

Manual Version 1.5
Software Version 2.5

Doosan Robot

M0609 | M0617 | M1013 | M1509

Reference Manual



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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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.

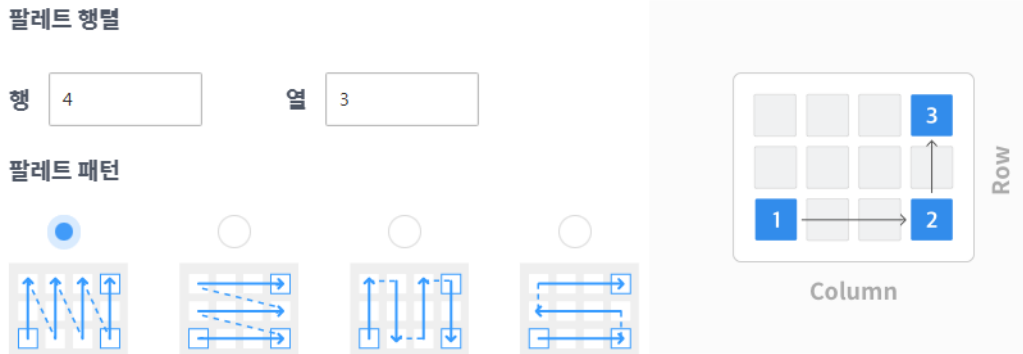
| Item | Description |
|---|---|
| Machine Operation | It configures the output signal for starting the injection molding machine. |
| Machine Operation Preparation Sensor | It configures the input signal for authorizing injection molding machine operation. |

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.

팔레트 형렬

행 열
 스택킹 두께 mm

팔레트 패턴

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

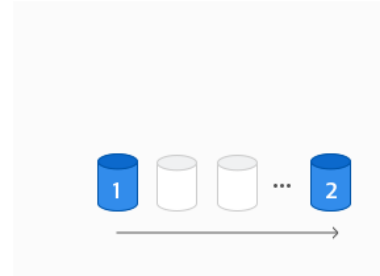
It is the Workcell Item for target batches with linear patterns, and after entering the number of targets on a linear pattern and skill used for single stacks, along with the stack and thickness, it automatically stacks the target or recommends a skill suited for picking and moving the target.

선형 패턴

카운트

스태킹

두께 mm



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 Bolt 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. |

| Item | Description |
|-----------------------|--|
| 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. |

| Item | Description |
|--------------------------|--|
| 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. |
| 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. |

| Item | Description |
|-----------------------------------|---|
| 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. |
| 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. |

| Item | Description |
|-----------------------------------|--|
| 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. 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 |

| Item | Description |
|-----------------------------------|---|
| | 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. |
| 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. |
| 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. |

| Item | Description |
|-------------------------|--|
| 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. |
| 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. |

| Item | Description |
|-----------------------|--|
| 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. |

| Item | Description |
|-------------------|--|
| 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. |
| 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. |

| Item | Description |
|-----------------------------------|---|
| 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 | <p>It is the signal allowing Robot arm approach, and the signal is outputted under the following conditions:</p> <ul style="list-style-type: none"> - 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 | <p>It is the Robot arm approach request signal for new workpiece approach. The signal must be outputted under the following conditions:</p> <ul style="list-style-type: none"> - MC Home position |

| Item | Description |
|---------------------------|---|
| | <ul style="list-style-type: none"> - Spindle stop - Robot uses - MEM Mode - No Machine lock - Door open - No Robot alarm |
| Unload LH Chuck | <p>It is the Robot arm approach request signal for new workpiece discharge. The signal must be outputted under the following conditions:</p> <ul style="list-style-type: none"> - 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. |

| Item | Description |
|-----------------------------------|--|
| Machine Online | When Serve & MC Ready is set in MEM Mode, it outputs this signal through the Robot. |
| Prermission to Robot | <p>It is the signal allowing Robot arm approach, and the signal is outputted under the following conditions:</p> <ul style="list-style-type: none"> - 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 | <p>It is the Robot arm approach request signal for new workpiece approach. The signal must be outputted under the following conditions:</p> <ul style="list-style-type: none"> - 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.

Note

If FTS is not installed when using the A-Series, the following functions cannot be used:

- Compliance Control and Contact Check
- Insert
- Push
- Touch

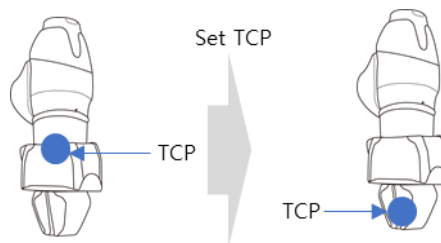
Refer to the **Note** of each skill to check whether the skill can be used.

1.2 Understanding Basic Principles of Skill Commands

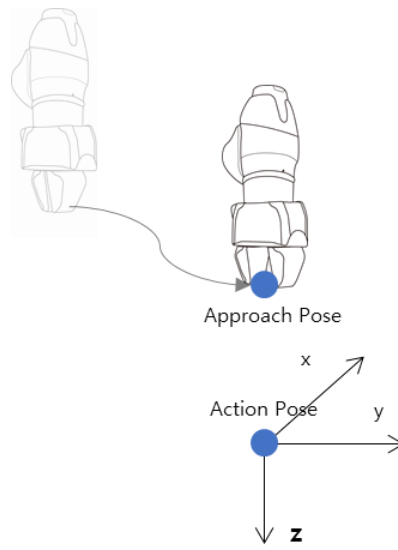
Skill commands are based on a few operation patterns.

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.

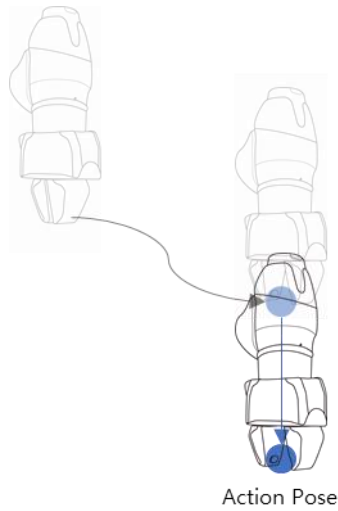
TCP Setting: Using an End Effector skill command will automatically change the TCP offset setting. The End Effector skill command execution stage includes an offset setting suited for the TCP of the End Effector. If the TCP offset changes, the Blending Motion function, which smoothly connects the previous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



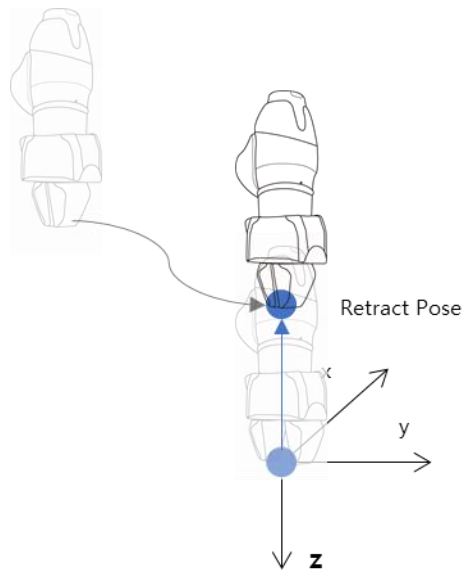
Move to **Approach Pose**: This is a point available to move to the Approach Pose. It is set in the -Z direction from the Approach Pose, and a different direction can also be selected. The Approach Distance entered is automatically calculated for the Action Pose and moves to the corresponding point.



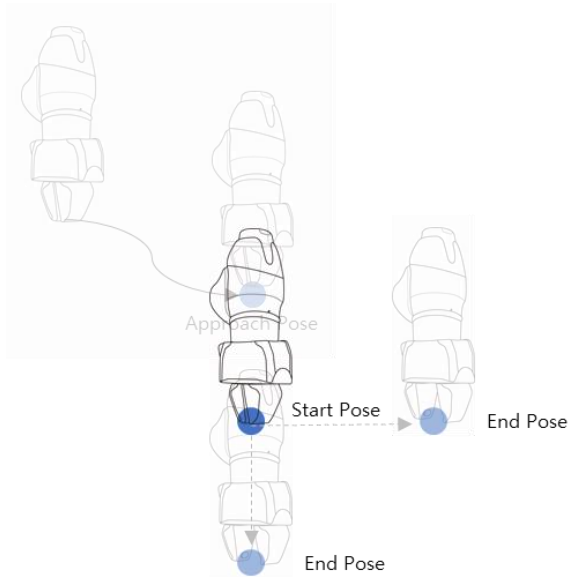
Move to Action pose: This is the point on the workpiece where the End Effector performs work. (e.g., Picking Pose, Placing Pose)



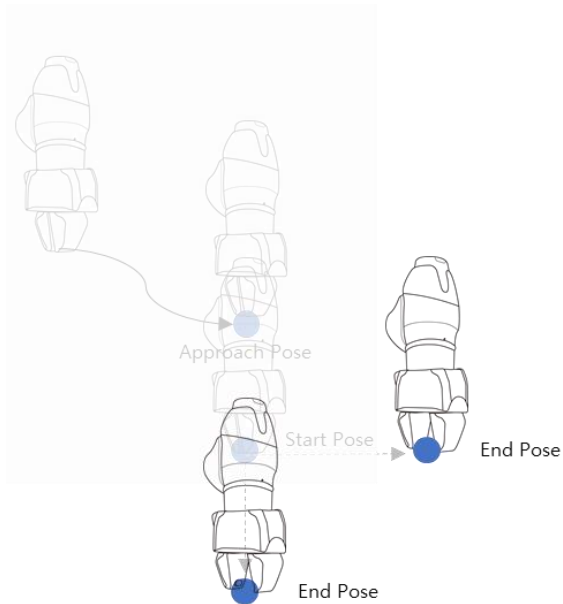
Move to Retract Pose: This is the point to pick up the workpiece and move it safely to another point. It is the -Z direction from the Approach Pose, and a different direction can also be selected. The Retract Distance entered is automatically calculated for the Action Pose and moves to the corresponding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



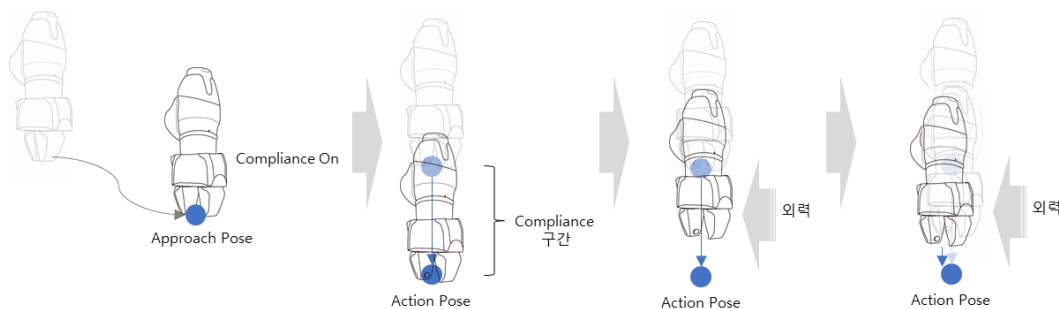
Move to Action End Pose: If the End Effector execution target does not end with a single motion, there may be an intermediate point and an end point, and the Action End Pose is the point where the work ends. (e.g., Door Open Skill – End Pose, Screw Drive Skill – End Pose)



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.

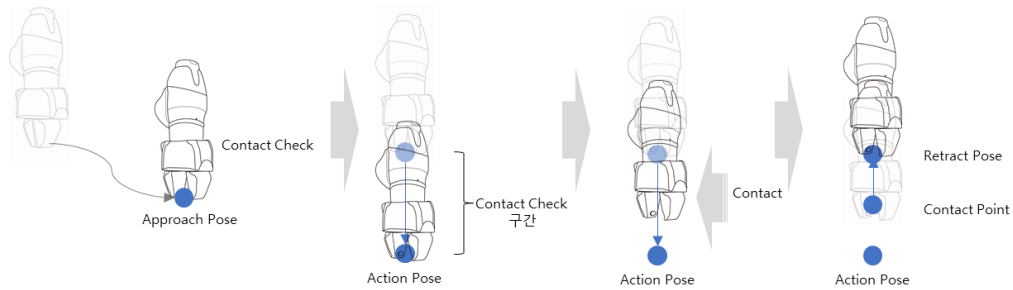


Contact Check: The function detects contact with the target, stops at a corresponding position and activates the gripper to grab the target based on the **Contact Force**, **Contact Determination Range** and **Authorized Force** values entered.

- 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.
- If FTS is not installed when using the A-Series, the Contact Detection function cannot be used. Also, Compliance Control can be used limitedly. Only the stiffness value of the Translation (X, Y, Z) direction can be modified.

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. |

| Item | Description |
|--------------------------------------|---|
| Retract Distance | This configures the offset distance for the Action Pose to allow movement without colliding with the target. |
| 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

It is the command for checking whether work has been completed.

| 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

It is a skill configured to execute the motion of closing the Turning Center Door. 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. It performs deburring according to the hole depth and repeat count configured based on the point entered.

| 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. |

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. |

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.

1.5.13 End

It is the skill that defines the end pose of the corresponding tool in a continuous deburring routine on a 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. |

| Item | Description |
|------------------------------|---|
| 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. |
| 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. |
| 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. |

 **Note**

If A-Series is not installed with FTS, the Insert skill cannot be used.

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

It is a skill configured to execute the motion of opening the Turning Center Door. 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. |

| Item | Description |
|------------------------------|---|
| 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. |

 **Note**

If A-Series is not installed with FTS, the Push skill cannot be used.

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.

1.5.42 Screwdrive

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 |
|-----------------|---|
| 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. |

| Item | Description |
|------------------------------|---|
| 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. |

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. |

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. |
| 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.

1.5.47 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 to use the Move Spline command.

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.
- The compliance function must simultaneously be enabled or disabled on Start/End skills.

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. |

 **Note**

If A-Series is not installed with FTS, the Touch skill cannot be used.

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

2.1.1 Single Gripper

| <u>Work Procedure</u> | <u>Command</u> |
|------------------------------|----------------|
| <u>Grasp the workpiece</u> | <u>Pick</u> |
| <u>Release the workpiece</u> | <u>Place</u> |

2.1.2 Double Gripper

| <u>Work Procedure</u> | <u>Command</u> |
|-----------------------------|----------------|
| <u>Grasp workpiece #1</u> | <u>Pick</u> |
| <u>Grasp workpiece #2</u> | <u>Pick</u> |
| <u>Release workpiece #1</u> | <u>Place</u> |
| <u>Release workpiece #2</u> | <u>Place</u> |

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

- Turning Center
- Air blow Nozzle
- Pallet

2.2.1 Single Gripper

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

2.2.2 Double Gripper

| <u>Work Procedure</u> | <u>Type 1</u> | <u>Type 2</u> | <u>Type 3</u> | <u>Type 4</u> |
|----------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | <u>Command</u> | | | |
| <u>Grasp the workpiece</u> | <u>Pick Pallet</u> | <u>Pick Pallet</u> | <u>Pick Pallet</u> | <u>Pick Pallet</u> |
| <u>TC ready check</u> | <u>Check TC Ready</u> | <u>Check TC Ready</u> | <u>Check TC Ready</u> | <u>Check TC Ready</u> |

| | | | | |
|-----------------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|
| <u>Open door</u> | <u>Open Auto TC Door</u> | <u>Open Manual TC Door</u> | <u>Open Auto TC Door</u> | <u>Open Manual TC Door</u> |
| <u>Finished piece air blowing</u> | = | = | <u>Air blow</u> | <u>Air blow</u> |
| <u>Unload finished piece</u> | <u>Pick TC</u> | <u>Pick TC</u> | <u>Pick TC</u> | <u>Pick TC</u> |
| <u>Chuck air blowing</u> | = | = | <u>Air blow</u> | <u>Air blow</u> |
| <u>Load the workpiece</u> | <u>Place TC</u> | <u>Place TC</u> | <u>Place TC</u> | <u>Place TC</u> |
| <u>Close door</u> | <u>Close Auto TC Door</u> | <u>Close Manual TC Door</u> | <u>Close Auto TC Door</u> | <u>Close Manual TC Door</u> |
| <u>Start processing</u> | <u>Start TC</u> | <u>Start TC</u> | <u>Start TC</u> | <u>Start TC</u> |
| <u>Release finished piece</u> | <u>Place Pallet</u> | <u>Place Pallet</u> | <u>Place Pallet</u> | <u>Place Pallet</u> |

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

| <u>Work Procedure</u> | <u>Command</u> |
|----------------------------|----------------|
| <u>Grasp the workpiece</u> | <u>Pick</u> |

| | |
|----------------------------------|----------------------------------|
| <u>Load the workpiece</u> | <u>Place Press Machine</u> |
| <u>Start processing</u> | <u>Start Press Machine</u> |
| <u>Press Machine Ready Check</u> | <u>Check Press Machine Ready</u> |
| <u>Unload finished piece</u> | <u>Pick Press Machine</u> |
| <u>Release finished piece</u> | <u>Place</u> |

