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Reference Manual

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This manual is composed of four parts.Part 1 describes Workcell Item Setting options, part 2 describes Task program commands and Template Setting options, part 3 describes the operation and use of the Smart Vision module, and part 4 describes how to operate conveyor tracking.

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This manual is a detailed manual for a specific software version of the robot. For details on updated manuals, refer to the Robot LAB website (https://robotlab.doosanrobotics.com/).

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Part 1
Workcell Item

1. Workcell Item Summary

Workcell Item refers to the robot and all peripherals used together with the robot.

Workcell items can be configured in the Workcell Manager screen before use. Also, the Workcell Manager can set commands for peripherals and can configure commands for the robot to perform certain patterns and actions.

The combination of skills available change according to the configured Workcell Items, and in certain conditions, the Task Builder can recommend a suitable task template.

This manual describes the Workcell Item Setting options in the Workcell Manager for the end effector, machine and peripherals.

Item	Description
End Effector	End effectors can be added to the robot, and the added end effector is displayed.
Machine	Machines compatible with the robot can be added, and the added machine is displayed.
Peripherals	Peripherals connected to the robot can be added, and the added peripheral is displayed.

1.1 Workcell Item Common Setting Options

Common setting options for Workcell Items are as follows:

Item	Description
Output Signal	It selects the output signal type.
Input Signal	It selects the input signal type.

2. End Effector

2.1 Gripper

There are the Pneumatic Gripper, Vacuum Gripper and Electric Gripper, and gripper setting options are as follows:

Item	Description
Grasp	It configures the output signal for grasping the target.
Release	It configures the output signal for releasing the target.
Gripper Close Sensor	It configures an input signal that checks whether the grasping of the target is complete. This item is optional.
Gripper Open Sensor	It configures an input signal that checks whether the releasing of the target is complete. This item is optional.

2.1.1 Pneumatic Gripper

It is a gripper that uses pneumatic pressure supplied externally. It has a finger that allows it to grasp or release an object according to the digital signal it receives. It is connected to a pneumatic pressure control device where it opens and closes according to signals. In general, it is connected to a double-action pneumatic pressure control device.

2.1.2 Vacuum Gripper

It is a gripper that uses an externally supplied vacuum. It has a vacuum pad connected to an external vacuum generator, and it opens and closes according to digital signals from the vacuum generator. In general, it is connected to a double-action pneumatic pressure control device.

2.1.3 Electric Gripper

It is a gripper operated with electric power supplied by the robot or an external power source. It has a Finger that allows it to grasp or release an object according to the digital signal it receives.

2.2 Screwdriver

It is a tool that tightens bolts with power supplied externally. The tool operates when a signal is received, and it does not operate when a signal is not received. If the tool has an auto tightening torque check function, the successful tightening status is delivered via electrical signals.

Item	Description
Screw	It configures the signal that operates the screwdriver tool. The tool operates when a signal is received, and it does not operate when a signal is not received.
Counter-Rotation Mode	Configures the counter-rotation mode signal of tools that support counter-rotation mode with external signals.
Vacuum On	Configures the vacuum on signal to pick up a screw when a screw is supplied from an external feeder if a separate vacuum tool is installed.
Vacuum Off	Configures the vacuum off signal to pick up a screw when a screw is supplied from an external feeder if a separate vacuum tool is installed.
Torque OK	It configures the input signal of the tightening torque OK status if the tool has an auto tightening torque check function.
Torque NG	It configures the input signal of the tightening torque NG status if the tool has an auto tightening torque check function.

2.3 Gluing Tool

This is a device mounted on the end of a robot. It discharges liquid at a desired location or in a specific linear shape using hydraulic or pneumatic pressure. The robot installed with the tool is capable of smoothly moving along the shape the user configured.

Item	Description
Glue	It configures the signal that operates the Gluing tool. The tool operates when a signal is received, and it does not operate when a signal is not received.

2.4 Deburring Tool

This is a device mounted on the end of a robot. It is a device that removes burrs from products using a cutting blade or brush mounted on the end of a device rotated with hydraulic or pneumatic pressure, or electric power. The robot installed with the tool is capable of smoothly moving along the shape the user configured (such as product edges).

Item	Description
Deburr	It configures the signal that operates the Deburring tool. The tool operates when a signal is received, and it does not operate when a signal is not received.

2.5 Air Blow Nozzle

It is a device attached to the robot end, and it is installed next to the gripper where it removes chips using pneumatic pressure during machining support and cleaning work.

Item	Description
Air Blow	It configures the signal that operates the air blow tool. The tool operates when a signal is received, and it does not operate when a signal is not received.

2.6 Polish

This is a device mounted on the end of a robot. It is a device that polishes the surfaces of products using a brush mounted on the end of a device rotated with hydraulic or pneumatic pressure, or electric power. The robot with the tool installed is capable of moving smoothly along the shape the user has configured on the product surface.

Item	Description
Polish	It configures the signal that operates the Polishing tool. The tool operates when a signal is received, and it does not operate when a signal is not received.

3. Machine

3.1 Press Machine

A press machine is generally a device that compresses a flat material to form desired shapes. After the material is placed in the press machine and pressed, the robot removes the workpiece and places it in a designated location.

Item	Description
Press	It configures the output signal for starting the press machine.
Machine Operation Preparation Sensor	It configures the input signal for authorizing press machine operation.

3.2 Turning Center

It is a type of machine tool that turns cylindrical material to allow the material to be cut to the desired form using a tool turret. After the machining of the material placed in the machine tool is complete, the robot removes the workpiece and places it on a pallet or in a designated location.

Item	Description
Machine Operation	It configures the output signal for starting the machine tool.
Open Chuck	It configures the output signal for grasping the target.
Close Chuck	It configures the output signal for releasing the target.
Open door	It configures the output signal for closing the door of the machine tool.
Close door	It configures the output signal for opening the door of the machine tool.
Reset Machine	It configures the output signal for the robot connection initialization signal sent to the machine tool.
Robot Online	It configures the output signal for resetting the machine tool.
Wash Workpiece	It configures the output signal for operating the air blow device installed on the machine tool to clean the workpiece.
Tailstock Forward	It configures the output signal for moving the machine tool tailstock forward.
Tailstock Retreat	It configures the output signal for moving the machine tool tailstock backward.
Open Steady Rest	It configures the output signal for opening the steady rest.

Item	Description
Close Steady Rest	It configures the output signal for closing the steady rest.
Approach Authorization	It configures the input signal for authorizing the machine tool operation.
Chuck Open Check	It configures the input signal to check whether the chuck is properly closed.
Chuck Close Check	It configures the input signal to check whether the chuck is properly opened.
Door Open Check	It configures the input signal to check whether the door is properly closed.
Door Close Check	It configures the input signal to check whether the door is properly opened.
Workpiece Wash Completion Check	It configures the input signal to check whether the air blow device installed on the machine tool completed its operation.
Tailstock Forward Check	It configures the input signal to check whether the tailstock forward movement is complete.
Tailstock Retreat Check	It configures the input signal to check whether the tailstock backward movement is complete.
Steady Rest Open Check	It configures the input signal to check whether the steady rest is opened.
Steady Rest Close Check	It configures the input signal to check whether the steady rest is closed.

3.3 Injection Molding Machine

The injection molding machine is a device that molds shapes by injecting materials such as plastic into a mold. The robot removes the molded workpiece from the injection molding machine and places it in a designated location.

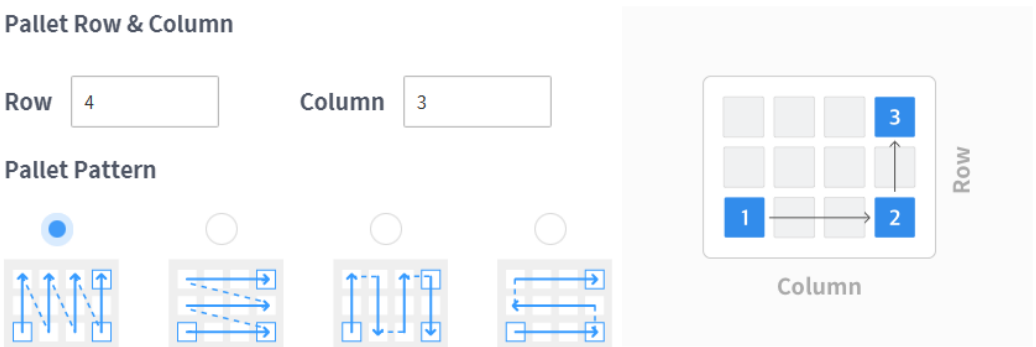
Item	Description
Machine Operation	It configures the output signal for starting the injection molding machine.
Machine Operation Preparation Sensor	It configures the input signal for authorizing injection molding machine operation.

4. Peripherals

4.1 Pallet

It is a type of cradle that allows the target to be placed in a set formation. All targets on a pallet can be handled with minimum instructions. It is the Workcell Item for pallets with a square grid pattern.

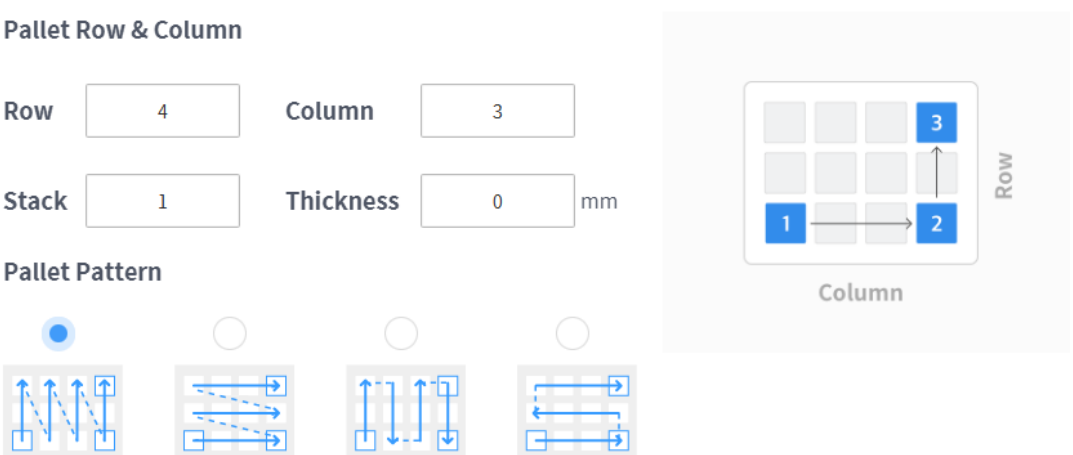
It supports four order patterns as shown in the figure below, so the user can select a pattern as needed.



4.2 Pallet (Stack)

It is the Workcell Item for pallets with grid type patterns, and after entering the row and column values along with the stack and thickness, it automatically stacks the target or recommends a skill suited for picking and moving the target.

It supports four order patterns as shown in the figure below, so the user can select a pattern as needed.



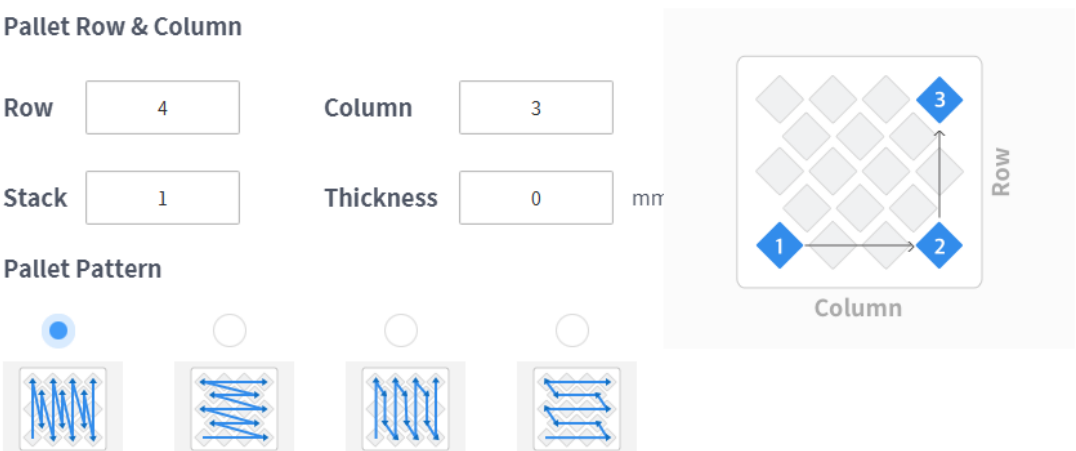
Note

- To automatically calculate the offset direction of stacked or picked items according to the pallet's upward/downward direction, it is recommended that the Workcell Item's three points be instructed in a counter-clockwise direction on a guide image.

4.3 Pallet (Rhombus)

It is the Workcell Item for pallets with intersecting rhombus patterns, and after entering the row and column values based on the pallet position and skill used for single stacks, along with the stack and thickness, it automatically stacks the target or recommends a skill suited for picking and moving the target.

It supports four order patterns as shown in the figure below, so the user can select a pattern as needed.

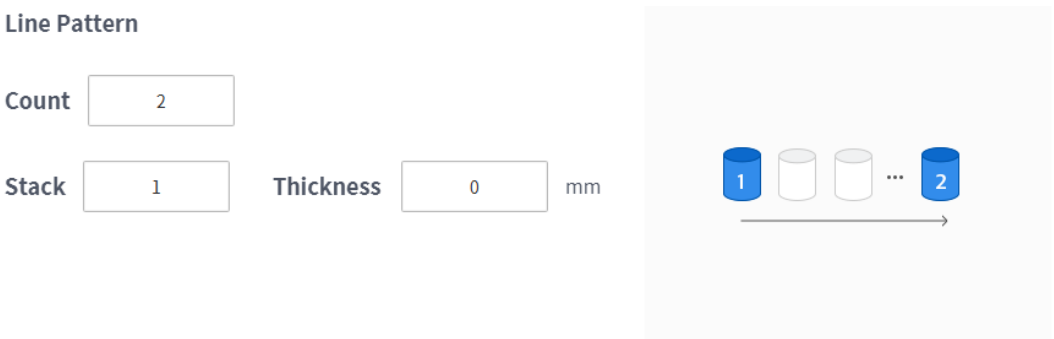


Note

- To automatically calculate the offset direction of stacked or picked items according to the pallet's upward/downward direction, it is recommended that the Workcell Item's three points be instructed in a counter-clockwise direction on a guide image.

4.4 Line Pattern

It is the Workcell Item for target batches with linear patterns, and after entering the number of targets on a linear pattern and skill used for single stacks, along with the stack and thickness, it automatically stacks the target or recommends a skill suited for picking and moving the target.



4.5 Shooting Bolt Feeder

It is a type of feeder that feeds a bolt through a tube from the screw assembly to the screwdriver end. If a sensor is installed, it checks whether a bolt is prepared before feeding it to the screwdriver end.

Item	Description
Bolt Shooting	It configures the bolt shooting signal.
Bolt Preparation Sensor	It selects the input signal to check whether a bolt is prepared at the bolt feeder.

4.6 Pick-up Bold Feeder

It is a type of feeder that feeds bolts to the system from the screw assembly, and the robot must pick up the bolt. If a sensor is installed, it sends a signal to the robot indicating whether a bolt is ready.

Item	Description
Bolt Preparation Sensor	It selects the input signal to check whether a bolt is prepared at the bolt feeder.

5. Additional Workcell Items

5.1 Common Setting Options

Additional common setting options for Workcell Items are as follows:

Item	Description
Output Signal	It selects the output signal type.
Input Signal	It selects the input signal type.

5.2 Additional Workcell Item List

5.2.1 Schmalz - FXCB

Item	Description
Type	There are two methods of creating a vacuum according to each FXCB model. - Normally Open: Vacuum is created when the power supply is off or if the Suction On/Off Signal is off. - Normally Closed: Vacuum is created when the Suction On/Off Signal is on.
Port Number	Configures the port number of the output signal.
Motion	Outputs a signal to test a motion through the port number configured for the output signal.
Suction On/Off	It selects the input signal type.
Vent On/Off	It configures an input signal that checks whether the grasping of the target is performed. This item is optional.
Gripper Close Sensor	Checks the gripper close input signal configured by the port number of the configured input signal.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet

- Insert

5.2.2 Shumalz - CobotPump

Item	Description
Grasp	It configures the output signal for grasping the target.
Release	It configures the output signal for releasing the target.
Gripper Close Sensor	It configures an input signal that checks whether the grasping of the target is performed. This item is optional.
Gripper Open Sensor	It configures an input signal that checks whether the releasing of the target is performed. This item is optional.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.3 Shunk - MPG

Item	Description
Grasp	It configures the output signal for grasping the target.
Release	It configures the output signal for releasing the target.
Gripper Close Sensor	It configures an input signal that checks whether the grasping of the target is performed. This item is optional.
Gripper Open Sensor	It configures an input signal that checks whether the releasing of the target is performed. This item is optional.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place

- Pick Pallet
- Place Pallet
- Insert

5.2.4 Shunk - Co-act

Item	Description
Grasp	It configures the output signal for grasping the target.
Release	It configures the output signal for releasing the target.
End	Pressing this button will end the gripper.
Error Correction	Pressing the button lights up the LED according to the error.
Gripper Close Sensor	It configures an input signal that checks whether the grasping of the target is performed. This item is optional.
Gripper Open Sensor	It configures an input signal that checks whether the releasing of the target is performed. This item is optional.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.5 Zimmer - GEP2000

Item	Description
Grasp	It configures the output signal for grasping the target.
Release	It configures the output signal for releasing the target.
Position Check	This configures an input signal that checks the position value detected based on two values entered in the gripper setting. This item is optional.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.6 Zimmer - HCR03

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Load	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Gripper Setting	Motions for gripper setting are performed.
Initialize	It sends an initialization signal to the gripper to perform gripper initialization.
Teaching Pose	The gripper position when the corresponding workpiece is grasped. It can be configured from a minimum of 0.00 mm to a maximum of 20.00 mm.
Tolerance	This is the teaching pose tolerance deviation. It can be configured from a minimum of 0.00 mm to a maximum of 2.55 mm.
Force	This is the force the gripper applies to grasp an item. It can be configured from Lv1 up to Lv4.
Device Mode	This is the pose when the gripper grasps an item. Select one from inward, outward and universal.
Actual Position	It is the area displaying the current position measured through the gripper's grasp/release motion tests.
Grasp	Performs tests for grasping a target item.
Release	Performs tests for releasing a target item.

Item	Description
Add New Workpiece	A new workpiece can be added. Up to 32 workpieces can be added.
Gripper Status	This is the input signal for the gripper's status code. The following are the meanings of each status code. 0x06: Gripper PLC Active, 0x08: Base Position, 0x09: Teach Position, 0x0a: Work Position, 0x0b: Undefined Position, 0x0c: Data transfer ok, 0x0d: ControlWord 0x100, 0x0e: ControlWord 0x200, 0x0f: Error
Diagnosis	This is the input signal for the gripper's diagnosis code.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.7 Robotiq - 2F-85

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Auto Release Option	It selects the gripper's release option during a robot undergoing emergency stop. The definition of each option is as follows: Auto Release Close: Gripper closes to maximum upon robot emergency stop Auto Release Open: Gripper opens to maximum upon robot emergency stop.
Gripper Setting	Motions for gripper setting are performed.

Item	Description
Initialize	It sends an initialization signal to the gripper to perform gripper initialization.
Grasp	The gripper position when the corresponding workpiece is grasped.
Release	The gripper position when the corresponding workpiece is released.
Velocity	Gripper movement speed.
Force	The gripper's force.
Current Position	It is the area displaying the current position measured through the gripper's grasp/release motion tests.
Grasp	Performs tests for grasping a target item.
Release	Performs tests for releasing a target item.
Add New Motion	A new motion can be added. Up to eight motions can be added.
Grasp Status Sensing	This is the input signal for the gripper's status.
Fault Status Sensing	This is the input signal for the gripper's error status.
Requested Position Sensing	This is the input signal for the position value sent to the gripper.
Current Position Sensing	This is the input signal for the current position of the gripper.
Current Sensing	This is the input signal for the current current value of the gripper.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.8 Robotiq - 2F-140

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Auto Release Option	It selects the gripper's release option during a robot undergoing emergency stop. The definition of each option is as follows: Auto Release Close: Gripper closes to maximum upon robot emergency stop Auto Release Open: Gripper opens to maximum upon robot emergency stop.
Gripper Setting	Motions for gripper setting are performed.
Initialize	It sends an initialization signal to the gripper to perform gripper initialization.
Grasp	The gripper position when the corresponding workpiece is grasped.
Release	The gripper position when the corresponding workpiece is released.
Velocity	Gripper movement speed.
Force	The gripper's force.
Current Position	It is the area displaying the current position measured through the gripper's grasp/release motion tests.
Grasp	Performs tests for grasping a target item.
Release	Performs tests for releasing a target item.
Add New Motion	A new motion can be added. Up to eight motions can be added.
Grasp Status Sensing	This is the input signal for the gripper's status.
Fault Status Sensing	This is the input signal for the gripper's error status.
Requested Position Sensing	This is the input signal for the position value sent to the gripper.
Current Position Sensing	This is the input signal for the current position of the gripper.

Item	Description
Current Sensing	This is the input signal for the current current value of the gripper.

The following list contains skills and commands that can be used in conjunction with this Workcell Item. Refer to each skill's manual for the operation of each skill.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.9 Robotiq - Hand-E

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Auto Release Option	It selects the gripper's release option during a robot undergoing emergency stop. The definition of each option is as follows: Auto Release Close: Gripper closes to maximum upon robot emergency stop Auto Release Open: Gripper opens to maximum upon robot emergency stop.
Gripper Setting	Motions for gripper setting are performed.
Initialize	It sends an initialization signal to the gripper to perform gripper initialization.
Grasp	The gripper position when the corresponding workpiece is grasped.
Release	The gripper position when the corresponding workpiece is released.
Velocity	Gripper movement speed.

Item	Description
Force	The gripper's force.
Current Position	It is the area displaying the current position measured through the gripper's grasp/release motion tests.
Grasp	Performs tests for grasping a target item.
Release	Performs tests for releasing a target item.
Add New Motion	A new motion can be added. Up to eight motions can be added.
Grasp Status Sensing	This is the input signal for the gripper's status.
Fault Status Sensing	This is the input signal for the gripper's error status.
Requested Position Sensing	This is the input signal for the position value sent to the gripper.
Current Position Sensing	This is the input signal for the current position of the gripper.
Current Sensing	This is the input signal for the current current value of the gripper.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.10 Robotiq - 3-Finger

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.

Item	Description
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Gripper Setting	Motions for gripper setting are performed.
Initialize	It sends an initialization signal to the gripper to perform gripper initialization.
Grasp	The gripper position when the corresponding workpiece is grasped.
Release	The gripper position when the corresponding workpiece is released.
Mode	Selects the gripper's operation mode. Select one from Basic Mode, Pinch Mode, Wide Mode and Scissor Mode.
Velocity	Gripper movement speed.
Force	The gripper's force.
Current Position	It is the area displaying the current position measured through the gripper's grasp/release motion tests.
Grasp	Performs tests for grasping a target item.
Release	Performs tests for releasing a target item.
Add New Motion	A new motion can be added. Up to eight motions can be added.
Finger A Position	This is the input signal for the position of gripper finger A.
Finger B Position	This is the input signal for the position of gripper finger B.
Finger C Position	This is the input signal for the position of gripper finger C.
Scissor Position	This is the input signal for the position of the gripper scissor.
Finger A Current	This is the signal for the present current value of gripper finger A.
Finger B Current	This is the signal for the present current value of gripper finger B.
Finger C Current	This is the signal for the present current value of gripper finger C.
Scissor Current	This is the input signal for the current current value of the gripper scissor.

Item	Description
Gripper Status	This is the input signal for the gripper's status.
Item Status	This is the input signal for the item detected by the gripper.
Defect Status	This is the input signal code for the gripper defect status.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.11 Sick - Safety Laser Scanner

Item	Description
Protective Field	Only safety input signals can be selected, and the light curtain detection status is displayed.
Port Number	This selects the port number for the safety input signal.
Input Mode	Configures the safety input mode for the input signal configuring the safety input signal. NC / NC, NC / NO and NO / NO modes are available.
Motion	It checks the status of the input signal.
Warning Field	Only safety input signals/controller ports can be selected, and the light curtain detection status is displayed.
Error	It displays the sensed error and checks its status by text.
Reset Required	It displays whether reset is necessary.

5.2.12 Sick - Safety Light Curtain

Item	Description
Port Number	It selects the port number of the corresponding signal.
Motion	It outputs an On or Off signal through the selected port.
Safety Light Curtain	It displays the input signal for whether detection is made by the light curtain.
Port Number	It selects the port number of the corresponding signal.
Input Mode	Configures the safety input mode for the input signal configuring the safety input signal. NC / NC, NC / NO and NO / NO modes are available.
Motion	It checks the status of the input signal.

5.2.13 Omron - MC3

Item	Description
Port Number	It selects the port number of the corresponding signal.
Motion	It outputs a Reset signal through the selected port.
Safety Mat	It displays the input signal for whether detection is made by the **Safety Mat**.
Port Number	It selects the port number of the corresponding signal.
Input Mode	Configures the safety input mode for the input signal configuring the safety input signal. NC / NC, NC / NO and NO / NO modes are available.
Motion	It checks the status of the input signal.

5.2.14 Doosan - Lynx Series

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Motion	It sends the signal of the corresponding output.

Item	Description
Robot Online	It sends the Robot Online status to MC. The interface signal operates normally only if this signal is on.
Robot in the inside of machine	It goes on when the Robot Arm enters the equipment interior.
Open M/C Door	Front or Top Door opens automatically.
Close M/C Door	Front or Top Door closes automatically.
Start program	When the corresponding signal is On, the MC starts the NC-program.
Open chuck#1 (LH Spindle)	When the corresponding signal is On, the MC unclamps the Chuck.
Close chuck#1 (LH Spindle)	When the corresponding signal is On, the MC clamps the Chuck.
Clean LH spindle	When the corresponding signal is On, the MC air blows the Spindle.
LH Chuck loaded	When the corresponding signal is On, the MC finishes the load signal and executes the next block.
LH Chuck unloaded	When the corresponding signal is On, the MC finishes the Service M-code request signal and executes the next block.
Tailstock forward	When the corresponding signal is On, the MC finishes the Service M-code request signal and executes the next block.
Tailstock backward	When the corresponding signal is On, the MC finishes the Service M-code request signal and executes the next block.
Machine Online	When Serve & MC Ready is set in MEM Mode, it outputs this signal through the Robot.
Permission to Robot	It is the signal allowing Robot arm approach, and the signal is outputted under the following conditions: - MC Home position - Spindle stop - Robot uses - MEM Mode - No Machine lock

Item	Description
	- Door open
Cycle on	This signal is outputted when the NC-program is in auto operation.
M/C Door opened	This signal is outputted when the Robot Approach Door is opened.
M/C Door closed	This signal is outputted when the Robot Approach Door is closed.
Program end	When processing is complete, M02 or M30 is executed and then this signal is outputted. This signal is maintained until NC is reset, auto mode changes to manual mode, or auto operation begins.
Open chuck#1 (LH Spindle)	It is the Main Chuck unclamp check signal.
Close chuck#1 (LH Spindle)	It is the Main Chuck clamp check signal.
Clean LH spindle	It is the Spindle air blow completion signal.
Load LH Chuck	It is the Robot arm approach request signal for new workpiece approach. The signal must be outputted under the following conditions: - MC Home position - Spindle stop - Robot uses - MEM Mode - No Machine lock - Door open - No Robot alarm
Unload LH Chuck	It is the Robot arm approach request signal for new workpiece discharge. The signal must be outputted under the following conditions: - MC Home position - Spindle stop - Robot uses - MEM Mode - No Machine lock - Door open - No Robot alarm
Tailstock forward	It is the Tailstock forward/backward completion signal.
Tailstock backward	It is the Tailstock forward/backward completion signal.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Open TC Door
- Close TC Door
- Open TC Chuck
- Close TC Chuck
- Start TC
- Check TC Ready
- Robot Online
- Workpiece Clean
- Tailstock Forward
- Tailstock Backward
- Pick TC Chuck
- Place TC Chuck

5.2.15 Doosan - Puma Series

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Motion	It sends the signal of the corresponding output.
Robot Online	It sends the Robot Online status to MC. The interface signal operates normally only if this signal is on.
Robot in the inside of machine	It goes on when the Robot Arm enters the equipment interior.
Open M/C Door	Front or Top Door opens automatically.
Close M/C Door	Front or Top Door closes automatically.
Start program	When the corresponding signal is On, the MC starts the NC-program.
Open chuck#1 (LH Spindle)	When the corresponding signal is On, the MC unclamps the Chuck.
Close chuck#1 (LH Spindle)	When the corresponding signal is On, the MC clamps the Chuck.
Clean LH spindle	When the corresponding signal is On, the MC air blows the Spindle.
LH Chuck loaded	When the corresponding signal is On, the MC finishes the load signal and executes the next block.
LH Chuck unloaded	When the corresponding signal is On, the MC finishes the Service M-code request signal and executes the next block.
Tailstock forward	When the corresponding signal is On, the MC finishes the Service M-code request signal and executes the next block.
Tailstock backward	When the corresponding signal is On, the MC finishes the Service M-code request signal and executes the next block.
Machine Online	When Serve & MC Ready is set in MEM Mode, it outputs this signal through the Robot.

Item	Description
Prermission to Robot	It is the signal allowing Robot arm approach, and the signal is outputted under the following conditions: - MC Home position - Spindle stop - Robot uses - MEM Mode - No Machine lock - Door open
Cycle on	This signal is outputted when the NC-program is in auto operation.
M/C Door opened	This signal is outputted when the Robot Approach Door is opened.
M/C Door closed	This signal is outputted when the Robot Approach Door is closed.
Program end	When processing is complete, M02 or M30 is executed and then this signal is outputted. This signal is maintained until NC is reset, auto mode changes to manual mode, or auto operation begins.
Open chuck#1 (LH Spindle)	It is the Main Chuck unclamp check signal.
Close chuck#1 (LH Spindle)	It is the Main Chuck clamp check signal.
Clean LH spindle	It is the Spindle air blow completion signal.
Load LH Chuck	It is the Robot arm approach request signal for new workpiece approach. The signal must be outputted under the following conditions: - MC Home position - Spindle stop - Robot uses - MEM Mode - No Machine lock - Door open - No Robot alarm

Item	Description
Unload LH Chuck	It is the Robot arm approach request signal for new workpiece discharge. The signal must be outputted under the following conditions: - MC Home position - Spindle stop - Robot uses - MEM Mode - No Machine lock - Door open - No Robot alarm
Tailstock forward	It is the Tailstock forward/backward completion signal.
Tailstock backward	It is the Tailstock forward/backward completion signal.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Open TC Door
- Close TC Door
- Open TC Chuck
- Close TC Chuck
- Start TC
- Check TC Ready
- Robot Online
- Workpiece Clean
- Tailstock Forward
- Tailstock Backward
- Pick TC Chuck
- Place TC Chuck

5.2.16 OnRobot RG2

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.

Item	Description
Grasp	The gripper position when the corresponding workpiece is grasped.
Release	The gripper position when the corresponding workpiece is released.
Force	The gripper's force.
Grasp	Performs tests for grasping a target item.
Release	Performs tests for releasing a target item.
Add New Motion	A new motion can be added. Up to eight motions can be added.
Actual depth	It is the current gripper depth that will be used to compensate for the gripper's depth. The depth is based on the completely closed position set in 1/10 mm increments. The value is displayed in 2's complements.
Actual relative depth	It is the current gripper depth that will be used to compensate for the gripper's depth. The depth is based on the recent motion start position set in 1/10 mm increments. The value is displayed in 2's complements.
Actual width	The current width between gripper fingers is displayed in 1/10 mm increments.
Status	It displays the current state and motion of the gripper.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.17 OnRobot RG6

Item	Description
Modbus Address	It selects the predefined Modbus address. The IP address and name configured by the user for the Modbus slave

Item	Description
	equipment are displayed. To add new items, go to Setting > Network > Predefined Modbus menu, and configure.
Connect	Equipment is connected to the selected Modbus address, and buttons used to test gripper motion are activated.
Grasp	The gripper position when the corresponding workpiece is grasped.
Release	The gripper position when the corresponding workpiece is released.
Force	The gripper's force.
Grasp	Performs tests for grasping a target item.
Release	Performs tests for releasing a target item.
Add New Motion	A new motion can be added. Up to eight motions can be added.
Actual depth	It is the current gripper depth that will be used to compensate for the gripper's depth. The depth is based on the completely closed position set in 1/10 mm increments. The value is displayed in 2's complements.
Actual relative depth	It is the current gripper depth that will be used to compensate for the gripper's depth. The depth is based on the recent motion start position set in 1/10 mm increments. The value is displayed in 2's complements.
Actual width	The current width between gripper fingers is displayed in 1/10 mm increments.
Status	It displays the current state and motion of the gripper.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.18 Zimmer_HCR-03-DIO

Item	Description
Grasp	It configures the output signal for grasping the target.
Release	It configures the output signal for releasing the target.
Gripper Close Sensor	It configures an input signal that checks whether the grasping of the target is complete. This item is optional.
Gripper Open Sensor	It configures an input signal that checks whether the releasing of the target is complete. This item is optional.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Grasp
- Release
- Pick
- Place
- Pick Pallet
- Place Pallet
- Insert

5.2.19 Dynabrade Robotic Sanders

Item	Description
Polish	It configures the signal that operates the Polishing tool. The tool operates when a signal is received, and it does not operate when a signal is not received.

