MITSUBISHI ELECTRIC

Mitsubishi Electric Industrial Robot

Robot Seminar Textbook (Fundamentals of Collaborative Robots)

RV-5AS-D

MELFA robot seminar schedule <Fundamentals>

Day 1		Day 2	
Agenda	**Time**	**Agenda**	**Time**
Seminar introduction Orientation 1) Safety-related laws ■Safety Manual ■Safety laws	1 hr 20 min	6) Review of the previous day's lesson (programming, operation) 7) Practice (robot operation) ■Exercise 2 ■Exercise 3	1 hr 20 min
Break	10 min	Break	10 min
2) Introduction to collaborative robots ■System architecture ■Safety extension unit ■Operation buttons ■Status indicator LED 3) Operating the robot manually (robot operation) ■Joint free, translational motion ■Opening and closing the hand, others	1 hr	8) Practice (robot operation) ■Program blocks ・Pallet ■Exercise 4	1 hr
Lunch	—	Lunch	—
4) Functions of RT VisualBox ■Screen operations ■Program blocks ・Move ・Hand ・Wait ・Signal ・Pause ・Branch ・Repeat ・Calculate	1 hr 50 min	9) How to use a vision sensor (hand eye) ■Vision sensor connection ■Vision sensor settings ■Autocalibration ■Program blocks ・Vision ■Exercise 5 ■Program verification ■Automatic operation	1 hr 40 min
Break	15 min	Break	15 min
5) Operating the collaborative robot ■Programming with RT VisualBox ■Position teaching ■Program verification ■Automatic operation End	1 hr 50 min	10) Practice (robot operation) ■Exercise 6 11) Setting safety conditions using RT VisualBox ■Monitoring model ■Speed limit, position limit ■Safety I/O settings, area settings 12) Others End (certification of completion)	1 hr 30 min

Safety

Related Laws

Precautions

Work using a robot is designated as "Dangerous and Injurious Works".

Laws and Standards for Ensuring Safety

1. Manufacturer side: (Ministry of Economy, Trade and Industry) JIS "B8433" Manipulating Industrial Robots - Safety
2. User side: (Ministry of Health, Labor and Welfare) Industrial Safety and Health Laws, Labor Safety and Health Regulations

Special Safety and Health Training Curriculum

(Ministry of Health, Labor and Welfare Ministerial Notification No. 49)
The following two articles have been added to Article 17.

■Special training related to teaching of industrial robots, etc.

Article 18 Special training related to operations listed in the Safety and Health Provisions Article 36-31 shall be carried out with classroom training and practical training.

1. The above mentioned classroom training shall follow the courses listed below. The scope listed below shall be covered for the specified time.
2. For the practical training in Section 1, the following courses shall be conducted for the specified time or longer.

Course	Scope	Time
Basics of Industrial Robots	Types of industrial robots, and functions and handling methods of each part	2 hours
Basics of Industrial Robot Operations such as Teaching	Operation methods such as teaching, risks of operations such as teaching, coupling with related machines, etc.	4 hours
Related Laws	Laws, ordinances and related articles in Safety and Health Provisions	1 hour

- How to operate an industrial robot: 1 hour
- How to teach an industrial robot, etc.: 2 hours

■Special training related to inspection of the industrial robot, etc.

Article 19 Special training related to the operations listed in Safety and Health Provisions Article 36-32 shall be carried out with classroom training and practical training.

1. The above mentioned classroom training shall follow the courses listed below. The scope listed below shall be covered for the specified time.
2. For the practical training in Section 1, the following courses shall be conducted for the specified time or longer.

Course	Scope	Time
Basics of Industrial Robots	Types of industrial robots, control methods, drive methods, structure, function and handling of each part, types and characteristics of control parts	4 hours
Basics of Industrial Robot Inspections, etc.	Inspection, etc., methods, risks in inspection work, etc., coupling with related machines, etc.	4 hours
Related Laws	Laws, ordinances and related articles in Safety and Health Provisions	1 hour

- How to operate an industrial robot: 1 hour
- How to inspect an industrial robot, etc.: 3 hours

Matters excluded from industrial robot

1. Machine having a drive motor with a rated output of 80 watts or less (if machine has two or more drive motor, the motor with the larger rated output)
2. Machine that repeats a simple operation of manipulator extension, vertical movement, left/right movement or turning based on information from a fixed sequence control unit.
3. In addition to the machine listed in item 2 above, machine approved by the manager of the Ministry of Health, Labor and Welfare's Labor Standards Bureau as a machine having a structure and performance that will not pose a risk to the operator even if the said machine is touched.

Qualifications for Dangerous and Injurious Work

Degree of risk	Qualification	Duty	Jurisdiction	Work Type
↑ High ↓ Low	License	Acquired	National, Prefectural	Crane, gas equipment, X-ray, boiler
	Skill training course	Completed	Bureau-designated training agency	Slinging, fork lift, high-pressure gas
	Special training	Completed	Place of business	Electric, arc, grinding, robot

Industrial Accidents Caused by Industrial Robots

All of the following fatal accidents were caused by people being crushed after entering the enclosure while an industrial robot was operating.

No.	Overview of fatal accidents caused by industrial robots
1	At a plant where one industrial robot and four metal processing machines were surrounded by a safety fence, the industrial robot started moving while the victim was measuring the product inside the safety fence after it had been manufactured. The victim was crushed from behind onto the product by the robot, which resulted in death by asphyxiation due to pressure on their abdomen.
2	The victim was found in an automated line with their face in a coolant tank from where their head had been pushed down from above by the tip of a manipulator. They died a month later in hospital.
3	While the victim was dealing with machine trouble, the tray hand of an industrial robot which had been on stand by above them fell. The victim died after being crushed between the tray hand and tray.
4	An industrial robot stopped with an error, and the victim cleared the error by removing the workpiece that the robot was grabbing. At that time, the robot started moving and the victim died after their chest was crushed between the end of the robot manipulator and transfer table.
5	The victim entered the operating area without stopping an industrial robot that transfers pallets, and died after their chest was crushed between the robot support column and the transfer manipulator.
6	When the victim entered a robot operating area surrounded by a safety fence, they died after a product holding guide at the tip of a manipulator holding a container swung round and crushed the victim between the robot stand.
7	When the victim went under a 30cm gap in the fence of an industrial robot while the industrial robot was automatically loading cargo onto a pallet, the manipulator that was holding the cargo fell onto them and they died after their neck was crushed between the cargo and the floor.
8	A welding robot stopped due to an error. When the victim was fixing it, the manipulator unexpectedly started to work and their chest was crushed. They died of asphyxiation.
9	The victim went under the manipulator of an industrial robot that transports workpieces automatically which has an integrated NC lathe. They died after their neck was crushed by the manipulator.

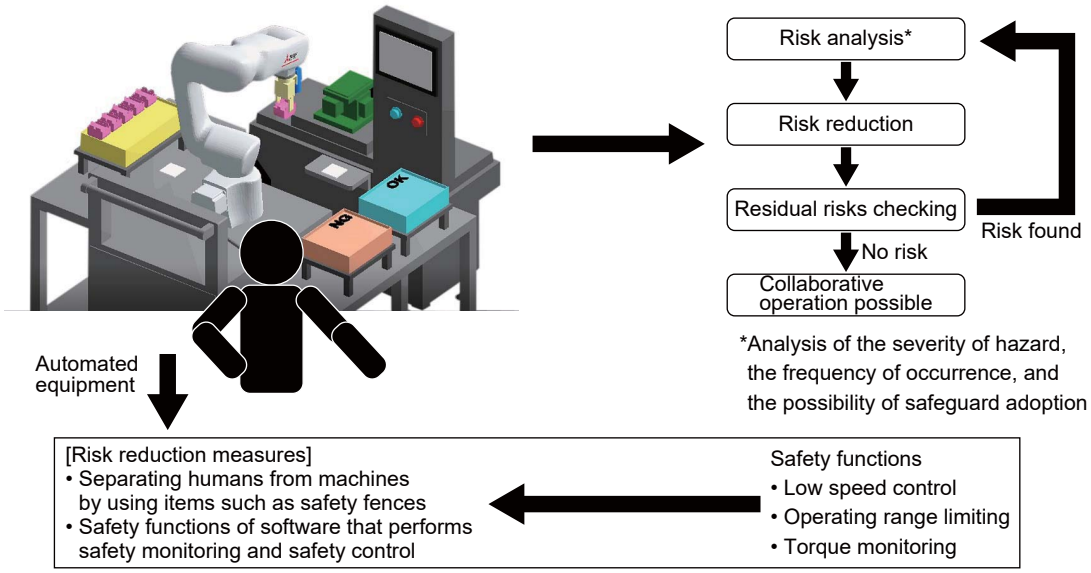
(Excerpts from item 1-1 by Safety Division, Industrial Safety and Health Department, Labor Standards Bureau, Ministry of Health, Labor, and Welfare)

Safety standards that permit human-industrial robot collaboration

Ordinance on Industrial Safety and Health, based on Article 20 of Industrial Safety and Health Act, in order to prevent hazards during operation of industrial robots (hereafter "Safety and Health Provision").
If there is a possibility that hazards will arise by coming into contact with an industrial robot whose rated output is over 80W as stipulated in Article 150-4, a fence, enclosure, or similar items shall be installed. However, it was unclear about whether human-industrial robot collaboration was possible. Therefore, safety standards that permit human-industrial robot collaboration were clearly stipulated by Notification 1224, No. 2 created on December 24, 2013 (hereafter "Notification No. 2").
Collaboration operation is permitted when hazards can be prevented after risk assessments. (Notification No.2)

Precautions when using collaborative robots (risk assessment)

Collaborative robots have a variety of safety functions, so unlike conventional industrial robots, they can work in the same space as humans without being separated by a machine guard.
Even though collaborative robots are equipped with safety functions, it does not guarantee that they will not cause injury. To prevent injury, robot users, machine manufacturers who construct robot systems, and system builders such as system integrators must select and use functions correctly. Peripherals must be designed, manufactured, set, programmed, maintained, and inspected appropriately. Before working with collaborative robots, conduct risk assessments, check that no risk is present, and ensure all required documentation is in order.
It is vitally important that all the points mentioned above are fully understood in order to work with collaborative robots safely and without incident. When using collaborative robots, always keep in mind that they may move unexpectedly.



Collaborative operation modes

The robot's operation status will change under the following conditions:

• Operating status switching condition

Collaborative operation mode		Condition
High-speed operation (1000mm/s)		No presence of anyone in the monitored space that is monitored by area sensors, etc. (No one is approaching the robot.) The robot can be set to operate at low speed in low-speed spaces. Do not use this setting for collaborative operation with humans.
Collaborative operation	Standard operation*1 (250mm/s)	• A person is in the monitored space. (Someone is approaching the robot.) Use devices, such as area sensors, to monitor spaces when switching from High-speed operation mode to Standard operation mode. • The robot is not in the low-speed space*3. (The robot is operating outside the low-speed space*3.)
	Low-speed operation*2 (50mm/s)	• A person is in the monitored space. (Someone is approaching the robot.) • The robot is in the low-speed space*3. (The robot is operating inside the low-speed space*3.)

*1 Use this operation mode only in situations where there is no risk of body parts, such as hands and fingers, becoming trapped.

*2 Use this operation mode only in situations where there is a risk of body parts, such as hands and fingers, becoming trapped or where collision points cannot be limited.

*3 Specify the space of *2 as a cuboid called "low speed space".

⚠ CAUTION

When using High-speed operation, always connect the safety sensors (such as area sensors and light curtains) or interlock to DSI1 according to the result of the risk assessment.

Safety functions

The following shows the safety-related control system performance and conforming standards and the stop category of the protective stop circuit input.

Item		Description	Remarks
Safety function*1	STO function	Electrically shuts off power to the motors in the robot.	IEC 60204-1 Applicable to stop category 0
	SS1 function	Decelerates the motors in the robot. After the motors stop, the robot goes into the STO state.	IEC 60204-1 Applicable to stop category 1
	SS2 function	Decelerates the motors in the robot. After the motors stop, the robot goes into the SOS state.	IEC 60204-1 Applicable to stop category 2
	SOS function	Checks that the robot has stopped without shutting off power to the motors in the robot.	When SOS, SLS, SLP, and STR detect error, activate SS1. EN 61800-5-2 compliant
	SLS function	Checks that parts of the robot arm do not exceed the speed limit.	
	SLP function	Checks that a predetermined position does not pass through the position monitoring plane.	
	STR function	Ensures that the torque limits of each motor in the robot are not exceeded.	

*1 The safety functions conform to EN 61800-5-2.

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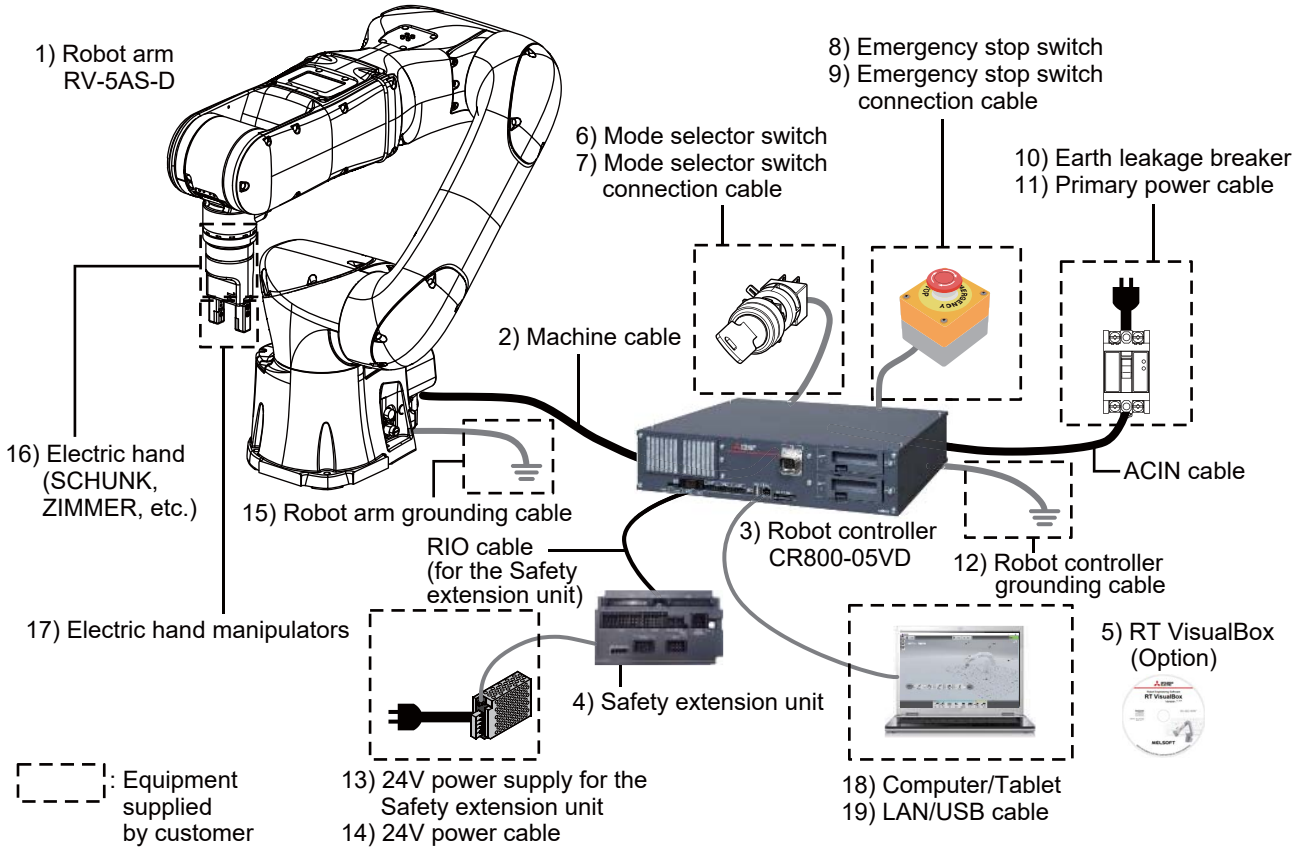
1 Introduction to collaborative robots

1.1 System architecture (general configuration)



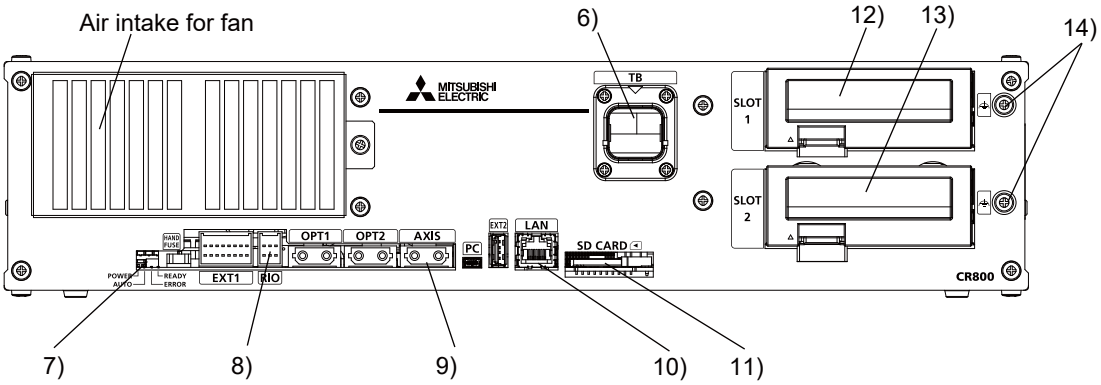
System architecture

No.	Name	Specifications/Recommended products	Remarks
1)	Robot arm	RV-5AS-D	Standard configuration
2)	Machine cable	Fixed /Length: 5 m /Weight: 5 kg	Standard configuration
3)	Robot controller	CR800-05VD Ver.A4z	Standard configuration
4)	Safety extension unit	4F-SF002-01	Standard configuration
5)	RT VisualBox	Ver.1.0.0 or later (Japanese version): 3G-30C-WINJ (English version): 3G-30C-WINE	Option
6)	Mode selector switch	Recommended product: HA1K-2C2A-2 (manufactured by IDEC)	Supplied by customer
7)	Mode selector switch connection cable	Refer to the mode selector switch catalog to select a connector cable.	Supplied by customer
8)	Emergency stop switch	Use an IEC 60204-1 compliant emergency stop switch, which has two NC contacts for redundancy and a mechanical latching function.	Supplied by customer
9)	Emergency stop switch connection cable	Refer to the emergency stop switch catalog to select a connector cable.	Supplied by customer
10)	Earth leakage breaker	Recommended product: Single phase NV30FAU-2P-10A-AC100-240V-30mA (manufactured by Mitsubishi Electric). Make sure to attach the TCS-05FA2 terminal cover (manufactured by Mitsubishi Electric).	Supplied by customer Recommended specifications: • Rated current: 10 A • Rated sensed current: 30 mA • Rated breaking capacity: 2.5 kA
11)	Primary power supply connection cable	Min. size: #14 AWG (2 mm^2)	Supplied by customer
12)	Robot controller grounding cable	Min. size: #14 AWG (2 mm^2)	Supplied by customer
13)	24 V power supply for the safety extension unit	Choose a product that meets the following specifications: Voltage: 24 V DC ±5% Max. current draw: 300 mA	Supplied by customer

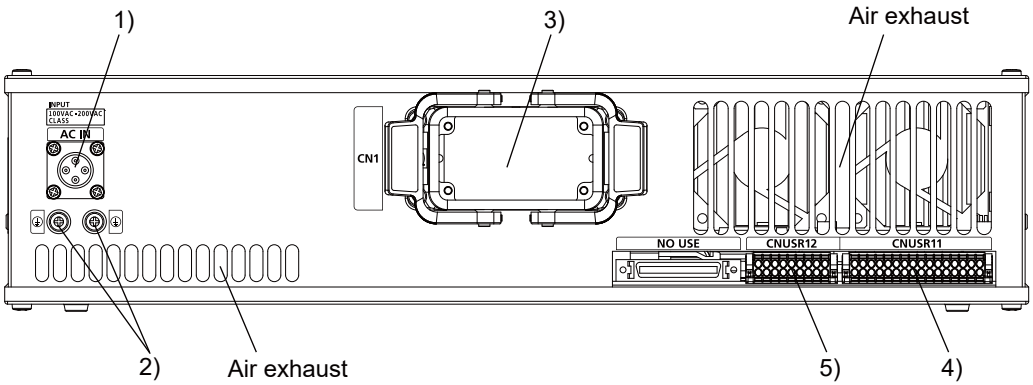
No.	Name	Specifications/Recommended products	Remarks
14)	24 V power cable	Recommended cable Conductor size: 0.5 to 1.42 mm^2, (20 to 16 AWG) Outer sheath diameter: 1.8 to 2.8 mm Shielded	Supplied by customer
15)	Robot arm grounding cable	Min. size: #11 AWG (4.2 mm^2)	Supplied by customer
16)	Electric hand	Use a hand that satisfies the needs of the customer. For recommended hands, refer to the following manual: 📖RV-5AS-D Standard Specifications (BFP-A3727)	Supplied by customer
17)	Electric hand fingers	Use fingers that satisfy the needs of the customer.	Supplied by customer
18)	Tablet/Computer	Used to run the engineering tool (RT VisualBox) that enables startup settings and programming easily.	Supplied by customer
19)	LAN cable/USB cable	LAN: 10BASE-T or 100BASE-TXUSB: USB Type-A / Mini USB Type-B	Supplied by customer

1.2 Names of robot controller parts

· Controller front



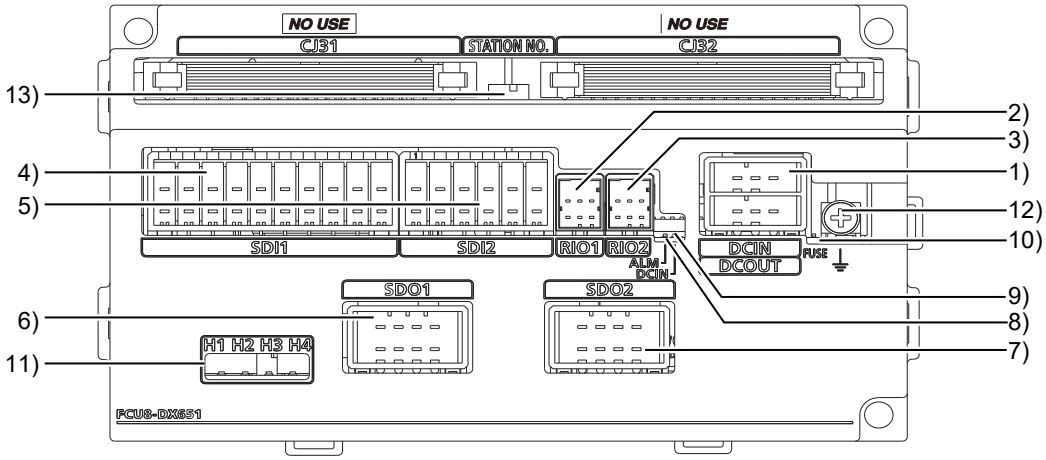
· Controller rear



No.	Name	Description
1)	ACIN socket	Socket used to connect the supplied ACIN cable (input voltage: 100 V AC/200 V AC)
2)	PE terminal	Grounding terminal (M4 screw × 2)
3)	CN1 port	Machine cable connection port
4)5)	CNUSR port	I/O (emergency stop I/O, mode selector switch input, error output, and others) connection ports for the robot 4): CNUSR11, 5): CNUSR12 For details on the connection method and pin assignment, refer to the following manual: Controller Setup and Maintenance (BFP-A3731)
6)	T/B port	T/B connection port
7)	LED	The four LEDs indicate the status of the controller.
8)	RIO	Port used to connect the safety extension unit
9)	AXIS	Port used to connect the force sensor
10)	LAN	Ethernet connection port
11)	SDCARD	SD memory card slot
12) 13)	Option slot	Option card slots (covers required when not used) 19): SLOT1, 20): SLOT2
14)	FG terminal	Terminal used to ground the cable connected to the option card (M4 screw × 2)

1.3 Safety extension unit

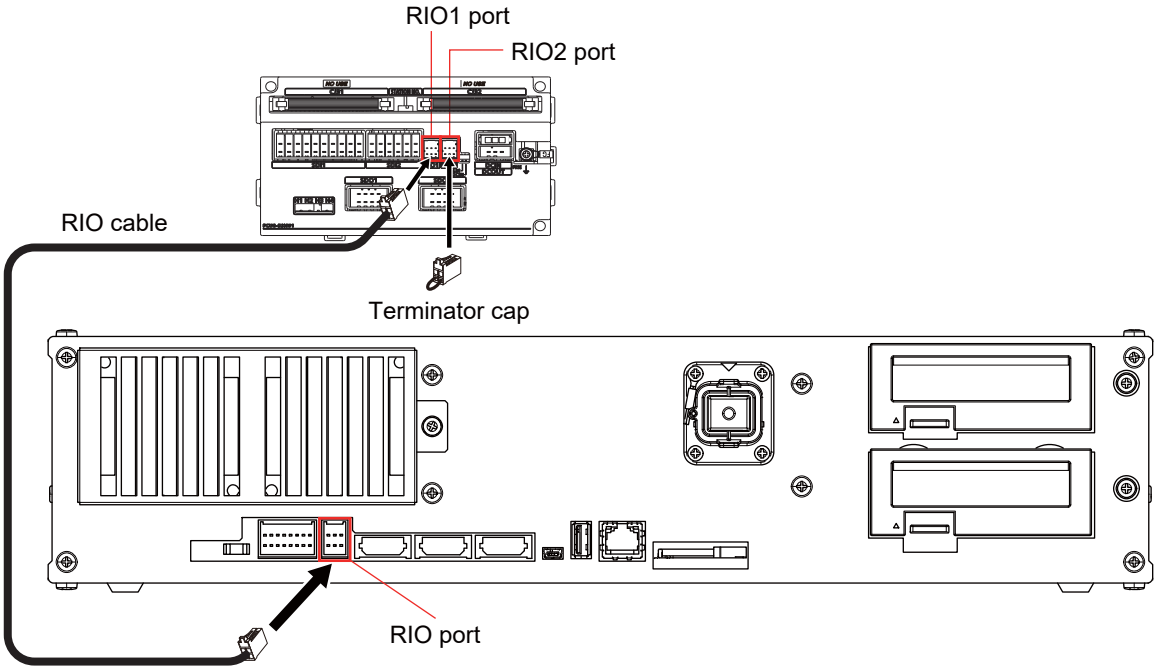
The safety extension unit is a component that expands the robot's safety functions when used with external devices such as safety switches and light curtains.



No.	Name	Specifications/Recommended products
1)	DCIN socket	Socket used to connect the supplied DCIN cable (input voltage: 24 V DC)
2)	RIO1 port	Port used to connect the robot controller
3)	RIO2 port	Do not use. Connect the supplied terminator cap (2F-SFTM).
4)	SDI1 port	Safety DI input port
5)	SDI2 port	Safety DI input port
6)	SDO1 port	Safety relay output port
7)	SDO2 port	Safety relay output port
8)	ALMLED	This LED indicates remote I/O communication status. On: Error / Off: Normal
9)	DCINLED	This LED indicates the status of the 24 V DC power supply. On: Normal / Off: Error
10)	FUSELED	This LED indicates the status of the fuse. On: Normal / Off: Fuse blown
11)	H1, H2, H3, H4LED	This LED indicates the status of the relay. On: Normal / Off: Relay welded
12)	FG terminal	This is the terminal used to ground the safety option. (M4 screw × 1)
13)	STATION NO. switch	Station number switch. Set to "2" at the factory. Do not change.

Connecting the safety extension unit and the robot controller

Connect one end of the RIO cable to the safety extension unit's RIO1 port and the other end to the robot controller's RIO port.



1.4 Emergency stop

The controller's dedicated I/O terminal connector has a duplicate emergency stop circuit. The following figure shows a safety measure example. Refer to the figure when creating safety measures.
The figure represents a system which is operating normally (i.e. A system not in an emergency stop state).

Precautions

For wiring examples not shown in this textbook, refer to the following manual:
📖Controller Setup and Maintenance (BFP-A3731)

⚠CAUTION

The emergency stop circuit inside the controller is a redundant (duplicated) configuration. Use a 2-contact type emergency stop switch or mode selection switch, and be sure to connect both of the contacts to the controller-dedicated I/O terminal pins to ensure that the wiring is duplicated. If only one of the pins is connected, an error cannot be cleared.

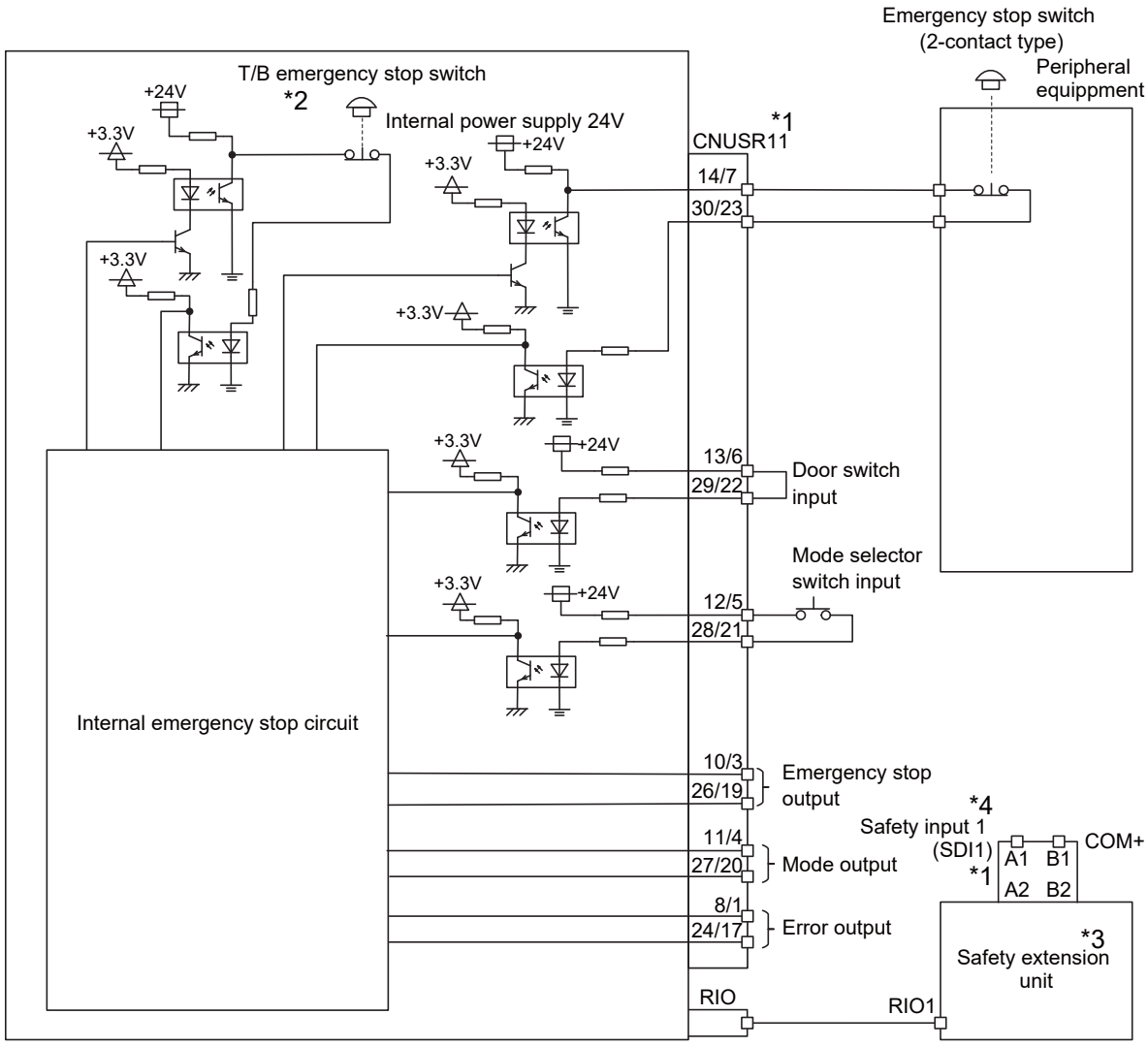
CR800-05VD controller

<Wiring example>: Connect the emergency stop switch of the peripheral equipment.

The power used for emergency stop detection is supplied via the internal power supply of the controller.

<Emergency stop mechanism>: Pressing the emergency stop switch on the peripheral equipment will also bring the robot to an emergency stop.

<Safety input 1 mechanism>: Opening the terminals will keep the robot in collaborative operation mode.



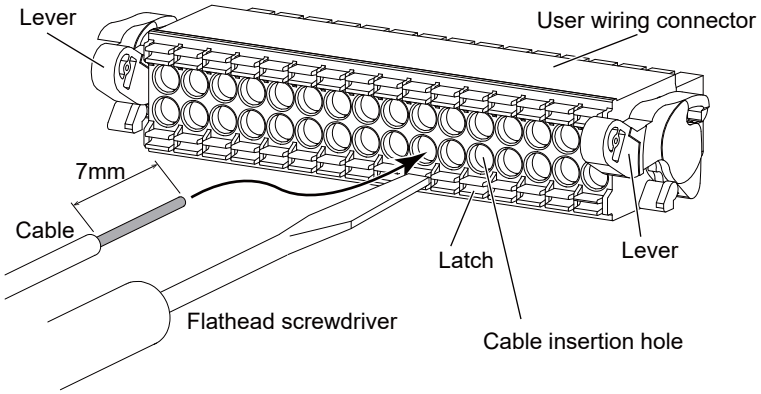
*1 The CNUSR11 port and SDI1 port both have two rows of terminals, indicating that there are two channels. Both channels must be connected.

*2 This is emergency stop switch of the teaching pendant that is connected to the robot controller.

*3 If a safety extension unit is not connected to the robot controller, error H2260 "Safety function execution disabled (No extended safety unit)" will occur.

*4 For safety input 1 connection examples, refer to the manual:
📖"Connecting the safety extension unit to the controller" in Controller Setup and Maintenance (BFP-A3731)

■CNUSR11 port



1.5 Mode selector switch

The operation panel is not available for the CR800-05VD controller.
To enable mode switching (teaching/automatic operation), prepare an emergency stop switch, door switch, and mode selection switch (mode selector switch) and connect them with the controller before using the robot.
For details, refer to the following manual.
📖Controller Setup and Maintenance (BFP-A3731)

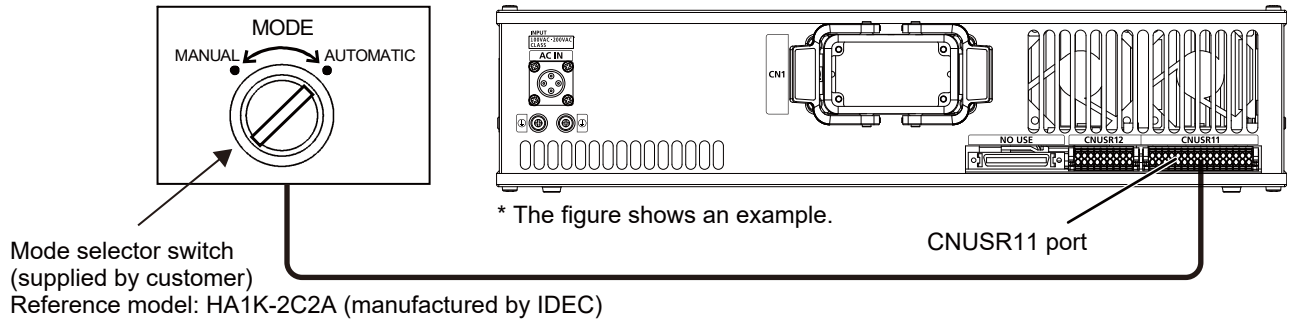
Controller mode

- AUTOMATIC (automatic operation): Operation from external devices is enabled. Operations that require operation rights from the T/B cannot be performed. For connection with external devices, set the parameter to acquire operation rights. For details on the AUTOMATIC mode, refer to the following manual:

📖Detailed explanations of functions and operations (BFP-A3478)

- MANUAL (teaching): When the T/B is enabled, operation can only be performed from the T/B. Operations that require operation rights from external devices cannot be performed.

Connecting the mode selector switch input



Connect the contacts of the switch to the following pins.

Pin No. and function (Connector: CNUSR11)		Mode selection*1	
Pin No.	**Function**	**MANUAL**	**AUTOMATIC**
21	Key input channel 1	Open	Close
5	Power supply to key input channel 1 +24 V		
28	Key input channel 2	Open	Close
12	Power supply to key input channel 2 +24 V		

*1 Mode switching occurs when pins No. 21-5 and pins No. 28-12 simultaneously open or close.
If the input status differs between the two channels, error H0044 (operation panel mode key line error) occurs.

Precautions

- Do not ground the + side of the customer device's 24 V power supply for input/output (emergency stop and parallel I/O) that is used to connect the controller.

Connecting the controller with the + side grounded may cause a failure of the controller.

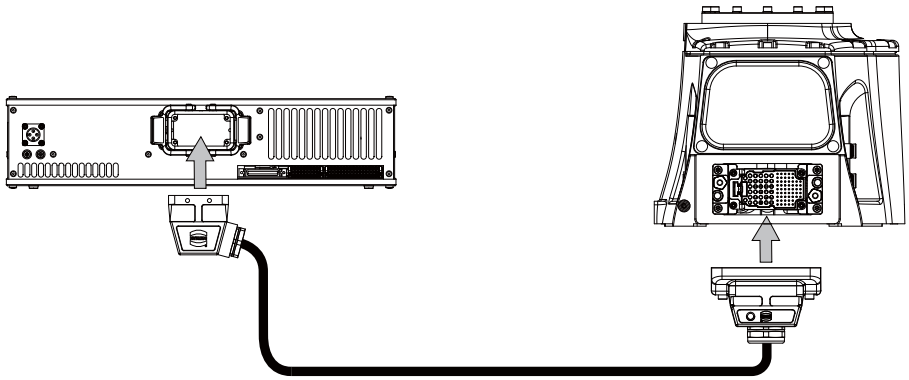
- The mode selector (switching) switch circuit inside the controller is configured redundant (duplicated).

Use a 2-contact type mode selector (switching) switch, and be sure to connect both of the contacts to the controller-dedicated input terminal pins to ensure that the wiring is duplicated.

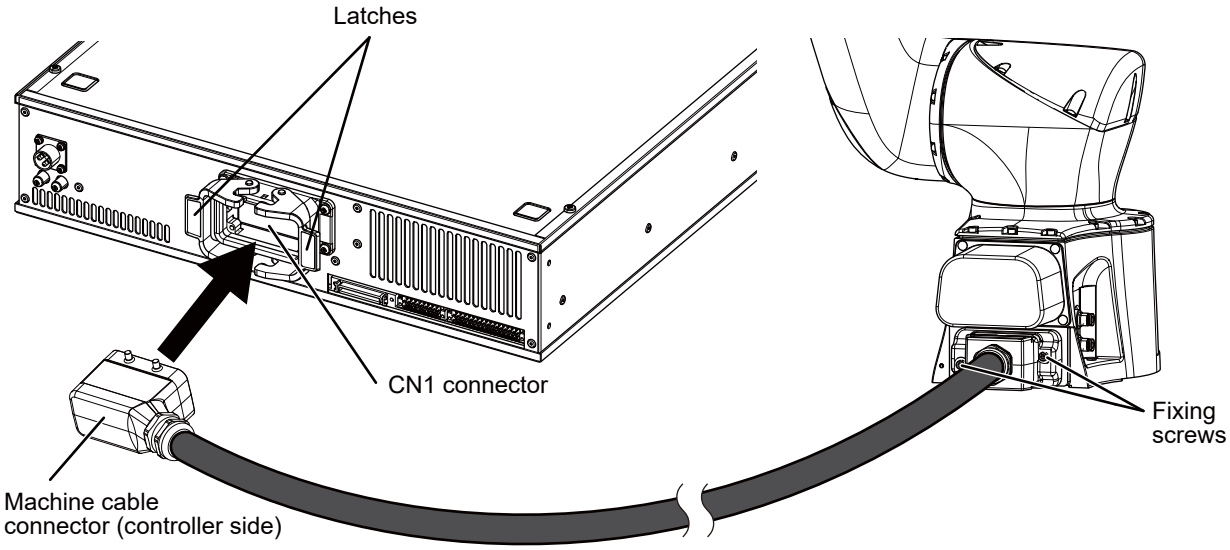
1.6 Robot arm and controller

Connecting the robot arm to the controller

Connect a robot arm and the controller with a machine cable.



1. Ensure that the controller is powered off.
2. Connect the machine cable connector (controller side) to the CN1 port on the back of the controller.
3. Close the latches of the CN1 port to fix the connector.



4. Connect the machine cable connector (robot side) to the robot.
5. Tighten the two fixing screws to lock the connector in place. (Recommended tightening torque: 4.0 N•m)
6. Use the same method to connect the machine cable (replacement type) to an option.

⚠CAUTION

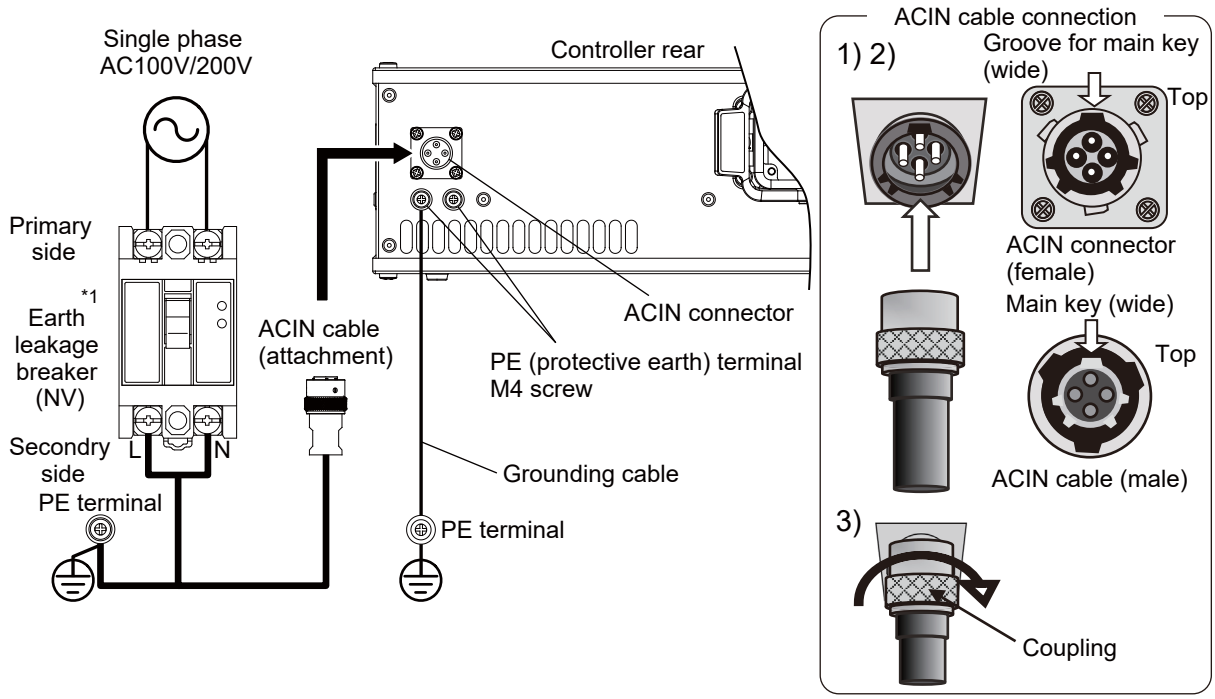
- When connecting and disconnecting the connector, be careful not to get your hand pinched.
- When connecting or disconnecting the connector, keep it parallel to the port. If one side is heavily loaded, a connector pin may be damaged, resulting in poor contact.
- When disconnecting the connector, open the latches to unlock the connector, then hold the connector and pull it out. Pulling the cable may cause it to come off or break.
- Take special care when wiring connection cables. Forcibly pulling or excessively bending the connected cable may result in disconnection of the cable or damage to the connector.
- Connect the machine cable at a place that is not susceptible to dust and oil mist.

1.7 Power supply connection

This section explains how to connect the power cable and grounding cable to the controller.

⚠CAUTION

To protect the controller against ground faults, connect an earth leakage breaker to the controller's primary power supply. Failure to do so may result in electric shock.



*1 Always use the terminal cover for the earth leakage breaker.

1. Supply the following equipment.

Item	Specifications	Remarks
Earth leakage breaker	Recommended product: Single phase NV30FAU-2P-10A-AC100-240V-30mA (manufactured by Mitsubishi Electric) Make sure to attach the TCS-05FA2 terminal cover (manufactured by Mitsubishi Electric).	Supplied by customer Recommended specifications • Rated current: 10 A • Rated sensed current: 30 mA • Rated breaking capacity: 2.5 kA
Primary power supply connection cable	Min. size: #14 AWG (2 mm^2)	Supplied by customer Tightening torque for terminal tightening screws: 2 to 3 N•m
Grounding cable	Min. size: #14 AWG (2 mm^2)	Supplied by customer Tightening torque for terminal tightening screws: 2 to 3 N•m
ACIN cable	Terminal size: M5 (cable length: 3 m)	Packaged with the product

2. Confirm that the primary power matches the power supply specifications.

3. Ensure that the primary power is shut off and the power switch of the earth leakage breaker is off.

4. Connect the ACIN cable.

Connect the power terminals of the ACIN cable to the secondary side terminals of the earth leakage breaker. Also, ground the FG terminal.

5. Connect the ACIN cable to the ACIN socket on the back of the controller.

1) Face the main key on the ACIN cable plug upwards. (Refer to the "ACIN cable connection" illustration.)

2) Align the main key of the ACIN cable plug with the grooves on the ACIN socket. Push the plug into the socket as far as it will go.

The plug may be damaged if it is not correctly aligned with the socket.

3) Tighten the coupling on the ACIN cable, turning it clockwise until it locks.

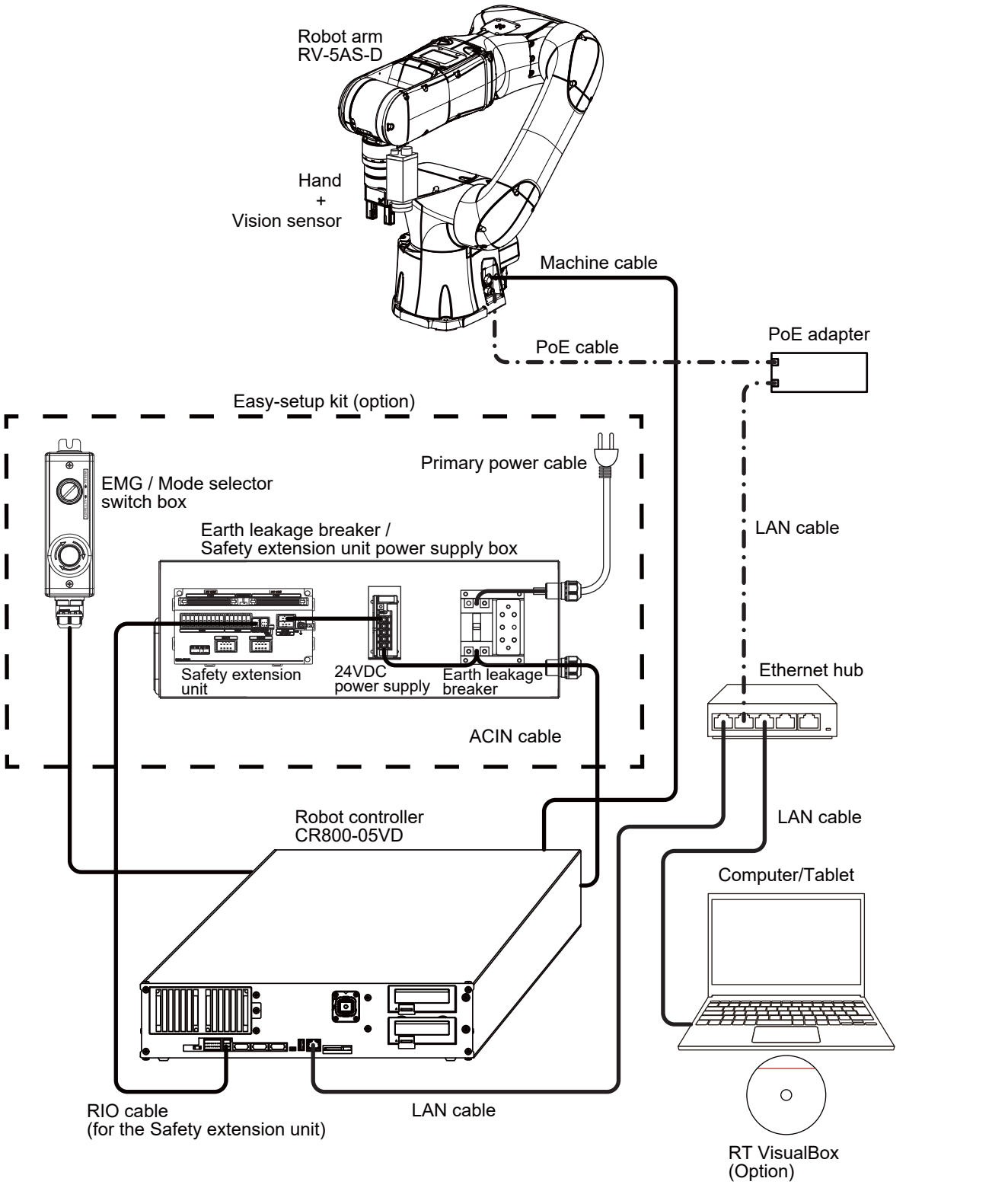
6. Connect one end of the grounding cable to the PE (protective earth) terminal of the controller and ground the other end (2-point grounding) to meet the requirements of EN 61800-5-1 for the touch current of 3.5 mA or more.

7. Connect the primary power supply connection cable to the primary side terminals of the earth leakage breaker.

Easy-setup kit

■System architecture

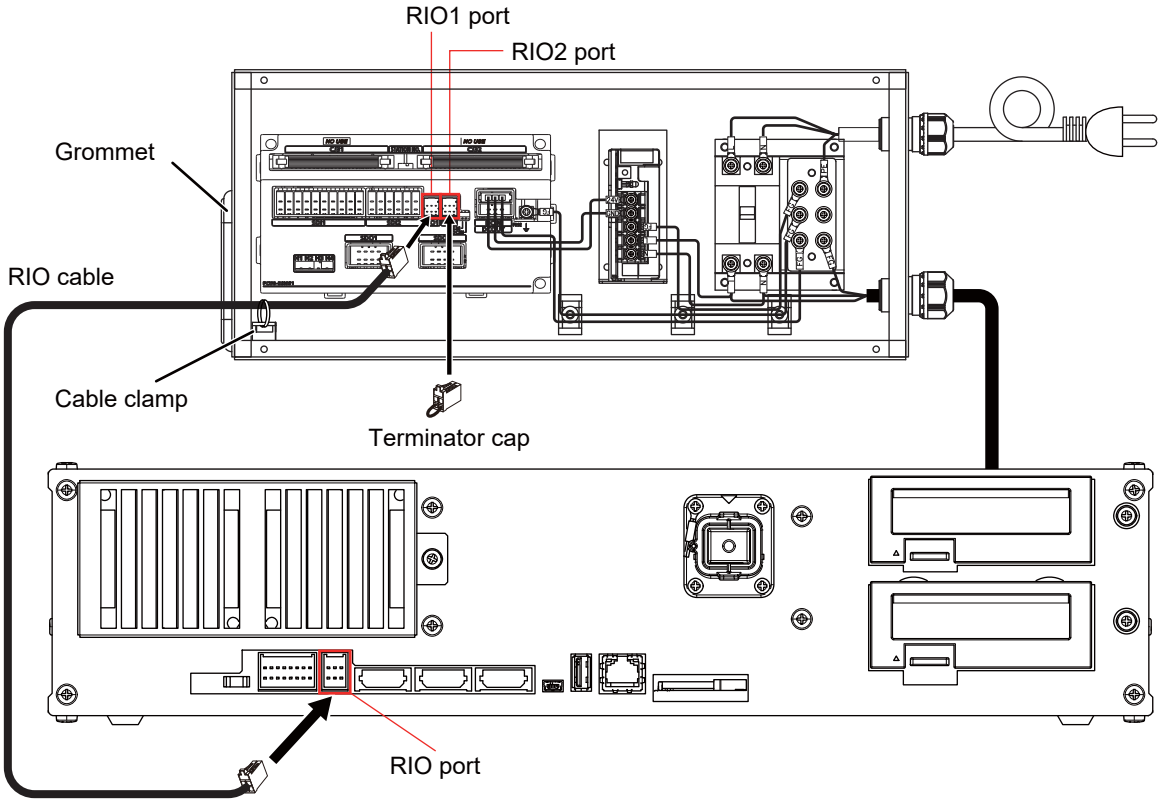
The following shows the system architecture when the easy-setup kit is used.



■Easy-setup kit

■Earth leakage breaker / Safety extension unit power supply box

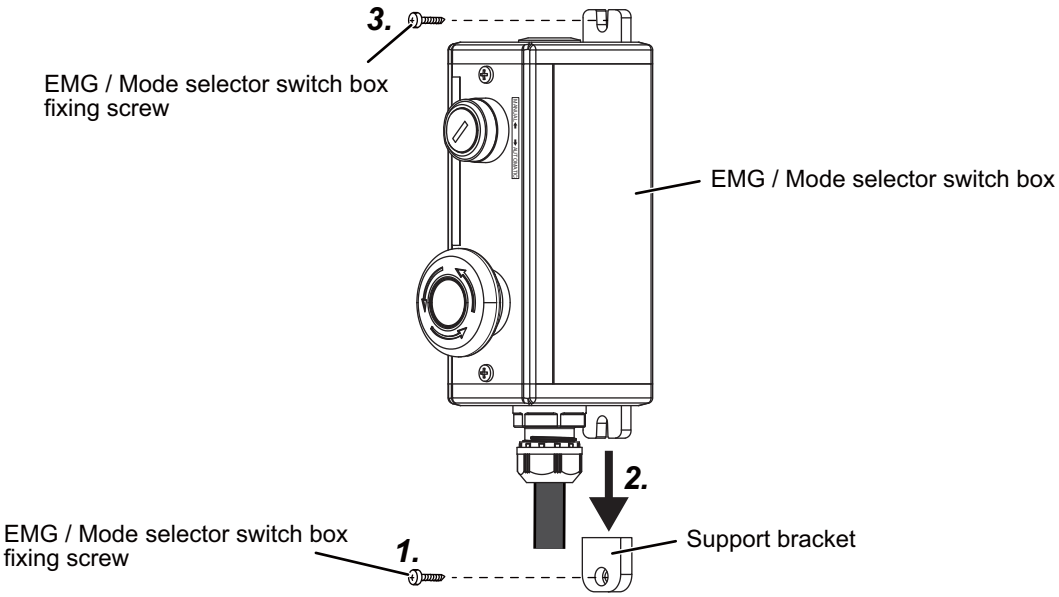
Position the Earth leakage breaker / Safety extension unit power supply box within reach of the RIO cable (1 m).



■EMG / Mode selector switch box

Position the EMG / Mode selector switch box within 3 m from the robot controller considering accessibility.

Follow the steps below to fix the EMG / Mode selector switch box.



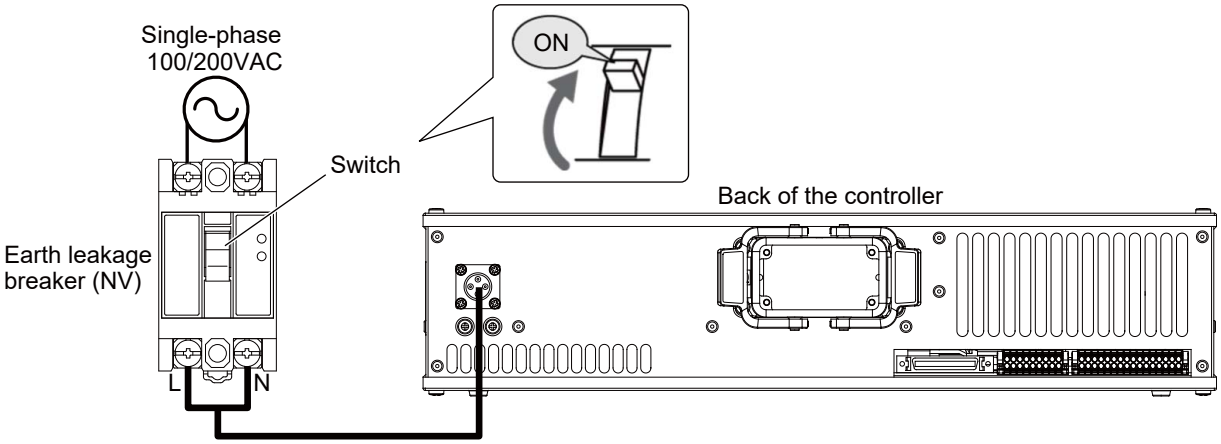
1. Fix the support bracket (included with the Easy-setup kit) in place using a fixing screw.

2. Slot the lower tab on the EMG / Mode selector switch box into the support bracket.

3. Fix the other side of the EMG / Mode selector switch box in place using a fixing screw.

1.8 Control power on

After wiring of the primary power supply, turn on the control power of the controller.
Turn on/off the earth leakage breaker using the switch installed externally.
Turn on the safety extension unit before the robot.

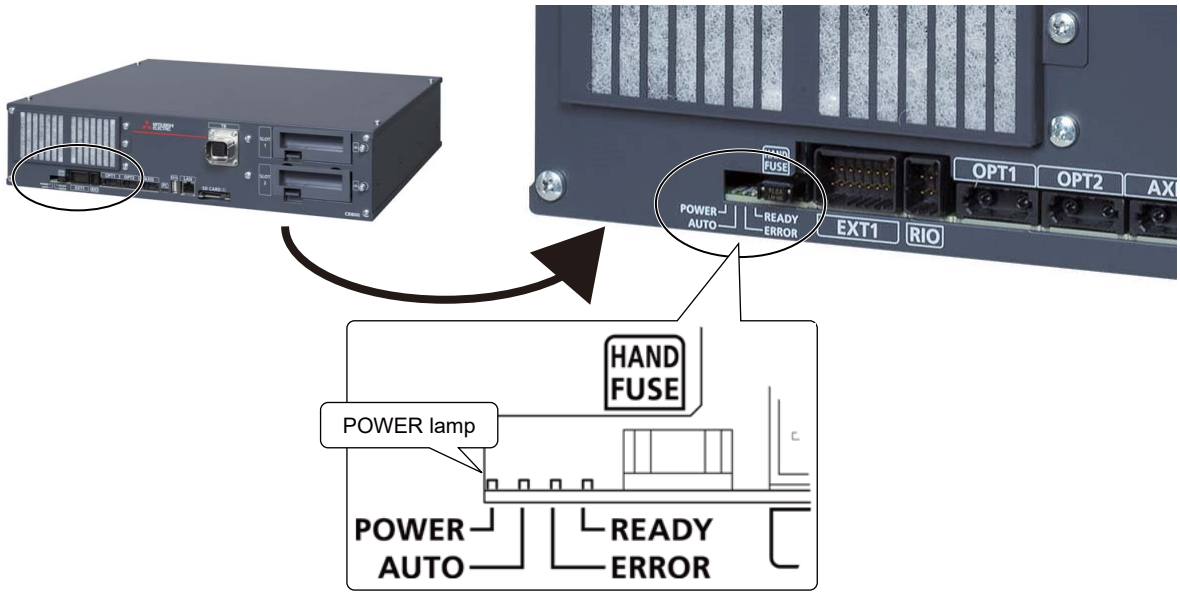


CR800-05VD controller

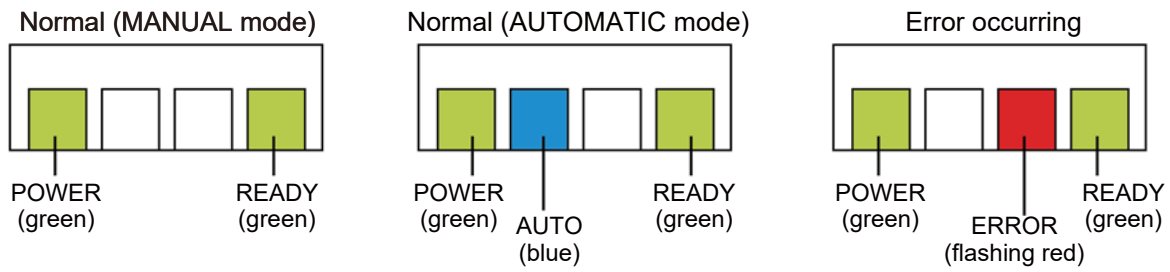
Operating procedure

1. Turn on the switch of the earth leakage breaker, then the power.
2. The POWER lamp will turn on and the control power will turn on.
3. After a short time, the READY lamp turns on and the controller is ready.

When the key switch is in the "AUTO" position, the AUTO lamp also turns on.



LED status at control power ON



Status of each LED

LED	Color	Explanation	Status
POWER	Green	Indicates the control power status.	On: Control power on Off: Control power off
AUTO	Blue	Indicates the controller mode.	On: AUTOMATIC mode Off: MANUAL mode
ERROR	Red	Indicates the error status.	On: Low level error or caution Rapid flashing: High-level error Off: Operating normally
READY	Green	Indicates the operation status.	On: The controller is ready. Slow flashing: Operating Rapid flashing: Suspended

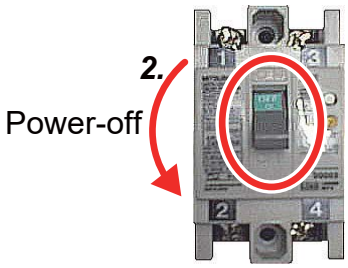
1.9 Control power off

This section explains the procedure for turning off the power.

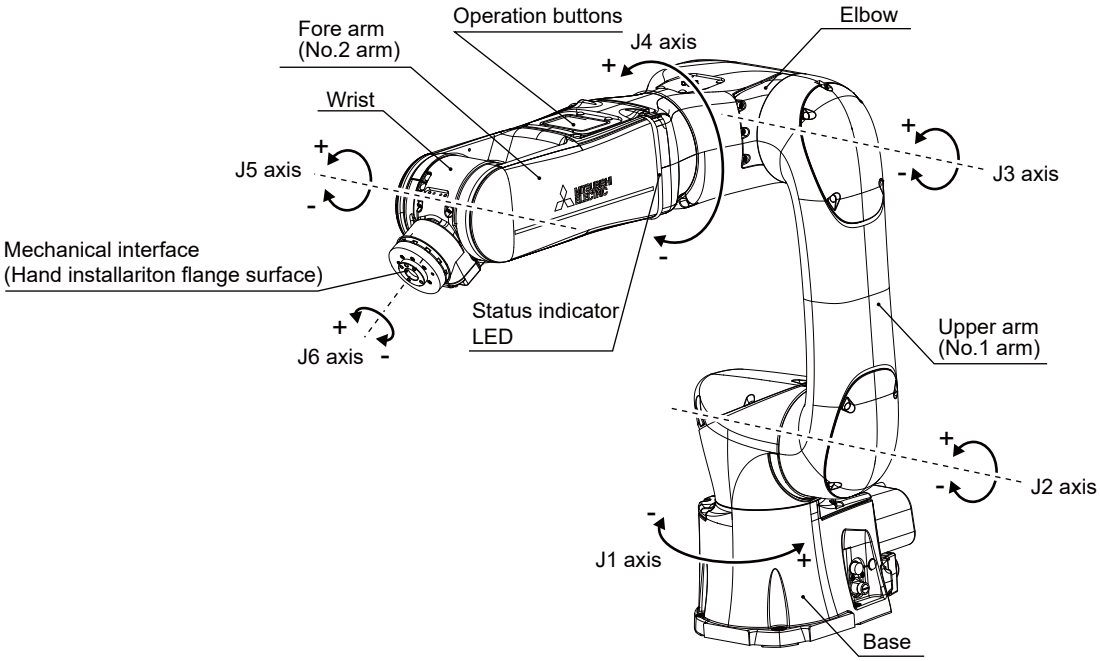
1. Check that the robot is stopped.

If the robot is operating, tap/click the stop button in RT VisualBox.

2. Turn off the control power switch.



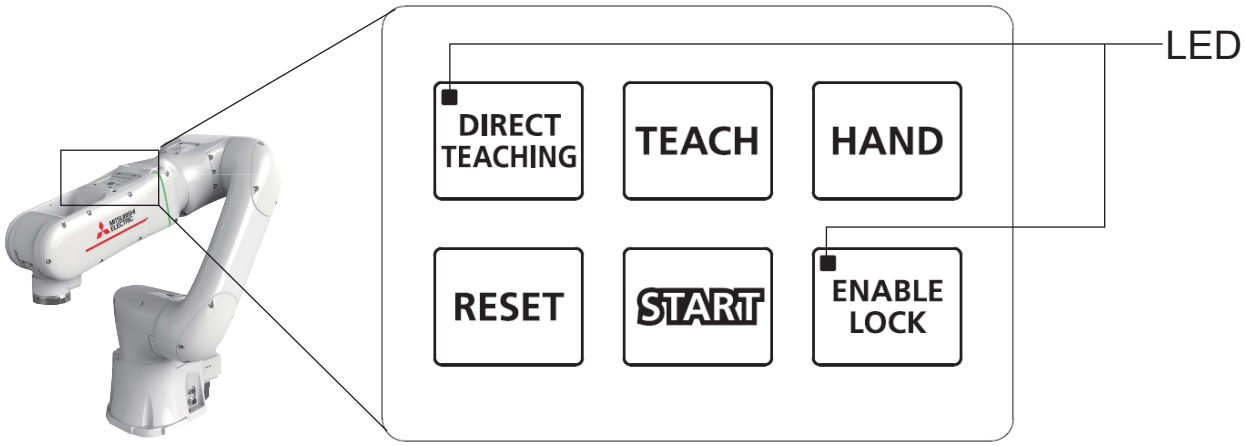
1.10 Names of robot arm parts



1.11 Operation buttons

This section explains the operation buttons on the robot forearm.

Operation button and the layout



Operation buttons

Button	Function	Information
DIRECT TEACHING	Direct teaching	Hold this button for 2+ seconds to turn direct teaching On/Off. Changes the direct teaching mode. The operation mode switches in the following order. Joint free → Translational Pressing this button in Translational mode switches the motion type back to Joint free mode. When direct teaching is turned on, the mode is set to Joint free mode. The LED indicates the following states. Off: Direct teaching is off. On: Direct teaching is on (Joint free mode). Flashing: Direct teaching is on (Translational mode).
TEACH	Position teaching	Press this button to teach the current position. A teaching point is created every time this button is pressed. RT VisualBox is required to teach positions. This button cannot be used unless RT VisualBox is connected.

Button	Function	Information
HAND	Hand operation	Hold this button for 2+ seconds to align the hand. For hand alignment, refer to the following page: ☞ Page 41 Hand alignment Press this button to open/close the hand.
RESET	Reset	When an error occurs: Press this button to reset the error. While programs are suspended: Press this button to reset the program.
START	Start	When collaborative operation has stopped: Hold this button for 2+ seconds to execute the program from the start. While collaborative operation is suspended: Hold this button for 2+ seconds to restart the program from the current command. Check whether collaborative operation is stopped or suspended in RT VisualBox.
■ ENABLE LOCK	Operation rights acquired	Press this button to acquire/relinquish operation rights. Taking control of operation rights via this button prevents other devices from operating the robot. The LED indicates the following states. On: Operation rights acquired Off: Operation rights relinquished For information on operation rights, refer to the following page: ☞ Page 28 Operation rights

⚠CAUTION

Before opening/closing the hand, ensure that doing so will not cause workpieces to fall or fingers to become trapped.

1.12 Status indicator LED

The status indicator LED is located on the forearm.

Color	Description	
	On	Flashing
Red	Error occurring (low level error)	Error occurring (high level error)
Yellow	Error occurring (warning, low-speed operation/standard operation)*1	Error occurring (warning, high-speed operation)
Blue	Stopped (low-speed operation/standard operation)	Stopped (high-speed operation)
Green	Collaborative operation mode (low-speed operation)	Collaborative operation mode (standard operation)
White	—	High-speed operation mode
Light blue	Servo OFF	Controller restarting (not including times when the software is rebooted)

*1 Flashes during servo OFF.

⚠CAUTION

Under certain lighting, the colors of the status indicator LED may become difficult to distinguish. Ensure that this does not result in unintended operation.

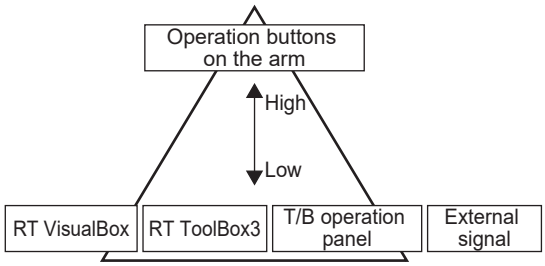
1.13 Operation rights

Multiple devices, such as the operation buttons on the robot arm, RT VisualBox, or external signals, can be used to operate the robot controller. However, only one device can operate the controller, i.e., one device can send commands for operation, servo ON, etc.. This single device has "operation rights".
Operations that involve risk require operation rights. It is essential that other workers are not able to obtain operation rights when you are near the robot while it is operating.
Operations that start the robot, such as starting a program or servo ON, require operation rights. For safety reasons, operations that stop the robot, such as stopping a program or servo OFF, do not require operation rights.

Devices that can acquire operation rights in specific modes

Mode	Device
MAUNAL	T/B
AUTOMATIC	Operation buttons on the arm, RT VisualBox, RT ToolBox3, external signals, T/B operation panel

Priority of operation rights in AUTOMATIC mode



Conditions required to acquire operation rights from other devices

Operation rights can only be acquired from devices of lower priority.
They cannot be acquired from devices with the same level of priority.

Precautions

Operation rights are not required to change the settings such as the installation type, hand settings, workpiece settings, and workpiece grasp position. Ensure it is safe to do so before changing these settings.
The settings cannot be changed during direct teaching or automatic operation.

Operations that require operation rights

Direct teaching requires operation rights.

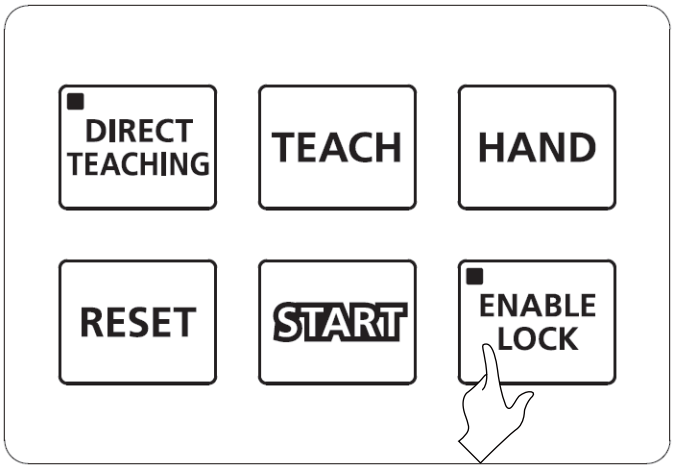
For other operations that require operation rights, refer to the following manual:

📖Detailed explanations of functions and operations (BFP-A3478)

Acquiring/relinquishing operation rights

When using the operation button on the arm

Press the [ENABLE LOCK] button on the arm to acquire/relinquish operation rights.



LED status

On: Operation rights acquired

Off: Operation rights relinquished

When using RT VisualBox

The current status of operation right can be displayed and the status can be switched with the icon in the upper right corner.

■Location

■Status

	This icon indicates that operation rights have not been requested. Tap/click the icon to request operation rights.
	This icon indicates that operation rights have been requested but have not yet been secured. Other devices, such as the operation buttons or teaching pendant, may have already acquired operation rights. Tap/click this icon to cancel the request for operation rights.
	This icon indicates that operation rights have been acquired. Tap/click the icon to relinquish operation rights.

1.14 Robot operation

This chapter explains how to operate the robot.
There are some robot operation types. Some of the types involve touching of the robot, and other types involve use of the engineering tool (RT VisualBox) on a personal computer.

Operation	Robot	RT VisualBox
Direct teaching (movement)	○(Joint free, Translational)	—
Jog operation (move in the coordinate (Cartesian) axes)	—	○(Translational, Rotational)
Inching (specified amount movement)	—	○(Translational, Rotational)
Joint operation (joint axis movement)	—	○(Joint axis)
Teach	○*1	○
Hand alignment	○	○
Hand open/close	○	○
Home position	—	○

*1 Connection with RT VisualBox must be established.

Direct teaching is an operation method of holding the robot arm directly with hand and pushing or pulling the arm manually.
Jog operation/joint operation is a method of moving the robot within the tool coordinate system or moving each joint of the robot.
Inching operation is a method of quantitatively performing jog operation/joint operation. This method is used for finer positioning.
Use direct teaching to change the robot posture greatly and use jog, joint, or inching operation to adjust the robot's position.

