User Manual

g-Series

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1. Preface

Content disclaimer

Universal Robots A/S continues to improve the reliability and performance of its products, and as such reserves the right to upgrade products, and product documentation, without prior warning. Universal Robots A/S makes every effort to ensure the content of the User Manuals is precise and correct, but is not responsible for any errors or missing information.

This manual does not contain warranty information.

Online manuals

Manuals, guides and handbooks can be read online. We have gathered a large number of documents at
https://www.universal-robots.com/manuals

- PolyScope X Software Handbook with descriptions and instructions for the software.
- The Service Handbook with instructions for troubleshooting, maintenance, and repair.
- The Script Directory with scripting for in-depth programming.

Academy

The UR Academy site academy.universal-robots.com offers a variety of training opportunities.

Support

The support site www.universal-robots.com/support contains other language versions of this manual.

Data Notice

In compliance with Regulation (EU) 2854/2023 (“Data Act”), a Data Notice for this product along with instructional information on how to obtain Readily Available data can be found at the following location: https://www.universal-robots.com/legal/data-notice/

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Contents

2. Liability and Intended Use

Description

This section states Universal Robots' limitation of liability and defines the intended industrial use of the robot system. It explains approved applications and environments, lists prohibited uses.
The user shall ensure safe installation and operation through proper risk assessment and compliance with applicable standards.

2.1. Limitation of Liability

Description

Any information provided in this manual must not be construed as a warranty, by UR, that the industrial robot will not cause injury or damage, even if the industrial robot complies with all safety instructions and information for use.

2.2. Intended Use

Description

Universal Robots robots are intended for industrial use, to handle tools/end effectors and fixtures, or to process or transfer components or products.

All UR robots are equipped with safety functions, which are purposely designed to enable collaborative applications, where the robot application operates together with a human. The safety function settings must be set to the appropriate values as determined by the robot application risk assessment.

The robot and Control Box are intended for indoor use where, normally, only non-conductive pollution occurs, i.e., Pollution degree 2 environments.

Collaborative applications are only intended for non-hazardous applications, where the complete application, including tool/end effector, workpiece, obstacles and other machines, is low risk according to the risk assessment of the specific application.

WARNING

Using UR robots or UR products outside of the intended uses can result in injuries, death and/or property damage. Do not use the UR robot or products for any of the below unintended uses and applications:

- Medical use, i.e., uses relating to disease, injury or disability in humans including the following purposes:
  - Rehabilitation
  - Assessment
  - Compensation or alleviation
  - Diagnostic
  - Treatment
  - Surgical
  - Healthcare
  - Prosthetics and other aids for the physically impaired
  - Any use in proximity to patient/s
- Handling, lifting, or transporting people
- Any application requiring compliance with specific hygienic and/or sanitation standards, such as proximity or direct contact with food, beverage, pharmaceutical, and/or cosmetic products.
  - UR joint grease leaks, and can also be released as vapor into the air.
  - UR joint grease is not “food grade”.
  - UR robots do not meet any food, National Sanitation Foundation (NSF), Food and Drug Administration (FDA), or hygienic design standards.

  Hygienic standards, for example ISO 14159 and EN 1672-2, require a hygiene risk assessment be conducted.
- Any use, or any application, deviating from the intended use, specifications, and certifications of UR robots or UR products.
- Misuse is prohibited as the result could be death, personal injury, and/or property damage.

UNIVERSAL ROBOTS EXPRESSLY DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR ANY PARTICULAR USE.

WARNING

Failure to consider the added risks due to the reach, payloads, operating torques and speeds associated with the robot application can result in injury or death.

- Your application risk assessment shall include the risks associated with the application's reach, motion, payload and speed of the robot, end effector and workpiece.

NOTICE

Universal Robots takes no responsibility and assumes no liability for unapproved uses of its robots or uses for which its robots are not intended and Universal Robots will provide no support for unintended uses.

READ MANUAL

Failure to use the robot in accordance with the intended use can result in hazardous situations.

- Read and follow the recommendations for intended use and the specifications provided in the User Manual.
- Perform a risk assessment. Install and use in accordance with the electrical and mechanical specifications provided in this User Manual.

2.3. Integration and Responsibility

Description

The information in this manual does not cover designing, installing, integrating and operating a robot application, nor does it cover all peripheral equipment that can influence the safety of the robot application. The robot application must be designed and installed in accordance with the safety requirements set forth in the relevant standards and regulations of the country where the robot is installed.

Persons integrating the UR robot are responsible for ensuring that the applicable regulations in the country concerned are observed and that any risks in the robot application are adequately reduced. This includes, but is not limited to:

- Performing a risk assessment for the complete robot system
- Interfacing other machines and additional safeguarding if required by the risk assessment
- Setting the correct **Safety Settings** in the software
- Ensuring safety measures are not modified
- Validating that the robot application is designed, installed, and integrated
- Specifying instructions for use
- Marking the robot installation with relevant signs and contact information of the integrator
- Retaining all documentation, including the application risk assessment, this manual, and additional relevant documentation.

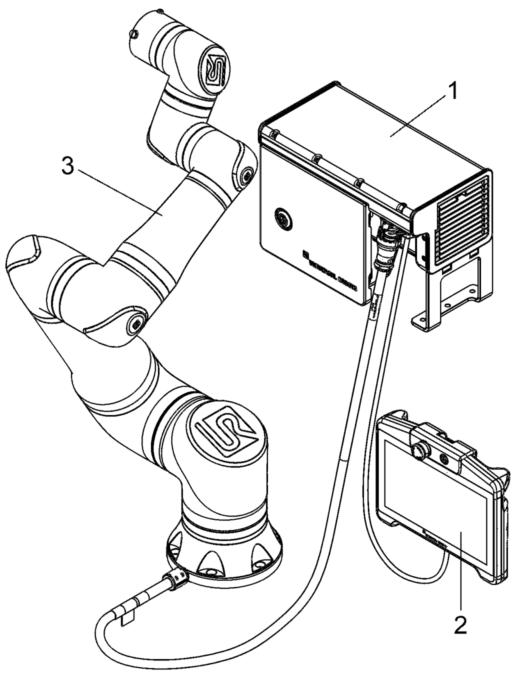
NOTICE

Universal Robots disclaims any and all liability if the Robot (Robot Arm, Control Box, with or without Teach Pendant) is damaged, changed or modified in any way. Universal Robots cannot be held responsible for any damages caused to the robot or any other equipment due to programming errors, unauthorized access to the UR robot and its contents, or malfunctioning of the robot.

3. Your Robot

Description

The Universal Robots robot is designed to mimic the range of motion of a human arm, allowing for a wide range of flexibility in your automation installation.
Universal Robots' patented programming interface, PolyScope X, allows you to create, load, and run your automation applications.



1	Control Box	3	Robot Arm
2	Teach Pendant		

Robot assembly

Universal Robots delivers a partly completed system. A Declaration of Incorporation (original) is provided, which may consist of the following main components:

- The Robot Arm provides controlled motion in six axes, enabling precise positioning and orientation of tools during operation.
- The Control Box contains the robot controller, power supply, and safety functions. It executes programs, controls motion, and provides interfaces for external equipment.
- The Teach Pendant is the user interface for programming and operating the robot. It includes a touchscreen with PolyScope X for configuration, operation, and diagnostics.
- Cables connect the Robot Arm, Control Box, and Teach Pendant. Correct installation is required to ensure reliable operation and compliance with safety requirements.
- PolyScope X is the graphical user interface that operates the robot arm. PolyScope X comes with built-in safety features. These must be configured and validated as part of the overall system integration, and a risk assessment is required for each robot application.

3.1. Robot Arm (g-Series)

Description

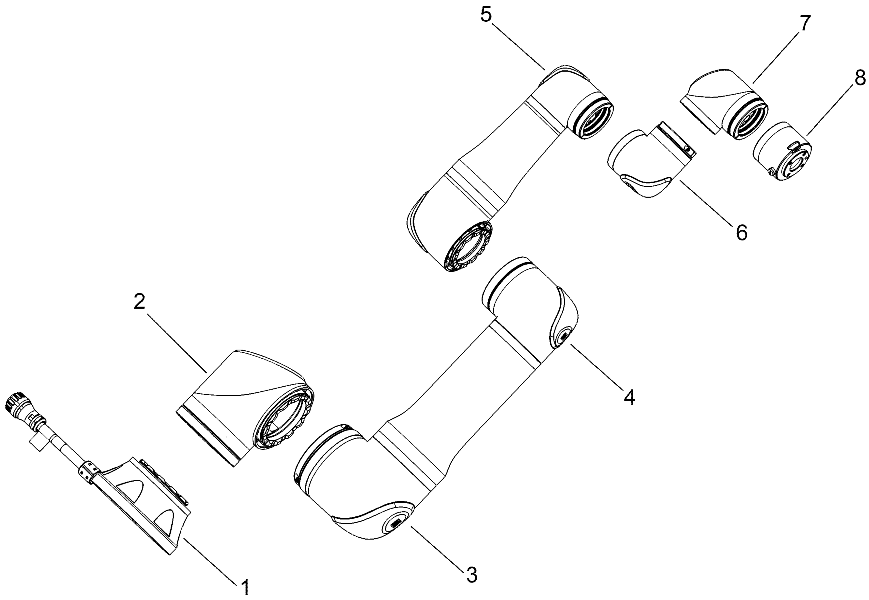
The Robot Arm g-Series consists of six servo joints interconnected by aluminum tubes, a base flange, and a g-Series Performance Tool Flange.
The g-Series tool flange includes an Ethernet port and an additional power outlet at the end of the arm, an optional detachable Smart Panel, and an M8 tool I/O port.

The Robot Arm g-Series pairs exclusively with a Control Box (CB7) and a Teach Pendant (TP7).

You can identify the Robot Arm g-Series by its model name, which is marked on the robot.
Model names follow the format URXXg-YYYY, where:

- UR indicates Universal Robots.
- XX indicates the payload in kg.
- g indicates the generation (g-Series).
- YYYY indicates the reach in mm.

Main Components



1	Base	5	Wrist 1 joint
2	Base joint	6	Wrist 2 joint
3	Shoulder joint	7	Wrist 3 joint
4	Elbow joint	8	Tool Flange

Robot Arm main components

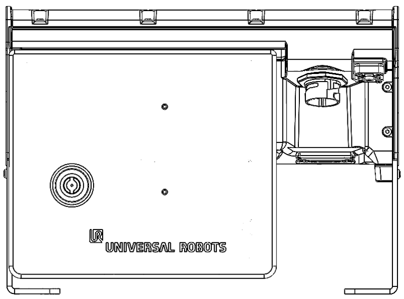
3.2. Control Box (CB7 Core)

Description

The CB7 Core, CB7 Core Compact, and CB7 Core Compact 0.55 m are the Control Box variants for the g-Series robot system. They provide control, power, and communication for robot operation.

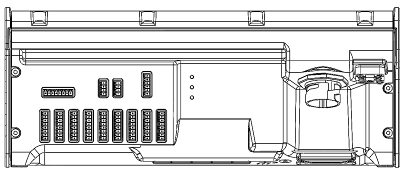
Control Box (CB7) variants

The CB7 Core is an enclosed unit for use in a robot cell.

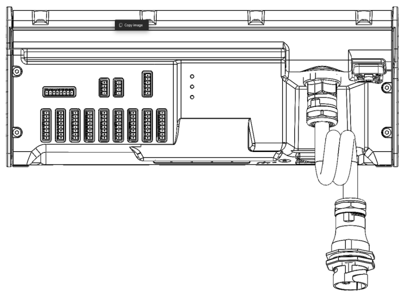


CB7 Core

The CB7 Core Compact and CB7 Core Compact 0.55 m integrate into customer-built electrical cabinets or machines. The 550 mm longer cable variant adds a longer robot-interface lead for panel-mount connection on the customer cabinet wall. All three variants offer the same control functionality and work with a Teach Pendant (TP7) and a robot arm to form a robot system.



CB7 Core Compact



CB7 Core Compact 0.55 m

3.3. Teach Pendant (TP7)

Description

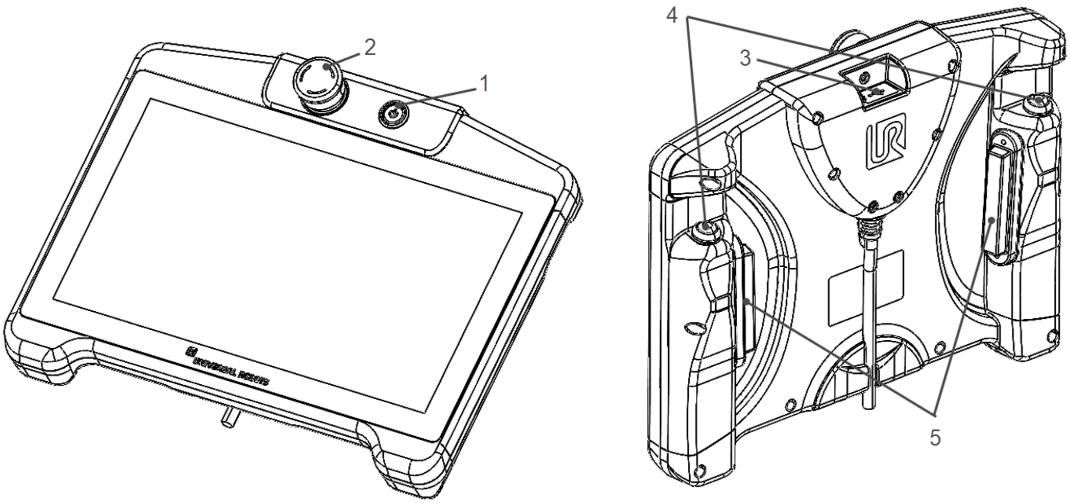
The TP7 is the standard Teach Pendant for the g-Series robot system. It provides a user interface for operating, programming, and monitoring the robot during installation, setup, and manual operation. TP7 is designed as a handheld device that can be carried by a single person and used directly at the robot cell. When not in use, it can be mounted on a wall or on the Control Box using a dedicated mounting bracket.

NOTICE
The USB port on the TP7 can only be used to connect keyboard or mouse.

NOTICE
CB7 Core does not support the Universal Robots 3PE Teach pendant.

The unit includes a touchscreen interface and integrated safety controls, enabling the operator to interact with the robot and perform manual movements under controlled conditions. In configurations equipped with a 3-Position Enabling device, robot motion during manual operation requires continuous operator engagement.

TP7 has two user-configurable buttons, each of which can be assigned a Smart Skill in PolyScope X. When a button is pressed, it executes the selected Smart Skill.



1	Power button	4	TP7 Smart buttons
2	Emergency stop button	5	3PE buttons (ambidextrous)
3	USB port (comes with a removable dust cover)		

TP7 controls

3.4. Robot Cables (g-Series)

Description	The g-Series robot cable connects the robot arm to the Control Box and provides power, control, and high-speed communication. It includes an integrated Ethernet connection and updated Harting connectors and supports cable lengths up to 40 m. The cable is compatible only with g-Series robot systems.

Warnings

WARNING: ELECTRICITY

Conducting installation and/or maintenance of equipment connected to a power source can result in injury or death due to electric shock.

- Disconnect equipment from the power source before conducting installation or maintenance tasks.

CAUTION

Incorrect mating or unmating can damage the Harting connector.

- Do not force the connector if the end-marking letters are not aligned.
- Do not twist the connector before it is fully seated.
- Do not pull on the cable to disconnect the connector.
- Do not rock or tilt the connector during mating or unmating.

NOTICE

Improper cable selection, usage, or connections can result in loss of power to the robot arm.

- Do not extend the connection by joining more than one cable between the Control Box and the robot.

NOTICE

Connecting the Base Flange cable directly to any Control Box can result in damage to equipment and property.

- Do not connect the Base Flange cable to your Control Box.
- Always use a UR robot cable to connect the Base Flange to your Control Box.

NOTICE

Use the same mating and unmating steps at the Control Box connector and at the robot Base Flange connector. For the mating and unmating procedure, see Robot Cables (g-Series).

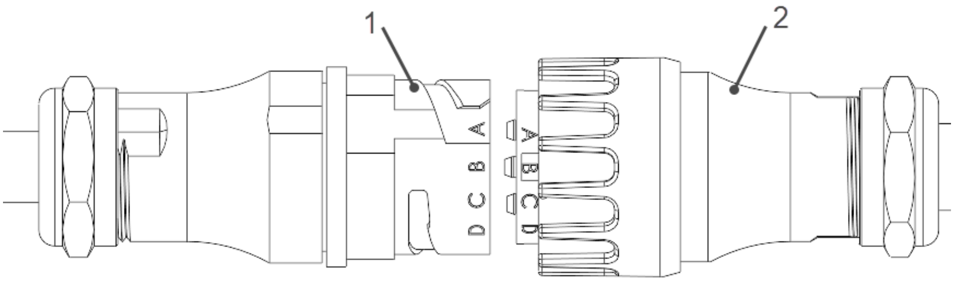
READ MANUAL

Failure to use the robot in accordance with the intended use can result in hazardous situations.

- Read and follow the recommendations for intended use and the specifications provided in the User Manual.

The g-Series robot cable has several key features:

- It includes an integrated Ethernet connection, enabling networked end-of-arm tooling without additional external cables.
- It uses Harting connectors.



1	Harting Receptacle	2	Harting Plug

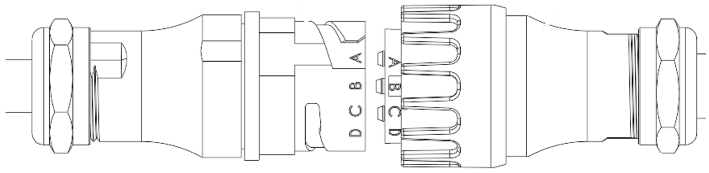
Harting Connector

- The cable supports lengths ranging from 1-40 m with multiple lengths as standard options.
- It comes in a standard and drag chain variant for dynamic cable management.
- The cable supports 100/1000 Mbps Ethernet.

Mating and Unmating Harting Connector

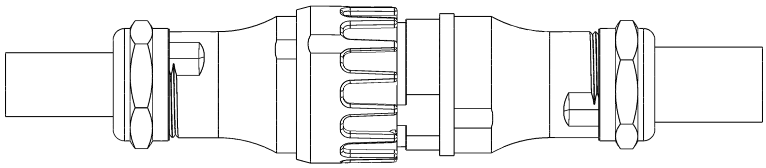
To mate the Harting connector:

1. Align the end-marking letters on the Harting Plug and Harting Receptacle.



Harting Connector Alignment

2. Gently push the plug straight into the receptacle until it is fully seated. Do not tilt the connector.
3. Twist the connector clockwise to lock it securely.



Connected Harting Connector

To unmate the connector:

1. Hold the connector housing. Do not pull on the cable.
2. Twist the connector counterclockwise until it unlocks.
3. Gently pull the plug straight out of the receptacle. Do not pull at an angle.

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4. Lifting and Mounting g-Series

Description

This section describes how to safely lift and handle the robot arm.
Proper lifting and mounting of the robot arm are essential for safe handling and to prevent equipment damage and personal injury. Follow the specified procedures when using lifting equipment, including a round sling, to maintain stability and control throughout the operation.
The round sling is provided by UR with g-Series robots. Use it for lifting and handling the robot arm during transport, unpacking, and mounting.

WARNING

Using a damaged round sling can result in injury.

- Carefully examine the sling visually before each use.
- Do not use the sling if it is cracked, ripped, or the stitching is loose.
- Do not use the sling if there are signs of heat damage.

WARNING

Failure to secure the robot arm to a sturdy surface can lead to injury caused by the robot falling.

- Ensure the robot arm is secured to a sturdy surface.

WARNING

Incorrect assembly of components and/or wiring can lead to injury.

- Personal protective gear (footwear, eyewear, gloves) can be required.

WARNING: ELECTRICITY

Installing or maintaining equipment connected to a power source can result in injury or death from electric shock.

- Disconnect equipment from the power source before conducting installation or maintenance tasks.

CAUTION

Failure to use an appropriate lifting device for the weight of the robot can lead to injury and property damage.

- Use lifting equipment when lifting a heavier robot arm.
- For weights, see Technical Specifications g-Series.

NOTICE

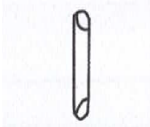
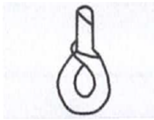
Specific regulations for inspecting lifting equipment and for assembly lifting may apply in your region.

- Observe local regulations for inspection of lifting equipment, including inspection frequency.
- Follow local regulations and guidelines for lifting.

Round sling specifications

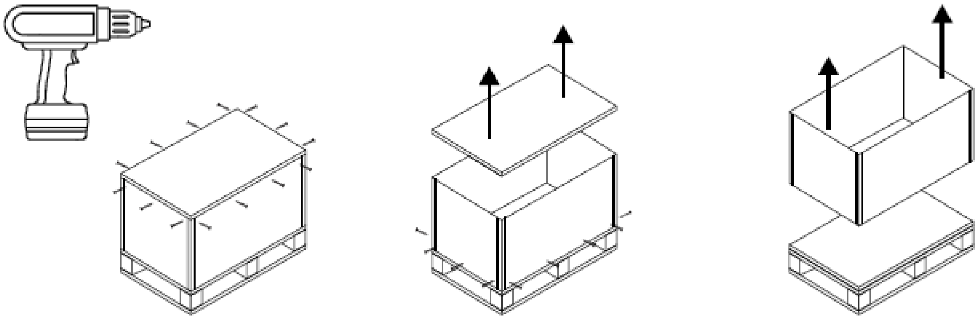
The round sling conforms to the following standards:

- EN 1492-1 :2000+A1 :2008 Textile slings - Safety - Flat woven webbing slings, made of man-made fibers, for general purpose use.
- EN 1492-2 :2000+A1 :2008 Textile slings - Safety - Round slings, made of man-made fibers, for general purpose use.

Item	Color	Material	WLL factor	
Round sling (1T x 1 m/2 m)	Violet (according to EN 1492-2)	Polyester	1.0 (1000 kg)  Straight Lift	0.8 (800 kg)  Choke Hitch

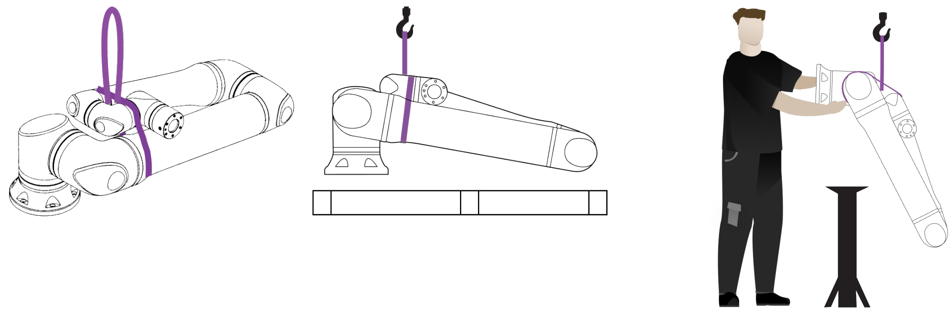
How to lift and mount your robot

1. Transport the robot to the site using a forklift.
2. Open the box as illustrated.



Remove the upper row of screws	Remove the lid and bottom screws	Remove side walls

3. Securely strap the robot arm with the lifting sling. Lift the robot arm out of the box. Support the robot arm as you rotate and hang it.



Attach the sling	Use lifting equipment	Support the robot arm

4. Mount the robot arm and secure it with six bolts.
5. Tighten the bolts and apply torque as specified in the following table.

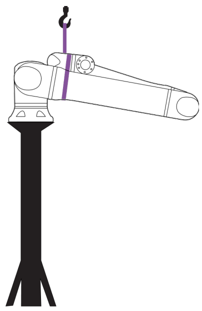
Robot	Bolts	Torque	Pins
UR10g-1750 UR17g-1300 UR18g-950	6x M10 (8.8)	45 Nm	Ø8 h6, Ø8x13 mm slot

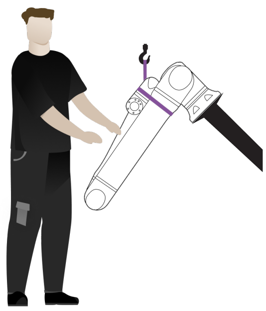
Bolt specification

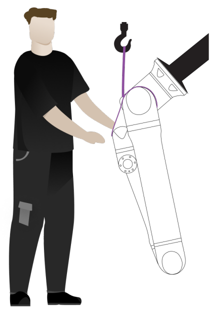
6. Remove the sling.

Tilted mounting

The robot arm can be mounted on a tilt from -180° to 180°. The most common positions are illustrated below.







0° angle mounting	Mounted at 45°	Mounted at 135°

How to mount in tilted position

To mount the robot arm at a tilt, follow these steps:

1. Secure the robot arm on a 0° stand.
2. Follow the first boot sequence and adjust the robot base to the position that matches your desired tilt.
3. Power down the robot.
4. Unplug all electrical connections.
5. Use the round sling to lift the arm into position.
6. Mount the robot arm. Tighten the screws and apply torque as specified in the Bolt specification table.
7. Remove the sling.

5. Mounting and Connecting

Description

Mount the Control Box and Teach Pendant correctly and assemble them with the Robot Arm to ensure stable installation and reliable system setup. Securely install and connect all components according to the specified requirements to prepare the system for PolyScope X.

WARNING

Mounting and operating the robot in environments exceeding the recommended IP rating can result in injury.

- Mount the robot in an environment suited to its IP rating. Do not operate the robot in environments that exceed the applicable IP ratings. For IP ratings of the Teach Pendant (TP7) and Control Box (CB7), see 18.3 Technical Specifications Teach Pendant (TP7) on page 191 and 18.2 Technical Specifications Control Box (CB7) on page 189.

WARNING

Unstable mounting can result in injury.

- Always make sure the robot parts are properly and securely mounted and bolted in place.

5.1. Mounting of Control Box (CB7)

Description

Proper mounting of the Control Box is required for safe operation, reliable performance, and adequate cooling. The Control Box must be installed securely in a location that provides sufficient clearance for operation, service, and airflow.

WARNING

A wet Control Box can cause fatal injury.

- Make sure the Control Box and cables do not come into contact with liquids.
- Place the Control Box in an environment suited for the IP rating.

WARNING

Risk of damage and injury.

- Do not step on the Control Box. Doing so can result in mechanical damage, electrical hazards, or malfunction, and can lead to equipment failure or personal injury.

WARNING

Risk of tipping.

- Unsecured mounting may cause the product to become unstable and tip over.
- This can result in equipment damage or personal injury.
- Fully tighten both finger screws after mounting.

WARNING

Damage protection.

- No tools; over tightening can damage screws or the Control Box.

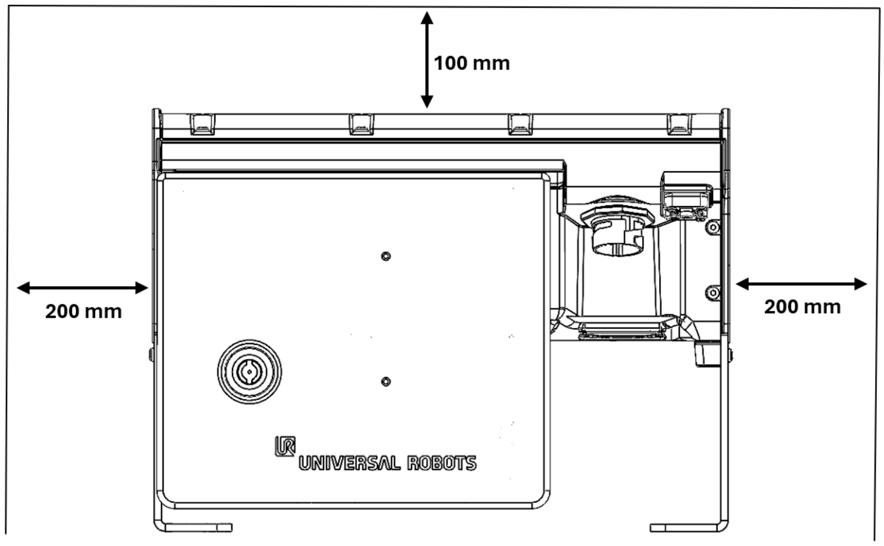
NOTICE

Keep clear working space around the Control Box. Leave at least 900 mm / 3 ft of unobstructed clearance in front of the Control Box so you can operate, inspect, and disconnect power safely in an emergency, as required by applicable electrical standards.

NOTICE

Mount the Control Box securely in a well-ventilated location, and install it so you can disconnect power quickly and safely at all times.

Box Clearance The flow of hot air in the Control Box can result in equipment malfunction. The recommended Control Box clearance is 200 mm on each side, 100 mm on the top for sufficient airflow and 100 mm at the front for opening the door.



Control Box Mounting Clearances

CB7 Core standing

- Place the Control Box in the standing position by setting it upright on a level, stable floor using the factory-mounted feet.
- Keep the recommended clearance around the unit so airflow and front door access are not obstructed.

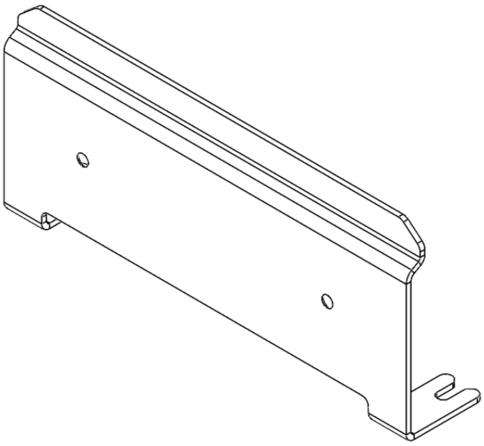
CB7 Core wall mount

WARNING

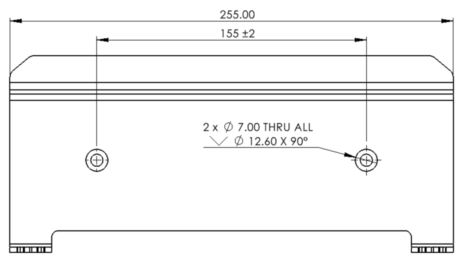
Unstable mounting can result in injury.

- After mounting, tighten the two thumb screws at the bottom of the Control Box by hand to secure it to the wall mounting bracket.
- Do not use tools to tighten the thumb screws. Overtightening can damage the screws or the Control Box.

1. Mount the bracket on a sturdy wall.

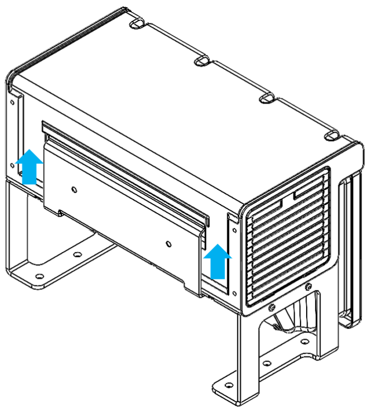


Control Box bracket

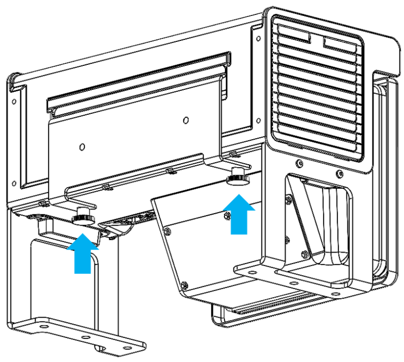


Bracket wall mounting hole pattern

2. Hang the Control Box on the bracket using the mounting slit on the back. Secure the Control Box to the wall mounting bracket with two thumb screws.



Control Box mounted on bracket



Location of the two thumb screws

CB7 Core Compact / CB7 Core Compact 0.55 m mounting

CB7 Core Compact is an AC-powered controller that mounts inside your electrical cabinet. It has no outer enclosure, so you install it directly in the cabinet.

CB7 Core Compact 0.55 m uses the same controller and includes a 550 mm longer robot-interface lead. The extra lead connects the robot interface from the internal controller board to the panel-mount connector on the exterior of the cabinet, allowing the robot arm cable to be connected and disconnected without opening the enclosure.

Both CB7 Core Compact variants support vertical and horizontal orientations. Use the mounting bracket the same way as for the CB7 Core. Access the Teach Pendant the same way on both Compact variants.

NOTICE

Keep the robot arm and Teach Pendant (TP7) connectors pluggable and accessible from outside your electrical cabinet to support maintenance, hot-plugging, safety compliance, and integration with OEM and compact enclosures.

NOTICE

Ensure there is enough space for cables and air circulation around the Control Box.

NOTICE

Leave at least 50 mm of space around the air intake and outlets, and avoid recirculating air.

5.2. Mounting of Teach Pendant (TP7)

Description

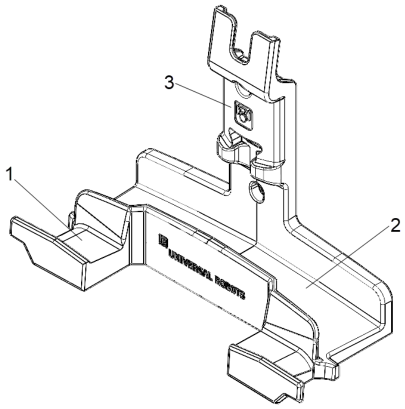
The Teach Pendant can be mounted on a wall or directly onto the Control Box. Teach Pendant can be carried by a single person. During operation, all cables must be coiled and handled properly to prevent tripping hazards.

The operator must clearly understand the effect of the Emergency Stop Push Button on the Teach Pendant when it is activated. In multi-robot installations, there may be uncertainty about whether the Emergency Stop affects the entire installation or only the connected robot. This distinction must be clearly communicated.
If there is any potential for confusion, the Teach Pendant must be stored in a manner that prevents the Emergency Stop Push Button from being visible or accessible.

Teach Pendant bracket

The TP7 Mounting Bracket securely supports the TP7 Teach Pendant on a tabletop or workstation surface, wall and on the Control Box during robot operation.

- Teach Pendant holder - When TP7 is mounted vertically, the Teach Pendant holder can be used to store the Teach Pendant (TP7).
- Cable management - Integrated routing channel to organize and store the Teach Pendant cable, preventing tripping hazards and cable damage.
- Smart panel holder - Dedicated slot to hold the Smart Panel accessory alongside the Teach Pendant.

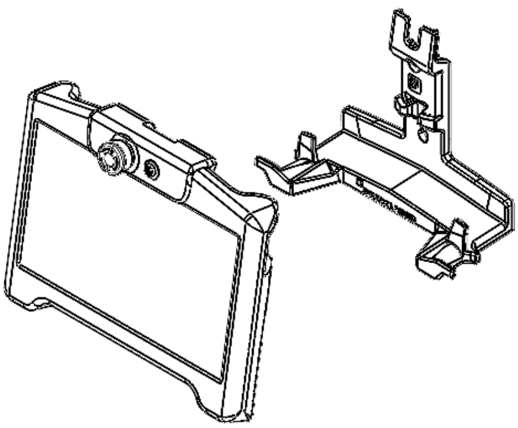


1	Teach pendant holder	3	Smart panel holder
2	Cable management		

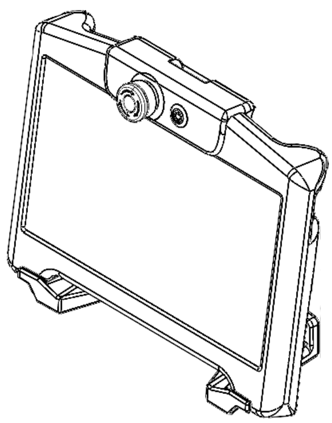
TP7 Mounting Bracket

Mounting Teach Pendant (TP7) to a wall

Use the bracket to mount the Teach Pendant (TP7) to a wall.



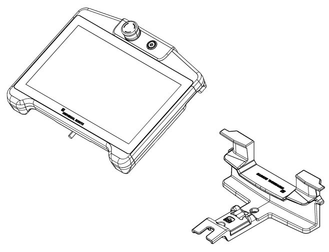
TP7 and Mounting Bracket

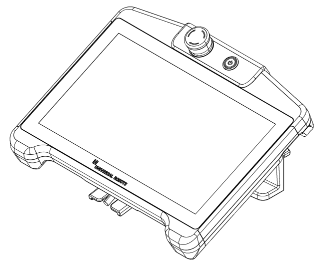


TP7 mounted to a wall

Mounting Teach Pendant (TP7) to a table or working surface

Use the bracket to mount the Teach Pendant (TP7) to a table or a working surface.

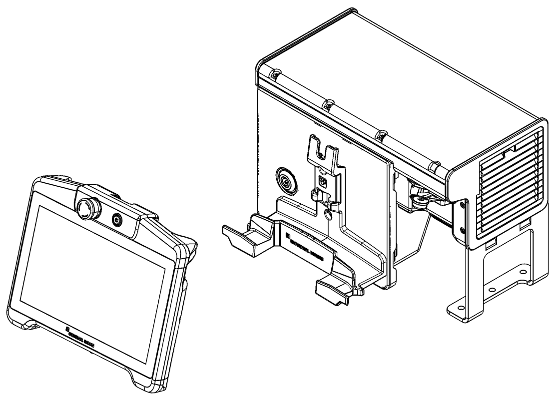


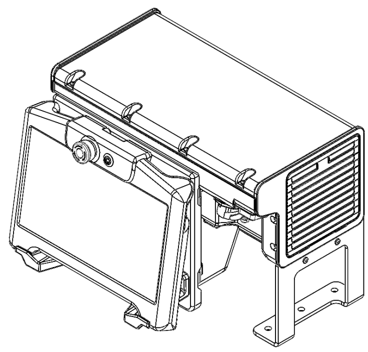


TP7 and Mounting Bracket	TP7 mounted to a table

Mounting Teach Pendant (TP7) to Control Box (CB7)

Use the bracket to mount the Teach Pendant (TP7) to the front of the Control Box (CB7).





Teach Pendant (TP7) and Mounting Bracket	Teach Pendant (TP7) mounted to Control Box

5.3. Connecting Teach Pendant (TP7) to Control Box (CB7)

Description

The Teach Pendant (TP7) is connected to the Control Box (CB7) to operate, program, and monitor the robot system. The connection provides power and communication between the Teach Pendant and the Control Box.

After establishing the connection, the TP7 serves as the system's user interface, enabling user interaction with the robot through the CB7.

NOTICE

There is only one port in the CB7, called ethTP, where the TP7 cable fits so you cannot plug it into the wrong one.

NOTICE

After physical connection, CB7 automatically provides network settings to the pendant, the pendant discovers CB7 services, and the PolyScope X interface loads on the TP7 screen.

NOTICE

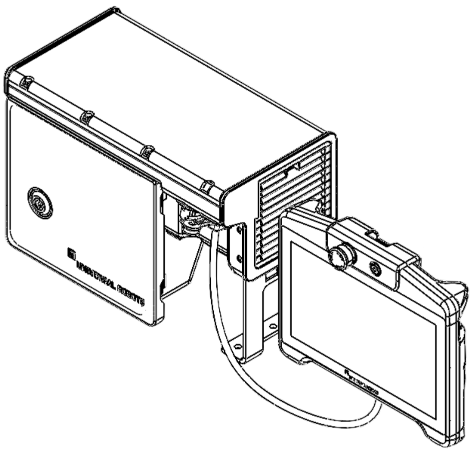
The TP7 can be connected to or disconnected from the CB7 at any system power state.

NOTICE

The TP7 always has a length of cable that can be a tripping hazard if you do not store it properly.
Always store the TP7 and the cable properly to avoid tripping hazards.

To connect TP7 to Control Box

1. Locate the Teach Pendant port on the Control Box (CB7).
2. Insert the TP7 connector into the Teach Pendant port.

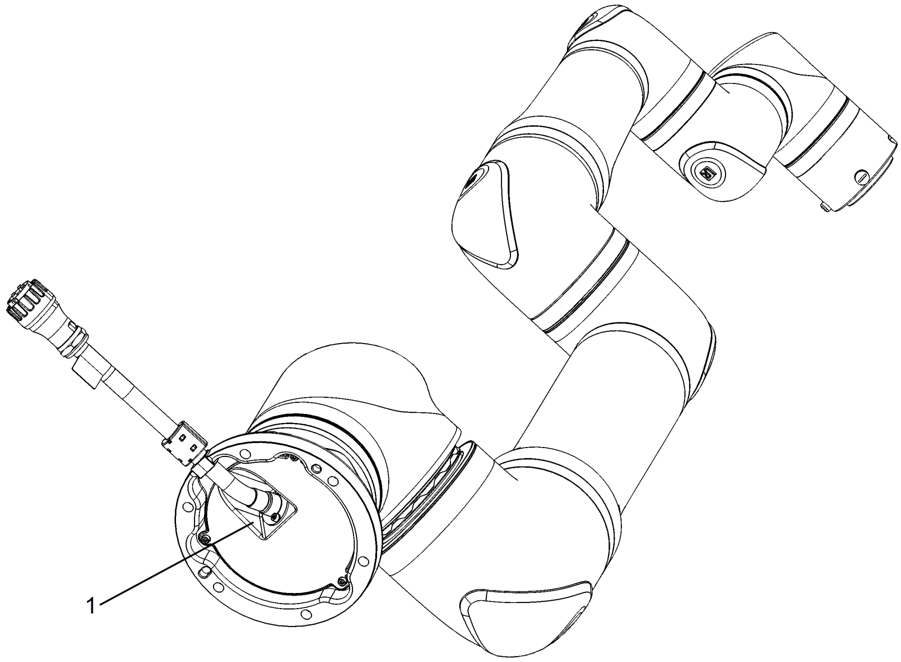


Teach Pendant connected to Control Box

5.4. Connecting Robot Arm to Control Box (CB7)

Description

Connecting the robot arm to the Control Box establishes power, communication, and safety functions required for robot operation. The robot power and communication cable connects and exits directly through the bottom plate of the robot base, called a bottom-mounted cable exit, rather than exiting horizontally from the side.



Bottom-mounted cable exit

Ensure all connections are correct before you power on the system.

CAUTION

Improper robot connection can result in loss of power to the robot arm.

- Do not disconnect the Robot Cable when the robot arm is turned on.
- Do not modify the original Robot Cable.

CAUTION

Incorrect mating or unmating can damage the Harting connector.

- Do not force the connector if the end-marking letters are not aligned.
- Do not twist the connector before it is fully seated.
- Do not pull on the cable to disconnect the connector.
- Do not rock or tilt the connector during mating or unmating.

NOTICE

Connecting the Base Flange Cable directly to any Control Box can result in equipment or property damage.

- Do not connect the Base Flange Cable directly to the Control Box.
- Always use a UR robot cable to connect the Base Flange to your Control Box.

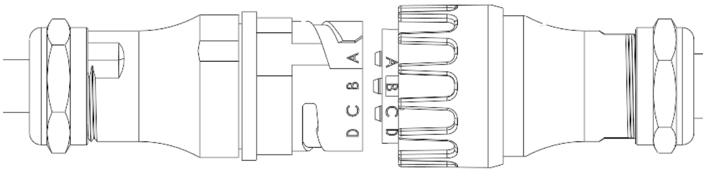
NOTICE

Use the same mating and unmating steps at the Control Box connector and at the robot Base Flange connector. For the mating and unmating procedure, see Robot Cables (g-Series).

Robot Cable to Control Box

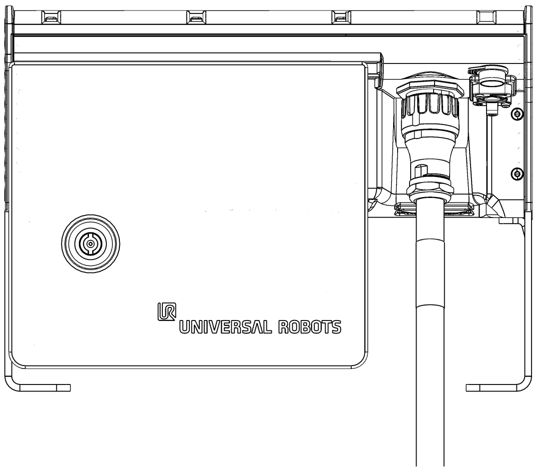
The Robot Cable connects the robot arm to the Control Box.

1. Plug the Robot Cable into the robot cable connector on the Control Box. Align the end-marking letters on both connector ends.



Robot Cable marking alignment

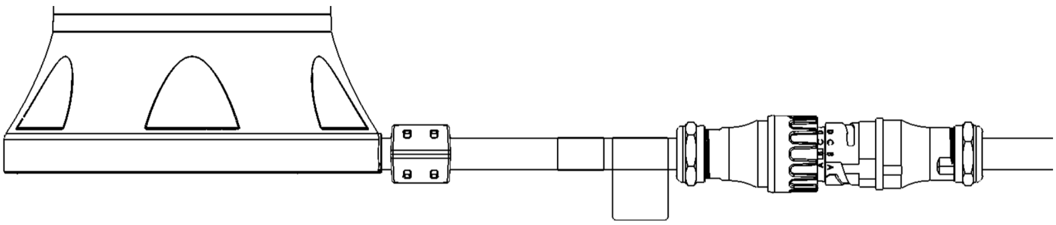
2. Twist the connector clockwise to lock it securely.
3. Confirm the connector is fully locked.



