

EPSON

6-Axis Robots

VT series

MANIPULATOR MANUAL

Rev.1

EM18YR3817F

MANIPULATOR MANUAL

VT series Rev.1

6-Axis ROBOT

VT series Manipulator Manual

Rev.1

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FOREWORD

Thank you for purchasing our robot products.

This manual contains the information necessary for the correct use of the manipulator.

Please carefully read this manual and other related manuals before installing the robot system.

Keep this manual handy for easy access at all times.

WARRANTY

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

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

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

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

Warnings, Cautions, Usage:

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

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

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

MANUFACTURER

SEIKO EPSON CORPORATION

Regarding battery disposal



The crossed out wheeled bin label that can be found on your product indicates that this product and incorporated batteries should not be disposed of via the normal household waste stream. To prevent possible harm to the environment or human health please separate this product and its batteries from other waste streams to ensure that it can be recycled in an environmentally sound manner. For more details on available collection facilities please contact your local government office or the retailer where you purchased this product. Use of the chemical symbols Pb, Cd or Hg indicates if these metals are used in the battery.

This information only applies to customers in the European Union, according to DIRECTIVE 2006/66/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC and legislation transposing and implementing it into the various national legal systems.

For other countries, please contact your local government to investigate the possibility of recycling your product.

The battery removal/replacement procedure is described in the following manuals:

VT series manipulator manual

Maintenance: 18.4 Replacing the Lithium Battery

Before Reading This Manual

This section describes what you should know before reading this manual.

Structure of Robot System

The VT series Manipulators can be used with the following combinations of software.

VT6-A901S		Controller Firmware
		Ver.7.4.53.0 or later
EPSON RC+ 7.0	Before Ver.7.3.2	!!!
	Ver.7.4.3 or later	OK

OK: Compatible All functions of the EPSON RC+ 7.0 and the robot system are available.

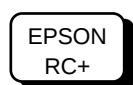
!!!: Compatible Connection is OK. It is recommended to use the following versions or later. Display or control may not be operated properly.

Shape of Motors

The shape of the motors used for the Manipulator that you are using may be different from the shape of the motors described in this manual because of the specifications.

Setting by Using Software

This manual contains setting procedures by using software. They are marked with the following icon.



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Setup & Operation

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

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

1. Safety

Installation and transportation of manipulators and robotic equipment shall be performed by qualified personnel and should conform to all national and local codes. Please read this manual and other related manuals before installing the robot system or before connecting cables.

Keep this manual handy for easy access at all times.

1.1 Conventions

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

 WARNING	This symbol indicates that a danger of possible serious injury or death exists if the associated instructions are not followed properly.
 WARNING	This symbol indicates that a danger of possible serious injury or death caused by electric shock exists if the associated instructions are not followed properly.
 CAUTION	This symbol indicates that a danger of possible harm to people or physical damage to equipment and facilities exists if the associated instructions are not followed properly.

1.2 Design and Installation Safety

Only trained personnel should design and install the robot system. Trained personnel are defined as those who have taken robot system training and maintenance training classes held by the manufacturer, dealer, or local representative company, or those who understand the manuals thoroughly and have the same knowledge and skill level as those who have completed the training courses.

To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the Installation and Design Precautions in the Safety chapter of the EPSON RC+ User's Guide.

The following items are safety precautions for design personnel:

 WARNING	■ Personnel who design and/or construct the robot system with this product must read the <i>Safety</i> chapter in the <i>EPSON RC+ User's Guide</i> to understand the safety requirements before designing and/or constructing the robot system. Designing and/or constructing the robot system without understanding the safety requirements is extremely hazardous, may result in serious bodily injury and/or severe equipment damage to the robot system, and may cause serious safety problems. ■ The robot system must be used within the environmental conditions described in their respective manuals. This product has been designed and manufactured strictly for use in a normal indoor environment. Using the product in an environment that exceeds the specified environmental conditions may not only shorten the life cycle of the product but may also cause serious safety problems. ■ The robot system must be used within the installation requirements described in the manuals. Using the robot system outside of the installation requirements may not only shorten the life cycle of the product but also cause serious safety problems.
--	---

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

1.3 Operation Safety

The following items are safety precautions for qualified Operator personnel:

 WARNING	■ Please carefully read the 1.3 <i>Safety-related Requirements</i> in the <i>Safety</i> chapter of the <i>Safety and Installation</i> manual before operating the robot system. Operating the robot system without understanding the safety requirements is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system. ■ Do not enter the operating area of the Manipulator while the power to the robot system is turned ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even if it seems to be stopped. ■ Before operating the robot system, make sure that no one is inside the safeguarded area. The robot system can be operated in the mode for teaching even when someone is inside the safeguarded area. The motion of the Manipulator is always in restricted (low speed and low power) status to secure the safety of an operator. However, operating the robot system while someone is inside the safeguarded area is extremely hazardous and may result in serious safety problems in case that the Manipulator moves unexpectedly. ■ Immediately press the Emergency Stop switch whenever the Manipulator moves abnormally while the robot system is operated. Continuing the operation while the Manipulator moves abnormally is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.
 WARNING	■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Before performing any replacement procedure, turn OFF the robot system and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system. ■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.

 CAUTION	■ Whenever possible, only one person should operate the robot system. If it is necessary to operate the robot system with more than one person, ensure that all people involved communicate with each other as to what they are doing and take all necessary safety precautions. ■ Each Joint: If the joints are operated repeatedly with the operating angle less than 5 degrees, the Manipulator may get damaged early due to the bearings are not being covered with grease during movement. To prevent early breakdown, move the joints larger than 30 degrees for about five to ten times a day. ■ Vibration (resonance) may occur continuously depending on the combination of robot motion speed, Arm orientation, and end effector load. Vibration arises from natural vibration frequency of the Arm and can be controlled by following measures. - Changing Manipulator speed - Changing the teach points - Changing the end effector load ■ Manipulator may be heated due to motor heat etc. Do not touch the Manipulator until temperature falls. After confirming that the temperature of the Manipulator falls and is not hot when you touch it. Then perform teaching or maintenance.
--	---

1.4 Emergency Stop

If the Manipulator moves abnormally during operation, immediately press the Emergency Stop switch. Pressing the Emergency Stop switch immediately changes the manipulator to deceleration motion and stops it at the maximum deceleration speed.

However, avoid pressing the Emergency Stop switch unnecessarily while the Manipulator is running normally. Pressing the Emergency Stop switch locks the brake and it may cause wear on the friction plate of the brake, resulting in the short life of the brake.

Normal brake life cycle: About 2 years (when the brakes are used 100 times/day)

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

Refer to the *Setup & Operation: 12. EMERGENCY* for instructions on how to wire the Emergency Stop switch circuit.

Do not turn OFF the power while the Manipulator is operating.

If you attempt to stop the Manipulator in emergency situations such as “Safeguard Open”, make sure to stop the Manipulator using the Emergency Stop switch.

If the Manipulator is stopped by turning OFF the power while it is operating, following problems may occur.

Reduction of the life and damage of the reduction gear unit

Position gap at the joints

In addition, if the manipulator was forced to be turned OFF by blackouts and the like while the Manipulator is operating, make sure to check the following points after power restoration.

Whether or not the reduction gear is damaged

Whether or not the joints are in their proper positions

If there is a position gap, perform calibration by referring to the *Maintenance 16. Calibration* in this manual. Also, the same troubles may occur if an error occurs and the Manipulator stops in emergency during the operation. Check the Manipulator condition and perform calibration if necessary.

Before using the Emergency Stop switch, be aware of the following.

- The Emergency Stop (E-STOP) switch should be used to stop the Manipulator only in case of emergencies.
- To stop the Manipulator operating the program except in emergency, use Pause (halt) or STOP (program stop) commands
Pause and STOP commands do not turn OFF the motors. Therefore, the brake does not function.
- For the Safeguard system, do not use the circuit for E-STOP.

For details of the Safeguard system, refer to the following manuals.

EPSON RC+ User's Guide

2. Safety - Installation and Design Precautions - Safeguard System

Safety and Installation

2.5 Connection to EMERGENCY Connector

To check brake problems, refer to the following manuals.

Manipulator Manual *Maintenance*

2.1.2 *Inspection Point - Inspection While the Power is ON*

(Manipulator is operating)

Safety and Installation

5.1.1 *Manipulator*

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

Free running distance in emergency

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

The free running time/angle/distance of the Manipulator are shown below. However, remember that the values vary depending on following conditions.

Weight of the end effector	Weight setting
Weight of workpiece	Speed setting
Operating pose	Accel setting

Conditions for measurement

	VT series
ACCEL Setting	100
SPEED Setting	100
Load [kg]	6
WEIGHT Setting	6

			VT6-A901**
Free running time [sec.]	Arm #1		0.2
	Arm #2		0.3
	Arm #3		0.2
	Arm #4		0.2
	Arm #5		0.2
	Arm #6		0.2
Free running angle [deg.]	Arm #1	Table Top Ceiling	50
		Wall	30
	Arm #2		70
	Arm #3		20
	Arm #4		20
	Arm #5		20
	Arm #6		30

1.5 How to Move Arms with the Electromagnetic Brake

When the electromagnetic brake is operating such as an emergency status, all arms cannot be moved.

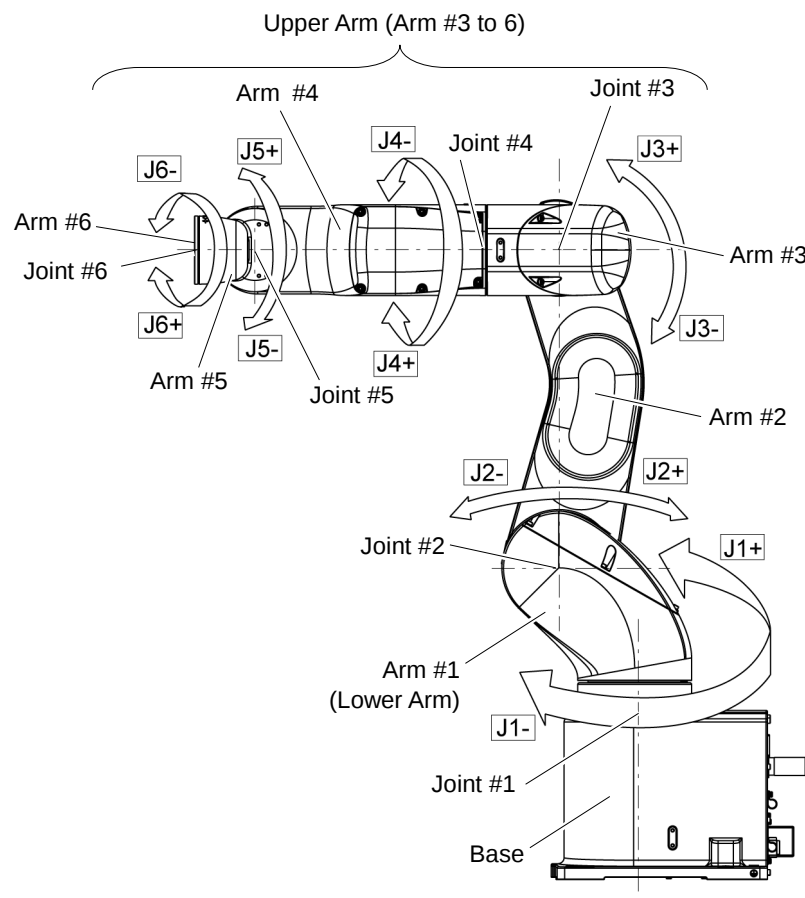
For procedures to release the electromagnetic brake, refer to the following section.

When the electromagnetic brake is released, the arms can be moved by hand.

1.5.2 Release the Brake by the Software

(When the software is available)

1.5.1 Arm Motions



Joint Motion

Joint #1 : The whole Manipulator revolves.

Joint #2 : The lower arm swings.

Joint #3 : The upper arm swings.

Joint #4 : The wrist revolves.

Joint #5 : The wrist swings.

Joint #6 : The hand rotates.

1.5.2 Release the Brake by the Software

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

EPSON
RC+

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

>Reset

>Brake Off, [the arm (#1 to #6) whose brake will be turned off]

Execute the following command to turn on the brake again.

>Brake On, [the arm (#1 to #6) whose brake will be turned on]

1.6 Precaution for Operation in Low Power Status

In the low power status, the Manipulator operates at low speed and low torque.

If in close proximity to the Manipulator, operate the Manipulator carefully. Otherwise, your hands or fingers may get caught during operation. The Manipulator may also collide with peripheral equipment and cause equipment damage or malfunction of the Manipulator.

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

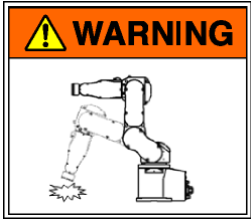
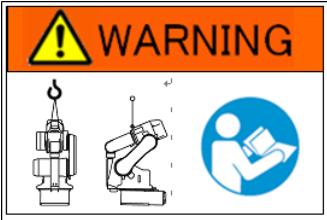
1.7 Labels

The Manipulator has the following warning labels.

The warning labels are attached around the locations where specific dangers exist.

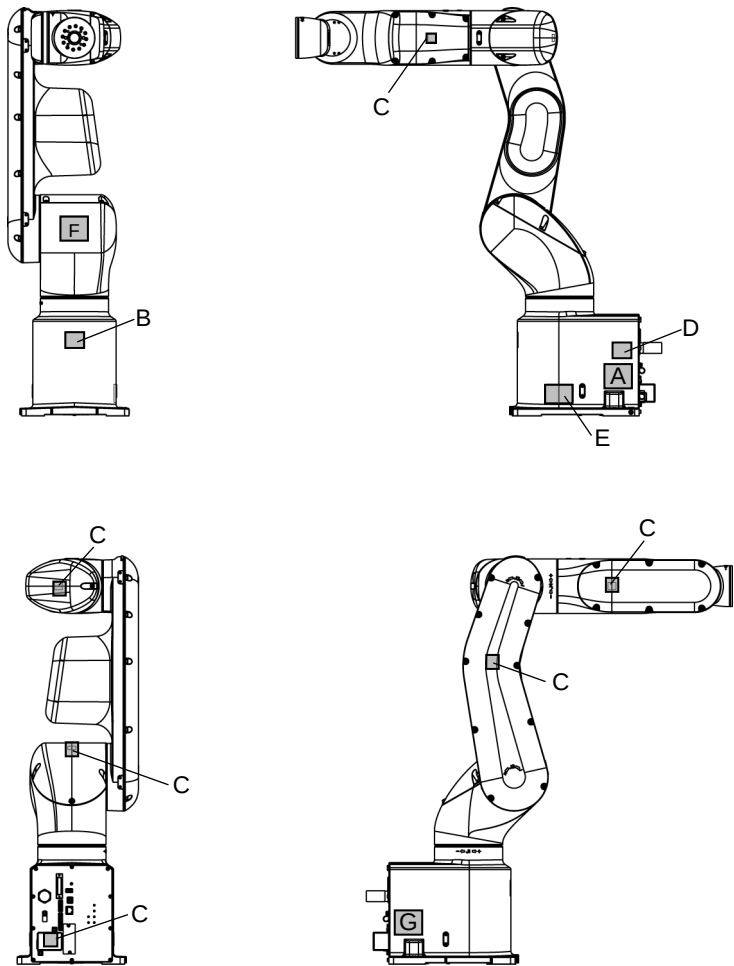
Be sure to comply with descriptions and warnings on the labels to operate and maintain the Manipulator safely.

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

Location	Warning Label	NOTE
A		Before loosening the base mounting screws, hold the arm and secure it tightly with a band to prevent hands or fingers from being caught in the Manipulator. For transport and install procedures, follow the steps described in this manual.
B		Do not enter the operation area while the Manipulator is moving. The robot arm may collide against the operator. This is extremely hazardous and may result in serious safety problems.
C		Hazardous voltage exists while the Manipulator is ON. To avoid electric shock, do not touch any internal electric parts.
D		When releasing the brakes, be careful of the arm falling due to its own weight. This warning label is attached on the Manipulator and optional brake release box.
E		Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.
F		You may get your hand or fingers caught when bringing your hand close to moving parts.

Location	Warning Label	NOTE
G	MODEL : VT6-A901S SERIAL NO. : 0000000001 MANUFACTURED : 04/2018 AC100-240V 50/60Hz SINGLE PHASE 1200VA max WEIGHT:40kg MAX PAYLOAD:6kg MOTOR POWER AXIS1 : 300W AXIS2 : 300W AXIS3 : 200W AXIS4 : 100W AXIS5 : 100W AXIS6 : 100W MANUFACTURER : SEIKO EPSON CORPORATION 3-5,OWA3-CHOME,SUWA-SHI NAGANO-KEN,392-8502JAPAN https://global.epson.com/company/ ENTITY PLACING ON EU MARKET: EPSON DEUTSCHLAND GmbH OTTO-HAHN-STR.4,D-40670 MEERBUSCH GERMANY https://neon.epson-europe.com/de/en/rebels/  0000000001 MADE IN CHINA	Signature label S/N (Serial Number) label

Location of labels



2. Specifications

2.1 Features of VT series Manipulators

The VT series Manipulators are controller integrated manipulators.

The features of the VT series Manipulators are as follows:

For Device design and tooling

- There is no external controller
 - No installation space required for an external controller.
 - No design is required for external controller installation or tooling.
- No robot to controller external cables
 - There are no external cables required between the robot and controller.

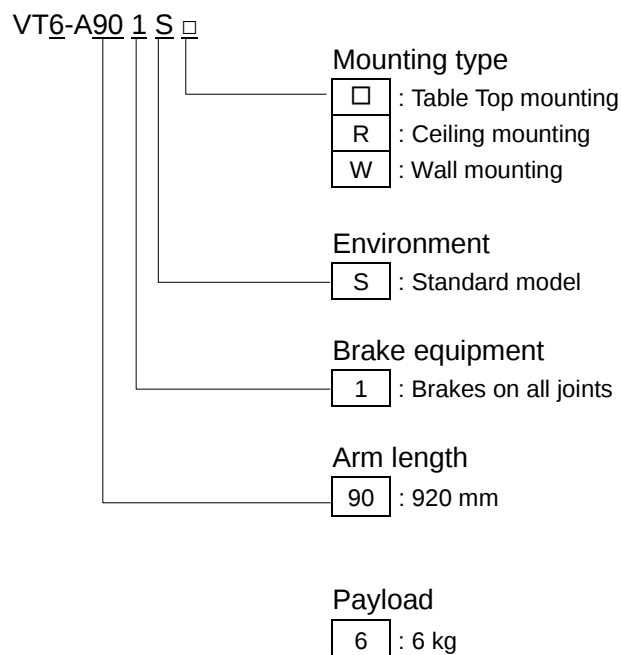
For Maintenance

- There are no motor unit batteries for the robot
 - No longer necessary to connect external devices for battery replacement.
- Easy to replace the Manipulator

Others

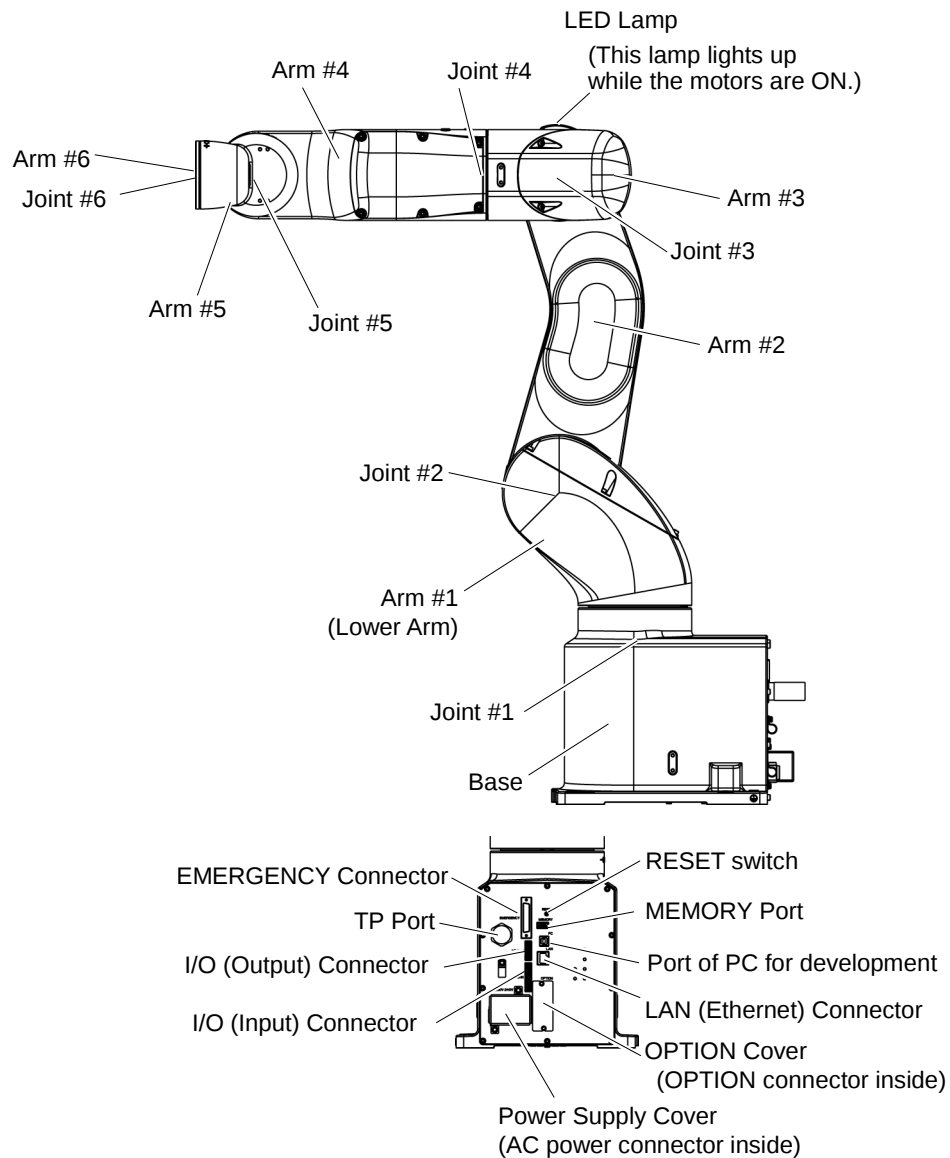
- Power-saving
 - VT6L: Approx. 1/5 compared to C4L/RC700-A

2.2 Model Number



For details on the specifications, refer to *Setup & Operation: 2.7 Specifications*.

2.3 Part Names



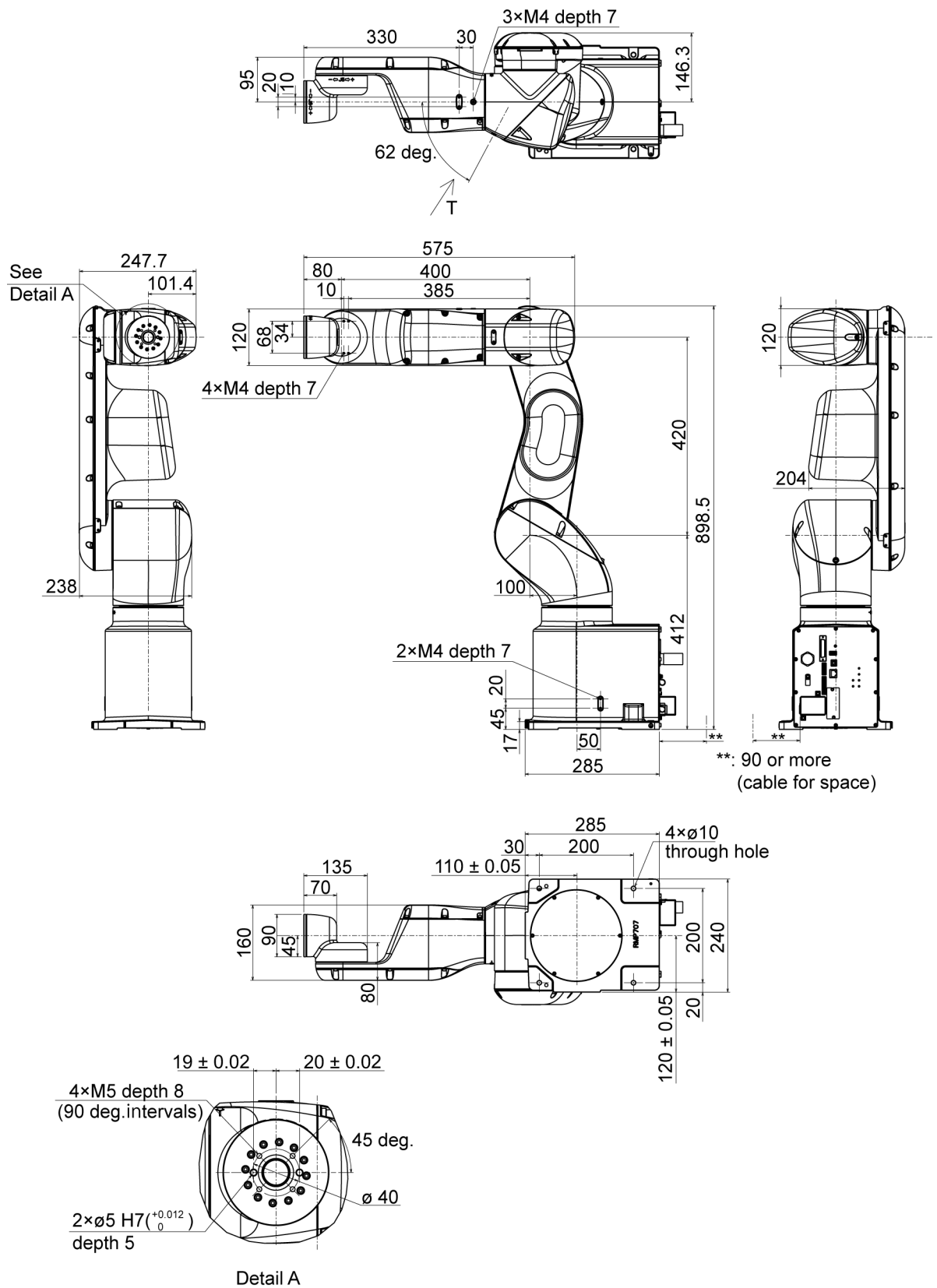
NOTE

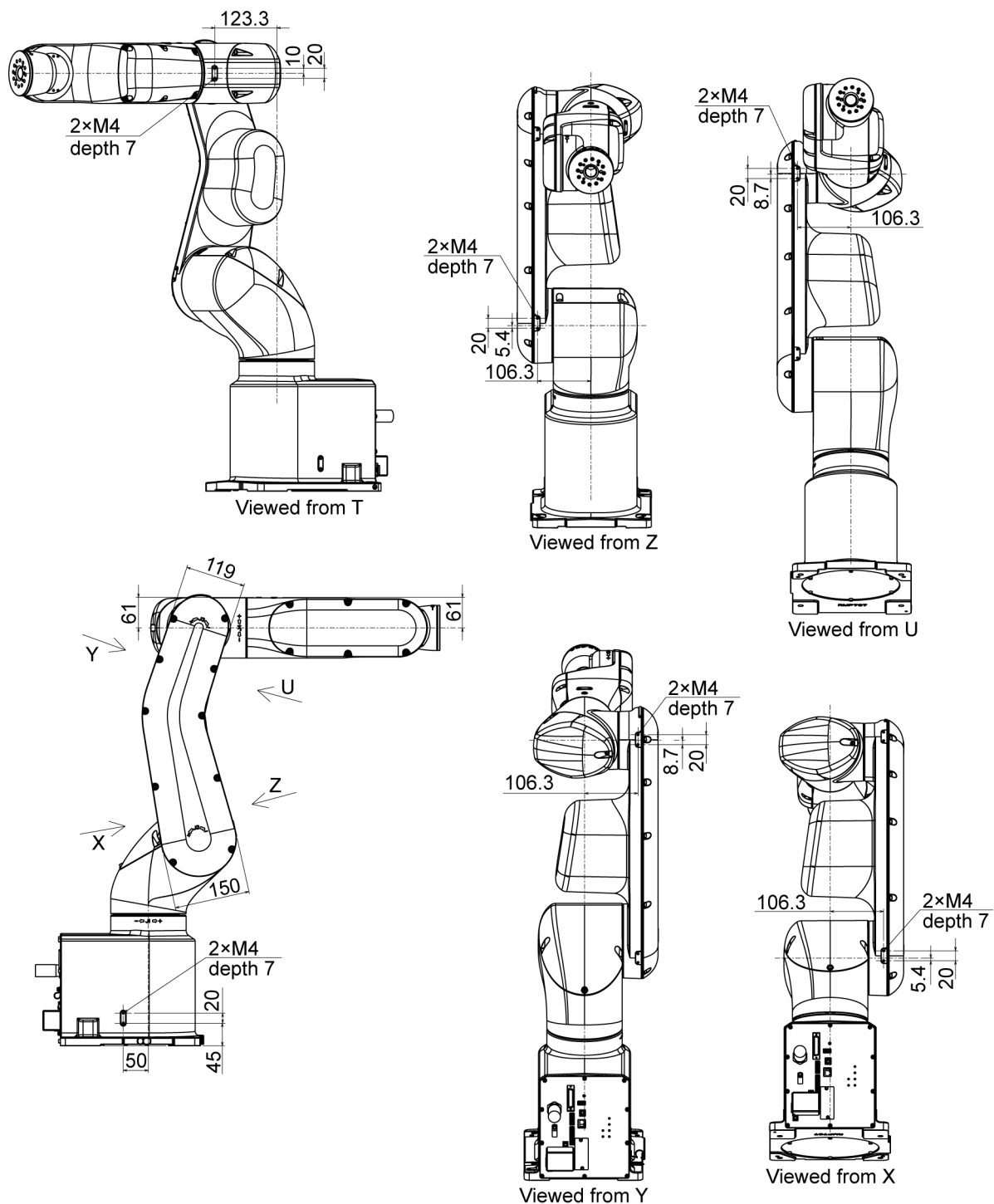


When the LED lamp is lighting or the controller power is ON, the current is being applied to the manipulator. (The LED lamp may not be seen depending on the Manipulator's posture. Be very careful.)

Performing any work with the power ON is extremely hazardous and it may result in electric shock and/or improper function of the robot system. Make sure to turn OFF the controller power before the maintenance work.

2.4 Outer Dimensions

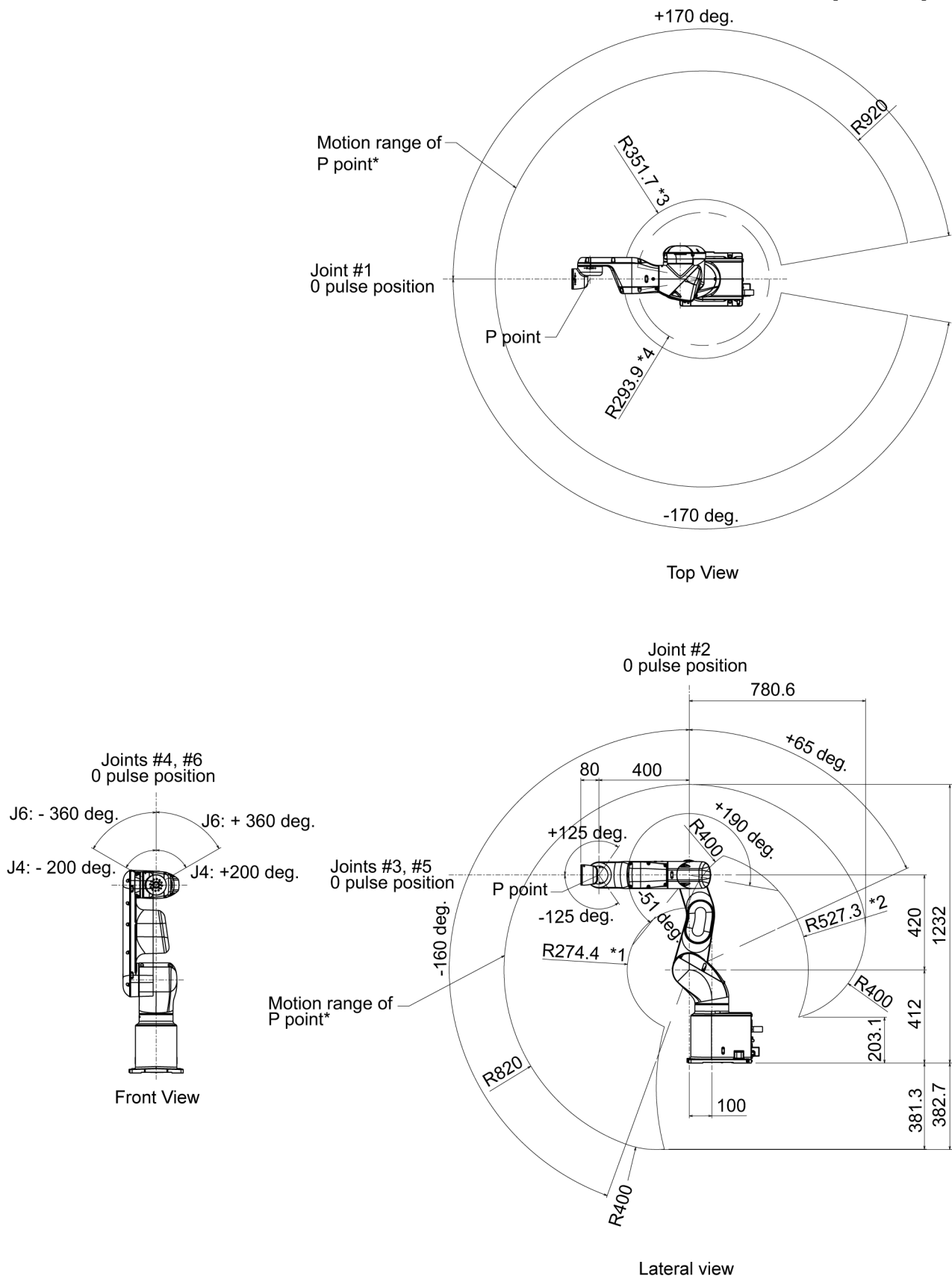




[Unit: mm]

2.5 Standard Motion Range

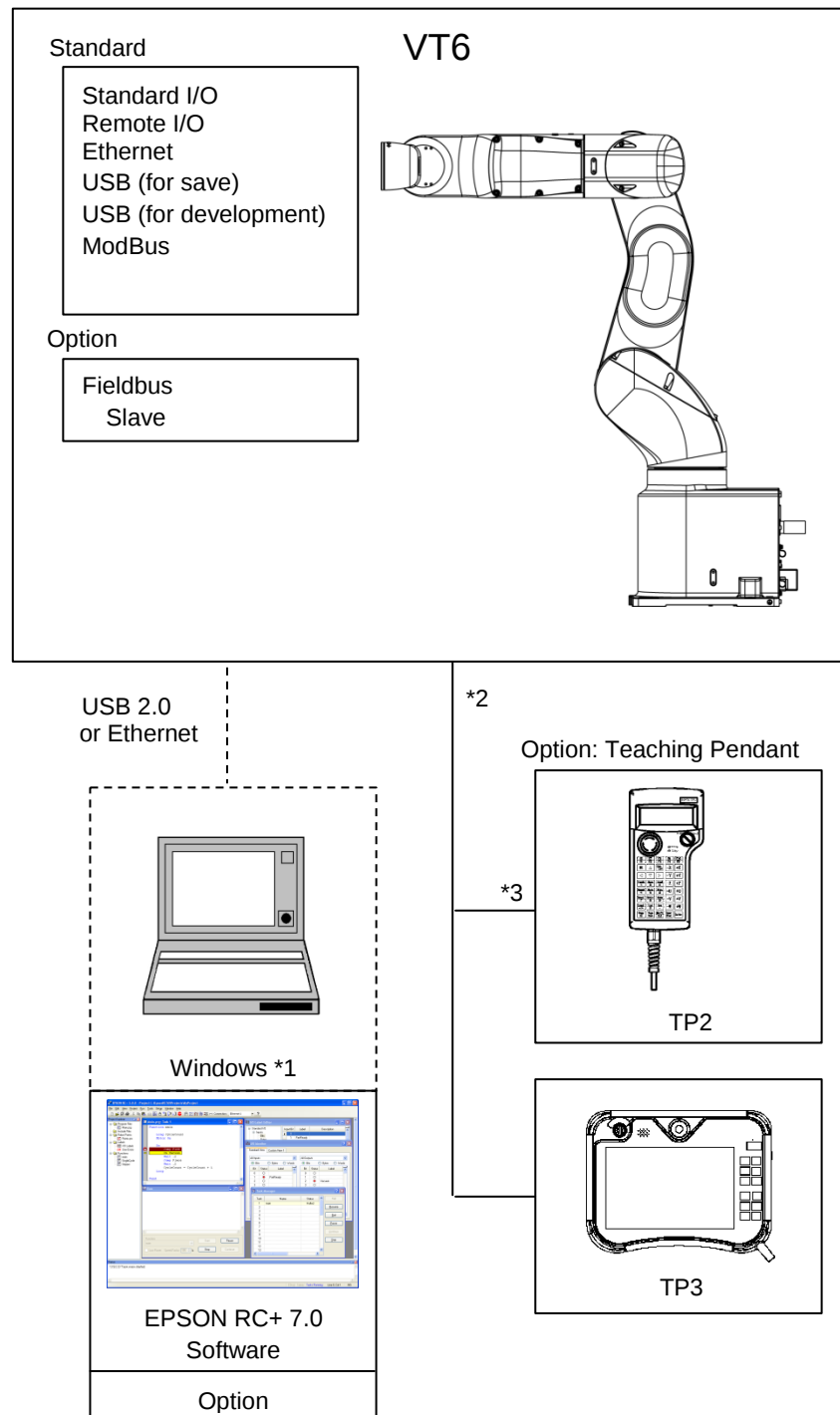
[Unit: mm]



- * P point : Intersection of the rotation centers for Joint #4, #5, and #6
- *1 : P point from top with Joint #3 declining -51 deg (Joint #2 center – P point center)
- *2 : P point from top with Joint #3 tilting up $+190$ deg (Joint #2 center – P point center)
- *3 : P point from lateral with Joint #3 declining $+190$ deg (Joint #1 center – P point center)
- *4 : P point from lateral with Joint #3 tilting up -51 deg (Joint #1 center – P point center)

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

2.6 System Example



*1 EPSON RC+ 7.0 supports the following OS

Windows 7 Professional Service Pack 1

Windows 8.1 Pro (EPSON RC+7.0 Ver.7.1.0 or later)

Windows 10 Pro (EPSON RC+7.0 Ver.7.2.0 or later)

*2 Either teaching pendant is available.

*3 When connecting to VT series manipulators, specified convert cable is necessary.

2.7 Specifications

Item		Specifications		
Model Number		VT6-A901S	VT6-A901SR	VT6-A901SW
Model Name		VT6L		
Mounting type *1		Table Top mounting	Ceiling mounting	Wall mounting
Weight (not include the weight of cables or shipping jigs)		40 kg : 89 lb.		
Driving method	All joints	AC servo motor		
Max. operating speed *2	Joint #1	183.7°/s		
	Joint #2	122.5°/s		
	Joint #3	118.8°/s		
	Joint #4	271.4°/s		
	Joint #5	296.8°/s		
	Joint #6	293.2°/s		
Maximum synthetic speed		4522 mm/s		
Repeatability	Joint #1 ~ #6	± 0.1 mm		
Max. motion range	Joint #1	± 170°		± 30°
	Joint #2	− 160° ~ + 65°		
	Joint #3	− 51° ~ + 190°		
	Joint #4	± 200°		
	Joint #5	± 125°		
	Joint #6	± 360°		
Max. pulse range	Joint #1	± 8488472		±1497966
	Joint #2	− 9986438 ~ + 4056990		
	Joint #3	− 2343172 ~ + 8729465		
	Joint #4	±8048281		
	Joint #5	± 4599018		
	Joint #6	± 13410735		
Resolution	Joint #1	0.0000200°/pulse		
	Joint #2	0.0000160°/pulse		
	Joint #3	0.0000217°/pulse		
	Joint #4	0.0000248°/pulse		
	Joint #5	0.0000271°/pulse		
	Joint #6	0.0000268°/pulse		
Motor power consumption	Joint #1	300 W		
	Joint #2	300 W		
	Joint #3	200 W		
	Joint #4	100 W		
	Joint #5	100 W		
	Joint #6	100 W		
Payload *3	Rated.	3 kg		
	Max.	6 kg		
Allowable moment	Joint #4	12 N·m (1.22 kgf·m)		
	Joint #5	12 N·m (1.22 kgf·m)		
	Joint #6	7 N·m (0.71 kgf·m)		
Allowable moment of inertia *4 (GD ² /4)	Joint #4	0.3 kg·m ²		
	Joint #5	0.3 kg·m ²		
	Joint #6	0.1 kg·m ²		

Item		Specifications	
Environmental requirements *5	Ambient Temperature	5 ~ 40 °C	
	Ambient relative humidity	10 ~ 80 % RH (no condensation)	
	Vibration	4.9 m·s ² (0.5 G) or less	
Noise level *6		L _{Aeq} = 80 dB (A) or less	
Environment		Standard	
Default values (Max. setting values)	Speed	(5) 100	
	Accel *7	(5, 5) 120, 120	
	SpeedS	(50) 2000	
	AccelS *8	(200) 10000	
	Fine	(10000, 10000, 10000, 10000, 10000, 10000) 65535, 65535, 65535, 65535, 65535, 65535	
	Weight	3 (6)	
	Inertia	0.03 (0.1)	
Motion Control	Development Environment	EPSON RC+ 7.0	
	Programming Language	SPEL+ (multi-tasking robot language)	
	Joint Control	Standard 6 joints simultaneous control Digital AC servo control	
	Positioning Control	PTP (Point-To-Point control) CP (Continuous Path control)	
	Speed Control	PTP motion : Programmable in the range of 1 to 100% CP motion : Programmable (Actual value to be manually entered.)	
	Acceleration/Deceleration Control	PTP motion : Programmable in the range of 1 to 100% Auto acceleration/deceleration CP motion : Programmable (Actual value to be manually entered.)	
External Interface	EMERGENCY		EMERGENCY STOP: Redundant (Category 3) Supported for internal/external power supply Safeguard System: Redundant (Category 3) Supported for external power supply
	I/O	Standard I/O (Rear side of Manipulator)	Input: 24 points Output: 16 points Non-polar, Supported for both Sink and Source
		Remote I/O (Remote functions are applied to Standard I/O)	Input: 8 points Program, 3 points Start, Stop, Pause, Continue, Reset Output: 8 points Ready, Running, Paused, ErrorEStopOn, SafeguardOn, SError, Warning
	Field bus Slave (Option)		Input: 256 points Output: 256 points Enable to add only one more module
	TP Connection Port		Supported for teach pendant (Option: TP2, TP3)
	PC Connection Port		USB B connector Supported for USB 2.0 High Speed / Full Speed
	USB Memory Connection Port		USB A connector Supported for USB 2.0 High Speed / Full Speed
	Ethernet Port		Supported for 10/100 Mbps Available up to 8 ports
	RESET Switch		Enable to use for reset of system

Item		Specifications
Display	Mode Display LED	TEACH, AUTO, PROGRAM, TestMode, Error, E-STOP
Controller Status Save		Save to USB memory Save in RC+ (PC)
Voltage		100 ~ 240 VAC
Phase		Single phase
Frequency		50 / 60 Hz
Momentary Power Interrupt		Less than 10 ms
Rating Capacity		1, 200 VA
Peak Current (When AC power is turned ON)		Max. 60A (Less than 2 ms)
Leak Current		Max. 10 mA
Ground Resistance		Less than 100Ω
Safety standard		CE Mark EMC Directive, Machinery Directive ANSI/RIA R15.06-2012 NFPA 79 (2007 Edition)

*1: Mounting types other than “Table Top mounting”, “Ceiling mounting”, and “Wall mounting” are out of specification. If you prefer other mounting types, please contact us.

*2: In case of PTP control

*3: Do not apply the load exceeding the maximum payload.

*4: If the center of gravity is at the center of each arm. If the center of gravity is not at the center of each arm, set the eccentric quantity using INERTIA command.

*5: For details of the environmental requirements, refer to the *Setup & Operation 3.1 Environmental Conditions*.

*6: Conditions of Manipulator at measurement are as follows:

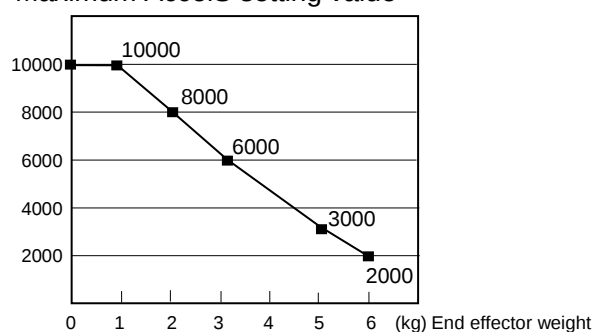
Operating conditions: Under rated load, all arms simultaneous motion, maximum speed, maximum acceleration, VT6L: duty 50%

Measurement point: 1000 mm apart from the rear of Manipulator

*7: In general use, Accel setting 100 is the optimum setting that maintains the balance of acceleration and vibration when positioning. Although values larger than 100 can be set to Accel, it is recommended to minimize the use of large values to necessary motions since operating the manipulator continuously with the large Accel setting may shorten the product life remarkably.

*8: Maximum AccelS setting value varies depending on the load. Refer to the table below for details. Setting the value which exceeds the maximum AccelS causes an error. In such a case, check the setting value.

Maximum AccelS setting value



2.8 How to Set the Model

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



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



If the custom specifications number (MT***) is described on MODEL of the signature label (S/N label), the Manipulator has custom specifications.

The custom specifications may require a different configuration procedure; check the custom specifications number (MT***) and contact us when necessary.

The Manipulator model can be set from software.

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

3. Environments and Installation

3.1 Environmental Conditions

A suitable environment is necessary for the robot system to function properly and safely. Be sure to install the robot system in an environment that meets the following conditions:

Item	Conditions
Ambient temperature	5 to 40°C (with minimum temperature variation)
Ambient relative humidity	10 to 80% (with no condensation)
First transient burst noise	2 kV or less (Power supply wire) 1 kV or less (Signal wire)
Electrostatic noise	4 kV or less
Environment	· 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. - Keep away from strong electric or magnetic fields.



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

Special Environmental Conditions

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

Rapid change in temperature and humidity can cause condensation inside the Manipulator. If your requirements specify that the Manipulator handles food, please consult your distributor to check whether the Manipulator will damage the food or not.

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

 WARNING	■ Use an earth leakage breaker on the AC power cable of the Manipulator to avoid electric shock and circuit breakdown caused by short circuit.
 CAUTION	■ When cleaning the Manipulator, do not rub it strongly with alcohol or benzene. It may lose luster on the coated face.

3.2 Base Table

A base table for anchoring the Manipulator is not supplied. Please make or obtain the base table for your Manipulator. The shape and size of the base table differs depending on the use of the robot system. For your reference, we list some Manipulator table requirements here.

Base table is necessary for support not only the weight of the manipulator but also dynamic motion when operating at the fastest speed. Provides enough beams to give sufficient strength.

The torque and reaction force produced by the movement of the Manipulator are as follows:

	VT6-A901*
Max. Reaction torque on the horizontal plate	500 N·m
Max. Horizontal reaction force	500 N
Max. Vertical reaction force	3100 N

The threaded holes required for mounting the Manipulator base are M8. Use mounting bolts with specifications conforming to ISO898-1 property class: 10.9 or 12.9. For dimensions, refer to *Setup & Operation: 3.3 Mounting Dimensions*.

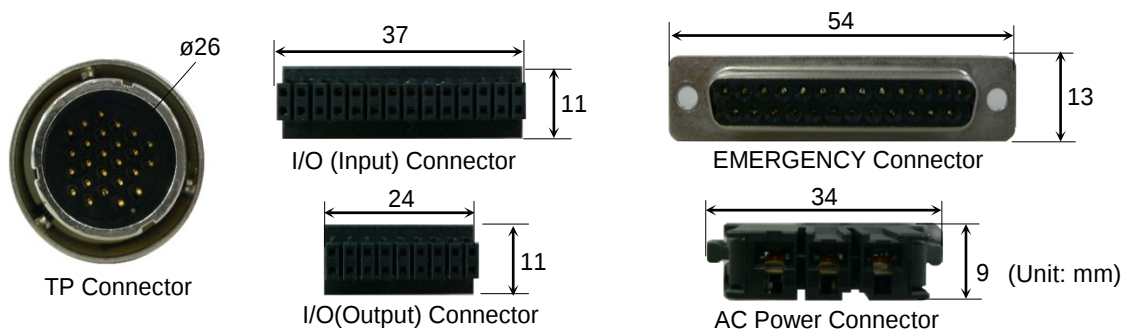
The plate for the Manipulator mounting face should be 20 mm thick or more and made of steel to reduce vibration. The surface roughness of the steel plate should be 25 µm or less.

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

The Manipulator must be installed horizontally.

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

If you are passing cables through the holes on the base table, see the figures below.



- To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the *EPSON RC+ User's Guide*.

3.3 Mounting Dimensions

Mounting Area

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

Space for teaching points

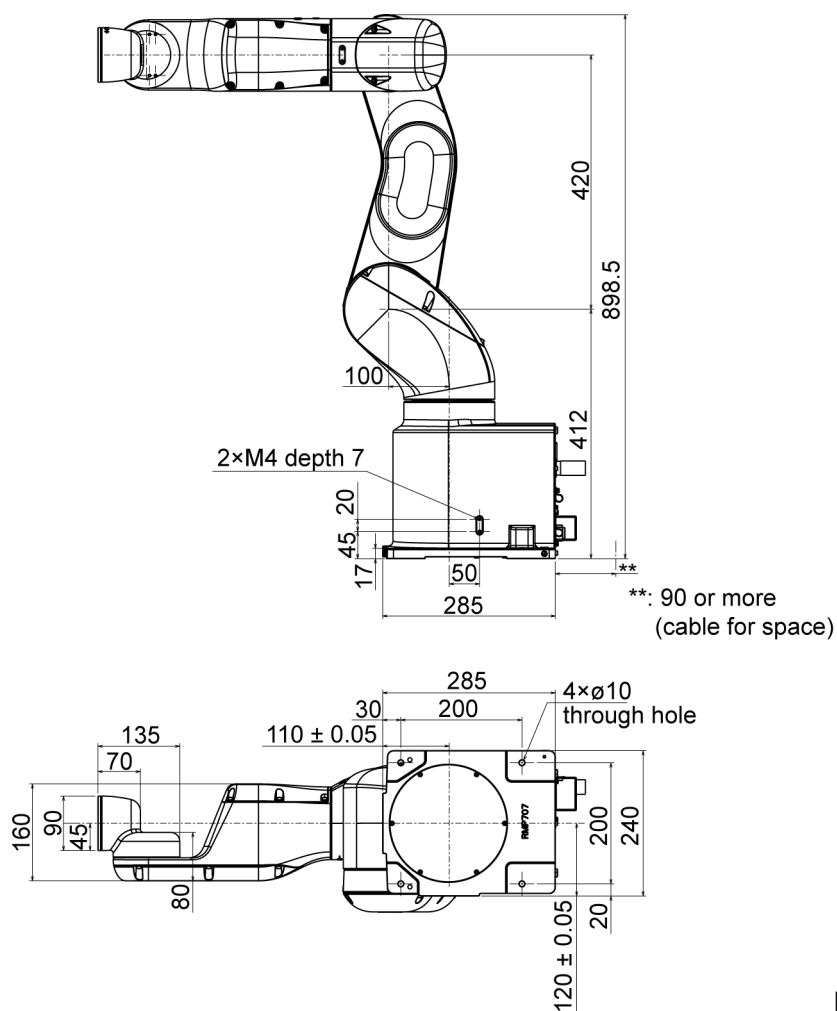
Space for maintenance and inspections

(Ensure a space to open the covers and plates for maintenance.)

Space for cables

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

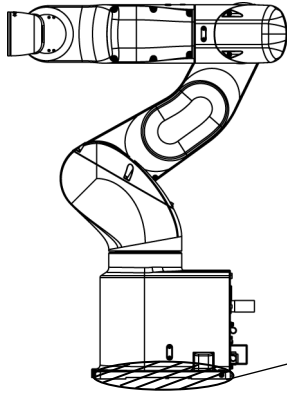
Ensure distance to the safeguard from the maximum motion range is more than 100 mm.



3.4 Unpacking and Transportation

THE INSTALLATION SHALL BE PREFORMED BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES.

 WARNING	■ Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system. ■ Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system as the fall of the Manipulator.
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 CAUTION	■ Using a cart or similar equipment, transport the Manipulator in the same manner as it was delivered. ■ When removing the anchor bolts, support the Manipulator to prevent falling over. Removing the anchor bolts without supporting the Manipulator may get hands, fingers, or feet caught as the Manipulator may fall over. ■ To transport the Manipulator, secure it to the delivery equipment or have at least 2 people to hold it by hand. Also, do not hold the bottom of the base (the shaded area in the figure). Holding the area by hand is extremely hazardous and may cause your hands and fingers caught.  VT6-A901* : Approx. 40 kg: 89 lb. DO NOT hold the bottom of the base by hand. ■ When transporting the Manipulator, avoid excessive vibration or shock. Excessive vibration or shock may cause equipment damage and/or malfunction of the Manipulator. ■ Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in fall of the Manipulator. ■ When transporting the Manipulator for a long distance, secure it to the delivery equipment directly so that the Manipulator never falls over. If necessary, pack the Manipulator in the same style as it was delivered.
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3.5 Installation Procedure

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

 WARNING	■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the Installation and Design Precautions in the Safety chapter of the EPSON RC+ User's Guide. ■ Install the Manipulator in a location with sufficient space so that a tool or a work piece does not touch a wall or a safeguard when the Manipulator extends its arm fully while holding a work piece. Installing the Manipulator at a location with insufficient space is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system as a tool or a work piece may collide with a wall or a safeguard. ■ Anchor the Manipulator before turning ON the power or operating the Manipulator. Turning ON the power or operating the Manipulator that is not anchored is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system as the Manipulator may fall down. ■ Before installing and operating the Manipulator, make sure that all parts of the Manipulator are in place and have no external defects. Missing or defective parts may cause improper operation of the Manipulator. Improper operation of the Manipulator is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.
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 CAUTION	■ The Manipulator must be installed to avoid interference with buildings, structures, utilities, other machines and equipment that may create a trapping hazard or pinch points. ■ Vibration (resonance) may occur during operation depending on rigidity of the installation table. If the vibration occurs, improve rigidity of the table or change the speed or acceleration and deceleration settings. ■ Install the Table Top Mounting Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator. VT6-A901* : Approx. 40 kg: 89 lb.
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Mounting bolt

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

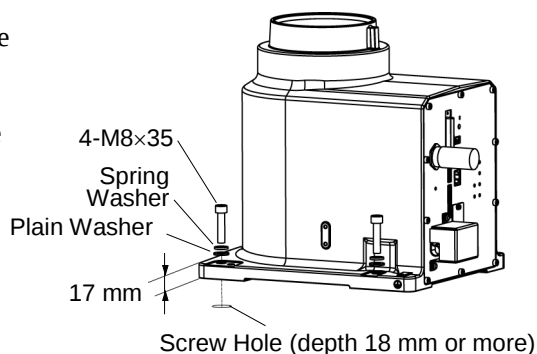
There are four threaded holes for the Manipulator base.



Use M8 mounting bolts conforming to the strength of ISO898-1 property class 10.9 or 12.9.

