However, if for some reason the machine reference is outside the tolerance range, adjust with the procedure below.

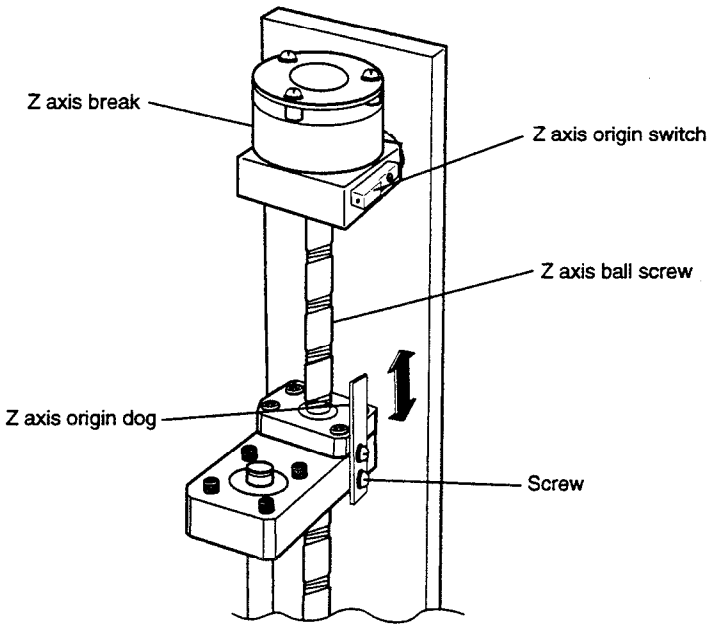
[1] Stand outside the movement area of the manipulator, and then turn on the controller.
Ensure safety for surrounding area before turning on the controller.

[2] Perform return-to-origin.
Refer to 2-1 in this chapter for performing return-to-origin.

[3] After return-to-origin is complete, check the Z axis machine reference displayed on the LCD of the programming unit.
When the machine reference is within the tolerance range (40 to 60%), there is no need for adjustment. If it is outside the tolerance range, adjust with the procedure below.

[4] Turn off the controller.

[5] Loosen the screws of the Z axis cover and remove the Z axis cover.
The origin sensor is attached to the upper end of the Z axis, and the origin dog to the slide plate.



Adjusting the Z axis machine reference

6 Loosen the screws securing the Z axis origin dog, and move it (5mm maximum) to adjust the machine reference as follows:

7 Move the Z axis slide plate by hand (4mm maximum) to adjust the machine reference as follows:
When the machine reference < 40%: move upward
When the machine reference > 60%: move downward

NOTE

A 1mm movement of the origin dog corresponds to 10% of the machine reference. Do not move the slide plate more than 5mm, because moving it too far may cause the origin to shift.

8 Tighten the screws of the origin dog.

9 Stand outside the movement area of the manipulator, and then turn on the controller.

10 Perform return-to-origin and check the Z axis machine reference.
When the machine reference is within the tolerance range (40 to 60%), the adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 6.

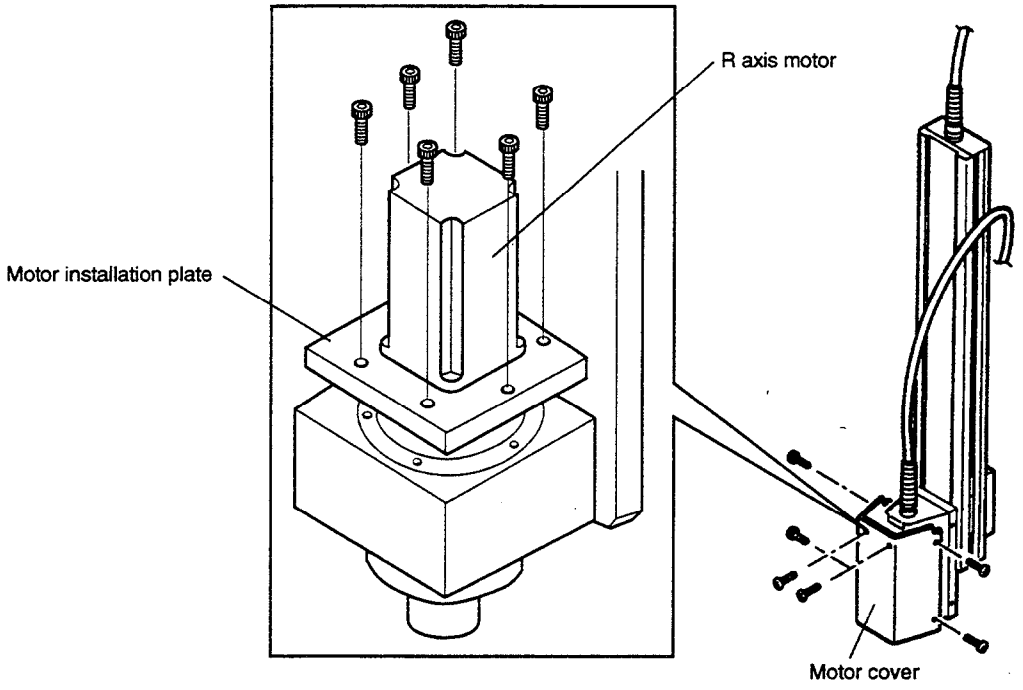
11 After the adjustment is complete, reattach the Z-axis cover.

2-5 Adjusting the R axis machine reference

The R axis origin position cannot be changed. The machine reference is adjusted to an optimum value before shipment and does not deviate from the tolerance range during normal operation. However, when the return-to-origin direction is changed, it will be necessary to adjust the machine reference. Use the procedures below for adjustment.

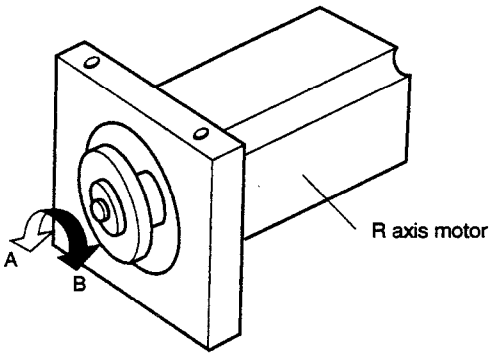
2-5-1 ZRLA, ZRHA, ZRFA

1. **Stand outside the movement area of the manipulator, and then turn on the controller.**
   Ensure safety for surrounding area before turning on the controller.
2. **Perform return-to-origin.**
   Refer to 2-1 in this chapter for performing return-to-origin.
3. **After return-to-origin is complete, check the R axis machine reference.**
   When the machine reference is within the tolerance range (40 to 60%), there is no need for adjustment. If it is outside the tolerance range, adjust with the procedure below.
4. **Turn off the controller.**
5. **Loosen the screws of the motor cover and remove the motor cover.**
6. **Remove the bolts (6 pieces) of the motor installation plate.**
7. **Pull up the motor along with the plate.**
   At this point, be careful to keep the speed reducer (harmonic drive) installed with the motor from rotating. Also be careful not to allow dirt and foreign matter to adhere to it.



Removing the motor cover and motor installation plate

8 Rotate the harmonic driver (motor shaft) by hand (180 degrees maximum) to adjust the R axis machine reference as follows:
When the R axis machine reference < 40%: rotate in direction A
When the R axis machine reference > 60%: rotate in direction B



Adjusting the R axis machine reference

NOTE
A 36 degree rotation of the motor shaft equals to 10% of the machine reference

9 Reinstall the motor in the original position while keeping the speed reducer (harmonic drive) from rotating.
Take care not to apply shock to the harmonic drive when inserting the motor.

10 Tighten the bolts (6 pieces) of the motor installation plate using an even torque.

11 Stand outside the movement area of the manipulator, and then turn on the controller.

12 Perform return-to-origin and check the R axis machine reference.
When the R axis machine reference is within the tolerance range (40 to 60%), the machine reference adjustment is complete. If it is still outside the tolerance range, turn off the controller and then readjust from Step 6.

13 After the adjustment is complete, attach the motor cover.

2-5-2 ZRSA

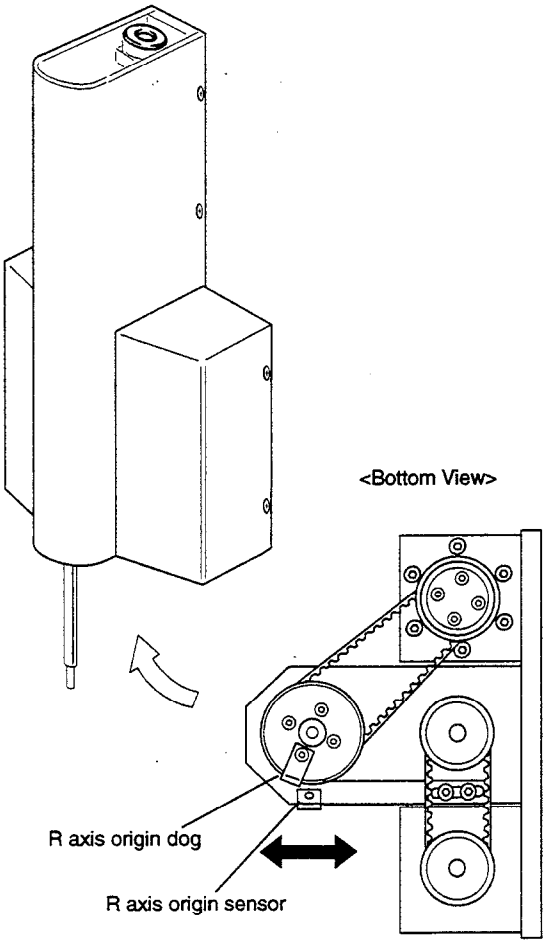
1 **Stand outside the movement area of the manipulator, and then turn on the controller.**
Ensure safety for surrounding area before turning on the controller.

2 **Perform return-to-origin.**
Refer to 2-1 in this chapter for performing return to origin.

3 **After return-to-origin is complete, check the R axis machine reference.**
When the machine reference is within the tolerance range (40 to 60%), there is no need for adjustment. If it is outside the tolerance range, adjust with the procedure below.

4 **Turn off the controller.**

5 **Loosen the screws of the Z axis cover and remove the Z axis cover.**
The R axis origin sensor and dog can be seen from the bottom as shown below.



R axis origin sensor and dog

6 Loosen the bolt securing the origin sensor to the frame.

7 Slide the origin sensor slightly to the right or left to adjust the machine reference.
At this point, be careful not to allow the origin sensor to touch the origin dog.

8 Retighten the bolt to secure the origin sensor.

9 Stand outside the movement area of the manipulator, and then turn on the controller.

10 Perform return-to-origin and check the R axis machine reference.
When this value is within the tolerance range (40 to 60%), the machine reference adjustment is complete. If the R axis machine reference is still outside the tolerance range, turn off the controller and then readjust from Step 6.

11 After the adjustment is complete, reattach the Z axis cover.

CHAPTER 5

Maintenance

1 Introduction

Regular maintenance of the YAMAHA robot system is essential in order to ensure safe and proper operation. Follow the procedures listed in this chapter and set up a regular maintenance schedule according to the checklists. Maintenance procedures are grouped according to three basic periods:

- Everyday Procedures
- Procedures for Every Six Months
- Procedures for Every Three Years

2 Precautions

Before beginning maintenance, read the safety precautions described in "2-5 Adjustment and maintenance" in Chapter 1 and follow the instructions. Some important instructions are listed again below as a double check.