Robot Cable connection to Control Box

Robot Cable to Base Flange Connector

Connect the Robot Cable to the Base Flange Connector to prepare the robot system for operation.



Robot Cable connection to Robot Arm

1. Align the pins using the end-marking letters on both connector ends.
2. Insert and twist the connector clockwise to lock it securely.

5.5. Connecting Control Box (CB7) to Mains

Description

To power the robot, the Control Box shall be connected to the mains via the supplied power cord. The IEC C13 connector on the power cord connects to the IEC C14 appliance inlet at the bottom of the Control Box.

A main switch shall be installed to power off all equipment in the robot application as an easy means of lockout. For electrical specifications of the mains, see 14.1 Electrical Installation of the Mains on page 165.

WARNING: ELECTRICITY

Failure to follow any of the below can result in serious injury or death due to electrical hazards.

- Ensure the robot is grounded correctly (electrical connection to ground). Use the unused bolts associated with grounding symbols inside the Control Box to create common grounding of all equipment in the system. The grounding conductor shall have at least the current rating of the highest current in the system.
- Lockout all power for the complete robot installation during service.
- Ensure other equipment shall not supply power to the robot I/O when the robot is locked out.
- Ensure all cables are connected correctly before the Control Box is powered.

WARNING: ELECTRICITY

Failure to correctly place the mains connection can result in injury.

- The power plug for the mains connection shall be placed outside the reach of the robot, such that power can be removed without exposing personnel to potential hazards.
- If additional safeguarding is implemented, the power plug for the mains connection shall also be placed outside the safeguarded space such that power can be removed without exposure to any potential hazards.

NOTICE

Always use a power cord with a country-specific wall plug when connecting to the Control Box.

For <200 VAC countries, use a power cord with 15 A ampacity.

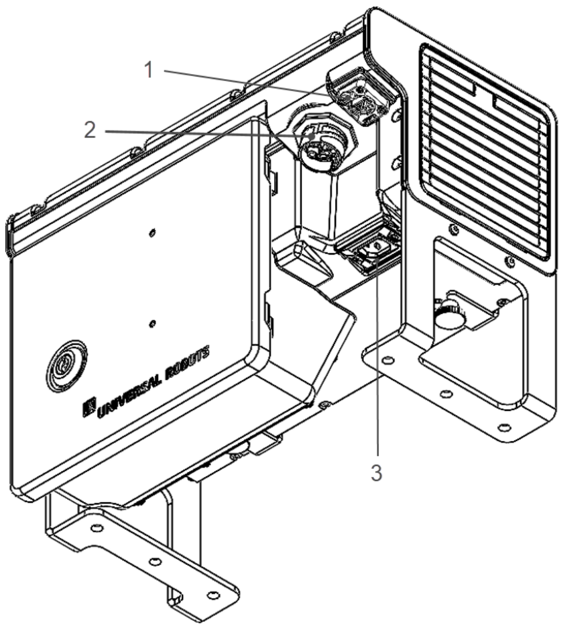
For >200 VAC countries, use a power cord with 10 A ampacity.

Do not use an adapter.

Attaching the power cord

Attaching the power cord from the Control Box.

1. Locate the IEC C14 appliance inlet at the bottom of the Control Box.
2. Fully insert the power cord into the inlet until it is securely seated.
3. Route the power cord to prevent strain and avoid tripping hazards.
4. Connect the other end of the power cord to the mains in accordance with local electrical installation requirements.



1	Robot cable connector uses a Harting ICC20 connector
2	Teach Pendant (TP) connector is an RJ45-type Ethernet port
3	Power Cable connector is an IEC C14 connector.

Control Box Cable Ports

Removing the Power Cord

Removing the power cord from the Control Box.

1. Follow the normal shutdown procedure to power off the Control Box.
2. Unplug the power cord from the wall socket.
3. Grip the connector, not the cable, push down the lock and pull the cord straight out of the IEC C14 appliance inlet on the Control Box.
4. Store the power cord safely to prevent damage or unintended reconnection.

6. Power Up the Robot

Description

The first boot is the initial sequence of actions you take with the robot after assembly. PolyScope X first boot takes about 10 minutes.
This initial sequence requires you to:

- Insert the USB drive into the USB port in the Control Box.
- Power on the robot.
- Install the robot image.
- Insert the serial number.
- Verify the installation.
- Initialize the robot arm.
- Test the mount and payload using Freedrive.
- Power down the robot.

CAUTION

Failure to verify the payload and installation before starting up the robot arm can cause injury to personnel and/or property damage.
Incorrect payload and installation settings prevent the robot arm and Control Box from functioning correctly. Incorrect payload values can adversely affect stopping distance, force limitation, trajectory accuracy, and fault detection.

- Always verify that the actual payload and installation settings are correct before starting up the robot arm.

NOTICE

Starting up the robot in low temperatures can result in lower performance or stops due to temperature-dependent oil and grease viscosity.

- Starting up the robot in low temperatures can require a warm-up phase.

6.1. Inserting the USB Drive

Insert USB drive

Take the USB drive from the box and insert it into a USB port in the Control Box.

NOTICE

Do not use the USB port on the Teach Pendant. The USB port on the Teach Pendant is not supported for first boot or image installation.

6.2. Powering On the Robot

To power on the robot

Powering on the robot turns on the Control Box and loads the display on the TP screen.

1. On the Teach Pendant, press the emergency stop button.
2. Press the power button on the Teach Pendant to power on the robot.

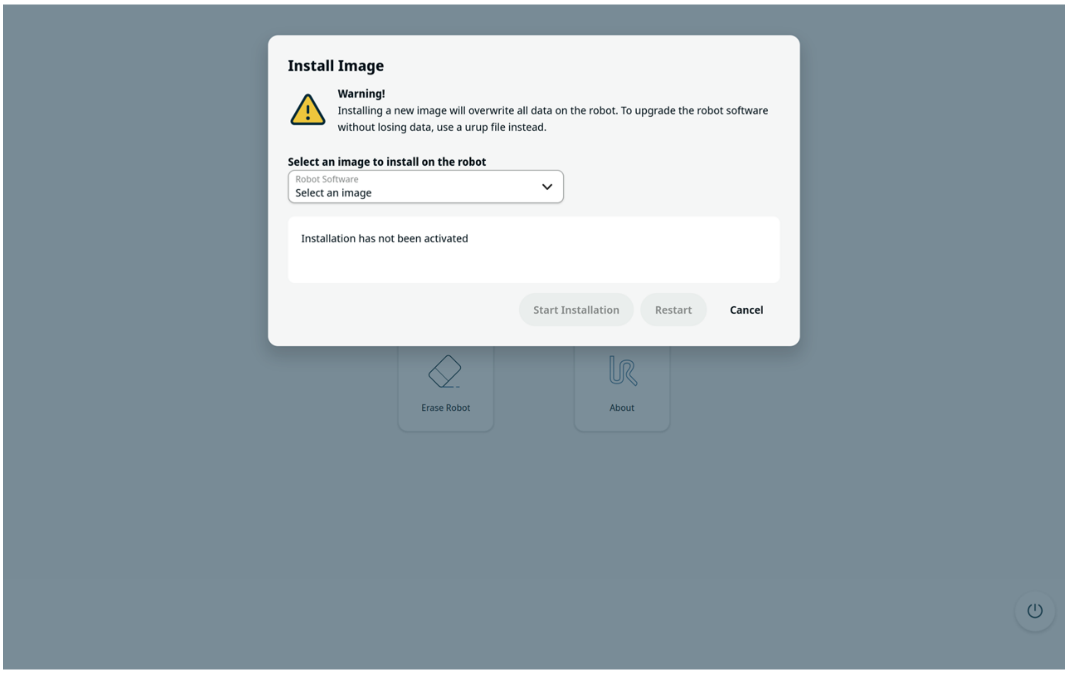
6.3. Installing the Robot Image

Description

Use **Install Robot** to install a compatible robot image from the data partition of the USB drive.
Insert the USB drive into the Control Box, then start Robot Tools.
When you copy a robot image from your PC to the USB drive, you do not need to modify the image file.

WARNING

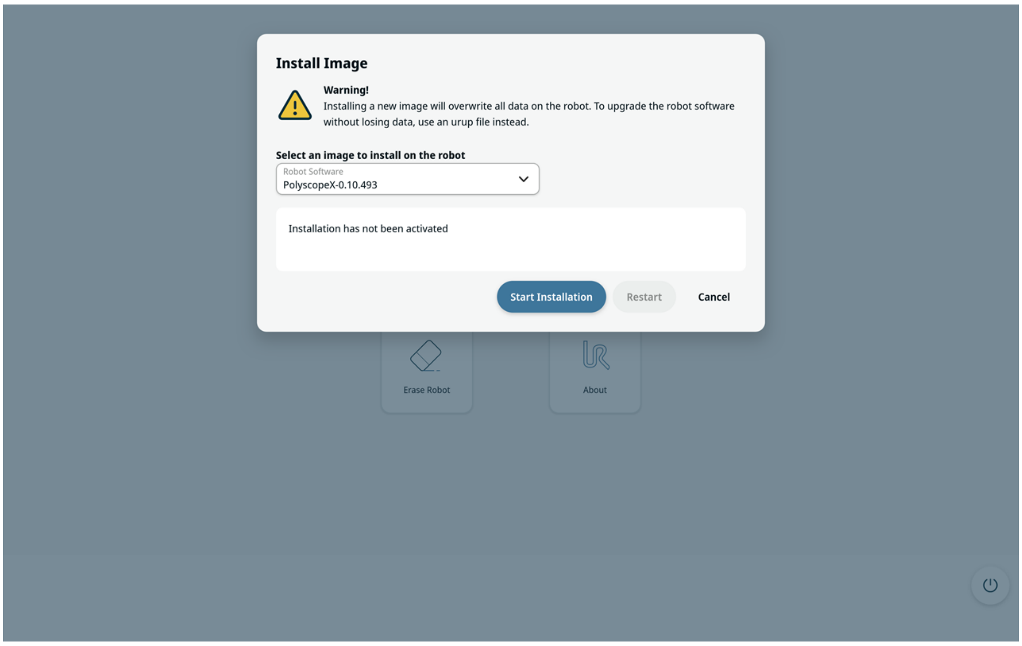
Installing a new image overwrites all data on the robot.



Install Image Screen

Install Image

1. On the main screen, select **Install Robot**.
2. Under **Select an image to install on the robot**, open the drop-down menu and select the image that you want to install.
3. Select **Start Installation**.
4. If prompted, confirm that you want to overwrite the robot disk.
5. Wait until the installation is complete. You cannot cancel the installation after it starts.
6. When the installation is complete, remove the USB drive.
7. Select **Restart**.



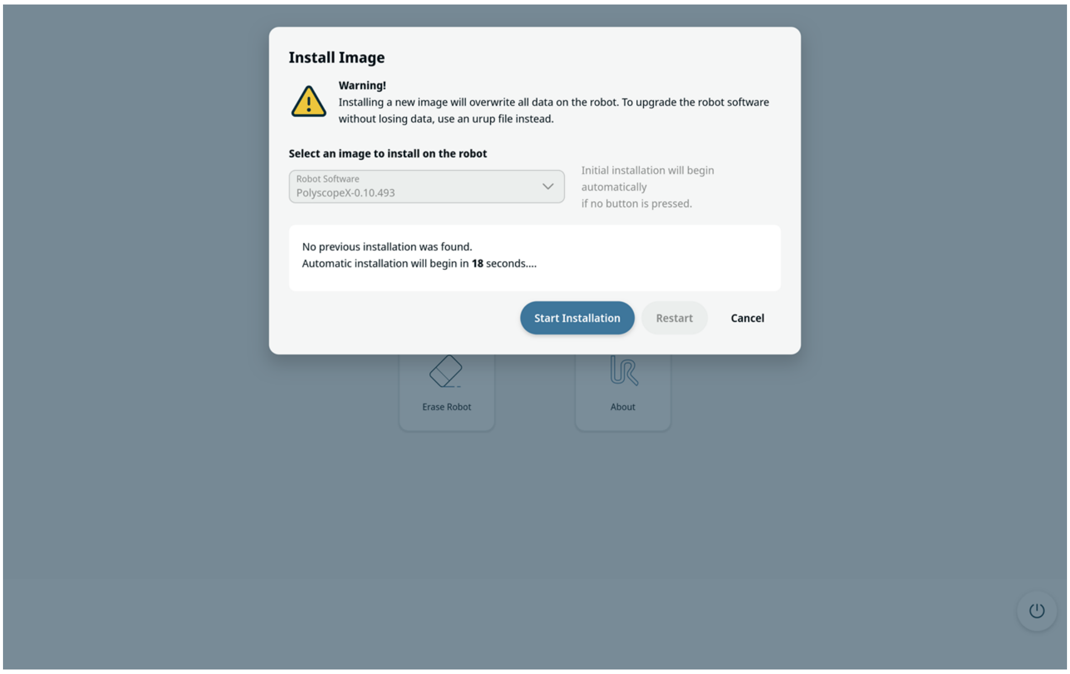
Successful Installation Screen

Before the installation starts, select **Cancel** to return to the main screen without changing the robot disk.

Automatic installation

If the robot disk is blank and the USB drive contains one compatible robot image, the installation screen can open automatically and display a countdown. Select **Start Installation** to start immediately, or select **Cancel** to stop the countdown and return to the main screen.

The USB drive with Robot Tools contains a file named `autoinstall`.
In this file, you can configure which image to install first during an automatic installation. This also works when the USB drive contains more than one image.
If you delete the `autoinstall` file, automatic installation does not work.



Automatic Robot Installation

For a comprehensive guide to using Robot Tools in PolyScope X, see Robot Tools.

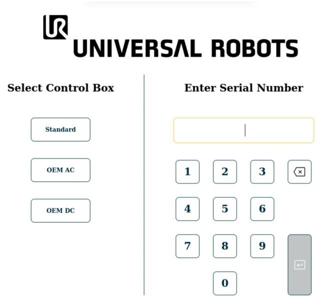
6.4. Inserting the Serial Number

To insert the serial number

Installing your robot for the first time requires you to enter the serial number on the robot arm. This procedure is also required when you reinstall the software. For example, when you install a software update.

1. Select your Control Box.
2. Insert the serial number as it is written on the robot arm.
3. Tap **OK** to end.

It can take a few minutes for the start screen to load.



Enter Serial Number

6.5. Verifying the Installation

Description

Mounting settings describe whether the robot is mounted vertically, horizontally, or at an angle. This allows the robot to determine the direction of gravity, enabling smooth and precise movement.
This screen also allows you to specify the orientation of the robot base in relation to the viewer, giving the robot an accurate appearance in the visualizations.

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.

Changing the mounting settings

To change the mounting settings of the robot arm:

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 and load PolyScope X.
3. On the screen, tap **OK** when the **Robot Emergency Stop** dialog appears.
4. Tap the **Application** icon in the Main Navigation on the left side of the Teach Pendant screen.

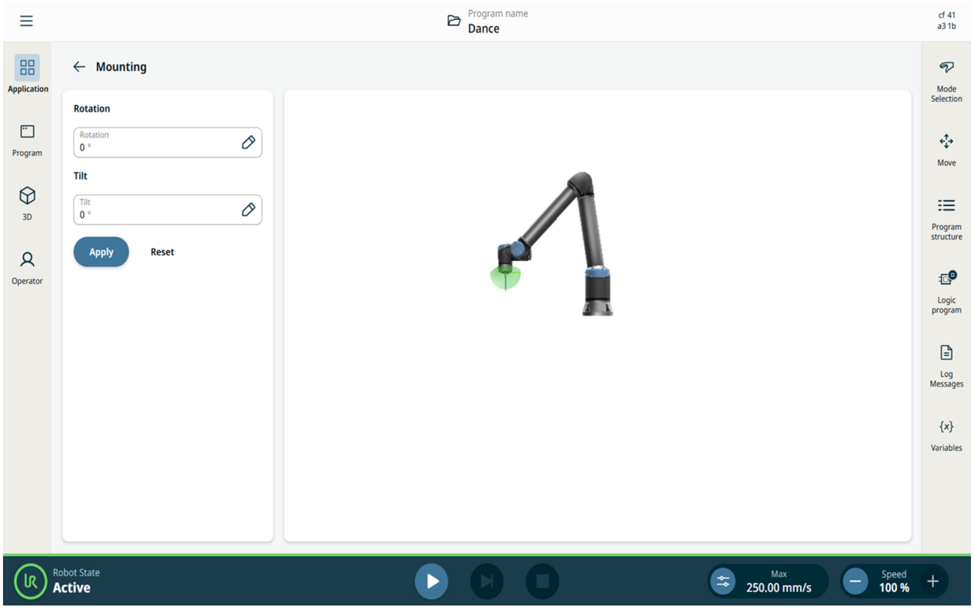
   Tap the **Mounting** icon.

   A screen appears with two fields on the left side:

   Rotation. The alignment with respect to the power cable.

   Tilt. The angle of the base in degrees: 0 being horizontal floor mounting, 90 being wall mounting, and 180 being ceiling mounting.

   The robot arm is seen in the center of the screen.



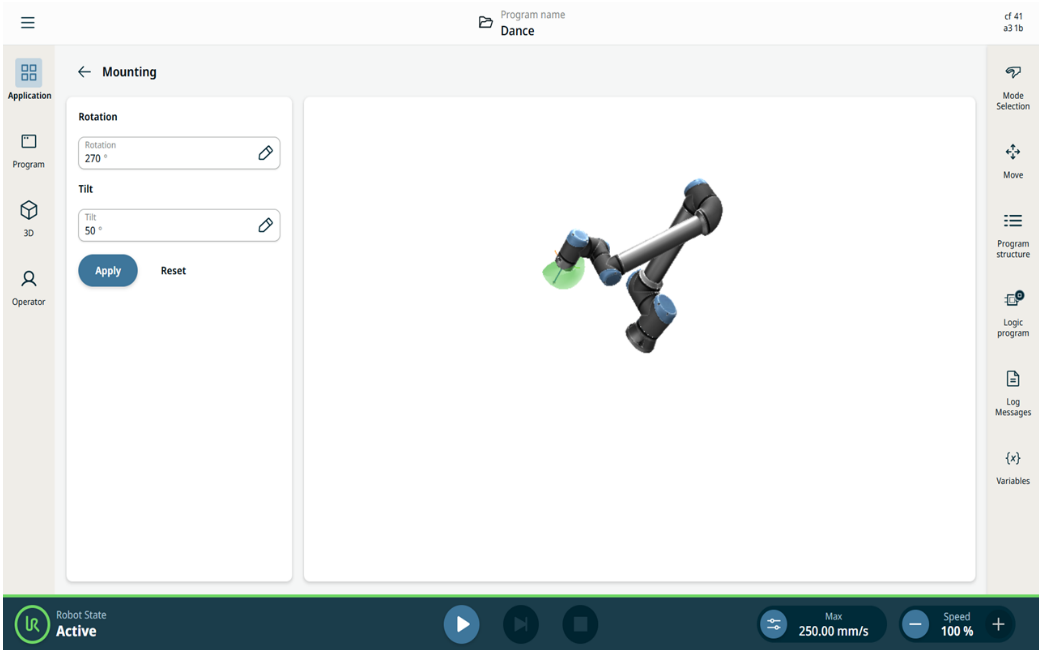
Vertical mounting setting

5. You can use the following touch gestures to adjust the view of the robot arm. Only the current view is changed.
   - **Press and rotate** clockwise or counterclockwise.

     Function: Changes your viewing direction of the robot.
   - **Pinch**. Touch the screen with two fingers and bring them closer together.

     Function: Zooms the robot image out.
   - **Spread**. Touch the screen with two fingers and move them apart.

     Function: Zooms the robot image in.
6. Tap the **Rotation** field, enter your value in degrees, and **Confirm**.
7. Tap the **Tilt** field, enter your value in degrees, and **Confirm**. The current view is updated to show the corresponding change in the robot arm configuration.



Tilted mounting setting

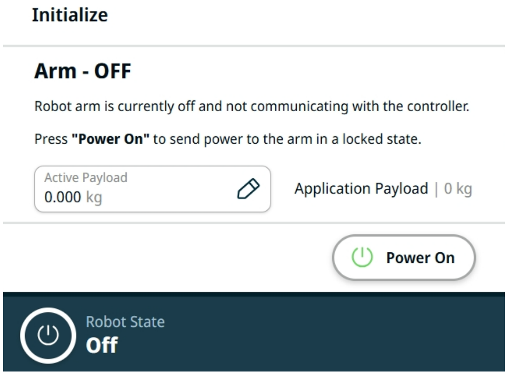
8. Tap the back arrow to return to the previous screen.

Verify active payload

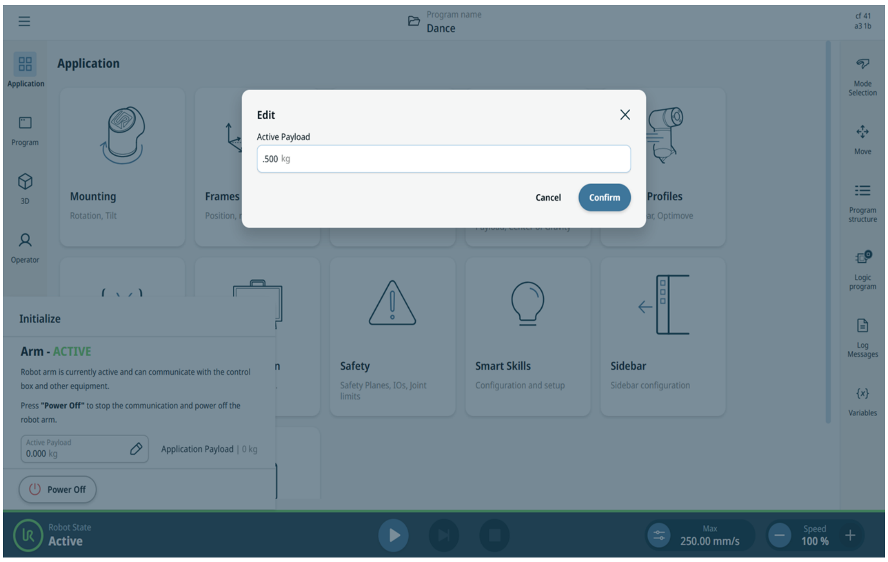
Starting the robot arm disengages the braking system, allowing you to start moving the robot arm and to start using PolyScope X. Before powering on the robot arm, you need to verify that the correct active payload is configured.

1. Check the **Robot State** in the footer of the screen.

   If the state is **Emergency Stopped**, hold and twist the emergency stop button to reset. The arm will then be in **Off** state.
2. Step outside the reach (workspace) of the robot arm.
3. Tap the on-screen **Power** button.



4. In the Initialize box, tap **Power On**. On a new robot or the first boot after the software update, an **Updating Firmware** dialog may appear. When the arm firmware update is complete, the robot state will change to **Locked**.
5. In the **Active Payload** field, verify the payload mass.
6. Tap the **Active Payload** field, and an **Edit** field appears in the main screen.
7. Enter your active payload and tap **Confirm**.



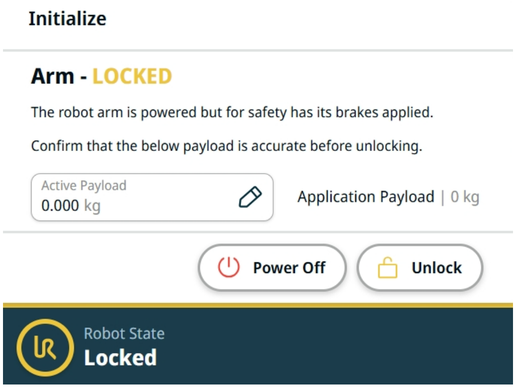
You can now **Unlock** the brakes and start moving the robot arm.

6.6. Starting the Robot Arm

To start the robot

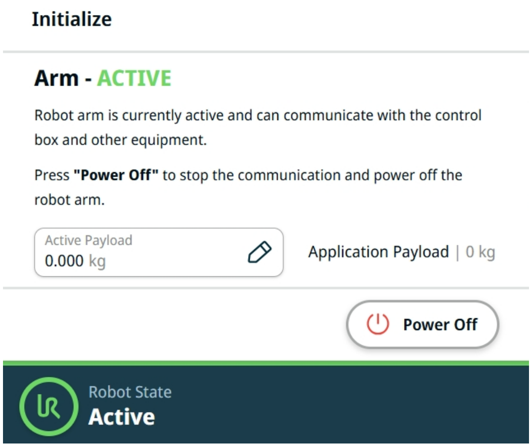
Starting the robot arm disengages the braking system, allowing you to start moving the robot arm and to start using PolyScope X.

1. On the left side of the footer, tap the power or **Robot State** icon.
2. If the robot arm state is **Off**, tap **Power On** in the Initialize box. The robot arm state will change to **Booting** and **Locked**.
3. Tap **Unlock** to release the brakes.



Robot arm initialization is accompanied by sound and slight movements as the joint brakes are released.

4. The robot arm state is now **Active**, and you can start to use the interface.



5. You can tap **Power Off** to turn off the robot arm or check **Freedrive** to verify robot arm mounting.

6.7. Testing Mount and Payload using Freedrive

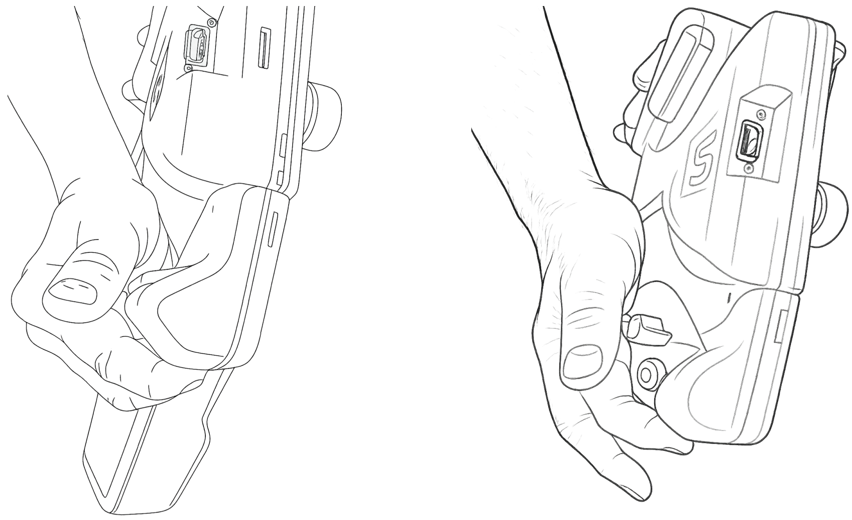
Description

Freedriving the robot lets you quickly check whether the robot is functioning normally and whether mounting settings and payload are correctly specified.
For a detailed description, see the **Freedrive** section.

To test Freedrive

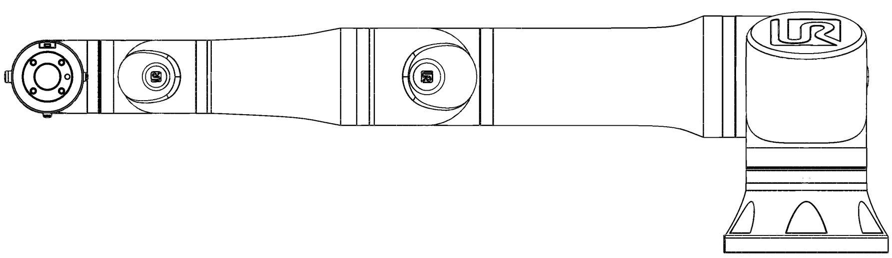
1. Set **Active Payload** to zero if there are no tools attached to the robot arm.
Alternatively, set the **Active Payload**, TCP (tool center point) and CoG (center of gravity) according to tool specifications.
See **Payload and Center of Gravity** for details.
2. To move the robot arm in Freedrive, quickly light-press, release, then light-press again and hold the 3PE button in that position.

   Now you can pull the robot arm into a desired position, while the light-press is maintained.



Light press	Release

3. Pull or push the robot arm to a horizontally elongated position and release. See figure below.



Elongated horizontal position of UR robot

4. Verify the robot arm can maintain this position without support while activating Freedrive.

UNIVERSAL ROBOTS

6.8. Powering Down the Robot

To power down the robot arm

> **WARNING**
>
> Unexpected startup and/or movement can lead to injury.
>
> - Power down the robot arm to prevent unexpected startup during mounting and dismounting.

1. On the left side of the footer, tap the **Robot State** icon to turn off the robot arm.

   The icon color changes from green to white.
2. Press the power button on the Teach Pendant to turn off the Control Box.
3. If a **Shutdown** dialog box appears, tap **Power Off**.

You can now:

- Unplug the mains cable/power cord from the wall socket.
- Wait 30 seconds for the robot to discharge any stored energy.

7. Installation

Description

The robot controller provides multiple interface options to support integration with external equipment, communication systems, and service tools. Proper use of these interfaces enables reliable operation, flexibility in system design, and efficient commissioning of the robot system.

Install and configure safety functions, limits, and protective devices according to the safety instructions and the risk assessment. For details, see the topics under Safety Configuration.

WARNING

Failure to follow any of the below can result in serious injury or death, as the safety functions could be overridden.

- Never connect safety signals to a PLC that is not a safety PLC with the correct safety level. It is important to keep safety interface signals separated from the normal I/O interface signals.
- All safety-related signals shall be constructed redundantly (two independent channels).
- Keep the two independent channels separate so a single fault cannot lead to loss of the safety function.

WARNING: ELECTRICITY

Failure to follow any of the below can result in serious injury or death due to electrical hazards.

- Make sure all equipment not rated for water exposure remains dry. If water is allowed to enter the product, lockout-tagout all power and then contact your local Universal Robots service provider for assistance.
- Only use the original cables supplied with the robot. Do not use the robot for applications where the cables are subject to flexing.
- Use caution when installing interface cables to the robot I/O. The metal plate in the bottom is intended for interface cables and connectors. Remove the plate before drilling holes. Make sure that all shavings are removed before reinstalling the plate. Remember to use correct gland sizes.

CAUTION

Disturbing signals with levels higher than those defined in the specific IEC standards can cause unexpected behavior from the robot. Be aware of the following:

- The robot has been tested according to international IEC standards for **Electromagnetic Compatibility (EMC)**. Very high signal levels or excessive exposure can damage the robot permanently. EMC problems are found to happen usually in welding processes and are normally prompted by error messages in the log. Universal Robots cannot be held responsible for any damages caused by EMC problems.
- I/O cables going from the Control Box to other machinery and factory equipment may not be longer than 30 m, unless additional tests are performed.

GROUND

Negative connections are referred to as Ground (GND) and are connected to the casing of the robot and the Control Box. All mentioned GND connections are only for powering and signalling. For PE (Protective Earth) use the M4-size screw connections marked with frame symbols inside the Control Box. The grounding conductor shall have at least the current rating of the highest current in the system.

7.1. Control Box Connection Ports

Description

The Control Box provides the primary interfaces for communication and data handling within the robot system.

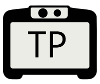
The integrated Ethernet interface enables connection to networked systems, such as PLCs and other control devices, supporting data exchange, remote access, and seamless integration into automated production environments.
In addition, the Control Box includes USB ports for local data operations, allowing easy transfer of programs, backups, and software updates to support commissioning, maintenance, and service activities.

The Control Box (CB7) has 5 Ethernet ports (3 on the connector plate, 1 end-of-arm, and 1 Teach Pendant), 2 USB-A ports, 2 USB-C ports with DisplayPort on both USB-C ports, and an I/O terminal block with 16 configurable digital I/O, analog I/O, and encoder inputs.

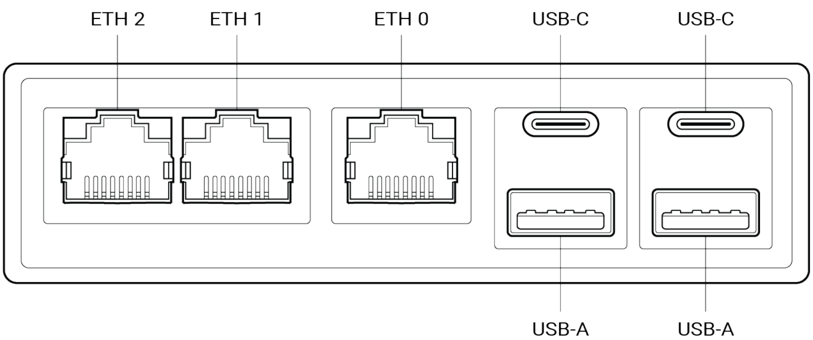
NOTICE
The Ethernet interface supports auto-negotiation and automatically adjusts the communication speed to the highest supported value.

External connection ports

The ports for external connections are as follows:

- 

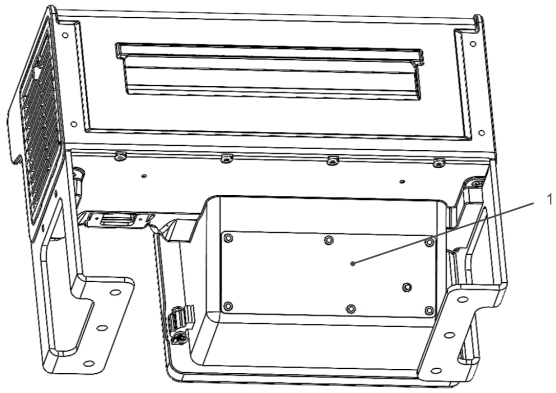
Teach Pendant port to use the Teach Pendant to control or program the robot arm.
- **ETH** Ports to allow Ethernet network connections.
- **USB-C** Ports support external storage devices. DisplayPort output is supported on both USB-C ports.
- **USB-A** Ports support storage and pointing devices. Standard keyboard and mouse could be connected to these ports.
- I/O Terminal Block connects digital, analog, encoder and safety devices through a unified interface.



External Connection Ports

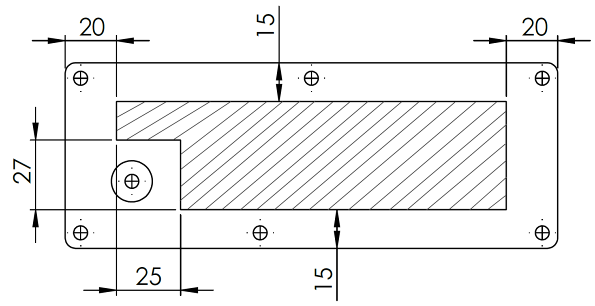
Connecting the Ethernet

1. Remove the cable gland plate from the Control Box case, which is located at the lower back of the Control Box.



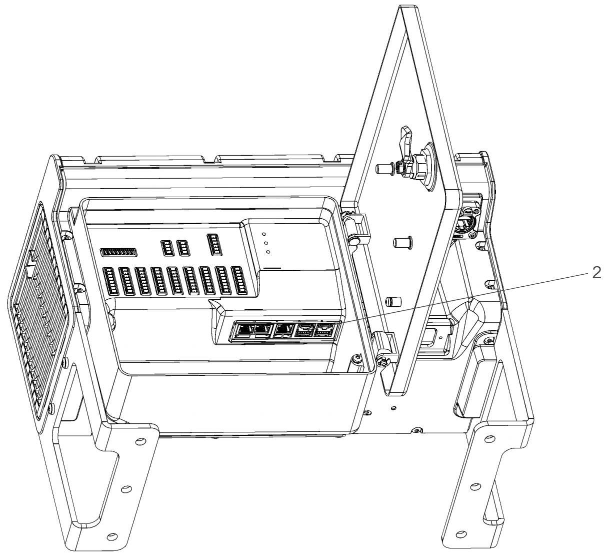
Cable gland plate

2. Drill a hole within the shaded area of the cable gland plate for the Ethernet cable, according to your preference. Size the hole to fit the cable gland for the Ethernet cable.



Inside view of the Cable gland plate

3. Attach a cable gland in the hole, pass the Ethernet cable through the cable gland and connect the cable to the Ethernet port inside the Control Box.



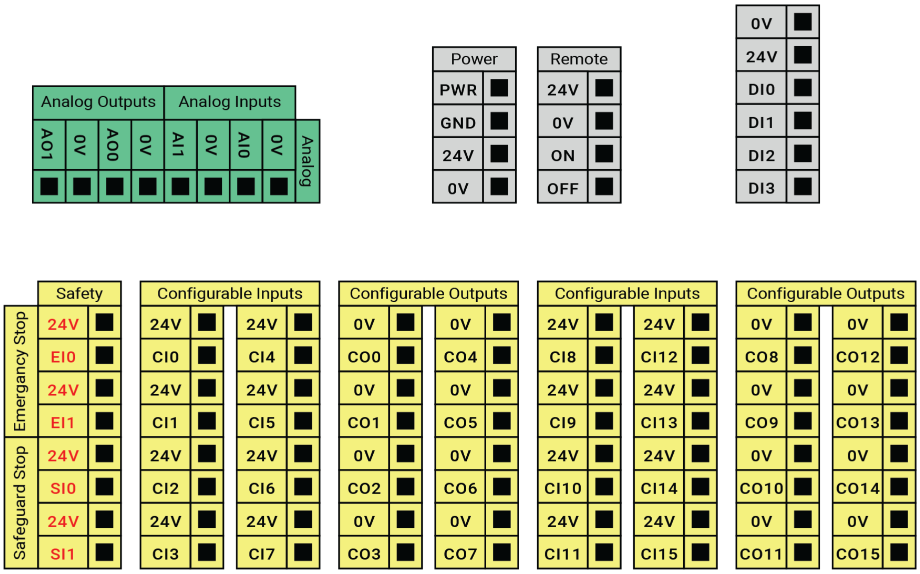
Ethernet port

7.2. Controller I/O Layout

Description

Controller I/Os are the electrical signal interfaces on the robot's Control Box that allow the robot to communicate with external equipment such as sensors, switches, relays, PLCs, conveyor belts, lamps, etc.

The illustration below shows the layout of electrical interface groups inside the Control Box. Observe and maintain the color scheme as illustrated below.



Yellow with red text	Dedicated safety signals
Yellow with black text	Configurable I/Os
Gray with black text	External power, remote ON/OFF and digital input
Green with black text	General purpose analog I/O

CB7 Controller I/Os

NOTICE

Configurable I/O are I/O configured as either safety-related I/O or general purpose I/O. These are the yellow terminals with black text.

Digital I/O specification

The digital I/Os are constructed in compliance with IEC 61131-2. The electrical specifications are shown below.

Terminals	Parameter	Min	Typ	Max	Unit
Digital Outputs					
`[COx / DOx]`	Current*	0	-	1	A
`[COx / DOx]`	Voltage drop	0	-	0.5	V
`[COx / DOx]`	Leakage current	0	-	0.1	mA
`[COx / DOx]`	Function	-	PNP	-	Type
`[COx / DOx]`	IEC 61131-2	-	1A	-	Type
Digital Inputs					
`[EIx/SIx/CIx/DIx]`	Voltage	-3	-	30	V
`[EIx/SIx/CIx/DIx]`	OFF region	-3	-	5	V
`[EIx/SIx/CIx/DIx]`	ON region	11	-	30	V
`[EIx/SIx/CIx/DIx]`	Current (11-30 V)	2	-	15	mA
`[EIx/SIx/CIx/DIx]`	Function	-	PNP +	-	Type
`[EIx/SIx/CIx/DIx]`	IEC 61131-2	-	3	-	Type

*For resistive loads or inductive loads of a maximum of 1 H.

7.3. Dedicated Safety I/O

Description

Dedicated Safety I/O consists of safety inputs and outputs that are hardwired for dedicated safety circuits. Typical circuits include the system Emergency Stop (E-Stop) input and output loops, such as Teach Pendant E-Stop, cabinet external E-Stop buttons, or safety relay outputs.

Safety I/O, identified by yellow terminals with red text, is paired (redundant) so that a single fault does not cause loss of the safety function. Keep the safety I/O as two separate branches.

The permanent safety input types are:

- **Robot Emergency Stop** for emergency stop equipment only.
- **Safeguard Stop** for protective devices.

Install safety devices and equipment according to the safety instructions and the risk assessment. For details, see Safety Configuration.

CAUTION

Failure to verify and test the safety functions regularly can lead to hazardous situations.

- Safety functions shall be verified before putting the robot into operation.
- Safety functions shall be tested regularly.

Stop Categories

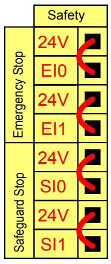
Depending on the circumstances, the robot can initiate three types of stop categories defined according to IEC 60204-1. These categories are defined in the following table.

Stop Category	Description	Stop Function
0	Stop the robot by immediate removal of power.	
1	Stop the robot in an orderly, controlled manner. Power is removed once the robot is stopped.	Emergency Stop
2	*Stop the robot with power available to the drives, while maintaining the trajectory. Drive power is maintained after the robot is stopped.	Safeguard Stop

*Universal Robots' Category 2 stops are further described as SS1 or SS2 type stops according to IEC 61800-5-2.

Default Safety Configuration

The robot is delivered with a default configuration that enables operation without additional safety equipment.



Functional Difference

The following table shows the functional differences between Emergency Stop, Safeguard Stop, and 3PE Stop.

	Emergency Stop	Safeguard Stop	3PE Stop
Robot stops moving	Yes	Yes	Yes
Robot Program execution	Pauses	Pauses	Pauses
Logic Program execution	Continues running	Continues running	Continues running
Drive power	Off	On	On
Reset	Manual	Automatic or manual	Automatic or manual
Frequency of use	Infrequent	Every cycle to infrequent	Every cycle to infrequent
Requires re-initialization	Brake release only	No	No
Stop Category (IEC 60204-1)	1	2	2
Performance level of monitoring function (ISO 13849-1)	PLd	PLd	PLd
Purpose	Emergency use only	Protection from hazards during normal operation	Protects operators performing manual programming, jogging, or teaching inside or near the workspace.
Triggered by	E-Stop button (Teach Pendant or external)	External protective devices, safety inputs	Three-position enabling device (Teach Pendant or external)
Intended use	Last resort	Routine safeguarding (for example, entering a workspace)	User-focused safety; prevents unintended motion whether the operator releases the pendant or squeezes it.

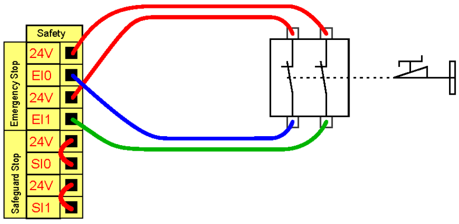
7.3.1. Emergency Stop

Description

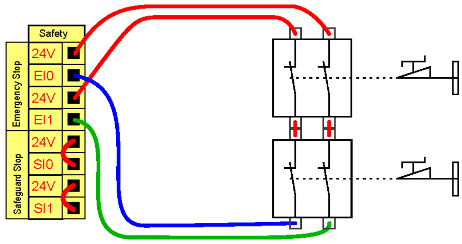
The **System Emergency Stop Output** is driven automatically when the dedicated **Robot Emergency Stop** input or a **Teach Pendant Emergency Stop** is active. The output is monitored, but you cannot change its assignment. It always signals the dedicated emergency stop state to other equipment.

Connecting emergency stop buttons

Most applications require one or more extra emergency stop buttons. The following illustrations show how to connect one or more emergency stop buttons.



Connection for one emergency stop button



Connection for multiple emergency stop buttons

7.3.2. Safeguard Stop

Description

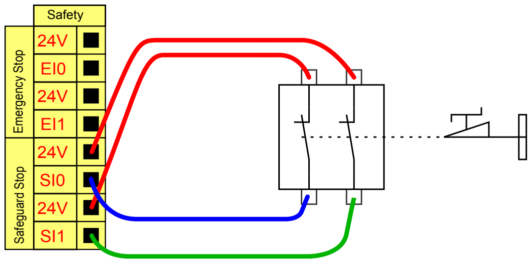
Safeguard Stop is a safety-rated stop function (PLd Category 3) triggered by an external protective device, such as a light curtain, safety gate, area scanner, or pressure mat. It prevents unexpected or unsafe robot motion.

Safeguard Stop with automatic resume

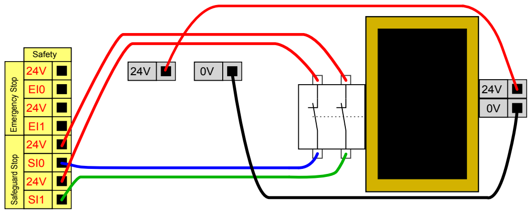
Use automatic reset only when a person cannot remain in the safeguarded space while the safeguard signal is restored.
Use configurable I/O to set up a reset button outside the door to reactivate robot motion. The robot resumes movement automatically when the signal is restored.

WARNING

Do not use this configuration if the signal can be restored from inside the safety perimeter.



