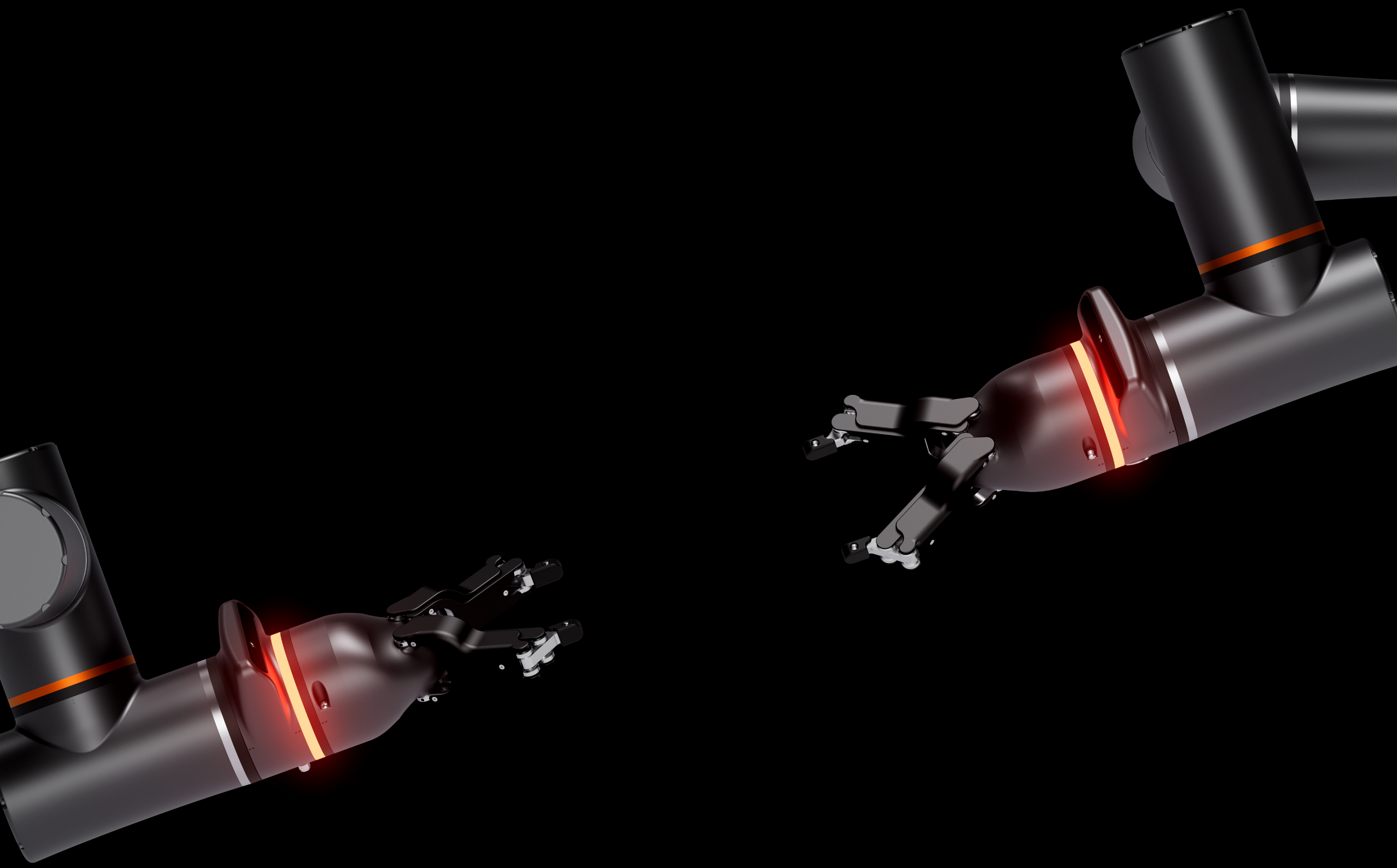
RO1 Collaborative Robot

User Manual



STANDARD BOTS

RO1 User Manual

Standard Bots

Revised October 7, 2024

Table of Contents

Chapter 1

Introduction

1.1 Welcome!

Congratulations on your new RO1 collaborative robot.

At Standard Bots, we believe robots can elevate people's lives — but only if people can use them. We created the RO1 to be an affordable robot that anyone can use, yet is still capable of tackling the toughest, most complex challenges.

This manual is meant to include everything needed to get you up and running. But if you ever need help, we're here to assist!

1.2 Contacting Standard Bots

- **Email:** live-support@standardbots.com
- **Phone:** 1-888-9-ROBOTS
- **Address:** 80 Pratt Oval, Glen Cove, NY, 11542

1.3 Intended Use & Limitations

The Standard Bots RO1 robot and control box are intended to be used in applications where products need to be picked and placed or applications where a repetitive process can be completed with compatible tooling. The RO1 robot and controller are intended to be used within the environmental constraints outlined in this manual. The RO1 robot and controller are intended to be implemented together, the robot is not intended to be used with any other controller and the controller is not intended to be used with any other robot.

The RO1 robot provides various safety settings and measures that, when implemented correctly and evaluated with a risk assessment, allow the robot to work in an unguarded collaborative environment in close proximity to humans.

The RO1 robot is not designed to work in applications outside the bounds of this manual and any implementation violating the indented use shall be deemed misuse. These applications include but are not limited to:

- Medical applications
- Applications in an explosive environment
- Applications where ingress protection above IP54 is required
- Applications with improper safety integration or where a risk assessment has not been created and evaluated
- Applications requiring a high degree of food safety

Standard Bots expressly denies any liability or expressed or implied warranty claims arising from intentional or unintentional misuse.

1.4 Warnings & Risks

1.4.1 Introduction

This manual is not a comprehensive guide to designing and installing a robot cell. This manual does not cover the selection and integration of 3rd party components that may be required to complete a safe installation. The solution must be designed according to the standards provided by the governing body in the country where the solution will be installed. Standard Bots is not responsible for ensuring the installation of the robot meets the standards for any given installation. The integrator assumes all responsibility for ensuring the robot installation meets all applicable standards and safety guidelines.

1.4.2 Installation

- Make sure to install the robot and all electrical equipment according to requirements and specifications in this manual (see Chapter 2).
- The RO1 control box should only be connected to secure networks.

- **Risk Assessment**: The RO1 is provided as a partially completed machinery. As such, the robot should only be used as part of a cell after a comprehensive risk assessment has taken place.
  - Aside from the robot itself, such a risk assessment may consider the robot's payload, pinching hazards, any toxic or hazardous substances in the cell, and risks involved with sharp end effectors.
  - Risk assessments must cover the entire scope of the integration, including components provided by other suppliers.
  - The risk assessment will help determine any speed or force limits to set up on the robot and what safety accessories (like light curtains or area scanners) can be used. These settings are covered in Chapter 4.
  - Anti-gravity (hand-guided) mode should only be used if risk assessment approves its use.

  - Refer to ISO 10218-2 and ISO/TS 15066 for comprehensive guidelines.
- Only trained, instructed, and otherwise qualified personnel may conduct cleaning, maintenance and repair of the robot.

1.4.3 Operator Safety

- Always ensure that the robot is well-maintained and in good mechanical condition before operating it. Always inspect it before use.
- Don't wear jewelry or loose clothing when working with the RO1. Tie back any long hair.
- Never open the control box cabinet door during operation. Never feed wires through the door; feed them through the rubber slot on the bottom of the box.
- Don't expose the robot to strong magnetic fields. This may damage the robot or cause malfunctions.
- Depending on other noise in the environment where the robot is used, hearing protection may be required.
- Never attempt to make any repairs, adjustments, or inspections while the robot is running.
- Operators should stay alert and focused when operating the robot. Avoid distractions and keep attention on the task at hand.

1.4.4 Cybersecurity

The Standard Bots RO1 is able to connect to both wired and wireless internet in order to facilitate remote access, troubleshooting and software updates. It is imperative to follow best cybersecurity practices, as you would with any industrial device capable of being accessed online.

1. Secure communication: Make sure the communication channels used by your robot are encrypted and secure, so that unauthorized individuals cannot access the robot's data or control its actions.
2. Strong passwords: Set strong passwords for your robot's user accounts and ensure that they are changed regularly. Use a password manager to help you create and manage secure passwords.
3. Regular updates: Keep your robot's software and firmware up-to-date, as updates often contain security patches that address vulnerabilities.
4. Physical security: Ensure that physical access to the robot and tablet is restricted, and that the robot is stored in a secure location when not in use.
5. Network security: Keep your robot on a separate network or VLAN, and restrict access to that network to only authorized users.
6. Regular testing: Conduct regular security testing to identify any vulnerabilities and ensure that your robot is secure.

By following these best practices, you can help ensure the security of your robot and protect it from potential cybersecurity threats.

Chapter 2

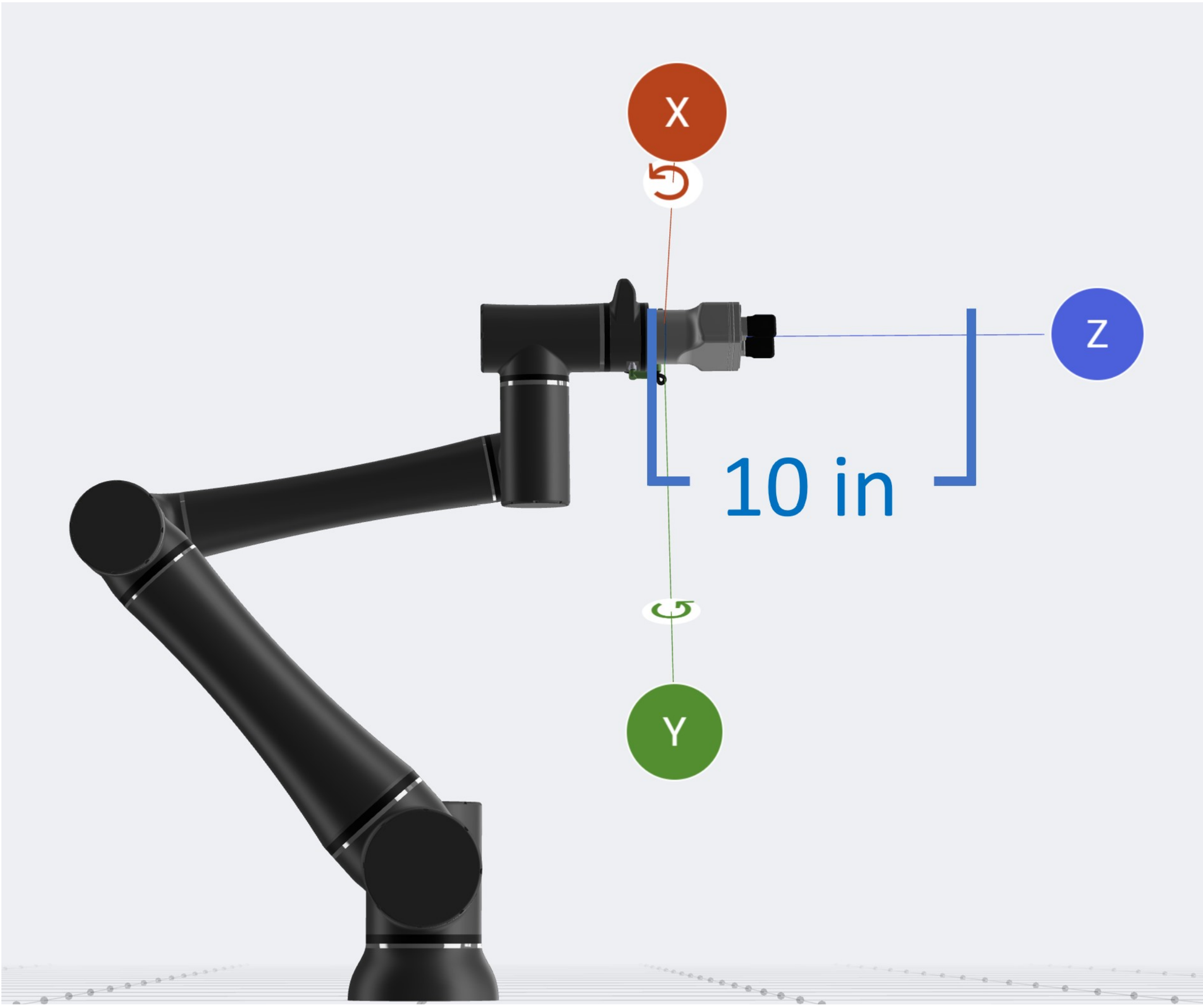
Hardware Overview

2.1 Arm

2.1.1 Overview

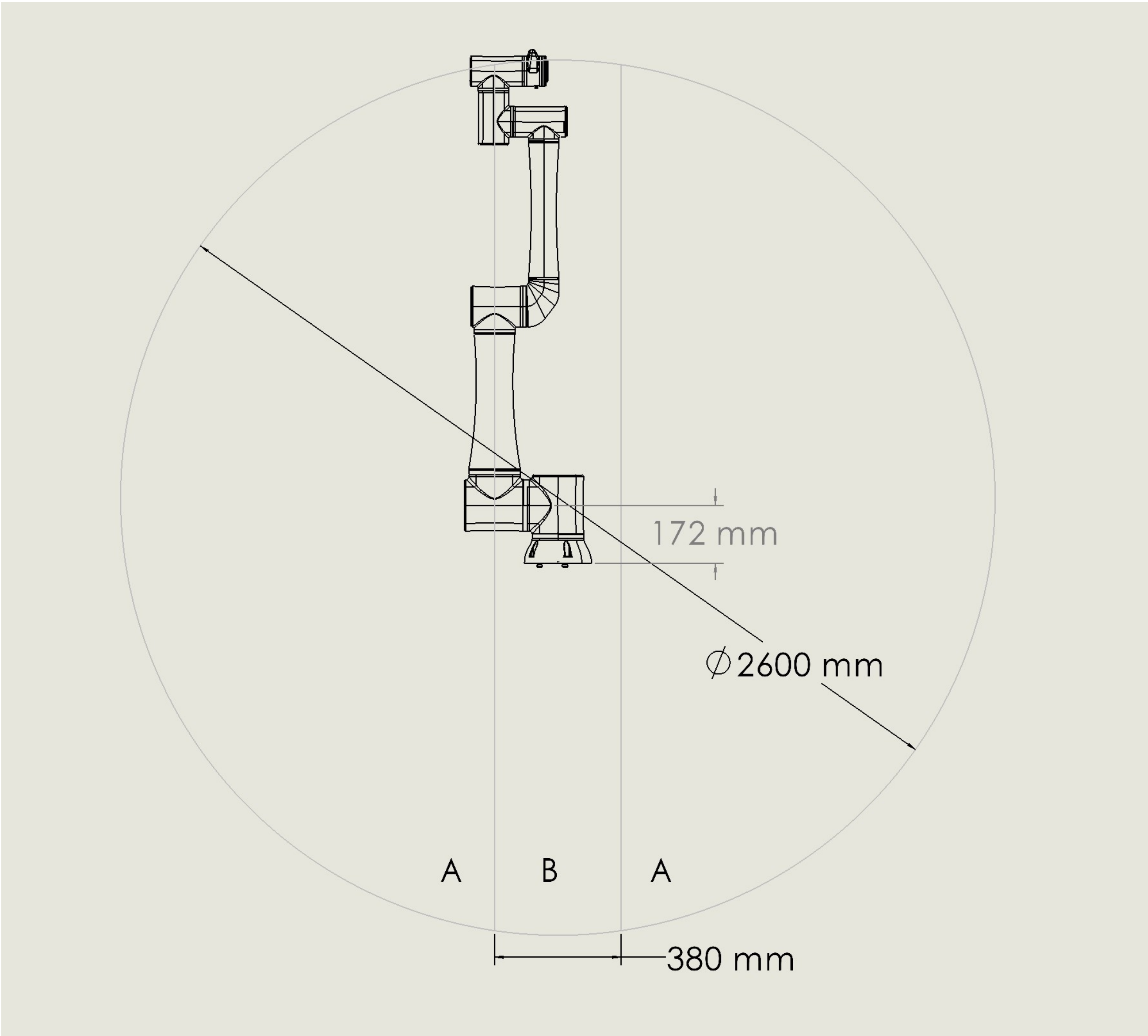
The RO1's arm contains 6 joints connected by a CAN bus. Each joint has two encoders, two different methods to sense torque, and fail-safe brakes that provide emergency braking torque when power is removed from the arm.

2.1.2 Payload



The RO1 robot can support a maximum of 18kg (39lbs) of payload with a center of mass at 10 in (254mm) straight off the face of the tool flange as shown above. Total payload must include EOAT and any other equipment attached to the robot.

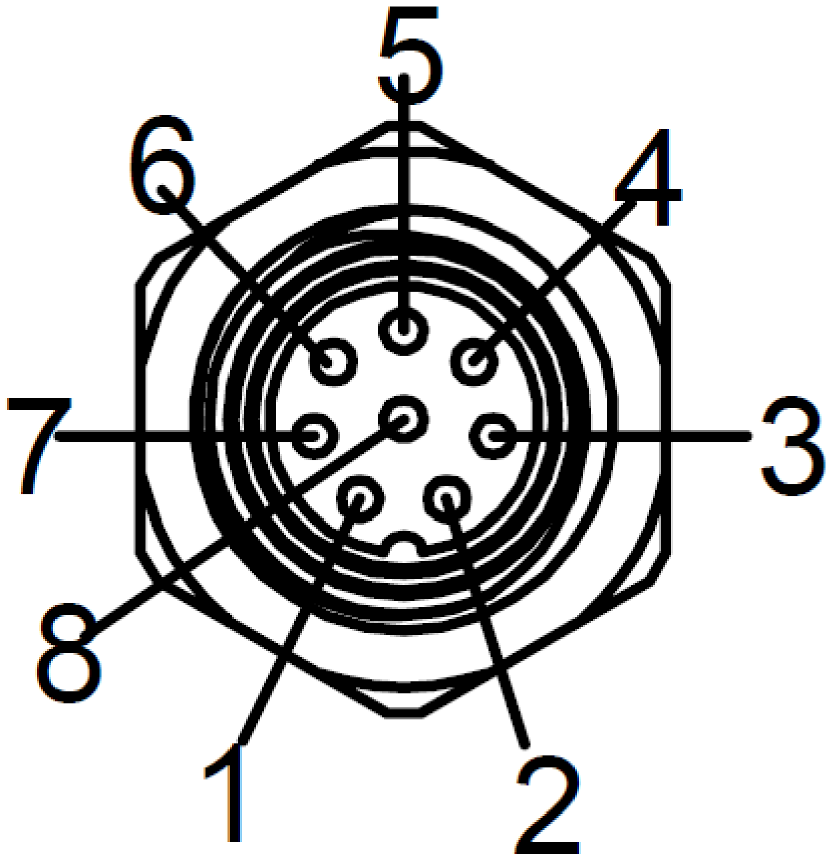
2.1.3 Reach



The RO1 robot can reach 1300 mm (51 in) in a radius from the center of the base (A). There is a radius from the center base of 190 mm (7.5 in) (B) where the robot cannot reach due to it's structure. Tools added to the robot end of arm will impact the reach of the robot.

2.1.4 Tool Flange Pinout

The current limit on the 24V DC line of the flange is 3 amps. The flange is capable of PNP or NPN operation and is auto switching. The pinout at the end of the Tool Flange is laid out as shown:



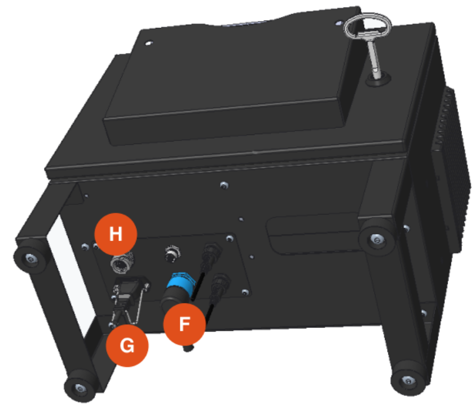
Pin #	Output
1	RS485+
2	RS485-
3	DIG IN 1
4	DIG IN 0
5	POWER 24V
6	DIG OUT 1
7	DIG OUT 0
8	GND

2.1.5 LED Colors

The robot end of arm has an LED status light for assisting in determining the robot status. The color codes are as follows:

Robot State	Color
Idle or Paused	Solid Green
Bootup / Startup	Color Cycle
Full Speed (above collaborative threshold in Safety Settings)	Yellow Ring Pattern
Reduced Speed (below collaborative threshold in Safety Settings)	Solid Yellow
Antigravity Mode	Solid Blue
Firmware Update	White Ring Pattern
Recoverable Error	Red Pulsing
Fatal Error	Braked

2.2 Control Box

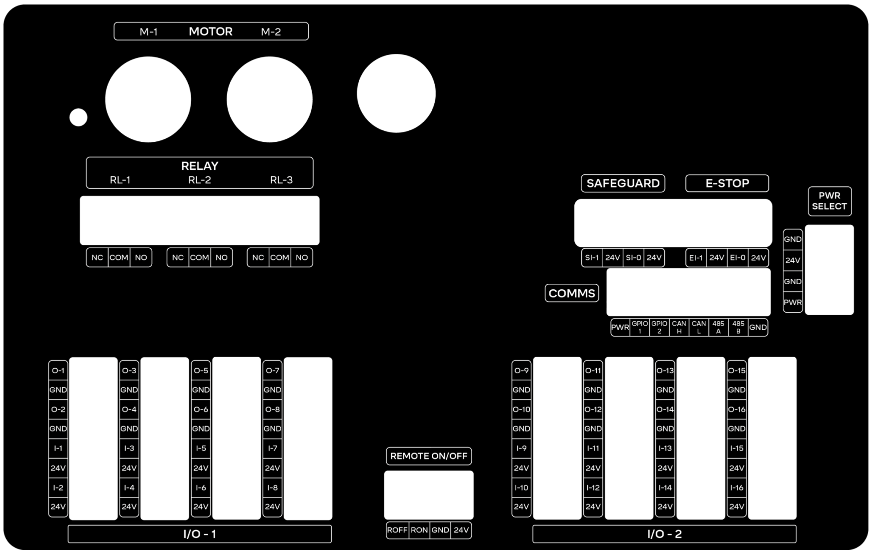


There are several features to note on the control box:

Item	Name	Description
A	**E-Stop**	Pressing the E-stop button initiates an emergency (category 1) stop, cutting power to the arm. Twist the button to reset it.
B	**Handle**	
C	**Button Controls**	Play, Pause, and Programmable button (unused)
D	**Bluetooth & Wi-Fi Antennae**	The R01 ships with two antennas that can be screwed into the top to give the control box access to Bluetooth and Wi-Fi. Bluetooth is used to pair the tablet.
E	**Lock & Key**	The RO1 includes a key that can be used to lock the control box door.
F	**Arm data + power connection**	This links the control box to the arm. Power to the arm runs at 48V
G	**Power**	The control box accepts 120V through a power supply module already certified to IEC 62368-1 and FCC EMI limits.
H	**Ethernet** (RJ45)	This can be used to communicate with other devices in the cell, or to the tablet for programming.

2.2.1 Front Panel

Inside the front panel are many ports that can be used to connect the robot to other equipment in the cell:



Section	Port Labels	Description
I/O - 1 and **2**	DI, 24V, GND	This section includes 16 24V I/O ports which can be used to control other equipment in the cell. They are also safety-rated and can be used in pairs to activate safety functions of the robot via the Safety I/O feature.
Relay	RL-1, RL-2, RL3	The relays can be closed to form a circuit and can be used to control equipment in the cell.
Safeguard	-	Unsupported.
E-Stop	-	This can be hooked up to an external E-stop button. When the input is low, it will force the robot to stop. If no external E-stop button is in use, these ports should have jumpers installed.
Motor:	M-1, M-2	Unsupported.
Remote On/Off	ROFF, RON, GND, 24V	Unsupported.
Comms	PWR, GPIO 1+2, CAN H, CAN L, 485 A, 485B	Unsupported. Future software will enable communication with other equipment in cell over serial ports.

2.3 Specs

Performance	
Power consumption	Depends on program and payload
Collaboration operation	Speed & force limiting per ISO/TS 15066, collision detection, and other safety features
Ambient temperature range	0-55°C
Humidity	90%RH (non-condensing)

Specification	
Payload capacity	18kg (39 lbs)
Reach	1.3m (51.2 in)
Max joint speed	435° /s
Degrees of freedom	6 degrees

Physical	
Footprint	Ø 200 mm
Materials	Aluminum, steel, plastic
Tool connector type	M8 8-pin & M8 4-pin
Cable length, robot arm	2m (79 in)
Weight, including cable	32.5 kg (71.6 lbs)

Features	
IP classification	IP54
Noise	Depends on program; typically less than 58dB
Robot mounting	Floor mount
I/O ports	Digital In: 2 (24V tolerant, 1A max open-drain), Digital Out: 2, Analog In: 2 (24V tolerant), Analog Out: None RS-485 / UART Max data rate: 10mbps
I/O power supply in tool	12V/24V, 3A continuous max

Control Box	
IP classification	IP54

IP class clean-room | N/A

Control Box	
Ambient temperature range	0-55°C
I/O ports	Digital In: 16 (24V Tolerant), Digital Out: 16 (24V 0.7A Out continuous), Analog In: 4 (24V Tolerant), Analog Out: 2 (Current: 0-20mA; Voltage: 0-10V)
I/O power supply	24V, 3A max continuous
Communication	24V I/O, RS-485 (UART / Modbus), USB 2.0, USB 3.0, TCP/IP, Ethernet/IP
Power source	90 ~ 264VAC, 47-63Hz
Humidity	90%RH (non-condensing)
Control box size (WxHxD)	330 mm x 460 mm x 350 mm (13.0 in x 18.1 in x 13.8 in) optional legs add 120mm (4.7 in) to height
Weight	14.4kg (31.7 lbs)
Materials	Powder-coated steel

Movement	
Repeatability	+/- 0.025 mm
Shoulder 1 & 2	Working range: ±360°, Maximum speed: ±287°/sec
Elbow	Working range: ±360°, Maximum speed: ±335°/sec
Wrist 1, 2 & 3	Working range: ±360°, Maximum speed: ±435°/sec
Typical TCP speed	1 m/sec (39.4 in/sec)

2.4 Hazardous Energy

2.4.1 Overview

Stored energy is a potential source of danger in many industrial settings. When energy is stored in machines or equipment, it can cause serious injury or death if it is released unexpectedly. This type of hazard is commonly known as hazardous stored energy, and it can take many forms, including electrical, hydraulic, pneumatic, chemical, and mechanical energy.

Some common examples of hazardous stored energy include:

- A compressed air cylinder that has not been properly vented before maintenance or repair work is performed
- A hydraulic cylinder that has not been properly locked out before maintenance or repair work is performed
- A battery that is still connected to a piece of equipment, even though the equipment has been shut down
- A piece of machinery that is still moving, even though the power has been turned off

To protect workers from hazardous stored energy, it is important to follow proper lockout/tag-out procedures. Lockout/tag-out procedures involve shutting off the energy source, isolating the equipment, and securing it with a lock or tag to prevent accidental startup. Before any maintenance or repair work is performed on equipment, workers should always verify that the equipment is properly locked out/tagged out.

/pagebreak

Additionally, workers should receive proper training on lockout/tag-out procedures and the potential hazards associated with hazardous stored energy. They should understand the importance of following these procedures to prevent injuries and fatalities. Employers should also regularly review and update their lockout/tag-out procedures to ensure that they are effective and up-to-date with the latest safety standards.

Remember, hazardous stored energy can be deadly if not properly controlled. By following proper lockout/tag-out procedures and receiving proper training, workers can stay safe on the job and prevent accidents from occurring. /pagebreak

2.4.2 Hazardous Energy in Standard Bots System

Several types of stored energy can exist in a system utilizing a Standard Bots robot:

Electrical: The Standard Bots control box utilizes 120 VAC power as a primary means of power. The control box utilizes electrical devices such as capacitors which store electrical energy even after the control box has been unplugged from the power source. There are no serviceable parts inside Standard Bots control box and it should not be opened except by trained Standard Bots Employees.

Additionally, the Standard Bots RO1 robot also contains capacitors to store electrical energy. The robot should not be opened except by Standard Bots personnel. In some cases it may be required to open the joint caps of the robot. This should only be done after the control box power source has been unplugged for at least 2 minutes, and should only be done while following explicit instructions from Standard Bots personnel.

Mechanical: The Standard Bots RO1 is capable of lifting 39 lbs (18kg). If the robot is stopped mid cycle and currently has a workpiece in the end of arm tool, a hazard will be present as the workpiece could unexpectedly fall if the source providing the clamping force is de-energized. Always exercise caution and remove the workpiece from the end of arm tool when approaching the robot.

Pneumatic: The RO1 is compatible with a variety of pneumatic accessories. Stored energy exists in the form of compressed air in pneumatic systems. Bodily or hearing injury can occur from accidentally releasing compressed air from pneumatic systems while performing maintenance. Unexpected motion can occur from components when working on energized pneumatic systems. All compressed air should be removed from the system before performing maintenance on any pneumatic system.

2.4.3 Performing a Lockout

Should a lockout of the Standard Bots RO1 be required, unplug the AC input cord and use a plug lockout with appropriate lock. Follow all standard lockout tag-out procedures.

If applicable, also lock out any compressed air sources to devices integrated with the RO1 using standard lockout tag-out procedures.

2.5 Anti-Gravity Mode

The RO1 has functionality allowing the user to move the robot to a desired position by manually moving the physical robot instead of jogging the robot with the pendant.

When Anti-Gravity mode is engaged, the robot will compensate for its own weight and set payload to maintain its position without the brakes applied. Additionally, the robot will sense external feedback from the user moving the robot and assist with moving in the desired direction. Provided the payload is set correctly, the robot will move with minimal force applied by the user.

The procedure for using the anti-gravity mode is as follows:

1. Ensure you have the desired tooling connected to the robot.
2. Navigate to the Move Robot view on the user interface.
3. If the robot brakes are not currently applied, click the hexagon icon in the bottom right, then select the "Brake Robot" button.
4. Set the payload to the current payload.
5. Save the payload.
6. Click "Unbrake Robot".
7. Depress the raised button on the end of the robot arm:

8. Gently manually maneuver the robot into the desired position while depressing the button.
9. In the "Move Robot" view, go to the Space area in the bottom left menu. The icon is a square.
10. Click the plus button to add a position.
11. Give the position a name.
12. Click "Set" to set the position to the current robot position.

The current robot position is now saved and ready to be used in the routine.

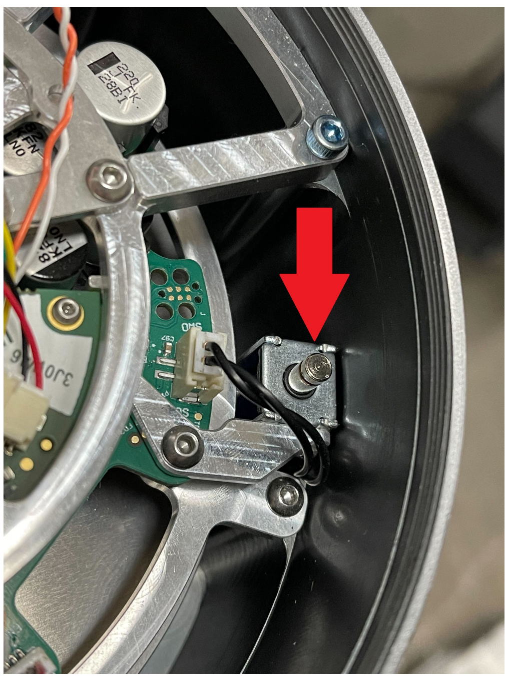
2.6 Movement Without Drive Power

Do not attempt to move the RO1 robot without drive power unless instructed by Standard Bots personnel, otherwise damage could occur.

The RO1 is a collaborative robot, and is designed to work in environments alongside humans. As such, under normal circumstances moving the robot without drive power is not required. Should the robot position need to be changed, simply use pendant to jog the robot into the required position.

Should you be instructed to move the robot without drive power by Standard Bots personnel, the below procedure can be used on each joint individually to adjust the robot position:

1. Unplug the robot.
2. Remove the cover on either Joint 0 or Joint 1 (bottom 2 joints, shown in attached image) by twisting it off.
3. Press the brake release button (shown in below image) and hold down while moving joint.



4. Move the robot away from the collision a short distance.
5. Release brake button.
6. Replace joint cap.
7. Plug the robot back in.
8. Confirm proper robot operation.

Chapter 3

Assembly & Setup

3.1 Requirements

The RO1 has the following utilities requirements:

Utility	Requirement
Electrical	90 ~ 264VAC, 47-63Hz, 15 A maximum at 120VAC.
Internet	Wi-Fi or RJ45 (Ethernet) wired connection for remote updates and support.
Floor	200 PSI capacity rating. Depending on application a floor capable of supporting lagging may be required.

3.2 Lifting the RO1

Proper lifting techniques should be observed when lifting the RO1 robot or controller. Improper lifting can cause strains, sprains, and other serious injuries to the back, neck, shoulders, and other parts of the body.

To lift properly, start by standing close to the object with your feet shoulder-width apart. Bend at the knees and keep your back straight as you lift with your legs, not your back. Hold the object close to your body and avoid twisting your body while lifting or carrying the object. If the object is too heavy, ask for help or use equipment such as a dolly or forklift.

Remember to always warm up before lifting and take breaks when necessary to avoid fatigue. It's also important to wear appropriate clothing and footwear that provides adequate support.

By following these guidelines and using proper lifting techniques, you can reduce your risk of injury and stay safe while handling heavy objects.

3.3 Setting Up the Caster Base

To watch a video to accompany the steps below, go to https://youtu.be/Zv5V01DnnQM.