1) Have any and all personnel who are to perform maintenance of the robot be familiar with the proper methods of maintenance. All maintenance must be performed by or in the presence of personnel who have participated in the Robot Training Seminar given by YAMAHA or YAMAHA Sales Representative personnel.

2) When the robot does not need to be operated during adjustment or maintenance, always turn off the controller and the external switch board.

3) Do not touch the inside of the control unit until the controller has been turned off for at least 5 seconds.

4) Use only the lubricant and grease specified by YAMAHA or YAMAHA Sales Representatives.

5) Replace parts only with parts specified by YAMAHA or YAMAHA sales representatives.

6) If the maintenance procedure calls for operation of the robot, stay out of the working area of the manipulator during the service work. Do not touch any parts inside the controller.

7) During robot adjustment or maintenance, place a sign indicating that the robot is being adjusted or serviced, to prevent other persons from inadvertently touching the control keys or switches. Provide a lock of the switch keys or ask someone to keep a watch as necessary.

3 Daily Checklist

The following is a list of maintenance operations that must be performed every day before and after operating the robot.

CHECK POINT	PROCEDURE
Working Area Guards	Check to see if guards are securely installed in place.
Cables	Check for scratches, dents, kinks and chemical adhesion.
Motor, Encoder, Harmonic Drive	Check for excessive vibration and noise, overheating, etc.
Air Pressure	• Check air pressure reading. • Check for air leaks. • Drain. • Check air filter

4 Six Month Checklist

The following is a list of maintenance operations to be performed every six months.

Inspection or replacement place	Inspection or replacement details
Main bolts and screws on the robot	Check for looseness. If loose, tighten.
X axis, Y axis drive section (Ball screw, linear guide)	• Check for looseness in the X and Y axis drive sections (ball screw, linear guide). Tighten if necessary. • Check for vibration during operation. Tighten drive section, and X and Y axis installation bolts if necessary. • Check for wear and backlash. If any abnormality is found, contact YAMAHA sales representatives.
Z axis ball spline, ball screw	Check for backlash. If any abnormality is found, contact YAMAHA sales representatives.
Z or R axis timing belt	Check the tension.
Machine reference	Perform origin to return and comfirm that the machine reference is optimum. (Refer to "4. Adjustment".)
Origin sensor and dog of each axis	Clean if necessary.
Wiring in robot	• Check for damages or scratches on the cables, etc. • Check for looseness in the relay connectors, etc.
Interior of controller	• Check for looseness at the terminals. • Check for looseness in the connectors.
Fan for air-cooling on rear side of controller	• Check that the fan rotates. • Check that the fan is not blocked. • Check for abnormal sounds during rotation. Visually check if necessary. If any foreign matter is found, remove it. If no foreign matter is found, contact YAMAHA sales representative. • Check for dirt on the fan cover. Remove and clean if dirty.
Lubrication of X, Y and Z axis ball screw nut sections and linear guides	Apply Albania (Showa Shell), Daphney Coronex No.2 (Idemitsu Kosan) to the ball screw nut sections and linear guides. (Refer to "6. Grease Replenishment" in Chapter 5.)

CAUTION

Robots designed for clean room operation should have their specified grease LG-2 (manufactured by NSK) replaced in about one-half the normal replacement period.

5 Three Year Checklist

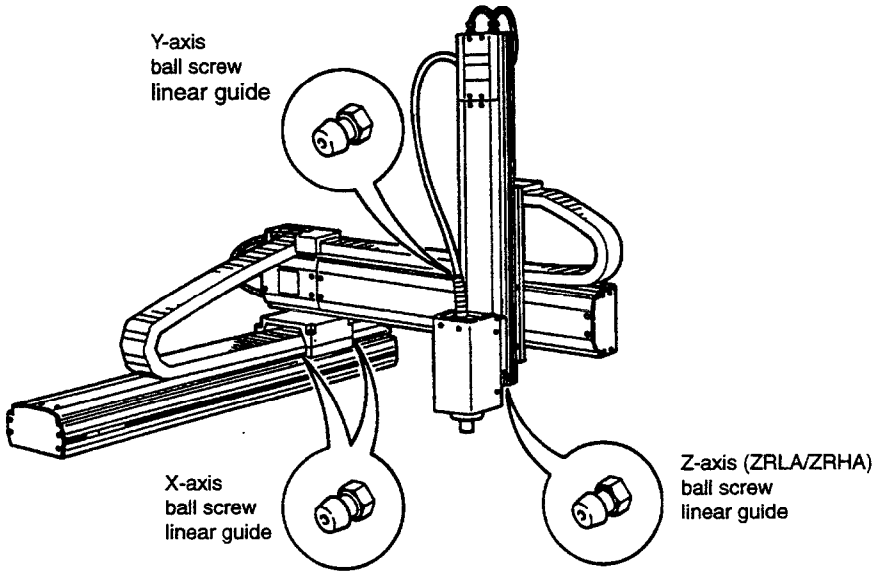
Inspect the the following items every three years and make the necessary adjustments or replacements.

Inspection place	Inspection details
R axis speed reducer (Harmonic drive)	Refer to "7. Replacing the Harmonic Grease" in Chapter 5.)
X, Y and Z axis drive sections (Ball screw nut sections and linear guides)	Check for wear and looseness in the ball screw, nut and linear guide.

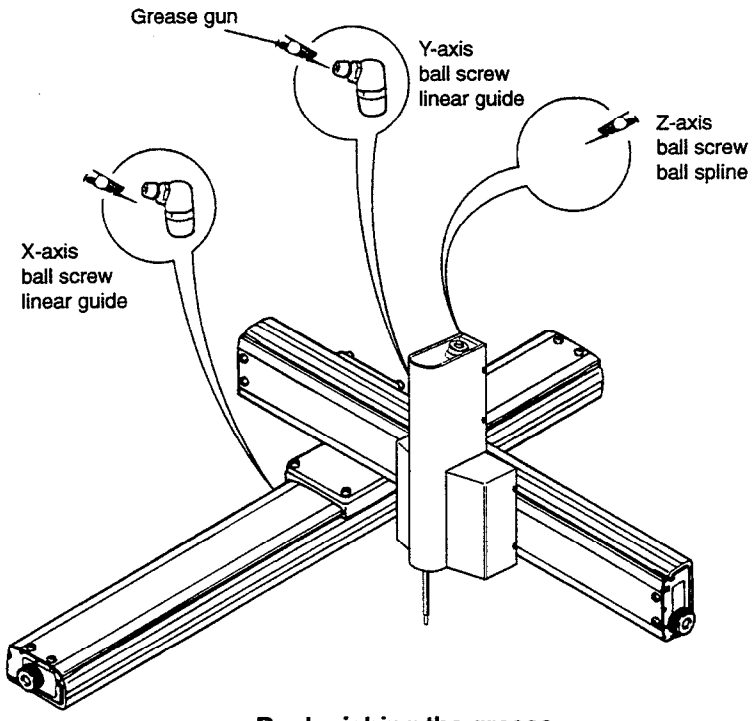
6 Grease Replenishment

Grease should be applied to the following points on the X, Y and Z axes. Use the specified grease according to the six month checklist.

HXYA, MXYA



SXYA



Replenishing the grease

CAUTION

For robots designed for clean room operation, apply a thin coat of the specified grease by hand over the entire surface of the ball screw and spline.

7 Replacing the Harmonic Grease

The XYA series robots use a harmonic drive as the speed reducer for the R axis (ZRLA, ZRHA, ZRFA units). Harmonic grease HC-1A (made by Harmonic Drive Systems Inc.) is used to lubricate the harmonic drive. When this grease deteriorates with operating time, the service life of the harmonic drive may shorten.
Replace the harmonic grease every three years, or use the guideline explained below to determine the replacement period and replace the used grease.

7-1 Replacement period

The harmonic grease replacement period is determined by the total number of turns of the wave generator used in the harmonic drive. We recommend replacement of the harmonic grease when the total number of turns has reached 1.5×10^8 (-10 to +40°C). This means that the replacement period will differ depending on the following operating conditions.

n : Number of arm movements per minute
θ : Average turn per arm movement
N : 1/reduction ratio
h : Operation time per day
D : Operation days per year

For example, when the robot is used under the following conditions, the replacement period can be calculated as follows.

n : 10
θ : 1/4 turn
N : 80
h : 24 hours per day
D : 240 days per year

Replacement period $= 1.5\times10^8/(n\times60\times h\times D\times N\times\theta)$
$= 1.5\times10^8/(10\times60\times24\times240\times80\times1/4) = 2.17$ years

7-2 Replacing the harmonic grease

The following explains the procedure for replacing the harmonic grease used for the R axis of the ZRLA unit. Basically, use the same procedure to replace the harmonic grease for other units (ZRHA , ZRFA units, etc.)

CAUTION

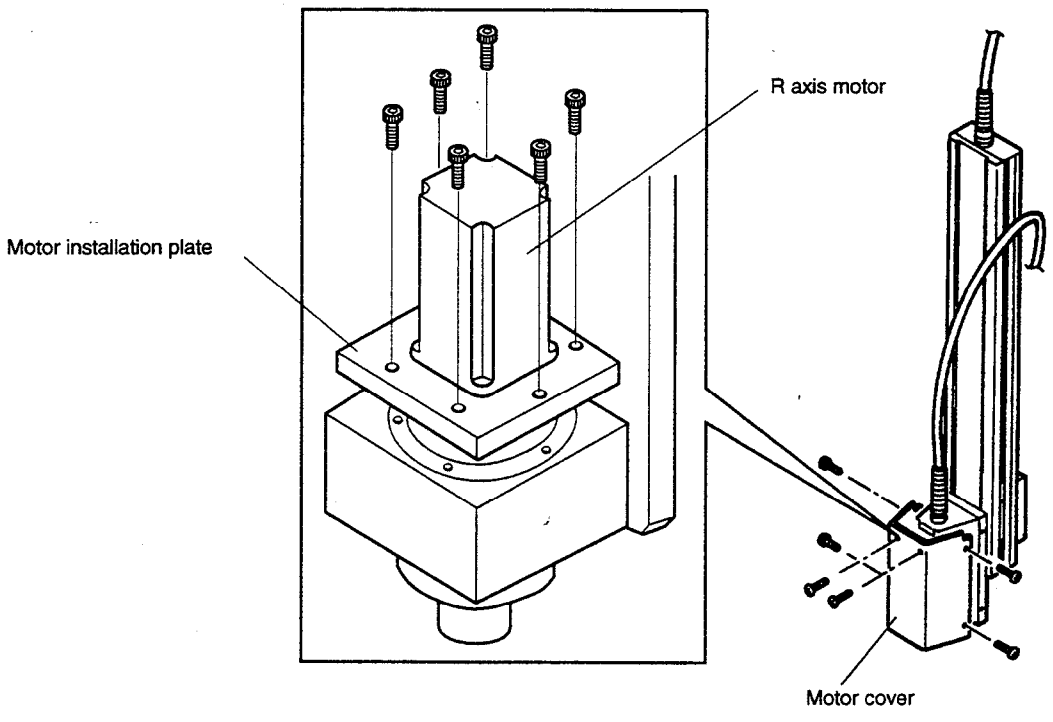
After the grease has been replaced, the machine reference adjustment (Chapter 4) and point data setting must be performed again because of position shifts during the grease replacement.

[1] Prepare the specified grease and necessary tools.

- Harmonic grease HC-1A
- Cleaning oil (white gasoline, etc.)
- Waste cloth, air gun
- Tools (phillips screwdriver, hex wrench, torque wrench, etc.)

[2] Loosen the screws of the cover of the R axis cover and remove the R axis cover.

