JANOME DESKTOP ROBOT

JR3000 Series

JANOME CARTESIAN ROBOT

JC-3 Series

JANOME SCARA ROBOT

JS3 Series

Operation Manual

Camera & Sensor Functions

Thank you for purchasing this Janome Robot.

- **Before using your robot, read this manual thoroughly and always make sure you use the robot correctly. In particular, be sure to thoroughly read "For Your Safety" as it contains important safety information.**

- **After reading this manual, store in a safe place that can be easily accessed at any time by the operator.**

JANOME

PREFACE

This manual covers the JR3200, JR3300, JR3400, JR3500, JR3600, JC-3, and the JS3 Series.

There are several manuals pertaining to these robots.

Manual	Details	JR3000	JC-3	JS3
Read This First	• For Your Safety Be sure to thoroughly read “For Your Safety” as it contains important safety information. • Package Contents (JS3 Series only) Check the items included with your robot. • CD-ROM Contents Explains the CD-ROM contents.	✓	✓	✓
Setup (JR3000 / JC-3) Installation (JS3)	Explains how to set up the robot. ■ Make sure you read this manual when installing the robot ■ NOTE: This manual is designed for people who have received safety and installation training regarding the robot.	✓	✓	✓
Maintenance	Explains maintenance procedures for the robot. ■ Make sure you read this manual when performing maintenance ■ NOTE: This manual is designed for people who have received safety and maintenance training regarding the robot.	✓	✓	✓
Basic Instructions	Provides part names, data configurations, and the basic knowledge necessary to operate the robot.	✓ (Common)		✓
Quick Start	Explains the actual operation of the robot by creating and running simple programs.	✓ (Common)		✓
Teaching Pendant Operation	Explains how to operate the robot via the teaching pendant.	✓ (Common)		✓
Functions I	Explains point teaching.	✓ (Common)		
Functions II	Explains commands, variables, and functions.	✓ (Common)		
Functions III	Explains functions such as All Program Common Settings and PLC programs.	✓ (Common)		
Functions IV	Explains Customizing Functions.	✓ (Common)		
External Control (I/O / Fieldbus)	Explains I/O and Fieldbus. Refer to this manual if you are using Fieldbus.	✓	✓	✓
Communication Control (COM/LAN)	Explains COM 1 – 3 and LAN communication control.	✓ (Common)		
Camera & Sensor Functions	Explains the functions of the attachable camera and Z position sensor.	✓ (Common)		

Manual	Details	JR3000	JC-3	JS3
Specifications	Outlines general specifications such as the robot's operating range, mass, etc.	✓	✓	—
Auxiliary Axis Functions	Explains the auxiliary axis functions.	✓ (Common)		
Application Specifications	Explains the specialized functions of the various application specifications.	Standard model: - Application model: ✓		

⚠ Warning

Do not handle or operate the robot in ways not covered in the manuals listed here.
Contact Janome (listed on the back of this manual) for repairs.
Failure to do so can cause electric shock or injury.

⚠ Caution

To make full use of the machine's functions and capabilities, make sure that you use the robot according to the correct handling/operation procedures that are written in the manuals pertaining to this robot.

If you turn OFF the power after making changes to robot's settings or data without saving, those changes are lost and the robot will revert to its original settings.
Make sure that you save any changes to data and/or settings.

Before using this robot for the first time, make sure you back up robot data and save the individual configuration information. Individual configuration information is needed when replacing internal circuit boards.
For details on how to back up robot data, refer to "3. BACKING UP AND RESTORING ROBOT DATA" in the operation manual *Setup* for the JR3000 Series, "6.1 Backing Up and Restoring Robot Data" in the operation manual *Setup* for the JC-3 Series, and "9.1 Backing Up and Restoring Robot Data" in the operation manual *Installation* for the JS3 Series.

- The descriptions within this manual are based on standard specifications. The menu item names etc. may vary depending on the model type.
- Menu items related to the Z axis may appear with 2 axis specifications; however settings made for these items are not applied.

- For information regarding optional additions for this robot, refer to "24. Specifications" in the operation manual *Specifications* for the JR3000 Series,“14. Specifications” in the operation manual *Specifications* for the JC-3 Series, and "15. Specifications" in the operation manual *Basic Intructions* for the JS3 Series. The notation “optional” is not used in the main text of this manual except for diagrams.
- Machine specifications may be modified without prior notice to improve quality.

Remarks:

- The operation methods described in this manual are indicated as follows:

  TP Operation via the teaching pendant

  PC Operation via PC (JR C-Points II)

- Click text that appears blue and is underlined to jump to that section.
  Example: Refer to “1. FUNCTION OVERVIEW.”

CONTENTS

FOR YOUR SAFETY

The safety notes outlined below are provided in order to ensure safe and correct usage of the product, and to prevent injury to the operator or other people, and damage to property.

・・・・・Be sure to follow the safety guidelines detailed here・・・・・

Symbols are also listed alongside the safety note explanations. Refer to the information below for understanding these terms and symbols.

■ Symbols that indicate the level of danger and/or damage.
The level of danger or damage that could occur as a result of ignoring these safety guidelines and misusing the robot are classified by the following symbols.

Danger	This symbol indicates an imminent risk of serious injury or death.
Warning	This symbol indicates a risk of serious injury or death.
Caution	This symbol indicates the possibility of serious injury or damage to property.

■ The following symbols indicate the nature of the danger and any necessary safety precautions to be taken.

	Indicates caution must be taken
	Take Caution (General Precaution)
	Indicates a forbidden action
	Never do this (General Prohibition)
	Do not disassemble, modify or repair.
	Do not touch (Contact Prohibition)
	Indicates a required action
	Be sure to follow instructions (General Requirement)
	Be sure to unplug the power cord
	Make sure the machine is grounded

FOR YOUR SAFETY

■■■■■■■■■■■■■■■■■■■■ JR3000 Series ■■■■■■■■■■■■■■■■■■■■

If using auxiliary axis functions to operate a motor, such as a servo motor, that produces feedback and/or a motor with high output etc., or when using auxiliary axes in the robot setup etc., we ask that you perform a risk assessment on your side and take any necessary safety measures.

If Using Auxiliary Axis Functions in a Way that Require Safety Measures

⚠ Danger

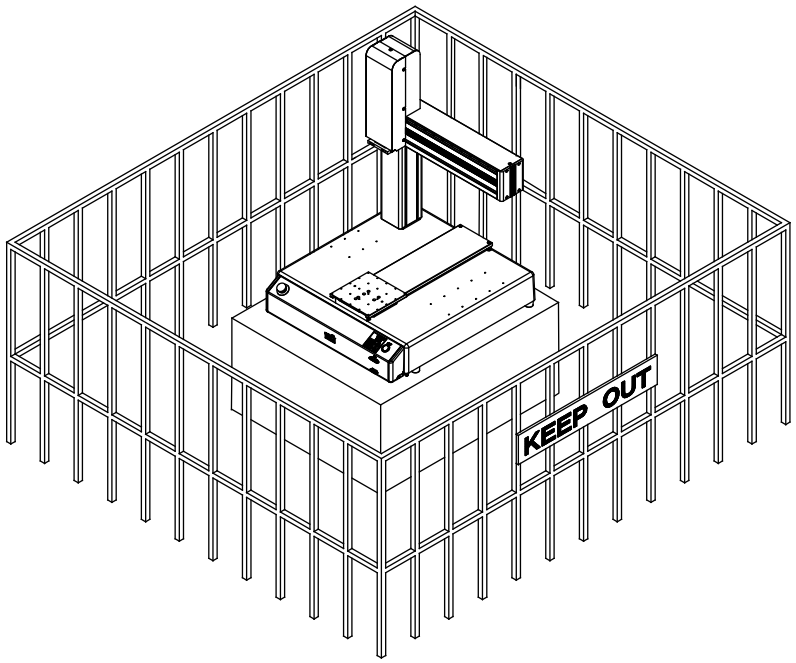
Always set up safety guards around the robot or the auxiliary axes so the moveable parts cannot be touched.

Anyone within the maximum reach of the robot and the auxiliary axes being controlled by the robot may be injured. Set up an **emergency stop interlock device that cuts off the motor power to the auxiliary axes when the entrance to the safety guard is opened** and make sure this entrance is the only way to access the machine.

NOTE: A stop made via a device connected to the I/O-S connector is a category 2 stop. Make sure to perform a separate risk assessment of the interlock device.

Furthermore, put up a **"Keep Out"** or **"Do Not Operate"** warning sign in a clearly visible place.

Example:



FOR YOUR SAFETY

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If Using Auxiliary Axis Functions in a Way that Require Safety Measures

⚠ Danger

When power to the robot is ON, never enter the safety guard or put your head, hands, or any part of your body inside.
Entering the safety guard could result in injury.

When entering the safety guard due to something wrong with the robot or a peripheral device, or to inspect or lubricate the machine etc., **with both the power supply breaker and the robot switched OFF, make sure to lockout and tagout and confirm there is no electricity flowing to the robot.**
Failure to do so can cause electric shock or injury.

⚠ Warning

When creating a robot system using auxiliary axis functions, if the system can be categorized as an industrial robot, make sure to use the robot in accordance with the laws and guidelines of the country where it is used.

Before performing a run or operation, always check the following:

- **Obstacles** : Make sure there are no obstacles or people within the safety guard.
- **Installation** : Make sure the robot is installed properly, that there are no abnormalities with the robot and the surrounding devices, and that the teaching pendant and tools are in the appropriate places.
- **Emergency Stop Switch** : Make sure the I/O-S circuit (interlock) and emergency stop switch(es) are functioning properly.

It is potentially dangerous to operate the robot without making these checks first.

FOR YOUR SAFETY

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If Using Auxiliary Axis Functions in a Way that Require Safety Measures

⚠ Warning	
	**Construct safety guards that are strong enough to protect the operator against such dangers as the tool or workpiece splintering, etc.** When working within the safety guard, use protective gear such as a helmet, protective gloves, protective goggles, and safety shoes. Failure to follow these safety measures can result in injury.
	If objects that the robot grasps have a risk of falling or being projected, **take into account the size, mass, and chemical composition of the objects for the required safety precautions.** Failure to do so can result in injury or unit breakdown.
	**When working within the safety guard, make sure not to come within the maximum range of the robot.** Failure to do so can cause injury.
	When starting a run, first confirm there are **no people inside of the safety guard and there are no obstacles that could interfere with the run.** Failure to do so can cause injury or unit breakdown.

FOR YOUR SAFETY

■■■■■■■■■■■■■■■■■■■■ JR3000 Series ■■■■■■■■■■■■■■■■■■■■

⚠ Danger

Do not use where flammable or corrosive gas is present.
Leaked gas accumulating around the unit causes explosions or fire.

⚠ Warning

Make sure that you securely install the unit in a place that can fully withstand both the unit's weight and its usage. Install the robot on a workbench 60 cm or higher above floor level, in the center of the workbench.
In addition, **for units with a cooling fan on the back, allow for 30 cm or more clearance between the back of the unit and the wall.**
Install the switchbox 60 cm or more above floor level in an easily accessible place.
If installation is inadequate, the unit can drop or fall over causing injury and unit breakdown. Also, inadequate installation causes overheating or fire.

Make sure to power the unit within its rated current range.
Failure to do so causes electric shock, fire, or unit breakdown.

Plug the power cord into the power outlet firmly.
Failure to do so causes the plug to heat up resulting in fire.

Be sure to use the unit within its indicated voltage range.
Failure to do so causes unit breakdown, fire, or electric shock.

When replacing fuses, or inspecting or lubricating the unit, unplug the power cord from the power outlet, then remove the cord from the main unit and make sure there is no electrical current. Also, do not touch any of the power inlet pins within 5 seconds of removing the power cords. Failure to follow these steps causes electric shock or injury.

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⚠ Warning	
	Always **make sure the machine is grounded through the power cord.** **Do not use the machine when it is not grounded.** Improper grounding causes electric shock, fire, malfunction, or unit breakdown.
	**Wipe the power plug with a clean, dry cloth periodically to eliminate dust.** Dust accumulation deteriorates the electrical insulation or causes fire.
	**Be sure to unplug the power cord from the power outlet when the unit is not in use for long periods of time.** Dust accumulation causes fire.
	**Be sure to turn OFF the unit before inserting or removing cords and cables such as the teaching pendant cable or LAN cable.** Failure to do so causes electric shock, data loss, unit breakdown, or malfunction.
	**If disassembling this machine, follow the instructions in the operation manual *Maintenance*, and do not disassemble in any other way other than those specified.** Do not modify the machine in any way. Inappropriate disassembly or modification causes electric shock or unit breakdown.
	**Do not allow water or oil to come in contact with the unit, control box or the power cord.** Contact with water or oil causes electric shock, fire, or unit breakdown. IP Protection Rating: IP20.
	**If anything unusual occurs, such as a burning smell or unusual sound, stop operation and unplug the power cord immediately. Contact Janome (details on the back of this manual) or a Janome dealer.** Continuing to use the robot without addressing the problem causes electric shock, fire, or unit breakdown.

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■■■■■■■■■■■■■■■■■■ JR3000 Series ■■■■■■■■■■■■■■■■■■

⚠ Caution	
	**Do not drop or jar the unit during transport and/or installation.** This can cause injury or damage the unit.
	**Before performing any operation, ensure there is no imminent danger to any of the operators.** Failure to do so causes injury.
	**Use the unit in an environment between 0 and 40 °C, with a humidity level of 20 to 90 %, and without condensation.** Use outside of these conditions can cause unit breakdown or malfunction.
	**Use the unit in an environment where no electrical noise is present.** Failure to do so causes unit malfunction or breakdown.
	**For models with I/O-S circuits*, when installing the unit, take safety measures such as setting up area sensors and safety guards.** If there are no safety measures in place and someone enters the area of operation when the robot is running, they may be injured.
	**Keep the emergency stop switch within reach of the operator when running or operating the robot.** If the robot is operated when the emergency switch is not within reach, it may not be possible to stop the robot immediately and safely. This is potentially dangerous.
	**Make sure that you regularly perform a function check of the emergency stop switch(es). Also, for models with I/O-S circuits*, regularly perform an I/O-S circuit function check.** If the robot is operated without making these checks, it may not be possible to stop the robot immediately and safely in an emergency. This is potentially dangerous.

* A stop made via a device connected to the I/O-S connector is a category 2 stop. Make sure to perform a separate risk assessment of the interlock device.

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⚠ Caution
When attaching tools, a USB camera, or any other device, make sure they are securely fitted before running the robot. Failure to do so causes injury or breakdown.
When using the machine for extended periods of time, check and make sure none of the main unit's mounting screws are loose, and perform a routine inspection every 3 months or after every 750 hours of operation. Failure to do so causes injury or breakdown.
Be sure to check the connections of the cords and cables to the main unit. Improper wiring causes unit malfunction or breakdown.
When lifting or transporting the robot, do so in accordance with the following: • **Secure the movable parts of the unit (the Z/ZR mechanism) before transportation.** • **Lift and transport the JR3200 Series with 2 or more people.** • **Lift and transport the JR3300 – JR3600 Series with 2 or more people or use a lifter.** • **Hold the bottom of the base and keep the robot horizontal.** • **Do not hold the robot by the column or Y body.** Failure to adhere to this can cause injury or damage the robot.
Use the unit in an environment that is not exposed to direct sunlight. Direct sunlight causes unit malfunction or breakdown.
Individual Configuration Information varies for each individual unit even if they are the same model. **Do not use backup data with a different robot. The robot cannot function normally with backup data from a different robot.**

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■■■■■■■■■■■■■■■■■■■ JC-3 Series ■■■■■■■■■■■■■■■■■■■

Industrial Robot Safety Standards

Make sure to use the robot in accordance with the laws and guidelines of the country where it is used.

FOR YOUR SAFETY

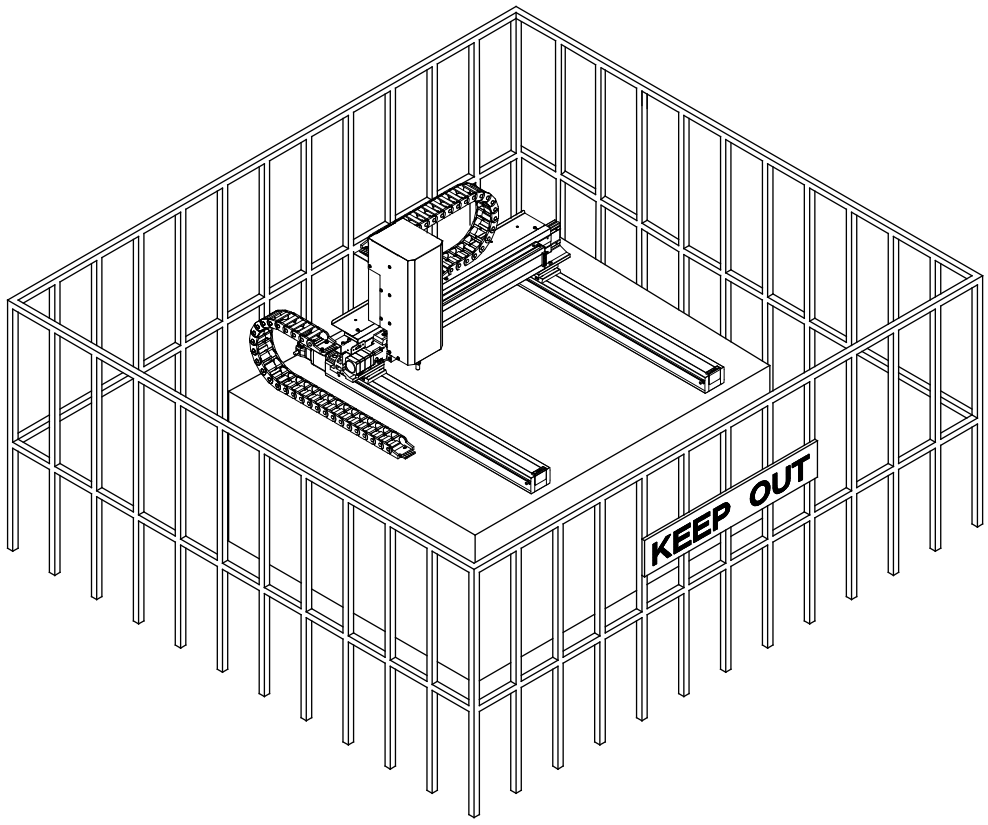
■■■■■■■■■■■■■■■■■■■■ JC-3 Series ■■■■■■■■■■■■■■■■■■■■

⚠ Danger

Do not use where flammable or corrosive gas is present.
Leaked gas accumulating around the unit causes explosions or fire.

Always set up safety guards.
Anyone within the maximum reach of the robot may be injured.
Using the included EMG OUT connector, set up an emergency stop interlock system that is triggered when the entrance to the safety guard is opened and make sure this entrance is the only way to access the machine.
Furthermore, put up a **"Keep Out"** or **"Do Not Operate"** warning sign in a clearly visible place.

Example:



FOR YOUR SAFETY

■■■■■■■■■■■■■■■■■■ JC-3 Series ■■■■■■■■■■■■■■■■■■

⚠ Danger

Construct a safety circuit before operating the robot.
Use the EMG OUT connector to maintain safety by installing a relay such as an external stop device on the power supply line which cuts the DC 48 V power input. Construct the safety circuit so it operates as a category 0 stop when the emergency stop switch is pressed. Without the construction of a safety circuit, motor power 48 V will not be cut OFF even if the emergency stop switch is pressed, leading to unexpected accidents and injury. An error will occur if you construct the safety circuit without it operating as a category 0 stop when the emergency stop switch is pressed.

When power to the robot is ON, never enter the safety guard or put your head, hands, or any part of your body inside.
Entering the safety guard could result in injury.

Before entering the safety guard or inspecting or performing maintenance on the robot, make sure there is no electrical current.
・ Unplug the controller power cord from the power outlet. Do not touch any of the power inlet pins within 5 seconds of removing the power cords.
・ If using a controller with a terminal block (DC 48 V), turn the power OFF and remove the wiring from the terminal block.
Failure to follow these steps can cause unexpected operation, electric shock, or injury.

Before performing a run or operation, always check the following:

- **Obstacles** : Make sure there are no obstacles or people within the safety guard.
- **Installation** : Make sure the robot is installed properly, that there are no abnormalities with the robot and surrounding devices, and that the teaching pendant and tools are in the appropriate places.
- **Emergency Stop Switch** : Make sure the EMG OUT circuit (interlock) and emergency stop switch(s) are functioning properly.

It is potentially dangerous to operate the robot without making these checks first.

FOR YOUR SAFETY

■■■■■■■■■■■■■■■■■■ JC-3 Series ■■■■■■■■■■■■■■■■■■

⚠ Danger

Keep the emergency stop switch within reach of the operator when running or operating the robot.
If the robot is operated when the emergency switch is not within reach, it may not be possible to stop the robot immediately and safely. This is potentially dangerous.

Make sure that you regularly perform a function check of the emergency stop switch(s). Also regularly perform an EMG OUT circuit function check.
If the robot is operated without making these checks, it may not be possible to stop the robot immediately and safely in an emergency. This is potentially dangerous.

⚠ Warning

Make sure to power the unit within its rated current range.
Failure to do so causes electric shock, fire, or unit breakdown.

Plug the power cord into the power outlet firmly.
Failure to do so causes the plug to heat up resulting in fire.

Make sure to connect and use crimp terminals with the power cord connecting to the terminal block (DC 48 V input) and to securely tighten the terminal block screws. Failure to do so causes electric shock, fire, or unit breakdown.

Make sure to perform work from outside of the safety guards when the power is ON. Failure to do so can cause injury.

Be sure to use the unit within its indicated voltage range.
Failure to do so causes unit breakdown, fire, or electric shock.

Install the controller within an industrial control panel, and make sure when the industrial control panel door is opened, the controller power is automatically cut off. In addition, for controllers with a cooling fan, allow for a clearance of 30 cm or more from the top of the controller, as well as 10 cm or more from the air vent on the side. Inadequate installation can cause overheating, fire, electric shock, or injury.

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■■■■■■■■■■■■■■■■■■ JC-3 Series ■■■■■■■■■■■■■■■■■■

⚠ Warning

With the 3 axis specifications, if releasing the brake, do so after either removing the attached tool or taking measures to prevent the tool from dropping.
If you release the brake when turning the power ON in Teaching Mode, Switch Run Mode, or External Run Mode, the axis may drop down depending on the mass attached to the Z axis. If the Z axis drops down, it can cause injury or unit breakdown.

When inspecting or performing maintenance on the controller, **make sure there is no electrical current and perform the following**:

- **Unplug the controller power cord from the power outlet. Do not touch any of the power inlet pins within 5 seconds of removing the power cords.**
- **If using a controller with a terminal block (DC 48 V), turn the power OFF and remove the wiring from the terminal block.**

Failure to follow these steps can cause electric shock, injury, data loss, unit breakdown, or malfunction.

Always **make sure the machine is grounded through the power cord.**
Do not use the machine when it is not grounded.
Improper grounding causes electric shock, fire, malfunction, or unit breakdown.

Wipe the power plug with a clean, dry cloth periodically to eliminate dust.
Dust accumulation deteriorates the electrical insulation or causes fire.

Be sure to unplug the power cord from the power outlet when the unit is not in use for long periods of time. Dust accumulation causes fire.

If disassembling this machine, follow the instructions in the operation manual *Maintenance*, and do not disassemble in any other way other than those specified. Do not modify the machine in any way.
Inappropriate disassembly or modification causes electric shock or unit breakdown.

Do not allow water or oil to come in contact with the unit, controller or the power cord. Contact with water or oil causes electric shock, fire, or unit breakdown.
IP Protection Rating: IP20.

FOR YOUR SAFETY

■■■■■■■■■■■■■■■■■■ JC-3 Series ■■■■■■■■■■■■■■■■■■

⚠ Warning

If anything unusual occurs, such as a burning smell or unusual sound, stop the run, unplug the controller power cord from the power outlet, and make sure there is no electrical current. Contact Janome (details on the back of this manual) or a Janome dealer.

- **Unplug the controller power cord from the power outlet. Do not touch any of the power inlet pins within 5 seconds of removing the power cords.**
- **If using a controller with a terminal block (DC 48 V), turn the power OFF and remove the wiring from the terminal block.**

Continuing to use the robot without addressing the problem causes electric shock, fire, or unit breakdown.

Make sure to use the robot in accordance with the laws and guidelines of the country where it is used.

⚠ Caution

Do not drop or jar the unit during transport and/or installation.
This can cause injury or damage the unit.

Before performing any operation, ensure there is no imminent danger to any of the operators.
Failure to do so causes injury.

Use the unit in an environment between 0 and 40°C, with a humidity level of 20 to 90 %, and without condensation.
Use outside of these conditions can cause unit breakdown or malfunction.

Use the unit in an environment where no electrical noise is present.
Failure to do so causes unit malfunction or breakdown.

When attaching tools, a USB camera, or any other device, make sure they are securely fitted before running the robot.
Failure to do so causes injury or breakdown.

FOR YOUR SAFETY

■■■■■■■■■■■■■■■■■■ JC-3 Series ■■■■■■■■■■■■■■■■■■

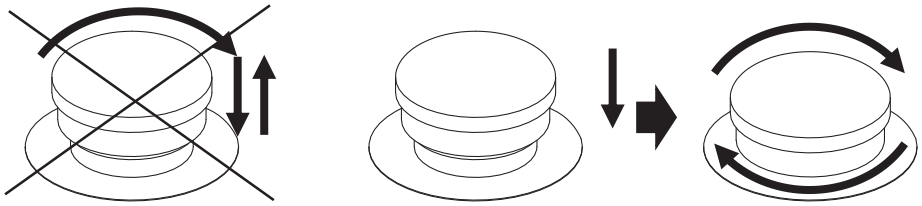
⚠ Caution

When using the machine for extended periods of time, check and make sure none of the main unit's mounting screws are loose, and perform a routine inspection every 3 months or after every 750 hours of operation. Failure to do so causes injury or breakdown.

Be sure to check the connections of the cords and cables to the main unit and controller.
Improper wiring causes unit malfunction or breakdown.

Make sure to wait for more than 1 second to power cycle after the external power supply to the controller (DC 48 V) is cut off. Failure to do so can cause breakdown.
Make sure to wait for more than 1 second between the following operations:

- When power cycling after the external power supply DC 48 V is cut off
- When releasing the emergency stop after the emergency stop switch is pressed
- When releasing the emergency stop after the emergency stop on the external device is activated
- Operations to release the emergency stop switch on the switch box and teaching pendant when in the releasing position



Do not release the emergency stop switch when in releasing position.

Press straight down

Turn and release (Do not pull)

Make sure to construct a power circuit allowing for the rated current so that the external power supply DC 48 V interruption does not occur. Failure to do so can cause breakdown.
External Power Supply Output :DC 48 V, 6.25 A or more
DC 48 V, 8.15 A or more (Absolute Encoder Model)

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⚠ Caution	
	**When using the external safety circuit using the EMG-OUT connector and the emergency stop device is activated, make sure to release the emergency stop after resolving the cause of the emergency stop.** Failure to do so can cause injury or unit breakdown. Adhere to the followings: • Do not use the external safety circuit or external emergency stop device to stop a run. • When not in emergency, use the start / stop switch on the switch box or use the I/O-SYS signal to stop a run. • Using the external power supply DC 48 V to stop a run by cutting off / re-supply the power can cause breakdown.
	**Secure the movable parts of the unit before transportation.** Failure to do so causes injury or breakdown.
	**When lifting and transporting the robot, do so with 2 or more people.** Failure to do so causes injury or breakdown.
	**Use the unit in an environment that is not exposed to direct sunlight.** Direct sunlight causes unit malfunction or breakdown.
	Individual Configuration Information varies for each individual unit even if they are the same model. **Do not use backup data with a different robot. The robot cannot function normally with backup data from a different robot.**

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Industrial Robot Safety Standards

Make sure to use the robot in accordance with the laws and guidelines of the country where it is used.

FOR YOUR SAFETY

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Safety Precautions Regarding Installation

Robot Unit

⚠ Danger

Anyone within the maximum reach of the robot may be injured.
Install safety guards in adherence with the following:

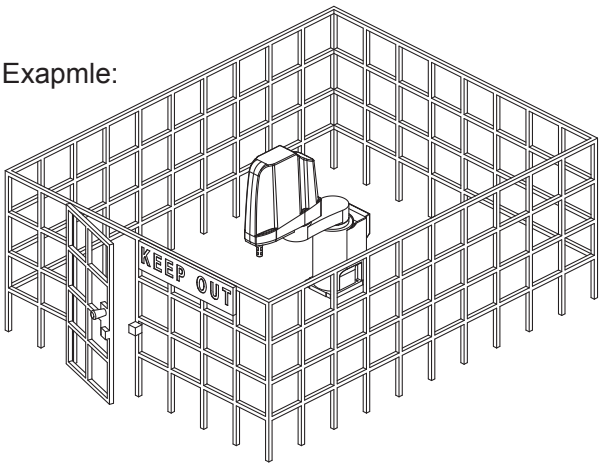
- The safety guards cannot easily be moved.
- The safety guards cannot easily fall over or be broken.
- Allow enough clearance between the robot and the safety guards so that even if the robot falls over, it does not hit the safety guards.
- No part of your body, such as your head or hands, can enter the safety guards.
- Install an interlock device on the entrance to the safety guards that activates an emergency stop when opened and make sure this entrance is the only way to access the machine. Connect the interlock device to the controller by using the included I/O-S connector.
- Place a warning sign such as [Keep Out] or [Do not Operate] on the safety guard entrance in a location that is easily visible.
- Affix the included danger sticker (shown below) in a location that is easily visible.

NOTE:

- A stop made via a device connected to the I/O-S connector is a category 1 stop. Make sure to perform a separate risk assessment for the interlock device.
- Refer to the operation manual *Installation* for details regarding I/O-S connections.
- After installing the unit, make sure to perform pre-operation checks from outside of the safety guards.

Warning Sticker

Exapmle:



FOR YOUR SAFETY

■■■■■■■■■■■■■■■■■■ JS3 Series ■■■■■■■■■■■■■■■■■■

⚠ Danger

Do not remove the fixing plates from the robot arm until after transportation is complete.
Failure to do this can cause injury or breakdown.

If temporarily placing the robot on a mount, etc., make sure to secure the robot to the mount by tightening 2 or more bolts into the mounting holes on the mounting base to prevent the robot from tipping over.
Failure to do this may cause the robot to fall, resulting in injury or breakdown.

To set the home position for the J3 or J4-axis, release the brake and move the J3-axis (shaft) manually with two hands. When releasing the brake, take the following precautions:

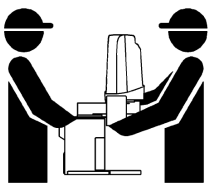
- Always release the brake with at least 2 people present.
- After the brake is released, the tool mass may cause the J3-axis to drop down. Make sure no people are within the operating range of the robot before releasing the brake.
- If there is risk that the robot may hit a peripheral device, make sure to position the robot arm appropriately before releasing the brake.

Failure to adhere to this can cause injury or breakdown.

⚠ Warning

Construct safety guards that are strong enough to protect the operator against such dangers as the tool or workpiece splintering, etc.
For the safety of the operator when working within the safety guard, use protective gear such as a helmet, protective gloves, protective goggles, and safety shoes.
Entering the safety guards could result in injury.

Always have 2 people carry the robot with the fixtures attached as shown in the illustration to the right.
Mass: JS3-3520: Approx. 39 kg, JS3-4520: Approx. 40 kg
JS3-5520: Approx. 41 kg
Refer to “2.3 Transporting the Robot Unit” in the operation manual *Installation* for further details.



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⚠ Warning	
	Avoid using the robot in operating environments such as the ones below. If using the robot in environments such as these, take measures to protect the robot from the direct effects of the work environment. • An environment where the robot vibrates or is bumped at 3.5 G or more during transportation. • An environment where the robot vibrates or is bumped at 0.5 G or more during operation. Using the robot in these environments can cause malfunction or breakdown.
	Avoid using the robot in an environment that exceeds the radiation tolerance value for the average person. If using the robot in an environment such as this, take measures to protect the robot from the direct effects of the work environment. Using the robot in this environment can cause malfunction or breakdown.

⚠ Caution	
	**Do not hold the robot from the left and right sides or hold the robot by the covers.** Doing so may tip the robot over or the covers may break; causing the robot to fall resulting in injury.
	Do not hold the robot by the J2 arm cover during transportation. Doing so can damage the cover.
	**Do not apply force to the shaft (J3-axis).** Doing so can damage the shaft and cause an overload error to occur when the robot is run.
	**Do not tip or place the robot on its side.** Doing so can cause a grease leak or breakdown.
	Mount the robot on a steel base that is designed to withstand both the robot's mass and the force generated during operations. Inadequate installation may cause the robot to fall, resulting in injury or breakdown.

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⚠ Caution	
	Firmly fix the robot to a specified horizontal mounting surface using the mounting bolts and make sure that positional displacements cannot occur.
	Install the robot in a location that provides enough clearance to replace the battery at the front of the robot and enough clearance to connect the motor power cable and the encoder cable to the back of the robot. Also, do not install the robot in a place where it is exposed to direct sunlight or heat from lighting. The robot surface may heat up and cause errors to occur.
	The robot requires periodic lubrication. Make sure you install the robot in a location where greasing is possible. (Refer to “4.8 Lubrication” in the operation manual *Maintenance*.
	Check the air tubing is connected correctly, has not come loose, or cannot easily come loose. If there is a problem, reconnect the tubing as required. Failure to do so can cause injury or breakdown.
	**After installing the robot, make sure to remove the fixing plates attached to the robot arm.** Failure to do so may cause breakdown.
	After installation, perform a periodic inspection (every 3 months or 750 hours of use, depending on how often the robot is in use) to check the tightening torque of the mounting screws with a torque wrench, etc.
	Adhere to the following when constructing or selecting a hand for the robot: • Make sure the total mass of the hand and the workpiece does not exceed the rated payload capacity of the robot. Especially if attaching an unconventional hand, check that the wrist does not exceed the allowable moment of inertia. • Use a hand or tool that has sufficient ability to grasp workpieces. • Secure the hand to the mechanical interface using bolts that are sized accordingly for the attachment dimensions. Make sure the tool has no protruding parts or sharp edges, other than those required for operation, and construct a cover for the tool if required. Failure to adhere to this can cause injury or breakdown.

