Force/Torque sensors
URCaps Software

This document is a URCaps manual for Bota Systems Force/Torque sensors

Revision 1.2

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1 Table of Contents

2 Safety

The safety section describes general safety guidelines for the product(s), an explanation of the notifications found in this manual, and the safety precautions applicable to the product(s). More specific notifications are embedded within the sections of the manual where they apply.

2.1 Explanation of notes

The notifications included here are specific to the products covered by this manual. The user should also be aware of the notifications of other components from other manufacturers installed in the system /robot.

DANGER: Indicate[s] a hazardous situation which, if not avoided, will result in death or serious injury. The signal word "DANGER" is to be limited to the most extreme situations. DANGER [signs] should not be used for property damage hazards unless personal injury risk appropriate to these levels is also involved.

WARNING: Indicate[s] a hazardous situation which, if not avoided, could result in death or serious injury. WARNING [signs] should not be used for property damage hazards unless personal injury risk appropriate to this level is also involved.

CAUTION: Indicate[s] a hazardous situation which, if not avoided, could result in minor or moderate injury. CAUTION [signs] without a safety alert symbol may be used to alert against unsafe practices that can result in property damage only.

NOTICE: Notification of specific information or instructions about maintaining, operating, installation, or setup of the product that if not followed could result in damage to equipment. The notification can emphasize but is not limited to specific grease types, good operating practices, or maintenance tips.

2.2 General safety guidelines

The user should verify that the Force/Torque sensor is rated for maximum loads and torques expected from the operation. The user should be aware of the dynamic loads caused by the robot during acceleration or deceleration of the mounted masses.

2.3 Safety precautions

WARNING: Performing maintenance or repair on the sensor, while circuits (e.g. power, water, and air) are energized could result in serious injury. Discharge and verify all circuits are deactivated in accordance with the user's safety practices and policies.

CAUTION: Modifying or disassembly of the sensor could cause damage. Use the robot or adapter mounting bolt pattern and the tool side mounting bolt pattern to mount the sensor to the robot and user tooling to the sensor. Refer to the Force/Torque sensor model drawings and specifications sheet for more information.

CAUTION: Using fasteners that exceed the user mounting bolt pattern interface depth penetrates the body of the sensor, potentially damaging the electronics. Refer to the Force/Torque sensor model drawings and specifications for more information.

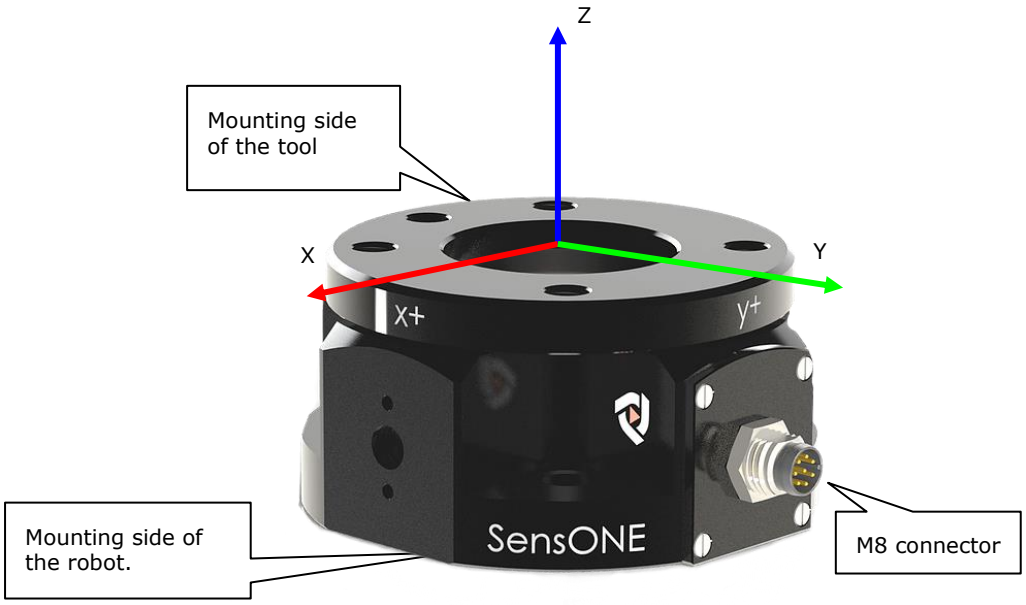
CAUTION: Do not overload the sensor. Exceeding the single-axis overload values of the sensor, causes irreparable damage.

CAUTION: Overload values refer to static overloading the sensor. This shouldn't be confused with the dynamic loading. The sensor should be dynamically loaded at the rated values of force and torque.

3 Sensor overview

The Bota Systems F/T sensor system measures (6) components of force and torque (Fx, Fy, Fz, Mx, My, Mz) and streams data to user devices that use Serial or EtherCAT communication. The sensor has two mounting sides. These sides are the connecting mechanical interfaces of the sensor. Refer to the Force/Torque sensor model drawings and specifications for more information. The sensor is IP67 rated. An IP67 rated connector is for the cable assembly provided with the sensor. The sensor is powered through this connector. For the electrical connector pin assignments, refer to the user manual. The Bota Systems sensors provide resolved force and torque data measured in N and Nm accordingly. Each F/T sensor model has its own reference frame which is shown in its specification sheet.

