

DENSO ROBOT

Compact, vertical articulated

VC-F SERIES

INSTALLATION & MAINTENANCE GUIDE

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Preface

Thank you for purchasing this high-speed, high-accuracy assembly robot.

Before operating your robot, read this manual carefully to safely get the maximum benefit from your robot in your assembling operations.

Robot series and/or models covered by this manual

Series	Model		Remarks
	Floor-mount	Overhead-mount	
Compact, vertical articulated VC-F (Models configured with RC7 controller)	VC-5353F	←	5 axes robot
	VC-6353F	←	6 axes robot

NOTE: Model names listed above apply to the models of robot systems. The model names of robot units are followed by M. If the robot system model is VC-6353F, for example, the robot unit model is VC-6353FM.

Important

To ensure operator safety, be sure to read the precautions and instructions in "SAFETY PRECAUTIONS."

How the documentation set is organized

The documentation set consists of the following books. If you are unfamiliar with this robot and option(s), please read all books and understand them fully before operating your robot and option(s).

GENERAL INFORMATION ABOUT ROBOT

Provides the packing list of the robot and outlines of the robot system, robot unit, and robot controller.

INSTALLATION & MAINTENANCE GUIDE - this book -

Provides instructions for installing the robot components and customizing your robot, and maintenance & inspection procedures.

BEGINNER'S GUIDE

Introduces you to the DENSO robot. Taking an equipment setup example, this book guides you through running your robot with the teach pendant, making a program in WINCAPSII, and running your robot automatically.

SETTING-UP MANUAL

Describes how to set-up or teach your robot with the teach pendant, operating panel, or mini-pendant.

WINCAPSII GUIDE

Provides instructions on how to use the teaching system WINCAPSII which runs on the PC connected to the robot controller for developing and managing programs.

PROGRAMMER'S MANUAL (I), (II)

Describes the PAC programming language, program development, and command specifications in PAC.

RC7 CONTROLLER INTERFACE MANUAL

Describes the RC7 controller, interfacing with external devices, system- and user-input/output signals, and I/O circuits.

ERROR CODE TABLES

List error codes that will appear on the teach pendant, operating panel, or PC screen if an error occurs in the robot series or WINCAPSII. These tables provide detailed description and recovery ways.

OPTIONS MANUAL

Describes the specifications, installation, and use of optional devices.

How this book is organized

This book is just one part of the robot documentation set. This book consists of SAFETY PRECAUTIONS, chapters one through three.

SAFETY PRECAUTIONS

Defines safety terms and related symbols and provides precautions that should be observed. Be sure to read this section before operating your robot.

Chapter 1 Installing Robot Components

Provides information about physical site planning, installation procedures, and engineering-design notes for hands.

Chapter 2 Customizing Your Robot

Describes how to customize your robot--defining the software motion space and restricted space, CALSEting, and setting control set of motion optimization.

Chapter 3 Maintenance and Inspection

Describes the regular maintenance and inspections necessary for maintaining the performance and functions of your robot.

SAFETY PRECAUTIONS

Be sure to observe all of the following safety precautions.

Strict observance of these warning and caution indications are a **MUST** for preventing accidents, which could result in bodily injury and substantial property damage. Make sure you fully understand all definitions of these terms and related symbols given below, before you proceed to the text itself.

 WARNING	Alerts you to those conditions, which could result in serious bodily injury or death if the instructions are not followed correctly.
 CAUTION	Alerts you to those conditions, which could result in minor bodily injury or substantial property damage if the instructions are not followed correctly.

Terminology and Definitions

Maximum space: Refers to the volume of space encompassing the maximum designed movements of all robot parts including the end-effector, workpiece and attachments. (Quoted from the RIA* Committee Draft.)

Restricted space: Refers to the portion of the maximum space to which a robot is restricted by limiting devices (i.e., mechanical stops). The maximum distance that the robot, end-effector, and workpiece can travel after the limiting device is actuated defines the boundaries of the restricted space of the robot. (Quoted from the RIA Committee Draft.)

Motion space: Refers to the portion of the restricted space to which a robot is restricted by software motion limits. The maximum distance that the robot, end-effector, and workpiece can travel after the software motion limits are set defines the boundaries of the motion space of the robot. (The "motion space" is DENSO WAVE-proprietary terminology.)

Operating space: Refers to the portion of the restricted space (or motion space in Denso robot) that is actually used by the robot while performing its task program. (Quoted from the RIA Committee Draft.)

Task program: Refers to a set of instructions for motion and auxiliary functions that define the specific intended task of the robot system. (Quoted from the RIA Committee Draft.)

(*RIA: Robotic Industries Association)

1. Introduction

This section provides safety precautions to be observed during installation, teaching, inspection, adjustment, and maintenance of the robot.

2. Installation Precautions

2.1 Insuring the proper installation environment

2.1.1 For standard type

The standard type has not been designed to withstand explosions, dust-proof, nor is it splash-proof. Therefore, it should not be installed in any environment where:

- (1) there are flammable gases or liquids,
- (2) there are any shavings from metal processing or other conductive material flying about,
- (3) there are any acidic, alkaline or other corrosive gases,
- (4) there is cutting or grinding oil mist,
- (5) it may likely be submerged in fluid,
- (6) there is sulfuric cutting or grinding oil mist, or
- (7) there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise.

2.1.2 For dust-proof, splash-proof type

The dust-proof, splash-proof type is an IP54-equivalent structure, but it has not been designed to withstand explosions. (The HS-E-W and the wrist of the VM-D-W/VS-E-W are an IP65-equivalent dust-proof and splash-proof structure.)

Note that the robot controller is not a dust- or splash-proof structure. Therefore, when using the robot controller in an environment exposed to mist, put it in an optional protective box.

The dust-proof, splash-proof type should not be installed in any environment where:

- (1) there are any flammable gases or liquids,
- (2) there are any acidic, alkaline or other corrosive gases,
- (3) there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise,
- (4) it may likely be submerged in fluid,
- (5) there are any grinding or machining chips or shavings,
- (6) any machining oil not specified in this manual is in use, or
Note: Yushiron Oil No. 4C (non-soluble) is specified.
- (7) there is sulfuric cutting or grinding oil mist.

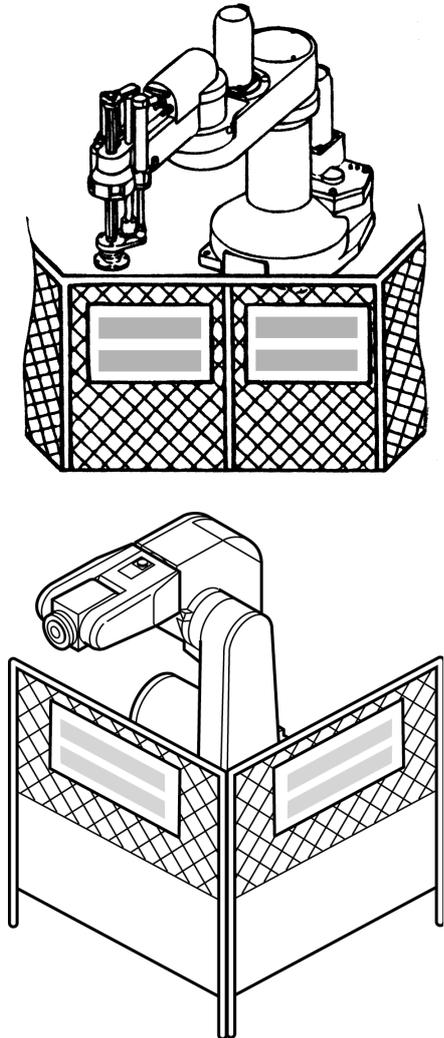
2.2 Service space

The robot and peripheral equipment should be installed so that sufficient service space is maintained for safe teaching, maintenance, and inspection.

SAFETY PRECAUTIONS

- 2.3 Control devices outside the robot's restricted space** The robot controller, teach pendant, and operating panel should be installed outside the robot's restricted space and in a place where you can observe all of the robot's movements when operating the robot controller, teach pendant, or operating panel.
- 2.4 Positioning of gauges** Pressure gauges, oil pressure gauges and other gauges should be installed in an easy-to-check location.
- 2.5 Protection of electrical wiring and hydraulic/pneumatic piping** If there is any possibility of the electrical wiring or hydraulic/pneumatic piping being damaged, protect them with a cover or similar item.
- 2.6 Positioning of emergency stop switches** Emergency stop switches should be provided in a position where they can be reached easily should it be necessary to stop the robot immediately.
- (1) The emergency stop switches should be red.
 - (2) Emergency stop switches should be designed so that they will not be released after pressed, automatically or mistakenly by any other person.
 - (3) Emergency stop switches should be separate from the power switch.
- 2.7 Positioning of operating status indicators** Operating status indicators should be positioned in such a way where workers can easily see whether the robot is on temporary halt or on an emergency or abnormal stop.

2.8 Setting-up the safety fence or enclosure



A safety fence or enclosure should be set up so that no one can easily enter the robot's restricted space. If it is impossible, utilize other protectors as described in Section 2.9.

- (1) The fence or enclosure should be constructed so that it cannot be easily moved or removed.
- (2) The fence or enclosure should be constructed so that it cannot be easily damaged or deformed through external force.
- (3) Establish the exit/entrance to the fence or enclosure. Construct the fence or enclosure so that no one can easily get past it by climbing over the fence or enclosure.
- (4) The fence or enclosure should be constructed to ensure that it is not possible for hands or any other parts of the body to get through it.
- (5) Take any one of the following protections for the entrance/exit of the fence or enclosure:
 - 1) Place a door, rope or chain across the entrance/exit of the fence or enclosure, and fit it with an interlock that ensures the emergency stop device operates automatically if it is opened or removed.
 - 2) Post a warning notice at the entrance/exit of the fence or enclosure stating "In operation--Entry forbidden" or "Work in progress--Do not operate" and ensure that workers follow these instructions at all times.

When making a test run, before setting up the fence or enclosure, place an overseer in a position outside the robot's restricted space and one in which he/she can see all of the robot's movements. The overseer should prevent workers from entering the robot's restricted space and be devoted solely to that task.

2.9 Positioning of rope or chain

If it is not possible to set up the safety fence or enclosure described in Section 2.8, hang a rope or chain around the perimeter of the robot's restricted space to ensure that no one can enter the restricted space.

- (1) Ensure the support posts cannot be moved easily.
- (2) Ensure that the rope or chain's color or material can easily be discerned from the surrounds.
- (3) Post a warning notice in a position where it is easy to see stating "In operation--Entry forbidden" or "Work in progress --Do not operate" and ensure that workers follow these instructions at all times.
- (4) Set the exit/entrance, and follow the instructions given in Section 2.8, (3) through (5).

SAFETY PRECAUTIONS

2.10 Setting the robot's motion space

The area required for the robot to work is called the robot's operating space.

If the robot's motion space is greater than the operating space, it is recommended that you set a smaller motion space to prevent the robot from interfering or disrupting other equipment.

Refer to the "INSTALLATION & MAINTENANCE GUIDE."

2.11 No robot modification allowed

Never modify the robot unit, robot controller, teach pendant or other devices.

2.12 Cleaning of tools

If your robot uses welding guns, paint spray nozzles, or other end-effectors requiring cleaning, it is recommended that the cleaning process be carried out automatically.

2.13 Lighting

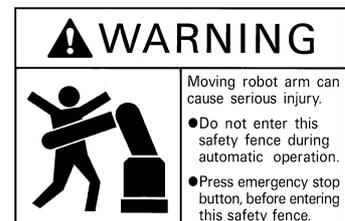
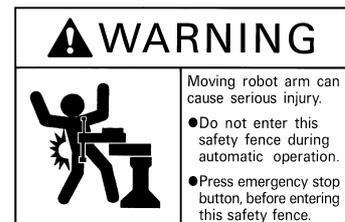
Sufficient illumination should be assured for safe robot operation.

2.14 Protection from objects thrown by the end-effector

If there is any risk of workers being injured in the event that the object being held by the end-effector is dropped or thrown by the end-effector, consider the size, weight, temperature and chemical nature of the object and take appropriate safeguards to ensure safety.

2.15 Affixing the warning label

Place the warning label packaged with the robot on the exit/entrance of the safety fence or in a position where it is easy to see.



3. Precautions while robot is running



Warning

Touching the robot while it is in operation can lead to serious injury. Please ensure the following conditions are maintained and that the cautions listed from Section 3.1 onwards are followed when any work is being performed.

WARNING	
	Moving robot arm can cause serious injury. ● Do not enter this safety fence during automatic operation. ● Press emergency stop button, before entering this safety fence.
WARNING	
	Moving robot arm can cause serious injury. ● Do not enter this safety fence during automatic operation. ● Press emergency stop button, before entering this safety fence.

- 1) Do not enter the robot's restricted space when the robot is in operation or when the motor power is on.
- 2) As a precaution against malfunction, ensure that an emergency stop device is activated to cut the power to the robot motor upon entry into the robot's restricted space.
- 3) When it is necessary to enter the robot's restricted space to perform teaching or maintenance work while the robot is running, ensure that the steps described in Section 3.3 "Ensuring safety of workers performing jobs within the robot's restricted space" are taken.

3.1 Creation of working regulations and assuring worker adherence

When entering the robot's restricted space to perform teaching or maintenance inspections, set "working regulations" for the following items and ensure workers adhere to them.

- (1) Operating procedures required to run the robot.
- (2) Robot speed when performing teaching.
- (3) Signaling methods to be used when more than one worker is to perform work.
- (4) Steps that must be taken by the worker in the event of a malfunction, according to the contents of the malfunction.
- (5) The necessary steps for checking release and safety of the malfunction status, in order to restart the robot after robot movement has been stopped due to activation of the emergency stop device
- (6) Apart from the above, any steps below necessary to prevent danger from unexpected robot movement or malfunction of the robot.
 - 1) Display of the control panel (See Section 3.2 on the following page)
 - 2) Assuring the safety of workers performing jobs within the robot's restricted space (See Section 3.3 on the following page)

3) Maintaining worker position and stance

Position and stance that enables the worker to confirm normal robot operation and to take immediate refuge if a malfunction occurs.

4) Implementation of measures for noise prevention

5) Signaling methods for workers of related equipment

6) Types of malfunctions and how to distinguish them

Please ensure "working regulations" are appropriate to the robot type, the place of installation and to the content of the work.

Be sure to consult the opinions of related workers, engineers at the equipment manufacturer and that of a labor safety consultant when creating these "working regulations".

3.2 Display of operation panel

To prevent anyone other than the worker from accessing the start switch or the changeover switch by accident during operation, display something to indicate it is in operation on the operating panel or teach pendant. Take any other steps as appropriate, such as locking the cover.

3.3 Ensuring safety of workers performing jobs within the robot's restricted space

When performing jobs within the robot's restricted space, take any of the following steps to ensure that robot operation can be stopped immediately upon a malfunction.

- (1) Ensure an overseer is placed in a position outside the robot's restricted space and one in which he/she can see all robot movements, and that he/she is devoted solely to that task.
 - ① An emergency stop device should be activated immediately upon a malfunction.
 - ② Do not permit anyone other than the worker engaged for that job to enter the robot's restricted space.
- (2) Ensure a worker within the robot's restricted space carries the portable emergency stop switch so he/she can press it (the robot stop button on the teach pendant) immediately if it should be necessary to do so.

3.4 Inspections before commencing work such as teaching

Before starting work such as teaching, inspect the following items, carry out any repairs immediately upon detection of a malfunction and perform any other necessary measures.

- (1) Check for any damage to the sheath or cover of the external wiring or to the external devices.
- (2) Check that the robot is functioning normally or not (any unusual noise or vibration during operation).
- (3) Check the functioning of the emergency stop device.
- (4) Check there is no leakage of air or oil from any pipes.
- (5) Check there are no obstructive objects in or near the robot's restricted space.

3.5 Release of residual air pressure

Before disassembling or replacing pneumatic parts, first release any residual air pressure in the drive cylinder.

3.6 Precautions for test runs

Whenever possible, have the worker stay outside of the robot's restricted space when performing test runs.

3.7 Precautions for automatic operation

(1) At start-up

Before the robot is to be started up, first check the following items as well as setting the signals to be used and perform signaling practice with all related workers.

- 1) Check that there is no one inside the robot's restricted space.
- 2) Check that the teach pendant and tools are in their designated places.
- 3) Check that no lamps indicating a malfunction on the robot or related equipment are lit.

(2) Check that the display lamp indicating automatic operation is lit during automatic operation.

(3) Steps to be taken when a malfunction occurs

Should a malfunction occur with the robot or related equipment and it is necessary to enter the robot's restricted space to perform emergency maintenance, stop the robot's operation by activating the emergency stop device. Take any necessary steps such as placing a display on the starter switch to indicate work is in progress to prevent anyone from accessing the robot.

3.8 Precautions in repairs

- (1) Do not perform repairs outside of the designated range.
- (2) Under no circumstances should the interlock mechanism be removed.
- (3) When opening the robot controller's cover for battery replacement or any other reasons, always turn the robot controller power off and disconnect the power cable.
- (4) Use only spare tools specified in this manual.

4. Daily and periodical inspections

- (1) Be sure to perform daily and periodical inspections. Before starting jobs, always check that there is no problem with the robot and related equipment. If any problems are found, take any necessary measures to correct them.
- (2) When carrying out periodical inspections or any repairs, maintain records and keep them for at least 3 years.

5. Management of floppy disks

- (1) Carefully handle and store the "Initial settings" floppy disks packaged with the robot, which store special data exclusively prepared for your robot.
- (2) After finishing teaching or making any changes, always save the programs and data onto floppy disks.

Making back-ups will help you recover if data stored in the robot controller is lost due to the expired life of the back-up battery.
- (3) Write the names of each of the floppy disks used for storing task programs to prevent incorrect disks from loading into the robot controller.
- (4) Store the floppy disks where they will not be exposed to dust, humidity and magnetic field, which could corrupt the disks or data stored on them.



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Chapter 1 Installing Robot Components

1.1 Preparing a Proper Environment for Installation

Before installing the robot unit and robot controller, confirm that the operating environment is in conformity with each item of "SAFETY PRECAUTIONS, 2. Installation Precautions," and that the surrounding environment of the location where the robot is to be used meets the specifications as described below. Also, take proper measures to protect the components from vibration.

In an inappropriate environment, the robot will not operate to its full capacity or performance, components may not last long, and unexpected failure may result.

1.1.1 Installation Environments

The robot is not explosion-proof, dust-proof or splash-proof, so it should not be installed in any environment where:

- (1) there are flammable gases or liquids,
- (2) there are any shavings from metal processing or other conductive material flying about,
- (3) there are any acidic, alkaline or other corrosive gases,
- (4) there is cutting or grinding oil mist,
- (5) there is sulfuric cutting or grinding oil mist, or
- (6) there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise.

1.1.2 Ambient Temperature and Humidity

Keep the ambient temperature between 0°C and 40°C during operation.

Keep the ambient humidity at 20 to 80%RH to prevent dew condensation.

1.1.3 Vibration

Do not install the robot in an environment where it will be exposed to excessive vibration or impact.

Caution: When the excessive vibration is added to the robot unit at power-off during transportation, ERROR 2AF1 (Encoder reference position error) may occur.
If the ERROR 2AF1 occurs when turning the robot controller ON at first after purchasing the robot, refer to the "ERROR CODE TABLES" or contact our Robot Service Section.

1.1.4 Connecting the Robot Unit and Robot Controller

Before delivery, the robot unit and the robot controller are adjusted to each other as a set. When two or more robots are to be used, use the robots and robot controllers that have been adjusted to each other as a set.

Caution: The robot unit and robot controller in a set are given the same serial number.

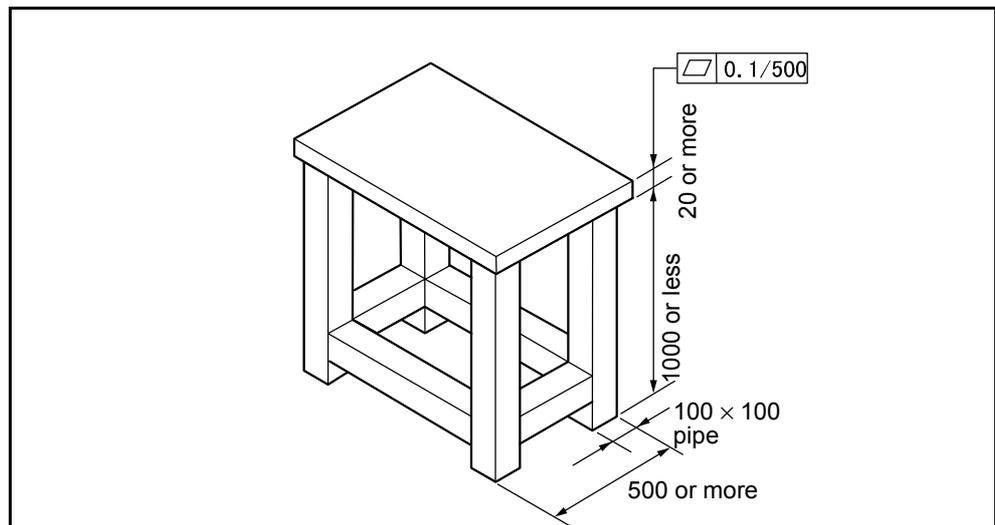
1.1.5 Installation Environment of the Robot Unit

Below table lists the installation requirements for the robot unit. Prepare a highly rigid mount as shown in next page.

⚠ Caution Do not electric-weld the equipment including the robot. A large current may flow through the motor encoder or robot controller resulting in a failure. If electric welding is required, remove the robot unit and the robot controller from the equipment beforehand.