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⚠ Caution
If connecting cables or hoses to the hand, make sure they do not restrict the robot movements and make sure the robot operations do not cause the cables or hoses to get tangled and/or cause them to break. Improperly attached cables or hoses can cause breakdown.
If using a pneumatic hand, make sure to provide clean air at the specified pressure. Also, make sure the air pressure does not exceed 0.7 MPa (7 kgf/cm^2). Air pressure higher than this may cause the robot's internal air hoses to burst.

Robot Unit and Controller

⚠ Danger
Do not use the robot where flammable or corrosive gas is present. Leaked gas accumulating around the unit causes explosions and fire.

⚠ Warning
Use protective gear such as a helmet, protective gloves, protective goggles, and safety shoes when installing the machine. Entering the safety guards could result in injury.
Before wiring the power cords, make sure there is no electrical current and perform the following: • **Lockout/tagout with the power source circuit breaker in the OFF position, and remove the power cords from the terminal block.** • Do not touch the terminal block within 5 seconds of removing the power cords. Failure to adhere to this may cause electric shock, injury, data loss or breakdown.
Be sure to use the unit within its indicated voltage range. **Failure to do so causes unit breakdown, fire, or electric shock.**

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⚠ Warning

Make sure to isolate the robot motor power cable, the encoder cable, and external I/O cables from the power cable or grounding wire of other devices. Also make sure the external I/O cables are shielded.
Do not apply voltages to terminals other than those specified in the operation manuals. Doing so can damage the robot or cause the terminal to explode.

⚠ Caution

When transporting the robot, **do not excessively shock or vibrate the robot.**
Doing so can cause malfunction or breakdown.

Do not drop or jar the unit during transport and/or installation.
This can cause injury or damage the unit.

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

Place the machine in a well-ventilated area for the health and safety of the operator.

Use the robot in an environment that meets the following conditions:

- **Ambient temperature of 0 to 40°C**
- **Relative humidity of 45 to 85 % (no condensation)**
- **Altitude not exceeding 1000 m above sea level**
- **The installation space is not in a vacuum.**

Use outside of these conditions may cause malfunction or unit breakdown. If the unit is used where these conditions are not met, we cannot guarantee its operation. IP protection rating for the both the robot and the controller is IP20.

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⚠ Caution	
	**Use the unit in an environment where no electrical noise is present.** Noise may cause unit malfunction or breakdown.
	**Do not use the machine in an environment that is damp or dusty.** Dust and moisture can cause malfunction or breakdown. IP protection rating for the both the robot and the controller is IP20 (not water resistant).
	Install the cables and connectors so there is no stress on them and do not forcefully bend or pull, or stand on them after they are installed. Protect the cables and connectors by using piping and covers, etc., as necessary. Make sure the latches and screws securing the cables and connectors are firmly secured. If the cables and connectors are not secure, they may come loose during a run.
	If the hand input cable (optional) has free terminals, make sure to insulate them before supplying power to the hand input cable (optional). Uncovered terminals can cause a short circuit to occur.

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Controller

⚠ Danger	
	**Mount the controller outside of the safety guards in a location where the switches can easily be reached and the controller can always be monitored by the operator without turning their back on the robot unit itself.** Mount the controller so that the operation panel is 600 mm or more above floor level for maintenance work.
	Before connecting a Fieldbus, make sure safety can be maintained at all times when the robot is run. If signals such as a start signal, etc., are assigned to the Fieldbus, the Fieldbus may standby waiting to send signals and cause the robot to start running immediately after it is connected. Failure to do so can cause injury or breakdown.

⚠ Warning	
	Use a lifter, etc., to transport the controller. Failure to do so can cause injury or breakdown.
	If external vibrations can cause the controller to move, fix it in place using the base plate of the controller. (Do so without removing the rubber feet)
	**Make sure that you securely install the unit in a place that can fully withstand both the unit's mass and its usage.** If installation is inadequate, the unit can drop or fall over causing injury and unit breakdown. Inadequate installation can also cause overheating and fire.
	The controller has a fan and ventilation intakes for cooling. Do not block these openings and make sure there is a clearance of at least 20 mm on both the left and right sides and at least 40 mm on the back side. Blocking these openings can cause overheating or breakdown.

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⚠ Warning	
	Leave approximately 200 mm or more clearance from the front of the controller so there is no stress on the connectors and enough room to work. Failure to do so can cause malfunction or breakdown.
	In addition to the clearance required for installation, leave sufficient space around the controller for removing covers (with a screwdriver) as a contingency for maintenance work. The controller may get hot during a malfunction. Do not touch the controller immediately after use.
	Make sure the power cord prepared on your side uses the **correct crimped terminals for connecting to the terminal block. Make sure they are within the sizes outlined below and never forcefully connect them.** Incorrect connections may cause fire or breakdown. • Conductor size: AWG10 (cross-sectional area: 6.0 mm^2) • Crimped terminal: M4, with a width of 9.5 mm or less
	After wiring the power supply terminal block, attach the cover included to prevent electric shock. An unprotected terminal block can cause electric shock, fire, or unit breakdown.
	**Always make sure to connect the protective ground through the power cord. Do not use the machine when the protective ground is not connected. Make sure the protective grounding resistance is 100 Ω or less.** Improper grounding causes electric shock, fire, malfunction, or unit breakdown, etc.

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⚠ Caution	
	Do not apply pressure to any protruding parts, such as a switch, the terminal block, or a connector when transporting the controller. Doing so can cause breakdown.
	If you want to use the controller, operation box (optional), or teaching pendant as a monitor while in Run Mode, **mount the respective device 600 mm or more above floor level in an easily accessible place so that the emergency stop switch can be immediately reached in the event of an emergency.** It is dangerous to operate the machine without the emergency stop switch within reach; you will not be able to stop the robot immediately and safely in the event of an emergency. Installing one of these devices too low can also result in malfunction from people knocking the device with their feet, etc.
	Make sure installation allows for access to the memory port during maintenance.

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Safety Precautions Regarding Usage

Robot Unit

⚠ Warning	
	If objects that the robot grasps have a risk of falling or being projected, **take into account the size, mass, and chemical composition of the objects for the required safety precautions.** Failure to do so can result in injury or unit breakdown.
	**When manually moving the robot arm, do not insert your hands or fingers into any of the joints or openings.** Your hands or fingers may get caught in these openings depending on the robot pose.

⚠ Caution	
	Before performing any operation, make sure there is no imminent danger to any of the operators. Failure to do so causes injury.
	**When attaching tools, a USB camera, or any other device, make sure they are securely fitted before running the robot.** A loose tool can cause injury or breakdown.
	If weight is applied to the J3 (Z) / J4 (R) axis, the load may cause the J3/J4 axis to drop down when the power to the robot is turned OFF. To prevent this from happening, remove the load from the J3/J4 axis or install a safety block, etc.
	When performing work inside the safety guards, perform your own risk assessment and establish **"work regulations", as outlined below, with thorough planning for safety.** Entering the safety guards may result in injury. • Work regulations should be relevant and appropriate for the type of work, and consist of details such as robot operating procedures and signs to be used between operators. • When creating work regulations, incorporate the opinion of operators and work safety specialists. Make sure to review and update the contents of the work regulations regularly.

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⚠ Caution	
	If manually moving the robot arm, do so slowly. Moving the arm at high speed can cause large amounts of backlash, reducing the robot's accuracy and damage the backup data.
	Depending on the arm pose, the shaft may come in contact with the robot base even when operating the robot within the work envelope. Make sure the shaft does not come in contact with the base while making JOG movements*. * A JOG movement refers to moving the robot arm via the teaching pendant.
	The J3 (Z) axis is equipped with a brake. Do not forcibly move the J3-axis using an external source when the brake is active. Forcibly moving the axis can reduce accuracy and/or wear the brake, damaging the reduction drive.
	If the robot picks up a workpiece that is charged with static electricity, the electricity is discharged through the hand and the robot arm. To prevent the robot from malfunctioning, make sure to insulate the hand and robot arm. Also, when the robot places a charged workpiece on a device, the electricity is discharged through the device and may cause it to malfunction. Configure the system so that it provides a route for appropriate electrical discharge from charged workpieces. Failure to do so can cause malfunction or unit breakdown.
	The lubricant is not completely effective at low temperatures. Make sure to use the warmup function to prevent loss of positioning accuracy and to prevent servo errors such as Excessive Margin of Error.
	Take care when affixing tape that has a strong adhesive, such as gummed tape, to the painted surfaces on the robot. The tape may damage the painted surfaces when it is peeled off.

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Robot Unit and Controller

⚠ Danger	
	**When power to the robot is ON, never enter the safety guard or put your head, hands, or any part of your body inside.** Entering the safety guards could result in injury.
	When changing modes or starting a run, first confirm there are **no people inside of the safety guard and there are no obstacles that could interfere with the run.** Entering the safety guards could result in injury.
	**Before performing a run or operation, always check the following:** • **Obstacles** Make sure there are no obstacles or people within the safety guard. • **Installation** Make sure the robot is installed properly, that there are no abnormalities with the robot and the surrounding devices, and that the teaching pendant and tools are in the appropriate places. • Emergency Stop Function Check Make sure the I/O-S circuit (interlock) and emergency stop switch(es) are functioning properly. It is potentially dangerous to operate the robot without making these checks first.
	If entering the safety guards without cutting off the power, **always make sure the select switch on the teaching pendant is set to TEACH** (Teaching Mode). If the select switch is set to AUTO (Run Mode), external commands can start the robot while you are inside the safety guards. Failure to adhere to this can cause injury or breakdown.
	If there are any safety devices that you disable while teaching, make sure to enable them after teaching to reestablish full functionality. Example: Enable the interlock device on the safety guard entrance, etc. Failure to do so can result in injury.

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⚠ Warning	
	**Make sure to use a power source that is in accordance with the range indicated on the rating identification plate.** Failure to do so causes electric shock, fire, or unit breakdown.
	**Do not allow water or oil to come in contact with the unit or power cord.** Contact with water or oil causes electric shock, fire, or unit breakdown. IP Protection Rating: IP20.
	**Make sure that no foreign objects can enter the robot or controller.** In particular, a conductive or flammable foreign matter, such as a screw, metal shard or oil, can cause an explosion or damage the unit, etc.
	**Be sure to turn OFF the unit before inserting or removing cords and cables such as the teaching pendant cable or LAN cable.** Failure to do so can cause electric shock, data loss, unit breakdown, or malfunction.
	**Firmly connect and secure the power cord after checking that the connection area is not covered with dust, etc.** If the power cord is not firmly plugged in, the connectors may heat up and cause a fire.
	**Be sure to unplug the power cord from the power outlet when the unit is not in use for long periods of time.** Dust accumulation may cause fire.
	**If anything unusual occurs, such as a burning smell or unusual sound, stop operation and turn the power supply circuit breaker OFF. Unplug the power cord after confirming there is no power supplied to the robot and then contact Janome or a Janome dealer.** Continuing to use the robot without addressing the problem causes electric shock, fire, or unit breakdown.

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⚠ Caution	
	**Be sure to check the connections of the cords and cables to the main unit.** Improper wiring may result in unit malfunction or breakdown.
	Make sure to save if you modify any settings or data. If you turn OFF the power after making changes to robot settings or data without saving, those changes are lost and the robot will revert to its original settings.
	Diagnostic Mode and Mechanical Adjustment Mode are for maintenance personnel* use only.

* Maintenance personnel are individuals who have received maintenance training from Janome or from a Janome dealer.

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Controller

⚠ Warning

Do not touch the terminal block when there is an electrical current present. Touching the terminal block can result in electric shock or injury.

⚠ Caution

Keep the emergency stop switch within reach of the operator when running or operating the robot.
If you operate the robot without the emergency switch in reach, you may not be able to stop the robot immediately and safely. This is potentially dangerous.

Individual Configuration Information varies for each individual unit even if they are the same model.
Do not use backup data with a different robot.
The robot cannot function normally with backup data from a different robot.

Do not turn OFF the power while the robot is running.
Turning OFF the power during a run can cause the arm to drop down or coast to a stop, which may result in the arm hitting a peripheral device.

When an error occurs, the error code that appears on the 7 segment LED and the teaching pendant display are useful indicators for finding the source of the error. Record the error number and then refer to the operation manual *Maintenance* for the countermeasure.

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Safety Precautions Regarding Maintenance

Robot Unit

⚠ Warning	
	Do not touch or come in contact with any potentially hot components on the robot. Doing so can result in burns and serious accidents. The servomotor may get hot. Do not touch or come in contact with the servomotor while the power is ON, only do so when the power is OFF and after it has cooled down.

⚠ Caution	
	**Check that the mounting screws are always firmly tightened with a periodic inspection (every 3 months or 750 hours of use, depending on how often the robot is in use).** A loose tool can cause injury or breakdown.
	**Periodically replace the robot battery.** Failure to do so can cause malfunction or breakdown. Replace the battery approximately every 1 year.

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Robot Unit and Controller

⚠ Danger	
	**If entering the safety guards, turn the power source circuit breaker OFF, lock and tag it, and then make sure there is no power supplied to the robot before continuing.** Failure to do so can cause electric shock, injury, or the robot may move unexpectedly.
	**If entering the safety guards, perform your own risk assessment and establish "work regulations," as outlined below, with thorough planning for safety.** • Work regulations should be relevant and appropriate for the type of work, and consist of details such as robot operating procedures and signs to be used between operators. • When creating work regulations, incorporate the opinion of operators and work safety specialists. Make sure to review and update the contents of the work regulations regularly.
	**When setting the home position or other such work that requires you to enter the safety guards with the power ON, make sure to activate the emergency stop switch before entering the safety guards and to perform the work with the robot in this state.** Failure to do so can result in injury.

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⚠ Warning

When inspecting or performing maintenance on the controller, **make sure there is no electrical current and perform the following:**

- **Lockout/tagout with the power source circuit breaker in the OFF position, and remove the power cords from the terminal block.**
- Do not touch the terminal block within 5 seconds of removing the power cords.

Failure to adhere to this may cause electric shock, injury, data loss or breakdown.

If disassembling this machine, follow the instructions in the operation manual *Maintenance*, and do not dissemble in any ways other than as specified. Do not modify the machine in any way.
Inappropriate disassembly or modification causes electric shock or unit breakdown.

For your safety, **do not modify the machine in any way.**
Inappropriate disassembly or modification causes electric shock or unit breakdown.
We cannot accept any responsibility for machines that malfunction due to modification.

After cutting OFF power to the system, energy stored by the devices is potentially dangerous, so make sure to establish means to reduce this risk.

- Controller
  Make sure the energy stored by the controller is discharged before opening the controller.
- Hand
  Use a hose connected to the solenoid valve to expel compressed air from a pneumatic chuck hand.

⚠ Caution

Perform daily and periodic inspections to check and make sure there are no abnormalities with the robot or peripheral devices. Additionally, keep records of the inspections and store them for 3 years or more so that the details can be referred to for future inspections.

Place a sign such as “Robot Inspection in Progress” in the necessary locations and establish means so as to prevent operation of the robot by those who may be unaware of the maintenance work. Whenever possible, also perform maintenance with at least one other person present so as to stop any unexpected robot movements.

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⚠ Caution	
	For a smooth and long operating life, **lubricate the shaft once for every 2,000 km the robot is run.** If the robot is run for 24 hour periods, lubricate the machine more frequently because the running time between lubrication periods is longer. The lubrication periods are calculated based on runs at maximum speed.
	Make sure to use the specified grease. Use of grease other than the specified grease can adversely affect the robot's performance or cause breakdown.
	If the arm joints or the Z-axis is subject to only minute operational angles or distances, fretting may occur in the internal robot bearings. Fretting refers to wear that occurs when minute operation angles do not allow the lubricant within the bearings to fully coat the working parts as required. This is also applies to axes that are inactive, as the counterforce from other axis operations or vibrations from the robot mounting surface cause minute movements in the inactive axes, which may result in fretting damage. To prevent fretting damage, we recommend running the arm joints more than 30 degrees and the Z-axis more than 20 mm per day.
	Do not charge, dispose of in a fire, or reuse the robot unit battery or controller battery (unit) in any way.
	The robot unit battery and controller battery (unit) are considered industrial waste. Make sure they are disposed of in accordance with the national and/or local authority laws and legislations.

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Controller

⚠ Danger

Before entering the safety guard because of something wrong with the robot or a peripheral device, or to **inspect or lubricate the machine etc., always make sure to turn the controller and power source circuit breakers OFF, lock and tag them, and make sure there is no electrical current.**
Failure to follow these steps can cause electric shock or injury.

⚠ Warning

When replacing fuses, or inspecting or lubricating the unit, turn OFF the power supply, then remove the cord from the main unit and make sure there is no power supplied to the robot before continuing.
Also, **do not touch the terminal block within 5 seconds of removing the power cords.** Failure to follow these steps can cause electric shock or injury.

1. FUNCTION OVERVIEW

1.1 Specialized Point Types

- Single Camera Shoot Point
  The robot makes a PTP movement and photographs marks on the workpiece. The adjustment values from the workpiece adjustment data set in [Ref. Work Adj. No.] are applied. You can use these workpiece adjustments by setting them to PTP Points, etc. By applying [No Tool] tool data to this point, the robot does not deviate from the taught position. The robot position will not change even if the tool data for the main tool TCP is modified.

- Multi Camera Shoot Point
  Use this point type when you want to split and take photographs and make adjustments separately when photographing multiple workpieces. Use this to collectively photograph the multiple workpieces. After doing so, you can collectively make adjustments so that these adjustments are applied to PTP Points, etc., according to the mark photograph results. Register the workpiece adjustment type as [CCD Camera Adjst. with Counter/Z-Adjst.] for workpiece adjustment data set to [Ref. Work Adj. No.]. By applying [No Tool] tool data to this point, the robot does not deviate from the taught position. The robot position will not change even if the tool data for the main tool TCP is modified.

- Double Camera Shoot Point 1
- Double Camera Shoot Point 2
  An image acquired with the Double Camera Shoot Points is done by splitting the photographing into two separate shots, allowing you to make adjustments using a wider area than you can with one imaging point. This makes for even more precise adjustments. To execute the Double Camera Shoot Points, you need to consecutively teach Double Camera Shoot Point 1 and Double Camera Shoot Point 2. Create two work adjustment numbers in sequence for the work adjustment used at the two photographing locations. Set the smaller workpiece adjustment number to [Ref. Work Adj. No.] for Double Camera Shoot Point 1. The other workpiece adjustment number, which was created in sequence, is automatically applied to Double Camera Shoot Point 2. The robot makes a PTP movement to the photographing locations and photographs the marks on the workpiece. The photograph results are applied as adjustment values to the workpiece adjustment data set in [Ref. Work Adj. No.]. You can use the adjustment data by setting this workpiece adjustment data to PTP Points, etc. By applying [No Tool] tool data to this point, the robot does not deviate from the taught position. The robot position will not change even if the tool data for the main tool TCP is modified.

NOTE: There is no dedicated point type for a 4-point camera adjustment. Use the standard point types and point jobs to perform a 4-point camera adjustment.

1.2 Camera and Sensor Functions

A robot connected with a camera and a distance/touch sensor, etc., can use the following functions:

- Workpiece position discrepancy compatibility
- Read workpiece positions with the camera

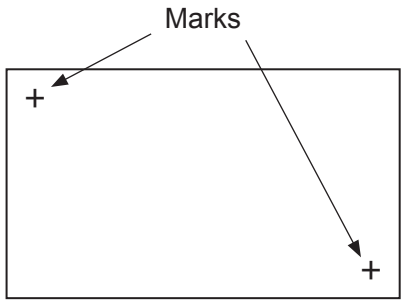
To deal with camera functions, you need the following knowledge:

- Knowledge of CCD camera operation
- Basic knowledge of text transmissions with COM communication or Ethernet communication (non-procedural communication)
- Knowledge regarding point jobs
- Basic knowledge of memory read/write operations (adjustments for cameras with counters only)

1.2.1 Camera Adjustment (XY Adjustment) Functions

Camera functions are adjustment functions which use an industrial type CCD camera mainly as a means to make position adjustments.

By acquiring marks (distinctions) on the workpiece with the camera and confirming those positions, the workpiece's position discrepancy is identified.



Mark Example

1.2.2 Camera Adjustment Example

This explains an example of a camera adjustment.

Example: if dispensing a liquid in the center of the workpiece.

- So long as the workpiece is within the camera shooting range, workpiece placement may be done freely.
- After acquiring the image with the camera, the robot automatically calculates how much of a position discrepancy there is with the reference position.
- The discrepancy of the freely placed workpiece is offset and the liquid is dispensed in the center of the workpiece at the dispensing point.

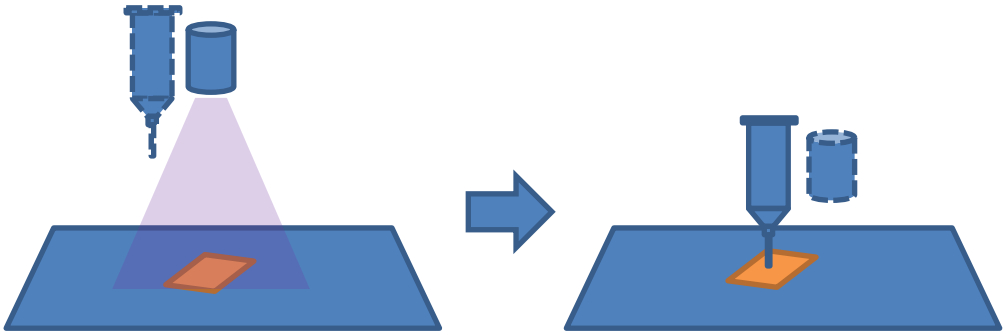
A program such as this is used:

■ Point 1

The workpiece is photographed with the CCD camera.
Once the photo is taken, the workpiece position (camera pixel coordinates) from the camera is sent to the robot.

■ Point 2

The robot calculates the workpiece position sent from the camera and offsets the workpiece discrepancy to the appropriate position.
The robot does point dispensing in the center of the workpiece as a result of applying the adjustment.



So long as the workpiece is within the camera shooting range, it can be placed freely

The following settings are necessary to set camera functions:

- Camera communication settings
- Calibration
- Get Standard Mark (reference mark acquisition)
- Parameters during execution (execute parameter setting)

1.3 How to Use the Camera Functions

To set up camera functions, settings need to be made in an order such as this:

■ Preparation (check the robot and camera's connection and communication connections)

1. Make sure you prepare a mark (or distinction) on the workpiece for position discrepancy detection
2. Set workpiece information to the camera
3. Connect the robot and the camera
4. Set the communication settings for the robot and camera

■ Workpiece adjustment settings

1. Make a workpiece adjustment number
2. Calibration (match up the robot and camera positioning systems).
3. Standard data settings (set the reference positions)
4. Execute Parameter Setting (set up the optional operations)

■ Point Teaching (make position discrepancy adjustments during operation using the camera)

1. Set the point that the camera will photograph from
2. Set the point you want to adjust with the workpiece adjustment number

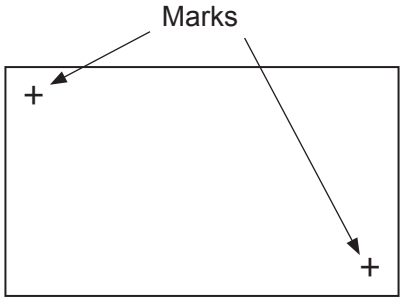
1.3.1 Preparation 1: Adding marks to the workpiece

Prepare marks on the workpiece for position discrepancy detection.
When photographed by the camera, these marks are used to detect how much the workpiece has moved.

Assume the camera has the following settings for the explanations in this example:

- Settings on the camera side are made so one kind of mark (marks of the same shape) can be identified with each camera data acquisition.
- The camera can identify two or more marks of the same shape with one photograph.

NOTE: Adjust and make the appropriate settings to match the environment for which you will use these camera functions.



Calibration Mark Example

1.3.2 Preparation 2: Setting Workpiece Information to the Camera

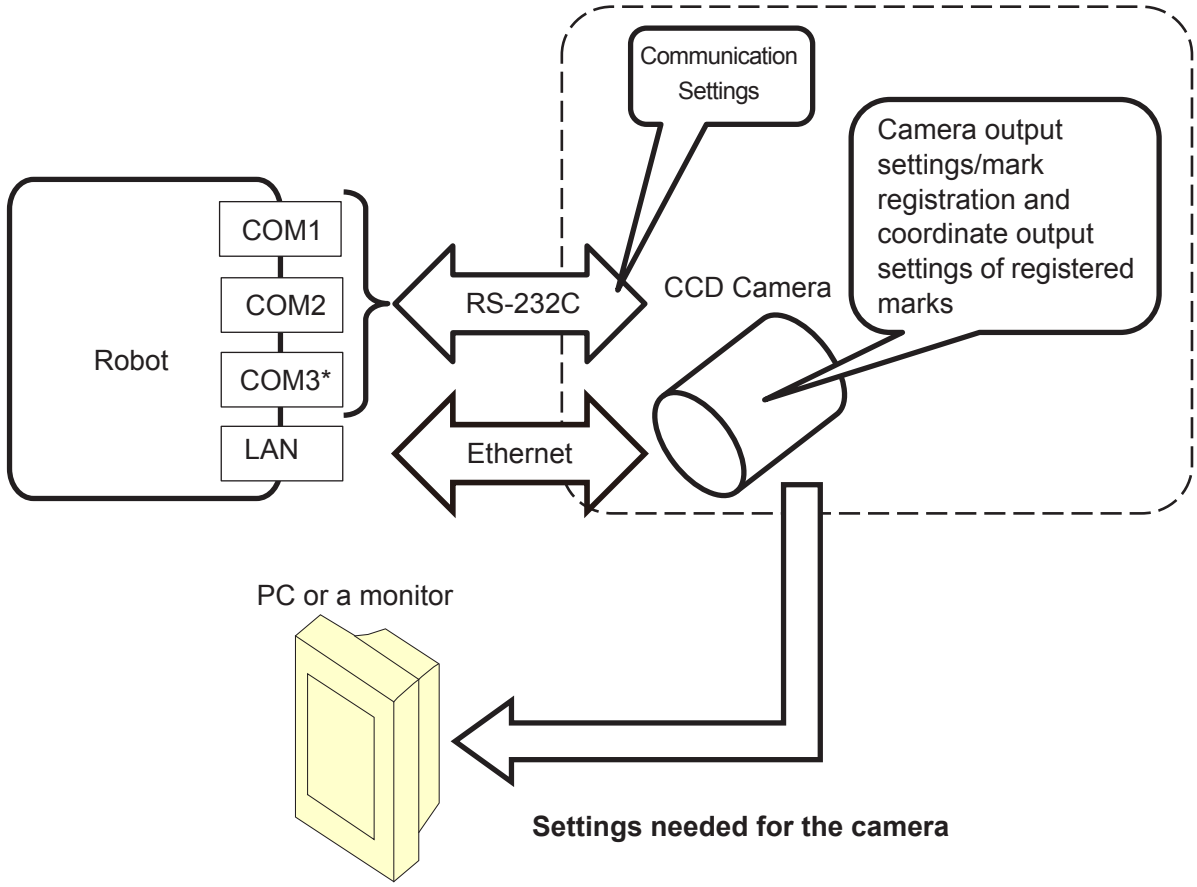
Take a photo of a workpiece that already has marks on it, and make camera settings for calibration mark position output.

Here, you need to make the following settings on the camera side:

- Communication settings
  RS-232C serial communication settings
- Output Settings
  X,Y, Θ coordinate output settings
  (refer to “7. ADDENDUM: CAMERA SETTINGS LIST.”)
- Mark registration, and coordinate output settings for registered marks

For camera setting methods, check the manufacturer’s camera operation manual.

Set up the mark positions so they are output as X, Y, Θ camera coordinates for when registered marks are photographed (when you are detecting the mark positions).



* JR3000/JC-3 Series only

1.3.3 Preparation 3: Connecting the Camera to the Robot

This explains about connecting the robot and camera.

The connection interface between the robot and camera is RS-232C (JR3000/JC-3 Series: COM 1 - COM 3, JS3 Series: COM 1 or COM 2) and Ethernet. Ethernet may not be compatible depending on the camera models. Refer to the table below for details.

Useable CCD camera models are listed below (as of August, 2018).

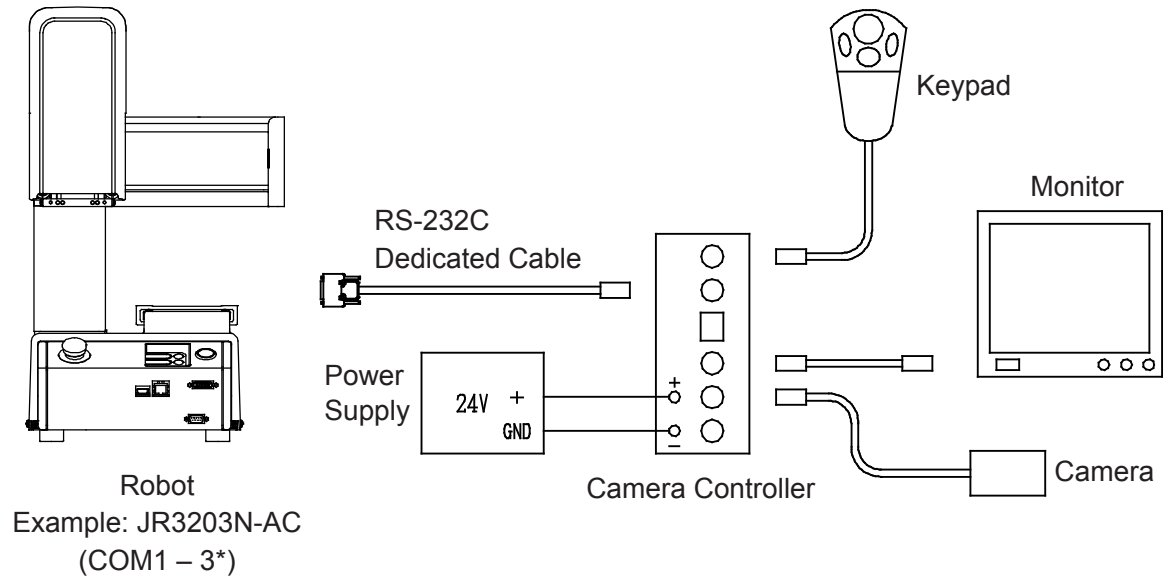
Manufacturer	Model	Ethernet Compatibility
Panasonic	A110	
	A210	
	PV310	
	PV510/PV200	✓
Keyence	CV3000	✓
	CV-X100	✓

In addition to the robot and camera connection, also properly connect the camera controller's power supply or input device etc., after checking your model's camera controller operation manual.

⚠ Warning

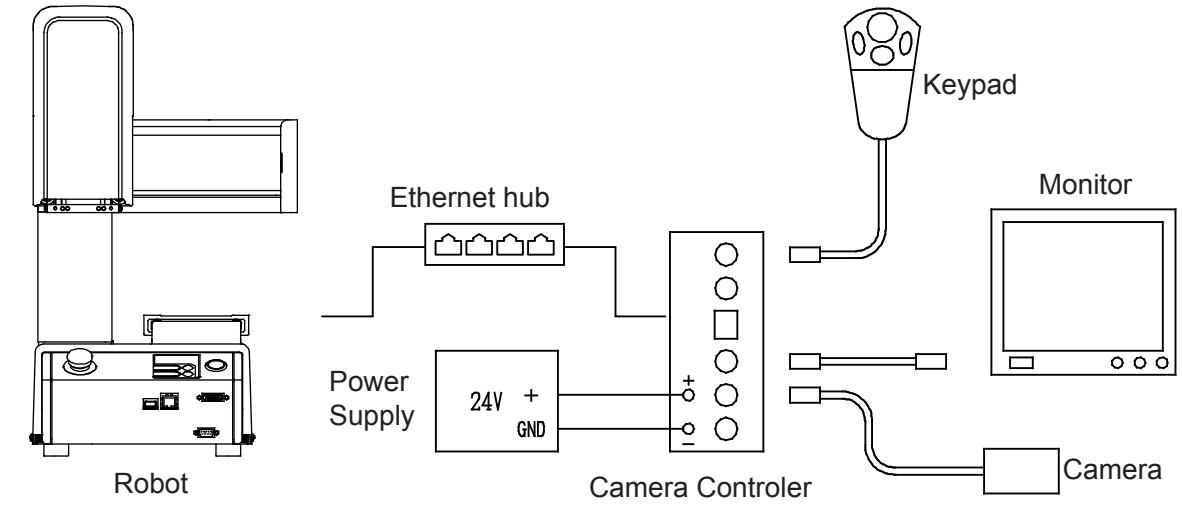
Always make sure that the robot's power switch (circuit breaker for the JS3 Series) is OFF when making connections. Failure to do so can cause electric shock and injury.

■ JR3000 Series Panasonic A210 Connection Example

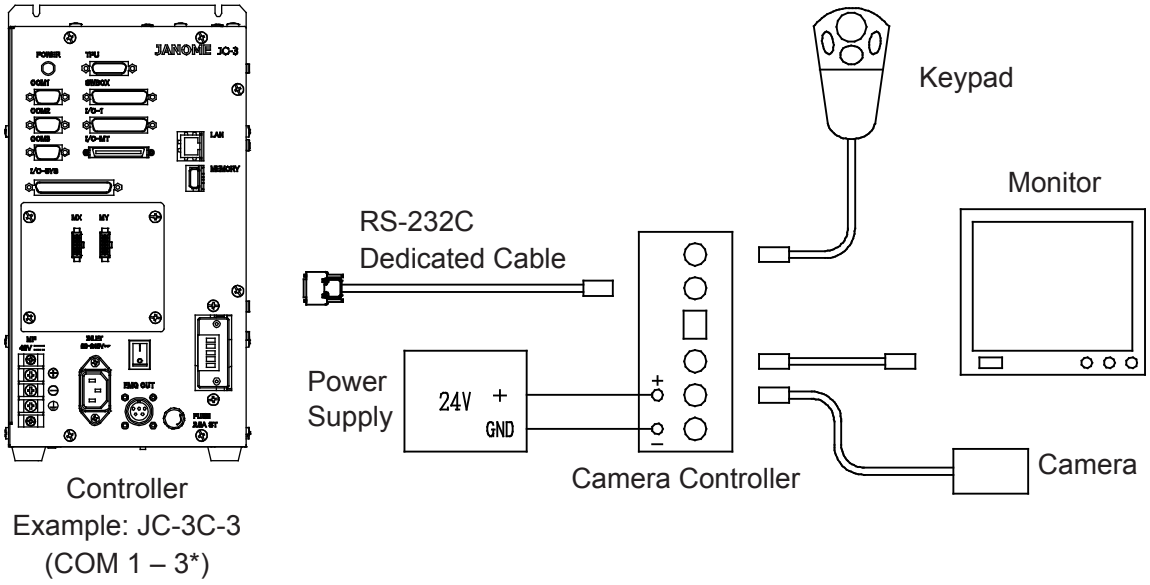


* Do not set the start channel to the same COM port that the camera is connected to. A camera communication error will occur.