[3] Loosen and remove the bolts (6 pieces) of the motor installation plate, and remove the plate along with the motor.

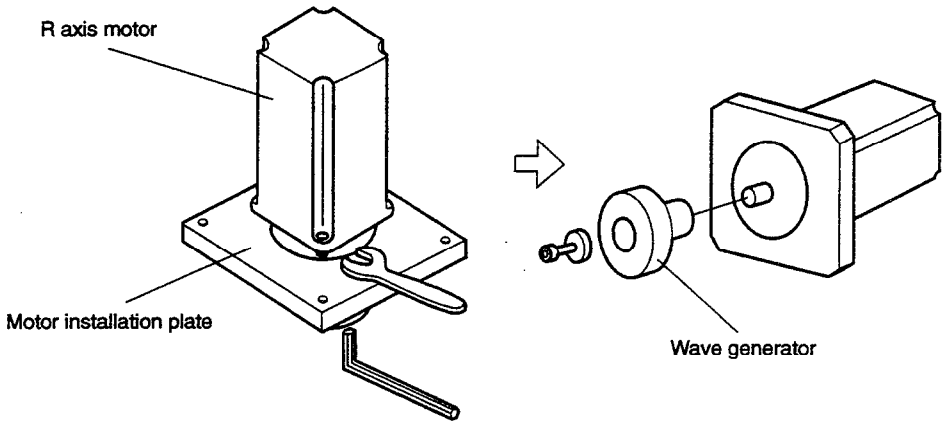


Removing the cover of the R axis and the motor installation plate

4 Loosen the bolts (4 pieces) securing the motor to the plate.
At this point, be careful not to bring the speed reducer (wave generator) installed with the motor into contact with the plate.

5 Place a wrench between the motor and the plate, so it contacts the two surfaces of the motor shaft.

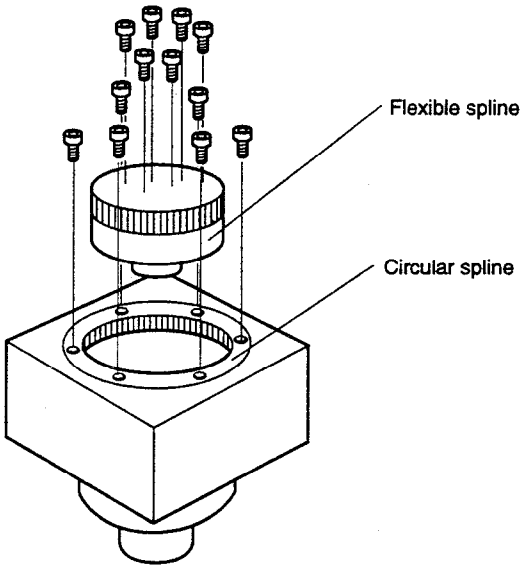
6 While holding the motor shaft with the wrench, loosen and remove the hex socket head bolt at the end of the motor shaft, then slowly pull out the wave generator.



Removing the wave generator

7 Loosen and remove the hex socket head bolts (6 pieces), and gently remove the cup-shaped speed reducer (flexible spline).

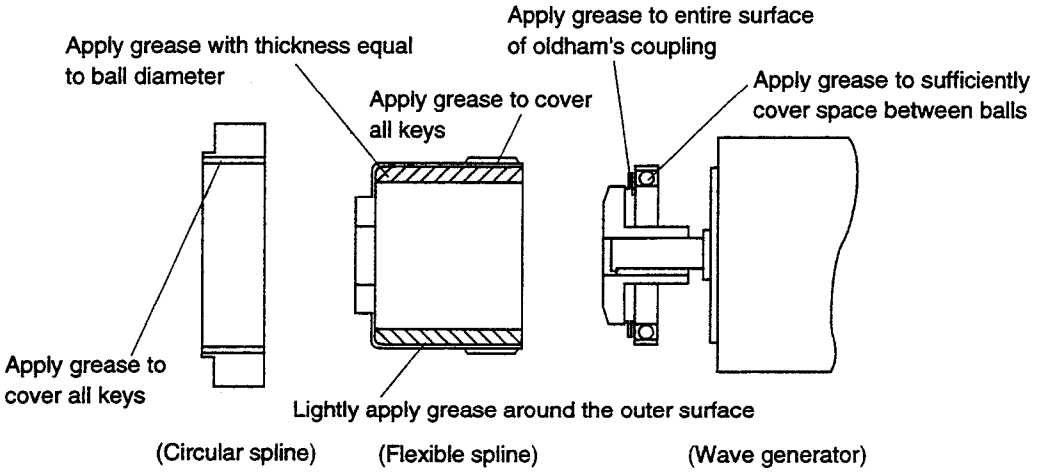
8 Loosen and remove the bolts (6 pieces) of the circular spline, and gently remove the circular spline.



Removing the flexible spline and circular spline

9 Using an air gun or waste cloth, remove the used grease from the wave generator, circular spline and flexible spline. If grease degradation is widespread, clean each part with cleaning oil (white gasoline, etc.).

10 Apply new harmonic grease to each component as illustrated below.



Applying the harmonic grease

11 Reassemble each component in the reverse of the above procedure.
Tighten each bolt to the following torque.

M4 bolts : 46kgf-cm
M5 bolts : 92kgf-cm
M6 bolts : 156kgf-cm

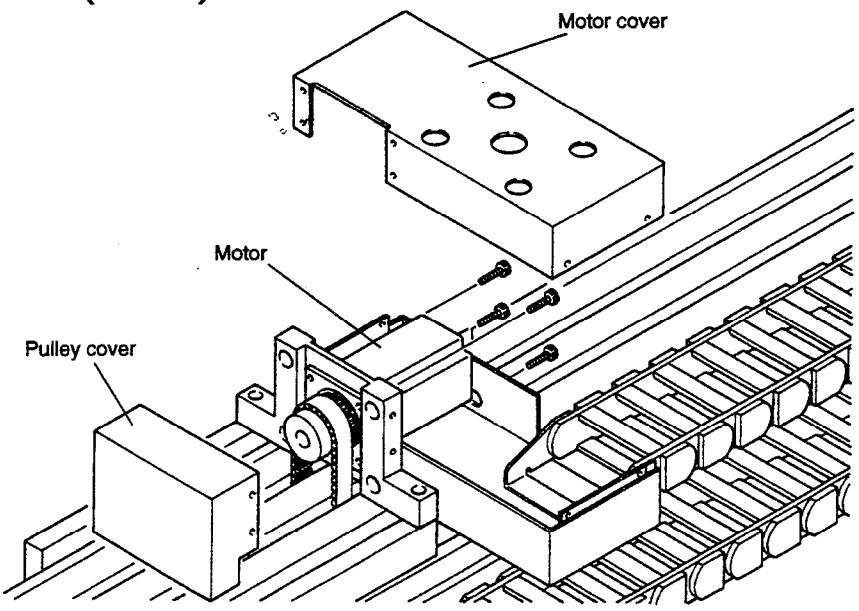
CAUTION

Take sufficient care not to allow dirt and foreign matter to adhere to the harmonic drive or grease during disassembly and reassembly.

8 Replacing the Motor

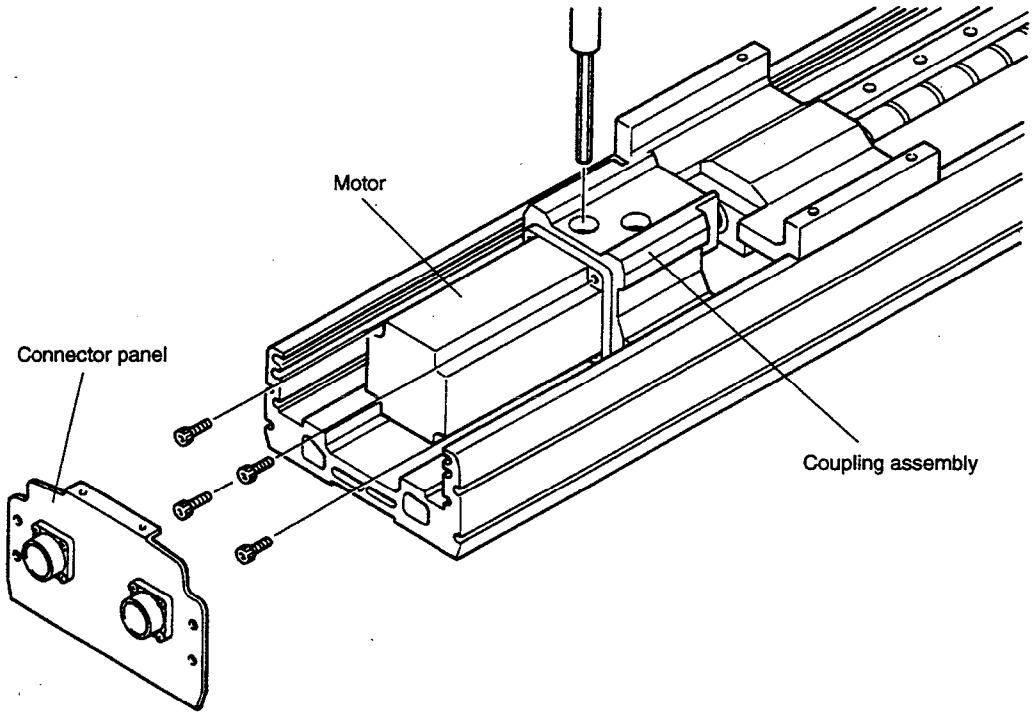
To replace the motor of each axis, follow the procedures below. Before beginning the work, ensure that the robot controller and external switch board are turned off.

8-1 HXYLA (X axis)



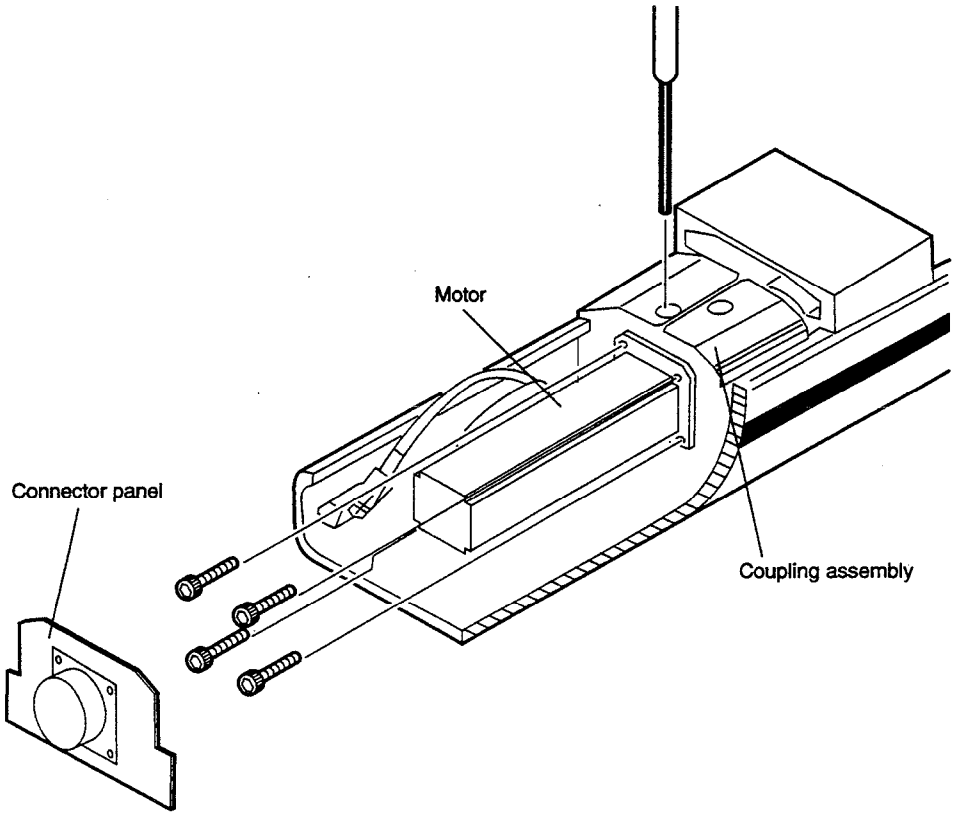
1. **Loosen the screws of the motor and pulley covers and remove these covers.**
2. **Disconnect the motor code and encoder code connectors.**
3. **Using the 4mm hex wrench, loosen the bolts securing the motor installation plate to the manipulator frame, and remove the belt from the motor pulley.**
4. **Loosen the setscrew securing the pulley to the motor shaft and remove the pulley.**
5. **Remove the bolts securing the motor to the installation plate and remove the motor.**
6. **Install the new motor in place and tighten the bolts securely.**
7. **Attach the pulley just removed, to the new motor and tighten the setscrew.**
8. **Retighten the belt to its correct tension and tighten the bolts to secure the installation plate to the manipulator frame.**
9. **Fasten the motor code and encoder code connectors.**
10. **Readjust the machine reference.**
    Refer to 2-3-1 in Chapter 4.
11. **Reattach the motor covers.**