Tightening torque:

$32.0 \pm 1.6 \text{ N}\cdot\text{m}$ ($314 \pm 16 \text{ kgf}\cdot\text{cm}$)



3.6 Power Supply



WARNING

- There is no power switch on the Manipulator. Right after inserting power plug to power, the Robot System turns ON.
Be careful about electric shock when inserting power plug.

3.6.1 Specifications

Ensure that the available power meets following specifications.

Item	Specification
Voltage	100 to 240 VAC (Input voltage should be within $\pm 10\%$ of the rated voltage.)
Phase	Single phase
Frequency	50/60 Hz
Momentary Power Interrupt	Less than 10 msec.
Rating Capacity	1,200VA
Peak Current (When AC power is turned ON)	Max. 60A (Less than 2 ms)
Leak Current	Max. 10 mA
Ground Resistance	100 Ω or less

3.6.2 AC Power Cable



WARNING

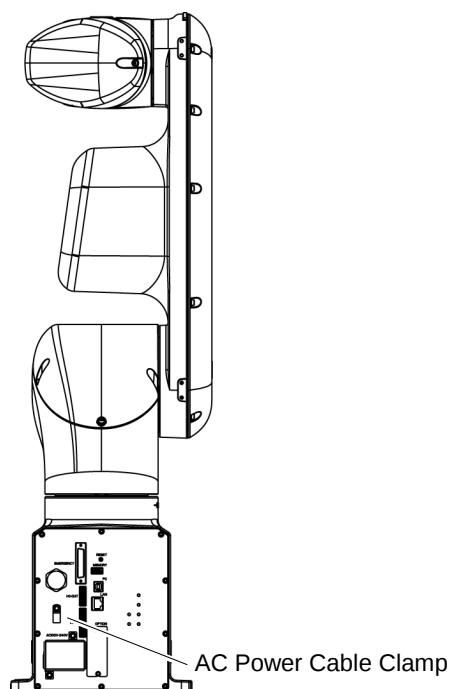
- Make sure that the operations are done by a qualified person.
- Be sure to connect the earth wire (green/yellow) of the AC power cable to the earth terminal of the factory power supply.
Also, we recommend to ground directly via a hole on the base to ground the manipulator completely.
The equipment must be grounded properly at all times to avoid the risk of electric shock.
- Always use a plug or a disconnecting device for power connecting cable. Never connect the Controller directly to the factory power supply.
- Select a plug or a disconnecting device which conforms to safety standards of each country.

When connecting the connector of AC cable to the Manipulator, make sure to insert completely.

Connection Specification of Cable Wire

Item	Specification
AC power wire (2 cables)	Black, White
Ground wire	Green/Yellow
Cable length	5 m
Terminal	M4 round solderless terminal

Use cable clamp on rear side of the Manipulator to fix AC power cable.



3.6.3 Breaker

Install an earth leakage circuit breaker or a circuit breaker in the AC power cable line.
For the rated electric current of the circuit breaker, refer to the following set values.

Manipulator	Power	Rated electric current
VT6L	AC100V	20A
	AC200V	10A

If you install a circuit breaker, please select one that can handle the “peak current” described in the following section.

Setup & Operation 3.6.1 Specifications

The power receptacle shall be installed near the equipment and shall be easily accessible.

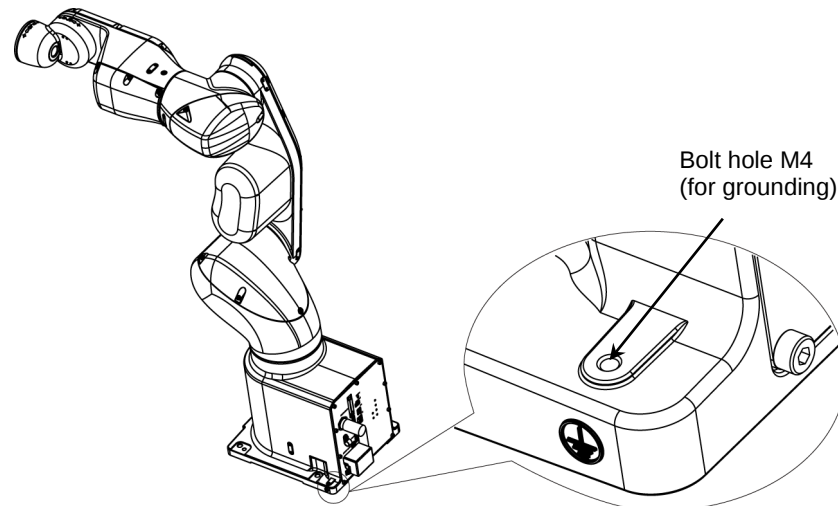
3.6.4 Grounding



- Ground resistance must be 100 Ω or less. Improper ground resistance may result in fire and/or electric shock.
- Do not use the ground line for the Manipulator in common with other ground lines or grounding electrodes for other electric power, motor power, welding devices, etc. Using the ground line for the Manipulator in common with other ground lines or grounding electrodes may result in electric shock and/or malfunction of the robot system.
- When using metal ducts, metallic conduits, or distributing racks for cable, ground in accordance with national and local electric equipment technical standards. Grounding that does not meet the standards may result in electric shock and/or malfunction of the robot system.

Follow local regulations for grounding. It is recommended that the core size of the grounding wire be 5.5 mm² or more.

Directly connect the ground line to the Manipulator using bolt hole in the figure below.



3.7 Connecting the Cables



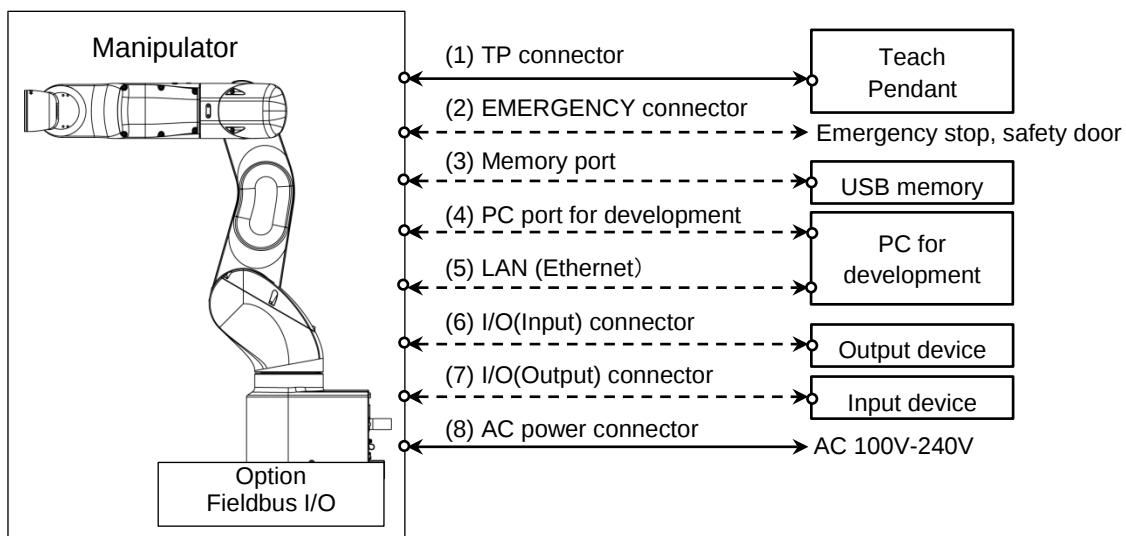
- To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
- Grounding the manipulator is done by connecting with Power cable. Ensure that the Power cable and ground wire are correctly connected. If the ground wire is improperly connected to ground, it may result in the fire or electric shock.



- Make sure that the serial numbers on each equipment match. Improper connection between the Manipulator and Controller may not only cause improper function of the robot system but also serious safety problems.
- Before connecting the connector, make sure that the pins are not bent. Connecting with the pins bent may damage the connector and result in malfunction of the robot system.

3.7.1 Connection Example

- Detachable connector
- Supplied cable
- Not supplied cable (Prepare by yourself)

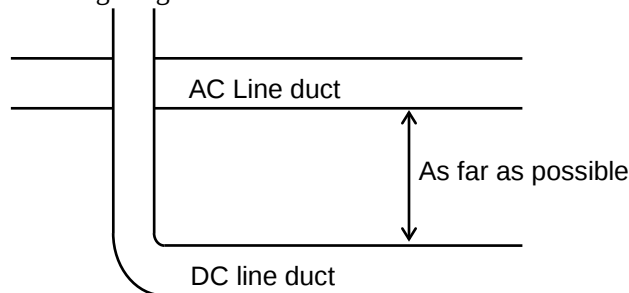


- (1) TP connector
Connect the option Teach Pendant.
For details, refer to the *Setup & Operation 10.TP Port*.
- (2) EMERGENCY
The EMERGENCY connector has inputs to connect the Emergency Stop switch and the Safety Door switch. For safety reasons, connect proper switches for these input devices.
For details, refer to the *Setup & Operation 12. EMERGENCY*.
- (3) Memory port
Connect to USB memory.
For details, refer to the *Setup & Operation 8. Memory port*.
- (4) PC for development
Connect the PC for development.
For details, refer to the *Setup & Operation 7. Development PC Connection Port*
- (5) LAN (EtherNet Communication)
Connect the EtherNet cable.
For details, refer to the *Setup & Operation 9. LAN (Ethernet Communication) Port*.
- (6) I/O (Input) connector
This input connector is for output device of the user.
When there is output device, use this connector.
For details, refer to the *Setup & Operation 13. Standard I/O connector*.
- (7) I/O (Output) connector
This output connector is for input device of the user.
When there is input device, use this connector.
For details, refer to the *Setup & Operation 13. Standard I/O connector*.
- (8) AC power connector
Connector for AC power supply to the manipulator.

3.7.2 Noise Countermeasures

To minimize electrical noise conditions, the following items must be observed in the system's cable wiring:

- The earth wire of the power supply should be grounded. (Ground resistance: 100 Ω or less) It is important to ground the frame of Manipulator not only for prevention from electric shock, but also for reducing the influence of electric noise around the Manipulator. Therefore, be sure to connect the earth wire (yellow/green) of the Manipulator's power cable to the ground terminal of the factory power supply. For details about the plug and AC power cable, refer to the *Setup & Operation 3.6 Power Supply*.
- Do not tap power from a power line that connects to any equipment which may cause noise.
- Do not run AC power lines and DC power lines in the same wiring duct, and separate them as far as possible. For example, separate the AC motor power line and the Manipulator power line as far as possible from the sensor or valve I/O lines; and do not bundle both sets of wiring with the same cable tie. If more than one duct/cable must cross each other, they should cross perpendicularly. The preferable example is shown in the right figure.



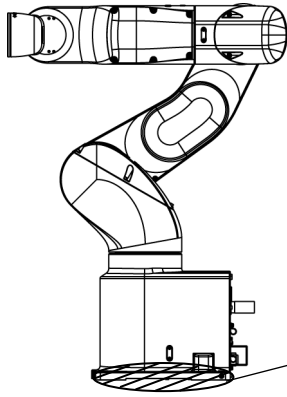
- Wire as short as possible to the I/O connector and EMERGENCY connector. Use a shielded cable and clamp the shield to the attached connector interior. Make sure to keep away from the peripheral noise source as far as possible.
- Make sure that the induction elements used to connect to the Manipulator's I/O (such as relays and solenoid valves) are noise suppression parts. If an induction element without protection against noise is used, make sure to connect a noise suppression part such as a diode located at the induction element in parallel with it. In selecting noise suppression parts, make sure that they can handle the voltage and current incurred by the induction load.
- As they are easily influenced by noise, keep cable such as USB, Ethernet, or fieldbus away from peripheral noise sources.

3.8 Relocation and Storage

3.8.1 Precautions for Relocation and Storage

Observe the following when relocating, storing, and transporting the Manipulators.

THE INSTALLATION SHALL BE PREFORMED BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES.

 WARNING	■ Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system. ■ Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system as the fall of the Manipulator.
 CAUTION	■ When removing the anchor bolts, support the Manipulator to prevent falling over. Removing the anchor bolts without supporting the Manipulator may get hands, fingers, or feet caught as the Manipulator may fall over. ■ To transport the Manipulator, secure it to the delivery equipment or have at least 2 people to hold it by hand. Also, do not hold the bottom of the base (the screened parts in the figure). Holding these parts by hand is extremely hazardous and may cause your hands and fingers caught.  ■ Make sure not to hold the power unit when transporting the manipulator. Also, avoid excessive vibration or shock during Manipulator transporting. Excessive vibration or shock may cause equipment damage and/or malfunction of the Manipulator. ■ Stabilize the Manipulator with your hands when hoisting it. Unstable hoisting is extremely hazardous and may result in fall of the Manipulator. ■ When transporting the Manipulator for a long distance, secure it to the delivery equipment so that the Manipulator will not fall over. If necessary, pack the Manipulator in the same way as it was delivered.

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

Item	Conditions
Ambient temperature	0 to 45 °C
Ambient relative humidity	10 % to 80 % (no condensation)

During unpacking and relocation, avoid applying external force to the arms and motors of the Manipulator.

When the Manipulator is used for a robot system again after long-term storage, perform a test run to verify that it works properly, and then operate it thoroughly.

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

3.8.2 Relocation



- Install or relocate the Manipulator with two or more people. The Manipulator weights are as follows. Be careful not to get hands, fingers, or feet caught and/or have equipment damaged by a fall of the Manipulator.
VT6-A901* : Approx. 40 kg :89 lb.

- (1) Turn OFF the power on all devices.

NOTE

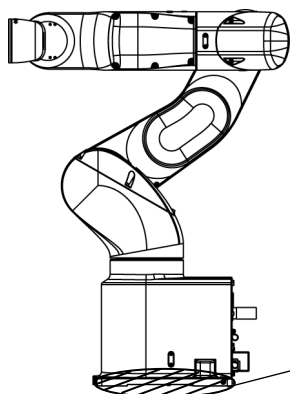


Remove the mechanical stops if using them to limit the motion range. For details on the motion range, refer to *Setup & Operation: 5.2 Motion Range Setting by Mechanical Stops*.

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

Recommend : Joint #2 +55 deg
Joint #3 –55 deg

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



VT6-A901* : Approx. 40 kg: 89 lb.
DO NOT hold the bottom of the base by hand.

Using Eyebolt

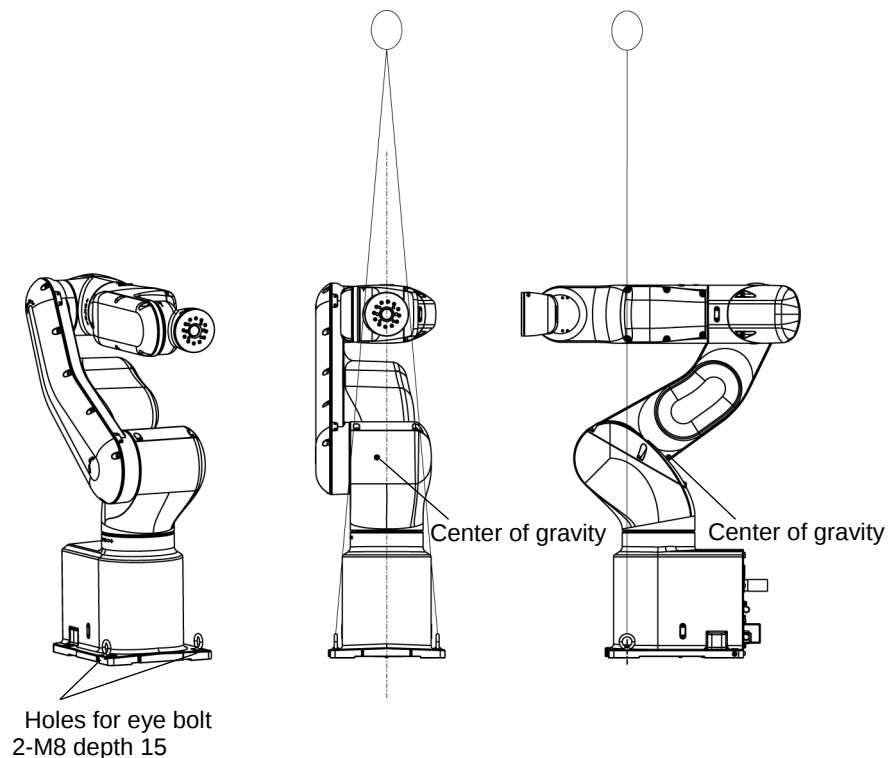
Check that the eyebolts are securely fastened before transporting the Manipulator.

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

The eyebolts (accessory, 2 pcs) and wire must be strong enough to withstand the weight (See the figures below).

If you use the eyebolts to lift up the Manipulator, make sure to put hands on it to keep the balance. The Manipulator may fall if the balance is lost and this is extremely hazardous.

To prevent damage on the covers and arms, it is recommended to protect the contacting parts of the wire and arm with a cloth.



VT6-A901* : Approx. 40 kg: 89 lb.



CAUTION

- Remove the eyebolts from the Manipulator after transportation/relocation is completed.

If the Manipulator is operated with the eyebolts left on it, the arm may collide with the eyebolts and it may cause equipment damage and/or malfunction of the Manipulator.

THE INSTALLATION SHALL BE PREFORMED BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES



WARNING

- Only authorized personnel should perform sling work and operate a crane and a forklift. When these operations are performed by unauthorized personnel, it is extremely hazardous and may result in serious bodily injury and/or severe equipment damage to the robot system.

3.9 Checking the Basic Orientation

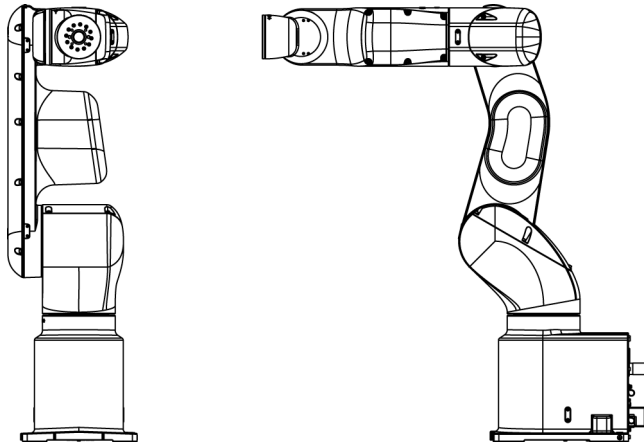
After parts have been replaced (motors, reduction gear units, belts, etc.), the Manipulator cannot operate properly because a gap exists between the origin positions stored in each motor and these stored in the Controller. The process to compensate the position gap is called “Calibration”.

At the time of shipment, the basic orientation of the Manipulator shown below is set as the origin position.

After installing the Manipulator and setup the operating environment, move the Manipulator to the origin position and check if it moves to the basic orientation properly.

To make the Manipulator move to the origin position, select [Tools]-[Robot Manager] - [Control Panel] and click <Home>.

If the gap still exists and the Manipulator cannot be in the basic orientation after the calibration, please contact us.



4. Setting of End Effectors

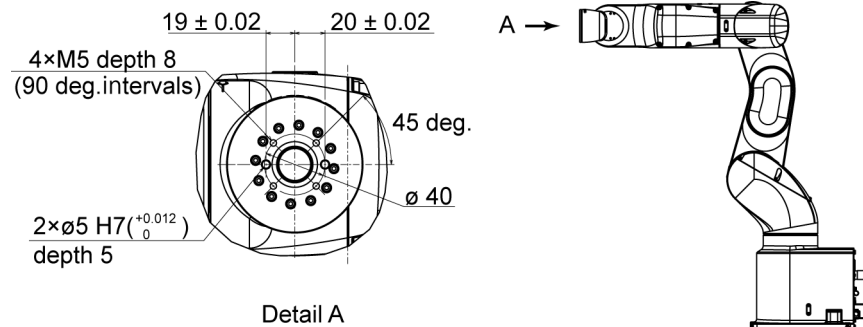
4.1 Attaching an End Effector

Create an end effector for your Manipulator.

Flange dimensions of the wrist attached to the end of Arm #6 is as below.

 CAUTION	■ If you use an end effector equipped with a gripper or chuck, connect wires and/or pneumatic tubes properly so that the gripper does not release the work piece when the power to the robot system is turned OFF. Improper connection of the wires and/or pneumatic tubes may damage the robot system and/or work piece as the work piece is released when the Emergency Stop switch is pressed. I/O outputs are configured at the factory so that they are automatically shut off (0) by power disconnection, the Emergency Stop switch, or the safety features of the robot system.
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Wrist Flange



Arm #6

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

Layouts

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

Compatibility with ISO flange:

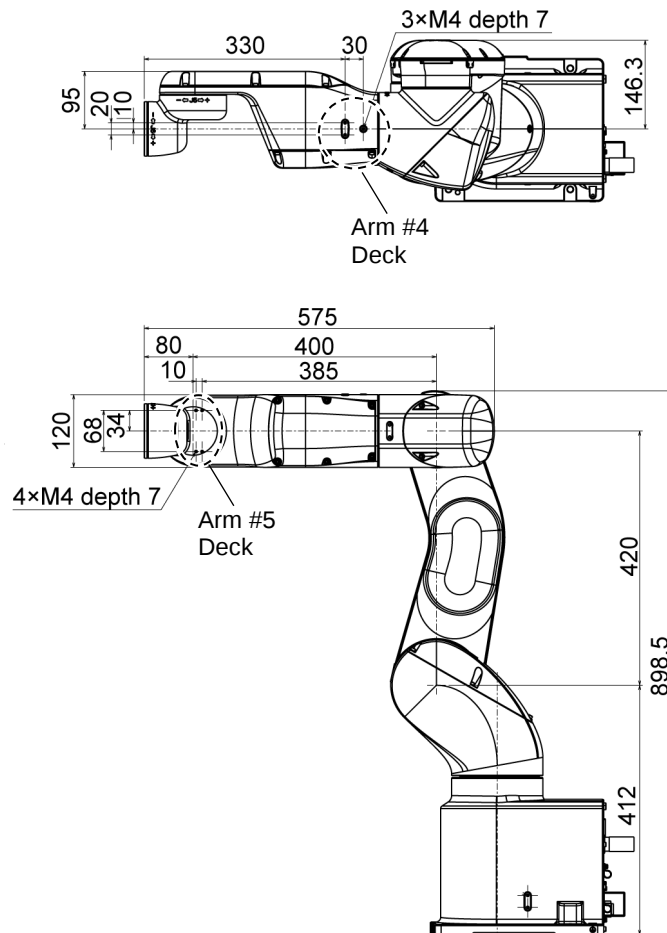
To install the end effector whose mounting dimensions are designed for the ISO flange, we provide the optional "Tool Adapter (ISO flange)". For details, refer to *Setup & Operation: 11. Options*.

4.2 Attaching Cameras and Air Valves

Decks are equipped to Arms #4 and #5 to enable the easy installation of air valve.

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

We provide the optional “Camera Plate Unit”. For details, refer to *Setup & Operation: 11. Options*.



4.3 Weight and Inertia Settings

The WEIGHT and INERTIA (inertia moment and eccentricity) commands are for setting the load parameters of the Manipulator. These settings optimize the Manipulator motion.

WEIGHT Setting

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

INERTIA Setting

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

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

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

Setting parameters makes the operation of the Manipulator optimal, reduces vibration to shorten the operating time, and improves the capacity for larger loads. In addition, it reduces persistent vibration produced when the inertia moment of the end effector and work piece is bigger.

The allowable load for VT series Manipulators is 6 kg at the maximum.

Due to the limitations of the moment and inertia moment shown in the table below, the load (end effector weight + work piece weight) should also meet these conditions.

Allowable Load

Joint	Allowable Moment	GD2/4 Allowable Moment of Inertia
Joint #4	12.0 N·m (1.22 kgf·m)	0.3 kg·m ²
Joint #5	12.0 N·m (1.22 kgf·m)	0.3 kg·m ²
Joint #6	7.0 N·m (0.71 kgf·m)	0.1 kg·m ²

Moment

The moment indicates amount of torque applied on the joint in order to support the gravity on the load (end effector + work piece).

The moment increases as weight of the load and amount of eccentricity increase. As this also increases the load applied on the joint, make sure to keep the moment within the allowable value.

Inertia moment

The inertia moment indicates how difficult the load (end effector + work piece) to rotate when the Manipulator joint starts to rotate (amount of inertia). The inertia moment increases as weight of the load and amount of eccentricity increase. As this also increase the load applied on the joint, make sure to keep the inertia moment within the allowable value.

The moment M (Nm) and inertia moment I (kgm^2) when the volume of the load (end effector + work piece) is small can be obtained by the following formula.

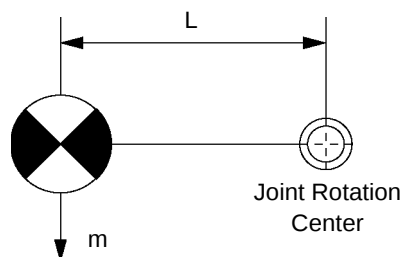
$$M \text{ (Nm)} = m(\text{kg}) \times L \text{ (m)} \times g \text{ (m/s}^2\text{)}$$

$$I \text{ (kgm}^2\text{)} = m(\text{kg}) \times L^2 \text{ (m)}$$

m : Weight of load (kg)

L : Eccentric quantity of load (m)

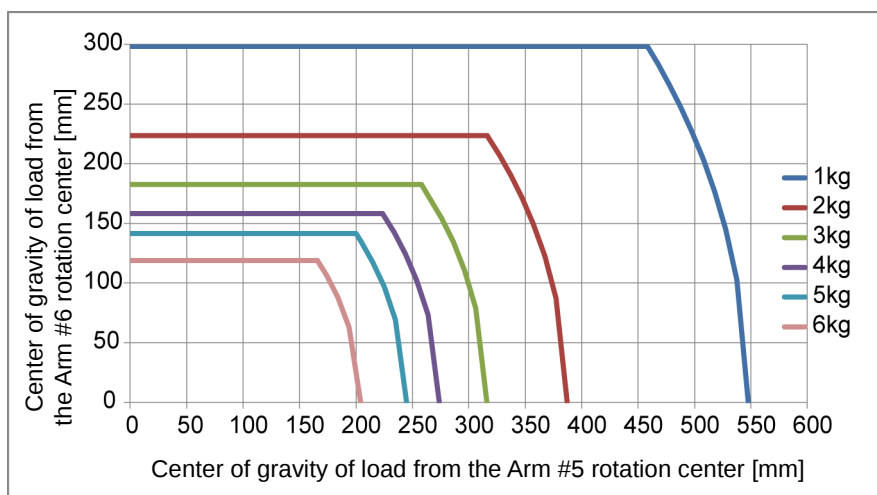
g : Gravitational acceleration (m/s^2)



The figure below shows distribution of the center of gravity when the volume of the load (end effector + work piece) is small.

Design the end effector so that the center of gravity is within the allowable moment.

If the volume of the load is large, calculate the moment and inertia moment by referring to *Setup & Operation 4.3.2 INERTIA setting - Calculating the Inertia Moment*.



Max. Eccentric Quantity of Load

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

Joint	1 kg	2 kg	3 kg	4 kg	5 kg	6 kg
#4	548 mm	387 mm	316 mm	274 mm	245 mm	204 mm
#5	548 mm	387 mm	316 mm	274 mm	245 mm	204 mm
#6	300 mm	224 mm	183 mm	158 mm	141 mm	119mm

When calculating the critical dimension of the load using the allowable moment and inertia moment, the calculated value represents a distance from the Arm #5 rotation center, not the distance from the flange. To calculate the distance from the flange to the load's center of gravity, subtract the distance from the center of the Arm #5 rotation center to the flange (=80 mm) as shown in the example below.

Example: Calculation of the critical dimension of the load (a) when the load is 6 kg.

Center of gravity by the allowable moment control:

$$12.0 \text{ Nm} / (6 \text{ kg} \times 9.8 \text{ m/s}^2) = 0.204 \text{ m} = 204 \text{ mm}$$

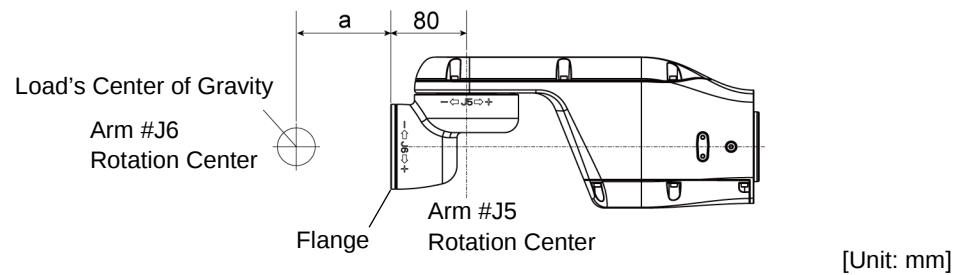
Center of gravity by the allowable inertia moment control:

$$(0.3 \text{ kgm}^2 / 6 \text{ kg})^{1/2} = 0.223 \text{ m} = 223 \text{ mm}$$

Due to the allowable moment control, center of gravity for the load limit is 212 mm from the Arm #5 rotation center.

$$\begin{aligned} \text{Distance (a) from the flange to the center of gravity for the load limit} \\ = 204 \text{ mm} - 80 \text{ mm} = 124 \text{ mm} \end{aligned}$$

Critical Dimension of Load



4.3.1 Weight Setting



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

The VT series Manipulators can operate without limitations on the condition unless and until the load exceeds this maximum payload. Always set the Weight parameters of the WEIGHT command according to the load. Setting a value that is smaller than the actual load may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.

The acceptable weight capacity (end effector and work piece) for VT series Manipulators is as follows:

Rated	Maximum
3 kg	6 kg

Change the setting of the Weight parameter according to the load.

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

Setting method of Weight parameters

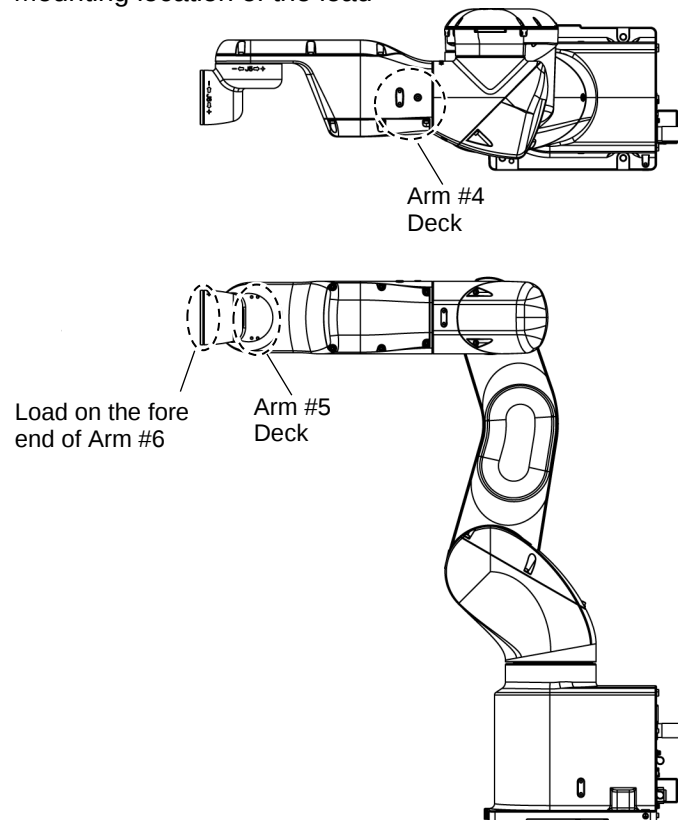


Select [Tools]-[Robot Manager]-[Weight] panel and set the value in [Weight:].

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

Load on the Manipulator

Mounting location of the load



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

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

Weight Parameter Formula

Weight parameter = $M_w + W_a + W_b$

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

W_a : Equivalent weight of the Arm #4 deck (kg)

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

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

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

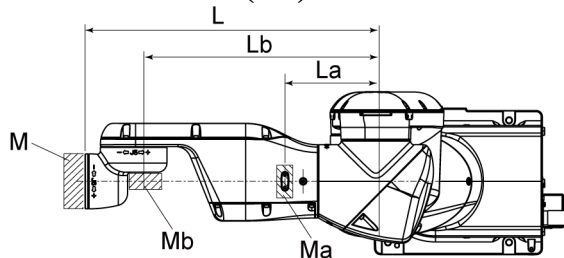
M_a : Weight of the air valve on the Arm #4 deck

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

L : Length of the upper arm (480 mm)

L_a : Distance between the Joint #3 and the center of gravity of the air valve on the Arm #4 deck (mm)

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



<Example> The fore end of the Arm #6 is 480mm (L) away from the Joint #3 of VT6-A901S* (VT6L).

Load on the fore-end of Arm #6 is 5 kg (M_w).

Load on the Arm #4 deck is 1.5 kg (M_a).

The deck is 150 mm (L_a) away from Joint #3.

Load on the Arm #5 deck is 1.0 kg (M_b).

The deck is 390 mm (L_b) away from the Joint #3.

$$W_a = 1.5 \times 150^2 / 480^2 = 0.15 \rightarrow 0.2 \text{ (round up)}$$

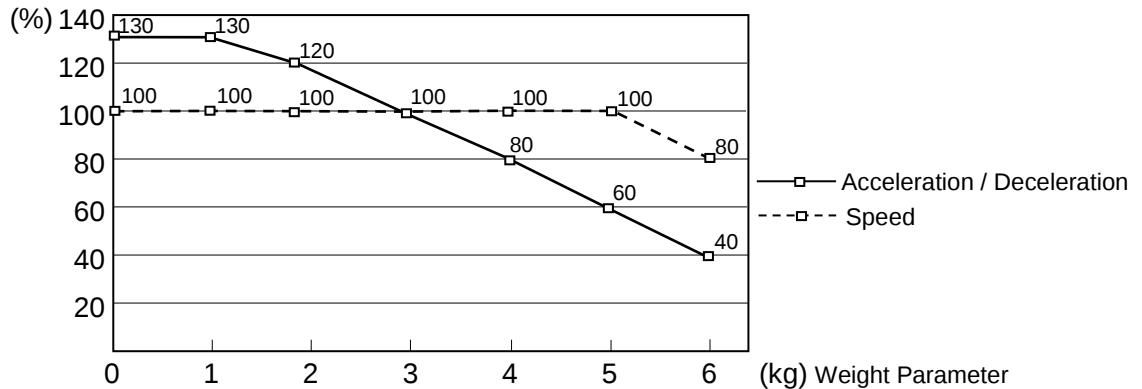
$$W_b = 1.0 \times 390^2 / 480^2 = 0.66 \rightarrow 0.7 \text{ (round up)}$$

$$M_w + W_a + W_b = 5 + 0.2 + 0.7 = 5.9$$

Enter "5.9" for the Weight parameter.

Automatic speed setting by Weight

The percentages in the graphs are based on the speed at rated weight (3 kg) as 100%.



Weight parameter (kg)	Acceleration / Deceleration	Speed
0	130	100
1	130	100
2	120	100
3	100	100
4	80	100
5	60	100
6	40	80

4.3.2 INERTIA Setting

Moment of Inertia and the INERTIA Setting

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



CAUTION

- The moment of inertia of the load (weight of the end effector and work piece) must be $0.1 \text{ kg}\cdot\text{m}^2$ or less. The VT series Manipulators are not designed to work with a moment of inertia exceeding $0.1 \text{ kg}\cdot\text{m}^2$. Always set the Weight parameters according to the load. Setting a value that is smaller than the actual load may cause errors, excessive shock and insufficient function of the Manipulator. Also, the life cycle of parts is shortened and positional gap due to belt tooth bumping occurs.

The acceptable inertia moment of load for VT series Manipulators is $0.01 \text{ kg}\cdot\text{m}^2$ nominal rating and $0.1 \text{ kg}\cdot\text{m}^2$ maximum. Change the setting of the inertia moment according to the inertia moment of the load using the INERTIA command. After the setting has been changed, the maximum acceleration/deceleration speed of Arm #6 responding to “inertia moment” is set automatically.

Inertia moment of load on Arm #6

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

EPSON
RC+

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

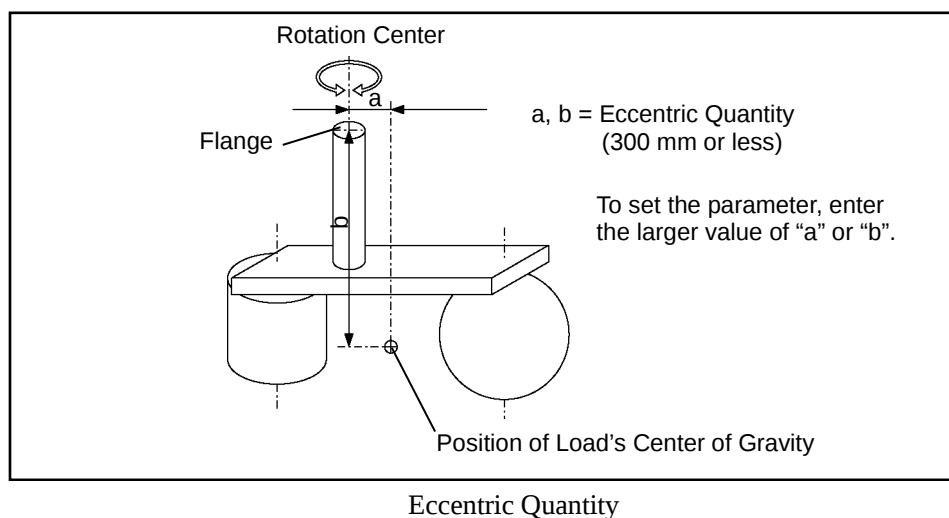
Eccentric Quantity and the INERTIA Setting



- The eccentric quantity of the load (weight of the end effector and work piece) must be 300 mm or less. The VT series Manipulators are not designed to work with eccentric quantity exceeding 300 mm. Always set the eccentric quantity parameter according to the eccentric quantity. Setting a value that is smaller than the actual eccentric quantity may cause errors, excessive shock, insufficient function of the Manipulator, and/or shorten the life cycle of parts/mechanisms.

The acceptable eccentric quantity of the load for VT series Manipulators is 50 mm at nominal rating and 300 mm at maximum.

When the eccentric quantity of the load exceeds the rating, change the setting of eccentric quantity parameter using the INERTIA command. After changing the setting, the maximum acceleration/deceleration speed of Manipulator corresponding to “eccentric quantity” is set automatically.



Eccentric Quantity

Eccentric quantity of load on Arm #6

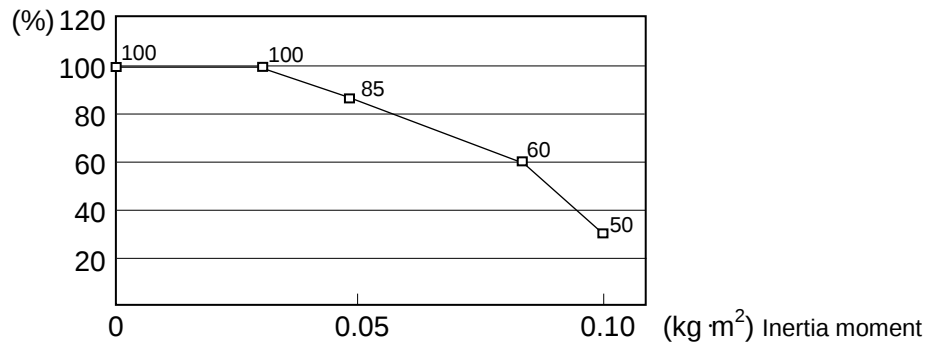
The eccentric quantity of the load (weight of the end effector and work piece) on the Arm #6 can be set by the “eccentric quantity” parameter of the INERTIA command.
Enter the larger value of either “a” or “b” in the figure above to [Eccentricity].

EPSON
RC+

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

Automatic acceleration/deceleration setting by INERTIA (eccentric quantity)

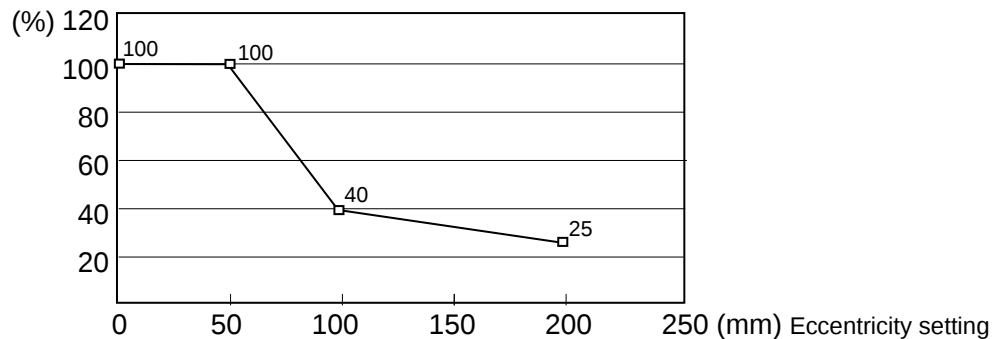
The percentage in the graph is based on the acceleration/ deceleration at rated eccentricity ($0.03 \text{ kg}\cdot\text{m}^2$) as 100%.



Moment of inertia setting ($\text{kg}\cdot\text{m}^2$)	Automatic acceleration/deceleration setting by Inertia (moment of inertia) (%)
0	100
0.03	100
0.05	85
0.08	60
0.1	50

Automatic setting by eccentricity setting

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

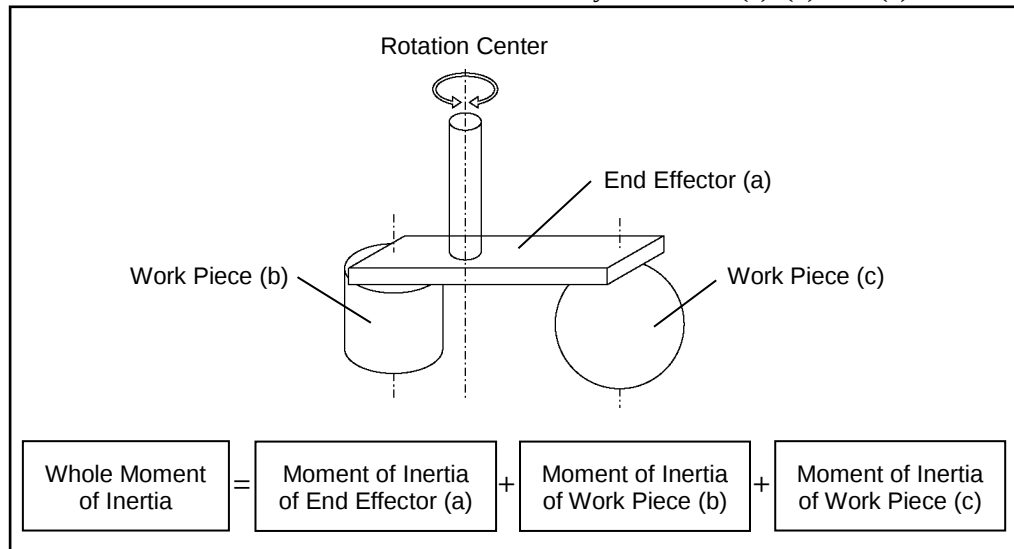


Eccentric quantity parameter (mm)	Automatic acceleration/deceleration setting by Inertia (eccentric quantity) (%)
0	100
50	100
100	40
200	25

Calculating the Inertia Moment

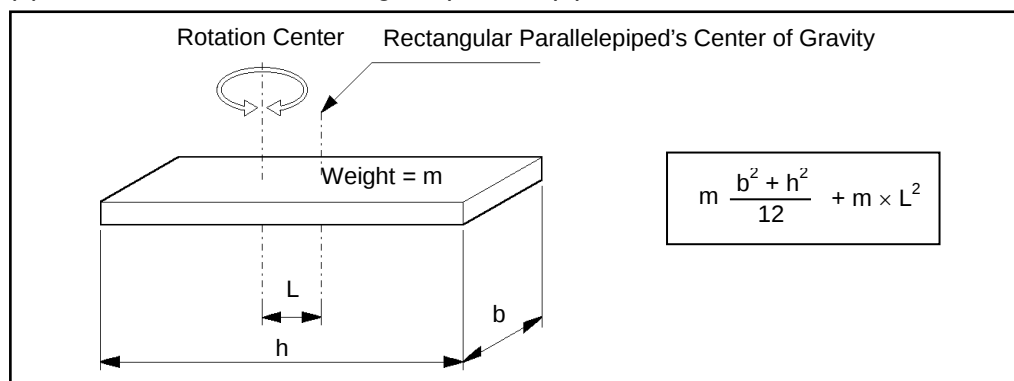
Refer to the following example formulas to calculate the inertia moment of the load (end effector with work piece).

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

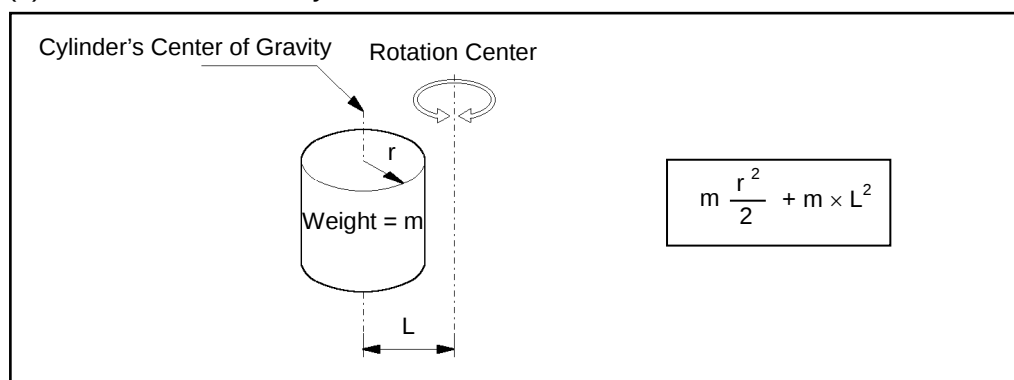


The methods for calculating the inertia moment for (a), (b), and (c) are shown in this and the next page. Figure out the whole inertia moment using the basic formulas below.

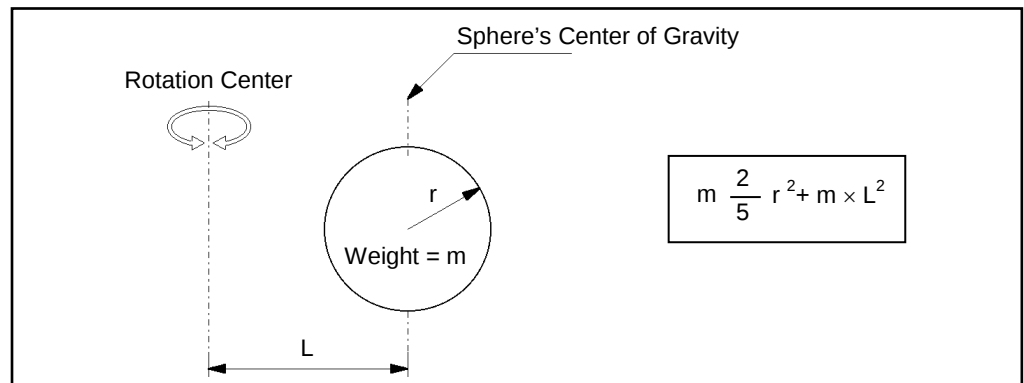
(a) Inertia moment of a rectangular parallelepiped



(b) Inertia moment of a cylinder



(c) Inertia moment of a sphere



4.4 Precautions for Auto Acceleration/Deceleration of Joint #3

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

WEIGHT Setting

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

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

INERTIA Setting

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

Auto Acceleration/Deceleration According to Manipulator's Posture

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

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

5. Motion Range



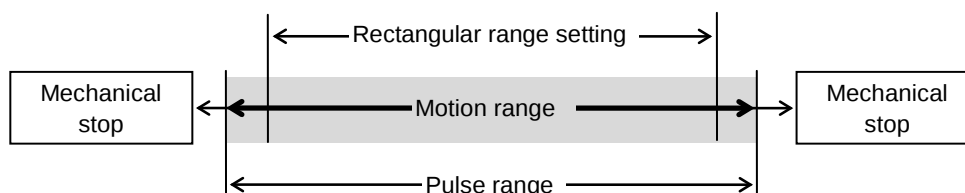
CAUTION

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

The motion range is preset at the factory as explained in *Setup & Operation: 5.4 Standard Motion Range*. That is the maximum motion range of the Manipulator.

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

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



When the motion range is changed due to layout efficiency or safety, follow the descriptions in 5.1 to 5.3 to set the range.

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

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

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

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



The Arm #4 and #6 do not have a mechanical stop.



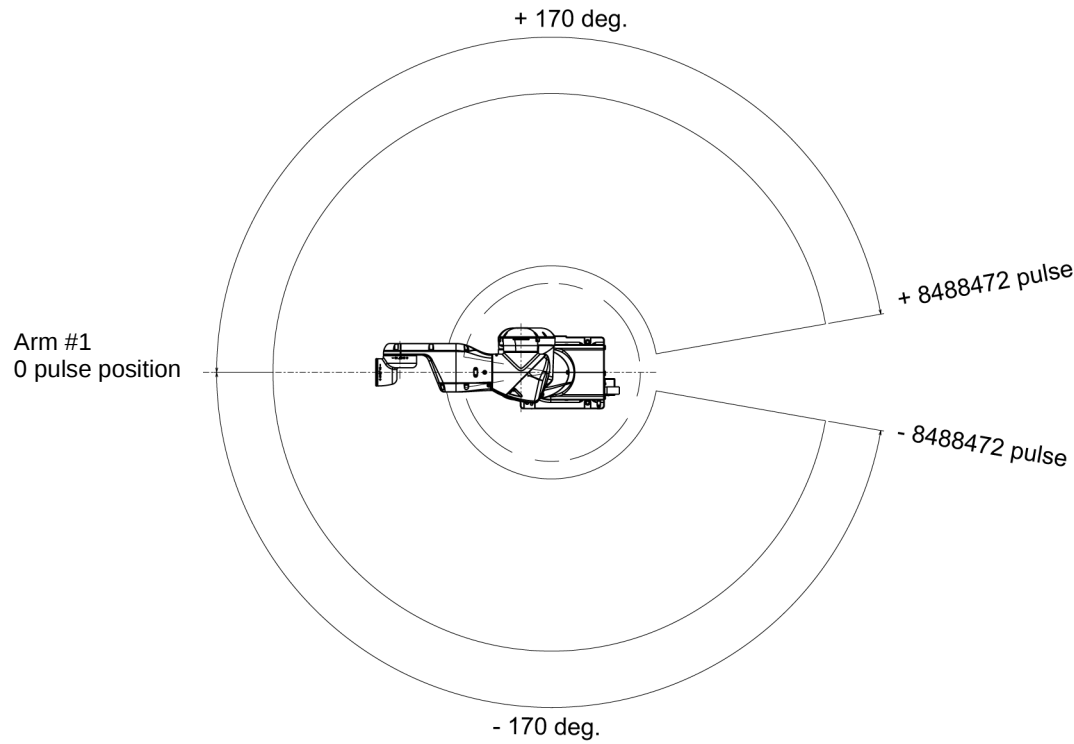
Once the Manipulator receives an operating command, it checks whether the target position specified by the command is within the pulse range before operating. If the target position is out of the set pulse range, an error occurs and the Manipulator does not move.



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

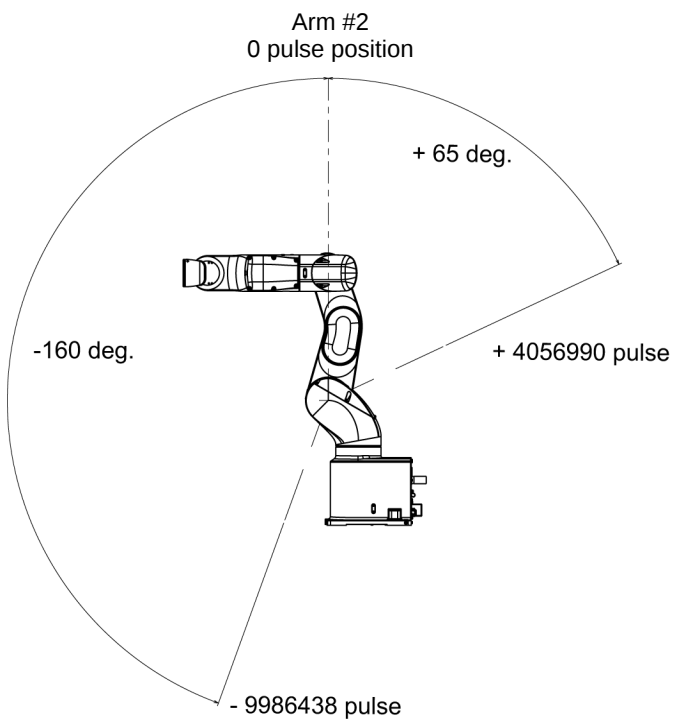
5.1.1 Max. Pulse Range of Joint #1

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



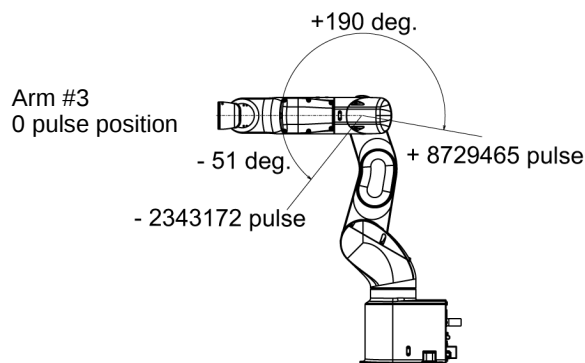
5.1.2 Max. Pulse Range of Joint #2

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



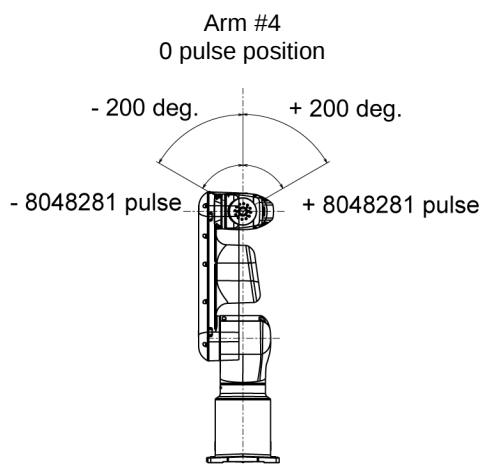
5.1.3 Max. Pulse Range of Joint #3

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



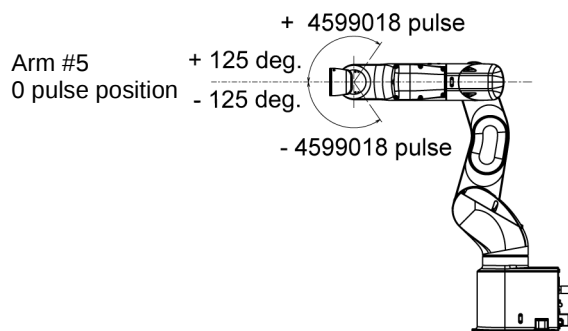
5.1.4 Max. Pulse Range of Joint #4

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



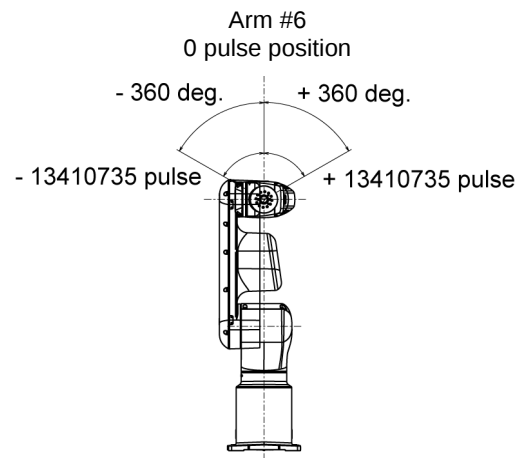
5.1.5 Max. Pulse Range of Joint #6

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



5.1.6 Max. Pulse Range of Joint #6

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



5.2 Motion Range Setting by Mechanical Stops

Using the adjustable mechanical stops (option) physically limits the absolute area that the Manipulator can move.

