UNIVERSAL ROBOTS

Software Handbook
PolyScope X

SW 10.7

Original instructions (en)

Contents

1. Preface

Congratulations on the purchase of your new Universal Robots e-Series robot.

The robot can be programmed to move a tool, and communicate with other machines using electrical signals. It is an arm composed of extruded aluminum tubes and joints.

Using our PolyScope X programming interface, it is easy to program the robot to move the tool along a desired trajectory.
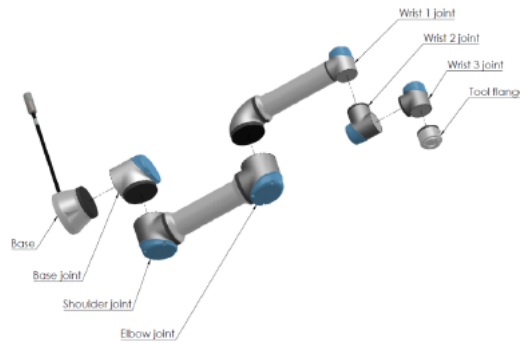
1.1: *The joints, the base and the tool flange of the Robot Arm.*

With six joints and a wide scope of flexibility, Universal Robots e-Series collaborative robot arms are designed to mimic the range of motion of a human arm. Using our patented programming interface, PolyScope, it is easy to program the robot to move tools and communicate with other machines using electrical signals. Figure 1.1 The joints, the base and the tool flange of the Robot Arm. above illustrates the main components of the robot arm and can be used as a reference throughout the manual.

1.1. What Do the Boxes Contain

When you order a robot, you receive two boxes. One contains the robot arm, the other contains:

- Control Box with Teach Pendant
- Mounting bracket for the Control Box
- Mounting bracket for the Teach Pendant
- Key for opening the Control Box
- Cable for connecting the robot arm and the Control Box
- Mains cable or Power cable compatible to your region
- This manual

1.2. Important Safety Notice

The robot is **partly completed machinery** (see 6 Safety on page 17) and as such a risk assessment is required for each installation of the robot. You must follow all of the safety instructions in chapter 6 Safety on page 17.

1.3. How to Read this Manual

This manual contains instructions for installing and programming the robot. The manual is separated into two parts:

Hardware Installation Manual
    The mechanical and electrical installation of the robot.

PolyScope X Manual
    Programming of the robot.

This manual is intended for the robot integrator who must have a basic level of mechanical and electrical training, as well as be familiar with elementary programming concepts.

1.4. Purpose of this Manual

The purpose of this document is to allow for the safe setup of a Universal Robots robot arm with the PolyScope X software. The instructions in this document shall be considered as general guidelines.

It is assumed that the integrator has a high level of technical knowledge.

Universal Robots disclaims any liability, even though all guidelines contained within this document are followed.

Always perform a thorough risk assessment for the specific application.

Consult the safety section in the Universal Robots User Manual for general precautions.

UNIVERSAL ROBOTS

2. Robot Arm Basics

The Universal Robots robot arm is composed of tubes and joints. The coordinated motion of these tubes and joints, via PolyScope X software, moves the robot arm.

- **Base**: where the robot arm is mounted.
- **Shoulder** and **Elbow**: where the larger movements originate.
- **Wrist 1** and **Wrist 2**: where the finer movements originate.
- **Wrist 3**: where the tool attaches to the tool flange.

You can attach a tool to the flange at the end of Wrist 3. Moving the robot arm positions the tool.

> ⚠️ **CAUTION**
> You cannot position the tool directly above, or directly below the Base.

2.1. Teach Pendant

The Teach Pendant, the touch screen that controls the robot, is optimised for use in industrial environments. Unlike consumer electronics, the Teach Pendant touch screen sensitivity is, by design, more resistant to environmental factors such as:

- Water droplets and/or machine coolant droplets
- Radio wave emissions
- other conducted noise from the operating environment

The touch sensitivity is designed to avoid false selections on the interface, and to prevent unexpected motion of the robot.

2.1.1. Using the screen

For best results, use the tip of your finger to make a selection on the screen.

In this manual, this is referred to as a "tap".

A commercially available stylus may be used to make selections on the screen if desired.

3. Installing the Roobot

To start using PolyScope X, make sure your robot arm and Control Box are assembled and the power cable is plugged in.

3.1. Assembling the robot arm and Control Box

If the robot is not assembled, you may need to assemble and mount the robot arm and Control Box.

⚠️ **WARNING**
Tipping hazard. If the robot is not securely placed on a sturdy surface, the robot can fall over and cause injury.

To assemble and power-on the robot arm

1. Unpack the robot arm and the Control Box.
2. Mount the robot arm on a sturdy, vibration-free surface, using screws and a hex key (Allen wrench). Mounting the robot may require two people.
3. Place the Control Box on its Foot.
4. Connect the robot cable to the robot arm and the Control Box.
5. Plug in the main/power cable of the control box.
6. Press the power button on the Teach Pendant to turn on the robot.

4. PolyScope X Overview

PolyScope X is the Graphical User Interface (GUI) installed on the Teach Pendant that operates the robot arm via a touch screen. The PolyScope X interface allows you to create, load and execute programs.

4.0.1. Screen Layout

The interface is divided as shown in the following illustration:

- **Header** - with button to load or create programs and access program modules.
- **Left Header** - with icons/tabs to select a main screen.
- **Right Header** - with icons/tabs to select a multitask screen.
- **Footer** - with buttons to control robot power and your loaded program.
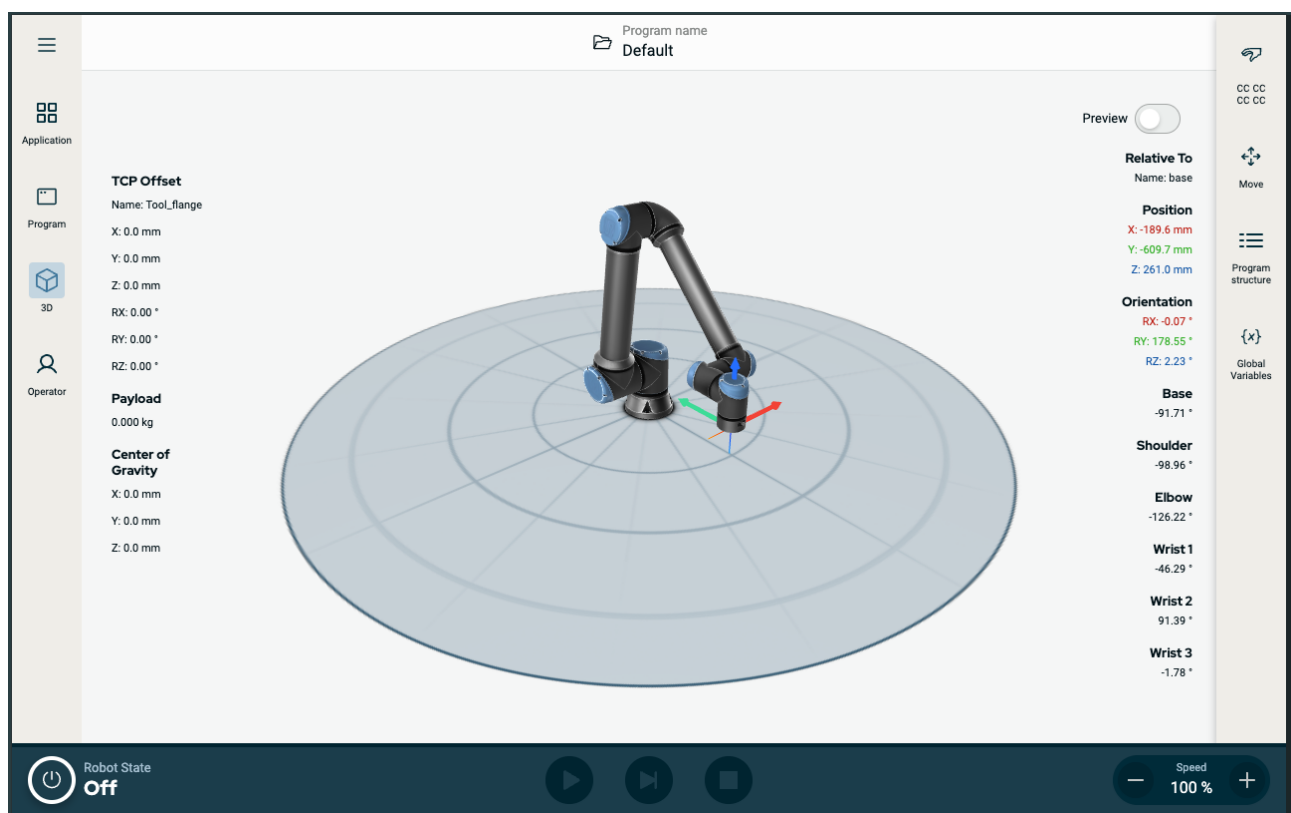
Figure 1.2: *Main screen*