Installation Requirements for the Robot Unit

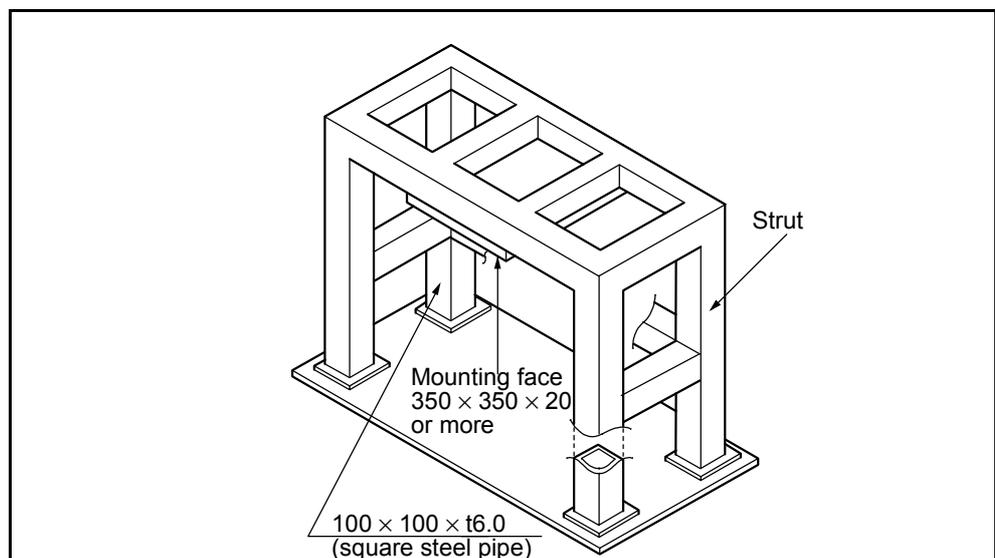
Item	Environments and Conditions
Flatness of the mount	0.1/500 mm
Rigidity of the mount	Use steel materials. <Maximum reaction forces of the robot unit> Maximum torque at horizontal rotation: 100Nm (1 st -axis motion direction) Maximum torque at vertical rotation: 200Nm (2 nd -/3 rd -axis motion direction)
Installation type	Floor-mount or Overhead-mount
Ambient temperature	During operation : 0 to 40°C During storage and transportation : -10 to 60°C
Humidity	During operation : 20 to 80%RH (No dew condensation allowed.)
Vibration	During operation : 4.9 m/s ² (0.5G) or less During storage and transportation : 29.4 m/s ² (3G) or less
Safe installation environment	The robot should not be installed in an environment where: <ul style="list-style-type: none"> • there are flammable gases or liquids, • there are any acidic, alkaline or other corrosive gases, • there is sulfuric cutting or grinding oil mist, or • there are any large-sized inverters, high output/high frequency transmitters, large contactors, welders, or other sources of electrical noise. • there are any shavings from metal processing or other conductive material flying about, • there is cutting or grinding oil mist, or • it may be directly exposed to water, oil or cutting chips.
Working space, etc.	<ul style="list-style-type: none"> • Sufficient service space must be available for inspection and disassembly. • Keep wiring space (230 mm or more) behind the robot, and fasten the wiring to the mounting face or beam so that the weight of the cables will not be directly applied to the connectors.
Grounding conditions	Grounding resistance: 100 Ω or less



⚠ Caution (1) When the robot operates at high speed, the robot mount undergoes large reaction forces. The mount must be rigid enough so that it will not vibrate or be displaced due to reaction forces. It is also advisable to mechanically join the robot mount with heavy equipment.

(2) Some mounts may produce a resonance sound (howling). If this sound is loud, increase the rigidity of the mount or slightly modify the robot speed.

Robot Mount Example for Floor-mount



⚠ Caution (1) When the robot operates at high speed, the top plate structure undergoes large reaction forces. Design the vibration-proof mount so that the top plate will not vibrate due to reaction forces. Also design the top plate structure so that it separates from other top plate structures in the equipment.

(2) Some mounts may produce a resonance sound (howling). If this sound is loud, increase the rigidity of the mount or slightly modify the robot speed.

Robot Mount Example for Overhead-mount

1.2 Installing the Robot Unit

⚠ Caution: Before handling or installing the robot unit, be sure to read "SAFETY PRECAUTIONS, 2. Installation Precautions."

[1] Transporting the Robot Unit

(1) Precautions in transporting the robot

The VC-F series weighs approximately 25kg. Use a crane suitable for the robot weight. Have at least two workers handle this job.

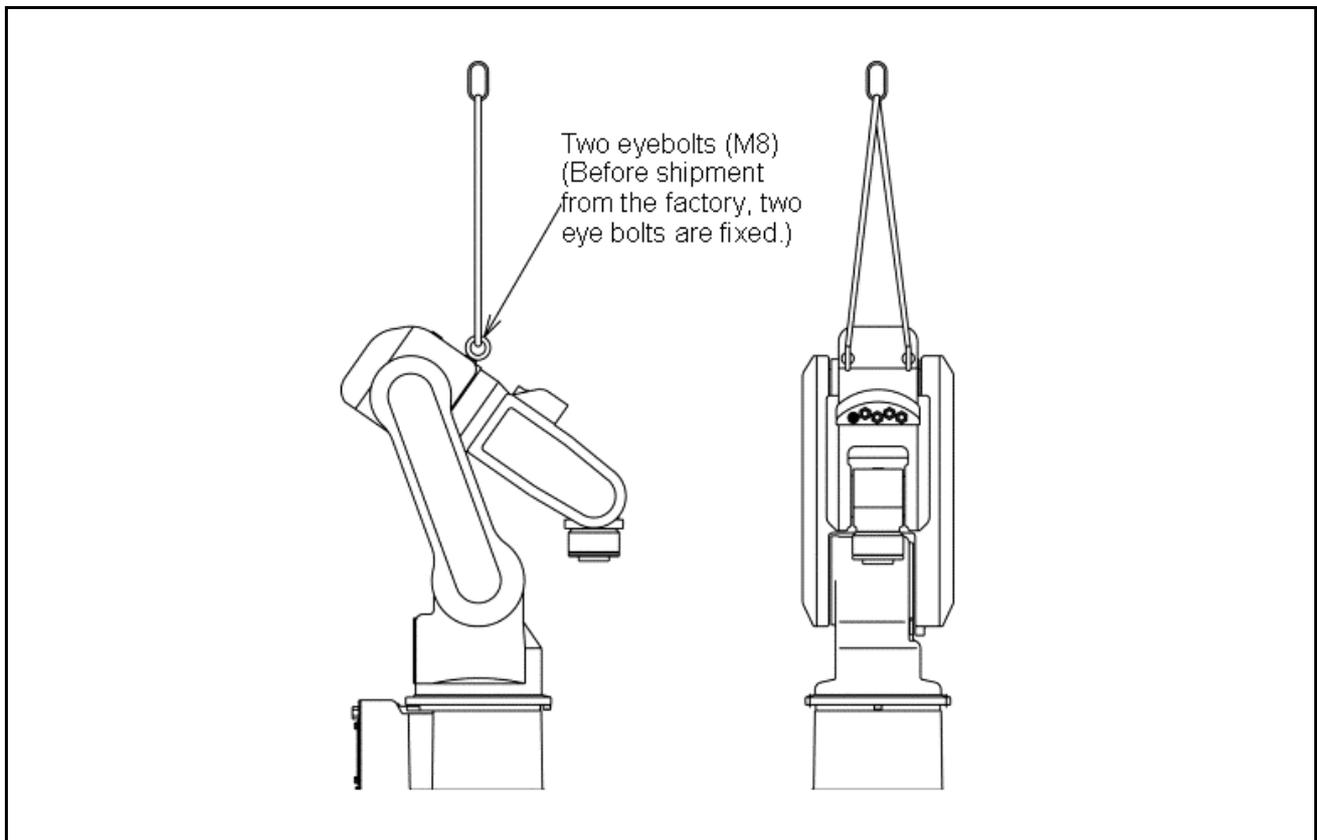
Workers should wear helmets, safety shoes, and gloves during transport.

⚠ Caution Pass the hoisting wires through the specified eyebolts as illustrated below. Passing them through other sections may drop the robot unit, resulting in a broken robot or bodily injuries.

(2) Transporting the robot

Before transportation, set the robot in a transport position as shown in below figure. When unpacked first, the robot is in the transport position, so this job is not required.

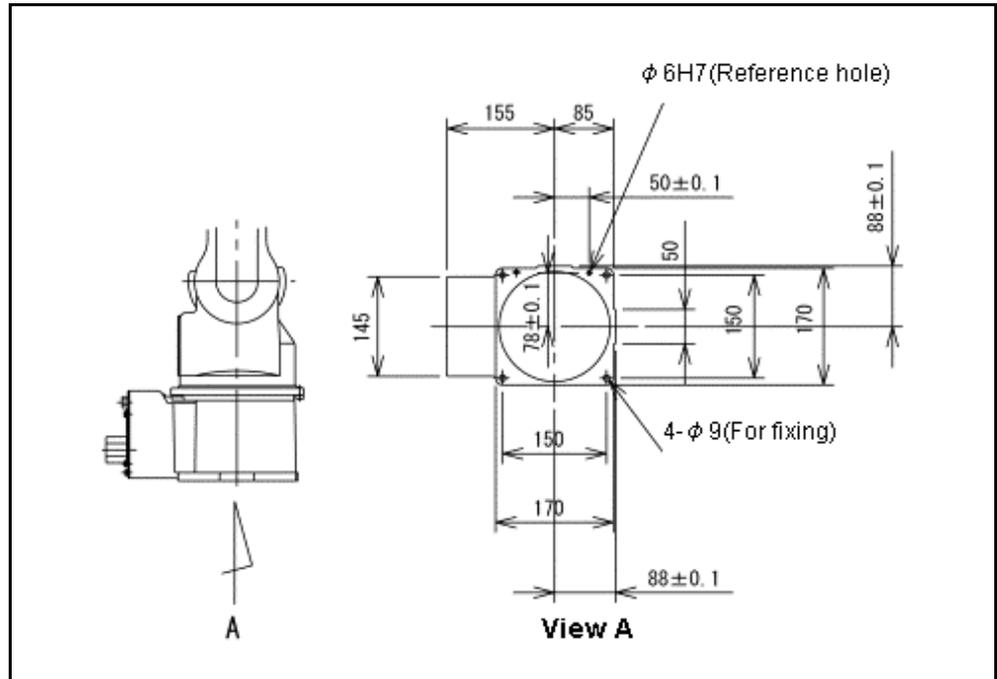
Hoist the robot using a crane as shown in below figure and transport it safely.



Hoisting Points for Transportation

[2] Installing the Robot Unit

- (1) Drill four bolt holes (M8) 15-mm deep or more in the robot mount where the robot unit is to be secured, according to the dimensions shown in below figure.



Bolt Positions for Securing the Robot

- (2) Secure keys or pins to the reference planes.

NOTE: Be sure to secure keys or pins. They can minimize positional deviations when you remove and reinstall the robot unit for maintenance.

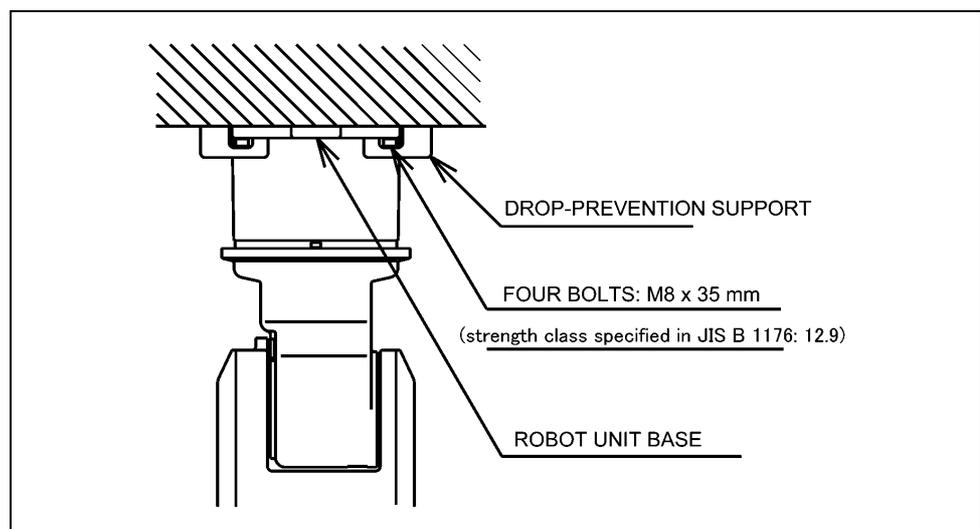
- (3) Set the robot unit into place on the robot mount.

NOTE: When transporting the robot unit, follow the instructions given in "[1] Transporting the Robot Unit."

- (4) Secure the robot to the mount with four bolts and plain washers.

- Bolt: M8 \times 35 mm (strength class specified in JIS B 1176: 12.9)
- Tightening torque: 35.3 ± 7 Nm

- (5) To overhead-mount the robot, the drop-prevention procedures are required.

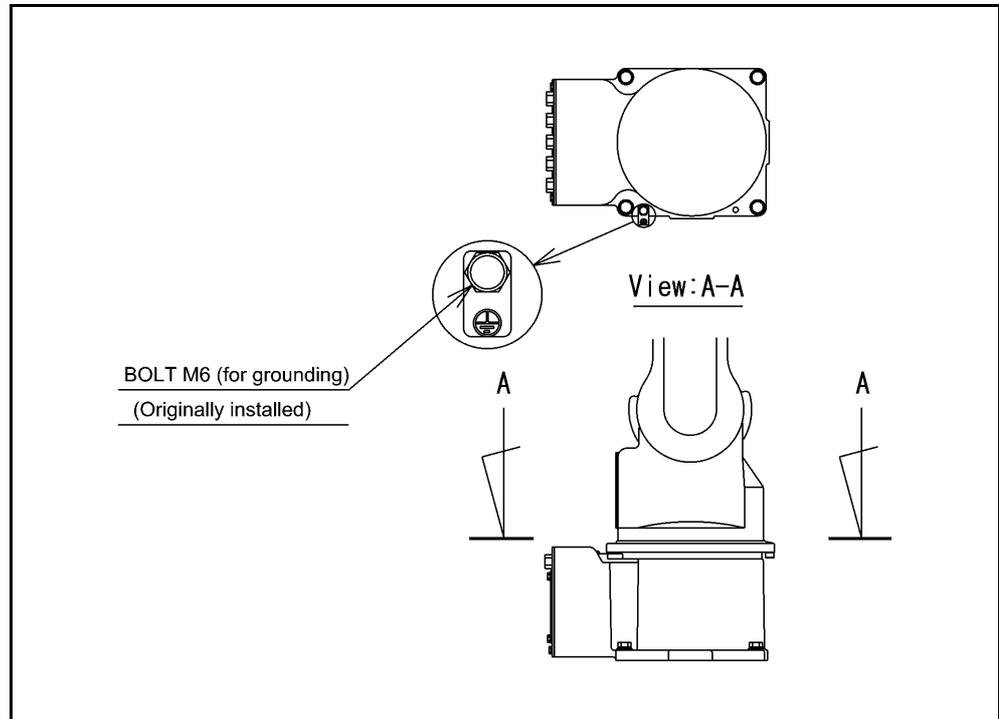


Drop-prevention Procedures

[3] Grounding the Robot Unit

Ground the grounding terminal of the robot unit with a wire of 5.5 mm² or more.

NOTE: Use a dedicated grounding wire and grounding electrode. Do not share them with any other electric power or power equipment such as a welder.



Grounding the Robot Unit

1.3 Installing the Robot Controller

For the installing procedures of the robot controller, refer to the “ Section 6.2 Installing the Robot Controller, RC7 CONTROLLER INTERFACE MNUAL”.

1.4 Engineering-design Notes for Robot Hands

Design a hand (end-effector) so that it will satisfy conditions (1) and (2) described below.

⚠ Caution: Strictly observe these engineering-design notes. Otherwise, the clamped sections of the robot unit will become loose, rattle or be out of position. In the worst case, the mechanical parts of the robot unit and the robot controller may be damaged.

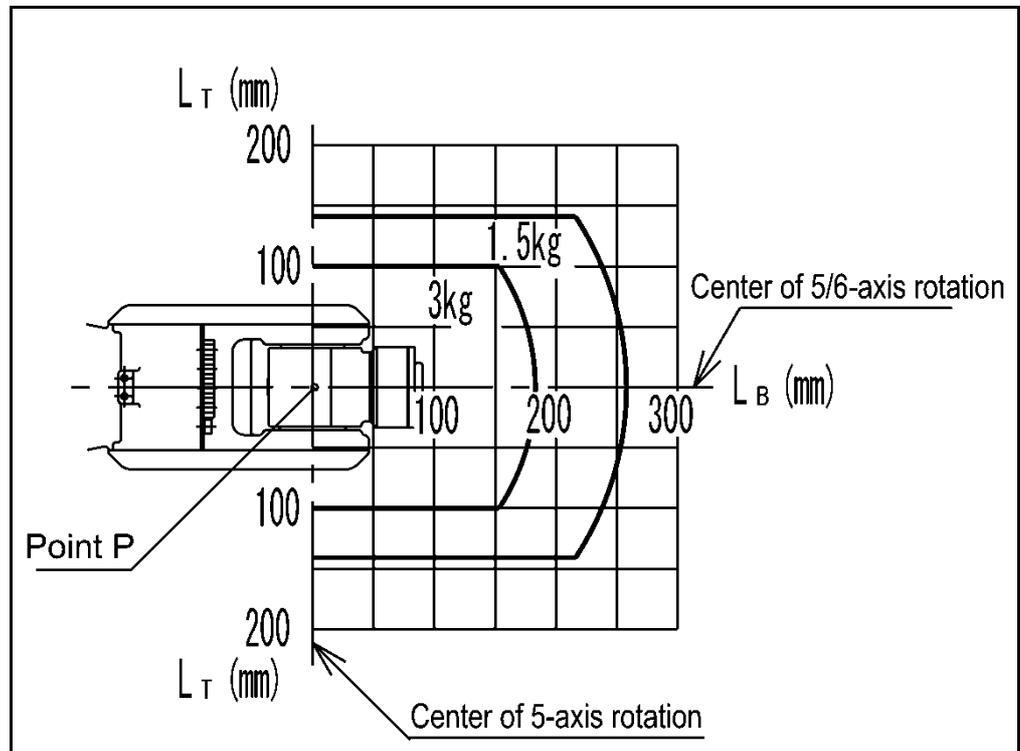
(1) Mass of hand

The total mass of a hand or tool (including workpiece) should be less than the maximum allowable payload of the robot. Be sure to include the mass of wirings and piping used for a hand or tool.

Total mass of hand or tool (incl. workpiece) \leq Max. allowable payload (3kg)

(2) Allowable range of the load-fixing dimension

If the volume of the load is small, design an end-effector so that the load-fixing dimension is within the range shown in below figure.



Allowable range of the load-fixing dimension

(3) Moment of inertia around J4, J5 and J6

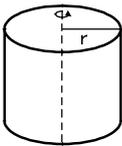
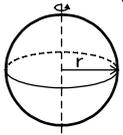
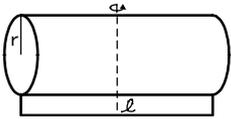
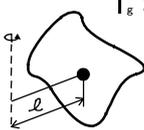
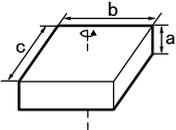
Design an end-effector so that its moments of inertia around J4, J5 and J6 (including workpiece) do not exceed the maximum allowable moment of inertia of the robot.

Moment of inertia around J4, J5 and J6 of end-effector (incl. mass of workpiece) ≤ Max. allowable moment of inertia (Note)

Note: Max. allowable moment of inertia around J4, J5 and J6		
Axis	Moment	Max. allowable moment of inertia
J4 (only VC-6353)	5.39 Nm	0.1 kgm ²
J5	5.39 Nm	0.1kgm ²
J6	2.94 Nm	0.03 kgm ²

When calculating the moment of inertia around J4, J5 and J6 of the end-effector, use the formulas given in following table and figure.

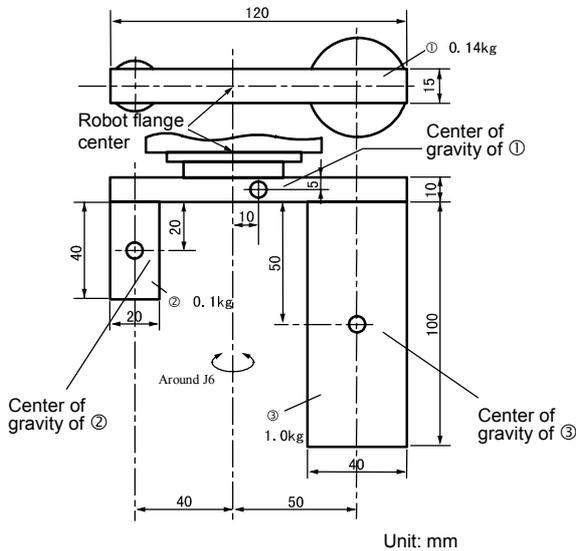
Moment-of-Inertia Formulas

<p>1. Cylinder (1) (Axis of rotation = Center axis)</p>  $I = \frac{mr^2}{2}$	<p>4. Sphere (Axis of rotation = Center axis)</p>  $I = \frac{2mr^2}{5}$
<p>2. Cylinder (2) (The axis of rotation passes through the center of gravity.)</p>  $I = \frac{m}{4} \left(r^2 + \frac{l^2}{3} \right)$	<p>5. Center of gravity not on the axis of rotation</p>  <p>I_g: Inertia moment around center of gravity [kgm²]</p> $I = I_g + m.l^2$
<p>3. Rectangular parallelepiped (The axis of rotation passes through the center of gravity.)</p>  $I = \frac{m}{12} (b^2 + c^2)$	<p> I: Moment of inertia (kgm²) m: Mass (kg) r: Radius (m) b, c, l: Length (m) </p>

Calculation example : When calculating the moment of inertia of a complicated shape, divide it into simple parts as much as possible for easier calculations.

As shown in the figure below, divide the end-effector into three parts (①, ②, ③).

(1) Moment of inertia around J6



Moment of inertia around J6 of ①: I_1 (from 3 and 5 in before table)

$$I_1 = (0.14/12) (0.12^2 + 0.015^2) + 0.14 \times 0.01^2$$

$$= 1.85 \times 10^{-4} \text{ [kgm}^2\text{]}$$

Moment of inertia around J6 of ②: I_2 (from 1 and 5 in before table)

$$I_2 = (0.1 \times 0.01^2)/2 + 0.1 \times 0.04^2$$

$$= 1.65 \times 10^{-4} \text{ [kgm}^2\text{]}$$

Moment of inertia around J6 of ③: I_3 (from 1 and 5 in before table)

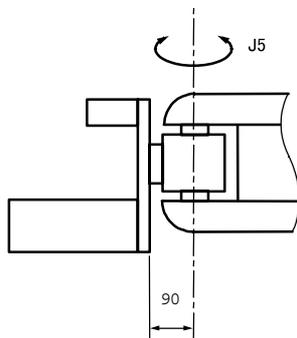
$$I_3 = (1.0 \times 0.02^2)/2 + 1.0 \times 0.05^2$$

$$= 2.7 \times 10^{-3} \text{ [kgm}^2\text{]}$$

Moment of inertia around J6 of entire end-effector: I_{J6}

$$I_{J6} = I_1 + I_2 + I_3 = 0.003 \text{ [kgm}^2\text{]}$$

□2□ Moment of inertia around J4 and J5



For the following figure, the moment of inertia around J4 and J5 can be calculated according to the same formula.