Be sure to turn OFF the Manipulator in advance.

Use bolts conforming to the specified length and surface processing (ex: nickel plating) with high corrosion resistance.

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

For details on the pulse range setting, refer to the the following section.

Setup & Operation 5.1 Motion Range Setting by Pulse Range (for All Arms).

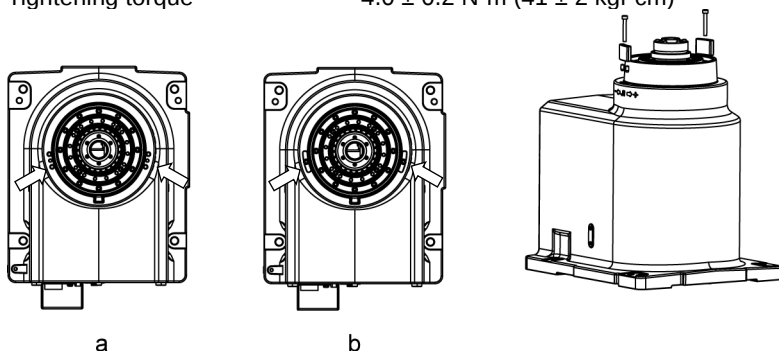
Be sure to set the pulse range not to exceed the setting angles of the mechanical stop.

5.2.1 Motion Range Setting of Joint #1

Install the adjustable mechanical stop (J1) to the threaded hole corresponding to the angle you want to set.)

Hexagon socket head cap bolt M4 × 28×1 bolt

Tightening torque $4.0 \pm 0.2 \text{ N}\cdot\text{m}$ ($41 \pm 2 \text{ kgf}\cdot\text{cm}$)

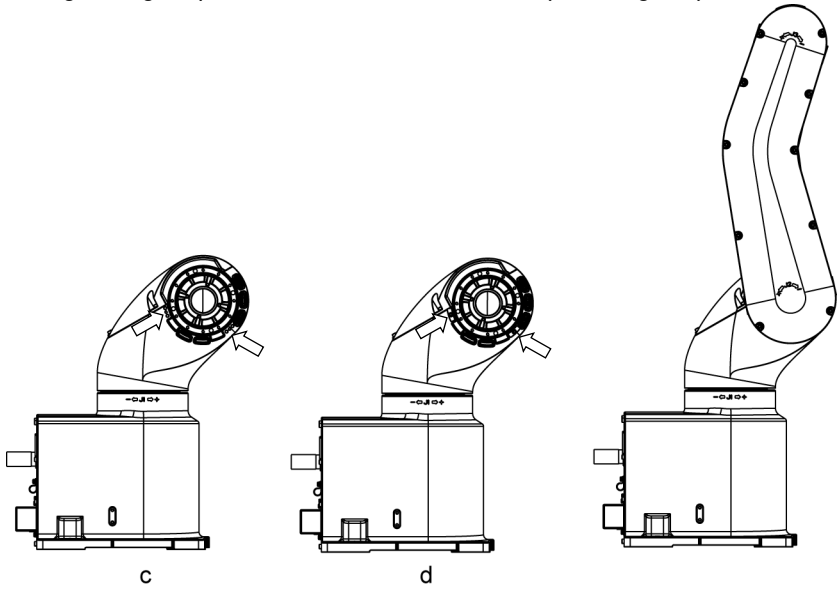


	a	b
Angle (deg)	± 170	-170 to $+84$ or -84 to $+170$
Pulse (pulse)	± 8488472	-8488472 to $+4194304$, or -194304 to $+8488472$
Adjustable mechanical stop (J1)	Not applied (standard)	Applied

5.2.2 Motion Range Setting of Joint #2

Install the adjustable mechanical stop (J2) to the threaded hole corresponding to the angle you want to set.)

Hexagon socket head cap bolt M4 × 16×1 bolt
Tightening torque 4.0 ± 0.2 N·m (41 ± 2 kgf·cm)



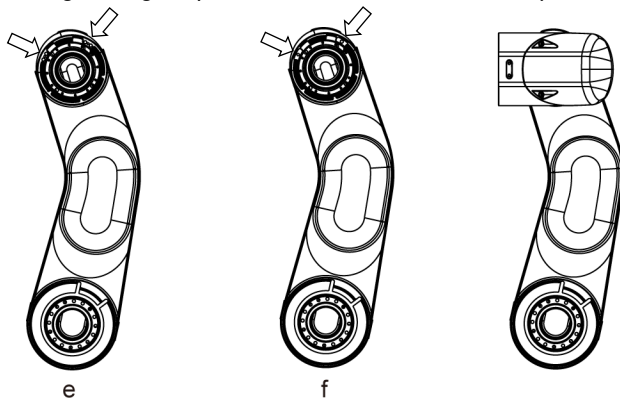
	c	d
Angle (deg)	-160, +65	-160 to +43, or -148 to +65
Pulse (pulse)	-9986438 +4056990	-9986438 to +2683855, or -9237455 to +4056990
Adjustable mechanical stop (J2)	Not applied (standard)	Applied

5.2.3 Motion Range Setting of Joint #3

Install the adjustable mechanical stop (J3) to the threaded hole corresponding to the angle you want to set.)

Hexagon socket head cap bolt M4 × 16×1 bolt

Tightening torque $4.0 \pm 0.2\text{N}\cdot\text{m}$ ($41 \pm 2\text{ kgf}\cdot\text{cm}$)



	e	f
Angle (deg)	-51, +190	-34 to +190, or -51 to +173
Pulse (pulse)	-2343172 +8729465	-1562115 to +8729465, or -2343172 to +7948407
Adjustable mechanical stop (J3)	Not applied (standard)	Applied

5.3 Restriction of Manipulator Operation by Joint Angle Combination

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

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

The restriction to Manipulator operation is enabled:

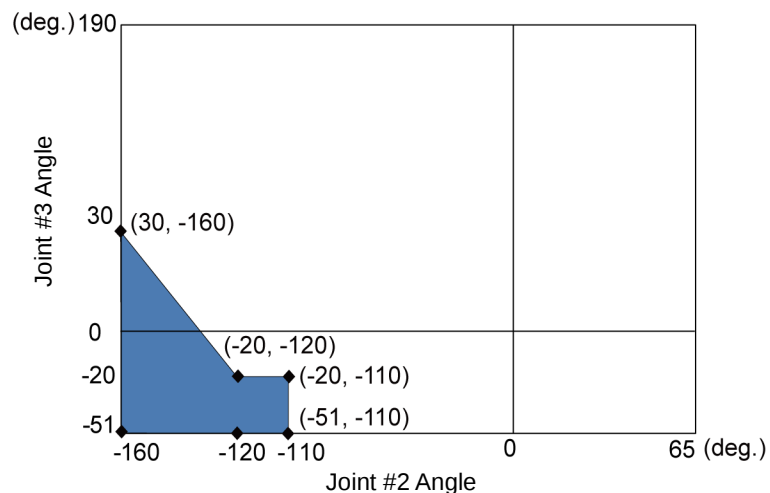
- During CP motion command execution
- When you attempt to execute the motion command for moving the Manipulator to a target point (or pose) in the specified motion range.

The restriction to the Manipulator operation is disabled:

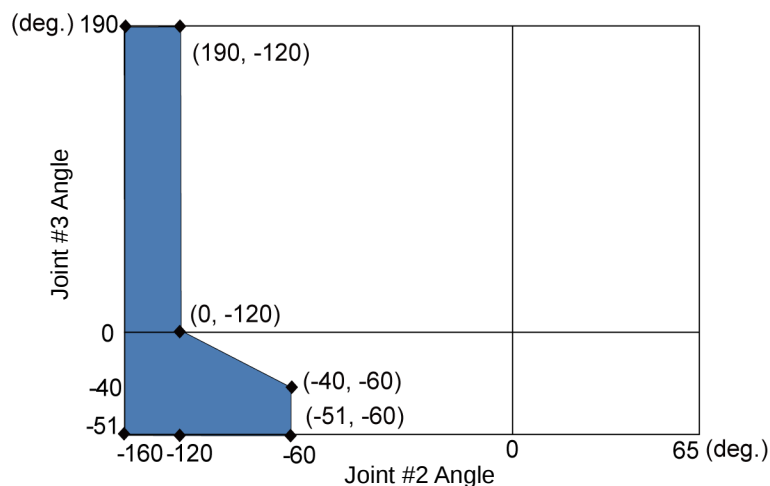
- The Arms of the Manipulator momentarily go through the specified motion range during the PTP motion command execution even though the joint angles of the Arms are in the colored area of the figures above.

Combination of Joint #2 and #3

J1: -110 deg ~ 110 deg



J1: -110 deg ~ -170 deg or 110 deg ~ 170 deg

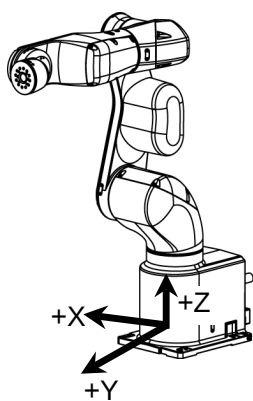


5.4 Coordinate System

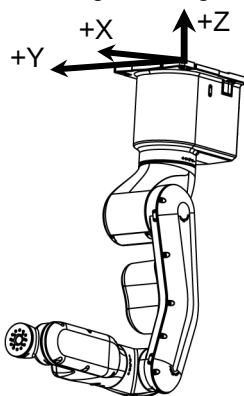
The origin point is where the Manipulator's installation face intersects with the rotation axis of Joint #1.

For details on the coordinate system, refer to the *EPSON RC+ User's Guide manual*.

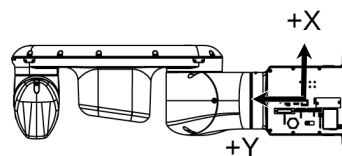
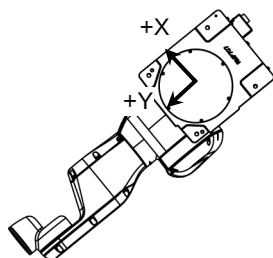
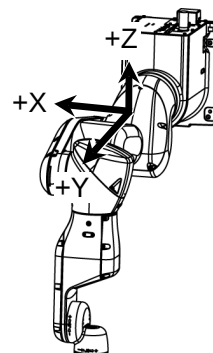
Table Top mounting



Ceiling mounting



Wall mounting



5.5 Changing the Robot

This section describes how to change the manipulator model on EPSON RC+.



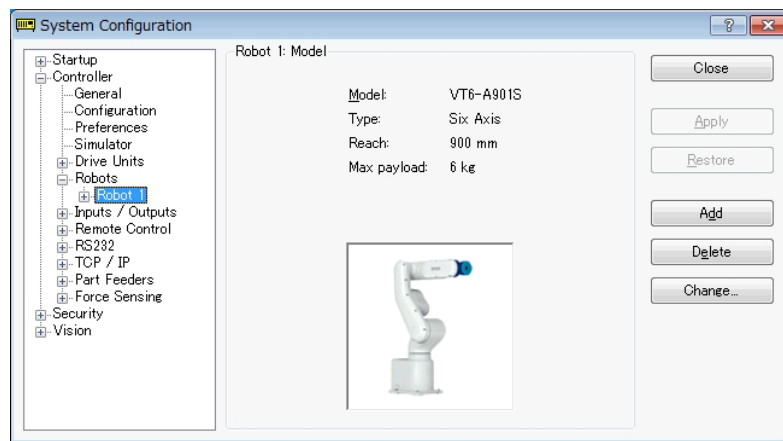
- Changing the manipulator should be done with great caution. It initializes the robot calibration parameters (Hofs, CalPIs), additional axis information, and PG parameter data.

Before changing the robot, make sure to save the calibration data by following the procedure below.

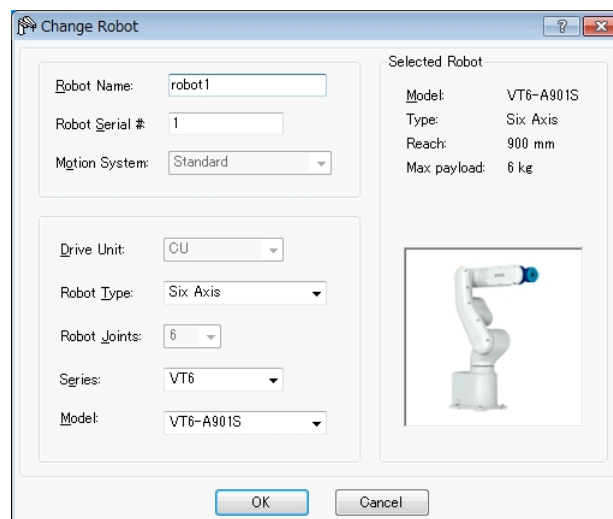
1. Select the EPSON RC+ 7.0 menu-[Setup]-[System Configuration].
2. Select [Robot]-[Robot**]-[Calibration] from the tree list. Then, click <Save>.

(1) Select the EPSON RC+ 7.0 menu-[Setup]-[System Configuration].

(2) Select [Robot]-[Robot**] from the tree list.



(3) Click the <Change...> button. The following dialog box will be displayed.



(4) Input the robot name and serial number printed on the name plate of the manipulator. Any serial number can be entered. However, enter the number printed on the manipulator.

(5) Select the robot type in the [Robot Type] box.

(6) Select the series name of the manipulator in the [Series] box.

- (7) Select the robot model in the [Model] box. Available robots will be displayed according to the format of the currently installed motor driver. When [Dry run] is used, all the manipulators of the series selected in Step 6 will be displayed.
- (8) Click the <OK> button. The controller will be restarted.

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

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

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

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

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



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

6. Operation Mode & LED

6.1 Overview

The Robot system has three operation modes.

- | | |
|------------|--|
| TEACH mode | This mode enables point data teaching and checking close to the Manipulator using the Teach Pendant.
In this mode the Manipulator operates in Low power status. |
| AUTO mode | This mode enables automatic operation (program execution) of the Robot system for the manufacturing operation, and also programming, debug, adjustment, and maintenance of the Robot system.
This mode cannot operate the Manipulators or run programs with the Safety Door open. |
| TEST mode | This mode enables program verification while the Enable Switch is held down and the safeguard is open.
This is a low speed program verification function (T1: manual deceleration mode) which is defined in Safety Standards.
This mode can operate the specified Function with multi-task / single-task, multi-manipulator / single-manipulator at low speed. |

6.2 Switch Operation Mode

Change the operation mode using the mode selector key switch on the Teach Pendant.

- | | |
|------------|--|
| TEACH mode | Turn the mode selector key switch to “Teach” for TEACH mode.
Switching to TEACH mode pauses the program if it was running.
The operating manipulator stops by Quick Pause. |
| AUTO mode | Turn the mode selector key switch to “Auto” and turn on the latch release input signal for AUTO mode. |
| TEST mode | Turn the mode selector key switch to “Teach” for “TEACH” mode.
Push <F1> key-[Test Mode] in [Jog & Teach] dialog of TEACH mode. The mode will be changed to TEST |

6.3 Program Mode (AUTO)

6.3.1 What is Program Mode (AUTO)?

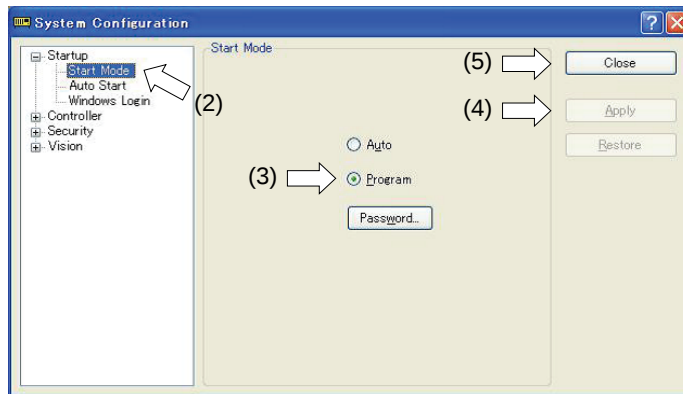
Program mode is for programming, debug, adjustment, and maintenance of the Robot system.

Follow the procedures below to switch to the Program mode.

6.3.2 Setup from EPSON RC+ 7.0

Switch the mode to Program mode from the EPSON RC+ 7.0.

- (1) Select EPSON RC+ 7.0 menu-[Setup]-[System Configuration] to display the [System Configuration] dialog.



- (2) Select [Startup].
- (3) Select [Start mode]-<Program> button.
- (4) Click the <Apply> button.
- (5) Click the <Close> button.

6.4 Auto Mode (AUTO)

6.4.1 What is Auto mode (AUTO)?

Auto mode (AUTO) is for automatic operation of the Robot system.

Procedures for switching to the Auto mode (AUTO) are the following.

A : Set the start mode of the EPSON RC+ 7.0 to “Auto” and start the EPSON RC+ 7.0.

(Refer to *Setup & Operation 6.3.2 Setup from EPSON RC+ 7.0.*)

B : Offline the EPSON RC+ 7.0.

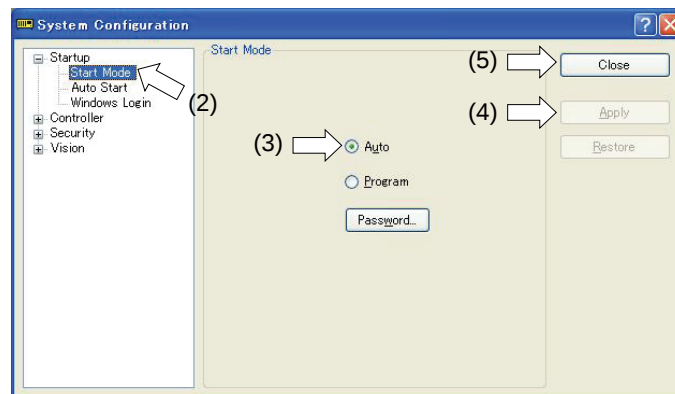


Execute and stop the program from the control device specified by the EPSON RC+ 7.0.
(Refer to *Setup & Operation 6.4.3 Setup Control Device.*)

6.4.2 Setup from EPSON RC+ 7.0

Switch the mode to Auto mode (AUTO) from the EPSON RC+ 7.0.

- (1) Select EPSON RC+ 7.0 menu-[Setup]-[System Configuration] to display the [System Configuration] dialog.

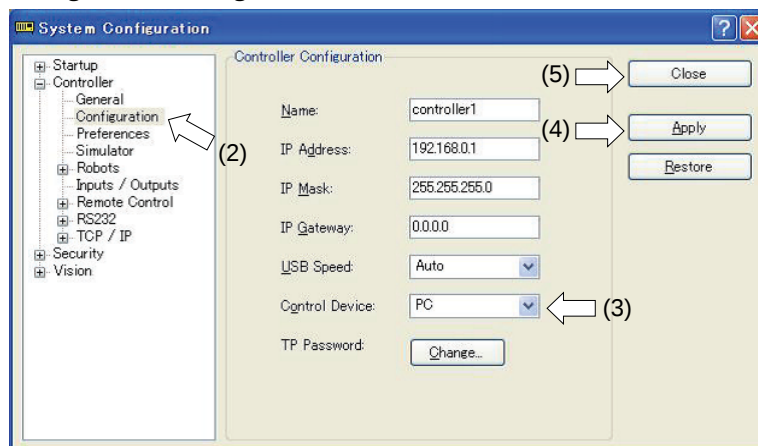


- (2) Select [Startup].
- (3) Select [Start Mode]-<Auto> button.
- (4) Click the <Apply> button.
- (5) Click the <Close> button.

6.4.3 Setup from Control Device

Set the control device from EPSON RC+ 7.0.

- (1) Select EPSON RC+ 7.0 menu-[Setup]-[System Configuration] to display the [System Configuration] dialog.

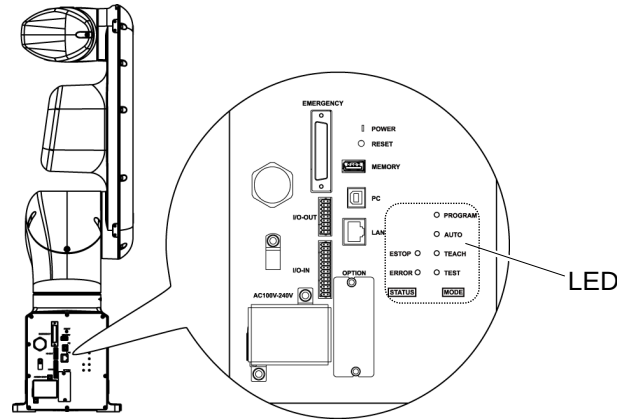


- (2) Select [Controller]-[Configuration].
- (3) Select [Control Device] to select the control device from the following two types.
 - PC
 - Remote (I/O)
- (4) Click the <Apply> button.
- (5) Click the <Close> button.

6.5 LED

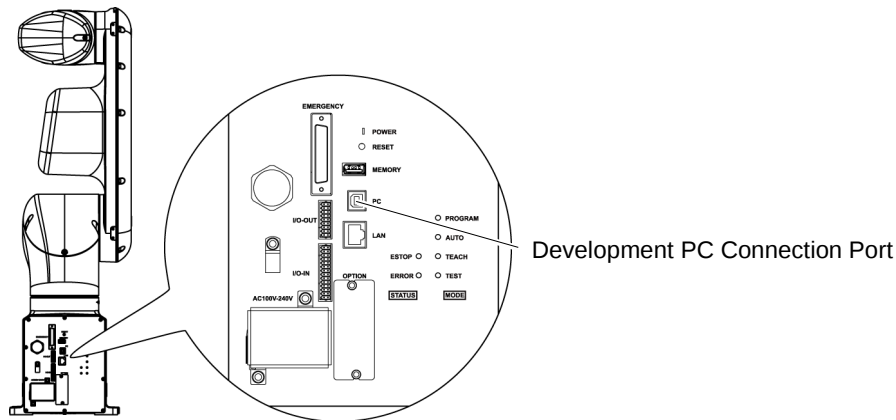
Six LEDs are located on the front panel of the Manipulator.

LEDs (ERROR, E-STOP, TEACH, TEST, AUTO, PROGRAM) turn ON according to the Controller status (error, Emergency Stop, TEACH mode, Auto mode, Program mode).



Controller status	LED display
Start up (Required time is different depending on the connection status of the device.)	1. TEST, TEACH, AUTO, and PROGRAM blink (for 15 seconds) 2. All turn OFF (10 seconds) 3. All turn ON (to 10 seconds) 4. All turn OFF (10-30 seconds) 5. Either of TEACH, AUTO, or PROGRAM turns ON
Execute Controller status storage function to the USB memory	TEACH, AUTO, PROGRAM blink.
Complete Controller status storage to USB memory	TEACH, AUTO, PROGRAM turn ON (for 2 seconds). ERROR turns OFF even if an error occurs.
Failure of Controller status storage to USB memory	ERROR, TEACH, AUTO, PROGRAM turn ON (for 2 seconds).
Error	ERROR turns ON
Warning	ERROR blinks.
Emergency Stop	E-STOP turns ON.
TEACH mode	TEACH blinks.
Auto mode (AUTO mode)	AUTO blinks.
Program mode (AUTO mode)	PROGRAM blinks.
AC power supply drop	TEACH, AUTO turn ON.
TEST mode	TEST blinks.

7. Development PC Connection Port



NOTE


- For other details of development PC and Manipulator connection, refer to the following manual.

EPSON RC+ 7.0 User's Guide

5.12.1 PC to Controller Communications Command.

- Be sure to install the EPSON RC+ 7.0 to the development PC first, then connect the development PC and Manipulator with the USB cable.

If Manipulator and the development PC are connected without installing the EPSON RC+ 7.0 to the development PC, [Add New Hardware Wizard] appears. If this wizard appears, click the <Cancel> button.

7.1 What is Development PC Connection Port

The development PC connection port supports the following USB types.

- USB2.0 HighSpeed/FullSpeed (Speed auto selection, or FullSpeed mode)
- USB1.1 FullSpeed

Interface Standard : USB specification Ver.2.0 compliant
 (USB Ver.1.1 upward compatible)

Connect the Manipulator and development PC by a USB cable to develop the robot system or set the Manipulator configuration with the EPSON RC+ 7.0 software installed in the development PC.

Development PC connection port supports hot plug feature. Cables insert and remove from the development PC and the Manipulator are available when the power is ON. However, stop occurs when USB cable is removed from the Manipulator or the development PC during connection.

7.2 Precaution

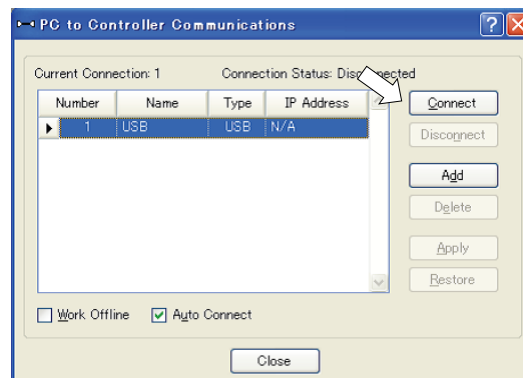
When connecting the development PC and the Manipulator, make sure of the following:

- Connect the development PC and the Manipulator with a 5 m or less USB cable.
Do not use the USB hub or extension cable.
- Make sure that no other devices except the development PC are used for development PC connection port.
- Use a PC and USB cable that supports USB2.0 HighSpeed mode to operate in USB2.0 HighSpeed mode.
- Do not pull or bend the cable strongly.
- Do not allow unnecessary strain on the cable.
- When the development PC and the Manipulator are connected, do not insert or remove other USB devices from the development PC. Connection with the Manipulator may be lost.

7.3 Software Setup and Connection Check

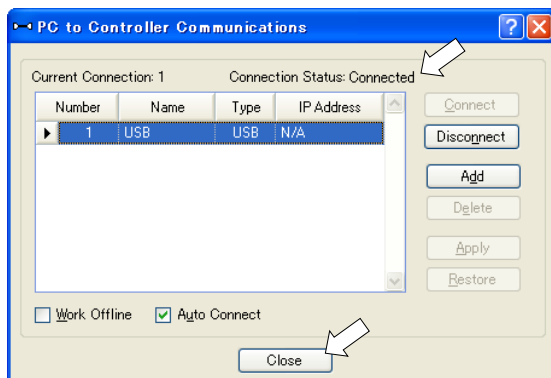
Connection of the development PC and the Manipulator is indicated.

- (1) Make sure that software EPSON RC+ 7.0 is installed to the Manipulator connected to the development PC.
(Install the software when it is not installed. Refer to *Robot System Safety and Installation* or *EPSON RC+ 7.0 User's Guide*.)
- (2) Connect the development PC and the Manipulator using a USB cable.
- (3) Turn ON the Manipulator.
- (4) Start EPSON RC+ 7.0.
- (5) Select the EPSON RC+ 7.0 menu-[Setup]-[PC to Controller Communications] to display the [PC to Controller Communications] dialog.



- (6) Select "No.1 USB" and click the <Connect> button.

- (7) After the development PC and the Manipulator connection has completed, “Connected” is displayed at [Connection status]. Make sure that “Connected” is displayed and click the <Close> button to close the [PC to Controller Communications] dialog.



The connection between the development PC and the Manipulator is completed. Now the robot system can be used from EPSON RC+ 7.0.

7.4 Disconnection of Development PC and Manipulator

Disconnection of the development PC and the Manipulator communication.

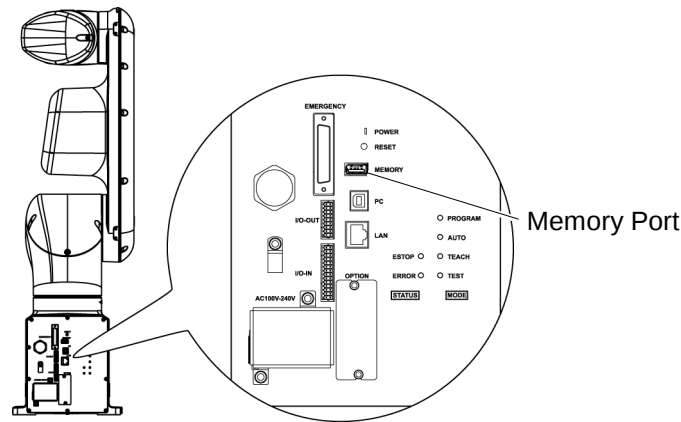
- (1) Select the EPSON RC+ 7.0 menu-[Setup]-[PC to Controller Communications] to display the [PC to Controller Communications] dialog.
- (2) Click the <Disconnect> button.
Communication between the Manipulator and the development PC is disconnected and the USB cable can be removed.



If the USB cable is removed when the Manipulator and the development PC are connected, the Manipulator will stop. Be sure to click the <Disconnect> button in the [PC to Controller Communications] dialog before USB cable is removed.

8. Memory Port

Connect a commercial USB memory to the Manipulator memory port to use the Controller status storage function to the USB memory.



8.1 What is Controller Status Storage Function?

This function saves various kinds of Manipulator data to the USB memory. Data saved in USB memory is loaded to EPSON RC+ 7.0 to get the status of the Manipulator and the program simply and accurately.

The saved data can also be used for restoring the Manipulator.

Unable to execute status storage to USB memory when operating the Manipulator.

8.2 Before Using Controller Status Storage Function

8.2.1 Precautions



CAUTION

- Controller status storage function is available at any time and in any Manipulator status after starting the Manipulator. However, operations from the console including stop and pause are not available while executing this function. Also, this function influences the Manipulator cycle time and the communication with EPSON RC+ 7.0. Other than only when it is necessary, do not execute this function when operating the Manipulator.

- Make sure that the USB port is used only for USB memory even though the port on the Controller is a universal USB port.
- Insert the USB memory directly into the Manipulator memory port. Connection with cables or hubs between the Manipulator and the USB memory is not assured.
- Make sure that the USB memory is inserted or removed slowly.
- Do not edit the saved files with an editor. Operation of the robot system after data restoration to the Manipulator is not assured.

8.2.2 Adoptable USB Memory

Use USB memory that meets following conditions.

- USB2.0 supported
- Without security function
USB memory with password input function cannot be used.
- No installation of a driver or software is necessary for Windows 7, Windows 8, or Windows 10, Linux.
(For supported operating systems for the EPSON RC+ 7.0, refer to *Setup & Operation 2.5 System Example.*)

8.3 Controller Status Storage Function

8.3.1 Controller Status Storage

 CAUTION	■ Controller status storage function is available at any time and in any Manipulator status after starting the Manipulator. However, operations from the console including stop and pause are not available while executing this function. Also, this function influences the Manipulator cycle time and the communication with EPSON RC+ 7.0. Other than only when it is necessary, do not execute this function when operating the Manipulator.
--	--

Use this procedure to save the status of the Manipulator to USB memory.

- (1) Insert the USB memory into the memory port.
When the data transfer starts, the LED of TEACH, AUTO, and PROGRAM starts blinking. Wait until the LED status changes.
(The data transfer time varies according to the data size such as of the projects.)
- (2) When the Manipulator status storage is completed successfully, the LED of TEACH, AUTO, and PROGRAM are turned ON for two seconds. Note that the LED of ERROR turns OFF even in the error status.
If it ends in failure, the LED of ERROR, TEACH, AUTO, and PROGRAM are turned ON for two seconds.
- (3) Remove the USB memory from the Manipulator.

NOTE

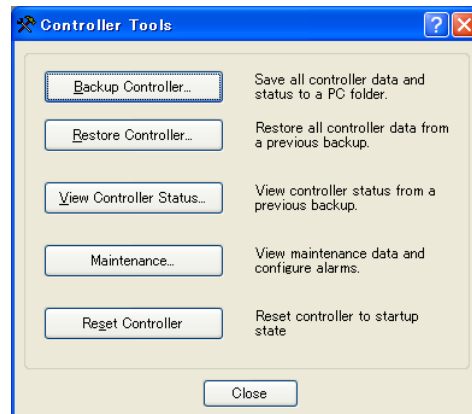


- USB memory with LED is recommended to check the status changes.
- When storage is executed during Motor ON status, it may fail to store the status. Use another USB memory or execute the storage during Motor OFF status.

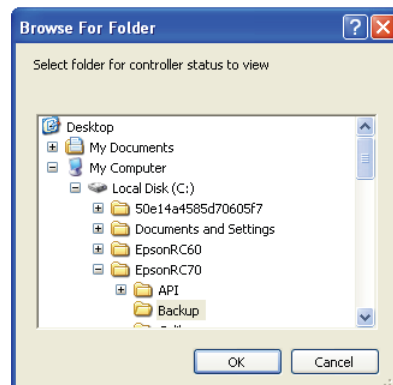
8.3.2 Load Data with EPSON RC+ 7.0

The following shows the procedure to load the data stored in the USB memory by EPSON RC+ 7.0 and display the Controller status.

- (1) Insert the USB memory into the PC with EPSON RC+ 7.0.
- (2) Make sure that the following folder is indicated in the USB memory.
B_VT_serial number_data status was saved
→ Example: B_VT_12345_2013-10-29_092951
- (3) Copy the folder confirmed in procedure (2) to the “\EpsonRC70\Backup” folder.
- (4) Select the EPSON RC+ 7.0 menu-[Tools]-[Controller] to display the [Controller Tools] dialog.

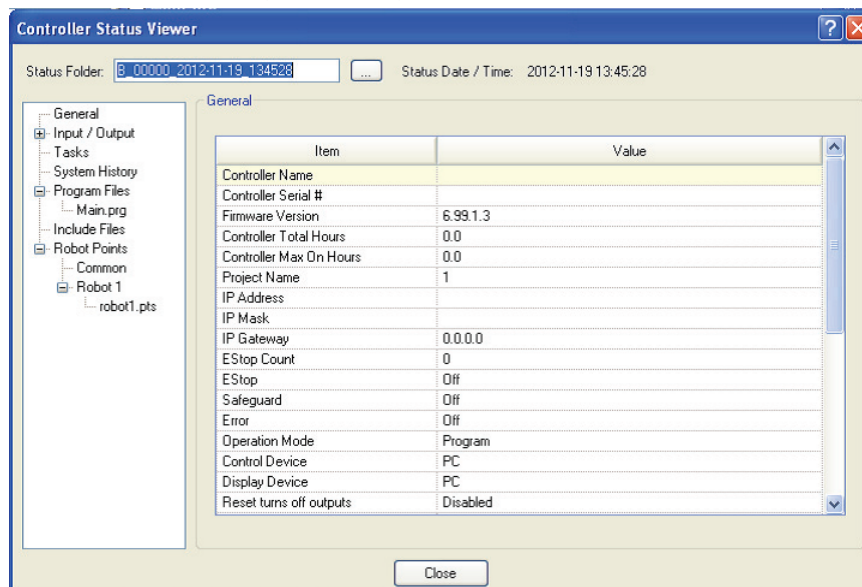


- (5) Click the <View Controller Status...> button.
- (6) [Browse For Folder] dialog appears. Select the folder copied in procedure (3) and click the <OK> button.



(7) [Controller Status Viewer] dialog appears to confirm the Controller status.

For details, refer to *View Controller Status* in *EPSON RC+ 7.0 User's Guide 5.11.8 Controller Command (Tools Menu)*.



8.3.3 Transfer with E-mail

Follow this procedure to transfer the data by e-mail that was saved to the USB memory.

- (1) Insert the USB memory to a PC that supports sending of e-mail.
- (2) Make sure that the USB memory has following folders.

B_VT_serial number_data status was saved

→ Example: B_VT_12345_2013-10-29_092951

- (3) Send all the folders by e-mail.

NOTE



Delete files that do not relate to the project before transfer.

This function is used to send the data to the system director and EPSON from the end users for problem analysis.

8.4 Details of Data

The following data files are created by the Controller status storage function.

File Name	Outline	
Backup.txt	Information file for restore	File with information for Manipulator restore.
CurrentMnp01.PRM	Robot parameter	Saves information such as ToolSet.
CurrentStatus.txt	Save status	Saves program and I/O status.
ErrorHistory.csv	Error history	
InitFileSrc.txt	Initial setting	Saves various settings of the Controller.
MCSys01.MCD	Robot setting	Saves information of connected Manipulator.
SrcmcStat.txt	Hardware information	Saves installation information of hardware.
ProjectName.obj	OBJ file	Result of project build. Prg file is not included.
GlobalPreserves.dat	Global Preserve variables	Saves values of Global Preserve variables.
WorkQueues.dat	WorkQue information	Saves information of Queues information of the WorkQue.
MCSRAM.bin MCSYSTEMIO.bin MCTABLE.bin MDATA.bin SERVOSRAM.bin VXDWORK.bin	Inner information of Manipulator	
All files related to project except ProjectName.obj *1	Project	When [Include project files when status exported] check box is checked in EPSON RC+ 7.0 menu-[Setup]-[System Configuration]-[Controller]-[Preference], the project file is stored. Includes program files.

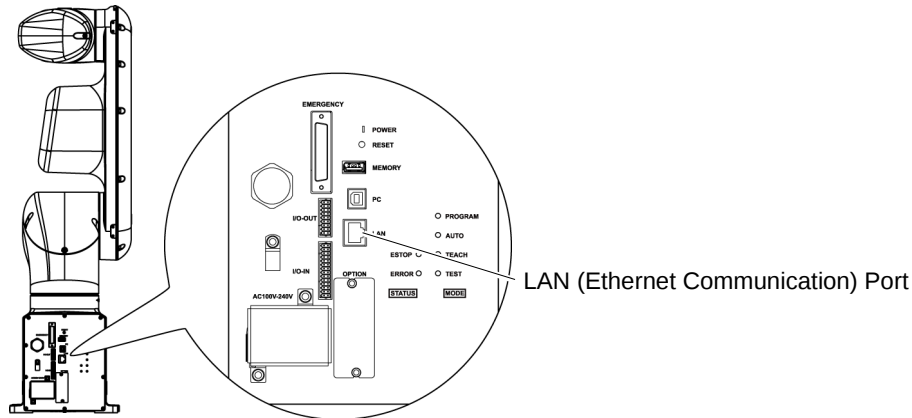
*1 Storage of “All files related to project except ProjectName.obj” can be specified by a setting.

9. LAN (Ethernet Communication) Port

NOTE



- Refer to *EPSON RC+ 7.0 User's Guide 5.12.1 [PC to Controller Communications] Command (Setup Menu)* for other details for the development PC and Manipulator connection.
- For Ethernet (TCP/IP) communication with robot application software, refer to *EPSON RC+ 7.0 Online Help* or *User's Guide 14. TCP/IP Communications*.



9.1 What is the LAN (Ethernet Communication) Port

Ethernet communication port supports 100BASE-TX / 10 BASE-T.

This port is used for two different purposes.

Connection with development PC

LAN (Ethernet communication) port is used for connection of the Manipulator and the development PC.

Equivalent operation is available to connect between the Manipulator and the development PC with the development PC connection port.

(Refer to *Setup & Operation 7. Development PC Connection Port*)

Connection with other Manipulator, Controller, or PC

The LAN (Ethernet communication) port can be used as an Ethernet (TCP/IP) communication port to communicate between multiple controllers from robot application software.

9.2 IP Address

Set the proper IP address or subnet mask depending on the Manipulator and development PC configuration to use the LAN port.

Do not input a random value for the IP address of the network configured TCP/IP. This is the only address that specifies the computer using an Internet connection.

The IP address is assigned from the company or organization that has control of IP address.

Use an address from the following Internet private environment such as P2P or line. Make sure that the address is not redundantly assigned inside the closed network.

Private Address List

10.0.0.1	to	10.255.255.254
172.16.0.1	to	172.31.255.254
192.168.0.1	to	192.168.255.254

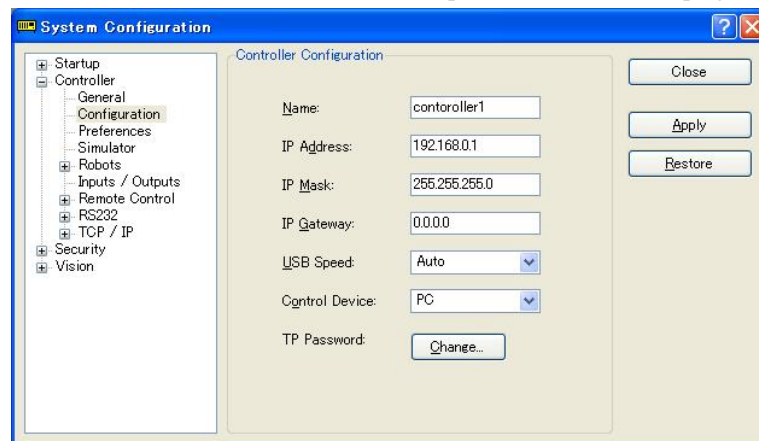
The following is the configuration of the controller Manipulator at delivery.

IP Address : 192.168.0.1
 IP Mask : 255.255.255.0
 IP Gateway : 0.0.0.0

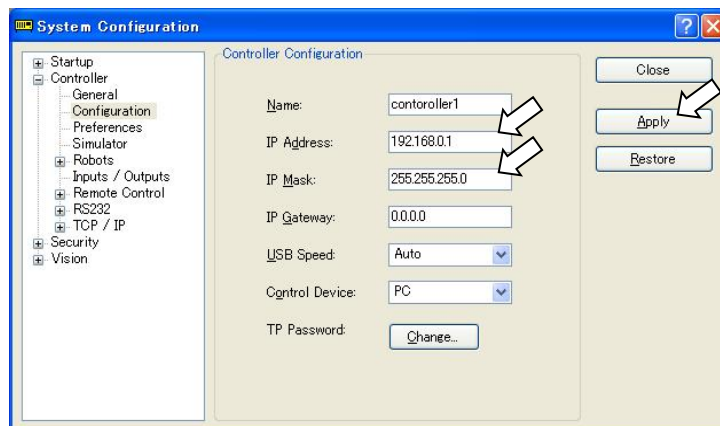
9.3 Changing Manipulator IP Address

In this section, the procedure to change the Manipulator IP address when connecting Manipulator development PC connection port and the development PC by the USB cable is indicated.

- (1) For connection between the development PC and the Manipulator.
 Refer to *Setup & Operation: 7. Development PC Connection Port*.
- (2) Select the EPSON RC+ 7.0 menu-[Setup]-[Controller] to display the following dialog.



- (3) Select [Controller]-[Configuration].



- (4) Enter the proper IP address and subnet mask and click the <Apply> button.
- (5) Click the <Close> button. The Manipulator reboots automatically.
 IP address configuration is completed and the Manipulator reboot dialog disappears.

NOTE

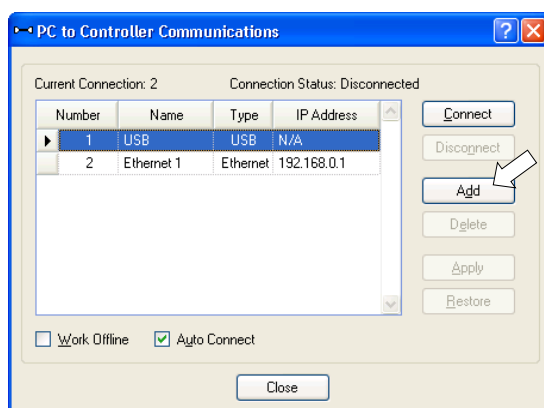


When the Manipulator and the development PC are connected via the Ethernet, the Manipulator IP address can also be changed. However, Manipulator and the development PC do not connect automatically after rebooting the Manipulator at Ethernet connection.

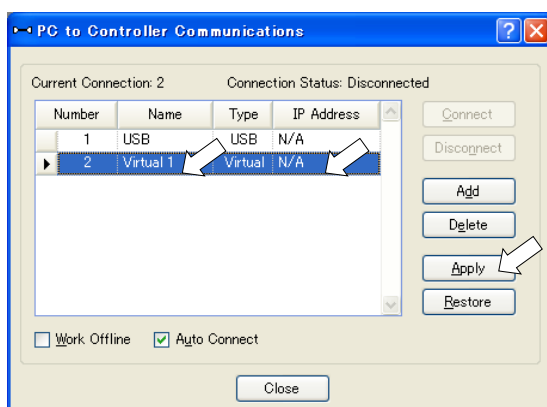
9.4 Connection of Development PC and Manipulator with Ethernet

Connection between the development PC and the Manipulator is shown below.

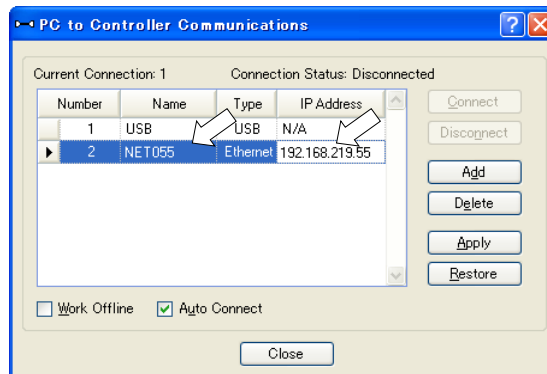
- (1) Connect the development PC and the Manipulator using the Ethernet cable.
- (2) Turn on the Manipulator.
- (3) Start EPSON RC+ 7.0.
- (4) Display the [PC to Controller Communication] dialog from [Setup] in EPSON RC+ 7.0 menu.
- (5) Click the <Add> button.



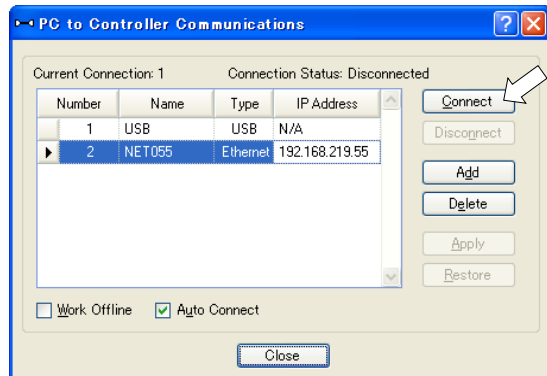
- (6) Connection "No.2" is added. Set the following and click the <Apply> button.
 Name : Valid value to identify the Manipulator to connect
 IP Address : IP address for Manipulator to connect



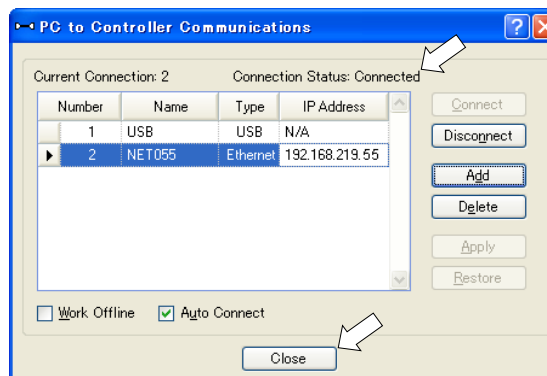
- (7) [Name] and [IP Address] specified in procedure (6) is displayed.



- (8) Make sure that “No.2” is selected, and click the <Connect> button.



- (9) After the development PC and Manipulator connection is completed, “Connected” is displayed in the [Connection status:]. Make sure that “Connected” is displayed and click the <Close> button to close the [PC to Controller Communications] dialog.



Connection between the development PC and the Manipulator is complete. Now the robot system can be used via an Ethernet connection from EPSON RC+ 7.0.

9.5 Disconnection of Development PC and Manipulator with Ethernet

Disconnection of the development PC and the Manipulator is shown below.

(1) Display [PC-Controller Connection] dialog from [Setup] in EPSON RC+ 7.0 menu.

(2) Click the <Disconnect> button.

Communication between the Manipulator and the development PC is disconnected and the Ethernet cable can be removed.

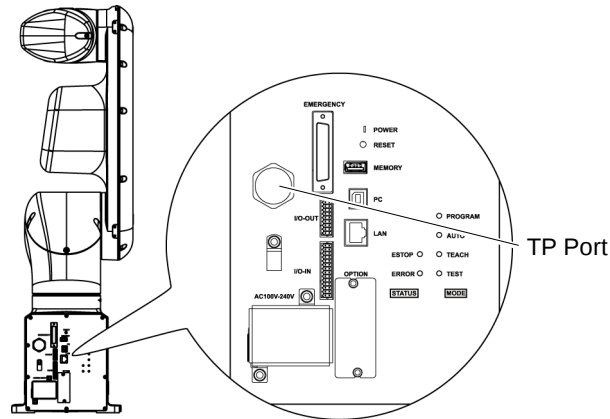
NOTE



If the Ethernet cable is removed when the Manipulator and the development PC is connected, Emergency Stop occurs and the Manipulator stops. Be sure to click the <Disconnect> button in the [PC to Controller Communications] dialog before the Ethernet cable is removed.

10. TP Port

10.1 What is the TP Port?



The TP port connects the Teach Pendant (TP2, TP3) to the manipulator.

Dedicated convert cable* is necessary if connecting TP2 to VT series manipulator. Contact to regional office if only convert cable is necessary.

* TP Exchange Cable: R12NZ900L6



When nothing is connected to the TP port, Emergency Stop status occurs in the Manipulator. When the Teach Pendant is not connected, connect the TP bypass plug.

Do not connect the devices except TP2, TP3 to the TP port. Connecting these devices may result in malfunction of the device since the pin assignments are different.

10.2 Teach Pendant Connection

A dedicated cable is attached to the Teach Pendant. Connect this cable connector to the TP port.

Communication is set automatically. Enable the Teach Pendant by one of the following procedures.

- Insert the Teach Pendant connector to the Manipulator and turn ON the Manipulator.
- Insert the Teach Pendant connector while the Manipulator is turned ON.



Teach Pendant connection and disconnection from the Controller are allowed when the Manipulator power is ON.

When the Teach Pendant connector is removed from the Manipulator with the mode selector key switch of the Teach Pendant in the “Teach” position, the operation mode will remain in the TEACH mode. The operation mode cannot be switched to AUTO mode. Be sure to remove the Teach Pendant after switching the operation mode to “Auto” mode.

For details, refer to the following manuals:

Robot Controller RC700/RC90 Option Teach Pendant TP2.

Robot Controller RC700-A Option Teach Pendant TP3.

11. Options

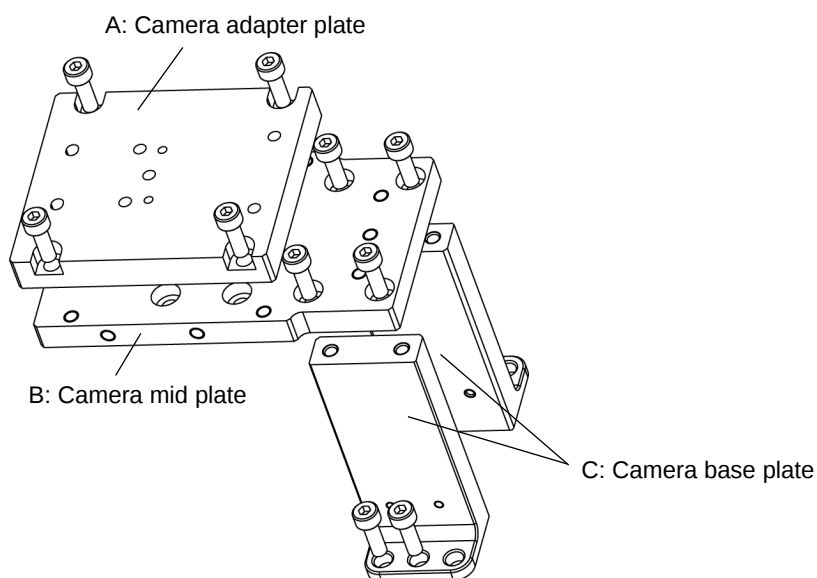
VT series Manipulator has the following options.

- 11.1 Camera Plate Unit
- 11.2 Tool Adapter (ISO flange)
- 11.3 Adjustable Mechanical Stops
- 11.4 External Wiring Kit

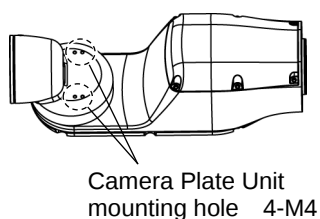
11.1 Camera Plate Unit

To mount a camera to the VT series manipulator, the camera plate unit is required.

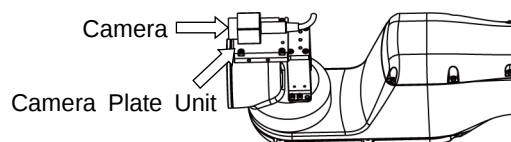
	Parts included	Qty.
A	Camera adapter plate	1
B	Camera mid plate	1
C	Camera base plate	1
D	Hexagon socket head screws M4×12	12



Installation



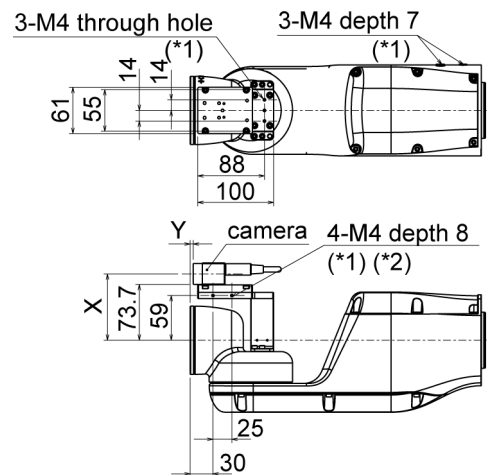
Appearance of arm end with camera



For the installation steps, refer to the following manual:

EPSON RC+ Option Vision Guide 7.0 Hardware & Setup

Dimensions after installing the Camera Plate Unit



*1: Available for fixing the cables

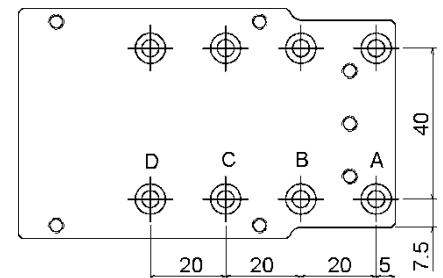
*2: Includes the opposite side

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

Camera mid plate

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

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



Camera and VT series Manipulator Joint #5 motion range (reference values)

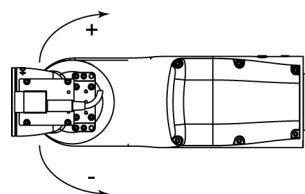
The Joint #5 motion range varies depending on the mounting position of camera mid plate and the camera you are using.

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

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

	A	B	C	D	X
USB camera, GigE camera	-135 deg ~ +70 deg	-135 deg ~ +60 deg	-135 deg ~ +45 deg	-135 deg ~ +35 deg	95.5 mm
	A	B	C	D	
Y	50 mm	30 mm	10 mm	-10 mm	

Direction of the Joint #5 motion

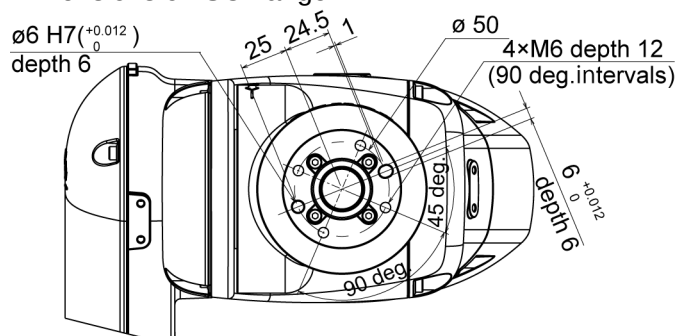


11.2 Tool Adapter (ISO flange)

Using the tool adapter, you can mount the end effector whose dimensions are designed for the ISO flange to the VT series Manipulators. For more details on the installation procedures, please contact the supplier of your region.