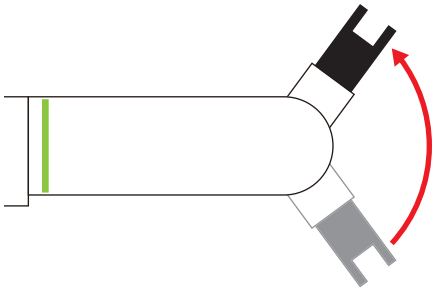
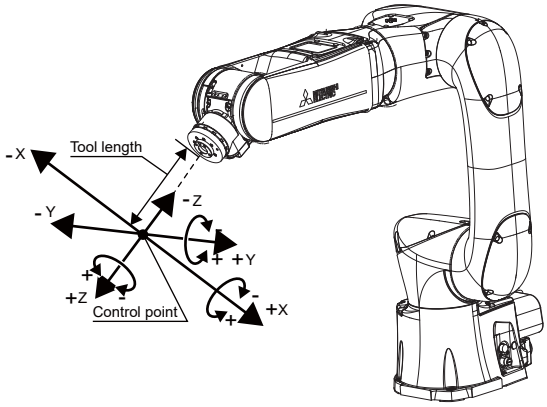
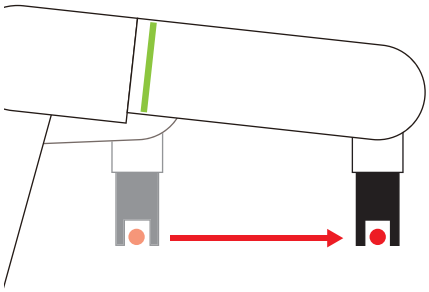
Direct teaching

Direct teaching is the operation performed by holding and moving the robot by hand.
The arm can be moved by simply pushing or pulling it.
The robot's movement can be limited to translational motion.

Direct teaching modes

There are two direct teaching modes.

Direct teaching modes

Type	Description	Operation image
Joint free	Axes can be moved individually or collectively to the desired position. With the J4 axis and J6 axis aligned (singular posture), the J4 axis may rotate when the J6 axis is operated.	
Translational motion	The robot can move in the coordinate (Cartesian) axes within the tool coordinate system while maintaining the posture relative to the tool center point. Refer to the following figure for information on the tool coordinate system. 	

Point

- The robot arm moves slowly as it nears the singularities stated below in order to suppress vibrations and prevent coasting during translational motion.

J3 axis: -30° to +30°

- The SLS function is enabled even during direct teaching. Moving the robot arm at a speed exceeding the speed limit will trigger an error. Move the robot arm at a speed below the speed limit. Moving the robot arm near singularities in translational motion while the robot operates in Low-speed operation mode may cause an error as the robot will exceed the speed limit. If an error occurs in this situation, release the brakes and move the robot using direct teaching.
- The STR function is activated even when the direct teaching function is used. Moving the robot arm abruptly may trigger error H221n.

When using the operation button on the arm

This section explains how to use direct teaching with operation buttons.

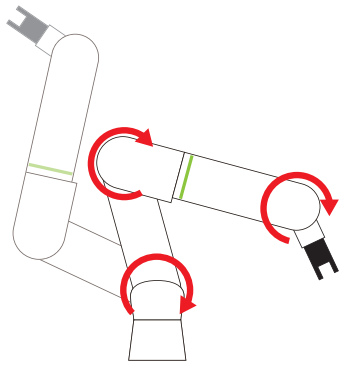
Point

- Direct teaching can only be turned on when the robot is in AUTOMATIC mode and Collaborative operation mode (standard operation or low-speed operation).
- Direct teaching cannot be turned on with the teaching pendant.

⚠CAUTION

- Place an emergency stop switch in an easily accessible place near the robot. Connect the emergency stop switch to the external emergency stop terminals of the robot controller.
- If the settings for the hand are not configured correctly, the arm may rise or fall when direct teaching is turned on. Furthermore, the safety functions may not work properly. Ensure the settings are correct.
- Inertia may cause the robot arm to move. Do not release your hands from the robot arm until it stops completely.
- Workpiece settings are not enabled during direct teaching. The robot arm may fall depending on the weight of the workpiece. Do not release your hands from the robot arm until it stops completely.
- If using one of the hand settings from HADDAT1 to HADDAT8 set in RT ToolBox3, be aware that the hand setting in the controller will be reset to HNDDAT0 if the controller's power is cycled. In this case, the arm may rise or fall as the correct hand settings will no longer be set.

1. Set the mode selector switch input of the controller to "AUTOMATIC".
2. Hold the [DIRECT TEACHING] button (for 2+ seconds) to turn on direct teaching. Check that the LED of the [DIRECT TEACHING] button is on or the status indicator LED is on or flashing green.
3. Hold the robot arm directly with your hands, and move it to the desired position/posture.



4. Press the [DIRECT TEACHING] button to change mode. The mode switches in the following order: Joint free → Translational → Joint free
5. Press the [TEACH] button to teach the current position. Then, the current position is applied to RT VisualBox.
6. Hold the [DIRECT TEACHING] button again (for 2+ seconds) to turn off direct teaching. Check that the LED of the [DIRECT TEACHING] button turns off or the status indicator LED changes from green to blue.

Point

The LED of the [DIRECT TEACHING] button indicates the following states.

- Off: Direct teaching is off.
- On: Direct teaching is on (Joint free mode).
- Flashing: Direct teaching is on (Translational mode).

RT VisualBox is required to teach positions.

Direct teaching is turned off under the following conditions:

- If the robot arm is not moved for a certain period of time (the initial value is 60 seconds) after direct teaching is turned on.

To change the time until direct teaching automatically turns off, change parameter DTTMR.

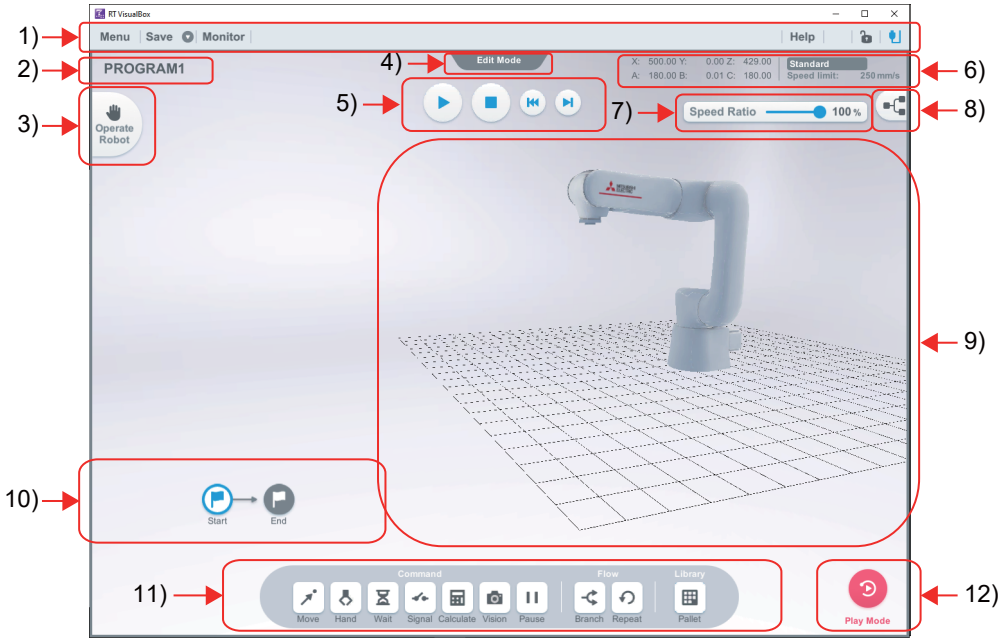
- When stop signals are input
- When a high or low level error occurs For further information on errors, refer to the following manual:

📖Troubleshooting (BFP-A3480)

- When communications with RT VisualBox have been lost (30 seconds)

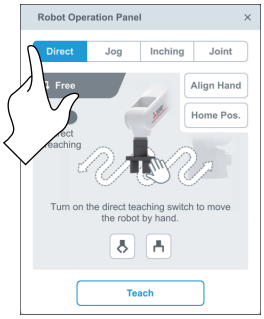
When using RT VisualBox

The figure and table below explain the interface of the main screen.



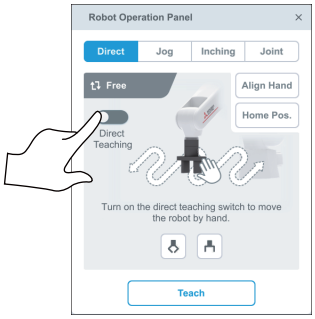
No.	Name	Use
1)	Menu bar	Contains various menus and indicates the connection status of the robot controller.
2)	Program name	Displays the name of the program.
3)	Operate Robot button	Displays a panel used for operating the robot.
4)	Display mode	Displays the current display mode. • Edit mode: Program creation mode • Play mode: Program execution mode
5)	Program execution buttons	Start, stop, or reset the program or perform step operation.
6)	Robot status	Displays the robot's current position, safe speed mode, and speed limit. "Current position" refers to the current position of the tip of the hand.
7)	Speed slider-bar	Sets the robot's operation speed.
8)	Programming/3D view button	Switches between programming view and 3D view.
		Indicates that the programming mode is enabled.
		Indicates that the 3D mode is enabled.
9)	3D area	Displays a 3D model of the robot and positions that have been taught to it.
10)	Programming area	The area used to create a program by placing and arranging program blocks
11)	Program block panel	Used to select program blocks when creating a program (Displayed in Edit mode)
12)	Mode button	Switches between Edit mode and Play mode.

Operating procedure

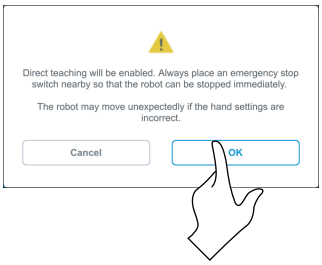


1. Tap/click the [Operate Robot] button on the main screen.

2. Select the [Direct] tab in the Robot Operation panel.

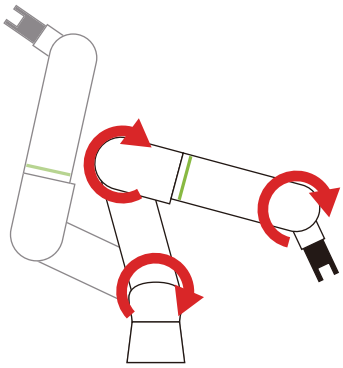


3. Tap/click the [Direct Teaching] switch in the Robot Operation panel. A conformation dialog box will appear.



4. Tap/click the [OK] button in the confirmation dialog box to turn on direct teaching.

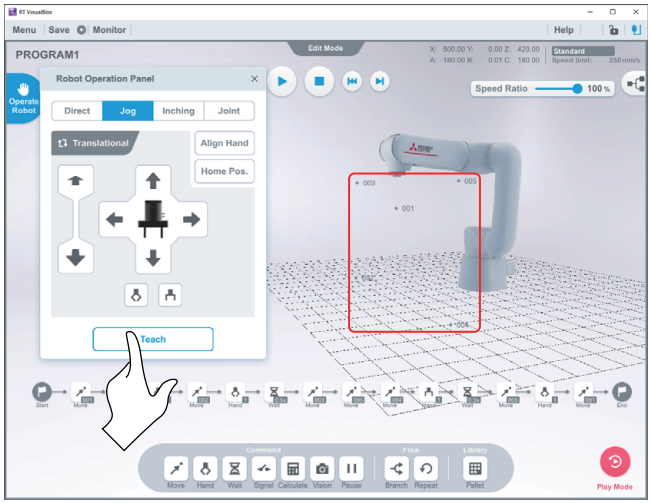
Direct teaching will remain enabled until the [Direct Teaching] switch is turned off.



5. The robot can be put in the desired position/posture by moving the arm directly with your hands.

Point

- Direct teaching is automatically turned off when switching to the Jog, Inching, or Joint window, or when an error occurs.



6. Tap/click the [Teach] button to teach the current position.

(Positions which are taught to the robot are stored in the program.)

Positions that are taught to the robot are automatically numbered from 001 and stored in consecutive order.

The taught position data is displayed in the 3D display area.

Detailed coordinate data can be checked by going to [Monitor] → [Position List].

Taught positions can be selected in the [Move] block properties.

Point

- "Current position" refers to the current position of the tip of the hand.

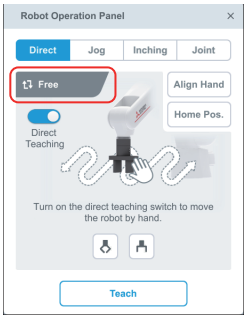
Refer to the following page for information on how to set the current position.

RT VisualBox Instruction Manual (BFP-A3696)

- Pressing the [TEACH] button on the robot arm performs the same operation as tapping/clicking the [Teach] button in the Robot Operation panel.

Tapping/clicking the [Motion type] button in the Robot Operation panel allows you to switch between motion types.

- Free: Each joint moves freely.
- Translational: The robot moves in the coordinate (Cartesian) axes.



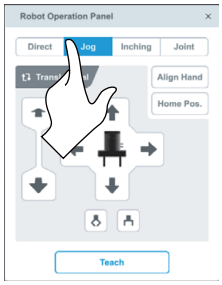
Press the [DIRECT TEACHING] button on the robot arm to turn direct teaching on or switch between motion types.

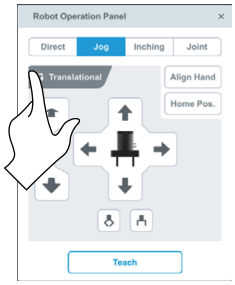
Operation	Direct teaching status	Operation
Press and hold (Two seconds or more)	OFF	Turns Direct teaching on.
	ON	Turns Direct teaching off.
Single press	OFF	—
	ON	Switches the operation mode in the following order: Free → Translational Pressing this button in Translational mode switches the motion type back to Free mode.

Jog operation

Jog operation allows the robot arm to be moved in the coordinate (Cartesian) axes via the Robot Operation panel. Translational or rotational movement can be selected.

Operating procedure





1. Select the [Jog] tab in the Robot Operation panel.

2. Tapping/clicking the [Motion type] button in the Robot Operation panel allows you to switch between motion types.

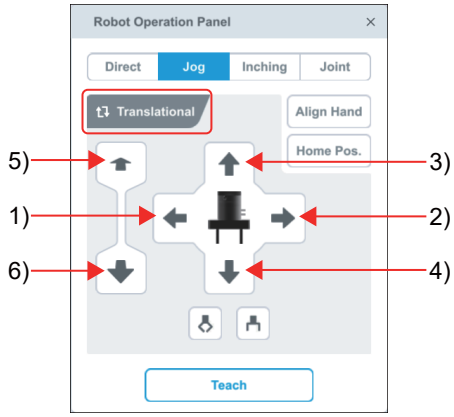
- Translational: The robot moves in the coordinate (Cartesian) axes within the tool coordinate system.
- Rotational: The robot moves in the rotational direction within the tool coordinate system.

Refer to the page below for information on the tool coordinate system.

📖RT VisualBox Instruction Manual (BFP-A3696)

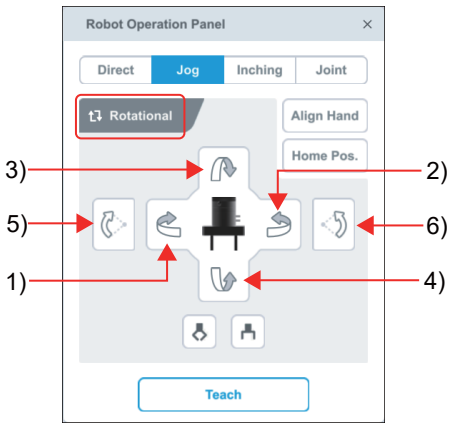
The robot moves in the specified direction while any of the move buttons (arrows) in the Robot Operation panel are pressed.

Motion type: Translational motion



No.	Direction
1)	Moves the arm in the negative Y direction.
2)	Moves the arm in the positive Y direction.
3)	Moves the arm in the negative Z direction.
4)	Moves the arm in the positive Z direction.
5)	Moves the arm in the positive X direction.
6)	Moves the arm in the negative X direction.

Motion type: Rotational motion



No.	Direction
1)	Rotates the arm in the positive C direction.
2)	Rotates the arm in the negative C direction.
3)	Rotates the arm in the negative B direction.
4)	Rotates the arm in the positive B direction.
5)	Rotates the arm in the positive A direction.
6)	Rotates the arm in the negative A direction.

Inching

Inching mode allows the robot arm to be moved in specific distances via the Robot Operation panel.
Translational or rotational movement can be selected.

Operating procedure

1. Select the [Inching] tab in the Robot Operation panel.

2. Tapping/clicking the [Motion type] button in the Robot Operation panel allows you to switch between motion types.

- Translational: The robot moves in the coordinate (Cartesian) axes within the tool coordinate system.
- Rotational: The robot moves in the rotational direction within the tool coordinate system.

Refer to the page below for information on the tool coordinate system.

📖RT VisualBox Instruction Manual (BFP-A3696)

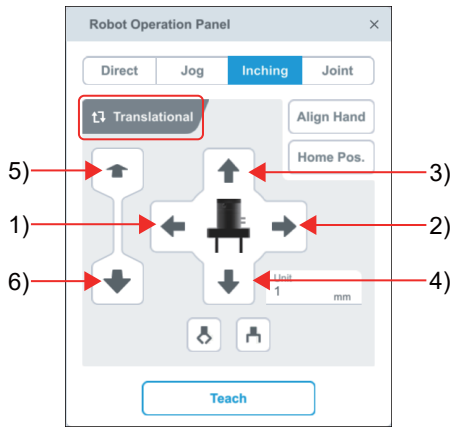
3. In the Unit field, set the distance of each movement in Inching mode.

The value entered in the Unit field needs to be entered separately for both translational and rotational motion.

- Translational: Enter distances in millimeters.
- Rotational: Enter distances in degrees.

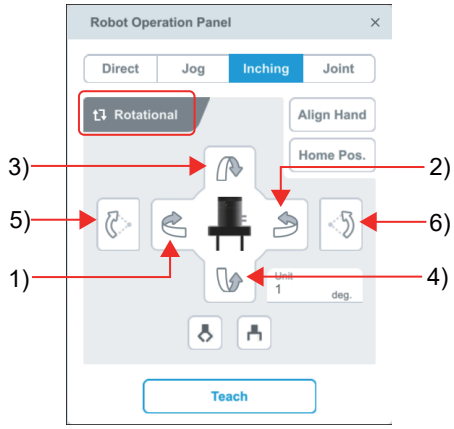
Numbers with up to two decimal places can be entered.
The robot moves the distance set in the Unit field when any of the arrows in the Robot Operation panel are pressed.
The robot will stop moving once it reaches the specified distance even if the arrow buttons continue to be held down.

Motion type: Translational motion



No.	Direction
1)	Moves the arm in the negative Y direction.
2)	Moves the arm in the positive Y direction.
3)	Moves the arm in the negative Z direction.
4)	Moves the arm in the positive Z direction.
5)	Moves the arm in the positive X direction.
6)	Moves the arm in the negative X direction.

Motion type: Rotational motion

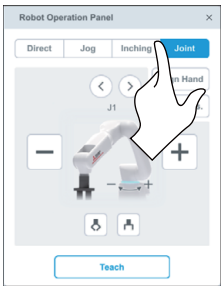


No.	Direction
1)	Rotates the arm in the positive C direction.
2)	Rotates the arm in the negative C direction.
3)	Rotates the arm in the negative B direction.
4)	Rotates the arm in the positive B direction.
5)	Rotates the arm in the positive A direction.
6)	Rotates the arm in the negative A direction.

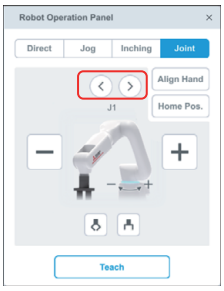
Joint operation

Joint operation allows individual joints of the robot arm to be moved via the Robot Operation panel.

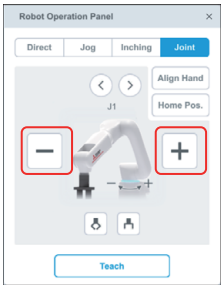
Operating procedure



1. Select the [Joint] tab in the Robot Operation panel.



2. Tap/click the joint selection buttons in the Robot Operation panel to select the joint you want to operate (J1 to J6).

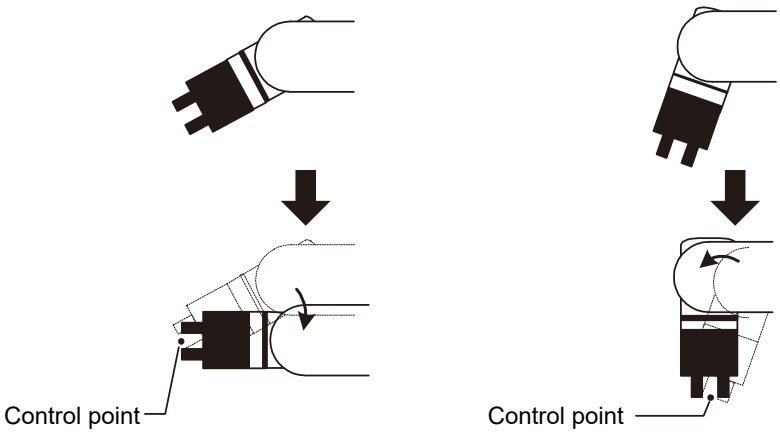


3. Hold down the [+] or [-] buttons to move the robot in the respective directions.

- [-] button: Rotates the specified joint in the negative direction.
- [+] button: Rotates the specified joint in the positive direction.

Hand alignment

The posture of the robot hand can be aligned in 90° increments.
This function moves the hand in 90° increments to the values closest to the current positions of components A, B, and C.



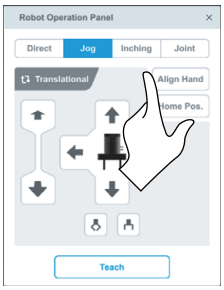
For details on hand alignment, refer to the following manual:
📖Detailed explanations of functions and operations (BFP-A3478)

When using the operation button on the arm

1. Set the mode selector switch input of the controller to "AUTOMATIC".
2. Hold the [HAND] button for 2+ seconds and release the finger from the button to align the hand.

When using RT VisualBox

Operating procedure



1. Tap/click the [Align Hand] button in any operation mode to align the hand.

If the robot is in High-speed operation mode, the speed ratio will reduce to 20%.

Opening/closing the hand

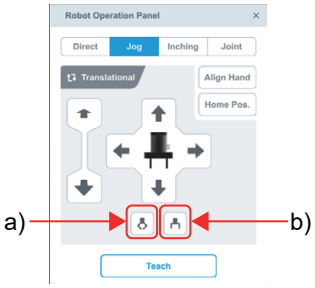
Open/close the hand attached to the robot.

When using the operation button on the arm

Press the [HAND] button on the arm to open/close the hand.

When using RT VisualBox

Operating procedure



1. Tap/click the buttons indicated by "a" and "b" in any operation mode to open/close the hand.

- a: Outputs the Close hand signal.
- b: Outputs the Open hand signal.

Home position

The Home Position function moves the robot to a safe position where it will not interfere with any peripheral devices or equipment.

This function is used to move the robot to a safe position after an error has caused the robot to stop.

This allows you to reset the error while the robot is in a safe position.

It can also be used to move the robot to a safe, preset position before a program starts.

Operating procedure

1. Tap/click the [Home Pos.] button in any of the operation modes to move the robot to the home position.

If the robot is in High-speed operation mode, the speed ratio will reduce to 20%.

Point

The image below shows the default home position.

For information on the parameter to set for home position, refer to "Safe point position" in "List Movement parameter" of the following manual:

📖Detailed explanations of functions and operations (BFP-A3478)

2 Functions of RT VisualBox

RT VisualBox is intuitive, easy-to-use software with support for touch-screen devices. It enables users to easily set up and program robots, even without specialist robot knowledge.
The basic functions of RT VisualBox are described below.

Function		Description
Robot connection		Used to select how the robot is connected
Initial settings		Used to configure the initial settings (installation type, hand settings, workpiece settings, and workpiece grasp position)
Programming	Visual programming (Main screen)	• Programs can be created by dragging and dropping program blocks. • Programs can be executed and debugged. • The 3D layout and simulation can be viewed from this screen.
	Block properties	Used to configure the advance settings of each block
	Robot operation panel	Used to operate the robot arm The robot can be operated using the following four modes: Direct teaching, Jog, Inching, and Joint mode.
	Monitor	Position list, signals, variables, errors
Custom settings	Select language	Used to select the display language
	Workpiece grasp position settings	Used to configure the workpiece grasp position settings (These settings are available in the initial settings.)
	Signal settings	A separate name can be specified for each input signal and each output signal.
	Date and time settings	Used to set the date and time
Safety settings		Used to configure the mandatory settings of safety functions
Vision sensor settings	Connection settings	Used to configure the vision sensor connection settings
	Workpiece transportation	Used to configure pick-up point and workpiece identification settings
Maintenance	Backup	Exports data from the currently connected robot as a backup file
	Restore	Sends backup file data to the currently connected robot
	Origin settings	• Used to configure the origin settings of each axis • Used to release the brakes
	Parameter settings	Used to read and write parameters
Help	Manual	Displays the Instruction Manual for this product
	Software version	Shows the software version

2.1 Shared screen operations

This section explains the common operations performed on RT VisualBox screens.

Touch operations and equivalent mouse operations

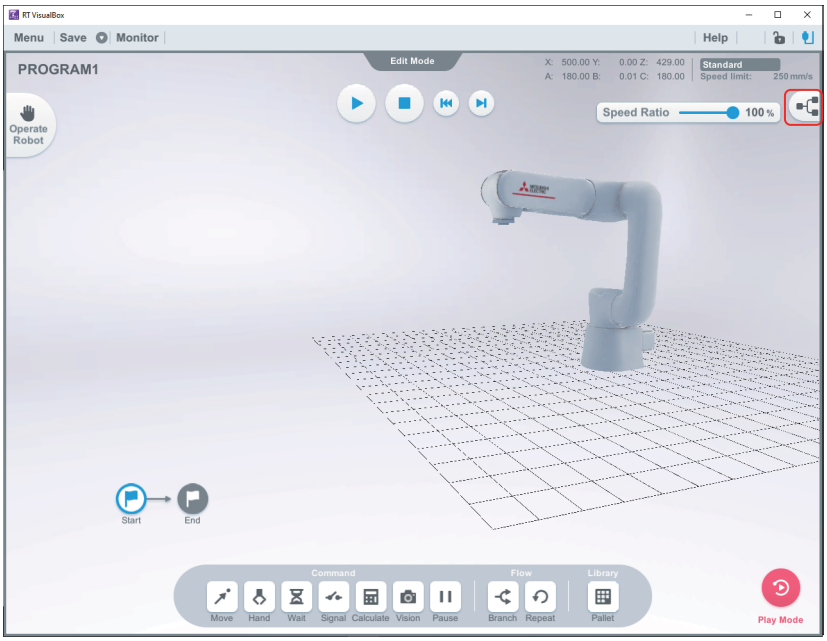
Touch operation	Mouse operation
Tap	Left-click
Double-click	Double left-click
Press and hold	Right-click
Drag	Left-click drag
Two-finger drag	Right-click drag
Pinch-in/Pinch-out	Ctrl + mouse wheel

The screen cannot be swiped, flicked, and rotated using a mouse.

Programming screen modes

Switching modes

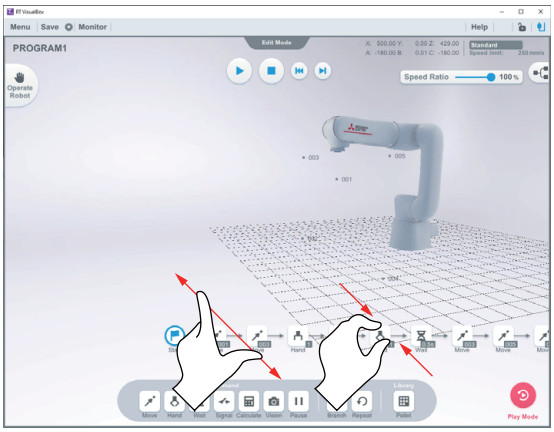
Tapping/clicking the Programming/3D mode button allows you to switch between Programming mode and 3D mode.



	Indicates that Programming mode is enabled. Programs can be edited in this mode. The position and size of programs can be adjusted, which is helpful when constructing long programs.
	Indicates that 3D mode is enabled. Programs cannot be edited in this mode. The angle and position of which the robot is viewed in can be adjusted in 3D mode.

Mouse and touch operations for Programming/3D mode

■Programming mode



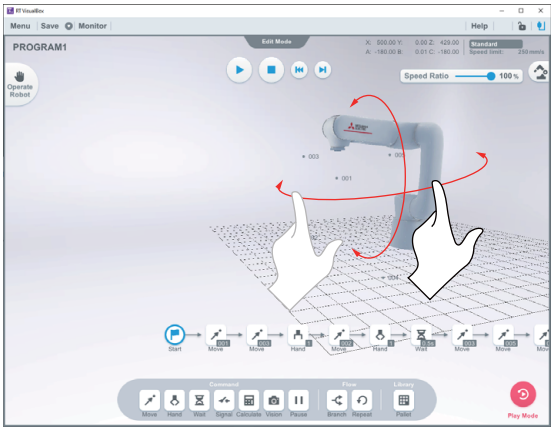
Touch operation: Pinch-in/Pinch-out

Mouse operation: Ctrl + mouse wheel

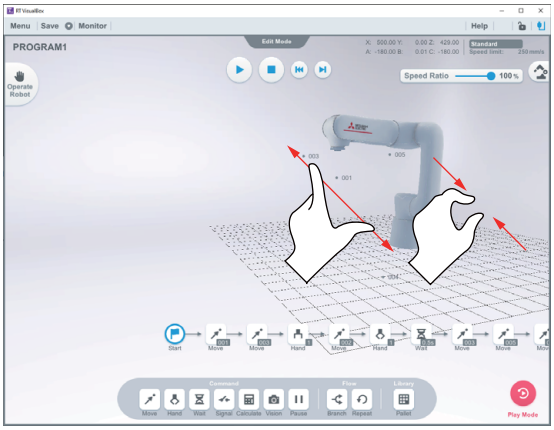
Action: Increases/decreases the size of the programming blocks.

Touch operation: Drag
Mouse operation: Left-click drag
Action: Moves the programming blocks up, down, left and right.

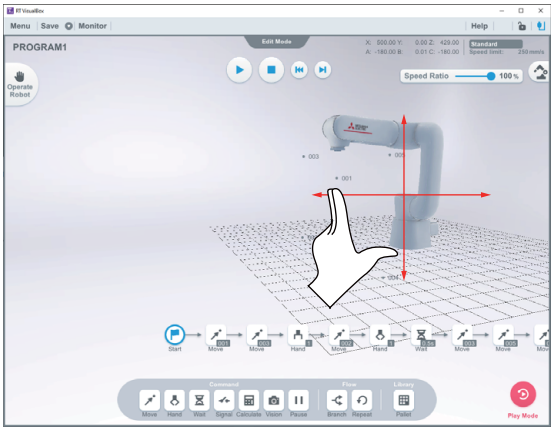
■3D mode



Touch operation: Drag
Mouse operation: Left-click drag
Action: Rotates the view around the robot.



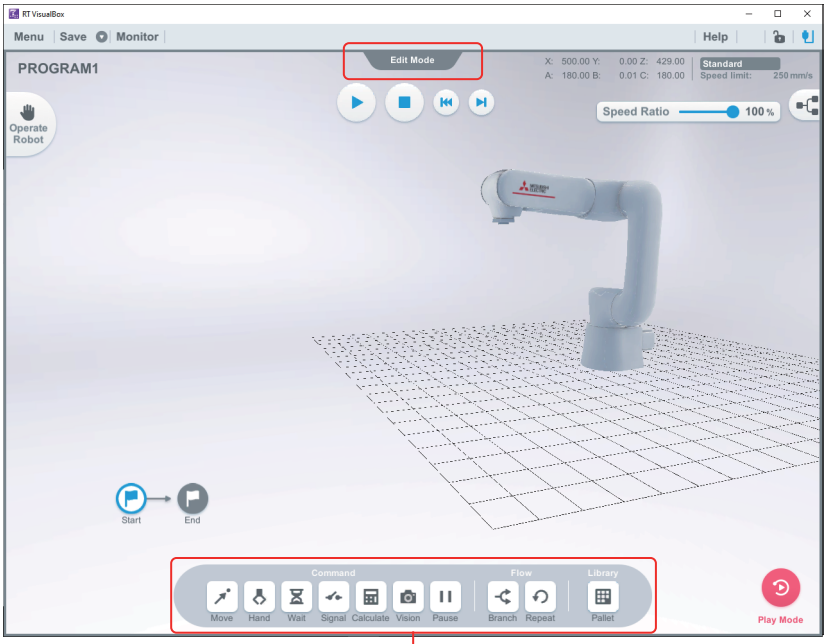
Touch operation: Pinch-in/Pinch-out
Mouse operation: Ctrl + mouse wheel
Action: Zooms in/out on the robot.



Touch operation: Two-finger drag
Mouse operation: Right-click drag
Action: Moves the view of the robot up, down, left and right.

2.2 Program blocks

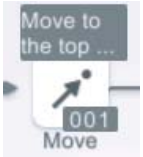
This chapter provides detailed information on the functions of the program blocks used in RT VisualBox programming.
Program blocks are displayed in the program block panel at the bottom of the screen in Edit mode.
Explanations of each block are provided in the table below.



Block name	Description
Move	Moves the robot (Tap/click to configure settings).
Hand	Opens/closes the hand (Tap/click to configure settings).
Wait	Instructs the robot to wait (Tap/click to configure settings).
Output	Outputs signals (Tap/click to configure settings).
Pause	Pauses the operation.
Branch	Branches conditions (Tap/click to configure settings).
Repeat	Repeats the operation (Tap/click to configure settings).
Calculate	Performs calculations (Tap/click to configure settings).
Pallet	Used to set up palletizing operations (Tap/click to configure settings).
Vision	Recognizes the workpiece (Tap/click to configure settings). (This block becomes available when a robot is connected to the software.)

Point

Comments entered in a block's settings will be displayed above the block.
The comment will be displayed in two lines. Not all of the comment will be visible.



Move block

Function

This block is used to move the robot from its current position to another position.

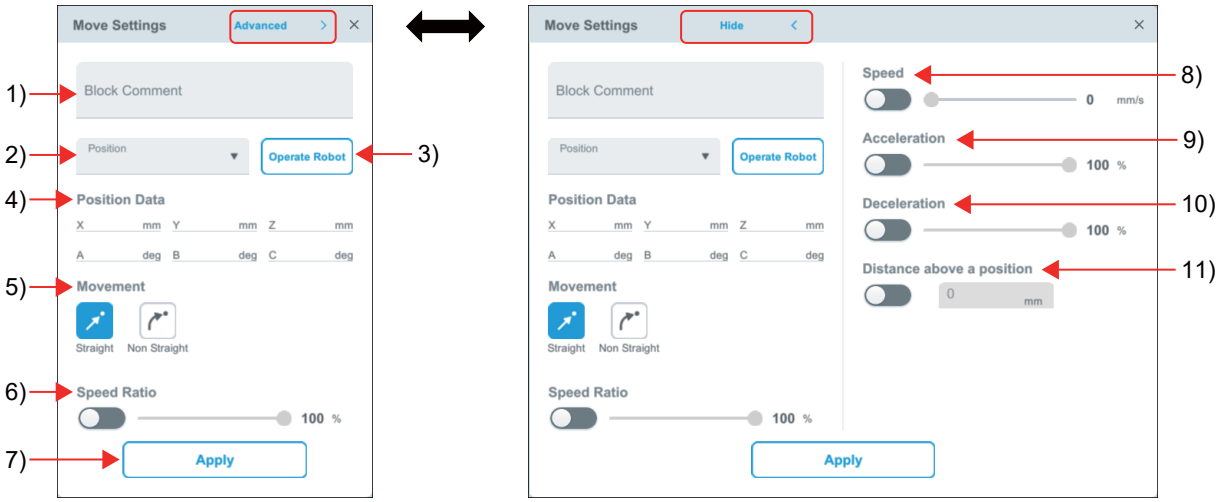
Program block

Block properties

Tap/click the [Move] block in the program to open the Move Settings window.

Advanced settings can be configured here.

Tap/click [Advanced] in the top right of the window to open the screen used for setting speed, acceleration, deceleration, and a distance above a position.



No.	Name	Use	
1)	Block comment	This field is used to enter comments for this block.	
2)	Position	Select a position from the list of registered positions.	
			The number of the selected position is displayed in the bottom right of the program block once it is set.
3)	Operate Robot	Displays a panel used for operating the robot. Moving the robot arm and then tapping/clicking [Teach] performs one of the following operations. If no position is selected: Creates a new position. If a position is selected: Updates the current position.	
4)	Position Data	Displays the coordinates of the selected position.	
5)	Movement	Select how the robot moves.	
			Straight: Performs linear interpolation. In linear interpolation, the tool center point moves along a straight trajectory. For details on the movement, refer to the following page: ☞ Page 49 Difference between linear interpolation and joint interpolation
			Non Straight: Performs joint interpolation. Joint interpolated motion evenly interpolates the joint angle difference of each axis. Therefore, the trajectory of the tip of the hand may change. For details on the movement, refer to the following page: ☞ Page 49 Difference between linear interpolation and joint interpolation

No.	Name	Use	
6)	Speed ratio	This switch is used to enable/disable the speed ratio. The initial value is 100%. The speed ratio can be specified from 0% to 100% of the robot movement speed. Once set, the speed is maintained until it is changed by the next Move block, or until the program finishes or is reset. The speed ratio value returns to the initial value when the program reaches "End" or is reset.	
			Off: Operates at the speed specified in the previous operation.
			On: Operates at the speed set with the slider. The slider becomes active. Specify the speed from 0% to 100%. The switch turns to the Off position when the slider is set to 0%.
7)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.	
8)	Speed	This can only be set when [Movement] is set to [Straight]. This switch is used to enable/disable speed settings. The initial value is 1000 mm/s. The speed can be specified from 0 to 1000 mm/s for straight movement. Once set, the speed is maintained until it is changed by the next Move block, or until the program finishes or is reset. The speed ratio value returns to the initial value when the program reaches "End" or is reset.	
			Off: Operates at the speed specified in the previous Move block.
			On: Operates at the speed set with the slider. The slider becomes active. Specify the speed from 0 mm/s to 1000 mm/s. The switch turns to the Off position when the slider is set to 0 mm/s.
9)	Acceleration	This can only be set when [Movement] is set to [Straight]. This switch is used to enable/disable acceleration settings. The initial value is 100%. The acceleration of the robot's movement can be specified from 0% to 100%. Once set, acceleration is maintained until it is changed by the next Move block, or until the program finishes or is reset. The acceleration value returns to the initial value when the program reaches "End" or is reset.	
			Off: The robot accelerates according to the value specified in the previous Move block.
			On: The robot accelerates according to the value set with the slider. The slider becomes active. Specify the acceleration from 0% to 100%. The switch turns to the Off position when the slider is set to 0%.
10)	Deceleration	This can only be set when [Movement] is set to [Straight]. This switch is used to enable/disable deceleration settings. The initial value is 100%. The deceleration of the robot's movement can be specified from 0% to 100%. Once set, deceleration is maintained until it is changed by the next Move block, or until the program finishes or is reset. The deceleration value returns to the initial value when the program reaches "End" or is reset.	
			Off: The robot decelerates according to the value specified in the previous Move block.
			On: The robot decelerates according to the value set with the slider. The slider becomes active. Specify the deceleration from 0% to 100%. The switch turns to the Off position when the slider is set to 0%.
11)	Distance above a position	This switch is used to enable/disable the "Distance above a position" settings. This setting is disabled by default. Moving diagonally to a position or moving to a position that is far away may increase the possibility of the robot colliding with something and losing its grasp on the workpiece. Enabling this setting prevents collisions by allowing the robot to move to a position set above a taught position. For details on the distance above a position, refer to the following page: ☞ Page 49 Distance above a position	
			Disabled: The robot moves to a taught position.
			Enabled: The robot moves to a position at specified distance above a taught position. The switch turns to the Off position if a distance of 0 mm is specified.

Precautions

When [Moving Method] is set to [Straight], there may be instances when linear movement is not possible due to the robot's posture or the relationship between the start position and end position of the movement. In such instances, an error will occur. This can be rectified with the following methods:

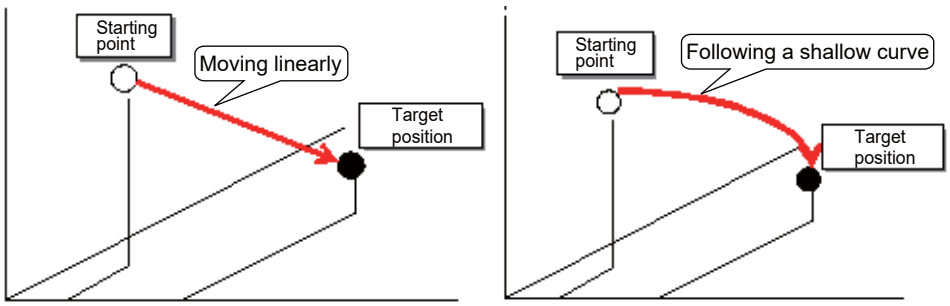
- Change the movement to [Non Straight].
- Change the robot's posture or the start/end position of the movement.
- Set a via point between the start and end positions of the movement.

⚠ CAUTION

Changing how the robot moves will change the path that the robot takes. Be aware that this may cause the robot to interfere with workpieces or peripheral devices.

■Difference between linear interpolation and joint interpolation

The following shows the difference in movement between when [Straight] is selected and [Non Straight] is selected in the [Move] block settings.



When [Straight] is selected　　When [Non Straight] is selected

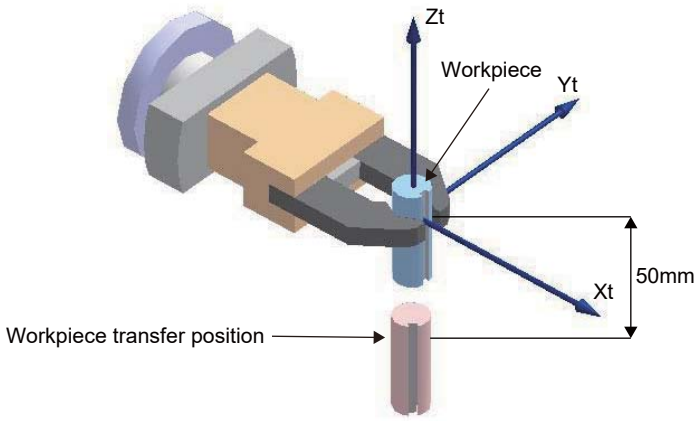
■Distance above a position

Enabling Distance above a position in the [Move] block settings allows you to specify the approach/retreat distance, which facilitates the workpiece pick-up/transfer movement settings. The approach/retreat direction is the Z direction within the tool coordinate system.

For a move to the position 50 mm above the workpiece transfer position, enter [50] in the entry field for [Distance above a position].

Setting the Z direction within the tool coordinate system according to the orientation and motion of the workpiece will increase productivity.

In the following example, the Z-axis direction within the tool coordinate system is aligned with the workpiece orientation so that the workpiece is inserted/removed by the side-facing hand.



Hand block

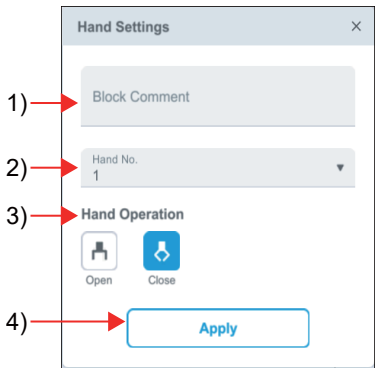
Function

This block is used to operate the hand.

Program block

Block properties

Tap/click the [Hand] block in the program to open the Hand Settings window.
Advanced settings can be configured here.



No.	Name	Use	
1)	Block comment	This field is used to enter comments for this block.	
2)	Hand No.		No. 1 is the only number selectable.
3)	Hand motion	These buttons are used to select the operation of the hand. Verification of hand open/closed status signals is done with hand signals (Wait block, Signal block, and Branch block).	
			Open: Opens the hand.
			Close: Closes the hand.
4)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.	

Wait block

Function

This block is used to make the robot wait until specified conditions are met.

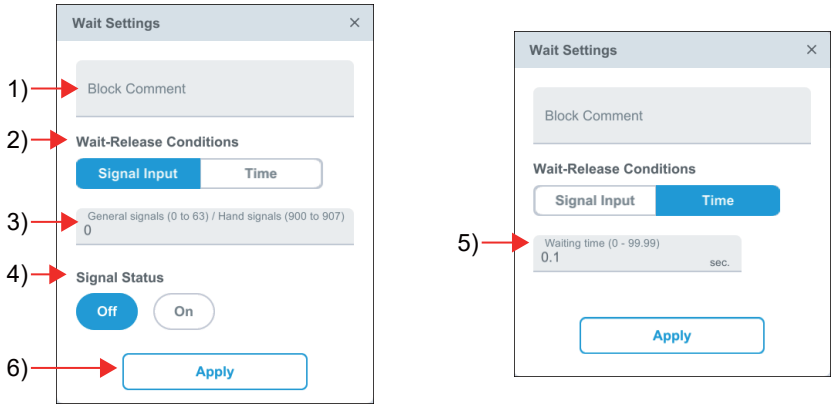
When executing a program in simulation mode while the Wait-Release Conditions field is set to [Signal Input], the program moves to the next block without waiting for signal input.

Program block

Block properties

Tap/click the [Wait] block in the program to open the Wait Settings window.

Advanced settings can be configured here.



No.	Name	Use	
1)	Block comment	This field is used to enter comments for this block.	
2)	Wait-release conditions	This field is used to select the conditions under which the program should stop waiting. • Signal Input: The program will stop waiting depending on the input status of the specified signal. • Time: The program will stop waiting when the specified time has elapsed.	
3)	Input signal number		This field is displayed when [Wait-Release Conditions] is set to [Signal Input]. This field is used to select an input signal that will be used as the condition. Signals 0 to 63 can be specified for general-purpose signals. Signals 900 to 907 can be specified for hand signals. The input signal is displayed in the bottom right of the program block once it is set.
4)	Signal status	This field is displayed when [Wait-Release Conditions] is set to [Signal Input]. Select the status of the signal that will be used as the condition. • Off: The program stops waiting when the specified signal turns off. • On: The program stops waiting when the specified signal turns on.	
5)	Time setting		This field is displayed when [Wait-Release Conditions] is set to [Time]. Set the amount of time the program should wait. The wait time can be set from 0 to 99.99 sec. The standby time is displayed in the bottom right of the program block once it is set.
6)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.	

Signal block

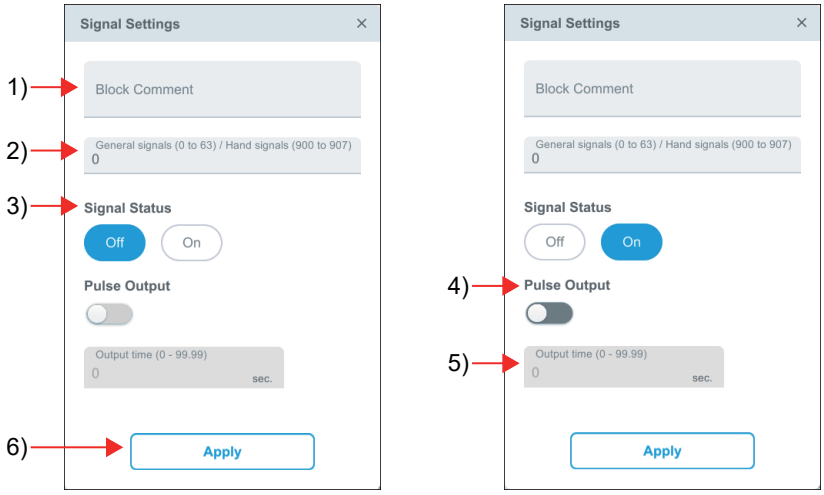
Function

This block is used to output signals (bits).

Program block

Block properties

Tap/click the [Signal] block in the program to open the Signal Settings window.
Advanced settings can be configured here.



No.	Name	Use	
1)	Block comment	This field is used to enter comments for this block.	
2)	Output signal number		Set the output signal number. Signals 0 to 63 can be specified for general-purpose signals. Signals 900 to 907 can be specified for hand signals. The output signal is displayed in the bottom right of the program block once it is set.
3)	Signal status	Used to select the status of the output signal • Off: Turns the output signal Off. • On: Turns the output signal On.	
4)	Pulse output	This can be set when [Signal Status] is set to On. It enables/disables pulse output.	
			Off: Outputs a constant signal.
			On: Outputs a pulse signal.
5)	Output time	This can be set when [Signal Status] is set to On. This field is used to set the pulse output time. The pulse output time can be set from 0 to 99.99 sec.	
6)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.	

Pause block

Function

This block is used to suspend the program and make the robot wait.

Tap/click the [Play] button or [Step forward] button to restart the program.

Program block

Block properties

This block does not have block properties.

Branch block

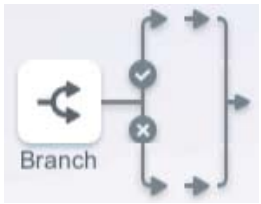
Function

This block branches the program according to conditions set by the user.

If the conditions set for the branch block are met, the upper path is executed. If the conditions set for the branch block are not met, the lower path is executed.

Program block

Branch block in the block panel

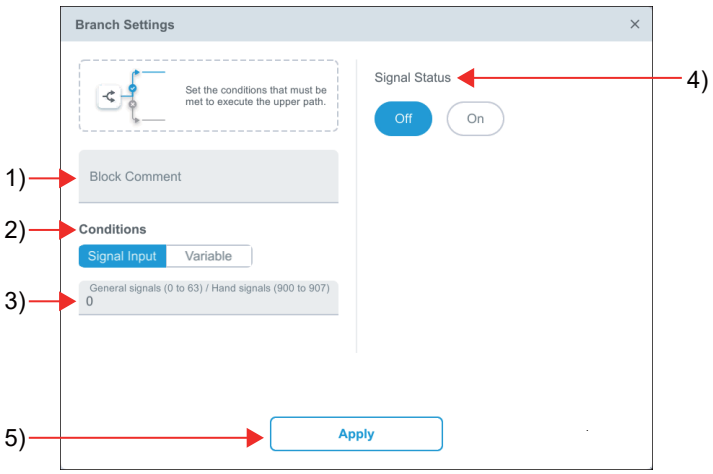


Branch block placed in the program

Block properties

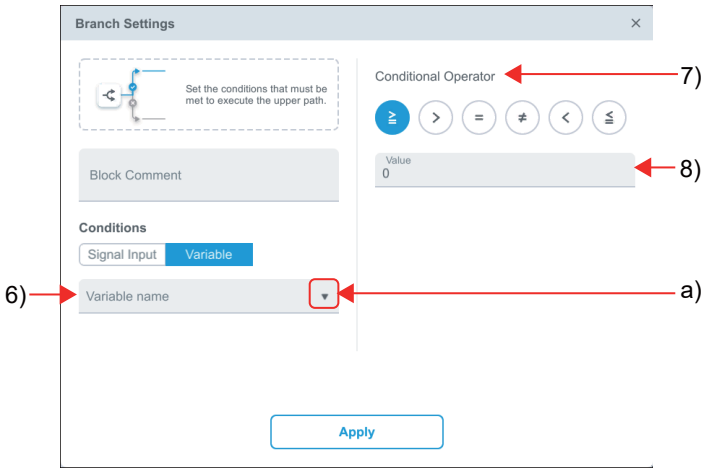
Tap/click the [Branch] block in the program to open the Branch Settings window.

Advanced settings can be configured here.



No.	Name	Use
1)	Block comment	This field is used to enter comments for this block.

No.	Name	Use
2)	Conditions	This field is used to set the conditions by which the upper path is executed. • Signal Input: The status of the specified input signal number is used as the condition. • Variable: The status of the variable is used as the condition.
3)	Input signal number	This is displayed when [Conditions] is set to [Signal Input]. This field is used to select an input signal that will be used as the condition. Signals 0 to 63 can be specified for general-purpose signals. Signals 900 to 907 can be specified for hand signals.
4)	Signal status	This is displayed when [Conditions] is set to [Signal Input]. This field is used to set the status of the input signal being used as the condition. • Off: If the signal is Off, the upper path is executed. • On: If the signal is On, the upper path is executed.
5)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.



No.	Name	Use
6)	Variable name	This field is displayed when [Conditions] is set to [Variable]. This field is used to select the variable which will be used as the condition. Tapping/clicking the arrow indicated by "a" displays the set variable name. A variable name can be selected from the variables displayed. Variable names can be entered by tapping/clicking anywhere in the field next to the arrow indicated by "a". Use this field to enter a new variable name.
7)	Conditional expression symbols	This field is displayed when [Conditions] is set to [Variable]. Select the expression to be used as the condition.
8)	Condition value	This field is displayed when [Conditions] is set to [Variable]. This field is used to enter a numeric value which will be used as the condition.

Precautions

Only numerical variables can be entered for the settings of the variable selected. Do not enter a variable name starting with P, J, C or W.

Variable names are in single-precision floating-point format.

Refer to the section "MELFA-BASIC VI" in the manual stated below for information on the programming language of variables.

📖Detailed explanations of functions and operations (BFP-A3478)

Repeat block

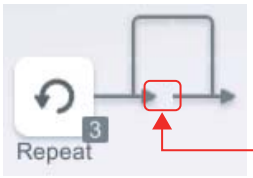
Function

This block is used to repeat the program.

It will repeat the operations of blocks placed within the repeat range the number of times specified. It will also repeat the operations as long as the specified conditions are met.

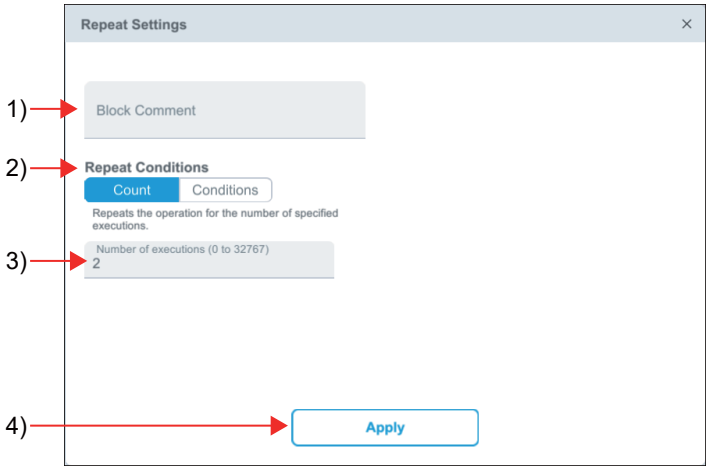
Program block

Repeat block in the block panel



Repeat block placed in the program

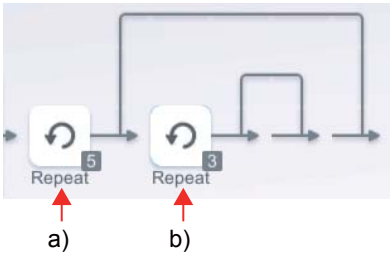
Block properties

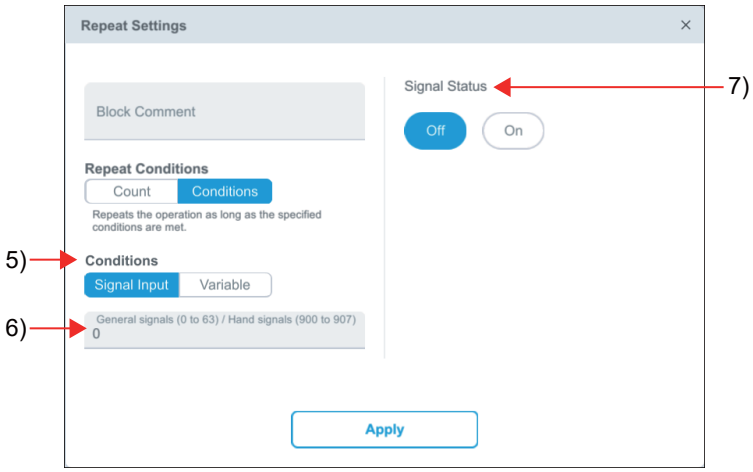


No.	Name	Use
1)	Block comment	This field is used to enter comments for this block.
2)	Repeat conditions	This setting is used to set repeat conditions. • Count: Repeats the operation for the number of specified executions. • Conditions: Repeats the operation as long as the specified conditions are met.
3)	Number of executions	Set the number of times to repeat the operations of blocks placed within the repeat range.
4)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.

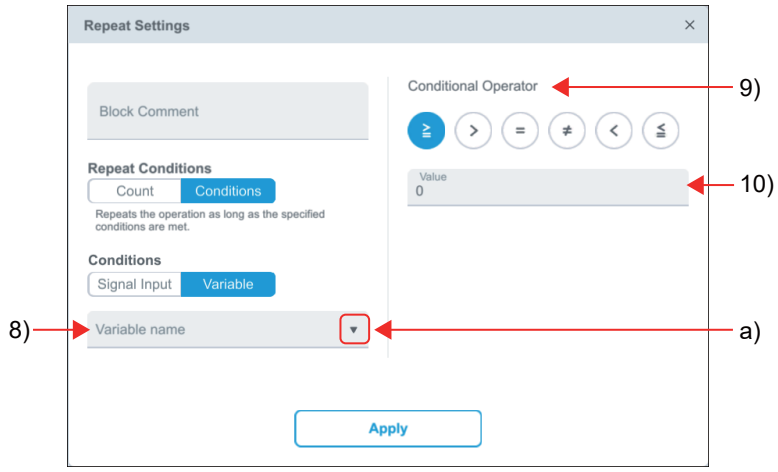
Point

The variable names "MrepeatN" are created automatically. The current number of times the program has been repeated is stored in the variable.
"N" represents a number at the end of a variable name. This number indicates the position of the block within the order of Repeat blocks.
For example, the variable name of the Repeat block indicated by "a" below is Mrepeat1, and the block indicated by "b" is Mrepeat2.
This variable can be set in the conditions of the Branch block.





No.	Name	Use
5)	Conditions	This setting is used to select the type of condition to be used for the repeat block. • Signal Input: The status of the specified input signal number is used as the condition. • Variable: The status of the variable is used as the condition.
6)	Input signal number	This is displayed when [Conditions] is set to [Signal Input]. This field is used to select an input signal that will be used as the condition. Signals 0 to 63 can be specified for general-purpose signals. Signals 900 to 907 can be specified for hand signals.
7)	Signal status	This is displayed when [Conditions] is set to [Signal Input]. This field is used to set the status of the input signal being used as the condition. • Off: If the signal is Off, the operation is repeated. • On: If the signal is On, the operation is repeated.



No.	Name	Use
8)	Variable name	This field is displayed when [Conditions] is set to [Variable]. This field is used to select the variable which will be used as the condition. Tapping/clicking the arrow indicated by "a" displays the set variable name. A variable name can be selected from the variables displayed. Variable names can be entered by tapping/clicking anywhere in the field next to the arrow indicated by "a". Use this field to enter a new variable name.
9)	Conditional expression symbols	This field is displayed when [Conditions] is set to [Variable]. Select the expression to be used as the condition.
10)	Condition value	This field is displayed when [Conditions] is set to [Variable]. This field is used to enter a numeric value which will be used as the condition.

Precautions

Only numerical variables can be entered for the settings of the variable selected. Do not enter a variable name starting with P, J, C or W.

Variable names are in single-precision floating-point format.

Refer to the section "MELFA-BASIC VI" in the manual stated below for information on the programming language of variables.

📖Detailed explanations of functions and operations (BFP-A3478)

Calculate block

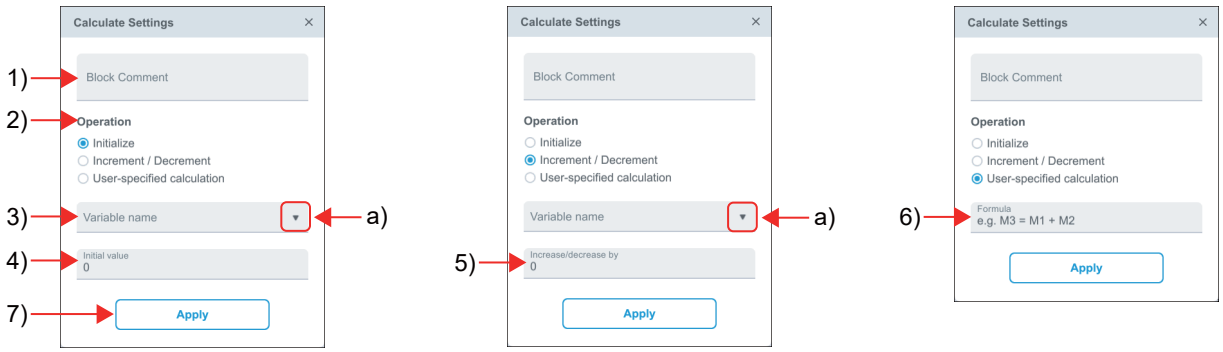
Function

This block is used to calculate variables.

Program block

Block properties

Tap/click the [Calculate] block in the program to open the Calculate Settings window.
Advanced settings can be configured here.



No.	Name	Use
1)	Block comment	This field is used to enter comments for this block.
2)	Operation	This field is used to select an operation type. • Initialize: Initial values are assigned to variables. • Increment / Decrement: Variables are incremented/decremented. • User-specified calculation: User-specified calculations are executed.
3)	Variable name	This field is displayed when [Operation] is set to [Initialize] or [Increment / Decrement]. This field is used to select the variable name. Tapping/clicking the arrow indicated by "a" displays the set variable name. A variable name can be selected from the variables displayed. Variable names can be entered by tapping/clicking anywhere in the field next to the arrow indicated by "a". Use this field to enter a new variable name.
4)	Initial value	This field is displayed when [Operation] is set to [Initialize]. Enter a value to be used as the initial value.
5)	Increase / Decrease Amount	This field is displayed when [Operation] is set to [Increment / Decrement]. Enter a value to be added/deducted. • If a positive value has been entered, the variable is incremented (increased). • If a negative value has been entered, the variable is decremented (decreased).
6)	Formula	This field is displayed when [Operation] is set to [User-specified calculation]. User-specified formulas can be entered in this field.
7)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.

Precautions

Only numerical variables can be entered for the settings of the variable selected. Do not enter a variable name starting with P, J, C or W.

Variable names are in single-precision floating-point format.

Refer to the section "MELFA-BASIC VI" in the manual stated below for information on the programming language of variables.

📖Detailed explanations of functions and operations (BFP-A3478)

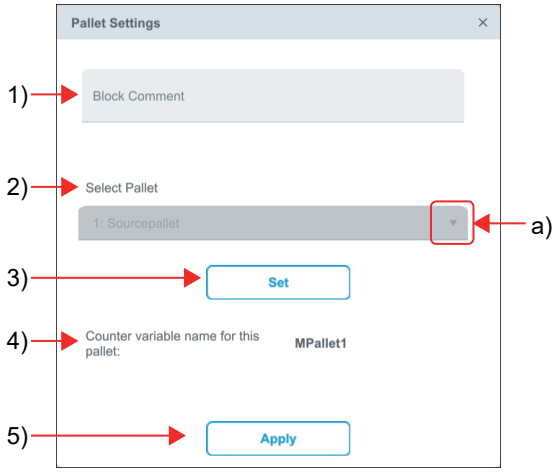
Pallet block

Function

This function is used to palletize and depalletize workpieces/products. I.e. it loads and unloads pallets neatly.
When the robot moves to a pallet cell, its hand will be fixed to the posture (direction) it was in at the start position.

Program block

Block properties



No.	Name	Use
1)	Block comment	This field is used to enter comments for this block.
2)	Select Pallet	This field is used to create new pallet settings or select existing ones. Tapping/clicking the arrow indicated by "a" displays existing pallet settings. If this window appears after placing a pallet block in the program, this setting will be unavailable.
3)	Pallet settings	Tap/click this button to configure the pallet settings (size, position, operation pattern, etc.). Pallet settings can be configured for a new or existing pallet. Refer to the following page for information on how to configure pallet settings. ☞ Page 60 Pallet settings
4)	Counter variable name for this pallet	This is the variable name which will be used as the counter for this pallet when a program is being executed. This counter variable can be used when you want to change the settings of a specific pallet. The variable name for this counter is "MPalletN". The letter "N" indicates the pallet number. This variable name will only appear after a pallet block has been configured and placed in the program.
5)	Apply	This button only becomes available once existing pallet settings have been selected. Tap/click the [Apply] button to apply the settings that have been made.

Precautions

- Up to eight pallets can be set in any one program. If a new pallet cannot be created, delete any unnecessary pallet blocks, save the program, then try again.
- This function does not support the use of a vision sensor. It is not possible to use a vision sensor to adjust the movement to pallet cells.
- If an error occurs with this block when the program is executed, change the positions in the pallet settings.

☞ Page 63 Editing existing pallet settings

If the error persists, it may have something to do with the relationship between the position of the robot and pallet. For further information, refer to "Def Plt (Define pallet)" in the following manual:

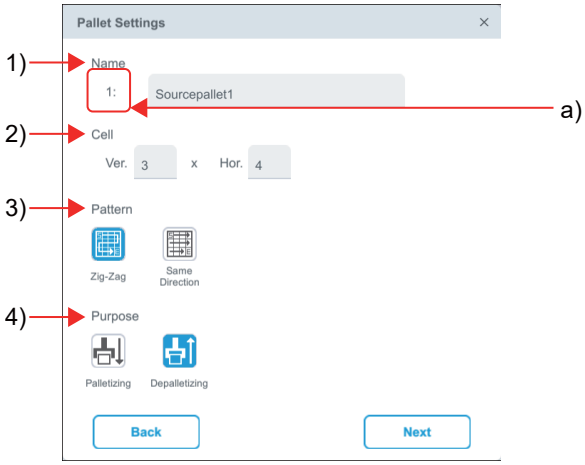
📖Detailed explanations of functions and operations (BFP-A3478)

Pallet settings

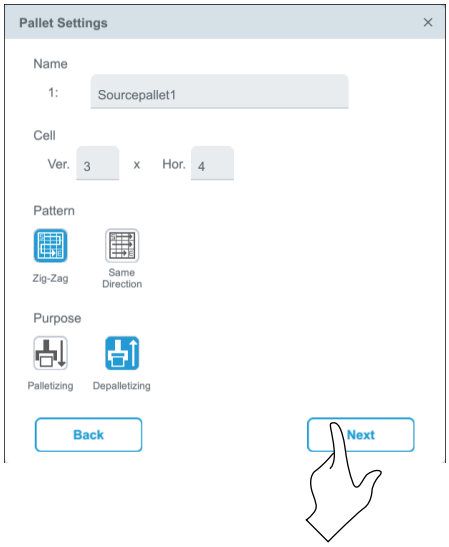
■Creating new pallet settings

Operating procedure

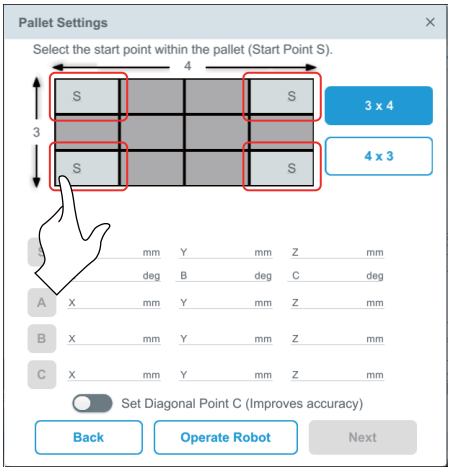
1. Configure the basic pallet settings.



No.	Name	Use
1)	Name	Enter a pallet name. The number indicated by "a" is the pallet number.
2)	Cell	Enter the number of cells in the horizontal and vertical directions. Cell numbers can be specified from 1 to 999.
3)	Pattern	Choose the direction in which the robot should operate.
4)	Purpose	Choose the purpose of the operation. Palletize: Stack workpieces (goods or materials) onto a pallet. Depalletize: Remove workpieces (goods or materials) from a pallet.

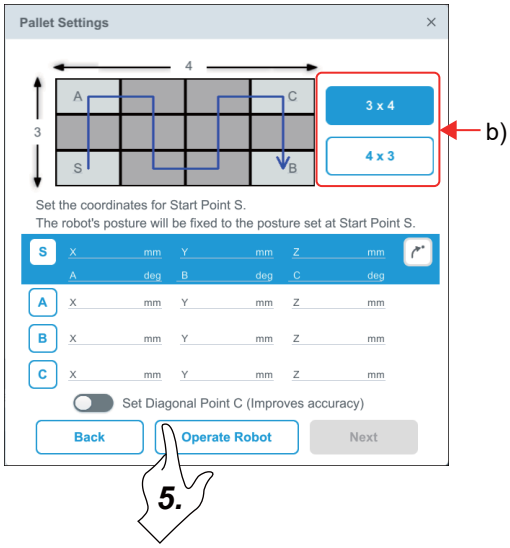


2. Tap/click [Next].



3. Click one of the cells in the four corners of the pallet to set Start Point S.

Start Point S: The first point the robot will move to.
End Point A: The first point the robot should not continue past. The robot will continue the operation for every cell from the side of Start Point S to the side of End Point A.
End Point B: The second point the robot should not continue past.
Diagonal Point C: The cell diagonally-opposite Start Point S.



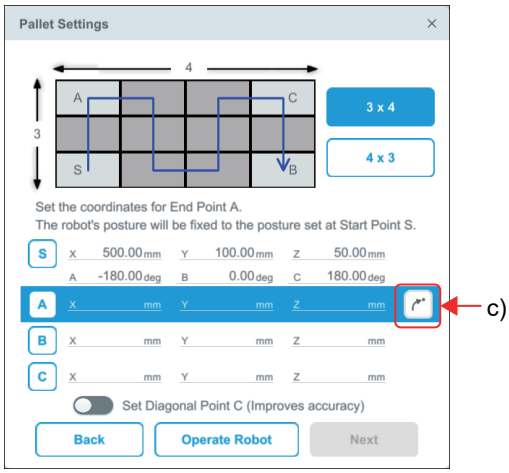
4. The direction of the pallet operation will be displayed. Tap/click the buttons indicated by "b" to invert End Point A and End Point B. Tapping/clicking a corner other than that of Start Point S will show the direction of the pallet operation with the selected cell set as Start Point S.

5. Tap/click [Operate Robot], then move the robot to the position of Start Point S.

6. Tap/click [Teach] in the Robot Operation panel.

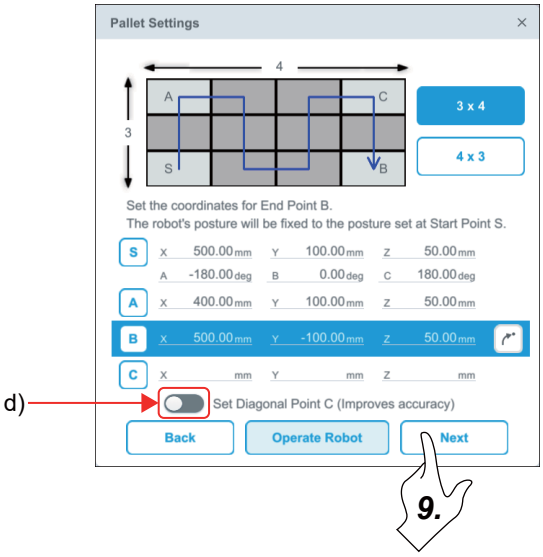
⚠ CAUTION

The direction of the pallet operation shown in the figure above is for illustration purposes only. The actual pallet operation will follow the positions that have been set for points S, A, B, and C.
Teach positions S, A, B, and C so that they match the figure in the Pallet Settings window.



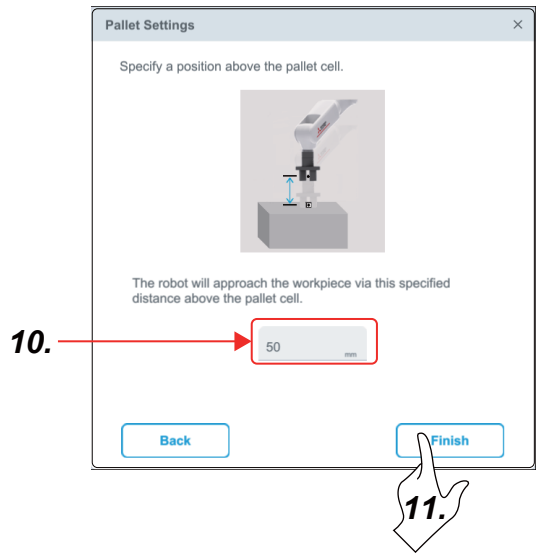
7. Teach End Point A and End Point B the same way as indicated in steps 5 and 6.

Tapping/clicking the [Jump position] button indicated by "c" will move the robot to the selected set point.



8. By default, Diagonal Point C does not need to be set. Turn on [Set Diagonal Point C (Improves accuracy)] and set Diagonal Point C if the pallet you are using is distorted or you want to improve the accuracy of the pallet operation.

