

EPSON

SCARA ROBOT

HS

BL-CL TYPE

Rev. 2

EM967R478F

CE

SCARA ROBOT

BL-CL TYPE

EPSON

SCARA ROBOT

BL-CL TYPE

Rev. 2

WARRANTY

The robots and their options are shipped to our customers only after being subjected to the strictest quality controls, tests and inspections to certify their compliance with our high performance standards.

Product's malfunction(s) resulting from normal handling operation will be repaired free of charge up to 12 months after delivery.

However, customers will be charged for repairs in the following cases:

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

SERVICE CENTER

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

Please have the model name, M. CODE, software version and a description of the problem ready when you call.



MANUFACTURER

SEIKO EPSON CORPORATION

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NOTICE

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The content of this manual is subject to change without notice.

Seiko Epson asks that you please notify it if you should find any errors in this manual or if you have any comments regarding its content.

Safety Precautions

WARNING

The robot system manufacturer/supplier shall design and construct robot systems in accordance with the principles described in "Safety section" of the user's manual. Please read user's manual first.

This robot has been designed and manufactured strictly for use in a normal indoor environment. Do not use the robot in an environment that exceeds the conditions set forth in the manuals for the manipulator and controller.

Do not use the robot in excess of the usage conditions and product specifications described in the manuals. Doing so will not only adversely affect the life of the product but may also present a serious safety problem.

Only trained personnel should be allowed to design, install, operate, perform function test, and maintain this robot and the robot system.

Trained personnel are those who have taken a robot training course held by the dealer on a regular basis or those who have carefully read the manuals and have equivalent knowledge or skill.

FOREWORD

This manual specifies matters that you need to know to use the BN-type manipulator correctly. Please thoroughly read this and other related manuals before using the equipment.

MANUALS

1. User's manual

A manual that gives a general description of robots. It describes such things as safety precaution, operating methods, teaching methods, programming methods, and file management. Please read user's manual first.

2. Manipulator manual

A manual for the manipulator itself. It describes such things as robot installation, motion range, safety, and hands.

3. Robot controller manual

A manual for the robot controller. It describes such things as installation, switch settings, and connection with peripheral equipment.

4. Reference manual

A manual that describes the commands for the SPEL III robot language.

5. Maintenance manual

A manual that describes the maintenance procedure of the robot. It describes such things as check points, troubleshooting, how to repair and so on.

6. Operating unit manual (option)

A manual for the operating unit that describes such things as operating methods.

7. Programming support software manual (option)

A manual for the program development support software. It describes such things as operating environment and operating methods of SPEL Editor or SPEL for Windows.

We provide two kinds of software, SPEL Editor (for MS-DOS) and SPEL for Windows (for Microsoft Windows). We also provide Vision Guide, the integrated robot vision system, as an option of SPEL for Windows.

8. Teaching pendant manual (option)

A manual for the teaching pendant. It describes such things as how to operate the teaching pendant.

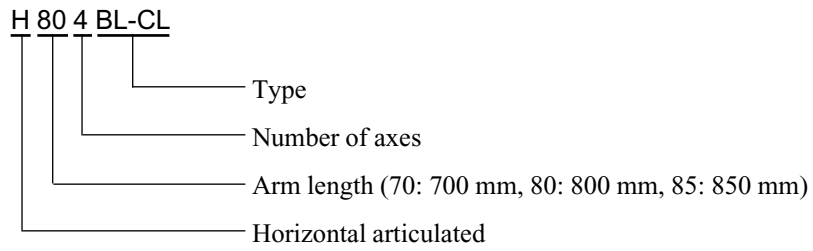
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1. Manipulator Part Names

The model name of this manipulator is written as follows.



Manipulator parts

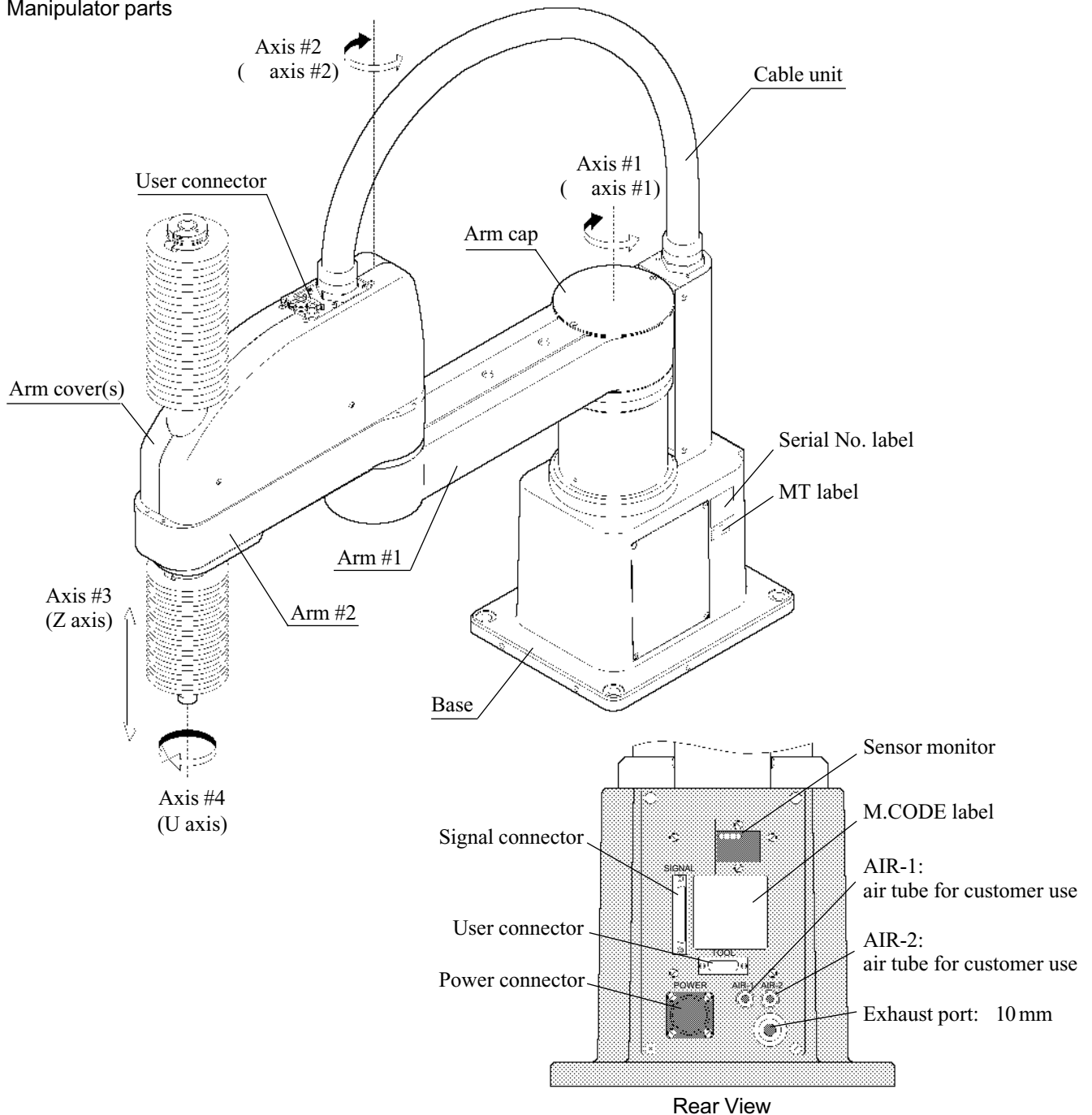


Figure 1 Manipulator

2. Installation Requirements

2.1 Environmental conditions

The specification of this manipulator is designed for clean room use, and clean class is 10 (0.3 μm). A suitable environment is necessary for the manipulator to function properly and safely. Please install the robot in a place that meets the following requirements.

Ambient temperature	5 ~ 40 °C	(with minimum temperature variation)
Ambient relative humidity	10 ~ 80 %	(no condensation)
Impulse noise	1000 V (1 μs) max.	(between primary power source and ground)
Electrostatic noise	5 kV max.	(capacitor charge system)
Environment	<ul style="list-style-type: none">· Install indoors.· Keep away from direct sunlight.· Keep away from dust, oily smoke, salinity, metal powder or other contaminants.· Keep away from flammable or corrosive solvents and gases.· Keep away from water.· Keep away from shocks or vibrations.· Keep away from sources of electric noise. <p>This robot with this standard specification is not suitable for the operation in bad environment such as painting, etc. Contact the service center or the manufacturer for details.</p>	

2.2 Installation area

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

space for teaching

space for performing maintenance and inspections

space for cables

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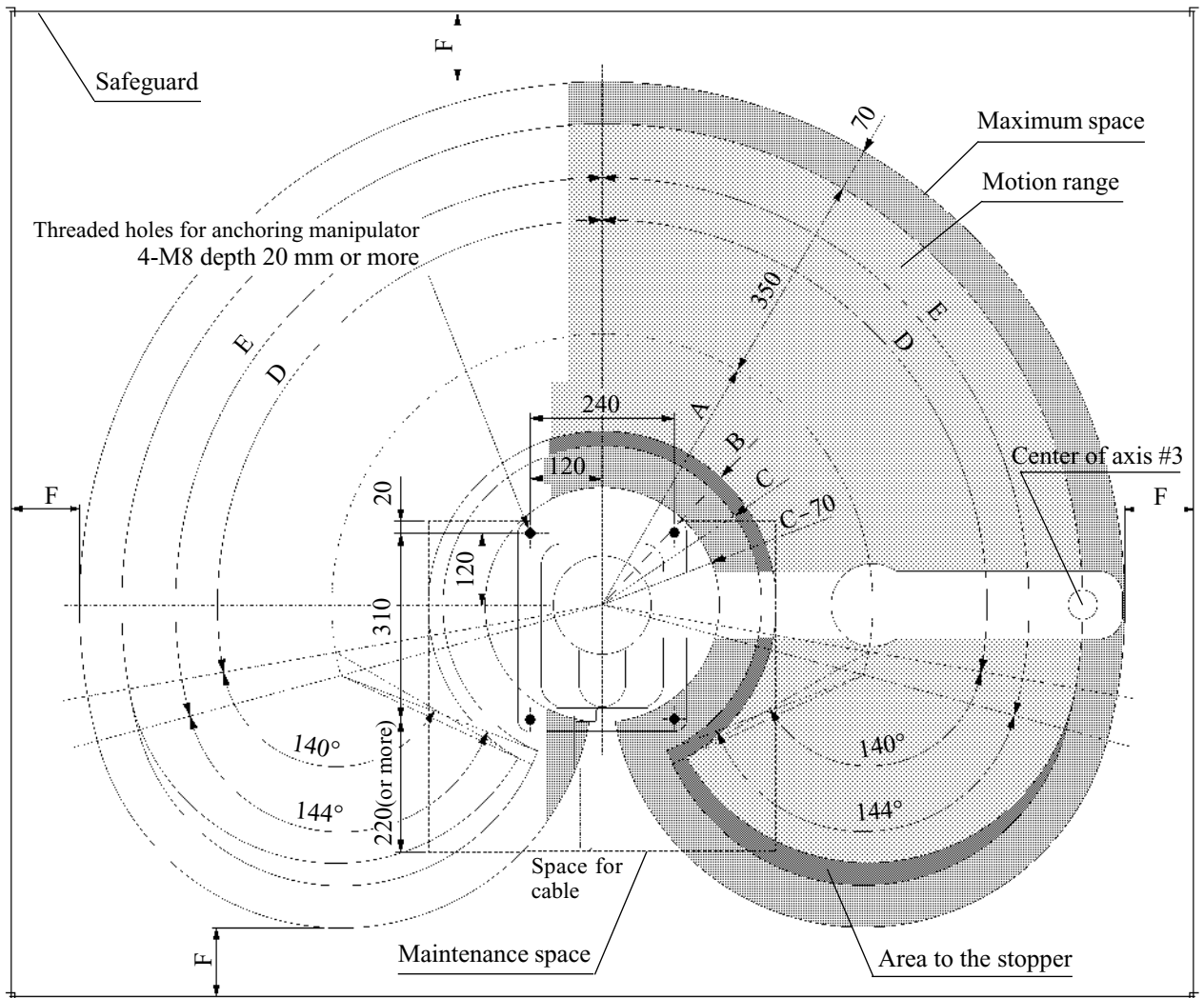
The minimum bend radius of the power cable is 130 mm. When you install the manipulator make certain to maintain sufficient distance from obstacles. Leave enough space for other cables also, so that they don't have to be bent at extreme angles.