■ JR3000 Series CV-X100 Connection Example (Ethernet Connection Example)

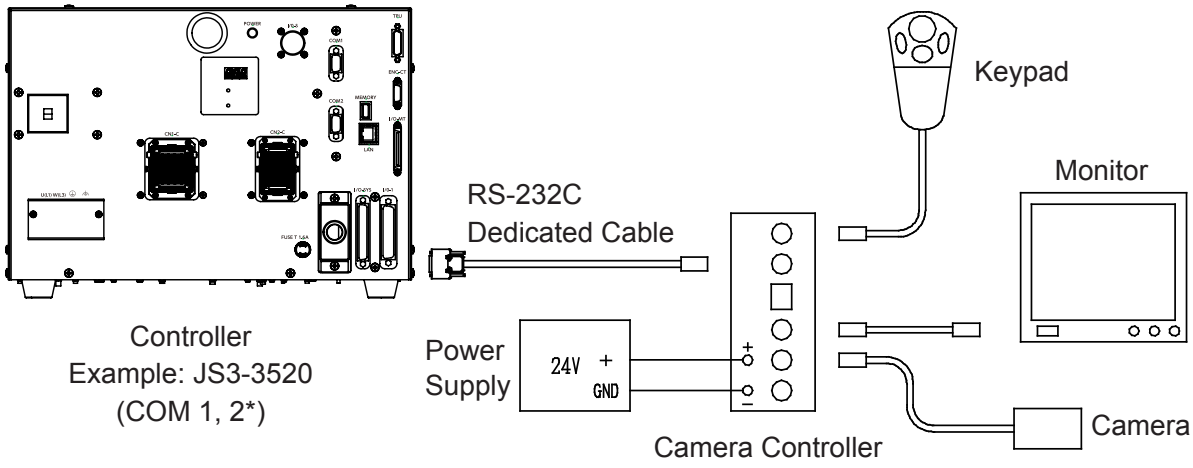


■ JC-3 Series Panasonic A210 Connection Example



* Do not set the start channel to the same COM port that the camera is connected to. A camera communication error will occur.

■ JS3 Series Panasonic A210 Connection Example



* Do not set the start channel to the same COM port that the camera is connected to. A camera communication error will occur.

1.3.4 Preparation 4: Making the Robot and Camera Connection Settings

■ Robot Communication Settings

- If connecting via COM communication

  The communication settings of the port the camera is connected to must be set in advance:

  - Baud Rate
  - Character Length
  - Stop Bit
  - Parity

You can set the robot communication settings in Administration Settings Mode.

JR3000/JC-3 Series

TP MODE [Administration]

[Administration Settings Mode]

[COM Settings]

[COM 1 – 3 Communication Settings]

JS3 Series

TP UTILITY [Change Mode] → [Administration]

[Administration Settings Mode]

[COM Settings]

[COM 1, 2 Communication Settings]

- If connecting via Ethernet Connection
  Ethernet connection is compatible with non-procedural communication. (Refer to the specifications for the camera)
  In this application, a camera communicates as a server and a robot communicates as a client.
  The communication protocol for the camera is the same as that for the COM communication.
  The communication settings of the client port must be set in advance to communicate with the camera. (Client port 1 to 3)
  - IP address
  - Port number

You can set the robot communication settings in Administration Settings Mode.

T P MODE [Administration] (JR3000/JC-3 Series)/
UTILITY [Change Mode][Administration] (JS3Series)
[Administration Settings Mode]
[Ethernet Settings]
[Ethernet Client1]
[Ethernet Client2]
[Ethernet Client3]

■ Check the connection using the Diagnostic Mode

- If connecting via COM communication
  By performing [COM 1 – 3 Communication] (JR3000/JC-3 Series), [COM 1, 2 Communication Settings] (JS3 Series) in Diagnostic Mode you can check whether or not the data exchange is occurring.
  You can check the following data exchanges with this function:
  - Character String Send; from the robot to the camera
  - Character String Receive; from the camera to the robot

- If connecting via Ethernet Connection
  By executing the “Ethernet” in the Diagnostic Mode, you can check if the robot is communicating.
  With this function, you can check the following data communications:
  - Communication by the PING
    By sending the ping to the IP address on the camera side, you can check if there is a response or not.

⚠ Caution

❗	The baud rate changes in Diagnostic Mode are for testing purposes. Once you exit Diagnostic Mode, these revert to the values registered in the COM communication settings in Administration Mode.
❗	If you need to change any settings other than the baud rate (character length, stop bit, parity) in Diagnostic Mode, change the COM communication settings in Administration Mode.

JR3000/JC-3 Series

TP MODE [Administration]

[Diagnostic Mode]

[COM 1 – 3 Communication Settings]

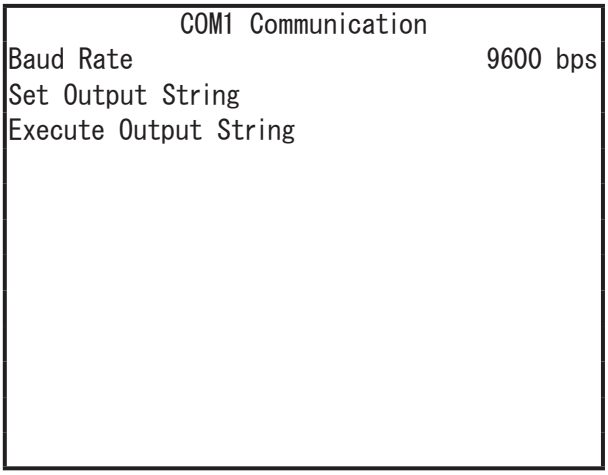
JS3 Series

TP UTILITY [Change Mode] → [Administration]

[Diagnostic Mode]

[COM 1, 2 Communication Settings]

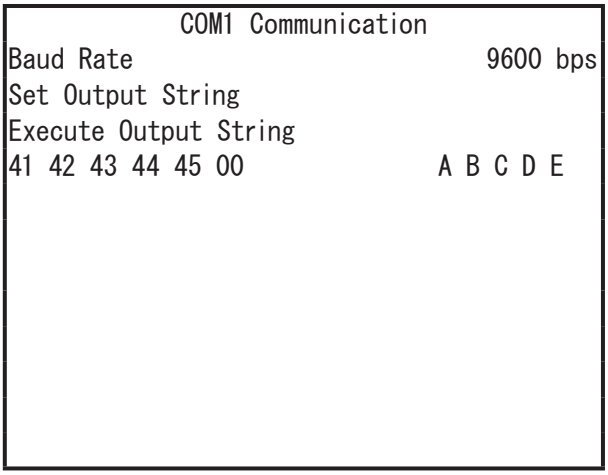
This is an example of a diagnostic performed on the COM port the camera controller is connected to.
You can use this to check the communication connection between the robot and camera.



COM 1 Communication Diagnostic Selection Screen Example

Status of a character string received from an external device.
(Character string example: ABCDE [CR])

Character string reception:
Characters not displayed (00H – 1FH and 7FH – FFH) are HEX format only (left side of the screen). ASCII sections (right side of the screen) appear as blank spaces.



COM 1 Communication Diagnostic
Selection Screen Example

COM 1 – 3 Communication Diagnostic Menu Overview:

Menu	Details
Baud Rate	You can select from the following values: ・ 2400 bps ・ 4800 bps ・ 9600 bps ・ 19200 bps ・ 38400 bps ・ 57600 bps ・ 76800 bps ・ 115200 bps Communication is carried out at the selected communication speed.
Set Output String	You can set the output string you want here. The default is “JR3000” (JR3000 Series), “JC-3” (JC-3 Series), “JS3” (JS3 Series).
Execute Output String	The character string set in Set Output String is output from the COM port being checked. The output status of the character string from an external device (host PC etc.) is checked.
From the 6th line and downwards (on the teaching pendant screen)	The character string input from an external device is displayed on the LCD. Binary code and ASCII code are displayed.

1.3.5 Workpiece Adjustment Settings 1: Making Workpiece Adjustment Numbers

To set workpiece adjustment functions, you need to make an additional function data workpiece adjustment.

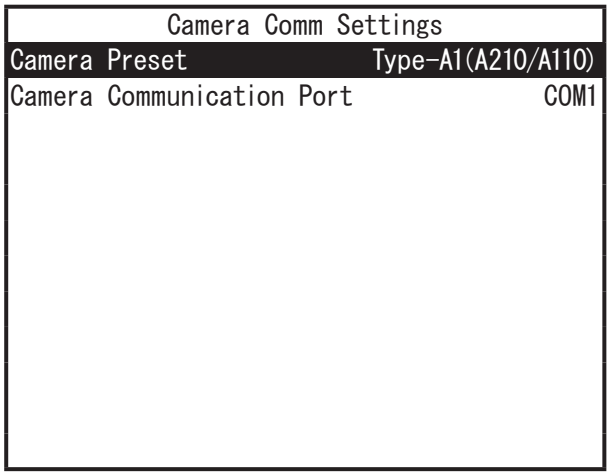
In the Teaching Mode menu, select [Additional Function Data Settings] → [Workpiece Adjustment Settings], and create a suitable new [Workpiece Adjustment Number].
Once you select [CCD Camera Adjustment], the following settable items are displayed:

CCD Camera Adjustment Menu Overview:

Menu	Details
CCD Camera Adjustment	A “workpiece adjustment” type. There are three types: [Numeric Adjustment], [CCD Camera Adjustment], [CCD Camera Adjustment with Counter].
Camera Comm. Settings	Select the camera communication port (COM or client port) on the robot side connecting the camera. Select the camera model for the camera connected to the robot.
Calibration	Settings to convert camera coordinates to robot coordinates
Standard Data Settings	Acquires reference data. These values are used as reference data for calculating the adjustment values during a run.
Execute Parameter Setting	Settings to specify the operation when the workpiece adjustment is executed.
Display Adjustment	Settings to display (display only) the workpiece adjustment values calculated during operation of a “Test Run”/”Point Run”.
Z-Adjustment	Settings for the distance sensor if the camera and distance/touch sensor are simultaneously used and XYZ direction workpiece position discrepancies are adjusted.

To start with, select [Camera Comm Settings], and select the robot side COM port or client port the camera is connected to and the type of camera connected to the robot.

NOTE: You can select the client port when Type-P3 (PV510/PV200), Type-K1(CV3000) or Type-K2 (CV-X100) is selected.



1.3.6 Workpiece Adjustment Settings 2: Calibration (Match up the Robot and Camera Positioning)

■ Calibration Overview

To use the robot and camera, first you need to set up the calibration settings.
The calibration settings are for finding the “conversion coefficient” to convert camera coordinates into robot coordinates.

⚠ Caution

Before calibration, settings on the camera side (workpiece registration) need to be made.

The calibration menu performs an operation to designate where within the robot coordinates the mark positions photographed by the camera are when the marks are indicated by the robot’s tool tip.
After indicating multiple mark positions, the robot automatically calculates the “conversion coefficient”.
By calculating the camera coordinate values and the automatically calculated conversion coefficient, the robot can convert the camera coordinate values into robot coordinate values.

The marks used in calibrations are called “calibration marks”.
There are two calibration methods:

■ Standard Settings

With standard settings, photograph the calibration marks and manually enter the calibration mark positions. It is possible to make detailed settings.

■ Simple Settings

Simple settings, in comparison with manual calibration, are a method for completing calibration in a short period of time.

Standard Settings

Standard settings are a settings screen for manually setting the calibration marks.
With standard settings, photograph multiple calibration marks that are already established on the workpiece. By indicating the positions for each of the calibration marks with the robot's tool tip, the camera coordinates and robot coordinates are matched up.
You can set up to 2 – 6 calibration marks, and by specifying the coordinates for each of these marks, you can acquire a very precise conversion coefficient.

Standard Setting Menu Overview

Menu	Details
Standard Settings	You can switch to "Simple Settings" here.
Camera Data Acquisition No Movement	You can select to always take workpiece photographs from the same position, or to take workpiece photographs from positions that are not calibration mark positions.
Calibration Mark Number	This sets the number of marks (2 – 6) to use as references for calibration. Set this according to the number of calibration marks on the workpiece.
Get Calibration Mark	Acquire (photographic image) the marks you are using as calibration reference marks. Select these after setting the calibration mark number. If the number of marks obtained from the camera and the calibration mark number do not match, an error occurs.
Robot Coordinate Position	This specifies the camera coordinates and the corresponding point coordinates on the robot. Check the camera's direction (facing up /down), and enter the robot coordinates. "C1" "C2" ⋯ are the mark coordinates on the camera side acquired with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2 respectively. The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates. "C1," "C2," ⋯ and "P1," "P2" only display their respective [Calibration Mark Number] settings. The camera coordinate "T" indicates the mark angle.
Camera Facing Up / Down	This is the direction of the camera. Set whether the camera is attached facing up or down.
Calculate and Register	This calculates and registers the coordinate conversion coefficient (the 4 items below). Set the 4 items above before selecting this.
Unit Coefficient	Displays the calculated coordinate conversion coefficient (K)
Rotate Angle [deg]	Displays the calculated coordinate conversion coefficient (ø)
X Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ X)
Y Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ Y)
Calibration Position	This is the tool center point position when the calibration marks were acquired.

Coordinate Conversion Formula

$X = K * x * \cos(ø) - K * y * \sin(ø) + \Delta X$

$Y = K * x * \sin(ø) + K * y * \cos(ø) + \Delta Y$

$\Theta = T + ø$

Camera coordinates (x, y, T), Robot coordinates (X, Y, Θ)

Simple Settings

Simple Settings is a function whereby the robot, can automatically enter the items entered manually with standard settings on its own.

In comparison with standard settings, the following settings are automatically set by “auto calibration”:

- Calibration Mark Number
- Get Calibration Mark
- Robot Coordinate Position
- Calculate and Register

Automatic Calibration Function

The robot’s XY axes move while one of the calibration marks placed on the X table is photographed. Compared to manual calibration, calibration can be completed within a short period of time.

⚠ Caution

The robot axes move when you perform automatic calibration. Check the surrounding area and execute once it is safe to do so.

Simple Settings Menu Overview

Menu	Explanation
Simple Settings	You can switch to “Standard Settings” here.
Camera Facing Up /Down	This is the direction of the camera. Set whether the camera is attached facing up or down.
Start Auto Calibration*	The robot performs this operation once selected. Before selecting this, confirm the surrounding area and execute once it is safe to do so. Only set one workpiece mark. One operation at a time is photographed with auto calibration, and 6 calibration points are registered per workpiece. After the auto calibration, move the tool tip to the calibration mark position. When auto calibration is made successfully, the values for the two items below are updated.
Reference Coefficient	You can refer to the conversion coefficient unit calculated from auto calibration here.
Calibration Position	This registers the auto calibration finishing position.

* With the JS3 Series, auto calibration works correctly only when a camera is attached to the R-axis.

1.3.7 Workpiece Adjustment Settings 3: Standard Data Settings (Set the Reference Position)

The details of each of the items in Standard Data Settings are outlined below.

Standard Data Setting Menu Overview

Menu	Explanation
Standard Mark Number	This is the number of marks used as adjustment references. (1 – 7). NOTE: If you are adjusting the rotation direction of the workpiece as well, set two or more marks here.
Get Standard Data	This photographically acquires the reference marks. Select this after setting [Standard Mark Number].
P1, P2 ... P7	X,Y: the acquired reference mark coordinates (robot coordinates) T: the angle Values for the exact number of marks set in [Standard Mark Number] are displayed.

Set the number of marks to Standard Mark Number.

The marks used for Get Standard Data do not necessarily need to be the same marks as the calibration marks. The marks used for Get Standard Data need to be previously set to the camera controller.

Get Standard Data sets the workpiece reference positions.

During workpiece adjustment, position adjustment is performed by adding the distance obtained from the camera to the position obtained through Get Standard Data.

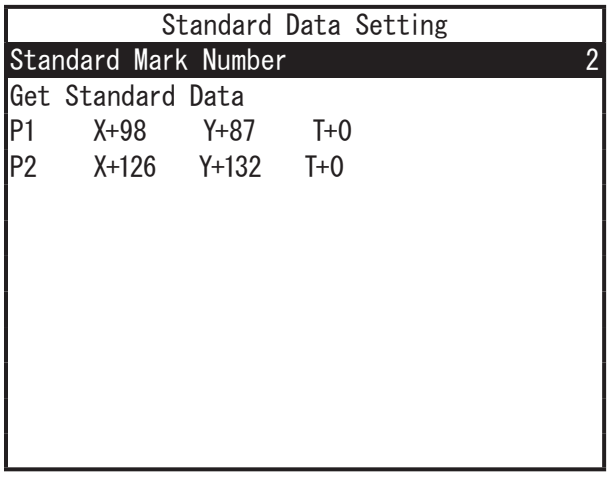
⚠ Caution

For Get Standard Data you always need to complete calibration beforehand.

If you select [Get Standard Data], the camera takes a photograph, and loads the marks. This data is used as workpiece position references when the robot is running.

At this time, if the number of marks acquired by the camera and the number set in [Standard Mark Number] do not match, an error occurs.

When acquiring a photographic image, make sure to acquire the photographic image under the same conditions (workpiece, workpiece placement position, camera position) as you do during an actual run.
Once the photographic image is acquired successfully, the acquired reference data is displayed in P1, P2... P7.



1.3.8 Workpiece Adjustment Settings 4: Execute Parameter Setting

Select [Execute Parameter Setting] from the CCD camera adjustment menu and switchover to the item you want to modify. The content of each item is as follows:

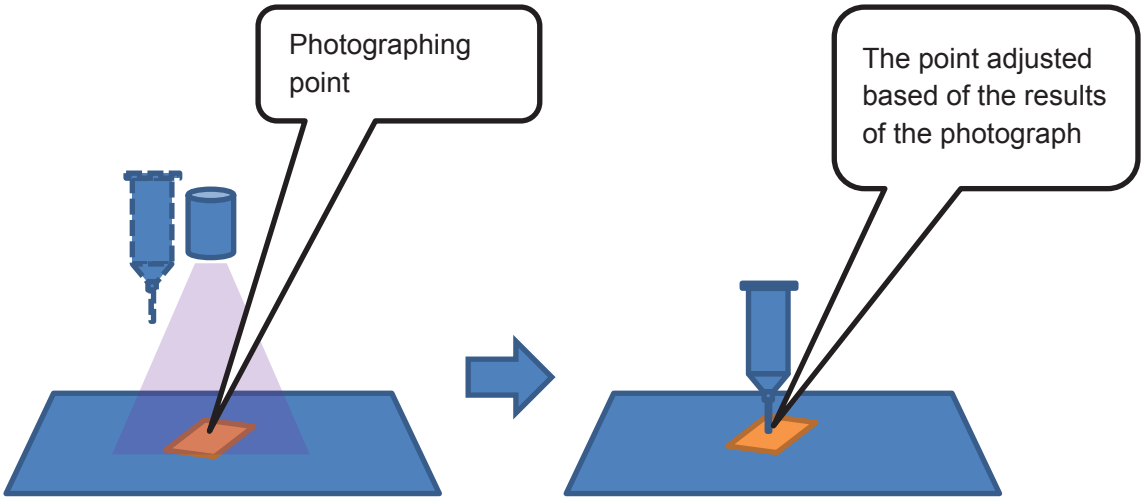
Execute Parameter Setting Menu Overview

Menu	Explanation
Apply Rotation to R-Axis	Select whether or not to apply workpiece rotation (T) to the R axis. If the angle of the workpiece and the reference data are different, match up the angle to the workpiece angle and rotate/do not rotate the R axis.
Reset Z Adjustment	When acquiring data from the camera, select to reset/do not reset the Z axis (height) adjustment to 0.
Reset at Program Start	Select to reset/not reset the workpiece adjustment amount at the start of a run. When you are switching to various programs and performing a series of operations, if the camera data acquisition point on the workpiece and the job point to where you are applying the adjustment are in different programs, you need to set this to [Do Not Reset at Program Start].

1.3.9 Point Teaching 1: Setting a Point for Photographing with the Camera

For a camera adjustment, you need two points; a photographing point and a point you will adjust based on the results of the photograph.

This section explains about the photographing point.



■ Set the point

First, register the “photographing point”. Register the point at any position where the camera can photograph the workpiece.

■ Create a point job

Create a point job to control the camera.

Actions such as the ones on the following page must be performed in advance at the point job to take a photograph with the camera:

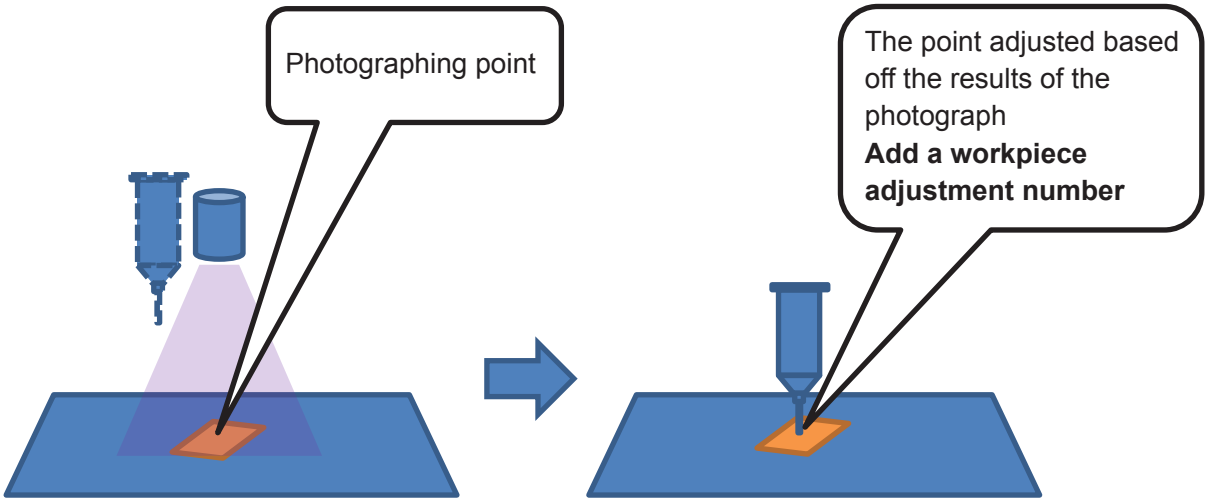
- If a PTP movement is made directly before photographing, the photograph will blur, therefore, set a wait time to prevent the blurring. (Adjust the wait time according to the mass of the workpiece and/or tool).
- Take a photograph
- Use the photographic results to devise and include methods to deal with any errors before they occur.

Point Job Settings Example

```
delay500                        // 0.5 sec. wait time (time to prevent blurring)
cameraWadj 1                    // camera data acquisition command
if
        ld #sysFlag(31)         // Camera adjustment acquisition error = ON (conditional)
then                            // if #sysFlag(31)=1(true), (if an error occurs)
        goRPoint PTP 0, 1       // jump ahead 1 point (the point after the job point)
endif
```

1.3.10 Point Teaching: Setting Workpiece Adjustment to Points You Want to Adjust

Set a workpiece adjustment number to the point that needs position adjustment. By setting a workpiece adjustment, position adjustment can be performed according to the workpiece photography results.



2. CAMERA ADJUSTMENT RELATED FUNCTIONS

You can use the camera adjustment functions in various ways depending on the application.

■ Basic Camera Adjustment Functions and their Uses
These are explained using the following examples:

1. Basic Function: Photograph → Adjustment Repeated Alternately ... CCD Camera Adjustment
After photographing the workpiece adjustment subject, the adjustment is performed immediately.
This is a most basic program. This section also explains adjustments with multiple points.

2. Practical Application: Photographing a Workpiece Larger than the Camera's Field of View... CCD Camera Adjustment (Double Camera/4-Point Camera)
With CCD camera adjustment, if the workpiece is large, or the field of view is narrow due to high camera magnification, etc., and you cannot obtain all of the marks in one photograph, you can break up the photographic image acquisition into two parts. For this function set 2 workpiece adjustments and a point job for the double camera.
You can also break up the image acquisition into four parts. To do so, set 4 workpiece adjustments and 4 point jobs for the 4 image acquisition points.

3. Practical Application: After Photographing Multiple Workpieces Together, Adjust them Together... CCD Camera Adjustment with Counter
This is a function used when you want to split up the photography and adjustments of multiple workpieces. If you have a large number of workpieces, this function can be expected to reduce this work time. With this function, you need to set up a CCD camera (with counter) adjustment and a point job for the CCD camera (with counter) adjustment.

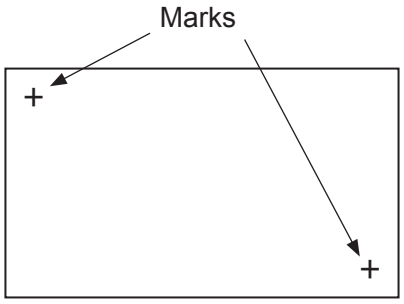
2.1 Basic Function: Photograph -> Adjustment - Repeated Alternately ... CCD Camera Adjustment

This is an example of a program where after photographing the subject of workpiece adjustment, the adjustment is performed immediately. This is a most basic program.
This section also explains adjustments with multiple points.
The setup method for "photograph → adjustment" is content introduced in "1.3 How to Use the Camera Functions." Focusing on workpiece adjustment settings and by using a concrete example, this section introduces how to set up photograph → adjustment settings.

By acquiring marks (a photographic image) on the workpiece with the camera and confirming those positions, the workpiece's position discrepancy can be identified.
Assume the camera has the following settings for the explanations in this example:

- Settings on the camera side are made so one kind of mark (marks of the same shape) can be identified with each camera data acquisition.
- The camera can identify two or more marks of the same shape with one photograph.

NOTE: Adjust and make the appropriate settings to match the environment for which you will use these camera functions.



Workpiece Example

2.1.1 Create a New Program

Open a new program.

2.1.2 Tool Data Settings

Set up [Main TCP Setting] in [Main-Tool Configuration].

- Tool Mass
  When the camera is mounted on the robot axis set the total weight of the tool and the camera as [Tool Mass].

JR3000 Series

Model	Tool Mass		
	1	2	3
JR3200	1 kg	3.5 kg	
JR3300 – JR3600	1 kg	4 kg	7 kg

JC-3 Series

Model	Tool Mass (Fixed Values)				
JC-3	2 Axes Single Sided	2 Axes Double Sided	3 Axes Single Sided	3 Axes Double Sided	4 Axes Double Sided
	4 kg	8 kg	4 kg	8 kg	3 kg

JS3 Series

Model	Tool Mass		
	1	2	3
JS3	1 kg	3 kg	6 kg

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

2.1.3 Register the Work Home

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

2.1.4 Register the Point Positions

Register the positions of the camera data acquisition point (P01) and the point that performs the job on the workpiece (P02).

■ The Camera Data Acquisition Point
This is a point set with point job data that contains the camera data acquisition command. Here the camera takes a photographic image and calculates how far out of place the current workpiece is from the reference coordinates. Register this point to a position where the camera can acquire a photographic image of the workpiece preceding the point you want to adjust. (Refer to the diagram in “1.3.10 Point Teaching: Setting Workpiece Adjustment to Points You Want to Adjust.”)

NOTE: When the camera is not attached to the robot axis and the camera position is fixed, it is not necessary to set a dedicated camera data acquisition point. As long as the camera data acquisition point comes before the point where the job is performed on the workpiece, you can set it to a point that also serves as a point for another job (it does not need to be directly before the job).

■ The Point that performs the Job on the Workpiece
This is the point where an operation such as screw driving or dispensing is actually performed on the workpiece. Set the additional function [Work Adjustment] to this point. Once [Work Adjustment] is set here, the robot adjusts the coordinates and makes the run with the exact “discrepancy” calculated at the “camera data acquisition point.”

2.1.5 Workpiece Adjustment Settings

Open a new [Workpiece Adjustment Settings] in the [Additional Function Data Settings].
Select [CCD Camera Adjustment] as the workpiece adjustment type. Once you have selected [CCD Camera Adjustment], the following setting items are displayed.

CCD Camera Adjustment Menu Overview

Menu	Details
CCD Camera Adjustment	A “workpiece adjustment” type. There are three types: [Numeric Adjustment], [CCD Camera Adjustment], [CCD Camera Adjustment with Counter].
Camera Communication Settings	Select the COM connector on the robot side connecting the camera. Select the camera model for the camera connected to the robot.
Calibration	Settings to convert camera coordinates to robot coordinates.
Standard Data Settings	Acquires reference data. These values are used as reference data for calculating the adjustment values during a run.
Execute Parameter Setting	Settings to specify the operation for when the workpiece adjustment is executed.
Display Adjustment	Settings to display (display only) the workpiece adjustment values calculated during operation from a “Test Run”/”Point Run”.
Z Adjustment	Settings for the distance sensor if the camera and distance/touch sensor are simultaneously used and workpiece position discrepancies are adjusted in XYZ orientations.

2.1.6 Camera Communication Settings

Select [Camera Communication Settings] from the CCD camera adjustment menu and select the COM Port or client port on the robot side (on the main unit for the JR3000 series or on the controller for the JC-3/JS3 Series) which connects to the camera. Also, select the type of camera connected to the robot.

Set the same values which are set in Administration Mode to the camera side.
If there are differences with these settings, the robot and camera cannot communicate.
The communication settings made on the robot can be confirmed in Administration Settings Mode.

JR3000/JC-3 Series

TP MODE [Administration]
→ [Administration Settings Mode]
→ [COM Settings]
→ [COM 1 – 3 Communication Settings]

JS3 Series

TP UTILITY [Change Mode] → [Administration]
→ [Administration Settings Mode]
→ [COM Settings]
→ [COM 1, 2 Communication Settings]

2.1.7 Camera Operation: Setting Calibration Marks (Calibration Preparation)

Here, settings on the CCD camera side are made. No robot operations are necessary.

To use the camera, first the calibration settings (convert the camera coordinates into robot coordinates) need to be made. To calibrate, first acquire the marks within the camera data acquisition range, and by specifying where these marks are within the robot's coordinates, the coordinate conversion coefficient between the robot and camera is obtained. These marks are called "calibration marks".
In the example here, the marks indicating the workpiece position during runs are also used as calibration marks.

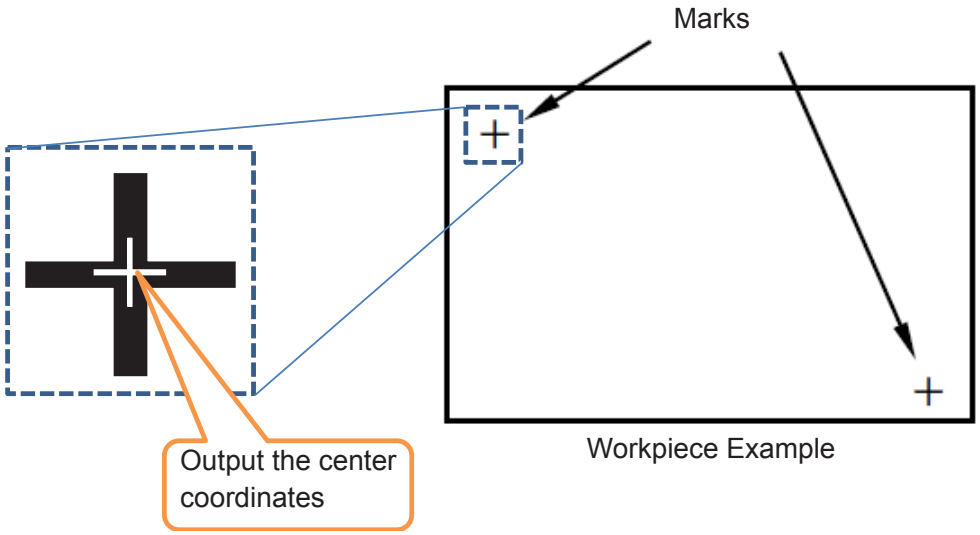
As long as the camera data acquisition range is constant, the calibration marks and the marks used for indicating the workpiece position during runs do not need to be the same. If there is no mark present on the workpiece useable as a calibration mark, you can affix a sticker with a mark to the workpiece, or use something other than the workpiece. Make sure, however, that the camera's data acquisition range and focus are the same here as they are when running the robot.

Generic settings for CCD cameras are explained here.
For CCD camera setting methods, confirm with the operation manual supplied by your CCD camera's manufacturer.

■ Calibration Mark Settings
Set the calibration marks you want to detect on the camera side.
Calibration calculation is done on the robot side.

NOTE: You do not need to make calibration settings on the camera side.

With the camera, make settings to detect the center of the "+" mark on the workpiece below.
Also, make settings so that both of the identical marks are detected.
When detecting identical marks, confirm the sorting sequence in the camera coordinates to see which one is the first mark.



■ Calibration Mark Coordinate Output Settings (ASCII text settings)

Set the output character strings in the following order on the camera controller side:

[Header] [Mark Number] [X –1] [Y – 1] [T – 1] [X – 2] ... [Y – n] [T – n]

1st mark coordinates (C1) 2nd and onward mark coordinates (C2 – C6)

The output data formats differ depending on each manufacturer.

For further details, refer to “7. ADDENDUM: CAMERA SETTINGS LIST.”

