



# USER MANUAL

## RG2-FT

### Industrial Robot Gripper

For the Universal Robots

Edition E1

OnRobot URCap Plugin Version 3.3.0

July 2018

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## 1 Preface

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### 1.1 Target Audience

This document is intended for integrators who design and install complete robot applications. Personnel working with the gripper are expected to have the following expertise:

- A. Basic knowledge of mechanical systems
- B. Basic knowledge of electronic and electrical systems
- C. Basic knowledge of the robot system

### 1.2 Intended Use

The gripper is designed for grabbing objects, installed on the end effector of a robot, typically used in pick and place and assembly applications. OnRobot is not liable for any damage or injury resulting from misuse.

Misuse includes, but is not limited to:

- Use in potentially explosive environments.
- Use in medical and life critical applications.
- Use the Force/Torque sensor values for safety related purposes
- Use outside the permissible operational conditions and specifications
- Use before performing a risk assessment.

### 1.3 Important Safety Notice

The gripper is *partly completed machinery* and a risk assessment is required for each application the gripper is a part of. It is important that all safety instructions herein are followed. The safety instructions are limited to the gripper only and do not cover the safety precautions of a complete application.

Below is listed some potential dangerous situations, that the integrator as a minimum must take to consideration. Please note that there can be other dangerous situations depending on the specific situation.

- Entrapment of limbs between the Grippers finger arms.
- Penetration of skin by sharp edges and sharp points on the grabbed object.
- Consequences due to incorrect mounting of the Gripper.
- Objects falling out of the Gripper, e.g. due to incorrect gripping force or to high acceleration from a robot.

The complete application must be designed and installed, in accordance with the safety requirements specified in the standards and regulations of the country where the application is installed.

## 1.4 Warning Symbols

**DANGER:**

This indicates a very dangerous situation which, if not avoided, could result in injury or death.

**WARNING:**

This indicates a potentially hazardous electrical situation which, if not avoided, could result in injury or damage to the equipment.

**WARNING:**

This indicates a potentially hazardous situation which, if not avoided, could result in injury or major damage to the equipment.

**CAUTION:**

This indicates a situation which, if not avoided, could result in damage to the equipment.

**NOTE:**

This indicates additional information such as tips or recommendations.

## 1.5 Typographic Conventions

The following typographic conventions are used in this document.

**Table 1: Conventions**

Courier Text	File paths and file names, code, user input and computer output.
<i>Italicized text</i>	Citations and marking image callouts in text.
<b>Bold text</b>	UI elements, including text appearing on buttons and menu options.
<b>Bold, blue text</b>	External links, or internal cross-references.
<angle brackets>	Variable names that must be substituted by real values or strings.
1. Numbered lists	Steps of a procedure.
A. Alphabetical lists	Image callout descriptions.

## 2 Getting Started

### 2.1 Scope of Delivery

In the Universal Robots OnRobot RG2-FT Gripper Kit everything is provided that is required to connect the OnRobot gripper to your UR robot.



- A** OnRobot RG2-FT Industrial Robot Gripper
- B** OnRobot RG2-FT Single Mounting Bracket
- C** OnRobot RG2-FT Standard Fingertips
- D** OnRobot USB drive
- E** OnRobot Compute Box (CB)
- F** UTP cable (RJ45 – RJ45) – 0.5 m
- G** CAN cable – 5m
- H** Compute BOX power cable – 1 m

#### Accessories

- I** Cable Gland - PG16
- J** T20 Torx L-key (for M6 and M4 screws)
- K** T6 Torx L-key (for M2 screws)

#### Plastic bag – mounting parts, containing:

- L** M6x8 Torx screws (4 pcs)
- M** M4x8 Torx screws (6 pcs)
- N** Cable holder

#### Plastic bag – spare parts, containing:

- M6x8 Torx screws (2 pcs)
- M4x8 Torx screws (2 pcs)
- M2x6 Torx screws (4pcs)

## 2.2 Mounting

Use only the screws provided with the gripper. Longer screws could damage the gripper or the robot.

To mount the gripper, follow this process:

1. Fasten the Gripper bracket to the Robot by four M6x8 screws. Use 7 Nm tightening torque. Use the T20 Torx L-key.
2. Fasten the Gripper to the adapter by six M4x8 screws. Use 2 Nm tightening torque. Use the T20 Torx L-key.

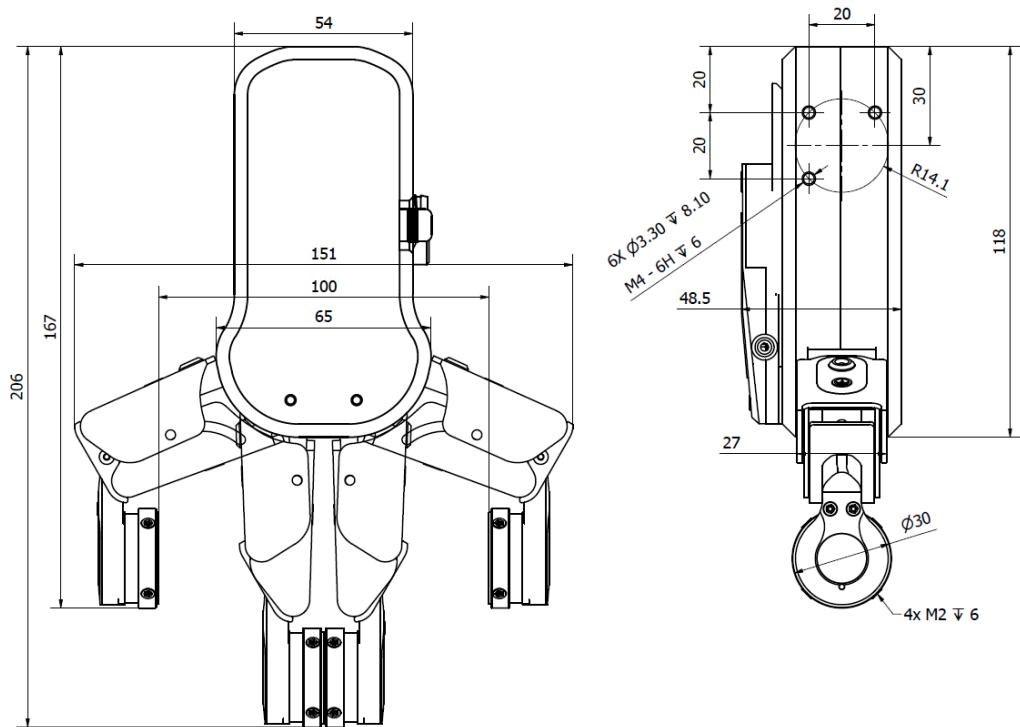


### CAUTION:

The design of the standard Gripper bracket allows the angle of the Gripper to be adjusted from 0° to 180° in steps of 30°.

However, to ensure all software functions work properly, mount the gripper straight, exactly as you can see on the exploded view. Please also note where the tool connector is relative to the gripper connector.

## 2.3 Mechanical Dimensions

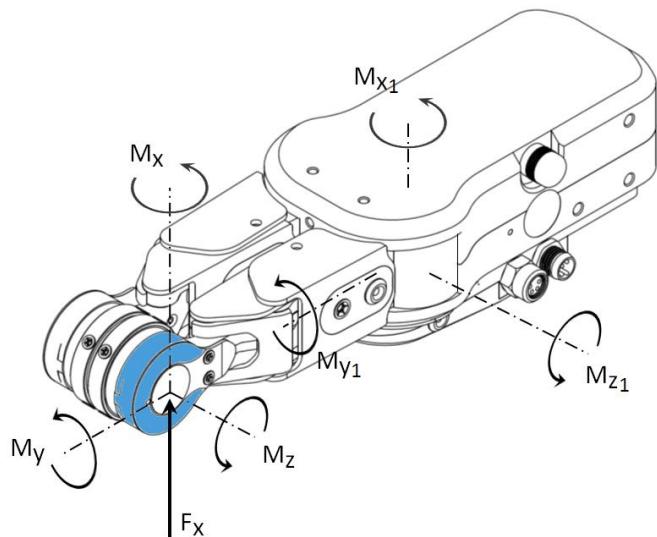


The dimensions are in millimeters.

## 2.4 Load Capacity

### 2.4.1 Gripper Load

Be aware that when grasping on an object, some of the parameters below are not directly applicable, but can be used to calculate the load on the Gripper.

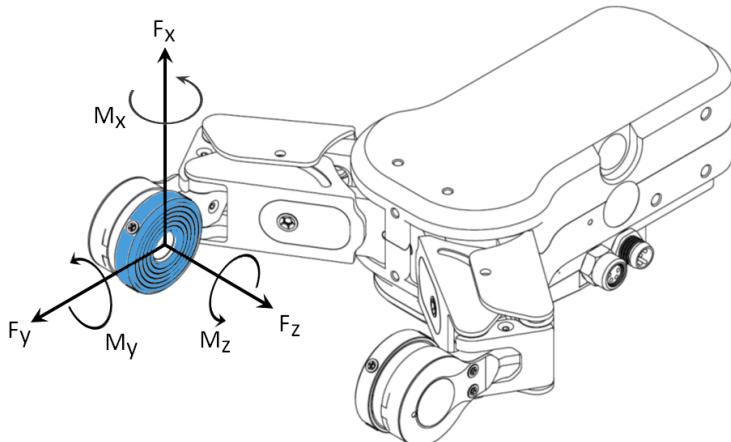


Parameter	Static	Unit
Fx	362	[N]
Mz	7,55	[Nm]
Mx	4,1	[Nm]
My	6,92	[Nm]
Mz <sub>1</sub>	22	[Nm]
Mx <sub>1</sub>	11	[Nm]
My <sub>1</sub>	22	[Nm]

The parameters in the fingertips are calculated at the shown position and will change in relation to the finger positions.

#### 2.4.2 Finger Sensor Load

The load that the gripper can handle is limited by the finger sensor. The actual object weight that the gripper can lift may vary with the actual fingertips been used.



Parameter	Static	Unit
Fx	20	[N]
Fy	20	[N]
Fz	20	[N]
Mx	0.7	[Nm]
My	0.7	[Nm]
Mz	0.5	[Nm]

**NOTE:**

The black elastic ring of the finger sensor should not be loaded at all. If any object contacts that part of the fingertips the sensor measurement will be corrupted and therefore be avoided.

## 2.5 Fingertips

The standard fingertips can be used for many different workpieces. If custom fingertips are required, they can be made to fit the Gripper fingers.

**NOTE:**

During the fingertip design, the following shall be considered to maintain optimal performance:

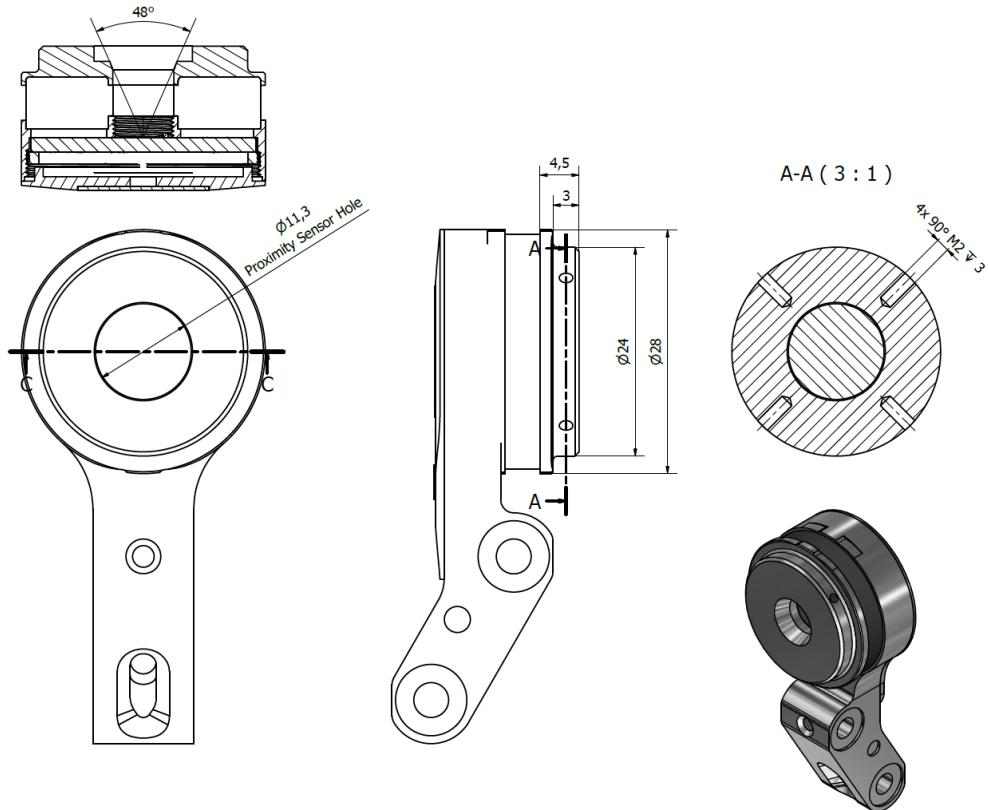
- Clear optical path for the proximity sensors
- Protect the proximity sensors from direct sunlight or strong light source
- Avoid dust and liquid penetration

**WARNING:**

The proximity sensors are sensitive parts and shall be protected against:

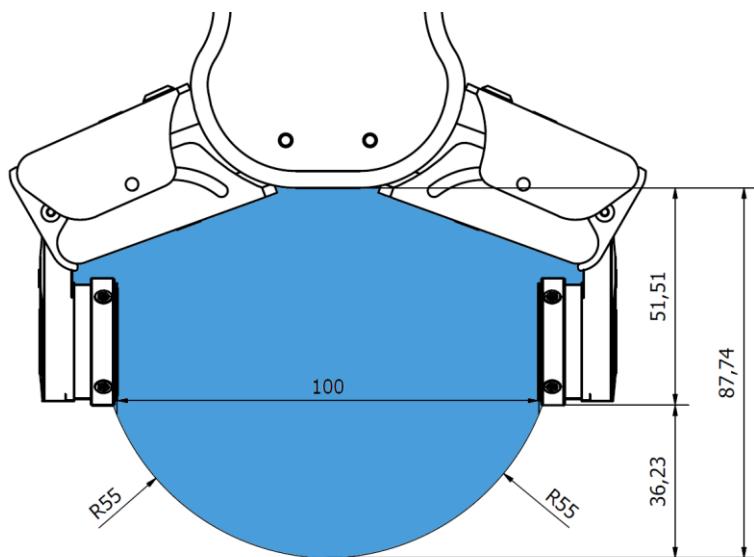
- Direct strong light (such as directional laser sources)
- Direct high temperature
- Mechanical contacts in any case
- Expose to any liquid or fine conductive dust

Dimensions of the Gripper's finger, in millimeters.



