JANOME SCARA/GANTRY ROBOT

JS/JSR4400N/JSG Series

JANOME DESKTOP ROBOT

JR2000N Series

Operation Manual

Camera & Sensor Features

Thank you for purchasing a Janome Robot.

- **Read this manual thoroughly in order to ensure proper use of this robot. Be sure to read "For Your Safety" before you use the robot. The information will help you protect yourself and others from possible dangers during operation.**

- **After reading this manual, keep it in a handy place so that you or the operator can refer to it whenever necessary.**

- **This manual is written according to IEC 62079.**

JANOME

FOR YOUR SAFETY

Safety Precautions

The precautions in this manual are provided for the customer to make the best use of this product safely, and to provide preventive measures against injury to the customer or damage to property.

Please follow these instructions

Various symbols are used in this manual. Please read the following explanations of each symbol.

● Symbols Indicating the Degree of Potential Damage or Danger

The following symbols indicate the degree of damage or danger which may be incurred if the safety notes are ignored.

Warning	The Warning symbol indicates the possibility of death or serious injury.
Caution	The Caution symbol indicates the possibility of accidental injury or damage to property.

● Symbols Indicating the Type of Danger and Preventive Measures

The following symbols indicate the type of safety measures that should be taken.

	Indicates the safety measures that should be taken.
	Be careful. (General caution)
	Indicates a prohibition.
	Never do this. (General prohibition)
	Do not disassemble, modify or repair.
	Do not touch.
	Indicates a necessity.
	Be sure to follow instructions.
	Be sure to unplug power cord from wall outlet.
	Be sure to check grounding.

FOR YOUR SAFETY

JR2000N Series

⚠ Warning

Do not use the unit where flammable or corrosive gas is present.
Leaked gas accumulated around the unit can cause fire or explosion.

Use the robot in a condensation-free environment between 0 and 40 degrees centigrade with a humidity level of 20 to 95 percent.
Failure to do so may result in malfunction.
IP Protection Rating: IP30 (IP40 for CE specification models)

Use the robot in an electric noise-free environment.
Failure to do so may result in malfunction or breakdown.

Use the robot in an indoor environment where it is not exposed to direct sunlight.
Direct sunlight may cause malfunction or breakdown.

Install the robot in a place which can endure its weight and conditions while running.
Placing the unit in an insufficient or unstable surface may cause the unit to fall or overturn, thereby causing damage or injury.
Leave a space of at least 30cm between the back of the robot (the side with a cooling fan) and the wall. Insufficient space can lead to overheating or fire.

Be sure to use within the voltage range indicated on the unit.
Failure to do so may cause electric shock or fire.

If your robot has the I/O-S circuit, be sure to install a safeguard such as an area sensor when installing the robot.
Without a safeguard, going near the robot while it is operating may cause injury.

Plug the power cord into the wall outlet firmly.
Failure to do so can cause the plug to heat up and may result in fire.

FOR YOUR SAFETY

JR2000N Series

⚠ Warning

Wipe the power plug with a clean, dry cloth periodically to eliminate dust.
Dust accumulation can undermine the electrical insulation and cause fire.

Ensure that the robot is properly grounded before use. Do not use without grounding.
Insufficient grounding can cause electric shock and/or fire.

Be sure to use within the voltage range indicated on the unit.
Failure to do so may cause fire or unit malfunction.

Keep water and oil away from the robot and power cable.
Contact with water or oil can cause electric shock, fire, or unit malfunction.
IP Protection Rating: IP30 (IP40 for CE specification models)

If tools have been attached (such as the electric screwdriver), make sure they are properly connected.
Failure to do so may result in injury or breakdown.

During prolonged use, be sure to regularly check that the mounting screws are sufficiently tightened.
Loose screws may cause injury or breakdown.

Be sure to check the wiring to the main unit.
Improper wiring may result in malfunction or breakdown.

Be sure to secure the movable parts of the robot before transportation.
Failure to do so may result in injury or breakdown.

FOR YOUR SAFETY

JR2000N Series

⚠ Warning

Do not bump or jar the unit while it is being transported or installed.
Doing so can cause breakdown.

Be sure to check that no danger is around the operator before starting the robot.
Careful attention will protect the operator from injury.

Do not attempt to disassemble or modify the unit.
Disassembly or modification may cause electric shock or malfunction.

Be sure to unplug the power cord from the wall outlet when examining or lubricating the machine.
Failure to do so may cause electric shock or injury.

If anything unusual (e.g. a burning smell or an unusual sound) occurs, stop operation and unplug the cable immediately. Contact the dealer from whom you purchased the robot or the office listed on the last page of this manual.
Continuous use without repair can cause electric shock, fire, or unit breakdown.

Do not leave the unit plugged in (power cord and connectors) when it is not in use for long periods of time. Accumulated dust can cause fire.
Be sure to shut off the power supply before removing the power cord.

Be sure to turn off the robot before inserting and removing all cables.
Failure to do so may result in electric shock, fire, data loss or unit malfunction.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

FOR YOUR SAFETY

JR2000N Series

⚠ Warning

Regularly check that the emergency stop switch works properly.
For models with I/O-S circuits, also check that they work properly.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

FOR YOUR SAFETY

JSR4400N Series

⚠ Warning

Do not leave the unit plugged in (power cable and connectors) when it is not in use for long periods of time. Accumulated dust can cause fire.
Be sure to shut off the power supply before removing the power cable.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

Regularly check that the emergency stop switch works properly.
For models with I/O-S circuits, also check that they work properly.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

During prolonged use, check the mounting screws etc, regularly and ensure that they are firmly tightened.
Loose screws may cause injury or breakdown.

Be sure to use within the voltage range indicated on the unit.
Failure to do so may cause fire or unit malfunction.

Keep water and oil away from the robot and power cable.
Contact with water or oil can cause electric shock, fire, or unit malfunction.
IP Protection Rating: IP20

Wipe the power plug with a clean, dry cloth periodically to eliminate dust.
Dust accumulation can undermine the electrical insulation and cause fire.

FOR YOUR SAFETY

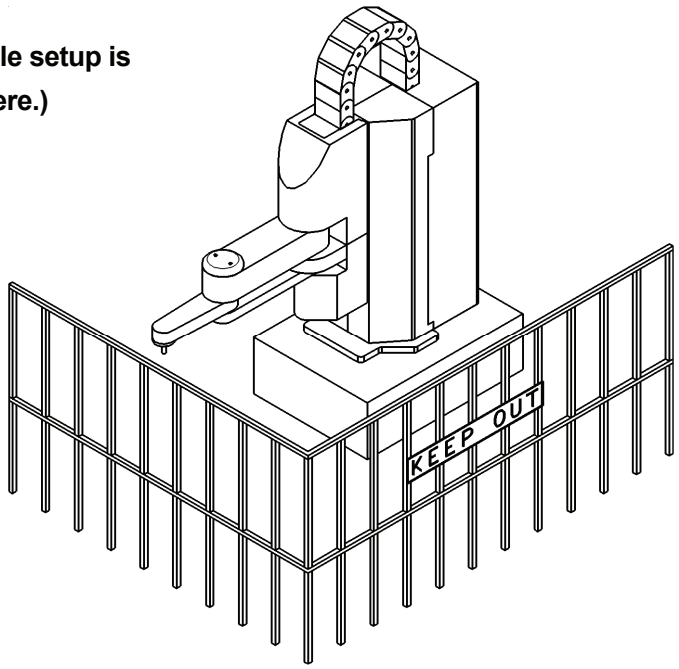
JSR4400N Series

INSTALLATION

⚠ Warning

Always set up a safety barrier.
Anyone entering the operating range of the robot may be injured.
Set up an emergency stop interlock system that is triggered when the entrance to the safety barrier is opened.
Use the I/O-S connector included in the package. Ensure there is no other way of entering the restricted area.
Furthermore, **put up a "No Entry" or "No Operating" warning sign** in a clearly visible place.

(An example setup is pictured here.)



Make sure the safety barrier is strong enough to protect the operator from flying debris caused during robot operation.
Always wear protective gear (helmet, protective gloves, protective glasses, and protective footwear) when going inside the safety barrier.

If the object the robot is holding is in danger of flying off or falling, make sure **safety precautions adequate for the object's size, weight, temperature and chemical composition have been taken.**

FOR YOUR SAFETY

JSR4400N Series

INSTALLATION

⚠ Warning

Be sure to check grounding before using the unit.
Improper grounding can cause electric shock, fire, unit malfunction, or breakdown.

Install the robot in a place which can endure its weight and conditions while running.
Placing the unit in an insufficient or unstable surface may cause the unit to fall or overturn, and may cause injury or damage.

There is an air intake vent on the lower back of the robot (18mm above the ground). Do not block this vent, or overheating or fire may result.

Do not use the unit in the presence of flammable or corrosive gas.
Leaked gas accumulated around the unit can cause fire or explosion.

For the health and safety of the operator, place the unit in a well-ventilated area.

Use the robot in a condensation-free environment between 0 and 40 degrees centigrade with a humidity level of 20 to 90 percent.
Failure to do so may result in malfunction.
IP Protection Rating: IP20

Use the robot in an electric noise-free environment.
Failure to do so may result in malfunction or breakdown.

Use the robot in an indoor environment where it is not exposed to direct sunlight.
Direct sunlight may cause malfunction or breakdown.

Be sure to use within the voltage range indicated on the unit.
Failure to do so may cause electric shock or fire.

FOR YOUR SAFETY

JSR4400N Series

INSTALLATION

⚠ Warning

Do not attempt to disassemble or modify the unit.
Disassembly or modification may cause electric shock or malfunction.

Be sure to secure the movable parts of the robot before transportation.
Failure to do so may result in injury or breakdown.

Do not bump or jar the unit while it is being transported or installed.
Doing so can cause breakdown.

Be sure to confirm that all the air tubes are connected correctly and firmly.

If tools have been attached (such as the electric screwdriver), make sure they are properly connected.
Failure to do so may result in injury or breakdown.

Be sure to check the wiring to the main unit.
Improper wiring may result in malfunction or breakdown.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

Turn off the unit before inserting and removing cables.
Failure to do so may result in electric shock, fire, or unit malfunction.

Be sure to turn off the robot before plugging it in.

FOR YOUR SAFETY

JSR4400N Series

INSTALLATION

⚠Warning

Plug the power cable firmly into the wall outlet.
Incomplete insertion into the wall outlet causes the plug to heat up and may result in fire. Be sure to turn off the robot before connecting the power cable.

Place the operation box on a flat surface more than 80cm above the floor so that it is easy to operate.

Use the unit in an environment that is not dusty or damp.
Dust or dampness may lead to breakdown or malfunction.
IP Protection Rating: IP20

FOR YOUR SAFETY

JSR4400N Series

DURING OPERATION

⚠ Warning

When lubricating or inspecting the unit, unplug the power cable from the robot.
Failure to do so may result in electric shock or injury.
Be sure to shut off the power supply before removing the power cable from the robot.

Put up a **"Do Not Operate"** sign on the start switch when people are entering the safety barrier.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

Make sure the safety barrier is strong enough to protect the operator from flying debris caused during robot operation.
Always wear protective gear (helmet, protective gloves, protective glasses, and protective footwear) when going inside the safety barrier.

Make sure all the air tubes are connected correctly and firmly.

Always be aware of the robot's movement, even in the Teaching mode.
Careful attention will protect the operator from injury.

FOR YOUR SAFETY

JSR4400N Series
DURING OPERATION

⚠ Warning

When entering the safety barrier, **do not enter the operating range of the robot.**

If you must go inside the safety barrier, make sure you **push the emergency stop switch** and **put a "Do Not Operate" sign** on the start switch.

When activating the robot, check that **no one is inside the safety barrier and that no object will interfere with the robot's operation.**

Under no circumstances should you go inside the safety barrier or place your hands or head inside the safety barrier while the robot is operating.

If anything unusual (e.g. a burning smell or an unusual sound) occurs, stop operation and turn off the robot. Contact the dealer from whom you purchased the robot or the office listed on the last page of this manual.
Continuous use without repair can cause electric shock, fire, or breakdown of the unit.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

FOR YOUR SAFETY

JS Series and JSG Series

⚠ Warning

When not in use for extended periods of time, unplug the power cable from the power source. Accumulated dust leads to fires.
When unplugging the cord, make sure the power is off.

Change the robot battery periodically (approximately every three years) to prevent unit malfunction or breakdown.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since the robot may not be able to be stopped immediately and safely.

Regularly check that the I/O-S circuits and emergency stop switch work properly.
Failure to do so is dangerous since the robot may not be able to be stopped immediately and safely.

FOR YOUR SAFETY

JS Series and JSG Series

⚠ Warning

During prolonged use, check the mounting screws etc, regularly and ensure that they are firmly tightened.
Loose screws may cause injury or breakdown.

Power the unit only with the rated voltage.
Excessive voltage can cause fire or unit malfunction.

Keep water or oil away from the robot, control box and power cable.
Contact with water or oil can cause electric shock, fire, or unit malfunction.
IP Protection Rating: IP40

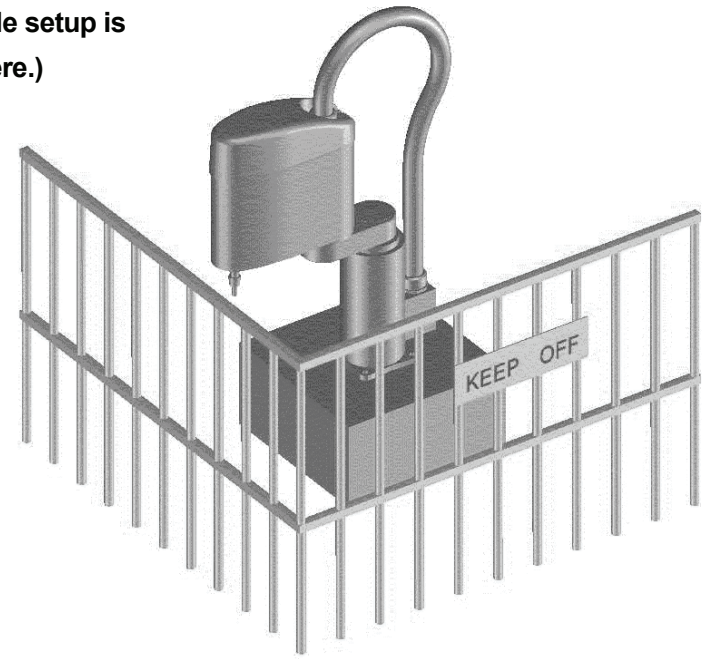
FOR YOUR SAFETY

JS Series and JSG Series
INSTALLATION

⚠ Warning

Always set up a safety barrier.
Anyone entering the operating range of the robot may be injured.
Set up an emergency stop interlock system that is triggered when the entrance to the safety barrier is opened.
Use the I/O-S connector included in the package. Ensure there is no other way of entering the restricted area.
Furthermore, **put up a "No Entry" or "No Operating" warning sign** in a clearly visible place.

(An example setup is pictured here.)



Make sure the safety barrier is strong enough to protect the operator from flying debris caused during robot operation.
Always wear protective gear (helmet, protective gloves, protective glasses, and protective footwear) when going inside the safety barrier.

If the object the robot is holding is in danger of flying off or falling, make sure **safety precautions adequate for the object's size, weight, temperature and chemical composition have been taken.**

FOR YOUR SAFETY

JS Series and JSG Series
INSTALLATION

⚠ Warning

Be sure to check grounding before you use the unit.
Improper grounding can cause electric shock, fire, unit malfunction, or breakdown.

Plug the power cable firmly into the wall outlet and check for dust.
Incomplete insertion into the wall outlet causes the plug to heat up and may result in fire.
Be sure to shut off the power supply before connecting the power cable.

Install the robot in a place which can endure its weight and conditions while running.
Placing the unit on an insufficient or unstable surface may cause the unit to fall or overturn, thereby causing damage or injury.
Be sure to leave a space of at least 30cm between the back of the robot (the side with a cooling fan) and the wall. Insufficient space can lead to overheating or fire.

Do not attempt to disassemble or modify the unit.
Disassembly or modification may cause electric shock or malfunction.

Be sure to use within the voltage range indicated on the unit.
Failure to do so may cause electric shock or fire.

Do not use the unit where flammable or corrosive gas is present.
Leaked gas accumulated around the unit can cause fire or explosion.

For the health and safety of the operator, place the unit in a well-ventilated area.

Turn off the unit before inserting and removing cables.
Failure to do so may result in electric shock, fire, or unit malfunction.

FOR YOUR SAFETY

JS Series and JSG Series

INSTALLATION

⚠ Warning

Be sure to confirm that all the air tubes are connected correctly and firmly.

Use the robot in a condensation-free environment between 0 and 40 degrees centigrade with a humidity level of 20 to 90 percent.
Failure to do so may result in malfunction.
IP Protection Rating: IP40

Use the robot in an electric noise-free environment.
Failure to do so may result in malfunction or breakdown.

Be sure to secure the movable parts of the robot before transportation.
Failure to do so may result in injury or breakdown.

Do not bump or jar the unit while it is being transported or installed.
Doing so can cause breakdown.

Use the robot in an indoor environment where it is not exposed to direct sunlight.
Direct sunlight may cause malfunction or breakdown.

If tools have been attached (such as the electric screwdriver unit), make sure they are properly connected.
Failure to do so may result in injury or breakdown.

Check the wiring to the main unit.
Improper wiring may result in malfunction or breakdown.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

FOR YOUR SAFETY

JS Series and JSG Series

INSTALLATION

⚠ Warning

Be sure to turn off both the robot and the power source before plugging in the power cable.

Be sure to remove the eyebolt after installing the robot.
If it is not removed, the Arm may collide with it, thereby causing damage or injury.

Place the control box on a flat surface more than 80 cm above the floor so that it is easy to operate.

Use the unit in an environment that is not dusty or damp.
Dust or dampness may lead to breakdown or malfunction.
IP Protection Rating: IP40

Use the Clean Room type model in an environment of Clean Class 10* or less.
*: Federal Standard 209D (FED-STD209D)

FOR YOUR SAFETY

JS Series and JSG Series

DURING OPERATION

⚠ Warning

When lubricating or inspecting the unit, unplug the power cable from the robot.
Failure to do so may result in electric shock or injury.
Be sure to shut off the power supply before removing the power cable from the robot.

Put **a "Do Not Operate" sign** on the start switch when people are entering the safety barrier.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

Make sure the safety barrier is strong enough to protect the operator from flying debris caused during robot operation.
Always wear protective gear (helmet, protective gloves, protective glasses, and protective footwear) when going inside the safety barrier.

Make sure all the air tubes are connected correctly and firmly.

Always be aware of the robot's movement, even in the Teaching mode.
Careful attention will protect the operator from injury.

FOR YOUR SAFETY

JS Series and JSG Series
DURING OPERATION

⚠ Warning

When entering the safety barrier, **do not enter the operating range of the robot.**

If you must go inside the safety barrier, make sure you **push the emergency stop switch** and **put a "Do Not Operate" sign** on the start switch.

When starting the robot, check that **no one is within the safety barrier and that no object will interfere with the robot's operation.**

Under no circumstances should you go inside the safety barrier or place your hands or head inside the safety barrier while the robot is operating.

If anything unusual (e.g. a burning smell or an abnormal sound) occurs, stop operation and turn off the robot. Contact the dealer from whom you purchased the robot or the office listed on the last page of this manual.
Continuous use without repair can cause electric shock, fire, or breakdown of the unit.

Keep the emergency stop switch within reach of an operator while teaching or running the robot.
Failure to do so is dangerous since it may not be possible to stop the robot immediately and safely.

CAMERA & SENSOR FEATURES

Mount the camera, distance sensor, and touch sensor on the robot to activate the following features:

- **Workpiece Position Detection**
  Often, when multiple workpieces are carried on a conveyor belt, the workpieces are not aligned with each other. In such a case, the camera, distance sensor, and touch sensors connected to the robot will locate the position of the workpiece and calculate the deviation from the standard position.

- **Reading the Workpiece Position**
  When multiple workpieces are placed randomly, the robot reads the workpiece positions with the camera in order to carry out the job at each position.

- This operation manual explains how to operate a robot equipped with a camera, distance sensor, and analog controller as indicated below. Please also refer to the manufacturers' instruction manuals together with this manual:

  Camera: Micro-Image Checker A210/A110, manufactured by Matsushita Electric Works, Ltd.
  Distance Sensor: D5VA series, manufactured by OMRON Corporation
  Analog Controller: RD50R, manufactured by KEYENCE Corporation

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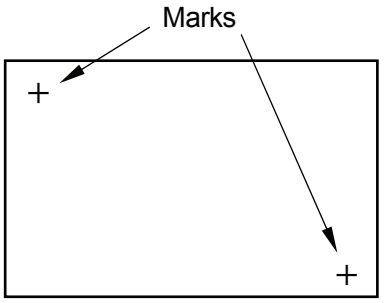
XY ADJUSTMENT WITH CAMERA

By photographing the marks (images) on the workpiece with the camera, any positional errors of the workpiece can be identified. The size of the mark is not important as long as it fits into the camera search area. However, the camera can only identify one kind of mark (marks with the same shape) at a time. If you need to photograph multiple marks, be sure to use marks of the same shape. Different marks, such as [Δ] and [x], cannot be identified at the same time. The adjustment procedure will be explained with reference to the workpiece example shown on the right.

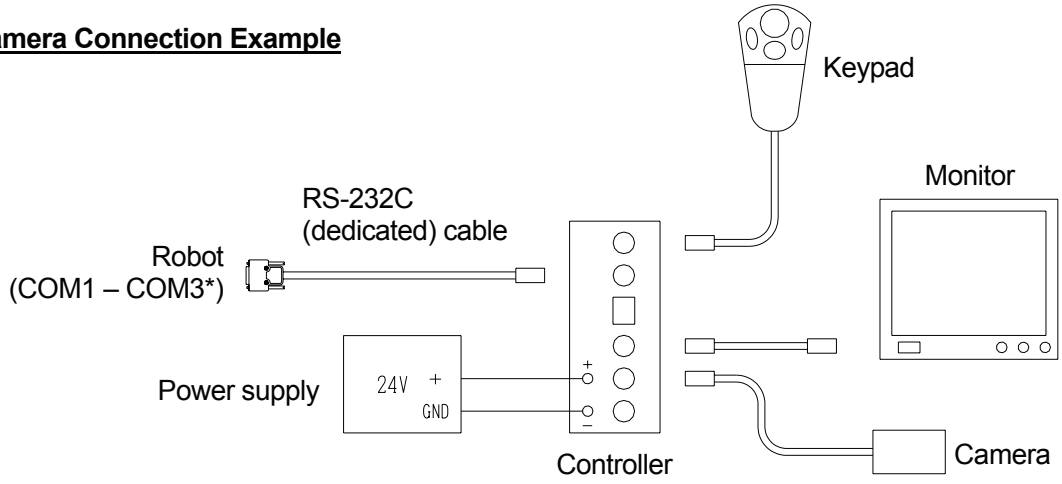


Connection

Connect the camera, monitor, and keypad to the controller. Connect the controller to COM1, COM2 or COM3 on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series) with an RS-232C (dedicated) cable.

