10. First Time Use

Description

This section describes how you get started using the robot. Among other things, it covers easy start-up, an overview of the Polyscope user interface and how to set up your first program. Additionally, it covers free drive mode and basic operation.

10.1. Quick System Start-up

Quick System Start

MANDATORY ACTION

Before using the PolyScope, verify the robot arm and Control Box are correctly installed.

This is how you quickly start up the robot.

1. On the **Teach Pendant**, press the emergency stop button.
2. On the Teach Pendant, press the power button and allow the system to start, displaying text on the **PolyScope**.
3. A popup appears on the touch screen indicating that the system is ready and that the robot must be initialized.
4. In the popup dialog, tap **Go to Initialize Screen** to access the Initialize screen.
5. Unlock the emergency stop button to change robot state from **Emergency Stopped** to **Power off**.
6. Step outside the reach (workspace) of the robot.
7. On the **Initialize Robot** screen, tap the **ON** button and allow robot state to change to **Idle**.
8. In the **Payload** field, in **Active Payload**, verify the payload mass. You can also verify the mounting position is correct, in the **Robot** field.
9. Tap the **Start** button, for the robot to release its brake system. The robot vibrates and makes clicking sounds indicating it is ready to be programmed.

NOTICE

Learn to program your Universal Robots robot on www.universal-robots.com/academy/

10.2. Safety-related Functions and Interfaces

Description

Universal Robots robots are equipped with a range of built-in safety functions as well as safety I/O, digital and analog control signals to or from the electrical interface, to connect to other machines and additional protective devices. Each safety function and I/O is constructed according to EN ISO13849-1 (see Certifications) with Performance Level d (PLd) using a category 3 architecture.
See Software Safety Configuration for configuration of the safety functions, inputs and outputs in the user interface. See Safety I/O for descriptions on how to connect safety devices to I/O.

WARNING

The use of safety configuration parameters different from those determined as necessary for risk reduction, can result in hazards that are not reasonably eliminated, or risks that are not sufficiently reduced.

- Ensure tools and grippers are connected correctly to avoid hazards due to interruption of power.

WARNING: ELECTRICITY

Programmer and/or wiring errors can cause the voltage to change from 12V to 24V leading to fire damage to equipment.

- Verify the use of 12V and proceed with caution.

Additional Information

NOTICE

- The use and configuration of safety functions and interfaces must follow the risk assessment procedures for each robot application. (see chapter **Safety** section **Safety-related Functions and Interfaces**)
- The stopping time should be taken into account as part of the application risk assessment
- If the robot detects a fault or violation in the safety system (e.g. if one of the wires in the Emergency Stop circuit is cut or a safety limit is exceeded), then a Stop Category 0 is initiated.

NOTICE

The end effector is not protected by the UR safety system. The functioning of the end effector and/or connection cable is not monitored

10.2.1. Configurable Safety Functions

Description

Universal Robots robot safety functions, as listed in the table below, are in the robot but are meant to control the robot system i.e. the robot with its attached tool/end effector. The robot safety functions are used to reduce robot system risks determined by the risk assessment. Positions and speeds are relative to the base of the robot.

Safety Function	Description
Joint Position Limit	Sets upper and lower limits for the allowed joint positions.
Joint Speed Limit	Sets an upper limit for joint speed.
Safety Planes	Defines planes, in space, that limit robot position. Safety planes limit either the tool/end effector alone or both the tool/end effector and the elbow.
Tool Orientation	Defines allowable orientation limits for the tool.
Speed Limit	Limits maximum robot speed. The speed is limited at the elbow, at the tool/end effector flange, and at the center of the user-defined tool/end effector positions.
Force Limit	Limits maximum force exerted by the robot tool/end effector and elbow in clamping situations. The force is limited at the tool/end effector, elbow flange and center of the user-defined tool/end effector positions.
Momentum Limit	Limits maximum momentum of the robot.
Power Limit	Limits mechanical work performed by the robot.
Stopping Time Limit	Limits maximum time the robot uses for stopping after a robot stop is initiated.[1]
Stopping Distance Limit	Limits maximum distance travelled by the robot after a robot stop is initiated.

Safety Function

When performing the application risk assessment, it is necessary to take into account the motion of the robot after a stop has been initiated. In order to ease this process, the safety functions *Stopping Time Limit* and *Stopping Distance Limit* can be used.
These safety functions dynamically reduces the speed of the robot motion such that it can always be stopped within the limits. The joint position limits, the safety planes and the tool/end effector orientation limits take the expected stopping distance travel into account i.e. the robot motion will slow down before the limit is reached.
The functional safety can be summarized as:

[1] Robot stop was previously known as "Protective stop".

Safety Function	Accuracy	Performance Level	Category
Emergency Stop	-	d	3
Safeguard Stop	-	d	3
Joint Position Limit	5 °	d	3
Joint Speed Limit	1.15 °/s	d	3
Safety Planes	40 mm	d	3
Tool Orientation	3 °	d	3
Speed Limit	50 mm/s	d	3
Force Limit	25 N	d	3
Momentum Limit	3 kg m/s	d	3
Power Limit	10 W	d	3
Stopping Time Limit	50 ms	d	3
Stopping Distance Limit	40 mm	d	3
Safe Home	1.7 °	d	3

Warnings

CAUTION

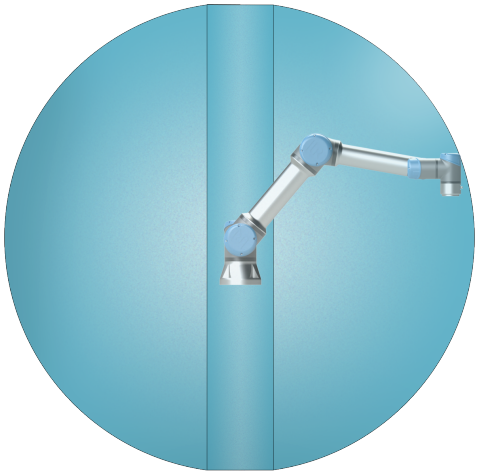
Failure to configure the maximum speed limit can result in hazardous situations.

- If the robot is used in manual hand-guiding applications with linear movements, the speed limit must be set to maximum 250 mm/s for the tool/end effector and elbow unless a risk assessment shows that higher speeds are acceptable. This will prevent fast movements of the robot elbow near singularities.

NOTICE

There are two exceptions to the force limiting function that are important when designing an application.
As the robot stretches out, the knee-joint effect can give high forces in the radial direction (away from the base) at low speeds. Similarly, the short leverage arm, when the tool/end effector is close to the base and moving around the base, can cause high forces at low speeds.

Workspace



Front	Tilted

Due to the physical properties of the robot arm, certain workspace areas require attention regarding pinching hazards. One area (left) is defined for radial motions when the wrist 1 joint is at least 450 mm from the base of the robot. The other area (right) is within 200 mm of the base of the robot, when moving tangentially.

Placing the robot in certain areas can create pinching hazards that can lead to injury.

Safety inputs

The robot also has the following safety inputs:

Safety Input	Description
Emergency Stop Button	Performs a Stop Category 1 (IEC 60204-1) informing other machines using the *System Emergency Stop* output, if that output is defined. A stop is initiated in anything connected to the output.
Robot Emergency Stop	Performs a Stop Category 1 (IEC 60204-1) via Control Box input, informing other machines using the *System Emergency Stop* output, if that output is defined.
System Emergency Stop	Performs a Stop Category 1 (IEC 60204-1) on robot only, in all modes and takes precedence over all other commands.
Safeguard Stop	Performs a Stop Category 2 (IEC 60204-1) in all modes, except when using a 3-Position Enabling Device and a mode selector - then when in Manual Mode, the Safeguard Stop can be set to only function in Automatic Mode.
Automatic Mode Safeguard Stop	Performs a Stop Category 2 (IEC 60204-1) in Automatic mode ONLY. *Automatic Mode Safeguard Stop* can only be selected when a Three-Position Enabling Device is configured and installed.
Safeguard Reset	Returns from the *Safeguard Stop* state, when a rising edge on the Safeguard Reset input occurs.
Reduced Mode	Transitions the safety system to use the *Reduced mode* limits.
Three-Position Enabling Device	Initiates a Stop Category 2 (IEC 60204-1) when the enabling device is fully pressed or fully released in manual mode only. Three-Position Enabling Device Stop is triggered when an input goes low. It is unaffected by a Safeguard Reset.
Freedrive on robot	Enables freedrive, when the robot is not in Automatic Mode.
Operational Mode	Switches between Operational modes. The robot is in Automatic mode when input is low, Manual mode when input is high.
Automatic Mode Safeguard Reset	Returns from the *Automatic Mode Safeguard Stop* state, when a rising edge on the Automatic Mode Safeguard Reset input occurs.

Safety outputs

For interfacing with other machines, the robot is equipped with the following safety outputs:

Safety Output	Description
System Emergency Stop	While this signal is logic low, the *Robot Emergency Stop* input is logic low or the Emergency Stop button is pressed.
Robot Moving	While this signal is logic high, no single joint of the robot moves more than 0.1 rad/s.
Robot Not Stopping	Logic high when the robot is stopped or in the process of stopping due to an Emergency Stop or Safeguard Stop. Otherwise it will be logic low.
Reduced	Logic low when the safety system is in Reduced Mode.
Not Reduced	Logic low when the system is not in Reduced Mode.
Safe Home	Logic high when robot is in the configured Safe Home Position.

All safety I/O are dual channel, meaning they are safe when low (e.g., the Emergency Stop is active when the signals are low).

10.2.2. Safety Functions

Description

The safety system acts by monitoring if any of the safety limits are exceeded or if an Emergency Stop or a Safeguard Stop is initiated.
The reactions of the safety system are:

Trigger	Reaction
Emergency Stop	Stop Category 1
Safeguard Stop	Stop Category 2
3PE Stop (if a 3-Position Enabling device is connected)	Stop Category 2
Limit Violation	Stop Category 0
Fault Detection	Stop Category 0

NOTICE

If the safety system detects any fault or violation, all safety outputs re-set to low.

10.2.3. Safety Parameter Set

Description

The safety system has the following set of configurable safety parameters:

- Normal
- Reduced

Normal and Reduced

You can set up the safety limits for each set of safety parameters, creating distinct configurations for normal, or higher settings, and reduced. The reduced configuration is active when the tool/end effector is positioned on the reduced side of a Trigger Reduced Plane, or when the reduced configuration is externally triggered by a safety input.
Using a plane to trigger the Reduced configuration: When the robot arm moves from the side of the trigger plane configured with reduced safety parameters, to the side that is configured with normal safety parameters, there is a 20 mm area around the trigger plane where both normal and reduced limits are allowed. This area around the trigger plane prevents nuisance safety stops when the robot is exactly at the limit.
Using an input to trigger the Reduced configuration: When a safety input starts, or stops, the reduced configuration, up to 500 ms can elapse before the new limit values become active. This can happen in either of the following circumstances:

- Switching from the reduced configuration to normal
- Switching from the normal configuration to reduced

The robot arm adapts to the new safety limits within the 500 ms.

Recovery

When a safety limit is exceeded, the safety system must be restarted. For example, if a joint position limit is outside a safety limit, at start-up, Recovery is activated.
You cannot run programs for the robot when recovery is activated, but the robot arm can be manually moved back within limits using Freedrive, or by using the Move tab in PolyScope.
The safety limits for Recovery are:

Safety Function	Limit
Joint Speed Limit	30 °/s
Speed Limit	250 mm/s
Force Limit	100 N
Momentum Limit	10 kg m/s
Power Limit	80 W

The safety system issues a Stop Category 0 if a violation of these limits appears.

WARNING

Failure to use caution when moving the robot arm in recovery mode can lead to hazardous situations.

- Use caution when moving the robot arm back within the limits, as limits for the joint positions, the safety planes, and the tool/end effector orientation are all disabled in recovery mode.

10.3. Software Safety Configuration

Description

This section covers how to access the robot safety settings. It is made up of items that help you set up the robot Safety Configuration.

WARNING

Before you configure your robot safety settings, your integrator must conduct a risk assessment to guarantee the safety of personnel and equipment around the robot. A risk assessment is an evaluation of all work procedures throughout the robot lifetime, conducted in order to apply correct safety configuration settings. You must set the following in accordance with the integrator's risk assessment.

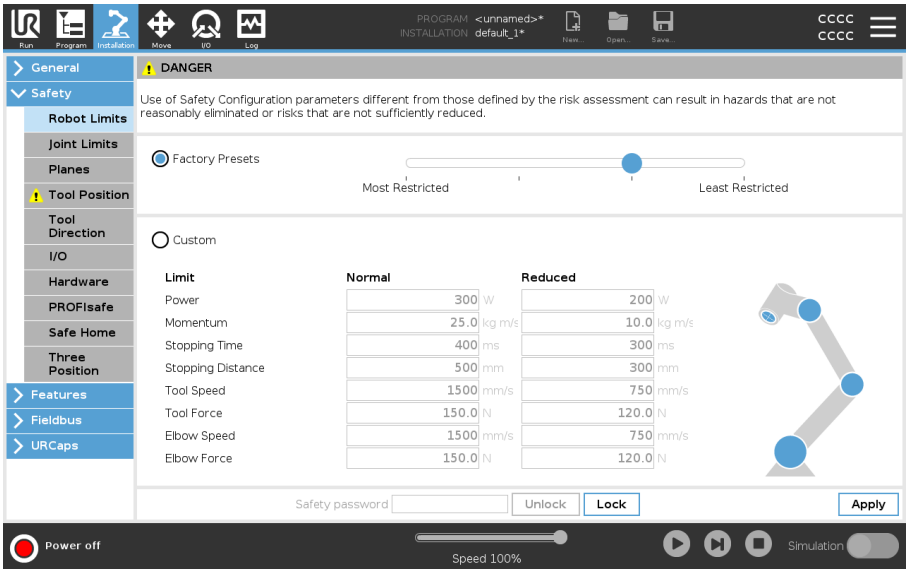
1. The integrator must prevent unauthorized persons from changing the safety configuration e.g. installing password protection.
2. Use and configuration of the safety-related functions and interfaces for a specific robot application.
3. Safety configuration settings for set-up and teaching before the robot arm is powered on for the first time.
4. All safety configuration settings accessible on this screen and sub-tabs.
5. The integrator must ensure that all changes to the safety configuration settings comply with the risk assessment. See Hardware Installation Manual.

Accessing Software Safety Settings

Safety Settings are password protected and can only be configured once a password is set and subsequently used.

To access the software safety settings

1. In your PolyScope header, tap the **Installation** icon.
2. In the Side Menu on the left of the screen, tap **Safety**.
3. Observe that the **Robot Limits** screen displays, but settings are inaccessible.
4. If a **Safety password** was previously set, enter the password and press **Unlock** to make settings accessible. Note: Once Safety settings are unlocked, all settings are now active.
5. Press **Lock** tab or navigate away from the Safety menu to lock all Safety item settings again.



10.3.1. Setting a Software Safety Password

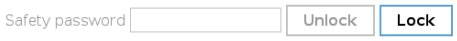
Description

You must set a password to Unlock all safety settings that make up your Safety Configuration. If no safety password is applied, you are prompted to set it up.

To set a Software Safety password

You can tap the **Lock** tab to lock all Safety settings again or simply navigate to a screen outside of the Safety menu.

1. In your PolyScope header right corner, press the **Hamburger** menu and select **Settings**.
2. On the left of the screen, in the blue menu, press **Password** and select **Safety**.
3. In **New password**, type a password.
4. Now, in **Confirm new password**, type the same password and press **Apply**.
5. In the bottom left of the blue menu, press **Exit** to return to previous screen.



