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Revisions

Robotiq may modify this product without notice, when necessary, due to product improvements, modifications or changes in specifications. If such modification is made, the manual will also be revised, see revision information. See the latest version of this manual online at: support.robotiq.com.

Revision 2019/05/22

Updated Software section to include the "current vs targeted position" and "motion frame"

Updated section Signals Specification section and Environmental and Operating Conditions section

Revision 2019/03/13

Updated mechanical specifications (section 5.2)

Updated signal specifications (section 5.3)

Revision 2019/02/26

Updated Software section to include Force Event (Click Detection and Wait for Force feature) and Collision Detection

Revision 2018/10/09

Initial release
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Information provided by Robotiq in this document is believed to be accurate and reliable. However, no responsibility is assumed by Robotiq for its use. There may be some differences between the manual and the product if the product has been modified after the edition date.

The information contained in this document is subject to change without notice.
1. General Presentation

The term "Force Copilot" used in the following manual refer to the Robotiq Force Copilot unless otherwise specified. The Robotiq Force Copilot is a software package designed for using the force and torque values read by a force torque sensor in the framework of robotic applications. The software interface provides force and torque feedback that can be used for robot hand guiding, force control processes, assembly tasks, product testing, and much more.

**Info**
The following manual uses the metric system. Unless specified, all dimensions are in millimeters.

1.1. Main features

1.1.1. Force Copilot

The hardware counterpart of Force Copilot is the license dongle, a USB storage device hosting the product license.

The Force Copilot software is used for the implementation of a force torque sensor operational commands in a user interface.

![Fig. 1.1: Force Copilot License Dongle.](image)
2. Safety

Warning
The operator must have read and understood all the instructions in this manual before using Force Copilot.

Info
The term "operator" refers to anyone responsible for:
Any of the following usage of Force Copilot the and the associated operational commands:
- Installation
- Control
- Calibration
- Programming

The drawings and photos in this documentation are representative examples and differences may exist between them and the delivered product.
2.1. Warning

**Info**
Any use of Force Copilot in noncompliance of these warnings is inappropriate and may cause injury or damage.

**Warning**
A force torque sensor used in human-robot collaboration must not be considered a complete safety measure, additional dedicated safety device(s) must be considered. Sensor failure can occur and result in danger for workers or machinery. See local or international safety measure for human-robot collaboration.
2.2. Intended Use

Info
Always comply with local and/or national laws, regulations and directives on automation safety and general machine safety.

The unit may be used only within the range of its technical specifications. Any other use of the product is deemed improper and unintended use. Robotiq will not be liable for any damages resulting from any improper or unintended use.
3. Installation

Warning
Be sure to read and understand the safety instructions related to the Robotiq Force Copilot prior to installation.

3.1. Scope of Delivery

Standard delivery for a Force Copilot kit

<table>
<thead>
<tr>
<th>Force Copilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robotiq Force Copilot License Dongle</td>
</tr>
<tr>
<td>Axes labelling decals</td>
</tr>
<tr>
<td>Stylus for touch screen</td>
</tr>
</tbody>
</table>
3.2. Software Installation for Universal Robots

Info
The robot PolyScope version must be 5.0 and later to install and use Force Copilot.

Installation
Follow this procedure to install Force Copilot on Universal Robots.

- Browse to support.robotiq.com
- Select Force Copilot
- Download UCS-X.X.X.urcap
- Decompress the file on the USB license dongle
- Insert the USB license dongle in the robot teach pendant, robot controller, or USB hub connected to the robot controller

Caution
Make sure that the license dongle stays connected to the robot.

- Make sure that your PolyScope version is up-to-date.
- On the teach pendant, tap the triple bar icon in the upper right corner of the screen.
- Select Settings.
- Tap System in the navigation pane on the left and select URCaps.
Tip

Tap the triple bar icon in the upper right corner of the teach pendant screen and select About. A window containing the Universal Robots software version will pop up.

1 Tap **System** in the navigation pane on the left.
2 Select **URCaps**.
3 Tap the **Plus (+)** button to display the storage devices and browse for the URCap file.

1 Tap **Robotiq_Force_Copilot-XXX.urcap** to select it.
2 Tap the **Open** button.
Uninstalling the URCap Package

If you wish to uninstall the Force Copilot URCap, follow this procedure:

1. Tap the Restart button to complete the URCap installation. By doing so, you accept the license agreement detailed in the URCap information textbox.

2. On the teach pendant, tap the triple bar icon.

3. Select Settings.
1. Select **System** in the navigation pane on the left.
2. Tap **URCaps**.
3. In the **Active URCaps** box, tap the **Robotiq_Force_Copilot** URCap; the URCap should be highlighted.
4. Tap the minus (-) button to uninstall the URCap.
5. Restart PolyScope to complete the uninstallation process.
License Agreement

END-USER LICENSE AGREEMENT

YOU SHOULD CAREFULLY READ THE FOLLOWING AGREEMENT BEFORE USING THE SOFTWARE (as this term is hereinafter defined). Using the Software indicates your acceptance of the agreement. If you do not agree with it, you are not authorized to use the Software.

IMPORTANT; READ CAREFULLY: This End-User License Agreement (the “Agreement”) is a legal agreement between you and the Licensor (as this term is hereinafter defined), the licensor of the Software. This Agreement covers the Software. The Software includes any “on-line” or electronic documentation and all modifications and upgrades related thereto. By downloading, installing, or otherwise using the Software, you agree to be bound by the terms of this Agreement. If you do not agree to the terms of this Agreement, the Licensor cannot and does not license the Software to you. In such event, you must not download, use or install the Software.

