GARMO INSTRUMENTS

GARLINE User manual

URCaps Interface

GARMO INSTRUMENTS, S.L.
1-2-2022
Version 1.0

INDEX

1. ABOUT THIS DOCUMENT

1.1. Safety warning

	The instruction manual is part of the equipment and must be delivered and kept together with it. Before carrying out any type of manipulation of the equipment, read this manual carefully, as well as the ones related to each specific machine or component that you will be working with. This manual must be read by all persons authorized to intervene in any way in the handling of the equipment.
	Operator's assumed responsibilities are as follows: Maintain the safety regulations during the operation of the equipment (laser profilometer). Use the profilometer correctly according to the established in terms of safety. Maintain the required safety and hygiene levels.
	Regarding the equipment pictograms, GarLine sensor includes security warning sign labels that must be kept in perfect condition in order to allow compliance with their instructions to the operator and/or user. In case of deterioration, they must be replaced.
	The use of laser profilometers, in conditions NON FORESEENED and/or PROHIBITED by this manual, can lead to serious dangers for the worker, people and things around the equipment and for the equipment itself.
	For your safety and the one of those around you, follow the instructions for using laser profilometers according to the information provided in this manual.

ACTIONS IN THE EVENT OF ACCIDENTS

GarLine integrates security devices that minimize and avoid the possibility of accidents.

In case of accident, immediately contact your local medical emergencies service or contact the telephone number assigned to the company's risk prevention department for this type of events.

Manual version history

Version 1.0. – February 2022

1.2. Liability disclaimer

The manufacturer does not take responsibility for equipment failure or damage caused by it, in cases where its handling or maintenance does not correspond to the indications in this manual, as well as in cases where it has been used for different purposes of those of normal use for which it has been designed.

The user is not allowed to carry out unauthorized investigations on any aspects of the equipment, unless the company had previously designated him as an authorized operator. Any attempt by the user or unauthorized personnel to disassemble or modify the equipment without previous authorization will exempt the manufacturer from all responsibility for eventual damage to people, things or other affected goods.

1.3. Manufacturer information

GARMO INSTRUMENTS, S.L. is a company dedicated to the manufacture of optical instruments, and photographic and cinematographic material.

The equipment beholden in this manual (laser profilometer GarLine) was manufactured by:

MANUFACTURER	GARMO INSTRUMENTS, S.L.
With registered office at:	Pol. Ind. Malpica, c/ E 32-39, nave 43, 50016, Zaragoza (SPAIN)
VAT	ES - B99562340

CERTIFICATIONS

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2. GARLINE SENSOR: GENERAL DESCRIPTION

GarLine is a laser profilometer sensor for seam tracking, and it would be used in specialized machines or welding robots.

The sensor is considered part of an equipment, so it wouldn't be contemplated as one single component, so there is no option for the sensor to perform on its own. The sensor is meant to complement a welding robot or a specialized machine.

GarLine laser seam tracking sensor is based on triangulation principle. The equipment contains a diode laser that projects a red stripe across the weld joint. Since the laser includes a 3R laser within, it is not potentially dangerous for user's eyesight, as long as all safety measures and instructions are properly followed.

Since the sensor was designed as a complement to other machines or robots, there is no precise way to detail how to use it because its usage would depend on users' necessities.

2.1. Identification of the main elements of GarLine sensor

The following table shows the main components of the sensor, their purpose and description:

MAIN COMPONENTS		
COMPONENT	**FUNCTION**	**DETAILS**
Housing	Protection	Aluminum housing composed of 4 pieces, a set of disposable polycarbonate protective windows to be inserted in the external frontal side of the sensor, a protective Gorilla Glass window in the inner frontal side of the sensor and a mounting plate at the bottom to join the sensor to another machine.
Laser	Measuring	Continuous wave laser, type 3R, 30mW power and a 685 nm wavelength.
Camera	Data collection	1,3Mpx camera. It is not just a camera, but also a complete optical system designed by GARMO INSTRUMENTS, S.L. which includes a central 685 nm band filter.
Printed circuit boards	Calculation and analysis	The internal system includes 3 boards: a connection board for power and data transferring; a Main Board for information processing; and an IO board to process the internal connections.

GarLine contains no user-serviceable parts. In case any support is required, please get in touch with GARMO INSTRUMENTS, S.L.

Before using GarLine sensor, please make sure that the user has previously read and properly understood the sensor operating process and that all suitable precautions are taken.

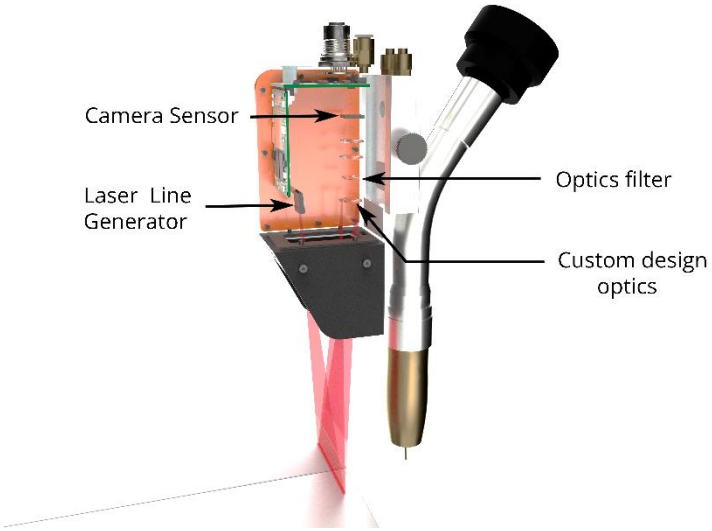
2.2. Introduction to sensor working principle

In automated arc welding, the welding torch is mounted on a mechanism of some kind, which can be a robot or some other type of welding machine, such as a lathe, seamer, gantry or column & boom manipulator. The parts to be welded are normally mounted on the welding system using jigs, fixtures and positioners or fed into the welding station as in tube and pipe mills. Such mounting of the parts is never completely accurate and repeatable.

Thermal distortion during the welding process then causes the weld joint to move and change shape as a result of the welding process itself. In some cases, movement of the parts being welded is an inherent feature of the manufacturing process.

Laser guidance is widely used in both robotic and automated welding. The laser sensor is also mounted to look in front of the welding torch in the welding direction. It detects the shape of the weld joint, which is analysed in an electronic system to identify key points. The position of these key points is compared with a template storing the ideal position of the points relative to the welding electrode. Any error is input to a software algorithm, which determines how to move the robot or weld head slides to eliminate the error.

Laser seam tracking is based on the principle of triangulation, as shown below. Triangulation is a way of extracting geometrical information from measurements and has many applications. The normal meaning in welding sensors refers to using a structured light source, usually a laser diode, in conjunction with an imaging device to produce a series of 3D slices through the weld joint.



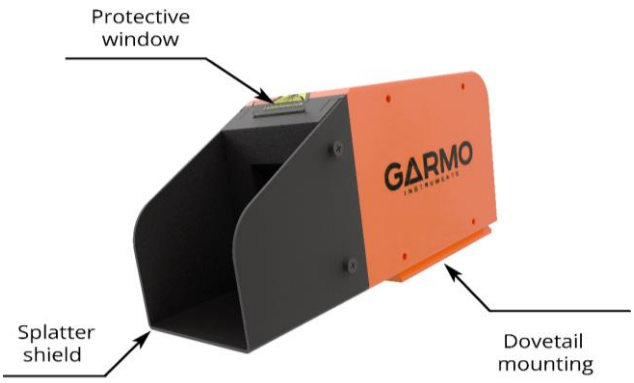
As indicated by its name, this type of sensor projects a laser stripe across the weld joint. The stripe is then deformed by the shape of the weld joint. The deformed stripe is imaged by a two-dimensional camera (CMOS type – or Complementary Metal Oxide Semiconductor). An optical filter perceives only the light, which is at the same wavelength as the laser, projecting it into the camera. This eliminates most other light, including arc light.

3. GARLINE TECHNICAL DATA

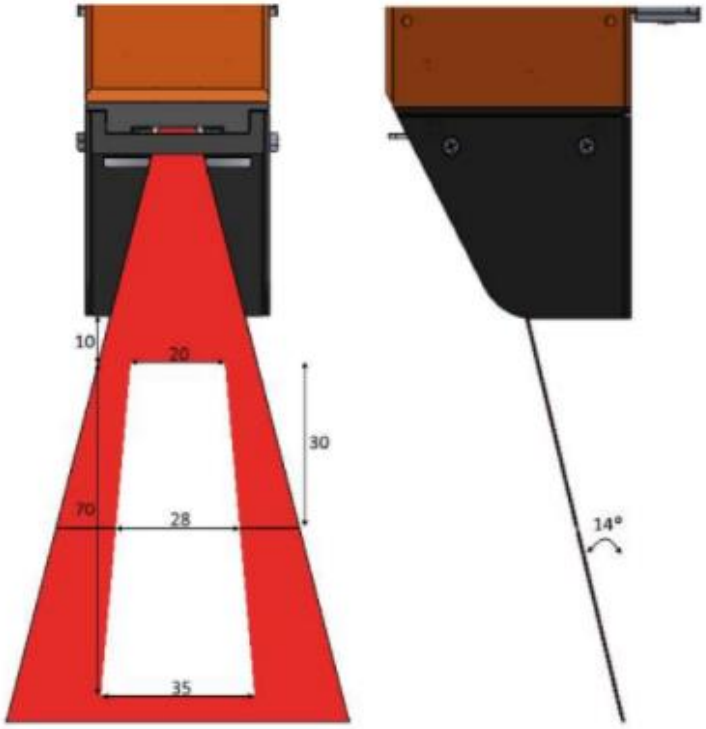
TECHNICAL DATASHEET – LASER PROFILOMETER DEVICE CHARACTERISTICS			
TYPE	**BRAND**	**VERSION**	**ID NUMBER**
LASER PROFILOMETER	GARMO	GARLINE	E30-0001

TECHNICAL DATA	
Optical data (all measurements in mm)	
Standoff	50
Field of view	28
Depth of field	70
Horizontal (at nominal distance)	±0.2
Vertical (at nominal distance)	±0.25
Mechanical data	
Temperature range	between 0ºC and 45ºC
Storage temperature range	between -20ºC and 70ºC
Measuring rate	42Fps
Protection	IP67
Housing material	Aluminum
Disposable protective windows	Polycarbonate
Weight	450 g
Electrical data	
Current consumption (max)	30W
Transmission speed	100/1000 Mbit/
Interface Ethernet	TPC/IP
Connector type	M12 X-Code
Supply power	PoE IEEE802.3at
Integrated web server	Yes
Laser	
Laser class	3R 660-699nm (IEC60825-2021)

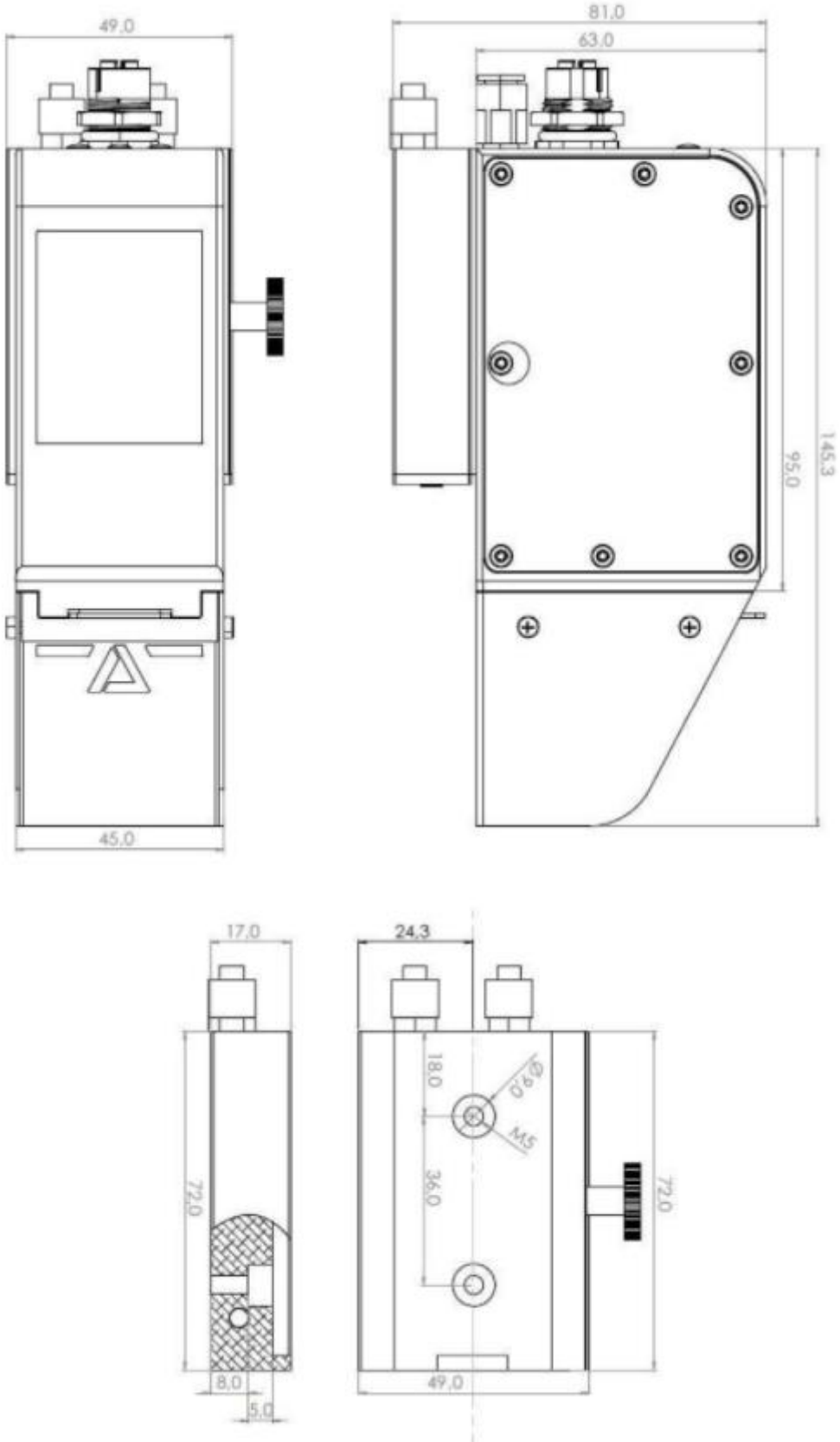
3.1. Hardware description



3.2. Field of view



3.3. Dimensions



3.4. GarLine laser

	GarLine sensor is a class 3R laser product. It is not potentially dangerous to eyesight. Read and follow the safety instructions carefully

On sensors head you will find the following warning labels indicating lasers wavelength and intensity.

The GarLine sensor uses a laser line generator. This is a semiconductor (GaAs) laser in the 685 nm range (670 nm to 700 nm). The laser beam emitted by the diode is spread by lens combinations in a thin, uniform line onto the workpiece. As previously explained, the laser projects a stripe (not a spot) onto the workpiece placed under the sensor head. The laser projects a continuous wave (not a pulsed light).

Although the beam source is emitted within close range onto the workpiece, through carelessness, it cannot cause damage to the eyesight. Anyway, when the sensor is operating, ensure that all suitable precautions are taken to avoid direct eye contact with the beam. The beam should not be viewed at close range, either directly or through a lens or mirror.

It is recommended to instruct workers on safety measures, precautions and any potential risk that laser radiation may cause. GarLine is a 3R class device that meets with the UNE-EN 60825:2014 standard requirements. The user must provide all the necessary safety measures in accordance with all national, federal and local regulations

4. COMMISSIONING

4.1. Mounting plate

GarLine sensor employs a dovetail type mounting bracket method. This technique helps to ensure that the sensor can be repeatedly installed on a specific location from the workpiece, and can also be easily removed or installed on another robot. The mounting plate contains ball plungers on its base that, along with the retaining screw at the top of the mounting plate, maintain the sensor in alignment. Cooling of the sensor body is accomplished by supplying cold water through the water-cooled mounting plate. Where less cooling is required, then the sensor can instead be cooled by passing cooling air through the same connection on the mounting plate.

The camera, lens, and illumination are housed within the sensor body. Air flows from around the optics provide protection from dust, fluid and small metal splatter, and prevent from contaminating too rapidly the front of the sensor and the disposable polycarbonate window. In this way, thanks to air flows and frontal disposable protective window, dirt does not get inside the device.

4.2. Important consideration for mounting

RF Noise / Isolation of the sensor head

The sensor system has been designed to be used in an electrically noisy environment. The control unit and all signal cables are screened. This provides excellent protection from RF noise produced in an industrial environment (to achieve this, the grounding of the cable is necessary). Also, the camera cables should not be wrapped around high voltage cables and should wherever possible be separately routed, together with other low voltage cables.

In the unlikely event that the system is affected by electrical noise, then ensure that the sensor head is electrically isolated from the machinery. This is typically accomplished by using the suggested isolation mounting plate.

Position of the sensor

Make sure that the sensor is properly fixed on the mounting plate and to the welding torch. Also, the sensor should be oriented toward seam and welding torch as in the following table (note that the position of the sensor and the welding torch may vary depending on the type of welding):

		
Sensor should be installed parallel to the welding torch. The welding torch should be pointing to the welding seam (perpendicular position towards the seam).	The sensor should be installed 2 cms beyond the welding point (this might also depend on the type of welding). The welding seam should be in the sensor's field of view (around 30 mm from the seam to the sensor's camera). The seam should be placed perpendicular to the sensor and the welding torch.	

Air flow supply

In order to protect the sensor head from welding smoke and splatter, GarLine sensor head must be provided with a supply of air flow during welding through the air connector at the rear part of the sensor. The air flow should be approximately 5-10 litters/minute. If the sensor is provided with air, please ensure that clean, dry and oil free air is supplied. Oil or water in the air supply will get the sensor protective window dirty.

Sensor cooling through water-cooled mounting plate

Cooling of the sensor body is accomplished by supplying cold water through the water-cooled mounting plate. Where less cooling is required, then the sensor can instead be cooled by passing cooling air through the same connection on the mounting plate.

5. GARLINE SENSOR MAINTENANCE

	GarLine sensor head contains no internal user serviceable parts. Work on the sensor should be done by authorized personnel only. Please ensure that the correct operation and safety procedures are properly followed. Safety information is provided in this manual

It is advisable that the sensor has an air supply when welding. This will help protect the sensor head from the smoke and splatter from the welding process. It will also provide some cooling for the sensor head.

It is also advisable to ensure suitable cooling through the mounting plate.

GarLine is designed to keep the maintenance required to a minimum. However, to ensure good performance and a longer lifespan, periodic preventive maintenance checks are required

	Please turn off sensor before performing any sensor inspection. Refer to laser safety information provided in the introduction of this manual.

The frequency of sensor maintenance will vary with the severity of the working environment. For any internal inspection, maintenance or reparation (e.g.: sensor's inner cleansing, lens replacement, CCD camera replacement, laser replacement and calibration), contact GARMO INSTRUMENTS, S.L. Don't perform any internal operation on your own.

Do not use the sensor without protective windows and the splatter shield. Trained personnel are required for periodical protective window replacement. Protective window replacement is essential, since particles from the welding process can accumulate on the sensor protective window.

Please check the sensor head for damage approximately every month. Before doing this, disconnect the sensor. Any smoke or splatter should be carefully wiped off with a soft cloth, or a nylon brush. If you see any evidence of oil on the glass of the sensor, check the air supply immediately, and if necessary, improve the filtering to the sensor head.

5.1. GarLine maintenance interval

The frequency of the maintenance of the sensor will depend on the application and the type of welding process. We recommend having two maintenances frequencies:

Regular maintenance:

- At the beginning of every shift, remove any dust particles from the outside of the sensor using clean compressed air.
- If the disposable protective window is damaged or dirty, replace it with a new one.

Every week:

- Clean any excess of dust or splatter from the outside of the sensor with an alcohol moistened cloth or compressed air.
- In case of cooling the sensor through air flow connector, you may use a vortex tube.
- Check that all cables and connections to the sensor head are in good condition. Please replace the wires if they are kinked or frayed.

5.2. Assembly and disassembly of the sensor head

Sensor head dismount:

- Turn the power to the sensor off.
- Remove the single connector to the sensor head (in case air flow cable is connected, remove it too).
- Loosen the locking nut at the top of the mounting plate and then unscrew the knurled bolt until the sensor is free.
- Lift the sensor off.