10.3.2. Changing the Software Safety Configuration

Description	Changes to the Safety Configuration settings must comply with the risk assessment conducted by the integrator.
Recommended procedure for the integrator:	To change the safety configuration 1. Verify that changes comply with the risk assessment conducted by the integrator. 2. Adjust safety settings to the appropriate level defined by the risk assessment conducted by the integrator. 3. Verify that the settings are applied. 4. Place following text in the operators' manuals: Before working near the robot, make sure that the safety configuration is as expected. This can be verified e.g. by inspecting the Safety Checksum in the top right corner of PolyScope for any changes. (See Safety Checksum).

10.3.3. Applying a New Software Safety Configuration

Description

The robot is powered off while you make changes to the configuration.
Your changes only take effect after you tap the **Apply** button.
The robot cannot be powered on again until you select **Apply and Restart** to visually inspect your robot Safety Configuration which, for safety reasons, is displayed in SI Units in a popup.
You can select **Revert Changes** to return to the previous configuration. When your visual inspection is complete you can select **Confirm Safety Configuration** and the changes are automatically saved as part of the current robot installation.

Safety Checksum

Description

The **Safety Checksum** icon displays your applied robot safety configuration.

It could be four or eight digits.
A four-digit Checksum should be read from top to bottom and left to right, while an eight-digit Checksum is read left to right, top row first. Different text and/or colors indicate changes to the applied safety configuration.

The **Safety Checksum** changes if you change the **Safety Functions** settings, because the **Safety Checksum** is only generated by the safety settings.
You must apply your changes to the **Safety Configuration** for the **Safety Checksum** to reflect your changes.

10.3.4. Safety Configuration without Teach Pendant

Description

You can use the robot without attaching the Teach Pendant. Removing the Teach Pendant requires defining another Emergency Stop source. You must specify if the Teach Pendant is attached to avoid triggering a safety violation.

> **CAUTION**
> If the Teach Pendant is detached or disconnected from the robot, the Emergency Stop button is no longer active. You must remove the Teach Pendant from the vicinity of the robot.

To safely remove the Teach Pendant

The robot can be used without PolyScope as the programming interface.
To configure the robot without a Teach Pendant

1. In the Header tap **Installation**.
2. In the Side Menu on left tap **Safety** and select **Hardware**.
3. Input Safety password and **Unlock** the screen.
4. Deselect **Teach Pendant** to use robot without PolyScope interface.
5. Press **Save and restart** to implement changes.

10.3.5. Software Safety Modes

Description

Under normal conditions, i.e. when no robot stop is in effect, the safety system operates in a Safety Mode associated with a set of safety limits [1]:

- **Normal mode** is the safety mode that is active by default
- **Reduced mode** is active when the robot **Tool Center Point** (TCP) is positioned beyond a Trigger Reduced mode plane (see Software Safety Restrictions), or when triggered using a configurable input.
- **Recovery mode** activates when a safety limit from the active limit set is violated, the robot arm performs a Stop Category 0. If an active safety limit, such as a joint position limit or a safety boundary, is violated already when the robot arm is powered on, it starts up in **Recovery** mode. This makes it possible to move the robot arm back within the safety limits. While in Recovery mode, the movement of the robot arm is restricted by a fixed limit that you cannot customize.

WARNING

Limits for **joint position**, **tool position** and **tool orientation** are disabled in Recovery mode, so take caution when moving the robot arm back within the limits.

The menu of the Safety Configuration screen enables the user to define separate sets of safety limits for Normal and Reduced mode. For the tool and joints, Reduced mode limits for speed and momentum are required to be more restrictive than their Normal mode counterparts.

10.3.6. Software Safety Limits

Description

In the Safety Configuration the safety system limits are specified. The *Safety System* receives the values from the input fields and detects any violation if any these values are exceeded. The robot controller attempts to prevent any violations by making a robot stop or by reducing the speed.

Robot Limits

Description

Robot Limits restrict general robot movements. The Robot Limits screen has two configuration options: **Factory Presets** and **Custom**.

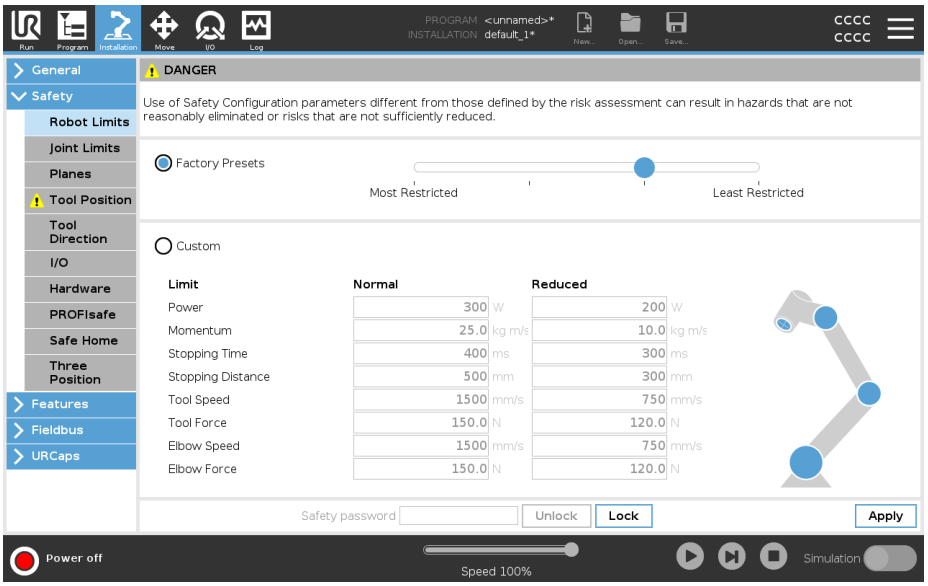
[1] Robot stop was previously known as "Protective Stop" for Universal Robots robots.

Factory Presets

Factory Presets is where you can use the slider to select a predefined safety setting . The values in the table are updated to reflect the preset values ranging from **Most Restricted** to **Least Restricted**

NOTICE

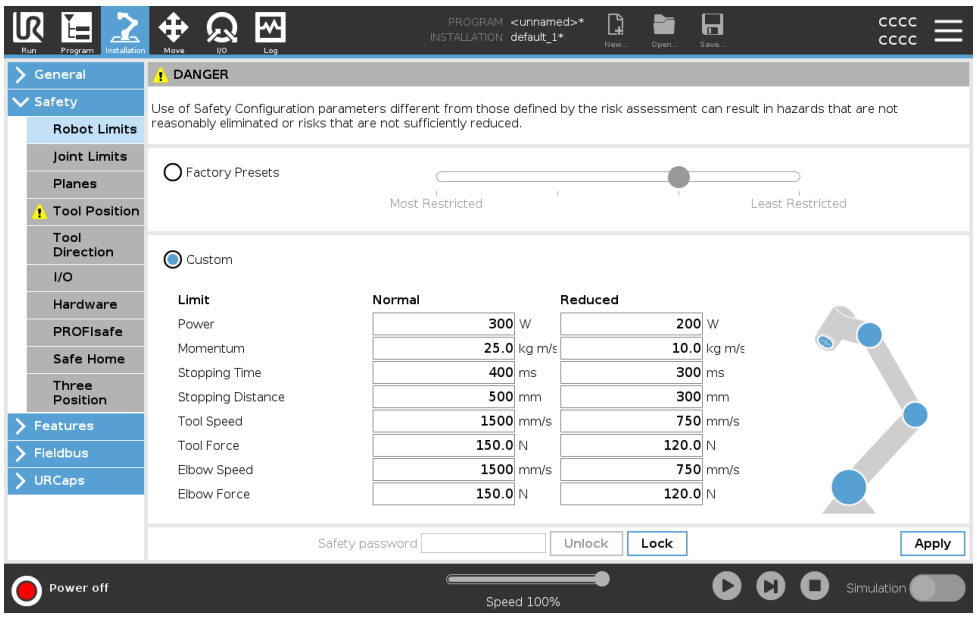
Slider values are only suggestions and do not substitute a proper risk assessment.



Custom Custom is where you can set Limits on how the robot functions and monitor the associated Tolerance.

Power	Limits maximum mechanical work produced by the robot in the environment. This limit considers the payload a part of the robot and not of the environment.
Momentum	Limits maximum robot momentum.
Stopping Time	Limits maximum time it takes the robot to stop e.g. when an emergency stop is activated.
Stopping Distance	Limits maximum distance the robot tool or elbow can travel while stopping. **NOTICE** Restricting stopping time and distance affect overall robot speed. For example, if stopping time is set to 300 ms, the maximum robot speed is limited allowing the robot to stop within 300 ms.
Tool Speed	Limits maximum robot tool speed.
Tool Force	Limits maximum force that the robot tool exerts on the environment to prevent clamping situations.
Elbow Speed	Limits maximum robot elbow speed.
Elbow Force	Limits maximum force that the elbow exerts on the environment to prevent clamping situations.

The tool speed and force are limited at the tool flange and the center of the two user-defined tool positions, (see Tool Position Restriction).



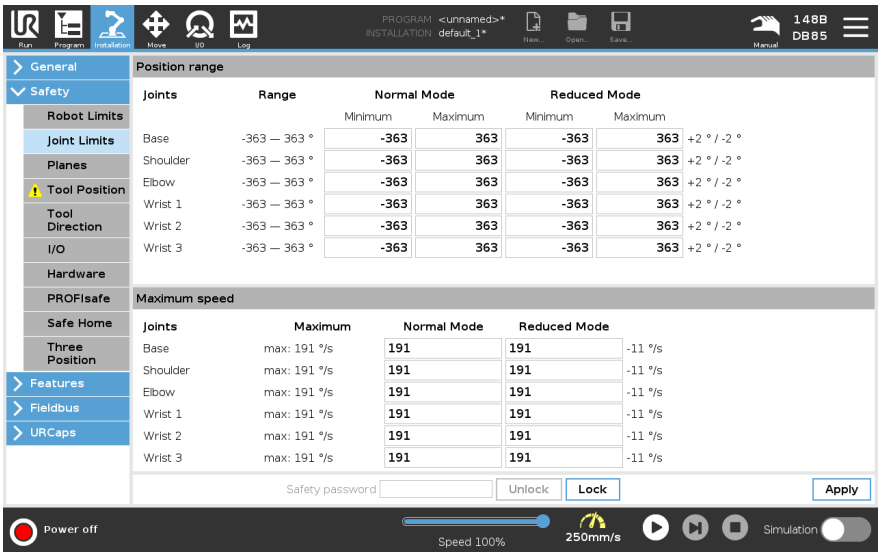
NOTICE

You can switch back to **Factory Presets** for all robot limits to reset to their default settings.

Joint Limits

Description

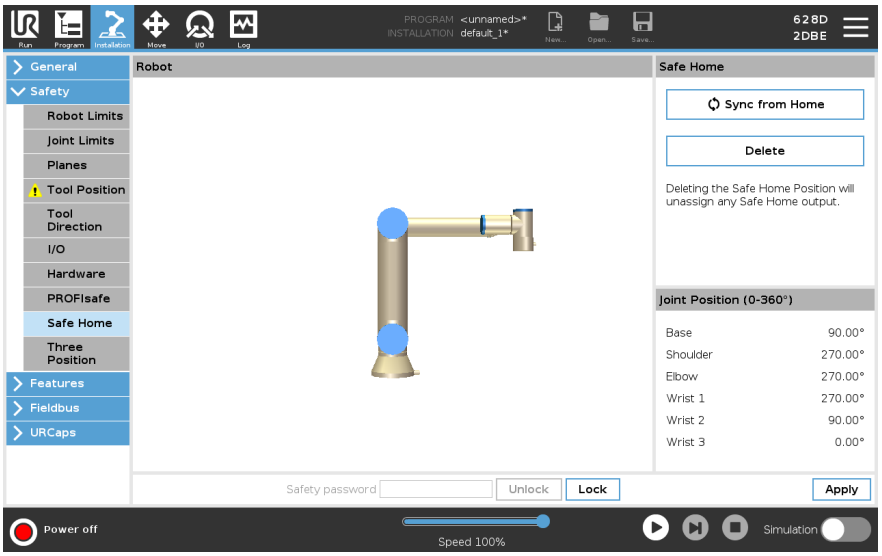
Joint limits allow you to restrict individual robot joint movements in joint space i.e. joint rotational position and joint rotational speed. Joint limiting can also be called software based axis limiting. The joint limit options are: **Maximum speed** and **Position range**.



10.3.7. Safe Home Position

Description

Safe Home is a return position defined by using the user-defined Home Position.
Safe Home I/Os are active when the Robot Arm is in the Safe Home Position and a Safe Home I/O is defined.
The Robot Arm is in the Safe Home Position if the joint positions are at the specified joint angles or a multiple of 360 degrees thereof.
The Safe Home Safety Output is active when the robot is standing still at the Safe Home Position.



Syncing from Home

To sync from Home

1. In the Header, tap **Installation**.
2. In the Side Menu on the left of the screen, tap **Safety** and select **Safe Home**.
3. Under **Safe Home**, tap **Sync from Home**.
4. Tap **Apply** and in the dialog box that appears, select **Apply and restart**.

Safe Home Output

The Safe Home Position must be defined before the Safe Home Output (see I/O).

Defining Safe Home Output

To define Safe Home Output

1. In the Header, tap **Installation**.
2. In the Side Menu on the left of the screen, under **Safety**, select **I/O**.
3. On the I/O screen in the Output Signal, under Function Assignment, in drop-down menu, select **Safe Home**.
4. Tap **Apply** and in the dialog box that appears, select **Apply and restart**.

Editing Safe Home

To edit Safe Home

Editing Home does not automatically modify a previously defined Safe Home position. While these values are out of sync, Home program node is undefined.

1. In the Header, tap **Installation**.
2. In the Side Menu on the left of the screen, under **General**, select **Home**.
3. Tap **Edit Position** and set the new robot arm position and tap **OK**.
4. In the Side Menu, under **Safety**, select **Safe Home**. You need a Safety password to **Unlock** the Safety Settings (See Setting a Software Safety Password).
5. Under **Safe Home**, tap **Sync from Home**

10.4. Software Safety Restrictions

Description

NOTICE

Configuring planes is entirely based on features. We recommend you create and name all features before editing the safety configuration, as the robot is powered off once the Safety Tab has been unlocked and moving the robot will be impossible.

Safety planes restrict robot workspace. You can define up to eight safety planes, restricting the robot tool and elbow. You can also restrict elbow movement for each safety plane and disable by deselecting the checkbox. Before configuring safety planes, you must define a feature in the robot installation. The feature can then be copied into the safety plane screen and configured.

WARNING

Defining safety planes only limits the defined Tool spheres and elbow, not the overall limit for the robot arm. This means that specifying a safety plane, does not guarantee that other parts of the robot arm will obey this restriction.

Safety Planes Modes

You can configure each plane with restrictive **Modes** using the icons listed below.

	Disabled	The safety plane is never active in this state.
	Normal	When the safety system is in Normal mode, a normal plane is active and it acts as a strict limit on the position.
	Reduced	When the safety system is in Reduced mode, a reduced mode plane is active and it acts as a strict limit on the position.
	Normal & Reduced	When the safety system is either in Normal or Reduced mode, a normal and reduced mode plane is active and acts as a strict limit on the position.
	Trigger Reduced Mode	The safety plane causes the safety system to switch to Reduced mode if the robot Tool or Elbow is positioned beyond it.
	Show	Pressing this icon hides or shows the safety plane in the graphics pane.
	Delete	Deletes the created safety plane. There is no undo/redo action. If a plane is deleted in error, it must be remade.
	Rename	Pressing this icon allows you to rename the plane.