Parts included	Qty.
ISO flange	1
Pin	2
Hexagon socket head screw with low head M5×15	4

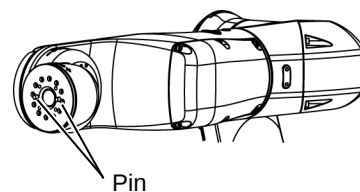
Dimensions of ISO flange



To mount the ISO flange

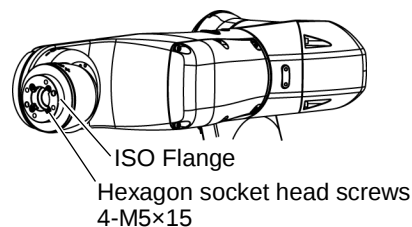
- (1) Press-fit the pin to the Arm #6 end flange.

Pin projection : 4 mm from the flange



- (2) Align the pin and the pin hole on the ISO flange, and then mount the ISO flange.

Hexagon socket head screw: 4-M5×15



11.3 Adjustable Mechanical Stops

This option is used to mechanically limit the motion range of the Manipulator.

For installation and angle restriction measures, refer to *Setup & Operation 5.2 Motion Range Setting by Mechanical Stops*.

Adjustable mechanical stop (J1)

Parts included	Qty.
Adjustable mechanical stop (J1)	1
Hexagon socket head screw M4×28	1
Pin	2

Adjustable mechanical stop (J2)

Parts included	Qty.
Adjustable mechanical stop (J2)	1
Hexagon socket head screw M4×16	1
Pin	2

Adjustable mechanical stop (J3)

Parts included	Qty.
Adjustable mechanical stop (J3)	1
Hexagon socket head screw M4×16	1
Pin	2

11.4 External Wiring Kit

Using the external wiring kit, you can fix the wirings and air tubes for the hand along with the Manipulator.

For more details, please contact the distributor of your region.

Parts included		Qty.
Cable fixing plate	for base	1
	for Joint #2	1
	for Joint #3 1	1
	for Joint #3 2	1
	for Joint #5	1
Insulation lock tie		5
Cable protection sheet		5
Hexagon socket head cap bolts M4×10		16

12. EMERGENCY

NOTE



The details of safety requirements for this section are described in *EPSON RC+ 7.0 User's Guide 2. Safety*. Please refer to them to keep the robot system safe.

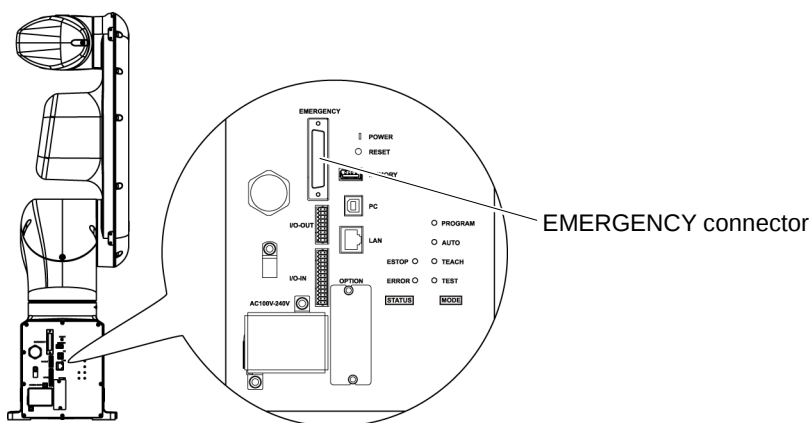


WARNING

- Make sure that emergency stop or safeguard operate properly before operating, not only booting but also usage changed such as options added or parts replaced as maintenance.
- Before connecting the connector, make sure that the pins are not bent. Connecting with the pins bent may damage the connector and result in malfunction of the robot system.

Connect a safeguard switch or Emergency Stop switch to the EMERGENCY connector for safety.

When nothing is connected to the EMERGENCY connector, the robot system does not operate normally.



12.1 Safeguard Switch and Latch Release Switch

The EMERGENCY connector has input terminals for the Safeguard switch and the Emergency Stop switch. Be sure to use these input terminals to keep the system safe.

Connector	Standard
EMERGENCY connector (Manipulator side)	D-Sub 25 pin female (cable side) D-Sub 25 pin male (board side)

* The E-STOP BOX, EMERGENCY connector cable, terminal block, and EMERGENCY connector kit are offered as options.

12.1.1 Safeguard Switch



- The interlock of the Safeguard must be functioning when the robot system is operated. Do not operate the system under the condition that the switch cannot be turned ON/OFF (e.g. The tape is put around the switch.). Operating the robot system when the switch is not functioning properly is extremely hazardous and may cause serious safety problems as the Safeguard input cannot fulfill its intended function.

In order to maintain a safe working zone, a safeguard must be erected around the Manipulator. The safeguard must have an interlock switch at the entrance to the working zone. The Safeguard that is described in this manual is one of the safeguards and an interlock of the Safeguard is called a Safeguard switch. Connect the Safeguard switch to the Safeguard input terminal on the EMERGENCY connector.

The Safeguard switch has safety features such as temporary hold-up of the program or the operation-prohibited status that are activated whenever the Safeguard is opened.

Observe the following in designing the Safeguard switch and the Safeguard.

- For the Safeguard switch, select a switch that opens as the Safeguard opens, and not by the spring of the switch itself.
- The signal from the Safeguard (Safeguard input) is designed to input to two redundant signals. If the signals at the two inputs differ by two seconds or more, the system recognizes it to be a critical error. Therefore, make sure that the Safeguard switch has two separate redundant circuits and that each connects to the specified pins at the EMERGENCY connector on the Controller.
- Make sure to design the safeguard to prevent the door from closing accidentally.

12.1.2 Latch Release Switch

The controller software latches these conditions:

- The safeguard is open.
- The operation mode is set to "TEACH".

The EMERGENCY connector has an input terminal for a latch release switch that cancels the latched conditions.

Open : The latch release switch latches conditions that the safeguard is open or the operation mode is "TEACH".

Closed : The latch release switch releases the latched conditions.



When the latched TEACH mode is released while the safeguard is open, the status of Manipulator power is operation-prohibited because the safeguard is open at that time. To execute a Manipulator operation, close the safeguard again, and then close the latch release input.

12.1.3 Checking Latch Release Switch Operation

After connecting the safeguard switch and latch release switch to the EMERGENCY connector, be sure to check the switch operation for safety by following the procedures described below before operating the Manipulator.

- (1) Turn ON the Controller while the safeguard is open in order to boot the controller software.
- (2) Make sure that “Safety” is displayed on the main window status bar.
- (3) Close the safeguard, and turn ON the switch connecting to the latch release input. Make sure that the “Safety” is dimmed on the status bar.

The information that the safeguard is open can be latched by software based on the latch release input condition.

Open : The latch release switch latches the condition that the safeguard is open.
To cancel the condition, close the safeguard, and then close the safeguard latch release input.

Closed : The latch release switch does not latch the condition that the safeguard is open.



The latch release input also functions to acknowledge the change of to TEACH mode. In order to change the latched condition of TEACH mode, turn the mode selector key switch on the Teach Pendant to “Auto”. Then, close the latch release input.

12.2 Emergency Stop Switch Connection

12.2.1 Emergency Stop Switch

If it is desired to add an external Emergency Stop switch(es) in addition to the Emergency Stop on the Teach Pendant and Operator Panel, be sure to connect such Emergency Stop switch(es) to the Emergency Stop input terminal on the EMERGENCY connector.

The Emergency Stop switch connected must comply with the following and related safety standard (IEC60947-5-5, etc.):

- It must be a push button switch that is “normally closed”.
- A button that does not automatically return or resume.
- The button must be mushroom-shaped and red.
- The button must have a double contact that is “normally closed”.



The signal from the Emergency Stop switch is designed to use two redundant circuits. If the signals at the two circuits differ by two seconds or more, the system recognizes it as a critical error. Therefore, make sure that the Emergency Stop switch has double contacts and that each circuit connects to the specified pins on the EMERGENCY connector at the Controller. Refer to the *Setup & Operation 12.4 Circuit Diagrams*.

12.2.2 Checking Emergency Stop Switch Operation

Once the Emergency Stop switch is connected to the EMERGENCY connector, continue the following procedure to make sure that the switch functions properly. For the safety of the operator, the Manipulator must not be powered ON until the following test is completed.

- (1) Turn ON the Manipulator to boot the controller software while pressing the Emergency Stop switch.
- (2) Make sure that E-STOP LED of the Manipulator is lighting.
- (3) Make sure that “EStop” is displayed on the status bar on the main window.
- (4) Release the Emergency Stop Switch.
- (5) Execute the RESET command.
- (6) Make sure that E-STOP LED is turned OFF and that “EStop” is dimmed on the main window status bar.

12.2.3 Recovery from Emergency Stop

To recover from the emergency stop condition, follow the procedure of safety check as required by the system.

After safety check, the operations below are required to recover from the emergency stop condition.

- Release the Emergency Stop Switch
- Execute the RESET command

12.3 Pin Assignments

The EMERGENCY connector pin assignments are as follows: (D-Sub 25 pin male)

Pin No.	Signal	Function	Pin No.	Signal	Function
1	ESW11	Emergency Stop switch contact (1) ^{*3}	14	ESW21	Emergency Stop switch contact (2) ^{*3}
2	ESW12	Emergency Stop switch contact (1) ^{*3}	15	ESW22	Emergency Stop switch contact (2) ^{*3}
3	ESTOP1+	Emergency Stop circuit 1 (+) ^{*4}	16	ESTOP2+	Emergency Stop circuit 2 (+) ^{*4}
4	ESTOP1-	Emergency Stop circuit 1 (-) ^{*4}	17	ESTOP2-	Emergency Stop circuit 2 (-) ^{*4}
5	Not Used	^{*1}	18	SDLATCH1	Safeguard Latch Release
6	Not Used	^{*1}	19	SDLATCH2	Safeguard Latch Release
7	SD11	Safeguard input (1) ^{*2}	20	SD21	Safeguard input (2) ^{*2}
8	SD12	Safeguard input (1) ^{*2}	21	SD22	Safeguard input (2) ^{*2}
9	24V	+24V output	22	24V	+24V output
10	24V	+24V output	23	24V	+24V output
11	24VGND	+24V GND output	24	24VGND	+24V GND output
12	24VGND	+24V GND output	25	24VGND	+24V GND output
13	Not Used	^{*1}			

^{*1} Do not connect anything to these pins.

^{*2} A critical error occurs if the input values from the Safeguard 1 and Safeguard 2 are different for two or more seconds. They must be connected to the same switch with two sets of contacts.

^{*3} A critical error occurs if the input values from the Emergency Stop switch contact 1 and Emergency Stop switch contact 2 are different for two or more seconds. They must be connected the same switch with two sets of contacts.

^{*4} Do not apply reverse voltage to the Emergency Stop circuit.

Emergency Stop switch output rated load	+30 V 0.3 A or under	1-2, 14-15 pin
Emergency Stop rated input voltage range	+24 V $\pm 10\%$	3-4, 16-17 pin
Emergency Stop rated input current	37.5 mA $\pm 10\%$ /+24 V input	
Safeguard rated input voltage range	+24 V $\pm 10\%$	7-8, 20-21 pin
Safeguard rated input current	10 mA/+24 V input	
Latch Release rated input voltage range	+24 V $\pm 10\%$	18-19 pin
Latch Release rated input current	10 mA/+24 V input	



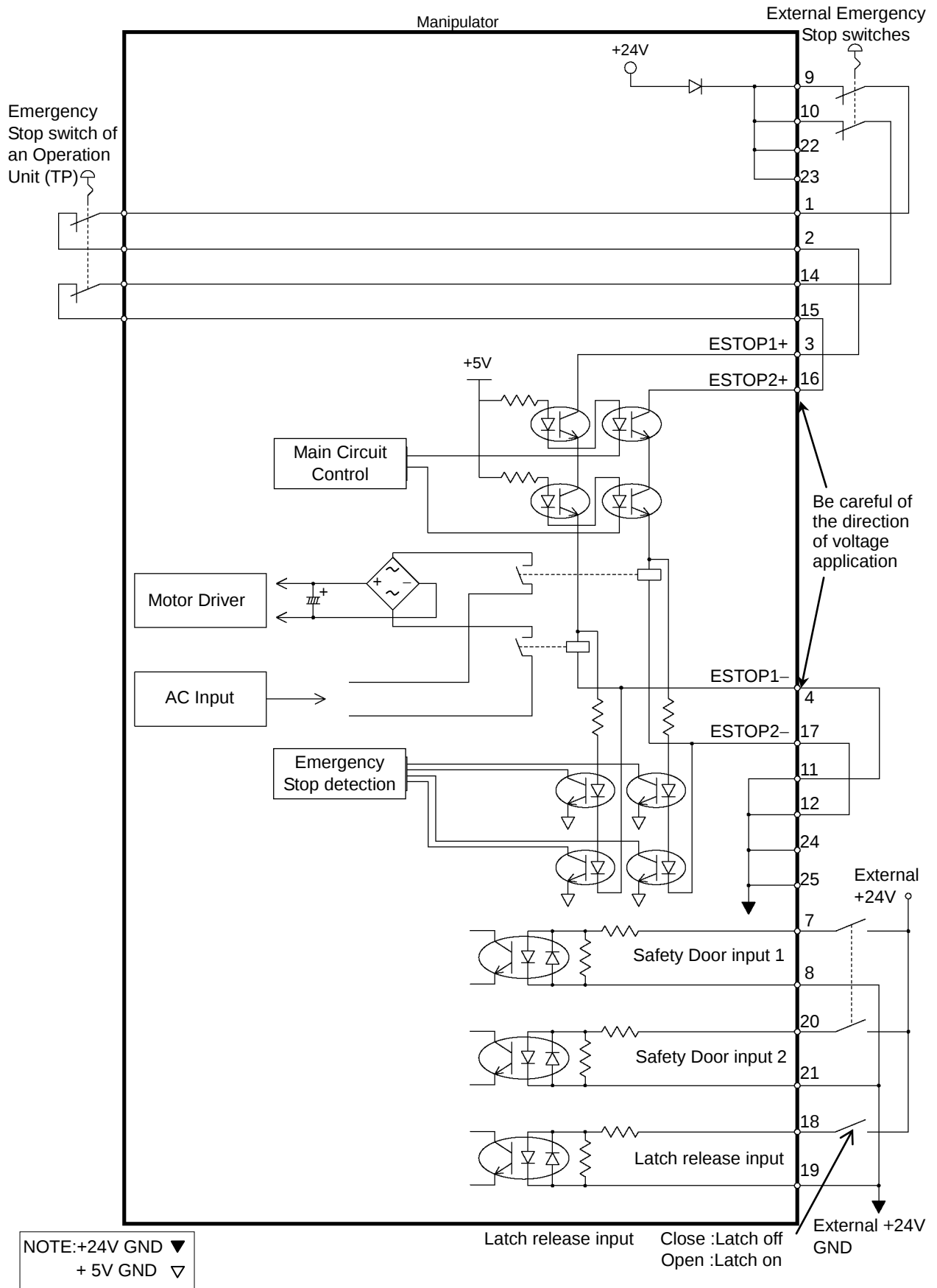
The total electrical resistance of the Emergency Stop switches and their circuit should be 1 Ω or less.



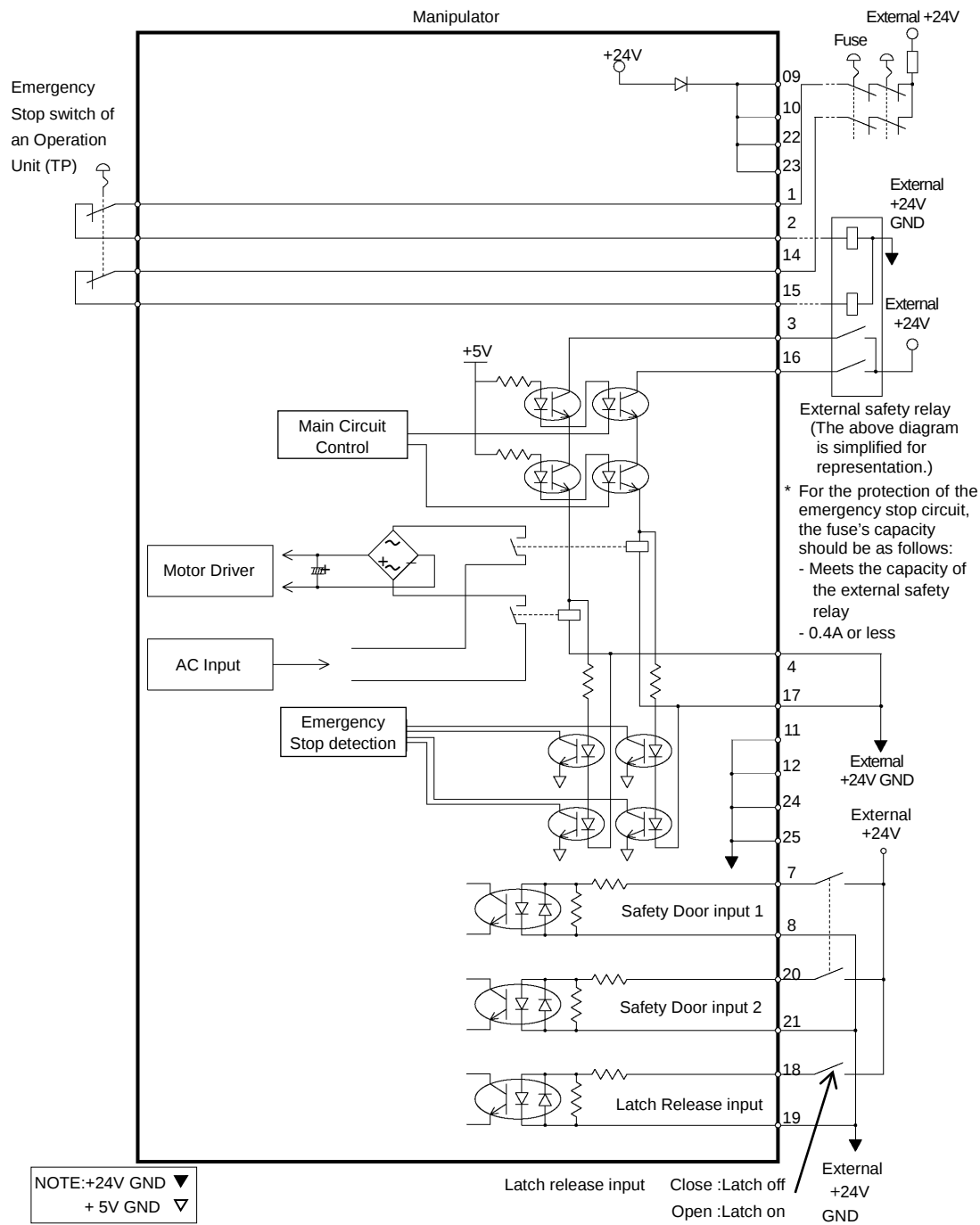
- The 24 V output is for emergency stop. Do not use it for other purposes. Doing so may result in system malfunction.
- Do not apply reverse voltage to the Emergency Stop circuit. Doing so may result in system malfunction.

12.4 Circuit Diagrams

12.4.1 Example 1: External emergency stop switch typical application



12.4.2 Example 2: External safety relay typical application



13. Standard I/O Connector



CAUTION

- Be careful not to exceed rated current range or rated current which are defined in manual.
If exceeding rated current, the Manipulator may now operate at worst.

Standard I/O Connector is a connector mounted on back side of the Manipulator for connecting your input/output equipment to the system.

Connector name	Pins	Bit number
I/O (Input) Connector	24	0-23
I/O (Output) Connector	16	0-15

For cable wiring, refer to the *Setup & Operation 3.7.2 Noise Countermeasures* in order to prevent noise.

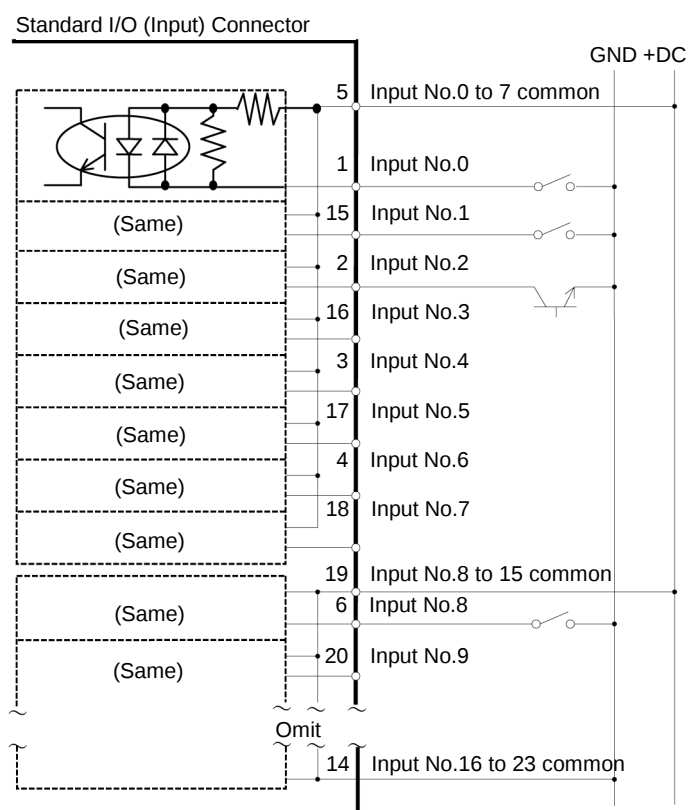
Remote function is initially assigned to both input and output from 0 to 7. For further details, refer to *Setup & Operation 14. I/O Remote Settings*.

13.1 Input Circuit

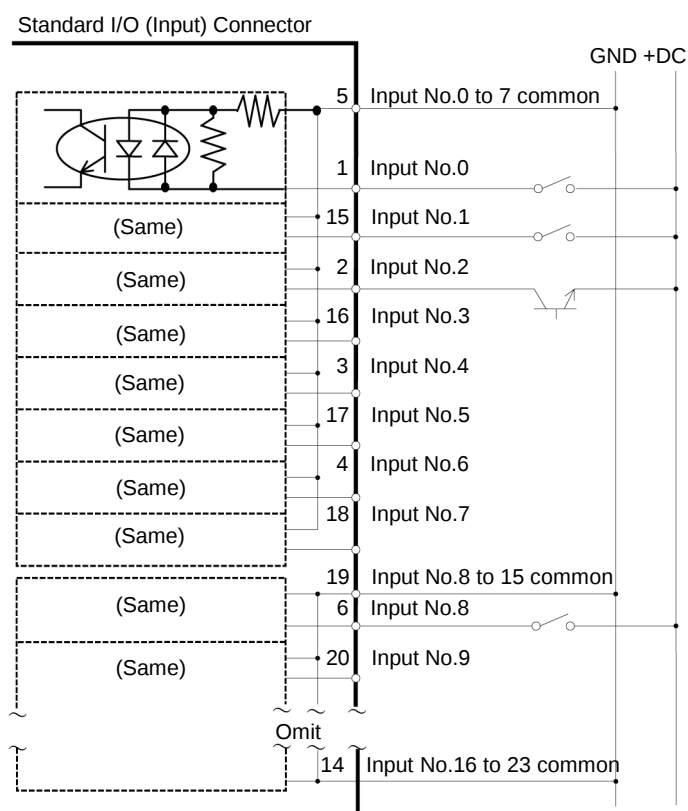
Input Voltage Range	: +12 to 24 V $\pm 10\%$
ON Voltage	: +10.8 V (min.)
OFF Voltage	: +5 V (max.)
Input Current	: 10 mA (TYP) at +24 V input

Two types of wiring are available for use with the two-way photo coupler in the input circuit.

13.1.1 Typical Input Circuit Application



13.1.2 Typical Input Circuit Application 2



13.1.3 Pin Assignments of Input Circuit

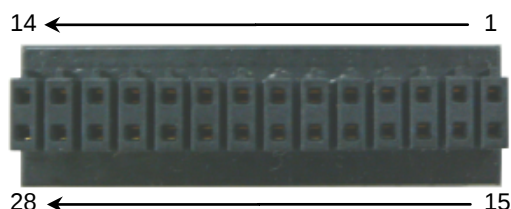
Pin No.	Signal Name	Pin No.	Signal Name
1	Input No. 0 (Start)	15	Input No. 1 (SelProg1)
2	Input No. 2 (SelProg2)	16	Input No. 3 (SelProg4)
3	Input No. 4 (Stop)	17	Input No. 5 (Pause)
4	Input No. 6 (Continue)	18	Input No. 7 (Reset)
5	Input common No. 0 to 7	19	Input common No. 8 to 15
6	Input No. 8	20	Input No. 9
7	Input No. 10	21	Input No. 11
8	Input No. 12	22	Input No. 13
9	Input No. 14	23	Input No. 15
10	Input No. 16	24	Input No. 17
11	Input No. 18	25	Input No. 19
12	Input No. 20	26	Input No. 21
13	Input No. 22	27	Input No. 23
14	Input common No. 16 to 23	28	Not Used

Remote function inside () in the table above is initially assigned to input from 0 to 7.
For further details, refer to *Setup & Operation 14. I/O Remote Settings*.

Connector	Connector model
I/O (Input) Connector	DMC 0,5/14-G1-2,54 P20THR R72 (Board side) DFMC 0,5/14-ST-2,54 (Cable side) (PHOENIX CONTACT)

* I/O connector is included with shipment.

I/O (Input) Connector pin assignment



13.2 Output Circuit

Rated Output Voltage : +12 V to +24 V $\pm 10\%$

Maximum Output Current : TYP 100 mA/1 output

Output device : PhotoMOS relay

ON resistance : Less than 0.7 Ω

The following two wirings are available since non-polar PhotoMOS relay is used for output circuit.

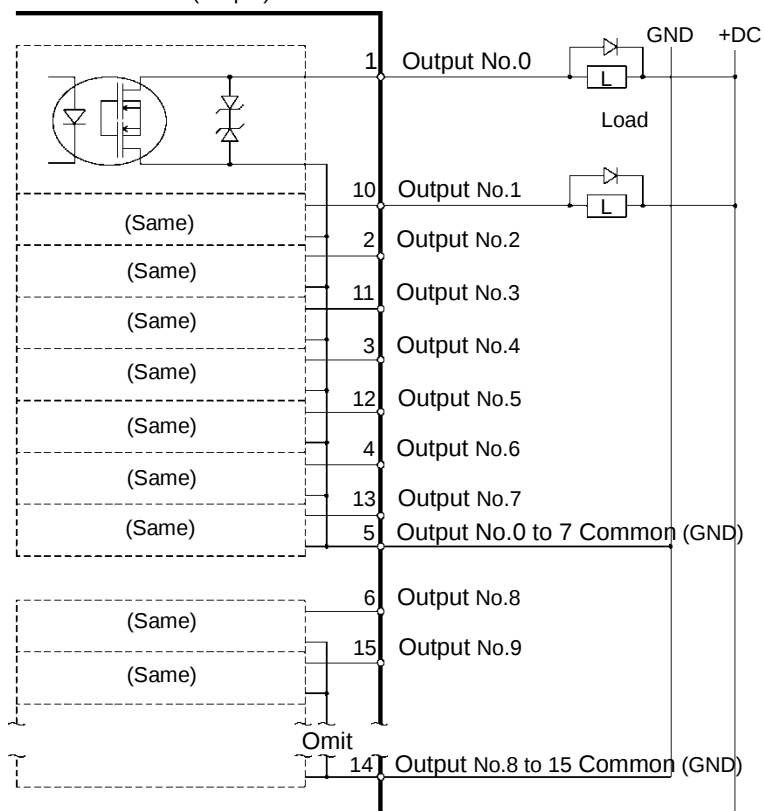


CAUTION

- Be sure to wire the output circuit properly because it has no protection circuitry for short-circuit and reverse-connection. Improper wiring may cause malfunction of the parts on the board and then improper function of the robot system.

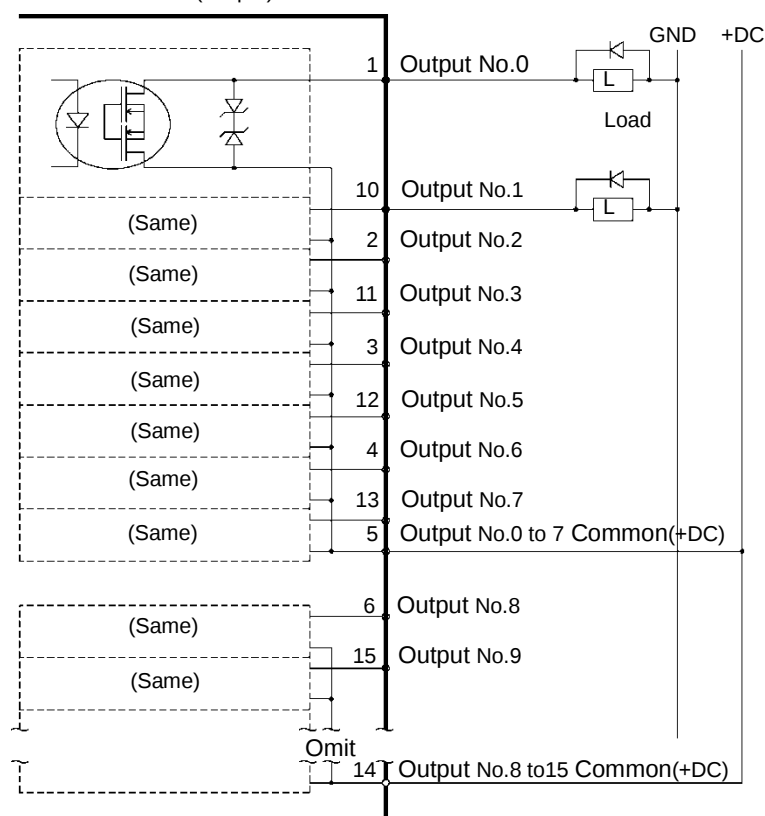
13.2.1 Typical Output Circuit Application 1

Standard I/O (Output) Connector



13.2.2 Typical Output Circuit Application 2

Standard I/O (Output) Connector



13.2.3 Pin Assignments of Output Circuit

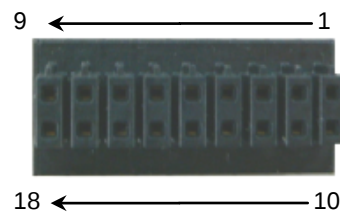
Pin No.	Signal Name	Pin No.	Signal Name
1	Output No. 0 (Ready)	10	Output No.1 (Running)
2	Output No.2 (Paused)	11	Output No.3 (Error)
3	Output No.4 (EstopOn)	12	Output No.5 (SafeguardOn)
4	Output No.6 (SError)	13	Output No.7 (Warning)
5	Output common No. 0 to 7	14	Output common No. 8 to 11
6	Output No. 8	15	Output No. 9
7	Output No.10	16	Output No.11
8	Output No. 12	17	Output No. 13
9	Output No. 14	18	Output No. 15

Remote function inside () in the table above is initially assigned to output from 0 to 7.
For further details, refer to *Setup & Operation 14. I/O Remote Settings*.

Connector	Connector model
I/O (Output) Connector	DMC 0,5/9-G1-2,54 P20THR R44 (Board side) DFMC 0,5/ 9-ST-2,54 (Cable side) (PHOENIX CONTACT)

* I/O connector is included with shipment.

I/O (Output) Connector pin assignment



13.3 I/O Cable Product Procedure

The following describes I/O cable product procedure for connecting user's input/output devices.

13.3.1 I/O Cable Connecting Method

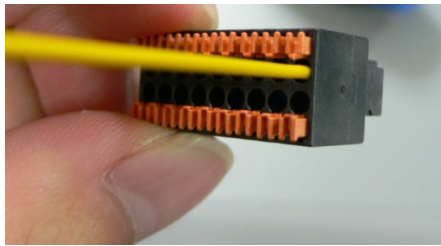
- (1) Prepare for I/O connector and cable which are included with shipment.

Adaption cable:

Electric wire capacity: 0.14 to 0.5mm²

Wire type: single wire, stranded wire, stranded wire with rod terminal.

- (2) Push the edge of cable into wire insertion slot.



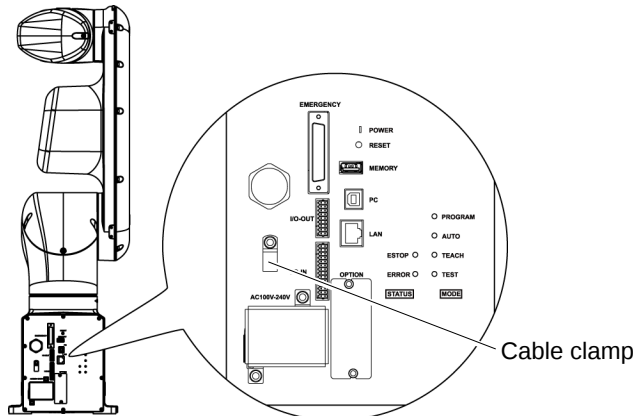
For single wire and stranded wire, peel off the covering of the cable.



- NOTE**
- If using a twisted wire or finer single wire, insert it while pushing orange colored open button.
 - Orange push pins are easy to come off. Be careful during operation.
 - There is a cable check hole above the open button. You can check cables using tester.

13.3.2 How to Fix the I/O Cable

You can fix the I/O cables using cable clamp on the back of the manipulator.



NOTE Fixing cables with I/O cable clamp, wiring of I/O cables is difficult to disconnect.

14. I/O Remote Settings

This section describes the functions and timings of input and output signals.

The remote functions may be assigned to your standard I/O board(s), or fieldbus I/O board(s) to enhance robot system control - either from an operational unit of your choice or a sequencer.

Remote function is initially assigned to both input and output from 0 to 7.

To accept external remote inputs, assign the remote function and the control device is remote. For further details, refer to the section, *Remote Control Software Configuration* in *EPSON RC+ 7.0 User's Guide - Remote Control*.

The user defines the I/O number that a remote function is assigned to using software configuration. For further details, refer to the section, *Remote Control Software Configuration* in *EPSON RC+ 7.0 User's Guide - Remote Control*.

For details about I/O cable connection, refer to sections on *Setup & Operation 13: Standard I/O Connector* and *17. Fieldbus I/O*.

For details about communication with external equipment, refer to *EPSON RC+ 7.0 User's Guide -12. Remote Control*.



- When using remote I/O, always make sure of the following. Using the robot system under unsatisfactory conditions may cause malfunction of the system and/or safety problems.

- Assign remote functions to inputs/outputs correctly and wire correctly when setting up remote I/O signals.
- Make sure that the functions correspond to the correct input/output signals before turning ON the system.

When verifying the robot system operation, prepare for failures with initial settings or wiring. If the Manipulator functions unusually by the failures with initial settings or wiring, press the Emergency Stop switch immediately to stop the Manipulator.



- Remote function is available when virtual I/O is enabled.
- When you set up a remote I/O signal, please either keep a written record of the settings or store the data in a file for later reference.
- When you set up a fieldbus I/O signal to the remote function, response depends on the baud rate of the fieldbus. For details of fieldbus response, refer to the following manual.
Robot Controller RC700 / RC90 Option Fieldbus I/O.

14.1 I/O Signal Description

Remote function is initially assigned to both input and output from 0 to 7.

To change the function assignment from the initial setting, use EPSON RC+ 7.0.

To use all signals, you will need to add Fieldbus I/O module.

14.1.1 Remote Input Signals

Remote inputs are used to control the Manipulators and start programs. Certain conditions must be met before inputs are enabled, as shown in the table below.

To accept external remote inputs, assign the remote function and set remote to the control device. When external remote input is available, “AutoMode output” turns ON.

Except “SelProg”, the signals execute each function when the signal starts in input acceptance condition. The function executes automatically. Therefore, no special programming is needed.

NOTE



When an error occurs, you must execute a “Reset” to clear the error condition before any other remote input commands can be executed. Use the “Error output” and “Reset input” to monitor the error status and clear error conditions from the remote device.

Name	Initial	Description	Input Acceptance Condition (*1)
Start	0	Execute function selected at SelProg. (*2)	Ready output ON Error output OFF EStopOn output OFF SafeguardOn output OFF Pause input OFF Stop input OFF
SelProg1 SelProg2 SelProg4 SelProg8 SelProg16 SelProg32	1 2 3 Not Set Not Set Not Set	Specify the executing Main function number. (*2)	
Stop	4	All tasks and commands are stopped.	
Pause	5	All tasks are paused. (*3)	Running output ON
Continue	6	Continue the paused task.	Paused output ON Pause input OFF Stop input OFF
Reset	7	Reset emergency stop and error. (*4)	Ready output ON
Shutdown	Not set	Terminates the system	
ForcePowerLow (*6)	Not Set	Operates as the forced low power function. The manipulator is operated in the low power mode. Power High control from the command is not accepted. Executes the following according to the manipulator preferences. Stops or temporarily stops all the tasks and commands. (*12)	Any time This input is acceptable even AutoMode output is OFF.
SelRobot	Not Set	Changes the output condition of MotorsOn, AtHome, PowerHigh, and MCalReqd.(*9)	

Name	Initial	Description	Input Acceptance Condition (*1)
SelRobot1 SelRobot2 SelRobot4 SelRobot8 SelRobot16	Not set	Specify the number of manipulator which executes a command. (*5)	
SetMotorsOn	Not set	Turn ON manipulator motors. (*5) (*6)	Ready output ON EStopOn output OFF SafeguardOn output OFF SetMotorOff input OFF
SetMotorsOff	Not set	Turn OFF manipulator motors.	Ready output ON
SetPowerHigh	Not set	Set the manipulator power mode to High (*5)	Ready output ON EStopOn output OFF SafeguardOn output OFF SetPowerLow input OFF
SetPowerLow	Not set	Set the manipulator power mode to Low. (*5)	Ready output ON
Home	Not set	Move the manipulator Arm to the home position defined by the user.	Ready output ON Error output OFF EStopOn output OFF SafeguardOn output OFF MotorsOn output ON Pause input OFF Stop input OFF
MCal	Not set	Execute MCal (*5) (*7)	Ready output ON Error output OFF EStopOn output OFF SafeguardOn output OFF MotorsOn output ON Pause input OFF Stop input OFF
Recover	Not set	After the safeguard is closed, recover to the position where the safeguard is open.	Paused output ON Error output OFF EStopOn output OFF SafeguardOn output OFF RecoverReqd output ON Pause input OFF Stop input OFF
ResetAlarm	Not Set	Cancel the alarm (*11)	
SelAlarm1 SelAlarm2 SelAlarm4 SelAlarm8	Not Set	Specify the alarm number to cancel (*10)	
ALIVE	Not Set	Input signal for alive monitoring of the manipulator. Same signal as the input will be output to ALIVE output. The master equipment can perform alive monitoring of the manipulator by switching the input periodically and checking the output signal.	

(*1) "AutoMode output" ON is omitted from the table. This is an input acceptance condition for all functions.

(*2) “Start input” executes Function specified by the following six bits: SelProg 1, 2, 4, 8, 16, and 32.

Function name	SelProg1	SelProg2	SelProg4	SelProg8	SelProg16	SelProg32
Main	0	0	0	0	0	0
Main1	1	0	0	0	0	0
Main2	0	1	0	0	0	0
Main3	1	1	0	0	0	0
⋮						
Main60	0	0	1	1	1	1
Main61	1	0	1	1	1	1
Main62	0	1	1	1	1	1
Main63	1	1	1	1	1	1

0=OFF, 1=ON

(*3) “NoPause task” and “NoEmgAbort task” do not pause.

For details, refer to *EPSON RC+ 7.0 Online Help* or *Pause* in *SPEL⁺ Language Reference*.

(*4) Turns OFF the I/O output and initializes the manipulator parameter.

For details, refer to *EPSON RC+ 7.0 Online Help* or *Reset* in *SPEL⁺ Language Reference*.

(*5) VT series is invalid.

(*6) Initializes the manipulator parameter.

For details, refer to *EPSON RC+ 7.0 Online Help* or *Motor* in *SPEL⁺ Language Reference*.

(*7) For details, refer to *EPSON RC+ 7.0 Online Help* or *MCal* in *SPEL⁺ Language Reference*.

(*8) This is for experienced users only. Make sure that you fully understand the input specification before using.

CmdRunning output and CmdError output will not change for this input.

“NoEmgAbort task” will not stop by this input.

When the input changes from ON to OFF, all tasks and commands will stop.

(*9) This function changes the output condition of MotorsOn, AtHome, PowerHigh, and MCalReqd.

By setting this signal with the condition selected using SelRobot1 - SelRobot16, you can switch the output condition.

Once you select the condition, it will be kept until you change it or turn off / restart the Controller. All manipulators are selected as default.

(*10) The values specified by “SelAlarm1, 2, 4, and 8” correspond to the alarm numbers.

Alarm #	Target	SelAlarm1	SelAlarm2	SelAlarm4	SelAlarm8
1	Controller battery	1	0	0	0
2	-	0	1	0	0
3	Manipulator grease	1	1	0	0
4	-	0	0	1	0
5	-	1	0	1	0
6	-	0	1	1	0
7	-	1	1	1	0
8	-	0	0	0	1
9	-	1	0	0	1

0=OFF, 1=ON

The following parts are subject to grease up.

Ball screw spline unit on the Joint # 3

(*11) The specified alarm can be canceled by selecting the conditions using SelAlarm1-SelAlarm8 and setting this signal.

(*12) Operation of all tasks and commands, power mode of the manipulator, and PowerHigh command by the setting of the manipulator preferences.

Preferences (1): “Motor power low when ForcePowerLow signal OFF”

Preferences (2): “ForcePowerLow signal change pauses all tasks”

For details of the manipulator preferences, refer to *EPSON RC+ 7.0 User's Guide [Setup]-[System Configuration]-[Controller]-[Preferences]* in 5.12.2 [System Configuration] Command (Setup Menu).

Preferences (1)	Preferences (2)	ForcePowerLow	All tasks and commands	Power mode	PowerHigh
0	0	1→0	Stop	Low only	Accept
0	0	0→1	Stop	Low only	Not accept
0	1	1→0	Continue	High/Low	Accept
0	1	0→1	Temp. stop	Low only	Not accept
1	0	1→0	Stop	Low only	Not accept
1	0	0→1	Stop	Low only	Accept
1	1	1→0	Temp. stop	Low only	Not accept
1	1	0→1	Continue	High/Low	Accept

14.1.2 Remote Output Signals

Remote output is a function to output a status of the Manipulator or operation mode.

Remote outputs provide the assigned function using with any control device. The outputs execute automatically. Therefore, no special programming is needed.

Name	Initial	Description
Ready	0	Turns ON when the manipulator startup completes and no task is running.
Running	1	Turns ON when task is running. However, turns OFF when “Paused output” is OFF.
Paused	2	Turns ON when pause task exists.
Error	3	Turns ON when an error occurs. Use “Reset input” to recover from the error.
EStopOn	4	Turns ON at Emergency Stop.
SafeguardOn	5	Turns ON when the safeguard is open.
SError	6	Turns ON when critical error occurs. When a critical error occurs, “Reset input” does not function. Reboot the controller to recover.
Warning	7	Turns ON when warning occurs. The task runs as normal with the warning. However, be sure to eliminate the cause of the warning as soon as possible.
MotorsOn	Not set	Turns ON when the manipulator motor is ON. (*5)
AtHome	Not set	Turns ON when the manipulator is in the home position. (*5)
PowerHigh	Not set	Turns ON when the manipulator’s power mode is High. (*5)
MCalReqd	Not set	Turns ON when the manipulator hasn’t executed MCal. (*5)
RecoverReqd	Not set	Turns ON when at least one manipulator is waiting for Recover after the safeguard is closed.
RecoverInCycle	Not set	Turns ON when at least one manipulator is executing Recover.
CmdRunning	Not set	Turns ON when an input command is executing.
CmdError	Not set	Turns ON when an input command cannot be accepted.
CurrProg1 CurrProg2 CurrProg4 CurrProg8 CurrProg16 CurrProg32	Not set	Indicates the running or the last main function number (*1)
AutoMode	Not set	Turns ON in remote input acceptable status. (*2)
TeachMode	Not set	Turns ON in TEACH mode.
ErrorCode1 ⋮ ErrorCode8192	Not set	Indicates the error number.
InsideBox1 ⋮ InsideBox15	Not set	Turns ON when the manipulator is in the approach check area. (*3)

Name	Initial	Description
InsidePlane1 ⋮ InsidePlane15	Not set	Turns ON when the manipulator is in the approach check plane. (*4)
Alarm	Not set	Turns ON when any of the alarms is occurring. (*9)
Alarm1	Not set	Turns ON when a battery alarm of the manipulator is occurring.
Alarm2	Not set	Turns ON when a battery alarm of the manipulator connected to CU is occurring.
Alarm3	Not set	Turns ON when a grease alarm of the manipulator connected to CU is occurring.
Alarm4	Not set	Turns ON when a battery alarm of the manipulator connected to DU1 is occurring.
Alarm5	Not set	Turns ON when a grease alarm of the manipulator connected to DU1 is occurring.
Alarm6	Not set	Turns ON when a battery alarm of the manipulator connected to DU2 is occurring.
Alarm7	Not set	Turns ON when a grease alarm of the manipulator connected to DU2 is occurring.
Alarm8	Not set	Turns ON when a battery alarm of the manipulator connected to DU3 is occurring.
Alarm9	Not set	Turns ON when a grease alarm of the manipulator connected to DU3 is occurring.
PositionX	Not set	Outputs current X coordinate in the World coordinate system (*6) (*7)
PositionY	Not set	Outputs current Y coordinate in the World coordinate system (*6) (*7)
PositionZ	Not set	Outputs current Z coordinate in the World coordinate system (*6) (*7)
PositionU	Not set	Outputs current U coordinate in the World coordinate system (*6) (*7)
PositionV	Not set	Outputs current V coordinate in the World coordinate system (*6) (*7)
PositionW	Not set	Outputs current W coordinate in the World coordinate system (*6) (*7)
Torque1	Not set	Outputs the current torque value of Joint #1 (*6) (*7)
Torque2	Not set	Outputs the current torque value of Joint #2 (*6) (*7)
Torque3	Not set	Outputs the current torque value of Joint #3 (*6) (*7)
Torque4	Not set	Outputs the current torque value of Joint #4 (*6) (*7)
Torque5	Not set	Outputs the current torque value of Joint #5 (*6) (*7)
Torque6	Not set	Outputs the current torque value of Joint #6 (*6) (*7)
CPU	Not set	Outputs the CPU load factor of the user program (*8)
ESTOP	Not set	Outputs how many times emergency stops have been executed.
ALIVE	Not set	Output signal for alive monitoring of the manipulator. The signal input by ALIVE input will be output. The master equipment can perform alive monitoring of the manipulator by switching the input periodically and checking the output signal.

(*1) Outputs the current or the last function number of CurrProg1, 2, 4, 8, 16, or 32.

Function name	CurrProg1	CurrProg2	CurrProg4	CurrProg8	CurrProg16	CurrProg32
Main	0	0	0	0	0	0
Main1	1	0	0	0	0	0
Main2	0	1	0	0	0	0
Main3	1	1	0	0	0	0
⋮						
Main60	0	0	1	1	1	1
Main61	1	0	1	1	1	1
Main62	0	1	1	1	1	1
Main63	1	1	1	1	1	1

0=OFF, 1=ON

(*2) Remote function is available in the following conditions.

- The setting is Auto mode and the control device is remote.
- The setting is Program mode and Remote I/O is enabled.

(*3) For details, refer to *EPSON RC+ 7.0 Online Help* or *Box* in *SPEL⁺ Language Reference*.

(*4) For details, refer to *EPSON RC+ 7.0 Online Help* or *Plane* in *SPEL⁺ Language Reference*.

(*5) Manipulator status is output as follows, according to the condition selected in SelRobot.

Wait at least 40 ms before inputting the signal after changing the condition in SelRobot.

Name	(SelRobot1- SelRobot16) condition when inputting SelRobot	
	0: All robots are selected	1 - 16: Particular robot number is selected
MotorsOn	Turns ON when at least one manipulator motor is ON.	Turns ON when the motor of the selected manipulator is ON.
AtHome	Turns ON when all manipulators are in the home position.	Turns ON when the selected manipulator is in the home position.
PowerHigh	Turns ON when at least one manipulator's power mode is High.	Turns ON when the selected manipulator's power mode is High.
MCalReqd	Turns ON when at least one manipulator hasn't executed MCal.	Turns ON when the selected manipulator hasn't executed MCal.

(*6) T series is invalid.

(*7) Outputs information in Real format.

(*8) Outputs the total load factor of the user created tasks. For details on the CPU load factor, refer to the task manager.

(*9) The signal turns on when the alarm occurs in the manipulator alarm information.

14.2 Timing Specifications

14.2.1 Precautions for Remote Input Signals

The following charts indicate the timing sequences for the primary operations of the Controller.

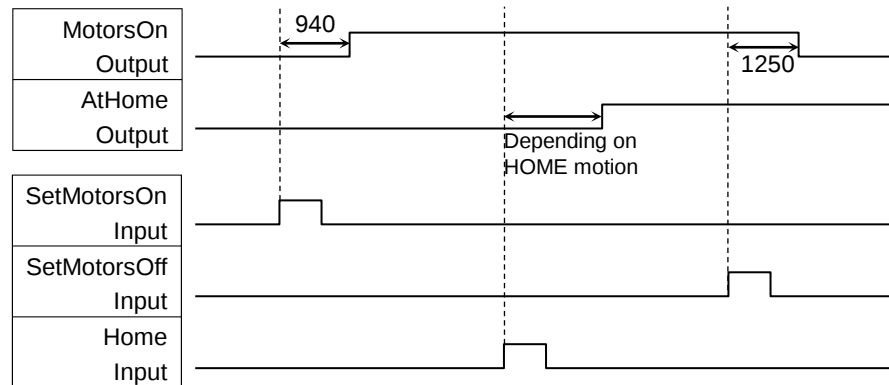
The indicated time lapses (time durations) should be referred to only as reference values since the actual timing values vary depending on the number of tasks running, as well as CPU speed of the Manipulator. Check carefully and refer to the following charts for the timing interrelation when you enter an input signal.

During system design, make sure that you actuate only one remote input operation at a time, otherwise an error will occur.

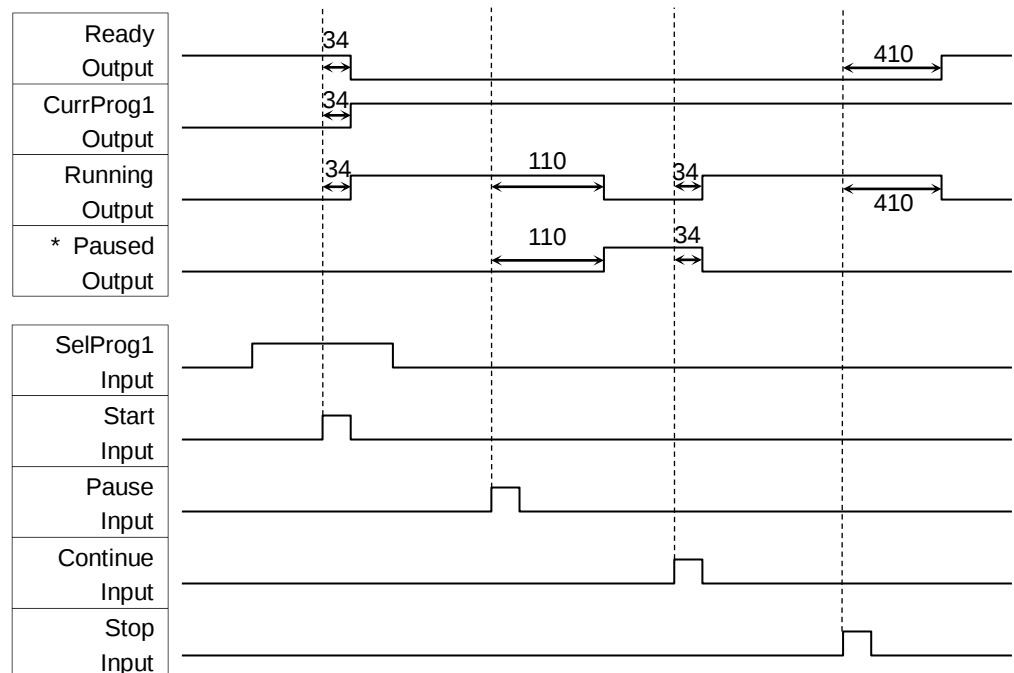
The pulse width of an input signal must be 25 or more milliseconds to be detected.

[Unit: ms]

14.2.2 Timing Diagram for Operation Execution Sequence

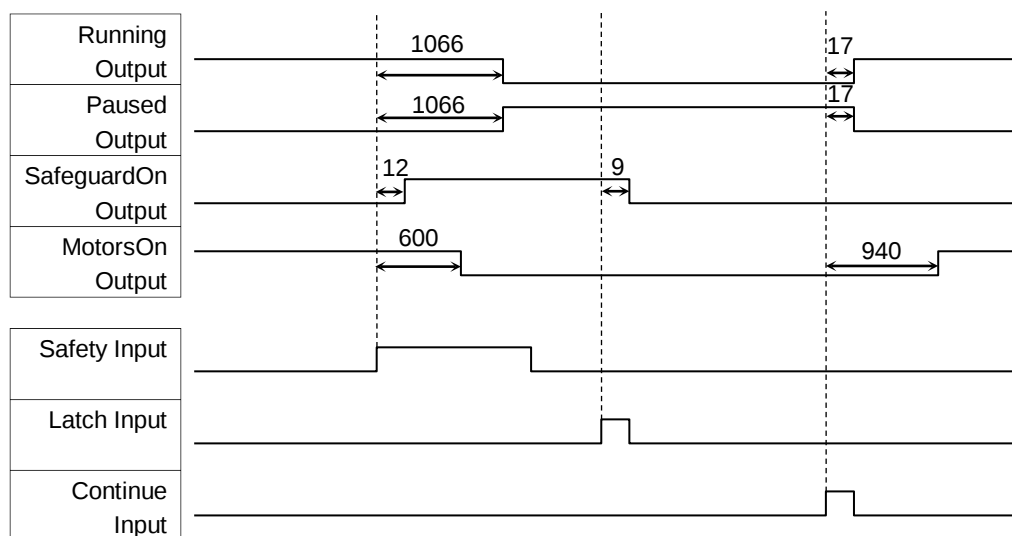


14.2.3 Timing Diagram for Program Execution Sequence

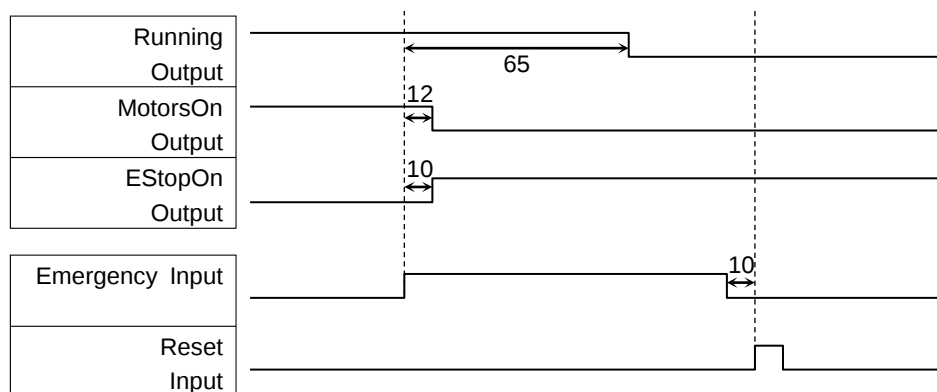


* The duration varies depending on the Quick Pause (QP) setting and the program's operating status at the time of Pause input

14.2.4 Timing Diagram for Safety Door Input Sequence



14.2.5 Timing Diagram for Emergency Stop Sequence

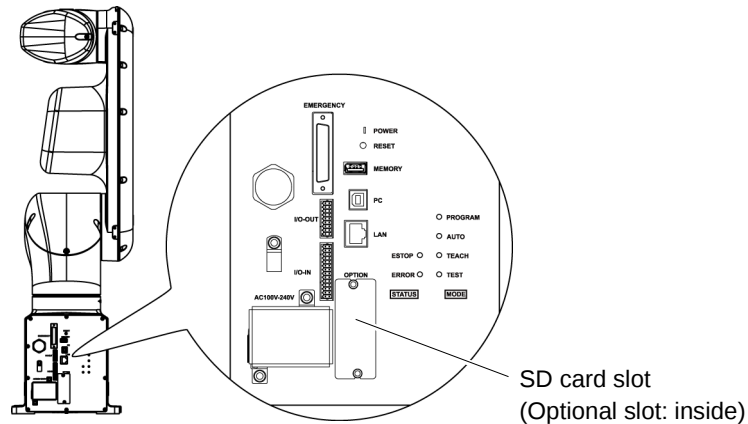


15. SD Card Slots



CAUTION

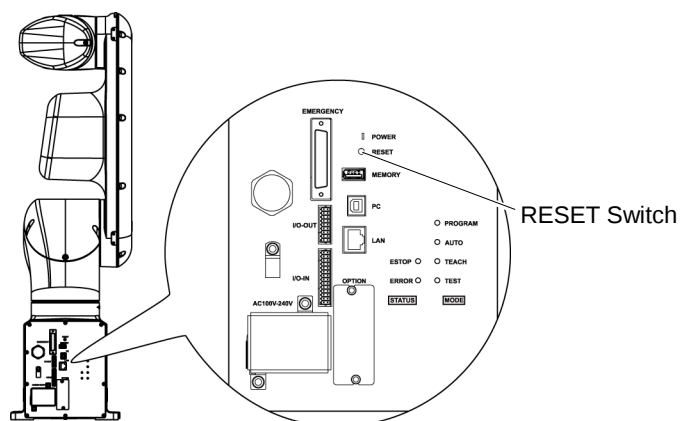
- Do not use any SD card other than accessories.
If using other SD card, system may not operate properly.
- SD card is only available for robot system.
SD card is written only for robot system. Unable to use for reading/writing data.
If you write data on SD card, robot system may not operate properly.