2.3.2 Double Gripper

| <u>Work Procedure</u> | <u>Command</u> |
|----------------------------------|----------------------------------|
| <u>Grasp the workpiece</u> | <u>Pick</u> |
| <u>Press Machine Ready Check</u> | <u>Check Press Machine Ready</u> |
| <u>Unload finished piece</u> | <u>Pick Press Machine</u> |
| <u>Load the workpiece</u> | <u>Place Press Machine</u> |
| <u>Start processing</u> | <u>Start Press Machine</u> |
| <u>Release finished piece</u> | <u>Place</u> |

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

| <u>Work Procedure</u> | <u>Command</u> |
|----------------------------------|----------------------------------|
| <u>Press Machine Ready Check</u> | <u>Check Press Machine Ready</u> |
| <u>Unload finished piece</u> | <u>Pick Press Machine</u> |
| <u>Start processing</u> | <u>Start Press Machine</u> |

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

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

2.6 **Gluing**

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

- Gluing Tool

| <u>Work Procedure</u> | <u>Command</u> |
|-----------------------|-------------------|
| <u>Start Gluing</u> | <u>Start Glue</u> |
| <u>End Gluing</u> | <u>End Glue</u> |

2.7 **Deburring**

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

- Deburring Tool

| <u>Work Procedure</u> | <u>Command</u> |
|------------------------|---------------------|
| <u>Start Deburring</u> | <u>Start Deburr</u> |
| <u>End Deburring</u> | <u>End Deburr</u> |

2.8 **Polishing**

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

- Polishing Tool

| <u>Work Procedure</u> | <u>Command</u> |
|------------------------|---------------------|
| <u>Start Polishing</u> | <u>Start Polish</u> |
| <u>End Polishing</u> | <u>End Polish</u> |

Part 3
Smart Vision Module

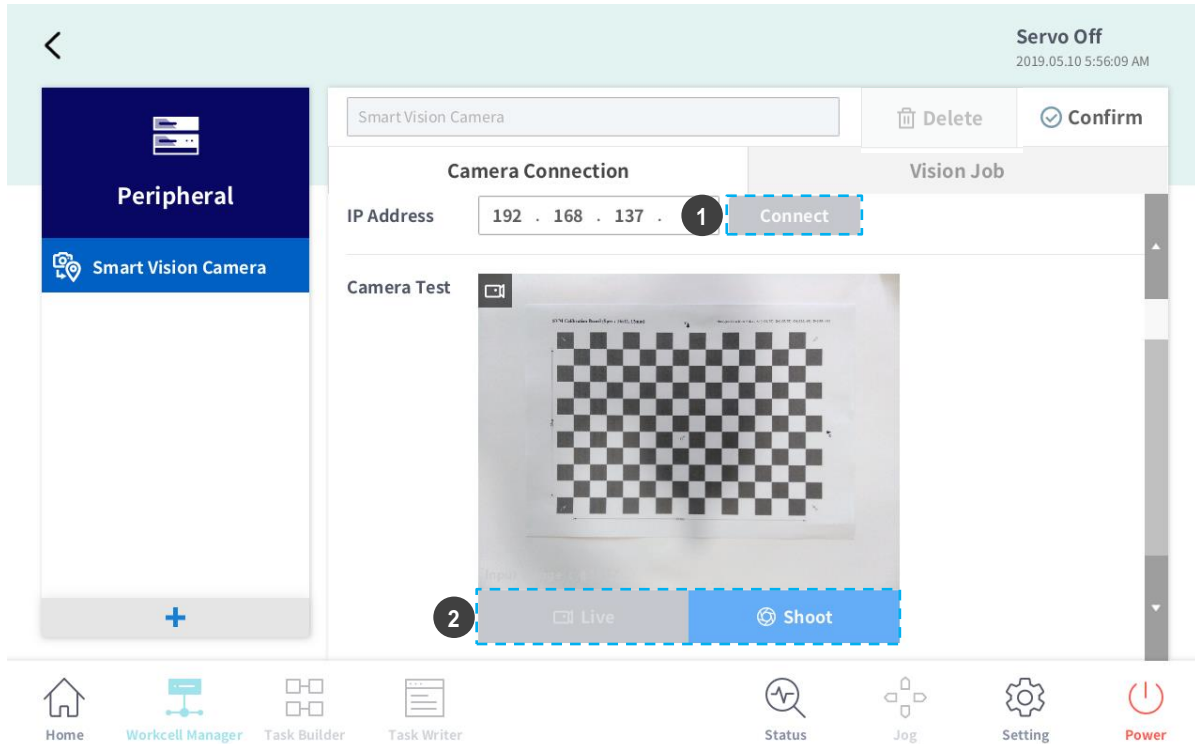
1. Precautions Before Use

- 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 heavily influenced by ambient illumination. Establish and maintain work conditions with illumination of 300 lux or higher in the camera measurement area.
- 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.

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 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.

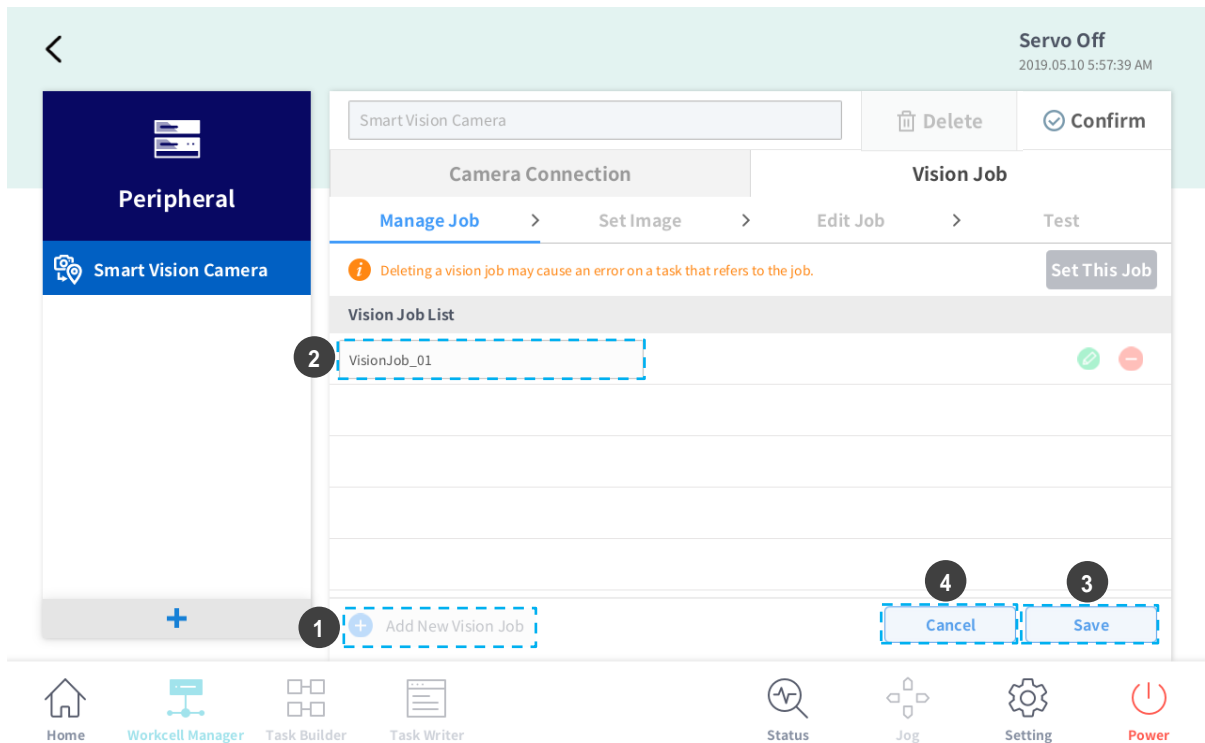
Status indicator LED function

- The status indicator LED on top of the SVM module operates in four modes: 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 |  |

2.2 Vision Job > Manage Job

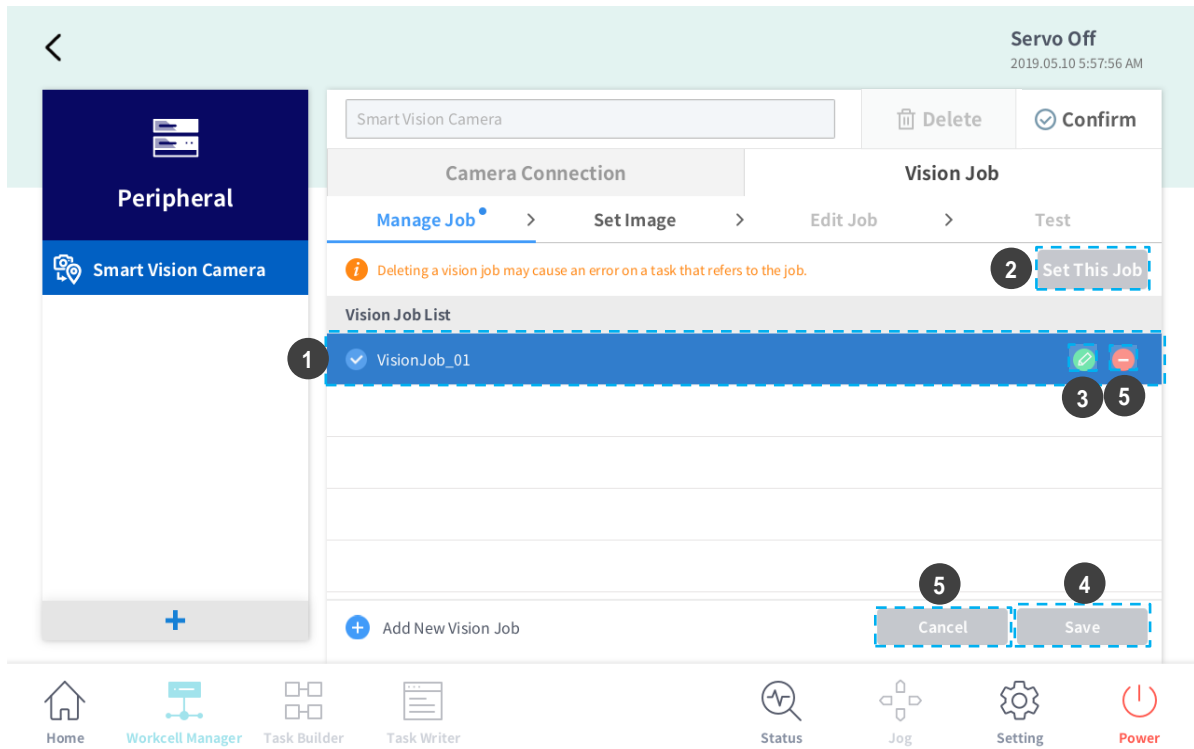
2.2.1 Create Vision Job



| 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 |

| No. | Item | Description |
|-----|------------------------|---|
| | | 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 | After the job name is edited, save the created job. |
| 4 | Cancel | Cancels the Vision Job creation. |

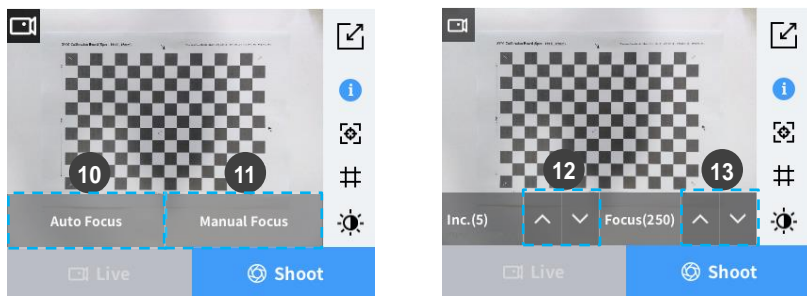
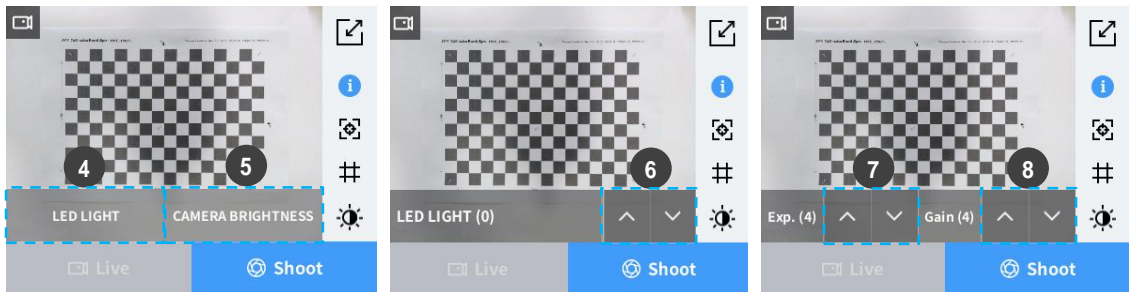
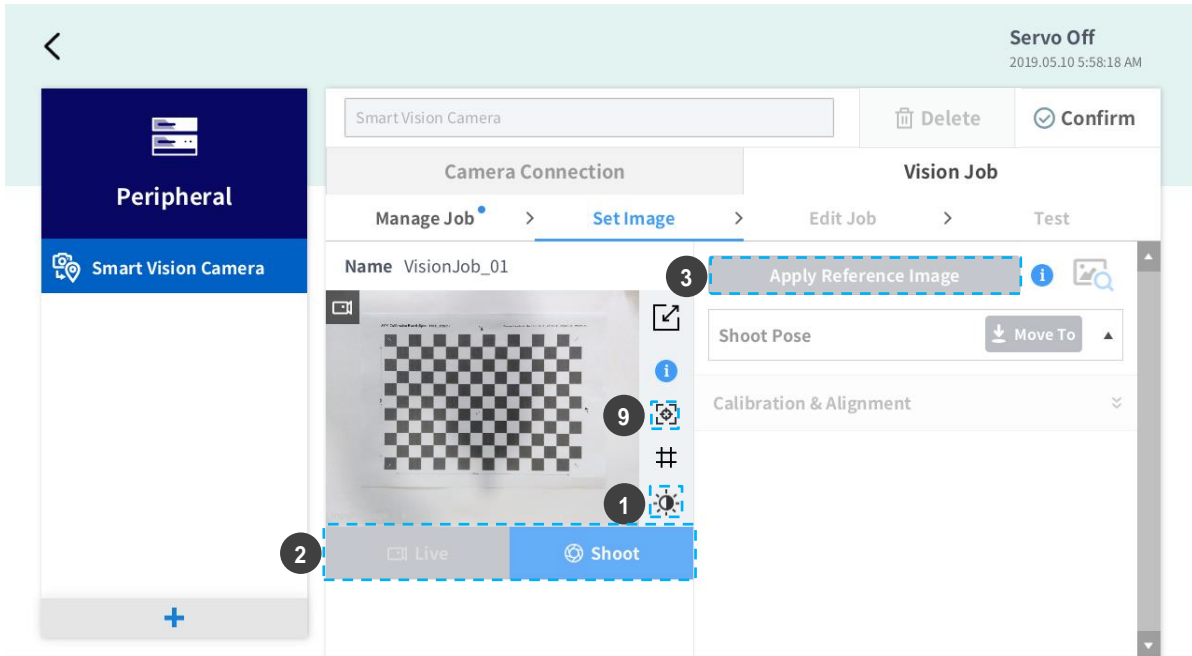
2.2.2 Edit and Delete Vision Job

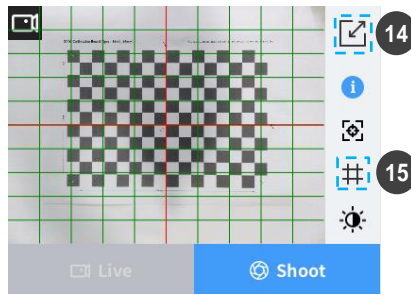


| No. | Item | Description |
|-----|------------------------|--|
| 1 | Vision Job List | The selected vision job is highlighted in blue. |
| 2 | Set This Job | The job selected from the Vision Job List is set as the Setting job. |
| 3 | 수정 | The job selected from the Vision Job List triggers the edit 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. |

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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • The exposure time of the camera can be adjusted from 0 to 10. • Higher numbers create a brighter image. |
| 8 | Gain Level Setting | <ul style="list-style-type: none"> • The gain level can be adjusted from 0 to 10. • Higher numbers increase image brightness, but this also increases image noise. |
| 9 | Focus Control | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • The focus of the camera is adjusted automatically. |
| 11 | Manual Focus | <ul style="list-style-type: none"> • Camera focus can be adjusted in a range from 0 to 500. |
| 12 | Inc | <ul style="list-style-type: none"> • The value changes in the order of 1, 5, 10, 50, and 100. |
| 13 | Focus | <ul style="list-style-type: none"> • The focus increases or decreases by the amount of Inc. |
| 14 | Full Screen | Displays the image in the full screen. |

| No. | Item | Description |
|-----|------|---|
| 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.