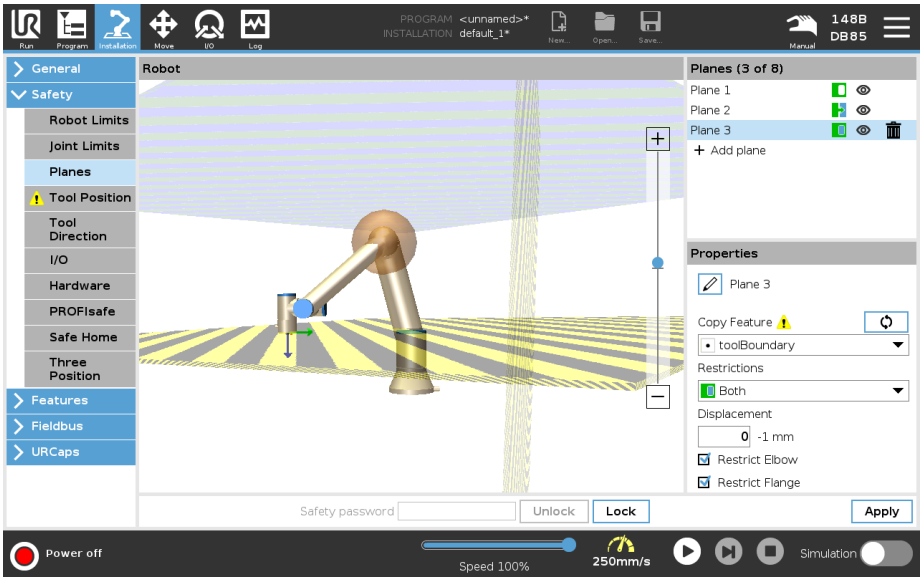
Configuring safety planes

1. In your PolyScope header, tap **Installation**.
2. In the Side Menu on the left of the screen, tap Safety and select **Planes**.
3. On the top right of the screen, in the Planes field, tap **Add plane**.
4. On the bottom right of the screen, in the **Properties** field, set up Name, Copy Feature and Restrictions.

Copy Feature

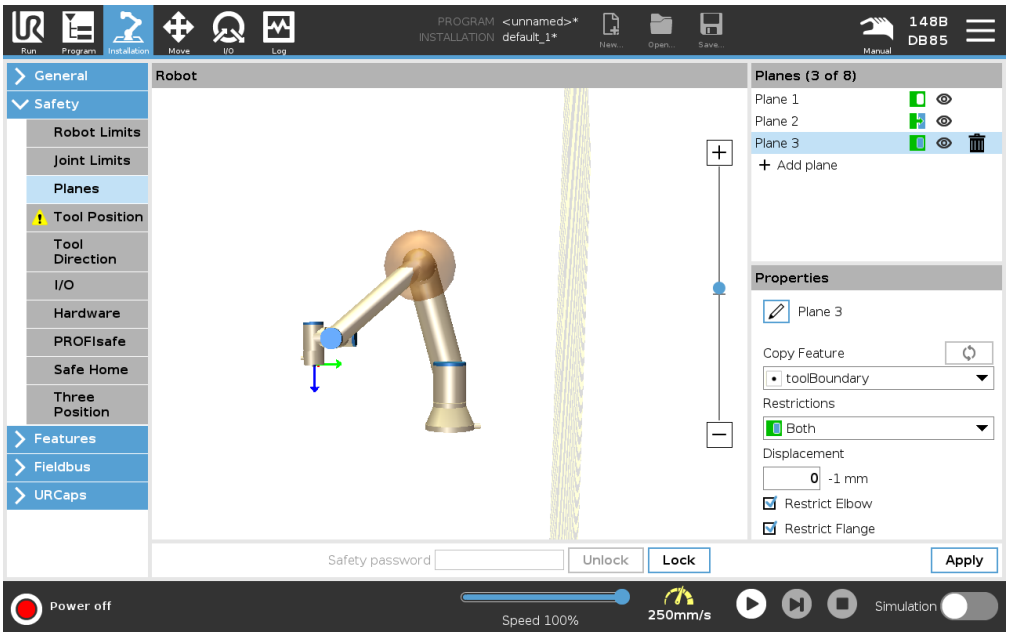
In **Copy Feature**, only Undefined and Base are available. You can reset a configured safety plane by selecting **Undefined**

If the copied feature is modified in the Features screen, a warning icon appears to the right of the Copy Feature text. This indicates that the feature is out of sync i.e. the information in the properties card is not updated to reflect the modifications that may have been made to the Feature.



Color Codes

Gray	Plane is configured but disabled (A)
Yellow & Black	Normal Plane (B)
Blue & Green	Trigger Plane (C)
Black Arrow	The side of the plane the tool and/or elbow is allowed to be on (For Normal Planes)
Green Arrow	The side of the plane the tool and/or elbow is allowed to be on (For Trigger Planes)
Gray Arrow	The side of the plane the tool and/or elbow is allowed to be on (For Disabled Planes)

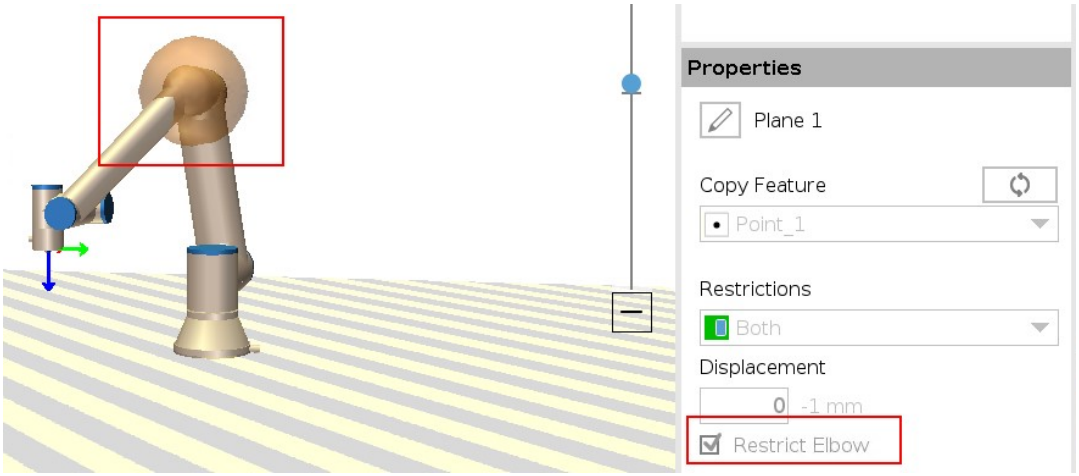


Elbow Restriction

You can enable **Restrict Elbow** to prevent robot elbow joint from passing through any of your defined planes. Disable Restrict Elbow for elbow to pass through planes.
The diameter of the ball that restricts the elbow is different for each size of robot.

UR3e	0.1 m
UR5e	0.13 m
UR10e / UR16e	0.15 m
UR20 / UR30	0.19 m

The information about the specific radius can be found in the *urcontrol.conf* file on the robot under the section [Elbow].



Tool Flange Restriction

Restricting the tool flange prevents the tool flange and the attached tool from crossing a safety plane. When you restrict the tool flange, the unrestricted area is the area inside of the safety plane, where the tool flange can operate normally.
The tool flange cannot cross the restricted area, outside of the safety plane.

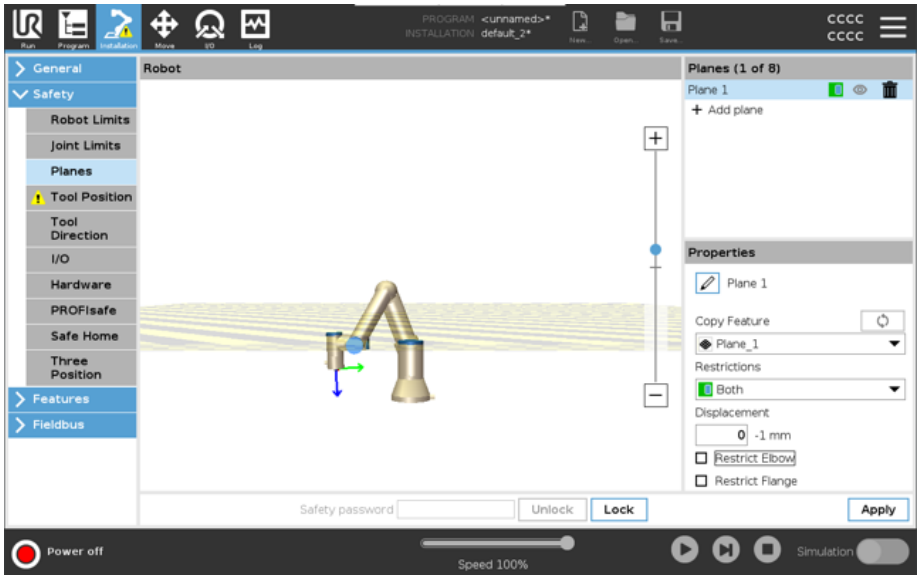
Removing the restriction allows the tool flange to go beyond the safety plane, to the restricted area, while the attached tool remains inside of the safety plane.

You can remove the tool flange restriction when working with a large tool off-set. This will allow extra distance for the tool to move.

Restricting the tool flange requires the creation of a plane feature. The plane feature is used to set up a safety plane later in the safety settings.

Adding a plane feature example

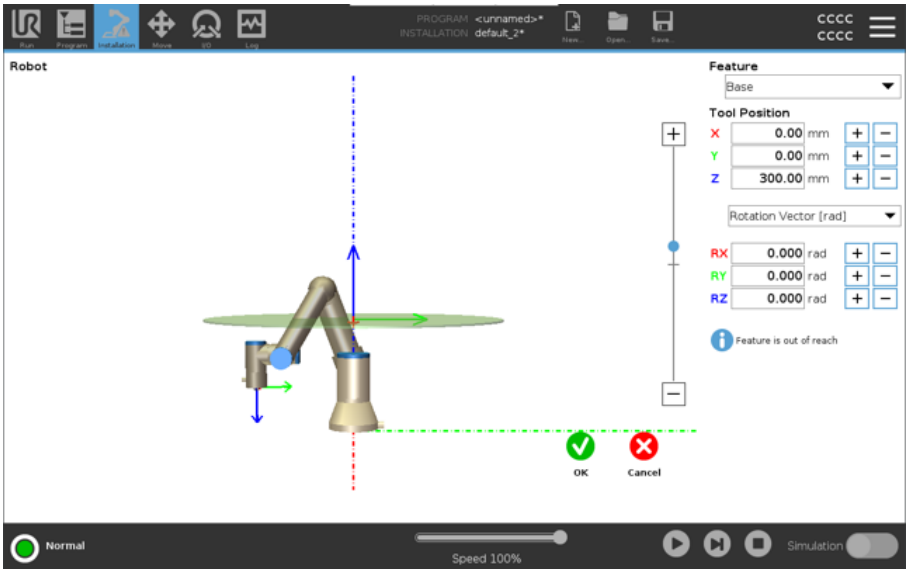
Displacement offsets the plane in either the positive or negative direction along the plane normal (Z-axis of the plane feature).
Deselect the checkbox for the Elbow and the Tool Flange so they do not trigger the safety plane. The Elbow can remain checked as needed by your application.



The unrestricted tool flange can cross a safety plane, even when no tool is defined.
If no tool is added, a warning on the Tool Position button prompts you to correctly define the tool.
When working with an unrestricted tool flange and a defined tool, it is ensured that the dangerous part of the tool can't go above and/or beyond certain area. The unrestricted tool flange can be used for any application where safety planes are needed, like Welding or Assembly.

Tool flange restriction example

In this example, an X-Y-plane is created with an offset of 300mm along the positive Z-axis with reference to the base feature.
The Z-axis of the plane can be thought of as “pointing” towards the restricted area.
If the safety plane is needed on e.g., the surface of a table, rotate the plane 3.142 rad or 180° around either the X- or Y-axis so the restricted area is under the table.
(TIP: Change the display of rotation from “Rotation Vector [rad]” to “RPY [°]”)



If needed it is possible to offset the plane in either positive or negative Z-direction later in the safety settings.
When satisfied with the position of the plane, tap OK.

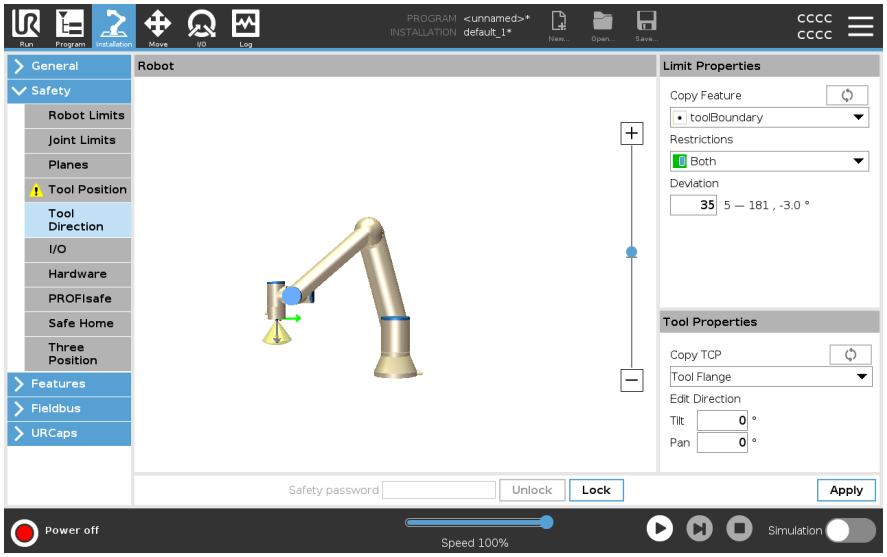
10.4.1. Tool Direction Restriction

Description

The Tool Direction screen can be used to restrict the angle in which the tool is pointing. The limit is defined by a cone that has a fixed orientation with respect to the robot arm Base. As the robot arm moves around, tool direction is restricted so it remains within the defined cone. The default direction of the tool coincides with the Z-axis of the tool output flange. It can be customized by specifying tilt and pan angles.
Before configuring the limit, you must define a point or plane in the robot installation. The feature can then be copied and its Z axis used as the center of the cone defining the limit.

NOTICE

Configuration of the tool direction is based on features. We recommend you create desired feature(s) before editing the safety configuration, as once the Safety Tab has been unlocked, the robot arm powers off making it impossible to define new features.



Limit Properties

The Tool Direction limit has three configurable properties:

1. **Cone center**: You can select a point or plane feature from the drop-down menu, to define the center of the cone. The Z axis of the selected feature is used as the direction around which the cone is centred.
2. **Cone angle**: You can define how many degrees the robot is allowed to deviate from center.

Disabled Tool direction limit	Never active
Normal Tool direction limit	Active only when safety system is in **Normal mode**
Reduced Tool direction limit	Active only when the safety system is in **Reduced mode**
Normal & Reduced Tool direction limit	Active when the safety system is in **Normal mode** as well as when it is in **Reduced mode**.

You can reset the values to default or undo the Tool Direction configuration by setting the copy feature back to "Undefined".

Tool Properties

By default, the tool points in the same direction as the Z axis of the tool output flange. This can be modified by specifying two angles:

- **Tilt angle**: How much to tilt the Z axis of the output flange towards the X axis of the output flange
- **Pan angle**: How much to rotate the tilted Z axis around the original output flange Z axis.

Alternatively, the Z axis of an existing TCP can be copied by selecting that TCP from the drop-down menu.