2.1.8 Calibration

This section explains about the calibration (coordinate conversion) standard settings screen. Acquire the marks with the camera ([Get Calibration Mark]), specify the positions of these marks with the robot ([Robot Coordinate Position]), and calculate the coordinate conversion coefficient between the camera and the robot ([Calculate and Register]).

Select [Calibration] from the CCD camera adjustment menu in [Workpiece Adjustment]. The following setting items are displayed:

Standard Settings Menu Overview

Menu	Explanation
Standard Settings	You can switch to [Simple Settings] here. For further details, refer to “2.1.16 Addendum 3: Calibration Settings (Simple Settings).”
Camera Data Acquisition No Movement	You can select to always take workpiece photographs from the same position, or to take workpiece photographs from positions that are not calibration mark positions.
Calibration Mark Number	This sets the number of marks (2 – 6) to use as references for calibration. Set this according to the number of calibration marks on the workpiece.
Get Calibration Mark	Acquire the marks (photographic image) that will be used as calibration reference marks. Select this after setting the calibration mark number. If the number of marks obtained from the camera and the calibration mark number do not match, an error occurs.
Robot Coordinate Position	This specifies the camera coordinates and the corresponding point coordinates on the robot. Check the camera’s direction (facing up /down), and enter the robot coordinates. “C1” “C2” ⋯ are the mark coordinates on the camera side acquired with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2 respectively. The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates. “C1,” “C2,” ⋯ and “P1,” “P2,” ⋯ only display their respective [Calibration Mark Number] settings. The camera coordinate “T” indicates the mark angle.
Camera Facing Up /Down	This is the direction of the camera. Set whether the camera is attached facing up or down.
Calculate and Register	This calculates and registers the coordinate conversion coefficient (the 4 items below). Set the 4 items above before selecting this.
Unit Coefficient	Displays the calculated coordinate conversion coefficient (K)
Rotate Angle [deg]	Displays the calculated coordinate conversion coefficient (ø)
X Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ X)
Y Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ Y)
Calibration Position	This is the tool center point position when the calibration marks were acquired.

Coordinate Conversion Formula

$X = K * x * \cos(ø) – K * y * \sin(ø) + \Delta X$

$Y = K * x * \sin(ø) + K * y * \cos(ø) + \Delta Y$

$\Theta = T + ø$

Camera coordinates (x, y, T), Robot coordinates (X, Y, Θ)

1. Enter [Calibration Mark Number].
   With the workpiece example, there are two marks you want to detect, so enter “2.”

2. Select [Get Calibration Mark].
   Once this is selected, the CCD camera takes a photograph, and the image is acquired.
   Make sure to acquire the photographic image under the same conditions (camera position, focus, and data acquisition range) as you have during the actual run. Also, after calibration, do not change the camera data acquisition point coordinates and the camera attachment position etc.
   If the number of marks acquired by the camera at this time do not coincide with the [Calibration Mark Number], a “Camera Data Acquisition Error” occurs.

NOTE: Depending on the camera type, an image acquisition error will occur if the mode on the camera side is not set to photography mode.

3. Check the direction the camera is facing (up or down) and enter [Robot Coordinate Position].
   C1 and C2 are camera coordinates of the marks acquired by the camera with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2.
   First select P1, then match the robot’s tool center point with the C1 mark and fix the coordinates.
   Likewise, enter and fix the corresponding coordinates for P2 and all other marks.
   The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates.
   C1, C2, and P1, P2 only display their respective [Calibration Mark Number] settings. The camera coordinate “T” indicates the mark angle.

4. Select [Calculate and Register] from the calibration menu.
   The coefficient to convert the camera coordinates into robot coordinates is calculated and registered. The calculated values are saved as the following items:
   - Unit Coefficient
   - Rotate Angle
   - X Moving Amount
   - Y Moving Amount

The calibration (data conversion) settings are now complete.

2.1.9 Standard Data Settings

This registers the positions that will be adjustment references. In this example the calibration marks are registered as the reference positions.

1. Move the robot to P01 (camera data acquisition point).
   (Press the [GO] key to move the robot to the displayed coordinates.)

NOTE: In the workpiece example, the calibration marks and the marks used to confirm the workpiece position during the run are the same; therefore, the camera settings made in “Calibration” can be used. It is not necessary to make new settings on the camera side. If the shape and the number of the marks for confirming the workpiece position during the run are not the same as those of the calibration marks, you need to make new settings for the CCD camera.

2. Select [Standard Data Setting] from the CCD camera adjustment menu.
   The details of each of the items in Standard Data Settings are outlined below.

Standard Data Setting Menu Overview

Menu	Explanation
Standard Mark Number	This is the number of marks used as adjustment references. (1 – 7). NOTE: If you are adjusting the rotation direction of the workpiece as well, set two or more marks here.
Get Standard Data	This photographically acquires the reference marks. Select this after setting the number of reference marks.
P1, P2 ... P7	X,Y: the acquired reference mark coordinates (robot coordinates) T: the angle Values for the exact number of marks set in [Standard Mark Number] are displayed.

3. Enter the number of marks on the workpiece used in the operation into [Standard Mark Number]. In the workpiece example P1, there are two marks (+) you want to detect, so enter “2” as the [Standard Mark Number].

4. Select [Get Standard Data]. Once selected, the camera takes the photograph and loads the marks from the photographic image. When the robot is running, this data is used as reference positions for calculating the workpiece’s offset amount.
   At this time, if the number of marks acquired by the camera and the number set in [Standard Mark Number] do not match, an error occurs.
   When acquiring the photographic image, make sure to acquire the photographic image under the same conditions (workpiece, workpiece placement position, camera position) as you have during an actual run.

5. The acquired reference data is displayed in P1, P2... P7.

The reference data settings are now complete.

2.1.10 Execute Parameter Setting

Select [Execute Parameter Setting] from the CCD camera adjustment menu, and switchover to the item you want to modify. The content of each of the items is as follows:

Execute Parameter Setting Menu Overview

Menu	Explanation
Apply Rotation to R-Axis	Select whether or not to apply workpiece rotation (T) to the R axis. If the angle of the workpiece and the reference data are different, match up the angle to the workpiece angle and rotate/do not rotate the R axis.
Reset Z Adjustment	When acquiring data from the camera, select to reset/not reset the Z axis (height) adjustment to 0.
Reset at Program Start	Select to reset/not reset the workpiece adjustment amount at the start of a run. When you are switching to multiple programs and performing a series of operations, if the camera data acquisition point on the workpiece and the job point to where you are applying the adjustment are in different programs, you need to set this to [Do Not Reset at Program Start].

The execute parameter settings are now complete. (This is the end of the explanations regarding basic CCD camera adjustment settings).

2.1.11 Set the Workpiece Adjustment Settings to a Point

Set the [Work Adjustment Number] (additional function data settings) you created to the point that performs the job (the point to where you want to set the workpiece adjustment).

2.1.12 Creating and Setting Point Job Data Example (CCD Camera Adjustment)

1. Open new point job data.

2. To prevent blurring of the photographic image, set a wait time preceding the camera data acquisition command.
   Use the conditional wait command *waitCondTime* or the wait command *delay*, etc.
   In this example, enter a wait time of 0.5 sec.

3. Camera Data Acquisition (Photographic Image) Command
   Set the camera data acquisition command *cameraWadj* and the work adjustment number you made. When this command is executed, the robot acquires the photographic image with the camera and calculates the adjustment values according to the [Workpiece Adjustment] specified as a number by the obtained data.
   When making a Z adjustment, also use the *takeZWadj* command.

4. Command for when a Camera Data Acquisition Error Occurs
   If a camera data acquisition error occurs, an incorrect offset amount is applied to the job point coordinates. In this situation, enter a command to specify the operation for when camera data acquisition errors occur. By referring to the system flag, you can specify the operation to execute by point job when a camera data acquisition error occurs.

System Flag	Error
No. 31	Camera Communication Error (no response)
	Camera Data Acquisition Error

Example of Point Job Data

```
delay500
cameraWadj 1
if
   ld #sysFlag(31)
then
   goRPoint PTP 0, 1
endif
```

Stand by for 0.5 seconds (time to prevent blurring)
Camera data acquisition command (when workpiece adjustment number 1)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
Jump ahead one point (the point after the job point).

If there are no further commands to set, point job data creation is complete.
Set the point job data number you created to the camera data acquisition point.

2.1.13 Create and Set the Point Job Data

Set point job data that executes the operation you want to perform (screw tightening, dispensing, etc.) on the workpiece to the point that performs the job (the point to where you set the workpiece adjustment).

All the settings necessary for “workpiece position discrepancy adjustment (CCD camera adjustment)” are complete.

If you wish to adjust the workpiece position in the Z direction, refer to “4. DISTANCE SENSOR ADJUSTMENT (Z ADJUSTMENT)” or “5. TOUCH SENSOR ADJUSTMENT (Z ADJUSTMENT).”

2.1.14 Addendum 1: Camera Adjustment (XY Adjustment) With Camera Movement

The following items are in Calibration Mode:

Item	Explanation
Camera Data Acquisition No Movement	The camera shoots at the calibrated position. (If you are always photographing at the same point, or the camera is physically fixed)
Camera Data Acquisition Movement	The camera also shoots at positions other than the calibrated position. Select this item if the camera is attached to the YZ mechanism (the camera moves with the YZ axis).
Camera Data Acquisition Movement (Y)	The camera also shoots at positions other than the calibrated position. Select this item if the camera is attached to the Y mechanism (the camera moves with the Y axis).
Camera Data Acquisition Movement (J2)	The camera also shoots at positions other than the calibrated position. Select this item if the camera is attached to the J2 arm (the camera moves with the J2 arm).
Camera Data Acquisition Movement (R)	The camera also shoots at positions other than the calibrated position. Select this item if the camera is attached to the R axis (the camera moves with the ZR axis).

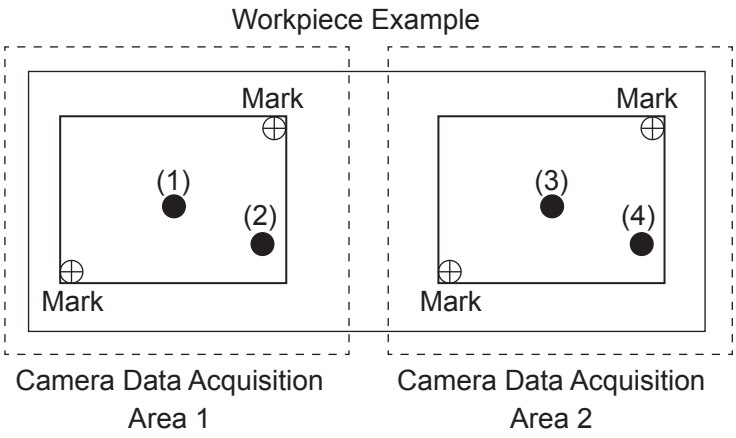
NOTE: Selection items for each models are as follows:

- JR3000/JC-3 Series (3-axis models)
  Camera Data Acquisition No Movement / Camera Data Acquisition Movement
- JR3000/JC-3 Series (4-axis models)
  Camera Data Acquisition No Movement / Camera Data Acquisition Movement (Y) / Camera Data Acquisition Movement (R)
- JS3 Series
  Camera Data Acquisition No Movement / Camera Data Acquisition Movement (J2) / Camera Data Acquisition Movement (R)

The setting Items for Camera Data Acquisition Movement are common.

(1) Camera data acquisition point 1
(2) Job point 1
(3) Camera data acquisition point 2
(4) Job point 2

With the workpiece example to the right, points (2) and (4) are set with the [Workpiece Adjustment] and used for camera adjustment (XY adjustment).



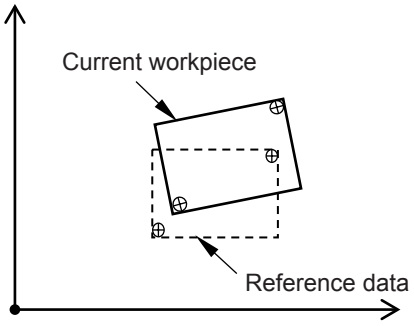
If you create a calibrated workpiece adjustment to match point (1) (camera data acquisition point (1)) and set it to both points (2) and (4), the workpiece adjustment set to point 4 deviates from the correct position. The reason for this deviation is in the workpiece adjustment calculation method.

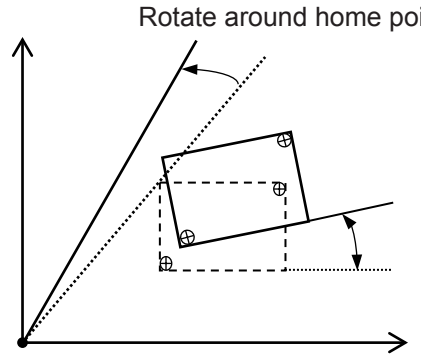
■ Normal Workpiece Adjustment

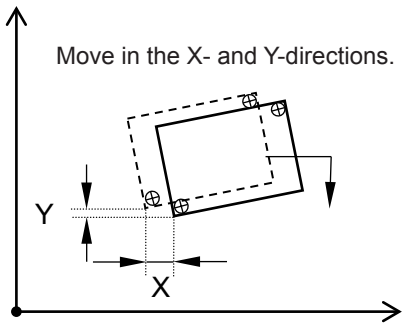
This is a normal workpiece adjustment, carried out as follows:

With the example shown to the right, you need to calculate how much to rotate the reference data around the home point (0, 0 in the robot coordinates), and after that, how much to move the reference data in the XY directions so it overlaps with the current workpiece.

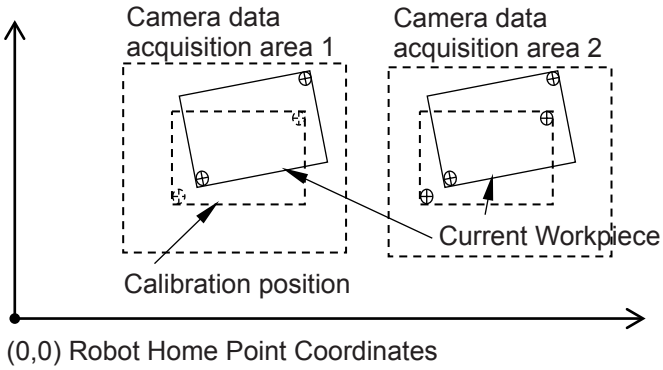
The rotation angle and the distances calculated are the workpiece adjustment amounts.



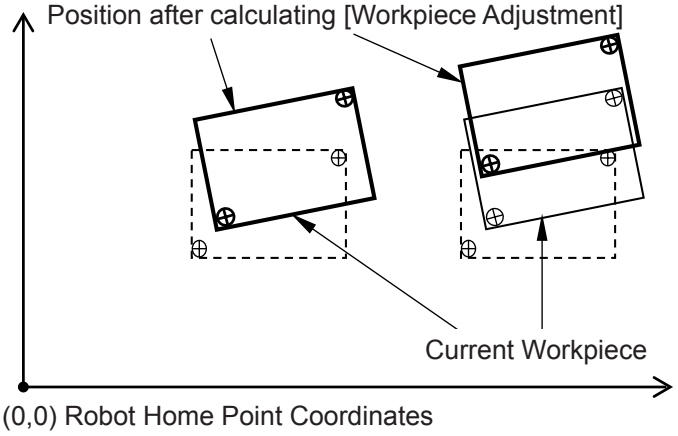




The workpiece adjustment is performed by calculating the rotation angle around the robot's home coordinates (0, 0). Accordingly, if you set a point to a position other than where calibration was made, as shown on the right, even when the workpiece is out of position by the same amount as other workpieces, the further the point is from the calibration position, the larger the position discrepancy (see the illustration below).



Accordingly, to correctly apply point 4's workpiece adjustment, you need to create a workpiece adjustment calibrated to suit point 3 (all settings other than the calibration are exactly same as the workpiece adjustment set to point 1), and set it to point 4. However, this is burdensome if you have to set two or more job points.



In cases such as this, set [Camera Data Acquisition No Movement] to [Camera Data Acquisition Movement] in the workpiece adjustment. When this is set to [Camera Data Acquisition Movement], even if the position where calibration was made and the position of camera data acquisition (camera data acquisition point) during the run are different, the robot coordinates are calculated in reverse, the coordinate conversion coefficient and reference mark positions are recalculated, and the workpiece adjustment is applied correctly.

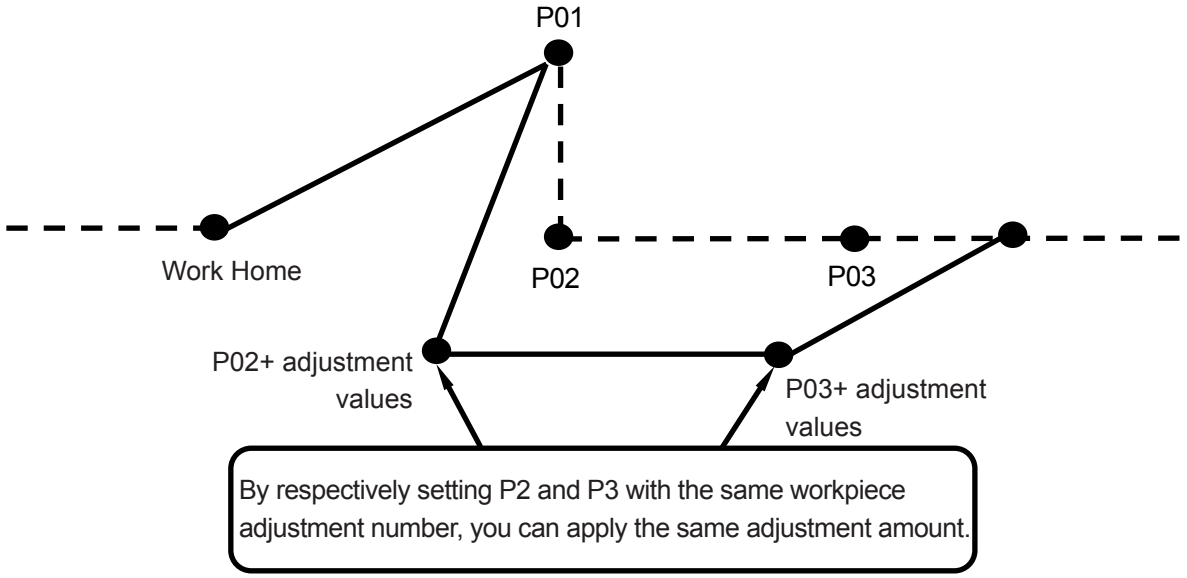
■ How to Set [Camera Data Acquisition Movement]

Select the workpiece adjustment [Calibration] which is calibrated according to point (1).
Change and set up Calibration Mode ([Camera Data Acquisition No Movement]) to [Camera Data Acquisition Movement] according to the position where the camera is attached. (If calibration is set to [Simple Settings], [Camera Data Acquisition Movement] is automatically set.)

For the workpiece example, create the workpiece adjustment according to point 1 and set it to [Camera Data Acquisition Movement] when calibrating. If you set this workpiece adjustment to point 4, the workpiece adjustment for point 4 is also applied correctly.

2.1.15 Addendum 2: Adjusting Multiple Points

If you want adjustment information acquired by the camera reflected in multiple points, set workpiece adjustment numbers to each of the job points subject to adjustment.



2.1.16 Addendum 3: Calibration Settings (Simple Settings)

Simple Settings is a function whereby the robot, operating on its own, can automatically enter the items entered manually using Standard Settings.

In comparison with standard settings, the following settings are automatically set by “auto calibration”:

- Calibration Mark Number
- Get Calibration Mark
- Robot Coordinate Position
- Calculate and Register

■ Auto Calibration Function

The robot photographs one of the calibration marks while horizontally moving the axes.

Compared to manual calibration, you can complete calibration within a short period of time.

⚠ Caution

The robot axes move when you perform automatic calibration. Confirm the surrounding area and execute once it is safe to do so.

Simple Settings Menu Overview

Menu	Explanation
Simple Settings	You can switch to “Standard Settings” here.
Camera Facing Up /Down	This is the direction of the camera. Set whether the camera is attached facing up or down.
Start Auto Calibration*	The robot performs this operation once selected. Before selecting this, check the surrounding area and execute once it is safe to do so. Only set one workpiece mark. One operation at a time is photographed with auto calibration, and 6 calibration points are registered per workpiece. After the auto calibration, move the tool tip to the calibration mark position. When auto calibration is successfully completed, the values of the two items below are updated.
Reference Coefficient	You can refer to the conversion coefficient unit calculated from auto calibration here.
Calibration Position	This registers the auto calibration finishing position.

* With the JS3 Series, auto calibration works correctly only when a camera is attached to the R-axis.

1. Automatic Calibration Preparation
   To do automatic calibration, you need to prepare a dedicated calibration mark. Adjust the size of the dedicated calibration mark on the screen so that it is shown as approximately 1/5 of the lateral side of the screen.
   Note that an error occurs if the calibration mark size is either too big or too small.

2. Set the calibration marks you want to detect on the camera side.
   Calibration calculation is done on the robot side.

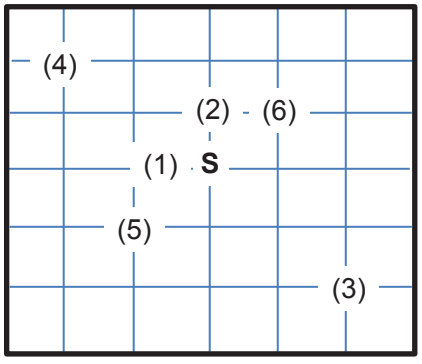
NOTE: You do not need to make calibration settings on the camera side.
   Make settings to detect the center of the calibration mark with the camera.

3. Select Automatic Calibration
   Once you select automatic calibration, the axes operate automatically.

⚠ Caution

The robot axes move when you perform automatic calibration. Confirm the surrounding area and execute once it is safe to do so.

Automatic Calibration Mark Acquisition Positions Example



S: Mark Position
(1) – (6): Photograph Areas

NOTE: Acquisition is repeated a number of times so the actual operation is repeated a number of times.

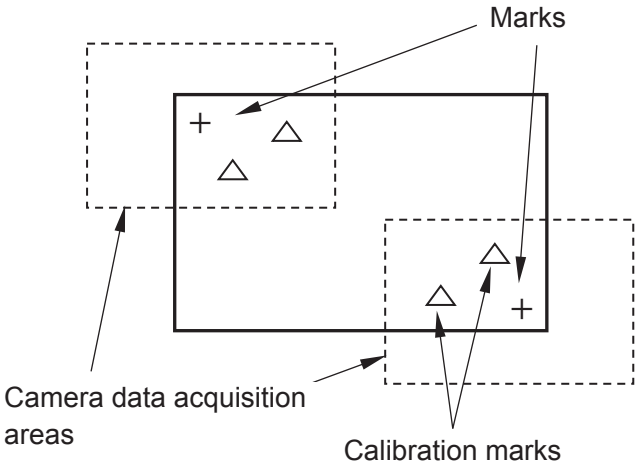
4. After the axes stop moving, move the tool tip to the calibration mark position.

2.2 Practical Application: Shooting a Workpiece Larger than the Camera's Field of View ... CCD Camera Adjustment (Double Camera/4-Point Camera)

With this function you need to set 2 workpiece adjustments and a point job for the double camera. You can also set 4 workpiece adjustments and 4 point jobs for a 4-point camera operation.

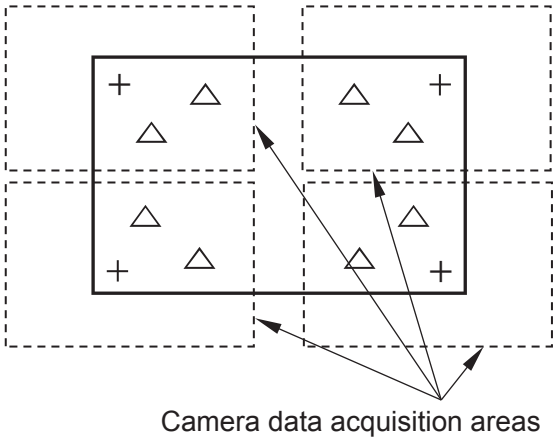
With a workpiece position discrepancy adjustment (CCD camera adjustment), if the workpiece is large, or the field of view is narrow due to high camera magnification, etc., and you cannot obtain all of the marks in one photograph, you can break up the photographic image acquisition into two or 4 parts. This section is explained using the workpiece examples to the right.

Workpiece Example



■ To use this function, the following procedures are necessary
Confirm the robot and camera are connected correctly and also set the workpiece and the calibration marks (2 – 3 marks within one camera data acquisition area) the same way you do during a run.
A minimum of 2 and a maximum of 6 calibration marks are needed within one data acquisition range. Therefore, in this workpiece example, you cannot use the (+) marks used for confirming the workpiece position during runs as calibration marks.

4-Point Camera Workpiece Example



NOTE: In addition, if you do not use the marks used for confirming the position during runs as calibration marks, make sure the shape of the calibration marks and the marks used for confirming the position during runs are different. When you set a double camera function, you need to set two sequential workpiece adjustment numbers or four sequential workpiece numbers for a 4-point camera operation.

■ Operation Flow

NOTE: 2.2.7 is a camera operation. All other steps are robot operations.

2.2.1 Create a New Program

Open a new program.

2.2.2 Tool Data Settings

Set up [Main TCP Setting] in [Main-Tool Configuration].

- Tool Mass
  When the camera is mounted on the robot axis, set the total weight of the tool and the camera as [Tool Mass].

JR3000 Series

Model	Tool Mass		
	1	2	3
JR3200	1 kg	3.5 kg	
JR3300 – JR3600	1 kg	4 kg	7 kg

JC-3 Series

Model	Tool Mass (Fixed Values)				
JC-3	2 Axes Single Sided	2 Axes Double Sided	3 Axes Single Sided	3 Axes Double Sided	4 Axes Double Sided
	4 kg	8 kg	4 kg	8 kg	3 kg

JS3 Series

Model	Tool Mass		
	1	2	3
JS3	1 kg	3 kg	6 kg

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

2.2.3 Register the Work Home

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

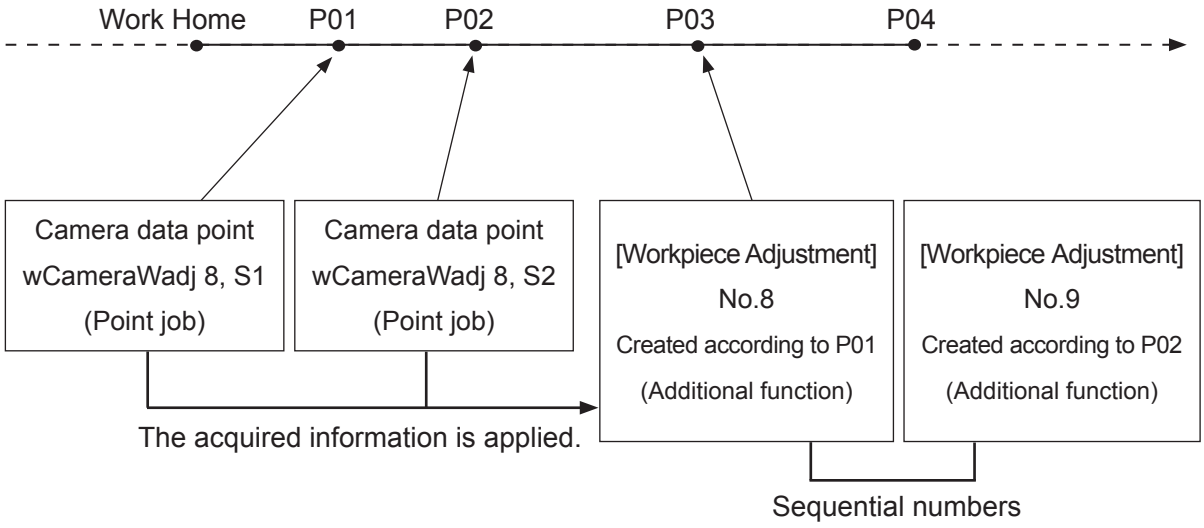
2.2.4 Register the Point Positions

■ For Double Camera Adjustments

Register the positions of the two camera data acquisition points (P01 and P02 below) and the point where the point job is carried out on the workpiece (P03 below).

The following data is assigned to each point for a workpiece position discrepancy adjustment (double camera adjustment) operation:

P01: Camera data acquisition (imaging) point 1 (shot 1)
P02: Camera data acquisition (imaging) point 2 (shot 2)
P03: The point where screw tightening or dispensing, etc., is carried out on the workpiece



Camera data acquisition is performed at P01 and P02. This information is applied to the additional function [Workpiece Adjustment] set at P03, thereby finalizing P03's position (P03 coordinate values + adjustment values).

■ For 4-point Camera Adjustments

Register the positions of the four camera data acquisition points (P01, P02, P03 and P04) and the point where the point job is carried out on the workpiece (P05 below).

The following data is assigned to each point for the workpiece position discrepancy adjustment (4-point camera adjustment) operation:

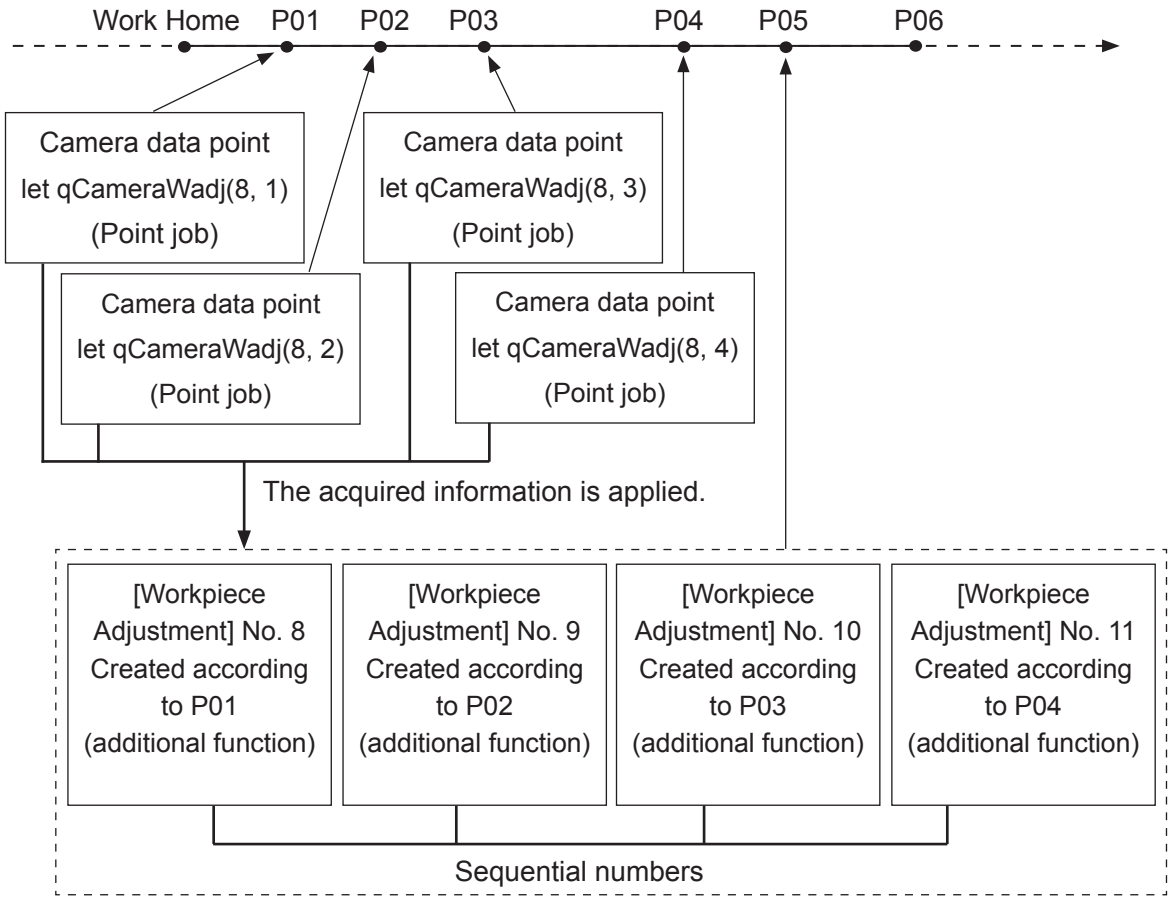
P01: Camera data acquisition (imaging) point 1 (shot 1)

P02: Camera data acquisition (imaging) point 2 (shot 2)

P03: Camera data acquisition (imaging) point 3 (shot 3)

P04: Camera data acquisition (imaging) point 4 (shot 4)

P05: The point where screw tightening or dispensing, etc., is carried out on the workpiece



Camera data acquisition is performed at P01, P02, P03 and P04. This information is applied to the additional function [Workpiece Adjustment] set at P05, thereby finalizing P05's position (P05 coordinate values + adjustment values).

2.2.5 Camera Communication Settings

Select [Camera Communication Settings] from the CCD camera adjustment menu and select the COM Port or client port on the robot side which connects to the camera.
Also, select the type of camera connected to the robot.

Set the same values which are set in Administration Mode to the camera side.
If there are differences with these settings, the robot and camera cannot communicate.
The communication settings made on the robot can be confirmed in Administration Settings Mode.

JR3000/JC-3 Series

TP MODE [Administration]
[Administration Settings Mode]
[COM Settings]
[COM 1 – 3 Communication Settings]

JS3 Series

TP UTILITY [Change Mode] → [Administration]
[Administration Settings Mode]
[COM Settings]
[COM 1, 2 Communication Settings]

2.2.6 Create the First Workpiece Adjustment

When performing a CCD camera adjustment (double camera), you need to set two sequential [Workpiece Adjustment] numbers. For a 4-point camera adjustment, you need to set four sequential [Workpiece Adjustment] numbers. Create the first [Workpiece Adjustment] to start.