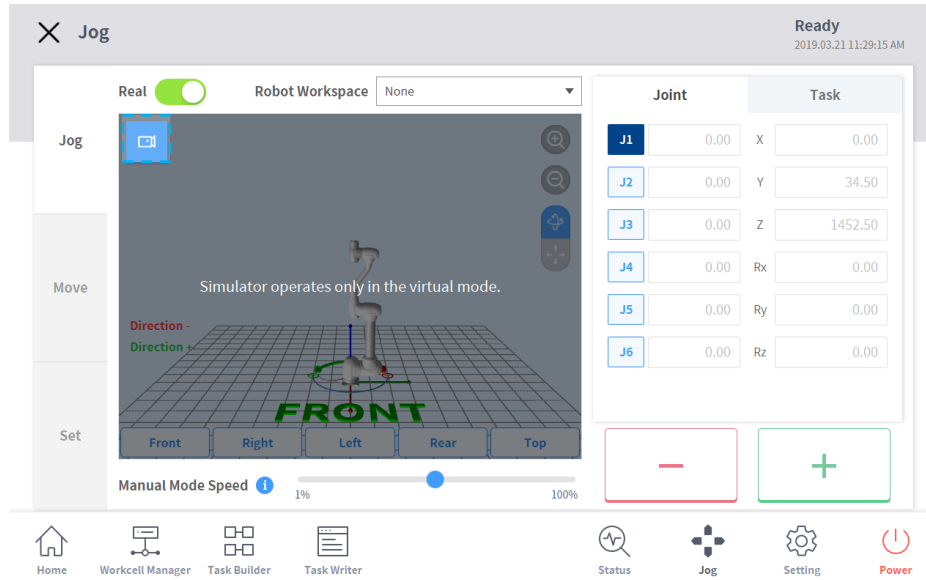


Caution

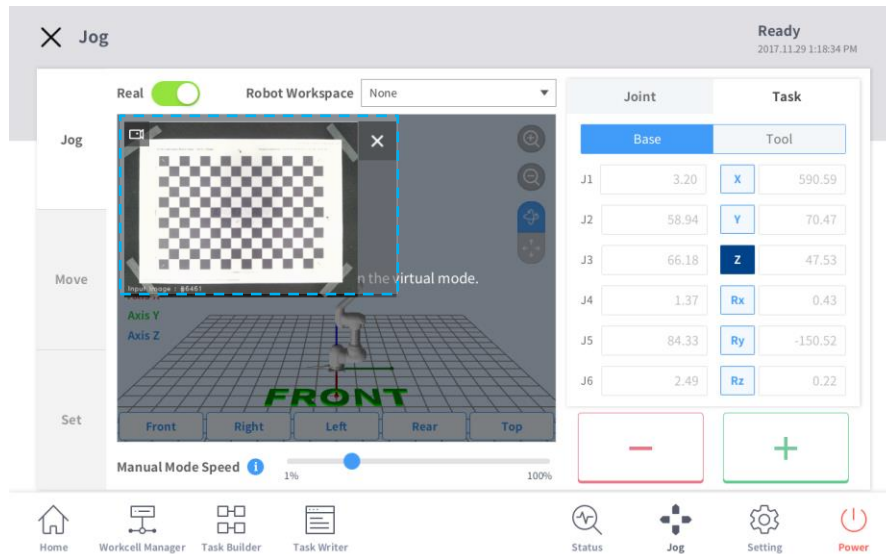
During calibration, it is necessary to align the camera lens and the checkerboard in parallel as much as possible. In addition, when performing calibration, the calibration board must be placed at the surface height of the item to be measured. If the height of the checkerboard during calibration differs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

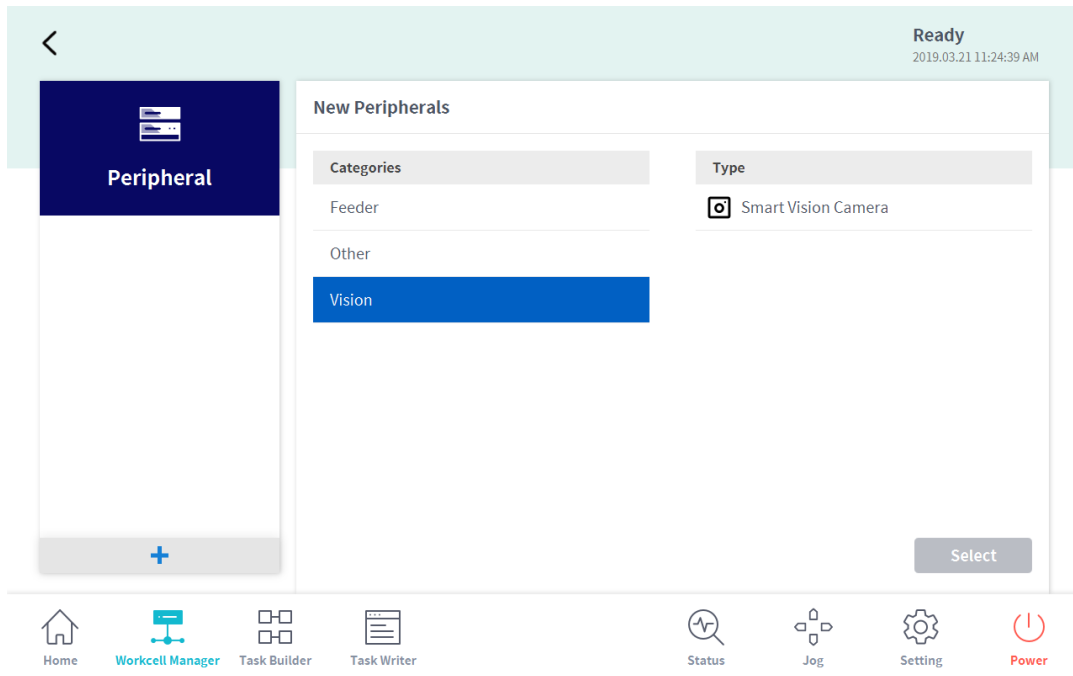
- The Live screen is displayed on the Jog



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

기술자료

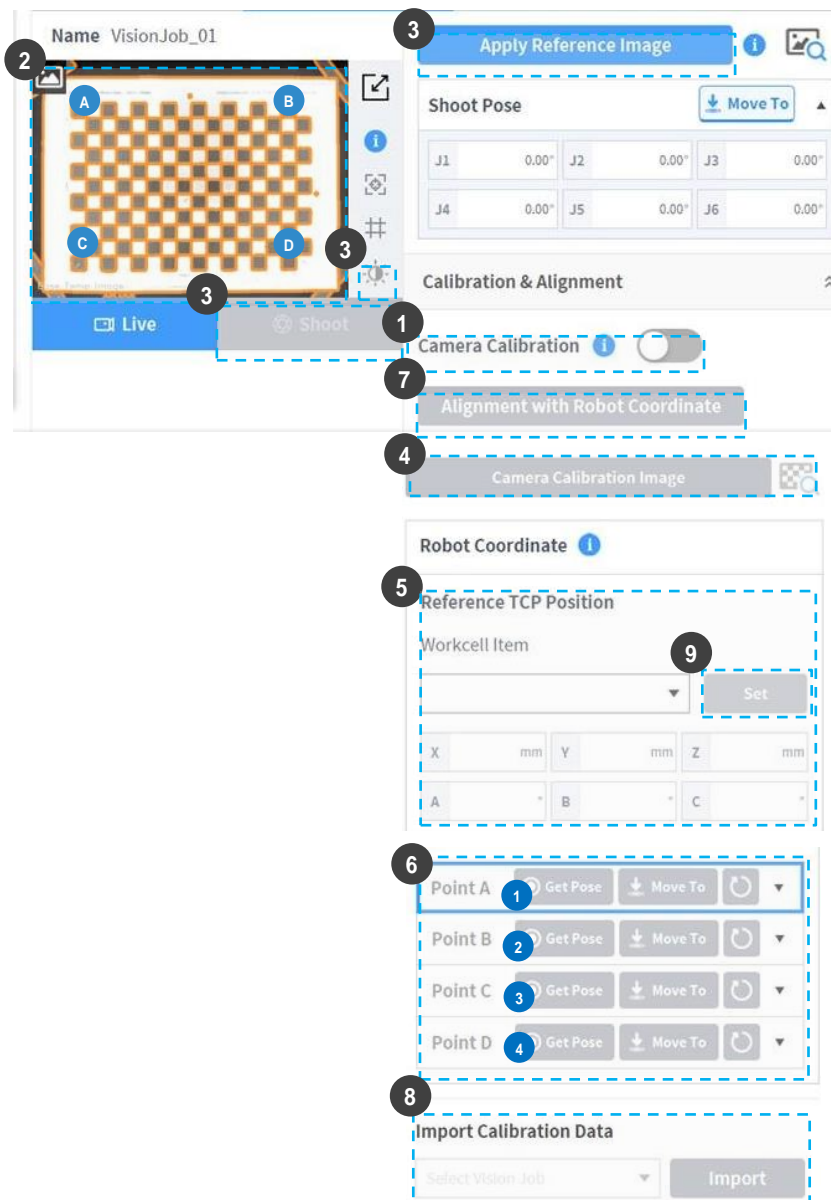
검색어를 입력하세요.



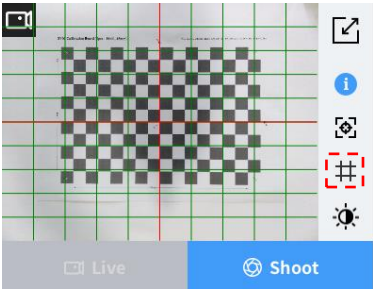
The screenshot displays a technical data page with a sidebar on the left containing filters for '2D 도면', '3D 모델', '인증서', and '참고자료', all of which are checked. The main content area features three cards:

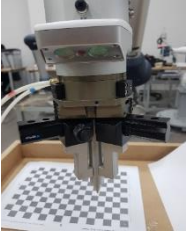
- SVM 보정용 보드** (SVM Calibration Board): 2019/06/04, with a '자세히 보기' button.
- Base & Flange Drawing**: 2019/04/18, with a '자세히 보기' button.
- Robot Model (STEP)**: 2019/03/22, with a '자세히 보기' button.

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



| No. | Item | Description |
|-----|--------------------|--|
| 1 | Camera Calibration | Enables Camera - Robot Calibration function. <ul style="list-style-type: none"> After the Camera Calibration function is enabled, the Camera Calibration Image button is enabled. |

| No. | Item | Description |
|-----|--|---|
| 2 | Live/Shoot Image | <p>The Live/Shoot Image can be checked.</p> <p>To ensure proper camera calibration, a checkerboard is placed as follows:</p> <ul style="list-style-type: none"> • 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:  <ul style="list-style-type: none"> • 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 | <p>Adjust the focus, brightness and lighting to display the edge of the checkerboard clearly.</p> <ul style="list-style-type: none"> • 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 | <p>Run checkerboard corner point detection.</p> <ul style="list-style-type: none"> • 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 | <p>Sets the information of the Tool currently equipped on the robot as TCP.</p> <ul style="list-style-type: none"> 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  <p>to the Workcell Manager End Effector Management section of the User Manual.</p> |
| 6 | Obtain PointA - PointD Points | <p>Obtains the robot pose [x, y, z, rx, ry, rz] of PointA - PointD.</p> <ul style="list-style-type: none"> 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. |

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).

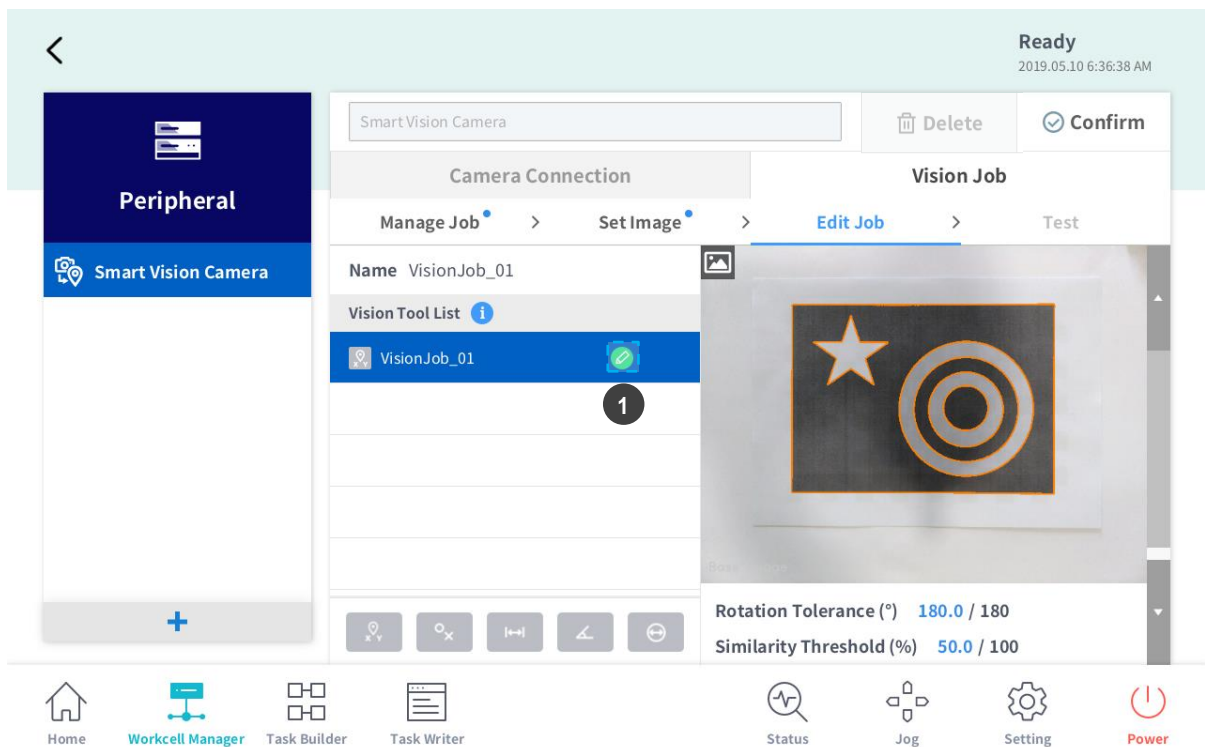
Items to Check Upon Failure

- 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. <ul style="list-style-type: none"> 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. |