2.3 Base table

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

When the controller is put in the table, please read the controller manual which describes space requirements as environment condition.

M12 steel bolts (property class 10.9 or 12.9) are used for anchoring the manipulator to the table. The positions of these threaded holes for anchoring are shown in Figure 2.



Standard range of the manipulator	H704BL-CL	H804BL-CL	H854BL-CL
A (arm #1 length)	350 mm	450 mm	500 mm
B	239 mm	289 mm	323 mm
C	216 mm	265 mm	299 mm
D (motion range of axis #1)	100 °	100 °	110 °
E (range to the stopper of axis #1)	105 °	105 °	115 °
F (range to the safeguard)	approx. 100 mm *		

* In the case that the safeguard completely prevents a person from touching the robot inside, such as a transparent acryl cover for example. Refer to the "Safety section" in the user's manual for an actual dimension "F".

Figure 2 Manipulator installation dimensions (unit: mm)

NOTE
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There is a limitation for the motion range of H704BL-CL. Refer to "8. The Motion Range and Robot Coordinates" for the details of motion range. Manipulator dimensions are described in "7. External Dimensions".

NOTE
F

In (the previous) figure 2 the distance between "area to stopper" and "maximum space" is 70 mm. It is applicable only when the maximum radius of the end effector is 70 mm or less.

If the maximum radius of your end effector is longer than 70 mm, the distance between the area to stopper and the maximum space must be the actual radius of your end effector.

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

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

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

The manipulator must be installed levelly.

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

You may want to make holes in the base table through which you can pass cables. See "7. External Dimensions" for connector dimensions.

NOTE
F

In addition to the table, users are also responsible for making or obtaining the hand. Please see "5. Hands" for additional information.

2.4 Preinstallation safety precautions

During transport

Before you transport the manipulator, firmly secure it to a pallet. If you are using a hoist or a similar apparatus to lift the equipment, make certain that the manipulator is well balanced in the belt. (See "3.1 Opening the box.")

Be certain to firmly secure the manipulator's arms before transporting it. (See "3.5 Relocating the manipulator.")

Designing peripheral equipment

Enclose the manipulator from all sides with safeguard, to protect personnel when the robot is in motion. (See Figure 2.) In figure 2 the distance between the maximum space of manipulator and the safeguard is described. However, if your safeguard is like a fence or a wire net that has an opening, the described value is inadequate.

The design of safeguard shall be in accordance with the principles described in "Safety section" of the user's manual.

The door or opening of the enclosure should be provided with a reliable interlock switch. Connect this switch to the special connector (REMOTE1) located on the back of the controller. (See the user's manual and the controller manual)

Make certain the base table is sufficiently strong and stable. (See "2.3 Base table")

A hand equipped with a chuck should chuck when the power is off. (See "5.1 Attaching a hand")

The hand should be within the specified weight and within axis #4's allowable moment of inertia. (See "5.2 The hand and operating acceleration/deceleration speed")

3. Installation

3.1 Opening the box

Box contents	Manipulator body
	Controller
	Standard accessories
	Power cable
	Signal cable
	Connector and clamp hood for user wiring (2 sets)
	50-pin D-sub I/O connector and clamp hood (1 sets)
	Jumper socket (5 pcs.)
	REMOTE1 connector (1 set)
	REMOTE2 connector (1 set)
	Ballscrew spline grease (70 g)

Necessary equipment Lifter, hoist or other belt-equipped lifting apparatus

CAUTION

The manipulator weighs approximately 60 kg and is bolted to a wooden pallet prior to shipping. Please do not remove the pallet until after you have hoisted and transported the manipulator.

The manipulator can easily tip over unless it is firmly secured. If you find it necessary to remove the pallet before transporting the manipulator, either secure the manipulator to the transportation apparatus or lift it with a belt and stabilize it by hand when transporting it. If you hoist the manipulator, install two M12 eye bolts into threaded holes on the arm #1, pass a belt through the bolts, and lift it up slowly. (See Figure 3)

The controller weighs 24 kg (standard). Transport it with a hand truck. If you find it necessary to carry by hands, be sure to hold by two persons.

Do not hold the pulls on the front panel of the controller when moving.

NOTE F

Secure the manipulator's arms to prevent them from moving. Leave them secured until you have finished installing the manipulator.

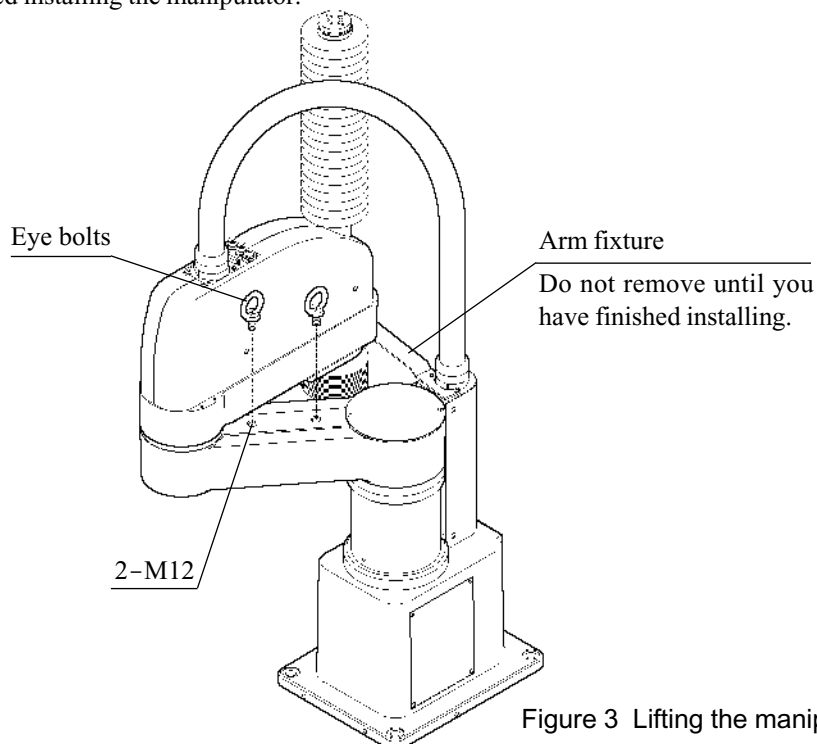


Figure 3 Lifting the manipulator

3.2 Installation method

Pass a belt through the eyebolts. While pulling up the belt slightly so that the manipulator will not fall down, and remove the bolts that secure the manipulator to the wooden pallet. Transfer the manipulator to the base table to be well-balanced using a hoist or other transport apparatus.

NOTE
F

Before installing the manipulator in the clean room, clean it up. It's preferable to wipe off the dust with a little alcohol on lint-free cloth.

Anchor the base of the manipulator to the base table using the four M8 steel bolts (property class 10.9 or 12.9). See Figure 4.

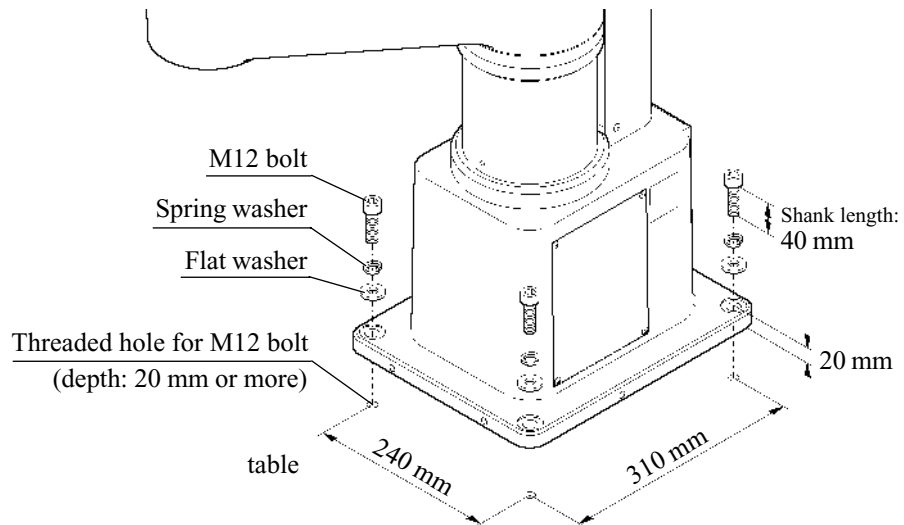


Figure 4 Manipulator installation

Remove the arm fixture after you have secured the manipulator firmly.

The arm fixture is bolted to the underside of the end of arm #2, and on the installing plate of cable unit with two bolts (3-M4×12).

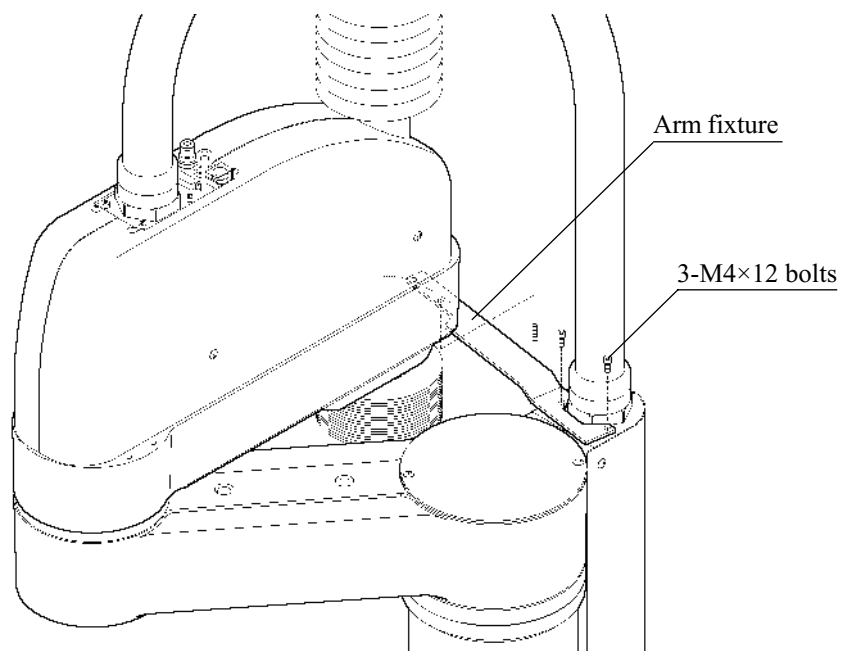


Figure 5 Removing the arm fixture

NOTE
F

The arms of the manipulator must be securely fastened to prevent them from moving when you transport the manipulator. (See "3.5 Relocating the manipulator"). Please keep the arm fixture in case you need them in the future.

The hole positions of the arm fixture for bolt differ from H704BL-CL to H804BL-CL and H854BL-CL. The arm figures also differ when fixed.