Select [Workpiece Adjustment Settings] from the [Additional Function Data Settings] menu.
Select [CCD Camera Adjustment] and the following settable items are displayed:

CCD Camera Adjustment Menu Overview

Menu	Details
CCD Camera Adjustment	A “workpiece adjustment” type. There are three types: [Numeric Adjustment], [CCD Camera Adjustment], [CCD Camera Adjustment with Counter].
Camera Communication Settings	Select the COM connector on the robot side for connecting to the camera. Select the camera model for the camera connected to the robot.
Calibration	Settings to convert camera coordinates to robot coordinates.
Standard Data Setting	Acquires reference data. These values are used as reference data for calculating the adjustment values during a run.
Execute Parameter Setting	Settings to specify the operation when the workpiece adjustment is executed.
Display Adjustment	Settings to display (display only) the workpiece adjustment values calculated during operation of a “Test Run”/”Point Run”.
Z Adjustment	Settings for the distance sensor if the camera and distance/touch sensor are simultaneously used and XYZ direction workpiece position discrepancies are adjusted.

2.2.7 Camera Operation: Setting Calibration Marks (Calibration Preparation)

Here, settings on the CCD camera side are made. No robot operations are necessary.

To use the camera, first the calibration settings (convert the camera coordinates into robot coordinates) need to be made. To calibrate, first acquire the marks within the camera data acquisition range, and by specifying where these marks are within the robot's coordinates, the coordinate conversion coefficient between the robot and camera is obtained. These marks are called "calibration marks".

If there is no mark present on the workpiece useable as a calibration mark, you can affix a sticker with a mark to the workpiece, or use something other than the workpiece. Make sure, however, that the camera's data acquisition range and focus are the same here as they are when running the robot.

When performing a double camera adjustment, you need two workpiece adjustments. These are needed to calibrate each of the two camera data acquisition points. For a 4-point camera adjustment, you need 4 workpiece adjustments. First, calibrate the first camera data acquisition point.

Using the double camera point as an example, generic settings for CCD cameras are explained here.
For CCD camera setting methods, confirm with the operation manual supplied by your CCD camera's manufacturer.

■ Calibration Mark Settings

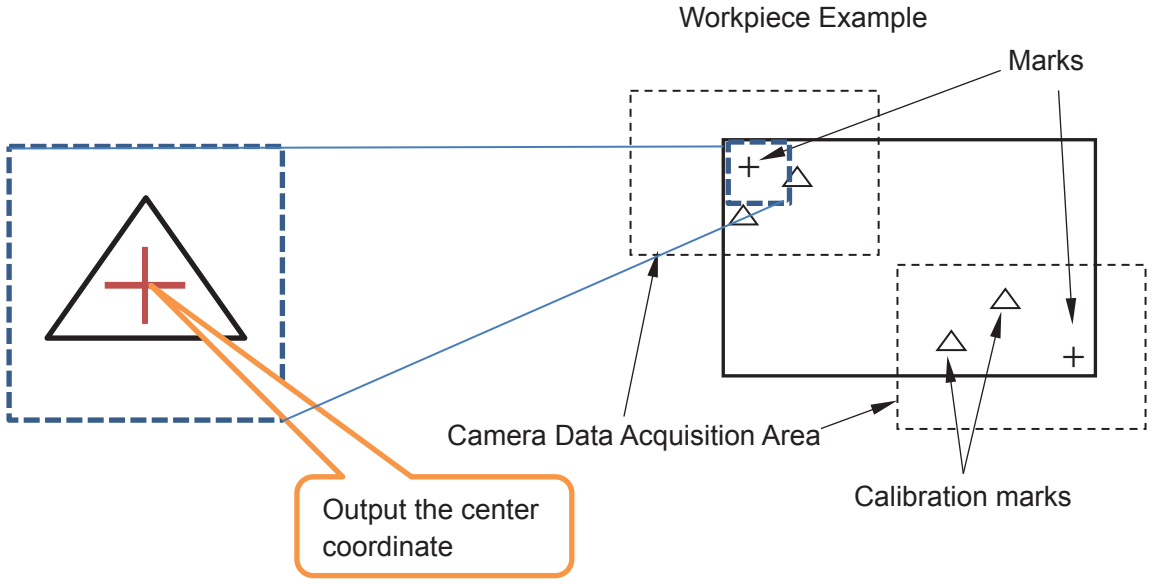
Set the calibration marks you want to detect on the camera side.

Calibration calculation is done on the robot side.

NOTE: You do not need to make calibration settings on the camera side.

With the camera, make settings to detect the center spot of the “+” mark on the workpiece below. Also, make settings so that both of the identical marks are detected.

When detecting identical marks, confirm the sorting sequence in the camera coordinates to see which one is the first mark.



⚠ Warning

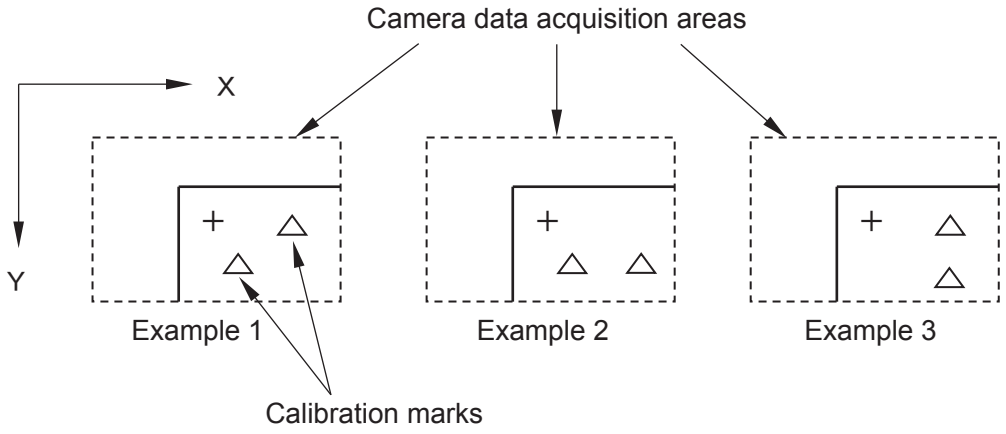
Sorting Identical Marks

When detecting multiple identical marks, sorting is to confirm beforehand in what kind of sequence the marks will be detected. If using a camera controller with settable sorting sequences, confirm the sequence before making settings.

Example 1: Both X and Y coordinates are possible.

Example 2: X coordinate (if the Y coordinate is used, it is difficult to identify which mark is C1.)

Example 3: Y coordinate (if the X coordinate is used, it is difficult to identify which mark is C1.)



■ Calibration Mark Coordinate Output Settings (ASCII text settings)

Set the output character strings in the following order on the camera controller side:

[Header] [Mark Number] [X –1] [Y – 1] [T – 1] [X – 2] ... [Y – n] [T – n]

1 st mark coordinates (C1) 2nd and onward mark coordinates (C2 – C6)

The output data formats differ depending on each manufacturer.

For further details, refer to “7. ADDENDUM: CAMERA SETTINGS LIST.”

2.2.8 Calibration

This section explains about the calibration (coordinate conversion) standard settings screen.

Acquire the marks with the camera ([Get Calibration Mark]), specify the positions of these marks with the robot ([Robot Coordinate Position]), and calculate the coordinate conversion coefficient between the camera and the robot ([Calculate and Register]).

Select [Calibration] from the CCD camera adjustment menu in [Workpiece Adjustment]. The following settable items are displayed:

Standard Settings Menu Overview

Menu	Explanation
Standard Settings	You can switch to [Simple Settings] here. For further details, refer to “2.1.16 Addendum 3: Calibration Settings (Simple Settings).”
Camera Data Acquisition No Movement	You can select to always take workpiece photographs from the same position, or to take workpiece photographs from positions that are not calibration mark positions.
Calibration Mark Number	This sets the number of marks (2 – 6) to use as references for calibration. Set this according to the number of calibration marks on the workpiece.
Get Calibration Mark	Acquire the marks (photographic image) that will be used as calibration reference marks. Select these after setting the calibration mark number. If the number of marks obtained from the camera and the calibration mark number do not match, an error occurs.
Robot Coordinate Position	This specifies the camera coordinates and the corresponding point coordinates on the robot. Check the camera’s direction (facing up/down), and enter the robot coordinates. “C1” “C2” ⋯ are the mark coordinates on the camera side acquired with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2 respectively. The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates. “C1,” “C2,” ⋯ and “P1,” “P2,” ⋯ only display their respective [Calibration Mark Number] settings. The camera coordinate “T” indicates the mark angle.
Camera Facing Up /Down	This is the direction of the camera. Set whether the camera is attached facing up or down.
Calculate and Register	This calculates and registers the coordinate conversion coefficient (the 4 items below). Set the 4 items above before selecting this.
Unit Coefficient	Displays the calculated coordinate conversion coefficient (K)
Rotate Angle [deg]	Displays the calculated coordinate conversion coefficient (ø)
X Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ X)
Y Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ Y)
Calibration Position	This is the tool center point position when the calibration marks were acquired.

Coordinate Conversion Formula

$X = K * x * \cos(ø) – K * y * \sin(ø) + \Delta X$

$Y = K * x * \sin(ø) + K * y * \cos(ø) + \Delta Y$

$\Theta = T + ø$

Camera coordinates (x, y, T), Robot coordinates (X, Y, Θ)

1. Enter [Calibration Mark Number].
   With the workpiece example, there are two marks you want to detect, so enter “2”.

2. Select [Get Calibration Mark].
   Once this is selected, the CCD camera takes a photograph, and the image is acquired.
   Make sure to acquire the photographic image under the same conditions (camera position, focus, and data acquisition range) as you have during the actual run. Also, after calibration, do not change the camera data acquisition point coordinates and the camera attachment position etc.
   If the number of marks acquired by the camera at this time do not coincide with the [Calibration Mark Number], a “Camera Data Acquisition Error” occurs.
   When the communication error below occurs, deal with it according to the “Content･Countermeasure”.

Error Code (rv=N)	Output Message	Content･Countermeasure
-1	Unmatched Mark Number Recieved Mark Number = (Number of Received Mark)	Received Unmatched Data The number of mark set for the robot does not match the number of mark received from the camera. Recheck the settings.
-2	Move Error, Auto Calibration Aborted	A movement error (mainly a move area limit error) occurs during the auto calibration. Recheck the auto calibration start position.
-3	I/O-S OPEN, Auto Calibration Aborted	The I/O-S circuit contacts are opened during the auto calibration. Close the I/O-S circuit contacts to ensure safety.
-10,-11,-12	Communication Time Out	Communication Timeout No response from the camera within 5 seconds after issuing the trigger. Recheck the communication settings for both the robot and camera.
-13,-14,-15	Convert Error	Convert Error Received a character string that cannot be converted. Recheck the camera communication settings.

NOTE: -2 and -3 are errors occurring during “auto calibration” in the simple settings display.

3. Check the direction the camera is facing (up or down) and enter [Robot Coordinate Position].
   C1 and C2 are camera coordinates of the marks (+) acquired by the camera with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2.
   First select P1, then match the robot’s tool center point with the C1 mark and lock in the coordinates.
   Likewise, enter and fix the corresponding coordinates to P2 and all other marks.
   The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates.
   C1, C2, and P1, P2 only display their respective [Calibration Mark Number] settings. The camera coordinate “T” indicates the mark angle.

4. Select [Calculate and Register] from the calibration menu.
   The coefficient to convert the camera coordinates into robot coordinates is calculated and registered. The calculated values are saved as the following items:
   - Unit Coefficient
   - Rotate Angle
   - X Shifting Amount
   - Y Shifting Amount

The calibration (data conversion) settings are now complete.

2.2.9 Create and Calibrate the Second Workpiece Adjustment

Refer to the first workpiece adjustment and calibration settings to create the second workpiece adjustment and calibrate the coordinates.

First, move the axes to P02 (camera data acquisition point (2)).
(Press the [GO] key to move the robot to the currently displayed coordinates.)

1. Create the Workpiece Adjustment
   Create the second [Workpiece Adjustment]. If the first [Work Adjustment Number] is set to [8], the second [Work Adjustment Number] must be [9]. Make sure to create [Workpiece Adjustment] using sequential numbers.

2. (Camera Operation) Camera Calibration Mark Settings
   If the number and calibration mark shape at P01 (camera data acquisition point (1)) are not the same as the calibration marks at P02 (camera data acquisition point (2)), you need to make new CCD Camera side calibration mark settings. If the number and shape of the marks are the same, you can use the settings as they are on the CCD camera side. You do not need to make new settings.

3. Calibration Settings
   Set up the [Workpiece Adjustment] calibration according to P02 (camera data acquisition point (2)).

NOTE: When making a double camera adjustment, set [Calibration Mark Number] within 2 – 3 marks. A number of 4 or higher causes a data acquisition error.

2.2.10 Create and Calibrate the Third and Fourth Workpiece Adjustments (4-point camera)

Refer to the second workpiece adjustment and calibration settings to create the third and fourth workpiece adjustments and calibrate the coordinates. The setting procedure is the same as that for the second adjustment.

2.2.11 Standard Data Settings

Also match up and respectively perform reference data acquisition at the two or 4 camera data acquisition points.

■ CCD Camera Controller Settings (Preparation for Acquiring Reference Data)
Move the robot to P01 (camera data acquisition point (1)), and set up the camera with the calibration marks. (The number and shape of the calibration marks (△) and the reference marks (+) are different, therefore you need to set up the calibration marks even though they are in the same camera data acquisition range).

■ Acquire the Workpiece Adjustment Reference Data

1. Move the robot to P01 (camera data acquisition point (1))
   (Press the [GO] key to move the robot to the currently displayed coordinates.)
2. Select [Standard Data Setting] from the CCD camera adjustment menu.
   The details of each of the items in Standard Data Settings are outlined below.

Standard Data Setting Menu Overview

Menu	Explanation
Standard Mark Number	This is the number of marks used as adjustment references. (1 – 7). NOTE: With a double camera or 4-point camera (Q-camera) adjustment, set no more than 3 marks. If you set 4 or more marks, a camera communication error occurs when the program is run.
Get Standard Data	This photographically acquires the reference marks. Select this after setting the number of reference marks.
P1, P2 ... P7	X,Y: the acquired reference mark coordinates (robot coordinates) T: the angle Values for the exact number of marks set in [Standard Mark Number] are displayed.

3. Select [Standard Mark Number], and enter the number of marks on the workpiece.
   In the workpiece example, the number of marks in the data acquisition range is 1, therefore enter 1.

4. Select [Get Standard Data]. Once selected, the camera takes the photograph and loads the marks from the photographic image. While the robot is running, this data is used as the 1st reference position for calculating the workpiece's offset amount. At this time, if the number of marks acquired by the camera and the number set in [Standard Mark Number] do not match, an error occurs.
   When acquiring the photographic image, make sure to acquire the photographic image under the same conditions (workpiece, workpiece placement position, camera position) as you have when actually running the robot. The acquired reference data is displayed in [P1, P2 ... P7].
   When the communication error below occurs, deal with it according to the "Content・Countermeasure".

Error Code (rv=N)	Output Message	Content・Countermeasure
-1	Unmatched Mark Number Recieved Mark Number = (Number of Received Mark)	Received Unmatched Data The number of mark set for the robot does not match the number of mark received from the camera. Recheck the settings.
-10,-11,-12	Communication Time Out	Communication Timeout No response from the camera within 5 seconds after issuing the trigger. Recheck the communication settings for both the robot and camera.
-13,-14,-15	Convert Error	Convert Error Received a character string that cannot be converted. Recheck the camera communication settings.

5. Move the robot to P02 (camera data acquisition point (2))
   (Press the [GO] key to move the robot to the currently displayed coordinates.)

6. Display the CCD camera adjustment menu of the [Workpiece Adjustment] created according to camera data acquisition point (2).
   Enter the number of reference marks into [Standard Mark Number] in [Standard Data Settings], and select [Get Standard Data]. Once selected, the marks from the photographic image are read according to the settings on the CCD camera side. This data is used as the second reference for workpiece positions during a run. At this time, if the number of marks acquired by the camera and the number set in [Standard Mark Number] do not match, an error occurs.
   When acquiring the photographic image, make sure to acquire the photographic image under the same conditions (workpiece, workpiece placement position, camera position) when actually running the robot. If the number and calibration mark shape at P01 (camera data acquisition point (1)) are not the same as the calibration marks at P02 (camera data acquisition point (2)), you need to make new settings on the CCD camera side. If the number and shape of the marks are the same, you can use the settings set on the CCD camera side. You do not need to make new settings.

7. For 4-point camera adjustments, follow steps 5 and 6 to set the data to P03 and P04.

8. The acquired reference data is displayed in P1, P2 ... P7.

The reference data settings are now complete.

2.2.12 Execute Parameter Settings

Select [Execute Parameter Setting] from the CCD camera adjustment settings menu for the [Workpiece Adjustment] created according to the first camera data acquisition point, and switch to the item you want to modify. The content of each of the items is as follows. (The [Execute Parameter Setting] for the workpiece adjustments created according to the second to fourth camera data acquisition points is ignored).

Execute Parameter Setting Menu Overview

Menu	Explanation
Apply Rotation to R-Axis	Select whether or not to apply workpiece rotation (T) to the R axis. If the angle of the workpiece and the reference data are different, match up the angle to the workpiece angle and rotate/do not rotate the R axis.
Reset Z Adjustment	When acquiring data from the camera, select to reset/not reset the Z axis (height) adjustment to 0.
Reset at Program Start	Select to reset/not reset the workpiece adjustment amount at the start of a run. When you are switching to multiple programs and performing a series of operations, if the camera data acquisition point on the workpiece and the job point to where you are applying the adjustment are in different programs, you need to set this to [Do Not Reset at Program Start].

The execute parameter settings are now complete (for basic CCD camera adjustment settings).

2.2.13 Set the Workpiece Adjustment to a Job Point

After calibration, reference data settings and execution parameter settings are complete, set the [Workpiece Adjustment] (the smaller sequential number) (additional function data) created according to the first camera data acquisition point to the point that performs the job (the point to where you want to set the work adjustment).
You do not need to set the [Workpiece Adjustment] created according to the second to fourth camera data acquisition points to a point.

2.2.14 Creating and Setting Point Job Data Example (Double Camera/4-Point Camera Adjustments)

■ Double Camera Adjustment

Create two sets of point job data and set them respectively to the two camera data acquisition points.

1. Wait Time Setting

   To prevent blurring of the photographic image, set a wait time subsequent to the camera data acquisition command.

   Enter a conditional wait time of 0.5sec for the *waitCondTime* or *delay* command.

2. Camera Data Acquisition (Photographic Image) Command

   Enter the camera data acquisition command *wCameraWadj* (command category: [Camera, Z Adjustment]) and the work adjustment number (the smaller sequential number) set to the point job. Enter the work adjustment number and shot number.

   Enter “1” as the shot number for the point job at the first camera data acquisition point; “2” for the point job at the second camera data acquisition point.

   When this command is executed, the robot acquires the photographic image with the camera and calculates the adjustment values according to the workpiece adjustment specified as a number in the obtained data.

3. Command for when a Camera Data Acquisition Error Occurs

   If a camera data acquisition error occurs, an incorrect offset amount is applied to the job point coordinates. To prevent this, enter a command to specify the operation for when camera data acquisition errors occur.

   By referring to the system flag, you can use a point job to specify the operation you want to execute when a camera data acquisition error occurs.

System Flag	Error
No. 31	Camera Communication Error (no response) Camera Data Acquisition Error

Check the following when an error occurs:

- The correct work adjustment number is specified.
- The work adjustment is set to [CCD Camera Adjustment].
- Camera communication settings are correct: [Camera Preset], [Camera Communication Port], and the COM port baud rate (Administration Settings)
- Settings on the camera side (external device) are correct: imaging settings, data output settings, communication settings, etc.
- The number of standard marks is set between 1 and 3. (If 4 or more marks are set, an error occurs.)

Example of Point Job Data at P01

```
waitCondTime 500
endWait
wCameraWadj 8, S1
if
  ld #sysFlag(31)
then
  goRPoint PTP0, 3
endIf
```

Camera data acquisition command (when workpiece adjustment number 8 is the first shot)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
jump ahead three points.

Example of Point Job Data at P02

```
waitCondTime 500
endWait
wCameraWadj 8, S2
if
  ld #sysFlag(31)
then
  goRPoint PTP0, 2
endIf
```

Camera data acquisition command (when workpiece adjustment number 9 is the second shot)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
jump ahead two points.

If there are no further commands to set, the creation process for the point job data is complete. Set this created point job data to the camera data acquisition points (P01 and P02).

■ 4-Camera Adjustment

Create four sets of point job data and set them respectively to the four camera data acquisition points.

1. Wait Time Setting

   To prevent blurring of the photographic image, set a wait time subsequent to the camera data acquisition command.

   Enter a conditional wait time of 0.5 sec for the *waitCondTime* or *delay* command.

2. Camera Data Acquisition (Photographic Image) Command

   Enter the workpiece adjustment number and shot number into the camera data acquisition function *qcameraWadj*. Enter the top sequential number into the workpiece adjustment number according to the point jobs for the first to fourth camera data acquisition points

   Enter the shot numbers in order from 1 to 4 respectively for the first to fourth camera data acquisition points.

3. Command for when a Camera Data Acquisition Error Occurs

   If a camera data acquisition error occurs, an incorrect offset amount is applied to the job point coordinates. To prevent this, enter a command to specify the operation for when camera data acquisition errors occur.

   By referring to the system flag, you can use a point job to specify the operation you want to execute when a camera data acquisition error occurs.

System Flag	Error
No. 31	Camera Communication Error (no response) Camera Data Acquisition Error

Check the following when an error occurs:

- The correct work adjustment number is specified.
- The work adjustment is set to [CCD Camera Adjustment].
- Camera communication settings are correct: [Camera Preset], [Camera Communication Port], and the COM port baud rate (Administration Settings)
- Settings on the camera side (external device) are correct: imaging settings, data output settings, communication settings, etc.
- The number of standard marks is set between 1 and 3. (If 4 or more marks are set, an error occurs.)

Example of Point Job Data at P01

```
delay 500
let qCameraWadj(8, 1)
if
  ld #sysFlag(31)
then
  goRPoint PTP0, 5
endIf
```

Camera data acquisition command (when workpiece adjustment number 8 is the first shot)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
jump ahead 5 points.

Example of Point Job Data at P02

```
delay 500
let qCameraWadj(8, 2)
if
  ld #sysFlag(31)
then
  goRPoint PTP0, 4
endIf
```

Camera data acquisition command (when workpiece adjustment number 8 is the second shot)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
jump ahead 4 points.

Example of Point Job Data at P03

```
delay 500
let qCameraWadj(8, 3)
if
  ld #sysFlag(31)
then
  goRPoint PTP0, 3
endIf
```

Camera data acquisition command (when workpiece adjustment number 8 is the third shot)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
Jump ahead three points.

Example of Point Job Data at P04

```
delay 500
let qCameraWadj(8, 4)
if
  ld #sysFlag(31)
then
  goRPoint PTP0, 2
endIf
```

Camera data acquisition command (when workpiece adjustment number 8 is the fourth shot)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
jump ahead two points.

If there are no further commands to set, the creation process for the point job data is complete. Set this created point job data to the camera data acquisition points (P01, P02, P03 and P04).

2.2.15 Create and Set the Point Job Data

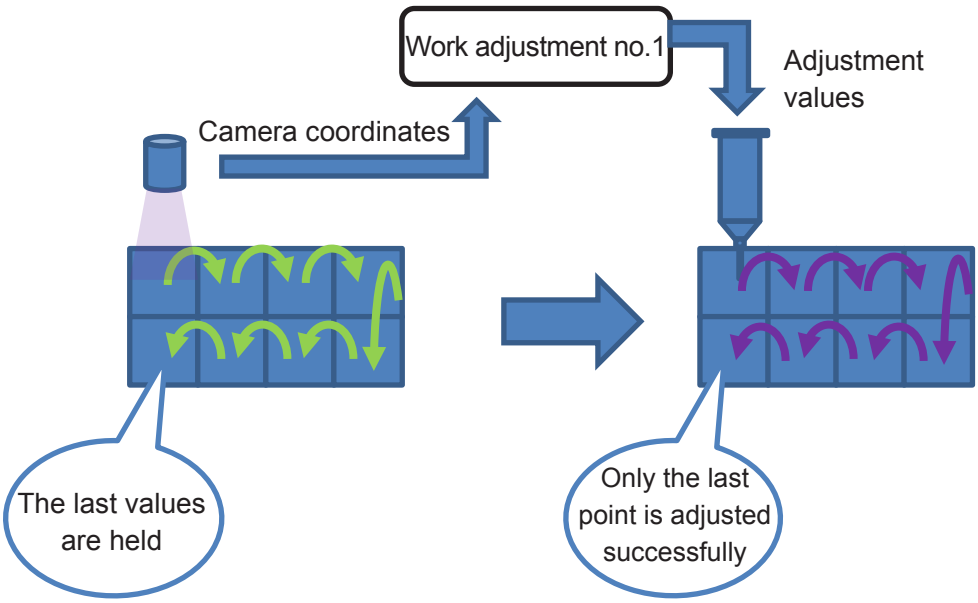
Set point job data that executes the operation you want to perform (screw tightening, dispensing, etc.) on the workpiece to the point that performs the job (the point to where you set the workpiece adjustment).

All the settings necessary for a “workpiece position discrepancy adjustment (double camera/4-point adjustment)” are complete.

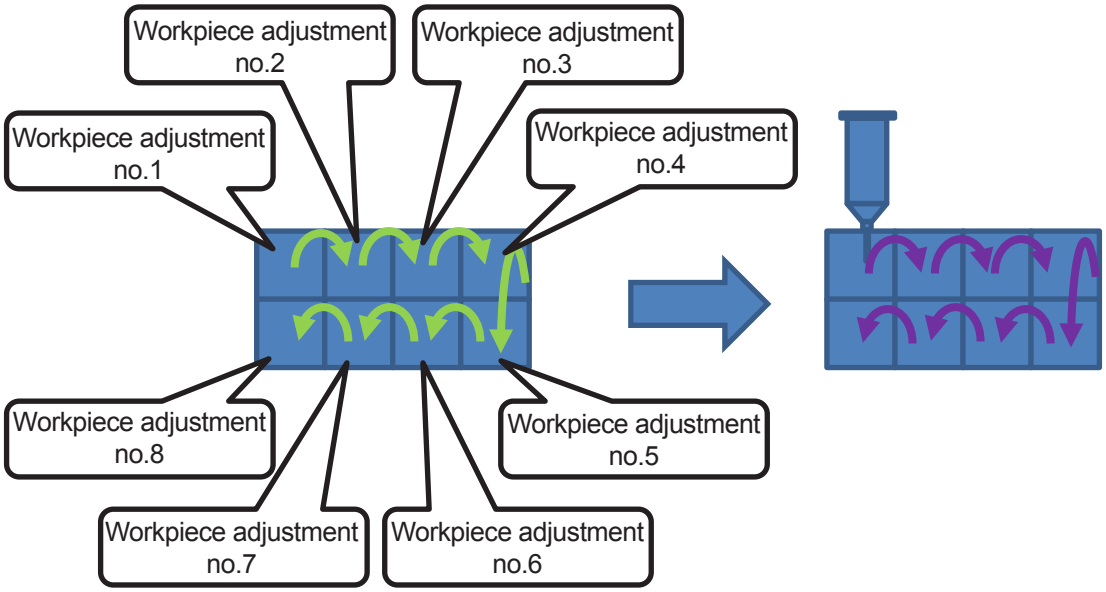
2.3 Practical Application: After Photographing Multiple Workpieces Together, Adjust them Together... CCD Camera Adjustment with Counter

This is a function used when you want to split up “photography” and “adjustments” for multiple workpieces. If you have a large number of workpieces, you can expect this function to reduce your work time.
Basic set up methods for workpiece adjustment settings here are the same as for CCD camera adjustments.

■ When you want to make workpiece adjustments after first photographing multiple workpieces with [CCD Camera Adjustment]
With a normal CCD camera adjustment, if you use one workpiece adjustment number to make adjustments to multiple workpieces and you first photograph the workpieces altogether, each time you photograph a workpiece, the adjustment values held by the one workpiece adjustment number are updated (the adjustment values are overwritten).
This means that the adjustment value for the workpiece adjustment number maintains the very last adjustment value photographed.
If you actually make workpiece adjustments using the adjustment values photographed last, position discrepancy adjustments are made according to the adjustment values of the point photographed last. Therefore, all points except for the point photographed last will be out of place.



To avoid a situation such as this, you need to handle the workpieces by setting a different workpiece adjustment number to each workpiece for each photograph.

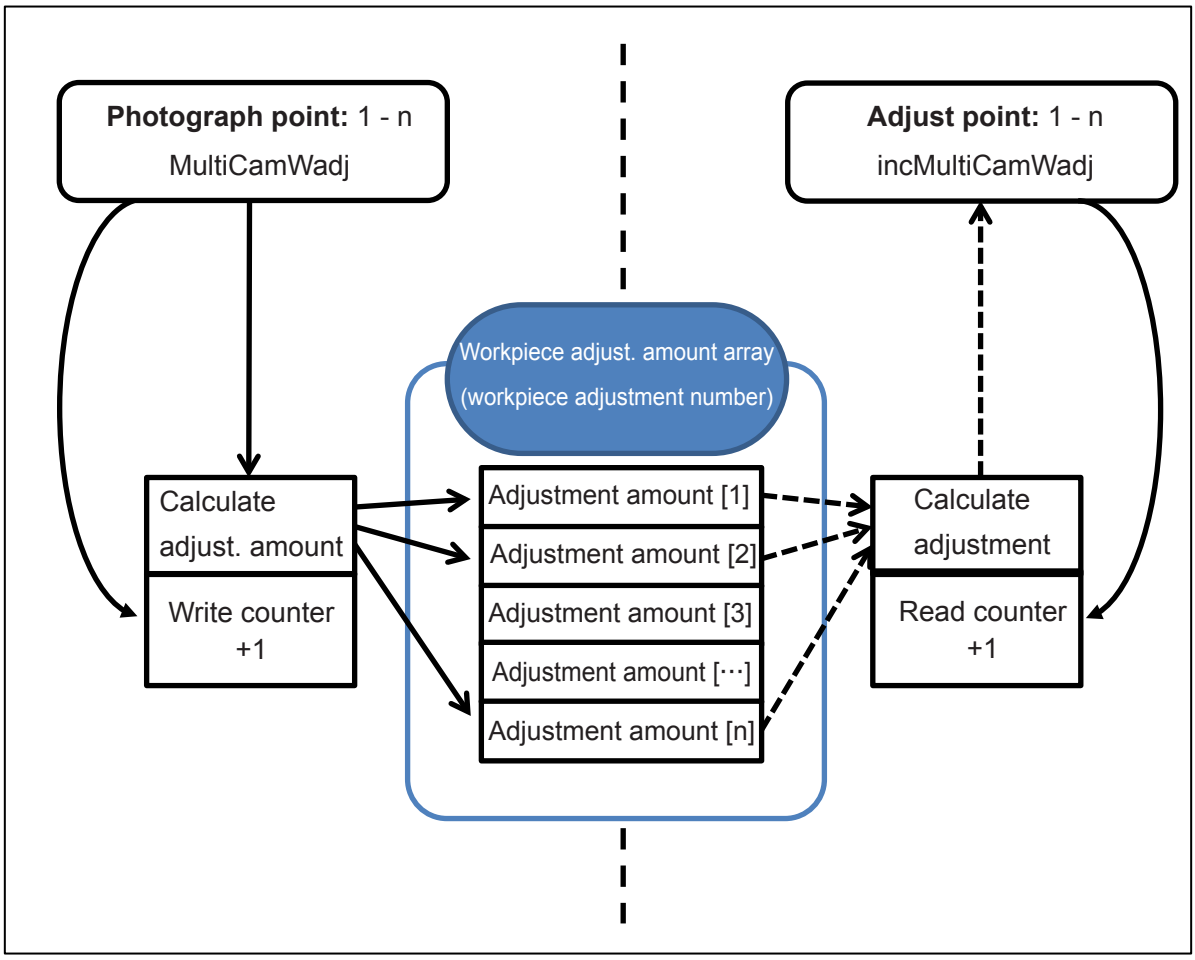


Using this method you can resolve the issue of making workpiece adjustments after first photographing multiple workpieces; however, managing them can be difficult when there are many workpieces.
To easily resolve issues such as this, use the [CCD Camera Adjustment with Counter] function.

■ [CCD Camera Adjustment with Counter] Overview

With the [CCD Camera Adjustment with Counter] function, there is a memory domain (data array) that can record multiple workpiece adjustment amounts in one workpiece adjustment setting. There are receptacles prepared in advance for storing multiple adjustment amounts in the memory domain.

The adjustment amounts are recorded in this sequence per photograph:
Adjustment amount [1] → Adjustment amount [2] ... Adjustment amount [n]



- With a CCD camera adjustment with counter, there is a “write counter” and a “read counter” in the memory domain.
- After storing an adjustment value in the memory domain (this is done after every photograph), 1 is added to the “write counter” and the “write counter” prepares to write to the next memory domain.
- 1 is added to the “read counter” each time an adjustment value is read on an adjustment point, and the “read counter” prepares to take the next readout from the memory.

NOTE: With the read counter, other than automatically adding 1 (increment) when the adjustment values are read, you can control the counter increment (adding 1) via [Increment by Point Job] control.

- The counters can be reset at any given time. If you perform a reset, both the read counter and the write counter are reset.

⚠ Caution

There is one memory domain (shared by all workpiece adjustments) within the robot for the CCD camera adjustment with counter.
If you operate one program with two cameras with counter adjustments, the adjustment values obtained from the first CCD camera with counter are overwritten and lost when photographing is performed with the second CCD camera adjustment with counter.
Basically, only one CCD camera adjustment with counter should be set per program. If you need two CCD cameras with counter adjustments at one time, do so by creating two programs.

2.3.1 Workpiece Preparation

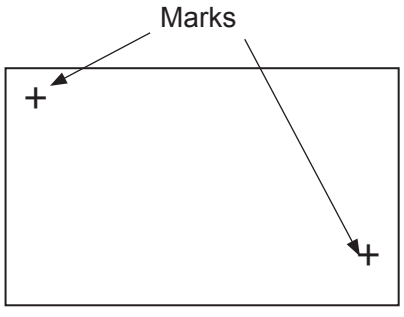
By acquiring marks (a photographic image) on the workpiece with the camera and confirming those positions, the workpiece's position discrepancy is identified.