Moment of inertia around J4 and J5 of ①: I_1 (from 3 and 5 in before table)

$$I_1 = (0.14/12) (0.015^2 + 0.01^2) + 0.14 \times (0.09 + 0.005)^2$$

$$= 1.3 \times 10^{-3} \text{ [kgm}^2\text{]}$$

Moment of inertia around J4 and J5 of ②: I_2 (from 2 and 5 in before table)

$$I_2 = (0.1/4)(0.01^2 + 0.04^2/3) + 0.1 \times (0.09 + 0.01 + 0.02)^2$$

$$= 1.46 \times 10^{-3} \text{ [kgm}^2\text{]}$$

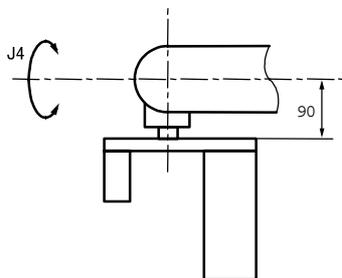
Moment of inertia around J4 and J5 of ③: I_3 (from 2 and 5 in before table)

$$I_3 = (1.0/4)(0.02^2 + 0.1^2/3) + 1.0 \times (0.09 + 0.01 + 0.05)^2$$

$$= 2.3 \times 10^{-3} \text{ [kgm}^2\text{]}$$

Moment of inertia around J6 of entire end-effector: I_{J6}

$$I_{J4} = I_{J5} = I_1 + I_2 + I_3 = 2.6 \times 10^{-2} \text{ [kgm}^2\text{]}$$

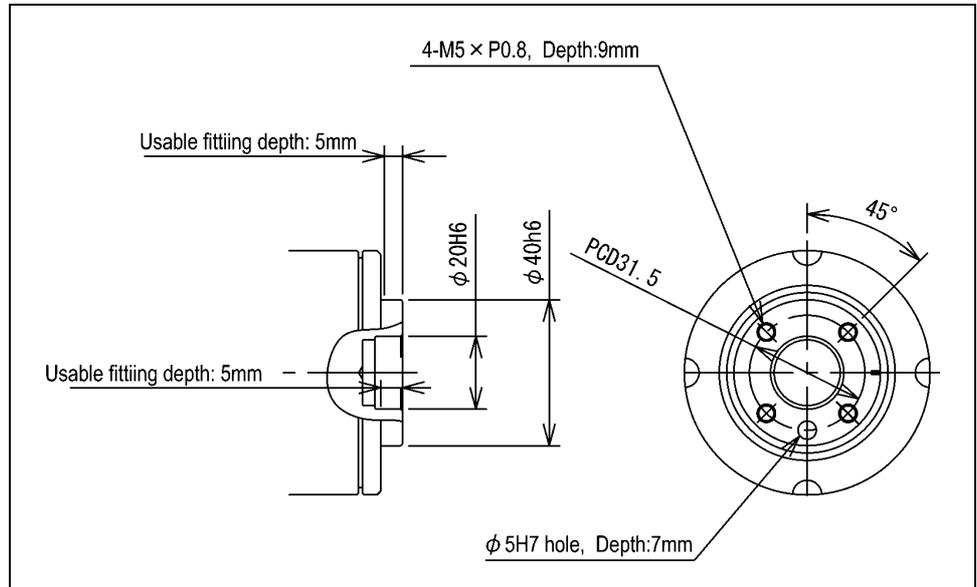


End-effector Moment of Inertia Calculation Example

(4) Detailed drawing of end-effector mounting face

The detailed drawing of end-effector mounting face is shown in below figure. When installing an attachment to the mounting face, use the inner knock so as to recognize the fitting-mark. When using the inner or outer knock, the fitting-depth should be less than 5mm.

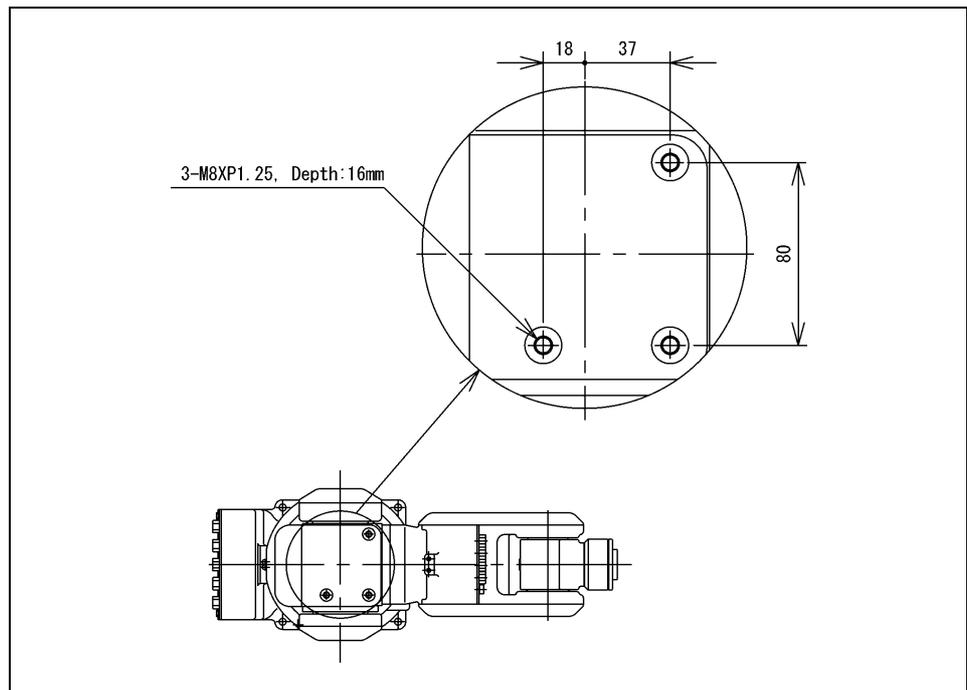
Note: Wipe the yellow paint for rust prevention off the flange with the thinner or light oil.



Detailed drawing of end-effector mounting face

(5) Fitting space for peripherals on the second arm

The fitting space and taps are prepared on the second arm for easy installation of peripherals for system applications.

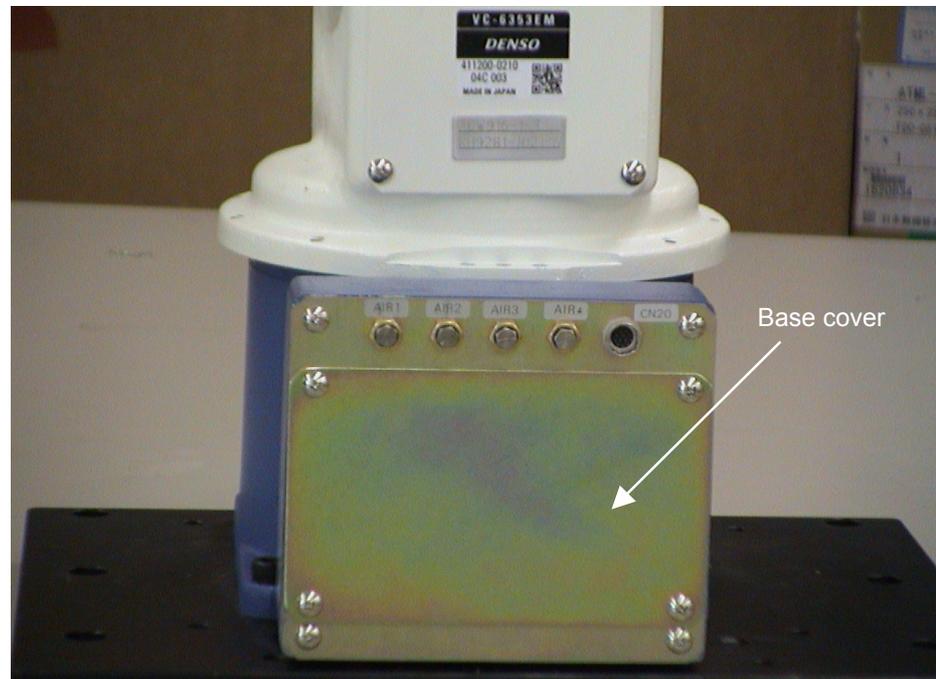


Fitting space for peripherals on the second arm

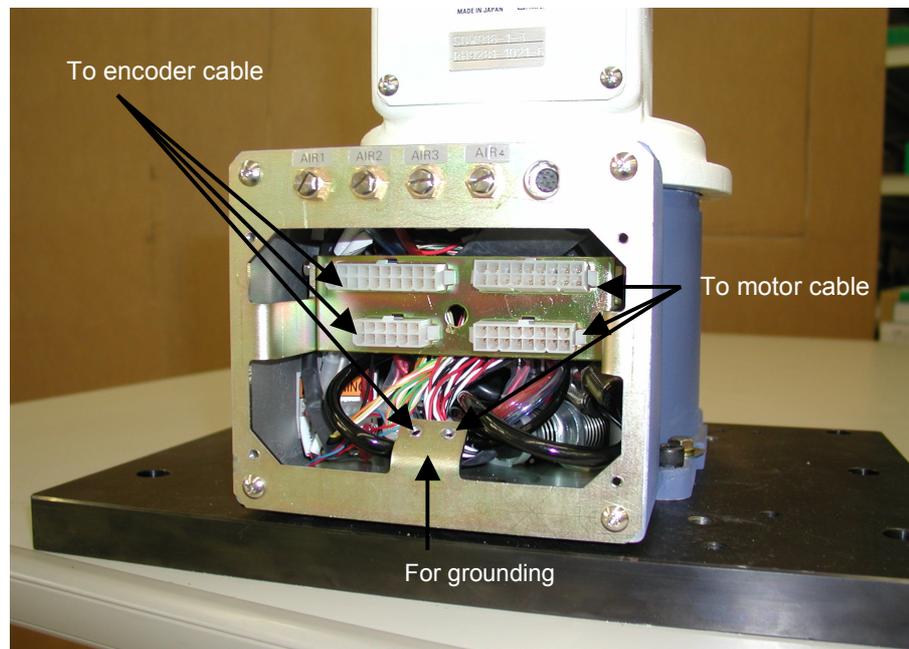
1.5 Connecting Motor Cable & Encoder Cable with Plate (For Standard type robot)

Connect the motor cable & encoder cable with plate to the robot unit as follows.

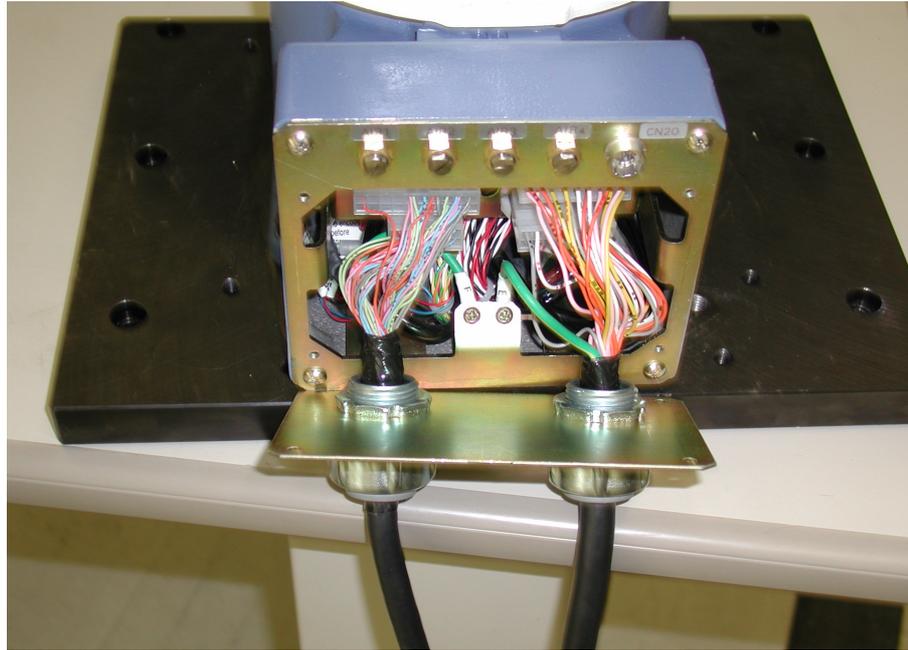
- (1) Remove the base cover from the robot unit after unscrewing four screws.



- (2) The motor cable and the encoder cable are connected to the connectors shown in below Figure.



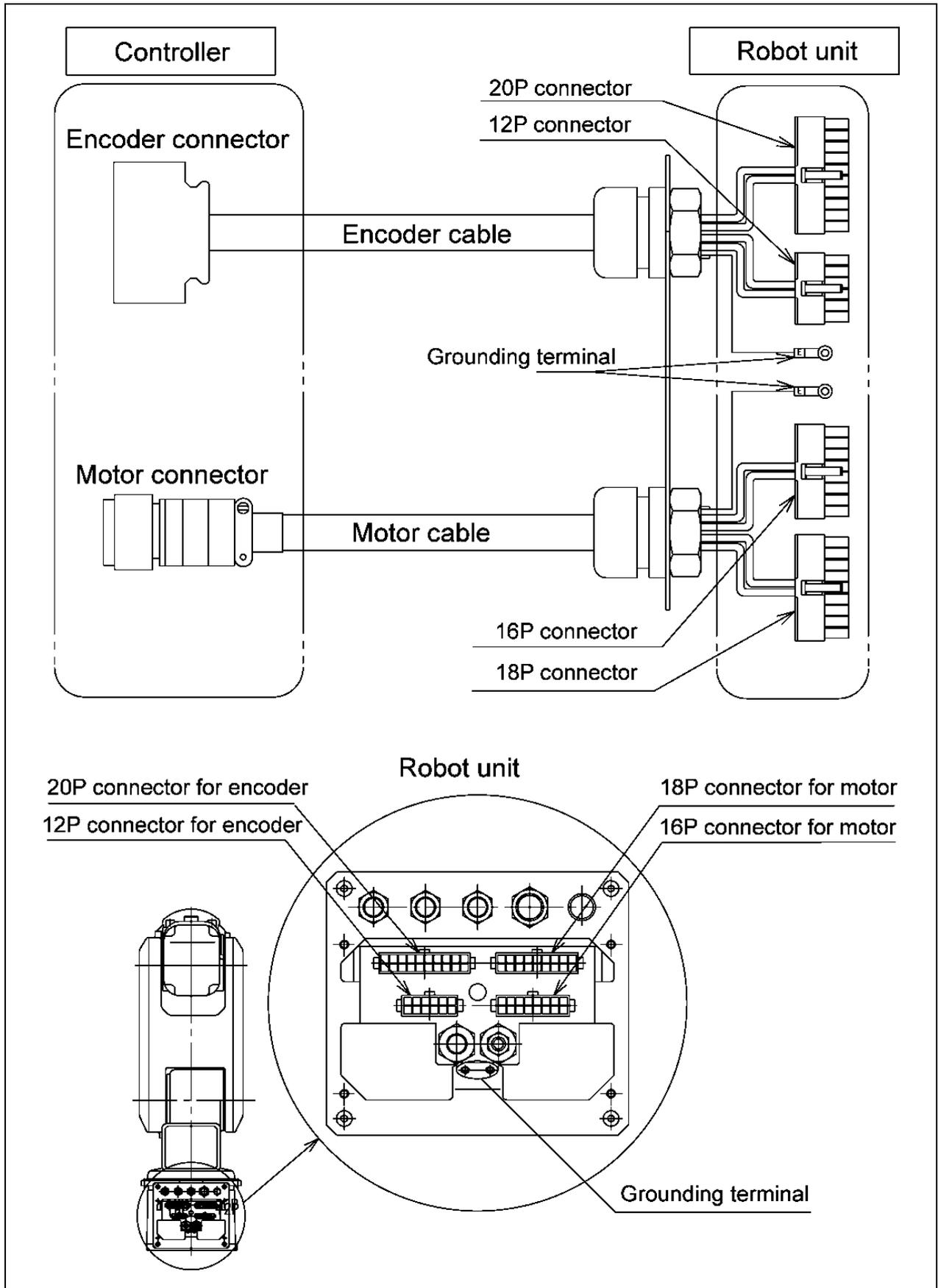
- (3) Connect the motor cable & encoder cable with plate to four connectors and two grounding terminals of the robot unit.



- (4) Fix the cover plate to the robot unit with four screws.



- (5) Connect the motor cable and the encoder cable to the controller as shown in below figure.

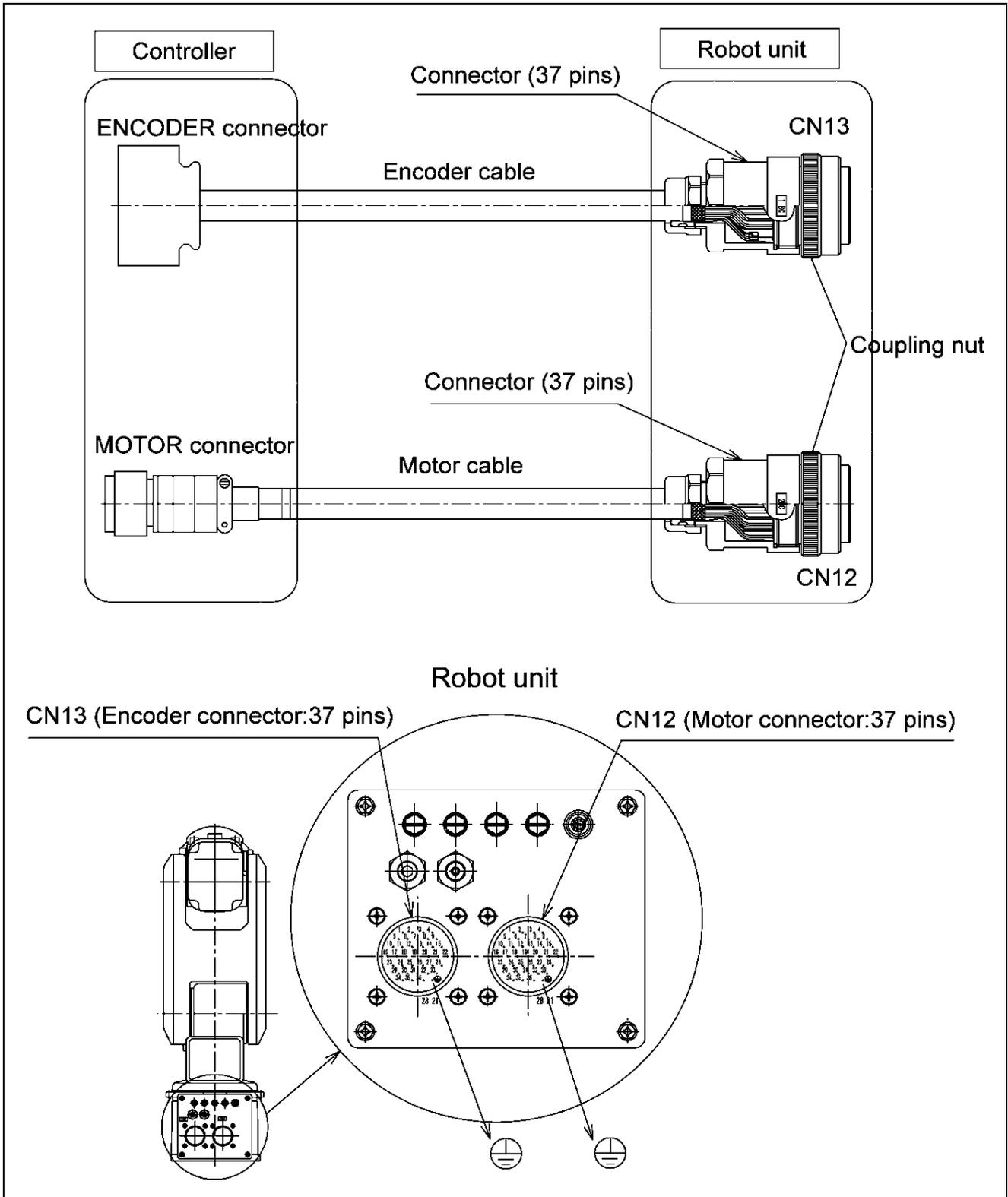


Connections of motor cable & encoder cable

1.6 Connecting Motor Cable & Encoder Cable (For CE-Compliant type robot)

Connect the motor cable to the CN12 connector on the robot unit and connect the encoder cable to the CN13 connector on the robot unit.

Note: When connecting the cable, rotate the coupling nut to be rocked clockwise.



Chapter 2 Customizing Your Robot

2.1 What Is Customization?

You may customize your robot by modifying or setting the following:

- Software motion limits for defining motion space
- Control set of motion optimization
- Robot installation conditions

You are recommended to define new motion space and restricted space in order to prevent interference with other devices or entanglement of the end-effector wiring and piping.

WARNING:

Always set the software motion limits and mechanical ends so that the motion space will be within the restricted space. Otherwise, the robot will bump the mechanical stops, causing serious accidents.