8-2 HXYLA (Y axis) HXYA (X, Y axes), MXYA (X axis)



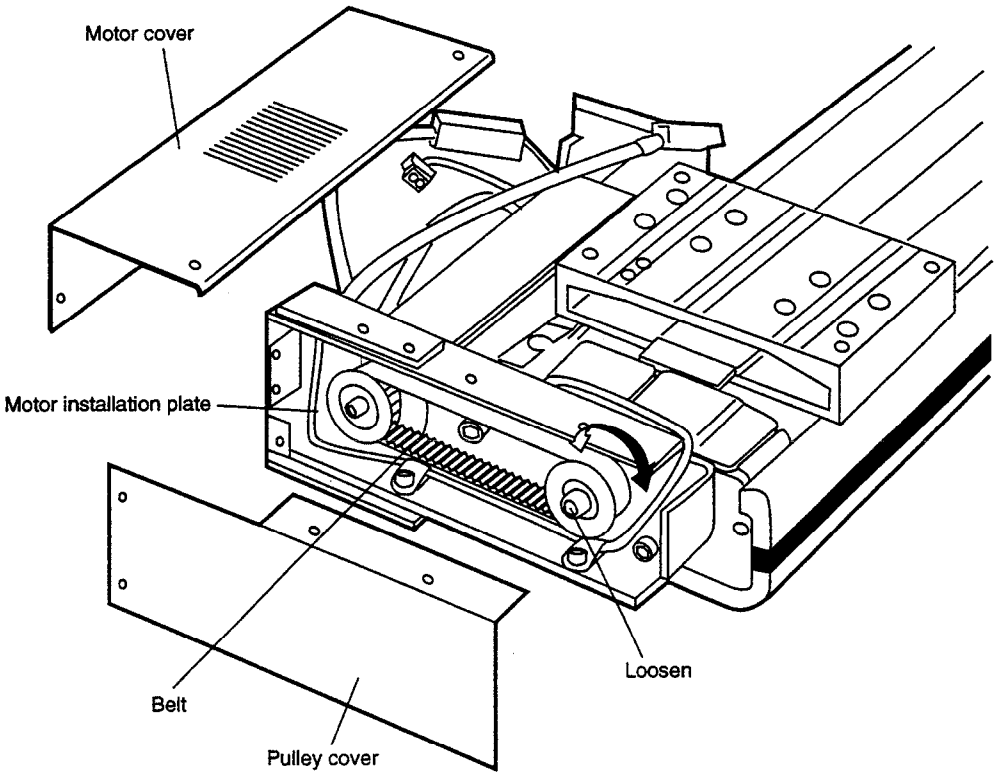
1. **Loosen the screws of the motor cover and connector panel, and remove the cover and panel.**
   To remove the X axis motor cover, remove the wiring box along with it.
2. **Disconnect the motor code and encoder code connectors.**
3. **Using the 4mm hex wrench, loosen the bolt securing the coupling on the motor side.**
   To loosen the bolt, align it with the hole (motor side) of the coupling assembly.
4. **Remove the bolts securing the motor to the coupling assembly and remove the motor.**
5. **Install the new motor in place and tighten the bolts to secure the motor to the coupling assembly.**
6. **Tighten the bolt to secure the motor shaft to the coupling.**
7. **Fasten the motor code and encoder code connectors.**
8. **Readjust the machine reference.**
   Refer to 2-3-2 in Chapter 4.
9. **Reattach the motor cover and connector panel.**

8-3 HXYA (ZLA, ZHA), MXYA (Y axis), SXYA (X, Y axes)



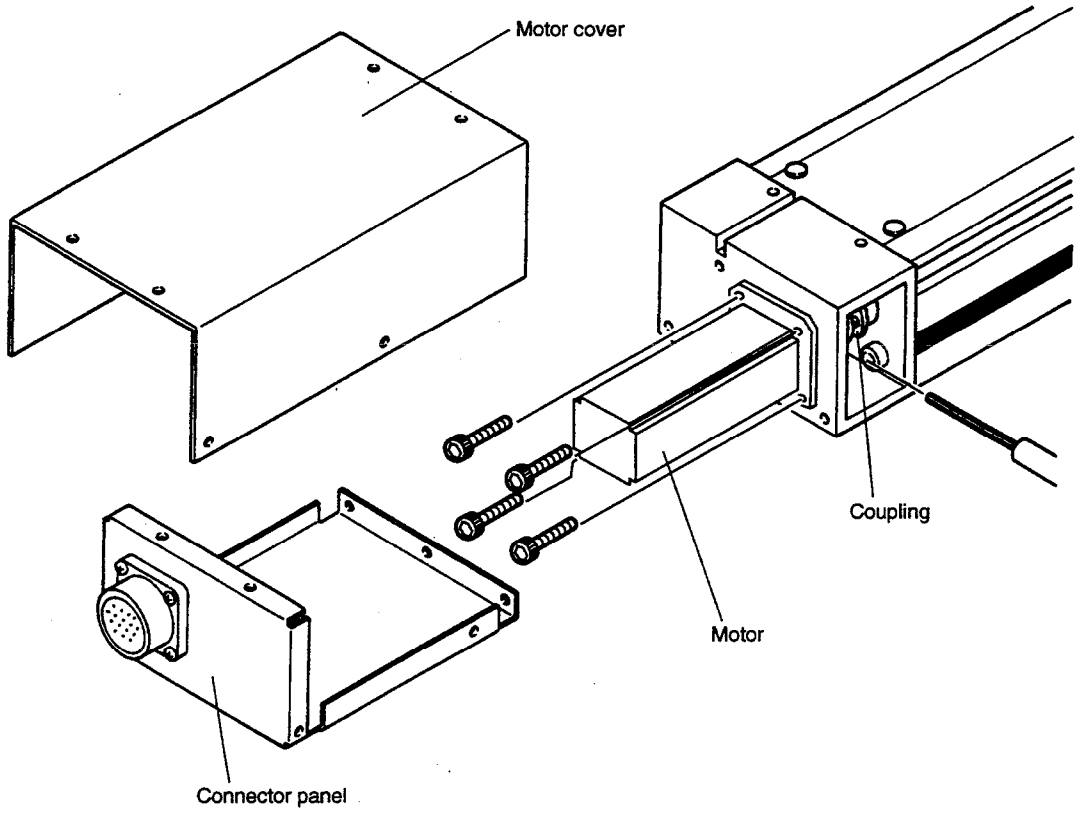
1. **Loosen the screws of the motor cover and connector panel, and remove the cover and panel.**
2. **Disconnect the motor code and encoder code connectors.**
3. **Using the 2.5mm hex wrench, loosen the bolt securing the coupling on the motor side.**
   To loosen the bolt, align it with the hole (motor side) of the coupling assembly.
4. **Remove the bolts securing the motor to the coupling assembly and remove the motor.**
5. **Install the new motor in place and tighten the bolts to secure the motor to the coupling assembly.**
6. **Tighten the bolt to secure the motor shaft to the coupling.**
7. **Fasten the motor code and encoder code connectors.**
8. **Readjust the machine reference.**
   Refer to 2-3 or 2-4 in Chapter 4.
9. **Reattach the motor cover and connector panel.**

8-4 SXYA (Bent Y axis)



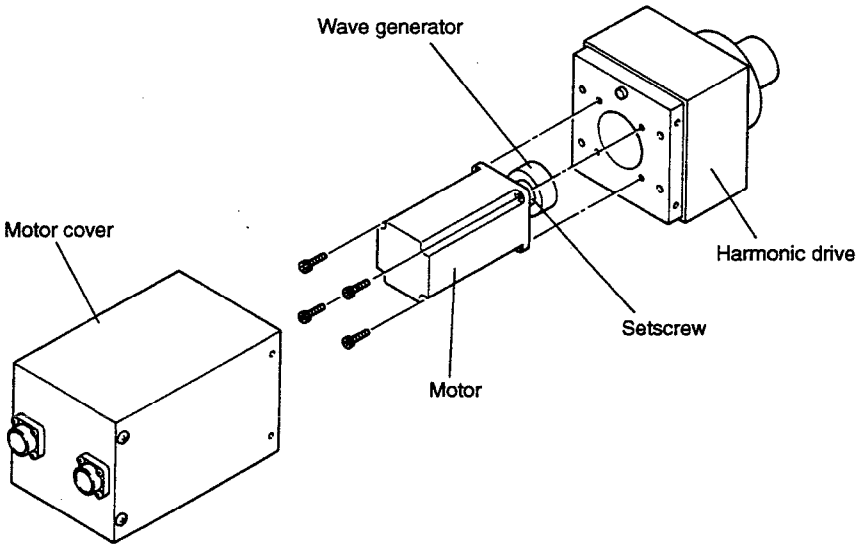
1. Loosen the screws of the motor and pulley covers, and remove these covers.
2. Disconnect the motor code and encoder code connectors.
3. Using the 4mm hex wrench, loosen the bolts securing the motor installation plate to the manipulator frame, and remove the belt from the motor pulley.
4. Loosen the setscrew securing the pulley to the motor shaft and remove the pulley.
5. Remove the bolts securing the motor to the installation plate and remove the motor.
6. Install the new motor in place and tighten the bolts securely.
7. Attach the pulley just removed, to the new motor and tighten the setscrew.
8. Retighten the belt to its correct tension and tighten the bolts to secure the installation plate to the manipulator frame.
9. Fasten the motor code and encoder code connectors.
10. Readjust the machine reference.
    Refer to 2-3-5 in Chapter 4.
11. Reattach the motor and pulley covers.