4.0.2. Screen Combinations

The main screen and the multitask screen make up the operating screen combination for the robot.

The multitask screen is independent of the main screen, so you can do separate tasks. For example, you can configure a program in the main screen, while moving the robot arm in the multitask screen. You also can hide the multitask screen if it is not needed.

- **Main screen** - with fields and options to manage and monitor robot actions.
- **Multitask screen** - with fields and options often relating to the main screen.

Figure 1.3: *Main screen and multitask screen*

To show/hide the multitask screen

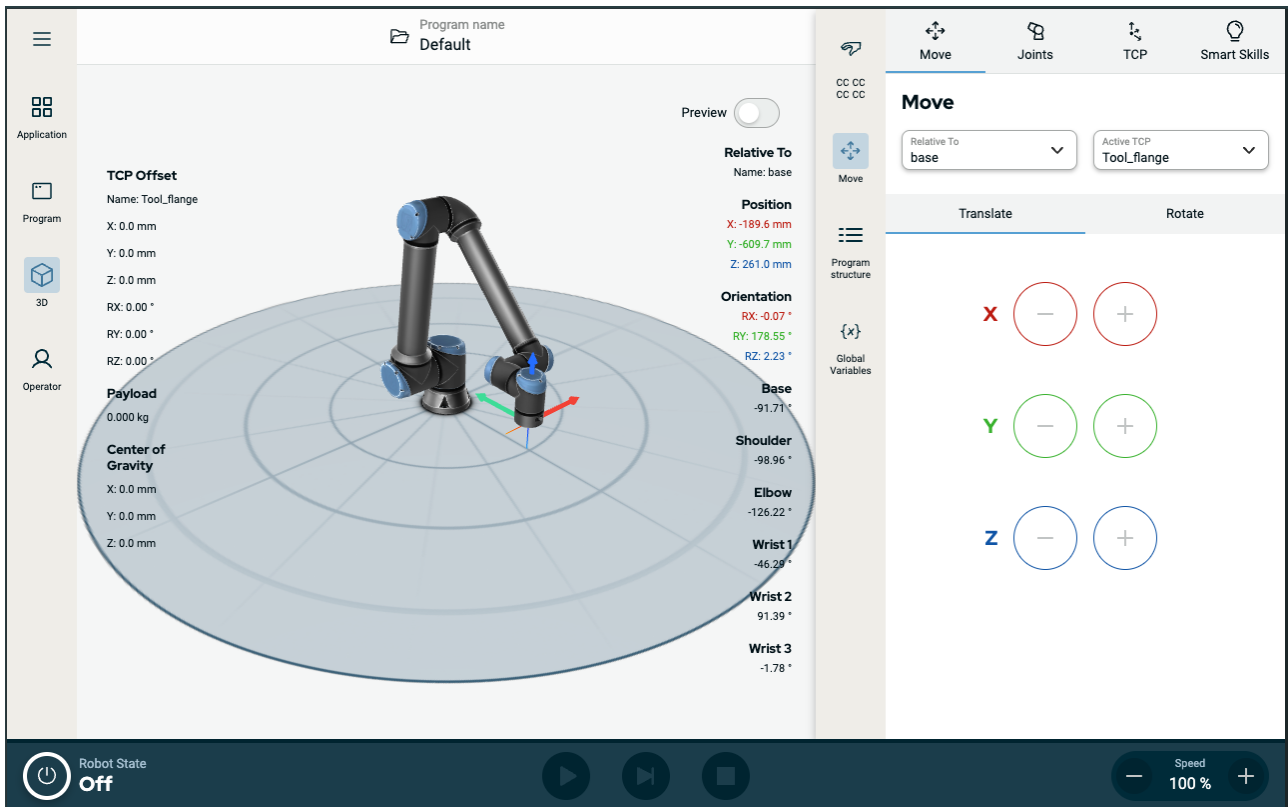1. In the right header, tap any icon to show the multitask screen.

   The right header expands to the middle of the screen to accommodate the multitask screen.

2. Tap the currently selected icon in the right header to hide the multitask screen.

4.1. Touch Screen

The Teach Pendant touch screen is optimised for use in industrial environments. Unlike consumer electronics, Teach Pendant touch screen sensitivity is, by design, more resistant to environmental factors such as:

- Water droplets and/or machine coolant droplets
- Radio wave emissions
- Other conducted noise from the operating environment

The touch sensitivity is designed to avoid false selections on Polyscope X, and to prevent unexpected motion of the robot.

Using the Touch Screen

For best results, use the tip of your finger to make a selection on the screen. In this manual, this is referred to as a "tap". A commercially available stylus may be used to make selections on the screen if desired. The following section lists and defines the icons/tabs and buttons in the Polyscope X interface.

The following section lists and defines the icons/tabs and buttons in the Polyscope X interface.

4.2. Icons

Left Header Icons

Icon	Title	Description
⚇	Operator	A simple means of operating the robot using pre-written programs.
⊞	Application	To configure the robot arm settings and external equipment, eg mounting and TCPs.
▭	Program	Modifies the current robot program.
◻	3D	Controls and/or regulates robot movement.
≡	More	Access to About information and Settings.
ⓘ	About	Displays information about the robot.
⚙	Settings	To configure settings about the software, eg language and units.
⏻	Power	To power on or off the robot.
CC CC CC CC	Safety Checksum	Displays the active safety checksum and detailed parameters, and change the operation mode.