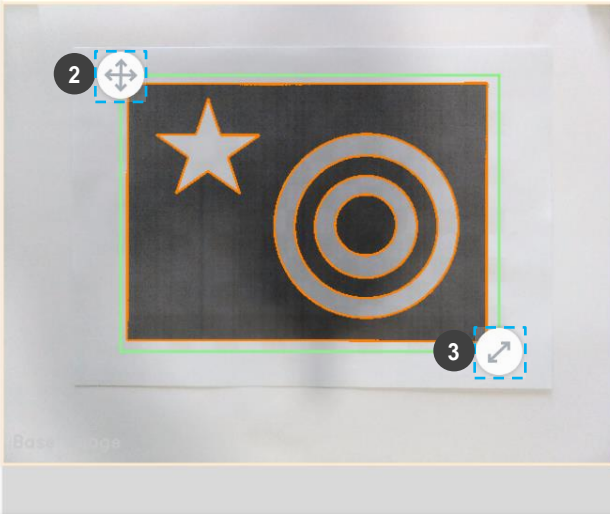
2.4 Vision Job > Edit Job

2.4.1 Vision Tool Teaching Area Setting





Edit Position



12 Cancel 11 Apply

4 Position Name
VisionJob_01

5 Crop Inspection Area

6 Rotation Tolerance (°) 180

7 Similarity Threshold (%) 50

Advanced Option



Home



Workcell Manager



Task Builder



Task Writer



Status



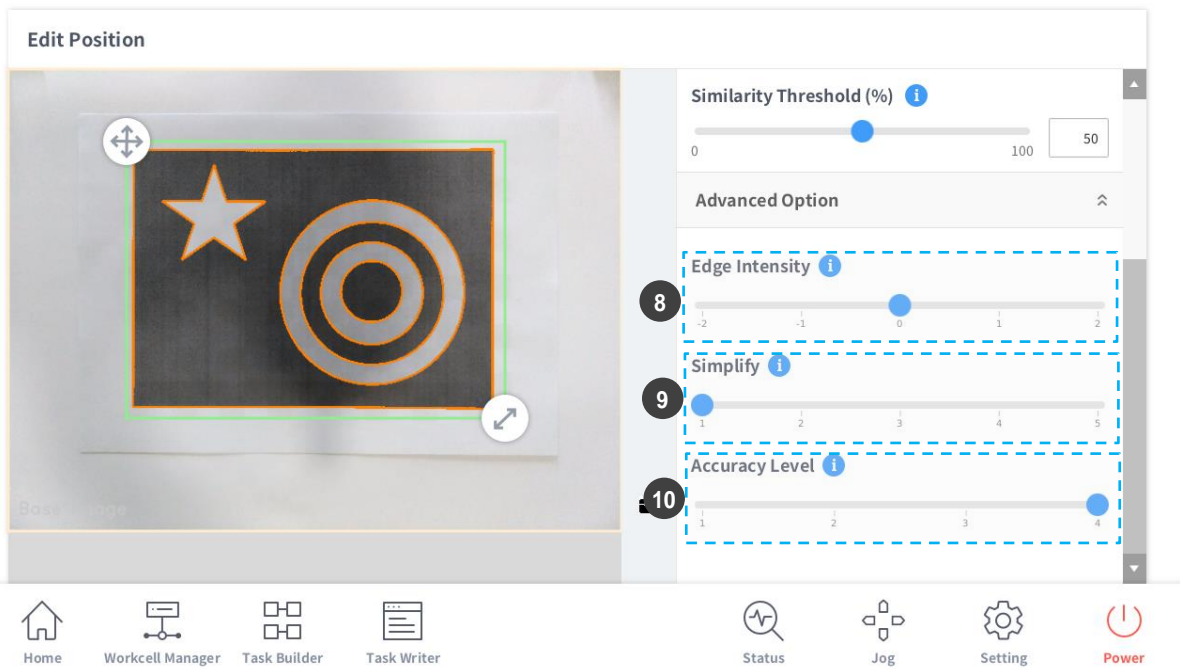
Jog



Setting



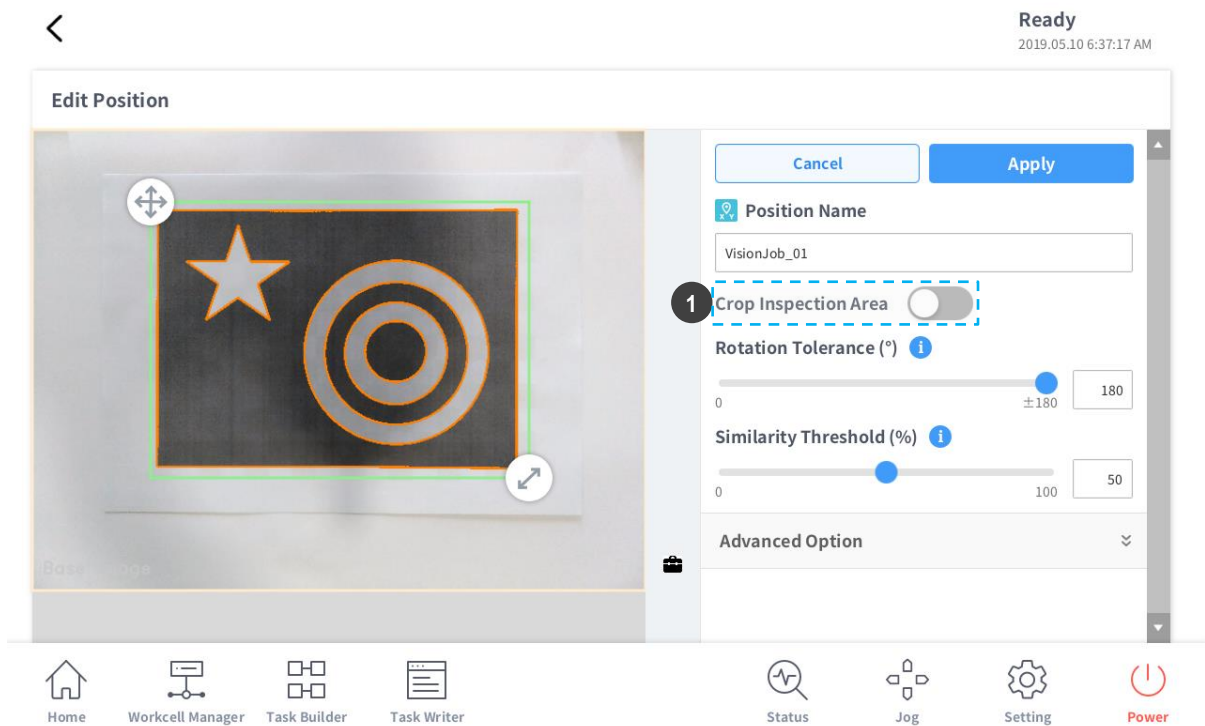
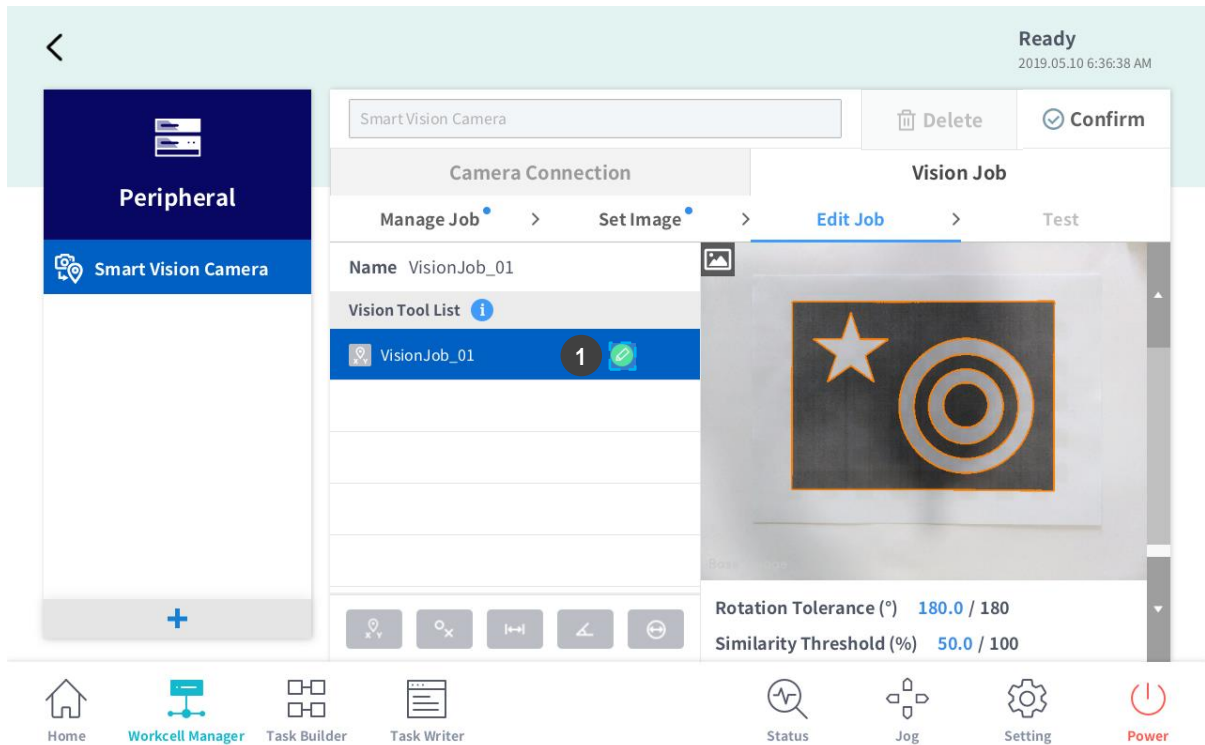
Power

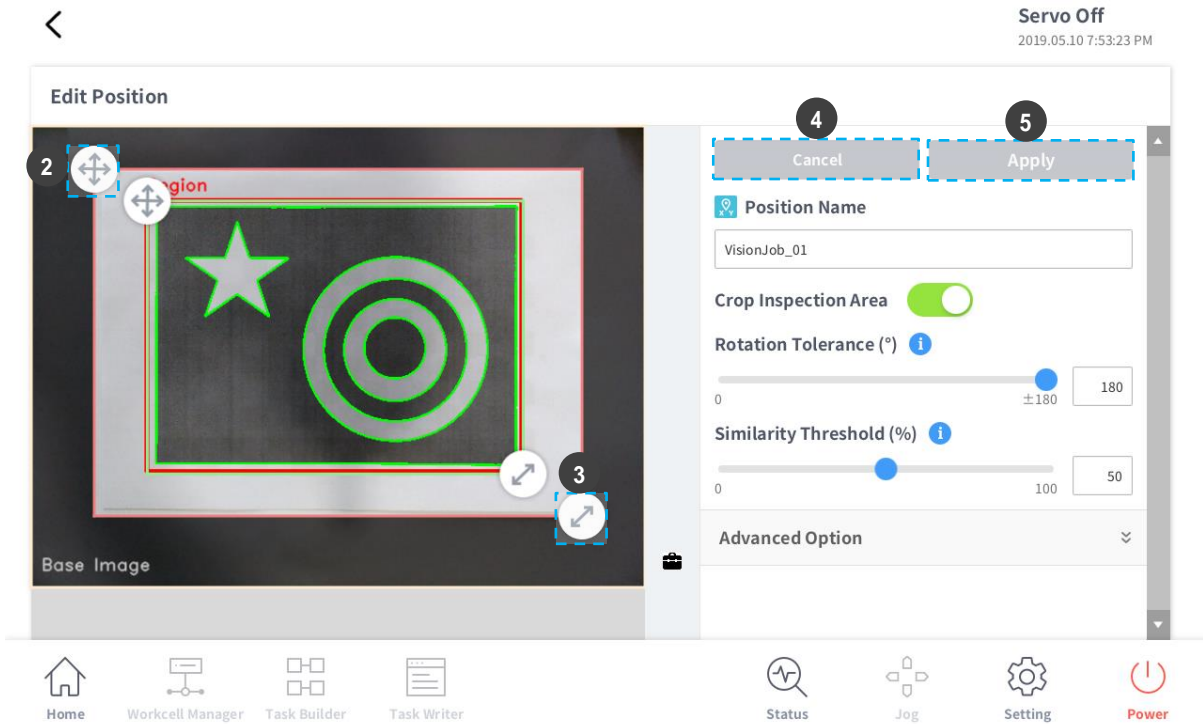


| No. | Item | Description |
|-----|---|---|
| 1 | Edit | The settings popup window for the job selected from the Vision Tool List is displayed. |
| 2 | Move Teaching Area (green area) | Press and hold the arrow to move the teaching area. <ul style="list-style-type: none"> Press the Apply button to set the selected area. |
| 3 | Adjust Teaching Area Size (green area) | Press and hold the arrow to adjust the teaching area size. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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... <ul style="list-style-type: none"> 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°) <ul style="list-style-type: none"> 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 |

| No. | Item | Description |
|-----|-----------------------------|--|
| | | <p>10° from the Reference Image. Setting a larger Angle Tolerance value increases detection speed, and a smaller value decreases detection speed.</p> <ul style="list-style-type: none"> • The tolerance is immediately applied when the scroll is moved. |
| 7 | Similarity Threshold | <p>Configures the similarity threshold from the reference value. (0~100%)</p> <ul style="list-style-type: none"> • 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 | <p>Sets the intensity of edges detected.</p> <ul style="list-style-type: none"> • Larger color differences in the area surrounding the edge result in higher edge intensity, and smaller color differences result in lower edge intensity. • 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 | <p>Clean up edges by simplifying them.</p> <ul style="list-style-type: none"> • 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 | <p>Adjust the Accuracy Level if you want to detect items more accurately or faster.</p> <ul style="list-style-type: none"> • 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



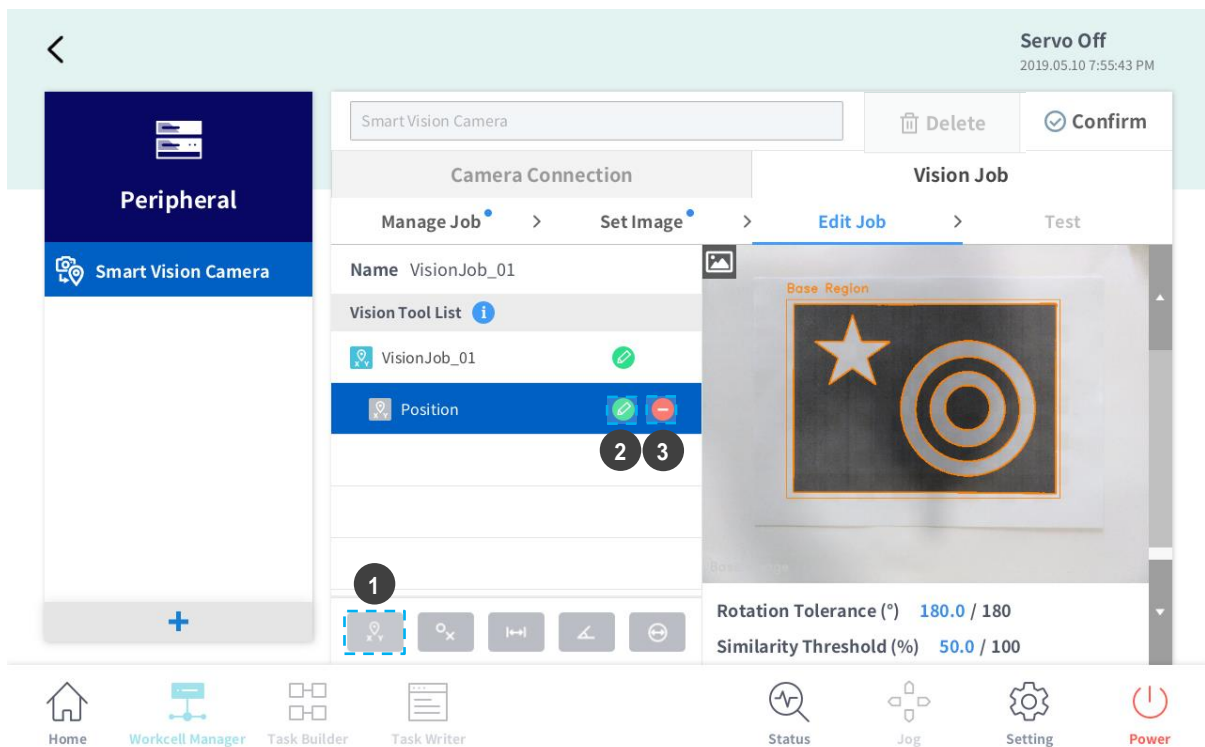


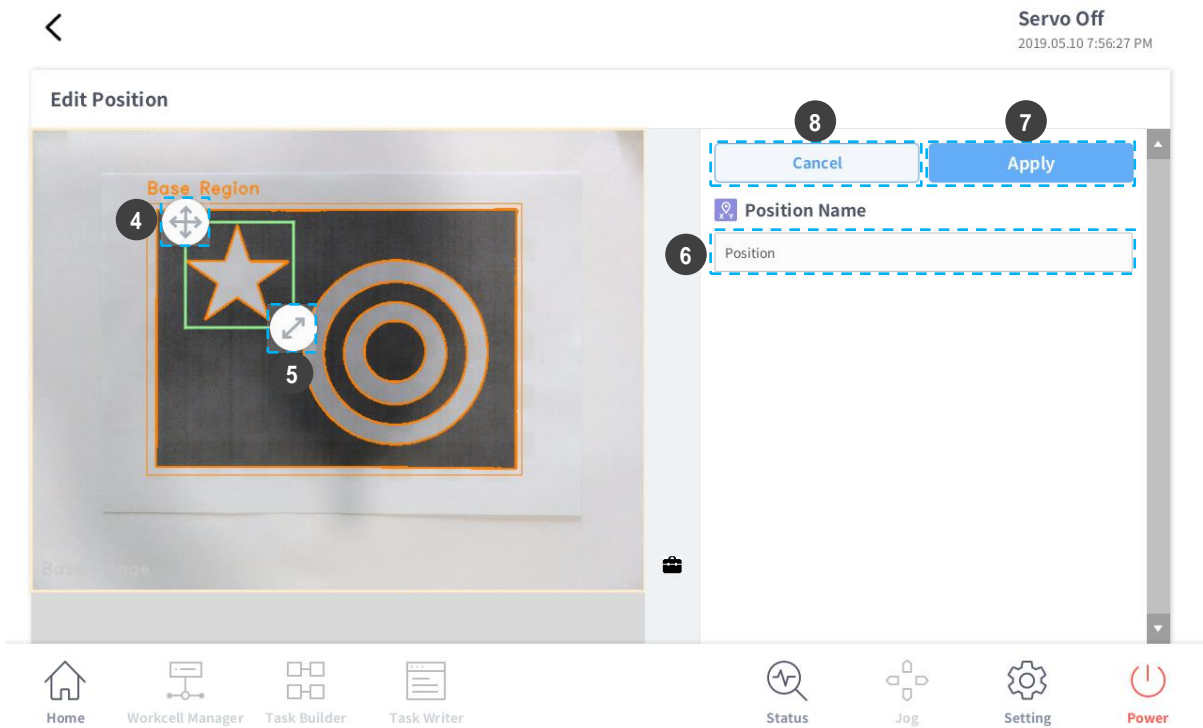
| No. | Item | Description |
|-----|--|---|
| 1 | Crop Inspection Area | Displays an area setting tool that limits the teaching area. <ul style="list-style-type: none"> The set area is saved by pressing the Apply button. |
| 2 | Move the Teaching Limit Area (red area) | Press and hold the arrow to move the area. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> The set area is saved by pressing the Apply button. |
| - | Scale/Move | Press the briefcase icon to display the Scale/Move selection window. <ul style="list-style-type: none"> 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. |

| No. | Item | Description |
|-----|--------|-----------------------------------|
| 5 | Cancel | Cancels Vision Job Tool 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.