Sensor replacement:

- Place the sensor head on the mounting plate.
- Tighten the locking nut finger tight. This is particularly important on applications where the sensor head is mounted on a robot, to ensure that the retaining bolt does not come loose and to avoid any tracking errors.
- Reconnect the sensor cable (and the air flow cable if necessary).
- The sensor head can now be powered on again. However, a calibration may be required.

Note that the mounting plate of the sensor is designed so that the sensor can be easily removed if necessary. The mount provides a very repeatable mounting position for the sensor head, to minimize any setup required if a sensor head is replaced. However, calibration may be necessary.

Remember that GarLine sensor head contains no internal user serviceable parts. Work on the sensor should be done by authorized personnel only. If necessary, contact GARMO INSTRUMENTS, S.L.

5.3. LED indicators

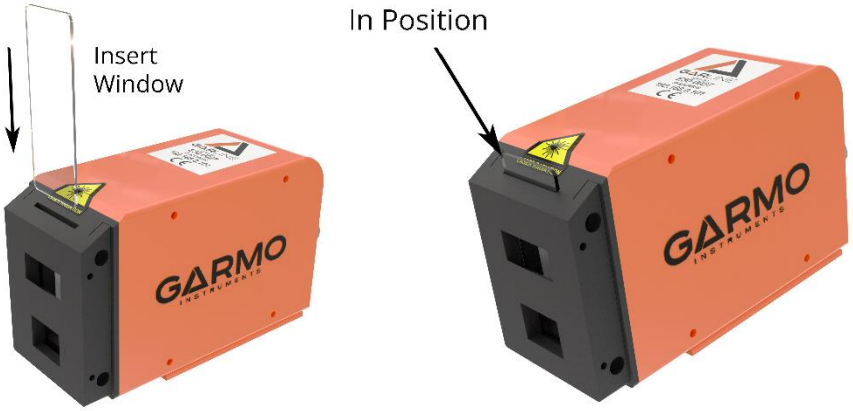
GarLine is provided with three lightning indicators on the sensor head that show different process statuses of the sensor (find the image and table below):

LASER		Shows whether the laser is on or off. When the laser is on, the LED light turns orange.
STATUS		Indicates different sensor statuses.
	White	The sensor is turning on / standby position.
	Blue	The laser is on but seam tracking and key points are not properly detected
	Green	The laser is on and both seam tracking and key points are properly detected.
	Red (intermittent)	The sensor is rebooting.
	Yellow (static)	When the sensor is connected and turned on, the Status light turns yellow for around 3 seconds before turning white. Do not turn off nor disconnect the sensor at this stage. Note that, if the sensor is turned off or disconnected for 3 times at this stage (while the LED is yellow), the sensor would restore its original settings and all stored data and settings would disappear (such as IP, net or gateway configurations). In case of doubt or any clarification required, do not hesitate to contact GARMO INSTRUMENTS, S.L.
	Yellow (intermittent)	The sensor is being updated. In case of any update or bug fixing, GARMO INSTRUMENTS, S.L. would get in touch with the client to inform about the necessary sensor update. While the update is being installed, the Status LED would blink yellow. Do not turn off nor disconnect the sensor while the update is in progress.
ETHERNET		Shows the status of network connection (a wire to Ethernet connection is required).
	Off	No connection with the remote computer.
	Green(static)	Connection established.
	Green (intermittent)	Data transfer in progress.

5.4. Frontal disposable protective window

The optics of the sensor head is protected from welding smoke and splatter of the welding process by a black copper splatter shield. This splatter shield holds a clear polycarbonate window, which must be changed when it has smoke or splatter on it. Typically, for MIG/MAG welding this will need to be done once per shift, but this mainly depends on the welding process in your application. Depending on welding consistency, you will soon find the best interval for changing the protective window for your application. Note that with TIG and laser welding, the window needs to be changed less frequently as there is less weld splatter.

If you use an anti-splatter spray on the welding torch, please be careful not to spray it into the sensor. Cover the end of the copper splatter shield before spraying the welding torch.



⚠	NEVER WELD WITHOUT THE DISPOSABLE WINDOW FITTED. Otherwise, welding splatter and smoke will get onto the front of the sensor head.

5.5. Basic rules for using the GarLine sensor

General instructions cannot be specified since the device described in this manual is considered a complement to other equipment, hence it cannot perform on its own. The instructions to be followed are the ones provided for the equipment which the sensor would be installed on. GARMO INSTRUMENTS, S, L. cannot provide general instructions given the unknowledge of the equipment, which GarLine sensor would be installed on.

	The use of the GarLine sensor for any use other than those provided for by GARMO INSTRUMENTS, S, L. is strictly prohibited.
	It is strictly prohibited to handle the equipment by unauthorized persons or those who have not read and understood this manual.
	It is strictly prohibited to make any modification of the GarLine sensor, without expressly written authorization from GARMO INSTRUMENTS, S, L.
	It is mandatory to carry out the GarLine sensor maintenance plan, detailed in this manual.
	The correct working state of the GarLine sensor must be checked before each use.
	This manual should be kept always available to any user of the sensor.
	The use of all necessary personal protective equipment is mandatory.
	It is mandatory to comply with any other regulations or applicable legislation regarding the use of the sensor and its use and not included in this manual.
	It is essential for the operator / user to maintain visibility over the area of operation at all times.
	It is mandatory to pay attention to people or things nearby the GarLine sensor during use.
	Maintenance, repair or adjustment tasks will only be performed if the equipment is placed on a balanced and stable location.

The sensor is considered part of an equipment, so it is not considered as a single element, so it would not be possible for it to work on its own. It will depend on the use to which it is intended.

Risks derived from non-compliance with the instructions

Failure to comply with the detailed instructions in this user manual can endanger people, things, and the equipment itself, in the same way, it can lead to the cancellation of all right to claim damages.

The main risks associated with non-compliance with the operation and maintenance instructions specified in said manual are as follows:

- Exposure to laser due to inadequate mechanical adjustments or poor condition of the device or equipment where the sensor is installed.
- Others: those that correspond to the device or equipment where the sensor is installed.

Compliance with regulations relating to safety at work

In the different phases of its useful life, all current regulations that are applicable to the use of equipment and workplaces aimed at guaranteeing the safety and health of workers shall be complied with.

Safety and expected use conditions

It is mandatory that anyone who intervenes on the equipment has read and understood this manual, so as to guarantee safe use and avoid any dangerous situations.

Before intervening for the first time, the user must be instructed by another user with accredited experience in the operations to be carried out, or by technical personnel from GARMO INSTRUMENTS, S.L. You will also need to get familiarized with the functionality of the GarLine sensor and its operation devices.

The GarLine sensor has been designed to be used solely and exclusively to measure the geometry of a welding seam performed by a welding machine or a welding robot and to improve the precision of their performance.

In addition, it can be used for welding inspection, making an analysis of the surface characteristics of the weld, and should not be used for any other purpose.

The equipment has been designed to perform in the following conditions:

- Do not exceed design limitations.
- To be used by duly trained and authorized personnel.
- Carry out periodic adjustment and maintenance operations.
- Observe the safety measures of the work center and the instruction manual.

5.6. Training

A comprehensive reading of this instruction manual seeks a basic level of training regarding the use and operation of the GarLine sensor, which ensures safe and risk-free operation for users.

Although to carry out specific tasks and due to the complexity that some technical components may have, if necessary, consult additional maintenance information or contact GARMO INSTRUMENTS, S.L.

Users' insight and reasonably foreseeable behaviours have been taken into account in the development of this manual, so the manufacturer appeals to the logic and common sense when using the GarLine sensor.

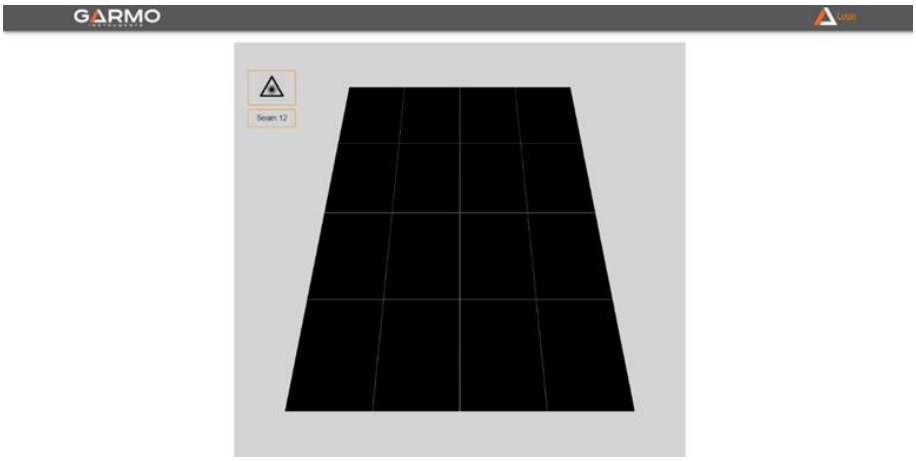
The initial commissioning of the equipment is in turn a formative act. It will be carried out by authorized personnel by GARMO INSTRUMENTS, S.L. accompanied by the personnel foreseen for the use of the equipment, in order to instruct and familiarize them with the use and operation of the equipment.

In order to promote safety, the user of the GarLine sensor must inform GARMO INSTRUMENTS, S.L. and future users of any possible incidents that may arise during the use of the equipment, by recording them in the reports.

6. GARLINE SENSOR INTERFACE

GarLine sensor can be controlled from a web interface which can be accessed by connecting the computer to the sensor's IP address that it is display in the top label of the sensor.

Once you access sensor's interface, you will find the following main page:



Login tab

Log in/Log out the website. Switching users or adding new ones.

Main Board

Displays the information obtained by the sensor's profilometer. Here will appear the laser line in orange (either as points or lines), the welding point in black and the welding key points of the seam in grey. In case of enabling the Teach option, a white square will be displayed, together with a green square showing the offset.

laser on/off

ID label for the current workpiece

Measurement panel

Displays the different measures that can be useful to the welder (e.g.: coordinate in mm of the welding point). The measurements taken on the Main Board will also be displayed here.

Click to measure

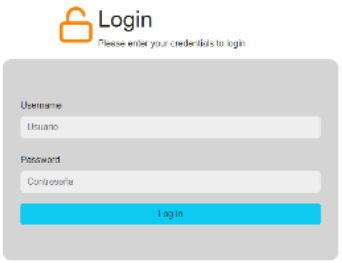
User may click the side of the Main Board to get the coordinates (in mm) of the chosen point or to measure distances, in case several points are selected.

6.1. Main Menu

User Loging

The access to the different settings of the sensor is control by the user levels.

Click on Login button in the top-right corner and enter your username and password:



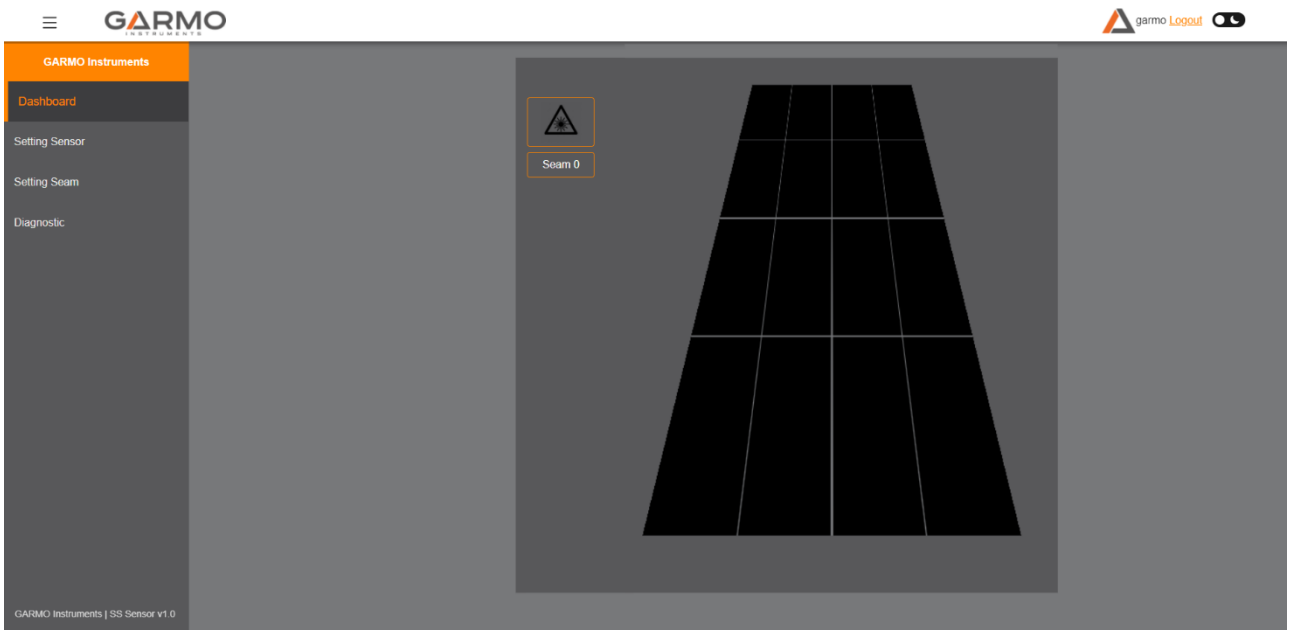
Once logged in, the user accesses the GarLine menu.

User Levels

- **User:** No login (no username, nor password provided). The user can only access Dashboard.
- **Maintenance:** User: Maintenance | Password: GarmoMaintence
- **Engineer:** User: Engineer | Password: GarmoEngineer

There is no option to create more users but the passwords can be changed in sensor settings. In case the password is forgotten or lost, the sensor can be recovered by factory reset.

Main menu



There are several tabs in the main menu on the left side of Main Board:

SETTING SENSOR:

Menu for sensor configuration. Available for: Engineer

SETTING SEAM:

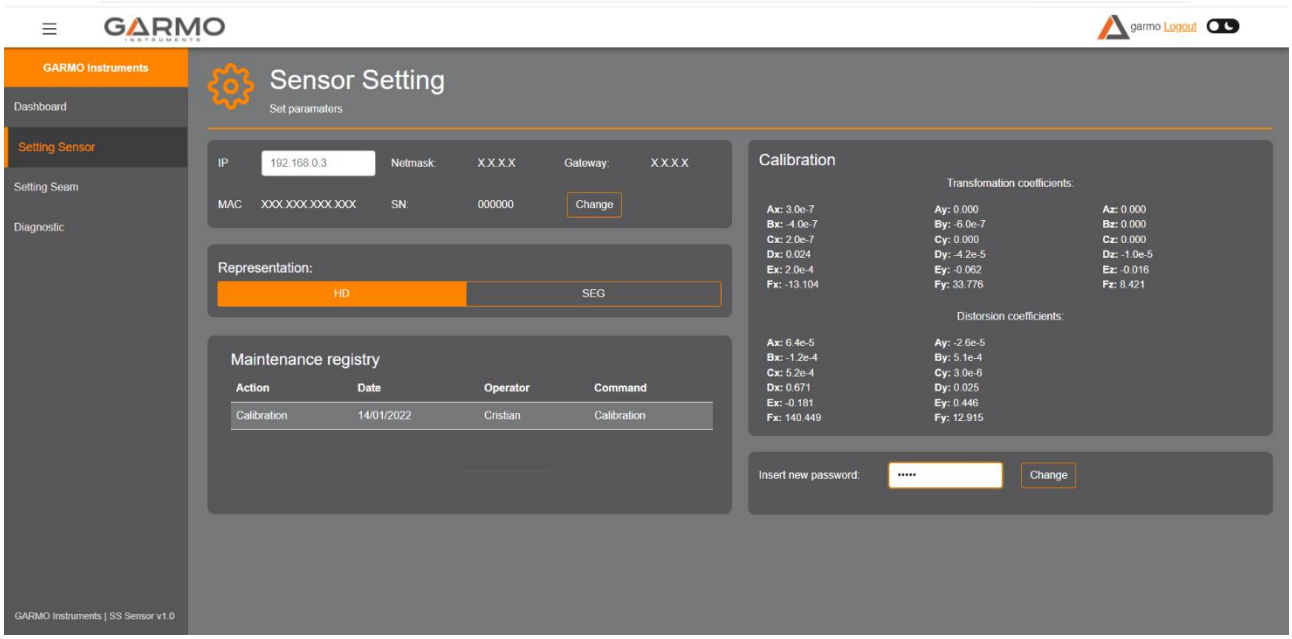
Menu for welding and joint parameters configuration. Available for: Engineer and Maintenance

DIAGNOSTIC:

A record of sensor's messages. Available for: Engineer and Maintenance

6.2. Setting sensor

This tab collects the information corresponding to the sensor configuration. Note that this configuration does not affect the development of the welding process.



- Sensor factory settings: Shows the default values set at the moment of sensor manufacture. The user may insert any required IP address and then press on the "change" button. Note that the IP format must contain four integers between 0 and 255 separated by dots, otherwise a warning message would pop up and the IP would not be changed.

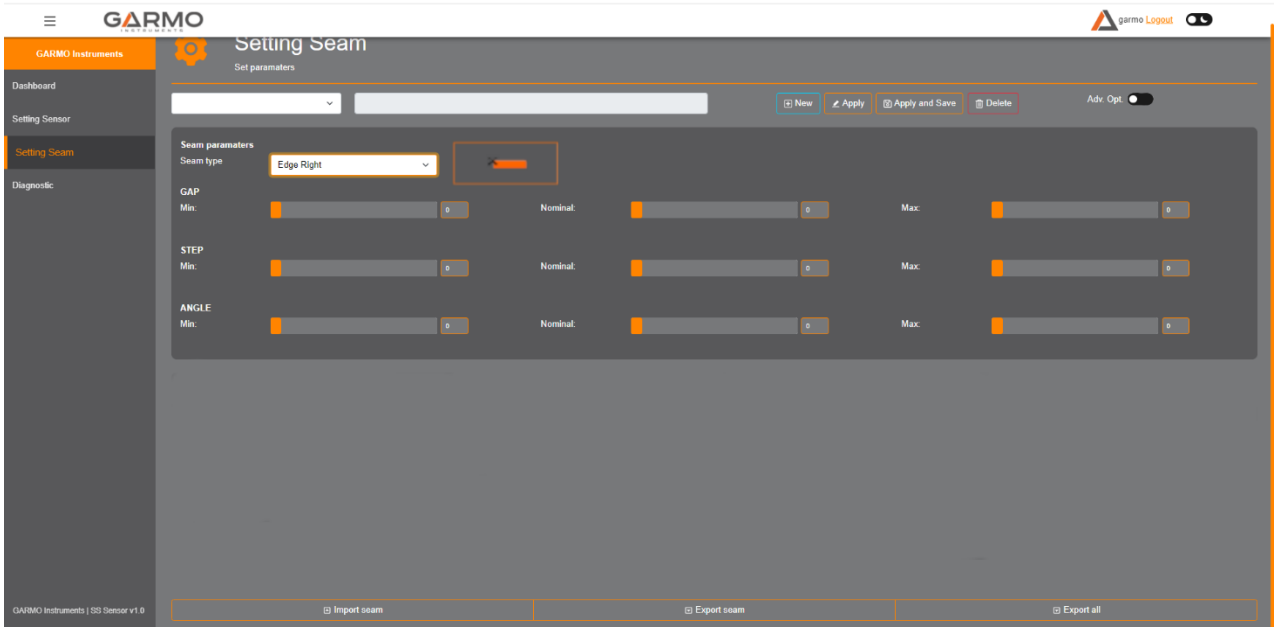
- Representation: This section allows changing the representation of the data displayed on the Main Board. User might select either HD (for dot format) or SEG (for line format). Any of these representations can be used depending on user's needs or to control the different stages of tracking. The type of representation does not affect the seam process.

- Maintenance registry: This section will show the maintenance operations record performed by GARMO INSTRUMENTS, S.L. operators.

- Calibration: The sensor is calibrated at GARMO INSTRUMENTS, S.L. offices by a specialized calibration team and the values obtained are displayed on this panel.