SD card slot is a slot for inserting SD card.
Firmware to operate the manipulator is written on the SD card.

Reference: *Maintenance 18.6 Replacing SD Card*

16. RESET Switch



RESET switch has following function.

Manipulator reboot

Push the RESET switch for three seconds when booting the manipulator.
Manipulator reboots.

Shape of RESET switch is difficult to push. Use a sharp edged object when pushing the RESET switch.

17. Fieldbus I/O

Fieldbus I/O of the VT series supports the following model.

DeviceNet™	CC-Link
PROFIBUS-DP	PROFINET
EtherNet/IP™	EtherCAT®

For details, refer to the following manual.

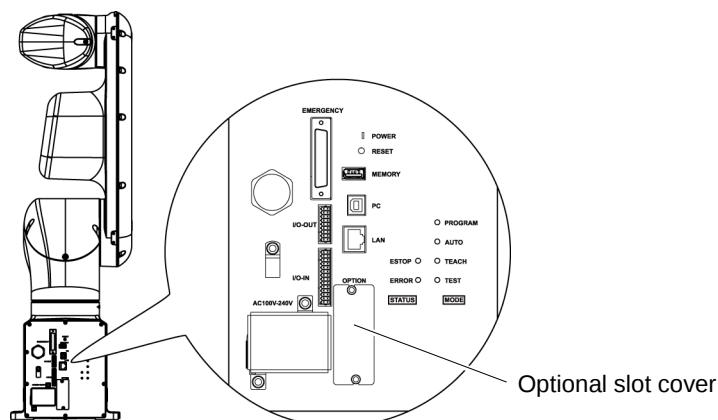
Robot Controller RC700 / RC90 Option Fieldbus I/O

 WARNING	■ Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system. ■ To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source. ■ Be sure to perform installing procedure with turning OFF the robot system and related equipment and disconnect the power plug. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
 CAUTION	■ Check the tabs of the fieldbus I/O module are securely hooked on the board when installing fieldbus I/O module. If tabs do not be hooked securely, connector or fieldbus I/O module may get damages.

Fieldbus
I/O Module
Installation

- (1) Turn OFF the Manipulator.
- (2) Remove the optional slot cover on the back side of the Manipulator.

Sems bolt: 2-M3×6



- (3) Inset the fieldbus I/O module to the optional slot.



CAUTION

- Check the tabs of the fieldbus I/O module are securely hooked on the board when installing fieldbus I/O module. If tabs do not be hooked securely, connector or fieldbus I/O module may get damages.

- (4) Tighten screws by using special tool until fieldbus I/O module is fixed completely.



Image of installation



Front



Back

Fieldbus
I/O Module
Removal

- (1) Unscrew the screws by using special tool until fieldbus I/O module is loosened.
- (2) Remove the fieldbus I/O module.
You can remove the module by pulling loosened screws toward.
- (3) Mount the optional slot cover.

Maintenance

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

1. Safety Maintenance

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

Only authorized personnel who have taken safety training should be allowed to maintain the robot system.

Safety training is the program for industrial robot operators that follows the laws and regulations of each nation.

The personnel who have taken safety training acquire knowledge of industrial robots (operations, teaching, etc.), knowledge of inspections, and knowledge of related rules/regulations.

The personnel who have completed the robot system-training and maintenance-training classes held by the manufacturer, dealer, or locally-incorporated company are allowed to maintain the robot system.



- Do not remove any parts that are not covered in this manual. Follow the maintenance procedure strictly as described in this manual. Improper removal of parts or improper maintenance may not only cause improper function of the robot system but also serious safety problems.
- Keep away from the Manipulator while the power is ON if you have not taken the training courses. Do not enter the operating area while the power is ON. Entering the operating area with the power ON is extremely hazardous and may cause serious safety problems as the Manipulator may move even it seems to be stopped.
- When you check the operation of the Manipulator after replacing parts, be sure to check it while you are outside of the safeguarded area. Checking the operation of the Manipulator while you are inside of the safeguarded area may cause serious safety problems as the Manipulator may move unexpectedly.
- Before operating the robot system, make sure that both the Emergency Stop switches and safeguard switch function properly. Operating the robot system when the switches do not function properly is extremely hazardous and may result in serious bodily injury and/or serious damage to the robot system as the switches cannot fulfill their intended functions in an emergency.



- To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.

 WARNING	■ Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
---	---

 CAUTION	■ Manipulator may be warmed up due to motor heat or similar causes. Do not touch the Manipulator until temperature falls. Also, make sure the temperature of the Manipulator falls and is not hot when you touch it. Then perform teaching or maintenance.
---	--

2. General Maintenance

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

2.1 Maintenance Inspection

2.1.1 Schedule for Maintenance Inspection

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

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

	Inspection Point					
	Daily inspection	Monthly inspection	Quarterly inspection	Biannual inspection	Annual inspection	Overhaul (replacement)
1 month (250 h)	Inspect every day	√				
2 months (500 h)		√				
3 months (750 h)		√	√			
4 months (1000 h)		√				
5 months (1250 h)		√				
6 months (1500 h)		√	√	√		
7 months (1750 h)		√				
8 months (2000 h)		√				
9 months (2250 h)		√	√			
10 months (2500 h)		√				
11 months (2750 h)		√				
12 months (3000 h)		√	√	√	√	
13 months (3250 h)		√				
⋮	⋮	⋮	⋮	⋮	⋮	⋮
20000 h						√

h = hour

2.1.2 Inspection Point

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

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check looseness or backlash of bolts, screws. Tighten them if necessary. (For the tightening torque, refer to <i>Maintenance: 2.3 Tightening Hexagon Socket Head Cap Bolts.</i>)	End effector mounting bolts	√	√	√	√	√
	Manipulator mounting bolts	√	√	√	√	√
	Each joint	√	√	√	√	√
	Bolts, screws securing motors, reduction gear units, etc.					√
Check looseness of connectors. If the connectors are loosen, push it securely or tighten.	External connectors on Manipulator (on the connector plates etc.)	√	√	√	√	√
	Manipulator cable unit		√	√	√	√
Visually check for external defects. Clean up if necessary.	External appearance of Manipulator	√	√	√	√	√
	External cables		√	√	√	√
Check for bends or improper location. Repair or place it properly if necessary.	Safeguard etc.	√	√	√	√	√
Check tension of timing belts. Tighten it if necessary.	Inside of Arm #2				√	√
Lithium Battery	Refer to <i>Maintenance: 18.4 Replacing Lithium Battery</i>					

Inspection While the Power is ON (Manipulator is operating)

Inspection Point	Inspection Place	Daily	Monthly	Quarterly	Biannual	Annual
Check motion range	Each joint					√
Move the cables back and forth lightly to check whether the cables are disconnected.	External cables (including cable unit of the Manipulator)				√	√
Push each arm in MOTOR ON status to check whether backlash exists.	Each joint					√
Check whether unusual sound or vibration occurs.	Whole	√	√	√	√	√
Measure the accuracy repeatedly by a dial gauge when positional gap occurs.	Whole					√
Execute Brake off command (brake off, joint #) from the command window of the EPSON RC+ while the motors are OFF, and then check the sound of the electromagnetic brake. If there is no sound, replace the brake.	Brake	√	√	√	√	√

2.2 Overhaul (Parts Replacement)



- Overhaul timing is based on an assumption that all joints are operated for equal distance. If a particular joint has a high duty or high load, it is recommended to overhaul all joints (as many as possible) before exceeding 20,000 operation hours with the joint as a basis.

The parts for the manipulator joints may cause accuracy decline or malfunction due to deterioration of the manipulator resulting from long term use. In order to use the manipulator for a long term, it is recommended to overhaul the parts (parts replacement).

The time between overhauls is 20,000 operation hours of the Manipulator as a rough indication.

However, it may vary depending on usage condition and degree of the load (such as when operated with the maximum motion speed and maximum acceleration / deceleration in continuous operation) applied on the Manipulator.

NOTE



For EPSON RC+ 7.0, the recommended replacement time for the parts subject to maintenance (motors, reduction gear units, and timing belts) can be checked in the [Maintenance] dialog box.

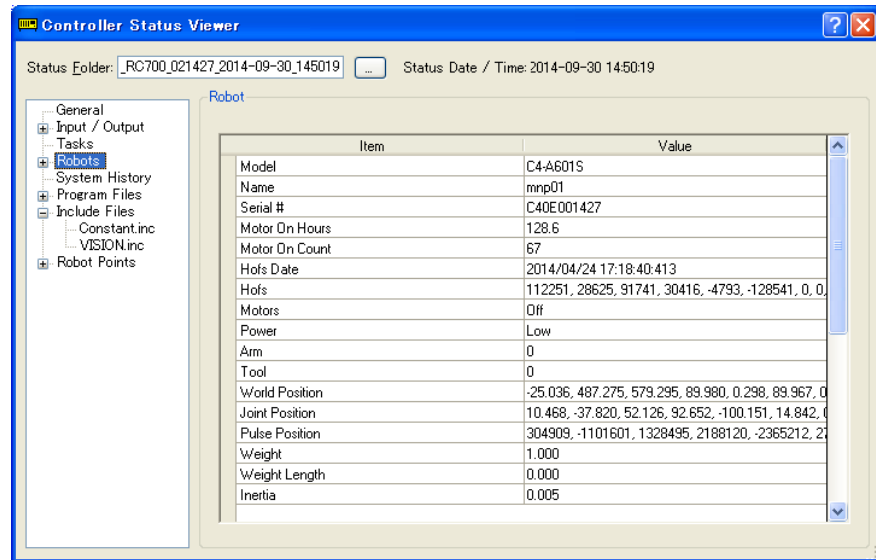
Refer to the *Maintenance: 4. Alarm*.

Note:

The recommended replacement time for the maintenance parts is when it reaches the L10 life (time until 10% failure probability). In the [Maintenance] dialog box, the L10 life is displayed as 100%.

The manipulator operation hours can be checked in [Controller Status Viewer] dialog -[Motor On Hours].

- (1) Select EPSON RC+ menu-[Tools]-[Controller] to open the [Controller Tools] dialog.
- (2) Click the <View Controller Status> button to open the [Browse For Folder] dialog.
- (3) Select the folder where the information is stored.
- (4) Click <OK> to view the [Controller Status Viewer] dialog.
- (5) Select [Robot] from the tree menu on the left side.



For the parts subject to overhaul, refer to *Maintenance: 22. Maintenance Parts List*.

For details of replacement of each part, refer to the *Maintenance* section.

Please contact the distributor of your region for further information.

2.3 Tightening Hexagon Socket Head Cap Bolts

Hexagon socket head cap bolts (herein after referred to as bolt) are used in places where mechanical strength is required. These bolts are fastened with the tightening torques shown in the following table.

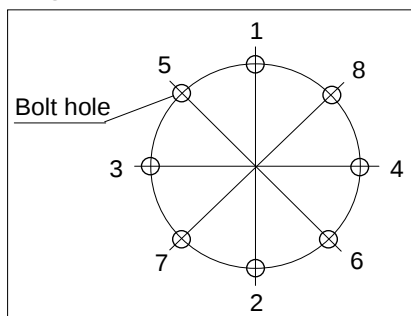
When it is necessary to refasten these bolts in some procedures in this manual (except special cases as noted), use a torque wrench so that the bolts are fastened with the appropriate tightening torques as shown below.

Bolt	Tightening Torque
M3	2.0 ± 0.1 N·m (21 ± 1 kgf·cm)
M4	4.0 ± 0.2 N·m (41 ± 2 kgf·cm)
M5	8.0 ± 0.4 N·m (82 ± 4 kgf·cm)
M6	13.0 ± 0.6 N·m (133 ± 6 kgf·cm)
M8	32.0 ± 1.6 N·m (326 ± 16 kgf·cm)
M10	58.0 ± 2.9 N·m (590 ± 30 kgf·cm)
M12	100.0 ± 5.0 N·m ($1,020 \pm 51$ kgf·cm)

Refer below for the set screw.

Set Screw	Tightening Torque
M4	2.4 ± 0.1 N·m (26 ± 1 kgf·cm)
M5	4.0 ± 0.2 N·m (41 ± 2 kgf·cm)

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



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

2.4 Matching Origins

After parts have been replaced (e.g. motor units, reduction gear units, timing belts), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Robot system.

Because of that, it is necessary to perform calibration (encoder rest and calibration) to match these origins.

For calibration, the pulse values for a specific position must be recorded in advance.

Before replacing parts, select easy point (pose) data from the registered point data to check the accuracy. Then, follow the steps below to display the pulse values and record them.

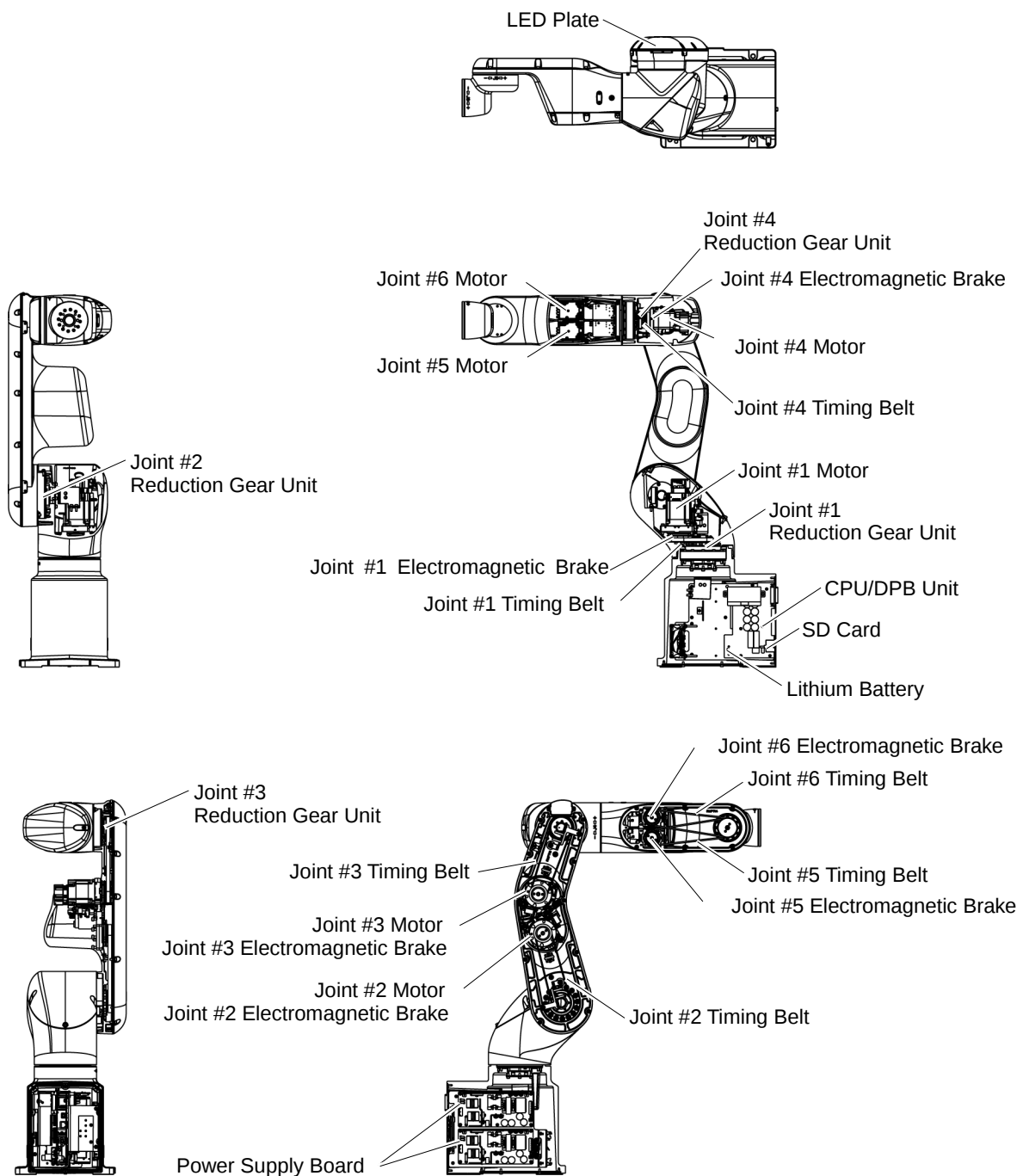
EPSON
RC+

Execute the following command from the [Command Window].

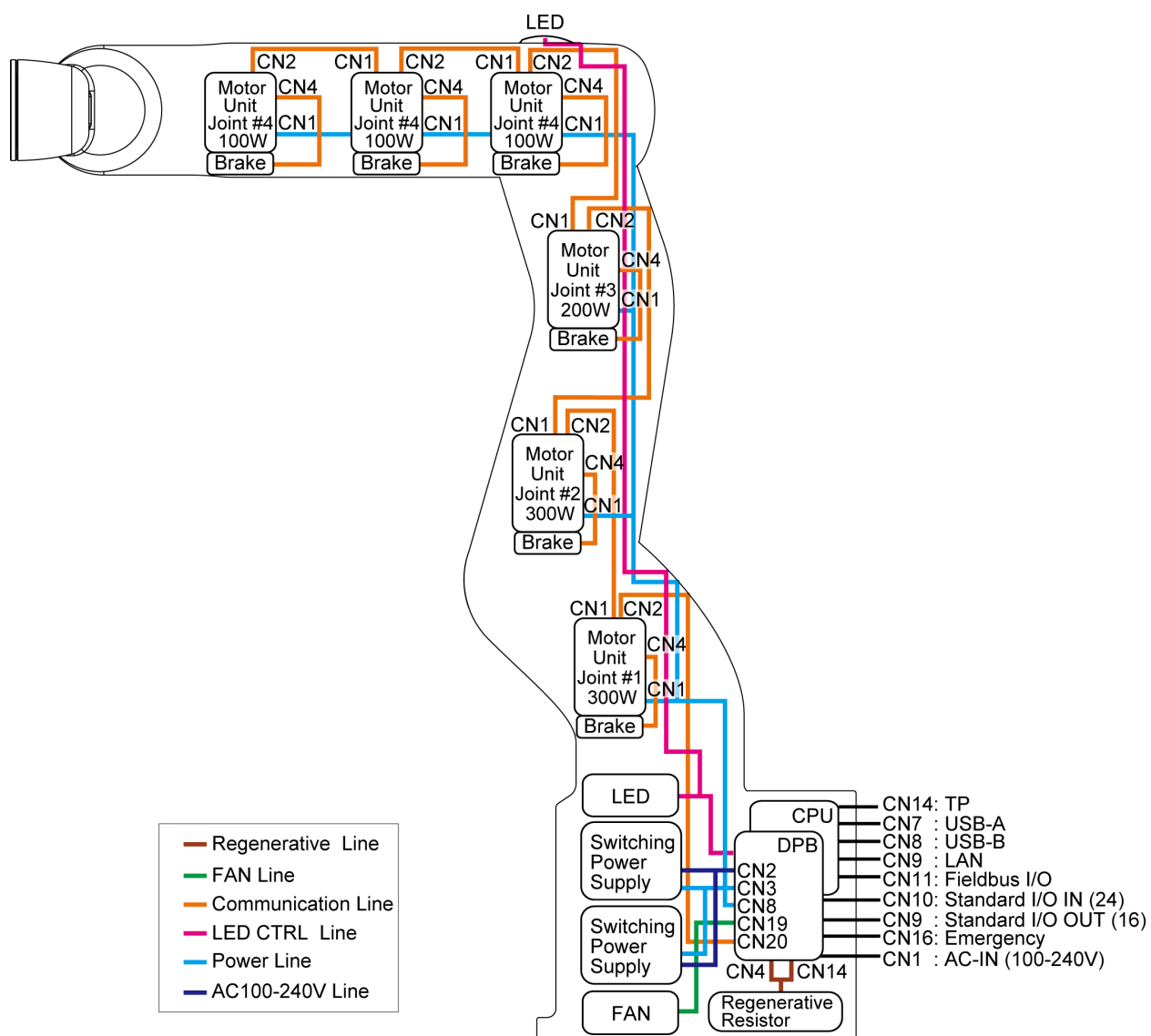
>PULSE

PULSE: [Joint #1 Pulse value] pls [Joint #2 Pulse value] pls [Joint #3 Pulse value]
pls [Joint #4 Pulse value] pls [Joint #5 Pulse value] pls [Joint #6 Pulse value] pls

2.5 Layout of Maintenance Parts



3. Manipulator Structure



4. Alarm

When the lithium batteries run out, a voltage reduction alarm warning occurs. However, the warning does not guarantee that the battery lasts until you replace it. Therefore, you need to replace the battery immediately. If the battery has run out, the manipulator parameters will be lost and recalibration of the manipulator will be required.

In addition, the parts of the manipulator joints may cause accuracy decline or malfunction due to deterioration of the parts resulting from long term use. If the manipulator breaks down due to deterioration of the parts, it will take significant time and cost for repair.

The following sections describe the alarm function which announces the following maintenance timings in order to perform maintenance well ahead of time before the warning error.

- Battery replacement
- Grease up
- Replacement of the timing belt
- Replacement of the motor
- Replacement of the reduction gear unit

4.1 Maintenance

The recommended replacement time can be configured for the batteries, timing belts, motors, and reduction gear units.

 CAUTION	■ Make sure that the date and time on the Manipulator are set correctly. Maintenance cannot be performed properly with improper date and time setting. ■ If the CPU/DPB board or SD card is replaced, the Maintenance information may be lost. When you replaced these parts, confirm the date and time of the Manipulator and the Maintenance information.
--	---

NOTE
 Settings of the Maintenance are different depending on installation methods of the firmware.

Initial installation : Maintenance is enabled.

Upgrade : Maintenance inherits the previous data.
(Disables as default)

For details for enabling or disabling the Maintenance, refer to the *EPSON RC+ 7.0 User’s Guide 5.12.2 [System Configuration] Command (Setup Menu) - [Setup]-[System Configuration]-[Controller]-[Preferences] Page.*

NOTE
 Maintenance is enabled at shipment.

If enabled, the Maintenance information for the timing belts, motors, and reduction gear units will be configured automatically when the robot is configured or changed.

When the Manipulator is deleted from the configuration, the Maintenance information will also be automatically deleted.

For details on the manipulator configuration, refer to *the EPSON RC+ 7.0 User’s Guide 10.1 Setting the Robot Model.*

 CAUTION	■ Changing of the manipulator should be done carefully. The alarm setting will be reset when the manipulator is changed.
--	--

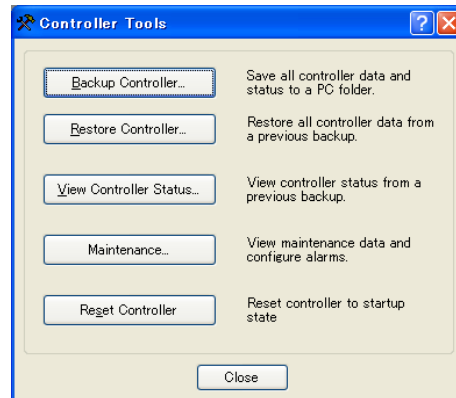
If the Maintenance is enabled, the battery is automatically configured at the first connection.

4.2 Maintenance Information

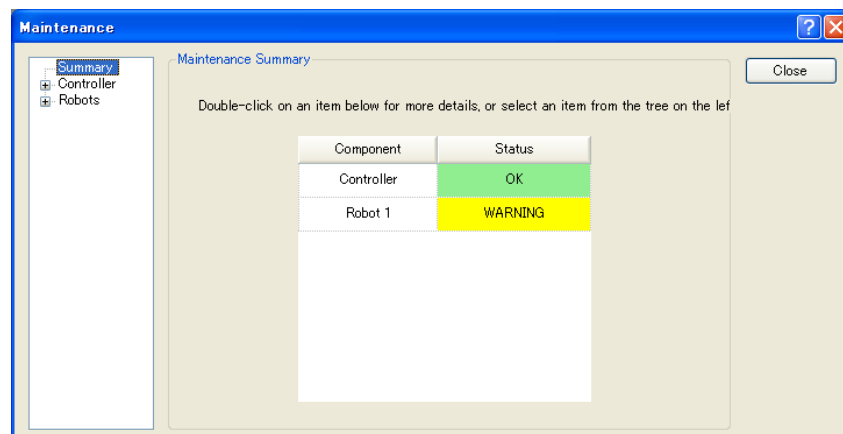
4.2.1 How to Check the Maintenance Information

The configured Maintenance information can be checked in the EPSON RC+.

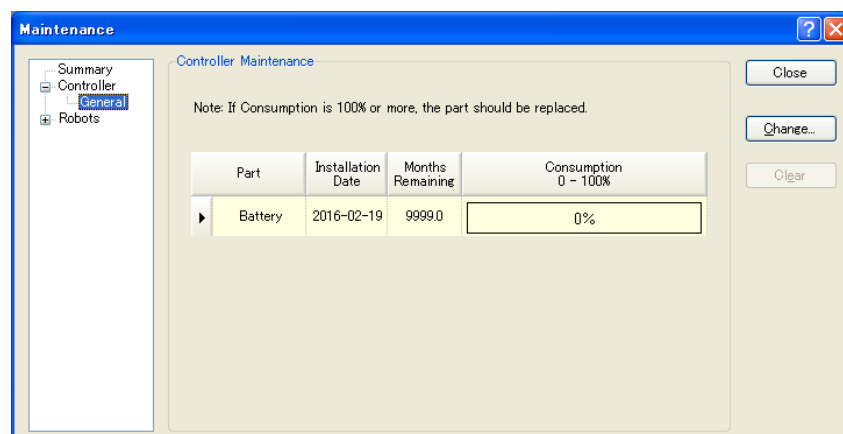
- (1) Select EPSON RC+ 7.0 menu-[Tools]-[Maintenance] to display the [Controller Tools] dialog box.



- (2) To check the controller Maintenance information, click the <Maintenance> button and display the [Maintenance] dialog box.



- (3) Select “General” or specify the axis from the tree to display information of the target parts.



The recommended replacement time for the battery is calculated based on the battery capacity and the Manipulator ON time. The battery may run out if it passes the recommended replacement time.



The recommended replacement time for the parts (e.g. timing belts, motors, reduction gear units) is when it reaches the L10 life (time until 10% failure probability). In the dialog window, the L10 life is displayed as 100%.

4.2.2 How to Edit the Maintenance Information

The configured Maintenance information can be edited in the EPSON RC+.

- (1) Select the EPSON RC+ 7.0 menu-[Tools]-[Maintenance] to display the [Controller Tools] dialog box.
- (2) To edit the Maintenance information, display the [Maintenance] dialog box.
- (3) Select “General” or specify the axis from the tree to display information of the target parts.
- (4) Select the alarm to be changed and click the <Change> button.
- (5) Display the [Change Alarm] dialog box and enter any of the following.



Purchase or replacement date of the battery
 Date of grease up
 Purchase or replacement date of the timing belt
 Purchase or replacement date of the motor
 Purchase or replacement date of the reduction gear unit

- (6) Click the <OK> button and change the specified alarm information.



The offset can be set for the consumption rate of already installed parts. Follow the steps below to calculate a rough offset setting value.

1. Measure the usable months for the past operation by HealthRBAAnalysis.
2. Confirm the past Motor ON time in the controller status viewer.
3. Calculate a rough offset value with the following formula.

$$\text{Offset} = 100 \times \frac{\text{Motor On time}}{24 \times 30.4375 \times \text{Usable months}}$$

For details, refer to the following manual.

EPSON RC+ 7.0 SPEL + Language Reference.

4.2.3 Alarm Notifying Method

The Manipulator status becomes warning and displays warning message if any parts required to perform replacement or grease up.

For details, refer to the following manual.

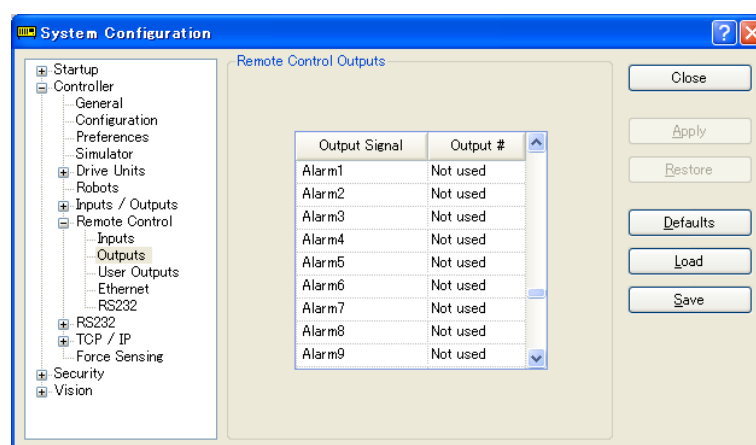
SPEL + Language Reference SPEL + Error Message

The alarm notifying method can be configured by the output bit of the Remote I/O.

The Remote I/O can be configured in the EPSON RC+ 7.0- [Setup] - [System Configuration] - [Controller] - [Remote Control].

For details, refer to the following manual.

EPSON RC+ 7.0 User's Guide 12.1 Remote I/O.



NOTE



The controller enters the warning state if an alarm occurs.

4.2.4 How to Cancel the Alarm

An alarm occurs when the consumption rate of the parts reaches 100%.

NOTE



The alarm cannot be canceled by executing the Reset command or restarting the controller. The alarm can be canceled by the following method.

Operation from [Maintenance] dialog box of the EPSON RC+ 7.0

HealthCtrlReset Command

HealthRBReset Command

Refer to the following section to change the alarm information in the same steps.

Maintenance 4.2.2 How to Edit the Maintenance Information

5. Backup and Restore

5.1 What is the Backup Controller Function

The Manipulator configuration set by EPSON RC+ 7.0 can be stored with the “Backup Controller” function.

The Manipulator settings can be restored easily using the data previously stored with “Backup Controller” after a configuration mistake or Manipulator problem.

Be sure to execute “Backup Controller” before changing the Manipulator setup, before maintenance, or after teaching.

For some problems, backup may not be available before maintenance has to be performed. Be sure to backup the data after making changes, before problems occur.



“Controller Status Storage” is one of the VT series Manipulator functions. It saves the Controller setup data same as “Backup Controller.”

There data can be used as the backup data at restoring.

The methods for “Controller Status Storage” are as follows:

A : “Controller status storage to USB memory”

For details, refer to *Setup & Operation 8. Memory Port.*

B : “Export Controller Status function” in EPSON RC+ 7.0.

For details, refer to the following manual.

EPSON RC+ 7.0 User’s Guide 5.9.9 Import Command (Project Menu).

5.2 Backup Data Types

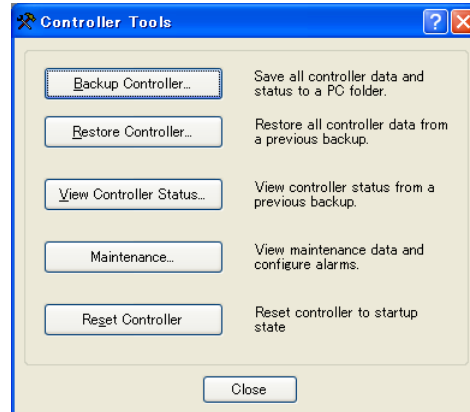
The table below shows the files created with “Backup Controller”.

File Name	Overview	
Backup.txt	Information file for restore	File including information for restoring the Manipulator.
CurrentMnp01.PRM	Manipulator parameters	Stores information such as ToolSet.
InitFileSrc.txt	Initial configuration	Stores various Manipulator parameters.
MCSys01.MCD	Manipulator configuration	Stores connected Manipulator information.
All the files related to Project	Project related	All the project files transferred to the Controller. Includes program files when EPSON RC+ 7.0 is configured to transfer source code to the Controller.
GlobalPreserves.dat	Global Preserve variables	Saves values of Global Preserve variables.
WorkQueues.dat	WorkQue information	Saves information of Queues information of the WorkQue.

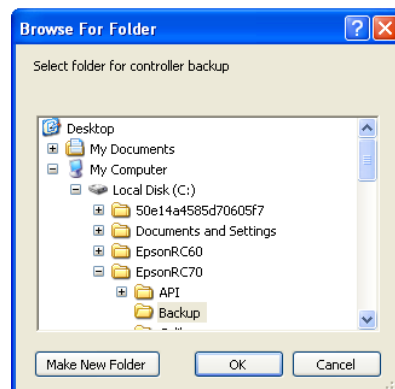
5.3 Backup

Backup the Manipulator status from EPSON RC+ 7.0.

- (1) Select EPSON RC+ 7.0 menu-[Tools]-[Controller] to display the [Controller Tools] dialog.



- (2) Click the <Backup Controller...> button to display the [Browse For Folder] dialog.



- (3) Specify the folder to save the backup data. Create a new folder if desired.
- (4) Click the <OK> button. A folder is created in the specified folder containing the backup data with a name in the following format.
- B_VT_ serial number_ date status was saved
 → Example: B_VT_12345_2016-04-03_092941



CAUTION

- Do not edit the backup files. Otherwise, operation of the robot system after data restoration to the Manipulator is not assured.

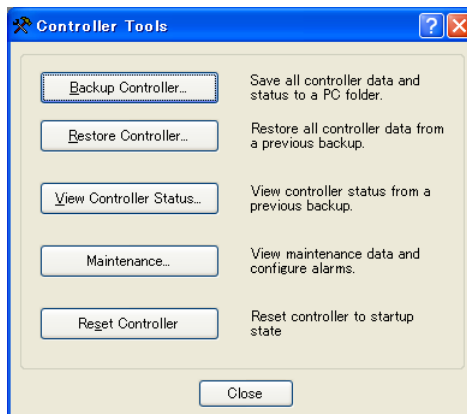
5.4 Restore

Restore the Manipulator status from EPSON RC+ 7.0.

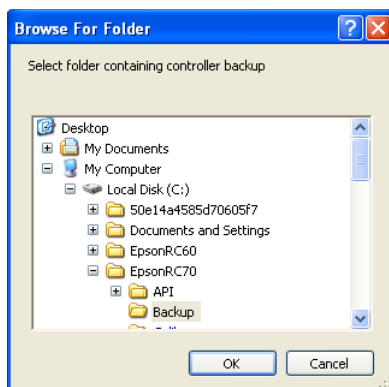


- Make sure that the data used for restore was saved previously for same Manipulator.
- Do not edit the backup files. Otherwise, operation of the robot system after data restoration to the Manipulator is not assured.

- (1) Select the EPSON RC+ 7.0 menu-[Tools]-[Controller] to display the [Controller Tools] dialog.



- (2) Click the <Restore Controller...> button to display the [Browse For Folder] dialog.



- (3) Specify the folder that contains the backup data. Backup data folders are named using the following format:

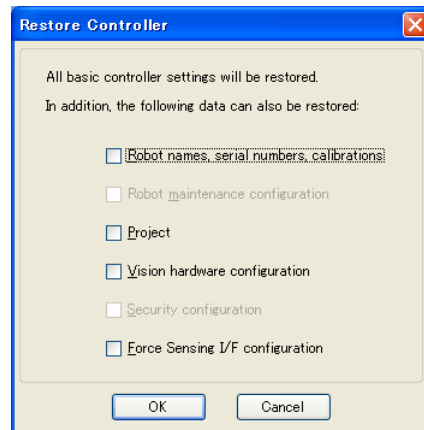
B_VT_ serial number_ date status was saved

→ Example: B_VT_12345_2016-04-03_092941



Controller status backup to USB memory function can also be specified for restore. Specify the following folder.

- (4) Click the <OK> button to display the dialog to select the restore data.



Robot name, serial #, calibration

This checkbox allows you to restore the robot (Manipulator) name, Manipulator serial number, Hofs data, and CalPIs data. Make sure that the correct Hofs data is restored. If the wrong Hofs data is restored, the Manipulator may move to wrong positions.

The default setting is unchecked.

Robot maintenance configuration

This checkbox allows you to restore the robot alarm related files.

For details, refer to *Maintenance 4. Alarm*.

This is not checked by the default setting.

Project

This checkbox allows you to restore the files related to projects.

The default is unchecked.

When a project is restored, the values of Global Preserve variables are loaded.

For details about Global Preserve variable backup, refer to the following manual.

EPSON RC+ 7.0 User's Guide 5.10.10 Display Variables Command (Run Menu).

Vision hardware configuration

This checkbox allows you to restore the vision hardware configuration.

For details, refer to refer to the following manual.

EPSON RC+ 7.0 option Vision Guide 7.0.

This is not checked by the default setting.

Security configuration

This checkbox allows you to restore the security configuration.

For details, refer to refer to the following manual.

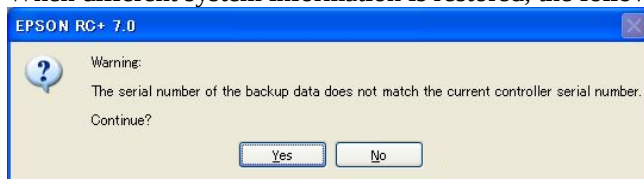
EPSON RC+ 7.0 User's Guide 15. Security.

This is not checked by the default setting.

- (5) Click the <OK> button to restore the system information.



Restore the system configuration saved using Backup Controller only for the same system. When different system information is restored, the following warning message appears.



Click the <No> button (do not restore data) except for special situations such a manipulator replacement.



When restoring the backup including the robot information other than VT series, an error occurs.



You cannot restore the backup including T series robot created in the virtual controller of EPSON RC+ 7.0 to the VT series robot.

6. Firmware Update

This chapter describes the firmware upgrade procedure and data file initialization when firmware or manipulator configuration errors cause Manipulator startup or operation failure.

6.1 Updating Firmware

Firmware (software stored in non-volatile memory) and data files necessary to control the Manipulator are preinstalled in the Manipulator. Controller configuration set from EPSON RC+ 7.0 is always saved in the Manipulator.

Firmware is supplied by CD-ROM as needed. Please contact us for information.

You must use a PC running EPSON RC+ 7.0 connected to a Manipulator with USB to update the Manipulator firmware. Firmware cannot be updated with an Ethernet connection.

6.2 Firmware Upgrade Procedure

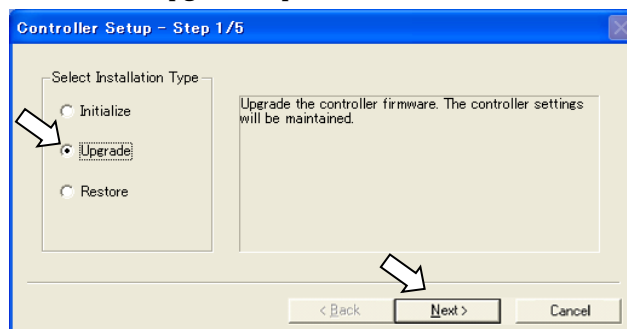
The firmware upgrade procedure is described as follows:



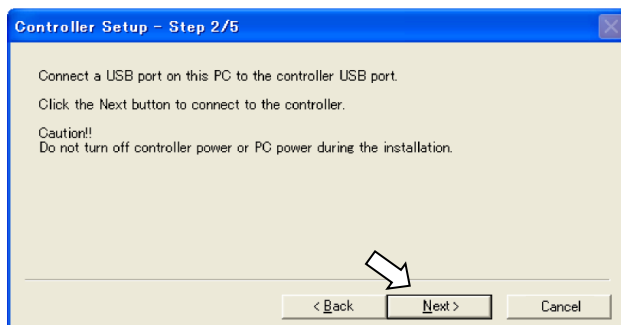
CAUTION

- DO NOT unplug the USB cable, or turn OFF the Manipulator or the development PC during upgrade of the firmware. Doing so may result in malfunction of the robot system.

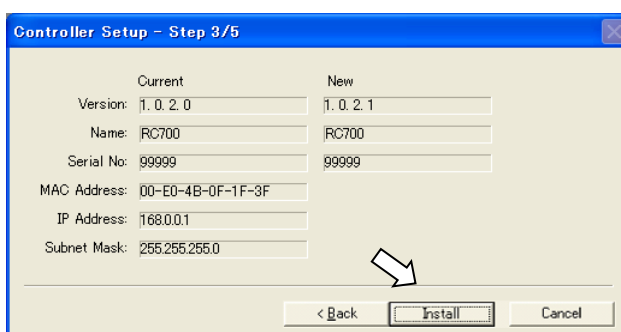
- (1) Connect the development PC and the Manipulator with a USB cable (the firmware cannot be changed with an Ethernet connection).
- (2) Turn ON the Manipulator. (Do not start the development software EPSON RC+ 7.0 until the firmware upgrade is completed.)
- (3) Insert the “firmware CD-ROM” in the development PC CD-ROM drive
- (4) Execute “CtrlsetupT.exe”. The following dialog appears.
- (5) Select the <Upgrade> option button and click the <Next> button.



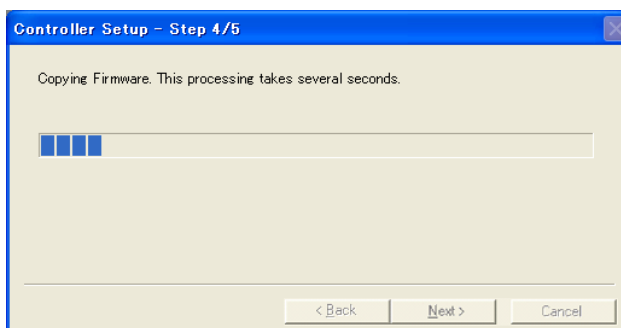
- (6) Make sure that the development PC is connected to the Manipulator with a USB cable and Click the <Next> button.



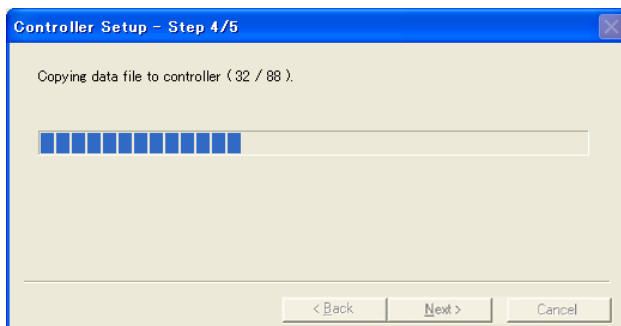
- (7) Check the current firmware version and the new firmware version and click the <Install> button.



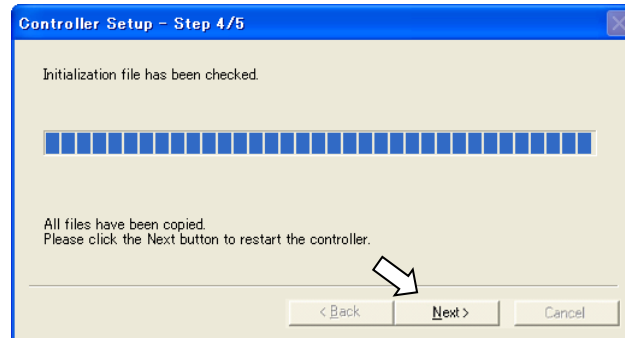
- (8) The firmware upgrade starts. It takes several minutes to complete.



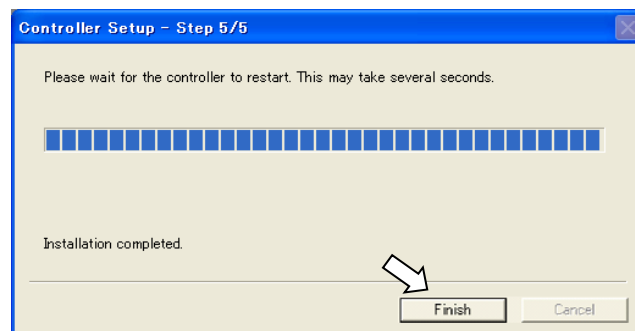
- (9) Continuous data file transfer starts.



- (10) The following dialog appears when transfer has completed. Click the <Next> button to reboot the Manipulator.



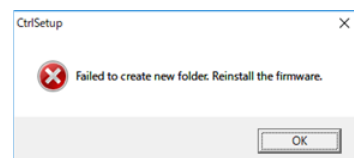
- (11) The following dialog appears after the Controller reboot. Click the <Finish> button.



The firmware upgrade is complete.



When you install the firmware (Ver.7.4.0.2 or later) on the controller which the firmware (before Ver.7.4.0.2) has been installed, the following message is displayed.



When the message is displayed, re-install the firmware.

6.3 Manipulator Recovery

If the Manipulator becomes inoperable, use the procedures described in this section to recover.



Controller Backup is recommended for easy recovery of the Controller operation. For details of Controller Backup, refer to the following manual.

Maintenance 5. Backup and Restore.

6.4 Firmware Initialization Procedure

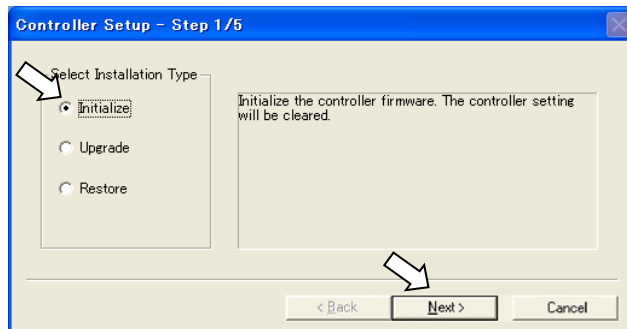
The firmware initialization procedures are described in this section.



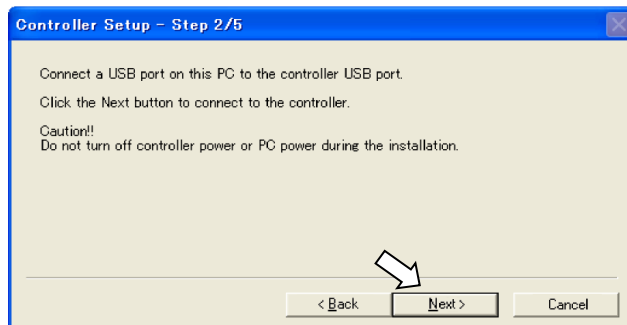
CAUTION

- DO NOT unplug the USB cable, or turn OFF the Manipulator or the development PC during upgrade of the firmware. Doing so may result in malfunction of the robot system.

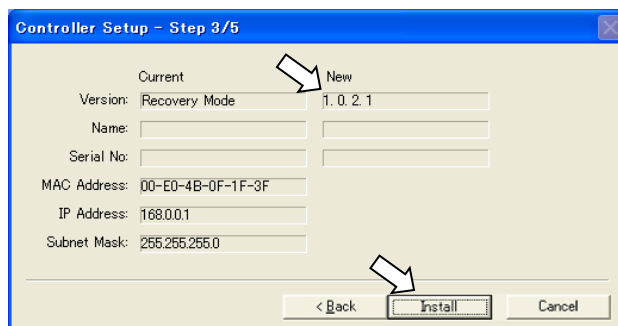
- (1) Connect the development PC to the Manipulator with a USB cable (the firmware cannot be changed with an Ethernet connection).
- (2) Turn ON the Manipulator. Do not start the development software EPSON RC+ 7.0 until firmware initialization is complete.
- (3) Insert the “Firmware CD-ROM” in the development PC CD-ROM drive.
- (4) Execute “Ctrlsetup.exe”.
- (5) Select the <Initialize> option button and click the <Next> button.



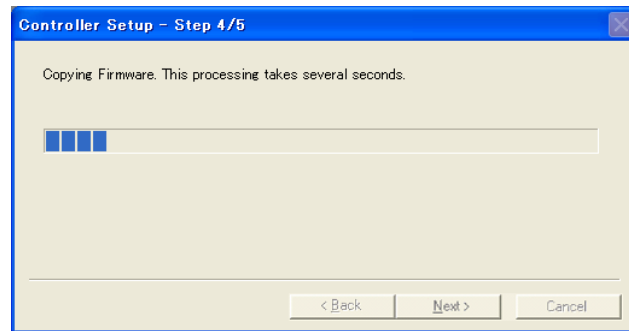
- (6) Make sure that the development PC is connected to the Controller with a USB cable and Click the <Next> button.



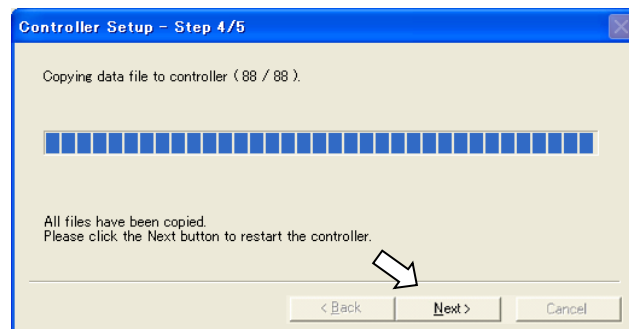
- (7) Check the version information and click the <Install> button.



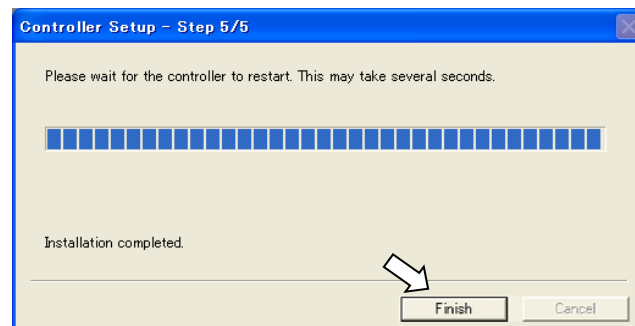
- (8) Firmware and data file transfer starts. It takes several minutes to complete.



- (9) The following dialog appears when transfer is completed. Click the <Next> button to reboot the Manipulator.



- (10) The following dialog appears after the Manipulator reboot. Click the <Finish> button.



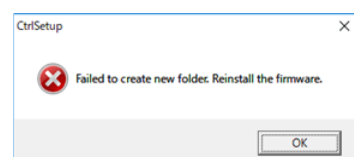
The firmware upgrade is completed.

Start EPSON RC+ 7.0 and restore the Controller settings.

For details of restoring the operating system, refer to *Maintenance 5. Backup and Restore*.



When you install the firmware (Ver.7.4.0.2 or later) on the controller which the firmware (before Ver.7.4.0.2) has been installed, the following message is displayed.



When the message is displayed, re-install the firmware.

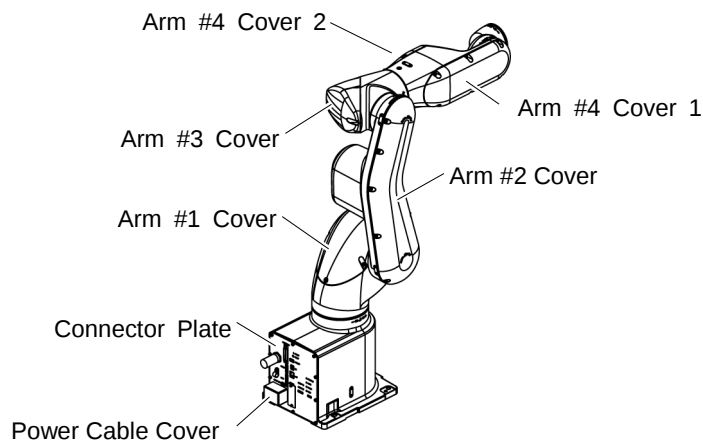
7. Covers

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



WARNING

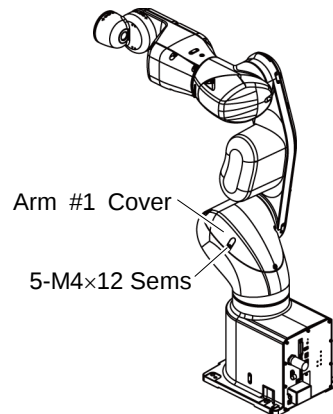
- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



7.1 Arm #1 Cover



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



Arm #1 Cover Removal

Unscrew the mounting bolts, and then lift the Arm #1 Cover.

NOTE



Be careful for wires and tubes when removing the cover.

NOTE



If the Arm #2 interferes with the tools when unscrewing the mounting bolts, move the Arm #2 to the position where it does not interfere with the tools before performing operations.

Arm #1 Cover Installation

Put the Arm #1 Cover to the Manipulator and secure with the mounting bolts.

Hexagon socket head cap bolts with captive washer: 5-M4×12 Sems

Tightening torque: 4 ± 0.2 Nm

NOTE

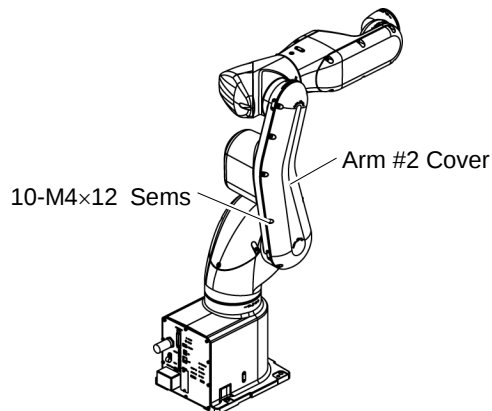


When installing the cover, be careful not to get the cables caught between the arm and cover

7.2 Arm #2 Cover



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



Arm #2 Cover Removal

Unscrew the mounting bolts, and then lift the Arm #2 Cover.

NOTE



Be careful for wires and tubes when removing the cover.

Arm #2 Cover Installation

Put the Arm #2 Cover to the Manipulator and secure with the mounting bolts.