- Please also refer to the camera instruction manual (Micro-Image Checker A210/A110) for details on the connection procedure.

Camera Connection Example



Be sure to turn the power off before making any connections.

*: If COM1 is connected to a PC, connect the controller to COM2 or COM3. If you are using the TPU (teaching pendant connector) instead of the COM ports, use an RS-422 (dedicated) cable.

■ **Operation Procedures**

Connect the camera, controller, monitor, keypad, power supply, and the robot, referring to the example on the previous page. Set the workpiece to the position where the job is to be carried out, and then create a new program following the procedures below.

1. New program
2. Tool data setting
3. Work home position
4. Point position
5. [Workpiece Adjustment Settings]
6. Communication settings
7. Smart Matching Checker settings (preparation for calibration)
8. [Calibration] settings
9. [Get Standard Data]
10. [Execute Parameter Setting]

Steps 5 – 10: Creation process for the additional function data item [Workpiece Adjustment]

11. Setting [Workpiece Adjustment] to the job point
12. Creating and setting point job data including camera-related commands
13. Preparing and setting point job data

- Step 7 is a camera setting. The other steps are robot settings.

1. New Program

Open a new program.

2. Tool Data Setting

Set [Tool Data] from [Program Data Settings].

- **Tool Weight**

  If the camera is mounted on the robot Axis, **set the combined total weight of the tools and the camera as the [Tool Weight].**

- **TCP-X, TCP-Y**

  If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

3. Work Home Position

Select [Work Home] from [Program Data Settings] and enter the work home position (coordinates).

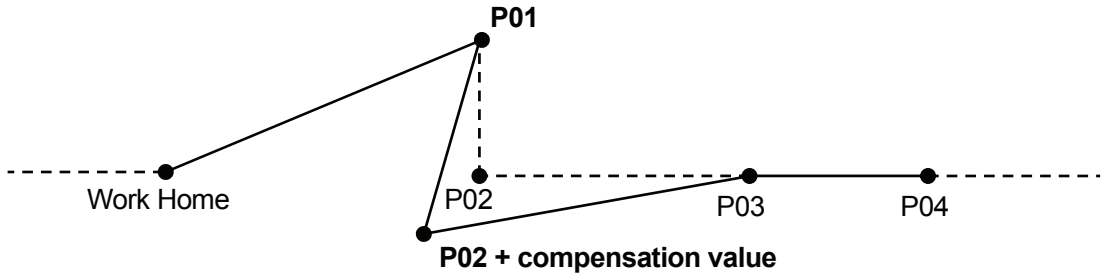
4. Point Position

Register the camera data point (P01) and the point where the point job will be carried out on the workpiece (P02).

If the camera is not attached to the robot Axis and the camera position is fixed, it is not necessary to set a particular camera data point. The camera data point (P01) can be any point which point job data can be set to, as long as it is before the job point for the workpiece (the point which [Workpiece Adjustment] has been set to). The camera data point can also be a previously registered job point.

Camera Data Point: P01

This is the point which the point job data, including the commands to get the camera data ([Camera, Z Adjustment] category), is set to. At this point, the robot photographs the camera image, and then calculates the difference between the standard coordinates and the current workpiece position. Set the camera data point to a point before the job point for the workpiece (to get the camera image).



Job Point for the Workpiece: P02 + compensation value

This is the point where a job, such as screw tightening or dispensing, is performed on the workpiece. Set the additional function data item [Workpiece Adjustment] to this point. After [Workpiece Adjustment] is set, the robot will adjust the registered coordinates (P02 in the illustration above) according to the difference calculated at the camera data point, and then start running.

5. [Workpiece Adjustment Settings]

Select [Workpiece Adjustment Settings] from the [Additional Function Data Settings] menu.
Enter a new [Workpiece Adjustment] number and then select [Camera A210/A110 Adjustment] as the workpiece adjustment type. ([Camera A210/A110 Adjustment]: A type of [Workpiece Adjustment]. Select either [Numeric Adjustment] or [Camera A210/A110 Adjustment].)
The following items will be displayed:

[Camera A210/A110 Adjustment] Menu

- [Camera COM Port]: The COM connector on the robot (or the control box) side; connected to the camera
- [Calibration]: Converts the camera coordinates into robot coordinates.
- [Standard Data Setting]: Records the standard data. During operation, the compensation value is calculated using the loaded standard data.
- [Execute Parameter Setting]: Designates the motion at the time when the workpiece adjustment is carried out.
- [Display Adjustment]: Displays the workpiece adjustment amount calculated by performing [Test Run] or [Point Run].
- [Z-Adjustment]: The distance sensor settings when using the camera together with the distance sensor (or the touch sensor) to adjust the workpiece position error in the X-, Y-, and Z-directions

6. Communication Settings

Select [Camera COM Port] from the [Camera A210/A110 Adjustment] menu. Select the COM Port connected to the camera on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series).

7. Smart Matching Checker Settings (Preparation for Calibration)

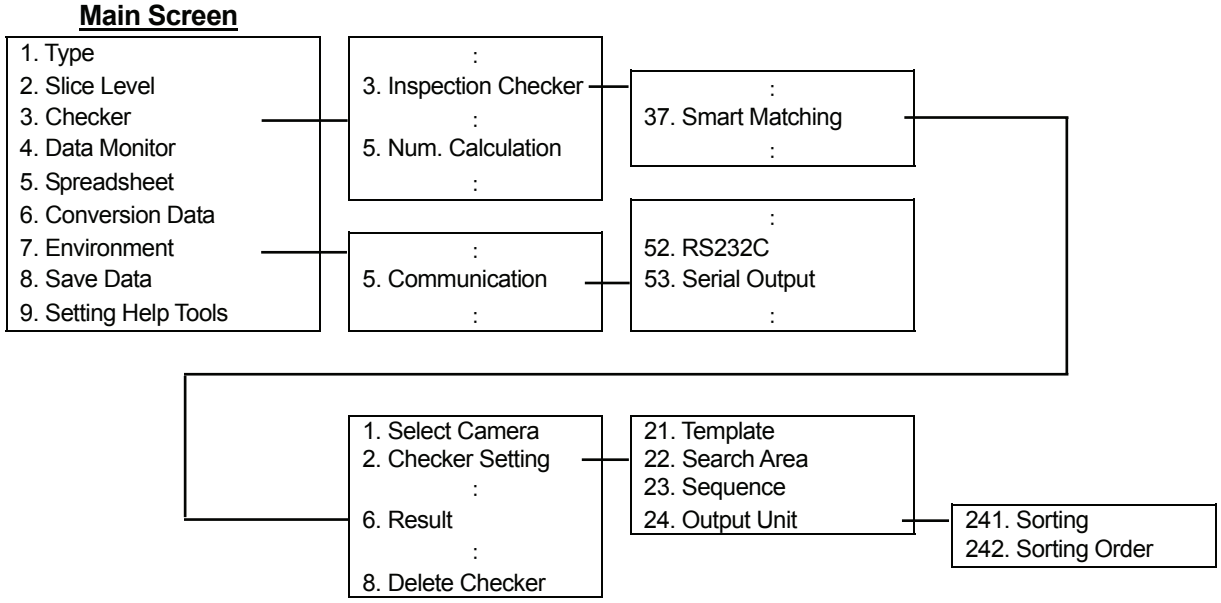
Before the camera is used, the calibration settings (conversion from the camera coordinates into robot coordinates) should be completed. First, load the mark (image) on the workpiece, then compare it with the robot coordinates and calculate the difference between them. The mark to be loaded is referred to as a ***calibration mark*** in this manual.

In the workpiece example on Page 1, the mark indicating the position of the workpiece during operation is also used as the *calibration mark*. A different type of mark can be used as the calibration mark as long as the marks fit into the same camera search area.

Shift the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates .

Turn on the camera and check that the workpiece is displayed on the monitor screen.

To manipulate the camera, press the [ENTER] key (on the keypad) to select (fix) an item, and the [C] key to cancel (return).



7.1 Type Data Number

Select [1. Type] from the main screen and then select a number.

7.2 Communication

Return to the main screen, and then select [Environment] to display the Environment menu.

Select [Communication] from the menu and match the serial settings ([RS232C]) with those for one of COM1 – COM3 (the terminal connected to the camera) on the robot.

Serial Settings (Camera)	COM1 – COM3 (Robot)	COM1 – COM3 (Robot) Default
Transmission Speed (bps)	Baud Rate	9600
Bit Length	Character Length	8bit
Stop Bit	Stop Bit	2bit
Parity	Parity	–
Flow Control	–	–

7.3 Output Settings

Select [Communication] from the Environment menu and then select [Serial Output]. Set [Numerical Calculation] to [Output].

7.4 Preparation for Calibration (Camera)

Return to the main screen. Select [Checker] and then select [Inspection Checker].

7.4.1 Select [Smart Matching] and then select a number.
If old data is stored under the number, select [Delete Checker] to delete the old data.

7.4.2 Select [Checker Setting] and press the [A] key on the keypad to record the image.

7.4.3 Select [Template] and enclose one of the standard marks with the mouse cursor using the cursor lever on the keypad. The smaller the enclosed area, the shorter the detection time.

7.4.4 Select [Search Area] and set a search area large enough to cover the area in which a workpiece position error may occur.

7.4.5 Select [Sequence] and set [Judgment] according to the level of detail required in the search. (The default setting is a detailed search.)

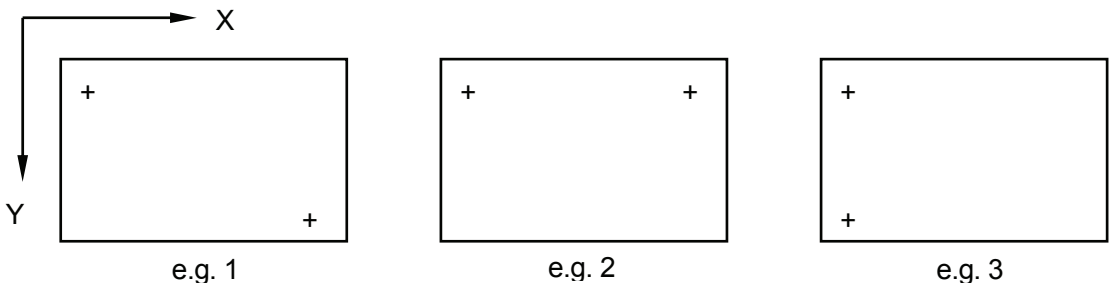
		Judgment		Result	
Step	Accuracy	Quantity	Correlation	Quantity	Correlation
1ST	16	16	0.60	0	0.00
2ND	8	8	0.60	0	0.00
3RD	4	4	0.60	0	0.00
4TH	2	2	0.60	0	0.00
5TH	S	2	0.60	0	0.00
Rotation		Angle	30deg	Accuracy	1deg

- Depending on the size of the template, the first step accuracy may be changed from [16] to [8] or [4].
- Enter the quantity of marks that you wish to have judged in the last step [S]. In the workpiece example shown below, there are two marks [+] to be judged, therefore, the quantity [2] should be entered for this step [S].

7.4.6 Select [Output Unit]. Set [Sorting] to [X] or [Y] (coordinate), and [Sorting Order] to [Des] (descending order). The marks detected are referred to as *C1* and *C2* respectively in the order they are set. If there are three or more marks, they are referred to as *C3*, *C4*, and so on. These marks are used as calibration marks. Be sure to identify which mark is C1, C2 etc.

Set [Sorting] referring to the examples below:

Example 1: Both the X- and Y- coordinates are possible.
Example 2: X-coordinate (if the Y-coordinate is used, it is hard to identify which mark is C1.)
Example 3: Y-coordinate (if the X-coordinate is used, it is hard to identify which mark is C1.)



7.4.7 Return to the main screen. Select [Checker] and then [Numerical Calculation].

Setting Example

	Model A210	Model A110	
CA01	SM01010	MT01010	Number of the Detected Mark
CA02	SM01012	MT01012	X-coordinate of C1
CA03	SM01013	MT01013	Y-coordinate of C1
CA04	SM01014	MT01014	Rotation angle of C1
CA05	SM01022	MT01022	X-coordinate of C2
CA06	SM01023	MT01023	Y-coordinate of C2
CA07	SM01024	MT01024	Rotation angle of C2

CA01 = SM 01 01 0
(1) (2) (3) (4)

(1) SM: Smart Matching (MT is used for Model A110.)
(2) 01: Checker Number (the number selected inParagraph 7.4.1.)
(3) 01: Object Number (02 indicates two objects.)
(4) 0: Number of detected marks, 2: X-coordinate, 3: Y-coordinate, 4: Rotation angle

The robot loads the values set here (CA01 – CA07).

7.4.8 Return to the main screen. Select [Checker], [Inspection Checker], [Smart Matching], and then [Result]. The detected mark (image) will be displayed. Check the position of the mark. If multiple marks are detected;

- Press the [B] key on the keypad to display each mark in the order of detection.
- Press the [A] key on the keypad to display all detected marks at the same time.

7.4.9 Return to the main screen. Select [Save Data], and then select [YES]. If you turn the camera off without saving the data, all the settings for the camera will return to the default.

8. [Calibration] Settings

Load the calibration mark in the camera search area ([Get Calibration Mark]), compare the position of the calibration mark with the [Robot Coordinate Position], and then calculate the difference between the camera coordinates and the robot coordinates ([Calculate and Register]).

Select [Calibration] from the [Camera A210/A110 Adjustment] menu ([Workpiece Adjustment]). The following items will be displayed.

[Calibration] Menu

- Fixed Taking Position: One of the calibration modes: Set "Fixed Taking Position" here. (Refer to "XY ADJUSTMENT WITH CAMERA, CHANGE OF TAKING POSITION" on Page15)
- Calibration Mark Number: Number of standard marks for calibration (2 – 6 marks)
- Get Calibration Mark: Record the standard data (image) for calibration. Select this parameter after setting [Calibration Mark Number].
- Robot Coordinate Position: Designate the corresponding robot point coordinates for each pair of camera coordinates.
- Looking Down/Looking Up: Direction in which the camera is facing: up, or down
- Calculate and Register: The four coefficients used to convert the camera coordinates to robot coordinates are calculated and registered. Select this parameter after setting the above four items ([Calibration Mark Number] – [Looking xx]).

  - Unit Coefficient: Displays the calculated coordinate converting amount (K).
  - Rotate Angle: Displays the calculated coordinate converting amount (ϕ).
  - X Shifting Amount: Displays the calculated coordinate converting amount (ΔX).
  - Y Shifting Amount: Displays the calculated coordinate converting amount (ΔY).

  Coordinates Algebraic Formula

  $X = K * x * \cos(\phi) - K * y * \sin(\phi) + \Delta X$
  $Y = K * x * \sin(\phi) + K * y * \cos(\phi) + \Delta Y$
  $\Theta = \theta + \phi$
  Camera coordinates (x, y, θ), Robot coordinates (X, Y, Θ)

- Calibrate Position: The tool center point at the position where the calibration mark is loaded

8.1 Calibration Mark Number

Enter [Calibration Mark Number].

In the workpiece example on Page 7, [2] is entered as the number of marks (+) to be detected.

8.2 Getting Calibration Mark

Select [Get Calibration Mark]. The robot loads the image according to the Camera Smart Matching Checker settings. (See the previous Section 7)

Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation. Do not change the camera data point coordinates or the camera setting position after the calibration is completed. If the number of marks recorded by the camera does not coincide with the [Calibration Mark Number], a [Camera Data Error] will be returned.

8.3 Robot Coordinates Position

Check the direction in which the camera is facing ([Looking Down] or [Looking Up]), and enter the [Robot Coordinate Position]. C1 and C2 are the coordinates of the marks (+) recorded by the camera in the [Get Calibration Mark] settings. Assign the C1 and C2 coordinate values to P1 and P2 as the robot coordinates.

Select [P1], line up the robot tool center point with the [C1] mark and then set the coordinates.

Accordingly, enter and set the [P] coordinates using the corresponding [C] marks.

The camera coordinate axes and the robot coordinate axes are sometimes not aligned. Be sure to confirm which mark is C1 before entering the corresponding robot coordinates.

The entered Cs and Ps are displayed according to the [Calibration Mark Number] settings.

For the camera coordinates, [T] indicates the angle of the mark.

8.4 Calculation and Registration

Select [Calculate and Register] from the [Calibration] menu. The coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. The calculated values are displayed as the following items:

- Unit Coefficient
- Rotate Angle
- X Shifting Amount
- Y Shifting Amount

The calibration settings (data conversion) are now complete.

9. [Get Standard Data]

9.1 Arm Shifting

Move the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

In the workpiece example on Page 1, the calibration mark and the mark indicating the workpiece position are the same; therefore, the Smart Matching Checker prepared in the calibration settings (Section 7) can be used. It is not necessary to set the Smart Matching Checker again.

If the shape and number of marks indicating the position of the workpiece during operation are not the same as those of the calibration mark, it will be necessary to set the Smart Matching Checker again.

9.2 Standard Data Setting

Select [Standard Data Setting] from the [Camera A210/110 Adjustment] menu.

Set the standard data required to calculate the offset amount during operation.

9.3 Standard Mark Number

Enter the number of marks on the workpiece as the [Standard Mark Number].

In the workpiece example on Page 1, [2] is entered as the number of marks (+) to be detected.

- Standard Mark Number: The number of standard marks (1 – 7) for adjustment
- Get Standard Data: Record the standard data (image). Select this parameter after setting the [Standard Mark Number].
- P1, P2…: X, Y: The robot coordinates corresponding to the loaded standard data
  T: Angle
  The Ps are displayed according to the [Standard Mark Number] settings.

9.4 Get Standard Data

Select [Get Standard Data]. The camera records the marks (image) according to the Smart Matching Checker settings. This data is used as the standard workpiece position during operation. If the number of marks recorded by the camera does not correspond to the [Standard Mark Number] settings, a [Camera Data Error] will be returned.

Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation.

9.5 Data Display

The loaded standard data will be displayed in the lines indicated as P1, P2 etc on the screen.

The standard data setting process is now complete.

10. [Execute Parameter Setting]

Select [Execute Parameter Setting] from the [Camera A210/A110 Adjustment] menu. Select the item you wish to change from the following:

- Rotation Apply to R-Axis (Rotation Not Apply to R-Axis):

  The rotation of the workpiece (T) is (is not) applied to the R-Axis.

  If the angle of the workpiece does not correspond to that of the standard data, the R-Axis rotates (does not rotate) according to the workpiece angle.
- Reset Z Adjustment (No Reset Z Adjustment):

  When you record data with the camera, the Z-Axis (height) offset, referred to as [Z Adjustment] in this manual, is reset (is not reset) to 0.

  If the point where the height is measured by the distance sensor is set ahead of the camera data point, select [No Reset Z Adjustment].
- Reset at Program Start (No Reset at Program Start):

  The workpiece adjustment amount is reset (is not reset) when the program is started.

  When you are switching between multiple programs to execute a series of jobs, select [No Reset at Program Start] if the camera data point and the workpiece adjustment point are not set in the same program.

Creation of the additional function data item [Workpiece Adjustment] (described in Sections 5 – 10) is now complete.

11. Setting [Workpiece Adjustment] to the Job Point

Set (Add) the prepared [Work Adjustment Number] to the job point where you wish to perform the workpiece adjustment.

12. Creating and Setting Point Job Data including the Camera-Related Commands

12.1 New Point Job Data

Open new point job data.

12.2 Setting [Wait Time]

To prevent blurring of the image, set a [Wait Time] before the command to receive the camera data.

In this example, set 0.5sec as the [Wait Time] and the [waitCondTime] command (command category: [if Branch, Wait Condition]).

12.3 Camera-Related (Imaging) Commands

Enter the command [cameraWadj] (command category: [Camera, Z Adjustment]) and the prepared [Work Adjustment Number].

When this command is executed, an image is recorded by the camera and the robot calculates the offset between the loaded data and the job point according to the [Workpiece Adjustment] amount that was entered.

12.4 Commands for Camera-Related Errors

If a camera-related error occurs, an incorrect offset will be applied to the coordinates of the job point.

Enter a command to specify the action to be carried out in case of camera-related errors.

By using a system flag, you can specify the point job to be executed if a camera-related error occurs.

System Flag	Error No.	Error
No. 31	No. 39	Camera Error (No response)
	No. 40	Camera Data Error

Example of Point Job Data

```
waitCondTime 0.5sec
cameraWadj 1
if
   Id #sysFlag(31)
   then
   goRPoint PTP0,2
endIf
```

Stand by for 0.5 seconds.
Record the image with the camera.

Refer to System Flag No. 31.
If #sysFlag(31)=1 (true) (if it is an error),
jump to two points ahead (the point next to the job point).

If there are no further commands to be set, the creation process for the point job data is complete.

Set the point job data number to the camera data point.

13. Preparing and Setting Point Job Data

Prepare and set the point job data you wish to perform (screw tightening or dispensing, for example) to the job point where the [Workpiece Adjustment] has been set.

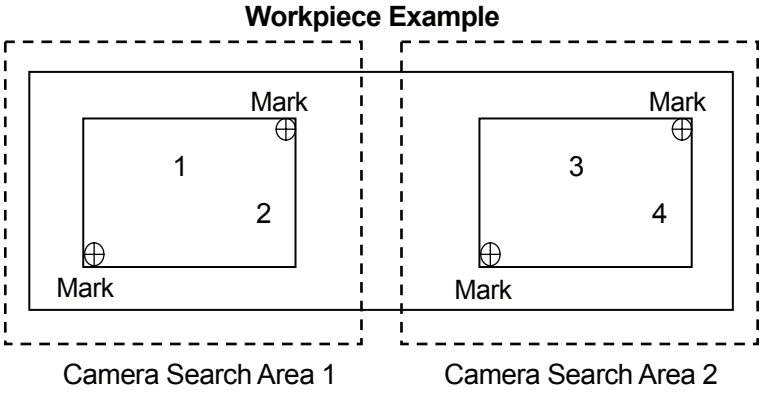
All the settings necessary for the workpiece position error adjustment (with camera) are now complete.