6.3. Setting seam

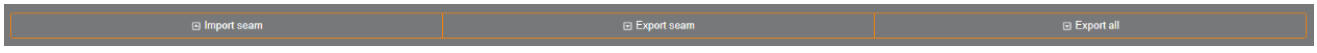
This tab is oriented to the configuration of the seam type:



Seam Controls

- **Number**: this select the current seam you are working.
- **An open text area**: give an easy to remember seam name
- **Create:** The user will be redirected to a wizard (7.1 Seam wizard)
- **Apply:** in case you only want to insert these changes provisionally or for testing the seam
- **Save:** to save the new settings for the current seam, which will overwrite the setting of the enabled seam
- **Delete**: This delete the current seam permantely

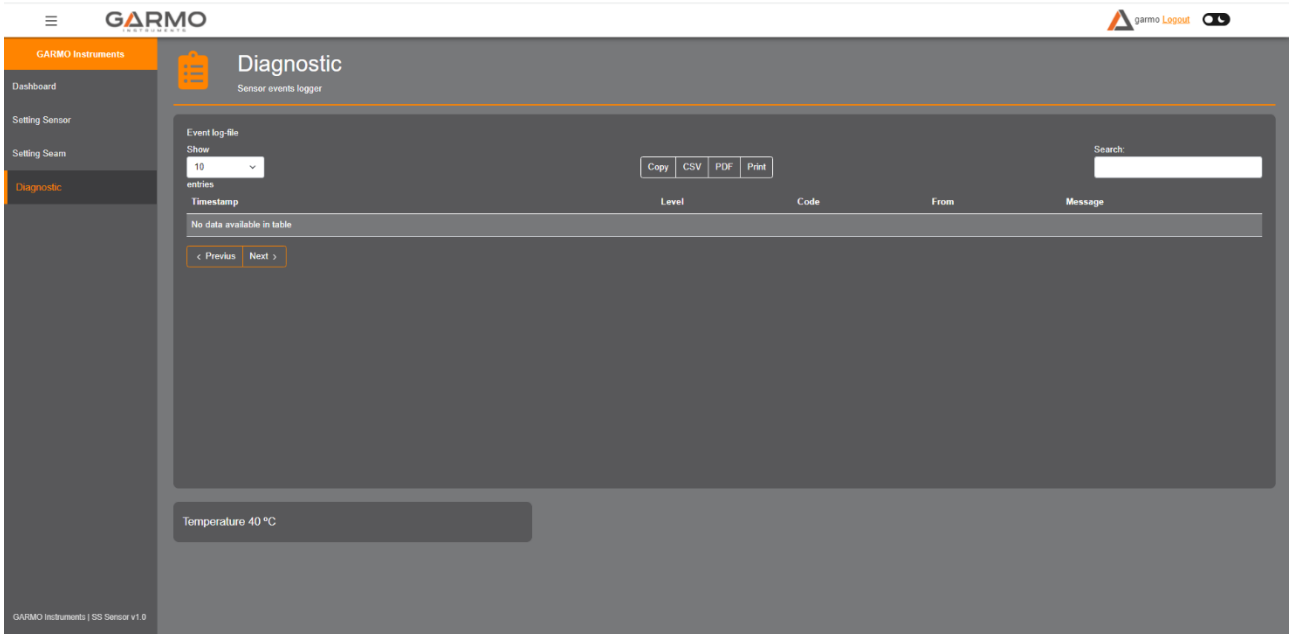
Seam Backup Options



- **Import seam:** Import seam or seams setting that are in the file
- **Export seam:** Export the current seam settings to a file
- **Export all:** Export all seam available in the sensor to a file

For backup and restore options, any restored seam will overwrite the current seam settings with the same number.

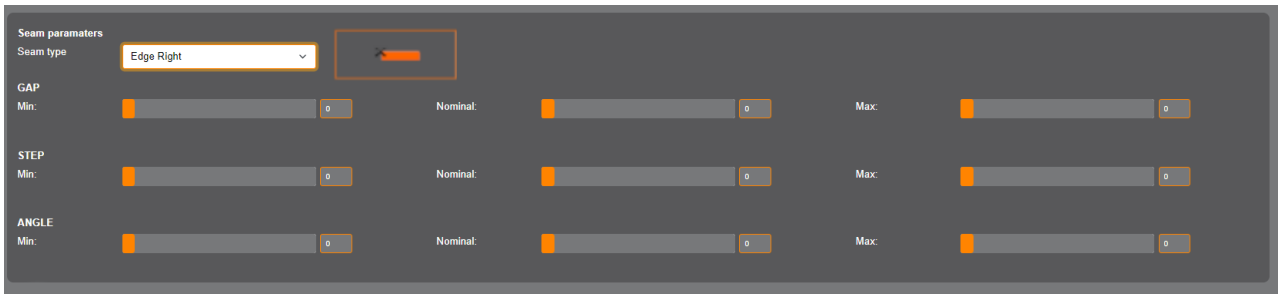
6.4. Diagnostic



It's a record of notifications of sensor's internal messages.

7. SEAM SETTINGS

Seam Parameters



This is where the lines are analysed. The slider can be moved to change the settings of the current seam parameters.

- Seam type: select the type of seam to be performed, by clicking on drop-down menu to choose one of the already performed ones.
- Gap: Horizontal distance between two points of the seam.
- Step: Vertical distance between two points of the seam.
- Angle: Angle formed by two pieces of the seam.

Then, set the parameters of the seam to be performed by setting the following sections. Each parameter depends on the seam user is working on, but generally speaking, these parameters can be defined as follows:

Advance seam settings

A multi-step process is used to perform the tracking. All of these steps can be configured in this window:

Pre-Process
At this step the camera finds and acquires the laser projected points. Here, the user configures this section for a clean visualization of a line of points:

- **Threshold**: The acquisition of the laser points allows to use those ones that exceed a minimum intensity of the brightest point of each column.
- **Threshold MIN**: Minimum intensity that the points must have in order to be accepted. In other words, high values in this parameter will interfere in the visualization of points.
- **AGC:** Stands for Automatic Gain Control. The laser intensity can be automatically regulated depending on the conditions of the welding piece or can be disabled for direct user control.

Segmentation:
The construction of lines is performed from the points collected.

- **Sensitivity X**: N/A
- **Sensitivity Y:** The segmentation uses tolerance parameters to consider the points that are most affected by noise. High values in this parameter will facilitate the construction and visualization of the lines which are more affected by the noise. However, note that the high tolerance level might complicate the distinction of the key points of the seam, which may lead to imprecise line detection.
- **Tolerance:** helps to restrict the variation of key point distances (in other words, it helps to precisely detect key points).
- **Length**: Minimal number of points that a line must have to be accepted by the algorithm.

7.1. Seam wizard

To start configuring a new seam in the Setting Seam menu, click on "New" button. A new window will then pop up (the SEAM WIZARD) with a selection of seams:

Figure 1

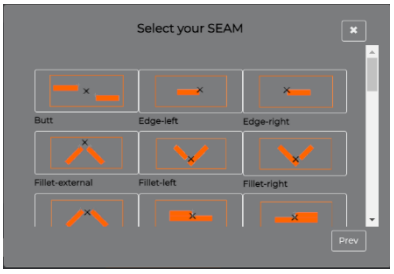


Figure 2

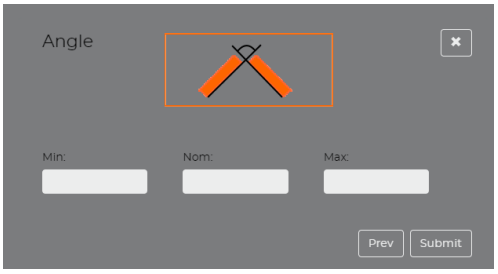


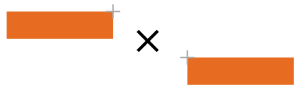
Figure 3

Each generated seam has an identification number and a name editable by the user (Figure 1). By clicking on the Wizard all the applicable seams of the algorithm are displayed (Figure 2). Once the seam application type is selected, a new window pops up (Figure 3). This window shows what parameter each item refers to and provides with some examples of values.

Finally, click on "Submit" button to generate the seam setup.

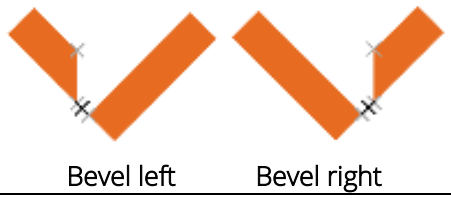
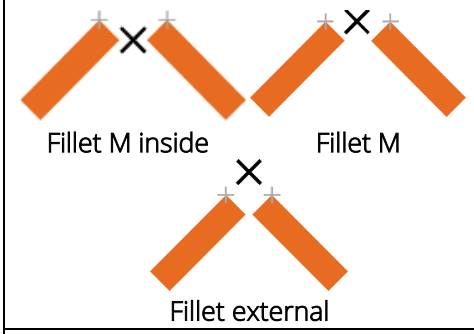
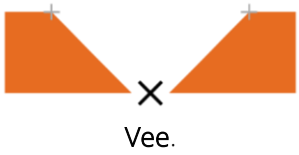
8. GARLINE SEAMS DEFINITIONS

8.1. Common Seam types

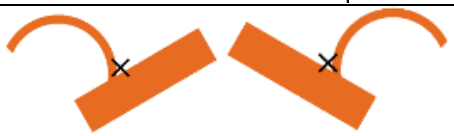
 Butt	**Gap min**. Minimal horizontal distance between upper gap lines. **Gap max**. Maximal horizontal distance between upper gap lines. **Step min**. Minimal vertical distance between upper gap lines. **Step max**. Maximal vertical distance between upper gap lines. **Angle min**. Minimal angle between upper gap lines. **Angle max**. Maximal angle between upper gap lines.
 Edge left Edge right	**Gap min**. Not required. **Gap max**. Maximal horizontal distance between the Edge line until detecting the next Edge (there might be several edges along the line, like cracks). **Step min**. Not required. **Step max**. Maximal vertical distance between the Edge line until detecting the next Edge (there might be several edges along the line, like cracks).
 Fillet external.	**Gap min**. Minimal horizontal distance between the end of fillet's lines. **Gap max**. Maximal horizontal distance between the end of fillet's lines. **Step min.** Minimal vertical distance between the end of fillet's lines. **Step max.** Maximal vertical distance between the end of fillet's lines. **Angle min**. Minimal angle of the angles forming the fillet. **Angle max**. Maximal angle of the angles forming the fillet.
 Fillet left Fillet right	**Gap min**. Minimal horizontal distance between the end of fillet's lines. **Gap max**. Maximal horizontal distance between the end of fillet's lines. **Step min.** Minimal vertical distance between the end of fillet's lines. **Step max.** Maximal vertical distance between the end of fillet's lines. **Angle min**. Minimal angle of the angles forming the fillet. **Angle max**. Maximal angle of the angles forming the fillet.
 Lap left Lap right	**Gap min**. Not required. **Gap max**. Maximal horizontal distance between the lap line and the next line to detect a lap. **Step min.** Minimal vertical distance between the upper lap line and the next line to detect a lap. **Step max**. Maximal vertical distance between the upper lap line and the next line to detect a lap. **Angle min**. Not required. **Angle max**. Not required.

 Line	**Gap min**. Not required. **Gap max.** Maximal horizontal distance between the Edge line and the next line to detector any possible edge. **Step min.** Not required. **Step max**. Maximal vertical distance between the Edge line and the next line to detector any possible edge. **Angle min.** Not required. **Angle max**. Not required.

8.2. Seams with bevels

	**Gap min**. Minimal horizontal distance between lower lines. **Gap max**. Maximal horizontal distance between lower lines. **Step min**. Minimal vertical distance between lower lines. **Step max**. Maximal vertical distance between lower lines. **Angle min**. Minimal angle between lower lines. **Angle max**. Maximal angle between lower lines.
	**Gap min**. Minimal horizontal distance between the fillet's lines. **Gap max**. Maximal horizontal distance between the fillet's lines. **Step min.** Minimal vertical distance between the fillet's lines. **Step max.** Maximal vertical distance between the fillet's lines. **Angle min**. Minimal angle between fillet's lines. **Angle max**. Maximal angle between fillet's lines.
	**Gap min**. Minimal horizontal distance between the ends of lower lines forming a V. **Gap max**. Maximal horizontal distance between the ends of lower lines forming a V. **Step min**. Minimal vertical distance between the ends of lower lines forming a V. **Step max**. Maximal vertical distance between the ends of lower lines forming a V. **Angle min**. Minimal angle between the lines forming a V. **Angle max**. Maximal angle between the lines forming a V.

8.3. Seams for pipes

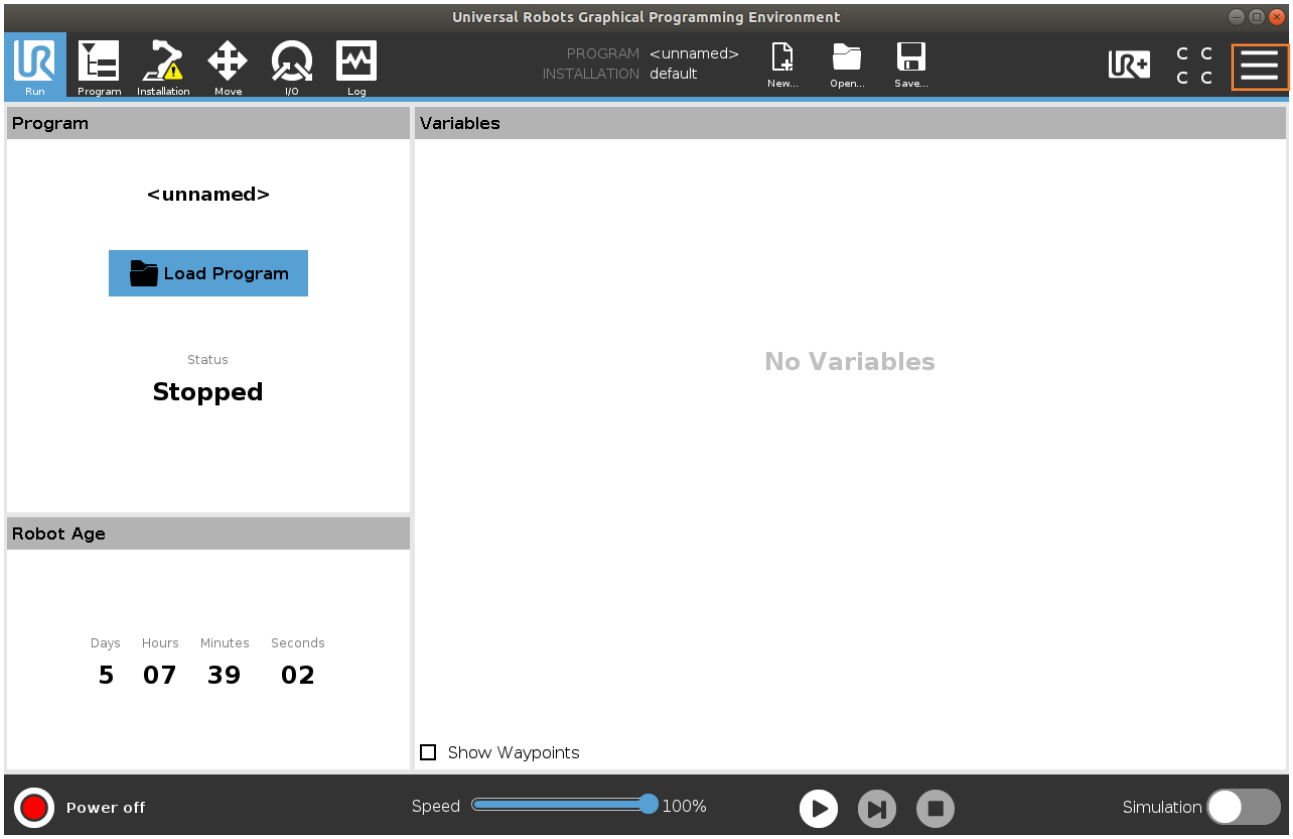
 Double-semi-downside/upside	No settings.
 Semi Left Semi Right.	No settings

9. UR INTERFACE

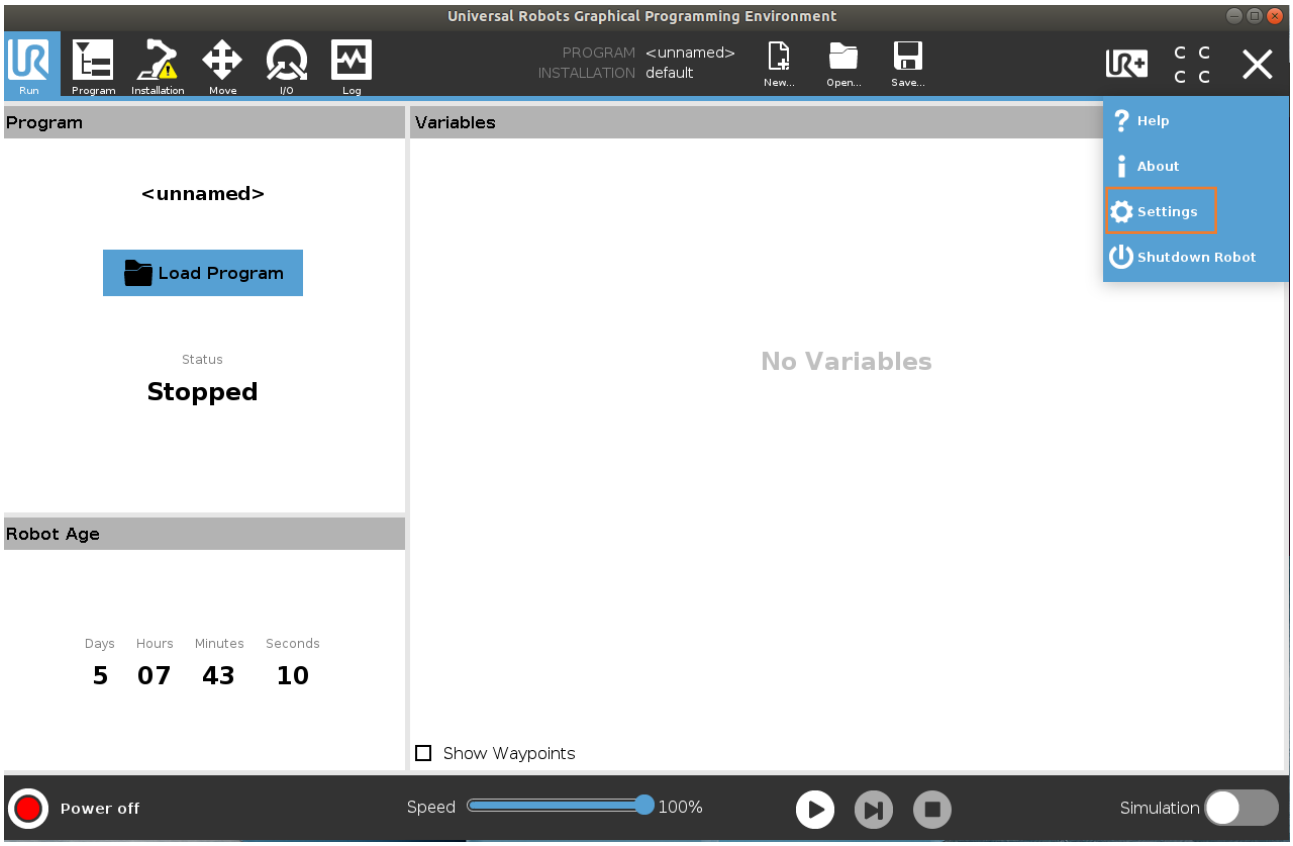
	Before using the sensor along with the UR, carefully read the user manual, especially the sections “3.4. GarLine laser” and “5.5. Basic rules for using the GarLine sensor”.
	While using URCaps, don’t make any changes in the UR speed: 

GarLine sensor features its own URCaps (provided by Garmo Intruments) which can be installed on the UR tablet as explained below (we recommend using Polyscope version 5.10 and above):

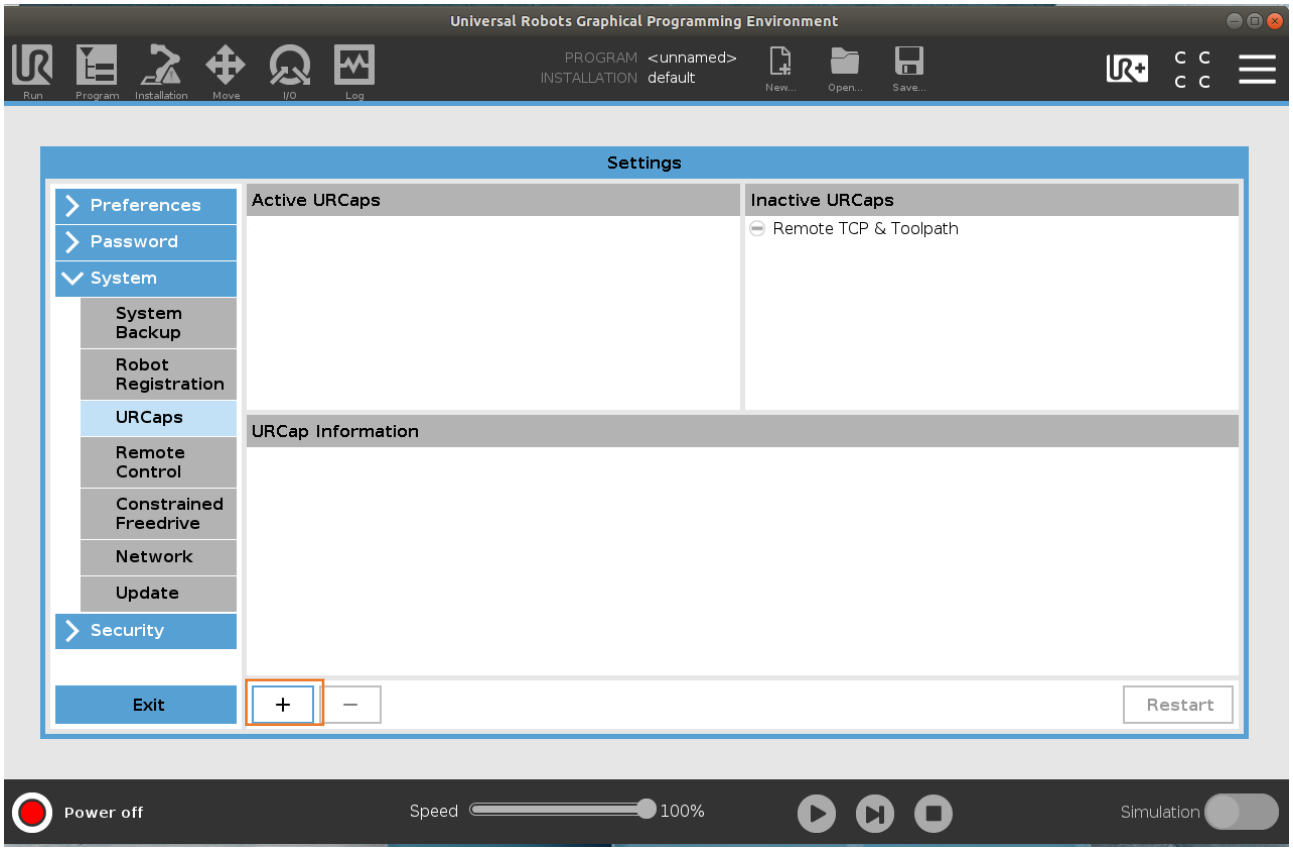
1. Save the URCaps installation program on a pen drive and connect it to the UR tablet.