8-5 MXYA (ZFA), SXYA (ZFA)



1. **Loosen the screws of the motor cover and connector panel, and remove the cover and panel.**
2. **Disconnect the motor code and encoder code connectors.**
3. **Using the 4mm hex wrench, loosen the bolt securing the coupling on the motor side.**
4. **Remove the bolts securing the motor to the coupling assembly and remove the motor.**
5. **Install the new motor in place and tighten the bolts to secure the motor to the coupling assembly.**
6. **Tighten the bolt to secure the motor shaft to the coupling.**
7. **Fasten the motor code and encoder code connectors.**
8. **Readjust the machine reference.**
   Refer to 2-3 or 2-4 in Chapter 4.
9. **Reattach the motor cover and connector panel.**

8-6 HXYA (ZRLA/H), MXYA (ZRFA), MXYA (ZRFA)



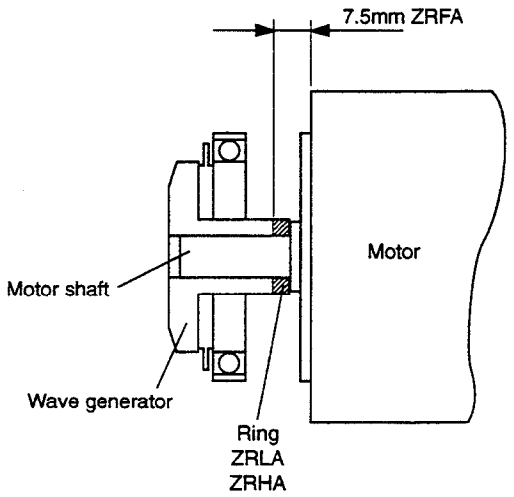
[1] Loosen the screws of the motor cover and remove the motor cover.

[2] Disconnect the motor code and encoder code connectors.

[3] Remove the bolts securing the motor to the harmonic drive.

[4] Using the 2mm hex wrench, loosen the setscrew securing the wave generator to the motor shaft and remove the wave generator.

[5] Fit the wave generator just removed, onto the shaft of the new motor.
For ZRLA and ZRHA units, first fit the ring onto the shaft and then the wave generator while pressing it all the way to the inside.
For ZRFA units, check with a caliper that the wave generator is at the position shown in the drawing below.



Installing the wave generator to the motor

6 Tighten the setscrew to secure the wave generator.
At this point, apply a small amount of "Screwlock" to the setscrew and then tighten.

7 Install the new motor in place and tighten the bolts to secure the motor to the harmonic drive.

NOTE

To install the motor smoothly, insert the wave generator gently into the harmonic drive while turning the R axis output shaft to the right and left. Take care not to apply impacts or shocks to the motor and harmonic drive.

8 Fasten the motor code and encoder code connectors .

9 Readjust the machine reference.
Refer to 2-5 in Chapter 4.

10 Reattach the motor cover.

CHAPTER 6

Specification

1 Manipulator Tolerable Moment

1-1 X and Y axis linear guide static tolerable moment

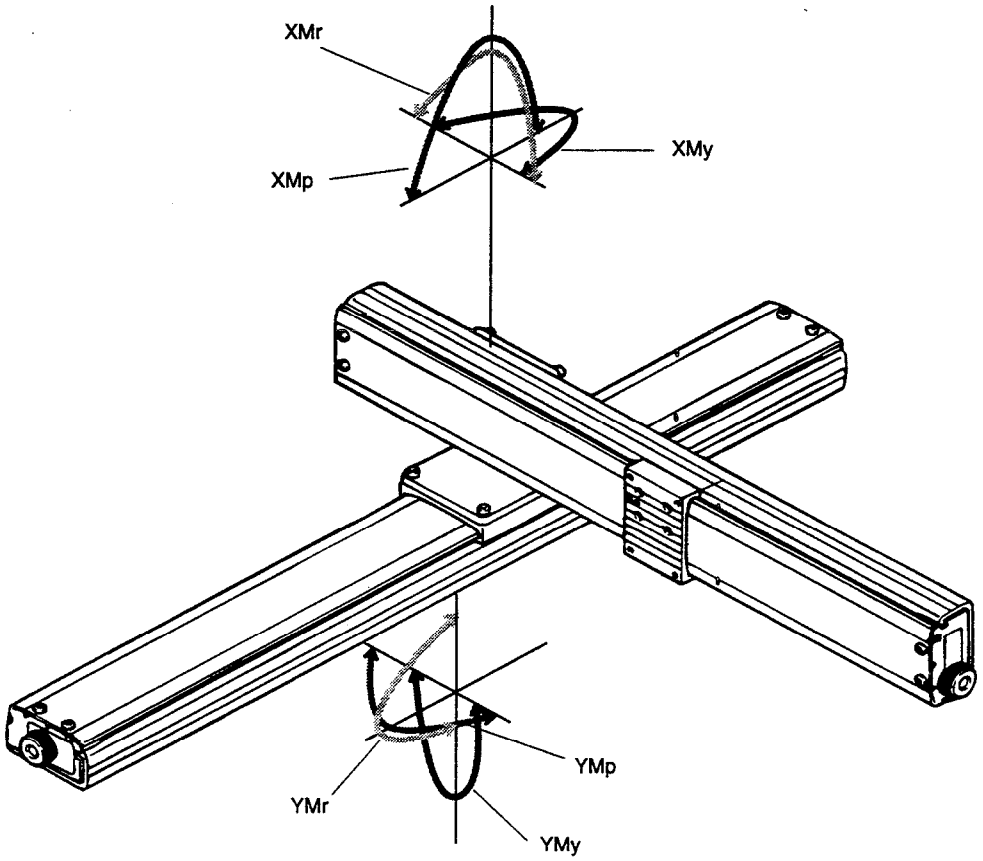


Figure 6-1

When an external force is applied to the manipulator in the still state, the tolerable range is as follows:

kgfm

	SXYA		MXYA		HXYA	
	X Axis	**Y Axis**	**X Axis**	**Y Axis**	**X Axis**	**Y Axis**
Yaw My	38	6	67	38	115	67
Pitch Mp	38	6	71	38	122	71
Roll Mr	36	9	87	36	157	87

1-2 R axis tolerable moment of inertia

(1) R axis tolerable moment of inertia

The load that can be installed to the R axis is limited by the R axis motor, speed reducer and timing belt strength specifications. Operating the robot with a load exceeding this limit will lead to a premature life reduction or mechanical damage of the above drive parts and residual vibrations during positioning. The limits of this R axis load are shown below with a term called the R axis tolerable moment of inertia.

Refer to the calculated examples of the moment of inertia shown on the subsequent pages and check that the moment of inertia of the R axis load does not exceed the tolerable value.

ZRLA, ZRHA

[Unit: kg•cm•sec²]

Tip load weight	ZRSA	ZRFA	ZRLA (ZRHA)
1	0.015	0.12	0.93
2	0.015	0.24	1.8
3	0.015	0.36	2.8
4	0.015	0.48	3.7
5	0.015	0.6	4.6
6	—	0.72	5.6
7	—	—	6.5
8	—	—	7.4
9	—	—	8.4
10	—	—	9.3

(2) Equation for moment of inertia calculation

Usually the R axis load is not a simple form, and the calculation of the moment of inertia is not easy. As a method, the load is replaced with several factors that resemble a simple form for which the moment of inertia can be calculated. The total of the moment of inertia for these factors is then obtained. The objects and equations often used for the calculation of the moment of inertia are shown below.

1. Moment of inertia for cylinder

The equation for the moment of inertia (J) for a cylinder that has a rotation center such as shown in Figure 6-2 is given below.

$$J = \frac{\rho\pi D^4 h}{32g} = \frac{WD^4}{8g} \quad (kg \cdot cm \cdot sec^2) \quad ...(4.1)$$

ρ : Density (kg/cm^3)
g : Gravitational acceration (cm/sec^2)
W : Weight of the cylinder (kg)

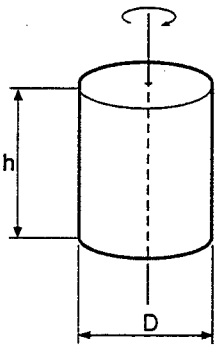


Figure 6-2

2. Moment of inertia for rectangular parallelepiped

The equation for the moment of inertia (J) for a rectangular parallelopiped that has a rotation center such as shown in Figure 6-3 is given as follows:

$$J = \frac{\rho abc(a^2 + b^2)}{12g} = \frac{W(a^2 + b^2)}{12g} \quad ... (4.2)$$

ρ : Density (kg/cm^3)
g : Gravitational acceration (cm/sec^2)
W : Weight of the rectangular parallelopiped (kg)

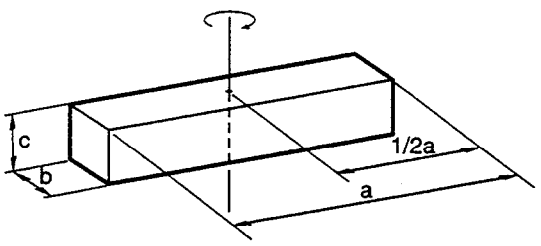


Figure 6-3

3. When the objects center line is offset from the rotation center.

When the center of the cylinder is offset by the distance "x" from the rotation center as shown in Figure 6-4, the equation for the moment of inertia (J) is given as follows.

$$J = \frac{\rho \pi D^4 h}{32g} + \frac{\rho \pi D^2 h x^2}{4g} = \frac{WD^2}{8g} + \frac{Wx^2}{g} \ (kg \bullet cm \bullet sec^2) \quad ... (4.3)$$

W : Weight of the cylinder (kg)

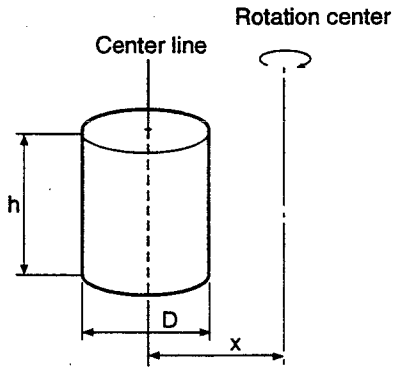


Figure 6-4

In the same manner, the equation for a rectangular parallelopiped is given as follows.

$$J = \frac{\rho abc(a^2 + b^2)}{12g} + \frac{\rho abcx^2}{g} = \frac{W(a^2 + b^2)}{12g} + \frac{Wx^2}{g} \ (kg \bullet cm \bullet sec^2) \quad ... (4.4)$$

W : Weight of the rectangular parallelopiped (kg)

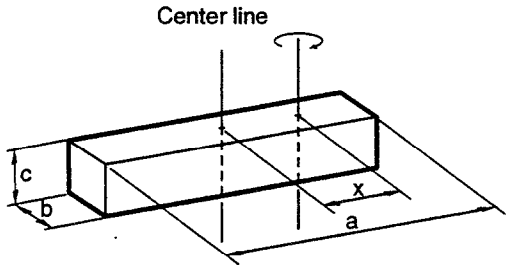


Figure 6-5

(3) Example of moment of inertia calculation

Let's discuss an example in which the chuck and workpiece are at a position offset by 10cm from the R axis by a stay as shown in Figure 6-5. The moment of inertia is calculated with the following three factors, assuming that the load material is steel and its density ρ is 0.0078kg/cm^3.