Footer Buttons

Icon	Title	Description
	Initialize	Manages the robot state. When RED, press it to make the robot operational. • Black, Power off. The robot arm is in a stopped state. • Orange, Idle. The robot arm is on, but not ready for normal operation. • Orange, Locked. The robot arm is locked. • Green, Normal. The robot arm is on and ready for normal operation. • Red, Error. The robot is in a fault state, such as e-stop. • Blue, Transition. The robot is changing state, such as brake releasing.
	Play	Starts the current loaded program.
	Step	Allows a program to be run single-stepped.
	Stop	Halts the current loaded program.
Speed 100 %	Speed slider	Manages the robot state. When RED, press it to make the robot operational.

5. Initialize

On the footer, to the left, the Initialize button indicates the status of the robot using colours:

- Black, Power off. The robot arm is in a stopped state.
- Orange, Idle. The robot arm is on, but not ready for normal operation.
- Green, Normal. The robot arm is on and ready for normal operation.
- Red, Error. The robot is in a fault state, such as e-stop.
- Blue, Transition. The robot is changing state, such as brake releasing.

5.1. Starting the Robot Arm

> **WARNING**
> Always verify the actual payload and installation are correct before starting up the robot arm. If these settings are incorrect, the robot arm and Control Box will not function correctly and may become dangerous to people or equipment.

> **CAUTION**
> Ensure the robot arm is not touching an object (e.g., a table) because a collision between the robot arm and an obstacle might damage a joint gearbox.

To start the robot:

- Tap the Robot State Off, followed by the START button with the green icon to start the initialization process. Then, the icon turns orange to indicate the power is on and in Idle.
- Tap the UNLOCK button with the orange icon to release the brakes.
- Tap the POWER OFF button with the red icon to power off the robot arm.

5.2. Safely Setting the Active Payload

Before using Polyscope X, verify that the Robot Arm and Control Box are correctly installed.

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, loading Polyscope X.
3. Tap the Robot State Off button on the bottom left
4. Unlock the emergency stop button to change robot state from Emergency Stopped to Power off.
5. Step outside the reach (workspace) of the robot.
6. On the Initialize popup, tap the START button and allow robot state to change to Locked.
7. In the Payload field, in Active Payload, verify the payload mass. You can also verify the mounting position is correct, in the Robot graphic.
8. Tap the UNLOCK button, for the robot to release its brake system. The robot vibrates and makes clicking sounds indicating it is ready to be programmed

6. Safety

> ⚠️ **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. (See Hardware Installation Manual)

6.1. Safety Checksum

The Safety Checksum icon displays your applied robot safety configuration. The checksum changes if and only if the safety configuration is changed.

6.2. Safety Configuration

> ℹ️ **NOTICE**
>
> Safety Settings are password protected.

1. In the PolyScope X left header, tap the Application icon.
2. On the Workcell screen tap the Safety icon.
3. Observe that the Robot Limits screen displays, but settings are inaccessible.
4. Enter the safety password and tap UNLOCK to make settings accessible. Note: Once Safety settings are unlocked, all settings are now active.
5. Tap LOCK or navigate away from the Safety menu to lock all Safety item settings again.

6.3. Setting a Safety Password

1. In your PolyScope X header left corner, tap the Hamburger menu and then tap Settings.
2. On the left of the screen, in the blue menu, tap Safety Password.
3. For Old Password, type the current Safety password.
4. For New Password, type a password.
5. For Repeat Password, type the same password and tap Change Password.
6. In the top right of the menu, press CLOSE to return to previous screen.

6.4. Safety Menu Settings

6.4.1. Robot Limits
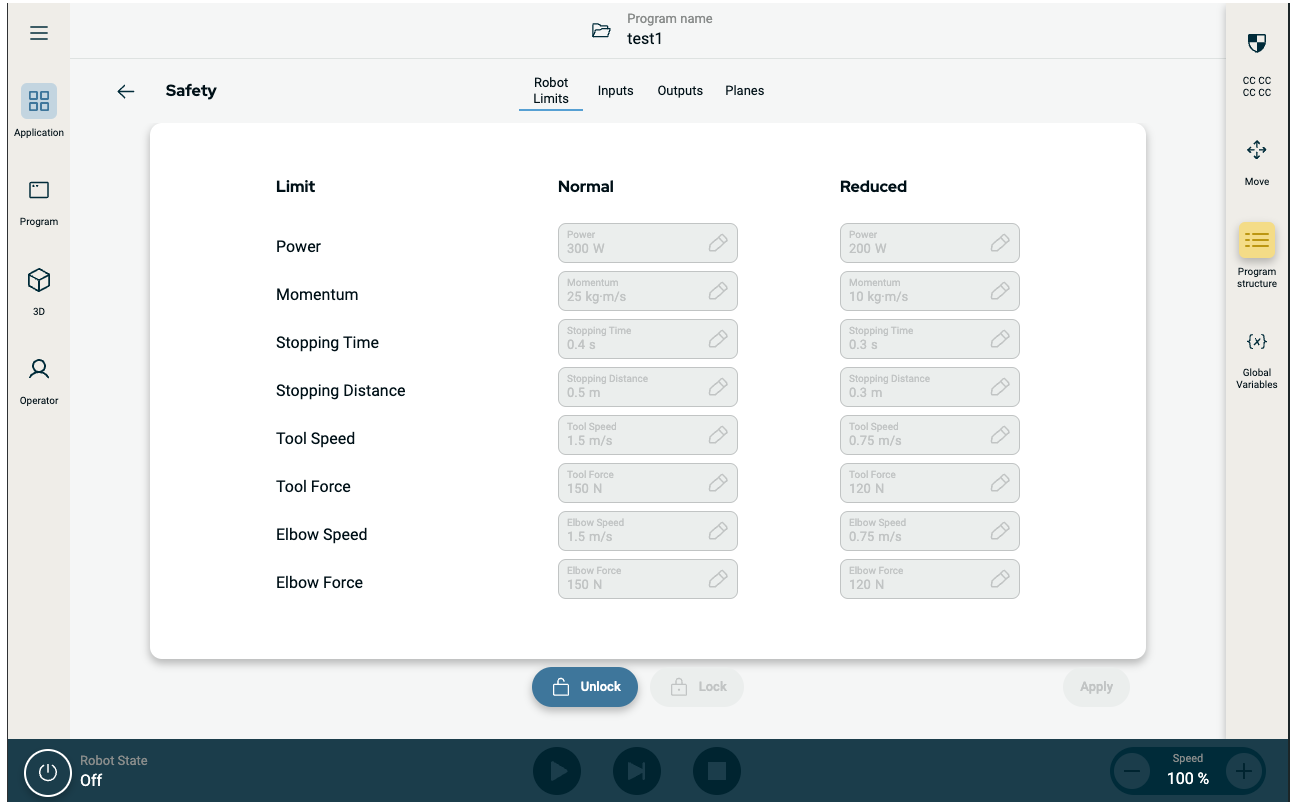
Limit	Description
Power	limits maximum mechanical work produced by the robot in the environment. This limit considers the payload a part of the robot and not of the environment.
Momentum	limits maximum robot momentum.
Stopping Time	limits maximum time it takes the robot to stop e.g. when an emergency stop is activated
Stopping Distance	limits maximum distance the robot tool or elbow can travel while stopping.
Tool Speed	limits maximum robot tool speed.
Tool Force	limits the maximum force exerted by the robot tool in clamping situations
Elbow Speed	limits maximum robot elbow speed
Elbow Force	limits maximum force that the elbow exerts on the environment

> **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.