2.2 Modifying Software Motion Limits to Define New Motion Space

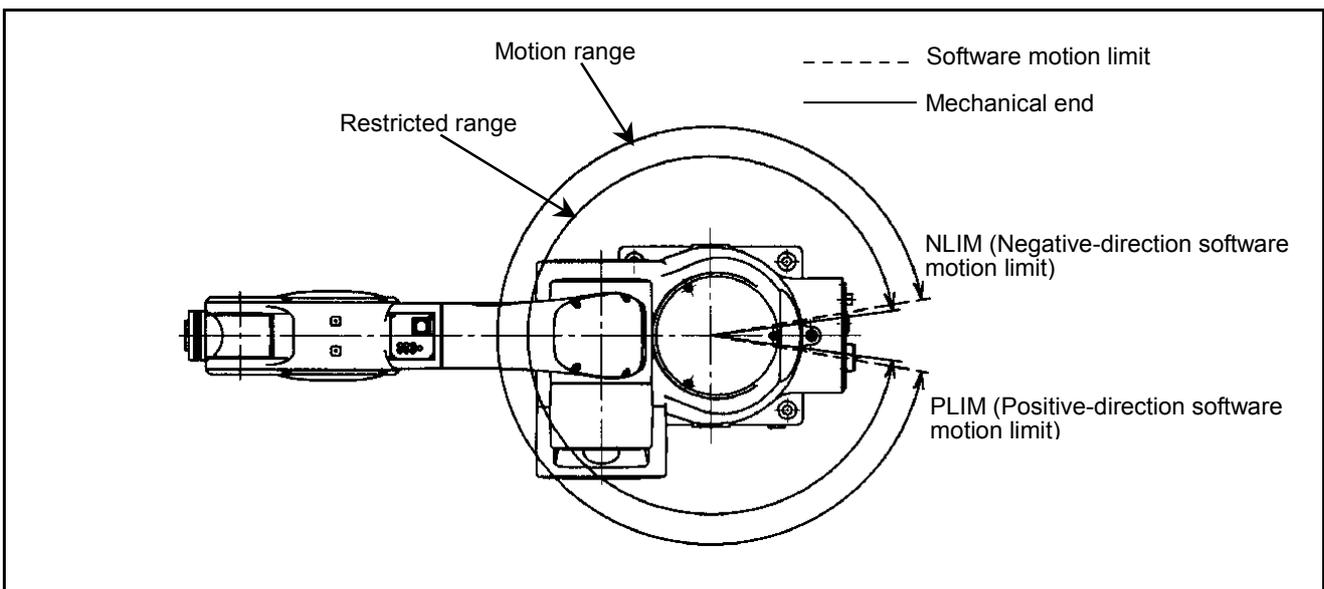
2.2.1 What Is a Software Motion Limit?

A limit to the operation range of the robot defined by the software is called a software motion limit. Software motion limits become valid after CAL of the robot has been completed and the robot has entered the range set by the limits.

A mechanical operation limit is called a mechanical end and set by a mechanical stop. To prevent the robot from striking against a mechanical stop, each software motion limit is set slightly in front of the mechanical end as shown in Figure 4-1. Although there is no mechanical stop for the 6th axis, a software motion limit is set.

If the robot reaches a software motion limit during manual or automatic operation, an error message will be displayed (error code starting from 6070; the first digit represents the axis number) and the robot will come to a stop. The power to the motor is also turned OFF in such a case during automatic operation.

All axes are assigned a software motion limit in both the positive and negative direction of the operation range. The software motion limit in the positive direction is called the positive-direction software motion limit and that in the negative direction is called the negative-direction software motion limit.



Software Motion Limits and Mechanical Ends (Figure is a typical model)

2.2.2 Software Motion Limits (Factory defaults)

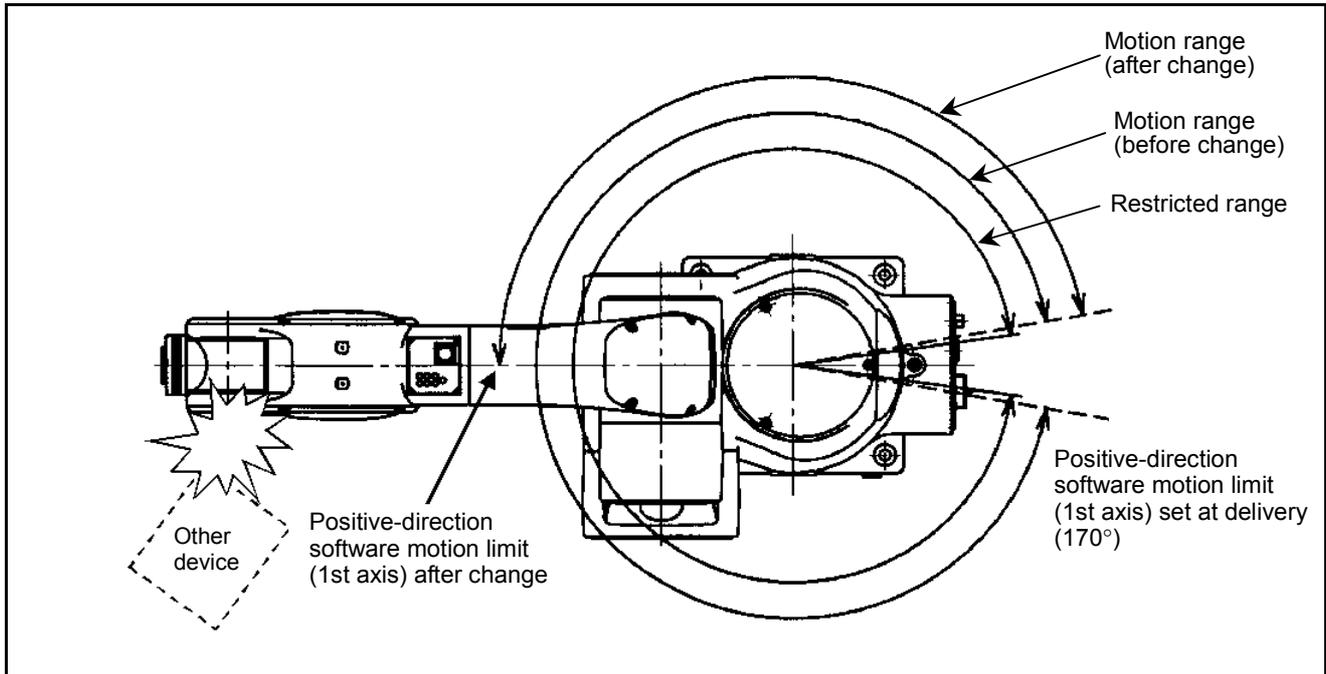
The table below lists the factory defaults of software motion limits.

Software Motion Limits (Factory defaults)

Robot model		1st axis	2nd axis	3rd axis	4th axis	5th axis	6th axis
VC-6353F	Positive direction	160°	90°	145°	170°	120°	360°
	Negative direction	-160°	-85°	-85°	-170°	-120°	-360°
VC-5353F	Positive direction	160°	90°	145°	–	120°	360°
	Negative direction	-160°	-85°	-85°	–	-120°	-360°

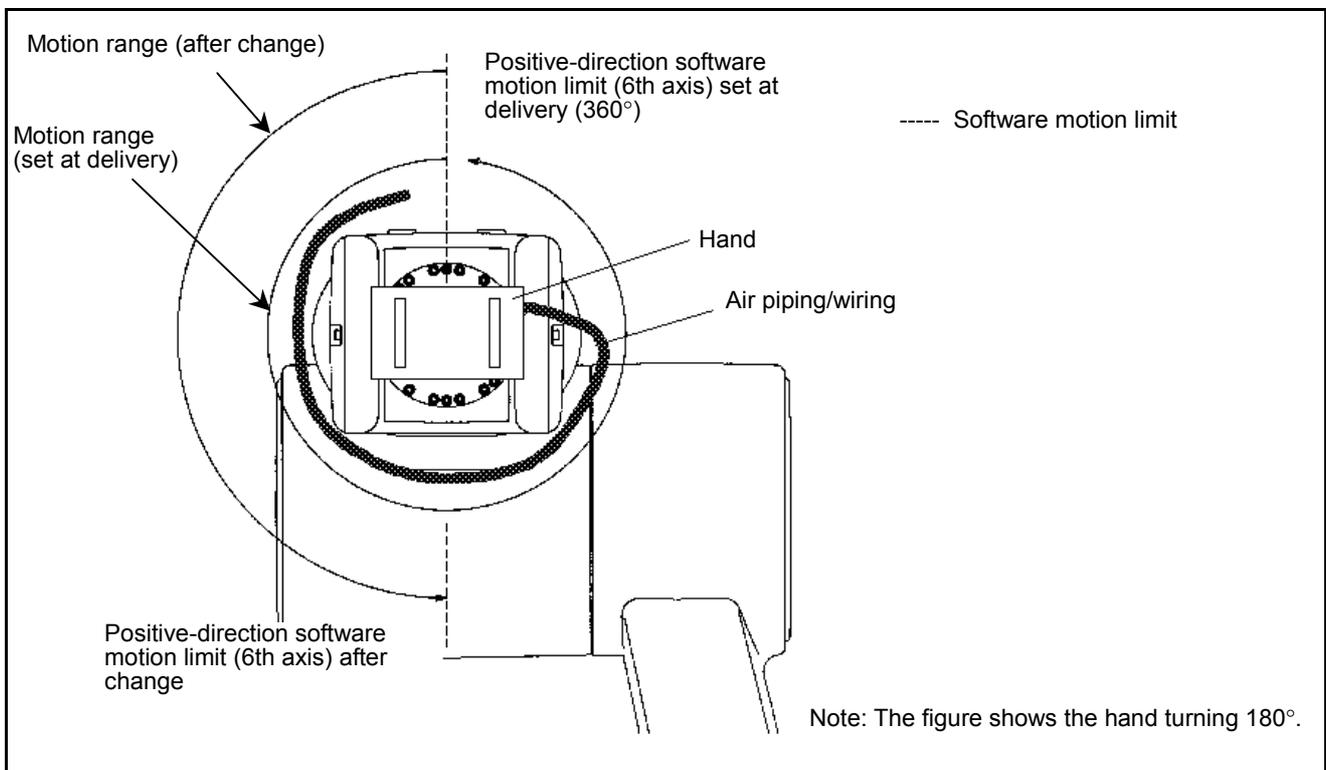
2.2.3 Changing Software Motion Limits

If the robot interferes with any other device, change the software motion limits to make the motion space smaller as shown in below figure.



Example 1: Changing Software Motion Limits (Figure is a typical model)

If the air piping or wiring of the end-effector becomes taut as the robot runs, then change the software motion limits to make the motion space smaller as shown in below figure.



Example 2: Changing Software Motion Limits (Figure is a typical model)

NOTE: When changing software motion limits, always make the new motion space smaller than the motion space defined by initial settings.

2.2.4 Precautions When Changing the Software Motion Limits

- (1) The software motion limits are invalid until CAL is completed.
- (2) Confirm the operating space of the robot in the actual working environment. Set the software motion limits using the correct unit of measurement.

If the operating space is too small, the robot may seem to become inoperable.

2.2.5 Procedure for Changing the Software Motion Limits

Described below is the procedure for changing the software motion limits.

▶ STEP 1

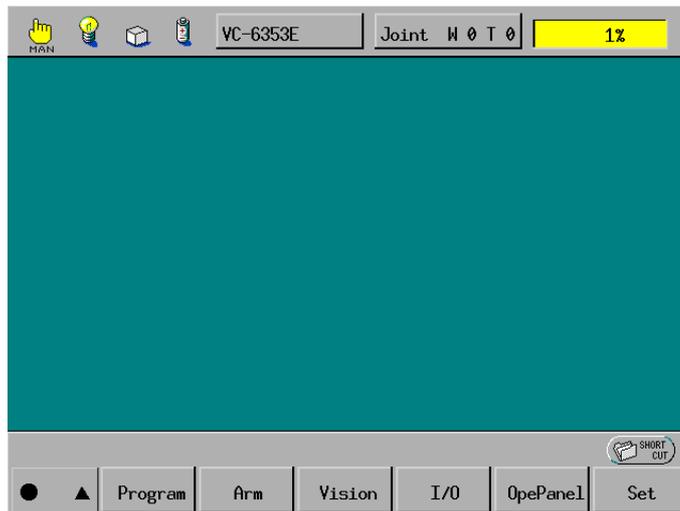
Turn the power switch of the robot controller to ON.

▶ STEP 2

Set the mode selector switch of the teach pendant to MANUAL.

▶ STEP 3

Press [F2 Arm] on the top screen of the teach pendant.

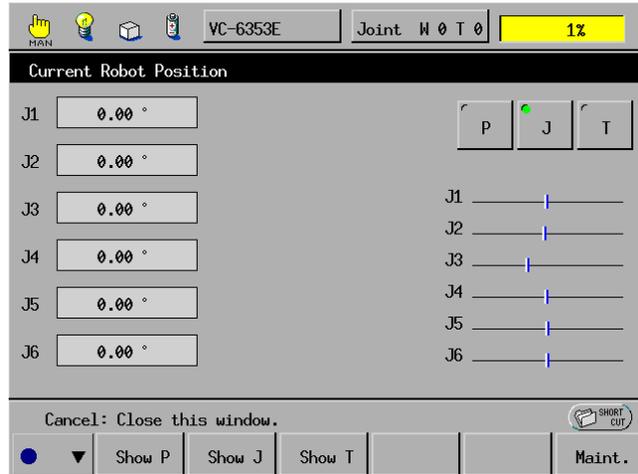


F2

The Current Robot Position window appears as shown in Step 4.

▶ STEP 4

Press the **SHIFT** key and then press **[F12 Maint.]**.



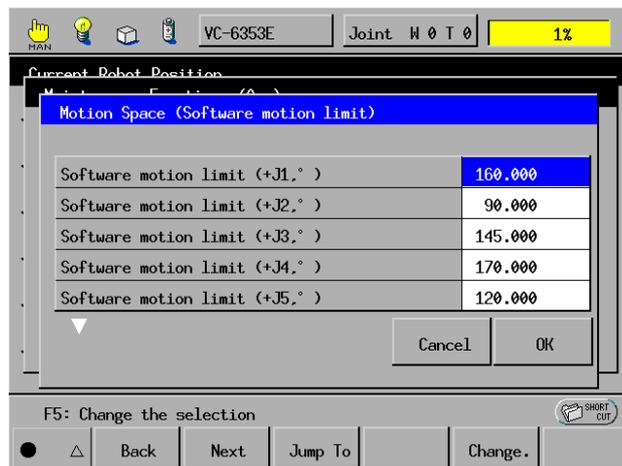
F12

The Maintenance Functions (Arm) window will appear.

▶ STEP 5

Press **[F1 M Space]** on the Maintenance Functions (Arm) window.

The Motion Space window will appear as shown below.

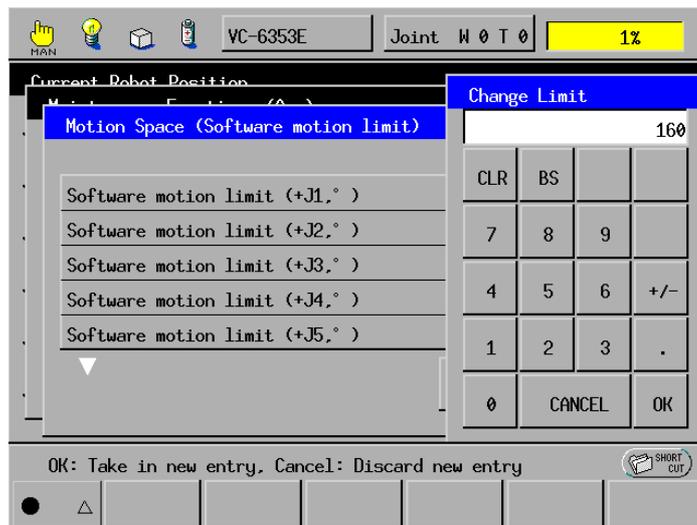


F5

▶ STEP 6

Select the item to be modified, then press [F5 Change].

The numeric keypad will appear as shown below.



Enter a desired value using the numeric keys, then press OK.

The new value will be set on the line of the item selected in the Motion Space window.

If two or more items must be changed, repeat Steps 4 and 5.

▶ STEP 7

Press OK in the Motion Space (Software motion limit) window.

▶ STEP 8

Turn OFF the power to the robot controller.

Caution: The new software motion limit(s) specified for the motion space will take effect after the robot controller restarts and CAL is completed.

2.3 Performing CALSET

2.3.1 What Is CALSET?

Calibrating the relationship between position-related information recognized by the robot controller and the actual position of the robot unit is called CALSET.

CALSET must be performed when the motor is replaced or when the encoder backup battery goes dead and the position-related data retained in the encoder is lost as a result.

After CALSET is completed, the calibrated data of the robot unit will be stored in the robot controller. This data is called CALSET data which differs on each robot.

This robot has been CALSET before delivery and the CALSET data is stored in the floppy disks that come with the robot unit. Therefore, even if the memory backup battery in the robot controller dies so that the CALSET data is lost, you do not need to CALSET the robot. Just reload the CALSET data from the floppy disks.

2.3.2 Preparation for CALSET

In all models, the 1st, 2nd, 3rd, and 5th axes are equipped with mechanical stops but the 6th axis is not.

To CALSET the 6th axis having no mechanical stop, you need to mount a CALSET jig before starting CALSET as described on the following pages. When CALSETing the 6th axis, you need to press also the 5th axis against the mechanical stop since CALSETing requires the positional relationship between the 5th and 6th axes.

CALSET requires some space for bringing each axis into contact with the mechanical end.

- Caution (1) When CALSETing, move the axis to be CALSET in the vicinity of the mechanical stop, release the brake, and bring the axis into contact with the mechanical stop.**
- The VC-E series will release brakes of all axes.
- (2) When performing CALSET, be careful with the robot motion. The execution of the CALSET command releases motor brakes so that the robot arms will move by its own weight.
- (3) After CALSET, confirm in the manual mode that each axis stops at the software motion limit before coming into contact with the mechanical end.
- (4) In automatic operation, start to run the robot at low speed. Ensuring safety, gradually increase the speed. It makes adjustment easy.
- (5) Position-related data in some programs made before CALSET may vary somewhat after CALSET.

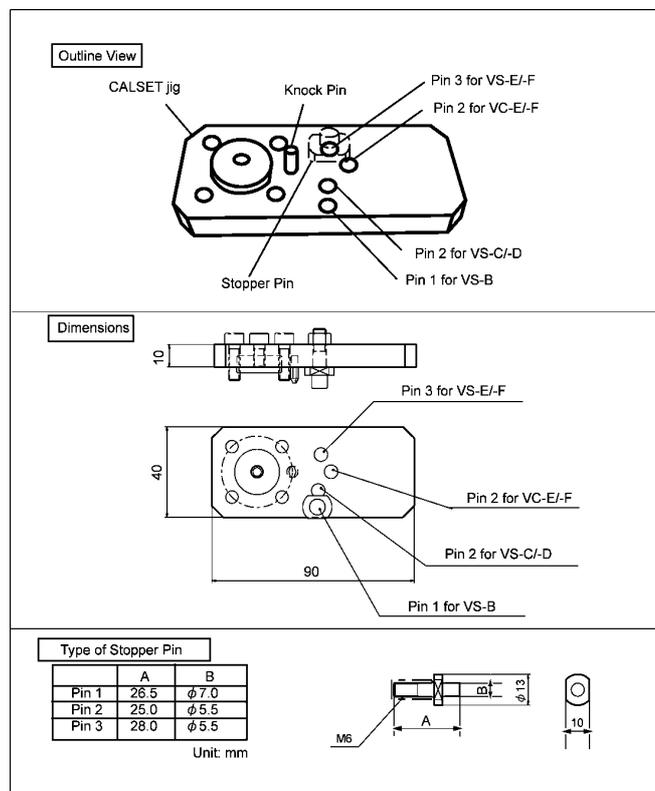
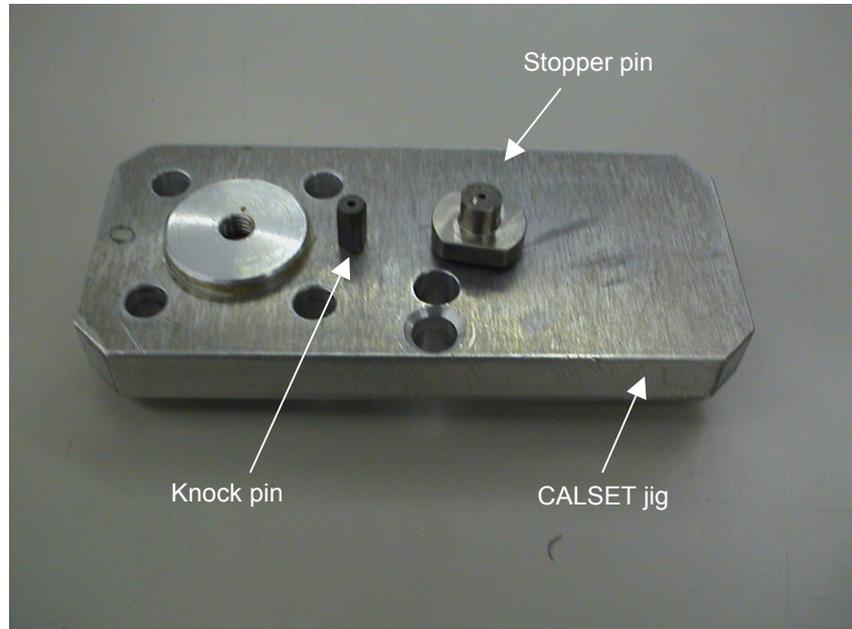
[1] Mounting the CALSET Jig

To CALSET the 6th axis, you need to mount the CALSET jig on the axis beforehand according to the following procedure.

Mounting the CALSET jig on the 6th axis

► STEP 1

Fit a stopper pin in the CALSET jig.



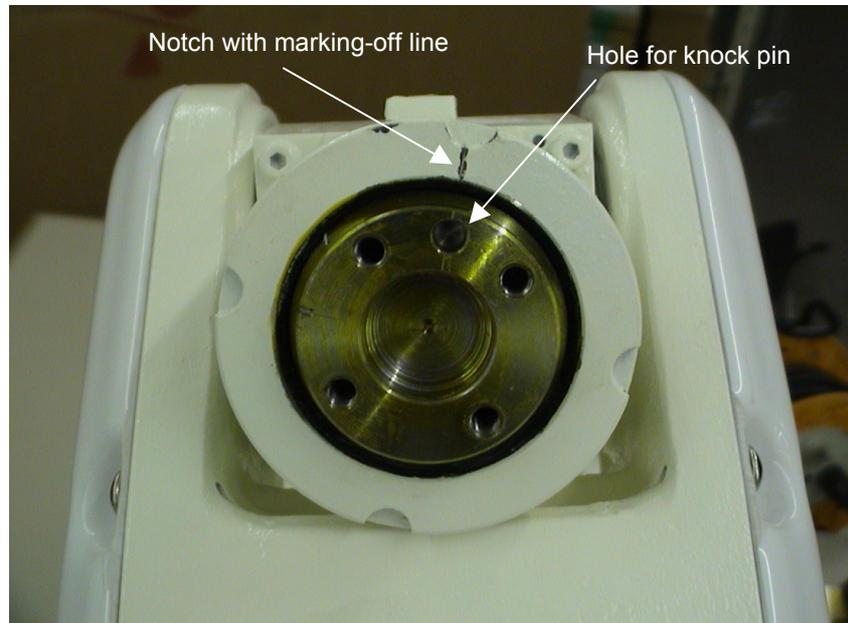
► STEP 2

Release the brake.