1. Definition

1.1. “UR” means Universal Robots A/S, a corporation incorporated under the laws of Denmark, having its registered office at Energivej 25, DK-5260 Odense S, which specializes into the conception, advanced manufacturing and sale of robotic products (the “UR’s Business”);

1.2. "Software” means any of the Licensor’s software provided to its customers for the purposes mentioned in sub-section 2.2 hereof including their modifications and upgrades and their related materials;

1.3. “Licensor” means Robotiq inc., a corporation incorporated under the laws of Quebec, having its registered office at 500-966 chemin Olivier, Lévis, Québec, Canada, G7A 2N1, which specializes into the conception, advanced manufacturing and sale of robotic products (the “Licensor’s Business”);

1.4. “End-User” means a customer authorized pursuant to this Agreement to install or use the Software with a specific product of the UR’s Products;

1.5. “Licensor’s Products” means those robotic products developed by the Licensor in the course of the Licensor’s Business;

1.6. “UR’s Products” means those products developed by UR in the course of the UR’s Business;

1.7. “Licensor’s Authorized Representatives” means and includes the Licensor and Licensor’s authorized vendors, resellers, distributors and licensors;

1.8. “Designated Equipment” means a personal computer that has a functional USB port and an operating system that is an equivalent or a more recent version of one of the following:

- Windows 7;
- Mac OSX;
- Linux Ubuntu 16.

1.9. “Purchase Agreement” means an agreement between the End-User and the Licensor pursuant to which the End-User purchased one or more of the Licensor’s Products;

1.10. “Trial Period” means the limited period during which the Software may be installed on the UR’s Product and used without any charge by the End-User in order to be used without a Licensor’s Product.

2. License and Object of the Agreement

2.1. License. Subject to the terms and conditions hereof, the Licensor grants to the End-User a personal, temporary, non-exclusive, non-assignable and non-transferable and revocable license to use the Software in accordance with the terms and conditions hereof.

2.2. Object of the Agreement. The object of this Agreement is the grant of a license for the use of software that enables control functionalities of UR’s Products devices or Licensor’s Products (the “Purpose”).

3.1. Download. The Software shall be downloaded from the Licensor’s website or provided to the End-User through a USB flash drive, according to the instructions set forth in the order summary sent to the End-User by email or by other means of communication, as decided by the Licensor (the “Order Summary”). The download of the Software shall be made with the End-User’s Designated Equipment.

3.2. Installation. The installation on the UR’s Product shall be done with a USB flash drive inserted into the UR’s Product. If the Software was downloaded from the Licensor’s website, it shall be uploaded on a USB flash drive device for the purpose of installation on the UR’s Product.

3.3. Utilisation. Two scenarios are possible according to the modalities set forth in the Order Summary:

a) The use of the Software is made with a Licensor’s Product. In this case, the End-User may start using the Software upon completed installation.

b) The use of the Software is made without a Licensor’s product. In this case, a Trial Period is granted to the End-User. At the end of the Trial Period, which shall be set forth in the Order Summary, the use of the Software requires the software protection dongle (the “Dongle”). The Dongle will be provided to the End-User for a fee as per section 5 of this Agreement, either by the Licensor or by a Licensor’s Authorized Representative.

3.4. Documentation. The Licensor may provide, if applicable, all documentation containing the detailed specifications for operation and use of the Software, which Software shall be used in accordance with such documentation. This documentation, if applicable, will be provided, wholly or in part, within (i) this Agreement, (ii) the Licensor’s Web site http://robotiq.com/ (iii) the Licensor’s Products and the Purchase Agreement therewith, or (iv) any other agreement, document, support, whatsoever decided by the Licensor.

4. Modifications and Upgrades. The Licensor shall be under no obligation to provide any upgrade, modification or patch to the Software. However, the End-User shall be entitled to receive free of charge the upgrades and patches of the Software provided by the Licensor if, at such time, the End-User is not in default in respect of any of its obligations contained herein. Modifications that create new functionalities may be offered to the End-User at a price set by the Licensor at its sole discretion.

Such modifications, upgrades and patches of the Software shall be installed by the End-User itself by consulting the Licensor’s website http://robotiq.com/ where a link to proceed to such installation will be made available thereof.

5. Fees. The End-User shall pay the Licensor for using the software as per the Order Summary. The fees shall cover upgrades and patches of the Software provided by the Licensor if, at the time of the upgrade or patch, the End-User is not in default in respect of any of its obligations contained herein.

New End-Users not using the Licensor’s Products will be entitled to a Trial Period, which shall begin on the date of the first installation on the UR’s Product and which shall end after the Trial Period as determined in the Order Summary.

6. Maintenance. During the term of this Agreement, the Licensor will maintain the Software in an operable condition and will make available any corrections and improvements as are generally incorporated in the Software by the Licensor without additional charge to the End-User.

7. Title to Software. The licensed Software is composed of confidential data and trade secrets and is proprietary to and constitutes trade secret information and intellectual property of the Licensor. Title and ownership rights to the Software, including the intellectual property rights related thereto, shall remain with the Licensor. The End-User agrees to maintain the confidential nature of the source code and libraries.

The license granted herein does not include the right to sublicense to others, and may not be assigned to others, in whole or in part, without the prior written consent of the Licensor. The End-User may not or allow others to modify or prepare derivative works, copy (except for normal backups for recovery purposes), reproduce, republish, reverse engineer, upload, post, transmit, or distribute, in any manner, the Software.

8. Restricted Use. The Software shall be used solely and exclusively by the End-User and its employees for the Purpose mentioned in sub-section 2.2 hereof. Any other use of the Software, including resell derivative modifications or extensions, is expressly prohibited.

9. Audit. During the term of this Agreement and for six (6) months after the termination, the Licensor shall have the right, during normal business hours and upon reasonable advance notice to the End-User, to visit the End-User’s premises for the purpose of
10. **Exclusion of Warranty on Software.** The End-User expressly acknowledges and agrees that use of the Software is at the End-User sole risk. The Software is provided “as is”. The Licensor warrants that, during the term of this Agreement and except if modified by the End-User, the Software will meet in all material respects the specifications provided for in the Licensor’s website.