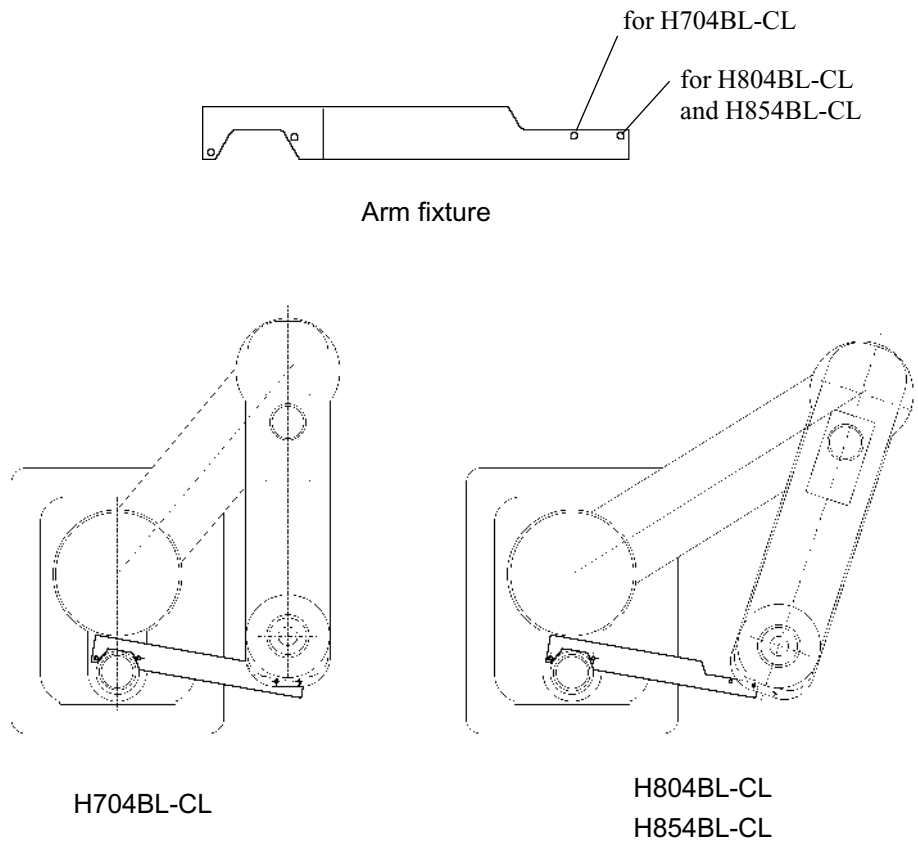


Figure 6 Fixing the arm

3.3 Connecting the cables and exhaust

Connecting the cables

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

WARNING

Be certain that the power has been turned off controller power before you plug or unplug any of the cables. Failure to do so could cause electrification and malfunction.

CAUTION

Plug the manipulator signal cable securely into the jack. Do not damage the signal cable by placing heavy objects on it or by bending it at extreme angles. A damaged signal cable could cause the robot to move abnormally.

When installing the cable between the manipulator and controller, make sure the M. CODEs (matching codes) match. The M. CODEs are written on the yellow labels which appear on the back sides of both the manipulator and the controller. Also, make sure that the lengths of the power cable and signal cable correspond to the length appear on the yellow labels mentioned above.

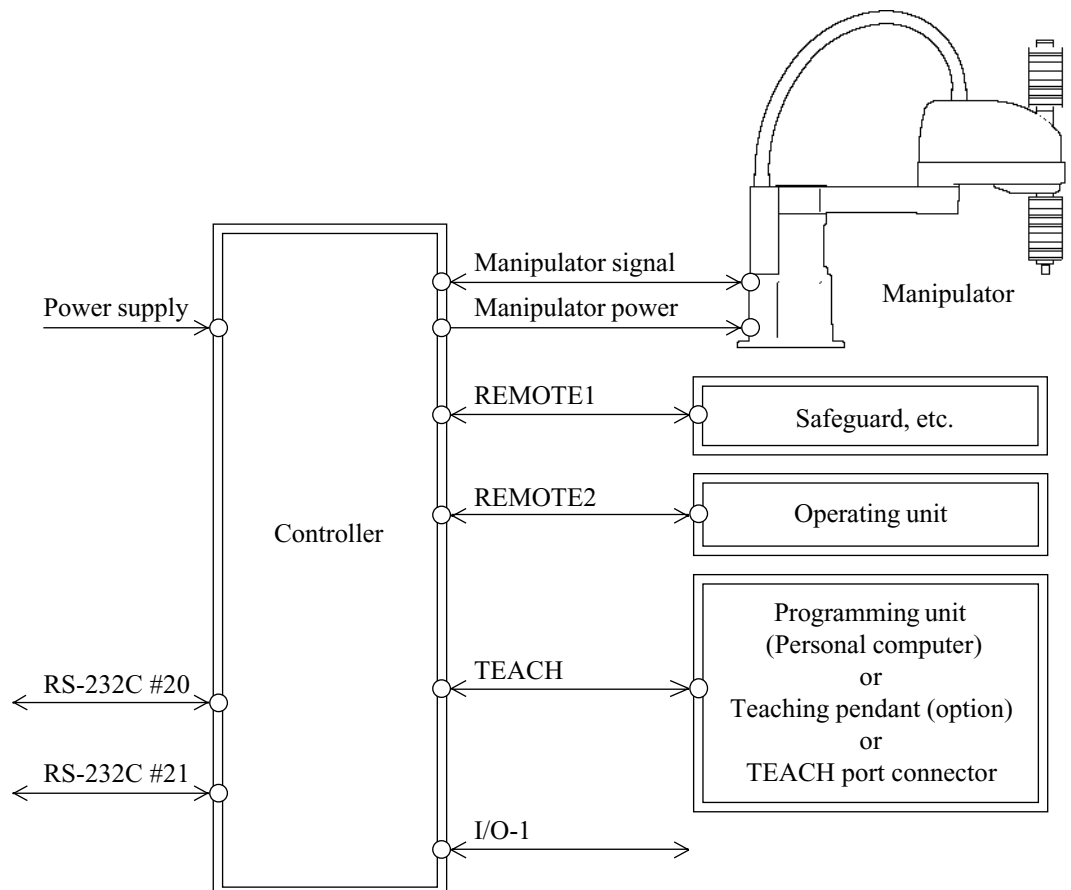



Figure 7 Cable connections

Exhaust

To maintain the cleanliness of the clean class 10 ($0.3\ \mu\text{m}$), exhaust is necessary. It requires the compulsory exhaust of 100 l/min. Use the exhaust port on the rear panel of the manipulator (see Figure 1). A quick fitting is attached to the port, and the outer diameter of the exhaust tube is 10 mm.

3.4 Safety precautions (after installation)

 WARNING	<p>Please read "Safety section" of user's manual first.</p> <p>Do not enter the motion range of the manipulator when the power is on even if the manipulator appears to have stopped. It is extremely dangerous to put any part of your body in the motion range.</p> <p>Be certain that the power has been turned off controller power before you plug or unplug any of the cables. Failure to do so could cause electrification and malfunction.</p>
--------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

During operation

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

Only trained personnel should teach and operate the robot and the robot system.

Trained personnel are those who have taken a robot training course held by the dealer on a regular basis or those who have equivalent knowledge or skill.

Generally only one person should operate the robot at a time. When, for unavoidable reasons, two or more people must operate the robot, they should be certain to tell each other what they are doing and take all other necessary safety precautions.

If you must enter the safeguard during teaching operations, first lock the mode switch in the TEACH position. If you are using the optional operating unit, put the mode switch in the TEACH position and remove the key, taking it with you.

A teaching operations supervisor should be present outside the safeguard whenever a person enters the safeguard. The supervisor should be someone with the prescribed training. He should not be performing some other operation when he is supervising.

Be certain that no one is inside the enclosure when you start and operate the robot.

The work area should be well-lighted (over 750 lx) during teaching operations.

Other

Perform daily inspections carefully before starting work. (See "maintenance manual")

Perform inspections and maintenance periodically in accordance with the maintenance manual.

Axis #3 (hand) descends under its own weight when you push the brake release button for axis #3. (See "5.1 Attaching a hand".)

3.5 Relocating the manipulator

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

Turn the power off and unplug the cables.

NOTE
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Remove the mechanical stoppers if you are using them to limit the motion range of the axis #1 and #2. (See "8.3 Changing the motion range".)

Attach the arm fixture on the installing plate of the cable unit with two M4×12 bolts.

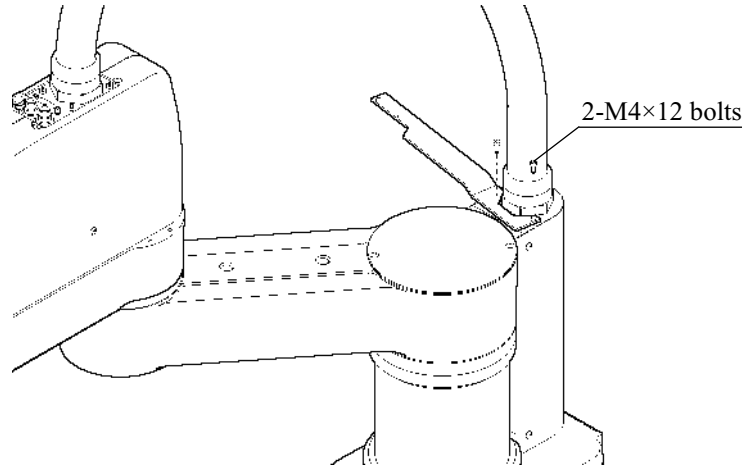


Figure 8 Attaching arm fixture

Gently push arm #2 in the minus direction (clockwise direction) until the position shown below.

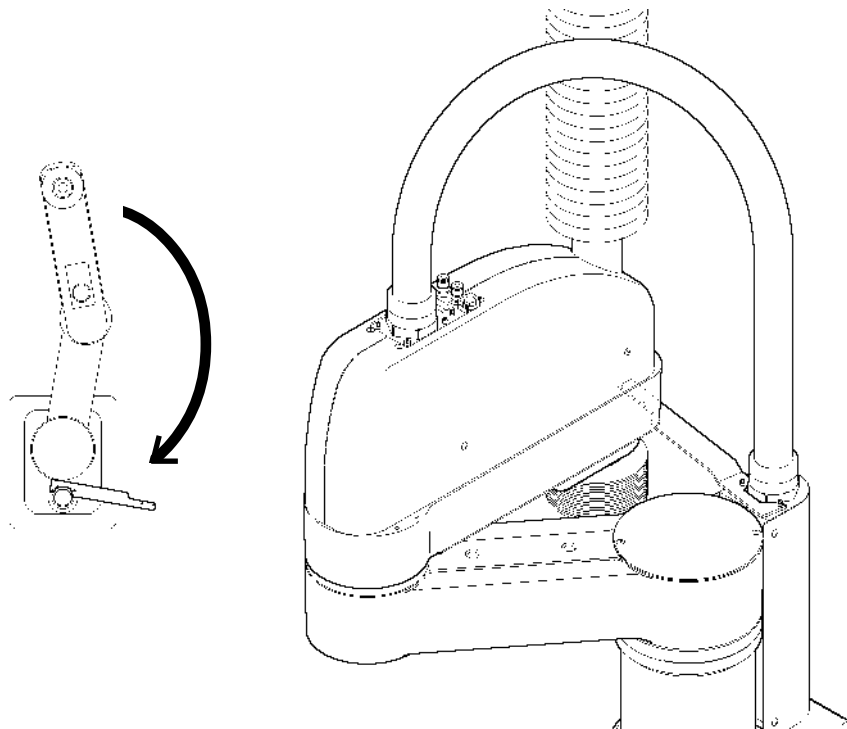


Figure 9 Position at which to secure arm

Bolt to the underside of the end of arm #2 through the fixture. The hole positions of the arm fixture for bolt differ from H704BL-CL to H804BL-CL and H854BL-CL. The arm figures also differ when fixed.

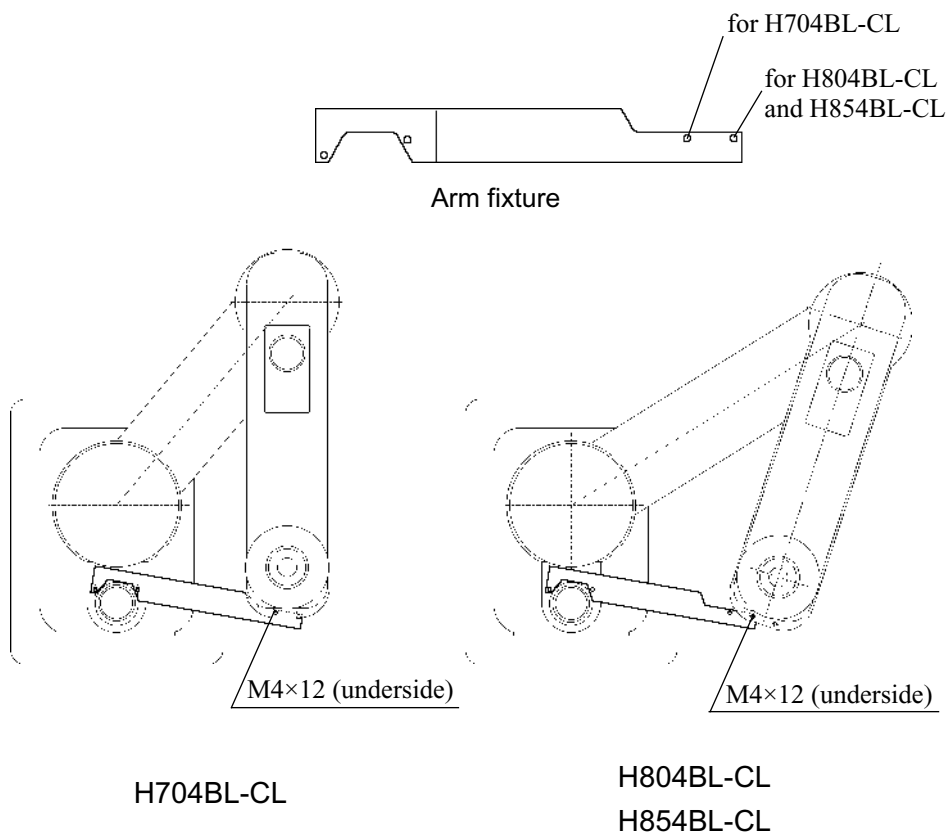


Figure 10 Position at which to secure arm

After securing the arm, remove the manipulator from the table.