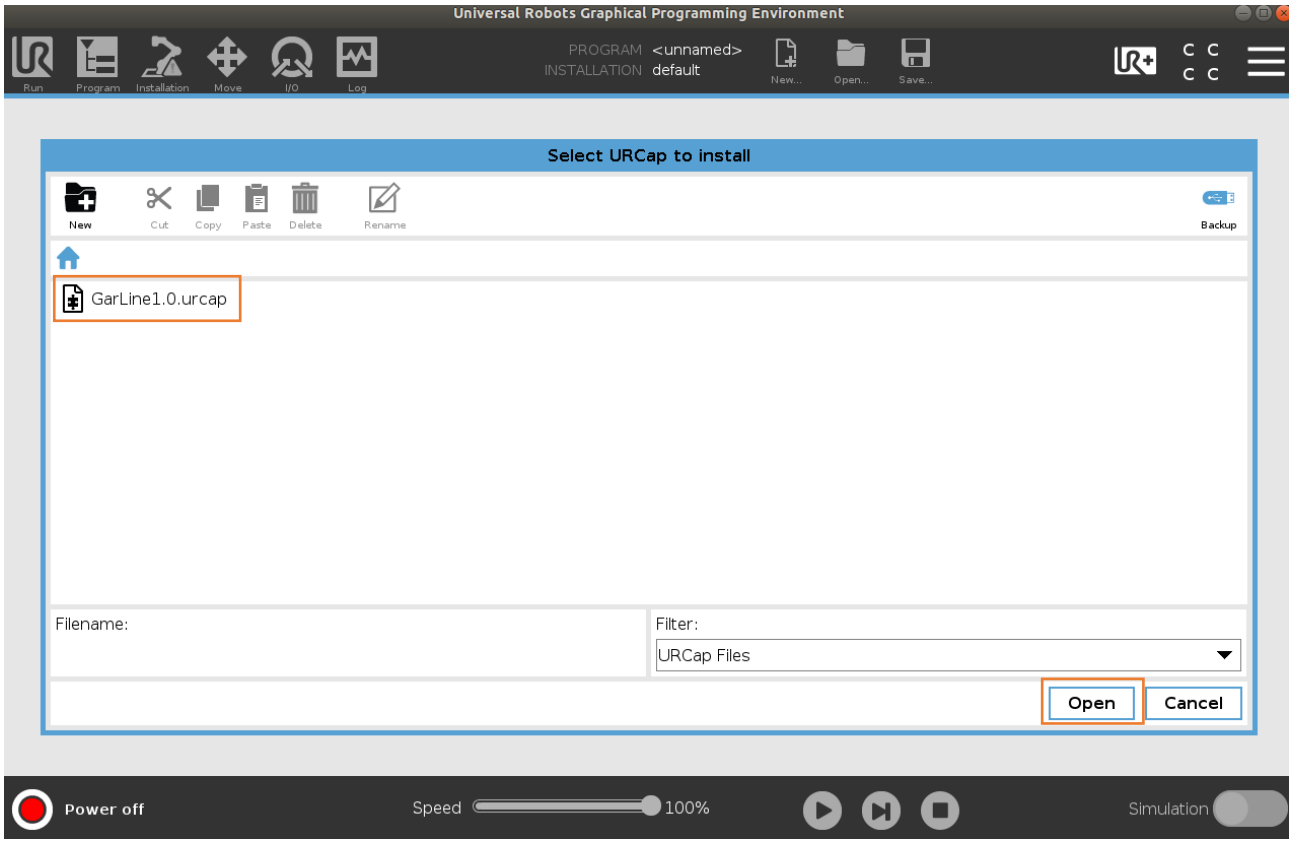
2. Click on the settings button  and select the Settings option:



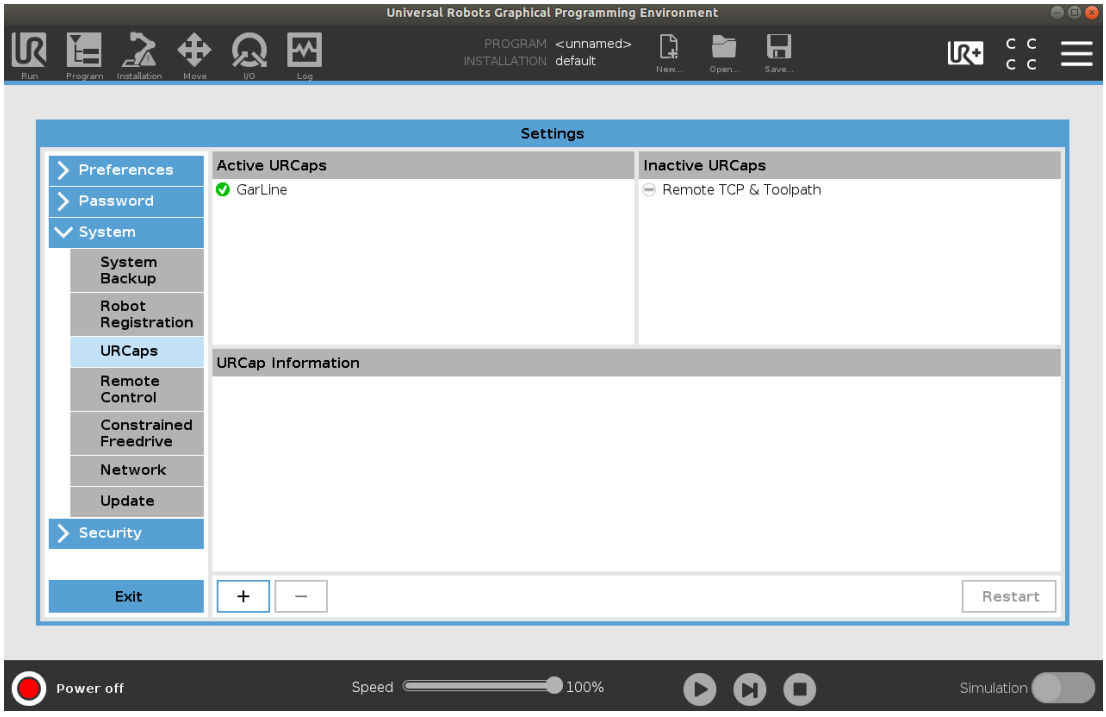
3. To install the URCaps, click on + button to open the files in USB.



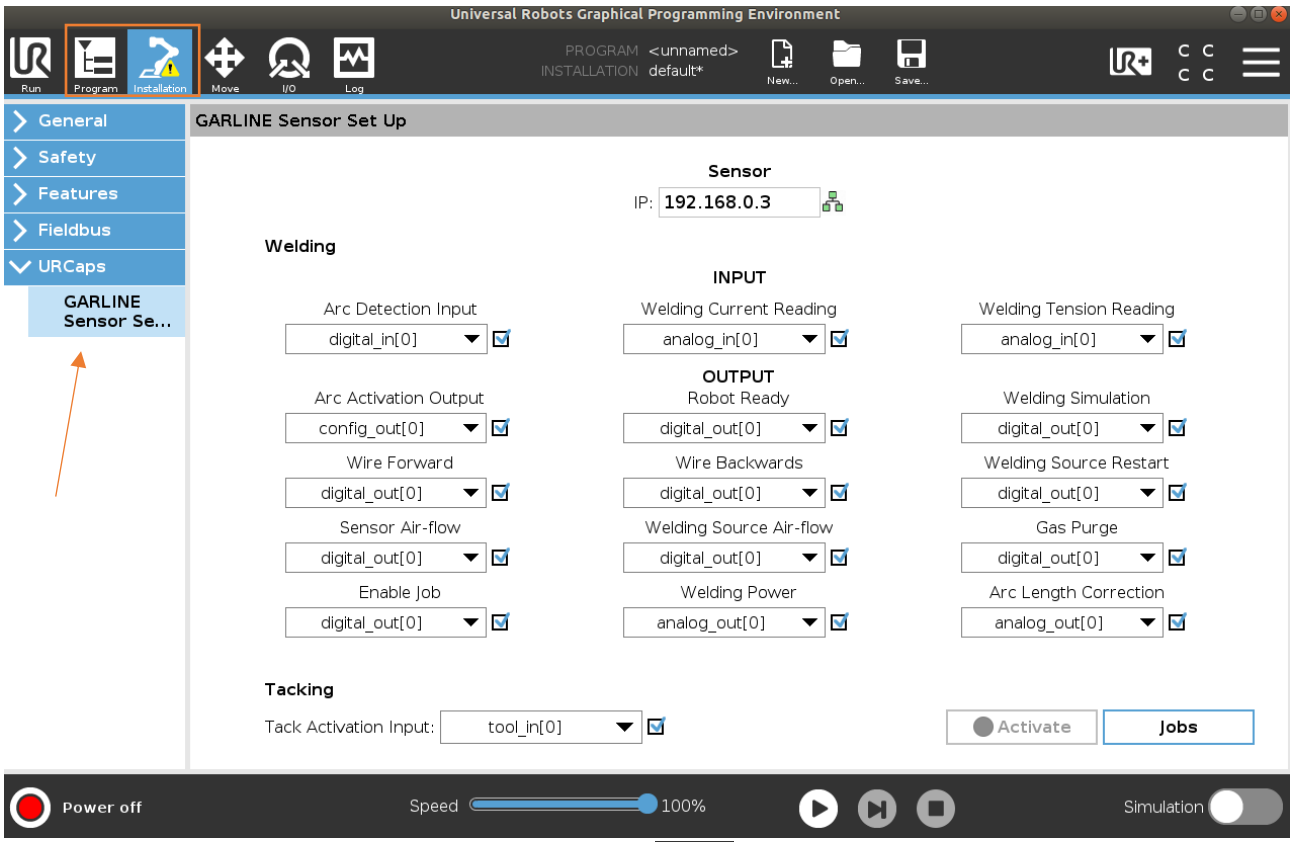
4. In the USB folder, select the “GarLine1.0.urcap” document and click on Open.



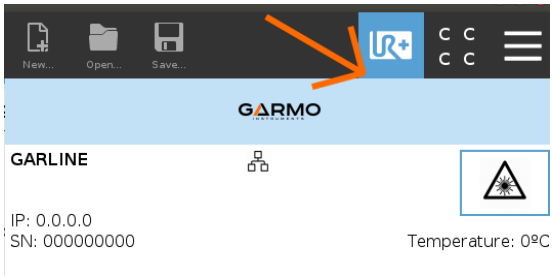
5. Once the GarLine URCaps is installed, press on restart button and the GarLine URCaps will be ready to use.



Once installed, you will find several URCaps nodes available, both in the Program and in Installation tabs (find image below).



On the top you will find the toolbar with UR+ icon.  By clicking on UR+ button, different sensor statuses will be shown (as exposed in the following image):



Besides, sensor's status is also displayed in the  icon next to sensor's IP address. The icon displays different colors, each of them corresponding to different sensor's statuses (red: not connected; yellow: connecting and green: connected).

9.1. TOOLBAR

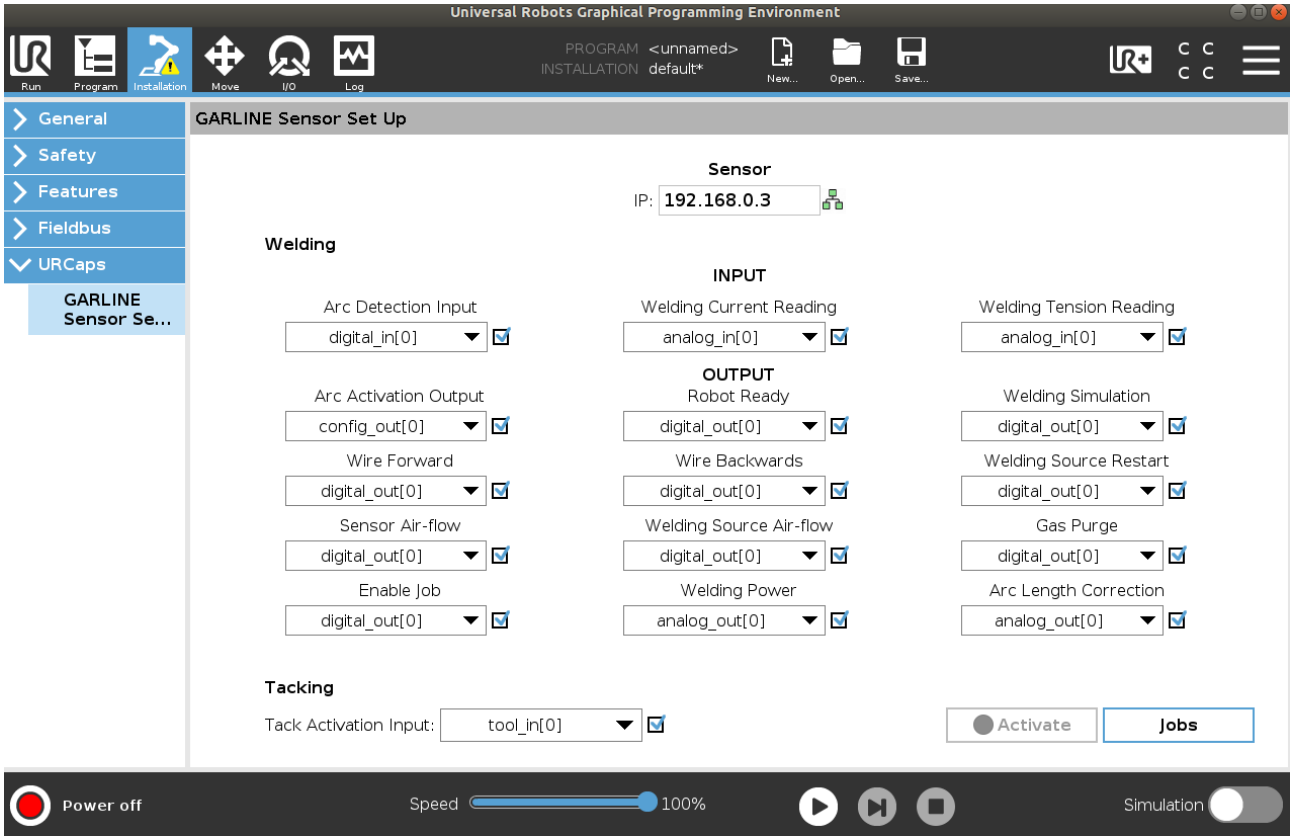
GarLine's toolbar shows the sensor's connection status which switches from red (power off) to green (power on). Besides, the toolbar displays other information such as temperature, sensor's IP address or the serial number. There is also a button to turn the laser on or off.

9.2. INSTALLATION TAB

First step during Garmo Instruments' URCaps installation process is to configure all the robot's inputs and outputs to the welding machine. Besides, if you're using a different IP address for the sensor from the one that was provided along with the manufacturing information, you might have to modify it. To verify whether the UR has been successfully connected to the sensor, check the connection icon on the toolbar and make sure it's green.

In the following image, you can find two buttons on the bottom right corner: "Activate" and "Jobs". The "Activate" button will remain disabled until all the input and output settings are configured. Make sure of the configuration before pressing it, once you are done and the button is enabled. In case any of the input/output settings is configured twice, by pressing "Activate", a warning message would appear to inform about the error, so you can correct it. You can disable any input or output you do not need by checking the appropriate box.