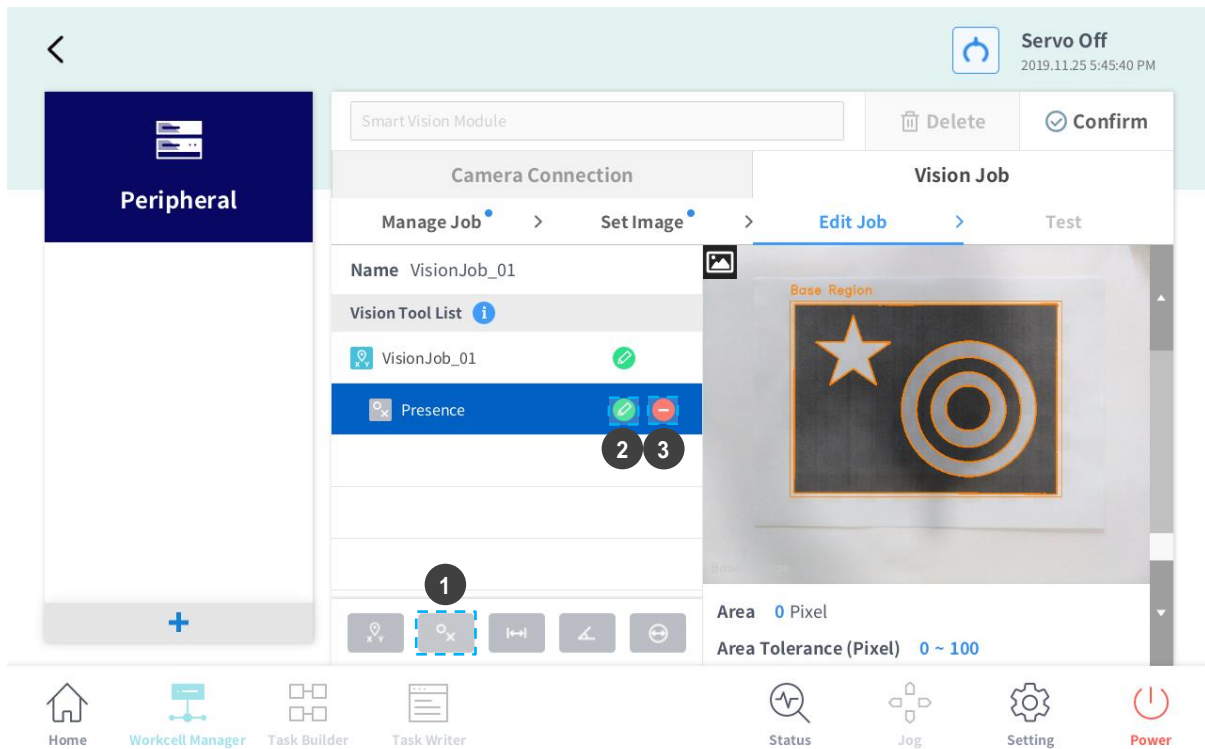


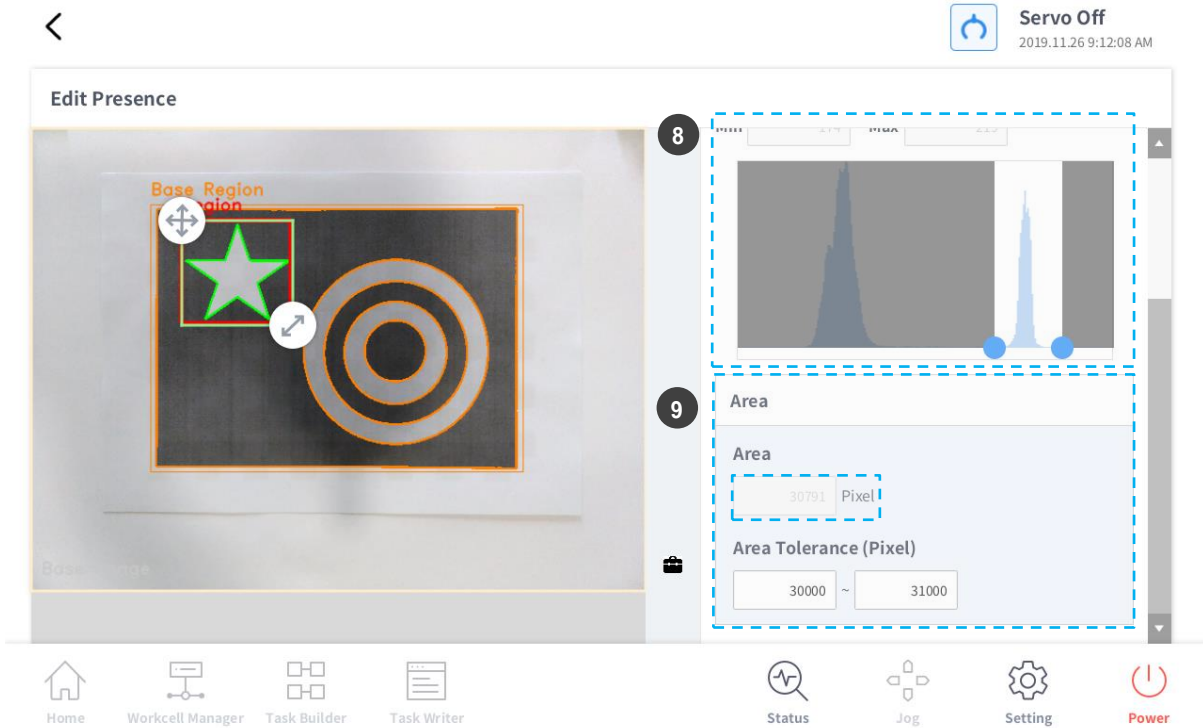
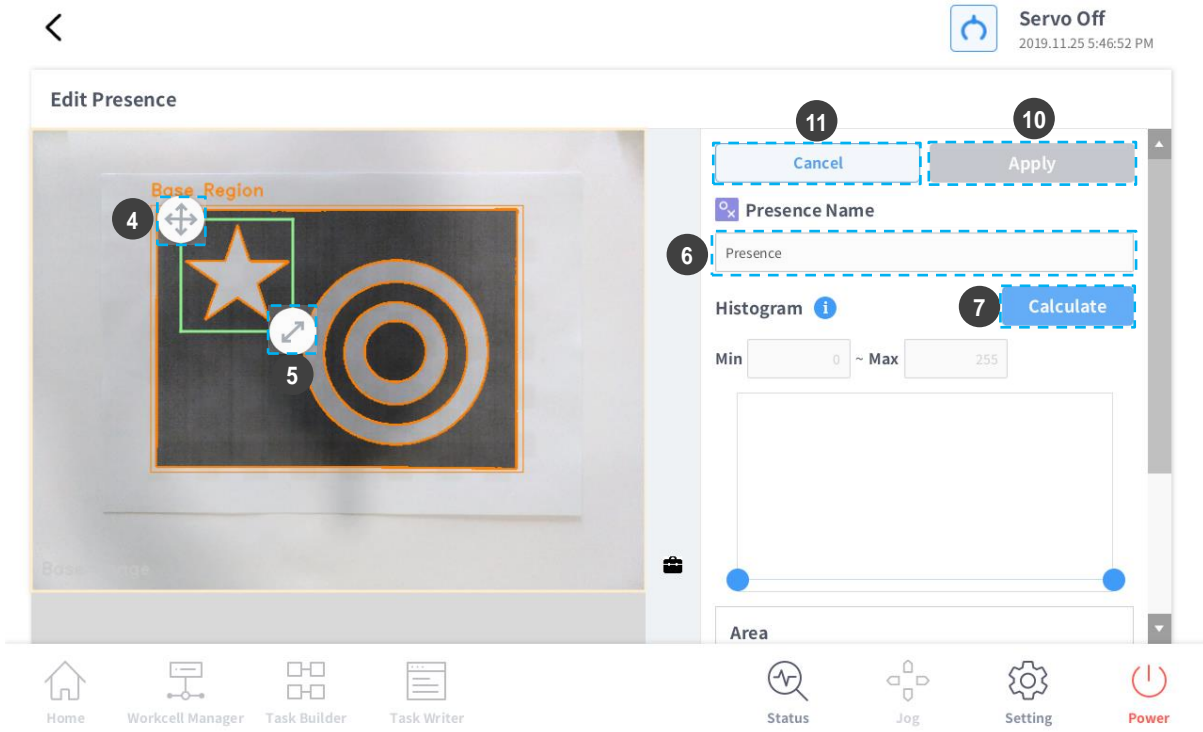


| No. | Item | Description |
|-----|------------------------------------|---|
| 1 | Add Position Tool | Adds a Position Tool to the Vision Tool List. |
| 2 | 수정 | A setting window of the job selected from the Vision Tool List is displayed. |
| 3 | Delete | The selected job from the Vision Job List is 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.

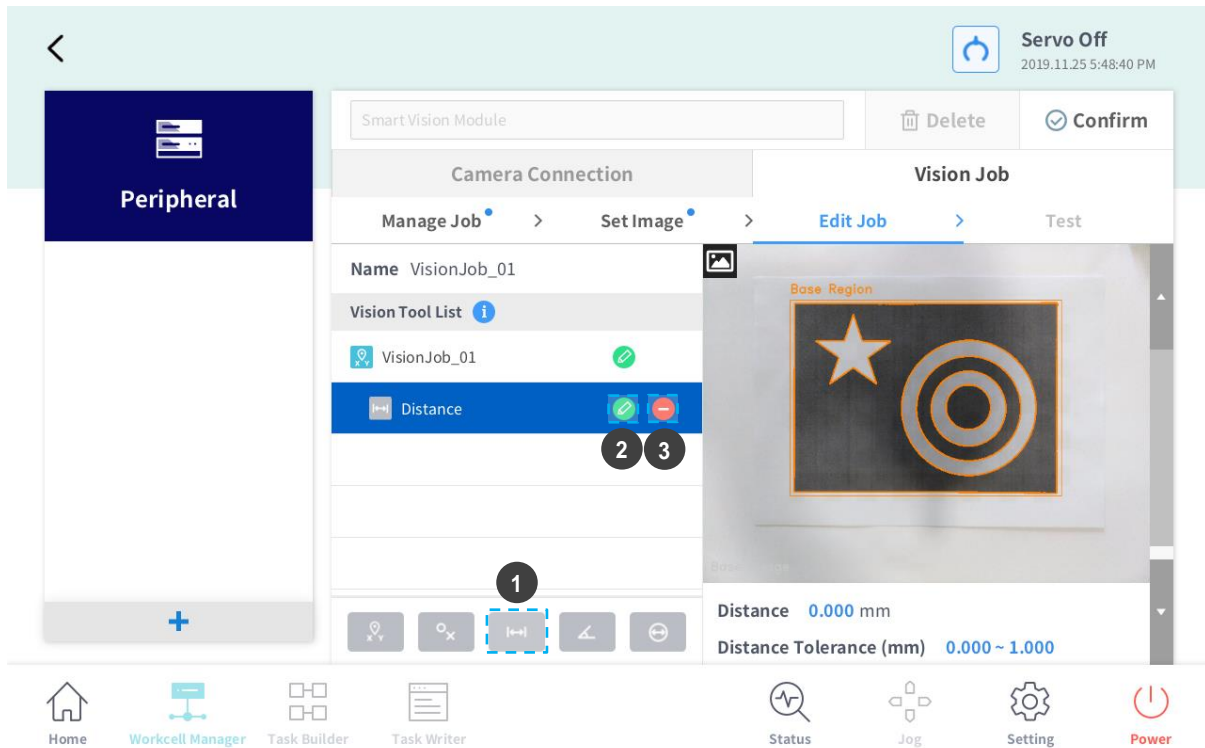




| No. | Item | Description |
|-----|-------------------------------------|--|
| 1 | Add Presence Tool | Adds a Presence Tool to the Vision Tool List. |
| 2 | Edit | A setting window of the job selected from the Vision Tool List is displayed. |
| 3 | Delete | The selected job from the Vision Job List 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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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

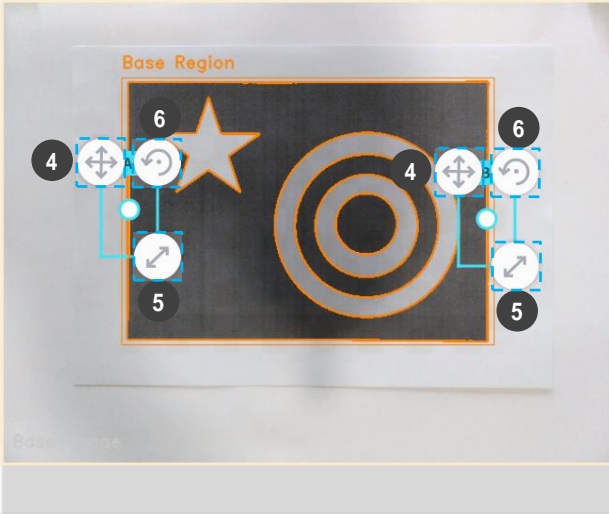
The Distance Tool measures the distance between two lines. Place areas A and B on a line you want to measure and press the Calculate button to measure the distance between A and B. Adjust the acceptance range (Tolerance) of the check based on measured distance values to set the distance check. [A→B]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



Cancel Apply

Distance Name

Distance

Distance *i* Calculate

0.000 mm

A → B B → A

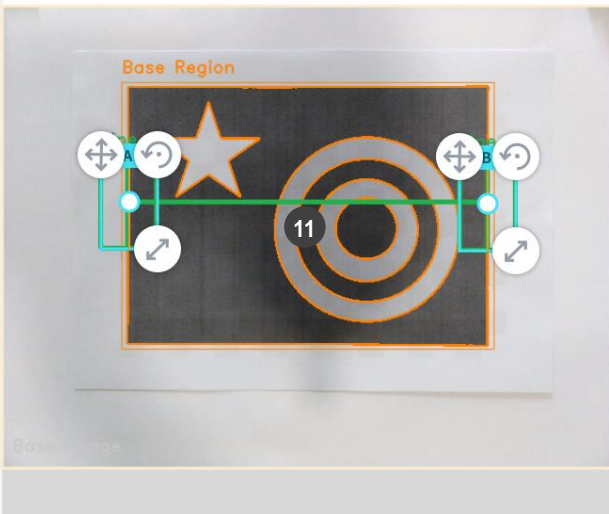
Distance Tolerance (mm)

0.000 ~ 1.000



Servo Off
2019.11.26 9:14:36 AM

Edit Distance



Cancel Apply

Distance Name

Distance

Distance *i* Calculate

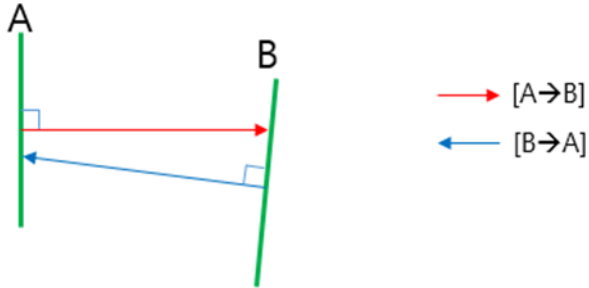
1125.010 mm

A → B B → A

Distance Tolerance (mm)

1120.000 ~ 1230.000



| 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) | <p>Select the directions for $A > B$ and $B > A$.</p> <ul style="list-style-type: none"> The direction is immediately applied when the button is pressed. $[A \rightarrow B]$ 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. |