Figure 1 – Example sensor Illustration : SensONE



NOTICE

NOTICE: The Sensor is powered through the cable connector. The USB version is powered directly from the USB port.

4 Installation

The Bota Systems URcap software is tested for PolyScope version 3.15 and later (cb-series) or 5.11 and later (e-series).

4.1 Mounting of the sensor

For instruction about mounting the sensor please have a look at our step-by-step tutorial on how to mount the sensor to the robot flange and on how to mount the SensONE Universal Robot kit.

The sensor can be directly mounted to the robot flange without adapters. Please make sure to only use the provided screws for tightening the sensor. All screws are accessible from the mounting side of the tool for tightening. Use the provided pin for the correct alignment of the sensor. In case an intermediate part is mounted between the robot flange and the sensor, make sure that the pin of on the mounting side of the robot and the pin of the robot flange are aligned.

NOTICE: The markings of the sensor about the X- and Y-axis are not aligned with the standard robot tool frame.

4.2 Installation of URCap software for Universal Robots

- Copy the file BotaFTInterface-X-X.urcap to a USB stick
- Insert the USB stick in the robot teach pendant, robot controller, or USB hub connected to the robot controller
- On the teach pendant, tap the triple bar icon in the upper right corner of the screen
- Select Setting
- Tap System in the navigation pane on the left and select URCaps
- Tap the Plus (+) button to display the storage device (USB stick) and browse for the URCap file
- Tap the BotaFTInterface-X-X.urcap to select it.
- Tap the Open button.
- Tap the Restart Button to complete the URCap installation. By doing so, you accept the license agreement detailed in the URCap information box.

4.3 Uninstalling the URCap software

- On the teach pendant, tap the triple bar icon in the upper right corner of the screen
- Select Setting
- Tap System in the navigation pane on the left and select URCaps
- Select the 'Bota Systems FT Sensor Interface' URcap and tap the Minus (-)
- Tap the Restart Button to complete the uninstallation