If you wish to adjust the workpiece position in the Z-direction, refer to “Z ADJUSTMENT WITH DISTANCE SENSOR” on Page 37 or “Z ADJUSTMENT WITH TOUCH SENSOR” on Page 45.

XY ADJUSTMENT WITH CAMERA, CHANGE OF TAKING POSITION

1: Camera Data Point 1
2: Job Point 1
3: Camera Data Point 2
4: Job Point 2

In the example shown to the right, [Workpiece Adjustment] is set to Points 2 and 4 on the workpiece in order to perform the camera adjustment (XY adjustment).

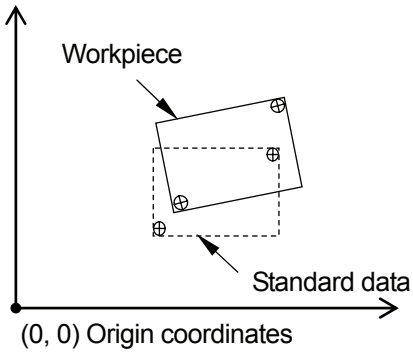


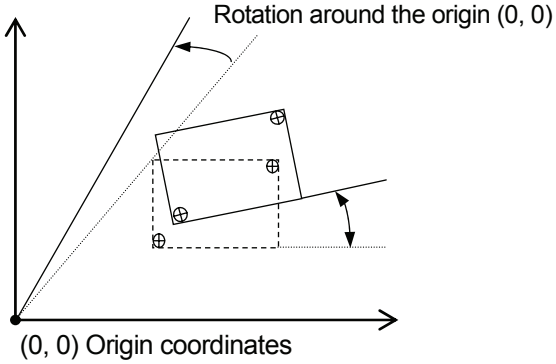
If you create a [Workpiece Adjustment] for Point 1 (Camera Data Point 1) and set it to both Points 2 and 4, the workpiece adjustment amount set to Point 4 will deviate from the correct position. This deviation is due to the method used to calculate the workpiece adjustment.

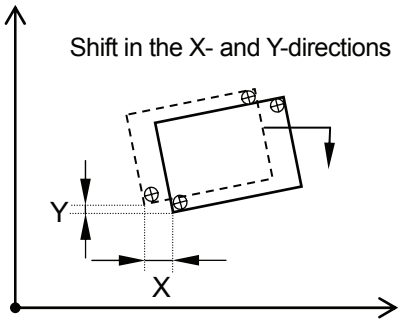
■ Normal Workpiece Adjustment

In the example shown to the right, it is necessary to match the standard data to the workpiece by rotating the standard data around the origin of the robot coordinates (0, 0) and then moving it in the X- and Y-directions (as illustrated below).

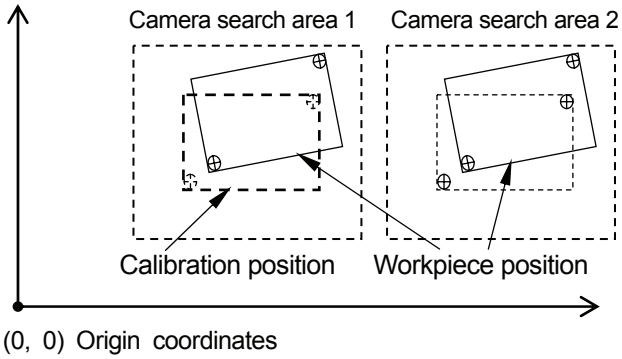
The rotation angle and the shifting distance are the [Workpiece Adjustment] amount.



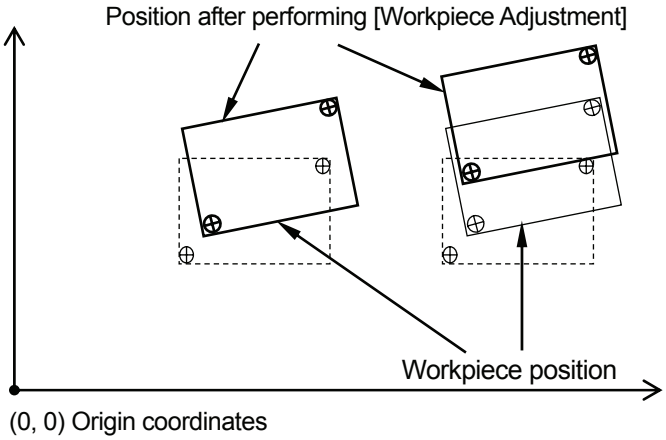




The workpiece adjustment is performed by calculating the rotation angle of the job point (Point 2 on the previous page) around the origin of the robot coordinates (0, 0). Therefore, if you set a job point (Point 4 on the previous page) other than the calibration position, the workpiece adjustment error will become greater, in accordance with the distance from the calibration position. (See illustration below)



To correctly perform the [Workpiece Adjustment] set to Point 4, create a new [Workpiece Adjustment] in accordance with Point 3 (Camera Data Point 2 on the previous page) and set it to Point 4. The [Workpiece Adjustment] settings are the same as those set to Point 1, except for [Calibration] in the [Camera A210/A110 Adjustment] menu. However, this will cause extra work if you have to set more than two job points.



In this case, change [Fixed Taking Position] to [Change of Taking Position] in the [Calibration] menu. Even if the calibration position and the camera data point are different, the robot coordinates will be calculated back, and then the coordinate conversion amount and the standard mark position will be recalculated in order to perform the [Workpiece Adjustment] on another job point.

■ **How to Set [Change of Taking Position]**

Select [Calibration] from the [Camera A210/A110 Adjustment] menu of the [Workpiece Adjustment] created for Point 1 (Camera Data Point 1).

Change the calibration mode ([Fixed Taking Position]) to [Change of Camera Position (x)] according to the position (x) where the camera is attached.

The following calibration modes are available:

Fixed Taking Position:	The camera records data at the calibration position.

Change of Taking Position (R):	The camera records data at positions other than the calibration position. Select this item if the camera is attached to the R-Axis (the camera rotates with the R-Axis).
Change of Taking Position:	The camera records data at positions other than the calibration position. Select this item if the camera is attached to the Y and Z mechanisms (the camera moves with the Y- and Z-Axes).
Change of Taking Position (Y):	The camera records data at positions other than the calibration position. Select this item if the camera is attached to the Y mechanism (the camera moves with the Y-Axis).
Change of Taking Position (J2):	The camera has recorded data at positions other than the calibration position. Select this item if the camera is attached to the J2 Arm (the camera moves with the J2 Arm).

For example, if you are using the JS or JSG Series robot and the camera is attached to the J2 Arm, rather than the R-Axis, select [Change of Camera Position (J2)].

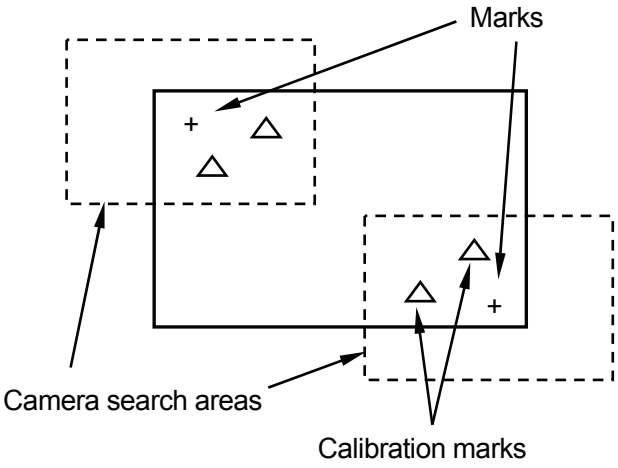
For the workpiece example on Page 15, create the [Workpiece Adjustment] settings for Point 1 and change the [Calibration] mode (select [Change of Taking Position x]), then set the settings to Point 4. The same [Workpiece Adjustment] will function correctly for both Point 2 and Point 4.

DOUBLE (XY) ADJUSTMENT WITH CAMERA

When you perform a workpiece position (XY) adjustment using the camera (see Page 1), the camera may sometimes not be able to record all the marks at one time, for example, if the workpiece is too big or the magnification of the lens on the camera is too high for the camera search area. In this case, you can take two photos.

The workpiece example shown to the right is used in this chapter.

Workpiece Example

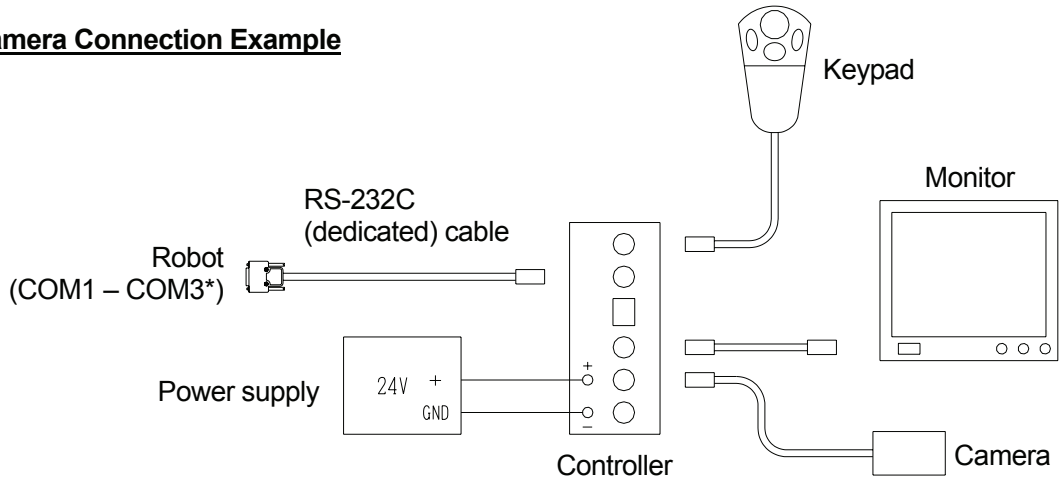


Connection

Connect the camera, monitor, and keypad to the controller. Connect the controller to COM1, COM2 or COM3 on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series) with an RS-232C (dedicated) cable.

- Please also refer to the camera instruction manual (Micro-Image Checker A210/A110) for details on the connection procedure.

Camera Connection Example



Be sure to turn the power off before making any connections.

*: If COM1 is connected to a PC, connect the controller to either COM2 or COM3. If you are using the TPU (teaching pendant connector) instead of the COM ports, use an RS-422 (dedicated) cable.

■ Operation Procedures

Ensure that the camera, controller, monitor, keypad, power supply, and the robot are properly connected, referring to the example on the previous page. Set the workpieces (2 or 3 per camera search area) at the position where the job is to be carried out, and then create a new program following the procedures below.

1. New program
2. Tool data setting
3. Work home position
4. Point position
5. First [Workpiece Adjustment Settings]
6. Communication settings
7. Smart Matching Checker settings (preparation for calibration)
8. [Calibration] settings
9. Second [Workpiece Adjustment Settings]
10. [Get Standard Data]
11. [Execute Parameter Setting]

Steps 5 – 11: Creation process for the additional function data item [Workpiece Adjustment]

12. Set [Workpiece Adjustment] to a point.
13. Creating and setting point job data including camera-related commands
14. Preparing and setting point job data

- Step 7 is a camera setting. The other steps are robot settings.

It is necessary to have 2 – 7 calibration marks within the camera search area. In the workpiece example on the previous page, the [+] mark cannot be used as a calibration mark since there is only one [+] mark in the camera search area.

If you wish to distinguish the marks indicating the workpiece position from the calibration marks during operation, be sure to use marks of a different shape.

1. New Program

Open a new program.

2. Tool Data Setting

Set [Tool Data] from [Program Data Settings].

- **Tool Weight**

  If the camera is mounted on the robot Axis, **set the total combined weight of the tools and the camera as the [Tool Weight].**

- **TCP-X, TCP-Y**

  If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

3. Work Home Position

Select [Work Home] from [Program Data Settings] and enter the work home position (coordinates).

4. Point Position

Register the two camera data points (P01 and P02) and the point where the point job will be carried out on the workpiece (P03).

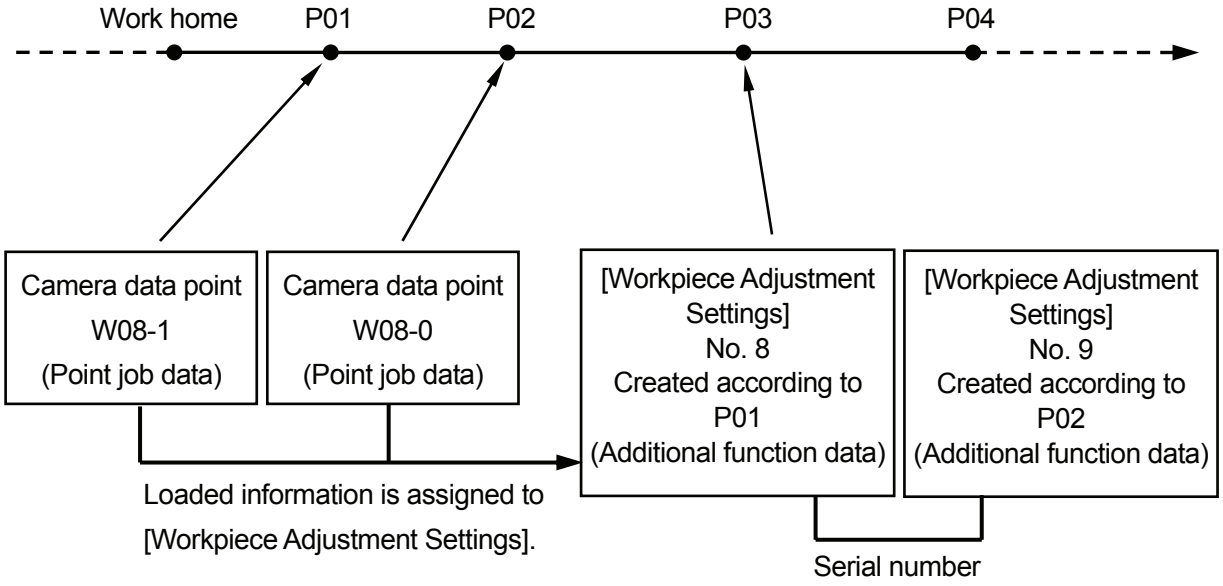
■ **Actions Required for the Double Workpiece Position Adjustment with Camera**

The following data is assigned to each point:

P01: Camera data (Imaging) point 1 (Shot 1)

P02: Camera data (Imaging) point 2 (Shot 2)

P03: Point where the point job (e.g. screw tightening or dispensing) is carried out



Load data with the camera at P01 and P02, and then assign the loaded data to the additional function data [Workpiece Adjustment Settings] to set the P03 position (coordinates and compensation value).

5. First [Workpiece Adjustment Settings]

When carrying out a double adjustment, it is necessary to set two sequential [Workpiece Adjustment Settings] numbers. This step creates the first [Workpiece Adjustment Settings].

Select [Workpiece Adjustment Settings] from the [Additional Function Data Settings] menu.
Enter a new [Workpiece Adjustment] number and then select [Camera A210/A110 Adjustment] as the [Workpiece Adjustment] type. ([Camera A210/A110 Adjustment]: the [Workpiece Adjustment] type. Select either [Numeric Adjustment] or [Camera A210/A110 Adjustment].)
The following items will be displayed:

[Camera A210/A110 Adjustment] Menu

- [Camera COM Port]: The COM connector on the robot (or the control box) side which is connected to the camera
- [Calibration]: Converts the camera coordinates into robot coordinates.
- [Standard Data Setting]: Loads the standard data. During operation, the compensation value is calculated using the loaded standard data.
- [Execute Parameter Setting]: Designates the motion at the time when the workpiece adjustment is carried out.
- [Display Adjustment]: Displays the workpiece adjustment amount calculated when a [Test Run] or [Point Run] is performed.
- [Z-Adjustment]: The distance sensor settings when the camera is used together with the distance sensor (or the touch sensor) to adjust the workpiece position error in the X-, Y-, and Z-directions

6. Communication Settings

Select [Camera COM Port] from the [Camera A210/A110 Adjustment] menu. Select the COM Port that is connected to the camera on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series).

7. Smart Matching Checker Settings (Preparation for Calibration)

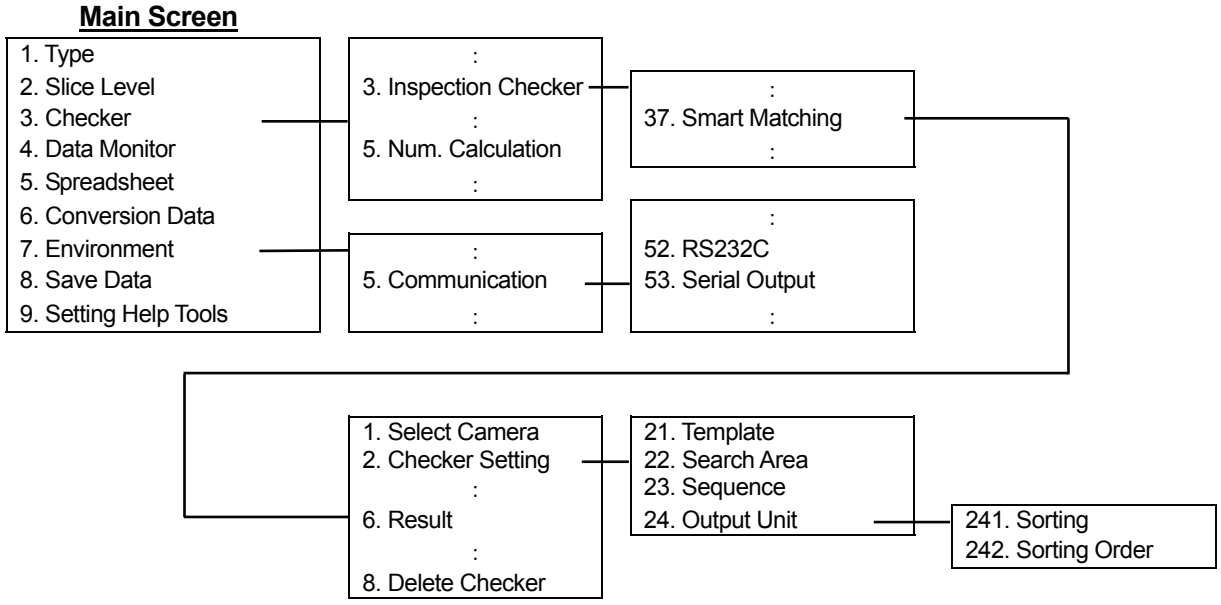
Before using the camera, the calibration settings (conversion of the camera coordinates into robot coordinates) should be completed. First, load the mark (image) onto the workpiece, then compare it with the robot coordinates and calculate the difference between them. The mark to be loaded is referred to as a ***calibration mark*** in this manual.

When performing a double adjustment, **it is necessary to calibrate each pair of camera data points**; therefore, two sequential [Workpiece Adjustment Settings] numbers are necessary.
This step completes the calibration settings for the first camera data point.

Shift the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

Turn on the camera and check that the workpiece is displayed on the monitor screen.
Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation.

To manipulate the camera, press the [ENTER] key (on the keypad) to select (fix) an item and the [C] key to cancel (return).



7.1 Type Data Number

Select [1. Type] from the main screen and then select a number.

7.2 Communication

Return to the main screen and then select [Environment] to display the Environment menu.

Select [Communication] from the menu and match the serial settings ([RS232C]) with those for one of COM1 – COM3 (the terminal connected to the camera) on the robot.

Serial Settings (Camera)	COM1 – COM3 (Robot)	COM1 – COM3 (Robot) Default
Transmission Speed (bps)	Baud Rate	9600
Bit Length	Character Length	8bit
Stop Bit	Stop Bit	2bit
Parity	Parity	–
Flow Control	–	–

7.3 Output Settings

Select [Communication] from the Environment menu and then select [Serial Output]. Set the [Numerical Calculation] to [Output].

7.4 Preparation for Calibration (Camera)

Return to the main screen. Select [Checker] and then select [Inspection Checker].

7.4.1 Select [Smart Matching] and then select a number.

If old data is stored under the number, select [Delete Checker] to delete the old data.

7.4.2 Select [Checker Setting] and press the [A] key on the keypad to record the image.

7.4.3 Select [Template] and enclose one of the standard marks using the cursor lever on the keypad. The smaller the enclosed area, the shorter the detection time.

7.4.4 Select [Search Area] and set a search area large enough to cover the area in which a workpiece position error may occur.

7.4.5 Select [Sequence], and set [Judgment] according to the level of detail required in the search. (The default setting is a detailed search.)

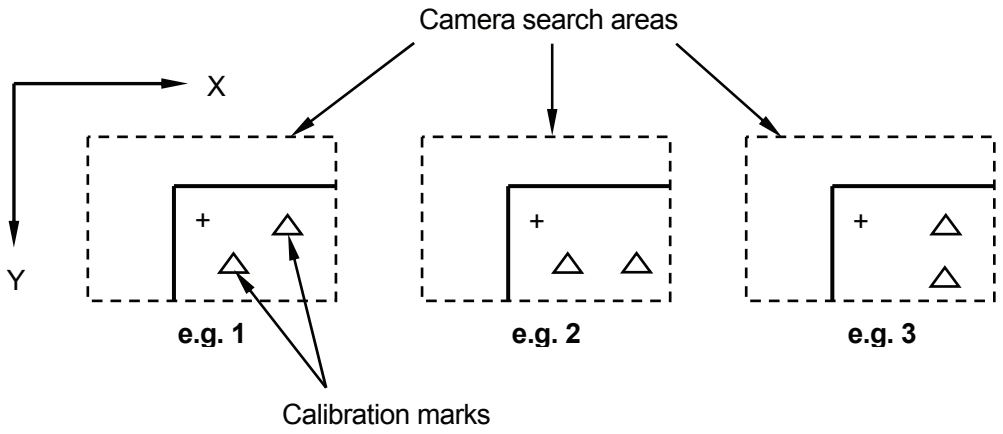
		Judgment		Result	
Step	Accuracy	Quantity	Correlation	Quantity	Correlation
1ST	16	16	0.60	0	0.00
2ND	8	8	0.60	0	0.00
3RD	4	4	0.60	0	0.00
4TH	2	2	0.60	0	0.00
5TH	S	2	0.60	0	0.00
Rotation		Angle	30deg	Accuracy	1deg

- Depending on the size of the template, the first step accuracy may be changed from [16] to [8] or [4].
- Enter the quantity of marks that you wish to have judged in the last step [S]. In the workpiece example shown below, there are two marks [△] to be judged, therefore, the quantity [2] should be entered for this step [S].