9. Tap/click [Next].

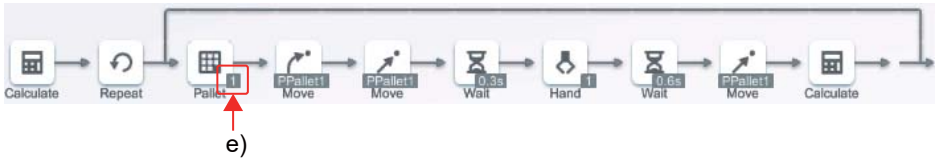


10. Specify the distance the robot should keep above the pallet before it approaches a pallet cell.

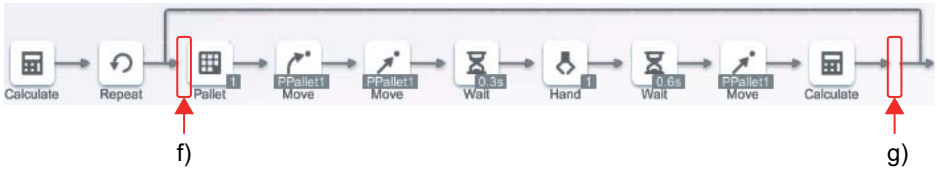
11. Tap/click the [Finish] button.

12. A repeating program for the number of cells in the pallet operation will be automatically inserted to the left and right of the [Pallet] block in the program.

The pallet number (indicated by "e") will appear in the bottom right of the [Pallet] block.



13. For palletizing operations, use the area indicated by "f" just before the [Pallet] block to instruct the robot where to pick the workpieces from. For depalletizing operations, use the area indicated by "g" just after the last [Calculate] block to instruct the robot where to place the workpieces.

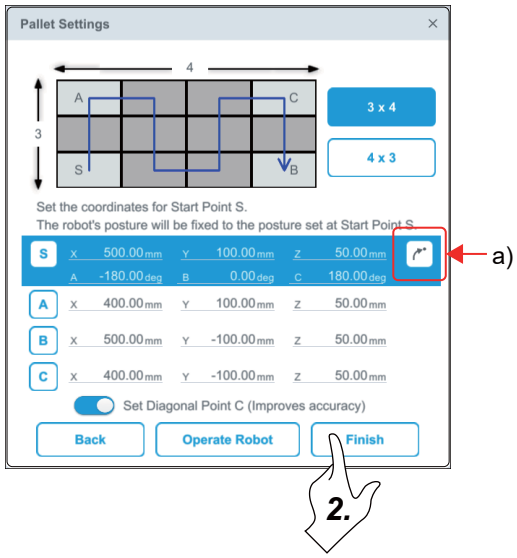


Point

By placing a pallet block in the areas indicated by "f" and "g", it is possible to make the robot transfer workpieces from one pallet to another.
When creating such an operation, edit the settings of blocks to create your desired program. For example, edit the conditions in the [Repeat] block or adjust the position of the [Calculate] block that initializes the operation counter.

■Editing existing pallet settings

Operating procedure



1. Change existing pallet settings (operation direction, pallet position, etc.) with the same steps used for creating new pallet settings.

Tapping/clicking the [Jump position] button indicated by "a" will move the robot to the selected set point.

2. Tap/click [Finish] once changes have been made.
3. To change the distance the robot should keep above the pallet, change the distance in the advance settings of the [Move] block.

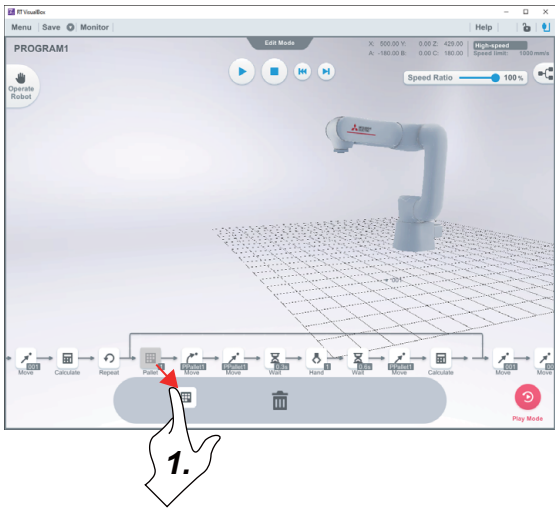
Point

If the robot is not moving to positions on the pallet accurately, setting Diagonal Point C may increase position accuracy.

Deleting Pallet blocks

Follow the steps below to delete any unnecessary [Pallet] blocks in the program.

Operating procedure



1. To delete the [Pallet] blocks that were automatically inserted into the program, drag them downwards into the trash can.

Point

By deleting the [Repeat] block in front of the [Pallet] block, it is possible to delete all the [Pallet] blocks in the repeat area at once. Be aware that by doing this, any blocks that have manually been inserted into this area will also be deleted.

Vision block

Function

This function is used to transport workpieces with the help of a vision sensor.

Precautions

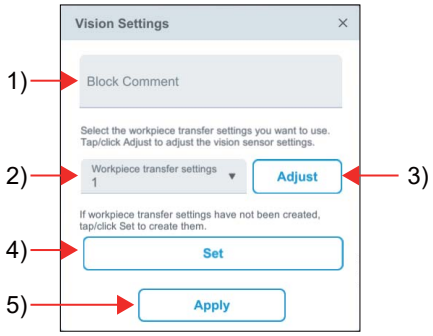
This block becomes available when a robot is connected to the software.

Program block

Block properties

Tap/click the [Vision] block in the program to open the Vision Settings window.

Advanced settings can be configured here.



No.	Name	Use
1)	Block comment	This field is used to enter comments for this block.
2)	Workpiece transfer settings	This field is used to select a registered workpiece transfer setting. Refer to the following page for information on how to configure the workpiece transfer settings. ☞ Page 133 Vision settings, autocalibration
3)	Adjust	This button is enabled when a setting is selected in [Workpiece transfer settings]. Tap/click this button to open the Adjusting workpiece identification settings screen. Refer to the following page for further information on how to adjust the vision sensor. 📖RT VisualBox Instruction Manual (BFP-A3696)
4)	Set	Workpiece transfer settings can be created if no settings have been registered yet. Tap/click this button to display the Vision Settings window.
5)	Apply	Tap/click the [Apply] button to apply the settings that have been made. Tapping/clicking [×] in the top right of the window discards the settings. Tapping/clicking another program block also discards the settings.

Refer to the following page for information on vision sensor settings and adjustment.

☞ Page 133 Vision settings, autocalibration

Precautions

Once the program has started and the vision sensor has imaged a workpiece, the vision sensor will try to identify that workpiece with the registered image of the master workpiece.
If the vision sensor can identify the workpiece, the robot will grasp the workpiece. If the vision sensor cannot identify the workpiece, the robot will stay in the imaging position.
The result of whether the vision sensor has identified the workpiece will be stored as the variable "M_VSFoundNum". If the workpiece can be identified, the value "1" will be stored. If the workpiece cannot be identified, the value "0" will be stored. Set these conditions for the variable "M_VSFoundNum" in the branch block and create the operations that will occur depending on whether the sensor was able to identify the workpiece.
☞ Page 53 Branch block
If the workpiece cannot be identified, check the position and angle of the workpiece as well as surrounding light levels.
Tap/click the [Adjust] button to open the Adjusting workpiece identification settings screen and check if the vision sensor can identify the workpiece.
For details, refer to the following manual:
📖RT VisualBox Instruction Manual (BFP-A3696)

2.3 Others

Variables

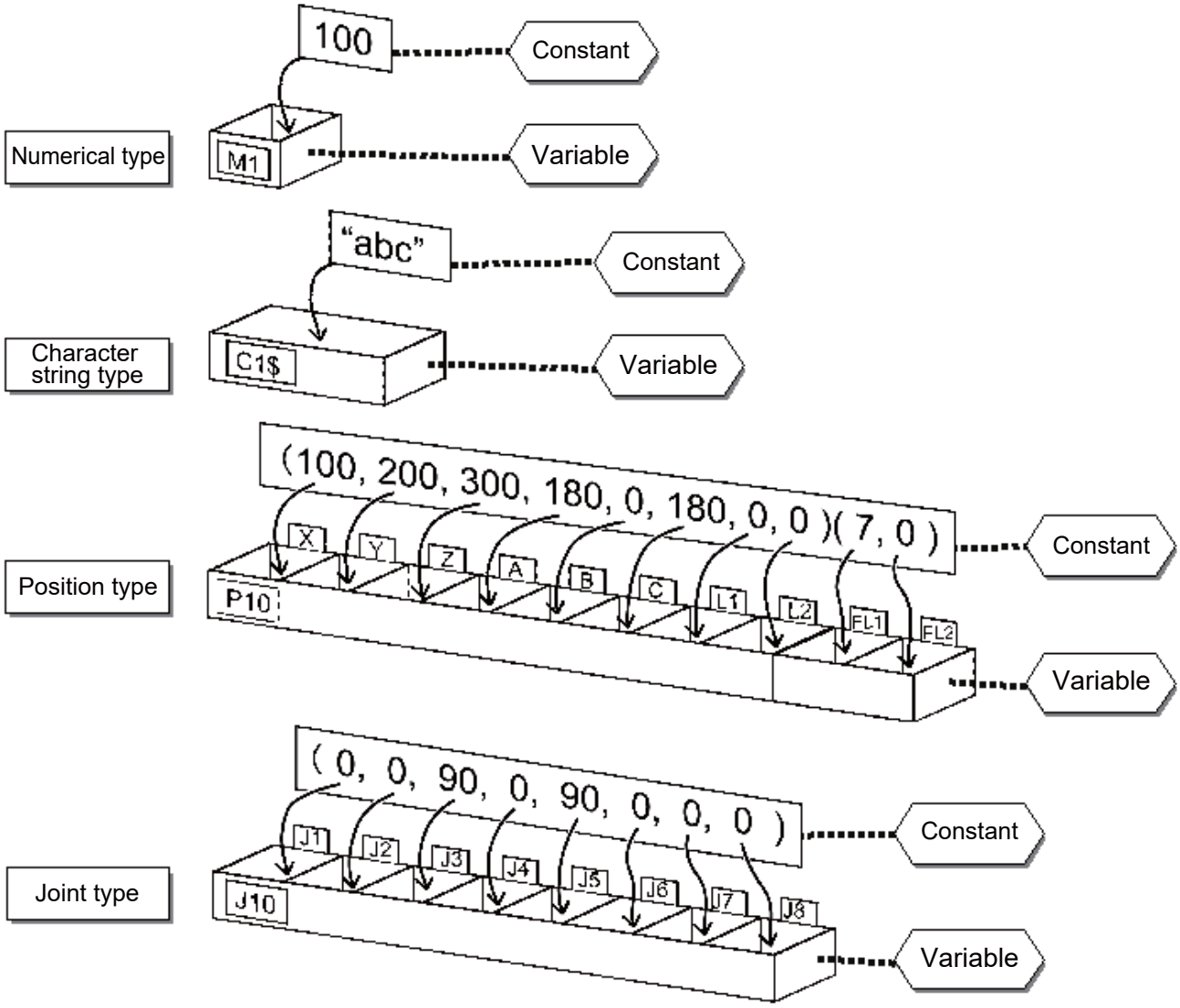
Constants and variables for programs

■Data types

A constant refers to a preset fixed value.

A variable refers to a container for data.

A variety of constant and variable types are available depending on the data to be handled or stored.

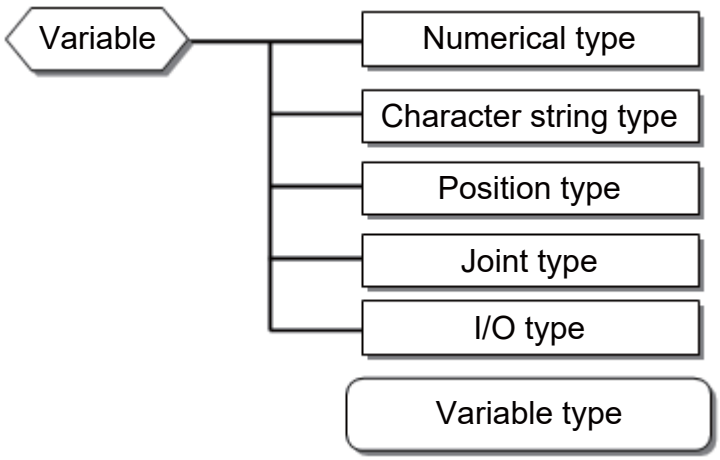


■Variables

Variables are any of the following types that are called variable types.

A variable name consists of 16 or fewer alphanumeric characters.

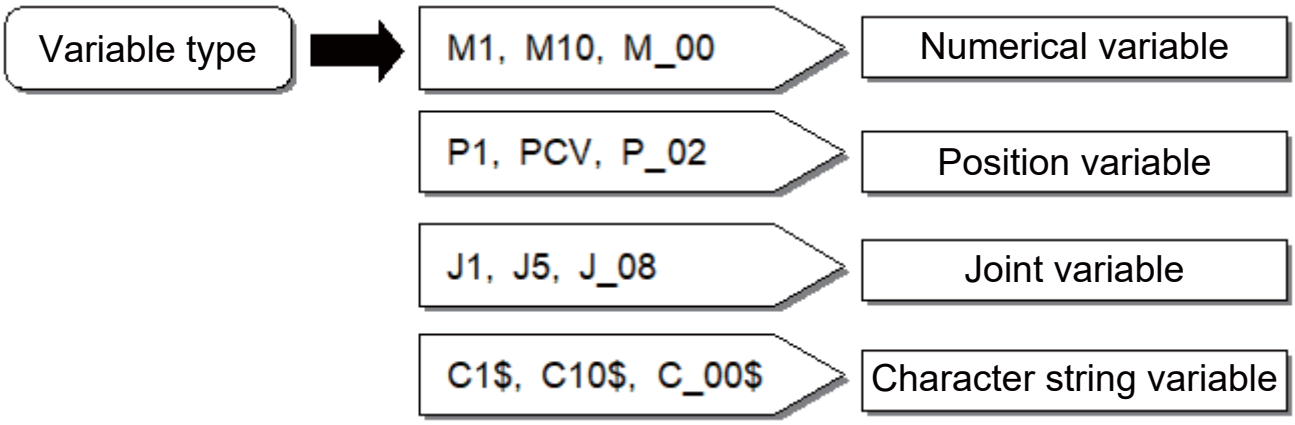
- Numeric value
- Character string
- Position
- Joint
- I/O



■Variable type

To indicate the variable type, an alphabetic character is prepended to each variable.

Variable type	Alphabet
Numerical variable	M
Position variable	P
Joint variable	J
Character string variable	C



I/O signal

Required devices

The customer needs to prepare a 24 V DC power supply.

Parallel I/O interface points (option)

Option slot	Input	Output
SLOT1	32 points (0 to 31 bits)	32 points (0 to 31 bits)
SLOT2	32 points (32 to 63 bits)	32 points (32 to 63 bits)

Power supply line	Pin No.
0V	1C
24V	1D, 2C

How to use I/O signals

A single parallel I/O interface allows 32 inputs and 32 outputs. The 32 points are divided into dedicated I/O signals (used for robot control) and general-purpose I/O signals (used for interlocks, workpiece types, sensor signals, and others in the program).

The following table shows examples of dedicated I/O signals. Set the bit number of a dedicated I/O signal with a parameter.

Dedicated input signal	Dedicated output signal
Stop	Operation suspended
Servo OFF	During servo OFF
Error reset	Error occurring
Start	During operation
Operation rights	Operation rights enabled
Servo ON	Within user-designated area

External I/O type

The following external I/O types are available.

■Dedicated I/O

I/O signals are used for remote operation such as execution and stop of the robot program and status display such as during execution information display and servo power status display. Assign a function to each I/O signal. For the assignment method, set the number of a signal used to a dedicated parameter or perform an emergency stop input. Frequently used signals are preassigned to parameters. Addition and change are possible.

■General-purpose I/O

Use the signals for communications with a PLC or other equipment in the robot program. Use the signals to receive the positioning signals of peripherals or check the robot's position.

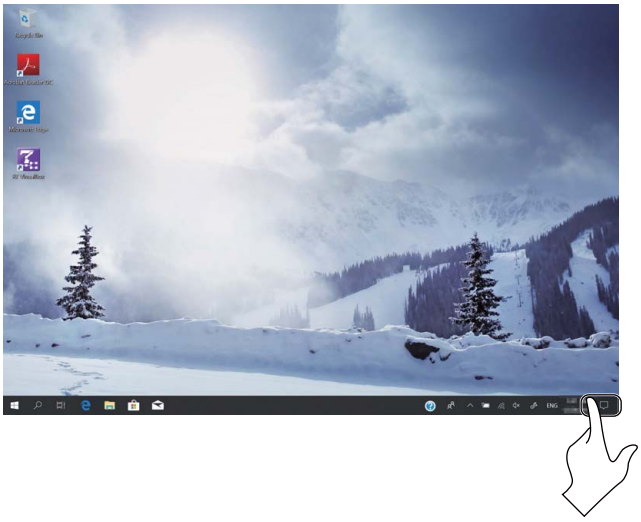
3 Operating the collaborative robot

This chapter describes connecting the robot to RT VisualBox, creating a program, teaching, and performing automatic operation.

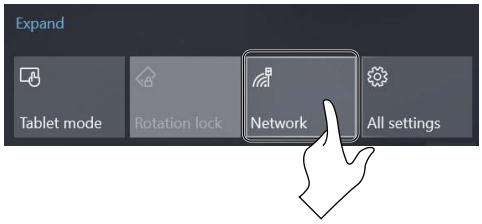
3.1 Connecting the computer to the robot controller

Check the network status of the computer, then connect the computer to the robot controller with a LAN cable.
If the computer is connected via Wi-Fi, turn off Wi-Fi.
To turn off Wi-Fi, follow the steps below.

Operating procedure



1. Tap/click the icon in the lower-right corner of the Windows Desktop screen.



2. Tap/click [Network].

3. Tap/click the Wi-Fi icon.

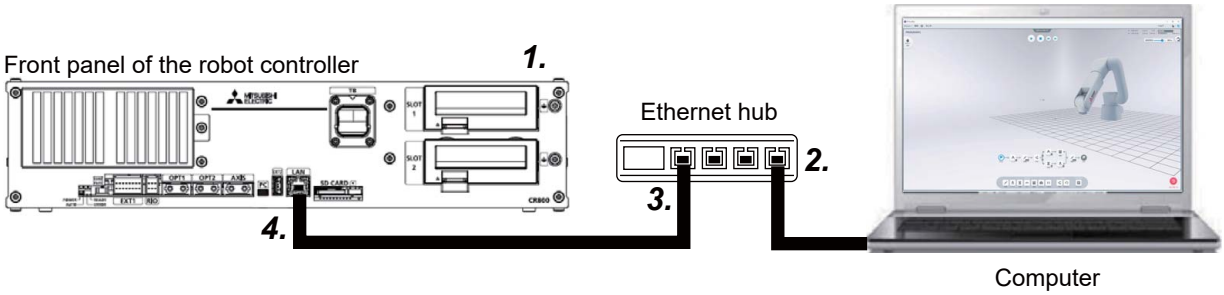
4. Check that "Wi-Fi Turned off" appears and the Wi-Fi icon turns gray (originally blue).

The following steps show how to connect the computer to the robot controller with a LAN cable.

Operating procedure

For further information on the Safety extension unit, refer to the following page:

☞ Page 14 Safety extension unit



1. Power on the Safety extension unit, then the robot controller.

2. Connect the computer and the Ethernet hub using a LAN cable.

3. Connect the robot controller and the Ethernet hub using a LAN cable.

4. Connect the LAN cable to the "LAN" port (for Ethernet) on the front of the robot controller.

To connect the computer to the robot controller with a USB cable, refer to the following manual:

📖RT VisualBox Instruction Manual (BFP-A3696)

Precautions

Do not disconnect the LAN/USB cable during communication with the robot controller. If the cable is disconnected during communication, data will not be acquired properly and the operation of the robot controller or computer may be affected. Only disconnect the cable while in Offline mode or after exiting RT VisualBox.

3.2 Creating a project

Robot settings

Precautions

Ensure that the following settings are configured correctly.

- Hand size, weight, and center of gravity (refer to step 13)
- Workpiece size, weight, and center of gravity (refer to step 14)
- Workpiece grasp position (refer to step 15)

If the settings for the hand are not configured correctly, the arm may rise or fall when direct teaching is turned on. Furthermore, the safety functions may not work properly. Ensure that the correct values are set.

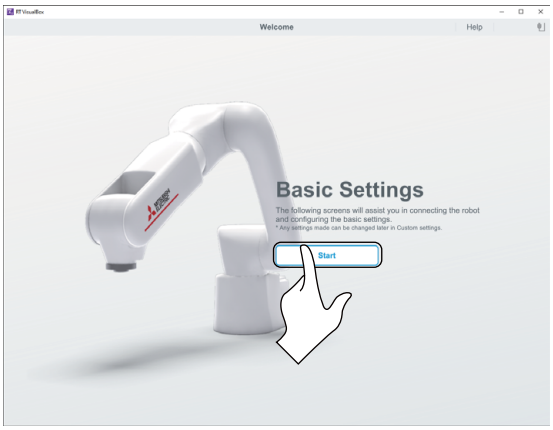
Operating procedure

Point

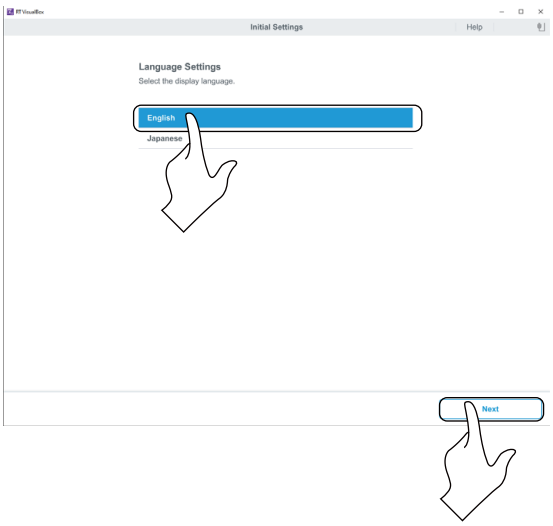
Check the following points before operating the robot.

- The robot is powered on.
- The mode selector switch is set to "AUTOMATIC".
- The robot is not set to High-speed operation mode.

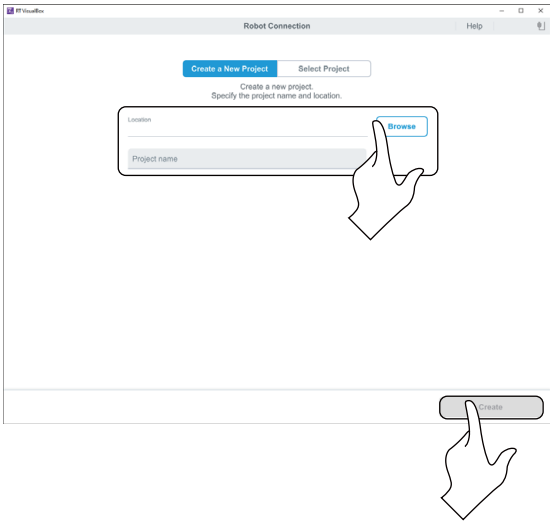
1. A shortcut will be created on the desktop after RT VisualBox has been installed. Double-tap/click this shortcut to start RT VisualBox.



2. The screen on the left only appears when RT VisualBox starts for the first time. Tap/click the [Start] button.

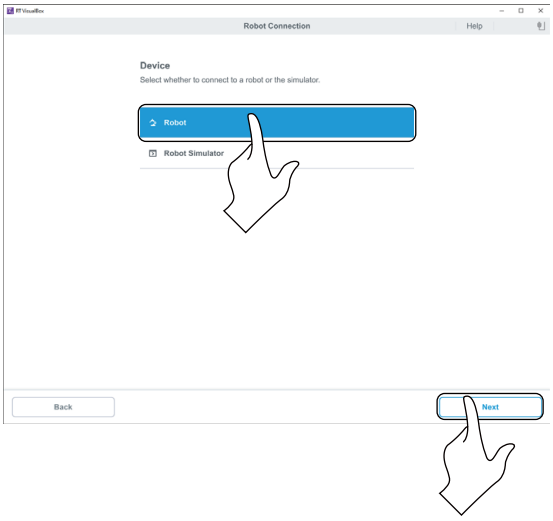


3. Select [English] on the Language Settings screen, then tap/click the [Next] button.

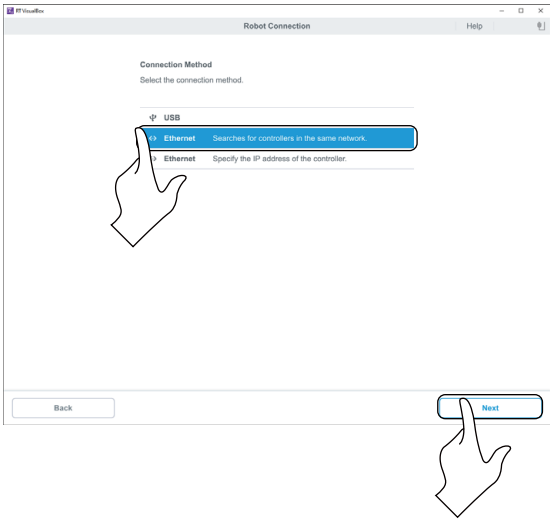


4. Select [Create a New Project].

Set Project path and Project name to save the project, then tap/click the [Create] button.



5. Select [Robot], then tap/click the [Next] button.

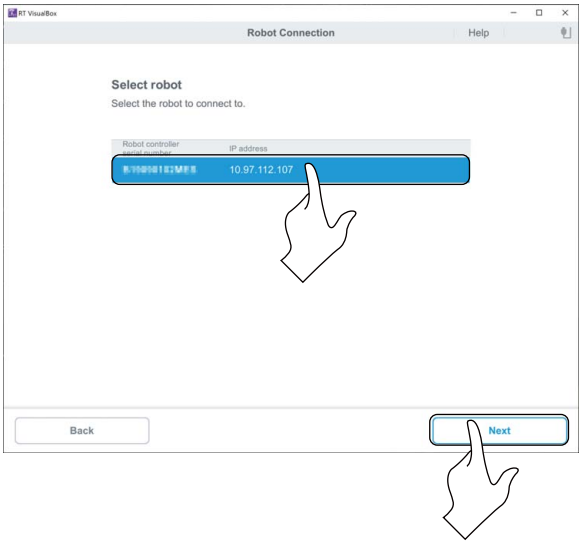


6. Select [Search for controllers on the same network] in the Connection Method screen, then tap/click the [Next] button.

The page may be blocked by a firewall depending on the settings of your computer.

If the software is being blocked by a firewall, refer to the following page:

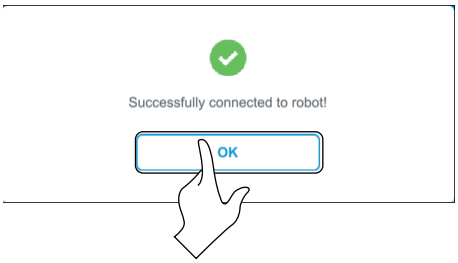
☞ Page 77 If blocked by a firewall



7. In the Robot Selection screen, select the robot you want to use, then tap/click the [Next] button.

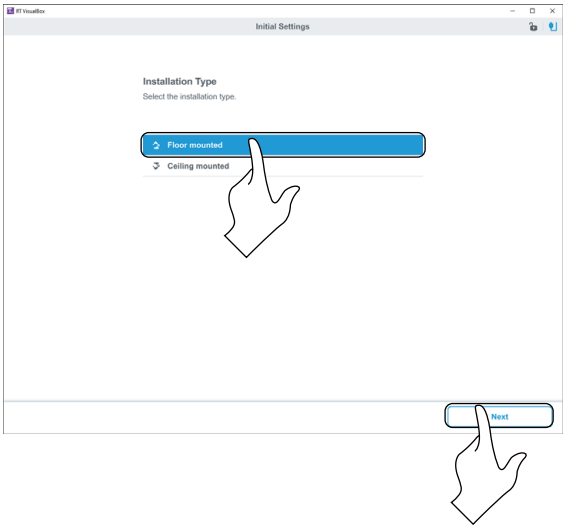
If the desired robot is not listed or cannot be connected, refer to the following page:

☞ Page 78 If the robot cannot be connected to RT VisualBox



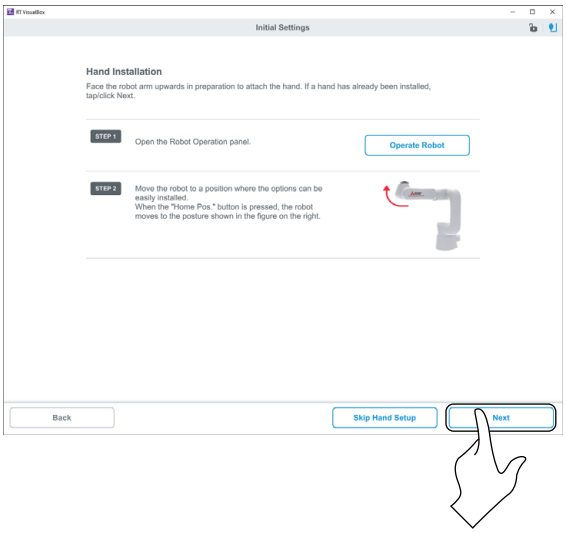
8. The dialog box on the left will appear once the robot has been successfully connected.

Tap/click the [OK] button to close the dialog box.



9. Select [Floor mounted] as the installation type, then tap/click the [Next] button.

If a hand is not attached, follow steps 10 and 11.

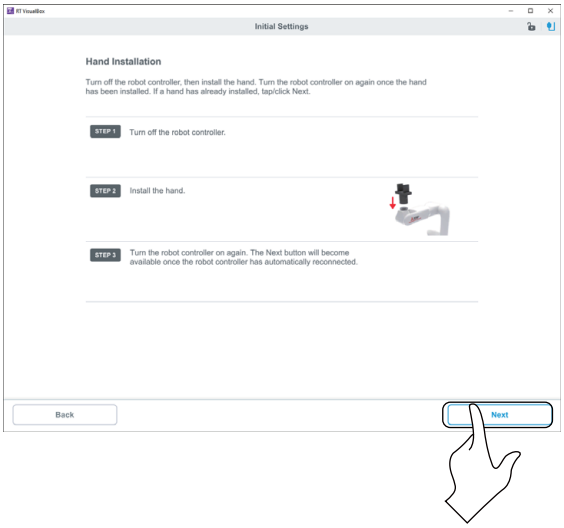


10. Tap/click the [Operate Robot] button.

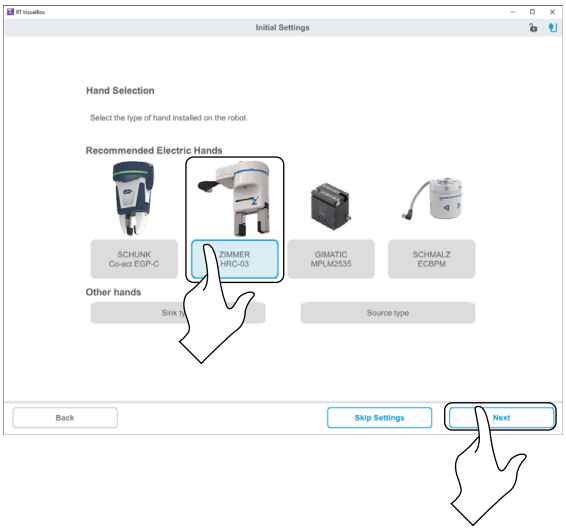
Turn direct teaching on.

A caution message will appear. Tap/click the [OK] button.

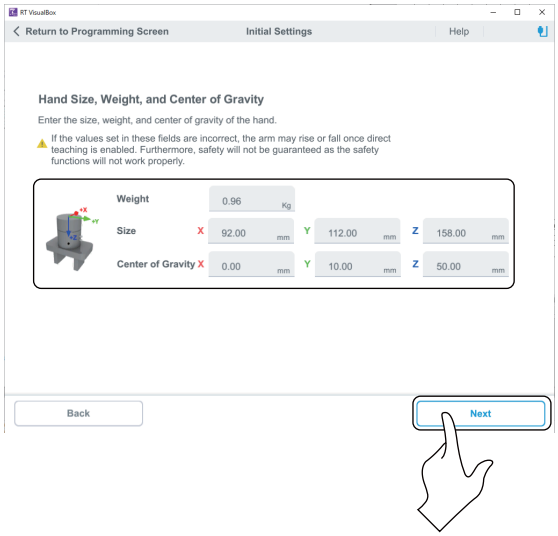
Tap/click the [Joint] tab, select the J5 axis, then tap/click [—] to face the flange surface upward.



11. Power off the robot, then connect a hand to the robot.



12. Select [ZIMMER HRC-03] in the Hand Selection screen, then tap/click the [Next] button.



13. In the Hand Size, Weight, and Center of Gravity screen, enter the following values, then tap/click the [Next] button.

When installing a hand only:

- Weight: 0.92 (kg)
- Size:

X: 92.00 (mm)
Y: 112.00 (mm)
Z: 158.00 (mm)

- Center of gravity:

X: 0.00 (mm)
Y: 10.00 (mm)
Z: 50.00 (mm)

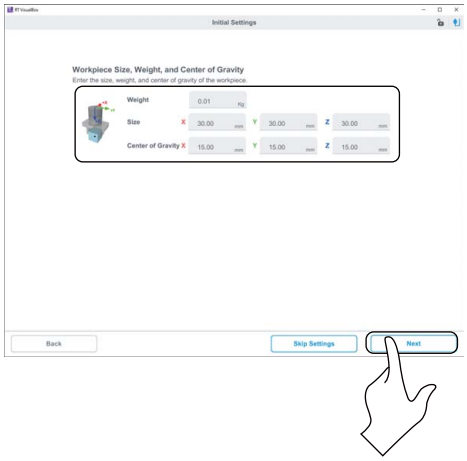
When installing a hand and vision sensor:

- Weight: 1.11 (kg)
- Size:

X: 131.00 (mm)
Y: 112.00 (mm)
Z: 158.00 (mm)

- Center of gravity:

X: 12.00 (mm)
Y: 8.60 (mm)
Z: 51.00 (mm)



14. In the Workpiece Size, Weight, and Center of Gravity screen, enter the following values, then tap/click the [Next] button.

A 30 mm × 30 mm × 30 mm block with a weight of 0.012 kg is used as a workpiece in this example.

Enter the size, weight, and center of gravity of the workpiece.

- Weight: 0.01 (kg)
- Size:

X: 30.00 (mm)

Y: 30.00 (mm)

Z: 30.00 (mm)

- Center of gravity:

X: 15.00 (mm)

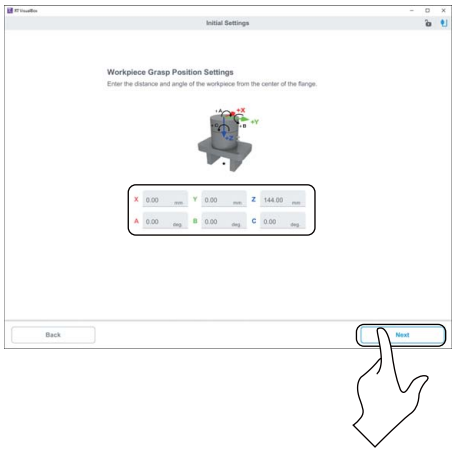
Y: 15.00 (mm)

Z: 15.00 (mm)

Point

Use a workpiece that is suitable for the size of the hand you are using.

Set the values according to the properties of the workpiece.



15. In the Work Gripping Position Setting screen, enter the following values, then tap/click the [Next] button.

- X, Y, and Z components of the grasp position:

X: 0.00 (mm)

Y: 0.00 (mm)

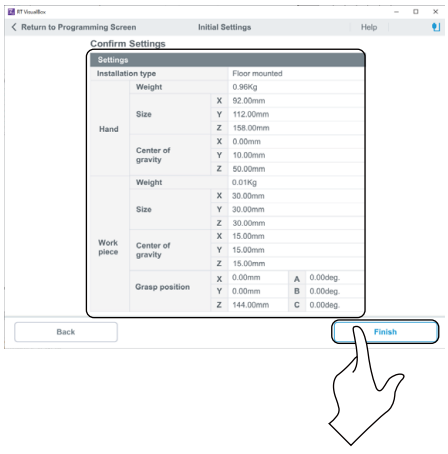
Z: 144.00 (mm)

- A, B, and C components of the grasp position:

A: 0.00 (deg)

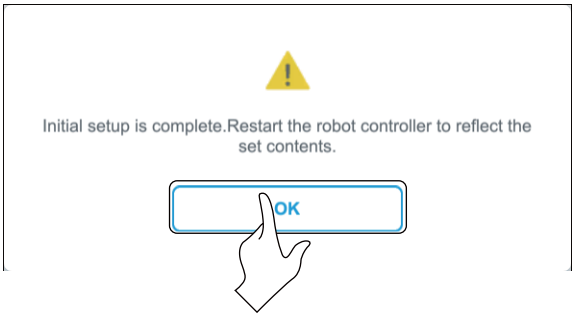
B: 0.00 (deg)

C: 0.00 (deg)



16. The values set in the steps above will be displayed in a table on Confirm Settings screen. If all the settings are correct, tap/click the [Finish] button.

If the settings are incorrect, tap/click the [Back] button and make corrections in the applicable setting screen.



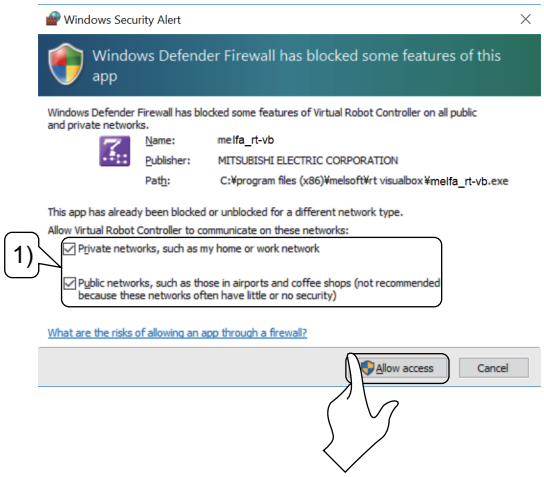
17. The dialog box on the left will appear once the settings have been configured.

Tap/click the [OK] button to restart the robot controller.

The program will return to the main screen once the robot controller restarts.

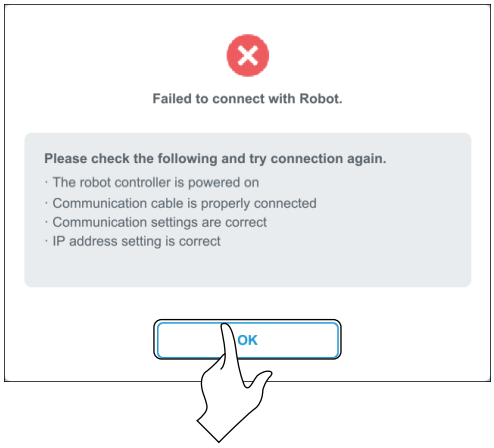
If blocked by a firewall

1. If the following window appears, select the two check boxes indicated by number 1, then tap/click the [Allow access] button.



2. Tap/click the [OK] button to display the screen shown in the following step:

☞ Robot settings(Step 6)



If the robot cannot be connected to RT VisualBox

If the robot does not appear in the Robot Selection screen or cannot be connected, do the following:

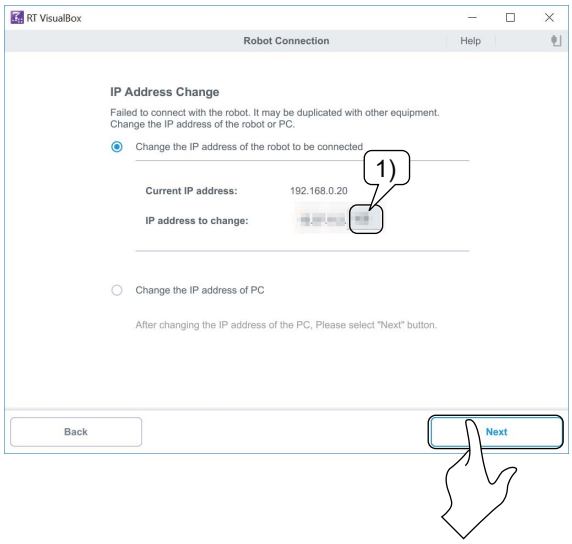
■The robot or the robot controller is not turned on

Check if the robot and robot controller are turned on. Turn on the robot and robot controller.

☞ Page 24 Control power on

■The IP address of the computer or robot is set incorrectly

The following screen will appear when the robot is connected to a computer on a network.



1. A free IP address on the network that the computer is currently connected to will be displayed in the Recommended IP address field in the Change IP Address screen. The software will select an IP address with digits (indicated by "1") that avoid creating a duplicated address on the network.
2. If you are satisfied with the IP address, tap/click the [Next] button. If you would like to change the address, enter an address which is not being used on the network using the digits from 1 to 254.
3. Return to the following step once the settings have been configured.

☞ Robot settings(Step 8)

Robot tool center point

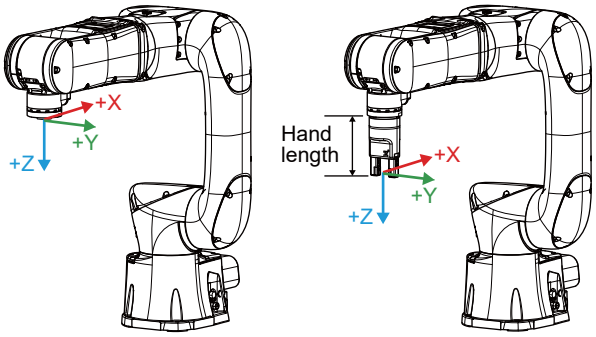
The robot tool center point is the motion point to be controlled in the XYZ jog mode and Tool jog mode.

The robot moves with reference to the tool center point.

The point is set at the center (flange center) of the mechanical interface at the time of shipment.

The tool center point can be changed to any position. For example, when installing a hand and moving the tool center point to the hand's tip, set the offset amount from the center of the mechanical interface in [Workpiece Grasp Position].

📖RT VisualBox Instruction Manual (BFP-A3696)

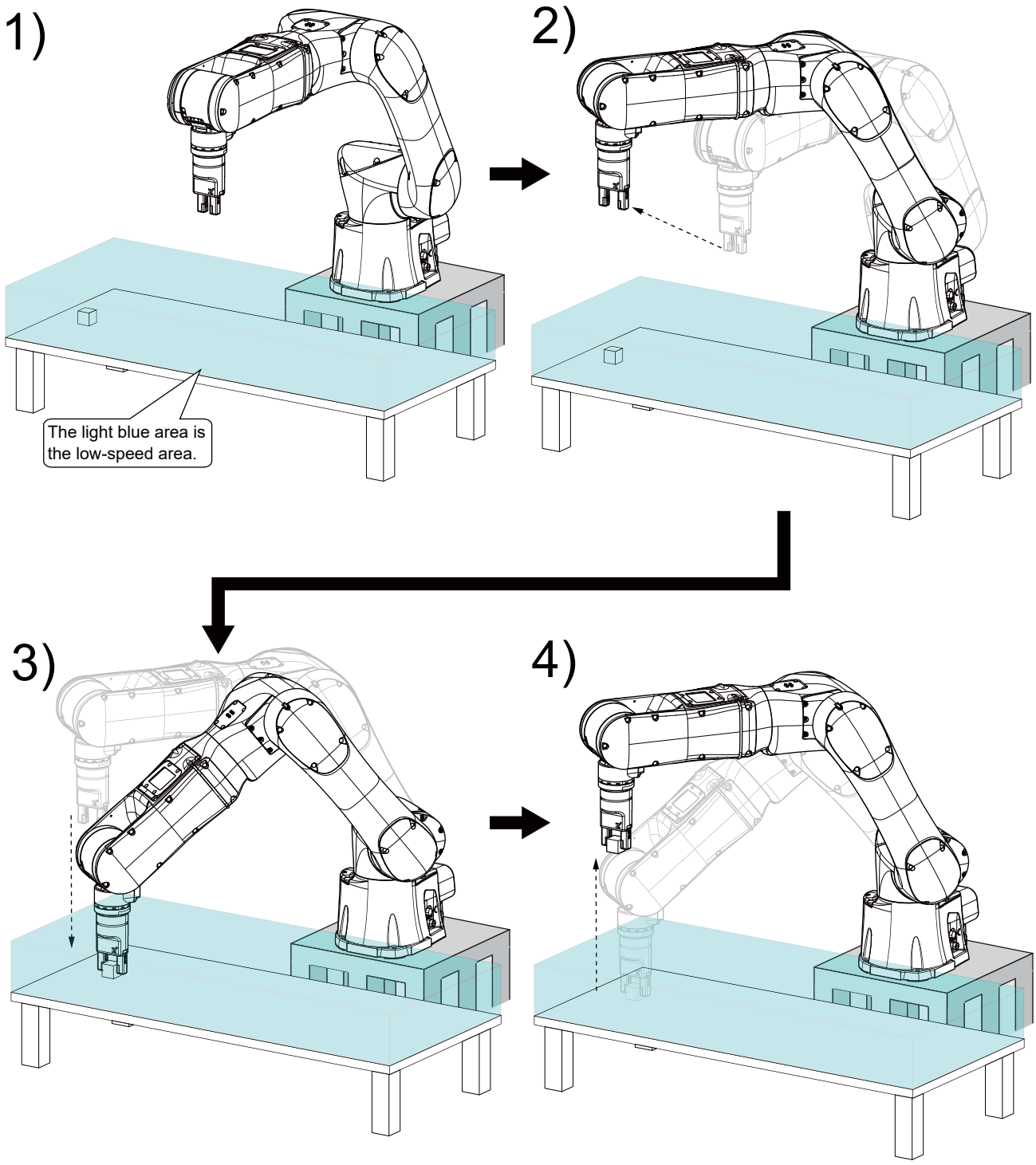


Position of the tool center point before shipment

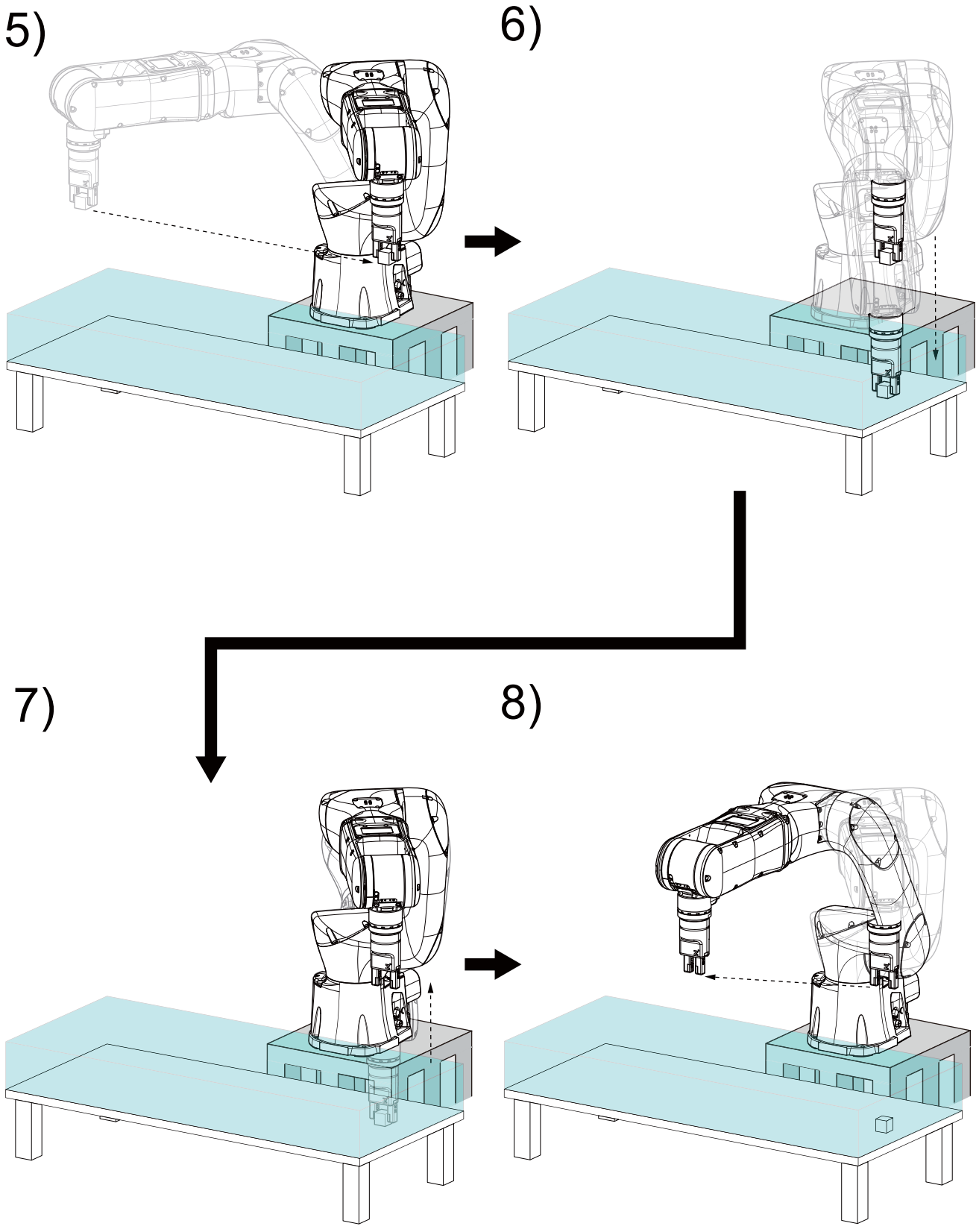
When moving the tool center point in the Z direction in the tool coordinate system

3.3 Pick-up and placement

This section explains how to connect a robot to RT VisualBox, how to create a program, and how to use that program to operate the robot.
The hand and workpiece platform used in this section are examples. Select a hand and a workpiece platform that are suitable for the system you want to create.
The program that will be created in this part of the manual will instruct the robot to operate in the manner shown in the figures below.
The light blue area in the figures below indicates a low-speed space.
The low-speed space is a space in the collaboration area where it is necessary to reduce the possibility of harm to people. For an explanation of technical terms, refer to the following manual:
📖Collaborative Robot: Detailed explanations of functions and operations (BFP-A3735)



Continue to step 5.
(On the next page)

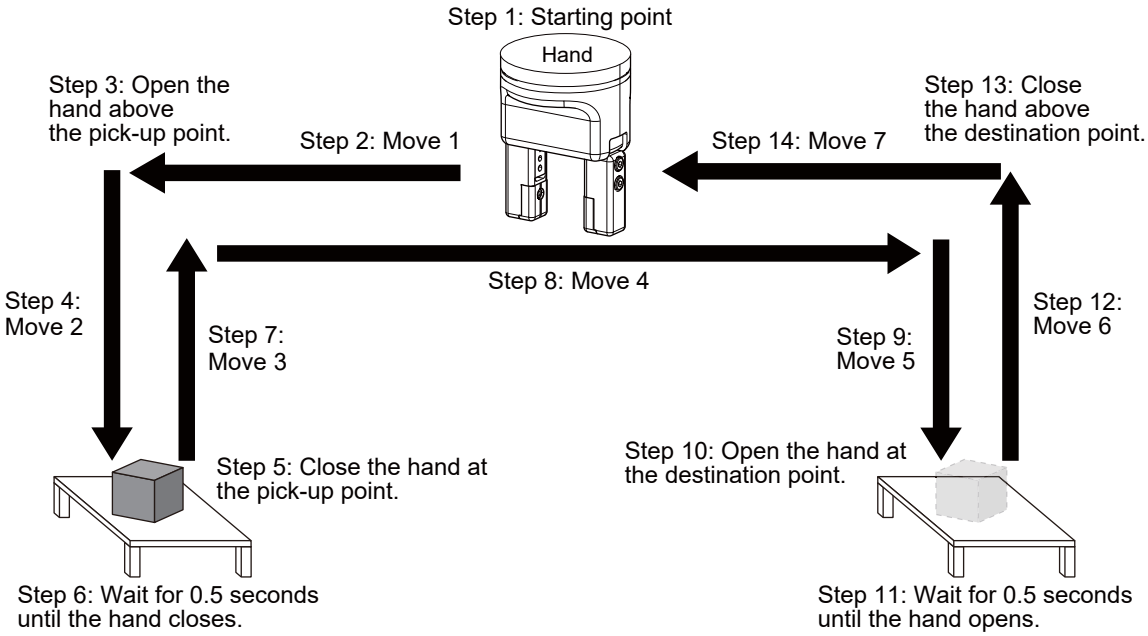


Go back to step 1.

3.4 Programming with RT VisualBox (Exercise 1)

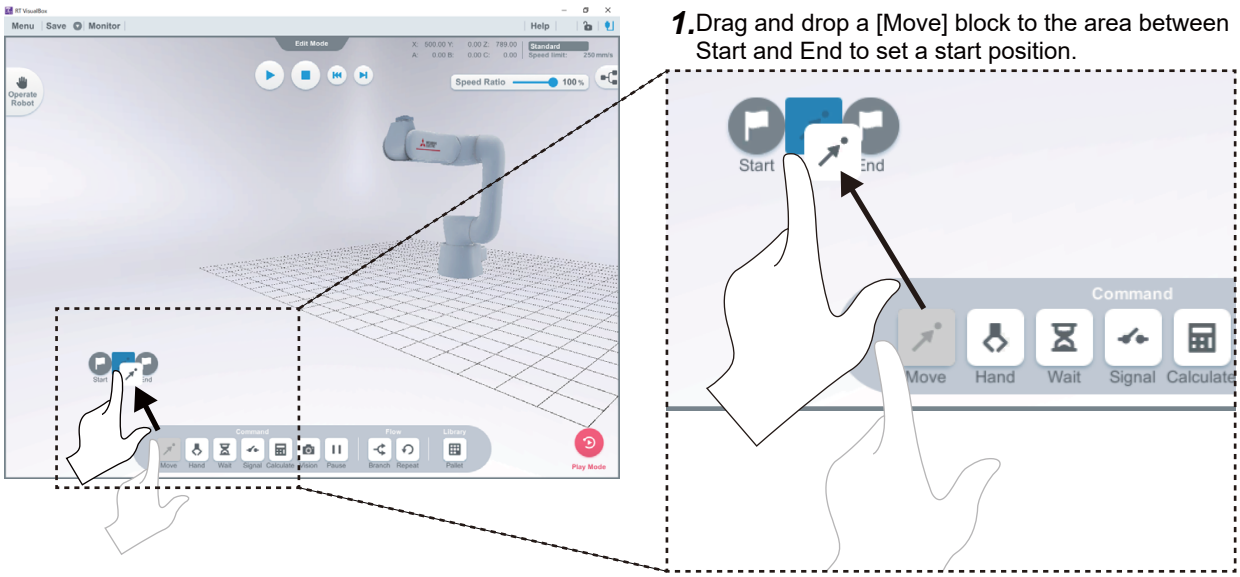
This chapter explains how to create and edit robot programs.

The figure below shows an overview of the program.

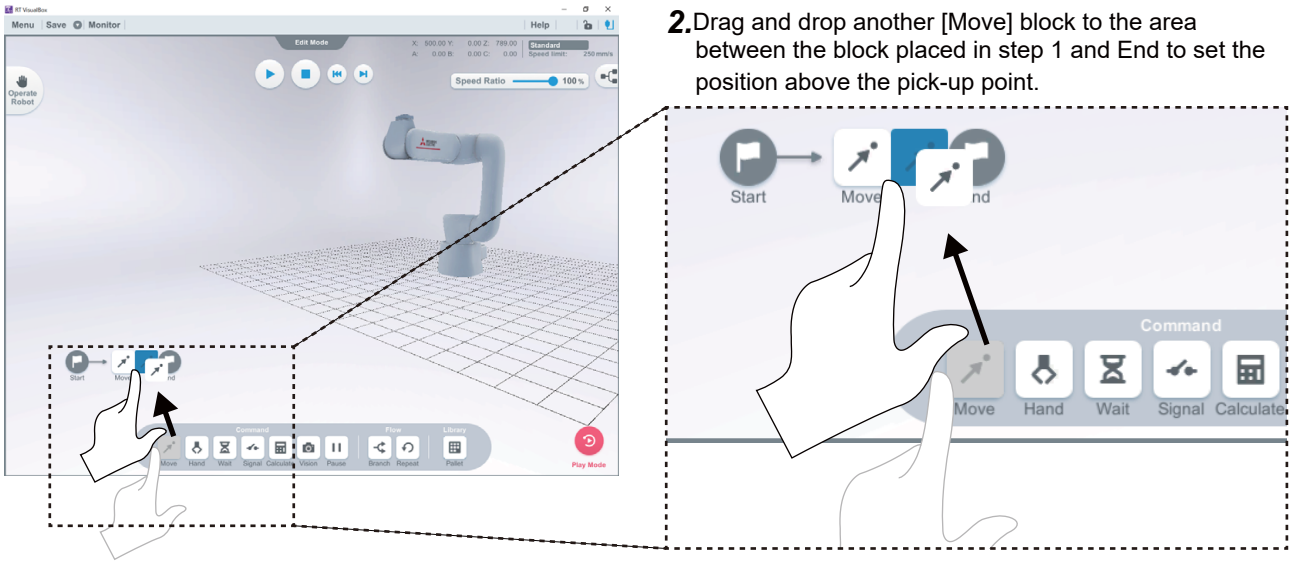


Operating procedure

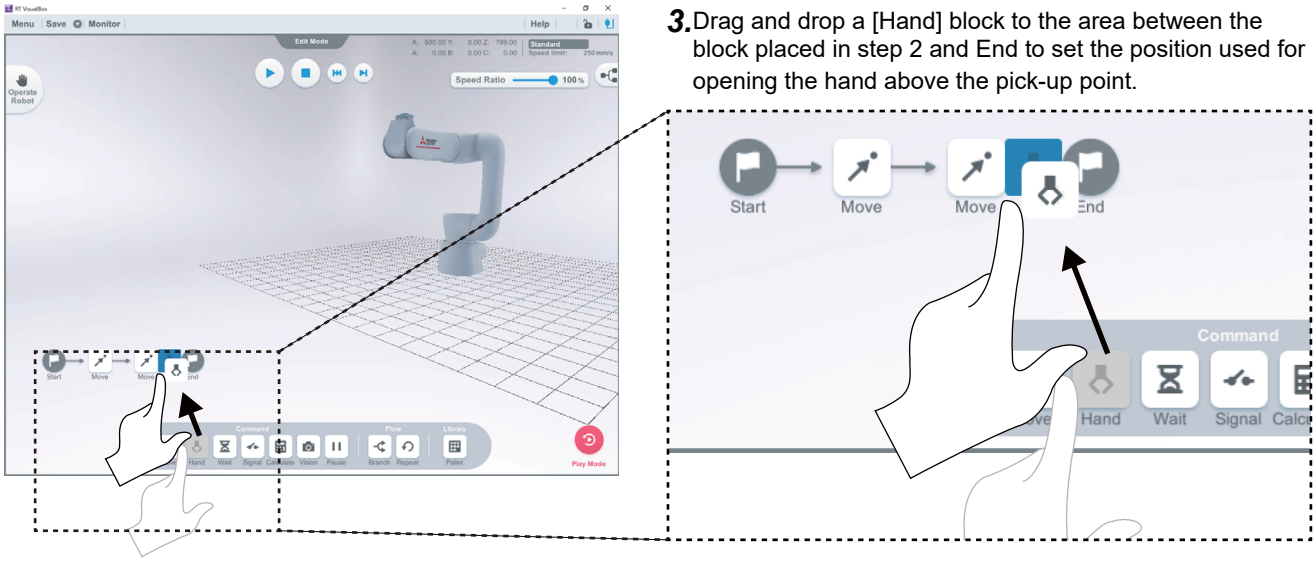
The robot program will be created by placing program blocks in order of operation.



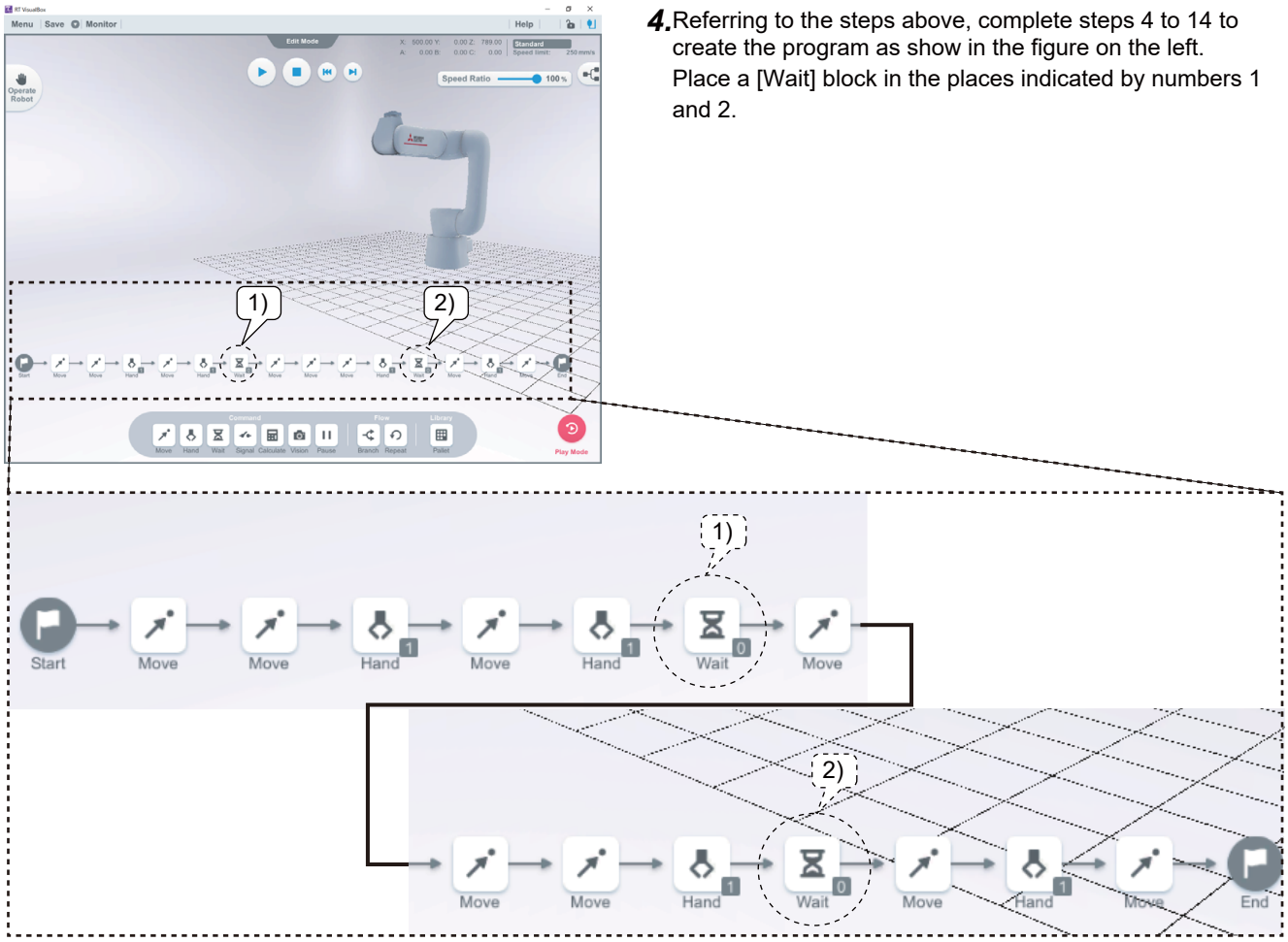
1. Drag and drop a [Move] block to the area between Start and End to set a start position.



2. Drag and drop another [Move] block to the area between the block placed in step 1 and End to set the position above the pick-up point.



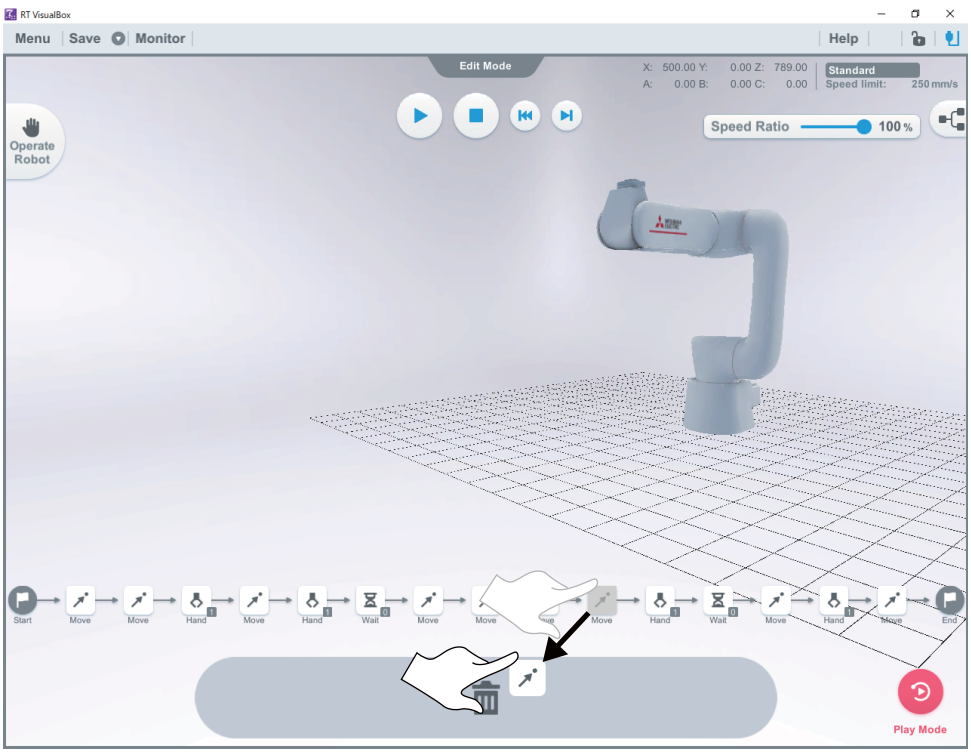
3. Drag and drop a [Hand] block to the area between the block placed in step 2 and End to set the position used for opening the hand above the pick-up point.



4. Referring to the steps above, complete steps 4 to 14 to create the program as show in the figure on the left. Place a [Wait] block in the places indicated by numbers 1 and 2.

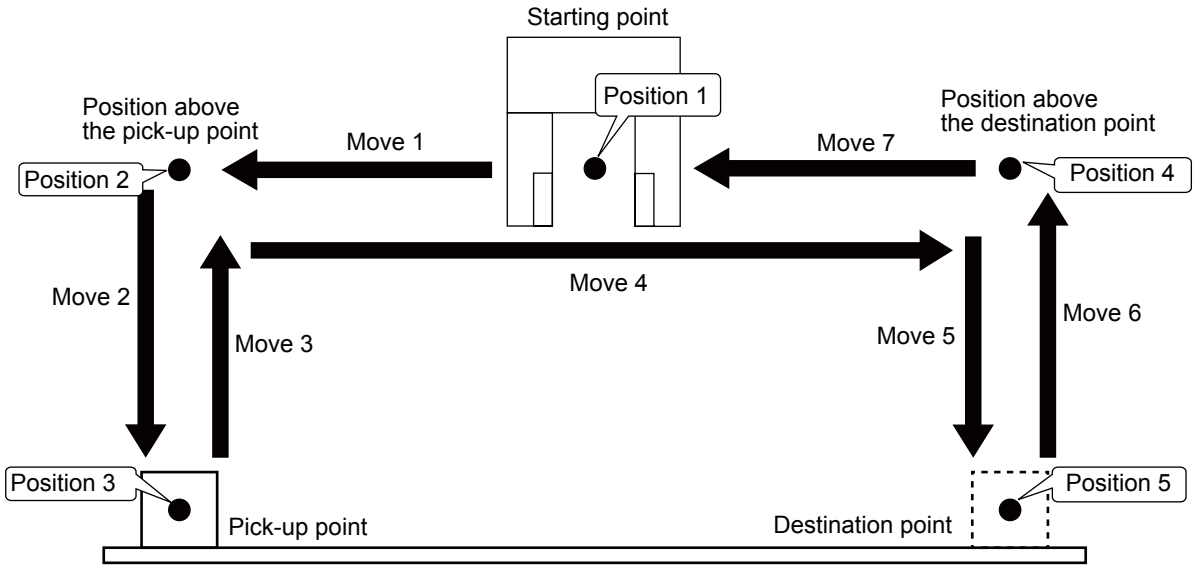
Deleting unnecessary blocks

Select a program block in the program and drag the block downwards. A trash can will appear. To delete the block, move it to the trash can and release it.



3.5 Teaching positions to which the robot moves

This section explains how to teach positions to the robot using either RT VisualBox or by moving the arm directly with your hands.

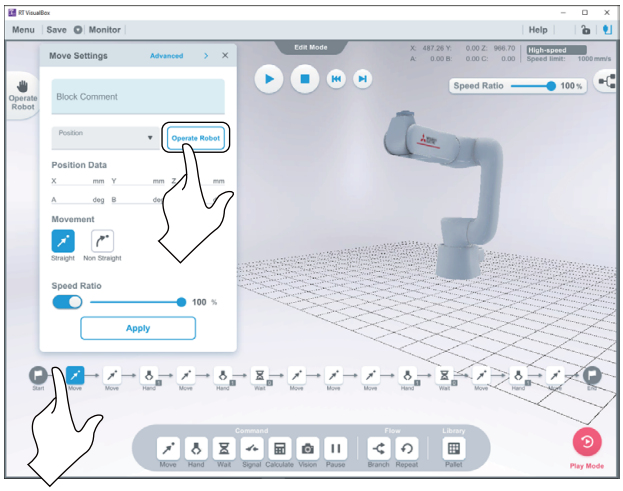


CAUTION

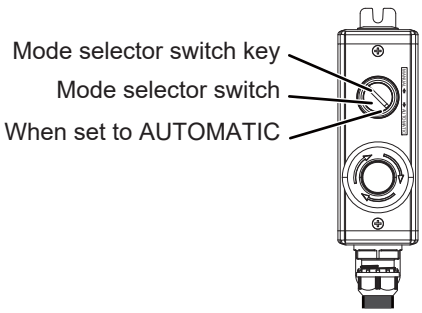
- Place an emergency stop switch in an easily accessible place near the robot. Connect the emergency stop switch to the external emergency stop input terminals of the robot controller.
- If the settings for the hand are not configured correctly, the arm may rise or fall when direct teaching is turned on. Furthermore, the safety functions may not work properly. Ensure the settings are correct.
- The robot arm may continue to move under its own inertia in direct teaching mode. Do not release your hands from the robot arm until it has stopped moving.
- Workpiece settings are not enabled during direct teaching. The robot arm may fall depending on the weight of the workpiece. Do not release your hands from the robot arm until it stops completely.

Teaching the 1st movement "position 1" (starting point)

Operating procedure

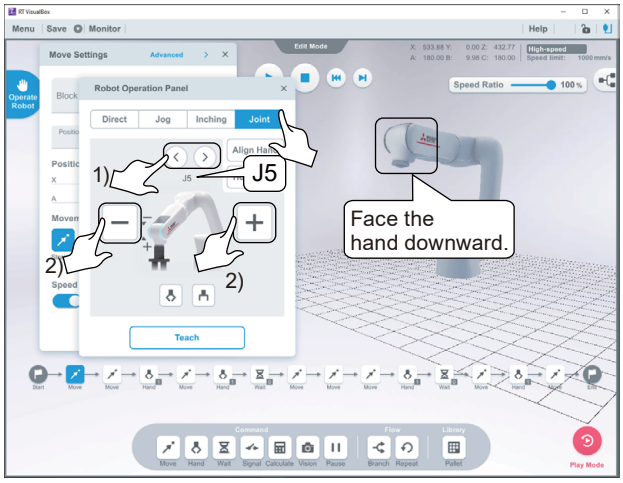


1. Set the robot controller mode selector switch to AUTOMATIC mode, then remove the mode selector switch key.



2. Tap/click the [Move] block to the right of Start to display the Move Setting window.

3. Tap/click the [Operate Robot] button.

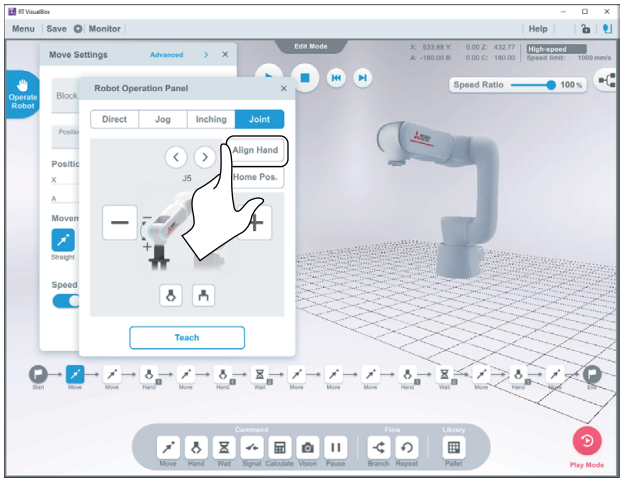


4. Use the Robot Operation panel to move the robot and face the hand downward.

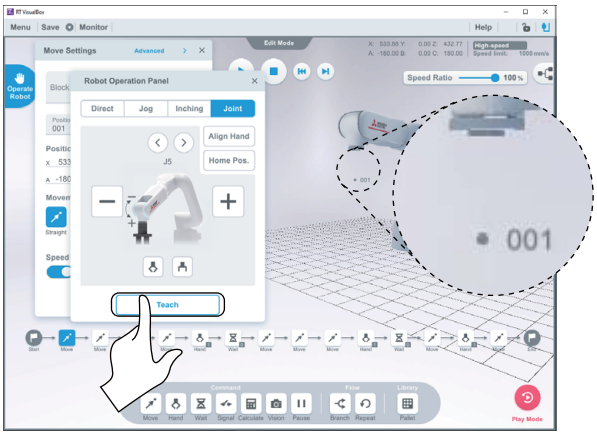
Move axis J5 using the controls in the [Joint] tab in the Robot Operation panel.