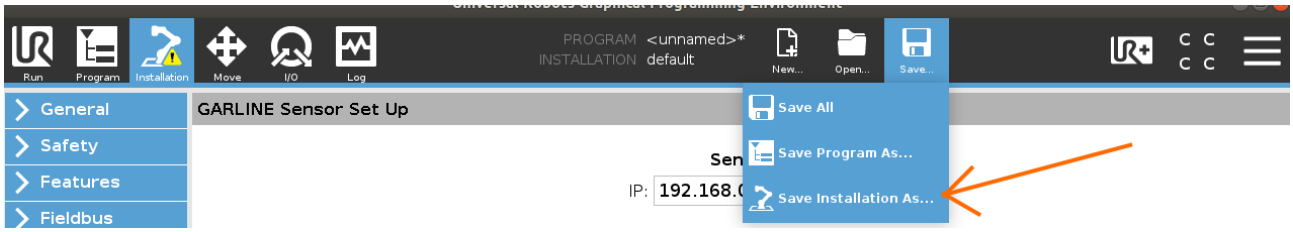
If all the inputs and outputs are set correctly, the "Activate" button would be enabled and by clicking it, the light indicator on the button would turn from red to green:



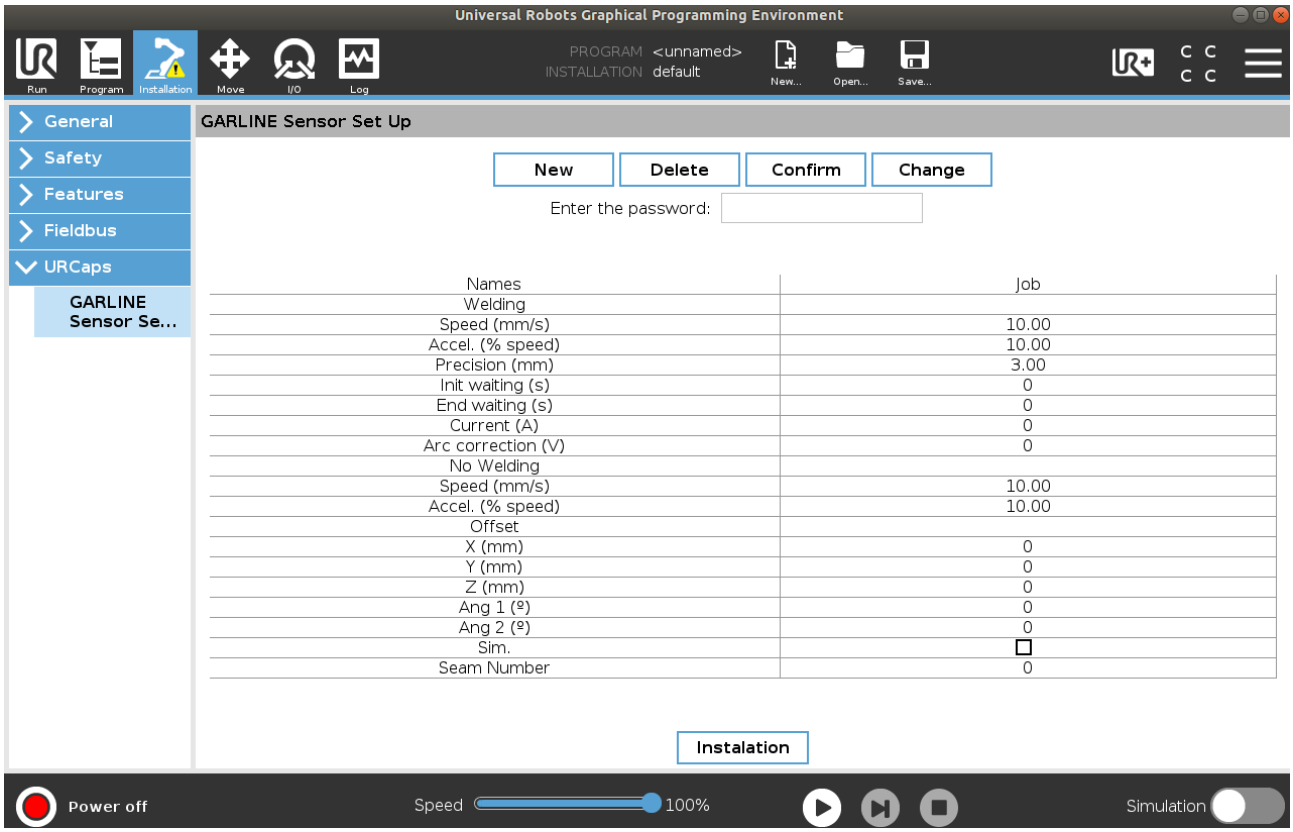
The input and output settings to be filled in are described below:

SENSOR: sensor's IP setting		
IP: a default IP address would appear. Insert the IP address that appears on the sensor head.		
WELDING: setting of the welding parameters		
INPUT data that the UR receives from the welding machine		
Arc Detection Input: the input to the robot detecting whether the torch is on.	Welding Current Reading: input reading the welding current.	Welding Tension Reading: input reading the welding tension.
OUTPUT data commands sent to the welding machine		
Arc Activation Output: the output to activate the torch.	Robot Ready: all the outputs are configured and the parameters are set up correctly.	Welding simulation: enable welding simulation (without turning the torch on)
Wire Forward: command to make the welding wire move forward.	Wire Backwards: command to make the welding wire move backwards.	Welding Source Restart: command to restart the welding source machine.
Sensor Air-Flow: command to enable sensor's air-flow.	Welding Source Air-Flow: command to enable air-flow on the welding source machine.	Gas Purge: command to activate the gas purge used during the welding.
Enable job: command sent to the welding machine to enable a job selection (find more information about Jobs on the next page).	Welding power: command to control the power parameters of the welding machine (analog output).	Arc Length Correction: command to control the length correction parameters of the welding machine (analog output).
TACKING: setting tacking points on the joint		
Tack Activation Input: command to activate the tacking.		

If you want to save the settings, press the "Save Installation As..." button in "Save" node, as described in the following picture:



The "Jobs" button will redirect you to a screen where you can configure the different welding parameters. These parameters are gathered in a chart (find image below):



Additionally, you will find four buttons in this screen "New", "Delete", "Confirm" and "Change":

- New: creates a new Job with generic name and parameters.
- Delete: deletes a Job from the last column selected.
- Confirm: this button saves the changes as long as the password is correct, otherwise an error message would appear. Take into account the "Confirm" button only saves the changes for the current session (for the one you are working on – and these changes would disappear in case of turning the UR tablet off). If you want to save the configuration settings, click on the "Save Installation As..." button on the top bar (clicking on the "Save" button 

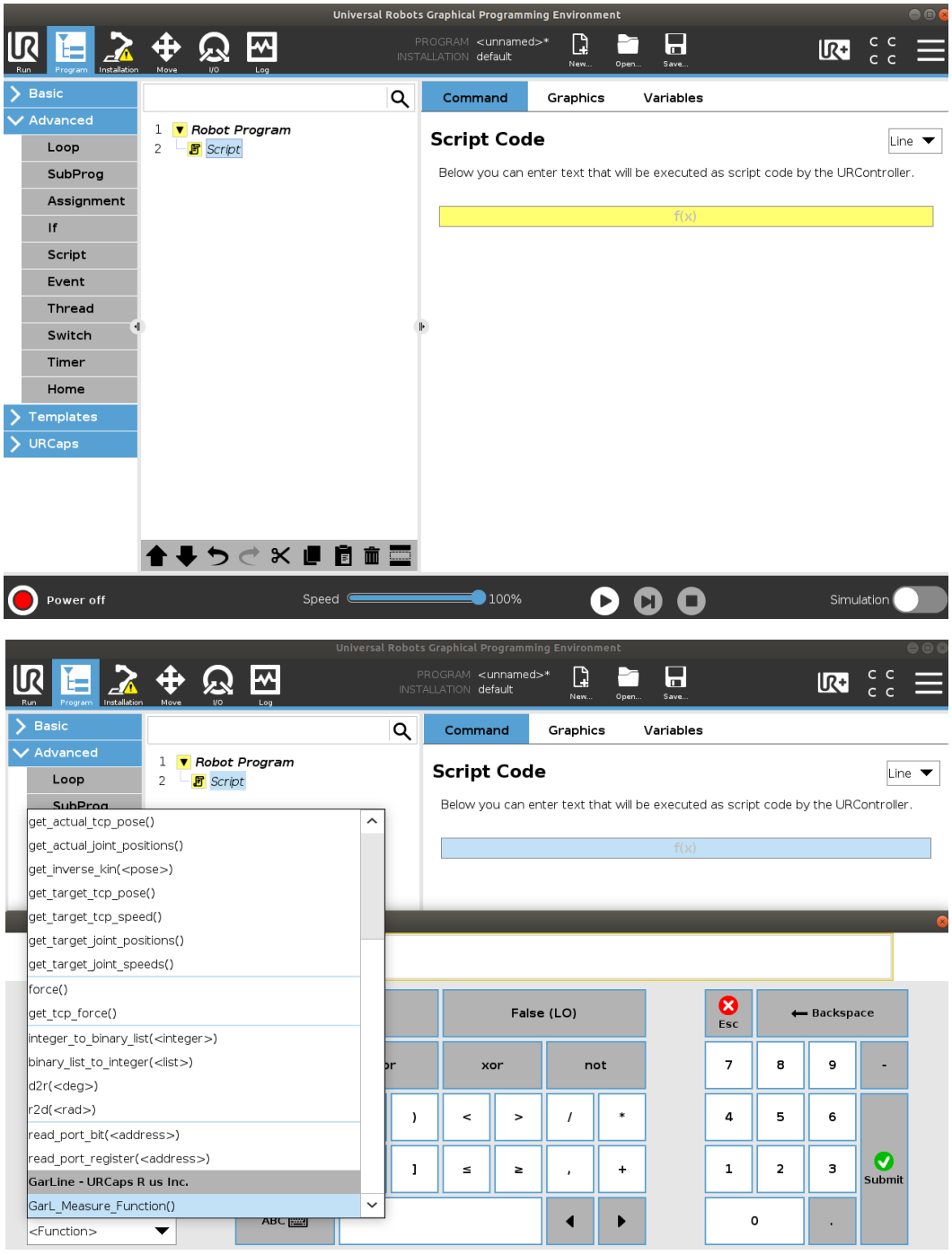
).
- Change: it modifies the selected name or parameter.

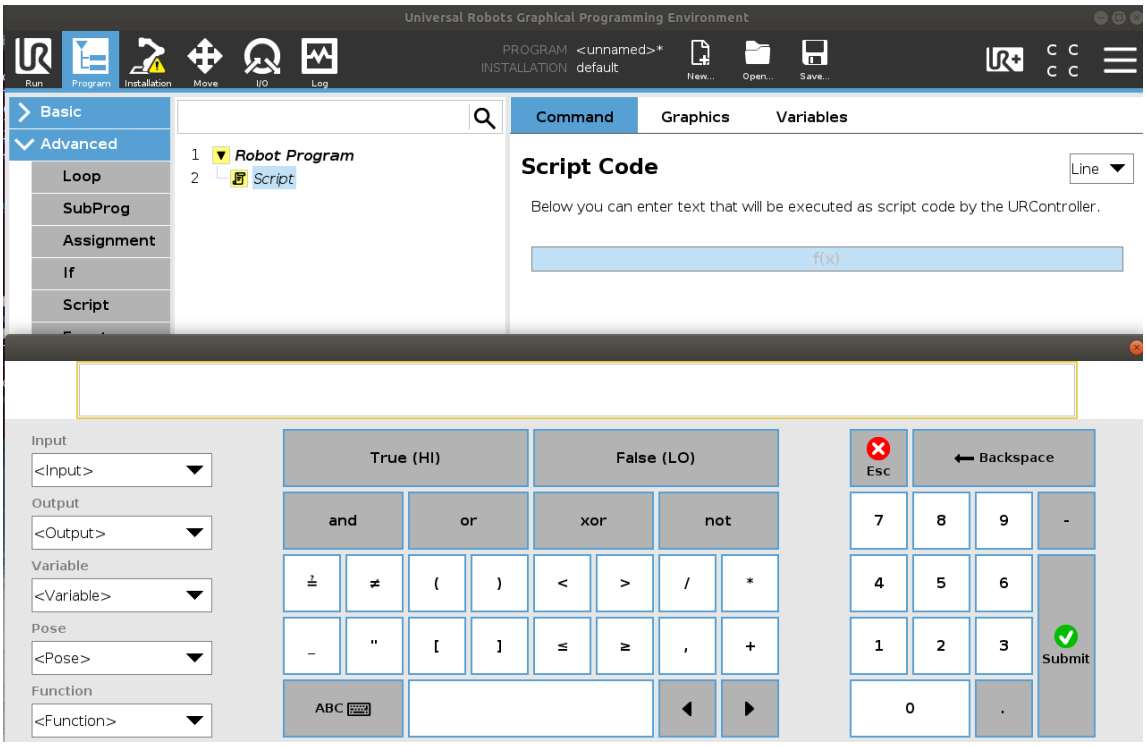
9.3. PROGRAM TAB

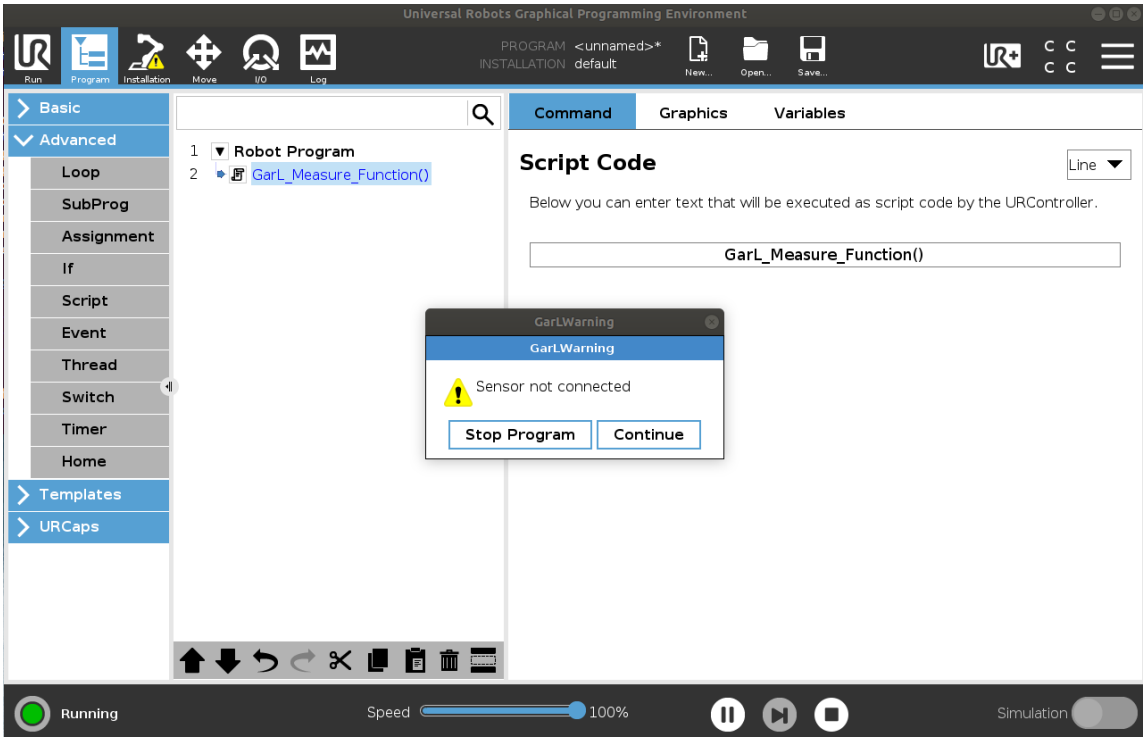
The URCaps Program Nodes is separated in two other nodes: "GarLine Calibration" and "GarLine". Besides, there is also the "GarL_Measure_Function" built in the URscript that you can use to build your own custom program nodes.

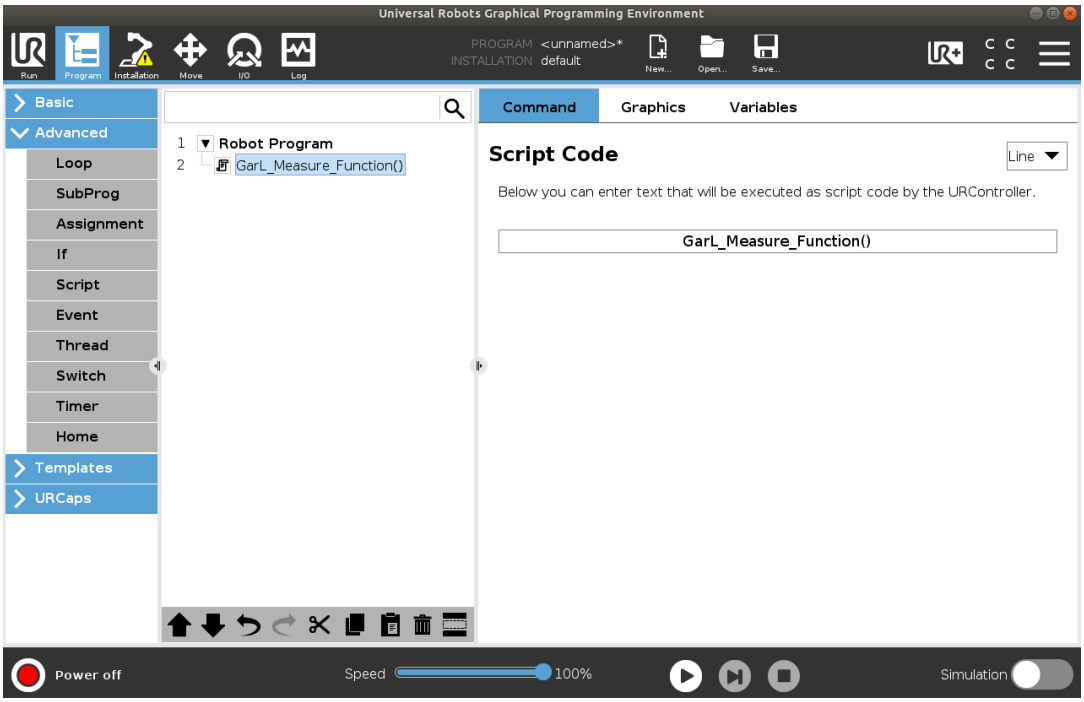
9.3.1. GarL_Measure_Function

The GarL_Measure_Function returns an array of 4 numbers indicating the position and angle of the measure (x, y, z, angle). In case the sensor is not connected it will show a warning and return four negative ones. In case it doesn't detect any seam, it will return four zeros. Find below the instructions on how to add the function:



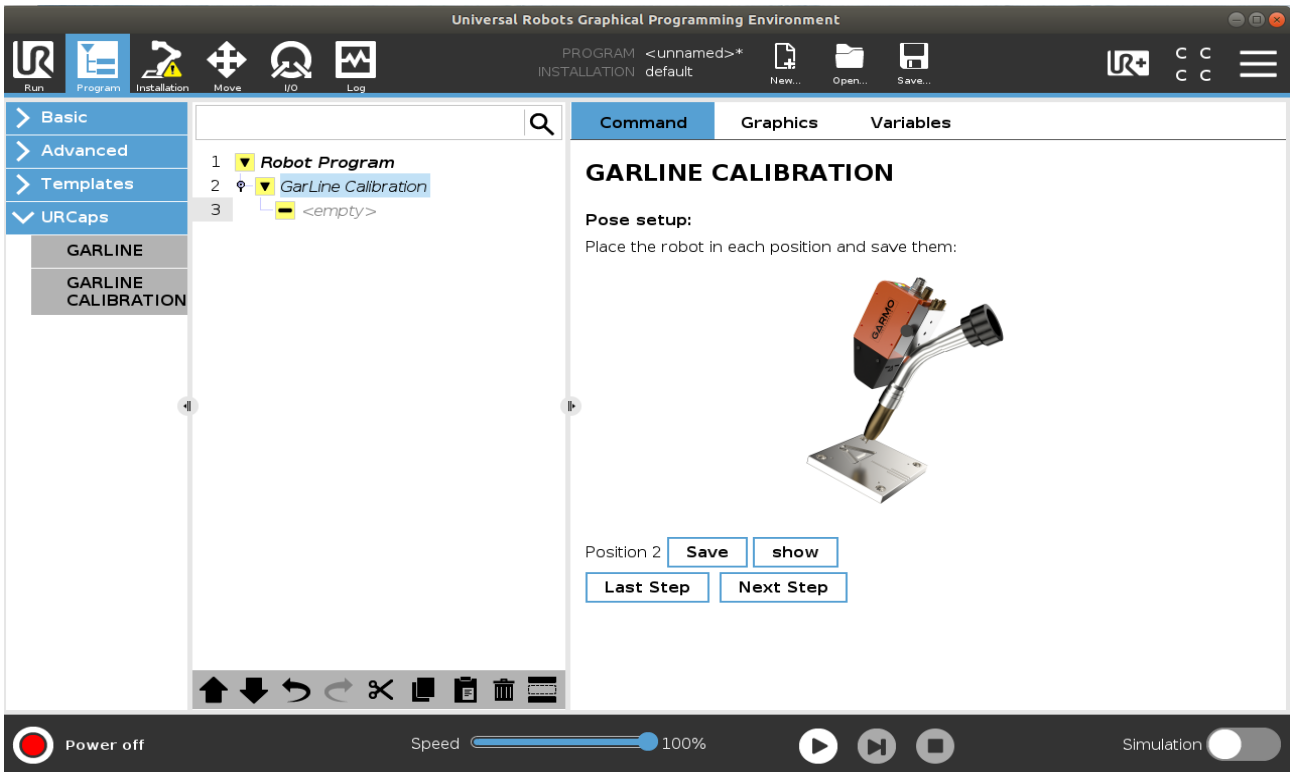

Universal Robots Graphical Programming Environment
Run
Program
Installation
Move
I/O
Log
PROGRAM <unnamed>*
INSTALLATION default
New...
Open...
Save...
Basic
Advanced
Loop
SubProg
Assignment
If
Script
1 Robot Program
2 Script
Command
Graphics
Variables
Script Code
Line
Below you can enter text that will be executed as script code by the URController.
f(x)
Input
<Input>
Output
<Output>
Variable
<Variable>
Pose
<Pose>
Function
<Function>
True (HI)
False (LO)
and
or
xor
not
Esc
Backspace
Submit
ABC