> **NOTICE**
>
> The tool speed and force are limited at the tool flange and the center of the two user-defined tool positions

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]:

Safety mode	Effect
Normal	This configuration is active by default.
Reduced	This configuration activates when the Tool Center Point (TCP) is positioned beyond a Trigger Reduced mode plane, or when triggered using a configurable input.

---

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

6.4.2. Safety I/O Signals

Description   The I/O are divided between inputs and outputs and are paired up so that each function provides a Category 3 PLd capability.
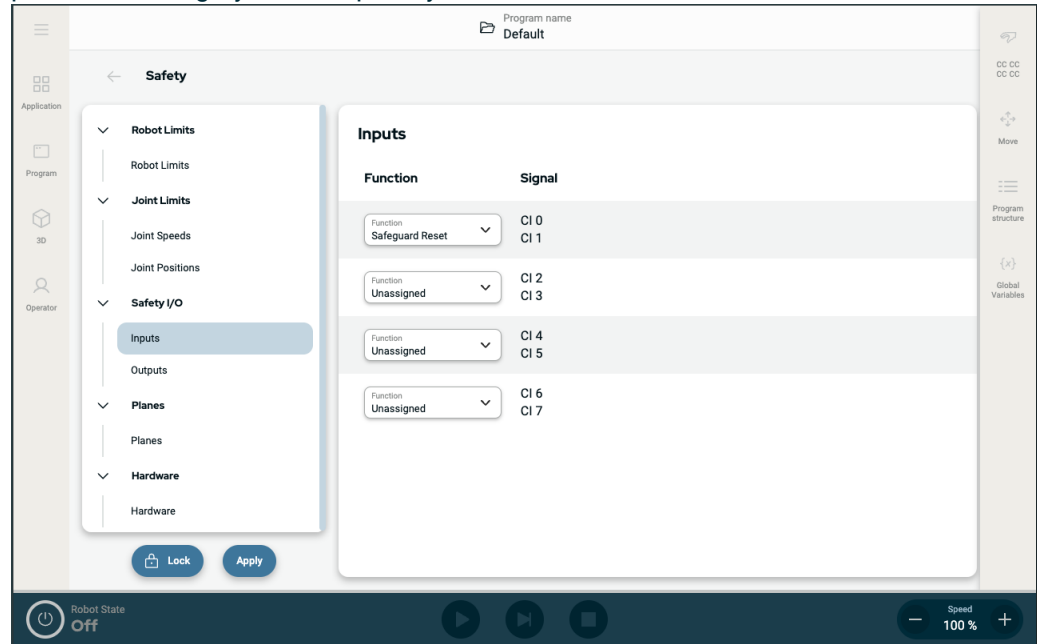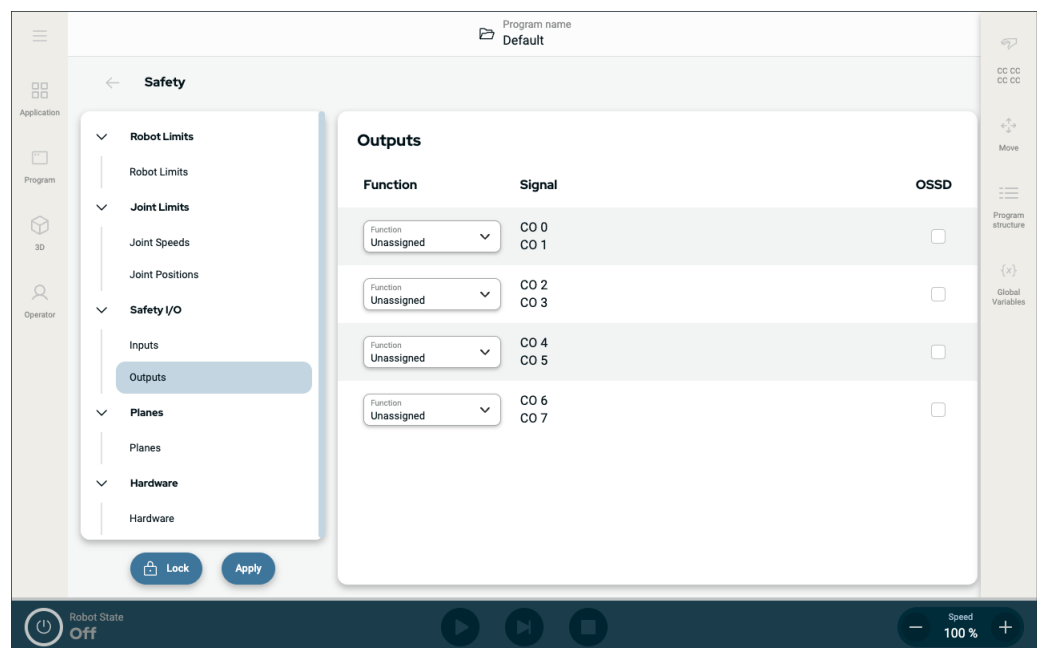

Figure 1.4: *PolyScope X screen displaying the Input signals.*

Input Signals

The inputs are described in the tables below:

Emergency Stop Button	Performs a Stop Category 1 (IEC 60204-1) informing other machines using the System 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.
External Emergency Stop	Performs a Stop Category 1 (IEC 60204-1) on robot only.
Reduced	All safety limits can be applied while the robot is using a **Normal** configuration, or a **Reduced** configuration. When configured, a low signal sent to the inputs causes the safety system to transition to the reduced configuration. The robot arm decelerates to satisfy the reduced parameters. The safety system guarantees the robot is within reduced limits less than 0.5s after the input is triggered. If the robot arm continues to violate any of the reduced limits, a Stop Category 0 is triggered. Trigger planes can also cause a transition to the reduced configuration. The safety system transitions to the normal configuration in the same way.

Input Signals   The inputs are described in the table below

Operational Mode	When an external mode selection is used it switches between **Automatic Mode** and **Manual Mode**. The robot is in Automatic mode when input is *low* and Manual mode when the input is *high*.
Safeguard Reset	Returns from the Safeguard Stop state, when a rising edge on the Safeguard Reset input occurs. When a Safeguard Stop occurs, this input ensures that the Safeguard Stop state continues until a reset is triggered.
Safeguard	A stop triggered by a safeguard input. Performs a Stop Category 2 (IEC 60204-1) in all modes, when triggered by a Safeguard.
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.
Automatic Mode Safeguard Reset	Returns from the Automatic Mode Safeguard Stop state when a rising edge on the Automatic Mode Safeguard Reset input occurs.
Freedrive on robot	You can configure the Freedrive input to enable and use Freedrive without pressing the Freedrive button on a standard TP, or without having to press-and-hold any of the buttons on the 3PE TP in the light-press position.

> ⚠️ **WARNING**
>
> When the default Safeguard Reset is disabled, an automatic reset happens when the safeguard no longer triggers a stop.
>
> This can happen if a person passes though the field of the safeguard.
>
> If a person is not detected by the safeguard and the person is exposed to hazards, automatic reset is forbidden by standards.
>
> • Use the external reset to ensure resetting only when a person is not exposed to hazards.