7.4.6 Select [Output Unit]. Set [Sorting] to [X] or [Y] (coordinate) and [Sorting Order] to [Des] (descending order). The marks detected are referred to as *C1* and *C2* respectively in the order they are set. If there are three or more marks, they are referred to as *C3*, *C4*, and so on. These marks are used as the calibration marks. Be sure to identify which mark is C1, C2, etc.

Set [Sorting], referring to the examples below:

Example 1: Both the X- and Y- coordinates are possible.
Example 2: X-coordinate (If the Y-coordinate is used, it is hard to identify which mark is C1.)
Example 3: Y-coordinate (If the X-coordinate is used, it is hard to identify which mark is C1.)



7.4.7 Return to the main screen. Select [Checker] and then [Numerical Calculation].

Setting Example

	Model A210	Model A110	
CA01	SM01010	MT01010	Number of the Detected Mark
CA02	SM01012	MT01012	X-coordinate of C1
CA03	SM01013	MT01013	Y-coordinate of C1
CA04	SM01014	MT01014	Rotation angle of C1
CA05	SM01022	MT01022	X-coordinate of C2
CA06	SM01023	MT01023	Y-coordinate of C2
CA07	SM01024	MT01024	Rotation angle of C2

CA01 = SM 01 01 0
(1) (2) (3) (4)

(1) SM: Smart Matching (MT is used for Model A110.)
(2) 01: Checker Number (number selected in Paragraph 7.4.1.)
(3) 01: Object Number (02 indicates two objects.)
(4) 0: Number of detected marks, 2: X-coordinate, 3: Y-coordinate, 4: Rotation angle

The robot loads the values set here (CA01 – CA07).

7.4.8 Return to the main screen. Select [Checker], [Inspection Checker], [Smart Matching], and then [Result]. The detected mark (image) will be displayed. Check the position of the mark. If multiple marks are detected;

- Press the [B] key on the keypad to display each mark in order of detection.
- Press the [A] key on the keypad to display all the detected marks at the same time.

7.4.9 Return to the main screen. Select [Save Data], and then select [YES]. If you turn the camera off without saving the data, all the settings for the camera will return to the default.

8. [Calibration] Settings

Load the calibration mark in the camera search area ([Get Calibration Mark]), compare the position of the calibration mark with the [Robot Coordinate Position], and then calculate the difference between the camera coordinates and the robot coordinates ([Calculate and Register]).

Select [Calibration] from the [Camera A210/A110 Adjustment] menu ([Workpiece Adjustment]). The following items will be displayed.

[Calibration] Menu

- Fixed Taking Position: One of the calibration modes: Refer to "XY ADJUSTMENT WITH CAMERA, CHANGE OF TAKING POSITION" on Page 15.
- Calibration Mark Number: Number of standard marks for calibration (2 – 6 marks)
- Get Calibration Mark: Record the standard data (image) for calibration. Select this parameter after setting the [Calibration Mark Number].
- Robot Coordinate Position: Designate the point coordinates of the robot which correspond to the camera coordinates.
- Looking Down/Looking Up: Direction in which the camera is facing; up, or down.
- Calculate and Register: The four coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. Select this parameter after setting the above four items ([Calibration Mark Number] – [Looking xx]).

  - Unit Coefficient: Displays the calculated coordinate conversion amount (K).
  - Rotate Angle: Displays the calculated coordinate conversion amount (ϕ).
  - X Shifting Amount: Displays the calculated coordinate conversion amount (ΔX).
  - Y Shifting Amount: Displays the calculated coordinate conversion amount (ΔY).

  Algebraic Formula for Coordinates

  $X = K * x * \cos(\phi) - K * y * \sin(\phi) + \Delta X$
  $Y = K * x * \sin(\phi) + K * y * \cos(\phi) + \Delta Y$
  $\Theta = \theta + \phi$
  Camera coordinates (x, y, θ), Robot coordinates (X, Y, Θ)

- Calibrate Position: The tool center point at the position where the calibration mark is loaded

8.1 Calibration Mark Number

Enter the [Calibration Mark Number].

In the workpiece example on Page 18, enter [2] as the number of marks (△) to be detected.

- When performing a double adjustment, set the [Calibration Mark Number] to 2 or 3. Numbers greater than 4 may generate a [Camera Data Error].

8.2 Getting Calibration Mark

Select [Get Calibration Mark]. The robot will load the image according to the Camera Smart Matching Checker settings. (See the previous Section 7)

Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation. Do not change the camera data point coordinates or the camera setting position after the calibration is completed. If the number of marks recorded by the camera does not correspond to the [Calibration Mark Number], a [Camera Data Error] will be returned.

8.3 Robot Coordinate Position

Check the direction the camera is facing ([Looking Down] or [Looking Up]), and enter the [Robot Coordinate Position]. C1 and C2 are the coordinates of the marks (+) recorded by the camera in the [Get Calibration Mark] settings. Assign the C1 and C2 coordinate values to P1 and P2 as the robot coordinates.

Select [P1], line up the tool center point of the robot with the [C1] mark and then set the coordinates. Accordingly, enter and set all the [P] coordinates using the corresponding [C] marks.

The camera coordinate axes and the robot coordinate axes are sometimes not aligned. Be sure to confirm which mark is C1 before you enter the corresponding robot coordinates.

The entered Cs and Ps are displayed according to the [Calibration Mark Number] settings.

For the camera coordinates, [T] indicates the angle of the mark.

8.4 Calculation and Registration

Select [Calculate and Register] from the [Calibration] menu. The coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. The calculated values are displayed as the following items:

- Unit Coefficient
- Rotate Angle
- X Shifting Amount
- Y Shifting Amount

The calibration settings (data conversion) are now complete.

9. Second [Workpiece Adjustment Settings]

Create the second workpiece adjustment and calibration settings according to the first workpiece adjustment and calibration settings as previously described in Sections 5, 7, and 8.

First, shift the robot Arm to P02 (camera data point 2). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

9.1 Creating the Second [Workpiece Adjustment Settings]

Be sure to use **sequential workpiece adjustment numbers**.

If the first [Work Adjustment Number] is set to [8], the second [Work Adjustment Number] must be [9].

9.2 Communication Settings

Select [Camera COM Port] from the [Camera A210/A110 Adjustment] menu. Select the COM Port that is connected to the camera on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series).

9.3 Smart Matching Checker Settings (Preparation for Calibration)

If the numbers or shapes of the calibration marks are not the same at P01 (camera data point 1) and P02 (camera data point 2), it will be necessary to set the Smart Matching Checker.

If they are the same, use the settings created in Section 7 (Page 23).

9.4 Calibration Settings

Complete the calibration settings according to the second [Workpiece Adjustment Settings] (for P02 (camera data point 2)).

- When performing a double adjustment, set the [Calibration Mark Number] to 2 or 3. Numbers higher than 4 may return a [Camera Data Error].

10. [Get Standard Data]

Record the standard data at camera data points 1 and 2.

10.1 Smart Matching Checker Settings (Preparation for Taking Standard Data)

Shift the robot Arm to P01 (camera data point 1) to set the Smart Matching Checker. (It is necessary to set the Smart Matching Checker if the number or the shape of the calibration mark (two [△] marks in this example) is different from the standard data mark (one [+] mark in this example), even in the same camera search area.)

Select [1. Type] from the main screen, and then select a number. Next, set [Communication] and [Serial Output] in the [Environment] menu, following the procedures described in Paragraphs 7.1 – 7.3 on Pages 23 – 24.

Set the communication and output settings. (Both settings will be the same as described in Section 7, “Setting Camera Smart Matching Checker (Preparing Calibration).”

10.1.1 Select [Checker Setting] and press the [A] key on the keypad to record the image.

10.1.2. Select [Template] and enclose one of the standard marks ([+] in this example) using the cursor lever on the keypad. The smaller the enclosed area, the shorter the detection time.

10.1.3. Select [Search Area] and set a search area large enough to cover the area in which a workpiece position error may occur.

10.1.4. Select [Sequence] and set [Judgment] according to the level of detail required in the search. (The default setting is a detailed search.)

		Judgment		Result	
Step	Accuracy	Quantity	Correlation	Quantity	Correlation
1ST	16	16	0.60	0	0.00
2ND	8	8	0.60	0	0.00
3RD	4	4	0.60	0	0.00
4TH	2	2	0.60	0	0.00
5TH	S	1	0.60	0	0.00
Rotation		Angle	30deg	Accuracy	1deg

- Depending on the size of the template, the first step accuracy may be changed from [16] to [8] or [4].
- Enter the quantity of marks that you wish to have judged in the last step [S]. In the workpiece example on page 19, there is one mark [+] to be judged, therefore, the quantity [1] should be entered for this step [S].

10.1.5 Return to the main screen. Select [Checker] and then [Numerical Calculation].

Setting Example

	Model A210	Model A110	
CA01	SM01010	MT01010	Number of the Detected Mark
CA02	SM01012	MT01012	X-coordinate of C1
CA03	SM01013	MT01013	Y-coordinate of C1
CA04	SM01014	MT01014	Rotation angle of C1

CA01 = SM 01 01 0
(1) (2) (3) (4)

(1) SM: Smart Matching (MT is used for Model A110.)
(2) 01: Checker Number (the number selected in Paragraph 10.1)
(3) 01: Object Number (01 indicates one object.)
(4) 0: Number of detected marks, 2: X-coordinate, 3: Y-coordinate, 4: Rotation angle

The robot loads the values set here (CA01 – CA04).

10.1.6 Return to the main screen. Select [Checker], [Inspection Checker], [Smart Matching], and then [Result]. The detected mark (image) will be displayed. Check the position of the mark.

10.1.7 Return to the main screen. Select [Save Data], and then select [YES]. If you turn the camera off without saving the data, all the settings for the camera will return to the default.

10.2 Performing [Get Standard Data] according to the [Workpiece Adjustment Settings]

10.2.1 Shift the robot Arm to P01 (camera data point 1). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.
To set the standard data required to calculate the offset amount during operation, select [Standard Data Setting] from the [Camera A210/A110 Adjustment] menu in the [Workpiece Adjustment Settings] created for camera data point 01.

10.2.2 Enter the number of marks on the workpiece as the [Standard Mark Number]. In the workpiece example on Page 18, [1] is entered as the number of marks (+).

- Standard Mark Number: The number of standard marks (1 – 7) for adjustment
- Get Standard Data: Record the standard data (image). Select this parameter after setting the [Standard Mark Number].
- P1, P2…: X, Y: The robot coordinates corresponding to the loaded standard data
  T: Angle
  The Ps are displayed according to the [Standard Mark Number] settings.

10.2.3 Select [Get Standard Data]. The camera records the marks (image) according to the Smart Matching Checker settings. This data is used as the first standard workpiece position during operation. If the number of marks recorded by the camera does not coincide with the [Standard Mark Number] settings, an error will be returned.
Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation.

10.2.4 The loaded standard data will be displayed in the lines indicated as P1, P2 etc on the screen.

10.2.5 Shift the robot Arm to P02 (camera data point 2). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

10.2.6 Select the [Workpiece Adjustment Settings] created for camera data point 2, and display the [Camera A210/110 Adjustment] menu.

Enter the number of marks on the workpiece as the [Standard Mark Number], then select [Get Standard Data]. The camera records the marks (image) according to the Smart Matching Checker settings. This data is used as the second standard workpiece position during operation. If the number of marks recorded by the camera does not correspond to the [Standard Mark Number] settings, an error will be returned.

Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation.

If the numbers or shapes of the standard marks are not the same at P01 (camera data point 1) and P02 (camera data point 2), it will be necessary to set the Smart Matching Checker.

If they are the same, use the settings created in Section 7 (Page 23).

10.2.7 The loaded standard data will be displayed in the lines indicated as P1, P2 etc on the screen. The standard data setting process is now complete.

11. [Execute Parameter Setting]

Select [Execute Parameter Setting] from the [Camera A210/A110 Adjustment] menu in the [Workpiece Adjustment Settings] created for camera data point 1. The [Execute Parameter Setting] in the [Workpiece Adjustment Settings] created for camera data point 2 does not affect the operation.

Select the item you wish to change from the following:

- Rotation Apply to R-Axis (Rotation Not Apply to R-Axis):

  Rotation of the workpiece (T) is (is not) applied to the R-Axis.

  If the angle of the workpiece does not correspond to that of the standard data, the R-Axis rotates (does not rotate) according to the workpiece angle.
- Reset Z Adjustment (No Reset Z Adjustment):

  When you record data with the camera, the Z-Axis (height) offset, referred to as the [Z Adjustment] in this manual, is reset (is not reset) to 0.

  If the point where the height is measured by the distance sensor is set above the camera data point, select [No Reset Z Adjustment].
- Reset at Program Start (No Reset at Program Start):

  The workpiece adjustment amount is reset (is not reset) when the program is started.

  When you are switching between multiple programs to execute a series of jobs, select [No Reset at Program Start] if the camera data point and the workpiece adjustment point are not set in the same program.

Setup for the [Execute Parameter Setting] is now complete.

12. Setting the [Workpiece Adjustment] to the Job Point

After Steps 1 – 11 have been completed, **set (add) the (smaller) [Work Adjustment Number] created for camera data point 1 to the job point where you wish to perform the workpiece adjustment.**

It is not necessary to set the (larger) [Work Adjustment Number] created for camera data point 2 to the job point.

13. Creating and Setting Point Job Data including Camera-Related Commands

Create the two point data sets and assign each set to each of the camera data points.

13.1 Setting [Wait Time]

To prevent blurring of the image, set a [Wait Time] before the command to receive the camera data.

In this example, set 0.5sec as the [Wait Time] and the [waitCondTime] command (command category: [if Branch, Wait Condition]).

13.2 Camera-Related (Imaging) Commands

Enter the command [wCameraWadj] (command category: [Camera, Z Adjustment]) and the smaller [Work Adjustment Number].

Then enter [Shot Number].

Enter [1] as the [Shot Number] for the point job at camera data point 1, and [2] for the point job at camera data point 2.

When this command is executed, the robot records the image with the camera and then calculates the offset between the loaded data and the job point according to the [Workpiece Adjustment] amount that was entered.

13.3 Commands for Camera-Related Errors

If a camera-related error occurs, an incorrect offset will be applied to the coordinates of the job point.

Enter a command to specify the action to be carried out in case of camera-related errors.

By using a system flag, you can specify the point job to be executed if a camera-related error occurs.

System Flag	Error No.	Error
No. 31	No. 39	Camera Error (No response)
	No. 40	Camera Data Error

Example of Point Job Data at P01

```
wCameraWadj 1-1
if
  ld #sysFlag(31)
then
  goRPoint PTP00,3
endIf
```

Record the image with the camera

Refer to System Flag No. 31

If #sysFlag(31)=1 (true) (if it is an error), jump to three points ahead.

Example of Point Job Data at P02

wCameraWadj 1-2	Record the image with the camera.
if	
ld #sysFlag(31)	Refer to System Flag No. 31
then	
goRPoint PTP00,3	If #sysFlag(31)=1 (true) (if it is an error),
endIf	jump to two points ahead.

13.4 Setting the Point Job Commands to the Job Points

If there are no further commands to be set, the creation process for the point job data is complete. Set the point job data numbers to camera data points P01 and P02.

14. Preparing and Setting Point Job Data

Prepare and set the point job data you wish to perform (e.g. screw tightening or dispensing) to the job point which the [Workpiece Adjustment] has been set to.

All the settings necessary for the workpiece position error double adjustment (with camera) are now complete.

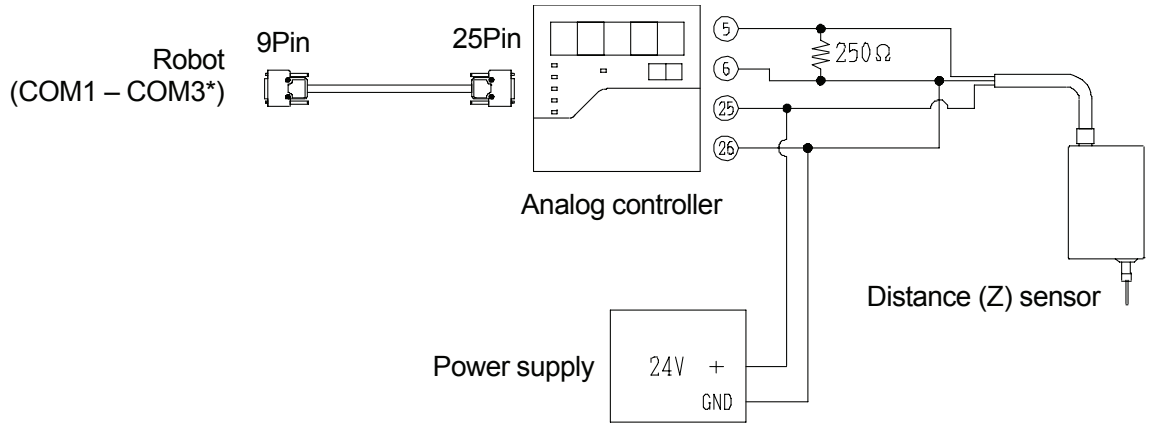
Z ADJUSTMENT WITH DISTANCE SENSOR

This chapter explains how to adjust a workpiece position error in the Z-direction (height) using the distance sensor.

Connection

Connect the distance sensor and power supply to the analog controller. Connect the analog controller to COM1, COM2 or COM3 on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series) with an RS-232C (dedicated) cable.

- Please also refer to the camera, distance sensor, and analog controller instruction manuals for details on the connection procedure. (See Page xxi for details of the manufacturers)



Distance Sensor Connection Example

Be sure to turn the power off before making any connections.

*: If COM1 is connected to a PC, connect the controller to COM2 or COM3. If you are using the TPU (teaching pendant connector) instead of the COM ports, use an RS-422 (dedicated) cable.

■ Operation Procedures

Ensure the distance sensor, analog controller, power supply, and the robot are properly connected, referring to the example on the previous page. Set the workpieces at the position where the job will be carried out, and then create a new program following the procedures below.

> If you wish to adjust the workpiece position error in the X-, Y-, and Z-directions using both the camera and the distance sensor, follow the procedure descibed in “XY ADJUSTMENT WITH CAMERA” (Page 2), and then go to Step 4 below (“Point position”).

1. New program
2. Tool data setting
3. Work home position
4. Point position
5. To the height measuring point
6. Creating and setting additional function data [Workpiece Adjustment]
    - 6.1 [Workpiece Adjustment Settings]
    - 6.2 Communication settings
    - 6.3 [Get Standard Data]
    - 6.4 Setting [Workpiece Adjustment] to the job point
7. Creating and setting point job data including the height measuring command
    - 7.1 New point job data
    - 7.2 The height measuring command [takeZWadj]
    - 7.3 The [Take Z Adjustment Data Error] command
    - 7.4 Setting the point job data to the height measuring point

1. New Program

Open a new program.

2. Tool Data Setting

Set [Tool Data] from [Program Data Settings].

- **Tool Weight**

  If the distance sensor is mounted on the robot Axis, set the total combined weight of the tools and the distance sensor as the [Tool Weight].

  If both **the distance sensor and the camera are mounted** on the robot Axis, **set the total combined weight of the tools, the distance sensor, and the camera as the [Tool Weight].**

- **TCP-X, TCP-Y**

  If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

3. Work Home Position

Select [Work Home] from [Program Data Settings] and enter the work home position (coordinates).

4. Point Position

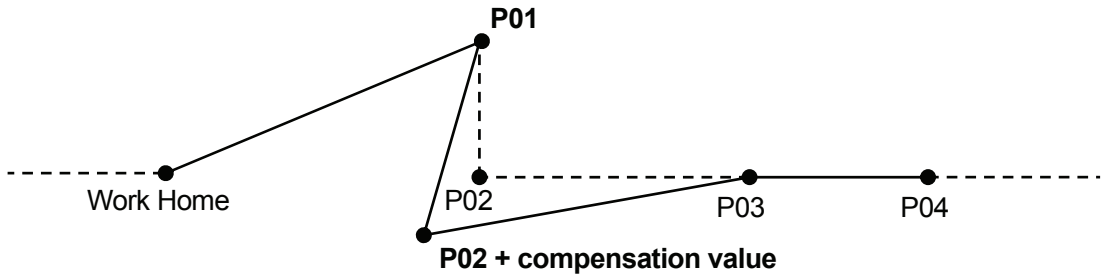
Register the height measuring point and the point where the point job will be carried out on the workpiece.

> If you wish to adjust the workpiece position error in the X-, Y-, and Z-directions using both the camera and the distance sensor, register the height measuring point only, using [Insert a Point] from the [Edit] menu if the height measuring point is different from the camera data point.
> If you set the camera data point and the height measuring point to the same point, you will not need to register the point position. Go to Step 5.

If the distance sensor is not mounted on the robot Axis and its position is fixed, it is necessary to set a particular height measuring point. The height measuring point can be any point which point job data can be set to, as long as it is before the job point for the workpiece (where the [Workpiece Adjustment] is set). The height measuring point can also be a previously registered job point.

Height Measuring Point: P01

This is the point which the point job data, including the command to measure the workpiece height ([takeZWadj]), is set to. At this point, the robot measures the workpiece height using the distance sensor, and then calculates the difference between the standard coordinates and the current workpiece position. Set the height measuring point to a point before the job point for the workpiece (to measure the workpiece height). The height measuring point can be set to the same point as the camera data point.



Job Point for the Workpiece: P02 + compensation value

This is the point where a job for the workpiece is carried out, e.g. screw tightening and dispensing. Set the additional function data item [Workpiece Adjustment] to this point. After the [Workpiece Adjustment] has been set, the robot will adjust the registered coordinates (P02 in the illustration above) according to the difference calculated at the height measuring point, and then start running.

5. To the Height Measuring Point

Shift the robot Arm to P01 (height measuring point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

6. Creating and Setting the Additional Function Data [Workpiece Adjustment]

6.1 New [Workpiece Adjustment]

Select [Workpiece Adjustment Settings] from the [Additional Function Data Settings] menu.
Enter a new [Workpiece Adjustment] number and then select [Numeric Adjustment] for the workpiece adjustment type. ([Numeric Adjustment]: a type of [Workpiece Adjustment]. Select either [Numeric Adjustment] or [Camera A210/A110 Adjustment].)
The following items will be displayed:

[Numeric Adjustment] Menu

- [X Adjustment]: Compensation value in the X-direction
- [Y Adjustment]: Compensation value in the Y-direction
- [Z Adjustment]: Compensation value in the Z-direction
- [R Adjustment]: Compensation value of the R-Axis rotation
- [Rotate Adjustment]: Angle of rotation around the origin point (0,0,0)
- [Z-Adjustment]: Settings for the distance sensor (or the touch sensor): Select either [Z-Adjustment with COM] or [Going Down Z-Adjustment].