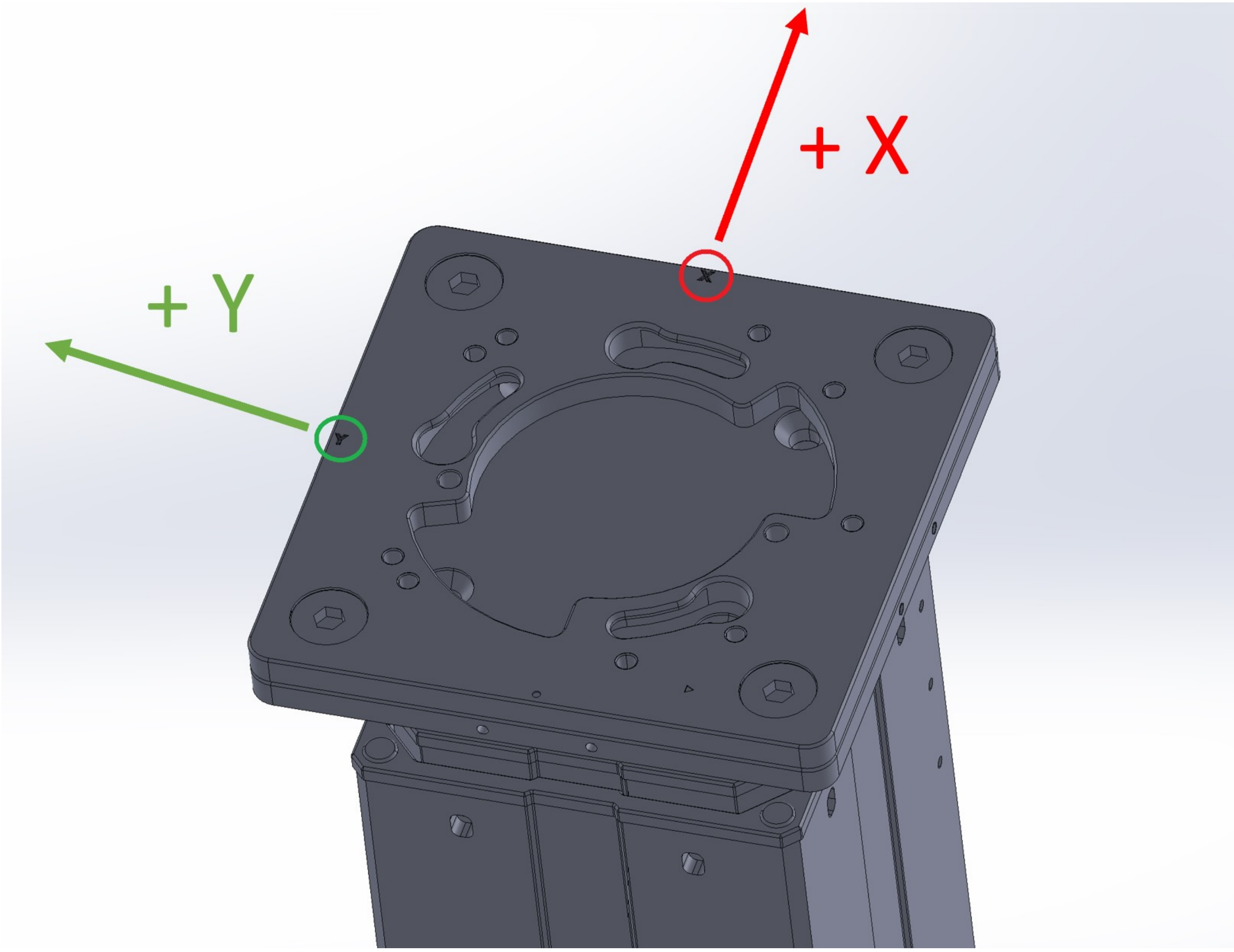
To assemble and set up the caster base:

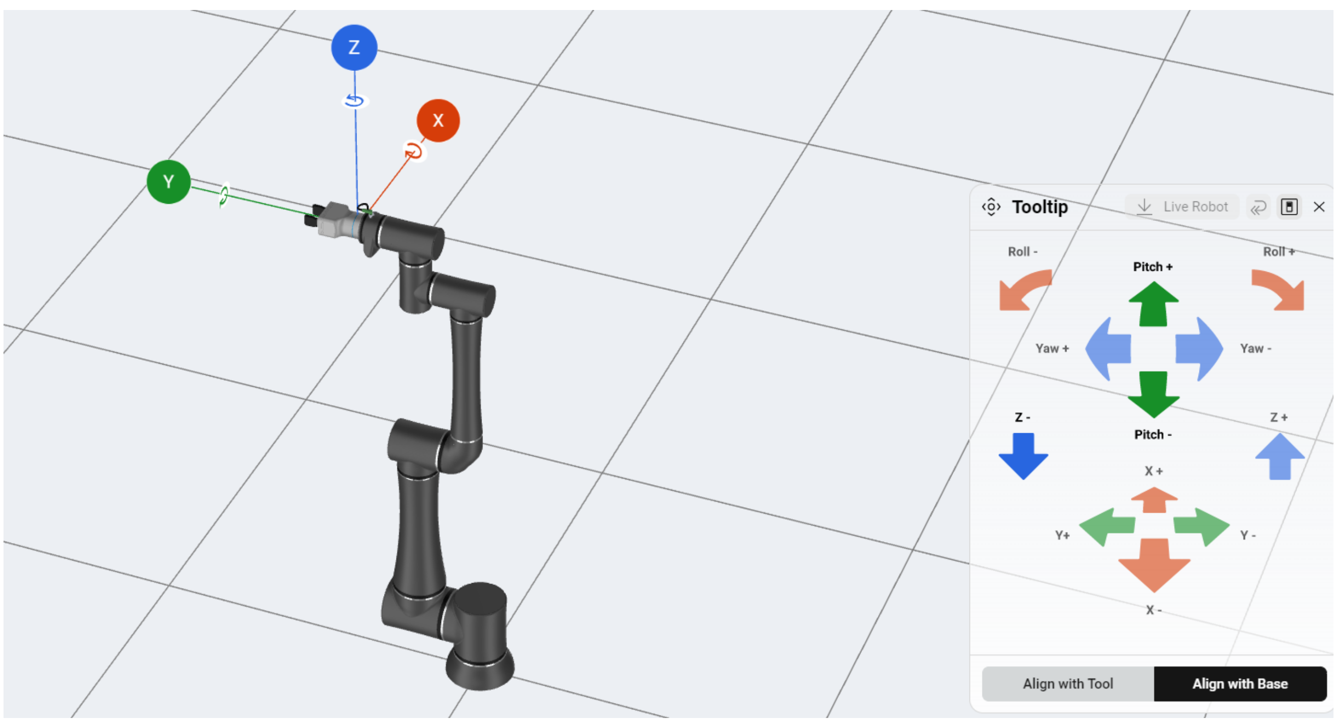
1. Install and fasten the 4 included leveling casters into the slots along one of the rectangular frames.
2. Flip it over, then place the pillar. Align and fasten one side using the 8-hole plate.
3. Fasten remaining sides of pillar
4. Attach 4 of the 12-hole corner brackets to the side of the pillar, fastening only the upper screws.
5. Attach each set from step 4 to opposite sides of the pillar. then level the pillar and make sure the bottom is flush with the bracket (using the SB-922 align tool).
6. Now tightly fasten all of the screws on the corner brackets.
7. Tightly fasten the 8-hole plate on the back.
8. Tightly fasten the 8-hole plate on the front.
9. Loosely assemble 2x frames with 12-hole plate and fasten both assemblies from step 8 to the pillar.
10. Place the U-frame onto base.
11. Loosely fasten two of the 12 hole plates to the U-frame
12. Loosely fasten the 8-hole plate to U-frame. Raise one frame and tightly fasten to the 8-hole plate. Finally, tightly fasten the 8-hole plate to the U-Frame, and tightly fasten both frames.
13. Tightly fasten 2x 12-hole plates onto the U-frame.
14. Tightly fasten 2x corner brackets to the U-frame.
15. Tightly fasten 2x 8-hole plates to the pillar.
16. Tightly fasten 5x cable tie mounts to the pillar.
17. Tightly fasten the front bracket to the U-Frame .

3.4 Connecting Control Box, Mounting and Unmounting Arm

3.4.1 Orientation

The RO1 only attaches to the base in one orientation. The orientation is shown by the X and Y markings on the baseplate, which line up with the tooltip orientation in the Move Robot view as shown:





It is possible to rotate the robot in 90 degree increments by rotating the base plate.

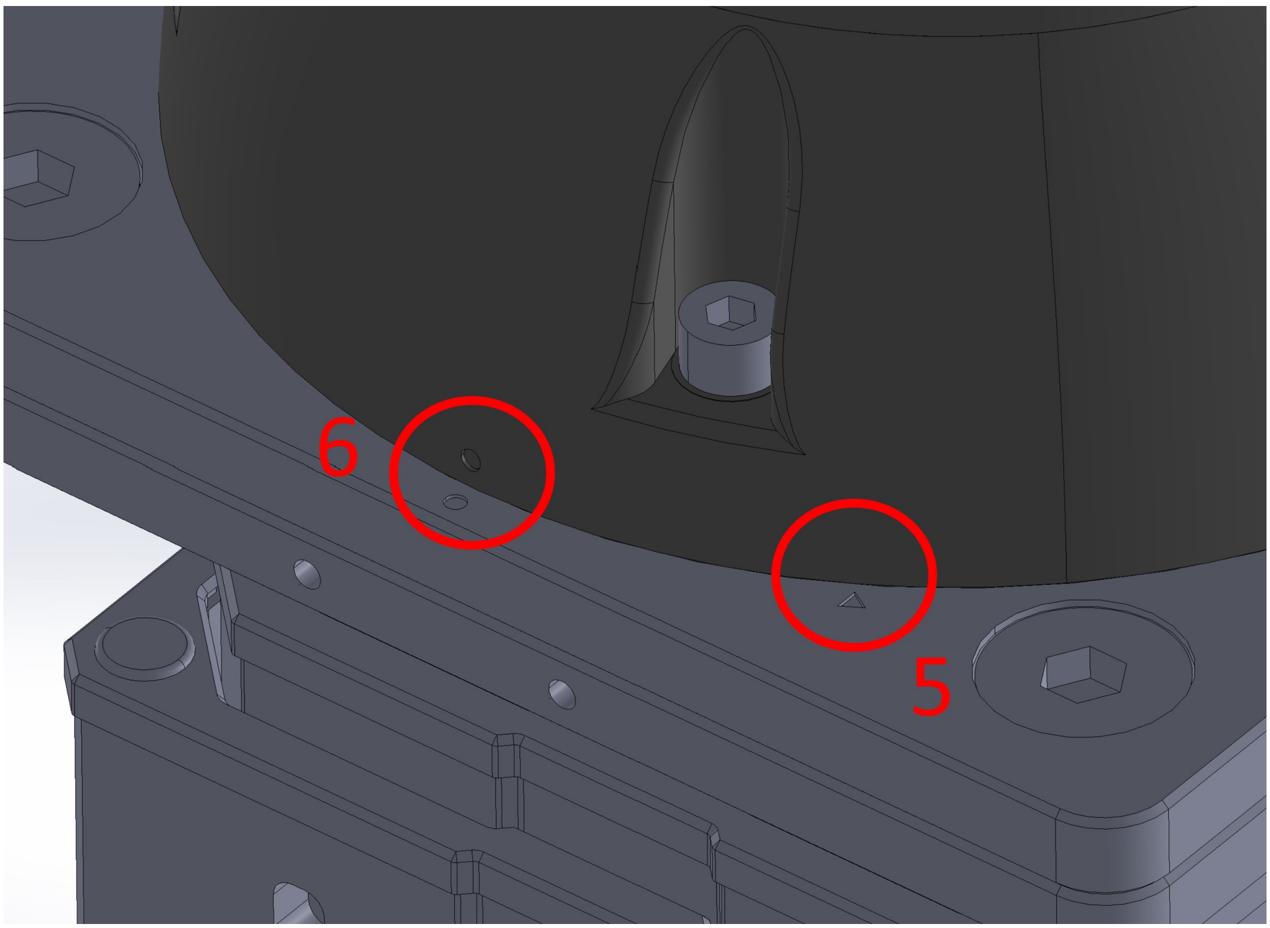
3.4.2 Video

To watch a video to accompany the steps below, go to https://youtu.be/y55gQTWBXWs.

3.4.3 Steps

To connect the control box and mount the arm on the base:

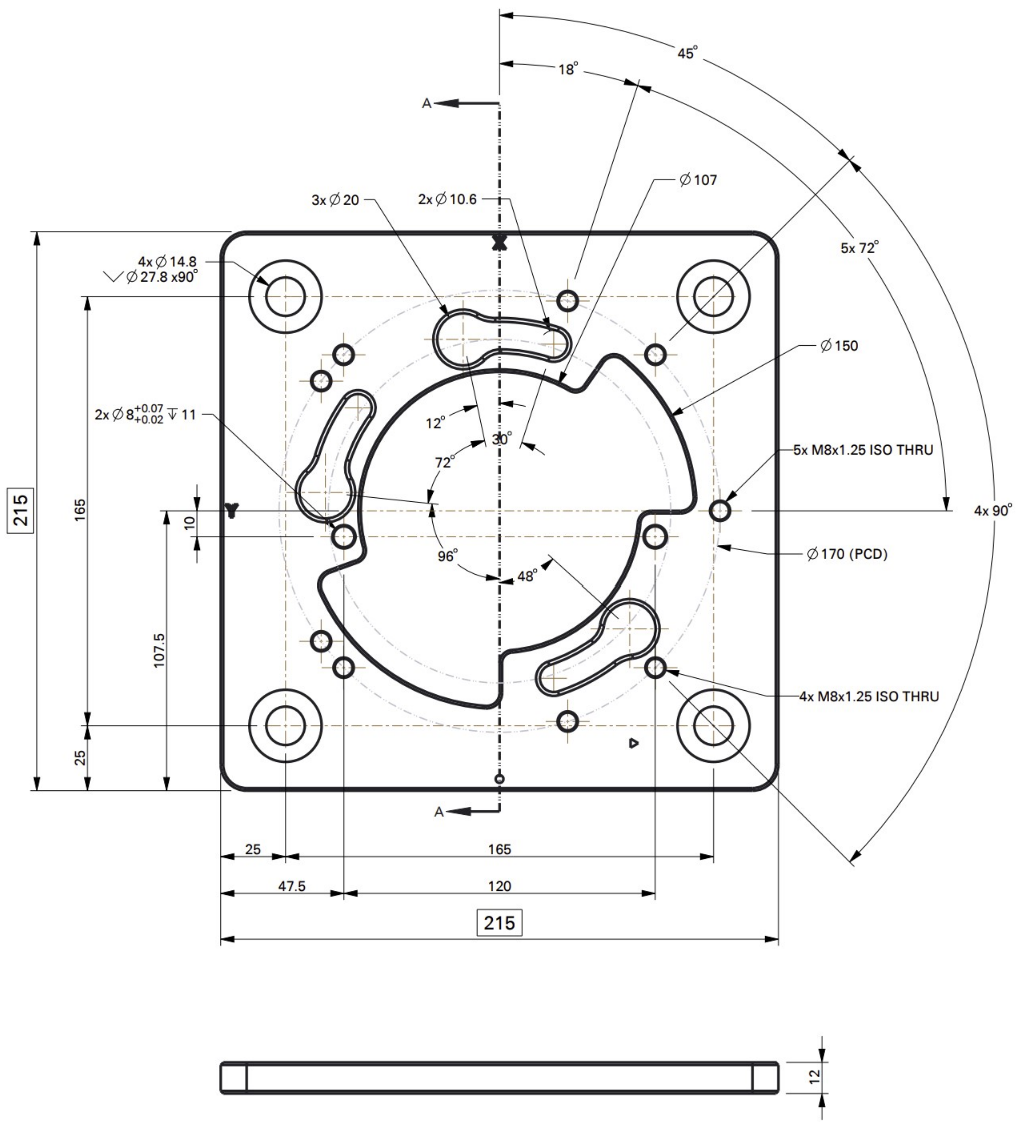
1. First, ensure the leveling feet have been raised on the base.
2. Lift the control box (with feet attached)
3. Hook the control box onto the base bracket.
4. Carefully lift the RO1 onto the base.



5. Place onto the pillar with the "O" on the robot base lined up with the triangle indicator shown above.
6. Rotate it clockwise until the "O" on the robot base lines up with the matching "O" indicator shown above.
7. Secure the RO1 base joint using five M8 30mm screws.
8. Connect the RO1 USB-C cable to the base joint. Connect the RO1 power and data cables to the base joint.

9. Use cable ties to restrain the cables to the pillar.
10. At the bottom of the control box, connect the RO1 power and data cables to the control box, as well as the USB cable. Connect the IEC (power) cable and lock it with the clip.
11. Press the power button on the top of the control box to start the RO1.

3.4.4 Mounting Base Diagram:



3.5 Setting up Tablet

The included iPad is used to configure, control, and program the RO1. Here's how to get it set up:

1. Take the iPad out of the box and turn it on.
2. If prompted at any point, enter the default passcode of "0000".
3. Open the "Settings" app on the iPad, then configure your network. If you are using Wi-Fi, there is a "Wi-Fi" section. If you are using an Ethernet adapter, an additional option to configure Ethernet should appear in the right sidebar.
4. Navigate to the home screen (by pressing the bottom button, if the iPad has one, or swiping up from the bottom, if it doesn't). Open the Standard Bots app.
5. Tap "Add Robot" on the home screen.
6. The iPad will search for the robot over Bluetooth. Make sure the RO1 is turned on and has the included antennaes screwed on. Once the RO1 shows up, choose it from the list and proceed.
7. The app will ask you to enter your network credentials again. You can configure the robot to connect over Wi-Fi or Ethernet, regardless of how your tablet is connected.
8. The app will also walk you through setting a PIN and choosing a name for your RO1.
9. After setup is completed, you can connect to your bot.
10. Once connect you can reset the estop (if required), unbrake, and begin jogging the robot. Refer to Section 5 for more details on operating the robot and constructing routines.

3.6 Unmounting & Transporting

3.6.1 Warnings

- Do not attempt to move the arm while it has power unless you are utilizing the any-gravity mode.

- Do not force the robot into a position while power is off, doing so may damage the robot.
- Only lift the RO1 arm with 2 people.

- The RO1 robot has a locking feature in the base of the robot. Do not attempt to force the robot straight off of the mounting structure.

3.6.2 Before transportation:

- Ensure the robot is in the desired position for transportation.

- If needed, the robot can be put into the position required for the original box by:
  - Navigating to the Move Robot view

  - Go to the Robot menu in the upper right
  - Select “Settings”
  - Select “Box Robot”
  - Set the Payload
  - Save and confirm the Payload
  - Click and hold down the “Move Live Arm To Visualizer Position” button. The robot will move into the packing pose.
- Click the hexagon button in the bottom right of the Move Robot view
- Select “Brake Robot”
- Unplug the control box from the AC power source
- Wait 30 seconds for stored power to dissipate
- Unplug the connector between the arm and robot buy twisting the locking mechanism and pulling down on each end
- Disconnect any inputs and outputs from the control box

The RO1 control box has an integrated handle for ease of transportation. Ensure all cables are disconnected from the RO1 control box before moving or shipping the control box. Ensure RO1 control box is well packaged, preferable in the original packaging, before shipping the RO1 control box.

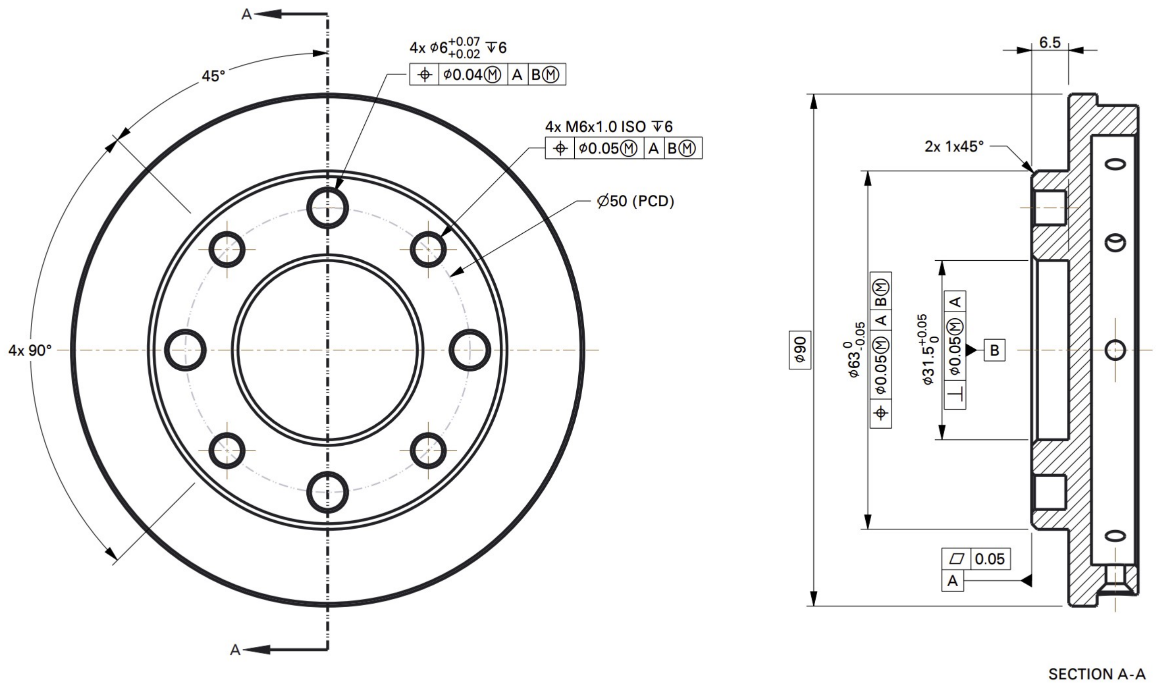
3.6.3 Unmounting the Arm From Base

1. Ensure the robot is powered off, unplugged and in the desired position before removing, if needed follow the above instructions to get the robot in the proper position.
2. Have 1 person steady the robot while the other removes the bolts.
3. Use a 4mm Allen key, remove the 5 M8 top down bolts around the robot base.
4. Ensure the robot is support, then have both people lightly twist the robot counter clockwise.
5. The robot will unlock from the base

3.7 Connecting End Effectors

3.7.1 Mechanical Connection

The RO1 robot uses a modified version of the standard ISO 9409-1-50-4-M6 50 mm ISO robot flange pattern. The RO1 offers four locations for the locating pin, where the ISO 9409-1-50-4-M6 standard offers 1 pin location. Any tool that follows the standard 50mm pattern will mount to the RO1 robot flange. A diagram of the mounting pattern is shown below.



HOLE PATTERN FOLLOWS
ISO 9409-1-50-4-M6

3.7.2 Fully Integrated Tools

Standard Bots supports full integration with the following tools. These tools can be fully controlled using standard instructions in the Standard Bots Routine Editor.

- OnRobot 2FG7
- OnRobot 3FG15
- OnRobot Screwdriver
- OnRobot Dual Quick Changer
- OnRobot VGP20

Follow the instructions provided with the tooling to connect the tooling to the robot flange, and connect the wire to the provided connector at the end of the robot arm.

Be careful when attaching the m8 tool connector. Ensure that you line up the key with the receiver when you plug it in. Do not twist it, the pins are fragile and this can cause the pins to break.

3.7.3 Other Supported Tools

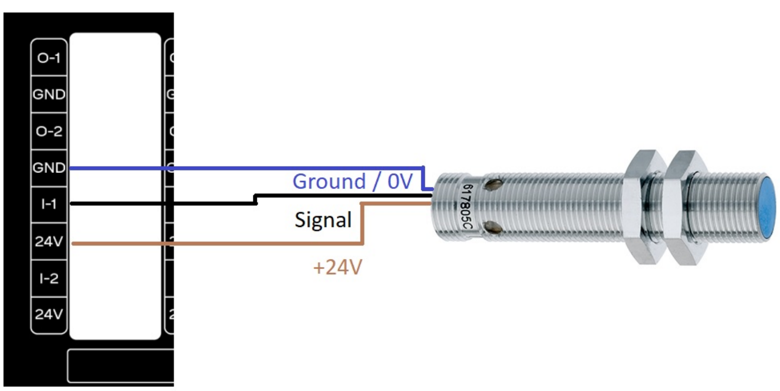
In addition to the above tools, Standard Bots generally supports most tools that mount to the 50 mm flange and that support 24VDC discrete control. Please contact Standard Bots support for assistance with confirming tooling compatibility.

3.8 Control Box Inputs and Outputs

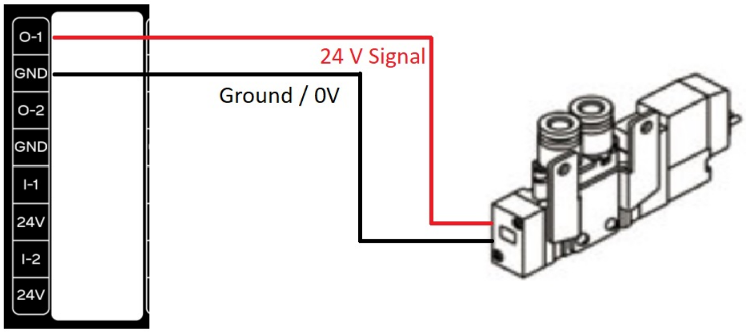
3.8.1 Digital Inputs and Outputs

The RO1 control box supports 16 24VDC digital inputs and 16 24VDC digital outputs. The signals are sourcing or PNP. The digital outputs support up to 0.7 amps of output, for larger capacity use the digital outputs from the robot to drive a relay coil to a separate power source.

Example of wiring a proximity sensor into the RO1 control box:



Example of wiring a pneumatic valve into the RO1 control box:



3.8.2 Analog Inputs and Outputs

The RO1 control box has 4 analog outputs and 2 analog inputs available on the control box. These are currently unsupported.

Chapter 4

Safety

4.1 Overview of Safety Features

The RO1 robot includes many safety features for operating in either collaborative or industrial applications. The exact implementation of these features will depend upon the application and risk assessment. The final performance level of the system will depend on the integration and must be calculated by the integrator.

The RO1 has parameters for the below settings that can be fully customized for the end application and allow for integration with a wide variety of industrial safety components.

- Joint Collision Thresholds
- Joint Velocity, Acceleration, and Torque limits
- Emergency Stop Inputs
- Safety IO / OSSD

4.1.1 Response Time

The RO1 responds to safety events within the tolerances in the below chart:

Safety Input Event	Worst Cast Detection Time	Worst Cast Power Off Time	Worst Case Response Time
Internal Emergency Stop	50ms	600ms	600ms
External Emergency Stop	50ms	600ms	600ms
External Safety IO Slow Speed Input	50ms	N/A	600ms
External Safety IO Emergency Stop	50ms	600ms	600ms
Tablet or Browser E-Stop	1000ms*	1600ms*	1600ms*

*Network Latency Dependent

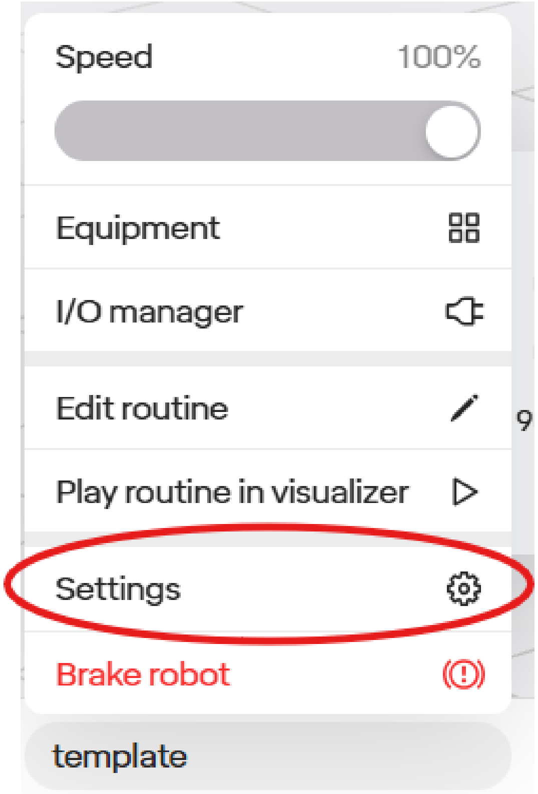
Safety Output Event	Worst Case Response Time
Robot E-Stop	50ms

4.1.2 Performance Level

The RO1 safety circuitry, including E-Stop circuitry and all digital inputs and outputs is PLe Cat 4.

4.2 Safety Settings

Safety Settings can be accessed by tapping the robot menu, then Settings > Safety.



Settings are locked by default; click the "Unlock" button and re-enter the robot PIN to make the settings here editable.

Safety settings do not take effect until you tap "Apply Settings."

4.2.1 Speed Limits

How Limits Work

The RO1 has several levels of limits; the robot is always gated to the **lowest** of all of these:

- **Global Limits**: defined in Safety settings, which affect tooltip speed and the acceleration, velocity, and torque of joints.
- **Speed Modifier % Slider**: the robot can be slowed down on an as-needed basis (for instance, to trial a routine) without requiring access to Safety Settings.
- **Step-Level Limits**: the robot can also apply an alternate set of speed limits only for the duration of a specific step.

All of these settings are described below.

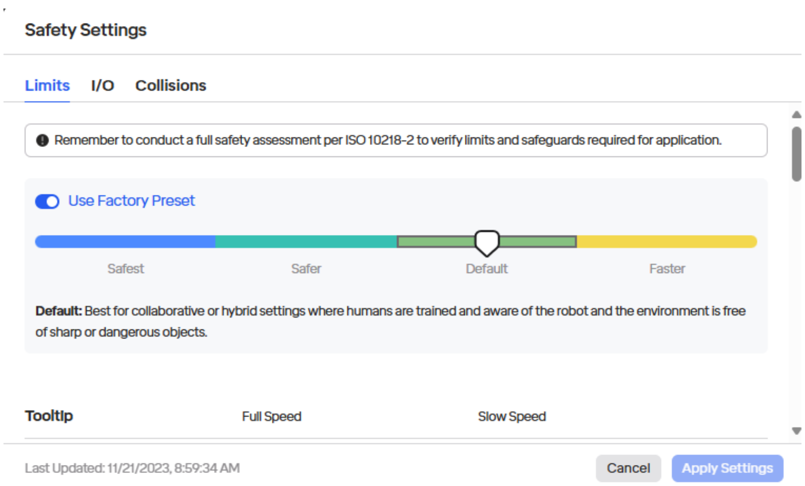
Editing Global Limits

The first tab of safety settings allows setting limits on the speed and acceleration of both the tooltip and the joints of the robot.

Using Factory Presets By default, you will be presented with the choice of several presets.

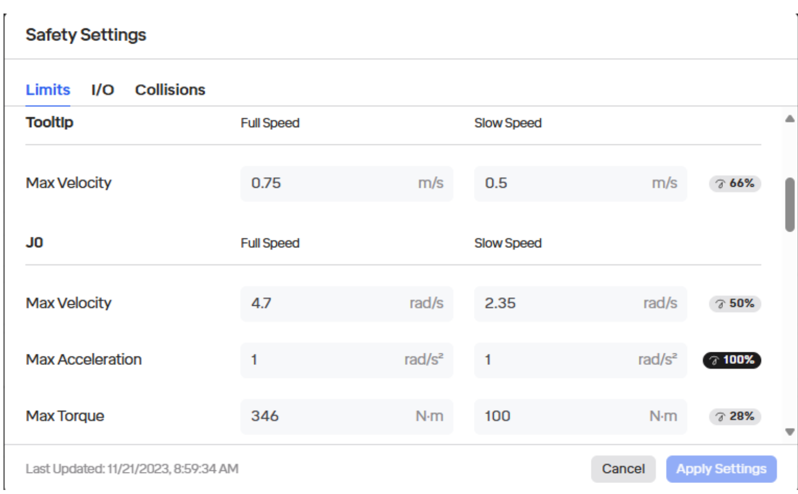
The "default" (middle) setting restricts the robot to a tooltip speed of 0.75m/s, which is safe for most collaborative settings. Several others are available; if there are factors that may require more caution (such as the robot's payload or end effectors), it may be desirable to select a more conservative setting.

Remember that many factors can affect whether a given speed is safe. Before putting the robot into production, you should always conduct a full safety assessment per ISO 10218-2 to determine the proper values for these settings and any other mitigations required.



To review the values set for these factory presets, you can scroll down.

Custom Limits To edit these limits, switch off "Use Factory Preset"; the limits should then become editable:



The following can be customized, both for when the robot operates at its full speed and in a "slow" mode that can be triggered via Safety I/O settings:

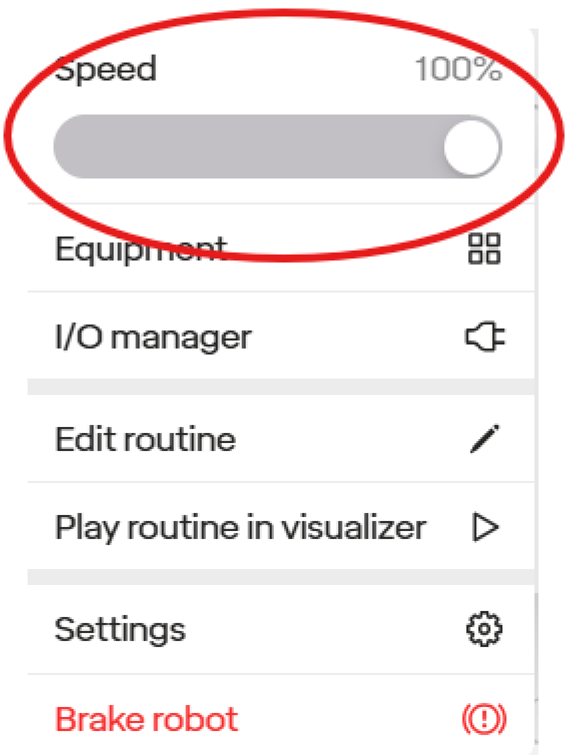
- **Tooltip Speed**: This limits the speed of the tooltip in Cartesian space.
- **Per joint**:
  - **Max velocity**: This is the maximum angular change in the joint's position per second permitted.
  - **Max acceleration**: This affects the rate at which the joint can change speed. If this is too low, the may not be able to achieve the maximum velocity otherwise permitted during the course of a movement.
  - **Max torque**: The maximum torque that the motor in the joint can exert.

4.2.2 Speed Modifier % Slider

The robot can be slowed down from its maximum as needed inside the robot menu.

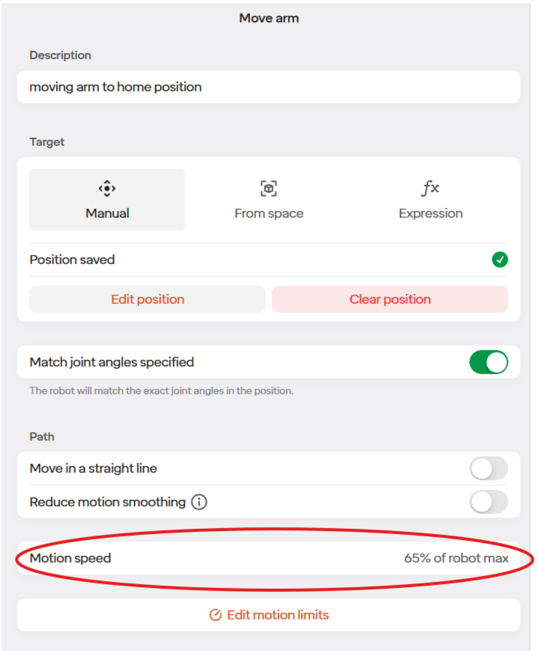
This is useful for trying out a routine before putting it into production.

Setting this slider only applies a cap to the maximum limits that would otherwise be set in Safety Settings; movements that were already slower than that are not affected.