Hexagon socket head cap bolts with captive washer: 10-M4x12 Sems

Tightening torque: 4 ± 0.2 Nm

NOTE

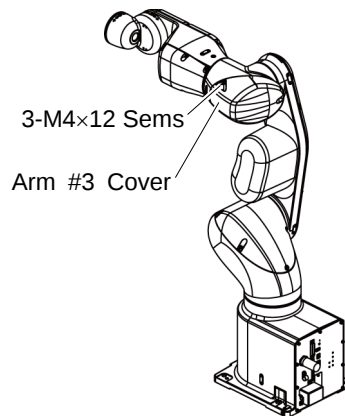


When installing the cover, be careful not to get the cables caught between the arm and cover

7.3 Arm #3 Cover



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



Arm #3 Cover Removal

Unscrew the mounting bolts, and then lift the Arm #3 Cover.

NOTE



Be careful for wires and tubes when removing the cover.

Arm #3 Cover Installation

Put the Arm #3 Cover to the Manipulator and secure with the mounting bolts.

Hexagon socket head cap bolts with captive washer: 3-M4×12 Sems

Tightening torque: 4 ± 0.2 Nm

NOTE

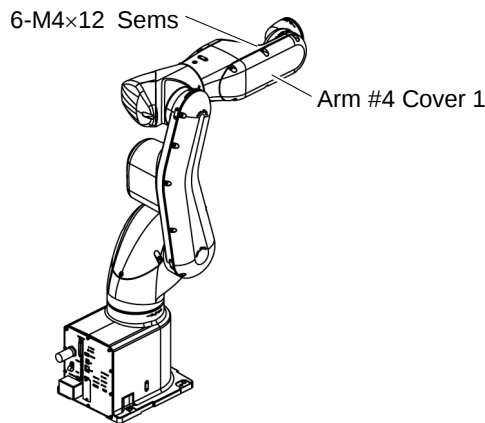


When installing the cover, be careful not to get the cables caught between the arm and cover.

7.4 Arm #4 Cover 1



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



Arm #4 Cover 1 Unscrew the mounting bolts, and then lift the Arm #4 Cover 1.

Removal

NOTE



Be careful for wires and tubes when removing the cover.

Arm #4 Cover 1 Put the Arm #4 Cover 1 to the Manipulator and secure with the mounting bolts.

Installation

Hexagon socket head cap bolts with captive washer: 6-M4x12 Sems

Tightening torque: 4 ± 0.2 Nm

NOTE

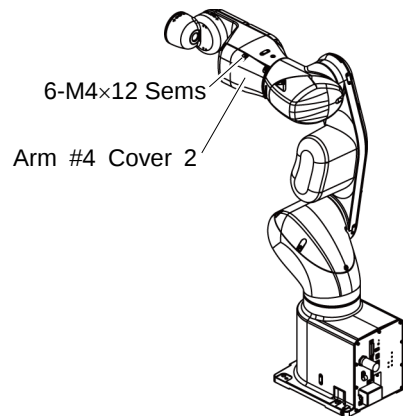


When installing the cover, be careful not to get the cables caught between the arm and cover

7.5 Arm #4 Cover 2



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



Arm #4 Cover 2 (1) Unscrew the mounting bolts, and then lift the Arm #4 Cover 2.

Removal

NOTE



Do not remove the cover forcibly when removing it.

(2) Disconnect the connector from the board mounted on the rear side of the Arm #4 Cover 2.

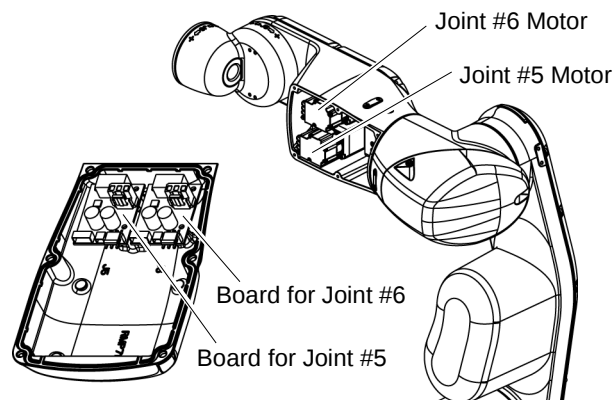
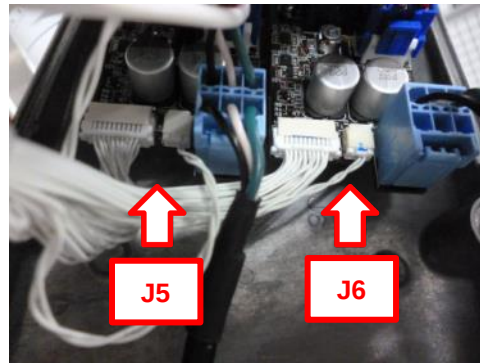
Arm #4 Cover 2 (1) Connect the connector to the board on the rear side of the Arm #4 Cover 2.

Installation

NOTE



Connect the connector to the board which supports each motor (J5, J6).
Be careful not to connect it to wrong board or forget to connect.



(2) Put the Arm #4 Cover 2 to the Manipulator and secure with the mounting bolts.

Hexagon socket head cap bolts with captive washer: 6-M4×12 Sems

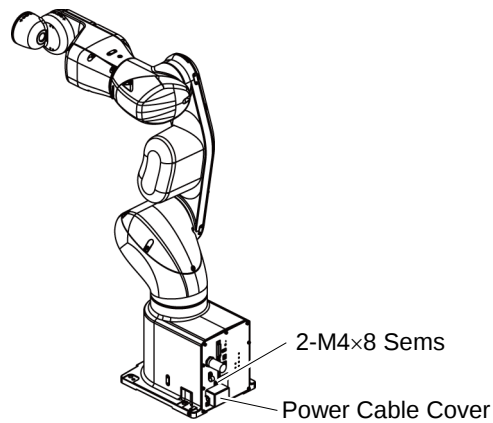
Tightening torque: 4 ± 0.2 Nm

NOTE



When installing the cover, be careful not to get the cables caught between the arm and cover.

7.6 Power Cable Cover



Power Cable Cover Removal

Unscrew the mounting bolts, and then lift the Power Cable Cover.

Power Cable Cover Installation

Put the Power Cable Cover to the connector plate and secure with the mounting bolts.

Hexagon socket head cap bolts with captive washer: 2-M4×8 Sems

Tightening torque: 0.9 ± 0.1 Nm

NOTE



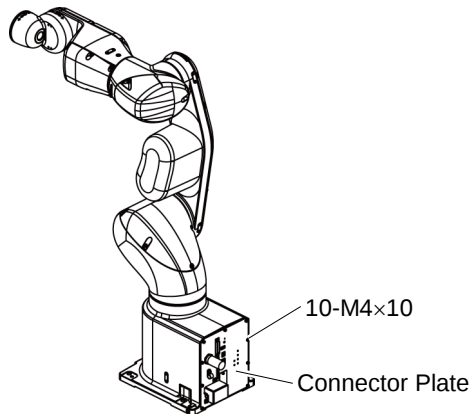
When installing the cover, be careful not to get the cables caught between the arm and cover

7.7 Connector Plate



CAUTION

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



Connector Plate Removal

- (1) Remove the Power Cable Cover.
Refer to *Maintenance: 7.6 Power Cable Cover*.
- (2) Remove the power cable clamp and then remove Power Cable Connector.

NOTE

When removing the Power cable connector, pull it out with pushing latches on both side of the connector.
- (3) Unscrew the Connector Plate mounting bolts and then remove the Connector Plate.

Connector Plate Installation

- (1) Put the Connector Plate to the base and secure using the mounting bolts.
Hexagon socket head cap button bolt: 10-M4×10
Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$
- (2) Connect the Power Cable Connector and install the power cable clamp.
- (3) Mount the Power Cable Cover.
Refer to *Maintenance: 7.6 Power Cable Cover*.

8. Cable



WARNING

- Do not connect or disconnect the motor connectors while the power to the robot system is turned ON. Connecting or disconnecting the motor connectors with the power ON is extremely hazardous and may result in serious bodily injury as the Manipulator may move abnormally, and also may result in electric shock and/or malfunction of the robot system.
- To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.
- Be careful not to get any foreign substances in the Manipulator, connectors, and pins during maintenance. Turning ON the power to the robot system when any foreign substances exist in them is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



CAUTION

- Be sure to connect the cables properly. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.

8.1 Replacing Cable Unit

	Name		Quantity	Note
Maintenance part	Cable Unit		1	2191349
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 hexagon socket head cap bolts
		width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Cross-point screwdriver (No. 2)		1	For cross-recessed screw
	Nippers		1	For cutting wire tie
Material	Wire tie		-	
Grease	GPL-224		-	For purchasing grease, please contact the supplier in your region.

 CAUTION	■ If the connectors have been disconnected during the replacement of the cable unit, be sure to reconnect the connectors to their proper positions. Refer to the wiring diagrams. Improper connection of the connectors may result in improper function of the robot system. For details on the connections, refer to the following manual. <i>Maintenance: 3. Manipulator Structure.</i> ■ When installing the cover, be careful not to allow the cables to interfere with the cover mounting and do not bend these cables forcibly to push them into the cover. Unnecessary strain on cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system. When routing the cables, observe the cable locations after removing the cover. Be sure to place the cables back to their original locations. ■ Be sure to connect the cables completely. Do not allow unnecessary strain on the cables. (Do not put heavy objects on the cables. Do not bend or pull the cables forcibly.) The unnecessary strain on the cables may result in damage to the cables, disconnection, and/or contact failure. Damaged cables, disconnection, or contact failure is extremely hazardous and may result in electric shock and/or improper function of the robot system.
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When removing the Joint #2 motor unit, tilt the Arm #2 and press it against the Arm #1.

Reference: *Maintenance: 10.1 Joint #2 - Replacing the Motor, Removal step (2)*

When removing the Joint #3 motor unit, tilt the Arm #3 and press it against the Arm #2.

Reference: *Maintenance: 11.1 Joint #3 - Replacing the Motor, Removal step (2)*

Cable Unit
Removal

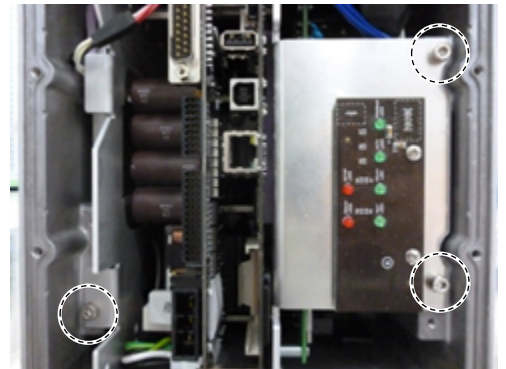
- (1) Move the Manipulator to the origin posture (0 pulse position).
- (2) Turn OFF the Manipulator.
- (3) Remove the following covers and plate.

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

Reference: *Maintenance 7 Covers*

- (4) Unscrew the mounting screws of the controller unit.

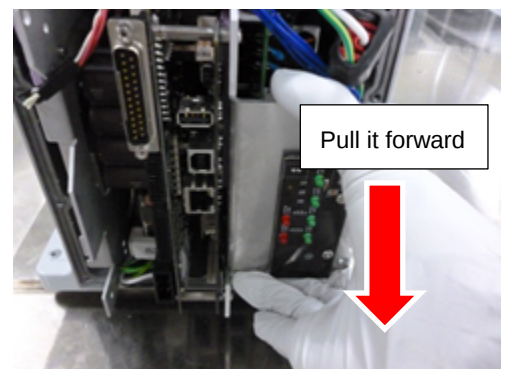
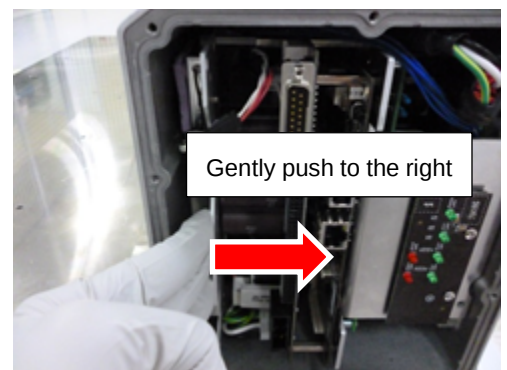
Hexagon socket head cap bolts:
3-M4×10 (with plain washer)



- (5) Pull out the controller unit from the Manipulator base.



When pulling it out, firstly push the plate of the controller unit to the right (see the picture) gently, then remove the thermal sheet on the base and the controller unit. Next, pull the controller unit forward.



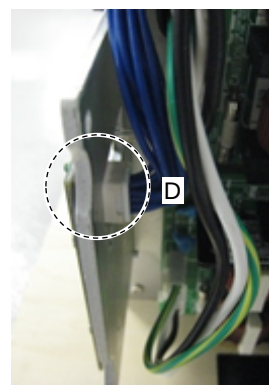
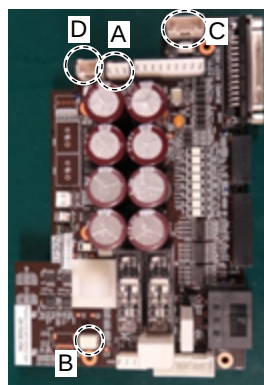
- (6) Disconnect the following connectors of the controller unit.

A: Power cable connector

B: Signal cable connector

C: Hand I/O connector

D: LED connectors × 2



- (7) Remove the ground wire terminals inside the base.

Cross recessed head screws: M4×6



- (8) Cut off the wire tie bound to the plate inside the base.

Wire tie: AB150



- (9) Cut off the wire ties bound inside the Arm #1.

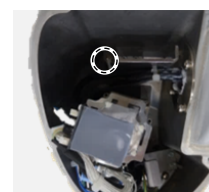
Wire ties : AB150 × 2

AB100 × 1



- (10) Remove the ground wire terminals of Arm #1.

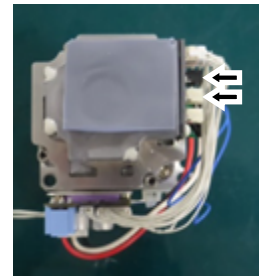
Cross recessed head screws: 2-M4× 6



- (11) Disconnect the power cable connector from the AMP board of Joint #1 motor.



- (12) Disconnect the signal cable connectors (for motor × 2) of Joint #1 motor.



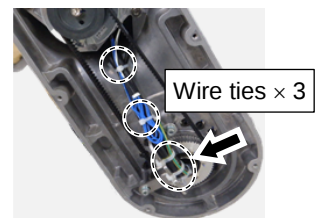
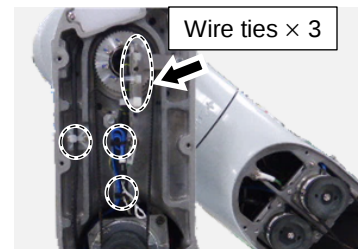
- (13) Cut off the wire ties bound to inside the Arm #2.

Wire ties : AB150 × 6
AB100 × 5

NOTE

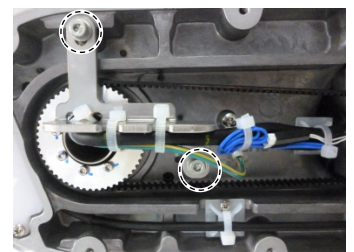
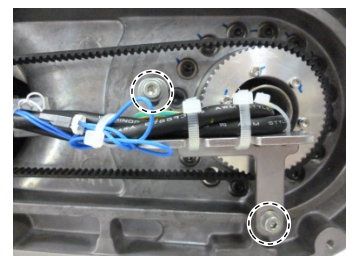


Be careful not to cut the harness.



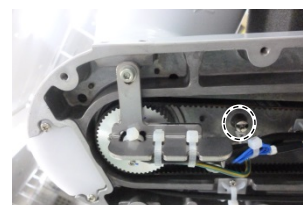
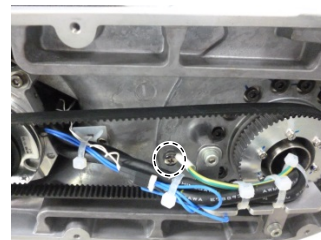
- (14) Remove the cable fixing plate of Arm #2.

Hexagon socket head cap bolts with captive washer: 4-M4×12



- (15) Remove the ground wire terminals of Arm #2.

Cross recessed head screws: 2-M4×6



- (16) Remove the Joint #2 motor.

Reference: *Maintenance 10.1 Replacing Joint #2 Motor*

- (17) Remove the Joint #3 motor.

Reference: *Maintenance 11.1 Replacing Joint #3 Motor*

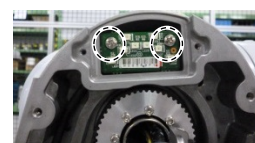
- (18) Remove the light guide plate.

Cross recessed head screws: 2-M3×10



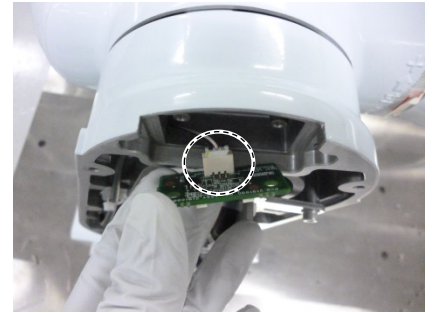
- (19) Unscrew the cross recessed head screws fixing the LED board.

Cross recessed head screws: 2-M3×6

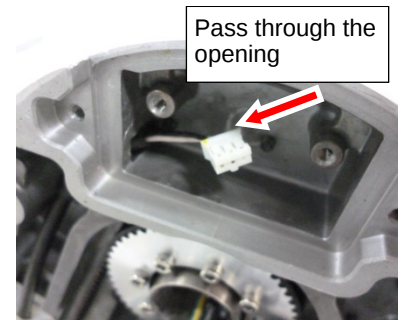


- (20) Disconnect the connector which is connected to the LED board.

Connector: LED_CN1

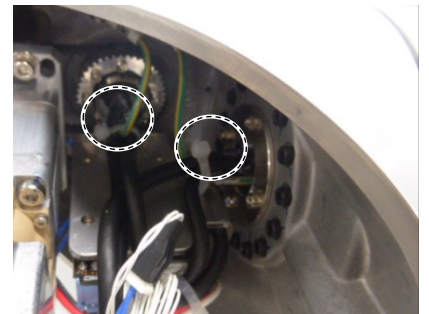


- (21) Pass the LED cable through the opening of the Arm #2 and pull the LED cable out.



- (22) Cut off the wire tie bound to the plate inside the Arm #3.

Wire ties: AB150 × 2



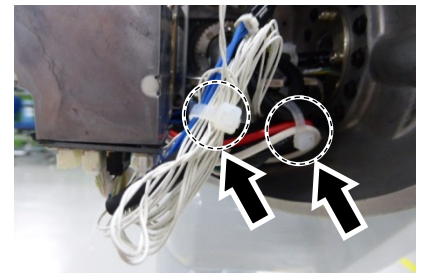
- (23) Cut off the wire ties that bind the power cable and the signal cable of Joint #4 motor.

Wire ties: AB100 × 2

NOTE

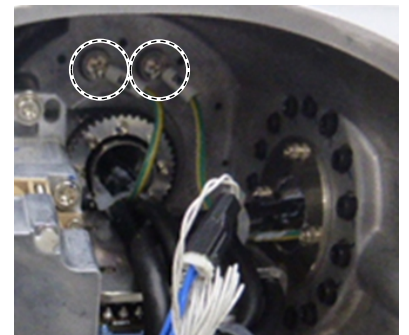


Be careful not to cut the harness.

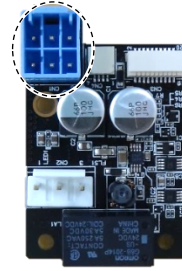


- (24) Remove the ground wire terminals of Arm #3.

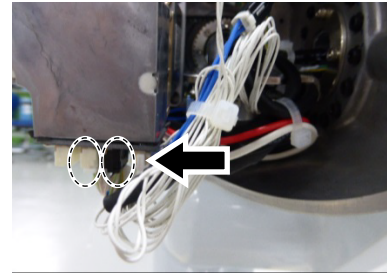
Cross recessed head screws: 2-M4×6



- (25) Disconnect the power cable connector from the AMP board of Joint #4 motor.

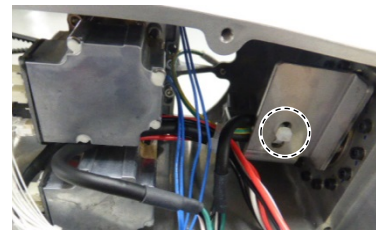


- (26) Disconnect the signal cable connectors (for motor × 2) of Joint #4 motor.



- (27) Cut off the wire ties bound to the plate inside the Arm #4.

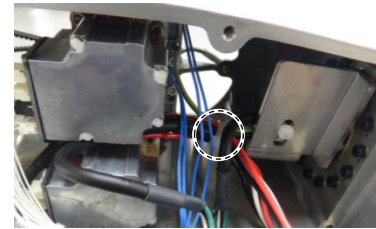
Wire tie: AB150



- (28) Cut off the wire tie that binds the following cables and ground wire.

Wire tie: AB100

Joint #5 motor cable
Signal cable (for motor)
Joint #6 motor cable
Ground wire

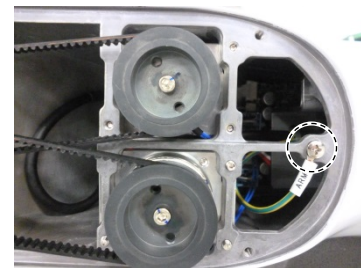


NOTE

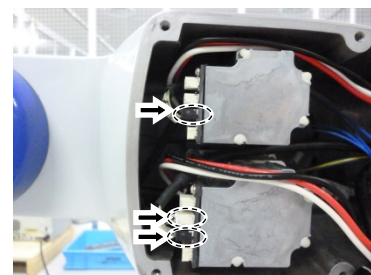
 Be careful not to cut the harness.

- (29) Remove the ground wire terminals of Arm #4.

Cross recessed head screws: M4×6



- (30) Remove the signal cable connectors (for motor × 3) of the Joint #5 motor and Joint #6 motor.



- (31) Pass the ground wire and the following cables of each arm through the sleeve of each joint and pull them out.

Ground wires × 4

Signal cables (for motor × 5)

LED cable × 1

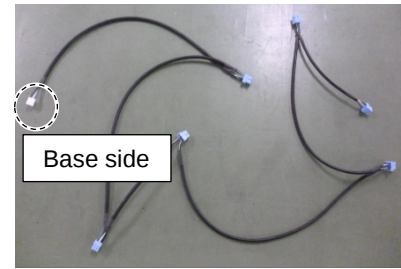
- (32) Pass the power cable through the sleeve of each joint and pull it out in the following order.

Arm #4 → Arm #3 → Arm #2 → Arm #1 → Base

Cable Unit
Installation

- (1) Pass the new power cable in the following order.

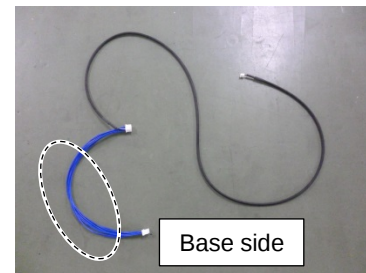
Base
→ Arm #1
→ Joint #1 Timing Belt
→ Arm #2
→ Arm #3
→ Joint #4 Timing Belt
→ Arm #4



NOTE When passing the cables between arms, be sure to pass them through the sleeve of each joint. The white connector is the base side.

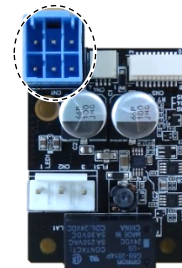
- (2) Pass the new LED cables in the following order.

Base
→ Arm #1
→ Joint #1 Timing Belt
→ Arm #2



NOTE When passing the cables between arms, be sure to pass them through the sleeve of each joint. The blue cable is the base side.

- (3) Connect the power cable connectors (× 6) of the Joint #1, 2, 3, 4, 5, 6 AMP board.



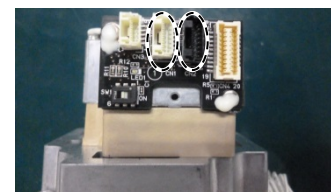
- (4) Connect the signal cable connector (for motor) of the Joint #1, 2, 3, 4, 5, 6 motor unit.



NOTE When passing the cables between arms, be sure to pass them through the sleeve of each joint.

Confirm that the joint marked on the wire marker of the signal cable and the joint of the motor unit to be connected are the same.

Also, the same colored connector is connected to each connector. (For the Joint #6 motor, only black colored connector is connected.)



- (5) Install the Joint #2 motor.

Reference: *Maintenance 10.1 Replacing Joint #2 Motor*

- (6) Install the Joint #3 motor.

Reference: *Maintenance 11.1 Replacing Joint #3 Motor*

- (7) Fix the ground wire between the base and the Arm #1.

Cross recessed head screws: 2-M4×6

Tightening torque: 2.0 ± 0.1 N·m

Base side:

Ground wire terminal marked “BASE” on the wire marker.



Arm #1 side:

Ground wire terminal marked “ARM1” on the wire marker.



- (8) Fix the ground wire between the Arm #1 and the Arm #2.

Cross recessed head screws: 2-M4×6

Tightening torque: 2.0 ± 0.1 N·m

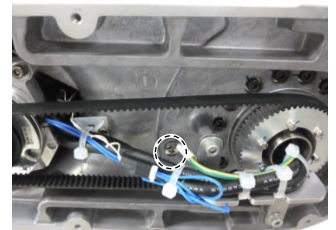
Arm #1 side:

Ground wire terminal marked “ARM1” on the wire marker.



Arm #2 side:

Ground wire terminal marked “ARM2” on the wire marker.



- (9) Fix the ground wire between the Arm #2 and the Arm #3

Cross recessed head screws: 2-M4×6

Tightening torque: 2.0 ± 0.1 N·m

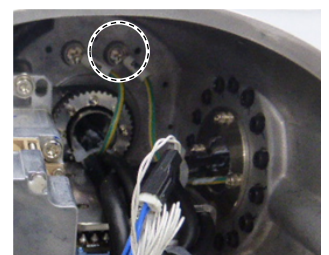
Arm #2 side:

Ground wire terminal marked “ARM2” on the wire marker.



Arm #3 side:

Ground wire terminal marked “ARM3” on the wire marker.



- (10) Fix the ground wire between the Arm #3 and the Arm #4.

Cross recessed head screws: 2-M4×6

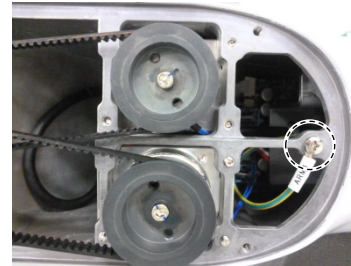
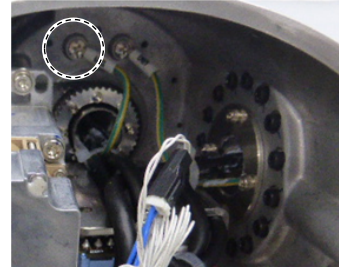
Tightening torque: $2.0 \pm 0.1 \text{ N}\cdot\text{m}$

Arm #3 side:

Ground wire terminal marked “ARM3” on the wire marker.

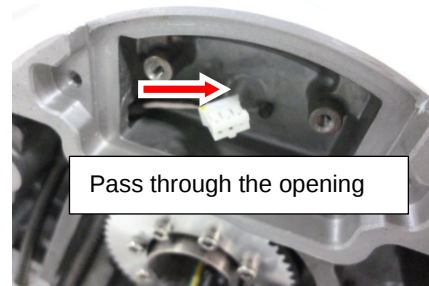
Arm #4 side:

Ground wire terminal marked “ARM4” on the wire marker.



- (11) Connect the LED cable connector to the opening of the end of Arm #2.

NOTE  You can pass the connector through the opening easily by using the wire tie.



- (12) Connect the LED cable connector to the LED board.

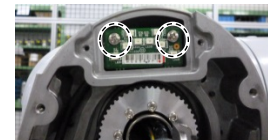
Connectors: LED_CN1



- (13) Fix the LED board.

Cross recessed head screws: 2-M3×6

Tightening torque: $0.45 \pm 0.1 \text{ N}\cdot\text{m}$



- (14) Fix the light guide plate.

Cross recessed head screws: 2-M3×10

Tightening torque: $0.45 \pm 0.1 \text{ N}\cdot\text{m}$



- (15) Pass the wire tie through the hole inside the base.
Bind the following cables and the ground wire with the wire tie.

Wire tie: AB150

Power cable

LED cable

Signal cable (for motor)

Ground wire



- (16) Pass the wire tie through the hole on the two plates of Arm #1. Bind the following cables and the ground wire with the wire tie.

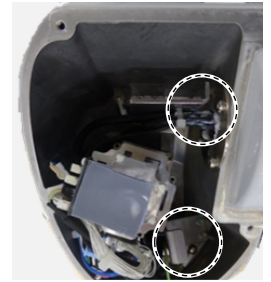
Wire tie: AB150

Power cable

LED cable

Signal cable (for motor)

Ground wire



- (17) Bind the following cables between the Joint #1 motor and the controller unit with the wire tie.

Wire tie: AB100

Signal cable (for motor)

Signal cable (for AMP board)



- (18) Pass the wire tie through the plate inside the Arm #2.
Bind the following cables with the wire tie.

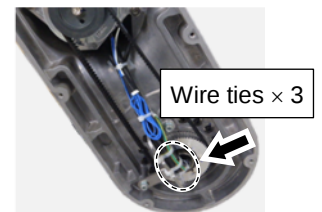
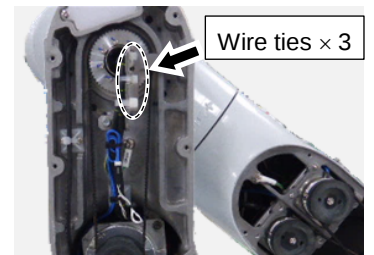
Wire tie: AB150

Power cable

LED cable (Joint #2 side only)

Signal cable (for motor)

Ground wire



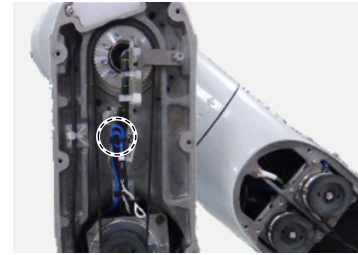
- (19) Fold the each brake cable for Joint #2 and Joint #3 motors into the length of 40mm. Bind it with the following cables with the wire tie.

Wire tie: AB100

Power cable

Signal cable (for motor)

Brake cable



- (20) Pass the wire tie through the mount base A and B inside Arm #2.

Bind the following cables with the wire tie.

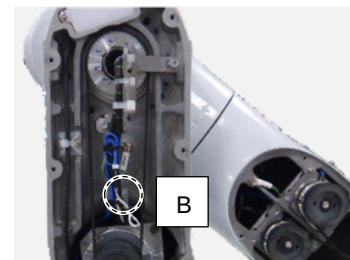
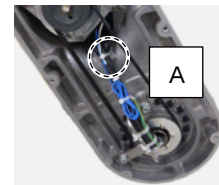
Wire tie: AB100

Power cable

Signal cable (for motor)

Brake cable

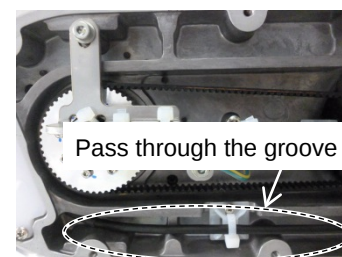
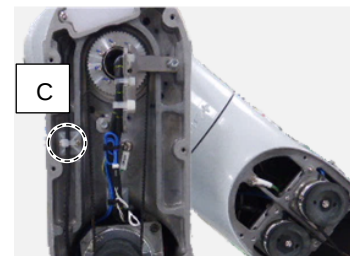
LED cable (mount base A only)



- (21) Pass the LED cable through the groove for LED cable wiring of Arm #2.

Pass the wire tie through the mount base C and bind the LED cable with the wire tie.

Wire tie: AB100



- (22) Pass the wire tie through the hole inside the Arm #3.

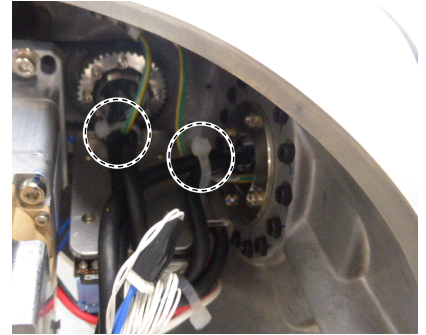
Bind the following cables with the wire tie.

Wire tie: AB150

Power cable

Signal cable (for motor)

Ground wire



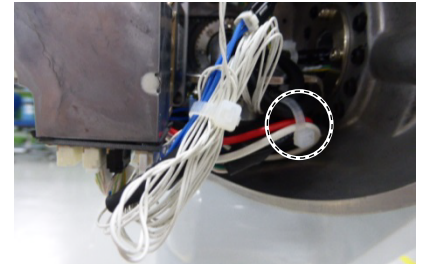
- (23) Bind the following cables between the Joint #4 motor and the Joint #3 motor with the wire tie.

Wire tie: AB100

Power cable

Signal cable (for motor)

Motor cable



- (24) Bind the following cables between the Joint #4 motor and the Joint #3 motor with the wire tie.

Wire tie: AB100

Signal cable(for AMP board)

Signal cable (for motor)

Brake cable



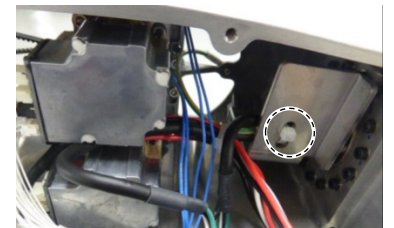
- (25) Pass the wire tie through the hole inside the Arm #4. Bind the following cables and the ground wire with the wire tie.

Wire tie: AB150

Power cable

Signal cable (for motor)

Ground wire



- (26) Bind the following cables and the ground wire with the wire tie.

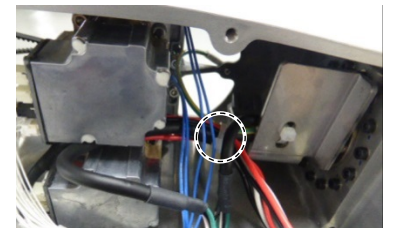
Wire tie: AB100

Motor cable (Joint #5)

Signal cable

Motor cable (Joint #6)

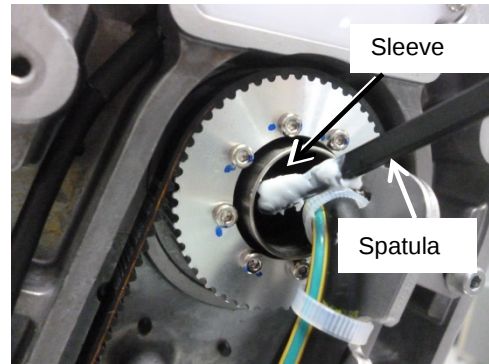
Ground wire



- (27) Apply grease to the cables inside the each Joint sleeve.

Grease: GPL-224

Between Base-Arm #1 : $4.5 \pm 1g$
 Between Arm #1-Arm #2 : $4.5 \pm 1g$
 Between Arm #2-Arm #3 : $2.8 \pm 0.5g$
 Between Arm #3-Arm #4 : $2.8 \pm 0.5g$

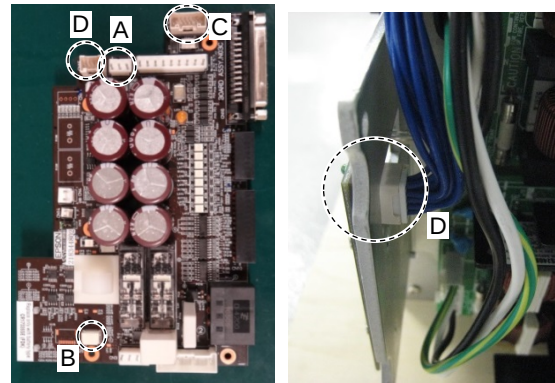


NOTE  Apply grease evenly to the entire cable inside the sleeve and the end of the sleeve by using a slim spatula

When applying the grease, be careful not to attach the grease to the AMP board.

- (28) Connect the following connectors to the controller unit.

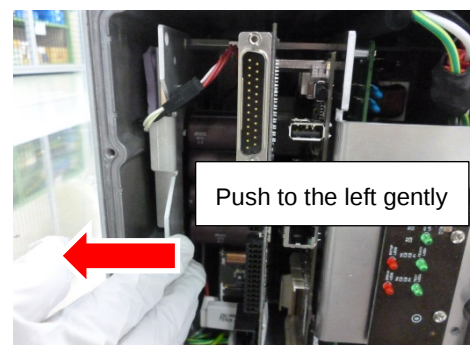
A: Power cable connector
 B: Signal cable connector
 C: Hand I/O connector
 D: LED connectors $\times 2$



- (29) Push the controller unit into the base.

NOTE  Insert the controller unit while moving it to the right (see the picture).

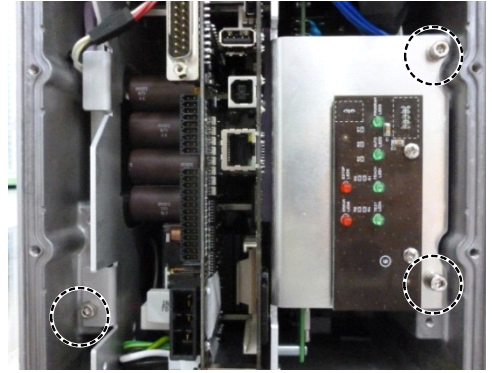
Then, gently move the plate of the controller unit to the left and let the thermal sheet contacts with the wall inside the base.



- (30) Tighten the mounting screws of the controller unit.

Hexagon socket head cap bolts: 3-M4×10
(with plain washer)

Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$



- (31) Install the following covers the plate.

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

Reference: *Maintenance 7 Covers*

8.2 Insert or Pull out of Power Cable

	Name	Quantity	Note
Tools	Cross-point screwdriver (No. 2)	1	For cross-recessed screw

- Power Cable Pull out
- (1) Turn OFF the Manipulator.
 - (2) Remove the power cable cover.

Reference: *Maintenance 7.6 Power Cable Cover*

- (3) Remove the power cable clamp.
- (4) Disconnect the power cable connector.



When removing the power cable connector, pull it out with pushing latches on both sides of the connector.

- Power Cable Insertion
- (1) Connect the power cable connector.
 - (2) Mount the power cable clamp.
 - (3) Mount the power cable cover.

Reference: *Maintenance 7.6 Power Cable Cover*

9. Joint #1



WARNING

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



CAUTION

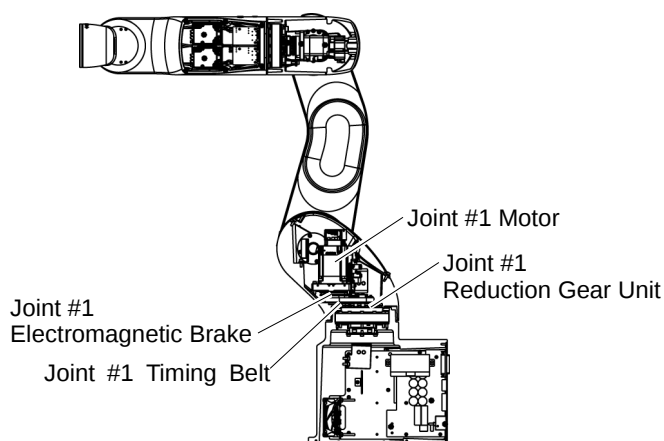
- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motor units, reduction gear units, timing belts), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Robot system.

Because of that, it is necessary to perform calibration (encoder rest and calibration) to match these origins.

After replacing the parts, refer to the following section to perform calibration.

Maintenance 19. Calibration.



9.1 Replacing Joint #1 Motor

	Name		Quantity	Note
Maintenance parts	Joint #1 motor unit		1	2194596
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 hexagon socket head cap bolts
		width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Nippers		1	For cutting wire tie
	Belt tension meter		1	Refer: Unitta U-505
Material	Wire tie		-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

Joint #1 Motor (1) Turn OFF the Manipulator.

Removal

(2) Remove the Arm #1 Cover.

Reference: *Maintenance 7.1 Arm #1 Cover.*

(3) Cut off the wire tie that binds the following cables.

Signal cable and the signal cable for AMP board
between the Joint #1 motor and the controller unit

NOTE



Be careful not to cut the harness.



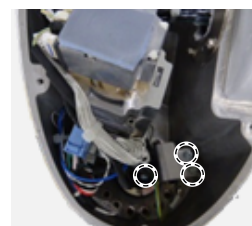
(4) Cut off the wire tie on the plate (Arm #1 sleeve side) and remove the plate.

Hexagon socket head cap bolts: 2-M4×12 (with washer)

NOTE

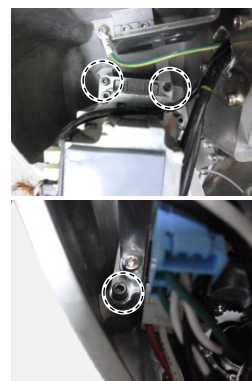


Be careful not to cut the harness.



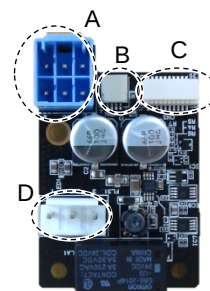
(5) Remove the motor unit from the Arm #1.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)



- (6) Disconnect the following connectors from the AMP board.

A: Power cable connector
 B: Brake connector
 C: Signal cable connector (for AMP board)
 D: Motor connector



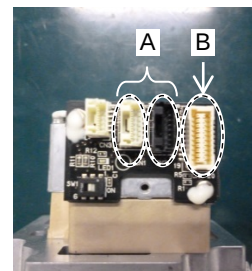
- (7) Disconnect the following connectors from the motor.

A: Signal cable connectors (for motor × 2)
 B: Signal cable connector (for AMP board)

NOTE



The cables will be necessary again.
 Be careful not to lose them.



- (8) Remove the AMP board fixing plate (with AMP board) from the motor unit.

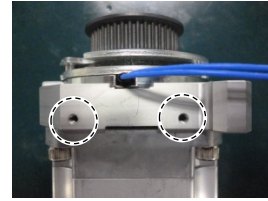
Hexagon socket head cap bolts: 2-M3×6



Joint #1 Motor Installation

- (1) Fix the AMP board fixing plate (with AMP board) to a new motor unit.

Hexagon socket head cap bolts: 2-M3×6
Tightening torque: 2.0 ± 0.1 N·m

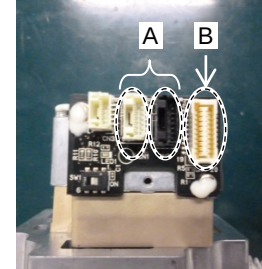


- (2) Connect the following connectors of the motor.

A: Signal cable connectors (for motor × 2)
B: Signal cable connector (for AMP board)

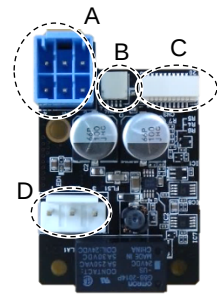


Connector for the signal cable connector (for motor) is the same color.

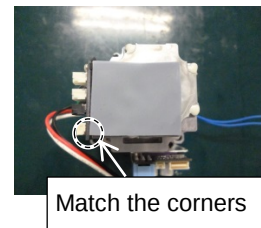


- (3) Connect the following connectors of the AMP board.

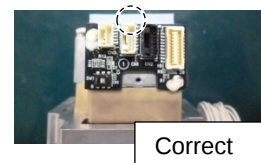
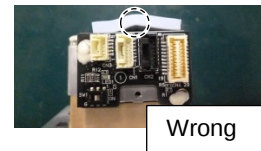
A: Power cable connector
B: Brake connector
C: Signal cable connector (for AMP board)
D: Motor connector



- (4) Attach the thermal sheet on the bottom of the motor unit.
For the attaching position, refer to the picture on the right.



Make sure that the entire surface of the thermal sheet contacts with the rear side of the motor unit without lifting up the center of the sheet.



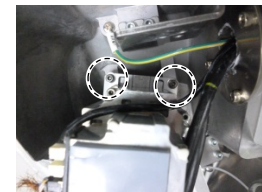
- (5) Pass the timing belt through the motor pulley and loosely secure to the Arm #1.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)



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

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



- (6) Apply proper tension to the motor unit and fix it.

Joint #1 timing belt tension: 34~70 N

Belt tension meter setting values

Weight: 2.5g/mm width×m span

Width: 9.0mm

Span: 60mm

Hexagon socket head cap bolts: 3-M4×22 (with slotted hole washer)

Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

NOTE



Regarding belt tension:

Jumping (position gap) may occur if the value is below the lower limit.

Vibration (abnormal noise) or reduction in life of the parts may occur if the value exceeds the upper limit.

When you replace with a new belt, belt extends and the belt tension may decrease in the initial stage. Make sure to operate the robot two to three days and check the belt tension again.

- (7) Mount the plate of the Arm #1 sleeve side.

Hexagon socket head cap bolts: 2-M4×12 (with a washer)

Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

Pass the wire tie through the hole on the plate.

Bind the following cables and the ground wire with the wire tie.

Motor cable

Signal cable (for motor)

LED cable

Ground wire



- (8) Bind the following cables between the Joint #1 motor and the controller unit with the wire tie.

Wire tie: AB100

Signal cable (for motor)

Signal cable (for AMP board)



- (9) Mount the Arm #1 cover.

Reference: *Maintenance 7.1 Arm #1 Cover*

- (10) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*

NOTE



When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

- (11) Calibrate the Joint #1.

Reference: *Maintenance 19. Calibration*

9.2 Replacing Joint #1 Reduction Gear Unit

Reduction gear unit is replaced by serviceman.

For replacement of the reduction gear unit, please contact the supplier of your region.

9.3 Replacing Joint #1 Timing Belt

	Name	Quantity	Note
Maintenance parts	Timing Belt	1	1751536
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Cross-point screwdriver (No. 2)	1	For cross-recessed screw
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

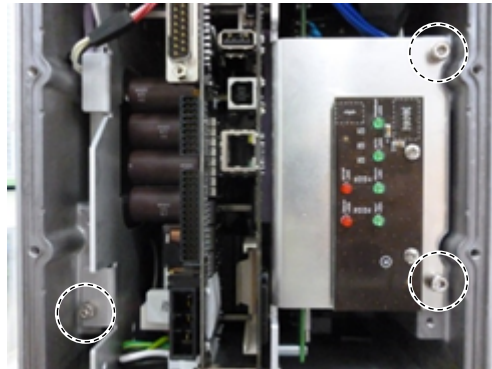
Joint #1
Timing Belt
Removal

- (1) Turn OFF the Manipulator.
- (2) Remove the Arm #1 cover and the connector plate.

Reference: *Maintenance 7. Covers*

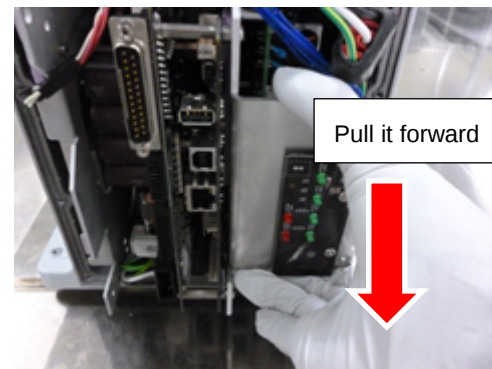
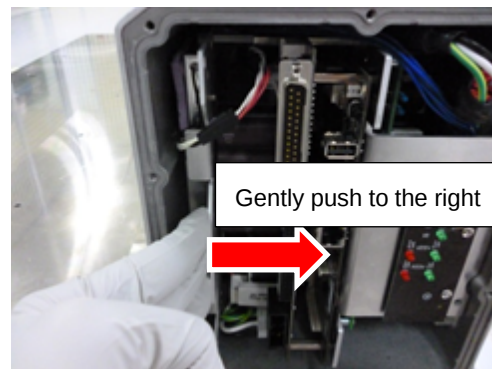
- (3) Unscrew the mounting screws of the controller unit.

Hexagon socket head cap bolts:
3-M4×10 (with a plain washer)



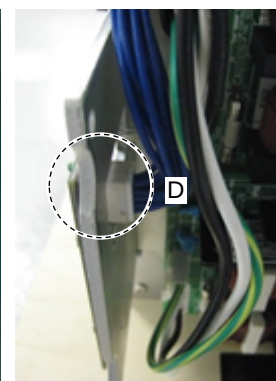
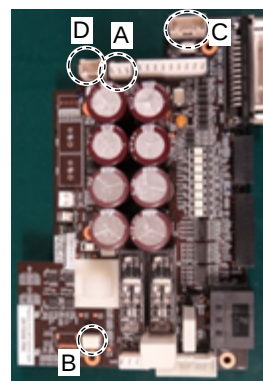
- (4) Pull out the controller unit from the Manipulator base.

NOTE When pulling it out,
firstly push the plate of the controller unit to the right (see the picture) gently, then remove the thermal sheet on the base and the controller unit.
Next, pull the controller unit forward.



- (5) Disconnect the following connectors of the controller unit.

A: Power cable connector
B: Signal cable connector
C: Hand I/O connector
D: LED connectors × 2



- (6) Remove the ground wire terminals inside the base.

Cross recessed head screws: M4×6



- (7) Cut off the wire tie bound to the plate inside the base.

Wire tie: AB150



- (8) Remove the Joint #1 motor unit.

Reference: *Maintenance 9.1 Replacing Joint #1 Motor*
Joint #1 Motor Removal (3) through (7)

- (9) Pull out the following cables from the Arm #1 side and remove the Joint #1 timing belt.

Power cable
Signal cable (for motor)
LED cable
Ground wire

Joint #1
Timing Belt
Installation

- (1) Pass the following cables through a new Joint #1 timing belt.

Power cable
Signal cable (for motor)
LED cable
Ground wire

- (2) Mount the Joint #1 motor unit.

Reference: *Maintenance 9.1 Replacing Joint #1 Motor*
Joint #1 Motor Installation (2) through (8)

- (3) Connect the ground wire terminals
inside the base.

Cross recessed head screws:
M4×6
Tightening torque: $2.0 \pm 0.1\text{N m}$



- (4) Pass the wire tie through the hole on
the plate inside the base.
Bind the following cables with the
wire tie.

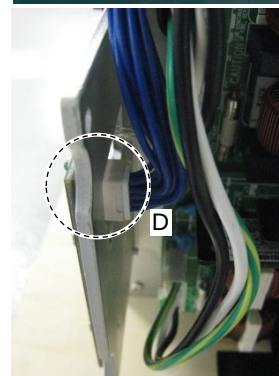
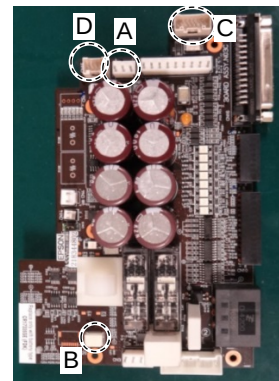
Wire tie: AB150

Power cable
LED cable
Signal cable (for motor)
Ground wire



- (5) Connect the following connectors to
the controller unit.

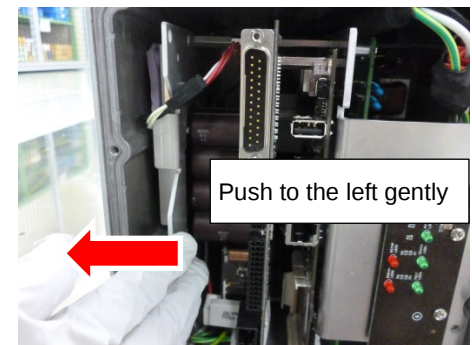
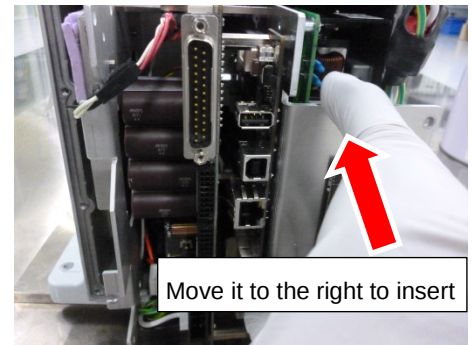
A: Power cable connector
B: Signal cable connector
C: Hand I/O connector
D: LED connectors × 2



- (6) Push the controller unit into the base.

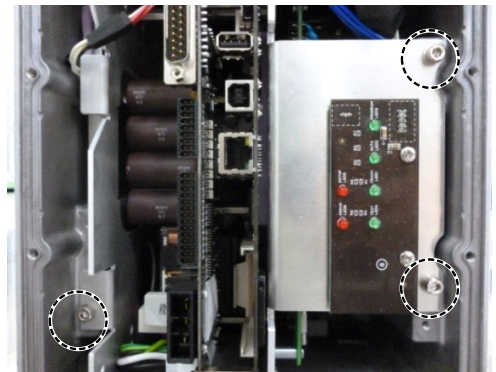
NOTE  Insert the controller unit while moving it to the right (see the picture).

Then, gently move the plate of the controller unit to the left and let the thermal sheet contacts with the wall inside the base.



- (7) Tighten the mounting screws of the controller unit.

Hexagon socket head cap bolts: 3-M4×10
(with a plain washer)
Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$



- (8) Mount the Arm #1 cover and the connector plate.

Reference: *Maintenance 7. Covers*

- (9) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*

- (10) Calibrate the Joint #1.

Reference: *Maintenance 19. Calibration*

10. Joint #2



WARNING

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



CAUTION

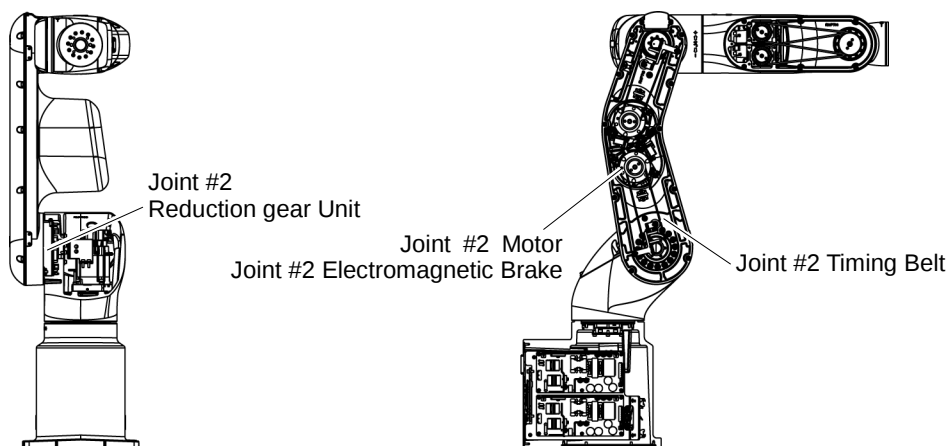
- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motor units, reduction gear units, timing belts), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Robot system.

Because of that, it is necessary to perform calibration (encoder rest and calibration) to match these origins.

After replacing the parts, refer to the following section to perform calibration.

Maintenance 19. Calibration.



10.1 Replacing Joint #2 Motor

 CAUTION	■ This procedure has possibility of damage or malfunction to the Manipulator. Be very careful when performing maintenance. ■ DO NOT loosen the bolts while the Arm #2 is not tilted. It may cause the belt come off and the Arm #2 falls down, and it is extremely hazardous. Be sure to do the Removal steps (1) and (2) before removing the motor.
---	--

	Name		Quantity	Note
Maintenance parts	Joint #2 motor unit		1	2194597
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 hexagon socket head cap bolts
		width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Nippers		1	For cutting wire tie
	Belt tension meter		1	Refer: Unitta U-505
Material	Wire tie		-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

When removing the Joint #2 motor, tilt the Arm #2 and press it against the Arm #1.