The following list contains skills and commands that can be used in conjunction with this Workcell Item.

- Start Polish
- End Polish
- Run Polish
- Stop Polish
- Polish (Hole)

Part 2
Task Programming Commands and Templates

1. Skill Command

1.1 Skill Command Summary

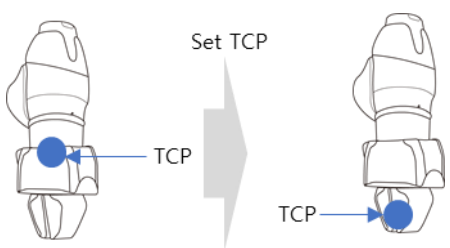
This is a function programmed through the robot and peripherals, and to use skills, it is necessary to configure the work and related Workcell Items. Necessary Workcell Items are indicated in each skill description.

1.2 Understanding Basic Principles of Skill Commands

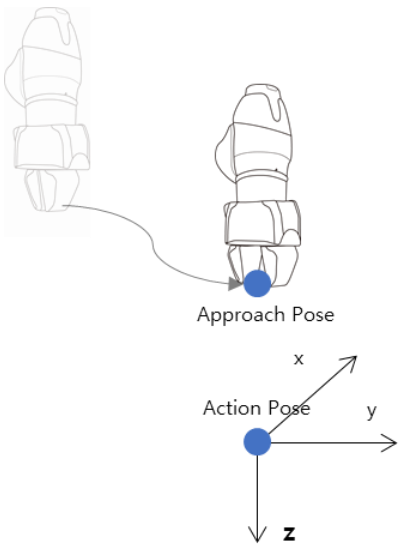
Skill commands are based on a few operation patterns.

For a robot to begin operation, the weight and tool center point (TCP) of the tool equipped on the robot must be configured, and the basic operation pattern of a skill command is to have an approach pose that is perpendicular to the action pose.

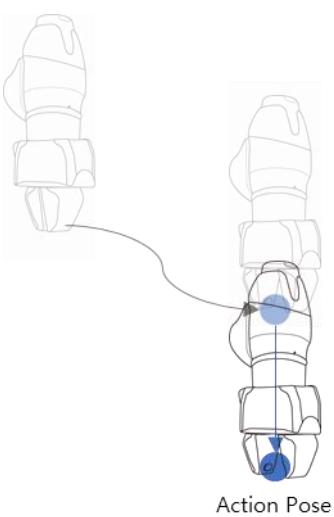
TCP Setting: Using an End Effector skill command will automatically change the TCP offset setting. The End Effector skill command execution stage includes an offset setting suited for the TCP of the End Effector. If the TCP offset changes, the Blending Motion function, which smoothly connects the previous motion command, cannot be used.



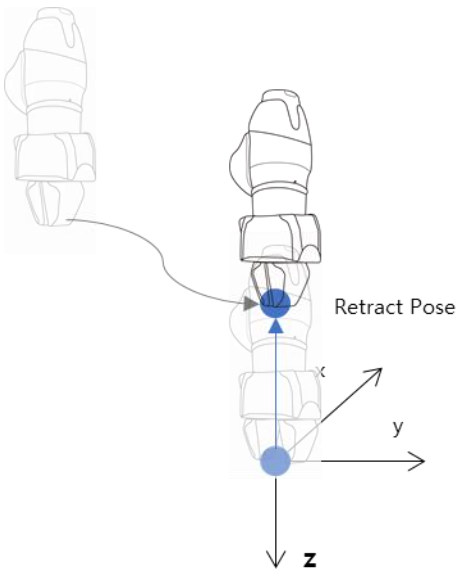
Move to **Approach Pose**: This is a point available to move to the Approach Pose. It is set in the -Z direction from the approach pose, but a different direction can also be selected. The Approach Distance entered is automatically calculated for the Action Pose and moves to the corresponding point.



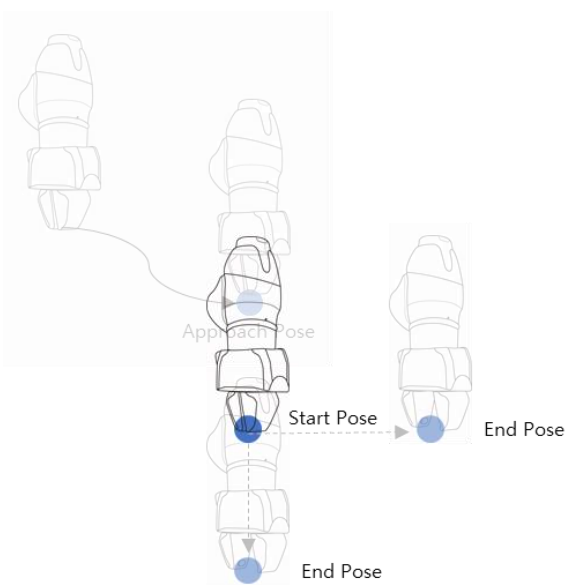
Move to **Action pose**: This is the point on the workpiece where the End Effector performs work. (e.g., Picking Pose, Placing Pose)



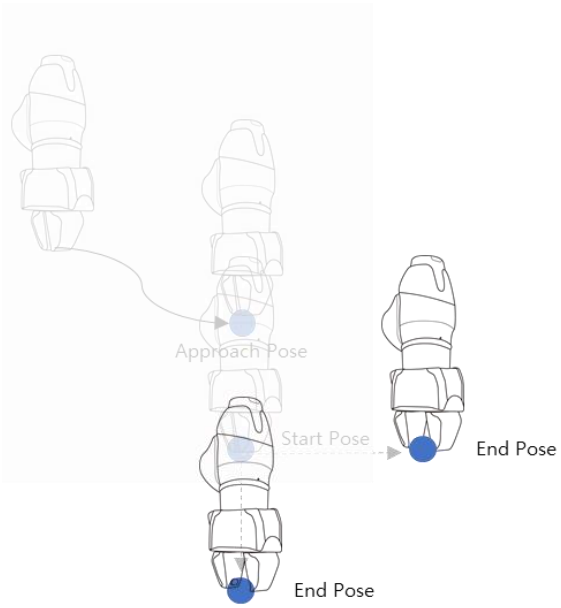
Move to Retract Pose: This is the point to pick up the workpiece and move it safely to another point. It is the –Z direction from the approach pose, but a different direction can also be selected. The Retract Distance entered is automatically calculated for the Action Pose and moves to the corresponding point.



Move to Action Start Pose: If the End Effector execution target does not end with a single motion, there may be an intermediate point and an end point, and the Action Start Pose is the point where the work starts. (e.g., Door Open Skill - Start Pose, Screw Drive Skill – Start Pose)



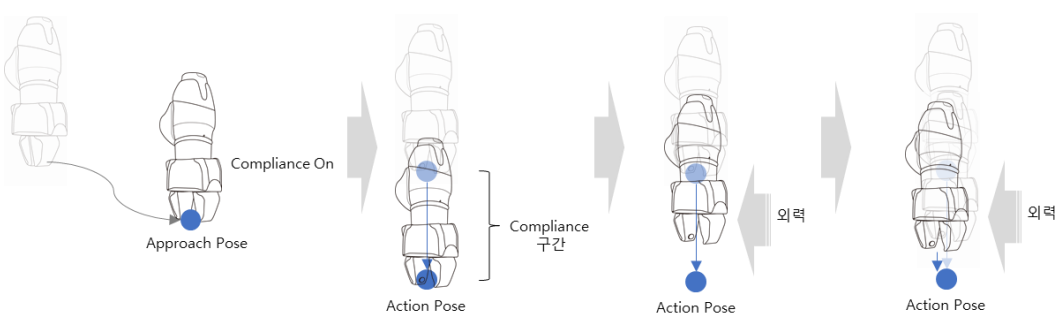
Move to Action End Pose: If the End Effector execution target does not end with a single motion, there may be an intermediate point and an end point, and the Action End Pose is the point where the work ends. (e.g., Door Open Skill – End Pose, Screw Drive Skill – End Pose)



1.3 Compliance Control and Contact Check

With the Compliance Control and Contact Check functions, which is the unique force control technology of Doosan Robotics, it is possible to easily perform teaching without repeated operation for accurate point designation since it allows position deviation within a tolerance range between the workpiece and surrounding items during robot operation.

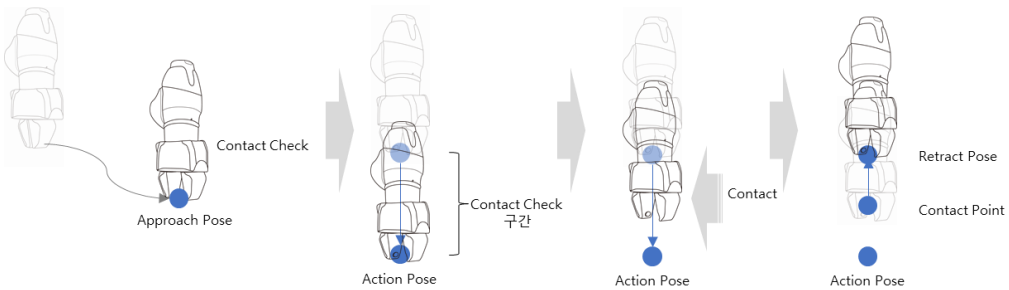
Compliance Control: If force is applied during Approach, Action → and Retract, → it allows deviation from the set position with some level of buffering, like a spring.



Contact Check: The function detects contact with the target, stops at a corresponding position and activates the gripper to grab the target based on the **Contact Force**, **Contact Determination Range** and **Authorized Force** values entered.

- This function must be used with the Compliance Control Function. If a **Force** value is entered and Compliance Control is not enabled, an error occurs.
- Contact is a function that detects contact with an external force, so the sensitivity of Collision Detection must be set at low levels or Collision Detection must be disabled.

- Pick skills (Pallet, Line, Destacking) have **Scratch Offset** to prevent scratches on the floor or the object.
- Be careful when using this function, as excessive force can be generated when contacting the external environment if the Compliance Control option stiffness (e.g., z-direction) value is too large or the work speed is too high. (It is necessary to make adjustments according to the situation by lowering the stiffness value if the work speed is too high or by increasing the stiffness if work speed is too low.)



Note

- If contact with a force greater than the set range occurs with Contact Check enabled, a notification window appears. To remove the obstacle and continue work, press the **Continue** button on the notification window and remove the obstacle.

1.4 Common Setting Options for Skill Commands

- Teach the robot directly or use the jog to position the robot in grab pose/default pose/action pose.
- Tap the Save Pose or Pallet button to load the current coordinates/movement speed of the robot.
- The Contact Force and margin (Contact Detection Range) for determining contact with external force can be configured.
- If Stiffness Control is used, turn on the toggle switch for Compliance Control. With Stiffness Control, it is possible to set the values (Stiffness) of each axis.
- If Contact Check is required, turn on the toggle switch for Contact Check. Then the Contact Force and margin (Contact Detection Range) can be configured.

Item	Description
Direction	It configures the direction of work. (Default: Z-direction)
Approach Distance	This configures the offset distance for the Action Pose to allow safe access to the target.
Retract Distance	This configures the offset distance for the Action Pose to allow movement without colliding with the target.

Item	Description
Approach Velocity	This configures the speed required to approach the Action Pose.
Retract Velocity	This configures the speed required to retract from the Reference Pose.
Approach/Retract Acceleration	This configures the acceleration required to approach or retract from the Action Pose. Low (250 mm/s^2), Mid (500 mm/s^2) and High (1000 mm/s^2) are available. (Default: High)
Compliance Control (On/Off)	It is the switch that turns Compliance Control on/off.
Stiffness	It configures the Stiffness required for Compliance Control.
Time (wait time)	It is the wait time required after operation.
Contact Check (On/Off)	It is the switch that turns Contact Check on/off.
Contact Force	It is the force required to determine a contact.
Contact Detection Range	It is the margin required to determine a contact.
Force	It is the level of force authorized in the working direction when contact detection is used.
Scratch Offset	It is the offset to prevent scratches on the floor or the object when using Pick skills.
Tool Weight Setting	When executing Pick/Place skills with Compliance Control applied, this designates the tool weight value for picking or placing an item.
Coordinate Setting	It is the setting that allows the user to select the coordinate when setting the teaching pose.
Pick-up Pose	It configures the point where the target pick-up pose is resumed.

1.5 Skill Command List

1.5.1 Air blow

It is a command that configures the motions of cleaning the target or equipment using the air blow nozzle. Entering a time value will execute cleaning of a single point for the time entered.

Item	Description
Air blow Nozzle	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	This configures the Air blowing start pose.

1.5.2 Bolt Shooting

It is the command to feed bolts through the Screw Bolt Feeder.

1.5.3 Check

This command is used to prepare work and check work completion, depending on the command type.

Item	Description
On	It is the button for starting work.
Off	It is the button for ending work.

The following is a list of Check commands.

- Check TC Ready
- Check Press Machine Ready
- Check Injection Molding Machine Ready
- Screw OK/NG Check

1.5.4 Close TC Chuck

It is the command to close the Turning Center Chuck.

Item	Description
Open Chuck	It is the button for opening the chuck.
Close Chuck	It is the button for closing the chuck.

1.5.5 Close TC Door

It is the command to close the Turning Center Door.

Item	Description
Open door	It is the button for opening the Turning Center Door.
Close door	It is the button for closing the Turning Center Door.

1.5.6 Close TC Manual Door

This command operates the robot directly to manually close the door of the turning center. The Close TC Manual Door skill consists of two motions: i) a motion using only point control, and ii) a motion using point control and Compliance Control.

Item	Description
Motion Start Pose	This configures the start pose of the motion for closing the door.
Motion End Pose	This configures the end pose for closing the door.

1.5.7 Deburr (Hole)

It is the skill that deburrs the interior of a hole using a deburring tool. This performs deburring according to the hold depth and repetition count, which are configured based on the deburring starting point.

Item	Description
Deburring Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	This configures the deburring start pose.
Hole Depth	Enter the depth of the hole. It calculates the end pose of the repeat motion considering the hole depth.
Area Repeat Count	Enter the number of repeat motions to be performed.

1.5.8 Deburr (Hole) Line

It is the skill that deburrs the interior of a hole positioned in a linear pattern using a rotating deburring tool. It performs work according to the hole depth and repeat count configured based on the position set on a linear pattern.

Item	Description
Linear Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Deburring Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

1.5.9 Deburr (Hole) Pallet

It is the skill that deburrs the interior of a hole positioned in a pallet pattern using a rotating deburring tool. It performs work according to the hole depth and repeat count configured based on the position set on a pallet pattern.

Item	Description
Pallet	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Deburring Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

Pallet-related skills are matched to the pattern position corresponding to the configuring pattern. If a variety of pallets are used, related skills can be differentiated using the pallet's name.

1.5.10 Destacking

It is a skill that handles objects with identical shapes stacked in a pattern by automatically calculating their locations according to the number of stacks entered. The Destacking skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Reference Pose	This configures the Reference Pose of the work.
Thickness	This configures the thickness of the workpiece.
Count	This configures the number of workpieces.

Note

The teaching point for the destacking skill is the top of a stack of items.

1.5.11 Destacking Line

It is a skill that handles objects with identical shapes stacked in a linear pattern by automatically calculating their locations according to the number of stacks entered.

Item	Description
Line Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

If both the destacking skill and a linear pattern are present, the linear pattern must be taught in reference to the top of the stack of items.

1.5.12 Destacking Pallet

It is a skill that handles objects stacked on a pallet with identical shapes by automatically calculating their locations according to the number of stacks entered.

Item	Description
Pallet	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pallet settings related to the skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

- Pallet-related skills are matched to the pattern position corresponding to the configuring pattern. If a variety of pallets are used, related skills can be differentiated using the pallet's name.
- If both the destacking skill and a pallet are present, the pallet must be taught in reference to the top of the stack of items.

1.5.13 End

This skill defines the end pose of the corresponding tool in a continuous deburring routine performed on a given target. When the previous motions are complete, it stops operation and retreats to the configured direction based on the end point of the previous motion.

Item	Description
Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.

The following is a list of End Skills according to the tool:

- End Glue
- End Deburr
- End Polish

It can be operated with default settings without additional configurations.

1.5.14 Glue (Point)

It is the skill that discharges glue on the instructed point. Entering a time value will execute gluing at a single point for the time entered.

Item	Description
Gluing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	This configures the gluing start pose.

1.5.15 Glue (Point) Line

It is the skill that discharges glue in a linear pattern. Entering a time value will execute gluing at a single point in a linear pattern for the time entered.

Item	Description
Linear Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Gluing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

1.5.16 Glue (Point) Pallet

It is the skill that discharges glue in a pallet pattern. Entering a time value will execute gluing at a single point in a pallet pattern for the time entered.

Item	Description
Pallet	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.

Item	Description
Gluing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

Pallet-related skills are matched to the pattern position corresponding to the configuring pattern. If a variety of pallets are used, related skills can be differentiated using the pallet's name.

1.5.17 Grasp

It is the command to close the gripper.

Item	Description
Grasp	It is the button for closing the gripper.
Release	It is the button for opening the gripper.

1.5.18 Insert

It is a skill that finds the target point by searching with Spiral motion near the target point when the workpiece must be inserted into a hole at an inaccurate point. If the workpiece must be inserted into the target in tasks, such as gear assembly, it is possible to execute insertion motions by inserting incorrectly positioned workpieces through periodic motions. Insert skill requires contact with external forces, so it requires Compliance Control by default.

- Spiral Search motion and Rotation Search motion to find holes must be configured.
- For Spiral Search motion, Max. Revolutions, Spiral Interval, Max. Radius, Velocity and Acceleration can be configured.
- For Rotation Search motion, Amplitude, Period and Repeat can be configured.
- The user can configure Timeout as a method to notify the failures of the two motions.

Item	Description
Pneumatic Gripper	Displays the Workcell Item (Insert → Pneumatic Gripper) required for configuring the corresponding skill.

Item	Description
Reference Pose	This configures the point point where the workpiece is inserted in the hole.
Depth	It configures the depth of the hole.
Force	This configures the force applied in the movement direction.
Spiral Interval	Configures the spiral interval of Spiral motion.
Max. Revolutions	This configures the total revolution count of the Spiral motion.
Max. Radius	This configures the final radius of the Spiral motion.
Velocity	This configures the velocity of the Spiral motion.
Acceleration	This configures the acceleration of the Spiral motion.
Amplitude	This configures the amplitude of the periodic motion.
Period	This configures the period of the periodic motion.
Repeat	This configures the repetition count of the periodic motion.
Timeout	This configures the time required for checking failed work.

1.5.19 Machine Reset

It is the command to reset the machine tool.

Item	Description
On	It is the button for starting Turning Center work.
Off	It is the button for ending Turning Center work.

1.5.20 Open TC Chuck

It is the command to open the Turning Center Chuck.

Item	Description
Open Chuck	It is the button for opening the chuck.
Close Chuck	It is the button for closing the chuck.

1.5.21 Open TC Door

It is the command to open the Turning Center Door.

Item	Description
Open door	It is the button for opening the Turning Center Door.
Close door	It is the button for closing the Turning Center Door.

1.5.22 Open TC Manual Door

This command operates the robot directly to manually open the door of the turning center. The Open TC Manual Door skill consists of two motions: i) a motion using only point control, and ii) a motion using point control and Compliance Control.

Item	Description
Motion Start Pose	It configures the Start Pose of the motion for opening the door.
Motion End Pose	It configures the End Pose for closing the door.

1.5.23 Pick

This skill operates the gripper and picks up the target when the robot moves to a specific point or approaches and contacts a target. The Pick skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Open Gripper before Approaching	If there is a situation where the gripper is closed before moving to the point to pick up the target, this option can be used to prevent collision with the target.

Note

If the speed and relative coordinate settings for each motion of Pick are required, click the > button on the right side of Pick-up Pose.

1.5.24 Pick Injection Molding Machine

This skill operates the gripper and picks up the target from a discharge unit of an injection molding machine when the robot moves to a specific point or approaches and contacts a target at an instructed

point. It consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Injection Molding Machine	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.

1.5.25 Pick Line

This skill operates the gripper and picks up the target when the robot moves to a specific point or approaches and contacts a target on a linear pattern. The motion point is entered when defining the Workcell Item pallet, and the entered point is automatically utilized when the skill is used. The Pick Line skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Linear Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

1.5.26 Pick Pallet

This skill operates the gripper and picks up the target when the robot moves to a specific point on the pallet or approaches and contacts a target. The motion point is entered when defining the Workcell Item pallet, and the entered point is automatically utilized when the skill is used. The Pick Pallet skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Pallet	It displays the Workcell Item (Pick Pallet → Pallet) required for configuring the corresponding skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

Pallet-related skills are matched to the pattern position corresponding to the configuring pattern. If a variety of pallets are used, related skills can be differentiated using the pallet's name.

1.5.27 Pick Press Machine

This skill operates the gripper and picks up the target from a press machine when the robot moves to a specific point or approaches and contacts a target at an instructed point. It consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Press Machine	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.

1.5.28 Pick TC Chuck

This skill operates the gripper and picks up the target when the robot moves to a point instructed in the Turning Center Chuck or approaches and contacts a target held by the chuck. After the motion point is instructed to the corresponding skill, it automatically instructs the point on the Place TC Chuck for the same machine tool present on the canvas. The Pick TC Chuck skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Turning Center	It displays the Workcell Item (Pick TC Chuck → Chuck) required for configuring the corresponding skill.

1.5.29 Place

This skill operates the gripper and releases the target when the robot moves to a specific point or approaches and contacts the work table. The Place skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Release	It configures the point where the target release pose is resumed.

1.5.30 Place Line

This skill operates the gripper and releases the target when the robot moves to a specific point on a linear pattern or approaches and contacts the work table. The Place Line skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Line Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

1.5.31 Place Pallet

This skill operates the gripper and releases the target when the robot moves to a specific point on the pallet or approaches and contacts a target settlement point on the pallet. The motion point is entered when defining the Workcell Item pallet, and the entered point is automatically utilized when the skill is used. The Place Pallet skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Pallet	It displays the Workcell Item (Place Pallet → Pallet) required for configuring the corresponding skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

Pallet-related skills are matched to the pattern position corresponding to the configuring pattern. If a variety of pallets are used, related skills can be differentiated using the pallet's name.

1.5.32 Place Press Machine

This skill operates the gripper and releases the target when the robot moves to a point instructed on the Turning Center Chuck or approaches and contacts the chuck. When the motion point is instructed to the corresponding skill, it automatically instructs the point on the Pick Press Machine for the same machine tool present on the canvas. The Place Press Machine skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Press Machine	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.

Item	Description
Release Pose	It configures the point where the target release pose is resumed.

1.5.33 Place TC Chuck

This skill operates the gripper and releases the target when the robot moves to a point instructed on the Turning Center Chuck or approaches and contacts the chuck. After the motion point is instructed to the corresponding skill, it automatically instructs the point on the Pick TC Chuck for the same machine tool that exists on the canvas. The Place TC Chuck skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Turning Center	It displays the Workcell Item (Place TC Chuck → Chuck) required for configuring the corresponding skill.
Release Pose	It configures the point where the target release pose is resumed.

1.5.34 Polish (Hole)

It is the skill that polishes the interior of a hole using a polishing tool. It performs deburring according to the hole depth and repeat count configured based on the point entered.

Item	Description
Polishing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	This configures the polishing start pose.
Hole Depth	Enter the depth of the hole. It calculates the end pose of the repeat motion considering the hole depth.
Repeat Count	Enter the number of repeat motions to be performed.

1.5.35 Polish (Hole) Line

It is the skill that polishes the interior of a hole positioned in a linear pattern using a rotating polishing tool. It performs work according to the hole depth and repeat count configured based on the position set on a linear pattern.

Item	Description
Linear Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Polishing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

1.5.36 Polish (Hole) Pallet

It is the skill that polishes the interior of a hole positioned in a pallet pattern using a rotating polishing tool. It performs work according to the hole depth and repeat count configured based on the position set on a pallet pattern.

Item	Description
Pallet	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Polishing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

Pallet-related skills are matched to the pattern position corresponding to the configuring pattern. If a variety of pallets are used, related skills can be differentiated using the pallet's name.

1.5.37 Push

It is a skill that applies constant force in the direction the user configured to move the robot. Push skill is a skill that requires force control in a specific direction, so it requires the Compliance Control by default.

Item	Description
Reference Pose	This configures the reference point force control initiates.
Axis Distance	This configures the maximum distance moved in the direction of the force.
Force	This configures the force applied in the movement direction.

1.5.38 Release

It is the command to open the gripper.

Item	Description
Grasp	It is the button for closing the gripper.
Release	It is the button for opening the gripper.

1.5.39 Robot Online

It is the command for checking the connection between the robot and machine tool.

Item	Description
On	It is the button for starting Turning Center work.
Off	It is the button for ending Turning Center work.

1.5.40 Run

It is the command that executes the Skill.

Item	Description
On	It is the button for turning on the Skill.
Off	It is the button for turning off the Skill.

The following is a list of Run Skills:

- Run Screw
- Run Air blow
- Run Glue
- Run Deburr
- Run Polish

1.5.41 Screw Pick Ready Check

It is the command to check whether the screw is ready in the Screw Bolt Feeder and to wait until a bolt is fed to the Screwdriver. If this is not prepared, the next movement cannot be performed.

1.5.42 Screwdrive

It moves the screwdriver to the target work point and moves it by the distance the user entered. This skill retracts the screwdriver to the retract pose after it completes its task, which is recognized when a completion signal is received or when the distance entered is reached. The screwdrive skill motion supports motion using point control, and motion control using point control and compliance control.

Item	Description
Screwdriver	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	Configures the screwing point. Values must be saved based on the location where screwing was completed.
Bolt Length	It is the distance moved to complete screwing. It moves at the speed entered from the point to the bolt length point based on the motion point.
Counter-Rotation Mode	If counter-rotation mode is set up in the Screwdriver Workcell Item, this mode setup allows you to configure whether to use counter-rotation.

1.5.43 Screwdrive Line

It is a skill that screws bolts at designated locations based on a number entered in a linear pattern calculated automatically.

It moves the screwdriver to the target work point and moves it by the distance the user entered. It is a skill that retracts the screwdriver to the Retract pose after the screwdriver completes its task, recognized by receiving a completion signal or by reaching the distance entered. The screwdrive skill motion supports motion using point control, and motion control using point control and compliance control.

Item	Description
Line Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Screwdriver	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	Configures the screwing point. Values must be saved based on the location where screwing was completed.
Bolt Length	It is the distance moved to complete screwing. It moves at the speed entered from the point to the bolt length point based on the motion point.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

1.5.44 Stacking

It is a skill for stacking objects to a specific number the user entered by automatically calculating their thickness. The Stacking skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Reference Pose	This configures the Reference Pose of the work.
Thickness	This configures the thickness of the workpiece.
Count	This configures the number of workpieces.

Note

The teaching point for the stacking skill is the bottom of a stack of items.

1.5.45 Stacking Line

It is a skill to stack a specific number of objects the user entered on a linear pattern in a designated location by automatically calculating their thickness. The Stacking Line skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Line Pattern	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pattern settings related to the skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

If both the stacking skill and a linear pattern are present, the linear pattern must be taught in reference to the bottom of the stack of items.

1.5.46 Stacking Pallet

It is a skill to stack a specific number of objects the user entered on a pallet in a designated location by automatically calculating their thickness. The Stacking Pallet skill consists of three motions: i) a motion using only point control, ii) a motion using point control and Compliance Control, and iii) a motion using point control, Compliance Control and Contact Check.

Item	Description
Pallet	It displays the Workcell Item required for configuring the corresponding skill. Click the button to change pallet settings related to the skill.
Gripper	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.

Item	Description
Velocity	It configures the speed at which the robot moves to a specific point on the pallet.
Position Change Count	Select the counter that acts as the reference point for position change on the pattern. Selecting a MainSub will change the position according to the increase in the all-area counter of the task program. Placing this skill between the Repeat syntax will allow counters of the corresponding Repeat syntax.

Note

- Pallet-related skills are matched to the pattern position corresponding to the configuring pattern. If a variety of pallets are used, related skills can be differentiated using the pallet's name.
- If both the stacking skill and a pallet are present, the pallet must be taught in reference to the bottom of the stack of items.

1.5.47 Start Deburr

It is the skill that defines the start pose of the Deburring Tool in a continuous deburring routine on a target. Instructing the starting point for deburring on a continuous routine will move the tool up to the point and execute the next motion after waiting for the configured wait time.

Item	Description
Deburring Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	This configures the continuous deburring start pose.
Direction	It configures the direction of work. (Default: Z-direction)

Note

Start / End skills are always used together. Freely teach the routine using motion commands that can be used between Start and End. It is recommended that Spline commands be used, such as MoveSX or MoveSJ.

1.5.48 Start Glue

It is the skill that defines the start pose of the Gluing Tool in a continuous gluing routine on a target. Instructing the starting point for gluing on a continuous routine will move the tool up to the point and execute the next motion after waiting for the configured wait time.

Item	Description
Gluing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Operation Point	This configures the continuous gluing start pose.
Time	It is the wait time required after operating the gluing tool.

Note

Start / End skills are always used together. Start/End skills can start a task in the direction of Tool Coordinates and Base Coordinates. Freely teach the routine using motion commands that can be used between Start and End. It is recommended to use the Move Spline command.

1.5.49 Start Injection Molding Machine

It is the command to start the Injection Molding Machine operation.

Item	Description
On	It is the button for starting Injection Molding Machine work.
Off	It is the button for ending Injection Molding Machine work.

1.5.50 Start Polish

It is the skill that defines the start pose of the Polishing Tool in a continuous polishing routine on a target. Instructing the starting point for polishing on a continuous routine will move the tool up to the point and execute the next motion after waiting for the configured wait time.

Item	Description
Polishing Tool	The Workcell Item required for configuring the corresponding skill can be tested or used in the instruction process.
Motion Start Pose	This configures the continuous polishing start pose.
Force	This configures the force applied in the operation direction.

Note

- Start / End skills are always used together. Freely teach the routine using motion commands that can be used between Start and End. It is recommended to use the Move Spline command.

1.5.51 Start Press Machine

It is the command to start Press Machine operation.

Item	Description
On	It is the button for starting Press Machine work.
Off	It is the button for ending Press Machine work.

1.5.52 Start TC

It is the command to start Turning Center operation.

Item	Description
On	It is the button for starting Turning Center work.
Off	It is the button for ending Turning Center work.

1.5.53 Steady Rest Clamp

It is the command to close the machine tool Steady Rest.

Item	Description
Close Steady Rest	It is the button for closing the machine tool Steady Rest.
Open Steady Rest	It is the button for opening the machine tool Steady Rest..

1.5.54 Steady Rest Unclamp

It is the command to open the machine tool Steady Rest.

Item	Description
Close Steady Rest	It is the button for closing the machine tool Steady Rest.
Open Steady Rest	It is the button for opening the machine tool Steady Rest..

1.5.55 Stop

It is the command for stopping Skill operation.

Item	Description
On	It is the button for turning on the Skill.
Off	It is the button for turning off the Skill.

The following is a list of Stop commands.

- Stop Air blow
- Stop Deburr
- Stop Glue
- Stop Polish
- Stop Screw

1.5.56 Tailstock Forward

It is the command to move the machine tool tailstock forward.