Check that the [X Adjustment], [Y Adjustment], and [Z Adjustment] are set to [0mm] and that the [R Adjustment] and [Rotate Adjustment] are set to [0deg]. Then select [Z-Adjustment].
Select [Z-Adjustment with COM] as the [Z-Adjustment] type.
If [Z-Adjustment with COM] is selected, the following menu will be displayed:

[Z-Adjustment with COM] Menu

- [Z-Adjustment COM Port]: The COM port on the robot side which is connected to the sensor
- [Get Standard Data]: Select this to measure the standard workpiece height.
- [Z Standard Data]: The value measured by [Get Standard Data] is displayed on the [Z Standard Data] line. Deviation from this value will be compensated.

If you wish to adjust the workpiece position in the X-, Y-, and Z-directions using both the camera and the distance sensor, select [Z-Adjustment] from the [Camera A210/A110 Adjustment] menu in the [Workpiece Adjustment Settings] created in “XY ADJUSTMENT WITH CAMERA” (Page 2).
In this case, it is not necessary to set the [X Adjustment], [Y Adjustment], [Z Adjustment], and [R Adjustment] to [0].

6.2 Communication Settings

Select [Z-Adjustment COM Port] from the [Z-Adjustment with COM] menu. Select the COM Port that is connected to the sensor on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series).

6.3 [Get Standard Data]

Turn on the distance sensor, and then select [Get Standard Data] from the [Z-Adjustment with COM] menu. The robot measures the standard height of the workpiece with the sensor.

After carrying out [Get Standard Data], the measured value is displayed on the [Z Standard Data] line. Any deviation from this value will be compensated in actual operation.

Be sure to carry out [Get Standard Data] at the same position as the height measuring position for actual operation.

Creation of the additional function data item [Workpiece Adjustment] is now complete.

6.4 Set [Workpiece Adjustment] to a Point.

Set (Add) the prepared [Work Adjustment Number] to the job point where you wish to perform the workpiece adjustment.

7. Creating and Setting Point Job Data including the Height Measuring Command

7.1 New Point Job Data

If you wish to use the camera and the distance sensor together and to set both the camera data point and the height measuring point to the same point, open the point job data created in “XY ADJUSTMENT WITH CAMERA” (Page 2), and then add or insert the height measuring command.

7.2 The Height Measuring Command [takeZWadj]

Select [takeZWadj] from the command list on the Select Category screen and enter an unregistered [Workpiece Adjustment] number.

When this command is performed, the robot measures the workpiece height with the distance sensor and calculates the compensation value corresponding to the designated [Workpiece Adjustment].

7.3 The [Take Z Adjustment Data Error] command

If a sensor-related error occurs, an incorrect offset will be applied to the coordinates of the job point. Enter a command to specify the action to be carried out in case of a sensor-related error.

By using a system flag, you can specify the point job to be executed if a sensor-related error occurs.

System Flag	Error No.	Error
No. 32	No. 41	Take Z Adjustment Data Error

Example of Point Job Data at P01

```
takeZWadj 8
if
   ld #sysFlag(32)
then
   goRPoint PTP00,2
endIf
```

The Height Measuring Command

Refer to System Flag No. 32.
If #sysFlag(32)=1 (true) (If it is an error), jump to two points ahead.

7.4 Setting the Point Job Data to the Height Measuring Point

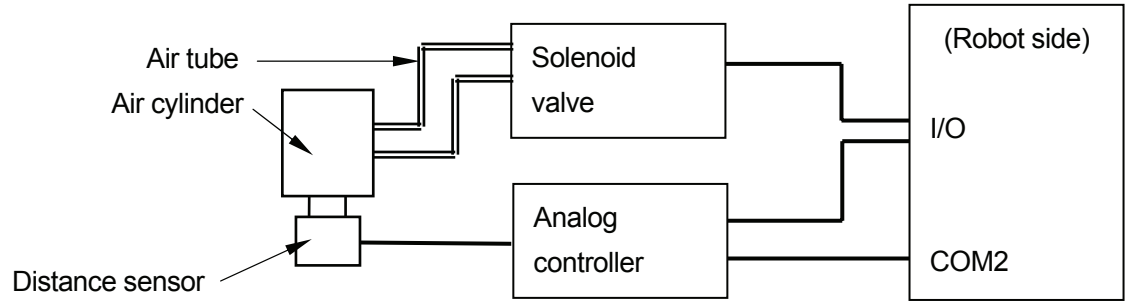
If there are no further commands to be set, the creation process for the point job data is complete. Set the point job data numbers to the height measuring point.

If you register the point positions after creating the [Workpiece Adjustment], be sure to set the height measuring point coordinates to the same position as that where [Get Standard Data] was performed.

All the settings necessary for the workpiece height adjustment (with distance sensor) are now complete.

Reference

Refer to the example below if you wish to use the distance sensor mounted on the air cylinder for measuring height.



- To lower the distance sensor: Turn #genOut1 on.
- To raise the distance sensor: Turn #genOut1 off.

This is an example of point job data set to the height measuring point.

set #genOut1	Lower the distance sensor.
waitCondTime 0.5sec	Wait until the sensor finishes descending.
takeZWadj 8	Measure the height. Set the result to [Workpiece Adjustment] No. 8.
reset #genOut1	Raise the distance sensor.
waitCondTime 0.5sec	Wait until the sensor finishes ascending.

- If the air cylinder is mounted on the robot Axis, be sure to add the weight of the air cylinder to the [Tool Weight].

When loading the standard data for the workpiece height adjustment, it is necessary to set the distance sensor to the same position as the height measuring position for actual operation. (See “6.3 [Get Standard Data]” on Page 42)

Prepare the point job data for lowering and raising the distance sensor during point teaching.

This is an example of point job data for lowering the distance sensor.

set #genOut1	Lower the distance sensor.

This is an example of point job data for raising the distance sensor.

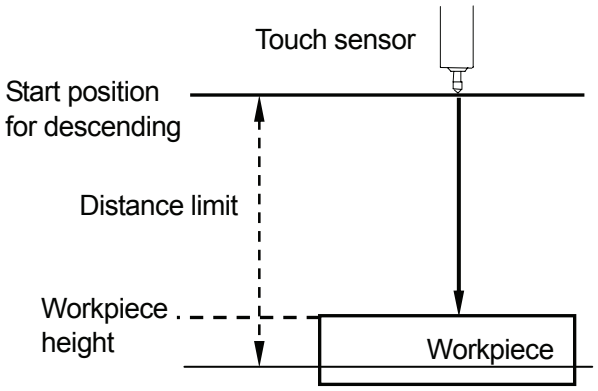
reset #genOut1	Raise the distance sensor.

Execute the point job data using the [Manual Job Number Setting] function (in the [Teaching Environment Setting] menu) if you are using the teaching pendant. If you are using a PC, select the desired point job in the JOG dialog box.

Z ADJUSTMENT WITH TOUCH SENSOR

This chapter explains how to adjust the workpiece position error in the Z-direction (height), using the touch sensor.

Lower the Z-Axis, and then read out the position where the touch sensor was turned on to compensate for deviation of the workpiece height in the Z-Axis direction.
An error ([Take Z Adjustment Data Error]) will be returned if the touch sensor does not turn on even after the Z-Axis moves over the designated [Distance Limit] (limit descent distance).

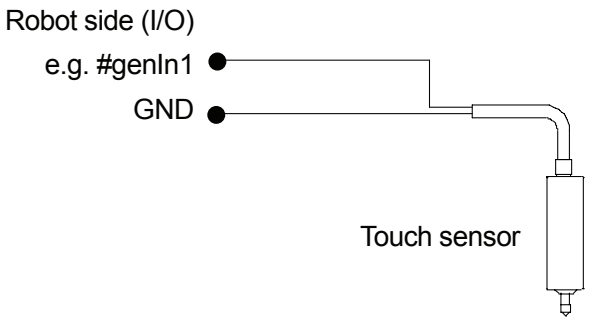


Connection

Connect the touch sensor to the I/O on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series).

- Please also refer to the touch sensor instruction manual for details on the connection procedure.

Touch Sensor Connection Example



Be sure to turn the power off before making any connections.

- If you wish to use an I/O signal which has a preassigned function, it will be necessary to change the function to [Free] using the [IO-SYS Function Assignment] ([IO Settings] menu under [Run Mode Parameter]).

■ **Operation Procedures**

Connect the touch sensor to the robot, referring to the example on the previous page. Set the workpieces at the position where the job is to be carried out, and then create a new program following the procedures below.

> If you wish to adjust the workpiece position error in the X-, Y-, and Z-directions using both the camera and the distance sensor, follow the operation procedure descibed in “XY ADJUSTMENT WITH CAMERA” (Page 2), and then go to Step 4 below (“Point position”).

1. New program
2. Tool data setting
3. Work home position
4. Point position
5. To the height measuring point
6. Creating and setting additional function data [Workpiece Adjustment]
    - 6.1 [Workpiece Adjustment Settings]
    - 6.2 Communication settings
    - 6.3 [Get Standard Data]
    - 6.4 Setting [Workpiece Adjustment] to the job point
7. Creating and setting point job data including the height measuring command
    - 7.1 New point job data
    - 7.2 The height measuring command [takeZWadj]
    - 7.3 The [Take Z Adjustment Data Error] commnad
    - 7.4 Setting the point job data to the height measuring point

1. New Program

Open a new program.

2. Tool Data Setting

Set [Tool Data] from [Program Data Settings].

- **Tool Weight**

  If the touch sensor is mounted on the robot Axis, set the total combined weight of both the tools and the touch sensor as the [Tool Weight].

  If **the touch sensor and the camera are mounted** on the robot Axis, **set the combined total weight of the tools, the touch sensor, and the camera as the [Tool Weight].**

- **TCP-X, TCP-Y**

  If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

3. Work Home Position

Select [Work Home] from [Program Data Settings] and enter the work home position (coordinates).

4. Point Position

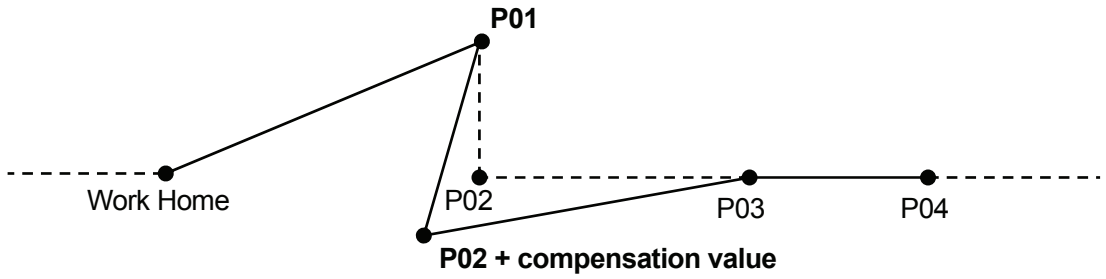
Register the height measuring point and the point where the point job will be carried out on the workpiece.

> If you wish to adjust the workpiece position error in the X-, Y-, and Z-directions using both the camera and the touch sensor, register only the height measuring point using [Insert a Point] in the [Edit] menu if the height measuring point is different from the camera data point.
> If you set the camera data point and the height measuring point to the same point, it will not be necessary to register the point position. Go to Step 5.

The height measuring point can be any point which point job data can be set to, as long as it is before the job point for the workpiece (where the [Workpiece Adjustment] has been set). The height measuring point can also be a previously registered job point.

Height Measuring Point: P01

This is the point where the point job data, including the command to measure the workpiece height ([takeZWadj]), is set. At this point, the robot measures the workpiece height using the touch sensor and calculates the difference between the standard coordinates and the current workpiece position. Set the height measuring point to a point before the job point for the workpiece (to measure the workpiece height). The height measuring point can be set to the same point as the camera data point.



Job Point for the Workpiece: P02 + compensation value

This is the point which performs a job on the workpiece, e.g. screw tightening or dispensing. Set the additional function data item [Workpiece Adjustment] to this point. After [Workpiece Adjustment] is set, the robot will adjust the registered coordinates (P02 in the illustration above) according to the difference calculated at the height measuring point, and then start running.

5. To the Height Measuring Point

Shift the robot Arm to P01 (the height measuring point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

6. Create and Set the Additional Function Data [Workpiece Adjustment].

6.1 New [Workpiece Adjustment]

Select [Workpiece Adjustment Settings] from the [Additional Function Data Settings] menu.

Enter a new [Workpiece Adjustment] number and then select [Numeric Adjustment] for the workpiece adjustment type. ([Numeric Adjustment]: A type of [Workpiece Adjustment]: Select either [Numeric Adjustment] or [Camera A210/A110 Adjustment].)

The following items will be displayed:

[Numeric Adjustment] Menu

- [X Adjustment]: Compensation value in the X-direction
- [Y Adjustment]: Compensation value in the Y-direction
- [Z Adjustment]: Compensation value in the Z-direction
- [R Adjustment]: Compensation value of the R-Axis rotation
- [Rotate Adjustment]: Angle of rotation around the origin point (0,0,0)
- [Z-Adjustment]: Settings for the distance sensor (or the touch sensor): Select either [Z-Adjustment with COM] or [Going Down Z-Adjustment].

Make sure that [X Adjustment], [Y Adjustment], and [Z Adjustment] are set to [0mm], and [R Adjustment] and [Rotate Adjustment] are set to [0deg]. Then select [Z-Adjustment].

Select [Going Down Z-Adjustment] as the [Z-Adjustment] type.

After [Going Down Z-Adjustment] is selected, the following menu will be displayed:

[Going Down Z-Adjustment] Menu

- [Input Channel]: The I/O Port on the robot side which is connected to the touch sensor
- [Down Speed]: The speed at which the Z-Axis descends
- [Distance Limit]: A [Take Z Adjustment Data Error] is returned if the touch sensor does not turn on even after the Z-Axis descends the preset [Distance Limit].
- [Get Standard Data]: Select this item to measure the standard workpiece height.
- [Z Standard Data]: The value measured by [Get Standard Data] is displayed on the [Z Standard Data] line. Deviation from this value will be compensated.

If you wish to adjust the workpiece position in the X-, Y-, and Z-directions using both the camera and the distance sensor, select [Z-Adjustment] from the [Camera A210/A110 Adjustment] menu in the [Workpiece Adjustment Settings] created in “XY ADJUSTMENT WITH CAMERA” (Page 2).
In this case, it is not necessary to set the [X Adjustment], [Y Adjustment], and [Z Adjustment], and [R Adjustment] to [0].

6.2 Communication Settings

Select [Input Channel] from the [Going Down Z-Adjustment] menu. Select the I/O Port that is connected to the sensor on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series).

- If you wish to use an I/O signal which has a preassigned function, it is necessary to change the function to [Free] using the [IO-SYS Function Assignment] ([IO Settings] menu in the [Run Mode Parameter]).

6.3 [Get Standard Data]

Set the desired values to [Down Speed] and [Distance Limit], and then select [Get Standard Data] from the [Going Down Z-Adjustment] menu. The robot lowers the Z-Axis until the touch sensor is turned on, and then measures the standard height of the workpiece with the sensor.
If the touch sensor is lowered pneumatically using the air cylinder mounted on the robot Axis, perform [Get Standard Data] after the touch sensor finishes descending.
Be sure to perform [Get Standard Data] at the same position as the height measuring position for actual operation.

After [Get Standard Data] has been completed, the value measured is displayed on the [Z Standard Data] line. Deviation from this value will be compensated for in actual operation.

Creation of the additional function data item [Workpiece Adjustment] is now complete.

6.4 Setting [Workpiece Adjustment] to the Job Point

Set (Add) the prepared [Work Adjustment Number] to the job point where you wish to perform the workpiece adjustment.

7. Creating and Setting Point Job Data including the Height Measuring Command

7.1 New Point Job Data

If you wish to use the camera and the touch sensor together, and to set both the camera data point and the height measuring point to the same point, open the point job data created in “XY ADJUSTMENT WITH CAMERA” (Page 2), and then add or insert the height measuring command.

7.2 The Height Measuring Command [takeZWadj]

Select [takeZWadj] from the command list on the Select Category screen and enter an unregistered [Workpiece Adjustment] number.

When this command is performed, the robot measures the workpiece height with the touch sensor and calculates the compensation value corresponding to the designated [Workpiece Adjustment].

7.3 The [Take Z Adjustment Data Error] Command

If a sensor-related error occurs, an incorrect offset will be applied to the coordinates of the job point. Enter a command to specify the action to be carried out in case of a sensor-related error.

By using a system flag, you can specify the point job to be executed if a sensor-related error occurs.

System Flag	Error No.	Error
No. 32	No. 41	Take Z Adjustment Data Error

Example of Point Job Data at P01

```
takeZWadj 8
if
   ld #sysFlag(32)
then
   goRPoint PTP00,2
endIf
```

The Height Measuring Command

Refer to System Flag No. 32.
If #sysFlag(32)=1 (true) (If it is an error), jump to two points ahead.

7.4 Setting the Point Job Data to the Height Measuring Point

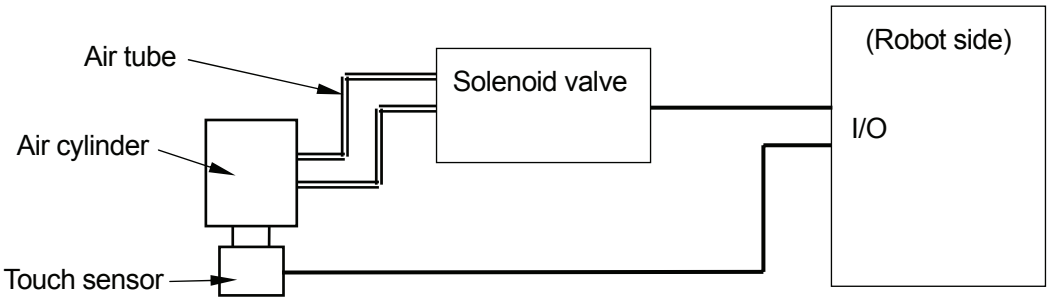
If there are no further commands to be set, the creation process for the point job data is complete. Set the point job data numbers to the height measuring point.

If you register the point positions after creating the [Workpiece Adjustment], be sure to set the height measuring point coordinates at the same position as those where [Get Standard Data] was performed.

All the settings necessary for the workpiece height adjustment (with touch sensor) are now complete.

Reference

Refer to the example below if you wish to use the touch sensor mounted on the air cylinder for measuring height.



- To lower the touch sensor: Turn #genOut1 on.
- To raise the touch sensor: Turn #genOut1 off.

This is an example of point job data set to the height measuring point.

set #genOut1	Lower the touch sensor.
waitCondTime 0.5sec	Wait until the sensor finishes descending.
takeZWadj 8	Measure the height. Set the result to [Workpiece Adjustment] No. 8.
reset #genOut1	Raise the touch sensor.
waitCondTime 0.5sec	Wait until the sensor finishes ascending.

- When the air cylinder is mounted on the robot Axis, be sure to add the weight of the air cylinder to the [Tool Weight].

When loading the standard data in the workpiece height adjustment, it is necessary to set the touch sensor at the same position as the height measuring position during actual operation. (See “6.3 [Get Standard Data]” on Page 50)
Prepare point job data for lowering and raising the touch sensor during point teaching.

This is an example of point job data for lowering the touch sensor.

set #genOut1	Lower the touch sensor.

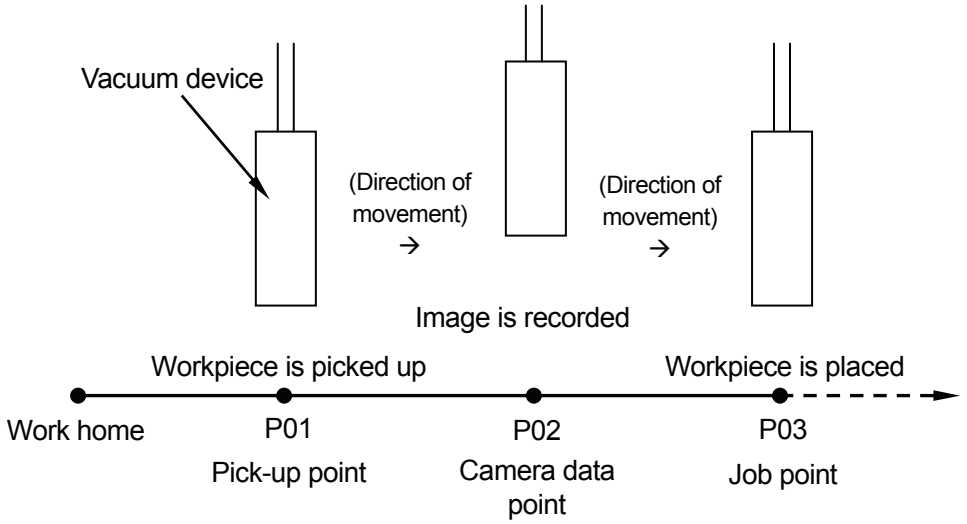
This is an example of point job data for raising the touch sensor.

reset #genOut1	Raise the touch sensor.

Execute the point job data using the [Manual Job Number Setting] function (in the [Teaching Environment Setting] menu) if you are using the teaching pendant. If you are using a PC, select the desired point job in the JOG dialog box.

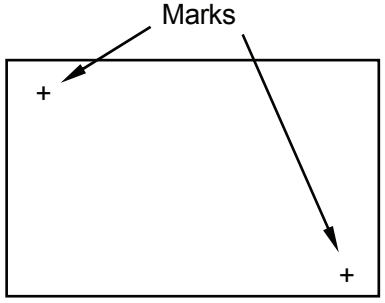
TOOL DATA ADJUSTMENT WITH CAMERA

The camera is attached to the work table and the vacuum device is mounted on the robot Axis as a tool.
The robot picks up the workpiece using the vacuum device (at P01), records an image of the workpiece with the camera attached to the work table (at P02), adjusts the position and angle of the workpiece, and then places it (at P03).



In this case, the tool center position (TCP-X and TCP-Y) at the job point must be adjusted instead of the workpiece position.
Select [Camera A210/A110 Setting TCP] from the additional function data [Point Tool Data Settings] menu. The robot calculates the tool center position with the camera and adjusts the [Tool Data] (TCP-X and TCP-Y) values at the job point.

In this example, the robot, the camera, the controller, the monitor, the keypad, and the power supply are connected as illustrated on the next page and the workpiece shown to the right is used.