11. **Limitation of Liability.** To the maximum extent permitted by law, the Licensor and Licensor’s Authorized Representatives shall not be liable for any indirect, incidental or consequential damages for breach of any express or implied warranty, breach of contract, negligence, strict liability or any other legal theory related to the Software. Such damages include, but are not limited to, loss of profits, loss of revenue, loss of data, loss of use of the product or any associated equipment, down time and user’s time, even if the Licensor has been advised of the possibility of such damages. In any case, the Licensor’s entire liability under any provision of this agreement shall be limited to the amount actually paid in respect of the Licensor’s products purchased by the end-user pursuant to a purchase agreement.

12. **Indemnification.** The End-User shall indemnify and hold the Licensor harmless from any liability, loss, claim and from any judgment, damage and cost (including, without limitation, the costs and fees of a dispute and reasonable legal fees), fine, penalty and interest whatsoever arising from any defence, dispute, compensation, claim or counterclaim as a result of the use of the Software by any third party authorized by the End-User.

13. **Training, Maintenance and Support.** There is no entitlement to training, maintenance and support under this license unless otherwise specified in the Purchase Agreement or any other written agreement between the End-User and the Licensor. The End-User may provide the Licensor with details regarding any bug, defect or failure in the Software promptly and with no delay from such event; the End-User shall comply with the Licensor’s request for information regarding bugs, defects or failures and furnish him with information, screenshots and try to reproduce such bugs, defects or failures upon Licensor’s demand.

14. **Expiration and Termination.** The Licensor may terminate this Agreement for default by the End-User by sending a ten (10) day notice to the End-User.

Upon the termination of this Agreement for any reason, the End-User shall promptly uninstall the Software on any UR’s Products and Licensor’s Products, computer, or server on which it has been installed, deliver to the Licensor all CDs, DVDs, USB flash drives, and other tangible items and materials embodying the Software, and return to the Licensor all copies thereof or destroy such copies and warrant in writing that all copies thereof have been destroyed or deleted. In the event of the termination of this Agreement, all obligations of the parties under this Agreement due for performance on the date of termination shall survive the termination, and the party terminating shall not be liable to the other party for any damages arising out of the termination.

15. **Miscellaneous.**

15.1. This Agreement constitutes the entire understanding and agreement between the Licensor and the End-User and replaces any prior agreement relating to the same subject matter.

15.2. This Agreement shall be governed and construed in accordance with the laws of the province of Quebec and the federal laws of Canada applicable therein. Any legal action or proceeding between the Licensor and the End-User for any purpose concerning this Agreement or the parties’ obligations hereunder shall be brought exclusively in a court of competent jurisdiction sitting in the judicial district of Québec, Québec.

15.3. The Licensor’s failure to insist upon or enforce strict performance of any provision of this Agreement shall not be construed as a waiver of any provision or right. Neither the course of conduct between the parties nor trade practice shall act to modify any provision of this Agreement.

15.4. The Licensor may assign its rights and duties under this Agreement to any party at any time without notice to the End-User. The End-User may not assign this Agreement without the prior written consent of the Licensor.

15.5. If any part of this Agreement is null, illegal or non-enforceable, this Agreement shall be interpreted as if this part was never part of this Agreement.

15.6. The provisions of this Agreement are for the benefit of the Licensor and its officers, directors, employees, agents, licensors and suppliers. Each of these individuals or entities shall have the right to assert and enforce those provisions directly against the
End-User on its own behalf. This Agreement is also for the benefit of, and binds, the End-User and its heirs, successors, legal representatives and permitted assigns.

15.7. The Licensor hereby confirms that there is no relationship of agency between the Licensor and UR, and that they are independent contractors.

15.8. Any rights not expressly granted herein are reserved.

15.9. The parties confirm that they have agreed that this Agreement and all related documents be drafted in English only. Les parties aux présentes confirment qu’elles ont accepté que la présente convention et tous les documents y afférents soient rédigés en anglais seulement.
4. Software

The following subsections provide instructions for the installation of the Force Copilot software package. This lets you receive input from a Force Torque Sensor.

4.1. Control with Universal Robots

Force Copilot contains many features to program and control the robot arm using a sensor force and torque readings. The package provides:

- ActiveDrive toolbar
- Path recording node
- Zero FT Sensor node
- Insertion node
- Find Surface node
- Force Control node
- Force Event node
- Collision Detection node
- Multipoint Path node
4.1.1. ActiveDrive Toolbar

The ActiveDrive Toolbar is automatically installed with the Force Copilot software package. It enhances the guiding mode on Universal Robots by allowing the robot to be hand-guided smoothly and easily towards a waypoint. The ActiveDrive feature is a great way to assist the Path recording described in the Path Recording section, by hand-guiding the robot while recording a path.

**Info**

The Force Copilot software Package contains the ActiveDrive Toolbar. Therefore, the toolbar is automatically installed with the URCap Package.

The robot speed set with the Speed slider will affect the speed at which the robot moves in the ActiveDrive mode. Verify and adjust the speed slider to the desired speed. It has to be greater than 50%.

**Overview**

**Toolbar collapsed**

Tap the UR+ button to expand the toolbar.