Item	Description
Tailstock Forward	It is the button for moving the machine tool Tailstock forward.
Tailstock Retreat	It is the button for retracting the machine tool Tailstock.

1.5.57 Tailstock Backward

It is the command to move the machine tool Tailstock backward.

Item	Description
Tailstock Forward	It is the button for moving the machine tool Tailstock forward.
Tailstock Retreat	It is the button for retracting the machine tool Tailstock.

1.5.58 Touch

It is the skill that stops movement to the target position when external force is detected and retracts to the Retreat Pose. Touch skill is a skill that stops operation when external force is detected, so it requires Compliance Control by default.

Item	Description
Reference Pose	This configures the target contact detection point.

1.5.59 Workpiece Clean

It is the command to operate the air blow device installed on the machine tool to clean the workpiece.

Item	Description
On	It is the button for starting workpiece cleaning.
Off	It is the button for ending workpiece cleaning.

2. Task Template

Task Template is a bundle of skills that compose a work procedure used with a combination of Workcell Items when a particular Workcell Item is registered. It is possible to easily create a task with the settings of skills already in the template without worrying about the work process.

2.1 Part Handling

It is the template for handling the target. It is fundamentally composed of Pick and Place skills. A template is recommended depending on whether a single gripper or two grippers are installed on the robot flange. Related Workcell Items are as follows:

- Pneumatic Gripper
- Electric Gripper

2.1.1 Single Gripper

Work Procedure	Command
Grasp the workpiece	Pick
Release the workpiece	Place

2.1.2 Double Gripper

Work Procedure	Command
Grasp workpiece #1	Pick
Grasp workpiece #2	Pick
Release workpiece #1	Place
Release workpiece #2	Place

2.2 CNC Machine Tending

It is the template for secondary work of the machine tool. The machine tool template recommends a template depending on whether a single gripper or two grippers are installed on the robot flange. Related Workcell Items are as follows:

- Pneumatic Gripper
- Electric Gripper
- Turning Center
- Air blow Nozzle
- Pallet

2.2.1 Single Gripper

Work Procedure	Type 1	Type 2	Type 3	Type 4
	Command			
Grasp the workpiece	Pick Pallet	Pick Pallet	Pick Pallet	Pick Pallet
Chuck air blowing	-	-	Air blow	Air blow
Load the workpiece	Place TC	Place TC	Place TC	Place TC
Close door	Close TC Door	Close Manual TC Door	Close TC Door	Close Manual TC Door
Start processing	Start TC	Start TC	Start TC	Start TC
TC ready check	Check TC Ready	Check TC Ready	Check TC Ready	Check TC Ready
Open door	Open TC Door	Open Manual TC Door	Open TC Door	Open Manual TC Door
Finished Piece Air blowing	-	-	Air blow	Air blow
Unload finished p iece	Pick TC	Pick TC	Pick TC	Pick TC
Release finished piece	Place Pallet	Place Pallet	Place Pallet	Place Pallet

2.2.2 Double Gripper

Work Procedure	Type 1	Type 2	Type 3	Type 4
	Command			
Grasp the workpiece	Pick Pallet	Pick Pallet	Pick Pallet	Pick Pallet
TC ready check	Check TC Ready	Check TC Ready	Check TC Ready	Check TC Ready
Open door	Open Auto TC Door	Open Manual TC Door	Open Auto TC Door	Open Manual TC Door
Finished piece air blowing	-	-	Air blow	Air blow
Unload finished piece	Pick TC	Pick TC	Pick TC	Pick TC
Chuck air blowing	-	-	Air blow	Air blow
Load the workpiece	Place TC	Place TC	Place TC	Place TC
Close door	Close Auto TC Door	Close Manual TC Door	Close Auto TC Door	Close Manual TC Door
Start processing	Start TC	Start TC	Start TC	Start TC
Release finished piece	Place Pallet	Place Pallet	Place Pallet	Place Pallet

2.3 Press Machine Tending

It is the template for secondary work of the machine tool. The machine tool template recommends a template depending on whether a single gripper or two grippers are installed on the robot flange. Related Workcell Items are as follows:

- Vacuum Gripper
- Press Machine

2.3.1 Single Gripper

Work Procedure	Command
Grasp the workpiece	Pick
Load the workpiece	Place Press Machine
Start processing	Start Press Machine
Press Machine Ready Check	Check Press Machine Ready
Unload finished piece	Pick Press Machine
Release finished piece	Place

2.3.2 Double Gripper

Work Procedure	Command
Grasp the workpiece	Pick
Press Machine Ready Check	Check Press Machine Ready
Unload finished piece	Pick Press Machine
Load the workpiece	Place Press Machine
Start processing	Start Press Machine
Release finished piece	Place

2.4 Injection Molding Machine Tending

It is the template for secondary work of the machine tool. The machine tool template recommends a template depending on whether a single gripper or two grippers are installed on the robot flange. Related Workcell Items are as follows:

- Vacuum Gripper
- Injection Molding Machine

Work Procedure	Command
Press Machine Ready Check	Check Press Machine Ready
Unload finished piece	Pick Press Machine
Start processing	Start Press Machine

2.5 Screw Drive

It is the template for screw assembly work. A template is recommended depending on the Pick-up bolt Feeder or Shooting bolt Feeder Workcell Item settings. Related Workcell Items are as follows:

- Screwdriver
- Shooting Bolt Feeder
- Pickup Bolt Feeder

Work Procedure	Type 1	Type 2
	Command	
Feeder ready check	Check Feeder Ready	N/A
Feed bolt	Pick-up bolt Feeder	Shoot Bolt
Grasp workpiece #2	Screw Drive	Screw Drive

2.6 Gluing

It is the template for continuous routine gluing work. Related Workcell Items are as follows:

- Gluing Tool

Work Procedure	Command
Start Gluing	Start Glue
End Gluing	End Glue

2.7 Deburring

It is the template for continuous routine deburring work. Related Workcell Items are as follows:

- Deburring Tool

Work Procedure	Command
Start Deburring	Start Deburr
End Deburring	End Deburr

2.8 Polishing

It is the template for continuous routine deburring work. Related Workcell Items are as follows:

- Polishing Tool

Work Procedure	Command
Start Polishing	Start Polish
End Polishing	End Polish

2.9 Insert

This template inserts the item in the target hole. It consists of Insert and Insert skills. Related workcell items are as follows:

- Pneumatic/Electric Gripper

Work Procedure	Command
Grasp the workpiece	Pick
Insert the item	Insert

Part 3
Smart Vision Module

1. Precautions Before Use

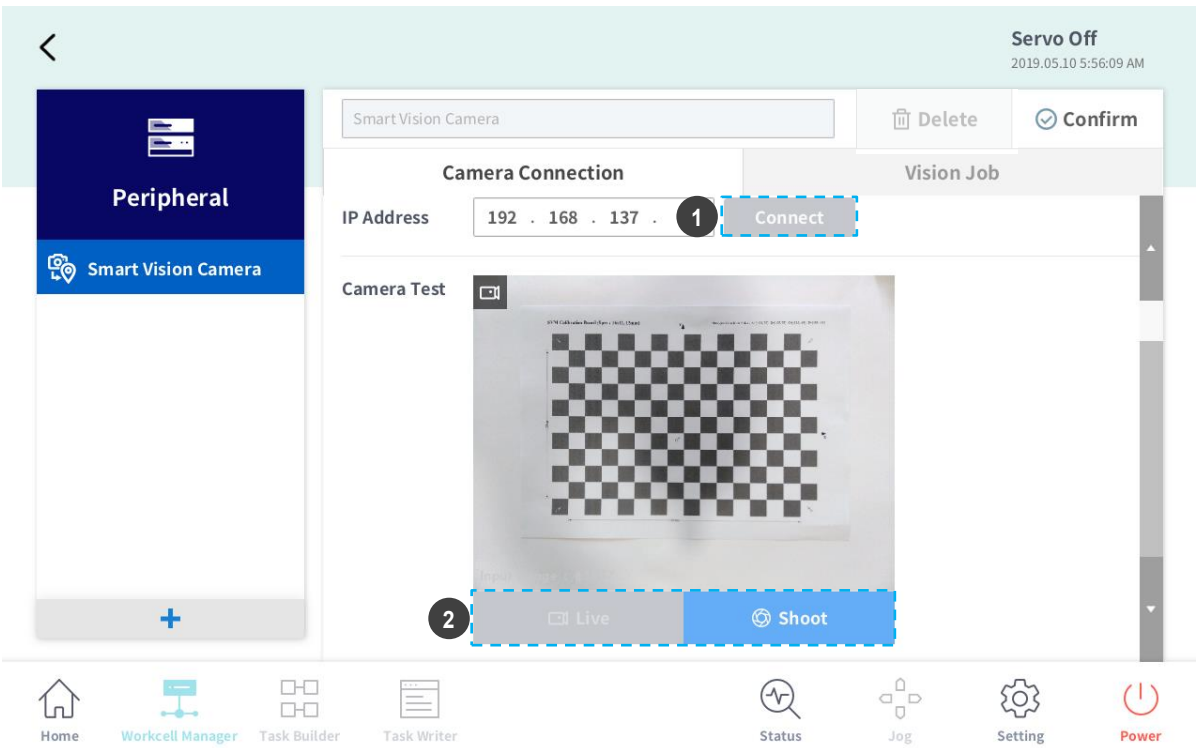
- The camera lens must be as parallel to the work surface as possible. The camera's line of view must be as perpendicular to the work surface as possible.
- Reflections from work items and the surrounding environment within the camera's measurement area must be avoided.
- The camera must measure the top view of the target item. If the item is slanted during measurement, distortion and incorrect measurement may occur due to perspective views.
- All cameras are strongly effected by ambient illumination. Establish and maintain work conditions with an illumination of 300 lux or higher in the camera measurement area using an illumination measuring instrument.
- For detailed information about measurable distance, field of view, and measurable item size and height, please refer to corresponding sections describing product specifications.
- When replacing SVM, create a job after deleting the Task Vision Command with Vision Job Command stored in the TB (Task Builder) or TW (Task Writer) on the TP. Vision Command can be deleted after deleting a Command depending on Vision Command.
- In order to update SVM firmware, make sure the current version is **DRST v1.2.0.2.6 version** or higher. Updating at a lower version can cause serious issues for the SVM OS. Please be careful.
- The SVM operates properly in version M2.2.1 or higher. In versions lower than M2.2.1, the robot must be updated.
- Match the robot version and the SVM version.

2. Setting with Workcell Manager

Add the Smart Vision Module to the Workcell Manager and configure the Smart Vision Module referring to the following setting options.

2.1 Changing the Camera Connection and IP Address

2.1.1 Camera Connection



No.	Item	Description
1	**Connect**	The camera IP address is a static IP, and the default address (192.168.137.5) is used for connection. After connection is successful, the Connect button is disabled.
2	**Live – Shoot**	Check the image in the camera's viewfinder to see if the camera is working properly. Live: Displays the streaming image. Shoot: Displays the static image in the camera’s field of view.

If the LAN/communication cable physically disconnects the SVM

- When the cable is physically removed while the Smart Vision Module (SVM) and Teach Pendant (TP) are connected, the power to the SVM and TP must be turned OFF/ON.

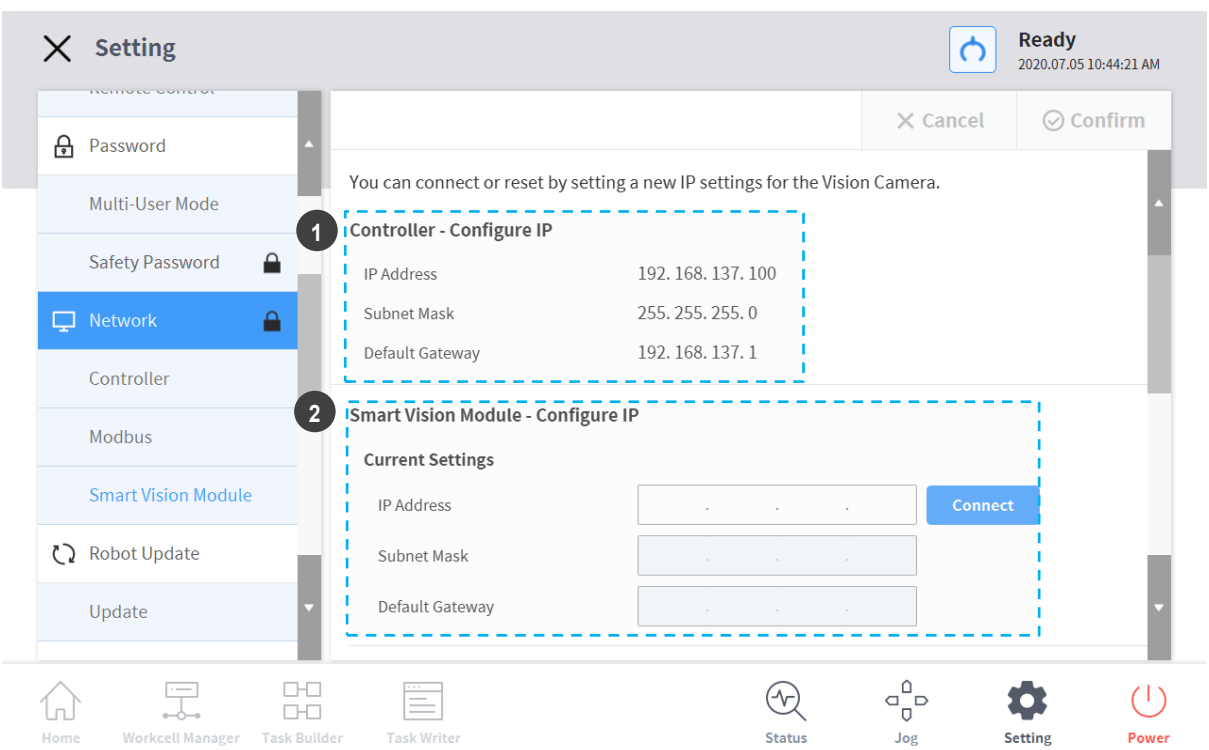
Status indicator LED function

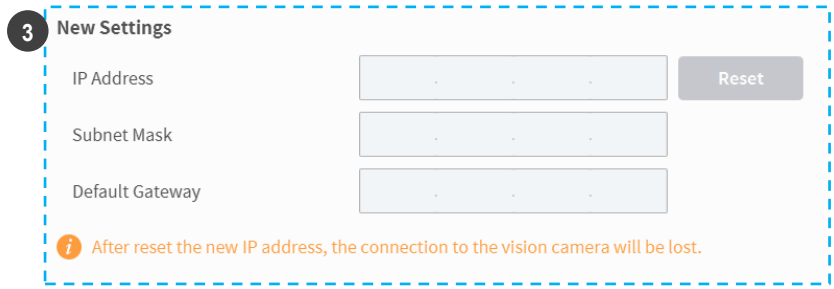
- The status indicator LED on top of the SVM module operates in five modes: power not connected, power supplied, connection standby, communication connected and processing.

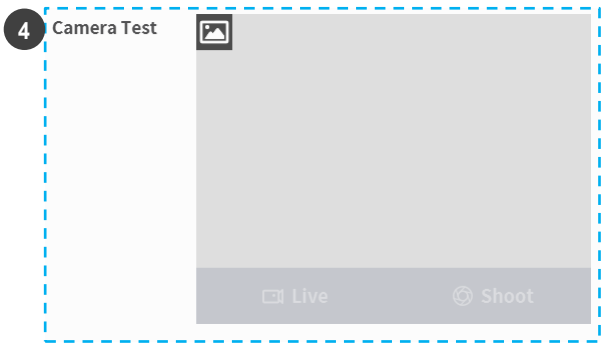
	Smart Vision Module Status Indicator LED	LED Operation	
1	Power not connected	Power off	
2	Power connected – OS booting	Solid Red	
3	Normal operation – Connection standby – Communication not connected	Solid Green	
4	Normal operation – Standby – Communication connected	Solid Blue	
5	Normal operation – Processing – (item recognition, teaching/save/loading)	Blink Blue	

2.1.2 Changing IP address of Camera

IP address of the camera can be changed through the Settings > Network > Smart Vision Module menu. To change the IP address, make sure that the vision is properly connected to the robot and remember the IP address to change.



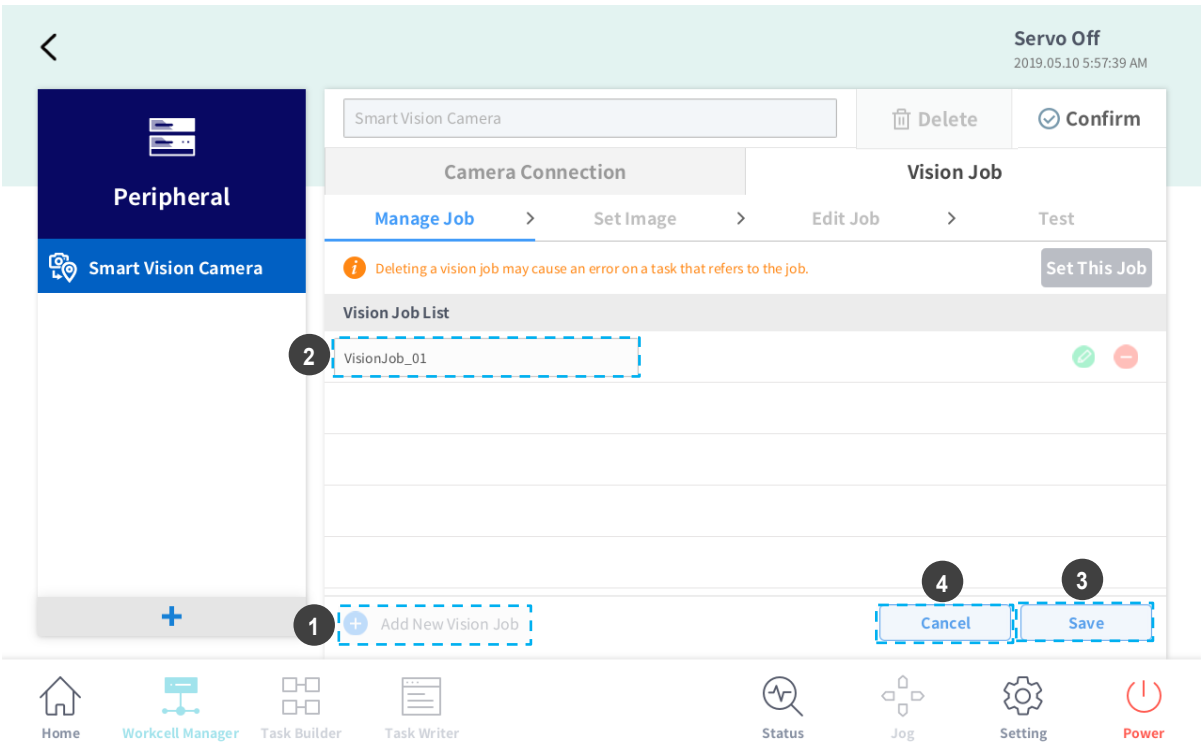




No.	Item	Description
1	**Controller – Configure IP**	Displays IP address of the controller
2	**Smarst Vision Module – Configure IP**	Enter and connect the IP address of the camera. • Connect: After entering IP address and select the Connect button, the set subnet mask and default gateway are displayed.
3	**New Settings**	Enter the IP address, subnet mask, and default gateway to change. • Reset: If the Reset button is selected, IP address, Subnet Mask and Default Gateway of the camera is changed. After changing, the connection to the camera is automatically terminated, and the setting is completed when the camera is powered off and on.
4	**Camera Test**	Check that the controller and the cemera are properly connected. • Live: Displays live images of the cemera. • Shoot: Displays stop image of the camera.

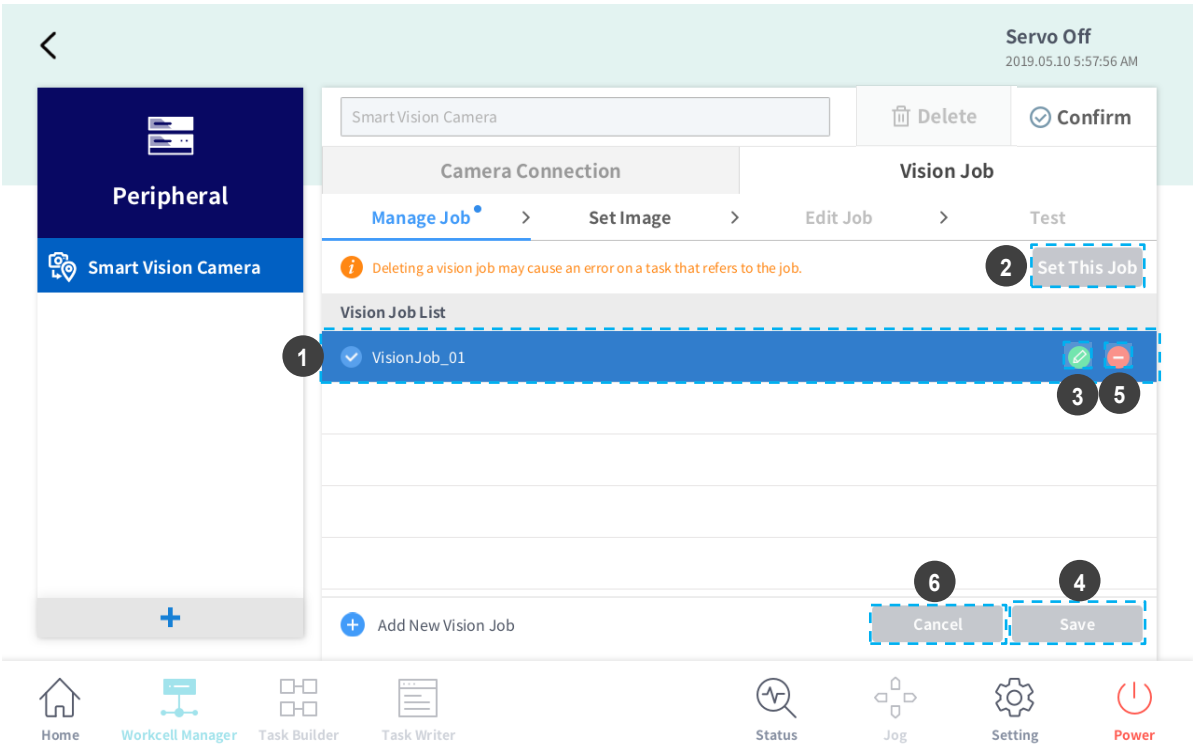
2.2 Vision Job > Manage Job

2.2.1 Create Vision Job



No.	Item	Description
1	**Add New Vision Job**	If there is no existing job, create a new job with the job name “VisionJob_01,” and if there is an existing job, create a new job with the job name with the following number of the existing job. (e.g., VisionJob_02)
2	**Vision Job List**	A virtual keyboard is displayed, and the job name can be edited.
3	**Save**	This saves changes made to the job name.
4	**Cancel**	Cancels the Vision job creation.

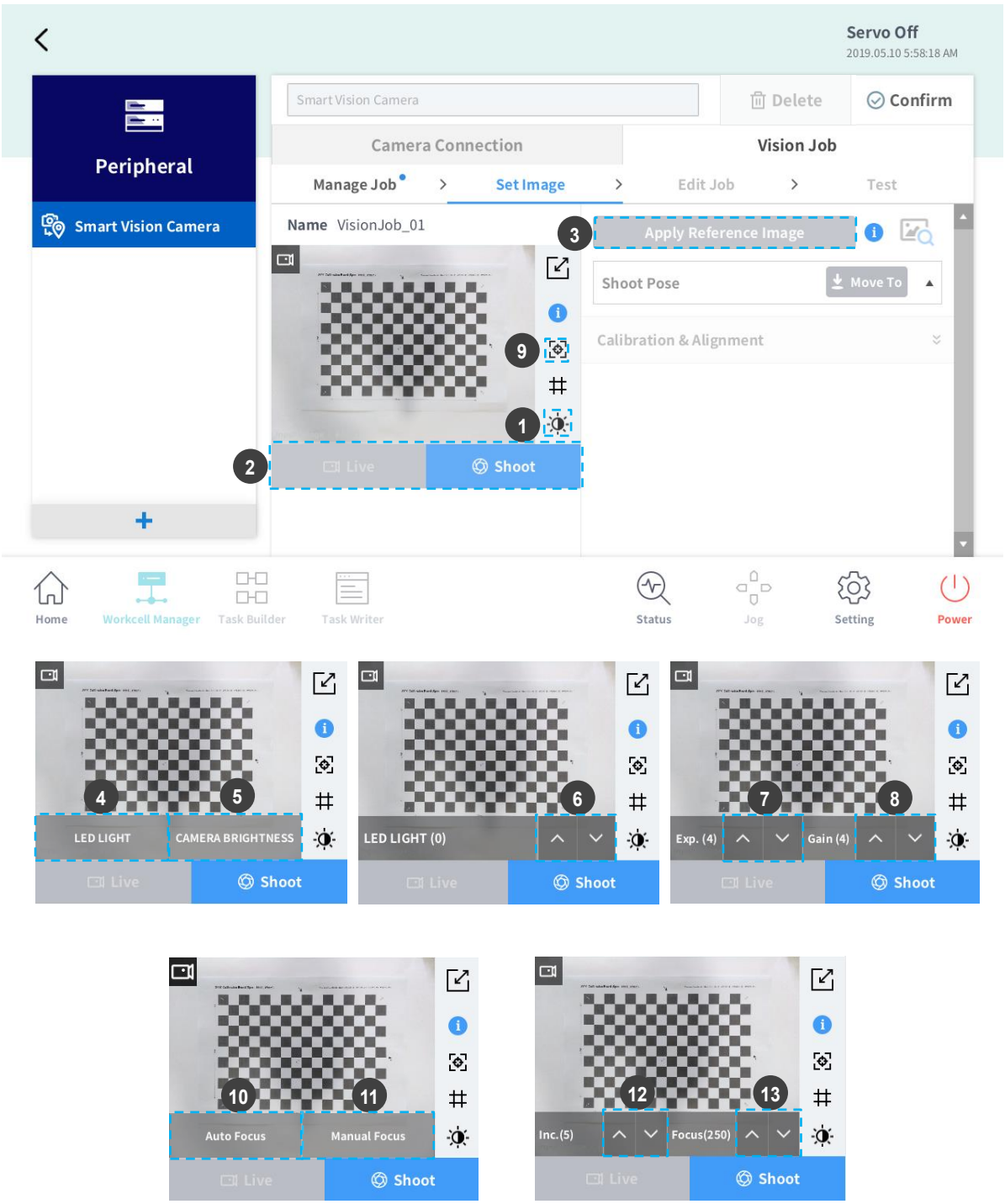
2.2.2 Edit and Delete Vision Job

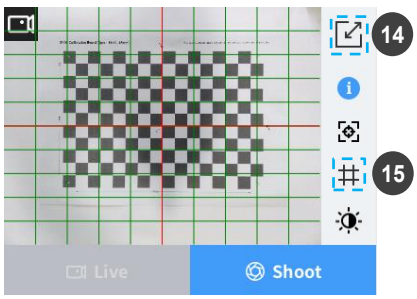


No.	Item	Description
1	**Vision Job List**	The selected vision job is highlighted in blue.
2	**Set This Job**	The job selected from the Vision Job List is set as the Setting job.
3	**Edit**	The job selected from the Vision Job List triggers the edit window where the “Job Name” can be edited.
4	**Save**	Saves the edited vision job name.
5	**Delete**	The selected job from the Vision Job List is deleted.
6	**Cancel**	This cancels changes made to the name.

2.3 Vision Job > Set Image

2.3.1 Save and Load Lighting/Exposure/Gain/Focus Setting





No.	Item	Description
1	**Image Brightness Setting**	Displays the LED LIGHT/CAMERA BRIGHTNESS select button.
2	**Live/Shoot**	• Displays the image from the Live/Shoot mode, and the button changes to gray. • Live: Displays the Live image of the camera. • Shoot: Displays the image obtained from the current camera with edge information.
3	**Apply Reference Image**	• It is enabled in blue in the Shoot mode. • A Reference Image is the reference information for the Vision Job setting. Select the item information to detect from the Reference Image, and then set default values for various tests. (Setting is made in the Edit Job tab) • Sets the current camera image as the Reference Image. • Saves the current camera focus/lighting/brightness information. • Saves the current robot Joint Pose as the Shoot Pose.
4	**LED Light**	Displays buttons that adjust the brightness of the lighting.
5	**Camera Brightness**	Displays buttons that adjust the Exposure/Gain levels.
6	**Lighting Brightness Setting**	The brightness of the lighting can be adjusted from 0 to 10.
7	**Exposure Time Setting**	• The exposure time of the camera can be adjusted from 0 to 10. • Higher numbers create a brighter image.
8	**Gain Level Setting**	• The gain level can be adjusted from 0 to 10. • Higher numbers increase image brightness, but this also increases image noise.
9	**Focus Control**	• Camera focus can be adjusted in a range from 0 to 500. • The focus must be set clearly prior to Robot-Vision Calibration.
10	**Auto Focus**	• The focus of the camera is adjusted automatically.
11	**Manual Focus**	• Camera focus can be adjusted in a range from 0 to 500.
12	**Inc**	• The value changes in the order of 1, 5, 10, 50, and 100.
13	**Focus**	• The focus increases or decreases by the amount of Inc.

No.	Item	Description
14	**Full Screen**	Displays the image in the full screen.
15	**Grid**	Displays a grid on the image. Each grid represents 10% of the screen.

Camera Brightness Adjustment (Exposure / Gain)

It is recommended to start with Gain set at level 1, adjust the Exposure to set the desired brightness, and then adjust Gain to make minor adjustments.

Conditions for a Good Reference Image

- The edge information of the item to detect must be clear.
- The size of the item to detect must be within 5%-70% of the overall screen size. It is recommended to set the size of the item to detect to 20%-40%. Use the grid pattern to check the size.
- The item to detect must be positioned in the center of the screen.
- Items/patterns other than the item to detect must not be on the screen.
- The background must have a clear difference in color from the item to detect, and it must not have patterns.

2.3.2 Camera Calibration

Camera - Robot Calibration is the process of synchronizing the coordinate information measured by the camera with the coordinate information of the robot.

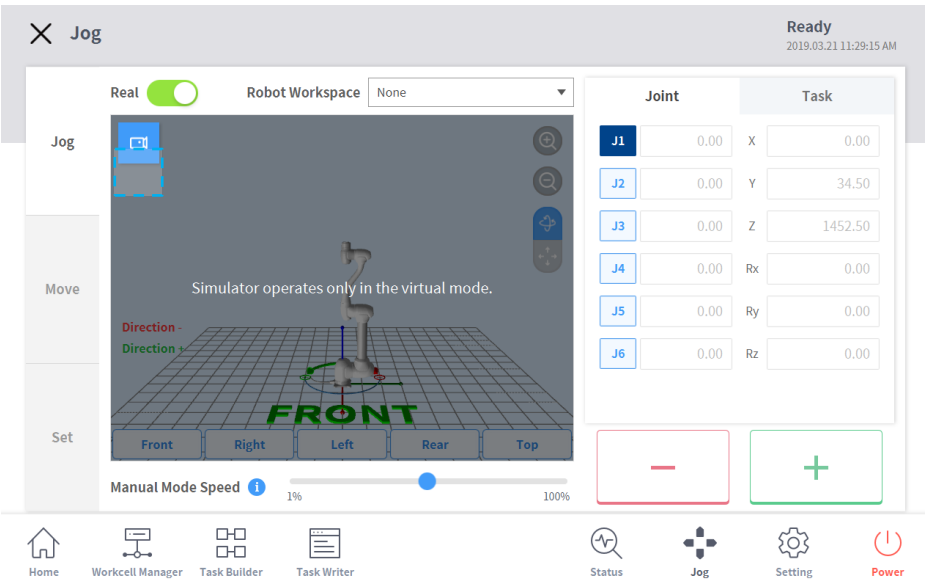
With Calibration, the camera can accurately move to the location of the measured item, and it can accurately measure dimensions in terms of length. During Calibration, a checkerboard with predefined design information is used. The method currently offered by Doosan Robotics is StandAlone calibration, and the elements required for this calibration are four robot poses taught based on the camera image of the checkerboard shot from the shooting position and tool tip.