## 2.6 Gripper Working Range

The working range is measured between the fingers. See the figure below, for the gripper working range.



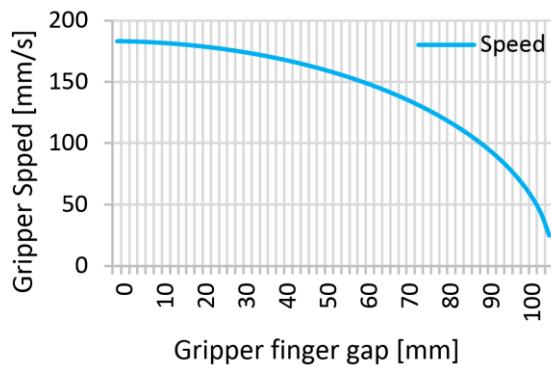
The dimensions are in millimeters.

## 2.6.1 Finger Thickness

The default fingertips are considered while the finger thickness has been set and could not be changed in the software. In case when custom fingertips are used, the user should manually compensate for the difference in the finger thickness.

## 2.6.2 Gripping Speed

Speed table illustrating the difference in speed relative to the Gripper finger position.



## 2.7 Cable Connections

To connect the gripper, follow this process:

1. Connect the 4 pin M8 cable (5m long) to the gripper. Ensure that the holes of the cable are aligned with the pins of the connector on the gripper.



**CAUTION:**

Do not rotate the cable, only rotate the connector lock.

2. Secure the cable to the robot with cable ties.



**CAUTION:**

Make sure that enough extra cable length is available around the joints for bending.

3. Place the Compute Box somewhere near or inside the UR robot control cabinet and connect the 4 pin M8 gripper cable. The provided cable gland can be used to lead the cable into the UR Control cabinet.
4. Connect the Compute Box's Ethernet interface with the UR controller's Ethernet interface via the supplied UTP cable.
5. Use the 3 pin M8 cable (1m long) to power the Compute Box from the UR's control box. Connect the brown cable to the 24V and the black cable to the 0V.

Power	
PWR	■
GND	■
24V	■
0V	■

Configurable Inputs			
24V	■	24V	■
CI0	■	CI4	■
24V	■	24V	■
CI1	■	CI5	■
24V	■	24V	■
CI2	■	CI6	■
24V	■	24V	■
CI3	■	CI7	■

Configurable Outputs			
0V	■	OV	■
CO0	■	CO4	■
0V	■	0V	■
CO1	■	CO5	■
0V	■	0V	■
CO2	■	CO6	■
0V	■	0V	■
CO3	■	CO7	■

For more information, refer to the UR's documentation.

6. Apply the correct network settings to both the Compute Box and the UR robot. The default Compute Box IP address is 192.168.1.1, to change it, see [Changing the IP of the Compute Box](#).

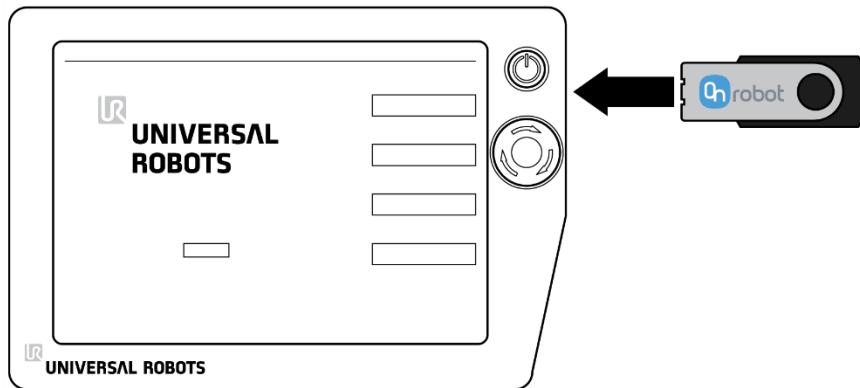
## 2.8 UR Compatibility

The Gripper URCap plugins were developed and tested on UR version 3.6. If the UR version is older than 3.6 it is recommended to upgrade the robot.

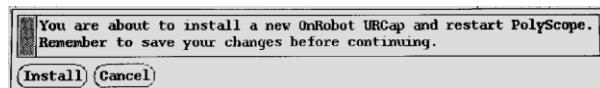
## 2.9 URCap Plugin Installation

To install the OnRobot URCap plugin, follow this process:

1. Insert the OnRobot USB drive in the USB slot on the right side of the Teach Pendant.



2. A message dialog window appears asking for your permission to continue with the installation.



**NOTE:**

During the installation the robot controller will be automatically restarted. Make sure no program is running or edited before proceeding.

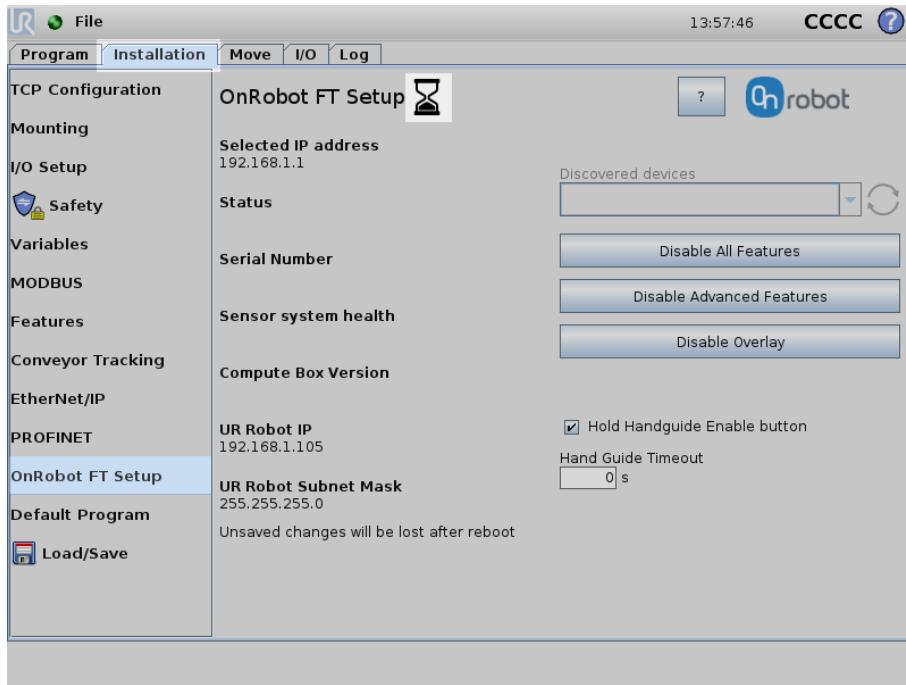
Tap on **Install** to continue

3. A progress bar appears, indicating the upload is in progress.
4. Wait for the robot to reboot.
5. Initialize the robot.

Continue with [URCap Plugin Setup](#).

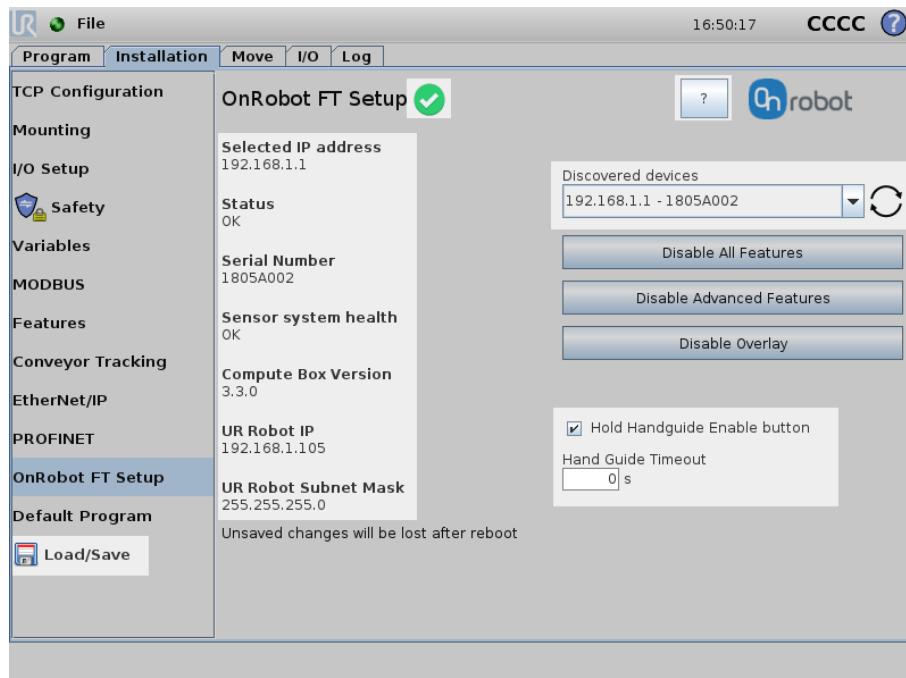
## 2.10 URCap Plugin Setup

Select the **Installation** tab, then select **OnRobot FT Setup**. The following screen is shown:



Wait a few seconds while the software is automatically discovering the available OnRobot RG2-FT devices. The hourglass icon indicates that the discovery is still in progress.

Once it finishes the first found device is selected and automatically tested, and the following screen is shown:



The ok  icon shows that the device is found, and the automatic test was successful, so the device is ready to be used.

If no device is found or there was an error during the automatic test, then an error  icon is displayed. For troubleshooting [URCap Plugin Setup error](#).



#### NOTE:

The discovery can be manually restarted by tapping on the refresh  icon.

If multiple devices are available, the pre-selected device could be changed by using the **Discovered devices** drop-down menu.

The status and basic information of the connected device is shown on the left:

**Selected IP address:** This shows the IP address of the selected device. Using the factory default settings on the Compute Box the value will be 192.168.1.1.

**Status:** This shows OK or the error message in case of a malfunction.

**Serial Number:** The serial number of the RG2-FT.

**Compute Box version:** The software version of the Compute Box. This must match the URCap version. If it does not match please update the Compute Box.

**Status:** This shows OK or in case of a malfunction it shows the error message.

The current network settings of the UR robot are showed to help the troubleshooting in case of an error:

**UR Robot IP:** This shows the current IP address of the robot. Using the factory default settings on the Compute Box the value must be 192.168.1.x.

**UR Robot Subnet mask:** The current subnet mask of the robot. Using the factory default settings on the Compute Box the value must be 255.255.255.0.

The Hand Guide settings are in the bottom left:

**Hold Handguide Enable** checkbox: If checked (default value) the Hand Guide enable button needs to be pressed constantly during the hand guiding. If unchecked, the hand guiding could be started by tapping on the enable button and stopped by tapping on the enable button again.

**Hand Guide Timeout:** After the set timeout value (in seconds) the hand guiding will be stopped automatically. The default value is 0 that sets the timeout to infinite.