**Toolbar expanded**

(Tap the mode selector to expand.)
### Features

<table>
<thead>
<tr>
<th>Primary icon</th>
<th>Functionality name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="ActiveDrive" /></td>
<td>ActiveDrive</td>
<td>Tap to toggle between the expanded and collapsed ActiveDrive Toolbar. When grey, the functionality is not available. Tap the button to see why it is not available.</td>
</tr>
<tr>
<td><img src="image" alt="Start / Stop" /></td>
<td>Start / Stop</td>
<td>Tap to start or stop ActiveDrive. ActiveDrive will automatically turn off after 30s of inactivity. When started, ActiveDrive allows you to move the robot freely by applying forces on robot’s end-effector. This is different from the Free Drive feature on the robot, where you can move the robot arm.</td>
</tr>
<tr>
<td><img src="image" alt="Modes" /></td>
<td>Modes</td>
<td>Shows the current ActiveDrive mode. When tapping the icon, the available modes will appear and you can change to a different mode. ActiveDrive modes allow you to restrain the robot to specific movements.</td>
</tr>
<tr>
<td><img src="image" alt="Free" /></td>
<td>Free</td>
<td>Free motion: all translations and rotations are allowed.</td>
</tr>
<tr>
<td><img src="image" alt="Scara" /></td>
<td>Scara</td>
<td>SCARA-style motion: all translations and horizontal rotation (twist) are allowed.</td>
</tr>
<tr>
<td><img src="image" alt="Translation" /></td>
<td>Translation</td>
<td>Translation motion: only translations are allowed. No rotation of the robot is possible in this mode.</td>
</tr>
<tr>
<td><img src="image" alt="Plane" /></td>
<td>Plane</td>
<td>Plane motion: horizontal translations and horizontal rotations (twist) are allowed (no vertical motions are allowed).</td>
</tr>
<tr>
<td><img src="image" alt="Drift Control" /></td>
<td>Drift Control</td>
<td>Tap this button to stop the robot from drifting (resets the sensor’s offset).</td>
</tr>
<tr>
<td>Primary icon</td>
<td>Functionality name</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><img src="image1.png" alt="Rabbit Icon" /></td>
<td>Speed</td>
<td>Motion speed control is toggled between fast and slow, allowing precise movement in slow motion. The force torque sensor will switch to slow speed automatically whenever high forces are detected, for example, during an impact with an object.</td>
</tr>
<tr>
<td><img src="image2.png" alt="Snail Icon" /></td>
<td>Square robot</td>
<td>Aligns the tool center point (TCP) orientation with the robot base. Tap and hold this button to automatically move the end-effector to the closest orthogonal orientation of the base axis system (just try it, you will see!).</td>
</tr>
</tbody>
</table>
Error Messages Overview

The ActiveDrive Toolbar will be automatically collapsed and be grayed whenever one of the following situations occurs. In such cases, by tapping the ActiveDrive button, the following messages will appear:

- **Message:**

  ![Excessive Force Applied to the Tool](image)

  Excessive Force Applied to the Tool

  ActiveDrive currently detects a force applied on the tool. If the tool is in contact with an obstacle, press "OK", move the robot away (with Free Drive or the Move tab) and start ActiveDrive again.

  Note: make sure that the tool is at rest and press "Zero Sensor" to start ActiveDrive.

  ![OK Zero Sensor](image)

- **Solution:**
  - Starting ActiveDrive while an excessive force is applied to the tool:
    - Determine if an external force is applied to the end-effector. If it is the case, tap **OK** and move the robot away from the obstacle (with Free Drive or Move tab), or remove any external forces and start ActiveDrive again.
    - If no external forces are applied, tap **Zero Sensor**.

  ![Robot not Initialized](image)

  Robot not Initialized

  ActiveDrive cannot start because the robot is not initialized.

  ![OK](image)

- **Message:**

  ![Robot not Initialized](image)

  Robot not Initialized

  ActiveDrive cannot start because the robot is not initialized.

  ![OK](image)

- **Solution:**
  - The robot is not initialized: Tap **OK** and go to PolyScope’s home page. Tap **Setup Robot** and go to **Initialize Robot** to start the robot.
• Message:
  ![Program Already Running](image)

  **Solution:**
  - A program is already running: The ActiveDrive Toolbar cannot be used while a program is running. Stop the program to enable the ActiveDrive feature.

• Message:
  ![Speed Setting Lower than 50%](image)

  **Solution:**
  - The speed setting of the robot is lower than 50%: The robot’s speed setting should be greater than 50%. Modify the speed setting in the robot program using the slider.

• Message:
  ![Robot in Freedrive Mode](image)

  **Solution:**
  - If the Freedrive button is pressed: The ActiveDrive mode cannot be used when the Free Drive mode is ON. Make sure you are not pressing on the teach pendant’s Teach button when trying to use the ActiveDrive toolbar.
4.1.2. Using the force and torque values

Force Torque Sensor functions are made available in the Universal Robots functions drop-down menu.

- The `rq_zero_sensor()` function can be called at any point in a robot program to zero the force and torque values of the Force Torque Sensor.

- The `get_sensor_Fx`, `get_sensor_Fy`, `get_sensor_Fz`, `get_sensor_Mx`, `get_sensor_My`, `get_sensor_Mz` functions allow the user to assign the sensor values to any variable.

- The `get_applied_tcp_force(<index>)` function returns the current wrench (force and torque vector) value currently applied at the tool center point (TCP).

- The `get_applied_base_force(<index>)` function returns the current wrench (force and torque vector) value applied at the robot arm base.

- The `express_force_in_frame(<T_from_to>,<wrench_from>)` function is used to convert the wrench (force and torque vector) reading in a given reference frame into another (end-effector to robot base, and vice-versa, for example).
  - `T_from_to` = relative pose of the reference frame into which the wrench reading is converted
  - `wrench_from` = wrench to transform in pose or list format (Fx, Fy, Fz, Mx, My, Mz)

![Diagram of two reference frames](image)

*Fig. 4.1: Example of two reference frames for the express_force_in_frame(<T_from_to>,<wrench_from>) function*

**Info**

Although displayed in real time in the Variables tab, the force and torque values can be seen in the Force Copilot Dashboard.
**Force Copilot Licensed**

<table>
<thead>
<tr>
<th>Force Values</th>
<th>Moment Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_x = -0.6$ N</td>
<td>$M_x = 0.00$ Nm</td>
</tr>
<tr>
<td>$F_y = -2.2$ N</td>
<td>$M_y = -0.06$ Nm</td>
</tr>
<tr>
<td>$F_z = 1.3$ N</td>
<td>$M_z = 0.06$ Nm</td>
</tr>
</tbody>
</table>

**Fig. 4.2:** Force Copilot Dashboard with force and torque values displayed in real time.
### 4.1.3. Path Recording

The Force Copilot software package adds a Path feature in Polyscope which can be used to record paths directly by moving the robot. The ActiveDrive Toolbar is a great tool to use while recording a path, as it is an easy way to hand guide the robot end-effector. Path recording can be used for specific processes requiring complex paths (polishing, gluing, etc.) or more generally, for any task otherwise requiring programming many waypoints. The Path node offers options to modify the recorded path to change its speed and play the path backwards or relative to a variable starting position.