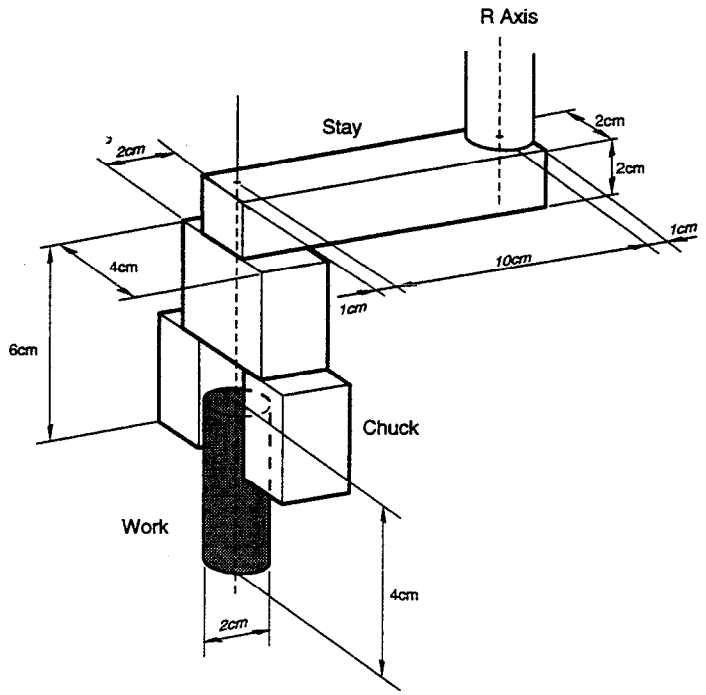


Figure 6-5

1. Moment of inertia of the stay

From Figure 6-6, the weight (Ws) is:

$$Ws = \rho\, abc = 0.0078 \times 12 \times 2 \times 2 = 0.37\,(kg)$$

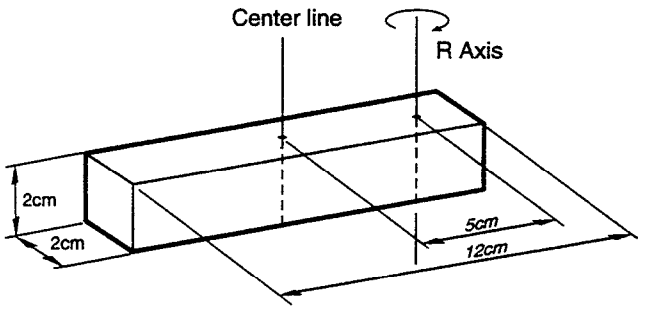


Figure 6-6

From equation (4.4), the moment of inertia (Js) is:

$$Js = \frac{0.37 \times (12^2 + 2^2)}{12 \times 980} + \frac{0.37 \times 10^2}{980} = 0.042\ (kg \bullet cm \bullet sec^2)$$

2. Moment of inertia of the chuck

When the chuck form resembles that shown in Figure 6-7, the width and moment of inertia (Jc) of chuck (Wc) is

$$Wc = 0.0078 \times 2 \times 4 \times 6 = 0.37(kg)$$

$$Jc = \frac{0.37 \times (2^2 + 4^2)}{12 \times 980} + \frac{0.37 \times 10^2}{980} = 0.038\ (kg \bullet cm \bullet sec^2)$$

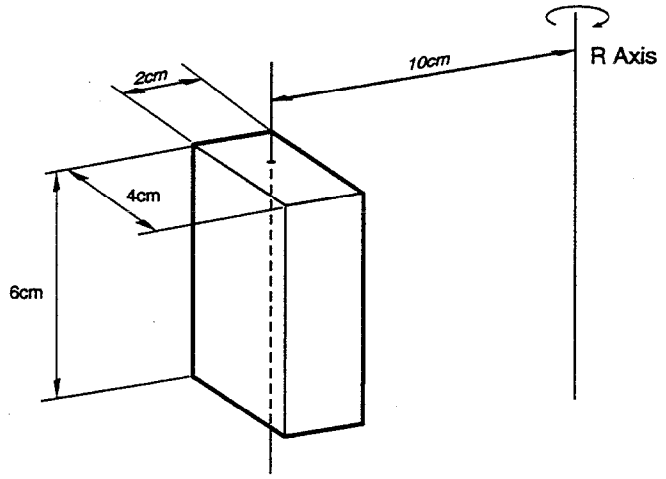


Figure 6-7

3. Moment of inertia of workpiece

From Figure 6-8, the weight (Ww) and the moment of inertia (Jw) of the workpiece is

$$Ww = \frac{\rho \pi D^2 h}{4} = \frac{0.0078 \pi \times 2^2 \times 4}{4} = 0.097(kg)$$

$$Jw = \frac{0.097 \times 2^2}{8 \times 980} + \frac{0.097 \times 10^2}{980} = 0.010\ (kg \bullet cm \bullet sec^2)$$

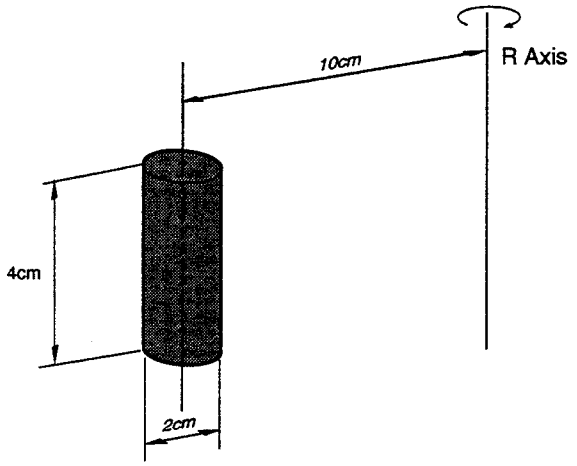


Figure 6-8

4. Total weight

The equation for the total weight (W) is given as follows.

$$W=Ws+Wc+Ww=0.83 \text{ (kg)}$$

5. Total moment of inertia

The equation for the total moment of inertia (J) is given as follows.

$$J=Js+Jc+Jw=0.09 \text{ (kg} \cdot \text{cm} \cdot \text{sec}^2\text{)}$$

2 Robot Control Signals

[DRCA]

MARK	SIGNAL	CN	No.	CONNECT	No.	CN	WIRE COLOR	WIRE
P1	PA	P1	2		1	P1	BLU	PA
	$\overline{PA}$		3		2		ORA	$\overline{PA}$
	PB		4		3		GRE	PB
	$\overline{PB}$		5		4		BRO	$\overline{PB}$
	PC		6		5		GRA	PC
	$\overline{PC}$		7		6		RED	$\overline{PC}$
	P5V		8		15		BLA	P5V
	PGND		10		16		YEL	PGND
	P5V		9		17		PIN	P5V
	PGND		11		18		PUR	PGND
	FG		1		25		WHI	FG
	24V	ORG1	13		19	ORG1	ORA/WHI1	24V
	ORG		12		11		GRE/WHI1	ORG
	24VGND		14		20		BRO/WHI1	24VGND
					12	LMT1		LS
					21			24V
					22			24VGND
	MB+	BK1	15		13	BK1	RED/WHI1	MB+
	MB–		16		14		BLA/WHI1	MB–
P2	PA	P2	2		25	P2	BLU	PA
	$\overline{PA}$		3		27		ORA	$\overline{PA}$
	PB		4		28		GRE	PB
	$\overline{PB}$		5		29		BRO	$\overline{PB}$
	PC		6		30		GRA	PC
	$\overline{PC}$		7		31		RED	$\overline{PC}$
	P5V		8		40		BLA	P5V
	PGND		10		41		YEL	PGND
	P5V		9		42		PIN	P5V
	PGN		11		43		PUR	PGND
	FG		1		50		WHI	FG
	24V	ORG2	13		44	ORG2	ORA/WHI1	24V
	ORG		12		36		GRE/WHI1	ORG
	24VGND		14		45		BRO/WHI1	24VGND
					37	LMY2		LS
					46			24V
					47			24VGND
	MB+	BK2	15		38	BK2	RED/WHI1	MB+
	MB–		16		39		BLA/WHIT1	MB–
					24			
M1	U	M1	3		1	M1	BRO	U
	V		8		2		RED	V
	W		10		3		ORA	W
	FG		1		7			FG
M2	U	M2	3		10	M2	BRO	U
	V		8		9		RED	V
	W		10		8		ORA	W
	FG		1		4			FG

Table 6-1 Robot cable wiring for the DRCA controller

[MRCA, QRCA]

MARK	SIGNAL	CN	No.	CONNECT	No.	CN	WIRE COLOR	WIRE
P1	PA	ZP	1		1	ZR	BLU	PA
	$\overline{PA}$		2		2		ORA	$\overline{PA}$
	PB		3		3		GRE	PB
	$\overline{PB}$		4		4		BRO	$\overline{PB}$
	PC		5		5		GRA	PC
	$\overline{PC}$		6		6		RED	$\overline{PC}$
	PGND		7		15		BLA	P5V
					16		YEL	PGND
	P5V		8		17		PIN	P5V
					18		PUR	PGND
	FG		9		25		GRE	FG
	24V	ZORG	1		11		WHI	24V
	ORG		2		20		BLU/RED1	ORG
	24VGND		3		19		ORA/WHI1	24VGND
					12		BLU	LS
					21			24V
					22		BLU	24VGN
	MB+	ZBK	1		13		RED/WHI1	MB+
	MB–		2		14		BLA/WHI1	MB–
P2	PA	RP	1		26		YEL/BLA1	PA
	$\overline{PA}$		2		27		PIN/BLA1	$\overline{PA}$
	PB		3		28		PUR/WHI1	PB
	$\overline{PB}$		4		29		WHI/BLU1	$\overline{PB}$
	PC		5		30		BLU/RED2	PC
	$\overline{PC}$		6		31		ORA/WHI2	$\overline{PC}$
	PGND		7		40		GRE/WHI2	P5V
					41		BRO/WHI2	PGND
	P5V		8		42		GRA/WHI2	P5V
					43		RED/WHI2	PGND
	FG		9		50		GRE	FG
	24V	RORG	1		36		BLA/WHI2	24V
	ORG		2		45		YEL/BLA2	ORG
	24VGND		3		44		PIN/BLA2	24VGND
					37		BLE	LS
					46			24V
					47		BLU	24VGND
	MB+	RBK	1		38		ORA/BLA1	MB+
	MB–		2		39		GRE/BLA1	MB–
			3		24			
M1	U	ZM	1		1	ZRM	WHI1	U
	V		2		2		WHI2	V
	W		3		3		WHI3	W
	FG		4		7		WHI4	FG
M2	U	RM	1		10		WHI5	U
	V		2		9		WHI6	V
	W		3		8		WHI7	W
	FG		4		4		WHI8	FG

Table 6-2 Robot cable wiring for the MRC, QRCA controller

MARK	SIGNAL	CN	No.	CONNECT	No.	CN	WIRE COLOR	WIRE
P1	PA	XP	1		1	XY	BLU	PA
	$\overline{PA}$		2		2		ORA	$\overline{PA}$
	PB		3		3		GRE	PB
	$\overline{PB}$		4		4		BRO	$\overline{PB}$
	PC		5		5		GRA	PC
	$\overline{PC}$		6		6		RED	$\overline{PC}$
	PGND		7		15		BLA	P5V
					16		YEL	PGND
	P5V		8		17		PIN	P5V
					18		PUR	PGND
	FG		9		25		GRE	FG
	24V	XORG	1		11		WHI	24V
	ORG		2		20		BLE/RED1	ORG
	24VGND		3		19		ORA/WHI1	24VGND
					12		BLU	LS
					21			24V
					22		BLU	24VGN
	MB+	XBK	1		13		RED/WHI1	MB+
	MB–		2		14		BLA/WHI1	MB–
P2	PA	YP	1		26		YEL/BLA1	PA
	$\overline{PA}$		2		27		PIN/BLA1	$\overline{PA}$
	PB		3		28		PUR/WHI1	PB
	$\overline{PB}$		4		29		WHI/BLU1	$\overline{PB}$
	PC		5		30		BLU/RED2	PC
	$\overline{PC}$		6		31		ORA/WHI2	$\overline{PC}$
	PGND		7		40		GRE/WHI2	P5V
					41		BRO/WHI2	PGND
	P5V		8		42		GRA/WHI2	P5V
					43		RED/WHI2	PGND
	FG		9		50		GRE	FG
	24V	YORG	1		36		BLA/WHI2	24V
	ORG		2		45		YEL/BLA2	ORG
	24VGND		3		44		PIN/BLA2	24VGND
					37		BLU	LS
					46			24V
					47		BLU	24VGND
	MB+	YBK	1		38		ORA/BLA1	MB+
	MB–		2		39		GRE/BLA1	MB–
			3		24			
M1	U	XM	1		1	XYM	WHI1	U
	V		2		2		WHI2	V
	W		3		3		WHI3	W
	FG		4		7		WHI4	FG
M2	U	YM	1		10		WHI5	U
	V		2		9		WHI6	V
	W		3		8		WHI7	W
	FG		4		4		WHI8	FG