**NOTE:**

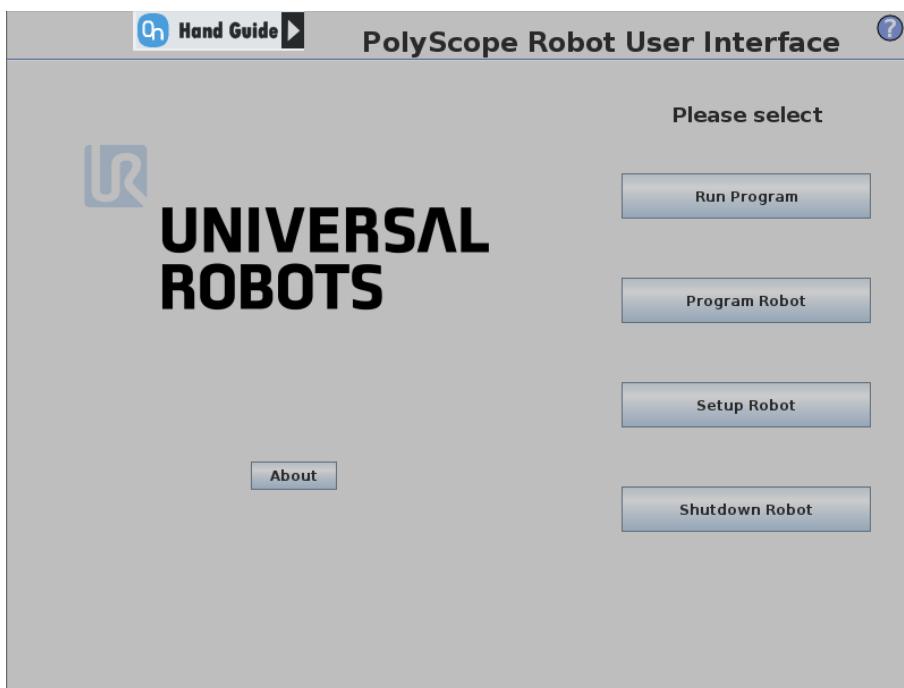
After setting up the device the changes need to be saved to be part of the current installation with the Load/Save button.

For embedded help, tap on the question mark icon.

## 3 Using the URCap Plugin

### 3.1 OnRobot Hand Guide Toolbar

After turning on the UR robot, the start screen of the PolyScope is visible. After 20 seconds, if it is activated, the OnRobot Hand Guide Toolbar appears on the top right.



#### NOTE:

It is normal to have a yellow warning signal during the boot-up for a few seconds. If it does not disappear than check the device settings at the [URCap plugin setup](#).

To activate the functions of the toolbar, tap on any point of the toolbar. The toolbar expands, and the available axes, the enable , the zero , and the snap to axes button will appear.

To select an axis, press the appropriate item. In the following example, the X and the Y items are selected to limit the movement along the X and Y axis (planar):



#### NOTE:

The used coordinate system is the Tool.

To deactivate any axis that has been selected, press the item again.

**NOTE:**

It is possible to activate or deactivate axes during hand guiding.

To start hand guiding the UR robot, first make sure that you do not touch the tool and then press and hold the enable button. The button turns to an hourglass icon while the hand guiding is being initiated. Wait until the enable button turns green and drive the robot by hand with the help of the OnRobot finger sensor.

**NOTE:**

Make sure that you do not touch the tool before the hand guiding is activated (enable button turned to green), otherwise the robot can behave abnormally (e.g.: the robot could move without any external force exerted). In this case, press the zero button, while you are not touching the tool. Make sure that you do not use the zero button while touching the tool.

To stop hand guiding the UR Robot, release the enable button. Immediately after deactivating hand guiding, the enable button is deactivated for 1 second, and turns into an hourglass icon.

**NOTE:**

Please always set the speed slider of the robot to 100% while using the hand guiding to have an optimal user experience.

The zero button is intended to be used when the tool orientation is changed during hand guiding, so that the effects of gravity or changes in the load of the robot can be neutralized.

The snap to axes button rotates the axes of the tool coordinate system to align with the closest axes of the base coordinate system, disregarding negative or positive directions. This allows the user to set the tool to face precisely horizontally, or vertically, after guiding by hand.

### 3.2 OnRobot Feedback Variables

<b>Feedback Variable</b>	<b>Unit</b>	<b>Description</b>
of_return		The return value for the OnRobot commands
rg_F3D_left	[N]	Length of the 3D force vector for the left finger sensor $\text{rg\_F3D\_left} = \sqrt{Fx_L^2 + Fy_L^2 + Fz_L^2}$
rg_F3D_right	[N]	Length of the 3D force vector for the right finger sensor $\text{rg\_F3D\_right} = \sqrt{Fx_R^2 + Fy_R^2 + Fz_R^2}$
rg_FT_left	[3xN,3xNm]	list of {Fx,Fy,Fz,Tx,Ty,Tz} for the left finger sensor
rg_FT_right	[3xN,3xNm]	list of {Fx,Fy,Fz,Tx,Ty,Tz} for the right finger sensor
rg_Grip_detected	True/False	True if Gripper has detected a work piece (must be reset by the user)
rg_Grip_lost	True/False	True if Gripper has dropped a work piece (must be reset by the user)
rg_Gripped	True/False	The actual status whether a workpiece has been gripped or not
rg_Gyro	[3 x m/s <sup>2</sup> ]	Reserved for further use
rg_Part_weight	[N]	The actual value of the detected part weight in N $\text{rg\_Part\_weight} = \sqrt{(Fx_L + Fx_R)^2 + (Fy_L + Fy_R)^2 + (Fz_L + Fz_R)^2}$
rg_part_width	[mm]	The actual value of the detected part width (-1 if it not applicable)
rg_Prox_left	[mm]	The left proximity (distance) sensor actual value
rg_Prox_right	[mm]	The right proximity (distance) sensor actual value
rg_Slip_alert	True/False	This goes True if the part will possible slip out of the gripper. $\text{rg\_Slip\_alert} = (\sqrt{Fx_L^2 + Fy_L^2} > Fz_L * 0.5) \text{ or } (\sqrt{Fx_R^2 + Fy_R^2} > Fz_R * 0.5)$
rg_T3D_left	[Nm]	Length of the 3D torque vector for the right finger sensor $\text{rg\_T3D\_left} = \sqrt{Tx_L^2 + Ty_L^2 + Tz_L^2}$
rg_T3D_right	[Nm]	Length of the 3D torque vector for the right finger sensor $\text{rg\_T3D\_right} = \sqrt{Tx_R^2 + Ty_R^2 + Tz_R^2}$
rg_Width	[mm]	Distance between the fingers of the Gripper (calculated by finger angle encoders)

### 3.3 OnRobot URCap Commands

These commands can be used to create complex pick and place and assembly applications easily with the help of the RG2-FT gripper.

In the next sub-sections each of these commands will be described.



#### NOTE:

For embedded help, tap on the question mark icon within each command.

#### 3.3.1 F/T Width

The F/T Width command controls the width of the gripper. It can open or close the gripper to a given width or a given force. It has advanced features like depth compensation and automatic centering.



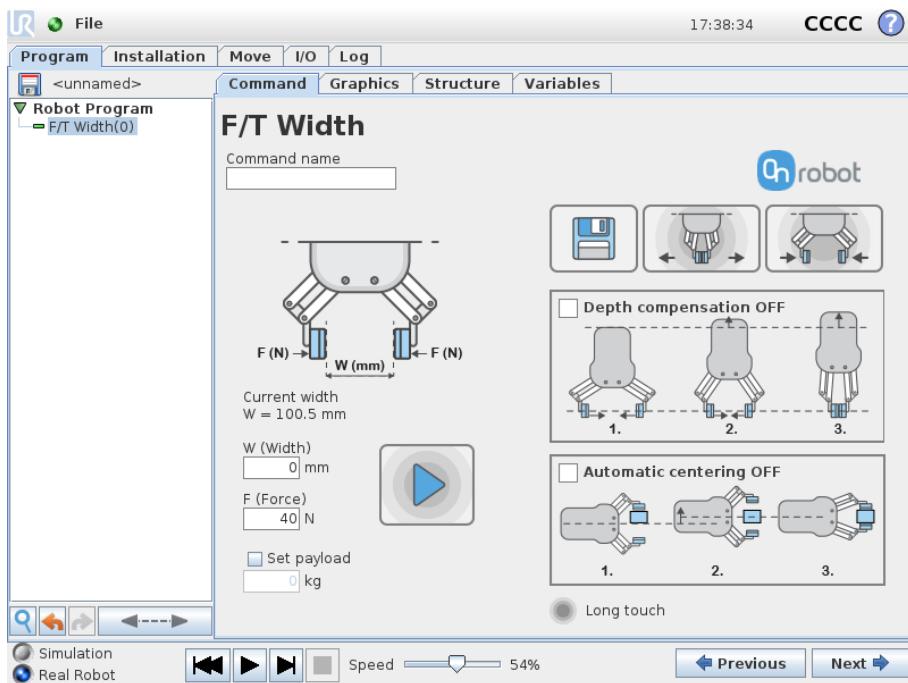
#### NOTE:

To cancel any force/torque offset, execute an F/T Zero command at the beginning of the F/T Width command and make sure the tool is not in contact with any object before starting the F/T Width, otherwise the command may not work properly.



#### NOTE:

To cancel any distance offset of the optical finger sensors, make sure to carry out the steps written in the [Zero the optical offset](#) sub-section, otherwise the command may not work properly.



**Current width W=...:** the current width of the gripper.

**W (Width):** Enter the desired gripper width. Note that if the specified force is achieved, the RG2-FT will stop at a width that differs from the target width.

**F (Force):** Enter the desired gripping force. Note that if the target width is reached before the target force, the RG2-FT will stop moving and the target force may not be achieved at the anticipated width.

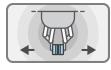
**Set Payload** checkbox: if checked, the UR payload settings are overridden by the given value.



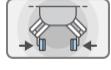
**Execute** button: executes the command with its current settings, without running the entire Program. Note that the button needs to be pressed (Long touch) continuously to operate.



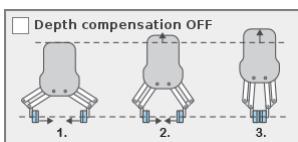
**Copy** button: Copy the current width value to the desired W(width) edit box.



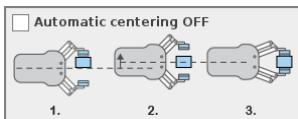
**Open gripper** button: hold the button to open the gripper. Can be stopped at any position.



**Close gripper** button: hold the button to close the gripper. Can be stopped at any position.



**Depth Compensation** checkbox: if checked, during closing and opening the gripper, the robot moves to compensate the movement of the fingertips so that it remains on the target.



**Automatic Centering** checkbox: if checked, during closing and opening the gripper, the robot moves the gripper sideways to grab the item symmetrically based on the proximity signals of the fingers.

For return values, see [F/T Width Command Return Values](#).

### 3.3.2 F/T Set Load

The F/T Set Load command can be used to set a new payload and to change the TCP settings within one command.

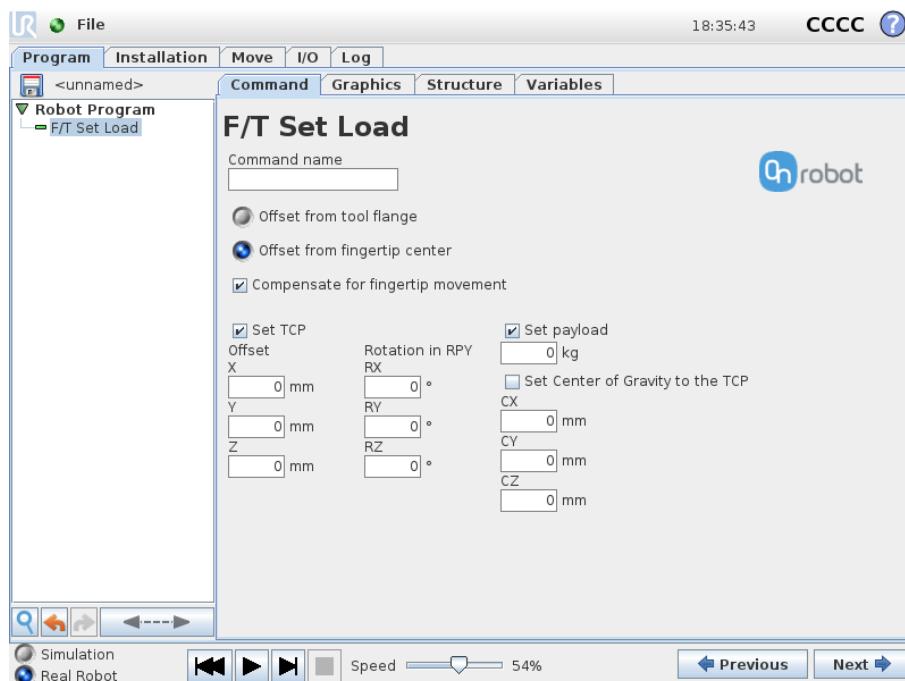
The TCP settings can be given in two ways:

**Offset from tool flange:** the TCP offsets is given relative to the tool flange

**Offset from fingertip center:** the TCP offsets is given relative to the middle of the fingertips center line. Choosing this way, the following option will become visible:

**Compensate for fingertip movement:** If checked the offset origin is changed when the fingertip moves

Either the TCP or the Payload needs to be checked to be set to enable the command to be executed.