**How to add and record a path**

1. In the ribbon at the top of the Polyscope interface, tap the **New** button to create a program or tap the **Open** button to load an existing program.

2. Select the **URCaps** menu.
3. Tap the **Path** button.
Overview

Path recording and visualization.

Path speed box.

Path options.

Warning section. Displayed whenever a setting results in a duration different than the original path duration.
When a Path node is empty (no path recorded), the only available button is the record button.

While recording a path, the only available button is the stop button.

When the speed of the original recording is modified using the speed slider, a warning message appears and the path time and speed information is updated.
### Features*

<table>
<thead>
<tr>
<th>Primary icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starts and stops the path recording.</td>
</tr>
<tr>
<td></td>
<td>Press and hold in order to move the robot at the path’s start.</td>
</tr>
<tr>
<td></td>
<td>Press and hold in order to move the robot at the path’s end.</td>
</tr>
<tr>
<td></td>
<td>Press and hold to move the robot to starting point, and play the path as run in the program.</td>
</tr>
<tr>
<td><img src="image" alt="Constant speed icon" /></td>
<td>If selected, the path is modified to play at a constant tool speed (linear speed at the tool center point). With this option, all pauses and hesitations (dead times) in the path will be removed.</td>
</tr>
<tr>
<td><img src="image" alt="Reverse path icon" /></td>
<td>If selected, the recorded path will be played backwards in the program. It can be useful if a path is copied and played backwards, resulting in a path played back and forth.</td>
</tr>
<tr>
<td><img src="image" alt="Relative path icon" /></td>
<td>If selected, the path will be played relative to the current robot position when the program enters the path instruction. This effectively offsets all the recorded path.</td>
</tr>
<tr>
<td><img src="image" alt="Warning icon" /></td>
<td>Displayed whenever a setting results in a duration different than the original path duration.</td>
</tr>
</tbody>
</table>

* When an icon is greyed, it means it is unavailable.
If you tap the record button when a path is already recorded in a node, a warning pop-up will ask if you want to overwrite the path (tap OK) or keep the previously recorded path (tap Cancel).

### 4.1.4. Insertion nodes

The Force Copilot software Package includes Insertion nodes, which can be used to perform spiral, rotational and linear movements to insert objects in holes or bores, or to make contact with a surface. It is an essential integration resource for streamlining robot programs in the framework of precise assembly applications.

When the task is performed by a human operator, the operator's fingers provide valuable feedback through the sense of touch, thus allowing the human to detect any resistance when trying to insert a pin in a hole, for instance. To a certain extent, Force Copilot gives that kind of sensitivity to the end effector.

#### How to add an Insertion node

- On the teach pendant, tap the **New** button to create a program or the **Open** button to load a program
- Tap the **URCaps** button in the navigation pane on the left
- Select **Insertion**
- Tap the **Insertion** node in the robot program to edit it

#### Info

The parent **Insertion** node is automatically followed by a **Zero Sensor** child node.
Child nodes

Insertion
Select an operation to add to the insertion sequence

1. **Spiral** button to insert a **Spiral** child node
2. **Rotational** button to insert a **Rotational** child node
3. **Linear** button to insert a **Linear** child node

**Spiral**
Following a contact established between the object grasped by the end effector (or the end effector itself) and the corresponding mating part or surface, a spiral motion is engaged on a specific plane to find the path of least resistance according to the direction, speed, force, radius increment per turn and maximum radius parameters set by the user.

**Rotational**
Following a contact established between the object grasped by the end effector (or the effector itself) and the corresponding mating part or surface, a rotational motion is engaged on a specific plane to find the path of least resistance, according to the direction, speed, force, maximum torque and maximum rotation angle parameters set by the user.

**Linear**
Following the successful spiral, rotational or fortuitous location of a mating hole or bore, a linear motion is engaged at a certain speed until the force threshold or maximum travel distance is reached.
Features (Spiral)

The Spiral child node is packaged with an On error condition line to be populated with a program instruction when/if the error condition occurs. The potential sequence after the Spiral instruction is followed by a program halt, by default.

**Spiral**

Function used to insert an object in a hole and to perform a spiral search if an obstacle is found.

**Motion**

1. **Teach position** button (Destination): Tapping this button saves the object’s destination as a waypoint in the robot program
2. **Reference frame** dropdown menu (Direction): Menu used to select the frame according to which the tool will move in space
3. **Axis** dropdown menu (Direction): Menu used to select the direction in which the tool will go to reach the destination
4. **Advanced parameters** box: Box that expands the advanced parameters menu when ticked
5. **Speed** parameter: Textbox for the user to enter a speed value
6. **Force initiating spiral move** parameter: Textbox for the user to enter a force threshold value that triggers the spiral move, after the part/tool has established contact with the mating part/surface
7. **Force initiating insertion** parameter: Textbox for the user to enter a force drop value indicating that the part/tool has found the path of least resistance, prior to completing the insertion process
8. **Radius increment per turn** parameter: Textbox for the user to enter the distance between each spiral turn on the spiral radius
9. **Enable peck mode** box: Box that enables the retraction of the tool between points of contact
10. **Maximum radius** (Error condition): Textbox for the user to enter the maximum radius of the spiral, considering that no path of least resistance has been found

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit of measurement</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference frame (Direction)</td>
<td>N/A</td>
<td>Tool</td>
</tr>
<tr>
<td>Axis (Direction)</td>
<td>N/A</td>
<td>Z+</td>
</tr>
<tr>
<td>Speed</td>
<td>mm/s</td>
<td>5</td>
</tr>
<tr>
<td>Force initiating spiral move</td>
<td>N</td>
<td>10</td>
</tr>
</tbody>
</table>

**Default values and units of measurement**
### Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit of measurement</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force initiating insertion</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>Radius increment per turn</td>
<td>mm</td>
<td>0.7</td>
</tr>
<tr>
<td>Maximum radius (Error condition)</td>
<td>mm</td>
<td>5</td>
</tr>
</tbody>
</table>

### Features (Rotational)

**Rotational**

Function used to insert an object into a hole and to rotate on a given tool axis if an obstacle is found.