Caution

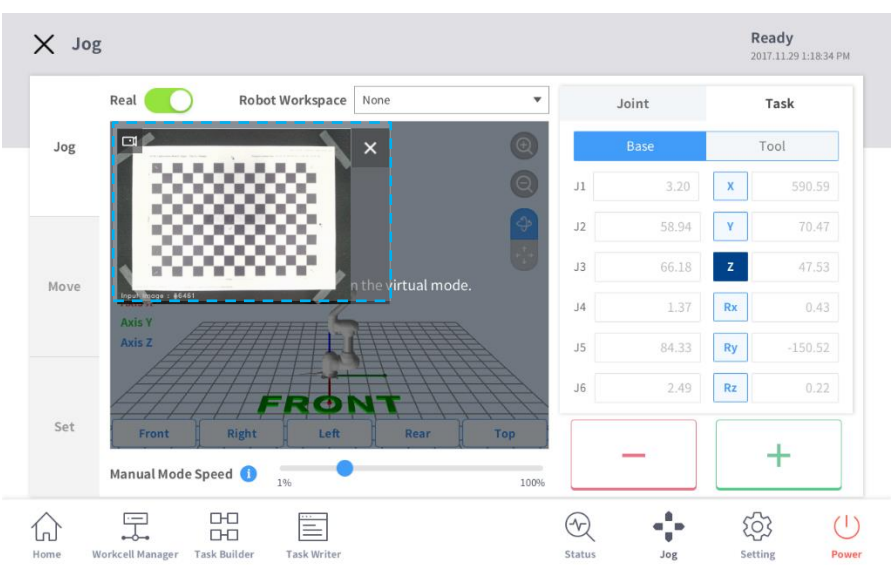
During calibration, it is necessary to align the camera lens and the checkerboard in parallel as much as possible. In addition, when performing calibration, the calibration board must be placed at the surface height of the item to be measured. If the height of the checkerboard during calibration differs from the surface height of the item to be measured, it can cause failure to detect the item or decrease measurement accuracy.

Additional Functions available with the SVM

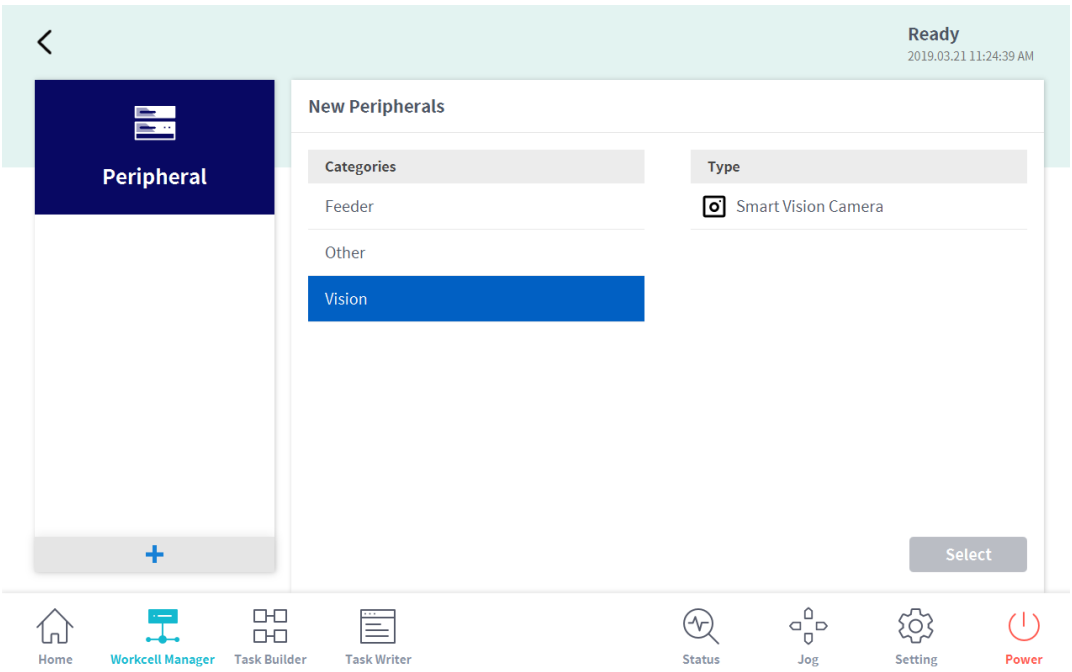
- The Live screen is displayed on the Jog



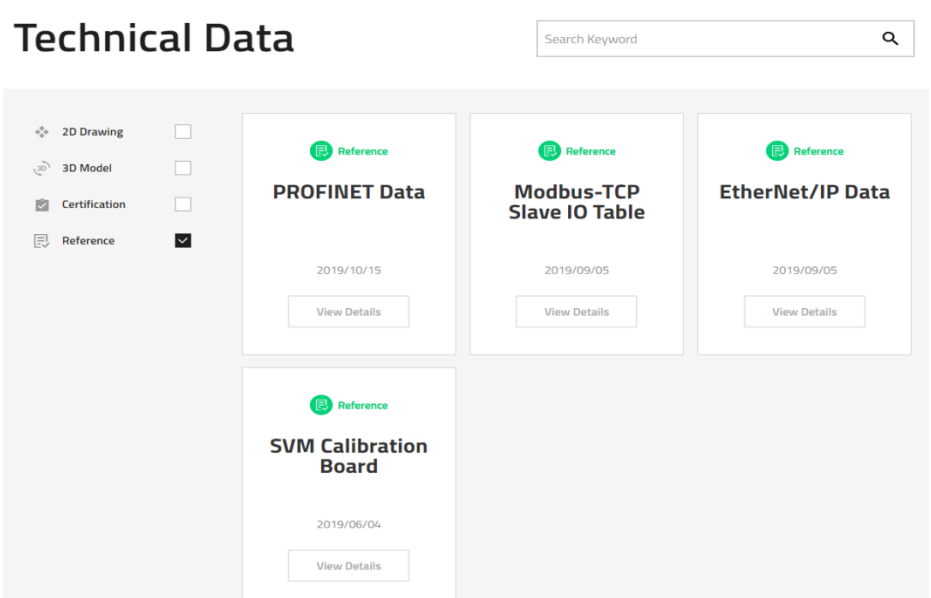
If the Vision license is entered, a live image can be viewed in the Jog tab. The user can operate the robot while viewing the live image.



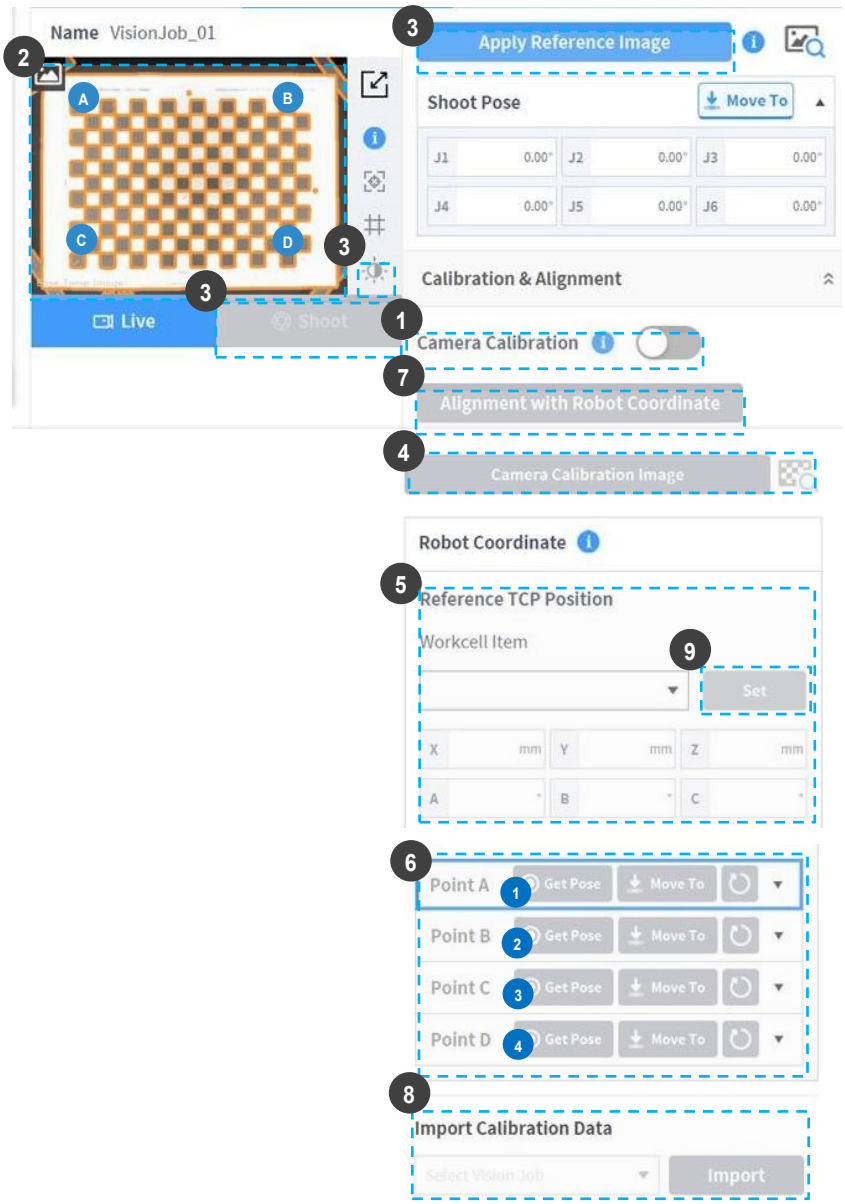
- Added Vision category to Peripheral



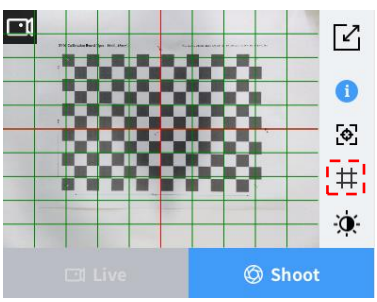
SVM Calibration Board Download

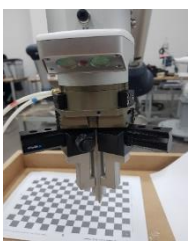


- The SVM Calibration Board can be downloaded from [https://lab.doosanrobotics.com/en/Index Robot LAB – Resources – Tech Data – Reference] after logging in.



No.	Item	Description
1	**Camera Calibration**	Enables Camera - Robot Calibration function. • After the Camera Calibration function is enabled, the Camera Calibration Image button is enabled.

No.	Item	Description
2	**Live/Shoot Image**	The Live/Shoot Image can be checked. To ensure proper camera calibration, a checkerboard is placed as follows: • The calibration image provided by Doosan Robotics is a 15 mm checkerboard. [Download Page] • Place the checkerboard at a distance of 300 mm~600 mm from the SVM. • The checkerboard and the camera must be parallel (less than 1°). • Use the Grid function of the image to position the checkerboard as follows:  • Place the center point where the center arrow “O” is pointing on the red cross at the center of the camera image. • Align the checkerboard vertically and horizontally along the green guide lines to prevent rotation.
3	**Lighting Setting/ Save Shoot Image/ Shoot Pose**	Adjust the focus, brightness and lighting to display the edge of the checkerboard clearly. • Press the Shoot button to check edge information. • Press the Apply Reference Image button to save the camera information and Shoot Pose.
4	**Camera Calibration Image**	Run checkerboard corner point detection. • Press the View Image button to check the detection results. • If detection fails, the checkerboard pattern is not displayed on the View Image button.

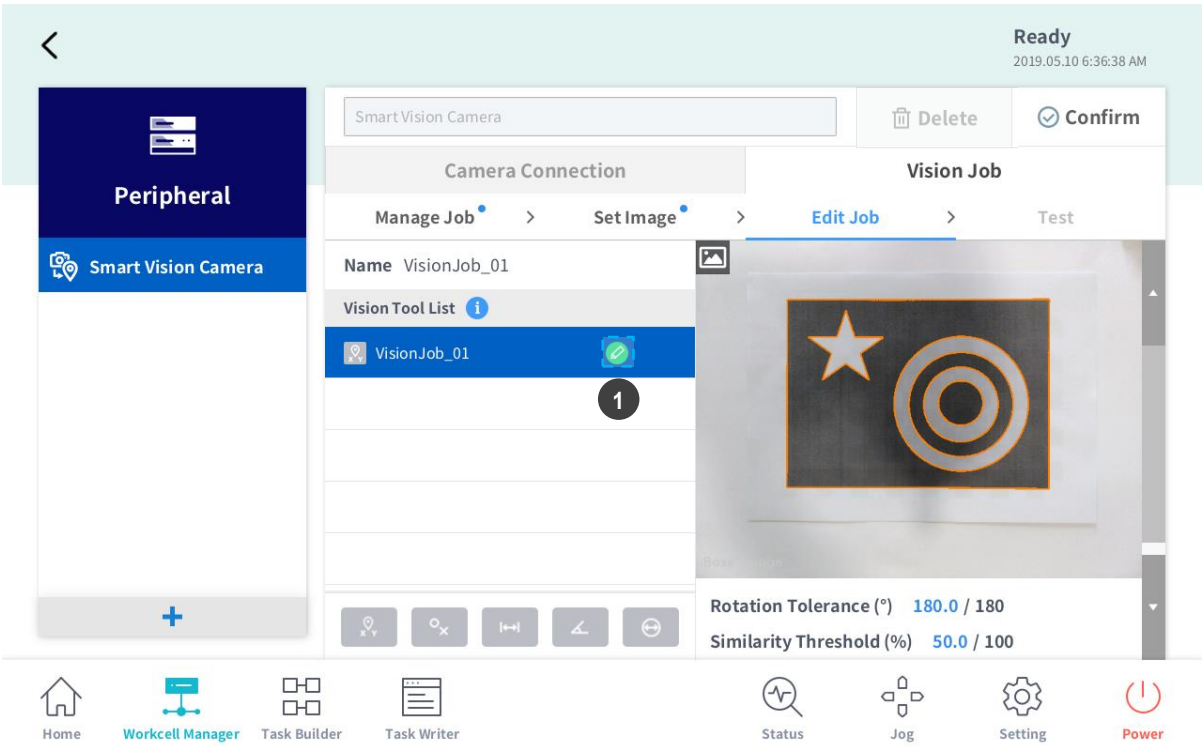
No.	Item	Description
5	**Load TCP Setting**	Sets the information of the Tool currently equipped on the robot as TCP. • A probe type Tool is recommended. If a gripper is used, it is recommended to make measurements with a probe-shaped item grabbed as in the following image: • For information about measuring the tool center position, refer  to the Workcell Manager End Effector Management section of the User Manual.
6	**Obtain PointA - PointD Points**	Obtains the robot pose [x, y, z, rx, ry, rz] of PointA - PointD. • If the base plane of the robot and the workspace are on the same plane, the tool center point of the robot is aligned based on the base axis. Robot poses corresponding to PointA-PointD are acquired with the aligned axis unchanged using plane lock and axis lock of the Constraints Motion button in the robot cockpit. Refer to Robot User Manual - Jog - Setting Screen - Align according to Base Axis for how to align the base axis with the TCP end. If the workspace where the target item located is slanted, unlike the base plane of the robot, align the tool center point according to a virtual vector area. Refer to Robot Manual – Jog – Setting Screen – Align according to Target Point. • Perform direct teaching of corner points on the checkerboard in the order of Ⓐ, Ⓑ, Ⓒ and Ⓓ with the end of the robot tool to enter the coordinates of each point. • Tap the Move To button to move to the corresponding point. • Press the Reset button to reset robot coordinates. • If the end of the tool fails to accurately pinpoint the corner points of the checkerboard, point deviation occurs.

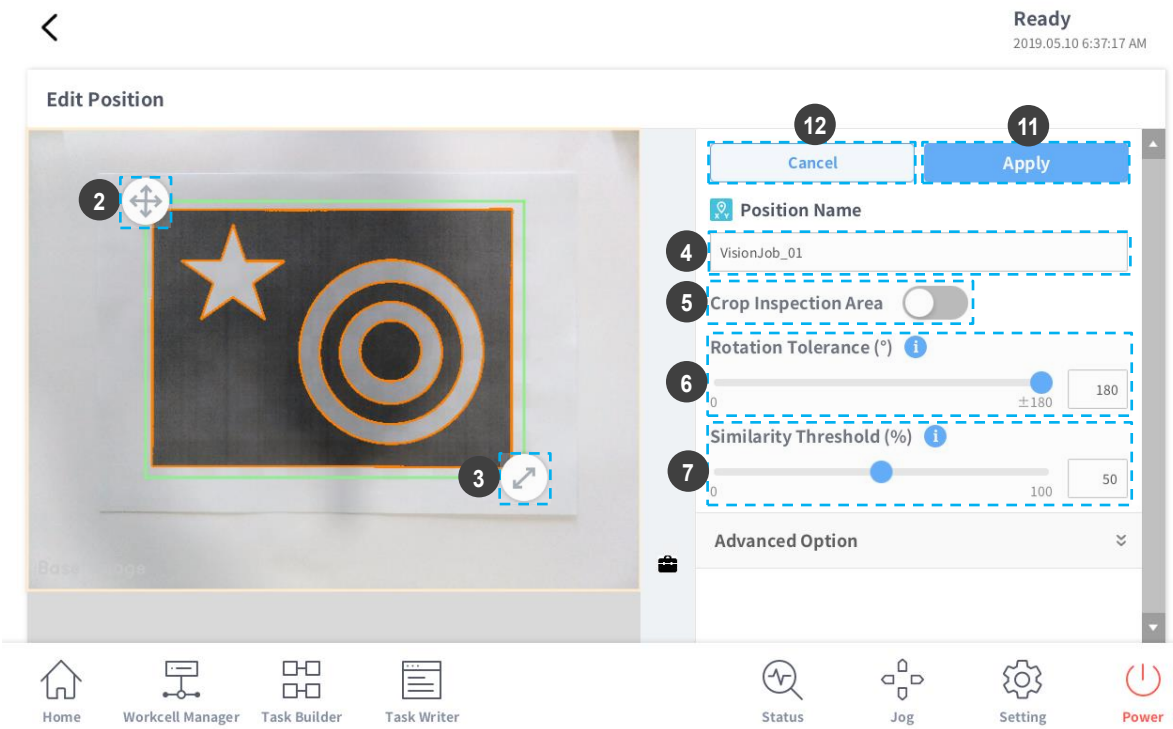
7	**Alignment with Robot Coordinate**	Run the camera - robot coordinate matching calculation. After calculation is completed, the results are displayed. If successful,save the Calibration information in the camera. To save the Calibration information in the UI, press the Confirm button on the top of the Workcell Manager. Success (Success) / Failure (Failure) **Success Criteria** • All grid patterns of the checkerboard must be displayed on the image. • Dark grid patterns of the checkerboard must be positioned on the top/bottom left. • Check whether all corner points are detected using View Image. • TCP information identical to the information of the tool equipped must be set. • Enter corner points of ABCD of the checkerboard with direct teaching to the robot. • Teach the robot tool the exact positions of ABCD corner points of the checkerboard. • The checkerboard position must not change during direct teaching. **Failure Criteria** • If all corner points of the checkerboard are not detected. • If the direct teaching order of ABCD corner points of the checkerboard is incorrect. • If the set TCP information does not match the information of the Tool equipped. • If the direct teaching of corner points of the checkerboard is not accurate. • If the ABCD coordinates measured by the camera are different from the ABCD coordinates taught to the robot by direct teaching (calibration fails if a deviation of more than 5 mm occurs). **Items to Check Upon Failure** • Check the position/direction of the checkerboard. • Check whether edges of the checkerboard are clearly displayed. • Check whether direct teaching was performed in the order of ABCD. • Check whether the TCP setting is correct. • Check whether the checkerboard print was moved after Camera Calibration Image. • Check whether the ABCD corner points of the checkerboard were taught accurately.

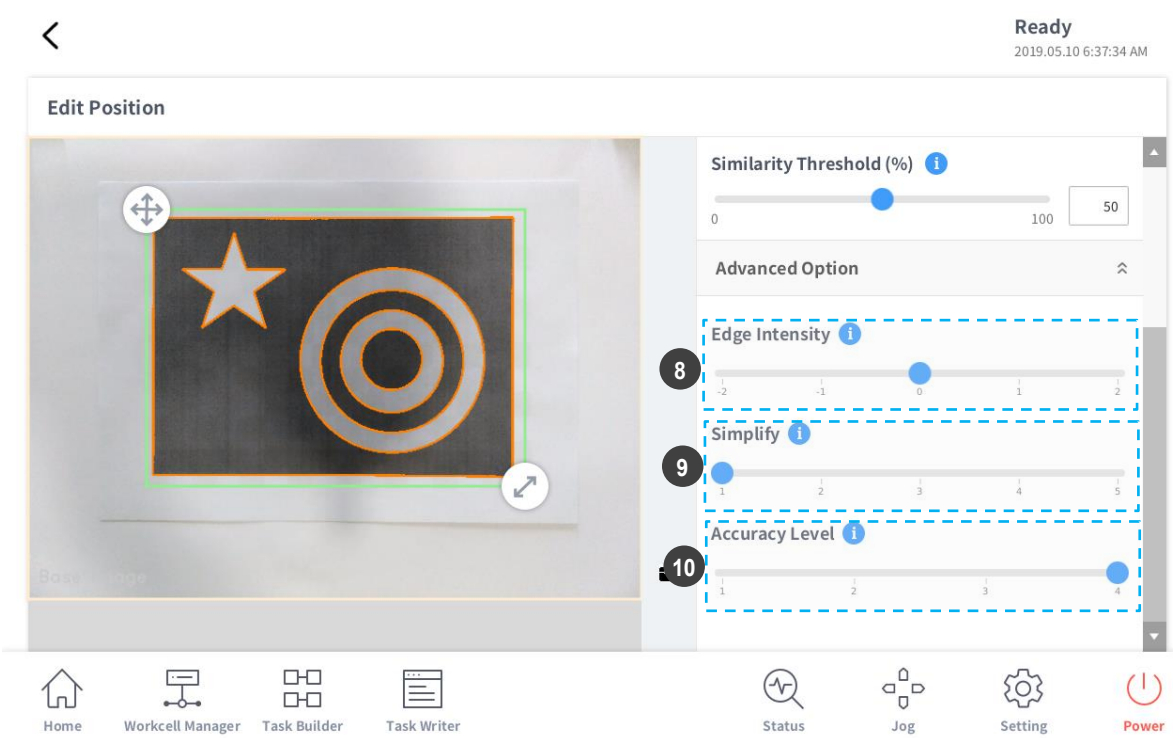
No.	Item	Description
8	**Import Calibration Data**	Imports calibration data that succeeded in existing vision works. • Select a vision work to import the calibration data and press the import button to save the corresponding calibration data.
9	**Set**	Sets the Workcell Item loaded on the left of the Set button to the current tool center point.

2.4 Vision Job > Edit Job

2.4.1 Vision Tool Teaching Area Setting



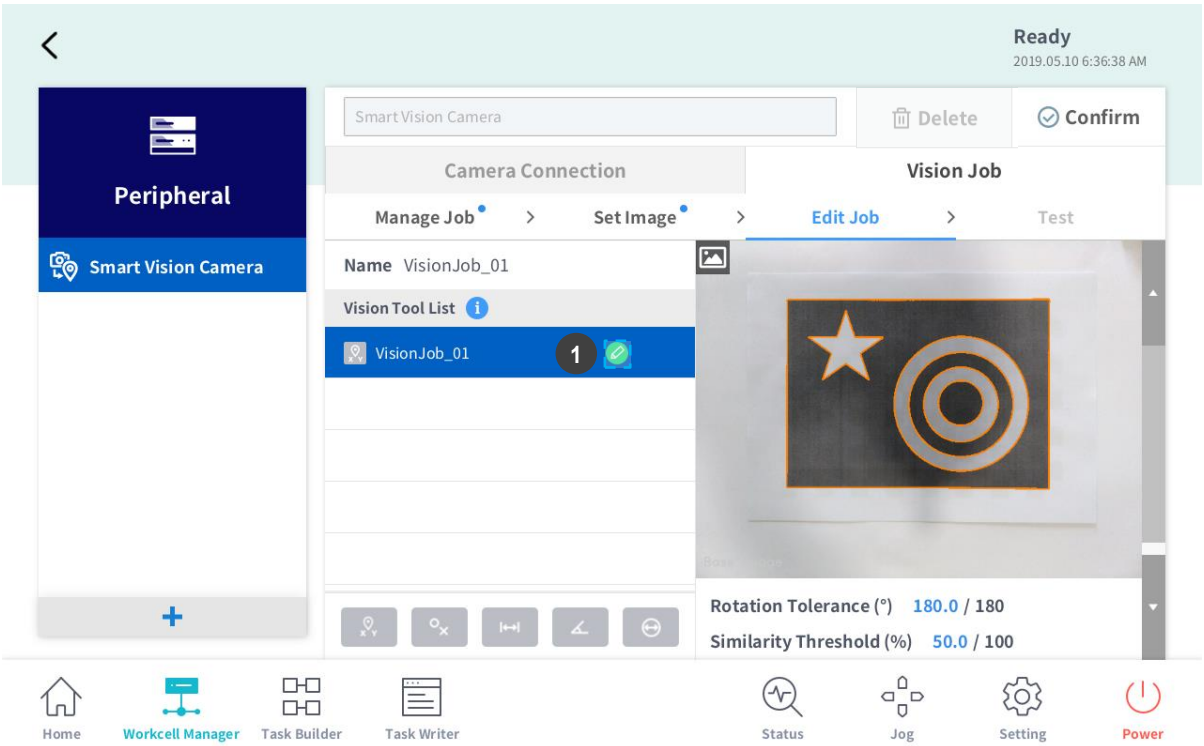

Ready
2019.05.10 6:37:17 AM
Edit Position
12
11
Cancel
Apply
Position Name
2
3
4
VisionJob_01
5
Crop Inspection Area
Rotation Tolerance (°)
6
0
±180
180
Similarity Threshold (%)
7
0
100
50
Advanced Option
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

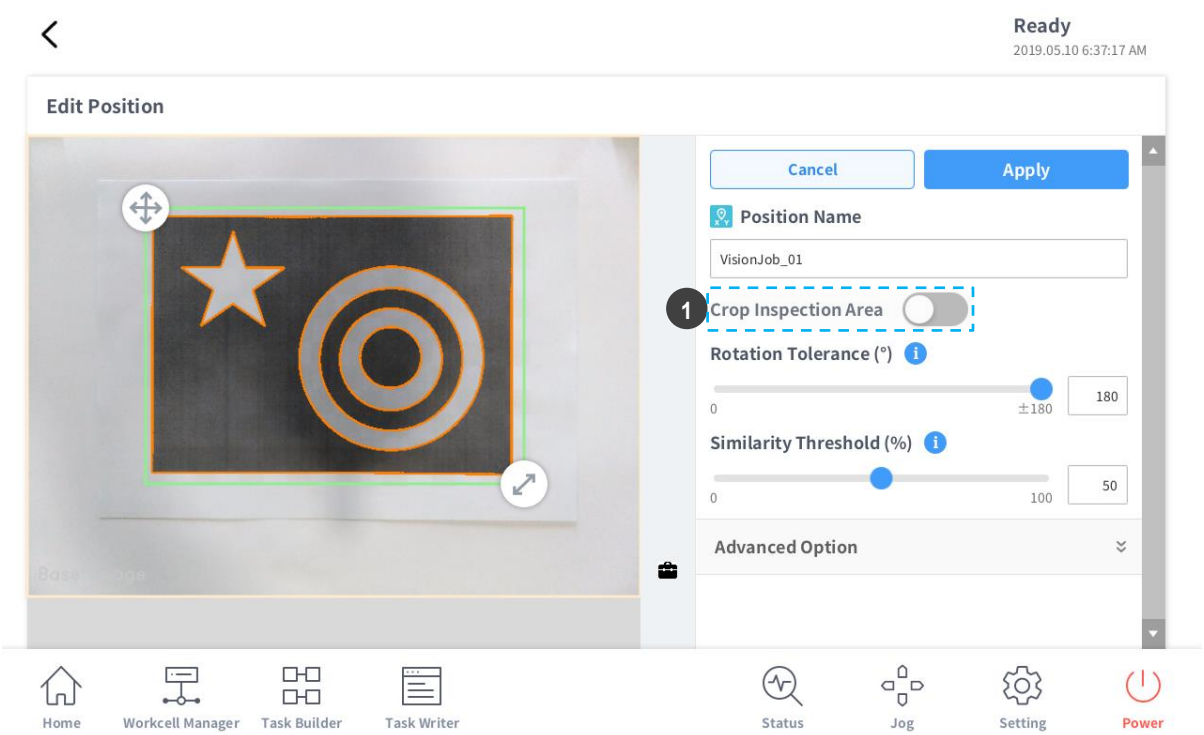

Ready
2019.05.10 6:37:34 AM
Edit Position
Similarity Threshold (%)
0
100
50
Advanced Option
8
Edge Intensity
-2
-1
0
1
2
9
Simplify
1
2
3
4
5
10
Accuracy Level
1
2
3
4
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

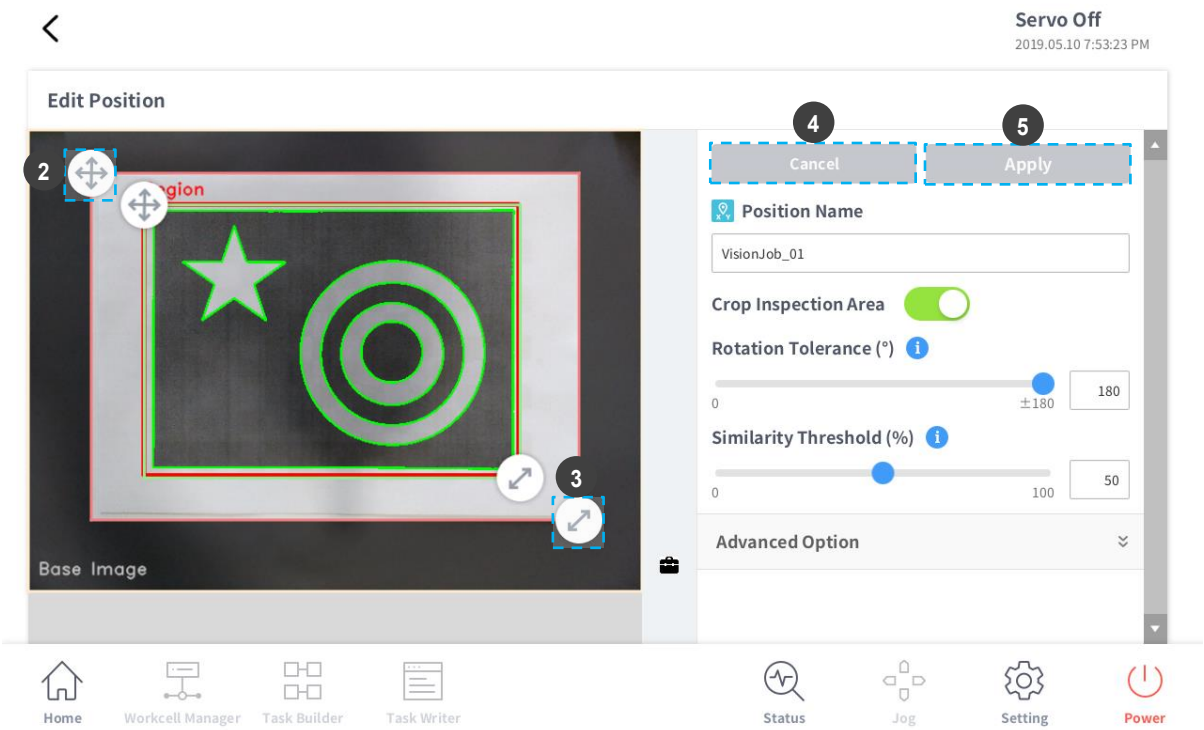
No.	Item	Description
1	**Edit**	The settings popup window for the job selected from the Vision Tool List is displayed.
2	**Move Teaching Area (green area)**	Press and hold the arrow to move the teaching area. • Press the Apply button to set the selected area.
3	**Adjust Teaching Area Size (green area)**	Press and hold the arrow to adjust the teaching area size. • Press the Apply button to set the selected area.
4	**Edit Job Name**	A virtual keyboard is displayed, and the job name can be edited. • Press the Apply button to apply the name to the camera.
5	**Crop Inspection Area**	A window limiting the teaching area is displayed. The set area is... • saved to the camera when the Apply button is pressed.
6	**Rotation Tolerance**	Configures the angle tolerance from the reference angle. (input range: 0~180°) • Sets the acceptance range for items rotated at an angle deviating from the Reference Image. • For example, if the Rotation Tolerance is 180 (-180~+180), it detects items in all rotation angle ranges, and if the Angle Tolerance is 10 (-10~+10), it only detects items rotated within 10˚ from the Reference Image. Setting a larger Angle Tolerance value increases detection speed, and a smaller value decreases detection speed. • The tolerance is immediately applied when the scroll is moved.
7	**Similarity Threshold**	Configures the similarity threshold from the reference value. (0~100%) • Similarity is the level of matching between the edge of the item image and the edge in the Reference Image. • The similarity of the item to detect can be set by adjusting the Similarity Threshold. • For example, if the Similarity Threshold is 50, the system only detects items matching a Reference Image of 50% or more. • Higher Similarity Threshold values increase the level of distinguishing similar items, but fail to measure items if there are items with small changes, camera distortions or light reflection changes. • Lower Similarity Threshold values allow flexibility in responding to item/environment changes, but this can cause incorrect measurements of similar items within the measurement area. • Setting a proper Similarity Threshold to match the measuring item/environment is crucial to the success of the Vision Job. • The tolerance is immediately applied when the scroll is moved.
8	**Edge Intensity**	Sets the intensity of edges detected. • Larger color differences in the area surrounding the edge result in higher edge intensity, and smaller color differences result in lower edge intensity.