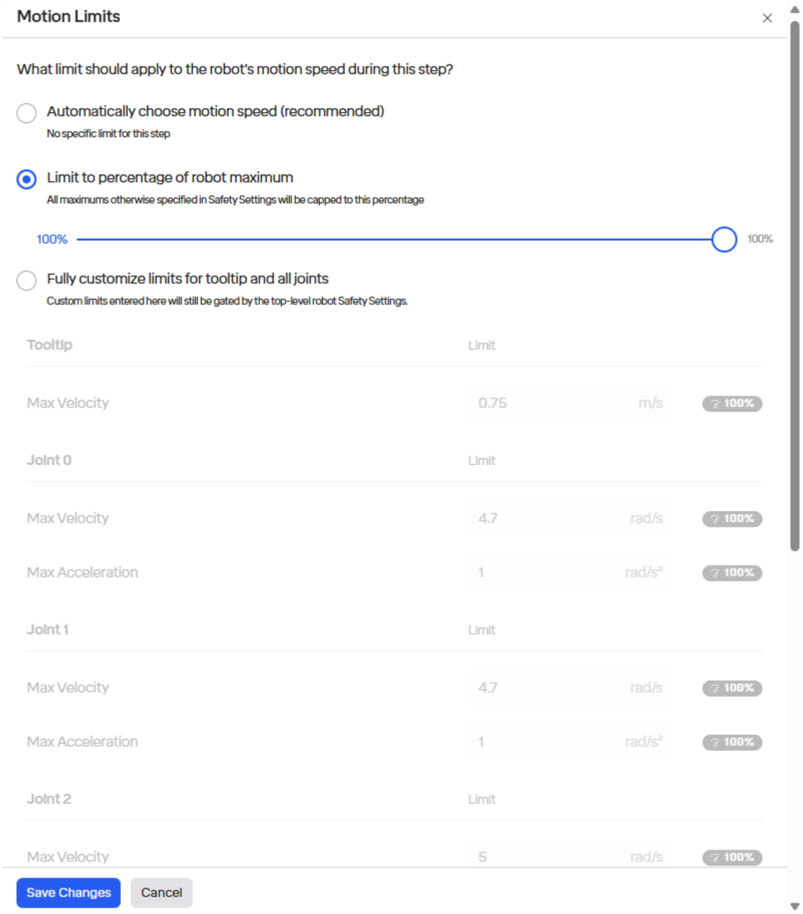
4.2.3 Customizing Speed Limits For A Step

When editing a “Move” step, the “Motion Speed” shows the speed of this specific step. This is useful to notice for delicate movements or when required for safety. To change the speed, tap the “Edit Motion Limits” icon.



By tapping “Edit Motion Limits”, several options are available. The motion can be restricted to percentage of the maximum (as with the global speed modifier in the robot menu), or to a new set of custom limits.

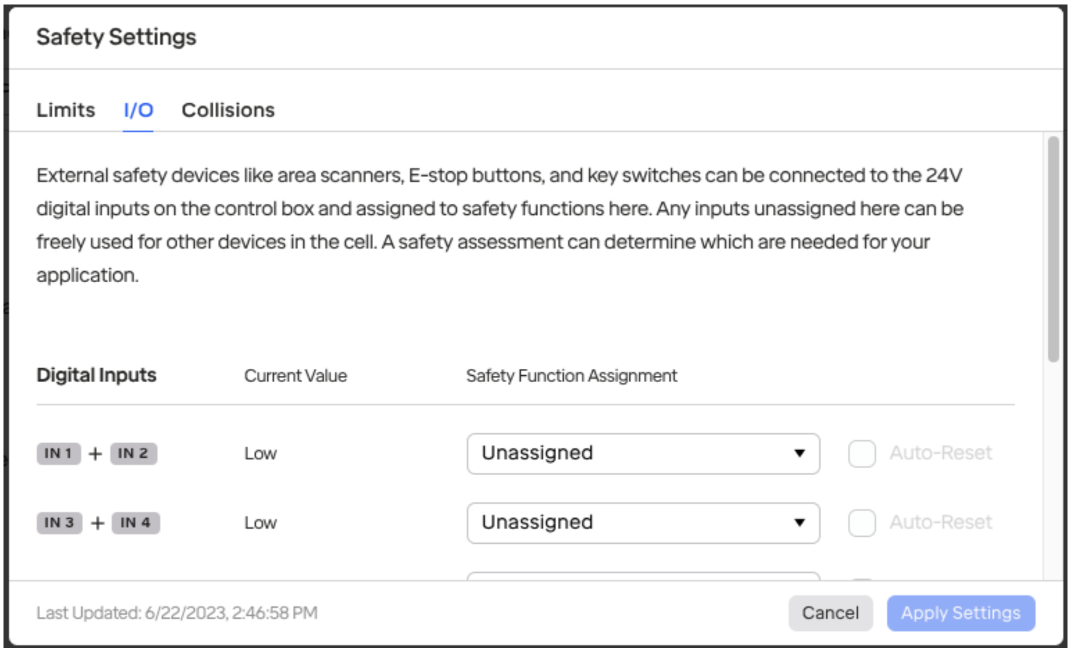
Note that these limits apply whether the robot is operating at full speed or at any “slow” speed mode defined in safety settings. The robot will always apply the lowest of all limits in effect. It is also not possible to set torque limits on a per-step basis.


Motion Limits
What limit should apply to the robot's motion speed during this step?
Automatically choose motion speed (recommended)
No specific limit for this step
Limit to percentage of robot maximum
All maximums otherwise specified in Safety Settings will be capped to this percentage
100%
100%
Fully customize limits for tooltip and all joints
Custom limits entered here will still be gated by the top-level robot Safety Settings.
Tooltip
Limit
Max Velocity
0.75
m/s
100%
Joint 0
Limit
Max Velocity
4.7
rad/s
100%
Max Acceleration
1
rad/s²
100%
Joint 1
Limit
Max Velocity
4.7
rad/s
100%
Max Acceleration
1
rad/s²
100%
Joint 2
Limit
Max Velocity
5
rad/s
100%
Save Changes
Cancel

4.3 Safety I/O

The "I/O" tab shows settings for Safety I/O, which allows you to configure safety devices like extra E-stop buttons, area scanners, light curtains, and more.

At present, only **inputs** are supported here; support for safety outputs for controlling other devices will be added in a future software update.

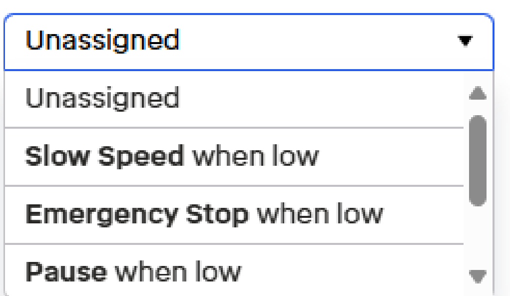


4.3.1 Configuring Safety Inputs

The sixteen 24V inputs on the control box are all safety-rated and can be used in pairs. Safety devices are connected in pairs to eliminate the possibility of a stray signal keeping the robot operating while actually in an unsafe condition. Therefore, if either of the paired inputs is below 24V, it will be treated as a "low" signal.

The following options are available:

- **Safety Function Assignment**: Any ports can be assigned to:
  - **Emergency Stop** when low: Triggers a category-0 stop that brakes robot and cuts power to arm.
  - **Pause** when low or when high: Pauses the currently-running routine but does not brake the robot.
  - **Slow Speed** when low: Makes the robot observe the "Slow Speed" set of limits defined in the "Limits" tab. This is useful, for instance, with an area scanner, to force the robot to move at a collaborative speed when people are nearby.
  - **Reset Safeguards When High**: This will reset the effects of any safeguard that does not have auto-reset (see below). This has no effect on emergency stop.
- **Auto-Reset**: This controls whether the effect of the function, once triggered, should go away (i.e. when we move back from low to high) or whether it requires a separate, explicit Reset. This is useful, for instance, with a sensor on a door to a fence around the robot: one would not want the robot to re-engage or speed up if the door is closed behind someone.



4.4 Collisions & Protective Stops

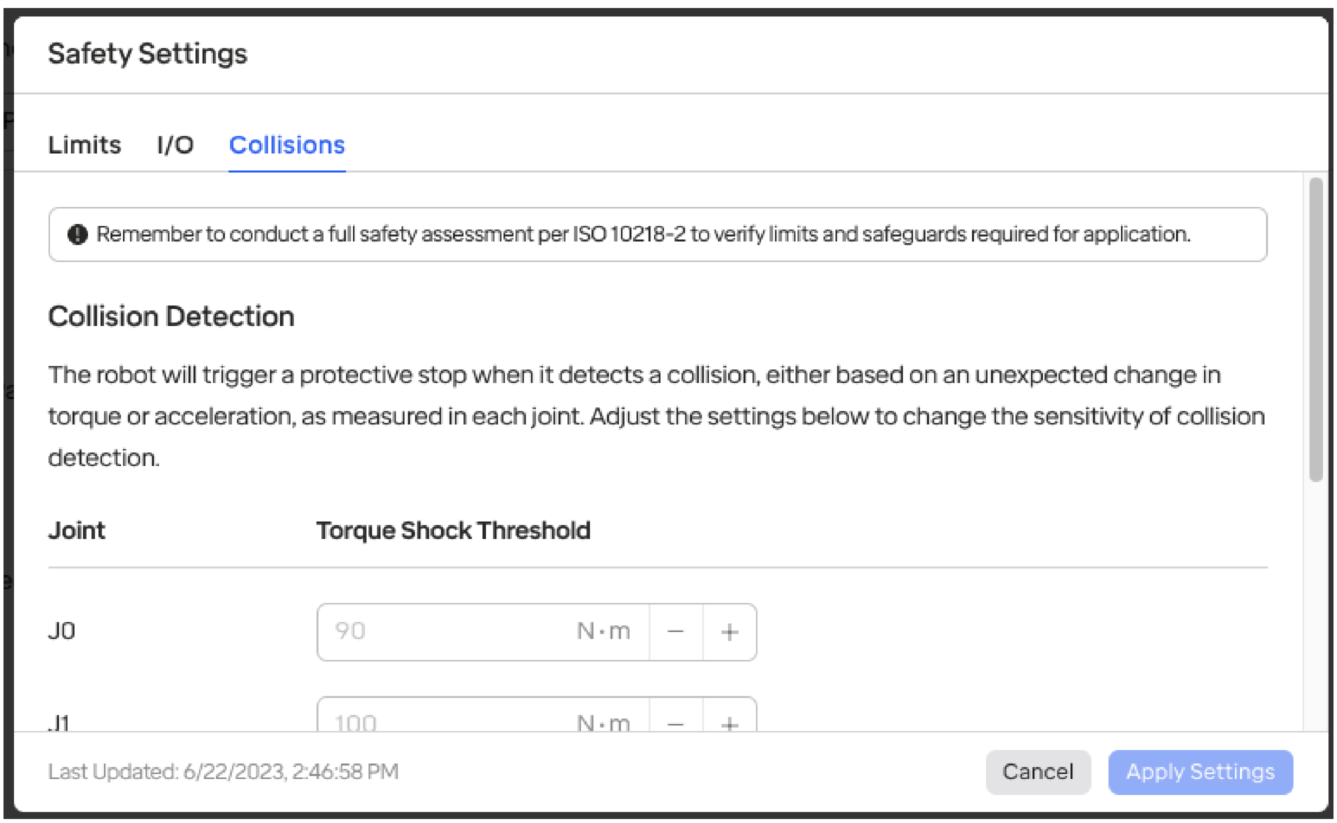
When the robot is running a routine and encounters a collision, it will stop. The routine can be re-started with the "Play" button in the top toolbar. Every time a collision occurs, it will also log the time and force measured, which can be reviewed in the Notification (bell) section.

Collisions are detected with two methods: 1) by monitoring the current coming out of the joint motor to measure torque and find discrepancies, 2) by monitoring an IMU (accelerometer) inside each joint.

4.4.1 Adjusting Collision Sensitivity

Depending on the environment and safety requirements, it may be desirable to change the sensitivity of collision detection. This can be done in the "Collisions" section of Safety IO.

This allows adjusting the thresholds used for both methods: the torque shock threshold (in newton-meters) and the acceleration threshold used by the IMU (in m/s²).



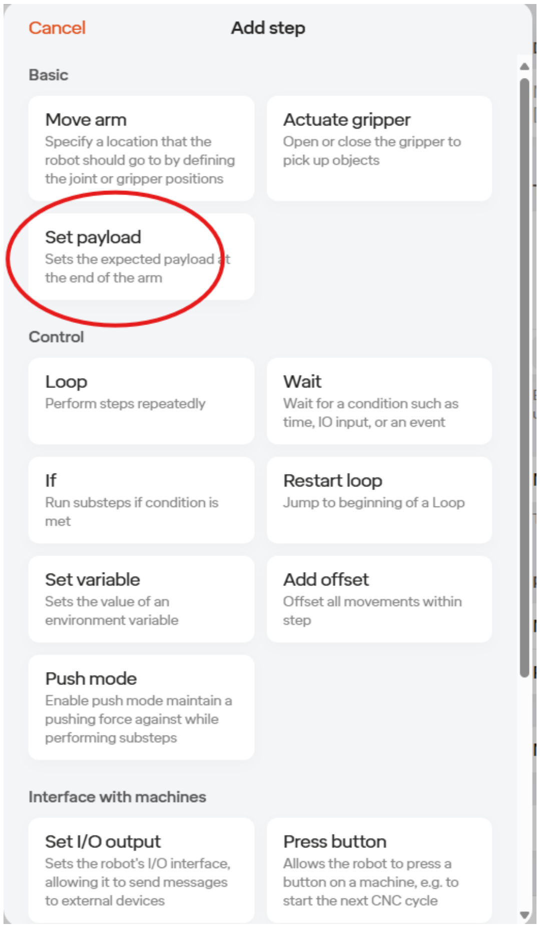
4.5 Setting the Robot's Payload Mass

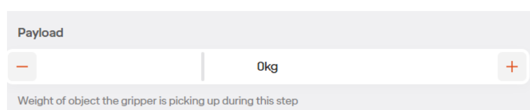
The robot's knowledge of its payload mass affects its ability to balance and sense collisions. It's important for overall safety to configure the payload as part of setting up a robot cell with the RO1.

There are two ways to set the payload:

1. By adding a **Set Payload** step to a routine
2. By setting the **payload** parameter within an **Actuate Gripper** step. This is useful for situations where the payload changes as a result of the gripper.

The payload mass entered should account not only for the mass of the payload itself but also that of any attached end effectors. The spec sheet for the end effector should include this information.





Chapter 5

Software Overview

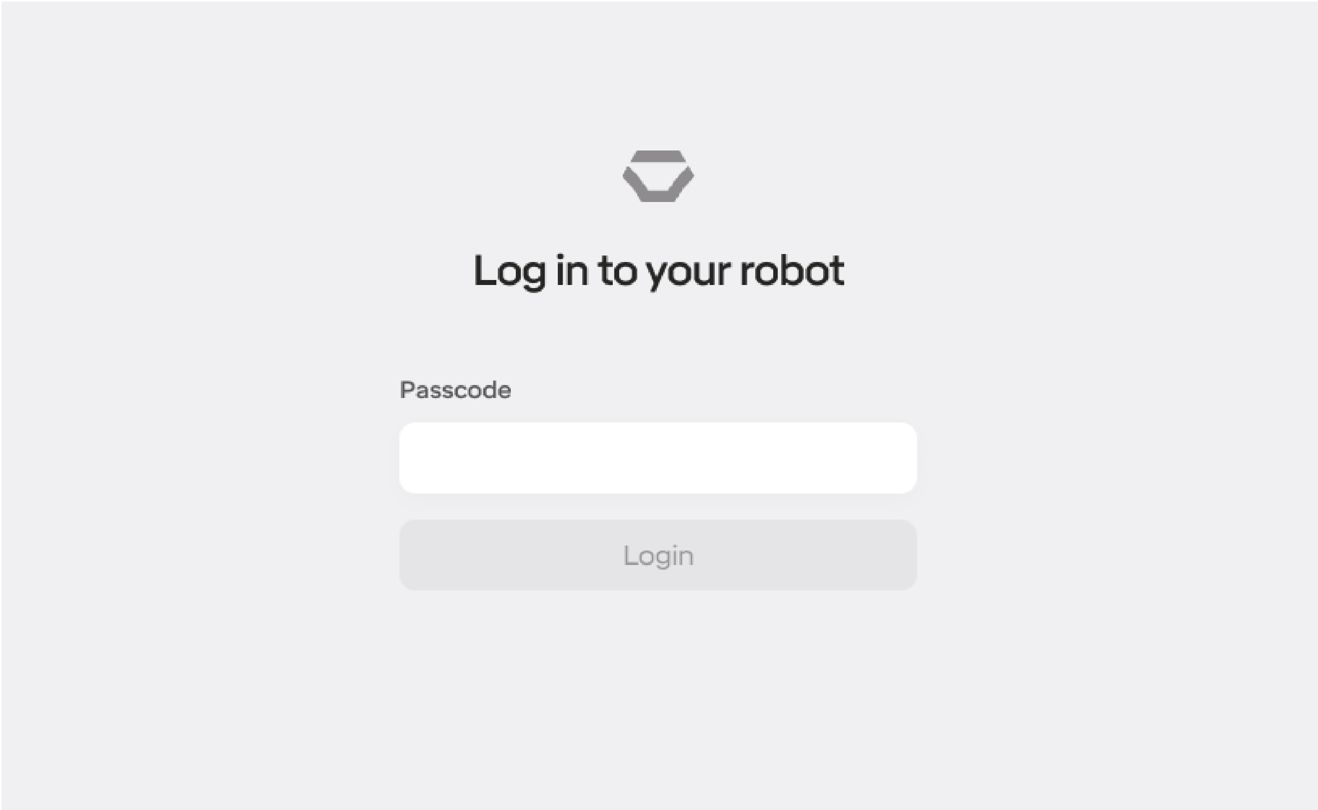
5.1 Connecting to the Robot

The included iPad can be connected to multiple RO1 robots (if needed) after pairing with them.

The home screen of the Standard Bots app shows the list of paired robots and their connection status. Tapping on the "…" button for a robot allows you to: * delete that robot * re-configure it (i.e. to change its network settings, PIN, etc) * show a details screen that can allow you to troubleshoot connectivity issues.

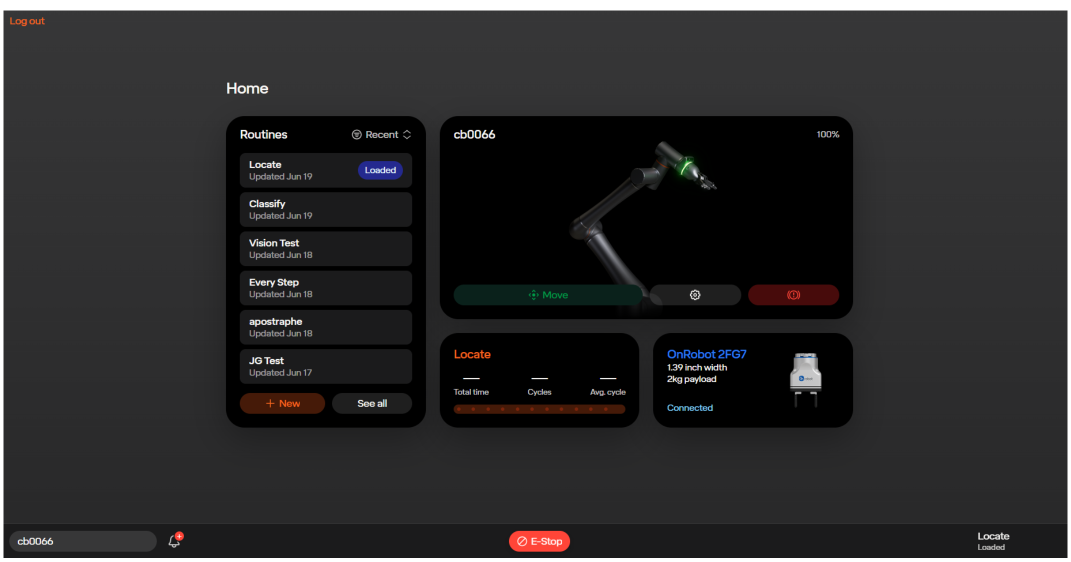
If a robot is powered on but not showing up here, after confirming the tablet is on the same network, check its details and contact customer support.

To connect to your robot, enter your PIN to log in. The default PIN is 0000:



5.1.1 Home Page

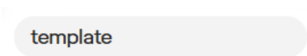
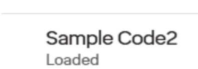
The Home Page shows the routines, the current robot, and the end effector that is connected to the robot. In the “routines” tab, you are able to load, edit, and create new routines for the robot. In the tab that shows the connected robot, this is where you can go to move the robot.



5.1.2 Footer

Once connected to an RO1, the software has a set of global controls in the footer of every page:

There are several important features worth calling out:

Element	Name	Description
	**Notifications**	Contains a log of failures, errors, and other notifications that have occurred when running the robot. If there are unread items here, there will be a red dot on this icon.
	**E-Stop**	Trigger an emergency stop and brake the robot
	**Robot Menu**	See status of current robot and access settings (see below)
	**Loaded Routine**	Shows what routine is loaded onto the robot

Robot Statuses

The robot menu displays the name of the robot and may show several status indicators:

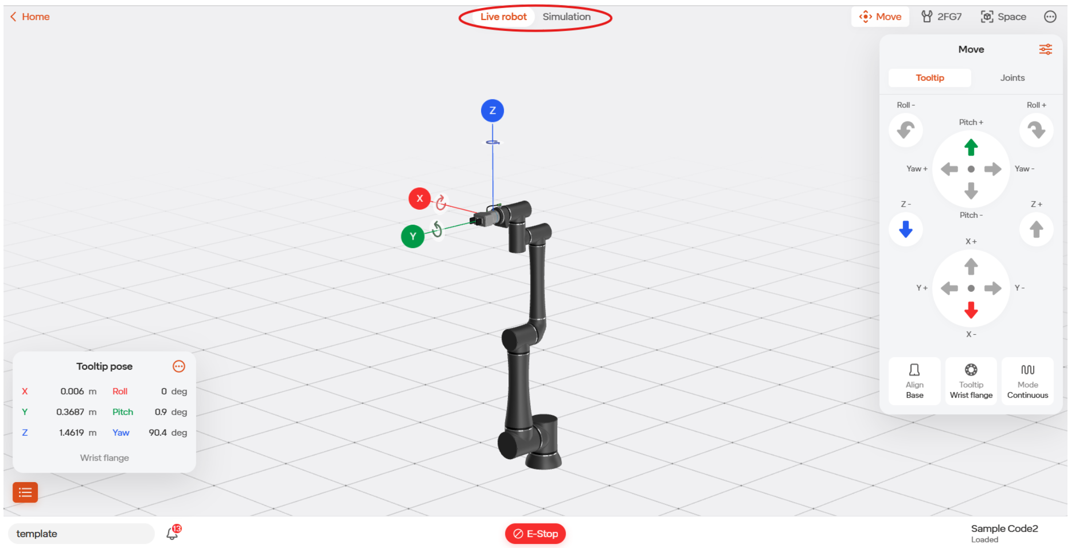
Status	Description
DISCONNECTED	The tablet is not able to connect to the robot.
LOADING	The tablet is trying to connect to the robot.
MOVING	The robot is being manually jogged now.
ANTI-GRAVITY	The robot is being moved in Anti-Gravity (hand-guided) mode.
RECOVERING	The robot has exceeded joint limits and can be moved back within limits now.
RUNNING	The robot is running a routine.
PAUSED	The robot is paused in a previously-running routine. You can press 'Play' to resume it.

Status	Description
E-STOP	The robot is in Emergency Stop mode. Reset the E-Stop button on the control box and any external E-stop buttons.
BRAKED	The robot is braked (either from having manually braked it or from a previous E-Stop). It can be unbraked in the Move screen.
FAILED	The robot has encountered a collision or has been affected by some other hardware issue.
(blue dot)	A software update is available. Check “Software Update” under “Settings.”
INSTALLING	The robot is installing a software update.

5.2 Jogging the Robot

The “Move Robot” tab brings you into the Move page.

This shows a visualization of the RO1. The switch on the top allows you to switch between visualizing (and controlling) the real robot or a simulated robot.



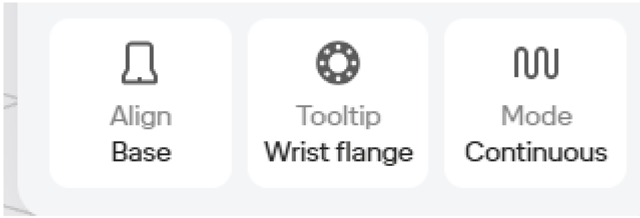
At the right of this screen are several useful tabs:

Icon	Tab Name	Description
Move	**Move**	Menu to access the “Joints” and “Tooltip” Tabs
Joints	**Joints**	Controls position of individual joints.
	Gripper	Controls any connected gripper
Space	**Space**	Allows defining points and grids that can be referenced in the routine
	I/O	Shows the status of the I/O ports and allows manually toggling them. Hidden behind the three dots icon.
Tooltip	**Tooltip**	Jogs the robot’s tooltip in Cartesian space

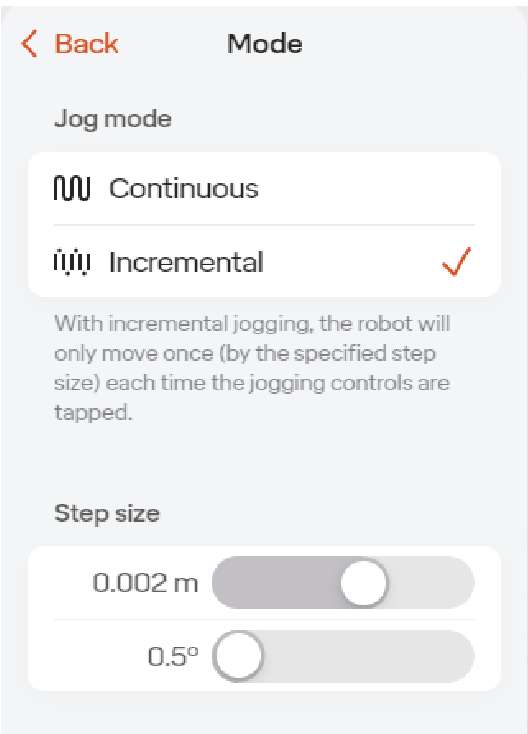
5.2.1 Jogging Tooltip

When jogging the tooltip, you are able to control the X, Y, Z coordinates of the tooltip, as well as the roll, pitch, and yaw.

This can be switched between "Base" (where the reference frame is the robot base) and "Tooltip" (where the reference frame is on the robot's tool flange). Moving to tooltip mode can be useful for maneuvering the tooltip in and out of tight spaces.



Selecting the "Mode" icon allows you to switch between continuous and incremental jogging. With continuous jogging, holding down a move robot icon will allow to robot to move as long as the icon is held down. With incremental jogging, when tapping on a move robot icon, the robot will only move a specified distance, this can be useful when fine tuning positions.

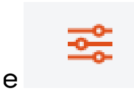


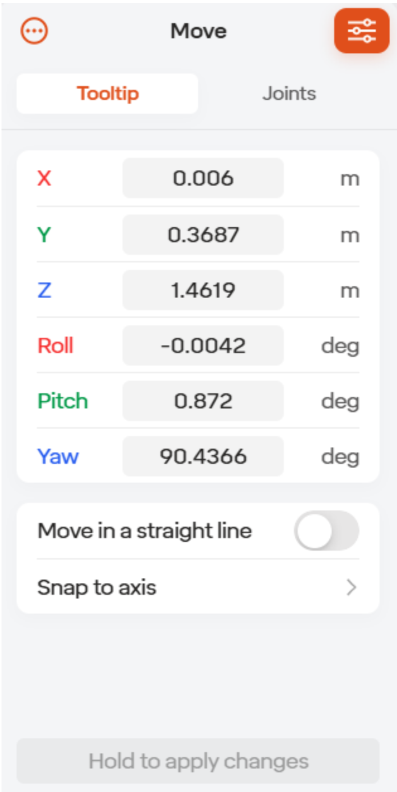
For safety, manually jogging the robot is always capped at a speed below the maximum that will apply when running. To make the robot jog even slower, you can change the global speed % slider in the robot menu.

5.2.2 Jogging Joints

The robot's joints can also be moved directly. This can be useful in avoiding collisions and in planning moves to minimize cycle time.

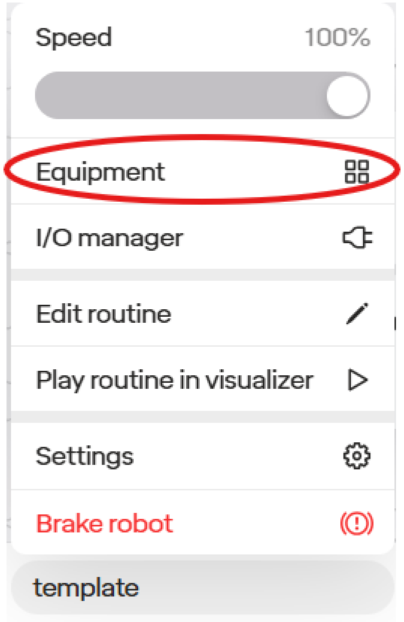
5.2.3 Entering Exact Values

When jogging in either mode, if you want to enter a more precise value, you can press the  button in the top right. Once you've entered the values you want, hold down the "Hold to Apply Changes" button at the bottom of the panel.

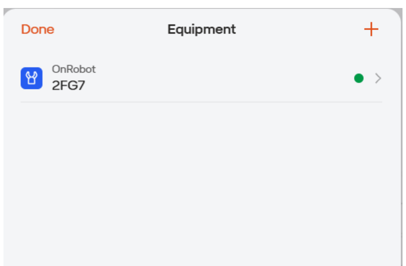


5.3 Managing Equipment

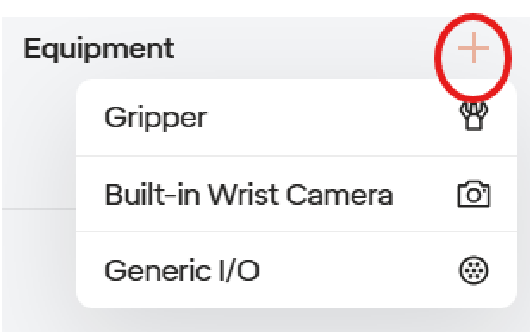
To manage equipment in the cell, including grippers, 7th axis devices, CNC machines, and more, open "Equipment" from the robot menu.



The equipment configured on the robot can be seen in the list on the left. To add new equipment, press the plus sign button in the upper right. Various settings for each connected device can be controlled on the right.

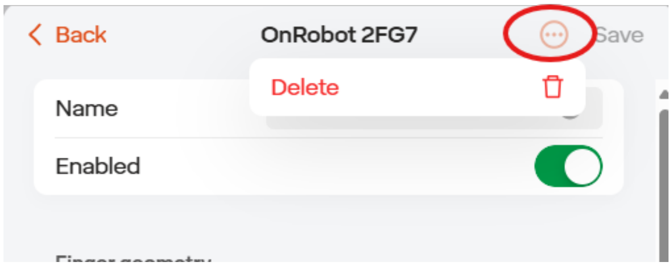


Currently, only one gripper can be added at a time (except when using the onRobot Dual Quick Changer). When adding a single tool on a single changer, you do not need to define a changer and instead simply add the tool.



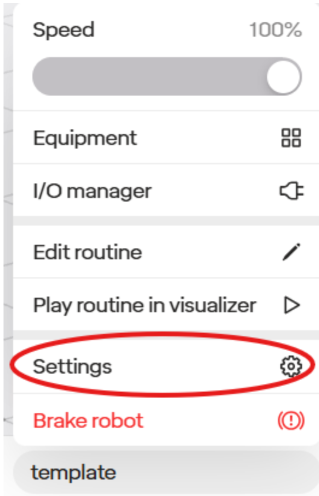
To remove equipment select the equipment that you would like to remove.

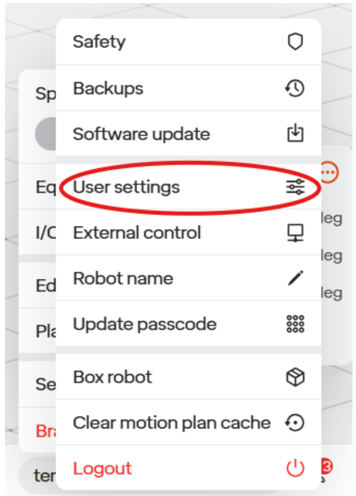
Then select the ‘circle with the three dots’ icon at the upper right of the tab to reveal the delete icon.


Back
OnRobot 2FG7
Save
Delete
Name
Enabled

5.4 Robot Settings

Settings for the robot are accessed via the robot menu. User interface settings are accessed separately within settings via the hamburger menu.





The following options are available on the RO1:

Section Name	Description
Safety	Speed limits, configuration of safeguard devices connected to I/O ports, and collision sensitivity settings
PIN	Update the robot's PIN
Robot Name	Name displayed in UI to distinguish it from any other RO1s you may be using.
Software Update	Allows checking for and installing any available software updates
Backups	Allows making and restoring from backups via external disk connected to USB
Interface Settings	Allows switching between imperial and metric units for displaying lengths in the UI
Box Robot	Places robot into pose that allows it to fit in Standard Bots' provided foam case in case it needs to be returned.

5.5 Singularities

A singularity is a configuration in which the robot end-effector becomes blocked in certain directions. A robot is unable to maintain a constant velocity while passing one.

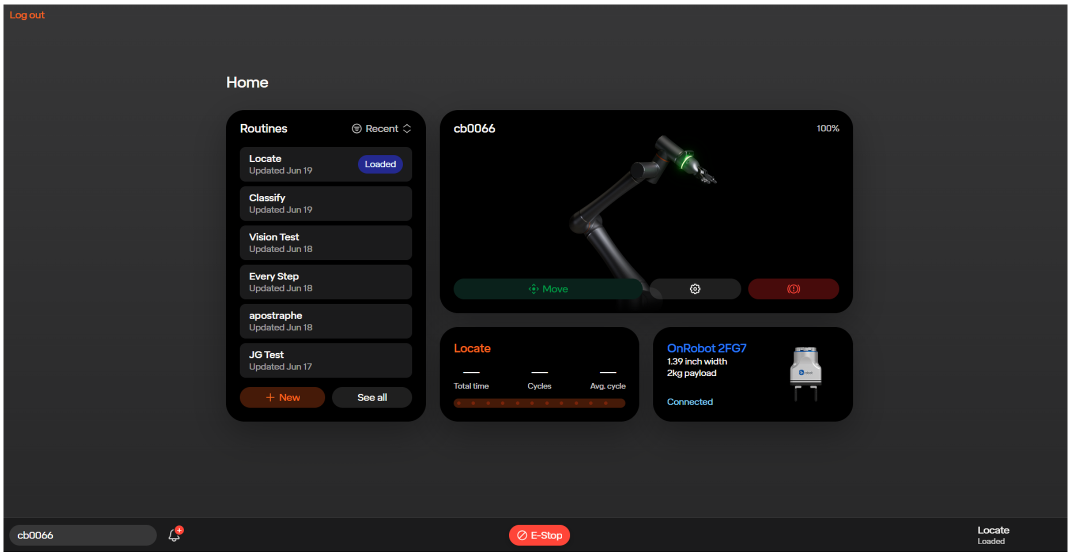
The RO1 handles this by never planning motion paths through singularities. If the robot is programmed in a manner in which it will encounter a singularity, the UI will display a “Motion Planning Failed” error and the robot will not attempt the movement.

To ensure routines are not created in which the robot will encounter a singularity, the user interface requires a play-through of any new routine in a simulation mode before running it on a real system. This ensures all motion plans are valid before running on a physical robot arm.

5.6 Routines

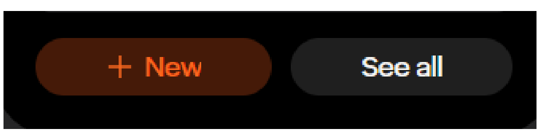
Standard Bots uses an intuitive “no-code” approach to programming the RO1 robot. The programs in the robots are referred to as “Routines”. The routine reads as a story. Routines can be developed and tested in simulation without moving the actual robot. The robot can store multiple routines. Routines contain all information the robot needs to complete the programmed task including moves, speeds, setting/reading IO, communicating with external equipment and more.