Assume the camera has the following settings for the explanations in this example:

- Settings on the camera side are made so one kind of mark (marks of the same shape) can be identified with each camera data acquisition.
- The camera can identify two or more marks of the same shape with one photograph.

NOTE: Adjust and make the appropriate settings to match the environment for which you will use these camera functions.

This section explains how to create a new program based on the following workpiece.



Workpiece Example

2.3.2 Create a New Program

Open a new program.

2.3.3 Tool Data Settings

Set up [Main TCP Setting] in [Main-Tool Configuration].

- Tool Mass
  When the camera is mounted on the robot axis set the total weight of the tool and the camera as [Tool Mass].

JR3000 Series

Model	Tool Mass		
	1	2	3
JR3200	1 kg	3.5 kg	
JR3300 – JR3600	1 kg	4 kg	7 kg

JC-3 Series

Model	Tool Mass (Fixed Values)				
JC-3	2 Axes Single Sided	2 Axes Double Sided	3 Axes Single Sided	3 Axes Double Sided	4 Axes Double Sided
	4 kg	8 kg	4 kg	8 kg	4 kg

JS3 Series

Model	Tool Mass		
	1	2	3
JS3	1 kg	3 kg	6 kg

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

2.3.4 Register the Work Home

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

2.3.5 Register the Point Positions

Register the positions for the camera data acquisition point (P01) and for the point that performs the job on the workpiece (P02).

■ The Camera Data Acquisition Point
This is a point set with point job data that contains the camera data acquisition command. Here the camera takes a photographic image and calculates how far out place the current workpiece is from the reference coordinates. Register this point to a position where the camera can acquire a photographic image of the workpiece preceding the point you want to adjust.

NOTE: When the camera is not attached to the robot axis and the camera position is fixed, it is not necessary to set a dedicated camera data acquisition point. As long as the camera data acquisition point comes before the point where the job is performed on the workpiece, you can set it to a point that also serves as a point for another job (it does not need to be directly before the job).

■ The Point that Performs the Job on the Workpiece
This is the point where an operation such as screw driving or dispensing is actually performed on the workpiece. Set the additional function [Work Adjustment] to this point. Once [Work Adjustment] is set here, the robot adjusts the coordinates and makes the run with the exact “discrepancy” calculated at the “camera data acquisition point.”

2.3.6 Workpiece Adjustment Settings

Open a new [Workpiece Adjustment Settings] from the [Additional Function Data Settings] menu. Select [CCD Camera Adjustment with Counter] as the workpiece adjustment type. Once you have selected [CCD Camera Adjustment with Counter], the items below are displayed.

CCD Camera Adjustment with Counter Overview

Menu	Details
CCD Camera Adjustment with Counter	A “workpiece adjustment” type. There are three types: [Numeric Adjustment], [CCD Camera Adjustment], [CCD Camera Adjustment with Counter].
Auto Increment / Increment by Point Job	You can select [Auto Increment] or [Increment by Point Job] here.
Camera Communication Settings	Select the COM connector on the robot side connecting the camera. Select the camera model for the camera connected to the robot.
Calibration	Settings to convert camera coordinates to robot coordinates.
Standard Data Settings	Acquires reference data. These values are used as reference data for calculating the adjustment values during a run.
Execute Parameter Setting	Settings to specify the operation when the workpiece adjustment is executed.
Display Adjustment	Settings to display (display only) the workpiece adjustment values calculated during operation of a “Test Run”/”Point Run.” You can refer to counter value by opening the workpiece adjustment amount on the CCD Camera Adj With Counter settings screen. However, if the data within the counter and the CCD camera workpiece adjustment number does not match, a message stating the workpiece adjustment amount does not match is first shown.
Z Adjustment	Settings for the distance sensor if the camera and distance/touch sensor are simultaneously used and XYZ direction workpiece position discrepancies are adjusted.

■ Variables for a CCD Camera Adjustment With Counter

#mulWorkAdj_Wrt_Cam	Write value of the workpiece adjustment counter
#mulWorkAdj_Wrt_Zadj	Write value of the Z adjustment counter
#mulWorkAdj_Read	Read value of the workpiece adjustment counter
#mulWorkAdj _Num	Workpiece adjustment number of the workpiece adjustment counter
#mulWorkAdj_Result	Counter data result -1: No data 0: Unsatisfactory result 1: OK

Workpiece adjustment counter variables are variables for accessing counter values of a workpiece adjustment. The address variables for writing values to the workpiece adjustment counter are camera variables (#mulWorkAdj_Wrt_Cam) and Z adjustment variables (#mulWorkAdj_Wrt_Zadj). To obtain the workpiece adjustment amount for a given address, specify the address with the read counter (#mulWorkAdj_Read) and read out the workpiece adjustment variable.
The workpiece adjustment counter uses memory shared with the system and occupies one workpiece adjustment number. You can obtain the occupied workpiece adjustment number with #mulWorkAdj _Num.
The workpiece adjustment counter retains whether or not each adjustment value is appropriate (whether or not a camera acquisition error, etc., occurred).
You can process and skip addresses by reading out the counter data results.

2.3.7 Auto Increment/Increment by Point Job

This allows you to set the method of counter control.
Setting auto increment makes an increment (adds 1) to the counter value each time an adjustment amount is read.
Setting an increment by point job allows you to make counter increments with the point job command “incMultiCamWadj.” Use this when you want to use adjustment values with multiple points. This example is explained using the “Auto Increment” method.

2.3.8 Camera Communication Settings

Select [Camera Communication Settings] from the CCD camera adjustment with counter menu and select the COM Port or client port on the robot side which connects to the camera.
Also, select the type of camera connected to the robot.

Set the same values which are set in Administration Mode to the camera side.
If there are differences with these settings, the robot and camera cannot communicate.
The communication settings made on the robot can be confirmed in Administration Settings Mode.

JR3000/JC-3 Series
T P MODE [Administration]
[Administration Settings Mode]
[COM Settings]
[COM 1 – 3 Communication Settings]

JS3 Series
T P UTILITY [Change Mode] → [Administration]
[Administration Settings Mode]
[COM Settings]
[COM 1, 2 Communication Settings]

2.3.9 Camera Operation: Setting Calibration Marks (Calibration Preparation)

Here, settings on the CCD camera side are made. No robot operations are necessary.

To use the camera, first the calibration settings (convert the camera coordinates into robot coordinates) need to be made. To calibrate, first acquire the marks within the camera data acquisition range, and by specifying where these marks are within the robot's coordinates, the coordinate conversion coefficient between the robot and camera is obtained. These marks are called "calibration marks".
In the example here, the marks indicating the workpiece position during runs are also used as calibration marks.
As long as the marks fit into the camera data acquisition range, the calibration marks and the marks used for indicating the workpiece position during runs do not need to be the same. If there is no mark present on the workpiece useable as a calibration mark, you can affix a sticker with a mark to the workpiece, or use something other than the workpiece. Make sure, however, that the camera's data acquisition range and focus are the same here as they are when running the robot.

Generic settings for CCD cameras are explained here.
For CCD camera setting methods, confirm with the operation manual supplied by your CCD camera's manufacturer.

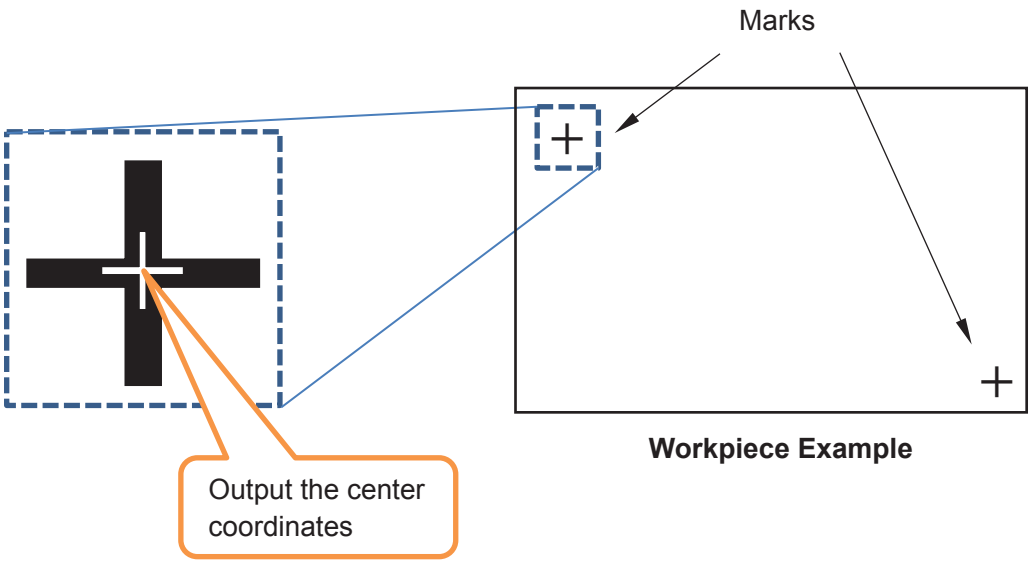
■ Calibration Mark Settings

Set the calibration marks you want to detect on the camera side.

Calibration calculation is done on the robot side.

NOTE: You do not need to make calibration settings on the camera side.

With the camera, make settings to detect the center of the "+" mark on the workpiece below.
Also, make settings so that both of the identical marks are detected.
When detecting identical marks, confirm the sorting sequence in the camera coordinates to see which one is the first mark.



Workpiece Example

■ Calibration Mark Coordinate Output Settings (ASCII text settings)

Set the output character strings in the following order on the camera controller side:

[Header] [Mark Number] [X –1] [Y – 1] [T – 1] [X – 2] ... [Y – n] [T – n]

1st mark coordinates (C1) 2nd and onward mark coordinates (C2 – C6)

The output data formats differ depending on each manufacturer.
For further details, refer to "7. ADDENDUM: CAMERA SETTINGS LIST."

2.3.10 Calibration

This section explains about the calibration (coordinate conversion) standard settings screen.

Acquire the marks with the camera ([Get Calibration Mark]), specify the positions of these marks with the robot ([Robot Coordinate Position]), and calculate the coordinate conversion coefficient between the camera and the robot ([Calculate and Register]).
Select [Calibration] from the CCD camera adjustment menu in [Workpiece Adjustment]. The settable items on the next page are displayed.

Standard Settings Menu Overview

Menu	Explanation
Standard Settings	You can switch to [Simple Settings] here. For further details, refer to “2.1.16 Addendum 3: Calibration Settings (Simple Settings).”
Camera Data Acquisition No Movement	You can select to always take workpiece photographs from the same position, or to take workpiece photographs from positions that are not calibration mark positions.
Calibration Mark Number	This sets the number of marks (2 – 6) to use as references for calibration. Set this according to the number of calibration marks on the workpiece.
Get Calibration Mark	Acquire the marks (photographic image) that will be used as calibration reference marks. Select these after setting the calibration mark number. If the number of marks obtained from the camera and the calibration mark number do not match, an error occurs.
Robot Coordinate Position	This specifies the camera coordinates and the corresponding point coordinates on the robot. Check the camera’s direction (facing up/down), and enter the robot coordinates. “C1” “C2” ⋯ are the mark coordinates on the camera side acquired with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2 respectively. The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates. “C1,” “C2,” ⋯ and “P1,” “P2,” ⋯ only display their respective [Calibration Mark Number] settings. The camera coordinate “T” indicates the mark angle.
Camera Facing Up /Down	This is the direction of the camera. Set whether the camera is attached facing up or down.
Calculate and Register	This calculates and registers the coordinate conversion coefficient (the 4 items below). Set the 4 items above before selecting this.
Unit Coefficient	Displays the calculated coordinate conversion coefficient (K)
Rotate Angle [deg]	Displays the calculated coordinate conversion coefficient (ø)
X Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ X)
Y Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ Y)
Calibration Position	This is the tool center point position when the calibration marks were acquired.

Coordinate Conversion Formula

$X = K * x * \cos(ø) - K * y * \sin(ø) + \Delta X$

$Y = K * x * \sin(ø) + K * y * \cos(ø) + \Delta Y$

$\Theta = T + ø$

Camera coordinates (x, y, T), Robot coordinates (X, Y, Θ)

1. Enter [Calibration Mark Number].
   With the workpiece example, there are two marks you want to detect, so enter “2”.

2. Select [Get Calibration Mark].
   Once this is selected, the CCD camera takes a photograph, and the image is acquired.
   Make sure to acquire the photographic image under the same conditions (camera position, focus, and data acquisition range) as you have during the actual run. Also, after calibration, do not change the camera data acquisition point coordinates and the camera attachment position etc.
   If the number of marks acquired by the camera at this time do not coincide with the [Calibration Mark Number], a “Camera Data Acquisition Error” occurs.

3. Check the direction the camera is facing (up or down) and enter [Robot Coordinate Position].
   C1 and C2 are camera coordinates of the marks (+) acquired by the camera with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2.
   First select P1, then match the robot’s tool center point with the C1 mark and fix the coordinates. Likewise, enter and fix the corresponding coordinates to P2 and all other marks.
   The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates.
   C1, C2, and P1, P2 only display their respective [Calibration Mark Number] settings.
   The camera coordinate “T” indicates the mark angle.

4. Select [Calculate and Register] from the calibration menu.
   The coefficient to convert the camera coordinates into robot coordinates is calculated and registered. The calculated values are saved as the following items:
   - Unit Coefficient
   - Rotate Angle
   - X Shifting Amount
   - Y Shifting Amount

The calibration (data conversion) settings are now complete.

2.3.11 Standard Data Settings

This registers the adjustment reference positions. In this example the calibration marks are registered as the reference positions.

1. Move the robot to P01 (camera data acquisition point).
   (Press the [GO] key to move the robot to the displayed coordinates.)

NOTE: In the workpiece example, the calibration marks and the marks used to confirm the workpiece position during the run are the same; therefore, the camera settings made in "Calibration" can be used. It is not necessary to make new settings on the camera side (if the shape and the number of the marks indicating the workpiece position during the run are not the same as those of the calibration marks, you need to make new settings for the CCD camera).

2. Select [Standard Data Setting] from the CCD camera adjustment menu.
   The details of each of the items in Standard Data Settings are outlined below.

Standard Data Setting Menu Overview

Menu	Explanation
Standard Mark Number	This is the number of marks used as adjustment references. (1 – 7). NOTE: If you are adjusting the rotation direction of the workpiece as well, set two or more marks here.
Get Standard Data	This photographically acquires the reference marks. Select this after setting the number of reference marks.
P1, P2 ... P7	X,Y: the acquired reference mark coordinates (robot coordinates) T: the angle Values for the exact number of marks set in [Standard Mark Number] are displayed.

3. Enter the number of marks on the workpiece used in the operation into [Standard Mark Number]. In the workpiece example P1, there are two marks you want to detect, so enter "2" into [Standard Mark Number].

4. Select [Get Standard Data]. Once selected, the camera takes the photograph and loads the marks from the photographic image. While the robot is running, this data is used as reference positions for calculating the workpiece's offset amount. At this time, if the number of marks acquired by the camera and the number set in [Standard Mark Number] do not match, an error occurs.
   When acquiring the photographic image, make sure to acquire the photographic image under the same conditions (workpiece, workpiece placement position, camera position) as you have when actually running the robot.

5. The acquired reference data is displayed in P1, P2... P7.
   The reference data settings are now complete.

2.3.12 Execute Parameter Setting

Select [Execute Parameter Setting] from the CCD camera adjustment setting menu, and switchover to the item you want to modify. The content of each of the items is as follows:

Execute Parameter Setting Menu Overview

Menu	Explanation
Apply Rotation to R-Axis	Select whether or not to apply workpiece rotation (T) to the R axis. If the angle of the workpiece and the reference data is different, match up the angle to the workpiece angle and rotate/do not rotate the R axis.
Reset Z Adjustment	When acquiring data from the camera, select to reset/not reset the Z axis (height) adjustment to 0.
Reset at Program Start	Select to reset/not reset the workpiece adjustment amount at the start of a run. When you are switching to multiple programs and performing a series of operations, if the camera data acquisition point on the workpiece and the job point to where you are applying the adjustment are in different programs, you need to set this to [Do Not Reset at Program Start]. If this is set to [Reset at Program Start], the “write counter” and “read counter” are reset at the start of the run.

The [Execute Parameter Settings] are now complete. (This is the end of explanations regarding basic CCD camera adjustment settings).

2.3.13 Set the Workpiece Adjustment Settings to a Point

Set the [Work Adjustment] numbers (additional function data settings) you created to all the points that perform jobs (the points to which you want to set the workpiece adjustment).

■ Error During Acquisition of Workpiece Adjustment Amount Indicated by the Read Counter

System Flag	Error Content
No. 37	Whether or not an error occurred during acquisition of the workpiece adjustment amount indicated by the read counter.

Below is an example of an adjustment made to a point set with a [Job Before Moving] point job.

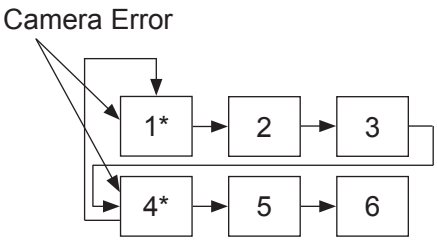
Point Job Data Example

```
if
ld #sysFlag(37)<>0
then
   incPallet 1
   incMultiCamWadj 1
   goPoint 0,n
endif
```

Check the counter data 0: Normal, 1: Error

Add 1 to pallet number 1 and jump to the next pallet.
Add 1 to the camera count value to match up the pallet pos.
Set the point number being executed to *n* to restart from the same point.

■ Operation Example (Camera error at pallet numbers 1 and 4)



Camera Counter Value	System Flag No. 37	
1	1	Error
2	0	Normal
3	0	Normal
4	1	Error
5	0	Normal
6	0	Normal

* The deviation amount cannot be detected for pallet counters 1 and 4 due to a camera counter value error. The robot does not execute pallets 1 and 4, and proceeds to the following pallets.

If there are no further commands to set, point job data creation is complete.
Set the point job data numbers you created to all the camera data acquisition points.

2.3.14 Creating and Setting Point Job Data Example (Camera Adjustment with Counter)

1. Open new point job data.

2. To prevent blurring of the photographic image, set a wait time preceding the camera data acquisition command.
   Use the conditional wait command *waitCondTime* or the wait command *delay*, etc. In this example, enter a wait time of 0.5sec.

3. Camera Data Acquisition (Photographic Image) Command
   Set the camera data acquisition command *multiCamWadj* and the work adjustment number (CCD camera adjustment with counter) you made.
   When this command is executed, the robot acquires the photographic image with the camera and calculates the adjustment values according to the [Workpiece Adjustment] specified as a number by the obtained data. At this time, the obtained adjustment values are recorded to the memory domain. When making a Z adjustment, also use the *multiTakeZWadj* command.

4. Command for when a Camera Data Acquisition Error Occurs

   If a camera data acquisition error occurs, an incorrect offset amount is applied to the job point coordinates. In this situation, enter a command to specify the operation for when camera data acquisition errors occur.

   By referring to the system flag, you can specify the operation to execute by point job when a camera data acquisition error occurs.

System Flag	Error
No. 31	Camera Communication Error (no response) Camera Data Acquisition Error

Example of Point Job Data

```
delay 500
multiCamWadj 1
if
   ld #sysFlag(31)
then
   endProg
endif
```

Stand by for 0.5 seconds (time to prevent blurring)
Camera data acquisition command (when workpiece adjustment number 1)
Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (if it is an error),
Finish the program.

If there are no further commands to set, point job data creation is complete.
Set the point job data numbers you created to all the camera data acquisition points.

2.3.15 Creating and Setting Point Job Data Example (Tool Data)

1. Open new point job data.

2. Set a wait time before the camera data acquisition command to prevent image blurring. Use a conditional command such as *waitCondTime* or *delay*, etc. For this example, set a wait time of 0.5 seconds.

3. Camera Data Acquisition Command
   Set the camera data acquisition command *cameraTool* and the [Tool Data] number you will use for teaching. (*cameraTool*: [Camera, Z Adjustment] command category. The robot captures an image using the camera and calculates the [TCP-X] and [TCP-Y] according to the [Tool Data] settings from the acquired data.)
   When this command is executed, the robot takes a photograph using the camera and calculates the [TCP-X] and [TCP-Y] according to the settings of the specified [Tool Data] number from the acquired data.

4. Command for when a Camera Data Acquisition Error Occurs
   If a camera data acquisition error occurs, incorrect [TCP-X] and [TCP-Y] values are set. To prevent this from happening, enter a command to specify operation for when camera data acquisition errors occur. By referring to a system flag, you can specify the point job to execute if a camera data acquisition error occurs.

System Flag	Error Details
No. 31	Camera Communication Error (no response from the camera) Camera Data Acquisition Error

Example of Point Job Data

```
delay 500
cameraTool 1
if
   ld #sysFlag(31)
then
   goRPoint PTP00, 2
endif
```

Wait 0.5 seconds (to control blurring)
Camera data acquisition command (if using tool data #1)

Camera adjustment acquisition error = ON (conditional)
If #sysFlag(31)=1 (true) (If it is an error),
Jump ahead two points (the point after the job point).

If there are no further commands you want to set, point job data creation is complete.
Set the point job data number to all camera data acquisition points.

2.3.16 Create and Set Point Job Data

Create and set point job data that executes the operations you want to perform (screw tightening, dispensing, etc.) on the workpiece to the points that perform the jobs (the points to where you set the workpiece adjustment).
All the settings necessary for “workpiece position discrepancy adjustment (CCD camera adjustment with counter)” are complete. If you wish to adjust the workpiece position in the Z direction, refer to “4. DISTANCE SENSOR ADJUSTMENT (Z ADJUSTMENT)” or “5. TOUCH SENSOR ADJUSTMENT (Z ADJUSTMENT).”

2.3.17 Addendum: Auto Increment and Increment by Point Job

With a CCD camera adjustment with counter, there are two ways to increase the adjustment value read counter (memory numbers of the stored adjustment values). One is [Auto Increment] which automatically updates the counter, and the other is [Increment by Point Job] which does not update the counter (the counter does not move to next memory number of the stored adjustment value) unless the point job has been set to do so. You can switch between these two methods.
The adjustment values for each method use *multiCamWadj*. However, if set to [Auto Increment], you do not need to set a point job to control the read counter. The robot sequentially proceeds to the next memory number in the read counter, and the read counter is automatically updated.
If the counter value of the read counter is higher than that of the write counter, the adjustment value is read out as 0 (no position adjustment is performed).

2.4 Practical Application Example

2.4.1 Teaching Example of a Pallet Routine

By combining a CCD camera adjustment (with counter) with a pallet routine, you may be able to reduce the amount of work time.
For example, if you use a CCD camera adjustment (with counter) with a 2x2 plane pallet, it may take time to complete, as the photographing and jobs will be performed reciprocally, causing a lot of movement.
For an operation such as the one described in the example above, a CCD camera adjustment (with counter) combined with a pallet routine may save you time.

Example of the Existing Method

Point Number	1	2	3	4
Type	PTP Point	CP Start Point	CP Passing Point	CP End Point
Job Before Moving		Adjustment Data Check		
Job After Moving Number	2 Camera Data: CCD Camera Adjustment	-	-	2 Pallet Counter Increment
Pallet Routine Number	Plane Pallet: 2x2 (increment by point job)	Plane Pallet: 2x2 (increment by point job)	-	-
Work Adjustment Number	-	CCD Camera Adjustment	-	-

If teaching is done as shown above, the robot will operate as follows:
1: Imaging → Job is performed on the workpiece
2: Imaging → Job is performed on the workpiece
3: Imaging → Job is performed on the workpiece
4: Imaging → Job is performed on the workpiece
The more movement there is, the longer it takes to complete the jobs.

Example Using a CCD Camera Adjustment with Counter

Point Number	1	2	3	4
Type	PTP Point	CP Start Point	CP Passing Point	CP End Point
Job After Moving Number	1 Camera Data: CCD Camera Adjustment with Counter	-	-	-
Pallet Routine Number	Plane Pallet: 2x2 (auto increment)	Plane Pallet: 2x2 (auto increment)	-	-
Work Adjustment Number	-	CCD Camera Adjustment with counter	-	-

If teaching is done as shown on the previous page, the robot will operate as follows:
1: Imaging x4
2: Job performed on the workpiece x4
It may depend on the workpiece locations, however, by performing the camera photography first and then performing the jobs later, the amount of movement can be reduced and the operation time shortened.

2.4.2 Teaching Example using Increment by Point Job

A CCD camera adjustment (with counter) using the auto increment setting prepares the proceeding workpiece adjustment amount at the place the workpiece adjustment amount is read. For example, when performing point dispensing at multiple points on a workpiece and if using auto increment, a workpiece adjustment amount is readout at each dispensing point, resulting in the robot dispensing at offset positions.
For an operation such as this, use a CCD camera adjustment (with counter) with the increment by point job setting.

CCD Camera Adjustment with Counter

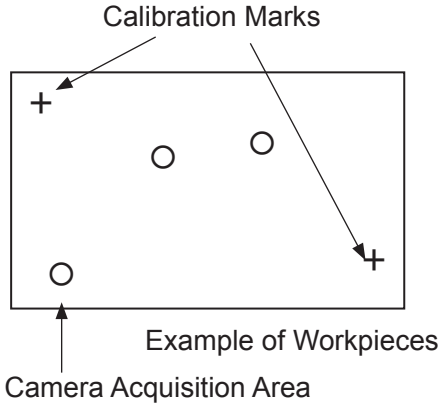
Point Number	1	2	3	4
Type	PTP Point	Point Dispense	Point Dispense	Point Dispense
Job After Moving Number	1 Camera data acquisition: CCD Camera Adjustment with Counter	-	-	-
Pallet Routine Number	Plane Pallet: 2x2 (increment by point job)	Plane Pallet: 2x2 (increment by point job)	Plane Pallet: 2x2 (increment by point job)	Plane Pallet: 2x2 (increment by point job)
Work Adjustment Number		CCD Camera Adjustment with Counter	CCD Camera Adjustment with Counter	CCD Camera Adjustment with Counter
Job After Moving	Pallet increment	-	-	Pallet increment, workpiece adjustment counter increment

If settings are made as shown above, adjustments are made from P2 to P4 with the same adjustment amount. If the workpiece adjustment counter increases at P4, the proceeding workpiece adjustment amount can be read out.

3. POINT JOBS (PALLET) AT POSITIONS PHOTOGRAPHED WITH THE CAMERA

Repeat by Camera is a function for workpieces which are freely placed in any area of the robot which is used to move the axes to the workpiece position when the robot recognizes the number of or the robot coordinate position of the registered workpiece photographed with the CCD camera.

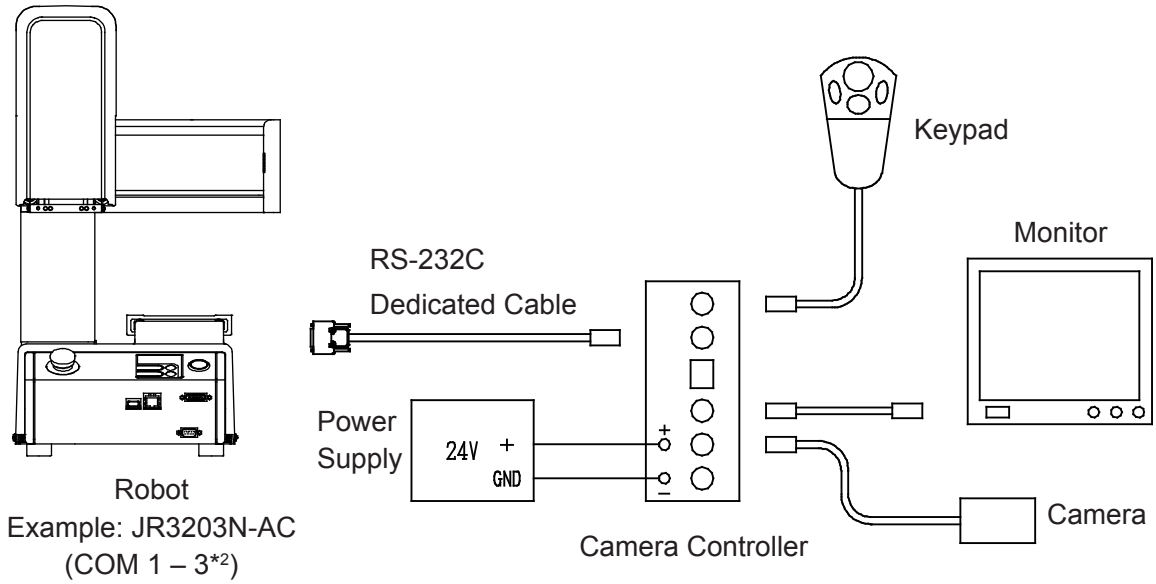
For example, assume that workpieces are placed at the positions marked as “O” and dispensing is performed on them as shown in the diagram to the right. The workpieces are acquired (as an image) with the camera, and once the number and positions of the marks are confirmed, the robot carries out the point job(s). Assume that the workpiece positions and number varies with each run.



3.1 Connection

Connect the camera, monitor, and keypad to the camera controller and then connect the camera controller and one of the COM1 – COM3*1*2 ports on the robot side with the RS-232C dedicated cable. For information regarding each of the connection methods, refer to the camera’s operation manual.

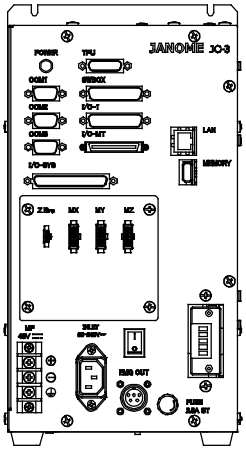
■ JR3000 Series Camera Connection Example



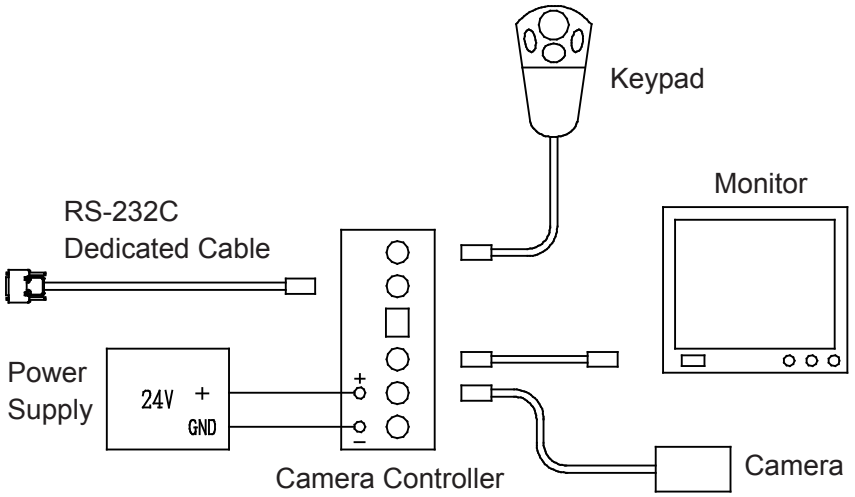
*1: COM port 1 or 2 for the JS3 Series.

*2: To use COM1 to communicate with a camera, set COM1 Command Communication Function to Invaild.

■ JC-3 Series Camera Connection Example

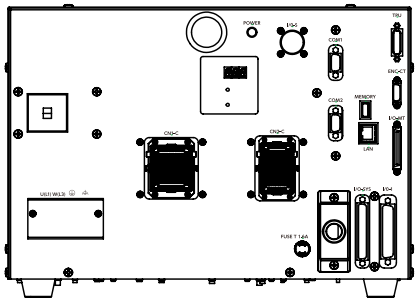


Controller
Example: JC-3C-3
(COM 1 – 3*)

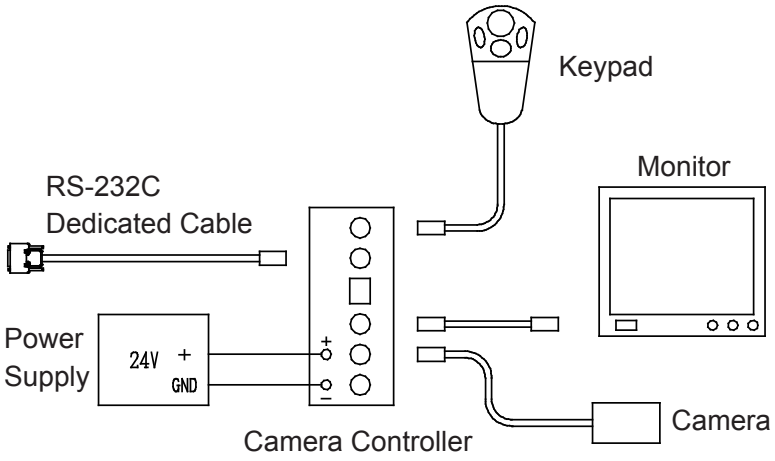


* To use COM1 to communicate with a camera, set COM1 Command Communication Function to Invaild.

■ JS3 Series Camera Connection Example



Controller
Example: JSC3-3520
(COM 1, 2*)



* To use COM1 to communicate with a camera, set COM1 Command Communication Function to Invaild.

⚠ Warning

Always make sure that the robot's power switch (circuit breaker for the JS3 Series) is OFF when making connections. Failure to do so can cause electric shock and injury.

The following procedures are necessary for using this function.
Connect the camera, controller, monitor, keypad and power supply to the robot correctly and set the workpiece in the same manner as it is during a run.

"3.2 Create a New Program"
"3.3 Tool Data Settings"
"3.4 Register the Work Home"
"3.5 Register the Point Positions"
"3.6 Move to the Camera Data Acquisition Point"
"3.7 Open Repeat by Camera"
"3.7.1 Camera Operation: Setting Calibration Marks (Calibration Preparation)"
"3.7.2 Calibration"
"3.8 Standard Data Settings"
"3.9 Execute Parameter Setting"
"3.10 Set Repeat by Camera to a Point"
Pallet Creation
"3.11 Create and Set Point Job Data"
"3.11.1 Create and Set Point Job Data that Includes Camera Data Acquisition Commands"
"3.11.2 Create and Set Point Job Data that Includes Pallet Control Commands"

3.7.1 is an operation performed on the camera side. All other sections are operations performed on the robot side.

3.2 Create a New Program

Open a new program.