No.	Item	Description
		• If the intensity is set as [+2] from the default [0], only edges with high intensity appear, and edges with low intensity are removed. Setting [-2] will display edges with both high and low intensities. • The tolerance is immediately applied when the scroll is moved.
9	**Simplify**	Clean up edges by simplifying them. • Small, noise-like edges among measured edges disturb the teaching of shapes. Changing the value from 1 to 5 will remove small edges. • Larger values remove smaller edges and improve calculation speed. • The tolerance is immediately applied when the scroll is moved.
10	**Accuracy Level**	Adjust the Accuracy Level if you want to detect items more accurately or faster. • Larger values improve shape detection accuracy. • Smaller values improve detection speed, but decrease shape detection accuracy. • The tolerance is immediately applied when the scroll is moved.
11	**Apply**	Applies Vision Job settings.
12	**Cancel**	Cancels Vision Job settings.

2.4.2 Vision Tool Teaching Limit Area Setting



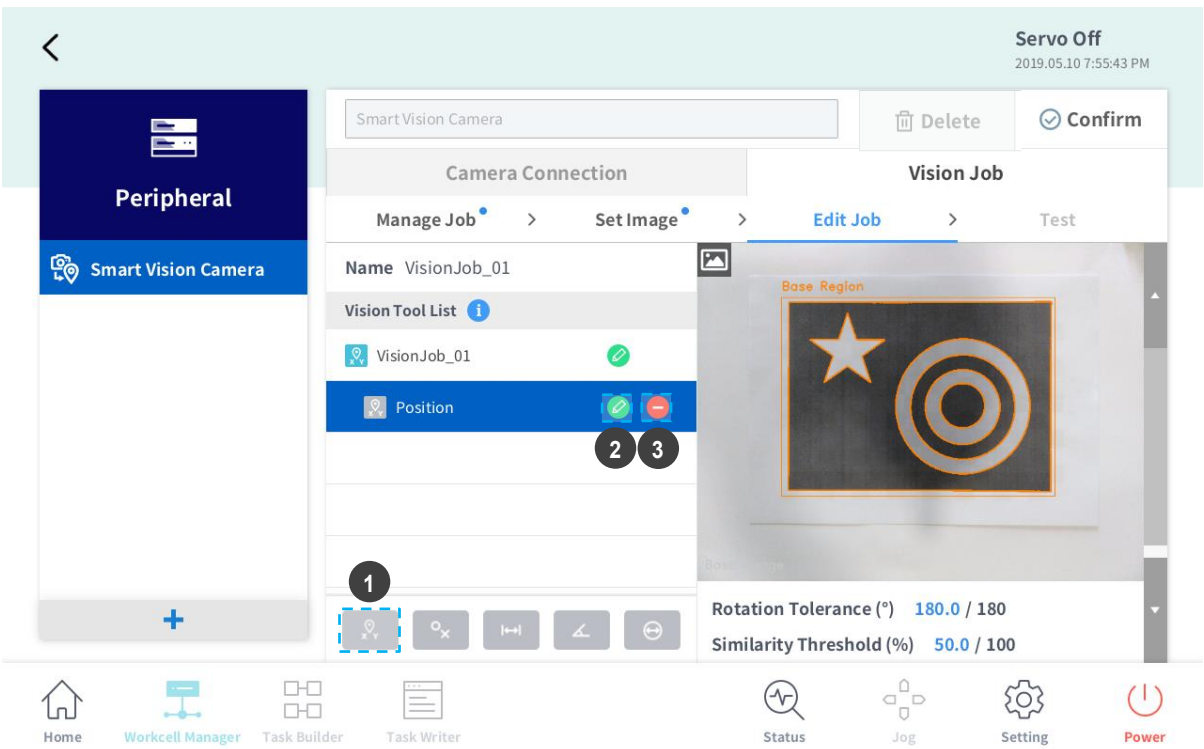


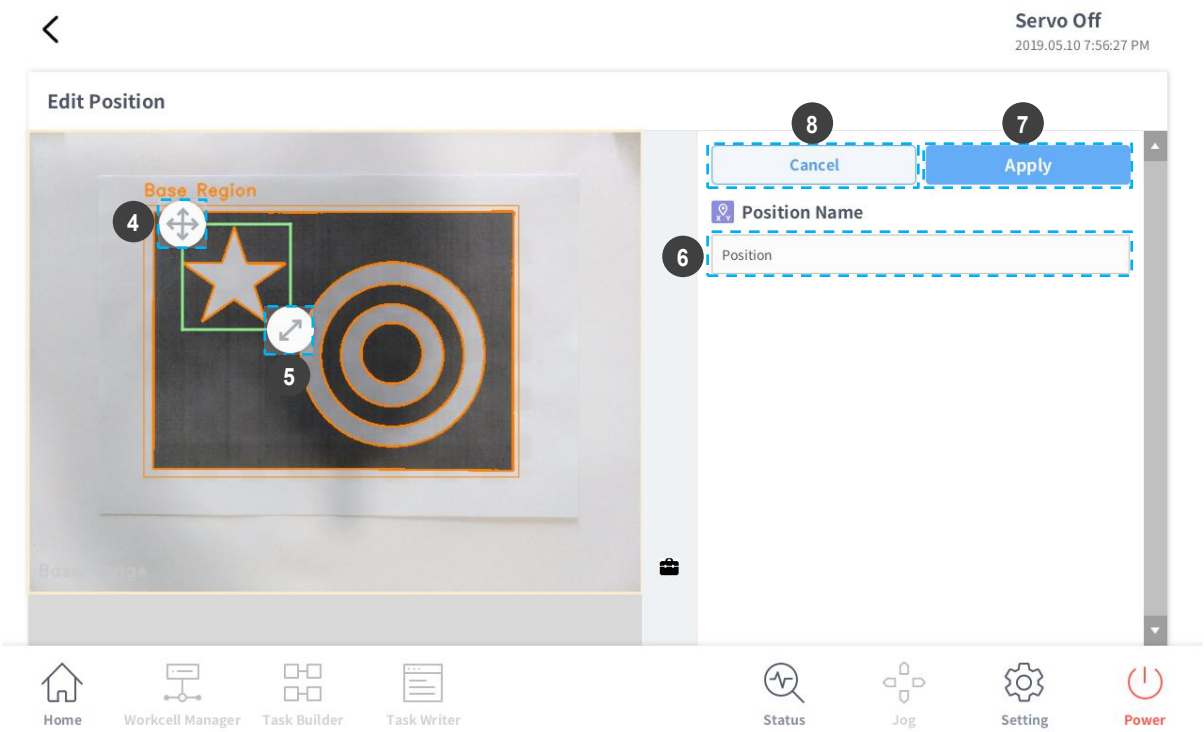


No.	Item	Description
1	**Crop Inspection Area**	Displays an area setting tool that limits the teaching area. • The set area is saved by pressing the Apply button.
2	**Move the Teaching Limit Area (red area)**	Press and hold the arrow to move the area. • The set area is saved by pressing the Apply button.
3	**Adjust the Teaching Limit Area (red area)**	Press and hold the arrow to adjust the size of the area. • The set area is saved by pressing the Apply button.
-	**Scale/Move**	Press the briefcase icon to display the Scale/Move selection window. • Fine adjustments to the Teaching Area position of the image can be made with Move. • Fine adjustments to the Teaching Area size of the image can be made with Scale. • UP/DOWN Scale buttons and UP/DOWN Move buttons are displayed. • Select A: Selects the Teaching Area setting. • Select B: Selects the Teaching Limit Area setting.
4	**Apply**	Applies Vision Job settings.
5	**Cancel**	This clears Vision Job settings.

2.4.3 Create Position Tool and Set Teaching Area

The Position Tool is used for measuring the position and angle of an object (shape). Teach the item (shape) area to measure from the Reference Image, and set related parameters. The Position Tool measures the amount of rotation (angle) from the center point of the teaching area and the teaching area.

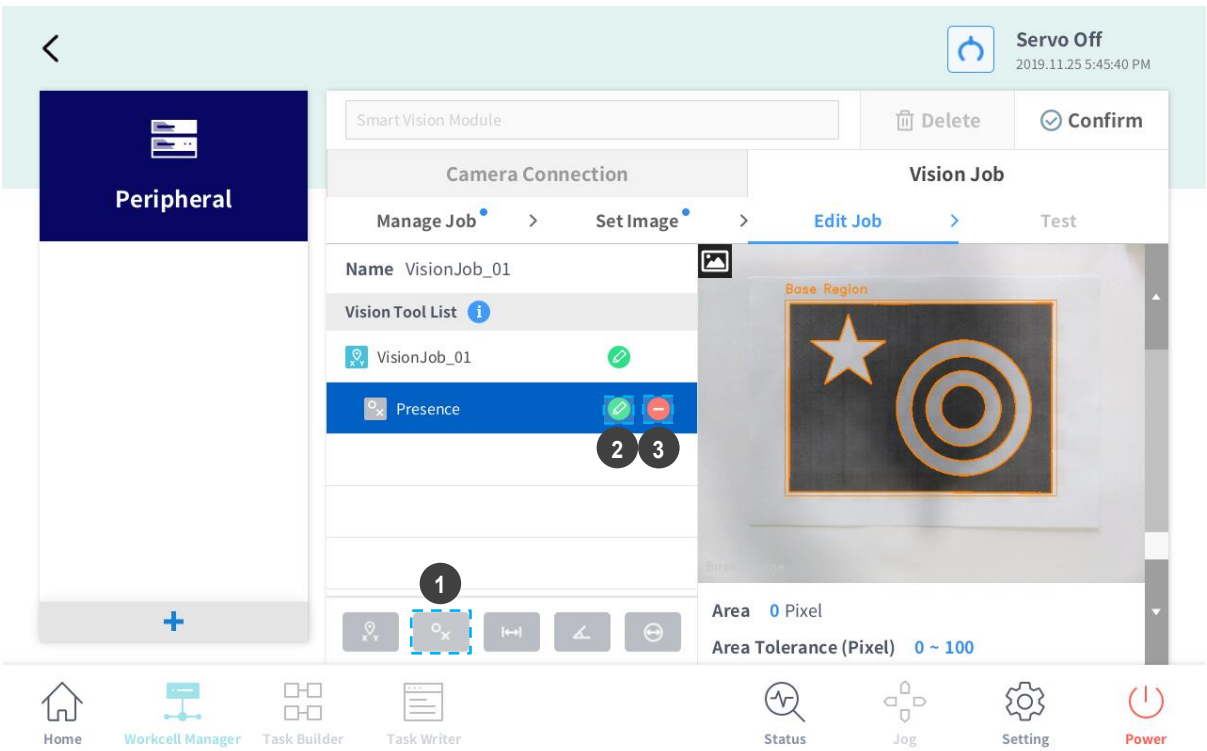


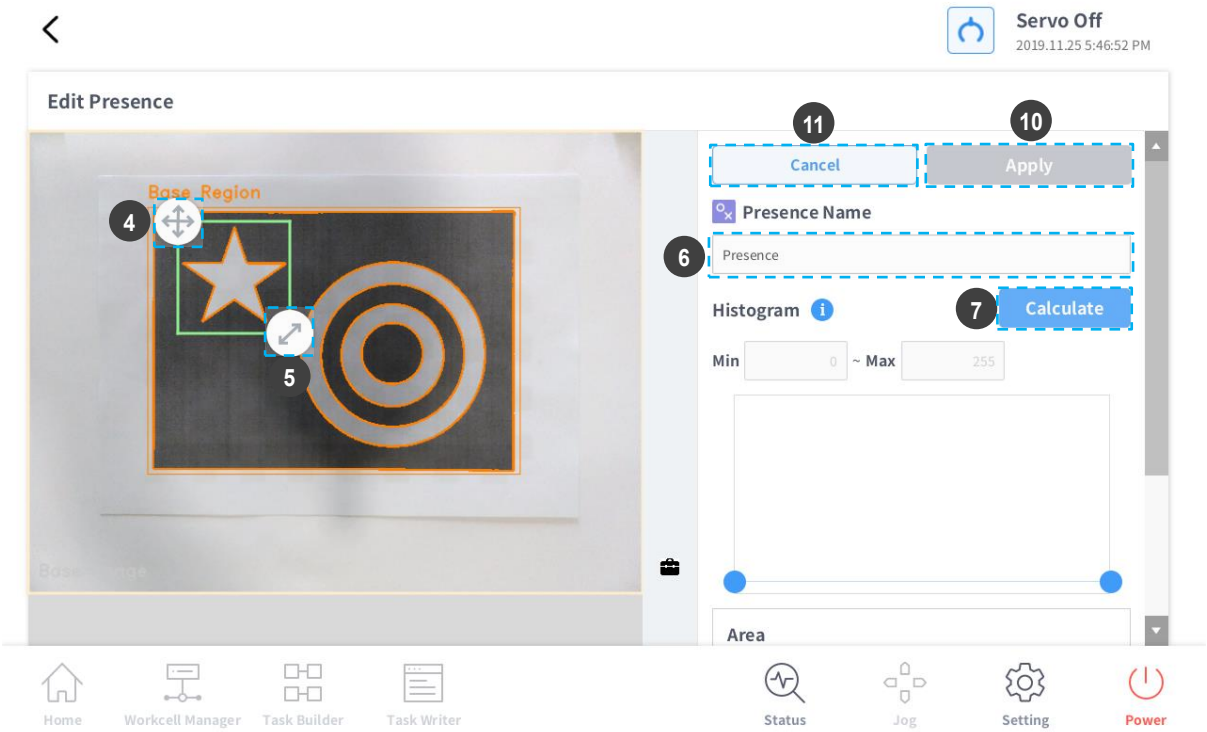


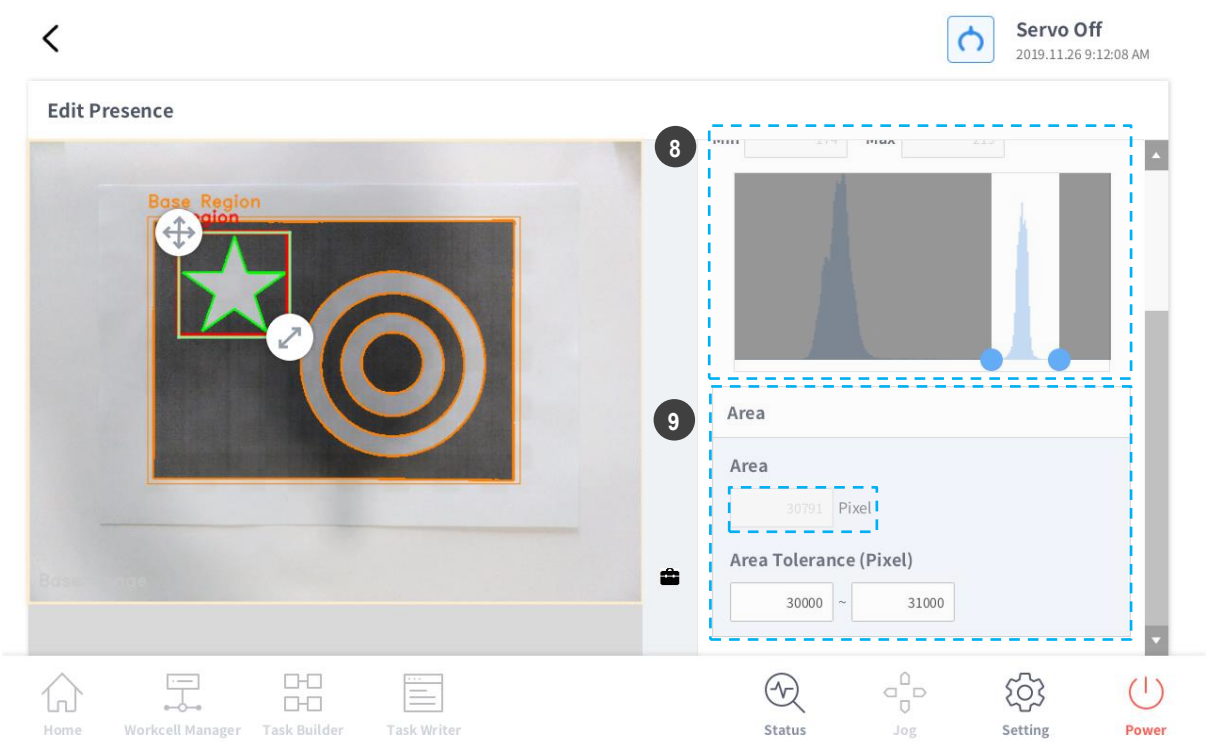
No.	Item	Description
1	**Add Position Tool**	Adds a Position Tool to the Vision Tool List.
2	**Edit**	A setting window of the job selected from the Vision Tool List is displayed.
3	**Delete**	The selected job from the Vision Job List is deleted.
4	**Move Teaching Area**	Press and hold the arrow to move the teaching area. • The set area is saved by pressing the Apply button.
5	**Adjust Teaching Area Size**	Press and hold the arrow to adjust the teaching area size. • The set area is saved by pressing the Apply button.
6	**Edit Job Name – Edit Window**	A virtual keyboard is displayed, and the job name can be edited. • Press the Apply button to apply the setting.
7	**Apply**	Applies Vision Job settings.
8	**Cancel**	Cancels Vision Job Tool settings.

2.4.4 Create Presence Tool and Set Teaching Area

The Presence Tool checks the histogram of shapes. The histogram of brightness (level 1-256) of each pixel in the teaching area is calculated (frequency table) to be used as default information for the presence check. Set the brightness range corresponding to the shape to check and press the Calculate button to measure the area of the shape (Pixel Count) by detecting pixels corresponding to the set brightness range. Adjust the acceptance range (Tolerance) of the check based on measured area values to set the presence check.



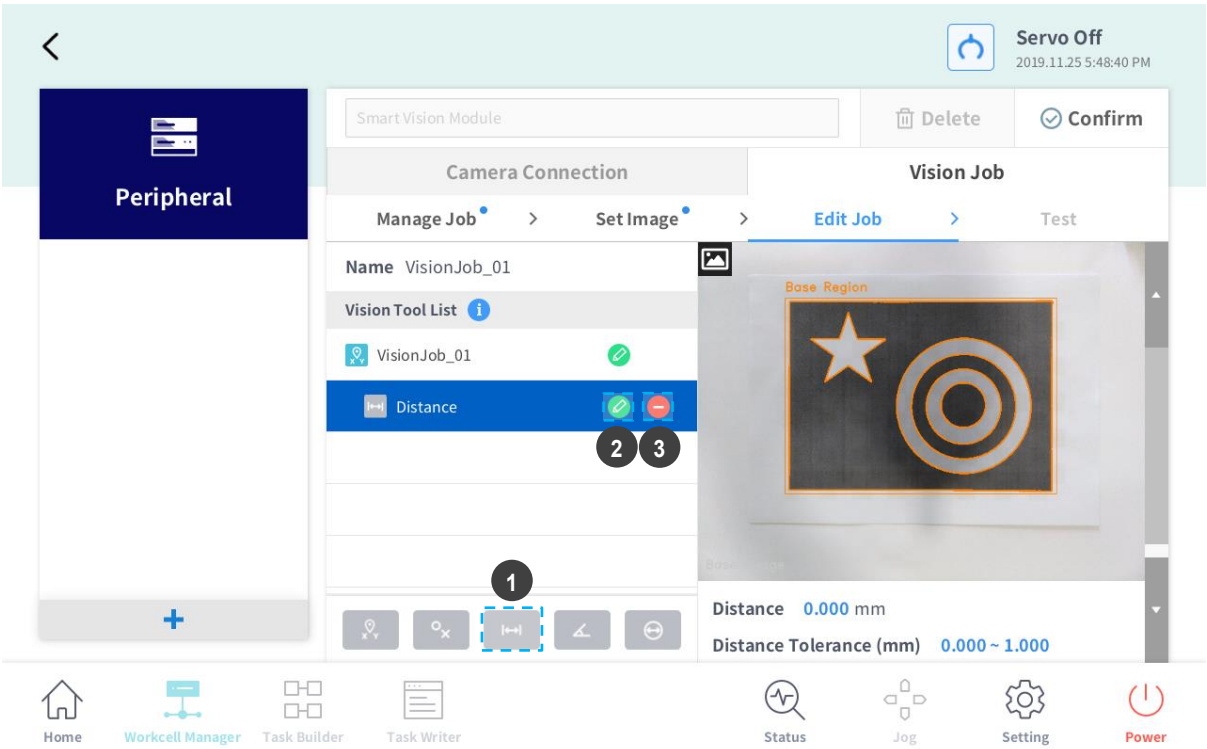

Servo Off
2019.11.25 5:46:52 PM
Edit Presence
11
10
Cancel
Apply
Base Region
4
Presence Name
6
Presence
Histogram
7
Calculate
Min
0
~ Max
255
5
Area
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

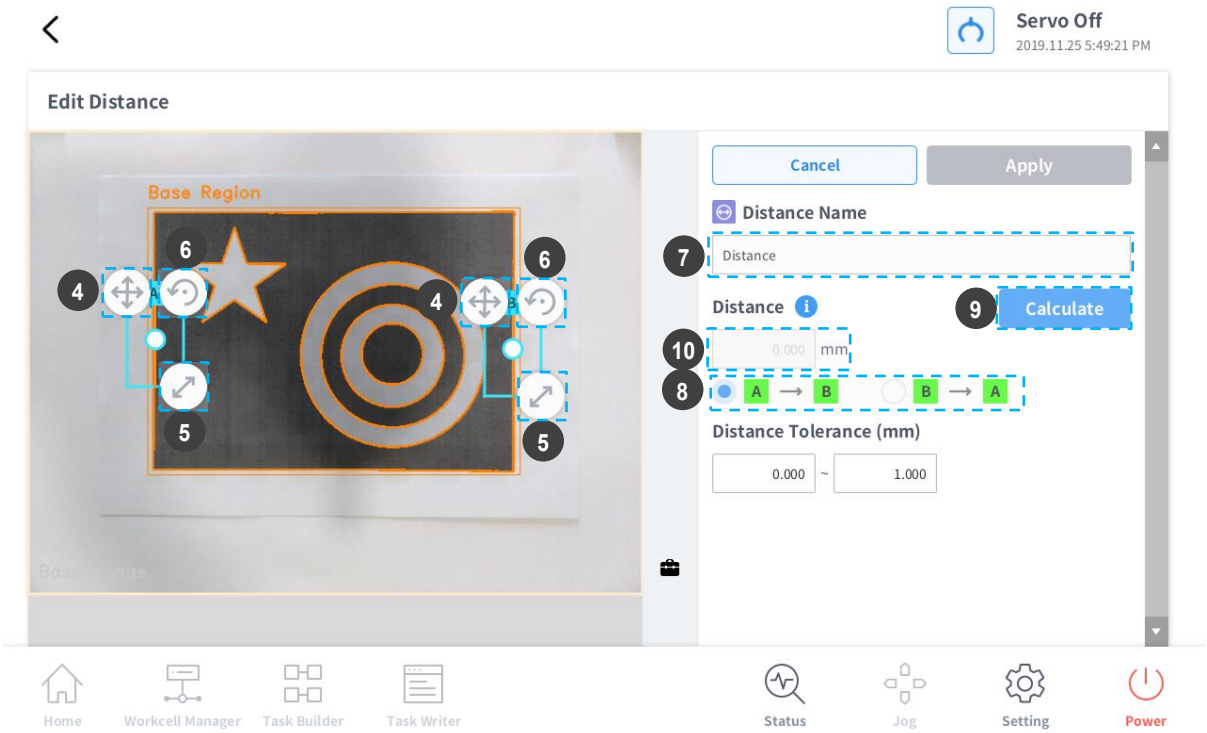

Servo Off
2019.11.26 9:12:08 AM
Edit Presence
8
Base Region
9
Area
Area
30791
Pixel
Area Tolerance (Pixel)
30000
~
31000
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

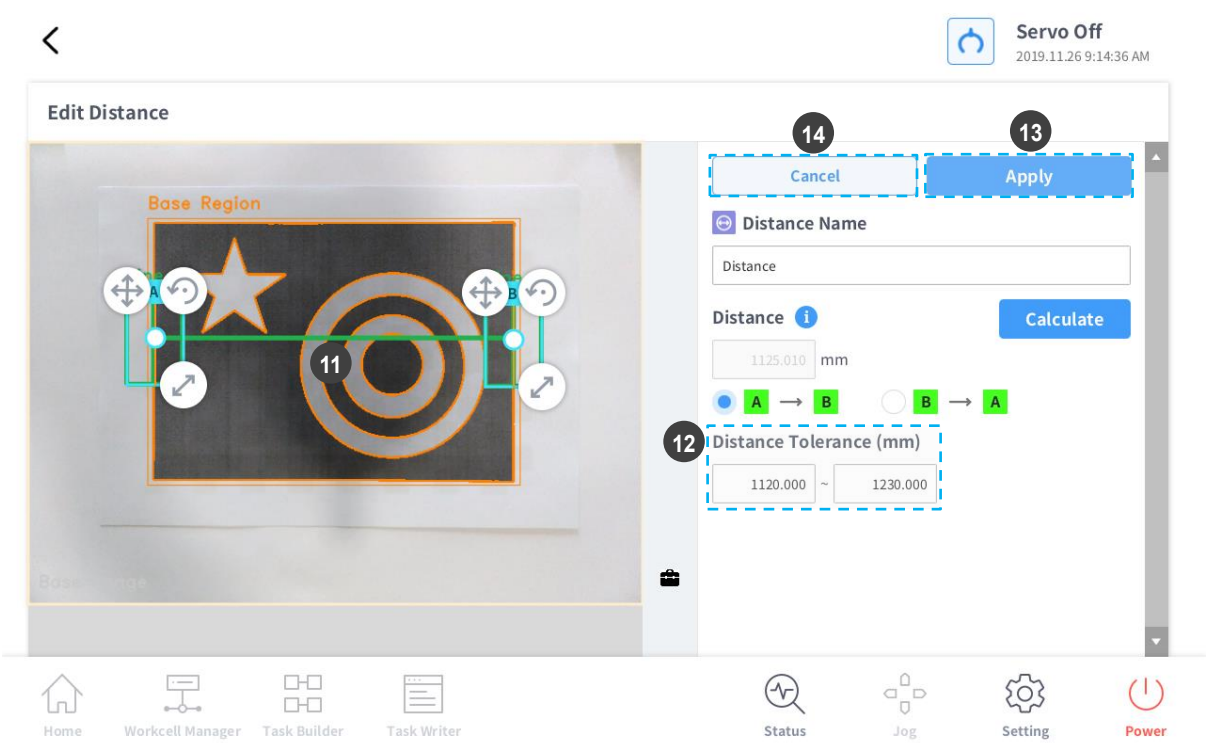
No.	Item	Description
1	**Add Presence Tool**	Adds a Presence Tool to the Vision Tool List.
2	**Edit**	A setting window of the job selected from the Vision Tool List is displayed.
3	**Delete**	The selected job from the Vision Job List is deleted.
4	**Move Teaching Area**	Press and hold the arrow to move the teaching area.
5	**Adjust Teaching Area Size**	Press and hold the arrow to adjust the teaching area size.
6	**Edit Job Name – Edit Window**	A virtual keyboard is displayed, and the job name can be edited. • Press the Apply button to apply the setting.
7	**Calculate**	Checks the histogram distribution of edges within the Presence Tool teaching area.
8	**Histogram Min/Max Setting**	Slide the horizontal Histogram Min/Max bar to adjust the detection level of desired edges. • Presence check uses histogram check. A histogram is list of the distribution of brightness of pixels within a measurement area from 0 to 255. If the measurement area is completely white, the brighter area (255) value in the histogram becomes larger, and if the measurement area is completely black, the darker area (0) value becomes larger. • You can adjust the range of pixels to the desired brightness using the blue button. If the button reaches the end points (0, 255), it obtains all pixel values within the measurement area. • For example, positioning the blue button between 1 and 2 will only obtain pixels with brightness corresponding to 1 and 2. • The tolerance is immediately applied when the button is pressed.
9	**Area Tolerance Limit Setting**	Enter the pixel value allowed within the detected area in the edit window. Values exceeding the value range entered are not detected. • Area displays the number of pixels corresponding to the brightness value set using the blue button (0-255). • If the value exceeds the Area Tolerance range, it is considered that the histogram is not similar, and the measurement fails. If a value exceeds the Test tolerance range, the inspection result outputs 0. • Press the Apply button to apply the setting.
10	**Apply**	Applies Vision Job settings.
11	**Cancel**	Cancels Vision Job Tool settings.

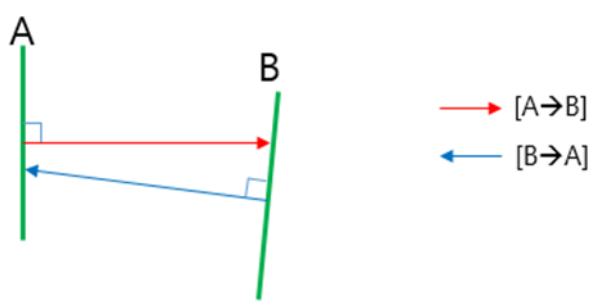
2.4.5 Create Distance Tool and Set Teaching Area

The Distance Tool measures the distance between two lines. Place areas A and B on a line you want to measure and press the Calculate button to measure the distance between A and B. Adjust the acceptance range (Tolerance) of the check based on measured distance values to set the distance check. [A→B] measurement refers to the length of the line connecting the center of line A to line B or an extension line of line B.