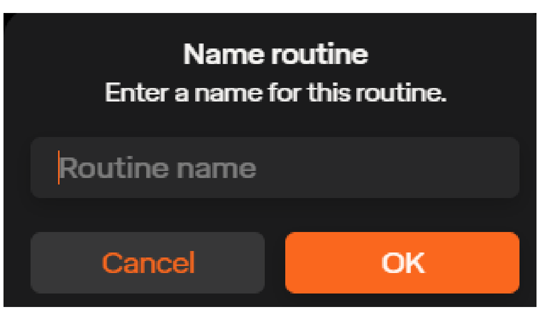
5.6.1 Routine Creation Example



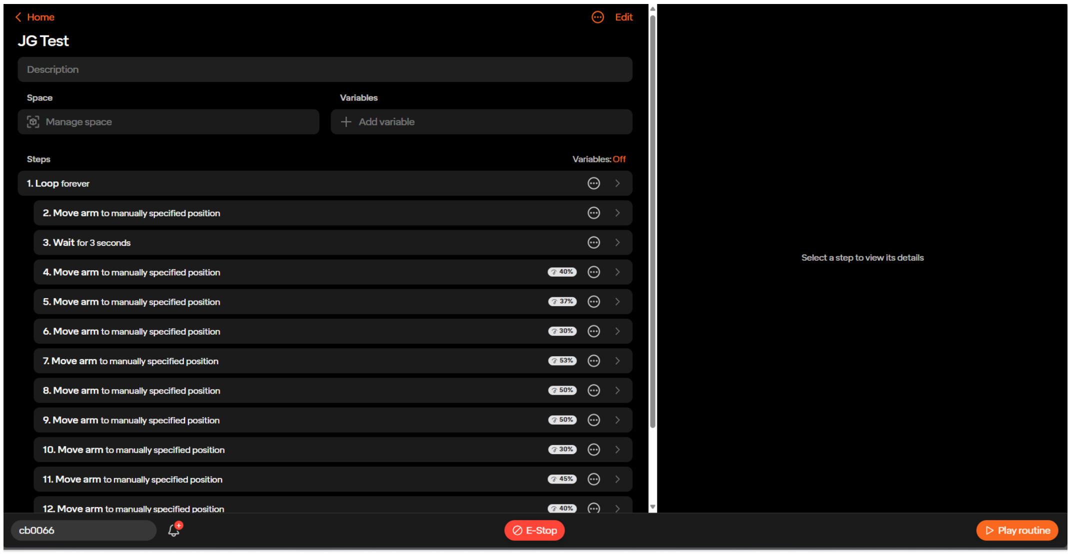
To get to the Routines area of the interface, return to the home page.

Existing Routines will be shown in the main window, and can be viewed and edited by clicking on them. To create a new routine select New.





To create a new routine, give it a name under Routine Name.



The routine interface is where you can add a description of your routine, and to edit and create steps.

1.Return to the **Space**.

2.Return to **Routine** list.

3.The **Routine** name.

4.Go to the **Space.**

5.Add variable to use in the **Routine.**

6.Lock or unlock editing.

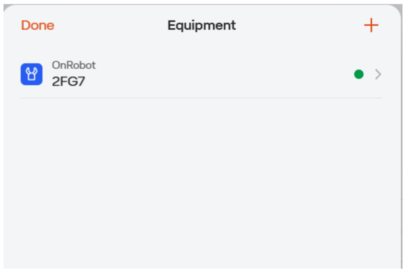
7.Load this **Routine** onto the robot.

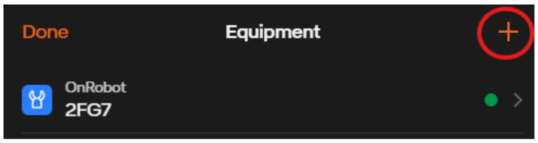
8.Add a new **Step** into the **Routine.**

9.List of **Steps** in the **Routine**

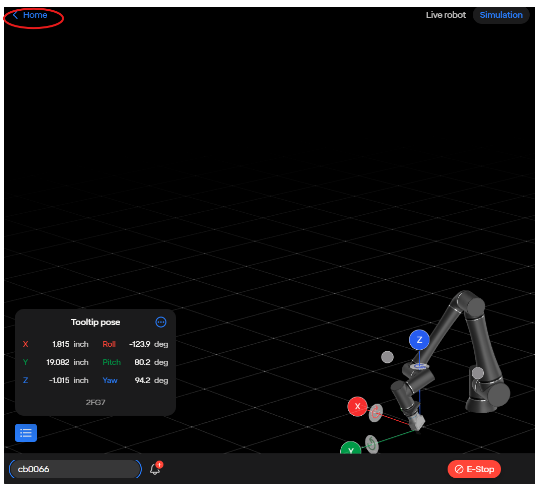
10.List of **Step** types that can be added to the routine.

If you are using a Standard Bots-supported tool, first add it using the manage equipment button on the robot page. If you are not using a supported tool, no need to add it. It will be controlled over I/O directly.

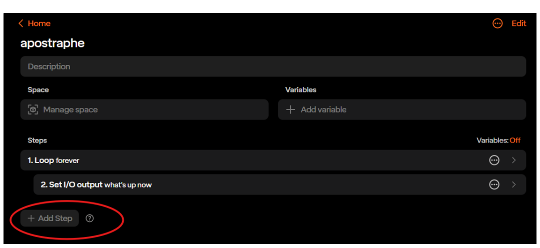




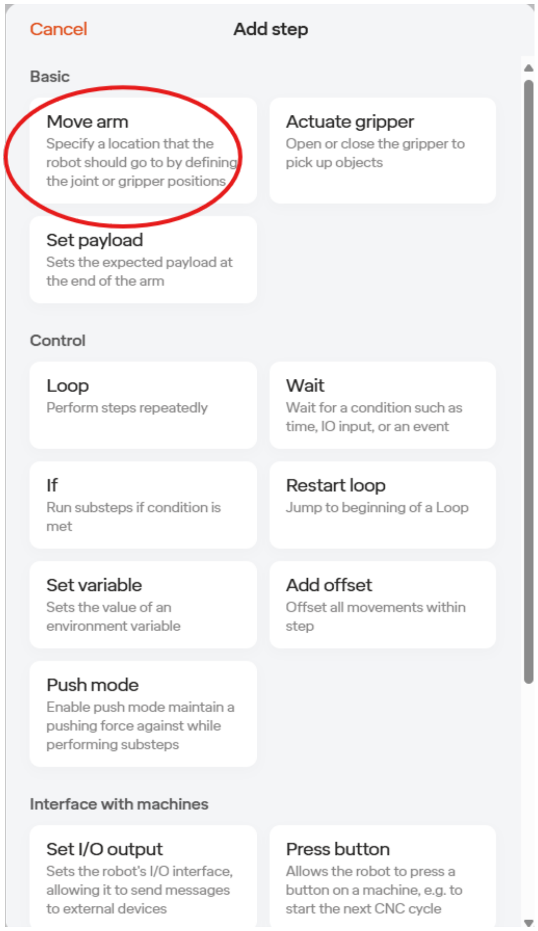
You will be directed back to the equipment tab to add the equipment. Click the +add to add the equipment. Select the equipment you have from the list. For our example, select OnRobot 2FG7. When adding a single tool on a single changer, you do not need to define a changer and instead simply add the tool.



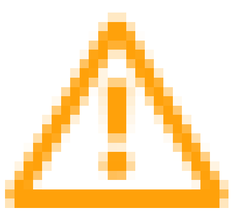
Select the back arrow in the upper left to go to the Home Page and then select on your routine to return to the Routine Page.



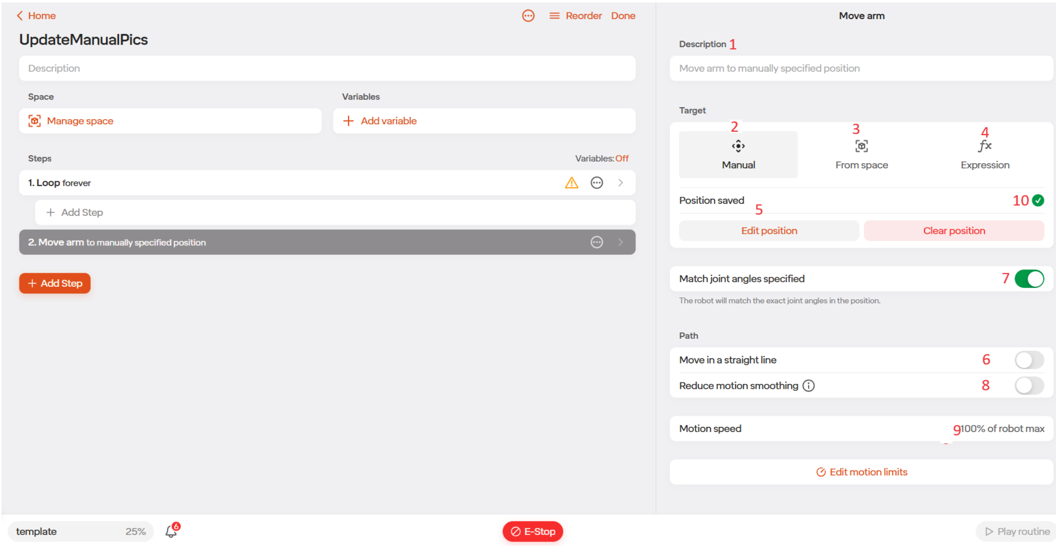
Click Add Step to begin creating the routine.



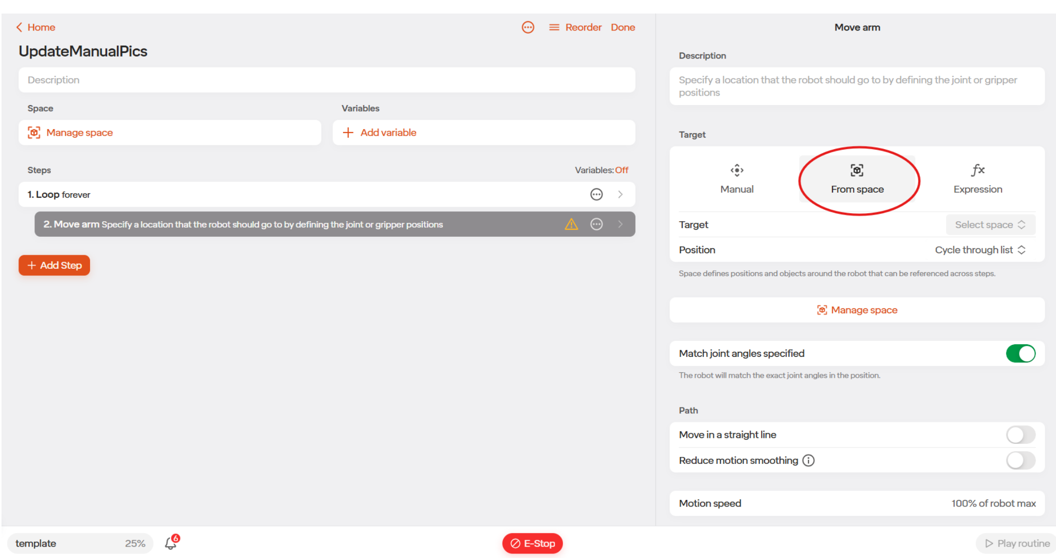
The menu will show all available step types with descriptions. For the sample routine, we will start with a Move Arm Step. A Move Arm step is how you tell the robot to go to a position. Click the Move Arm step to add it to the Routine.



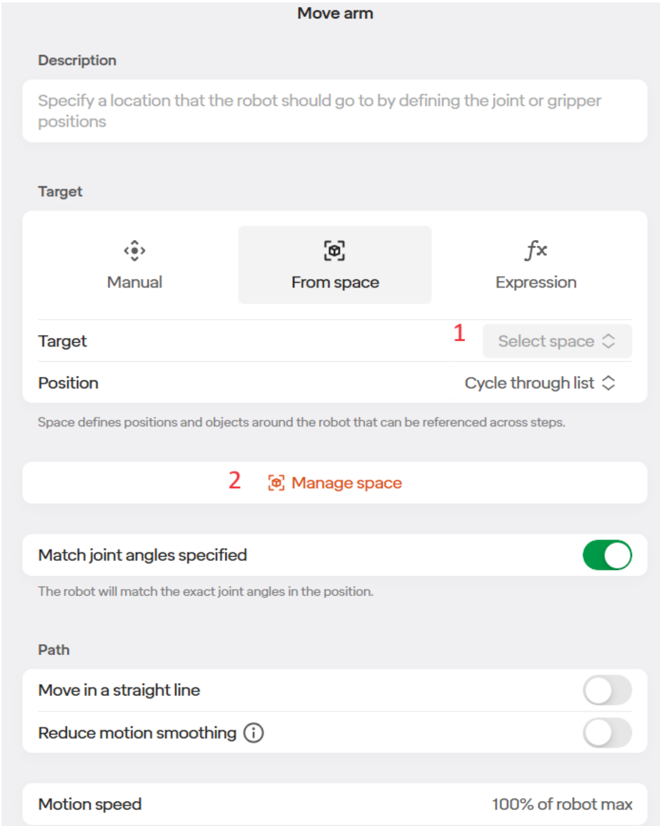
The Move Arm step will be added to the first line of the Routine. The yellow ! Indicates that an action is required for that step. Click the step to edit the step.



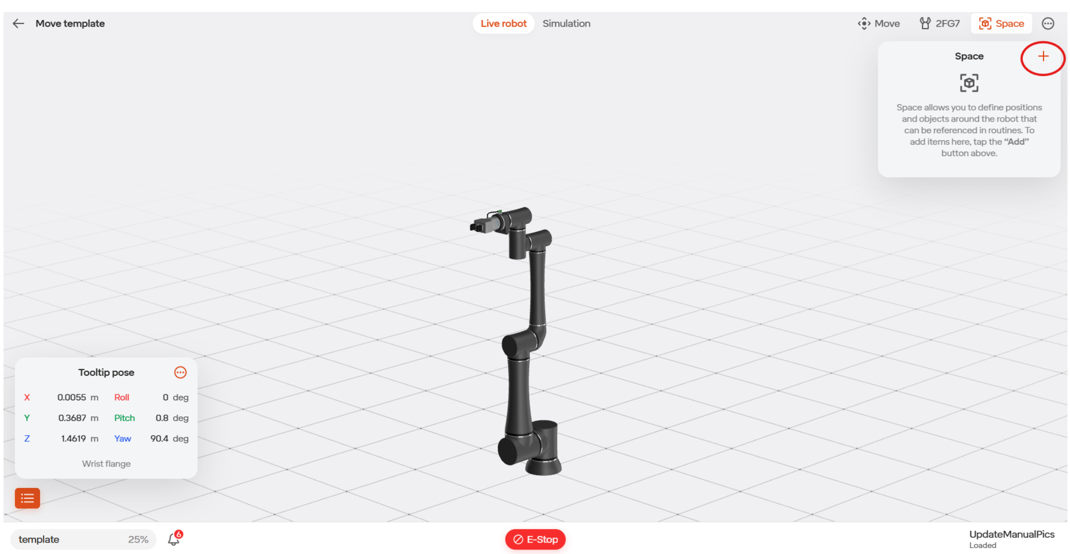
1. Editable description for this Step.
2. Specify the position for the robot to go to based on the current position.
3. Specify the position for the robot to go to based on a saved position from the Space.
4. Specify the position for the robot to go to based a math function and/or variables.
5. Edit the position for the robot to go to based on the current robot position.
6. Go to this position in a straight line (from the Tooltip perspective),
7. The robot can sometimes reach a point in multiple ways, this tells the robot to use this exact orientation when going to this point.
8. Reduces the motion smoothing like overshooting or false collisions.
9. Set the speed as a % of maximum defined in the Edit Motion Limits Settings.
10. Shows that the position has been saved.



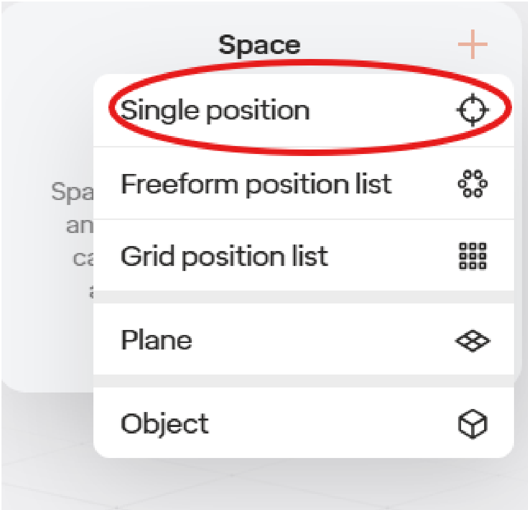
For our example we are going to select From Space. Defining a point in the Space allows you to use it in multiple places in the routine. Defining a point in the Space also lets you more easily modify the point in the future.



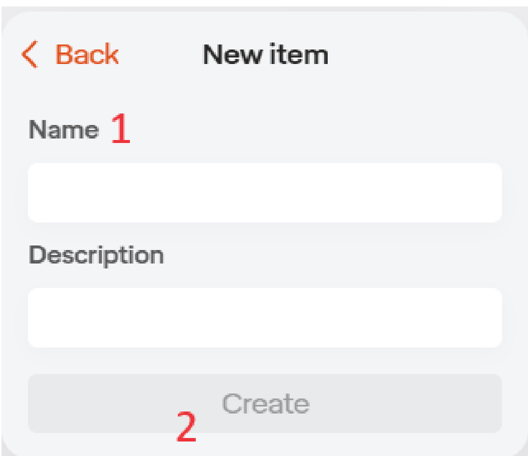
1. The indicated drop down will have all the positions from the Space listed. We have not defined any yet.
2. Select the Manage Space button to go to the Move Robot view.



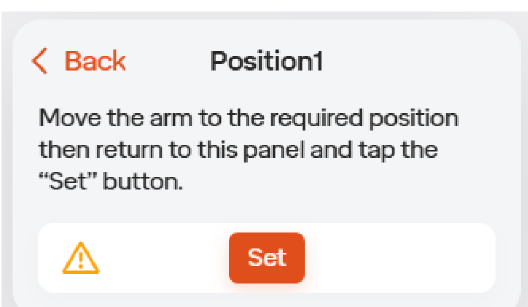
You will be brought back to the Move Robot view under the Space option in the upper right. Click the + button to add a new variable position.



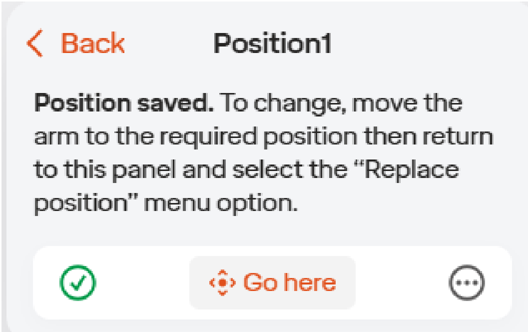
Select Single Position to create a new saved position.



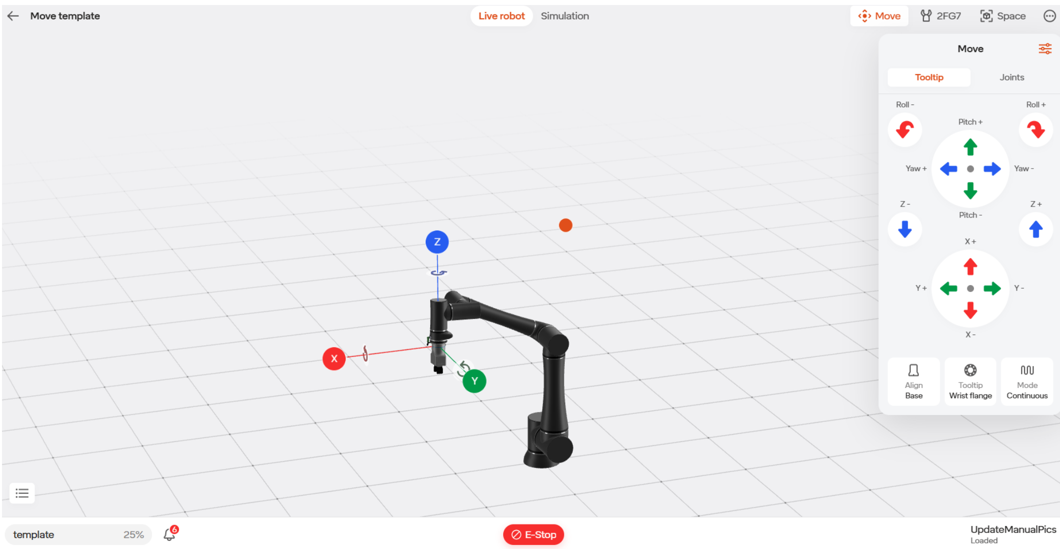
1. Give the position a name.
2. Select Create.



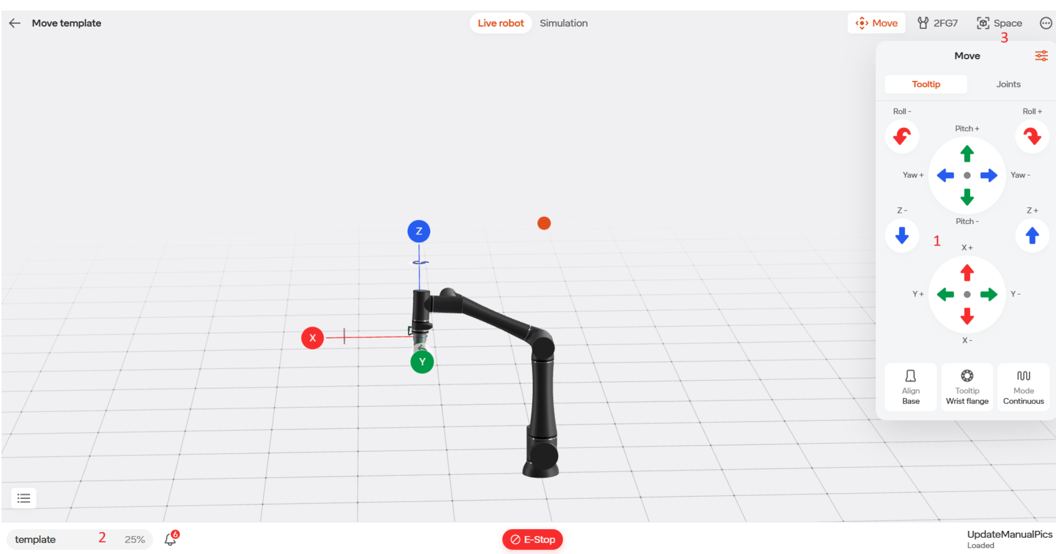
1. Set will set the position named "Position 1" to the current robot location.



2. Go Here will drive the robot to the saved position if held down.

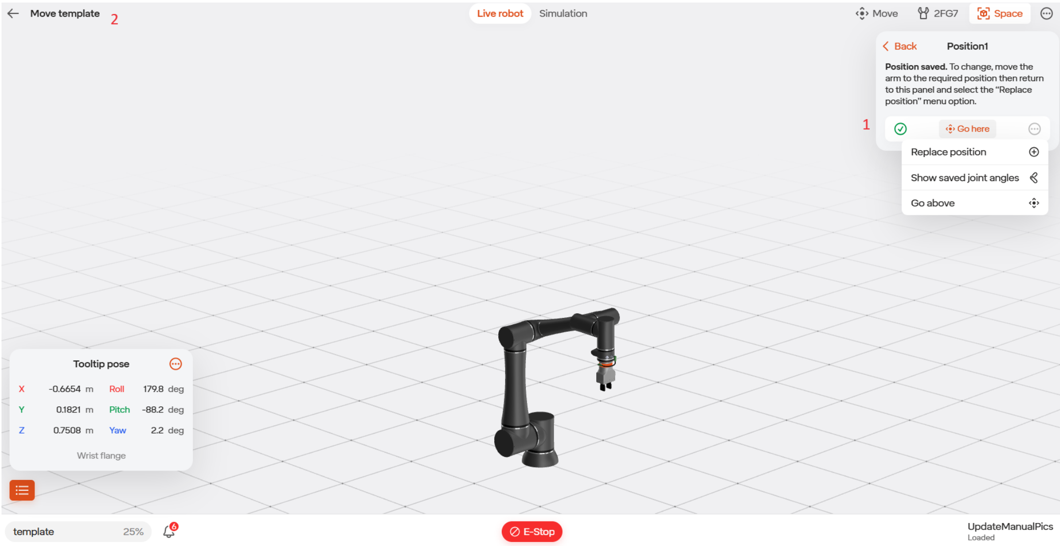


3. Use the Tooltip jogging area to move the robot to the desired initial position.
4. We are going to set a safe position above our work area for the robot to go to every time we start the routine.



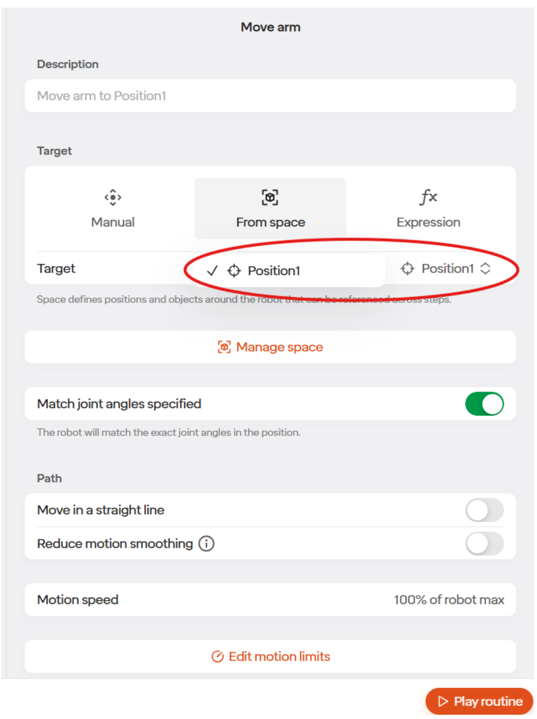
1. Jog the robot to the desired position using the arrows.
2. If needed, use the menu to change the robot speed.

3. Once you are in the desired position, use the Space icon to return to the Space positions.

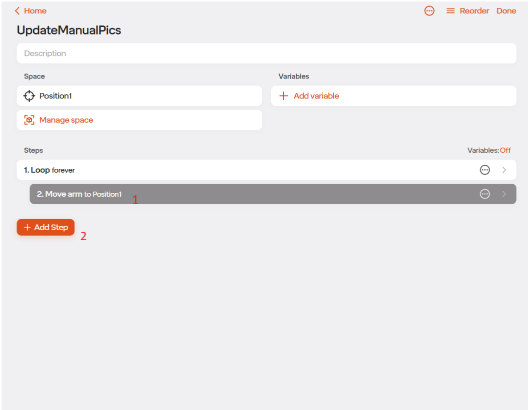


1. Set the position to the variable "Position 1".

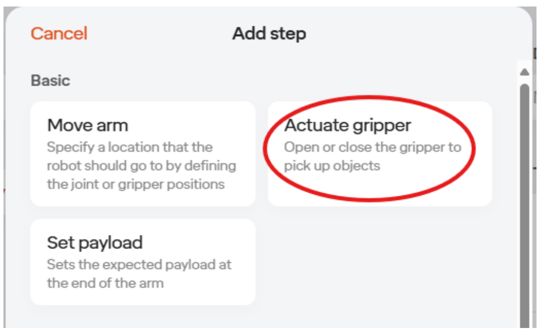
2. Select the back arrow to go back to the routine.



Select our new saved position "Position 1" from the drop down.

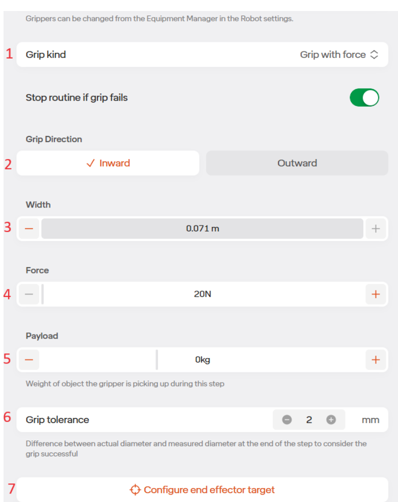


1. We now have our first step at the beginning of the routine.
2. Click + Add Step to add our next step.



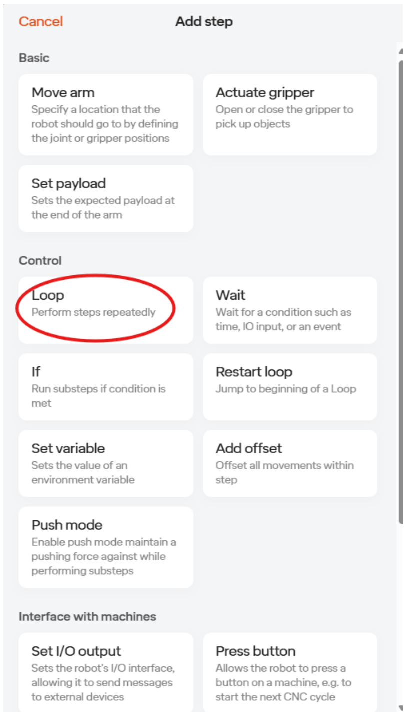
Often you will want to set your tool configuration at the beginning of the routine as you do not know how it will be left every time the robot stops. Select Actuate Gripper.

Select the Actuate Gripper the step to edit the step.

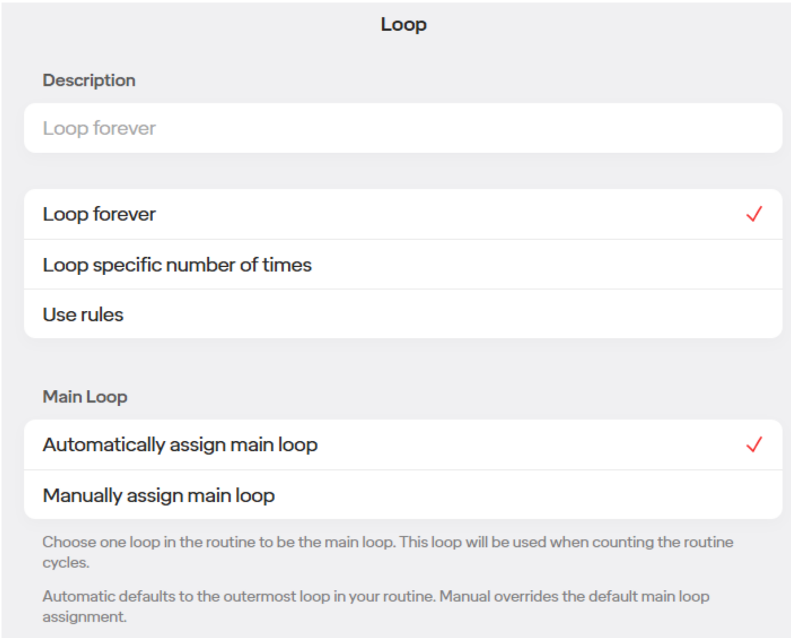


1. If we want to close the tool with some force select the Grip object with force checkbox. Since we are opening, we will change this option to Move To Position.
2. Set the GRIP DIRECTION to inward.
3. Set the gripper WIDTH, since we are opening, we will set it wide open

4. Set the FORCE to grip with. We will leave at 20N as we are opening.
5. Set the PAYLOAD for the target. Since we are just opening, this will be left at 0kg
6. Set the TOLERANCE for the gripper to be considered successful. This will be left at 2mm.
7. Click Configure End Effector Target.
8. The live robot page will open. Press the "Hold to Apply Changes" and then "Confirm End Effector Position" in the upper left. You'll then be brought back to the Routine page.



1. Select + Add Step as we did for the last two steps to add another step.
2. Select Loop.
3. Click on the Loop step to be able to edit the step.



For Loop under Basic Options you can choose to:

•Loop Forever: Loop until the program is stopped by the user.

•Loop specific number of times: Loop the number of times specified before going to the next step.

•Use Rules: Allows you to use math and variables to set the number of times the loop runs.

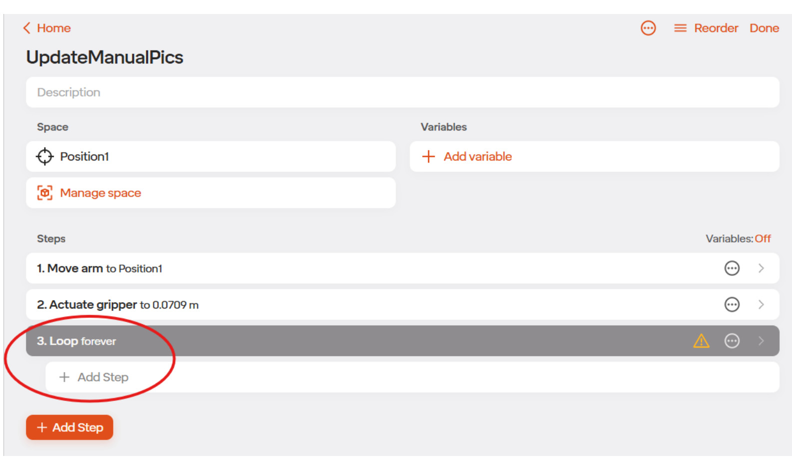
For our case leave as Loop Forever

•Under Main Loop you can choose:

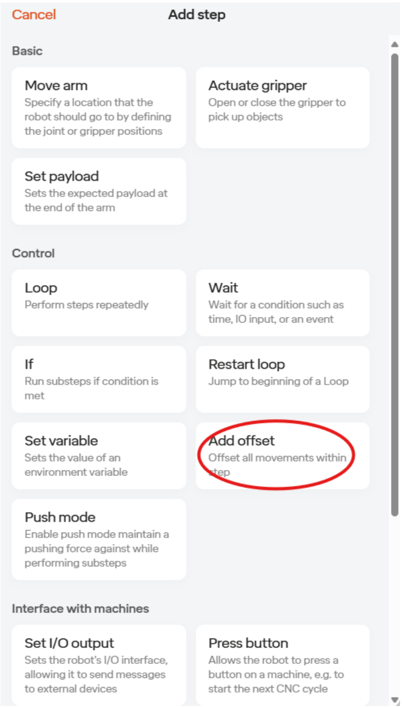
•Automatically assign Main Loop: Set the loop that is to count the number of times the routine runs as the one index most left in the routine window.

•Manually assign Main Loop: Set the loop that is to count the number of times the routine runs manually in the Loop setting using the checkbox below.