**Set TCP offset** checkbox: if checked, the installation TCP settings will be overridden with the given values.

**Offset X, Y, Z:** the translation values of the TCP relative to the tool flange (or the fingertip center).

**Rotation in RPY RX, RY, RZ:** the rotational values of the TCP relative to the tool flange (or the fingertip center).

**Set payload** checkbox: if checked, the installation Payload and Center of Gravity settings will be overridden with the given values. The payload must be the overall weight, including the gripper.

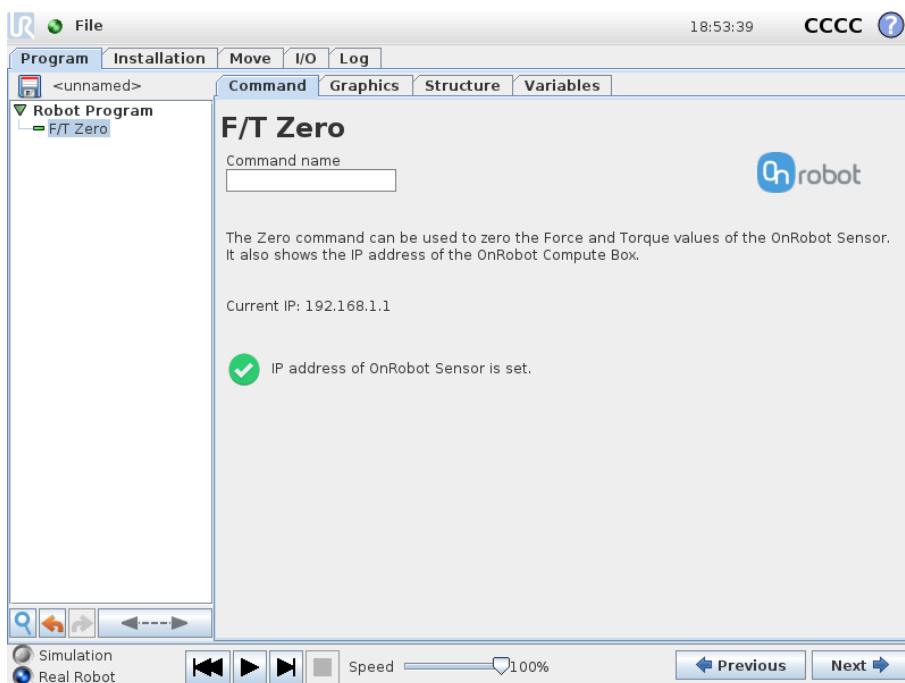
**CX, CY, CZ:** the coordinates of the Center of Gravity in relation to the tool flange (or the fingertip center).

**Set Center of Gravity to the TCP checkbox:** if checked, CX,CY,CZ values are given by the set TCP offset.

This command has no return value.

### 3.3.3 F/T Zero

The F/T Zero command can be used to zero the RG2-FT finger sensor force/torque values.



This command has no return value.

### 3.3.4 F/T Measure

The F/T Measure command can be used to measure a part placed between the fingers and store this information into a variable.

The measurement will give a cross-section width of the part. There are two ways to carry out the measurement either optically or touch based.



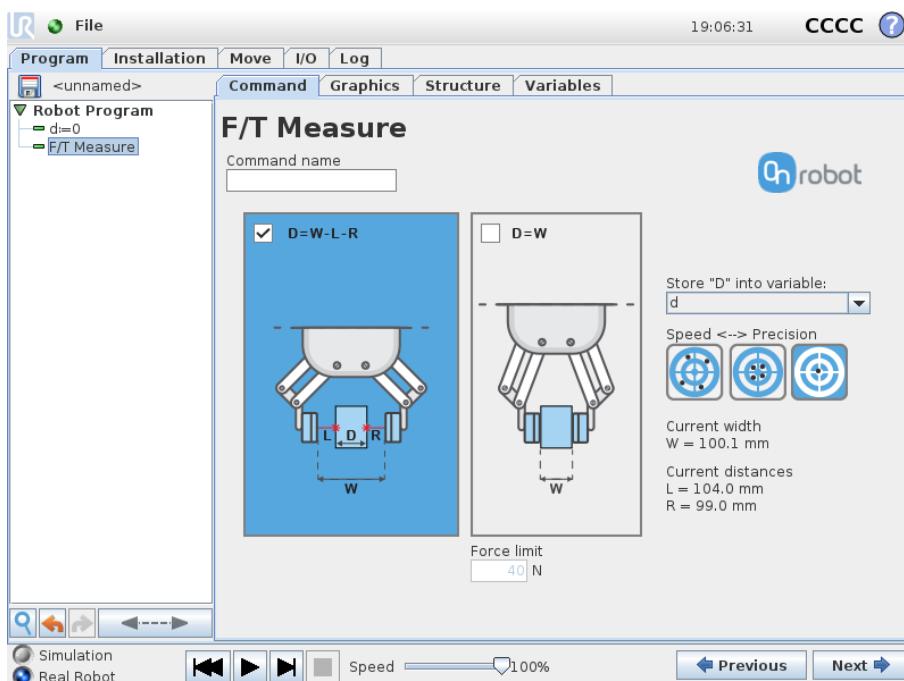
#### NOTE:

To cancel any force/torque offset, execute an F/T Zero command at the beginning of the F/T Measure command and make sure the tool is not in contact with any object before starting the F/T Measure, otherwise the command may not work properly.



#### NOTE:

To cancel any distance offset of the optical finger sensors, make sure to carry out the steps written in the [Zero the optical offset](#) sub-section, otherwise the command may not work properly.



**Optical measurement (D=W-L-R) checkbox:** if checked, the measurement is based on the width of the gripper and the optical sensor, without touching the part.



#### NOTE:

The measurement result (D) will be -1 if no object is placed between the fingers.

**Force measurement (D=W)** checkbox: if checked, the measurement is based on the width of the gripper when it has grabbed the part. The part is grabbed when the set force value has reached.

**Force Limit:** the set force value to be used to detect when a part is grabbed

**Store “D” into variable** dropdown list: an already existing variable can be selected, where the measured distance will be saved at the end of the measurement. The variable needs to be created first, by using an Assignment UR command. For further help on creating a variable refer to the UR Manual.

**Speed <--> Precision** selector buttons: the measurement precision can be selected.

**Current Width W=:** the current width of the gripper.

**Current distances L, R:** the current distance measured by the left and right side optical sensors.

This command has no return value.

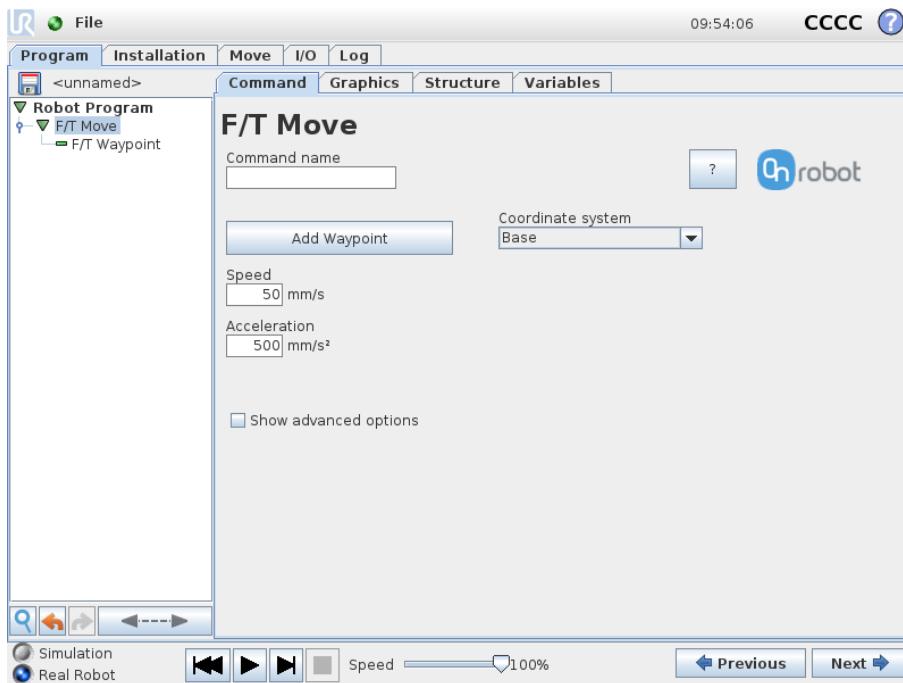
### 3.3.5 F/T Move

The F/T Move command can be used together with the F/T Waypoint command, to move the robot along a route, or together with the F/T Path to move the robot along a path and stop once the defined force/torque limits are reached (movement interrupted). In this case a warning can be generated. If the movement reaches the last waypoint, the move is successful.



#### NOTE:

To cancel any force/torque offset, execute an F/T Zero command at the beginning of the F/T Move command and make sure the tool is not in contact with any object before starting the F/T Move, otherwise the command may not stop at the given force/torque limit.



To operate the F/T Move command tap on the **Add Waypoint** button to add an F/T Waypoint as a child node. More waypoints can be added in the same way. To remove a waypoint, use the **Structure** tab **Delete** button.

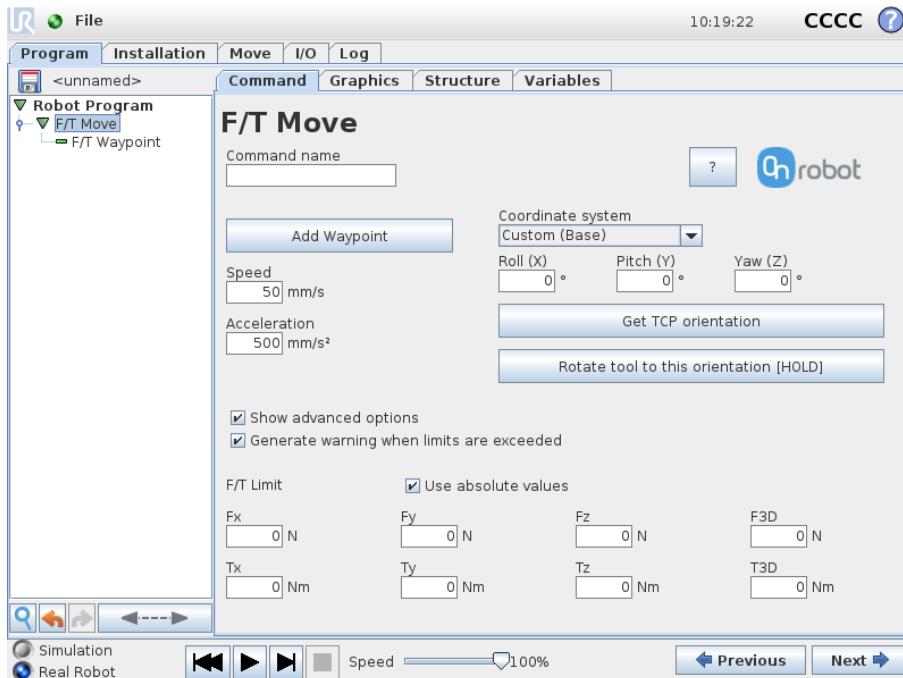
Alternatively, F/T Waypoint or F/T Path could be added as a child node of the F/T Move command by using the **Structure** tab.

**Speed:** The movement speed limit while moving. The movement is carried out in a constant translational speed. If the route or path has sharp changes in the direction, or the orientation, the actual speed of the robot may be less than specified, but still constant throughout the route or Path.

**Acceleration:** The acceleration and deceleration parameter of the movement.

**Coordinate system:** The coordinate system used both for the movement and for the sensor reading. It can be set to Base, Tool, Custom (Base) Custom (Tool) (according to the UR's reference frames). The Custom coordinate systems are calculated from the basis coordinate system and the given **Roll**, **Pitch** and **Yaw** values. For the Custom (Base) coordinate system, it is also possible to use the **Get TCP orientation** button to specify the orientation of the coordinate system, by the orientation of the current TCP. To test the given orientation, the **Rotate tool to this orientation [HOLD]** button can be used.

**Show advanced options** checkbox: If checked then more options become available:



**F/T Limit Fx,Fy,Fz,Tx,Ty,Tz,F3D,T3D:** This is the detection limit. From the Fx, Fy, Fz, Tx, Ty, Tz, F3D, T3D available options more than one can be set. In this case, if any of the values reach the set threshold the stop is triggered. Values equal to zero are neglected.

If the **Use absolute values** option is enabled, then it is not important whether the entered value is positive or negative (e.g.:  $|Fz| >= 3$ ), otherwise the sign defines how the threshold is calculated (e.g.:  $Fz >= 3$  or  $Fz <= -3$ )

**Generate warning (...):** If enabled then a pop-up message (blocking) appears if the target position is not reached (the move is not successful). If the move is successful, then no warning is displayed.