**Motion**

1. **Teach position** button (Destination): Tapping this button saves the object's destination as a waypoint in the robot program.
2. **Reference frame** dropdown menu (Direction): Menu used to select the frame according to which the tool will move in space.
3. **Axis** dropdown menu (Direction): Menu used to select the direction in which the tool will go to reach the destination.
4. **Advanced parameters** box: Box that expands the advanced parameters menu when ticked.
5. **Linear speed** parameter: Textbox for the user to enter a speed value for the approach motion towards the destination.
6. **Force initiating rotation** parameter: Textbox for the user to enter a force threshold value that triggers the rotation move, after the part/tool has established contact with the mating part/surface.
7. **Rotation speed** parameter: Textbox for the user to enter a speed value for the rotational (indexing) motion.
8. **Maximum torque** parameter: Textbox for the user to enter a torque threshold value used to prevent potential collision with objects during the rotational motion.
9. **Enable peck mode** box: Box that enables the retraction of the tool between points of contact.
10. **Maximum rotation angle** (Error condition): Textbox for the user to enter the maximum angle of the rotation motion, considering that no path of least resistance has been found.
Default values and units of measurement

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit of measurement</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference frame (Direction)</td>
<td>N/A</td>
<td>Tool</td>
</tr>
<tr>
<td>Axis (Direction)</td>
<td>N/A</td>
<td>Z+</td>
</tr>
<tr>
<td>Linear speed</td>
<td>mm/s</td>
<td>5</td>
</tr>
<tr>
<td>Force initiating rotation</td>
<td>N</td>
<td>10</td>
</tr>
<tr>
<td>Rotation speed</td>
<td>°/s</td>
<td>5</td>
</tr>
<tr>
<td>Maximum torque</td>
<td>Nm</td>
<td>1</td>
</tr>
<tr>
<td>Maximum rotation angle (Error condition)</td>
<td>°</td>
<td>45</td>
</tr>
</tbody>
</table>

Features (Linear)

1 Reference frame dropdown menu (Direction): Menu used to select the frame according to which the tool will move in space
2 Axis dropdown menu (Direction): Menu used to select the direction in which the tool will go to reach the destination
3 Advanced parameters box: Box that expands the advanced parameters menu when ticked
4 Speed parameter: Textbox for the user to enter a speed value for the approach motion towards the destination
5 Force threshold parameter: Textbox for the user to enter a force threshold value that completes the linear motion
6 Maximum travel distance (Error condition): Textbox for the user to enter the maximum distance value which, upon being reached, means the force threshold has never been reached in the linear motion
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit of measurement</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference frame (Direction)</td>
<td>N/A</td>
<td>Tool</td>
</tr>
<tr>
<td>Axis (Direction)</td>
<td>N/A</td>
<td>Z+</td>
</tr>
<tr>
<td>Speed</td>
<td>mm/s</td>
<td>5</td>
</tr>
<tr>
<td>Force threshold</td>
<td>N</td>
<td>10</td>
</tr>
<tr>
<td>Maximum travel distance (Error condition)</td>
<td>mm</td>
<td>100</td>
</tr>
</tbody>
</table>

### 4.1.5. Find Surface node

The Force Copilot software package includes the Find Surface node, which is a great tool for machine tending and various other applications that require repeated accurate positioning of objects.

The default parameters of the function allow for a versatile demo or a quick test of the features while the advanced parameters make it a more customizable asset.

**How to add a Find Surface node**

- On the teach pendant, tap the **New** button to create a program or the **Open** button to load a program
- Tap the **URCaps** button in the navigation pane on the left
- Select **Find Surface**
- Tap the **Find Surface** node in the robot program to edit it

1. **Direction relative to the tool** dropdown menu: Menu used to select the direction of the linear motion, relative to the tool
2. **Zero Sensor Before Execution** box: Box that inserts a Zero FT Sensor command right before the Find Surface instructions
3. **Advanced parameters** box: Box that expands the advanced parameters menu when ticked
4. **Motion speed** parameter: Textbox for the user to enter a speed value for the approach motion towards the destination
5. **Maximum distance traveled** (Stop condition): Textbox for the user to enter the maximum distance value which, upon being reached, means the force threshold has never been reached in the linear motion
6. **Insert instruction textbox**: Checkbox that inserts the corresponding stop condition in the robot program when ticked; its main function is to facilitate the programming and improve the user experience
7. **Force threshold** (Stop condition): Textbox for the user to enter a force threshold value that completes the linear motion
8. **Insert instruction textbox**: Checkbox that inserts the corresponding stop condition in the robot program when ticked; its main function is to facilitate the programming and improve the user experience
Fig. 4.3: Find Surface node with stop condition(s)
4.1.6. Force Control Node

Overview
The Robotiq Force Control node is used to apply force and torque values along and around axes.

How to add a Force Control node
- On the teach pendant, tap the New button to create a program or the Open button to load a program
- Tap the URCaps button in the navigation pane on the left
- Select Force Control
- Tap the Force Control node in the robot program to edit it

Warning
UR Move nodes (MoveL, MoveJ, MoveP) and Force nodes cannot be executed as child of the Robotiq Force Control node.

Tip
Where a UR Move node would normally be used, the user shall record a Robotiq Path emulating the desired Move.
In a situation where the user wants to make contact with a surface in accordance with the user-defined settings, a Wait instruction can be inserted as child of the Robotiq Force Control.