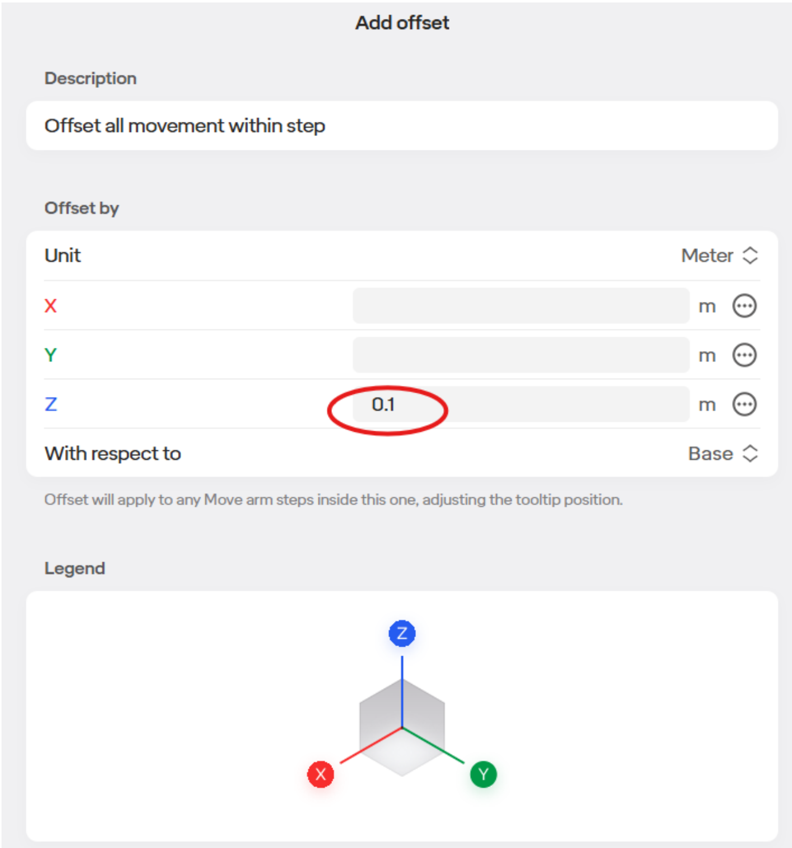
For our case leave as Automatically assign Main Loop.



The Loop will have a warning that steps are required below it when first added to the routine. Steps that are indexed to the right will loop according to what we set as the Loop parameters. If we add a step that is in line with our last Actuate Gripper instead of indexed over to the right, they would happen after the loop. Click Add Step in the transparent area below the loop to add a new step.



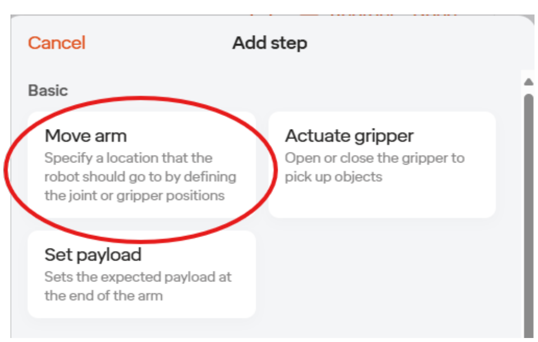
Often you want to approach a position from an offset based on the end position, for example when picking a part. If you do not set an in between point to ensure you approach the part from the top, you may approach it from the side and knock into it with the tool. Select Add Offset to add an offset to our next move in the loop. Click the step to edit our newly added Add Offset.



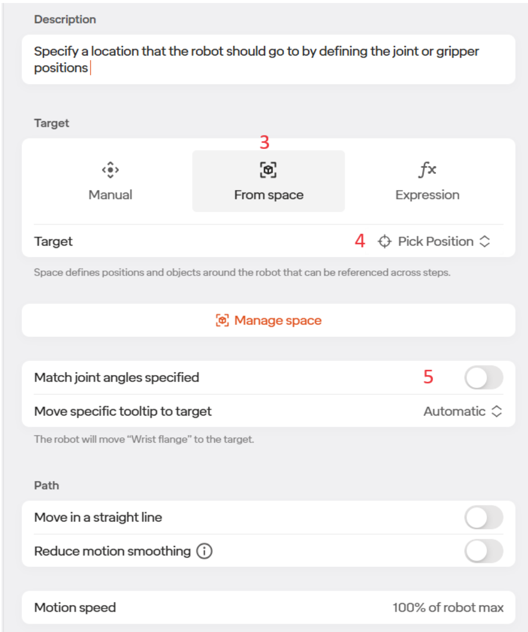
You can offset the part in X, Y or Z by a positive or negative offset.

We will be picking from above the part, so add a 0.1 meter offset in Z.

The newly added Add Offset will have a warning that it requires another step below it to offset. Any move below and indexed to the right of our Add Offset will be offset by the .1 meters we set in positive Z. Select Add Step in the translucent step below Add Offset

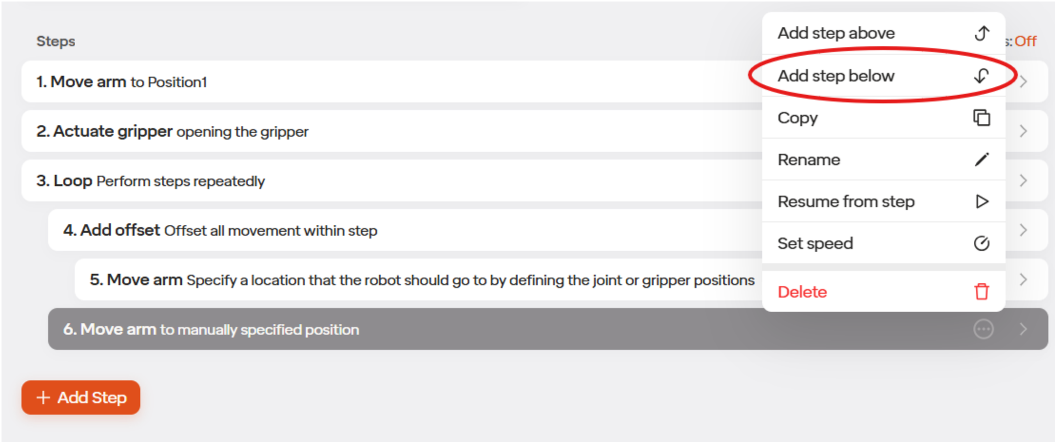


Select another Move Arm command. As we did in the first step, use the Space to move the robot to the pick position and create a new Single Position as a variable named Pick Position in the space.



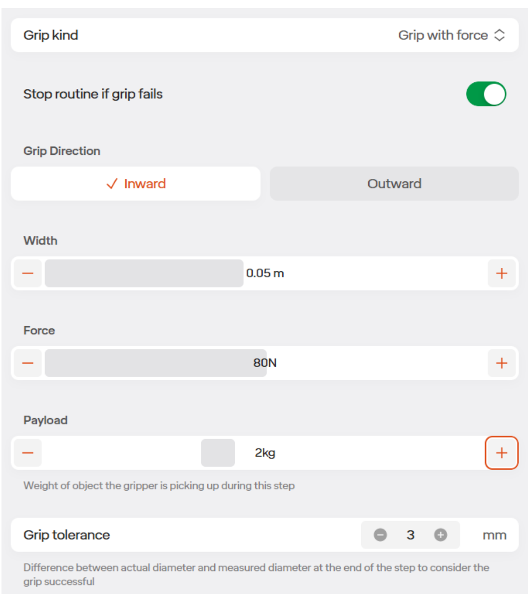
1. Select another Move Arm command.
2. As we did in the first step, use the Space to move the robot to the pick position that you want, and create a new Single Position as a variable in the space.
3. Select From Space.
4. Set the target as our new position Pick Position.
5. Ensure Match Joint Angles Specified is not checked as this is not allowed inside of an offset.

Next we want to add another Move Arm step. We want this step to be within our Loop, but not offset by our Add Offset so instead of clicking the +Add Step, select the three dot icon to the right of the Add Offset step, and select Add Step Below (you and also drag and move steps by selecting the orange "Reorder" icon at the top of the page).



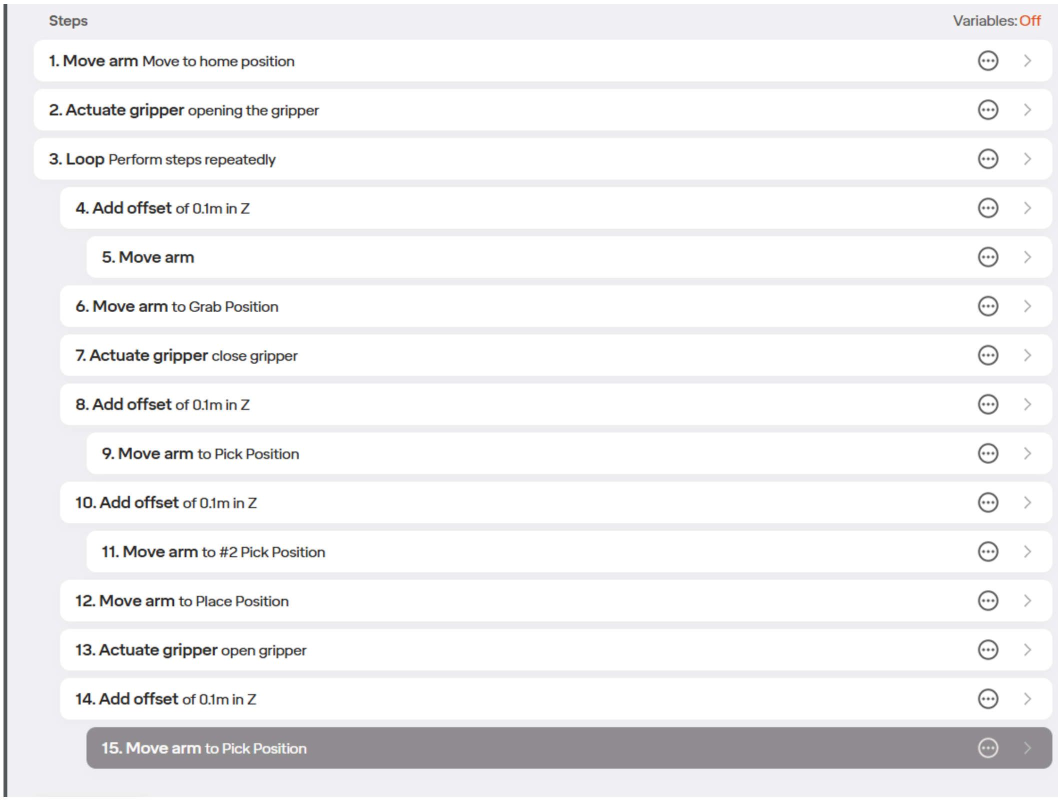
Next we will be adding another Actuate Gripper command.

1. Select the three dot icon on our new Move Arm Step.
2. Select Add Step Below.
3. Choose Actuate Gripper.



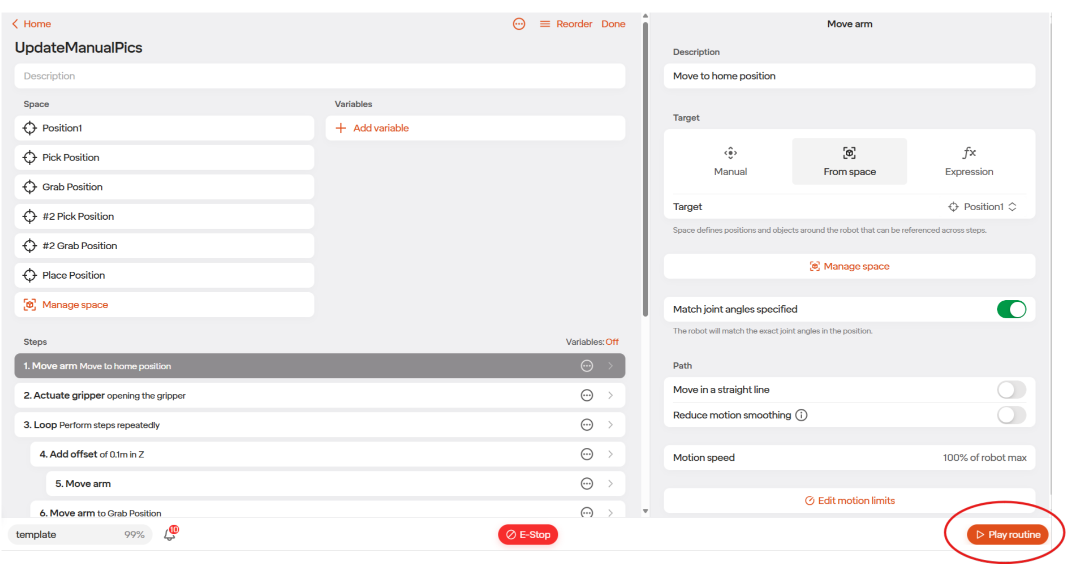
Configure the tool as shown, which will close the tool on a part with 80N of force.

As we did before the pick, configure another offset move to move above the Pick Position. This will ensure we do not drag the part before we move to the place. The routine should look like the image above.

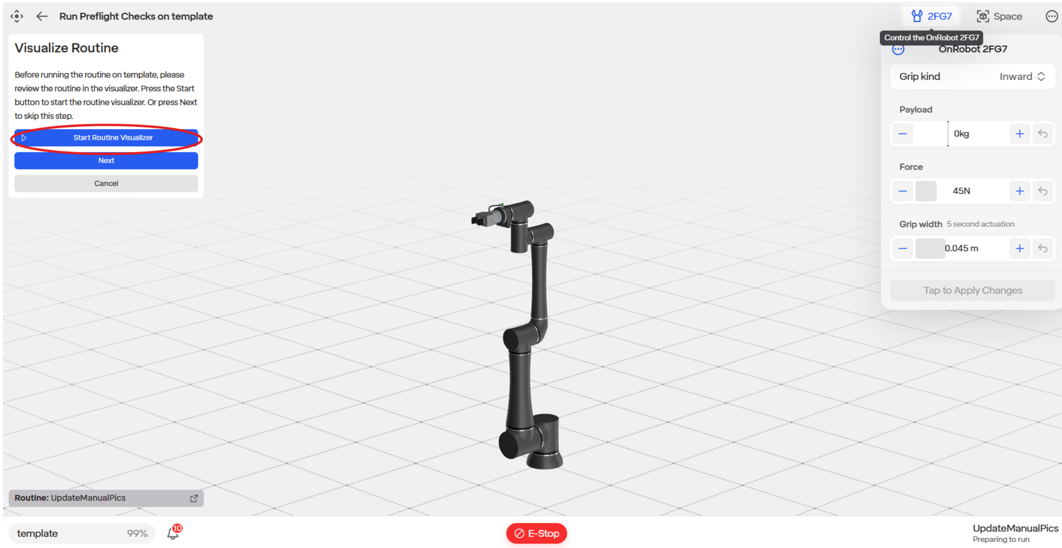


As we did for the pick, configure another set of steps to go to an offset above a new position, Place Position, go to the Place Position, Actuate the tool, and go to an offset above the Place Position. The routine should look like the image above. This routine should now continuously pick and place until it is manually stopped.

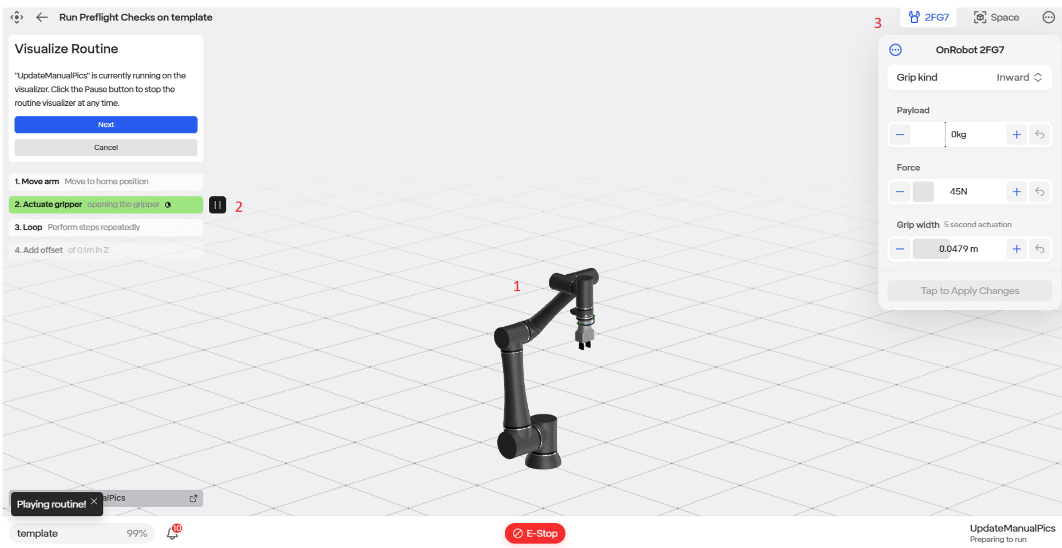
5.6.2 Running Routines



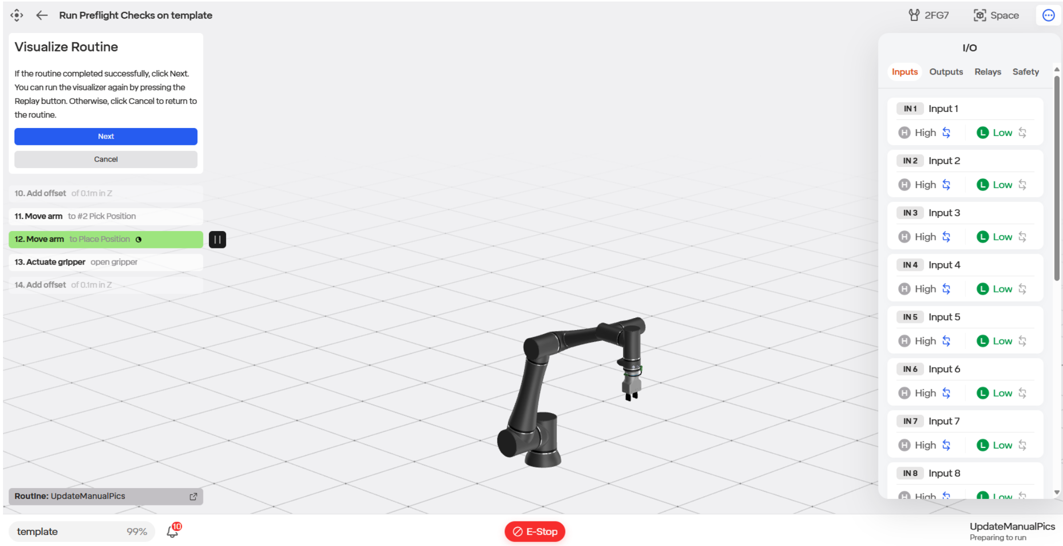
To test the routine, select the Play Routine icon.



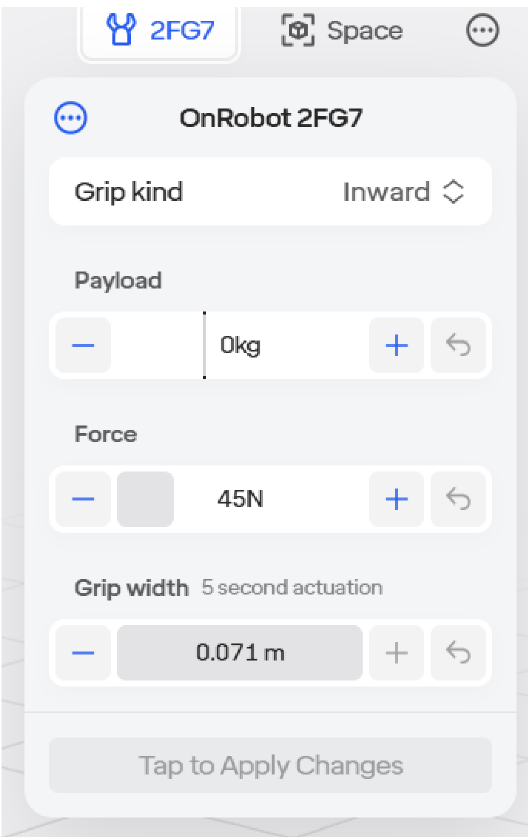
Select Start Routine Visualizer.



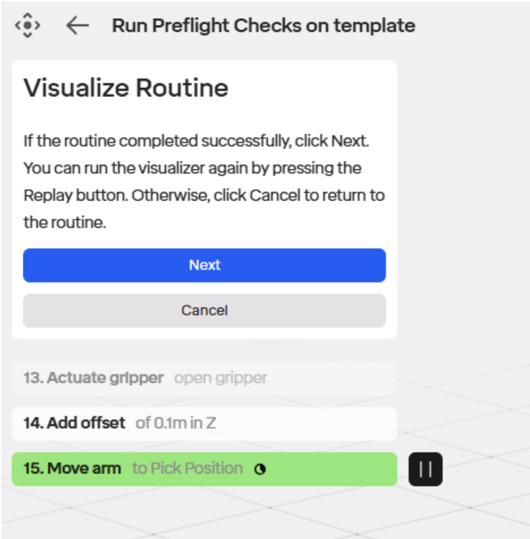
1. The robot will start completing the routine in a virtual environment.
2. The step the robot is currently completing will show on the left side of the screen.
3. The value of all Variables is shown in the upper right.
4. The routine will only loop once the first time. If you hit the “resume routine” button again it will loop indefinitely.



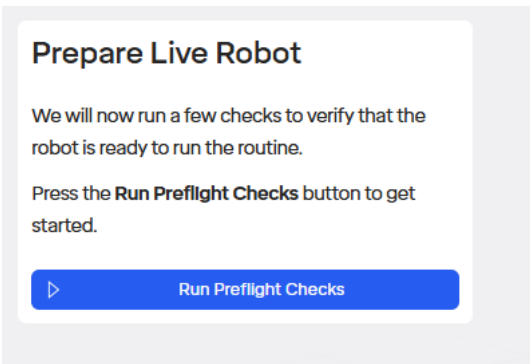
1. The **I/O** menu (hidden behind the three dot icon in the upper right) can be selected to show the IO values as the routine is running.



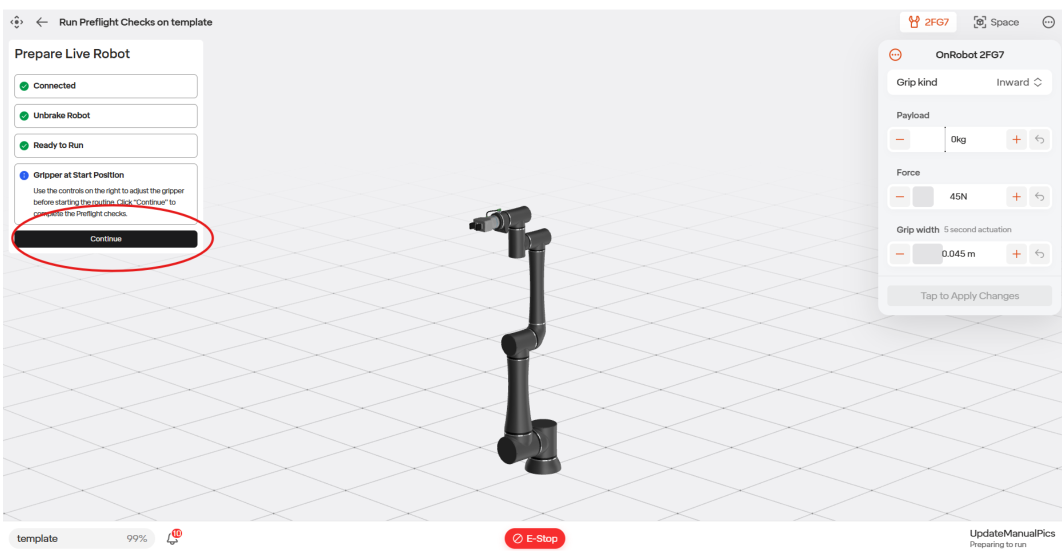
1.The **Gripper** menu can be selected to show the tool settings as the routine is running.



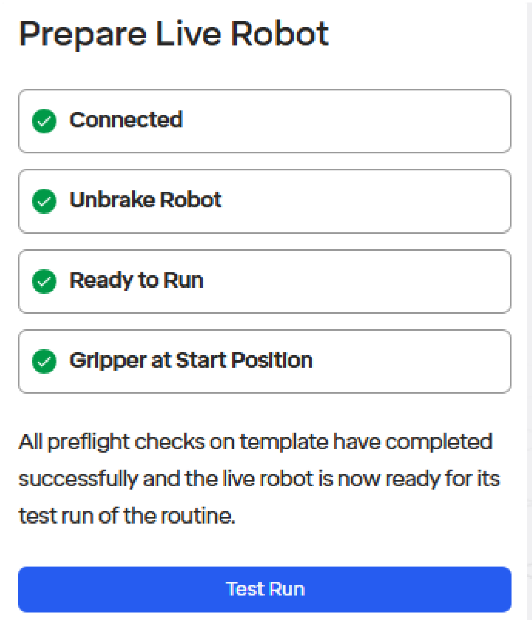
If the routine looks correct, it is ready to run on the physical robot. Select the blue **Next** button.



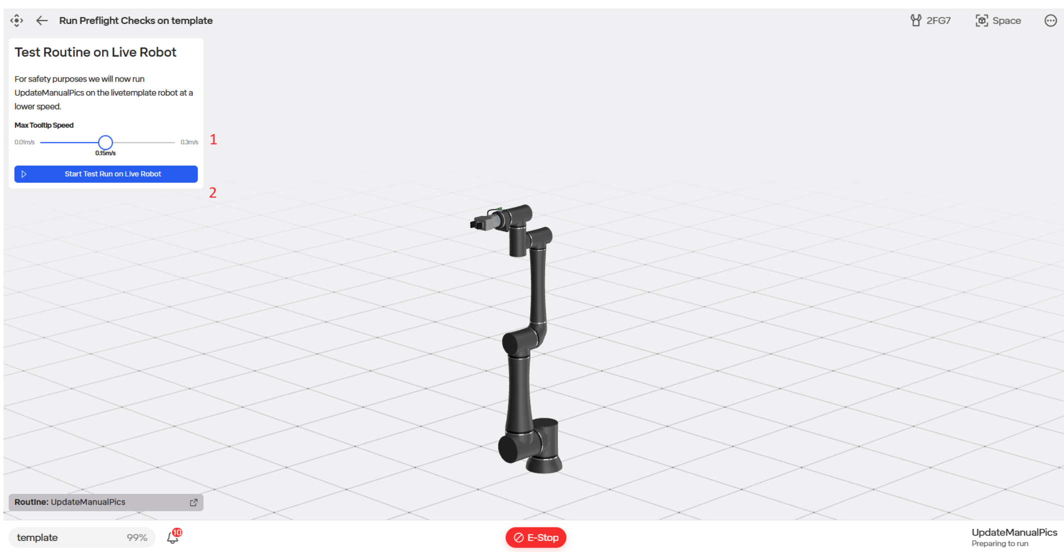
Select Run Pre-flight Checks.



Ensure the tool is in an acceptable position based on the start of your program. In our case we start by opening, so ensure the gripper is empty if you don't want to drop the product.

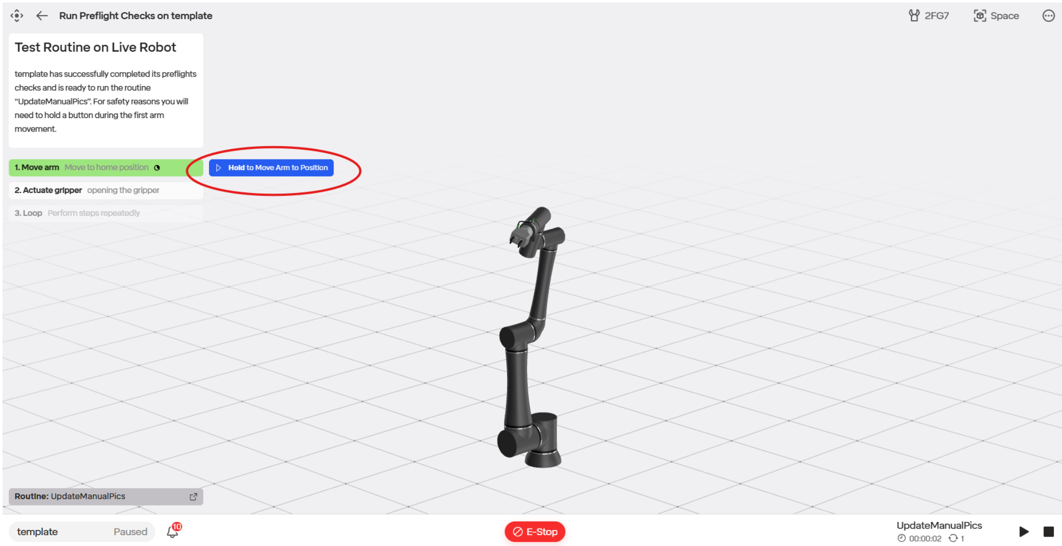


Click the blue Test Run button.



1.Select the maximum speed you want the end of the arm to move for the initial run by setting Max Tooltip Speed.

2.Click the Start Test Run on Live Robot button.



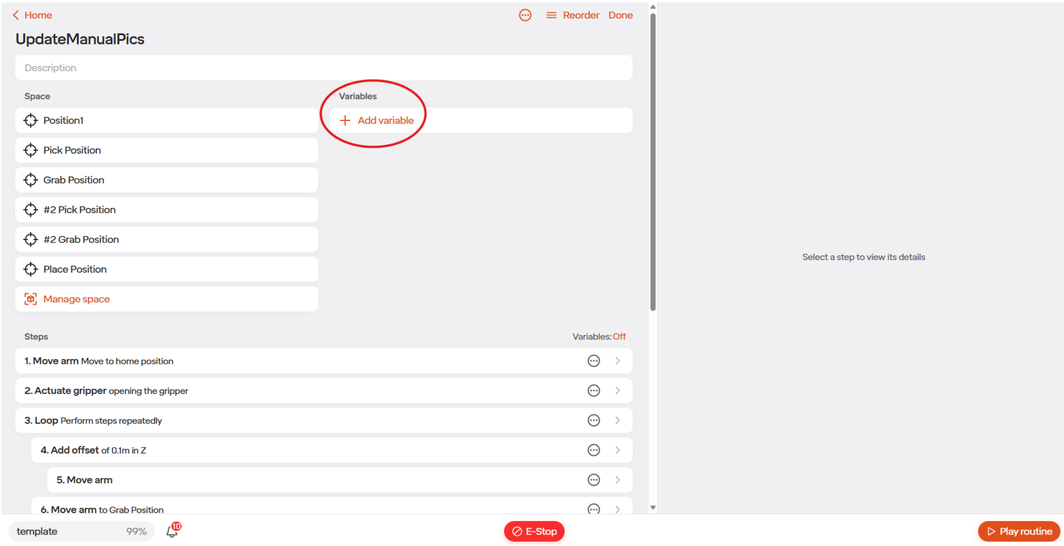
1. Click and hold the Hold to Move Arm to Position button to move the robot to the first position in the routine.
2. Watch the robot to ensure there are not going to be collisions during this move.
3. The routine will run at the specified reduced speed once and stop.
4. If the routine looks good, you can now play again with the "resume routine" icon that will appear in the upper right, and it will run at the speed specified in the menu in the lower left.

5.7 Advanced Routine Functionality

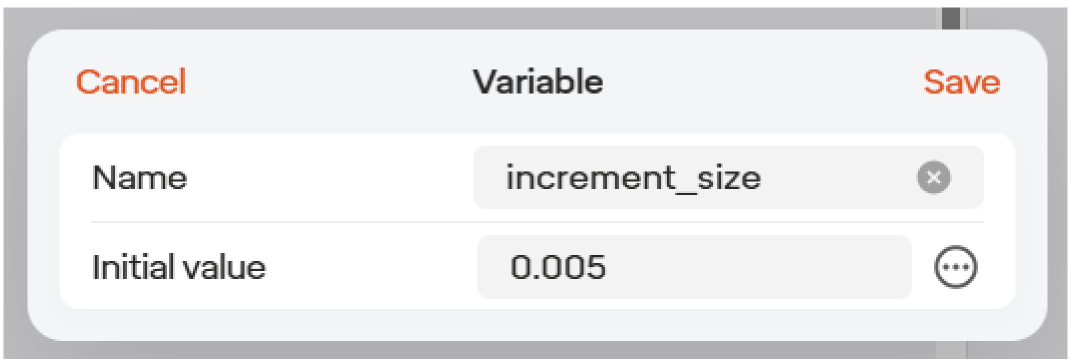
5.7.1 Variables

Variables can be used to assist with a variety of tasks within a routine such as:

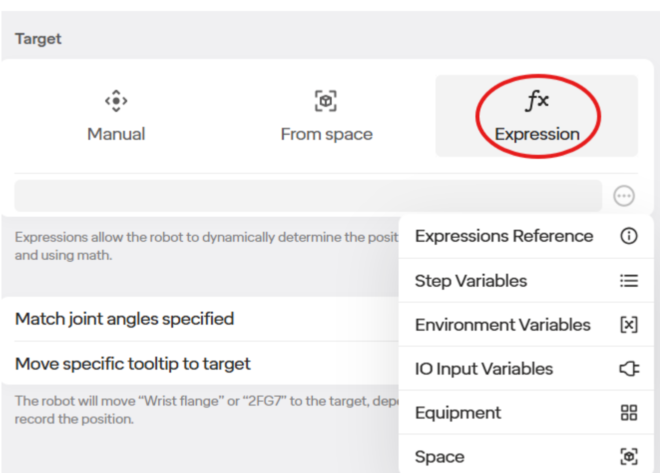
- Storing a part offset for use in multiple Add Offset steps.
- Keeping track of how many parts have been picked in a given row.
- Keeping track of how many layers have been placed on a pallet.



To create a variable, locate the variables are in the routine editor.



When creating a variable, be sure to set an initial value. If no value is set, the variable will be set to 0. The value in the initial value box will be used set for the variable every time the routine is started.



To use a variable in the routine, click the “Fx expressions” button in the given area of the step. There are several sets of variables available.

Expressions Reference: Help menu on how to construct expressions

Step Variables: Data from each routine step that can be used, for example the number of times it has been executed in a loop.

Environmental Variables: Variables created by the user in the routine.

IO Input Variables: Access to each of the 16 24VDC inputs, 0 if off 1 if on.

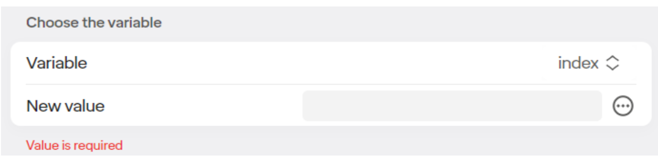
Gripper State: For supported grippers, inputs based on current state, for example closed or open.

Space: Data set in the space, such as saved positions.

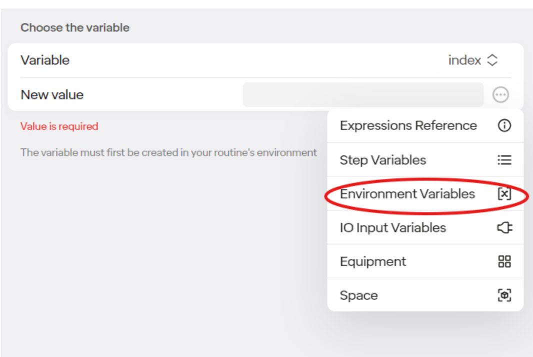
Note: If you are using a variable, you must add it using the “Fx expressions” button and then go to the three dots icon to find what variable you want to use (custom variables made will be found in “Environment Variables”). Do not manually type it in. Manually typing the variable will not include the correct prefix and will result in an error.

Here is an example of how to “add 1” to the value of a variable:

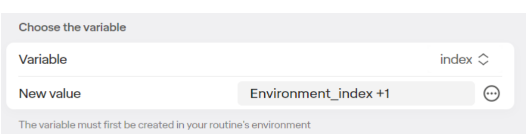
1. select the “set variable” step
2. select the variable you wish to add to (this example uses a variable named “index”)



3. select the three dots icon and click “environmental variables”.



4. Then select the variable you wish to change, it should automatically appear in the value bar. Notice how it’s shown as “Environment_...”, typing in the name of your variable into the bar will not work.
5. Then put “+1” in the value bar.