If disabled, then no pop-up message is shown but the user can handle any possible errors by the return value of the command.

For return values, see [F/T Move Command Return Values](#).

### 3.3.6 F/T Search

The F/T Search command is used together with the F/T Waypoint command, to move the robot along a route, or together with the F/T Path to move the robot along a Path and stop once the defined force/torque limits are reached (object found). If the movement reaches the last waypoint or the last point of the path, the search is not successful (the object is not found) and a warning is generated.



#### NOTE:

To cancel any force/torque offset, execute an F/T Zero command at the beginning of the F/T Search command and make sure the tool is not in contact with any object before starting the F/T Search, otherwise the command may not stop at the given force/torque limit.



To operate the F/T Search command tap on the **Add Waypoint** button to add an F/T Waypoint as a child node. More waypoints can be added in the same way. To remove a waypoint, use the **Structure** tab **Delete** button.

Alternatively, F/T Waypoint or F/T Path could be added as a child node of the F/T Search command by using the **Structure** tab.

**Speed:** The movement speed while searching for collision. The movement is carried out in a constant translational speed. If the route or path has sharp changes in the direction, or the orientation, the actual speed of the robot may be less than specified, but still constant throughout the route or Path.

**NOTE:**

The slower the speed during the searching phase is the better to work with hard contacts (such as metal surfaces) to avoid overshoots due to the robot's and the tool's momentum.

**Acceleration.:** The acceleration and deceleration parameter of the movement.

**F/T Limit Fx,Fy,Fz,Tx,Ty,Tz,F3D,T3D:** This is the detection limit. From the Fx, Fy, Fz, Tx, Ty, Tz, F3D, T3D available options more than one can be set. In this case, if any of the values reach the set threshold the stop is triggered. Values equal to zero are neglected.

If the **Use absolute values** option is enabled, then it is not important whether the entered value is positive or negative (e.g.:  $|Fz| \geq 3$ ), otherwise the sign defines how the threshold is calculated (e.g.:  $Fz \geq 3$  or  $Fz \leq -3$ )

**Coordinate system:** The coordinate system used both for the movement and for the sensor reading. It can be set to Base, Tool, Custom (Base) Custom (Tool) (according to the UR's reference frames). The Custom coordinate systems are calculated from the basis coordinate system and the given **Roll**, **Pitch** and **Yaw** values. For the Custom (Base) coordinate system, it is also possible to use the **Get TCP orientation** button to specify the orientation of the coordinate system, by the orientation of the current TCP. To test the given orientation, the **Rotate tool to this orientation [HOLD]** button can be used.

**Generate warning (...):** If enabled then a pop-up message (blocking) appears once the target position is reached or was already in collision (so the search is not successful). If the search is successful, then no warning is displayed.

If disabled, then no pop-up message is shown but the user can handle any possible errors by the return value of the command.

For return values, see [F/T Search Command Return Values](#).

### 3.3.7 F/T Waypoint

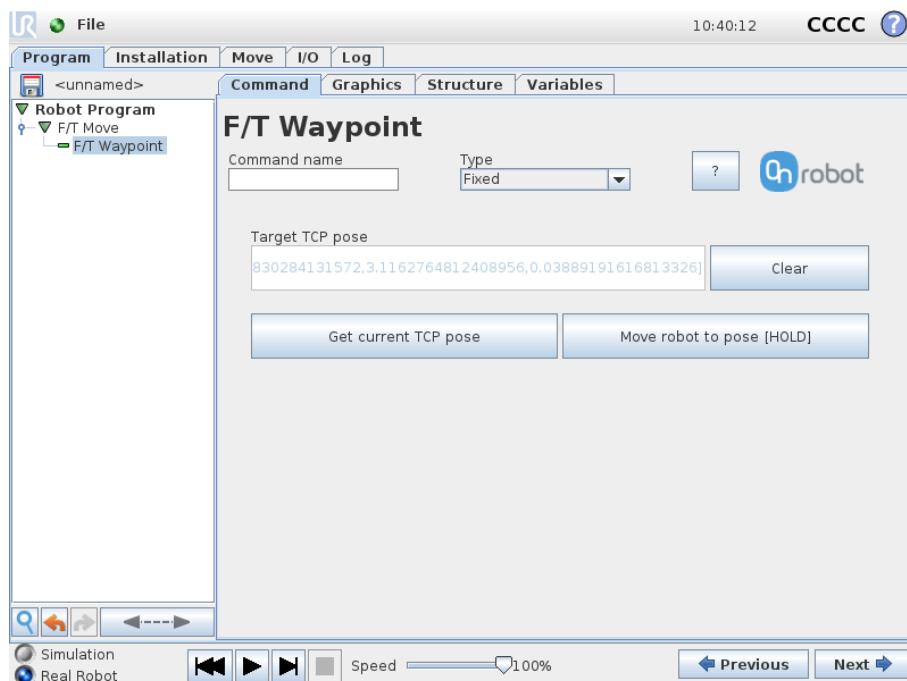
The F/T Waypoint command is used together with the F/T Move or F/T Search command, to move the robot along a route. There are three types of waypoints (Fixed, Relative, and Variable), that can be used in any combination.



#### NOTE:

Do not use consecutive F/T Waypoints that only contain rotations in the same F/T Move command. Use more than one F/T Move commands to achieve rotations without translational movements.

**Waypoint type:** The type of the waypoint. It can be set to Fixed, Relative or Variable.

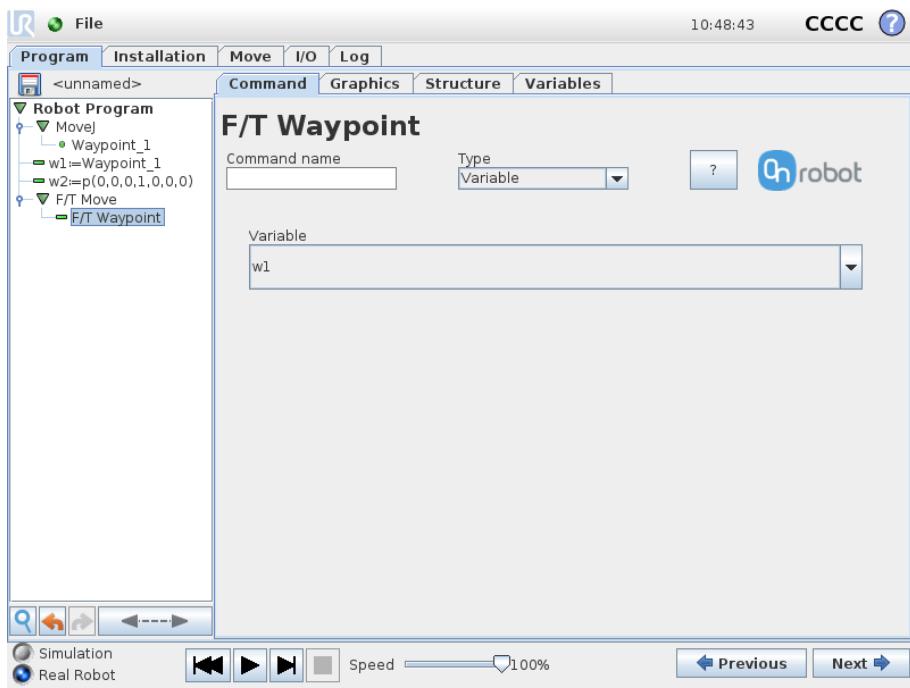


**Target TCP pose:** The position represented by the waypoint in the robot route. It is a read-only field and can be filled by using the **Get current TCP pose** button.

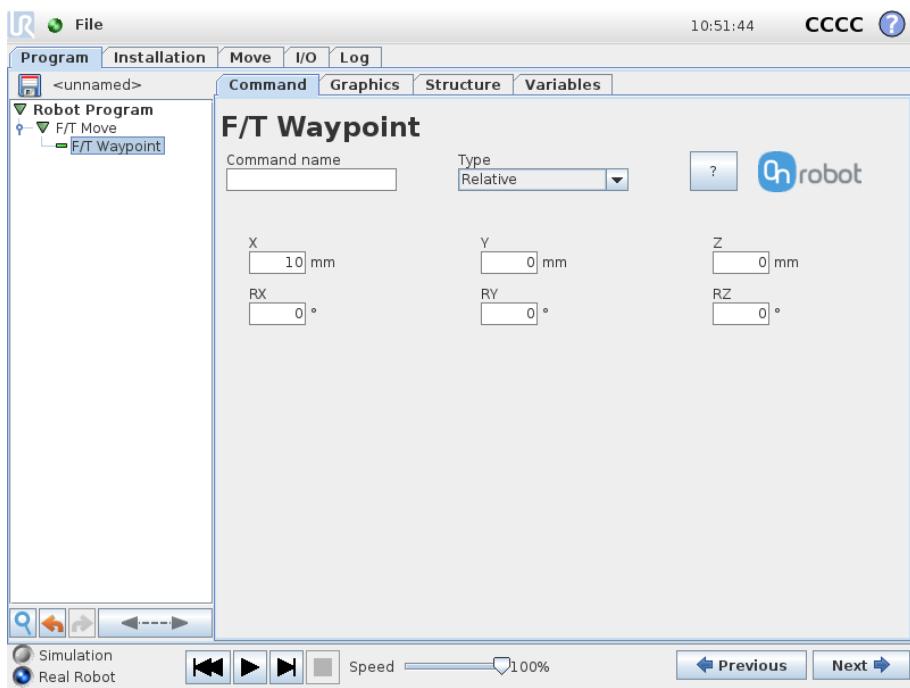
**Clear** button: deletes the contents of the **Target TCP pose** field.

**Get current TCP pose** button: inserts the current TCP coordinates into the **Target TCP pose** field.

**Move robot to pose [HOLD]** button: moves the robot to the pose set in the **Target TCP pose** field, if the button is pressed. Once it is released the robot stops.



**Variable:** The position represented by the waypoint in the robot route. A variable can define the target pose. The variable needs to be created first.

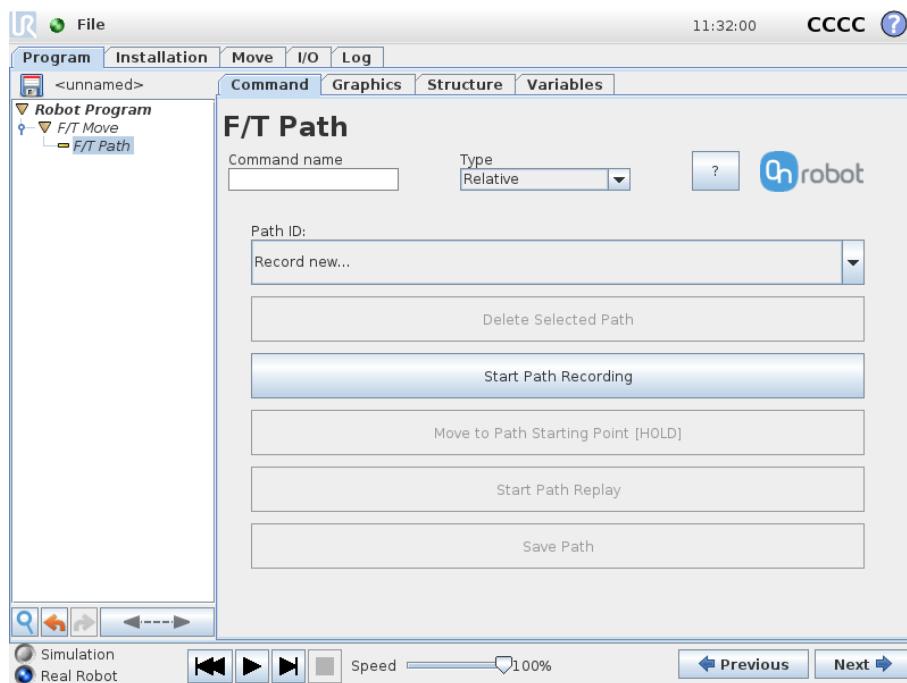


**Relative X, Y, Z, RX, RY, RZ:** the distances and rotations this waypoint represents, compared to the previous robot position.

This command has no return value.

### 3.3.8 F/T Path

The F/T Path command can be used together with the F/T Move or F/T Search command, to record and replay a Path.



**Type:** If relative is selected, the Path is replayed starting from the actual position of the Tool, instead of the absolute position where it was recorded. If absolute is selected, the Tool moves to the original starting point, and replays the Path from there.

**Path ID** dropdown list: Lists identifiers of all the Paths saved on the Compute Box. A Path ID is assigned to a path, when the path is saved. If there is no recorded unsaved path, there is a **Record new...** item, select it to record a new path. If there is a recorded Path that is not saved, there is an **Unsaved** item in the List.



#### NOTE:

Only one unsaved Path can exist, and it will be overwritten by starting a Path recording while the **Unsaved** Path is selected.

**Delete Selected Path** button: Deletes the path currently selected in the **Path ID** dropdown list from the Compute Box, permanently.



