13.　Calibration

13.1　About Calibration

After parts have been replaced (motors, reduction gear units, timing belts, etc.), the Manipulator cannot execute the positioning properly because a mismatch exists between the origin stored in each motor and its corresponding origin stored in the Controller.
After replacing the parts, it is necessary to match these origins.

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 EPSON RC+ User's Guide: *2.4 Installation and Design Precautions.* ■ 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.

Command Input
Calibration procedures include the process to input commands.　Select EPSON RC+ menu-[Tools]-[Command Window] to use the command window.

The information above is omitted in the calibration procedure.

Jog Motion
The process to set the jog motion is included in the [Jog & Teach] page of the Robot Manager.　Select EPSON RC+ menu-[Tools]-[Robot Manager] and select the [Jog & Teach] tab to use the [Jog & Teach] page.

The page above is indicated as [Jog & Teach] in the calibration procedure.

13.2   Calibration Procedure

EPSON RC+ has a wizard for calibration.

This section indicates the calibration using the calibration wizard of EPSON RC+.

The same calibration procedure is used for each joint.
The follow the steps below are calibration using Joint #1.   Follow the steps below to calibrate other joints.

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.   Execute the procedure in "Calibration Using Right / Left Arm Orientations" to accurately calibrate Joint #2.   For details, refer to *Maintenance: 13.3 Accurate Calibration of Joint #2*.

When calibrating Joint #4, you must calibrate Joint #3 and #4 at the same time.   You cannot calibrate Joint #4 alone because of the structure of the Manipulator.

NOTE

☞

If Err9716 or 5016 (Power supply failure of the absolute encoder. Replace the battery. Check the robot internal wiring) occurs, apply the procedure of *13.4 Calibration Procedure without using Calibration Wizard - 3. Encoder Initialization* and then, start the calibration wizard.
The reference point (a point to check the accuracy) needs to be specified for calibration.

(1) Start the calibration wizard.

For EPSON RC+ 5.0:

i. Select EPSON RC+ menu-[Setup]-[Controller] to display the [Controller] dialog.

ii. Select [Robot]-[Calibration] to display [Robot Calibration].
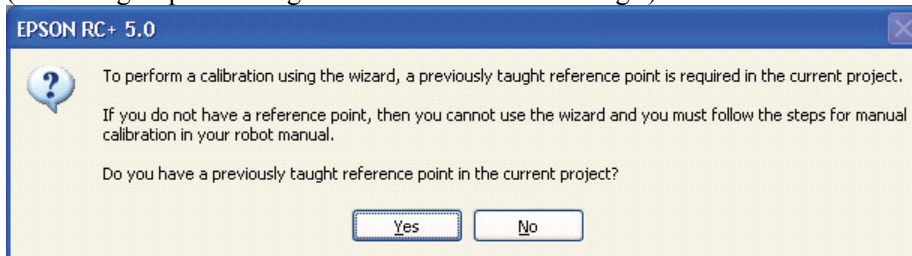
iii. Select the joint and click the <Calibrate…> button.
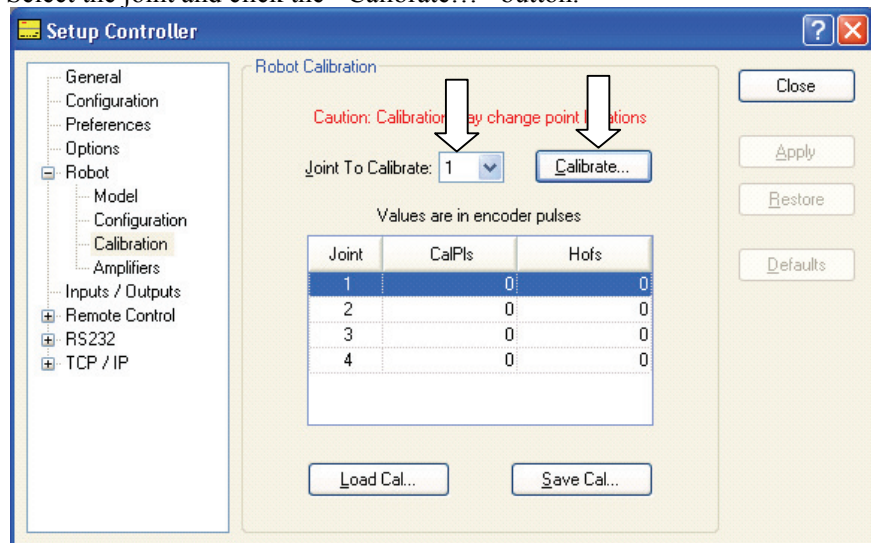
For EPSON RC+7.0:

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

ii.　Select [Robots]-[Robot**] to display [Calibration].