If you hoist the manipulator, attach eye bolts on the arm surface (see 3.1 Figure 3) and put a belt through the bolts. Then remove the bolt which anchored the manipulator.

⚠ CAUTION The manipulator can easily tip over without securing bolt.

To transport the manipulator, fasten it to a wooden pallet (for shipping) with 4-M12 bolts and use a lifter. If you don't have a pallet, fasten the manipulator to transportation apparatus and make sure that it does not tip over when transporting.

If necessary, package the manipulator as same as it was shipped and transport.

4. User Wires and Air Tubes

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

Electrical wires

Rated voltage	Allowable current	No. of cables	Nominal sectional area	Outer diameter	Note
AC/DC 30 V	1 A	15	0.204 mm ²	8.3 mm max.	Shielded

* Compatible connector : 15-pin D-sub connector.

Pins with the same number are connected.

Air tubes

Max. usable air pressure	No. of air tubes	Outer diameter × inner diameter
0.59 MPa (6 kgf/cm ²)	2	6 mm × 4 mm

The ends of each air tube are equipped with joints for connecting air tubes having an outer diameter of 6 mm.

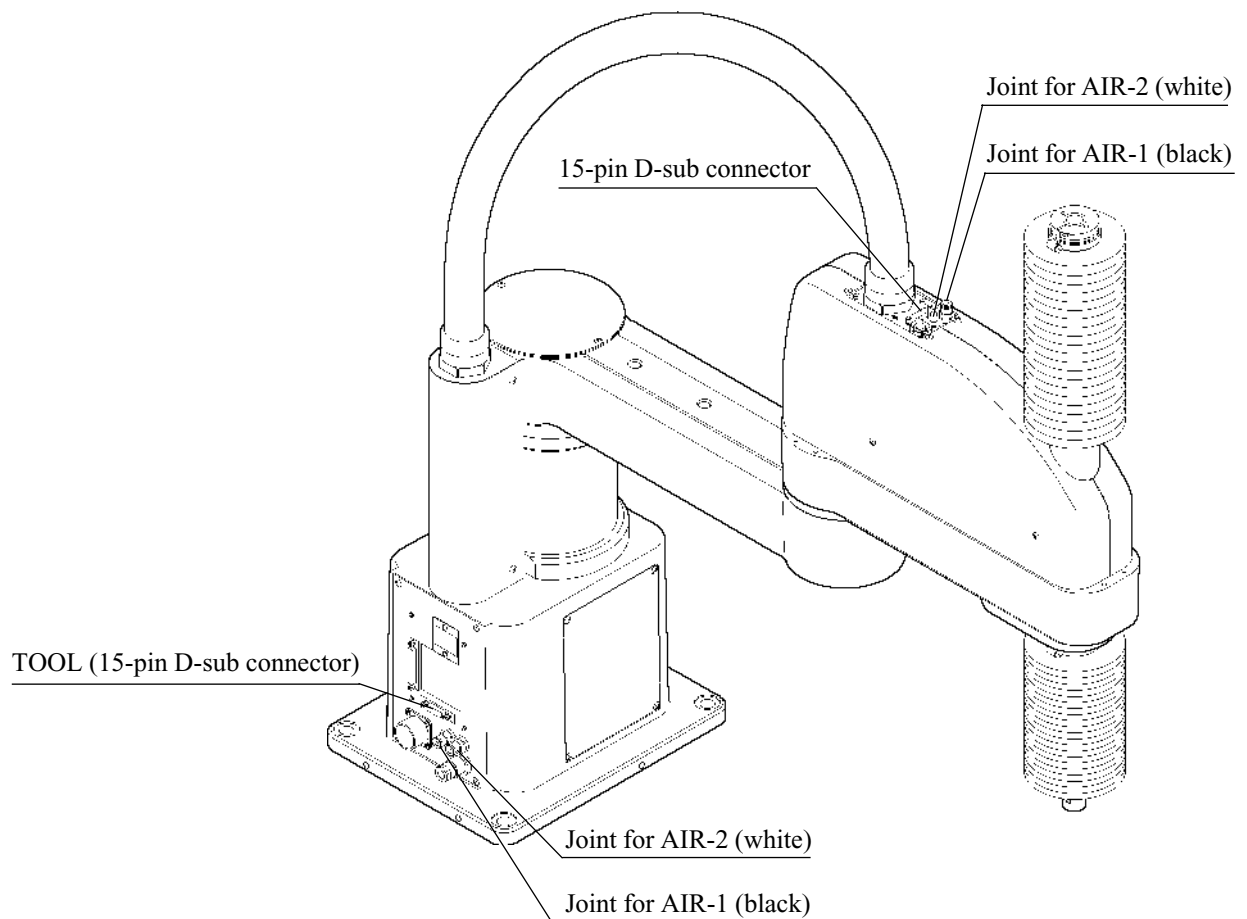


Figure 9 User wires and tubes

5. Hands

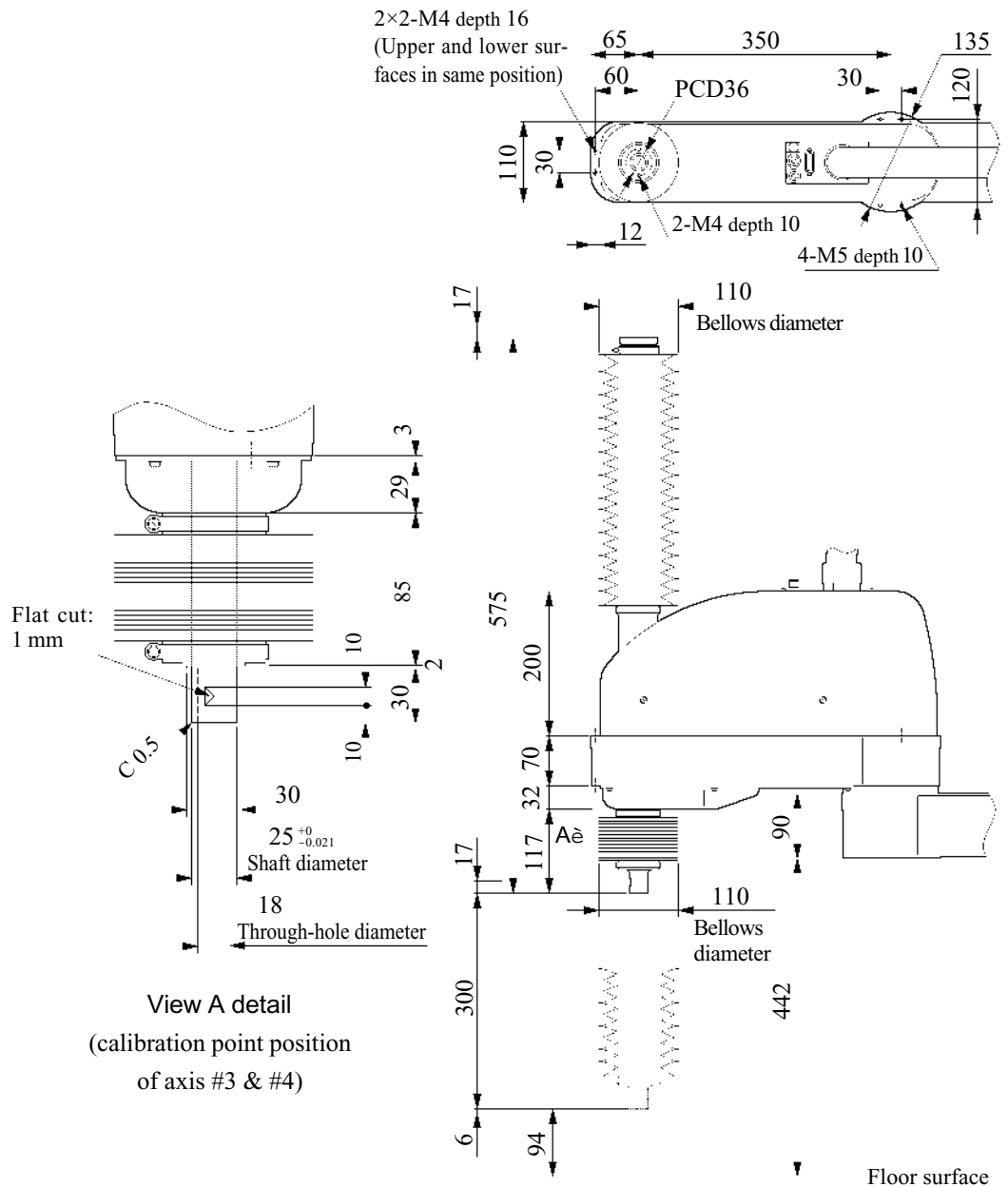
5.1 Attaching a hand

Users are responsible for making their own hands. Here, we point out some precautions to adhere to when attaching a hand.

NOTE
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When you operate the manipulator with a hand attached, the hand could touch the main body of the manipulator depending on the outer diameter of the hand, the size of the workpiece or the position of the arms. When you are laying out the system, pay close attention to the interference area.

A detail of the hand mount is shown in Figure 12. (See Figure 22 in "7. External Dimensions" for overall dimensions.)



An asterisk (*) indicates the position of the mechanical stopper.

Figure 12 Hand holder (unit: mm)

NOTE
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Do not move the upper-limit mechanical stopper which is on the lower side of the shaft. It also functions as part of the calibration point detector ($Z = 0$).

Use a split muff coupling with an M6 bolt or larger to attach a hand to the shaft.

You can use the flat cut on the end of the shaft to orient axis #4 by tightening a set screw.

The electromagnetic brake is applied to axis #3 when the power is off.

Axis #3 cannot be raised or lowered by hand when the brake is engaged. This prevents axis #3 from descending under the weight of the hand and striking any peripheral equipment and the like when the power is cut during robot operation or when the power is on but in the MOTOR OFF condition.

If you would like to raise and lower axis #3 when your are attaching a hand, turn on the controller and keep your finger down on the brake release button for axis #3.

NOTE
F

Axis #3 descends under its own weight while you have your finger down on the brake release button.

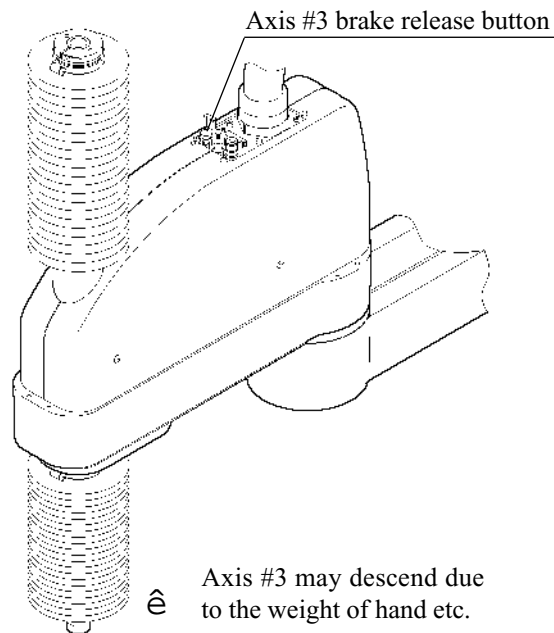


Figure 13 Axis #3 brake release button

Wire and tube layout

The shaft of axis #3 has through-hole to the hand for supplying air and electricity. The diameter of through-hole is 18 mm. The lower-limit mechanical stopper of axis #3 has a threaded hole for a 2-M4 (depth 10 mm) bolt for tooling.