Universal Robots Graphical Programming Environment
Run
Program
Installation
Move
I/O
Log
PROGRAM <unnamed>*
INSTALLATION default
New...
Open...
Save...
Basic
Advanced
Loop
SubProg
Assignment
If
Script
Event
Thread
Switch
Timer
Home
Templates
URCaps
1 Robot Program
2 GarL_Measure_Function()
Command
Graphics
Variables
Script Code
Line
Below you can enter text that will be executed as script code by the URController.
GarL_Measure_Function()
GarLWarning
GarLWarning
Sensor not connected
Stop Program
Continue
Running
Speed
100%
Simulation

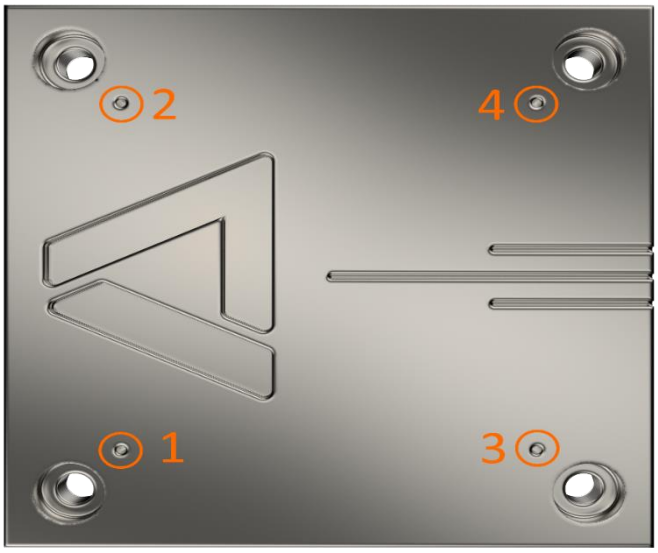

Universal Robots Graphical Programming Environment
Run
Program
Installation
Move
I/O
Log
PROGRAM <unnamed>*
INSTALLATION default
New...
Open...
Save...
Basic
Advanced
Loop
SubProg
Assignment
If
Script
Event
Thread
Switch
Timer
Home
Templates
URCaps
1 Robot Program
2 GarL_Measure_Function()
Command
Graphics
Variables
Script Code
Line
Below you can enter text that will be executed as script code by the URController.
GarL_Measure_Function()
Power off
Speed
100%
Simulation

9.3.2. GarLine Calibration Node

This tab is used for calibrating the sensor with the robot. To do so, you will need the calibration plate provided by Garmo Instruments and follow the steps described in the program as per bellow:



At each step you will have to place the torch on the point indicated by the program (place the torch on the point as if it was a welding point). If something goes wrong and you miss the calibration point, you can go backwards and save the calibration point again. In the image below, you can find the calibration plate and the order of calibration points to follow:



Once the calibration points are all saved, place the sensor head with the laser on point in the point situated below the "A" sign and above the longest line. The laser line should fit between the calibration points like in the picture below:

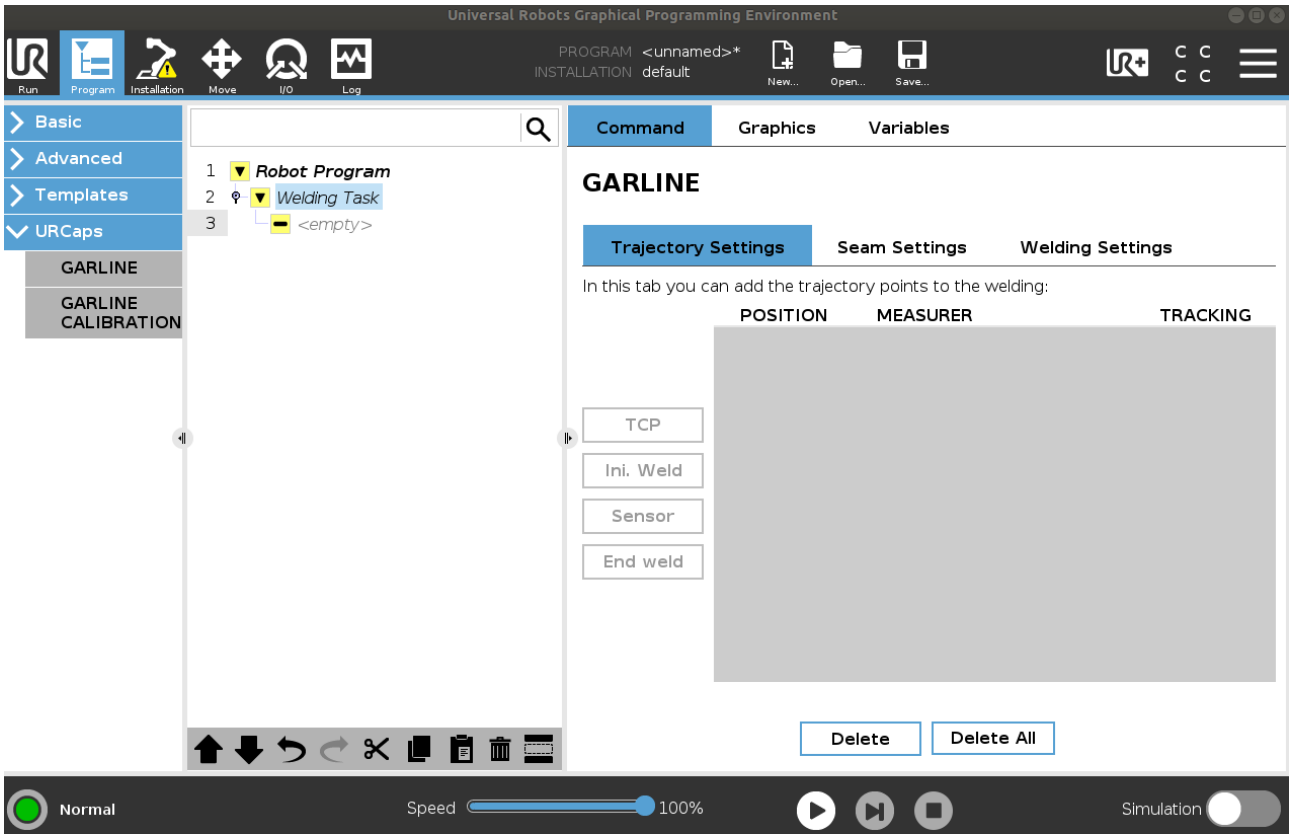
Then press the "play" ( ) button. In case the sensor or the torch are changed or moved from their position, you might have to repeat the calibration process.

Warning: Sensor's calibration program is designed to perform on its own, don't combine it with other programs in URCaps. Besides, you have the option to save the calibration program, but in case of using the saved calibration program again, make sure that the robot and the calibration plate are in the same position as during the initial calibration. In case you are not saving the calibration program, the robot and the sensor will be calibrated anyway.

Once the calibration is done and finished, reset the sensor.

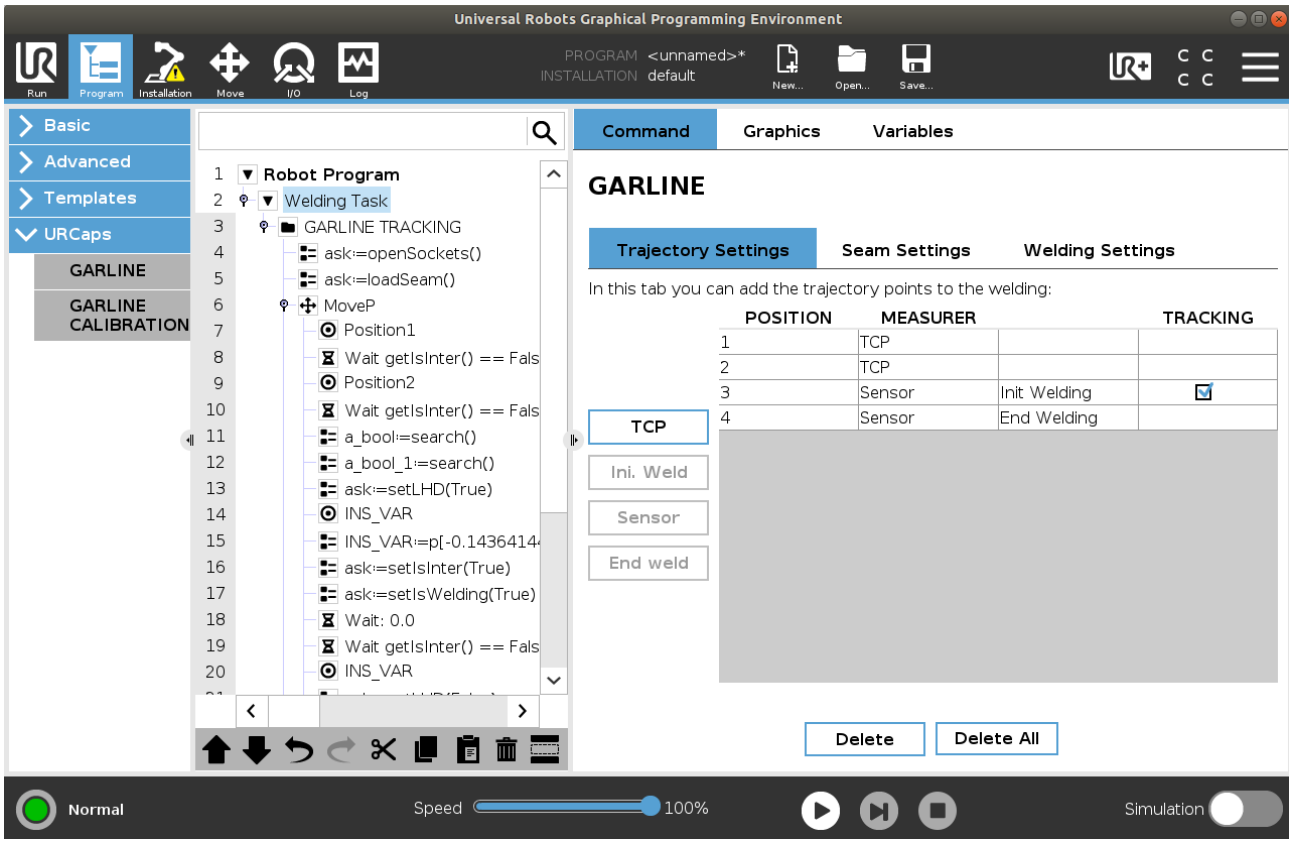
9.3.3. GarLine Node

The "GarLine" Node is classified in three tabs ("Trajectory Settings", "Seam Settings" and "Welding Settings"), as displayed in the image below:



Trajectory Settings tab

This section, in "GarLine" tab at "Program" upper tab, is used to configure the welding trajectory that the UR would follow (find image below).



Here you can find four buttons: "TCP", "Ini.Weld", "Sensor" and "End Weld". Before getting on with the configuration, make sure that that you have previously set the welding parameters in the Installation tab and in the Welding Settings tab. Once the parameters are set, the above-mentioned buttons will start getting consecutively enabled as you move forward along the welding trajectory settings. Each of these buttons corresponds to different welding process steps. In case you do not know why any button might be disabled, just place the mouse pointer on the button and an information message will appear. The program also offers settings for welding parameters – these ones should be configured before pressing the "play" button. Otherwise, an error message would appear and the robot wouldn't move (check section "Welding Settings tab"). Each button sets a robot programming which can be observed in the left column under Robot Program title.

- TCP: creates a position towards which the robot would be moving without sensor's help. This option is used to create initial and final points in the welding trajectory.

- Ini. Weld: Creates the position at which the welding process. This option defines a TCP position for the robot to move towards it and a position for the sensor to detect as welding initial point. The robot should be placed in the proper position before pressing this button.

- Sensor: This option sets half-way points between the beginning and the end of welding trajectory when the trajectory between initial and ending points is not completely straight (e.g.: when the trajectory is in L shape).

- End Weld: sets the ending point in welding trajectory for the sensor.

A welding trajectory must contain at least an initial and an ending point.

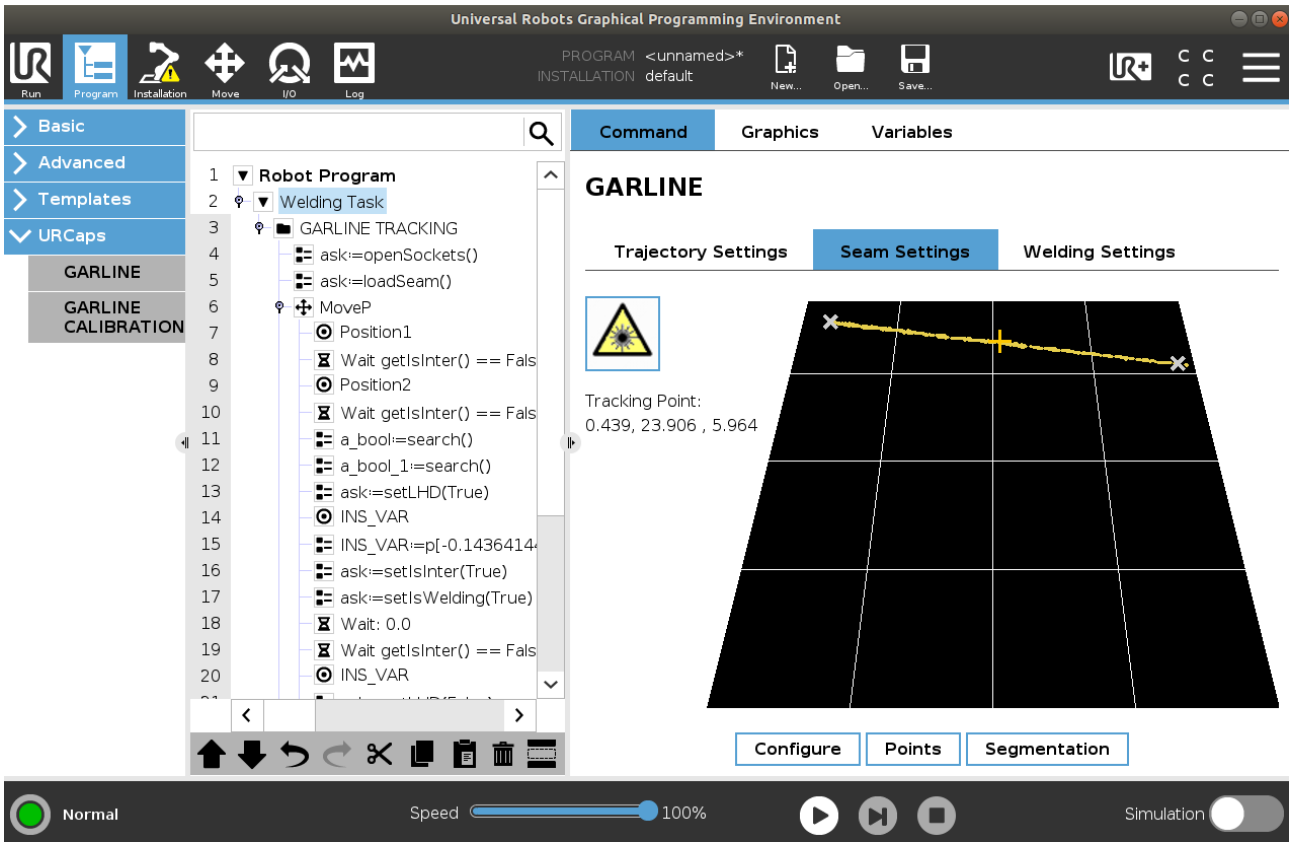
Every change made will be recorded in a table. You may also set the tracking process by clicking on the corresponding square in the "Tracking" column. These values cannot be changed until initial and ending points for welding trajectory are set.

You can also find the "delete" and "delete all" buttons to erase the last set point or to erase the whole trajectory.

You can also save the program (like the calibration program), but in case you change or move the torch and/or the sensor, but make sure that the robot and the welding joints are in the same position as during the initial configuration.

Seam Setting tab

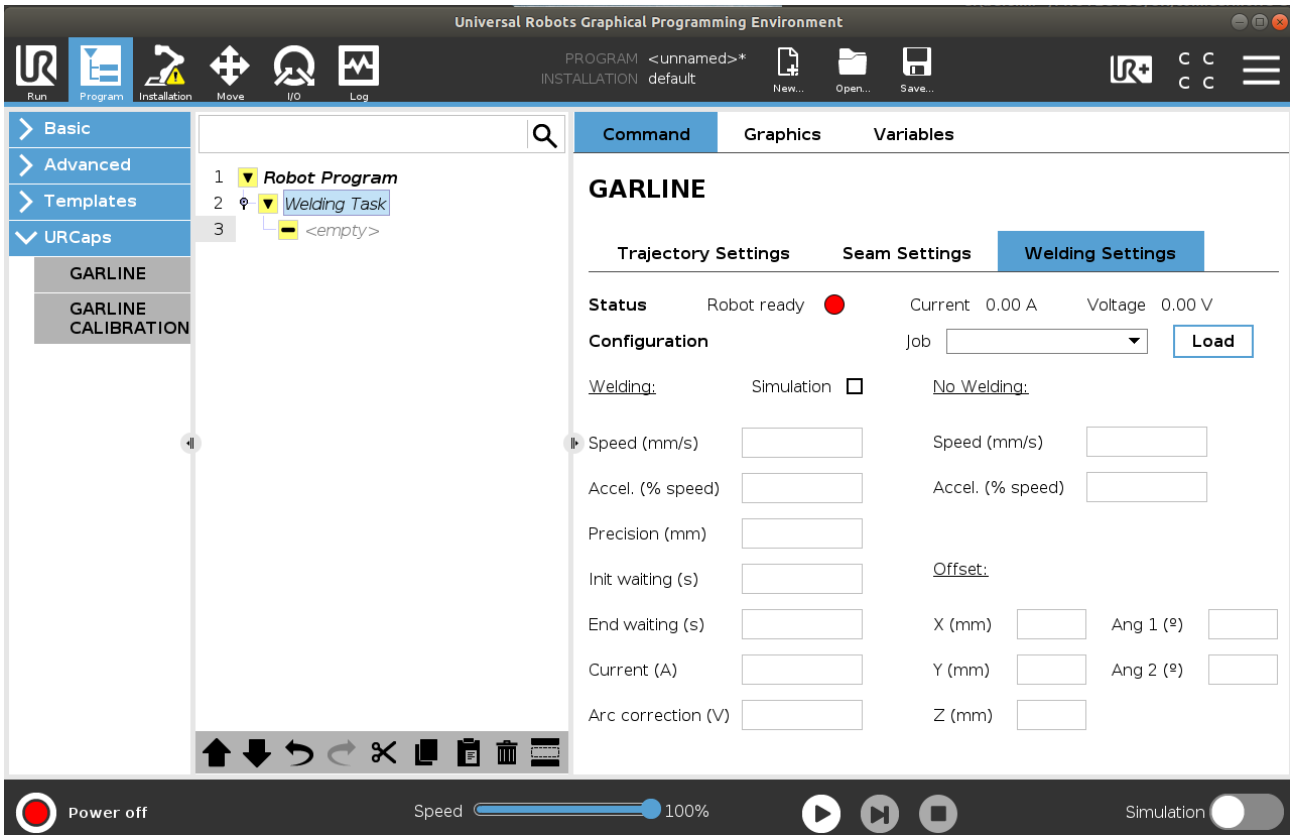
This tab is used to set the different seam options for the sensor, as explained in the section 8 "GARLINE SENSOR INTERFACE" in this user manual. Here you can find the button to turn the laser on or off, the tracking point button or you can also obtain the measurements by clicking in the corresponding section.



The “Configure” button is used to configure the seam and displays some images that may help you recognize the parameters by pressing on information button. The Advanced Options box (“Adv. Options”) will display a series of parameters which you can modify. To save the changes, click on “Submit” button (find image below).

Welding Settings tab

The Welding Settings tab displays different parameters to configure the welding. In addition, the tab displays some informative parameters.



Find all the parameters described below:

STATUS:

- Robot ready: if all the necessary outputs and values are conveniently set to start to weld, the indicator would turn green instead of red.
- Current / Voltage: real time values provided by the welding machine.
- Job: a drop-down containing the saved configurations

WELDING: parameters for the welding process.

- Simulation ☐ : by setting this opting, the welding function will be disabled, so you obtain a simulation of how the welding would be (useful for checking how the welding torch would go before actually performing the welding).
- Speed (mm/s): robot's speed during the welding trajectory. Before starting to weld, set a robot speed.