#### NOTE:

Do not delete a Path that any other F/T Path commands is using.

**Start Path Recording** button: Starts recording a Path by automatically enabling the Hand Guide function.

**Stop Path Recording** button: Stops the Hand Guide function and stores the recording to the memory. It does not permanently save the Path.

**Move to Path Starting Point [HOLD]** button: moves the Tool to the starting position of the Path, it can only be used if the path is not relative.

**Start Path Replay** button: Replays the Path, even if it is not saved, only stored in the memory.

**Stop Path Replay** button: Stops replaying the Path.

**Save Path** button: Saves the Unsaved Path to the Compute Box.



**NOTE:**

Rotational movements related to translational movements in Path recording are limited to 2.8 degrees/mm or less, since a larger ratio would cause the Robot to replay the path at a very low translational speed. Rotational movement without translational movement therefore cannot be recorded as Path.



**NOTE:**

The maximum error of the replayed Path compared to the original recorded movement can be up to 1 mm.

This command has no return value.

### 3.3.9 F/T Detect

The F/T Detect command can be used to find a part, together with the F/T Move, F/T Search or F/T Path commands.



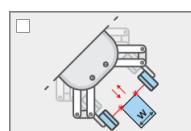
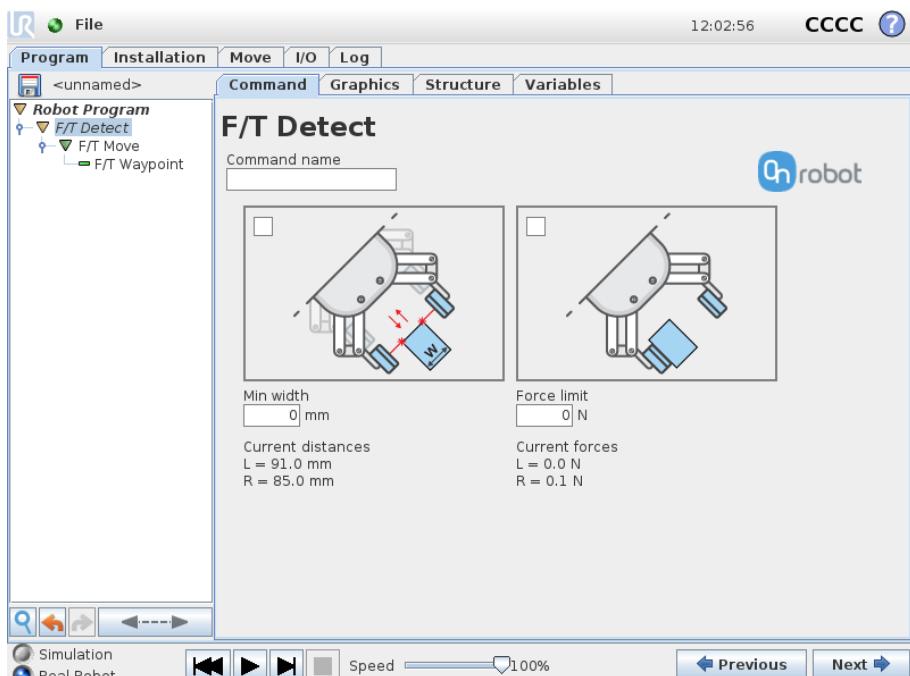
#### NOTE:

To cancel any force/torque offset, execute an F/T Zero command at the beginning of the F/T Detect command and make sure the tool is not in contact with any object before starting the F/T Detect, otherwise the command may not work properly.

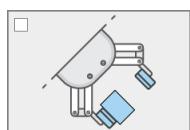


#### NOTE:

To cancel any distance offset of the optical finger sensors, make sure to carry out the steps written in the [Zero the optical offset](#) sub-section, otherwise the command may not work properly.



**Optical Detection** checkbox: if checked, the optical sensor is used to detect the item.



**Force Detection** checkbox: if checked, the force torque sensor is used to detect the item.

**Min width:** Items with less size are ignored.

Depending on the shape and orientation, an item with greater size than the maximum width can trigger the part detect command.

**Force Limit:** The amount of force needed to consider a part detected.

**Current distances L, R:** the current distance measured by the left and right side optical sensors.

**Current forces L, R:** the current overall force (F3D) measured by the left and right-side force sensors.

For return values, see [F/T Detect Command Return Values](#).

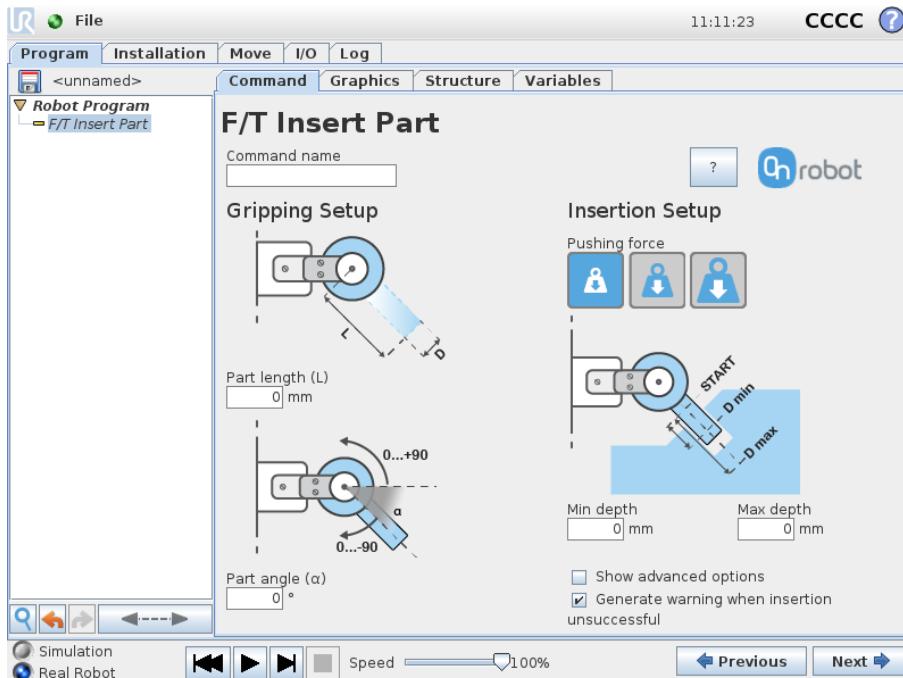
### 3.3.10 F/T Insert Part

The F/T Insert Part command can be used for precision fitting an object into a hole.



#### NOTE:

To cancel any force/torque offset, execute an F/T Zero command at the beginning of the F/T Insert Part command and make sure the tool is not in contact with any object before starting the F/T Insert Part, otherwise the command may not stop at the given force/torque limit.



**Part Length (L):** the distance between the center point of the fingertip sensors and the center point of the item to be inserted.

**Part angle ( $\alpha$ ):** the angle between the +Y axis of the fingertip sensor and the insertion direction of the item to be inserted.

**Pushing Force** buttons: the pushing force can be selected:

**Low Pushing Force** button: sets the pushing force to be 3N.

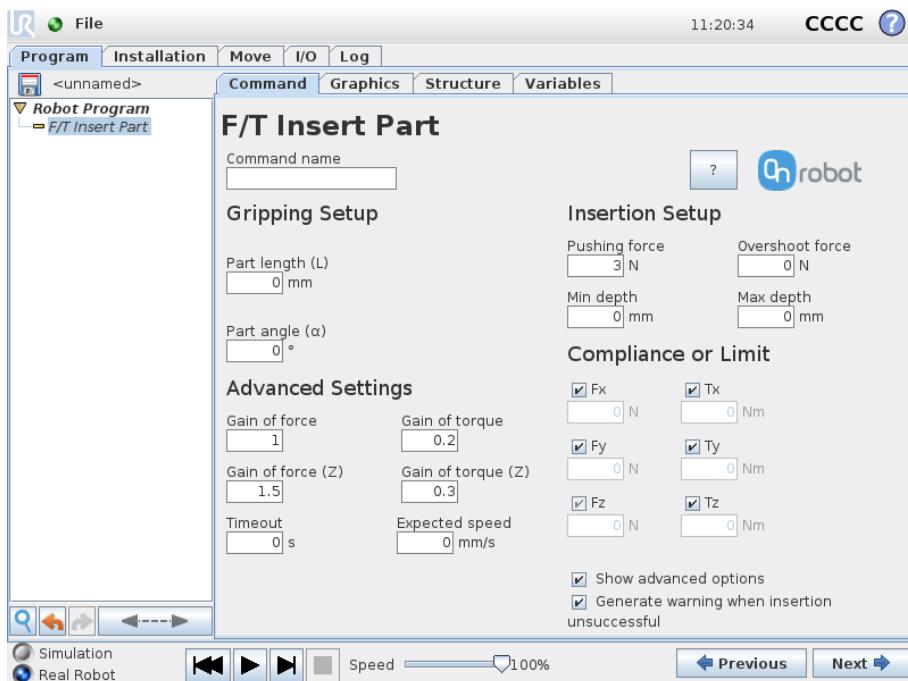
**Middle Pushing Force** button: sets the pushing force to be 6N.

**High Pushing Force** button: sets the pushing force to be 12N.

**Min depth:** The minimum distance required to consider the insertion successful, from the starting point.

**Max depth:** The maximum distance the insertion can reach, from the starting point.

**Show advanced parameters** checkbox: If checked, more options become available:



**Part Length (L):** the distance between the center point of the fingertip sensors and the center point of the item to be inserted.

**Part angle ( $\alpha$ ):** the angle between the +Y axis of the fingertip sensor and the insertion direction of the item to be inserted.

**Gain of force:** The proportional gain parameter of the force control for the side forces on compliant axes.

**Gain of torque:** The proportional gain parameter of the torque control for the compliant axes.

**Gain of force (Z):** The proportional gain parameter of the force control for the pushing force.

**Gain of torque (Z):** The proportional gain parameter of the torque control parallel to the insertion direction.

**Timeout:** The maximal allowed time for the whole insertion function. If it is set to zero, this exit criterium is neglected.

**Expected speed:** The minimum speed the insertion is expected to progress with. If this parameter is set, and the insertion is progressing at a slower pace, it is interrupted and considered unsuccessful. If it is set to zero, this exit criterium is neglected.

**Pushing Force:** The force target used for the force control to push the item into the hole.

**Overshoot force:** If this parameter is set, after the **Minimum depth** has been reached, a ‘bump’, an increase in the pushing force is expected (such as closing a snap-fit joint). This parameter is the additional force on top of **Pushing force** that the insertion is performed with, between the minimum and maximum depths.

**Min depth:** The minimum distance required to consider the insertion successful, from the starting point.

**Max depth:** The maximum distance the insertion can reach, from the starting point.

**Compliance or Limit Fx, Tx, Fy, Ty, Tz** checkboxes: if checked, the selected axis is compliant, meaning that the movement tries to keep the forces zero in the selected directions. If not checked a limit can be set for the force or torque, that if reached, stops the command.

**Generate warning (...):** If enabled, a pop-up message (blocking) appears if the insertion was not successful.

If disabled, then no pop-up message is shown but the user can handle any possible errors by the return value of the command.

For return values, see [F/T Insert Part Command Return Values](#).

### 3.3.11 F/T Control

The main purpose of the F/T Control command is to provide easy-to-use functions to application programmers, who want to develop force-controlled applications such as polishing, sanding or grinding. A large subset of these applications may require holding constant force/torque to a defined direction during movements.

The command tries to keep the set force/torque values constant along/about the axes set to be compliant while the commands under the F/T Control is executed. The F/T Control command does not control forces in the direction that the tool is moving using the F/T Move, the F/T Search, and the F/T Path commands.



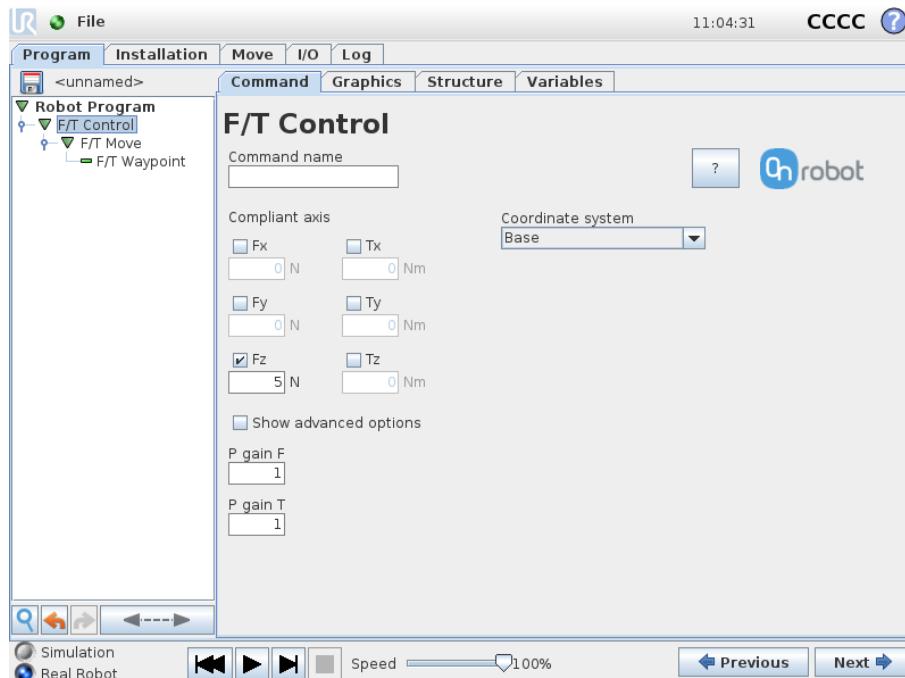
#### NOTE:

UR's built-in Move commands cannot be used under the F/T Control command. To move the robot under the force control, use the F/T Move or F/T Search command instead.