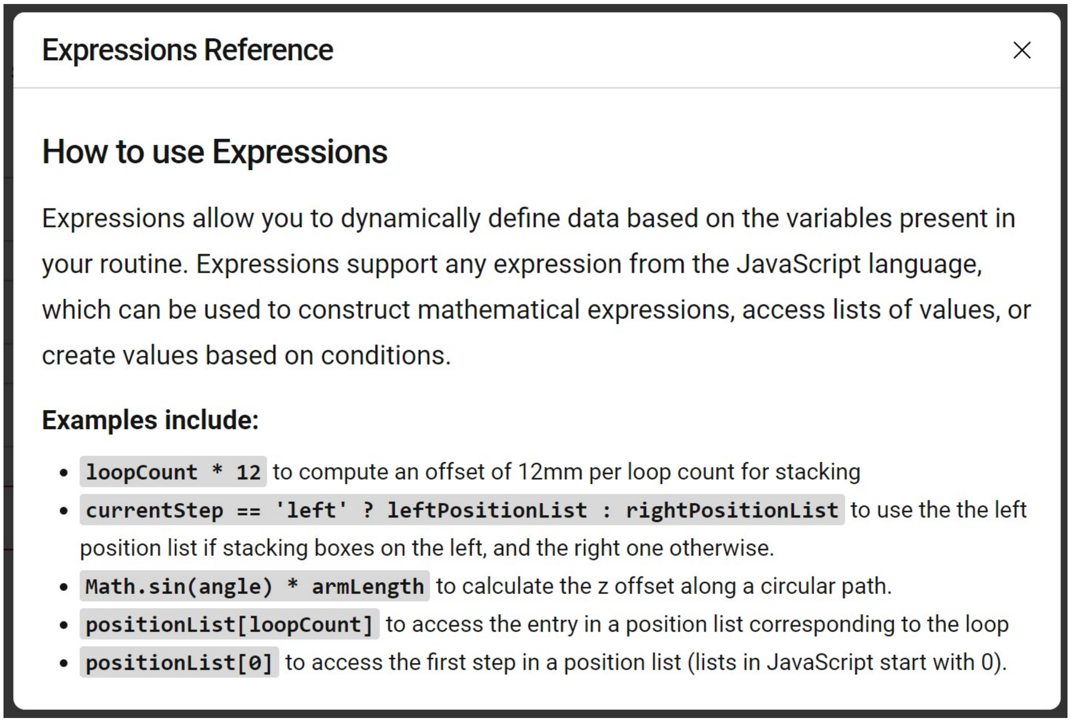


6. Now every time the routine gets to this step, the value of “index” will increase by one.

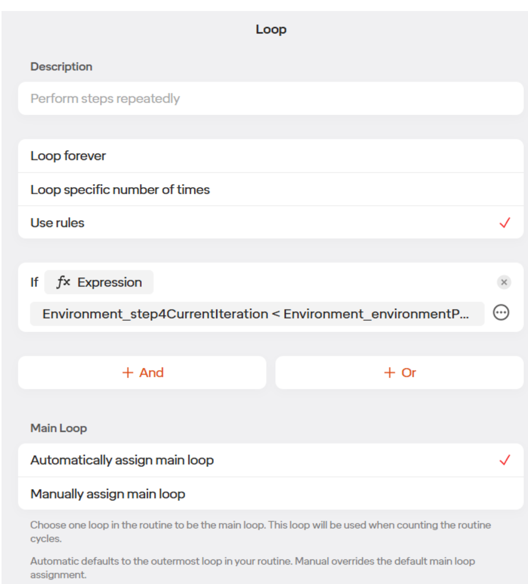
This doesn’t have to be only for addition, other math functions can be done as well.

5.7.2 Javascript

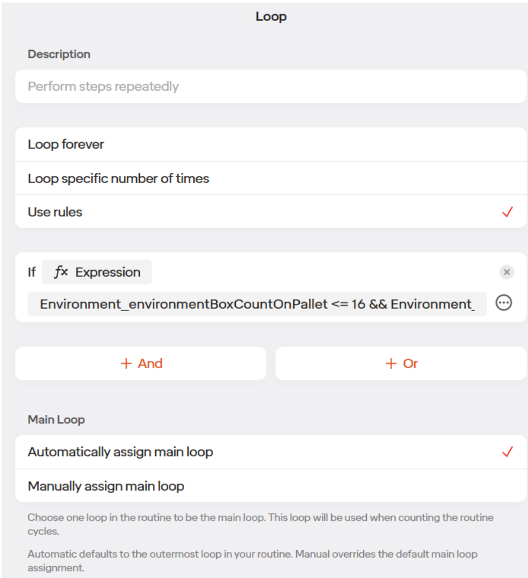
The Standard Bots routine editor provides the necessary instructions that address the requirements for the majority of applications. Should you need to to incorporate more advanced functions, the routine editor allows you to write your own JavaScript into Loops, Add Offsets, Move Arm steps, and more.

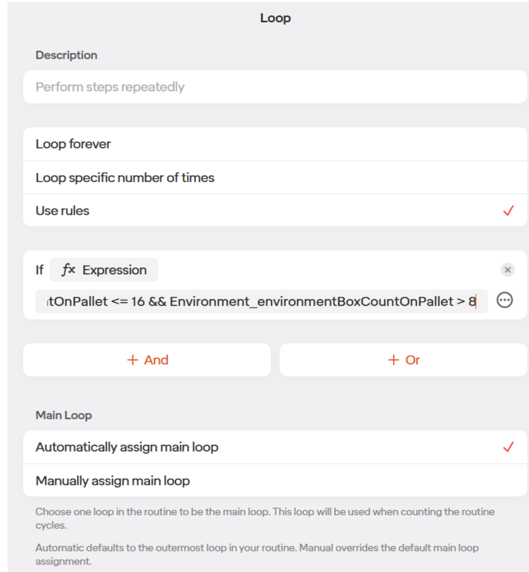


You can access the above help menu by clicking "Fx" in any text window in the routine editor and selecting "Expressions Reference".



In the above example, this loop will iterate until the loop has iterated more than the value set in an environmental variable, partsPerRow. After the loop has iterated more times than the value of partsPerRow, the routine will move to the next step after what is contained in this loop.

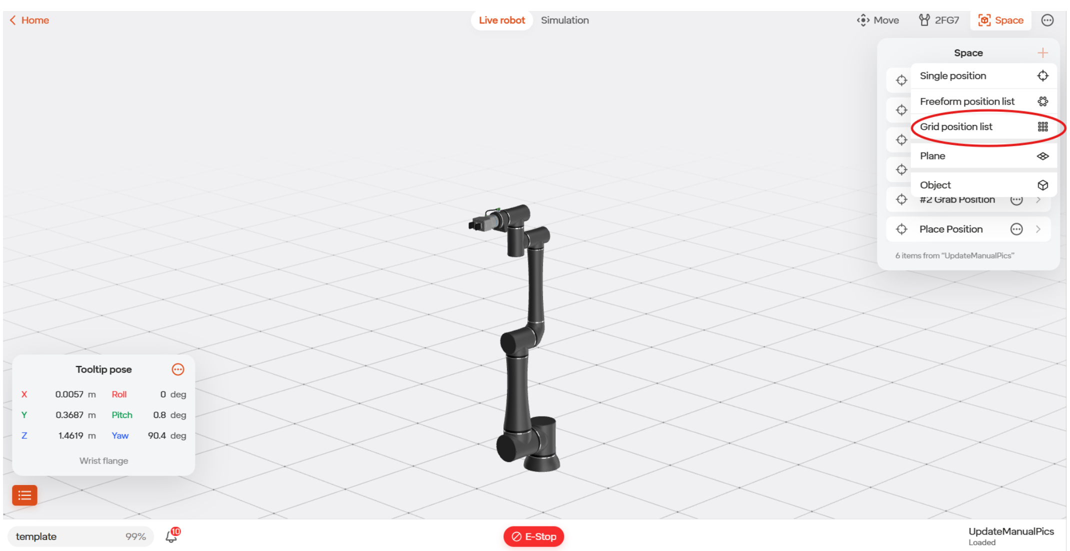




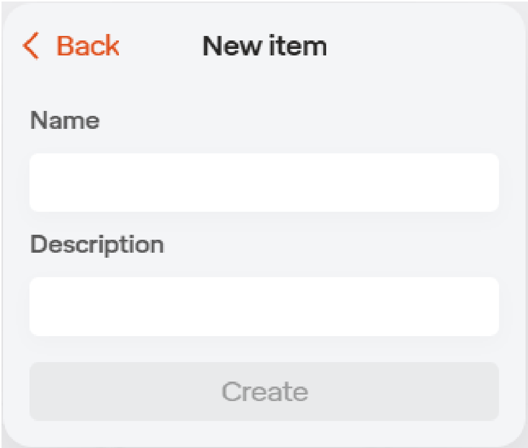
In the above example, the code is checking if a variable boxCountOnPallet is less than or equal to 16 but more than 8. If the above condition is true, whatever is indented below the If statement in the routine will execute.

5.7.3 Grid Position Lists

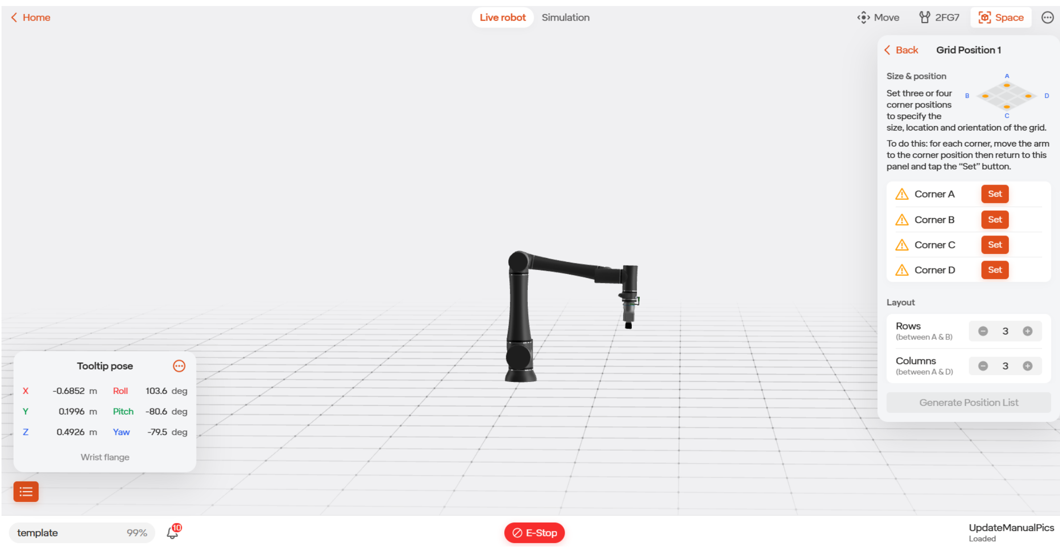
Grids are often used in robot programming when a large number of parts needs to be processed by a robot. Using the Grid Position List functionality when creating a routine can save significant time and effort.



To create a grid, go to the Move Robot area, go to the Space (square icon), select the Plus icon, and then select Grid Position List.

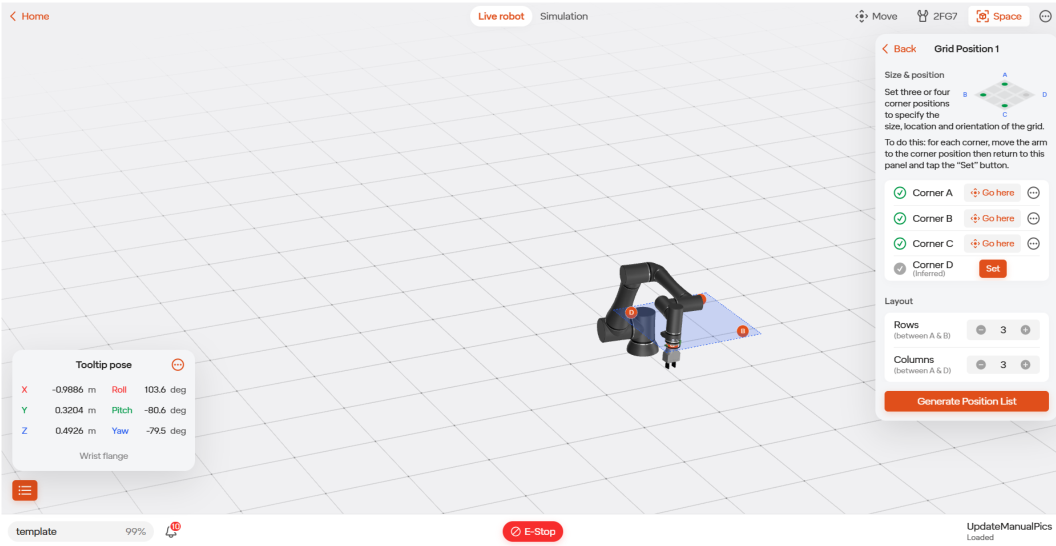


Give a name to the Grid Position List.

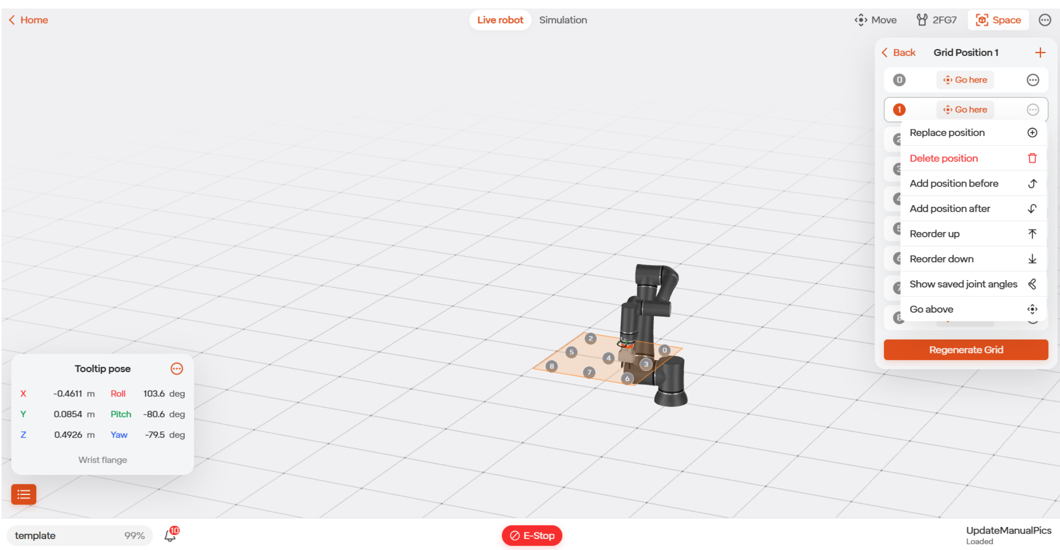


To create the grid, first drive the robot to a corner of the grid using the Jog Robot functionality in the Move Robot view. Set the position. Repeat for 3 corners of the grid.

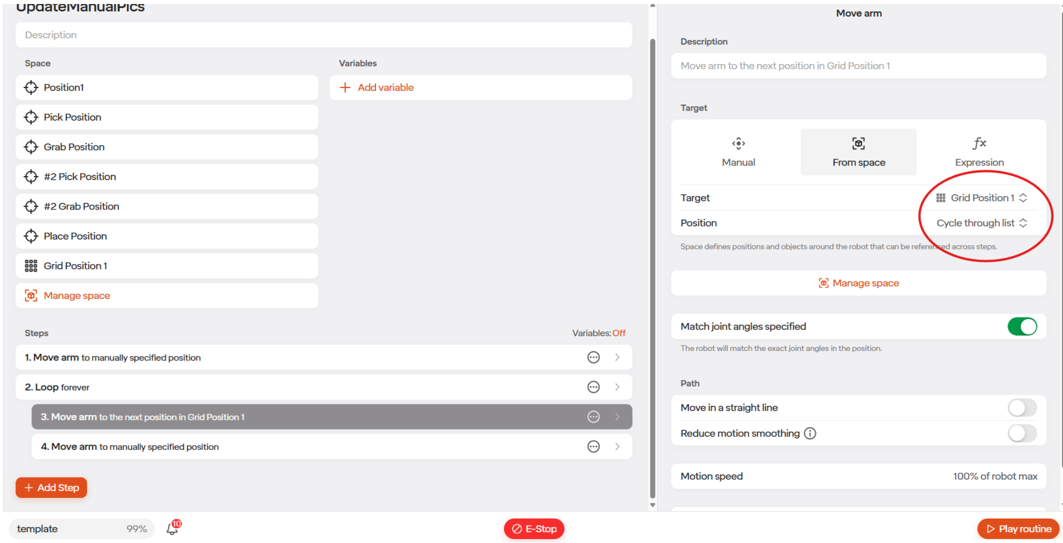
Under Layout, select the number of rows and columns in the grid. This will be the layout of the parts within the grid.



Select "Generate Position List".



After the grid is generated, you can go to the positions using "Go Here", tune them by using "Replace Position" (hidden behind the three dot icon), or exit.

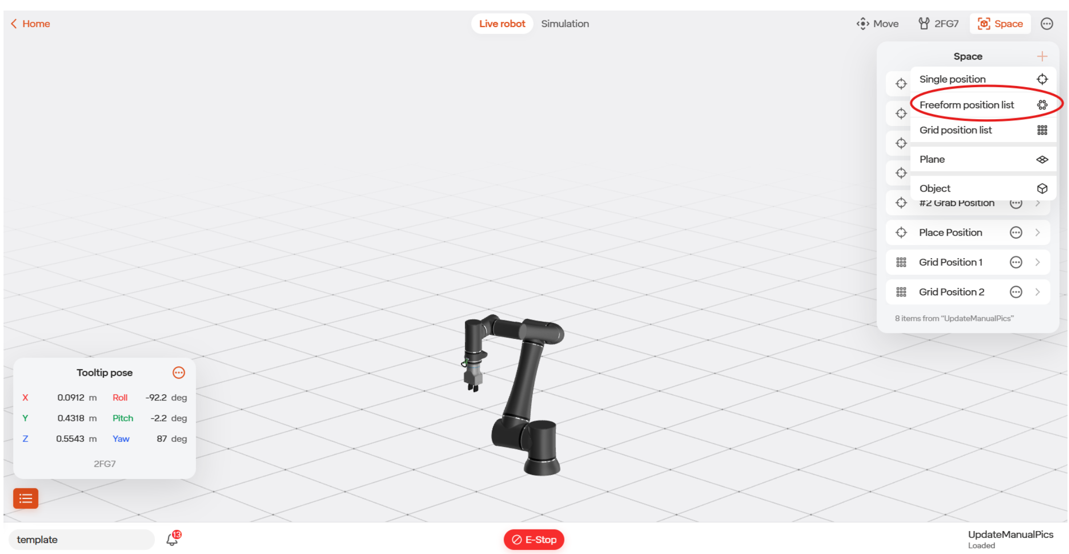


To use the grid, use a Move Arm command within a loop and select the grid within the "From Space" option. The robot will move to the positions in the grid, in order, each time the loop executes.

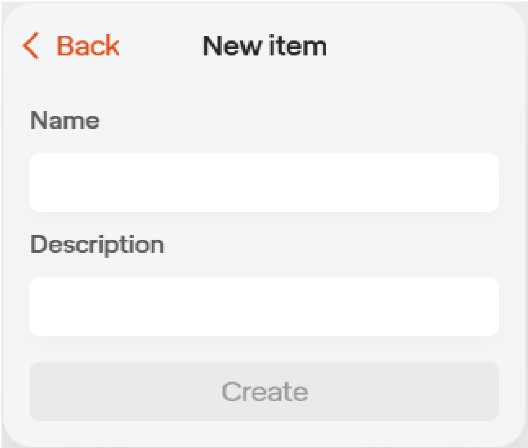
To program a grid with multiple layers, use an "Add Offset" to set an offset to the grid positions based on the number of times the loop has executed.

5.7.4 Freeform Position Lists

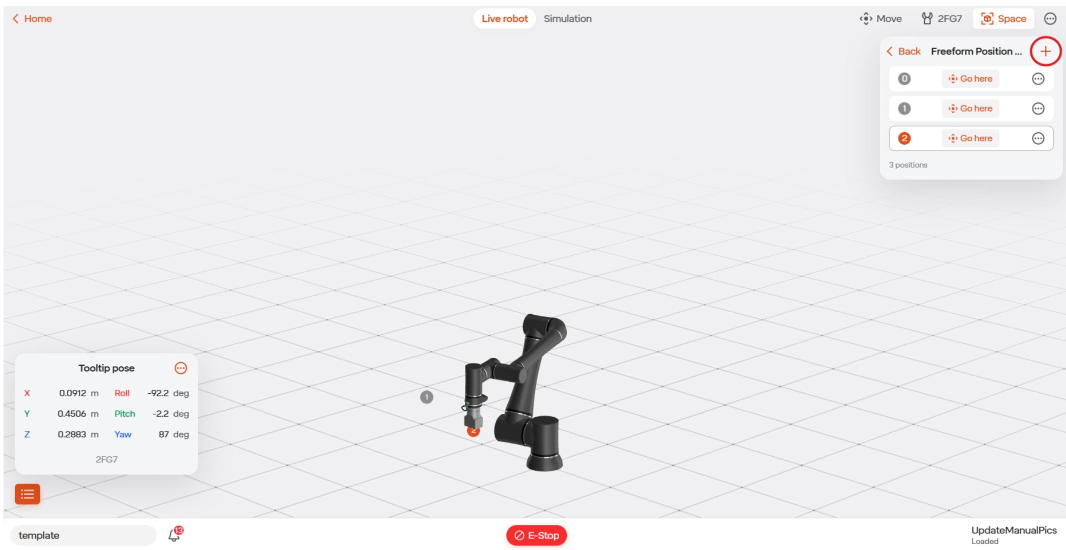
A Freeform Position List is a list of positions in an array. This can be useful when programming if you need to go to positions in order in a loop that are not in a grid, or indirectly address positions.



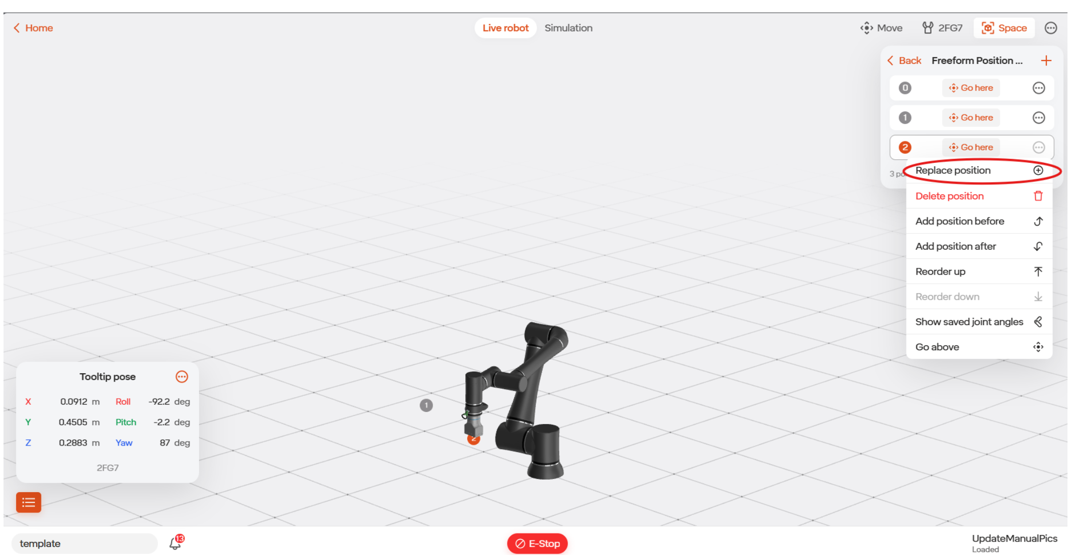
To create a Freeform Position List, go to the Move Robot area, go to the space (square icon), select the Plus icon, and then select Freeform Position List.



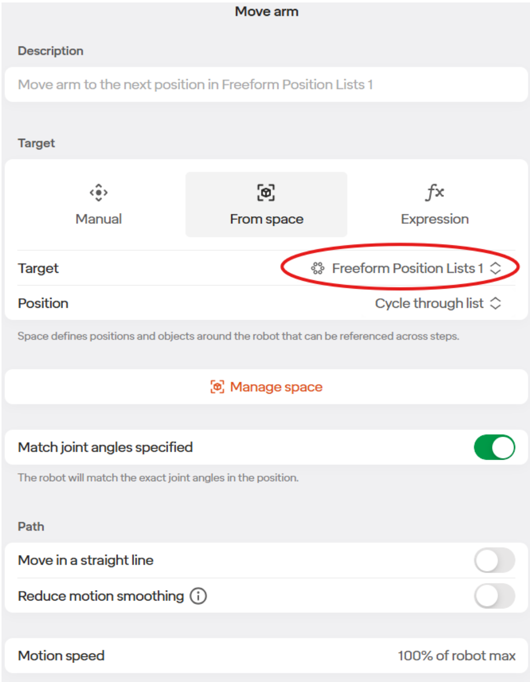
Give the position list a name.



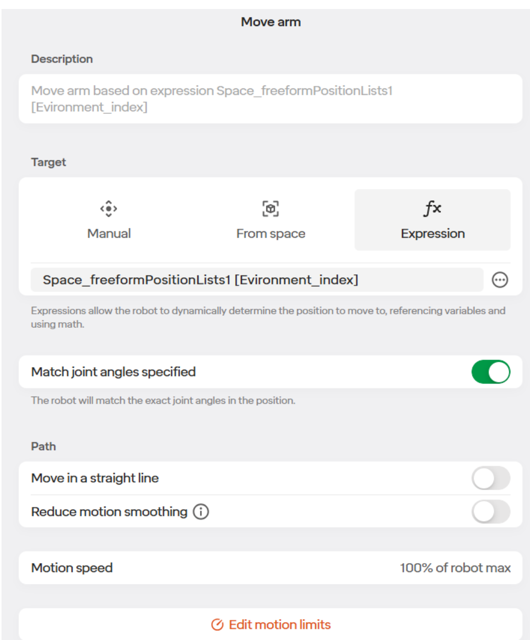
You can now drive to your first position using the Jog Robot functionality in the Move Robot view. Set the position. Repeat for the number of positions needed. Create the next position in the list using the "+" icon.



You can touch up the positions using “Go Here” and “Replace” (which is hidden behind the three dots icon). Once finished simply exit.



To go to the positions in order, use a Move Arm command and select the list from the Space.



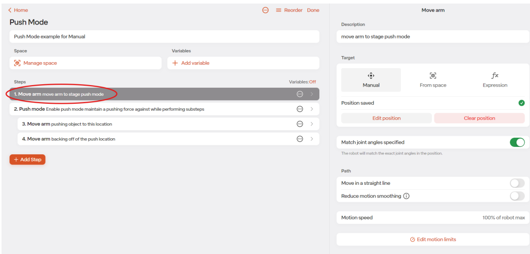
To access positions in the list not in order, use the “Expressions” option as shown. In this example we are going to the position in the list based off the environmental variable “index”.

5.7.5 Push Mode

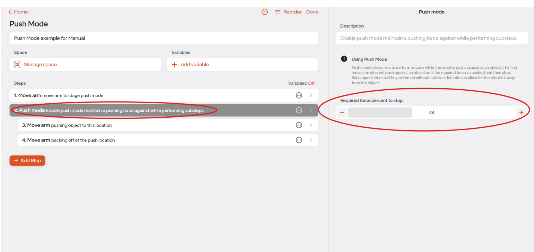
Push Mode allows you to perform actions while the robot is pushing against an object. The first move arm step will have the robot push against an object until the custom force requirement was reached. That step is finished once the force requirement is reached. Then the next step would be moving the robot away from the object. The steps are performed without the collision detection, allowing the robot to detect the needed amount of force.

Here is an example of implementing Push Mode into a routine:

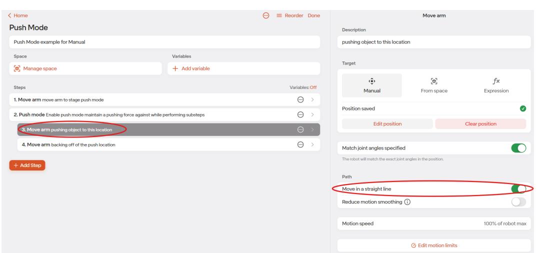
Step 1 in this example is used to move the robot into the initial position to push the object.



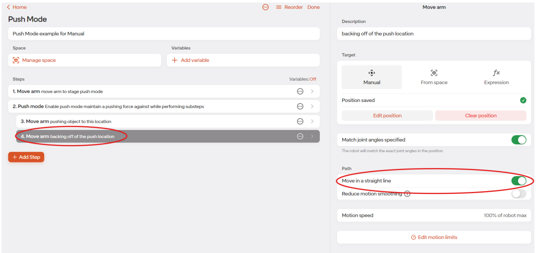
Step 2 in this example is enabling the push mode. Set the required amount of force for the robot to stop.



Step 3 in this example is the robot pushing the object to it's final position. The robot will stop when it detects the selected force percentage. It is required that "move in a straight line" is selected for this step to work.



Step 4 in this example is the robot arm backing away from the object. This step is done still under Push Mode because Push Mode turns off collision detection. Once the routine is out of Push Mode, collision detection is back on and if the robot is still pushed against the object an error will happen. "Move in a straight line" will still need to be selected for this step.



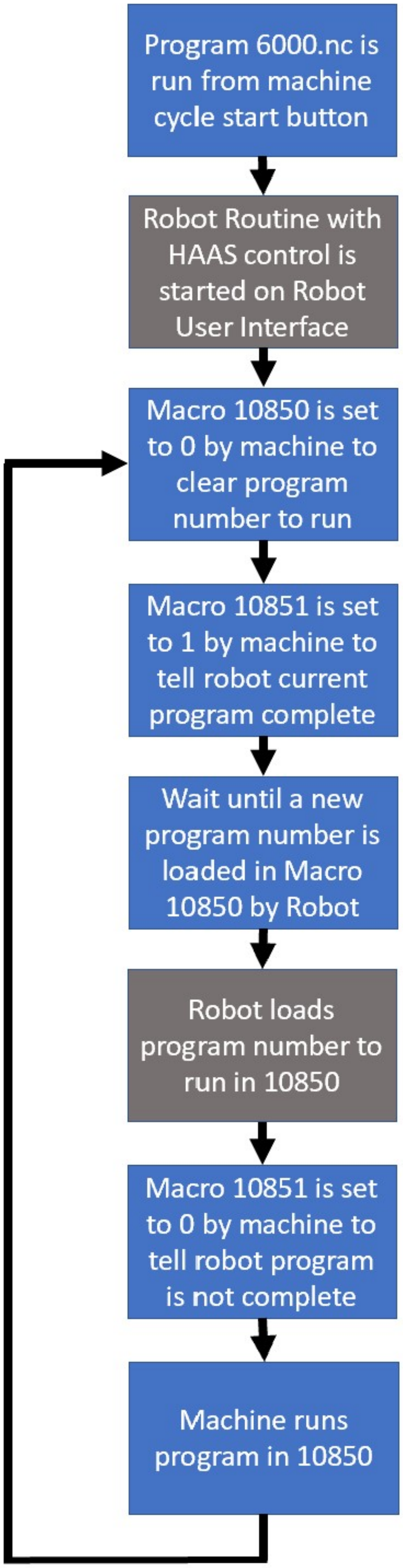
Once the robot is backed away from the pushed object, the steps after can leave Push Mode.

5.7.6 Haas Ethernet Integration

Introduction

For Haas machines that support Next Generation control (generally 2017 or newer machines) Standard Bots provides a first-class integration suite that allows for ethernet communication between the Standard Bots robot and Haas machine. This allows for quicker setup and more flexibility with less wiring.

Standard Bots provides a set of sample .nc files to get started with an ethernet Haas integration. The integration works by running a main program on the Haas machine (in the example this program is 6000.nc). It then uses Macros 10850 and 10851 to complete handshaking between the Haas machine and Standard Bots robot as shown below:


Program 6000.nc is run from machine cycle start button
Robot Routine with HAAS control is started on Robot User Interface
Macro 10850 is set to 0 by machine to clear program number to run
Macro 10851 is set to 1 by machine to tell robot current program complete
Wait until a new program number is loaded in Macro 10850 by Robot
Robot loads program number to run in 10850
Macro 10851 is set to 0 by machine to tell robot program is not complete
Machine runs program in 10850

Please be sure to review the comments in the sample code. G103 P1 is a required step in the 6000.nc main sample code to ensure the integration that happens through the macros functions correctly. Do not remove this step. If needed, add a G103 P0 as well as several empty lines after to the beginning the machine programs you create to run from the robot (called through macros from 6000.nc) to re-enable lookahead during those programs and ensure the fastest program speed. A P0 will disable block limiting, allowing the machine to look ahead as much as it wants. A number option will limit the number of blocks to look ahead.

Requirements:

- Haas machine with Next Generation control
- Network connection between machines (Either Wireless or Wifi)
- The “Cell Safe” signal must be held high using the “Monitor Haas Routine” step anytime the door is open. If the signal is dropped with the door open the Haas machine will go into Feed Hold and will need to be reset and then cycle start must be hit on the Haas again.

- HAAS sample programs located at: https://docs.google.com/document/d/1HYtyWCjeHh6-LjbQF4H48BQuOi488yxzRS0UnXByHUY/edit?usp=sharing

Network Configuration:

In order to ensure a reliable solution the network between the robot and Haas machine must be configured correctly. Setting a static address without consulting the router/network configuration can cause duplicate IP addresses and other issues which will result in the robot not being able to run the Haas programs remotely. The Haas machine must have a known set IP address reachable by the robot for the integration to work through power cycles. There are several acceptable methods to setup a network between the robot and Haas machine:

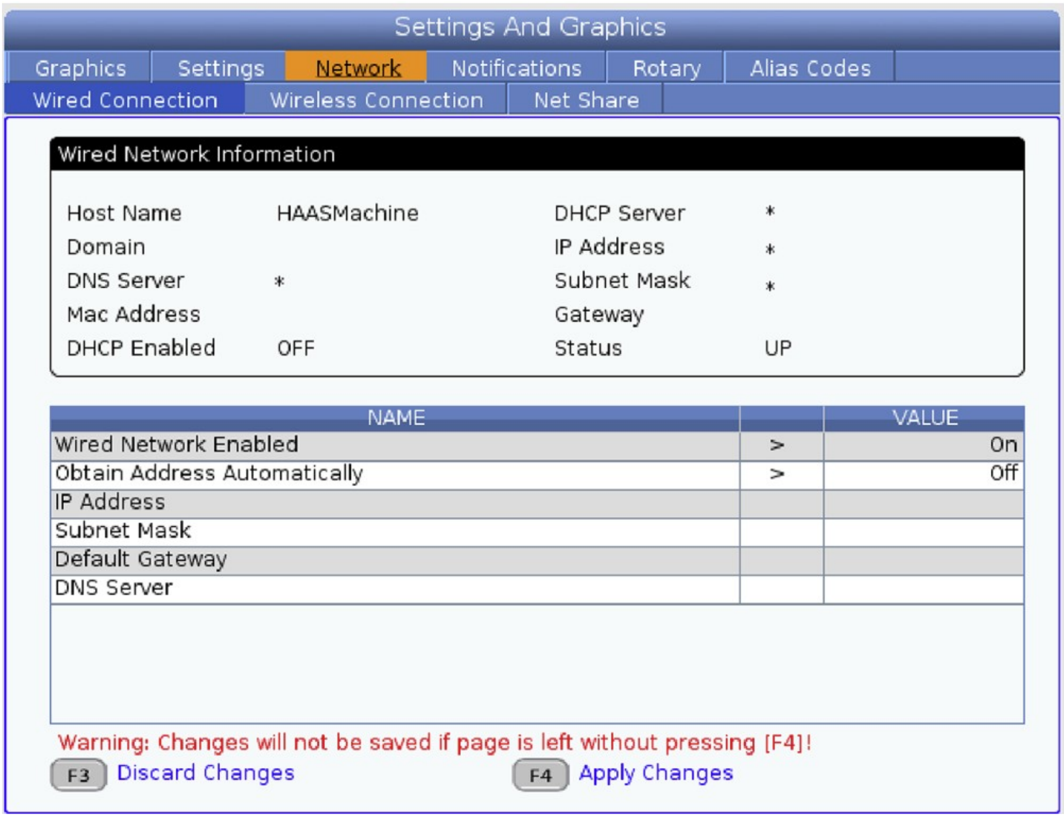
1. Configure the Haas machine on a wireless network. The IP address must be set to static on the machine with an address outside of any DHCP range or must be configured to always have the same IP address through the router configuration.