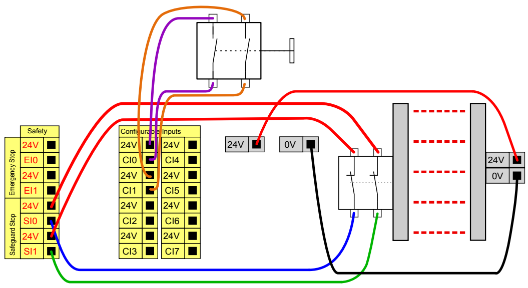
In this example, a door switch is a basic safeguard device that stops the robot when the door opens.



In this example, a safety mat is a safety device for which automatic resume is appropriate. This example also applies to a safety laser scanner.

Safeguard Stop with reset button

If you use the safeguard interface with a light curtain, a reset outside the safety perimeter is required. The reset button must be a two-channel type.



Safeguard Stop with reset button wiring connection

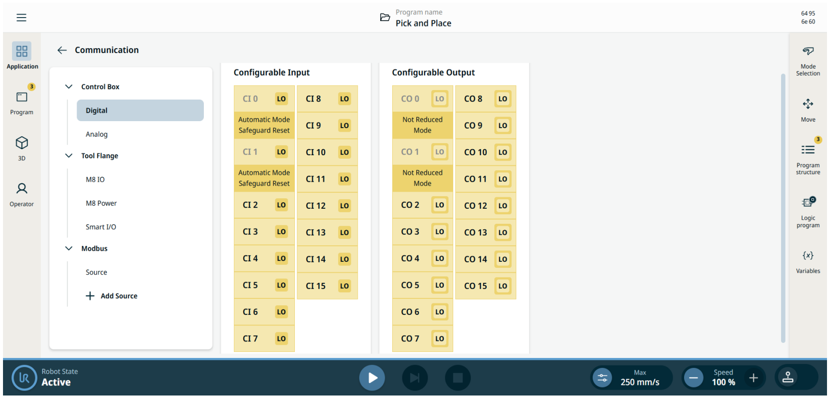
7.4. Configurable I/Os

Description

The Control Box has a set of configurable I/Os that allow you to integrate specific safety or standard functions and external equipment such as sensors, actuators, and control systems.

To monitor and set live I/O signals from and to the Control Box, tap **Communication** > **Control Box** > **Digital** on the Teach Pendant.

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



Configurable I/Os in PolyScope X

CAUTION

Failure to verify and test the safety functions regularly can lead to hazardous situations.

- Safety functions shall be verified before putting the robot into operation.
- Safety functions shall be tested regularly.

NOTICE

Use the configurable I/Os to set up additional safety I/O functionality (for example, **Emergency Stop Output**). Use the PolyScope X interface to define a set of configurable I/Os for safety functions.

Reserved Configurable I/Os

Configurable I/Os can be reserved for special safety settings defined in the Safety I/O setup. Reserved I/Os display the safety function name instead of the default or user-defined name.

Configurable inputs reserved for safety settings cannot be toggled. They display the input status as HIGH (HI) or LOW (LO).

Unreserved Configurable Inputs

For unreserved inputs, the following options are available:

- **Start Program**
- **Stop Program**
- **Pause Program**
- **Freedrive**

Unreserved Configurable Outputs

For unreserved outputs, the following options are available:

- **Low when not running**
- **High when not running**
- **High when running, low when stopped**
- **Low on unscheduled stop**
- **Low on unscheduled stop, otherwise High**
- **High when drive power is on, otherwise Low**
- **Low when drive power is on, otherwise High**
- **Continuous Pulse**

General Purpose I/Os

The General Purpose I/O can be used to drive equipment like pneumatic relays directly or for communication with other PLC systems.

General Purpose Inputs (GPIs) receive digital signals from external devices and can be used to trigger robot actions, monitor system states, or control program flow.

General Purpose Outputs (GPOs) transmit digital signals from the robot controller to external devices, allowing the robot to control peripherals such as grippers, indicators, or interlock systems.

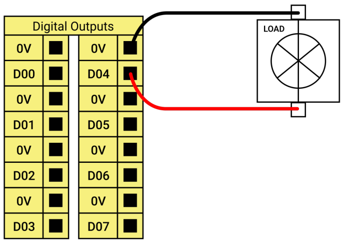
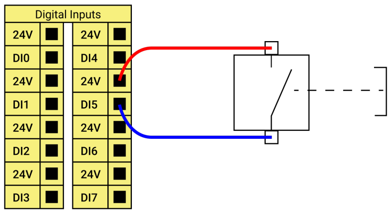
All GPIO signals are software-configurable and can be assigned to specific functions within robot programs or safety configurations.

> **NOTICE**
> The robot system is only a component of a larger installation. Proper design, validation, and testing of all external connections and signal interactions are the responsibility of the integrator.

General Purpose Digital I/O

All General Purpose Digital Outputs can be disabled automatically when program execution is stopped. In this mode, the output is always LOW when a program is not running.

Examples shown in the following subsections, use regular Digital Outputs. Any configurable outputs can be use if they are not configured to perform a safety function.

	
This example shows a load controlled from a Digital Output when connected.	This example shows a simple button connected to a Digital Input.

7.4.1. Drive Power Indicator

Description

The drive power indicator is a light that turns on when the robot arm is powered on or when there is power to the robot cable. When the robot arm is powered off, the drive power indicator turns off.

The drive power indicator is connected via the Configurable Outputs.

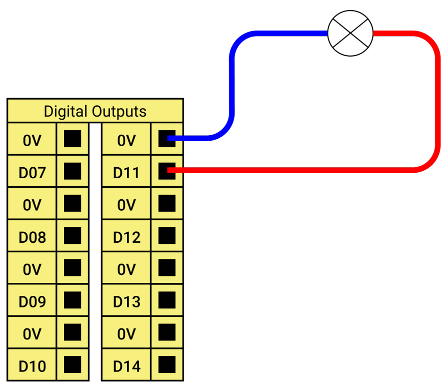
Indicator

The drive power indicator must be a light that can work at 24 VDC.

Set up the indicator

You need a light and wiring for the outputs:

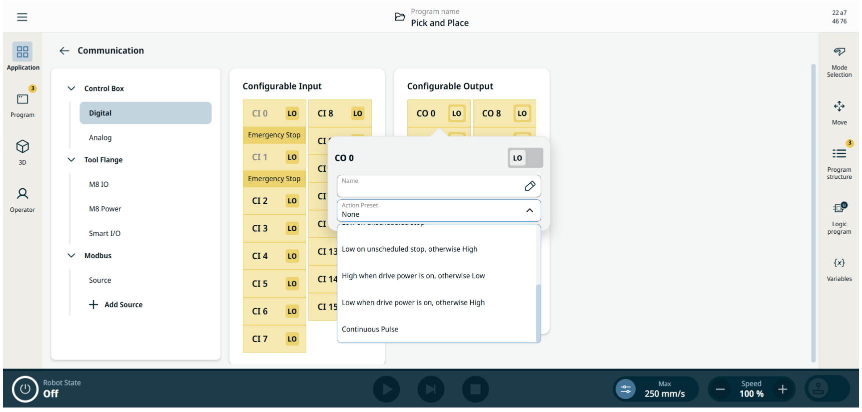
1. Connect your drive power indicator to the Digital Outputs as shown in the image below.
2. Verify that the drive power indicator is correctly connected.
   - Power on the robot arm and verify that the light turns on.
   - Power off the robot arm and verify that the light turns off.



Configure the indicator

1. In the **Navigation** menu, tap **Application**.
2. Select **Communication**.
3. In the side menu, expand **Control Box** and select **Digital**.
4. Tap the desired **Configurable Output** type.
5. Select **Action Preset**.

   You can name the selected output.
6. In the drop-down menu, select **High when drive power is on, otherwise Low**.

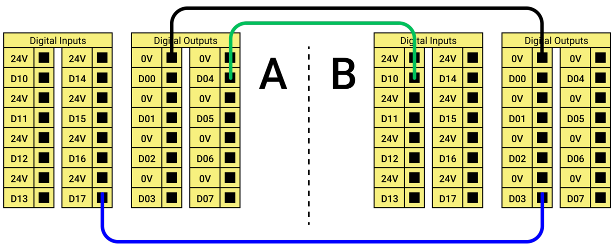


Configuring the drive power indicator

7.4.2. Communication with Other Machines or PLC

Description

Use the digital I/O to communicate with other equipment when a common GND (0 V) is established and the machine uses PNP technology, as shown below.



Digital I/O connection to other machines

NOTICE

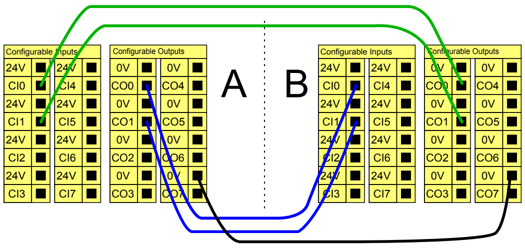
Use shielded cables to connect digital I/Os.

Sharing the Emergency Stop with Other Machines

You can set up a shared emergency stop function between the robot and other machines by configuring the following I/O functions in PolyScope X. The **Robot Emergency Stop** input cannot be used for sharing. If you connect more than two UR robots or other machines, use a safety PLC to control the emergency stop signals.

- Configurable input pair: **External Emergency Stop**.
- Configurable output pair: **System Stop**.

The illustration below shows how two UR robots share their emergency stop functions. In this example, the configured I/Os used are CI0-CI1 and CO0-CO1.



Digital I/O connection for shared emergency stop

NOTICE

The image shown is an example only. Verify its suitability as part of the system safety design.

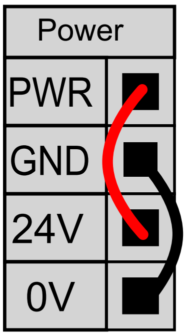
7.5. I/O Supply Power

Description

It is possible to power the digital I/O from an internal 24 V power supply or from an external power source by configuring the terminal block called **Power**. This block consists of four terminals. The upper two (PWR and GND) are 24 V and ground from the internal 24 V supply. The lower two terminals (24V and 0V) in the block are the 24 V input to supply the I/O. The default configuration uses the internal power supply.

Internal power supply

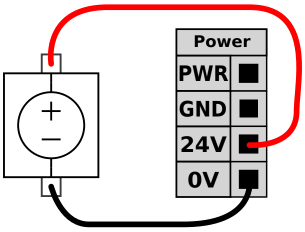
In this example, the default configuration uses the internal power supply. This is the factory default setting used when the robot is delivered.



Internal power supply default configuration

External power supply

If more current is needed, you can connect an external power supply as shown below.



External power supply

In this example, the configuration uses an external power supply for more current.

7.6. Remote ON/OFF control

Description

Use remote **ON/OFF** control to turn the Control Box on and off without using the Teach Pendant. Remote control is typically used:

- When the Teach Pendant is inaccessible.
- When a PLC system must have full control.
- When several robots must be turned on or off at the same time.

CAUTION

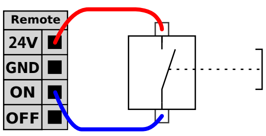
Maintaining a press and hold on the power button switches the Control Box off without saving.

- Do not press and hold the **ON** input or the **POWER** button without saving.
- Use the **OFF** input for remote OFF control to allow the Control Box to save open files and shut down correctly.

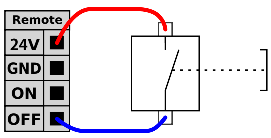
Remote Control

The remote **ON/OFF** control provides an auxiliary 24 V supply, which remains active when the Control Box is turned off. The **ON** input is intended for short-time activation only and works the same way as the **POWER** button. The **OFF** input can be held down as desired. Use a software feature to load and start programs automatically.
The electrical specifications are shown below.

Terminals	Parameter	Min	Typ	Max	Unit
`[24V - GND]`	Voltage	22.8	24	25.2	V
`[24V - GND]`	Current	-	-	100	mA
`[ON / OFF]`	Inactive voltage	-3	-	5	V
`[ON / OFF]`	Active voltage	11	-	30	V
`[ON / OFF]`	Input current	2	-	15	mA
`[ON]`	Activation time	200	-	600	ms



This example illustrates connecting a remote **ON** button.

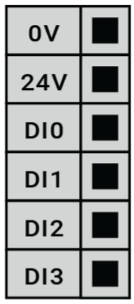


This example illustrates connecting a remote **OFF** button.

7.7. Digital Input for Conveyor Tracking

Description

You can use the Digital Inputs block (DI 0-DI 3), illustrated below, for quadrature encoding Conveyor Tracking.



Digital Input

Conveyor tracking in PolyScope X

Refer to the support article Conveyor Tracking: Using Encoder with Digital Pulses on the Universal Robots website.

7.8. General Purpose Analog I/O

Description

The analog I/O interface is the green terminal block. You use it to set or measure voltage (0-10 V) or current (4-20 mA) to and from other equipment.
The following directions are recommended to achieve the highest accuracy:

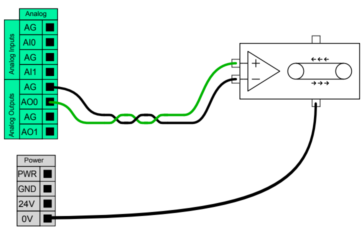
- Use the AG terminal closest to the I/O. The pair shares a common mode filter.
- Use a shielded cable. Connect the shield to the 0V terminal.
- Use equipment that works in current mode. Current signals are less sensitive to interference.

Electrical Specifications

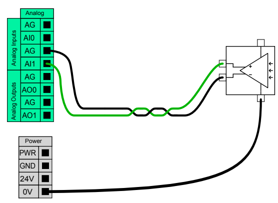
You can select input modes in PolyScope X. The electrical specifications are shown below.

Terminals	Parameter	Min	Typ	Max	Unit
Analog Input in current mode					
`[AIx - AG]`	Current	4	-	20	mA
`[AIx - AG]`	Resistance	-	TBD	-	ohm
`[AIx - AG]`	Resolution	-	16	-	bit
Analog Input in voltage mode					
`[AIx - AG]`	Voltage	0	-	10	V
`[AIx - AG]`	Resistance	-	10	-	Kohm
`[AIx - AG]`	Resolution	-	16	-	bit
Analog Output in current mode					
`[AOx - AG]`	Current	4	-	20	mA
`[AOx - AG]`	Voltage	0	-	TBD	V
`[AOx - AG]`	Resolution	-	13	-	bit
Analog Output in voltage mode					
`[AOx - AG]`	Voltage	0	-	10	V
`[AOx - AG]`	Current	-20	-	20	mA
`[AOx - AG]`	Resistance	-	1	-	ohm
`[AOx - AG]`	Resolution	-	13	-	bit

Analog Output and Analog Input



This example illustrates controlling a conveyor belt with an analog speed control input.



This example illustrates connecting an analog sensor.

8. End Effector Integration

Description

The end effector is the tool mounted on the tool flange and forms a critical part of the robot system. Proper integration is required to ensure safe operation and reliable application performance.
During integration, ensure correct mechanical mounting and define the end effector mass, center of gravity, and inertia accurately, as these affect motion, payload limits, and safety functions. Verify that electrical interfaces and I/O connections meet system requirements to avoid faults or damage.
Also consider the tool's interaction with the environment, including forces, timing, and potential hazards. All risks introduced by the end effector must be addressed as part of the system risk assessment.

The end effector can also be referred to as the tool and the workpiece in this manual.

NOTICE

UR provides documentation for the end effector to be integrated with the robot arm.

- Refer to the documentation specific to the tool/end effector/workpiece for mounting and connection.

8.1. Maximum Payload g-Series

Description

The rated robot arm payload depends on the center of gravity (CoG) offset of the payload, as shown below. The CoG offset is defined as the distance from the center of the tool flange to the center of gravity of the attached payload.

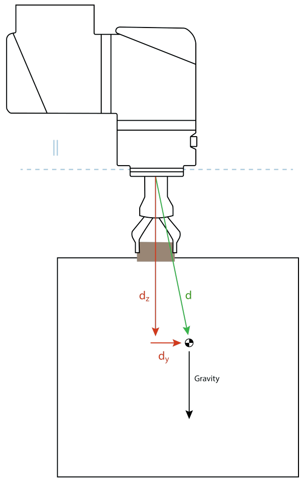
The robot arm can accommodate a long center of gravity offset, if the payload is placed below the tool flange. For example when computing the payload mass in a pick and place application, consider both the gripper and the workpiece.

The robot's capacity to accelerate can be reduced if the payload CoG exceeds the robot's reach and payload. You can verify the reach and payload of your robot in the Technical Specifications.

Payload capacity increase

The robot arm can accommodate higher payloads and longer CoG offsets if the payload is placed below the tool flange. You can increase the maximum payload capacity of the robot arm when the following criteria are met:

- Movement with high payload is with the tool oriented vertically downward, as is often the case in palletizing applications.
- The payload CoG is within the nominal horizontal reach of the robot.
- The CoG offset in the horizontal XY-plane does not exceed the expanded payload curve (long offsets in the Z-axis exceeding the payload curve are not an issue).



Computing the horizontal center of gravity offset

As illustrated above, the horizontal payload offset $\mathbf{d_y}$ should be within the payload curve.

Expanded payload is possible for any robot mounting orientation.

Increasing the maximum payload capacity can cause the robot to move at reduced speeds and acceleration. The higher load on the joints can limit some motions inside the working range of the robot. The robot software automatically ensures the mechanical limits of the robot are not exceeded.

NOTICE

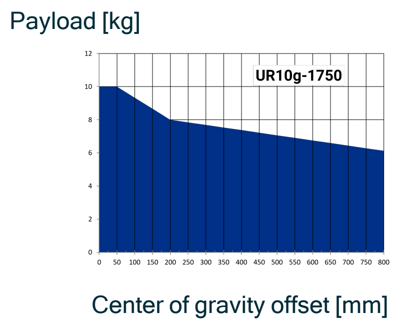
Using the expanded payload range does not void your robot warranty for this robot.

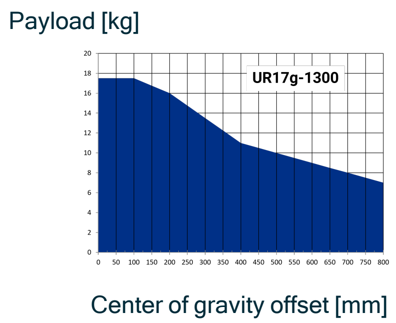
Payload inertia

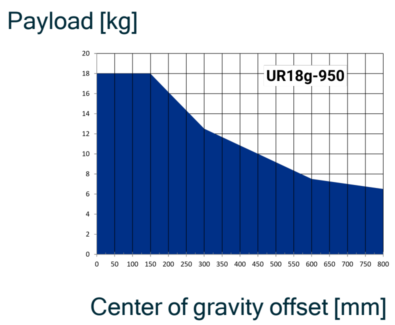
You can configure high inertia payloads, if the payload is set correctly.
The controller software automatically adjusts accelerations when the following parameters are correclty configured:

- Payload mass
- Center of gravity
- Inertia

You can use the URSim to evaluate the accelerations and cycle times of the robot motions with a specific payload.







UR10g-1750	UR17g-1300	UR18g-950

	Expanded Payload
	Full Performance

8.2. Mounting the End Effector

Description

The tool is mounted at the robot tool output flange. The flange complies with ISO 9409-1 and provides a standardized mechanical interface for accurate and secure attachment of end-effector tooling.
The interface is defined as ISO 9409-1-50-4-M6, ensuring compatibility with a wide range of tools designed to this standard.
To achieve precise positioning while avoiding mechanical over-constraint, it is recommended to use a radially slotted hole for the positioning pin.
This allows slight radial tolerance during mounting while maintaining accurate alignment of the tool relative to the robot flange.

NOTICE

The **Tool Connector** must be tightened to a maximum of 0.4 Nm.

CAUTION

Very long M6 bolts can press against the bottom of the tool flange and short-circuit the robot.

- Do not use bolts that extend beyond 8 mm to mount the tool.

WARNING

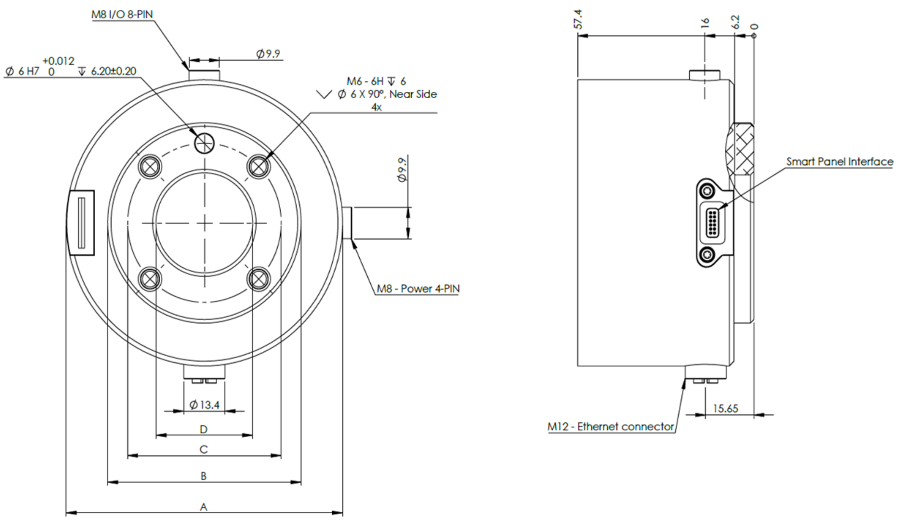
Failure to tighten bolts properly can cause injury due to loss of adapter flange and/or end-effector.

- Ensure the tool is properly and securely bolted in place.
- Ensure the tool is constructed such that it cannot create a hazardous situation by dropping a part unexpectedly.

Tool Flange The tool output flange is where the tool is mounted at the tip of the robot. Universal Robots uses ISO 9409-1 for the dimensions of the tool flanges.

	UR10g-1750	UR17g-1300	UR18g-950
Tool flange size	ISO 9409-1-50-4-M6	ISO 9409-1-50-4-M6	ISO 9409-1-50-4-M6

It is recommended to use a radially slotted hole for the positioning pin to avoid over-constraining, while keeping precise position.



A	OD (Outer Diameter)	C	PCD (Pitch Circle Diameter)
B	POD (Protrude Outer Diameter)	D	PID (Protrude Inner Diameter)

Tool output flange

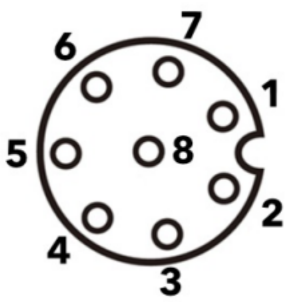
The following topics describe the electrical interfaces at the tool flange:

- For power and control signals for grippers and sensors, see M8 I/O 8-Pin.
- For pin assignment and electrical ratings of this power connector, see M8 Power 4-Pin.
- For Ethernet at the tool flange, see M12 Ethernet Connector.
- For the Smart Panel electrical interface, see Pogo Pin Connector .

8.3. M8 I/O 8-Pin

Description

The 8-pin I/O M8 Tool Connector provides power and control signals for grippers and sensors used on robot tools. The tool connector has eight holes and is located next to the tool flange on Wrist 3.
The eight wires inside the connector have different functions, as listed in the following table.
The electrical specifications are shown below. Access Tool I/O in the Installation Tab to set the internal power supply to 0 V, 12 V or 24 V.

M8 I/O 8-Pin Tool Connector	Pin #	Signal	Description
	1	AI3 / RS485-	Analog in 3 or RS485-
	2	AI2 / RS485+	Analog in 2 or RS485+
	3	TO0/PWR	Digital Outputs 0 or 0 V/12 V/24 V
	4	TO1/GND	Digital Outputs 1 or Ground
	5	POWER	0 V/12 V/24 V
	6	TI0	Digital Inputs 0 / Safety Input
	7	TI1	Digital Inputs 1 / Safety Input
	8	GND	Ground

Parameter	Min	Typ	Max	Unit
Supply voltage, 24 V	23.5	24	24.8	V
Supply voltage, 12 V	11.5	12	12.5	V
Supply current, continuous, single pin*	-	-	1	A
Supply current, peak, single pin*	-	-	2**	A
Supply current, continuous, dual pin*	-	-	2	A
Supply current, peak, dual pin*	-	-	2**	A
Supply capacitive load	-	-	8***	mF

* When connecting inductive loads, a protective diode shall be used.

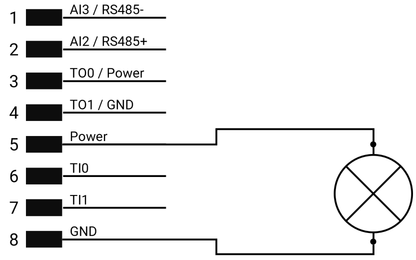
** Maximum peak duration is 1 second, with a duty cycle of maximum 10 %. The average current over 10 seconds must not exceed maximum continuous current.

*** When tool power is enabled, a soft start time begins to allow a capacitive load of 8 mF to be connected to the tool power supply at start-up. Hot-plugging the capacitive load is not allowed.

8.3.1. Tool Power Supply

Description

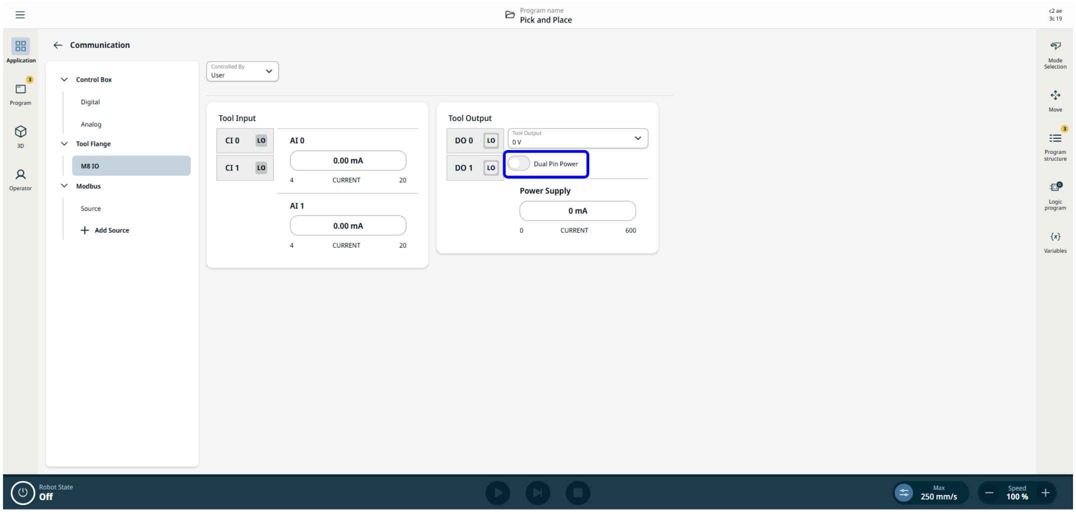
The tool power is supplied through dedicated power and ground pins in the tool connector. The output can be used to power external equipment directly from the robot without requiring a separate power source, provided the connected device remains within the specified electrical limits.



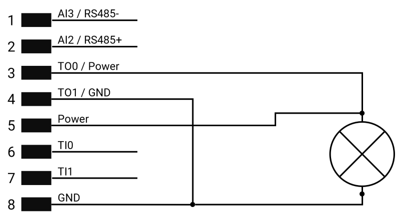
Tool power supply connection

Dual Pin Power Supply

In **Dual Pin Power** mode, the output current can be increased as listed in **Tool I/O**.



1. In the main navigation, tap **Application**.
2. In the main screen, tap **Communication**.
3. Tap **Robot**>**Tool I/O** and activate **Dual Pin Power**.
4. Connect the Power wire to TO0 and the Ground wire to TO1.



Connecting power wires

NOTICE
After an Emergency Stop, the voltage is set to 0 V for both power pins (power is off).

Current through GND

The electrical specifications are shown below:

Parameter	Min	Typ	Max	Unit
Current through GND, continuous	0	-	2000	mA
Current through GND, peak	0	-	3000*	mA

* Peak for max 1 second, duty cycle max: 10%. Average current over 10 seconds must not exceed continuous current.

8.3.2. Tool Digital Inputs

Description

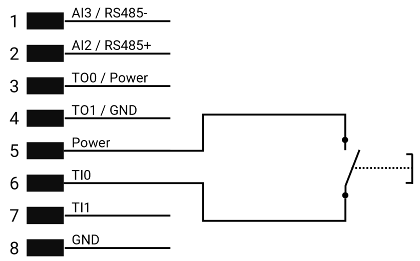
The Tool Digital Inputs allow external devices connected to the tool connector to provide signals directly to the robot controller. Typical applications include sensors, push buttons, part detection devices, and status signals from end-effectors. The state of the digital inputs can be monitored and used within robot programs to control robot behavior and application logic.

The Digital Inputs are implemented as PNP with weak pull-down resistors. This means that a floating input always reads as LOW. The electrical specifications are shown below.

Parameter	Min	Type	Max	Unit
Input voltage	-0.5	-	26	V
Logical LOW voltage	-	-	2.0	V
Logical HIGH voltage	5.5	-	-	V
Input resistance	-	47	-	kΩ

Using the Tool Digital Inputs

Tool Digital Inputs enable external devices and sensors to send signals to the robot system. Configure Tool Digital Inputs to detect and respond to input signals from equipment connected to the tool.

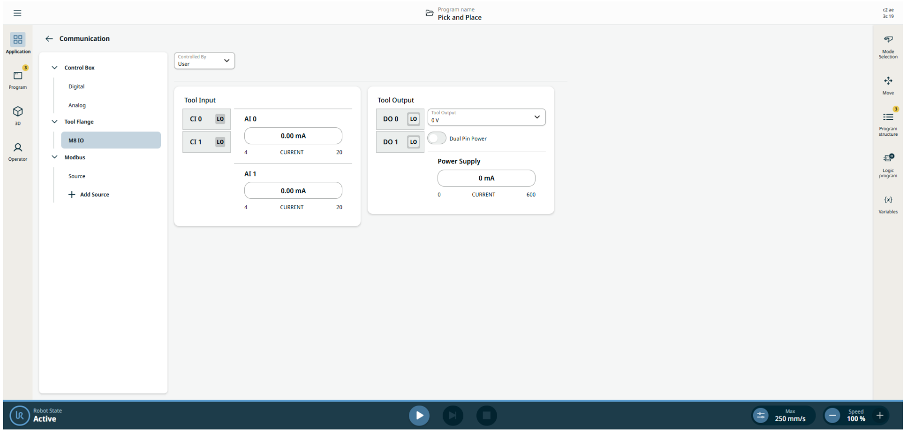


Digital tool connection

Configuring Tool Digital Inputs

To configure Tool Digital Inputs in PolyScope X:

1. On the main navigation, tap **Application**.
2. Select **Communication**.
3. Expand **Tool Flange** and select **M8 I/O**.
4. Configure the input settings as required.
5. Verify that the input changes state when the connected device is activated.



8.3.3. Tool Digital Outputs

Description

The Tool Digital Outputs allow the robot to control external devices connected to the tool connector, such as grippers, valves, indicators, relays, and other end-effectors. Output signals can be controlled from PolyScope X, robot programs, or URScript to interact with external equipment during robot operation.

CAUTION

The Digital Outputs in the tool are not current-limited. Overriding the specified data can cause permanent damage.

Output Modes

The tool digital outputs are integrated into the tool connector and can be configured to operate in different output modes to support a wide range of external devices and control architectures.

Mode	Active	Inactive
Sinking (NPN)	Low	Open
Sourcing (PNP)	High	Open
Push / Pull	High	Low

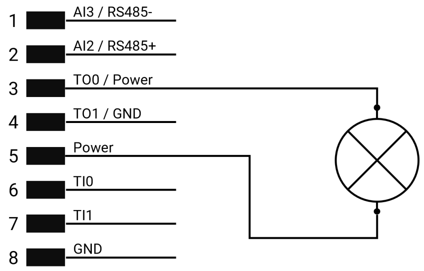
Access Tool I/O in the Installation Tab to configure the output mode of each pin. The electrical specifications are shown below:

Parameter	Min	Typ	Max	Unit
Voltage when open	-0.5	-	26	V
Voltage when sinking 1A	-	-	0.09	V
Current when sourcing/sinking, continuous	0	-	600	mA
Current when sourcing/sinking, peak	0	-	1000*	mA

* Peak for max 1 second, duty cycle max: 10%. Average current over 10 seconds must not exceed continuous current.

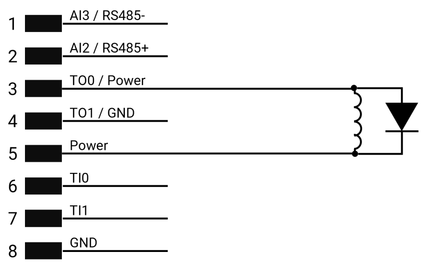
Using Tool Digital Outputs

This example illustrates turning on a load using the internal 12 V or 24 V power supply. The output voltage at the I/O tab must be defined. There is voltage between the POWER connection and the shield/ground, even when the load is turned off.



Digital tool output

When connecting inductive loads, a protective diode shall be used, as shown below.

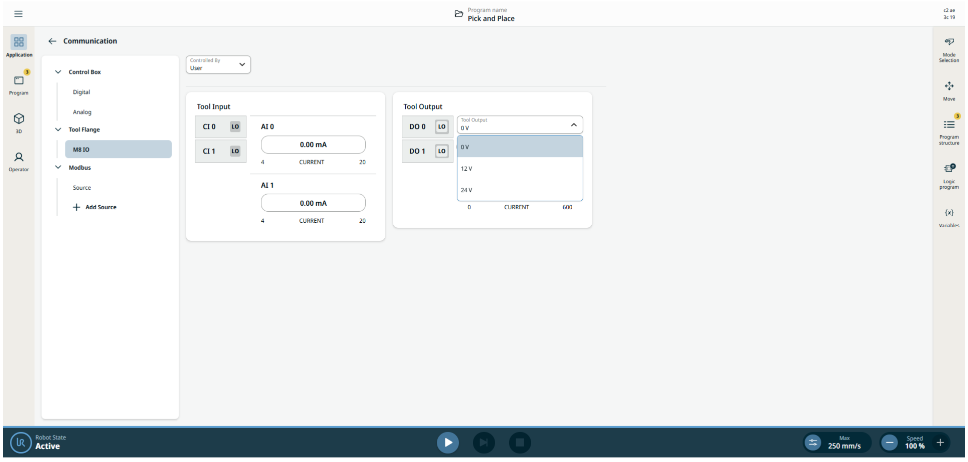


Inductive loads with protective diode

8.3.4. Tool Analog Inputs

Description

Tool Analog Inputs are non-differential and can be set to either voltage (0-10 V) or current (4-20 mA) on the **Communication**>**Tool Flange** tab.



The electrical specifications are shown below.

Parameter - Voltage mode	Min	Type	Max	Unit
Input voltage in voltage mode	-0.5	-	26	V
Input resistance @ range 0 V to 10 V	-	10.7	-	kΩ
Resolution	-	12	-	bit

Parameter - Current mode	Min	Type	Max	Unit
Input voltage in current mode	-0.5	-	5.0	V
Input current in current mode	-2.5	-	25	mA
Input resistance @ range 4 mA to 20 mA	-	182	188	Ω
Resolution	-	12	-	bit

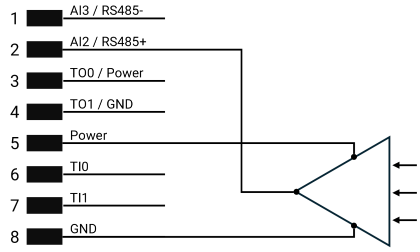
Two examples of using Analog Inputs are shown in the following subsections.

CAUTION

Analog Inputs are not protected against overvoltage in current mode. Exceeding the limit in the electrical specification can cause permanent damage to the input.

Using Tool Analog Inputs, Non-differential

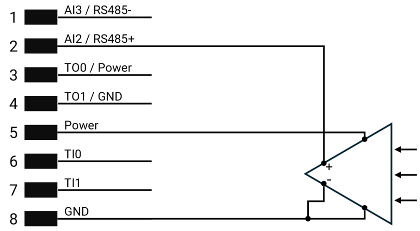
This example shows an analog sensor connection with a non-differential output. The sensor output can be either current or voltage, as long as the input mode of that Analog Input is set to the same mode in PolyScope X.
Note: You can check that a sensor with voltage output can drive the internal resistance of the tool, or the measurement might be invalid.



Analog sensor - non-differential output

Using Tool Analog Inputs, differential

This example shows an analog sensor connection with a differential output. Connecting the negative output part to GND (0 V) works in the same way as a non-differential sensor.

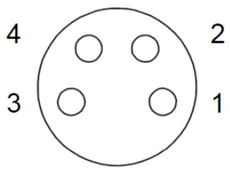


Analog sensor - differential output

8.4. M8 Power 4-Pin

Description

The 4-pin Power M8 Tool Connector is a 4-pin A-coded female connector according to EN 61076-2-104.

M8 Power 4-Pin Tool Connector	Pin #	Signal	Description
	1	-	+24/+48 V power
	2	-	+24/+48 V power
	3	-	Ground
	4	-	Ground

The electrical specifications are shown below. Access Tool I/O in the Installation Tab to set the internal power supply to 0 V, 24 V or 48 V.

Parameter	Min	Typ	Max	Unit
Output voltage, 48 V	42	48	50	V
Output voltage, 24 V	23	24	25	V
Output current, continuous	-	-	3	A
Output current, peak*	-	-	5	A
Output capacitive load	-	-	8	mF

* Maximum peak duration is 2 seconds, with a duty cycle of maximum 10 %. The average current over 20 seconds must not exceed maximum continuous current.

WARNING: ELECTRICITY

To prevent overloading, simultaneous loading of both M8 connectors is restricted. If the current drawn from one connector is 1 A or greater, the current drawn from the other connector shall not exceed 100 mA.

NOTICE

When the current drawn from the 4-pin M8 connector is greater than 2 A, both power pins and both return pins shall be connected.

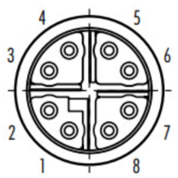
8.5. M12 Ethernet Connector

M12 Ethernet Connector

The M12 Ethernet port eliminates the need to route external Ethernet cables along the robot arm. It enables direct connection of:

- Ethernet-based grippers and end-effectors
- 2D/3D vision cameras
- Fieldbus devices (Modbus TCP, PROFINET, EtherNet/IP, EtherCAT via URCap)
- Any networked tooling at end-of-arm

This interface is a shielded 8-pin M12 X-code female connector according to IEC 61076-2-109, 100BASE-TX (IEEE 802.u) and 1000BASE-T (IEEE 802.3ab) with a length limited to 3 m.

M12 Ethernet Tool Connector	Pin #	Signal	Description
	1	-	D1+
	2	-	D1-
	3	-	D2+
	4	-	D2-
	5	-	D3+
	6	-	D3-
	7	-	D4+
	8	-	D4-

8.6. Pogo Pin Connector

Description

The tool flange is equipped with a Pogo Pin connector that provides an electrical interface for the Smart Panel.
The Pogo Pin connector enables transmission of power and signals between the robot and the mounted tool without the need for external cabling at the interface.
It uses spring-loaded contact pins to establish electrical contact when the tool is correctly mounted on the flange. The Pogo Pin connector is designed to ensure reliable contact during operation while compensating for small mechanical tolerances.
It supports repeated mounting and dismounting of compatible end-effectors while maintaining a stable electrical connection.

Female Pogo-Pin Connector

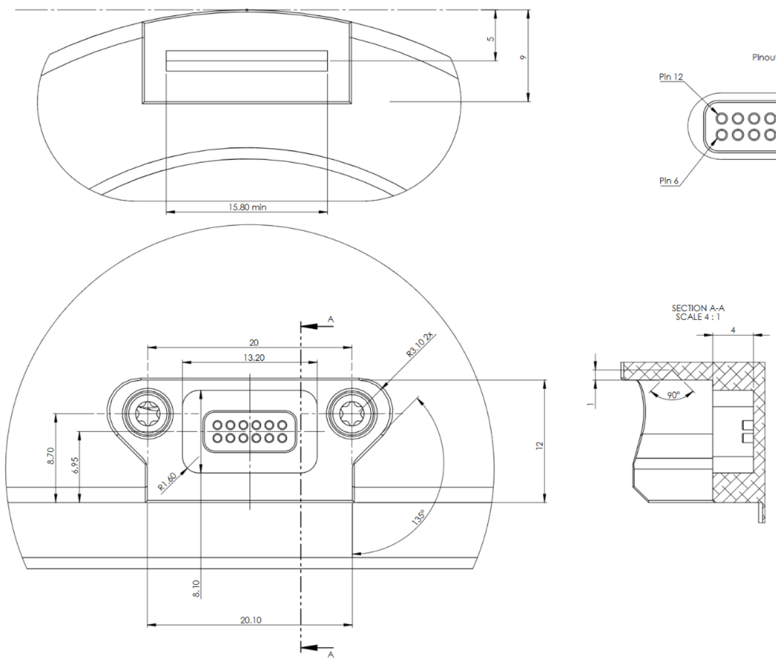
The female connector is situated on the tool flange, and is used to mount the button pad on the tool flange.

Male Pogo-Pin Connector

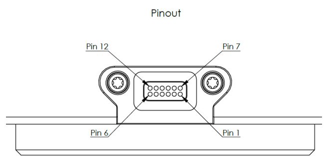
The keypad on the tool flange is attached with a 12-pin spring-pin interface, with the spring-pins being located on the robot-side, and capture pads on the mating connector.

The customer-side interface must adhere to the dimensions and pin designations according to Connector interface schematic below.

Pin description



Connector interface schematic

Pogo Pin Connector	Pin	Signal	Description
	1	Safety DI 1B	Safety Digital Input 1B
	2	GND	Ground
	3	DO1	Digital Output 1
	4	DO2	Digital Output 2
	5	DO3	Digital Output 3
	6	DO4	Digital Output 4
	7	Presence	Identification
	8	5 V	5 V output voltage
	9	Safety DI 1A	Digital Input 1 / Safety Digital Input 1A
	10	DI2	Digital Input 2
	11	DI3	Digital Input 3
	12	DI4	Digital Input 4

Specification

Description	Minimum	Typical	Maximum
Output voltage, supply pin	4.7 V	5 V	5.3 V
Output current, supply pin, continuous	-	-	250 mA
Digital output type		Open drain	
Digital output, sink current, per pin	-	-	100 mA
Digital output leakage current when not actively driven LOW	-	-	500 nA
Digital positive-going input threshold voltage	-	-	3.7 V
Digital negative-going input threshold voltage	1.1 V	-	-
Digital input resistance	-	33 kΩ	-

NOTICE

The digital input is of open-drain type and requires an external pull-up resistor to the supply pin.

The digital inputs, including the safety input, have a weak (33 kΩ) pull-down to GND.
The safety input has the same specifications as the basic digital inputs and has been designed according to ISO 13849-1 Category 3 PLd.

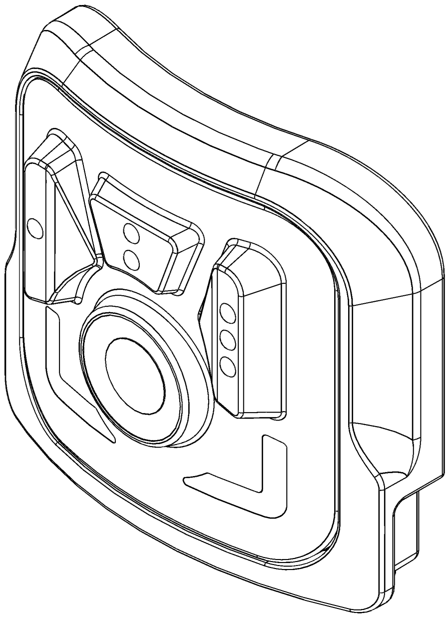
8.7. SP7 Smart Panel

Description

The **SP7 Smart Panel** is an optional accessory for g-Series robots. It mates with the 12-pin spring-pin (**pogo**) interface on the tool flange.
The panel is **detachable**. You can remove it when the application does not need end-of-arm buttons or LEDs, or when a UR+ end-of-arm device uses the same interface.
When mounted correctly, the robot arm and panel assembly are designed to maintain the environmental specifications of the robot arm, including ingress protection.

Typical uses include:

- Freedrive and hand-guided teaching at the end of the arm.
- Operator shortcuts by mapping Smart Skills to the programmable buttons.
- Status indication with the panel LEDs.