> ⚠️ **WARNING**
>
> When Automatic Mode Safeguard stop is enabled, a safeguard Stop is not triggered in Manual Mode.

Output Signals

All safety outputs go low in the event of a safety system violation or fault. This means the System Stop output initiates a stop even when an E-stop is not triggered.

You can use the following Safety functions output signals. All signals return to low when the state which triggered the high signal has ended:

[1]System Stop	Signal is *Low* when the safety system has been triggered into a stopped state including by the Robot Emergency Stop input or the Emergency Stop Button. To avoid deadlocks, if the Emergency Stopped state is triggered by the System Stop input, low signal will not be given.
Robot Moving	Signal is *Low* if the robot is moving, otherwise high.
Robot Not Stopping	Signal is *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	Signal is *Low* when reduced parameters are active or if the safety input is configured with a reduced input and the signal is currently low. Otherwise the signal is high.
Not Reduced	This is the inverse of Reduced, defined above.
3-Position Enabling Device	In Manual Mode, an external 3-Position Enabling Device must be pressed and held in the center-on position to move the robot. If you are using a built-in 3-Position Enabling Device, the button must be pressed and held in the mid position to move the robot.
Safe Home	Signal is *High* if the robot arm is stopped and is located in the configured Safe Home Position. Otherwise, the signal is *Low.* This is often used when UR robots are integrated with mobile robots.

> **ℹ NOTICE**
>
> Any external machinery receiving its Emergency Stop state from the robot through the System Stop output must comply with ISO 13850. This is particularly necessary in setups where the Robot Emergency Stop input is connected to an external Emergency Stop device. In such cases, the System Stop output becomes high when the external Emergency Stop device is released. This implies that the emergency stop state at the external machinery will be reset with no manual action needed from the robot's operator. Hence, to comply with safety standards, the external machinery must require manual action in order to resume.

---

[1]System Stop was previously known as "System Emergency Stop" for Universal Robots robots. PolyScope can display "System Emergency Stop".

6.4.3. Safety Planes

Safety planes restrict robot workspace, the tool and the elbow.

> ⚠️ **WARNING**
>
> Defining safety planes only limits the defined Tool spheres and elbow, not the overall limit for the robot arm.
>
> Defining safety planes does not guarantee that other parts of the robot arm will obey this type of restriction.
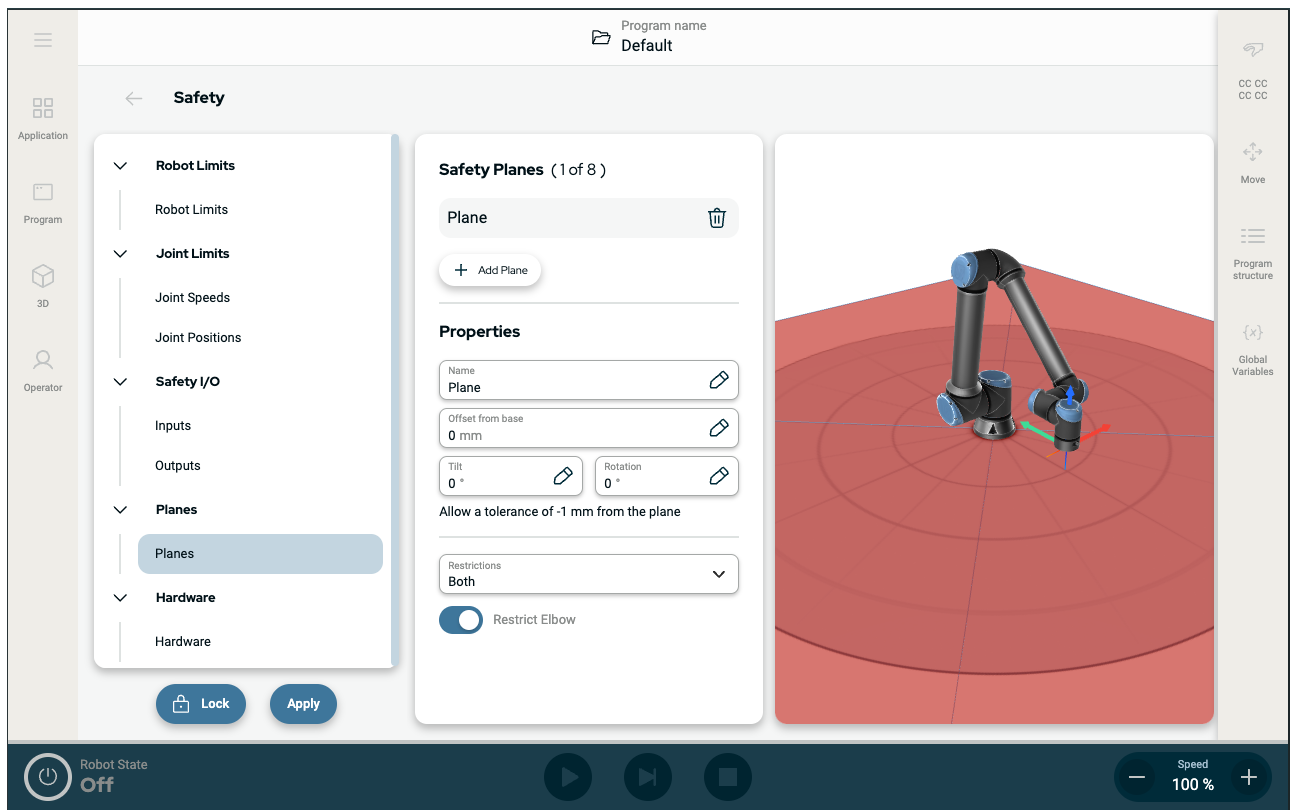

Figure 1.5: *PolyScope X screen displaying safety planes.*

- **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.

Configuring a safety plane

You can configure safety planes with the properties listed below:

- **Name** This is the name used to identify the safety plane.

- **Offset from base** This is the height of the plane from the base, measured in the -Y direction.

- **Tilt** This is the tilt of the plane, measured from the power cord.

- **Rotation** This is the rotation of the plane, measured clockwise.

You can configure each plane with the restrictions listed below:

- **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.

- **Both** 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.

Elbow Joint Restriction

You can prevent the robot elbow joint from passing through any of your defined planes.