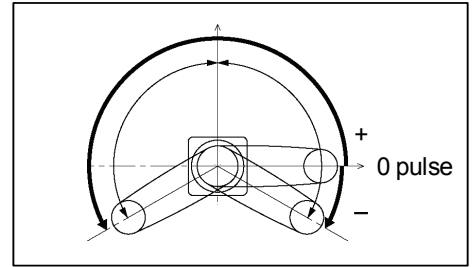iii.　Select the joint and click the <Calibrate…> button.
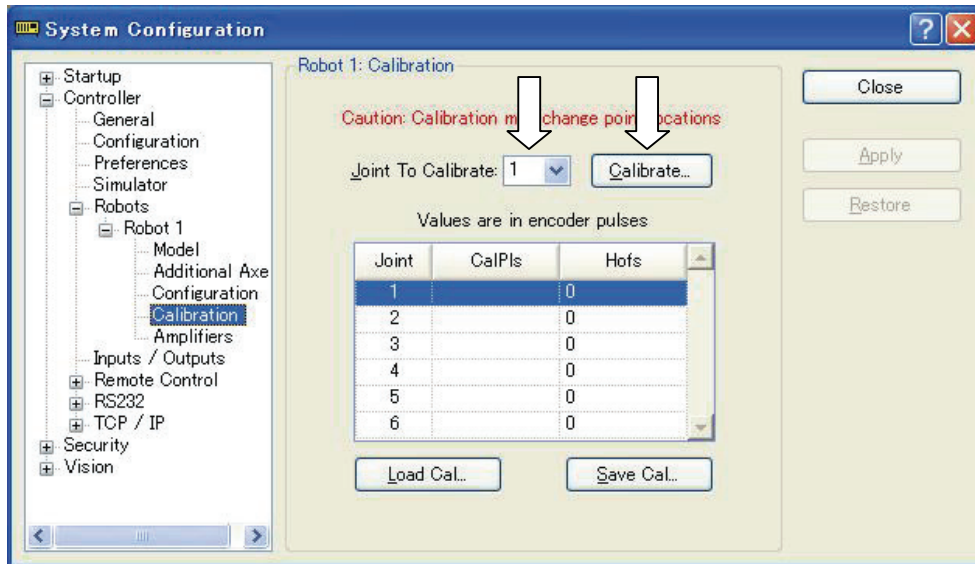
(2)　Confirm the warning message and click the <Yes> button.
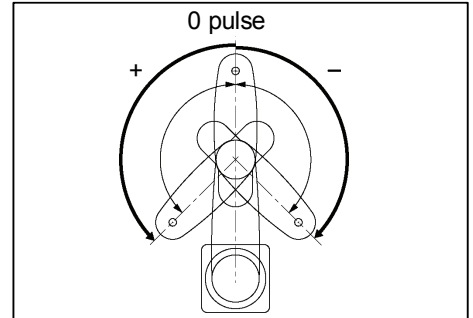(Following steps use images of EPSON RC+ 5.0 dialogs.)

(3)　Move the joint to calibrate manually to approximate zero position, as shown in the dialog.　After moving the joint click the <Next> button.
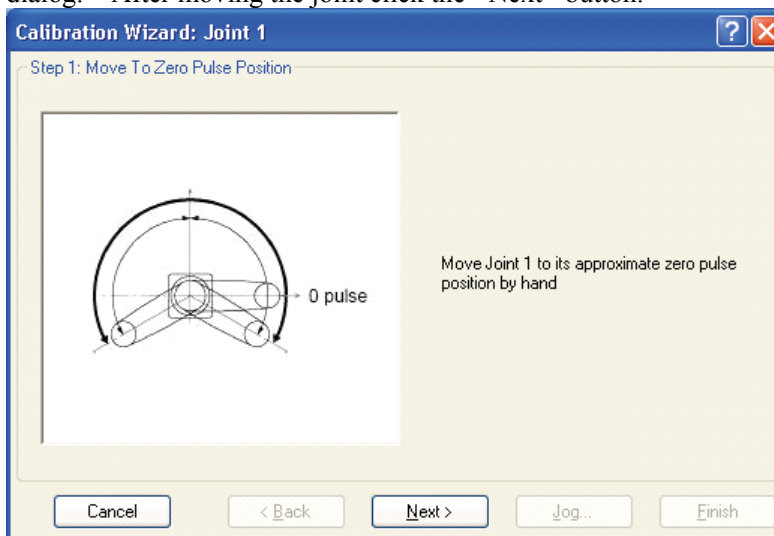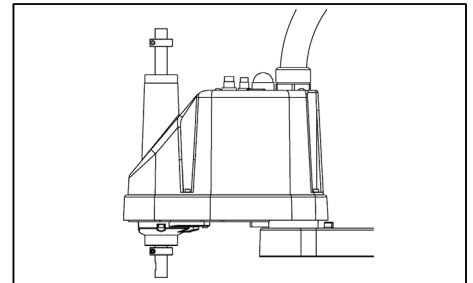
0 pulse position of Joint #1:

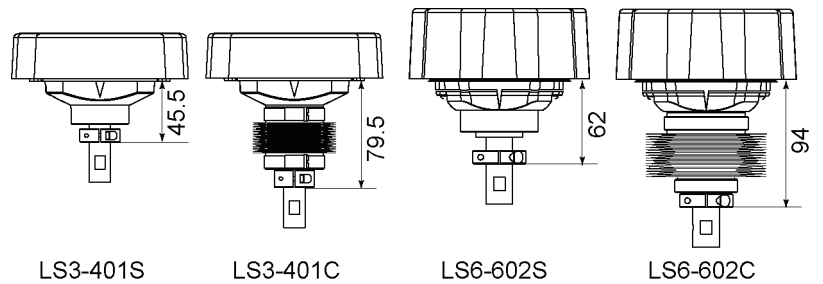   position aligned with X-axis in Robot coordinate system

0 pulse position of Joint #2:

    position where Arms #1 and #2 are in a straight line
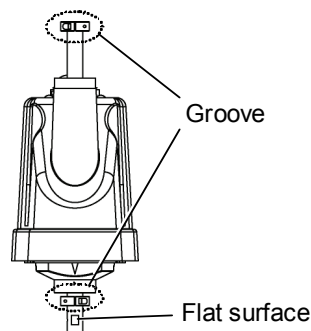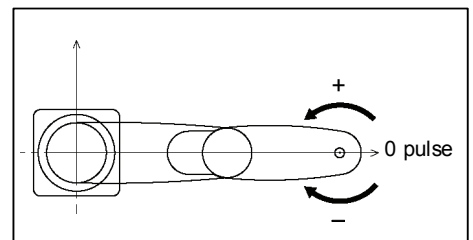
    (Regardless of the Joint #1 direction.)

0 pulse position of Joint #3:

    upper limit position in motion range

The height of Joint #3 depends on manipulator model.