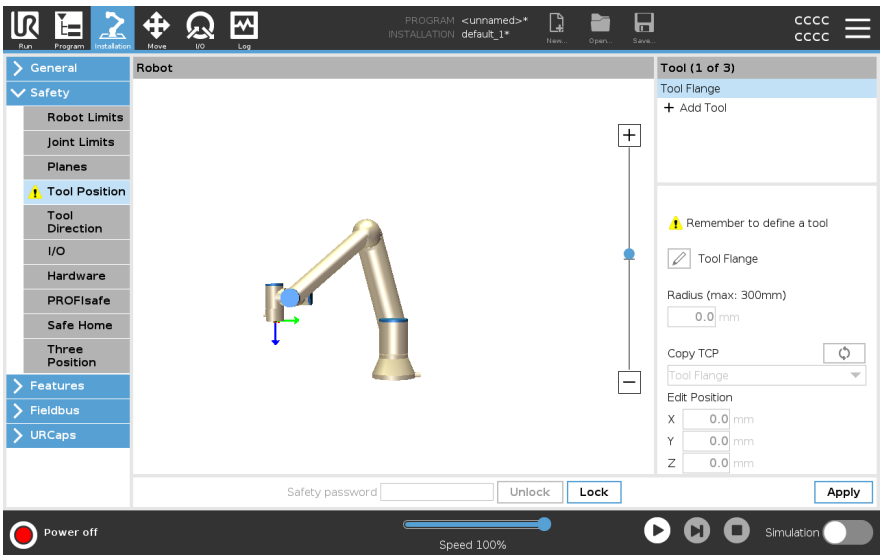
10.4.2. Tool Position Restriction

Description

The Tool Position screen enables more controlled restriction of tools and/or accessories placed on the end of the robot arm.

- **Robot** is where you can visualize your modifications.
- **Tool** is where you can define and configure a tool up to two tools.
- **Tool_1** is the default tool defined with values x=0.0, y= 0.0, z=0.0 and radius=0.0. These values represent the robot tool flange.

Under Copy TCP, you can also select **Tool Flange** and cause the tool values to go back to 0.
A default sphere is defined at the tool flange.

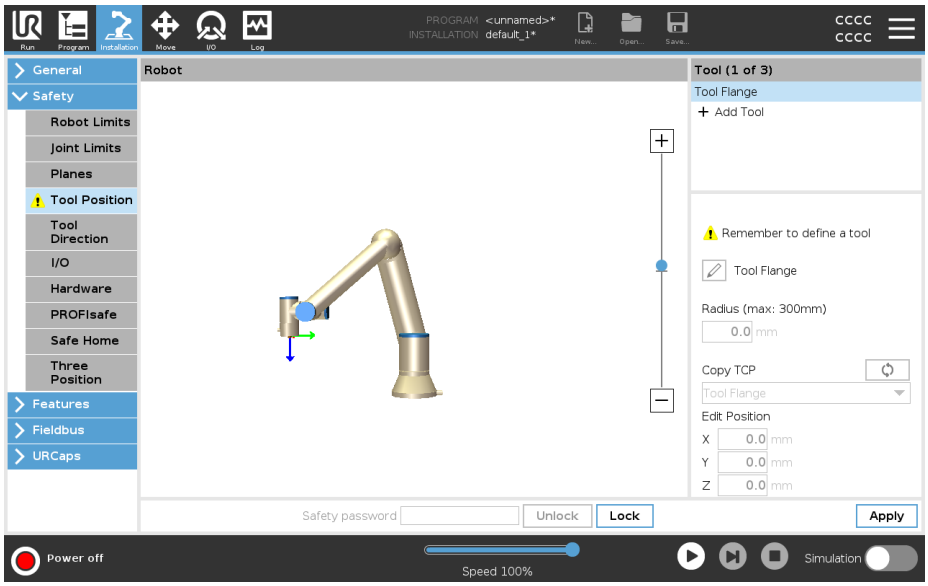


User defined tools

For the user defined tools, the user can change:

- **Radius** to change the radius of the tool sphere. The radius is considered when using safety planes. When a point in the sphere passes a reduced mode trigger plane, the robot switches to *Reduced* mode. The safety system prevents any point on the sphere from passing a safety plane (see Software Safety Restrictions).
- **Position** to change the position of the tool with respect to the tool flange of the robot. The position is considered for the safety functions for tool speed, tool force, stopping distance and safety planes.

You can use an existing Tool Center Point as a base for defining new tool positions. A copy of the existing TCP, predefined in General menu, in TCP screen, can be accessed in Tool Position menu, in Copy TCP drop-down list.
When you edit or adjust the values in the **Edit Position** input fields, the name of the TCP visible in the drop down menu changes to **custom**, indicating that there is a difference between the copied TCP and the actual limit input. The original TCP is still available in the drop down list and can be selected again to change the values back to the original position. The selection in the copy TCP drop down menu does not affect the tool name.
Once you apply your Tool Position screen changes, if you try to modify the copied TCP in the TCP configuration screen, a warning icon appears to the right of the Copy TCP text. This indicates that the TCP is out of sync i.e. the information in the properties field is not updated to reflect modifications that may have been made to the TCP. The TCP can be synced by pressing the sync icon (see).
The TCP does not have to be synced in order to define and use a tool successfully.
You can rename the tool by pressing the pencil tab next to the displayed tool name. You can also determine the Radius with an allowed range of 0-300 mm. The limit appears in the graphics pane as either a point or a sphere depending on radius size.



Tool Position Warning

You must set a Tool Position within the safety settings, for the safety plane to trigger correctly when the tool TCP approaches the safety plane.
The warning remains on the Tool Position if:

- You fail to add a new tool under Tool Flange.

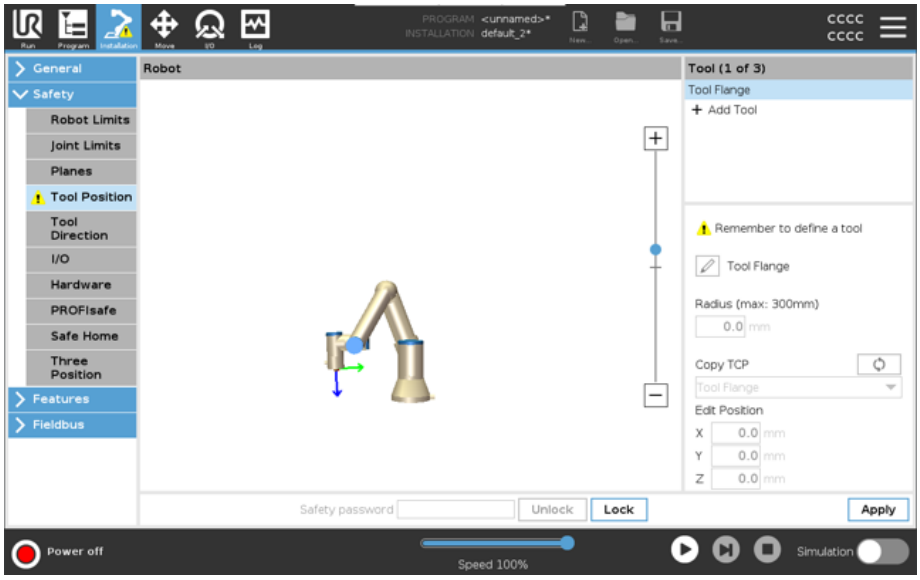
To configure the tool position

1. In the Header tap **Installation**.
2. On the left side of the screen, under Safety, tap **Tool Position**.
3. On the right side of the screen, select **Add Tool**.
   - The newly added tool has a default name: **Tool_x**.
4. Tap the edit button to rename **Tool_x** to something more identifiable.
5. Edit the Radius and Position to match that of the tool you are currently using, or use the Copy TCP drop-down and choose a TCP from the General>TCP settings if such is defined.

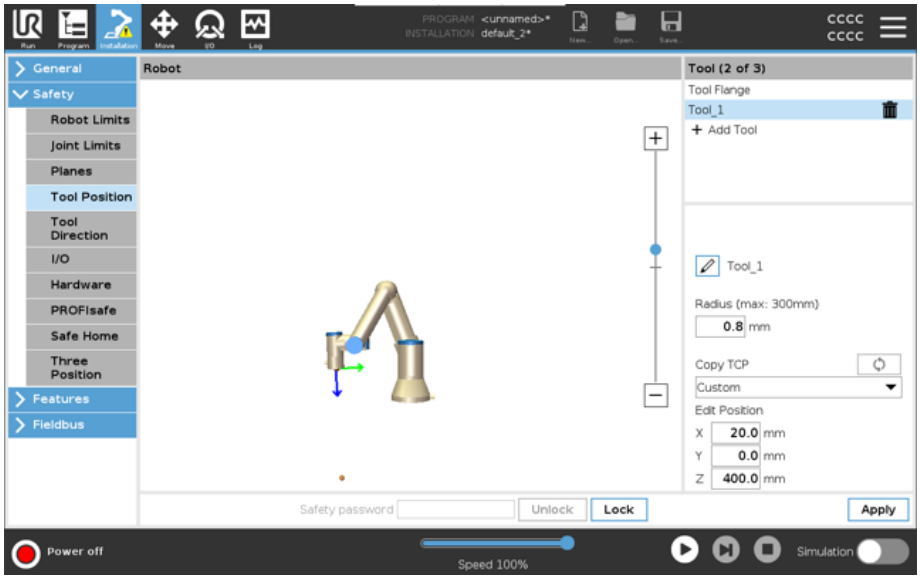
Tool Position Warning example

In this example, a Radius of 0.8mm is set and the TCP position to XYZ [20, 0, 400] in millimeters respectively. Optionally you can choose to ”Copy TCP” by using the drop-down menu if one has already been set in the ->General/TCP settings. Once the Apply is tapped in the bottom right corner of the screen, you are DONE.

The warning on the Tool Position button indicates a tool is not added under Tool Flange.



Tool Position button without the warning indicates a tool (other than the Tool Flange) is added.



10.5. The First Program

Description

A program is a list of commands telling the robot what to do. For most tasks, programming is done entirely using the PolyScope software. PolyScope allows you to teach the robot arm how to move using a series of waypoints to set up a path for the robot arm to follow.

Use the Move tab to move the Robot Arm to a desired position, or teach the position by pulling the Robot Arm into place while holding down the Freedrive button at the top of the Teach Pendant.

You can create a program can to send I/O signals to other machines at certain points in the robot's path, and perform commands like **if...then** and **loop**, based on variables and I/O signals.

To create a simple program

1. On PolyScope, in the Header **File Path**, tap **New...** and select **Program**.
2. Under Basic, tap **Waypoint** to add a waypoint to the program tree. A default MoveJ is also added to the program tree.
3. Select the new waypoint and in the Command tab, tap **Waypoint**.
4. On the Move Tool screen, move the robot arm by pressing the move arrows. You can also move the robot arm by holding down the Freedrive button and pulling the Robot Arm into desired positions.
5. Once the robot arm is in position, press **OK** and the new waypoint displays as Waypoint_1.
6. Follow steps 2 to 5 to create Waypoint_2.
7. Select Waypoint_2 and press the Move Up arrow until it is above Waypoint_1 to change the order of the movements.
8. Stand clear, hold on to the emergency stop button and in the PolyScope Footer, press **Play** button for the Robot Arm to move between Waypoint_1 and Waypoint_2. Congratulations! You have now produced your first robot program that moves the Robot Arm between the two given waypoints.

NOTICE

1. Do not drive the robot into itself or anything else as this may cause damage to the robot.
2. This is only a quick start guide to show how easy it is to use a UR robot. It assumes a harmless environment and a very careful user. Do not increase the speed or acceleration above the default values. Always conduct a risk assessment before placing the robot into operation.

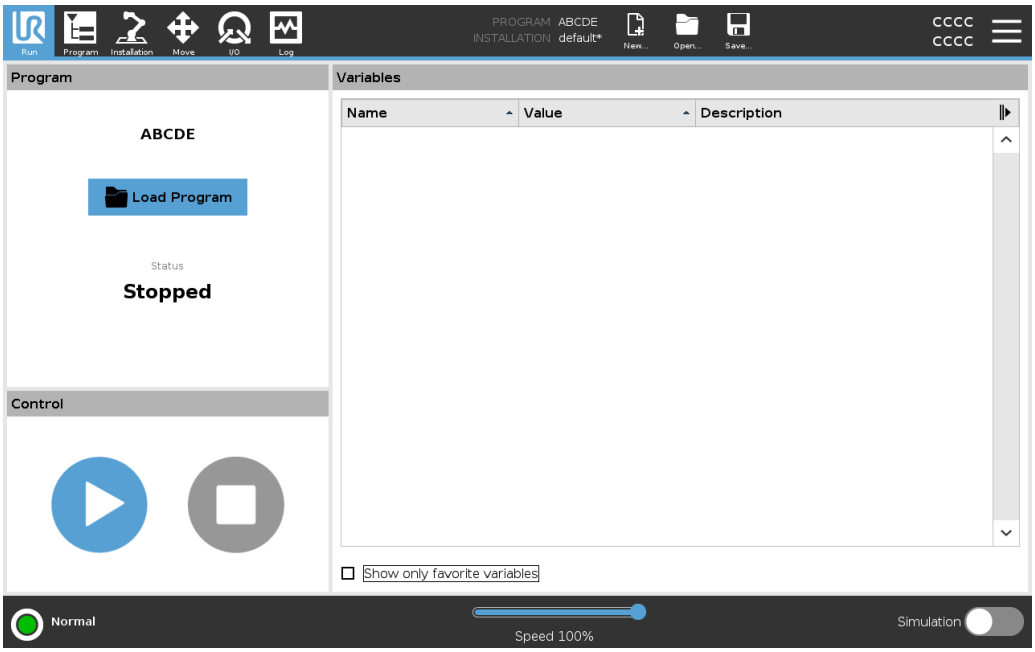
WARNING

Keep your head and torso outside the reach (workspace) of the robot. Do not place fingers where they can be caught.

10.5.1. Run Tab

Description

The **Run** tab allows you to do simple operations and monitor the state of your robot. You can load, play, pause and stop a program, as well as monitor variables. The Run Tab is most useful when the program is created and the robot is ready for operation.



Program

The Program pane displays the name and status of the current program.

To load a new program

1. In the Program pane, tap **Load Program**.
2. Select your desired program from the list.
3. Tap **Open** to load the new program.

   The variables, if present, are displayed when you play the program.

Variables

The Variables pane displays the list of variables used by programs to store and update values during runtime.

- Program variables belong to programs.
- Installation variables belong to installations that can be shared among different programs. The same installation can be used with multiple programs.

All program variables and installation variables in your program are displayed in the Variables pane as a list showing the Name, Value and Description of the variable.

Variable descriptions

You can add information to your variables by adding variable descriptions in the Description column. You can use the variable descriptions to convey the purpose of the variable and/or the meaning of its value to operators using the Run tab screen and/or other programmers.
Variable descriptions (if used) can be up to 120 characters, displayed in the Description column of the variables list on the Run tab screen and the Variables tab screen.

Favorite variables

You can display selected variables by using the **Show only favorite variables** option.
To show favorite variables

1. Under Variables, check the **Show only favorite variables** box.
2. Check **Show only favorite variables** again to show all variables.

You cannot designate favorite variables in the Run Tab, you can only display them. Designating favorite variables depends on the variable type.

To designate favorite program variables

1. In the Header, tap **Program**.
   The variables are listed under **Variable Setup**.
2. Select the desired variables.
3. Check the **Favorite variable** box.
4. Tap **Run** to return to your variable display.

To designate favorite installation variables

1. In the Header, tap **Installation**.
2. Under General, select **Variables**.
   The variables are listed under **Installation Variables**.
3. Select the desired variables.
4. Check the **Favorite variable** box.
5. Tap **Run** to return to your variable display.