#### NOTE:

To cancel any force/torque offset, execute an F/T Zero command at the beginning of the F/T Control command and make sure the tool is not in contact with any object before starting the F/T Control, otherwise the command may not work properly.



**Compliant axis Fx, Fy, Fz, TX, TY, TZ:** The axis selection that needs to be compliant. If an axis is enabled (compliant) the movement along/about that axis is force/torque controlled

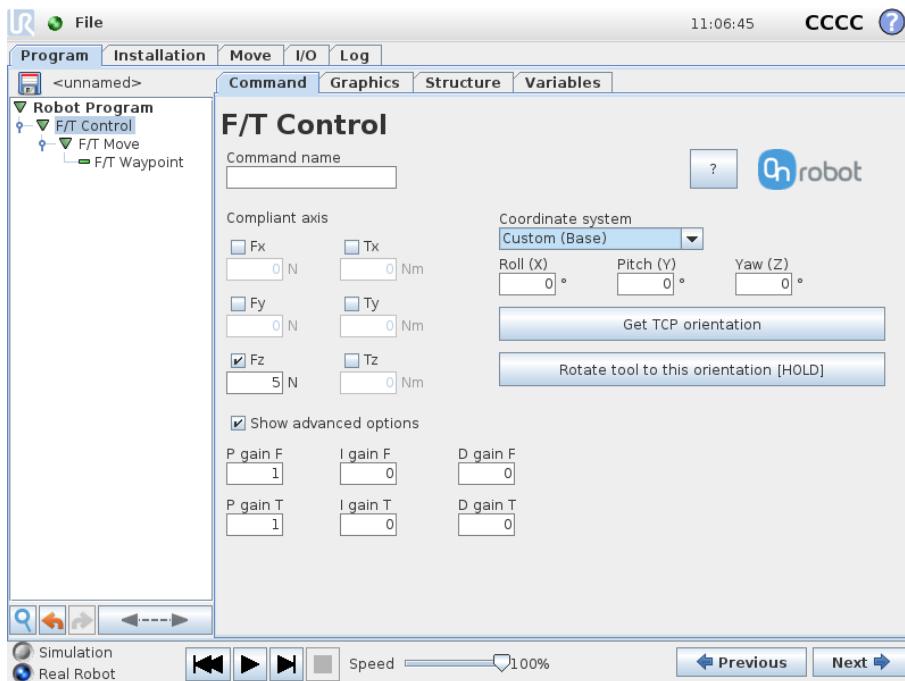
otherwise (non-compliant) position controlled. The enabled axis is controlled to keep the set force/torque value constant. At least one compliant axis must be selected.

**Coordinate system:** The coordinate system used both for the movement and for the sensor reading. It can be set to Base, Tool, Custom (Base) Custom (Tool) (according to the UR's reference frames). The Custom coordinate systems are calculated from the basis coordinate system and the given **Roll**, **Pitch** and **Yaw** values. For the Custom (Base) coordinate system, it is also possible to use the **Get TCP orientation** button to specify the orientation of the coordinate system, by the orientation of the current TCP. To test the given orientation, the **Rotate tool to this orientation [HOLD]** button can be used.

**P Gain F:** The force controller can be tuned with this proportional gain parameter. If any overshoots or vibrations occur, try lowering the gain value (e.g.: 0.5).

**P Gain T:** The torque controller can be tuned with this proportional gain parameter. If any overshoots or vibrations occur, try lowering the gain value (e.g.: 0.5).

**Show advanced parameters** checkbox: If checked then more options become available:



**I Gain F:** The force controller can be tuned with this integral gain parameter. If any overshoots or vibrations occur, try lowering the gain value.

**I Gain T:** The torque controller can be tuned with this integral gain parameter. If any overshoots or vibrations occur, try lowering the gain value.

**D Gain F:** The force controller can be tuned with this derivative gain parameter. If any overshoots or vibrations occur, try lowering the gain value.

**D Gain T:** The torque controller can be tuned with this derivative gain parameter. If any overshoots or vibrations occur, try lowering the gain value.

This command has no return value.

Guidelines to PID force/torque controller settings:

The PID force/torque controller continuously calculates the error value for the force/torque measured by the sensor, compared to the values set by the F/T Control command, and applies correction based on this error.

**P Gain:** The proportional term produces a correction that is proportional to the current error value. Increasing this parameter, has the following effects: faster reaction, overreaction, lower error, stability degradation.

**I Gain:** The integral term produces a correction that is proportional to both, the magnitude, and duration of the past error values. Increasing this parameter, has the following effects: faster reaction, overreaction, lower error, stability degradation.

**D Gain:** The derivative term produces a correction that is proportional to the slope or changing speed of past error values. Increasing this parameter, has the following effects: less overreaction, stability increase.

If the force control is too slow, that is, the tool occasionally leaves the surface instead of continually touching it, try increasing the **P Gain**, and **I gain** values.

If the force control is overreacting to changes, that is, the tool bounces off the surface, try decreasing the **P Gain** (or **D Gain**, if it is above 1).

If the force control is reacting to changes too slowly, that is it keeps pushing the surface hard after touching it, try decreasing the **I Gain**.

As a rule of thumb, it is recommended to use values:

1. P Gain < 5
2. I Gain < 0.25
3. D Gain < 1
4. The ratio of P Gain/I Gain = 10

Values that can be used as a base for tuning are:

P Gain F =1, I Gain F = 0.1, D Gain F = 0.3

P Gain T =0.2, I Gain T = 0, D Gain T = 0

## 3.4 Script Function

When the OnRobot URCap is enabled, there will be a defined RG2-FT script function:

```
of_gripper_proxi_offsets(ProxL = 0, ProxR = 0)
```

This function can be used to cancel any offset of the optical (proximity) finger sensor. The ProxL and ProxR are in millimeters.

### 3.4.1 Zero the optical offset

To zero the optical finger sensor's offset do the following steps:

1. Execute this script to unset any previous offset:  
`of_gripper_proxi_offsets(0,0)`
2. Place a white sheet of paper between the fingers and fully close the gripper.
3. Write down the left (L) and right(R) distances showed at an F/T Measure node.
4. Execute this script to set the new offset with the wrote down values (L,R)  
`of_gripper_proxi_offsets(L,R)`
5. Check again the displayed values at the F/T Measure node. The values now should be very close to 0.
6. Make sure that the script is called in each program's `Before start` section that uses the optical finger sensor's value (since the set offset will reset at power off)  
`of_gripper_proxi_offsets(L,R)`

## 3.5 Software Uninstallation

To uninstall the URCap plugin, follow this process:

1. Go to the Welcome screen of the PolyScope.
2. Click **Setup Robot**.
3. Click on **URCaps Setup** and locate the **RG - OnRobot** in the list of active URCaps.
4. Click on the - sign at the bottom to uninstall it.
5. Restart the robot.

## 4 List of Acronyms

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Acronym	Expansion
I/O	Input/Output
TCP	Tool Center Point
UR	Universal Robots
URCap	Universal Robots Capabilities
USB	Universal Serial Bus

## 5 Appendix

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### 5.1 Technical Specifications

RG2-FT General Properties	Min	Typical	Max	Units
Total stroke (adjustable)	0	-	100	[mm]
Finger position resolution	-	0,1	-	[mm]
Repetition accuracy	-	0,1	0,2	[mm]
Reversing backlash	0,2	0,4	0,6	[mm]
Gripping force (adjustable)	3	-	40	[N]
Gripping speed*	55	110	184	[mm/s]
Gripping time**	0,04	0,07	0,11	[s]
Ambient operating temperature	5	-	50	[°C]
Storage temperature	0	-	60	[°C]
Weight (without Compute Box)	-	0,77	-	[kg]

\* see speed [table](#)

\*\* based on 8mm total movement between fingers, see speed table

Force Sensor Properties	F <sub>xy</sub>	F <sub>z</sub>	T <sub>xy</sub>	T <sub>z</sub>
Nominal capacity (N.C.)	20 N	40 N	0.7 Nm	0.5 Nm
Single axis overload	200 %	200%	200%	200%
Noise free resolution	0.1 N	0.5 N	0.005 Nm	0.005Nm
Single axis deformation at N.C.	0.4 mm	0.1 mm	2°	5°
Temperature compensation	0 C° to +55°C			
Full scale nonlinearity Temperature compensation	< 2%			

Part Sensor Properties	Min	Typical	Max	Units
Sensing range	0	-	100	[mm]
Resolution*	3	1	0.5	[mm]
Accuracy	-	± 25	-	[%]

\* the actual resolution depends on the object properties (e.g: surface type and color)

Electrical Properties	Min	Typical	Max	Units
Power requirement	24	-	24	[Vdc]
Total power consumption (with CB)	6.5	-	22	[W]

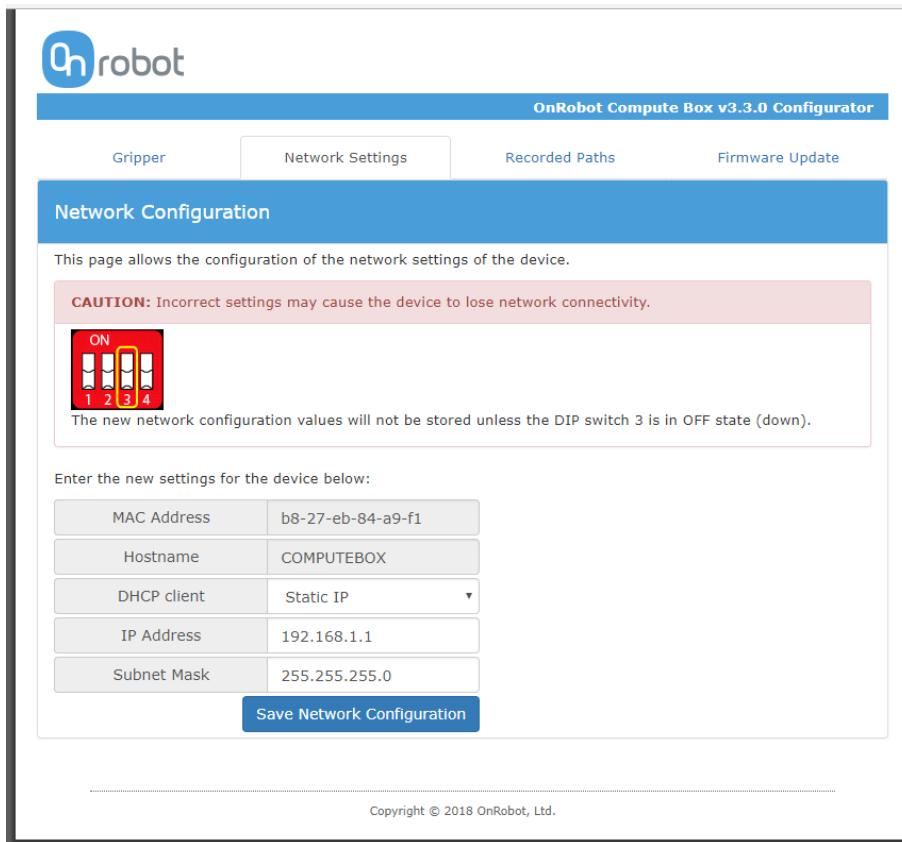
## 5.2 Changing the IP of the Compute Box

To change the IP address of the sensor, connect your laptop or an external PC to the OnRobot Compute Box.

1. Make sure that the device is not powered. Connect the device and the computer with the provided Ethernet cable.
2. If your device is in the factory default settings, proceed to step 3. Otherwise, make sure to switch the DIP switch 3 to the ON position (up) and the DIP switch 4 to the OFF position (down).



3. Power the device from the provided power supply and wait 30 seconds for the device to boot up.
4. Open a web browser (Firefox or Chrome is recommended) and navigate to <http://192.168.1.1>. Then Click on **Network Configuration** in the top menu. The following screen is displayed:



5. Uncheck the Enable DHCP client checkbox, if it is checked.
6. Edit the IP Address.
7. Set DIP switch 3 to off position.
8. Click the Save Network Configuration button
9. Open a web browser (Firefox or Chrome is recommended) and navigate to the IP Address set in step 7.