⚠ WARNING

If you use a hand equipped with a chuck, set up wires and air tubes in such a way that the chuck does not release the chucked object when the robot is turned off. All I/O's are set at the factory so that they automatically shut entirely off (0) when the robot is turned off, when the emergency stop switch is pushed, or when any of the robot's safety features are activated.

5.2 The hand and operating acceleration/deceleration speed

To ensure optimum robot performance, it is important to make certain that the load (hand weight + weight of transported object) and moment of inertia of the load are within the rating and that axis #4 does not become eccentric.

If the load or moment of inertia exceed the rating or if the load becomes eccentric, adjust operating acceleration/deceleration speed in accordance with the explanations below.

Load weight and the WEIGHT setting

The rated weight capacity is 2 kg, and the maximum weight capacity is 10 kg.

When a load is heavier than the rated weight, use the WEIGHT command to change the weight setting. Weigh the hand and the workpiece that the hand is to transport. Input their combined total weight as the Hand Weight parameter in the WEIGHT command. (See the reference manual for details on WEIGHT command.) Executing this command sets the maximum possible operating acceleration/deceleration speed of the robot automatically in accordance with Hand Weight parameter.

Besides Operating speed is not restricted by Hand Weight parameter of WEIGHT command.

NOTE
F

The BL-CL type is not designed to work with load exceed 10 kg. It must be required that hand weight + weight of transported object is below 10 kg.

Always set the weight in accordance with the load. The robot cannot fully operate as intended unless you set the correct weight value for the load. Setting a value that is smaller than the actual load may cause errors or an excessive vibration. It will also shorten the life of parts and mechanisms.

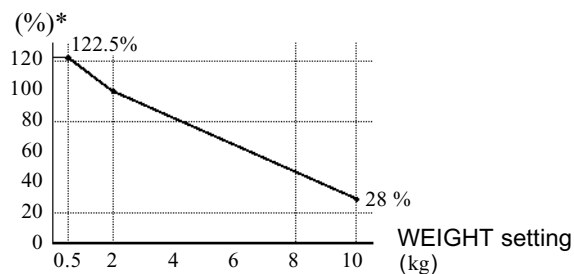


Figure 14 Automatic acceleration/deceleration setting by WEIGHT command of H704BL-CL and H854BL-CL

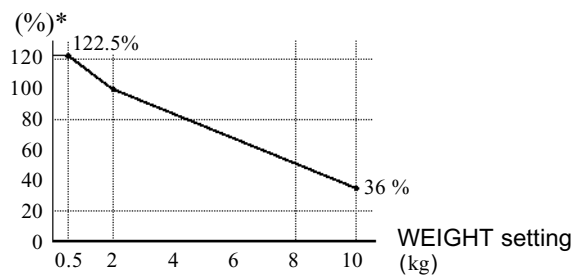


Figure 15 Automatic acceleration/deceleration setting by WEIGHT command of H804BL-CL

* The percentage in the graph is based on the acceleration/deceleration at rated weight (WEIGHT 2) as 100%.

NOTE
F

The above figures 14, 15 are the data of current model with HS mark on M.CODE label. The data of old model without HS mark is different from above figures. And Operating speed is restricted by Hand Weight parameter of WEIGHT command. Please refer the manual was attached old model as the information of manipulator without HS mark on M.CODE label.

Moment of inertia and the ACCEL setting

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

- W: weight of the hand in the Weight setting
- I : allowable moment of inertia (kg · m²)

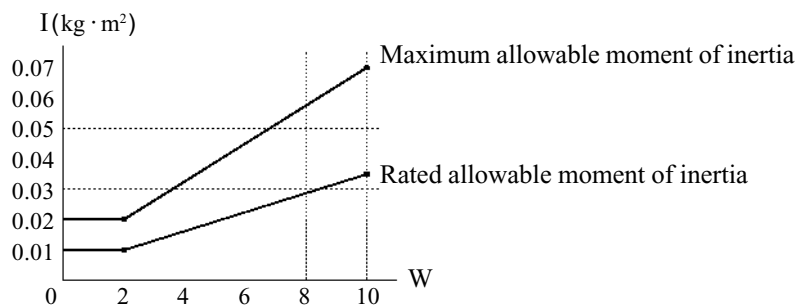


Figure 16 Allowable moment of inertia

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

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

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

A: ACCEL value in accordance with the moment of inertia
 I₀: rated allowable moment of inertia
 I : moment of inertia of the hand

Example For a hand weighing 6 kg and with a moment of inertia of 0.03 kg · m²:

```
WEIGHT 6
A = 0.0225 / 0.03 × 100 = 75 (%)
δ
ACCEL 75, 75
```

Calculating the moment of inertia

The moment of inertia is defined as "the ratio of the torque applied to a rigid body free to rotate about a given axis to the angular acceleration thus produced about that axis." It is described by values such as the moment of inertia, inertia, and GD^2 . Following is an example of how to calculate the moment of inertia.

Example Consider a hand and workpiece such as those shown in the diagram below. The moment of inertia of the entire load is found using the sum of each of the parts (a) - (c).

Moment of inertia of the whole = moment of inertia of hand (a) + moment of inertia of workpiece (b) + moment of inertia of workpiece (c)

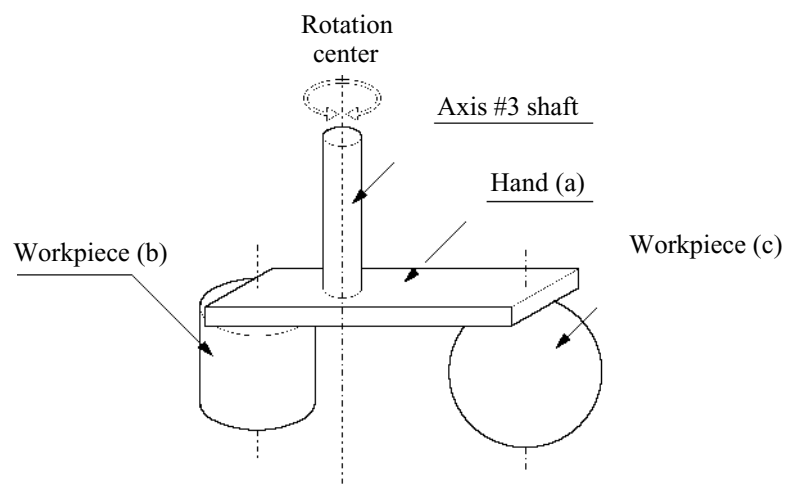


Figure 17 Example of load (hand carrying workpieces)

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

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

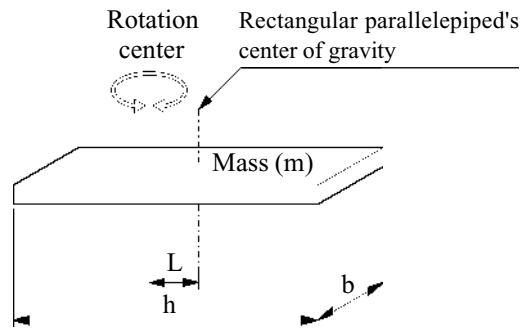


Figure 18(a) Rectangular parallelepiped

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

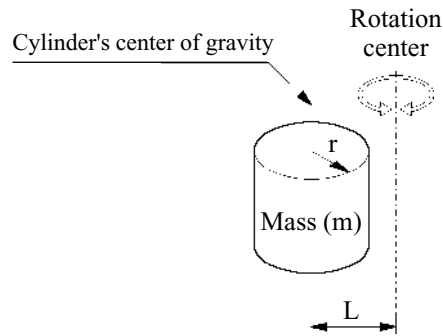


Figure 18(b) Cylinder

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

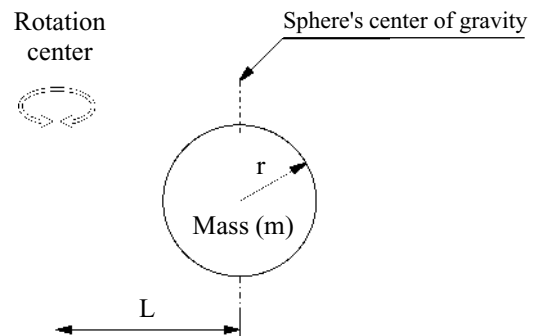


Figure 18 (c) Sphere

Eccentricity of axis #4

The eccentricity of axis #4 (rotation center) and the position of a load's center of gravity should not be more than 80 mm.

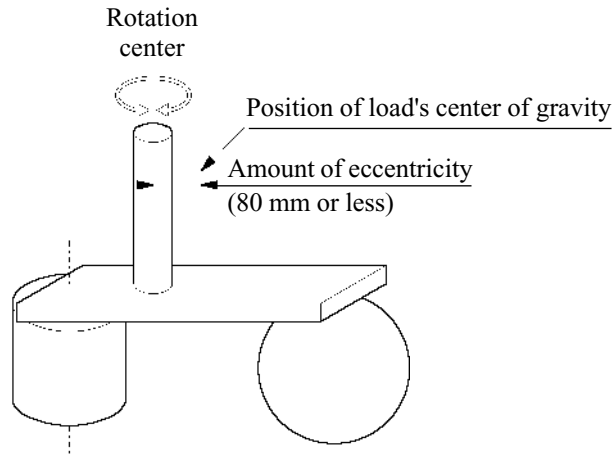


Figure 19 Amount of eccentricity

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

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

A : ACCEL setting value

A_i : ACCEL setting value according to moment of inertia

A_h : ACCEL % according to amount of eccentricity

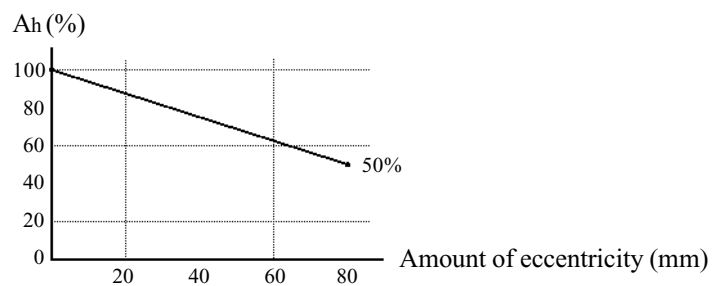


Figure 20 Eccentricity and ACCEL %

Example For a 6 kg hand with a moment of inertia of 0.03 kg · m² and eccentricity of 40 mm:

WEIGHT 3

$$A_i = 0.0225 / 0.03 \times 100 = 75 (\%)$$

$$A_h = 75 (\%)$$

$$A = 75 \times 75 / 100 = 56 (\%)$$

ð

ACCEL 56, 56

6. Attaching a Camera, Valve, and Other Devices

Arm #2 has eight threaded holes. Use these holes for attaching cameras, valves and other equipment. See Figure 12 in "5. Hands" or "7. External Dimensions" for information on dimensions.

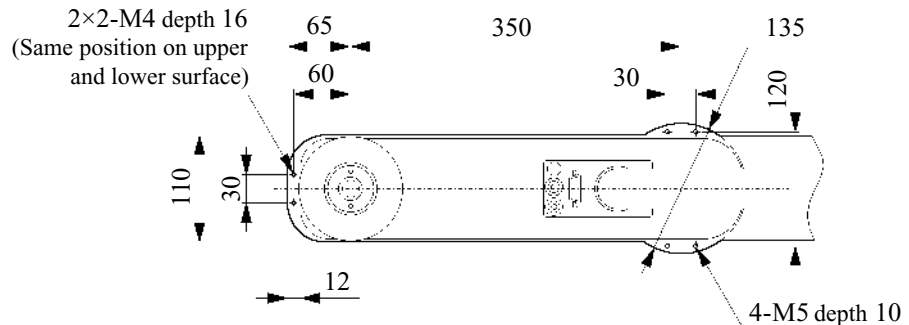


Figure 21 Position of threaded holes in arm #2 (unit: mm)

When you attach a load to the arm, you must consider changing the settings for maximum acceleration/deceleration speed using the WEIGHT command.