▶ STEP 3

Install the CALSET jig to the flange of the 6th axis as shown in below figure.

Tip: The CALSET position of the 6th axis refers to the point where the notch with marking-off line of the 6th flange comes into contact with the stopper pin by turning the 6th flange.

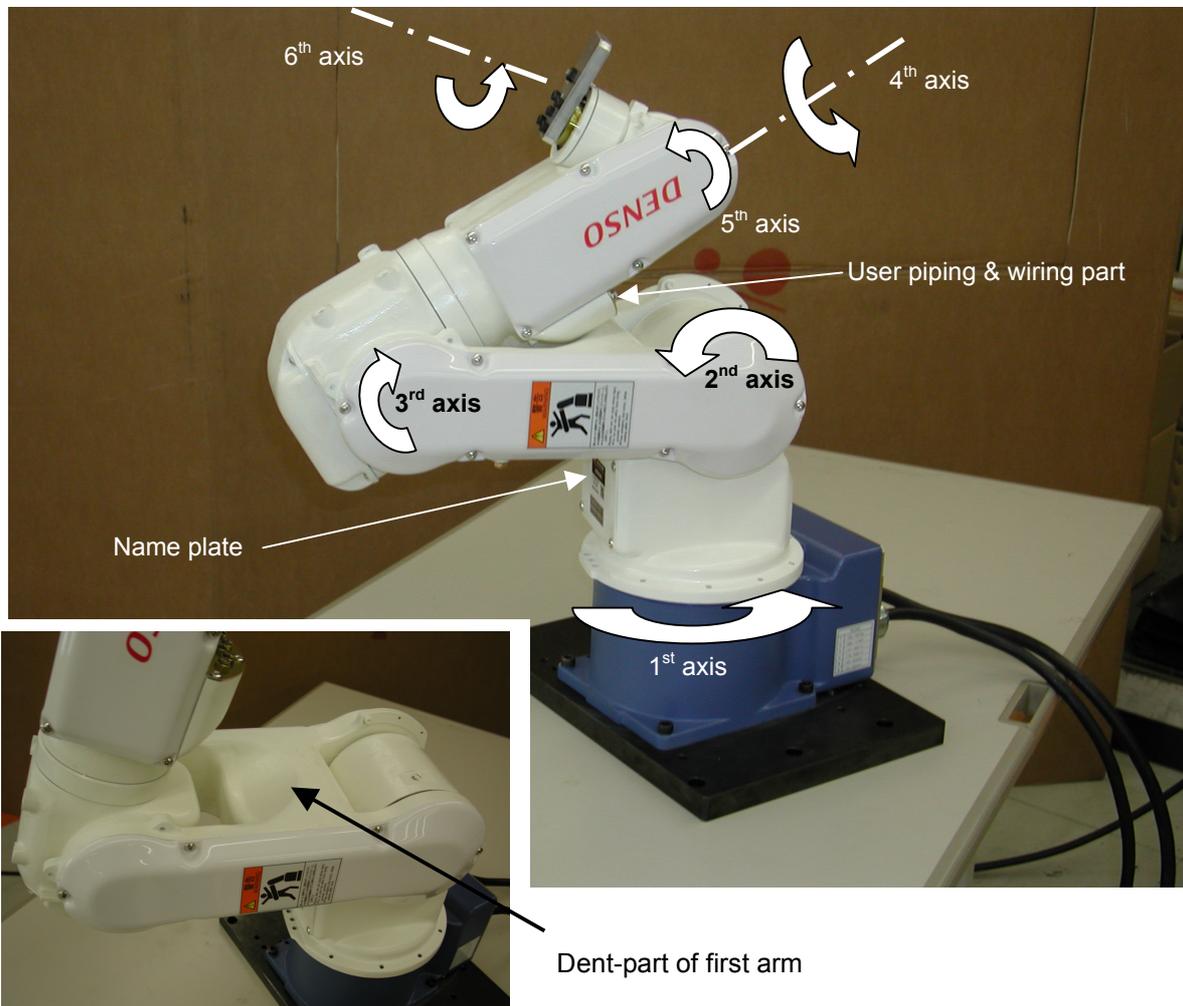


[2] What Is a CALSET Position?

The limit position of an arm to be CALSET is called a CALSET position.

Each axis has a mechanical end in each of the positive and negative directions. The mechanical ends shown in below figure are the CALSET positions.

Axis		CALSET positions
Position	1st axis	Turning end in the positive direction (counterclockwise end when viewed from top)
	2nd axis	Turning end in the negative direction (Name plate end)
	3rd axis	Turning end in the positive direction (Dent-part side of first arm)
	4th axis	Turning end in the positive direction (counterclockwise end when viewed from the arm end)
	5th axis	Turning end in the positive direction (Opposite side of user piping & wiring part)
	6th axis	Turning end in the positive direction, which is set by a CALSET jig



CALSET Positions

2.3.3 Performing CALSET

2.3.3.1 CALSET of a Single Axis

CALSETing a specified single axis only is called single-axis CALSET.

Perform single-axis CALSET if the motor of an axis is replaced so that the axis must be CALSET, or if some axes cannot be moved to the CALSET positions (mechanical stop positions) at any given time because of interference between the robot unit and its surrounding facilities.

NOTE: Step 1 is required for CALSETing the 4th and 6th axes and Step 2 is for CALSETing the 6th axis. When CALSETing any other axes, skip to Step 3.

▶ STEP 1

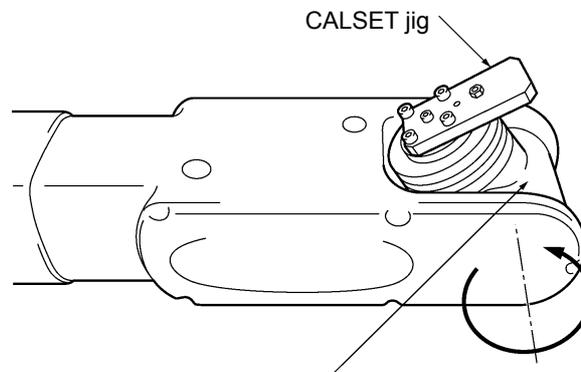
(Required for CALSETing the 6th axis)

Mount the CALSET jig according to Subsection 4.4.2.1 "Mounting the CALSET Jig."

▶ STEP 2

(Required for CALSETing the 6th axis)

Fully turn the 5th axis to its turning end in the positive direction.



Turn the 5th axis to its turning end in the positive direction.

▶ STEP 3

Turn the power switch of the robot controller to ON.

▶ STEP 4

Set the mode selector switch of the teach pendant to MANUAL.

▶ STEP 5

Press MOTOR to turn ON the power to the motor.

▶ STEP 6

Move the axis to be CALSET in the vicinity of the mechanical stop via the manual operation from the teach pendant.

▶ **STEP 7**

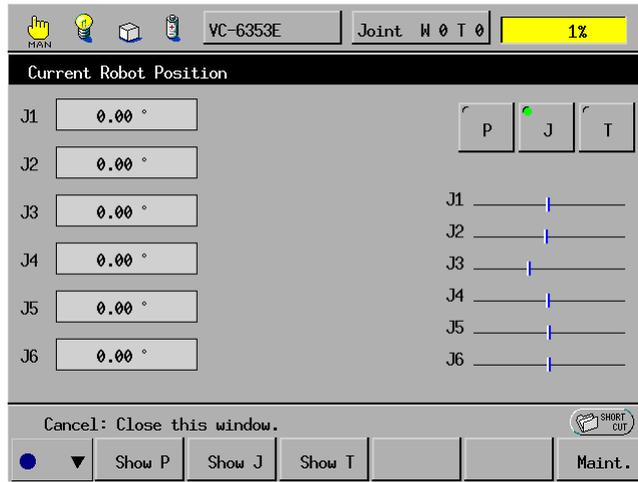
Press the MOTOR key on the teach pendant to turn OFF the power to the motor.

▶ **STEP 8**

Press [F2 Arm] on the teach pendant.

▶ **STEP 9**

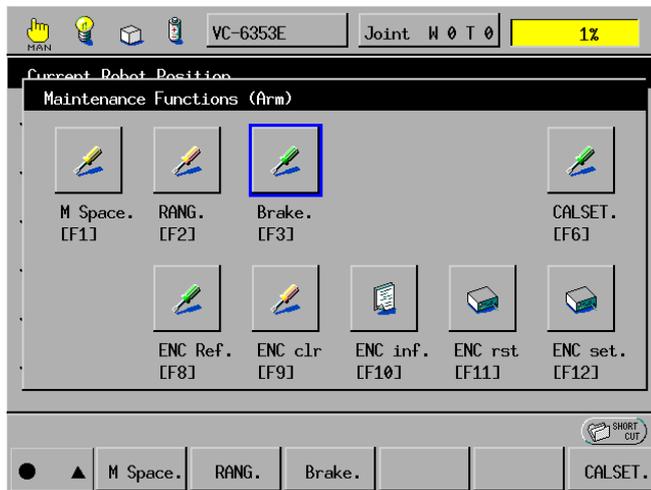
Press the SHIFT key and [F12 Maint.].



F12

▶ **STEP 10**

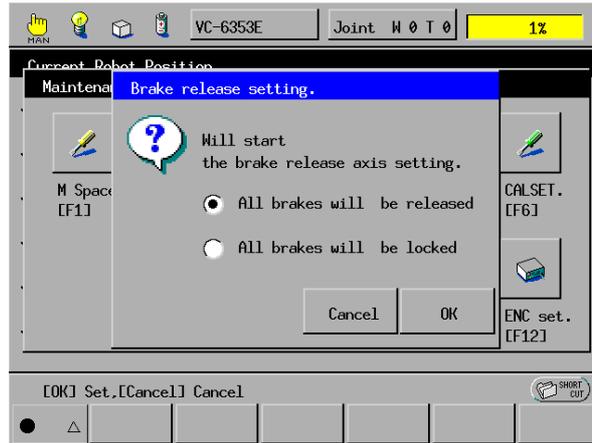
Press [F3 Brake.].



F3

▶ STEP 11

Select the "All brakes will be released."



▶ STEP 12

Confirm that there is no danger even if the arms fall as a result of released brakes.

CAUTION: The brakes of all axes will be released.

▶ STEP 13

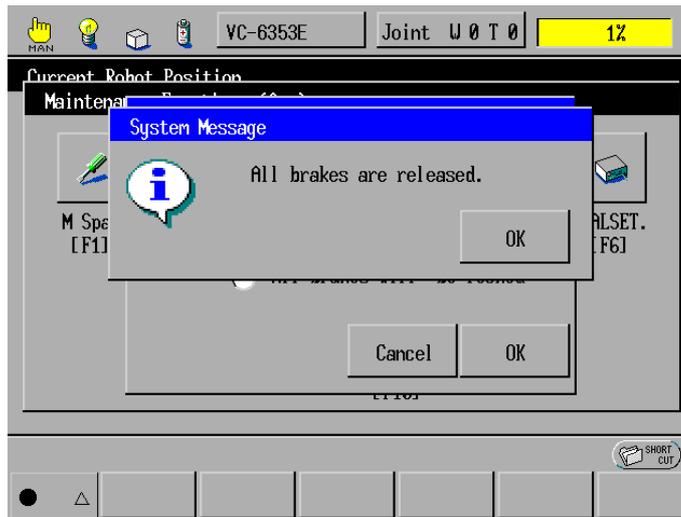
Press OK.

The system message appears asking you whether you want to change the brake settings.



▶ STEP 14

Press OK.
The system message appears informing that all brakes were released.

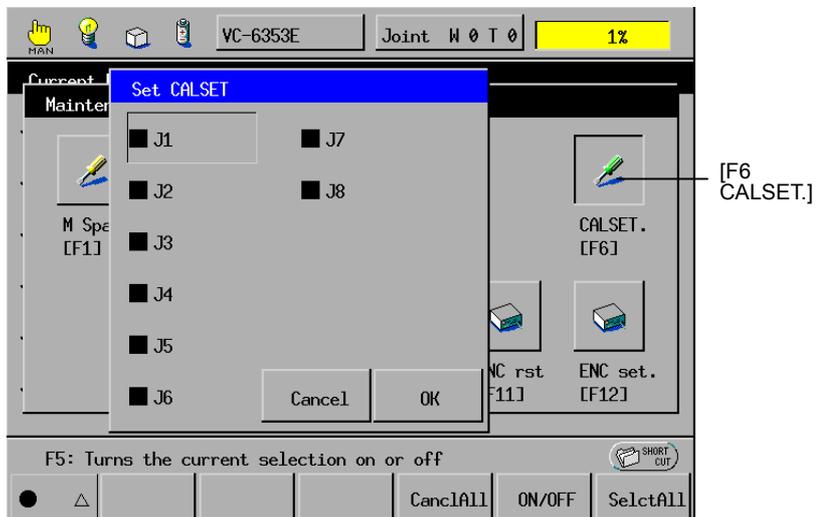


▶ STEP 15

Press the axis to be CALSET against the mechanical stop by hand.

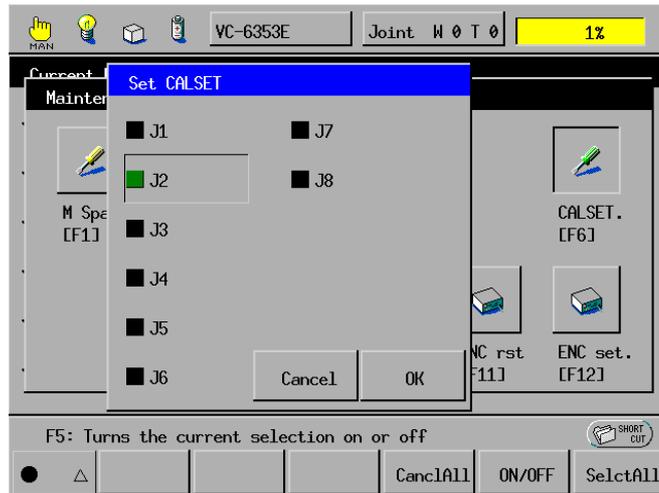
▶ STEP 16

Press [F6 CALSET].
The Set CALSET window appears.



▶ STEP 17

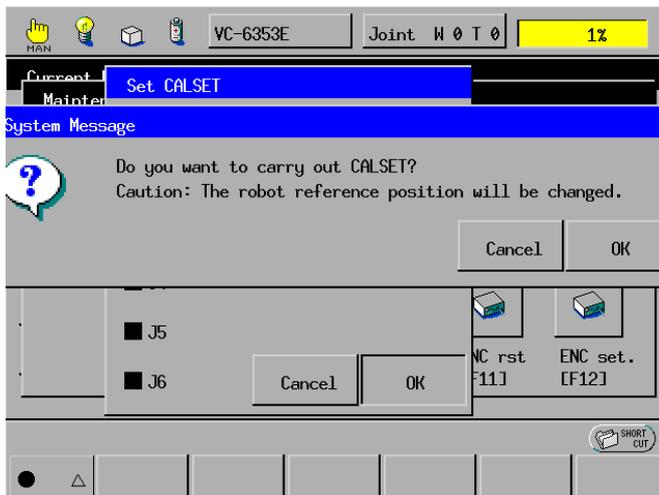
Press the axis number to be CALSET to select CALSET (green display). Deselect CALSET (black display) for the other axes that are not required to be CALSET.



▶ STEP 18

Press OK.

The system message appears asking whether you want to carry out CALSET and showing a caution that the robot reference position will change.



▶ STEP 19

Press OK.

The system message appears informing that CALSET was completed.

▶ STEP 20

Press the ROBOT STOP button.
The robot brake becomes activated.

▶ STEP 21

Turn the ROBOT STOP button to cancel robot stop.

▶ STEP 22

Press the MOTOR to turn ON the power to the motor.

Caution: A "motor lock overload" error may occur just after the power to the motor is turned ON. In this case, try to turn ON the power several times, or release the brake, move the axis a little in the opposite direction of the mechanical end, and turn ON the power again.

▶ STEP 23

Move the CALSETed axis in the opposite direction from the mechanical end by the manual operation of the teach pendant.

▶ STEP 24

Perform CAL. The single-axis CALSET of the specified axis is completed.

2.3.3.2 CALSET of All Axes

The CALSET of all axes is called all-axis CALSET.

The procedure is the same as that for single-axis CALSET except that you should select all axes for brake release and CALSET in Steps 17. For details of the procedure, see "2.3.3.1 CALSET of a Single Axis."

2.4 Setting Control Set of Motion Optimization

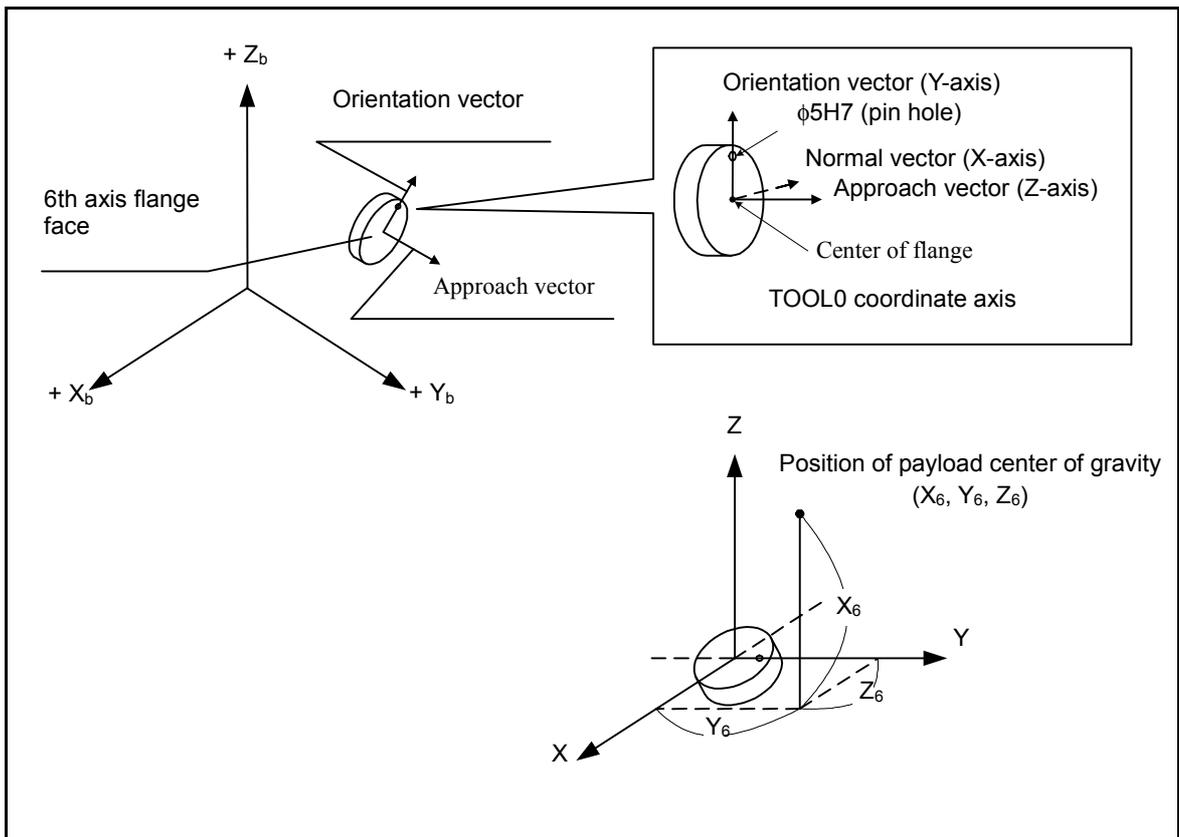
The optimum speed or acceleration will vary depending upon the payload and center of gravity of an end-effector or workpiece that is to be set at the end of the robot flange. Set the payload and center of gravity position of the end-effector or workpiece and the control set of motion optimization according to the payload and robot posture.

The mass of payload is a total mass of an end-effector and workpiece, expressed in grams.

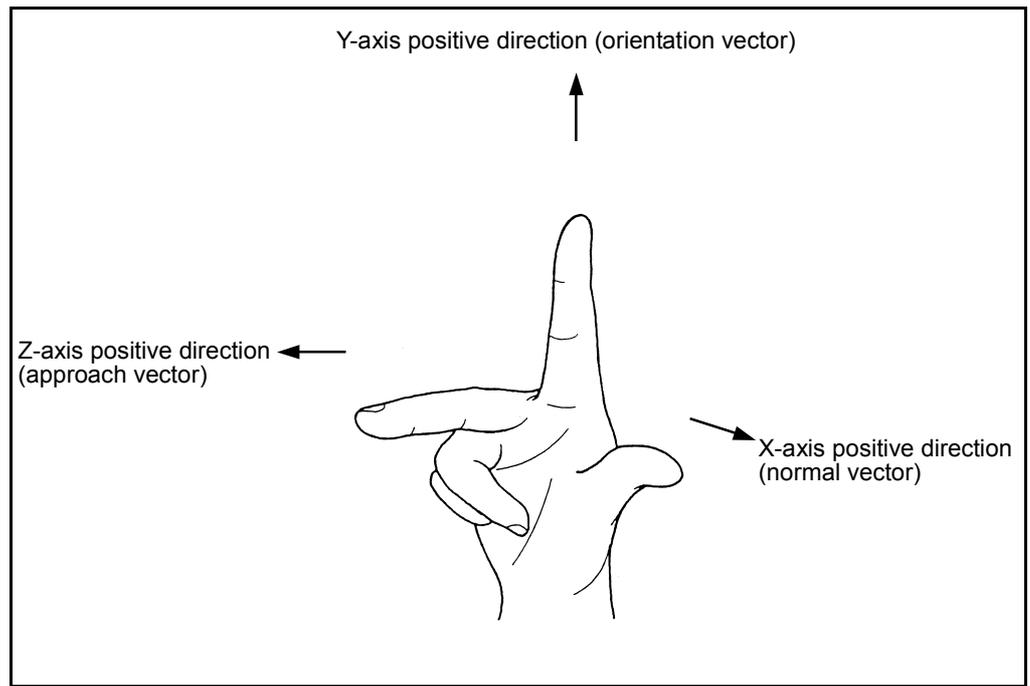
For further information, see the PROGRAMMER'S MANUAL, Section 4.7 "Setting the Master Control Parameters in User Preferences." For the setting procedure, refer to the SETTING-UP MANUAL, Section 2.9, "Setting the Master Control Parameters of the Payload, Center of Gravity, and Control Set of Motion Optimization."