LS3-401S   LS3-401C   LS6-602S   LS6-602C

0 pulse position of Joint #4:

    position where the flat surface (or groove in the up/down mechanical stop) on the shaft faces toward the tip of Arm #2
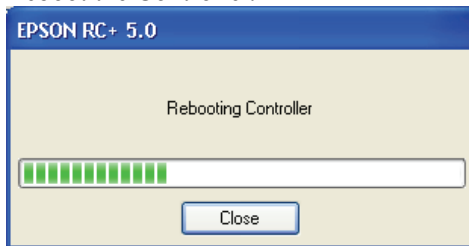

Groove

Flat surface

(4)   Click the <Yes> button to reset the encoder.
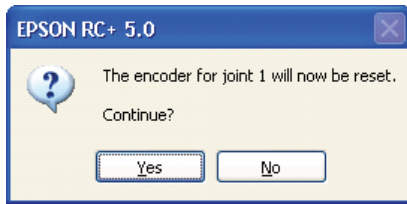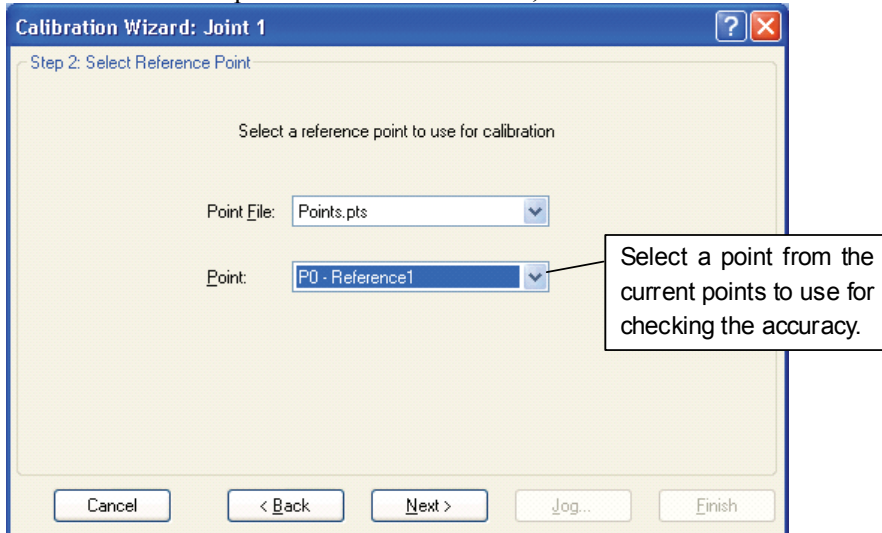
* This window will disappear when the Controller starts up.

(5)   Reboot the Controller.

* This window will disappear when the Controller starts up.

(6)   Select the reference point to use for calibration, and click the <Next> button.

Select a point from the current points to use for checking the accuracy.

(7)   Click the <Jog…> button to display the [Jog & Teach] dialog.
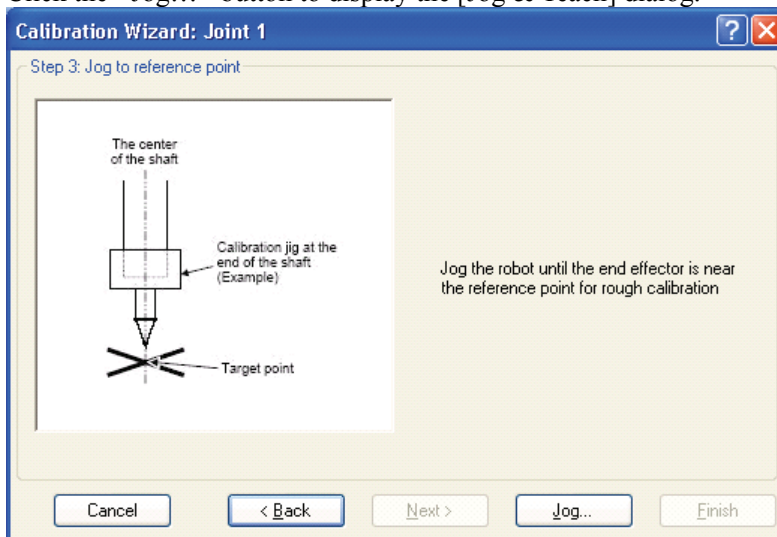
(8) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration.   Then click the <OK> button.

* Before operating the robot, open the [Jog & Teach] tab and click on the <Motor ON> button.

(9) Click the <Next> button.