- Accel. (% speed): robot's acceleration during welding trajectory. Before starting to weld, set a robot acceleration.
- Precision (mm): it's the precise distance between welding points detected by the sensor throughout the welding trajectory. The lower is the value, the higher will be the precision.
- Init waiting (s): it's the time elapsed from the moment the torch turns on until it starts moving.
- End waiting (s): it's the time elapsed from the moment the torch turns off after finishing the welding trajectory until starting to get into exiting position.
- Current (A): current value in amperes (to be determined according to the type of welding).
- Arc correction (V): voltage value in volts to be determined according to the type of welding).

NO WELDING: parameters out of tracking, without actually employing the welding (these values can be higher than the ones in WELDING configuration).

- Speed (mm/s): robot's speed during the welding trajectory.
- Accel. (% speed): robot's acceleration during welding trajectory.

OFFSET: welding axes setup.

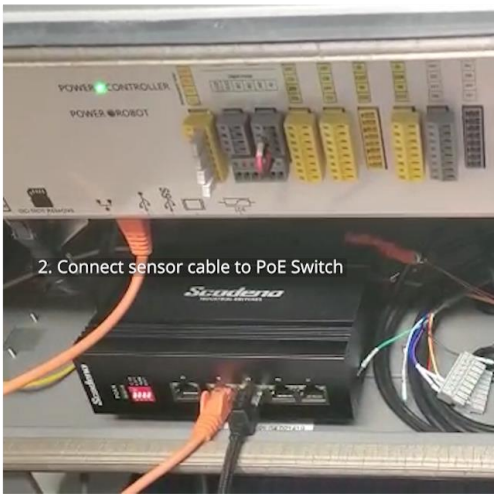
- x (mm): axes parallel to the laser line.
- y (mm): high-rise movement.
- z (mm): axes perpendicular to the laser line.
- Ang 1 (º): rotation angle to z.
- Ang 2 (º): rotation angle to x.

9.4. USING GARLINE SENSOR WITH UR

This section explains how to use GarLine sensor along with UR robot for welding. It's assumed that the user has already read and understood all URCaps Nodes and Configurations necessary for welding.

9.4.1. Sensor's hardware setup

1. Connect the Ethernet cable to UR and PoE switch

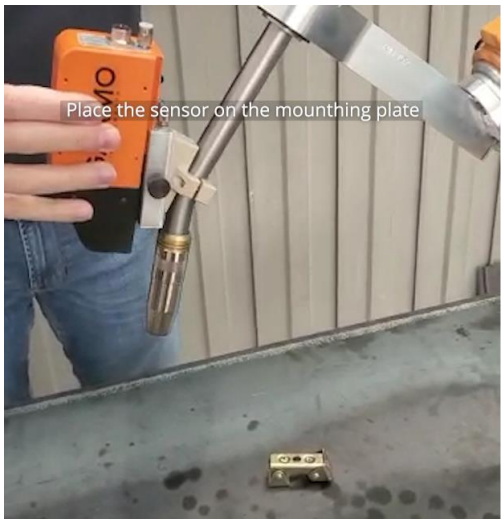


2. Connect the sensor cable to the PoE switch

3. Connect the welding outputs to enable welding to the UR and the welding source

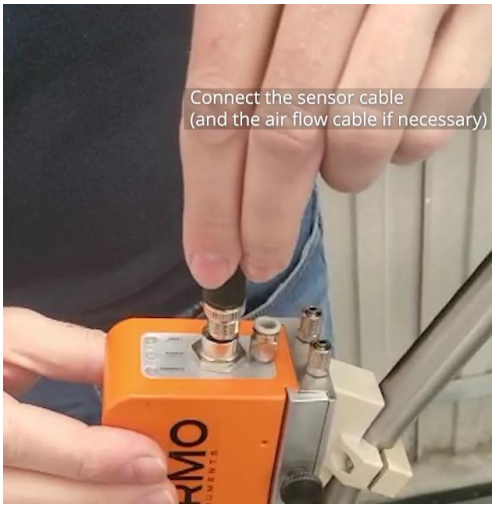
UR

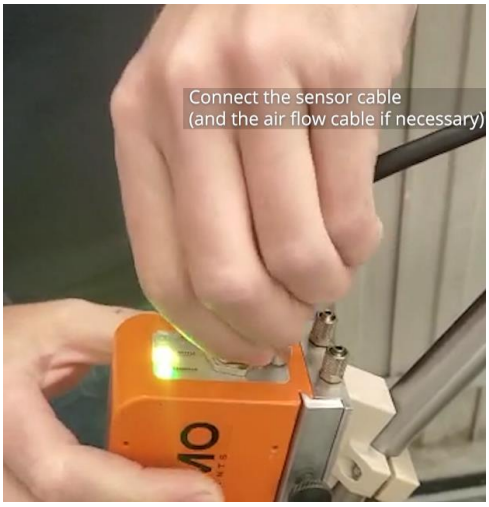
Welding source



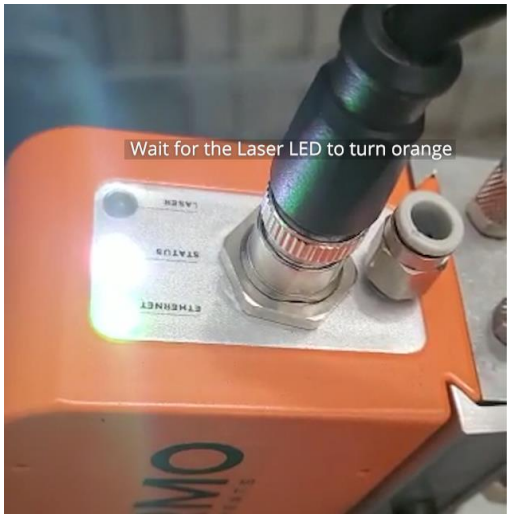
Place the sensor on the mounting plate

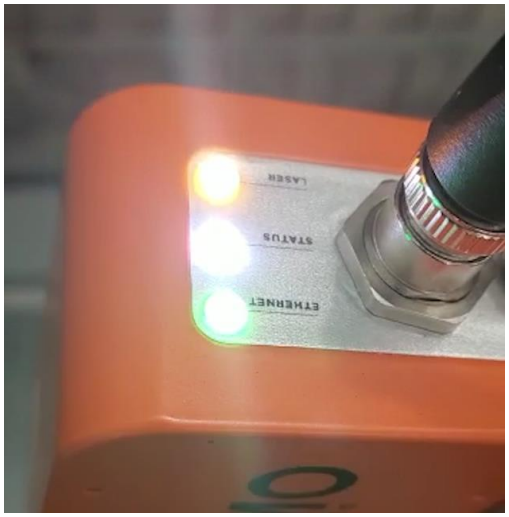
And tighten the locking nut tight until the sensor is fixed



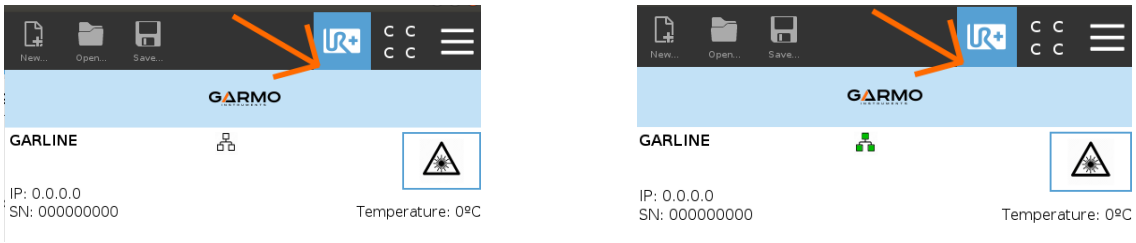


Connect the sensor cable until the LEDs turn on





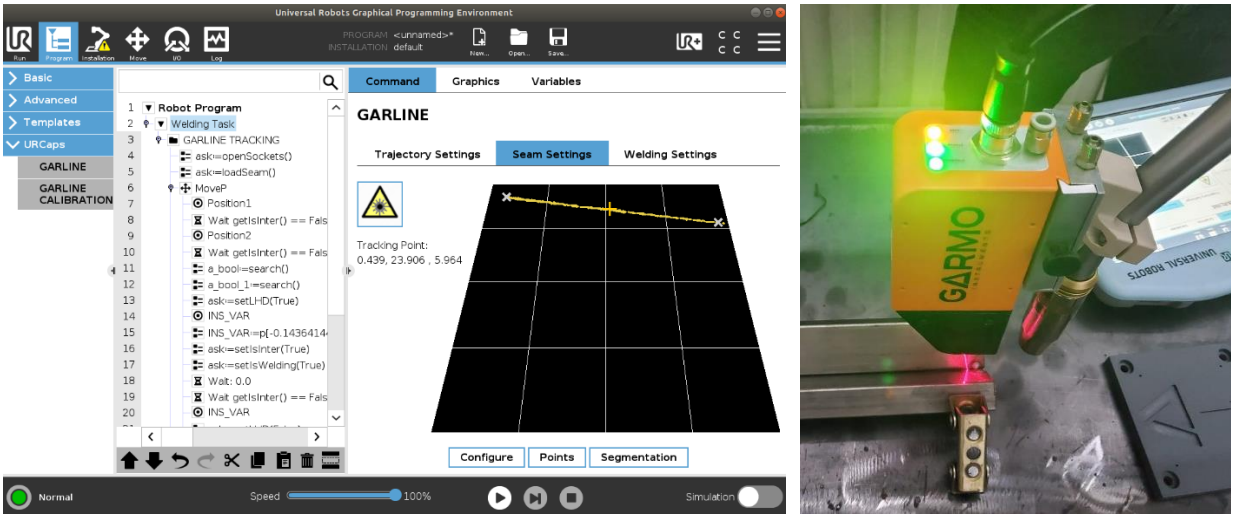
Wait until the Laser LED turns orange



Finally, make sure that the sensor's status on UR tablet turns green.

9.4.2. Configure seam

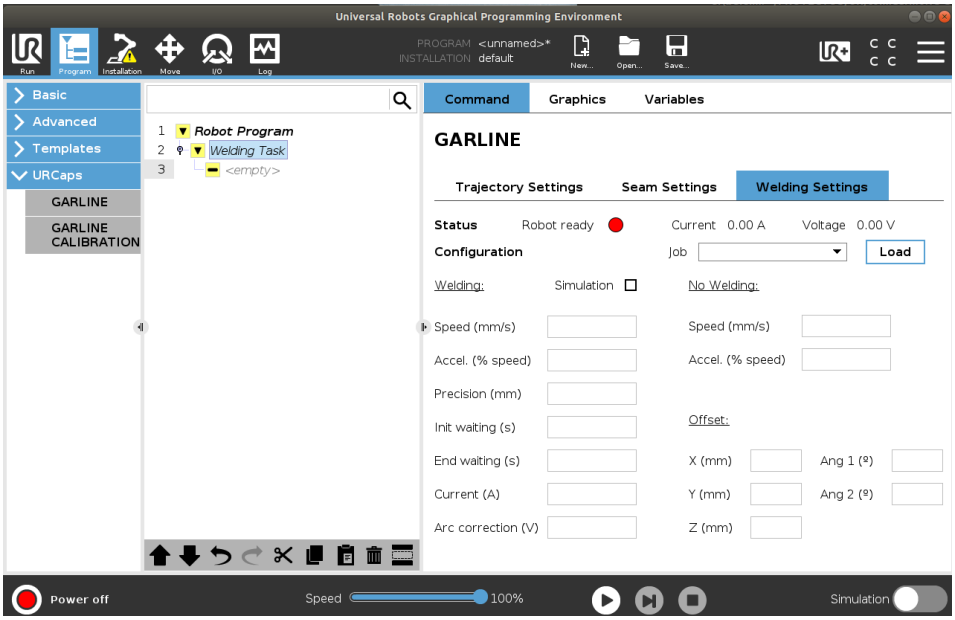
With the sensor pointing on the seam and having it in sensor's field of view, configure the seam type in the Seam Settings tab:



When the seam is correctly detected by the sensor, Status and Ethernet LEDs are green, while the Laser LED is orange.

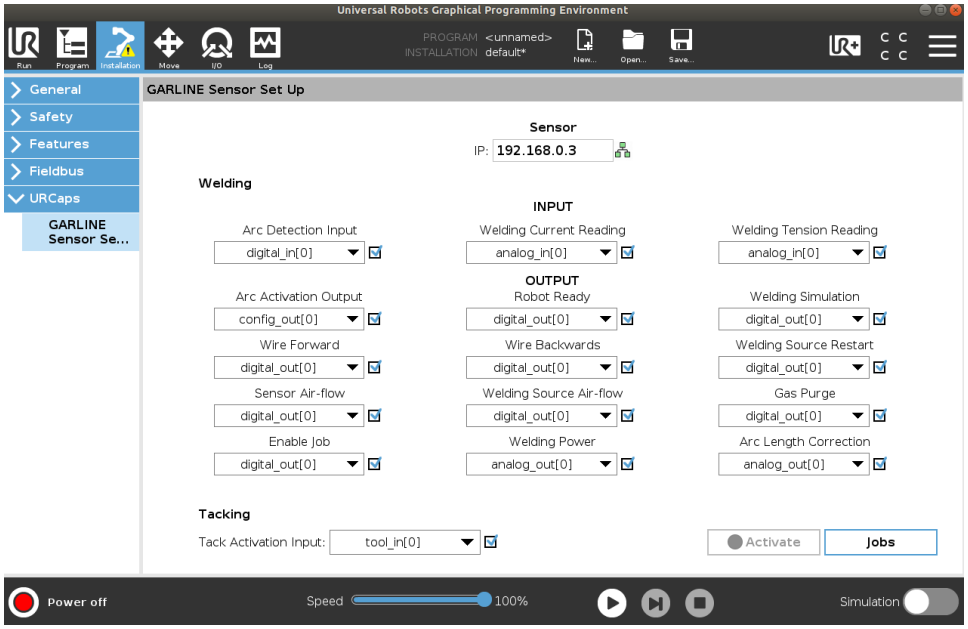
9.4.3. Configure welding

Configure welding parameters in the Welding Settings tab.

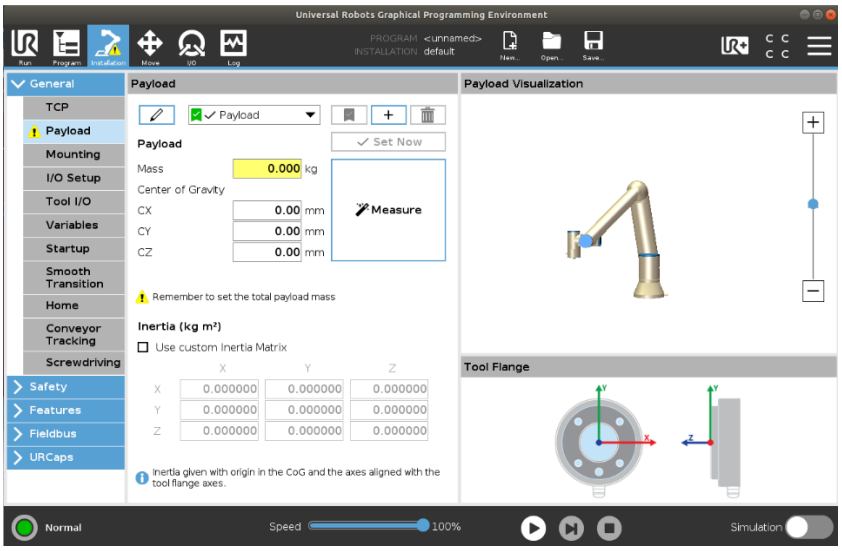


Make sure you've set speed, acceleration, precision in Welding column; and speed and acceleration in No Welding column. Other parameters are optional.

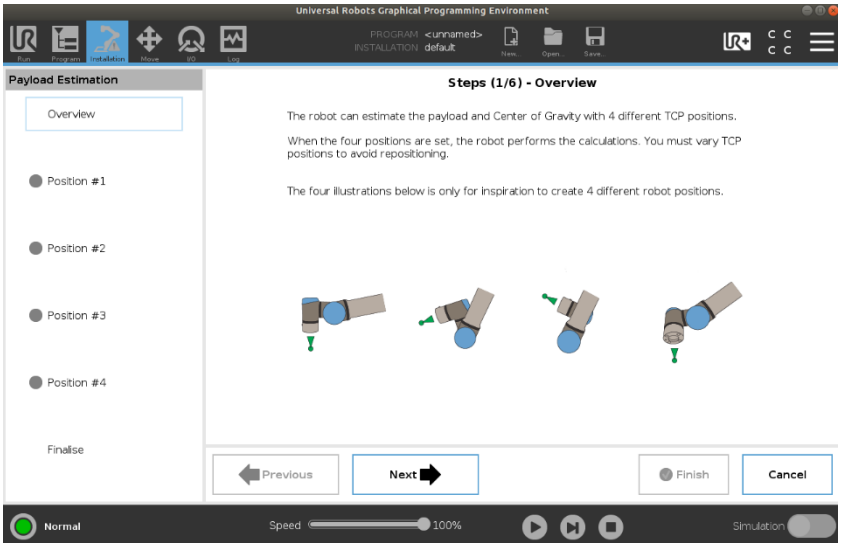
Remember to check if all the necessary inputs and outputs are properly set.



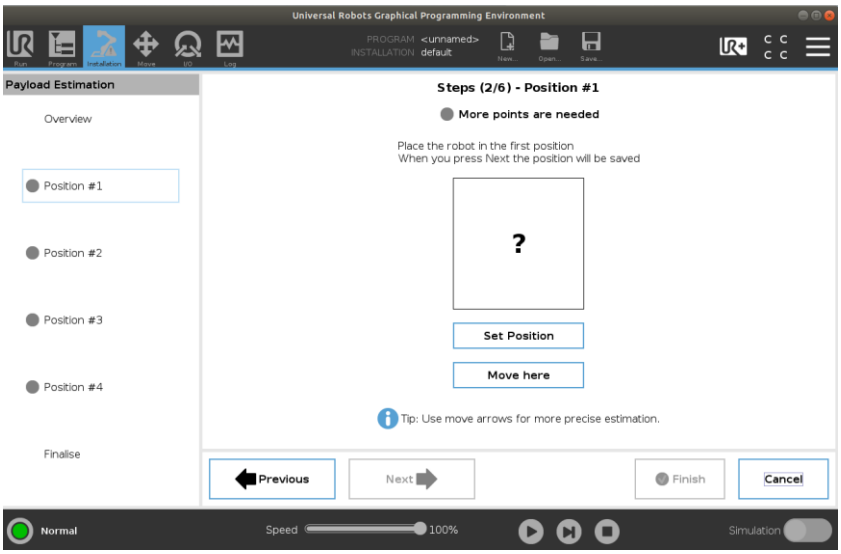
In “General” tab, set the correct payload for the robot before fixing robot’s position for welding.



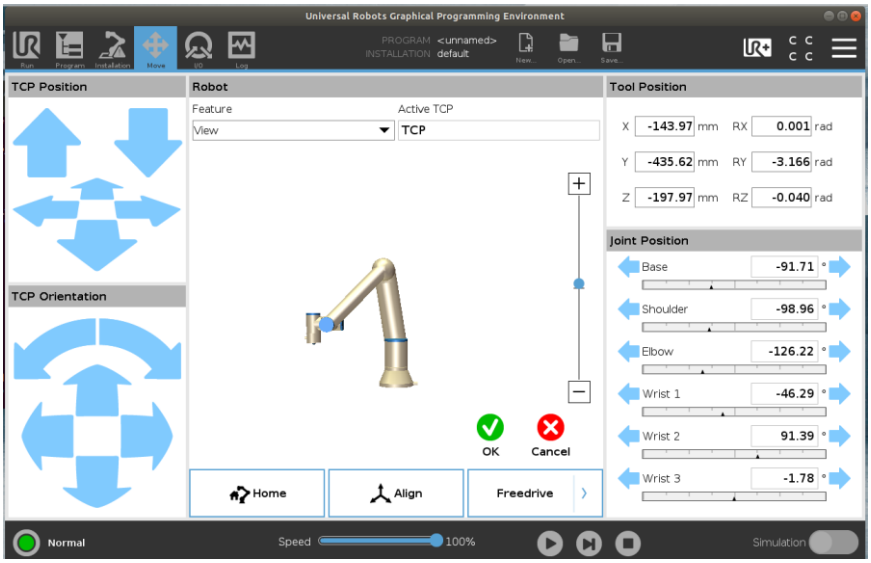
Click on “Measure” button.