3 Robot Cable Connection

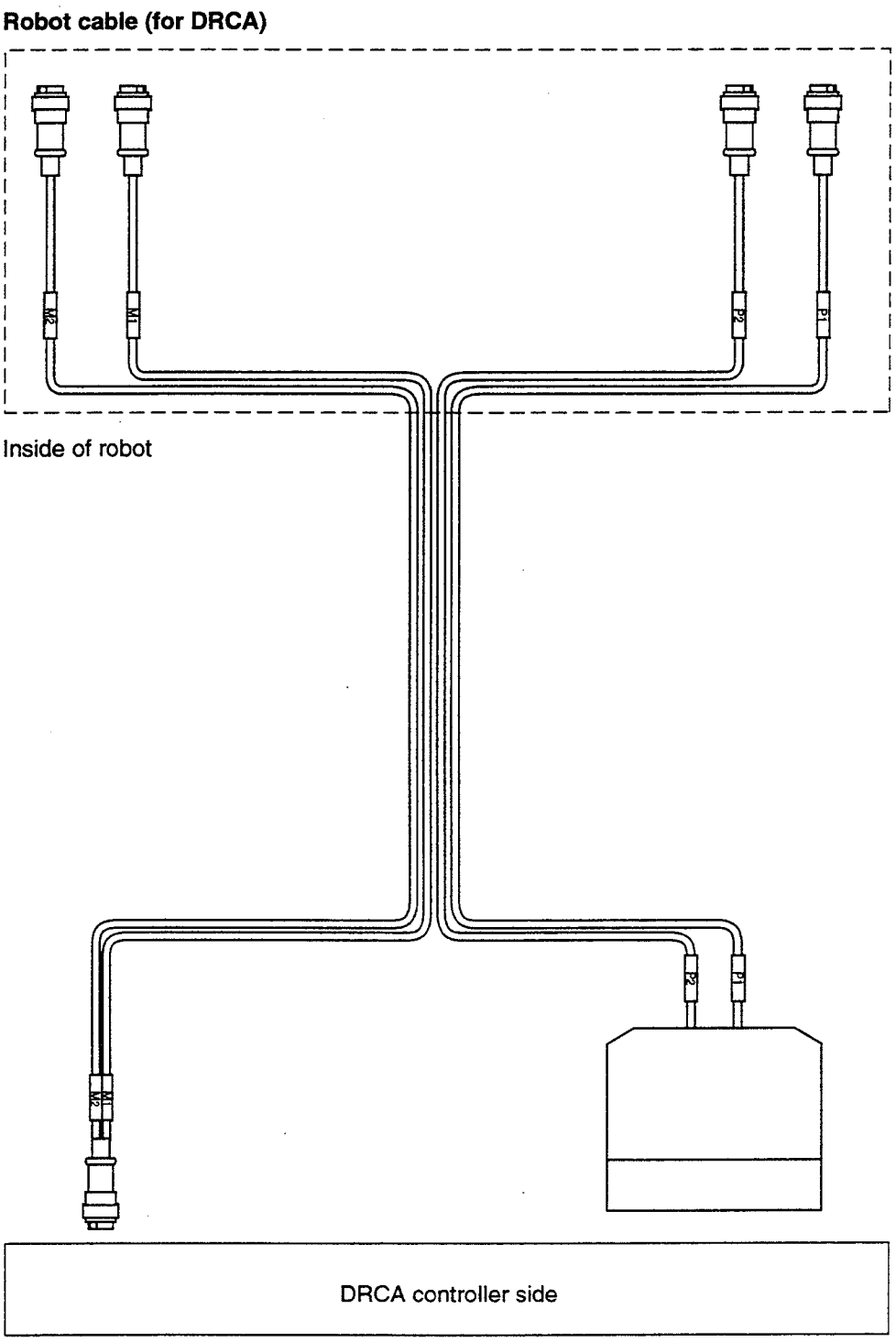


Figure 6-9 Robot cable connection to the DRCA controller

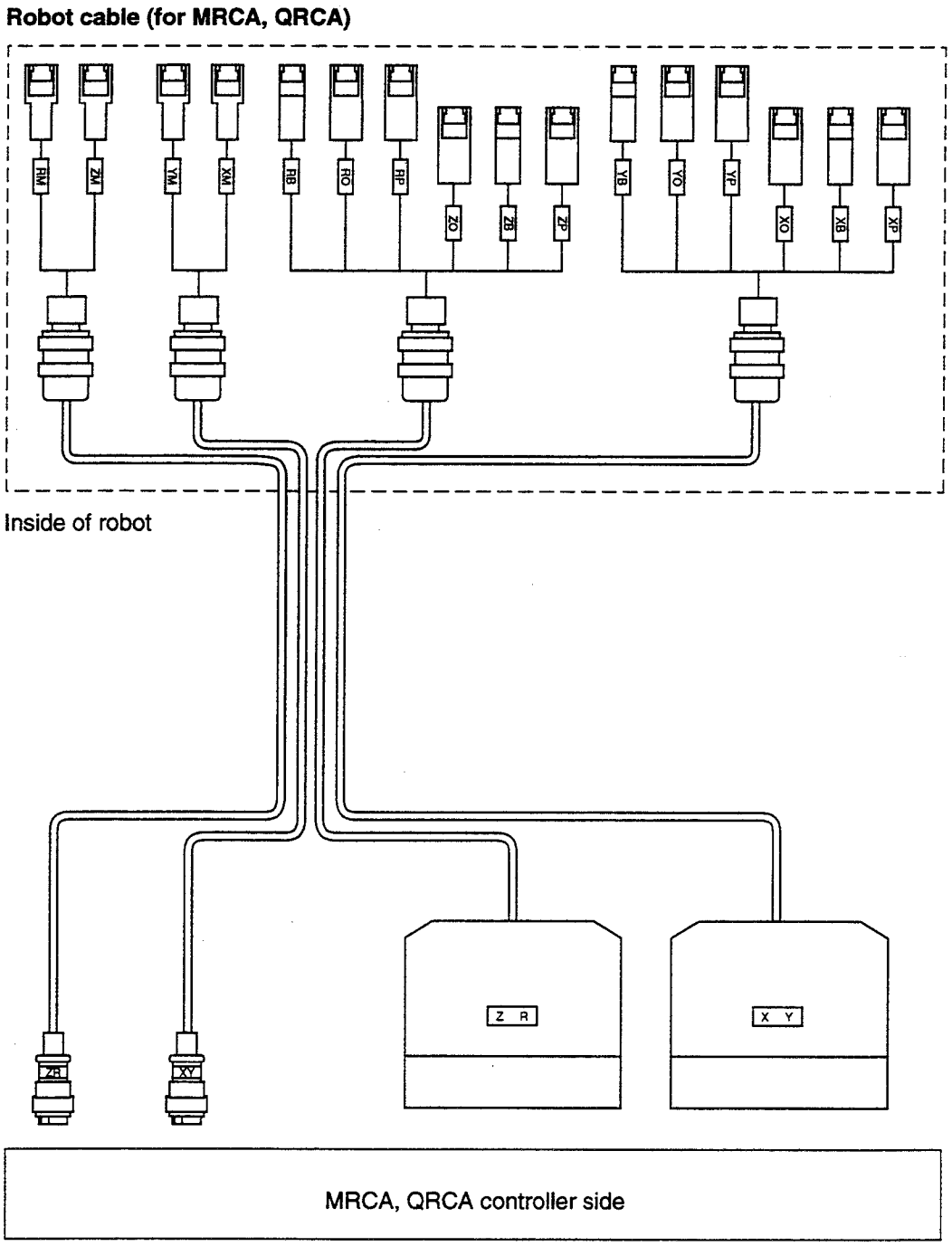


Figure 6-10 Robot cable connection to the MRC, QRCA controller (2 axis type)

4 Using the Cable Bearer

To insert additional cables or air tubes into the cable bearer equipped with the robot as standard, observe the following precautions.

CAUTION

1. Use cables with high resistance to bending.
2. Cables and air tubes should take up no more than 30% of the cable bearer area.
3. Store cables and air tubes neatly in the cable bearer so that they do not cross each other.
4. Do not fasten the cables or air tubes at the entrance or exit of the cable bearer. If they need to be fastened, fasten them lightly to allow a slight play.

NOTE

To enhance reliability and make maintenance easier, it is recommended to use partition plates within the cable bearer so that cables are separated from air tubes.