SP7 Smart Panel

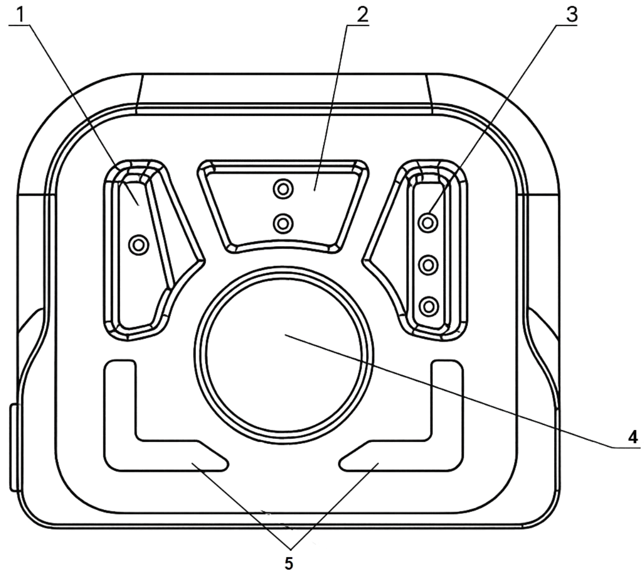
System connection

The smart panel connects only through the pogo interface on the tool flange. For mechanical interface and pin electrical specifications, see documentation for the pogo connector.

- **Power:** The robot supplies 5 V on the pogo interface when a compatible device is detected. Panel power is not controlled from programs.
- **Detection:** The controller detects whether a smart panel (or compatible device) is attached. Smart Panel button and lamp signals are available when the panel is present.
- **Mounting:** Mate and secure the panel and any end-of-arm tooling according to Securing Tool - Performance Tool Flange.

Controls on the panel

The smart panel has **four buttons** and **two LED indicators** on the housing.
Do not confuse the large center control with the three smaller programmable buttons.



Smart Panel buttons and indicators

	Control	PolyScope X UI reference	Role
1	Left button	**Button Left**	Programmable button input; map to a Smart Skill or use as a digital input in programs.
2	Center button (2)	**Button Center**	Programmable button input; map to a Smart Skill or use as a digital input in programs.
3	Right button (3)	**Button Right**	Programmable button input; map to a Smart Skill or use as a digital input in programs.
4	Center button (4)	Not configurable in UI.	Safety-rated **two-channel (2PE)** Freedrive / hand-guided control at the end of the arm.
5	LED indicators (5)	**Lights**	LED color when neutral is white. The interface also provides additional lamp outputs for integration; configure lamp outputs in **Tool I/O** when needed.

Integrator signal names (PTF Smart Panel connector, prefix **T1_**):

Function	Tool signal	URScript example
Left / Center / Right buttons	BI 0 ... BI 2	T1_DI0, T1_DI1, T1_DI2
Freedrive (2PE)	SBI 3, SBI 4	T1_DI3, T1_DI4 (safety)
Panel detection	SD	T1_DI5
LEDs / lamps	LO 0 ... LO 3	T1_DO0 ... T1_DO3

Safety and Freedrive

The center Freedrive button uses a **safety-rated input** on the pogo interface (designed according to ISO 13849-1 Category 3 PLd; see Pogo Pin Connector table). The safety system monitors this input; it is **not** assigned under **Smart Panel** or as a normal tool digital input action.
You cannot enable or disable Freedrive on the panel from application software. Use the center button according to your risk assessment for hand-guided control and Freedrive at the end of the arm.

WARNING

Injury to personnel can occur due to unexpected motion in Freedrive.

- Verify the configured payload matches the payload in use.
- Do not enable Freedrive while you are pushing or touching the robot arm.
- Use Freedrive only where your risk assessment allows it.

NOTICE

Freedrive on robot in **Safety I/O** assigns **other** tool or control box inputs. It does not replace or configure the smart panel center Freedrive button.

Use Freedrive with Smart Panel

1. Ensure the smart panel is mounted and detected.
2. Put the robot in a mode that allows Freedrive (for example Manual mode with applicable safeguards).
3. Press and hold the **center Freedrive button** on the panel to move the robot arm with reduced resistance, subject to safety limits and planes.
4. Release the button to exit Freedrive.

Configuring the Smart Panel in PolyScope X

Configure **what the three programmable buttons do** in the **Smart Panel** source. Configure **pin-level tool signals** (including lamp outputs and input presets) in **Tool I/O**.

1. On the main navigation, tap **Application**, then open **Sources**.
2. Select **Smart Panel**.
3. For **Button Left**, **Button Center**, and **Button Right**, choose a **Smart Skill** instance or **None**.
4. Set **Lights** to **On** or **Off**.

When a mapped button is pressed, PolyScope X toggles the assigned Smart Skill (starts it if inactive, stops it if already running).

Contributed Smart Skills from URCaps can be assigned the same way as native skills.
Tool I/O (signals and lamps)

1. Go to **Application** → **Communication**. See Communication.
2. Select **Robot Tool I/O** / **Tool I/O** to monitor or set Smart Panel-related signals when exposed in the UI.

NOTICE

If a tool input is assigned a **safety function**, you cannot assign the same input an application action on the **Tool I/O** page. See **Safety I/O** for tool input rules.

Using buttons and LEDs in programs

The three programmable buttons are available as digital inputs in URScript (when the hardware is present), for example:

```
left_pressed = io_get("T1_DI0")
io_set("T1_DO0", True)
```

Lamp outputs use T1_DO0 through T1_DO3. Use the symbolic names shown in **Tool I/O** where the UI lists them.

Programs and applications created for a control box or tool flange without a smart panel may show invalid I/O or Smart Panel settings if loaded on a system with a PTF. Resolve yellow-marked settings before running production programs.

9. Safety Configuration

Description

The safety system limits are defined in the Safety Configuration. The safety system receives values from the input fields and detects any violation if any the values are exceeded. The robot controller prevents violations by making a robot stop or by reducing the speed.

CAUTION

Use of Safety Configuration parameters different from those defined by the risk assessment can result in hazards that are not reasonably eliminated or risks that are not sufficiently reduced.

9.1. 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 ISO 13849-1 with Performance Level d (PLd) using a Category 3 architecture.

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 12 V to 24 V leading to fire damage to equipment.

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

NOTICE

- The use and configuration of safety functions and interfaces must follow the risk assessment procedures for each robot application.
- 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.

Stop Categories

Depending on the circumstances, the robot can initiate three types of stop categories defined according to IEC 60204-1. These categories are defined in the following table.

Stop Category	Description	Stop Function
0	Stop the robot by immediate removal of power.	
1	Stop the robot in an orderly, controlled manner. Power is removed once the robot is stopped.	Emergency Stop
2	*Stop the robot with power available to the drives, while maintaining the trajectory. Drive power is maintained after the robot is stopped.	Safeguard Stop

*Universal Robots' Category 2 stops are further described as SS1 or SS2 type stops according to IEC 61800-5-2.

9.2. 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 Functions

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 protective stop is initiated.
Stopping Distance Limit	Limits maximum distance travelled by the robot after a protective stop is initiated.

Safety Mode

When no protective stops are active, the safety system operates in a Safety Mode associated with a set of safety limits:

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.

Description

Robot Limits restrict general robot movements.

- Change the values in robot limits (Normal and Reduced) and apply to see the applied changes in safety checksum.
- Verify the values of reduced should be always less than the values in Normal.

> **NOTICE**
> The safety limits restrict forces and motions at the tool flange and the center of the two user-defined tool positions

9.3. Unlock Safety Settings

Description

You have to unlock the safety settings to change them.

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

The default password for safety: `ursafe`.

Unlock safety settings

1. In the PolyScope X Main Navigation, tap the Application tab.
2. On the workcell screen tap the Safety icon.
3. Observe that the Robot Limits screen displays, but the settings are inaccessible.
4. Tap UNLOCK to make settings accessible, and enter the safety password.
5. Tap Confirm, then Apply.
6. Tap the Apply and restart button to confirm configuration to lock all Safety item settings again.

9.4. Adjusting the Password

Description

In the password settings in PolyScope X, you can find three different passwords.

Protected area	What it unlocks	Default password
Operational Mode	Switching between Manual and Automatic mode.	`operator`
Safety	Safety settings and the safety configuration.	`ursafe`
Admin	Security screens: Secure Shell, Permissions, and Services.	`easybot`

It is possible to set the same password in all three instances, but it is also possible to set three different passwords to separate access and options.

> **NOTICE**
> The default passwords are publicly available. To prevent unauthorized access, change the default passwords before operating the system or connecting it to a network.

9.4.1. Password - Admin

Description

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

- **Secure Shell**
- **Permissions**
- **Services**

The settings can only be modified by designated administrators.
Unlocking any one of the options under Security also unlocks the other options until you exit the **Settings** menu.

Default Password

The default Admin password is `easybot`.

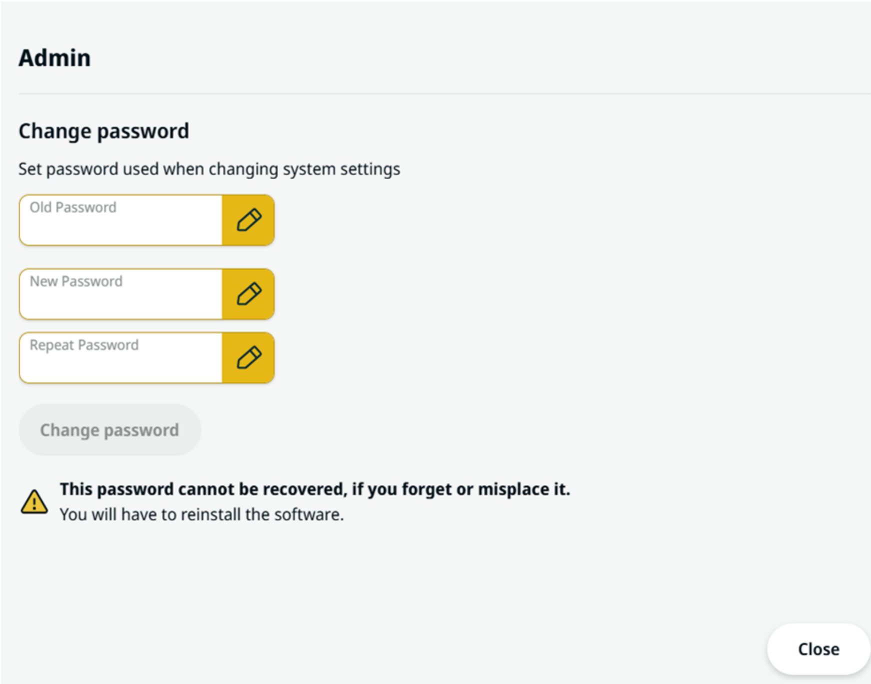
> **NOTICE**
> If you forget your Admin password, it cannot be replaced or recovered.
> You will have to reinstall the software.

To set the Admin password

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

1. Open 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.



Setting the admin password

9.4.2. Password - Operational Mode

Default Password

The default password for operational mode: `operator`.

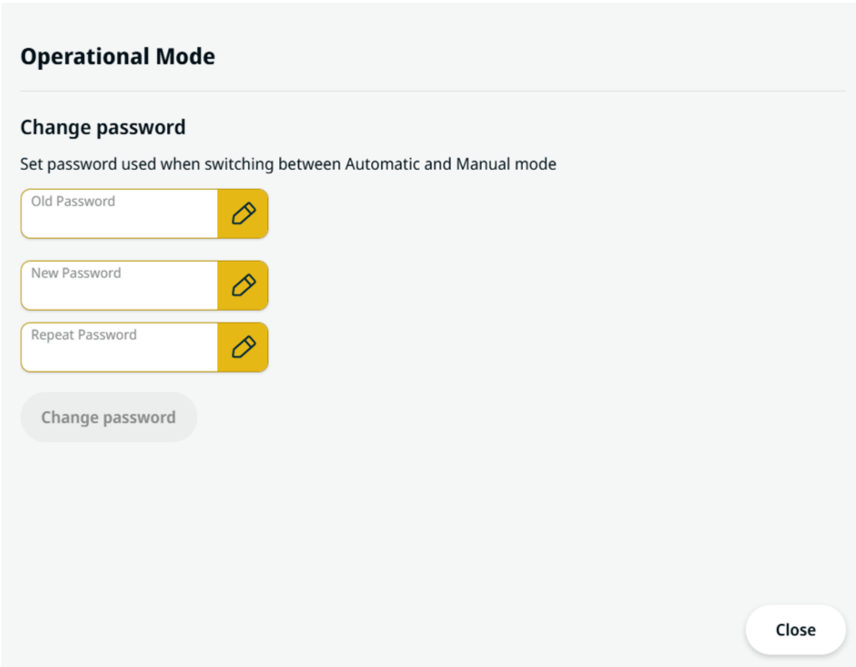
> **NOTICE**
> If you forget your password, it cannot be replaced or recovered.
> You will have to reinstall the software.

You must use the default password when you change the password for the first time.

Change Operational Mode password

This is how you change the password for operational mode in the PolyScope X setting.

1. Tap the hamburger menu in the main navigation.
2. Tap Settings.
3. Tap Operational Mode in the Password section.
4. Add the default password, if it is the first time.
5. Add your preferred password of at least 8 characters.



Changing the Operational mode password

9.4.3. Password - Safety

Default Password

The default password for safety: `ursafe`

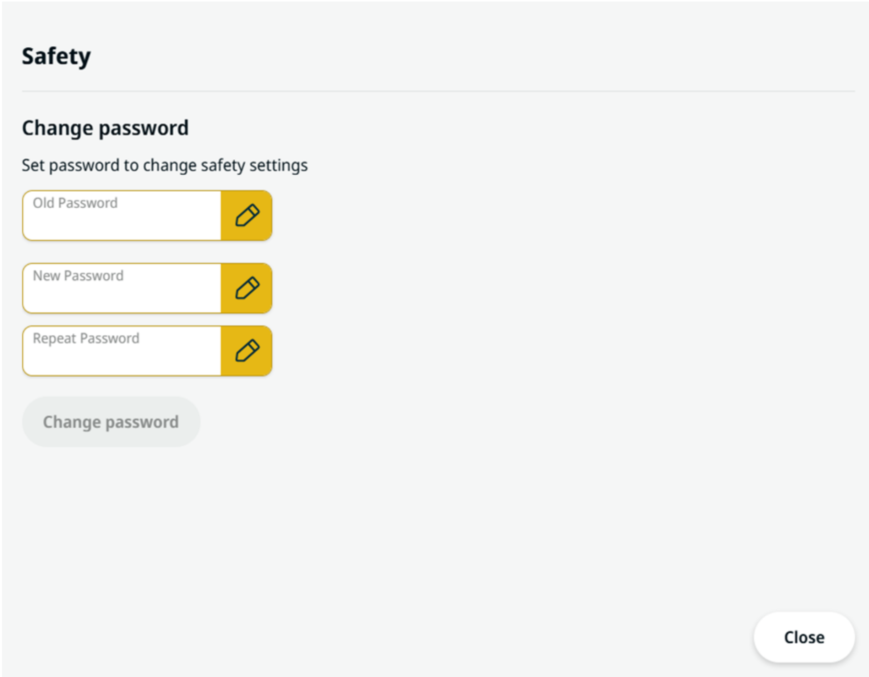
> **NOTICE**
> If you forget your password, it cannot be replaced or recovered.
> You will have to reinstall the software.

You have to use the default password when you change the password for the first time.

Change Safety Password

This is how you change the safety password in the PolyScope X setting.

1. Tap the hamburger menu in the main navigation.
2. Tap Settings.
3. Tap Safety in the Password section.
4. Add the default password, if it is the first time.
5. Add your preferred password of at least 8 characters.



Changing the safety password

9.5. Robot Limits

9.5.1. Speed Limits

Tool Speed

Tool Speed limits the maximum speed of your robot tool at the Tool Center Point (TCP). You set the limit, which applies at the tool flange and at the center of the two user-defined tool positions. As part of the Speed Limit safety function (SF6), it monitors TCP speed and, if you exceed the limit, either reduces speed or torque or triggers a robot stop.

	Normal	Reduced
Value	1.5 m/s	0.75 m/s
Function	Maximum permitted TCP speed while the safety system is in Normal mode.	Lower TCP speed cap enforced when the robot enters Reduced mode (for example, an operator approaches a safeguarded zone).

Elbow Speed

Elbow Speed limits the maximum speed of the robot elbow. As part of the Speed Limit safety function, it monitors both TCP and elbow speed, which covers the whole arm because the arm sections between the elbow and TCP cannot move faster than those endpoints.

	Normal	Reduced
Value	1.5 m/s	0.75 m/s
Function	Maximum elbow speed in Normal mode.	Lower elbow speed cap in Reduced mode.

Momentum

Momentum limits the maximum robot momentum, treating the payload as part of the robot. You use it to reduce the force of sudden impacts across the entire robot. When you lower the limit, the robot reduces its speed and acceleration to stay within it.

	Normal	Reduced
Value	25 kg·m/s	10 kg·m/s
Function	Maximum momentum in Normal mode.	Lower momentum limit in Reduced mode, reducing impact energy in a collision.

Stopping Time

Stopping Time limits the maximum time the robot takes to stop, such as when you activate an emergency stop. The safety function continuously monitors the robot's stopping capability during motion and dynamically reduces speed so the robot can always stop within your configured time. If stopping time is at risk of being exceeded, it initiates a stop. When you restrict the stopping time, you directly reduce the robot's overall speed.

	Normal	Reduced
Value	0.4 s	0.3 s
Function	Maximum allowed stopping time in Normal mode.	Tighter stopping-time limit in Reduced mode.

For stopping times and distances, see Stopping Times and Stopping Distances.

Stopping Distance

Stopping Distance limits the maximum distance the robot tool or elbow can travel while stopping. Like **Stopping Time**, it is continuously monitored in real time. The robot dynamically reduces its speed to stop within your set distance, and triggers a Category 0 stop if the limit is at risk of being exceeded. Both stopping settings automatically slow the robot before it reaches a limit (joint position, safety plane, or orientation), so you do not need to perform periodic stop-performance testing manually.

	Normal	Reduced
Value	0.5 m	0.3 m
Function	Maximum allowed stopping distance in Normal mode.	Shorter stopping-distance limit in Reduced mode, minimizing work area and floor space.

For stopping times and distances, see Stopping Times and Stopping Distances.

9.5.2. Power and Force

Tool Force

Tool Force limits the maximum force the robot tool exerts at the Tool Center Point (TCP) in clamping situations. You limit the force at the tool flange and at the center of the two tool positions you define. When the tool force exceeds your set limit, the robot triggers a protective stop. Force limits reduce risk but do not eliminate the possibility of injury.

	Normal	Reduced
Value	150 N	120 N
Function	Standard force ceiling at the tool flange and user-defined tool positions.	Lower force cap enforced when the robot enters Reduced mode (for example, an operator approaches a safeguarded zone).

Elbow Force

Elbow Force limits the maximum force the robot elbow exerts on its environment. The Force Limit safety function continuously calculates the torques allowed for each joint, keeping the forces at both the TCP and the elbow within the limit you define. When either force exceeds this limit, the robot stops.

	Normal	Reduced
Value	150 N	120 N
Function	Standard elbow force limit. The safety function keeps TCP and elbow forces within range.	Lower elbow force limit applied in Reduced mode to reduce contact energy.

Power

Power limits the maximum mechanical work (power) the robot produces in its environment. This limit treats the payload as part of the robot rather than part of the environment, so lowering it can reduce the speed and acceleration the robot achieves. The Power Limit safety function (SF9) monitors the mechanical work you allow the robot to perform.

	Normal	Reduced
Value	300 W	200 W
Function	Standard mechanical power ceiling (SF9 monitors joint torques × angular speeds).	Lower power ceiling in Reduced mode, which may further reduce achievable speed and acceleration.

Wrist Clamping

Wrist Clamping Torque limits how much torque the robot's wrist joints apply when pushing. You enable or disable this limit as needed. It is enabled by default.

When **enabled**, the robot limits torque in the wrist joints to prevent clamping between the wrist, payload, and the lower arm of the robot. When **disabled**, the robot can use higher pushing force with the wrist joints.

	Normal	Reduced
Value	Limit Enabled	Limit Enabled
Function	Robot limits wrist torque to prevent clamping between wrist, payload, and lower arm.	Same clamping protection maintained in Reduced mode.

> **NOTICE**
> Enabling **Wrist Clamping Torque** can reduce achievable contact forces well below your **Tool Force** and **Elbow Force** limits. You can disable it only in PolyScope X 10.12 and newer versions.

For related information, see Maximum Payload g-Series.

9.6. Joint Limits

Description

Joint Limits allow you to restrict individual robot joint movements in joint space (for example, joint rotational position and joint rotational speed). Joint limiting is also called software-based axis limiting.

Joint Positions

Set **Joint Positions** as follows:

1. Go to the **Application** tab.
2. Go to **Safety**.
3. **Unlock** and enter the safety password.
4. Select the settings for each joint in the corresponding fields.

Joint Positions

Joint		Normal		Reduced	
	Range	Minimum	Maximum	Minimum	Maximum
Base	-363 - 363 °	Limit for Base -363 °	Limit for Base 363 °	Limit for Base -363 °	Limit for B... 363 °
Shoulder	-363 - 363 °	Limit for Shou... -363 °	Limit for Shou... 363 °	Limit for Shou... -363 °	Limit for S... 363 °
Elbow	-363 - 363 °	Limit for Elbow -363 °	Limit for Elbow 363 °	Limit for Elbow -363 °	Limit for El... 363 °
Wrist 1	-363 - 363 °	Limit for Wrist 1 -363 °	Limit for Wrist 1 363 °	Limit for Wrist 1 -363 °	Limit for W... 363 °
Wrist 2	-363 - 363 °	Limit for Wrist 2 -363 °	Limit for Wrist 2 363 °	Limit for Wrist 2 -363 °	Limit for W... 363 °
Wrist 3	-363 - 363 °	Limit for Wrist 3 -363 °	Limit for Wrist 3 363 °	Limit for Wrist 3 -363 °	Limit for W... 363 °

Joint Positions in PolyScope X

Joint Speeds

Set **Joint Speeds** as follows:

1. Go to the **Application** tab.
2. Go to **Safety**.
3. **Unlock** and enter the safety password.
4. Select the settings for each joint in the corresponding fields.

Joint Speeds

Joint	Normal	Reduced
Base	Base 131 °/s	Base 131 °/s
Shoulder	Shoulder 131 °/s	Shoulder 131 °/s
Elbow	Elbow 161 °/s	Elbow 161 °/s
Wrist 1	Wrist 1 221 °/s	Wrist 1 221 °/s
Wrist 2	Wrist 2 221 °/s	Wrist 2 221 °/s
Wrist 3	Wrist 3 221 °/s	Wrist 3 221 °/s

Joint Speeds in PolyScope X

9.7. Safety I/O

Description

The Safety I/O is divided between inputs and outputs, and both are paired so that each function provides a Category 3 PLd capability.

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 through the field of the safeguard.

If a person is not detected by the safeguard and is exposed to hazards, automatic reset is forbidden by standards.

- Use the external reset to ensure that reset occurs 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.

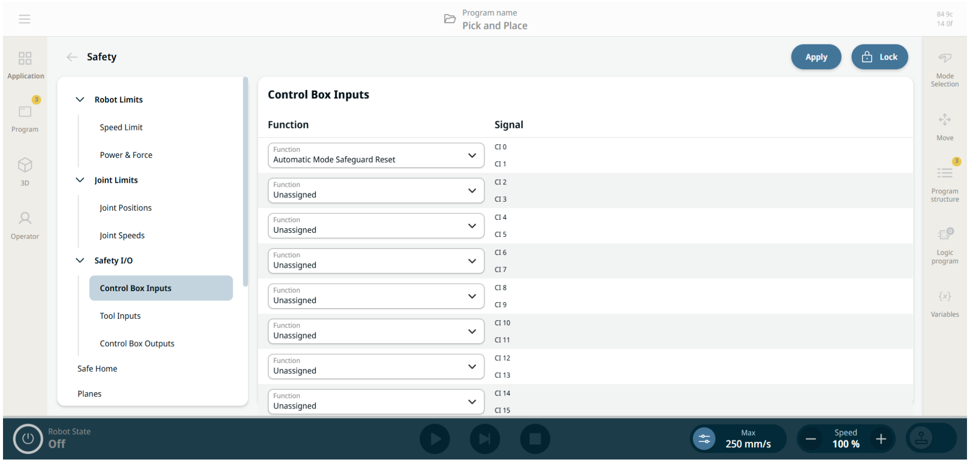
NOTICE

When starting programs from an I/O or fieldbus input, the robot can begin movement from its current position. No manual movement to the first waypoint in PolyScope X is required.

NOTICE

Any external machinery that receives its Emergency Stop state from the robot through the System Stop output must comply with ISO 13850. This is especially necessary when the Robot Emergency Stop input is connected to an external Emergency Stop device. In that case, the System Stop output becomes HIGH when the external Emergency Stop device is released. The emergency stop state at the external machinery then resets with no manual action from the robot operator. To comply with safety standards, the external machinery must require a manual action to resume.

Control Box Inputs



PolyScope X screen displaying the input signals

The following tables describe the inputs:

Function	Description
Automatic Mode Safeguard Reset	Returns from the Automatic Mode Safeguard Stop state when a rising edge on the Automatic Mode Safeguard Reset input occurs.
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. It is typically used with safety fencing, light curtains, or area scanners that protect the robot's operating envelope during automated production.
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.
Operational Mode	When an external mode selection is used, it switches between **Automatic Mode** and **Manual Mode**. The robot is in Automatic Mode when the input is *LOW* and Manual Mode when the input is *HIGH*. Enabled on the UI, and protected by a password. It can additionally be configured by defining an **Operational Mode Configurable I/O**.
Reduced Mode	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 that the robot is within reduced limits less than 0.5 s 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.
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.
3-Position Switch	Enables manual robot motion (jogging, teaching, freedrive) during programming operations.
Freedrive Enabled Input	You can configure the Freedrive input to enable and use Freedrive without pressing the Freedrive button on a standard Teach Pendant, or without pressing and holding any of the buttons on the 3PE TP in the light-press position. When the input is HIGH, the robot goes into Freedrive (similar to the **Freedrive** button). The input is ignored if other conditions disallow Freedrive.

Tool Inputs

On g-Series robots with a Performance Tool Flange, you can assign selected safety functions to the **Tool Inputs** on the application **Safety** screen, under **Safety I/O**.
The Tool Inputs are grouped as follows:

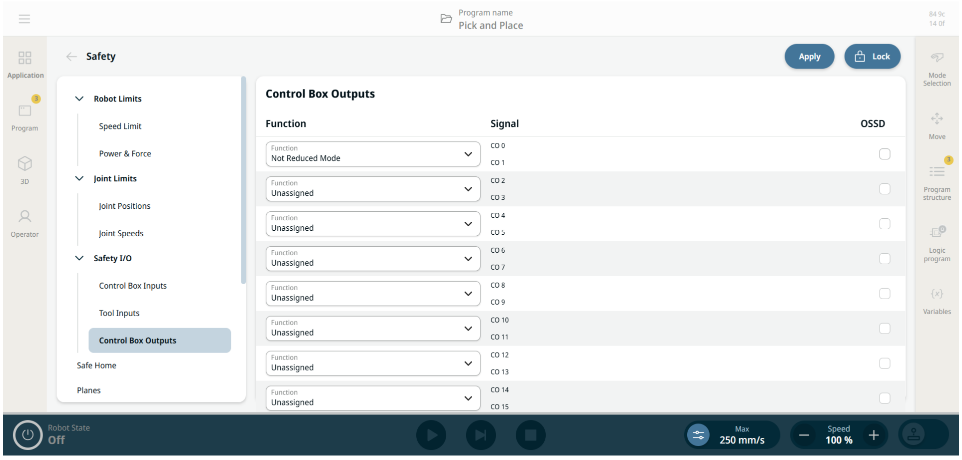
Input pair	Assignable safety functions
DI 0, DI 1	Unassigned, Freedrive on robot, 3-Position Enabling Device
SBI 3, SBI 4 (Smart Input)	Unassigned, Freedrive on robot. Requires a Smart Panel.

The functions are described in the table below:

Function	Description
Freedrive on robot	You can configure the Freedrive input to enable and use Freedrive without pressing the Freedrive button on a standard Teach Pendant, or without pressing and holding any of the buttons on the 3PE TP in the light-press position.
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.

DI 0, DI 1 can be assigned **Freedrive on robot** or **3-Position Enabling Device**.
SBI 3, SBI 4 (**Smart Input**) can be assigned **Freedrive on robot** only. When you assign Freedrive to **Smart Input**, you cannot assign Freedrive to another safety input.
It is not possible to assign a Safety Function to the Tool Inputs if one of the inputs is already assigned an action. In this case, the Function drop-down box is disabled.
When the Tool Inputs are assigned a Safety Function, it is not possible to rename a Tool Input or assign a Tool Input an action on the **Communication > Tool I/O** page.

Control Box Outputs



PolyScope X screen displaying the 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 function output signals. All signals return to LOW when the state that triggered the HIGH signal has ended:

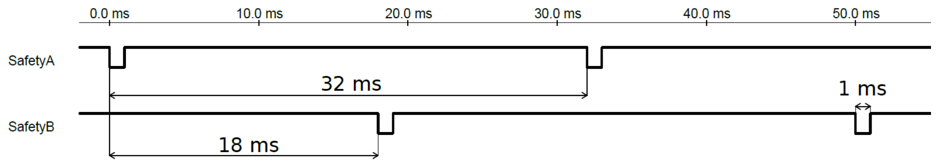
Function	Description
Not Reduced Mode	Signals to external equipment when the robot is operating under its Normal (non-reduced) safety parameter set. Also called **Reduced Not Active**.
Reduced	The signal is *LOW* when reduced parameters are active or if the safety input is configured with a reduced input and the signal is currently LOW. Otherwise, the signal is HIGH.
Robot Moving	The signal is *LOW* if the robot is moving; otherwise HIGH.
Robot Not Stopping	The signal is *HIGH* when the robot is stopped or in the process of stopping due to an emergency stop or safeguard stop. Otherwise, it is logic LOW.
System Emergency Stopped	The 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, a LOW signal is not given.
3-Position Enabling Stopped	The signal is LOW when a three-position stop is active, HIGH otherwise.
Not 3-Position Enabling Stopped	The signal is LOW when a three-position stop is inactive, HIGH otherwise.

OSSD signals

All configured and permanent safety inputs are filtered to allow the use of OSSD safety equipment with pulse lengths under 3 ms. The safety input is sampled every millisecond and the state of the input is determined by the most frequently seen input signal over the last 7 ms.

OSSD Safety Signals

You can configure the Control Box to output OSSD pulses when a safety output is inactive/HIGH. OSSD pulses detect the ability of the Control Box to make safety outputs active/LOW. When OSSD pulses are enabled for an output, a 1 ms LOW pulse is generated on the safety output once every 32 ms. The safety system detects when an output is connected to a supply and shuts down the robot.
The following illustration shows the time between pulses on a channel (32 ms), the pulse length (1 ms), and the time from a pulse on one channel to a pulse on the other channel (18 ms).



To enable OSSD for a safety output:

1. In the main navigation, tap **Application** and select **Safety**.
2. Under **Safety I/O**, select **Wired Outputs**.
3. Unlock the I/O screen and enter the safety password.
4. Select the desired OSSD checkbox and assign the output signal/function.

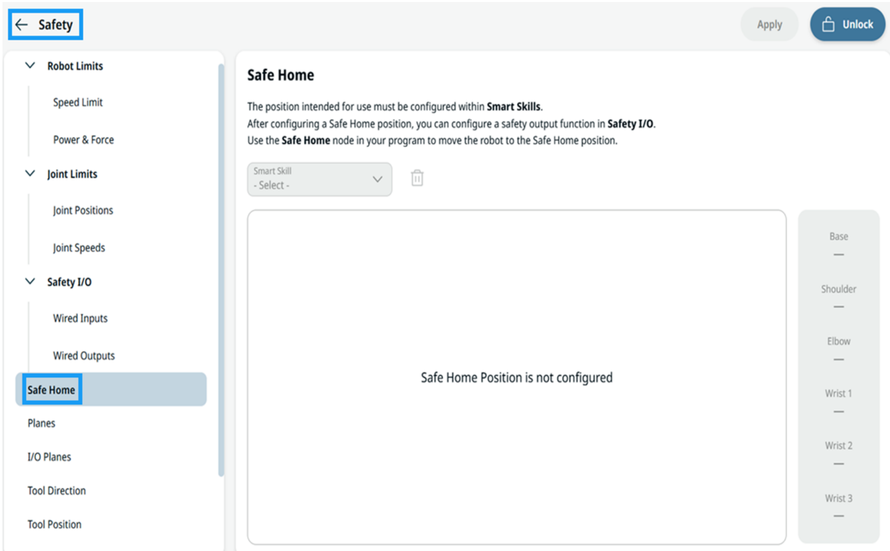
9.8. Safe Home

Description

Safe Home is a PolyScope X feature that enables users to define a safety-related output that activates when the robot reaches the configured safe home position. The user chooses **Home** in the dropdown of available smart skill positions, which can be assigned as the reference for the Safe Home position.

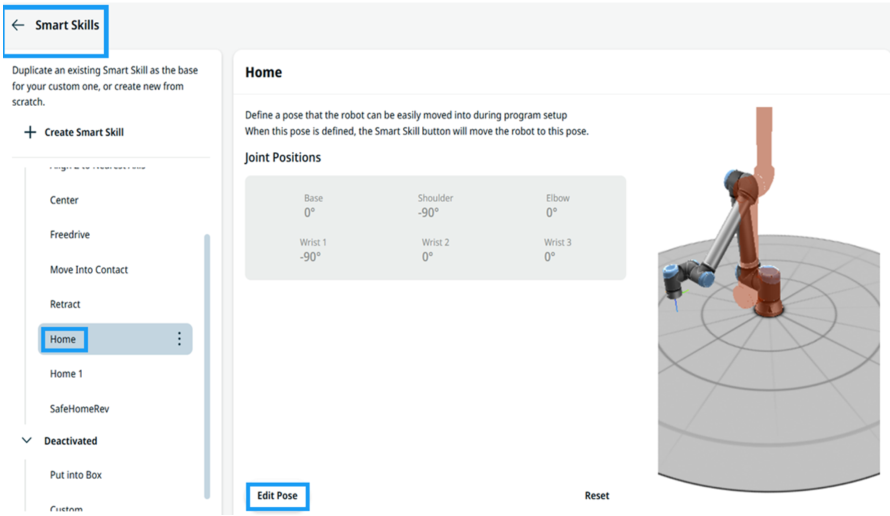
Access Safe Home

1. Tap the **Application Tab** and select **Safety Application**. In the left panel, select **Safe Home**.



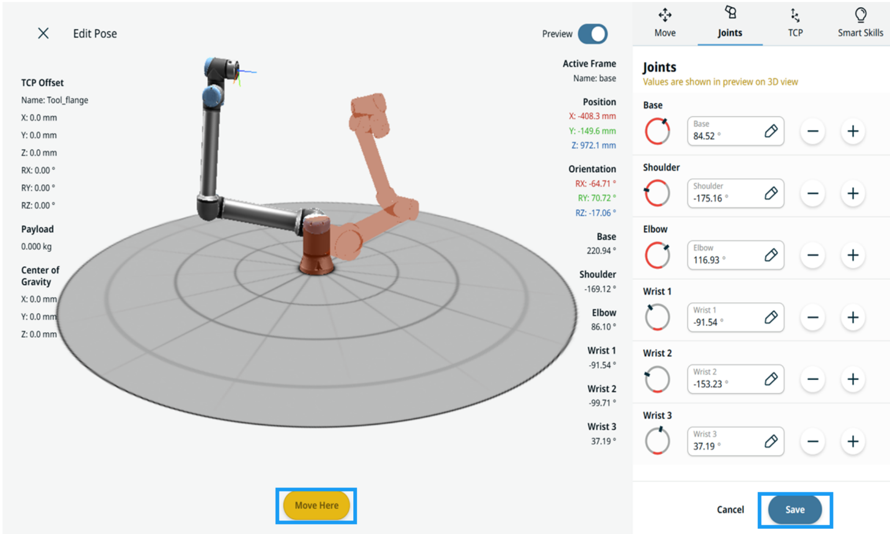
Accessing Safe Home

2. To configure the robot position, go to **Smart Skills Application** and select **Home**.
3. Tap the **Edit Pose** button, and the 3D view of the robot arm appears.

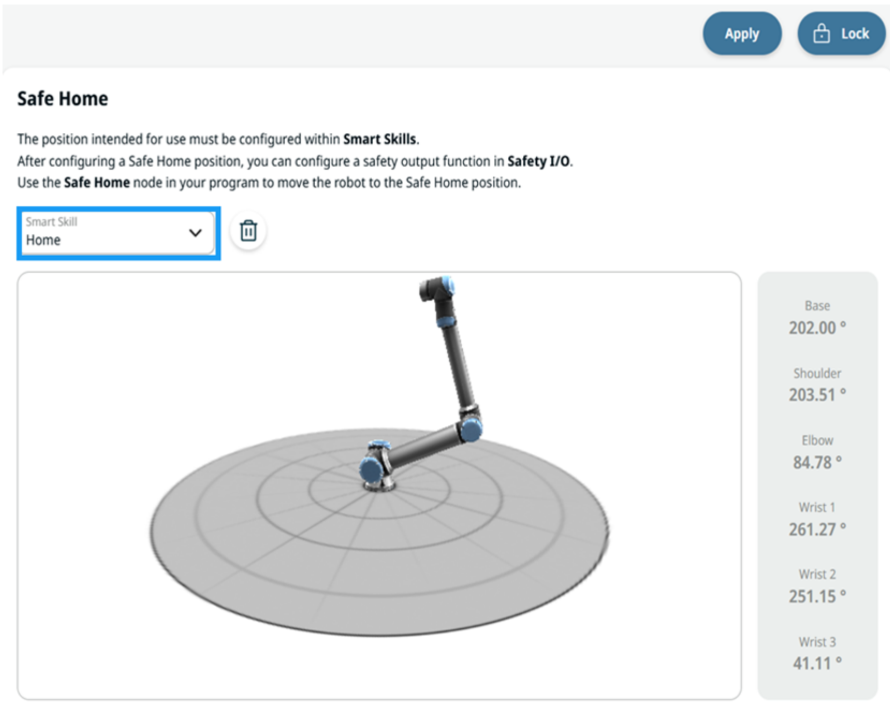


Edit Pose

4. Jog the robot to the intended position using the **Move**, **Joints**, **TCP** buttons.
5. Long press the yellow **Move Here** button until the previewed image is positioned to the new configuration.
6. Tap **Save** to finalize the configuration.



7. Go back to **Safe Home** in **Safety Application** and enter the safety password.
8. In the activated **Smart Skill** field, select **Home**, and the configured robot position appears in the main screen.
9. Tap **Apply** and choose **Apply and restart**. Then tap **Confirm Configuration**.

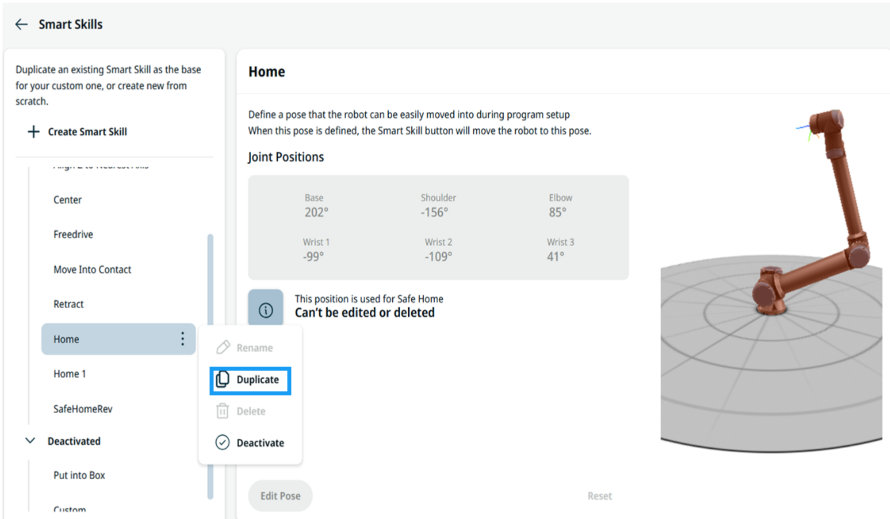


NOTICE

If the Position Smart Skill is selected as the position reference for Safe Home:

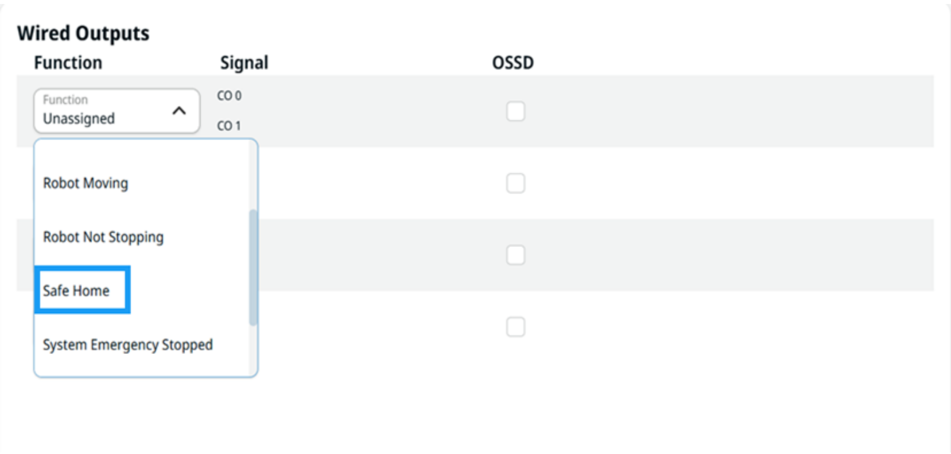
- The message box is displayed on the Position Smart Skill page.
- The Position Smart Skill configured as Safe Home cannot be renamed, edited, or deleted unless the user deletes or unassigns the Safe Home from the **Safety > Safe Home** screen.

10. In the Smart Skills screen, the Home position can be duplicated and edited. All the newly created Smart Skills are also available to be configured as Safe Home.



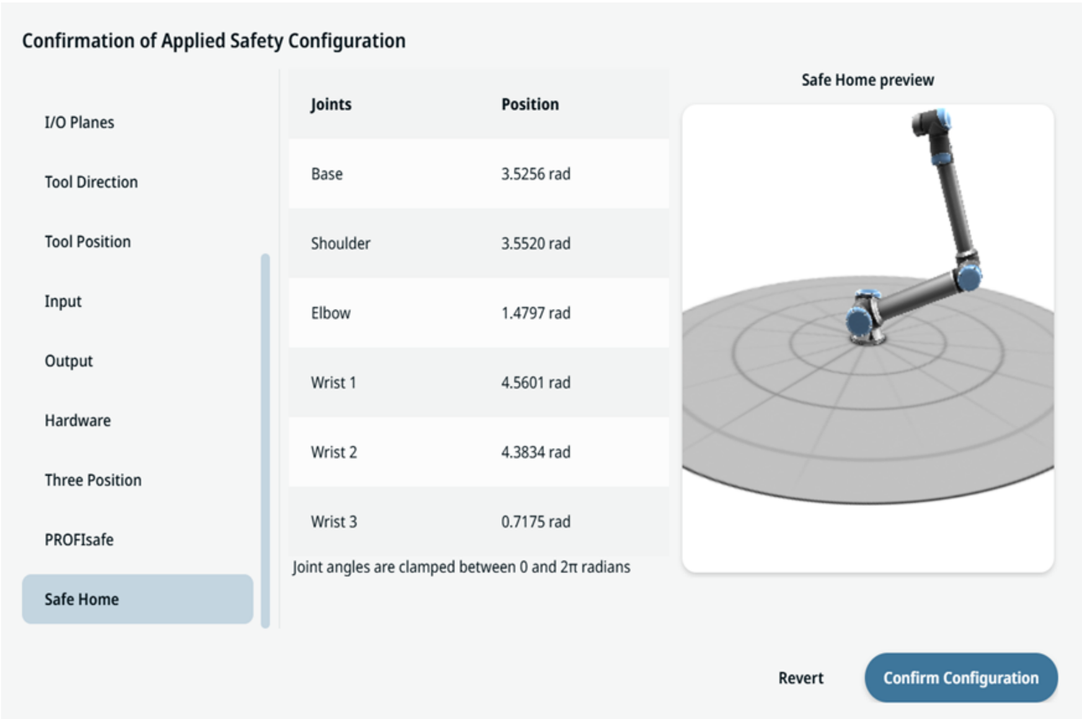
Safe Home function in outputs

If the **Home** position is assigned to a position smart skill in **Safety**, the safety output function dropdown contains **Safe Home** as a new function assignment.
Choose Safe Home in the **Function** fields in **Outputs** of Safety I/O.



Setting Safe Home function

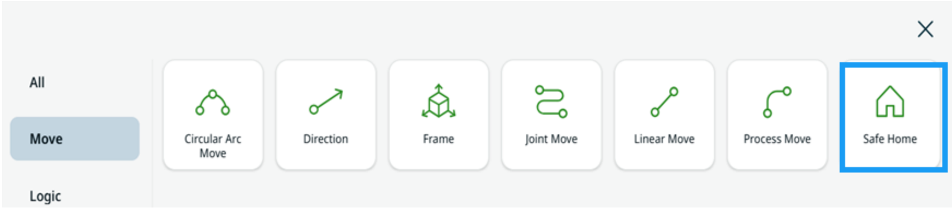
Safe Home can be seen in the table of function assignment on the **Confirmation of Applied Safety Configuration** overview dialog.