The Force Control node is primarily meant to be used with a Robotiq Path node.
With the various user-defined settings available, operators can use a force torque sensor to apply force/torque and thus follow irregular shapes and/or surfaces for applications such as polishing, deburring, finishing, dispensing, etc.
Features

Reference frame

The user can select a reference frame from a dropdown menu, as shown below.

The Tool reference frame uses the X, Y and Z axes of the end-effector to apply force and torque values in the appropriate direction. On the other hand, the Base reference frame takes into consideration the X, Y and Z axes of the robot arm base.

![Fig. 4.4: Force Control node with Reference Feature dropdown highlighted.]

Parameters

1. **Enable control**: each checkbox corresponds to the enablement of force feeding along an axis (upper three options) or torque feeding around an axis (lower three options)

2. **Force/Torque**: depending on which options were checked at step 1, the corresponding textboxes here should be filled with the desired force/torque values
   - a. Force values applied are in newtons (N) – the range allowed goes from -150 to +150 N
   - b. Torque values applied are in newton-metre (Nm) – the range allowed goes from -50 to +50 N.

Info

Tapping the text boxes brings up a numpad used to enter the values.

3. **Stiffness**: the stiffness settings act directly on the Sensor’s directional compliance depending on the orientation of the end-effector and the axes selected at step 1.
   - a. A stiffness value closer to 0% will provide greater compliance along/around the corresponding axis
   - b. A stiffness value of 100% offers no compliance along/around the corresponding axis

4. **Deviation range**: the deviation range limits the flexibility allowed along/around the corresponding axis.
   - a. The deviation range **along** the X, Y and Z axes is measured in **millimeters (mm)** – the negative range allowed goes from -1000 mm to 0 mm while the positive range allowed goes from 0 mm to 1000 mm.
   - b. The deviation range **around** the X, Y and Z axes is measured in **degrees (°)** – the negative range allowed goes from -179° to 0° while the positive range allowed goes from 0° to 179°.

Example

In a situation where 10 N are applied exclusively along the Z-axis, with 20% stiffness along the X and Y axes, and a deviation range that goes from -50 mm to +50 mm along all axes...

- The end-effector will systematically point towards its Z-axis
- The end-effector will not rotate around Rx, Ry and Rz (no torque feeding)
- The end-effector will be moderately flexible to move along the X and Y axes
- The movements along the X, Y and Z axes will be limited to -50 mm and +50 mm from the command position
5 **Enable adaptive stiffness**: this checkbox greys out the stiffness values in the boxes at step 3 since the Force Control calculates the rigidity of the surface/object with which the end-effector comes in contact. Thus, constant force/torque values are applied to surfaces with variable rigidity (e.g.: long, bent, bending or folded sheets or parts).

When entering into contact with a surface for the first time, the end-effector will pull back for it has reached the force/torque value entered at steps 2a and/or 2b. It will then go back to the surface and apply the same force/torque values while pulling back less and less over time.
**Current vs targeted position**

From the Force Control node, you can choose to either:

- Apply force at the current position
- Apply force based on a targeted position
Tip

- Use the targeted position option when your defined trajectory is close to the actual part that will be processed within the Force Control node.
- Use the current position option when your defined trajectory may not resemble to the actual part that is being processed.

Motion Frame

From the Force Control node, it is possible to choose your feature among:

- Tool
- Base
- Motion Frame
The motion frame option allows to apply constant forces and torques along a path. The X axis represents the motion direction, the Z axis is perpendicular to the X axis and is close to the robot’s Z axis.
**Test**

The Test button applies the user-defined settings of the Force Control node to the sensor, therefore moving along/around the corresponding axes, if the control had been enabled for the latter, regardless of other instructions entered before or after the Force Control node in the program tree.

### Force Control

<table>
<thead>
<tr>
<th>Feature</th>
<th>Tool</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable control</td>
<td>Force/Torque</td>
<td>Stiffness</td>
</tr>
<tr>
<td>x</td>
<td>Fx</td>
<td>5 N</td>
</tr>
<tr>
<td>y</td>
<td>Fy</td>
<td>0 N</td>
</tr>
<tr>
<td>z</td>
<td>Fz</td>
<td>0 N</td>
</tr>
<tr>
<td>Rx</td>
<td>Mx</td>
<td>10 Nm</td>
</tr>
<tr>
<td>Ry</td>
<td>My</td>
<td>0 Nm</td>
</tr>
<tr>
<td>Rz</td>
<td>Mz</td>
<td>0 Nm</td>
</tr>
</tbody>
</table>

- Enable adaptive stiffness

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**ROBOTIQ**
4.1.7. Force Event

The Force Copilot software package includes Force Event, which can be used to perform a click detection or to wait for a specific force or torque.

How to add a Force Event function

- On the teach pendant, tap the **New** button to create a program or the **Open** button to load a program
- Tap the **URCaps** button in the navigation pane on the left
- Select **Force Event**
- Tap the **Force Event** node in the robot program to edit it
- Select an operation to add to the **Force Event** sequence

1. **Wait for Force** function
   - The Wait for force feature is used to detect a specific force or torque inside a Force Control node.

2. **Click** detection function
   - The Click Detection feature is used to detect a drop that is followed by a rise of a force or a torque.

**Features (Click Detection)**

The Click Detection feature monitors forces and torques throughout the nodes placed within it. This feature senses if a drop in the force or torque is then followed by a sudden rise, thus making a “click”. If a click is detected within the Click detection node, the program then skips the remaining instruction lines that are included in the Click detection node. The program automatically goes to the following instruction.

Indeed, a program instruction can be added if no click is detected.
**Force Event**

*Click*

Use the force torque sensor data to detect a drop in force (click) when inserting a connector, pushing a button, etc.