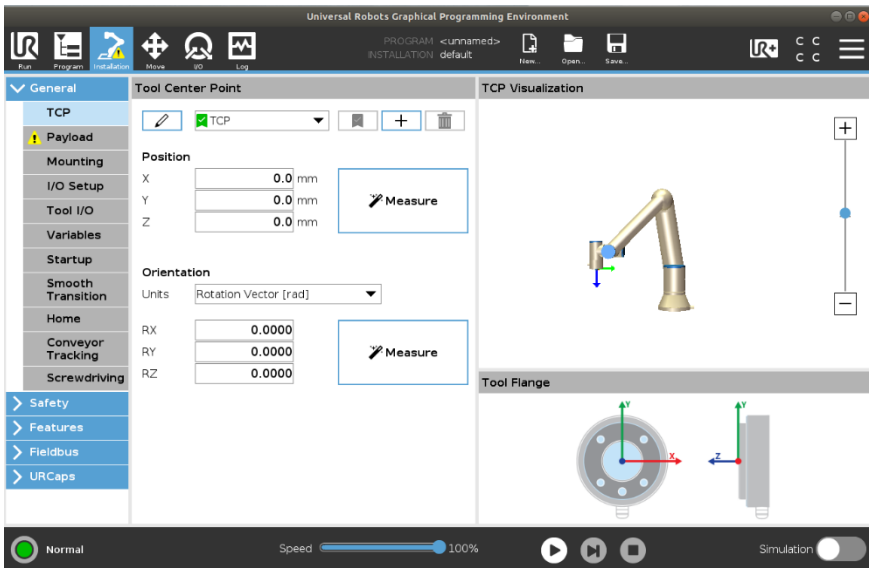
You will find the window (find picture above) with instructions on how to set the robot in four positions to measure the weight of the sensor and the welding torch. Then press “Next”.



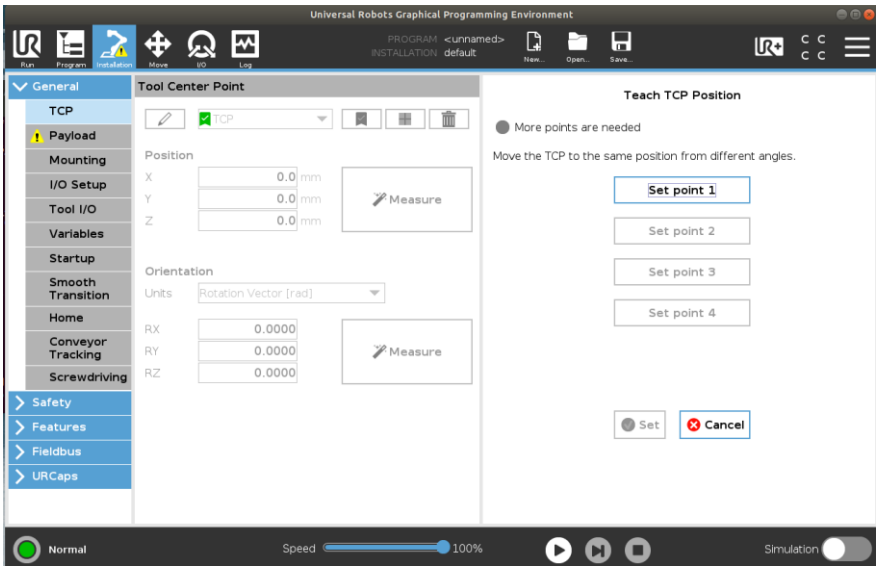
Set the four positions.



As you set each position, press “OK”.



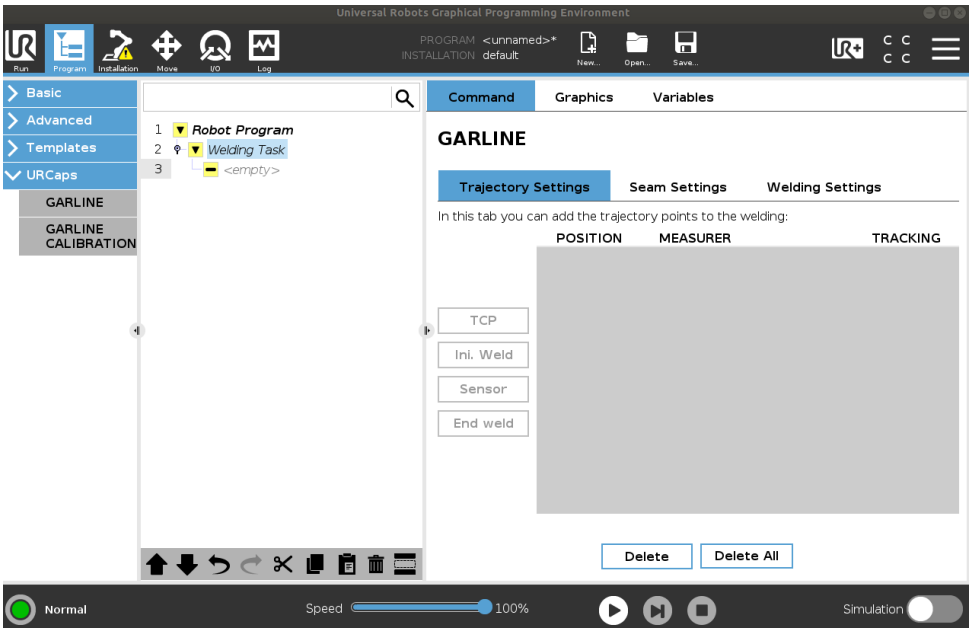
Next, set the four TCP positions by clicking on “Measure” button in TCP section (find picture above).



As shown in the picture above, follow the steps. The robot has to be oriented to the same point from different angles. Finally, click “Set”.

For more information, check sections 24.2 and 24.3 of the UR Manual.

9.4.4. Robot trajectory settings

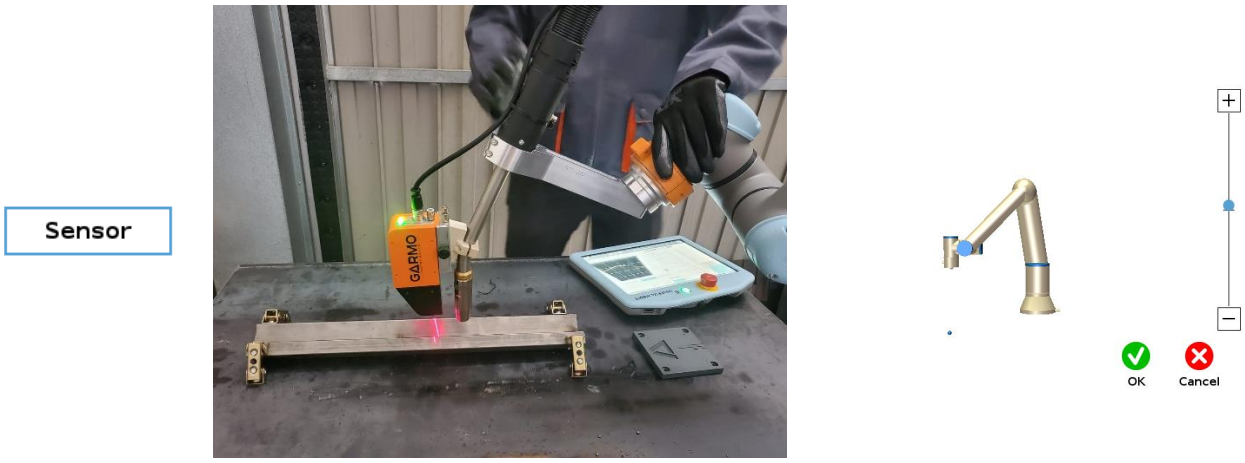


Go to Trajectory Settings tab and follow the steps to set robot's welding trajectory.

1. Press on TCP to set robot's initial entering position before starting the welding.

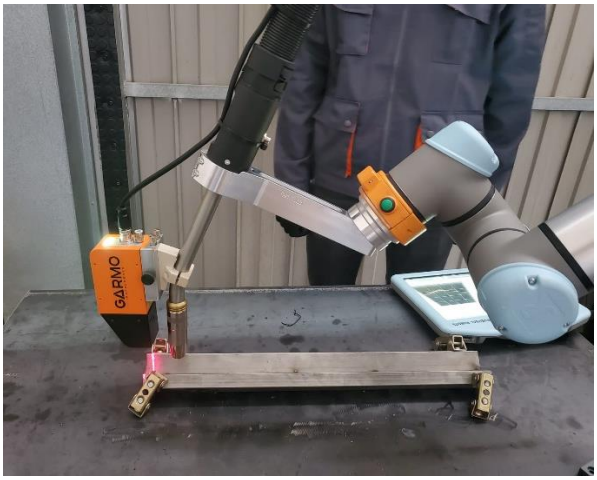
Then, press OK to confirm or Cancel to cancel and repeat the settings.

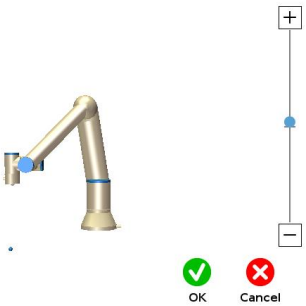
2. Press on Ini. Weld to set the initial welding point. Consider the initial point for the laser line (as shown in the photo). The sensor takes into account the distance between the laser line and the welding torch. Then, press ✅ to confirm or ❌ to cancel and repeat the settings.



3. Press on Sensor for setting any halfway points along the welding trajectory (this is optional, use it in case you don't have straight seam all along the z axe, but with some angles towards any of X axe directions).

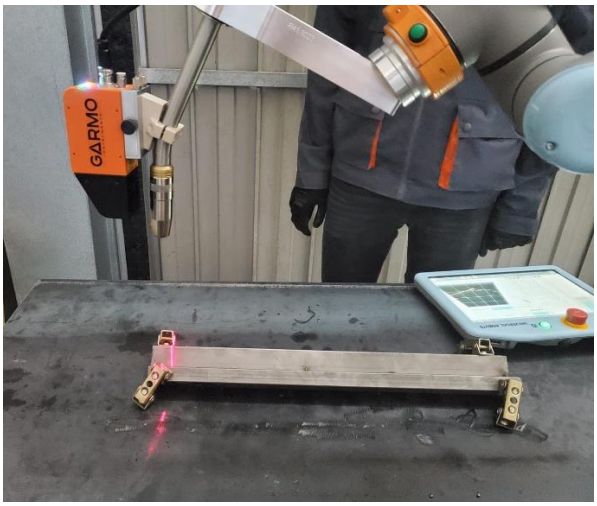
End weld

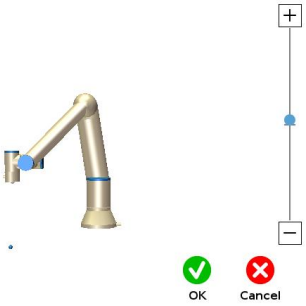




4. Press End Weld to set the final point of the welding trajectory. Consider the ending point for the laser line (as shown in the photo). The sensor takes into account the distance between the laser line and the welding torch.
Then, press ✅ to confirm or ❌ to cancel and repeat the settings.

TCP





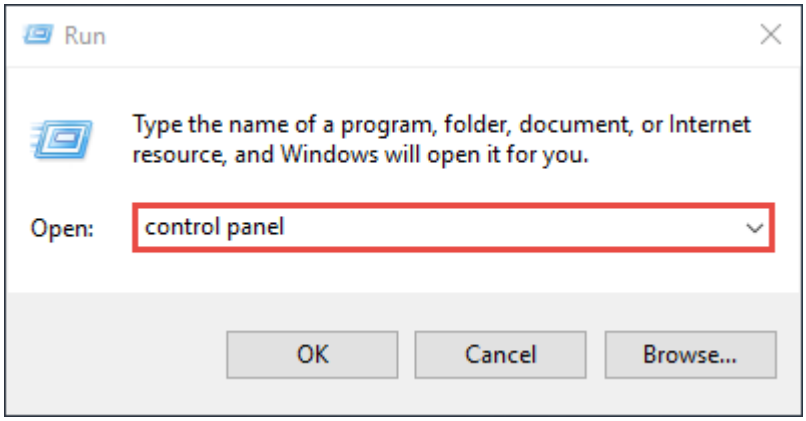
5. Press TCP to set robots outgoing position after finishing the welding process (once the torch is off). Then, press ✅ to confirm or ❌ to cancel and repeat the settings.

Finally, press play button ▶ to start the welding process.

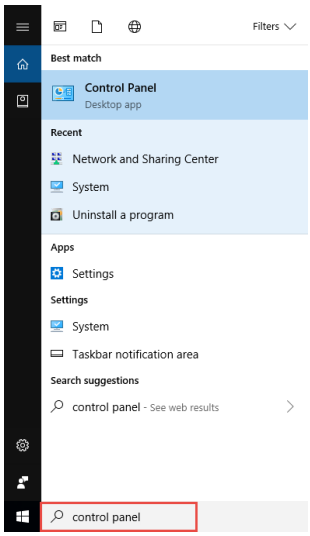
Annex

In this way, you might need to change the IP address on your computer for the sensor's IP address. To do so, follow the steps as per below:

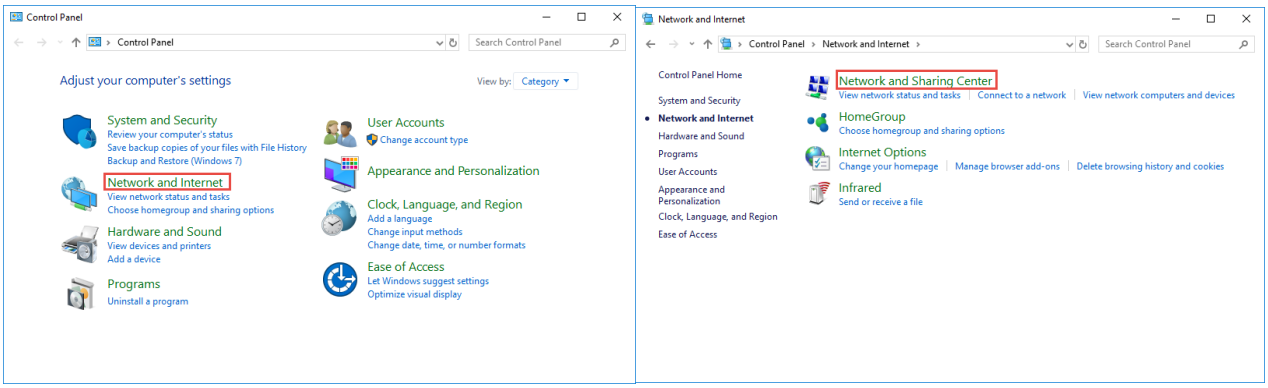
1. Press "**Windows**  + **R**", then a **Run** box comes out. Input **control panel** and press **Enter** to open the control panel.



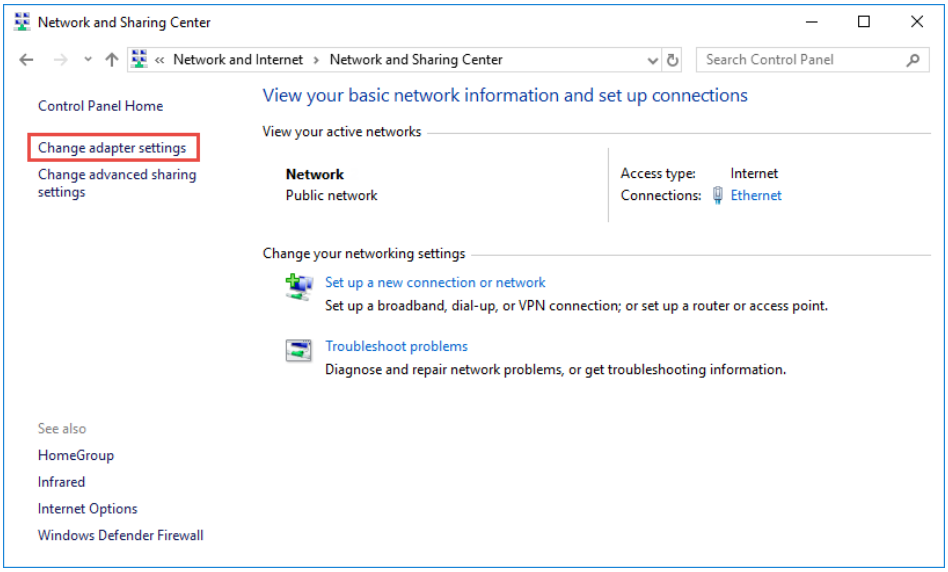
You can also type **control panel** in the search bar at the lower left of the screen and press **Enter** to open the control panel:



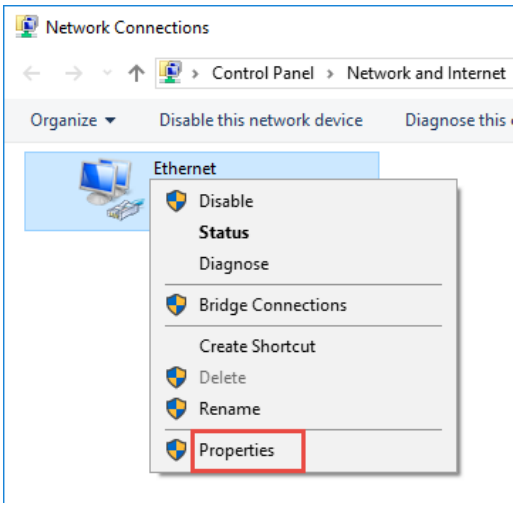
2. Go to Network and Internet > Network and Sharing Center.



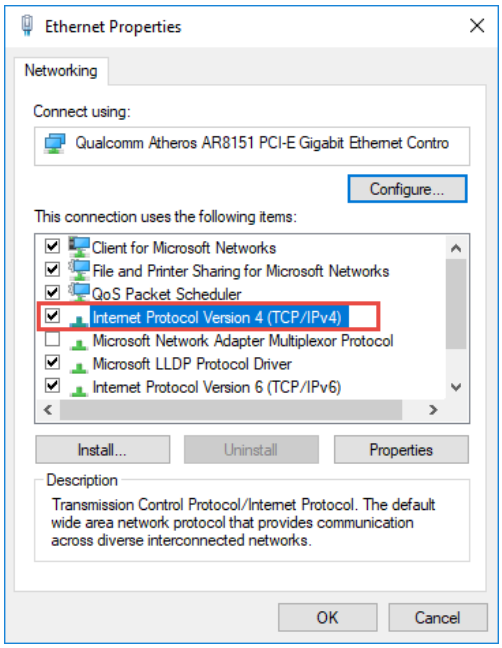
3. Select **Change adapter settings** on the left.



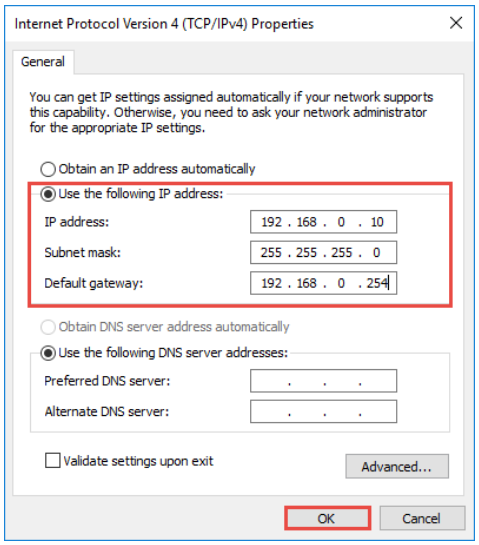
4. Right click the **Ethernet** icon and select **Properties** from the context menu.



5. Then double click Internet Protocol Version 4 (TCP/IPv4).



6. Finally, change the IP address for the sensor's one (you can find it on sensor's head).



7. Click on OK to sabe the settings and connect the sensor to the computer through the PoE switch.

An alternative to this process, you can also change sensor's IP in Setting Sensor section. In case you want to make some more advanced changes in configuration, you can also change sensor's subnet mask and the gateway (both in Setting Sensor section). For more information on advanced settings, get in touch with GARMO INSTRUMENTS, S.L.