Confirming configuration

Safe Home as a program node

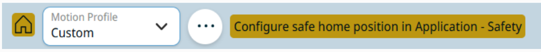
The **Safe Home** program node is located under the **Move nodes** category within the **Command Nodes**. This node is used to command the robot to move to its predefined safe home position, as configured in the safety application settings for safe home.



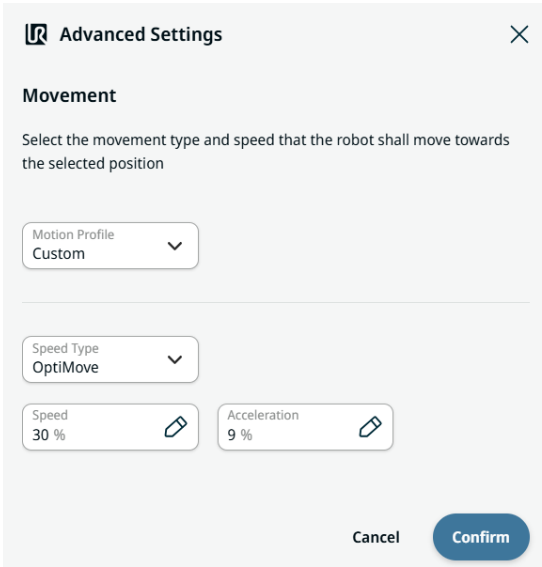
Move nodes

NOTICE

Adding the node without a safe home position configured in safety will mark the node as yellow.



The Safe Home command node has motion profiles options and other advanced settings when the ellipsis icon  is tapped.



Confirmation window

Advanced Settings

Users can create movement profiles in the Advanced Settings using the two tabs and two fields:

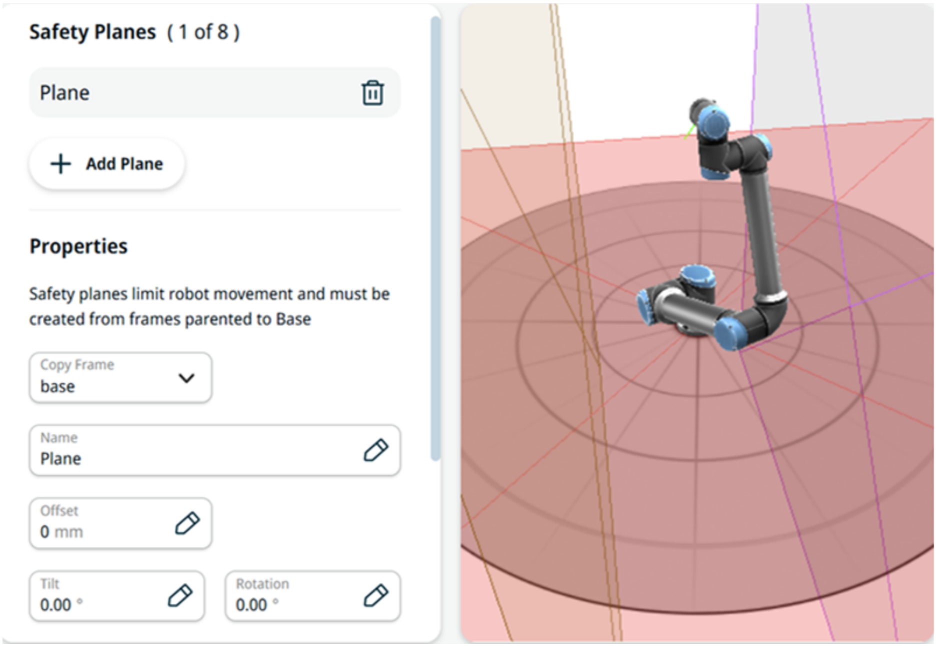
- Motion Profile
- Speed Type
- Speed tab
- Acceleration tab

Motion Profile is a feature enabling users to set predefined motion profiles in move nodes: Joint Move, Linear Move, Circular Arc Move, Process Move, and Direction. **Custom** Motion Profile enables users to define movement data in move node.
In the **Speed Type** field, **OptiMove** is the default option. Choose **Classic** movement if you want to input speed and acceleration in degrees per second or mm per second. OptiMove settings are specified in percent to simplify the usage and setup.
Users can configure the percentage of preferred speed in the **Speed tab**, which sets the target travel speed as a percentage of the robot's maximum speed capability.
Users can configure the percentage of preferred acceleration in the **Acceleration tab**, which sets the target torque limits during acceleration and deceleration as a percentage of the robot's maximum power.

9.9. Safety Planes

Description

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



PolyScope X screen displaying safety planes.

> **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.

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 in either Normal or Reduced mode, the 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

The feature is enabled by default.
You can enable **Restrict Elbow** to prevent the robot elbow joint from passing through any of your defined planes.
Disable **Restrict Elbow** to allow the elbow to pass through planes.

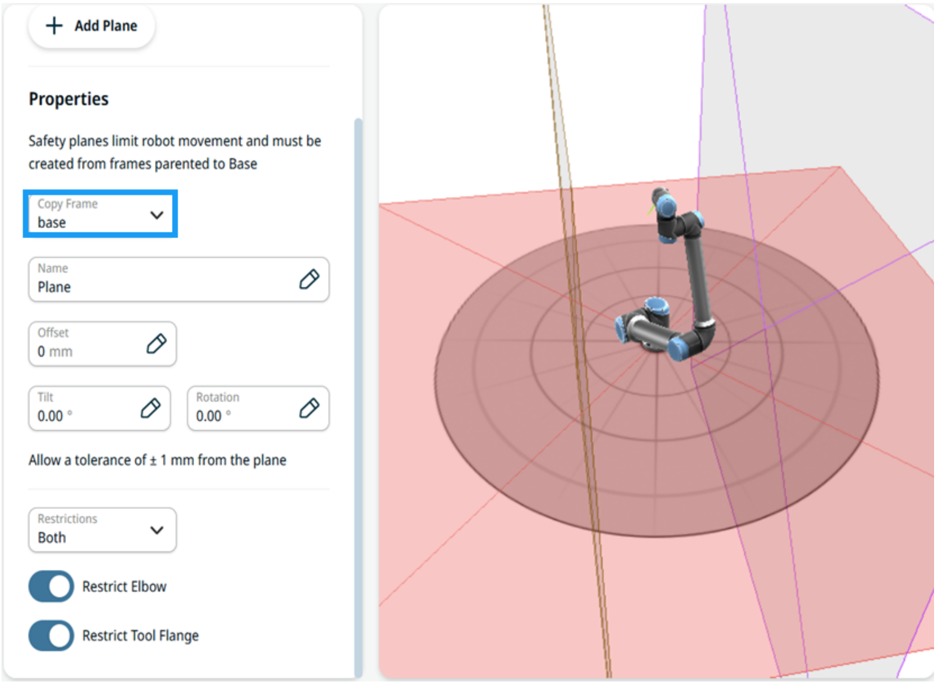
Tool flange and wrist joint restriction

Restricting tool flange and wrist joints prevents the tool flange and wrist joints from crossing a safety plane. The tool flange and wrist joints are monitored by the safety system, preventing them from crossing a safety plane.
Disabling the restriction can be useful if it is exclusively the attached tool that should be monitored, e.g. in welding applications where only the welding tool is dangerous and the robot moves at low speeds.
Safety planes are defined in relation to a frame defined in the installation or the robot world frame. The robot is allowed to move such that all monitored parts of the robot arm and user defined safety spheres are in front of the plane.

9.9.1. Create Safety Plane Using a Frame

Description

You can use an existing frame to define a safety plane. This provides a more intuitive way to specify plane parameters from a predefined position and rotation (X, Y, Z, RX, RY, RZ). Select the frame in the **Copy Frame** drop-down menu.



The **Copy Frame** drop-down menu is found in the parameters of a safety plane definition on the **Planes** screen. This list includes frames defined on the **Frames** screen. When you select a frame, it is used as the safety plane definition.
If you specify offset, tilt, and rotation parameters, they are applied to the selected frame (see "Configuring a Safety Plane"). The resulting safety plane combines all parameters.

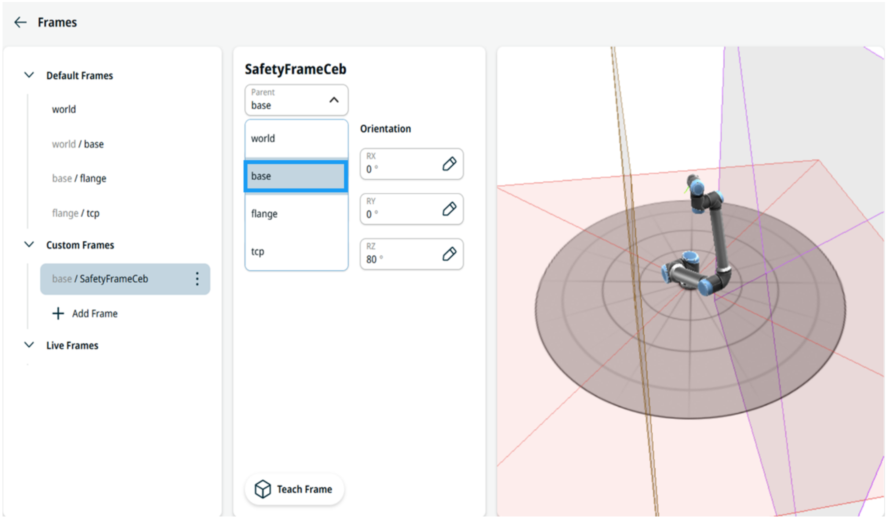
See the "Frames" section in Software Handbook.

Creating Safety Planes using Frames

1. In the **Application** tab, select **Frames**.
2. Tap **+ Add Frame** under **Custom Frames**, then rename the frame using the **three vertical dots** (**kebab icon**).

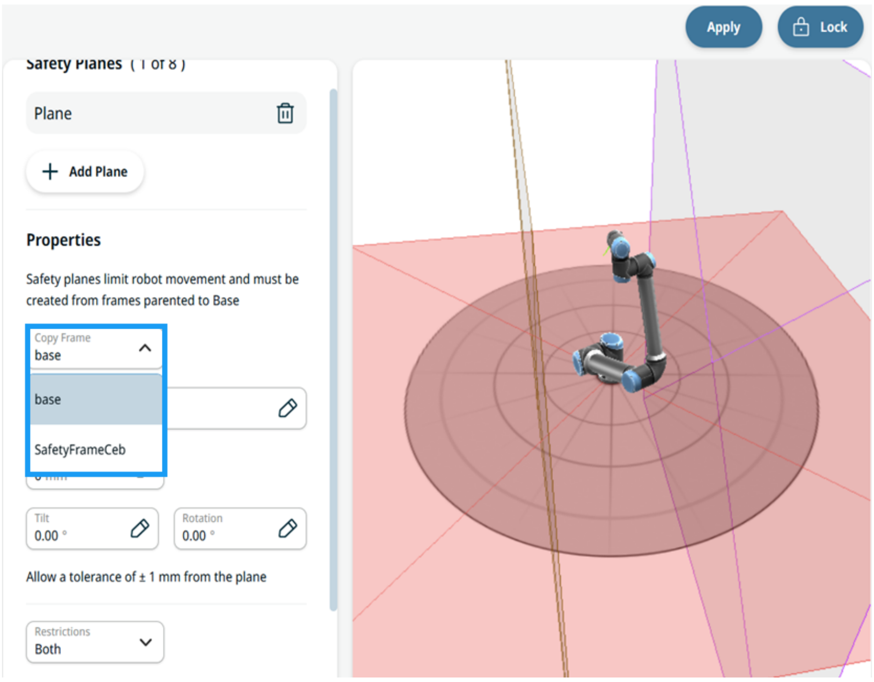
> **NOTICE**
> Frames are created relative to **Base**.

3. In the **Parent** field, select **Base**.



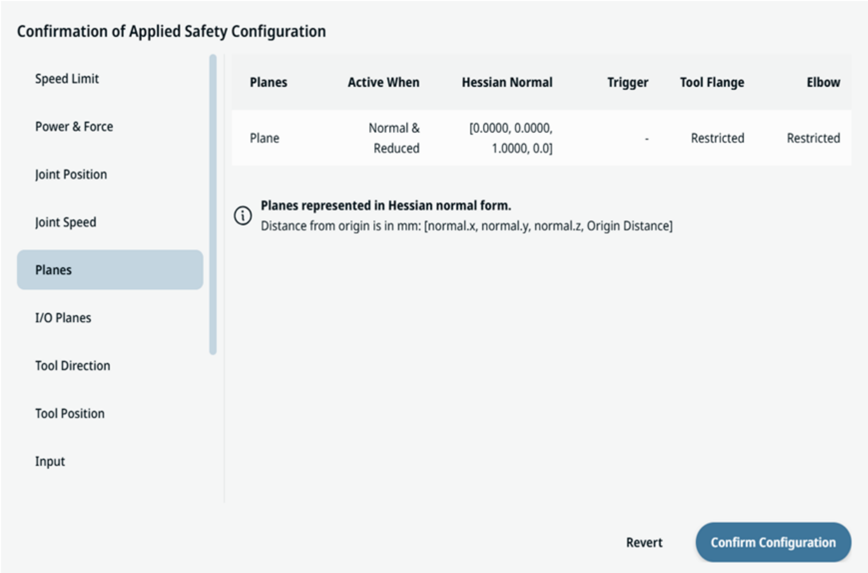
Selecting Reference Frame in Safety Plane

1. In **Application**, go to **Safety**, select **Planes**, and tap **Unlock**.
2. On the **Safety Planes** screen, select a frame in the **Copy Frame** drop-down menu. You can also apply offset, tilt, and rotation.



3. Tap the **Apply** button.

4. Configured planes are listed in the function assignment table on the **Confirmation of Applied Safety Configuration** overview dialog.



NOTICE

A frame used for a safety plane may be inverted from what you expect. If the robot is positioned on the violating side of the plane, add a tilt of 180 degrees.

For restrictions on plane configurations, elbow joint restriction, and tool flange restriction, see "Safety Planes".

9.10. I/O Planes

Description

The **I/O Planes** feature provides more flexible use of safety planes compared to the standard **Safety Planes** functionality. It lets you activate and deactivate safety planes using terminal inputs, and/or generate an output signal when the safety spheres cross a safety plane.

NOTICE

When the plane is inactive, the robot is allowed to move freely.
When the plane is active and the robot has not crossed the plane, the robot will stop before crossing the plane. If the plane is activated while the robot is moving on the edge of the plane, the robot can end up crossing the plane and will, in the worst case, stop according to the configured stopping distance and stopping time limits.
When the plane is activated and the robot has crossed the plane, the robot will stop according to the configured stopping distance and stopping time limits.

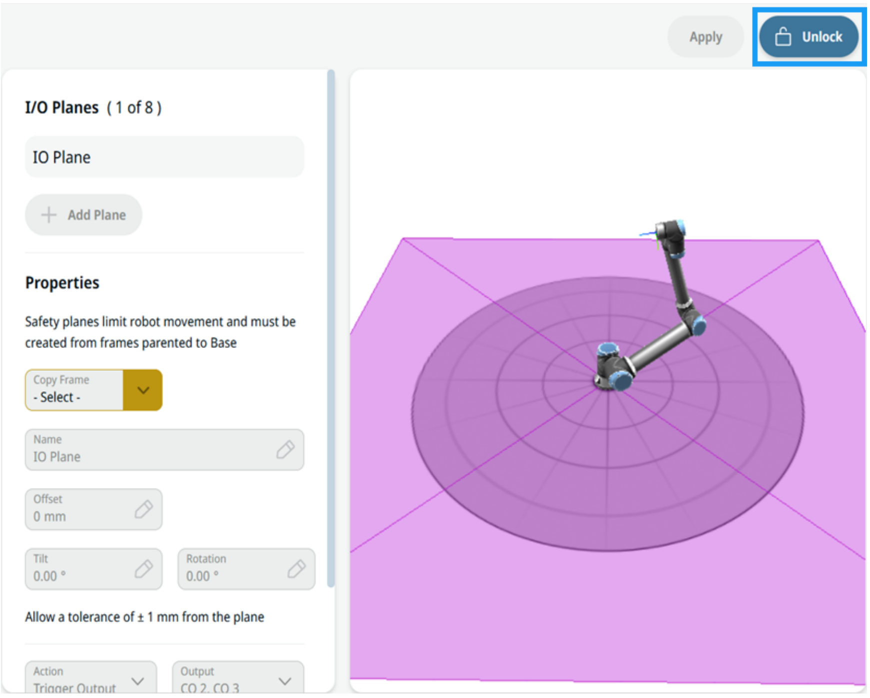
NOTICE

When any of the safety spheres has crossed a plane defined as **Trigger Output**, the safety output corresponding to that plane is activated.

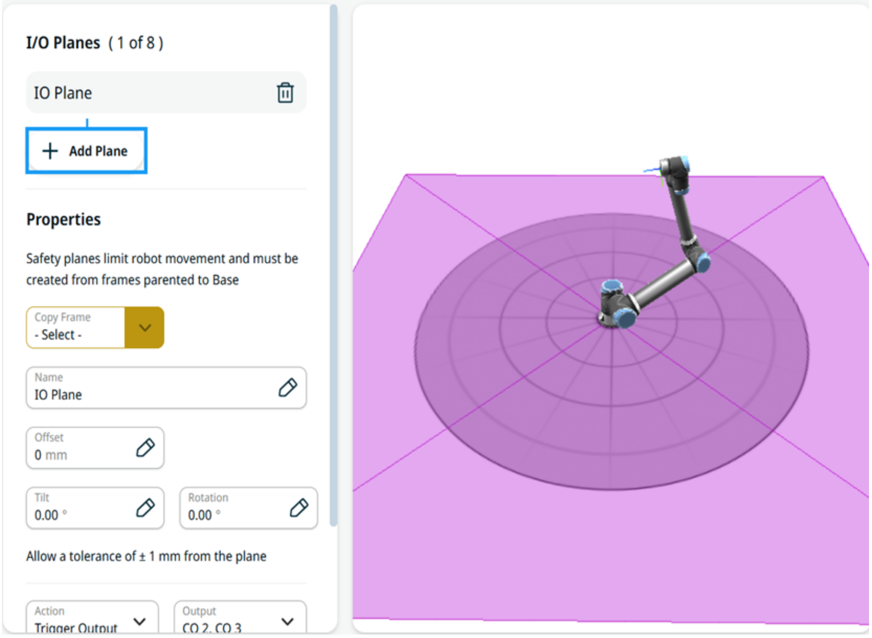
Input/Stop Plane

Trigger Stop triggers an I/O plane stop. It can be muted using a safety input.
Unless muted, moving toward the plane causes the robot to stop and wait until the safety input mutes the plane.

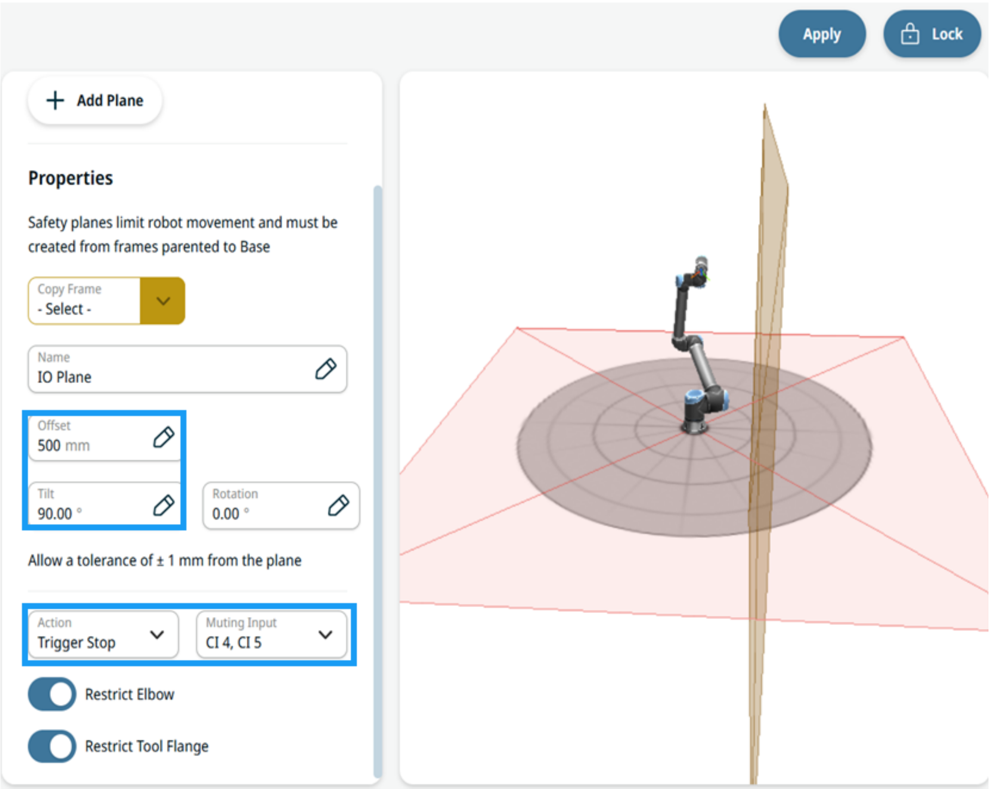
1. Go to **Safety** on the **Application** tab and tap **I/O Planes**.



2. **Unlock** and tap **Add Plane**.



3. Enter the values of **Offset** and **Tilt**.
4. In the **Action** field, select **Trigger Stop**.
5. In the **Muting Input** field, select **CI4** and **CI5**. Tap **Apply**.

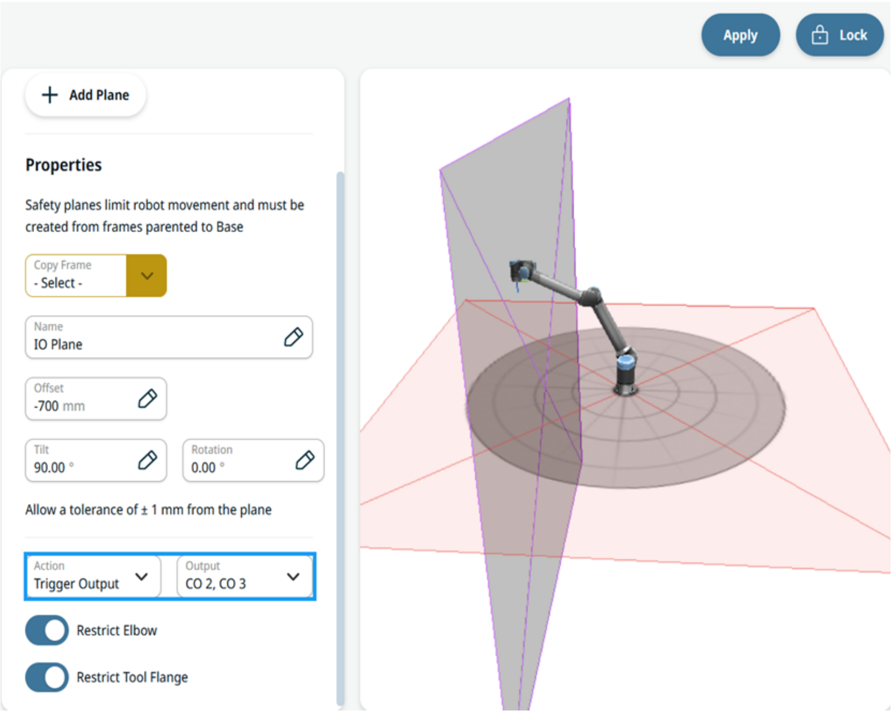


6. When you toggle a physical switch connected to the input, the plane disappears from the 3D Viewer. Tap the **Play** button, and the robot moves freely from one side of the plane to the other.
7. Toggle the switch again to unmute the plane, and the robot enters I/O stop.

Output Plane

Trigger Output generates a safety output based on whether one or more of the safety spheres have crossed the plane.
When one or more of the safety spheres have crossed a plane defined as **Trigger Output**, the safety output corresponding to that plane is activated. "Activated" means that the safety outputs are electrically set "LOW".

1. Enter the values of **Offset** and **Tilt**.
2. In the **Action** field, select **Trigger Output**.
3. In the **Output** field, select **CO2** and **CO3**. Tap **Apply**.



4. When you play the robot program, you can see the "LOW" and "HIGH" outputs in the **Communication** tab.

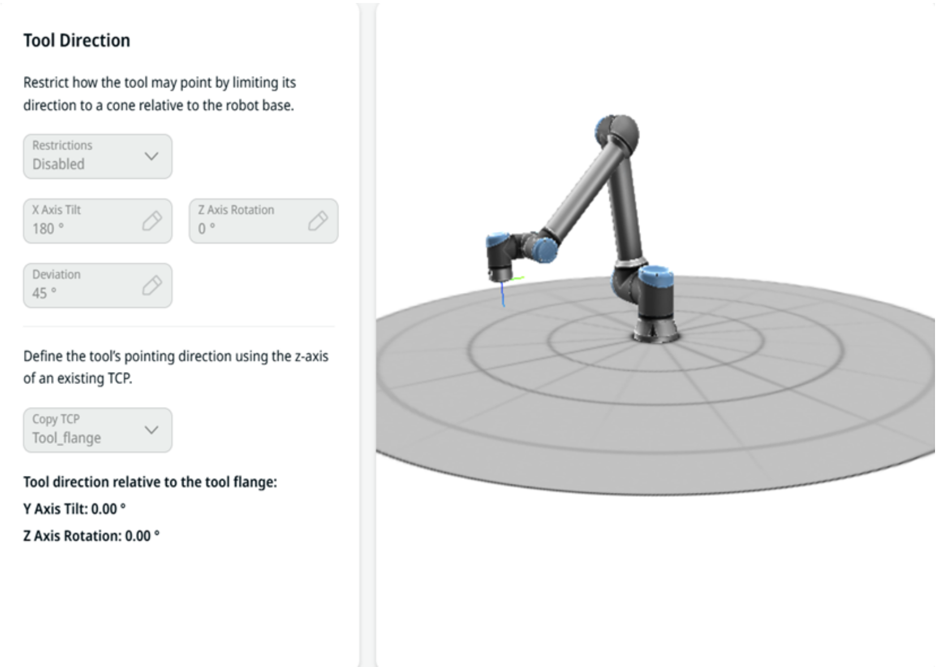
9.11. Tool Direction

Description

The Tool Direction screen enables you to configure a safety feature that restricts the angle at which the tool is allowed to point. You can see the Tool Direction limit, which is added to the safety settings. The limit is defined by a cone that has a fixed orientation relative to the robot arm's base reference frame. As the robot arm moves around, the tool direction is restricted so it remains within the defined cone.

NOTICE

The restrictions can be disabled or configured to apply in Reduced mode, Normal mode, or both.



NOTICE

The Tool Direction feature enables you to increase the safety of an application when you use a tool that can cause harm or injury when facing in a particular direction.

Limit Properties

The Tool Direction limit has five configurable properties:

1. **Restriction**: This is the main toggle on the Tool Direction screen. When you enable the Restrictions field, the other parameter fields become available, and a green cone appears at the TCP, visualizing the tool's pointing direction. Restrictions can be Disabled, Normal, Reduced, or Both.
2. **Tilt**: You can define the cone's opening angle from the central (reference) direction.
3. **Rotation**: You can define how the cone rotates around its central axis.
4. **Deviation**: You can define the maximum angular offset that is allowed between the desired direction and any direction inside the cone.
5. **Copy TCP**: This is a drop-down where you are given the alternative to manually enter Tilt and Z axis rotation angles. In here, you can select an existing TCP (already defined in End Effectors Application) and PolyScope X will copy that TCP's Z axis orientation to use as the central direction of the safety cone.

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**
Both (Normal and Reduced Tool direction limit)	Active when the safety system is in **Normal mode** as well as when it is in **Reduced mode**.

The tool's pointing direction is specified using a TCP configured in the **End Effectors application** settings.

Tool Properties

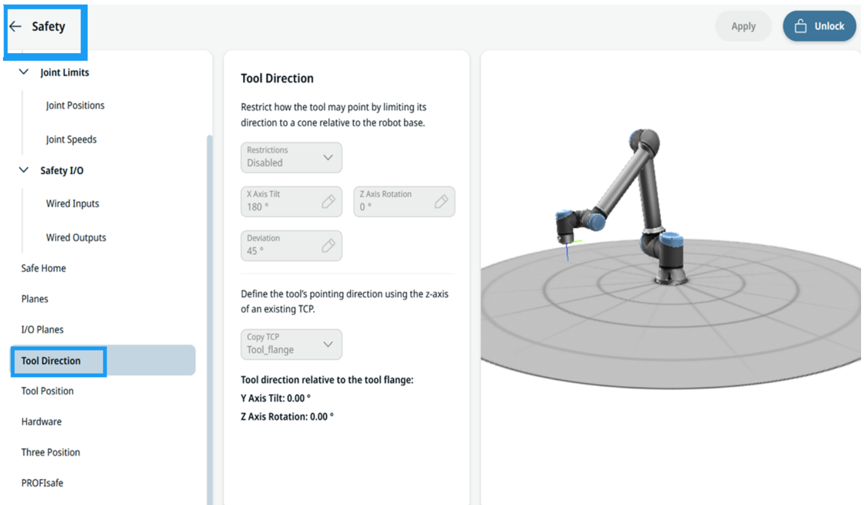
By default, the tool points in the same direction as the Z axis of the tool output flange. You can modify it by specifying two angles:

- **X Axis Tilt**: The parameter that defines how the tool's pointing direction differs from the default. By default, the tool points along the Z axis of the tool output flange. The Tilt angle specifies how much to tilt that Z axis toward the X axis of the output flange (i.e., it pitches the reference direction off the flange's Z axis toward its X axis).
- **Z Axis Rotation**: After you apply the Tilt, the Z axis rotation specifies how much to rotate the already-tilted Z-axis around the original output flange Z axis. Together, Tilt and Z axis rotation orient the reference (central) direction of the safety cone.
- **Deviation**: This is the safety tolerance. It is the maximum permissible misalignment between the commanded tool direction and any direction that still lies inside the cone before the safety system intervenes.

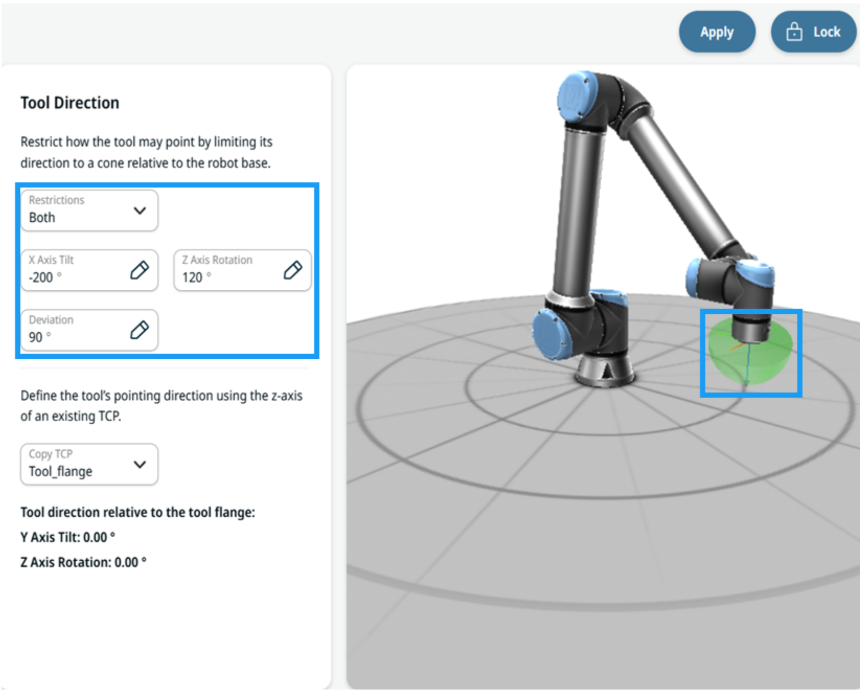
Alternatively, you can copy the Z axis of an existing TCP by selecting that TCP from the drop-down menu.

To access Tool Direction

1. Tap the **Application Tab** and select **Safety Application**. In the left panel, select **Tool Direction**.

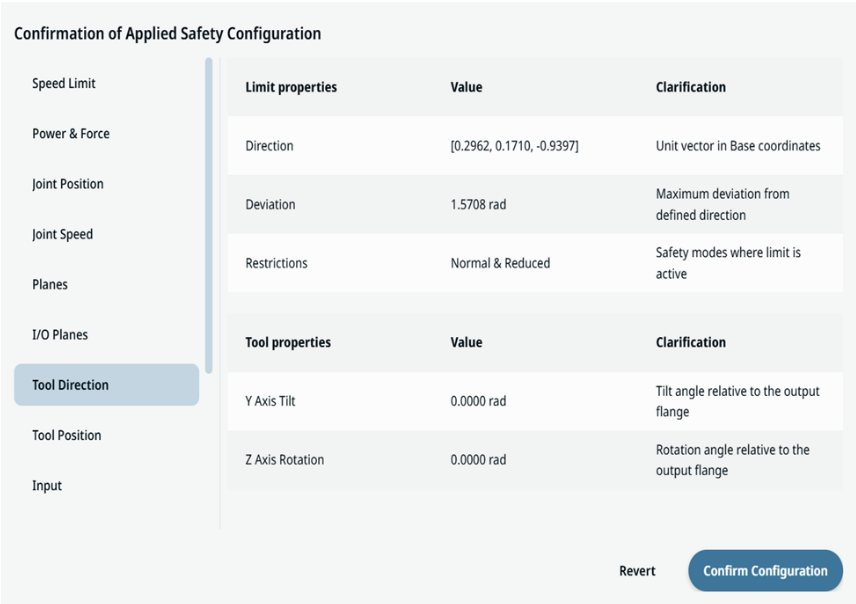


2. **Unlock** and enter the Safety password.
3. When you enable the **Restrictions** field, the other fields become available. A green cone appears in the TCP, showing the tool's pointing direction.



4. Tap the **Apply** button.

5. You can see **Tool Direction** in the function assignment table on the **Confirmation of Applied Safety Configuration** overview dialog.



9.12. Tool Position Restriction

Description

The Tool Position screen enables you to have a more controlled restriction of tools and/or accessories placed on the end of the robot arm by letting you define tool positions with a radius that will interact with the safety planes by either collision detection with Tool Position and plane or enter reduced mode when tool enters plane.

Details

Tool Position has two key benefits:

- Supports two custom configurations to specify where to react to safety planes.
- Visualizes Tool Positions in 3D model.

> **NOTICE**
> You can define, configure, and manage up to two tool positions.

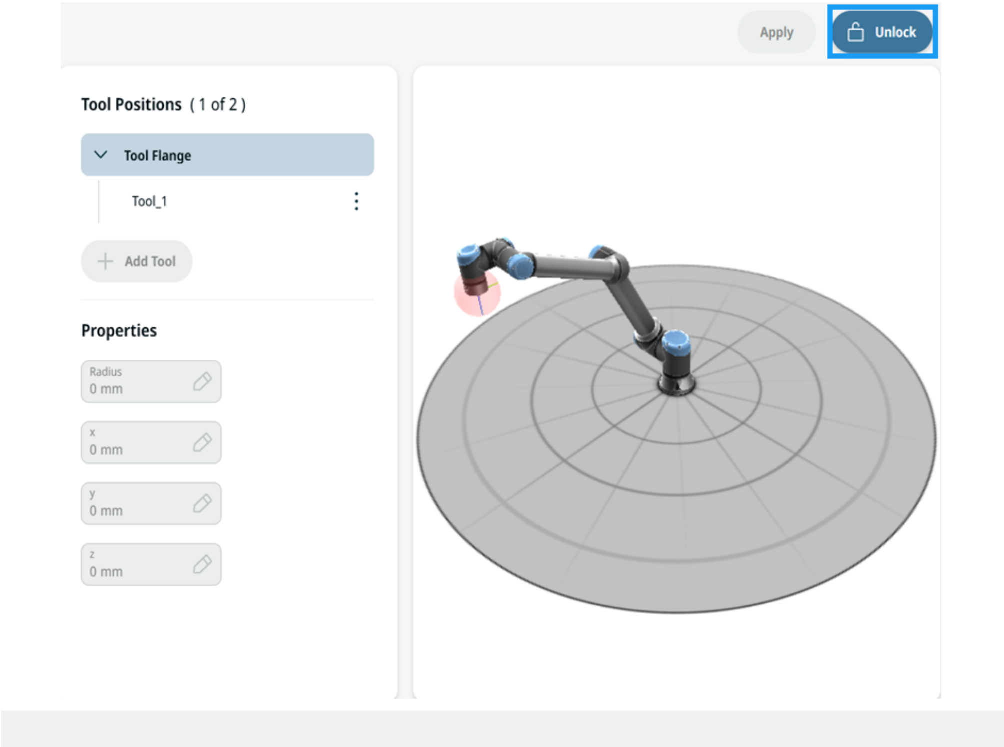
User-defined tools

For the user-defined tools, you can change:

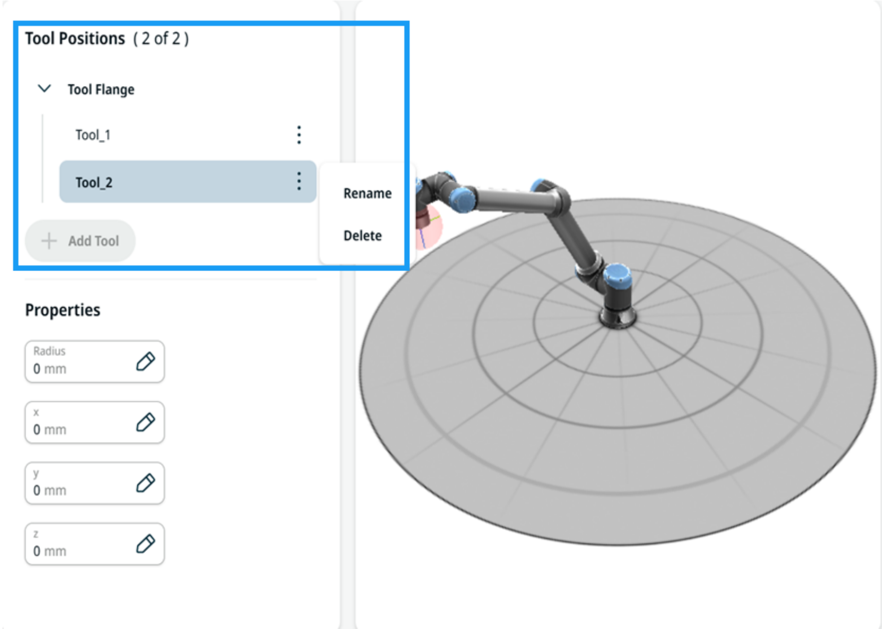
- Radius to change the radius of the tool sphere. The radius is considered when using safety planes.
- X, Y, Z positions to change the position of the tool with respect to the tool flange of the robot. The position is considered for the safety functions for tool speed, tool force, stopping distance, and safety planes.

To access Tool Position

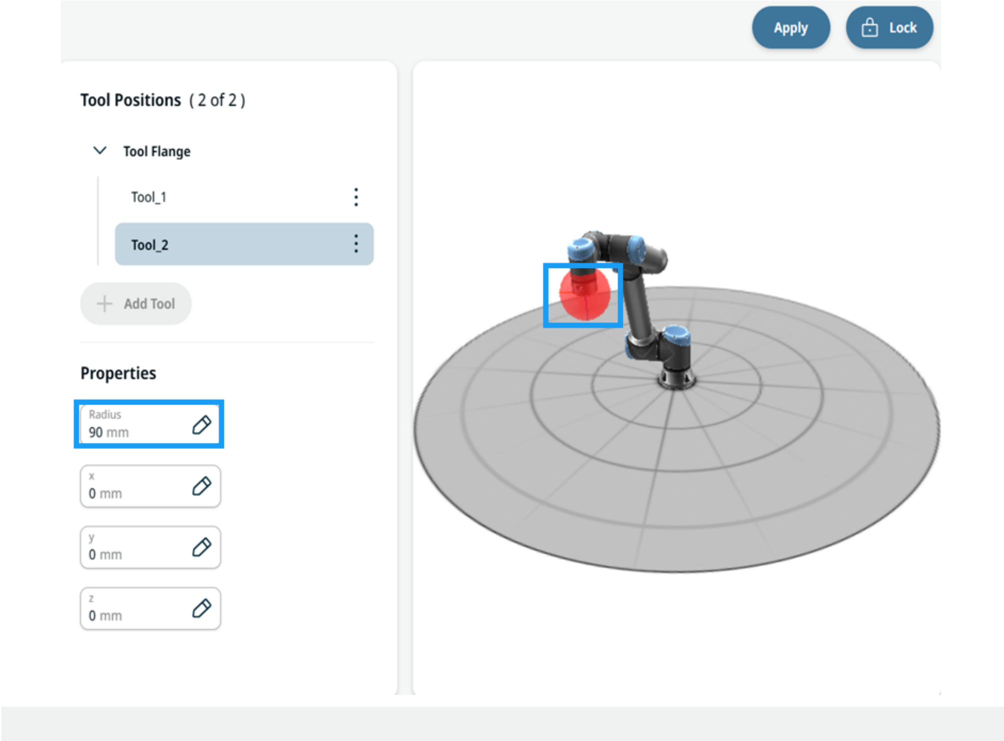
1. Navigate to **Safety** Application.
2. Tap **Tool Position** in the left panel. On the top right side of the main screen, tap **Unlock** to activate adding tools. Enter the safety password and **Confirm**.



3. In the central panel's **Tool Positions** column, tap **+ Add Tool**. The added tool, **Tool_1**, appears under the **Tool Flange tree**.
4. Tap the **kebab icon** of the added tool to rename it to something more identifiable. You can also delete it.



5. In the central panel's **Properties** column, you can find four editable fields for **radius, x, y, and z positions**. Tap the fields to change the radius and x ,y, z coordinates as needed. The sphere in the right panel updates live in the 3D model to assist with accurate placement.
6. Tap **Apply** in the top-right part of the main screen.



7. The robot will now interact with safety planes when the tool position spheres come into contact with them.

9.13. Teach Pendant Configuration

Description

In the **Hardware** section, select the Teach Pendant type connected to the Control Box so the robot's safety system knows what hardware to expect at power-up.
Your selection must match the physically connected hardware. Otherwise the safety system can expect an emergency stop source that is not present, and the robot cannot start.
The selections are:

- **3PE Enabled**. The robot operates with a three-position enabling Teach Pendant (3PE TP).
- **None**. No Teach Pendant is connected.

NOTICE
For safety reasons, the robot does not start if the selection does not reflect the connected hardware.

3PE Enabled

The connected Teach Pendant has an integrated Three-Position Enabling Device (3PE TP). The 3PE buttons are a safety-critical interface. In Manual Mode, hold one of the two underside enabling buttons at the light-press position to allow motion. When you release or fully press the button, the robot immediately performs a Category 2 safety stop (SF19 – 3PE Stop).

These are its main characteristics:

- Unlocks High Speed Manual Mode through the slider in the footer, so TCP and elbow speed can temporarily exceed 250 mm/s during teaching.
- Required to use Backdrive through the physical 3PE switch and to enable Freedrive through the rapid light-press, release, light-press, hold gesture.
- Plug-and-play; no URCap required.

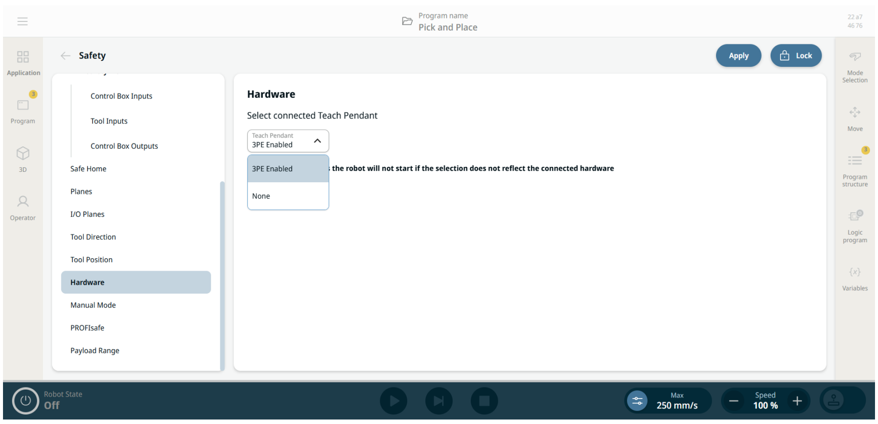
None

The **None** option supports setups where a Teach Pendant is not required or physically present. This enables more streamlined and flexible deployments, especially in automated or remote-controlled environments.
It gives you three key benefits:

- Supports headless configurations where no Teach Pendant is used.
- Simplifies hardware requirements for minimal setups.
- Improves start-up flexibility by removing dependency on Teach Pendant presence.