Reference: *Maintenance: 10.1 Joint #2 - Replacing the Motor*, Removal step (2)

Joint #2 Motor
Removal

- (1) Turn ON the Manipulator.
- (2) Release the Joint #2 brake. Tilt the Arm #2 and push it against the Arm #1.

The Arm #2 falls by its weight when the Joint #2 motor unit is removed. Therefore, release the brake and tilt the Arm #2 in advance.

EPSON RC+ Command
>brake off, 2

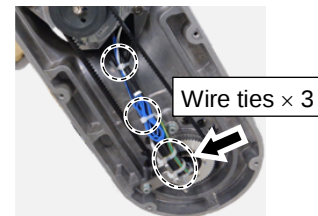
NOTE
When pushing the arm, push the Arm #2 slowly to the Arm #1.
If a strong impact is applied to the joint, the Manipulator may get damage.

- (3) Turn OFF the Manipulator.
- (4) Remove the Arm #2 Cover.

For details, refer to *Maintenance: 7.2 Arm #2 Cover*.

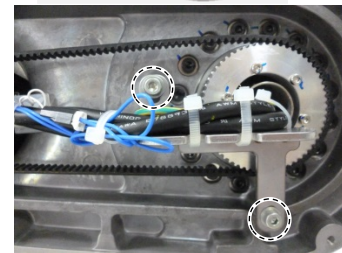
- (5) Cut off the wire tie bound inside the Arm #2.
Wire tie : AB150 × 3
AB100 × 2

NOTE
Be careful not to cut the harness.



- (6) Remove the cable fixing plate on the Arm #2.
(Joint #2 side)

Hexagon socket head cap bolts with captive washer: 2-M4×12



- (7) Loosen the mounting screws of the Joint #2 motor unit and remove the Joint #2 timing belt.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)

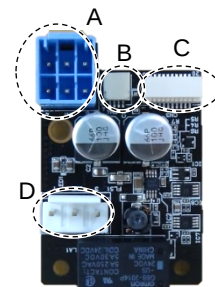
- (8) Remove the motor unit from the Arm #2.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)



- (9) Disconnect the following connectors from the AMP board.

- A: Power cable connector
- B: Brake connector
- C: Signal connector (for AMP board)
- D: Motor connector



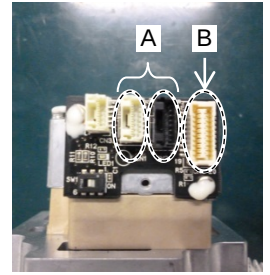
(10) Disconnect the following connectors of the motor.

A: Signal cable connectors (for motor × 2)

B: Signal cable connector (for AMP board)



NOTE
The cables will be necessary again.
Be careful not to lose them.



(11) Remove the AMP board fixing plate (with AMP board) from the motor unit.

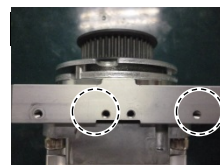
Hexagon socket head cap bolts: 2-M3×6



- Joint #2 Motor Installation
- (1) Fix the AMP board fixing plate (with AMP board) to a new motor unit.

Hexagon socket head cap bolts: 2-M3×6

Tightening torque: $2.0 \pm 0.1 \text{ N} \cdot \text{m}$



- (2) Connect the following connectors of the motor.

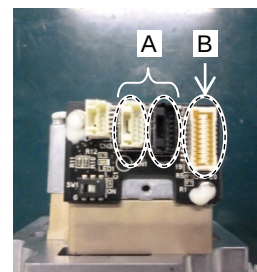
A: Signal cable connectors (for motor × 2)

B: Signal cable connector (for AMP board)

NOTE



Connector for the signal cable connector (for motor) is the same color.



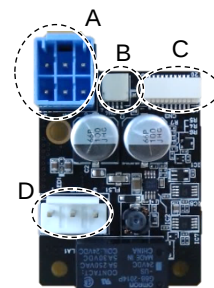
- (3) Connect the connectors of the AMP board.

A: Power cable connector

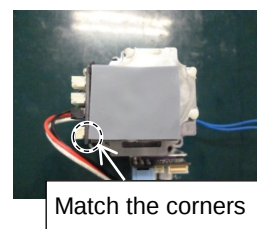
B: Brake connector

C: Signal cable connector (for AMP board)

D: Motor connector



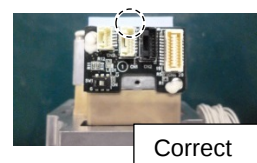
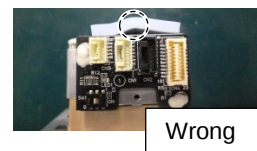
- (4) Attach the thermal sheet on the bottom of the motor unit.
For the attaching position, refer to the picture on the right.



NOTE

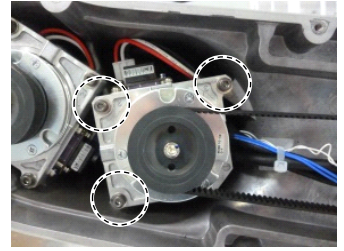


Make sure that the entire surface of the thermal sheet contacts with the rear side of the motor unit without lifting up the center of the sheet.



- (5) Pass the timing belt through the motor pulley and loosely secure to the Arm #2.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)



NOTE



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

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

NOTE



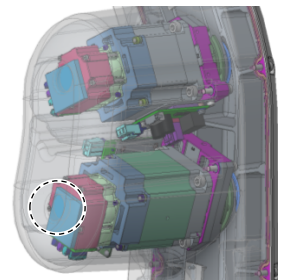
As shown on the picture, pass the cable through the rear side of the Arm #2 motor unit fixing part. Before fixing the motor unit, make sure that the cables are not caught in the gap between the motor unit and Arm #2.



NOTE



Press the thermal sheet on the rear side of the motor unit to the round convex part at the end of the Arm #2.



- (6) Apply proper tension to the motor unit and fix it.

Joint #2 timing belt tension: 34 - 58 N
Belt tension meter setting values
Weight: 2.5g/mm width×m span
Width: 9.0mm
Span: 172mm

Hexagon socket head cap bolts: 3-M4×22 (with slotted hole washer)
Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

NOTE



Regarding belt tension:

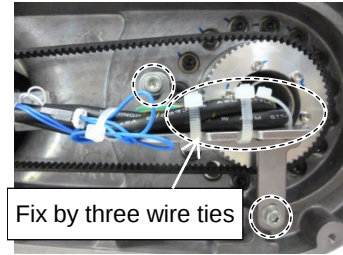
Jumping (position gap) may occur if the value is below the lower limit.

Vibration (abnormal noise) or reduction in life of the parts may occur if the value exceeds the upper limit.

When you replace with a new belt, belt extends and the belt tension may decrease in the initial stage. Make sure to operate the robot two to three days and check the belt tension again

- (7) Mount the cable fixing plate on the Arm #2.
(Joint #2 side)

Hexagon socket head cap bolts: 2-M4×12
(with a washer)
Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$



Pass the wire ties (×3) to the plate.
Fix the following cables and the ground wire with the wire tie.

Wire tie: AB150

Motor cable
Signal cable (for motor)
LED cable
Ground wire

- (8) Fold the brake cable of Joint #2 motor into the length of 40mm. Bind it with the following cables with the wire tie.

Wire tie: AB100

Power cable
Signal cable (for motor)
Brake cable



- (9) Pass the wire tie to the mount base inside the Arm #2.
Bind the following cables with the wire tie.

Wire tie: AB100

Power cable
Signal cable (for motor)
Brake cable
LED cable (mount base A only)



- (10) Mount the Arm #2 cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

- (11) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*

NOTE



When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

- (12) Calibrate the Joint #2.

Reference: *Maintenance 19. Calibration*

10.2 Replacing Joint #2 Reduction Gear Unit

Reduction gear unit is replaced by serviceman.

For replacement of the reduction gear unit, please contact the supplier of your region.

10.3 Replacing Joint #2 Timing Belt

 CAUTION	■ This procedure has possibility of damage or malfunction to the Manipulator. Be very careful when performing maintenance. ■ DO NOT loosen the bolts while the Arm #2 is not tilted. It may cause the belt come off and the Arm #2 falls down, and it is extremely hazardous. Be sure to do the Removal steps (1) and (2) before removing the motor.
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	Name	Quantity	Note
Maintenance parts	Timing Belt	1	1753920
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Cross-point screwdriver (No. 2)	1	For cross-recessed screw
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

When removing the Joint #2 motor, tilt the Arm #2 and press it against the Arm #1.

Reference: *Maintenance: 10.1 Joint #2 - Replacing the Motor*, Removal step (2)

Joint #2
Timing Belt
Removal

(1) Remove the Joint #2 timing belt.

Reference: *Maintenance 10.1 Replacing Joint #2 Motor*
Joint #2 Motor Removal Step (1) through (7)

Joint #2
Timing Belt
Installation

(1) Install the Joint #2 timing belt.

Reference: *Maintenance 10.1 Replacing Joint #2 Motor*
Joint #2 Motor Removal Step (5) through (11)

11. Joint #3



WARNING

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



CAUTION

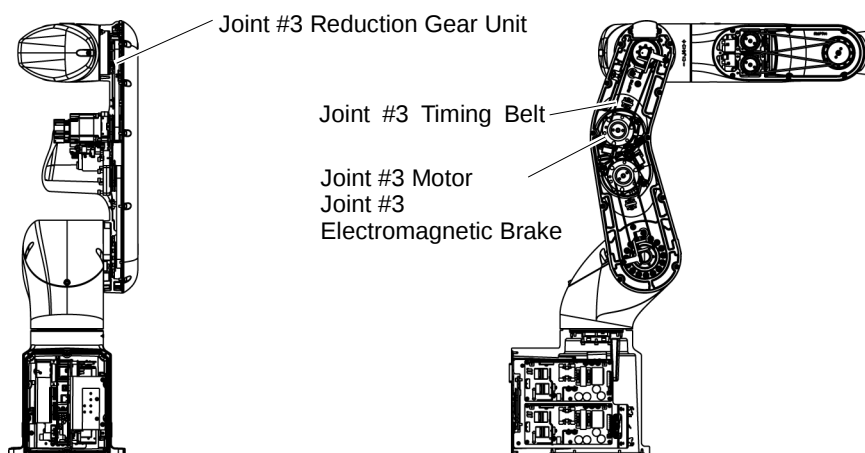
- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motor units, reduction gear units, timing belts), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Robot system.

Because of that, it is necessary to perform calibration (encoder rest and calibration) to match these origins.

After replacing the parts, refer to the following section to perform calibration.

Maintenance 19. Calibration.



11.1 Replacing Joint #3 Motor

 CAUTION	■ This procedure has possibility of damage or malfunction to the Manipulator. Be very careful when performing maintenance. ■ DO NOT loosen the bolts while the Arm #3 is not tilted. It may cause the belt come off and the Arm #3 falls down, and it is extremely hazardous. Be sure to do the Removal steps (1) and (2) before removing the motor.
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	Name		Quantity	Note
Maintenance parts	Joint #3 motor unit		1	2194598
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 hexagon socket head cap bolts
		width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Nippers		1	For cutting wire tie
	Belt tension meter		1	Refer: Unitta U-505
Material	Wire tie		-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

When removing the Joint #3 motor, tilt the Arm #3 and press it against the Arm #2.

Reference: *Maintenance: 11.1 Joint #3 - Replacing the Motor*, Removal step (2)

Joint #3 Motor Removal

- (1) Turn ON the Manipulator.
- (2) Release the Joint #3 brake. Tilt the Arm #3 and push it against the Arm #2.

The Arm #3 falls by its weight when the Joint #3 motor unit is removed. Therefore, release the brake and tilt the Arm #3 in advance.

EPSON
RC+

Command
>brake off, 3



When pushing the arm, push the Arm #3 slowly to the Arm #2.

If a strong impact is applied to the joint, the Manipulator may get damage.

- (3) Turn OFF the Manipulator.
- (4) Remove the Arm #2 cover.

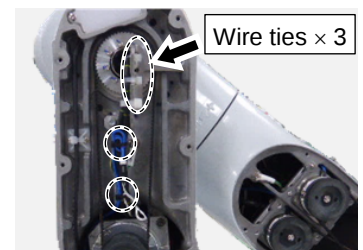
Reference: *Maintenance 7.2 Arm #2 Cover*

- (5) Cut off the wire tie bound inside the Arm #2.

Wire tie : AB150 × 3
AB100 × 2

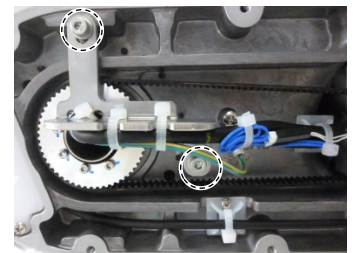


Be careful not to cut the harness.



- (6) Remove the cable fixing plate on the Arm #2.
(Joint #3 side)

Hexagon socket head cap bolts with captive washer: 4-M4×12

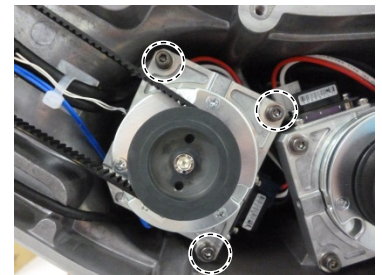


- (7) Loosen the mounting screws of the Joint #3 motor unit and remove the Joint #3 timing belt.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)

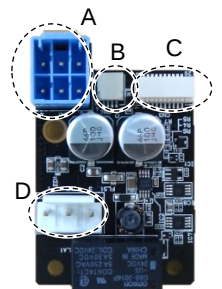
- (8) Remove the Arm #2 from the motor unit.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)



- (9) Disconnect the following connectors from the AMP board.

A: Power cable connector
B: Brake connector
C: Signal cable connector (for AMP board)
D: Motor connector



- (1 Disconnect the following connectors of the motor.
0)

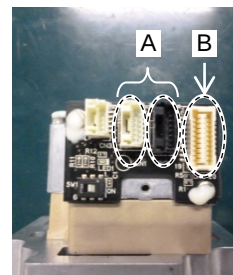
A: Signal cable connectors (for motor × 2)

B: Signal cable connector (for AMP board)

NOTE



The cables will be necessary again.
Be careful not to lose them.



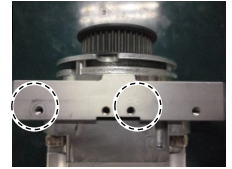
- (11) Remove the AMP board fixing plate (with AMP board) from the motor unit.

Hexagon socket head cap bolts: 2-M3×6



- Joint #3 Motor Installation (1) Fix the AMP board fixing plate (with AMP board) to a new motor unit.

Hexagon socket head cap bolts: 2-M3×6
Tightening torque: 2.0 ± 0.1 N·m



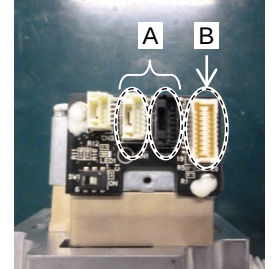
- (2) Connect the following connectors of the motor.

A: Signal cable connectors (for motor × 2)
B: Signal cable connector (for AMP board)

NOTE

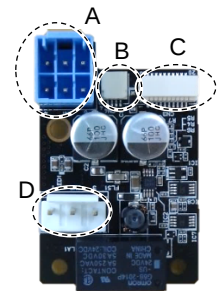


Connector for the signal cable connector (for motor) is the same color.

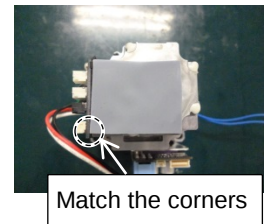


- (3) Connect the connectors of the AMP board.

A: Power cable connector
B: Brake connector
C: Signal cable connector (for AMP board)
D: Motor connector



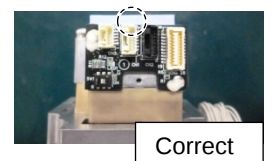
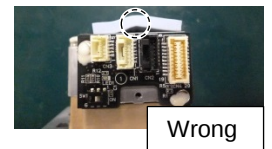
- (4) Attach the thermal sheet on the bottom of the motor unit.
For the attaching position, refer to the picture on the right.



NOTE

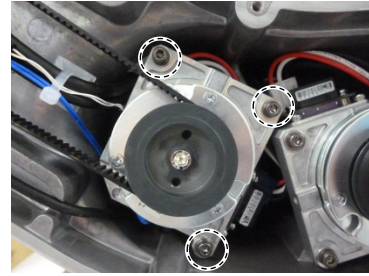


Make sure that the entire surface of the thermal sheet contacts with the rear side of the motor unit without lifting up the center of the sheet.



- (5) Pass the timing belt through the motor pulley and loosely secure to the Arm #2.

Hexagon socket head cap bolts: 3-M4×22
(with slotted hole washer)



NOTE



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

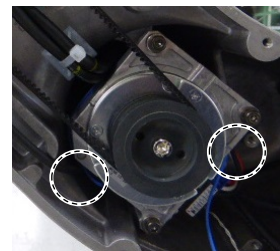
When securing the motor unit loosely, make sure that the motor unit can be moved by hand and it does not tilt when being pulled. If the unit is secured too loose or too tight, the belt will not have proper tension.

NOTE



As shown on the picture, pass the cable through the rear side of the Arm #2 motor unit fixing part.

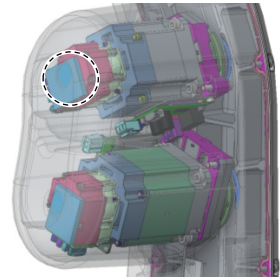
Before fixing the motor unit, make sure that the cables are not caught in the gap between the motor unit and Arm #2.



NOTE



Press the thermal sheet on the rear side of the motor unit to the round convex part at the end of the Arm #2.



- (6) Apply proper tension to the timing belt and fix it.

Joint #3 timing belt tension: 34 - 58 N

Belt tension meter setting values

Weight: 2.5g/mm width×m span

Width: 9.0mm

Span: 169mm

Hexagon socket head cap bolts: 3-M4×22 (with slotted hole washer)

Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

NOTE



Regarding belt tension:

Jumping (position gap) may occur if the value is below the lower limit.

Vibration (abnormal noise) or reduction in life of the parts may occur if the value exceeds the upper limit.

When you replace with a new belt, belt extends and the belt tension may decrease in the initial stage. Make sure to operate the robot two to three days and check the belt tension again

- (7) Mount the cable fixing plate on the Arm #2.
(Joint #3 side)

Hexagon socket head cap bolts: 2-M4×12
(with a washer)

Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

Pass the wire ties (×3) to the plate.

Bind the following cables and the ground wire
with the wire tie.

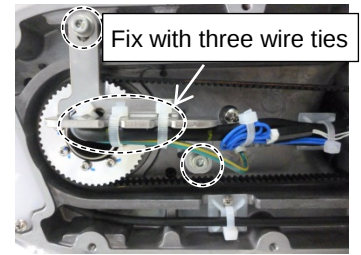
Wire tie: AB150

Motor cable

Signal cable (for motor)

LED cable

Ground wire



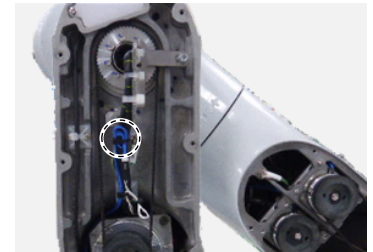
- (8) Fold the brake cable of Joint #3 motor into the
length of 40mm. Bind it with the following
cables with the wire tie.

Wire tie: AB100

Power cable

Signal cable (for motor)

Brake cable



- (9) Pass the wire tie to the mount base inside the Arm
#2.

Bind the following cables with the wire tie.

Wire tie: AB100

Power cable

Signal cable (for motor)

Brake cable



- (10) Mount the Arm #2 cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

- (11) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*



NOTE When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

- (12) Calibrate the Joint #3.

Reference: *Maintenance 19. Calibration*

11.2 Replacing Joint #3 Reduction Gear Unit

Reduction gear unit is replaced by serviceman.

For replacement of the reduction gear unit, please contact the supplier of your region.

11.3 Replacing Joint #3 Timing Belt

 CAUTION	■ This procedure has possibility of damage or malfunction to the Manipulator. Be very careful when performing maintenance. ■ DO NOT loosen the bolts while the Arm #3 is not tilted. It may cause the belt come off and the Arm #3 falls down, and it is extremely hazardous. Be sure to do the Removal steps (1) and (2) before removing the motor.
---	--

	Name	Quantity	Note
Maintenance parts	Timing Belt	1	1751537
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Cross-point screwdriver (No. 2)	1	For cross-recessed screw
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

When removing the Joint #3 motor, tilt the Arm #3 and press it against the Arm #2.

Reference: *Maintenance: 11.1 Joint #3- Replacing the Motor*, Removal step (2)

Joint #3 (1) Remove the Joint #3 timing belt.

Timing Belt

Removal

Reference: *Maintenance 11.1 Replacing Joint #2 Motor*

Joint #3 Motor Removal Step (1) through (7)

Joint #3 (1) Install the Joint #3 timing belt.

Timing Belt

Installation

Reference: *Maintenance 11.1 Replacing Joint #2 Motor*

Joint #3 Motor Removal Step (5) through (11)

12. Joint #4



WARNING

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



CAUTION

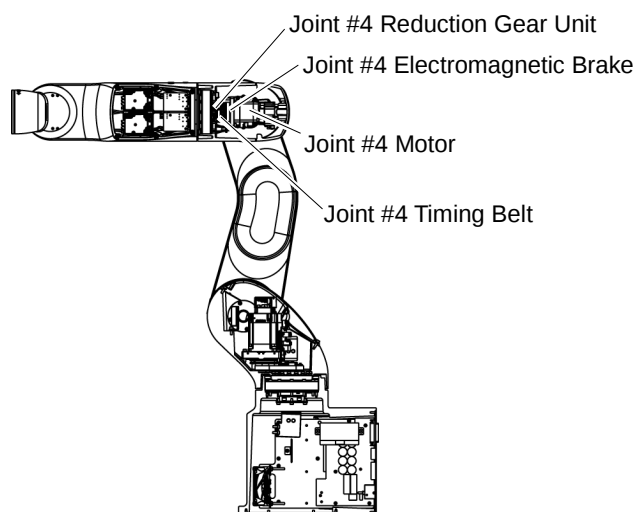
- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motor units, reduction gear units, timing belts), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Robot system.

Because of that, it is necessary to perform calibration (encoder rest and calibration) to match these origins.

After replacing the parts, refer to the following section to perform calibration.

Maintenance 19. Calibration.



12.1 Replacing Joint #4 Motor

	Name	Quantity	Note
Maintenance parts	Joint #4 motor unit	1	2194599
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

Joint #4 Motor (1) Turn OFF the Manipulator.

Removal (2) Remove the Arm #3 Cover.

For details, refer to *Maintenance: 7.3 Arm #3 Cover*.

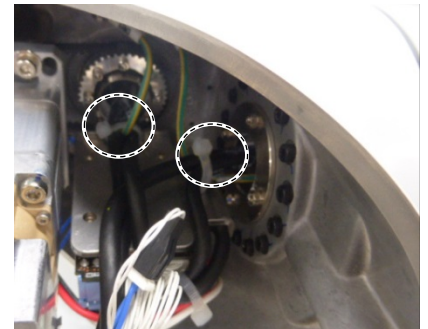
(3) Cut off the wire tie bound inside the Arm #3

Wire tie: AB150 × 2

NOTE



Be careful not to cut the harness.



(4) Cut off the wire tie that binds the following cables of the Joint #4 motor.

Wire tie: AB100 × 2

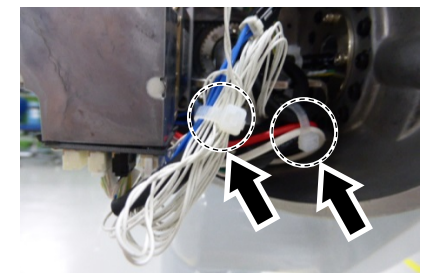
Power cable

Signal cable

NOTE

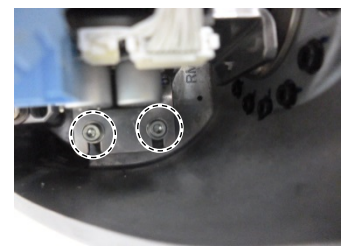


Be careful not to cut the harness.



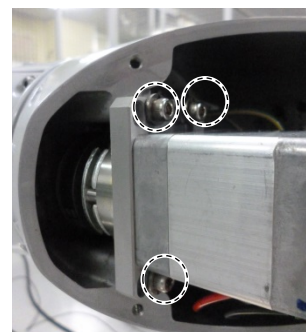
(5) Remove the plate (with AMP board) inside the Arm #3.

Hexagon socket head cap bolts with captive washer:
2-M4×12



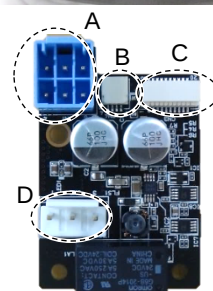
- (5) Remove the Joint #4 motor unit.

Hexagon socket head cap bolts: 3-M4×18
(with slotted hole washer)



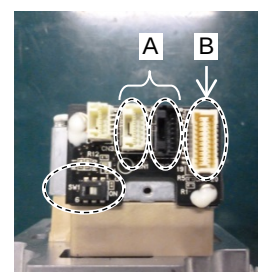
- (6) Disconnect the following connectors from the AMP board.

A: Power cable connector
B: Brake connector
C: Signal cable connector (for AMP board)
D: Motor connector



- (7) Disconnect the following connectors of the motor.

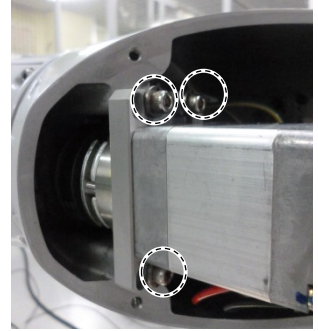
A: Signal cable connectors (for motor × 2)
B: Signal cable connector (for AMP board)



NOTE The cables will be necessary again.
Be careful not to lose them.

- Joint #4 Motor Installation (1) Pass the timing belt through the motor pulley and loosely secure to the Arm #3.

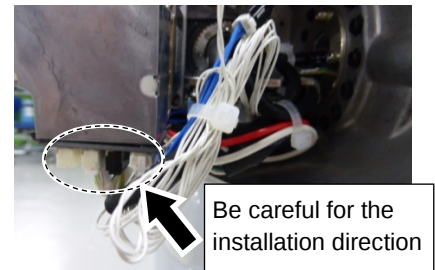
Hexagon socket head cap bolts: 3-M4×18
(with slotted hole washer)



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

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

NOTE  The direction to install the motor is the direction in which the connector of the motor faces downward.



- (2) Apply proper tension to the motor unit and fix it.

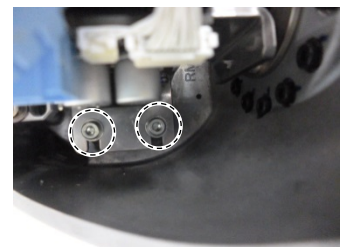
Joint #4 timing belt tension: 23 - 36 N
Belt tension meter setting values
Weight: 2.5g/mm width×m span
Width: 6.0mm
Span: 45mm

Hexagon socket head cap bolts: 3-M4×18 (with slotted hole washer)
Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

NOTE  Regarding belt tension:
Jumping (position gap) may occur if the value is below the lower limit.
Vibration (abnormal noise) or reduction in life of the parts may occur if the value exceeds the upper limit.
When you replace with a new belt, belt extends and the belt tension may decrease in the initial stage. Make sure to operate the robot two to three days and check the belt tension again

- (3) Mount the plate on the Arm #3.

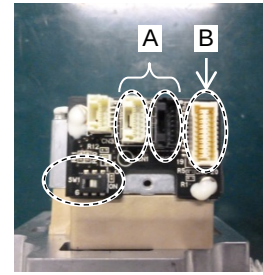
Hexagon socket head cap bolts with captive washer: 2-M4×12
Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$



- (4) Connect the following connectors of the motor.

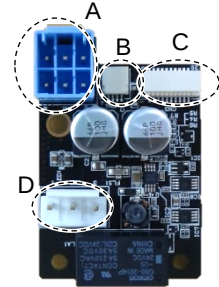
A: Signal cable connectors (for motor × 2)
B: Signal cable connector (for AMP board)

Connector for the signal cable connector (for motor) is the same color.



- (5) Connect the connectors of the AMP board.

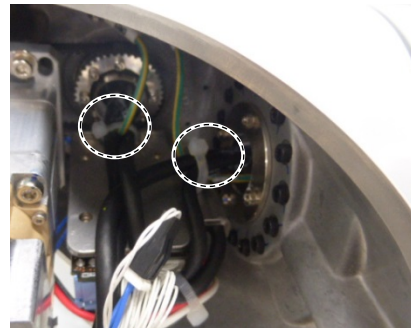
A: Power cable connector
B: Brake connector
C: Signal cable connector (for AMP board)
D: Motor connector



- (6) Pass the wire tie through the hole on the plate inside the Arm #3.
Bind the following cables with the wire tie.

Wire tie: AB150

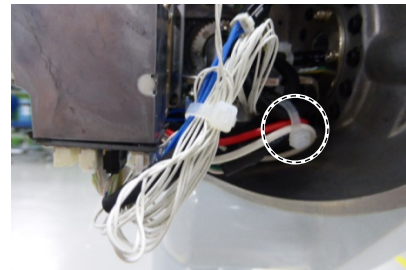
Power cable
Signal cable (for motor)
Ground wire



- (7) Bind the following cables between the Joint #4 motor and the Joint #3 motor with the wire tie.

Wire tie: AB100

Power cable
Signal cable (for motor)
Motor cable



- (8) Bind the following cables between the Joint #4 motor and the Joint #3 motor with the wire tie.

Wire tie: AB100

Signal cable (for AMP board)
Signal cable (for motor)
Brake cable



- (9) Mount the Arm #3 cover.

Reference: *Maintenance 7.3 Arm #3 Cover*

- (10) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*



When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

- (11) Calibrate the Joint #4.

Reference: *Maintenance 19. Calibration*

12.2 Replacing Joint #4 Reduction Gear Unit

Reduction gear unit is replaced by serviceman.

For replacement of the reduction gear unit, please contact the supplier of your region.

12.3 Replacing Joint #4 Timing Belt

	Name	Quantity	Note
Maintenance parts	Timing Belt	1	1751538
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Cross-point screwdriver (No. 2)	1	For cross-recessed screw
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

- Joint #4
Timing Belt
Removal
- (1) Turn OFF the Manipulator.
 - (2) Remove the following covers.

Arm #3 Cover
Arm #4 Cover 1
Arm #4 Cover 2

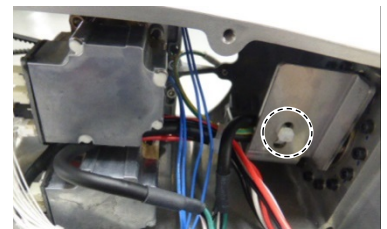
Reference: *Maintenance 7 Covers*

- (3) Remove the Joint #4 motor.

Reference: *Maintenance 12.1 Replacing Joint #4 Motor*
Joint #4 Motor Removal step (3) through (7)

- (4) Cut off the wire tie bound inside the Arm #4.

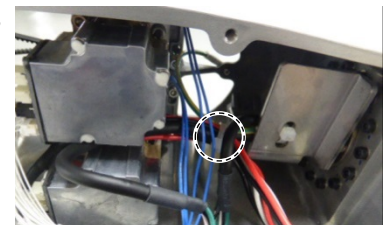
Wire tie: AB150



- (5) Cut off the wire tie that binds the following cables and the ground wire.

Wire tie: AB100

Joint #5 motor cable
Signal cable (for motor)
Joint #6 motor cable
Ground wire



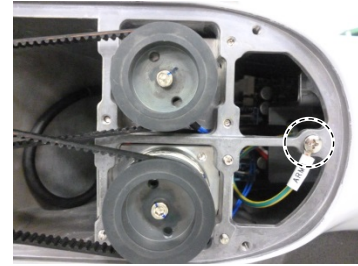
NOTE



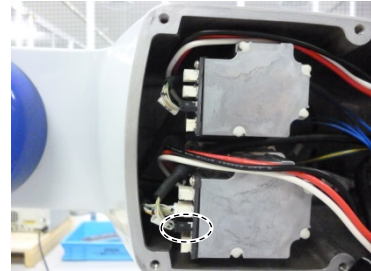
Be careful not to cut the harness.

- (6) Remove the ground wire terminals of the Arm #4.

Cross-recessed screw: M4×6



- (7) Disconnect the Joint #5 signal cable connector (for motor: black).



- (8) Pass the Joint #4 sleeve and the Joint #4 timing belt so that the following cables and the ground wire will be Arm #3 side.

Cables disconnected connectors in the step (2) through (7)

Power cable (Joint #5, 6 connector parts)

Joint #5 signal cable (for motor)

Ground wire

- (9) Remove the Joint #4 timing belt.

Joint #4
Timing belt
Installation

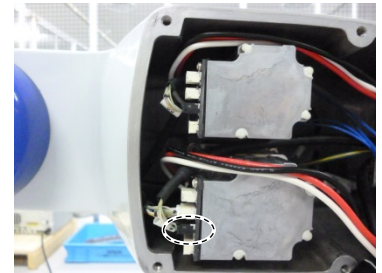
- (1) Pass the following cables through a new Joint #4 timing belt.

Power cable (Joint #5, 6 connector part)
Joint #5 signal cable (for motor)
Ground wire

- (2) Install the Joint #4 motor unit.

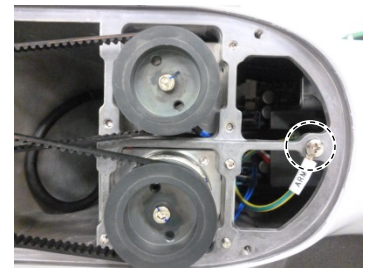
Reference: *Maintenance 12.1 Replacing Joint #4 Motor*
Joint #4 Motor Installation step (1) through (8)

- (3) Connect the Joint #5 signal cable connector (for motor: black).



- (4) Install the ground wire terminals of the Arm #4.

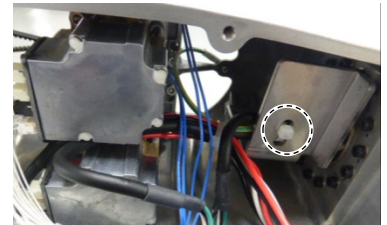
Cross-recessed screw: M4×6
Tightening torque: $2.0 \pm 0.1 \text{ N} \cdot \text{m}$



- (5) Pass the wire tie through the hole on the plate inside the Arm #4.

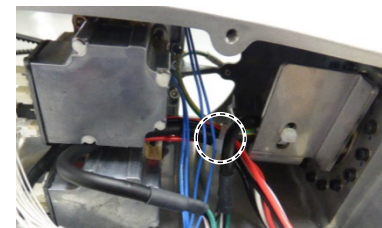
Bind the following cables with the wire tie.

Wire tie: AB150
Power cable
Signal cable (for motor)
Ground wire



- (6) Bind the following cables with the wire tie.

Wire tie: AB100
Motor cable(Joint #5)
Signal cable (Joint #5)
Motor cable (Joint #6)
Ground wire



- (7) Mount the following covers.

Arm #3 Cover
Arm #4 Cover 1
Arm #4 Cover 2

Reference: *Maintenance 7 Covers*

- (8) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*

NOTE



When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

- (9) Calibrate the Joint #4.

Reference: *Maintenance 19. Calibration*

13. Joint #5



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

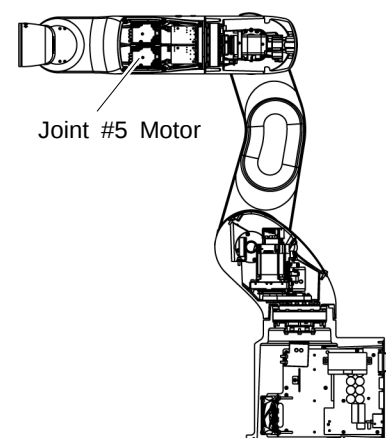
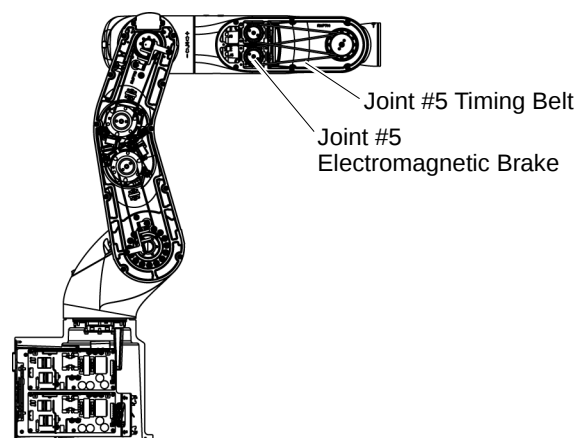


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motor units, reduction gear units, timing belts.), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Robot system. Because of that, it is necessary to perform calibration (encoder rest and calibration) to match these origins.

After replacing the parts, refer to the following section to perform calibration.

Maintenance 19. Calibration.



13.1 Replacing Joint #5 Motor

	Name	Quantity	Note
Maintenance parts	Joint #5 motor unit	1	2194600
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

- Joint #5 Motor Removal
- (1) Turn OFF the Manipulator.
 - (2) Remove the following covers.

Arm #4 Cover 1

Arm #4 Cover 2

Reference: *Maintenance 7. Covers*

- (3) Cut off the wire tie that binds the following cables and the ground wire.

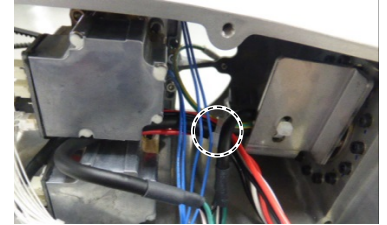
Wire tie: AB100

Joint #5 motor cable

Signal cable (for motor)

Joint #6 motor cable

Ground wire



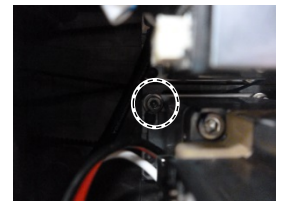
NOTE



Be careful not to cut the harness.

- (4) Remove the Joint #5 motor unit.

Hexagon socket head cap bolts: 3-M4×20
(with slotted hole washer)



- (5) Disconnect the following connectors of the motor.

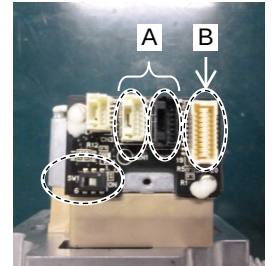
A: Signal cable connectors (for motor × 2)

B: Signal cable connector (for AMP board)

NOTE



The cables will be necessary again.
Be careful not to lose them.



- Joint #5 Motor Installation (1) Pass the timing belt through the motor pulley and loosely secure to the Arm #4.

Hexagon socket head cap bolts: 3-M4×20
(with slotted hole washer)

NOTE



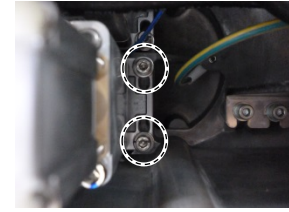
Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.

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

NOTE



The direction to install the motor is the direction in which the connector of the motor faces Joint #5 side.



- (2) Apply proper tension to the motor unit and fix it.

Joint #5 timing belt tension: 23 - 36 N

Belt tension meter setting values

Weight: 2.5g/mm width×m span

Width: 6.0mm

Span: 184mm

Hexagon socket head cap bolts: 3-M4×20 (with slotted hole washer)

Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

NOTE



Regarding belt tension:

Jumping (position gap) may occur if the value is below the lower limit.

Vibration (abnormal noise) or reduction in life of the parts may occur if the value exceeds the upper limit.

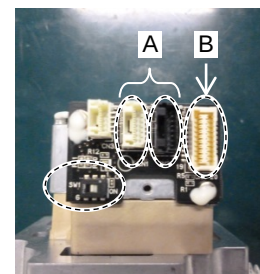
When you replace with a new belt, belt extends and the belt tension may decrease in the initial stage. Make sure to operate the robot two to three days and check the belt tension again

- (3) Connect the following connectors of the motor.

A: Signal cable connectors (for motor × 2)

B: Signal cable connector (for AMP board)

Connector for the signal cable connector (for motor) is the same color.



- (4) Bind the following cables and the ground wire with the wire tie.

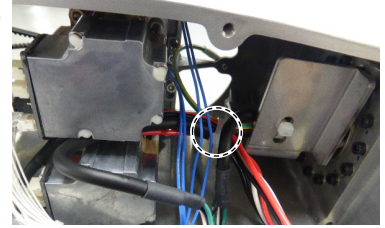
Wire tie: AB100

Motor cable (Joint #5)

Signal cable (Joint #5)

Motor cable (Joint #6)

Ground wire



- (5) Mount the following covers.

Arm #4 Cover 1

Arm #4 Cover 2

Reference: *Maintenance 7. Covers*

- (6) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*



NOTE When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

- (7) Calibrate the Joint #5 and the Joint #6.

Reference: *Maintenance 19. Calibration*

13.2 Replacing Joint #5 Reduction Gear Unit

Reduction gear unit is replaced by serviceman.

For replacement of the reduction gear unit, please contact the supplier of your region.

13.3 Replacing Joint #5 Timing Belt

	Name	Quantity	Note
Maintenance parts	Timing Belt	1	1762243
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Cross-point screwdriver (No. 2)	1	For cross-recessed screw
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

Joint #5 (1) Remove the Joint #6 timing belt.

Timing Belt Removal Reference: *Maintenance 14.3 Replacing Joint #6 Timing Belt*
Joint #6 Timing Belt Removal

(2) Remove the Joint #5 motor and the Joint #5 timing belt.

Reference: *Maintenance 13.1 Replacing Joint #5 Motor*
Joint #5 Motor Removal step (1) through (4)

Joint #5 (1) Remove the Joint #5 timing belt and the Joint #5 motor.

Timing Belt Installation Reference: *Maintenance 13.1 Replacing Joint #5 Motor*
Joint #5 Motor Installation step (1) through (5)

(2) Install the Joint #6 timing belt.

Reference: *Maintenance 14.1 Replacing Joint #6 Motor*
Joint #6 Motor Installation step (1) through (5)

(3) Mount the following covers.

Arm #3 Cover

Arm #4 Cover 1

Arm #4 Cover 2

Reference: *Maintenance 7. Covers*

(4) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*

 NOTE When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

(5) Calibrate the Joint #5 and the Joint #6.

Reference: *Maintenance 19. Calibration*

14. Joint #6



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

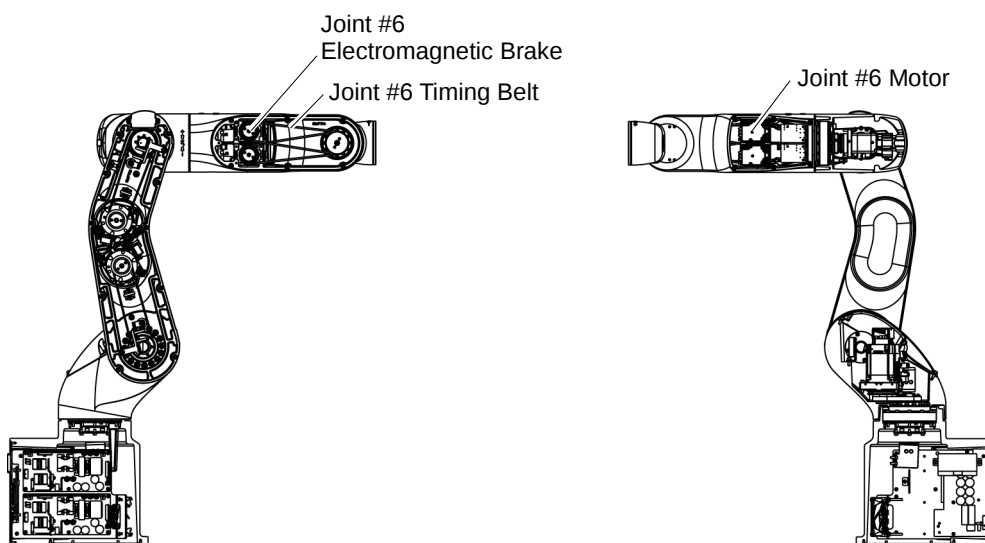


- Be careful not to apply excessive shock to the motor shaft when replacing the motors. The shock may shorten the life cycle of the motors and encoder and/or damage them.
- Never disassemble the motor and encoder. A disassembled motor and encoder will cause a positional gap and cannot be used again.

After parts have been replaced (motor units, reduction gear units, timing belts), the Manipulator cannot operate properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Robot system. Because of that, it is necessary to perform calibration (encoder rest and calibration) to match these origins.

After replacing the parts, refer to the following section to perform calibration.

Maintenance 19. Calibration.



14.1 Replacing Joint #6 Motor

	Name		Quantity	Note
Maintenance parts	Joint #6 motor unit		1	2194601
Tools	Hexagonal wrench	width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Nippers		1	For cutting wire tie
	Belt tension meter		1	Refer: Unitta U-505
Material	Wire tie		-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

- Joint #6 Motor Removal
- (1) Turn OFF the Manipulator.
 - (2) Remove the following covers.

Arm #4 Cover 1

Arm #4 Cover 2

Reference: *Maintenance 7. Covers*

- (3) Cut off the wire tie that binds the following cables and the ground wire.

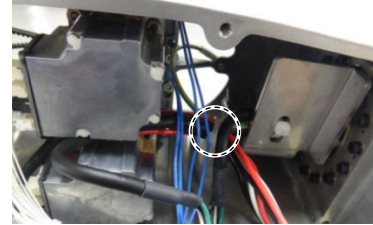
Wire tie: AB100

Joint #5 motor cable

Signal cable (for motor)

Joint #6 motor cable

Ground wire



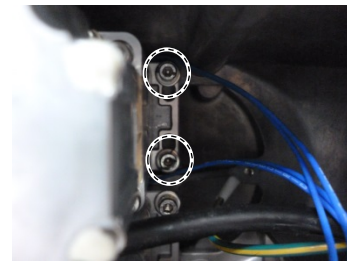
NOTE



Be careful not to cut the harness.

- (4) Remove the Joint #6 motor unit.

Hexagon socket head cap bolts: 3-M4×20
(with slotted hole washer)



- (5) Disconnect the following connectors of the motor.

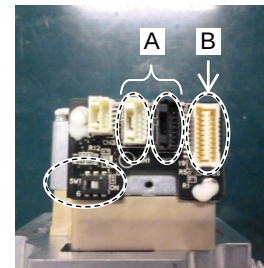
A: Signal cable connectors (for motor × 2)

B: Signal cable connector (for AMP board)

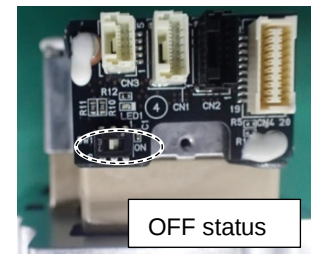
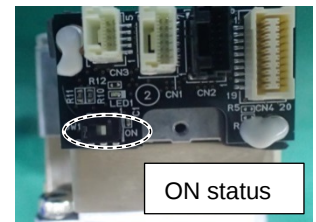
NOTE



The cables will be necessary again.
Be careful not to lose them.



- Joint #6 Motor Installation
- (1) Confirm that the terminating resistor switch of the Joint #6 motor is turned ON.
When the switch is OFF, push the tab to turn it ON.



- (2) Pass the timing belt through the motor pulley and loosely secure to the Arm #4

Hexagon socket head cap bolts: 3-M4×20
(with slotted hole washer)

NOTE



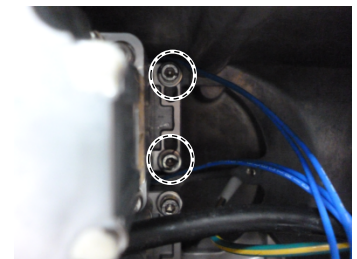
Make sure that the gear grooves of the timing belt are fit into those of the pulley completely.

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

NOTE



The direction to install the motor is the direction in which the connector of the motor faces Joint #5 side



- (3) Apply proper tension to the motor unit and fix it.

Joint #5 timing belt tension: 23 - 36N

Belt tension meter setting values

Weight: 2.5g/mm width×m span

Width: 6.0mm

Span: 184mm

Hexagon socket head cap bolts: 3-M4×20 (with slotted hole washer)

Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$

NOTE



Regarding belt tension:

Jumping (position gap) may occur if the value is below the lower limit.

Vibration (abnormal noise) or reduction in life of the parts may occur if the value exceeds the upper limit.

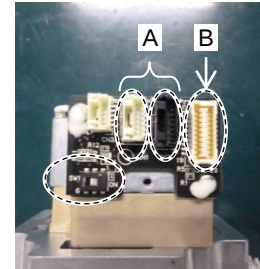
When you replace with a new belt, belt extends and the belt tension may decrease in the initial stage. Make sure to operate the robot two to three days and check the belt tension again

- (4) Connect the following connectors of the motor.

A: Signal cable connectors (for motor × 2)

B: Signal cable connector (for AMP board)

Connector for the signal cable connector (for motor) is the same color.



- (5) Bind the following cables and the ground wire with the wire tie.

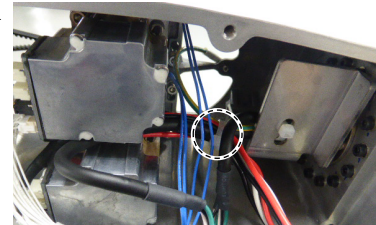
Wire tie: AB100

Motor cable (Joint #5)

Signal cable (Joint #5)

Motor cable (Joint #6)

Ground wire



- (6) Mount the following covers.

Arm #4 Cover 1

Arm #4 Cover 2

Reference: *Maintenance 7. Covers*

- (7) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*

NOTE



When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

- (8) Calibrate the Joint #6.

Reference: *Maintenance 19. Calibration*

14.2 Replacing Joint #6 Reduction Gear Unit

Reduction gear unit is replaced by serviceman.

For replacement of the reduction gear unit, please contact the supplier of your region.

14.3 Replacing Joint #6 Timing Belt

	Name	Quantity	Note
Maintenance parts	Timing Belt	1	1762243
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Cross-point screwdriver (No. 2)	1	For cross-recessed screw
	Nippers	1	For cutting wire tie
	Belt tension meter	1	Refer: Unitta U-505
Material	Wire tie	-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

Joint #6 Timing Belt Removal

(1) Remove the Joint #6 motor and the Joint #6 timing belt.

Reference: *Maintenance 14.1 Replacing Joint #6 Motor*
Joint #6 Motor Removal step (1) through (4)

Joint #6 Timing Belt Installation

(1) Install the Joint #6 timing belt and the Joint # motor.

Reference: *Maintenance 14.1 Replacing Joint #6 Motor*
Joint #6 Motor Installation step (1) through (5)

(2) Mount the following covers.

Arm #3 Cover
Arm #4 Cover 1
Arm #4 Cover 2

Reference: *Maintenance 7. Covers*

(3) Turn ON the Manipulator.

Reference: *Setup & Operation 6.5 LED*

NOTE



When starting the manipulator for the first time after replacing the motor unit, the motor unit firmware is automatically updated. DO NOT turn OFF the manipulator until it starts.

(4) Calibrate the Joint #5 and the Joint #6.

Reference: *Maintenance 19. Calibration*

15. AMP Board



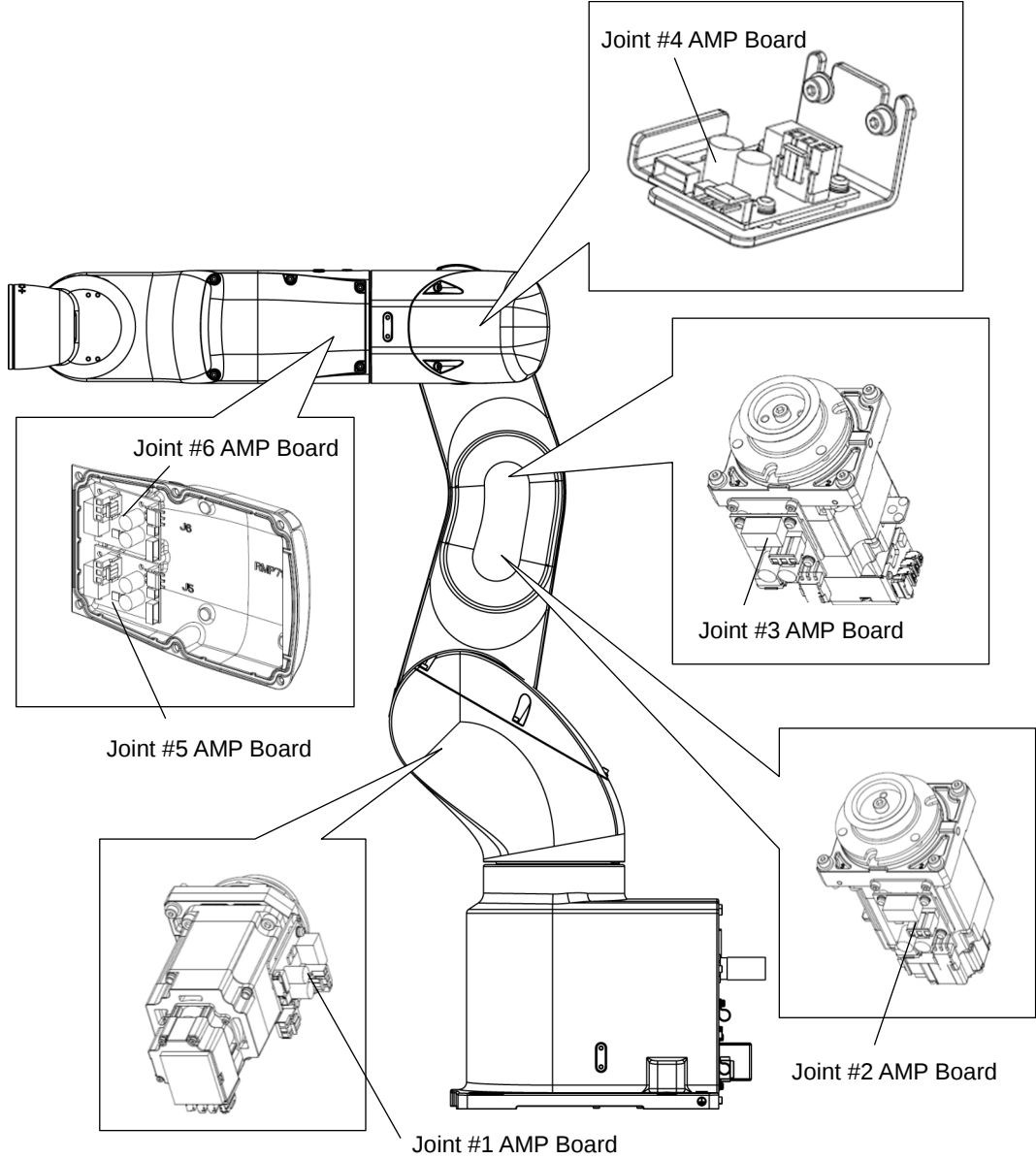
WARNING

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



CAUTION

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



15.1 Replacing AMP Board on Joint #1, #2, and #3

	Name		Quantity	Note
Maintenance parts	AMP Board		1	2189027
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 hexagon socket head cap bolts
		width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Cross-point screwdriver (No. 2)		1	For cross-recessed screw
	Nippers		1	For cutting wire tie
	Belt tension meter		1	Refer: Unitta U-505
Material	Wire tie		-	

The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

- AMP Board Removal
- (1) Turn OFF the Manipulator.
 - (2) Remove the plate (with AMP board) from the motor unit.