To restrict the elbow joint

1. Disable Restrict Elbow for elbow to pass through planes.

7. Application Tab

The Application tab allows you to configure the settings which affect the overall performance of the robot and PolyScope X.
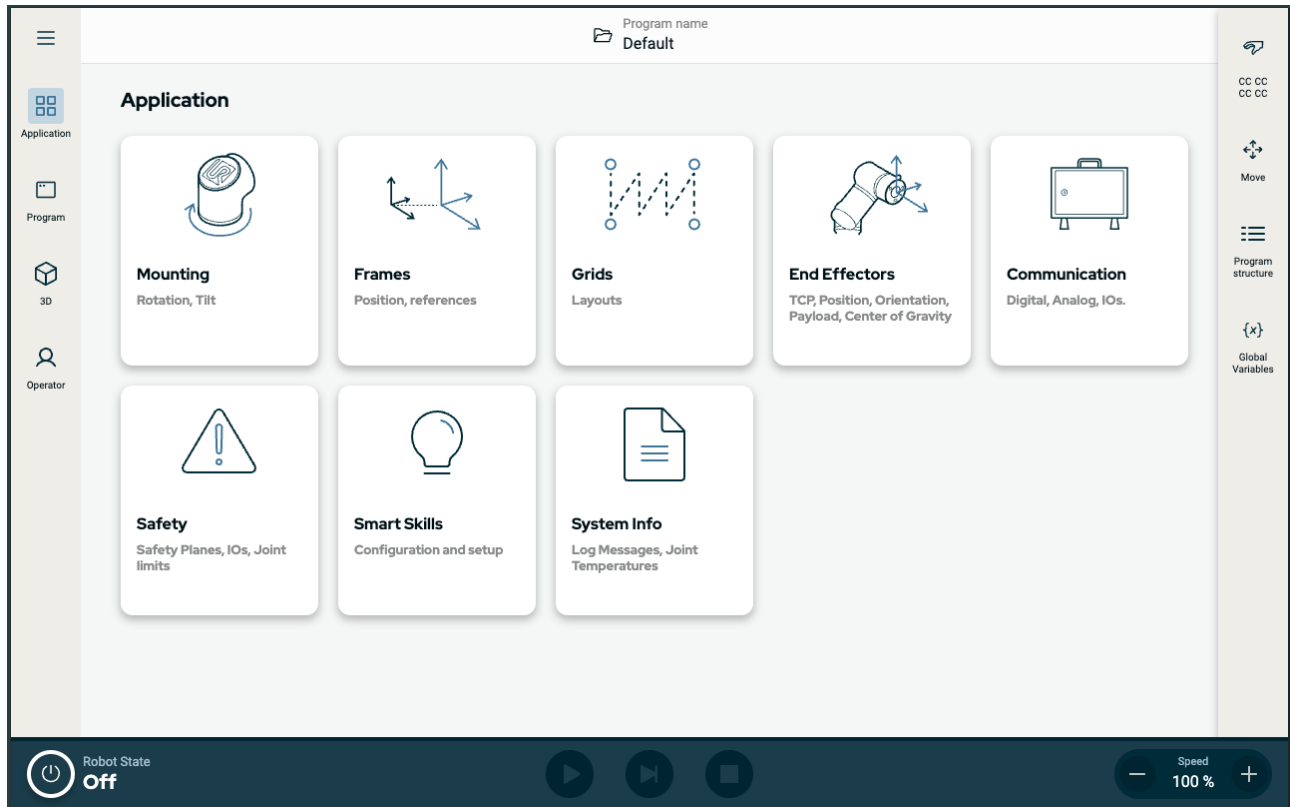
Figure 1.6: *Application screen displaying application buttons.*

Use the Application tab to access to the following configuration screens:

- Mounting
- Frames
- Grids
- End Effectors
- Communication
- Safety
- Smart Skills
- System Info

7.1. Communication

The Communication screen allows you to monitor and set the live I/O signals from/to the robot control box. The screen displays the current state of the I/O, including during program execution. If anything is changed during program execution, the program stops. At program stop, all output signals retain their states.

The Communication screen updates at 10Hz, so very fast signals may not display properly. You can reserve configurable I/Os for special safety settings defined in . Those which are reserved will have the name of the safety function in place of the default or user defined name. Configurable outputs reserved for safety settings cannot be selected, they are displayed as LEDs only.
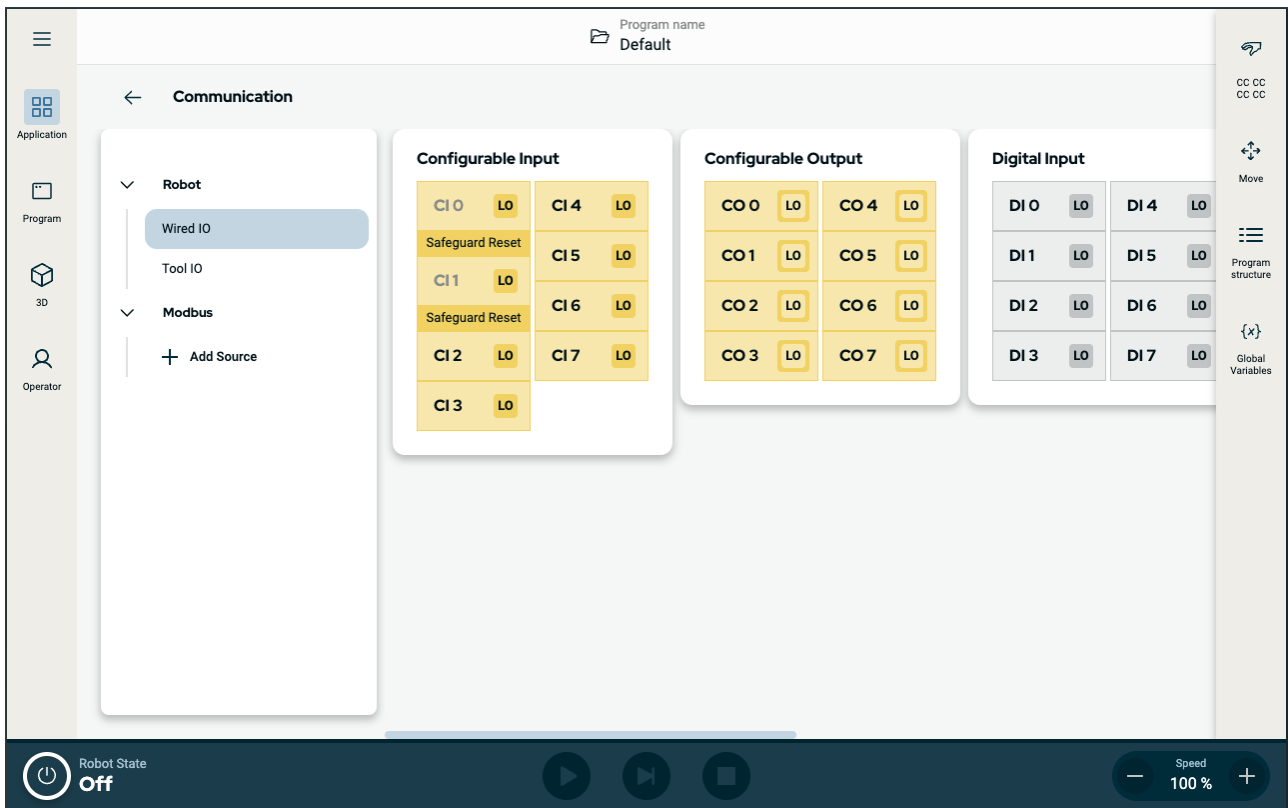