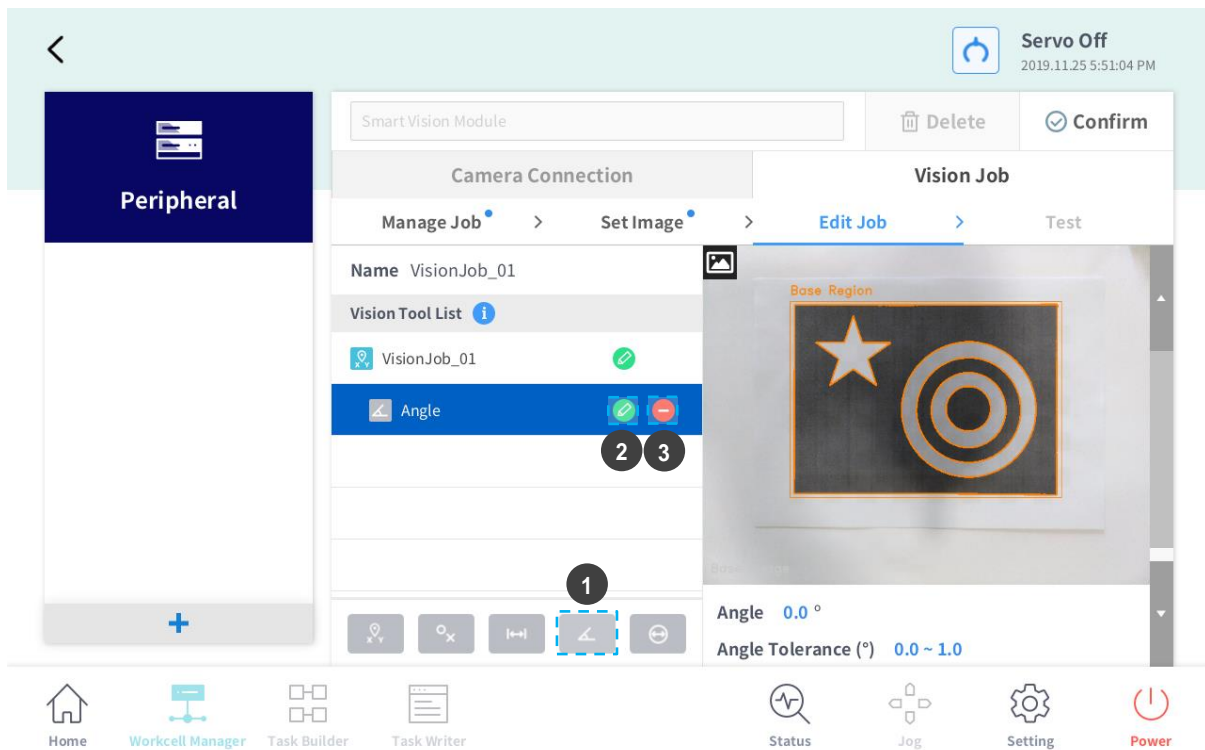
| No. | Item | Description |
|-----|-----------------------------------|--|
| 12 | Distance Tolerance Setting | Sets the line tolerance from the reference line value. <ul style="list-style-type: none"> If a value exceeds the Test tolerance range, the inspection result outputs 0. Press the Apply button to apply the setting.. |
| 13 | Apply | <ul style="list-style-type: none"> 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

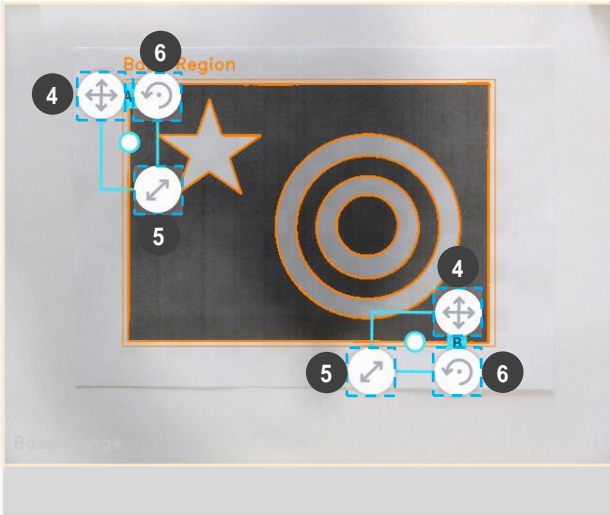
The Angle Tool measures the angle between two lines. Place areas A and B on a line you want to measure and press the Calculate button to measure the angle between A and B. Adjust the acceptance range (Tolerance) of the check based on measured angle values to set the angle check.





Servo Off
2019.11.25 5:51:38 PM

Edit Angle



Cancel Apply

Angle Name
Angle

Angle *i* Calculate

0.0 °

Angle Tolerance (°)

0.0 ~ 1.0



Home



Workcell Manager



Task Builder



Task Writer



Status



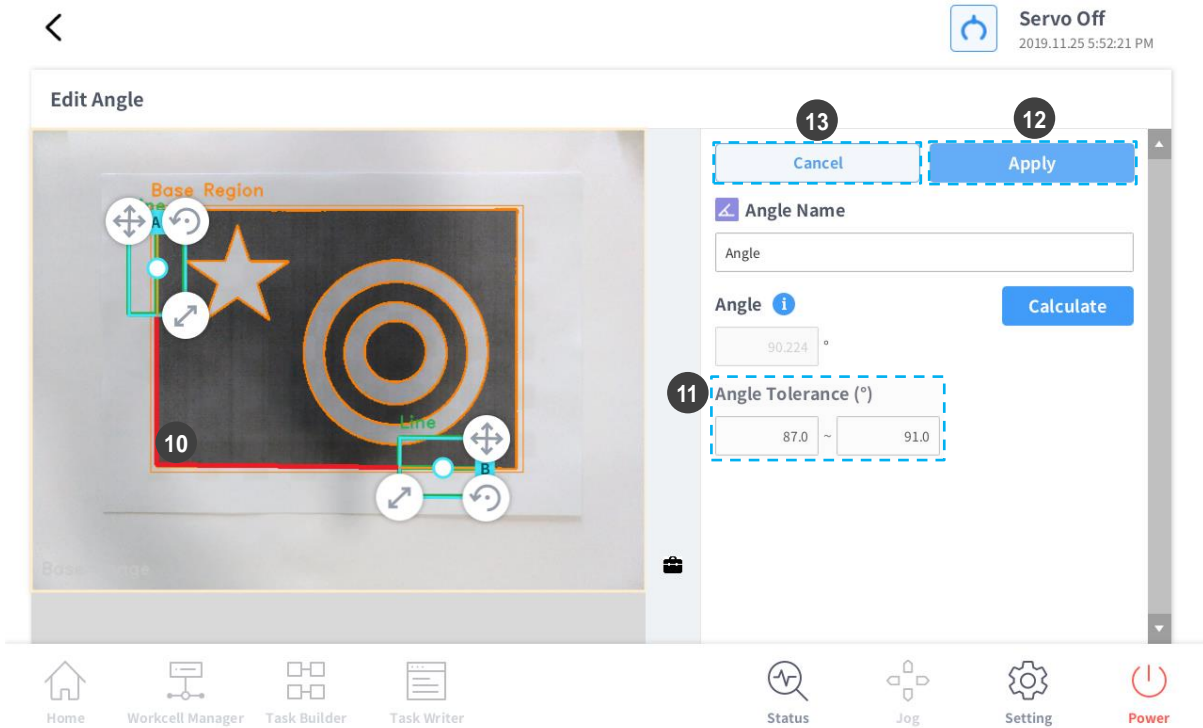
Jog



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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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. |

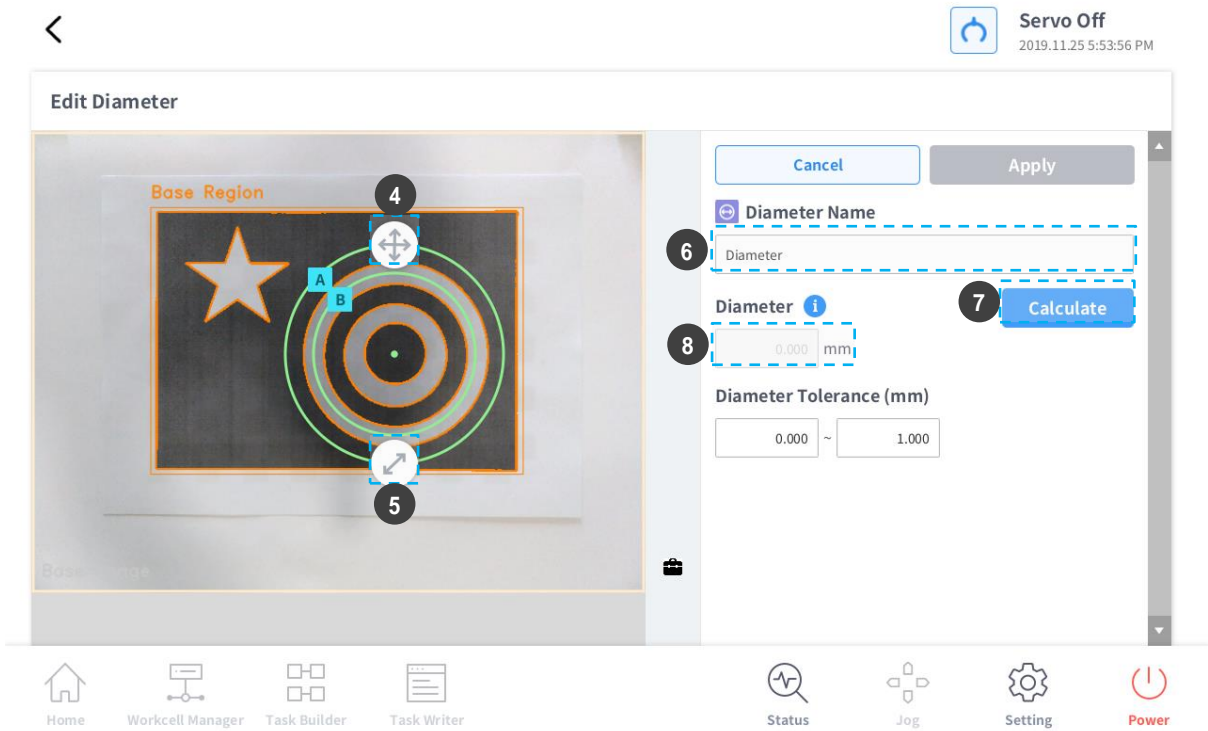
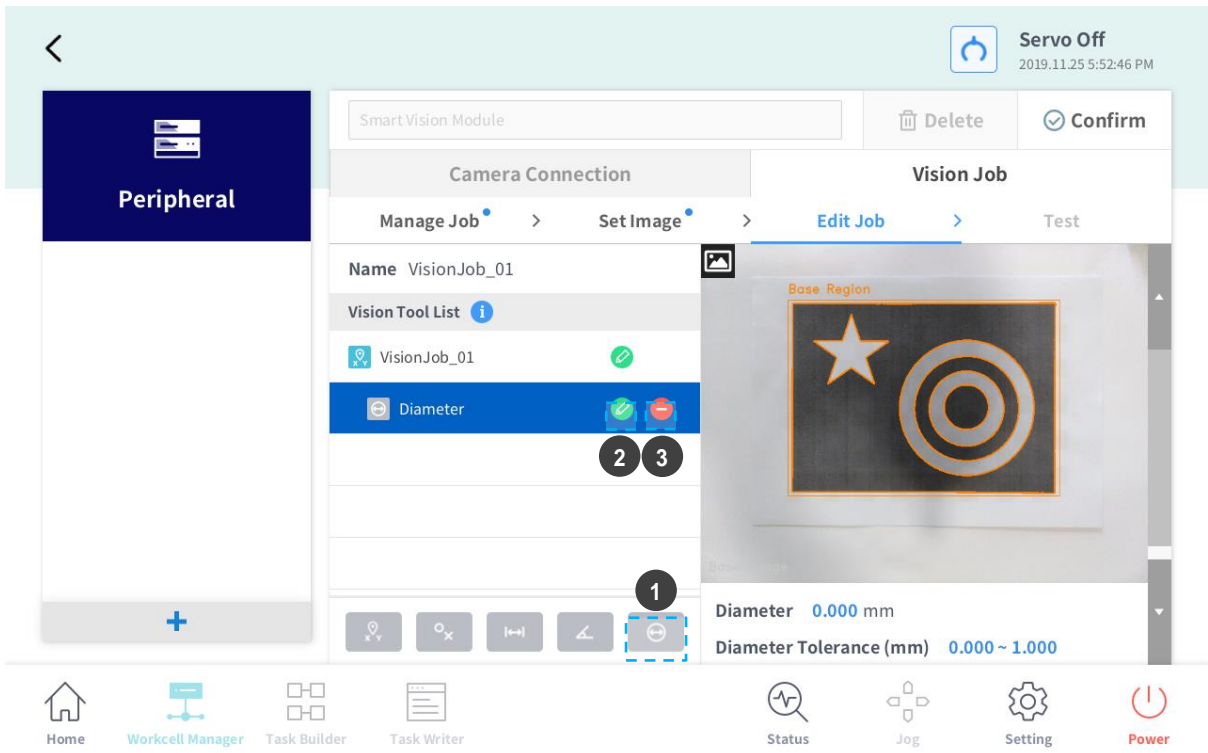
| No. | Item | Description |
|-----|-------------------------|--|
| 10 | Angle Image Display | Displays the angle between lines detected in two teaching areas on the image. |
| 11 | Angle Tolerance Setting | Configures the angle tolerance from the reference angle. <ul style="list-style-type: none"> • 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. |

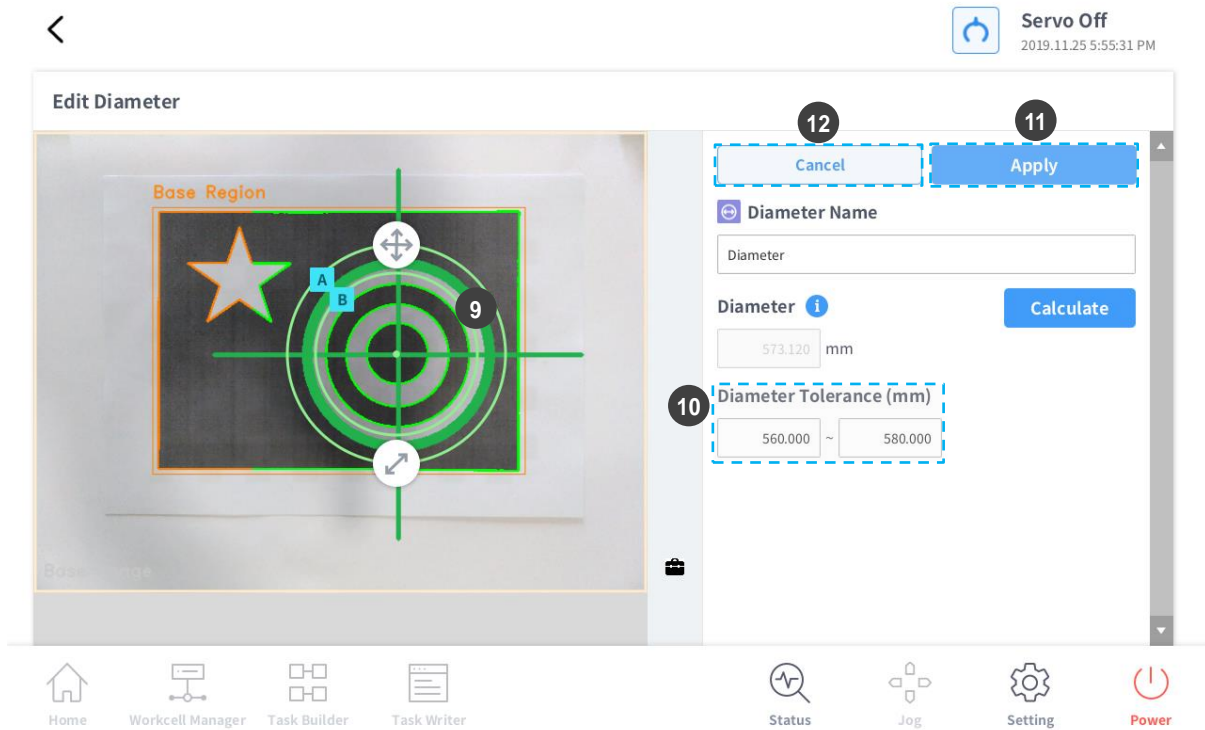


The center of Line A and Line B refers to the detected line center rather the guideline of the teaching area box.