3.3 Tool Data Settings

Set up [Main TCP Setting] in [Main-Tool Configuration].

- Tool Mass
  When the camera is mounted on the robot axis, set the total weight of the tool and the camera as [Tool Mass].

JR3000 Series

Model	Tool Mass		
	1	2	3
JR3200	1 kg	3.5 kg	
JR3300 – JR3600	1 kg	4 kg	7 kg

JC-3 Series

Model	Tool Mass (Fixed Values)				
JC-3	2 Axes Single Sided	2 Axes Double Sided	3 Axes Single Sided	3 Axes Double Sided	4 Axes Double Sided
	4 kg	8 kg	4 kg	8 kg	3 kg

JS3 Series

Model	Tool Mass		
	1	2	3
JS3	1 kg	3 kg	6 kg

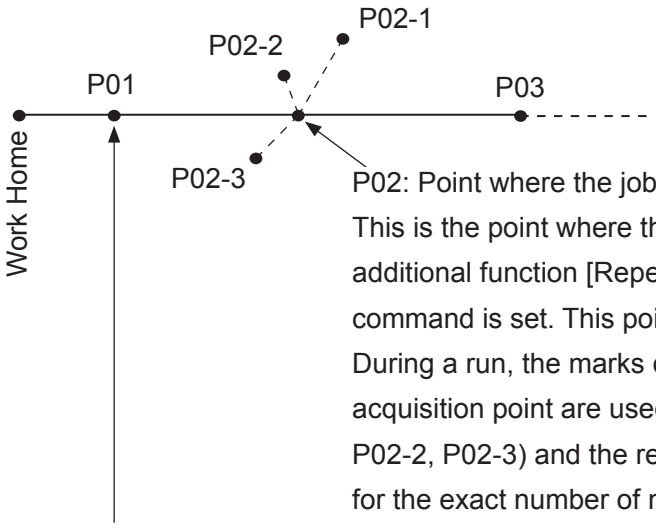
- TCP-X, TCP-Y
  If you have the exact TCP values, enter them. If not, select and perform [Direct TCP-XY Setting].

3.4 Register the Work Home

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

3.5 Register the Point Positions

Register the positions for the camera data acquisition point (P01) and for the point that performs the job on the workpiece (P02). Below is an example using 3 job points.
When the camera is not attached to the robot axis and the camera position is fixed, it is not necessary to set a dedicated camera data acquisition point. A camera data acquisition point (P01) can be any point where point job data is settable, as long as it comes before the point where the job is performed on the workpiece (the point to where you want to set [Repeat by Camera] to) (it does not need to be directly before the job). It is OK to register it to a point that also serves as a point for another job.



P02: Point where the job is performed
This is the point where the point job data which includes the additional function [Repeat by Camera] and the pallet control command is set. This point is not run at registered coordinates. During a run, the marks detected from the camera data acquisition point are used as coordinates (example: P02-1, P02-2, P02-3) and the registered point job is run repeatedly for the exact number of marks.

Camera Data Acquisition Point
This is the point where the point job data which includes the camera data acquisition command is set. Set this point before [Repeat by Camera] (it does not need to be directly before it) at a position where it can acquire the target image (P02-1, 2, 3).

3.6 Move to the Camera Data Acquisition Point

Move the axis to P01 (camera data acquisition point).
(Use the [GO] keys to move the axes to the coordinates currently displayed.)

3.7 Open Repeat by Camera

1. Open a new [Pallet Routine Data Settings] from [Additional Function Data Settings]. Select [Repeat by Camera] as the pallet type.

2. Enter the control method for the pallet counter and the maximum number of workpieces. For the maximum number of workpieces, enter the maximum number of workpieces (the “O” marks in this example) that can be detected with one acquisition. Up to 100 can be entered.

NOTE: If the number of marks acquired from the camera data acquisition exceeds [Maximum Workpiece Number], the error “Camera Data Error” occurs.

There are the following settable items for [Repeat by Camera].
Repeat by Camera Menu Overview

Menu	Details
Repeat by Camera	Pallet type. You can choose and modify your selection.
Auto Increment / Increment by Point Job	The control method for the pallet counter. You can select from [Auto Increment] and [Increment by Point Job].
Camera Communication Settings	Select the COM connector on the robot side connecting the camera. Select the camera model for the camera connected to the robot.
Calibration	Settings to convert camera coordinates to robot coordinates.
Standard Data Settings	Acquires reference data. These values are used as reference data for calculating the adjustment values during a run.
Execute Parameter Setting	Settings to specify the operation when the workpiece adjustment is executed.
Display Work Position	Once a test run/point run is made, this displays the workpiece position during the test run/point run.

3.7.1 Camera Operation: Setting Calibration Marks (Calibration Preparation)

Here, settings on the CCD camera side are made. No robot operations are necessary.

To use the camera, first the calibration settings (convert the camera coordinates into robot coordinates) need to be made. To calibrate, first acquire the marks within the camera data acquisition range, and by specifying where these marks are within the robot’s coordinates, the coordinate conversion coefficient between the robot and camera is obtained. These marks are called “calibration marks”.
In the example here, the marks indicating the workpiece position during runs are also used as calibration marks.

As long as the marks fit into the camera data acquisition range, the calibration marks and the marks used for indicating the workpiece position during runs do not need to be the same. If there is no mark present on the workpiece useable as a calibration mark, you can affix a sticker with a mark to the workpiece, or use something other than the workpiece. Make sure, however, that the camera's data acquisition range and focus are the same here as they are when running the robot.

Generic settings for CCD cameras are explained here.
For CCD camera setting methods, confirm with the operation manual supplied by your CCD camera's manufacturer.
NOTE: With a dispensing with camera model, if you select the camera as In-Sight(Ethernet) from [System-Camera COM Setting] → [System-Camera Model Setting], you need to use the PC software JR C-Points II to make camera settings. Refer to the operation manual *Dispensing with Camera Specifications*.

■ Communication Settings (CCD Camera Side)
Set the same values which are set in Administration Mode to the camera side.
If there are differences with these settings, the robot and camera cannot communicate.
The communication settings set up on the robot can be confirmed in Administration Settings Mode.

JR3000/JC-3 Series
T P MODE [Administration]
[Administration Settings Mode]
[COM Settings]
[COM 1 – 3 Communication Settings]

JS3 Series
T P UTILITY [Change Mode] → [Administration]
[Administration Settings Mode]
[COM Settings]
[COM 1, 2 Communication Settings]

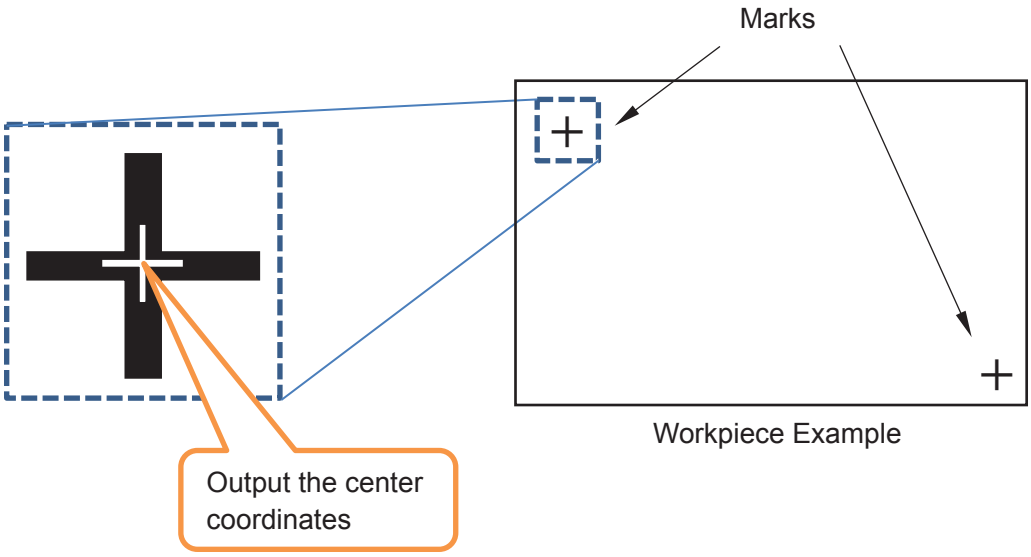
■ Calibration Mark Settings

Set the calibration marks you want to detect on the camera side.

Calibration calculation is done on the robot side.

NOTE: You do not need to make calibration settings on the camera side.

With the camera, make settings to detect the center of the “+” mark on the workpiece below.
Also, make settings so that both of the identical marks are detected.
When detecting identical marks, confirm the sorting sequence in the camera coordinates to see which one is the first mark.



■ Calibration Mark Coordinate Output Settings (ASCII text settings)

Set the output character strings in the following order on the camera controller side:

[Header] [Mark Number] [X –1] [Y – 1] [T – 1] [X – 2] ... [Y – n] [T – n]

1st mark coordinates (C1) 2nd and onward mark coordinates (C2 – C6)

The output data formats differ depending on each manufacturer.
For further details, refer to “7. ADDENDUM: CAMERA SETTINGS LIST.”

3.7.2 Calibration

This section explains about the calibration (coordinate conversion) standard settings screen.

Acquire the marks with the camera ([Get Calibration Mark]), find where these marks are within the robot coordinates ([Robot Coordinate Position]), and calculate the coordinate conversion coefficient between the camera and the robot ([Calculate and Register]).

Select [Calibration] from the repeat by camera menu in [Pallet Routine]. The following settable items are displayed:

Standard Settings Menu Overview

Menu	Explanation
Camera Data Acquisition No Movement	You can select to always take workpiece photographs from the same position, or to take workpiece photographs from positions that are not calibration mark positions.
Calibration Mark Number	This sets the number of marks (2 – 6) to use as references for calibration. Set this according to the number of calibration marks on the workpiece.
Get Calibration Mark	Acquire the marks (photographic image) that will be used as calibration reference marks. Select these after setting the calibration mark number. If the number of marks obtained from the camera and the calibration mark number do not match, an error occurs.
Robot Coordinate Position	This specifies the camera coordinates and the corresponding point coordinates on the robot. Check the camera's direction (facing up/down), and enter the robot coordinates. "C1" "C2" ⋯ are the mark coordinates on the camera side acquired with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2 respectively. The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates. "C1," "C2," ⋯ and "P1," "P2," ⋯ only display their respective [Calibration Mark Number] settings. The camera coordinate "T" indicates the mark angle.
Camera Facing Up / Down	This is the direction of the camera. Set whether the camera is attached facing up or down.
Calculate and Register	This calculates and registers the coordinate conversion coefficient (the following 4 items). Set the 4 items above before selecting this.
Unit Coefficient	Displays the calculated coordinate conversion coefficient (K)
Rotate Angle [deg]	Displays the calculated coordinate conversion coefficient (ø)
X Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ X)
Y Shifting Amount	Displays the calculated coordinate conversion coefficient (Δ Y)
Calibration Position	This is the tool center point position when the calibration marks were acquired.

Coordinate Conversion Formula

$X = K * x * \cos(ø) - K * y * \sin(ø) + \Delta X$

$Y = K * x * \sin(ø) + K * y * \cos(ø) + \Delta Y$

$\Theta = T + ø$

Camera coordinates (x, y, T), Robot coordinates (X, Y, Θ)

1. Enter [Calibration Mark Number].
   With the workpiece example, there are two marks you want to detect, so enter “2”.

2. Select [Get Calibration Mark].
   Once this is selected, the CCD camera takes a photograph, and the image is acquired.
   Make sure to acquire the photographic image under the same conditions (camera position, focus, and data acquisition range) as you have during the actual run. Also, after calibration, do not change the camera data acquisition point coordinates and the camera attachment position etc.
   If the number of marks acquired by the camera at this time do not coincide with the [Calibration Mark Number], a “Camera Data Acquisition Error” occurs.

NOTE: Depending on the camera type, a data acquisition error occurs if the camera is not set to photograph mode.

3. Check the direction the camera is facing (up or down) and enter [Robot Coordinate Position].
   C1 and C2 are camera coordinates of the marks (+) acquired by the camera with [Get Calibration Mark]. Enter the C1 and C2 coordinates on the robot side into P1 and P2.
   First select P1, then match the robot’s tool center point with the C1 mark and fix the coordinates. Likewise, enter and fix the corresponding coordinates to P2 and all other marks.
   The camera coordinate axes and the robot coordinate axes sometimes face different directions. Make sure to thoroughly check which mark is C1 before entering robot coordinates.
   C1, C2, and P1, P2 only display their respective [Calibration Mark Number] settings. The camera coordinate “T” indicates the mark angle.

4. Select [Calculate and Register] from the calibration menu.
   The coefficient to convert the camera coordinates into robot coordinates is calculated and registered. The calculated values are saved as the following items:
   - Unit Coefficient
   - Rotate Angle
   - X Shifting Amount
   - Y Shifting Amount

The calibration (data conversion) settings are now complete.

3.8 Standard Data Settings

Move the robot to P01 (the camera data acquisition point).
(Use the [GO] keys to move the axes to the coordinates currently displayed.)
If there are multiple workpieces (O marks) in the camera data acquisition area, leave only 1 workpiece in the area by covering the other O marks with tape etc. The number of marks that can be used when acquiring standard data is limited to 1. An error occurs if multiple marks are acquired.
Select [Get Standard Data]. Once selected, the camera performs the operation in accordance with the smart matching checker settings, and the robot loads the mark from the image. This data is used as a basis for the workpiece positions during a run. When acquiring the photographic image, make sure to acquire the photographic image under the same conditions (workpiece, workpiece placement position, camera position) as you have during an actual run.
Once the image is acquired successfully, the standard data coordinates are displayed.
The standard data coordinates can only be modified with [Get Standard Data].
We recommend teaching the position of the point where camera data acquisition is performed before creating the [Pallet Routine] data. The point coordinates can be referred to, however the coordinate values of the tool center point during the [Get Standard Data] procedure cannot be referred to.

3.9 Execute Parameter Setting

[Execute Parameter Setting] includes the following settable items. Confirm the settings.

Execute Parameter Setting Menu Overview

Menu	Explanation
Maximum Workpiece Number	The maximum number of marks that can be acquired by the camera during a run.
Apply Rotation to R-Axis	Select whether or not to apply workpiece rotation (T) to the R axis. If the angle of the workpiece and the reference data is different, match up the angle to the workpiece angle and rotate/do not rotate the R axis.

The creation of [Repeat by Camera] in the additional function [Pallet Routine] is now complete.

3.10 Set Repeat by Camera to a Point

Set [Repeat by Camera] (additional function data settings) you created to all the points that perform jobs (the points to you want to set the pallet).

3.11 Create and Set Point Job Data

3.11.1 Create and Set Point Job Data that Includes Camera Data Acquisition Commands

1. To prevent blurring of the photographic image, set a wait time preceding the camera data acquisition command. Use the conditional wait command *waitCondTime*, and enter a wait time of 0.5sec.

2. Camera Data Acquisition (Photographic Image) Command
   Set the camera data acquisition command *cameraPallet* (command category: [Camera, Z Adjustment]) and the pallet number you made.
   When this command is executed, the following operations are made:
   - The robot acquires the photographic image with the camera
   - The number of marks acquired and those coordinates are recorded
   - The pallet counter is reset

3. Command for when a Camera Data Acquisition Error Occurs
   If the number of marks exceeds the maximum number of workpieces during camera data acquisition or if the number of workpieces is set to 0, a camera data acquisition error occurs. Enter a command to specify the operation for when camera data acquisition errors occur. By referring to the system flag, you can specify the operation to execute by point job when a camera data acquisition error occurs.

System Flag	Error Content
No. 31	Camera Communication Error (no response) Camera Data Acquisition Error

Example of Point Job Data

```
waitCondTime 0.5 sec        Stand by for 0.5 seconds
endWait
cameraPallet 1              Camera data acquisition command
if
  ld #sysFlag(31)           Camera adjustment acquisition error = ON (conditional)
then                        If #sysFlag(31)=1 (true) (if it is an error),
  goRPoint PTP  0, 1        jump 1 points ahead (the point succeeding the job point).
endIf
```

If there are no further commands to set, the creation of point job data that includes camera data acquisition commands is complete. Set the point job data numbers you created to all the camera data acquisition points.

3.11.2 Create and Set Point Job Data that Includes Pallet Control Commands

Point job data that includes pallet control commands is the point job data which is set to points which perform jobs. First of all, enter the command for the job (dispensing, screw tightening etc.) you want to perform at the point. After this, enter the following pallet control commands.

NOTE:

- Once you perform the camera data acquisition, the pallet counter is reset. You cannot set the camera data acquisition command and the pallet control command to the same point.
- If P02 (the point where the job is performed) is not the point type [Point Dispense], you also need a command to perform dispensing separate from the pallet control command.

You do not need the following commands when the control method of [Pallet Routine] is set to [Auto Increment].

The pallet commands use the normal [Pallet Routine] control commands.

- *loopPallet*
  This adds 1 to the pallet counter, and the robot moves to the specified point if the counter has not reached the maximum value.
- *resPallet*
  This reset the pallet counter to 0.
- *incPallet*
  This adds 1 to the pallet counter.

Pallet Control Command Entry Example

```
  :
loopPallet 1, 7
```

Add 1 to the 1st pallet counter, and move to P07 if the number of marks acquired with the camera data acquisition point does not fill the counter.

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

The same content when not using the *loopPallet*.
(The pallet flag (*#palletFlag*) becomes “True (1)” when full.

Move to point number 7

If there are no further commands to set, the creation of point job data that includes pallet control commands is complete. Set the point job data numbers you created to P02 (point which performs the job).

All of the settings needed for “point jobs (pallet) at positions photographed with the camera” are now complete.

4. DISTANCE SENSOR ADJUSTMENT (Z ADJUSTMENT)

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

4.1 Connection

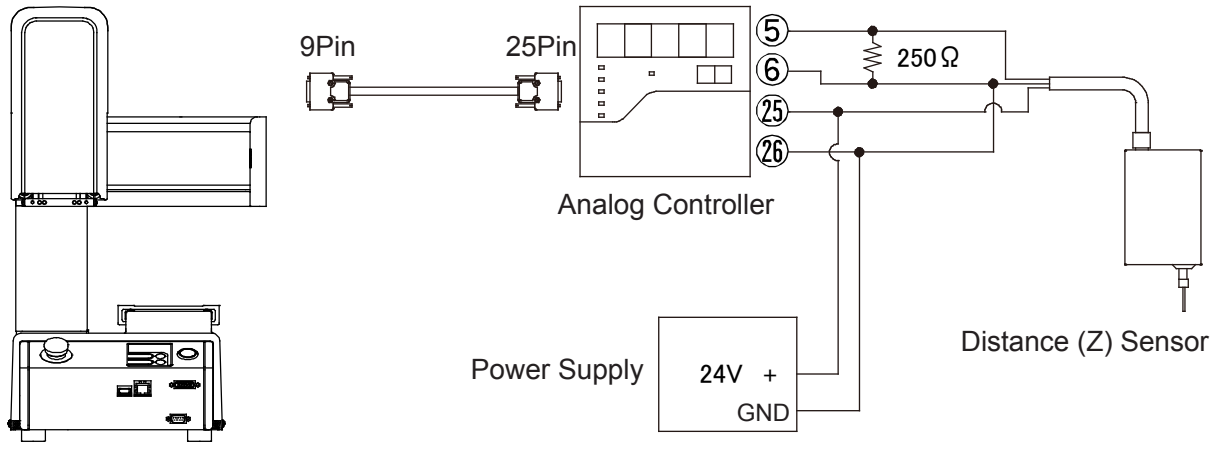
Connect the distance sensor and power supply to the analog controller. Connect the analog controller to COM1, COM2 or COM3*1*2 on the robot side with an RS-232C (dedicated) cable.

Also refer to the camera, distance sensor, and analog controller instruction manuals for the connection procedure.

⚠ Warning

Always make sure that the robot's power switch (circuit breaker for the JS3 Series) is OFF when making connections. Failure to do so can cause electric shock and injury.

■ JR3000 Series Distance Sensor Connection Example

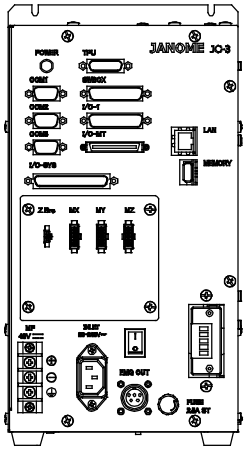


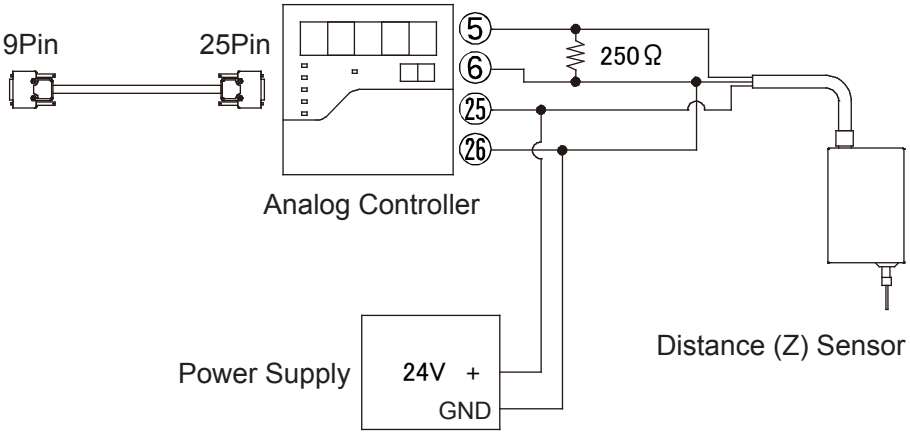
Robot
Example: JR3203N-AC
(COM 1 – 3)*2

*1: COM port 1 or 2 for the JS3 Series.

*2: To use COM1 to communicate with a distance sensor, set COM1 Command Communication Function to Invaild.

■ JC-3 Series Distance Sensor Connection Example

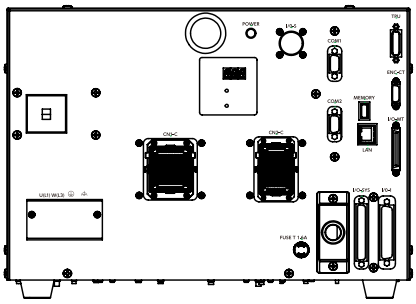


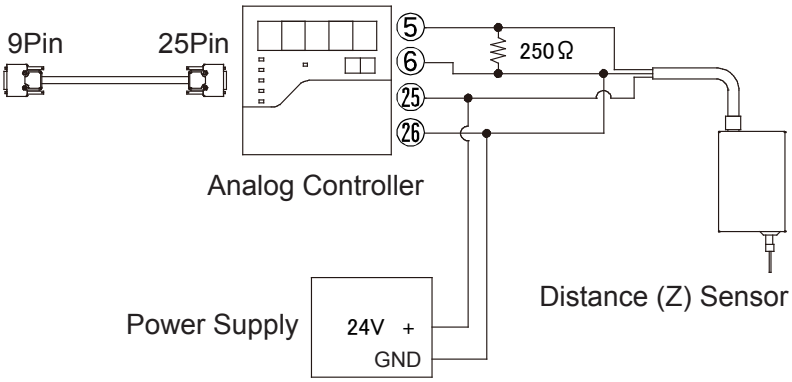


Controller
Example: JC-3C-3
(COM 1 – 3)*

* To use COM1 to communicate with a distance sensor, set COM1 Command Communication Function to Invaild.

■ JS3 Series Distance Sensor Connection Example





Controller
Example: JSC3-3520
(COM1, 2*)

* To use COM1 to communicate with a distance sensor, set COM1 Command Communication Function to Invaild.

The following procedures are necessary for using this function.
Connect the distance sensor, analog controller, and power supply to the robot properly, and set the workpiece in the same manner as it is during a run.
To adjust workpiece position discrepancies in the X, Y, and Z directions using the camera and the distance sensor together, perform the “workpiece position discrepancy adjustment (camera adjustment)” operation first, and then go to Step 4.5 below.

“4.2 Create a New Program”
“4.3 Tool Data Settings”
“4.4 Register the Work Home”
“4.5 Register the Point Positions”
“4.6 Move to the Height Measuring Point”
“4.7 Create and Set the Additional Function Data Workpiece Adjustment”
“4.7.1 Workpiece Adjustment”
“4.7.2 Camera Communication Settings”
“4.7.3 Get Standard Data”
“4.7.4 Set the Workpiece Adjustment to a Point”
“4.8 Create and Set Point Job Data that includes the Z Adjustment Acquisition Commands”
“4.8.1 New Point Job Data”
“4.8.2 Z Adjustment Acquisition Command”
“4.8.3 Command for an Error During Z Adjustment Acquisition”
“4.8.4 Height Measuring Point”

4.2 Create a New Program

Open a new program.

4.3 Tool Data Settings

Set up [Main TCP Setting] in [Main-Tool Configuration].

- Tool Mass
  When the distance sensor is mounted on the robot axis, set the total weight of the tool and the distance sensor as [Tool Mass]. When the camera is mounted on the robot axis, set the total weight of the tool and the camera as [Tool Mass].

JR3000 Series

Model	Tool Mass		
	1	2	3
JR3200	1 kg	3.5 kg	
JR3300 – JR3600	1 kg	4 kg	7 kg

JC-3 Series

Model	Tool Mass (Fixed Values)				
JC-3	2 Axes Single Sided	2 Axes Double Sided	3 Axes Single Sided	3 Axes Double Sided	4 Axes Double Sided
	4 kg	8 kg	4 kg	8 kg	3 kg

JS3 Series

Model	Tool Mass		
	1	2	3
JS3	1 kg	3 kg	6 kg

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

4.4 Register the Work Home

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

4.5 Register the Point Positions

Register the height measuring point and the position of the point that performs the job on the workpiece.
If you wish to adjust the workpiece position discrepancy in the X, Y, and Z directions using the camera and the distance sensor together, and your height measuring point differes from your camera data acquisition point, register only the height measuring point using [Insert a Point].
If you set the camera data acquisition point and the height measuring point to the same point, you do not need to register the point position. Proceed to the next step.

■ Height Measuring Point (this is a point set with point job data that contains the height measuring command)
At this point, the robot measures the workpiece height using the distance sensor and calculates how far out of place the current workpiece is from the reference height. Register this point to a position where the distance sensor can measure the workpiece height preceding the point to where you want to make height adjustments.
If the height sensor and camera are used at the same time, the height measuring point can be set to the same point as the camera data acquisition point (but this is not a requirement).

NOTE: If the distance sensor is not mounted on the robot axis and its position is fixed, you do not need to set a dedicated height measuring point. As long as the height measuring point comes before the point where the job is performed on the workpiece, you can set it to a point that also serves as a point for another job (it does not need to be directly before the job).

■ The Point that performs the Job on the Workpiece (this is the point where an operation such as screw driving or dispensing is actually performed on the workpiece)
Set the additional function [Work Adjustment] to this point. Once [Work Adjustment] is set here, the robot adjusts the coordinates and makes the run with the exact “discrepancy” calculated at the “height measuring point”.

4.6 Move to the Height Measuring Point

Move the axes to P01 (height measuring point).
(Press the [GO] key to move the robot to the currently displayed coordinates.)

4.7 Create and Set the Additional Function Data Workpiece Adjustment

4.7.1 Workpiece Adjustment

Open a new [Workpiece Adjustment Settings] from [Additional Function Data Settings].
Select [Numeric Adjustment] as the workpiece adjustment type. After selecting [Numeric Adjustment], the following items are displayed:

Numeric Adjustment Menu Overview

Menu	Details
Numeric Adjustment	A “workpiece adjustment” type. There are three types: [Numeric Adjustment], [CCD Camera Adjustment], [CCD Camera Adjustment with Counter].
X Adjustment	X directional adjustment amount
Y Adjustment	Y directional adjustment amount
Z Adjustment	Z directional adjustment amount
R Adjustment	R axis adjustment amount
Rotate Adjustment	Angle of rotation centered on the home (0,0,0)
Z-Adjustment	Sensor settings if you are using a distance sensor/touch sensor.

Make sure that [X Adjustment], [Y Adjustment], and [Z Adjustment] are set to “0mm” and that [R Adjustment] and [Rotate Adjustment] are set to “0deg.” Then select [Z-Adjustment].
Select [Z-Adjustment with COM] or [LK-G] as the [Z-Adjustment] type.

After selecting [Z-Adjustment with COM] or [LK-G], the following items are displayed:

Z-Adjustment with COM/LK-G Menu Overview

Menu	Details
Z Adjustment with COM/ LK-G	A [Z Adjustment] type. There are three types: [Z Adjustment with COM], [Going Down Z Adjustment], and [LK-G]. When you are using the distance sensor, set [Z Adjustment with COM]. If you are using a Keyence LK-G series sensor, set this to [LK-G].
Z-Adjustment COM Port	This is the COM port on the robot side connecting to the distance sensor
Get Standard Data	Select this to measure the height of the workpiece that will act as a reference.
Z Standard Data	This displays the value measured from [Get Standard Data]. This value is used as reference data and deviation from this value is compensated.

If you want to correct the workpiece position discrepancy in the X, Y, and Z directions using the camera and the distance sensor together, select [Z-Adjustment] from the CCD camera adjustment menu in the [Workpiece Adjustment] you created. In this case, it is not necessary to set each of the adjustments to “0.”

4.7.2 Camera Communication Settings

Select [Z-Adjustment COM Port] from the [Z-Adjustment] menu and select the COM Port on the robot side connected to the camera.

4.7.3 Get Standard Data

Turn ON the distance sensor, and then select [Get Standard Data] from the [Z-Adjustment with COM] menu. This executes reference data acquisition.

After successfully executing [Get Standard Data], the measured value is displayed in [Z Standard Data]. This data is used as the height reference during a run.
Make sure to acquire reference data with [Get Standard Data] at the distance sensor position in the height measuring point used during a run.

4.7.4 Set the Workpiece Adjustment to a Point

Set the [Work Adjustment Number] (additional function data settings) you created to the point that performs the job (to the point you want to set the workpiece adjustment).
Work adjustments for point additional functions are now complete.

4.8 Create and Set Point Job Data that includes the Z Adjustment Acquisition Commands

4.8.1 New Point Job Data

Open new point job data
To use the camera and the distance sensor together and to set both the camera data acquisition point and the height measuring point to the same point, open the point job data created in the camera adjustment , and add or insert the commands.

4.8.2 Z Adjustment Acquisition Command

Select *takeZWadj* and enter the [Workpiece Adjustment] number set to the job point.
When this command is performed, the robot measures the workpiece height with the distance sensor and calculates the adjustment value of the obtained data according to the specified [Workpiece Adjustment] number.

4.8.3 Command for an Error During Z Adjustment Acquisition

If a Z adjustment acquisition error occurs, an incorrect offset value is applied to the job point coordinates. In this situation, enter a command to specify the operation for Z adjustment acquisition errors. By referring to the system flag, you can specify the operation by point job to execute if a Z adjustment error occurs.

System Flag	Error Content
No. 32	Z Adjustment Data Acquisition Error

Example of Point Job Data at P01

takeZWadj 8	Z Adjustment Acquisition Command
if	
ld #sysFlag(32)	Z adjustment acquisition error = ON (conditional)
then	If #sysFlag(32)=1 (true) (if it is an error),
goRPoint PTP0, 2	Jump ahead two points.
endIf	

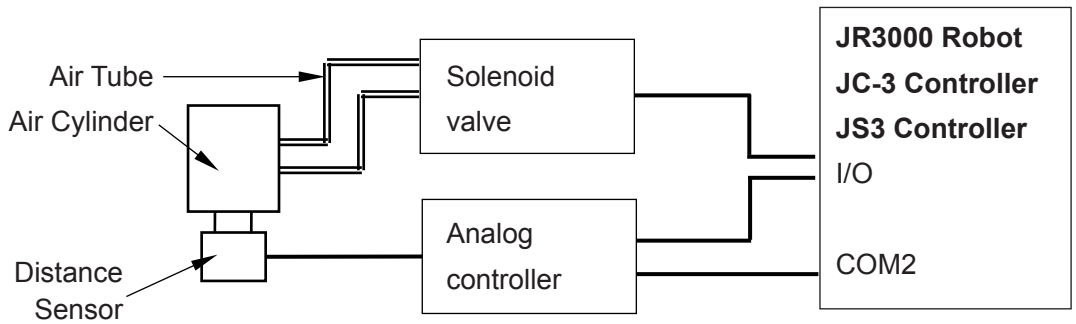
4.8.4 Height Measuring Point

If there are no further commands to be set, point job data creation is complete. Set the point job data you created to the height measuring point.
If you register the point positions after creating the [Workpiece Adjustment], make sure the height measuring point coordinates are at the same position where [Get Standard Data] was performed.

All the settings needed for the Distance Sensor Adjustment (Z adjustment) are now complete.

■ Note

If you are using a distance sensor attached to an air cylinder when you are acquiring height data and lowering the distance sensor, refer to the following information:



- To lower the distance sensor: Turn #genOut1 ON.
- To raise the distance sensor: Turn #genOut1 OFF.

When acquiring [Z Adjustment] reference data, you need to align the distance sensor with the height measuring position used during the run (refer to “4.7.3 Get Standard Data”).
If you specifically prepare point job data to lower and raise the distance sensor, you can then use this data to raise and lower the distance sensor during point teaching.

Sample point job data for lowering the distance sensor:

```
set #genOut1
```

Lower the distance sensor.

Sample point job data for raising the distance sensor:

```
reset #genOut1
```

Raise the distance sensor.

TP UTILITY [Teaching Environment Setting]
[Manual Job Number Setting]

PC [Robot] → [JOG] → [Point Job]

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

```
set #genOut1
waitCondTime 0.5 sec
endWait
takeZWadj 8
reset #genOut 1
waitCondTime 0.5 sec
endWait
```

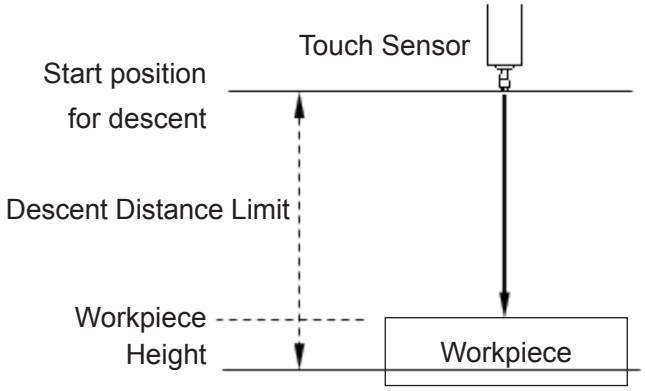
Lower the distance sensor.
Wait until the sensor finishes descending.