The payload center of gravity is represented by the TOOL0 coordinate system (see Figure 4-20) in the unit of mm.

The origin of the TOOL0 coordinate system is the center of the 6th axis flange. Its Y-component is in the direction from the flange center to the $\phi 5H7$ pin hole (orientation vector direction). The Z-component is in the vertical direction to the flange face across the flange center (approach vector direction). The X-component is in the X-axis direction of the right hand coordinate system (normal vector direction) with the orientation vector as the Y-axis and the approach vector as the Z-axis.



Payload Center of Gravity



Right Hand Coordinate System

2.5 Setting Robot Installation Conditions

The optimum operating conditions will differ depending on whether the robot is floor-mounted or overhead-mounted.

When the robot leaves the factory, it is set for floor-mount. If you overhead-mount your robot, you need to change the installation settings.

For the setting procedure, refer to the SETTING-UP MANUAL, Section 2.10, "Setting the Robot Installation Condition" and the PROGRAMMER'S MANUAL, Subsection 4.7.3 "Setting Robot Installation Conditions."

Chapter 3 Maintenance and Inspection

3.1 Maintenance & Inspection Intervals and Purposes

Below table lists the intervals and purposes of maintenance & inspection required for the VC-F series.

⚠ Caution: Before performing maintenance and inspection jobs, read the SAFETY PRECAUTIONS, "3 Precautions while robot is running" and "4 Daily and periodical inspections."

Maintenance & Inspection Intervals and Purposes

No.	Intervals		Purposes
1	Daily	Perform inspection jobs specified in <u>Section 3.2</u> every day before starting operations.	To use your robot safely.
2	Quarterly	Perform inspection jobs specified in <u>Section 3.3</u> every three months.	To maintain the precision of the robot and to prevent failures caused by overheat of the robot controller.
3	Every 1.5 years	Perform inspection jobs specified in <u>Section 3.4</u> every 1.5 years.	To check the rotary sections and slideways of the robot for wear, preventing seizure, breakage, and other serious failures that could result from wear.
4	Biennial	Replace backup batteries as specified in <u>Section 3.5</u> every two years.	To retain the robot-specific data (programs, parameters, etc.) stored in the internal memory of the robot controller.
5	Every 4 years	Perform inspection jobs specified in <u>Section 3.6</u> every four years.	To retain the position data stored in the electronic absolute encoder build in the robot unit.

3.2 Daily Inspections

3.2.1 Check Items

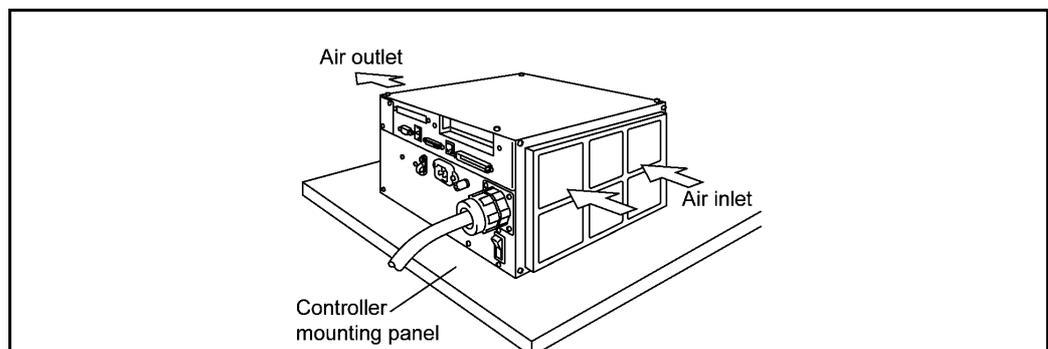
Before starting operations, check the items listed in below table.

Daily Inspections Table

No.	Check:	Controller Power	How to check:	Criterion	What to do: (Note 1)
1	Connectors (CN1 to CN12 on the robot controller) and their mating parts	OFF	Visually	No looseness, disengagement or dirt.	Engage the parts properly and clean them.
2	Cables (connected to CN1 to CN12 on the robot controller) and robot's external cables	OFF	Visually	Free of damage or gouges.	Repair or replace.
3	LCD on the teach pendant	ON	Visually	Properly displayed	Repair or replace.
4	Pilot lamps on the robot controller	ON	Visually	Should light.	Repair or replace.
5	Cooling fan in the robot controller	ON	Visually (Note 2)	Should work properly.	Repair or replace.
6	Calibration	ON	Visually	No error or unusual noise.	Repair or replace.
7	ROBOT STOP button on the teach pendant or the mini pendant	ON	Press the ROBOT STOP button.	The robot should come to an emergency stop.	Repair or replace.
8	Safety door	ON	Operate the safety door switch and open the switch-wiring door.	The robot should come to an emergency stop.	Repair or replace.

Note 1 Some repair and replacement operations, shown in "What to do:" column, may involve special work. Contact our Robot Service Section.

Note 2 The normal operation of the cooling fan is as shown in below figure.



Normal Operation of Cooling Fan

3.3 Quarterly Inspections

3.3.1 Check Items and Lubrication

Check the items listed in below table every three months.

Quarterly Inspections Table

No.	Check:	Controller Power	How to check:	Criterion	What to do:
1	Robot base mounting bolts	OFF	Measure the tightening torque with a torque wrench.	No looseness. Specified torque: 110 ±22 Nm	Tighten the bolts to the specified torque.
2	Air intake filter in the robot controller	OFF	Visually	No dust or dirt.	Clean the air intake filter. (Refer to Subsect. 3.3.2.)

3.3.2 Cleaning the Air Intake Filter in the Robot Controller

For the cleaning procedures of the air intake filter, refer to the “ Section 6.5 Cleaning the Air Intake Filter, RC7 CONTROLLER INTERFACE MANUAL”.

3.4 1.5 Years Inspections

3.4.1 Check Items

Check the items listed in below table every 1.5 years.

1.5 Years Inspection Table

No.	Check:	Controller Power	How to check:	Criterion	What to do:
1	Rotary sections and slideways of the robot	OFF	Lubricate the specified points, referring to Subsection 3.4.2. (See NOTE.)		

NOTE: Assuming that a factory is operating on two shifts, the lubrication interval is once/1.5 years. For single-shift operation, it should be every three years. As a guide, lubrication should be at 6000-hour intervals.

3.4.2 Lubrication Jobs

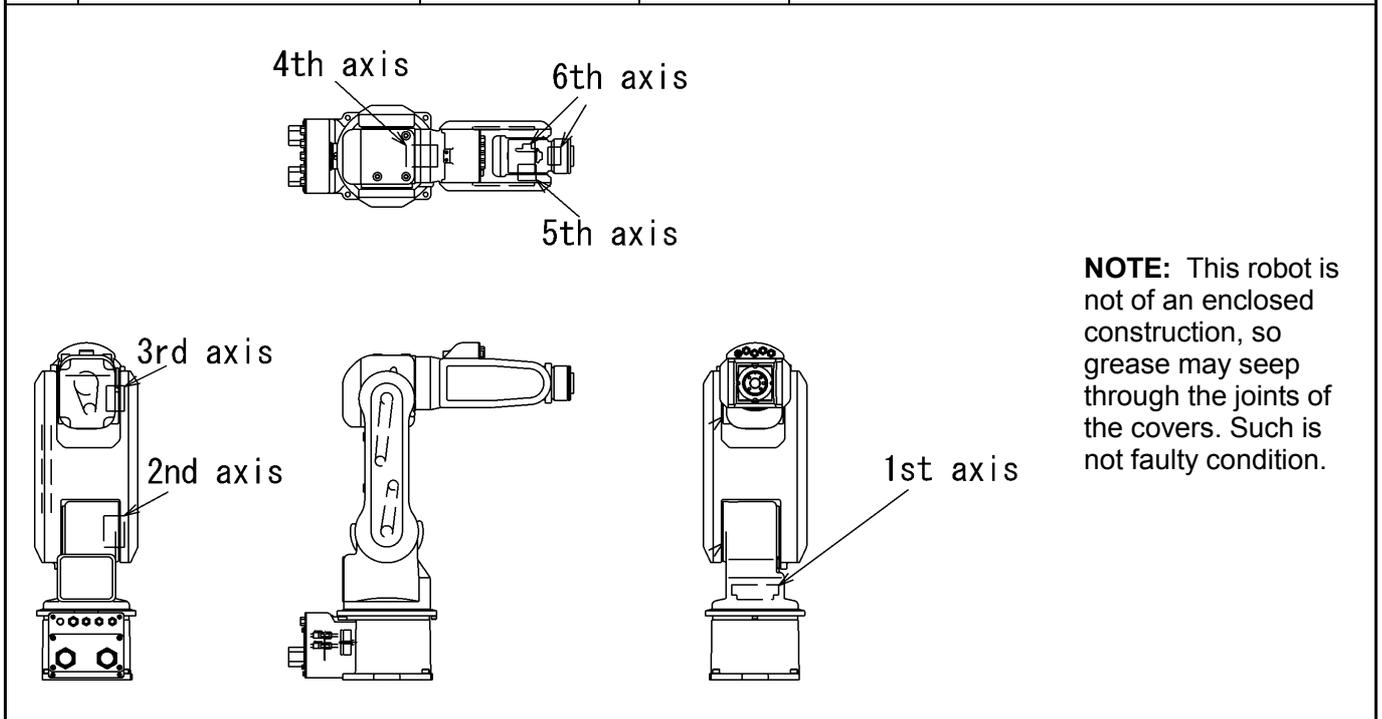
Apply the specified lubricants to the rotary sections and slideways of the robot unit according to the procedure given in this section.

3.4.2.1 Lubrication points and lubricants

Below table lists the lubrication points, lubricant type, and lubricant amount for all of the six axes.

Lubrication Points and Lubricants

No.	Lubrication points	Lubricant type	Lubricant amount	Remarks
1	1st-axis	Harmonic grease SK-1A	10cc	(1) For lubrication, use a grease gun. NOTE: The lubrication amount is expressed in the number of pushes when you use a recommended grease gun which discharges 1.4 cc of grease each time it is pushed. (Refer to Section 3.7, "Supplies and Tools for Maintenance.") (2) The drain plug of each axis should be removed at lubrication work.
2	2nd-axis		15cc	
3	3rd-axis		10cc	
4	4th-axis (only VC-6353E)		10cc	
5	5th-axis		3cc	
6	6th-axis		5cc	



3.4.2.2 Lubricating procedure

Lubricate each axis according to the procedure given below.

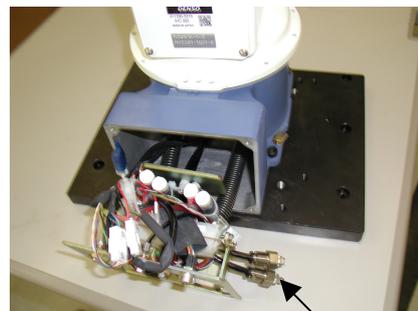
(1) Lubricating the 1st axis

▶ STEP 1

<For standard type robot>

<For standard type robot>

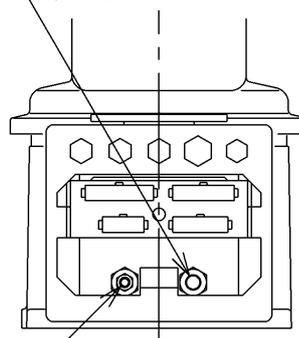
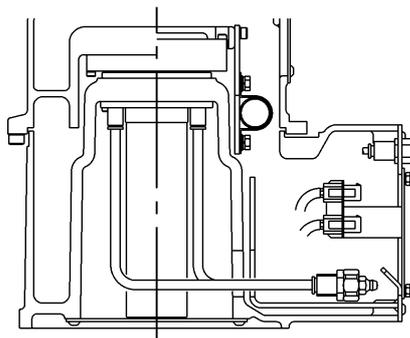
- (1) Remove the four screws to release the base plate. After taking out the base plate, disconnect four connectors and two grounding terminals.
- (2) Remove four screws from the connector base and take out the connector base. The grease nipple and air drain port for the 1st axis appears.



Grease nipple and air drain port

- (3) Remove the air drain plug for the 1st axis.

Air drain plug for 1st axis



1st axis grease nipple

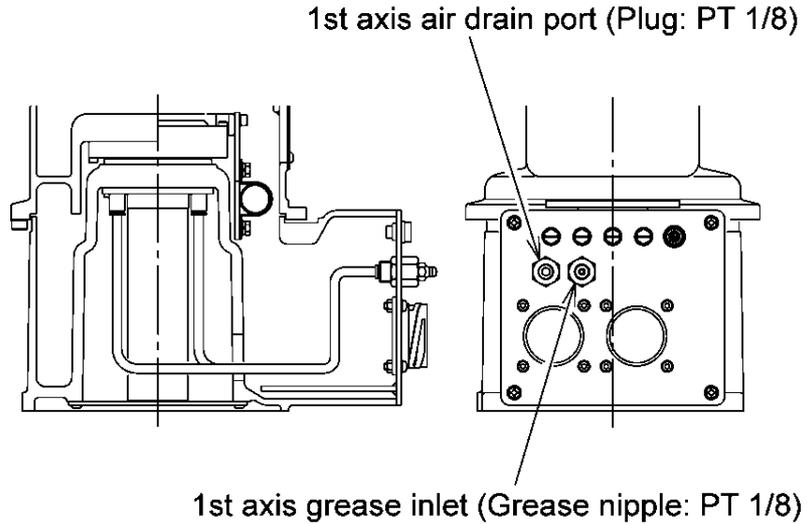
Caution: Before supplying grease, the air drain plug should be removed.

▶ STEP 1

<For CE-Compliant type robot>

<For CE-Compliant type robot>

Remove the air drain plug for the 1st axis and remove the grease nipple cap for the 1st axis grease inlet.



▶ STEP 2

Supply grease through the 1st axis grease nipple.

Lubricant amount: 7 pushes with a recommended grease gun (10 cc)

Caution: Be careful not to supply too much amount.

▶ STEP 3

Reinstall the air drain plug for the 1st axis.

▶ STEP 4

<For standard type robot>

Reinstall the base plate.

<For CE-Compliant type robot>

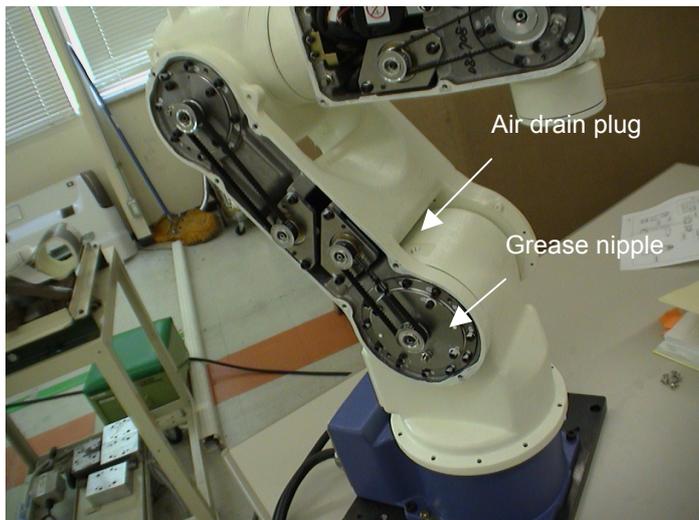
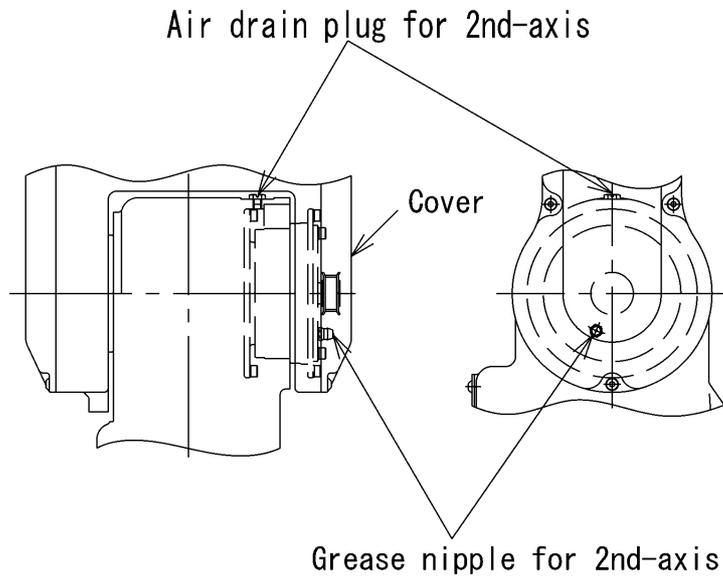
Reinstall the grease nipple cap.

(2) Lubricating the 2nd axis

Caution: The air drain plug and grease nipple are reverse side in following procedures at overhead-mount.

► STEP 1

(1) After removing the cover, remove the air drain plug for the 2nd axis.



Caution: Before supplying grease, the air drain plug should be removed.

► STEP 2

Supply grease through the 2nd axis grease nipple.

Lubricant amount: 10 pushes with a recommended grease gun (15 cc)

Caution: Be careful not to supply too much amount.

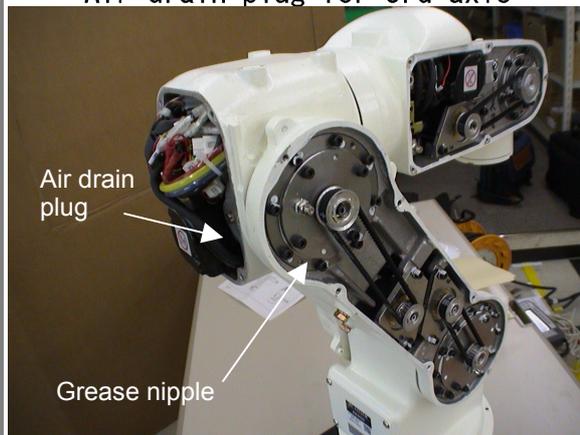
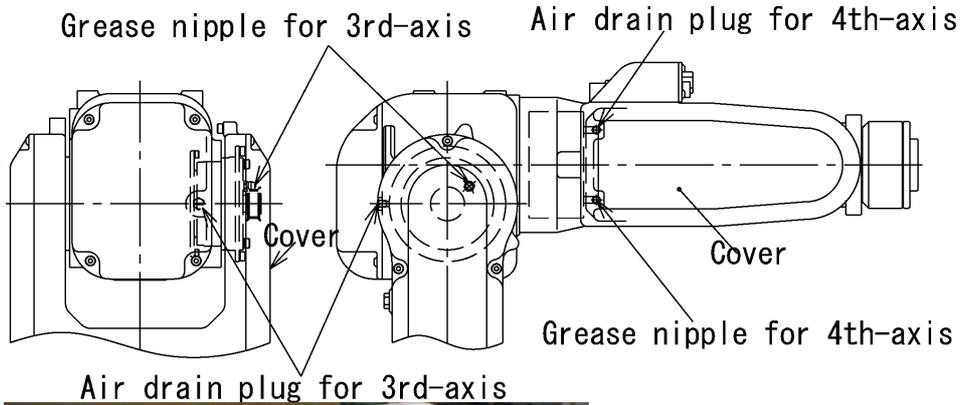
► STEP 3

Reinstall the air drain plug for the 2nd axis and reinstall the cover.

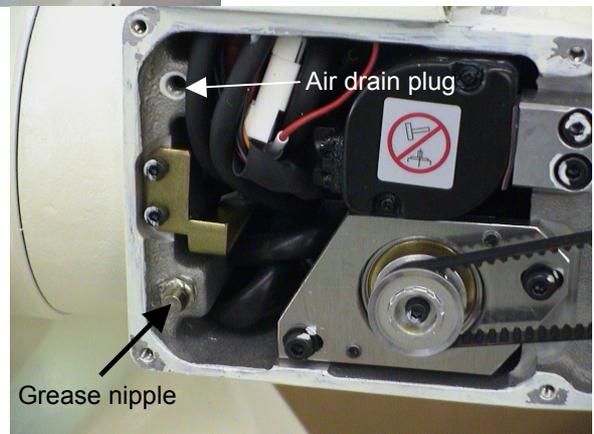
(3) Lubricating the 3rd and 4th axes

▶ STEP 1

After removing the cover, remove two air drain plugs for 3rd and 4th axes.



(For 4th Axis)



Caution: Before supplying grease, the air drain plug should be removed.

▶ STEP 2

Supply grease through the 3rd and 4th axes grease nipples.

<Lubricant amount>

3rd axis: 7 pushes with a recommended grease gun (10 cc)

4th axis: 7 pushes with a recommended grease gun (10 cc)
(Only for VC-6353F)

Caution: Be careful not to supply too much amount.