Figure 1.7: *Communication screen displaying I/Os.*
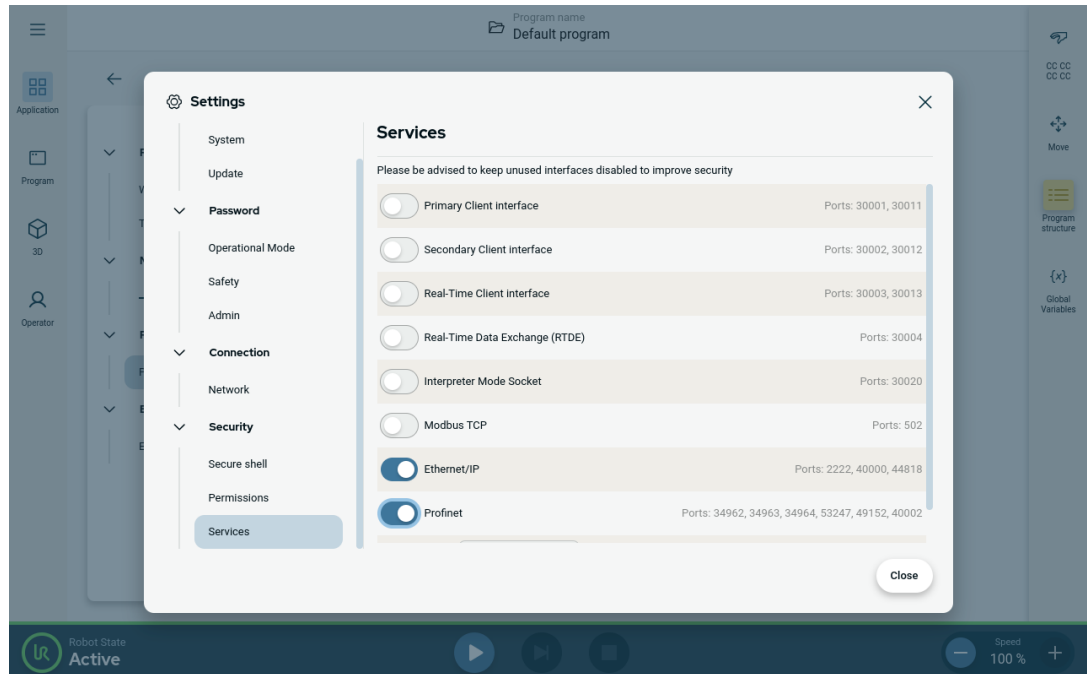
7.2. Profinet

Description	The PROFINET network protocol enables or disables the connection of the robot to an industrial PROFINET IO-Controller. If the connection is enabled, you can select the action that occurs when a program loses PROFINET IO-Controller connection.

Enable Profinet

This is how you enable to Profinet function in PolyScope X.

1. In the top right of the screen, tap the Hamburger menu and then tap Settings.

2. In the menu on the left, under Security, tap Services.

3. Tap the Profinet button to switch Profinet on.

Using Profinet

Find the profinet functions in PolyScope X:
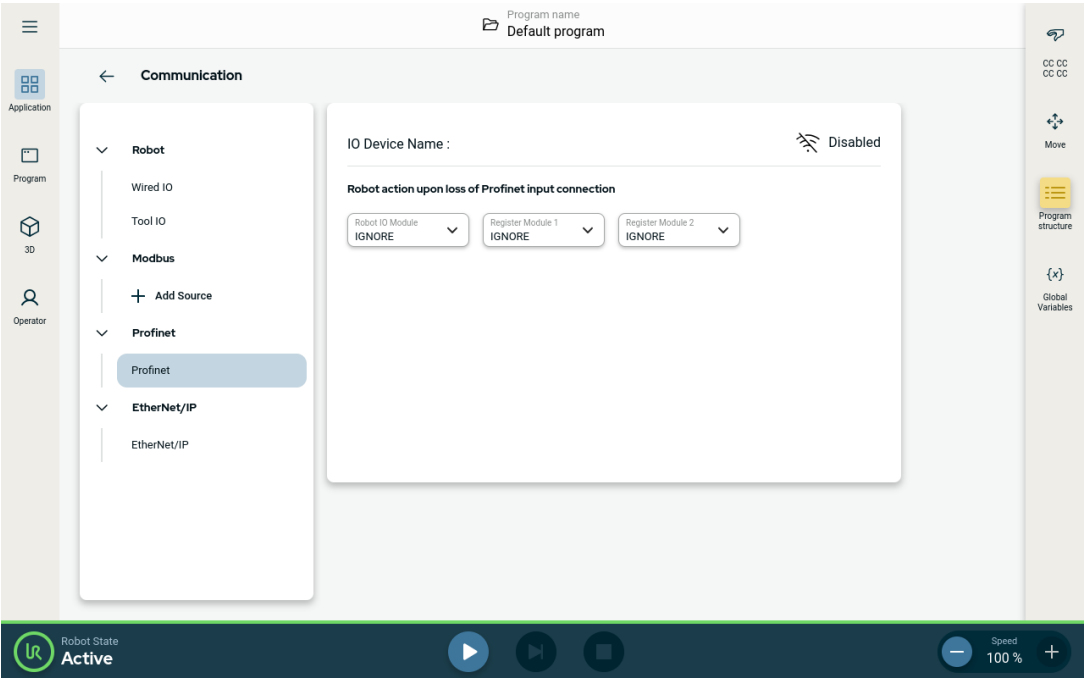
In the PolyScope X left header.

1. Tap the Application icon.
2. Select Profinet from the left menu.

Select the relevant action from the list:

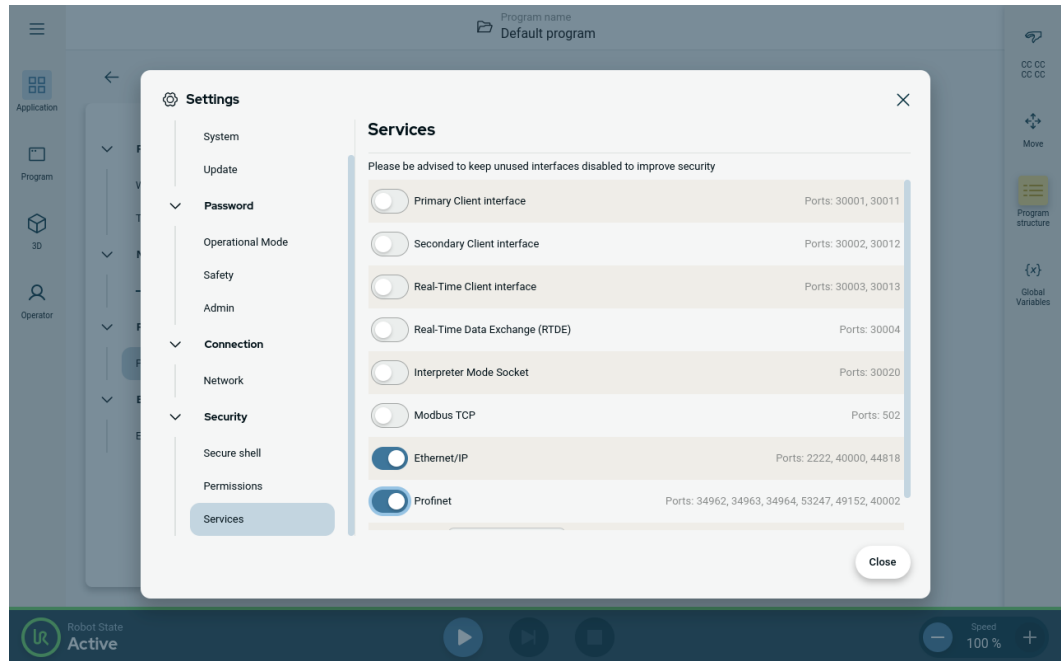| Ignore	PolyScope X ignores the loss of Profinet connection, and the program continues to run.
Pause	PolyScope X pauses the current program. The program resumes from where it stopped.
Stop	PolyScope X stops the current program.