1) Tap/click the button indicated by number 1 until "J5" appears.

2) Tap/click the button indicated by number 2 until axis J5 is roughly facing downward. (Move axis J5 so that the robot's posture is the same as that displayed in the window on the left.)



5. Tap/click the [Align Hand] button to face the hand straight down.

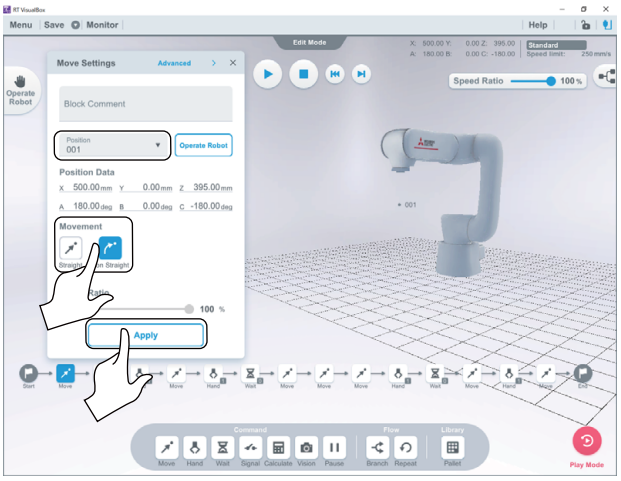


6. Tap/click the [Teach] button once. This will set the current position of the robot to position 1 which is shown in the program overview figure at the beginning of this chapter.

7. The number "001" will appear near the flange.

The number indicates the taught position.

Tap/click the [×] button in the top right of the Robot Operation panel to close the panel.



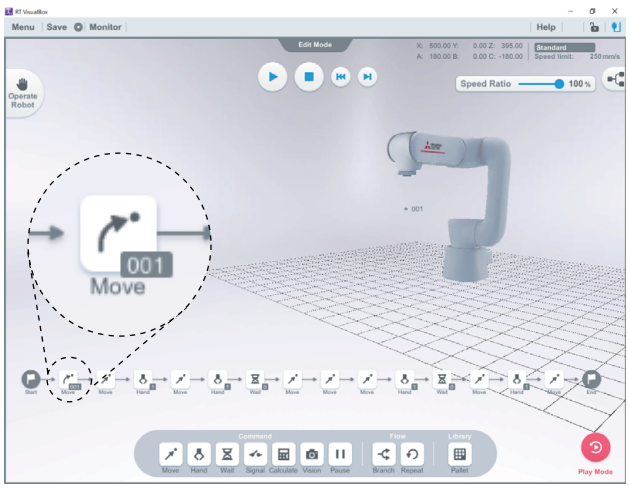
8. In the Move Settings window, check that [Position] and [Movement] are set as follows:

- Position: 001
- Movement: Non Straight

Ensure that the settings are correct, then tap/click the [Apply] button.

Point

The robot arm moves differently depending on the Movement settings which are explained as follows:
Selecting [Non Straight] will move the robot arm faster than when [Straight] is selected. When [Non Straight] is selected, the robot arm moves to the destination while following a shallow curve. Select [Non Straight] if the robot can move without interfering with surrounding objects.
Selecting [Straight] will move the robot arm to the destination rectilinearly.
Select [Straight] if the robot arm needs to move up and down vertically above the pick-up point or the destination point in order to prevent the hand from interfering with the workpiece or the robot from interfering with surrounding objects.



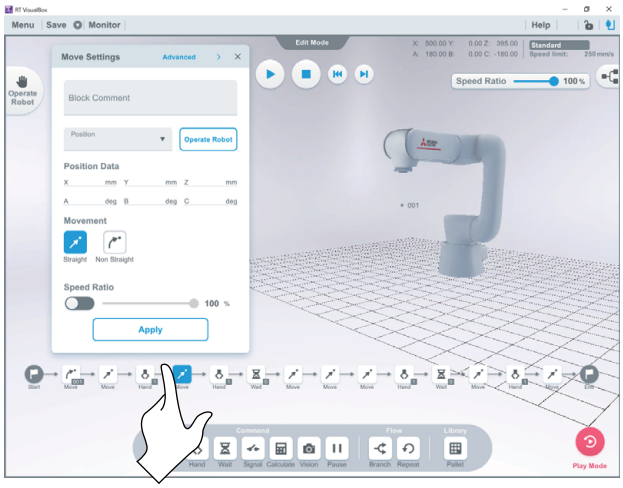
9. Once the settings have been configured, the number "001" will appear in the bottom right of the [Move] block.

Teaching the 3rd movement "position 3" (pick-up point)

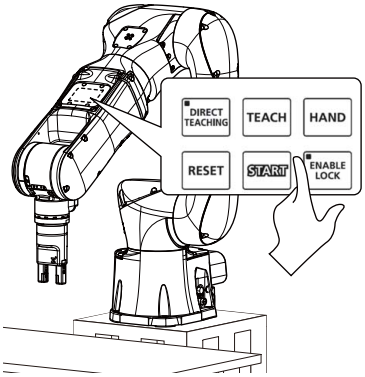
⚠CAUTION

• Do not operate the robot using any method other than the operation buttons on the arm when teaching the robot directly.

Operating procedure



1. Tap/click the [Move] block shown in the screen shown on the left to display the Move Setting window.



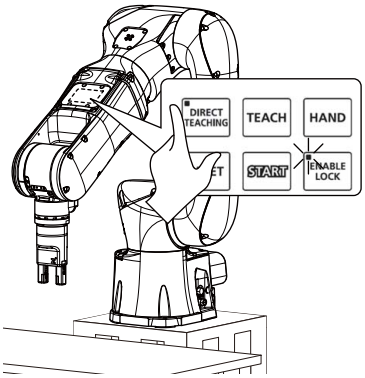
2. Press the [ENABLE LOCK] button on the arm.

The LED at the top-left of the [ENABLE LOCK] button will turn on.

Operating the robot will only be possible using the operation buttons on the arm once [ENABLE LOCK] has been turned on.

Point

Turning on [ENABLE LOCK] acquires the robot operation rights, rendering operation from other peripherals ineffective.

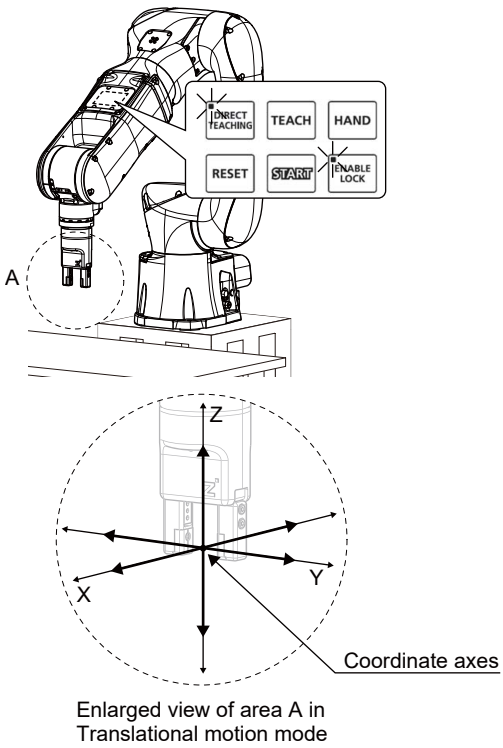


3. Hold down the [DIRECT TEACHING] button on the arm for 2+ seconds.

Point

Direct teaching is automatically turned off under the following conditions:

- The robot arm is not moved for a certain period of time (the initial value is 60 seconds) after direct teaching is turned on.
- The [Jog], [Inching] or [Joint] tab is selected in the Robot Operation panel.
- An error occurs.
- Communication with RT VisualBox is lost for 30 seconds.



Enlarged view of area A in Translational motion mode

4. The LED at the top-left of the [DIRECT TEACHING] button on the arm will turn on.

The Status indicator LED will flash green.

Point

When direct teaching is turned on, the mode is set to Joint free mode. The LED at the top-left of the [DIRECT TEACHING] button will turn on. Pressing the [DIRECT TEACHING] button once allows you to move the robot arm in translational motion.

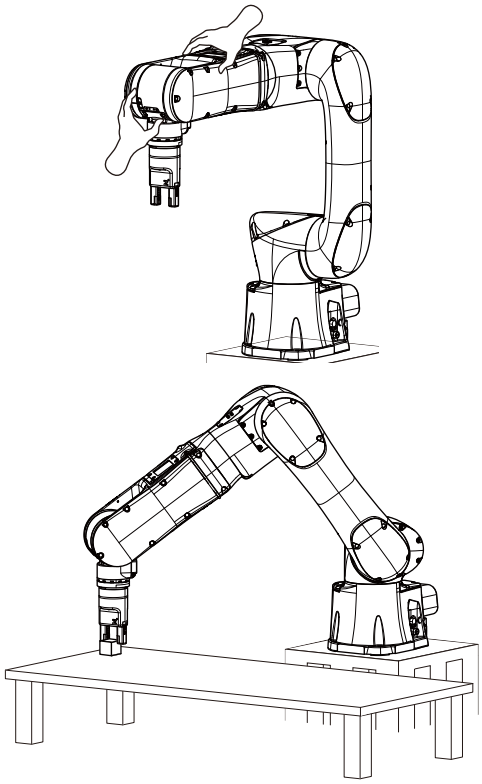
In this situation, the LED at the top-left of the button will flash.

The mode switches in the following order each time the [DIRECT TEACHING] button is pressed: Free → Translational → Free

Pressing the [Free] button in the [Direct] tab in the Robot Operation panel also allows you to switch the mode in the following order: Free → Translational → Free

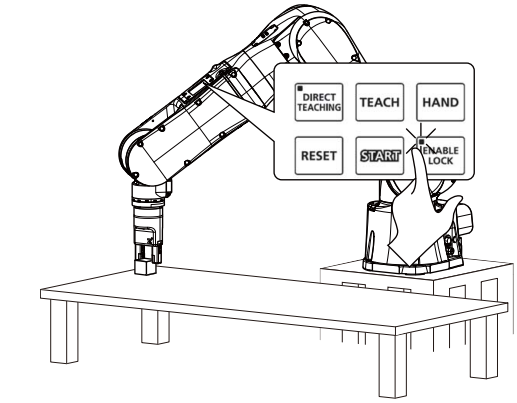
Translational: The robot moves in the coordinate (Cartesian) axes.

5. Hold the robot arm directly with your hands, and move it to the desired position/posture.

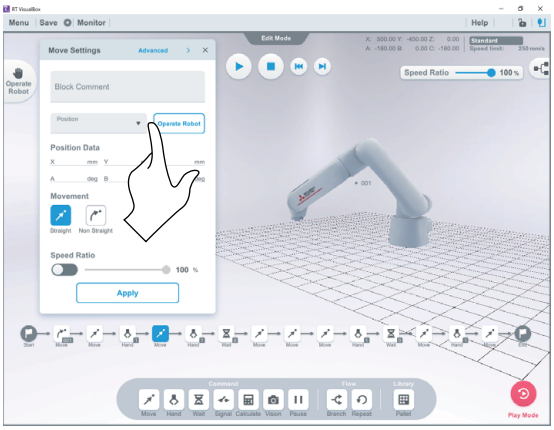


6. Move the robot arm so that the robot's posture is almost the same as that illustrated on the left.

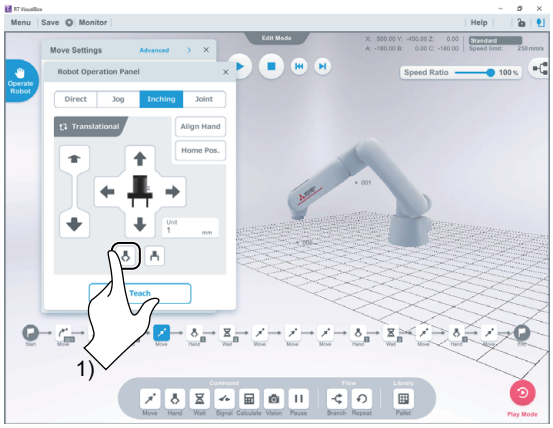
Adjust the posture of the robot so that the arm is in a position to grasp the workpiece at the pick-up point.



7. Press the [ENABLE LOCK] button on the arm.
The LED at the top-left of the [ENABLE LOCK] button will turn off.
Turning off [ENABLE LOCK] allows operation using any methods including the operation buttons on the arm.

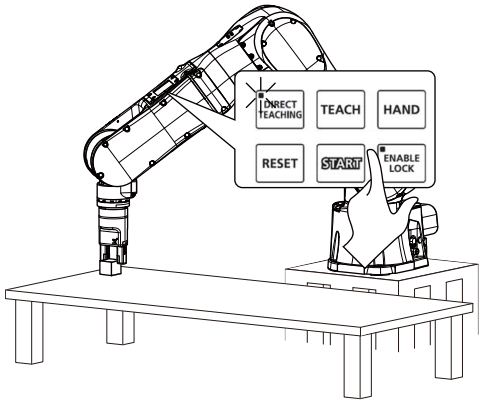


8. Tap/click the [Operate Robot] button shown in the screen shown on the left to display the Robot Operation panel.

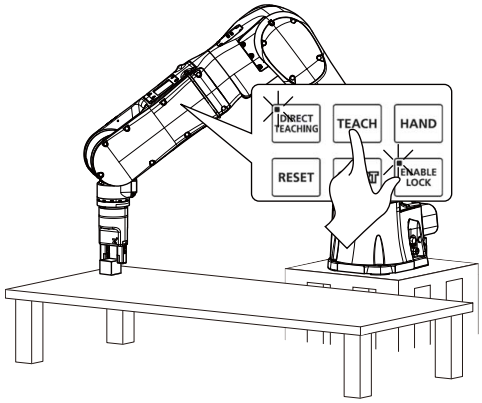


9. Fine-tune the workpiece grasp position by operating the robot in VisualBox.

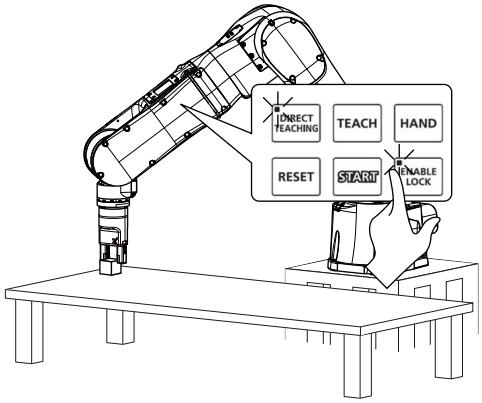
10. Tap/click the 1) button to cause the hand to grasp the workpiece.



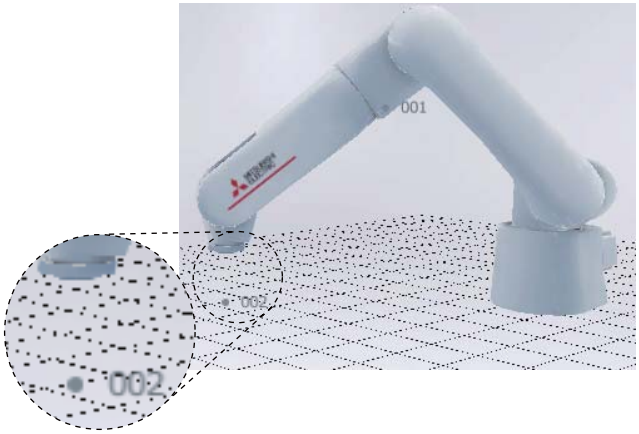
11. Press the [ENABLE LOCK] button on the arm.
The LED at the top-left of the [ENABLE LOCK] button will turn on.
Operating the robot will only be possible using the operation buttons on the arm once [ENABLE LOCK] has been turned on.



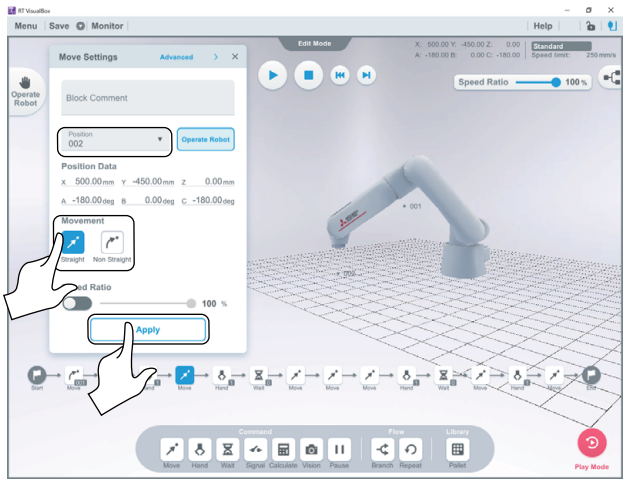
12. Press the [TEACH] button on the arm.



13. Press the [ENABLE LOCK] button on the arm.
The LED at the top-left of the [ENABLE LOCK] button will turn off.
Turning off [ENABLE LOCK] allows operation using any methods including the operation buttons on the arm.



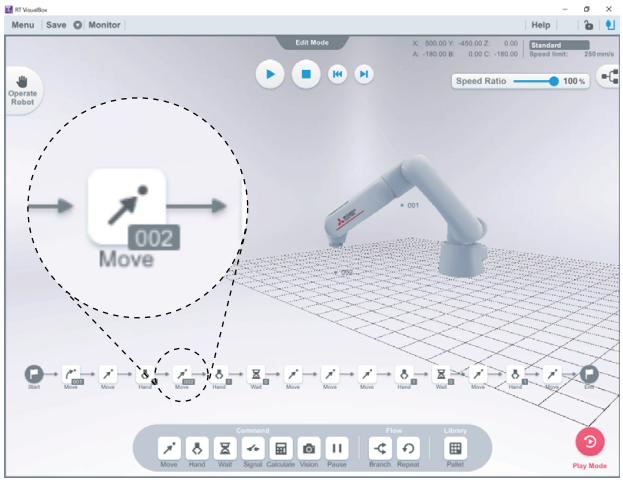
14. The number "002" will appear near the flange in RT VisualBox.



15. In the Move Settings window, check that [Position] and [Movement] are set as follows:

- Position: 002
- Movement: Straight

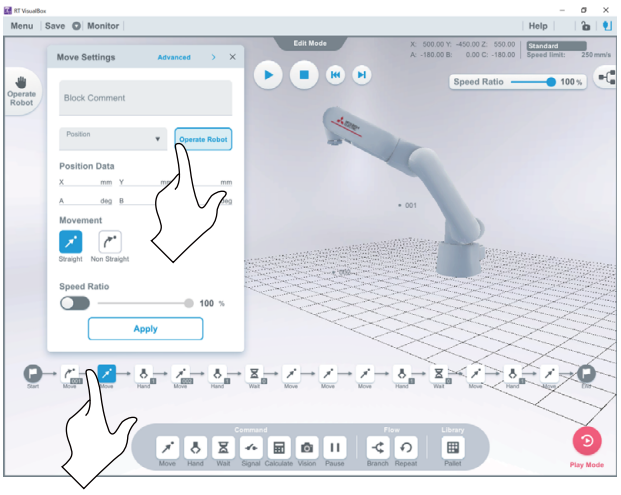
Ensure that the settings are correct, then tap/click the [Apply] button.

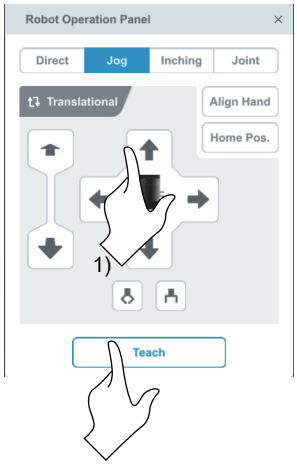


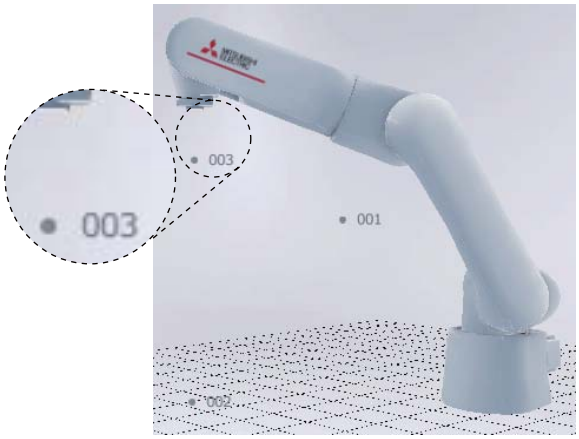
16. Once the settings have been configured, the number "002" will appear in the bottom right of the [Move] block.

Teaching the 2nd movement "position 2" (the position above the pick-up point)

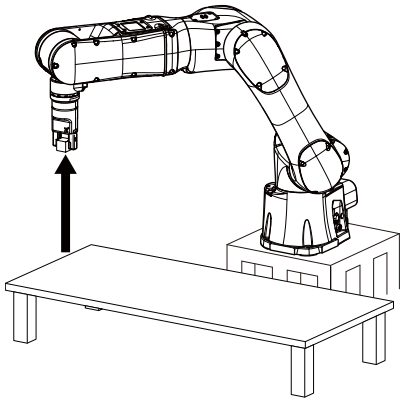
Operating procedure



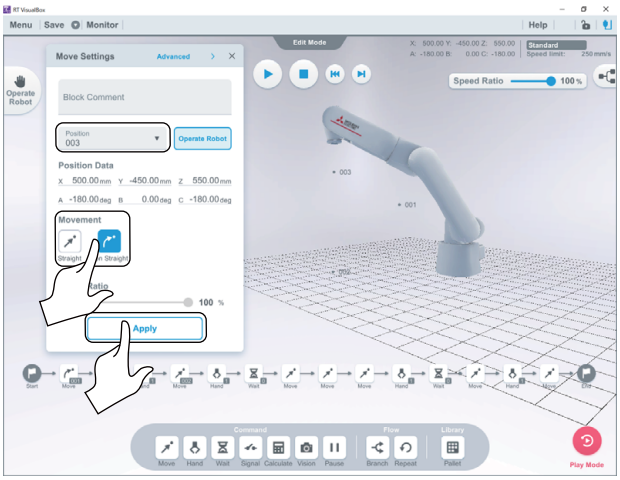




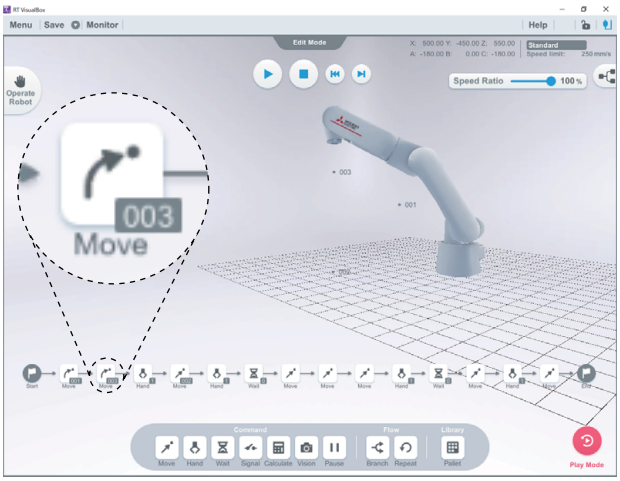
1. Tap/click the [Move] block shown in the screen shown on the left.
2. Tap/click the [Operate Robot] button.
3. In the Robot Operation panel, tap/click the 1) button to move the robot to position 2 (position above the pick-up point), directly above position 3 (pick-up point) where the robot shown at the beginning of this chapter will move.



4. Tap/click the [TEACH] button when the robot rises to position 2 (position above the pick-up point) where the robot will move.
5. The number "003" will appear near the flange in RT VisualBox.



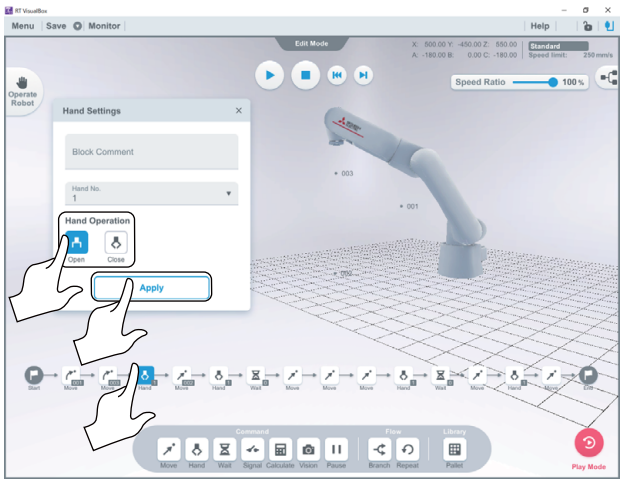
6. In the Move Settings window, "003" is displayed for "Position". Set [Non Straight] for [Movement] and tap/click the [Apply] button.



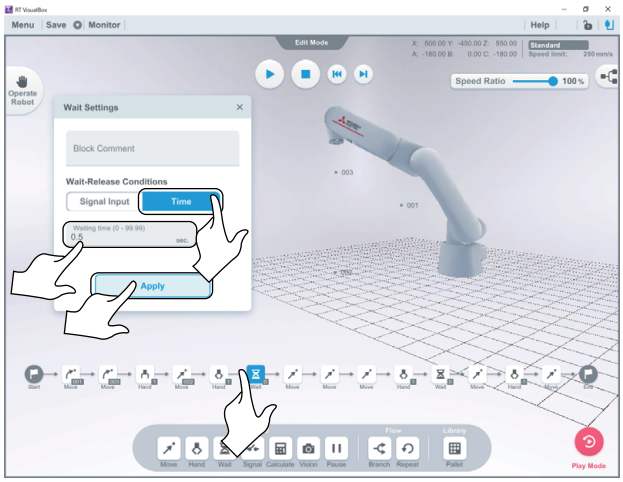
7. Once the settings have been configured, the number "003" will appear in the bottom right of the [Move] block.

Opening the hand and setting the standby time

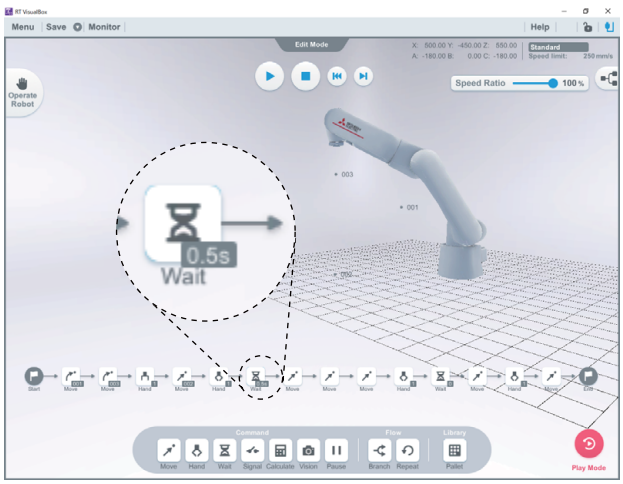
Operating procedure



1. Tap/click the [Hand] block shown on the screen shown on the left to display the Hand Setting window.
2. In the Hand Setting window, set [Hand Motion] to [Open], and tap/click the [Apply] button.



3. Tap/click the [Wait] block shown on the screen shown on the left to display the Wait Setting window.
4. Tap/click [Time] under [Wait Release Condition].
5. Enter 0.5 in the Waiting Time field, then tap/click the [Apply] button.

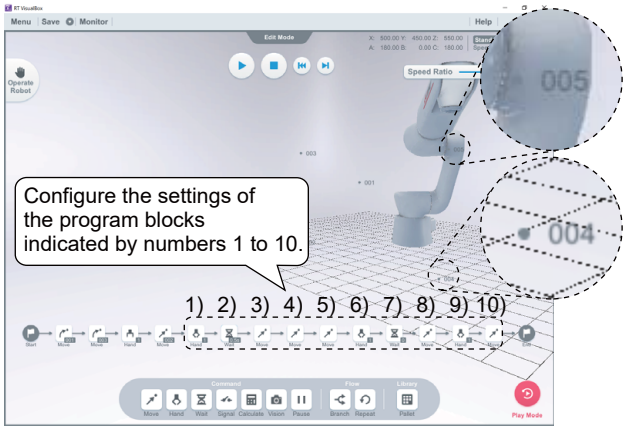


6. "0.5s" will appear in the bottom right of the [Wait] block.

Setting position 4 (position above the destination point) and position 5 (destination point) where the robot will move, hand conditions, and wait conditions

This section explains how to teach position 4 (position above the destination point) and position 5 (destination point) where the robot will move. It also explains how to set a hand open/close procedure and standby time which is not explained in "Opening the hand and setting the standby time".

Operating procedure



1. Refer to the screen on the left to set positions and configure the settings of each block.

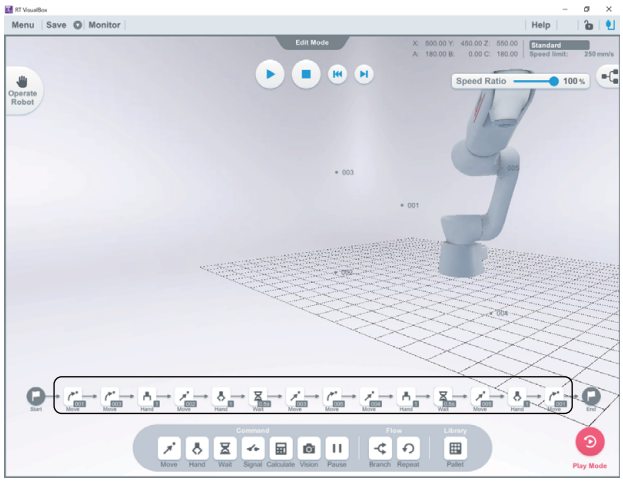
Information on the settings of each block is provided below.

1) Hand Operation: Close
2) Wait-Release Conditions: Time
   Waiting Time: 0.5 s
3) Position: 003
   Movement: Straight
4) Position: 005
   Movement: Non Straight
5) Position: 004
   Movement: Straight
6) Hand Motion: Open
7) Wait-Release Conditions: Time
   Waiting Time: 0.5 s
8) Position: 005
   Movement: Straight
9) Hand Operation: Close
10) Position: 001
    Movement: Non Straight

Refer to the operations for the pick-up point and position above the pick-up point for how to set [Move] blocks.
Refer to the hand open procedure and standby time for how to set [Hand] and [Wait] blocks.

Point

Depending on the start position, an error may occur or the robot may not move as intended when the robot moves from position 4 to position 1. To avoid this situation, create a via point between positions 4 and 1 by placing a [Move] block between the blocks of steps 8 and 10.



2. Once the settings of [Move] blocks have been configured, a position number will appear in the bottom right of the [Move] block.

Using values to teach position 2 (position above the pick-up point) and position 4 (position above the destination point) where the robot will move

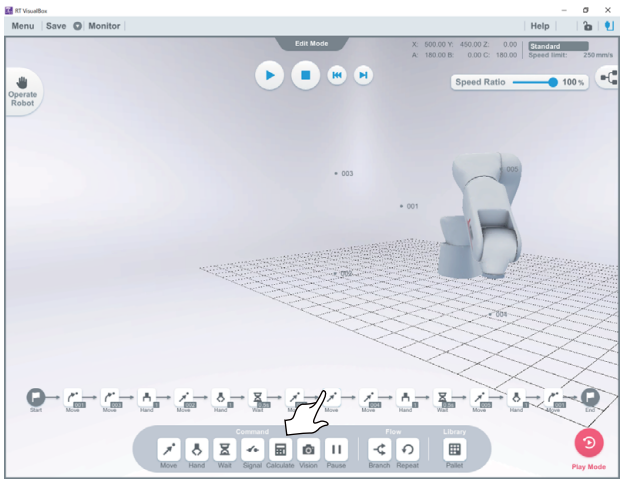
It is possible to use values to teach position 2 (position above the pick-up point) and position 4 (position above the destination point) where the robot will move

Below is an example of using values to teach position 4 (position above the destination point).

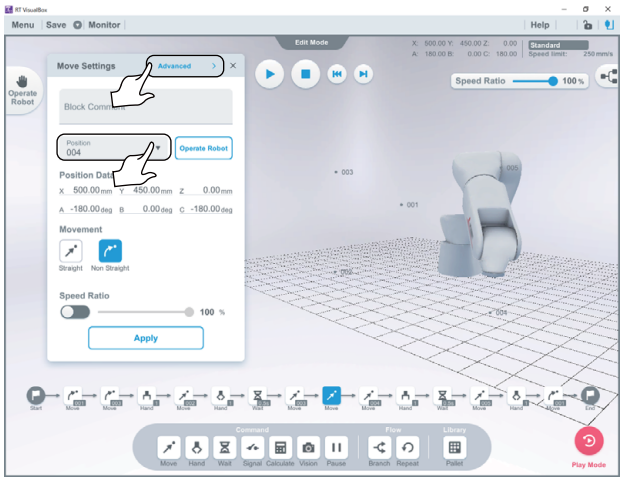
⚠ CAUTION

- Check that the robot does not collide with any obstacles after this setting has been changed.

Operating procedure

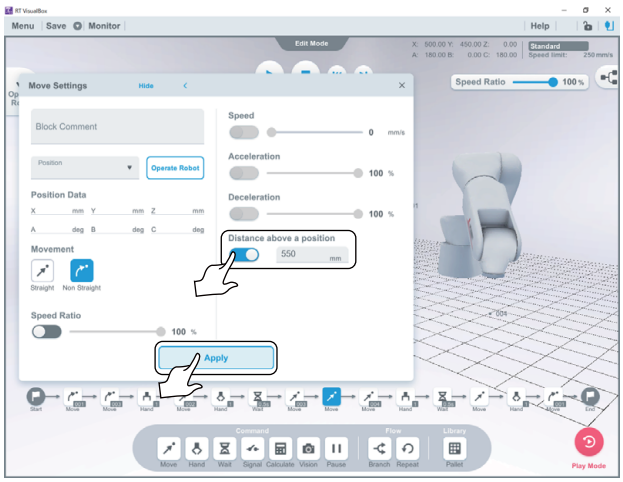


1. Tap/click the [Move] block shown in the screen shown on the left.



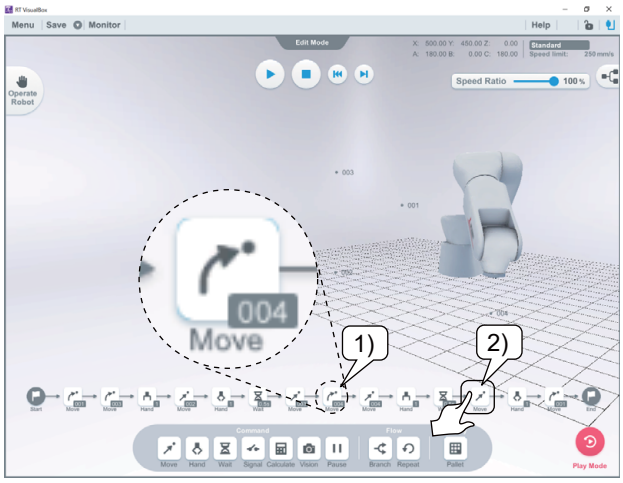
2. Select [Position 004] in the Move Settings window.

3. Tap/click [Advanced].



4. Tap/click the [Distance above a position] switch, then enter the distance for the 4th movement "position 5" (the position above the destination point).

5. Then, tap/click the [Apply] button.



6. Once the settings have been configured, the number "004" will appear in the bottom right of the [Move] block (indicated by "1").

7. Configure the same settings for the [Move] block indicated by "2".

Point

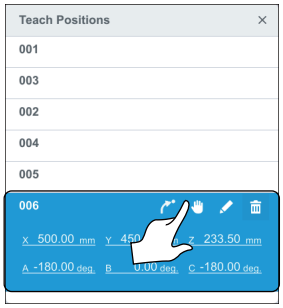
There are two methods to set taught positions to a program block as shown below.
1) Teach in the correct position and set the taught position to a program block.
2) Teach in a temporary position and set the taught position to a program block. Correct the position afterward.
In this textbook, 1) is used to explain.

Correcting the taught robot's position

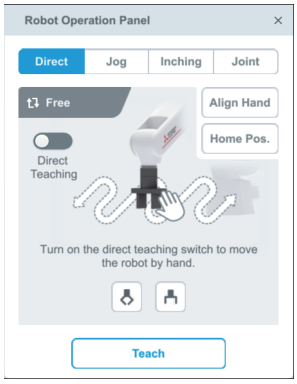
This section explains how to correct the temporarily taught position where the robot will move.

Operating procedure

1. Tap/click [Monitor] and select [Teaching Position List].
The Teaching Position List window will appear.

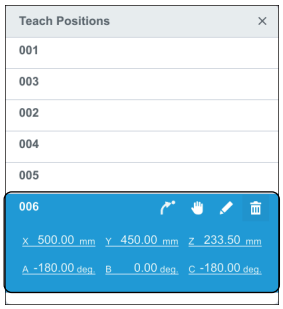


2. Select the position to be corrected from [Position List] and tap/click the button.



3. Move the robot to the position to be corrected in [Robot Operation].

4. Tap/click the [TEACH] button.



5. Tap/click the [×] button in the top right of the Robot Operation panel to close the panel.

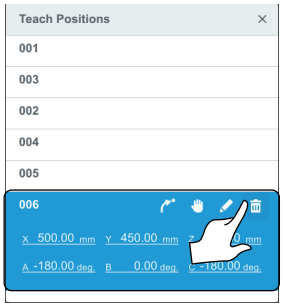
6. Check that the position corrected in step 4 is applied.

Deleting taught positions

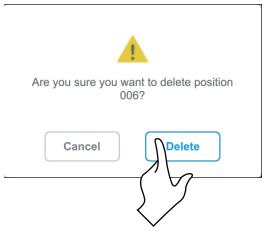
This section explains how to delete unnecessary positions.

Operating procedure

1. Tap/click [Monitor] and select [Teaching Position List]. The Teaching Position List window will appear.



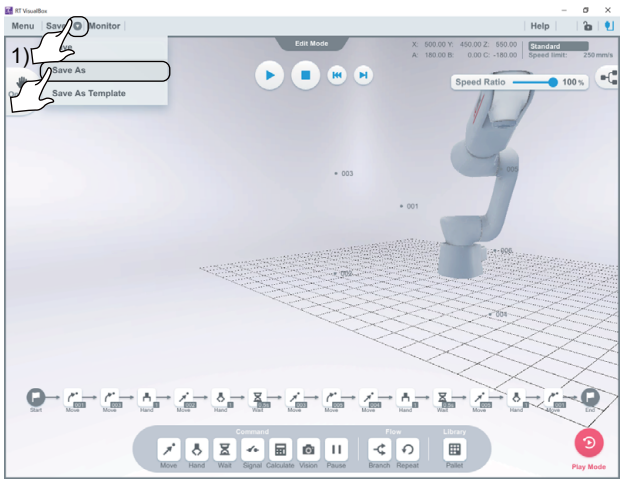
2. Select the deleting position where the robot will move and tap/click the button.



3. To delete the position number, tap/click the [Delete] button in the dialog box shown on the left.

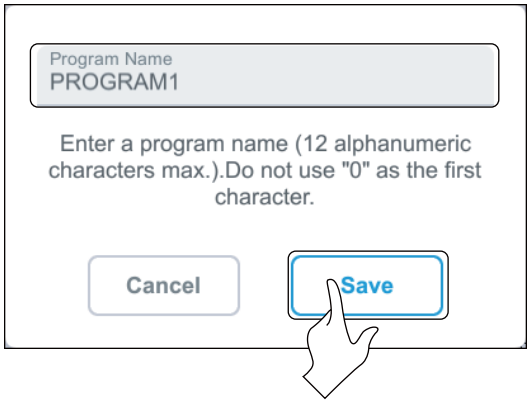
3.6 Saving the program

Operating procedure



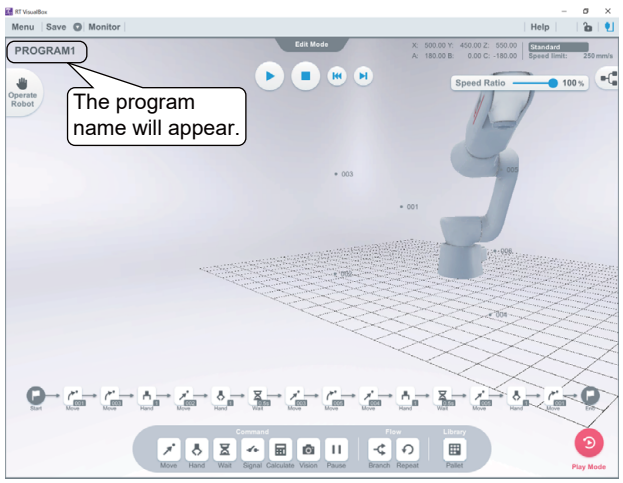
1. Tap/click the button to the right of [Save] (indicated by "1").

2. Select [Save As].



3. Enter a name in the Program Name field.

For this example project, tap/click the [Save] button to save the project with the displayed default name.



4. After saving the project, the program name will appear in the upper-left corner of the screen.

The data will be saved in the robot controller.

Point

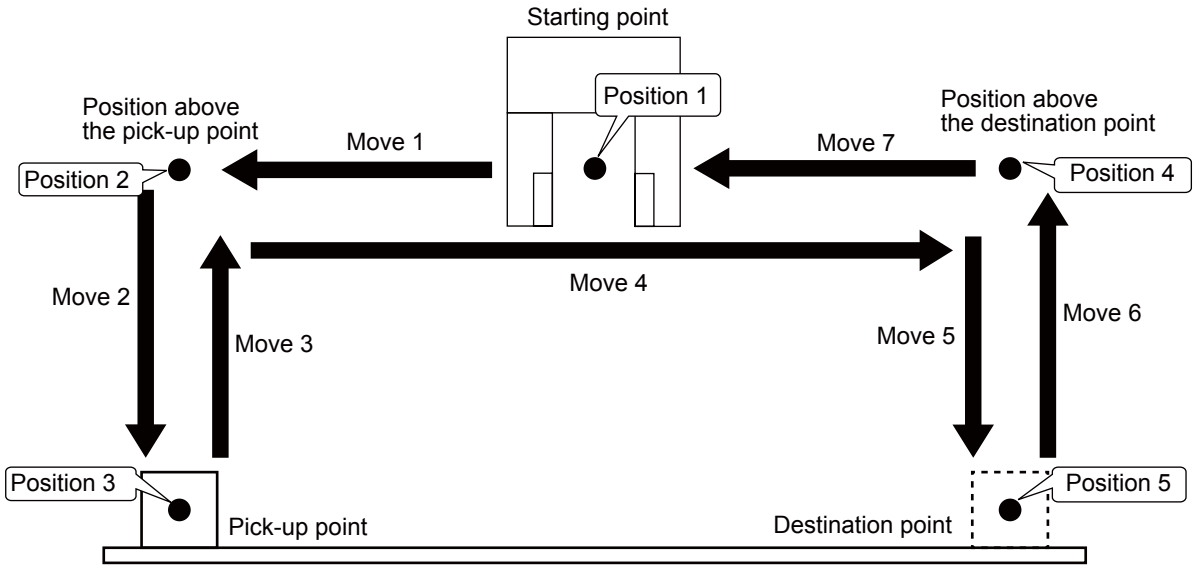
Programs containing errors cannot be saved. Check the properties of each block to see if all settings (such as position settings) have been configured.

Blocks with errors highlight in blue. Review the settings of the blocks.

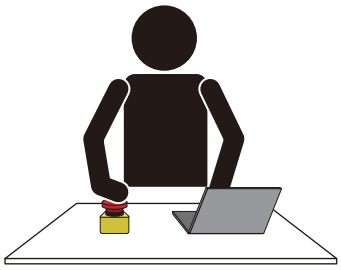
3.7 Program verification (step operation)

Check that there are no obstacles, such as tools, within the operating range of the robot before performing step operation. Screenshots from RT VisualBox are used to explain the following operation. Note that the robot will move during step operation.

When setting the workpiece down before using step operation, make sure that the workpiece is left in the same position and orientation that it was in when the teaching positions were taught.



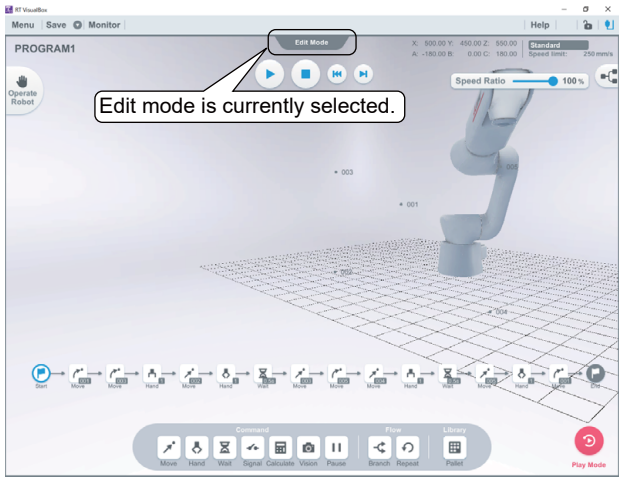
⚠ CAUTION



Before performing step operation, be sure to place an emergency stop switch nearby so that the robot can be stopped immediately.
The robot may move faster than expected during step operation.
To reduce the speed of the robot, set the Speed Ratio to less than 100%.

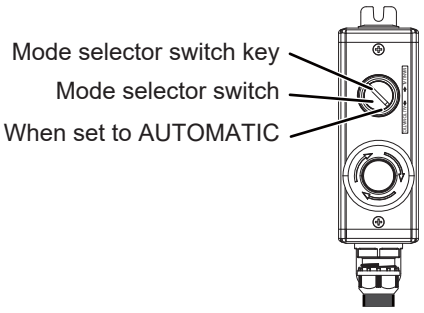
Operating procedure

Start with the Speed Ratio at 10% when checking the robot's movement for the first time, then gradually increase the Speed Ratio as required.

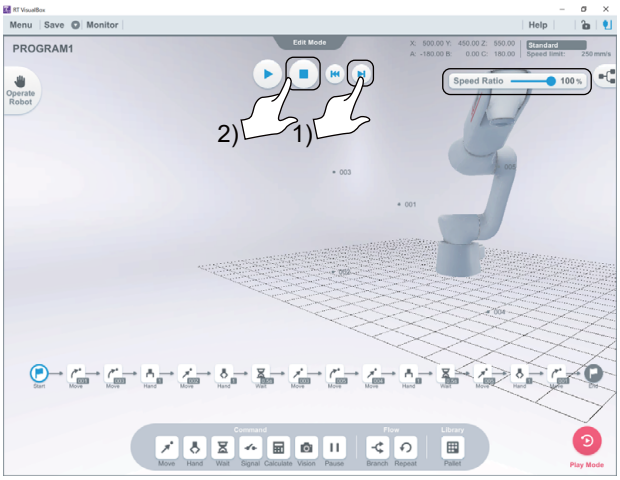


1. Check that the settings are as follows:

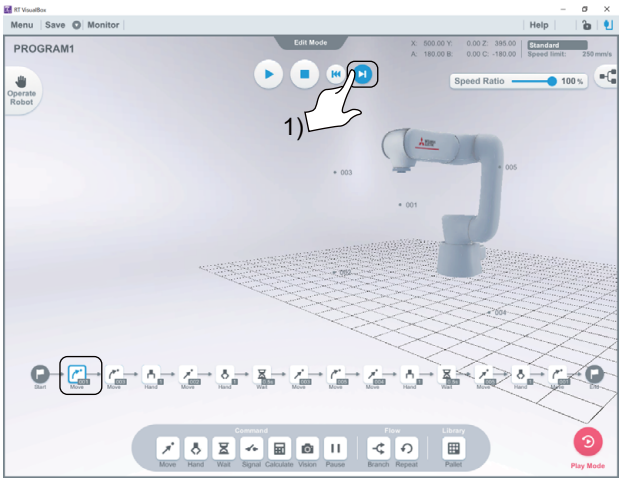
- The robot controller mode selector switch is set to AUTOMATIC mode and the mode selector switch key has been removed.



- RT VisualBox is in Edit mode.



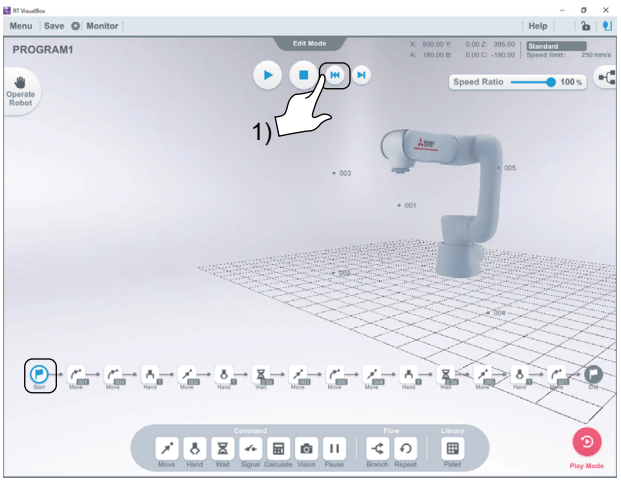
2. Tap/click the [Step forward] button (indicated by "1") to perform the next step from the current position in the program. Tap/click the [Stop] button (indicated by "2") to stop the robot.



3. Tap/click the [Step forward] button. The block that is currently being performed will highlight in blue.

The blue highlight will disappear once the current step is complete.

Tapping/clicking the [Step forward] button again will highlight the next block in blue.



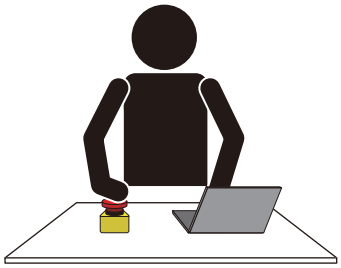
4. Run the program to END using step operation to check that the settings of all the blocks are configured correctly.

Tapping/clicking the [Reset] button (indicated by "1") will highlight [Start] in blue.

3.8 Automatic operation

Execute one cycle of the program or run the program repeatedly.
Screenshots from RT VisualBox are used to explain the following operation. Note that the robot will move while the program runs.
When setting the workpiece down before running the program, ensure that the workpiece is left at the taught pick-up point.

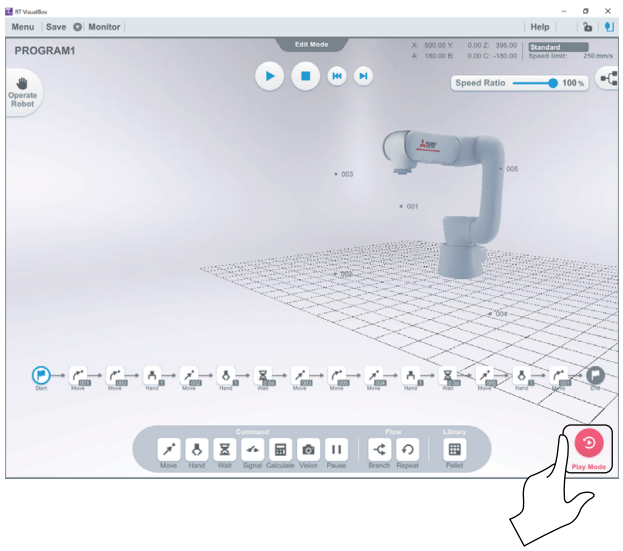
⚠CAUTION



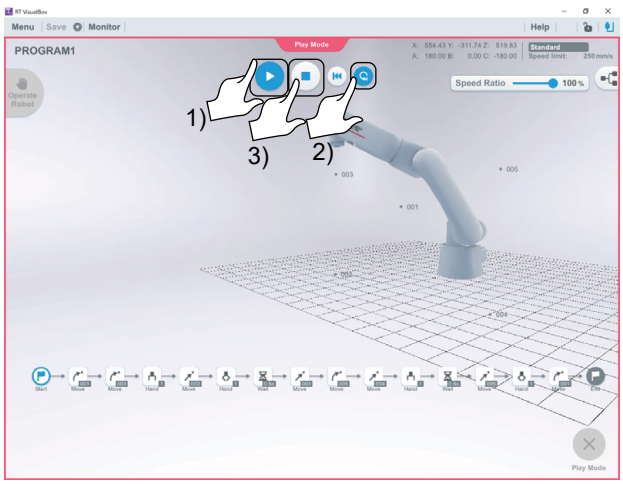
Before running the program, be sure to place an emergency stop switch nearby so that the robot can be stopped immediately.
The robot may move faster than expected while the program runs.
To reduce the speed of the robot, set the Speed Ratio to less than 100%.

Operating procedure

Start with the Speed Ratio at 10% when checking the robot's movement for the first time, then gradually increase the Speed Ratio as required.



1. Tap/click the [Play Mode] button in the lower-right corner of the screen to switch the mode from Edit Mode to Play Mode.



2. Tap/click the [Play] button (indicated by "1") to start the robot.

3. Tap/click the [End] button (indicated by "2") during robot operation. The robot will stop after one cycle of the program.

Tapping/clicking the [Stop] button (indicated by "3") during robot operation will stop the robot. Tapping/clicking the [Play] button will restart the robot from where it has stopped.

Point

The operation will repeat continuously until the [End] button is tapped/clicked.
Do not use a workpiece when repeatedly running the program created in this section.

3.9 Exercise

The following lists the program blocks used in each exercise.

Program block	Block name	Exercise No.							Description
		1	2	3	3 (Advanced)	4	5	6	
	Move	○	○	○	○	○	○	○	Moves the robot (Tap/click to configure settings).
	Hand	○	○	○	○	○	○	○	Opens/closes the hand (Tap/click to configure settings).
	Wait	○	○	○	○	○	○	○	Instructs the robot to wait (Tap/click to configure settings).
	Output	—	○	—	—	—	—	—	Outputs signals (Tap/click to configure settings).
	Pause	—	—	—	—	—	—	—	Pauses the operation.
	Branch	—	—	○	○	○	—	○	Repeats the operation (Tap/click to configure settings).
	Repeat	—	—	○	○	○	—	—	Branches conditions (Tap/click to configure settings).
	Calculate	—	—	—	○	○	—	—	Performs calculations (Tap/click to configure settings).
	Pallet	—	—	—	—	○	—	—	Used to set up palletizing operations (Tap/click to configure settings).
	Vision	—	—	—	—	—	○	○	Recognizes the workpiece (Tap/click to configure settings). This block becomes available when a robot is connected to the software.

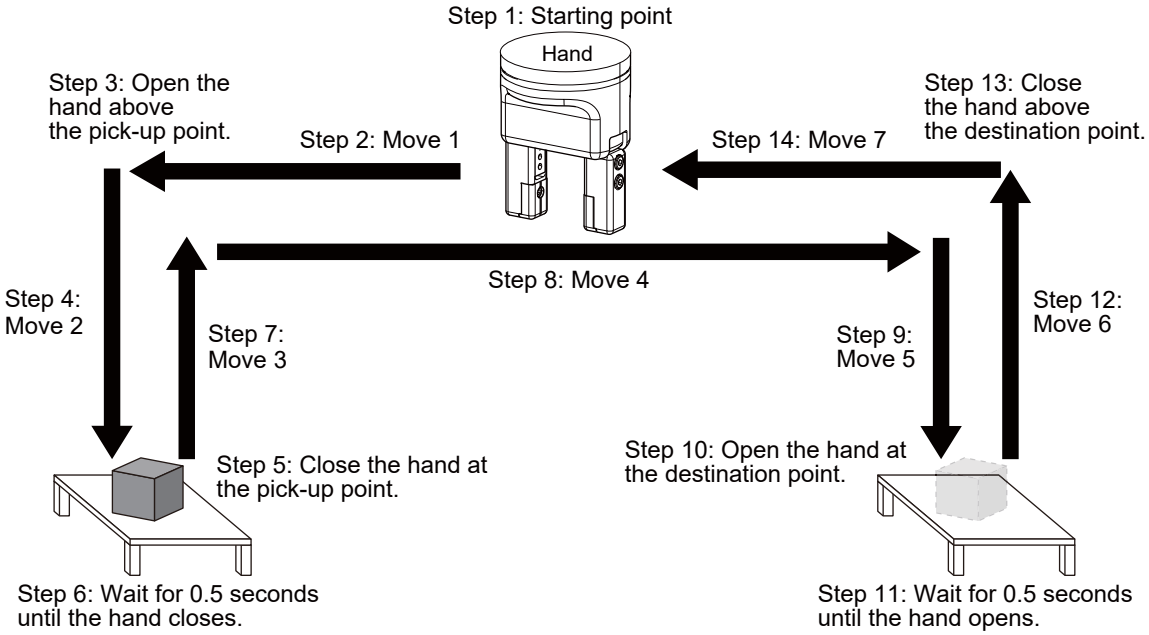
Pick-up and placement

Exercise 1

Move the workpiece from the pick-up point to the destination point.

The contents are the same as those in the following section.

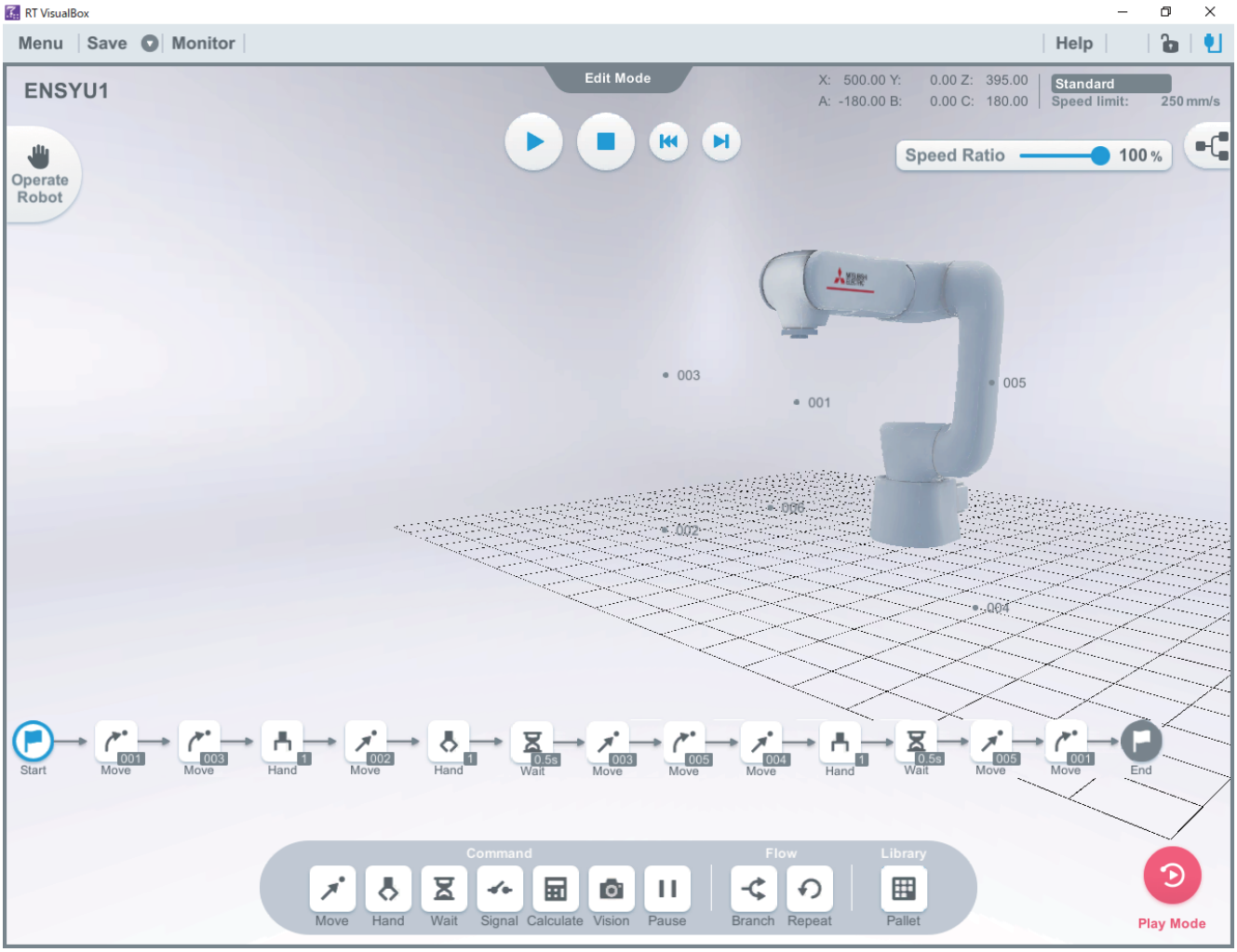
☞ Page 82 Programming with RT VisualBox (Exercise 1)

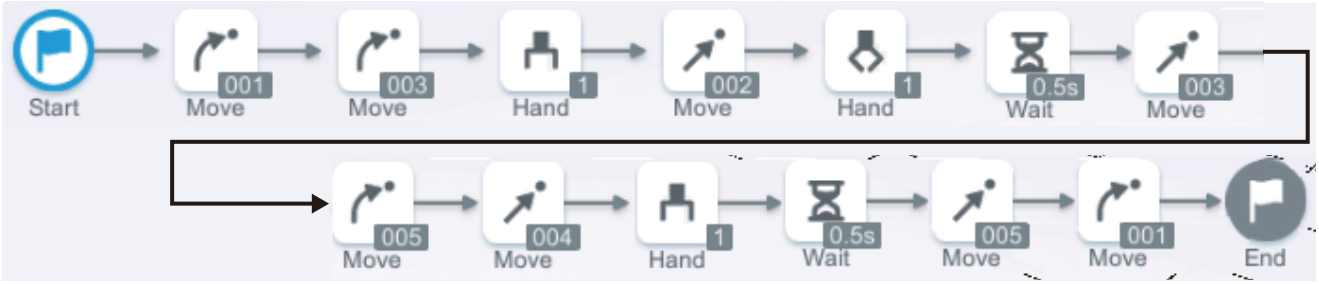


Exercise 1: Sample answer

The contents are the same as those in the following section.

☞ Page 82 Programming with RT VisualBox (Exercise 1)





Wait, input/output

Exercise 2

Transfer the workpiece from the pick-up point to the destination point.

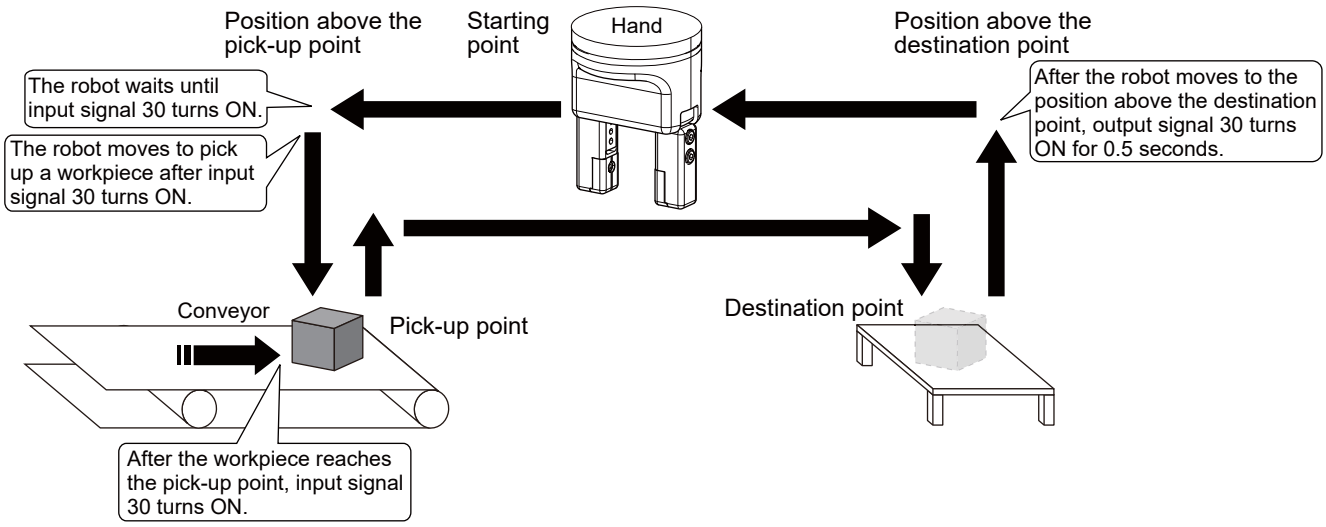
The robot waits in the position above the pick-up point until input signal 30 turns ON.

The robot moves to the pick-up point to pick up a workpiece when input signal 30 turns ON.

After the robot places the workpiece and moves to the position above the destination point, output signal 30 turns ON for 0.5 seconds.

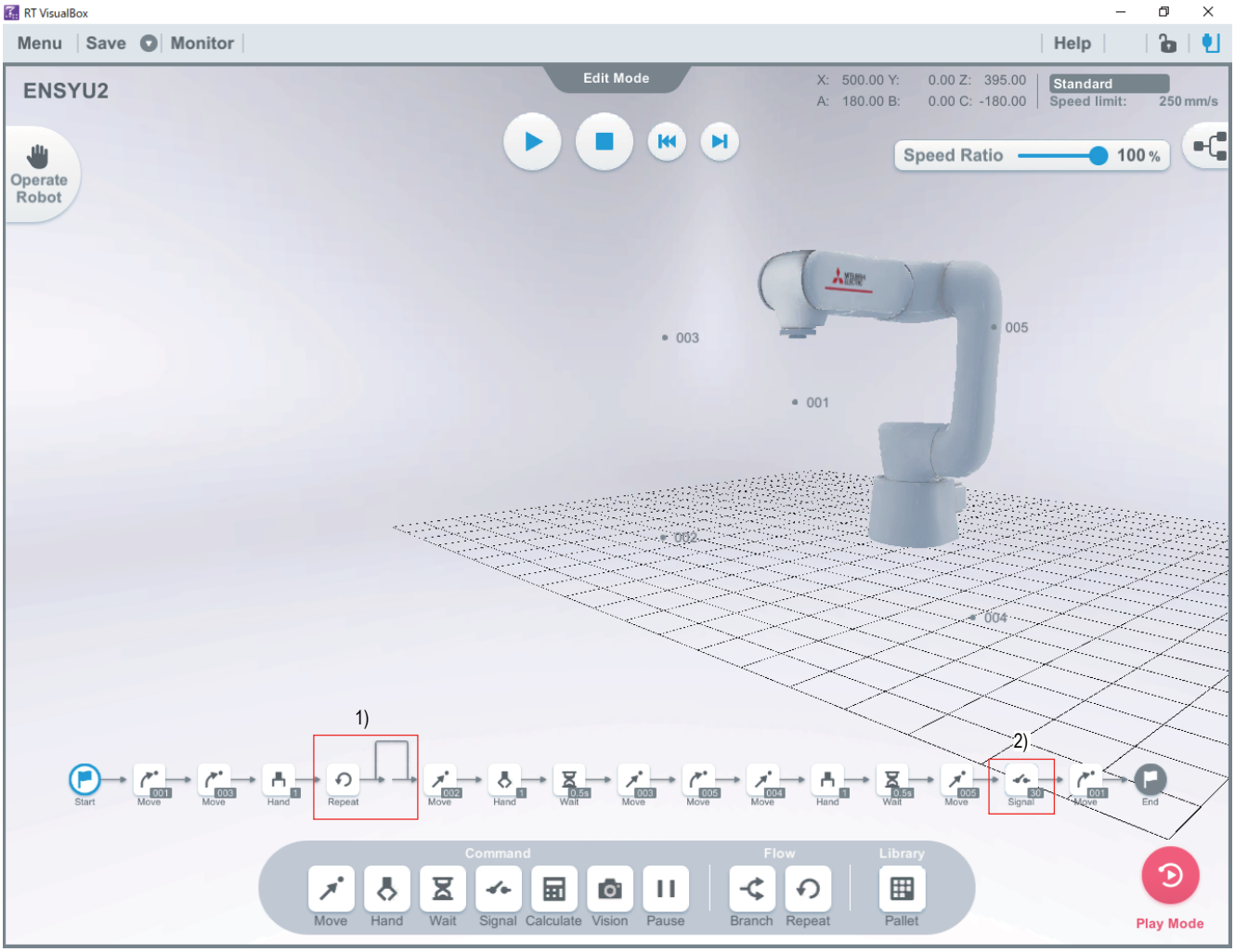
■Condition

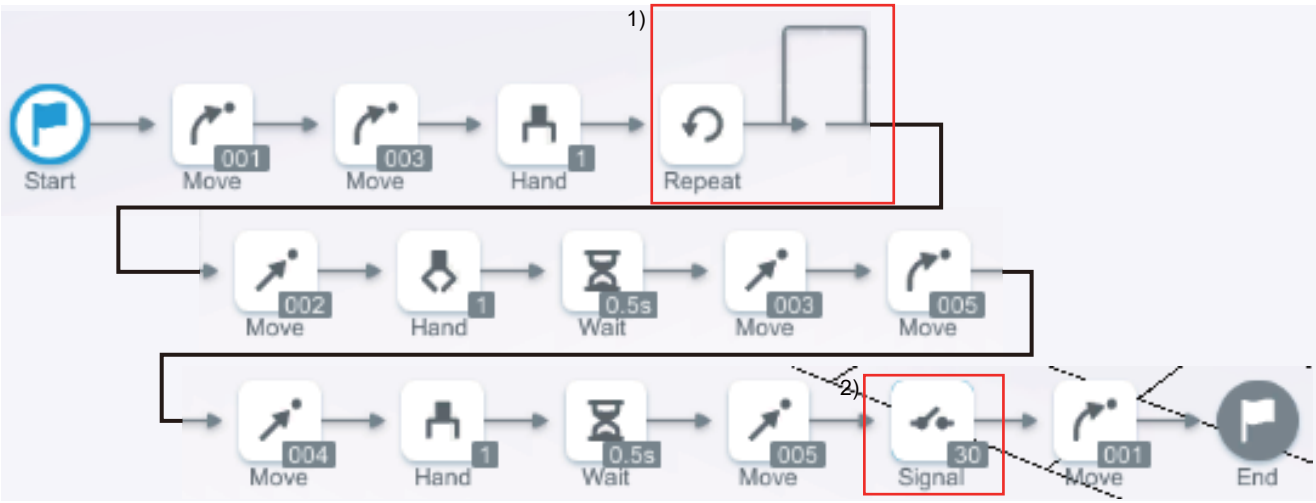
- Create a program using the program of exercise 1.
- Set the same pick-up point and destination point as those of exercise 1.
- Input/output signal: 30
- Hand open/close wait time: 0.5 seconds



Exercise 2: Sample answer

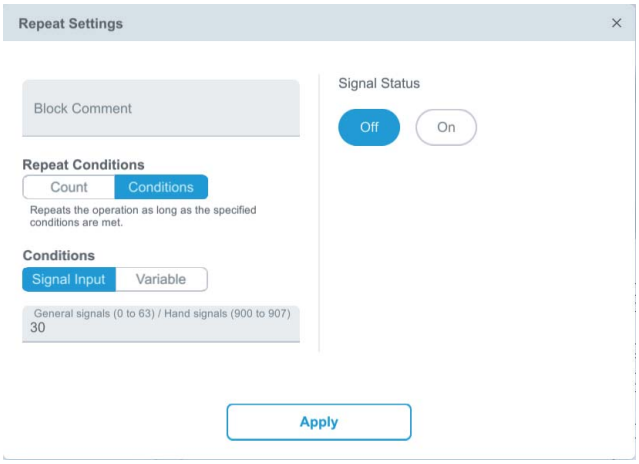
Add program blocks 1) and 2) to the program created in exercise 1.





■1) Repeat block

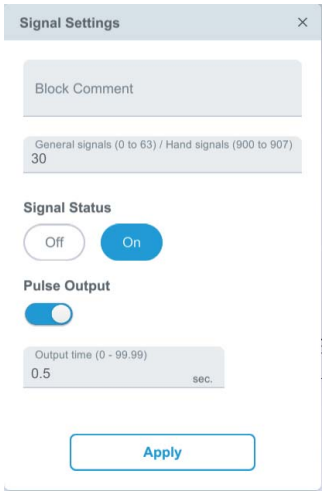
Repeats the operation until input signal 30 turns on.



• Repeat Conditions: Conditions
Repeats the operation as long as the specified conditions are met.
• Conditions: Signal Input
The status of the specified input signal is used as the condition.
• External signal: 30
Set the input signal number to 30.
• Signal status: Off
If the signal is Off, the operation is repeated.

■2) Signal block

Turns on output signal 30.



• General-purpose signal: 30
Set the output signal number to 30.
• Signal status: On
Turn on the specified output signal.
• Pulse output: Enabled
Outputs a pulse signal.
• Output time: 0.5
Outputs the signal as a pulse for 0.5 seconds.