As explained in "5.2 The hand and operating acceleration/deceleration speed", the WEIGHT command has a parameter called Hand Weight. Input into this parameter the weight of the load (hand + object to be transported) to be attached to the ball screw spline shaft of axis #3. When you attach a camera or other device to the arm rather than to axis #3 as part of the hand, calculate the weight as equivalent weight of axis #3, add this to the load weight, and execute the WEIGHT command.

Equivalent weight is found using the formula below.

When you attach the equipment to the base of arm #2 : $W_M = M(L_1)^2 / (L_1 + L_2)^2$

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

W_M : equivalent weight

M : weight of camera, etc.

L_1 : length of arm #1

L_2 : length of arm #2

L_M : distance from rotation center of axis #2 to center of gravity of camera, etc.

Example A 1 kg camera was attached to the end of the arm (450 mm from the rotation center of axis #2) of an H804BL-CL with a load weight of $W = 2$ kg.

$$M = 1$$

$$L_2 = 350$$

$$L_M = 450$$

$$W_M = 1 \times 450^2 / 350^2 = 1.65 \quad 1.7 \text{ (rounded up)}$$

$$W + W_M = 2 + 1.7 = 3.7$$

Input 3.7 as the Hand Weight parameter in the WEIGHT command. Execute the command.

WEIGHT 3.7

8. The Motion Range and Robot Coordinates

8.1 Standard motion range

The motion range and the robot coordinate of the BL-CL type is described below.

The following motion range shows the standard (maximum) specification. When each axis motor is engaged, the center of axis #3's lowest tip of the manipulator moves in the area shown below.

"Area to the stopper" means the area where the center of the axis #3's lowest tip can be moved when each axis motor is not engaged. Each axis is not possible to move over this area mechanically.

NOTE
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"Maximum space" in the drawing below is the area where the arm interferes. If the maximum radius of the end effector is over 70 mm, the area where the end effector interferes is over the maximum space in the following drawing. In such case, the interfered area by end effector should be the maximum space.

The physical relationship of the manipulator's anchor holes and point P (see Figure 23 and 24) varies from one manipulator to another, but the maximum variance is $\pm 2^\circ$ against the center of the manipulator base. Take this into account when you lay out your system equipment if you use the outermost circumference of the motion range.

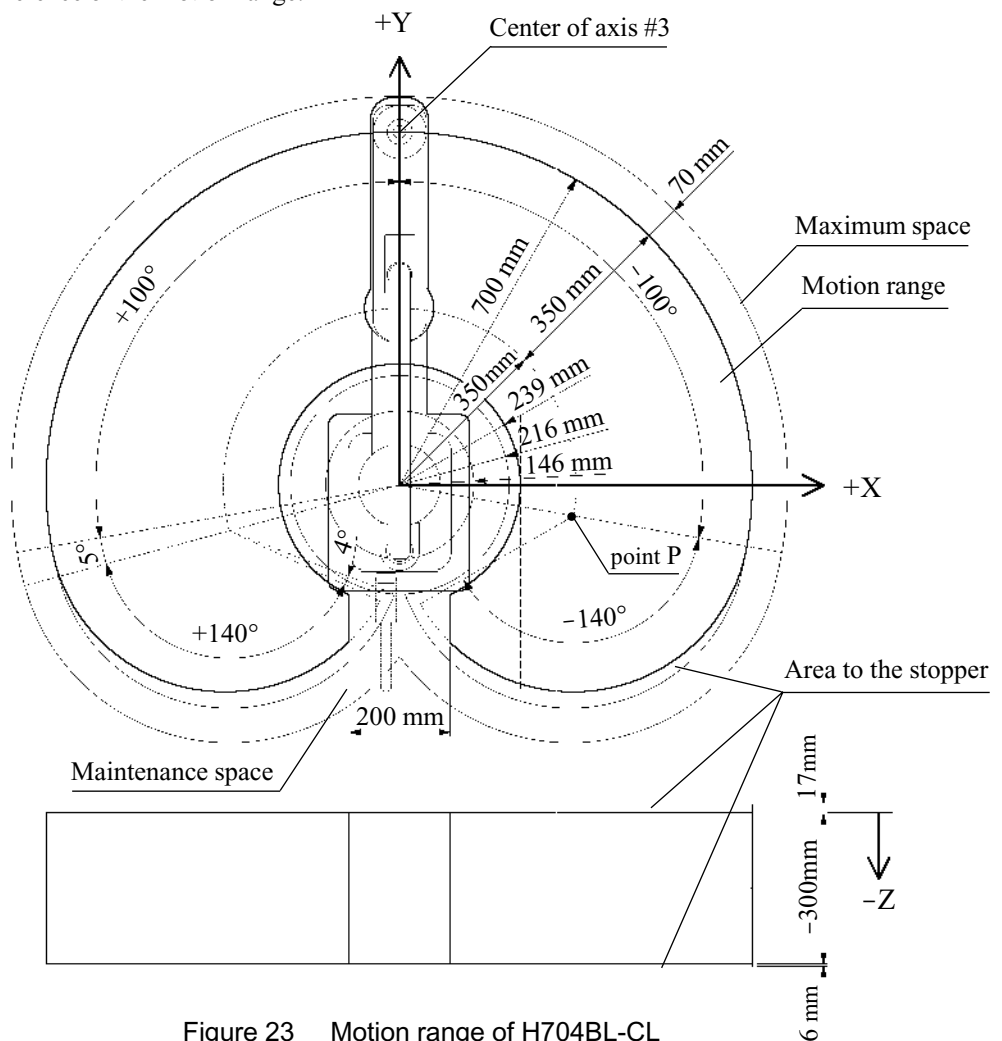


Figure 23 Motion range of H704BL-CL

NOTE
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In the case of H704BL-CL, if each axis motor is not excited, the end effector may hit the rear side of the manipulator depend on the shape of end effector or the axis #3 height. So your attention is necessary.

	H804BL-CL	H854BL-CL
Standard range of the manipulator	A	800 mm
	B	450 mm
	C	289 mm
	D	265 mm
	E	100 °
		110 °

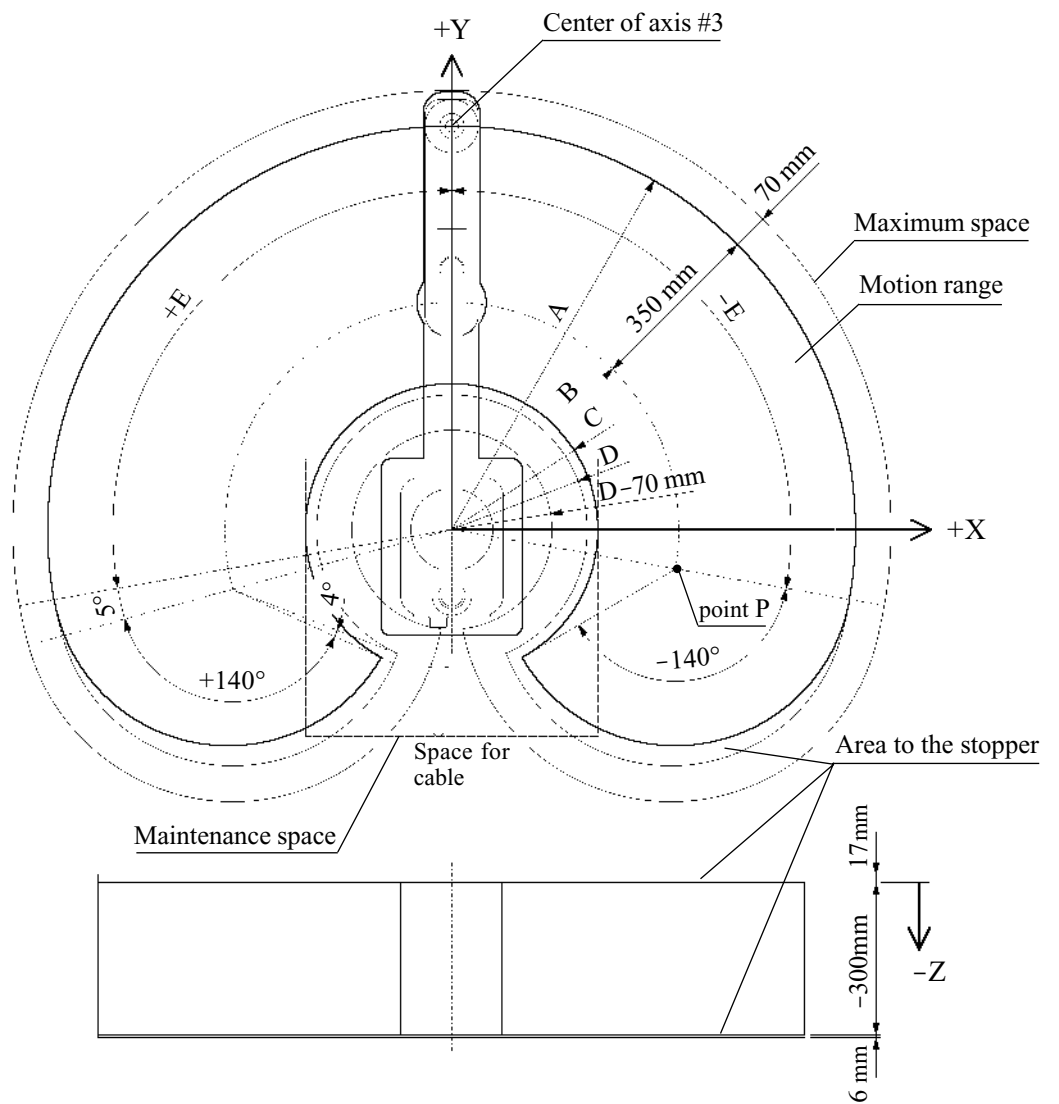
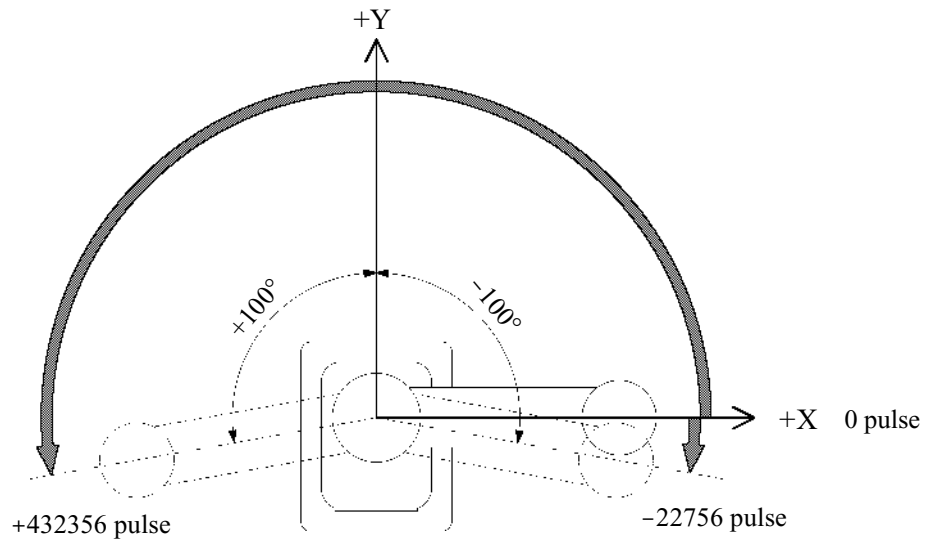


Figure 24 Motion range of H804BL-CL and H854BL-CL

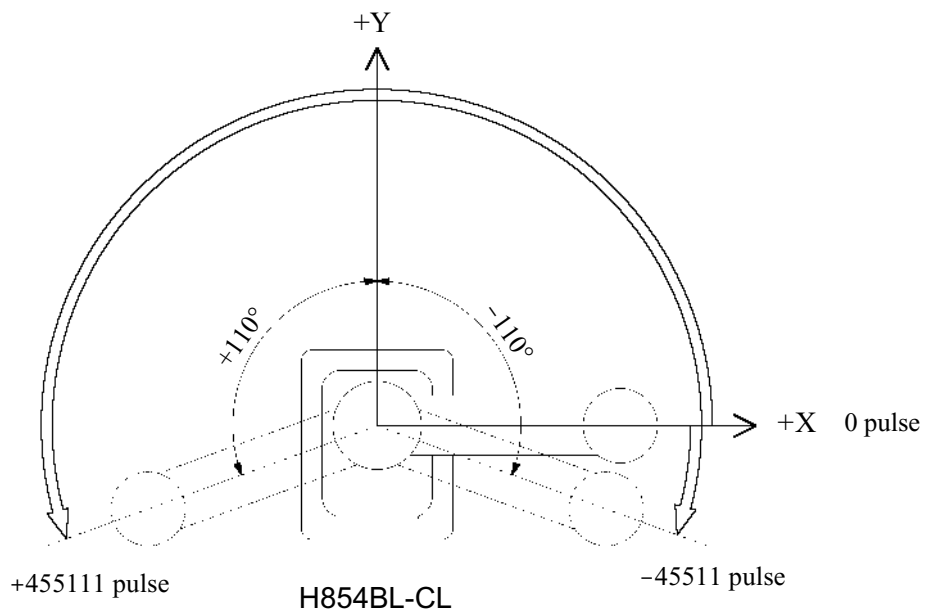
8.2 Pulse range

The manipulator's operating limit (motion range) is controlled by the pulse lower limit and the pulse upper limit of each axis. Pulse values are applied by the servomotor's encoder output. Here, we show the pulse range of each axis.

