

8.2. Safety I/O

Safety I/O This section describes dedicated safety input (Yellow terminal with red text) and configurable I/O (Yellow terminals with black text) when configured as safety I/O. Safety devices and equipment must be installed according to the safety instructions and the risk assessment in chapter Safety. All safety I/O are paired (redundant), so a single fault does not cause loss of the safety function. However, the safety I/O must be kept as two separate branches.

The permanent safety input types are:

- **Robot Emergency Stop** for emergency stop equipment only
- **Safeguard Stop** for protective devices
- **3PE Stop** for protective devices

Table The functional difference is shown below.

	Emergency Stop	Safeguard Stop	3PE Stop
Robot stops moving	Yes	Yes	Yes
Program execution	Pauses	Pauses	Pauses
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

Safety caution Use the configurable I/O to set up additional safety I/O functionality, e.g. Emergency Stop Output. Configuring a set of configurable I/O for safety functions are done through the GUI, (see part Part II PolyScope Manual).



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.

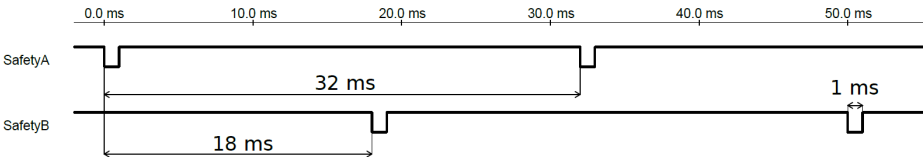
OSSD
signals

All configured and permanent safety inputs are filtered to allow the use of OSSD safety equipment with pulse lengths under 3ms. 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 milliseconds.

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 1ms low pulse is generated on the safety output once every 32ms. The safety system detects when an output is connected to a supply and shuts down the robot.

The illustration below shows: the time between pulses on a channel (32ms), the pulse length (1ms) and the time from a pulse on one channel to a pulse on the other channel (18ms)



To enable OSSD for Safety Output

1. In the Header, tap **Installation** and select **Safety**.
2. Under **Safety**, select **I/O**.
3. On the I/O screen, under Output Signal, select the desired OSSD checkbox. You must assign the output signal to enable the OSSD checkboxes.

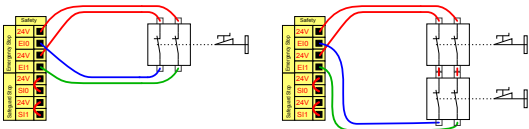
Default safety
configuration

The robot is delivered with a default configuration, which enables operation without any additional safety equipment (see illustration below).

Safety	
Emergency Stop	24V <input checked="" type="checkbox"/>
	E10 <input checked="" type="checkbox"/>
	24V <input checked="" type="checkbox"/>
	E11 <input checked="" type="checkbox"/>
Safeguard Stop	24V <input checked="" type="checkbox"/>
	S10 <input checked="" type="checkbox"/>
	24V <input checked="" type="checkbox"/>
	S11 <input checked="" type="checkbox"/>

Connecting
emergency
stop buttons

Most applications require one or more extra emergency stop buttons. The illustration below shows how one or more emergency stop buttons can be connected.

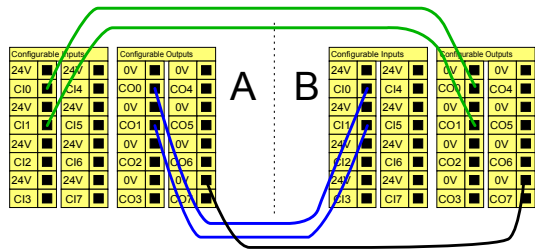


Sharing the
Emergency
Stop with other
machines

You can set up a shared emergency stop function between the robot and other machines by configuring the following I/O functions via the GUI. The Robot Emergency Stop Input cannot be used for sharing purposes. If more than two UR robots or other machines need to be connected, a safety PLC must be used to control the emergency stop signals.

- Configurable input pair: External emergency stop.
- Configurable output pair: System emergency 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.



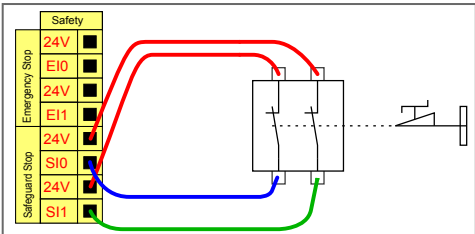
Safeguard
stop with
automatic
resume

This configuration is only intended for applications where the operator cannot go through the door and close it behind him. The configurable I/O is used to setup a reset button outside the door to reactivate robot motion. The robot resumes movement automatically when the signal is re-established.