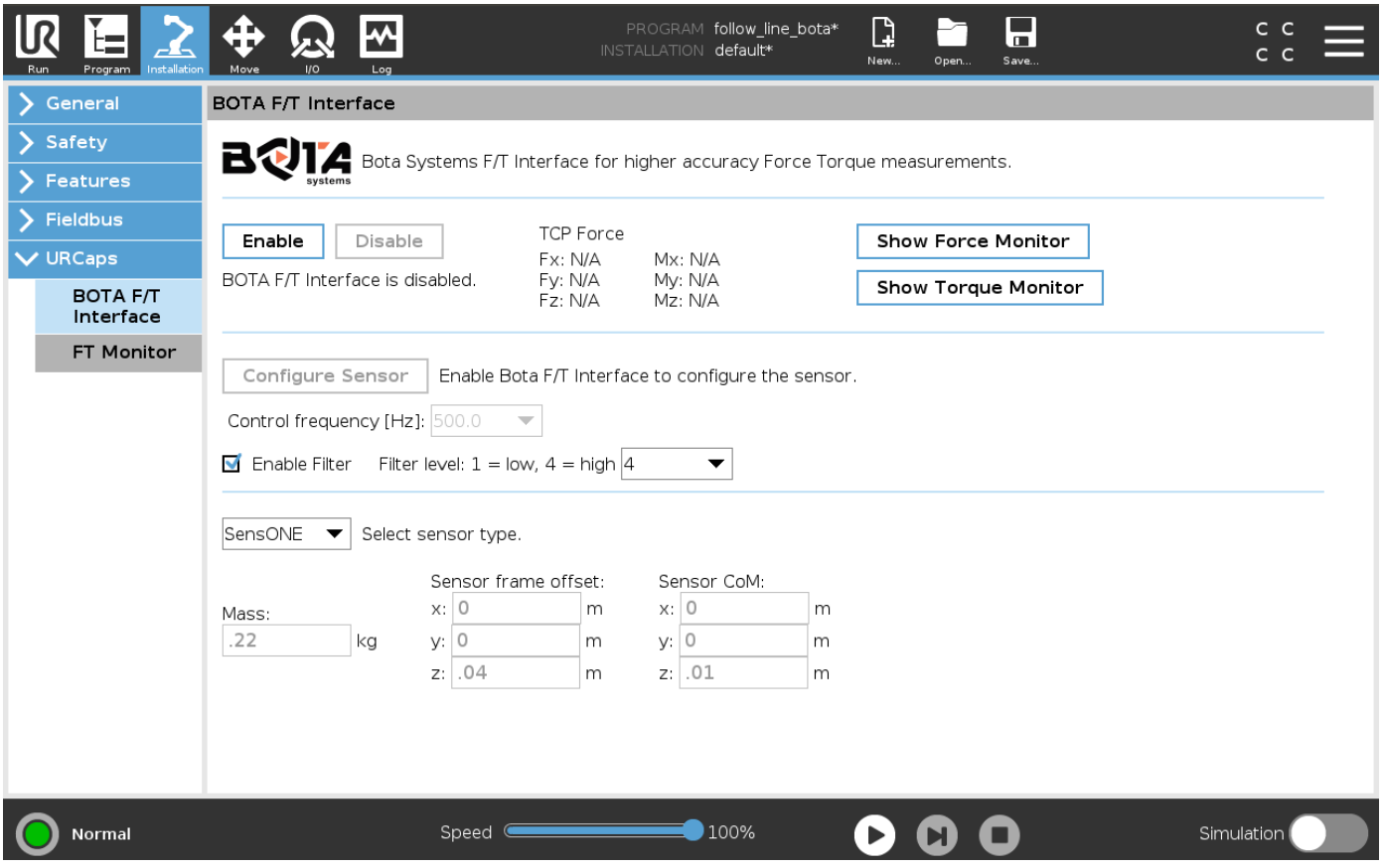
5 Software

In order to write programs that are using the Bota Systems force torque sensor (program nodes), external F/T measurements need to be enabled. The installation interface of the URCap allows to enable/disable the external sensor readings and configure the sensor configuration. Make sure that the sensor is connected (4.1) before continuing with the following instructions.

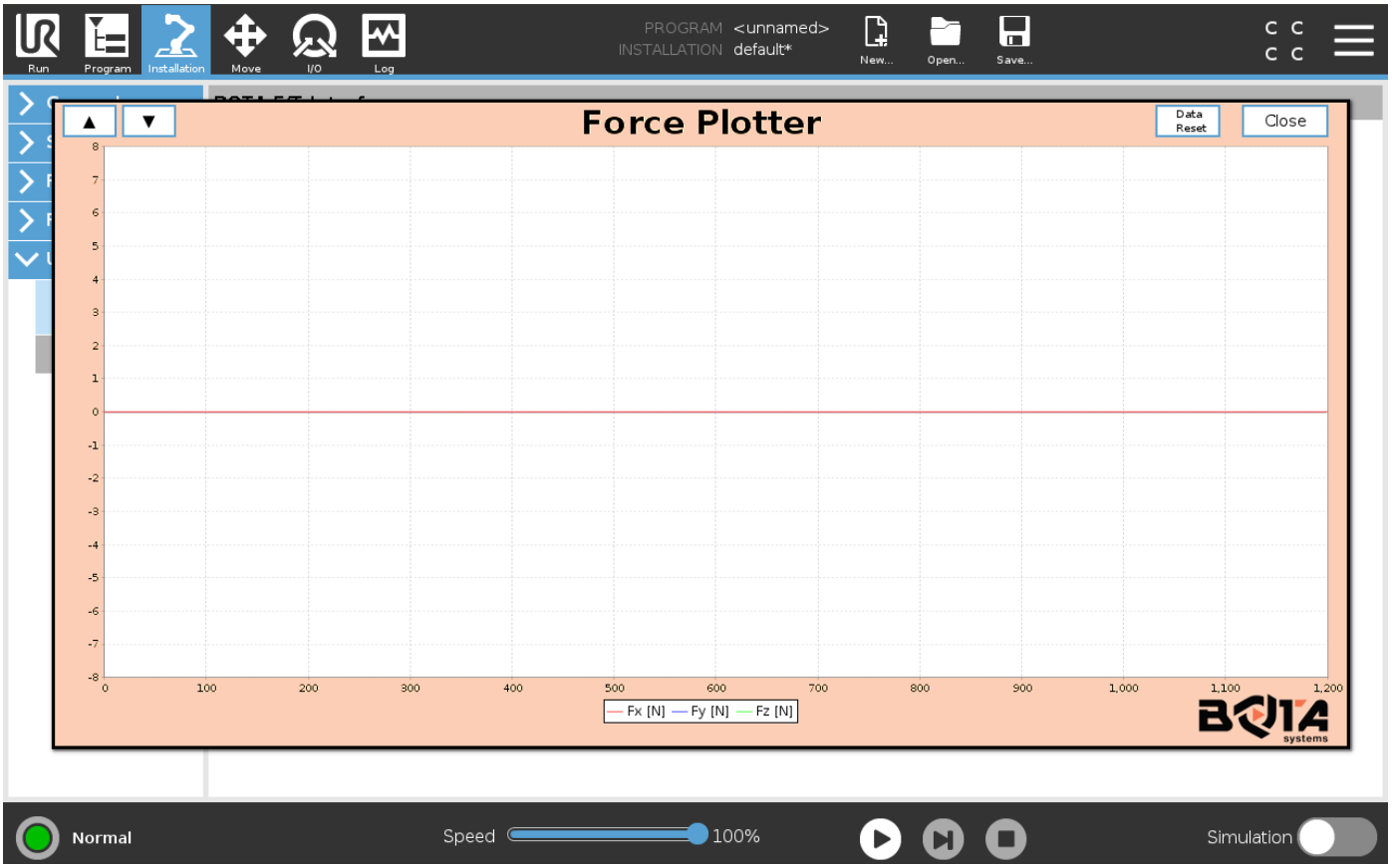
5.1 Installation Node

The setup of the installation node usually only needs to be done before the first usage of Bota Systems URCap. The external F/T measurements remain enabled/disabled after restarting the robot. To enable the Sensor and configure it, refer to the following steps:

- On the header, select the **Installation** icon
- In the menu on the left tap on **URCaps**
- Tap on **BOTA F/T Interface**
- Press the **Enable** button, wait for 5 sec. Note that you can see the current TCP force after enabling the sensor. However, only after starting a program it will use the external F/T sensor
- After enabling the BOTA F/T Interface, configure the sensor by pressing the **Configure Sensor** button. This will adjust the filtering to the selected update rate and safe the configuration on the sensor itself. We recommend using the default settings. Optionally, filtering can be disabled to achieve faster response time by reducing the filter level or disabling the filter (uncheck **Enable Filter**). The sensor needs to be configured only before the first use or after changing the settings.
- Optionally: select the sensor type or keep the default (SensONE, recommended)



To ease the setup of your application, there is the option to plot the forces and torques. Tap either on **Show Force Monitor** or **Show Torque Monitor** to open a window that shows the current force or torque stream (containing the last 1200 measurements). Tap on Close to close the window again and return to the installation menu. Note that you can see the current TCP force after enabling the sensor. However, only after starting a program it will use the external F/T sensor.