Conditional branch

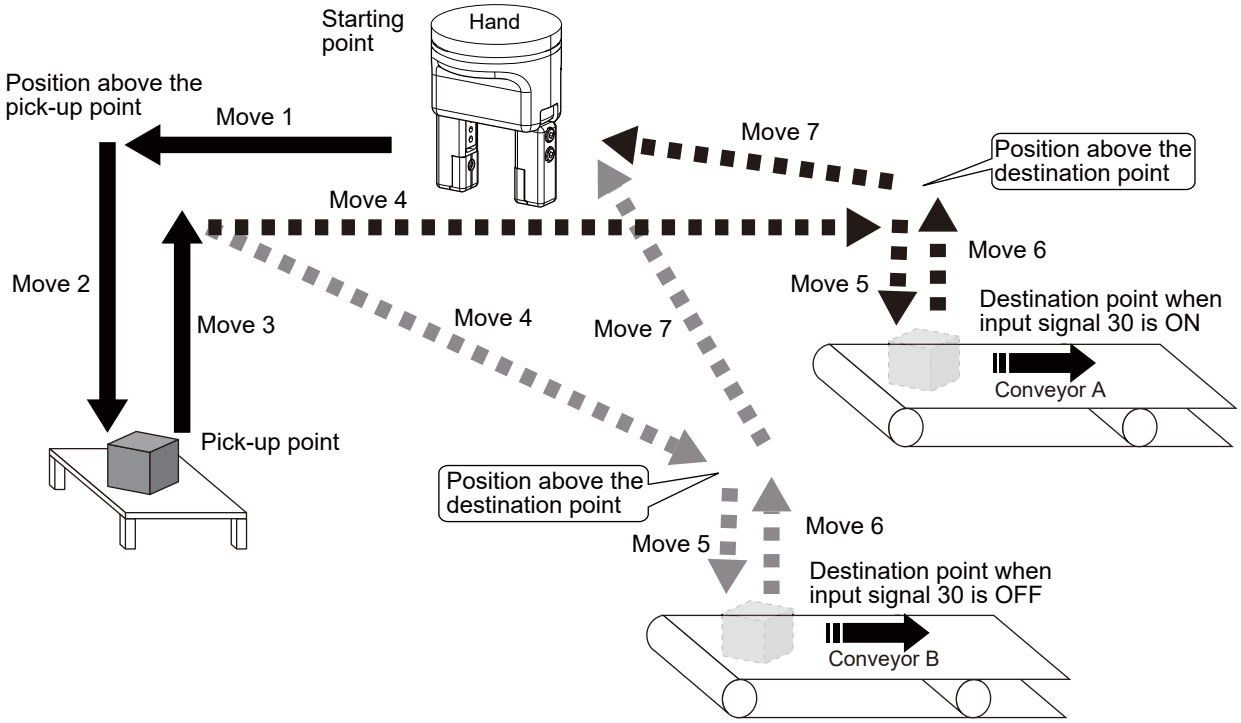
Exercise 3

Transfer the workpiece from the pick-up point to either of the two destination points (conveyors).

The workpiece is transferred to conveyor A when input signal 30 is on whereas the workpiece is transferred to conveyor B when the signal is off.

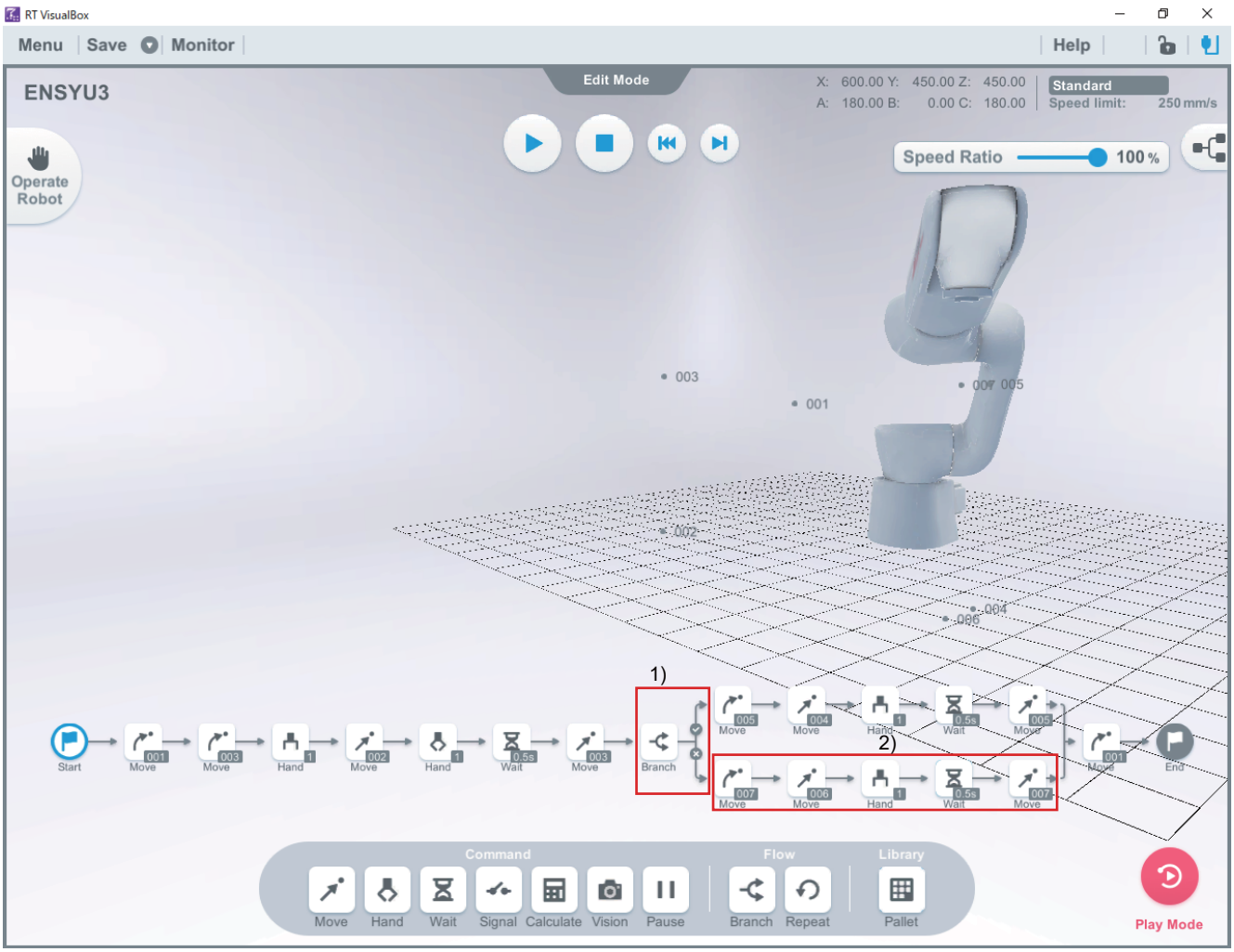
■Condition

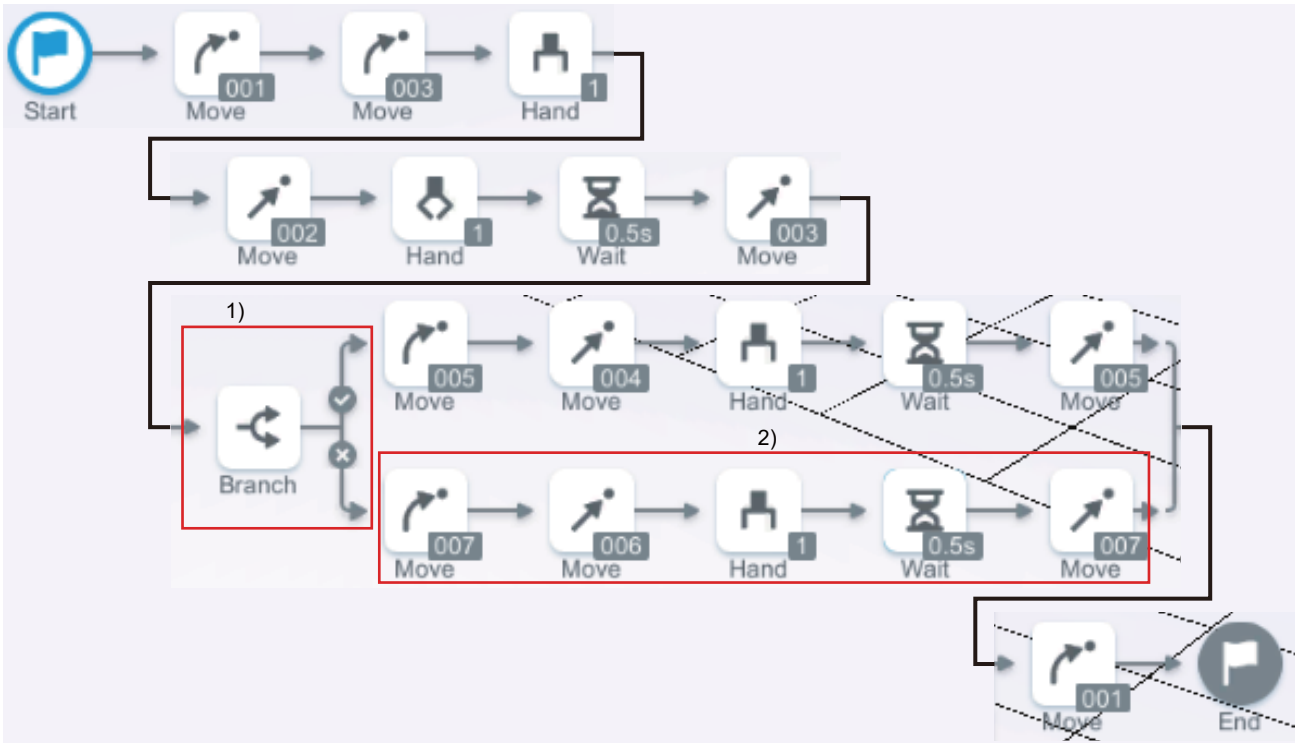
- Create a program using the program of exercise 1.
- Set the same pick-up point as that of exercise 1.
- For conveyor A, set the same destination point as that of exercise 1.
- For conveyor B, teach new destination point and position above the destination point.
- Input signal: 30
- Hand open/close wait time: 0.5 seconds



Exercise 3: Sample answer

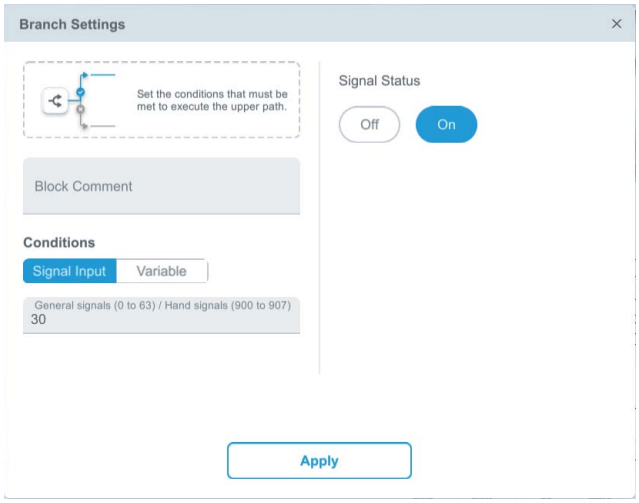
Add program blocks 1) and 2) to the program created in exercise 1.





■1) Branch block

Determine the status of input signal 30 and select the destination point.



• Conditions: Signal Input
Set the input signal as the branch condition.
• General-purpose signal: 30
Set the input signal number to 30.
• Signal status: On
If the signal is On, the upper path is executed.
If the signal is Off, the lower path is executed.

■2) Conveyor B transfer program

For how to create a program, refer to exercise 1.

☞ Page 82 Programming with RT VisualBox (Exercise 1)

Conditional branch (Advanced)

Exercise 3 (Advanced)

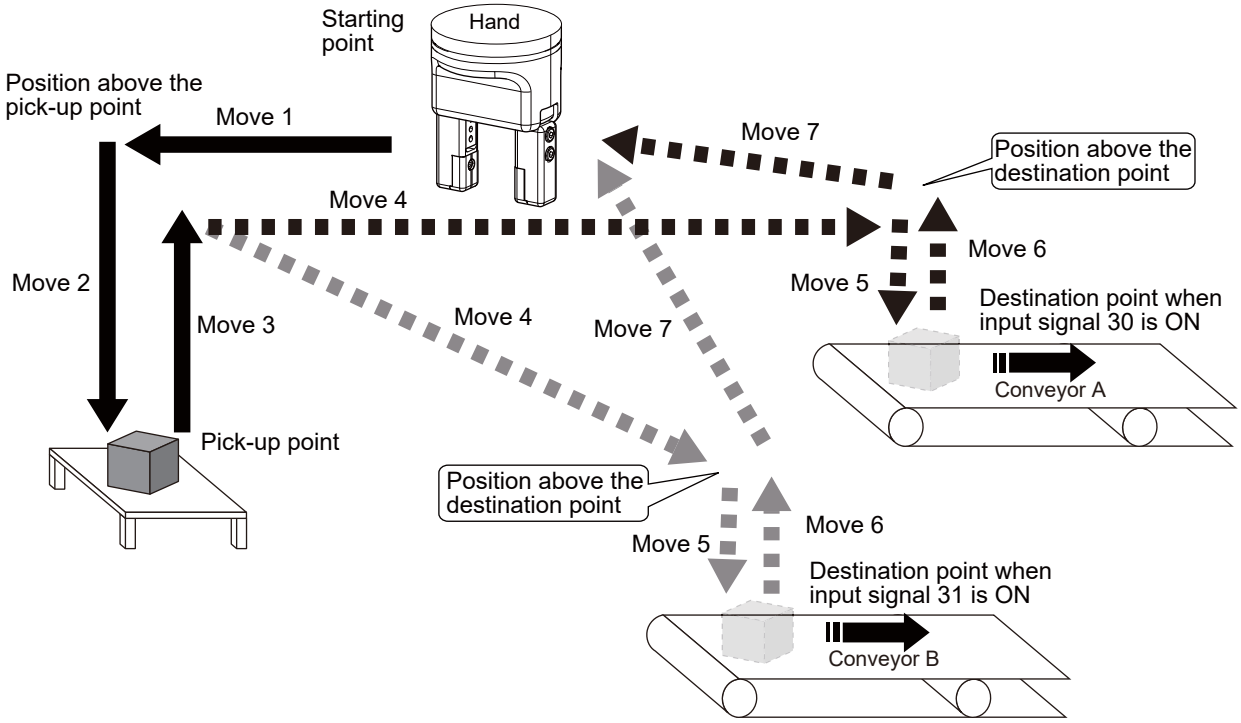
Transfer the workpiece to either of the two conveyors.

Transfer the workpiece to conveyor A if input signal 30 turns on or conveyor B if input signal 31 turns on.

Wait until either input signal 30 or 31 turns on if both signals are off.

■Condition

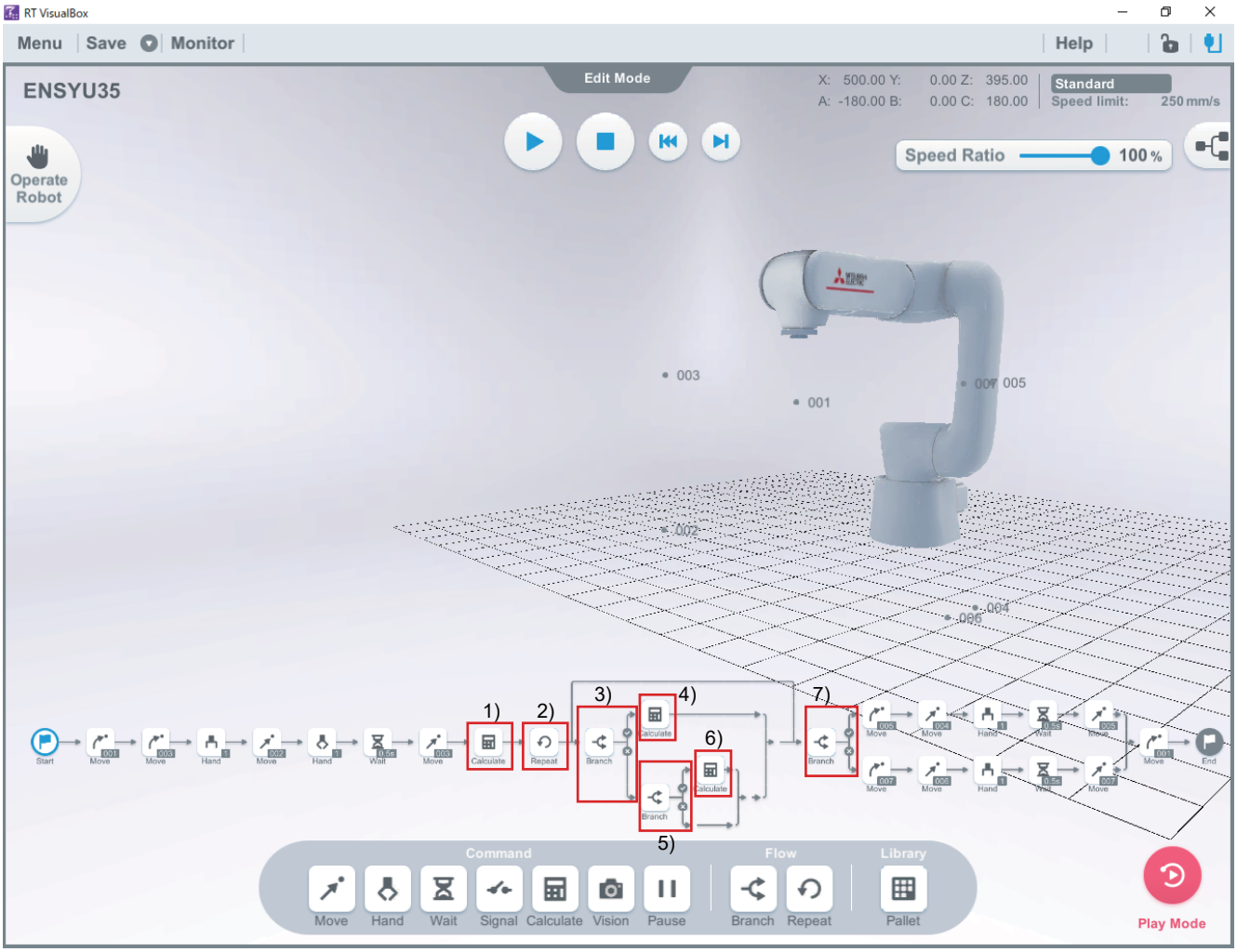
- Input signal: 30, 31
- Use MP for the counter name.
- For conveyor A, set the same destination point as that of exercise 1.
- For conveyor B, teach new destination point and position above the destination point.
- Hand open/close wait time: 0.5 seconds

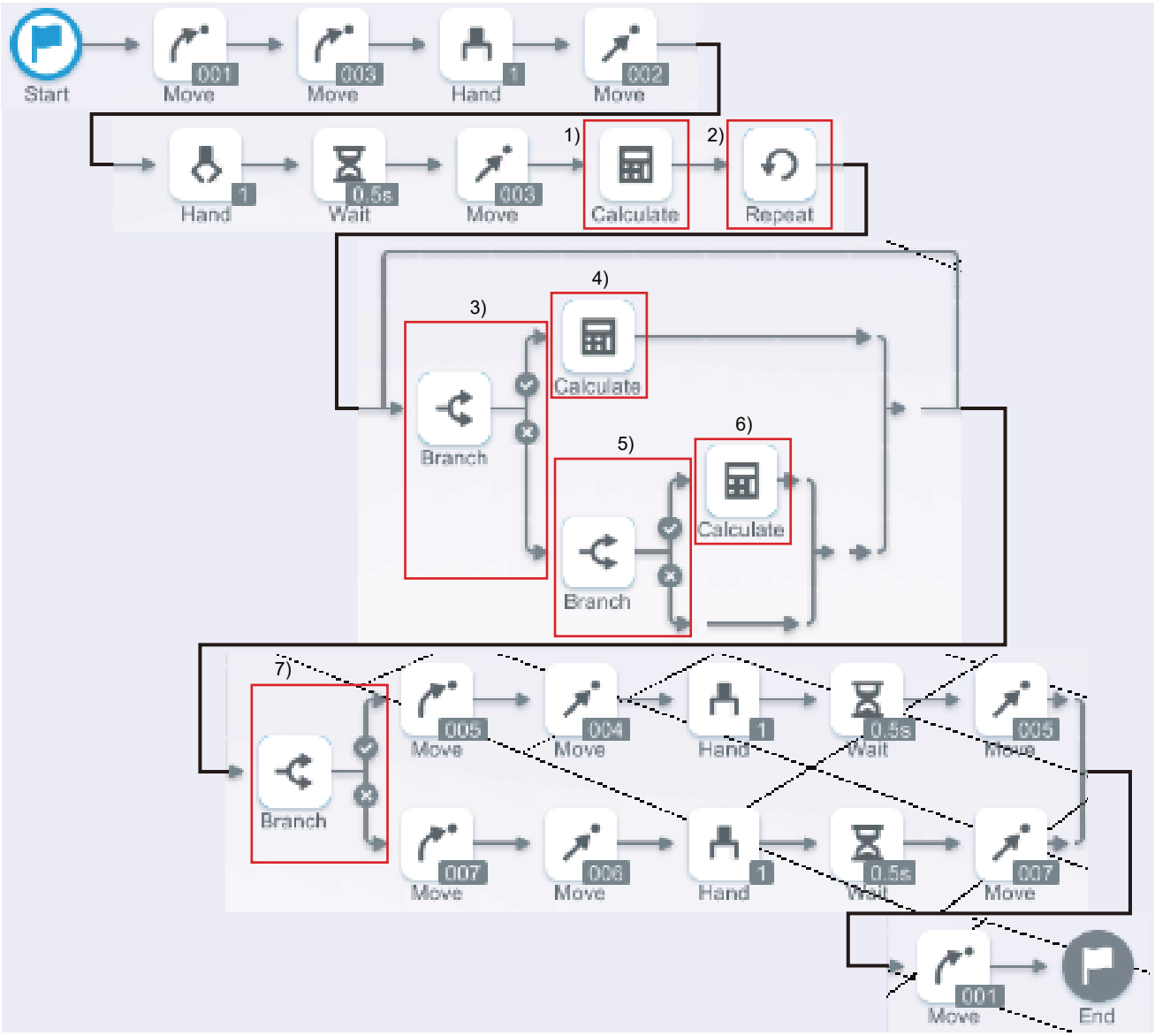


Exercise 3 (Advanced): Sample answer

Add program blocks 1) to 6) to the program created in exercise 3.

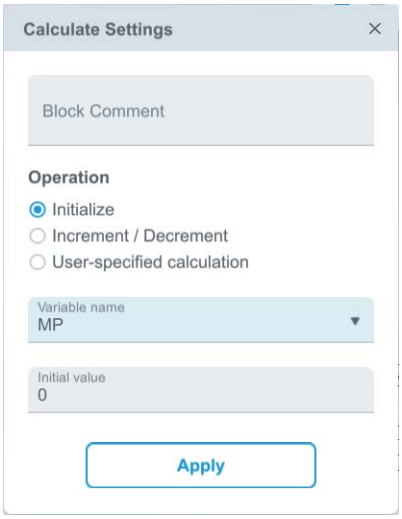
Change the settings of program block 7).





■1) Calculate block

Initializes the counter variable MP to 0.



- Processing: Initialization

Set the initial value.

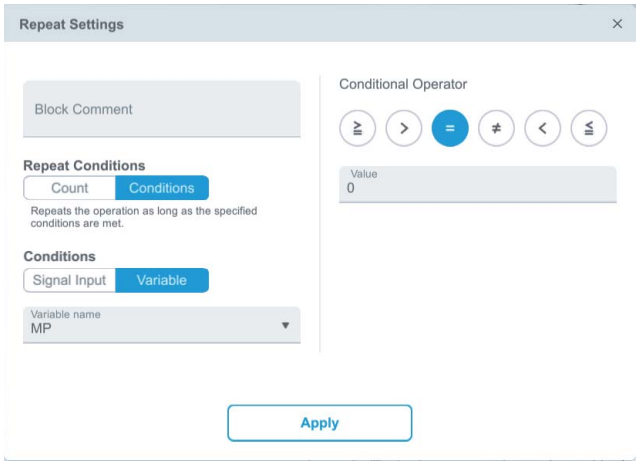
- Variable name: MP

Set the variable to MP.

- Initial value: 0

■2) Repeat block

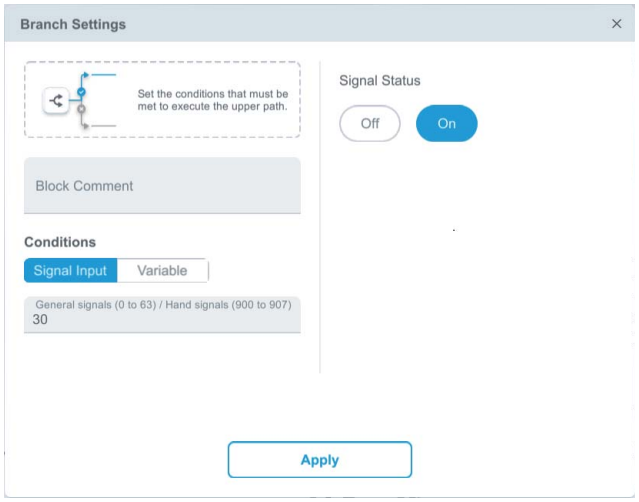
Repeats the program while the counter variable MP is "0".



• Repeat Conditions: Conditions
Repeats the operation as long as the specified conditions are met.
• Conditions: Variable
The value of the specified variable is used as the condition.
• Variable name: MP
Set the variable to MP.
• Conditional Operator: =
If the value of the variable is the same as the value of "Value", the upper path is executed.
• Value: 0

■3) Branch block

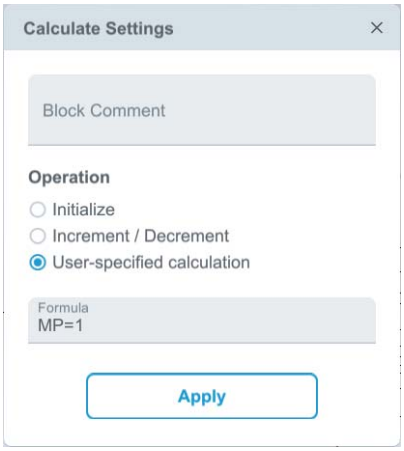
Determine the status of input signal 30.



• Conditions: Signal Input
Set the input signal as the branch condition.
• General-purpose signal: 30
Set the input signal number to 30.
• Signal status: On
If the signal is On, the upper path is executed.
If the signal is Off, the lower path is executed.

■4) Calculate block

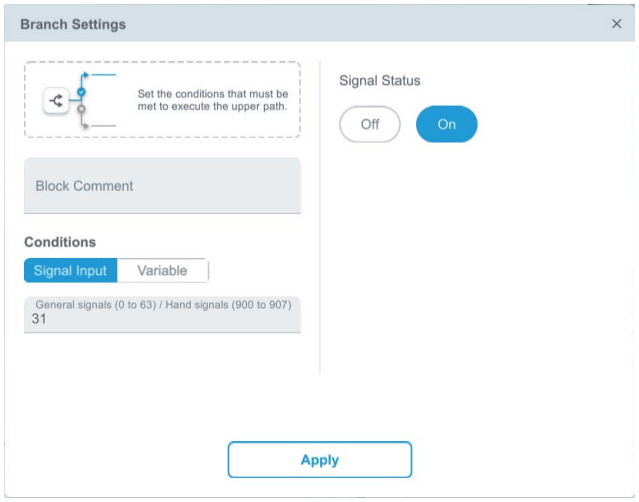
Set the counter variable MP to 1.



• Processing: User-specified calculation
Set any value.
• Formula: MP = 1
Set the variable MP to 1.

■5) Branch block

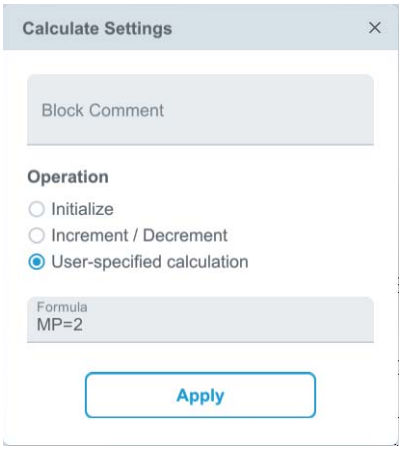
Determine the status of input signal 31.



• Conditions: Signal Input
Set the input signal as the branch condition.
• General-purpose signal: 31
Set the input signal number to 31.
• Signal status: On
If the signal is On, the upper path is executed.
If the signal is Off, the lower path is executed.

■6) Calculate block

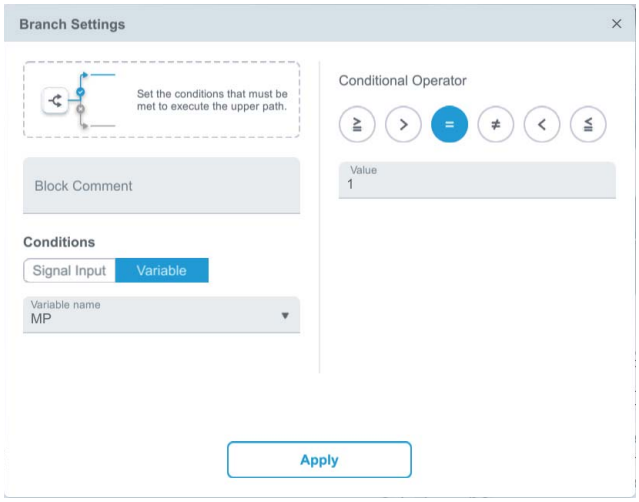
Set the counter variable MP to 2.



• Processing: User-specified calculation
Set any value.
• Formula: MP = 2
Set the variable MP to 2.

■7) Branch block

Determine the value of the counter variable MP and select the destination point.



• Conditions: Variable
The value of the specified variable is used as the condition.
• Variable name: MP
Set the variable to MP.
• Conditional Operator: =
If the value of the variable is the same as the value of "Value", the upper path is executed.
• Value: 1

Palletizing

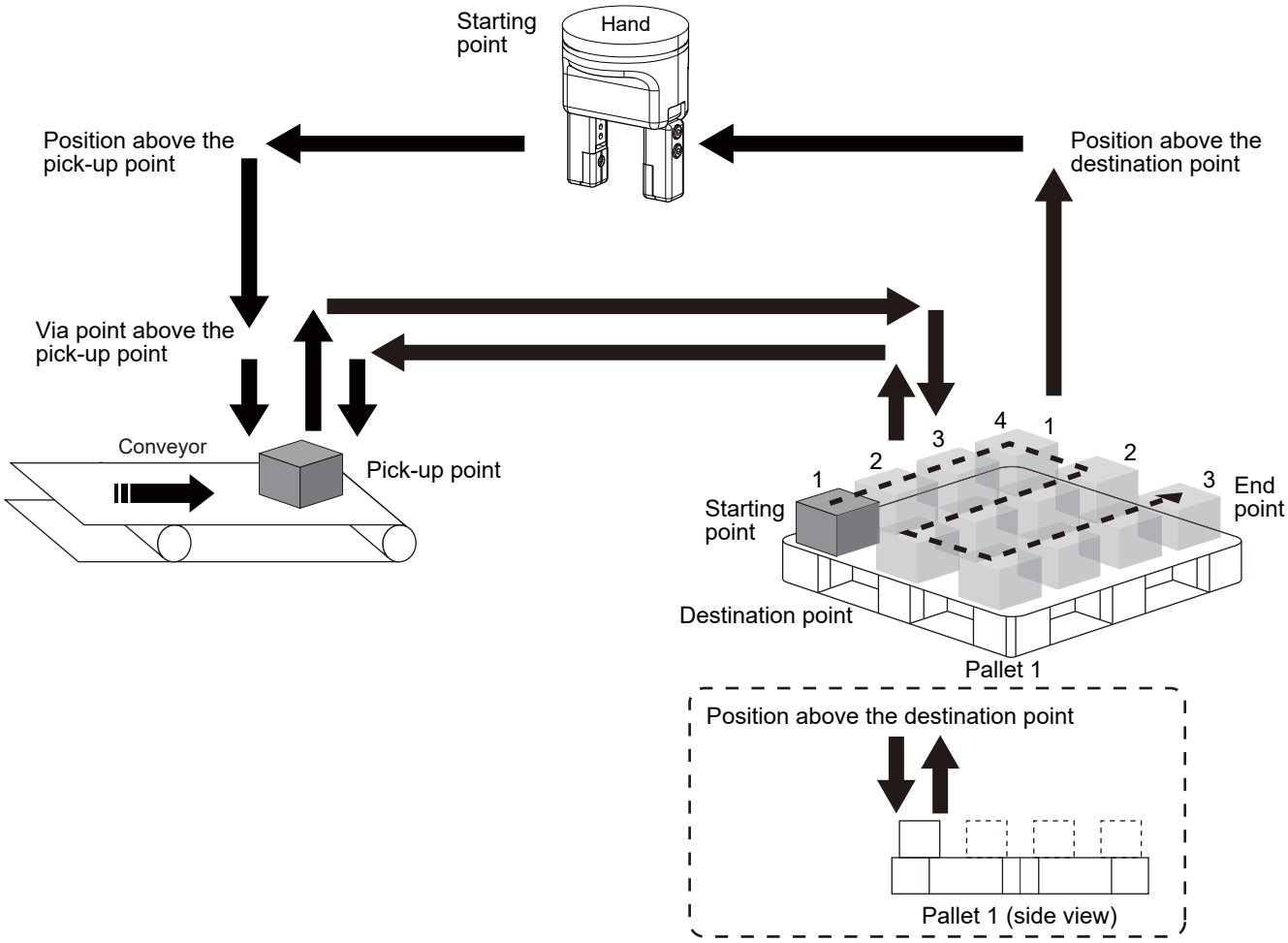
Exercise 4

Palletize workpieces from the workpiece pick-up point to a pallet (4 x 3 pcs).

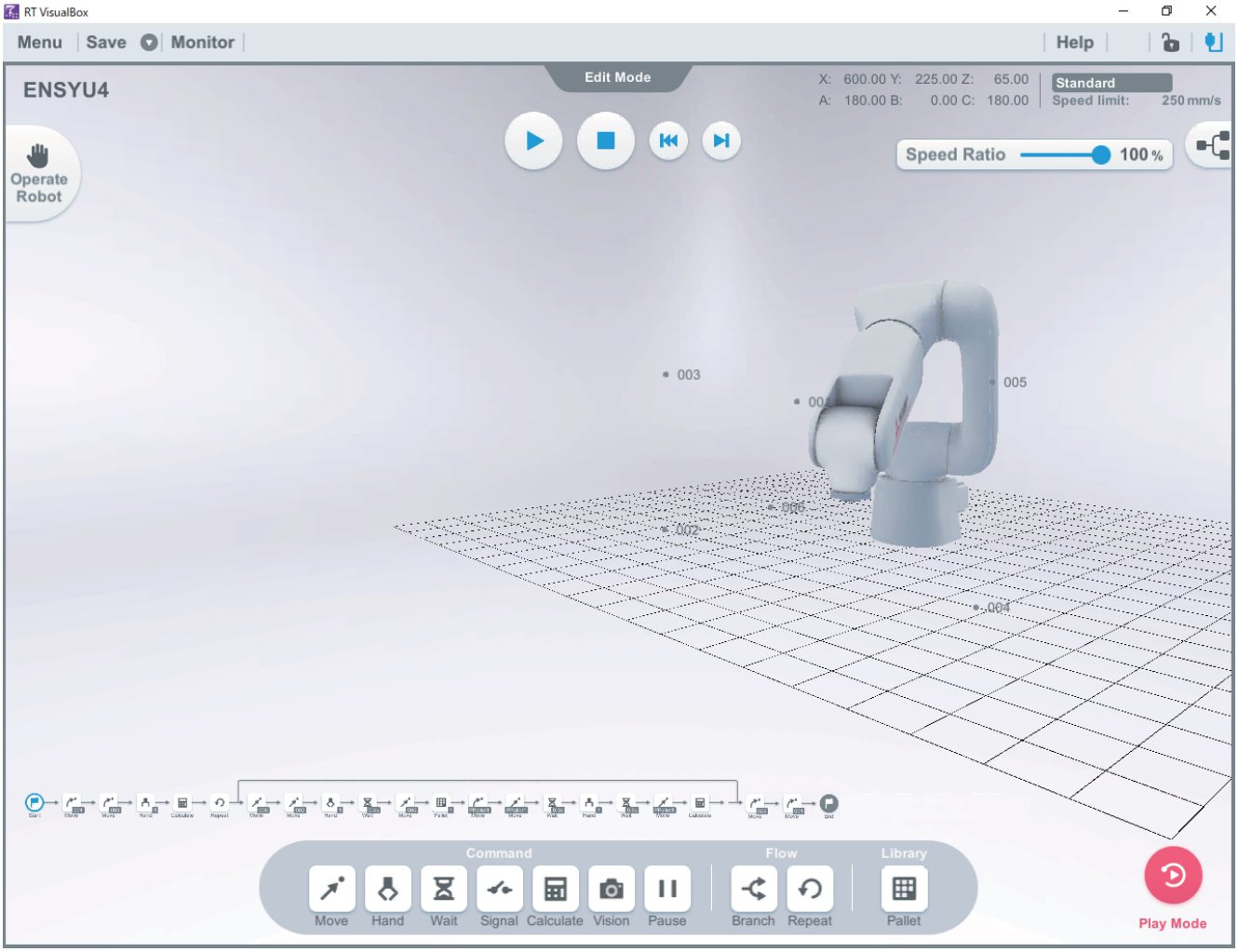
Palletize workpieces in pallet 1 in the order shown in the figure.

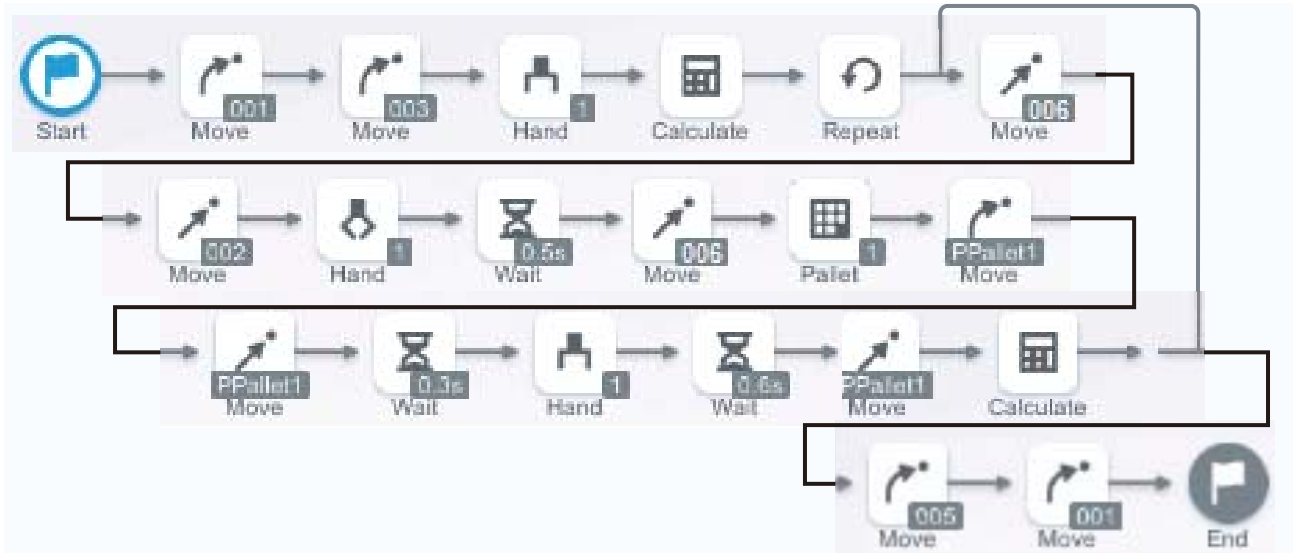
■Condition

- Create a program using the program of exercise 1.
- Set the same pick-up point as that of exercise 1.
- Set the destination point of exercise 1 as the start point of palletizing.
- Set the position 50 mm above the pick-up point as the via point above the pick-up point.
- Set the position 50 mm above the pallet as the via point above palletizing point.
- Hand open/close wait time: 0.5 seconds



Exercise 4: Sample answer



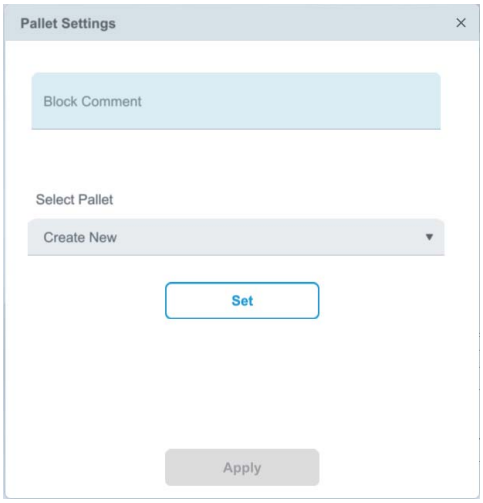


When a pallet block is added and the settings are configured, repeat blocks are automatically generated.

1. Add a pallet block between blocks 3 and 4 in the program of exercise 1.

2. Configure the palletizing settings.

In the [Select Pallet], select [New] → [Set].



3. Configure the following settings.

- Name: Plt1

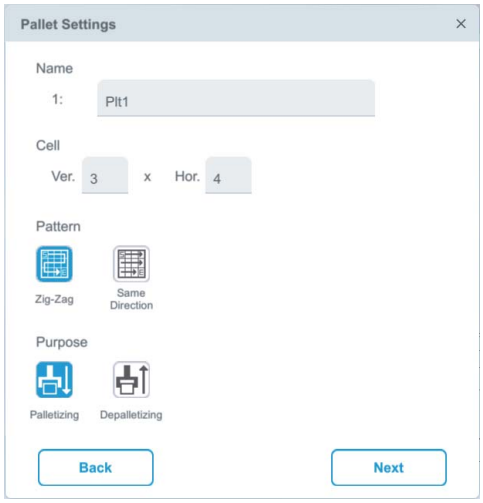
Set it as desired.

- Cell: Ver. 3 × Hor. 4

Set the pallet size to Ver. 3 × Hor. 4

- Pattern: Zig-Zag
- Purpose: Palletizing

The robot places a workpiece on the pallet.



4. Set the order of palletizing.

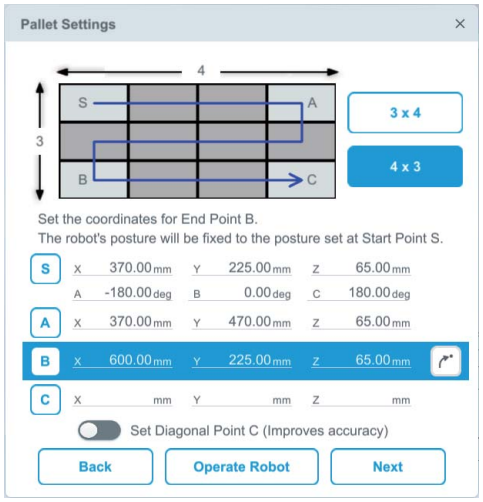
Select the palletizing start point "S" and set the palletizing direction.

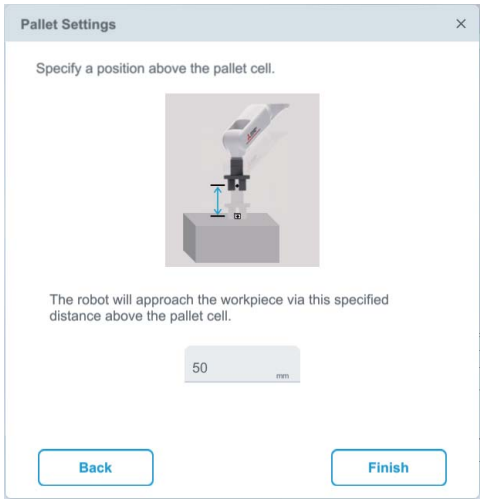
- Setting: 4 × 3

Proceeds from the start point to the long side.

5. Teach the start point "S" and via points "A" and "B".

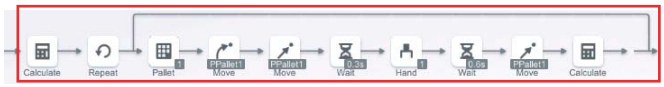
Select [Operate Robot] and teach each position using direct teaching.





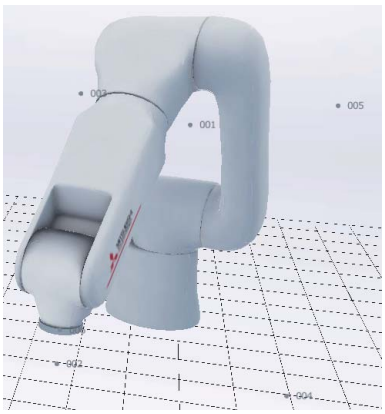
6. Set a via point above the palletizing position.

- Setting value: 50 mm



7. When a pallet block is set, the program is automatically created.

8. Teach the via point above the pick-up point. Teach the position 50 mm above the pick-up point.

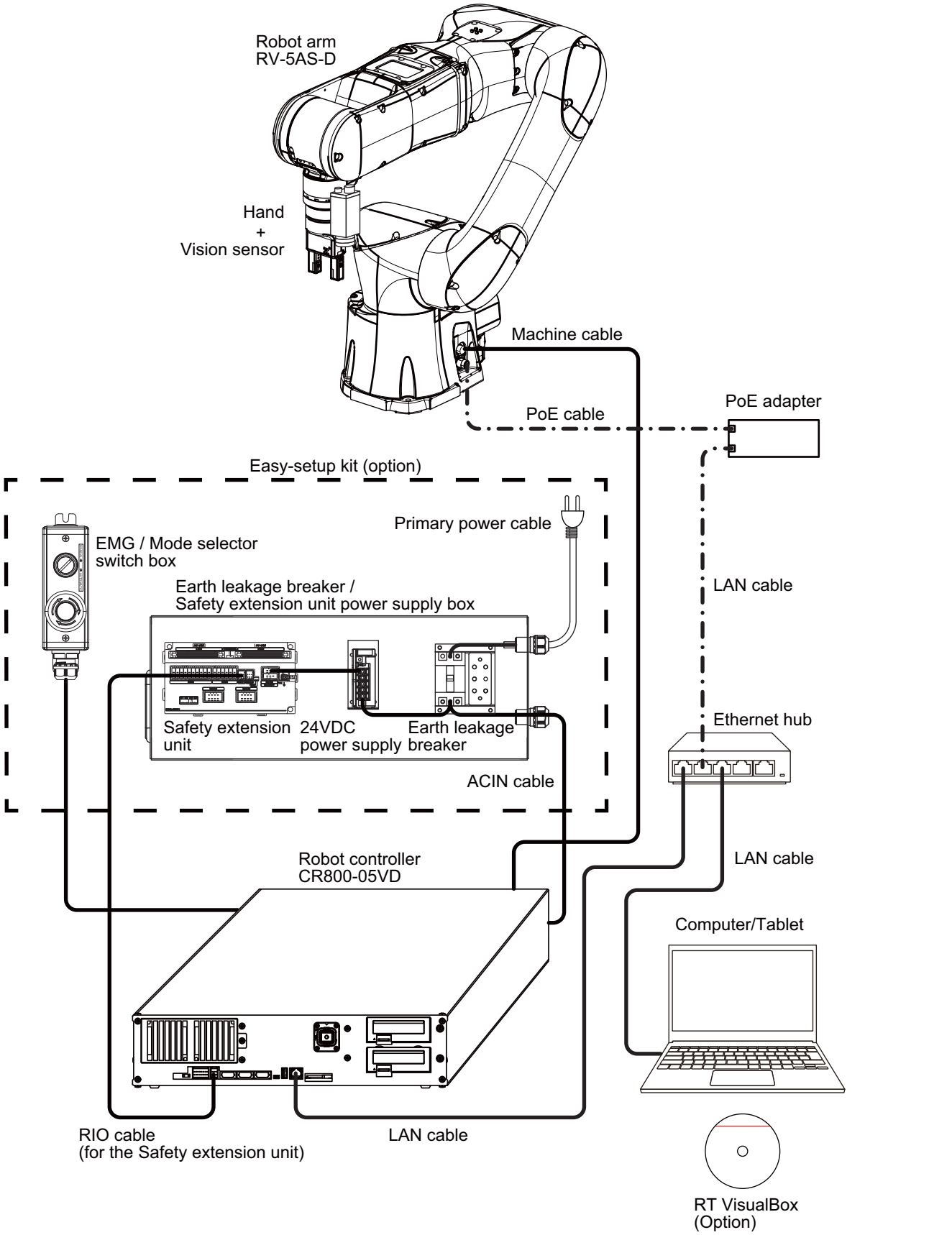


9. Create a program to pick up a workpiece at the pick-up point before the pallet block.

4 How to use a vision sensor (hand eye)

This chapter explains what equipment is required for the system below and how to connect the equipment.

4.1 Vision sensor connection (system architecture)

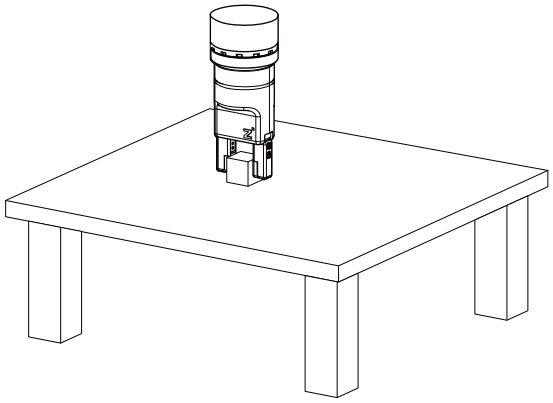

Robot arm
RV-5AS-D
Hand
+
Vision sensor
Machine cable
PoE cable
PoE adapter
Easy-setup kit (option)
Primary power cable
EMG / Mode selector
switch box
Earth leakage breaker /
Safety extension unit power supply box
LAN cable
Safety extension unit
24VDC power supply
Earth leakage breaker
Ethernet hub
ACIN cable
Robot controller
CR800-05VD
LAN cable
Computer/Tablet
RIO cable
(for the Safety extension unit)
LAN cable
RT VisualBox
(Option)
: Included with the Easy-setup kit
: Connect when using a vision sensor

4.2 Vision sensor

When picking and placing workpieces, there are times when workpieces cannot be grasped properly if they are not in a fixed position. Using a vision sensor allows the robot to utilize image data to automatically adjust its grasp position and angle. This allows the robot to transport multiple workpieces consecutively.

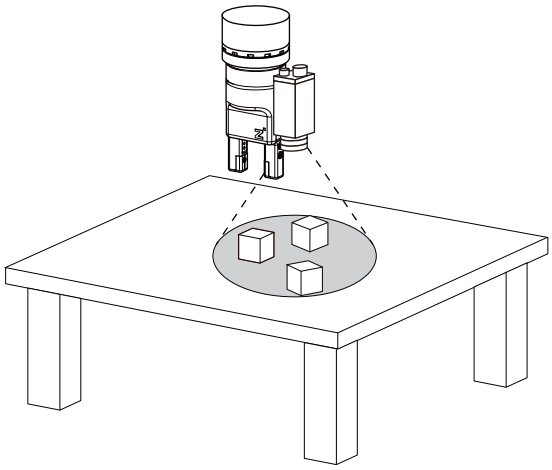
●Without a vision sensor

The robot can only move to a taught position.



●With a vision sensor

The vision sensor can identify workpieces within its field of view (FOV), so even if the position of workpiece is different to the taught pick-up point, the robot can automatically adjust its grasp position accordingly.



Supported vision sensors

RT VisualBox supports the following vision sensors. (As of April 2020)

Item	Description
Model	VS80M-202, VS80M-202-R (Manufactured by Mitsubishi Electric)*1*2 In-Sight 8402M-363-50, In-Sight 8402M-373-50 (Manufactured by Cognex)*2
Installation type	Installed on the robot hand bracket.

*1 Only available in Japan.

*2 Meets PoE Class 2 standards (6.49 W max.).
PoE is technology that allows an Ethernet cable to send both data and power to devices.

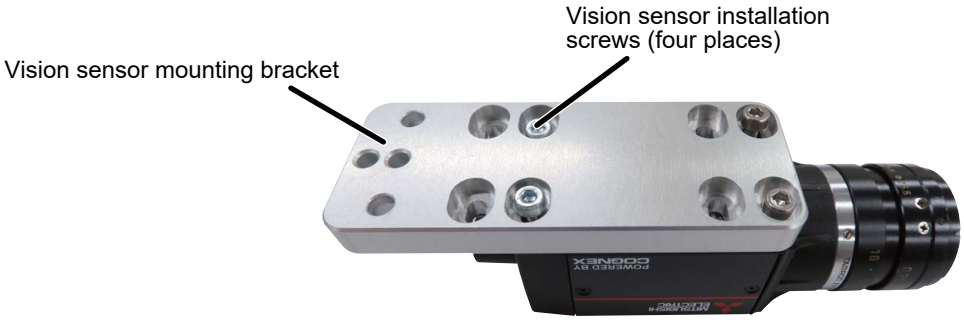
4.3 Installation procedure

The following equipment is required.

Item	Quantity	Item	Quantity
Scissors	1	Cable ties	2
Hexagon wrench	1	PoE adapter (CPS-AC-POE1A-JP manufactured by Cognex)	1
Vision sensor (VS80M-202 manufactured by Mitsubishi Electric)	1	Ethernet hub (100BASE-TX)	1
Vision sensor installation screw (M3 × 6)	4	C-mount lens (8 mm)	1
Vision sensor mounting bracket (1F-ASSISTA-2DVSFLG manufactured by Mitsubishi Electric)	1	Ethernet cable (100BASE-TX)	1
Vision sensor mounting bracket installation screw (M4 × 12)	2	PoE Ethernet cable (CCB-84901-2001-# manufactured by Cognex)	1
Vision sensor positioning pin	2	—	—

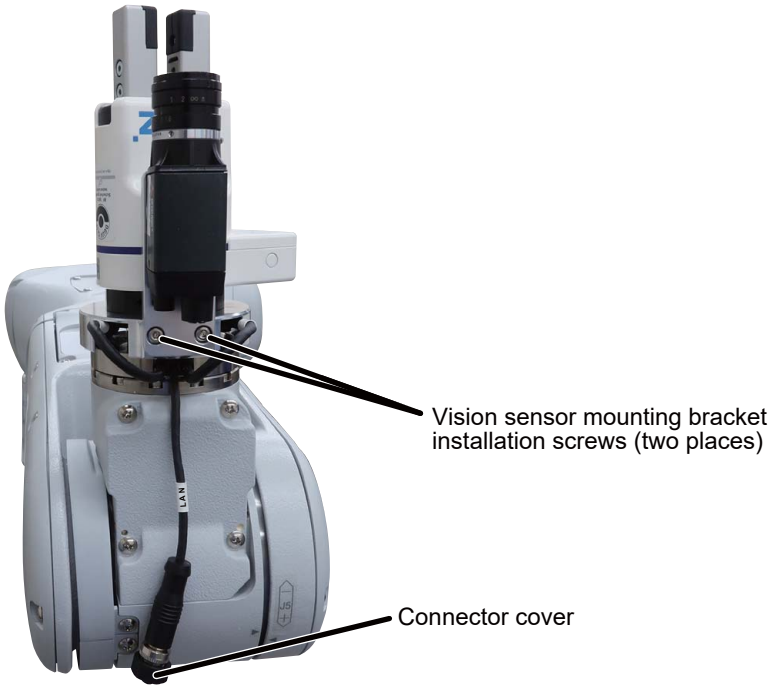
1. Ensure that the robot and peripheral devices are powered off. Check that the Status indicator LED has turned off. Turn the C-mount lens clockwise to attach it to the vision sensor.

2. Attach the vision sensor to the bracket using the vision sensor mounting bracket installation screws (four places).



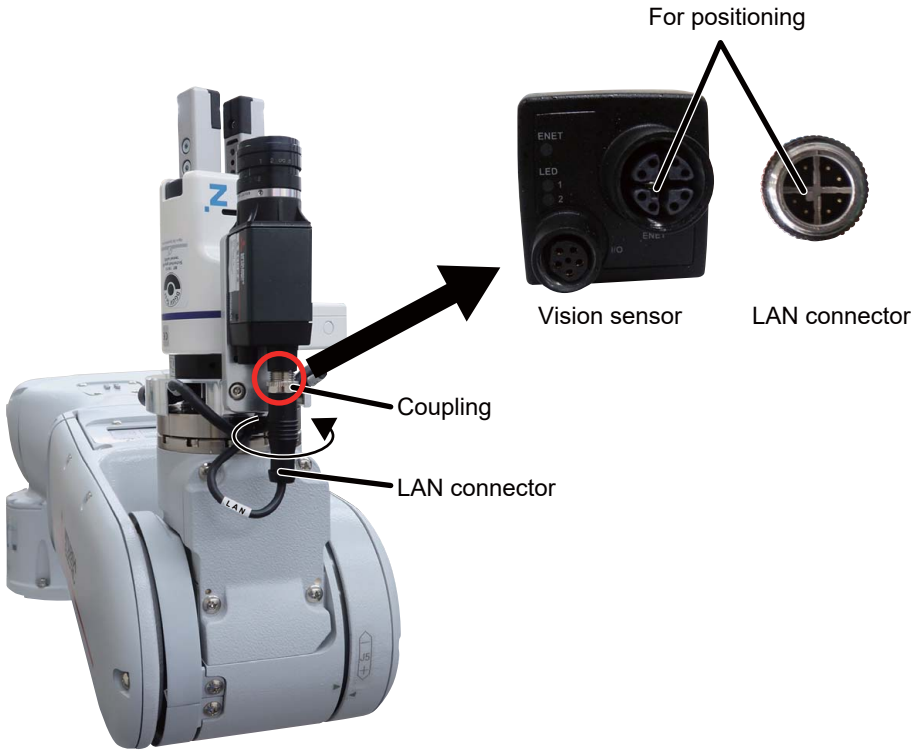
3. Insert the vision sensor positioning pins into the alignment holes on the vision sensor mounting bracket.

4. Fix the vision sensor to the hand bracket using the vision sensor mounting bracket installation screws (two places).



5. Remove the cover from the LAN connector. Line up both the LAN connector and vision sensor connector before connecting them. Then, tighten the LAN connector coupling by turning it clockwise.

Keep the LAN connector cover in a safe place.

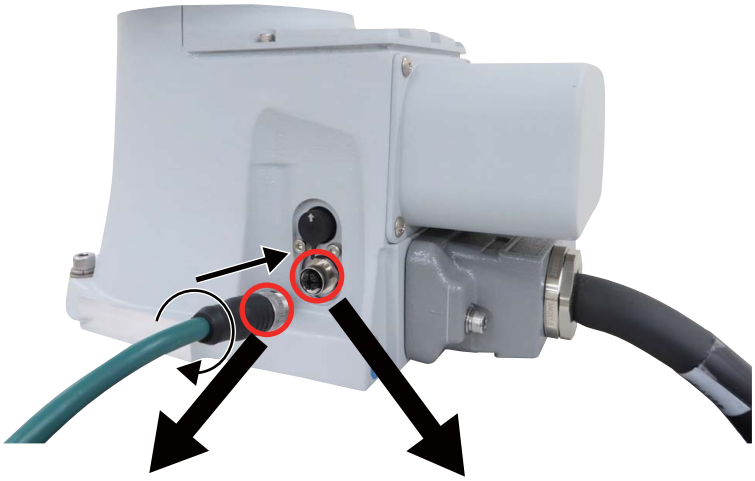


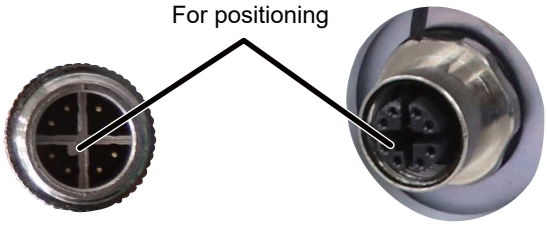
6. Secure the LAN cable to the LAN connector, and the HND cable to the LAN cable using cable ties. Use another cable tie to secure the FS cable in place.

Ensure that the LAN cable does not come into contact with the robot arm.

7. Connect the PoE Ethernet cable to the Ethernet receptacle on the robot.

Line up the keys of both the PoE Ethernet cable connector and the Ethernet receptacle before connecting them. Then, tighten the PoE Ethernet cable coupling by turning it clockwise.





PoE Ethernet cable (PoE)

Receptacle on the robot

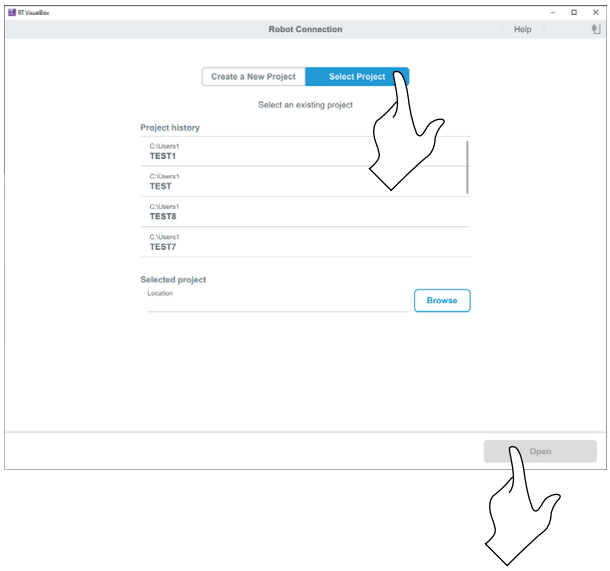
8. Connect the other end of the PoE Ethernet cable to the PoE adapter OUT port.

9. Connect the Ethernet hub using an Ethernet cable via the PoE adapter IN port.

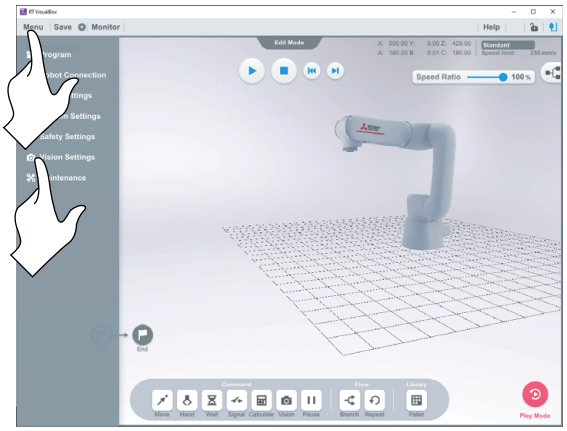
10. Connect the power cable to the PoE adapter.

4.4 Communication settings

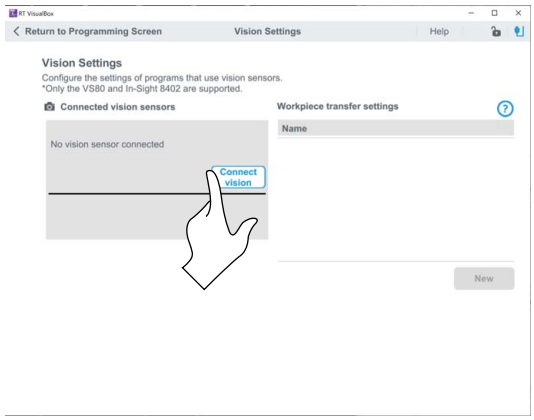
Operating procedure



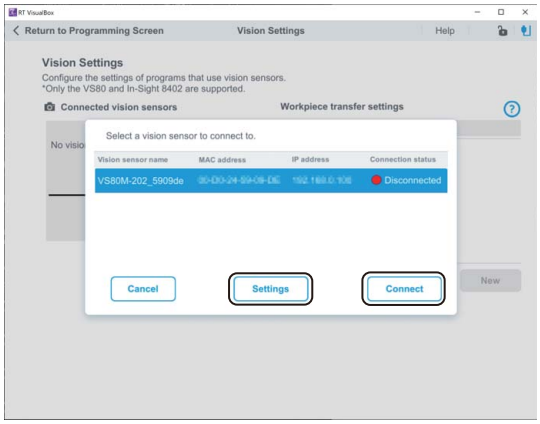
1. Connect the computer and robot controller to an Ethernet hub.
2. Start RT VisualBox, then tap/click [Select Project].
3. Select the project that was created in exercise 1, then tap/click [Open].



4. Tap/click the [Menu] tab on the menu bar.
5. Tap/click [Vision Settings] to display the Vision Settings screen.

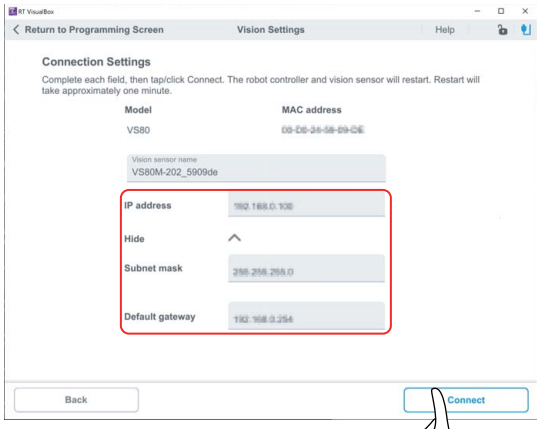


6. Tap/click [Vision connection].

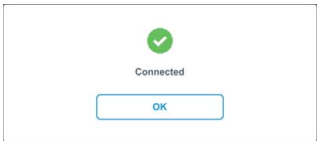


7. When connecting a vision sensor for the first time or if the connection fails, tap/click the [Settings] button.

For all other situations, select the vision sensor you want to connect and tap/click the [Connect] button.



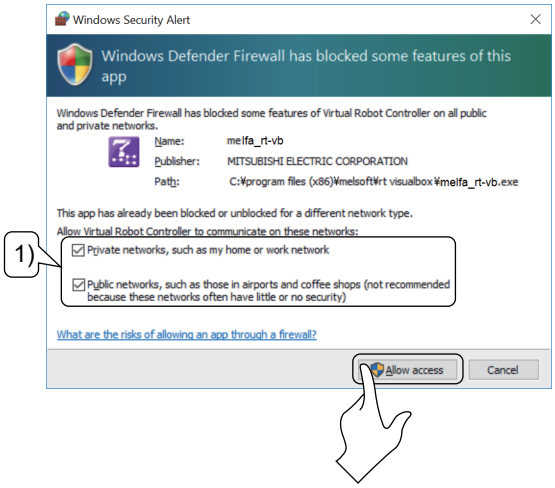
8. If settings need to be configured, enter the network settings then tap/click the [Connect] button. Once the settings have been configured, the robot controller and vision sensor will automatically restart.



9. Wait for a while until connection between the robot and vision sensor is established.

If blocked by a firewall

1. If the following window appears, select the two check boxes indicated by number 1, then tap/click the [Allow access] button.



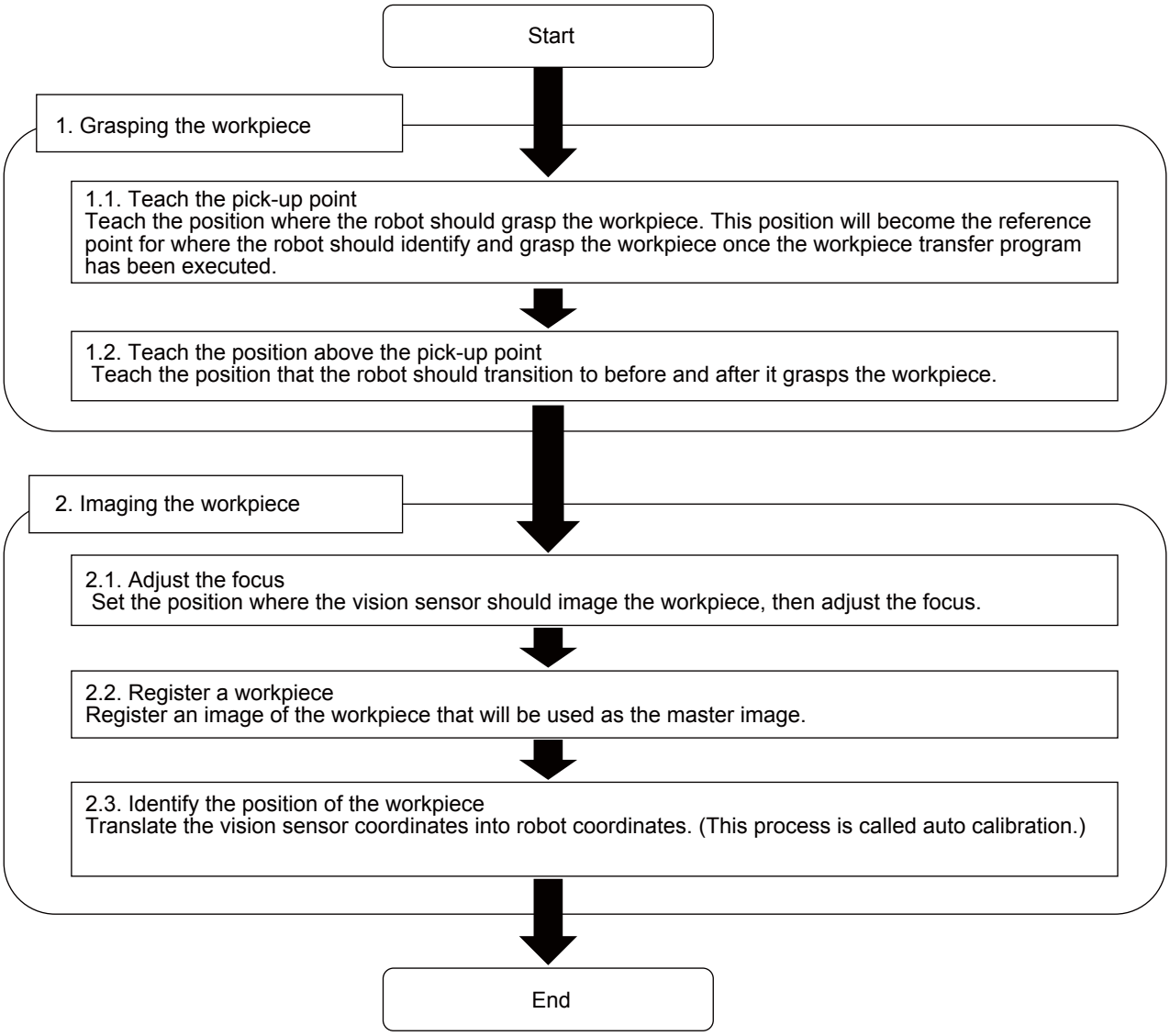
2. tap/click the [OK] button.

4.5 Vision settings, autocalibration

In this section we will configure the workpiece transfer program used for the vision sensor.
If the robot attempts to pick up a workpiece from a position specified by the Move block, it may not be able to grasp the workpiece properly if the workpiece has deviated from that position. However, once these settings have been configured, the robot will be able to utilize vision sensor image data to automatically adjust its grasp position.

Registering workpiece transfer settings

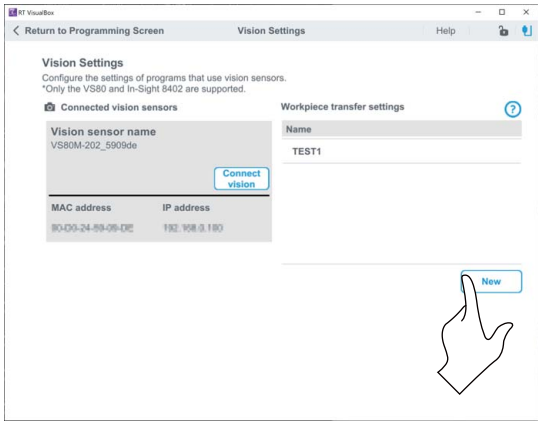
Follow the process below to configure the workpiece transfer settings. Configure these settings while the vision is connected to the computer and robot.



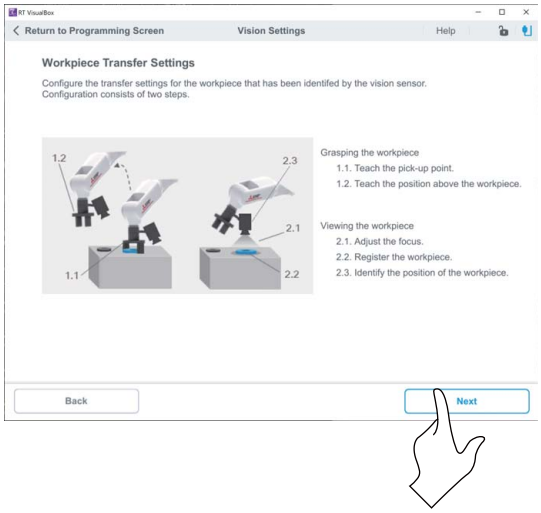
⚠ CAUTION

Ensure that the vision sensor connection cable does not come into contact with the robot arm while the robot is operating.