(10) The manipulator moves to the reference point.   Click the <Execute> button.
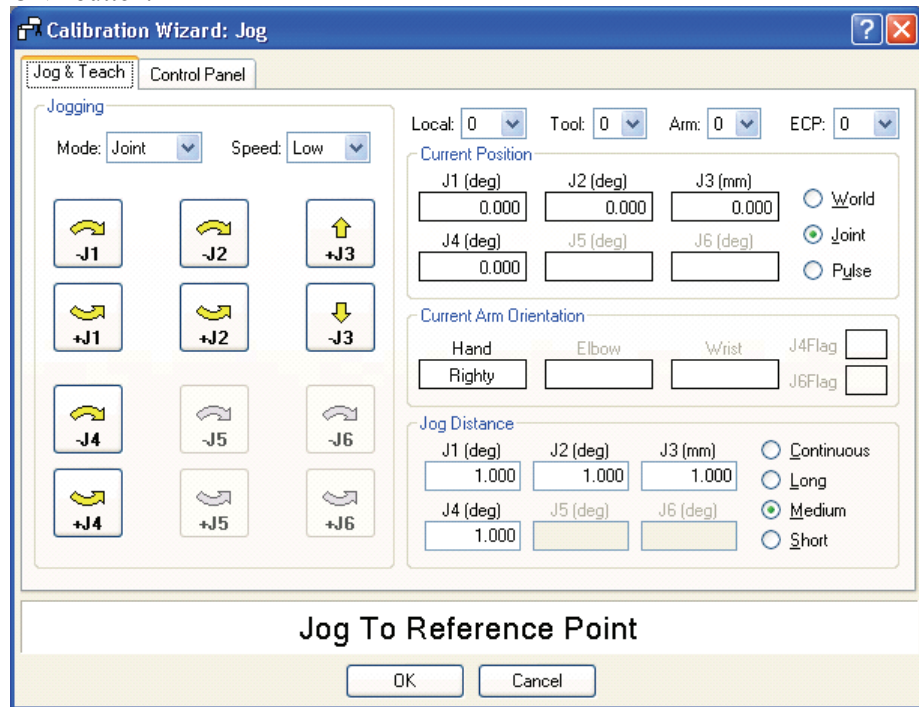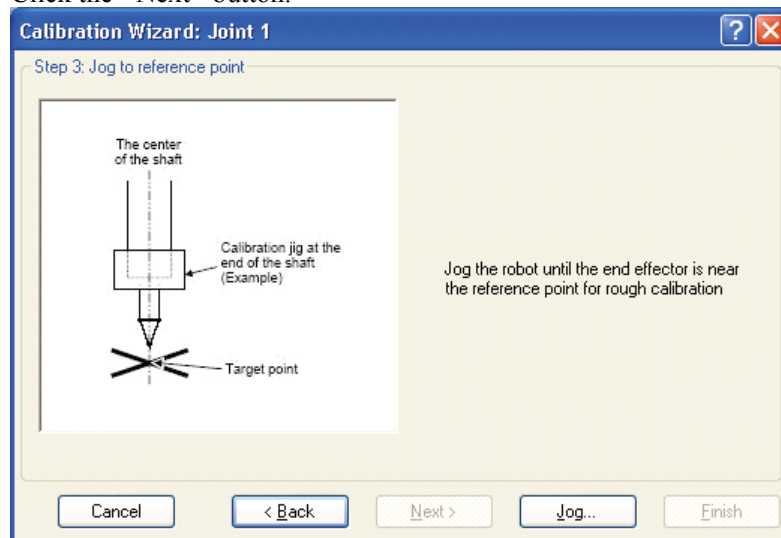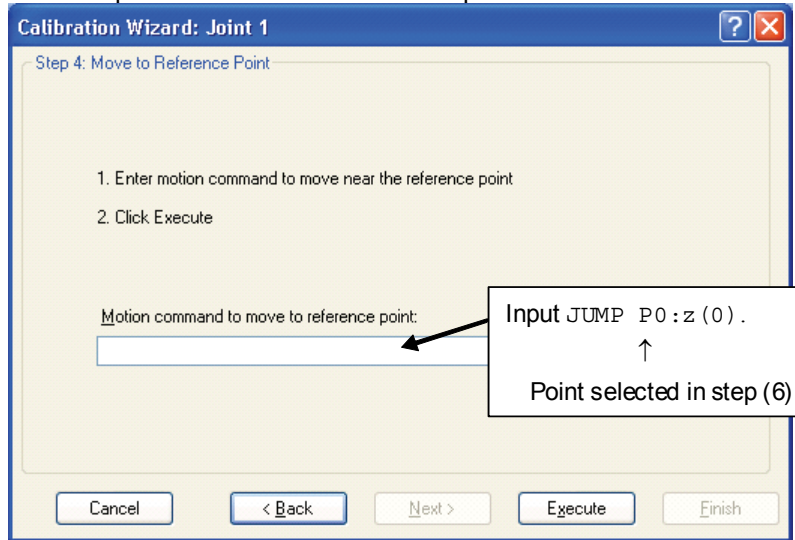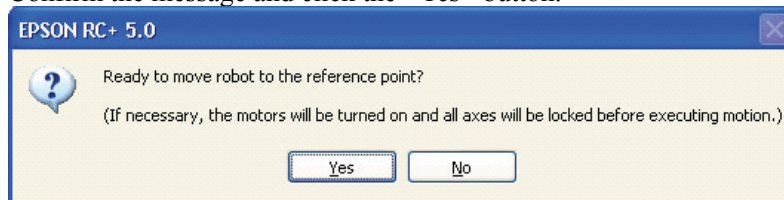
Calibration Wizard: Joint 1

Step 4: Move to Reference Point

1. Enter motion command to move near the reference point

2. Click Execute

Motion command to move to reference point:

Input JUMP P0:z(0).
↑
Point selected in step (6)

Cancel   < Back   Next >   Execute   Finish

(11) Confirm the message and click the <Yes> button.

EPSON RC+ 5.0

Ready to move robot to the reference point?

(If necessary, the motors will be turned on and all axes will be locked before executing motion.)

Yes   No

(12) After the manipulator moves to the reference point, click the <Next> button.

Calibration Wizard: Joint 1

Step 4: Move to Reference Point

1. Enter motion command to move near the reference point

2. Click Execute

Motion command to move to reference point:

Cancel   < Back   Next >   Execute   Finish
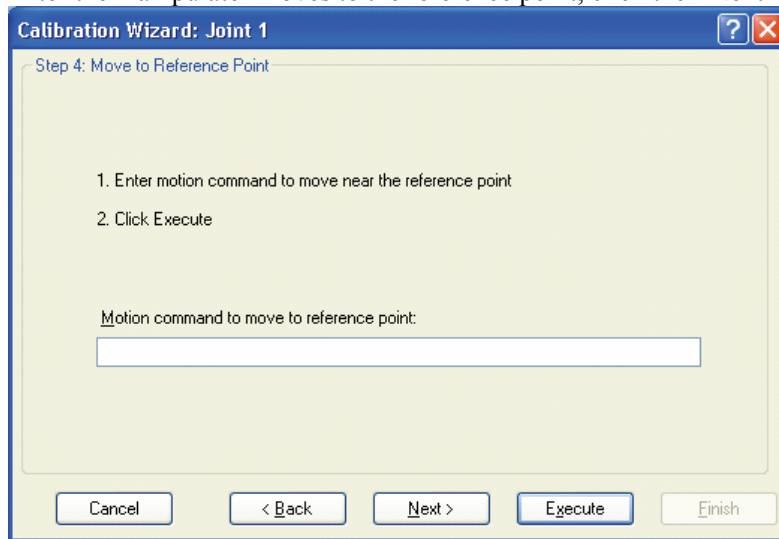
(13) Jog to the accurate reference position.
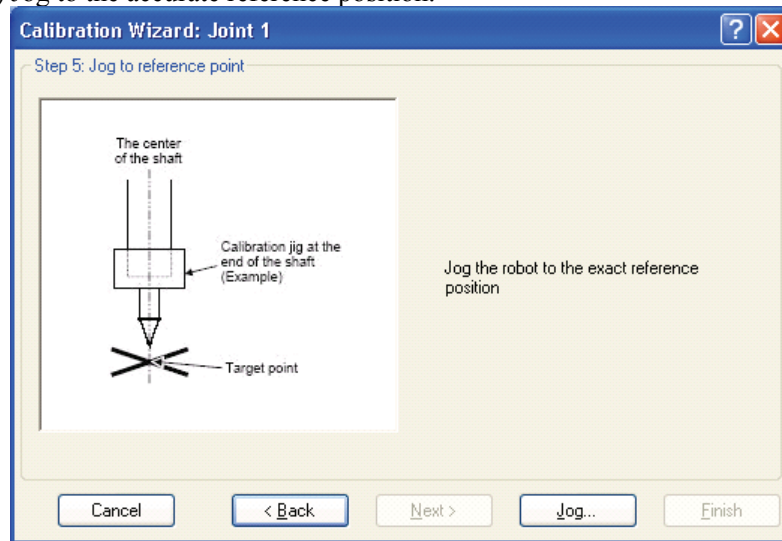
(14) Jog the end effector to approximate reference point in the [Jog & Teach] dialog for rough calibration.   Then click the <OK> button.
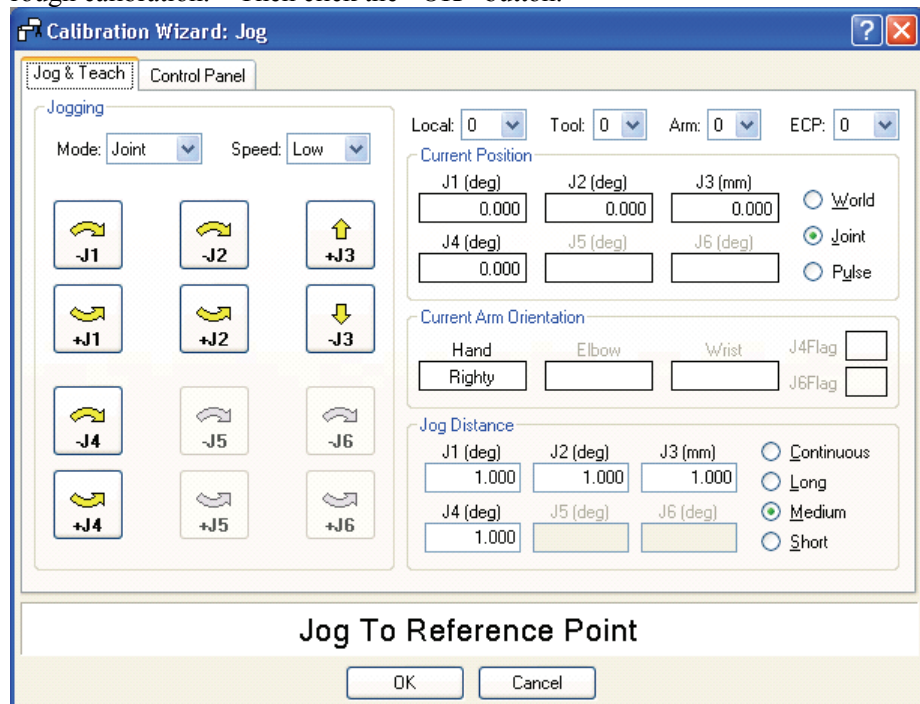
* Position Joint #2 only and move Joint #3 to around 0 pulse.

(15) Click the <Next> button.
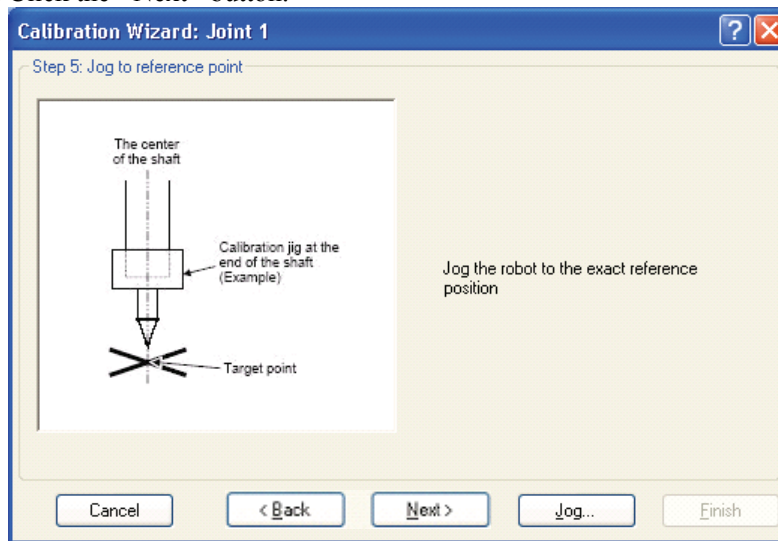
(16) Execute the procedure in "Calibration Using Right / Left Arm Orientations" to accurately calibrate Joint #2.
Go on to the step (17) for the other joints calibration.