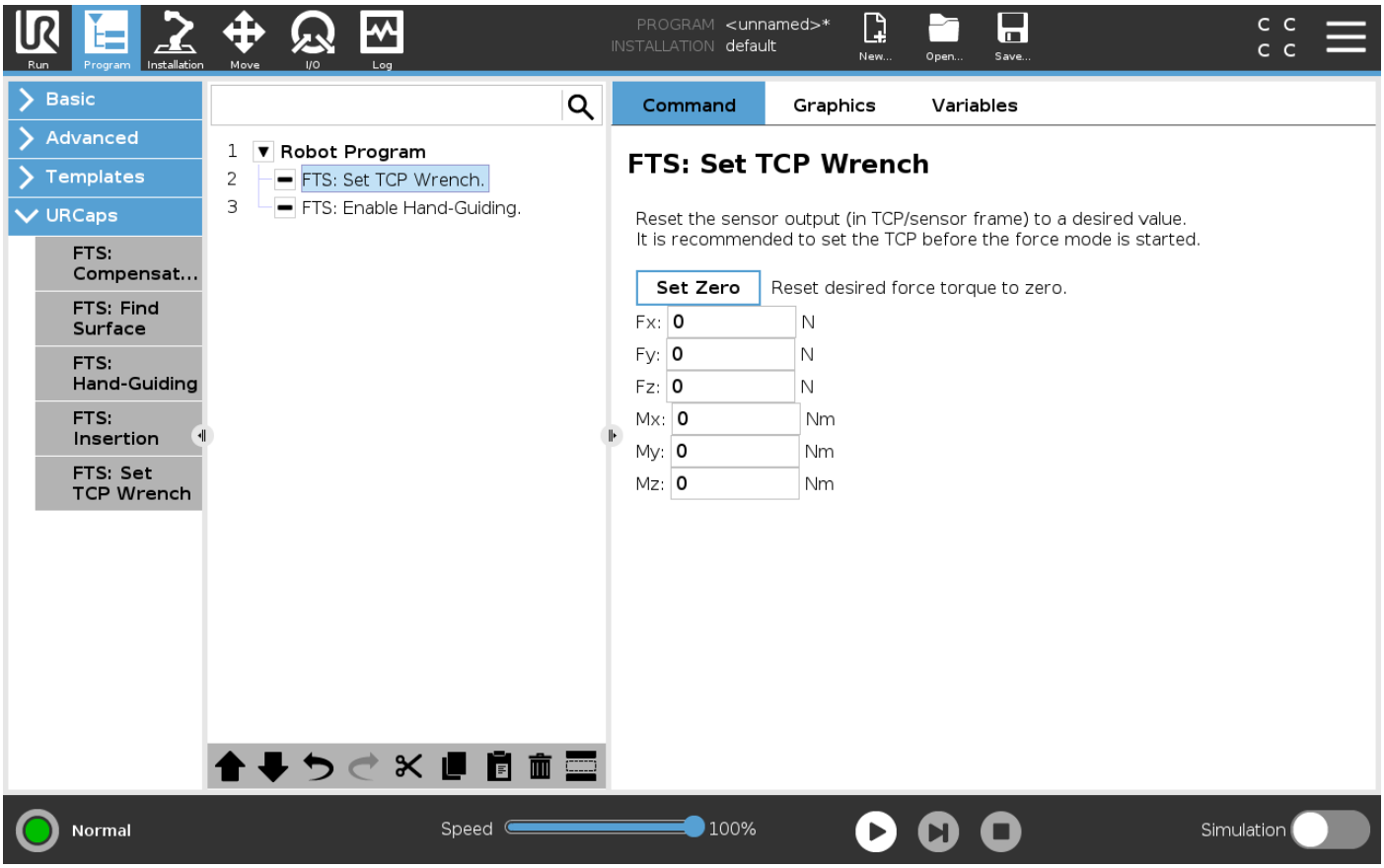
5.2 Programming nodes

The following program nodes are available under:

- On the header, select the **Program** icon
- In the menu on the left tap on **URCaps**
- Tap on **FTS: xxx**