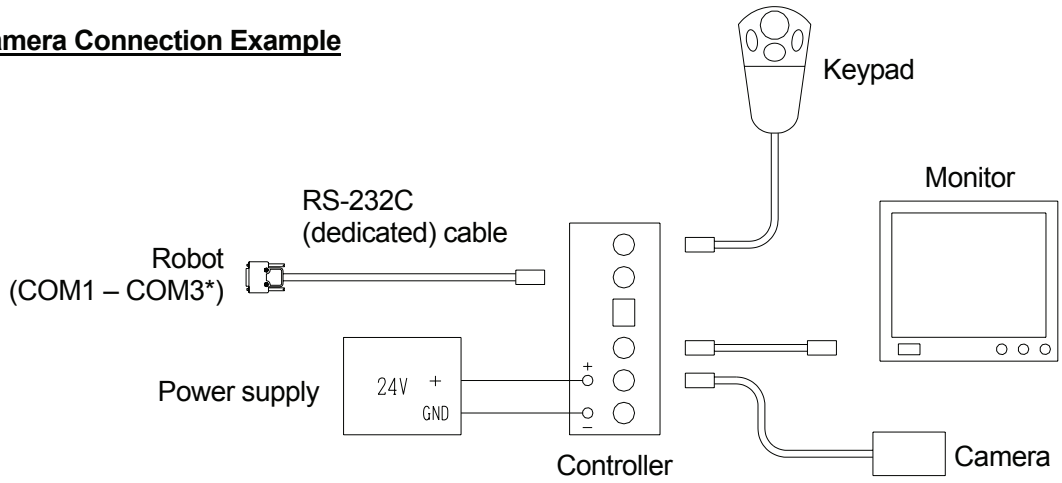
Workpiece Example

Connection

Connect the camera, monitor, and keypad to the controller. Connect the controller to COM1, COM2 or COM3 on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series) with an RS-232C (dedicated) cable.

- Please also refer to the camera instruction manual (Micro-Image Checker A210/A110) for details on the connection procedure.

Camera Connection Example



Be sure to turn the power off before making any connections.

*: If COM1 is connected to the PC, connect the controller to COM2 or COM3. If you are using the TPU (teaching pendant connector) instead of the COM ports, use an RS-422 (dedicated) cable.

■ **Operation Procedures**

Ensure that the camera, controller, monitor, keypad, power supply, and the robot are properly connected, referring to the example on the previous page. Set the workpiece at the position where the job will be carried out, and then create a new program following the procedures below.

1. New program
2. Tool data settings
3. Work home position
4. Point position
5. Preparing and setting point job data
6. Preparation for imaging
7. [Camera A210/A110 Setting TCP]
8. Communication settings
9. Smart Matching Checker settings (preparation for calibration)
10. Calibration settings for [Camera A210/A110 Setting TCP]
11. [Get Standarad Data]
12. [Rotation Apply to R-Axis]
13. Setting [Camera A210/A110 Setting TCP] to the job point
14. Re-registering the job point P03

Steps 7 – 12: Creation process for the additional function data item [Tool Data]

- Step 9 is a camera setting. The other steps are robot settings.

1. New Program

Open a new program.

2. Tool Data Setting

Set [Tool Data] from [Program Data Settings].

- **Tool Weight**

If the camera is mounted on the robot Axis, **set the combined total weight of the tools and the camera as the [Tool Weight].**

- **TCP-X, TCP-Y**

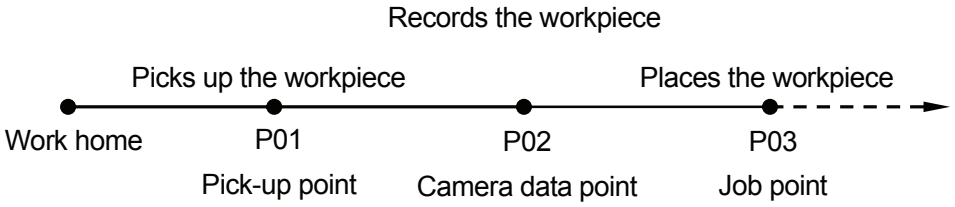
If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

3. Work Home Position

Select [Work Home] from [Program Data Settings] and enter the work home position (coordinates).

4. Point Position

Register the pick-up point (P01), the camera data point (P02), and the point where the point job will be carried out on the workpiece (P03).



Refer to the explanations below for details of each point.

Pick-Up Point (P01)

The workpiece is picked up with the vacuum device at this point.

Camera Data Point (P02)

Set the point job data commands including the camera-related commands to this point.

The robot records the marks on the workpiece with the camera and calculates the deviation from the standard position (P02).

Register this point in front of the point to be adjusted (job point).

Job Point (P03)

Set the additional function data item [Camera A210/A110 Setting TCP] ([Tool Data]) to this point.

The robot adjusts the [Tool Data] (TCP-X and TCP-Y) values set in the [Program Data Settings] according to the deviation calculated at the camera data point (P02).

The job point (P03) position needs to be registered again in accordance with the loaded standard data.

In this step, it is not necessary to register the point position precisely.

5. Preparing and Setting Point Job Data

Create point job data for Points P01, P02, and P03, and then set the data to each point.

5.1 Point Job Data for P01 and P03

5.1.1 Open the two new sets of point job data.

5.1.2 Create point job data for P01 (to pick up the workpiece) and P03 (to place the workpiece) and set the data to P01 (pick-up point) and P03 (job point).

- To pick up the workpiece: Turn #genOut1 on.
- To release the workpiece: Turn #genOut1 off.

This is an example of point job data set to the pick-up point (P01).

downZ 20,10	Lower the tool.
set #genOut1	Start picking up the workpiece.
waitCondTime 0.5sec	Wait until the workpiece is picked up.
upZ 20,10	Raise the tool.

This is an example of point job data set to the job point (P03).

downZ 20,10	Lower the tool.
reset #genOut1	Start releasing the workpiece.
waitCondTime 0.5sec	Wait until the workpiece is placed.
upZ 20,10	Raise the tool.

Execute the point job data for P01 (to pick up the workpiece) and P03 (to place the workpiece) using the [Manual Job Number Setting] function (in the [Teaching Environment Setting] menu) if you are using the teaching pendant.
If you are using a PC, select the desired point job in the JOG dialog box.

5.2 Point Job Data for P02

5.2.1 Open a new set of point job data.

5.2.2 To prevent blurring of the image, set a [Wait Time] before the command to receive the camera data.
In this example, set 0.5sec as the [Wait Time] and the [waitCondTime] command (command category: [if Branch, Wait Condition]).

5.2.3 Enter the command [cameraTool] (command category: [Camera, Z Adjustment]) and the [Tool Number] (tool data number) you wish to use.
When this command is executed, the robot records the image with the camera and adjusts the [Tool Data] (TCP-X and TCP-Y) values set in the [Program Data Settings] according to the deviation calculated at the camera data point (P02).

5.2.4 If a camera-related error occurs, incorrect [TCP-X] and [TCP-Y] values will be set to the coordinates of the job point. Enter a command to specify the action to be carried out in case of camera-related errors.
By using a system flag, you can specify the point job to be executed if a camera-related error occurs.

System Flag	Error No.	Error
No. 31	No. 39	Camera Error (No response)
	No. 40	Camera Data Error

Example of Point Job Data for P02

```
waitCondTime 0.5sec
camaraTool 1
if
   ld #sysFlag(31)
   then
   goRPoint PTP00,2
endIf
```

Wait for 0.5 seconds.
Record the image with the camera.

Refer to System Flag No. 31.
If #sysFlag(31)=1 (true) (if it is an error),
jump to two points ahead (the point next to the job point).

5.2.5 If there are no further commands to be set, the creation process for the point job data for P02 (record an image of the workpiece) is complete. Set the point job data number to P02 (camera data point).

6. Preparation for Imaging

6.1 Shift the robot Arm to P01 (pick-up point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

6.2 Pick up the workpiece using the point job data for P01 (pick up the workpiece).

6.3 Shift the robot Arm to P02 (camera data point) with the workpiece picked up.

7. [Camera A210/A110 Setting TCP]

7.1 Select [Point Tool Data Settings] from the [Additional Function Data Settings] selection screen, and then select [Camera A210/A110 Setting TCP] from the [Point Tool Data Settings] selection screen.
The following items will be displayed:

[Camera A210/A110 Setting TCP] Menu

- [Tool Weight]: The total tool weight mounted on the robot Axis
- [TCP-X]: Distances in the X- and Y-directions from the tool center point to
- [TCP-Y]: the standard tool position or the R-Axis center.
- [TCP-deltaZ]: The difference between the tool tip height when teaching and that during actual operation must be entered here.
- [Direct TCP-XY Setting]: The robot calculates the [TCP-X] and [TCP-Y] values.
- [Camera COM Port]: The COM connector connecting the camera to the robot (control box).
- [Calibration]: Converts the camera coordinates into robot coordinates.
- [Standard Data Setting]: Loads the standard data. During operation, the compensation value is calculated using the loaded standard data.
- [Rotation Apply to R-Axis]: Select whether to rotate the R-Axis ([Rotation Apply to R-Axis]) or not ([Rotation Not Apply to R-Axis]) to adjust the R-Axis angle when there is variation between the loaded data and the standard data during operation.
- [R Rotation]: Set the rotation angle of the R-Axis to be applied when [Rotation Apply to R-Axis] is selected.

7.2 Select [Tool Weight] and **enter the combined total weight of the tools and the workpiece.**

8. Communication Settings

Select [Camera COM Port] from the [Camera A210/A110 Setting TCP] menu, and then select the COM Port that is connected to the camera on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series).

9. Smart Matching Checker Settings (Preparation for Calibration)

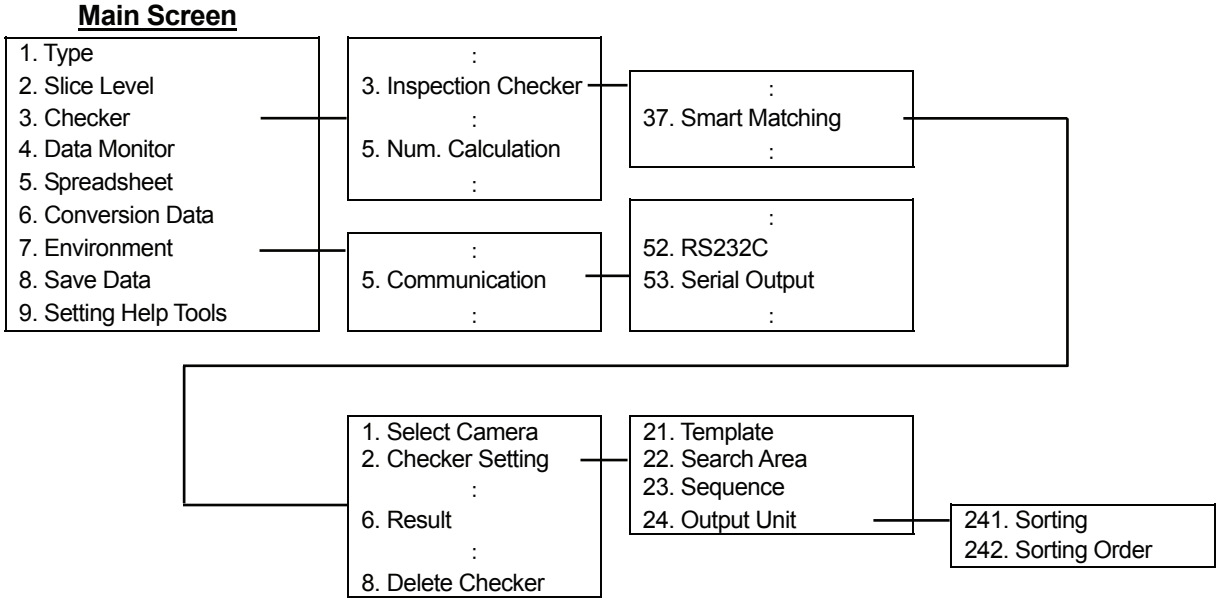
Before you use the camera, the calibration settings (the conversion of the camera coordinates into robot coordinates) should be completed. First, load the mark (image) on the workpiece, then compare it with the robot coordinates and calculate the difference between them. The mark to be loaded is referred to as a ***calibration mark*** in this manual.

In the workpiece example on Page 53, the mark indicating the workpiece position during operation is also used as the *calibration mark*. A different type of mark can be used as the calibration mark as long as the marks fit into the same camera search area.

Shift the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

Turn on the camera and check that the workpiece is displayed on the monitor screen.

To manipulate the camera, press the [ENTER] key (on the keypad) to select (fix) an item, and the [C] key to cancel (return).



9.1 Type Data Number

Select [1. Type] from the main screen and then select a number.

9.2 Communication

Return to the main screen and then select [Environment] to display the Environment menu.

Select [Communication] from the menu and match the serial settings ([RS232C]) with those for one of COM1 – COM3 on the robot (the terminal connected to the camera).

Serial Settings (Camera)	COM1 – COM3 (Robot)	COM1 – COM3 (Robot) Default
Transmission Speed (bps)	Baud Rate	9600
Bit Length	Character Length	8bit
Stop Bit	Stop Bit	2bit
Parity	Parity	–
Flow Control	–	–

9.3 Output Settings

Select [Communication] from the Environment menu and then select [Serial Output]. Set the [Numerical Calculation] to [Output].

9.4 Preparation for Calibration (Camera)

Return to the main screen. Select [Checker] and then select [Inspection Checker].

9.4.1 Select [Smart Matching] and then select a number.

If old data is stored under the number, select [Delete Checker] to delete the old data.

9.4.2 Select [Template] and enclose one of the standard marks with the mouse cursor using the cursor lever on the keypad. The smaller the enclosed area, the shorter the detection time.

9.4.3 Select [Search Area] and set a search area large enough to cover the area in which a workpiece position error may occur.

9.4.4 Select [Sequence] and set [Judgment] according to the level of detail required in the search. (The default setting is a detailed search.)

		Judgment		Result	
Step	Accuracy	Quantity	Correlation	Quantity	Correlation
1ST	16	16	0.60	0	0.00
2ND	8	8	0.60	0	0.00
3RD	4	4	0.60	0	0.00
4TH	2	2	0.60	0	0.00
5TH	S	2	0.60	0	0.00
Rotation		Angle	30deg	Accuracy	1deg

- Depending on the size of the template, the first step accuracy may be changed from [16] to [8] or [4].
- Enter the quantity of marks that you wish to have judged in the last step [S]. In the workpiece example shown below, there are two marks [+] to be judged, therefore, the quantity [2] should be entered for this step [S].

9.4.5 Select [Output Unit]. Set [Sorting] to [X] or [Y] (coordinate) and [Sorting Order] to [Des] (descending order). The marks detected are referred to as *C1* and *C2* respectively in the order they are set. If there are three or more marks, they are referred to as *C3*, *C4*, and so on. These marks are used as calibration marks. Be sure to identify which mark is C1, C2 etc.

9.4.6 Return to the main screen. Select [Checker] and then [Numerical Calculation].

Setting Example

	Model A210	Model A110	
CA01	SM01010	MT01010	Number of the Detected Mark
CA02	SM01012	MT01012	X-coordinate of C1
CA03	SM01013	MT01013	Y-coordinate of C1
CA04	SM01014	MT01014	Rotation angle of C1
CA05	SM01022	MT01022	X-coordinate of C2
CA06	SM01023	MT01023	Y-coordinate of C2
CA07	SM01024	MT01024	Rotation angle of C2

CA01 = SM 01 01 0
(1) (2) (3) (4)

(1) SM: Smart Matching (MT is used for Model A110.)
(2) 01: Checker Number (the number selected in Paragraph 7.4.1)
(3) 01: Object Number (02 indicates two objects.)
(4) 0: Number of detected marks, 2: X-coordinate, 3: Y-coordinate, 4: Rotation angle

The robot loads the values (CA01 – CA07) set here.

9.4.7 Return to the main screen. Select [Checker], [Inspection Checker], [Smart Matching], and then [Result]. The detected mark (image) will be displayed. Check the position of the mark. If multiple marks are detected;

- Press the [B] key on the keypad to display each mark in order of detection.
- Press the [A] key on the keypad to display all the detected marks at the same time.

9.4.8 Return to the main screen. Select [Save Data], and then select [YES]. If you turn the camera off without saving the data, all the settings for the camera will return to the default.

10. Calibration Settings for [Camera A210/A110 Setting TCP]

10.1 Select [Calibration] from the [Camera A210/A110 Setting TCP] menu.
The following items will be displayed:

[Calibration] Menu

- [Direct XY with R Rotation]: There is only one type of calibration for [Camera A210/A110 Setting TCP].
- [Calibration Mark Number]: Number of standard marks for calibration (2 – 6 marks)
- [Get Calibration Mark]: Record the standard data (image) for calibration. Select this parameter after setting the [Calibration Mark Number].
- [Robot Coordinate Position]: Designate the point coordinates of the robot which correspond to the camera coordinates.
- [Looking Down/Looking Up]: Direction in which the camera is facing: up, or down
- [Calculate and Register]: The four coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. Select this parameter after setting the above four items ([Calibration Mark Number] – [Looking xx]).

  - Unit Coefficient: Displays the calculated coordinate conversion amount (K).
  - Rotate Angle: Displays the calculated coordinate conversion amount (ϕ).
  - X Shifting Amount: Displays the calculated coordinate conversion amount (ΔX).
  - Y Shifting Amount: Displays the calculated coordinate conversion amount (ΔY).

  Algebraic Formula for Coordinates

  $X = K * x * \cos(\phi) - K * y * \sin(\phi) + \Delta X$
  $Y = K * x * \sin(\phi) + K * y * \cos(\phi) + \Delta Y$
  $\Theta = \theta + \phi$
  Camera coordinates (x, y, θ), Robot coordinates (X, Y, Θ)

- [Calibrate Position]: The tool center point at the position where the calibration mark is loaded

10.2 Enter [Calibration Mark Number].
In the workpiece example on 53, enter [2] as the number of marks (+) to be detected.

10.3 Check the direction in which the camera is facing ([Looking Down] or [Looking Up]) and then select [Get Calibration Mark]. The robot loads the image according to the Camera Smart Matching Checker settings. (See the previous Section 9)

Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation. Do not change the camera data point coordinates or the camera setting position after the calibration is completed. If the number of the marks recorded by the camera does not coincide with the [Calibration Mark Number], a [Camera Data Error] will be returned.

10.4 Select [Robot Coordinate Position]. C1 and C2 are the coordinates of the marks (+) recorded by the camera in the [Get Calibration Mark] settings. Enter the robot coordinates (TCP) values for P1 and P2.

The entered Cs and Ps are displayed according to the [Calibration Mark Number] settings.

For the camera coordinates, [T] indicates the angle of the mark.

10.5 Select [P1], and then select [Direct TCP-XY Setting].

10.6 Display a mark (e.g. the crosshair cursor) on the monitor screen and set its position. Shift each robot Axis to the point, match the [C1] calibration mark, and then set the coordinates.

Rotate the R-Axis (by approximately 90 degrees) to line up the point and the [C1] calibration mark, and then set the coordinates.

10.7 Select [P2], and then select [Direct TCP-XY Setting]. Set the robot coordinates using [C2].

Accordingly, enter and set the [P] coordinates using the corresponding [C] marks.

10.8 Select [Calculate and Register] from the [Calibration] menu.

The coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. The calculated values are displayed in the [Calibration] menu.

The calibration settings (data conversion) are now complete. The tool should still be holding the workpiece.

11. [Get Standard Data]

In the workpiece example on Page 53, the calibration mark and the mark indicating the workpiece position are the same; therefore, the Smart Matching Checker prepared in the calibration settings (Section 9) can be used. It is not necessary to set the Smart Matching Checker again.

If the shape and the number of marks indicating the position of the workpiece during operation are not the same as those for the calibration mark, you will need to set the Smart Matching Checker again.

Move the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

11.1 Select [Standard Data Setting] from the [Camera A210/A110 Setting TCP] menu.
Set the standard data required to calculate the offset amount during operation.

11.2 Enter the number of marks on the workpiece as the [Standard Mark Number].
In the workpiece example on Page 53, [2] is entered as the number of marks (+).

- Standard Mark Number: Number of standard marks (1 – 7) for adjustment
- Get Standard Data: Record the standard data (image). Select this parameter after setting the [Standard Mark Number].
- P1, P2…: X, Y: The robot coordinates corresponding to the loaded standard data
  T: Angle
  The Ps are displayed according to the [Standard Mark Number] settings.

11.3 Select [Get Standard Data]. The camera records the marks (image) according to the Smart Matching Checker settings. This data is used as the standard workpiece position during operation. If the number of marks recorded by the camera does not correspond to the [Standard Mark Number] settings, an error will be returned.

11.4 The loaded standard data will be displayed in the lines indicated as P1, P2 etc on the screen.
The standard data setting is now complete.
The values calculated according to the standard data are displayed as [TCP-X] and [TCP-Y] in the [Camera A210/A110 Setting TCP] menu. Make a note of these values.

12. [Rotation Apply to R-Axis]

You can select [Rotation Apply to R-Axis] or [Rotation Not Apply to R-Axis] from the [Camera A210/A110 Setting TCP] menu.

If the angle adjustment is not necessary when the workpiece is placed at the job point, select [Rotation Not Apply to R-Axis].
If you select [Rotation Apply to R-Axis], set the difference between the angle of the standard mark and that of the image loaded during operation (“standard mark” minus “loaded image”) as the [R Rotation]. The R-Axis rotates so as to coincide with the standard mark according to the [R Rotation] value.

The creation process for the additional function data item [Camera A210/A110 Setting TCP] ([Point Tool Data Settings]) is now complete.

13. Setting [Camera A210/A110 Setting TCP] to the Job Point

Set (Add) the prepared [Camera A210/A110 Setting TCP] to the job point (P03) where you wish to perform the workpiece adjustment.

14. Re-Registering the Job Point P03

14.1 Select [Tool for Teaching] from the [Teaching Environment Setting] menu.

14.2 Set [Tool for Teaching] to [Valid].

14.3 Set the [Setting Tool for Teaching] items as follows:

- [Tool Weight]: Tool weight + workpiece weight
- [TCP-X] and [TCP-Y]: The [TCP-X] and [TCP-Y] values displayed in the [Camera A210/A110 Setting TCP] menu in Section 11.4 on Page 66.