Collapse/expand the Description column

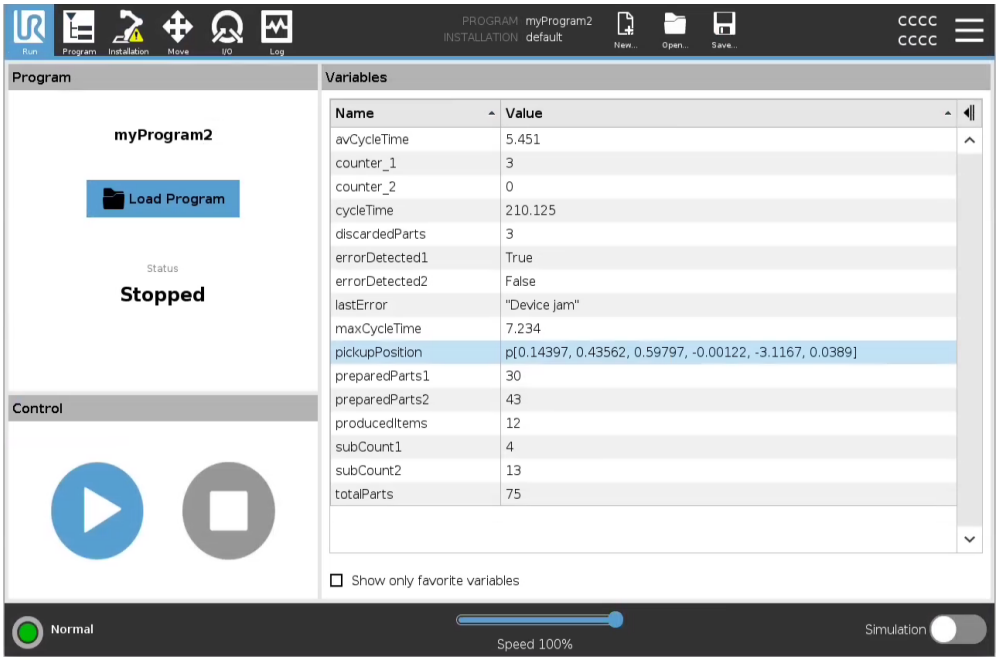
A variable description spans multiple lines to fit the width of the Description column if necessary. You can also collapse and expand the Description column by using the buttons shown below.

To collapse/expand the Description column

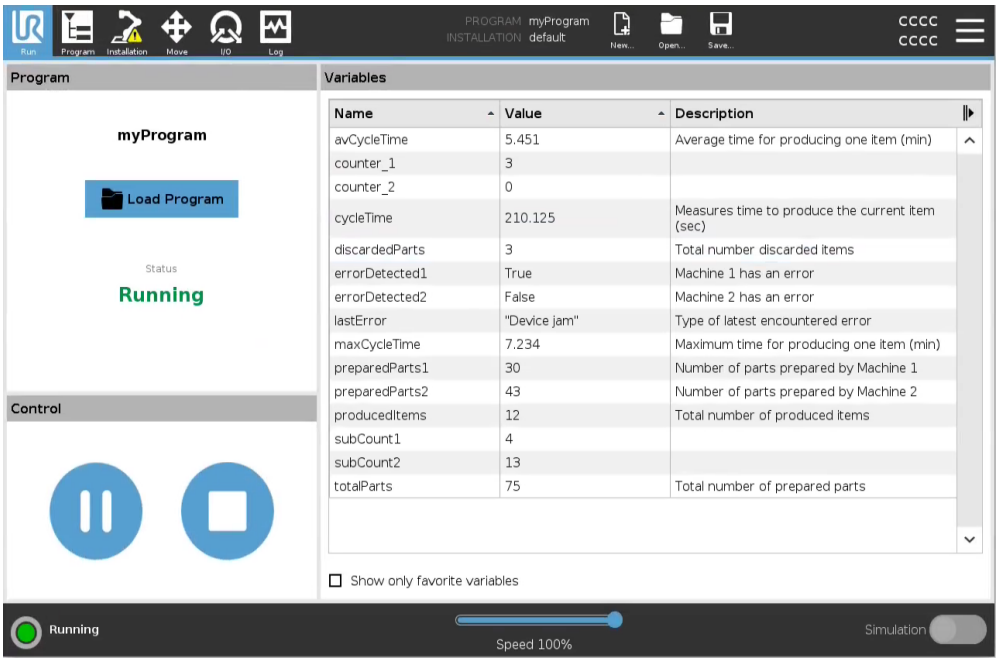
1. Tap  to collapse the Description column.
2. Tap  to expand the Description column.

here

Collapsed Description column



Expanded Description column



Control The Control pane allows you to control the running program. You can play and stop, or pause and resume a program, using the buttons listed in the table below:

- The Play button, Pause button and the Resume Button are combined.
- The Play button changes to Pause when the program is running.
- The Pause button changes to Resume.

Button		Function
Play		To play a program 1. Under Control, tap **Play** to start running a program from the beginning.
Resume		To resume a paused program 1. Tap **Resume** to continue running the paused program.
Stop		To stop a program 1. Tap **Stop** to stop the running program You cannot resume a stopped program. You can tap **Play** to restart the program.
Pause		To pause a program 1. Tap **Pause** to pause a program at a specific point. You can resume a paused program.

10.5.2. Move Robot into Position

Description

Access the **Move Robot into Position** screen when the Robot Arm must move to a particular start position before running a program, or when the Robot Arm is moving to a waypoint while modifying a program.

In cases where the **Move Robot into Position** screen cannnot move the Robot Arm to the program start position, it moves to the first waypoint in the program tree.
The Robot Arm can move to an incorrect pose if:

- The TCP, feature pose or waypoint pose of the first movement is altered during program execution before the first move is executed.
- The first waypoint is inside an If or Switch program tree node.

Accessing the Move Robot into Position Screen

1. Tap the Run tab in the header.
2. In the **Footer**, tap **Play** to access the **Move Robot into Position** screen.
3. Follow the on-screen instructions to interact with the animation and the real robot.

Move robot to

Hold down **Move robot to:** to move the Robot Arm to a start position. The animated Robot Arm displayed on-screen shows the desired movement about to be performed.

NOTICE

Collision can damage the robot or other equipment. Compare the animation with the position of the real Robot Arm to ensure the Robot Arm can safely perform the movement without colliding with any obstacles.

Manual

Tap **Manual** to access the **Move** screen where the Robot Arm can be moved by using the Move Tool arrows and/or configuring Tool Position and Joint Position coordinates.

10.5.3. Using the Program Tab

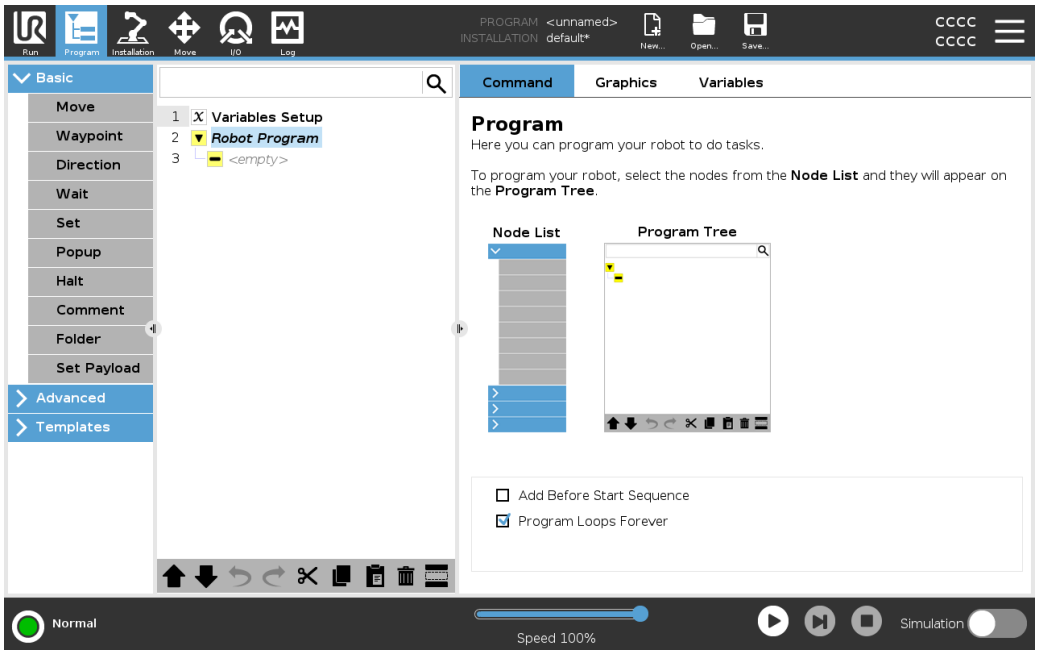
Description

The Program tab is the where you create and edit robot programs. There are two main areas:

- The left side contains the program nodes you can add to your robot program.

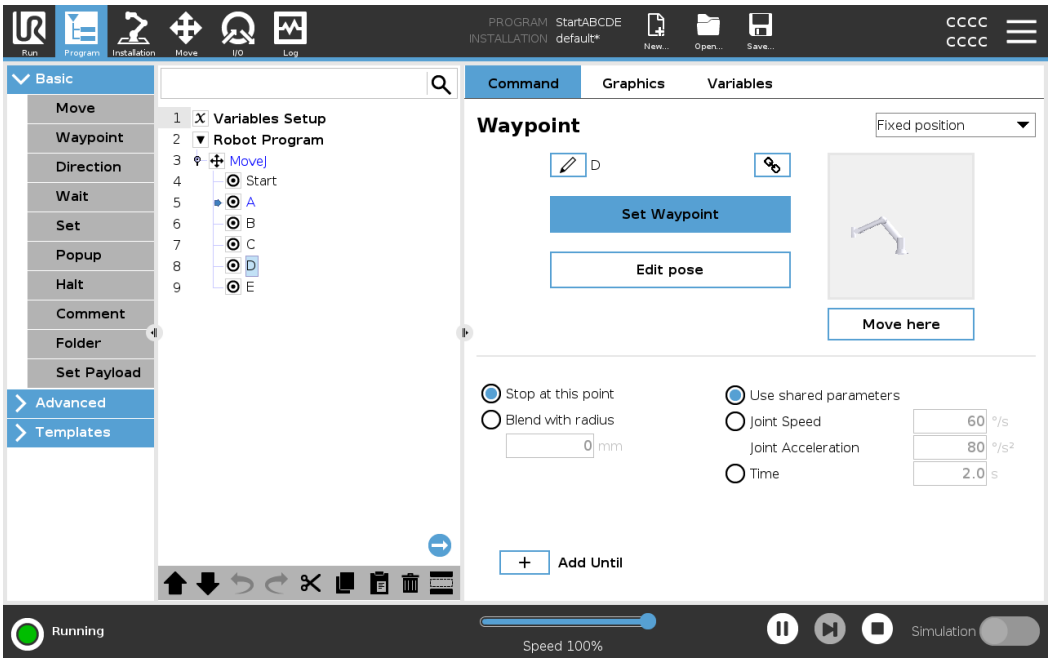
  You can use the Basic, Advanced and Template dropdowns to the very left.
- The right side contains the configuration of the program nodes you can add to your program.

  You can use Command, Graphics and Variables options.



Program Tree

The program tree is built as you add program nodes to your program.
You can use the Command tab to configure the functionality of the added program nodes.

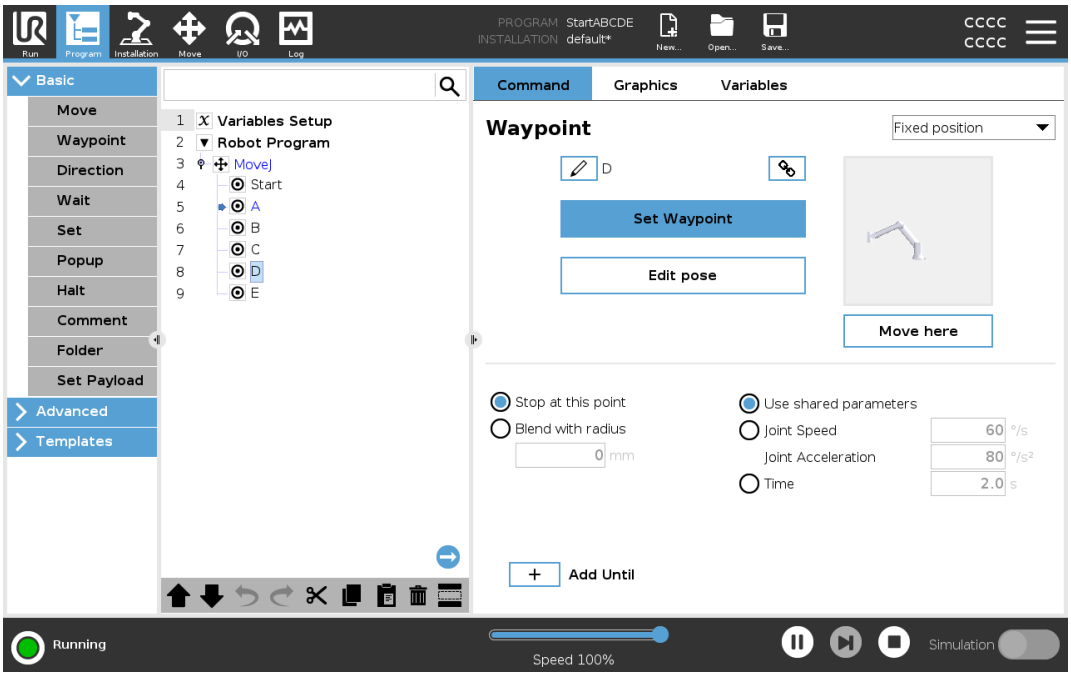


Adding program nodes

- You cannot run an empty program tree or a program containing incorrectly configured program nodes.
- Incorrectly configured programs nodes are higlighted in yellow.
- Correctly configured program nodes are highlighted in white.

Program Execution Indication

Robot programs often become quite long, so order to be able to see the flow of the robot program, you can look at what program node is active.



When the program is running, the program node currently being executed is indicated by a small icon next to that node.
The path of execution is highlighted with blue arrow .

Tapping the icon at the corner of the program allows it to track the command being executed

Search Button

You can also search for a specific command/program node. This is useful when you have a long program with many different program nodes.

10.5.4. Program Tree Toolbar

Description

You can work with the program nodes that have been added to the program tree by using the icons in the bottom of the program tree.

Icons in the Program Tree toolbar

Use the toolbar at the base of the Program Tree to modify the Program Tree.

Undo & Redo		undo and redo changes to commands.
Move Up & Move Down		changes the position of a node.
Cut		cuts a node and allows it to be used for other actions (e.g., paste it on other place on the Program Tree).
Copy		copies a node and allows it to be used for other actions (e.g., paste it on other place on the Program Tree).
Paste		pastes a node that was previously cut or copied.
Delete		removes a node from the Program Tree.
Suppress		suppresses specific nodes on the Program Tree.
Search Button		search in the Program Tree. Tap the  icon to exit search.

10.5.5. Using Selected Program Nodes

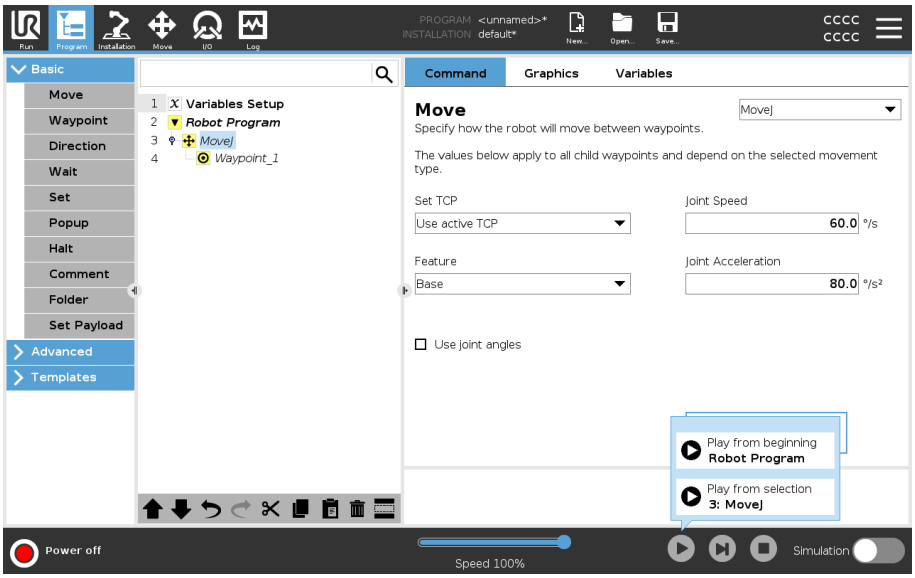
Description

You can start your robot program from any program node in the program tree. This is useful when you are testing your program.