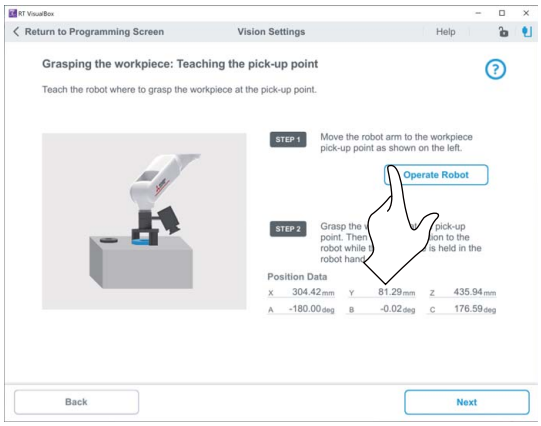
Operating procedure



1. Tap/click [New] under [Workpiece transfer settings].

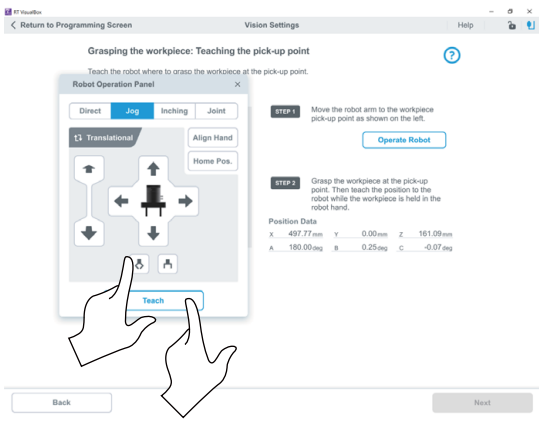


2. The workpiece transfer settings process will appear. Tap/click [Next].

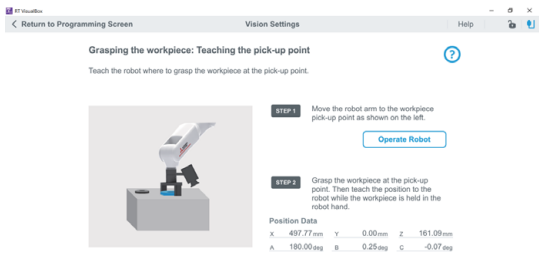


Teach the position where the robot should grasp the workpiece. This position will become the reference point used for adjusting the robot's grasp position during operation of the program that was created with the workpiece transfer settings.

3. Tap/click the [Operate Robot] button to display the Robot Operation panel.

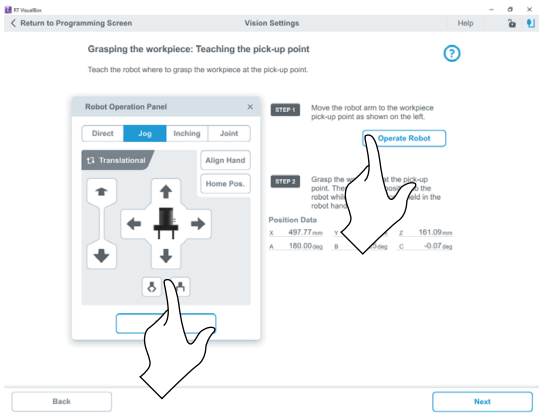


4. Move the robot to the position where it will grasp the workpiece. Grasp the workpiece and then tap/click [Teach] in the Robot Operation panel.

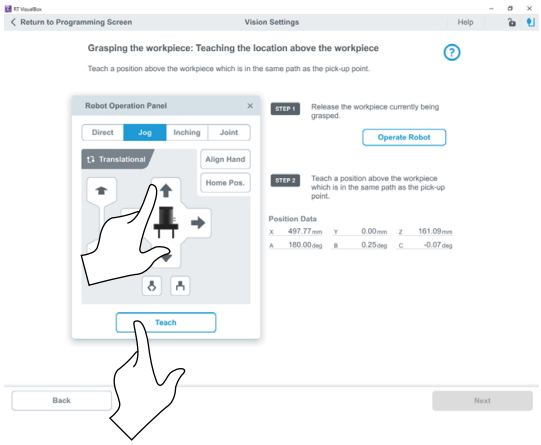


5. Check that the current position appears in the Position Data fields, then tap/click [Next].

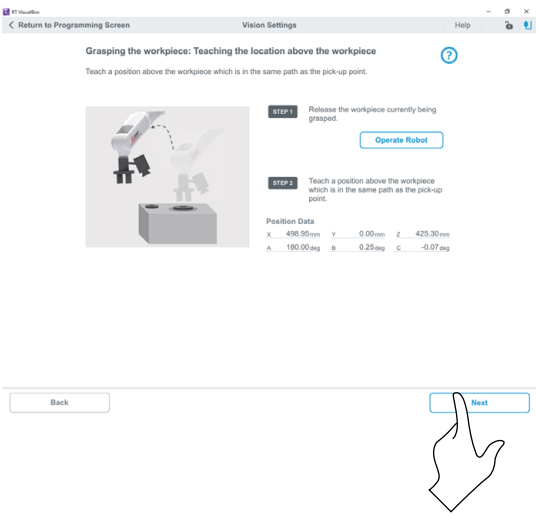
Teach the position above the pick-up point.



6. Tap/click [Operate Robot] and release the workpiece.



7. Move the robot arm to a position above the workpiece, then tap/click the [Teach] button in the Robot Operation panel. This position will become the via point.

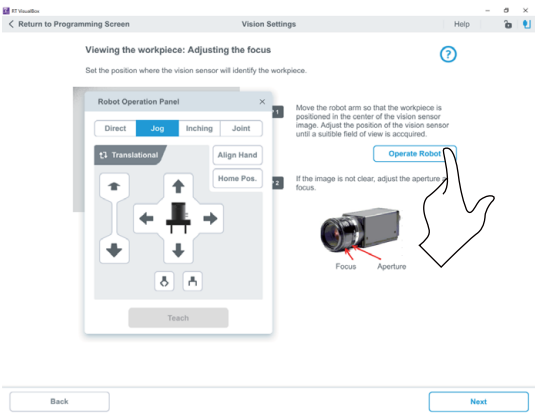


8. Check that the current position appears in the Position Data fields, then tap/click [Next].

This position will be the position the robot diverts to before and after it grasps the workpiece. If a position far away from the workpiece is taught, there is a possibility that the robot will collide with other objects. It may also become impossible for the robot to grasp the workpiece.

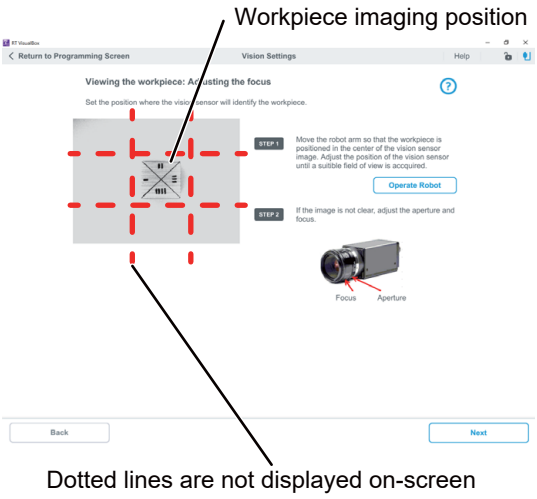
⚠CAUTION

After releasing the workpiece in Step 6, do not move the workpiece until it has been registered as instructed in Step 18. Doing so may lower recognition accuracy.



Move the robot arm to a position where the vision sensor can recognize the workpiece.

9. Tap/click the [Operate Robot] button to display the Robot Operation panel.



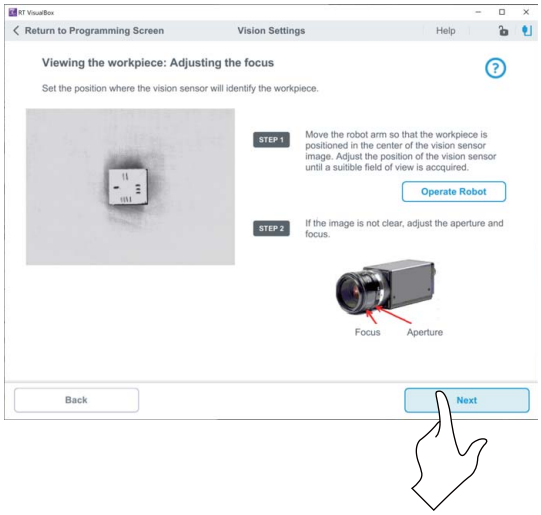
10. While looking at the image displayed by the vision sensor, move the robot so that the workpiece is in the center of the image and fits within the frame.

Set the workpiece display position so that the workpiece fits within the dashed red lines.

If not, the workpiece may not be recognized correctly at auto calibration in the next step.

Point

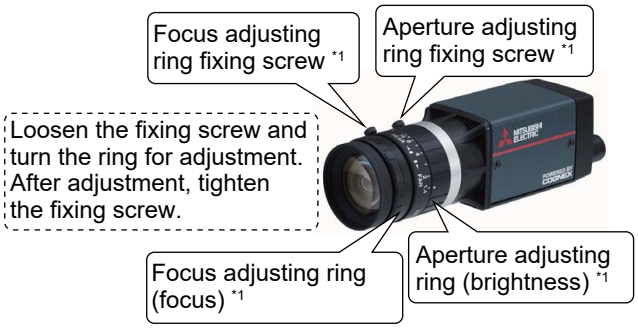
- Placing the workpiece on a plain surface will make registering a workpiece easier.

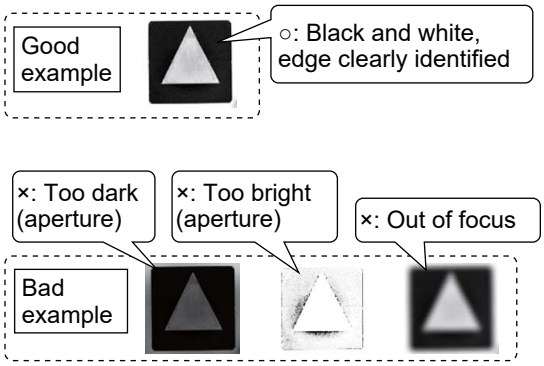


11. If the image is not clear, adjust the aperture and focus of the vision sensor installed on the robot arm.

Refer to the screen on the left for the aperture and focus adjustment points of the vision sensor.

12. After making the necessary adjustments, tap/click [Next].

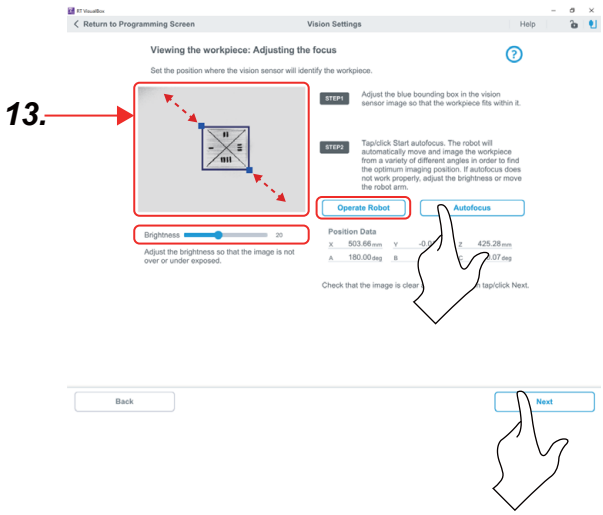




*1 The positions of the aperture and focus adjustment ring, depend on the lens used. Check your lens.

⚠ CAUTION

At this stage, the vision sensor's field of view has been determined. If the workpiece pick-up point will change during automatic operation, ensure that the vision sensor's field of view is large enough to encompass all the pick-up points.



Use autofocus to have the robot move to an optimal focal position.

13. Adjust the blue bounding box in the vision sensor image so that the workpiece fits within it.

14. Tap/click the [Autofocus] button.

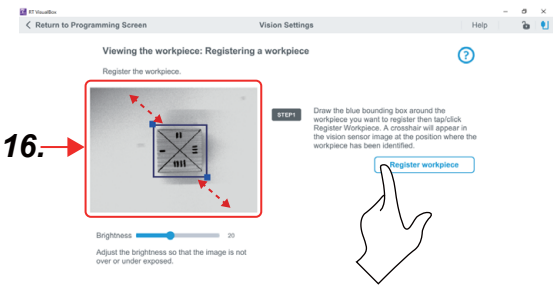
15. If autofocus is successful, the robot stops and the position data is updated. Tap/click [Next].

If autofocus fails, perform the following operations.

- When the workpiece is bright or dark: Adjust the brightness with the aperture of the vision sensor so that the workpiece appears clearly.
- When the workpiece is not centered: Tap/click the [Operate Robot] button to display the Robot Operation panel. Operate the robot so that the workpiece is centered.

⚠ CAUTION

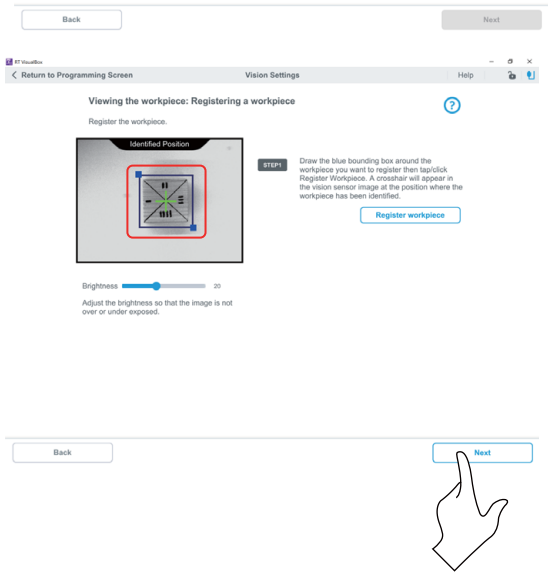
The robot moves during autofocus. Be sure to place an emergency stop switch nearby so that the robot can be stopped immediately.



Register the workpiece.

16. Adjust the blue bounding box in the vision sensor image so that the workpiece fits within it.

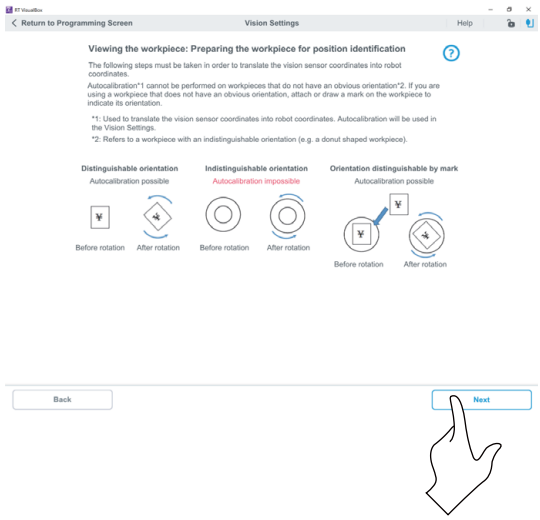
17. Tap/click [Register workpiece].



18. A crosshair will appear in the center of the workpiece. Tap/click [Next].

⚠ CAUTION

- This registered image will become the master image. Adjust the brightness to achieve the greatest possible clarity.
- Only one type of workpiece can be registered per set of workpiece transfer settings. To register a different type of workpiece, create a new set of workpiece transfer settings.



19. Precautions regarding workpiece orientation that should be noted when using autocalibration will appear. Follow the on-screen instructions and check if autocalibration is possible with the workpiece you are using.

Tap/click [Next].

Point

Autocalibration is a function that translates the vision sensor coordinates into robot coordinates. It allows the robot to distinguish its position in relation to positions in the image captured by the vision sensor.

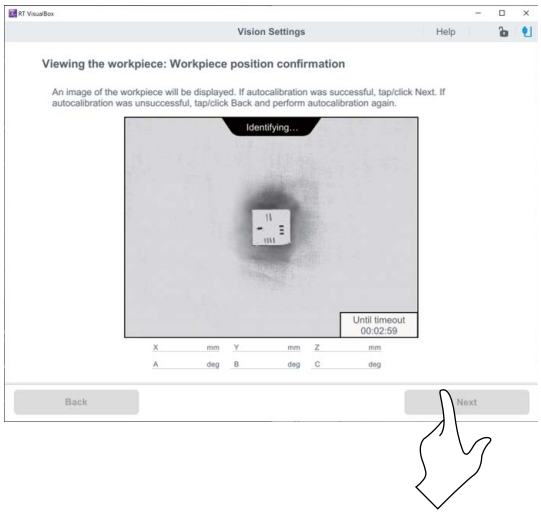
Execute autocalibration.
During autocalibration, the robot will move 100 mm in the forward, back, left, and right directions.

20. Draw a mark indicating the orientation of the workpiece if the workpiece does not have a feature that helps determine its orientation.

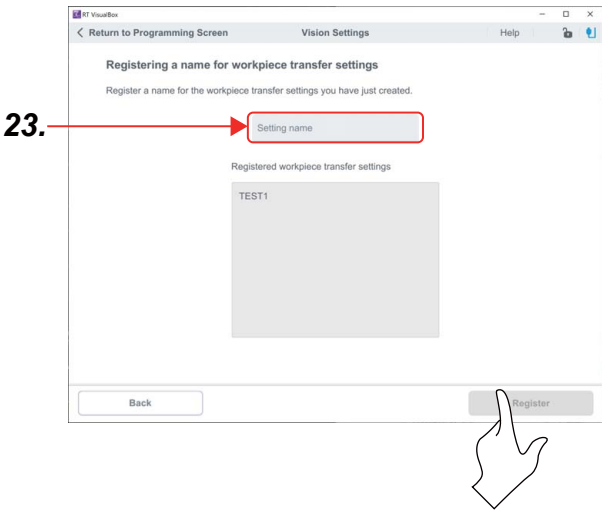
21. Draw the blue bounding box around the workpiece, then tap/click [Start Autocalibration].

⚠ CAUTION

The robot operates during autocalibration. Be sure to place an emergency stop switch nearby so that the robot can be stopped immediately.



22. Check the autocalibration result.
During autocalibration, an image will be displayed every time an image is captured.
If autocalibration is successful, the robot stops and the workpiece position data is updated. Tap/click [Next].
If autocalibration fails, return to Step 19. Refer to the following page and restart autocalibration.
☞ Page 140 If autocalibration fails



Decide on a name for the workpiece transfer settings.

23. Enter a name.

24. Tap/click the [Register] button.

If autocalibration fails

If autocalibration fails, tap/click [Move to Imaging Position] and check the points below after the robot has moved back to the position it was in before autocalibration.

No.	Check item	Solution
1	Are you trying to perform autocalibration on a workpiece that has an indistinguishable orientation?	Refer to the following page: ☞ Page 140 Solution to No.1
2	Is the workpiece within the vision sensor's FOV during calibration?	Refer to the following page: ☞ Page 140 Solution to No.2
3	Has error L2602 (DSTN pos. exceeds the limit) occurred?	Refer to the following page: ☞ Page 141 Solution to No.3
4	Has the robot arm come into contact with a surrounding object or become entangled with a cable during calibration?	Refer to the following page: ☞ Page 141 Solution to No.4
5	Did the software time-out before calibration finished?	Refer to the following page: ☞ Page 141 Solution to No.5
6	Was the workpiece within the blue bounding box before calibration started?	Refer to the following page: ☞ Page 141 Solution to No.6
7	Is the allowable error during calibration too small?	Refer to the following page: ☞ Page 141 Solution to No.7

■Solution to No.1

Go back to Step 19 and make sure that a mark has been put on the workpiece to indicate its orientation. Then perform auto calibration again.

■Solution to No.2

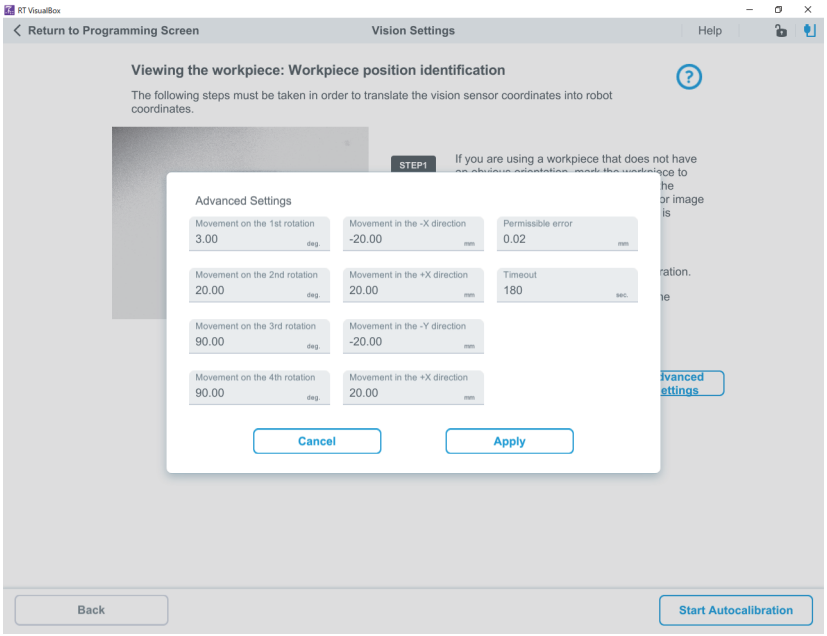
There are three solutions to this problem.

1. Place the workpiece in the center of the vision sensor's FOV, then start autocalibration. If the workpiece is not placed in the center of the vision sensor's FOV, it may leave the vision sensor's FOV altogether while the robot arm is moving during calibration.

2. Go to [Advanced Settings] and adjust the values of each movement stated below so that the workpiece is within the vision sensor's FOV.

- Rotational movement
- Movement in the X axis
- Movement in the Y axis

3. If none of the steps above resolve the problem, re-teach the pick-up point and try autocalibration again. Move the vision sensor back from the workpiece so that the workpiece occupies less space within the vision sensor's FOV.



■Solution to No.3

There are two solutions to this problem.

1. Go to [Advanced Settings] and adjust the values of each movement stated below to change the distance the arm is allowed to move during calibration.

- Rotational movement
- Movement in the X axis
- Movement in the Y axis

Inverting the direction of rotation is acceptable when adjusting the values for rotational movement.

2. If the above step does not resolve the problem, change the posture of the robot and configure the vision sensor settings from the start again.

■Solution to No.4

There are two solutions to this problem.

1. Go to [Advanced Settings] and adjust the value of the movement stated below. Change the distance the arm is allowed to move so that it does not interfere with surrounding objects or become entangled in cables, etc.

- Rotational movement

In order to improve accuracy, ensure that rotational movement increases in progressively larger degrees of movement as stated below:

1st rotation < 2nd rotation < 3rd rotation ≤ 4th rotation

2. Go to [Advanced Settings] and adjust the values of each movement stated below. Change the distance the arm is allowed to move so that it does not interfere with surrounding objects or become entangled in cables, etc.

- Movement in the X axis
- Movement in the Y axis

■Solution to No.5

There are two solutions to this problem.

1. The speed of the movement may be too slow. Increase the speed of the movement or increase the Time out time in [Advanced Settings].

2. The robot may have stopped due to the position limiting settings. Go to [Advanced Settings] and adjust the values of each movement stated below to change how much the robot moves during calibration.

- Rotational movement
- Movement in the X axis
- Movement in the Y axis

■Solution to No.6

Draw the blue bounding box around the workpiece, then start auto calibration.

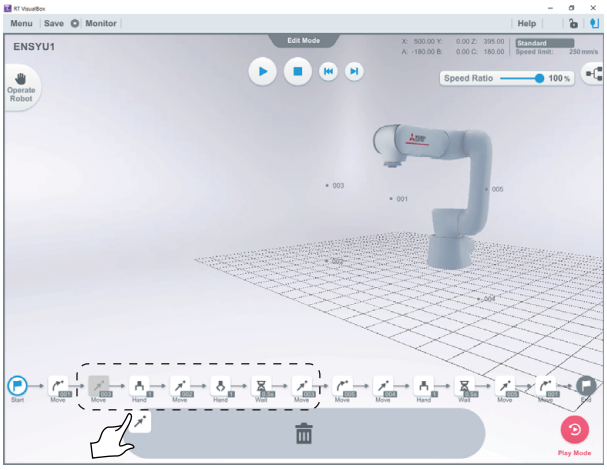
■Solution to No.7

Go to [Advanced Settings] and increase the permissible error in 0.01 increments, then perform autocalibration. "Permissible error" refers to the amount of error that is permissible between the resultant position and the target position.

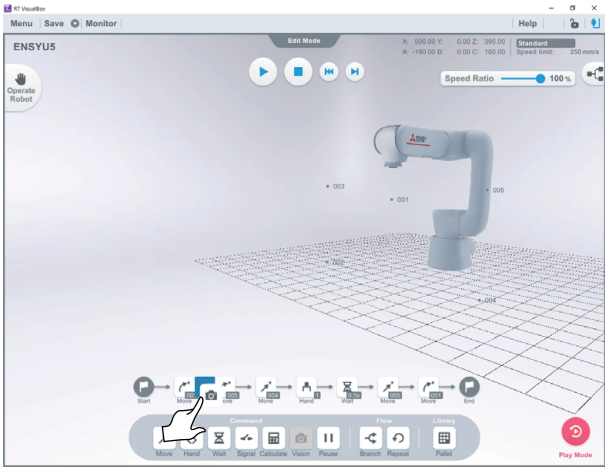
4.6 Programming with RT VisualBox (Exercise 5)

This section explains how to create and edit robot programs that incorporate a vision sensor.
This program will be created based on the program created in Exercise 1.

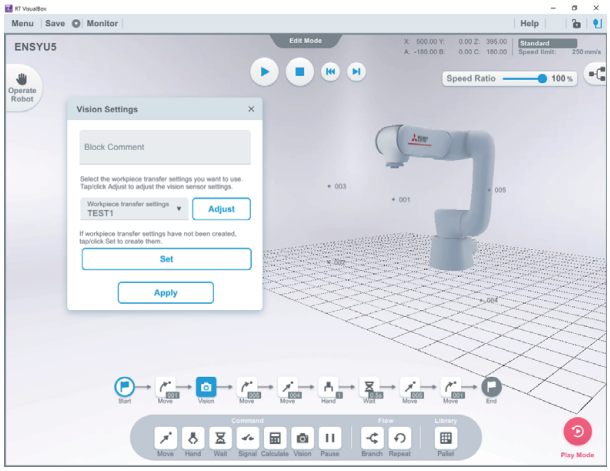
Operating procedure



1. Drag the program blocks within the dotted lines downwards and drop them into the trash can.



2. Drag and drop a [Vision] block in place of the program blocks that were deleted in step 1.



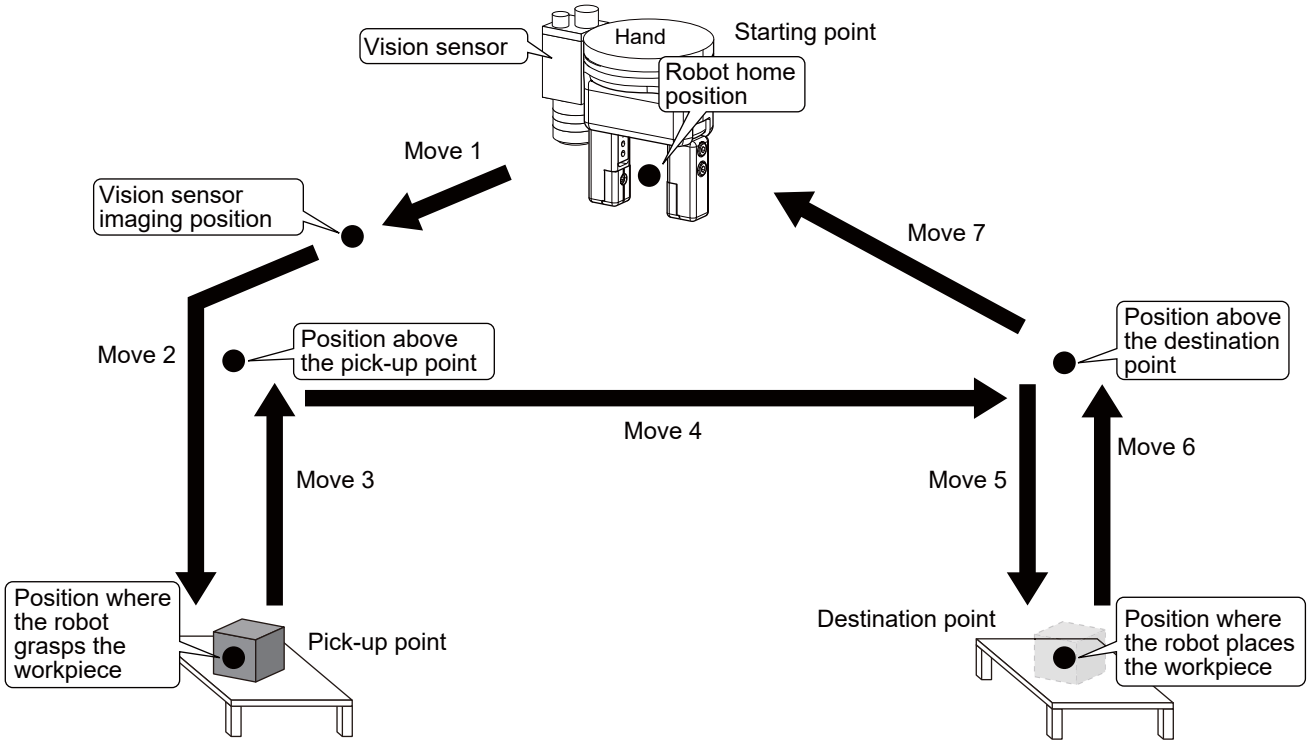
3. Tap/click the [Vision] block placed in the program in step 2.

4. Select the workpiece transfer settings you would like to use from the drop down list.

5. Then, tap/click the [Apply] button.

4.7 Program verification (step operation)

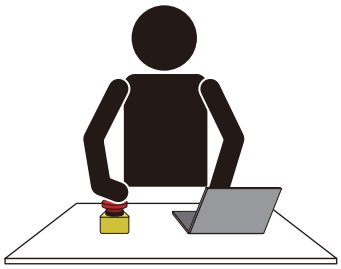
Check that there are no obstacles, such as tools, within the operating range of the robot before performing step operation.
The robot will operate as illustrated in the figure below.



Point

If the vision sensor cannot recognize the workpiece when it is at the imaging position, the [Vision] block program will be skipped. Tapping/clicking the [Step forward] button will move the robot to the position above the destination point.
If the workpiece can be identified, the value "1" will be stored in "M_VSFoundNum". If the workpiece cannot be identified, the value "0" will be stored in "M_VSFoundNum". When setting identification conditions, set them in the variable "M_VSFoundNum" found in the [Branch] block. Also create the operations that will occur depending on the identification result.
☞ Page 53 Branch block

⚠CAUTION



Before performing step operation, be sure to place an emergency stop switch nearby so that the robot can be stopped immediately.
The robot may move faster than expected during step operation.
To reduce the speed of the robot, set the Speed Ratio to less than 100%.

For further information on operation steps, refer to the following page:
☞ Page 103 Program verification (step operation)

4.8 Automatic operation

Execute one cycle of the program or run the program repeatedly.

Take the following precautions when running the program continuously.

- Ensure that there are no workpieces at the destination point. Ensure that the fingers of the robot hand do not interfere with workpieces.
- When transferring multiple workpieces, ensure that there is ample space for the fingers of the robot hand to access each workpiece.

For further information, refer to the following page:

☞ Page 105 Automatic operation

4.9 Exercise

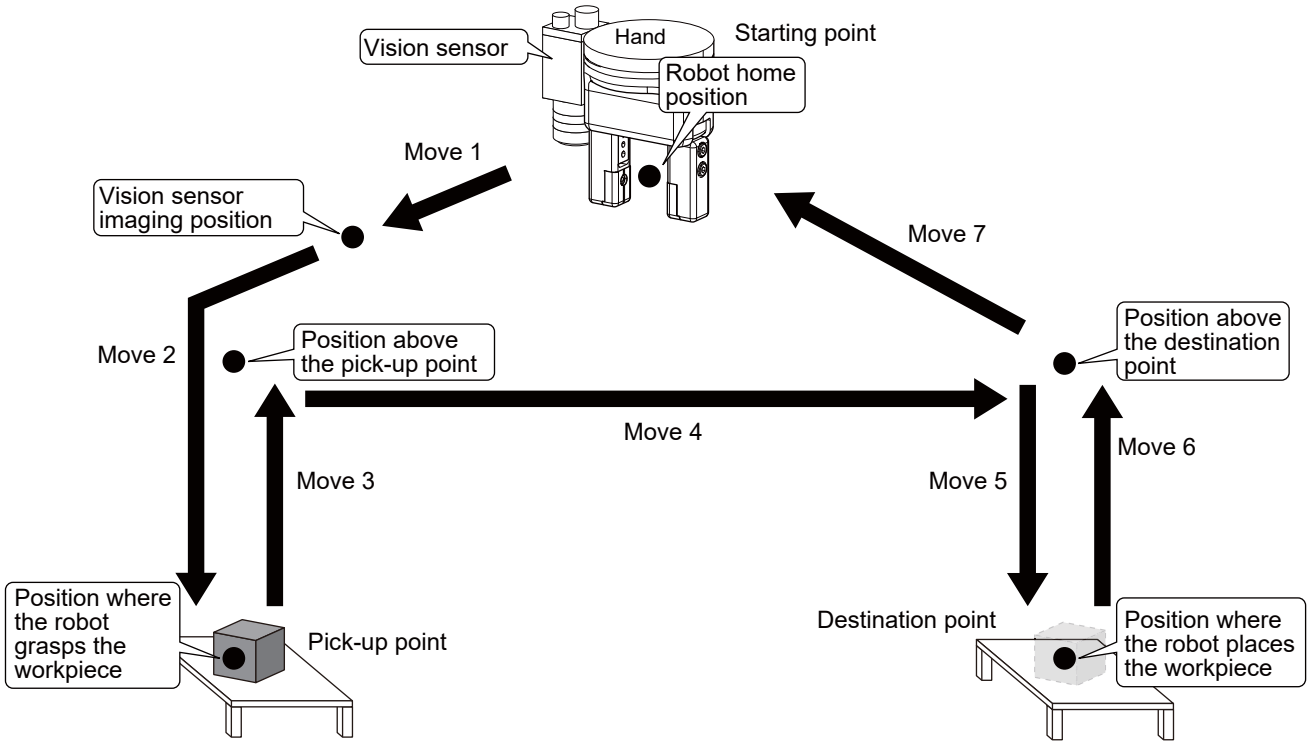
Pick-up and placement with a vision sensor

Exercise 5

Move the workpiece from the pick-up point to the destination point using the vision sensor.

The contents are the same as those in the following section.

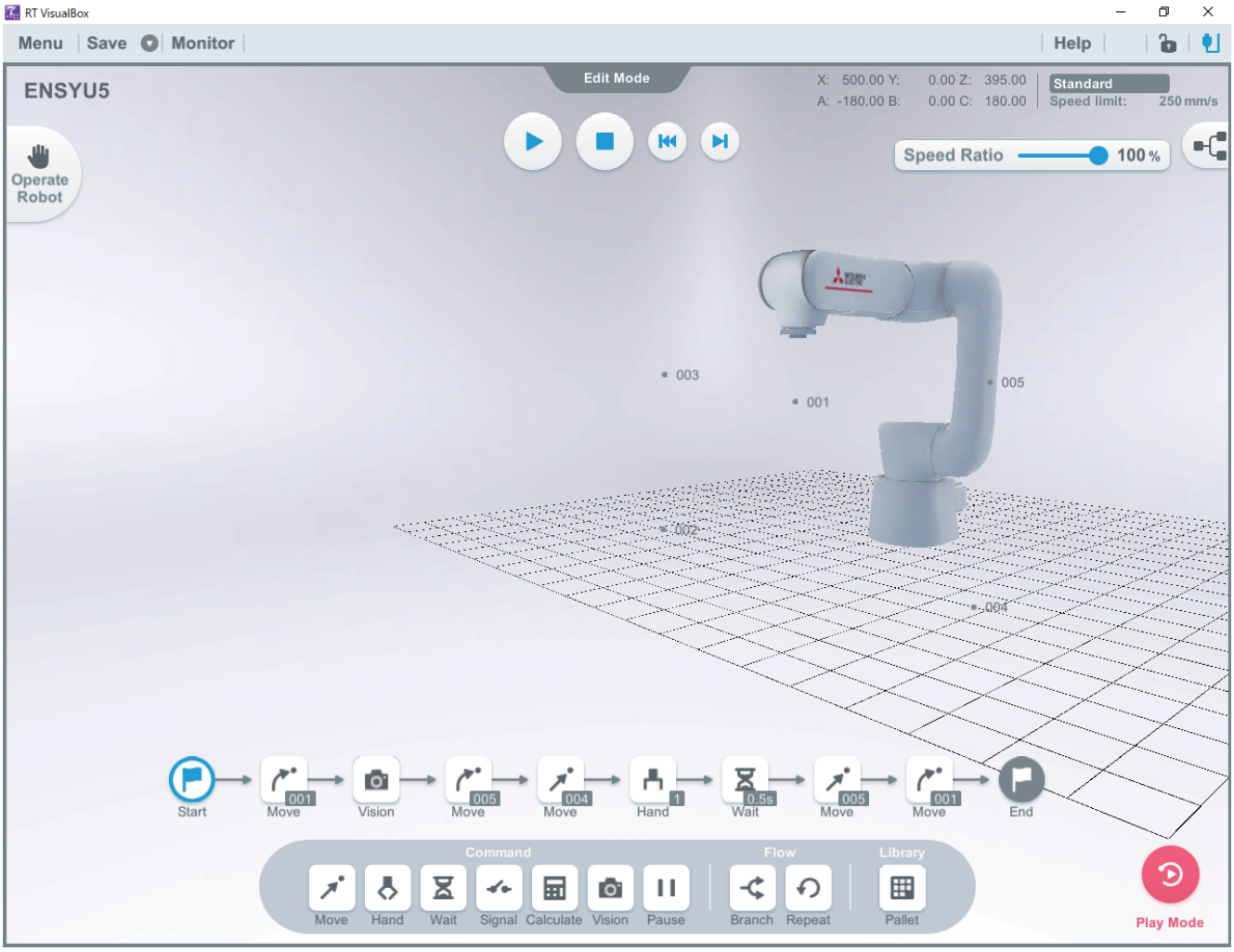
☞ Page 142 Programming with RT VisualBox (Exercise 5)

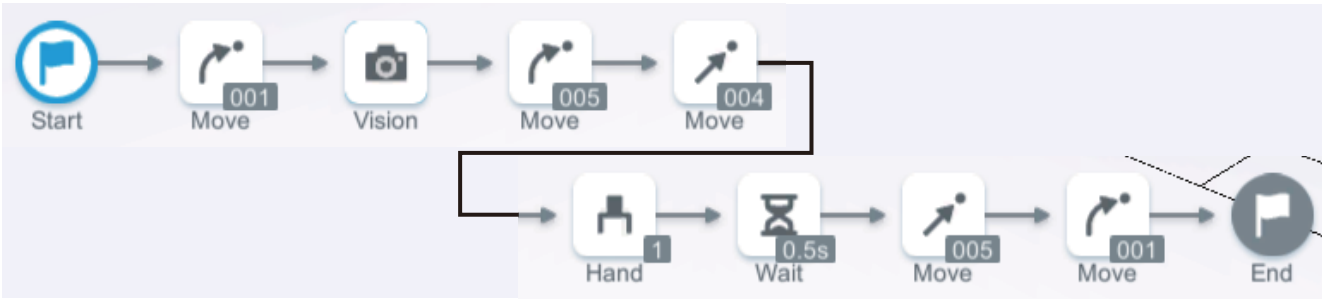


Exercise 5: Sample answer

The contents are the same as those in the following section.

☞ Page 142 Programming with RT VisualBox (Exercise 5)





Condition judgment

Exercise 6

Transfer the workpiece from the pick-up point to the destination point using the vision sensor.

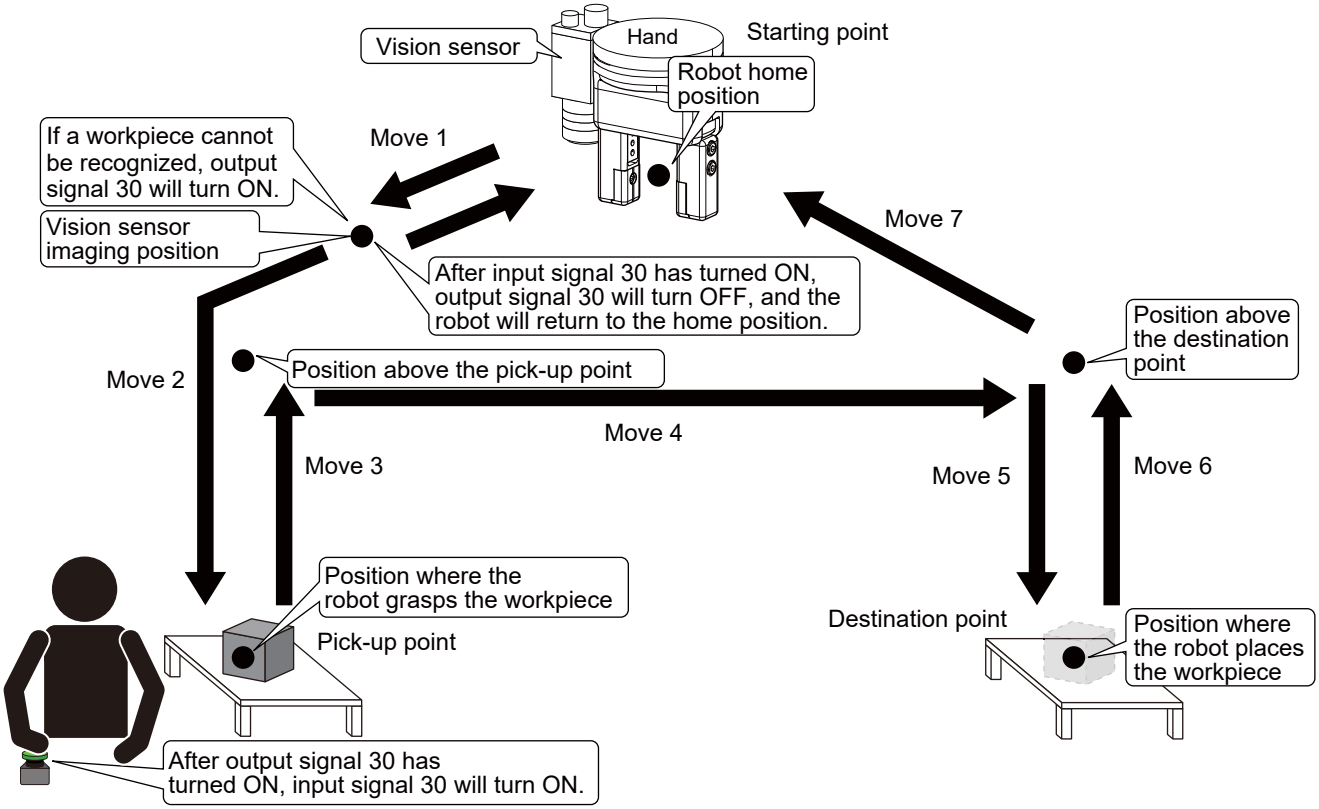
If the vision sensor recognizes the workpiece, the robot transfers the workpiece to the destination point.

If the vision sensor fails to recognize the workpiece, turn on output signal 30.

When input signal 30 turns on, turn off output signal 30 to move the robot to the home position.

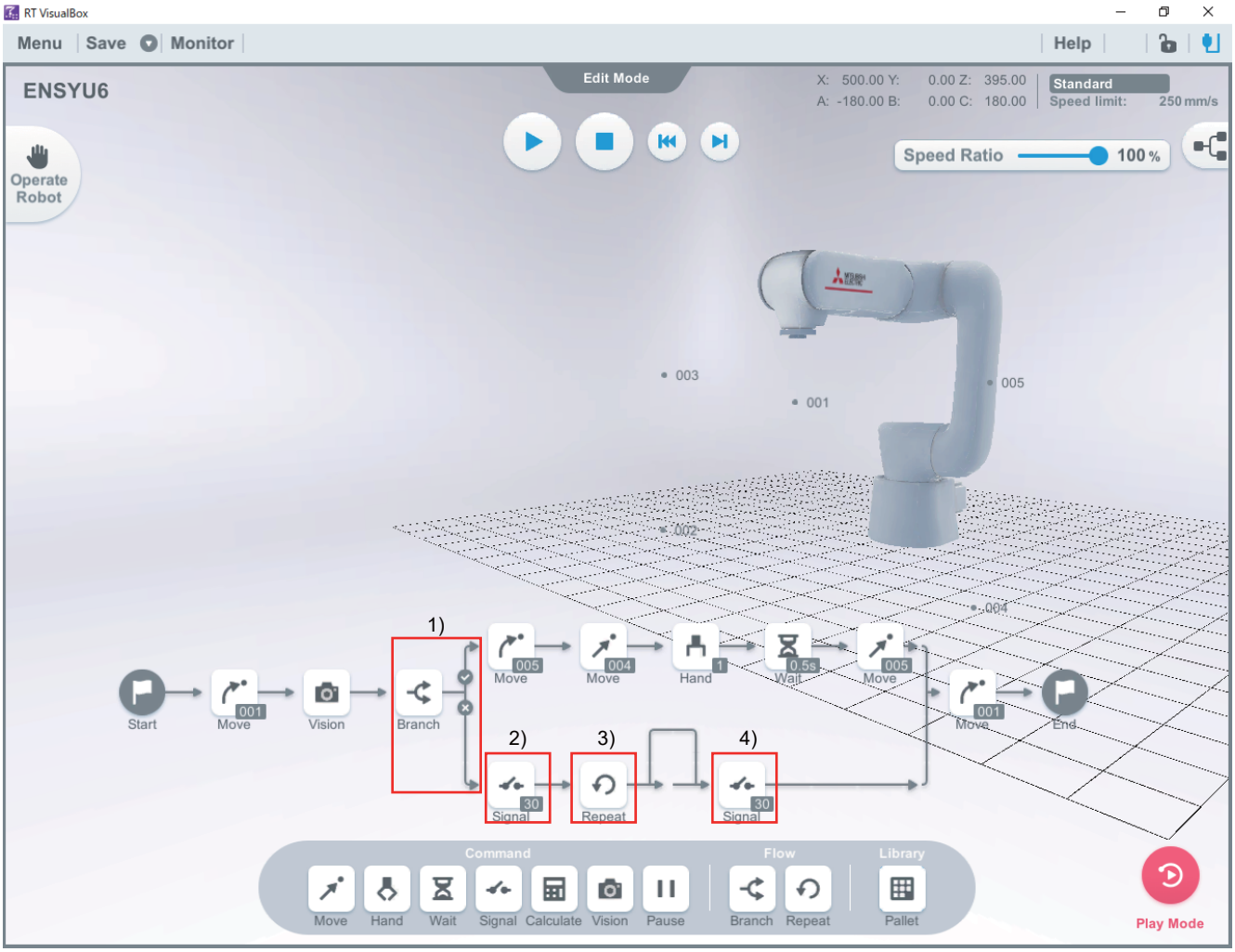
■Condition

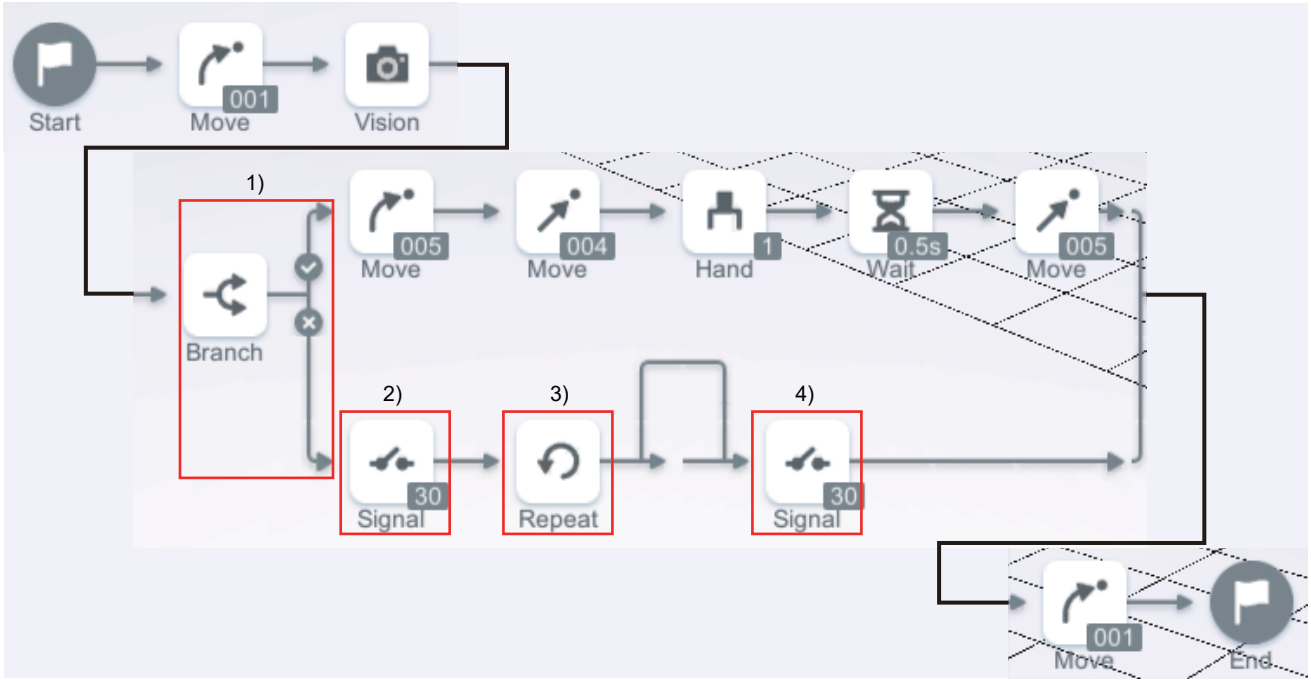
- Create a program using the program created in exercise 5.
- Set the same workpiece pick-up point and destination point as those of exercise 5.
- Use the same workpiece transfer settings as those of exercise 5.
- Input/output signal: 30
- Hand open/close wait time: 0.5 seconds



Exercise 6: Sample answer

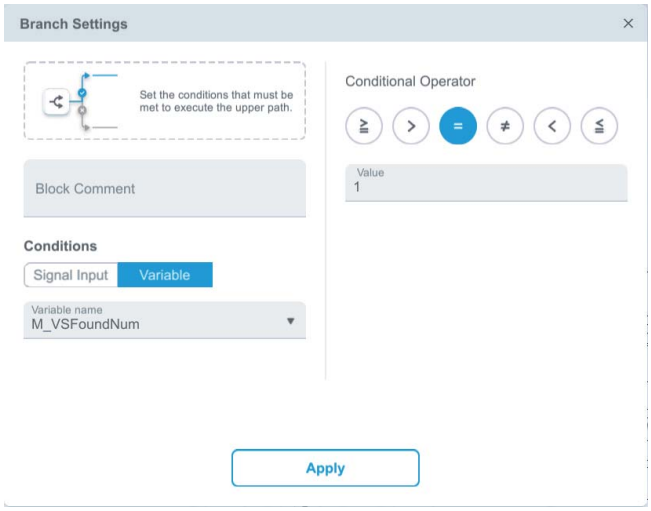
Add program blocks 1) to 4) to the program created in exercise 6.





■1) Branch block

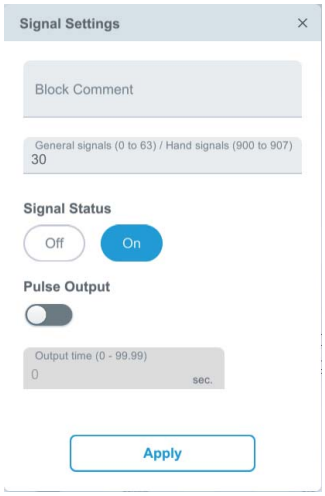
Determine whether a workpiece is at the pick-up point.



• Conditions: Variable
Set a variable for the branch condition.
• Variable name: M_VSFoundNum
Set the variable to M_VSFoundNum.
• Conditional Operator: =
If the value of the variable is the same as the value of "Value", the upper path is executed.
• Value: 1

■2) Signal block

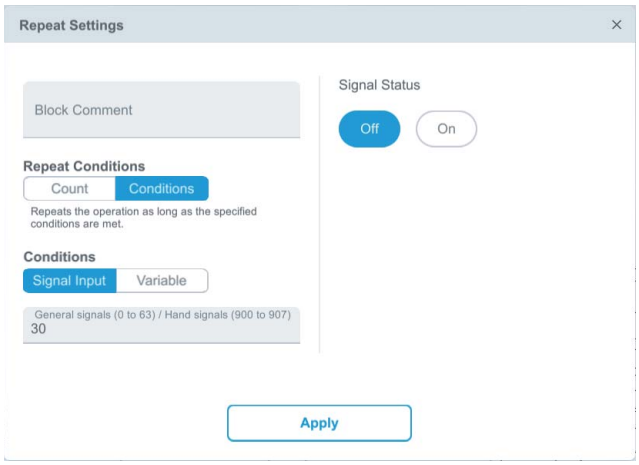
Turns on output signal 30.



• General-purpose signal: 30
Set the output signal number to 30.
• Signal status: On
Turn on the specified output signal.
• Pulse output: Disabled
Outputs output signals as a level.

■3) Repeat block

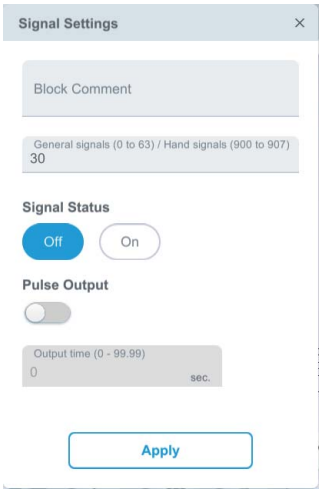
The robot waits until input signal 30 turns ON.



• Repeat Conditions: Conditions
Repeats the operation as long as the specified conditions are met.
• Conditions: Signal Input
The status of the specified input signal is used as the condition.
• General-purpose signal: 30
Set the input signal number to 30.
• Signal status: Off
If the signal is Off, the operation is repeated.

■4) Signal block

Turns off output signal 30.



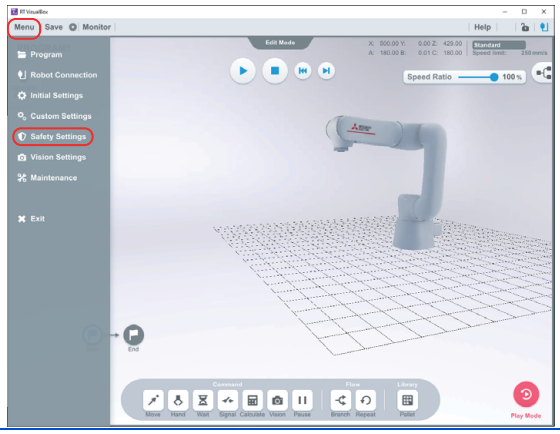
• General-purpose signal: 30
Set the output signal number to 30.
• Signal status: Off
If the signal is Off, the operation is repeated.

5 Setting safety conditions using RT VisualBox

This chapter explains how to configure safety settings.

Safety Settings Screen

Tapping/clicking [Menu] → [Safety Settings] on the menu bar displays the Safety Settings screen.



⚠CAUTION

These settings greatly affect the safety of the robot. Read the following precautions and document thoroughly before configuring safety settings. Take precautions as necessary.

☞ Page 6 Precautions when using collaborative robots (risk assessment)

📖Collaborative Robot Safety Manual (BFP-A3733)

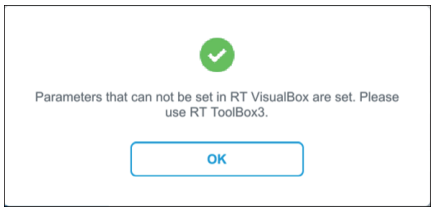
The following settings can be configured on the Safety Settings screen.

Setting	Description
Speed limiting	These setting are used to set the maximum speed and low-speed space for each operation type.
Safety I/O	These setting are used to assign safety inputs and safety outputs.
Position limiting	These settings are used to set the areas where the robot cannot enter.
Monitoring model	These settings are used to set the areas to be monitored.
Change Password	This setting is used to change the password for the safety settings.

If the robot is connected to this software, a password must be entered to change these settings.

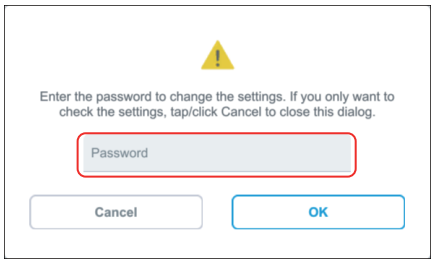
Precautions

The settings of some windows/screens cannot be configured using RT VisualBox if safety parameters have been set with RT ToolBox3. If the error message below appears, configure the settings in RT ToolBox3.

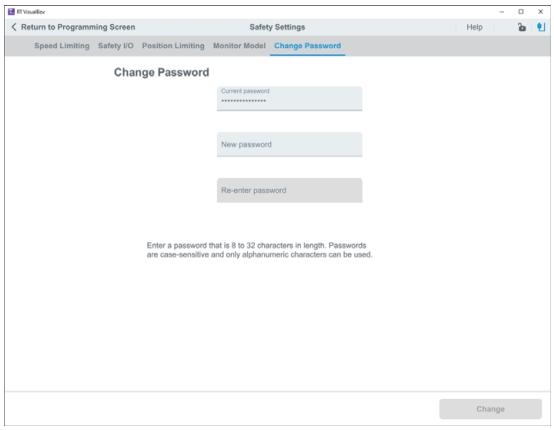


Entering/Changing Passwords

The Password Input window will appear when a robot is connected to this software or if an incorrect password has been entered. Enter the correct password.
The default password is "MELFASafetyPSWD".



The safety settings cannot be changed without changing the default password. When the default password is entered, the Change Password screen will appear. Change the password.



Precautions

- Even if a password has not been entered, it is still possible to view the Safety Settings screen. However, the setting values cannot be changed.
- The password must be 8 to 32 characters in length. Passwords are case-sensitive and only single-byte alphanumeric characters (0 to 9 and A to Z) can be used.
- Safety settings cannot be set without entering the correct password so ensure the password is something that is not easily forgotten.

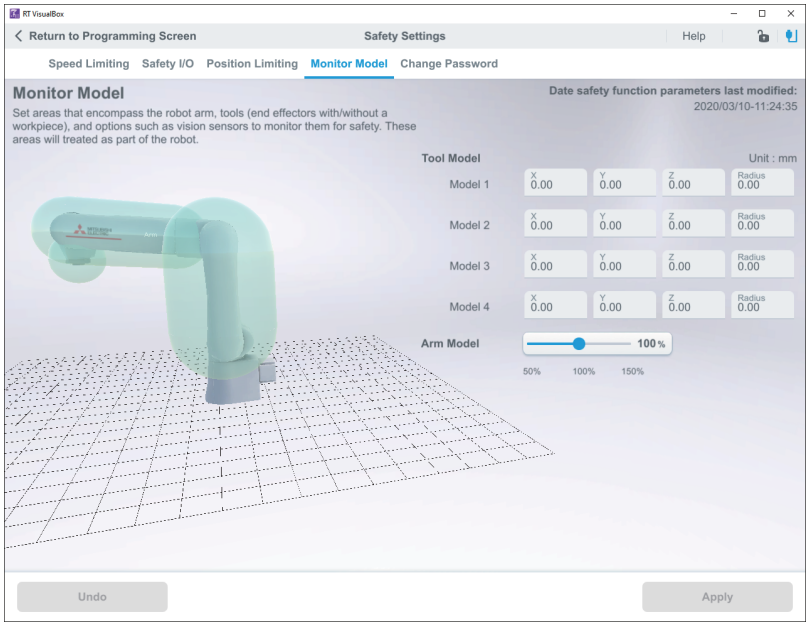
To reset the password, the robot controller must be returned to factory settings. Resetting the parameter “MECHRST” will clear the controller memory and return it to factory settings. For further information on resetting the controller memory, refer to the following manual:
📖Detailed explanations of functions and operations (BFP-A3478)

- To prevent inadvertent changes to the safety settings, keep your password secret and do not share it with third parties.

5.1 Monitoring model (tool/arm)

Areas set in this screen are monitored as a part of the robot and also used in the speed limiting settings and the position limiting settings.

If tools such a hand or a vision sensor are installed, configure the settings for "Tool Model" so that the set area can be recognized as a part of the robot. If accessories such as cables or solenoid valves are installed, set "Arm Model" so that the set area can be recognized as a part of the robot.



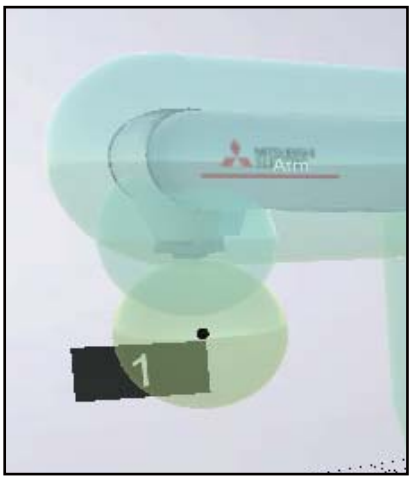
Tool model

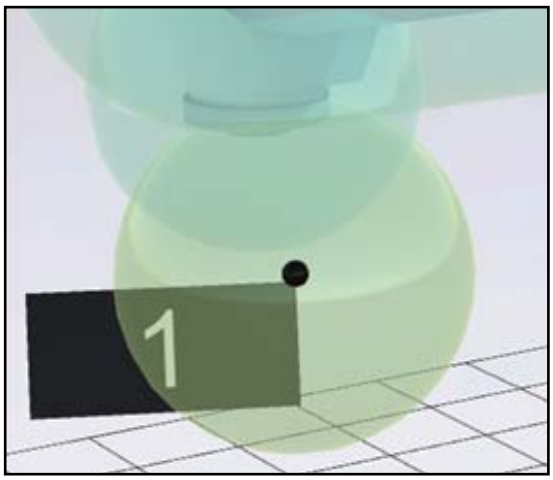
Define the shape of the tool (hand, vision sensor, etc.) with up to four spheres. Create a shape that is roughly the size of the tool that is attached to the robot. If the radius is greater than 0, the tool model will be subject to position monitoring.

The center of the tool model sphere will also be subject to speed monitoring. All tool models are subject to speed monitoring by default. Use RT ToolBox3 to disable the speed monitoring of specific tool models.

The coordinates are set in the mechanical interface coordinate system. By default (all coordinates set to "0"), the center of the mechanical interface is subject to speed monitoring. For information on the mechanical interface coordinate system, refer to the following manual:

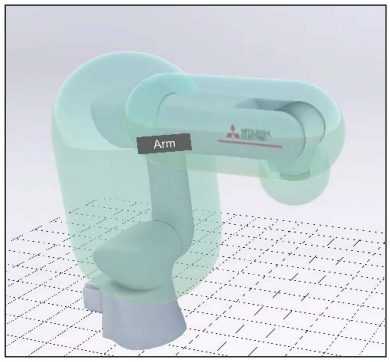
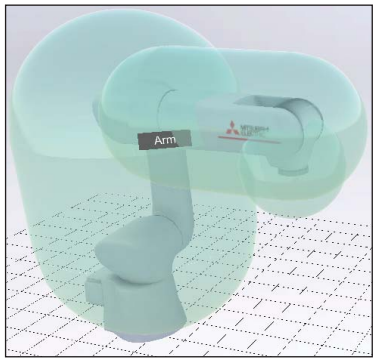
📖Detailed explanations of functions and operations (BFP-A3478)





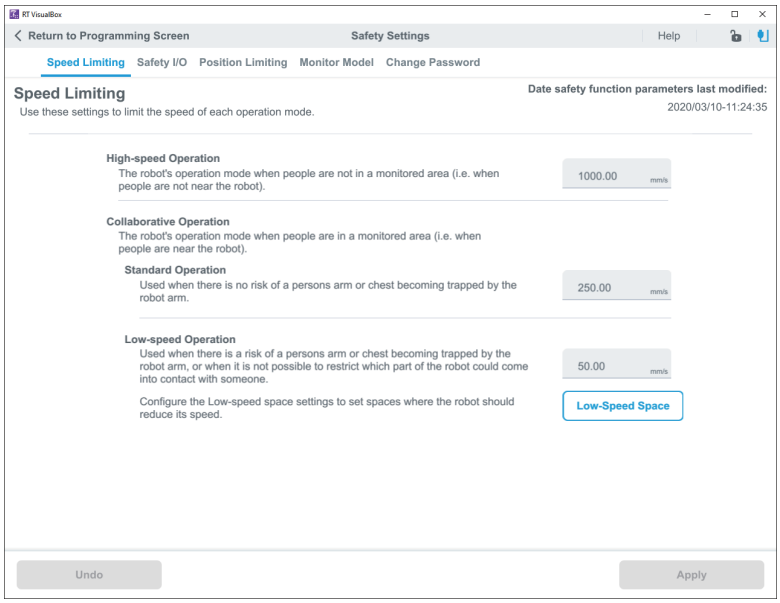
Arm model

After modeling the shape of the robot arm with spheres and cylinders, the speed and area of the robot can be determined.
When attaching accessories, such as cables and solenoid valves, to the robot arm, resize the model accordingly.
It is possible to adjust the radius of the spheres and cylinders. The length of the cylinders cannot be changed.

Scale: 70%	Scale: 100%	Scale: 150%
		

5.2 Speed limiting settings

The maximum speed and low-speed area can be set for each operation mode.
This setting is used for the speed-limiting safety function (SLS). This function monitors the speed of the robot arm and tools so that the speed does not exceed the specified value. For further information on this function, refer to the following manual:
📖Robot Safety Option Instruction Manual (BFP-A3531)
The maximum speed for each operation mode can be set.



The settings of the following operation modes can be configured.

- High-speed Operation
- Collaborative Operation (Standard Operation)
- Collaborative Operation (Low Speed Operation)

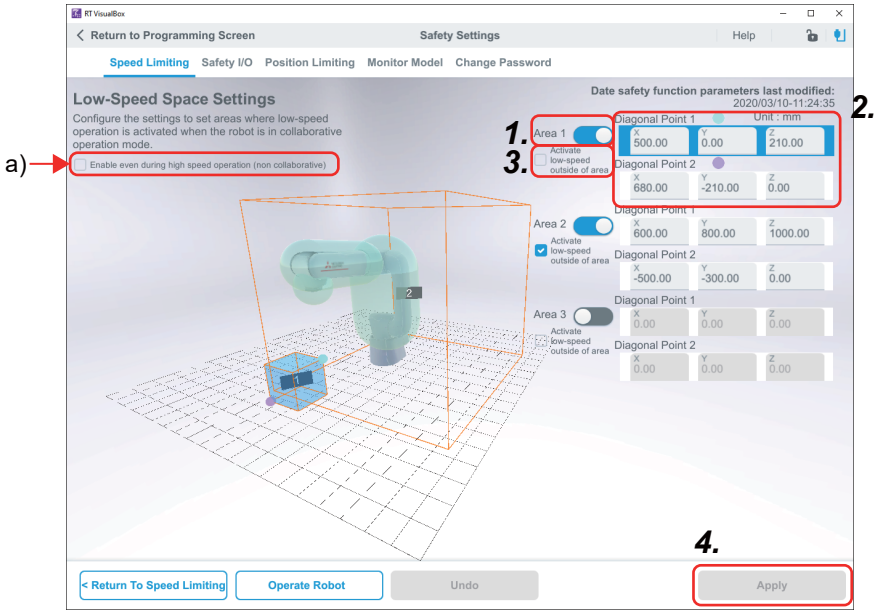
After changing the setting values, tap/click the [Apply] button.
A lower speed than the default setting value*1 can be set. A higher speed than the default setting value cannot be set.
To set low-speed areas, tap/click the [Low-Speed Space] button.

*1 Default setting values for the speed limit setting
High-speed operation: 1000 [mm/s]
Standard operation: 250 [mm/s]
Low-speed operation: 50 [mm/s]

5.3 Low-speed space settings

Up to three low-speed areas can be set.

Operating procedure



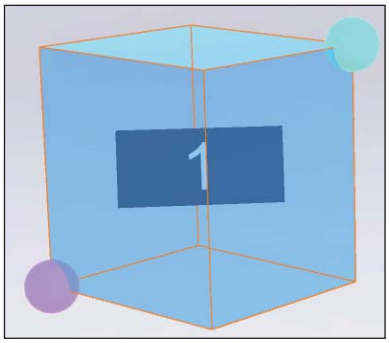
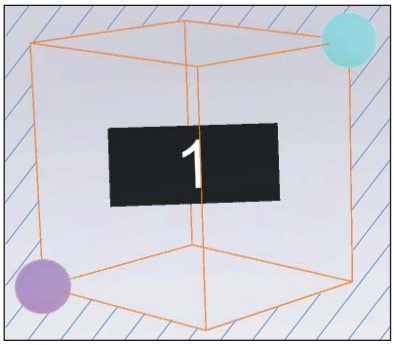
1. Turn on the area switch.

2. Enter two diagonal points. An area will appear on-screen once valid values have been set.

Diagonal points can also be set while moving the robot. To set points while moving the robot, tap/click the [Operate Robot] button, and move the robot to the desired destination. Then tap/click the [Teach] button. The current position is stored in the X, Y, and Z coordinates of the currently selected diagonal point.

3. Set which side of the created area is to be set as the low-speed area with the [Activate low-speed outside of area] check box.

4. Tap/click the [Apply] button.

[Activate low-speed outside of area]: OFF	[Activate low-speed outside of area]: ON
If the robot enters this area, it will operate at low speed.	If the robot exits the shaded area, it will operate at low speed.
	

⚠CAUTION

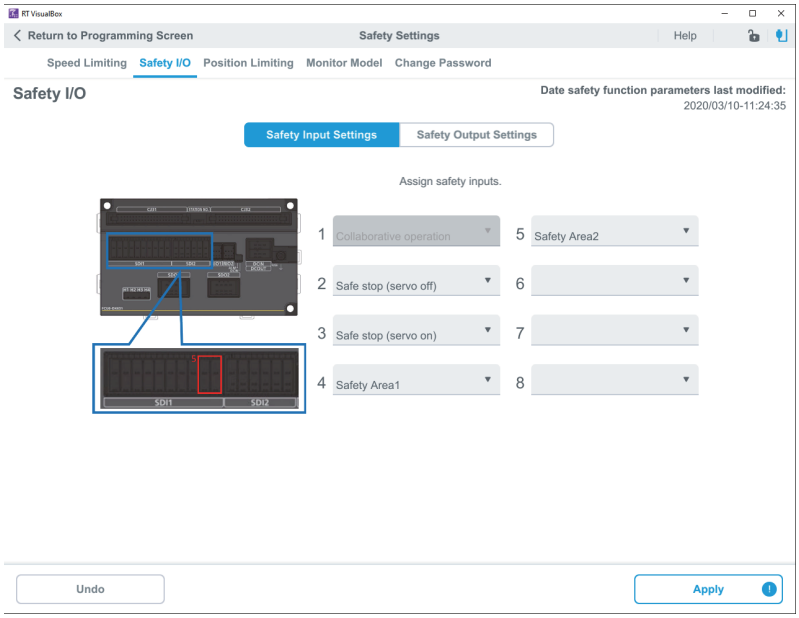
If [Enable even during high speed operation (non collaborative)] indicated by "a" and the area switch of a low-speed area are set to On, the robot operating at high speed will slow down upon entry into the low-speed area. In this situation, the robot is not in Collaborative operation mode. To work with the robot in the same space, follow risk assessments, use Safety input 1 and operate the robot in Collaborative operation mode.

5.4 Safety input/output settings

Safety inputs/outputs can be assigned.

Safety input setting

Assign safety inputs to the eight redundant signals of the SDI1 and SDI2 ports on the safety extension unit.



Assign the inputs show in the table below. Safety input 1 cannot be changed from "Collaborative operation". "Collaborative operation" can only be assigned to Safety input 1.

Setting	Description
Collaborative operation	When the input is enabled (Open), the robot is set to Collaborative operation mode*1. When the input is disabled (Closed), the robot is set to High-speed operation mode.
Safe stop (servo off)	When the input is enabled (Open), Safe stop 1 (SS1)*2 is activated.
Safe stop (servo on)	When the input is enabled (Open), Safe stop 2 (SS2)*3 is activated.
Safety areas 1 and 2	When input is enabled (Open), the area which the robot is not permitted to enter is enabled. Safety areas are set in "Position Limiting".

*1 Collaborative operation mode switches depending on whether the monitored area of the robot is in the low-speed area.

Collaborative operation mode	Conditions that enable this mode
Standard operation	When Safety input 1 is enabled (Open)
Low-speed operation	When Safety input 1 is enabled (Open) and the monitored area of the robot enters the low-speed area

*2 Safe stop 1: stops the robot safely and shuts off power to the motors even after the robot has stopped.

*3 Safe stop 2: stops the robot safely, maintains control over the motors even after they have stopped, and ensures that the robot does not move.