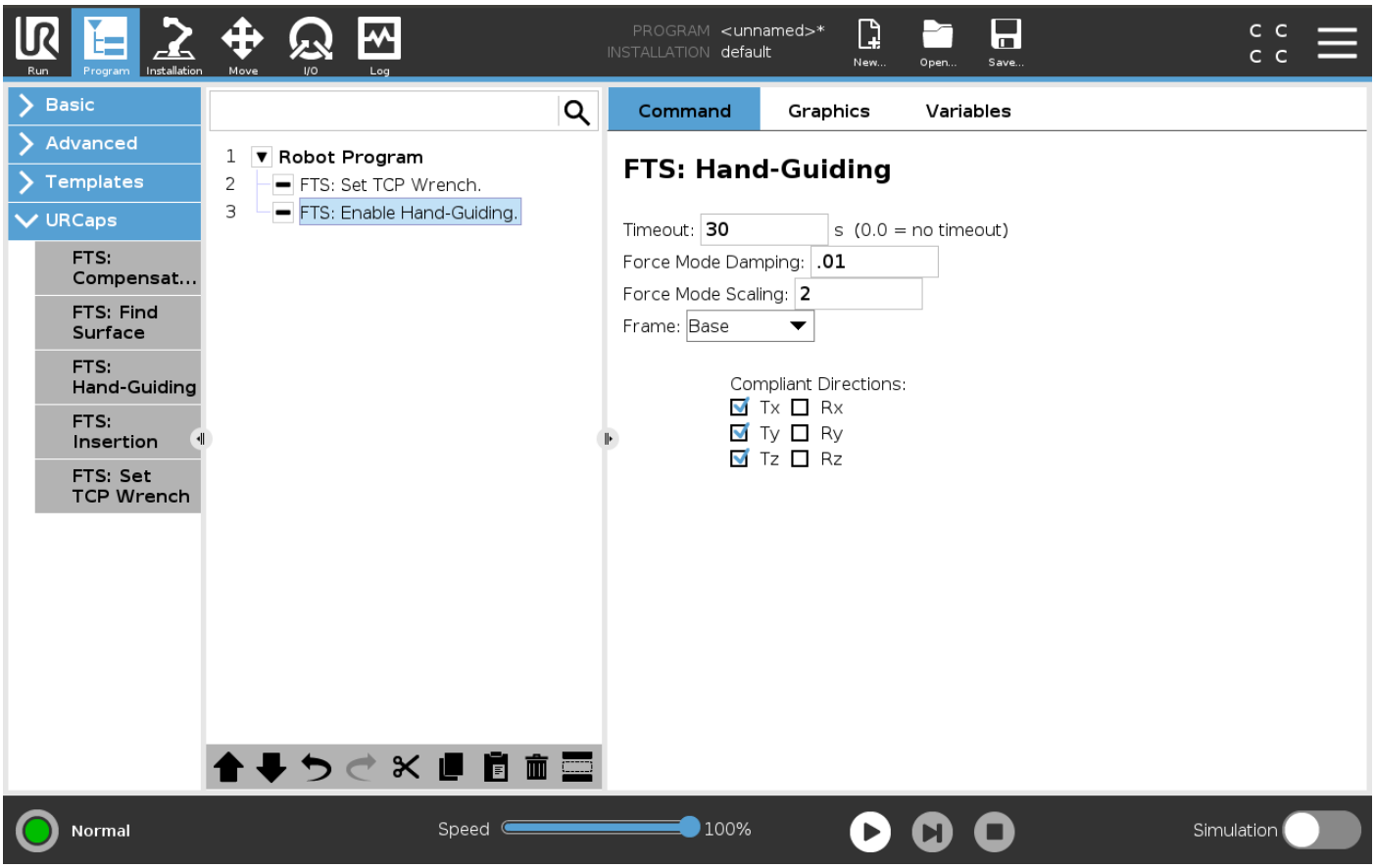
5.2.1 F/T sensor: Set TCP Wrench

This program is used to reset the bias of the sensor. By inserting this program node it is possible to reset the sensor output (in TCP/sensor frame) to a desired value at an arbitrary point in a custom program. It is recommended to set the TCP before the force mode is started.