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.





| No. | Item | Description |
|-----|------------------------------------|---|
| 1 | Add Diameter Tool | Adds a Distance Tool to the Vision Tool List. |
| 2 | e | 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. <ul style="list-style-type: none"> • 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, |

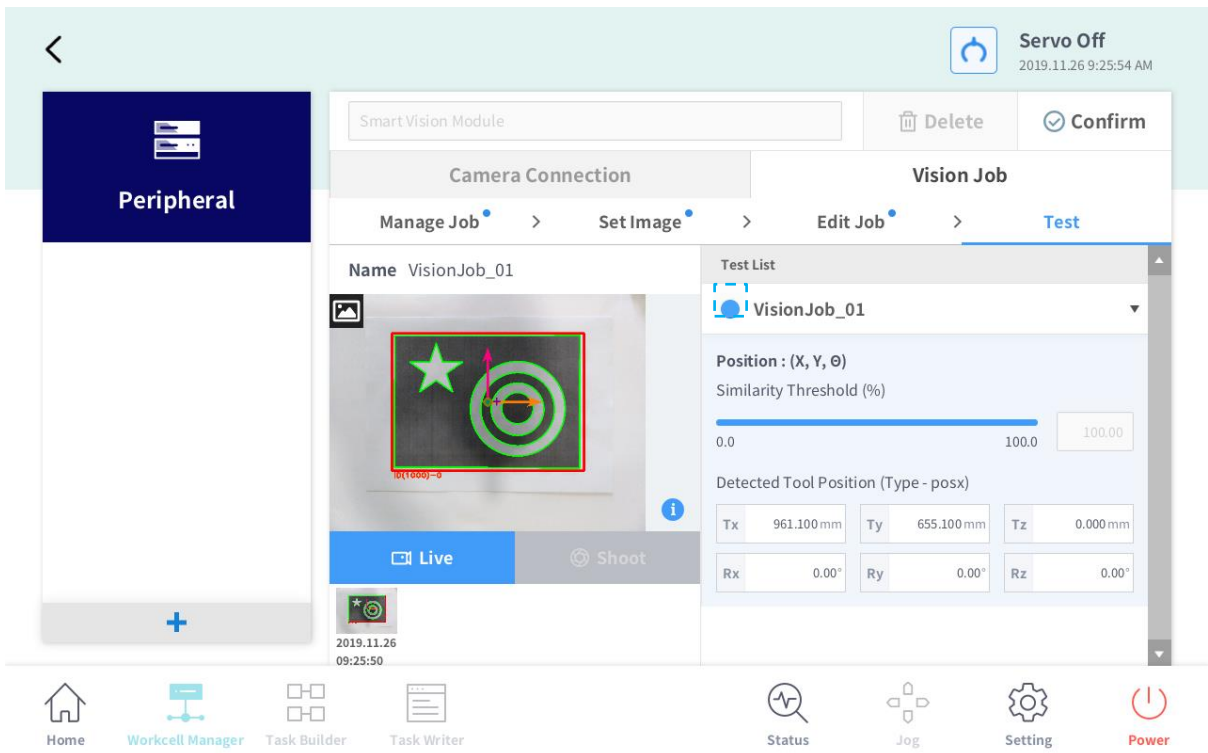
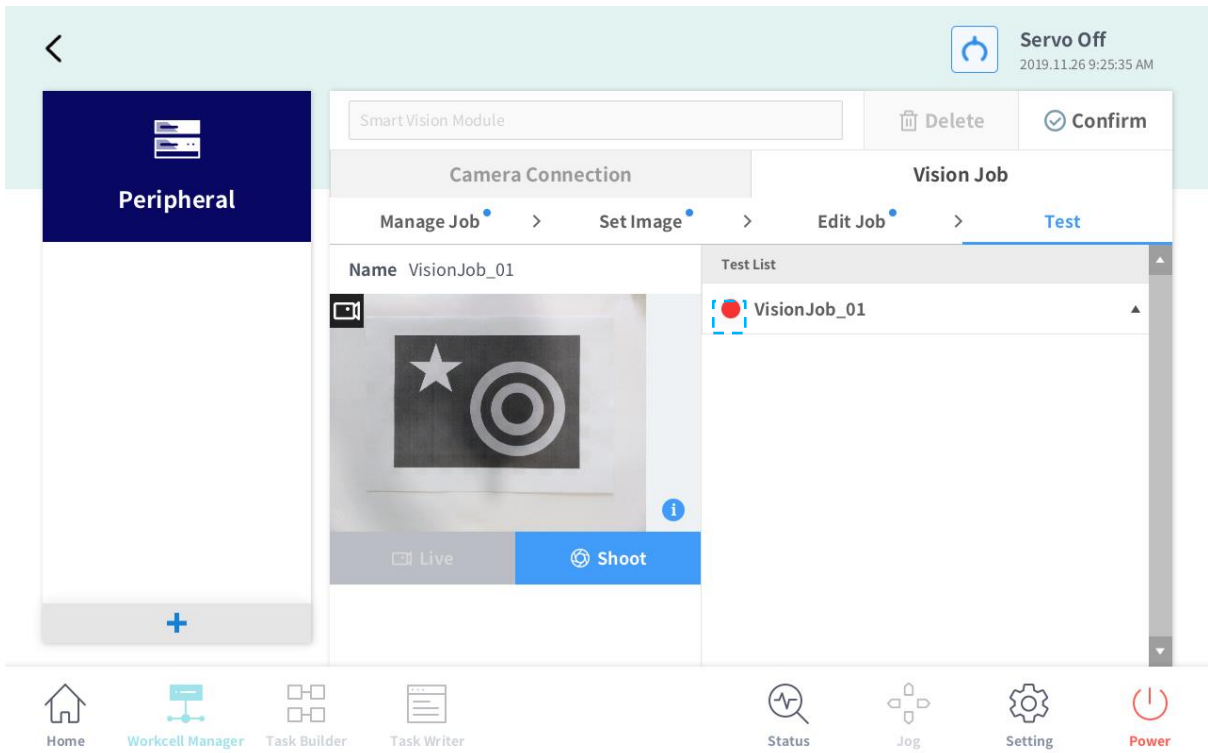
| No. | Item | Description |
|-----|--|---|
| | | <p>the circle between circle A and B is identified, and its diameter and center point positions are displayed.</p>  |
| 8 | Diameter Display (after #7) | Displays the diameter of the measured circle in the edit window. |
| 9 | Circle Display (after #7) | Displays the measured circle on the image. |
| 10 | Diameter Tolerance Length Setting - Edit Window | <p>Configures the length threshold from the reference length value.</p> <ul style="list-style-type: none"> • 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 | <p>Displays the image from the Live/Shoot mode, and the button changes to gray.</p> <p>The captured image is displayed beneath the Live/Shoot button.</p> <p>If the measurement is successful, the red circle (●) next to the Name changes to blue (●).</p> |

Tap the Confirm button after all tests are complete.



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

The screenshot shows the Task Builder interface for a task named 'Task_20171128_134538'. The 'Task List' on the left contains the following items:

| Tools | Task List |
|--------------|--|
| Multi-Select | 001 GlobalVariables |
| Copy | 002 CustomCode |
| Cut | 003 MainSub (Task Vel. 250.0, Acc. 1.0, Jo...) |
| Paste | 004 Vision |
| Delete | 005 End Vision |
| Row Up | 006 EndMainSub |
| Row Down | |

The 'Command' configuration panel for the 'Vision' command is shown on the right. It includes a 'Confirm' button and the following settings:

- 1** Select Vision Job: VisionJob_01
- 2** Move To Shoot Pose: Move To
- 3** [Image icon]
- 4** [Camera icon]

The bottom navigation bar includes: Home, Workcell Manager, Task Builder, Task Writer, Status, Jog, Setting, and Power.

5 Vision Variable configuration:


| Variable Name | Direction |
|-------------------------|-----------|
| VisionJob_01_pose | ▲ |
| VisionJob_01_similarity | ▲ |
| Presence_insp | ▲ |
| Presence_histogram | ▲ |
| Distance_insp | ▲ |
| Distance_distance | ▲ |
| Angle_insp | ▲ |
| Angle_angle | ▲ |
| Diameter_insp | ▲ |
| Diameter_diameter | ▲ |
| Diameter_pos | ▲ |

6 Advanced Option configuration:

Vision Exception

Retry: 0

Skip Vision Stop Task

| No. | Item | Description |
|-----|--|---|
| 1 | Select Vision Job | <p>The Vision Job List configured in the Workcell Manager displays the image of the Vision Job selected from the popup list.</p> <ul style="list-style-type: none"> • 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. <p>A Vision Job can be selected.</p> |
| 2 | Move to Shoot Pose | <p>Move to the Shoot Pose of the job selected with Select Vision Job.</p> <p>Disabling this option means that the Shoot Pose configured for the Vision Job will not be used.</p> |
| 3 | Display Image | <p>Default image, Live image and Shoot image are displayed.</p> |
| 4 |  Live/ Shoot | <p>Tap the Live button to display the live image.</p> <p>Tap the Shoot button to display the test result image.</p> <ul style="list-style-type: none"> • Obtains data of the Vision Tool added to the Vision Job with the Workcell Manager, and adds it to the Vision Variable list. <p>Live mode ends after 5 minutes of no action.</p> |
| 5 | Vision Variable | <p>Displays the data list of the Vision Tools added to the Vision Job.</p> <p>Press each item to view the values of the current Tool.</p> |
| 6 | Advanced Option > Vision Exception | <p>Select an action if Vision measurement fails.</p> <p>Retry: Set the number of Retry attempts if measurement fails. (Initial measurement + up to three retry attempts)</p> <p>Skip Vision: Skips the failed measurement stage and retries measurements according to the number of Retry attempts.</p> <p>Stop Task: Stops the Vision Task if measurement fails.</p> |



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

Task_20180630_162905 Ready
2018.06.30 4:29:32 PM

| Tools | Task List | Command | Property | Variable | Play |
|--------------|--|--------------------------|----------|----------|------|
| Multi-Select | 001 Global Variables | Advanced Command | | | |
| Copy | 002 Start MainSub (Task Vel. 250.0, Acc. 1.000, ...) | Vision | | | |
| Cut | 003 Vision | Hand Guide | | | |
| Paste | 004 1 Pick (Pneumatic Gripper) | Gripper Skill | | | |
| Delete | 005 End Vision | Pneumatic Gripper | | | |
| Row Up | 006 End MainSub | Destacking | | | |
| Row Down | | Grasp | | | |
| Suppress | | Pick | | | |
| | | Place | | | |

Home Workcell Manager **Task Builder** Task Writer Status Jog Setting Power

Task_20191126_150428 Ready
2019.11.26 3:11:09 PM

| Tools | Task List | Command | Property | Variable | Play |
|--------------|--|--|----------|-------------------------------------|------|
| Multi-Select | 001 Global Variables | Pick Confirm | | | |
| Copy | 002 Start MainSub (Task Vel. 250.0, Acc. 1.000, ...) | Release Sensor | | | |
| Cut | 003 Vision | <input type="radio"/> Picking Pose | | | |
| Paste | 004 3 Pick (Pneumatic Gripper) | Vision Position Offset | | <input checked="" type="checkbox"/> | |
| Delete | 005 End Vision | Vision Job | | VisionJob_01 | |
| Row Up | 006 End MainSub | Vision Variable | | VisionJob_01_pose | |
| Row Down | | Advanced Option | | | |
| Suppress | | | | | |

Home Workcell Manager **Task Builder** Task Writer Status Jog Setting Power

| No. | Item | Description |
|-----|--|--|
| 1 | Add Skill Command after Vision Shoot and before Teaching Position Entry | <p>Enter the desired robot position.</p> <p>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.)</p> <p>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.</p> |
| 2 | Picking Pose | Acquires the pose after moving the pose to pick based on the Vision Pose using direct teaching. |
| 3 | Vision Position Offset | <p>Match the Vision measurement pose and robot pose.</p> <p>The Vision measurement pose can be moved based on the robot.</p> |
| 4 | Vision Variable | Select a pose to match the Vision and robot coordinates. |

3.3 Task Writer: Using Vision in Motion Commands

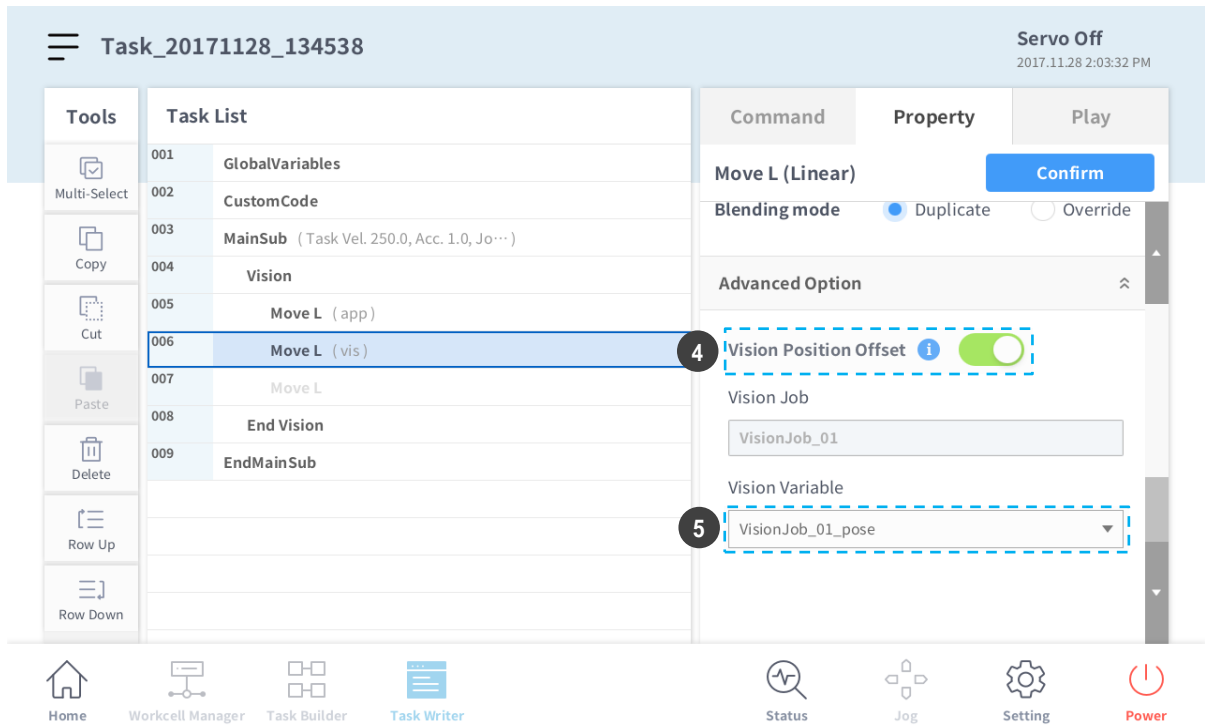
The screenshot displays the Task Writer interface for a task named 'Task_20171128_134538'. The top right corner shows 'Servo Off' and the time '2017.11.28 2:02:25 PM'. The interface is divided into several sections:

- Tools:** A vertical sidebar on the left contains icons for Multi-Select, Copy, Cut, Paste, Delete, Row Up, and Row Down.
- Task List:** A table with 9 rows:

| | |
|-----|--|
| 001 | GlobalVariables |
| 002 | CustomCode |
| 003 | MainSub (Task Vel. 250.0, Acc. 1.0, Jo... |
| 004 | Vision |
| 005 | Move L (app) |
| 006 | Move L (vis) |
| 007 | Move L |
| 008 | End Vision |
| 009 | EndMainSub |

 Circled numbers 1 and 2 point to the 'Move L (app)' and 'Move L (vis)' rows respectively.
- Command Panel:** On the right, the 'Command' tab is active, showing 'Move L (Linear)'. A 'Confirm' button is visible. Below this, the 'Coordinate' is set to 'BASE'. There are 'Absolute' and 'Relative' mode buttons. A 'Select Variable' dropdown is present. At the bottom of the panel, three buttons are shown: 'Get Pose' (circled with a 3), 'Move To', and 'Reset'. Below these buttons, a table displays coordinate values:

| | | | | | |
|---|-----------|---|----------|---|------------|
| X | 489.84 mm | Y | 74.31 mm | Z | -113.28 mm |
| A | 0.87° | B | -150.72° | C | -1.88° |
- Bottom Navigation:** A horizontal bar at the bottom contains icons for Home, Workcell Manager, Task Builder, Task Writer (highlighted), Status, Jog, Setting, and Power.



| 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 | <p>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.)</p> <p>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.</p> |
| 4 | Vision Position Offset | <p>Match the Vision measurement pose and robot pose.</p> <p>The Vision measurement pose can be moved based on the robot.</p> |
| 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.

2. Setting with Workcell Manager (WCI)

Set the External Encoder first, then check the Input Signal, and set the Conveyor Tracker.

2.1 External Encoder Setting

The External Encoder sets the Encoder Channel according to the encoder connection, sets A-B Phase according to the encoder specification, and sets S Phase Mode according to the triggering switch sensor specifications and configurations. For details on each setting, refer to User Manual 7.7.

2.1.1 Encoder Installation and A-B Phase Setting Check

To check whether encoder installation and A-B Phase settings are correct, check whether the Encoder Count of the Input Signal increases or decreases according to the setting by operating the conveyor.

2.1.2 Triggering Switch Installation and S Phase Setting Check

Whether triggering switch sensor installation and S Phase settings are correct can be checked in the settings of the External Encoder before setting the Conveyor Tracker. Set S Phase Mode as Count Clear Mode and allow workpieces to pass through the triggering switch, and see whether the Encoder Count is cleared as 0 or whether the Encoder Strobe Count increases by the set Edge amount.

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 connection with the conveyor.