When the robot is in Manual Mode (see Operational Modes), you can allow a program to start from a selected node or you can start the entire program from the beginning.

Play From Selection

The Play button in the Footer provides options for how to start the program.
In the image below, the **Play** button is selected and **Play from Selection** is displayed.



- You can start a program only from a node in the robot Program tree. The **Play from Selection** stops if a program cannot be run from a selected node.

  The program also stops and displays an error message if an unassigned variable in encountered while playing a program from selected node.
- You can use **Play from Selection** in a subprogram. The program execution halts when the subprogram ends.
- You cannot use **Play from Selection** with a thread because threads always start from the beginning.

To play a program from a selected node

1. In the Program tree, select a node.
2. In the Footer, tap **Play**.
3. Select **Play from Selection** to run a program from a node in the program tree.

Example

You can start a stopped program again from a specific node.

10.5.6. Using Basic Program Nodes

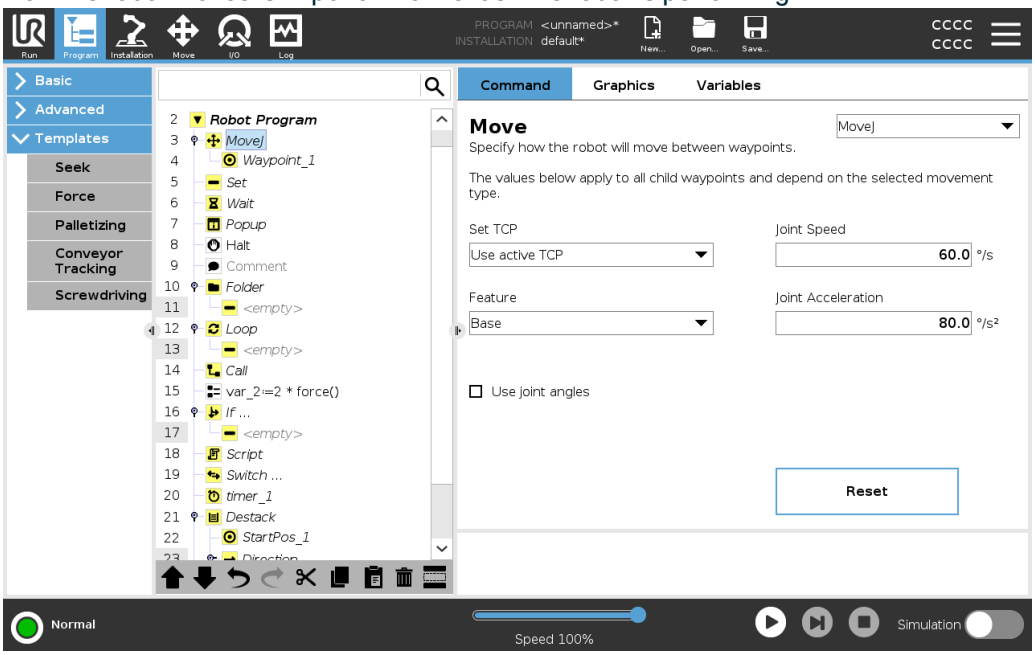
Description

Basic program nodes are used to create simple robot applications. Some basic program nodes are also used to organize your robot program and create comments in your robot program. This can be quite useful, if it is large robot program.

10.5.7. Basic Program Nodes: Move

Description

The Move command allows the robot to move from point A to point B.
How the robot moves is important to the task the robot is performing.



When you add a Move to your program tree, the Move pane appears to the right of the screen.

The Movecommand controls the robot's motion via waypoints.
Waypoints are automatically added when you add Move commands to a program.
Read more about Waypoints.
You can also use Moves to set acceleration and speed for the robot arm's movement between waypoints.

The robot moves using four Move commands. See the Move command types below:

MoveJ

The MoveJ command creates a movement from point A to point B that is optimal for the robot.
The movement may not be a direct line between A and B, but optimal for the start position of the joints and the end position of the joints.

Add a MoveJ command

1. In your robot program, select the place where you wish to add a Move.
2. Under Basic, tap **Move** to add a waypoint to the robot program together with a Move node.
3. Select the move node.
4. Select the MoveJ in the drop-down menu.

Detail

MoveJ makes movements that are calculated in the robot arm joint space. Joints are controlled to finish their movements at the same time. This movement type results in a curved path for the tool to follow. The shared parameters that apply to this movement type are the maximum joint speed and joint acceleration, specified in *deg/s* and deg/s^2, respectively. If it is desired to have the robot arm move fast between waypoints, disregarding the path of the tool between those waypoints, this movement type is the preferable choice.

MoveL

The MoveL command creates a movement that is a direct line from point A and point B.

Add a MoveL command

1. In your Robot Program, select the place where you wish to add a Move.
2. Under Basic, tap **Move** to add a waypoint to the robot program together with a Move node.
3. Select the move node.
4. Select the MoveL from the drop-down menu.

Detail

MoveL moves the Tool Center Point (TCP) linearly between waypoints. This means that each joint performs a more complicated motion to keep the tool on a straight line path. The shared parameters that can be set for this movement type are the desired tool speed and tool acceleration specified in *mm/s* and mm/s^2, respectively, and also a feature.

MoveP

The MoveP command creates a movement with a constant speed between the waypoints. Blend between waypoints is enabled to ensure constant speed. (See Blending).

Add a MoveP command

1. In your Robot Program, select the place where you wish to add a Move.
2. Under Basic, tap **Move** to add a waypoint to the robot program together with the Move node.
3. Select the move node.
4. Select the MoveP from the drop-down menu.

Detail

MoveP moves the tool linearly with constant speed with circular blends, and is intended for some process operations, like gluing or dispensing. The size of the blend radius is by default a shared value between all the waypoints. A smaller value will make the path turn sharper whereas a higher value will make the path smoother. While the robot arm is moving through the waypoints with constant speed, the robot control box cannot wait for either an I/O operation or an operator action. Doing so might stop the robot arm's motion, or cause a robot stop.

MoveCircle

The MoveCircle command creates a circular movement, by creating a half circle. You can only add CircleMove via a MoveP command.

Add a MoveCircle command

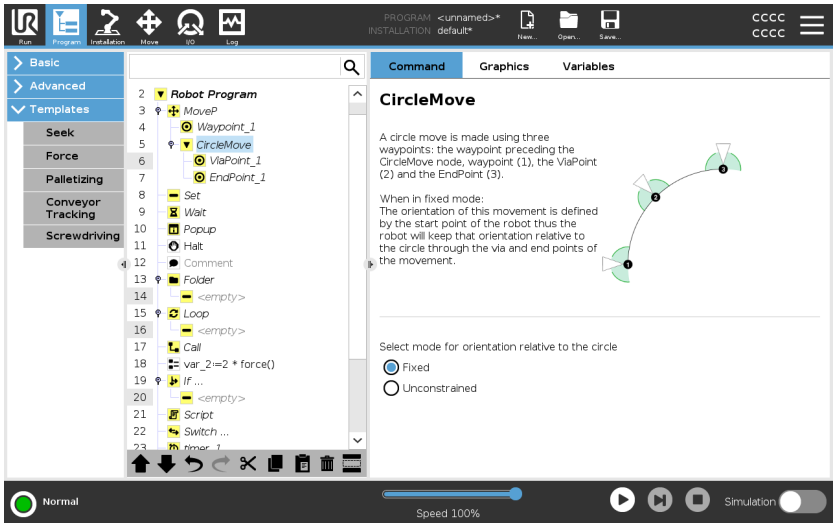
1. In your Robot Program, select the place where you wish to add a Move.
2. Under Basic, tap **Move**.

   A waypoint is added to the robot program together with the Move node.
3. Select the move node.
4. Select the MoveP from the drop-down menu.
5. Tap **Add circle move**
6. Select the orientation mode.

Detail

The robot starts the circular movement from its current position, or start point, and moves through a ViaPoint specified on the circular arc, to an EndPoint that completes the circular movement.
A mode is used to calculate tool orientation, through the circular arc.
The mode can be:

- Fixed: only the start point is used to define the tool orientation.
- Unconstrained: the start point transforms to the EndPoint to define tool orientation.



10.5.8. Basic Program Nodes: Waypoints

Description

Waypoints are one of the most central parts of a robot program, telling the robot arm where to go one movement at a time.

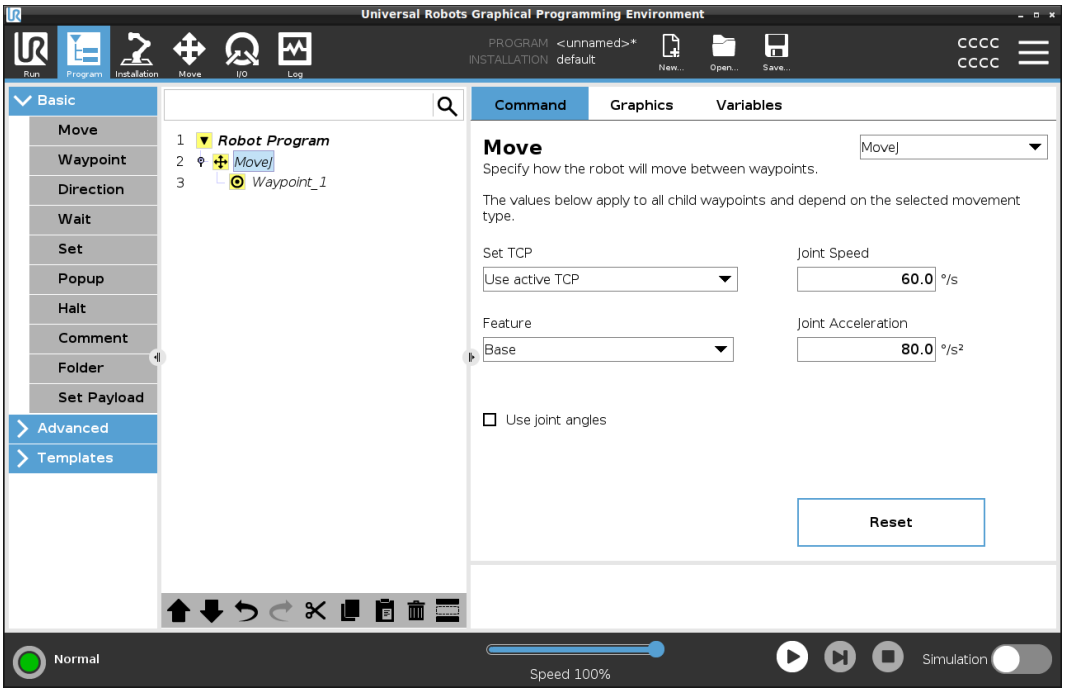
Add Waypoints

A waypoint accompanies a Move, so adding a Move is required for the first waypoint.

Add a waypoint to a robot program

1. In your Robot Program, select the place where you wish to add a Move.
2. Under Basic, tap **Move**.

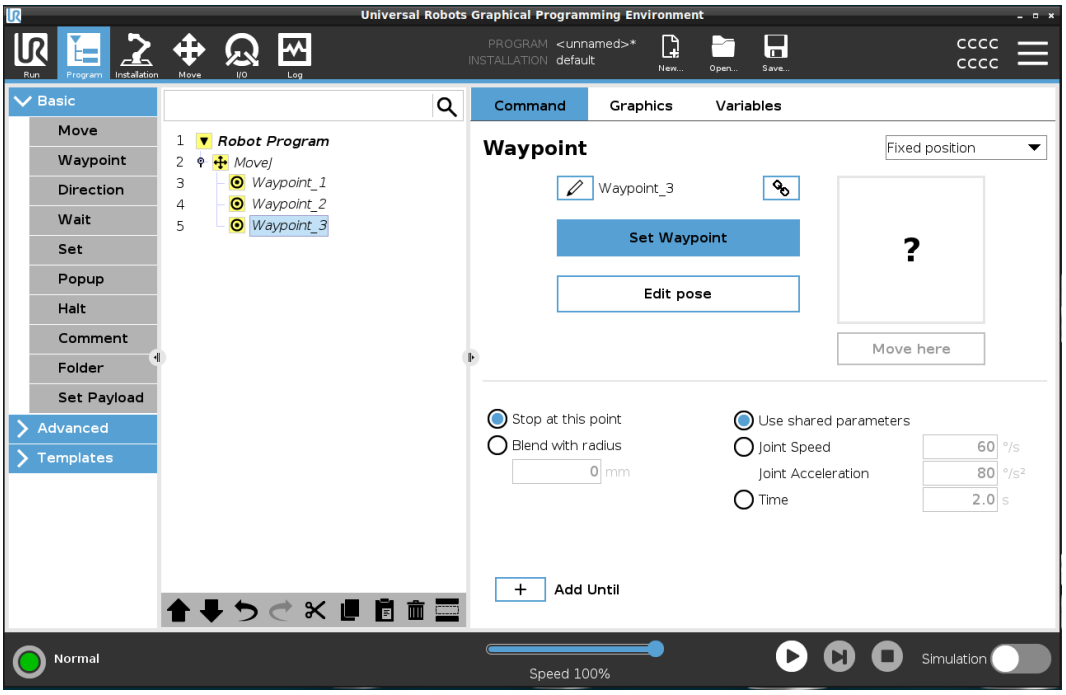
   A waypoint is added to the robot program together with the Move node.



Add additional waypoints to a Move or Waypoint

1. In your Robot Program, select a Move node or Waypoint node.
2. Under Basic, tap **Waypoint**.

   The additional waypoint is added in the Move node. This waypoint is part of the Move command.



The additional waypoint is added under the waypoint that you selected in the robot program.

Detail

Using a waypoint means applying the taught relationship between the feature and the TCP from the Move command. The relationship between the feature and the TCP, applied to the current selected feature, achieves the desired TCP location. The robot calculates how to position the arm to allow the current active TCP to reach the desired TCP position.

10.5.9. Set Payload

Description

The Set Payload command allows you to configure the payload for the robot. Payload is the combined weight of everything attached to the robot tool flange.
When to use:

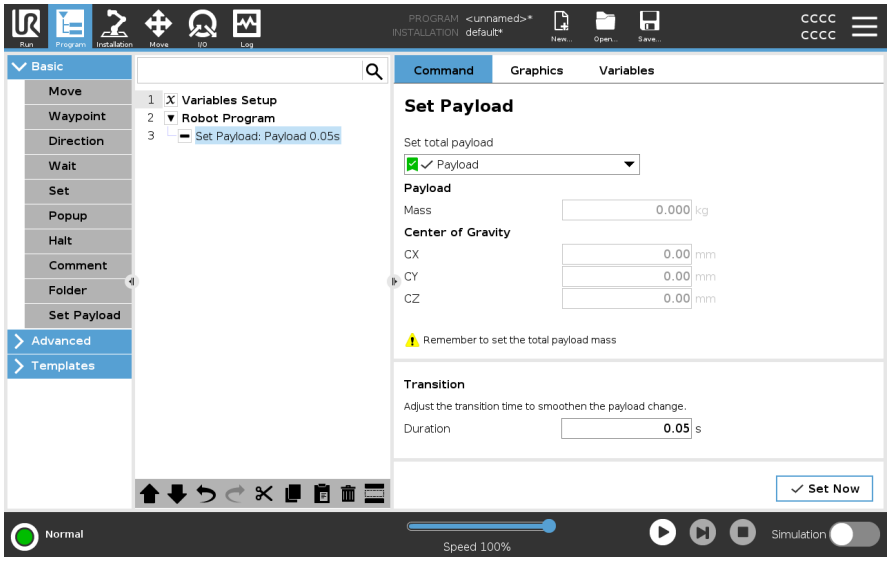
- When adjusting the payload weight to prevent the robot from triggering a robot stop. A correctly configured payload weight ensures optimal robot movement.