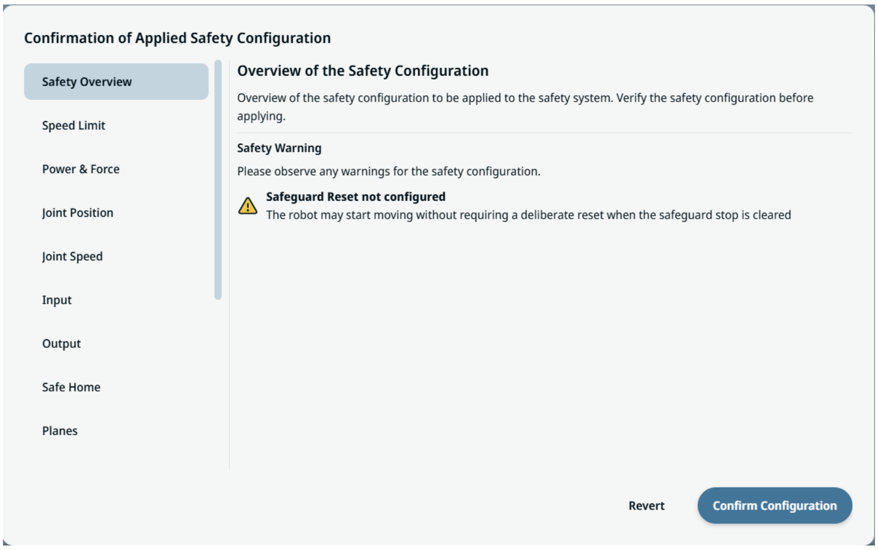
How to access Hardware

1. Tap **Hardware** in the left panel of the Safety screen.
2. Unlock the main screen at the top right, enter your safety password, and tap **Confirm**.
3. On the central panel, tap the **Teach Pendant** field and select an option from the drop-down menu.



Selecting connected Teach Pendant in PolyScope X

4. Tap **Apply** beside the **Lock** button.
5. Tap **Apply and restart** in the **Apply Safety Configuration** pop-up.
6. The **Confirmation of Applied Safety Configuration** pop-up appears. Tap **Revert** or **Confirm Configuration**.



Confirm configuration of Teach Pendant

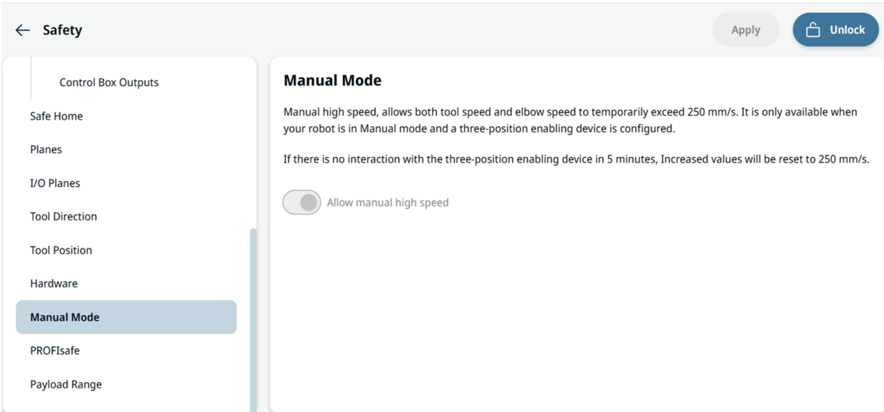
9.14. External Three-Position Enabling Device

Description

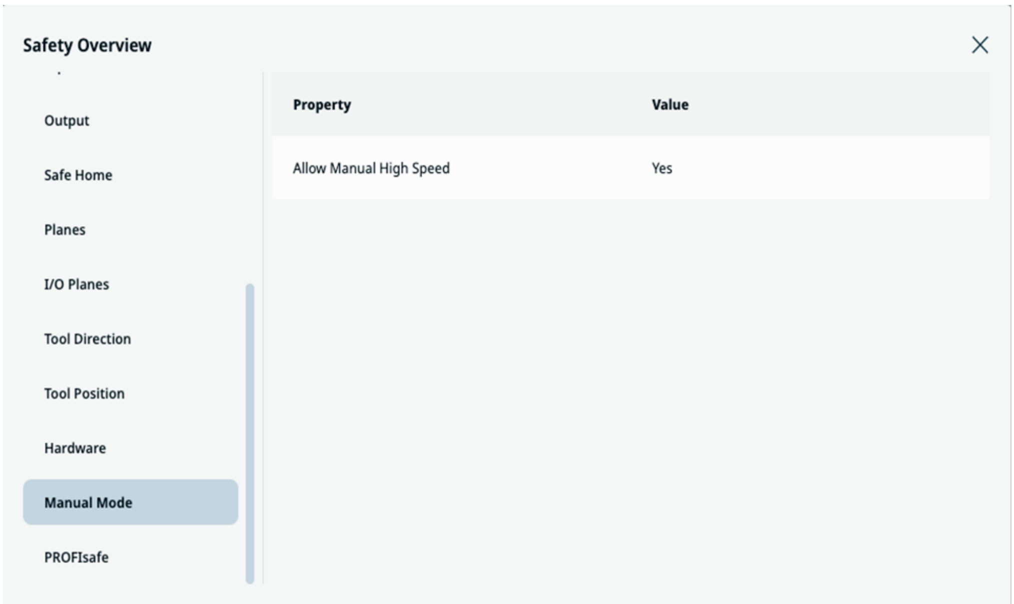
Manual high speed allows both tool speed and elbow speed to temporarily exceed 250 mm/s. It is only available when the robot is in Manual mode and a three-position enabling device is configured. If there is no interaction with the three-position enabling device for five minutes, increased values reset to 250 mm/s.

Access Manual Mode

1. In the main navigation, tap **Safety** and scroll down to select **Manual Mode**.
2. Tap **Unlock** on the upper-right side of the main screen.
3. Enter the safety password and **Confirm**.
4. On the central panel, slide the switch to **Allow manual high speed**.
5. Tap **Apply** to save the configuration and restart.

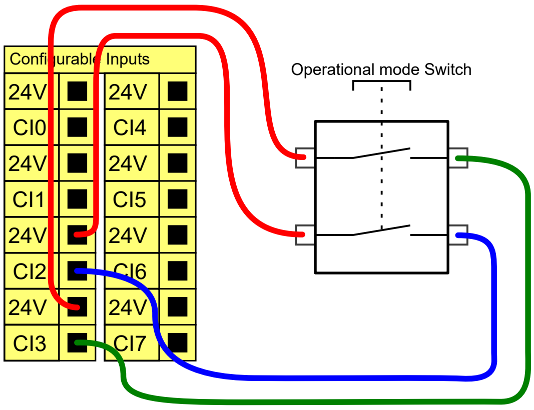


6. Manual Mode in the Safety Overview.



Operational Mode Switch

Using a three-position enabling device requires an **Operational Mode Switch**. The following illustration shows an **Operational Mode Switch**.



9.15. Operational Mode

Description

Access and activate the different modes using the Teach Pendant or the Dashboard Server. If an external mode selector is integrated, it controls the modes instead of PolyScope X or the Dashboard Server.

Automatic Mode When this mode is activated, the robot can only execute a program of predefined tasks. You cannot modify or save programs or installations.

Manual Mode When this mode is activated, you can program the robot. You can modify and save programs and installations. In Manual Mode, a person may be within reach of the robot. Limit the speed to a value appropriate for the application risk assessment to prevent injury.

Recovery Mode This mode activates when a safety limit from the active safety limit set is violated. The robot arm then performs a Stop Category 0. If an active safety limit, such as a joint position limit or a safety boundary, is already violated, the robot starts in Recovery Mode so you can move the robot arm back within the defined safety limits. In Recovery Mode, robot movement is restricted by fixed, non-configurable limits.

High Speed Manual Mode When this mode is enabled, you can temporarily exceed the default speed limit of the tool and the elbow.
The robot performs a Safeguard Stop in Manual Mode if a Three-Position Enabling Device is configured and is either released (not pressed) or fully pressed.

To switch from Automatic Mode to Manual Mode, fully release the Three-Position Enabling Device, then press it again before the robot can move. When using High Speed Manual Mode, use safety joint limits or safety planes to restrict the robot's moving space.

WARNING

Injury may result from operating the robot at excessive speed in Manual Mode.

WARNING

The suitability of High Speed Manual Mode shall be validated through the application risk assessment.

WARNING

- Any suspended safeguards must be returned to full functionality before selecting Automatic Mode.
- Whenever possible, Manual Mode shall only be used with all persons outside the safeguarded space.
- Any external mode selector must be placed outside the safeguarded space.
- No one may enter or remain within the safeguarded space during Automatic Mode, unless safeguarding is active or the collaborative application is validated for Power and Force Limiting (PFL).

NOTICE

The speed limit resets to the default after five minutes of inactivity.

To enable High Speed Manual Mode

1. Tap **Application** and select **Safety**.
2. Open the **Three Position** options.
3. Slide **Allow manual high speed** to enable the function.

Mode Switching

Operational Mode	Manual	Automatic
Move robot with +/- on **Move Tab**	x	
Freedrive	x	
Execute programs	Reduced speed*	x
Edit and save program	x	

*If a Three-Position Enabling Device is configured, the robot operates at Manual Reduced Speed unless High Speed Manual Mode is enabled.

Three-Position Enabling Device

When a Three-Position Enabling Device (3PE) is used and the robot is in Manual Mode, the robot moves only while the device is pressed to the center-on position. The 3PE has no effect in Automatic Mode.

A 3PE Teach Pendant is recommended for programming. If a person can enter the safeguarded space during Manual Mode, an additional enabling device must be integrated and configured for that person's use.

Switching Modes

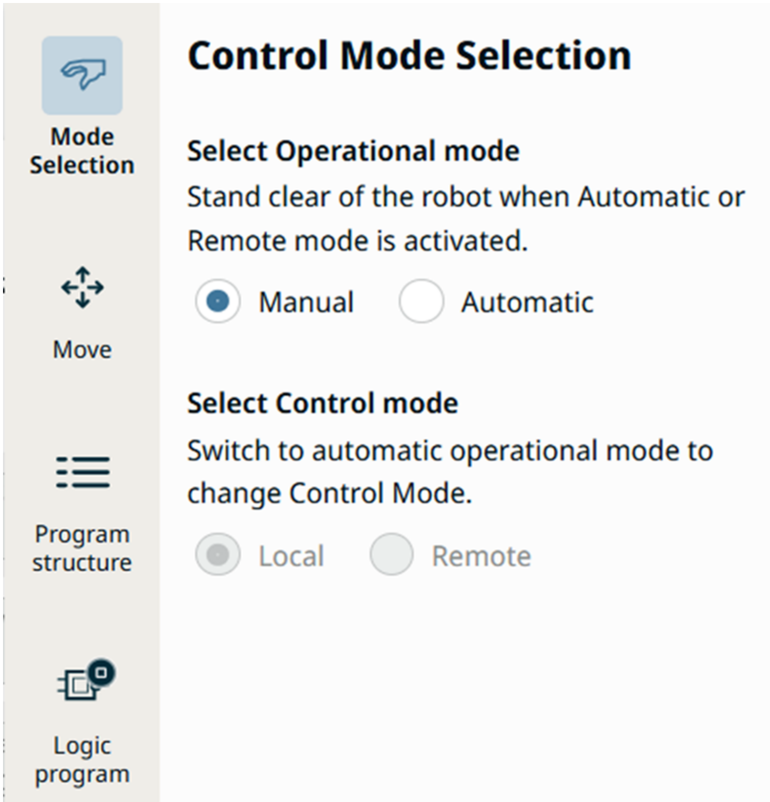
Select the profile icon to display the **Mode Selection** panel in the Sidebar.

- **Automatic** indicates that the robot's operational mode is set to Automatic.
- **Manual** indicates that the robot's operational mode is set to Manual.

PolyScope X is automatically in Manual Mode when the **Safety I/O** configuration with Three-Position Enabling Device is enabled.

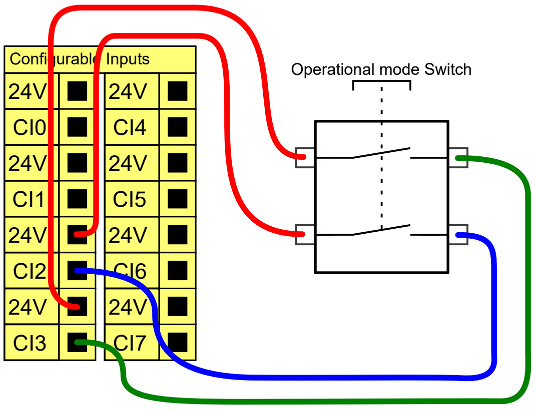
Select Remote Mode

You can change remote mode only when the operational mode is set to **Automatic**.
If you change remote mode from **Remote** to **Local**, the operational mode automatically returns to **Manual**.



Operational Mode Switch

Using a three-position enabling device requires an **Operational Mode Switch**.
The following illustration shows an **Operational Mode Switch**.



9.15.1. Remote Mode in Safety Overview

Description

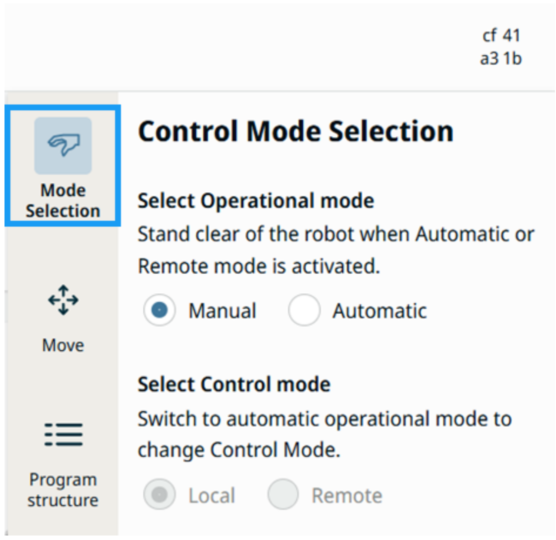
When activated, Remote Mode allows external devices to connect to key services such as the Primary Interface.

Remote Mode is enabled in the Mode Selection icon, which you can find in the sidebar.

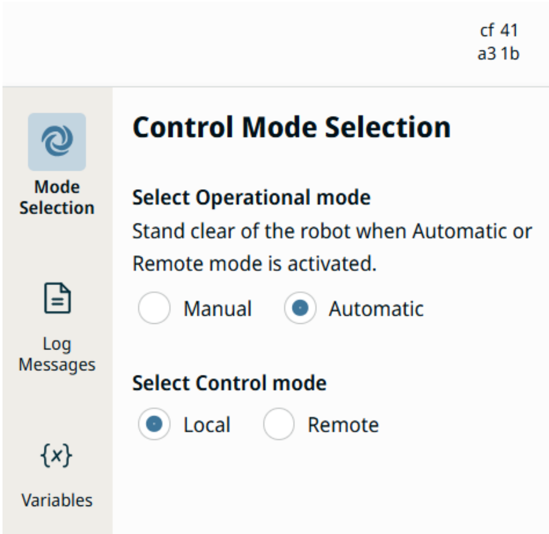
1. Go to Mode Selection in the sidebar. The sidebar expands and shows the Control Mode Selection panel.
2. You can now select Automatic and then Remote.

Local is toggled as default.
Remote is active only when the application is in Automatic mode.

Toggle Access

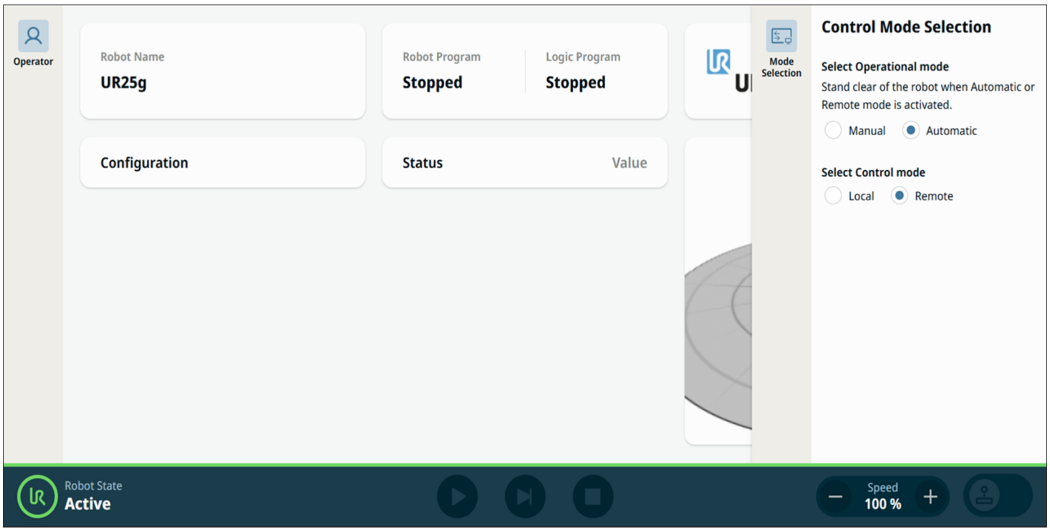


Automatic mode



Secure Lockdown

While in Remote Mode, PolyScope X interface enters a secure, read-only state. All editing and control actions are disabled, and only the Operator Screen remains accessible in view-only mode. Additionally, a Remote Mode icon is displayed above the Safety checksum to clearly indicate the system is under remote supervision.



I/O Controlled Safety

If the robot's operational mode is governed by an I/O signal, switching to Manual mode via I/O will automatically revert Remote Mode back to Local Mode.
This feature ensures a safe and structured environment for remote monitoring, while preserving local control integrity when needed.

9.15.2. Using I/O for Mode Selection

Description

You can configure the robot to switch between operational modes without the Teach Pendant. When you do, you cannot use the Teach Pendant to switch between Automatic mode and Manual mode.

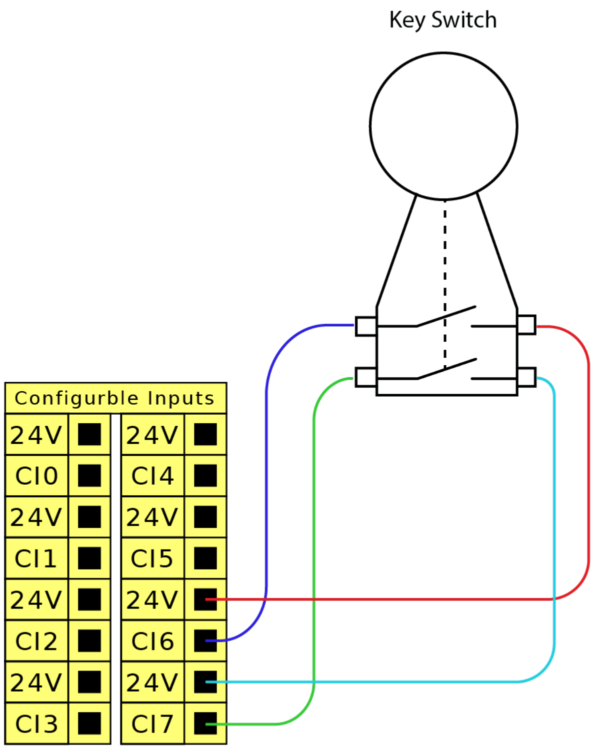
Switching modes without the Teach Pendant requires safety I/O configuration and a secondary device as a mode selector.

Mode selector

The mode selector can be a key switch with a redundant electrical layout, or it can use signals from a dedicated safety PLC.

To use the mode selector:

1. Connect the mode selector to the inputs as shown in the following image.
2. Verify that the mode selector is correctly connected and configured.



Mode selector switch connection

Configure the connected safety inputs

Unlock the safety I/O screen to configure the safety inputs for the secondary device.

1. In the main navigation, tap **Application**.
2. Select **Safety** and tap **Unlock**.

   When prompted, enter your password to unlock the Safety screen.

   If you have not previously defined a password, use the default password: `ursafe`.
3. Under **Safety I/O**, select **Control Box Inputs**.
4. Select one of the input signals by tapping one of the **Input** drop-down menu options.
5. In the drop-down menu, select **Operational Mode**.
6. Tap **Apply** and allow the robot to restart.
7. Tap **Confirm Safety Configuration**.

   You can only use the secondary device to select and/or switch between operational modes.

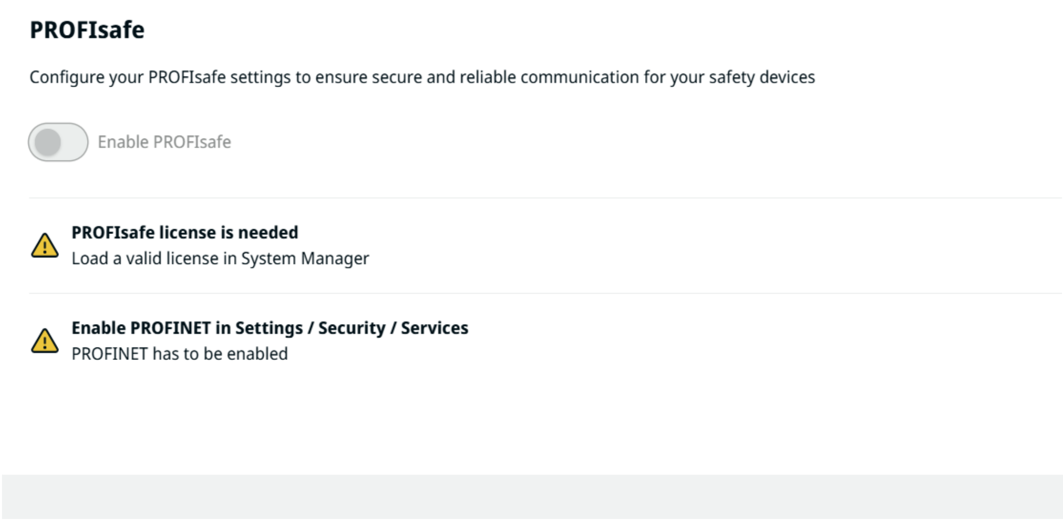
Once the input is assigned to the secondary device, switching modes via the Teach Pendant is disabled. If you attempt to switch modes with the Teach Pendant, a message appears confirming that the Teach Pendant cannot change the operational mode.

9.16. PROFIsafe

Description

The PROFIsafe network protocol (implemented as version 2.6.1) enables the robot to communicate with a safety PLC according to ISO 13849, Cat 3 PLd requirements.
The robot transmits safety-related information to a safety PLC and receives safety-related information from it.
Safety-related communications can be state messages or can trigger a safety function (e.g. reduced settings, stop). Stop commands are described according to IEC 60204-1, where the emergency stop is a Category 1 stop and the safeguard stop is a Category 2 stop.

The PROFIsafe interface provides a safe, network-based alternative to connecting wires to the safety IO pins of the robot control box.
Using the PROFIsafe interface maintains the UR robot's functional safety specifications (PL, category, and PFH). For details, see the "Safety Functions Table" section in the UR manual. For example, the "safeguard stop" is PLd Category 3 with a PFH value less than 1.8E-07 (1.8 x 10-7).



Safety PLC Out

A control message that the safety PLC sends to the robot contains the information shown in the following table.

Signal	Description
E-Stop by system	• 0: Asserts the system e-stop. • 1: Clear system e-stop.
Safeguard stop	• 0: Asserts the safeguard stop. • 1: Normal operation state. **Note**: Also refer to the “Reset safeguard stop” signal description.
Reset safeguard stop	Resets the safeguard stop state on a 0-to-1 transition when the “safeguard stop” signal is already set to 1.
Safeguard stop auto	• 0: Asserts safeguard stop if the robot is operating in Automatic mode. • 1: Normal operation state. Safeguard stop auto shall only be used when a 3-Position Enabling (3PE) Device is configured. If no 3PE Device is configured, the safeguard stop auto acts as a normal safeguard stop input. **Note**: Also refer to the “Reset safeguard stop auto” signal description.
Reset safeguard stop auto	Resets the safeguard stop auto state on a 0-to-1 transition when the “safeguard stop auto” signal is already set to 1.
Reduced	• 0: Activates the Reduced safety limits. • 1: Activates the “Normal mode” safety limits. The safety system guarantees the robot is within reduced limits less than 0.5s after the input is activated. If the robot arm continues to violate any of the reduced limits, a Stop Category 0 is triggered.
Operational mode	• 0: Activates the manual operational mode. • 1: Activates the automatic operational mode. If the safety configuration "Operational mode selection via PROFIsafe" is disabled, this field shall be omitted from the PROFIsafe control message.

Safety PLC In A status message that the robot sends to the safety PLC contains the information shown in the following table.

Signal	Description
Stop, cat. 0	• 0: Robot is performing, or has completed, a safety stop of category 0; a hard stop by immediate removal of power to the arm and the motors. • 1: Normal operation state.
Stop, cat. 1	• 0: Robot is performing, or has completed, a safety stop of category 1; a controlled stop after which the motors are left in a power-off state with brakes engaged. • 1: Normal operation state.
Stop, cat. 2	• 0: Robot is performing, or has completed, a safety stop of category 2; a controlled stop after which the motors are left in a power-on state. • 1: Normal operation state.
Violation	• 0: Robot is stopped because the safety system has failed to comply with the active safety limits defined. • 1: Normal operation state.
Fault	• 0: Robot is stopped because of an unexpected exceptional error in the safety system. • 1: Robot is not experiencing an unexpected exceptional error in the safety system.

E-stop by system	• 0: Robot is stopped because of one of the following conditions:
	  ◦ A safety PLC connected via PROFIsafe has asserted a system level e-stop.
	  ◦ An IMMI module connected to the control box has asserted a system level e-stop.
	  ◦ A unit connected to the system e-stop configurable safety input of the control box has asserted a system level e-stop.
	• 1: Robot is not in system e-stop.

E-stop by robot	• 0: The robot is stopped because of one of the following conditions:
	  ◦ The e-stop button of the teach pendant is pressed.
	  ◦ An e-stop button connected to the robot e-stop non-configurable safety input of the control box is pressed.
	• 1: Robot is not in e-stop by robot.

Safeguard stop	• 0: The robot is stopped due to one of the following conditions:
	  ◦ A safety PLC connected via PROFIsafe has asserted the safeguard stop.
	  ◦ A unit connected to the safeguard stop nonconfigurable input of the control box has asserted the safeguard stop.
	  ◦ A unit connected to the safeguard stop configurable safety input of the control box has asserted the safeguard stop.
	• 1: The robot is not stopped due to a safeguard stop.
	
	NOTICE
	Also refer to the “Reset safeguard stop” signal description.
	PROFIsafe enforces the use of the safeguard reset functionality.

Signal	Description
Safeguard stop auto	0: The robot is stopped because it is operating in Automatic mode and one of the following conditions applies: • A safety PLC connected via PROFIsafe has asserted safeguard stop auto. • A unit connected to a safeguard stop auto configurable safety input of the control box has asserted safeguard stop auto. 1: The robot is not stopped due to safeguard stop auto. **NOTICE** Also refer to the “Reset safeguard stop auto” signal description. PROFIsafe enforces the use of the safeguard reset functionality.

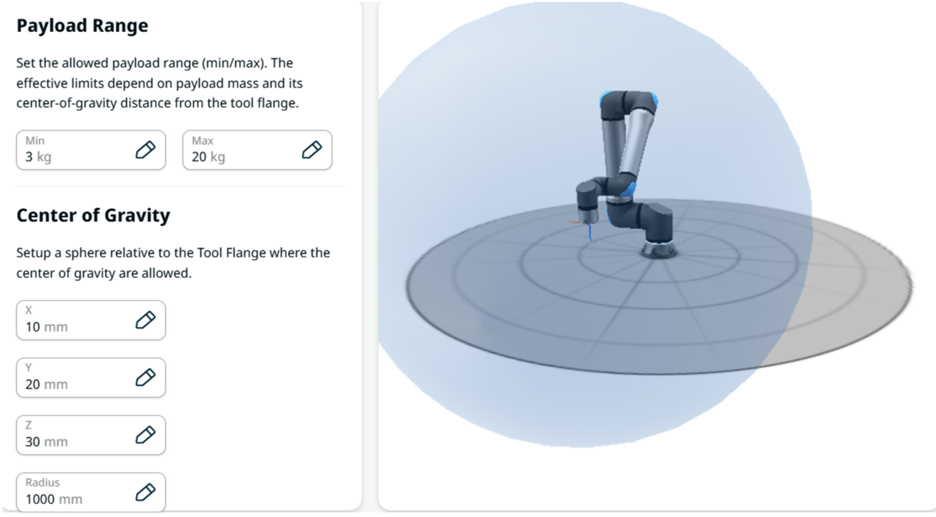
3PE stop	• 0: The robot is stopped because it is operating in Manual mode and one of the following conditions applies:
	  ◦ Any 3PE is pressed to the middle position, and Freedrive input is active.
	  ◦ Not all 3PE devices are pressed to the middle position.
	• 1: Robot is not stopped because of a 3-position enabling device.

Operational mode	Indication of the active operational mode of the robot. • 0: Disabled • 1: Automatic • 2: Manual
Reduced	• 0: Reduced safety limits are active. • 1: Normal safety limits are active.
Active limit set	The active set of safety limits. • 0: Normal • 1: Reduced • 2: Recovery
Robot moving	• 0: Robot is moving. If any joint moves at a velocity of 0.02 rad/s or higher, the robot is considered in motion. • 1: Robot is at standstill.
Safe home position	• 0: Robot is at rest (robot not moving), and in the position defined as the Safe Home Position. • 1: Robot is not at rest, or not in the position defined as the Safe Home Position.

9.17. Payload Range

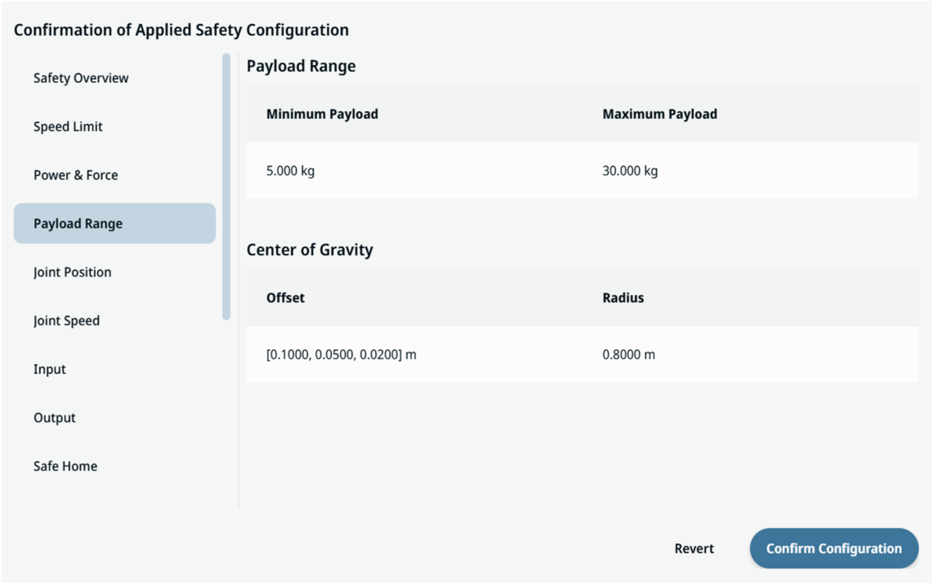
Description

Payload Range in the Safety Configuration defines the allowed payload configurations by weight and center of gravity. Use these limits to restrict the payloads permitted for a given application and ensure safe robot operation.
By default, the applied payload range exceeds the robot model's rated capabilities, so normal operation does not trigger a safety violation.



Payload Range in Safety Configuration

When you use the default configuration, a warning appears in the Safety Overview dialog. It is recommended that you specify an allowed payload range to gain greater control over safe operation.



Payload Range Confirmation of Applied Safety Configuration

NOTICE
The default payload range exceeds the robot model's rated capabilities.

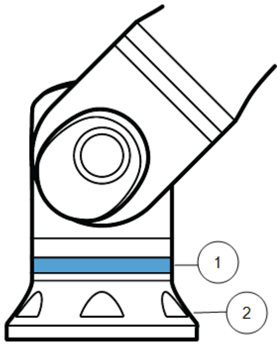
9.18. Light Ring

Description The light ring at the base of the robot arm provides status indication as described in the table below.

NOTICE
You can modify and/or disable the light ring configuration. See the Script Directory for further information.

NOTICE
The color spectrum of the light ring can deviate at the maximum ambient temperature.

Robot base



1	Light ring
2	Base

Color codes

Color	Mode	
	Steady	Flashing slow 0.5 Hz
Red	Robot not moving or in the process of stopping. 1. Emergency stop	
Yellow	Robot not moving or in the process of stopping. 1. Robot stop (previously known as Protective Stop) 2. Recovery 3. Safeguard stop (all types)	
Green	Automatic mode 1. Running	Automatic mode 1. Running at reduced parameters
Blue	Manual mode 1. Not Automatic, Not being moved 2. Booting process	Robot can be moved by hand 1. Backdrive 2. Freedrive
OFF	No power available to the robot arm 1. Fault 2. Violation 3. Loading Screen 4. System power OFF	

Controlling the light ring via URScript

You can control the light ring behavior using the following script commands:

Command	Description
`set_baselight_iec()`	Default. Sets the light ring to follow IEC 60204-1 standard colors for safety and operational modes.
`set_baselight_solid (r, g, b)`	Sets the entire ring to a custom color using RGB values (0-255).
`set_baselight_off()`	Turns the light ring off completely.

NOTICE

If you use `set_baselight_solid` or `set_baselight_off` in a program, the light ring remains in that state even if the program stops or a protective stop occurs. It does not revert to the standard IEC colors until `set_baselight_iec ()` is called again.

NOTICE

The light ring is purely informational and is not safety-rated. Do not rely on the light ring as an exclusive safety indication.

10. Cybersecurity Threat Assessment

10.1. General Cybersecurity

Description

Connecting a Universal Robots robot to a network can introduce cybersecurity risks. These risks can be mitigated by using qualified personnel and implementing specific measures for protecting the robot's cybersecurity.
Implementing cybersecurity measures requires conducting a cybersecurity threat assessment. The purpose is to:

- Identify threats
- Define trust zones and conduits
- Specify the requirements of each component in the application

WARNING

Failure to conduct a cybersecurity risk assessment can place the robot at risk.

- The integrator or competent, qualified personnel shall conduct a cybersecurity risk assessment.

NOTICE

Only competent, qualified personnel shall be responsible for determining the need for specific cybersecurity measures and for providing the required cybersecurity measures.

Security Architecture

PolyScope X implements multiple independent layers of security (Defense in Depth) so that compromise of any single layer does not grant unrestricted access to the system.

- Secure defaults. Network services are disabled at delivery. Only services explicitly enabled by an administrator are reachable from the network. From PolyScope X 10.14, inbound HTTP/HTTPS on ports 80 and 443 is closed by default and remains closed across reboots until an administrator enables it.
- Network perimeter. A configurable firewall restricts traffic to specified ports and IP addresses.
- Authentication. Three independent passwords (Admin, Operational Mode, Safety) protect separate functional domains. SSH supports key-based authentication as an alternative to passwords.
- Authorization. Admin-locked permission screens restrict access to network settings, software updates, URCap management, and service configuration. Operational Mode separation prevents program modification during automatic execution.
- Cryptographic identity. The robot maintains a digital certificate for secure identification. Self-signed and CA-signed certificates are supported through built-in certificate handling.
- Audit trail. Security-relevant configuration changes and events are logged, retained, and can be inspected using standard audit tools.

The integrator shall conduct a cybersecurity threat assessment to determine potential need of additional hardening for the specific application.

10.2. Cybersecurity Requirements

Description	Configuring your network and securing your robot requires you to implement the threat measures for cybersecurity. Follow all the requirements before you start configure your network, then verify the robot setup is secure.
Cybersecurity	• Operating personnel must have a thorough understanding of general cybersecurity principles and advanced technologies as used in the UR robot. • Physical security measures must be implemented to allow only authorized personnel physical access to the robot. • There must be adequate control of all access points. For example: locks on doors, badge systems, physical access control in general. **WARNING** Connecting the robot to a network that is not properly secured, can introduce security and safety risks. • Only connect your robot to a trusted and properly secured network.
Network configuration requirements	• Only trusted devices are to be connected to the local network. • There must be no inbound connections from adjacent networks to the robot. • Outgoing connections from the robot are to be restricted to allow the smallest relevant set of specific ports, protocols and addresses. • Only URCaps and magic scripts from trusted partners can be used, and only after verifying their authenticity and integrity
Robot setup security requirements	• Change the default password to a new, strong password. • Disable the "Magic Files" when not actively used (PolyScope 5). • Disable SSH access when not needed. Prefer key-based authentication over password-based authentication • Set the robot firewall to the most restrictive usable settings and disable all unused interfaces and services, close ports and restrict IP addresses. • Close unused HTTP/HTTPS access using the **HTTP** toggle in **Settings** > **Security** > **Services** (PolyScope X 10.14 and later). Keep ports 80 and 443 closed unless required for PolyScope web access, REST/Robot API, or externally available URCaps.

10.3. Cybersecurity Hardening Guidelines

Description

Although PolyScope X includes many features for keeping the network connection secure, you can harden security by observing the following guidelines:

- Before connecting your robot to any network, always change the default password to a strong password.
- Use the built-in settings to restrict the network access to the robot as much as possible.
- Disable the **HTTP** toggle in **Settings** > **Security** > **Services** when the robot does not need inbound web traffic (PolyScope X 10.14 and later). After upgrading to 10.14 or later, confirm the toggle state; port 80 no longer re-opens automatically on boot.
- Some communication interfaces have no method of authenticating and encrypting communication. This is a security risk. Consider appropriate mitigating measures, based on your cybersecurity threat assessment.
- SSH tunneling (Local port forwarding) must be used to access robot interfaces from other devices if the connection crosses the trust zone boundary.
- Remove sensitive data from the robot before it is decommissioned. Pay particular attention to the URCaps and data in the program folder.
  - To ensure secure removal of highly sensitive data, securely wipe or destroy the SD card.

NOTICE

You cannot retrieve or reset a forgotten or lost password.

- Store all passwords securely.

11. Risk Assessment

Description

Risk assessment requires an understanding of the hazards, risks and risk reduction measures for the robot application. Robot integration can require a basic level of mechanical and electrical training.

The risk assessment is a requirement that shall be performed for the application. The application risk assessment is the responsibility of the integrator. The user can also be the integrator.

The robot is partly completed machinery, as such the safety of the robot application depends on the tool/end effector, obstacles and other machines. The party performing the integration must use ISO 12100 and ISO 10218-2 to conduct the risk assessment. Technical Specification ISO/TS 15066 can provide additional guidance for collaborative applications. The risk assessment shall consider all tasks throughout the lifetime of the robot application, including but not limited to:

- Teaching the robot during set-up and development of the robot application
- Troubleshooting and maintenance
- Normal operation of the robot application

A risk assessment must be conducted **before** the robot application is powered on for the first time. The risk assessment is an iterative process. After physically installing the robot, verify the connections, then complete the integration. A part of the risk assessment is to determine the safety configuration settings, as well as the need for additional emergency stops and/or other protective measures required for the specific robot application.

If the robot is installed in a robot application where hazards cannot be reasonably eliminated or risks cannot be sufficiently reduced by use of the built-in safety-related functions (e.g. when using a hazardous tool/end effector, or hazardous process), then safeguarding is required.

WARNING

Failure to conduct an application risk assessment can increase risks.

- Always conduct an application risk assessment for foreseeable risks and reasonably foreseeable misuse.

  For collaborative applications, the risk assessment includes the foreseeable risks due to collisions and to reasonably foreseeable misuse.

  The risk assessment shall address:

  - Severity of harm
  - Likelihood of occurrence
  - Possibility to avoid the hazardous situation

Risk assessment

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.

11.1. Potential Hazard

Description

Universal Robots identifies the potential significant hazards listed below for consideration by the integrator. Other significant hazards can be associated with a specific robot application.

- Penetration of skin by sharp edges and sharp points on tool/end effector or tool/end effector connector.
- Penetration of skin by sharp edges and sharp points on nearby obstacles.
- Bruising due to contact.
- Sprain or bone fracture due to impact.
- Consequences due to loose bolts that hold the robot arm or tool/end effector.
- Items falling out of, or flying from the tool/end effector, e.g. due to a poor grip or power interruption.
- Mistaken understanding of what is controlled by multiple emergency stop buttons.
- Incorrect setting of the safety configuration parameters.
- Incorrect settings due to unauthorized changes to the safety configuration parameters.

WARNING

Failure to adhere to the general safety practices, listed below, can result in injury or death.

- Verify the robot arm and tool/end effector are properly and securely bolted in place.
- Verify the robot application has ample space to operate freely.
- Verify the personnel are protected during the lifetime of the robot application including transport, installation, commissioning, programming/teaching, operation and use, dismantling and disposing.
- Verify robot safety configuration parameters are set to protect personnel, including those who can be within reach of the robot application.
- Avoid using the robot if it is damaged.
- Avoid wearing loose clothing or jewelry when working with the robot. Tie back long hair.
- Avoid placing any fingers behind the internal cover of the Control Box.
- Inform users of any hazardous situations and the protection that is provided, explain any limitations of the protection and the residual risks.
- Inform users of the location of the emergency stop button(s) and how to activate the emergency stop in case of an emergency or an abnormal situation.
- Warn people to keep outside the reach of the robot, including when the robot application is about to start up.
- Be aware of robot orientation to understand the direction of movement when using the Teach Pendant.
- Adhere to the requirements in ISO 10218-2.

WARNING

Handling tools/end effectors with sharp edges and/or pinch points can result in injury.

- Make sure tools/end effectors have no sharp edges or pinch points.
- Protective gloves and/or protective eyeglasses could be required.

WARNING: HOT SURFACE

Prolonged contact with the heat generated by the robot arm and the Control Box, during operation, can lead to discomfort resulting in injury.

- Do not handle or touch the robot while in operation or immediately after operation.
- Check the temperature on the Log screen before handling or touching the robot.
- Allow the robot to cool down by powering it off and waiting one hour.

CAUTION

Failure to perform a risk assessment prior to integration and operation can increase risk of injury.

- Perform a risk assessment and reduce risks prior to operation.
- If determined by the risk assessment, do not enter the range of the robot movement or touch the robot application during operation. Install safeguarding.
- Read the risk assessment information.

CAUTION
Using the robot with untested external machinery, or in an untested application, can increase the risk of injury to personnel.

- Test all functions and the robot program separately.
- Read the commissioning information.

NOTICE
Very strong magnetic fields can damage the robot.

- Do not expose the robot to permanent magnetic fields.

READ MANUAL
Verify all mechanical and electrical equipment is installed according to relevant specifications and warnings.

11.2. Safety Configuration Settings Risk

Description

Identifying the correct safety configuration settings is a particularly important part of developing robot applications. Unauthorized access to the safety configuration must be prevented by enabling and setting password protection.
Some safety functions are purposely designed for collaborative robot applications. These are configurable through the safety configuration settings. They are used to address risks identified in the application risk assessment.

> **WARNING**
>
> Failure to set password protection can result in injury or death due to purposeful or inadvertent changes to configuration settings.
>
> - Always set password protection.
> - Set up a program for managing passwords, so that access is only by persons who understand the effect of changes.

The following limit the robot and as such can affect the energy transfer to a person by the robot arm, end effector, and workpiece.

- **Force and power limiting**: Used to reduce clamping forces and pressures exerted by the robot in the direction of movement in case of collisions between the robot and the operator.
- **Momentum limiting**: Used to reduce high transient energy and impact forces in case of collisions between the robot and the operator by reducing the speed of the robot.
- **Speed limitation**: Used to ensure the speed is less than the configured limit.

The following orientation settings are used to avoid movements and reduce exposure of sharp edges and protrusions to a person.

- **Joint, elbow and tool/end effector position limiting**: Used to reduce risks associated with certain body parts: Avoid movement towards head and neck.
- **Tool/end effector orientation limiting**: Used to reduce risks associated with certain areas and features of the tool/end effector and workpiece: Avoid sharp edges being pointed towards the operator, by turning the sharp edges inward towards the robot.