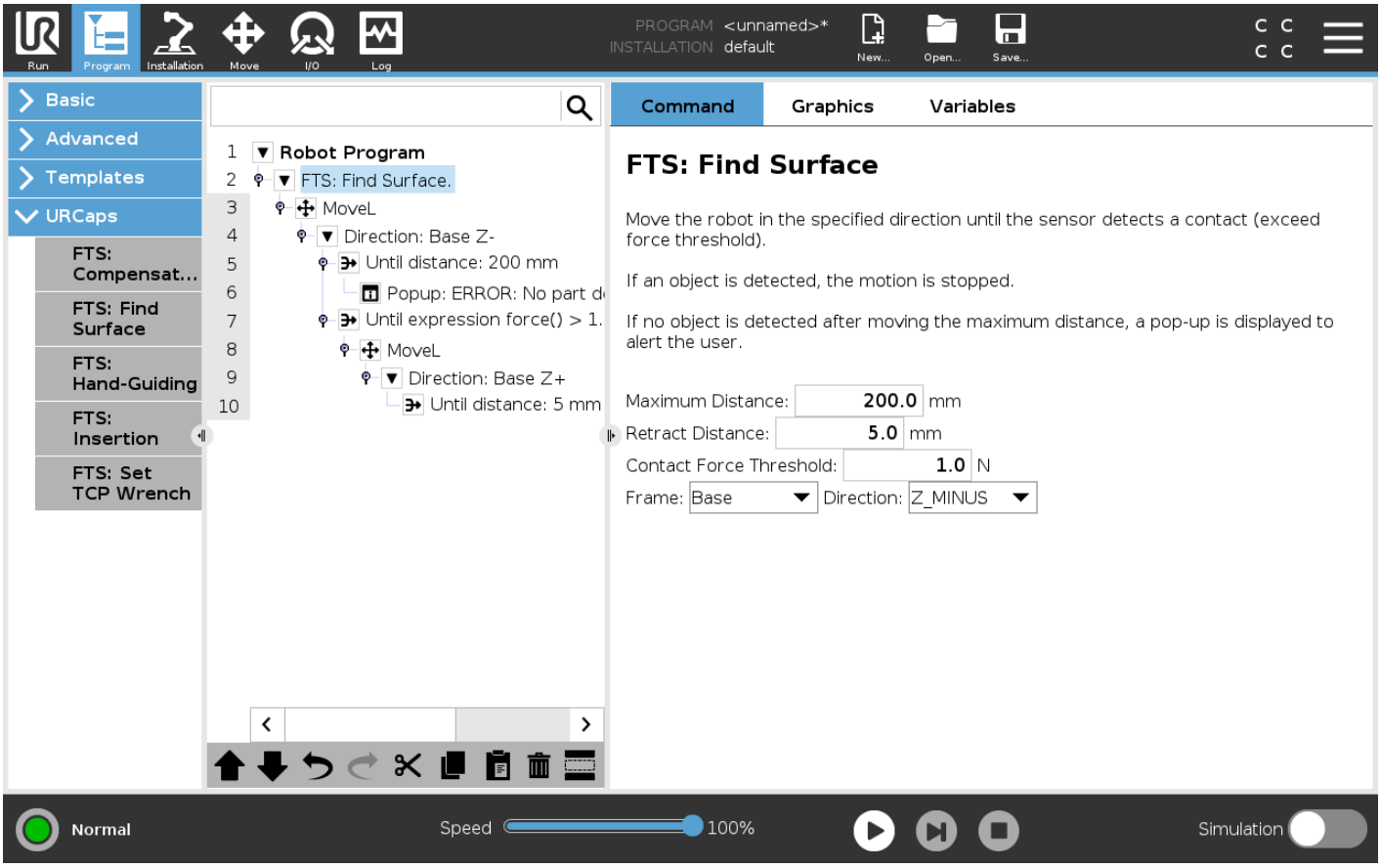
5.2.2 F/T sensor: Hand-Guiding

The hand-guiding mode allows to move by applying forces and moment to the tool attached to the sensor (entering the force mode). The compliant directions can be selected in the base or the tool frame. After acknowledging the popup message or after the timeout, the hand-guiding motion is finished and the robot mode is reset from force mode to normal mode. If the timeout is set to zero (timeout = 0.0), no timeout will be applied and the program is continued by acknowledging the popup message.