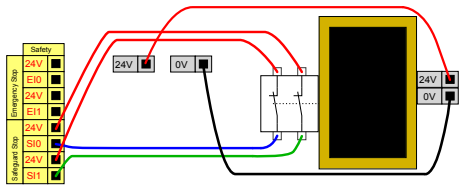


WARNING

Do not use this configuration if signal can be re-established from the inside of the safety perimeter.



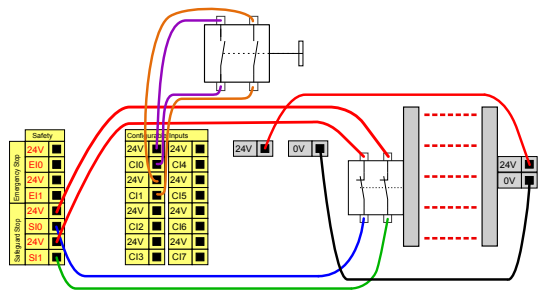
This example illustrates a door switch is a basic safeguard device where the robot is stopped when the door is opened.



This example illustrates a safety mat is a safety device where automatic resume is appropriate. This example is also valid for a safety laser scanner.

**Safeguard
Stop with
reset button**

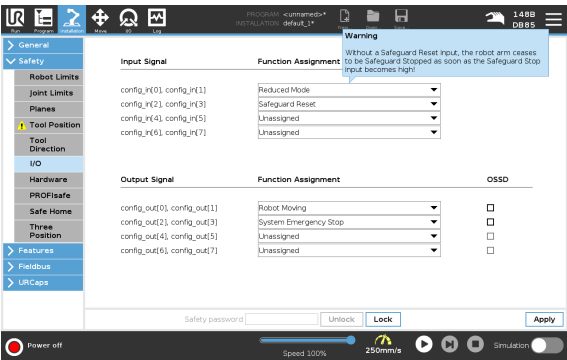
If the safeguard interface is used to interact with a light curtain, a reset outside the safety perimeter is required. The reset button must be a two channel type. In this example the I/O configured for reset is CI0-CI1 (see below).



8.2.1. I/O Signals

Description

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



Input Signals

The following Safety Functions can be used with the input signals:

System Emergency Stop	This is an emergency stop button alternative to the one on the Teach Pendant, providing the same functionality if the device complies with ISO 13850.
Reduced	All safety limits can be applied while the robot is using a Normal configuration, or a Reduced configuration (see Software Safety Modes). When configured, a low signal sent to the inputs causes the safety system to transition to the reduced configuration. The robot arm decelerates to satisfy the reduced parameters. The safety system guarantees the robot is within reduced limits less than 0.5s after the input is triggered. If the robot arm continues to violate any of the reduced limits, a Stop Category 0 is triggered. Trigger planes can also cause a transition to the reduced configuration. The safety system transitions to the normal configuration in the same way.
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.
Freedrive on robot	You can configure the Freedrive input to enable and use Freedrive without pressing the Freedrive button on a standard TP, or without having to press-and-hold any of the buttons on the 3PE TP in the light-press position.

Input
Signals

Operational Mode	When defined, this input can be used to switch between Automatic Mode and Manual Mode .
Safeguard Reset	When a Safeguard Stop occurs, this output ensures that the Safeguard Stop state continues until a reset is triggered.
Automatic Mode Safeguard Stop	Once configured, an Automatic Mode Safeguard Stop performs a Safeguard Stop when the input pins are low and ONLY when the robot is in Automatic mode.



WARNING

- If you disable the default Safeguard Reset input, the Robot Arm is no longer Safeguard Stop stopped as soon as the input is high. A program paused only by the Safeguard stop resumes.
- Similar to the Safeguard Reset, if the default Automatic Mode Safeguard Reset is disabled, the Robot Arm is no longer Safeguard Stop stopped once the Automatic Mode Safeguard Stop input is high. A program paused only by the Automatic Mode Safeguard Stop resumes.

**Output
Signals**

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

System Emergency Stop	Signal is <i>Low</i> when the safety system has been triggered into an Emergency Stopped state by the Robot Emergency Stop input or the Emergency Stop Button. To avoid deadlocks, if the Emergency Stopped state is triggered by the System Emergency Stop input, low signal will not be given.
Robot Moving	Signal is <i>Low</i> if the robot is moving, otherwise high.
Robot Not Stopping	Signal is <i>High</i> when the robot is stopped or in the process of stopping due to an emergency stop or safeguard stop. Otherwise it will be logic low.
Reduced	Signal is <i>Low</i> when the robot arm uses reduced parameters or if the safety input is configured with a reduced input and the signal is currently low. Otherwise the signal is high.
Not Reduced	This is the inverse of Reduced, defined above.
Safe Home	Signal is <i>High</i> if the Robot Arm is stopped in the configured Safe Home Position. Otherwise, the signal is <i>Low</i> .