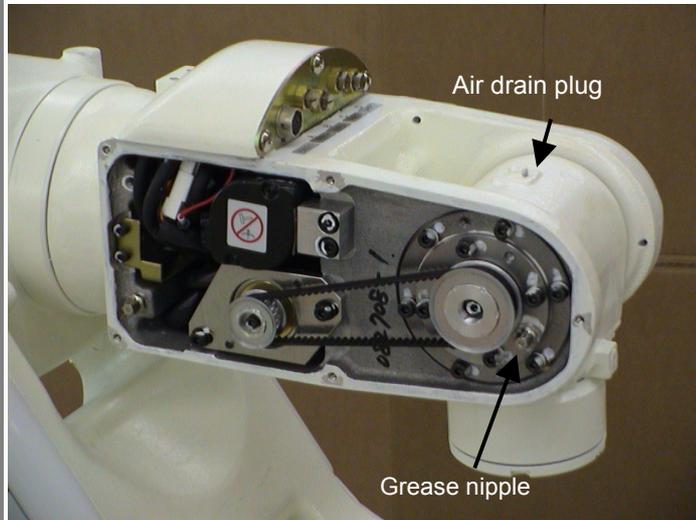
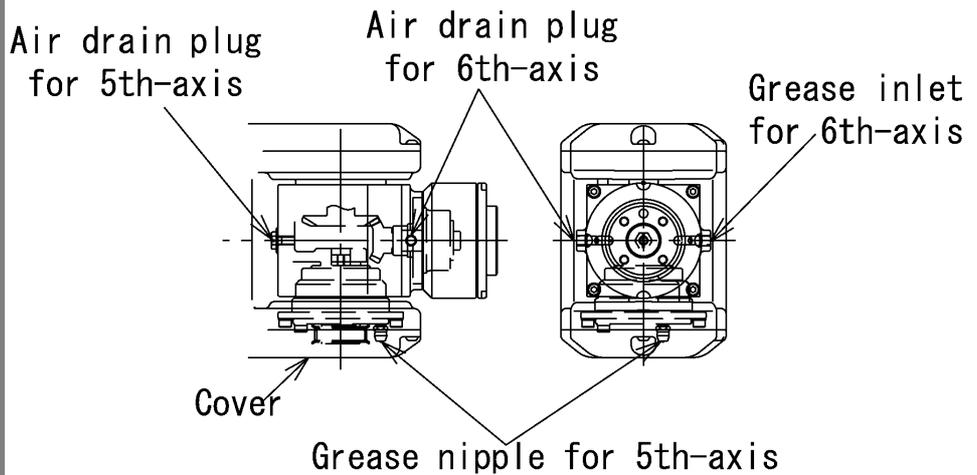
▶ STEP 3

Reinstall the air drain plugs and cover.

(4) Lubricating the 5th and 6th axes

▶ STEP 1

After removing the cover, remove two air drain plugs for 5th and 6th axes.



Caution: Before supplying grease, the air drain plug should be removed.

▶ STEP 2

After removing the grease inlet plug for the 6th axis, attach the grease nipple (A-MT6X1).

Note: If the robot is with the grease nipple, remove the grease nipple cap.

▶ STEP 3

Supply grease through the 5th and 6th axes grease nipples.

<Lubricant amount>

5th axis: 2 pushes with a recommended grease gun (3 cc)

6th axis: 3 pushes with a recommended grease gun (5 cc)

Caution: Be careful not to supply too much amount.

▶ STEP 4

(1) Reinstall the air drain plugs.

(2) After removing the grease nipple (A-MT6X1), reinstall the grease inlet plug for the 6th axis.

Note: If the robot is with the grease nipple, reinstall the grease nipple cap.

(3) Reinstall the cover.

3.5 Biennial Inspections

Replace the controller memory backup battery during biennial inspections and maintenance.

Programs, parameters, CAL data, etc. are stored in the internal memory of the robot controller.

The backup battery for each memory retains the above data while the power to the robot controller is turned OFF. However, these batteries have a limited lifetime and must, therefore, be replaced regularly.

NOTE: If two years elapse from replacement of either backup battery, the "Time to change controller backup battery" message will appear on the teach pendant.

 **Caution: Without replacing the backup batteries, important robot-specific data stored in each memory will be lost.**

3.5.1 Replacing the Memory Backup Battery

For the replacing procedures of the memory backup battery, refer to the "Section 6.6 Replacing the Memory Backup battery, RC7 CONTROLLER INTERFACE MNUAL".

3.5.2 Setting the Next Battery Replacement Date

After replacing the memory backup battery, set the next battery replacement date from the teach pendant, according to the following procedure.

NOTE: This procedure cannot be performed with the mini pendant.

NOTE: Check that the system clock of the robot controller shows the correct date beforehand. If it is incorrect, the next replacement date will also become incorrect.

- ▶ **STEP 1** **On the top screen of the teach pendant, press [F6 Set].**
The Settings (Main) window appears.

- ▶ **STEP 2** **Press [F6 Maint.] in the Settings (Main) window.**
The Maintenance menu appears.

- ▶ **STEP 3** **Press [F4 Battery] in the Maintenance menu.**
The Next Battery Replacement Date window appears.

In the top of the window, the current setting is displayed.

The date entry areas show the default replacement date that is two years later the current data at which you open this window, assuming that the battery service life is two years.

- ▶ **STEP 4** **Press OK.**
NOTE: If you do not want to change the replacement date, press Cancel.
The message "Are you sure you want to set the next battery replacement date?" appears.

- ▶ **STEP 5** **Press OK.**
The screen returns to the Settings (Main) window.

3.6 4 years Inspections

Replace the encoder backup battery during every four years inspections and maintenance.

The position data of the encoder built in the servomotor is stored in the internal memory of the encoder.

The backup battery for each memory retains the above data while the power to the robot controller is turned OFF. However, these batteries have a limited lifetime and must, therefore, be replaced regularly.

⚠ Caution: Without replacing the backup batteries, important robot-specific data stored in each memory will be lost.

3.6.1 Replacing the Encoder Backup battery

Replace the encoder backup battery according to the procedure below.

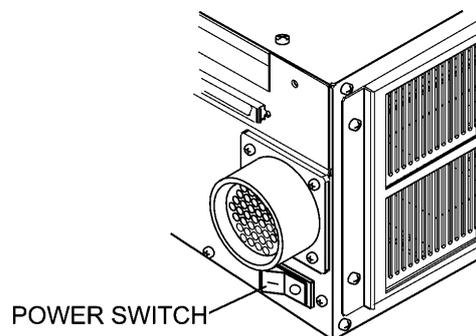
▶ STEP 1

Prepare two new sets of backup batteries for replacement.
<(for 1, 2 and 3 axes) and (for 4, 5 and 6 axes)>



▶ STEP 2

Turn the controller power OFF.



▶ STEP 3

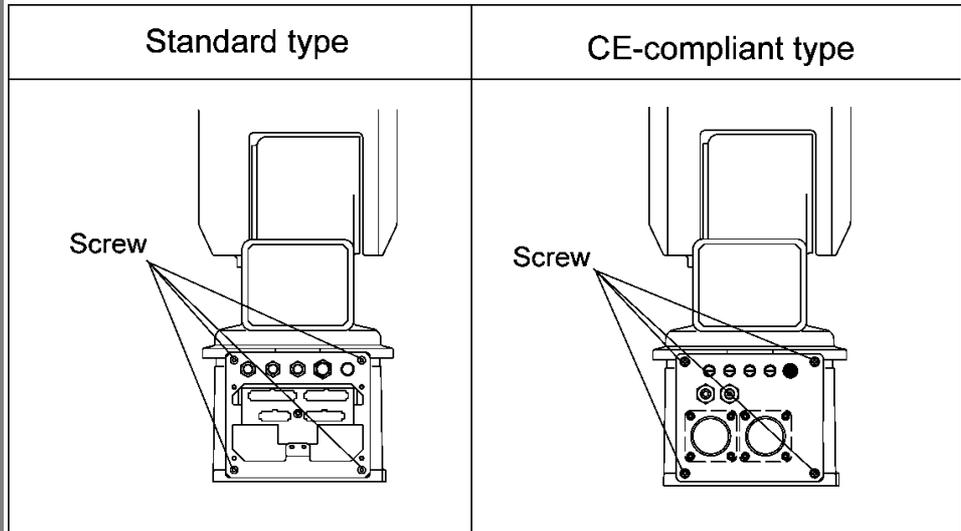
< This STEP is only for the standard type robot >

Remove four screws from the base plate.
After pulling out the base plate, disconnect four connectors and two grounding terminals.



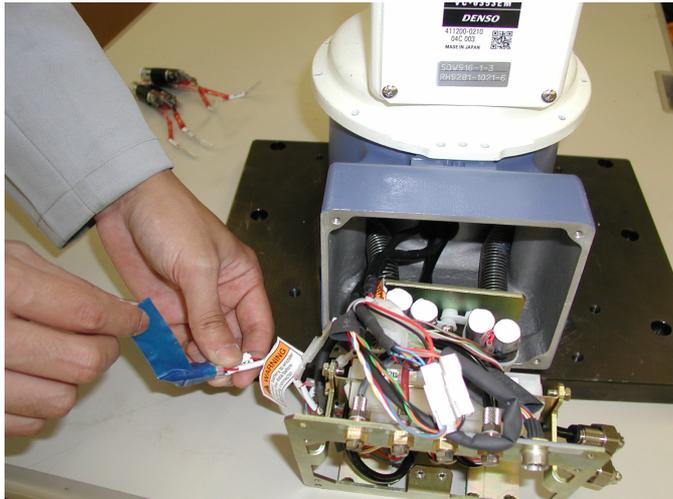
▶ STEP 4

After unscrewing four screws from the connector base, pull out the connector base.



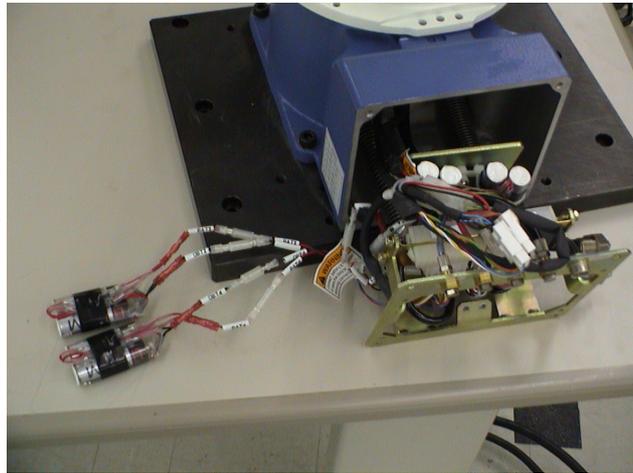
▶ STEP 5

Remove the protect-tape from the spare terminal for battery connection located in the inside of the robot unit.



▶ STEP 6

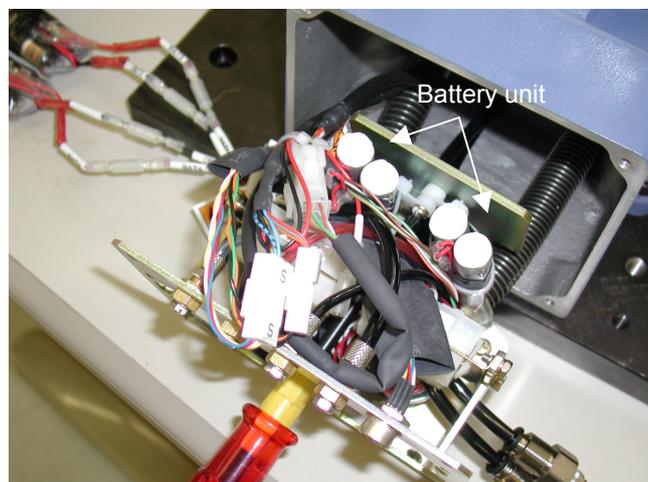
Connect two new battery unit sets to the spare terminals.



▶ STEP 7

Remove the battery unit fixing screw.

Note: This photo is for the standard type robot. For the CE-compliant type robot, refer to the "Reference drawing" on page 60.



▶ STEP 8

Disconnect two old battery units.

Caution: Do not disconnect old battery units before connecting new ones. If you do so, the encoder positional data may be lost. And also, take care not to do wrong connection between new battery units and old ones.

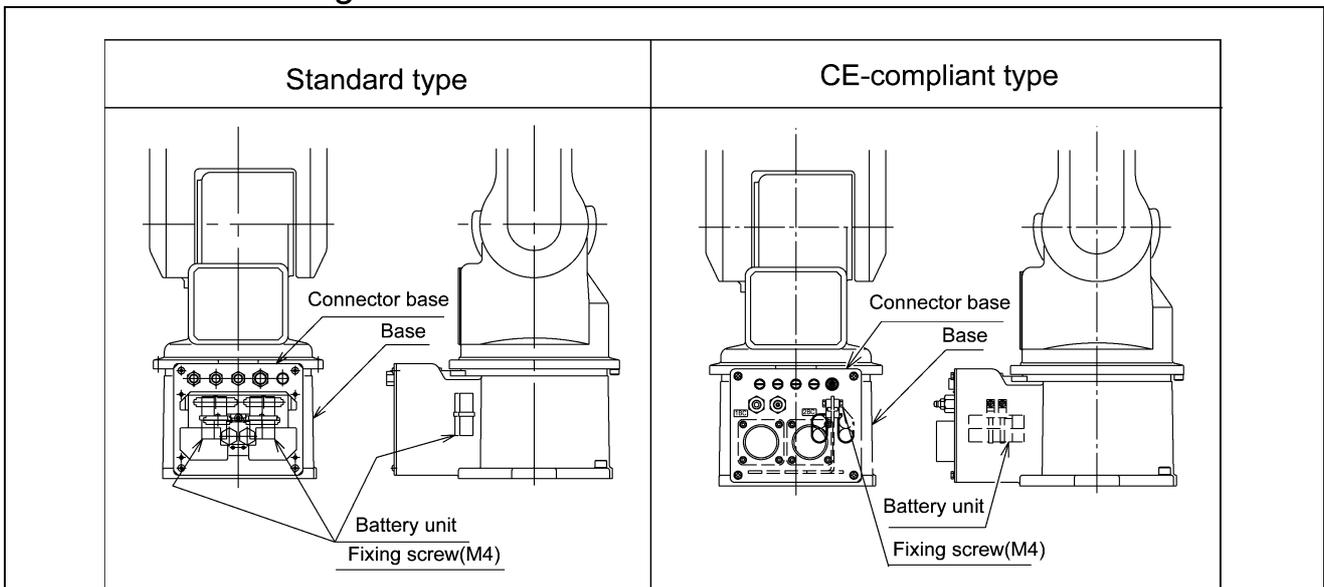
▶ STEP 9

Protect the battery terminal for battery connection located in the inside of the robot unit with protect-tape.

▶ STEP 10

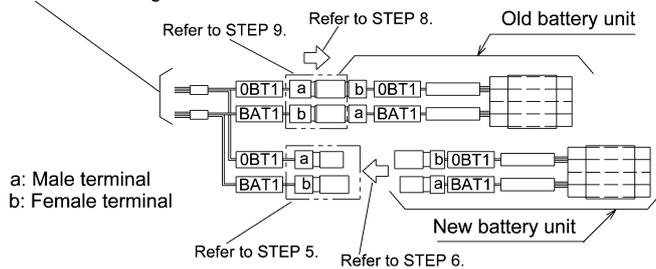
Reinstall the removed parts.

<Reference drawing>



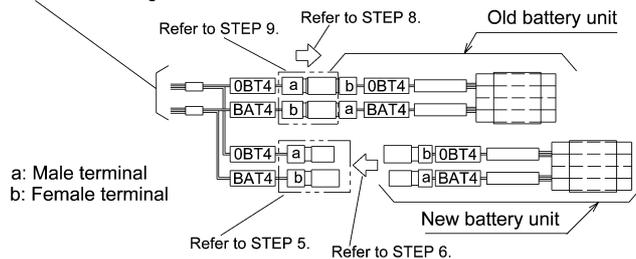
< Connection of battery unit for 1st, 2nd and 3rd axes >

1st, 2nd and 3rd axes side
robot inner wiring



< Connection of battery unit for 4th, 5th and 6th axes >

4th, 5th and 6th axes side
robot inner wiring



3.7 Supplies and Tools for Maintenance

The table below lists the supplies to be replaced regularly and required tools, out of components used in robots and the recommended tools for maintenance and inspection.

3.7.1 Supplies and Tools Required

List of Supplies and Tools Required

No	Name	Part No.	Remarks	
1	Grease	410971-0220	2.5 kg can	Harmonic grease SK-1A
2	Filter	410041-4730	Air intake filter in the robot controller	
3	Memory backup battery	410076-0260	Memory backup battery for controller	
4	Encoder backup battery	410076-0210	1set for <u>1st to 3rd axes</u> or <u>4th to 6th axes</u>	
5	Fuse (1.3A)	410054-0230	Fuse LM13 (1.3A) for controller I/O	
6	Fuse (0.3A)	410054-0240	Fuse LM03 (0.3A) for controller I/O	
7	IC for output (NPN)	410077-0010	IC (M54522P) for controller output	
8	IC for output (PNP)	410077-0020	IC (M54564P) for controller output	

3.7.2 Recommended Tools

List of Recommended Tools

No.	Tool name	Recommended tool (manufacturer)	Application
1	Grease gun	(Yamada Corporation) ·Body: KH-32 ·Standard nozzle: HSP-1	Greasing

3.8 Replacing Fuses and Output ICs

For the replacing procedures of the fuses and output ICs, refer to the “ Section 6.7 Replacing Fuses and Output ICs, RC7 CONTROLLER INTERFACE MANUAL.

3.9 Checking the Odometer and Trip Meter

You may check the odometer and trip meter which count traversed distance of each axis in the Odometer window of the teach pendant.

The access to the Odometer window is [F6 Set]—[F6 Maint.]—[F5 Odometer].

The Odometer window shows the following items:

[Odometer] Shows the total distance of each axis traversed after the robot leaves the factory. You cannot reset the odometer.

[Trip meter] Shows the distance of each axis traversed after you reset the trip meter to zero.

3.9.1 Displaying the Odometer and Trip Meter

▶ STEP 1

Turn the robot controller ON.

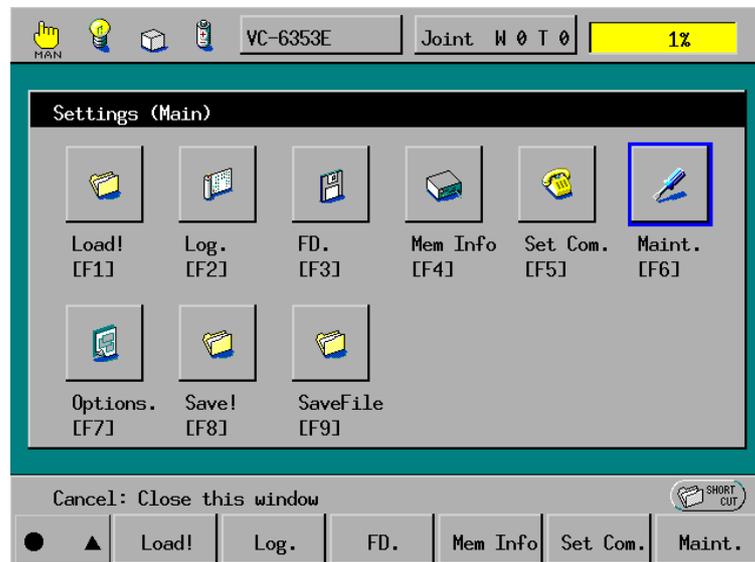
▶ STEP 2

On the teach pendant, set the mode switch to the MANUAL position.

▶ STEP 3

On the top screen, press [F6 Set].

The Settings (Main) window appears as shown below.

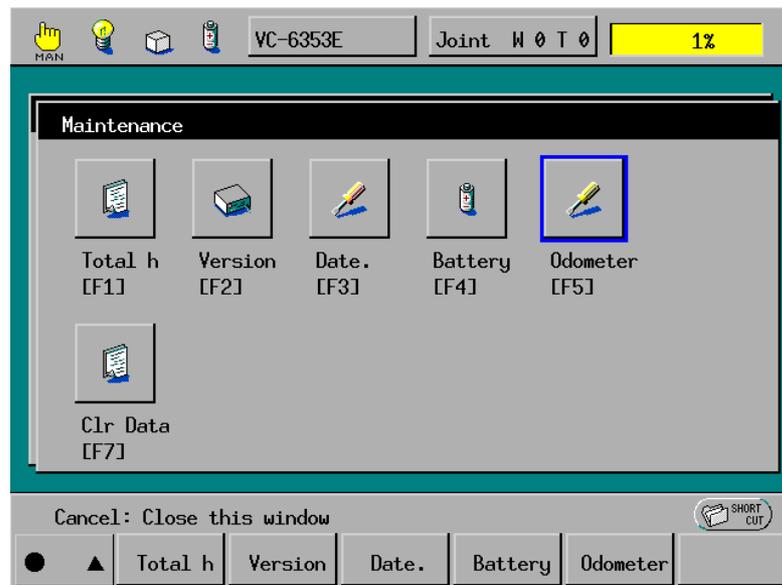


F6

Press [F6 Maint.].

► STEP 4

The Maintenance menu appears as shown below.

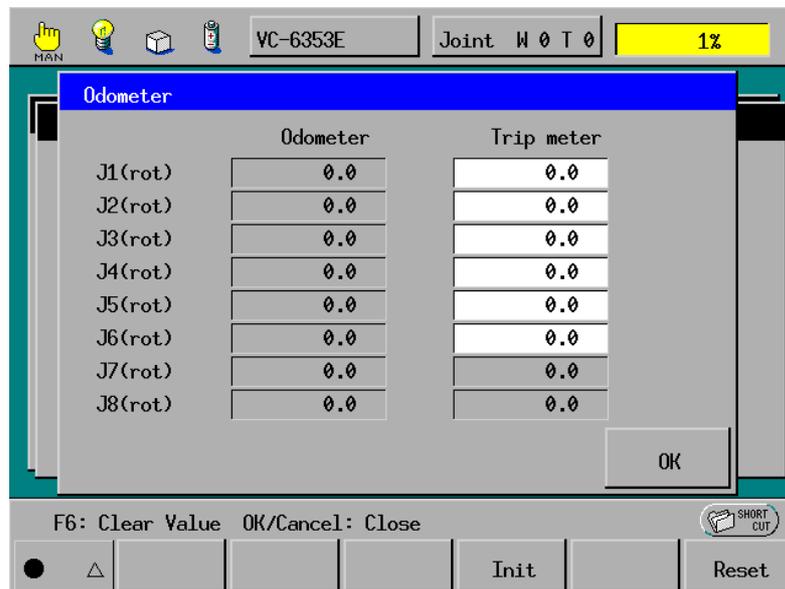


F5

Press [F5 Odometer].

► STEP 5

The Odometer window appears as shown below.