For further information, refer to the following manual:

Robot Safety Option Instruction Manual (BFP-A3531)

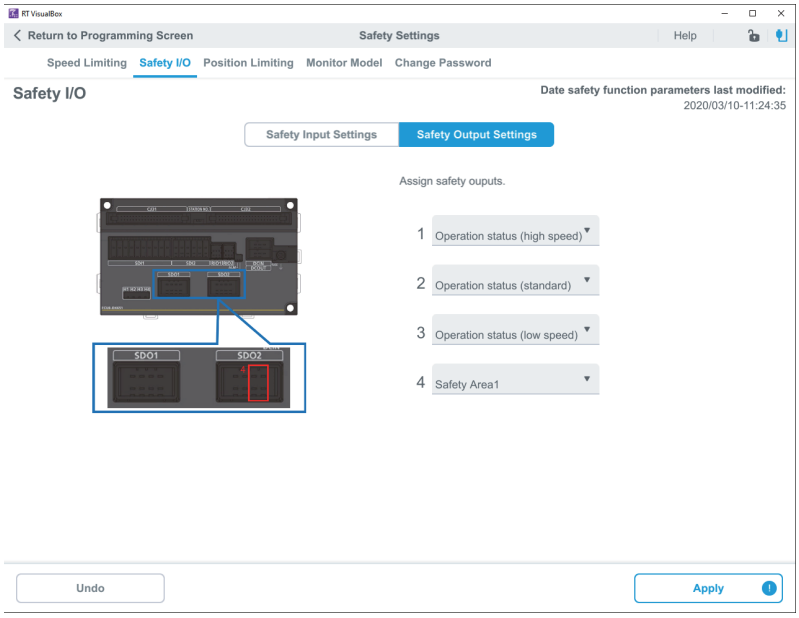
Point

- Advanced settings can be configured with RT ToolBox3. For further information, refer to the following manual:

RT ToolBox3 / RT ToolBox3 mini User's Manual (BFP-A3495)

Safety output settings

Assign safety outputs to the four redundant signals of the SDO1 and SDO2 ports on the safety extension unit.



Assign the outputs show in the table below.

Output	Description
Operation status (high speed, standard, low speed)	This signal turns on when the operation status has been switched and monitoring enabled.
Safe stop (servo off)	This signal turns on after the robot stops and the servo turns off (STO [Safe Torque Off]).*1
Safe stop (servo on)	This signal turns on after the robot stops (SOS [Safe Operating Stop]).*2
Safety areas 1 and 2	These signal turn on when safety areas are enabled.

*1 Safe Torque Off: shuts off power to the motors in the robot.
*2 Safe Operating Stop: checks that the robot has stopped without shutting off power to the motors in the robot.

For further information, refer to the following manual:

Robot Safety Option Instruction Manual (BFP-A3531)

Point

- Advanced settings can be configured with RT ToolBox3. For further information, refer to the following manual:

RT ToolBox3 / RT ToolBox3 mini User's Manual (BFP-A3495)

- Servo OFF:

When the robot servos are off, the safety outputs that set the robot's operation mode turn off.

CAUTION

There is a delay of up to 21.3 ms from when the redundant output signals turn off until the safety outputs turn off. This may temporarily cause multiple operation mode commands to be output at the same time (e.g. High speed and Standard operation mode commands output at the same time). Conduct a risk assessment to ensure safety.

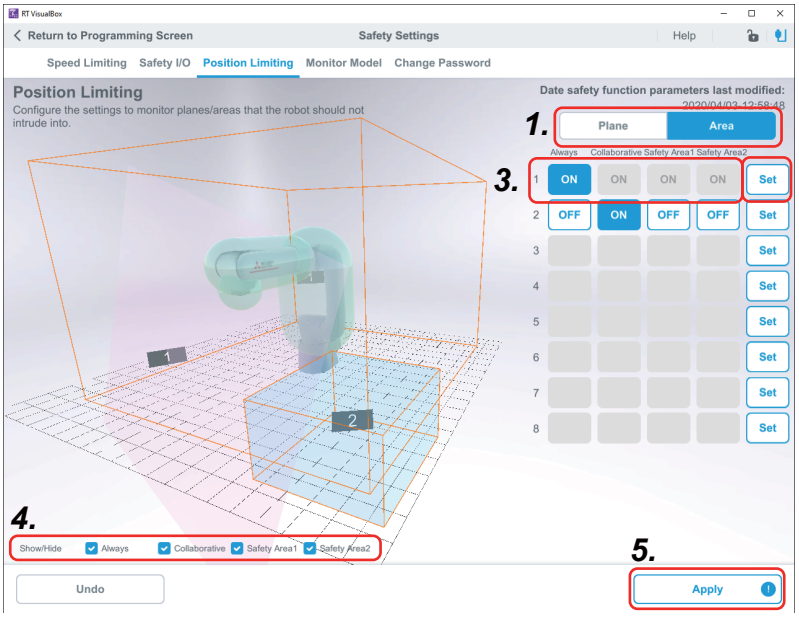
5.5 Position limiting settings

Areas and conditions can be set to prevent robot interfering with the workpiece platform or other equipment. The robot will stop when it nears designated safe areas.

This setting is used for the Safely-limited position function (SLP). This function monitors whether the hand or robot arm has entered a safe area. For further information, refer to the following manual:

📖Robot Safety Option Instruction Manual (BFP-A3531)

Operating procedure



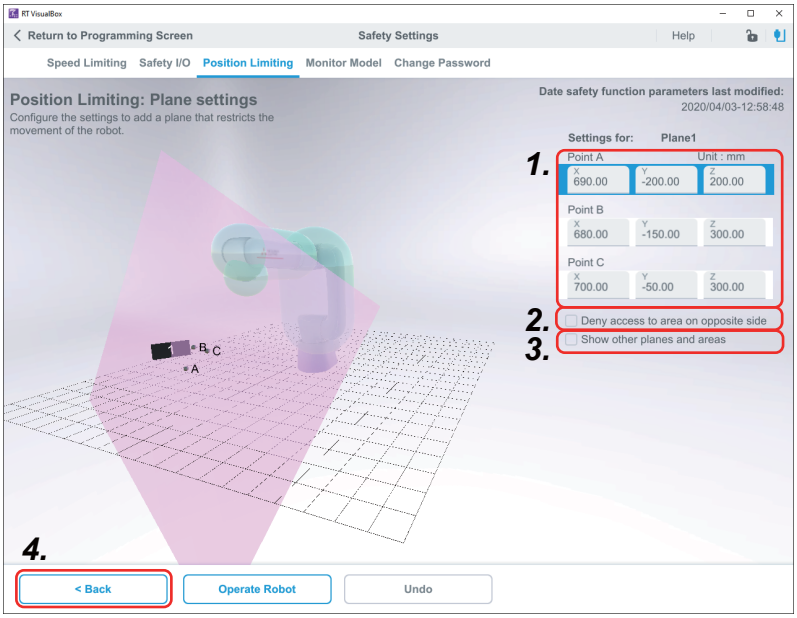
1. Select the plane or area to set by selecting the [Plane] or [Area] tab.
2. Tap/click the [Setting] button, and set a plane or area in the Plane Setting or Area Setting screen.
3. Use the ON/OFF buttons to enable/disable the conditions for each plane or area. ON/OFF buttons are only available if a plane or area has been created. Create a plane or area first.
4. Configure the settings then check them. Using the [Show/Hide] check boxes, show or hide a plane or area and check whether the conditions for enabling the plane or area are correct.
5. Tap/click the [Apply] button.

Condition	Description
Always	The plane or area is always enabled while the robot is moving.
Collaborative operation	The plane or area is enabled when the robot is in Collaborative operation mode (Standard or Low-speed operation mode). The plane or area is disabled when the robot is in High-speed operation mode.
Safety areas 1 and 2	The plane or area is enabled when "Safety area1" and "Safety area2" are assigned in the safety input settings.

5.6 Plane settings

Set a plane to be used in the position limiting settings.

Operating procedure



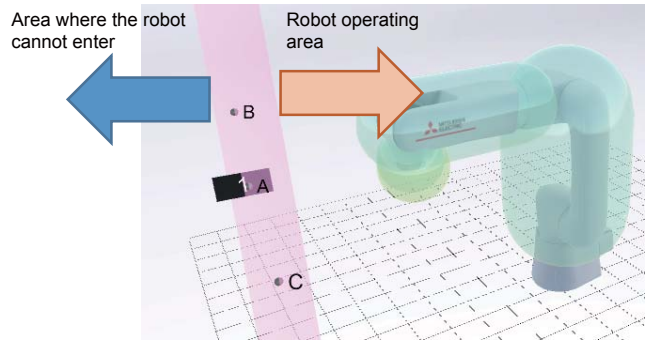
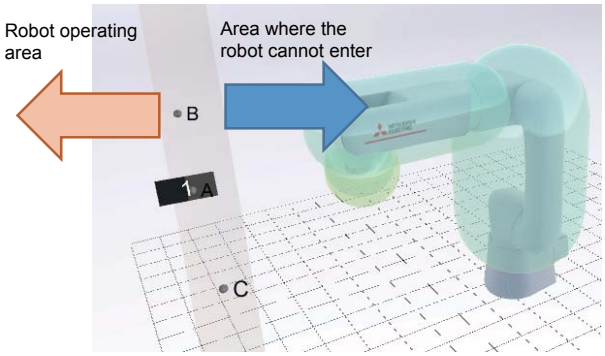
1. Enter points A to C. After the three points have been entered, a plane passing through the points will appear on the screen.

The points can also be set while moving the robot. To set points while moving the robot, tap/click the [Operate Robot] button, and move the robot to the desired destination. Then tap/click the [Teach] button. The current position is stored in X, Y, and Z of the currently selected point.

2. The robot cannot access the area on the pink side of the plane. By default, the area on the outside of the plane is inaccessible. To change the setting, select the [Deny access to area on opposite side] check box.

3. To keep previously set plains and areas visible while creating a new plane, select the [Show other planes and areas] check box.

4. After setting the plane, tap/click the [< Return to position restriction setting] button to return to the Position Restriction Setting screen.

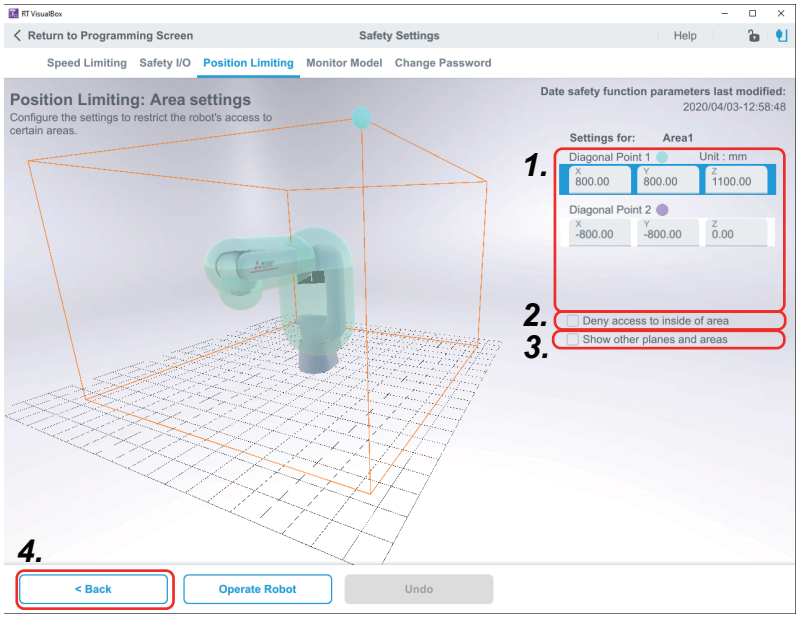
[Deny access to area on opposite side]: OFF	[Deny access to area on opposite side]: ON
	

* Robot origin indicates that X, Y, and Z (all axes) are 0.

5.7 Area settings

Set an area to be used for the position limiting settings.

Operating procedure



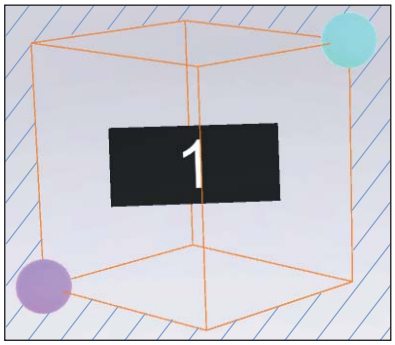
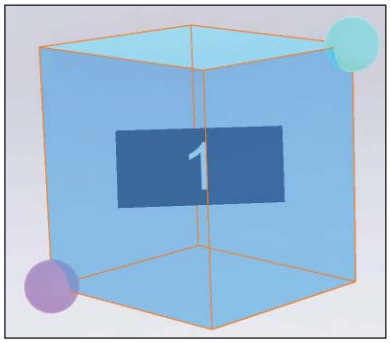
1. Enter two diagonal points. An area will appear on-screen once valid values have been set.

Diagonal points can also be set while moving the robot. To set points while moving the robot, tap/click the [Operate Robot] button, and move the robot to the desired destination. Then tap/click the [Teach] button. The current position is stored in the X, Y, and Z coordinates of the currently selected diagonal point.

2. By default, the area on the outside of a defined area is inaccessible. To change the settings, select the [Deny access to inside of area] check box.

3. To keep previously set plains and areas visible while creating a new plane, select the [Show other planes and areas] check box.

4. After setting the area, tap/click the [< Back] button to return to the Position Limiting screen.

[Deny access to inside of area]: OFF	**[Deny access to inside of area]: ON**
The robot will stop moving before it leaves the defined area.	The robot will stop moving before it enters the blue area.
	

Appendix

Appendix 1 Other functions of RT VisualBox

Monitor

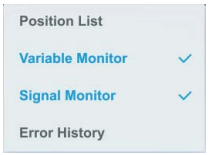
This chapter explains the monitor function.

The following items can be displayed with the monitoring function.

Item	Description
Position list	Used to check taught positions
Variable monitor	Used to monitor the values of variables
Signal monitor	Used to monitor the status of input/output signals
Error history	Used to check the error history

Point

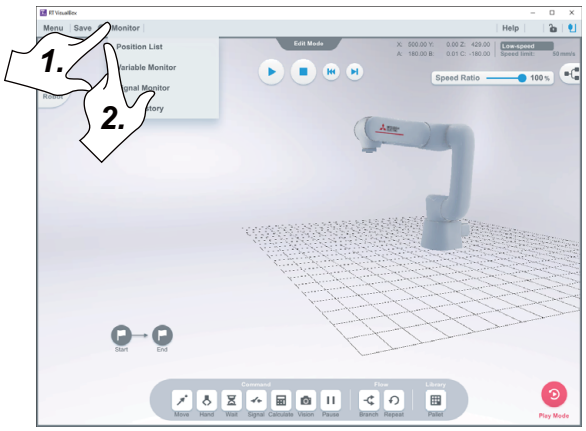
To close a monitor window, tap/click the [×] button in the top right of the window or select it again from the monitor list. A check mark will appear to the right of a monitor on the menu bar when it is open.



Position list

The teaching position list is a list of taught position data.

Operating procedure

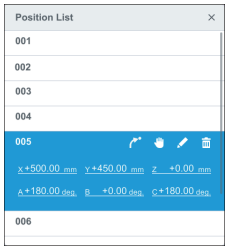


1. Tap/click [Monitor] on the menu bar.

2. Tap/click [Position List].

3. The Position List window will appear.

Click on the name of the taught position you want to check.



4. The coordinates of the taught position will be displayed.
The icons in the following table can be used to re-teach, delete, and jump positions, or to edit position numbers.

Icon	Description
	If a robot is connected to this software, a confirmation screen will appear when this button is pressed. Tapping/clicking the [OK] button will move the robot to the selected position. If the simulator is connected to this software, the confirmation screen will not appear. If the robot is in High-speed operation mode, the speed ratio will reduce to 20%.
	This icon displays the Robot Operation panel. When [Teach] is tapped/clicked in the Robot Operation panel, the position is overwritten with the robot's current position.
	This icon displays a window that is used to change the position number. Entering a new number and tapping/clicking the [Change] button changes the position number.
	This icon displays a window that is used to delete the selected position. Tapping/clicking the [OK] button deletes the position.

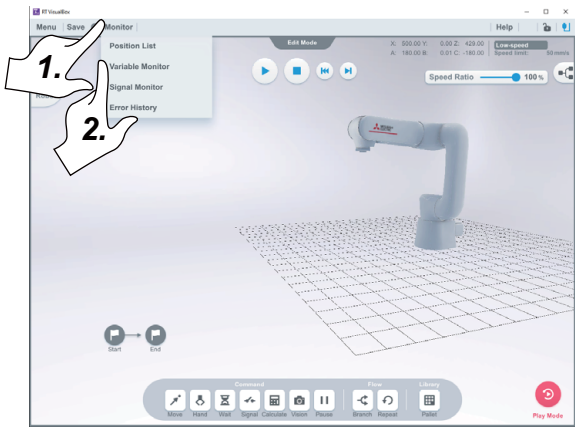
⚠CAUTION

Tapping/clicking the [Jump position] button will cause the robot to move. Be sure to place an emergency stop switch nearby so that the robot can be stopped immediately.

Variable monitor

The variable monitor displays the values of variables. Variables can be checked while viewing the robot with the program running.

Operating procedure

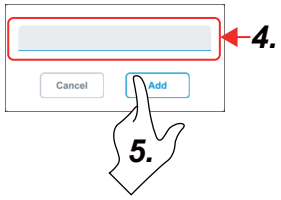


1. Tap/click [Monitor] on the menu bar.

2. Tapping/clicking [Variable Monitor] displays the Variable monitor window.

When this is displayed for the first time, variables used by the current program are listed.
From the second time onward, the variables listed previously will be displayed.

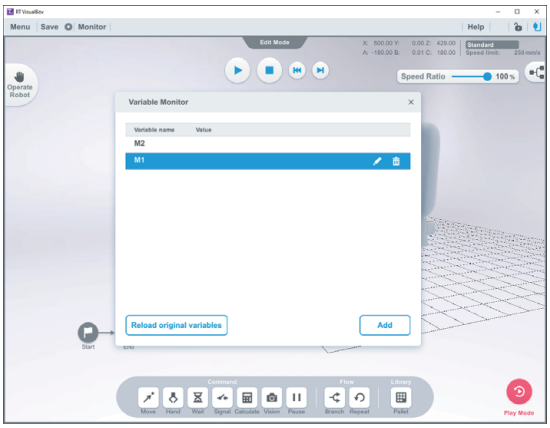
3. Tap/click the [Add] button.



4. Enter the name of the variable you want to monitor in the variable name input field.

5. Tap/click the [Add] button.

It is possible to add robot (system) state variables.



6. Added variable names and their current values are displayed in a list.

Selecting a variable name will display the icons in the table below. Variables can be deleted and their values edited by tapping/clicking on the icons in the table below.

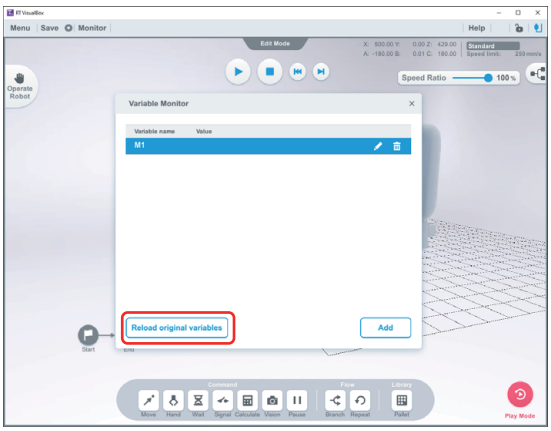
Icon	Description
	This icon displays a window that is used to edit variables. Tapping/clicking the [Change] button after editing the value overwrites the value of the variable.
	This icon displays the dialog box asking whether it is okay to delete the variable from the monitor. Tapping/clicking the [OK] button deletes the variable from the list.

Precautions

Variable values to be monitored or changed are not displayed if a program has not been saved or executed.

Point

The values of each variable in the list can be cleared and reread.
Tapping/clicking the [Reload original variables] button updates the variable list with only the variables that are used in the current program.

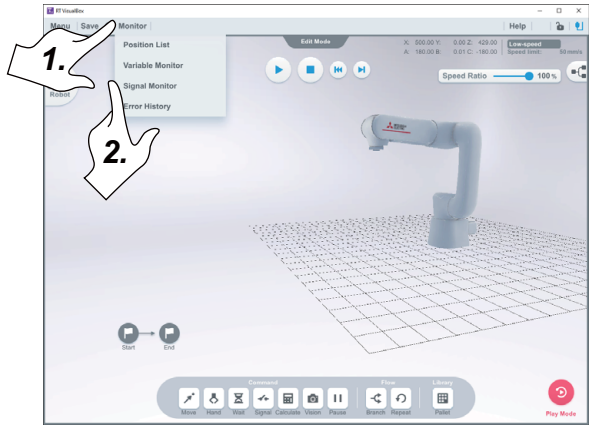


Signal monitor

The Signal monitor displays the state of input/output signals. Signal states can be checked while viewing the robot with the program running.

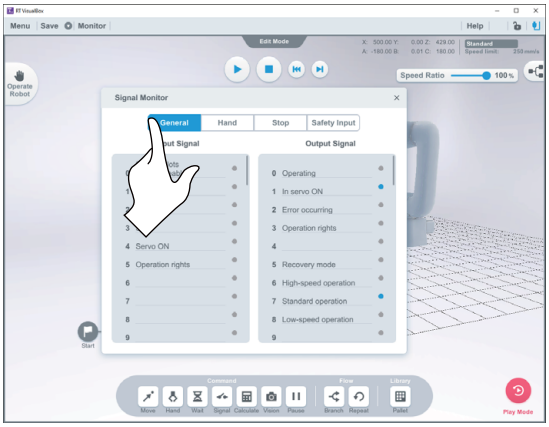
General-purpose signals, hand signals, stop signals, and safety input signals can be monitored with the signal monitor.

Operating procedure



1. Tap/click [Monitor] on the menu bar.

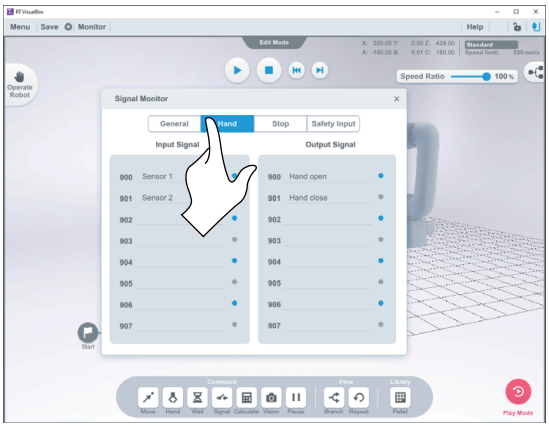
2. Tapping/clicking [Signal Monitor] displays the Signal Monitor window.



3. General-purpose signals

Tapping/clicking the [General] tab displays the names and numbers of general-purpose input/output signals and whether the signals are On/Off.

: ON
: OFF

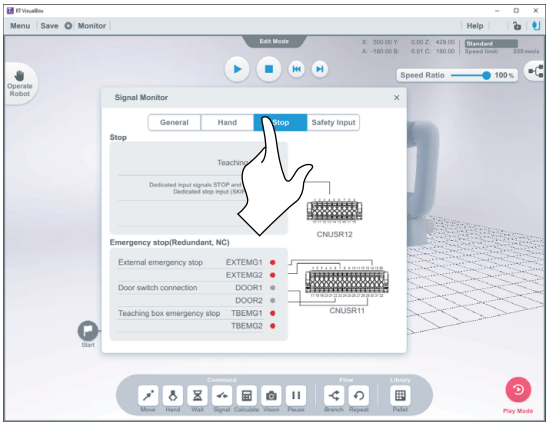


4. Hand

Tapping/clicking the [Hand] tab displays the names and numbers of hand input/output signals and whether the signals are On/Off.

: ON
: OFF

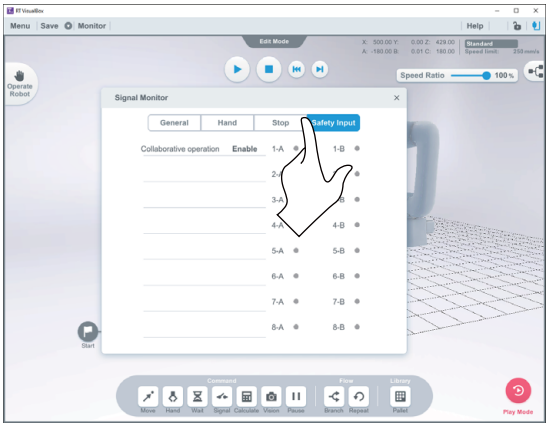
A



5. Stop signals

Tapping/clicking the [Stop] tab displays the names of stop signals and whether the signals are On/Off.

: ON
: OFF
: Emergency stop output



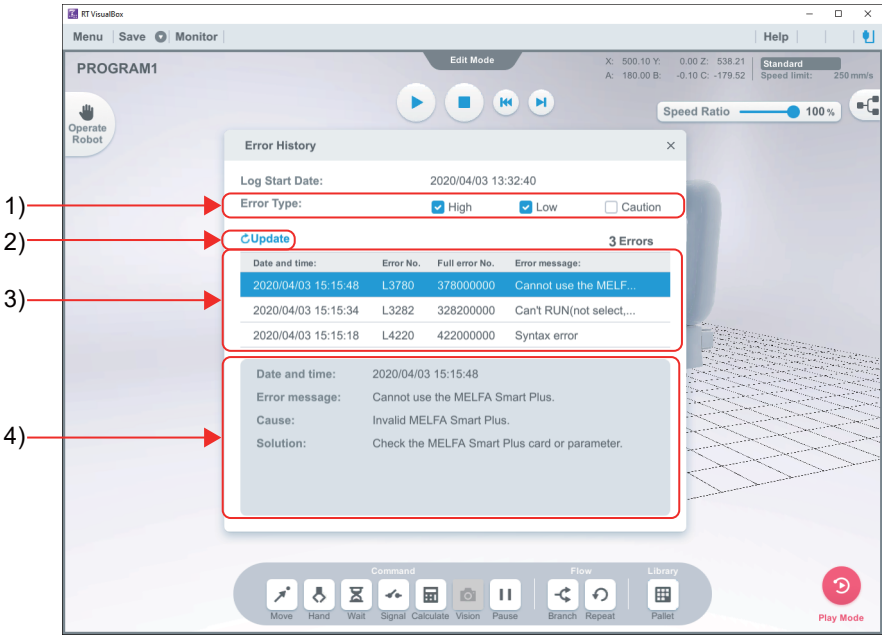
6. Safety input

Tapping/clicking the [Safety Input] tab displays whether the safety input signals are On/Off.

: ON
: OFF

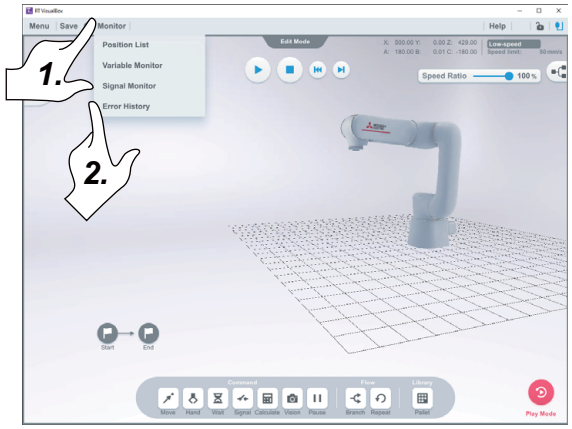
Error history

The error history displays errors that have previously occurred.



No.	Items in window	Description
1)	Error Type	It is possible to choose which error levels are displayed. Choose from High, Low, and Caution.
2)	Update	Tapping/clicking [Update] displays errors corresponding to the error levels selected will be found and the list will be updated.
3)	List	Errors that have occurred previously are displayed in the list.
4)	Error details	Selecting an error displays the details of that error.

Operating procedure



1. Tap/click [Monitor] on the menu bar.
2. Tapping/clicking [Error History] displays the Error history window.

A

Custom settings

This chapter explains the custom settings.

The following properties can be set in Custom settings.

Properties	Description
Language settings	Used to set the display language of this software
Workpiece grasp position	Used to set the workpiece grasp position
Signal settings	Used to set the names of input/output signals
Date & time	Used to set the current date and time of the robot controller

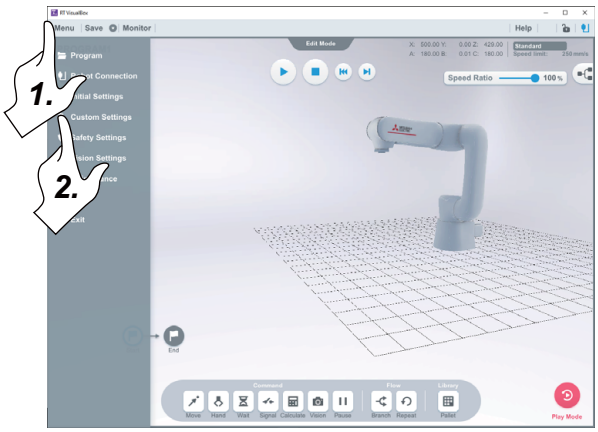
Language settings

The display language of RT VisualBox can be changed.

The following languages are available:

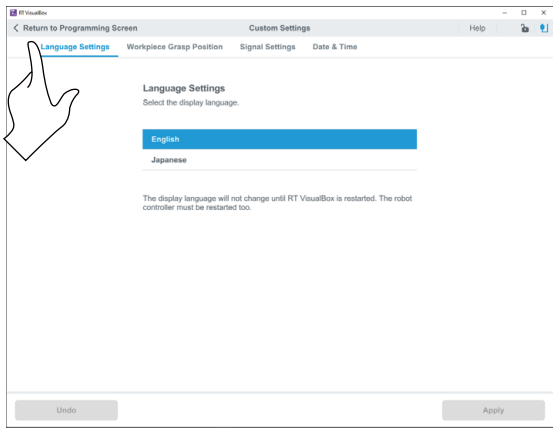
- English
- Japanese

Operating procedure

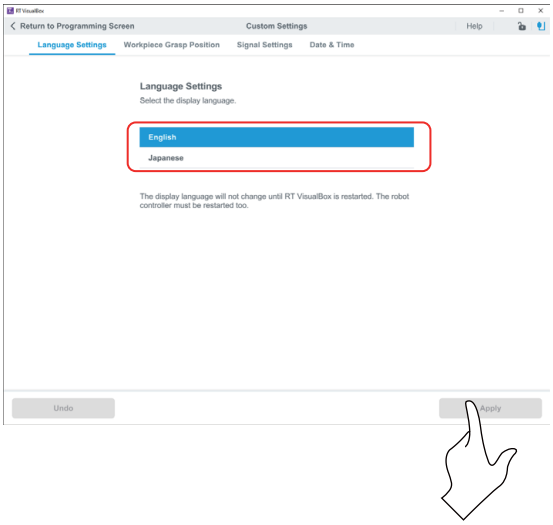


1. Tap/click the [Menu] tab on the menu bar.

2. Tap/click [Custom Settings].



3. To change the display language, tap/click the [Language Settings] tab.



4. Select the desired language and tap/click the [Apply] button.

Point

The display language will change next time RT VisualBox is started.

Workpiece grasp position settings

These settings are used to change the workpiece grasp position.

Set the distance and angle from the tip of the robot arm to the position where the hand grasps the workpiece.

These settings allow you to set the tool coordinate system for the tool (hand) that is installed on the robot.

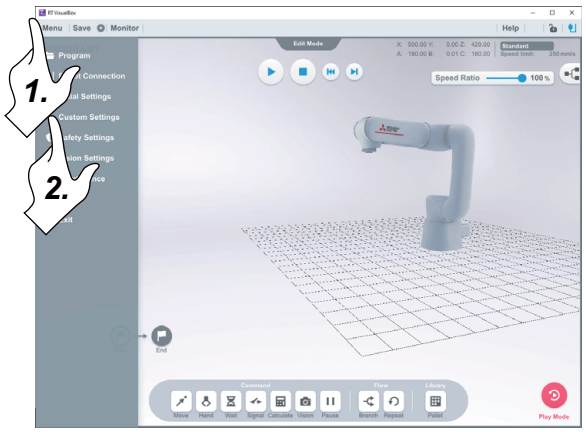
For information on the tool coordinate system, refer to the following manual:

📖RT VisualBox Instruction Manual (BFP-A3696)

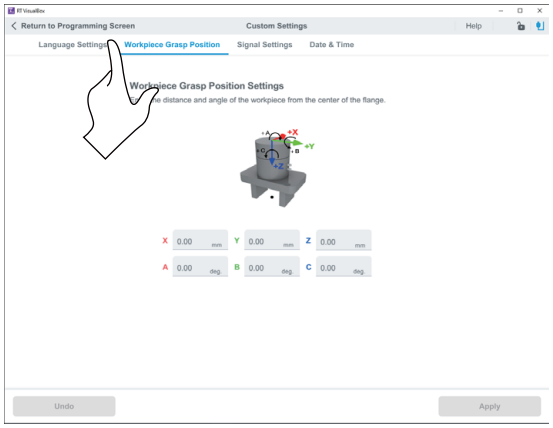
⚠CAUTION

Ensure that the correct values are set.

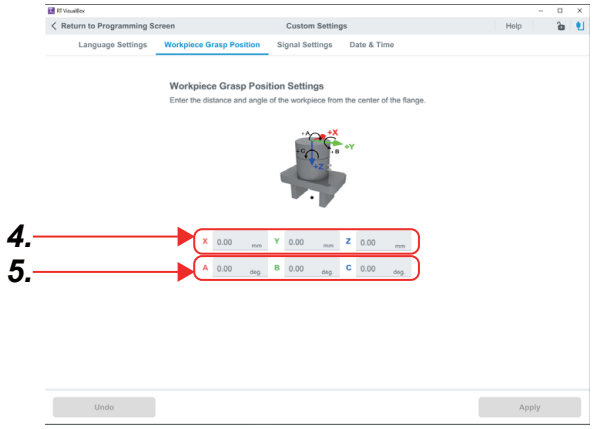
Operating procedure



1. Tap/click the [Menu] tab on the menu bar.
2. Tap/click [Custom Settings].



3. Tapping/clicking [Workpiece Grasp Position] displays the window used for changing the workpiece grasp position.

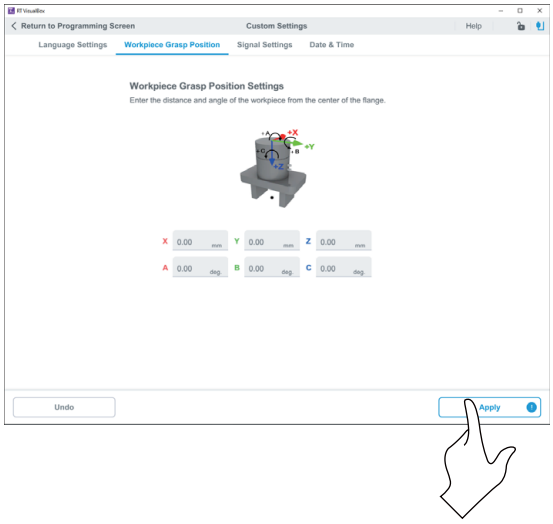


4. Enter the X, Y, and Z components of the grasp position. (Unit: mm)

X, Y, and Z components are set in the mechanical interface coordinate system.

5. Enter the A, B, and C components of the grasp position. (Unit: deg)

A, B, and C components are set in the mechanical interface coordinate system.



6. Tap/click the [Apply] button.

Point

For information on the mechanical interface coordinate system, refer to the following page:

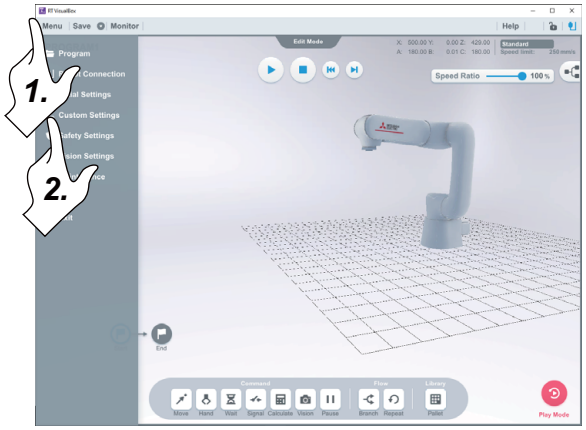
Detailed explanations of functions and operations (BFP-A3478)

Signal settings

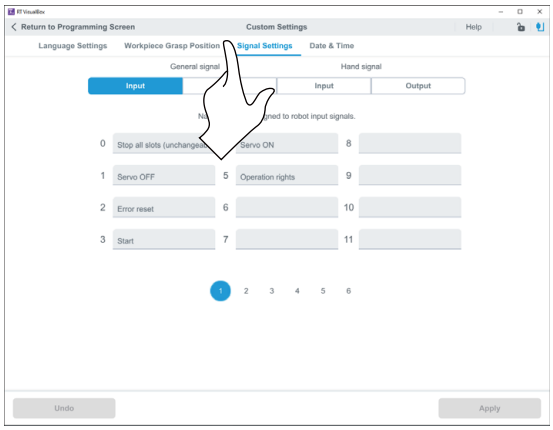
The names of the input/output signals can be set. Setting a name for each input/output signal allows for signals to be easily identified.

■Setting General-purpose signal names

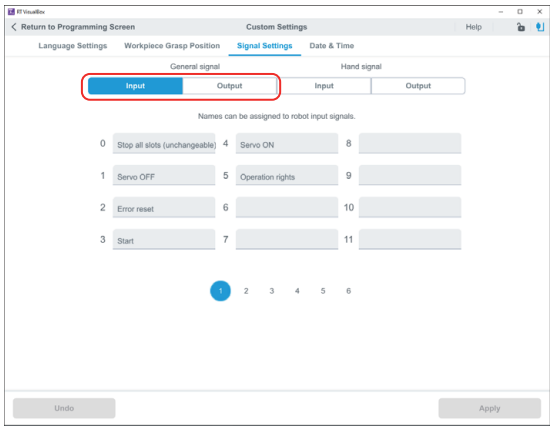
Operating procedure



1. Tap/click the [Menu] tab on the menu bar.
2. Tap/click [Custom Settings].

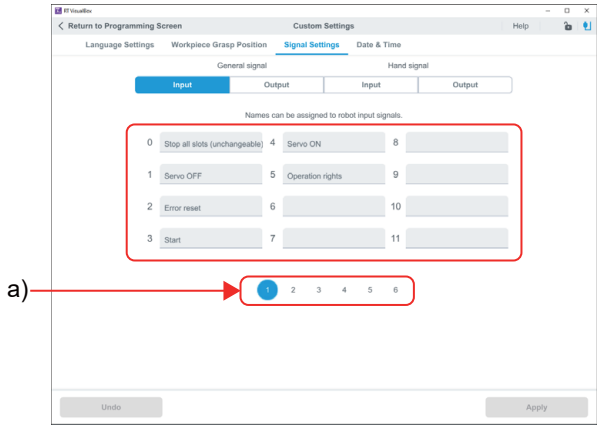


3. Tapping/clicking [Signal Settings] displays the screen for setting the input/output signal names.

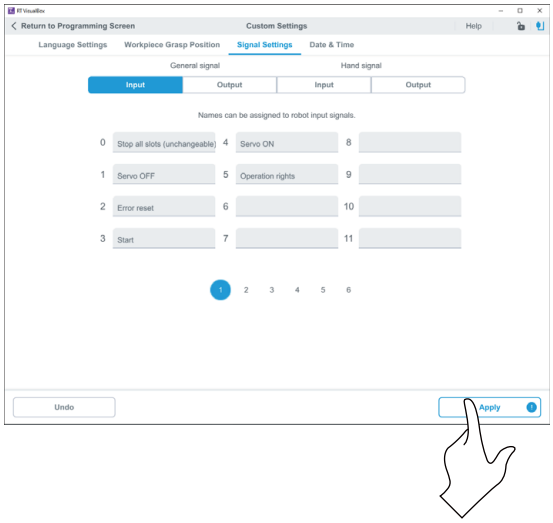


4. Tapping/clicking the [Input] or [Output] tab under "General signal" displays the screen used for setting the name of general-purpose signals.

A



5. Enter the signal name in the Signal name field. Tap/click the page buttons indicated by "a" in the figure to switch pages.



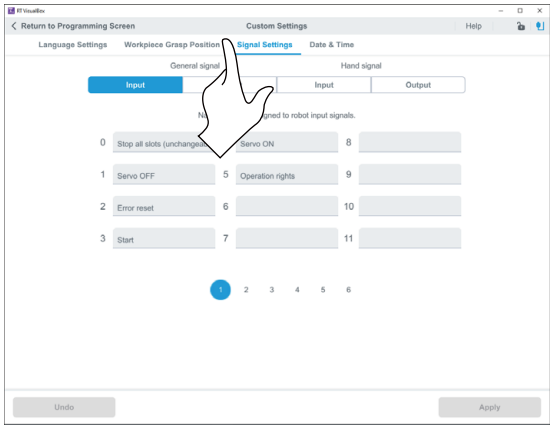
6. After entering the signal name, tap/click the [Apply] button. The entered name will be set.

■Setting Hand signal names

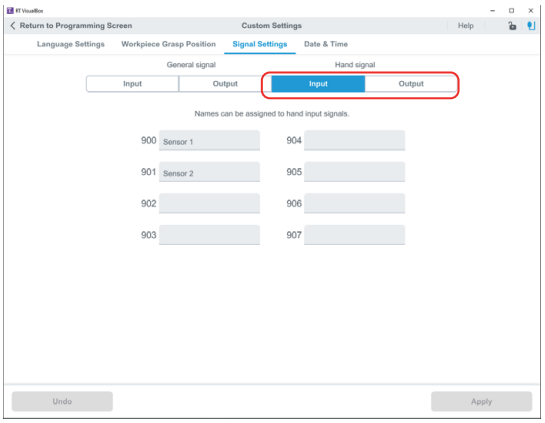
Operating procedure

1. Tap/click the [Menu] tab on the menu bar.

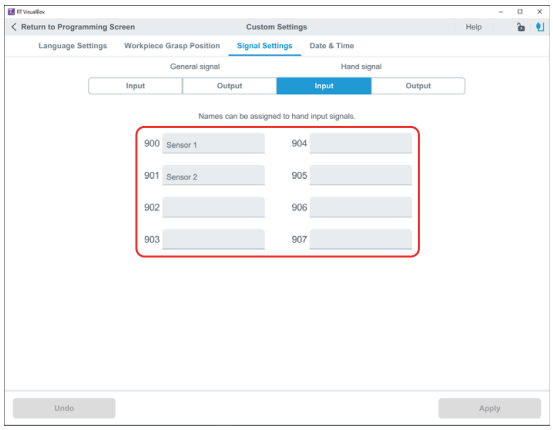
2. Tap/click [Custom Settings].



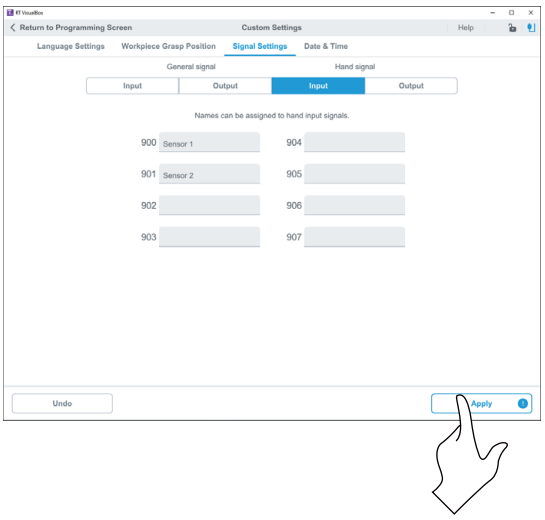
3. Tapping/clicking [Signal Settings] displays the screen for setting the input/output signal names.



4. Tapping/clicking the [Input] or [Output] tab under "Hand signal" displays the screen for setting the name of hand signals.



5. Enter the signal name in the Signal name field.



6. After entering the signal name, tap/click the [Apply] button. The entered name will be set.

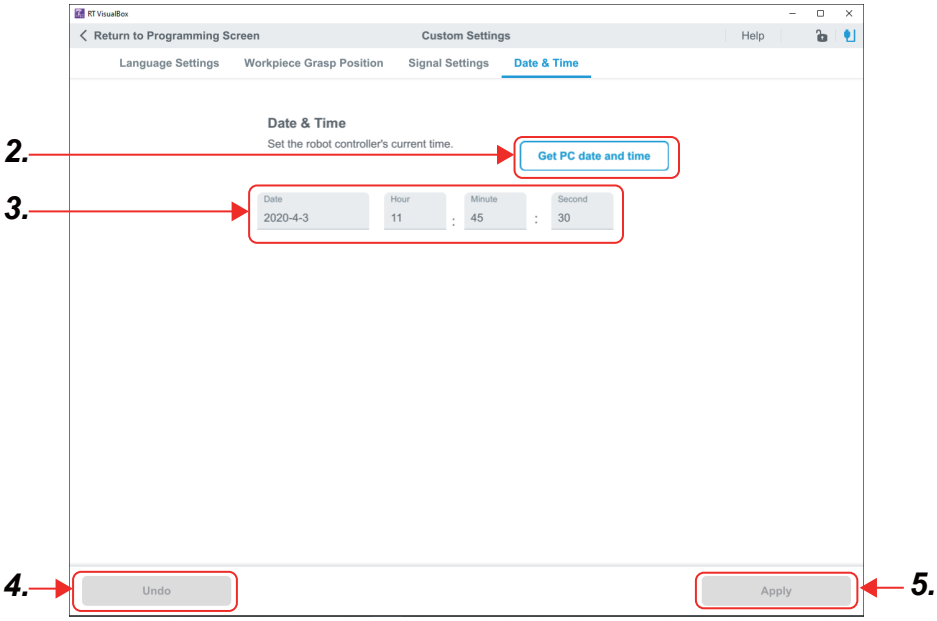
A

Date & Time settings

The current date and time of the robot controller can be set.

Operating procedure

1. Tap/click [Menu] → [Custom Settings] → [Date & Time] on the menu bar to display the screen for setting the time.



2. Get PC date and time

Tapping/clicking [Get PC date and time] displays the acquired values in the Date, Hour, Minute, and Second fields.

3. Date and time input field

The Date, Hour, Minute and Second fields can be set manually.

4. Undo

To discard the time settings, tap/click the [Undo] button.

5. Apply

Tap/click the [Apply] button to set the time that has been entered.

Precautions

This setting cannot be configured while in simulator mode.

Maintenance

This chapter is about maintenance. The actions in the table below can be carried out in order to conduct maintenance.

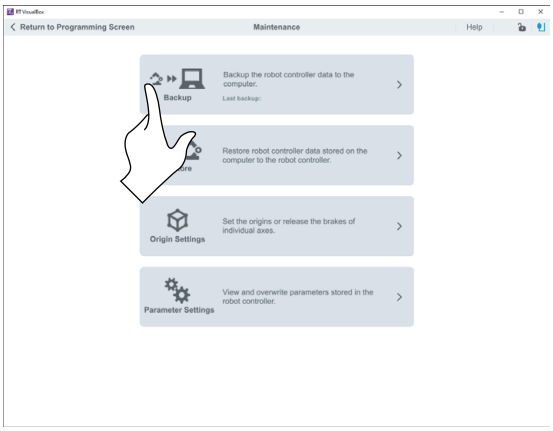
Action	Description
Backup	Use Backup to back up the data in the robot controller to the computer.
Restore	Use Restore to backup data stored on the computer to the robot controller.
Origin Settings	Use Origin Settings to set the origin position for each joint. The brakes of the joints can be temporarily released from this window.
Parameter Settings	Use Parameter Settings to view and overwrite parameters in the robot controller.

Backup

Backup performs a full backup of the data stored in the robot controller to the computer.

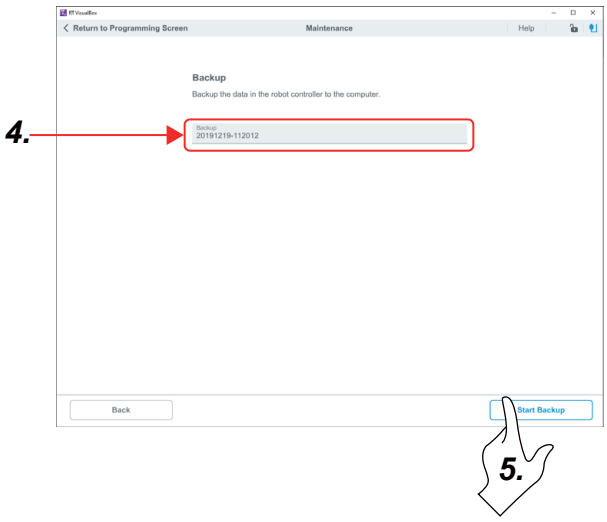
Operating procedure

1. Tap/click the [Menu] tab on the menu bar.
2. Tap/click [Maintenance] to display the Maintenance screen.



3. Tap/click [Backup]. The Backup screen will appear.

A



4. Enter a name for the backup.

5. Tap/click the [Start Backup] button.

The Backup in progress… dialog box will appear when the backup starts. When the backup is complete, the Backup complete! dialog box will appear.

Restore

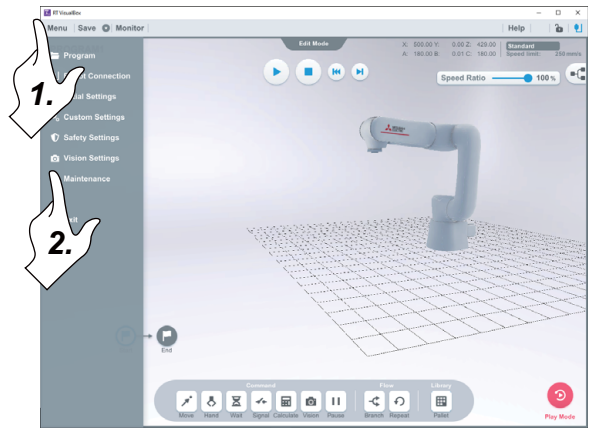
Restores the backup data stored on the computer to the robot controller. The content that is restored is the same as the default content displayed in the RT ToolBox3 Restore window. Refer to the following for further information.

- Program information
- Parameter information
- System program

Precautions

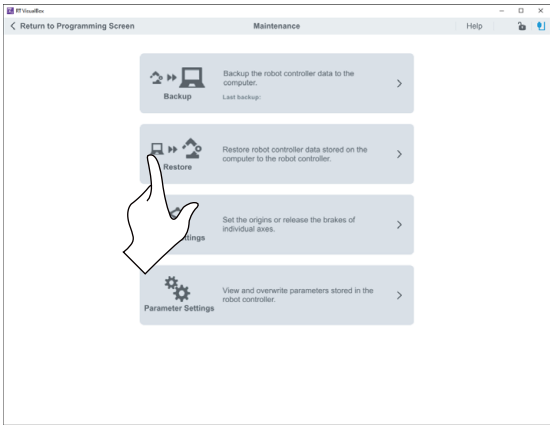
- Origin information is not overwritten.
- The serial number (the same serial number as the one on the robot arm) is not overwritten.
- File management data is not restored.
- Movement information is not restored.
- Preventive maintenance data is not overwritten.
- When [Only restore the program.] is set to [On], only program information will be restored.

Operating procedure

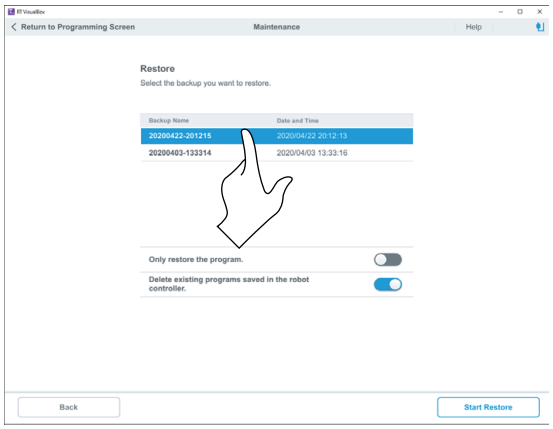


1. Tap/click the [Menu] tab on the menu bar.

2. Tap/click [Maintenance] to display the Maintenance screen.



3. Tap/click [Restore]. The Restore screen will appear.



4. A list of previously backed-up data will appear. Select the data that you want to restore.

5. To only restore programs from the backed up data, toggle the [Only restore the program.] switch to On.

Turn off to restore all data OFF

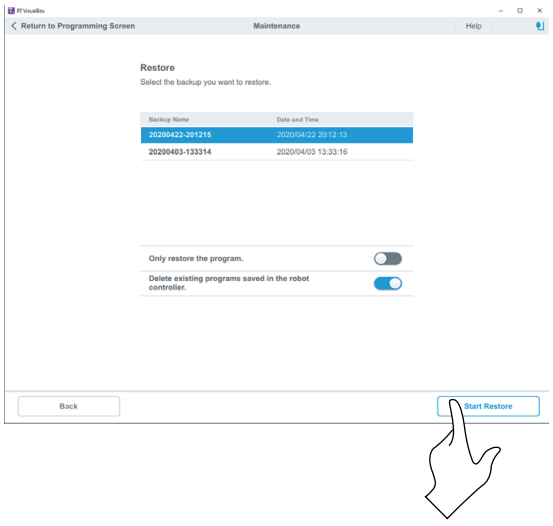
Turn on to restore programs only ON

6. To delete existing programs in the robot controller during a restore, toggle the [Delete existing programs saved in the robot controller.] switch to On.

Turn off to retain existing programs OFF

* Programs with the same name will be overwritten.

Turn on to delete existing programs ON



7. Tap/click the [Start Restore] button.

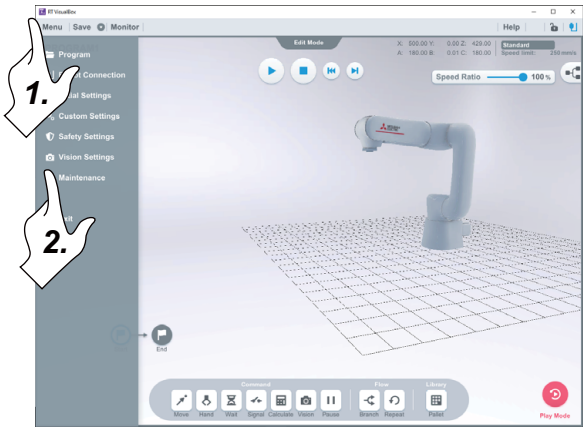
The Restoring… dialog box will appear and the restore will start. Once the restore is complete, a dialog box will appear indicating that the restore was successful and that the robot controller will restart. After the controller has restarted, another dialog box will appear indicating that the controller has restarted.

A

Origin settings

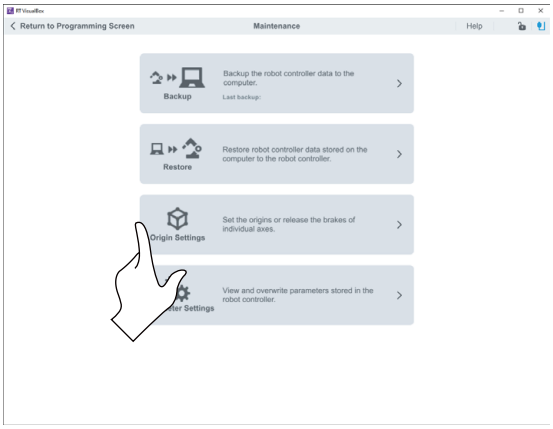
Set the origin position for each joint. The origin of each joint can be set from this screen if encoder backup data has been lost. The brakes of each joint can also be temporarily released from this screen.

Operating procedure

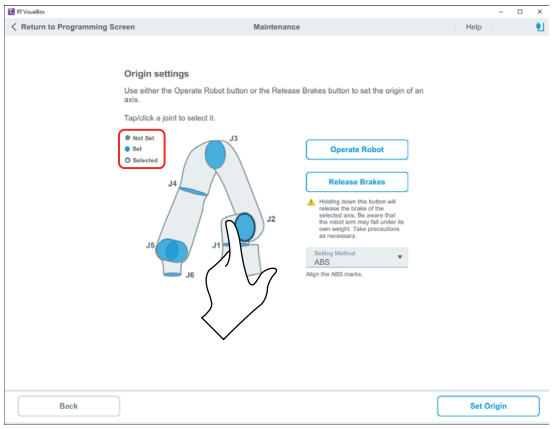


1. Tap/click the [Menu] tab on the menu bar.

2. Tap/click [Maintenance] to display the Maintenance screen.



3. Tap/click [Origin Settings]. The Origin Settings screen will appear.

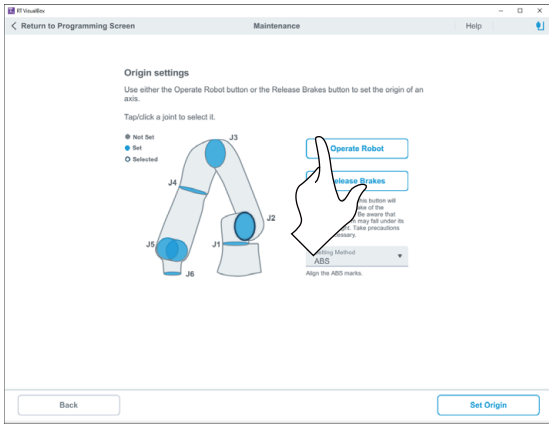


4. Select an axis to set its origin.

Each joint in the figure of the robot indicates whether the origin is set.

Tap/click on an axis in the figure to set the origin for that axis.

Tapping/clicking on an axis will release the brake of that axis (once "Release Brakes" has been selected).



5. Set the origin position of the robot arm.

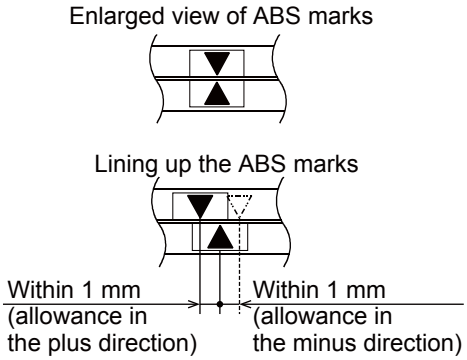
Tap/click the [Operate Robot] button to display the Robot Operation panel. Align the ABS marks of the joint selected in the Robot Operation panel. Refer to the following for further information on operating the robot.

📖RT VisualBox Instruction Manual (BFP-A3696)

Alternatively, tap/click the [Release Brakes] button to release the brake of the axis selected in the figure of the robot. The brake will be released while this button is pressed. Moving the arm by hand, align the ABS marks of the selected joint. The brakes of axis J2 and J3 will be repeatedly applied and released while the [Release Brakes] button is pressed. The brakes of all the other axes will be released continuously while the same button is pressed.

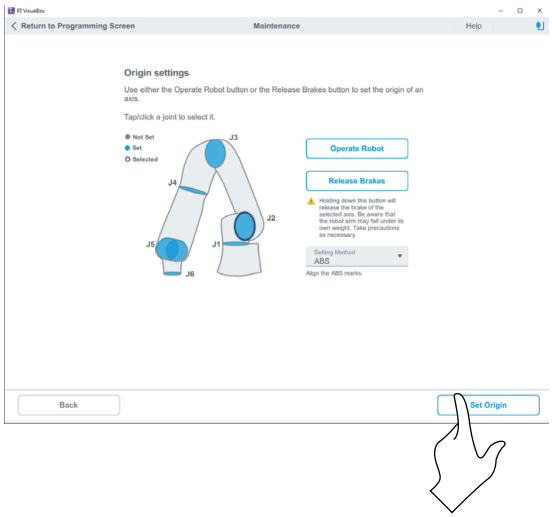
Point

The following figure shows how to align the ABS marks.



⚠CAUTION

The robot arm may fall under its own weight depending on which brake is released or how the robot is configured. Take steps such as supporting the arm to prevent it falling under its own weight.



6. Set the origin.

Tap/click [Set Origin] to set the origin of the selected axis to its current position.

To discard the settings, tap/click [Back].

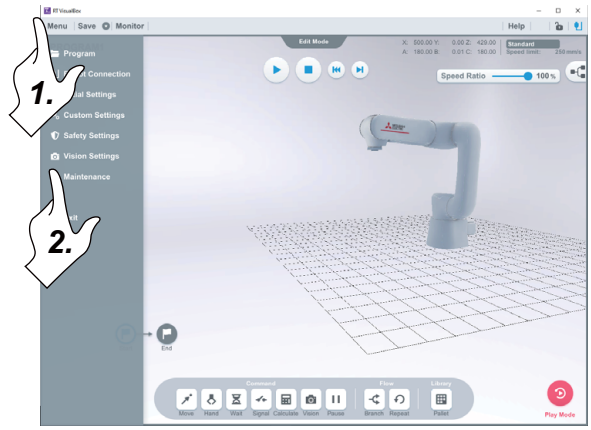
A

Parameter settings

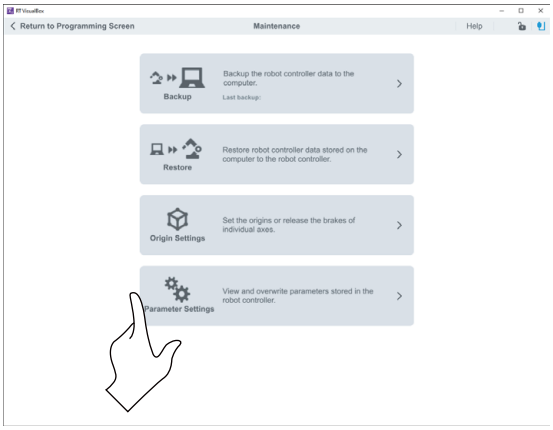
The parameters in the robot controller can be read and their values can be written.

■Reading parameters

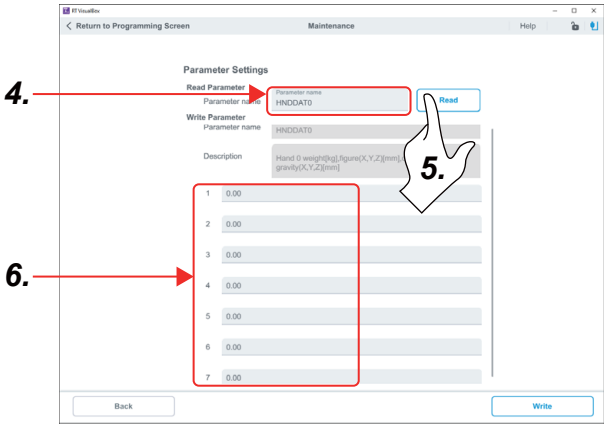
Operating procedure



1. Tap/click the [Menu] tab on the menu bar.
2. Tap/click [Maintenance] to display the Maintenance screen.



3. Tap/click [Parameter Settings]. The Parameter Settings screen will appear.



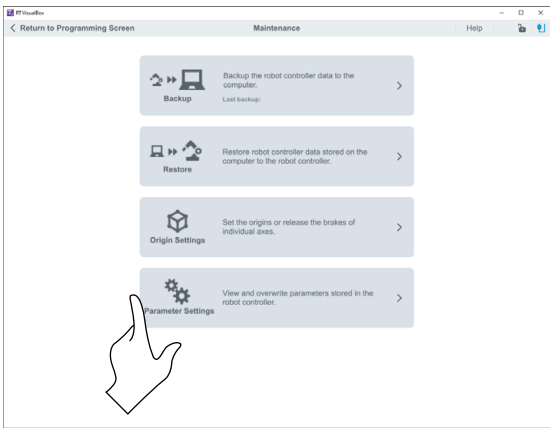
4. Enter the name of the parameter in the Parameter Name field.
5. Tap/click [Read].
6. The current values for the read parameter are displayed in the area below "Write Parameter".

■Writing parameters

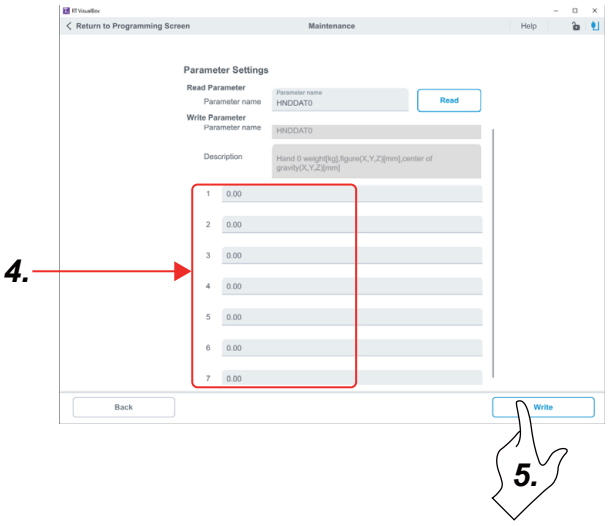
Operating procedure

1. Tap/click the [Menu] tab on the menu bar.

2. Tap/click [Maintenance] to display the Maintenance screen.



3. Tap/click [Parameter Settings]. The Parameter Settings screen will appear.



4. Overwrite the existing values with new values in the area below "Write Parameter".

5. Tap/click the [Write] button.

To cancel writing parameter values, tap/click the [Back] button.

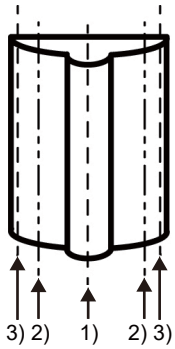
A

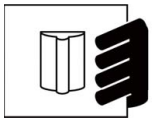
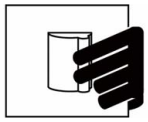
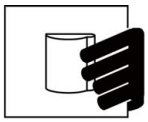
Appendix 2 Teaching pendant

Back of the teaching pendant

No.	Name	Description
1)	Enable switch on the teaching pendant	Enables/disables the operation with the teaching pendant.
2)	EMG.STOP switch (emergency stop)	Stops the robot immediately (turns off the servo power).
3)	STOP key	Decelerates the robot to a stop. Pressing the start button will resume operation. (The servo power will not turn off.)
4)	LCD display panel	Displays the operation status of the teaching pendant.
5)	Status display lamp	Displays the status of the teaching pendant or robot. (Power, enabled/disabled, servo status, error occurrence)
6)	[F1], [F2], [F3], and [F4] keys	Executes the function displayed in the function menu.
7)	FUNCTION key	Switches functions according to the menu. The functions that can be executed are displayed at the bottom of the display.
8)	SERVO key	Pressing this key while holding the enable switch will supply power to the robot servos.
9)	MONITOR key	Switches to monitor mode and displays the monitor menu. Pressing this key again will return to the previous screen.
10)	EXE key	Completes the entry.
11)	RESET key	Clears the current error.
12)	Enable switch*1	3-position switch located on the back. When the teaching pendant is enabled, lightly hold down the switch and establish the servo ON state before performing operations that require the servo ON state such as jog operation and step operation. Additionally, releasing or tightly holding (pressing) this switch during operation (servo ON) will turn off the servo and stop the moving robot immediately. If the servo OFF state is established by an emergency stop or servo OFF, the servos will not be turned on just by holding this switch. Lightly hold this switch again and turn on the servos.

*1 Behavior of the enable switch (3-position switch)



No.	Enable switch position	Enable switch status	Servo ON	Servo status
1)	Position 1 	OFF	Impossible	Servo OFF
2)	Position 2 	ON	Possible	Servo ON Operation possible
3)	Position 3 	OFF	Impossible	Servo OFF

For details, refer to the following manual:

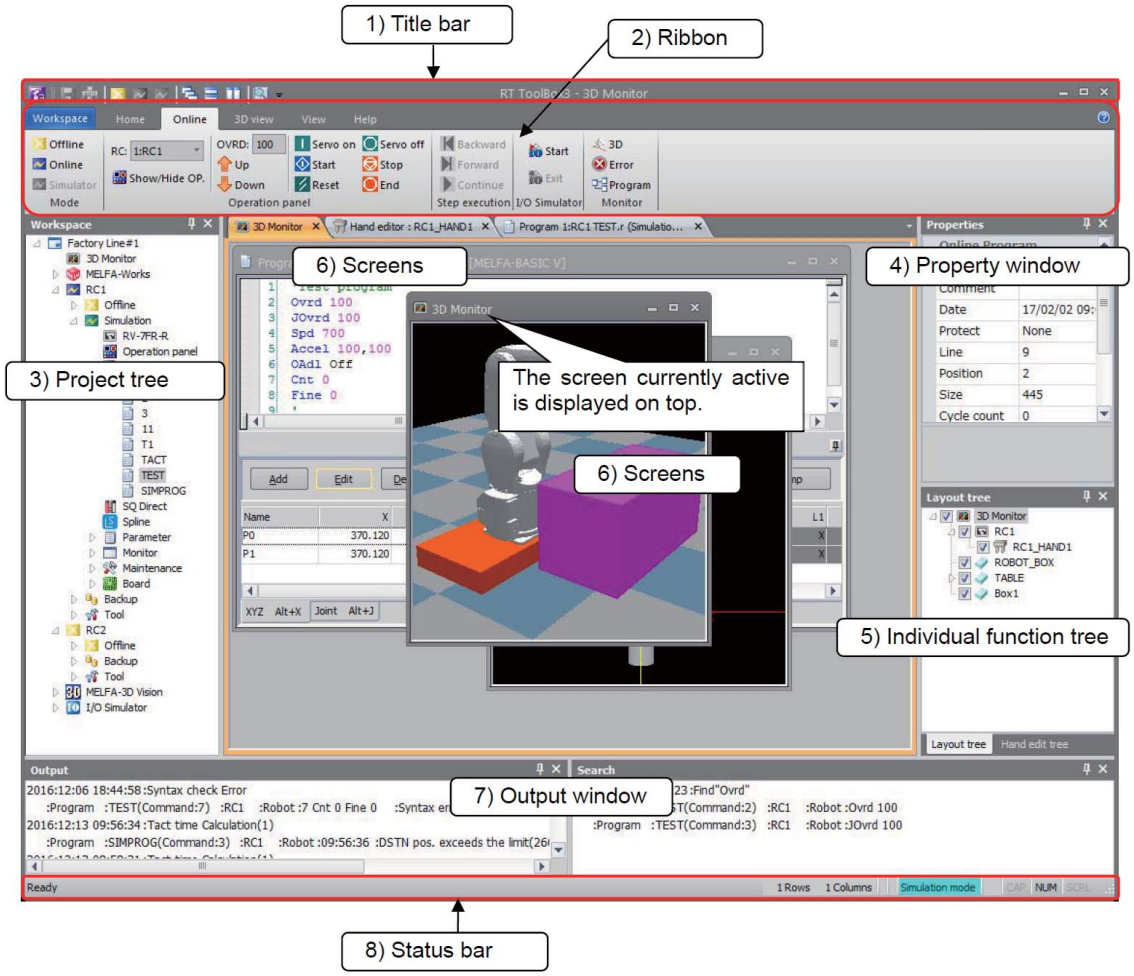
📖Detailed explanations of functions and operations (BFP-A3478)

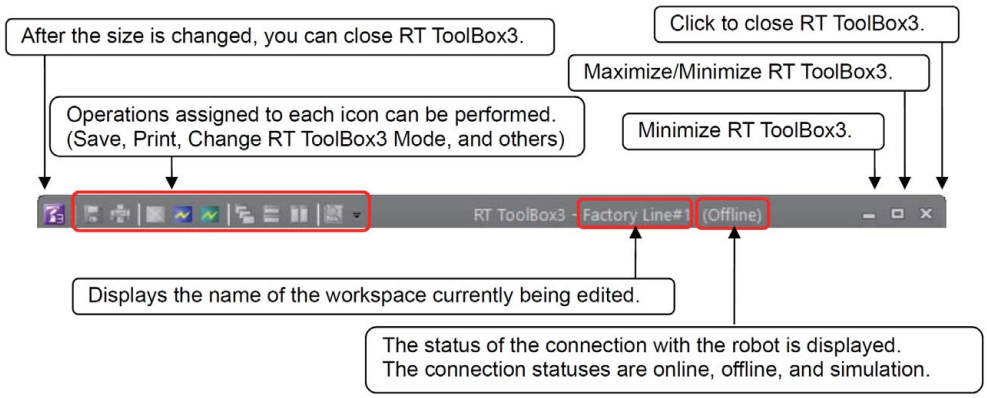
Appendix 3 RT ToolBox3

RT ToolBox3 screen

Main screen

The figure and table below explain the interface of the main screen.