Servo Off
2019.11.25 5:49:21 PM
Edit Distance
Base Region
Cancel
Apply
Distance Name
Distance
Distance
Calculate
0.000
mm
A → B
B → A
Distance Tolerance (mm)
0.000
~
1.000
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power


Servo Off
2019.11.26 9:14:36 AM
Edit Distance
Base Region
Cancel
Apply
Distance Name
Distance
Distance
Calculate
1125.010
mm
A → B
B → A
Distance Tolerance (mm)
1120.000
~
1230.000
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

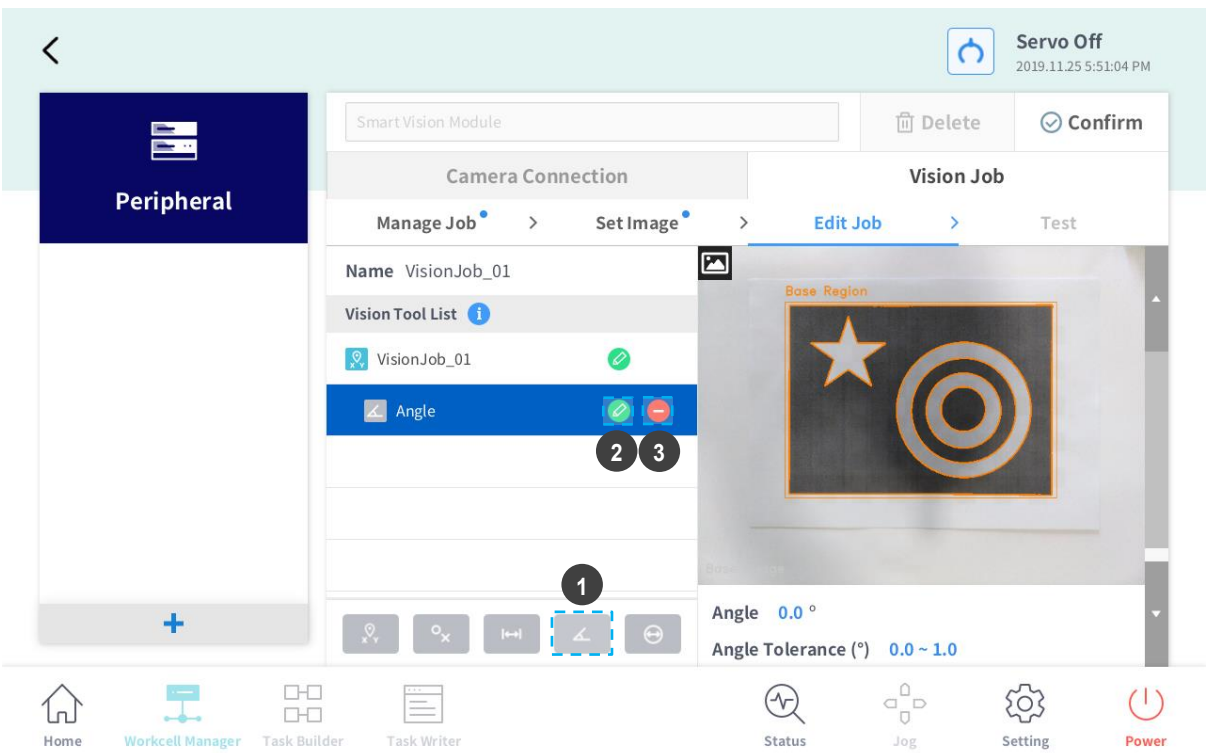
No.	Item	Description
1	**Add Distance Tool**	Adds a Distance Tool to the Vision Tool List.
2	**Edit**	A setting window of the job selected from the Vision Tool List is displayed.
3	**Delete**	The selected job from the Vision Job List is deleted.
4	**Move Teaching Area**	Press and hold the arrow to move the teaching area.
5	**Adjust Teaching Area Size**	Press and hold the arrow to adjust the teaching area size. • Adjust the area to allow one edge to be captured in it.
6	**Adjust Teaching Area Size (circular arrow)**	Press and hold the arrow to rotate the teaching area.
7	**Edit Job Name**	A virtual keyboard is displayed, and the job name can be edited. Press the Apply button to apply the setting.
8	**Select Directions of Line (A, B)**	Select the directions for A > B and B >A. • The direction is immediately applied when the button is pressed. • [A→B] measurement refers to the length of the line connecting the center of line A to line B or an extension line of line B. 
9	**Calculate**	Creates a line that connects the center position of lines A and B when lines exist in the two teaching areas (A, B). The direction is immediately applied when the button is pressed.
10	**Distance Display**	Enter the pixel value allowed within the detected area in the edit window. Values exceeding the value range entered are not detected.
11	**Distance Image Display**	Displays the distance between lines detected in two teaching areas in the edit window.
12	**Distance Tolerance Setting**	Sets the line tolerance from the reference line value. • If a value exceeds the Test tolerance range, the inspection result outputs 0. Press the Apply button to apply the setting..

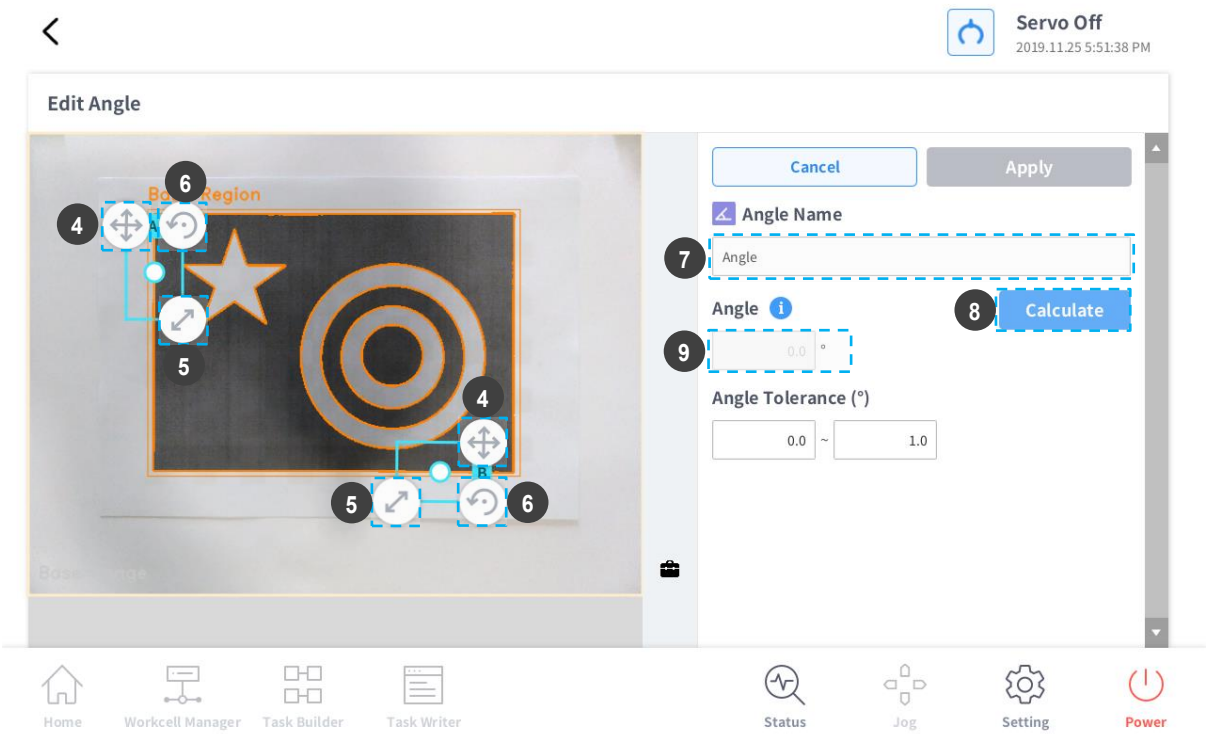
No.	Item	Description
13	Apply	• Applies Vision Job settings.
14	Cancel	Cancels Vision Job Tool settings.

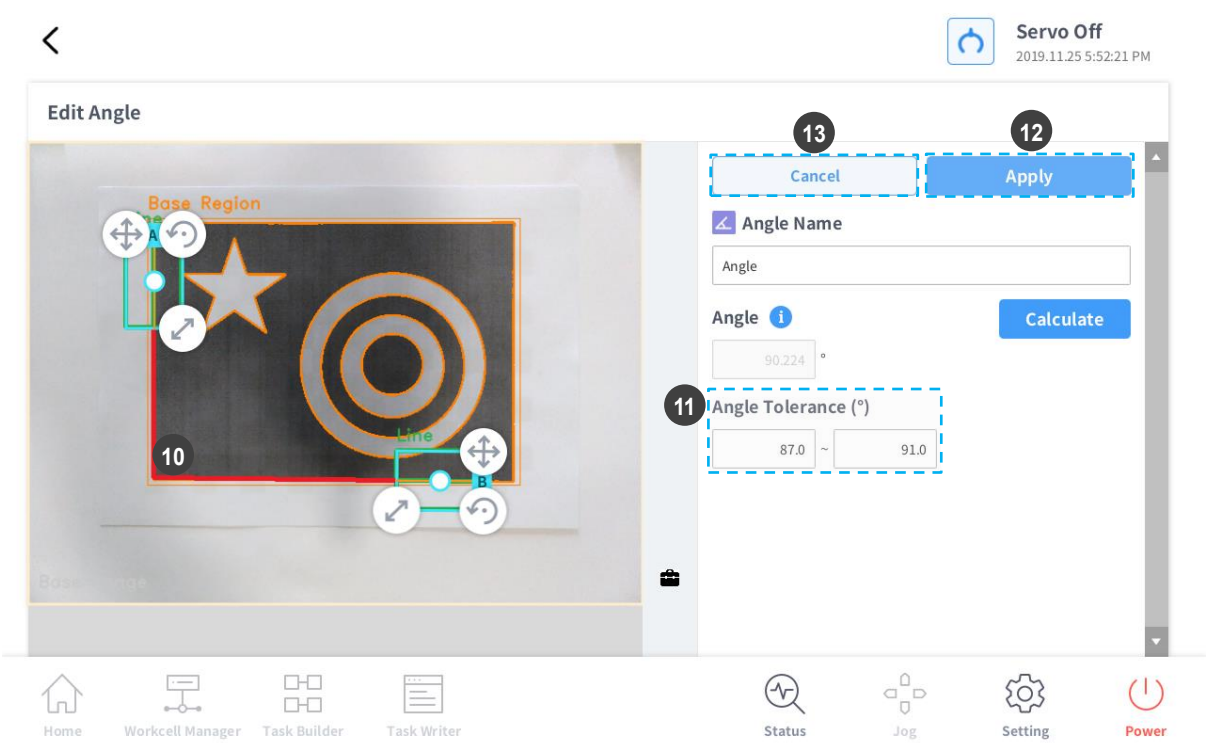
The center of Line A and Line B refers to the detected line center rather the guideline of the teaching area box.

2.4.6 Create Angle Tool and Set Teaching Area

The Angle Tool measures the angle between two lines. Place areas A and B on a line you want to measure and press the Calculate button to measure the angle between A and B. Adjust the acceptance range (Tolerance) of the check based on measured angle values to set the angle check.




Servo Off
2019.11.25 5:51:38 PM
Edit Angle
Cancel
Apply
Angle Name
Angle
Angle
Calculate
0.0
Angle Tolerance (°)
0.0
1.0
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

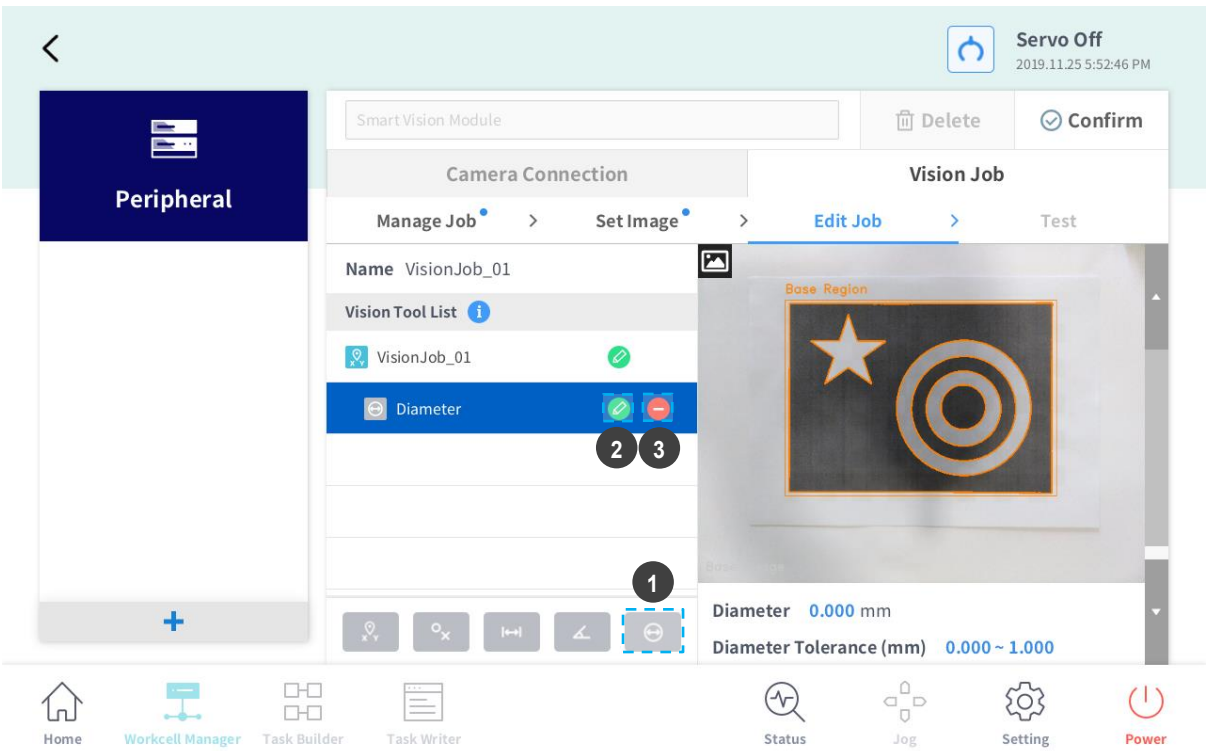

Servo Off
2019.11.25 5:52:21 PM
Edit Angle
Cancel
Apply
Base Region
Angle Name
Angle
Angle
Calculate
90.224
Angle Tolerance (°)
87.0
91.0
Line
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

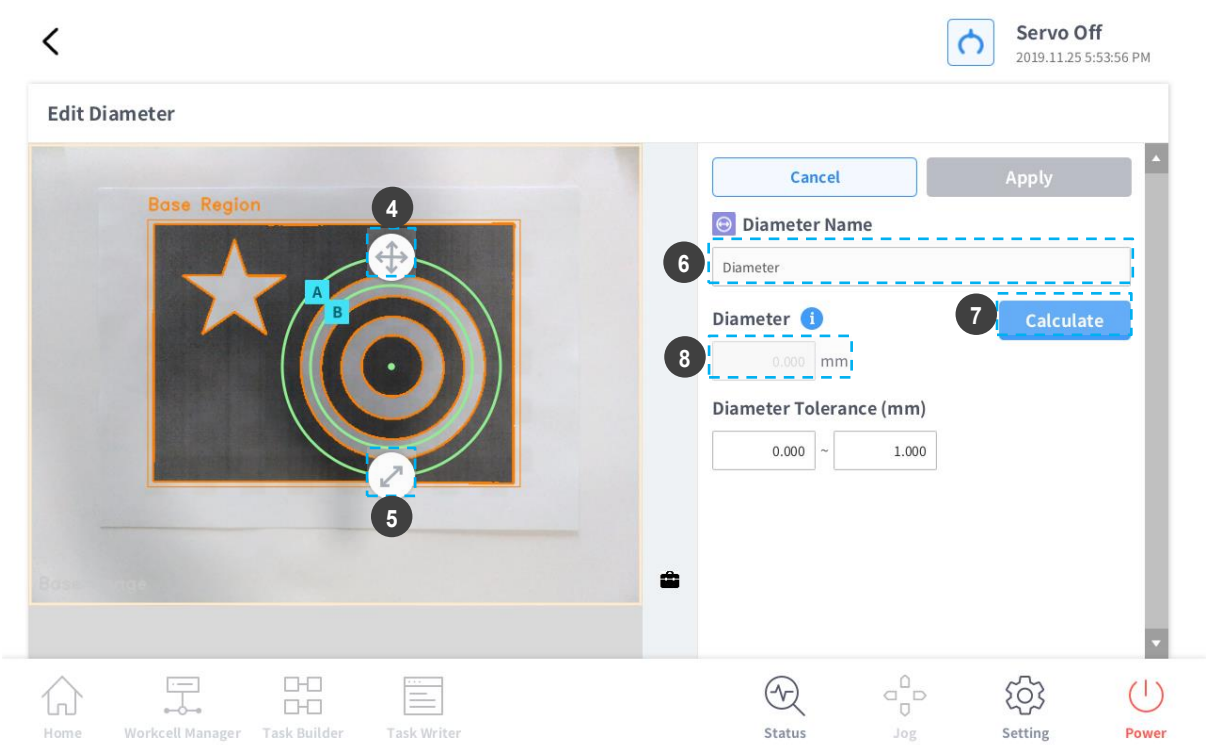
No.	Item	Description
1	**Add Angle Tool**	Adds an Angle Tool to the Vision Tool List.
2	**Edit**	A setting window of the job selected from the Vision Tool List is displayed.
3	**Delete**	The selected job from the Vision Job List is deleted.
4	**Move Teaching Area**	Press and hold the arrow to move the teaching area.
5	**Adjust Teaching Area Size**	Press and hold the arrow to adjust the teaching area size. • Adjust the area to allow one edge to be captured in it.
6	**Adjust Teaching Area Size (circular arrow)**	Press and hold the arrow to rotate the teaching area.
7	**Edit Job Name – Edit Window**	A virtual keyboard is displayed, and the job name can be edited. • Press the Apply button to apply the setting.
8	**Calculate**	Measures the angle at which the extension lines of each line meet when lines exist in the two teaching areas (A, B).
9	**Angle Display**	Displays the angle between lines detected in two teaching areas in the edit window.
10	**Angle Image Display**	Displays the angle between lines detected in two teaching areas on the image.
11	**Angle Tolerance Setting**	Configures the angle tolerance from the reference angle. • If a value exceeds the Test tolerance range, the inspection result outputs 0. • Press the Apply button to apply the setting.
12	**Apply**	Applies Vision Job settings.
13	**Cancel**	Cancels Vision Job Tool settings.

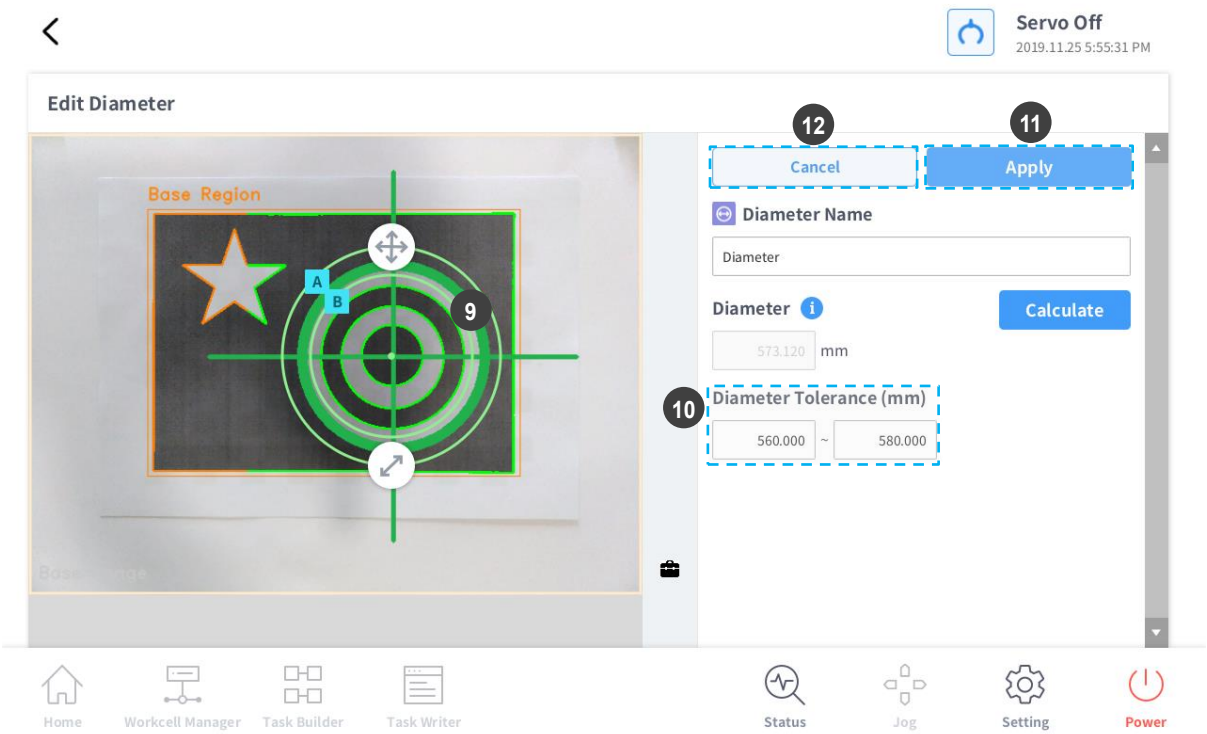
⚠ **The center of Line A and Line B refers to the detected line center rather the guideline of the teaching area box.**

2.4.7 Create Diameter Tool and Set Teaching Area

The Diameter Tool measures the diameter and the center point position of the measured circle. Align the circle center with the center of the circular item, position circle A outside the circular item to be measured, and position circle B inside the circular item. Press Calculate to measure the circle, and the diameter and center point of the circle are displayed. Adjust the acceptance range (Tolerance) of the check based on measured diameter values to set the diameter check.

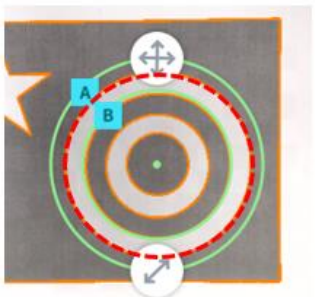

Servo Off
2019.11.25 5:52:46 PM
Peripheral
Smart Vision Module
Delete
Confirm
Camera Connection
Vision Job
Manage Job
Set Image
Edit Job
Test
Name VisionJob_01
Vision Tool List
VisionJob_01
Diameter
Base Region
Diameter 0.000 mm
Diameter Tolerance (mm) 0.000 ~ 1.000
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power


Servo Off
2019.11.25 5:53:56 PM
Edit Diameter
Base Region
Cancel
Apply
Diameter Name
Diameter
Diameter
Calculate
0.000 mm
Diameter Tolerance (mm)
0.000 ~ 1.000
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power



No.	Item	Description
1	**Add Diameter Tool**	Adds a Distance Tool to the Vision Tool List.
2	**Edit**	A setting window of the job selected from the Vision Tool List is displayed.
3	**Delete**	The selected job from the Vision Job List is deleted.
4	**Move Teaching Area**	Press and hold the arrow to move the teaching area.
5	**Adjust Teaching Area Size**	Press and hold the arrow to adjust the teaching area size.
6	**Edit Job Name – Edit Window**	A virtual keyboard is displayed, and the job name can be edited. • Press the Apply button to apply the setting.
7	**Calculate**	Detects circles that exist between two teaching areas (A, B). Move circle A to be positioned outside the circular item, and move circle B to be positioned inside the circular item. Place the green center point in the center of the item. After calculation is performed, the circle between circle A and B is identified, and its diameter and center point positions are displayed.

Detected Target Circle

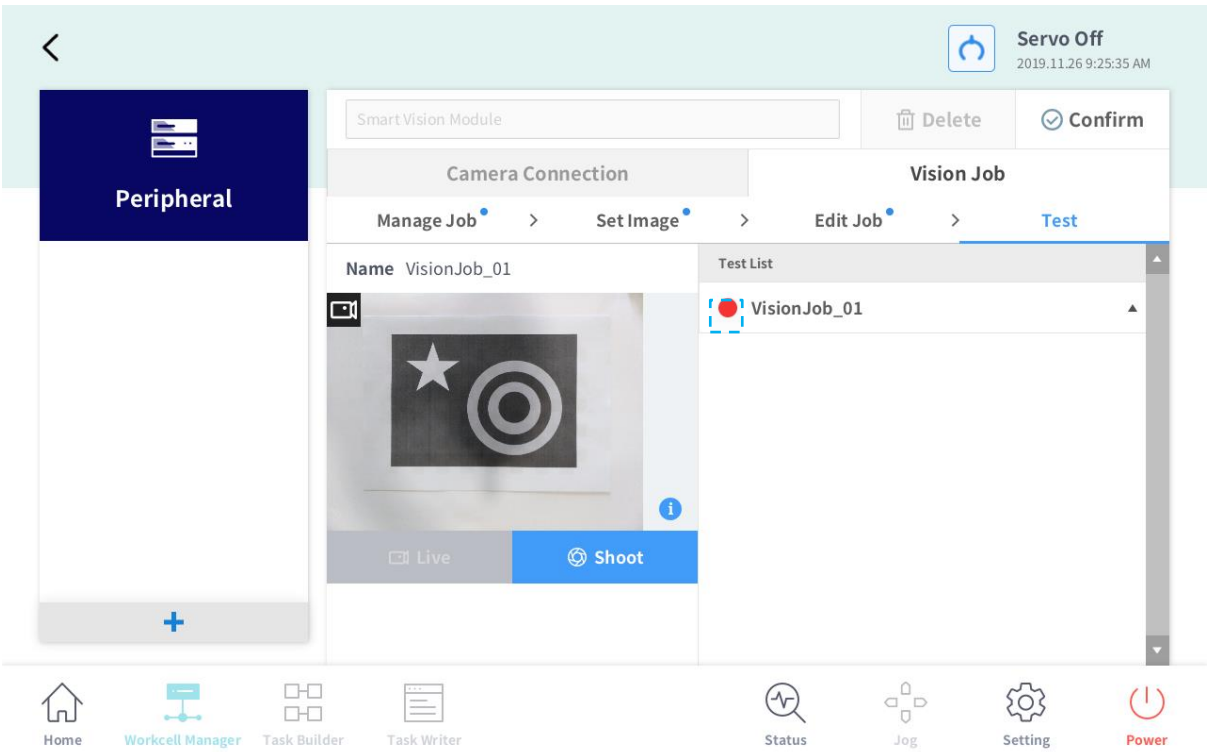
No.	Item	Description
		
8	**Diameter Display (after #7)**	Displays the diameter of the measured circle in the edit window.
9	**Circle Display (after #7)**	Displays the measured circle on the image.
10	**Diameter Tolerance Length Setting - Edit Window**	Configures the length threshold from the reference length value. • If a value exceeds the Test tolerance range, the inspection result outputs 0. • Press the Apply button to apply the setting.
11	**Apply**	Applies Vision Job settings.
12	**Cancel**	Cancels Vision Job Tool settings.

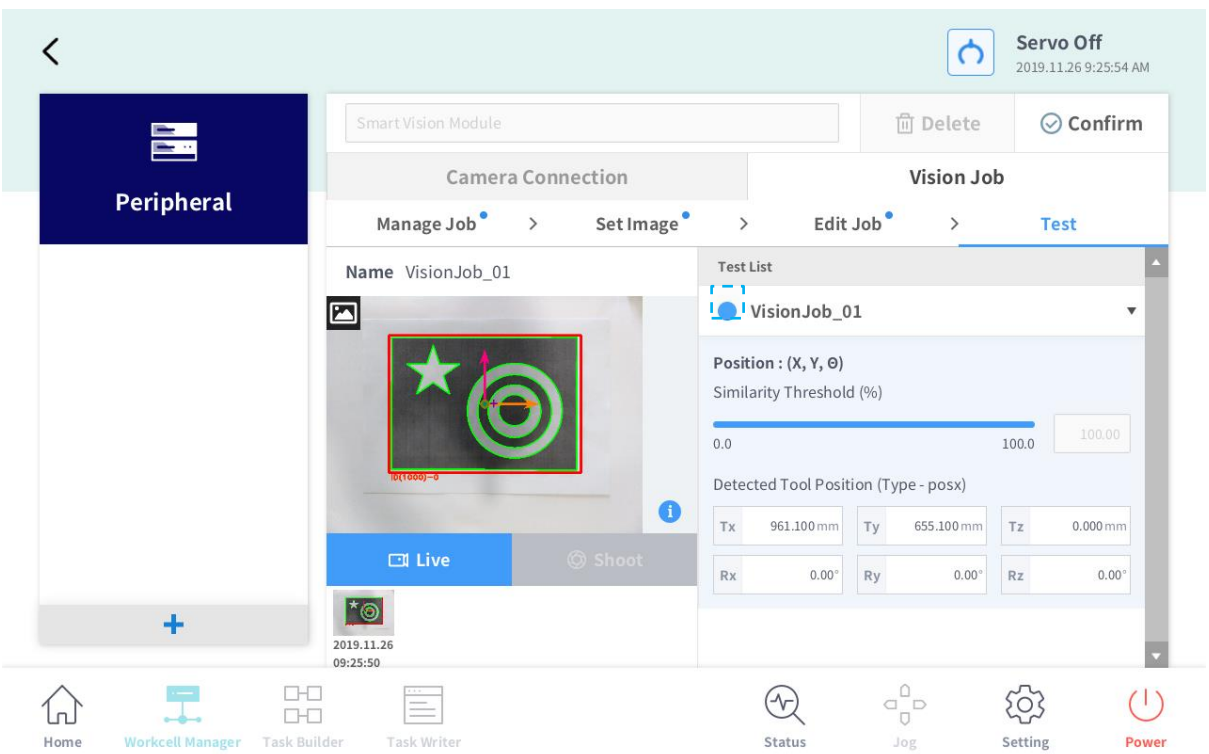
2.5 Vision Job > Test

Recognition tests for Vision Job, Position Tool, Presence Tool, Distance Tool, Angle Tool and Diameter Tool can be performed.

Item	Description
Live/Shoot Mode	Displays the image from the Live/Shoot mode, and the button changes to gray. The captured image is displayed beneath the Live/Shoot button. If the measurement is successful, the red circle (🔴) next to the Name changes to blue (🔵).

Tap the Confirm button after all tests are complete.


Servo Off
2019.11.26 9:25:35 AM
Peripheral
Smart Vision Module
Delete
Confirm
Camera Connection
Vision Job
Manage Job
Set Image
Edit Job
Test
Name VisionJob_01
Test List
VisionJob_01
Live
Shoot
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

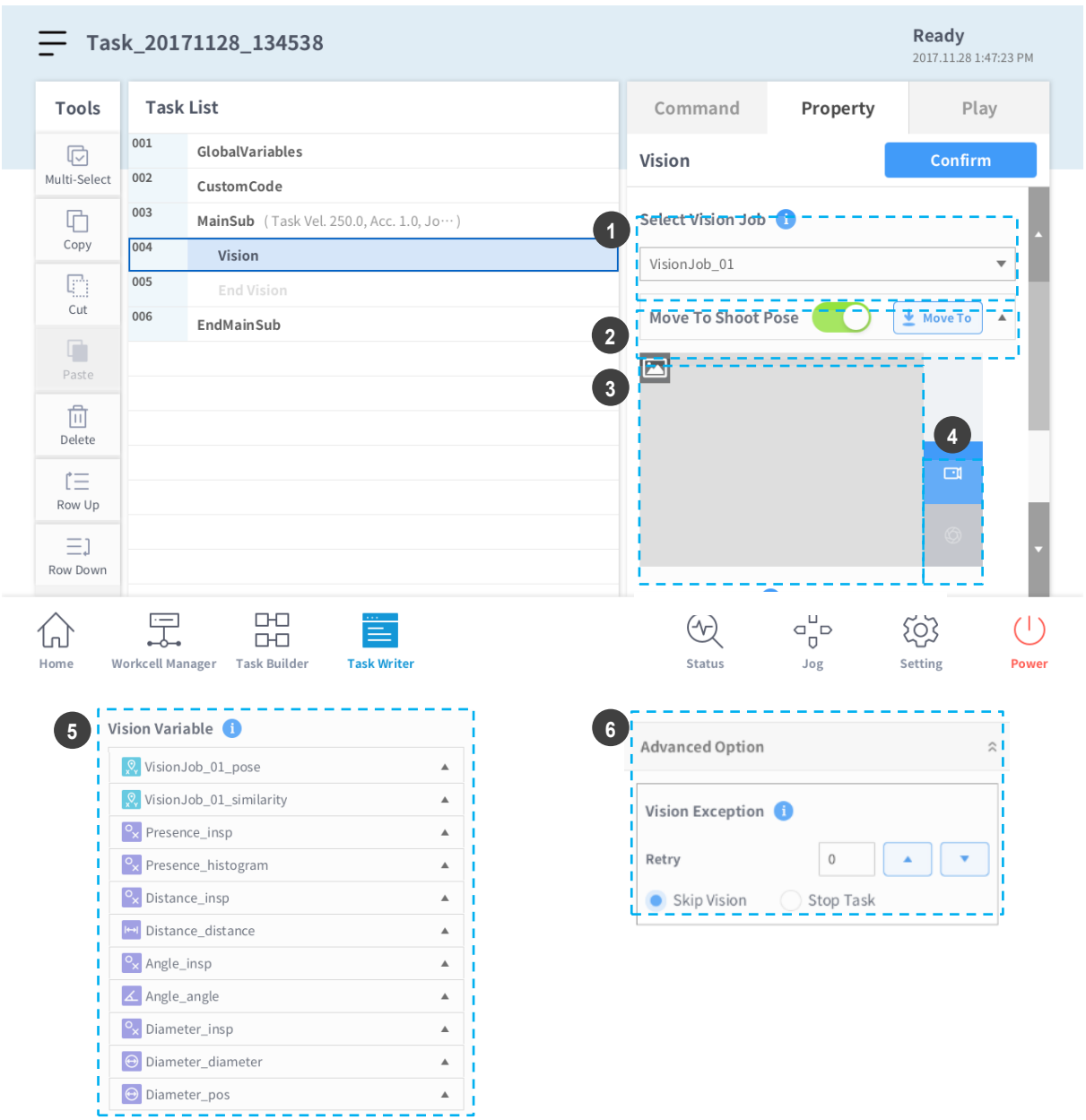

Servo Off
2019.11.26 9:25:54 AM
Peripheral
Smart Vision Module
Delete
Confirm
Camera Connection
Vision Job
Manage Job
Set Image
Edit Job
Test
Name VisionJob_01
Test List
VisionJob_01
Position : (X, Y, Θ)
Similarity Threshold (%)
0.0
100.0
100.00
Detected Tool Position (Type - posx)
Tx 961.100 mm
Ty 655.100 mm
Tz 0.000 mm
Rx 0.00°
Ry 0.00°
Rz 0.00°
Live
Shoot
2019.11.26
09:25:50
Home
Workcell Manager
Task Builder
Task Writer
Status
Jog
Setting
Power

3. Programming

Adding a Vision Command in the Task Builder will add Vision and End Vision.