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



H704BL-CL
H804BL-CL



H854BL-CL

Figure 25 Pulse range of axis #1

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

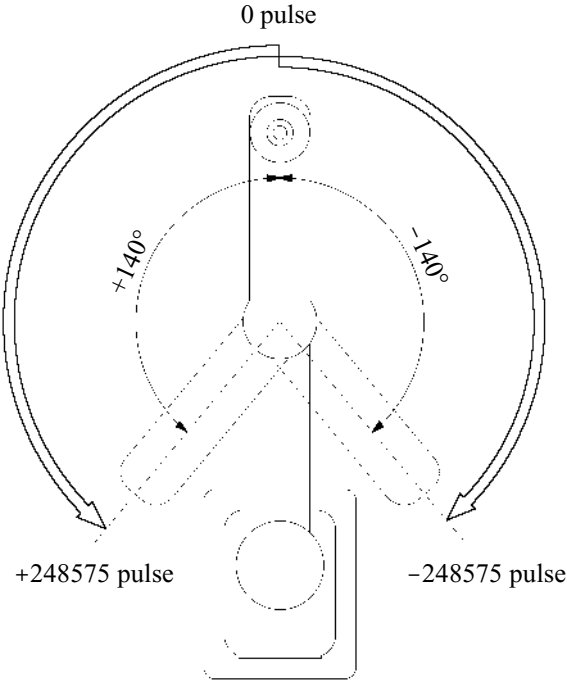


Figure 26 Pulse range of axis #2

The 0 pulse position of axis #3 is the ascension limit of axis #3. Axis #3 descends from the 0 pulse position and the pulse is negative (-).

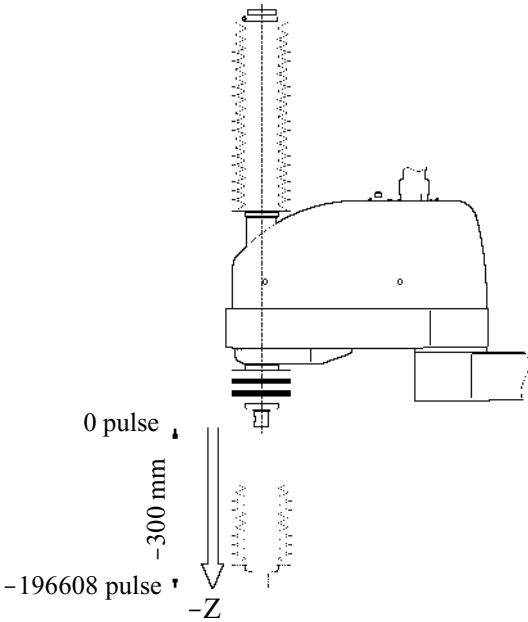


Figure 27 Pulse range of axis #3

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

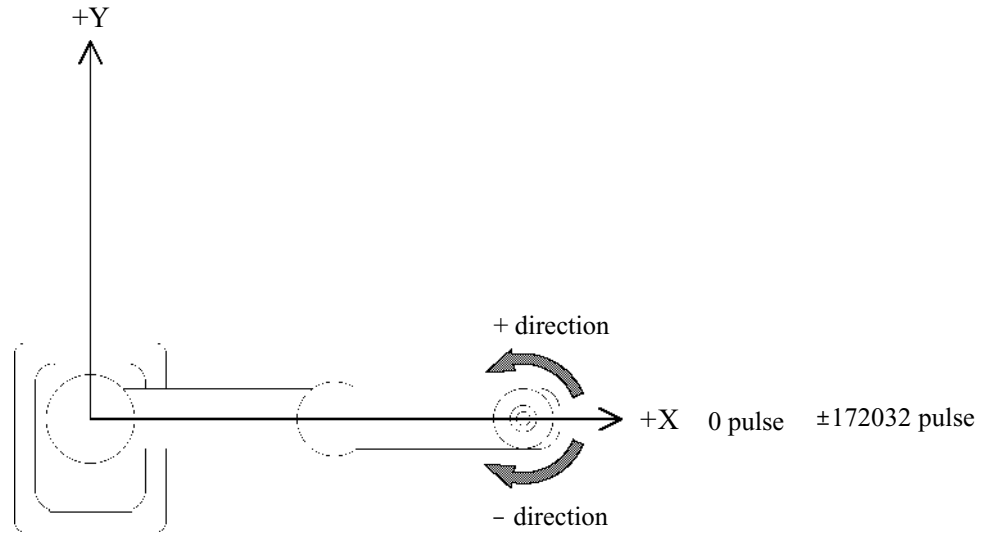



Figure 28 Pulse range of axis #4

8.3 Changing the motion range

 WARNING	Both the mechanical stopper and the software settings must always be set at the same time when a motion range is to be set up.
--------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------

The motion range is preset at the factory as explained in "8.1 Standard motion range." This is the manipulator's maximum motion range.

It is possible to change the motion range for reasons of layout efficiency or safety and the like. Make any changes in the motion range in accordance with the following explanation.

Methods of setting the pulse area

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

Setting the pulse range (all axes)

Setting the mechanical stoppers (axes #1 and #2)

Setting the rectangular range in the X, Y coordinate system of the robot (axes #1 and #2)

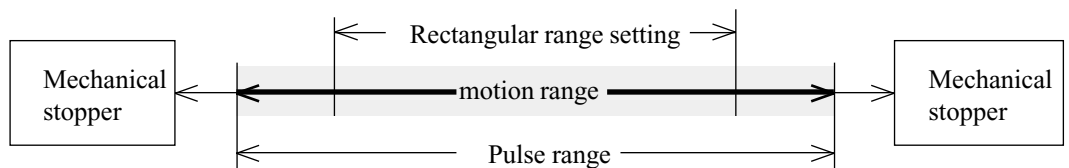


Figure 29 Setting the motion range

Changing the motion range using the pulse range (all axes)

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

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

RANGE	Sets the pulse ranges of all axes at once
JRANGE	Sets the pulse range of one axis at a time

The maximum pulse range is shown in "8.2 Pulse range". Always set pulse ranges to the inside of the mechanical stoppers.

When the robot receives a move command, it first checks whether or not the destination specified by the command is within the pulse range. The robot does not move if the destination is outside the set pulse range. Instead, it displays error 125.

Changing the motion range using the mechanical stoppers (axes #1 and #2)

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

Axis	Possible area settings using the mechanical stoppers											
Axis #1*	+100° /+110°	+90°	+60°	+30°	+0°	-0°	-30°	-60°	-90°	-100°/-110°		
Axis #2	+140°	+120°	+90°	+60°	+30°	+0°	-0°	-30°	-60°	-90°	-120°	-140°

* The Maximum setting position of Axis #1: H704BL-CL/H804BL-CL is $\pm 100^\circ$, H854BL-CL is $\pm 110^\circ$.

When you change the position of the mechanical stoppers, you must also input the corresponding pulse range.

The method of changing area settings using the mechanical stoppers is shown below.

Changing the position of the mechanical stoppers of axes #1 and #2

Both axis #1 and axis #2 has threaded holes in positions corresponding to the angles for area settings. You can change the position of the mechanical stoppers by setting bolts in the appropriate holes.

Turn off the controller.

Move the arms to the +Y axis of robot coordinates as shown in figure 30.

NOTE If you change the position of the mechanical stoppers without first moving the arms into the motion range, you may damage the calibration point sensor.

When you change the mechanical stopper position of axis #1, remove the arm cap from the top of axis #1 by unscrewing the 2-M4×8 truss head screws. There are threaded holes to change the mechanical stopper position in the arm. Axis #2 has threaded holes of the arm. It does not have a cap on the underside of the arm.

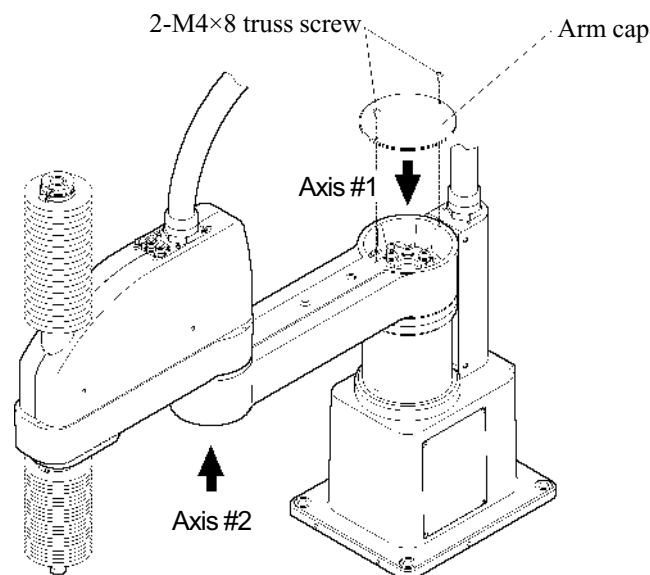
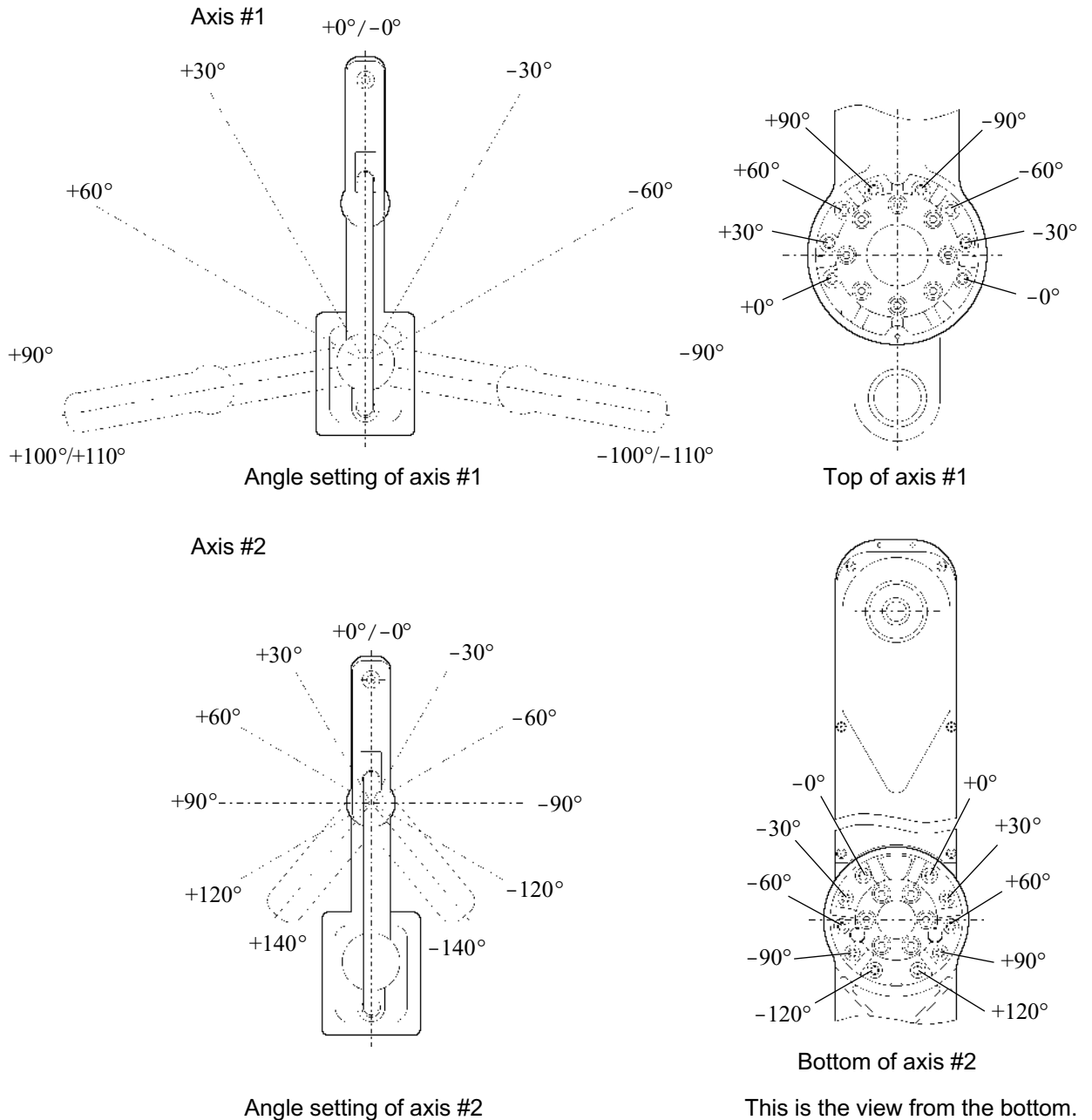