7.3. Ethernet/IP

Description

EtherNet/IP is a network protocol that enables the connection of the robot to an industrial EtherNet/IP scanner device. If the connection is enabled, you can select the action that occurs when a program loses EtherNet/IP scanner device connection.

Enable Ethernet/IP

This is how you enable to Ethernet/IP function in PolyScope X.

1. In the top right of the screen, tap the Hamburger menu and then tap Settings.

2. In the menu on the left, under Security, tap Services.

3. Tap the Profinet button to switch Profinet on.

Using Ethernet/IP

Find the Ethernet/IP functions in PolyScope X:

In the PolyScope X left header.

1. Tap the Application icon.

2. Select the relevant action from the list.

Ignore	PolyScope X ignores the loss of EtherNet/IP connection, and the program continues to run.
Pause	PolyScope X pauses the current program. The program resumes from where it stopped.
Stop	PolyScope X stops the current program.
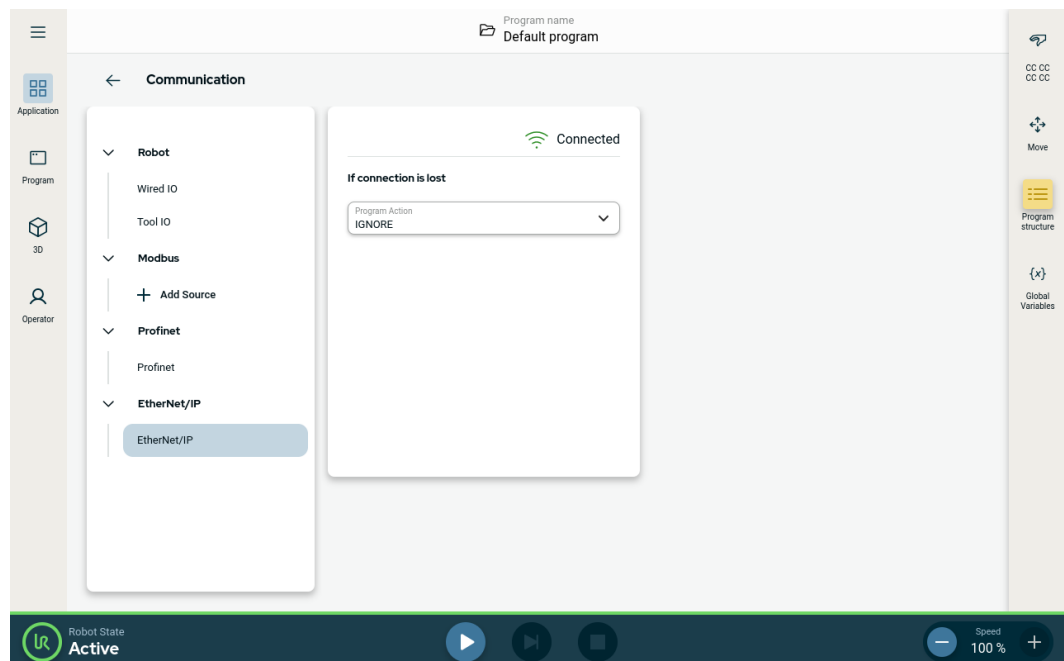
In the upper right corner of this screen, you can see the Ethernet/IP status.

Connected	The robot is connected to the Ethernet/IP Scanner Device.
No Scanner	Ethernet/IP is running, but no device is connected to the robot via Ethernet/IP.
Disabled	Ethernet/IP is not enabled.

8. Settings

8.1. Admin Password

Description

All options under Security are protected by an Admin password. The Admin password protected screens are locked by a transparent overlay rendering the settings unavailable. Accessing the Security allows you to configure the settings in the following:

- Secure Shell
- Permissions
- Services

The settings can only the modified by designated administrator/s.
Unlocking any one of the options under Security, also unlocks the other options until you exit the Settings menu.

To set the Admin password

Before you can use the Admin password to unlock protected screens, you have to change the default password.

1. Access the Hamburger menu and select **Settings**
2. Under Password, tap **Admin**.
3. Change the current Admin password to a new one.
   - If this is the first time, change the default Admin password from "easybot" to a new password. The new password must be at least 8 characters long.
4. Use the new password to unlock the Settings menu and access the options under Security.

To exit the Settings menu

When one of the Security options is unlocked, the Close button in the bottom right of the Settings menu changes. The Close button is replaced by the Lock and Close button indicating security is unlocked.

1. On the Settings menu locate and tap the **Lock and Close** button.

8.2. Secure Shell (SSH) Access

Description

You can manage remote access to the robot using Secure shell (SSH). The Secure shell security settings screen allows administrators to enable or disable SSH access to the robot.

To enable/disable SSH	1. Access the Hamburger menu and select **Settings**. 2. Under Security, tap **Secure shell**. 3. Slide the **Enable SSH** Access to the on position. To the far right of the Enable SSH Access toggle button, the screen shows the port used for SSH communication.
SSH Authentication	Authentication can occur with a password and/or with a pre-shared, authorized key. Security keys can be added by tapping the **Add Key** button and selecting a security key file. Available keys are listed together. Use the trash icon to remove a selected key from the list.

8.3. Permissions

Description	Access to the Networking, URCap Management and Updating PolyScope X screens is restricted by default, to prevent unauthorized changes to the system. You can change the permission settings to allow access to these screens. An Admin password is required to access Permissions.
To access Permissions	1. Access the Hamburger menu and select **Settings**. 2. Navigate to Security and tap **Permissions**.
Additional system permissions	You can also lock a few important screens/functionalities with the Admin password. On the Permissions screen in Security section in the Settings menu, it is possible to specify which additional screens are to be protected by the Admin password and which screens are available to all users. The following screens/functionalities can optionally be locked: • Network settings • Update settings • URCaps section in the System Manager
To enable/disable system permissions	1. Access Permission as previously described. The protected screens are listed under Permissions. 2. For the desired screen, slide the On/Off toggle switch to the On position to enable it. 3. To disable the desired screen, slide the On/Off toggle switch to the Off position. The screen locks again once the toggle is in the Off position.

8.4. Services

Description

Services allow administrators to enable or disable remote access to the standard UR services running on the robot, such as Primary/Secondary Client interfaces, PROFINET, Ethernet/IP, ROS2, etc.

Use the Service screen to restrict remote access to the robot by only allowing external access to the services on the robot which the specific robot application is actually using. All services are disabled by default to provide maximum security. The communication ports for each service are to right of the On/Off toggle button in the list of services.

Enabling ROS2

When the ROS2 service is enabled on this screen, you can specify the ROS Domain ID (values 0-9). After changing the Domain ID, the system restarts to apply the change.

Software Name: PolyScope X
Software Version: 10.7
Document Version: 10.9.101