Adding a Vision Command in the Task Writer will add Vision and End Vision.

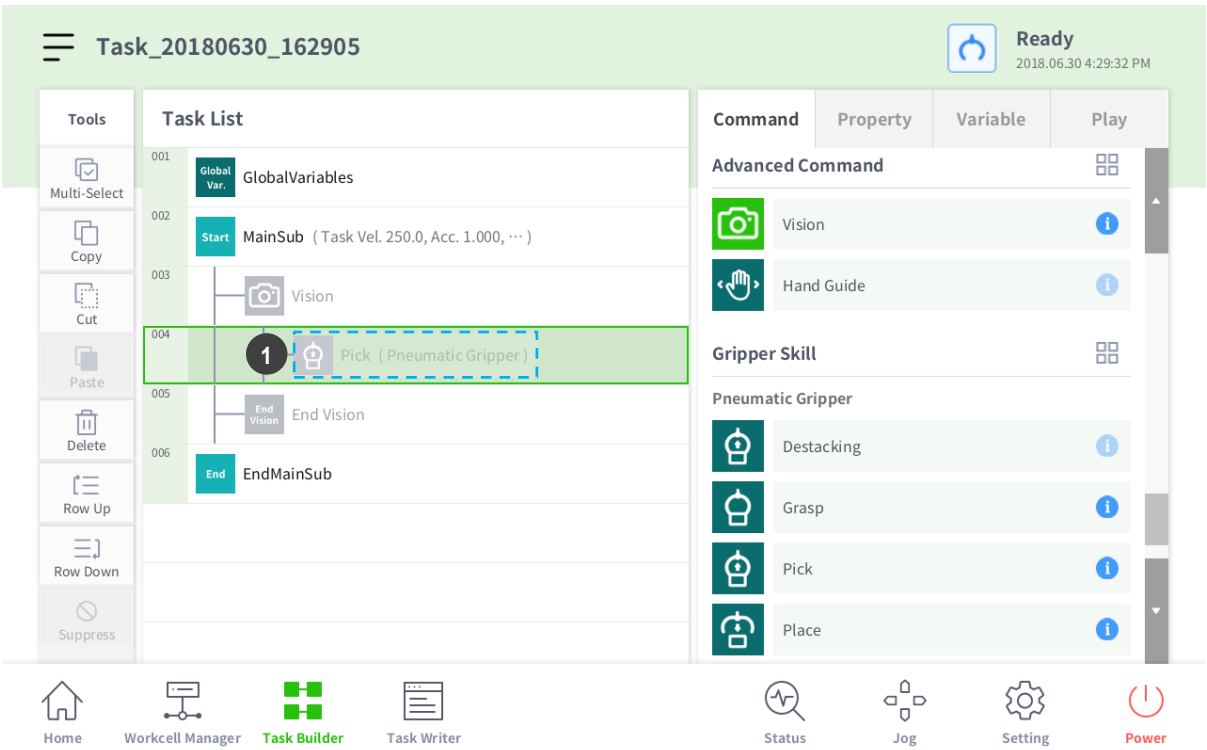
3.1 Vision Command Setting Options

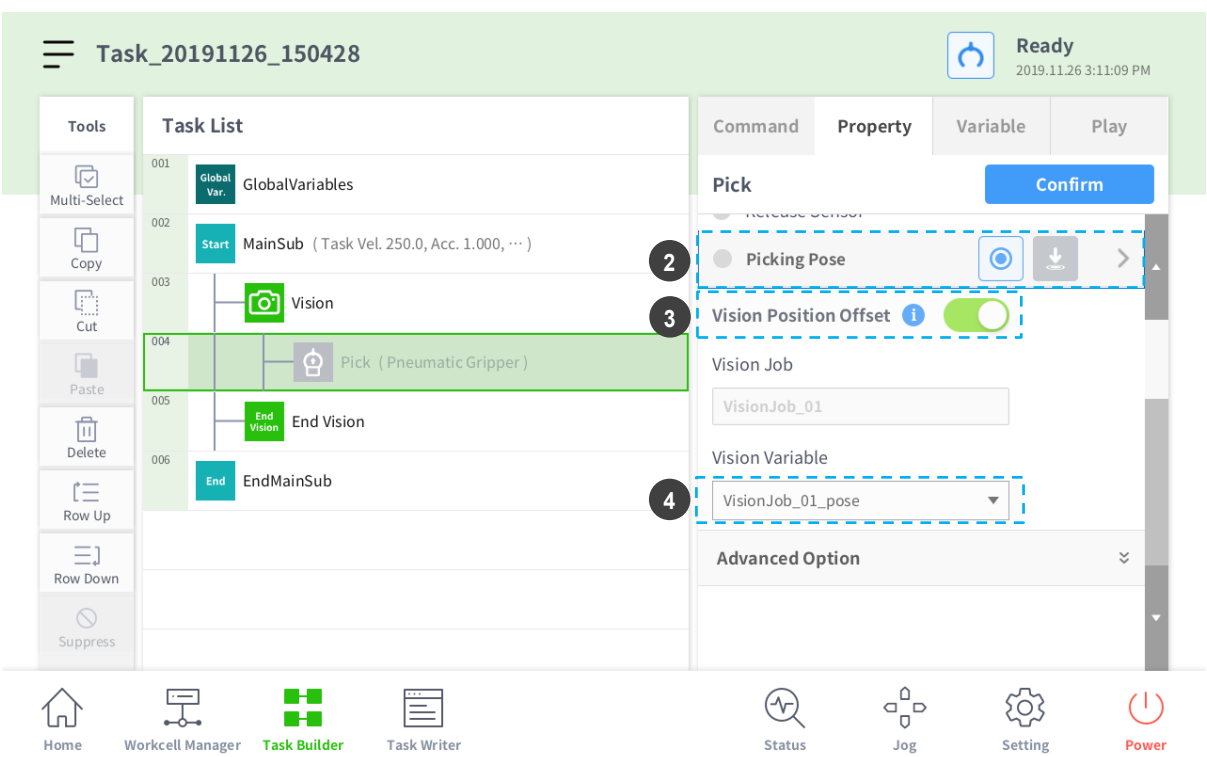


No.	Item	Description
1	**Select Vision Job**	The Vision Job List configured in the Workcell Manager displays the image of the Vision Job selected from the popup list. • Selecting a Vision Job using Select Vision Job enables Vision-related functions. • The Vision Variables of Tools included in the Vision Job can be obtained. A Vision Job can be selected.
2	**Move to Shoot Pose**	Move to the Shoot Pose of the job selected with Select Vision Job. Disabling this option means that the Shoot Pose configured for the Vision Job will not be used.
3	**Display Image**	Default image, Live image and Shoot image are displayed.
4	**Live/ Shoot**	Tap the Live button to display the live image. Tap the Shoot button to display the test result image. • Obtains data of the Vision Tool added to the Vision Job with the Workcell Manager, and adds it to the Vision Variable list. Live mode ends after 5 minutes of no action.
5	**Vision Variable**	Displays the data list of the Vision Tools added to the Vision Job. Press each item to view the values of the current Tool.
6	**Advanced Option > Vision Exception**	Select an action if Vision measurement fails. **Retry**: Set the number of Retry attempts if measurement fails. (Initial measurement + up to three retry attempts) **Skip Vision**: Skips the failed measurement stage and retries measurements according to the number of Retry attempts. **Stop Task**: Stops the Vision Task if measurement fails.

If an object is measured after the Shoot button is clicked, the object must not move until MoveL completes Get_pose. If the object is moved before Get_pose is complete, the robot will not move to a desired point during Vision offset.

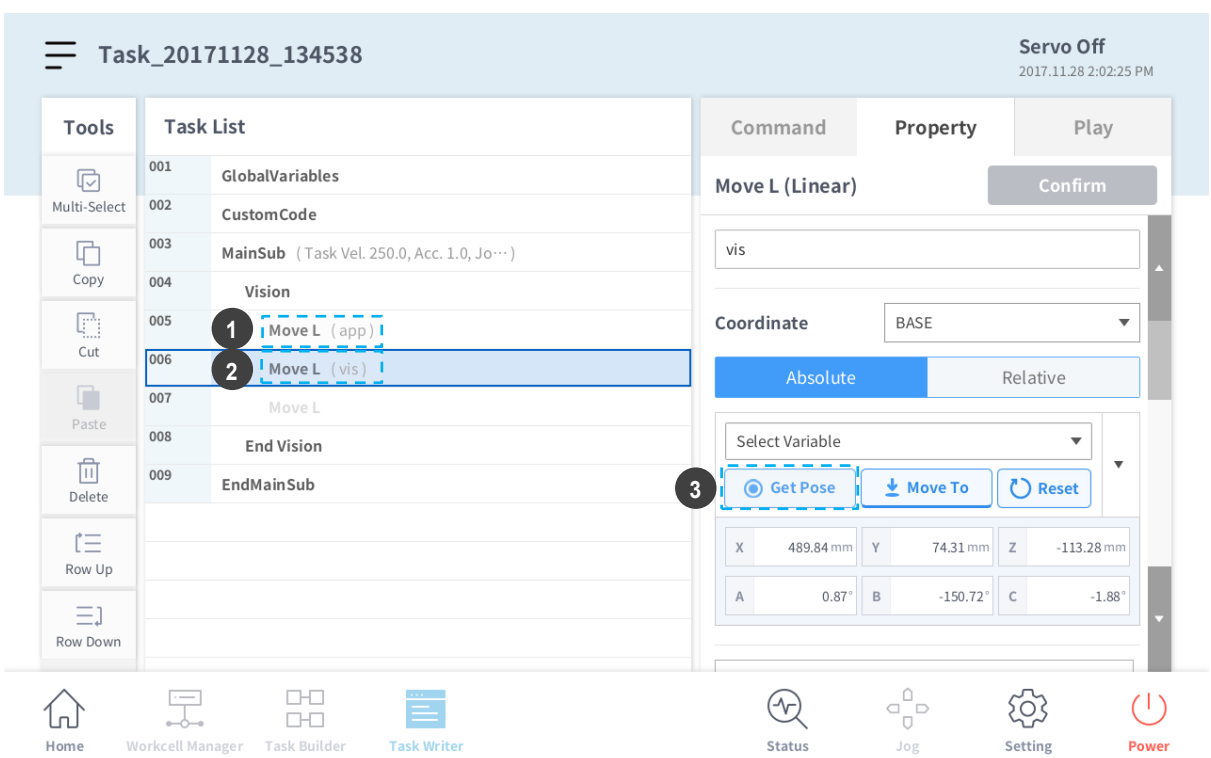
3.2 Task Builder: Using Vision in Skill Commands

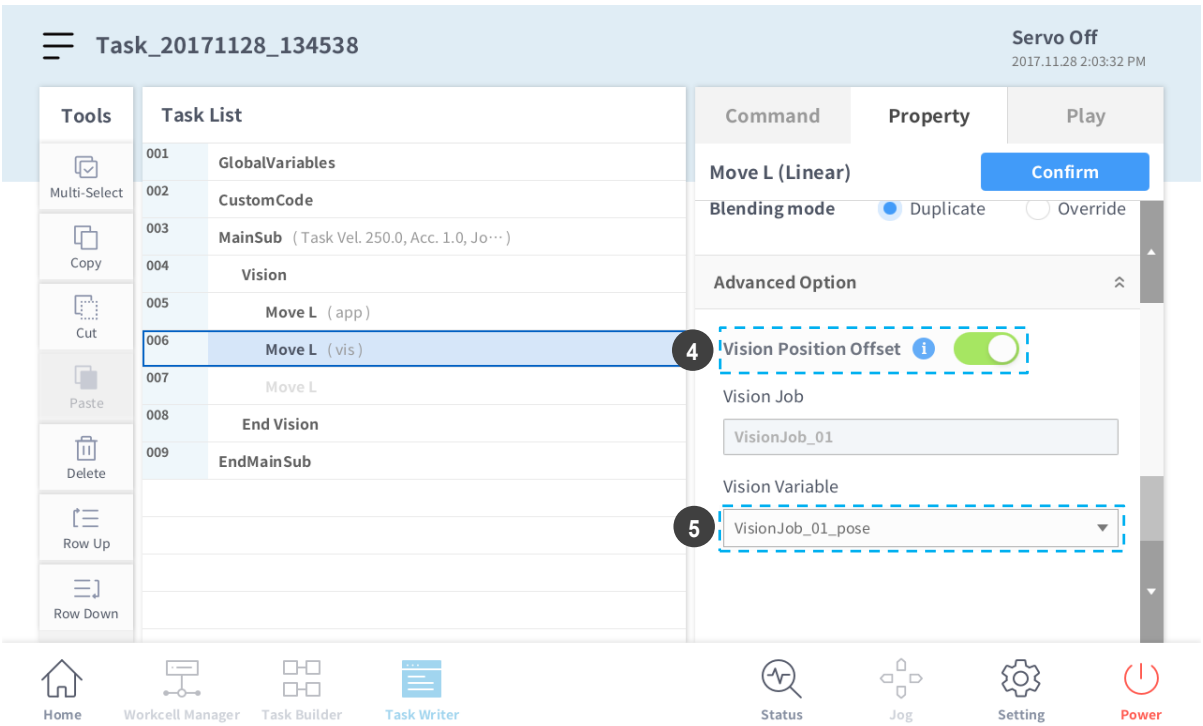




No.	Item	Description
1	**Add Skill Command after Vision Shoot and before Teaching Position Entry**	Enter the desired robot position. Inserting a Skill Command (Pick, Place, etc.) between Vision and End Vision in the Task List will create a toggle button for the skill command to use **Vision Position Offset**. (The button is not displayed if there is no Skill Command between VisionStart and VisionEnd.) Caution: To use **Vision Position Offset**, it is necessary to perform calibration in the Workcell Manager. Without calibration, the robot cannot be moved to a desired position.
2	**Picking Pose**	Acquires the pose after moving the pose to pick based on the Vision Pose using direct teaching.
3	**Vision Position Offset**	Match the Vision measurement pose and robot pose. The Vision measurement pose can be moved based on the robot.
4	**Vision Variable**	Select a pose to match the Vision and robot coordinates.

3.3 Task Writer: Using Vision in Motion Commands





No.	Item	Description
1	**Add Motion Command after Vision Shoot and before Teaching Position Entry**	Enter the desired robot position with Move L.
2	**Get pose**	Acquires the pose after moving the pose to pick based on the Vision Pose using direct teaching.
3	**Add Motion Command for Vision Offset Pose**	If you insert a Motion Command (Move L, Move B, etc.) between Vision and End Vision in the Task List, a toggle button for **Vision Position Offset** will appear, as shown in ③ in the last line of Move L. (The button is not displayed if there is no Motion Command between Vision and End Vision.) Caution: To use **Vision Position Offset**, it is necessary to perform calibration in the Workcell Manager. Without calibration, the robot cannot be moved to a desired position.
4	**Vision Position Offset**	Match the Vision measurement pose and robot pose. The Vision measurement pose can be moved based on the robot.
5	**Vision Variable**	Select a pose to match the Vision and robot coordinates.

4. Product Specifications

Dimensions (W x D x H)	92 mm X 132 mm X 25.6 mm
Weight	348 g
Resolution	CMOS 2.5 M pixel (1920 X 1440)
Camera	Manual Focus
Brightness	White LED X 2 EA (800 Lux@WD500 mm)
Communication	TCP/IP, 100 Mbps
Power	24 W (24 V, 1 A)

4.1 Measurement Distance

The camera measurement area varies according to the distance from the camera. The measurement area of the camera according to distance is as follows: If the distance is shorter than the recommended distance or the camera is outside the measurement area, the measurement accuracy will decrease or there may be misrecognition. When used in areas outside the measurement areas below, configure the work area after performing a sufficient number of tests.

Distance from the Camera (mm)		300	400	500	600
Measurement Area	W (Horizontal)	300	396	494	593
	D (Vertical)	220	293	367	440
Length / 1pixel (mm)		0.19	0.25	0.319	0.384

4.2 Size and Height of Measuring Items

The size of items to measure is limited by the size of the measurement area according to distance, and the system recognizes items with a size from 10% to 70% of the measurement area.

Distance from the Camera (mm)		300	400	500	600
Size of Item	Min. (WxH)	30x22	40x29	49x37	59x44
	Max. (WxH)	180x130	238x176	296x220	356x264
Max. Height of Item		22	29	37	44

All 2D Visions, including Vision by Doosan Robotics, can have misrecognition due to distortions created by perspective view. The maximum height of the item to be measured is recommended to not exceed the smallest surface dimension. Even if the measurement height is lower than the maximum height, misrecognitions can still occur due to perspective views created according to the camera view, and if the view is close to Top View, misrecognitions can be minimized even if the measurement height is higher than the maximum height.

4.3 Measuring Item and Background

Light reflected by surfaces of the measuring item or the background can cause misrecognition and hinder measurement accuracy. Also, if the measuring item and background have similar colors, this can also cause misrecognition and hinder measurement accuracy.

Part 4
Conveyor Tracking

1. Precautions Before Use

- Currently, only the Linear Conveyor is supported.
- One robot can support up to two conveyors.
- When connecting one conveyor, it is necessary to have one encoder, which can measure the traveling distance of the conveyor, and one triggering switch, which detects objects passing through a particular starting point.
- The encoder signal and triggering switch can only be used in one robot. In other words, one conveyor cannot be connected to more than two robots.
- The encoder and triggering switch are connected to the encoder terminals (TBEN1, TBEN2) of the control box. Connect the encoder with A phase or A/B phase depending on the specifications, and connect the triggering switch to S phase. For details about sensor selection and connection, refer to Installation Manual 4.2.6.
- The encoder resolution is selected by taking into account the resolution of the encoder itself and every reduction ratio from encoder input up to workpiece traveling mechanism. Select an encoder resolution that allows the entire system resolution to be at least 5000 count/m. If the entire system resolution is greater than 10000 count/m, there is no point in upgrading system performance.
- Conveyor speeds from 10 to 500 mm/s are supported.
- All task motions are supported during conveyor tracking. However, Absolute motion only allows Base, World and Conveyor Coordinates, and Relative motion allows all.
- The Compliance Control command can be executed during conveyor tracking.
- In the current version, the Force Control command cannot be executed during conveyor tracking.
- The Set Tool Weight command is allowed, but the Set Tool Center Position command is not allowed during conveyor tracking.
- The skill command is not supported during conveyor tracking.

2. Settings with Workcell Manager (WCI)

Set the external encoder in the Workcell Manager, check the hardware connection and signal settings, and set the conveyor tracker.

2.1 External Encoder Settings

The external encoder sets the encoder channel according to the encoder connection, sets the A-B phase according to the encoder specification, and sets the S Phase mode according to the triggering switch sensor specifications and configurations.

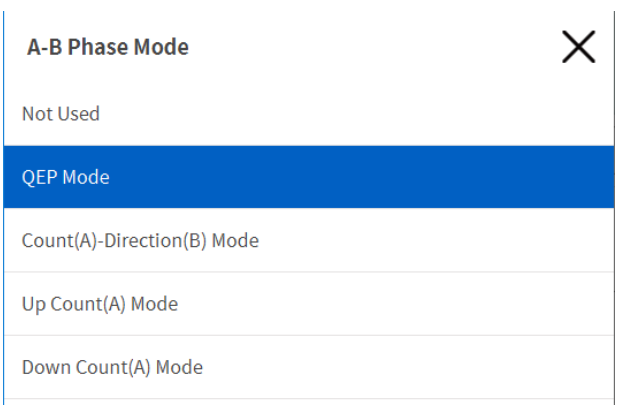
2.1.1 Encoder Channel Settings

Up to two encoder channels can be set. Check the port connected to the controller and set the channel.

2.1.2 A-B Phase Mode Settings

Set the A-B Phase. The A-B phase is a channel related to the encoder resolution. If the encoder supports two channels, a connection is made to the A-B phase, but if the encoder only supports one channel, the connection is made to the A phase.

There are four options in the A-B Phase Settings. QEP mode and Count(A)-Direction(B) mode are options that use two channels, and Up Count(A) mode and Down Count(A) mode are options that use 1 channel.



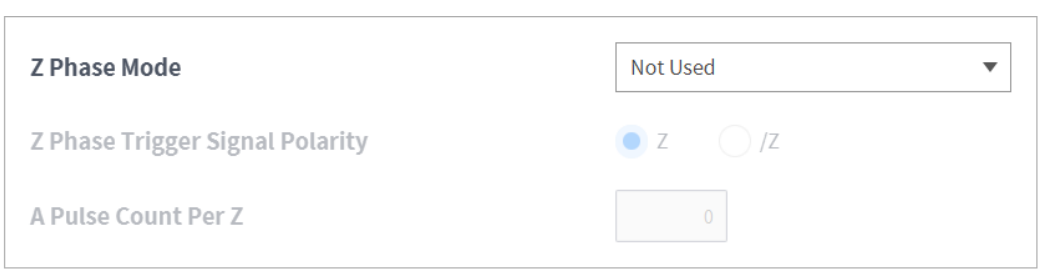
A-B Phase Mode	Description
QEP Mode	Quadrature Encoder Pulse Mode. This combines the counts of channels A and B to expand the resolution by four times. For example, if A and B phases have 500 counts each, the overall resolution will be 2000 = 500×4 counts.

Count(A)-Direction(B) Mode	A phase is an option for counts, and B phase is an option determining the direction. Depending on the high/low status of the B phase, the count of the A phase is adjusted up or down.
Up Count(A) Mode	This uses the A phase signal as an up count.
Down Count(A) Mode	This uses the A phase signal as a down count.

The A Phase Polarity and B Phase Polarity settings determine whether to use each phase as is or in reverse. Reversing each phase can change the up and down counts, so if changing the direction is the objective, using Inverse mode allows more intuitive settings.

2.1.3 Z Phase Mode Setting

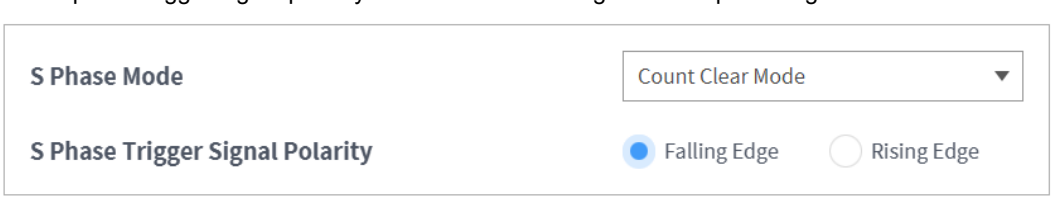
Z Phase mode uses the Z phase signal to compensate the encoder count. Conveyor tracking uses the incrementation of the encoder rather than its absolute value, so Z Phase mode is normally not used.



2.1.4 S Phase Mode Settings

The S Phase is the channel connected to the triggering switch. Use Count Clear mode to check the hardware connection with the external encoder alone, and use Signal mode to execute the conveyor tracking application. This is necessary because the encoder count is cleared only when the conveyor tracking application is running in Signal mode, so it is difficult to use it when debugging with hardware only. (To be integrated into Count Clear mode)

The S phase trigger signal polarity determines which edge of the S phase signal will execute clearing.



2.1.5 Inverse Mode Settings

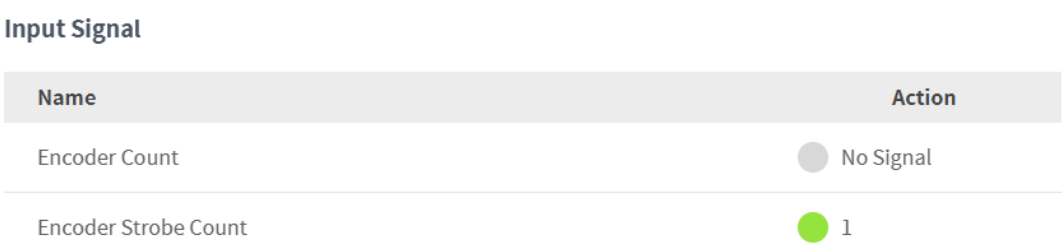
Inverse mode is capable of intuitively changing the count direction forward/backward.

2.1.6 Setting Check

After setting is complete, check the setting while operating the conveyor. Monitor the input signal to monitor the encoder count increase or decrease as the conveyor moves. The encoder count is only displayed in positive numbers from 0 to the maximum value. While it is not mandatory, it is recommended that the count be set to increase as the conveyor moves.

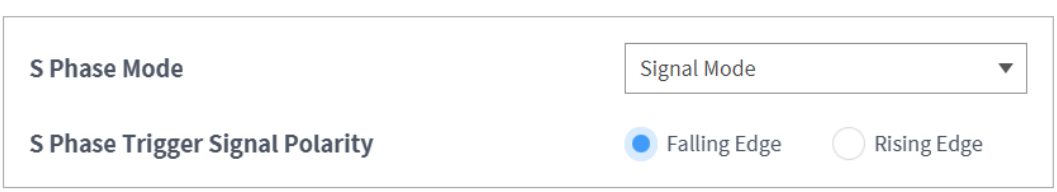
Encoder Strobe Count is a counter that increases each time an item is detected by the triggering switch. Block the triggering switch and check whether the accumulative count increases and the encoder count decreases to 0 at the desired edge.

Ideally, the encoder strobe count of the corresponding edge shall only increase by 1. However, there are cases where multiple counts are made at the edge due to signal noise. It is possible to compensate for such multiple counts accumulated at the edge with triggering_mute_time during conveyor tracking, but as noise can also influence the encoder count, it is recommended that the cause be eliminated by checking the hardware.



2.1.7 S Phase Mode Reset

Set S Phase Mode to Signal Mode and move to Conveyor Tracking Settings to check whether the triggering switch is operating properly according to the settings. (Signal mode and Count Clear mode are to be integrated into Count Clear mode)



If the triggering switch connection is incorrect or if there is noise, Encoder Strobe Count functions abnormally. Debug hardware connections and configurations while monitoring the trend.

After the check is complete, make sure to set S Phase Mode to Signal Mode to ensure proper a connection with the conveyor.

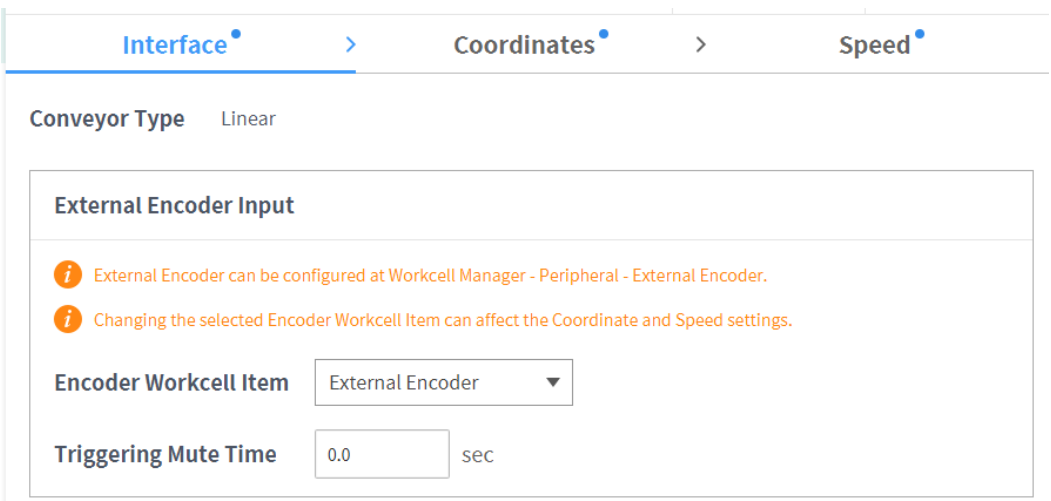
2.2 Conveyor Tracker Settings

The conveyor tracker is set in the order of Interface > Coordinates > Speed tab.

2.2.1 Interface Settings

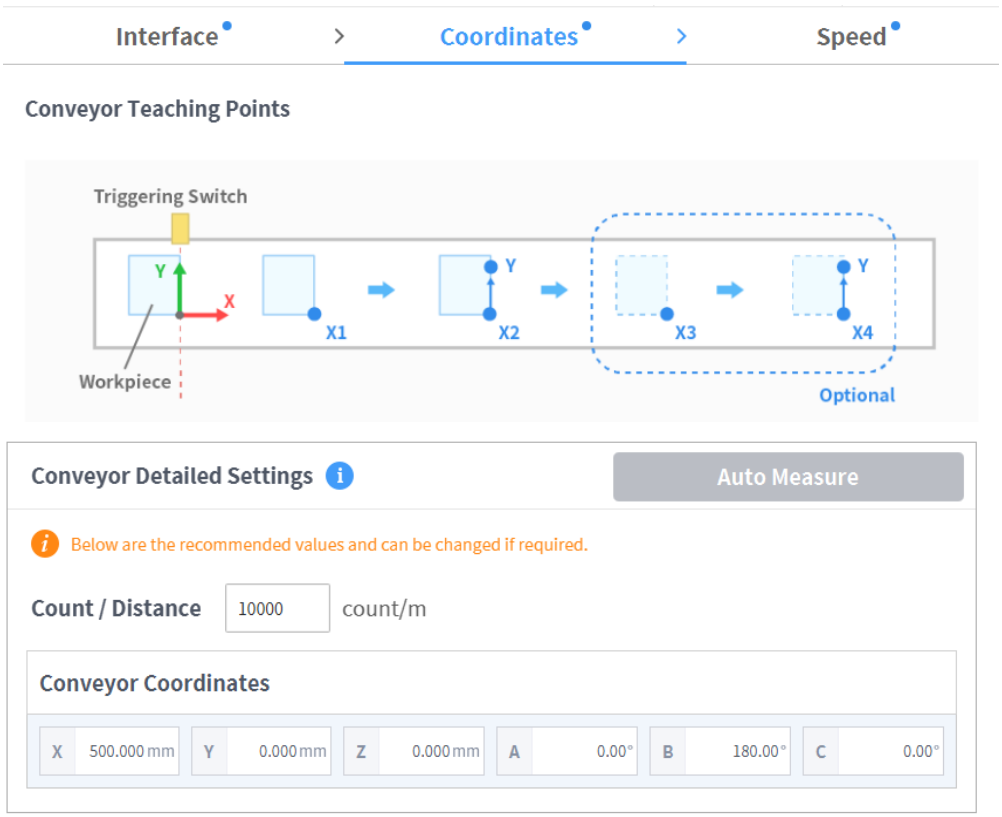
Load the external encoder configured under Encoder Workcell Item.

Triggering Mute Time is used when the noise in the triggering switch sensor is at an acceptable level. For example, when a workpiece passes through the triggering switch, an edge may be detected, but additional samples of the edge may be detected within a short period of time after detection due to the electric noise generated during signal switching. In such cases, set the mute time to allow the first edge detected to be recognized as a workpiece and subsequent edge detections after the first detection to be ignored for the set time. This setting is used when the workpiece interval can be estimated and electrical noise cannot be controlled due to poor conditions in the work environment.