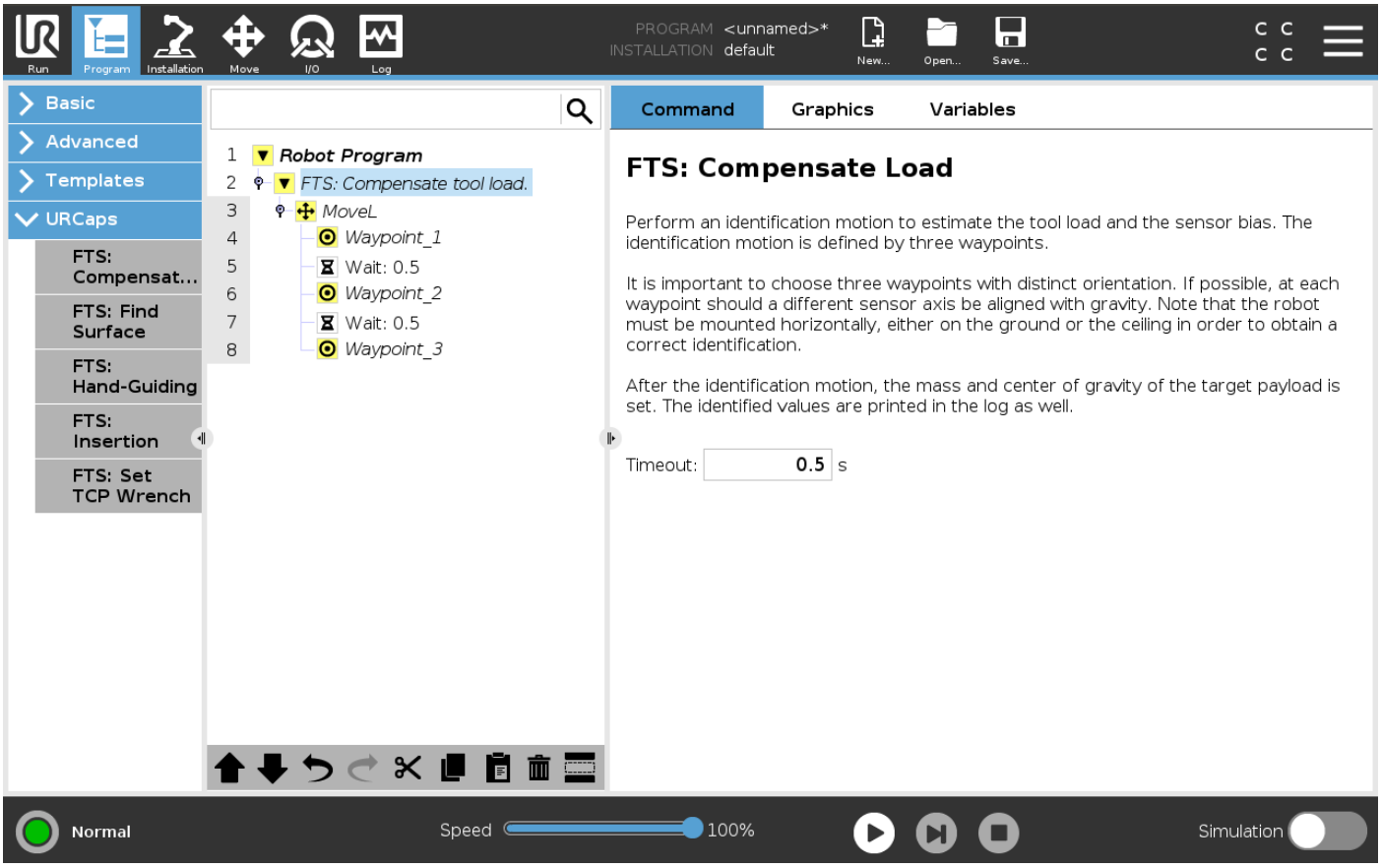
5.2.3 F/T sensor: Find Surface

Move the robot in the specified frame and direction until the sensor detects a contact (exceed force threshold). If an object is detected, the motion is stopped, and the arm is retracted (default = 5mm). If no object is detected after moving the maximum distance, a pop-up is displayed to alert the user.



5.2.4 F/T sensor: Compensate Tool Load

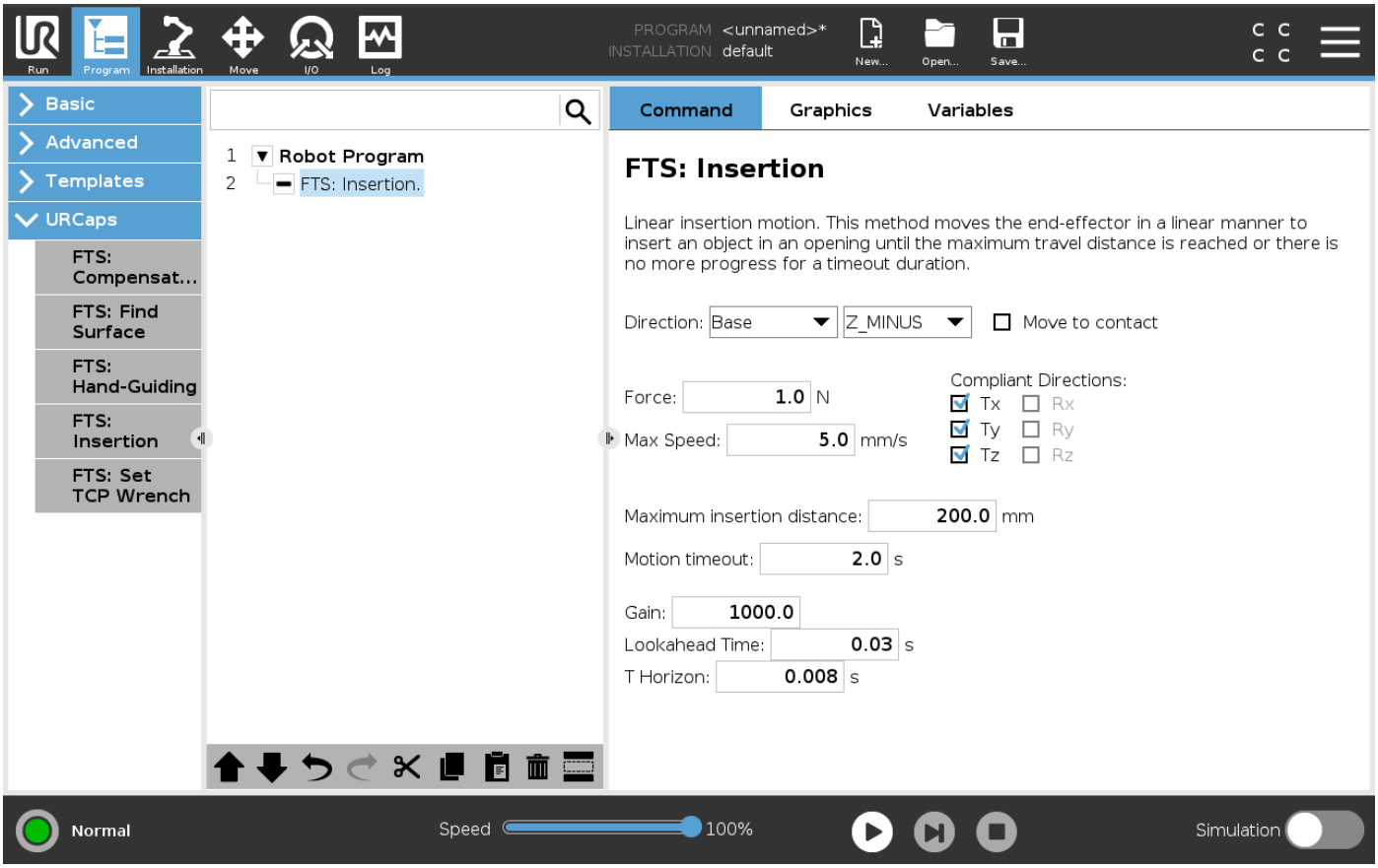
This program can be used to identify the inertial parameters of a new payload. It performs an identification motion to estimate the tool load and the sensor bias. The identification motion is defined by three waypoints. It is important to choose three waypoints with distinct orientation. If possible, at each waypoint should a different sensor axis be aligned with gravity. After the identification motion, the mass and center of gravity of the target payload is set. The identified values are printed in the log as well.