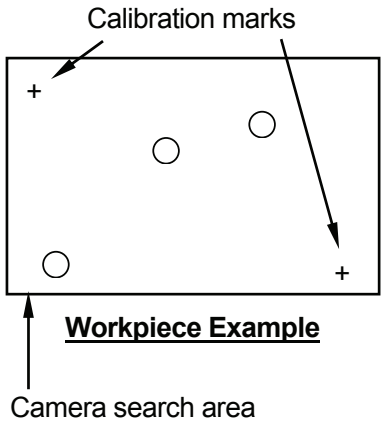
The values set here are referred to as [Tool for Teaching]: tool data valid only for a teaching operation.

14.4 Enter the coordinates of the job point (P03) where you wish to perform the workpiece adjustment, making sure the angle and position of the workpiece are accurate.

All the settings necessary for the tool data adjustment (with camera) are now complete.
Place the workpiece using the point job data for P03 (placing the workpiece) at job point P03.

POINT JOB AT CAMERA DATA POINTS (PALLET)

In the workpiece example shown to the right, the [○] marks indicate the workpieces, and dispensing is carried out at those positions.
Load the numbers and positions by recording an image of the workpieces with the camera, and then carry out the point job.
In this example, the numbers and positions of the workpiece vary in each operation.

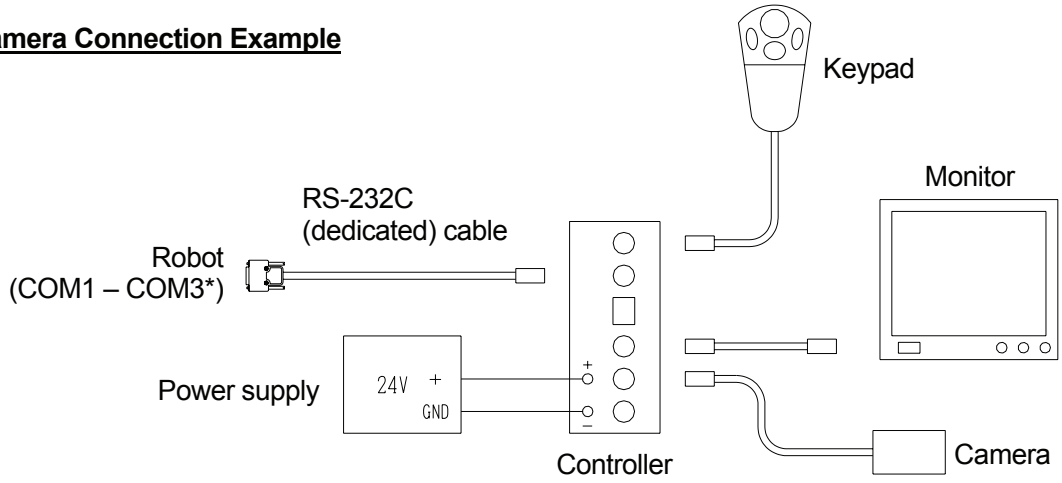


Connection

Connect the camera, monitor, and keypad to the controller. Connect the controller to COM1, COM2 or COM3 on the robot side (on the robot body for the JR2000N and JSR4400N Series, on the control box for the JS and JSG Series) with an RS-232C (dedicated) cable.

- Please also refer to the camera instruction manual (Micro-Image Checker A210/A110) for details on the connection procedure.

Camera Connection Example



Be sure to turn the power off before making any connections.

*: If COM1 is connected to a PC, connect the controller to COM2 or COM3. If you are using the TPU (teaching pendant connector) instead of the COM ports, use an RS-422 (dedicated) cable.

■ **Operation Procedures**

Ensure that the camera, controller, monitor, keypad, power supply, and the robot, are properly connected, referring to the example on the previous page. Set the workpiece at the position where the job is to be carried out, and then create a new program following the procedures below.

1. New program
2. Tool data settings
3. Work home position
4. Point position
5. To the camera data point
6. Open [Repeat by Camera A210/A110]
7. Smart Matching Checker settings
8. [Calibration] settings
9. [Standard Data Setting]
10. [Execute Parameter Setting]

Steps 6 – 10:
Creation process for the additional function data item [Pallet Routine]

11. Setting [Camera A210/A110 Setting TCP] to the job point
12. Creating and setting point job data
    12.1 Creating and setting point job data including camera-related commands
    12.2 Creating and setting point job data including pallet-related commands

● Step 7 is a camera setting. The other steps are robot settings.

1. New Program

Open a new program.

2. Tool Data Settings

Set [Tool Data] from [Program Data Settings].

- **Tool Weight**
  If the camera is mounted on the robot Axis, **set the total combined weight of the tools and the camera as the [Tool Weight].**
- **TCP-X, TCP-Y**
  If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

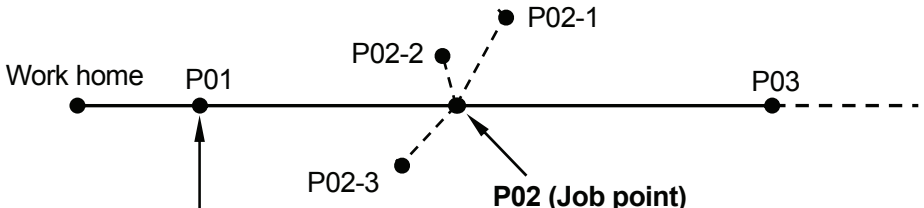
3. Work Home Position

Select [Work Home] from [Program Data Settings] and enter the work home position (coordinates).

4. Point Position

Register the camera data point (P01) and the point where the point job (dispensing) will be carried out on the workpiece (P02).

If the camera is not attached to the robot Axis and the camera position is fixed, it is not necessary to set a particular camera data point. The camera data point (P01) can be any point which point job data can be set to, as long as it is before the job point for the workpiece (the point which [Workpiece Adjustment] has been set to). The camera data point can also be a previously registered job point.



P02 (Job point)

This is the point where point job data, including the commands to control the pallet ([Pallet Control] category), and additional function data [Repeat by Camera A210/110] are set.

After this point is registered, the robot performs the set point job (dispensing in this example) at the marks loaded using the camera (P02-1, P02-2, and P02-3 above).

Camera data point

This is the point which the point job data, including the commands to get the camera data ([Camera, Z Adjustment] category) is set to.

To record images of the workpieces, set the camera data point to a point before the job point which the additional function data item [Repeat by Camera A210/110] is set to (P02 above).

5. To the Camera Data Point

Shift the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

6. Opening [Repeat by Camera A210/A110]

6.1 Select [Pallet Routine Data Settings] from the [Additional Function Data Settings] selection screen, and then select [Repeat by Camera A210/A110] from the [Pallet Routine Type] selection screen. The following items will be displayed:

[Repeat by Camera A210/A110] Menu

- [Auto Increment]: This is the [Counter Control Type] for controlling the pallet counter: Select either [Auto Increment] or [Increment by Point Job].
- [Camera COM Port]: This is the COM connector on the robot (control box) which is connected to the camera.
- [Calibration]: Converts the camera coordinates into robot coordinates.
- [Standard Data Setting]: Loads the standard data. During operation, the compensation value is calculated using the loaded standard data.
- [Execute Parameter Setting]: Designates the motion at the time when the workpiece adjustment is carried out.
- [Display Adjustment]: Displays the workpiece adjustment amount calculated by performing [Test Run] or [Point Run].

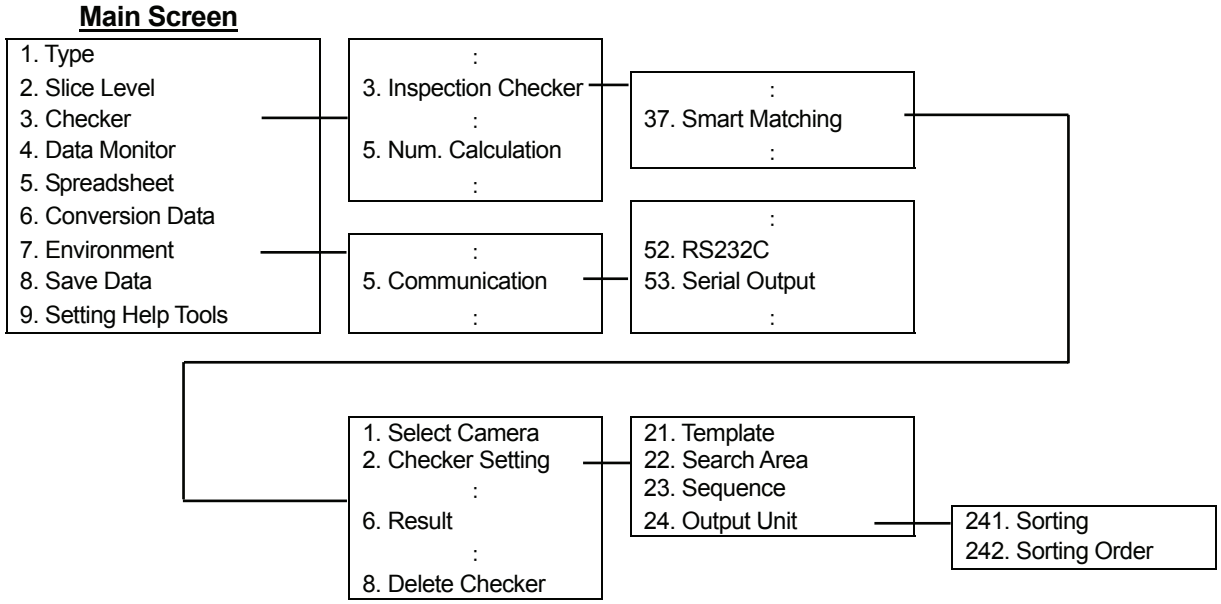
6.2 Enter [Counter Control Type] and [Maximum Workpiece Number] (the maximum number of [○] marks) that can be detected at one time. The [Maximum Workpiece Number] that can be entered is 100.

- If the number of marks loaded during operation is greater than the set [Maximum Workpiece Number], a [Camera Data Error] will be returned.

7. Smart Matching Checker Settings

Turn on the camera and check that the workpiece is displayed on the monitor screen.

To manipulate the camera, press the [ENTER] key (on the keypad) to select (fix) an item, and the [C] key to cancel (return).



7.1 Type Data Number

Select [1. Type] from the main screen and then select a number.

7.2 Communication

Return to the main screen and then select [Environment]. The Environment menu will appear.

Select [Communication] from the menu and match the serial settings ([RS232C]) with those for one of COM1 – COM3 on the robot (the terminal connected to the camera).

Serial Settings (Camera)	COM1 – COM3 (Robot)	COM1 – COM3 (Robot) Default
Transmission Speed (bps)	Baud Rate	9600
Bit Length	Character Length	8bit
Stop Bit	Stop Bit	2bit
Parity	Parity	–
Flow Control	–	–

7.3 Output Settings

Select [Communication] from the Environment menu and then select [Serial Output]. Set [Numerical Calculation] to [Output].

7.4 Preparation for Calibration (Camera)

Return to the main screen. Select [Checker] and then select [Inspection Checker].

7.4.1 Select [Smart Matching] and then select a number.
If old data is stored under the number, select [Delete Checker] to delete the old data.

7.4.2 Select [Template] and enclose one of the standard marks with the mouse cursor using the cursor lever on the keypad. The smaller the enclosed area, the shorter the detection time.

7.4.3 Select [Search Area] and set a search area large enough to cover the area in which a workpiece position error may occur.

7.4.4 Select [Sequence] and set [Judgment] according to the level of detail required in the search. (The default setting is a detailed search.)

		Judgment		Result	
Step	Accuracy	Quantity	Correlation	Quantity	Correlation
1ST	16	16	0.60	0	0.00
2ND	8	8	0.60	0	0.00
3RD	4	4	0.60	0	0.00
4TH	2	2	0.60	0	0.00
5TH	S	2	0.60	0	0.00
Rotation		Angle	30deg	Accuracy	1deg

- Depending on the size of the template, the first step accuracy may be changed from [16] to [8] or [4].
- Enter the quantity of marks that you wish to have judged in the last step [S]. In the workpiece example shown below, there are two marks [+] to be judged, therefore, the quantity [2] should be entered for this step [S].

7.4.5 Select [Output Unit]. Set [Sorting] to [X] or [Y] (coordinate) and [Sorting Order] to [Des] (descending order). The marks detected are referred to as *C1* and *C2* respectively in the order they are set. If there are three or more marks, they are referred to as *C3*, *C4*, and so on. These marks are used as calibration marks. Be sure to identify which mark is C1, C2 etc.

7.4.6 Return to the main screen. Select [Checker] and then [Numerical Calculation].

Setting Example

	Model A210	Model A110	
CA01	SM01010	MT01010	Number of the Detected Mark
CA02	SM01012	MT01012	X-coordinate of C1
CA03	SM01013	MT01013	Y-coordinate of C1
CA04	SM01014	MT01014	Rotation angle of C1
CA05	SM01022	MT01022	X-coordinate of C2
CA06	SM01023	MT01023	Y-coordinate of C2
CA07	SM01024	MT01024	Rotation angle of C2

CA01 = SM 01 01 0
(1) (2) (3) (4)

(1) SM: Smart Matching (MT is used for Model A110.)
(2) 01: Checker Number (the number selected in Paragraph 7.4.1)
(3) 01: Object Number (02 indicates two objects.)
(4) 0: Number of detected marks, 2: X-coordinate, 3: Y-coordinate, 4: Rotation angle

The robot loads the values set here (CA01 – CA07).

7.4.7 Return to the main screen. Select [Checker], [Inspection Checker], [Smart Matching], and then [Result]. The detected mark (image) will be displayed. Check the position of the mark. If multiple marks are detected;

- Press the [B] key on the keypad to display each mark in the order of detection.
- Press the [A] key on the keypad to display all the detected marks at the same time.

7.4.8 Return to the main screen. Select [Save Data], and then select [YES]. If you turn the camera off without saving the data, all the settings for the camera will return to the default.

8. [Calibration] Settings

Load the calibration mark in the camera search area ([Get Calibration Mark]), compare the position of the calibration mark with the [Robot Coordinate Position], and calculate the difference between the camera coordinates and the robot coordinates ([Calculate and Register]).

8.1 Select [Calibration] from the [Pallet Routine Data Settings] menu.
The following items will be displayed:

[Calibration] Menu

- Fixed Taking Position: One of the calibration modes: Refer to "XY ADJUSTMENT WITH CAMERA, CHANGE OF TAKING POSITION" on Page 15.
- Calibration Mark Number: Number of standard marks for calibration (2 – 6 marks)
- Get Calibration Mark: Record the standard data (image) for calibration. Select this parameter after setting the [Calibration Mark Number].
- Robot Coordinate Position: Designate the robot point coordinates corresponding to the camera coordinates.
- Looking Down/Looking Up: Direction in which the camera is facing: up, or down
- Calculate and Register: The four coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. Select this parameter after setting the above four items ([Calibration Mark Number] – [Looking xx]).

  - Unit Coefficient: Displays the calculated coordinate conversion amount (K).
  - Rotate Angle: Displays the calculated coordinate conversion amount (ϕ).
  - X Shifting Amount: Displays the calculated coordinate conversion amount (ΔX).
  - Y Shifting Amount: Displays the calculated coordinate conversion amount (ΔY).

  Algebraic Formula for Coordinates

  $X = K * x * \cos(\phi) - K * y * \sin(\phi) + \Delta X$
  $Y = K * x * \sin(\phi) + K * y * \cos(\phi) + \Delta Y$
  $\Theta = \theta + \phi$
  Camera coordinates (x, y, θ), Robot coordinates (X, Y, Θ)

- Calibrate Position: The tool center point at the position where the calibration mark is loaded

8.2 Enter [Calibration Mark Number].
In the workpiece example on Page 69, enter [2] as the number of marks (+) to be detected.

8.3 Select [Get Calibration Mark]. The robot loads the image according to the Camera Smart Matching Checker settings. (See the previous Section 7)

Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation. Do not change the camera data point coordinates or the camera setting position after the calibration is completed. If the number of marks recorded by the camera does not coincide with the [Calibration Mark Number], a [Camera Data Error] will be returned.

8.4 Check the direction in which the camera is facing ([Looking Down] or [Looking Up]) and enter the [Robot Coordinate Position]. C1 and C2 are the coordinates of the marks (+) recorded by the camera in the [Get Calibration Mark] settings. Assign the C1 and C2 coordinate values to P1 and P2 as the robot coordinates.

Select [P1], line up the tool center point of the robot with the [C1] mark and then set the coordinates.

Accordingly, enter and set the [P] coordinates using the corresponding [C] marks.

The camera coordinate axes and the robot coordinate axes are sometimes not aligned. Be sure to confirm which mark is C1 before you enter the corresponding robot coordinates.

The entered Cs and Ps are displayed according to the [Calibration Mark Number] settings.

For the camera coordinates, [T] indicates the angle of the mark.

8.5 Select [Calculate and Register] from the [Calibration] menu. The coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. The calculated values are displayed as the following items:

- Unit Coefficient
- Rotate Angle
- X Shifting Amount
- Y Shifting Amount

The calibration settings (data conversion) are now complete.

9. [Standard Data Setting]

Shift the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

If there are multiple workpieces ([○] marks) within the camera search area, cover them with tape so that only one workpiece will be detected. If multiple workpieces are detected, a [Camera Data Error] will be returned. (The [Standard Mark Number] is limited to [1] in this example.)

Select [Get Standard Data]. The camera records the marks (image) according to the Smart Matching Checker settings. This data is used as the standard workpiece position during operation.

Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation.

If [Get Standard Data] is successfully completed, the loaded standard data coordinates will be displayed.

- The standard data coordinates can only be changed by selecting [Get Standard Data].

- It is recommended that you register the camera data point position before creating the [Pallet Routine].

  Note that the position coordinates of the camera data point can be referred to after the [Pallet Routine] has been created; however, the coordinate values of the tool center point position loaded by selecting [Get Standard Data] cannot be referred to after the [Pallet Routine] has been created.

10. [Execute Parameter Setting]

Check the following [Execute Parameter Setting] items:

- Fixed Taking Position: The maximum number of marks that can be loaded using the camera during operation.
- Rotation Apply to R-Axis (Rotation Not Apply to R-Axis):
  The rotation of the workpiece (T) is (is not) applied to the R-Axis.
  If the angle of the workpiece does not correspond to that of the standard data, the R-Axis rotates (does not rotate) according to the workpiece angle.

The creation process for the additional function data item [Repeat by Camera A210/A110] ([Pallet Routine Data Settings]) is now complete.

11. Setting [Camera A210/A110 Setting TCP] to the Job Point

Set (Add) the prepared [Repeat by Camera A210/A110] to the job point which you wish to set the pallet to.

12. Creating and Setting Point Job Data

12.1 Creating and Setting Point Job Data including Camera-Related Commad

12.1.1 To prevent blurring of the image, set a [Wait Time] before the command to receive the camera data.
In this example, set 0.5sec as the [Wait Time], and the [waitCondTime] command (command category: [if Branch, Wait Condition]).

12.1.2 Enter the command [cameraPallet] that you wish to use (command category: [Camera, Z Adjustment]) and the prepared [Pallet Routine Number].
When this command is executed, the robot records the image with the camera, stores the numbers and coordinates of the loaded marks, and then resets the pallet counter.

12.1.3 A [Camera Data Error] will be returned if the number of the loaded marks is greater than the set [Maximum Workpiece Number], or if no mark is loaded.
Enter a command to specify the action to be carried out in case of camera-related errors.
By using a system flag, you can specify the point job to be executed if a camera-related error occurs.

System Flag	Error No.	Error
No. 31	No. 39	Camera Error (No response)
	No. 40	Camera Data Error

Example of Point Job Data for P02

```
waitCondTime 0.5sec
camaraPallet 1
if
   ld #sysFlag(31)
   then
   goRPoint PTP00,2
endIf
```

Wait for 0.5 seconds.
Record the image with the camera.

Refer to System Flag No. 31.
If #sysFlag(31)=1 (true) (if it is an error),
jump to two points ahead (the point next to the job point).

If there are no further commands to be set, the creation process for the point job data, including the camera-related command, is complete. Set the point job data number to P01 (camera data point).

12.2 Creating and Setting Point Job Data including Pallet-Related Commands

Set the point job data including the commands to control the pallet counter to the job point.

First, enter the point job you wish to perform (e.g. dispensing or screw tightening) at the job point. Then, enter the following pallet-related commands:

- [loopPallet] (Pallet loop): Add 1 to the pallet counter. If the pallet counter is at less than the maximum value, jump to the specified point.
- [resPallet] (Reset pallet): Reset the pallet counter (0).
- [incPallet] (Increase pallet): Increase the pallet counter number (+1).

- It is not necessary to set these commands when [Auto Increment] is selected as the [Counter Control Type].
- The pallet counter is reset when [Get Standard Data] is performed. Note that the pallet-related commands cannot be set to points which the camera-related commands are set to.
- If the point type for the job point (P02 in this example) is not [Point Dispense], it is necessary to set commands to perform dispensing as well as the pallet-related commands.

Example of Point Job Data including Pallet-Related Commands

```
      :
loopPallet 1,7
```

Add 1 to the pallet counter of Pallet Routine Number 1. If the count is less than the number of marks loaded at the camera data point, jump to P07.

```
      :
incPallet 1
if
   ld #palletFlag(1)
else
   goPoint PTP00,7
endIf
```

The above point job data can be written as shown to the left if [loopPallet] is not used.
(The pallet flag (#palletFlag) is true (1) if the count is at the maximum.)

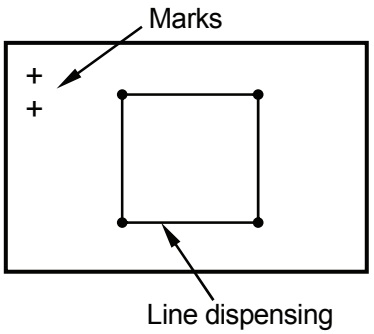
If there are no further commands to be set, the creation process for the point job data, including the pallet-related command, is complete. Set the point job data number to P02 (job point).

All the settings necessary for performing the point job at the camera data point ([Pallet Routine]) are now complete.