  Setting the payload correctly ensures optimal motion performance and avoids robot stops.
- When setting up the payload for use in a pick and place program, using a gripper.

Set Payload

Use the Set Payload command

1. In your robot program, select the place or node where you wish to add a Set command.
2. Under Basic, tap **Set Payload**.
3. Use the drop-down, under **Select Payload**.
   a. Select one of the payloads already configured.
   b. Or, use the drop-down to configure a new payload by selecting **Custom Payload** and completing the mass and CoG fields.



Tip You can also use the **Set Now** button to set the values on the node as the active payload.

Use tip Remember to always update your payload when making any changes to the configuration of the robot program.

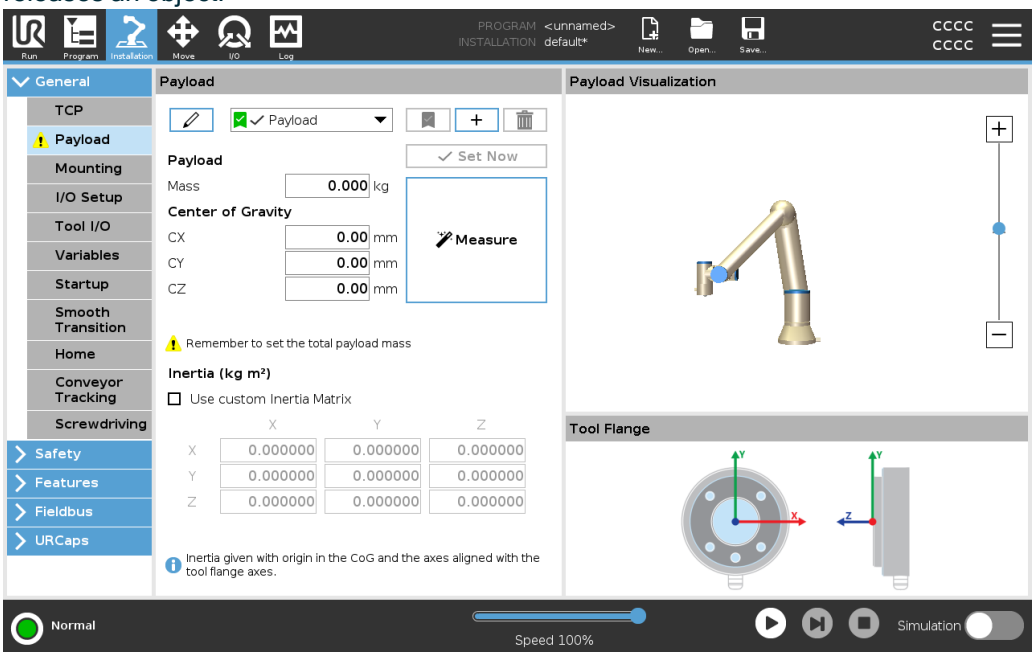
Example: Set Payload In a pick and place program, you would create a default payload in the installation. Then you add a Set Payload when picking up an object. You would update the payload after the gripper closes, but before starting to move.
Additionally, you would use the Set Payload after the object has been released.

Payload Transition Time This is the time it takes the robot to adjust for a given payload. At the bottom of the screen, you can set the transition time between different payloads.
You can add a payload transition time in seconds.
Setting a transition time larger than zero, prevents the robot from doing a small "jump", when the payload changes. The program continues while the adjustment is taking place.
Using the Payload Transition Time is recommended when picking up or releasing heavy objects or using a vacuum gripper.

10.5.10. Payload

Description

You must set the Payload, the CoG and the inertia for the robot to perform optimally. You can define multiple Payloads, and switch between them in your program. This is useful in Pick and Place applications, for example, where the robot picks up and releases an object.



Adding, Renaming, Modfying and Removing Payloads

You can start configuring a new Payload with the following actions:

- Tap the + to define a new Payload with a unique name. The new payload is available in the drop-down menu.
- Tap the to rename a Payload.
- Tap the to remove a selected Payload. You cannot remove the last Payload.

Active Payload

The checkmark in the drop-down indicates which payload is active ✓ Payload. The active Payload can be changed using the ✓ Set Now.

Default Payload

The default Payload is set as the active Payload before the program starts.

- Select the desired Payload and tap **Set as default** to set a Payload as the default.

The green icon in the drop-down menu indicates the default configured Payload ✓ Payload.

Setting the Center of Gravity

Tap the fields CX, CY and CZ to set the center of gravity. The settings apply to the selected Payload.

Payload Estimation

This feature allows the robot to help set the correct Payload and Center of Gravity (CoG).

Using the Payload Estimation Wizard

1. In the Installation Tab, under General, select **Payload**.
2. On the Payload screen, tap **Measure**.
3. In the Payload Estimation Wizard tap **Next**.
4. Follow the steps in the Payload Estimation Wizard to set the four positions. Setting the four positions requires moving the robot arm into four different positions. The load of the payload is measured at each position.
5. Once all measurements are complete, you can verify the result and tap **Finish**.

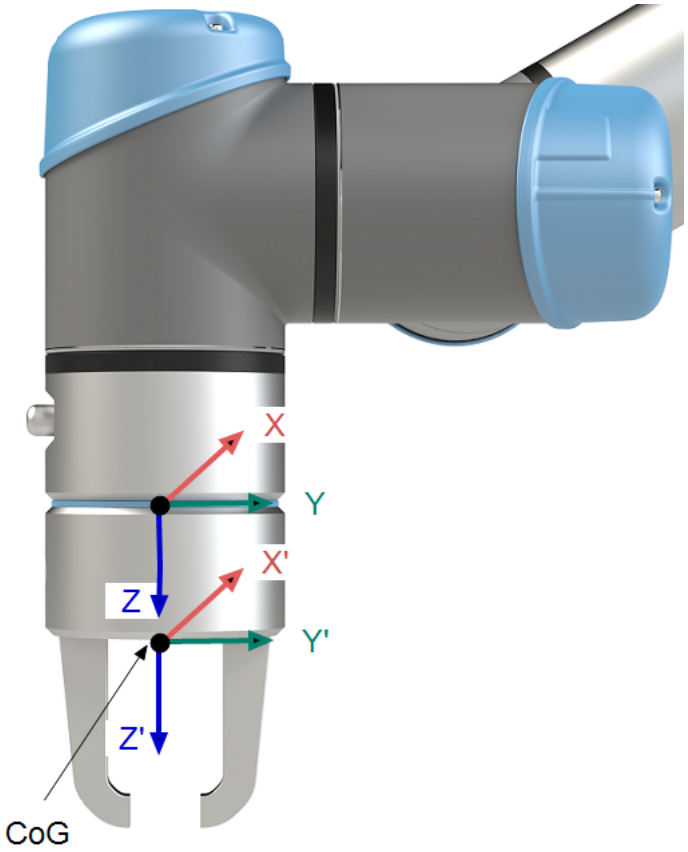
NOTICE

Follow the these guidelines for best Payload Estimation results:

- Ensure the TCP positions are as different as possible from each other
- Perform the measurements within a short timespan
- Avoid pulling on the tool and/or attached payload before and during estimation
- Robot mounting and angle must be correctly defined in the installation

Setting Inertia Values

You can select **Use custom Inertia Matrix** to set inertia values.
Tap the fields: `IXX`, `IYY`, `IZZ`, `IXY`, `IXZ` and `IYZ` to set the inertia for the selected Payload.
The inertia is specified in a coordinate system with the origin at the Center of Gravity (CoG) of the payload and the axes aligned with the tool flange axes.
The default inertia is calculated as the inertia of a sphere with the user specified mass, and a mass density of $1g/cm^3$



10.5.11. Mounting

Description

Specifying the mounting of the Robot arm serves two purposes:

1. Making the Robot arm appear correctly on screen.
2. Telling the controller about the direction of gravity.

An advanced dynamics model gives the Robot arm smooth and precise motions, as well as allows the Robot arm to hold itself in **Freedrive Mode**. For this reason, it is important to mount the Robot arm correctly.

WARNING

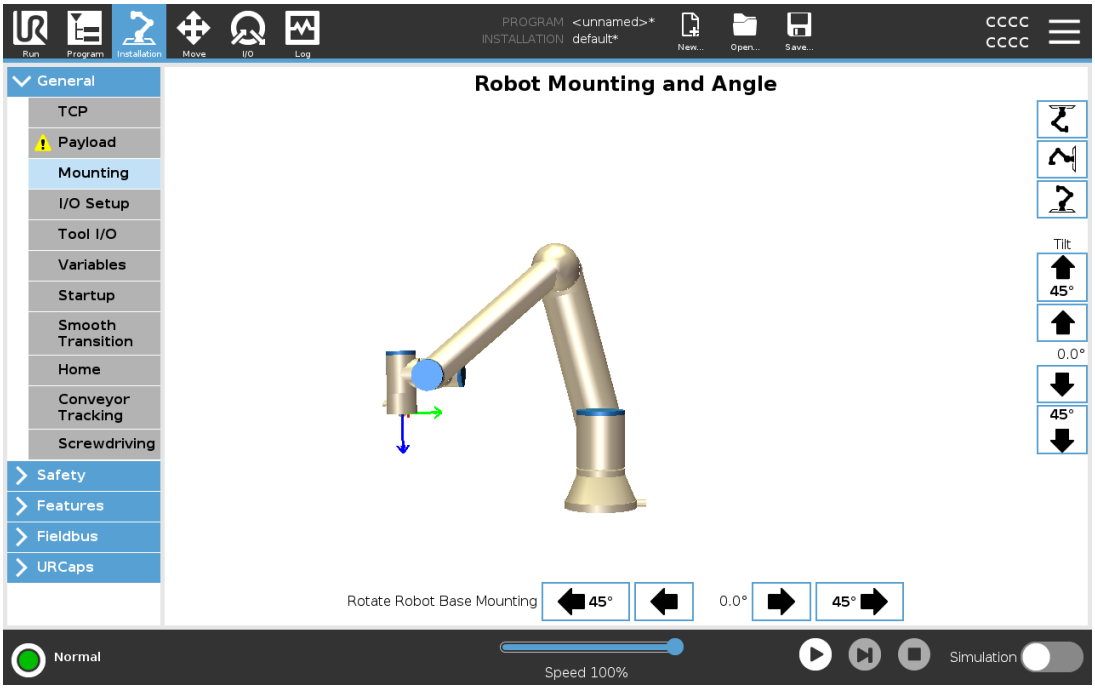
Failure to mount the Robot's arm correctly may result in frequent robot stops, and/or the Robot arm will move when pressing the **Freedrive** button.

If the Robot arm is mounted on a flat table or floor, no change is needed on this screen. However, if the Robot arm is **ceiling mounted**, **wall mounted**, or **mounted at an angle**, this needs to be adjusted using the buttons.
The buttons on the right side of the screen are for setting the angle of the Robot arm's mounting. The top three right side buttons set the angle to **ceiling** (180°), **wall** (90°), **floor** (0°). The **Tilt** buttons set an arbitrary angle.

The buttons on the lower part of the screen are used to rotate the mounting of the Robot arm to match the actual mounting.

WARNING

Use the correct installation settings. Save and load the installation files with the program.



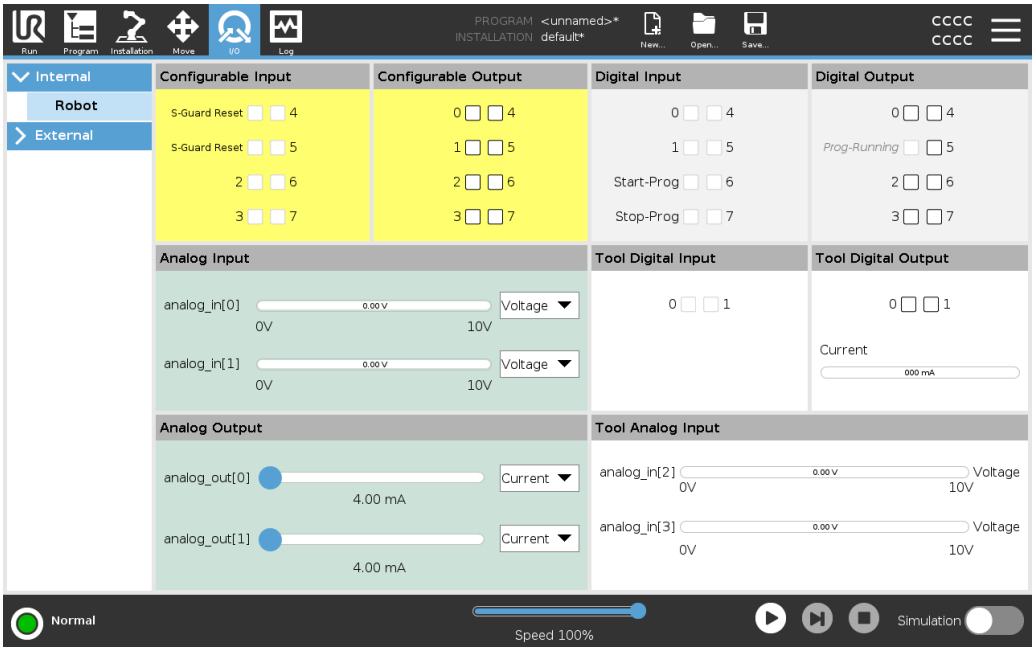
10.5.12. Using the I/O Tab

Description

Use the I/O Tab screen to monitor and set the live I/O signals from/to the Control Box.

The screen displays the current state of the I/O, including during program execution. The program stops if anything is changed during execution. At program stop, all output signals retain their states. The screen updates at 10Hz, so a very fast signal might not display properly.

Configurable I/Os can be reserved for special safety settings defined in the safety I/O configuration section of the installation (see I/O); those which are reserved will have the name of the safety function in place of the default or user defined name.
Configurable outputs that are reserved for safety settings are not togglable and will be displayed as LED's only.



Voltage

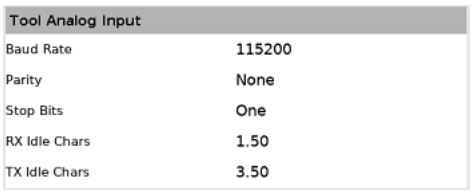
When the Tool Output is controlled by the user, you can configure Voltage. Selecting a URCap removes access to Voltage.

Analog Domain Settings

The analog I/O's can be set to either current [4-20mA] or voltage [0-10V] output. These settings are persistent over restarts of the robot controller and saved in the installation. Control over the tool I/Os could be assigned to a URCap in **Tool I/O** of the **Installation** tab. Selecting a URCap removes user's control over tool's analog I/O.

Tool Communication Interface

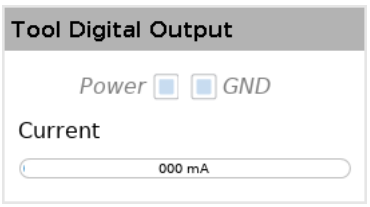
When the **Tool Communication Interface TCI** is enabled, the tool analog input becomes unavailable. On the **I/O** screen, the **Tool Input** field appears as shown.



Dual Pin power

When **Dual Pin Power** is enabled, the tool digital outputs must be named as follows:

- tool_out[0] (Power)
- tool_out[1] (GND)



10.5.13. Analog Input: Communication Interface

Description

The Tool Communication Interface (TCI) enables the robot to communicate with an attached tool via the robot tool analog input. This removes the need for external cabling. Once the Tool Communication Interface is enabled, all tool analog inputs are unavailable

Tool Communication Interface

1. Tap the Installation tab and under General tap Tool I/O.
2. Select Communication Interface to edit TCI settings.
   Once the TCI is enabled, the tool analog input is unavailable for the I/O Setup of the Installation and does not appear in the input list. Tool analog input is also unavailable for programs as Wait For options and expressions.
3. In the drop-down menus under Communication Interface, select required values. Any changes in values are immediately sent to the tool. If any installation values differ from what the tool is using, a warning appears.