Figure 30 Position of mechanical stoppers

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

	Hexagon socket head cap bolt	No. of bolts	Recommended tightening torque
Axis #1	M10 × 45 (fully threaded bolt)	1 per side	750 kgf · cm
Axis #2	M8 × 30 (fully threaded bolt)	1 per side	380 kgf · cm

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



NOTE
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This is the view from the bottom. It is symmetrical with the drawing on the left.

*If you set to the maximum angle, remove the bolts.

Please note, however, that the position of the threaded holes differs depending on whether it is +0° (for the left-side stopper) or -0° (for the right-side stopper).

Figure 31 Threaded holes for changing the position of mechanical stoppers

Turn on the controller.

Set the pulse range corresponding to the new positions of the mechanical stoppers using either the **RANGE** or **JRANGE** command. The pulse values corresponding to mechanical stopper setting angles are shown in the table below.

NOTE
F

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

Axis #1				Axis #2			
angle setting	pulse value	angle setting	pulse value	angle setting	pulse value	angle setting	pulse value
+0°	204800	-0°	204800	+0°	0	-0°	0
+30°	273067	-30°	136532	+30°	54614	-30°	-54614
+60°	341334	-60°	68265	+60°	109227	-60°	-109227
+90°	409600	-90°	0	+90°	163840	-90°	-163840
+100°	432356	-100°	-22756	+120°	218454	-120°	-218454
+110°	455111	-110°	-45511	+140°	254863	-140°	-254863

Example Axis #1 is set from -60° to +90° and axis #2 is set from -120° to +30°

```

>JRANGE 1, 68265, 409600      'Sets the pulse range of axis #1
>JRANGE 2, -218454, 54614    'Sets the pulse range of axis #2
>RANGE                        'Checks the setting using the RANGE
    68265      409600
   -218454     54614
   -196608      0
   -172032     172032

```

Check the following:

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

<Example> Axis #1 is set from -60° to +90° and the axis #2 is set from -120° to +30° (same as the example in).

```

>MOTOR ON
>SPEED 5                        'Set at slow speed.
>PULSE 68265, 0, 0, 0          'Moves to smallest pulse position of
                                axis #1 and checks.
>PULSE 406900, 0, 0, 0        'Moves to largest pulse position of axis
                                #1 and checks.
>PULSE 204800, -218454, 0, 0  'Moves to smallest pulse position of
                                axis #2 and checks.
>PULSE 204800, 54614, 0, 0    'Moves to largest pulse position of axis
                                #2 and checks.

```

When you check axis #2 in this example, axis #1 is moved to the 0° position (pulse value: 204800) near the center. When you move the axis like this using the **PULSE** command, place the other axes in a safe position.

If the arm is touching the mechanical stopper or if it has hit the stopper and an error has occurred, either reset the pulse range to a narrower setting to the extent that it is not an obstacle, or broaden the position of the mechanical stoppers.

Changing the motion range using the rectangular wave range in the X, Y coordinates of the robot (axis #1 and #2)

Use this method to set the upper and lower limits of the X and Y coordinates. Set them using the XYLIM command. For details on the XYLIM command, see the reference manual.

At the factory shipping, it is set as follows:

H704BL-CL : XYLIM -100,100,-320,0

H804BL-CL/H854BL-CL : XYLIM 0,0,0,0

If you need to change this setting for H704BL-CL, you have to be careful because the end effector may hit the rear side of the manipulator depend on the shape of end effector or the axis #3 position. (See "8. 1 Standard motion range".)

9. Notice on operation

9.1 Calibration

The manipulator is controlled on the basis of the calibration point of the encoder of each shaft motor. The manipulator does not operate properly unless the calibration point of these encoders coincides with the mechanical calibration point of each axis. The process of making them coincident is called "calibration."

After you turn the power on and before you execute a move command, you need to calibrate the robot using the MCAL command. After you have turned the power on, turn on the motor power using the MOTOR ON command and execute the MCAL command. (See the reference manual for command details.)

Execute the MCAL command near the center of the motion range.

A multi-calibration-point system is used for axes #1 and #2. When executing MCAL command the axis #1 may operate a maximum of $\pm 7.5^\circ$ and axis #2 a maximum of $\pm 13.5^\circ$ (The amount of movement depends on the positions of the arms). However, when you execute the MCAL command when the arm is near the limit of the motion range, the arm may go beyond the motion range and calibration becomes impossible. If this happens, execute the MOTOR OFF command, or turn off the power, and manually return the arm to the center of the motion range before starting over.

Axis #3 and axis #4 have a single-calibration-point system. They return to the calibration point -- the 0 pulse position -- when you execute the MCAL command.

9.2 Notice about axis #3 (Z300)

Please note the following about axis #3.

- You may be able to shorten operating time if you set axis #3 to a position higher than -150 mm when performing horizontal movements.

If the height of axis #3 is less than -150 mm when it is moving horizontally, the auto-accel function is activated. This function is set so as to slow the operating acceleration/deceleration speed the farther below axis #3 is from -150 mm.

Operating acceleration/deceleration speeds quicken when you raise axis #3 above -150 mm, but it takes more time for axis #3 to move up and down. Therefore, you should adjust the height of axis #3 in accordance with the spatial relationship between the current position and the destination. You can set the height of axis #3 using the LIMZ command.

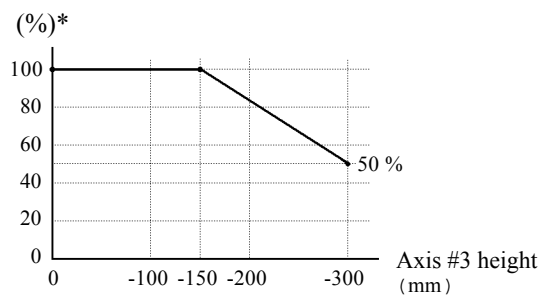


Figure 35 Axis #3 position and automatic acceleration/deceleration adjustment

- * The percentage in the graph is based on the acceleration/deceleration at the highest position of axis#3 as 100%.

- If axis #3 performs horizontal movements when it is set lower than -150 mm, there may be some overshoot during positioning.

We recommend that horizontal transfers be performed at a position higher than -150 mm whenever possible.




9.3 Emergency Stop

If the manipulator moves abnormally during operation, immediately push the emergency stop switch. By pushing the E. STOP switch, the motor power is cut and the dynamic brake activates and stops the rotation of motor as inertia.

However, you should not press the E. STOP switch during normal operation unnecessarily. The braking distance depends on timing to activate the emergency stop switch and motion speed, but robot arm may overrun the stop position under servo-control and may collide with peripheral equipment. We recommend pushing the E. STOP during the arm is not moving, in case of you would like to make the robot emergency condition in normal operation.

10. Specifications

Model		H704BL-CL	H804BL-CL	H854BL-CL
Arm length	Arm #1 + #2	350 mm + 350 mm	350 mm + 450 mm	350 mm + 500 mm
Weight		60 kg	60 kg	61 kg
Driving method	All axes	AC servo motor		
Max. operation speed ①	Axis #1 + #2	4770 mm/s	5180 mm/s	5390 mm/s
	Axis #3	937 mm/s	937 mm/s	937 mm/s
	Axis #4	1140 °/s	1140 °/s	1140 °/s
Repeatability	Axis #1 + #2	±0.025 mm		
	Axis #3	±0.020 mm		
	Axis #4	±0.02 °		
Max. motion range values in () are option	Axis #1	±100 °		±110 °
	Axis #2	±140 °		±140 °
	Axis #3	300 mm		300 mm
	Axis #4	±360 °		±360 °
Max. pulse range values in () are option	Axis #1	-22756 • +432356		-45511 • +455111
	Axis #2	±254863		±254863
	Axis #3	-196608 • 0		-196608 • 0
	Axis #4	±172032		±172032
Resolution	Axis #1	0.0004395 °/p		
	Axis #2	0.0005493 °/p		
	Axis #3	0.0015259 mm/p		
	Axis #4	0.0020926 °/p		
Motor power consumption	Axis #1	400 W		
	Axis #2	200 W		
	Axis #3	200 W		
	Axis #4	100 W		
Payload	rated • max.	2 kg • 10 kg		
Axis #4 allowable moment of inertia ②	rated • max.	With rated payload (2kg) : 0.01 kg • m ² • 0.02 kg • m ²		
		With max. payload (10kg) : 0.035 kg • m ² • 0.07 kg • m ²		
Spline diameter • Through hole diameter		f ₂₅ ^(+0, -0.021) mm • f ₁₈		
Axis #3 down force		150 N (15.3 kgf)		
Installed wire for customer use		15 wires (15-pin D-sub connector)		
Installed pneumatic tube for customer use		f ₆ mm 2 pneumatic tubes (Allowable pressure 0.59 MPa, 6 kgf/cm ²)		
Environmental requirements		Temperature: 5 ~ 40 °C (No drastic change is allowed.) Humidity: 10 ~ 80 % (No condensation is allowed.)		
Equivalent continuous A-weighted sound pressure level		68 dB (A)		
Applicable controller		SRC-300, SRC-310, SRC-310A, SRC-320		

Model		H704BL-CL	H804BL-CL	H854BL-CL
DIP switch setting *13				
Compulsory exhaust volume from exhaust port		100 l/min (Applicable exhaust tube diameter: ϕ 10 mm)		
Calibration motion for multiple homing type	Axis #1 Axis #2	max. $\pm 7.5^\circ$ max. $\pm 13.5^\circ$		
MCORG movement amount	Axis #1 Axis #2	max. $+22.5^\circ$ max. $+40.5^\circ$		
HTEST range	Axis #1 Axis #2 Axis #3 Axis #4	± 218 ± 218 ± 2048 ± 2048		
Default values	SPEED ACCEL SPEEDS ACCELS MCORDR HORDR FINE WEIGHT	5 10,10 50 200 &B0010,&B1101,0,0 &B0010,&B1101,0,0 20,20,20,20 2,350		

- *1: In case of PTP control. In case of CP control, max. operation speed on horizontal plane is 1120 mm/sec.
- *2: In case that the center of gravity is at the center of axis #3. If the center of gravity is not at the center of axis #3, speed and acceleration must be reduced.

NOTE


- *3: Never change the DIP switch settings.
This is setting for current model with HS mark. The setting for old model without HS mark differs. Please refer the manual was attached old model as the setting of manipulator without HS mark on M. CODE label.
DIP switch SD1 is on the MPU board in the controller.
In case of the robot with special specification, which has MT label on it, DIP switch settings may be different with the one shown above.
When you contact us or our distributor, please let us know the MT number on the label.

EPSON