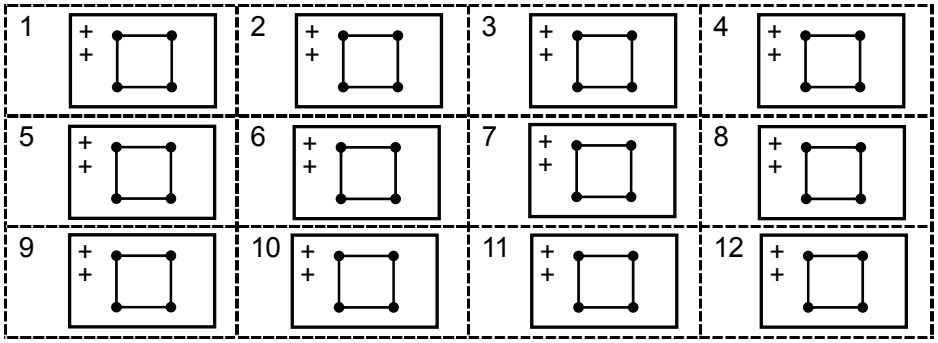
WORK ADJUSTMENT WITH CAMERA (PALLET)

In this example, the workpiece shown to the right is placed on the pallet as illustrated below.
To draw a square by performing a line dispensing on each workpiece, record an image of the workpiece with camera, adjust the workpiece position, draw a square by line dispensing, and shift to the next workpiece.
Repeat the procedure once for each workpiece.

Workpiece Example



(Pallet)
Row: 4
Column: 3



Ensure the camera, controller, monitor, keypad, power supply, and the robot are properly connected, referring to the example on the previous page. Set the workpiece at the position where the job is to be carried out, and then create a new program following the procedures below.

1. New program
2. Tool data settings
3. Work home position
4. Point position
5. Creating and setting [Pallet Routine Data]
6. [Workpiece Adjustment Settings]
7. Smart Matching Checker settings
8. [Calibration] settings
9. [Get Standard Data]
10. [Execute Parameter Setting]

Steps 6 – 10:
Creation process for the additional function data item [Workpiece Adjustment Settings]

11. Setting the [Workpiece Adjustment Settings] to the job point
12. Creating and setting point job data
    12.1 Point job data set to P01 (camera data point)
    12.2 Point job data set to P06 ([CP End Point] or [End of Line Dispense])

- Step 7 is a camera setting. The other steps are robot settings.

1. New Program

Open a new program.

2. Tool Data Settings

Set [Tool Data] from [Program Data Settings].

- **Tool Weight**

  If the camera is mounted on the robot Axis, **set the combined total weight of the tools and the camera as the [Tool Weight].**
- **TCP-X, TCP-Y**

  If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

3. Work Home Position

Select [Work Home] from the [Program Data Settings] and enter the work home position (coordinates).

4. Point Position

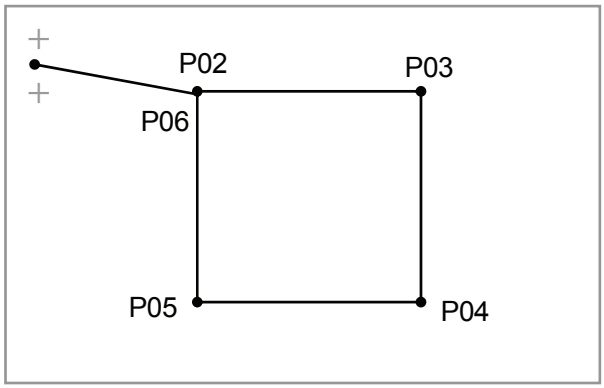
Register the camera data point (P01) and the points where the point job (dispensing) will be carried out on the workpiece (P02 – P06).

Points P01 – P06 will be run repeatedly on the pallet.

Camera Data Point (P01)

This is the point which the point job data, including the commands to get the camera data ([Camera, Z Adjustment] category), is set to. At this point, the robot gets the camera image, and then calculates the difference between the standard coordinates and the current workpiece position. Set the camera data point to a point before the job point for the workpiece (to get the camera image).

P01: [PTP Point]
P02: [CP Start Point] or [Start of Line Dispense]
P03: [CP Passing Point] or [Line Passing]
P04: [CP Passing Point] or [Line Passing]
P05: [CP Passing Point] or [Line Passing]
P06: [CP End Point] or [End of Line Dispense]



Job Points (P02 – P06)

Set the additional function data [Workpiece Adjustment Settings] and [Pallet Routine Data Settings] to P02 ([CP Start Point] or [Start of Line Dispense]).

When the robot Arm shifts in CP drive, the additional function set to the start point affects all the points through the end point. It is necessary to set [Workpiece Adjustment Settings] and [Pallet Routine Data Settings] to each job point.

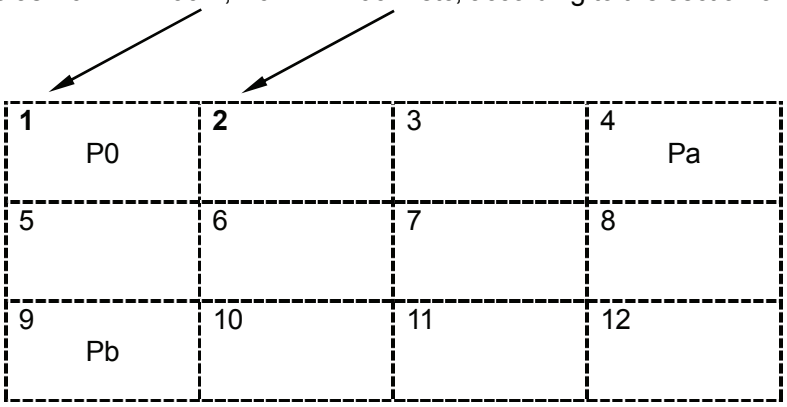
If [Workpiece Adjustment Settings] is set to P06 ([CP End Point] or [End of Line Dispense]), the next operation from P02 ([CP Start Point] or [Start of Line Dispense]) to P06 ([CP End Point] or [End of Line Dispense]) will be affected.

5. Creating and Setting [Pallet Routine Data]

5.1 For example, register the pallet as illustrated below.

Points P01 – P06 are referred to as P01-**1** – P06-**1**, P01-**2** – P06-**2** etc, according to the section of the pallet they are set to.

[Pallet Routine Number]: 1
[Pallet Routine Type]:
[Plane Pallet]
[Counter Control Type]:
[Increment by Point Job]
[Number of Rows]: 4
[Number of Columns]: 3



In this example, the coordinates P0 (P01-1), Pa (P01-4), and Pb (P01-9) are necessary to set the distance between the pallets.

The coordinates P0, Pa, and Pb can be set to any point (e.g. P02-1, P02-4, and P02-9) if the distances between P0 – Pa and P0 – Pb are the same as shown above.

5.2 Set (Add) the prepared [Workpiece Adjustment] to job points P01 (camera data point) and P02 ([CP Start Point] or [Start of Line Dispense]).

- If the job points P02 – P06 are all PTP points, you need to set the same [Workpiece Adjustment] to each job point (P01 – P06) to run the points on the pallet repeatedly.

6. [Workpiece Adjustment Settings]

Select [Workpiece Adjustment Settings] from the [Additional Function Data Settings] menu.

Enter a new [Workpiece Adjustment] number and then select [Camera A210/A110 Adjustment] for the workpiece adjustment type ([Work Adjustment Type]).

7. Smart Matching Checker Settings (Preparation for Calibration)

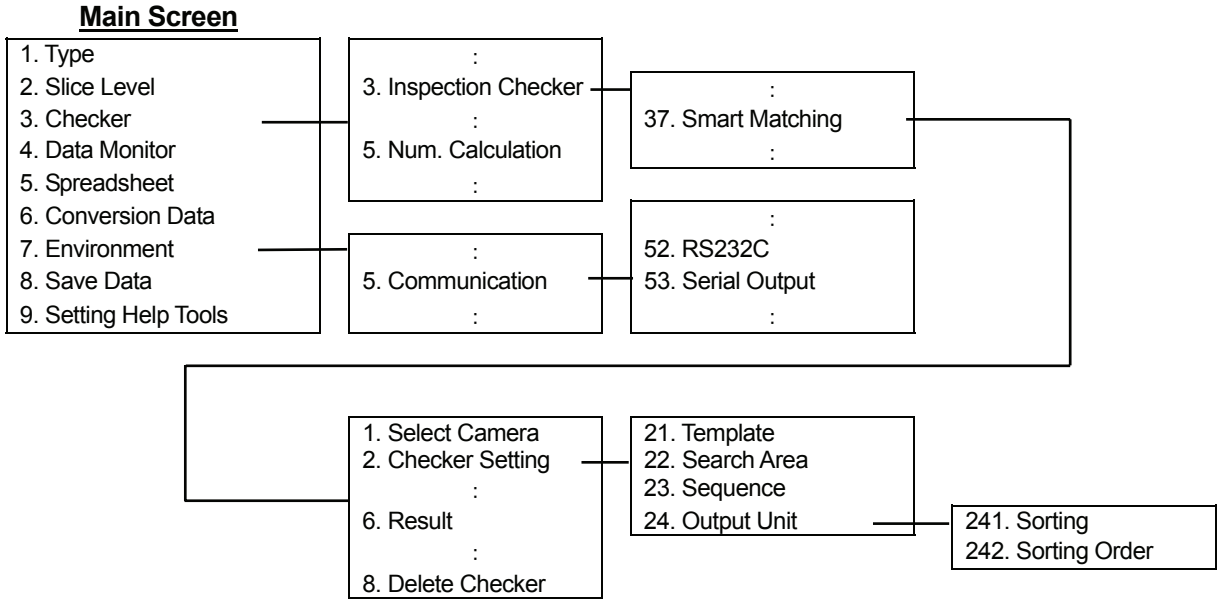
Before the camera is used, the calibration settings (the conversion of the camera coordinates into robot coordinates) should be completed. First, load the mark (image) on the workpiece, then compare it with the robot coordinates and calculate the difference between them. The mark to be loaded is referred to as a ***calibration mark*** in this manual.

In the workpiece example on Page 82, the mark indicating the workpiece position during operation is also used as the *calibration mark*.

Shift the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

Turn on the camera and check that the workpiece is displayed on the monitor screen.

To manipulate the camera, press the [ENTER] key (on the keypad) to select (fix) an item, and the [C] key to cancel (return).



7.1 Type Data Number

Select [1. Type] from the main screen, and then select a number.

7.2 Communication

Return to the main screen and then select [Environment] to display the Environment menu.

Select [Communication] from the menu and match the serial settings ([RS232C]) with those for one of COM1 – COM3 on the robot (the terminal connected to the camera).

7.3 Output Settings

Select [Communication] from the Environment menu and then select [Serial Output]. Set the [Numerical Calculation] to [Output].

7.4 Preparation for Calibration (Camera)

Return to the main screen. Select [Checker] and then select [Inspection Checker].

7.4.1 Select [Smart Matching] and then select a number.
If old data is stored under the number, select [Delete Checker] to delete the old data.

7.4.2 Select [Checker Setting] and press the [A] key on the keypad to record the image.

7.4.3 Select [Template] and enclose one of the standard marks with the mouse cursor using the cursor lever on the keypad. The smaller the enclosed area, the shorter the detection time.

7.4.4 Select [Search Area] and set a search area large enough to cover the area in which a workpiece position error may occur.

7.4.5 Select [Sequence] and set [Judgment] according to the level of detail required in the search. (The default setting is a detailed search.)

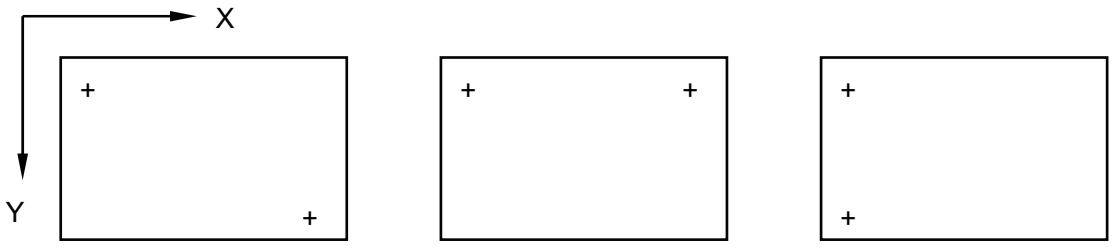
		Judgment		Result	
Step	Accuracy	Quantity	Correlation	Quantity	Correlation
1ST	16	16	0.60	0	0.00
2ND	8	8	0.60	0	0.00
3RD	4	4	0.60	0	0.00
4TH	2	2	0.60	0	0.00
5TH	S	2	0.60	0	0.00
Rotation		Angle	30deg	Accuracy	1deg

- Depending on the size of the template, the first step accuracy may be changed from [16] to [8] or [4].
- Enter the quantity of marks that you wish to have judged in the last step [S]. In the workpiece example on Page 82, there are two marks [+] to be judged, therefore, the quantity [2] should be entered for this step [S].

7.4.6 Select [Output Unit]. Set [Sorting] to [X] or [Y] (coordinate) and [Sorting Order] to [Des] (descending order). The marks detected are referred to as *C1* and *C2* respectively in the order they are set. If there are three or more marks, they are referred to as *C3*, *C4*, and so on. These marks are used as calibration marks. Be sure to identify which mark is C1, C2 etc.

Set [Sorting] referring to the examples below:

Example 1: Both the X- and Y- coordinates are possible.
Example 2: X-coordinate (If the Y-coordinate is used, it is hard to identify which mark is C1.)
Example 3: Y-coordinate (If the X-coordinate is used, it is hard to identify which mark is C1.)



e.g. 1 e.g. 2 e.g. 3

7.4.7 Return to the main screen. Select [Checker] and then [Numerical Calculation].

Setting Example

	Model A210	Model A110	
CA01	SM01010	MT01010	Number of the Detected Mark
CA02	SM01012	MT01012	X-coordinate of C1
CA03	SM01013	MT01013	Y-coordinate of C1
CA04	SM01014	MT01014	Rotation angle of C1
CA05	SM01022	MT01022	X-coordinate of C2
CA06	SM01023	MT01023	Y-coordinate of C2
CA07	SM01024	MT01024	Rotation angle of C2

CA01 = SM 01 01 0
(1) (2) (3) (4)

(1) SM: Smart Matching (MT is used for Model A110.)
(2) 01: Checker Number (the number selected in Paragraph 7.4.1)
(3) 01: Object Number (02 indicates two objects.)
(4) 0: Number of detected marks, 2: X-coordinate, 3: Y-coordinate, 4: Rotation angle

The robot loads the values set here (CA01 – CA07).

7.4.8 Return to the main screen. Select [Checker], [Inspection Checker], [Smart Matching], and then [Result]. The detected mark (image) will be displayed. Check the position of the mark. If multiple marks are detected;

- Press the [B] key on the keypad to display each mark in the order of detection.
- Press the [A] key on the keypad to display all detected marks at the same time.

7.4.9 Return to the main screen. Select [Save Data], and then select [YES]. If you turn the camera off without saving the data, all the camera settings will return to the default.

8. [Calibration] Settings

Load the calibration mark in the camera search area ([Get Calibration Mark]), compare the position of the calibration mark with the [Robot Coordinate Position], and calculate the difference between the camera coordinates and the robot coordinates ([Calculate and Register]).
Select [Calibration] from the [Camera A210/A110 Adjustment] menu ([Workpiece Adjustment]).

8.1 Change the calibration mode ([Fixed Taking Position]) to [Change of Camera Position (x)] according to the position (x) where the camera is attached.
Even if the calibration position and the camera data point are different, the robot coordinates are calculated back, and then the coordinate converting amount and the standard mark position are recalculated to perform the [Workpiece Adjustment] on another job point.

8.2 Enter [Calibration Mark Number].
In the workpiece example on Page 82, enter [2] as the number of marks (+) to be detected.

8.3 Select [Get Calibration Mark]. The robot loads the image according to the Camera Smart Matching Checker settings. (See the previous Section 7)
Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation. Do not change the camera data point coordinates or the camera setting position after the calibration is completed. If the number of the marks recorded by the camera does not correspond to the [Calibration Mark Number], a [Camera Data Error] will be returned.

8.4 Check the direction in which the camera is facing ([Looking Down] or [Looking Up]) and enter the [Robot Coordinate Position]. C1 and C2 are the coordinates of the marks (+) recorded by the camera in the [Get Calibration Mark] settings. Assign the C1 and C2 coordinate values to P1 and P2 as the robot coordinates.
Select [P1], line up the tool center point of the robot with the [C1] mark and then set the coordinates.
Accordingly, enter and set the [P] coordinates using the corresponding [C] marks.

The camera coordinate axes and the robot coordinate axes are sometimes not aligned. Be sure to confirm which mark is C1 before you enter the corresponding robot coordinates.

The entered Cs and Ps are displayed according to the [Calibration Mark Number] settings.
For the camera coordinates, [T] indicates the angle of the mark.

8.5 Select [Calculate and Register] from the [Calibration] menu. The coefficients used to convert the camera coordinates into robot coordinates are calculated and registered. The calculated values are displayed as the following items:

- Unit Coefficient
- Rotate Angle
- X Shifting Amount
- Y Shifting Amount

The calibration settings (data conversion) are now complete.

9. [Get Standard Data]

Shift the robot Arm to P01 (camera data point). Press the [GO] key and the enable switch simultaneously to shift the Arm to the displayed coordinates.

In the workpiece example on Page 82, the calibration mark and the mark indicating the workpiece position are the same; therefore, the Smart Matching Checker prepared in the calibration settings (Section 7) can be used. It is not necessary to set the Smart Matching Checker again.
If the shape and the number of the marks indicating the workpiece position during operation are not the same as those of the calibration mark, it will be necessary to set the Smart Matching Checker again.

9.1 Select [Standard Data Setting] from the [Camera A210/110 Adjustment] menu.
Set the standard data required for calculating the offset amount during operation.

9.2 Enter the number of marks on the workpiece as the [Standard Mark Number].
In the workpiece example on Page 82, [2] is entered as the number of marks (+).

9.3 Select [Get Standard Data]. The robot records the marks (image) with the camera according to the Smart Matching Checker settings. This data is used as the standard workpiece position during operation. If the number of marks recorded by the camera does not correspond to the [Standard Mark Number] settings, an error will be returned.
Be sure to record the image in the same way (i.e. using the same workpiece, workpiece position, and camera position) as you do during actual operation.

9.4 The loaded standard data will be displayed in the lines indicated as P1, P2 etc on the screen.
The standard data setting is now complete.

10. [Execute Parameter Setting]

Select [Execute Parameter Setting] from the [Camera A210/A110 Adjustment] menu. Select the item you wish to change.

Creation of the additional function data item [Workpiece Adjustment] (described in Sections 6 – 10) is now complete.

11. Setting the [Workpiece Adjustment] to the Job Point

Set (Add) the prepared [Work Adjustment Number] to the job point where you wish to perform the workpiece adjustment.

- If all the job points P02 – P06 are PTP points, you need to set the same [Work Adjustment Number] to each job point P01 – P06 to adjust the workpiece position on the points.

12. Creating and Setting Point Job Data

12.1 Point Job Data Set to P01 (camera data point)

Open a new set of point job data.

By using a system flag, you can specify the point job to be executed if a camera-related error occurs.

e.g. Program Termination

If a [Camera Data Error] occurs, the robot will sound the buzzer and terminate the program.

```
waitCondTime 0.5sec
camaraWadj 1
if
   ld #sysFlag(31)
then
   set #FBZ
   waitCondTime 3sec
   reset #FBZ
   goPoint PTP00,0
endIf
```

Wait for 0.5 seconds to prevent blurring of the image.
Record the image with the camera.

Refer to System Flag No. 31.
If a camera data error occurs,
  Sound the buzzer.
  Wait for 3 seconds.
  Stop the buzzer.
  Move to the work home and the program terminates.

e.g. Restart from the Same Point

If a [Camera Data Error] occurs, the robot will sound the buzzer and stand by for start instructions at the same point.

```
waitCondTime 0.5sec
camaraWadj 1
if
   ld #sysFlag(31)
then
   waitStartBZ
   goPoint PTP00,1
endIf
```

Wait for 0.5 seconds to prevent blurring of the image.
Record the image with the camera.

Refer to System Flag No. 31.
If a camera data error occurs,
  Sound the buzzer and stand by for start instructions at the same point.
  Move to P01* after receiving the start signal.

*: In this example, P01 is the current (same) point, as the command to increase the pallet counter (+1) is not included in the point job data. (See Section 12.2 on Page 80 for details of the pallet-related commands.)

If the current point is P01-1, the first point job data set to the same point (P01-1) is reexecuted.

e.g. To the Next Point

If a [Camera Data Error] occurs, the robot Arm will move to the next workpiece.

```
waitCondTime 0.5sec
camaraWadj 1
if
   ld #sysFlag(31)
then
   loopPallet 1,1
   goPoint PTP00,0
endIf
```

Wait for 0.5 seconds to prevent blurring of the image.
Record the image with the camera.

Refer to System Flag No. 31.
If a camera data error occurs,
Add [1] to the counter of Pallet No. 01, and go to P01* if the count is less than the maximum value.
If the count is at the maximum value, go to the work home.

*: In this example, P01 is the next point, as the command to increase the pallet counter (+1) is included in the point job data. (See Section 12.2 on Page 80 for details of the pallet-related commands.)

If the current point is P01-1, the robot Arm will move to P01-2.

e.g. Restart from the Next Point

If a [Camera Data Error] occurs, the robot Arm will move to the next workpiece.

```
waitCondTime 0.5sec
camaraWadj 1
if
   ld #sysFlag(31)
then
   waitStartBZ
   loopPallet 1,1
   goPoint PTP00,0
endIf
```

Wait for 0.5 seconds to prevent blurring of the image.
Record the image with the camera.

Refer to System Flag No. 31.
If a camera data error occurs,
Stand by for the start signal at that point.
After the start signal is received, add [1] to the counter of Pallet No. 1 and go to P01* if the count is less than the maximum value.
If the count is at the maximum value, go to the work home.

*: In this example, P01 is the next point, as the command to increase the pallet counter (+1) is included in the point job data. (See Section 12.2 on Page 80 for details of the pallet-related commands.)

If the current point is P01-1, the robot Arm moves to P01-2.

12.2 Point job data set to P06 ([CP End Point] or [End of Line Dispense])

Press the MENU key to select [Point Job Settings] from the menu screen, and then enter a new [Point Job Number] to create new point job data.

e.g.

loopPallet 1,1	Add [1] to the counter of Pallet No. 01. If the count is at the maximum value, execute the next command. (In this example, the program terminates since there are no more commands in the point job data.) If the count is less than the maximum value, go to P01*.

*: In this example, P01 is the next point, as the command to increase the pallet counter (+1) is included in the point job data. (See Section 12.2 on Page 80 for details of the pallet-related commands.)

If the current point is P01-1, the robot Arm moves to P01-2.

If P06 is a [CP End Point], enter the command to turn off the dispenser before the [loopPallet] command.

If P02 is a [CP Start Point], set the point job data, including the command to turn on the dispenser, to P02.

All the settings necessary for adjusting the workpiece position on the pallet with the camera are now complete.

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