11.3. Pinch Hazard

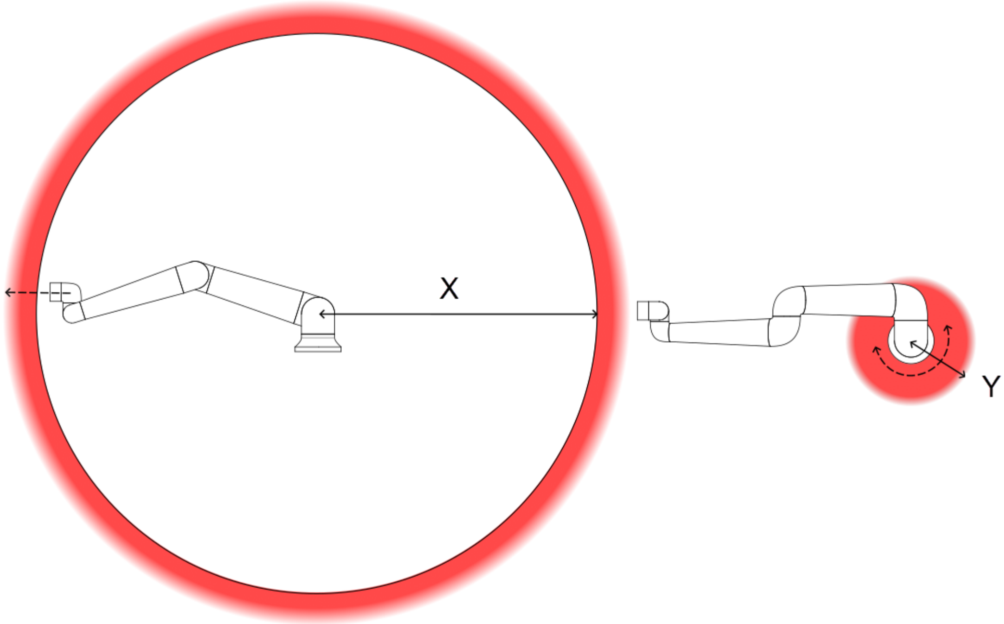
Description

You can avoid pinching hazards by removing obstacles in these areas, by placing the robot differently, or by using a combination of safety planes and joint limits to eliminate the hazards by preventing the robot moving into this area of its workspace.

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

Pinch-hazard workspace areas

Pinch hazard workspace areas for g-Series robots are shown below.



Due to the physical properties of the robot arm, certain workspace areas require attention regarding pinching hazards. X is defined for radial motions when the wrist 1 joint is at a certain distance from the base of the robot. Y is the distance within of the base of the robot, when moving tangentially.

Robot	Distance from the base of the robot to wrist 1 (X)	Distance within the base of the robot (Y)
UR10g-1750	1750 mm	400 mm
UR17g-1300	1150 mm	
UR18g-950	950 mm	

11.4. Stopping Performance Risks

Description

Some safety functions are purposely designed for any robot application. These features are configurable through the safety configuration settings. They are used to address risks associated with the stopping performance of the robot application.

The following limit the robot stopping time and stopping distance to ensure stopping will occur before reaching the configured limits. Both settings automatically affect the speed of the robot to ensure the limit is not exceeded.

- **Stopping Time Limit**: Used to limit the stopping time of the robot.
- **Stopping Distance Limit**: Used to limit the stopping distance of the robot.

If either of the above is used, there is no need for manually performed periodic stopping performance testing. The robot safety control does continuous monitoring.

11.4.1. Stopping Times and Stopping Distances

Description

The following section consolidates the stopping time and stopping distance graphs for g-Series robots.
The graphical data provided for **Joint 0 (Base)**, **Joint 1 (Shoulder)**, and **Joint 2 (Elbow)** is valid for stopping distance and stopping time:

- Stop Category 0
- Stop Category 1
- Stop Category 2

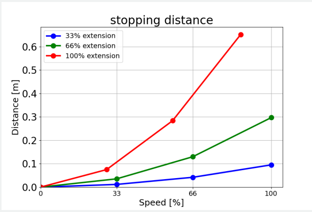
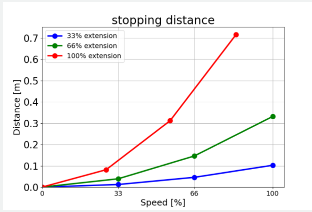
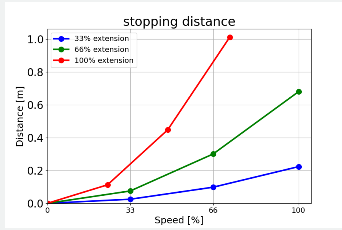
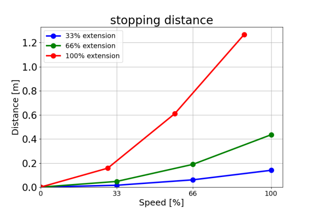
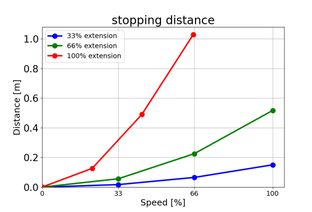
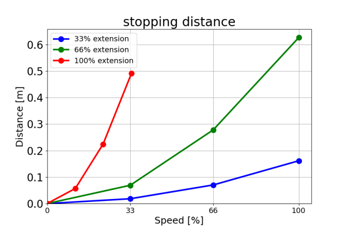
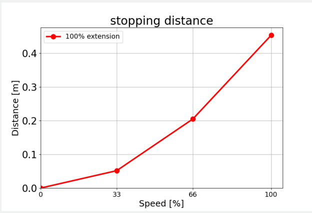
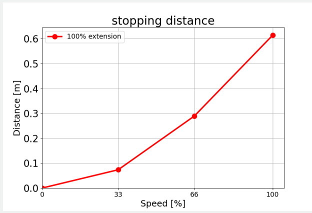
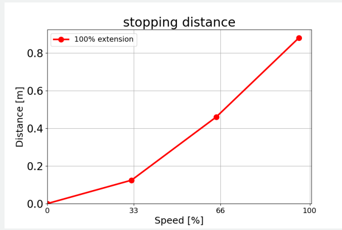
The **Joint 0** test was carried out using a horizontal movement, where the rotational axis was perpendicular to the ground. During the **Joint 1** and **Joint 2** tests, the robot followed a vertical trajectory, where the rotational axes were parallel to the ground, and the stop was done while the robot was moving downward.
The Y-axis is the distance from where the stop is initiated to the final position.

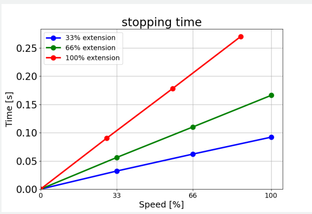
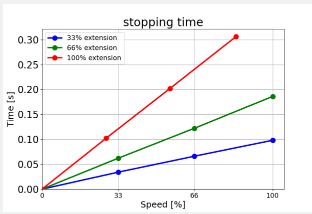
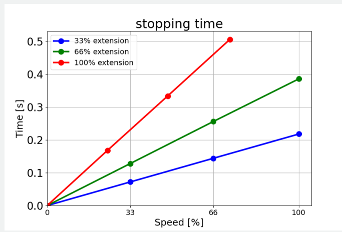
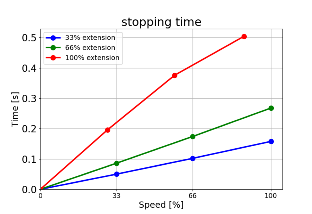
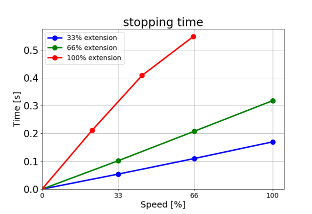
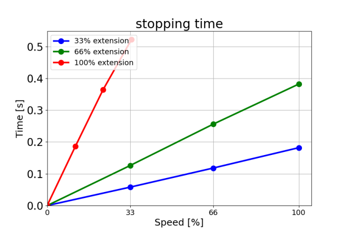
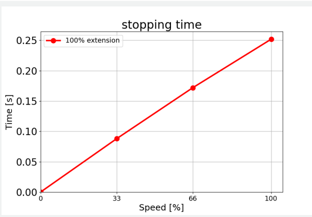
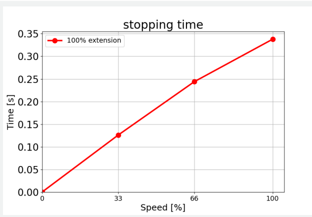
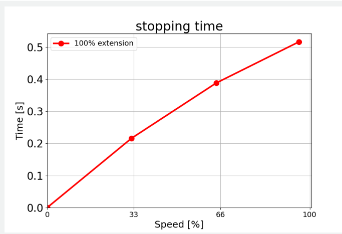
NOTICE
Some of the plots below may not reach 100% speed for high extensions and payloads. This occurs because the robot's built-in safety compliance functions dynamically reduce the robot speed to ensure safe operation in these high-load cases.

NOTICE
When a robot includes an extended payload capacity, an additional (fourth) graph column is provided to represent this extended payload, alongside the standard 33%, 66%, and 100% rated-payload cases.

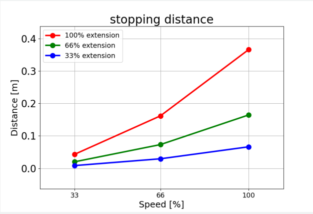
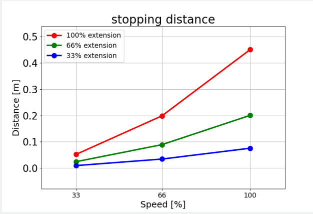
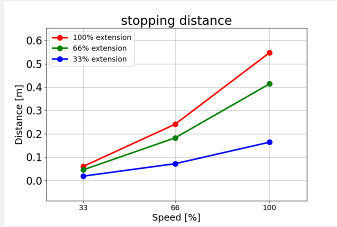
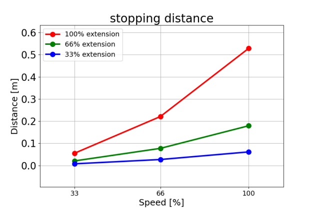
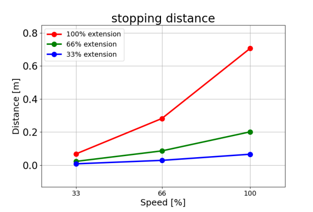
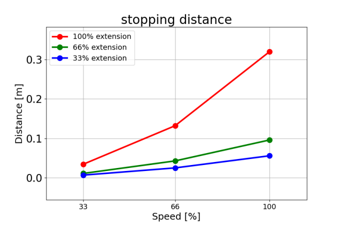
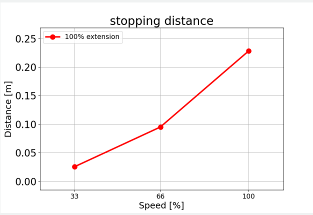
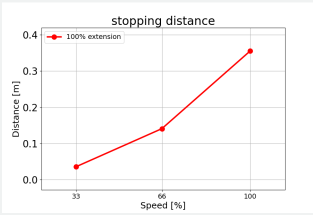
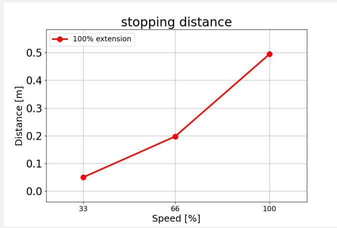
NOTICE
You can set user-defined safety-rated maximum stopping times and distances. If user-defined settings are used, the program speed is dynamically adjusted to always comply with the selected limits.

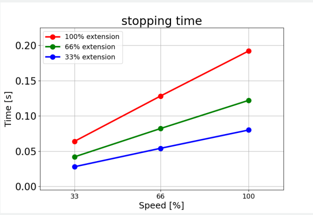
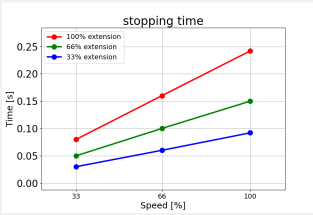
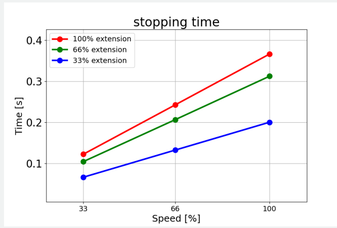
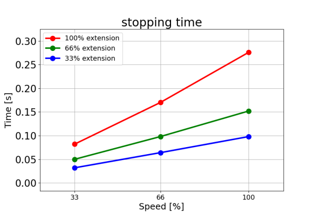
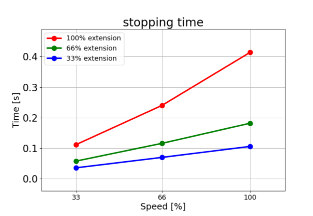
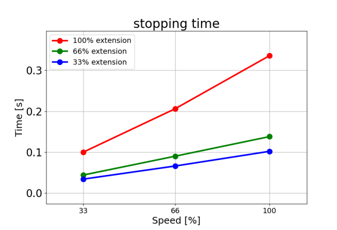
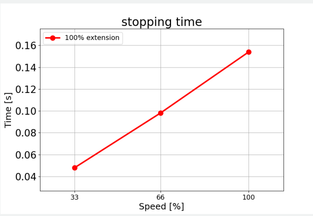
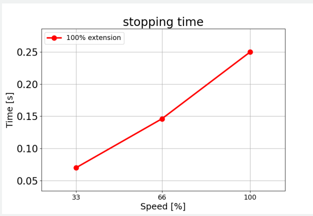
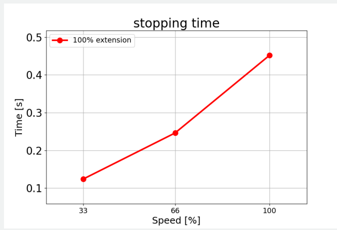
11.4.2. UR10g-1750

Stopping Distance UR10g-1750	33% of 8 kg	66% of 8 kg	100% of 8 kg
Joint 0 (Base)			
Joint 1 (Shoulder)			
Joint 2 (Elbow)			

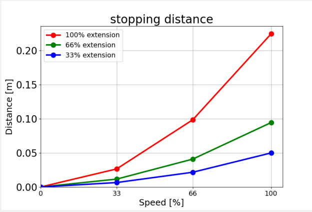
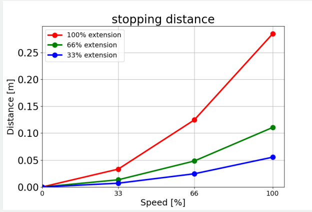
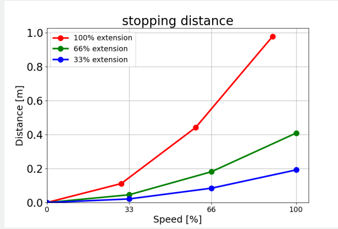
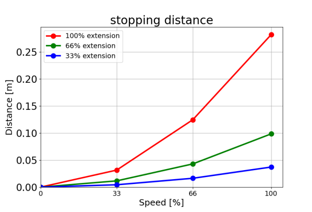
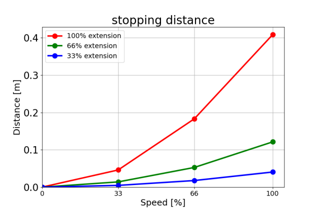
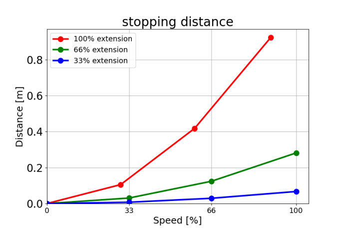
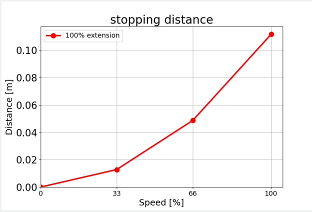
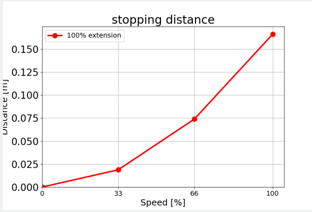
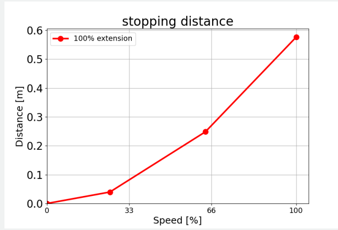
Stopping Time UR10g-1750	33% of 8 kg	66% of 8 kg	100% of 8 kg
Joint 0 (Base)			
Joint 1 (Shoulder)			
Joint 2 (Elbow)			

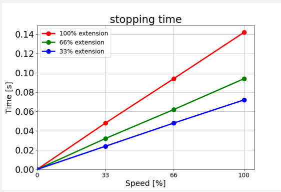
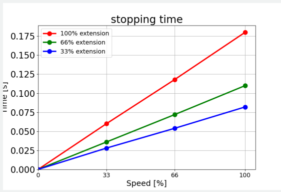
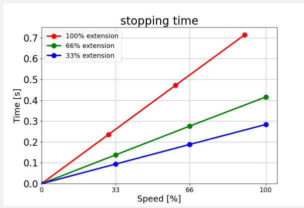
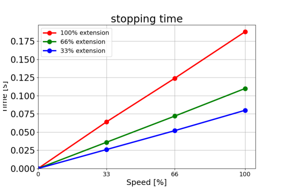
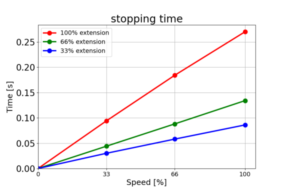
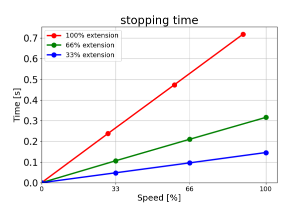
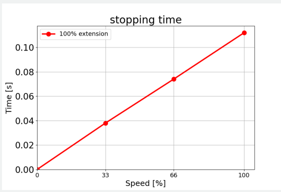
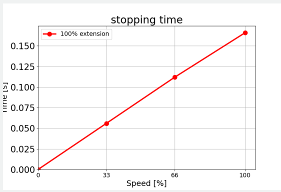
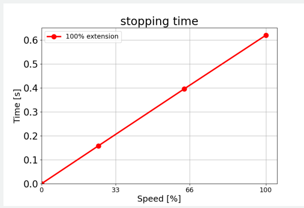
11.4.3. UR17g-1300

Stopping Distance UR17g-1300	33% of 17.5 kg	66% of 17.5 kg	100% of 17.5 kg
Joint 0 (Base)			
Joint 1 (Shoulder)			
Joint 2 (Elbow)			

Stopping Time UR17g-1300	33% of 17.5 kg	66% of 17.5 kg	100% of 17.5 kg
Joint 0 (Base)			
Joint 1 (Shoulder)			
Joint 2 (Elbow)			

11.4.4. UR18g-950

Stopping Distance UR18g-950	33% of 18 kg	66% of 18 kg	100% of 18 kg
Joint 0 (Base)			
Joint 1 (Shoulder)			
Joint 2 (Elbow)			

Stopping Time UR18g-950	33% of 18 kg	66% of 18 kg	100% of 18 kg
Joint 0 (Base)			
Joint 1 (Shoulder)			
Joint 2 (Elbow)			

12. Emergency Events

Description

Follow the instructions here to handle emergency situations, such as activating the emergency stop using the red push-button. This section also describes how to manually move the system without power.

12.1. Emergency Stop

Description

The Emergency Stop or E-stop is the red push-button located on the Teach Pendant. Press the emergency stop push-button to stop all robot motion. Activating the emergency stop push-button causes a stop category one (IEC 60204-1).
Emergency stops are not safeguards (ISO 12100).
Do not use the emergency stop for routine stopping or as a substitute for normal shutdown or power-off procedures.

Emergency stops are complementary protective measures that do not prevent injury. The risk assessment of the robot application determines if additional emergency stop push-buttons are required. The emergency stop function and the actuating device must comply with ISO 13850.

After an emergency stop is actuated, the push-button latches in that setting. As such, each time an emergency stop is activated, it must be manually reset at the push-button that initiated the stop.
Before resetting the emergency stop push-button, you must visually identify the condition for activating the emergency stop, correct the issue, and verify that the hazardous condition is removed.
Visual assessment of all the equipment in the application is required. Once the problem is solved, reset the emergency stop push-button.

To reset the emergency stop push-button

1. Hold the push-button and twist clockwise until the latching disengages.
   You should feel when the latching is disengaged, indicating the push-button is reset.
2. Verify the situation and whether to reset the emergency stop.
3. After resetting the emergency stop, restore power to the robot and resume operation.

12.2. Movement Without Drive Power

Description

In the event of an emergency, when powering the robot is either impossible or unwanted, you can use forced back-driving to move the robot arm.

Forced back-driving requires you to push or pull the robot arm hard to move the joint. Bigger robot arms can involve more than one person to move the joint.

Each joint brake has a friction clutch that enables movement during high forced torque. Forced back-driving requires high force and one or more people may be required to move the robot.

In clamping situations, two or more people are required to do the forced back-driving. In some situations, two or more people are required to disassemble the robot arm.

Personnel using the UR robot are to be trained to respond to emergency events. Supplemental information shall be provided on integration.

WARNING

Risks due to an unsupported robot arm breaking or falling can cause injury or death.

- Do not disassemble the robot during an emergency event.
- Support the robot arm before removing power.

NOTICE

Moving the robot arm manually is intended for emergency and service purposes only. Unnecessary moving of the robot arm can lead to property damage.

- Do not move the joint more than 160 degrees, to ensure the robot can find its original physical position.
- Do not move any joint more than necessary.

12.3. Backdrive

Description

During initialization of the robot arm, minor vibrations may be observed when the robot brakes are released. In some situations, such as when the robot is close to collision, these vibrations are undesirable. Use Backdrive to force specific joints to a desired position without releasing all brakes in the robot arm.

12.4. Heavy Backdrive

Description

If the robot arm is powered on and the brakes are released, the joints can be moved by force. The force required to initiate motion depends on the Force Limits specified in the safety settings.

12.5. Clamp Connection: Disassembly

Description

Use these instructions to disassemble the clamps that connect joints, pipes, and flanges when the robot arm is clamped and must be freed.

Failure to verify the existing joint before replacement can result in damage to property or equipment.

Always perform a joint verification test before you replace a joint. For more information, see the Joint Verification section in the Service Manual.

WARNING

Unsupported joints can fall or be dropped and cause injury.

- Support the joints while you remove the clamps.

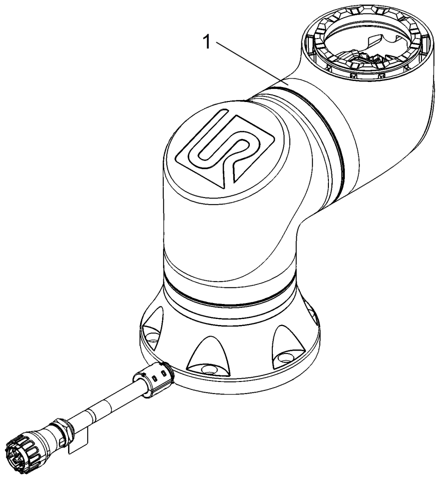
NOTICE

Failure to support the joints while you remove the clamps can result in damage to equipment.

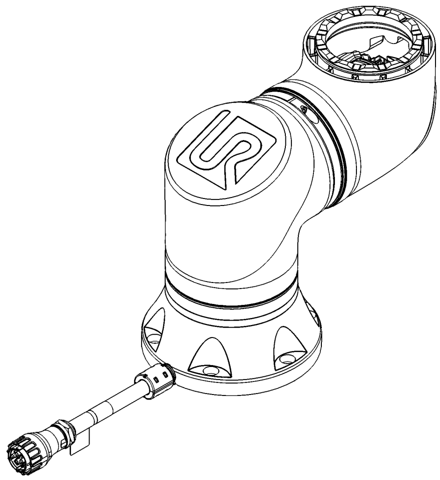
- Prevent the joints from falling while you remove the clamps by doing any of the following:
  - Place a support under the part that you are removing.
  - Disassemble the joint while it is lying down.
  - Support the joints with lifting equipment.

To Disassemble

1. Remove the black flat ring.
   You can use pointed tweezers or a small flat-head screwdriver.

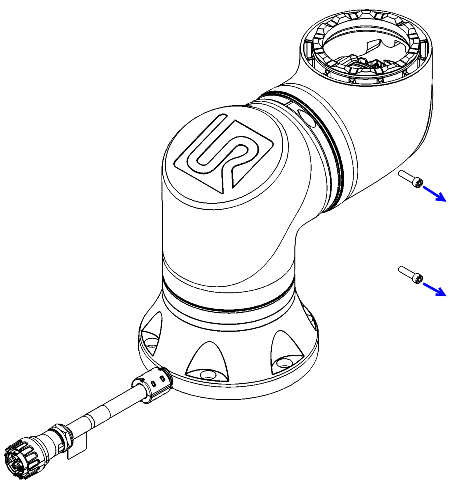


1 - Black flat ring

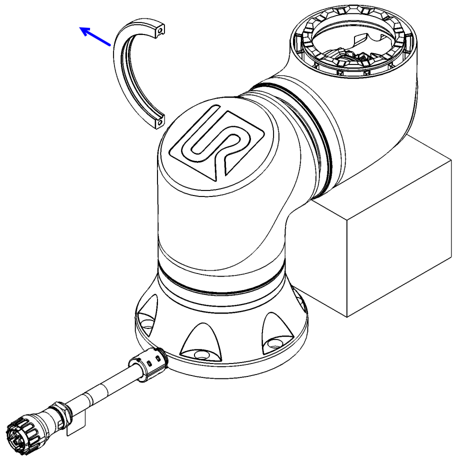


Remove the black flat ring

2. Remove the screws and the clamp on one side. You can use a 4 mm Allen key to unscrew the clamps on the base joint.

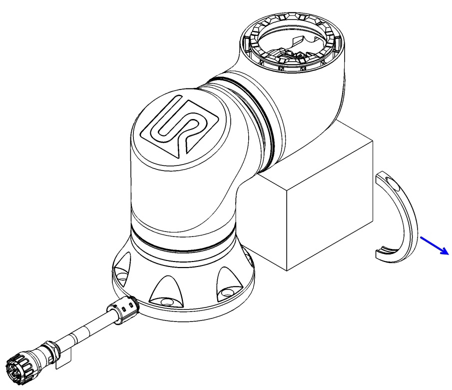


Remove the two screws



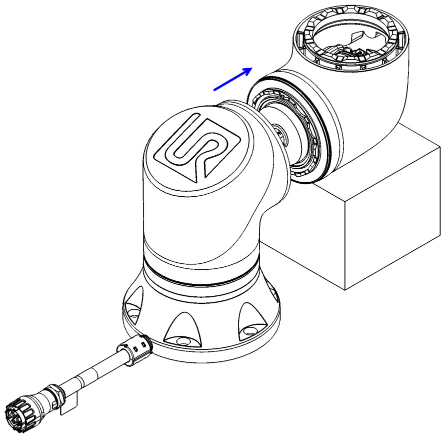
Remove one clamp

3. Support the joint with a lifting device, such as a round sling, as you remove the second side of the clamp.



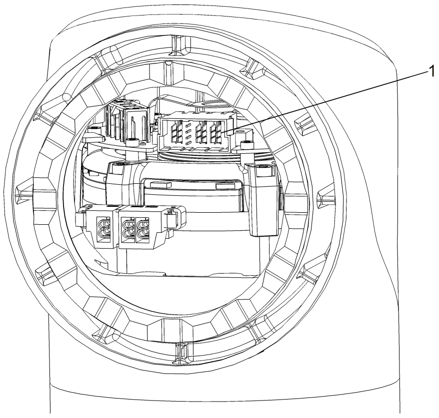
Remove the second clamp

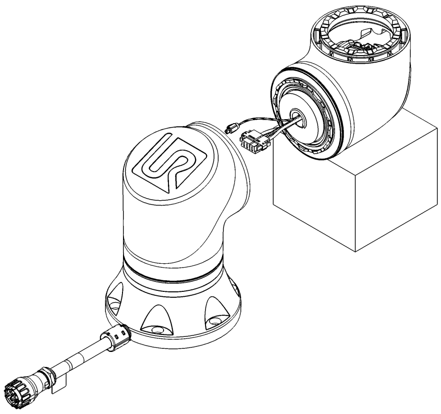
5. The joint is now loose. Remove it.



Remove the joint

6. Gently unplug the connector from the PCB on the joint.





1 - location of mating connector in PCB	Unplug the connector

7. The joint is now dismounted.

13. Commissioning

Description

The following tests must be conducted before using the robot application for the first time or after making any modifications.

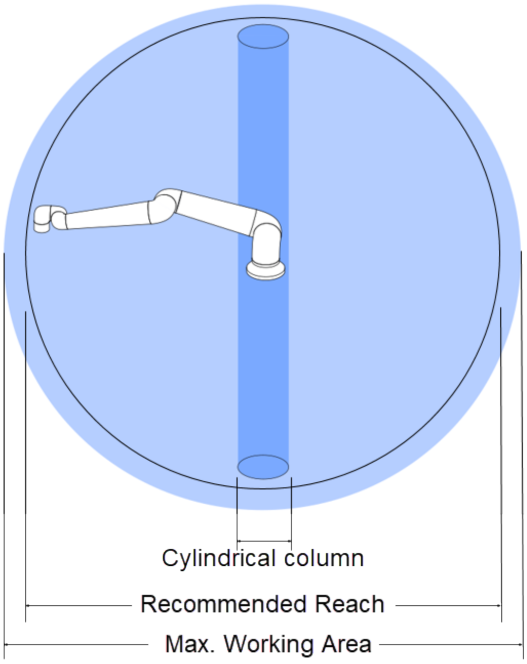
- Verify all safety inputs and outputs are correctly connected.
- Test that all connected safety inputs and outputs, including devices common to multiple machines or robots, are functioning as intended.
- Test emergency stop buttons and inputs to verify the robot stops and the brakes engage.
- Test safeguard inputs to verify the robot motion stops. If safeguard reset is configured, check that it functions as intended.
- Look at the initialization screen, activate the reduced input and verify the screen changes.
- Change the operational mode to verify the mode icon changes in the top right corner of the PolyScope X screen.
- Test the Three-Position Enabling Device to verify that pressing to the center-on position enables motion in Manual Mode at a reduced speed.
- If the Emergency Stop outputs are used, press the Emergency Stop push-button and verify that there is a stop of the whole system.
- Test the system connected to **Safety I/O Signals** in the **Installation** section to verify the output changes are detected.
- Determine the commissioning requirements of your robot application.

WARNING
An application risk assessment must be performed for the safety of personnel and equipment.

14. Operating Space

Description

The workspace is the range of the fully extended robot arm, horizontally and vertically. The operating space is the location where the robot is expected to function.
The robot workspace is spherical. In the Recommended Reach sphere, the robot can move the tool to any position with almost any orientation. The area outside the recommended reach is the Max Working Area. In this sphere, most positions can be reached but with restrictions on the tool orientation, because the robot physically cannot reach far enough in some situations. In the center of the workspace, directly above and below the base joint, there is a cylindrical column with movement restrictions.



Robot workspace

It is important to consider the cylindrical column when choosing a location to mount the robot. Moving the tool close to the cylindrical column should be avoided because it causes the joints to move fast even when the tool is moving slowly. This can cause the robot to work inefficiently and can make it difficult to conduct a risk assessment.

WARNING
The power plug for the mains connection shall be placed outside the reach of the robot, such that power can be removed without exposing personnel to potential hazards.

NOTICE
Disregard for the robot workspace and operating space can result in damage to property.

NOTICE
Moving the tool close to the cylindrical volume can cause the joints to move too fast, leading to loss of functionality and damage to property.

- Do not move the tool close to the cylindrical volume, even when the tool is moving slowly.

Singularity

A singularity is a pose that restricts the motion and the ability to position the robot. The robot arm can stop moving or have very sudden and fast movements when approaching and leaving a singularity. During placement of the robot in the workspace and definition of the operating space, it is important to take into consideration the singularity position.

The following cause singularity in the robot arm:

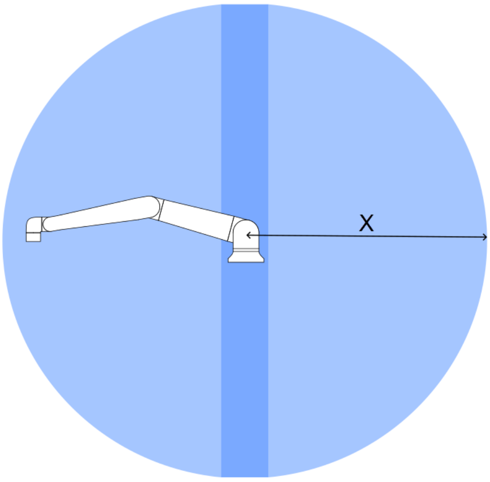
- Outer workspace limit
- Inner workspace limit
- Wrist alignment

WARNING
Make sure robot motion near a singularity does not create hazards to anyone within the range of the robot arm, end effector, and workpiece.

- Set safety limits for the speed and acceleration of the elbow joint.

Outer workspace limit

The singularity occurs because the robot cannot reach far enough or it reaches outside of the maximum working area.

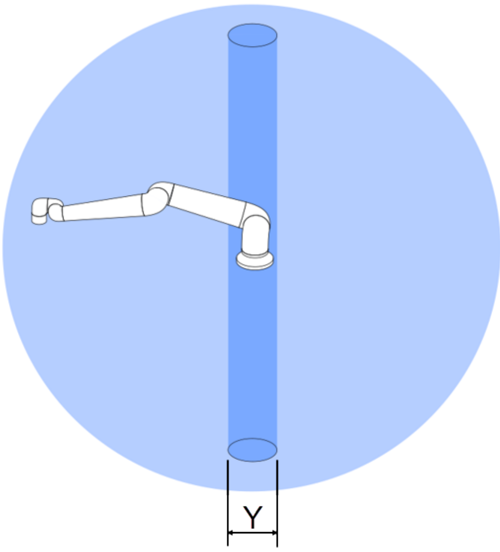


Outer workspace limit is defined by maximum reach

To avoid: Arrange the equipment around the robot to avoid it reaching outside of the recommended workspace. See Technical Specifications Robot Arm (g-Series).

Inner workspace limit

The singularity occurs because the movements are directly above or directly below the robot base. This causes many positions/orientations to be unreachable.

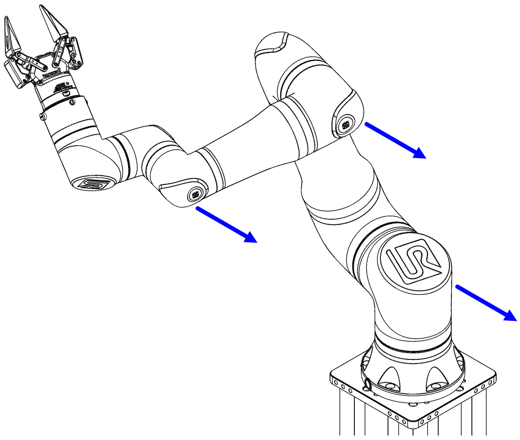


Inner workspace is defined by footprint

To avoid: Program the robot task in such a way that it is not necessary to work in or close to the central cylinder. You can also consider mounting the robot base on a vertical surface to rotate the central cylinder from a vertical to horizontal orientation, potentially moving it away from the critical areas of the task. See Technical Specifications Robot Arm (g-Series).

Wrist alignment

This singularity occurs because wrist joint 2 rotates on the same plane as the shoulder, elbow, and wrist joint 1. This limits the range of movement of the robot arm, regardless of workspace.



Wrist singularity

To avoid: Lay out the robot task in such a way that it is not necessary to align the robot wrist joints in this manner. You can also offset the direction of the tool, so that the tool can point horizontally without the problematic wrist alignment.

14.1. Electrical Installation of the Mains

Description

As part of the electrical installation, provide the following:

- Connection to ground
- Main fuse
- Residual current device
- A lockable (in the OFF position) switch

A main switch shall be installed to power off all equipment in the robot application as an easy means of lockout.

WARNING: ELECTRICITY

Failure to follow any of the below can result in serious injury or death due to electrical hazards.

- Ensure the robot is grounded correctly (electrical connection to ground). Use the unused bolts associated with grounding symbols inside the Control Box to create common grounding of all equipment in the system. The grounding conductor shall have at least the current rating of the highest current in the system.
- Ensure the input power to the Control Box is protected with a Residual Current Device (RCD) and a correct fuse.
- The power plug for the mains connection shall be placed outside the reach of the robot, such that power can be removed without exposing personnel to potential hazards.
- Lockout all power for the complete robot installation during service.
- Ensure other equipment shall not supply power to the robot I/O when the robot is locked out.
- IEC 61000-6-4:Chapter 1 scope: “This part of IEC 61000 for emission requirement applies to electrical and electronic equipment intended for use within the environment of existing at industrial (see 3.1.12) locations.”
- IEC 61000-6-4:Chapter 3.1.12 industrial location: “Locations characterized by a separate power network, supplied from a high- or medium-voltage transformer, dedicated for the supply of the installation”

Specifications of the Mains

The electrical specifications are shown in the table below.

Parameter	Min	Typ	Max	Unit
Input voltage	90	-	264	VAC
External mains fuse (90-200 V)		-	16	A
External mains fuse (200-264 V)	8	-	16	A
Input frequency	47	-	440	Hz
Stand-by power	-	-	<1.5	W
Nominal operating power	90			W

14.2. Dimensioning the Stand

Description

The structure (stand) on which the robot arm is mounted is a crucial part of the robot installation. The stand must be sturdy and free of any vibrations from external sources.

The magnitude of the loads depends on robot model, program, and multiple other factors. Dimensioning of the stand shall account for the loads that the robot arm generates during normal uninterrupted operation and during category 0, 1, and 2 stopping motion.

WARNING

- Potential tip-over hazards.
- The robot arm's operational loads can cause movable platforms, such as tables or mobile robots, to tip over, resulting in possible accidents.
- Prioritize safety by implementing adequate measures to prevent the tipping of movable platforms at all times.

CAUTION

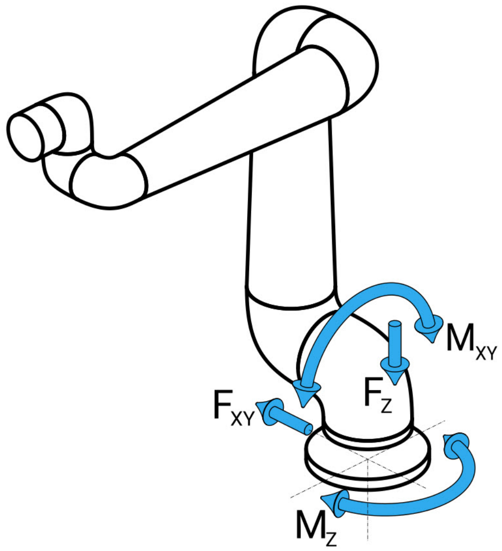
- If the robot is mounted on an external axis, the accelerations of this axis must not be too high.

  You can let the robot software compensate for the acceleration of external axes by using the script command:
  `set_base_acceleration()`
- High accelerations can cause the robot to make safety stops.

Dimensioning the Stand

Each robot joint produces a torque that moves and stops the robot arm. During normal uninterrupted operation and during stopping motion, the joint torques are transferred to the robot stand as:

- Mz: Torque around the base z-axis.
- Fz: Force along the base z-axis.
- Mxy: Tilting torque in any direction in the base xy plane.
- Fxy: Force in any direction in the base xy plane.



Force and moment at the base flange definition.

During stopping motion, the joints are allowed to exceed the maximum nominal operating torque. The load during stopping motion is independent of the stop category type.
The values stated in the following tables are maximum nominal loads in worst-case movements multiplied by a safety factor of 2.5. The actual loads will not exceed these values.

Robot Model	Mz	Fz	Mxy	Fxy
UR10g-1750	1310 Nm	2240 N	1690 Nm	1380 N
UR17g-1300	1310 Nm	2430 N	1730 Nm	1720 N
UR18g-950	1310 Nm	2600 N	1740 Nm	2000 N

Maximum joint torques during category 0, 1, and 2 stops.

Robot Model	Mz	Fz	Mxy	Fxy
UR10g-1750	1090 Nm	1870 N	1170 Nm	1100 N
UR17g-1300	1090 Nm	1860 N	1310 Nm	1490 N
UR18g-950	1090 Nm	2020 N	1500 Nm	1630 N

Maximum joint torques during normal operation.

The normal operating loads can generally be reduced by lowering the acceleration limits of the joints. Actual operating loads are dependent on the application and robot program. You can use URSim to evaluate the expected loads in your specific application.

Safety margins

You can incorporate added safety margins, factoring in the following design considerations:

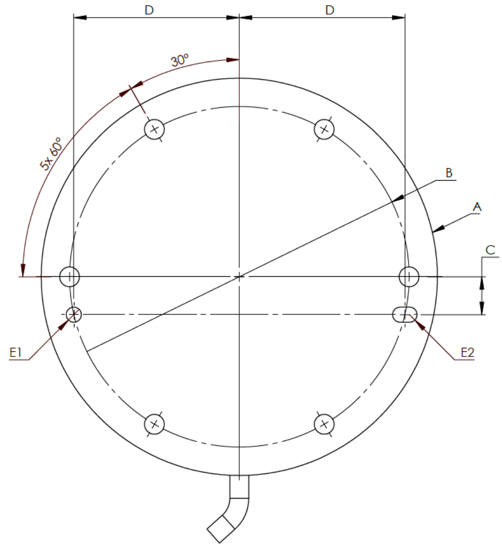
- **Static stiffness**: A stand that is not sufficiently stiff will deflect during robot motion, resulting in the robot arm not hitting the intended waypoint or path. Lack of static stiffness can also result in a poor Freedrive teaching experience or protective stops.
- **Dynamic stiffness**: If the frequency of the stand matches the movement frequency of the robot arm, the entire system can resonate, creating the impression that the robot arm is vibrating. Lack of dynamic stiffness can also result in protective stops. The stand should have a minimum resonance frequency of 45 Hz.
- **Fatigue**: The stand shall be dimensioned to match the expected operating lifetime and load cycles of the complete system.

Fixed and Movable Installation

Whether the robot arm is fixed (mounted to a stand, wall, or floor) or in a movable installation (linear axis, push cart, or mobile robot base), it must be installed securely to ensure stability through all motions.
The design of the mounting must ensure stability during movements of:

- the robot arm
- the robot base
- both robot arm and robot base

Dimensioning a base plate for mounting the robot



Bottom view of g-Series robot base

	UR10g-1750	UR17g-1300	UR18g-950
A Outside diameter	204 mm	204 mm	204 mm
B Pitch circle diameter	180 mm	180 mm	180 mm
C Dowel hole distance from center	20 mm	20 mm	20 mm
D Dowel hole distance from center	87.75 mm	87.75 mm	87.75 mm
E1 Dowel hole diameter	8 FG8	8 FG8	8 FG8
E2 Dowel hole diameter	8 FG8 x 13	8 FG8 x 13	8 FG8 x 13

14.3. Securing the Robot Arm

Description

This procedure describes how to securely mount the robot arm to prevent it from tipping and falling over. It provides the dimensions, hole position, and torque value for mounting the robot arm.

WARNING: ELECTRICITY

Conducting installation and/or maintenance of equipment connected to a power source can result in injury or death due to electric shock.

- Disconnect equipment from the power source before conducting installation or maintenance tasks.

To secure the robot arm

1. Place the robot arm on the mounting surface. The surface must be level and clean.
2. **For UR Series (UR10g-1750, UR17g-1300, UR18g-950)**: Tighten the six 8.8-strength, M10 bolts to a torque of 45 Nm.
3. If accurate remounting is required:
   - **UR10g-1750, UR17g-1300, UR18g-950**: Use the Ø8 mm hole and Ø8x13 mm slot with corresponding ISO 2338 Ø8 h6 positioning pins in the mounting plate.

15. Transportation and Storage

Description

Only transport the robot in its original packaging. Save the packaging material in a dry place if you want to move the robot later.
When moving the robot from its packaging to the installation space, hold both tubes of the robot arm at the same time. Hold the robot in place until all mounting bolts are securely tightened at the base of the robot.
Lift the Control Box by its handle.

WARNING

Incorrect lifting techniques, or using improper lifting equipment, can lead to injury.

- Avoid overloading your back or other body parts when lifting the equipment.
- Use proper lifting equipment.
- Follow all regional and national lifting guidelines.
- Mount the robot according to the instructions in the **Mechanical Interface** section.

NOTICE

If the robot is attached to a third-party application/installation during transport, refer to the following:

- Transporting the robot without its original packaging will void all warranties provided by Universal Robots A/S.
- If the robot is transported as part of a prefabricated solution, securely mounted, and in full compliance with the recommendations in "Transportation Without Packaging", it is not considered a breach of warranty.