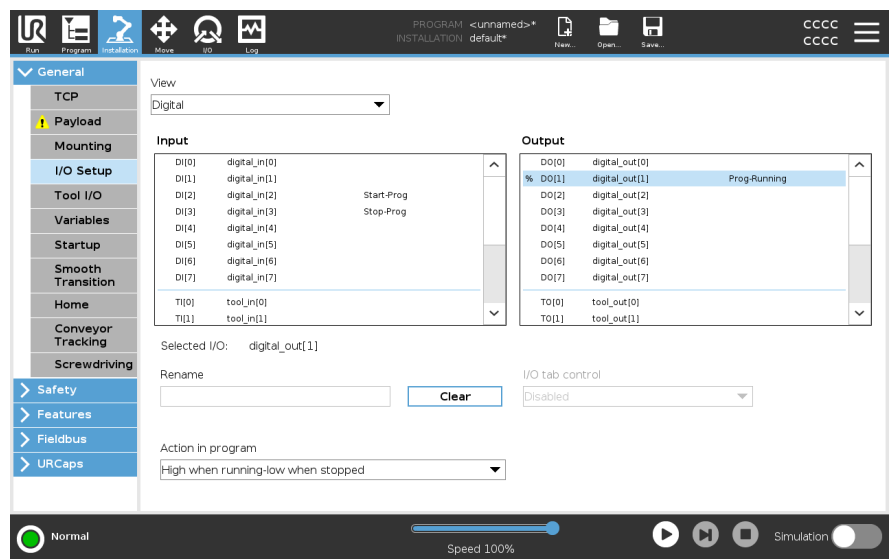
NOTICE

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

8.2.2. I/O Setup

Description

Use the I/O Setup screen to define I/O signals and configure actions with the I/O tab control. The types of I/O signals are listed under **Input** and **Output**. You can use a fieldbus, for example, Profinet and EtherNet/IP, to access the general purpose registers. If you enable the Tool Communication Interface (TCI), the tool analog input becomes unavailable.



NOTICE

When starting programs from an I/O or fieldbus input, the robot can begin movement from the position it has, there will not be any manual movement to the first waypoint via PolyScope required.

I/O Signal Type

To limit the number of signals listed under **Input** and **Output**, use the **View** drop-down menu to change the displayed content based on signal type.

Assigning User-defined Names

You can name the Input and Output signals to easily identify the ones being used.

1. Select the desired signal.
2. Tap the text field to type a name for the signal.
3. To reset the name to default, tap **Clear**.

You must provide a user-defined name for a general purpose register to make it available in the program (i.e., for a **Wait** command or the conditional expression of an **If** command). The **Wait** and **If** commands are described in ([Wait](#)) and ([If](#)), respectively. You can find named general purpose registers in the **Input** or **Output** selector on the **Expression Editor** screen.

I/O Actions
and I/O Tab
Control

You can use Physical and Fieldbus digital I/Os to trigger actions or react to the status of a program.

I/O Tab
Control

Use I/O Tab Control to specify whether an output is controlled on the I/O tab (by either programmers, or both operators and programmers), or if it is controlled by the robot programs.

Available
Input
Actions

Command	Action
Start	Starts or resumes the current program on a rising edge (only enabled in Remote Control, see Settings)
Stop	Stops the current program on a rising edge
Pause	Pauses the current program on a rising edge
Freedrive	When the input is high, the robot goes into freedrive (similar to the freedrive button). The input is ignored if other conditions disallow freedrive.



WARNING

If the robot is stopped while using the Start input action, the robot slowly moves to the first waypoint of the program before executing that program. If the robot is paused while using the Start input action, the robot slowly moves to the position from where it was paused before resuming that program.

Available
Output
Actions

Action	Output state	Program state
Low when not running	Low	Stopped or paused
High when not running	High	Stopped or paused
High when running, low when stopped	Low High	Running, Stopped or paused
Low on unscheduled stop	Low	Program terminated unscheduled
Low on unscheduled stop, otherwise High	Low High	Program terminated unscheduled Running, stopped or paused
Continuous Pulse	Alternates between high and low	Running (pause or stop the program to maintain the pulse state)

Program
Termination
Cause

An unscheduled program termination can occur for any of the reasons listed below:

- Robot stop
- Fault
- Violation
- Runtime exception