    i. Move to another point that has different pose (from righty to lefty) using Jump command.   Click the <Yes> button.
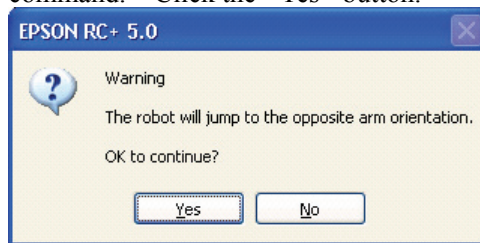
    ii. Jog to the accurate reference position.
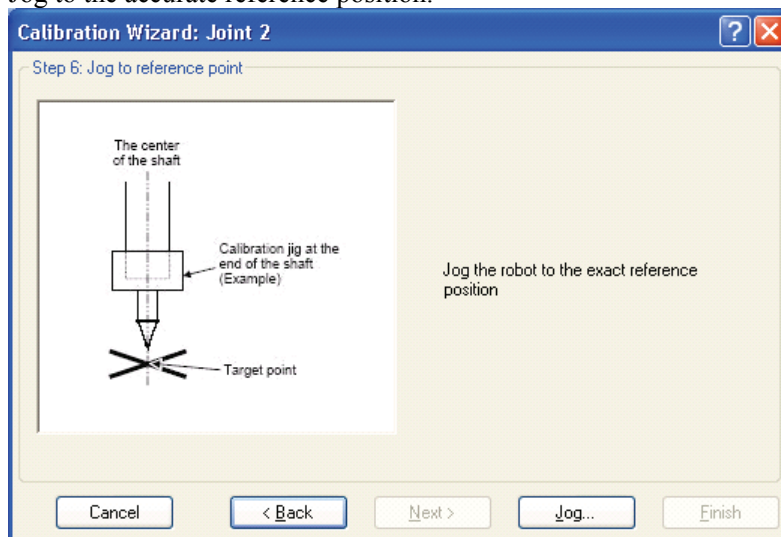
iii. Jog to the accurate reference position and adjust the position.   Click the <OK> button.
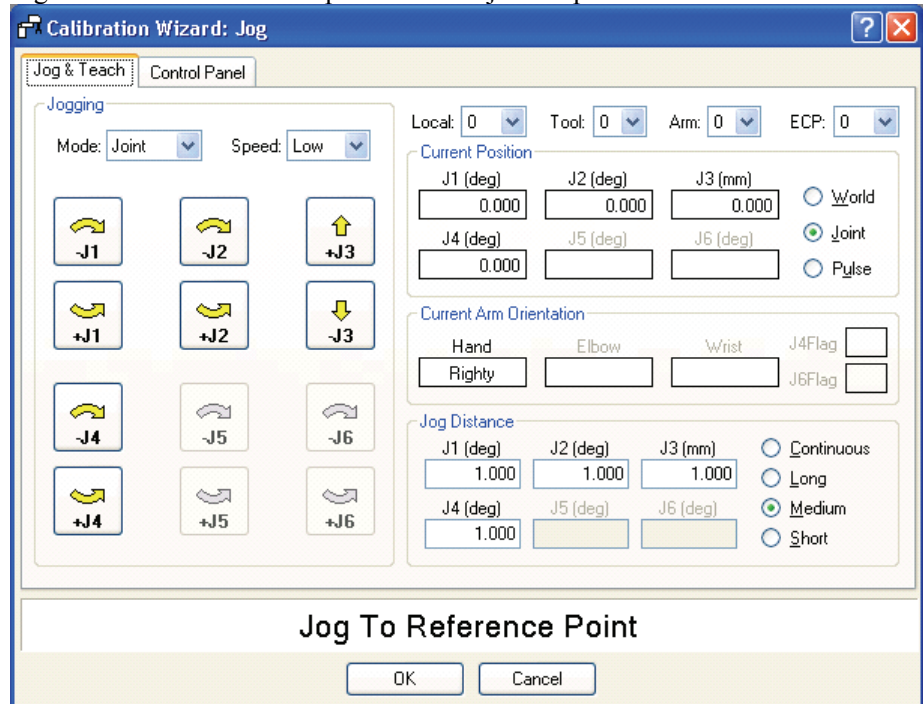
iv. Click the <Next> button.

(17) Calibration is complete.   Click the <Finish> button.

(18) Move the manipulator to other points and check if it can move without problems.
Teach points where appropriate.

13.3   Accurate Calibration of Joint #2

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.

NOTE
☞

If the accuracy of Joint #2 is not obtained through the steps in the section *13.2 Calibration Procedure*, follow the steps below "Calibration Using Right / Left Arm Orientations" to accurately calibrate Joint #2.
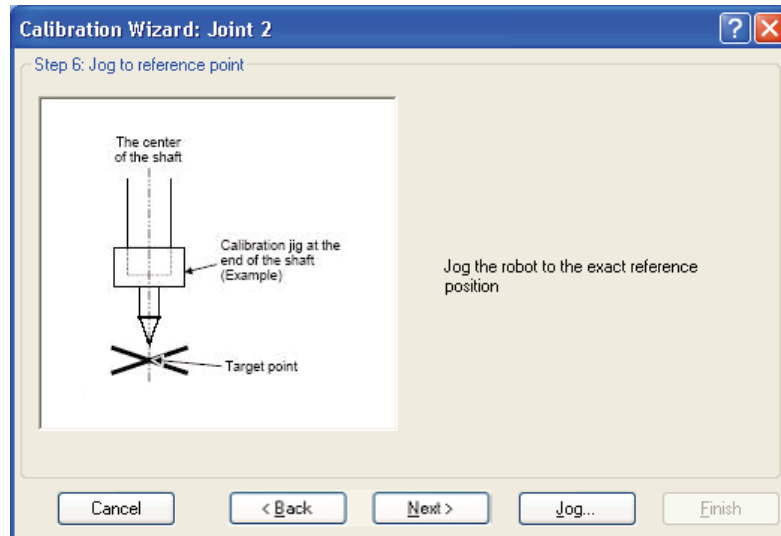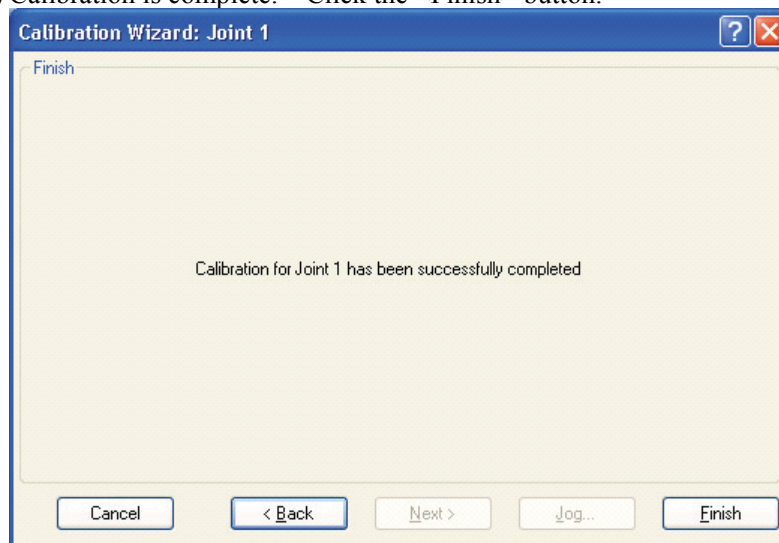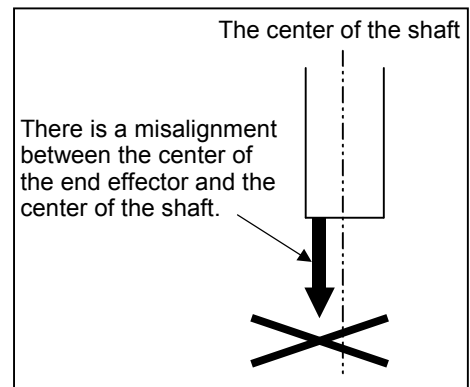
The reference point is the center of the ball screw spline shaft during this calibration.