Disclaimer

Universal Robots cannot be held responsible for any damage caused by transportation of the equipment.
See the recommendations for transportation without packaging at: universal-robots.com/manuals

15.1. Transportation Without Packaging

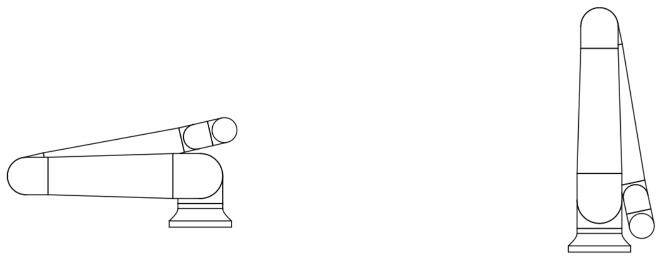
Description

Universal Robots always recommends transporting the robot in its original packaging.
These recommendations reduce unwanted vibrations in joints and brake systems and reduce joint rotation.
If you transport the robot without its original packaging, follow these guidelines:

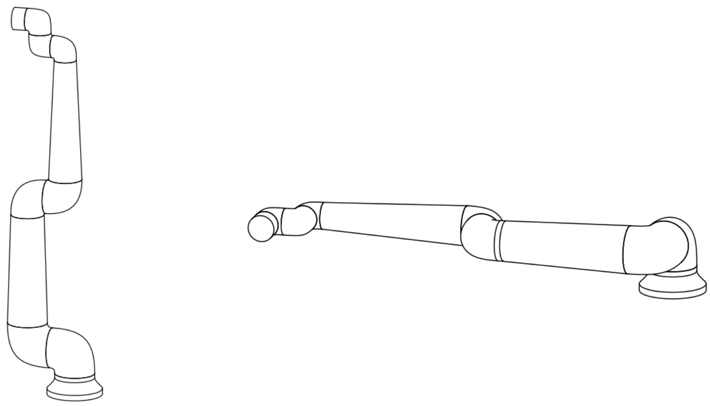
- Fold the robot as much as possible - do not transport the robot in the singularity position.
- Move the center of gravity of the robot as close to the base as possible.
- Secure each tube to a solid surface on two different points on the tube.
- Secure any attached end effector rigidly in 3 axes.

Transport

Fold the robot as much as possible.



Do not transport extended. (singularity position)



Secure the tubes to a solid surface.
Secure attached end effector in 3 axes.

15.2. Long Term Storage

Description

This section describes general guidelines for long-term storage of robots and spare parts.
This applies for all robot generations and spare parts.

A robot is considered long-term stored when it is stored for a period of 6 months or more.

Guidelines

In order to keep the robot and spare parts in its best possible condition, it is recommended to follow normal good practice which is:

- Storage temperature: 10°C - 30°C
- Humidity: RH 20-60%
- Universal Robots recommends to unpack and start up robots at least **yearly** and let them run a light load program rotating in all joints at least 90 degrees 5 times in each direction to distribute the lubricants.
  If possible, also mount spare parts joints on an arm and perform the same operation routine.
- In rare occurrences there may be a need for wiping down the robots after storage to remove any excess lubricants that have migrated out of the sealings.
- The battery is designed to last for the lifetime of the robot and will not be charged when power is applied to the system. The battery service life is 8 to 10 years, but for e-Series and UR Series it can be replaced.
- Flash memory can lose their data capacity over time, therefore there is a potential risk that the data on e.g. the SD-card will have to be re-flashed.

16. Maintenance and Repair

Description

Any maintenance work, inspection and calibration shall be conducted in compliance with all safety instructions in this manual, the UR e-Series, and according to local requirements.
Repair work shall be done by Universal Robots. Client designated, trained individuals can do repair work, provided they follow the Service Manual.

WARNING

Failure to adhere to any of the safety practices, listed below, can result in injury.

- Unplug the main power cable from the bottom of the Control Box to ensure that it is completely unpowered. Power off any other source of energy connected to the robot arm or Control Box. Take necessary precautions to prevent other persons from powering on the system during the repair period.
- Check the earth connection before re-powering the system.
- Observe ESD regulations when parts of the robot arm or Control Box are disassembled.
- Prevent water and dust from entering the robot arm or Control Box.

WARNING

Failure to leave space to accommodate the Control Box with the door fully open can lead to injury.

- Provide at least 915 mm of space to enable the Control Box door to open fully, providing access for servicing.

WARNING: ELECTRICITY

Disassembling the Control Box power supply too quickly after switching off can result in injury due to electrical hazards.

- Avoid disassembling the power supply inside the Control Box, as high voltages (up to 600 V) can be present inside these power supplies for several hours after the Control Box has been switched off.

WARNING: ELECTRICITY

Exposure to hazardous energy or the release of contained hazardous energy can result in electrical shock and serious injury.

- Use a power plug lockout to prevent the power cord from being reattached to the Control Box. For example, see Brady 148081 Plug Lockout for IEC plug or equivalent.

Safety for Maintenance

The purpose of maintenance and repair is to ensure the system is kept functioning as expected. When working on the robot arm or Control Box, you must observe the procedures and warnings. After troubleshooting, maintenance, and repair work, ensure that safety requirements are fulfilled. Adhere to national or regional work safety regulations. The correct functioning of all safety function settings shall also be tested and validated.

Lockout Tagout

UR robots can be de-energized and locked in the de-energized state. This is to control hazardous energy due to tasks associated with installation, maintenance, or repair of the robot, robot application, or robot cell.
To perform "Lockout" or "control of hazardous energy" of the power to the robot, you can use a power plug lockout to prevent the power cord from being reattached to the Control Box, for example, Brady 148081 Plug Lockout for IEC plug or equivalent.

16.1. Cleaning Methods

Description

To address the dust, dirt, or oil on the robot arm, Control Box, and Teach Pendant, simply use a cloth alongside one of the cleaning agents provided below.

Surface Preparation: Before applying the below solutions, surfaces may need to be prepared by removing any loose dirt or debris.

Cleaning Agents:

- Water
- 70% Isopropyl alcohol
- 10% Ethanol alcohol
- 10% Naphtha (Use to remove grease.)

Application: The solution is typically applied to the surface that needs cleaning using a spray bottle, brush, sponge, or cloth. It can be applied directly or diluted further depending on the level of contamination and the type of surface being cleaned.
Agitation: For stubborn stains or heavily soiled areas, the solution may be agitated using a brush, scrubber, or other mechanical means to help loosen the contaminants.
Dwell Time: If necessary, the solution is allowed to dwell on the surface for up to 5 minutes to penetrate and dissolve the contaminants effectively.
Rinsing: After the dwell time, the surface is typically rinsed thoroughly with water to remove the dissolved contaminants and any remaining cleaning agent residue. It's essential to ensure thorough rinsing to prevent any residue from causing damage or posing a safety hazard.
Drying: Finally, the cleaned surface may be left to air dry or dried using towels.

WARNING
DO NOT USE BLEACH in any diluted cleaning solution.

WARNING

Grease is an irritant and can cause an allergic reaction. Contact, inhalation, or ingestion can cause illness or injury. To prevent illness or injury, adhere to the following:

- PREPARATION:
  - Ensure that the area is well ventilated.
  - Have no food or beverages around the robot and cleaning agents.
  - Ensure that an eyewash station is nearby.
  - Gather the required PPE (gloves, eye protection).
- WEAR:
  - Protective gloves: oil-resistant gloves (nitrile), impermeable and resistant to product.
  - Eye protection is recommended to prevent accidental contact of grease with eyes.
- DO NOT INGEST.
- In the event of
  - contact with skin, wash with water and a mild cleaning agent.
  - a skin reaction, get medical attention.
  - contact with the eyes, use an eyewash station, get medical attention.
  - inhalation of vapors or ingestion of grease, get medical attention.
- After grease work
  - clean contaminated work surfaces.
  - dispose responsibly of any used rags or paper used for cleaning.
- Contact with children and animals is prohibited.

16.2. Inspection of Robot Arm (g-Series)

Description

The table below is a checklist of the type of inspections recommended by Universal Robots. Perform inspections regularly as advised in the table. Any referenced parts found to be in an unacceptable state must be rectified or replaced.

Inspection action type			Timeframe		
			Monthly	Every 6 months	Annually
1	Check flat rings	V		✗	
2	Check connected cables for damage (I/Os, robot cable, power cable, network cable, and other connected cables)	V		✗	
3	Check robot cable connection	V		✗	
4	Check Robot Arm mounting bolts *	F	✗		
5	Check Tool mounting bolts *	F	✗		
6	Check round sling	F			✗

where V = visual inspection; F = functional inspection; * = must also be checked after heavy collision

Notices

NOTICE

Using compressed air to clean the robot arm can damage the robot arm components.

- Never use compressed air to clean the robot arm.

NOTICE

If any damage is observed on a robot within the warranty period, contact the distributor where the robot was purchased.

Visual Inspection: Robot Arm

1. Move the Robot Arm to the ZERO position, if possible.
2. Turn off and disconnect the power cable from the Control Box.
3. Inspect the cable between the Control Box and the Robot Arm for any damage.
4. Check that the base mounting bolts are properly tightened.
5. Check that the tool flange bolts are properly tightened.
6. Inspect the flat rings for wear and damage.
   - Replace the flat rings if they are worn out or damaged.

Unacceptable states during Robot Arm inspection

The table below lists the parts and their corresponding unacceptable state.

Parts	State	Action
Joint Covers	Cracked or damaged	Replace
Screws and bolts	Missing, loose or improperly torqued	Replace/rectify; must meet torque specs defined in the Hardware Installation Manual
Sealing rings	Extensive wear or damage	Must be replaced to maintain the IP classification
wear rings	Extensive wear or damage	Must be replaced during reassembly
Black flexible flat rings		Must always be replaced with new ones after disassembly no matter what the state
Robot cables	Any visible damage, twisted	Replace
Foam seals on clamps	Damage	Must be replaced to maintain the IP classification

16.2.1. Testing Stopping Performance

Description

Test periodically to determine if stopping performance is degraded. Increased stopping times can require safeguarding to be modified, possibly with changes to the installation. If stop time and/or stop distance safety functions are used and are the basis of the risk reduction strategy, no monitoring or testing of stopping performance is required. The robot does continuous monitoring.

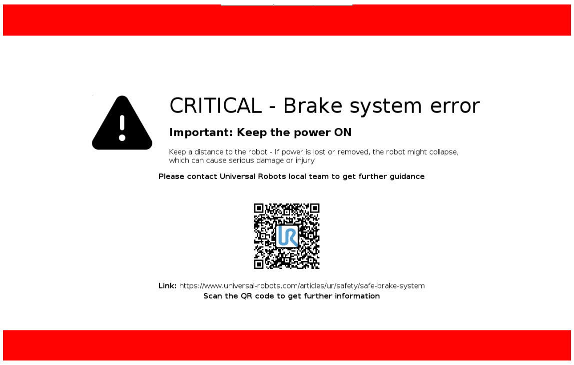
16.2.2. Safe Brake System

During shutdown, a violation, or an E-stop, UR Series robots run a procedure before the motors power off that detects whether the brake system in the robot arm engaged successfully.

If the robot detects that the brake system did not engage, power to the joint motors remains on. The robot arm stays at standstill until an operator powers off the arm in a controlled way.

> **NOTICE**
> The robot also performs this detection when leaving backdrive, but in this case it keeps the motors powered off.

When the system enters this state, the following screen appears in the PolyScope user interface: Long-press the exclamation mark icon to open a special power-off screen.



16.3. Inspection of Control Box (CB7)

Description Regular inspection of the CB7 Core including control box filter replacement, helps maintain optimal system performance.

Inspection Checklist

The table below is a checklist of the type of inspections recommended by Universal Robots. Perform inspections regularly as advised in the table. Any referenced parts found to be in an unacceptable state must be rectified or replaced.

Inspection action type			Timeframe		
			Monthly	Every 6 months	Annually
1	Check connected wires for damage (I/Os, robot cable, power cable, network cable, and other connected cables)	V		✗	
2	Check safety inputs and outputs (if connected)	F	✗		
3	Check and clean air filters on control box	V	✗		
4	Check terminals in control box	F			✗
5	Check main power to control box	F			✗

where V = visual inspection; F = functional inspection

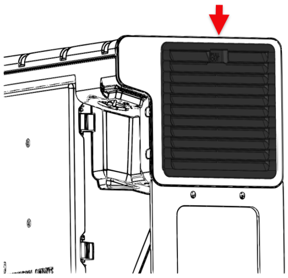
NOTICE

If any damage is observed on the Teach Pendant within the warranty period, contact the distributor where the robot was purchased.

Replace the Control Box Filters

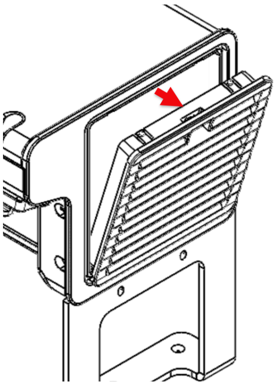
There is one filter on each side of the Control Box.

1. Gently pull at the points indicated by the red arrow in the image below to remove the outer plastic frame of the filter cassette.



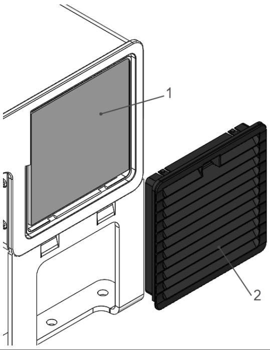
Filter cassette

2. The filter cassette tilts outward. Pull the filter cassette at the top.



Pull the filter cassette at the top

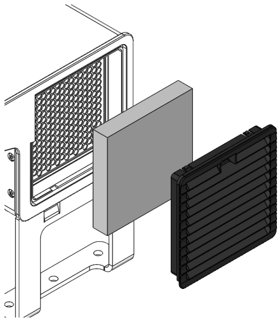
3. Carefully detach the filter cassettes from the Control Box.



1	Filter
2	Filter cassettes

Detach the filter cassettes

4. Remove the filter from the Control Box, then install the replacement filter in the same location.



Filter replacement

16.4. Inspection of Teach Pendant (TP7)

Description

The table below is a checklist of inspections recommended by Universal Robots. Perform inspections regularly as advised in the table. Rectify or replace any referenced parts found to be in an unacceptable state.

Inspection action type			Timeframe		
			Monthly	Every 6 months	Annually
1	Check emergency stop on Teach Pendant	V & F	✗		
2	Check Teach Pendant cable and connector	F		✗	

where V = visual inspection; F = functional inspection

NOTICE

If any damage is observed on the Teach Pendant within the warranty period, contact the distributor where the robot was purchased.

17. Disposal and Environment

Description

Universal Robots robots must be disposed of in accordance with the applicable national laws, regulations and standards. This responsibility rests with the owner of the robot.

UR robots are produced in compliance with restricted use of hazardous substances to protect the environment; as defined by the European RoHS directive 2011/65/EU. If robots (robot arm, Control Box, Teach Pendant) are returned to Universal Robots Denmark, then the disposal is arranged by Universal Robots A/S.

The disposal fee for UR robots sold on the Danish market is prepaid to DPA-system by Universal Robots A/S. Importers in countries covered by the European WEEE Directive 2012/19/EU must make their own registration to the national WEEE register of their country. The fee is typically less than 1€/robot.

You can find a list of national registers here: https://www.ewrn.org/national-registers.
Search for Global Compliance here: https://www.universal-robots.com/download.

Substances in Robots

Robot arm

- Tubes, Base Flange, Tool mounting bracket: Anodized aluminum
- Joint housings: Powder coated aluminum
- Black band sealing rings: AEM rubber
    - additional slip ring under black band: moulded black plastic
- Endcaps/ lids: PC/ASA Plastic
- Minor mechanical components e.g. screws, nuts, spacers (steel, brass, and plastic)
- Wire bundles with copper wires and minor mechanical components e.g. screws, nuts, spacers (steel, brass, and plastic)

Robot arm joints (internal)

- Gears: Steel and grease (detailed in the Service Manual)
- Motors: Iron core with copper wires
- Wire bundles with copper wires, PCB's, various electronic components and minor mechanical components
- Joint seals and O-rings contain a small amount of PFAS which is a compound within PTFE (commonly known as Teflon™).
- Grease: synthetic + mineral oil with a thickener of either lithium complex soap or Urea. Contains molybdenum.
    - Depending on model and date of production, the color of the grease could be yellow, magenta, dark pink, red, green.
    - The Service Manual details the handling precautions and Grease Safety Data Sheets

Control box

- Cabinet (enclosure): Powder coated steel
    - Standard Control Box
- Aluminum sheet metal housing (internal to the cabinet). This is also the housing of the OEM controller.
    - Standard Control Box and OEM controller.
- Wire bundles with copper wires, PCB's, various electronic components, plastic connectors, and minor mechanical components e.g. screws, nuts, spacers (steel, brass, and plastic)
- A lithium battery is mounted to a PCB. See the Service Manual for how to remove.

18. Technical Specifications g-Series

Description This section contains the detailed technical characteristics, capabilities, and parameters of g-Series robots.

18.1. Technical Specifications Robot Arm (g-Series)

Description This section contains the technical information for the robot arm.

General Specifications

	UR10g-1750	UR17g-1300	UR18g-950
Maximum payload	10 kg / 22 lbs. For maximum payload, see Maximum Payload g-Series.	17.5 kg / 38.58 lbs. For maximum payload, see Maximum Payload g-Series.	18 kg / 39.7 lbs
Reach	1750 mm / 68.9 in	1300 mm / 51.18 in	950 mm / 37.4 in
Degrees of freedom	6 rotating joints		
Joint architecture	2-1-3		
Power consumption (average)	Maximum power consumption: 615 W Average power consumption: 350 W	Maximum power consumption: 550 W Average power consumption: 350 W	Maximum power consumption: 570 W Average power consumption: 350 W
Control loop frequency	500 Hz		
Base flange connectors	Harting Plug		
Safety functions	23 configurable safety functions. PLd Category 3 in accordance with: EN ISO 13849-1.		
In safety compliance with	TÜV Rheinland EN ISO 13849-1 (PLd Category 3), TÜV Rheinland EN ISO 10218-1 and UL 1740		
Directives and regulatory compliance with	CE Declaration of Incorporation KC Mark RoHS		

Physical Specifications

	UR10g-1750	UR17g-1300	UR18g-950
Footprint	Ø204 mm / Ø8.03 in	Ø204 mm / Ø8.03 in	Ø204 mm / Ø8.03 in
Base size	Size 4 g-Series		
Materials	Aluminium, plastic, steel		
Tool flange	ISO 9409-1-50-4-M6		
Weight including cable	47.3 kg / 104.3 lbs	43.4 kg / 95.7 lbs	42 kg / 92.6 lbs

Movement

	UR10g-1750	UR17g-1300	UR18g-950
Maximum TCP speed	5 m/s	5 m/s	4 m/s
Pose repeatability per ISO 9283	± 0.08 mm	± 0.05 mm	± 0.05 mm
Working range (all joints)	± 360° for all joints		
Axis movement – maximum speed			
Base	± 180°/s	± 180°/s	± 180°/s
Shoulder	± 180°/s	± 180°/s	± 180°/s
Elbow	± 240°/s	± 240°/s	± 240°/s
Wrist 1	± 300°/s	± 300°/s	± 300°/s
Wrist 2	± 300°/s	± 300°/s	± 300°/s
Wrist 3	± 300°/s	± 300°/s	± 300°/s

Environment

	UR10g-1750	UR17g-1300	UR18g-950
Operating temperature (ambient)	0-50 °C / 32-122 °F Reduced performance from 35 °C and up.		
Humidity	≤ 90% RH (non-condensing)		
Noise level	< 55 dB(A)	< 55 dB(A)	< 55 dB(A)
Pollution degree	2		

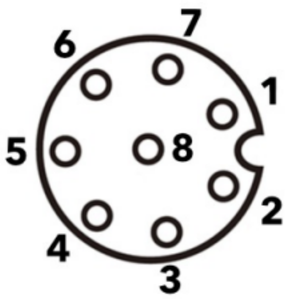
Protection

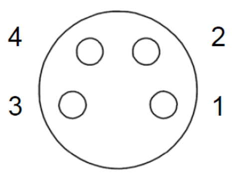
	UR10g-1750	UR17g-1300	UR18g-950
IP classification	IP65		

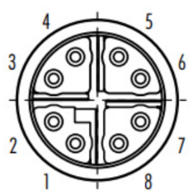
Force Torque

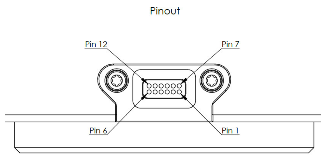
Force-torque sensing at tool flange	Force, x-y-z	Torque, x-y-z
Range	± 150.0 N	± 10.0 Nm
Precision	± 7.5 N	± 0.2 Nm
Accuracy	± 8.3 N	± 0.5 Nm

Electrical interface

M8 I/O 8-Pin Tool Connector	Pin #	Signal	Description
	1	AI3 / RS485-	Analog in 3 or RS485-
	2	AI2 / RS485+	Analog in 2 or RS485+
	3	TO0/PWR	Digital Outputs 0 or 0 V/12 V/24 V
	4	TO1/GND	Digital Outputs 1 or Ground
	5	POWER	0 V/12 V/24 V
	6	TI0	Digital Inputs 0 / Safety Input
	7	TI1	Digital Inputs 1 / Safety Input
	8	GND	Ground

M8 Power 4-Pin Tool Connector	Pin #	Signal	Description
	1	-	+24/+48 V power
	2	-	+24/+48 V power
	3	-	Ground
	4	-	Ground

M12 Ethernet Tool Connector	Pin #	Signal	Description
	1	-	D1+
	2	-	D1-
	3	-	D2+
	4	-	D2-
	5	-	D3+
	6	-	D3-
	7	-	D4+
	8	-	D4-

Pogo Pin Connector	Pin	Signal	Description
	1	Safety DI 1B	Safety Digital Input 1B
	2	GND	Ground
	3	DO1	Digital Output 1
	4	DO2	Digital Output 2
	5	DO3	Digital Output 3
	6	DO4	Digital Output 4
	7	Presence	Identification
	8	5 V	5 V output voltage
	9	Safety DI 1A	Digital Input 1 / Safety Digital Input 1A
	10	DI2	Digital Input 2
	11	DI3	Digital Input 3
	12	DI4	Digital Input 4

18.2. Technical Specifications Control Box (CB7)

Description

This section contains the technical information for the CB7 Core, CB7 Compact AC, and CB7 Compact AC 0.55m control box variants.

Model	Description
CB7 Core	Standalone enclosed control box for use in a robot cell
CB7 Compact AC	AC-powered Compact variant for integration into customer-built cabinets or machines (not for standalone use)
CB7 Compact AC 0.55m	Compact AC 0.55m with a longer robot-interface lead for panel-mount connection on the customer cabinet wall

Unless otherwise stated, CB7 Compact AC and CB7 Compact AC 0.55m share the same technical specifications. CB7 Compact AC 0.55m differs by the extended robot connector lead.

General Specifications

	CB7 Core	CB7 Compact AC	CB7 Compact AC 0.55m
Ambient temperature range	0-50 °C with reduced performance from 35 °C and up.		
Humidity	90% non-condensing		
Noise level	< 55 dB(A)		
Pollution degree	2		
Supported robot cable lengths	1-40 m		
Supported Teach Pendant cable lengths	5-40 m		

Protection

	CB7 Core	CB7 Compact AC	CB7 Compact AC 0.55m
IP classification	IP54	IP20	

Electrical interface

	CB7 Core	CB7 Compact AC	CB7 Compact AC 0.55m
Control Box I/O ports	16 configurable digital in, 16 configurable digital out (all safety-assignable as 8 dual-channel pairs), 2 analog in, 2 analog out, 4 quadrature digital in		
Control Box I/O power supply	24 V / 4 A		
System update frequency	500 Hz		
Fieldbus	MODBUS TCP, EtherNet/IP adapter, PROFINET		
USB	2x USB-A, 2x USB-C (DisplayPort on both USB-C ports)		
Network	3x Ethernet RJ-45 (10/100/1000 Mbps), 1000BASE-T		
Short-Circuit Current Rating (SCCR)	200A		
Control Box power source	C14, 100-240 VAC, 47-440 Hz		
Control Box Connector Type	Harting Receptacle		

Physical Specifications

	CB7 Core	CB7 Compact AC	CB7 Compact AC 0.55m
Control Box size (W × H × D)	393 x 284 x 201 mm	387 x 158 x 201 mm	
Control Box weight	12.4 kg / 27.3 lbs	8.5 kg / 18.7 lbs	8.5 kg / 18.7 lbs
Materials	Aluminum, steel and plastic.		
Robot connector length	N/A	N/A	550 mm cable to panel-mount connector
Mounting orientation	Wall / floor (enclosed cabinet)	Vertical and horizontal (inside customer enclosure)	

18.3. Technical Specifications Teach Pendant (TP7)

Description

This section contains the technical specifications for the Teach Pendant (TP7).

You can purchase the TP7 with a 5 m or 12 m cable.

General Specifications

	TP7 5m / 12m
Screen	Size: 11.6", resolution: 1920x1080p, aspect ratio: 16:9
Communication	USB 2.0 Type A*
Buttons	2x user-configurable buttons
E-stop	EN ISO 10218-1:2025
3PE enabling device	EN ISO 10218-1:2025

* USB 2.0 Type A supports a maximum transfer rate of 480 Mbps, but usable bandwidth on the TP7 USB 2.0 Type A port is capped at 100 Mbps by the internal link between the Teach Pendant (TP7) and the Control Box (CB7).

Environment

	TP7 5m / 12m
Ambient temperature range	0-50 °C with reduced performance from 35 °C and up.
Humidity	90% non-condensing
Pollution degree	2

Protection

	TP7 5m / 12m
Ingress Protection	IP54

Physical

	TP7 5m / 12m	
Cable length	5 m	12 m
TP size (W × H × D)	302 mm x 241 mm x 25 mm	
Materials	Aluminium, PC/ASA plastic	
TP weight	1.415 kg / 3.12 lbs, incl. 1 m Teach Pendant cable	
E-stop	EN ISO 10218-1:2025	
3PE enabling device	EN ISO 10218-1:2025	

18.4. Technical Specifications Robot Cables (g-Series)

Description This section contains technical information of the cables used in Robot system.

Cable Robot g (Black)

Sales Item Number		201929	201931	201934	201936	201938
Label Number		78872100	78872200	78872300	78872400	78872500
Length		1 m	2 m	3 m	6 m	12 m
Outer Material		PU or PUR				
Diameter		13.8 mm ± 0.8				
Robot Cable- Robot arm end connector		Harting Receptacle				
Robot Cable - Control Box end connector		Harting Plug				
Max tensile strain	Static	282 N				
	Dynamic	n/a				
Bend Radius	Static	4x diameter				
	Dynamic	n/a				
Mating cycles		500				

Cable Robot g CHAIN (Blue)

Sales Item Number		201953	201956	201958
Label Number		78872800	77281700	78872900
Length		3 m	6 m	12 m
Outer Material		TPU		
Diameter		16.5 mm ± 0.4		
Robot Cable- Robot arm end connector		Harting Receptacle		
Robot Cable - Control Box end connector		Harting Plug		
Torsion		±30 deg/m		
Max speed		120 m/min (2 m/s)		
Max acceleration		10 m/s²		
Bending Cycles		5 million		
Max tensile strain	Static	940 N		
	Dynamic	376 N		
Bend Radius	Static	4x diameter		
	Dynamic	8x diameter		
Mating cycles		500		

19. Declarations and Certifications

coming soon

19.1. Declaration of Incorporation (original)

coming soon

19.2. Certifications

coming soon

19.3. Certificates

coming soon

20. Safety Functions Table

Description

Universal Robots safety functions and safety I/O are PLd Category 3 (ISO 13849-1), where each safety function has a PFH value less than 1.8E-07.
The PFH values are updated to include greater design flexibility for supply chain resilience.
For safety I/O the resulting safety function including the external device, or equipment, is determined by the overall architecture and the sum of all PFHs, including the UR robot safety function PFH.
If any safety function limit is exceeded or a fault is detected in a safety function or safety-related part of the control system, UR defines the safe state as a stop with removal of drive power (either a stop category 1 or 0[4] immediate removal of power).

SF1 [1, 2, 3, 4] Emergency Stop (ISO 13850)	What happens?	Tolerance	Affects
Pressing the Estop PB on the pendant[1] or the External Estop (if using the Estop Safety Input) results in a Stop Cat 1[4] with power removed from the robot actuators and the tool I/O. Controller I/O goes "low". Commands[1] all joints to stop, and upon all joints coming to a monitored standstill state, power is removed. See Stop Time and Stop Distance Safety Functions[5]. **USE ONLY FOR EMERGENCY PURPOSES**; not to be used for safeguarding because actuation requires a manual action.	Stop Category 1 (IEC 60204-1)	N/A	Robot, robot tool I/O, and controller I/O
SF2 [3, 5] Safeguard Stop (Protective Stop according to ISO 10218-1*)	**What happens?**	**Tolerance**	**Affects**
This safety function is initiated by an external protective device using safety inputs which will initiate a Stop Cat 2[4]. The purpose is to protect people from injury, as compared to protecting the robot, equipment, or products. The tool I/O are unaffected by the safeguard stop. If an enabling device is connected, it is possible to configure the safeguard stop to function in automatic mode ONLY. See the Stop Time and Stop Distance Safety Functions.[5]. *Prior to 2006, this was called "safety stop" or "safeguard stop".	Stop Category 2 (IEC 60204-1) SS2 stop (as described in IEC 61800-5-2)	N/A	Robot
Safeguard Stop Reset	**What happens?**	**Tolerance**	**Affects**
When configured for Safeguard Reset and the external reset connections transition from low to high, safeguard stop resets. Safety input to initiate a reset of SF2.	Reset Input to SF2	N/A	Robot

SF3 Joint Position Limit (Software-Based Axis Limiting)	What happens?	Tolerance	Affects
Sets upper and lower limits for the allowed joint positions. Stopping time and distance is not considered as the limit(s) will not be violated. Each joint can have its own limits. *Directly limits the set of allowed joint positions that the joints can move within. It is safety-rated soft axis limiting and space limiting, according to ISO 10218-1:2011, 5.12.3.*	**Will not allow motion to exceed any limit settings.** Speed could be reduced so motion will not exceed any limit. A robot stop will be initiated to prevent exceeding any limit.	5°	Joint (each)
SF4 Joint Speed Limit	**What happens?**	**Tolerance**	**Affects**
Sets an upper limit for the joint speed. Each joint can have its own limit. This safety function has the most influence on energy transfer upon contact (clamping or transient). *Directly limits the set of allowed joint speeds which the joints are allowed to perform. It is used to limit fast joint movements, e.g. risks related to singularities.*	**Will not allow motion to exceed any limit settings.** Speed could be reduced so motion will not exceed any limit. A robot stop will be initiated to prevent exceeding any limit.	1.15° /s	Joint (each)
Joint Torque Limit	**What happens?**	**Tolerance**	**Affects**
Exceeding the internal joint torque limit (each joint) results in a Cat 0 Stop[4]. This safety function is not accessible to the user; it is a factory setting. It is NOT shown as here because there are no user settings.	N/A	N/A	N/A
SF5 Called with various names: Pose Limit, Tool Limit, Orientation Limit, Safety Planes, Safety Boundaries	**What happens?**	**Tolerance**	**Affects**
Monitors the **TCP** Pose (position and orientation) and will prevent exceeding a safety plane or TCP Pose Limit. Multiple pose limits are possible (tool flange and wrist joints, elbow, and up to 2 configurable tool offset points with a radius) Orientation restricted by the deviation from the feature Z direction of the tool flange OR the TCP. *Two parts: (1) is the safety planes for limiting the possible TCP positions. (2) is the TCP orientation limit, which is entered as an allowed direction and a tolerance. This provides TCP and wrist inclusion/exclusion zones due to the safety planes.*	**Will not allow motion to exceed any limit settings.** Speed or torques could be reduced so motion will not exceed any limit set for SF5, SF6, SF7, or SF8.	3° 40 mm	TCP, Tool flange and wrist joints, Elbow

SF6 Speed Limit TCP and Elbow	What happens?	Tolerance	Affects
Monitors the **TCP** and **elbow** speed to prevent exceeding a speed limit. Equivalent to monitoring the whole arm as the sections between the TCP and elbow cannot move faster than the endpoints of these sections.	A robot stop will be initiated to prevent exceeding any limit. **Will not allow motion to exceed any limit settings.**	50 mm/s	TCP
SF7 Force Limit (TCP)	**What happens?**	**Tolerance**	**Affects**
The Force Limit is the force exerted by the robot at the TCP (tool center point) and **elbow**. The safety function continuously calculates the torques allowed for each joint to stay within the defined force limit for both the TCP and the elbow. The joints control their torque output to stay within the allowed torque range. This means that the forces at the TCP or elbow will stay within the defined force limit. When a stop is initiated by the Force Limit SF, the robot will stop. The UR standard controller will cause motion to "back-off" to the position before the force limit was exceeded. This "back-off" is not part of the safety function as it is done by the standard controller. The safety controller has a fixed time (part of the response time) allowed before a robot stop is initiated.	A robot stop will be initiated to prevent exceeding any limit. **Will not allow motion to exceed any limit settings.**	25 N	TCP
SF8 Momentum Limit	**What happens?**	**Tolerance**	**Affects**
The momentum limit is very useful for limiting transient impacts. *The Momentum Limit affects the entire robot.*	A robot stop will be initiated to prevent exceeding any limit. *Will not allow motion to exceed any limit settings.*	3 kg m/s	Robot

SF9 Power Limit	What happens?	Tolerance	Affects
This function monitors the mechanical work (sum of joint torques times joint angular speeds) performed by the robot, which also affects the current to the robot arm as well as the robot speed. This safety function dynamically limits the current/torque but maintains the speed.	Dynamic limiting of the current/torque	10 W	Robot
SF10 UR Robot Stop Outputs	**What happens?**	**Tolerance**	**Affects**
When configured for a robot stop output and there is a robot stop, the dual outputs are LOW. If there is no robot stop initiated, dual outputs are high. Pulses are not used but they are tolerated. For an integrated safety function, see footnote.[6] These dual outputs change state for any external Estop that is connected to configurable safety inputs where this input is configured as an Emergency Stop input. For the Stop Output, validation is performed at the external equipment, as the UR output is an input to this external stop safety function for external equipment. NOTICE This stop output is not connected to the IMMI (Injection Moulding Machine Interface), to prevent having an unrecoverable stop.	Dual outputs go low in event of a stop if configurable outputs are set.	N/A	External connection to logic and/or equipment
SF11 "Moving" Safety Function with Digital Outputs	**What happens?**	**Tolerance**	**Affects**
Whenever the robot is moving (motion underway), the dual digital outputs are LOW. Outputs are HIGH when no movement. Functional safety is for what is within the UR robot. For an integrated safety function, see footnote[6].	Dual outputs are low during motion and high when no movement.	N/A	External connection to logic and/or equipment
SF12 "Not stopping" Safety Function with Digital Outputs	**What happens?**	**Tolerance**	**Affects**
Whenever the robot is STOPPING (in process of stopping or in a stand-still condition) the dual digital outputs are HIGH. When outputs are LOW, robot is NOT in the process or stopping and NOT in a stand-still condition. For an integrated safety function, see footnote[6].	Dual outputs are high when robot is either in the process of stopping or at a stand-still state.	N/A	External connection to logic and/or equipment

SF13 "Reduced Active" Safety Function with Digital Outputs	What happens?	Tolerance	Affects
When reduced settings are active (or initiated) for safety functions, the dual digital outputs are LOW. The functional safety is for what is within the UR robot. For the integrated safety function, see footnote[6].	Dual outputs are low when reduced settings are active.	N/A	External connection to logic and/or equipment
SF14 "Reduced Not Active" Safety Function with Digital Outputs	**What happens?**	**Tolerance**	**Affects**
Whenever the robot reduced settings for safety functions are NOT active (or not initiated), the digital outputs are LOW. The functional safety rating is for what is within the UR robot. For the integrated safety function, see below footnote.[6]	Dual outputs are low when reduced settings are NOT active.	N/A	External connection to logic and/or equipment
"Reduced Active" Input SF Parameter Settings Change	**What happens?**	**Tolerance**	**Affects**
Reduced is not a mode. It is a change of settings initiated: • internally by a safety plane/ boundary (starts when at 2 cm of the plane and reduced settings are achieved within 2 cm of the plane) or • externally by use of an external input, which will achieve reduced settings within 500 ms of the triggering input. When the external connections are Low, Reduced Mode is initiated. "Reduced Active" makes all reduced limits ACTIVE. Reduced is not a safety function. Reduced is a means of parametrization of safety functions. Reduced is a state change affecting the settings of the following safety functions: joint position, joint speed, TCP pose, TCP speed, TCP force, momentum, power, stopping time, and stopping distance. Verify and validate all parameter settings for the robot application.	N/A	N/A	Robot

SF15 Stopping Time Limit	What happens?	Tolerance	Affects
Real time monitoring of conditions such that the stopping time limit will not be exceeded. Robot speed is limited to ensure that the stop time limit is not exceeded.[7]	**Will not allow the actual stopping to exceed the limit setting.** Causes decrease in speed or a robot stop so as NOT to exceed the limit.	50 ms	Robot
SF16 Stopping Distance Limit	**What happens?**	**Tolerance**	**Affects**
Real time monitoring of conditions such that the stopping distance limit will not be exceeded. Robot speed is limited to ensure that the stop distance limit will not be exceeded. [7]	**Will not allow the actual stopping to exceed the limit setting.** Causes decrease in speed or a robot stop so as NOT to exceed the limit.	40 mm	Robot
SF17 Safe Home Position "Monitored Position"	**What happens?**	**Tolerance**	**Affects**
Safety function which monitors a safety-rated output, such that it ensures that the output can only be activated when the robot is in the configured and monitored “safe home position”. A stop cat 0 is initiated if the output is activated when the robot is not in the configured position.	The “safe home output” is only activated when the robot is in the configured “safe home position”	1.7 °	External connection to logic and/or equipment
Mode Switch INPUT	**What happens?**	**Tolerance**	**Affects**
When the external connections are Low, Automatic Mode (running) is active. When High, mode is programming/ teach. **Recommendation**: Use with an enabling device, i.e. UR Teach Pendant with an integrated 3- position enabling device. When in teach/program, initially the TCP speed is limited to 250 mm/s. Speed can manually be increased using the TP “speed-slider”, but upon activation of the enabling device, the speed limitation will reset to 250 mm/s.	Input to SF2	N/A	Robot

SF18 (3-Position Enabling) Safety Function [8] Inputs	What happens?	Tolerance	Affects
A 3-position enabling device [9] has 3 switch positions: off, on, off (in order of actuation when squeezing). When released completely, the device is off. When pressed or squeezed to the center position, it is on. Completely pressing (squeezing) results in an off state. When the 3P enabling device is "ON", motion is enabled. **When in Manual Mode** and when an external Enabling Device connection is OFF, internally the safety system initiates SF2, which is a Stop Category 2. **Recommendation:** Use with a mode switch as a safety input.[10]	**In manual mode, when the SF18 Input is LOW, SF2 is triggered internally.** Stop Category 2 (IEC 60204-1) SS2 (IEC 61800- 5-2)	N/A	Robot and external connection to SF19 and SF20
SF19 3PE (3-Position Enabling) Safety Function[8] with Digital Outputs	**What happens?**	**Tolerance**	**Affects**

In Automatic Mode ("running"), SF19's outputs are HIGH.
In Manual Mode and when any Enabling Device[11] is in the OFF state (not in the center-ON position, meaning the enabling device is released or fully pressed), a SF2 is triggered causing a Stop Category 2 (SS2) and SF19's outputs are Low. [8]
In Manual mode, when Freedrive and the 3PE are used:
• **If Freedrive is** activated and
  • ALL 3PE are in the OFF state, SF19's outputs are HIGH.
  • Any 3PE is in the ON state, SF19's outputs are LOW.
• **If Freedrive is not** activated, and
  • ALL 3PE are in the ON state, SF19's outputs are HIGH.
  • Any 3PE is in the OFF state, SF19's outputs are LOW.
	In manual mode, when the 3PE is in the Off state, the outputs are LOW and SF2 is triggered internally.
	Stop Category 2 (IEC 60204-1) SS2 (IEC 61800-5-2)
		N/A	External connection to logic and/or equipment

SF20 3PE (3-Position Enabling) "NOT state" Safety Function[8] with Digital Outputs	What happens?	Tolerance	Affects

In Automatic Mode ("running"), SF20's outputs are LOW.
In Manual Mode and when any Enabling Device[11] is in the OFF state (not in the centre-ON position, meaning the enabling device is released or fully pressed), SF20's outputs are High.[7]
In Manual mode, when Freedrive and the 3PE are used:
• **If Freedrive is** activated and:
  • ALL 3PE are in the OFF state, SF20's outputs are LOW.
  • Any 3PE is in the ON state, then SF20's outputs are HIGH.
• **If Freedrive is not** activated, and:
  • ALL 3PE are in the ON state, SF20's outputs are LOW.
  • Any 3PE is in the OFF state, SF20's outputs are HIGH.
Note: SF20 is an inverted version of the SF19 where the output state is logically reversed compared to SF19.
	In manual mode, when the 3PE is in the Off state, the outputs are HIGH.	N/A	External connection to logic and/or equipment

SF21 Wrist Clamping Torque Limit	**What happens?**	**Tolerance**	**Affects**
Monitors the torque of the wrist joints to avoid high clamping torques. Will not allow the wrist clamping torque limit to exceed the limit. NOTICE This safety function can be configured to be disabled.	Causes a robot stop so as NOT to exceed the limit.	N/A	Robot
SF22 Outputs Activated by a Safety Plane (SF5)	**What happens?**	**Tolerance**	**Affects**
Whenever the monitored TCP pose has crossed the safety plane, the dual outputs are LOW. Multiple poses can trigger the dual outputs (tool flange, elbow, and up to 2 configurable tool offset points with a radius). See Tool Position Restriction for further details.	The outputs are LOW when the monitored TCP pose crosses the safety plane.	40 mm same as SF5	External connection to logic and/or equipment

SF23 Safety Plane (SF5) Activated by inputs	What happens?	Tolerance	Affects

When both INPUTS are:
• HIGH.
  • The monitored TCP pose can move freely.
• LOW.
  • The Safety Function's intended result is to prevent the monitored TCP pose from crossing the safety plane. However, this is not possible if there is insufficient time or distance to stop.
  • If the monitored TCP pose has already crossed the safety plane or the monitored TCP pose is about to cross the safety plane, then the Robot will stop according to stopping time and stopping distance limit settings.
See Tool Position Restriction for further details.
	When
	• both inputs are LOW, and
	• the monitored TCP pose is moving towards the safety plane, and
	• there is sufficient time or distance to stop before reaching the safety plane, a robot stop is initiated to prevent exceeding the safety plane.
	If there is insufficient time or distance to stop before reaching the safety plane, a robot stop is initiated which will comply with the configured stopping time and stopping distance limit settings. However, the monitored TCP pose will pass the safety plane.
		40 mm same as SF5	TCP, Tool flange, Elbow

Table 1 footnotes

[1]**Communications** between the Teach Pendant, controller & within the robot are SIL 2 for safety data (per IEC 61784-3).

[2]**Estop validation:** The pendant Estop pushbutton is evaluated within the pendant, then communicated[1] to the safety controller by SIL2 communications. To validate the pendant Estop functionality, press the Pendant Estop pushbutton and verify that an Estop results. This validates that the Estop is connected within the pendant, the estop functions as intended, and the pendant is connected to the controller.

[3]**If a robot safety function** is "integrated" or "connected" with external equipment, devices or logic, the resulting integrated safety function has a PFH that is the sum of all PFH values, including the PFH value of the robot safety function.

[4]**Stop Categories** according to IEC 60204-1 (NFPA79). For the Estop, only stop category 0 and 1 are allowed.

- **Stop Category 0 & 1** result in the removal of drive power, with stop cat 0 being IMMEDIATE & stop cat 1 being a controlled stop (e.g. decelerate to a stop then removal of drive power).
- **Stop Category 2** is a stop where drive power is NOT removed. Stop category 2 is defined in IEC 60204-1. Descriptions of STO, SS1 & SS2 are in IEC 61800-5-2. With UR, a stop category 2 maintains the trajectory & retains power to the drives after stopping.

[5] **Stop Time & Stop Distance** Safety Functions should be used. When used, there is no need for periodic verification of stopping performance.

[6] **If a robot safety function** is "integrated" or "connected" with external equipment, devices or logic, the resulting integrated safety function has a PFH that is the sum of all PFH values, including the PFH value of the robot safety function.

[7] The stopping capability of the robot in the given motion(s) is continuously monitored to prevent motions that would exceed the stopping limit. If the time needed to stop the robot is at risk of exceeding the time limit, the speed of motion is reduced to ensure the limit is not exceeded. A stop will be initiated to prevent exceeding the limit.

[8] For the integrated functional safety rating with an external safety-related control system, add the PFH of this safety-related output to the PFH of the external safety-related control system. The safety function and its triggering of a stop are included in the PFH value for this SF.

[9] The enabling device can be on the teach pendant or external connected to the Enabling Function input (SF18).

[10] Use of an external mode switch is recommended when using a 3-position enabling device. If an external mode switch is not used and connected to the safety inputs, then the robot mode will be determined by the User Interface. If the User Interface is in

- "automatic mode", the enabling function will not be active.
- "manual mode", the enabling function will be active. Password protection for changing the mode can be configured.

[11] If any 3PE enabling device is released or fully pressed, the 3-position enabling safety function is OFF (not in the Center ON position).

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