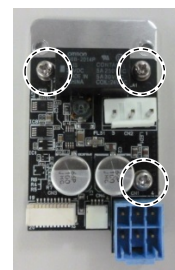
Reference: *Maintenance 9.1 Joint #1 Motor Removal*
Maintenance 10.1 Joint #2 Motor Removal
Maintenance 11.1 Joint #3 Motor Removal

- (3) Remove the AMP board from the plate.

Cross-recessed screws with a washer: 3-M3×6



If the thermal sheet is attached on the rear side of the AMP board, remove it. The thermal sheet will be necessary again. Be careful not to lose it.



AMP Board
Installation

- (1) If the thermal sheet is removed in the Removal step (3), attach the sheet on the plate.

NOTE

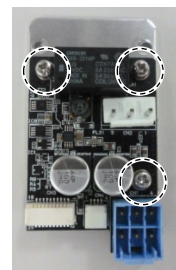


Attach the thermal sheet in the direction that the longer sides of the thermal sheet and the plate are parallel. As shown in the picture, the attachment position is inside the range surrounded by three spacers of the AMP board fixing part.

- (2) Mount the AMP board on the plate.

Cross-recessed screws with a washer: 3-M3×6

Tightening torque: 0.45 ± 0.1 N·m



- (3) Fix the plate (with AMP board) to the motor unit and mount the motor unit.

Reference: *Maintenance 9.1 Joint #1 Motor Installation*
Maintenance 10.1 Joint #2 Motor Installation
Maintenance 11.1 Joint #3 Motor Installation

15.2 Replacing AMP Board on Joint #4

	Name		Quantity	Note
Maintenance parts	AMP Board		1	2189027
Tools	Hexagonal wrench	width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Cross-point screwdriver (No. 2)		1	For cross-recessed screw
	Nippers		1	For cutting wire tie
Material	Wire tie		-	

AMP Board Removal

- (1) Turn OFF the Manipulator.
- (2) Remove the plate (with AMP board) from the Arm #3.

Reference: *Maintenance 12.1 Joint #4 Motor Removal*

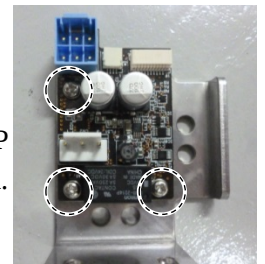
- (3) Remove the AMP board from the plate.

Cross-recessed screws with a washer: 3-M3×6

NOTE



If the thermal sheet is attached on the rear side of the AMP board, remove it. The thermal sheet will be necessary again. Be careful not to lose it.



AMP Board Installation

- (1) If the thermal sheet is removed in the Removal step (3), attach the sheet on the plate..

NOTE



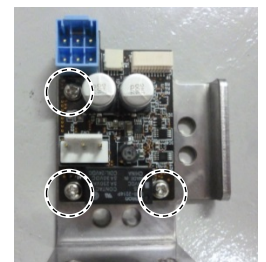
Attach the thermal sheet in the direction that the longer sides of the thermal sheet and plate are vertical. As shown in the picture, the attachment position is inside the range surrounded by three spacers of the AMP board fixing part.



- (2) Mount the AMP board on the plate.

Cross-recessed screws with a washer: 3-M3×6

Tightening torque: $0.45 \pm 0.1 \text{ N}\cdot\text{m}$



- (3) Mount the plate (with AMP board) on the Arm #3.

Reference: *Maintenance 12.1 Joint #4 Motor Installation*

15.3 Replacing AMP Board on Joint #5 and #6

	Name		Quantity	Note
Maintenance parts	AMP Board		1	2189027
Tools	Hexagonal wrench	width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Cross-point screwdriver (No. 2)		1	For cross-recessed screw

AMP Board Removal

- (1) Turn OFF the Manipulator.
- (2) Remove the Arm #4 Cover 2.

Reference: *Maintenance 7.5 Arm #4 Cover 2*

- (3) Remove the AMP board from the Arm #4 Cover 2.

Cross-recessed screws with a washer:
3-M3×6

AMP Board Installation

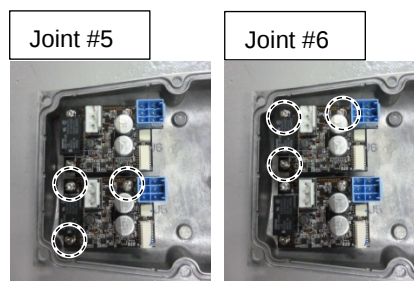
- (1) Fix the AMP board on the Arm #4 Cover 2.

Cross-recessed screws with a washer:
3-M3×6

Tightening torque: $0.45 \pm 0.1 \text{ N}\cdot\text{m}$

- (2) Mount the Arm #4 Cover 2.

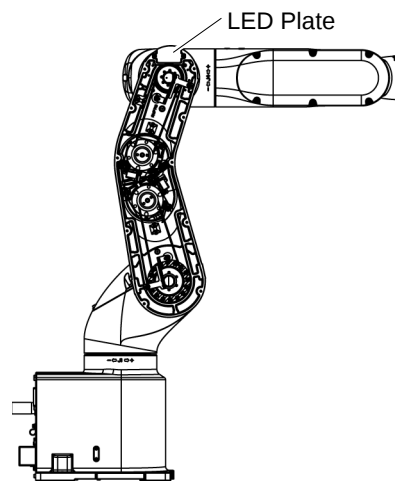
Reference: *Maintenance 7.5 Arm #4 Cover 2*



16. LED Plate



- To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



16.1 Replacing LED Plate

	Name		Quantity	Note
Maintenance parts	LED Plate		1	1749496
Tools	Hexagonal wrench	width across flats: 2.5 mm	1	For M3 hexagon socket head cap bolts
		width across flats: 3 mm	1	For M4 hexagon socket head cap bolts
	Torque wrench		1	For tightening torque control
	Cross-point screwdriver (No. 2)		1	For cross-recessed screw
	Nippers		1	For cutting wire tie
	Belt tension meter		1	Refer: Unitta U-505
Material	Wire tie		-	

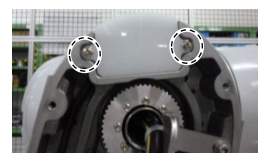
LED Plate Removal

- (1) Turn OFF the Manipulator.
- (2) Remove the Arm #2 Cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

- (3) Remove the LED plate.

Cross-recessed screws: 2-M3×10



LED Plate Installation

- (1) Install the LED plate.

Cross-recessed screws: 2-M3×10

Tightening torque: $0.45 \pm 0.1 \text{ N}\cdot\text{m}$

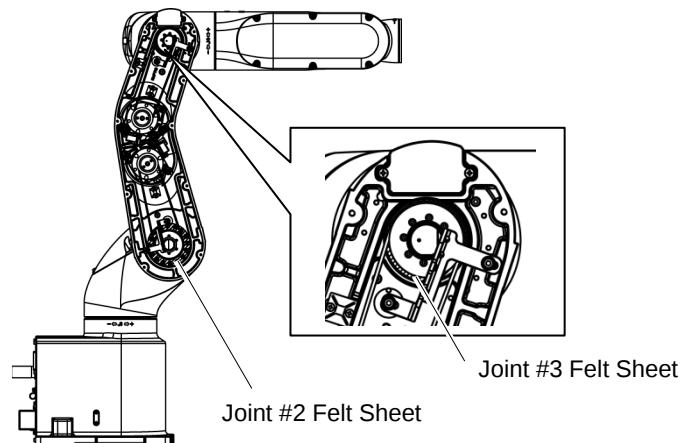
- (2) Mount the Arm #2 Cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

17. Felt Sheet



- To shut off power to the robot system, disconnect the power plug from the power source. Be sure to connect the AC power cable to a power receptacle. DO NOT connect it directly to a factory power source.
- Before performing any replacement procedure, turn OFF the Controller and related equipment, and then disconnect the power plug from the power source. Performing any replacement procedure with the power ON is extremely hazardous and may result in electric shock and/or malfunction of the robot system.



17.1 Replacing Joint #2 Felt Sheet

	Name	Quantity	Note
Maintenance parts	Felt Sheet	1	1755083

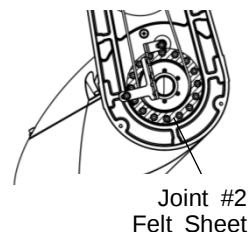
Joint #2 Felt Sheet Removal

- (1) Turn OFF the Manipulator.
- (2) Remove the Arm #2 Cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

- (2) Remove Joint #2 felt sheet from the Arm #2.

Hold a slit on the one side of felt sheet to remove the sheet from the outside of the Joint #2.



Joint #2 Felt Sheet Installation

- (1) Hold a slit on the one side of felt sheet to remove the sheet from the outside of the Joint #2.

One side of the felt sheet is a seal. Attach the felt sheet at the position where the Joint 2 screw holes and the holes of the Joint #2 felt sheet matches.

- (2) Mount the Arm #2 Cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

17.2 Replacing Joint #3 Felt Sheet

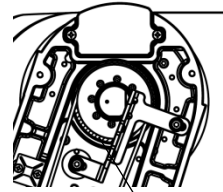
	Name	Quantity	Note
Maintenance parts	Felt Sheet	1	1755084

- Joint #3
Felt Sheet
Removal
- (1) Turn OFF the Manipulator.
 - (2) Remove the Arm #2 Cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

- (2) Remove Joint #3 felt sheet from the Arm #2.

Hold a slit on the one side of felt sheet to remove the sheet from the outside of the Joint #3.



Joint #3
Felt Sheet

- Joint #3
Felt Sheet
Installation
- (1) Hold a slit on the one side of the Joint #3 felt sheet to remove the sheet from the outside of the Joint #3.

One side of the felt sheet is a seal. Attach the felt sheet so that it fits in the groove of the Joint #3 of Arm #2.

- (2) Mount the Arm #2 Cover.

Reference: *Maintenance 7.2 Arm #2 Cover*

18. Controller Unit



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



- Take meticulous care when handling the lithium battery. Improper handling of the lithium battery as mentioned below is extremely hazardous and may result in heat generation, leakage, explosion, or inflammation. It also may cause serious safety problems.
<Improper Handling>

Attempting to charge	Deforming by pressure
Disassembling	Short-circuit (Polarity; Positive/Negative)
Connecting batteries improperly	Heating (85 °C or more)
Exposing to fire	Soldering the terminal of the lithium battery directly
Forcing discharge	
- When disposing the battery, consult with the professional disposal services or comply with the local regulation. Make sure that the battery terminal is insulated, even for a used battery. If the terminal contacts with the other metals, it may short and result in heat generation, leakage, explosion, or inflammation.

The life span of the lithium battery varies depending on the energizing hours and installation environment of the Manipulator. It is about 7 years as a rough guide (when the Manipulator is connected to power for 8 hours a day). When the Manipulator is not connected to power, the battery consumption will significantly increase compared to when the Controller is energized. If warnings of voltage reduction occur, replace the lithium metal battery even if it has not reached the above product life.



For EPSON RC+ 7.0, the recommended replacement time for the battery can be checked in the [Maintenance] dialog box.

Reference: *Maintenance 4. Alarm*

The battery may run out if it passes the recommended replacement time.

If no warnings of voltage reduction occur, the calibration for all joints is not necessary. You need to perform calibration if the position moves from the originals after replaced the battery.

Be sure to use the designated parts for the lithium battery.

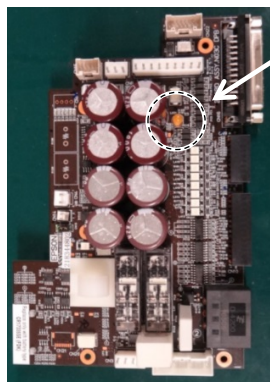
Reference: *Maintenance 22. Maintenance Parts List*

Be careful of the battery polarity to connect it correctly.

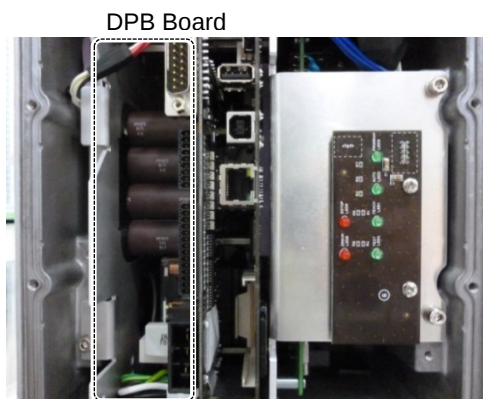
18.1 Replacing Controller Unit



- Make sure that orange colored charge confirmation LED on the DPB turns off when ejecting the controller unit. If operating without turning off the LED, electric shock or other serious problems for safety may occur.



Charge
confirmation
LED



	Name	Quantity	Note
Maintenance parts	Controller Unit	1	2194603
Tools	Hexagonal wrench (width across flats: 3 mm)	1	For M4 hexagon socket head cap bolts
	Torque wrench	1	For tightening torque control
	Cross-point screwdriver (No. 2)	1	

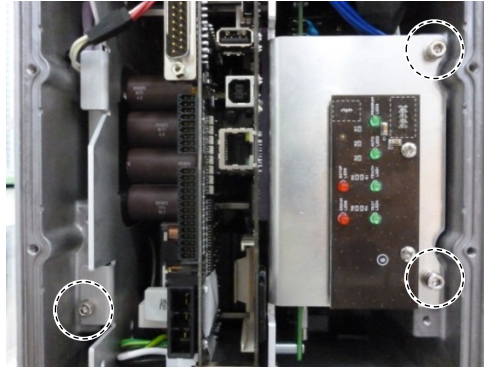
The brake is mounted on each joint to prevent the arm from lowering due to its own weight while the controller power is OFF or the motor is OFF status. The brake does not work during replacement. Be careful when performing maintenance work.

- Controller Unit Removal
- (1) Turn ON the Manipulator.
 - (2) Remove the connector plate.

Reference: *Maintenance 7.7 Connector Plate*

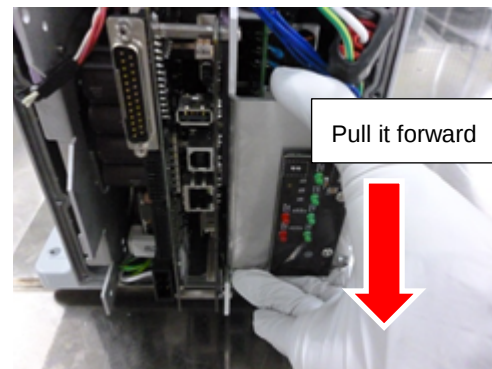
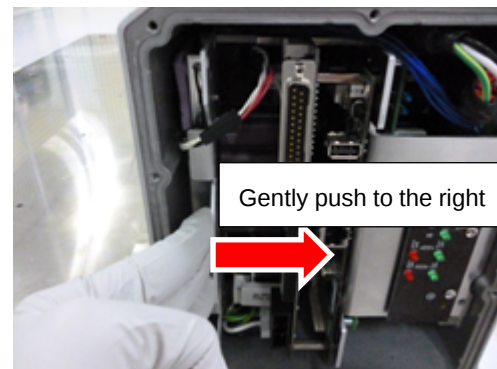
- (3) Disconnect the TP connector which is connected (inside) the connector plate.
- (4) Unscrew the mounting screws of the controller unit.

Hexagon socket head cap bolts:
3-M4×10 (with a plain washer)



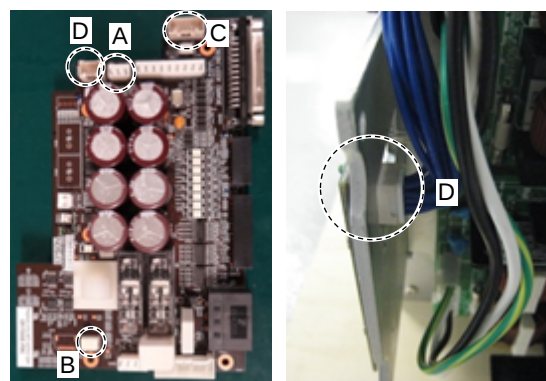
- (5) Pull out the controller unit from the Manipulator base.

NOTE  When pulling it out, firstly push the plate of the controller unit to the right (see the picture) gently, then remove the thermal sheet on the base and the controller unit. Next, pull the controller unit forward.



- (6) Disconnect the following connectors of the controller unit.

A: Power cable connector
B: Signal cable connector
C: Hand I/O connector
D: LED connectors × 2



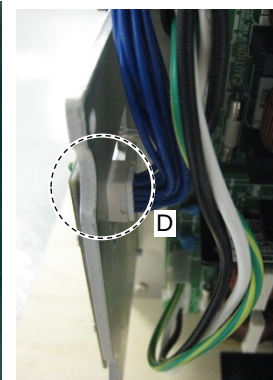
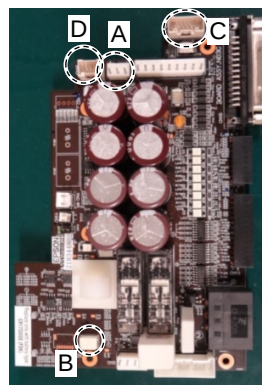
Controller Unit Installation (1) Connect the following connectors to the controller unit.

A: Power cable connector

B: Signal cable connector

C: Hand I/O connector

D: LED connectors × 2



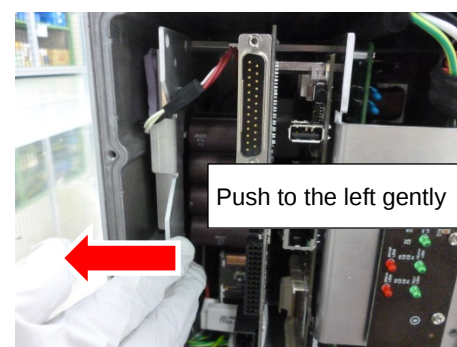
(2) Push the controller unit into the base.

NOTE



Insert the controller unit while moving it to the right (see the picture).

Then, gently move the plate of the controller unit to the left and let the thermal sheet contacts with the wall inside the base.



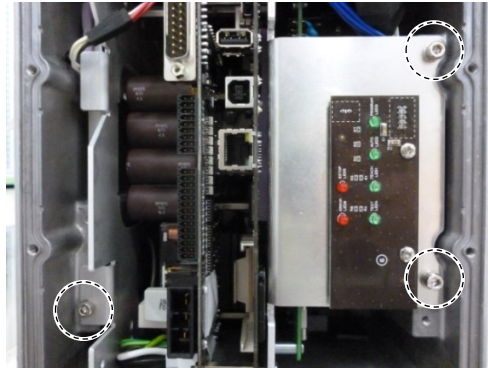
NOTE



Push the controller unit while fixing the cables from the Joint #1 motor at the base opening. Be careful not to push the cables to the back of the base.



- (3) Fix the controller unit to the base.
- Hexagon socket head cap bolts:
3-M4×10 (with a plain washer)
Tightening torque: $4.0 \pm 0.2 \text{ N}\cdot\text{m}$



- (4) Connect the TP connector inside the connector plate.
- (5) Mount the connector plate.

Reference: *Maintenance 7.7 Connector Plate*

18.2 Replacing Power Board

	Name	Quantity	Note
Maintenance parts	Power Board	2	2188638
Tools	Cross-point screwdriver (No. 2)	1	

Power Board Removal

- (1) Remove the controller unit.

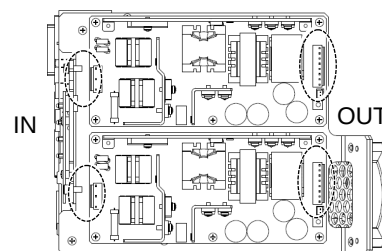
Reference: *Maintenance 18.1 Replacing Controller Unit*

- (2) Disconnect the connectors of the power board.

Power connectors
(IN/OUT ×2 for each)

- (3) Remove the power board.

Pan head screws: 10-M3×8 Sems



Power Board Installation

- (1) Mount a new power board.

Pan head screws: 10-M3×8 Sems
Tightening torque: $0.45 \pm 0.1 \text{ N} \cdot \text{m}$

- (2) Connect the connectors of the power board.

Power connectors (IN/OUT ×2 for each)

- (3) Mount the controller unit.

Reference: *Maintenance 18.1 Replacing Controller Unit*

18.3 Replacing CPU/DPB Board

	Name	Quantity	Note
Maintenance parts	CPU/DPB Board	1	2193553
Tools	Cross-point screwdriver (No. 2)	1	

CPU/DPB Board (1) Remove the power board.

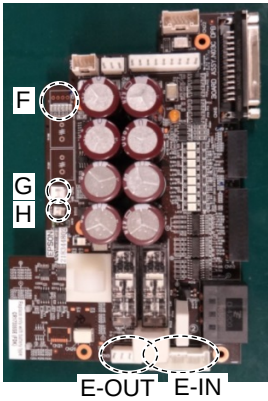
Removal

Reference: *Maintenance 18.2 Replacing Power Board*

(2) Disconnect the CPU/DPB board connectors.

- E: Power connector (IN/OUT ×1 for each)
- F: Cooling fan connector
- G: Regenerative resistor connector 1
- H: Regenerative resistor connector 2

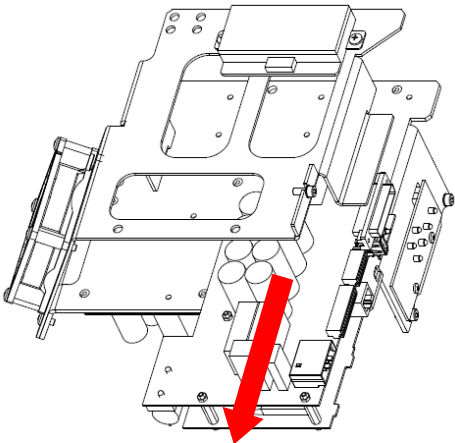
NOTE Remember the cable layout for reconnecting after replacement.



(3) Remove the CPU/DPB board.

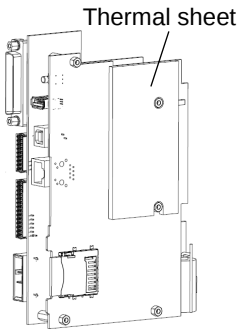
Binding head screws: 5-M3×6

NOTE Firstly, unscrew the mounting screws.
Next, pull the CPU/DPB board to the arrow direction.



(4) Remove the thermal sheet attached on the CPU board.

NOTE The thermal sheet will be necessary again.
Be careful not to lose them.
Be careful not to break the thermal sheet.



(5) Attach the thermal sheet on the surface (the side with no connectors) of the new CPU/DPB board

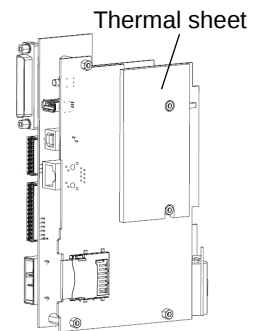
NOTE Make sure not to attach the sheet on the wrong surface.

CPU/DPB Board Installation (1) Attach the thermal sheet on the surface (the side with no connectors) of the new CPU/DPB board

NOTE



Make sure not to attach the sheet on the wrong surface.



(2) Mount the CPU/DPB board and fix it by the mounting screws.

Binding head screws: 5-M3×6

Tightening torque: $0.45 \pm 0.1 \text{ N}\cdot\text{m}$

(3) Connect the CPU/DPB board connectors.

E: Power connector (IN/OUT ×1 for each)

F: Cooling fan connector

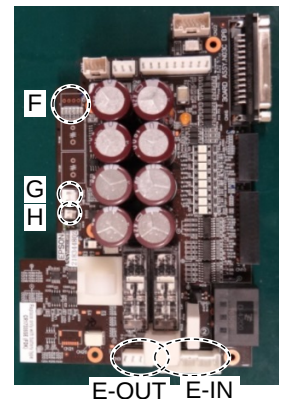
G: Regenerative resistor connector 1

H: Regenerative resistor connector 2

NOTE



Be careful not to connect the wrong connectors or forget to connect it.



(4) Mount the power board.

Reference: *Maintenance 18.2 Replacing Power Board*

18.4 Replacing Lithium Battery

	Name	Quantity	Note
Maintenance parts	Lithium Battery	1	2113554

NOTE Replace the battery within 30 minutes after turning OFF.
 If more than 30 minutes pass after removing the battery, voltage of the capacitor lower and time may be reset.

Lithium Battery Removal (1) Remove the CPU/DPB board from the base.

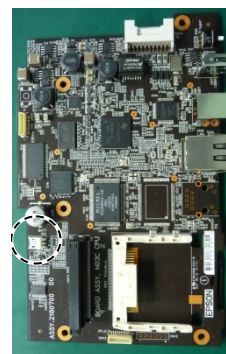
Reference: *Maintenance 18.3 Replacing CPU/DPB Board*

(2) Remove the battery from the battery connector.

Lithium Battery Installation (1) Connect a new battery to the battery connector.

(2) Mount the CPU/DPB board to the base.

Reference: *Maintenance 18.3 Replacing CPU/DPB Board*



18.5 Replacing Cooling Fan

	Name	Quantity	Note
Maintenance parts	Cooling Fan	1	2191301
Tools	Cross-point screwdriver (No. 2)	1	

Cooling Fan Removal

(1) Remove the controller unit.

Reference: *Maintenance 18.1 Replacing Controller Unit*

(2) Remove the cooling fan.

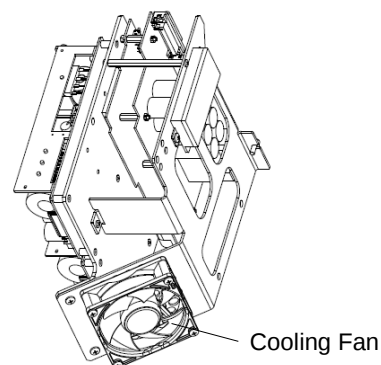
Binding head screws: 4-M4×30

Cooling Fan Installation

(1) Mount a new cooling fan.

Binding head screws: 4-M4×30

Tightening torque: $0.45 \pm 0.1 \text{ N}\cdot\text{m}$



(2) Mount the controller unit.

Reference: *Maintenance 18.1 Replacing Controller Unit*

18.6 Replacing SD Card

	Name	Quantity	Note
Maintenance parts	SD Card	1	2182748
Tools	Cross-point screwdriver (No. 2)	1	

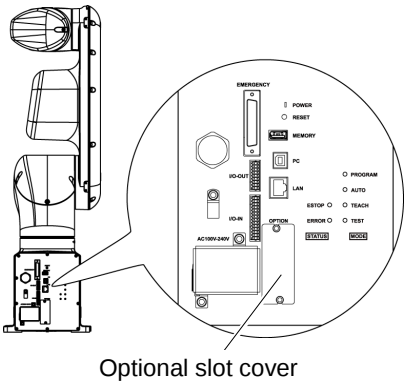
NOTE
Remove the SD card after removing the fieldbus I/O module if fieldbus I/O module is inserted to the optional slot. Also, install fieldbus I/O module after installing the SD card.

For more details about fieldbus I/O module, refer to the following.

Setup & Operation 17: Fieldbus I/O.

SD Card Removal

- (1) Turn OFF the Manipulator.
- (2) Remove the power plug.
- (3) Remove the optional slot cover.
Pan head screws: 2-M3×6 Sems
- (4) Push the SD card which is inserted near the optional slot to eject.



SD Card Installation

- (1) Push the SD card and inset to the SD card slot near the optional slot.
- (2) Mount the optional slot cover.
Pan head screws: 2-M3×6 Sems
Tightening torque: 0.45 ± 0.1N·m

19. Calibration

19.1 Overview

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot perform positioning properly because a gap exists between the origin stored in each motor encoder and its corresponding origin stored in the Controller. Therefore, it is necessary to match these origins after replacing the parts. The process of aligning the two origins is called “Calibration”. Note that calibration is not the same as teaching*.

* “Teaching” means to teach the Controller coordinate points (including poses) anywhere in the operating area of the Manipulator.

 WARNING	■ To ensure safety, a safeguard must be installed for the robot system. For details on the safeguard, refer to the <i>Installation and Design Precautions</i> in the <i>Safety</i> chapter of the <i>EPSON RC+ User's Guide</i>. ■ Before operating the robot system, make sure that no one is inside the safeguarded area. The robot system can be operated in the mode for teaching even when someone is inside the safeguarded area. The motion of the Manipulator is always in restricted (low speeds and low power) status to secure the safety of an operator. However, operating the robot system while someone is inside the safeguarded area is extremely hazardous and may result in serious safety problems in case that the Manipulator moves unexpectedly.
--	---

In EPSON RC+, a coordinate point including the arm pose is defined as “point” and its data is called “point data”.

There are two methods to move the Manipulator during calibration.

- Releasing the electromagnetic brake and moving the arms manually.
For details, refer to the *Setup & Operation 1.5 How to Move Arms with the Electromagnetic Brake*.
- Moving the Manipulator using Jog & Teach.

Moving the Manipulator while releasing the electromagnetic brake involves risk as described below.
It is recommended to move the Manipulator using Jog & Teach.

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

Also, pay attention to the following points at the encoder initialization.



- Joint #4 have no mechanical stops and they may be rotated more than 360 degrees. If the encoder initialization is performed with improper posture, the Manipulator moves outside the operation range. If the Manipulator was moved outside the operation range, the internal wiring may be damaged by being twisted or pinched and it may result in Manipulator malfunction.

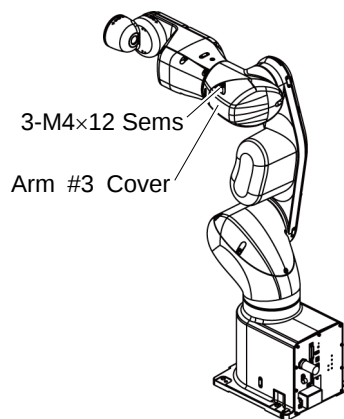
When the origin position of the Joint #4 is uncertain, check torsion of the internal cables. The origin position is where the Manipulator has the internal cables not twisted at the basic orientation described in *Setup & Operation 3.9 Checking the Basic orientation*.

NOTE



Torsion of the internal cables can be checked by removing the following cover.

Joint #4 : Arm #3 Cover



For details on Jog & Teach, refer to the following manual.

EPSON RC+ User's Guide

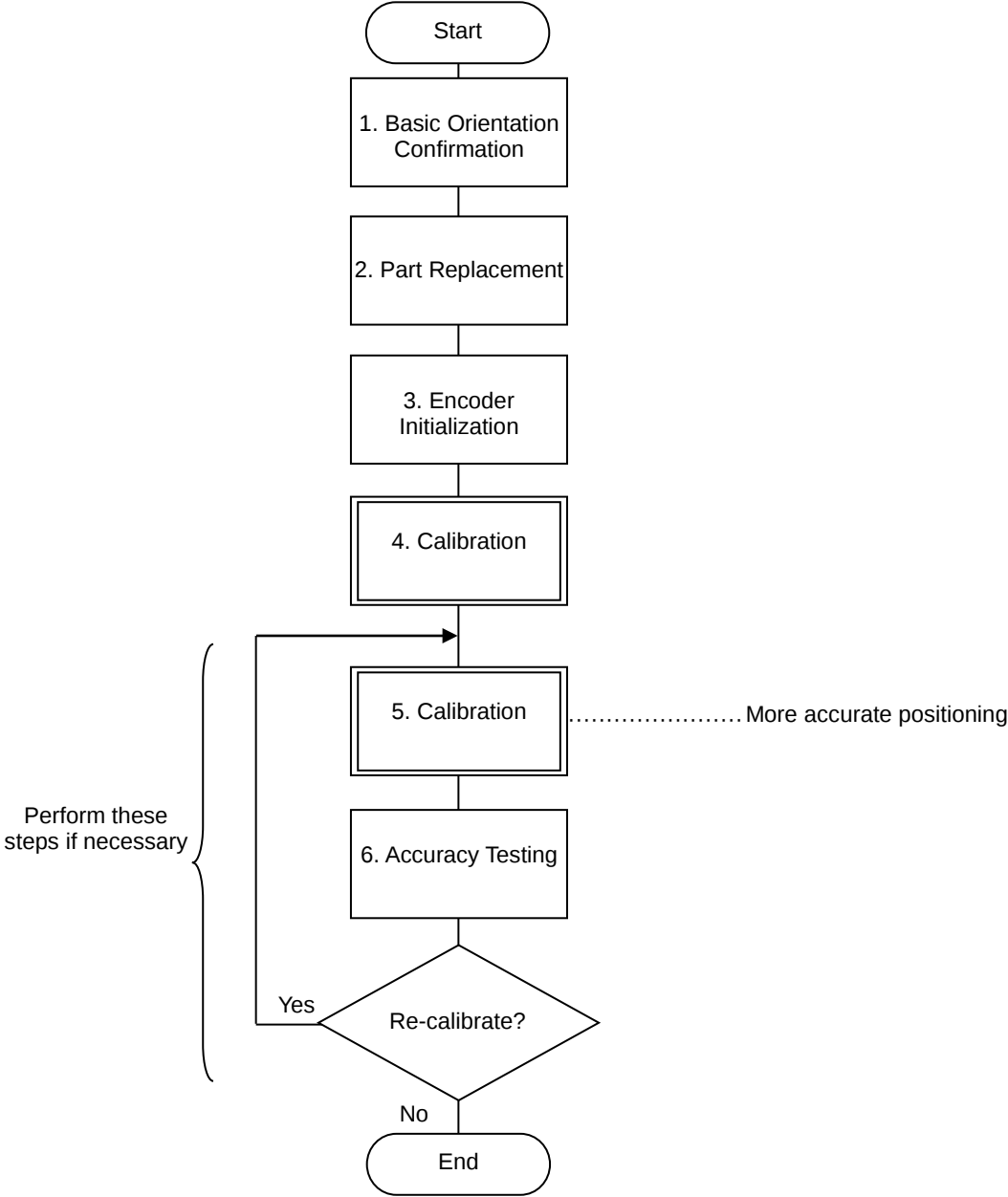
5.11.1 [Tools]-[Robot Manager]-[Jog and Teach] Page

NOTE



- For details about the basic orientation, refer to *Setup & Operation 3.9 Checking the Basic orientation*.
- Calibrate one joint at a time. (Also, replace parts of one joint at a time.) If you calibrate the origins for multiple joints simultaneously, it will be more difficult to verify their origins and obtain the origin correct positions.

Calibration Flowchart



19.2 Calibration Procedures

Command Input

Command execution is required in some calibration procedures.

Select the EPSON RC+ menu-[Tools]-[Command Window].

This step is omitted in the calibration procedures.

Jog Motion

Setting of the jog motion is required in some calibration procedures.

Select EPSON RC+ menu-[Tools]-[Robot Manager] and select the [Jog & Teach] page.

The page above is indicated as [Jog & Teach] in the calibration procedures.

Follow steps 1 to 6 to calibrate the Manipulator.

1. Basic Orientation Confirmation

Calibration is performed with the basic orientation of the Manipulator.

For details about the basic orientation, refer to Setup & Operation 3.9 Checking the Basic Orientation.

When the Manipulator cannot have the basic orientation, define the reference orientation in advance, and record the point data. Also, put the “match marks” to indicate the orientation.

The coordinate points including the Arm orientation are referred to as “points”, and the data of the points are called “point data” in EPSON RC+.

2. Part Replacement

Replace the parts as instructed in this manual.

Be careful not to injure yourself or damage parts during part replacement

3. Encoder Initialization

Follow the procedures below to initialize the encoder.

Execute the following command in the [Command Window].

EPSON
RC+

>Encreset [The joint number (1 to 6) of the encoder to be reset]

Select EPSON RC+ menu-[Tools]-[Controller], then click <Reset Controller>.

4. Calibration

4-1 Visually move the calibrating Joint of the Manipulator to the basic orientation

The logo consists of the text "EPSON" above "RC+" inside a rounded rectangular border.

Set the jog mode to “Joint” in the [Jog & Teach] panel from EPSON RC+ menu - [Tools] - [Robot Manager], and then move the Manipulator in Jog motion so that the target joint matches the basic orientation as much as possible.

When the Manipulator cannot have the basic orientation, move the Manipulator so that the “marks” depending on the predetermined reference orientation are aligned.

4-2 Initialize the Encoder

The logo consists of the text "EPSON" above "RC+" inside a rounded rectangular border.

Execute the command in the [Command Window] from EPSON RC+ menu - [Tools] according to the joint to adjust as follows.

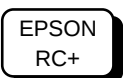
```
Joint #1 >Encreset 1
Joint #2 >Encreset 2
Joint #3 >Encreset 3
Joint #4 >Encreset 4
Joint #5 >Encreset 5, 6
Joint #6 >Encreset 6
```

4-3 Reboot the controller

The logo consists of the text "EPSON" above "RC+" inside a rounded rectangular border.

Click EPSON RC+ menu-[Tool]-[Controller]-<Reset Controller>.

4-4 Specify a pulse value set as an origin point

The logo consists of the text "EPSON" above "RC+" inside a rounded rectangular border.

Execute the command in the [Command Window] from EPSON RC+ menu - [Tools] according to the joint to adjust as follows.

```
>calpls J1 pulse, J2 pulse, J3 pulse, J4 pulse, J5 pulse, J6 pulse
```

* Manipulator will not move.

Specify the pulse values “0” when the Manipulator is aligned to the basic orientation, or the values recorded at the predetermined reference orientation (where the match marks are aligned) to the command parameters (pulse values).

If the point data for the reference orientation is “P1”, the command parameters can be specified as follows

```
>calpls ppls(P1,1), ppls(P1,2), ppls(P1,3), ppls(P1,4),
ppls(P1,5), ppls(P1,6)
```

4-5 Set the specified pulse value to the encoder

The logo consists of the word "EPSON" above "RC+" inside a rounded rectangular border.

Execute the command in the [Command Window] from EPSON RC+ menu - [Tools] according to the joint to adjust as follows.

Joint #1 >calib 1
Joint #2 >calib 2
Joint #3 >calib 3
Joint #4 >calib 4
Joint #5 >calib 5, 6
Joint #6 >calib 6

NOTE



When the origin of the Joint #5 is calibrated, the Joint #6 will be out of position. (Due to the structure of the Manipulator, any offset in the position of the Joint #5 affects the Joint #6.) Calibrate the origin of the Joint #6 together when calibrating the Joint #5.

Move the arm to several points to check if the arm moves to the original positions properly.

Teach points if fine adjustment is necessary.

5. Calibration (More accurate positioning)

The logo consists of the word "EPSON" in a bold, sans-serif font above the letters "RC+" in a similar font, all contained within a rounded rectangular border.

Move the Manipulator to the selected point data by jogging in [Jog & Teach].

Move the joint* which is not calibrated to the specified point by motion command.

*When the Joint #5 is calibrated, adjust the Joints #1 - #4.

For example, when the selected point data is "P1", execute "Motor On" in [Control Panel] and execute "Go P1" in [Jog & Teach].

Adjust the calibrated joints accurately by jog command so that the end effector is aligned to the selected point data position.

*When the Joint #5 is calibrated, adjust the Joint #5 and #6.

Select the "Joint" jog mode from [Jog & Teach] to change and adjust the angle of the calibrated joint.

Set the pulse values again at the adjusted point.

Execute the following command in the [Command Window] from EPSON RC+ menu - [Tools] to specify the pulse values to set.

```
>calpls J1 pulse, J2 pulse, J3 pulse, J4 pulse, J5 pulse, J6 pulse
```

* Manipulator will not move.

Specify the pulse values of the selected point data to the command parameters.

If the point data for the reference orientation is "P1", the command parameters can be specified as follows

```
>calpls ppls(P1,1), ppls(P1,2), ppls(P1,3), ppls(P1,4),  
ppls(P1,5), ppls(P1,6)
```

* Manipulator will not move.

Then, execute the following command in the [Command Window] to set the specified pulse values to the encoder according to the joint to set the origin point.

```
Joint #1 : >Calib 1
```

```
Joint #2 : >Calib 2
```

```
Joint #3 : >Calib 3
```

```
Joint #4 : >Calib 4
```

```
Joint #5 : >Calib 5,6
```

```
Joint #6 : >Calib 6
```

6. Accuracy Testing

Move the Manipulator to a different pose (point) to verify whether it moves back to the original position. If accuracy is inadequate, it is necessary to re-calibrate the origin using a different pose (point). You must set the pose (point) again if the Manipulator does not move back to the original position after re-calibration.

20. Restrictions

For VT series manipulator, there are commands with restrictions or may cause an error if executing. However, error does not occur when building a program.

Also, some functions have restrictions.

20.1 Commands Cannot Use

The following commands/ functions are not available.

AbortMotion	Aborts a motion command and puts the running task in error status.
Toff	Turns off execution line display on the LCD.
Ton	Specifies a task which shows an execution line on the LCD.
ShutDown	Shuts down EPSON RC+ and optionally shuts down or restarts Windows.
WindowsStatus	Returns the Windows startup status.

20.2 Commands Cause Motion Error If Specifying RS-232C

If specifying RS-232C port of the controller, the following commands/ functions cause motion error.

Input #	Allows string or numeric data to be received from a file, communications port, or database and stored in one or more variables.
Print #	Outputs data to the specified file, communications port, database, or device.
Line Input #	Reads data of one line from a file, communication port, database, or the device.
Lof	Checks whether the specified RS-232 or TCP/IP port has any lines of data in its buffer.
Read	Reads characters from a file or communications port.
ReadBin	Reads binary data from a file or communications port.
Write	Writes characters to a file or communication port without end of line terminator.
WriteBin	Writes binary data to a file or communications port.

20.3 Commands Cause Error

20.3.1 Conveyor Tracking Commands

If executing conveyor tracking commands/functions, motion error occurs.

Cnv_AbortTrack	Aborts tracking motion to a conveyor queue point.
Cnv_Accel Function	Returns acceleration and deceleration for the conveyor
Cnv_Accel	Sets acceleration and deceleration for the conveyor
Cnv_Downstream Function	Returns the downstream limit for the specified conveyor.
Cnv_Downstream	Sets the downstream limit for the specified conveyor.
Cnv_Fine Function	Returns the current Cnv_Fine setting.
Cnv_Fine	Sets the value of Cnv_Fine for one conveyor.
Cnv_Flag Function	Returns the tracking state of the robot
Cnv_Mode Function	Returns the setting mode value of the conveyor
Cnv_Mode	Sets the setting mode value of the conveyor
Cnv_Name\$ Function	Returns the name of the specified conveyor.
Cnv_Number Function	Returns the number of a conveyor specified by name.
Cnv_OffsetAngle	Sets the offset value for the conveyor queue data.
Cnv_OffsetAngle Function	Returns the offset value of the conveyor queue data.
Cnv_Point Function	Returns a robot point in the specified conveyor's coordinate system derived from sensor coordinates.
Cnv_PosErr Function	Returns deviation in current tracking position compared to tracking target.
Cnv_Pulse Function	Returns the current position of a conveyor in pulses.
Cnv_QueueAdd	Adds a robot point to a conveyor queue.
Cnv_QueueGet Function	Returns a point from the specified conveyor's queue.
Cnv_QueueLen Function	Returns the number of items in the specified conveyor's queue.
Cnv_QueueList	Displays a list of items in the specified conveyor's queue.
Cnv_QueueMove	Moves data from upstream conveyor queue to downstream conveyor queue.
Cnv_QueueReject	Sets and displays the queue reject distance for a conveyor.
Cnv_QueueReject Function	Returns the current part reject distance for a conveyor.
Cnv_QueueRemove	Removes items from a conveyor queue.
Cnv_QueueUserData	Sets and displays user data associated with a queue entry.
Cnv_QueueUserData Function	Returns the user data value associated with an item in a conveyor queue.
Cnv_RobotConveyor Function	Returns the conveyor being tracked by a robot.
Cnv_Speed Function	Returns the current speed of a conveyor.
Cnv_Trigger	Latches current conveyor position for the next Cnv_QueueAdd statement.
Cnv_Upstream Function	Returns the upstream limit for the specified conveyor.
Cnv_Upstream	Sets the upstream limit for the specified conveyor.

20.3.2 PG Commands

If executing PG commands, motion error occurs.

PG_FastStop	Stops the PG axes immediately.
PG_LSpeed	Sets the pulse speed of the time when the PG axis starts accelerating and finishes decelerating.
PG_Scan	Starts the continuous spinning motion of the PG robot axes.
PG_SlowStop	Stops slowly the PG axis spinning continuously.

20.3.3 R-I/O Commands

If executing R-I/O commands/functions, motion error occurs.

LatchEnable	Enable/Disable the latch function for the robot position by the R-I/O input.
LatchState Function	Returns the latch state of robot position using the R-I/O.
LatchPos Function	Returns the robot position latched using the R-I/O input signal.
SetLatch	Sets the latch function of the robot position using the R-I/O input

20.3.4 Force Sensing Commands

If executing force sensing commands/functions, motion error occurs.

Force_Calibrate	Sets zero offsets for all axes for the current force sensor.
Force_ClearTrigger	Clears all trigger conditions for the current force sensor.
Force_GetForces	Returns the forces and torques for all force sensor axes in an array.
Force_GetForce Function	Returns the force for a specified axis.
Force_Sensor	Sets the current force sensor for the current task.
Force_Sensor Function	Returns the current force sensor for the current task.
Force_SetTrigger	Sets the force trigger for the Till command.

20.3.5 Other (FineDist)

You cannot use the command: FineDist

Robot determines the position by set value of Fine even if using FineDist.

Fine	Specifies and displays the positioning error limits. (Unit: pulse)
FineDist	Specifies and displays the positioning error limits (Unit: mm)

20.3.6 Other (HealthCalcPeriod)

You cannot use the command: HealthCalcPeriod

A period of parts consumption commands information to calculate “remaining months” is one day and unable to change.

HealthCalcPeriod	Set the calculation period of parts consumption commands.
HealthCalcPeriod Function	Returns the calculation period of parts consumption commands.

20.3.7 Other (ChDisk)

You cannot specify USB option to the command: ChDisk

20.4 Restrictions of Functions

Some of the following functions are not available.

20.4.1 TP3

You cannot use build of the program. An error occurs to finish the program if executing it. Other functions are available.

20.4.2 Loop Processing

If the created robot control program is consisted of the multi-tasking and also there are some task with infinite loop, the system may become unstable and the connection with EPSON RC+ is disconnected.

The controller detects infinite loop tasks. If the possibilities to affect the system are detected, the following error occurs and stops the program.

If the error occurs, modify the program and make sure not to set infinite loop.

Error code : 2556

Error message : An excessive loop was detected.
Please reduce the number of looped tasks or set Wait

Do not perform any processing such as infinite loop or any other similar processing as much as possible.

Execute wait command or similar command in the loop processing and avoid occupying the CPU if performing calculation which required loop or waiting for I/O signals.

There is no problem if executing commands with Wait in the loop such as Wait command, robot operating command, Print command, and NetWait command.

NOTE: About infinite loop

Infinite loop is when commands are created only with command without Wait in the loop such as operation instruction, assignment command, and I/O check command.

Example 1: Turns ON output port "2" when Input port "0" turned ON

Example of program that may cause errors

```
Do
  If Sw(0) = On Then
    On(2)
  Exit Do
EndIf
Loop
```

Correction example

```
Wait Sw(0) = On
On(2)
```

Example 2: When performing the large amount of calculation with a loop structure.

Example of program that may cause errors

```
For i = 0 To 10000
  For j = 0 To 10000
    a = a + 1
  Next
Next
```

Correction example

```
For i = 0 To 10000
  For j = 0 To 10000
    a = a + 1
  Next
  Wait 0.01      ' Execute Wait to avoid occupying the CPU
Next
```

20.4.3 Camera Searching by CV1/CV2

You may not be able to use Camera searching by VT series Manipulator if CV1/CV2 is used and the following two conditions are fulfilled.

- When connecting PC and VT series Manipulator by USB connection
- When the configuration of default gateway of VT series Manipulator is None, or "0.0.0.0".

Type IP address for CV1/ CV2 manually when you cannot use Camera researching.

For more details of Camera researching, refer to the following.

Vision Guide 7.0 Hardware & Setup

Setup: 2.3.2 CV1/CV2 Camera Configuration

20.4.4 Restore the Data of Backup Controller Function

Backup controller function that acquired by virtual controller cannot be restored to VT series Manipulator.

NOTE : Backup controller function that acquired by actual equipment can be restored to VT series Manipulator.

21. Error Code Table

For error code, refer to the following manual.

EPSON RC+7.0 SPEL+ Language Reference *SPEL+ Error Messages*

22. Maintenance Parts List

Part Name			Code	Note	Reference: Maintenance	Overhaul *3	
Cover	Arm #1		1774549		7.1		
	Arm #2		1774548		7.2		
	Arm #3		1774547		7.3		
	Arm #4	1	1774546		7.4		
		2	1774550		7.5		
Cable unit			2191349		8.1, 8.2		
AC servo motor	Joint #1		2194596	300 W unit	9.1	✓	
	Joint #2		2194597		10.1	✓	
	Joint #3		2194598	200 W unit	11.1	✓	
	Joint #4		2194599	100W unit	12.1	✓	
	Joint #5, #6		2194600		13.1, 14.1	✓	
Reduction gear unit* *1	Joint #1, #2		1759296		9.2, 10.2	✓	
	Joint #3, #4		1759298		11.2, 12.2	✓	
	Joint #5, #6		1759300		13.2, 14.2	✓	
Timing belt	Joint #1		1751536	Width 9 mm	255mm	9.1, 9.3	✓
	Joint #2		1753920		501mm	10.1, 10.3	✓
	Joint #3		1751537		480 mm	11.1, 11.3	✓
	Joint #4		1751538	Width 6 mm	210 mm	12.1, 12.3	✓
	Joint #5, #6		1762243		495 mm	13.1, 13.3 14.1, 14.3	✓
Thermal sheet			1755573	For motor	9.1, 10.1, 11.1 12.1		
AMP board			2189027	For motor	15.1, 15.2, 15.3		
LED plate			1749496	Arm #2	16		
Felt sheet	Joint #2		1755083	Arm #2	17.1		
	Joint #3		1755084		17.2		
Controller unit			2194603	CPU board, DPB board, Cooling fan unit	18.1		
Power board			2188638		18.2.1		
CPU/DPB board			2193553	With: battery Without: SD, Thermal sheet	18.2.2		
Lithium battery			2113554		18.3		
Cooling fan			2191301		18.4		
SD card			2182748		18.5		

22. Maintenance Parts List

Part Name			Code	Note	Reference: Maintenance
Grease *3	SK-1A	Joint #1, #2, #3, #4	-	For purchasing grease, and adhesive, please contact the sales company in your region.	9.2, 10.2, 11.2, 12.2
	SK-2	Joint #5, #6, Bevel gear	-		13.2, 14.2
	GPL-224	Cable	-		8.1, 8.2
Adhesive *3	LOCTITE641		-		9.2, 10.2, 11.2, 12.2, 13.2, 14.2
Wire tie	AB100		1675753	1 bag (100 pcs: white)	8.1, 8.2
	AB150		1675754	1 bag (100 pcs: white)	

*1 Reduction Gear Unit:

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

Waveform generator

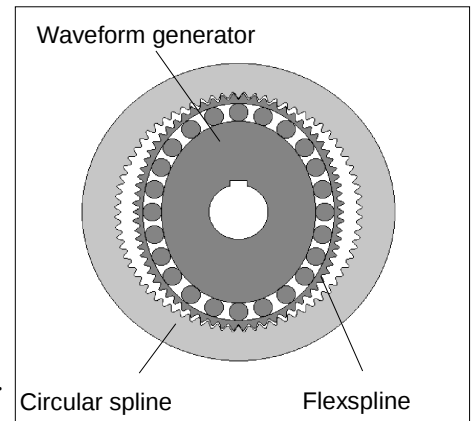
The waveform generator consists of an ellipsoidal cam and ball bearings on outer circumference. The inner ring of the bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.

Flexspline

A thin, elastic, cup-shaped metal body with gear teeth around the outer circumference of the opening.

Circular spline

A rigid, ring-shaped body with gear teeth on the inner circumference. The circular spline has two more teeth than the flexspline does.



The splines are greased. Be sure to keep the grease from being attaching to the clothes.

*2 Overhaul:

As a rough indication, perform the overhaul (parts replacement) before reaching 20,000 operation hours of the Manipulator. The operation hours can be checked in [Controller Status Viewer] dialog - [Motor On Hours]. For details, refer to *Maintenance 2.2 Overhaul*.

*3 Regarding purchase of grease and adhesive:

Due to the chemicals regulations of individual countries (the UN GHS), we are requesting our customers to purchase grease and other materials required for maintenance from the manufacturers listed in the table below as of April 2015.

Regarding purchase of grease and other materials, please contact the following manufacturers. If there is anything unclear, please contact the suppliers.

Product name	Manufacturer	URL
Harmonic Grease SK-1A Harmonic Grease SK-2	Harmonic Drive Systems Inc.	http://www.harmonicdrive.net/
Krytox®GPL-224	DuPont	http://www2.dupont.com/Our_Company/en_US/worldwide/us_country.html
LOCTITE641 LOCTITE243	LOCTITE	http://loctite.com/

Appendix A: Open Source Software License

(VT series Manipulator)

- (1) The VT series product includes open source software programs listed in Section (6) according to the license terms of each open source software program.
- (2) We provide the source code of the Open Source Programs (each is defined in Section (6)) until five (5) years after the discontinuation of same model of this option product. If you desire to receive the source code above, please contact the "SUPPLIER" in the first pages of the *Robot System Safety and Installation* manual. You shall comply with the license terms of each open source software program.
- (3) The open source software programs are WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. See the license agreements of each open source software program for more details, which are described on Section (7).
- (4) OpenSSL toolkit
The VT series product includes software developed by the OpenSSL project for use in the OpenSSL Toolkit (<http://www.openssl.org/>).
This product includes cryptographic software written by Eric Young (eay@cryptsoft.com).
- (5) The license terms of each open source software program are described on Section (7).
- (6) The list of open source software programs which the VT series product includes are as follows.

bash	dash	libc-bin	libc6
libcomerr2	libdevmapper 1.02.1	libgcc1	libstdc++6
libudev1	login	Logrotate	makedev
mount	mountall	net-tools	netbase
rsyslog	ssh	sudo	tzdata
ubuntu-minimal	udev	Linux	Xenomai

(7) For the each open source license, please refer to the URLs as follows.

bash	http://tiswww.case.edu/php/chet/bash/bashtop.html
dash	http://packages.ubuntu.com/ja/precise/dash
libc-bin	http://www.eglibc.org/home
libc6	http://www.eglibc.org/home
libcomerr2	http://packages.ubuntu.com/ja/precise/libcomerr2
libdevmapper1.02.1	ftp://sources.redhat.com/pub/lvm2/
libgcc1	ftp://gcc.gnu.org/pub/gcc/releases/
libstdc++6	ftp://gcc.gnu.org/pub/gcc/releases/
libudev0	http://packages.ubuntu.com/ja/precise/libudev0
login	http://packages.ubuntu.com/ja/precise/login
logrotate	https://fedorahosted.org/logrotate/
makedev	ftp.redhat.com
mount	ftp://ftp.us.kernel.org/pub/linux/utils/util-linux-ng/
mountall	http://packages.ubuntu.com/ja/precise/mountall
net-tools	https://developer.berlios.de/projects/net-tools/
netbase	http://packages.ubuntu.com/ja/precise/netbase
rsyslog	http://www.rsyslog.com
ssh	http://www.openssh.com/ftp.html
sudo	http://www.sudo.ws/
tzdata	http://www.iana.org/time-zones
ubuntu-minimal	http://packages.ubuntu.com/ja/precise/ubuntu-minimal
udev	http://packages.ubuntu.com/ja/precise/udev
Linux	http://www.kernel.org/
Xenomai	http://www.xenomai.org/