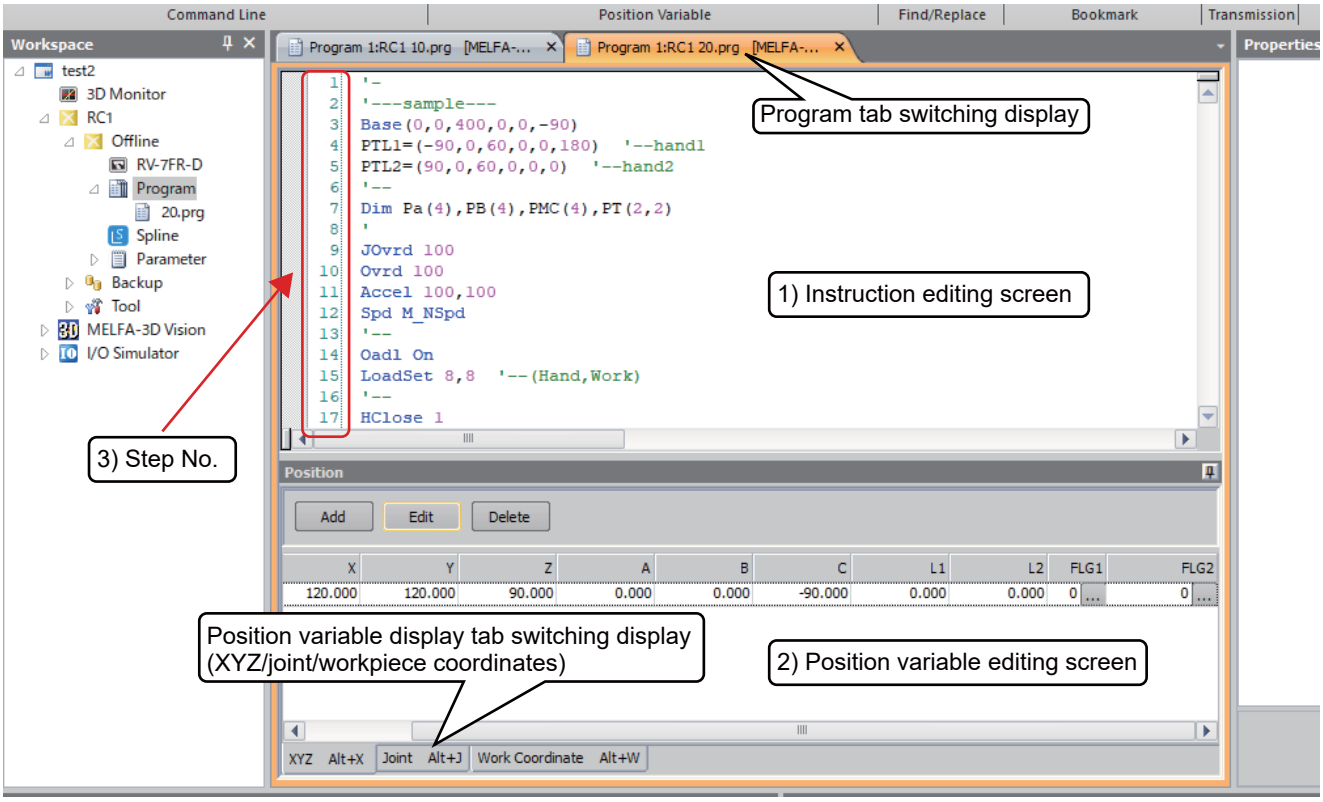


No.	Name	Description
1)	Title bar	Displays the name of the workspace being edited. 
2)	Ribbon	Tabs are grouped for each command type. Clicking a tab will display the list of commands registered in the tab.
3)	Project tree	Lists all the projects registered in the workspace and functions for each project. It can display screens such as the program editing screen and the monitor screen.
4)	Properties window	You can refer to various attributes of the workspace being edited. Clicking an item in the project tree will display the attribute.
5)	Individual function tree	If a specific window, such as the 3D monitor, is displayed, the dedicated tree will appear. If multiple trees are displayed, switching tabs will switch trees displayed.
6)	Each window	Displays the program editing screen, the monitor screen, or other screen that is selected in the project tree. The front-most window is the active window.
7)	Output window	Displays RT ToolBox3 event logs, search results, etc. Event logs such as error details of program syntax checks are displayed in the "Output" window and search results are output in the "Search" window, which enable users to copy the displayed character strings and save the display contents.
8)	Status bar	Displays status information such as RT ToolBox3 modes (offline, online, simulation) and the cursor position in the program being edited.

A

Program editing screen

The upper part of the screen is for instruction editing, and the lower part of the screen is for position variable editing.
Dragging the boundary of the screen with the mouse allows you to change the screen size.



No.	Name	Description
1)	Instruction editing screen	Describe a program. Programs can be input in the same way as a general editor like notepad.
2)	Position variable editing screen	Edit position variables. The screen shows a list of XYZ, joint, and workpiece coordinate variables.
3)	Step No.	At programming, pressing the [Enter] key on the keyboard will number the steps automatically.

For details, refer to the following manual:

📖RT ToolBox3 User's Manual (BFP-A3495)

Appendix 4 Robot language

Collaborative robot operation programs are created by placing program blocks in the order of steps (visual programming) using RT VisualBox. A dedicated programming language called "robot language" has conventionally been used in programs to operate industrial robots for work.
The Mitsubishi Electric industrial robot language "MELFABASIC" has been constructed by adding robot control commands to the BASIC language used widely throughout the world.

Visual programming with program blocks solely can operate robots for various types of work. However, "MELFABASIC" allows you to use many more control commands other than commands available by program blocks.
"MELFABASIC" can be used to program robots for more complex control and work that cannot be achieved only by program blocks.

The following table shows the comparison between visual programming commands and MELFABASIC. For details on "MELFABASIC", refer to the following manual:
📖Detailed explanations of functions and operations (BFP-A3478)

Comparison between visual programming and MELFABASIC

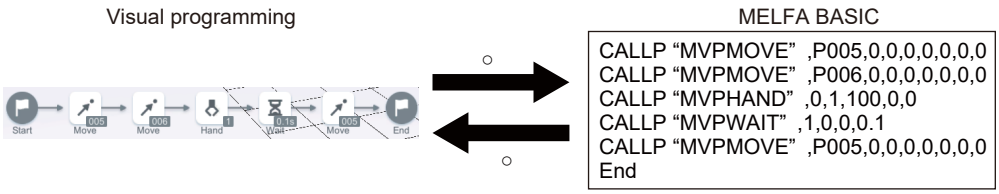
The table below shows the comparison between the commands of RT VisualBox editing programs (visual programs) and MELFABASIC.

Item	Name	Command	Visual programming	MELFABASIC
Movement	Joint interpolation	Mov	○	○
	Linear interpolation	Mvs	○	○
	Circular interpolation	Mvr, Mvc, etc.	×	○
	Arch command	Mva	×	○
	Spline movement	MvSpl	×	○
	Ex-T control	EMov, EMvs, etc.	×	○
	Appended statement	Wth/WthIf	×	○
	Mxt control	Mxt	×	○
	JRC command	Jrc	×	○
	Continuous operation	Cnt	×	○
	Acceleration/deceleration time	Accel	○	○
	Override settings	Ovrd/Jovrd	△*1	○
	Speed settings	Spd	○	○
	Target position arrival check	Fine/FineJ/FineP	×	○
Program control	Conditional branch	IFThenElse	○	○
	Repeat	ForNext/While	○	○
	Unconditional branch	Goto	×	○
	Subroutine	GosubReturn	×	○
	Program call	CallP	×	○
	Wait	Wait	○*2	○
	Timer	Dly	○	○
	Stop	Hlt	○	○
	Label	*	×	○

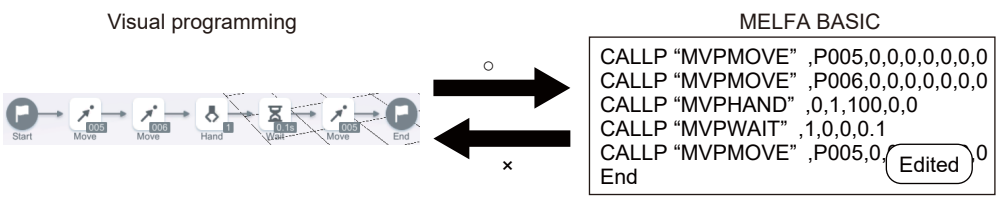
Item	Name	Command	Visual programming	MELFABASIC
Defined instruction	Pallet operation	DefPlt/Plt	○	○
	Tool/base switching	Tool/Base	×	○
	Frame conversion	Fram	×	○
	Zone command	Zone, etc.	×	○
	Interrupt	DefAct/Act	×	○
	Function	Function	×	○
	Library	Include	×	○
	GPS function	DefGps/DefMap	×	○
	Workpiece coordinate system	—	×	○
I/O, communication	Hand	HOpen/Hclose	△*3	○
	Signal input	M_In*()	△*4	○
	Signal output	M_Out*()	△*5	○
	Communication	Open/Close/Print/Input	×	○
Variable, function	Numerical variable	—	○	○
	Position variable	—	○	○
	Joint variable	—	×	○
	Character string variable	—	×	○
	I/O variable	—	×	○
	Array variable	—	×	○
	Program external variable	—	△*6	○
	User-defined external variable	—	×	○
	Robot state variable	—	△*6	○
	User-defined function	DefFN/FN	×	○
	Built-in function	—	×	○
Calculation	Data calculation	+/-, etc.	△*7	○
Multi-tasking	Multi-tasking	Xload/Xrun/XStp/XRst	×	○
	Mechanism control right	GetM/RlsM	×	○

*1 Only Ovrd is available.
*2 Only signal input waiting is available.
*3 Only hand 1 is available.
*4 Only M_In() is available. Signal numbers 0 to 63 and 900 to 907 are available.
*5 Only M_Out() is available. Signal numbers 0 to 63 and 900 to 907 are available.
*6 Only non-array numerical variables are available.
*7 Numerical variable initialization, increment, and decrement are available.

Programs created using visual programming are transferred to MELFABASIC and stored in the robot controller.



Visual programs can be edited with RT ToolBox3. However, it is not guaranteed that the edited programs can be used in RT VisualBox.



For details, refer to the following manual:

📖Detailed explanations of functions and operations (BFP-A3478)

Appendix 5 Daily inspection

The following shows what inspections should be performed on the robot arm.

Daily inspection

This section explains the procedure of daily inspections and what inspections should be performed. If any abnormalities are found, take appropriate countermeasures.

Robot

■Daily inspection items

• Before turning on the power (Check the following inspection items before turning on the power.)

Procedure	Inspection items (details)	Remedies
1	Are any of the robot installation bolts loose? (Visual inspection)	Securely tighten the bolts.
2	Are any of the cover tightening screws loose? (Visual inspection)	Securely tighten the screws.
3	Are any of the hand installation screws loose? (Visual inspection)	Securely tighten the screws.
4	Is the power cable securely connected? (Visual inspection)	Securely connect it.
5	Is the machine cable between the robot arm and controller securely connected? (Visual inspection)	Securely connect it.
6	Is the robot cracked, is any foreign matter adhered, or is there any interference?	Replace with a new part, or take remedial measures.
7	Is there any abnormality in the pneumatic system? Are there any air leaks, drain clogging or hose damage? Is the air source normal? (Visual inspection)	Perform draining, or remedy the air leaks (replace the part).

• After turning on the power (Turn on the power while monitoring the robot.)

Procedure	Inspection items (details)	Remedies
1	Is there any abnormal movement or noise when the power is turned on?	Refer to "Troubleshooting" for remedies.
2	Before using the robot, check that the STR function is operating properly. With the robot stopped and the servos in the ON state, check that the STO function turns the servos off when force is applied to the robot arm.	Contact the manufacturer.
3	Operate the robot at an override speed of 10% or more for roughly 30 seconds. Then check to see if the error "H0216 (Current sensor failure)" has not occurred. After that, check that the robot is detecting collision forces properly.	Contact the manufacturer.

• During operation (Move the robot with your program.)

Procedure	Inspection items (details)	Remedies
1	Check that the operation point is not deviated. If deviated, check the following items. • Are any of the installation bolts loose? • Are the bolts in the hand installation section loose? • Is the position of the jigs (other than the robot) deviated? • If the positional deviation cannot be eliminated, refer to the manual shown below to check and troubleshoot the issue. 📖Troubleshooting (BFP-A3480)	Refer to "Troubleshooting" for remedies.
2	Is there any abnormal movement or noise? (Visual inspection)	Refer to "Troubleshooting" for remedies.

A

Robot controller

■Daily inspection items

• Before turning on the power (Check the following inspection items before turning on the power.)

Procedure	Inspection items (details)	Remedies
1	Is the power cable securely connected? (Visual inspection)	Securely connect it.
2	Is the machine cable between the robot arm and controller securely connected? (Visual inspection)	Securely connect it.
3	Is the RIO cable between the controller and the safety extension unit securely connected? (Visual inspection)	Securely connect it.
4	Is the cover cracked, is any foreign matter adhered, or is there any interference?	Replace with a new part, or take remedial measures.

• After turning on the power (Turn on the power while monitoring the robot.)

Procedure	Inspection items (details)	Remedies
1	Is there any abnormal movement or noise when the power is turned on?	Refer to "Troubleshooting" for remedies.

• During operation (Move the robot with your program.)

Procedure	Inspection items (details)	Remedies
1	Check that the operation point is not deviated. If deviated, check the following items. • Are any of the installation bolts loose? • Are the bolts in the hand installation section loose? • Is the position of the jigs (other than the robot) deviated? • If the positional deviation cannot be eliminated, refer to the manual shown below to check and troubleshoot the issue. 📖Troubleshooting (BFP-A3480)	Refer to "Troubleshooting" for remedies.
2	Is there any abnormal movement or noise? (Visual inspection)	Refer to "Troubleshooting" for remedies.

Periodic inspection

Robot

■Periodic inspection items

• Monthly inspection

Procedure	Inspection items (details)	Remedies
1	Are any of the bolts or screws on the robot arm loose?	Securely tighten the bolts and screws.
2	Are any of the connector fixing screws or terminal block terminal screws loose?	Securely tighten the screws.

Robot controller

■Periodic inspection items

• Monthly inspection

Procedure	Inspection items (details)	Remedies
1	Are any of the connector fixing screws or terminal block terminal screws loose?	Securely tighten the screws.
2	Is the controller filter dirty?	Clean or replace with a new part. For details on inspection, cleaning, and replacement, refer to the following manual: 📖Robot Arm Setup and Maintenance (BFP-A3729)

Appendix 6 Frequently used parameters

Parameter	Parameter name	No. of arrays No. of characters	Description	Factory setting
Direct teaching automatic OFF setting	DTTMR	Integer 2	Set the direct teaching automatic OFF function. • Element 1: Enable/disable the automatic OFF function. 0: Disabled, 1: Enabled • Element 2: Time for automatic OFF [sec] Setting range: 1 to 300	1,60
Robot arm moving judgment speed value	DTVTHD	Real number 6	Set the threshold value of the robot arm movement speed to check that the arm is not moved at direct teaching. • Element 1: Threshold of J1 [rpm] Range: 0.00 to 1.00 • Element 2: Threshold of J2 [rpm] Range: 0.00 to 1.00 • Element 3: Threshold of J3 [rpm] Range: 0.00 to 1.00 • Element 4: Threshold of J4 [rpm] Range: 0.00 to 1.00 • Element 5: Threshold of J5 [rpm] Range: 0.00 to 1.00 • Element 6: Threshold of J6 [rpm] Range: 0.00 to 1.00	0.50, 0.50, 0.50, 0.50, 0.50, 1.00
Joint operating range	MEJAR	Real number 16	Specify the overrun limit value for the joint coordinate system. Set the operating range of each axis. It is not recommended to widen the operating range. Doing so may cause the robot to come into contact with the mechanical stopper. <Caution> If the J1 offset angle (J1OFFSET) is set for a vertical 5-axis robot, note that the joint operating range of the J1 axis cannot be changed. Two directions, negative and positive (-J1, +J1, -J2, +J2, ... -J8, +J8), unit: deg	Setting value for each mechanism
XYZ operating range	MEPAR	Real number 6	Specify the overrun limit value for the XYZ coordinate system. The value is used to limit the operating range of the robot in the XYZ coordinate system. Set the value so that the robot installed in a system will not interference with peripherals when the robot is operated manually. Two directions, negative and positive (-X, +X, -Y, +Y, -Z, +Z), unit: mm	(-X, +X, -Y, +Y, -Z, +Z) = -10000, 10000, -10000, 10000, -10000, 10000

Parameter	Parameter name	No. of arrays No. of characters	Description	Factory setting
User-defined area[*1]	Set user-defined areas (32 areas max.) and specify how the robot moves in these areas.			—
	AREA*CS * represents any value from 1 to 32.	Integer 1	Set the coordinate system for the user-defined area *. (* = 1 to 32) 0: World coordinate system (backward compatibility) 1: Base coordinate system	0
	AREA*P1 * represents any value from 1 to 32.	Real number 8	Set the position coordinates of diagonal point 1 in the user-defined area * and posture data and the coordinates of the additional axis. Starting from the first element, X, Y, Z, A, B, C, L1, and L2 are defined in this order. • Components X, Y, and Z: Set the position coordinates of diagonal point 1. (Unit: mm) • Components A, B, and C: Set the posture area. (Unit: deg) • Components L1 and L2: Set the additional axis area. (Unit: mm, deg) <Caution> • Set the values on the coordinate system specified by AREA*CS. • If skipping posture check, set the A, B, and C coordinates to -360. • When using an additional axis, set components L1 and L2. • Even if components X, Y, Z, L1, and L2 set in AREA*P1 are replaced with those set in AREA*P2, the defined area remains the same.	(X, Y, Z, A, B, C, L1, L2) = 0.0, 0.0, 0.0, -360.0, -360.0, -360.0, 0, 0
	AREA*P2 * represents any value from 1 to 32.	Real number 8	Set the position coordinates of diagonal point 2 in the user-defined area * and posture data and the coordinates of the additional axis. Starting from the first element, X, Y, Z, A, B, C, L1, and L2 are defined in this order. • Components X, Y, and Z: Set the position coordinates of diagonal point 2. (Unit: mm) • Components A, B, and C: Set the posture area. (Unit: deg) • Components L1 and L2: Set the additional axis area. (Unit: mm, deg) <Caution> • Set the values on the coordinate system specified by AREA*CS. • If skipping posture check, set the A, B, and C coordinates to +360. • When using an additional axis, set components L1 and L2. • Even if components X, Y, Z, L1, and L2 set in AREA*P2 are replaced with those set in AREA*P1, the defined area remains the same.	(X, Y, Z, A, B, C, L1, L2) = 0.0, 0.0, 0.0, +360.0, +360.0, +360.0, 0, 0
User-defined area[*1]	AREA*ME * represents any value from 1 to 32.	Integer 1	Specify a mechanism number that enables the user-defined area *. Set any number from 1 to 3 for the mechanism number (set 1 normally). 0: Disabled 1: Mechanism 1 (normal setting) 2: Mechanism 2 3: Mechanism 3 (If 0 is set, area check will be skipped.)	0
	AREA*AT * represents any value from 1 to 32.	Integer 1	Specify how the robot moves in a user-defined area. 0: Disabled 1: Signal output (dedicated output/status variable output)[*2] 2: Error output[*2]	0 (disabled)
Free plane limit[*3]	Overrun limit specified with the free plane. A plane is created from the coordinates of three points. The area that does not include the origin is outside the operating range. Up to eight limits can be set with the following three parameters.			—
	SFC*P * represents any value from 1 to 8.	Real number 9	Specify three points to create a plane. X1, Y1, Z1: Origin position on a plane X2, Y2, Z2: Position on the X-axis of the plane X3, Y3, Z3: Position on the X-Y plane of the plane in the +Y direction	(X1, Y1, Z1, X2, Y2, Z2, X3, Y3, Z3) = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
	SFC*ME * represents any value from 1 to 8.	Integer 1	Specify a mechanism number that enables the free plane limit. Set any number from 1 to 3 for the mechanism number (set 1 normally).	0
	SFC*AT * represents any value from 1 to 8.	Integer 1	Specify whether to enable or disable the set free plane limit. 0: Disabled (initial value) 1: Enabled (The area including the robot coordinate origin is the operating range.) -1: Enabled (The area that does not include the robot coordinate origin is the operating range.)	0 (disabled)

Parameter	Parameter name	No. of arrays No. of characters	Description	Factory setting
Safe position	JSAFE	Real number 8	Specify a safe position. Execute Mov P_SAFE using the robot program or input the external SAFEPOS signal to move the robot to a safe position. (J1, J2, J3, J4, J5, J6, J7, J8), unit: deg	The setting varies depending on the model.
Standard tool coordinate*4	MEXTL	Real number 6	Set initial values for the relationship between the tip of the hand (tool center point) and the mechanical interface (hand installation surface). The mechanical interface is set to the tool center point from the factory. When a hand is installed, the tool center point can be changed to the tip of the hand. (During XYZ or TOOL jog operation, the tip of the hand can be used for posture control.) (X, Y, Z, A, B, C), unit: mm for XYZ, deg for ABC	(X, Y, Z, A, B, C) = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
Hand and workpiece conditions (used for optimum acceleration/ deceleration and collision detection)*5	Set the hand and workpiece conditions when Oadl is on in the program. Up to eight conditions can be set. Combinations of the conditions can be selected using the LoadSet command. <Caution> Set the hand and workpiece conditions correctly. If a value lower than the actual load is set, the life of robot mechanical parts may be shortened.			—
	HNDDAT0	Real number 7	Set the initial hand condition. (The condition is specified in the tool coordinate system.) These setting values are applied immediately after the power turns on. To use the impact detection function during jog operation, set the actual hand condition beforehand. Otherwise, false detection may occur. (Weight, size X, size Y, size Z, center of gravity X, center of gravity Y, center of gravity Z), unit: Kg, mm	The setting varies depending on the model.
	HNDDAT* * represents any value from 1 to 8.	Real number 7	Set hand conditions. (The conditions are specified in the tool coordinate system.) (Weight, size X, size Y, size Z, center of gravity X, center of gravity Y, center of gravity Z), unit: Kg, mm	Standard load , 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
	WRKDAT0	Real number 7	Set initial workpiece conditions. (The conditions are specified in the tool coordinate system.) This setting value is applied immediately after the power turns on. (Weight, size X, size Y, size Z, center of gravity X, center of gravity Y, center of gravity Z), unit: Kg, mm	0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
	WRKDAT* * represents any value from 1 to 8.	Real number 7	Set workpiece conditions. (The conditions are specified in the tool coordinate system.) (Weight, size X, size Y, size Z, center of gravity X, center of gravity Y, center of gravity Z), unit: Kg, mm	0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
	HNDHOLD* * represents any value from 1 to 8.	Integer 2	Specify whether or not to grasp a workpiece when HOPEN* or HCLOSE* is executed. (Settings at OPEN, settings at CLOSE) (Not grasped/grasped = 0/1)	0, 1

*1 For details on the user-defined area, refer to the following manual:
Detailed explanations of functions and operations (BFP-A3478)

*2 The following table shows the settings of signal output and error output.

Setting	Inside	Outside
Signal output	Dedicated output signal ON System status variable (M_Uar32, M_Uar)	Dedicated output signal OFF
	Corresponding bit of the status variable ON Set the signal number of the dedicated I/O using USRAREA.	Corresponding bit of the status variable OFF
Error output	Stopped by error output (when H2090 occurs)	—

Note: If error output is selected, only the position area check is performed, ignoring the posture area check and the additional axis area check.

*3 For details on the free plane limit, refer to the following manual:
Detailed explanations of functions and operations (BFP-A3478)

*4 For details on the standard tool coordinate, refer to the following manual:
Detailed explanations of functions and operations (BFP-A3478)

*5 For details on the hand and workpiece conditions, refer to the following manual:
Detailed explanations of functions and operations (BFP-A3478)

Appendix 7 Dedicated I/O

The dedicated I/O signals have the functions shown in the table below.
The dedicated I/O signals are used with the parallel I/O unit by assigning signal numbers to parameters.
To assign signal numbers, specify them in the "input signal" and "output signal" of each parameter in this order.
For information on how to set the parameters, refer to the following manual:
📖Detailed explanations of functions and operations (BFP-A3478)
If -1 is specified in the number of the signal to be assigned, the signal will not be used.
The I/O parameters can be set on the parameter screen of the teaching pendant or with the maintenance tool of the computer supported software (option). Refer to the following manual for examples of signal timing charts.
📖Detailed explanations of functions and operations (BFP-A3478)
The dedicated input signal is enabled when the robot controller mode is "AUTOMATIC" and the operation rights input signal (IOENA) is ON.

Parameter name	Category	Name	Function	Signal level*1	Signal number at the factory setting
RCREADY	Input	—	—	—	-1 (No meaning)
	Output	Robot controller turned ON	Indicates that external input signals can be received after the power has turned on.	—	-1
ATEXTMD	Input	—	—	—	-1 (No meaning)
	Output	Remote mode output	Indicates that the controller mode is "AUTOMATIC". It is remote mode. This signal must be turned on before performing any control tasks using external signals.	—	-1
TEACHMD	Input	—	—	—	-1 (No meaning)
	Output	Teaching mode output	Indicates that the robot controller mode is "MANUAL".	—	-1
ATTOPMD	Input	—	—	—	-1 (No meaning)
	Output	Automatic mode output	Indicates that the controller mode is "AUTOMATIC".	—	-1
IOENA	Input	Operation rights input signal	Sets the validity of the operation rights for the external signal control.	Level	5
	Output	Operation rights output signal	Outputs the operation rights valid state for the external signal control. The operation rights are given to external signals when the robot controller mode is set to "AUTOMATIC", the operation rights input signal is ON, and no other devices have the operation rights.	—	3
START (operation rights required)	Input	Start input	Runs the program. To run the specified program, select the program using program selection signal "PRGSEL" and numerical input "IODATA", then input the start signal. However, enabling parameter "PST" will read the program number from the numerical input (IODATA), and run the program. (Program selection is not required.) During multi-task operation, all task slots are executed. However, slots for which the start condition is set to ALWAYS or ERROR using parameter "SLT**" are not executed.	Edge	3
	Output	Operating output	Indicates that a program is currently running. During multi-task operation, this signal turns ON when at least one task slot is operating. However, the signal does not turn ON for slots for which the start condition is set to ALWAYS or ERROR using parameter "SLT*".	—	0

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Parameter name	Category	Name	Function	Signal level[*1]	Signal number at the factory setting
STOP	Input	Stop input	Stops the program that is currently running. (This signal function is not applied for slots for which the start condition is set to ALWAYS or ERROR.) Stop input is set to input number 0, and cannot be changed from the number. During multi-task operation, all task slots are stopped. However, slots for which the start condition is set to ALWAYS or ERROR using parameter "SLT**" are not stopped. Parameter INB can be used to switch between NO contact and NC contact.	Level	0 (unchangeable)
	Output	Operation suspended output	Indicates that the program is paused. During multi-task operation, this signal turns ON when no slots are operating and at least one slot is paused. However, the signal does not turn ON for slots for which the start condition is set to ALWAYS or ERROR using parameter "SLT**".	—	-1
STOP2	Input	Stop input	Stops the program that is currently running. (Specifications are the same as those of the STOP parameter.) Unlike the STOP parameter, the signal number can be changed.	Level	-1
	Output	Operation suspended output	Indicates that the program is paused. (Specifications are the same as those of the STOP parameter.)	—	
STOPSTS	Input	—	—	—	-1 (No meaning)
	Output	Stop signal is input	Indicates that the stop signal is input. (It is logical add of all devices.)	—	-1
SLOTINIT (Operation rights required)	Input	Program reset	Cancels the suspended state of the program and returns the execution line to the beginning. Resetting the program makes it possible to select a program. During multi-task operation, the program is reset in all task slots. However, the program is not reset in slots for which the start condition is set to ALWAYS or ERROR using parameter "SLT**".	Edge	-1
	Output	Program selection enabled output	Indicates that a program can be selected. This signal turns ON when the program is not being executed or paused. During multi-task operation, this signal turns ON when all task slots are not operating or paused. However, the signal does not turn ON for slots for which the start condition is set to ALWAYS or ERROR using parameter "SLT**".	—	
ERRRESET	Input	Error reset input signal	Releases the error state.	Edge	2
	Output	Error occurring output signal	Indicates that an error has occurred.	—	
SRVON (Operation rights required)	Input	Servo ON input signal	Powers on the robot servos. For multiple mechanisms, it powers on the servos of all the mechanisms.	Edge	4
	Output	In servo ON output signal	Turns ON when the robot servo is powered on. It turns OFF when the servo is powered off. For multiple mechanisms, it turns ON when at least one of the mechanisms is in the servo ON state.	—	1
SRVOFF	Input	Servo OFF input signal	Powers off the robot servos. (This applies to all the mechanisms.) The servo ON state cannot be established while this signal is being input.	Level	1
	Output	Servo ON disabled output signal	Indicates that the servo power supply cannot be turned on. (Echo back)	—	-1
AUTOENA	Input	Automatic operation enabled input	Disables automatic operation in inactive state. If this signal is inactive and the robot is in AUTOMATIC mode, the low-level error L5010 will occur. This is used to interlock operations from the operation panel with external signals. It is not mandatory to use this signal.	Level	-1
	Output	Automatic operation enabled output	Outputs the automatic operation enabled state.	—	

Parameter name	Category	Name	Function	Signal level[*1]	Signal number at the factory setting
CYCLE	Input	Cycle stop input signal	Starts the cycle stop.	Edge	-1
	Output	In cycle stop operation output signal	Indicates that the cycle stop is operating. It turns OFF when the cycle stop is completed.	—	
MELOCK (Operation rights required)	Input	Machine lock input signal	Sets/releases the machine lock state for all mechanisms. Setting/releasing is available when all slots are in the program selection enabled state. In the program selection enabled state, the signal level will be Level.	Level	-1
	Output	Machine locking output signal	Outputs that the machine is locked. It turns ON when at least one of the mechanisms is in the machine lock state. When the machine is locked, the robot does not operate, and program operation is possible.	—	
SAFEPOS (Operation rights required)	Input	Safe position return input signal	Requests the operation to return to the safe position. Joint interpolation is performed to move the robot to the position set using the parameter "JSAFE". The speed depends on the override. Prevent interference with the peripheral devices.	Edge	-1
	Output	Safe position returning output signal	Indicates that the operation to return to the safe position is executing.	—	
BATERR	Input	—	—	—	-1
	Output	Battery voltage low	Indicates that the controller battery voltage is low. After the battery is replaced, powering off and on the robot controller will turn off the output. It is output even in the following condition: • The cumulative power off time of the robot controller exceeds 14600 hours. The output turns off when the battery consumption time is initialized.	—	
OUTRESET (Operation rights required)	Input	General-purpose output signal reset	Resets the general-purpose output signal. The operation at the input is set using the parameters ORST0 to ORS18160.	Edge	-1
	Output	—	—	—	-1 (No meaning)
HLVLERR	Input	—	—	—	-1 (No meaning)
	Output	High-level error output signal	Indicates that a high-level error has occurred.	—	-1
LLVLERR	Input	—	—	—	-1 (No meaning)
	Output	Low-level error output signal	Indicates that a low-level error has occurred.	—	-1
CLVLERR	Input	—	—	—	-1 (No meaning)
	Output	Warning level error output signal	Indicates that a warning level error has occurred.	—	-1
EMGERR	Input	—	—	—	-1 (No meaning)
	Output	Emergency stop output signal	Indicates that an emergency stop has occurred. [EMGERR output condition] • External emergency stop error: H0050, H0051 (Dual line error) • Operation panel emergency stop error: H0060, H0061 (Dual line error) • Teaching pendant emergency stop error: H0070, H0071 (Dual line error) • Door switch error: H0039, H0040 (Dual line error) • EMGIN connector wiring error: H0141	—	-1
SnSTART (n = 1 to 32) (Operation rights required)	Input	Slot n start input	Starts each slot. n = 1 to 32	Edge	-1
	Output	Slot n operating output	Outputs the operating state for each slot. n = 1 to 32	—	
SnSTOP (n = 1 to 32)	Input	Slot n stop input	Stops each slot. n = 1 to 32	Level	-1
	Output	Slot n operation suspended output	Indicates that each slot is temporarily stopped, and program operation is suspended. n = 1 to 32	—	

Parameter name	Category	Name	Function	Signal level[*1]	Signal number at the factory setting
MnSRVOFF (n = 1 to 3)	Input	Mechanism n servo OFF input signal	Turns off the servo for each mechanism. n = 1 to 3 The servo ON state cannot be established while this signal is being input.	Level	-1
	Output	Mechanism n servo ON disabled output signal	Outputs the servo ON disabled state. (Echo back)	—	
MnSRVON (n = 1 to 3) (Operation rights required)	Input	Mechanism n servo input signal	Turns on the servo for each mechanism. n = 1 to 3	Edge	-1
	Output	Mechanism n in servo output signal	Outputs the servo ON state. n = 1 to 3	—	
MnMELOCK (n = 1 to 3) (Operation rights required)	Input	Mechanism n machine lock input signal	Sets/releases the machine lock state for each mechanism. n = 1 to 3	Edge	-1
	Output	Mechanism n machine locking output signal	Indicates that the machine is locked. n = 1 to 3	—	
BRKLOCK	Input	Brake lock input	Turns ON when the brake is locked during servo ON. This applies to all the brake axes.	Level	-1
	Output	Brake locking output	Turns ON when brake lock input is on.	—	
PRGSEL (Operation rights required)	Input	Program selection input signal	Specifies the setting value for the program No. with numeric value input signals. Select a program for slot 1. Output this signal after 15 ms or more after the output to the numerical input (IODATA). This signal should also be output to the robot for at least 15 ms.	Edge	-1
	Output	—	—	—	
OVRDSEL (Operation rights required)	Input	Override selection input signal	Sets the value for the override with numeric value input signals. Output this signal after 15 ms or more after the output to the numerical input (IODATA). This signal should also be output to the robot for at least 15 ms.	Edge	-1
	Output	—	—	—	
IODATA	Input	Numerical input (start bit No., end bit No.)	Reads the following as a binary value. • Program number (read by PRGSEL). When parameter "PST" is enabled, it is read by the start signal. • Override (read by OVRDSEL). The bit width can be set arbitrarily. However, the value is not guaranteed when the output value exceeds the predetermined bit width. Output this input to the robot for at least 15 ms before inputting the PRGSEL or other setting signals.	Level	-1 (start bit), -1 (end bit)[*2]
	Output	Numerical output (start bit No., end bit No.)	Outputs the following as a binary value. • Program number (output with PRGOUT) • Override (output with OVRDOUT) • Line number (output with LINEOUT) • Error number (output with ERROUT) The bit width can be set arbitrarily. However, the value is not guaranteed when the output value exceeds the predetermined bit width. Read this signal after 15 ms or more after the input of the program number (PRGOUT) or other signals to the robot.	—	
PRGOUT	Input	Program No. output request	Outputs the program number for task slot 1 to the numerical output (IODATA). Read the numerical output (IODATA) signal after 15 ms or more after the input of this signal to the robot.	Edge	-1
	Output	Program No. output signal	Outputs the "program number output in progress" status to the numerical output.	—	
LINEOUT	Input	Line No. output request	Outputs the line number for task slot 1 to the numerical output (IODATA). Read the numerical output (IODATA) signal after 15 ms or more after the input of this signal to the robot.	Edge	-1
	Output	Line No. output signal	Outputs the "line number output in progress" status to the numerical output.	—	

Parameter name	Category	Name	Function	Signal level[*1]	Signal number at the factory setting
OVRDOUT	Input	Override value output request	Outputs the OP override to the numerical output (IODATA). Read the numerical output (IODATA) signal after 15 ms or more after the input of this signal to the robot.	Edge	-1
	Output	Override value output signal	Outputs the "override output in progress" status to the numerical output.	—	
ERROUT	Input	Error No. output request	Outputs the error number to the numerical output (IODATA). Read the numerical output (IODATA) signal after 15 ms or more after the input of this signal to the robot.	Edge	-1
	Output	Error No. output signal	Outputs the "error number output in progress" status to the numerical output.	—	
JOGENA (Operation rights required)	Input	Jog valid input signal	Performs jog operation for the specified axis in the specified mode. Operation is performed while this signal is ON.	Level	-1
	Output	Jog valid output signal	Performs jog operation for the specified axis in the specified mode. Operation is performed while this signal is ON.	—	
JOGM	Input	Jog mode input (start No., end No.)	Specifies the jog mode. 0/1/2/3/4/5 = joint/XYZ/cylinder/3-axis XYZ/tool/workpiece (Ex-T) CAUTION: For information on EX-T control and Ex-T jog, refer to the following manual: 📖Detailed explanations of functions and operations (BFP-A3478)	Level	-1 (start bit), -1 (end bit)[*3]
	Output	Jog mode output (start No., end No.)	Outputs the current jog mode.	—	
JOGMENO	Input	Jog mechanism number input (start No., end No.)	Specifies a mechanism number. If this parameter is not set, mechanism number is fixed to mechanism 1.	Level	-1 (start bit), -1 (end bit)
	Output	Jog mechanism number output (start No., end No.)	Outputs the current mechanism number.	—	
JOG+	Input	Jog feed plus side for 8-axes (start No., end No.)	Specifies an axis for jog operation. During joint jog: J1, J2, J3, J4, J5, J6, J7, and J8 axes from the start number. During XYZ jog: X, Y, Z, A, B, C, L1 and L2 axes from the start number. During cylinder jog: X, θ, Z, A, B, C, L1 and L2 axes from the start number. During 3-axis XYZ jog: X, Y, Z, J4, J5 and J6 axes from the start number. During tool jog: X, Y, Z, A, B and C axes from the start number. During work jog (Ex-T jog): X, Y, Z, A, B and C axes from the start number. CAUTION: For information on EX-T control and Ex-T jog, refer to the following manual: 📖Detailed explanations of functions and operations (BFP-A3478)	Level	-1[*4]
	Output	—	—	—	
JOG-	Input	Jog feed minus side for 8-axes (start No., end No.)	Specifies an axis for jog operation. During joint jog: J1, J2, J3, J4, J5, J6, J7, and J8 axes from the start number. During XYZ jog: X, Y, Z, A, B, C, L1 and L2 axes from the start number. During cylinder jog: X, θ, Z, A, B, C, L1 and L2 axes from the start number. During 3-axis XYZ jog: X, Y, Z, J4, J5 and J6 axes from the start number. During tool jog: X, Y, Z, A, B and C axes from the start number. During work jog (Ex-T jog): X, Y, Z, A, B and C axes from the start number. CAUTION: For information on EX-T control and Ex-T jog, refer to the following manual: 📖Detailed explanations of functions and operations (BFP-A3478)	Level	-1[*4]
	Output	—	—	—	

Parameter name	Category	Name	Function	Signal level[*1]	Signal number at the factory setting
JOGWKNO	Input	Workpiece coordinate number	Specifies the workpiece coordinate number (Ex-T coordinate number) used as a reference in work jog operation with a numerical value from 1 to 8. CAUTION: This input signal is read by the edge (change from off to on) of the jog valid input signal (JOGENA). To change the workpiece coordinate number, change the jog valid input signal (JOGENA) from off to on once. CAUTION: For information on EX-T control and Ex-T coordinate number, refer to the following manual: 📖Detailed explanations of functions and operations (BFP-A3478)	Level	-1 (start bit), -1 (end bit)[*3]
	Output		Outputs the input workpiece coordinate number (Ex-T coordinate number). CAUTION: For information on EX-T control and Ex-T coordinate number, refer to the following manual: 📖Detailed explanations of functions and operations (BFP-A3478)	—	
JOGNER (Operation rights required)	Input	Error disregard at jog input signal	Temporarily ignores errors that cannot be reset during jog operation. * This signal is only for mechanism 1.	Level	-1
	Output	During error disregard at jog output signal	Indicates that errors are being ignored. * This signal is only for mechanism 1.	—	
HNDCNTLn (n = 1 to 3)	Input	—	—	—	—
	Output	Mechanism n hand output signal status (start No., end No.)	Outputs the status of the hand output (n = 1) 900 to 907. Outputs the status of the hand output (n = 2) 910 to 917. Outputs the status of the hand output (n = 3) 920 to 927. Example) To output four points from 900 to 903 to general-purpose output signals 3, 4, 5, and 6, set the HNDCNTL1 to (3, 6).	—	-1 (start bit), -1 (end bit)
HNDSTSn (n = 1 to 3)	Input	—	—	—	-1,
	Output	Mechanism n hand input signal status (start No., end No.)	Outputs the status of the hand input (n = 1) 900 to 907. Outputs the status of the hand input (n = 2) 910 to 917. Outputs the status of the hand input (n = 3) 920 to 927. Example) To output four points from 900 to 903 to general-purpose output signals 3, 4, 5, and 6, set the HNDSTS1 to (3, 6).	—	-1 (start bit), -1 (end bit)
HANDENA	Input	Hand control permission input	Permits or prohibits control of the robot hand by external signals. 1/0 = permit/prohibit CAUTION: Robot hand control is available during automatic operation. To ensure safety, be sure to interlock the robot with external devices such as a programmable controller. When robot hand control by external signals is permitted, "HOpen/HClose" commands from the program is invalid.	Level	-1
	Output	Hand control permission output	Indicates whether control of the robot hand by external signals is permitted or prohibited. 1/0 = permitted/prohibited When the hand control permission input signal is ON, this signal turns ON when the teaching pendant is not available.	—	
HANDOUT	Input	Hand output control signal	Sets an external input signal range for robot hand control. The input signals set here are associated with the hand signals set in the parameter "HANDTYPE" in order. Element 1: Hand output control signal start No. Element 2: Hand output control signal end No.	—	-1
	Output	—	—	—	—
HNDERRn (n = 1 to 3)	Input	Mechanism n hand error input signal	Requests a hand error occurrence. The low-level error No. 30 will occur.	Level	-1
	Output	Mechanism n hand error output signal	Indicates that a hand error has occurred.	—	
AIRERRn (n = 1 to 5)	Input	Mechanism n pneumatic pressure error input signal	Requests a pneumatic error occurrence. The low-level error No. 31 will occur.	Level	-1
	Output	Mechanism n pneumatic pressure error output signal	Indicates that a pneumatic pressure error has occurred.	—	

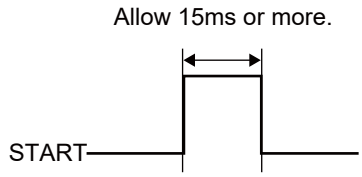
Parameter name	Category	Name	Function	Signal level[*1]	Signal number at the factory setting
USRAREA [*6]	Input	—	—	—	-1 (start bit), -1 (end bit)[*5]
	Output	32 user-defined areas (start No., end No.)	Indicates that the robot is in the user-defined area. The signal is sequentially output for areas 1, 2, and 3 from the start number. The areas are set in parameters AREA1P1, AREA1P2 to AREA32P1, and AREA32P2. Setting example) USRAREA is used as an example here. When using only area 1, USRAREA: 8, 8 → Settings enabled When using areas 1 and 2, USRAREA: 8, 9 → Settings enabled USRAREA: -1, -1 → Settings disabled USRAREA: 8, -1 → Settings disabled (no error) USRAREA: -1, 8 → Settings disabled (no error) USRAREA: 9, 8 → Settings disabled (L6643 error)	—	
MnPTEXC (n = 1 to 3)	Input	—	—	—	-1 (No meaning)
	Output	Maintenance parts replacement time warning	Indicates that a maintenance part has reached the replacement time.	Level	-1
MnWUPENA (n = 1 to 3) (Operation rights required)	Input	Mechanism n warm-up operation mode enable input signal	Enables warm-up operation mode of each mechanism. (n = 1 to 3) CAUTION: To switch to enable or disable warm-up operation mode using this input signal, warm-up operation mode needs to be enabled using a parameter (such as WUPENA) in advance. When warm-up operation mode is disabled using a parameter, the mode cannot be enabled by inputting this input signal.	Level	-1
	Output	Mechanism n warm-up operation mode output signal	Indicates that warm-up operation mode is enabled. (n = 1 to 3)	—	
MnWUPMD (n = 1 to 3)	Input	—	—	—	-1 (No meaning),
	Output	Mechanism n warm-up operation status output signal	Indicates that warm-up operation is performed and the robot operates at a decreased speed. (n = 1 to 3)	—	-1
PSSLOT	Input	Position data output slot number specification	Specifies the target slot number (1 to 32) for position data output. Load the target program in the slot specified here in advance. * The slot number cannot be changed unless the input signal of the parameter "PSOUT" (position data output instruction) is OFF in the external device.	Level	-1 (input start bit), -1 (input end bit), -1 (output start bit), -1 (output end bit) * Maximum 6-bit width for both input and output.
	Output	Position data output slot number output	Outputs (responds) the current target slot number for position data output.		
PSTYPE	Input	Position data type specification	Specifies the type of the target data for position data output. 1/0 = joint type variable/position type variable * The position data type cannot be changed unless the input signal of the parameter "PSOUT" (position data output instruction) is OFF in the external device.	Level	-1
	Output	Position data type output	Outputs (responds) the type of the current target data for position data output. 1/0 = joint type variable/position type variable		
PSNUM	Input	Position data number specification	Specifies the number of the target data (the number of joint type variable/position type variable) for position data output. Range of position data number: 0 to 65535 Example) When P100 is the target data, specify the numerical value "100" between the input start bit and input end bit. CAUTION: A variable whose upper digit is "0" such as "P001" cannot be specified. * The position data number cannot be changed unless the input signal of the parameter "PSOUT" (position data output instruction) is OFF in the external device.	Level	-1 (input start bit), -1 (input end bit), -1 (output start bit), -1 (output end bit) * Maximum 16-bit width for both input and output.
	Output	Position data number output	Outputs (responds) the number of the current target data for position data output. The position number specified for the input signal is output.		

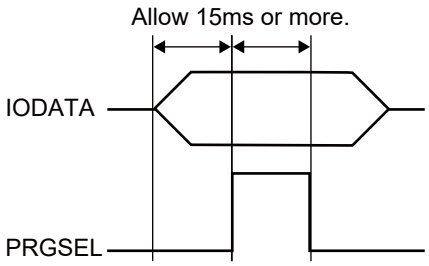
Parameter name	Category	Name	Function	Signal level[*1]	Signal number at the factory setting
PSOUT	Input	Position data output instruction	This is the instruction to output the current target data for position data output. When this signal status changes from off to on (edge), the current target position data is output to the signal number specified in the parameter "PSPOS" (position data output bit area). The data continues to be output while this signal remains ON (level). (Real time update is not performed.) (Edge: updating position data output, Level: keeping output value) 0 → 1: Updating position data output 1: Keeping output state 0: Target position data can be changed	Edge + Level	-1
	Output	Position data being output	Indicates that the specified position data is output. [Output information] OFF: Position data not output ON: Position data being output		
PSPOS	Input	—	—	—	-1 (No meaning)
	Output	Position data output signal area	Specifies the start number of the signal area for position data output. The area requires 320-bit continuous area having coordinate values and configuration flags for eight axes (coordinate values: 32 bits x 8 axes, configuration flags: 32 bits x 2 elements). The range of the setting value is as follows: (1) CR800-R/Q series 10000 to 17872: CPU buffer memory (2) CR800-D series 2000 to 3632: Profibus 6000 to 7728: CC-Link Order of output position data Position type variable: X, Y, Z, A, B, C, L1, L2, FL1, FL2 Joint type variable: J1, J2, J3, J4, J5, J6, J7, J8 Each coordinate value is multiplied by 1000 and output as an integer. (mm, degrees) Multiply the value by 1/1000 for an external device. However, FL1 and FL2 are output as they are. Range of output data Signed integers from -2147483648 to 2147483647 Refer to the following manual and check the time chart and notes. 📖Detailed explanations of functions and operations (BFP-A3478)	—	-1
TMPOUT	Input	Internal temperature output request	Outputs the internal temperature of the robot controller to the numerical output (IODATA). The temperature is output as an integer binary value (binary number). Read the numerical output (IODATA) signal after 15 ms or more after the input of this signal to the robot.	Edge	-1
	Output	Internal temperature being output	Outputs the "temperature output in progress" status to the numerical output.	—	
RSTBAT	Input	Battery cumulative time reset	Resets the battery cumulative time.	—	-1
	Output	Reset completion	Outputs reset completion.	—	
RSTGRS	Input	Maintenance forecast reset (grease)	Resets the grease information of the maintenance forecast. * The axis bit pattern is specified by IODATA or DIODATA.	—	-1
	Output	Reset completion	Outputs reset completion.	—	
RSTBLT	Input	Maintenance forecast reset (belt)	Resets the belt information of the maintenance forecast. * The axis bit pattern is specified by IODATA or DIODATA.	—	-1
	Output	Reset completion	Outputs reset completion.		
SVDATA	Input	—	—	—	-1
	Output	Load ratio data	Outputs the maximum load factor (%) of J1 to J8 axes to the register numbers specified as the third and fourth elements in this parameter. The load factor output is updated in two second intervals. (CC-Link register is supported.)		-1 (start register), -1 (end register)

Parameter name	Category	Name	Function	Signal level*1	Signal number at the factory setting
DOORSTS1	Input	—	—	—	-1
	Output	Door switch 1 status	Outputs the status of the channel 1 of the door switch.		
DOORSTS2	Input	—	—	—	-1
	Output	Door switch 2 status	Outputs the status of the channel 2 of the door switch.		
DOORSTS	Input	—	—	—	-1
	Output	Door switch status	Outputs the logical add of the channels 1 and 2 of the door switch. This signal turns ON only when both channels are ON.	—	
DTON	Input	—	—	—	-1 (No meaning)
	Output	Direct teaching ON state output	Sets the signal that outputs the ON state of direct teaching.	Level	-1
DTMD	Input	—	—	—	-1 (No meaning)
	Output	Direct teaching operation mode output	Sets the start and end numbers of the signal area that outputs direct teaching operation mode. Assigns an operation mode to each bit. 1/0 = Used/Not used ↓Start number 7 0 00000000 | |...bit0: Direct teaching is on (Joint free mode). |.....bit1: Direct teaching is on (Translational mode). All bits are set to "0" when direct teaching is stopped.	Level	-1
SFMODE	Input	—	—	—	-1
	Output	Operation status output signal	Sets the start and end numbers of the signal that outputs the operation status. First element: Reserved for system Second element: Operation status output signal start No. Setting range: -1 to 19999 An error occurs when the output signal area of 3 bits from the signal start number does not exist.	—	6

*1 The signal level has the following meanings.
Level: → The designated function is enabled when the signal is ON, and is disabled when the signal is OFF.
Allow 15 ms or more for the signal ON time.
Edge: → The designated function is enabled when the signal changes from OFF to ON, and the function maintains the original state even when the signal then turns OFF.

Example)





*2 When it is used as the input or output of an actual numeric value, it is indicated as a binary number using the start number to the end number. The start number indicates the lowest bit, and the end number indicates the uppermost bit. Set the bits as much as necessary to indicate numeric values.
For example, when it is used for program selection and only programs 1 to 6 are available, it can be indicated with 3 bits. Up to 16 bits can be set.
The following shows examples of assignment.
Example) When setting the start input signal to general-purpose input 10016 and the operating output signal to general-purpose output 10026:
Parameter START = {10016, 10026}
Example) When setting 4 bits of numerical input to general-purpose inputs 10027 to 10030 and 5 bits of numerical output to general-purpose outputs 10027 to 10031:
Parameter IODATA = {10027, 10030, 10027, 10031}

*3 A numeric value is indicated as a binary number using the start number to the end number. The start number indicates the lowest bit, and the end number indicates the uppermost bit. Set the bits as much as necessary to indicate numeric values.
For example, when using only the joint mode and XYZ mode in the jog mode input (JOGM), set 1 bit.

*4 Order: Input start number, input end number. Specify J1/X axis for the start number. If using J8/L2 axis (maximum number), specify it for the end number. For example, when using a 6-axis robot, set 6 bits.
When using a 4-axis robot in the XYZ mode, set 6 bits since the C axis is required. Up to 8 bits can be set.

*5 Order: Output start number, output end number. Specify area 1 for the start number. If using area 32 (maximum number), specify it for the end number. If using two areas only, set 2 bits. Up to 32 bits can be set.

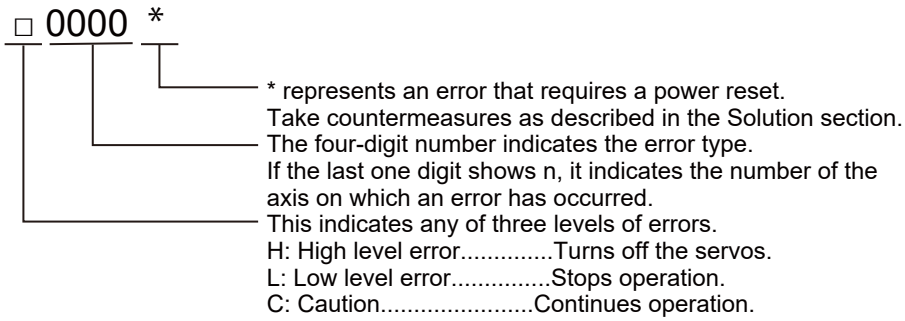
*6 Refer to the following manual for details.
📖Detailed explanations of functions and operations (BFP-A3478)

Appendix 8 Main error codes

The list below shows errors that may occur during this course.
Errors not described in this chapter may occur depending on the conditions and timing of error detection.
For errors not described in the error list, refer to the following manual: 📖CR800 Series Controller INSTRUCTION MANUAL Troubleshooting (BFP-A3480)

Error No.

The error code has the following meanings.



Error code information, causes, and solutions

Error No.	Causes and solutions	
H0046	Error message	Faulty wiring (Mode sel. switch)
	Cause	There are two contacts on the mode selector switch, but only one of the contacts is connected. Or only one contact functions.
	Solution	Check whether there is a problem with the wiring of the mode selector switch. Additionally, check that the two contacts are wired correctly. For information on wiring of the mode selector switch, refer to the following manual: 📖Standard Specifications (BFP-A3727)
H0048	Error message	Faulty line (Mode Selector switch)
	Cause	The state of the duplicated lines of the mode selector switch is inconsistent.
	Solution	If the same error recurs, contact the manufacturer.
H0050	Error message	EMG signal is input. (external)
	Cause	The external emergency stop signal has been input. Alternately, a fuse of the safety unit is blown. This error may occur when a teaching pendant emergency stop command is input.
	Solution	Release the external emergency stop or teaching pendant emergency stop. If the error cannot be cleared, check the wiring of the external emergency stop line. If the same error recurs, contact the manufacturer. For information on wiring of the external emergency stop, refer to the following manual: 📖Standard Specifications (BFP-A3727)
H0051	Error message	Wiring of the external emergency stop is abnormal
	Cause	There are two contacts on the external emergency stop, but only one of the contacts is connected. Or only one contact functions. Or a fuse of the safety unit is blown. This error may occur when a teaching pendant emergency stop command is input.
	Solution	Release the external emergency stop or teaching pendant emergency stop. If the error cannot be cleared, check the wiring of the external emergency stop line. If the same error recurs, contact the manufacturer. For information on wiring of the external emergency stop, refer to the following manual: 📖Standard Specifications (BFP-A3727)
H0061	Error message	EMG line is faulty. (O.Panel)
	Cause	The emergency stop line is not stable.
	Solution	Turn off the power and check whether there is a problem with the wiring of the external emergency stop device. Check whether the device is wired for redundancy. For information on wiring of the external emergency stop, refer to the following manual: 📖Standard Specifications (BFP-A3727) Check the wiring, then turn on the power again.

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Error No.	Causes and solutions	
C0150	Error message	Undefined robot serial number
	Cause	The serial number of the robot arm is not set.
	Solution	Set the serial number of the robot arm. Refer to the following manual for the setting method. 📖Controller Setup and Maintenance (BFP-A3731)
H094n (n indicates the axis number (1 to 8).)	Error message	Overload (over weight 1)
	Cause	Operation with high load has continued for a certain period of time. Effective current of the motor has exceeded the rated value for a certain period of time.
	Solution	Decrease the operating speed, or lengthen the acceleration/deceleration time. Refer to the following manual for detailed explanation of command words ("Accel (Accelerate)", "Ovrd (Override)", and "Spd (Speed)"), robot status variables ("M_SetAdl", "M_LdfAct"), and functions set with parameters ("JADL (Optimum acceleration/deceleration adjustment rate parameter)"). 📖Detailed explanations of functions and operations (BFP-A3478) Check that transferring conditions (hand weight, workpiece weight) are within the specification value. If the same error recurs, contact the manufacturer.
H096n (n indicates the axis number (1 to 8).)	Error message	Excessive error 1
	Cause	The deviation of the position command and actual position has exceeded. This error may occur during emergency stop deceleration.
	Solution	• Check the load weight, robot's pressing, and other factors. Check the connection of power cables (such as machine cables and traveling cables). When the surrounding temperature is low or when operation is started after long term stop, perform warm-up operation at low speed or use the warm-up operation mode. • When the RH-20FRH operates with a fixed acceleration/deceleration while the hand offset (eccentricity) amount is large or when this error occurs during tracking, decrease the acceleration/deceleration time (Accel instruction), operating speed (Ovrd instruction) and other values. For details on instructions, refer to the following manual. (This error may occur during emergency stop deceleration.) 📖Detailed explanations of functions and operations (BFP-A3478) • When this error occurs while the robot operates in compliance mode of the joint coordinate system (Cmp Jnt instruction), increase the setting value of the parameter "CMPJCLL" to suppress this error. Refer to the following manual for detailed explanation of command words ("Cmp Jnt (Compliance Joint)") and movement parameter ("CMPJCLL (Current limit level for Cmp Jnt)"). 📖Detailed explanations of functions and operations (BFP-A3478) This error may have been triggered by the following errors. If this is the case, follow the solutions to each error. H0216: Current sensor failure H221n: STR (ROBOT torque error 2)
H098n (n indicates the axis number (1 to 8).)	Error message	Excessive error 3
	Cause	The deviation of the position command and actual position has exceeded with no current flowing in the motor.
	Solution	Check the connection of power cables (such as machine cables and traveling cables).
H101n (n indicates the axis number (1 to 8).)	Error message	Collision detection
	Cause	A collision of the robot was detected.
	Solution	1) If the robot has stopped by interfering with peripheral devices, move the robot away using jog operation. Depending on the collision degree, the collision detection error may occur again. In such a case, turn on the servo power again and move the robot using jog operation. If the error still occurs, release the brake and move the robot away. 2) If this error occurs when no collision occurs, adjust the collision detection level. If a false detection occurs during automatic operation, increase the value of the corresponding axis in the parameter "COLLVL". If a false detection occurs during jog operation, increase the value of the corresponding axis in the parameter "COLLVLJG". Be careful not to increase the value too much since it lowers the detection sensitivity. In addition, note that a false detection tends to occur due to incorrect settings of parameters "HNDDATn" and "WRKDATn". 3) When the speed overlimit error has occurred at the same time, the torque change due to rapid speed fluctuation may be detected as a collision. Remove other causes of the error and check movement again. 4) In the operation under the low temperature or after the long term stop, the collision detection error may occur since the robot cannot exhibit its performance due to viscosity change of the grease, which is used for lubrication of the drive part. In this case, operate the robot by accustoming at low speed (warm-up) or in the warm-up operation mode.
H112n* (n indicates the axis number (1 to 8).)	Error message	Encoder ABS position data lost
	Cause	The current position data was lost. The voltage of the backup battery of the robot or the additional axis may be low.
	Solution	There may be a problem with the encoder. Please contact the manufacturer. When the robot battery voltage is low, the robot can be operated without replacing the battery by resetting the error and then setting the ABS origin. However, it is recommended to replace the battery at an early stage since this error will occur again when the controller is restarted. For details on the settings of the ABS origin, refer to the following manual: 📖RT VisualBox Instruction Manual (BFP-A3696)

Error No.	Causes and solutions	
C133n (n indicates the axis number (1 to 8).)	Error message	Encoder battery voltage low
	Cause	The battery voltage supplied to the position detector is low.
	Solution	Replace the backup battery. For the replacement method, refer to the following manual: 📖Detailed explanations of functions and operations (BFP-A3478) (Even when this warning has occurred, operation can be performed without any problems unless the controller is restarted. However, if the battery is extremely exhausted, the encoder ABS position data lost error (H112n) may occur when the controller is restarted. It is recommended to replace the battery at an early stage.)
C1700	Error message	Cannot brake operation (EMG)
	Cause	The brake cannot be released during emergency stop input.
	Solution	Perform operation after releasing the emergency stop.
C1710	Error message	Cannot brake operation (SRVON)
	Cause	The brake cannot be operated during servo ON.
	Solution	Perform operation after establishing the servo OFF state.
L182n (n indicates the axis number (1 to 8).)	Error message	Pos. data disagree. Check origin
	Cause	The motor rotated one revolution or more from when the power was turned off until the power was turned on. (An axis that does not have a brake operated, the motor rotated due to external force or vibration during transportation, or the multiple rotation information for encoder holding was deviated.)
	Solution	Check the origin position and set it again as required. If the origin is deviated, set the ABS origin of the axis. For information on the settings of the ABS origin, refer to the following manual: 📖RT VisualBox Instruction Manual (BFP-A3696)
L2000	Error message	The servo is OFF
	Cause	The robot cannot be operated during servo OFF.
	Solution	Turn on the servos, then start operation.
H2090	Error message	In interference zone n. (n indicates the zone number (1 to 32).)
	Cause	The robot attempted to enter the user-defined area.
	Solution	Adjust the position so that the movement target position does not exist in the user-defined area.
H211n (n indicates the plane number (1 to 8).)	Error message	Free plane n overrun
	Cause	The robot attempted to enter outside the plane defined with the free plane n.
	Solution	Adjust the position so that the movement target position exists on the free plane.
H213n (n indicates the axis number (1 to 8).)	Error message	Jn Speed is excessive (command)
	Cause	The speed command of the n axis has exceeded the permissible value. When the robot moves using linear interpolation (or circular interpolation) keeping the speed of the tool center point, the motor needs to be rotated at high speed depending on the motion posture. If a too high speed is specified, the speed command to the motor may exceed the permissible value.
	Solution	Decrease the operating speed of the tool center point using Ovrd command and Spd command. Or change the position to which the robot moves.

Error No.	Causes and solutions	
H220m (m: monitoring plane, area, or axis number (1 to 8))	One of the errors below is detected. Please take measures corresponding to an error message.	
	Error message	SLP (Position error:CMD Plane)
	Cause	The safely-limited position function detected that the position command exceeded the plane limit value.
	Solution	Review the operation of the robot and settings of the related parameters.
	Error message	SLP (Position error:FB Plane)
	Cause	The safely-limited position function detected that the position feedback exceeded the plane limit value.
	Solution	Review the operation of the robot and settings of the related parameters.
	Error message	SLP (Position error:CMD Area)
	Cause	The safely-limited position function detected that the position command exceeded the area limit value.
	Solution	Review the operation of the robot and settings of the related parameters.
	Error message	SLP (Position error:FB Area)
	Cause	The safely-limited position function detected that the position feedback exceeded the area limit value.
	Solution	Review the operation of the robot and settings of the related parameters.
	Error message	SLP (Joint error:CMD)
	Cause	The safely-limited position function detected that the joint command exceeded the operating range limit value.
	Solution	Review the operation of the robot and settings of the related parameters.
	Error message	SLP (Joint error:FB)
	Cause	The safely-limited position function detected that the joint feedback exceeded the operating range limit value.
	Solution	Review the operation of the robot and settings of the related parameters.
H221n (n indicates the axis number (1 to 8).)	Error message	STR (ROBOT torque error)
	Cause	The safe torque range function detected a torque error.
	Solution	The safe torque range function detected a feedback torque exceeding the permissible torque. Remove the cause of the collision. Then check that it is safe to restart the operation before doing so. If the error still occurs, review the operation of the robot and settings such as hand and workpiece settings. The STR function may incorrectly detect faults at low temperatures. To clear this error, warm up the robot using the warm-up operation while the robot is in high-speed operation mode. Warming up an affected joint by releasing its brake and moving it around will also clear this error. The following errors may be triggered if the torque level is close to the limits of the permissible torque range. If any of these errors occur, cycle the controller power and check the robot operation. H0242: Fault in Safety Data (S_CMD) H0242: Fault in Safety Data (S_ALM)
H221n* (n indicates the axis number (1 to 8).)	Error message	STR (ROBOT torque error 2)
	Cause	Excessive torque was detected in the time between when the torque error triggered the robot to stop and when the robot stopped.
	Solution	Torque exceeding the permissible torque was detected while the robot decelerated. Remove the cause of the collision. Then check that it is safe to restart the operation before doing so. If the error still occurs, review the operation of the robot and settings such as the permissible torque and hand load settings. The following errors may also occur in conjunction with this error. Follow the solutions to the errors noted below. H081n: Voltage error at accel/decel (n: axis number) H0117: 12V power supply error (brake) H096n: Excessive error 1 This error cannot be reset even in recovery mode.
H2260*	Error message	Safety Unit communication error
	Cause	Communication with the Safety extension unit failed.
	Solution	In order to use the safety monitoring functions, the Safety extension unit (robot safety option) must be connected to the controller. Connect the Safety extension unit to the controller. If the error occurs even when the Safety extension unit is connected, check that the Safety extension unit is powered on. Or check whether pseudo-input mode has been enabled. If none of these solutions rectify the problem, the Safety extension unit may be faulty. Contact Mitsubishi Electric.
H2261*	Error message	Extended safety unit's No. error
	Cause	The station number setting of the Safety extension unit is incorrect.
	Solution	Set the station number of the Safety extension unit to 2.
H2270	Error message	Cannot servo ON (SS1/STO active)
	Cause	The servos cannot be turned ON during stop due to SS1/STO.
	Solution	Disable SS1 and then turn ON the servos.
H2280	Error message	SS1 deceleration time exceeded
	Cause	After SS1 is enabled, the robot did not stop within the deceleration time.
	Solution	Check the robot operation command, the load on the hand, and the parameter for stop speed (SFSPZERO).

Error No.	Causes and solutions	
H2281	Error message	SS2 deceleration time exceeded
	Cause	After SS2 is enabled, the robot did not stop within the deceleration time.
	Solution	Check the robot operation command, the load on the hand, and the parameter for stop speed (SFSPZERO).
H2282	One of the errors below is detected. Please take measures corresponding to an error message.	
	Error message	SOS (Position error)
	Cause	The function detected that position changed during SOS monitoring.
	Solution	The function detected that position feedback changed due to external force during SOS monitoring. Remove the cause of external force or conduct risk assessments. Then adjust the parameter "SOSTLRNC" to extend the permissible range of SOS monitoring.
	Error message	SOS (Speed error)
	Cause	The function detected that speed feedback exceeded the limit during SOS monitoring.
	Solution	Check the related parameters and check that no external force is applied.
	Error message	SOS (Position command error)
	Cause	The function detected that position command changed during SOS monitoring.
	Solution	Review the operation of the robot and settings of the related parameters.
	Error message	SOS (Speed command error)
	Cause	The function detected that speed command exceeded the limit during SOS monitoring.
	Solution	Review the operation of the robot and settings of the related parameters.
H230n (n indicates the axis number (1 to 8).)	Error message	SLS (Joint Speed Error)
	Cause	The speed-limiting safety function detected excessive speed.
	Solution	The speed-limiting safety function detected a speed exceeding the predetermined speed. Review the operation of the robot and the monitoring speed setting. Or, check that the deceleration delay time (parameter "SLSDLY") is long enough.
H231n (n indicates the direction in which the error was detected. 1: Composite speed, 2: X+, 3: X-, 4: Y+, 5: Y-, 6: Z+, 7: Z-)	Error message	SLS (XYZ Speed Error)
	Cause	The speed-limiting safety function detected excessive speed.
	Solution	The speed-limiting safety function detected a speed exceeding the predetermined speed. Review the operation of the robot and the monitoring speed setting. Or, check that the deceleration delay time (parameter "SLSDLY") is long enough.
L2601	Error message	Start pos. exceeds the limit
	Cause	The start position is outside the joint operating range, at a narrow/wide angle, or outside the XYZ operating range.
	Solution	Revise the start position data. For the joint operating range and the XYZ operating range, refer to the parameters [MEJAR] and [MEPAR]. For narrow/wide angles, refer to the following manual: 📖Standard Specifications (BFP-A3468)
L2602	Error message	DSTN pos. exceeds the limit
	Cause	The destination position is outside the joint operating range, at a narrow/wide angle, or outside the XYZ operating range.
	Solution	Revise the destination position data. For the joint operating range and the XYZ operating range, refer to the parameters [MEJAR] and [MEPAR]. For the joint operating range and the XYZ operating range, refer to the parameters [MEJAR] and [MEPAR]. For narrow/wide angles, refer to the following manual: 📖Standard Specifications (BFP-A3468)
L2603	Error message	Med pos. data exceeds the limit
	Cause	The intermediate position is outside the joint operating range, at a narrow/wide angle, or outside the XYZ operating range.
	Solution	Check that the route during linear interpolation or the passing point during circular interpolation is within the operating range. For the joint operating range and the XYZ operating range, refer to the parameters [MEJAR] and [MEPAR]. For narrow/wide angles, refer to the following manual: 📖Standard Specifications (BFP-A3468) Revise the start, intermediate, or destination position data.

Error No.	Causes and solutions	
L2800	Error message	Illegal position data
	Cause	A point that the robot cannot reach when passing the singularity has been set. Or, points that cannot form a circle or circular during circular interpolation have been set.
	Solution	Check the line for which the error has occurred. Check whether the applicable position variable value makes the set position data outside the operating range when the robot passes the singularity. Then revise the position variable value. For circular interpolation command, check that three points can form a circular. Check whether two or three points are the same or whether three points nearly form a line. Then revise the position variable value.
L2801	Error message	Illegal position data (start)
	Cause	The start position has been set to a point that the robot cannot reach.
	Solution	Check the line for which the error has occurred. Check whether the start position value has been set to a point that the robot cannot reach. Then revise the position data.
L2802	Error message	Illegal position data (dstn)
	Cause	The destination position has been set to a point that the robot cannot reach.
	Solution	Check the line for which the error has occurred. Check whether the destination position value has been set to a point that the robot cannot reach. Then revise the position data.
L2803	Error message	Illegal assisting position data (intmed)
	Cause	The route during linear interpolation or the passing point during circular interpolation has been set to a point that the robot cannot reach.
	Solution	Check the line for which the error has occurred. Check whether any points on the route toward the destination position has been set to a point that the robot cannot reach. Then revise the start, intermediate, or destination position.
L2810	Error message	Posture flag is disagree
	Cause	The configuration flags of the start position and destination position are inconsistent.
	Solution	Adjust the position data.
L2920	Error message	Direct teaching is disable
	Cause	The robot cannot be taught directly in manual mode.
	Solution	Reset the error. After switching the mode to AUTOMATIC, teach the robot directly.
L2921	Error message	Can't execute program
	Cause	Programs cannot be executed during direct teaching.
	Solution	Reset the error. After teaching the robot directly, check safety before running a robot program.
L2922	Error message	Can't operate in this posture
	Cause	The robot cannot be moved due to the singular posture.
	Solution	If the robot is taught directly in Translational motion or Rotational motion mode, the arm cannot avoid passing a singularity (where the rotational axes of J4 and J6 align). To continue direct teaching, start the direct teaching function, and operate the robot in Joint free mode. Prevent the arm from passing a singularity using Joint jog operation.
C2923	Error message	Parameter can't be changed
	Cause	Parameters cannot be changed during direct teaching.
	Solution	Parameters cannot be changed during direct teaching. After resetting the error, check that the direct teaching function is OFF, and change parameters again.

Error No.	Causes and solutions	
L2924	One of the errors below is detected. Please take measures corresponding to an error message.	
	Error message	Direct teaching is disable
	Cause	Direct teaching function is not available while force sense control is enabled.
	Solution	Force sense control and the direct teaching function cannot be used together. To teach the robot directly, use the direct run command "Fsc Off" to disable force sense control and then start the direct teaching function.
	Error message	Direct teaching is disable
	Cause	Direct teaching function is not available while compliance control is enabled.
	Solution	Compliance control and the direct teaching function cannot be used together. To teach the robot directly, use the direct run command "Cmp Off" to disable compliance control and then start the direct teaching function.
	Error message	Direct teaching is disable
	Cause	The direct teaching function cannot be started while a stop command is being input.
	Solution	The direct teaching function cannot be started while a stop command is being input. Clear the command.
	Error message	Direct teaching is disable
	Cause	Direct teaching is not available in high-speed operation mode.
	Solution	Direct teaching is not available in high-speed operation mode. Use the function in collaborative operation mode.
	Error message	Direct teaching is disable
	Cause	Direct teaching is not available while SS2 is enabled.
	Solution	Direct teaching is not available while SS2 is being input. Disable SS2.
	Error message	Direct teaching is disable
	Cause	Direct teaching is not available while vibration suppression mode is activated.
	Solution	Direct teaching is not available while vibration suppression mode (MvTune4) is activated. Exit or reset the robot program that is currently running.
H2925*	Error message	Direct teaching System fault
	Cause	The direct teaching function has failed to start or stop.
	Solution	The direct teaching function has failed to start or switch off. Turn on the power again. If the same error recurs, contact the manufacturer.
L3285	Error message	Cannot execute (RUN or WAI)
	Cause	It cannot be executed while the program is being executed or suspended.
	Solution	Reset the program (release the suspended state).
L4130	Error message	Illegal program name
	Cause	The program name includes unusable characters. Or, when the program number is specified by external input signals, the input signal status is 0.
	Solution	Change the program name (numbers and alphabetical characters can be used). Or, check the status of external input signals for program number specification.
L4140	Error message	The program was not found
	Cause	The specified program was not found.
	Solution	Specify a different program or create the specified program.
L4170	Error message	The program is being edited
	Cause	The program is being edited.
	Solution	Close the program being edited.
L4180	Error message	Program is running
	Cause	The program is running.
	Solution	Stop the program.
L4190	Error message	The program is selected
	Cause	The program is preparing to execute. A user base program is selected. Or, the program to be executed is used for a different slot.
	Solution	Reset the program.
L4340	Error message	The variable is not defined
	Cause	The variable has not been defined.
	Solution	Define the variable.
H5000	Error message	TB Enable key is ON
	Cause	The teaching pendant enable key is ON in AUTOMATIC mode.
	Solution	Set the teaching pendant enable key to OFF or select the teaching mode.

Error No.	Causes and solutions	
L5600	Error message	Cannot execute during an error
	Cause	It cannot be executed during an error.
	Solution	Clear the error.
C7500	Error message	No battery voltage (robot)
	Cause	The battery is exhausted.
	Solution	Replace the battery and configure the origin settings. For replacement, contact your nearest Mitsubishi Electric branch or dealer.
C7510	Error message	Battery voltage low (robot)
	Cause	The battery will be exhausted soon.
	Solution	Replace the battery. For replacement, contact your nearest Mitsubishi Electric branch or dealer.

Revisions

*The manual number is on the bottom left of the back cover.

Revision date	*Manual No.	Description
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