- Force drop: 10 N
- Torque drop: 1 Nm

**Tip**

To perform a click button action, as shown by the animated gif, a Find Surface function has to be added up in the Click detection node.
Features (Wait for Force)

The Wait for Force feature is used to detect a specific force or torque inside a Force Control node. The program waits until the force or torque is reached prior to the program continuation. The values are defined by the Force Control's force and torque parameters. To be sure the program is not incessantly running, a Timeout option is available.
4.1.8. Collision Detection

The Collision Detection feature is used to stop a program when the forces and the torques, monitored by the embedded e-Series sensor, exceed the defined limits. By default, the program does not monitor forces and torques.

How to add a Collision Detection

- On the teach pendant, tap the **New** button to create a program or the **Open** button to load a program.

- From the **Installation** tab:
  - Go to the **Installation** tab and tap the **URCaps** submenu.
  - Select **Force Copilot**.
  - Tap the **Configuration** tab to edit it.

- From the **Program** tab:
  - Tap the **URCaps** button in the navigation pane on the left.
  - Select **Collision Detection**.
  - Tap the **Collision Detection** node to edit it.

You can either choose to halt (stop) or suspend (pause) the program when a collision is detected. The forces and torques monitored in the collision detection node are the ones measured by the embedded sensor. Thus, any forces or torques applied to the robot arm will not be detected. Only those applied to the end-of-arm tooling are monitored.

The Collision Detection feature in the installation tab can be configured to start the monitoring upon every robot program start. On the other hand, the Collision Detection node in the Program tab starts a thread that runs in parallel with the rest of the robot. 
program. If the Stop monitoring option is selected in the Collision Detection node, the thread stops and the program continues without monitoring the force or the torque.

4.1.9. Multipoint Path Node

The Multipoint Path node is an advanced version of the Path node, combining complex trajectory recording and point-to-point teaching, with the option to define each segment as a straight line or as a curve.

**Tip**
Try inserting a Multipoint Path node in a Robotiq Force Control node. The former will perform the movements that were taught while taking into consideration the parameters set in the latter.

**How to add a Multipoint Path node**

- On the teach pendant, tap the **New** button to create a program or the **Open** button to load a program
- Tap the **URCaps** button in the navigation pane on the left
- Select **Multipoint Path**
- Tap the **Multipoint Path** node in the robot program to edit it

![Multipoint Path node](Fig. 4.10: Multipoint Path node (empty))

**Info**
Please note that a Multipoint Path parent node is always followed by a MoveJ command leading to the starting waypoint of the path sequence.
How to set up a Multipoint Path

Step 1

- Select the **MoveJ To waypoint** child node in the program tree.
- A menu will display in the **Command** tab.
- Using the Freedrive mode or the UR Move menu, move the robot arm to the position you want to be the starting point of your Multipoint Path.
- Tap the **Set waypoint** button. The UR waypoint interface will pop up and ask you to define the waypoint.
- Adjust the position if needed, then press **OK**.

At this point, the interface will look like this:

1. Tap the **Edit waypoint** button to open the UR waypoint interface and adjust the position of the robot arm (this works for every waypoint of the Multipoint Path).
2. Tap the **Delete** button to cancel the waypoint (deleting the starting waypoint will turn it to unassigned).
3. Tap and hold the **Move here** button to make the robot arm travel to the corresponding waypoint.
4. Tap the **Add line** button to let the system know that a **straight line** will be linking the current waypoint and the next waypoint.
5. Tap the **Add curve** button to let the system know that a **curve** will be linking the current waypoint and the next waypoint.

**Important**

Whether the path is made of straight lines, curves or a mix of both, it inevitably passes through each waypoint set by the user.

**Important**

The curve segments are not generated and/or represented according to a spline model; they are rather based on Bézier curves.
Info
For describing the continuity of the curves used in the Multipoint Path node, control points are generated on the bisector of each waypoint junction (angle). Curves are therefore tangent to those bisectors.

Step 2
- Using the Freedrive mode or the UR Move menu, move the robot arm to the next desired position.
- Add another waypoint in the program tree by tapping the Add line or Add curve button.

![Waypoint Interface](image.png)

Fig. 4.11: Multipoint Path interface with Line/Curve options.
Caution
Adding several waypoints (lines or curves) without moving the robot in between them will result in the generation of identical waypoints.

In order to remedy this situation, the user can edit each waypoint created and adjust its position.

Tip
You can toggle at any time between the **Line to waypoint** and **Curve to waypoint** options.
Select the waypoint in the program tree and tap the appropriate radio button in the **Command** tab.

Repeat step 2 until you complete your Multipoint Path.

![Diagram](image)

*Fig. 4.12: Representation of a six-waypoint Multipoint Path with both curves and straight lines.*
5. Troubleshooting

5.1. Troubleshooting on Universal Robots

5.1.1. Monitoring the Sensor state

In order to view the sensor status and verify the force and torque values:

- Tap the Installation button in the ribbon at the top of the screen
- Select the URCaps menu in the navigation pane on the left
- Tap Copilot
- Tap the Dashboard tab

Info

If needed, the user can tap the About tab to get further information regarding the force torque sensor.

Dashboard

About

Force Copilot Licensed

<table>
<thead>
<tr>
<th>Force Values</th>
<th>Moment Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fx = -0.6 N</td>
<td>Mx = 0.00 Nm</td>
</tr>
<tr>
<td>Fy = -2.2 N</td>
<td>My = -0.06 Nm</td>
</tr>
<tr>
<td>Fz = -1.3 N</td>
<td>Mz = 0.05 Nm</td>
</tr>
</tbody>
</table>

Zero sensor

☐ Show ActiveDrive toolbar
6. Warranty

Robotiq warrants the Force Copilot against defects in material and workmanship for a period of one year from the date of reception when utilized as intended.

6.1. Exclusions

Robotiq reserves the right to make changes in the design or construction of any of its products at any time without incurring an obligation to make any changes whatsoever on units already purchased.

This warranty excludes failure resulting from: improper use or installation, normal wear and tear, accident, abuse, neglect, fire, water, lightning or other acts of nature, causes external to the product or other factors beyond Robotiq's control.
7. Contact

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Appendices

Appendix A – Applied Standards

Coming soon.