When there is a misalignment between the center of the end effector and the center of the ball screw spline shaft, remove the end effector and execute the calibration of the shaft.

Make a calibration jig as shown in the right figure and attach it on the end of the shaft to make the center of the shaft clear.

Decide a target point and mark a cross (×) on it so that you can easily verify the center of the shaft after switching the arm pose between right and left.
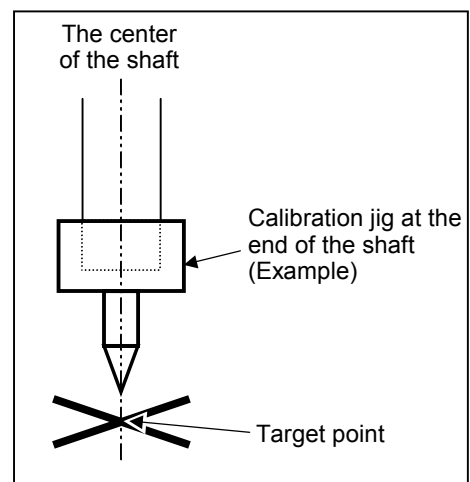
After removing the end effector and executing the calibration, install the end effector and move the Manipulator to the teaching point to verify whether there is a positional gap.   If there is a positional gap, fine-tune the installation position of the end effector and teach the point again.

Coordinates for the working point requires calculation in the following cases:

· Teaching the working point by entering the coordinate values (MDI teaching)
· Switching the arm orientation between right and left at a given point
· Using the Pallet command
· Executing CP control (such as liner or circular interpolation)
· Using the Local command
· Pose data specified with relative coordinates <Example: P1+X(100) >
· Vision Guide camera calibrations

Calibration Using Right / Left Arm Orientations

(1) Check the point data for calibration

Use a point you can easily verify the accuracy within the work envelop of both right and left arm.   Then, check the number of points you want to use.

(2) Open the Tools menu | Robot Manager | Control Panel and click the MOTOR ON.

(3) Click the <Free All> button to free all joints from servo control.   Now, you can move arms by hands.

(4) Move the arms to the position of point data for calibration in rightly arm orientation.

(5) From the current position, teach any point data number unused.
This point is now called P1.

Specify the point number "1" and click the <Teach> button in the [Jog & Teach].

(6) Click the Lock All in the [Control Panel] to lock all joints under servo control.

(7) Switch to the lefty arm orientation.   Then, move the arm to the same point.

```
>Jump P1/L:Z(0)   '  Change the arm orientation from righty to lefty
                     Z is the maximum position
```

* If there is interference on the way from right to lefty, click the Free All in the [Control Panel] and change the arm orientation to lefty by hands.   Then, go to the step (6), (7).

(8) The joints are slightly out of position.

Adjust the gap with the −Z in the Jogging group in the [Jog & Teach].   Then, teach another point data number unused.   This point is now called P2.

Specify point number "P2" and click the <Teach> button in [Jog & Teach].

(9) Input the new Hofs value.

```
>Hofs Hofs (1), Hofs (2) + (Ppls(P1,2) + Ppls(P2,2)) /
 2, Hofs(3), Hofs(4)
```

(10) From the current lefty arm orientation (the position in the step (8)), teach the point data number used in the step (8).   This point is called P2.

Specify point number "P2" and click the <Teach> button in [Jog & Teach].

(11) Switch to the righty arm orientation.   Then, make sure the manipulator move to the correct position.

```
>Jump P2/R     '  Change the arm orientation from lefty to righty
```

* If there is any interference on the way from lefty to righty, click the Free All in the [Control Panel] and change the arm orientation to righty by hands.   Then, go to the step (6), (11).

(12) Move the manipulator to other point data and make sure it moves to the correct position.   Teach some more points if required.

* Delete the two points taught for the Joint #2 calibration.

13.4   Calibration Procedure without using Calibration Wizard

NOTE
☞
This section indicates the calibration without using the calibration wizard of EPSON RC+. For details of calibration using the calibration wizard, refer to *13.2 Calibration Procedure*.

When coordinates for the Manipulator working point require calculation, it is important for Joint #2 to be calibrated accurately.   Execute the procedure in "Calibration Using Right / Left Arm Orientations" to accurately calibrate Joint #2.   For details, refer to *Maintenance: 13.3   Accurate Calibration of Joint #2*.

You cannot calibrate Joint #4 alone because of the structure of the Manipulator.   When calibrating Joint #4, you must calibrate Joint #3 and #4 at the same time.

NOTE
☞
The reference point (a point to identify the position of the manipulator) needs to be specified for calibration.

Follow steps 1 to 6 described below in order to calibrate the origin.

1.   Basic Pose Confirmation

(1)-1   After the part replacement, execute the calibration using the point data currently registered.
Confirm the point data number (P*) to reconstruct the correct manipulator position.

* Point data before the parts replacement (motor, reduction gear, belt, etc.) is necessary for the calibration.

2.   Part Replacement

(2)-1   Replace parts as dictated by this manual.
* Be careful not to injure yourself or damage parts during part replacement.
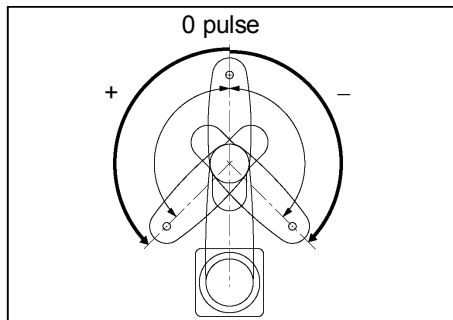
3.   Encoder Initialization

(3)-1   Turn ON the Controller when all joints are in the motion range.