F6

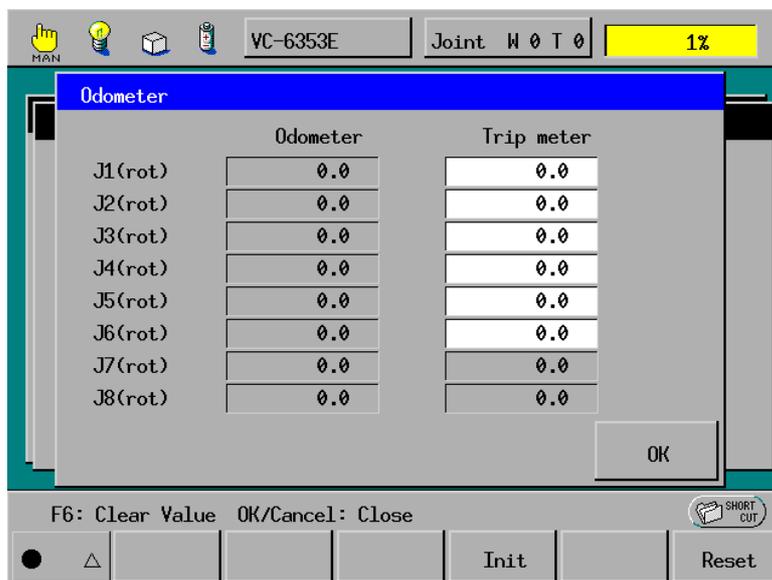
In the above Odometer window, the J1, J2 and J4 are expressed in number of revolutions and J3 in meter.

3.9.2 Resetting the Trip Meter to Zero

▶ STEP 1

Call up the Odometer window.

Access: [F6 Set] – [F6 Maint.] – [F5 Odometer]

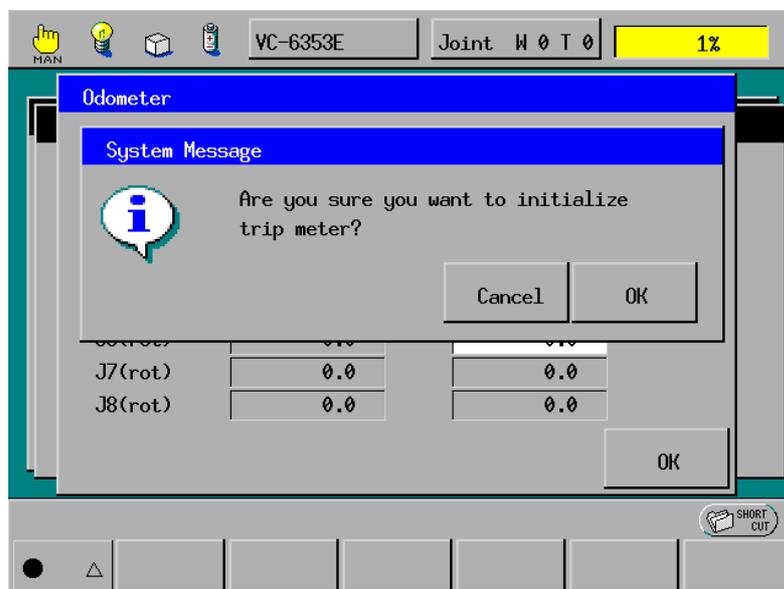


F6

Press [F6 Reset].

▶ STEP 2

The following message appears.



F5

Press the OK button.

The trip meter has been reset to zero.

3.10 Checking the Controller ON-Time and the Robot Running Time and Resetting Their User Counters

You may check the robot controller ON-time and the robot running time in the Total hours window of the teach pendant.

The Total hours window shows the following items:

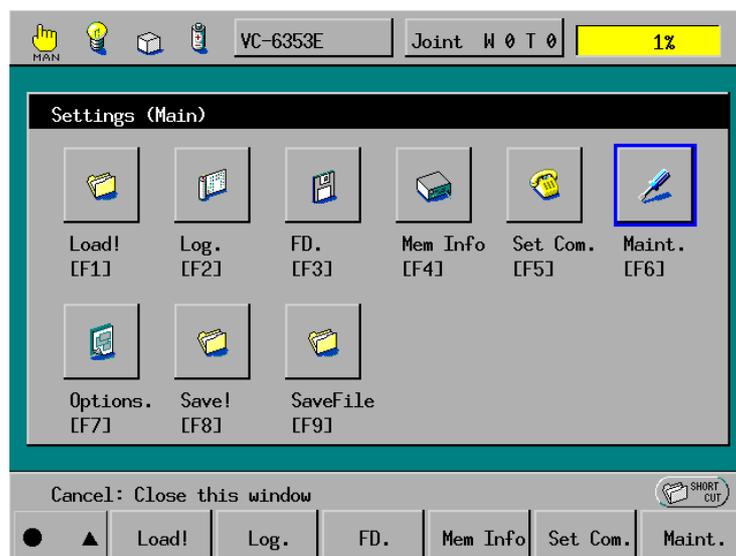
[Total operation]	Shows the grand total of the robot controller ON-time counted after the controller leaves the factory.
[Total running]	Shows the grand total of the robot running time counted after the robot leaves the factory.
[Cumulative operation]	Shows the total of the robot controller ON-time counted after you reset the user counter to zero.
[Cumulative running]	Shows the total of the robot running time counted after you reset the user counter to zero.
[Operation]	Shows the ON-time of the robot controller counted after it is turned ON this time.
[Running]	Shows the running time of the robot counted after the robot controller is turned ON this time.

3.10.1 Displaying the Controller ON-time and the Robot Running Time

- ▶ **STEP 1** | Turn the robot controller power ON.

- ▶ **STEP 2** | On the teach pendant, set the mode switch to the MANUAL position.

- ▶ **STEP 3** | On the top screen, press [F6 Set].
The Settings (Main) window appears as shown below.

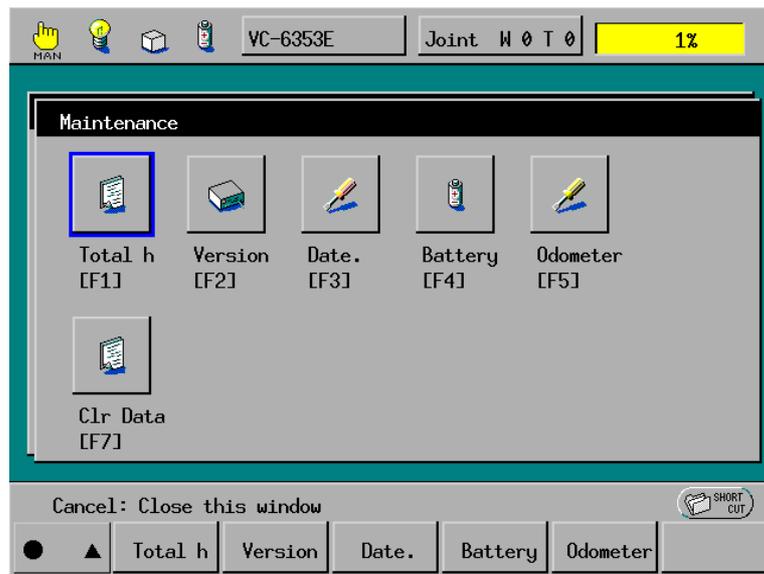


Press [F6 Maint.].

F6

► STEP 4

The Maintenance menu appears as shown below.

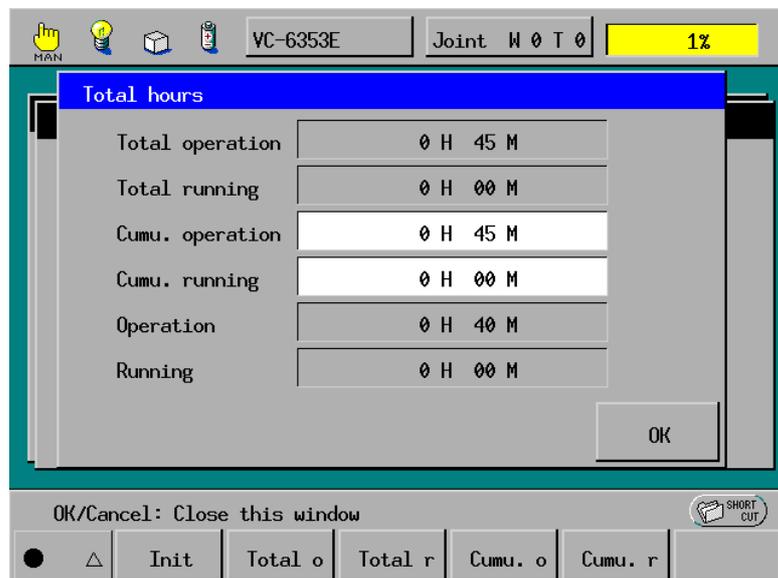


F1

Press [F1 Total h].

► STEP 5

The Total hours window appears as shown below.

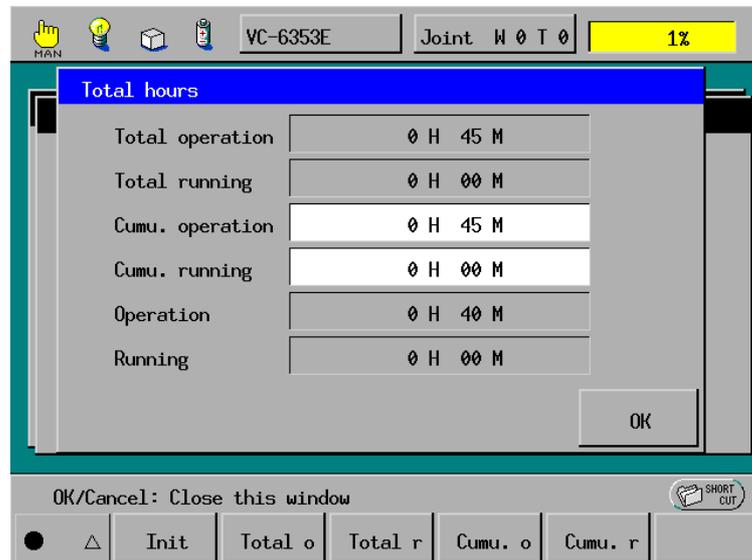


3.10.2 Resetting the User Counters of the Controller ON-Time and the Robot Running Time

► STEP 1

Call up the Total hours window.

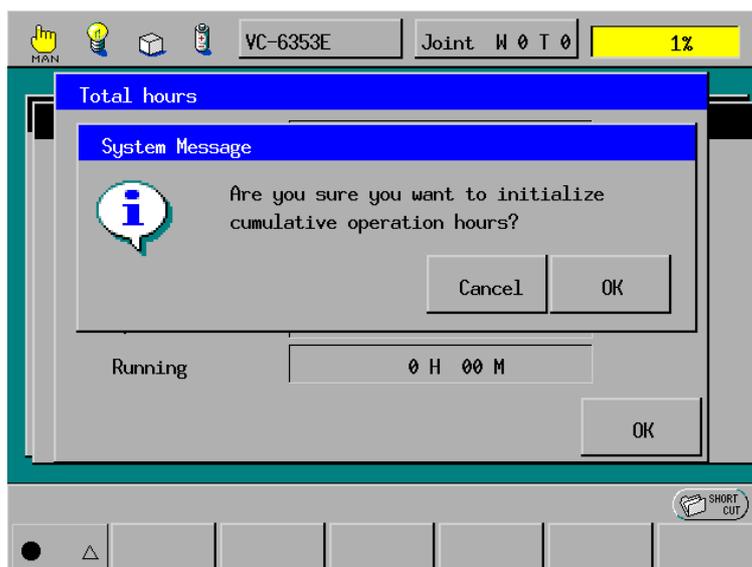
Access: [F6 Set] – [F6 Maint.] – [F1 Total h]



To reset the user counter of the controller ON-time to zero, press [F4 Cumu. o].

► STEP 2

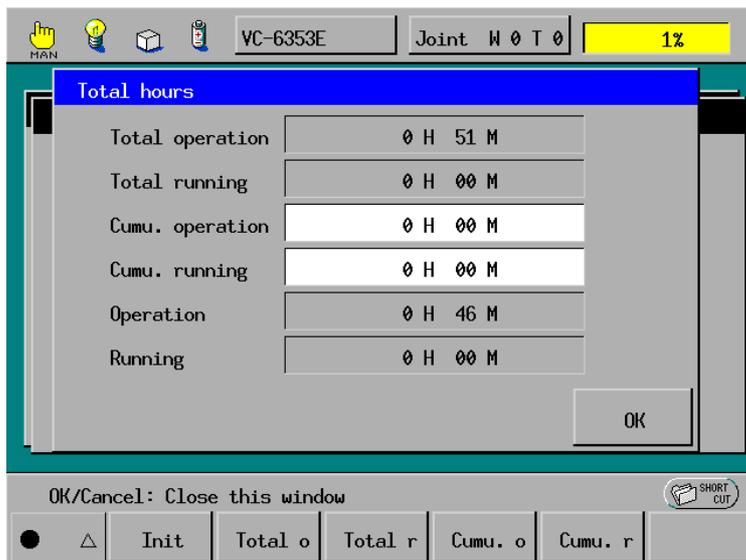
The following system message appears.



Press the OK button.

▶ STEP 3

The user counter of the controller ON-time has been reset to zero.



3.11 Using the Initialization Floppy Disk

The initialization floppy disk (*.arm) stores arm data in WINCAPSII format.

You transfer the stored arm data to the robot controller in these two steps:

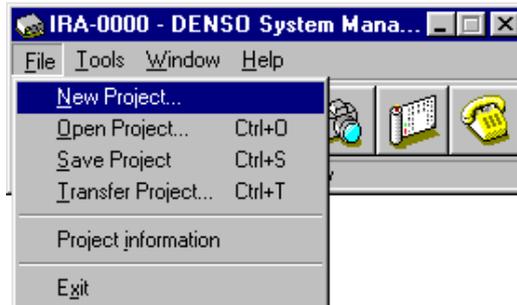
- (1) Create a project by using the data stored in the floppy disk.
- (2) Transfer the trajectory generation file in the project to the robot controller.

Creating a project to be transferred

▶ STEP 1

Create a new project.

Start WINCAPSII. From the File menu of System Manager, click the New Project.

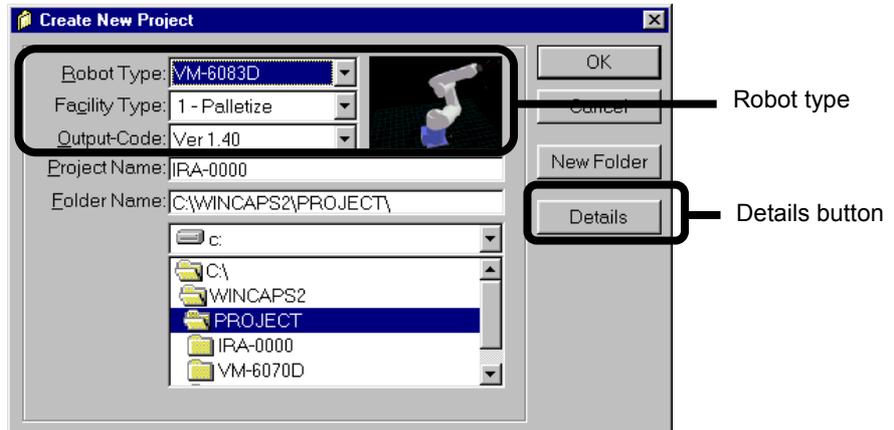


[File menu: Creating a new project]

▶ STEP 2

Select your robot type.

Select the robot type of the controller to which you want to transfer data.

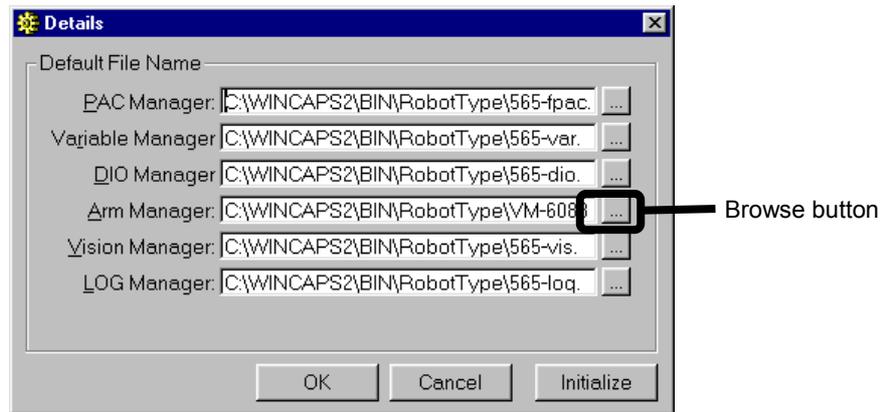


[Create New Project window]

▶ STEP 3

Select arm data.

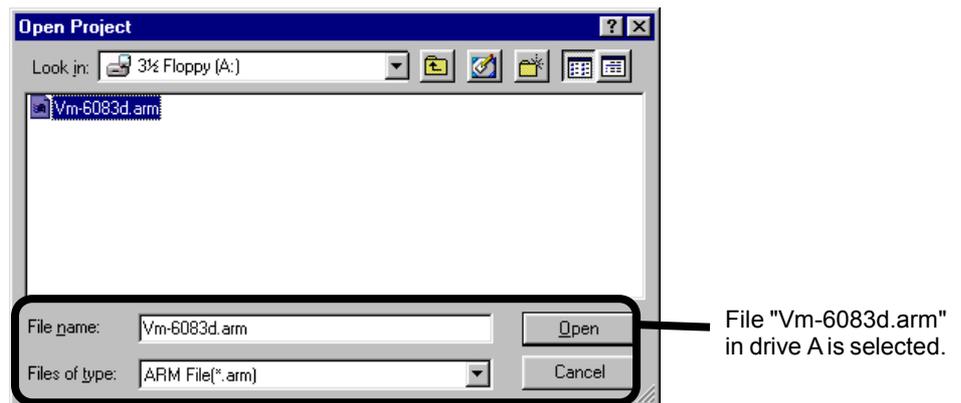
- (1) Press the Details button to call up the window below.



[Details window]

- (2) Press the Browse button in Arm Manager to call up the Open Project window.

Select desired file in the floppy disk, then press the Open button.



[Selecting a file]

- (3) The screen will return to the Details window where you press OK button.

▶ STEP 4

Create a project.

On the Create New Project window, press OK button. Now, a project to be transferred has been created.

Transferring the trajectory generation file

► STEP 1

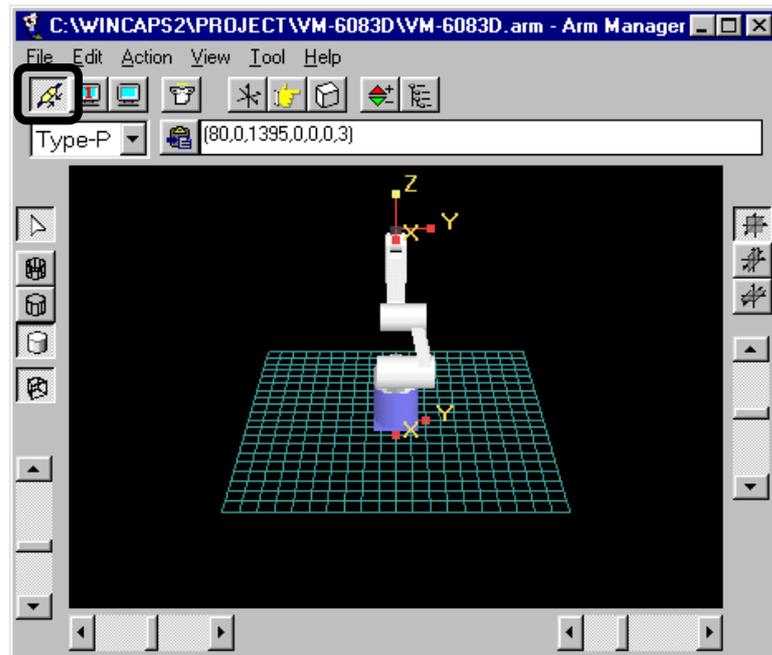
Start of Arm Manager

From System Manager, run Arm Manager.

► STEP 2

Connection with the robot controller

Press the Connect button to connect with the robot controller.

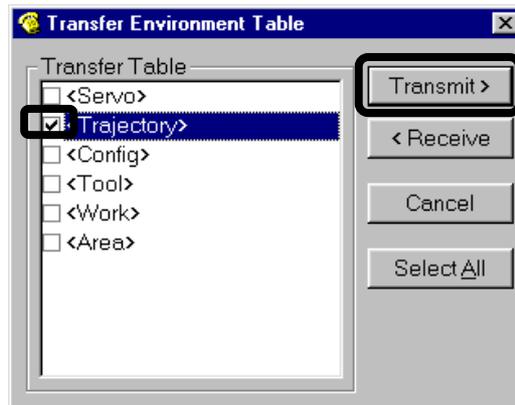


[Arm Manager window]

▶ STEP 3

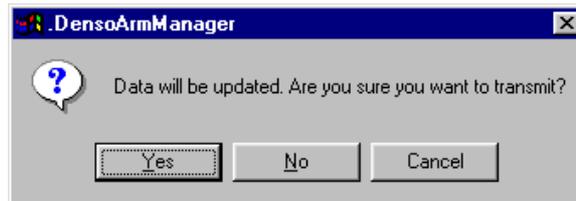
Data transmission

- (1) From the File menu of Arm Manager window, click Transfer command. The Transfer Environment Table appears as shown below.



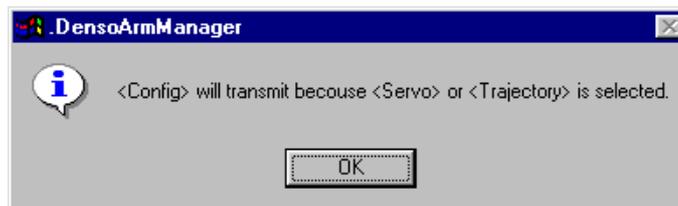
[Transfer Environment Table]

- (2) On the table shown above, select the Trajectory and press the Transmit> button.
- (3) The following message appears.
Press Yes.



[Confirmation dialog]

The following message appears.
Press OK.



[Configuration transfer dialog]

During data transfer, the following dialog is displayed.



[Transfer Trajectory Generation Table]

(4) Upon completion of transfer, the following message appears.

Press OK.

The arm data stored in the initialization floppy disk has been transferred to the robot controller.

Turn the controller power off and then on.



[Transfer completion message]

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Compact, Vertical Articulated Robot VC-F SERIES

INSTALLATION & MAINTENANCE GUIDE

First Edition February 2004

DENSO WAVE INCORPORATED
Factory Automation Division

2F**C

The purpose of this manual is to provide accurate information in the handling and operating of the robot. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.

In no event will DENSO WAVE INCORPORATED be liable for any direct or indirect damages resulting from the application of the information in this manual.