Acquire the height. Set the result to workpiece adjustment No. 8.
Raise the distance sensor.
Wait until the sensor finishes ascending.

NOTE: When the air cylinder is mounted on the robot axis, make sure to add the air cylinder weight to [Tool Mass].

5. TOUCH SENSOR ADJUSTMENT (Z ADJUSTMENT)

This chapter explains how to adjust a workpiece position discrepancy in the Z direction (height) using a touch sensor.



The Z axis is lowered, and the position where the touch sensor comes ON is used as the workpiece height. The height difference between the reference data and this position is corrected.
If the Z axis descends for the exact distance specified in [Distance Limit] and the touch sensor does not come ON, an error occurs.

5.1 Connection

Connect the touch sensor to the I/O on the robot side.

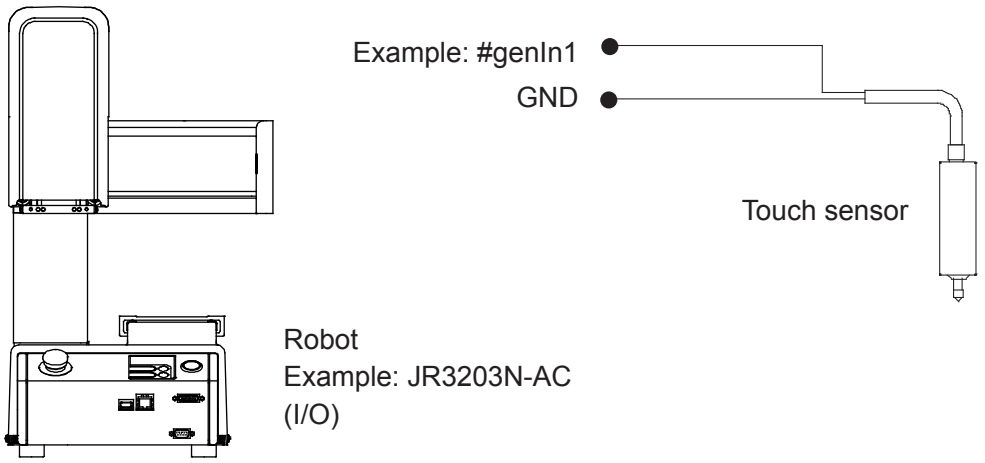
⚠ Warning

Always make sure that the robot's power switch (circuit breaker for the JS3 Series) is OFF when making connections. Failure to do so can cause electric shock and injury.

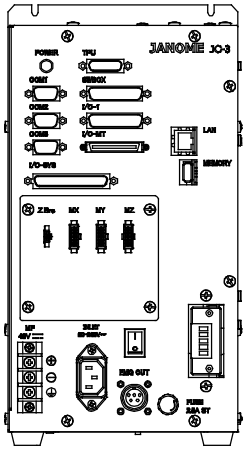
NOTE: To use an I/O signal which has a preassigned function on the robot side, you need to set that I/O signal to [Free] in [I/O-SYS Function Assignment].

Also refer to the touch sensor instruction manual for the connection procedures.

■ JR3000 Series Touch Sensor Connection Example



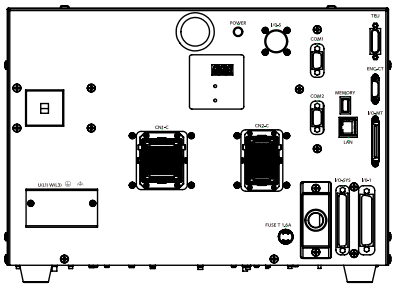
■ JC-3 Series Touch Sensor Connection Example



Example: #genIn1
GND
Touch sensor

Controller
Example: JC-3C-3
(I/O)

■ JS3 Series Touch Sensor Connection Example



Example: #genIn1
GND
Touch sensor

Controller
Example: JSC3-3520
(I/O)

The following procedures are necessary for using this function.
Connect the touch sensor to the robot correctly, and set the workpiece in the same manner as it is during a run.
To adjust the workpiece position discrepancy in the X, Y, and Z directions using the camera and the touch sensor together, perform the “workpiece position discrepancy adjustment (camera adjustment)” operation first, and then go to step 5.5 below.

“5.2 Create a New Program”
“5.3 Tool Data Settings”
“5.4 Register the Work Home Position”
“5.5 Register the Point Positions”
“5.6 Move to the Height Measuring Point”
“5.7 Create and Set the Additional Function Data Workpiece Adjustment”
“5.7.1 Workpiece Adjustment”
“5.7.2 Camera Communication Settings”
“5.7.3 Get Standard Data”
“5.7.4 Set the Workpiece Adjustment to a Job Point”
“5.8 Create and Set Point Job Data that Includes the Z Adjustment Acquisition Commands”
“5.8.1 New Point Job Data”
“5.8.2 Z Adjustment Acquisition Command”
“5.8.3 Command for an Error During Z Adjustment Acquisition”
“5.8.4 Height Measuring Point”

5.2 Create a New Program

Open a new program.

5.3 Tool Data Settings

Set up [Main TCP Setting] in [Main-Tool Configuration].

- Tool Mass
  When the touch sensor is mounted on the robot axis, set the total weight of the tool and the touch sensor as [Tool Mass].
  When the touch sensor and the camera are mounted on the robot axis, set the total weight of the tool, the touch sensor, and the camera as [Tool Mass].

JR3000 Series

Model	Tool Mass		
	1	2	3
JR3200	1 kg	3.5 kg	
JR3300 – JR3600	1 kg	4 kg	7 kg

JC-3 Series

Model	Tool Mass (Fixed Values)				
JC-3	2 Axes Single Sided	2 Axes Double Sided	3 Axes Single Sided	3 Axes Double Sided	4 Axes Double Sided
	4 kg	8 kg	4 kg	8 kg	3 kg

JS3 Series

Model	Tool Mass		
	1	2	3
JS3	1 kg	3 kg	6 kg

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

5.4 Register the Work Home Position

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

5.5 Register the Point Positions

Register the height measuring point and the position of the point that performs the job on the workpiece. If you want to correct any workpiece position discrepancies in the X, Y, and Z directions using the camera and the touch sensor together, and your height measuring point differs from your camera data acquisition point, register only the height measuring point position using [Insert a Point]. If you set the camera data acquisition point and the height measuring point to the same point, you do not need to register the point position. Proceed to the next step.

As long as the height measuring point comes before the point where the job is performed on the workpiece, you can set it to a point that also serves as a point for another job (it does not need to be directly before the job).

■ Height Measuring Point (this is a point set with point job data that contains the height measuring command)
At this point, the robot measures the workpiece height using the touch sensor and calculates how far out of place the current workpiece is from the reference height. Register this point to a position where the touch sensor can measure the workpiece height preceding the point to where you want to make height adjustments.
If the height sensor and camera are used at the same time, the height measuring point can be set to the same point as the camera data acquisition point (but this is not a requirement).

■ The Point that performs the Job on the Workpiece (this is the point where an operation such as screw driving or dispensing is actually performed on the workpiece)
Set the additional function [Work Adjustment] to this point. Once [Work Adjustment] is set here, the robot adjusts the coordinates and makes the run with the exact “discrepancy” calculated at the “height measuring point”.

5.6 Move to the Height Measuring Point

Move the axes to P01 (height measuring point).
(Press the [GO] key to move the robot to the currently displayed coordinates.)

5.7 Create and Set the Additional Function Data Workpiece Adjustment

5.7.1 Workpiece Adjustment

Open a new [Workpiece Adjustment] from [Additional Function Data Settings].
Select [Numeric Adjustment] as the workpiece adjustment type. After selecting [Numeric Adjustment], the following items are displayed:

Numeric Adjustment Menu Overview

Menu	Details
Numeric Adjustment	A “workpiece adjustment” type. There are three types: [Numeric Adjustment], [CCD Camera Adjustment], [CCD Camera Adjustment with Counter].
X Adjustment	X directional adjustment amount
Y Adjustment	Y directional adjustment amount
Z Adjustment	Z directional adjustment amount
R Adjustment	R-Axis adjustment amount
Rotate Adjustment	Angle of rotation centered on the home (0,0,0)
Z-Adjustment	Sensor settings if you are using a distance sensor/touch sensor.

Make sure that [X Adjustment], [Y Adjustment], and [Z Adjustment] are set to “0mm” and that [R Adjustment] and [Rotate Adjustment] are set to “0deg”. Then select [Z-Adjustment].
Select [Going Down Z-Adjustment] as the [Z-Adjustment] type.

After selecting [Going Down Z-Adjustment], the following items are displayed:

Going Down Z-Adjustment Menu Overview

Menu	Details
Going Down Z Adjustment	A [Z Adjustment] type. There are three types: [Z Adjustment with COM], [Going Down Z Adjustment], and [LK-G]. When you are using a touch sensor, set [Going Down Z Adjustment].
Input Channel	I/O signal on the robot side connecting to the touch sensor
Down Speed	Speed at which the Z axis descends.
Distance Limit	Even if the Z axis descends for the exact distance specified here and the touch sensor does not come ON (the I/O signal is ON), a Z adjustment acquisition error occurs.
Get Standard Data	Select this to measure the height of the workpiece that will act as a reference.
Z Standard Data	This displays the value measured from [Get Standard Data]. This value is used as a reference data and deviation from this value is compensated.

If you want to correct the workpiece position discrepancy in the X, Y, and Z directions using the camera and the touch sensor together, select [Z-Adjustment] from the CCD camera adjustment menu in the [Workpiece Adjustment] you created. In this case, it is not necessary to set each of the adjustments to “0”.

5.7.2 Camera Communication Settings

Select [Input Channel] from the [Going Down Z-Adjustment] menu and specify the I/O signal on the robot's side connecting the touch sensor.

NOTE: To use an I/O signal which has a preassigned function on the robot side, you need to set that I/O signal to [Free] from [I/O-SYS Function Assignment].

5.7.3 Get Standard Data

Enter the values you want to set for the [Down Speed] and [Distance Limit].

After that, select [Get Standard Data]. The robot lowers the Z axis until the touch sensor comes ON, measuring the height of the workpiece with the sensor.
During height measurement, if the touch sensor is lowered pneumatically by an air cylinder connected to the touch sensor, perform [Get Standard Data] after the touch sensor finishes descending.
Make sure to acquire reference data with the sensor at the height measuring position used during a run.

By successfully completing [Get Standard Data], the value measured is displayed in [Z Standard Data]. This data is used as reference data for workpiece height during a run.

The additional function data [Workpiece Adjustment] creation is now complete.

5.7.4 Set the Workpiece Adjustment to a Job Point

Set the [Work Adjustment Number] you created to the job point where you want to perform the workpiece adjustment.

5.8 Create and Set Point Job Data that Includes the Z Adjustment Acquisition Commands

5.8.1 New Point Job Data

Open new point job data.
To use the camera and the touch sensor together and to set both the camera data acquisition point and the height measuring point to the same point, open the point job data created in the camera adjustment , and add or insert the commands.

5.8.2 Z Adjustment Acquisition Command

Select *takeZWadj* and enter the [Workpiece Adjustment] number set to the job point.
When this command is performed, the robot measures the workpiece height with the touch sensor and calculates the adjustment value of the obtained data according to the specified [Workpiece Adjustment] number.

5.8.3 Command for an Error During Z Adjustment Acquisition

If a Z adjustment acquisition error occurs, an incorrect offset value is applied to the job point coordinates. In this situation, enter a command to specify the operation for Z adjustment acquisition errors. By referring to the system flag, you can specify the operation by point job to execute if a Z adjustment error occurs.

System Flag	Error Content
No. 32	Z Adjustment Data Acquisition Error

Example of Point Job Data

```
takeZWadj 8
if
  ld #sysFlag(32)
then
  goRPoint PTP0, 2
endIf
```

Z adjustment data acquisition command

Z adjustment acquisition error = ON (conditional)
If #sysFlag(32)=1 (true) (if it is an error),
Jump ahead two points.

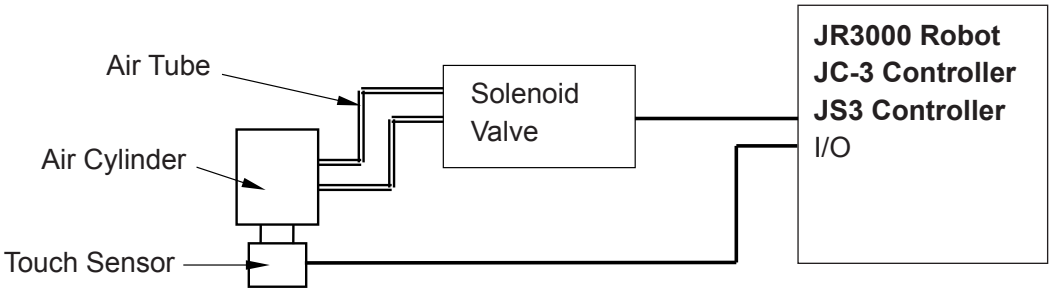
5.8.4 Height Measuring Point

If there are no further commands to be set, point job data creation is complete. Set the point job data you created to the height measuring point.
If you register the point positions after creating the [Workpiece Adjustment], make sure the height measuring point coordinates are at the same position where [Get Standard Data] was performed.

All the settings needed for the “Touch Sensor Adjustment (Z Adjustment)” are now complete.

■ Note

If you are using a touch sensor attached to an air cylinder when you are acquiring height data and lowering the distance sensor, refer to the following information:



- To lower the touch sensor: turn #genOut1 ON.
- To raise the touch sensor: turn #genOut1 OFF.

When acquiring Z adjustment reference data, you need to align the touch sensor with the height measuring position used during the run (refer to “5.7.3 Get Standard Data”).
If you specifically prepare point job data to lower and raise the touch sensor, you can then use this data to raise and lower the touch sensor during point teaching.

This is an example of point job data to lower the touch sensor.

set #genOut1	Lower the touch sensor.

This is an example of point job data to raise the touch sensor.

reset #genOut1	Raise the touch sensor.

TP UTILITY [Teaching Environment Setting]
[Manual Job Number Setting]

PC [Robot] → [JOG] → [Point Job]

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

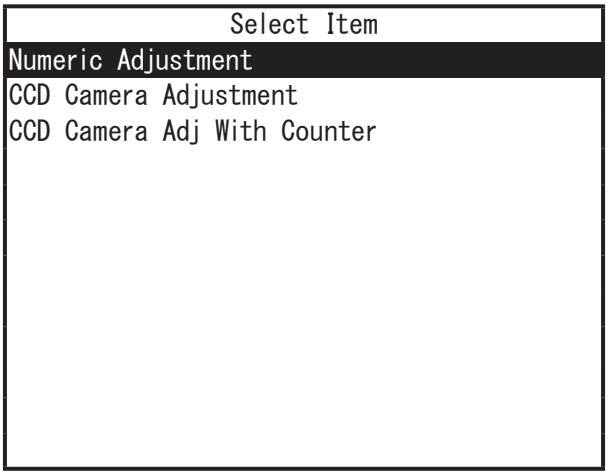
set #genOut1	Lower the touch sensor.
delay 500	Wait until the sensor finishes descending.
takeZWadj 8	Measure the height. Set the result to [Workpiece Adjustment] No. 8.
reset #genOut1	Raise the touch sensor.
delay 500	Wait until the sensor finishes ascending.

NOTE: When the air cylinder is mounted on the robot axis, make sure to add the air cylinder weight to [Tool Mass].

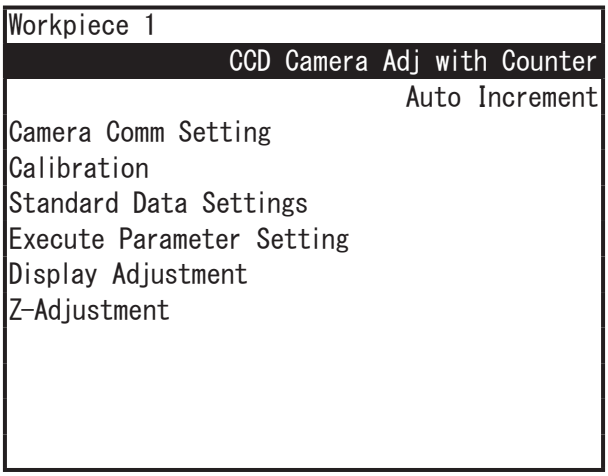
6. DISPLAY SCREEN EXAMPLES

■ Select: [MENU] → [Additional Data Function Settings] → [Workpiece Adjustment Settings] → [Workpiece Adjustment Number]→ [F2] (NEW) → [ENTR] → make a selection

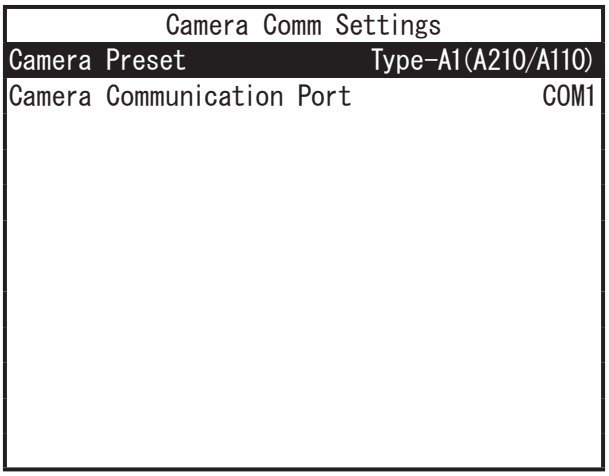
New Adjustment



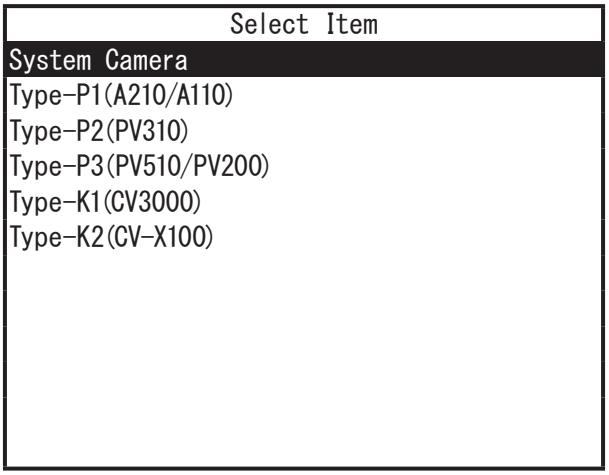
■ CCD Camera Adj With Counter Screen



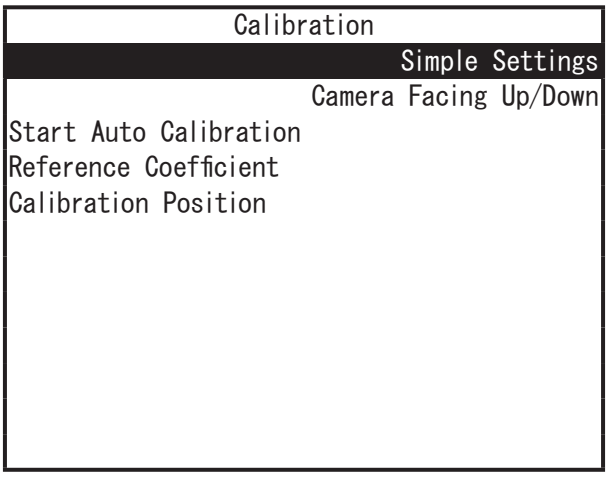
■ CCD Camera Adjustment Screen → Camera Comm Settings



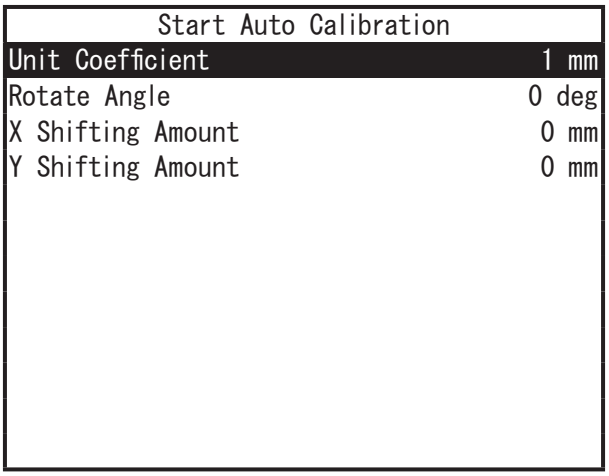
■ CCD Camera Adjustment Screen → Camera Comm Settings → Camera Preset



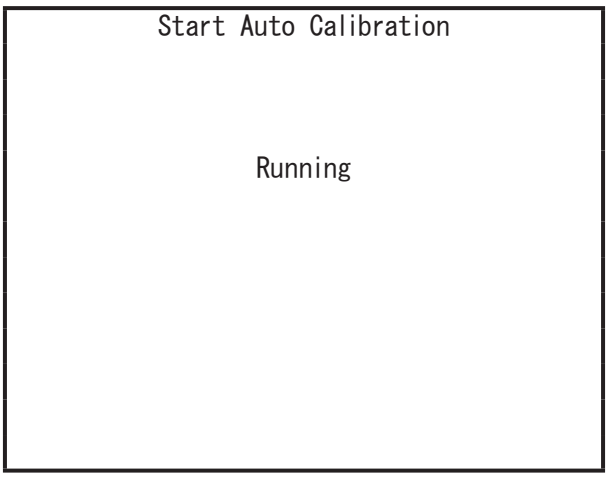
■ CCD Camera Adjustment Screen → Calibration (Simple Settings)



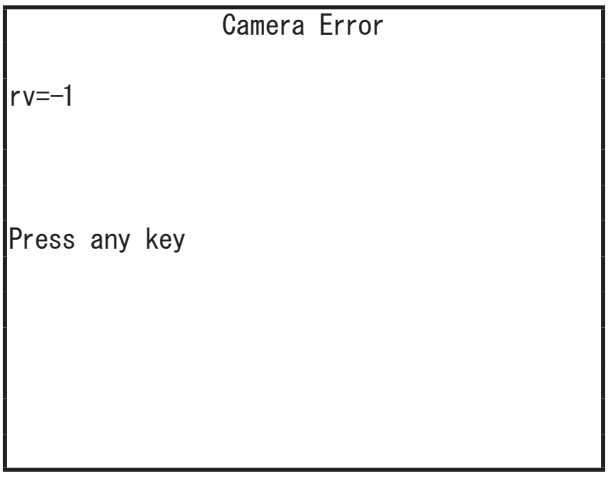
■ CCD Camera Adjustment Screen → Calibration → Reference Coefficient



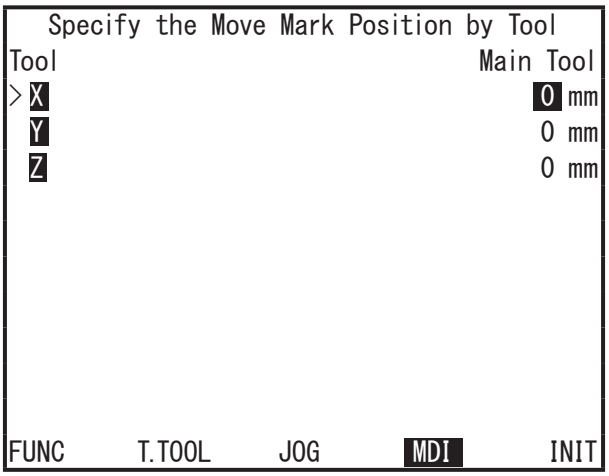
■ CCD Camera Adjustment Screen → Calibration → Start Auto Calibration (executing)



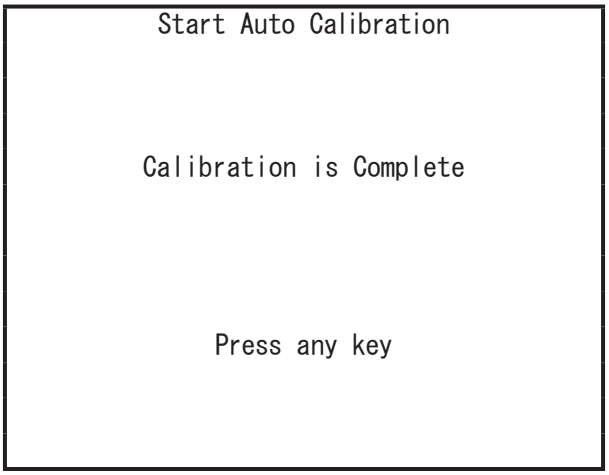
■ CCDCamera Adjustment Screen → Calibration → Start Auto Calibration (error example)



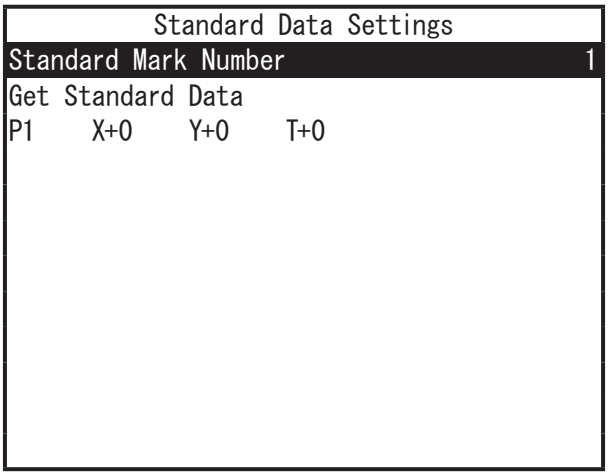
■ CCD Camera Adjustment Screen → Calibration → Start Auto Calibration (after calibration)



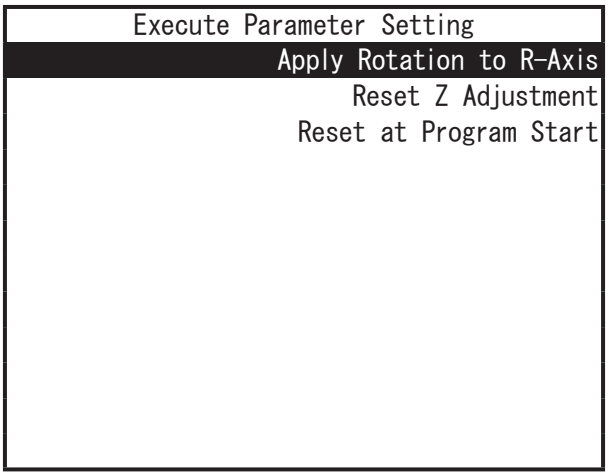
■ CCD Camera Adjustment Screen → Calibration → Start Auto Calibration (finished)



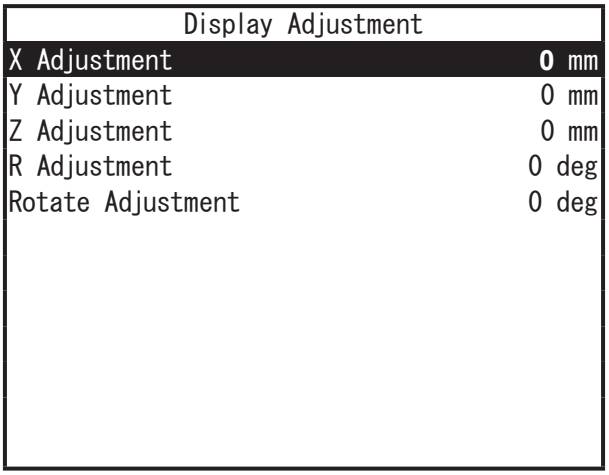
■ Camera Adjustment Screen → Standard Data Settings



■ CCD Camera Adjustment Screen → Execute Parameter Setting



■ CCD Camera Adjustment Screen → Display Adjustment



7. ADDENDUM: CAMERA SETTINGS LIST

Camera Model	A210/110
Start command	%S<CR>
Serial Setting Initialization Value/ Default RS-232C	Transmission Rate/Baud Rate:9600 Bit Length:8 Stop Bit: 2 Parity: None Flow Control: None
Serial Settings/RS-232C Menu Position	ENVIRONMENT => Communication => Serial Settings/RS-232C
Serial Output Setting Value Serial Output	Digit: 8 (Default:14)*1 Inval.Digit: Del.(Default: Del.) Numerical Calc.: Out(Default: None) *1: Decimal points are not output (the original value is multiplied by 10 and output)
Robot Coordinate Data Format	Total Digits: 8 digits 3 integer digits , 1 digit after the decimal point Ex.1234=>123.4 -123=>-12.3
Serial Output Menu Position	ENVIRONMENT => Communication => Serial Output
Data Output Format (Numerical Settings) Output data format by Numerical Calc.	[1], [2], [3], [4], [5], [6]…<CR> [1] Detected Number [2] X Coordinate (mark 1) [3] Y Coordinate (mark 1) [4] Rotation Angle (mark 1) [5] X Coordinate (mark 2)*2 [6]Y Coordinate (mark 2)*2 ... *2: Create data output sections for the exact number of detection marks for mark 2 and onwards.
Numerical Output Menu Position	CHECKER => Numerical Calculation*3 *3: This setting is not available in the simple camera version (the data format is automatically output according to the mark numbers and template numbers).

Camera Model	PV300
Start command	%S<CR>
Serial Setting Initialization Value/ Default RS-232C	Transmission Rate/Baud Rate: 9600 Bit Length: 8 Stop Bit: 1 Parity: Odd Flow Control: None
Serial Settings/RS-232C Menu Position	Serial Settings/RS-232C Menu Position ENVIRONMENT => Serial Communication => Port Settings/RS-232C
Serial Output	Digit: 7 (Default:11)*1 Inval.Digit: Repl.0(Default:Del.) Numerical Calc.: Out(Default:None) *1: Decimal points are not output (the original value is multiplied by 10 and output)
Robot Coordinate Data Format	Total Digits: 7 Digits 1 symbol digit; 5 integer digits; 1 digit after decimal point Ex.0001234=>+123.4 -0000123=>-12.3
Serial Output Menu Position	ENVIRONMENT => Date Output Setting => General Output
Output data format by Numerical Calculation	[1] [2] [3] [4] [5] [6] ⋯<CR> [1] Detected Numbers [2] X Coordinate (Mark 1) [3] Y Coordinate (Mark 1) [4] Rotation Angle (Mark 1) [5] X Coordinate (Mark 2) *2 [6] Y Coordinate (Mark 2) *2 ⋯ *2: Create data output sections for the exact number of detection marks for mark 2 and onwards.
Numerical Output Menu Position	TOOL =>Calcu.-Stat.-Output => Num.Calcu.

- If the Run Mode screen is not displayed, models PV310, PV510, and PV200 cannot communicate with the robot.
- With the PV410 model, (EU Specifications), “%B” is attached to the beginning of output data by the default setting. As such, communication cannot be made with the robot using the default setting. By making settings on the camera side so that “%B” is not output, you are able to use [Workpiece Adjustment]. (Select either “CCD Camera” or “PV310”.)

Camera Model	PV500/PV200
Start command	%S**<CR>
Serial Settings Initialization Value Default RS-232C	Transmission Rate/Baud Rate:9600 Length: 8 Stop Bit: 1 Parity:Odd Flow Control:None
Serial Settings/RS-232C Menu position	ENVIRONMENT => Input/Output => Serial
Serial Output	Output Setting: Serial(Per Start)(Default: Not Output) Digit: 8 *1 Decimal Digit: 3 (Default: 3) Unused Digit: 0 /Fill with Zeros(Default:0/Fill with Zeros) Numerical Calculation: Out (Default: None) *1: Decimal points are not output (the original value is multiplied by 1000 and output)
Robot Coordinate Data Format	Output Digit:8 1 symbol, 4 integer, 3 digits after the decimal point Ex.01234456=>+123.456 -012345=>-12.345
Serial Output Menu Position	ENVIRONMENT => Input/Output => General Output
Output data format by Numerical Calc.	%S$52<CR>[1] [2] [3] [4] [5] [6] …<CR> [1] Detected Numbers [2] X Coordinate (Mark 1) [3] Y Coordinate (Mark 1) [4] Rotation Angle (Mark 1) [5] X Coordinate (Mark 2)*2 [6] Y Coordinate (Mark 2)*2 … *2: Create data output sections for the exact number of detection marks for mark 2 and onwards.
Numerical Output Menu Position	INSPECTION => Num.Calcu.

- If the Run Mode screen is not displayed, models PV310, PV510, and PV200 cannot communicate with the robot.
- With the PV410 model, (EU Specifications), “%B” is attached to the beginning of output data by the default setting. As such, communication cannot be made with the robot using the default setting. By making settings on the camera side so that “%B” is not output, you are able to use [Workpiece Adjustment]. (Select either “CCD Camera” or “PV310”.)

Camera Model	CV3000/CV-X100
Start command	T1<CR>
Serial Setting Initialization Value/ Default RS-232C	Mode: No Protocol(RS-232C) Transmission Rate/Baud rate: 9600 Stop Bit: 1 Parity BitNone Flow Control: None Delimiter: CR
Serial Setting/RS-232C Menu Position	Global => RS-232C ・ PLC link
Serial Output	Unmodifiable
Robot Coordinate Data Format	Output Digits: 12 1 signal, 7 integer, 1 decimal point, 3 digits after decimal point Ex. 123.456mm=>+0000123.456 -12.34deg=>-0000012.340
Serial Output Menu Position	Unmodifiable
Output data format by Numerical Calc.	T1, [1], [2], [3], [4], [5], [6] …<CR> [1] Detected Number [2] X Coordinate (Mark 1) [3] Y Coordinate (Mark 1) [4] Rotation Angle (Mark 1) [5] X Coordinate (Mark 2)*1 [6] Y Coordinate (Mark 2)*1 … *1: Create data output sections for the exact number of detection marks for mark 2 and onwards.
Numerical Output Menu Position	Calculation Expression Creation: Calc. Output Calculation Expression: Output => RS-232C ・ PLC Link

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