10.5.14. Digital Output

Description

The tool communication interface allows two digital outputs to be independently configured. In PolyScope, each pin has a drop-down menu that allows the output mode to be set. The following options are available:

- Sinking: This allows the pin to be configured in an NPN or Sinking configuration. When the output is off, the pin allows a current to flow to the ground. This can be used in conjunction with the PWR pin to create a full circuit.
- Sourcing: This allows the pin to be configured in a PNP or Sourcing configuration. When the output is on, the pin provides a positive voltage source (configurable in the IO Tab). This can be used in conjunction with the GND pin to create a full circuit.
- Push / Pull: This allows the pin to be configured in a Push / Pull configuration. When the output is on, the pin provides a positive voltage source (configurable in IO Tab). This can be used in conjunction with the GND pin to create a full circuit When the output is off, the pin allows a current to flow to the ground.

After selecting a new output configuration, the changes take effect. The currently loaded installation is modified to reflect the new configuration. After verifying the tool outputs are working as intended, make sure to save the installation to prevent losing changes.

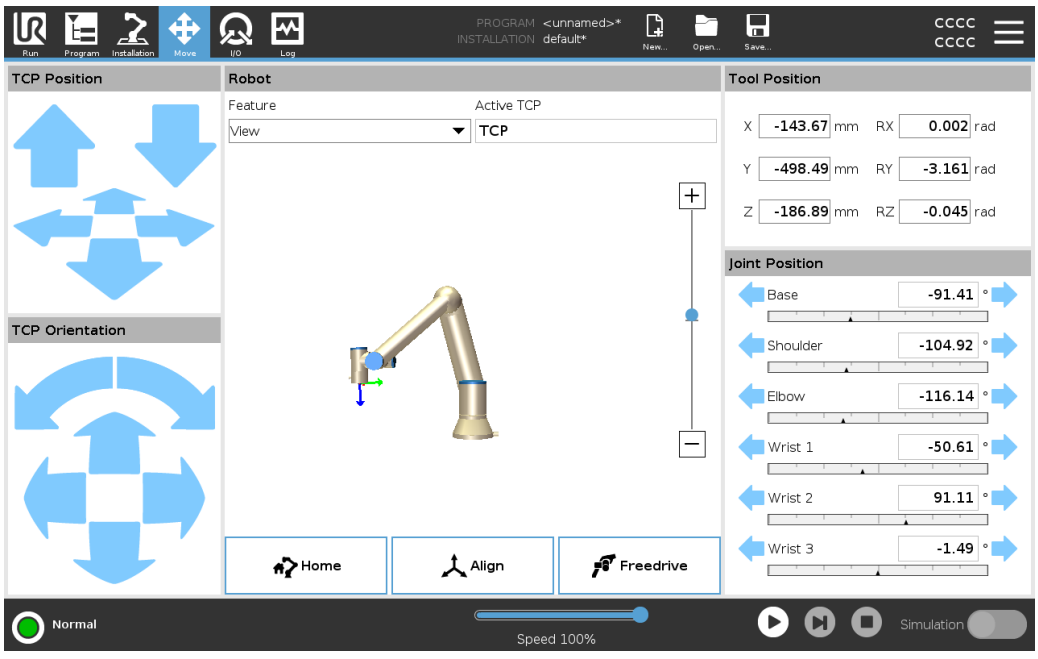
Dual Pin Power

Dual Pin Power is used as a source of power for the tool. Enabling Dual Pin Power disables default tool digital outputs.

10.5.15. Using the Move Tab

Description

Use the Move Tab screen to move (jog) the robot arm directly, either by translating/rotating the robot tool, or by moving robot joints individually.



To use the Move Tool arrows

Hold down any of the **Move Tool** arrows to move the robot arm in the corresponding direction.

- The **Translate arrows** (upper) move the tool flange in the direction indicated.
- The **Rotate arrows** (lower) change the orientation of the tool in the indicated direction. The rotation point is the Tool Center Point (TCP), i.e.the point at the end of the robot arm that gives a characteristic point on the tool. The TCP is shown as a small blue ball.

Robot

If the current position of the TCP approaches a safety plane, a trigger plane, or the orientation of robot tool is near the tool orientation boundary limit , a 3D representation of the proximate boundary limit is shown. The visualization of boundary limits is disabled during program execution.

Safety planes display in yellow and black with an arrow indicating which side of the plane, the robot TCP is allowed to be positioned.

Trigger planes display in blue and green with an arrow indicating the side of the plane, where the **Normal** mode limits are active.

The tool orientation boundary limit is visualized with a spherical cone together with a vector indicating the current orientation of the robot tool. The inside of the cone represents the allowed area for the tool orientation (vector).
When the robot TCP is no longer in proximity of the limit, the 3D representation disappears. If the TCP is in violation or very close to violating a boundary limit, the visualization of the limit turns red.

Feature

Under **Feature**, you can define how to control the robot arm relative to **View**, **Base** or **Tool** features. For the best feel for controlling the robot arm you can select the **View** feature, then use **Rotate arrows** to change the viewing angle of the 3D image to match your view of the real robot arm.

Active TCP

In the **Robot** field, under **Active TCP**, the name of the current active Tool Center Point (TCP) is displayed.

Home

The **Home** button accesses the **Move Robot into Position** screen, where you can hold down the **Auto** button to move robot into position previously defined under Installation. The Home button's default setting returns the Robo Arm to an upright position .

Freedrive

The on-screen **Freedrive** button allows the Robot Arm to be pulled into desired positions/poses.

Align

The **Align** button allows the Z axis of the active TCP to align to a selected feature.

Tool Position The text boxes display the full coordinate values of the TCP relative to the selected feature. You can configure several named TCPs (see). You can also tap **Edit pose** to access the **Pose Editor** screen.

Joint Position The **Joint Position** field allows you to directly control individual joints. Each joint moves along a default joint limit range from − 360° to + 360°, defined by a horizontal bar. Once the limit is reached you cannot move a joint any further. You can configure joints with a position range different from the default, this new range is indicated with red zone inside the horizontal bar.

Using Freedrive in the Move tab The **Freedrive** button shall only be used in applications if allowed by the risk assessment.

WARNING

Failure to correctly configure the mounting setting can result in unwanted robot arm movement when you use the **Freedrive** button.

- Payload settings and robot mounting settings shall be set correctly before using Freedrive.
- All personnel shall remain outside the reach of the robot arm, when **Freedrive** is in use.

WARNING

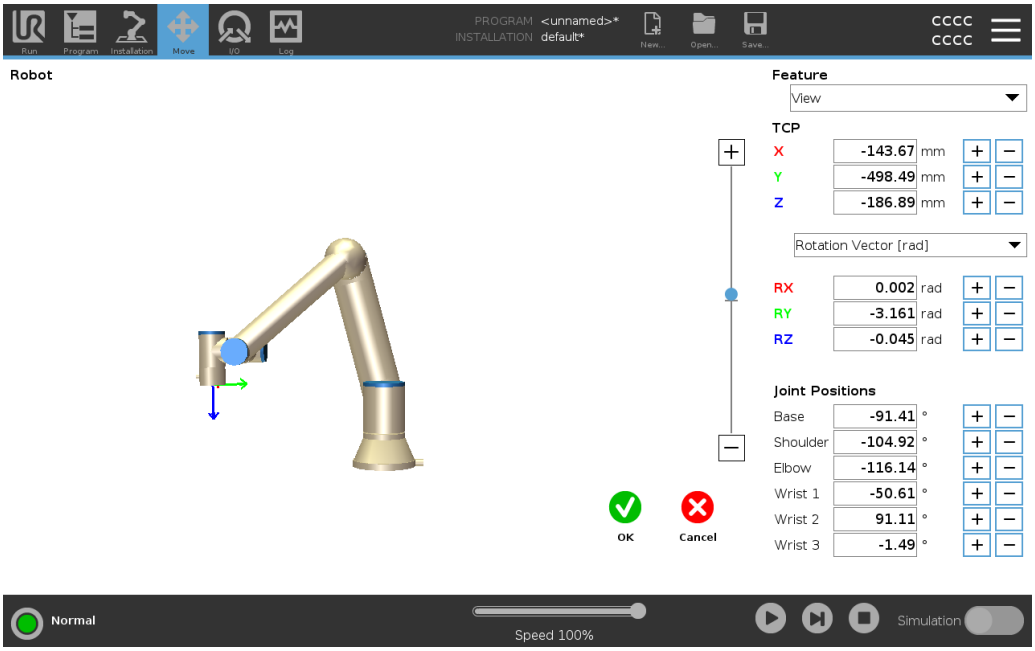
Failure to correctly configure the installation settings, can increase the risk of the robot arm falling during **Freedrive**, due to payload errors.

- Verify the installation settings are correct (e.g. Robot mounting angle, payload mass and payload center of gravity offset) . Save and load the installation files along with the program.
- Save and load the installation files along with the program.

10.5.16. Pose Editor

Description

Once you access the **Pose Editor** screen, you can precisely configure a target joint positions, or a target pose (position and orientation) for the TCP. Note: This screen is **offline** and does not control the Robot Arm directly.



Robot

The 3D image shows the current Robot Arm position. The **shadow** shows the Robot Arm target position controlled by the specified values on the screen. Press the magnifying glass icons to zoom in/out or drag a finger across it to change the view.
If the specified target position of the robot TCP is close to a safety or trigger plane, or the orientation of robot tool is near the tool orientation boundary limit, a 3D representation of the proximate boundary limit is shown. Safety planes are visualized in yellow and black with a small arrow representing the plane normal, which indicates the side of the plane on which the robot TCP is allowed to be positioned. Trigger planes are displayed in blue and green and a small arrow pointing to the side of the plane, where the **Normal** mode limits are active. The tool orientation boundary limit is visualized with a spherical cone together with a vector indicating the current orientation of the robot tool. The inside of the cone represents the allowed area for the tool orientation (vector). When the target robot TCP is no longer in proximity of the limit, the 3D representation disappears. If the target TCP is in violation or very close to violating a boundary limit, the visualization of the limit turns red.

Feature and Tool Position

The active TCP and coordinate values of the selected feature are displayed. The **X**, **Y**, **Z** coordinates specify tool position. The **RX**, **RY**, **RZ** coordinates specify orientation.
Use the drop down menu above the **RX**, **RY** and **RZ** boxes to choose the orientation representation type:

- **Rotation Vector** `[rad]` The orientation is given as a *rotation vector*. The length of the axis is the angle to be rotated in radians, and the vector itself gives the axis about which to rotate. This is the default setting.
- **Rotation Vector** `[°]` The orientation is given as a *rotation vector*, where the length of the vector is the angle to be rotated in degrees.
- **RPY** `[rad]` *Roll*, *pitch* and *yaw* (*RPY*) angles, where the angles are in radians. The RPY-rotation matrix (X, Y', Z" rotation) is given by:
  $R_{rpy}(\gamma, \beta, \alpha) = R_Z(\alpha) \cdot R_Y(\beta) \cdot R_X(\gamma)$
- **RPY** `[°]` *Roll*, *pitch* and *yaw* (*RPY*) angles, where angles are in degrees.

You can tap the values to edit the coordinates. You can also tap the **+** or **-** buttons to the right of a box to add/subtract an amount to/from the current value. Or you can hold down a button to directly increase/decrease the value.

Joint Positions

Individual joint positions are specified directly. Each joint position can have Joint Limit range from − 360° to + 360°. You can configure Joint Positions as follows:

- Tap the joint position to edit the values.
- Tap the **+** or **-** buttons to the right of a box to add or subtract an amount to/from the current value.
- Hold down a button to directly increase/decrease the value.

OK Button

If you activate this screen from the **Move** screen (see), tap the **OK** button to return to the **Move** screen. The Robot Arm moves to the specified target. If the last specified value was a tool coordinate, the Robot Arm moves to the target position using movement type **MoveL**; or it uses movement type **MoveJ** if a joint position was specified last.

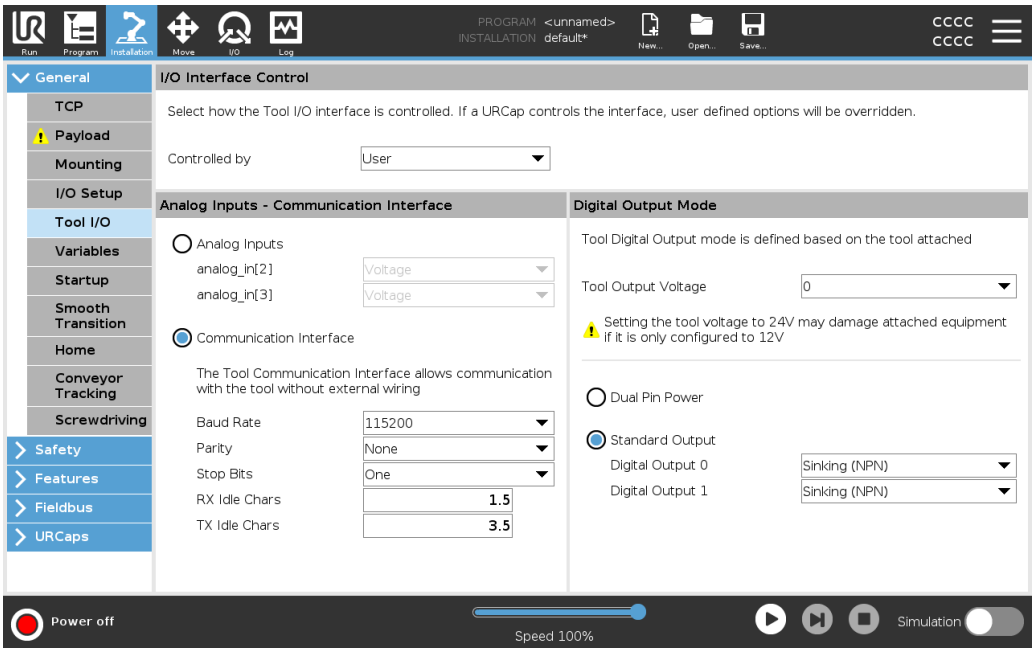
Cancel Button

The **Cancel** button exits the screen discarding all changes.

10.5.17. I/O Interface Control

Description

The I/O Interface Control allows you to switch between user control and URcap control.



I/O Interface Control

1. Tap the Installation tab and under General, tap Tool I/O
2. Under I/O Interface Control, select User to access the Tool Analog Inputs and/or Digital Output Mode settings. Selecting a URCap removes access to the Tool Analog Inputs and the Digital Output Mode settings.

NOTICE

If a URCap controls an end-effector, such as a gripper, then the URCap requires control of the Tool IO Interface. Select the URCap in the list, to allow it to control the Tool IO Interface.

10.6. UR Connect

Description

The URCap UR Connect comes pre-installed with 5.19 PolyScope 5 software.
To ensure correct operation, there are some additional prerequisites that must be installed.
Please refer to the URCap documentation for additional information.
UR Connect Installation and User Guide
Go here for more information about the product: https://www.universal-robots.com/optimization-services/ur-connect/

Install UR Connect

To install the UR Connect, please follow the steps below:

1. Go to the Installation tab.
2. Hit the tab URCaps in the left side of the screen.
3. Hit Install to start installation the prerequisites.
4. Follow the steps on the screen.

Activate UR Connect

The UR Connect URCap needs to be paired with myUR to send data to MyUR.
Please refer to the MyUR documentation on the UR Connect for further information.

UR Connect URCap Update

You can find the URCaps on the Installation Tab.

1. Go to the Installation tab.
2. Hit the tab URCaps in the left side of the screen.
3. Hit the button Check for Updates in the bottom right corner.
4. You can now download, dismiss or delay the update.
    a. If you delay or dismiss, the update will only refresh when there is a new version.
5. Follow the update steps.
6. Restart PolyScope when the update is complete.

NOTICE

You can still update UR Connect even if it is NOT installed.