2. Configure the Haas machine on a wired network with router. The IP address must be set to static on the machine with an address outside of any DHCP range or must be configured to always have the same IP address through the router configuration. Allow the robot to DHCP through the network router.

3. Run a single cable between the robot and Haas machine. The Haas machine must have a static IP address set manually. Contact Standard Bots Support for assistance setting a static IP address on the robot on the same subnet as the Haas machine.

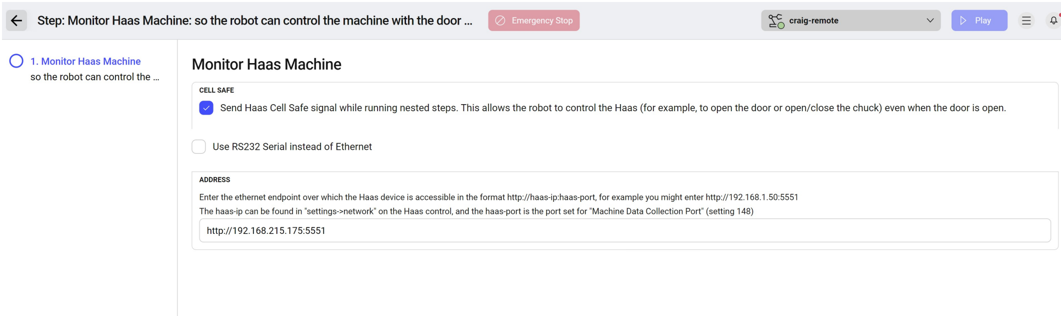
Integration:

1. Ensure program numbers 6000.nc-6005.nc are available on the Haas machine.
2. Load Standard Bots sample NC files onto the Haas machine.

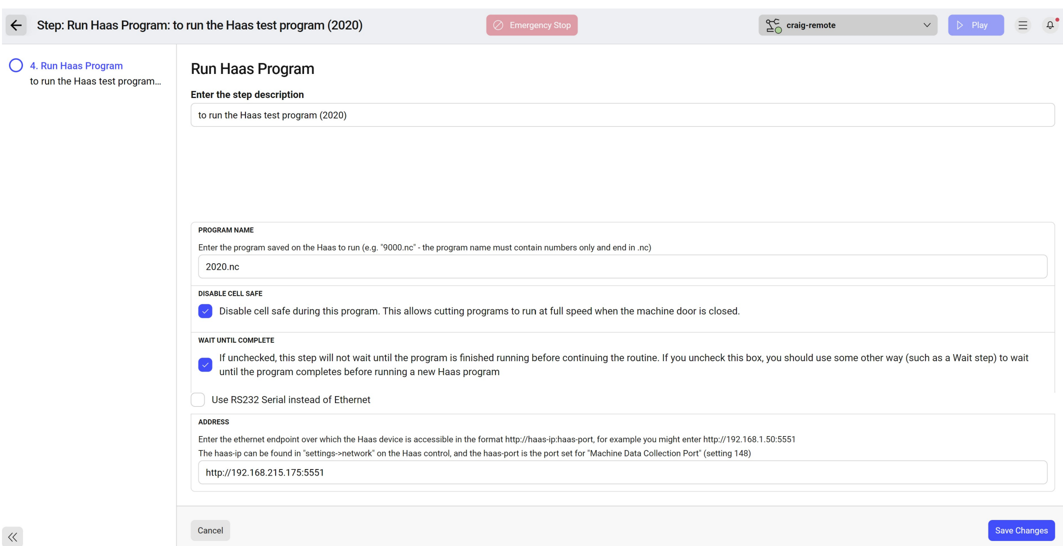


3. If using a wired connection, run an ethernet cable from the Ro1 cabinet to the Haas machine cabinet. The ethernet port on the Ro1 box is on the underside of the IO connection points in the box. The ethernet port on the Haas for Machine Data Collect is usually on the upper left when looking at the back of it. To get to the ethernet settings on the Haas navigate to Settings→Network→Wired/Wireless Connection.
4. Set the Haas machine up to communicate with the robot. The robot and Haas machine must be on the same subnet (3rd set of numbers in IP address) and be on the same wireless or wired network to communicate with each other. To ensure Haas can talk to the robot even through a power cycle the Haas must be set to a static IP address (no DHCP) or have network provisions made to ensure it is always the same IP address.
5. Enable machine data collect on the Haas (settings 143) and set the port to 5551.
6. If you are using a wired connection without DHCP, use the Standard Bots tablet application to set the IP address. You may need to log out of the User Interface by going to robot name menu in the bottom left then selecting Logout.
7. Load the sample "haas test" program provided by Standard Bots into the routine editor by going to Actions-> Edit Routine Schema and pasting the contents of the text file in. Then select "Create

Routine”.



8. Edit the first step of the sample routine. Leave the “Send Haas Cell Safe” button checked. This allows the robot to run routines with the door open, which is often required (IE, when you need to close the door).
9. Update the IP address of the Monitor Haas Machine step to match the IP address of the Haas. Ensure the port remains at the end of the address. The format is: http://xxx.xxx.xxx.xxx:port . I.e., http://192.168.215.175:5551. Save the step.
10. Go back and edit Step 4, Run Haas Program.



11. The “haas test” program will attempt to run 2020.nc. In many Haas machines, this is the spindle warmup program. If needed, change this program number to a different program under “Program Name”.
12. Leave “Wait until Complete” checked. This will ensure the routine stays at the current step until the Haas has completed the program sent above under “Program Name”.
13. Update the IP address of the Monitor Haas Machine step to match the IP address of the Haas. Ensure the port remains at the end of the address. The format is: http://xxx.xxx.xxx.xxx:port . I.e., http://192.168.215.175:5551. Save the step.
14. Start program 6000.nc on the Haas using the standard cycle start button on the Haas.

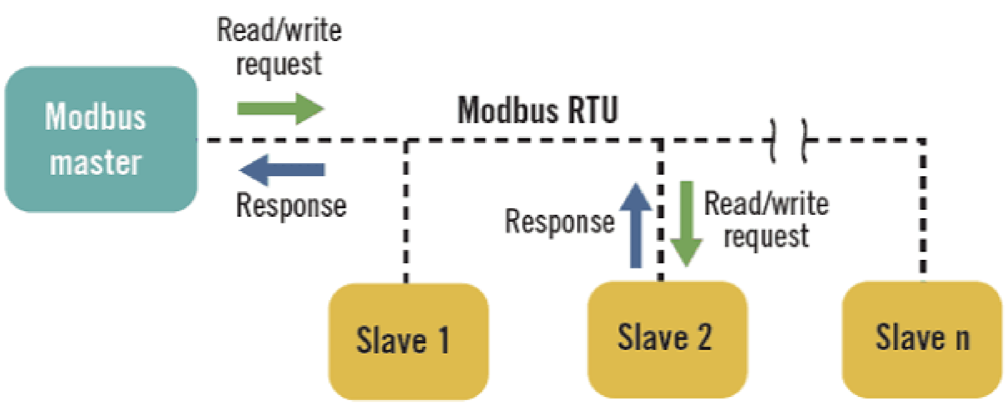
15. Start the sample program on the robot by running the routine.
16. The spindle warmup program (or alternative program chosen above) should now run. If it does not work verify the 10850 macro variable is updating. If it is not, verify communication between robot and machine.

5.7.7 Modbus

One way for the robot to communicate with other devices is through Modbus, one of the oldest and most widely used communication protocols in industrial settings. Modbus provides a common language that enables different devices to communicate with each other (such as an Allen Bradley PLC talking to a Siemens PLC), allowing devices from different manufacturers to work together. A Modbus Controller initiates communication and manages the data exchange between the compatible devices.

Modbus can operate over various physical layers, including serial communication methods like RS-232, RS-485, and RS-422, as well as Ethernet. Modbus TCP allows Modbus communication to occur over TCP/IP networks, enabling it to coexist alongside other Ethernet protocols.

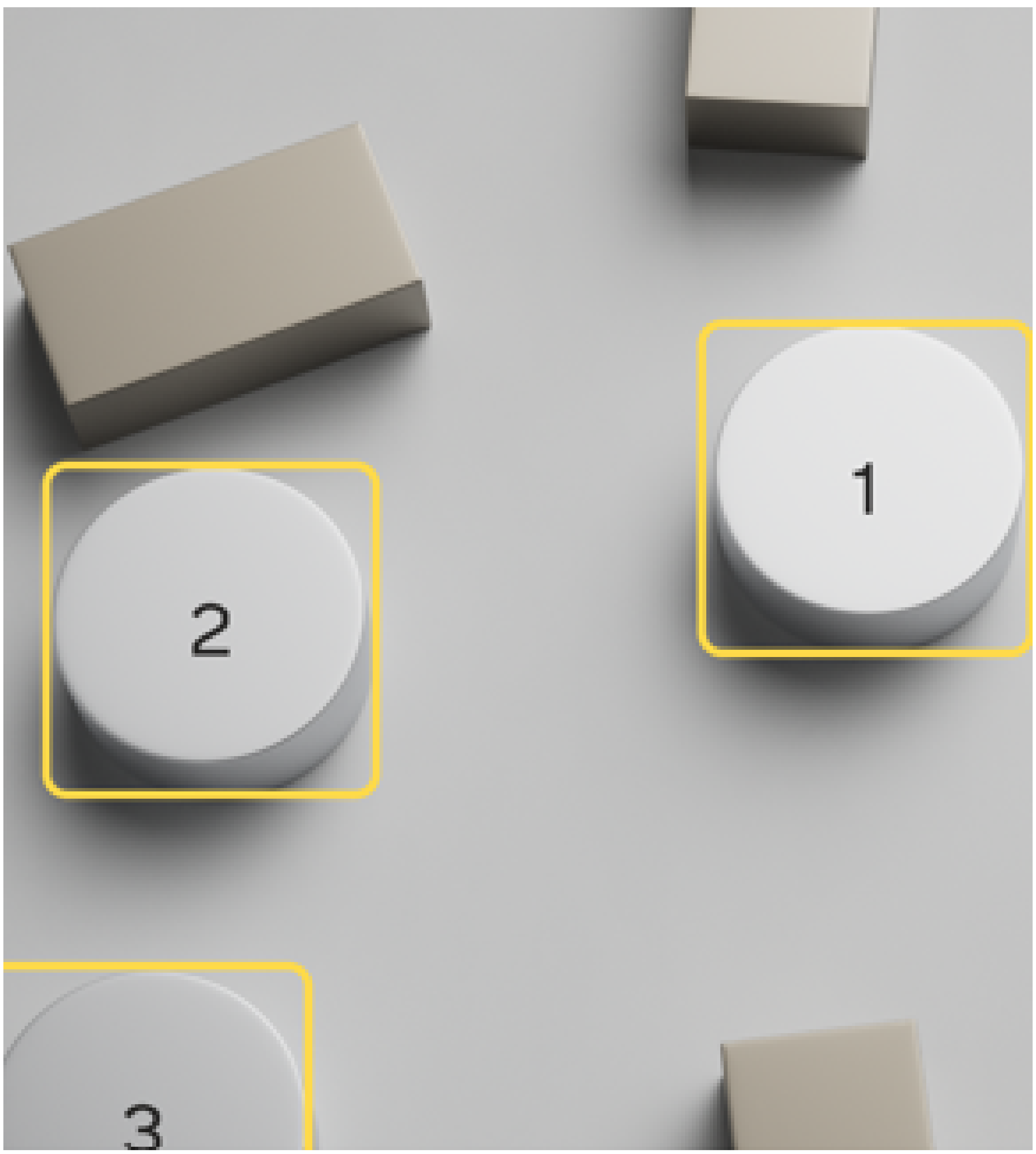
Modbus can be used to send commands to the Robot, which would allow the Robot to integrate into the automation system. Modbus uses master-slave architecture for communication. In this setup, the Modbus Controller sends requests to the slave devices (such as the Robot) and manages the communication flow. Each slave device responds to requests from the Controller, allowing for data exchange. This architecture simplifies the network.



Chapter 6

Vision

6.1 Locate



6.1.1 Use Cases

Standard Bots Locate feature is designed to locate items on a 2D flat plane to allow for picking and placing them using the integrated wrist camera. Items to be picked do not need to be organized but must be distinguishable from each other. Locate is not designed for 3D applications (stacked items). 3D functionality will be an optional upgrade provided at a later date. Locate accuracy is dependent on how far the robot is from the plane, but at closer distances +/- 1/8 in is possible depending on lighting and calibration.

6.1.2 Setup

Required Items

- Robot with Camera
- USB Cable connected between robot and camera. Cable will be located inside the control box from the factory.

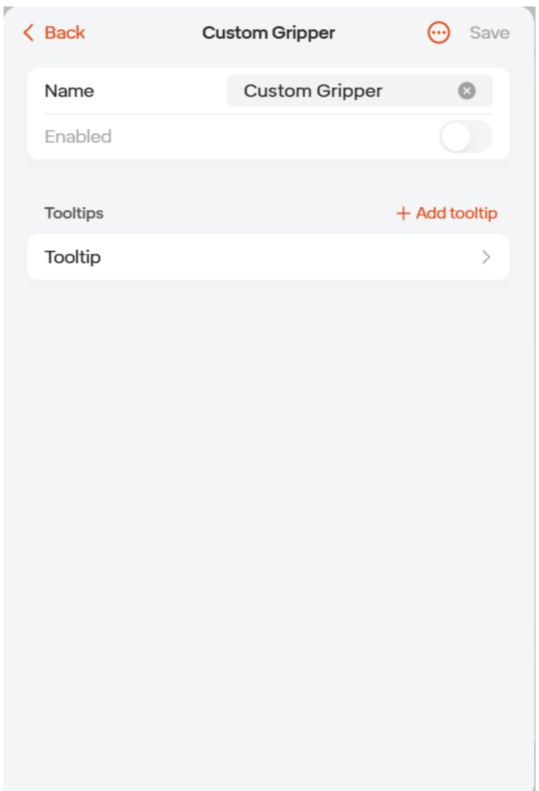
- Calibration spike (Provided by Standard Bots or custom)
- Vision calibration grid: http://camera-calibration.standardbots.com/
- Accuracy Calibration Grid (Optional): http://accuracy-calibration.standardbots.com/
- Flat plane to pick from
- Items to pick
- Tooling to pick items

Camera Setup

1. Go to the Move Robot view, check to make sure that you are Live Robot mode not Simulation mode.
2. If needed, unbrake the robot.
3. Select the three dots icon in the upper right, then select the camera icon. If you do not have this icon, contact Standard Bots Support.
4. You should see the camera view. If you cannot. Ensure the provided USB cable is connected between the robot and control box. If it is, try rotating the orientation of the usb-c plug 180 degrees in the robot.
5. Go to "Equipment" in the robot menu (Menu has the robot name in it and is located in the lower left of the screen).
6. Click the "+" icon in the upper right of the window.
7. Add the Built-in Wrist Camera.
8. You do not need to perform any calibration here.
9. Click save in the upper right of the window.
10. Click done in the upper left of the window.

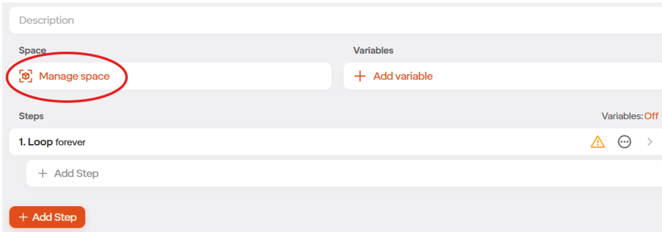
Calibration Spike Setup

1. Go to the Move Robot view (located in the upper right of the screen).
2. Go to “Equipment” in the robot menu (Menu has the robot name in it).
3. Click the “+” icon in the upper right of the window.
4. Select “Custom Gripper”.
5. Select “Tooltip”.
6. If using the Standard Bots provided spike, set the z height to 50mm. If using another spike, set the offsets accordingly.
7. Click save in the upper right.
8. Click save again in the upper right.

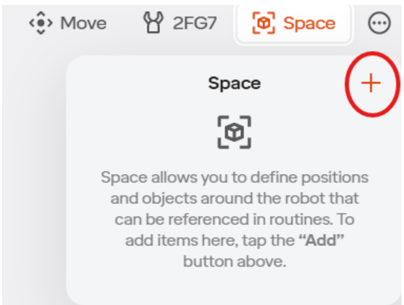


Space Setup

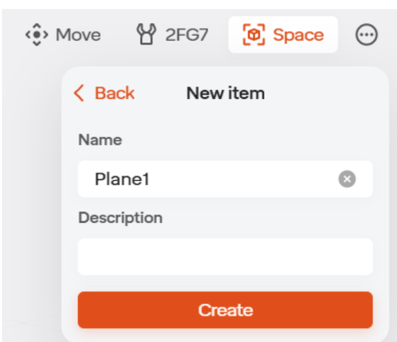
1. Create a new routine, or open the routine you want to run locate in.
2. Select “Manage Space”.



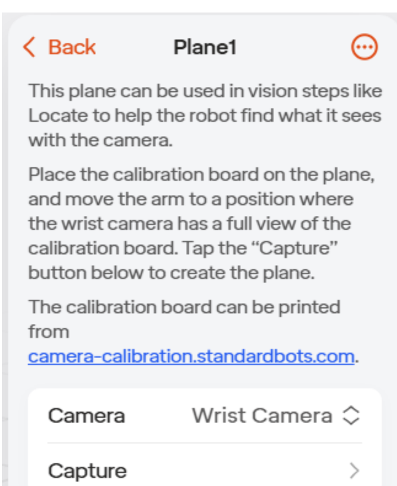
3. Go to “Space” in the Move Robot view (square icon located in the upper right of the screen).
4. Click the “+” icon in the upper right of the “Space” window in on the right side of the User Interface.



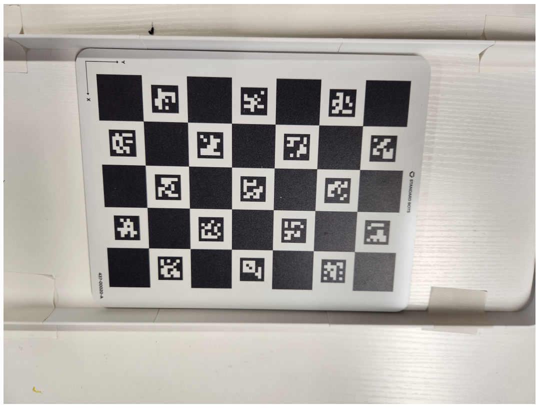
5. Select “Plane” in the list that appears. If you do not have this option contact Standard Bots Support.
6. Name the plane and select “Create”.



7. Select “Create with Camera” and then select “Capture”.



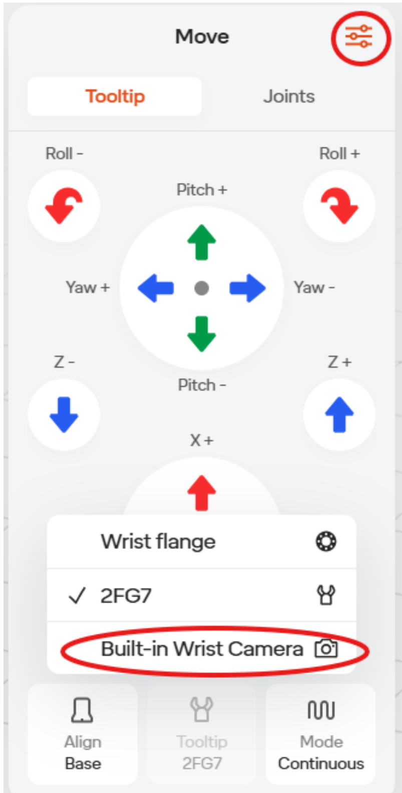
8. Place the larger, full 8.5 x 11 size calibration board on your plane.



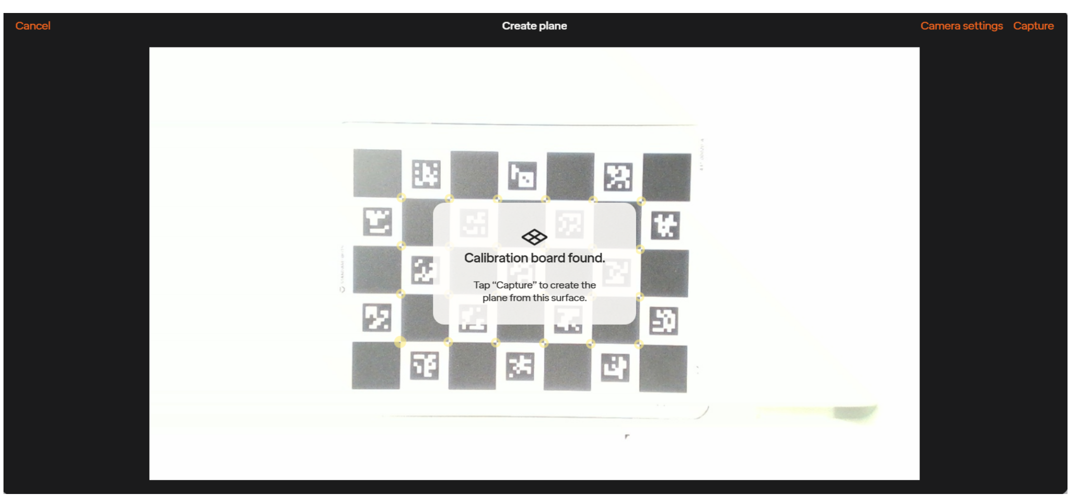
9. In the "Tooltip" jogging view, ensure the calibration spike custom tooltip is the current tooltip.

10. Drive the robot so you can see the calibration board with the camera. You can see the camera view while jogging by selecting the camera icon. Ensure the joint positions make sense and don't appear at risk of hitting your plane.

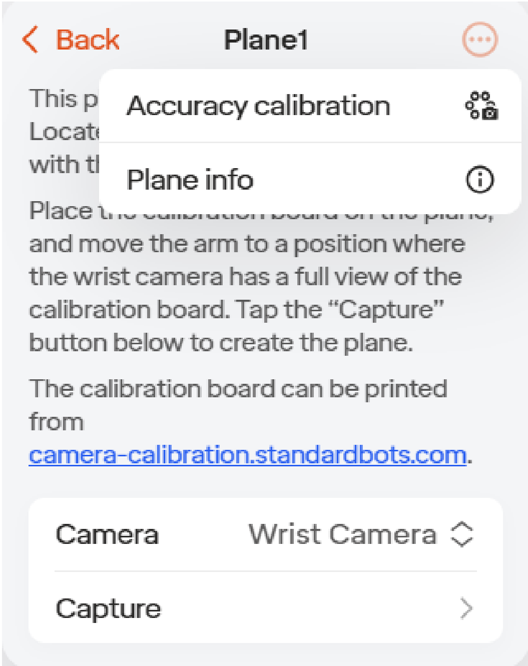
11. Under "Tooltip" jogging you can select the "Wrist Camera" frame. You can then select the slider Icon in the top right of the tooltip jogging view. Using "Snap to Axis" you can align the wrist camera to the robot base.



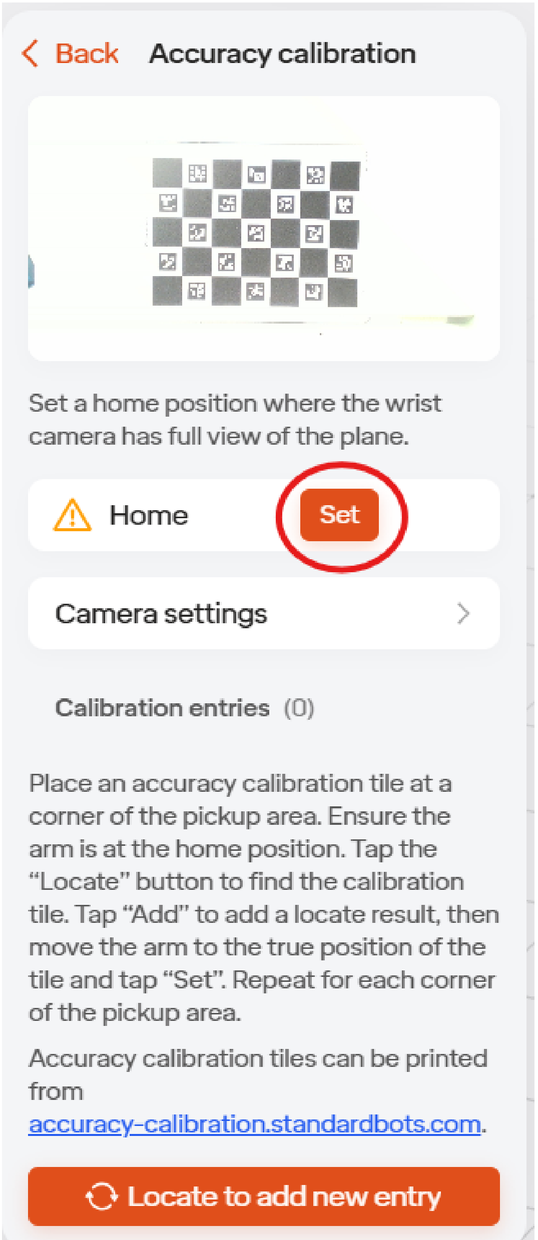
12. Once you have the calibration grid in view, get the robot as close to it as possible while still seeing the whole grid.
13. Go back to the "Space" in the bottom right.
14. Select "Create with camera".
15. Select "Capture" in the upper right of the window. If capture is greyed out ensure you can see the whole grid, it is the correct grid and the lighting is good enough. "Calibration Board Found" will appear on the screen.



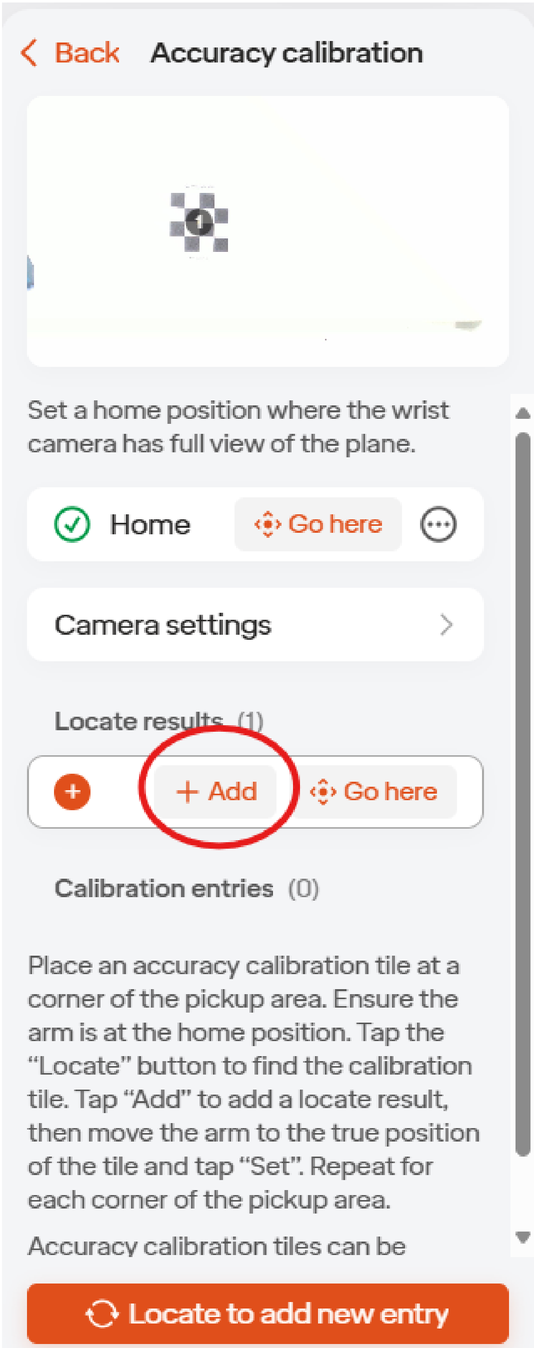
16. Click the 3 dot menu in the upper right of the plane calibration view.
17. Select Accuracy Calibration.



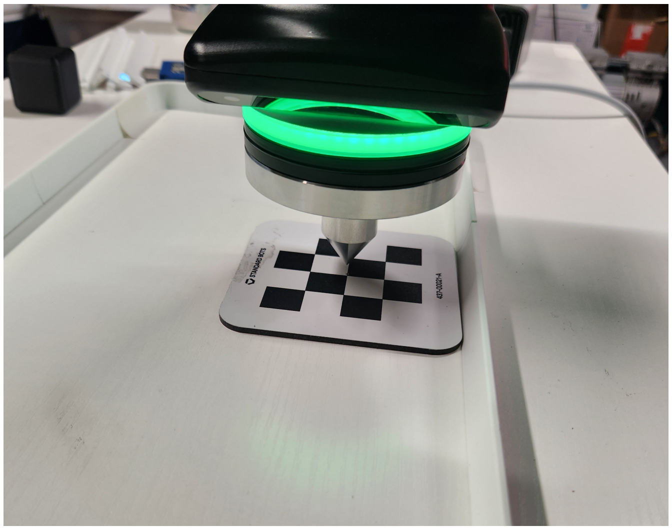
18. Jog the robot so you can see the whole work area. Ensure you have your custom tooltip selected in the bottom right of the tooltip jogging view.
19. Go back to the plane setup in the space view .
20. Click "Set" to create your home position in the plane view in space.



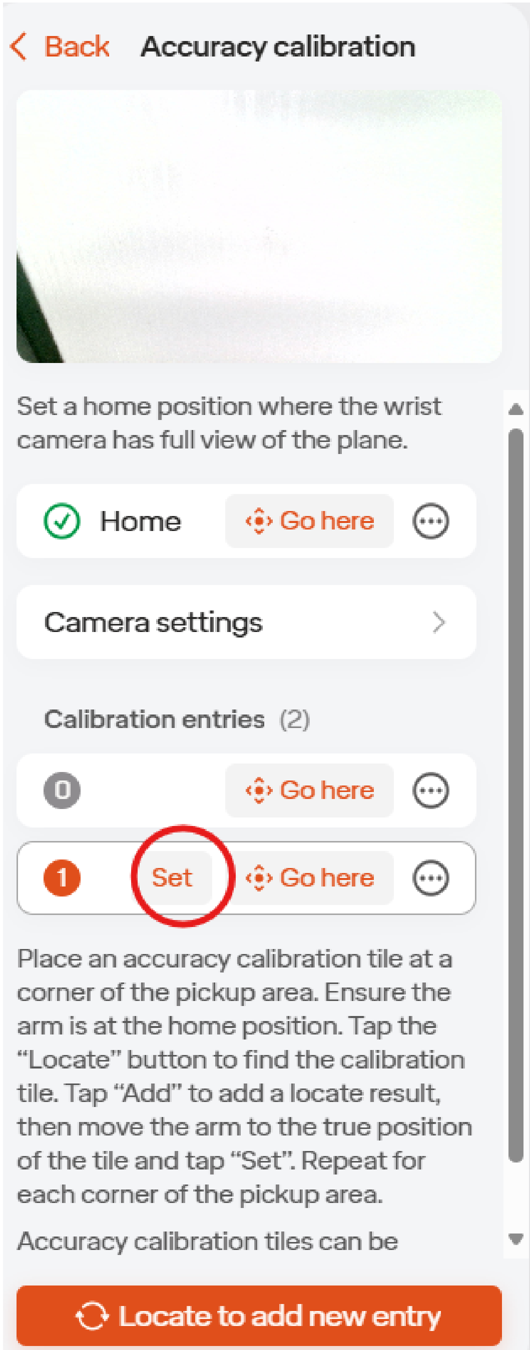
21. Place one of the smaller checkerboard calibration images in the robot view.
22. Select "locate to add new entry".
23. Add the entry. Ensure you do this before navigating away from the space window to jog.



24. Hold down "Go Here". Robot will drive above the grid.
25. Jog the robot to the center of the grid with the point of the spike touching the center. You can do this via the UI or with Anti-Gravity. Ensure the grid does not move. It is best to do this with the robot going at a slow speed.



26. Go to the Space window again, and click “Set” for this position.

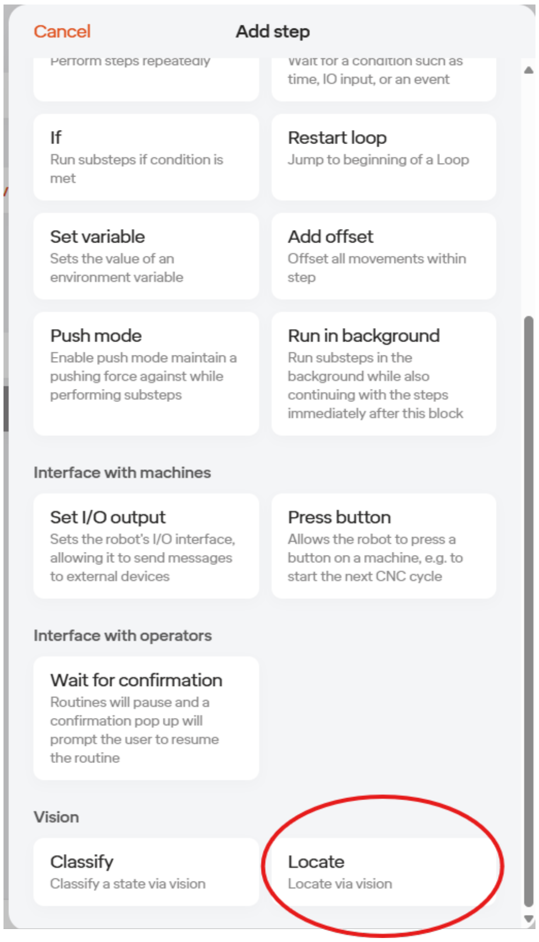


27. Bring the robot view back to the home position an repeat at least 4 times around your work area.
28. The plane is now ready to use in a Locate step.

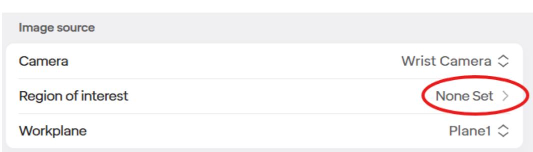
Routine Setup

1. Setup a tooltip or select a standard tool under equipment manager to use in your routine.
2. Go to the routine you created your plane in.
3. Leave the existing main loop and add all the below steps in this main loop.