### 5.3 Return Values

Those OnRobot commands that has return values updates the `of_return` variable once the command exit. This global variable can be used with the UR's built in `If` conditional expressions (for example: `if of_return == 1 then do something`).

#### 5.3.1 F/T Width Command Return Values

- 0 The Gripper Set Width command reached the set force or width.

#### 5.3.2 F/T Move Command Return Values

- 0 The move ended without detecting a force or torque greater than the set limit.
- 1 The move ended, because a force or torque greater than the set limit was detected.

- 3 The move cannot start due to a force or torque exceeding the set limit.
- 11 The move cannot start, because there is no recorded Path on the Compute Box with the selected.
- 12 The move cannot start, because there are no recorded points in this Path.
- 13 The move cannot start, because the Path file found at this Path ID is empty.
- 14 The move cannot start, because the Path file is corrupted.

### **5.3.3 F/T Search Command Return Values**

- 0 The search ended successfully, because a force or torque greater than the set limit was detected.
- 1 The search ended without detecting a force or torque greater than the set limit.
- 3 The search cannot start due to a force or torque exceeding the set limit.
- 11 The search cannot start, because there is no recorded Path on the Compute Box with the selected.
- 12 The search cannot start, because there are no recorded points in this Path.
- 13 The search cannot start, because the Path file found at this Path ID is empty.
- 14 The search cannot start, because the Path file is corrupted.

### **5.3.4 F/T Detect Command Return Values**

- 0 Part detected.
- 1 Nothing detected.

### **5.3.5 F/T Insert Part Command Return Values**

- 0 The Insert Part command reached the maximal distance.
- 1 The Insert Part command exited at a bump after the minimal insertion depth.
- 2 The Insert Part command got stuck after the minimal insertion depth. Insertion is slower than required.
- 3 The Insert Part command got stuck before the minimal insertion depth. Insertion is slower than required.
- 4 The Insert Part command exited with timeout after the minimal insertion depth.

- 5      The Insert Part command exited with timeout before the minimal insertion depth.
- 6      The Insert Part command exited due to too high side-forces/-torques at the non-compliant axes after the minimal insertion depth.
- 7      The Insert Part command exited due to too high side-forces/-torques at the non-compliant axes before the minimal insertion depth.
- 8      The Insert Part command has a parameter error.

## 5.4 Troubleshooting

### 5.4.1 URCap Plugin Setup error

There are three possible reason why the error  icon could be displayed.

1. If the **Discovered devices** drop-down menu shows “NO DEVICES FOUND!” error message for troubleshooting, see “[No devices found](#)”.
2. If the OnRobot device(s) found successfully but the **UR Robot IP** shows “N/A” for troubleshooting, see [UR Robot IP is “N/A”](#).
3. If both the OnRobot device(s) found successfully and the UR Robot IP shows a valid IP address, then for troubleshooting see [Device found, and UR has IP](#).

#### 5.4.1.1 “No devices found”

If the **Discovered devices** drop-down menu shows “NO DEVICES FOUND!” error check the connections with the Compute Box and the sensor, then try to restart the Compute Box.

After 60 seconds (when both status LEDs of the Compute Box turned to green) try to manually repeat the discovery by tapping on the refresh  icon.

#### 5.4.1.2 UR Robot IP is “N/A”

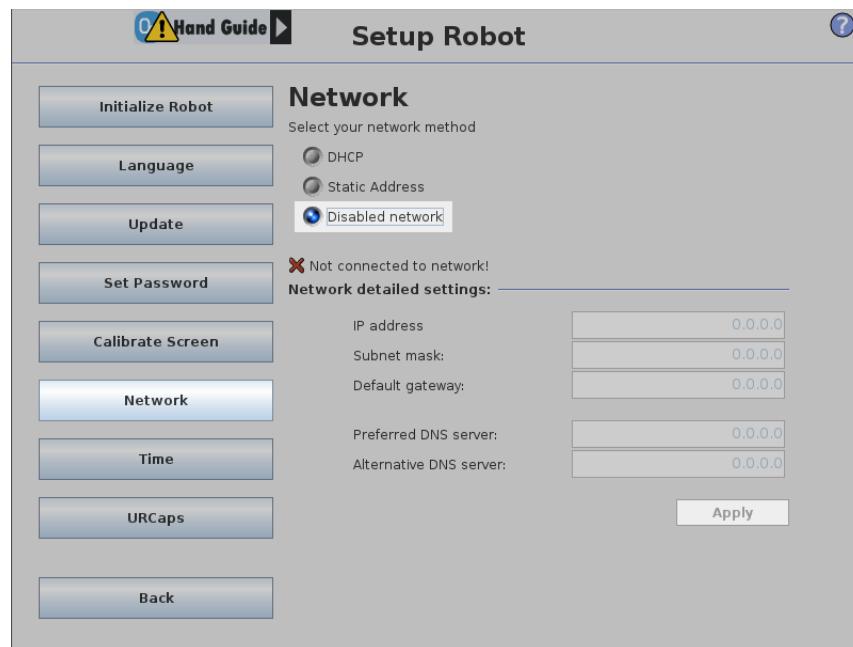
This error can happen, when the Network Configuration of the UR Robot has not been set.

To resolve the problem, check the Network Configuration of the UR Robot, by doing the following:

1. Press the Setup Robot button.



2. Press the Setup Network button.
3. If the network of the UR is disabled:
4. If the OnRobot device is connected to the UR robot directly, select DHCP, and press the Apply button. The OnRobot service assigns an IP.
5. If the OnRobot device is not directly connected to the UR robot, check if the OnRobot device is connected to the same network (router, switch, and so on) as the UR Robot, or consult the Network Supervisor.
6. If DHCP or Static Address is selected, and the problem remains consult your Network Supervisor.



In case of a DHCP, after the proper IP address is assigned to the UR robot switch to Static address mode (the IP address of the UR robot should remain the same) and press the **Apply** button. The IP address is now fixed and does not change later.

Finally start over with the [URCap Plugin Setup](#).

#### 5.4.1.3 Device found, and UR has IP

This error can happen when the robot and device are not in the same subnet.

To resolve the problem, follow this procedure:

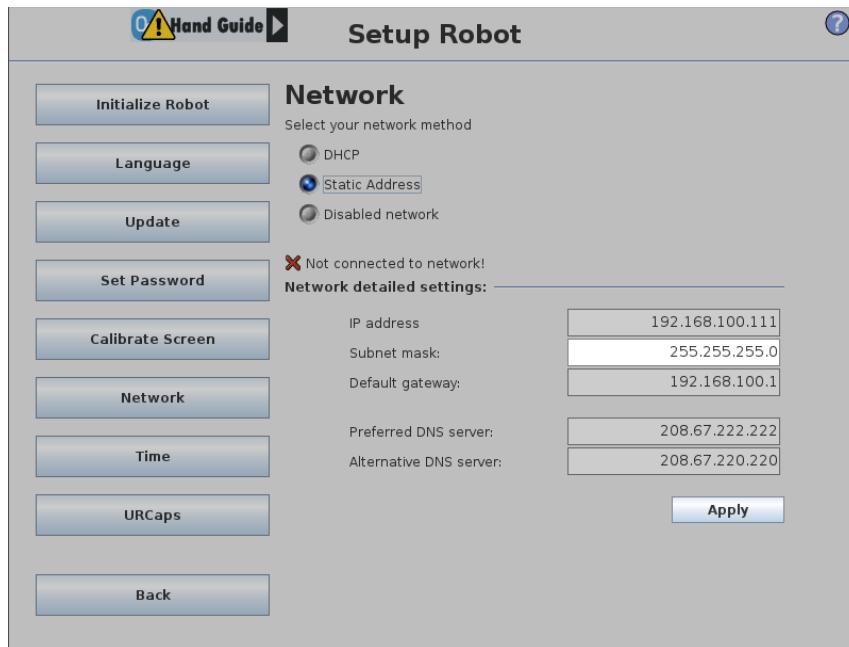
1. If the OnRobot device is not directly connected to the UR Robot, check if the DIP Switch 3 is in off state on the Compute Box, as shown on the following figure:



2. If the DIP Switch is in on state, set it to off, then restart the OnRobot device (by disconnecting the power) and repeat the steps in Example Setup section.

If the problem is still present, follow this procedure:

1. Open the Setup Network page of the UR robot explained in [UR Robot IP is “N/A”](#).
2. Modify the Subnet mask to “255.0.0.0”.
3. Press the Apply button.



Finally start over with the [URCap Plugin Setup](#).

#### 5.4.2 Too Close to Singularity

During hand guiding, if the tool is guided too close to the cylindrical volume directly above or below the robot base, a warning message is displayed.



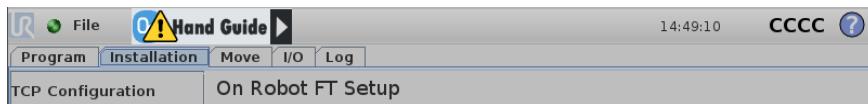
Pressing the **Stop Program** button will disable the Hand Guide function. Pressing the **Continue** button will switch to Safe Mode, which prevents the tool flange from moving into the cylindrical volume directly above or below the robot base by the Hand Guide function. Moving 10 mm away from that volume turns Safe Mode off, enabling movement in all directions again.



##### NOTE:

For safety and accuracy, the Hand Guide mode keeps the tool flange at a greater distance from the cylindrical volume than the physical possibility of the UR robot. Moving the tool flange closer is possible, by using the PolyScope Move tab, or move commands.

### 5.4.3 Warning sign on Hand Guide Bar



If the OnRobot device is not running properly, a warning sign appears. Repeat the steps of the [URCap Plugin Setup](#).

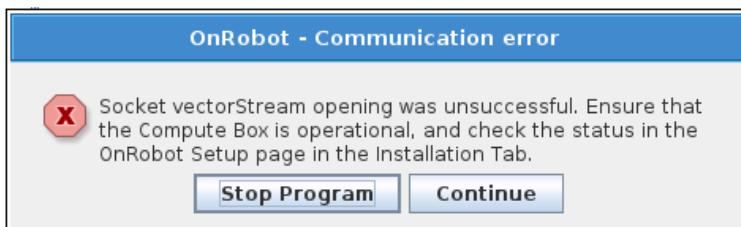
### 5.4.4 “socket\_read\_binary\_integer: timeout”

If any command is running for more than 2 seconds, a **socket\_read\_binary\_integer: timeout** entry appears in the **Log**.

This has no impact on the program execution by the robot.

### 5.4.5 “Socket vectorStream opening was unsuccessful.”

If the Robot Controller cannot connect to the Compute Box, the “Socket vectorStream opening was unsuccessful.” error message is displayed.



In this case, ensure that the Compute Box is connected to the Robot Controller, and powered on.

### 5.4.6 Path Replay is Slower than Expected

When using the F/T Path command, it is possible that the recorded Path is not smooth due to the limits of human dexterity. In these cases, the robot can only replay the Path at a very slow speed. To avoid this problem, try recording the Path again, with confident smooth movements with as little variations in translational and rotational speeds, as possible. Also, try to avoid recording Paths that contain rotations without translational elements.

### 5.4.7 “Error number -2” on Path Saving

If an empty Path is recorded, when trying to save the path, the “Error number: -2” error message is displayed.



In this case, ensure that the robot is moved between starting and stopping the path recording function.

#### 5.4.8 “Error number -3” on Path Saving

If a Path cannot be saved due to not enough storage space on the Compute Box, the “Error number -3” error message is displayed.



In this case, delete previously recorded paths that are not used anymore.

## 5.5 Declarations and Certificates

### 5.5.1 CE/EU Declaration of Incorporation (original)

According to the European Machinery Directive 2006/42/EC annex II 1.B.

The manufacturer:

OnRobot A/S  
Teglvärskej 47H  
DK-5220, Odense SØ  
Denmark  
+45 53 53 57 37

declares that this product:

Type: Industrial Robot Gripper

Model: RG2-FT

Serial number from: 0108000001 (find actual number in the gripper's back side)

is partly completed machinery according to 2006/42/EC. The product must not be put into service before the complete machine is in full compliance with all essential requirements of 2006/42/EC. A comprehensive risk assessment must be carried out for each application as part of ensuring that all essential requirements are fulfilled. All essential requirements must be assessed. Instructions and guidance provided in the RG2-FT user manual must be followed.

Technical documentation compiled according to 2006/42/EC annex VII part B is available to national authorities upon request.

The product is in conformity with, and CE marked according to, the following directives:

2014/30/EU — Electromagnetic Compatibility Directive (EMC)

2011/65/EU — Restriction of the use of certain hazardous substances (RoHS)

2014/35/EU — Low Voltage Directive (LVD)



Nicolae Gheorghe Tuns  
RD Director

Odense, August 1<sup>st</sup>, 2018

## **5.6 Editions**

<b>Edition</b>	<b>Comment</b>
Edition 1	This is the First Edition of this document.