(3)-2   Manually move the joint that needs origin alignment to its approximate 0 pulse position.
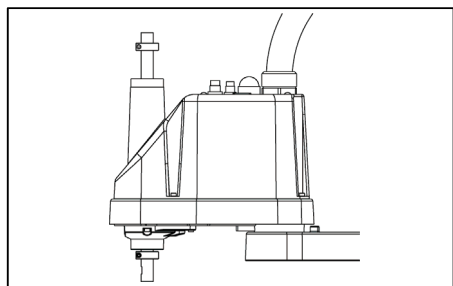
0 pulse position of Joint #1:
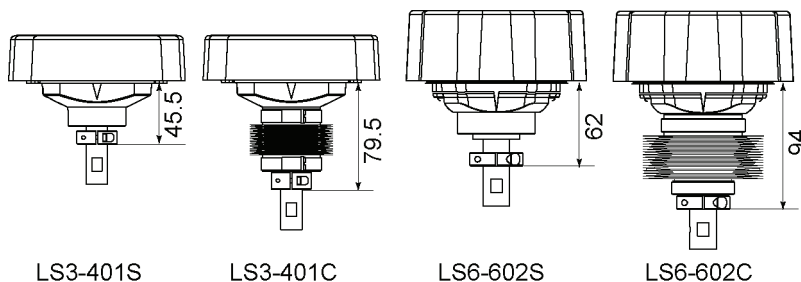position aligned with X-axis in Robot coordinate system
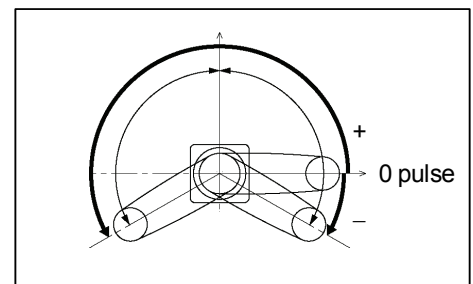
0 pulse position of Joint #2:
 position where Arms #1 and #2 are in a straight line (Regardless of the Joint #1 direction.)
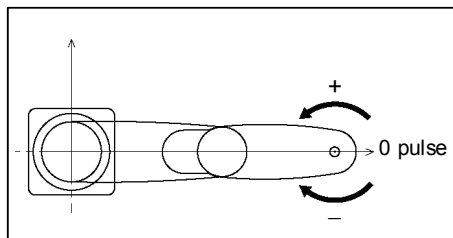

0 pulse position of Joint #3:
 upper limit position in motion range

The height of Joint #3 depends on manipulator model.

| LS3-401S | LS3-401C | LS6-602S | LS6-602C |

0 pulse position of Joint #4:
 position where the flat surface (or groove in the up/down mechanical stop) on the shaft faces toward the tip of Arm #2

Groove

Flat surface
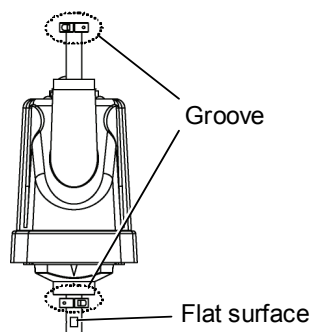
(3)-3   Connect EPSON RC+ to the Controller.

Select a robot to be calibrated.   Input as below in the [Command Window] and execute it.
(This example uses "robot 1".)

```
> robot 1
```

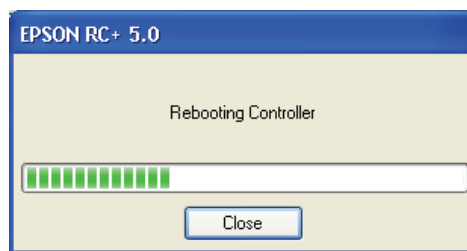(3)-4   Execute the absolute encoder initialization command.

Input one of the following commands to [Command Window] according to the joint being calibrated.

Joint #1: `>EncReset 1`
Joint #2: `>EncReset 2`
Joint #3: `>EncReset 3`
Joint #4: `>EncReset 3, 4`

(3)-5   Reboot the Controller.

Select EPSON RC+ menu-[Tools]-[Controller] and click the <Reset Controller> button.

* This window will be disappeared when the Controller starts up.

4.   Rough Calibration

(4)-1   Turn ON the motor from EPSON RC+ menu-[Tools]-[Robot Manager]-[Controller Panel].

(4)-2   Click the <Free All> button in the [Control Panel] page to free all joints and move the arms manually.

(4)-3   Move the Manipulator to the approximate position and orientation.

(4)-4   To execute temporary calibration, input the pulse value of the specified point data.
When the specified point data is "P1," input and execute the following command to [Command Window] according to the joint being calibrated.

`> Calpls Ppls(P1,1), Ppls(P1,2), Ppls(P1,3), Ppls(P1,4)`

(4)-5   Execute the temporary calibration.

Input and execute one of the following commands to [Command Window] according to the joint being calibrated.

Joint #1: `>Calib 1`
Joint #2: `>Calib 2`
Joint #3:: `>Calib 3`
Joint #4: `>Calib 3, 4`

5. Calibration (Accurate Positioning)

(5)-1 Click the <Lock All> button in [Control Panel] to put all joints back under servo control.

(5)-2 Move the joint to the specified point using a motion command.

For example, when the specified point data is "P1", click <MOTOR ON> button in [Control Panel] and execute "Jump P1:Z(0)" from [Jog & Teach].

* The joint NOT being calibrated moves to the original position.

(5)-3 Accurately align the joint* being calibrated to the specified point using jog commands.

* You must move Joint #3 and #4 to the position when calibrating Joint #4.

Select the jog mode [Joint] from [Jog & Teach] to execute the jog motion.

(5)-4 Execute the calibration.

Input and execute one of the following commands to [Command Window] according to the joint being calibrated.

```
Joint #1: >Calib 1
Joint #2: >Calib 2
Joint #3: >Calib 3
Joint #4: >Calib 3, 4
```

6. Accuracy Testing

(6)-1 Move the Manipulator to another point to confirm that it moves to the same position.
If it does not move to the same position, re-calibrate using another point. You must set the point again if reproducibility cannot be assured through calibration.