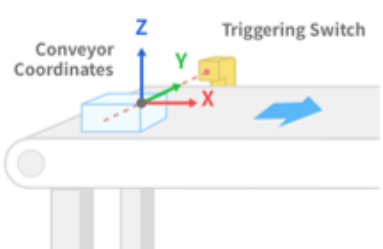


2.2.2 Coordinate Settings

The purpose of the Coordinates tab is to set the Count/Distance values and the conveyor coordinates under Conveyor Detailed Settings. This calculates the converted value, which indicates how much the encoder count increases when the conveyor moves, and which point the conveyor is fixed to in a particular space.



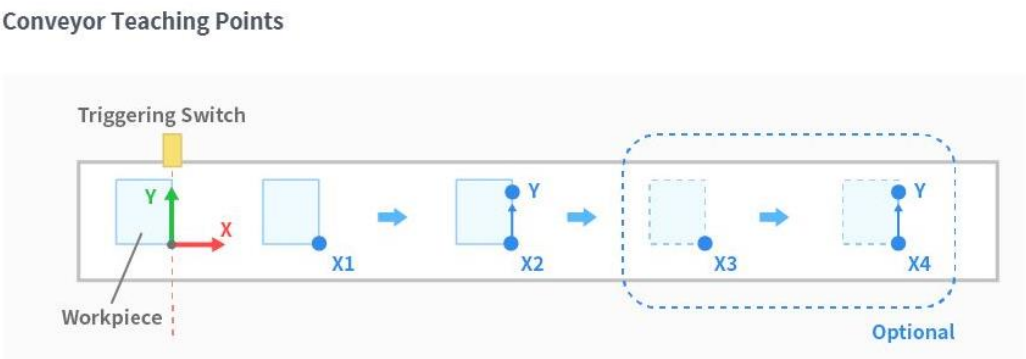
The x-axis of the conveyor coordinates is the direction of the conveyor's movement in terms of the reference coordinates (Base or World).



Methods to calculate these values are Auto Measure, after teaching the conveyor teaching points to the robot, and Manual Calculation from the system design specifications. It is possible to use Manual Calculation if it is difficult to teach the robot about the workpiece, but Auto Measure is recommended in most scenarios.

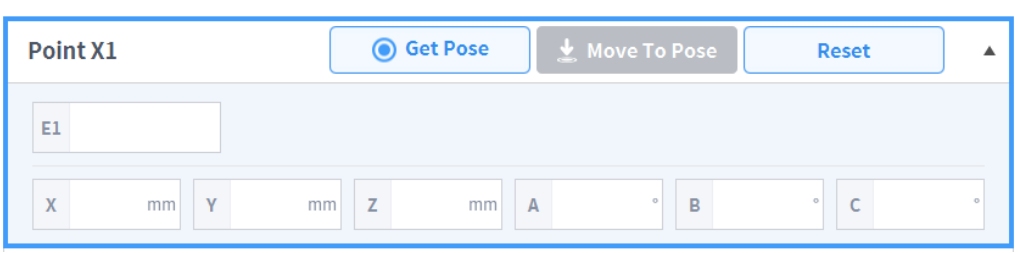
Auto Measure

Teaching consists of placing the workpiece before the workpiece detection switch, operating the conveyor, and stopping the conveyor intermittently to teach the robot to obtain position information. Check that the TCP is identically set in the program to be used before teaching.

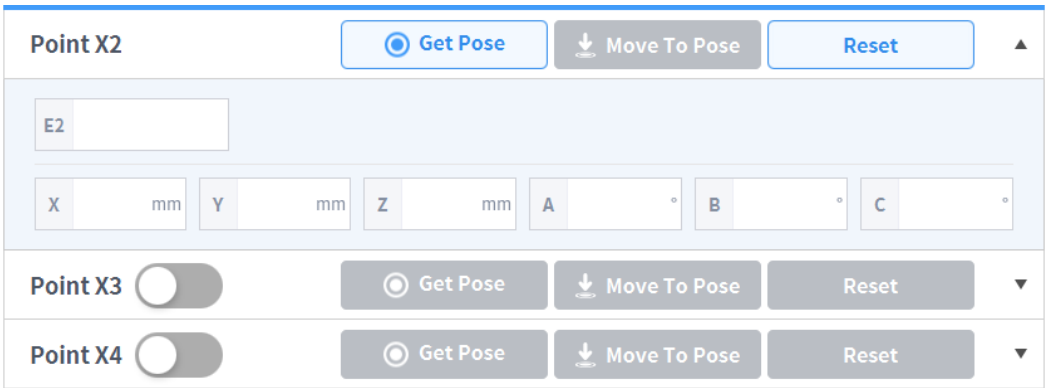


Base Coordinates and World Coordinates can be selected as the reference coordinates during teaching. World Coordinates is helpful as it allows two robots to share a single conveyor without re-teaching.

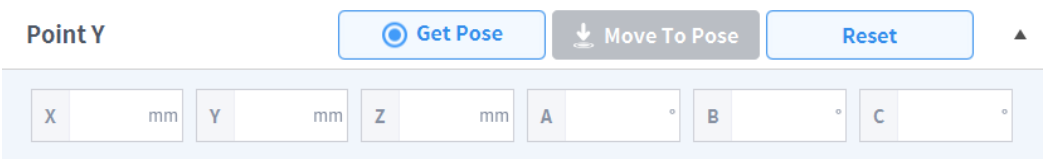
Place a workpiece on the conveyor before the workpiece detection switch in the same way it is done during actual work. Turn on the conveyor and stop it after the workpiece passes the conveyor's triggering switch. Teach the reference point of the workpiece at this moment, and press Save Pose to acquire the current encoder count and robot location of Point X1.



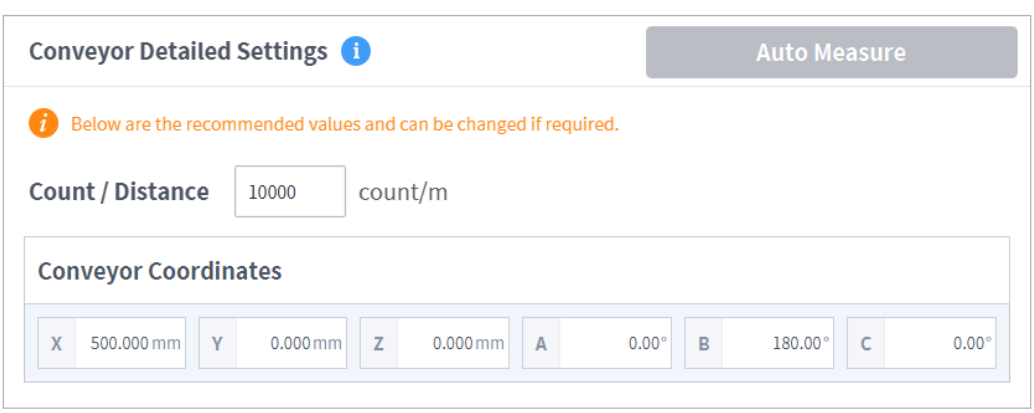
Turn on the conveyor again and stop it in the same way to acquire a location for Point X2. Point X is used to calculate the x-axis of the conveyor coordinates. While just X1 and X2 are sufficient, up to four points can undergo teaching to improve accuracy. Depending on the number of teachings, spread the position within the range where the robot can undergo teaching.



Point Y is used to calculate the y-axis of the conveyor coordinates, so it is acquired by teaching a workpiece placed on an X-Y plane to generate a y-axis in addition to Point X.

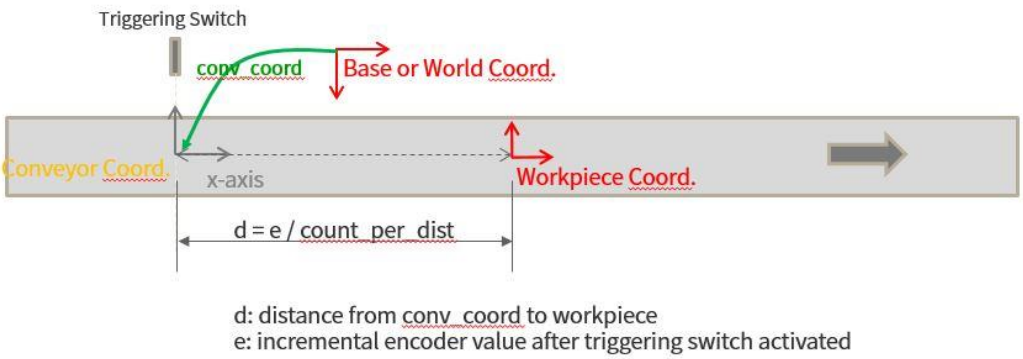


Acquire a teaching point and press Auto Measure to automatically calculate Conveyor Detailed Settings. Check whether the conveyor coordinates are calculated to a point near the physical location of the triggering switch. (Depending on the detected edge, offset may exist in the direction of the conveyor)



Manual Settings

The workpiece's location is calculated by applying the encoder count, increasing in the direction of x for the conveyor coordinates, when the workpiece passes the triggering switch. The setting is set based on the triggering switch, conveyor position and workpiece reference point, and even in situations where it is difficult to identify the exact position, setting the correct x-axis direction for Conveyor Coordinates will allow the remaining offset to be accurately entered in Task Motion under TB/TW, so it is acceptable to not enter the exact value.



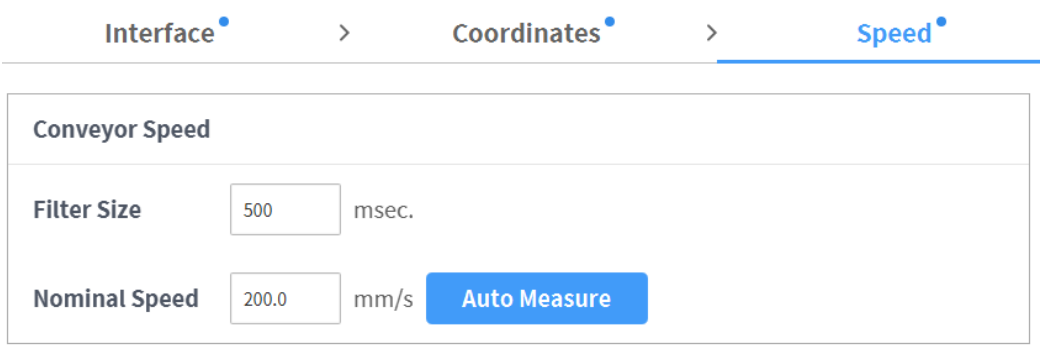
Count and Distance are conveyor tracking commands in TB/TW, and entering the Wait command without a task motion will result in the tracking of conveyor movement from the current position. The user can adjust this while monitoring the speed trend. If the robot moves more slowly than the conveyor, reduce the Count/Distance, and if the robot moves faster, increase the Count/Distance.

2.2.3 Speed Settings

The conveyor speed and section settings are under the Speed tab.

The filter size under Conveyor Speed is the size of the conveyor speed filter. Select an intuitive moving-average filter under Conveyor Tracking. Increase the filter value if there is vibration in the robot and reduce the value if the tracking performance in the conveyor acceleration section is low.

Measure Nominal Speed using the Auto Calculate button while operating the conveyor. If the conveyor speed is 200% higher than Nominal Speed, it can be used to provide information. It does not require an accurate value, so entering a design specification value without actual measuring is acceptable.

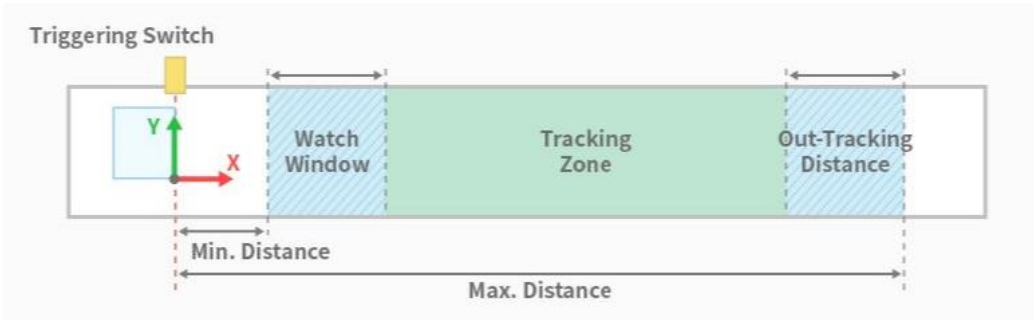


Next, set up Conveyor Section. Min Distance and Max Distance are related to the work section of Conveyor Tracking. A larger Min Distance value allows the work to begin at a location further away from the workpiece detection switch. The robot can conduct conveyor tracking up to an area the size of the Max Distance value, but not that of the Out-Tracking Distance.

If the robot enters the out-tracking distance, it generates an error and decelerates. Increase the out-tracking distance to apply gradual deceleration.

The watch window is the area where work candidates are determined. Workpieces in this area can only become work targets once the work begins. Starting from the minimum distance, setting a wider area will increase the number of work targets. However, in a worst-case scenario, this can cause

workpieces at the end of the watch window to become targets, so it is recommended that the watch window size be adjusted to allow all work in the tracking zone to be completed.

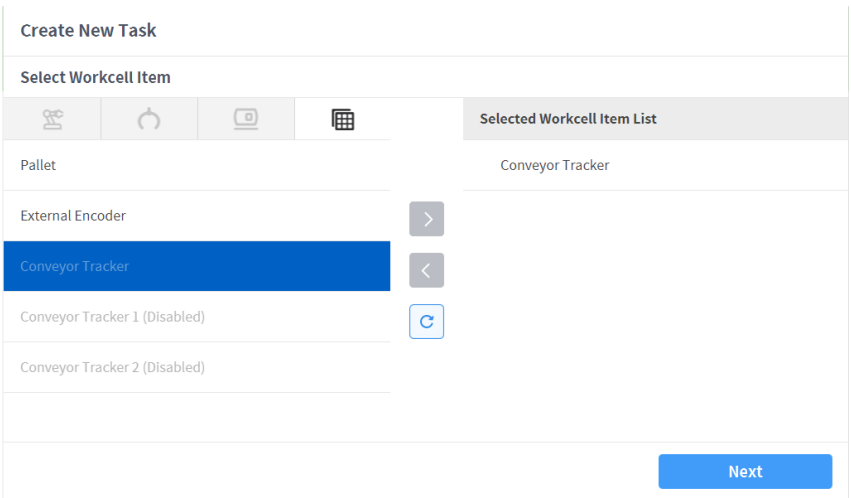


Min. Distance	0.000	mm
Max. Distance	1000.000	mm
Watch Window	200.000	mm
Out-Tracking Distance	50.000	mm

3. Programming (TB/TW)

Programming of conveyor tracking is done through the Conveyor Coordinates command and Conveyor Tracking command in TB/TW. Coordinate information of the workpiece is obtained with the Conveyor Coordinates command, and conveyor tracking motions are performed with the Conveyor Tracking command. The Conveyor Tracking command also offers a function for acquiring a teaching point from the conveyor coordinates.

Select Conveyor Tracker from Workcell Item when creating a task on TB.

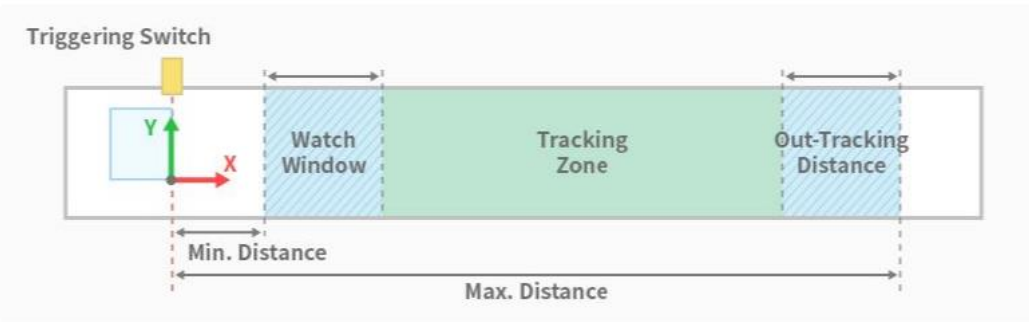


Then, the Conveyor Coordinates and Conveyor Tracking commands will be available under Advanced Commands.

TW will make the Conveyor Coordinates and Conveyor Tracking commands available under Advanced Commands.

3.1 Conveyor Coordinates

This command acquires the coordinate information of the moving workpiece. This command returns the coordinates information of a workpiece in the watch window at the time the command is executed.



This selects the set conveyor workcell item.

Conveyor Tracker Workcell Item

Conveyor Tracker

This enters a name for the conveyor coordinates. This saves the conveyor coordinate numbers (121-150) on the entered variable.

Conveyor Coordinates Name

Coord1

Time Out sets the standby time until workpiece information is received. Setting it as Disable or as 0 will put it on standby indefinitely until a workpiece is delivered. If a workpiece is not delivered within the set time, it skips to the next program line.

Time Out 0.0 sec

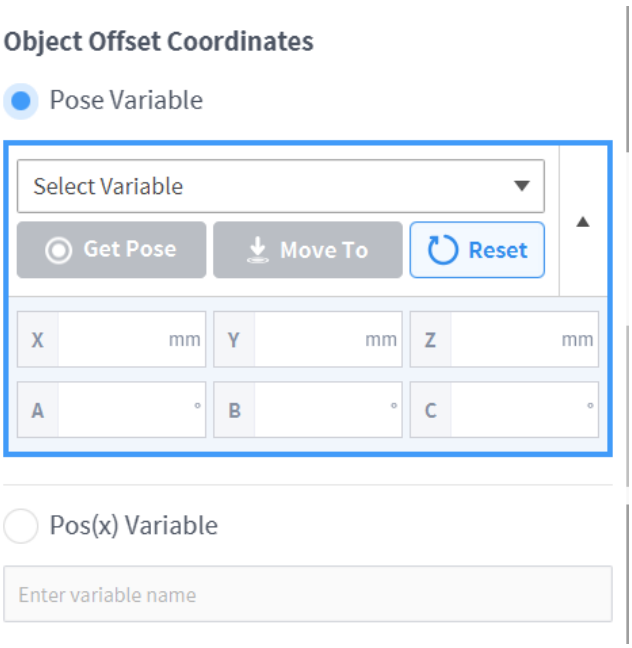
Time Out 2.0 sec

Picking Rules determines whether to work on workpieces received first or workpieces received last. First In First Out or Last In Last Out can be selected.

Picking Rule

First In First Out

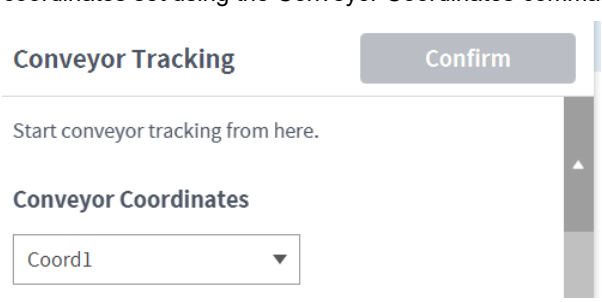
This is used to offset Object Offset Coordinates. If the corresponding variable requires it, this updates the program in real time with Pose Variable, which is used to give a static offset, and Pos(x) Variable, which is used to dynamically change the offset.



3.2 Conveyor Tracking

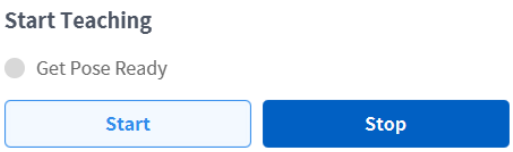
Inserting the Conveyor Tracking command into the programming creates a Conveyor Tracking node and an End Conveyor Tracking node. At this time, the robot will perform the conveyor tracking motion. It is possible to insert the Wait command to check whether tracking is being performed well, or insert various other Task Motion commands to develop the desired work.

Conveyor Coordinates gives the workpiece coordinates used to execute conveyor tracking. The coordinates set using the Conveyor Coordinates command are listed.

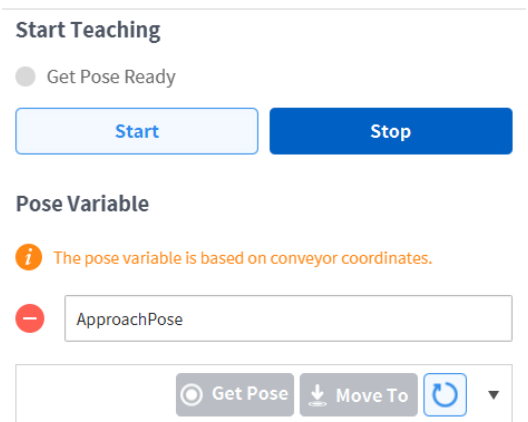


Also, it is possible to obtain a teaching point for using Task Motion. The teaching point for Conveyor Tracking must be entered based on the workpiece coordinates, so in order to obtain an accurate teaching point, the coordinates must be entered manually based on CAD information or be obtained through the following procedure: This step can be omitted if the coordinates can be obtained with only the designed value.

- With the Start button pressed, let workpieces flow through like during an actual workflow.



- When a workpiece enters the monitoring section, a green indicator lights goes on at Get Pose Ready. After the indicator light goes on, stop the conveyor in a position where the robot can perform teaching properly. If the green indicator light does not go on, press Stop and restart the process.



- After teaching the robot based on a workpiece during the stop, press Save Pose to obtain as many teaching points as necessary. (up to 20 points)

Teaching points can be loaded using Task Motion between the Conveyor Tracking commands by referring to the entered pose variable name.

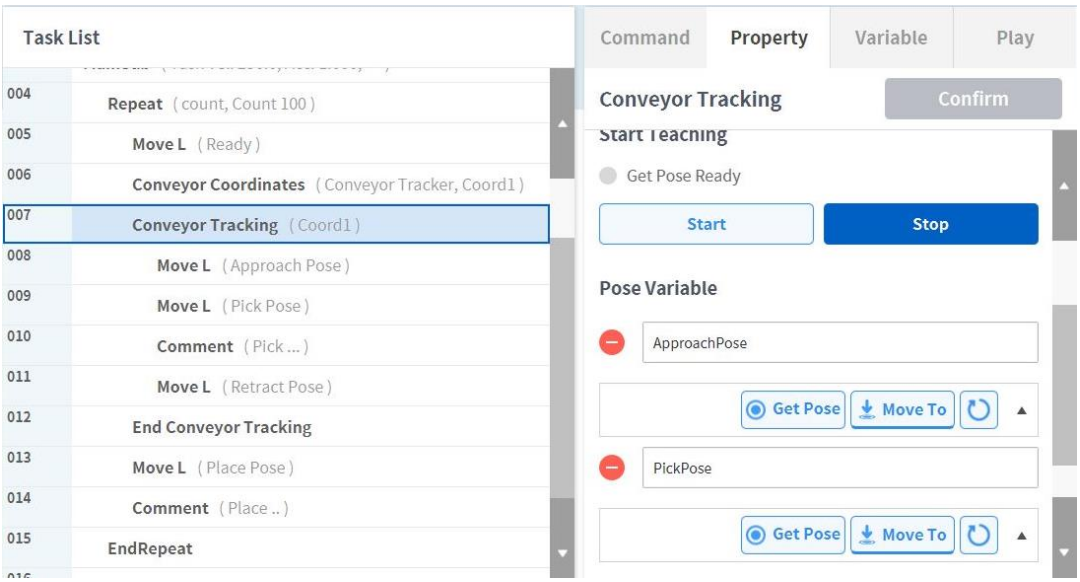
In addition to workpiece coordinates, the teaching point supports teaching points in Base or World coordinates. In order to use them, it is necessary to obtain the teaching points of the corresponding coordinates in the Task Motion Property window.

4. Other Items to Note

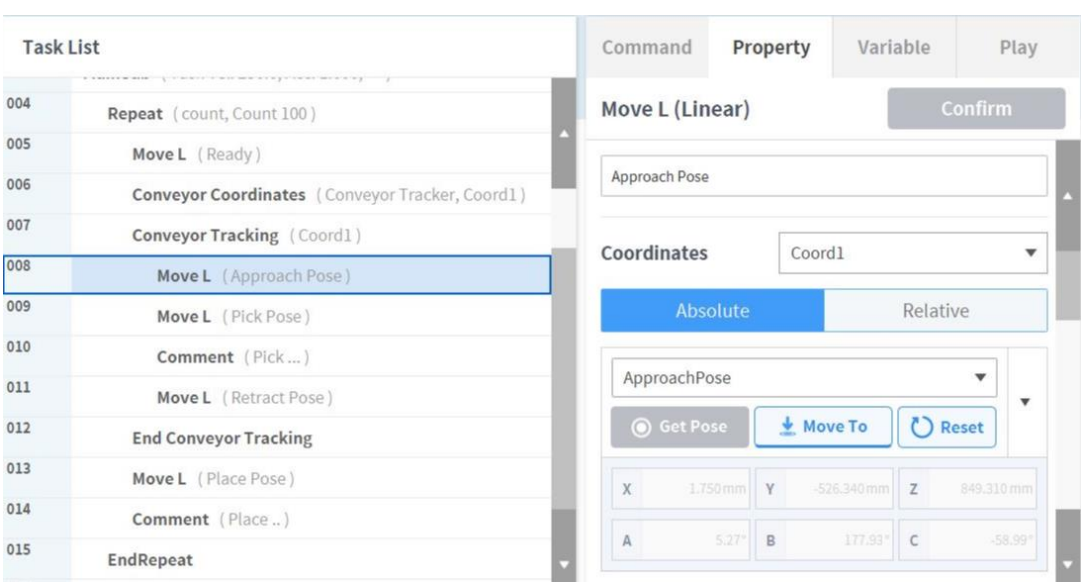
Here are the program templates commonly used.

4.1 Pick & Place (One Conveyor)

This example picks a workpiece moving on one conveyor and places it outside the conveyor. Perform teaching of ApproachPose and PickPose at Conveyor Tracking Property.

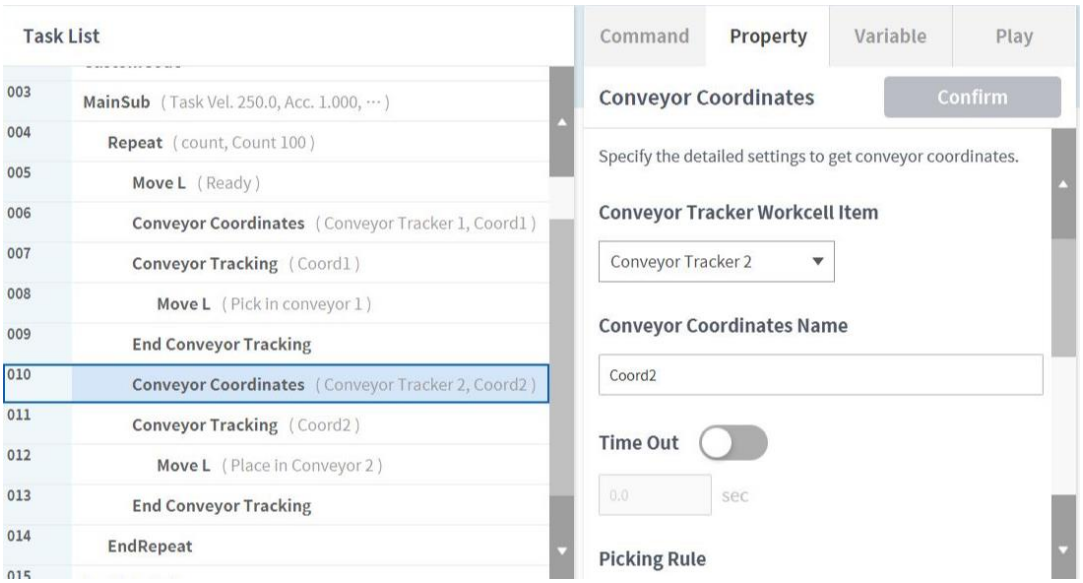


By selecting Conveyor Coordinates (Coord1 in the example) as the coordinates at MoveL in the Conveyor Tracking node, it is possible view teaching points that underwent teaching at Conveyor Tracking. Select a teaching point (ApproachPose, PickPose) to complete programming.



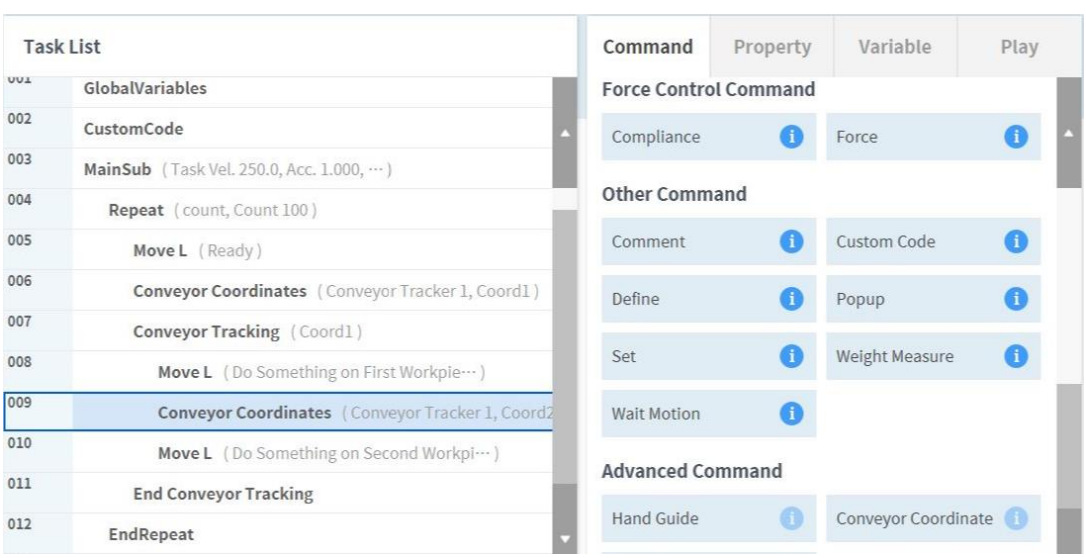
4.2 Pick & Place (Two Conveyors)

This example picks a workpiece moving on one conveyor and places it on another conveyor. While the method is identical to the example in 4.1, it requires two pairs of Conveyor Coordinates and Conveyor Tracking commands, and each must be programmed at different conveyors.

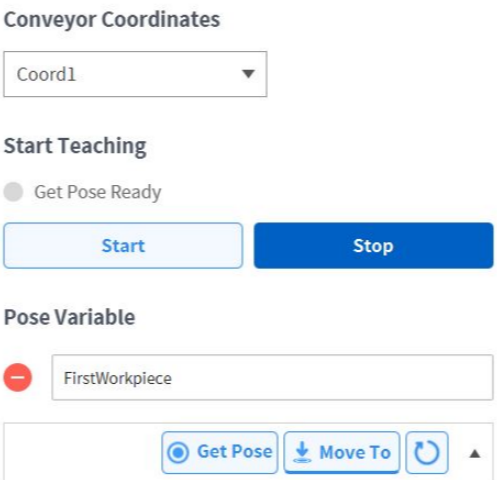


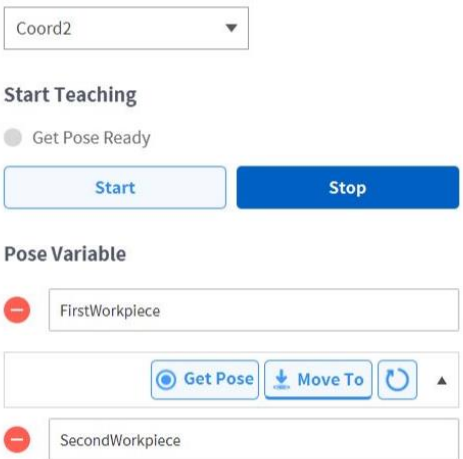
4.3 Multiple Workpiece Handling

This example handles workpieces continuously supplied by one conveyor. If a workpiece is handled between Conveyor Tracking and End Conveyor Tracking, and if the overall work time is not sufficient, obtain Conveyor Coordinates information rather than performing End Conveyor Tracking to continue the work.



Note that it is necessary to differentiate the first coordinates and the second coordinates when teaching. Select coordinates suited for the workpiece, perform Start Teaching, and perform Get Pose to obtain teaching points suited for each coordinate. If the workpiece is identical, it is acceptable to share identical teaching points.


Conveyor Coordinates
Coord1
Start Teaching
Get Pose Ready
Start
Stop
Pose Variable
FirstWorkpiece
Get Pose
Move To


Coord2
Start Teaching
Get Pose Ready
Start
Stop
Pose Variable
FirstWorkpiece
Get Pose
Move To
SecondWorkpiece