2.2 Conveyor Tracker Setting

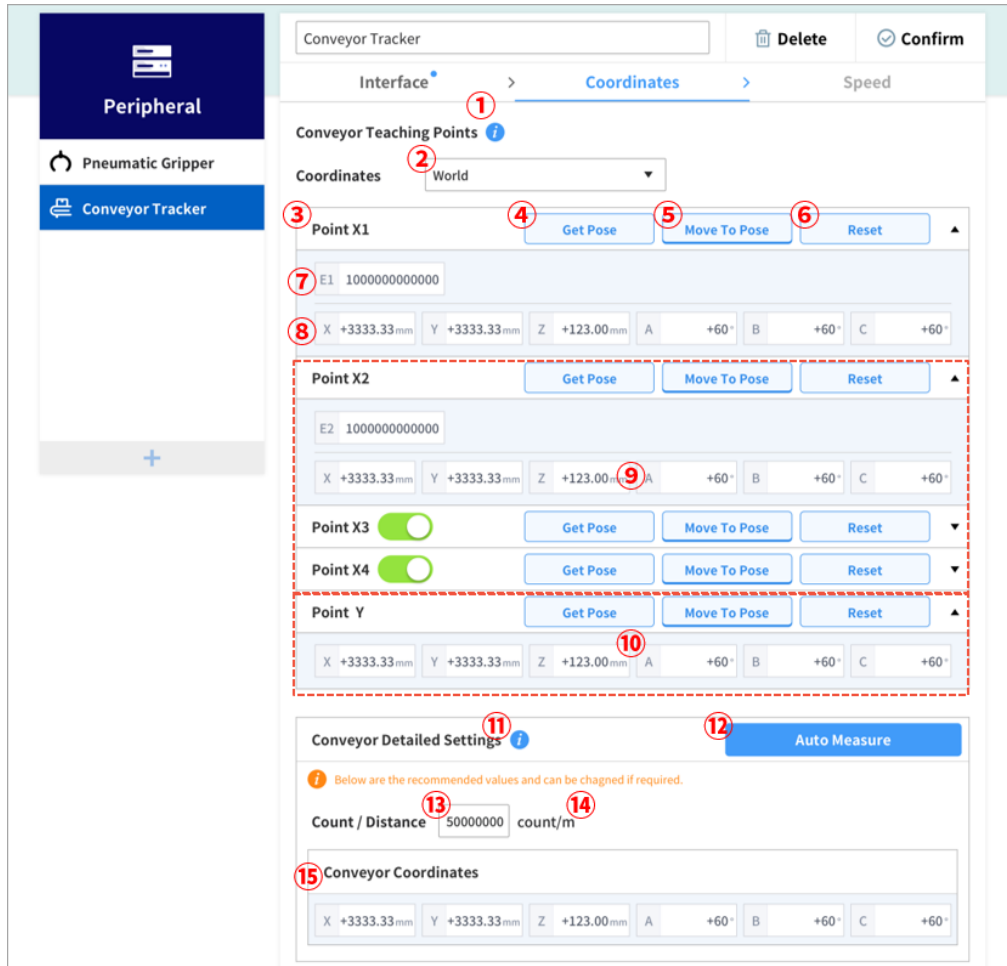
The Conveyor Tracker is set sequentially in the order of Interface > Coordinates > Speed tab. For basic settings, refer to User Manual 7.7. This section only describes noteworthy items in each tab.

2.2.1 Interface Setting

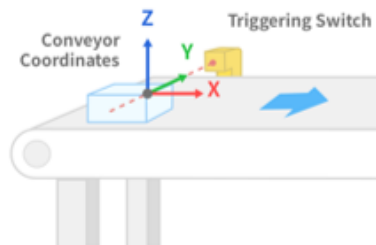
Triggering Mute Time is used when the noise in the triggering switch sensor is at an acceptable level. For example, when a workpiece passes through the triggering switch, there are cases where an edge is detected, but additional samples of the edge may be detected within a short period of time after 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 within the time to be ignored. This setting is used when the workpiece interval can be estimated and electrical noise cannot be controlled due to poor work environment conditions.

| | | | | |
|--|--------------------|--------------------|---|--------------|
| Conveyor Tracker | Delete | Confirm | | |
| Interface | > | Coordinates | > | Speed |
| Conveyor Type Linear | | | | |
| External Encoder Input | | | | |
| External Encoder can be configured at Workcell Item - Peripheral - External Encoder. | | | | |
| Encoder Workcell Item | External Encoder ▼ | | | |
| Triggering Mute Time | 0.0 | sec | | |

2.2.2 Coordinates Setting



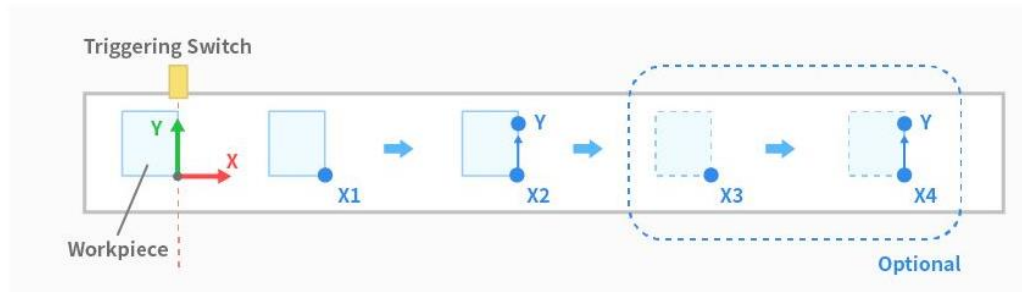
The purpose of the Coordinates tab is to set the Count/Distance value and Conveyor Coordinates of Conveyor Detailed Settings. It calculates the converted value, which indicates how much the Encoder Count increases when the conveyor moves, and which point the conveyor is fixed to in a particular space. The x-axis of the Conveyor Coordinates is the direction the conveyor moves in terms of the reference coordinates (Base or World).



Methods to calculate these values are Auto Measure after teaching the Conveyor Teaching Point to the robot and Manual calculation from the system design specifications. Auto Measure is recommended for the purpose of reducing errors, but Manual calculation is possible if it is difficult to teach the robot of the workpiece.

Auto Measure

Conveyor Teaching Points



Place a workpiece on the conveyor in the same way it would be during actual work. Operate the conveyor and stop the conveyor as soon as the workpiece passes the triggering switch of the conveyor. Teach the reference point of the workpiece at this moment, and acquire the location of Point X1 using Get Pose.

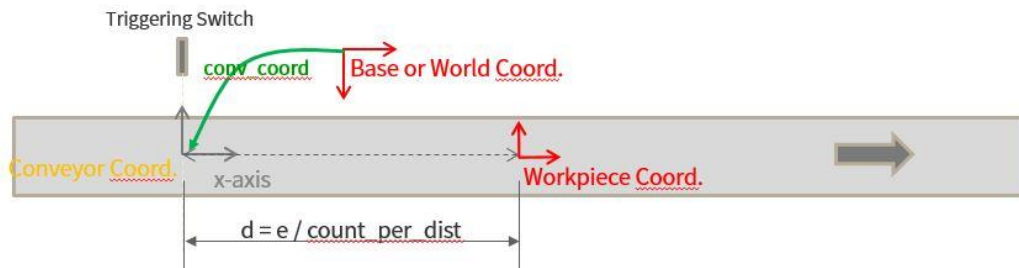
Operate the conveyor again and stop it to acquire the location of Point X2 in the same way. Point X is used to calculate the x-axis of the Conveyor Coordinates. While it is sufficient for X1 and X2, up to four points can undergo teaching to improve accuracy. Depending on the number of teachings, spread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

Point Y is used to calculate the y-axis of 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 the Conveyor Detailed Settings.

Manual Setting

Workpiece location is calculated by applying the Encoder Count increasing in the direction of x on 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 of Conveyor Coordinates will allow the remaining offset to be accurately entered in the Task Motion of TB/TW, so it is acceptable to not enter the exact value.



d: distance from conv_coord to workpiece
e: incremental encoder value after triggering switch activated

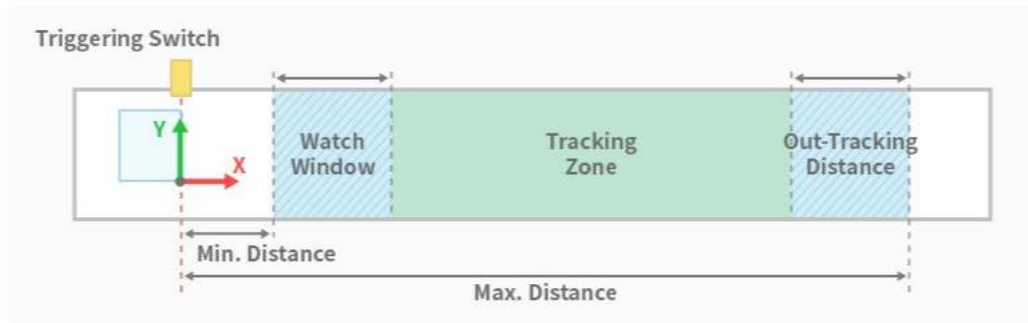
Count/Distance are Conveyor Tracking commands in TB/TW, and entering the Wait command without Task Motion will result in tracking of conveyor movement from the current position. The user can adjust it while monitoring the speed trend. If the robot moves slower than the conveyor, reduce the

Count/Distance, and if the robot moves faster, increase the Count/Distance.

2.2.3 Speed Setting

Filter Size is the conveyor speed filter size. Use an intuitive Moving Average Filter in Conveyor Tracking, and 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 Measure button while operating the conveyor. If the conveyor speed is 200% higher than Nominal, it is used to provide information. It does not require an accurate value, so it is acceptable to enter a design specification value without actual measuring.



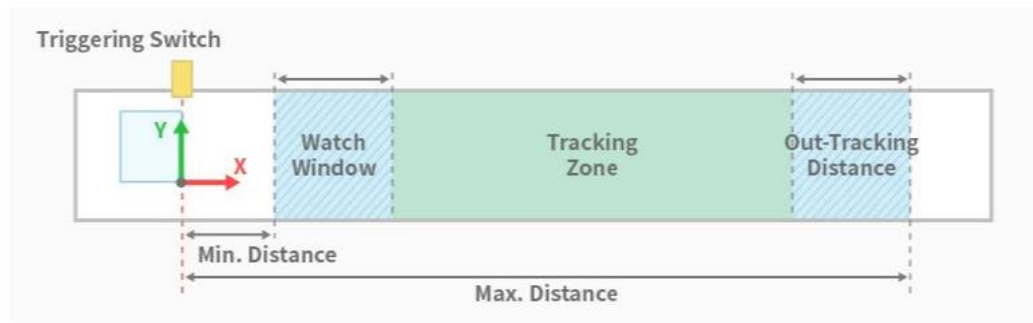
The Watch Window in the Conveyor Section is the area that determines work candidates. Workpieces in this area can only be targets once the work begins. The work itself can begin with the Watch Window, but in the worst case, this can cause workpiece at the end of the Watch Window to be a target, so it is recommended to adjust the Watch Window size to allow all work in the Tracking Zone to be completed.

3. Programming (TB/TW)

Programming of Conveyor Tracking is made with the Conveyor Coordinates command and Conveyor Tracking command in TB/TW. Coordinates information of the workpiece is obtained through the Conveyor Coordinates command, and Conveyor Tracking motion is performed with the Conveyor Tracking command.

3.1 Conveyor Coordinates

For basic a description of the command, refer to User Manual 7.7. This command returns the coordinates information of a workpiece in the Watch Window at the time the command is executed according to its Picking Rule. If there is no workpiece in the Watch Window, the command stands by, but it only remains on standby for the time set by Time Out. (If Time Out = 0, it remains on standby indefinitely)



Object Offset Coordinates is used to give an offset to the reference coordinates of a workpiece. Update the program with Pose Variable, which is used to give a static offset, when necessary, and Pos(x) Variable, which is used to dynamically change the offset.

3.2 Conveyor Tracking

Inserting the Conveyor Tracking command into programming creates the Conveyor Tracking node and End Conveyor Tracking node. At this time, the robot performs the Conveyor Tracking motion. It is possible to insert the Wait command to check whether Tracking is performing well, or insert various other Task Motion commands to develop the desired work.

Also, it is possible to obtain a teaching point for using Task Motion. The teaching point of Conveyor Tracking must be entered based on the workpiece coordinates, so in order to obtain the accurate teaching point, the coordinates must be entered manually based on CAD information or be obtained through the following procedure:

- Select the Conveyor Coordinates to track in the Conveyor Tracking command Property window.
- With the Start button pressed, let workpieces flow through like an actual workflow.
- When a workpiece enters the Watch Window, a green indicator lights goes on at Get Pose Ready, and 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 repeat the process starting from #2.
- After teaching the robot based on a workpiece at stop, press Get Pose to obtain as many teaching points as necessary. (up to 20 points)

Teaching points can be loaded by Task motion between Conveyor Tracking commands by referring to the Pose Variable name.

In addition to workpiece coordinates, the teaching point supports teaching points in Base or World Coordinates, and 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.

The screenshot shows the software interface with the 'Conveyor Tracking' node selected in the Task List. The Task List on the left contains the following steps:

| Task List |
|---|
| 004 Repeat (count, Count 100) |
| 005 Move L (Ready) |
| 006 Conveyor Coordinates (Conveyor Tracker, Coord1) |
| 007 Conveyor Tracking (Coord1) |
| 008 Move L (Approach Pose) |
| 009 Move L (Pick Pose) |
| 010 Comment (Pick...) |
| 011 Move L (Retract Pose) |
| 012 End Conveyor Tracking |
| 013 Move L (Place Pose) |
| 014 Comment (Place..) |
| 015 EndRepeat |

The right-hand panel shows the configuration for the 'Conveyor Tracking' node. It includes a 'Start Teaching' section with 'Get Pose Ready' and buttons for 'Start' and 'Stop'. Below this is the 'Pose Variable' section, which lists 'ApproachPose' and 'PickPose', each with a 'Get Pose' button and a 'Move To' button.

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

The screenshot shows the software interface with the 'Move L (Linear)' node selected in the Task List. The Task List on the left contains the following steps:

| Task List |
|---|
| 004 Repeat (count, Count 100) |
| 005 Move L (Ready) |
| 006 Conveyor Coordinates (Conveyor Tracker, Coord1) |
| 007 Conveyor Tracking (Coord1) |
| 008 Move L (Approach Pose) |
| 009 Move L (Pick Pose) |
| 010 Comment (Pick...) |
| 011 Move L (Retract Pose) |
| 012 End Conveyor Tracking |
| 013 Move L (Place Pose) |
| 014 Comment (Place..) |
| 015 EndRepeat |

The right-hand panel shows the configuration for the 'Move L (Linear)' node. It includes a 'Coordinates' dropdown menu set to 'Coord1'. Below this are radio buttons for 'Absolute' and 'Relative' modes. The 'ApproachPose' is selected, and there are 'Get Pose', 'Move To', and 'Reset' buttons. At the bottom, the current pose values are displayed:

| X | Y | Z |
|----------|-------------|------------|
| 1.750 mm | -526.340 mm | 849.310 mm |
| A | B | C |
| 5.27° | 177.93° | -58.99° |

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.

| Task List | Command | Property | Variable | Play |
|-----------|-----------------------|--------------------------------------|----------|------|
| 003 | MainSub | (Task Vel. 250.0, Acc. 1.000, ...) | | |
| 004 | Repeat | (count, Count 100) | | |
| 005 | Move L | (Ready) | | |
| 006 | Conveyor Coordinates | (Conveyor Tracker 1, Coord1) | | |
| 007 | Conveyor Tracking | (Coord1) | | |
| 008 | Move L | (Pick in conveyor 1) | | |
| 009 | End Conveyor Tracking | | | |
| 010 | Conveyor Coordinates | (Conveyor Tracker 2, Coord2) | | |
| 011 | Conveyor Tracking | (Coord2) | | |
| 012 | Move L | (Place in Conveyor 2) | | |
| 013 | End Conveyor Tracking | | | |
| 014 | EndRepeat | | | |
| 015 | | | | |

| Command | Property | Variable | Play |
|--|----------|----------|------|
| Conveyor Coordinates Confirm | | | |
| Specify the detailed settings to get conveyor coordinates. | | | |
| Conveyor Tracker Workcell Item | | | |
| Conveyor Tracker 2 | | | |
| Conveyor Coordinates Name | | | |
| Coord2 | | | |
| Time Out <input type="checkbox"/> | | | |
| 0.0 sec | | | |
| Picking Rule | | | |

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.

| Task List | Command | Property | Variable | Play |
|-----------|-----------------------|--------------------------------------|----------|------|
| 001 | GlobalVariables | | | |
| 002 | CustomCode | | | |
| 003 | MainSub | (Task Vel. 250.0, Acc. 1.000, ...) | | |
| 004 | Repeat | (count, Count 100) | | |
| 005 | Move L | (Ready) | | |
| 006 | Conveyor Coordinates | (Conveyor Tracker 1, Coord1) | | |
| 007 | Conveyor Tracking | (Coord1) | | |
| 008 | Move L | (Do Something on First Workpie...) | | |
| 009 | Conveyor Coordinates | (Conveyor Tracker 1, Coord2) | | |
| 010 | Move L | (Do Something on Second Workpi...) | | |
| 011 | End Conveyor Tracking | | | |
| 012 | EndRepeat | | | |

| Command | Property | Variable | Play |
|------------------------------|----------|---------------------|----------|
| Force Control Command | | | |
| Compliance | <i>i</i> | Force | <i>i</i> |
| Other Command | | | |
| Comment | <i>i</i> | Custom Code | <i>i</i> |
| Define | <i>i</i> | Popup | <i>i</i> |
| Set | <i>i</i> | Weight Measure | <i>i</i> |
| Wait Motion | <i>i</i> | | |
| Advanced Command | | | |
| Hand Guide | <i>i</i> | Conveyor Coordinate | <i>i</i> |

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

Pose Variable

Coord2 ▾

Start Teaching

Get Pose Ready

Pose Variable