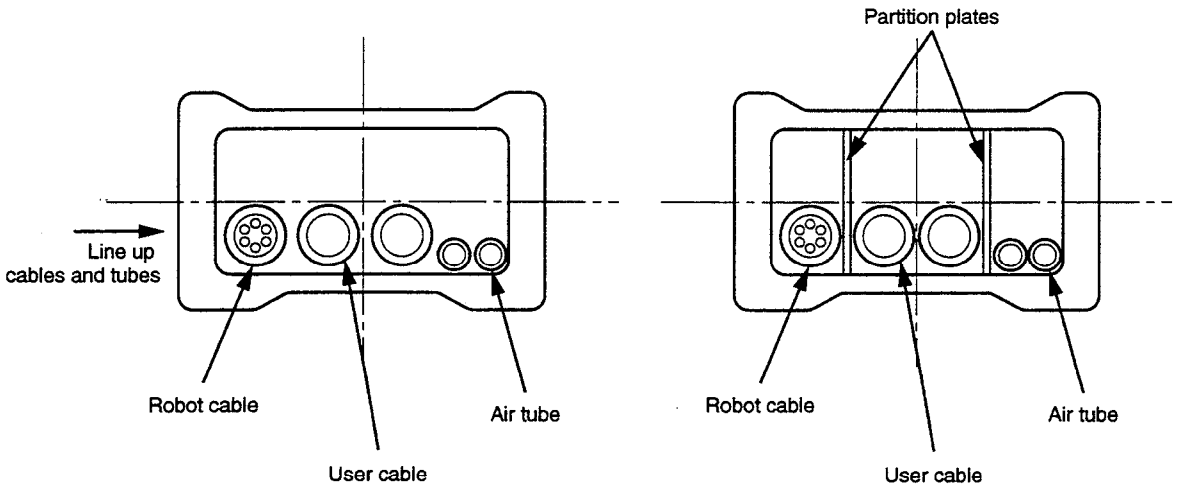


Figure 6-11 Cable and air tube arrangement in cable bearer

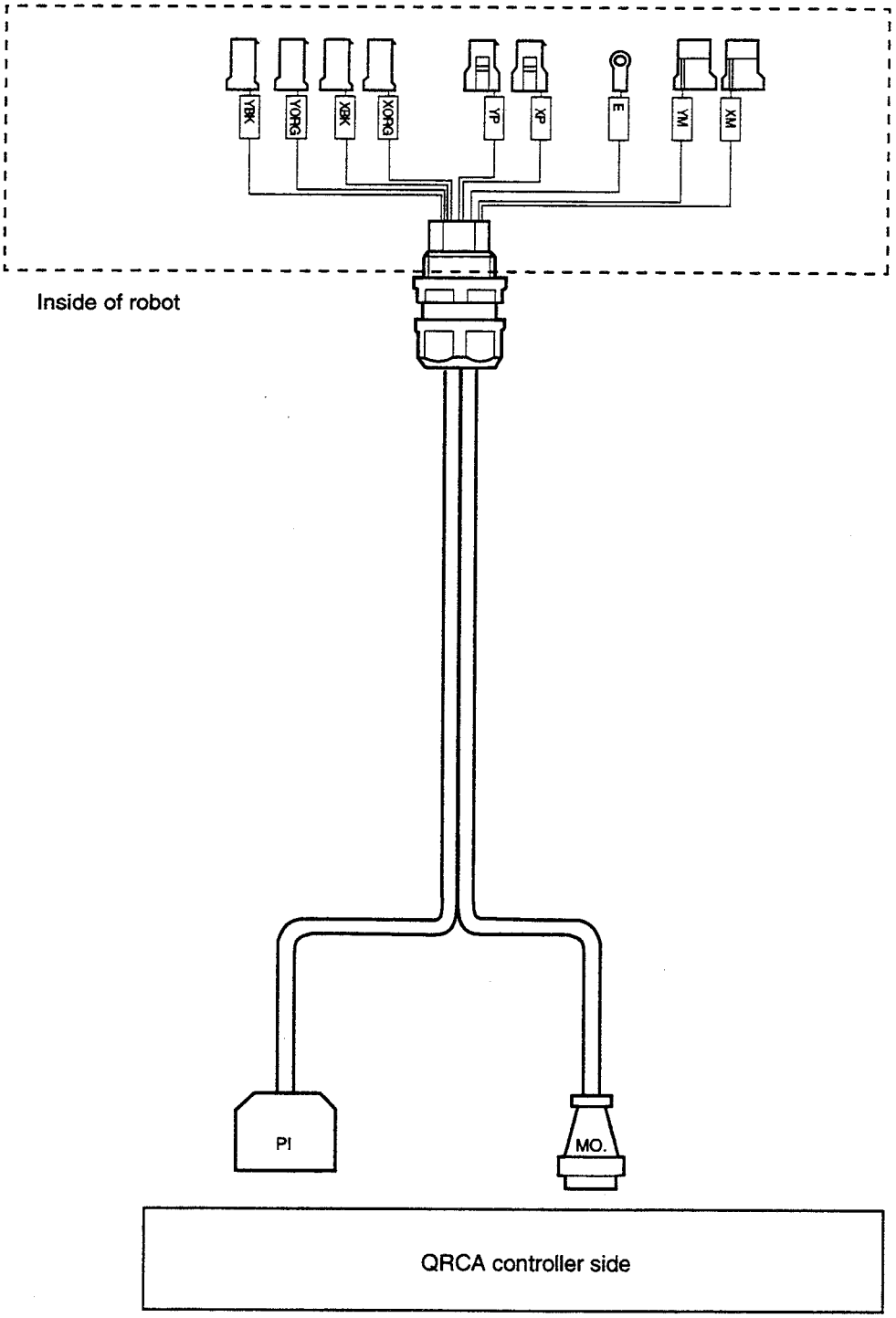


Figure 6-10 Robot cable connection to the QRCA controller (2 axis type)

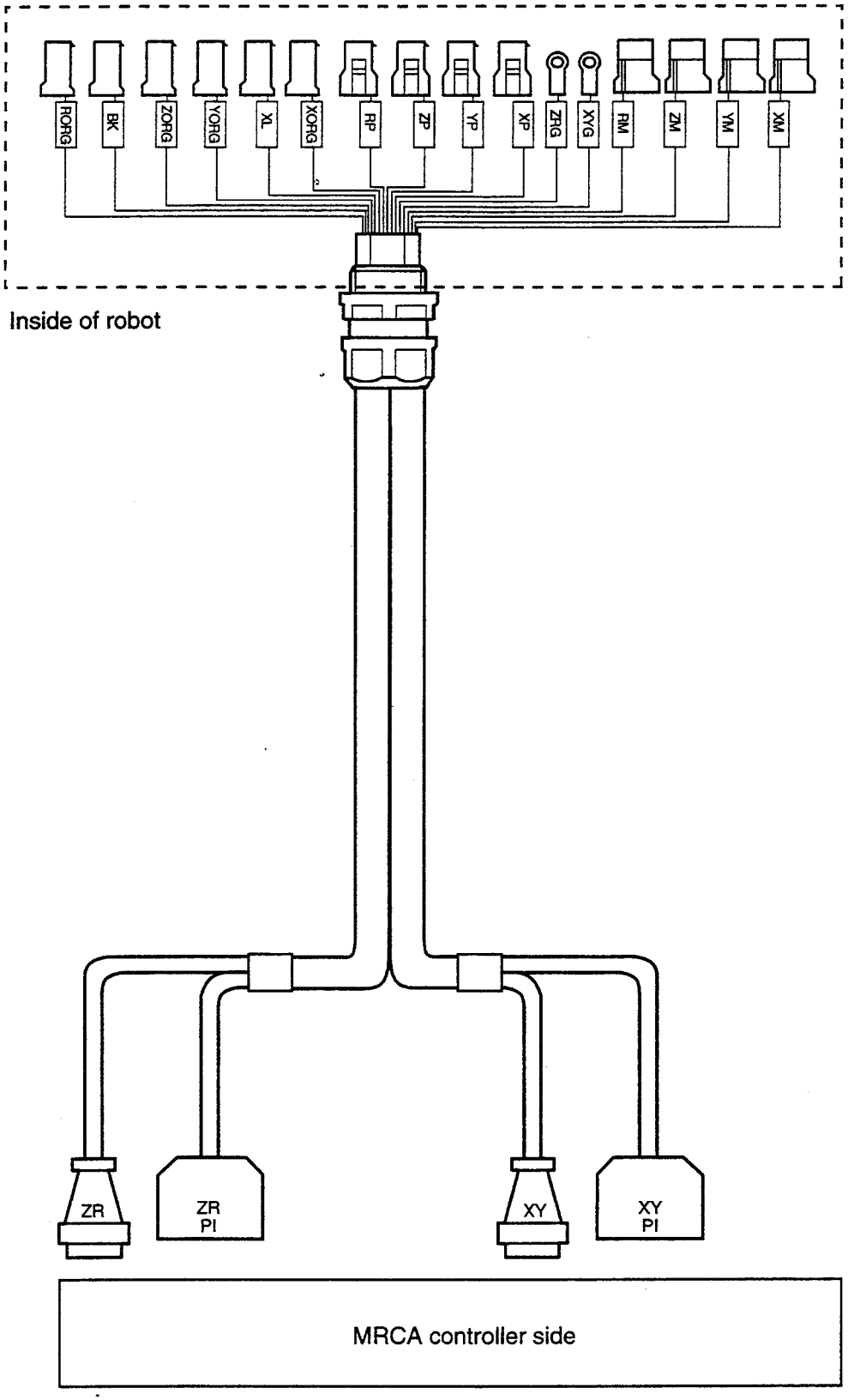


Figure 6-11 Robot cable connection to the MRCA controller

4 Using the Cable Bearer

To insert additional cables or air tubes into the cable bearer equipped with the robot as standard, observe the following precautions.

CAUTION

1. Use cables with high resistance to bending.
2. Cables and air tubes should take up no more than 30% of the cable bearer area.
3. Store cables and air tubes neatly in the cable bearer so that they do not cross each other.
4. Do not fasten the cables or air tubes at the entrance or exit of the cable bearer. If they need to be fastened, fasten them lightly to allow a slight play.

NOTE

To enhance reliability and make maintenance easier, it is recommended to use partition plates within the cable bearer so that cables are separated from air tubes.

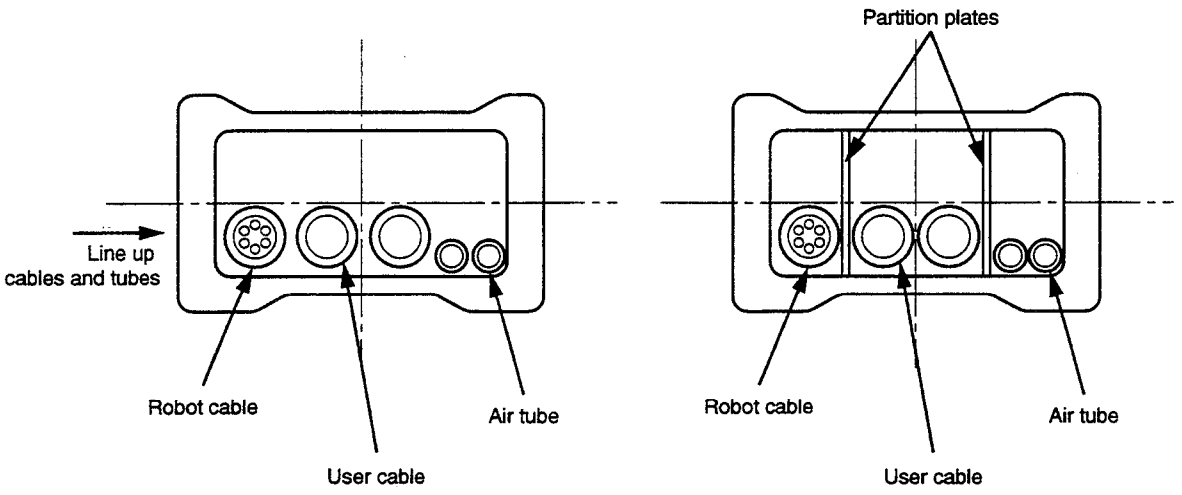
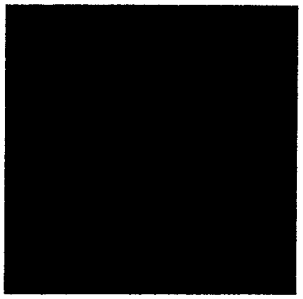


Figure 6-12 Cable and air tube arrangement in cable bearer



Appendix

Request for owner's manual correction

To Your Distributor

Title of owner's manual	XY series FXY series Scalar series Clean scalar series	QRC series DRC series	
Date of purchasing robot			
Issuer	PHONE – – FAX – –	Date of issue	
Correction description	1. Incorrect description 2. Insufficient description 3. Unclear description 4. Typographical error 5. Insufficient description of terms 6. Inconsistent use of terms 7. Request 8. Other		

Line	Page	Correction (Indicate with above numbers.)	Description to be corrected	Suggested correction

Request for service

Issue date:

To: Your Distributor	Customer	Company
		Contact
		Address
		PHONE
		FAX
	Sales representative	Company
		Contact
		PHONE
		FAX

Request description	☐ Complaint	☐ Call.
	☐ Paid repair	☐ Visit.
	☐ Periodical inspection	☐ Problem part is sent for repair.
	☐ Other	☐ Other

Product	Date of delivery :	
	Mechanism type :	Controller model :
	Mechanism manufacturing number :	Controller manufacturing number :

Problem description	Positioning error, abnormal noise, error messages, frequency of occurrence, etc.
Remarks	

AC SERVO MOTOR
CARTESIAN ROBOTS
XYA SERIES

OWNER'S MANUAL

May. 1996

IM OPERATIONS

YAMAHA

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