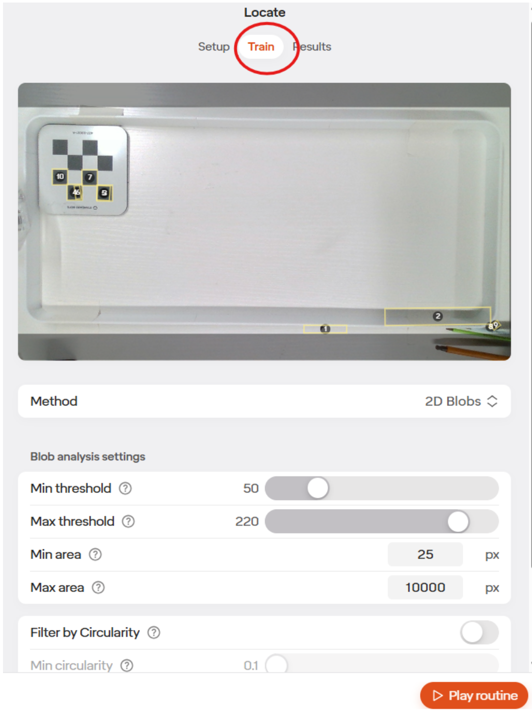
4. Setup a Move To Position positioned such that the camera can see the work area.
5. Add a Locate step (found at the bottom of the "Add Step" window.



6. Under the Setup tab of the locate step, set a region of interest. This is the area you want to pick from.



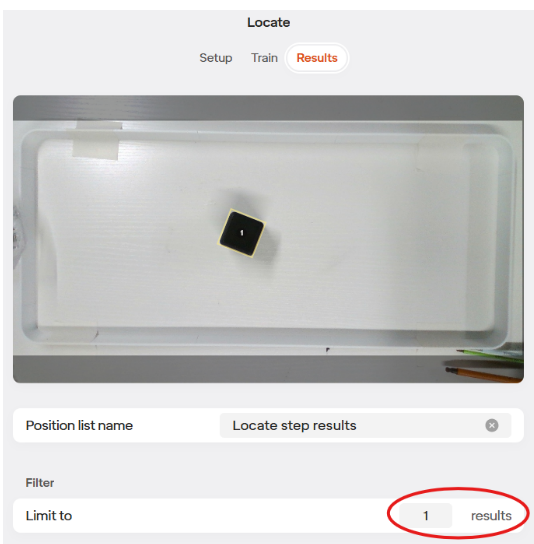
7. Under workplane, select the plane created in previous steps.
8. If needed adjust the camera settings so the items are visible. Generally the defaults are a good starting point.
9. Under the Train tab (located at the top of the Locate window), setup your blob or shape settings.



10. If using blobs, adjust the 0-255 Min and Max threshold greyscale value and Min and Max area values until just the items you wish to pick are indicated in the above image.

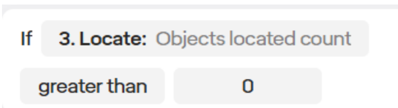
    If using Shapes, Teach the image by taking an image and highlighting the items you wish to pick. Set the bounding box around the item. Adjust the % match required until all items you wish to pick are indicated in the above image.

11. Under results (located to the right of the Train tab), if needed limit the number of items locate should find.



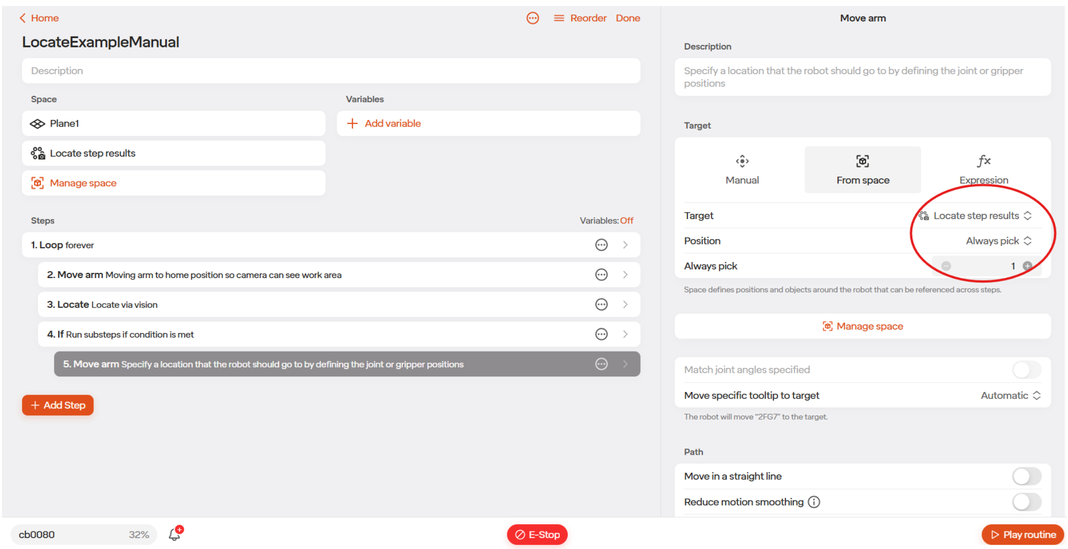
12. If needed, in results set a transform to apply to the located position when the robot goes to pick. Generally, it is good to start with a larger z offset of 40mm or so and tune from there.
13. Add an if statement below the locate step.

14. Set the if statement to say "IF Objects located count greater than 0". Objects located count is automatically created for you when you add a locate step. This will ensure the robot only tried to pick if there are items to pick.



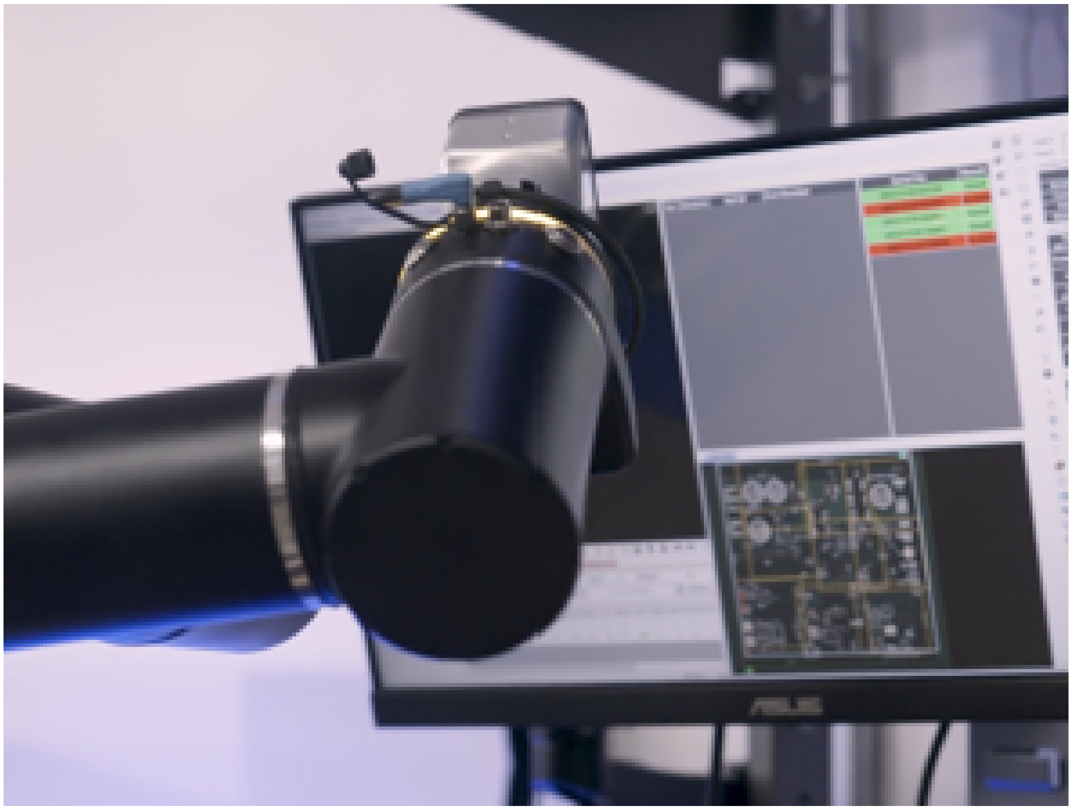
15. Add a Move Arm.

16. Select "From space" in the Move Arm command. Select "Locate Step Results". Set it to always pick 1. This will pick the first item in the locate step results list.



17. Fill out the rest of the routine as desired. You likely will want to do an add offset to to the locate results item before driving to it, etc.

6.2 Classify



6.2.1 Use Cases

Standard Bots Classify feature is designed to allow the robot to look at an item and determine it's state by comparing the current view to reference images. Classify can be used to look at a light stack to determine the machine state or to look at a HMI screen to know when a program is finished. Classify is not suited for detailed inspection / metrology applications.

6.2.2 Setup

Required Items

- Robot with Camera
- USB Cable connected between robot and camera. Cable will be located inside the control box from the factory.

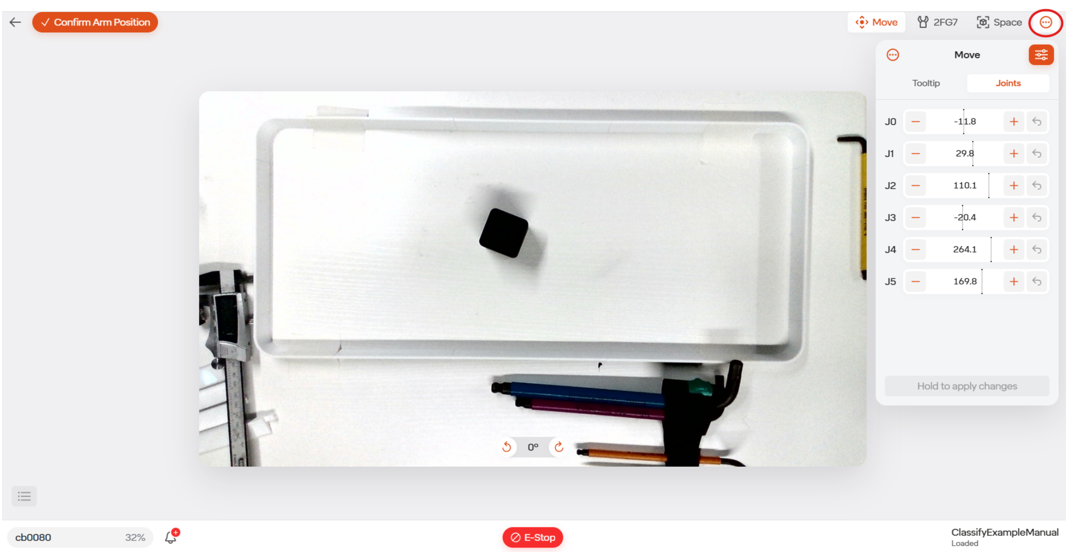
Camera Setup

1. Go to the Move Robot view, make sure the Robot view is in Live view and not Simulation.
2. If needed, unbrake the robot.
3. Select the three dots icon in the upper right, then select the camera icon. If you do not have this icon, contact Standard Bots Support.

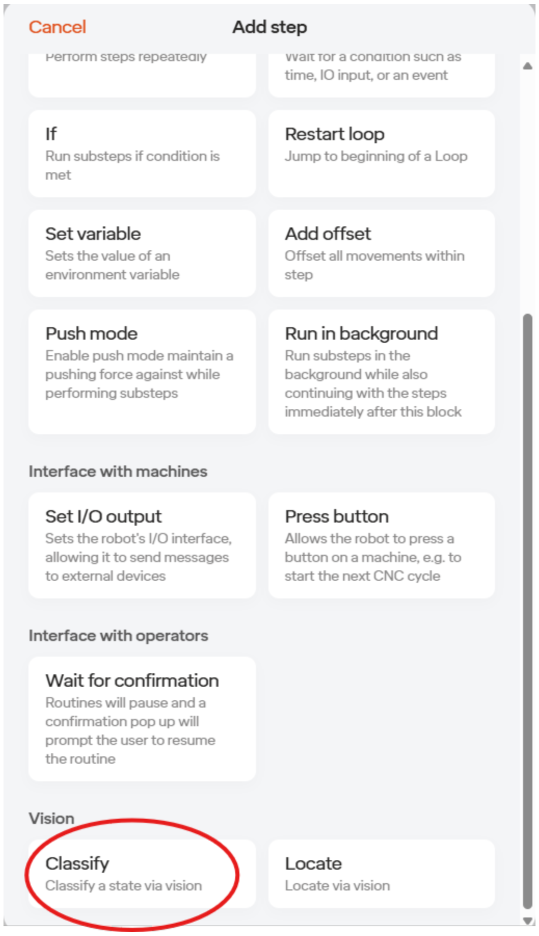
4. You should see the camera view. If you cannot. Ensure the provided USB cable is connected between the robot and control box. If it is, try rotating the orientation of the usb-c plug 180 degrees in the robot.
5. Go to “Equipment” in the robot menu (Menu has the robot name in it, located in the lower left of the screen).
6. Click the “+” icon in the upper right of the window.
7. Add the Built-in Wrist Camera.
8. You do not need to perform any calibration here.
9. Click save in the upper right of the window.
10. Click done in the upper left of the window.

Routine Setup

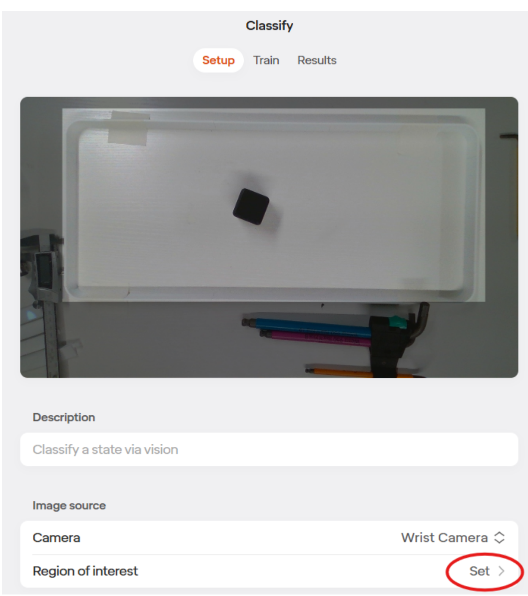
1. Create a new routine, or open the routine you want to run classify in.
2. Add a “Move Arm” step and set the position such that the camera can see the item you want to determine the state of. You can see the camera view while jogging by selecting three dots icon located in the upper right, then by selecting the camera icon.



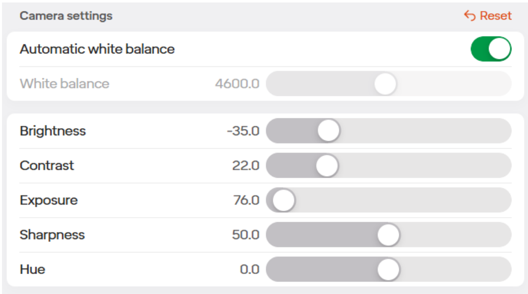
3. Add a “Classify” step (located at the bottom of the Add Step Window).



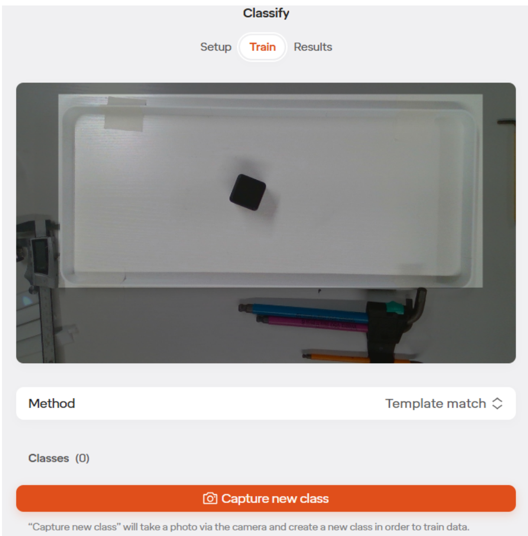
4. Under "Setup" set the Region of interest to be only the part of the screen that is going to change state. Move the box outline and when done select "Crop".



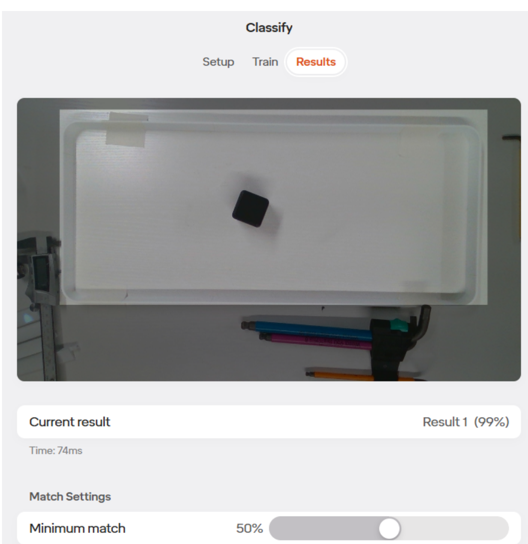
5. You can adjust camera settings if needed, but the defaults work for most applications.



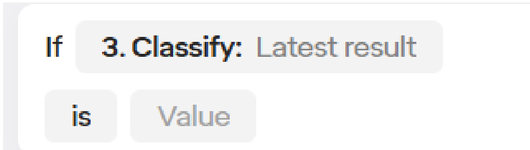
6. Under “Train” in the Classify step (located at the top of the Classify window), Capture a new class for each state and provide it a name.



7. If desired, add a fallback class to default to if no state is matched.
8. Under “Results” (located at the top of the Classify window), test the different states to see if the right result is reported. Adjust the minimum match threshold as needed.



9. Add an IF statement below the Classify step. You can now adjust the IF to say “IF Classify Results is (State programmed in Classify)”.



10. Create the rest of the program as desired.

Chapter 7

Maintenance

The RO1 robot and controller are designed for long life with minimal maintenance. If the robot is installed according to the intended use instructions the robot and controller will provide years of service.

7.1 User-Serviceable Parts

Part	Description	Part #	Replacement Interval
Control Box Fan Filter	120mm Sq Nylon Mesh 8 Micron Filter	SB-0596-A	6 months, application dependent

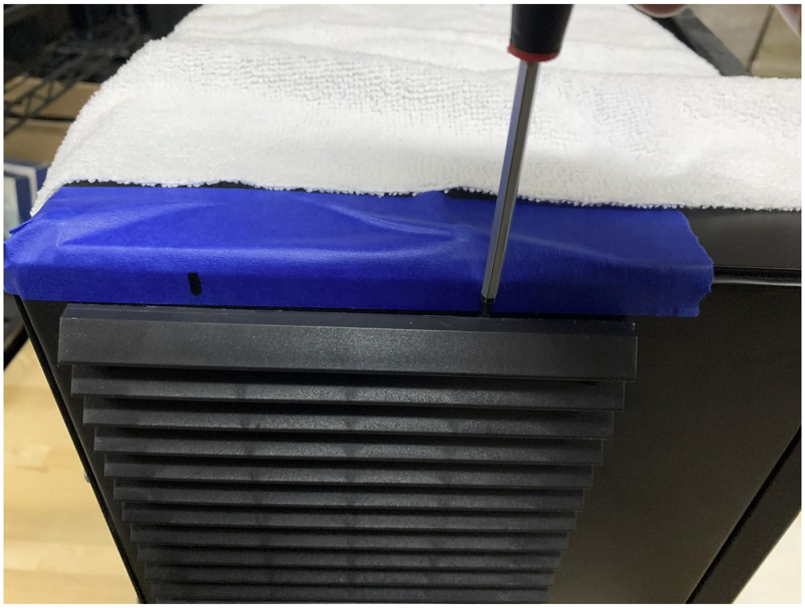
7.2 Replacement Procedures

7.2.1 Controller Fan

1. Stop the robot.
2. Apply the robot brakes through the Move Robot view in the user interface.
3. Unplug the controller.
4. Wait 30 seconds for power to dissipate.
5. Tape up the area as shown below to avoid damaging surface:

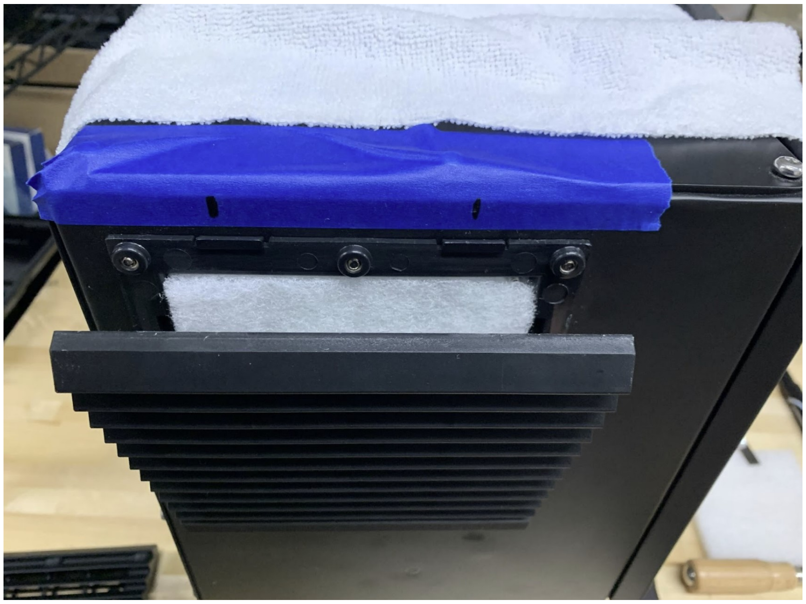
6. Measure from corner of fan shroud and mark tape at 1.5” and 4.5”:

7. Insert a flat head screwdriver just past the lip of the shroud and pry one side out. You will hear a snap noise:

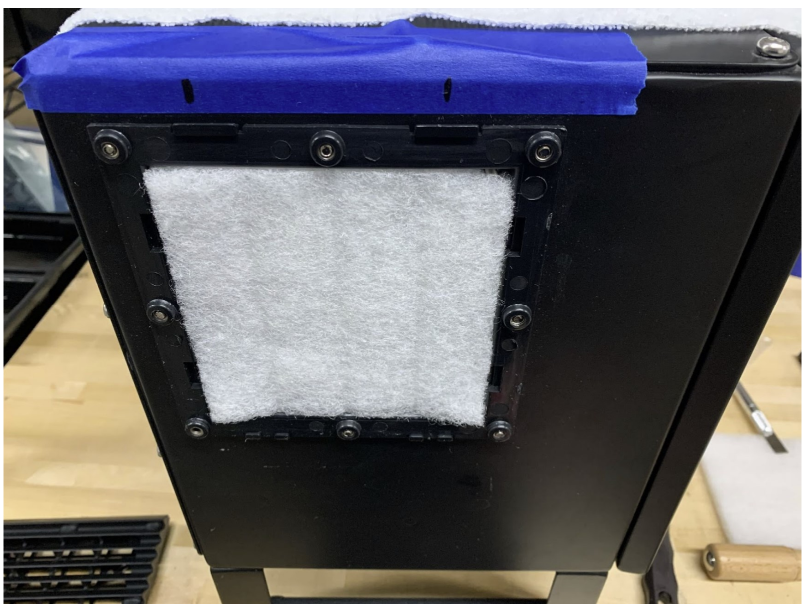


8. Repeat for the other side:

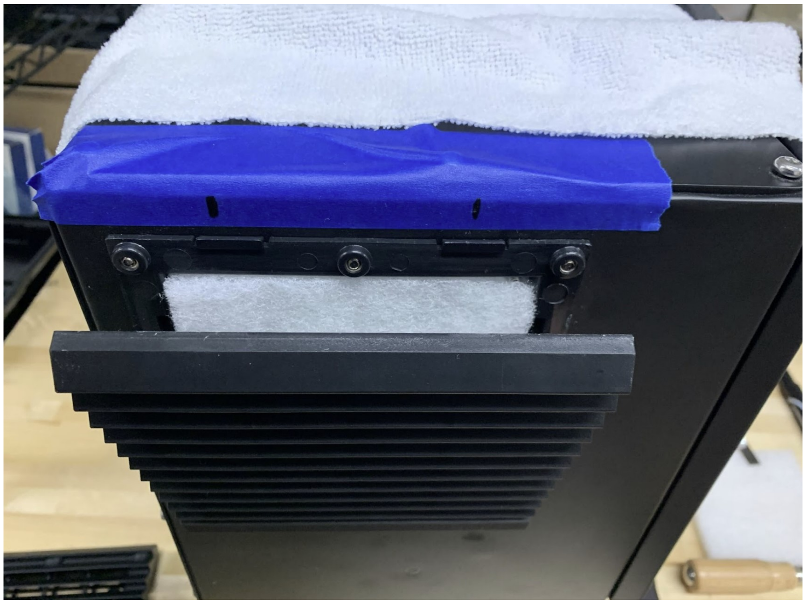
9. Pull shroud downward and remove shroud as shown:



10. Remove and replace filter:



11. Engage bottom of shroud with bottom of assembly:



12. Press in top of shroud with hand.
13. Remove tape.

7.3 Limited Product Warranty

Standard Bots Company (the "Company") warrants to the original lessor of the Standard Bots Robot (the "Original Purchaser" and the "Product", respectively) from the Company, that the Product shall be free from defects in materials and workmanship under normal use and in conformance with the Company's instructions, for so long as such Original Purchaser continues to lease the Product from the Company (the "Warranty Period").

If a defect arises during the Warranty Period, the Company will, at its option, (i) repair the Product at no charge, using new or refurbished replacement parts, (ii) exchange the Product with a refurbished or new product with equivalent functionality or (iii) provide the Original Purchaser with a replacement part accompanied by instructions on installation, and any requirements for the disposal of the replaced part. The Company shall not be responsible for any labor costs you incur relating to DIY parts service.

This warranty excludes (i) normal depletion of consumable parts such as batteries and (ii) defects caused by the user's fault.

This warranty is subject to your following the RMA process as may be in place at the Company from time to time. In order to obtain warranty service, please contact customer service at live-support@standardbots.com. It is your responsibility to backup any data, software or other materials you may have stored on the Product, as such data, software or other materials may be lost or reformatted during warranty service and the Company will not be responsible for such loss. In addition, it is your sole responsibility to delete all sensitive and personal information stored in, or in accessible form in, the Product prior to shipping the Product to us, and to disable or remove all security passwords.

Without derogation, this warranty does not apply in any of the following cases:

- Products not leased from the Company
- Damage caused by accident, abuse or misuse
- Products that have been dismantled, tampered with, modified or repaired by anyone other than the Company or a service provider authorized by the Company.

7.4 Return Merchandise Authorization

Should you believe you need to return a Standard Bots product please contact us through one of the below contact methods. Unauthorized returns will not be accepted.

Standard Bots Support: **Phone:** 888-976-1287 **Email:** live-support@standardbots.com

Chapter 8

Appendix A - Error List

Error	Reason	How to Fix Error
E-Stop was triggered	The E-Stop was pressed	The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel.
Internal communication failure		The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel.
Robot encountered a control system issue	Failed to receive encoder information for [Time in ms]	The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel.
Failed plan joint motion	Joint is already at limit of relative joint motion and can not travers any further in that direction.	The joint can not move any further in the direction of travel. The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel.

Error	Reason	How to Fix Error
Arm has encountered a collision	The arm collided with an object and stopped. The joint will be identified in the error, along with the detected Nm force and the threshold set force in Nm	The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel. Furthermore you can check the threshold settings and evaluate if the numbers are set correctly based on a safety study of the application
Unable to enter ANTIGRAVITY state		The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel.
CSI_collision detected	There was a collision detected. The threshold crossing limit will be displayed in m/s2	The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel. Furthermore you can check the threshold settings and evaluate if the numbers are set correctly based on a safety study of the application
Failed to run program: Already running program or robot-main is not running on Haas machine		Restart the robot or the CNC and verify the robot-main program is running on the CNC
Failed to receive encoder status	The E-Stop was pressed or the control box to robot cable is unplugged	Ensure Estop is not pressed and that cable between robot and control box is connected firmly
IO state timeout	The E-Stop was pressed or the control box to robot cable is unplugged	Ensure Estop is not pressed and that cable between robot and control box is connected firmly
Routine Invalid: Waypoint steps must have terminal Move Arm step	Waypoints can only be used when the next step is a Move Arm	Uncheck “Treat as waypoint” or add Move Arm step after Waypoint step.
Motion failed	Robot cannot plan a path between current position and target position, likely due to a singularity.	Adjust starting position or target position.

Error	Reason	How to Fix Error
Torque Limit Exceeded	Too much torque was recorded on the joint named in the error message	Reduce payload, speed or reach.
Joint Limit Exceeded	Joint is already at limit of relative joint motion and can not traverse any further in that direction.	The joint can not move any further in the direction of travel. The robot requires recovery. Navigate to the Routine Editor and press the Play button to access the Recovery Panel.
Error Loading Camera Feed	Vision camera does not disply video feed	Check camera connection to robot. Rotate USB-C cable 180 degrees and try camera again
EOAT Not Detected	The robot is not detecting the EOAT	Check the EOAT connection to the robot. Verify that you added the EOAT into Equipment after it was connected to the robot.
Ipad will not connect to robot	There is a wierless issue between the Ipad and the robot either over WiFi or Bluetooth	Make sure the Ipad and the robot are on the same network. Verify that Bluetooth is enabled on the Ipad.

Chapter 9

Appendix B - FAQ

Below is a list of common questions and answers for the Standard Bots system

Do you need to have the robot connected to the internet to use the robot?

No, the robot can run on a local network or simply with a single ethernet cable connected between the robot and a PC or tablet. If the robot is not online it will still operate without issue, however remote diagnostics and automatic updates will not be available.

Do you need to have the Ipad connected to the robot to run a program?

No, the Ipad is only needed for setting the Network setting for the robot. Once the robot is connected to the network, you can use the Ipad to control the robot or a computer using Google Chrome or by using the 24V External Control Interface.

How do I connect the robot to the network?

The robot can be connected to the network by going to the robot menu in the Ipad application and selecting the network icon. From there you can select the network you want to connect to and enter the password.

How do I access my robot from a computer?

If the robot is on the internet: You can access the robot from a computer by entering the robot name into the address bar of Google Chrome. You will then be prompted to enter the password for the robot. This will be cbXXXX.sb.app where XXXX is the last 4 digits of the controller serial number. This number can be found inside of the controller door.

If the robot is not on the internet: Use the Ipad application to find the ip address of the robot. Then, in the broswer of a computer on the same local network of the robot type in the robot ip address port 3000 as shwon in the ipad application. Example: 192.168.110.20:3000.

How do I access the network settings after initial setup?

To access the network settings of the robot, for example if you want to set a static IP address, use the Standard Bots application on the tablet. If you are already logged into the robot: In the User Interface on the tablet go to the Move Robot view. Go to the robot name menu in the bottom left and select "Logout". You will now be back to the tablet application main screen. On the left side you can select your robot. Once selected, the network settings will be on the right side.

How do I connect my robot to a tablet or PC directly?

You will need an ethernet cable to go between the robot ethernet port and your pc or tablet. You may also need a usb c to ethernet or similar adapter.

If you are simply using a wire, there will not be a router to give both devices an IP address. This means you will need to set the address manually, and set them on the same subnet.

Using the Standard Bots application on the tablet, set an IP address on the wired port of the robot under the network settings in the application. Then set a static address on the pc or tablet. Generally the address follows the format of 192.168.x.y. x would be the subnet, and both the robot and pc or tablet need to have the same number for x. Y would be unique for each device. Ex, the robot could be 192.168.110.5 and the pc or tablet could be 192.168.11.6.

Then on the pc or tablet go to the robot address you assigned in a browser tab. The format is generally 192.168.x.y:3000.

How do I connect my robot to a tablet or PC without setting static IP address and wires but not have the robot on the internet?

You can setup a simple local network for the robot using a standard wireless router. You will need to purchase a wireless router. Ensure it is not just an access point, as an access point will not assign IP addresses.

Setup a standard wireless network on the router. Do not connect the router to your LAN or internet. Connect the tablet to the wireless network. Use the iPad application to connect the robot to the new wireless network. In the tablet, check the network status for the robot Ip address, which will be in the format xxx.xxx.xxx.xxx:3000. Any device on your new wireless network can access the robot using this address. The cbxxxx.sb.app link will not work if the robot is not online.

Which end effectors work with the RO1?

The following tools are supported directly in the Standard Bots interface:

DH Robotics AG-105-145 Linkage Tool

DH Robotics PGC-300-60

Onrobot 2FG7 Parallel Tool

Onrobot 3FG15 2 Finger Centric Tool

Onrobot Dual Changer

Schunk EGU

Standard Bots also supports any tools that are discrete IO driven, including Onrobot tools that are not listed above through the use of the OnRobot Compute Box.

Currently, Robotiq tools are not supported as they cannot be controlled over discrete IO.

How do I change which tool I want to use on the RO1?

To change which tool is on the robot, go to the robot menu (has the robot name in an oval) and go to equipment. You can then add or delete tools.

Which protocols does the RO1 support?

Currently, the RO1 supports 24V discrete IO and Modbus TCP. There is also a REST API, a python SDK and typescript API.

What are the power requirements of the RO1?

The control box requires 90 ~ 264VAC, 47-63Hz. The robot draws less than 15 amps at 120V.

How do I get started with a new RO1?

Please start the included iPad, open the Standard Bots application, and follow the instructions.

What is the payload capacity of the RO1?

Depending on speeds and move types, the RO1 can carry up to 18 kg.

What is the maximum speed of the RO1?

The RO1 joints can move up to 435 degrees / second.

What is the maximum reach of the RO1?

1.3 Meters

What is the bolt pattern at the end of the arm?

ISO 50mm pattern. The pattern follows the standard and has 4 m6 bolts on a 50mm circle.

How do I move a routine to a different robot?

Open the routine you would like to copy in the first robot. Select the … menu, and select "schema". Copy the text in the window. Open up the second robot and create a routine. Again select the … menu and "schema". Copy the text into the window, rename the routine and select "create routine".

How do I import a model into the environment?

To import a model, go to the Move Robot view and go to the space area. The icon is in the bottom right of the view and looks like a square. In this view select the "+" to add an item, and select "Object". The UI will tell you which file formats are supported.

How do I get a Developer API Token?

The developer API token and setting can be found in the robot menu. Go to the Move Robot page, click on the robot name, settings, Configure developer API.

My robot says it is online but I cannot access it?

1. Check the device you are accessing the robot from (Ipad, PC) is on the same network as the robot.
2. Check that the network the robot is connected to does not have a "splash" page you need to log into. This is often the case with guest networks. The robot does not support web based logins like this.

I imported a model as an object but I cannot see it?

- Try changing the scale. The import is in Meters. Often you must convert to meters by setting the scale to .001.

- Check that the file is valid

How do I get the robot back into the box or case?

1. Ensure all tools are disconnected and that the robot has sufficient space to move
2. Power on the robot
3. Go to the Move Robot page of the interface (where you jog the robot)
4. Click on the robot name menu (where the speed is)
5. Go to Settings
6. Go to Box Robot
7. Hold the Prepare Robot For Shipping button down to bring the robot to the box position.

Standard Bots Company
80 Pratt Oval
Glen Cove, NY 11542 USA

www.standardbots.com
1-888-9-ROBOTS