Note that the robot must be mounted horizontally, either on the ground or the ceiling in order to obtain a correct identification.

5.2.5 F/T sensor: Insertion

Move the robot along a linear direction in the base frame for an insertion motion. This method moves the end-effector in a linear manner in the specified direction to insert an object in an opening until the bottom or maximum motion distance is reached.



6 Sensor Maintenance

6.1 Inspection

If the sensor is used in applications that frequently move the system's cabling and dismount the connector, the cable jacket and connector pins should be checked for signs of wear. The Bota Systems sensors are IP67 rated. Debris and dust should be kept from accumulating on or in the sensor if the Seals that provide dust and water protection are broken.

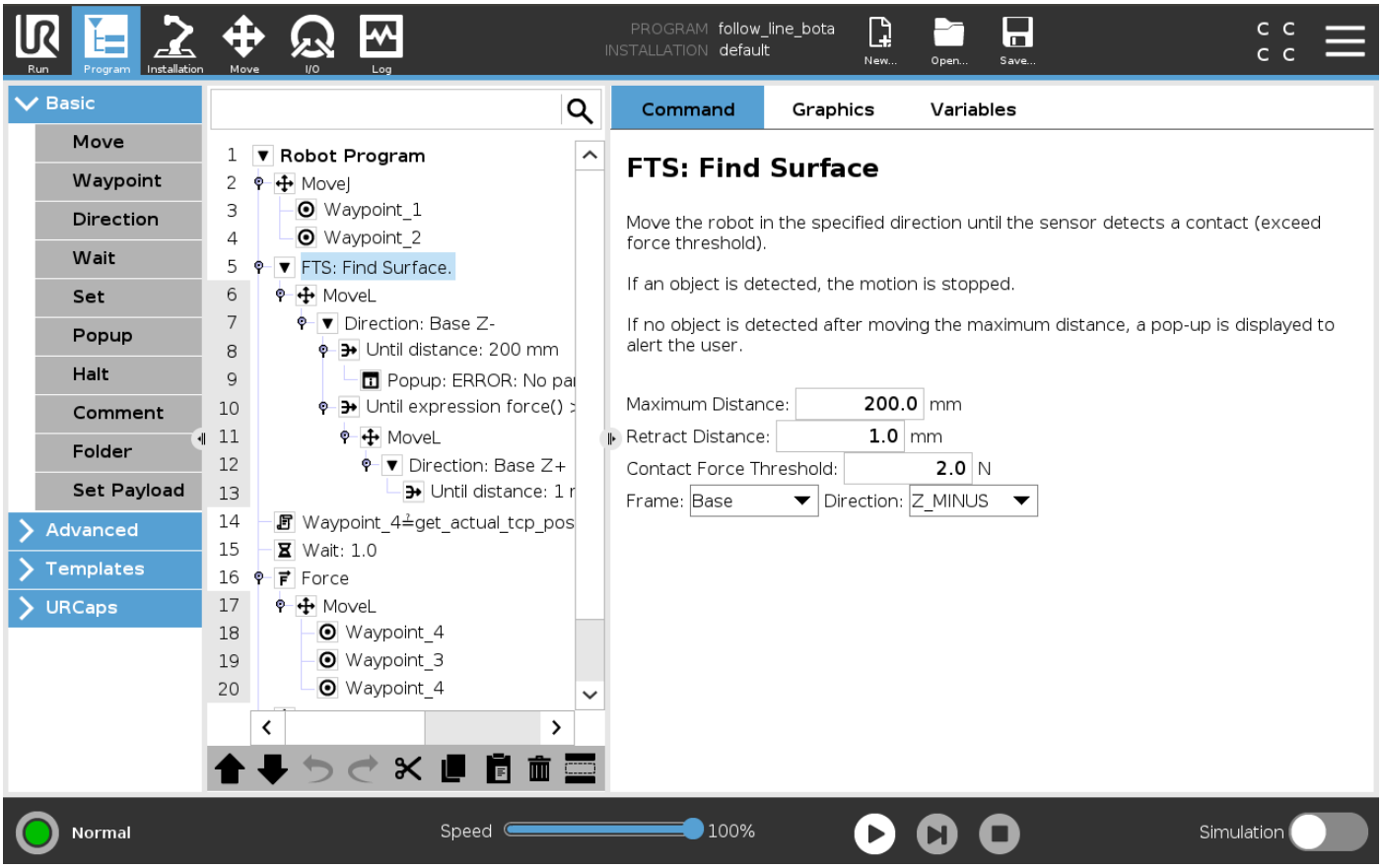
6.2 Calibrating

Periodic calibration of the sensor and its electronics is required to maintain traceability to international standards. Applicable ISO-9000-type standards for calibration should be followed. It is recommended annual re-calibrating, especially when the sensor is used in cycle loads applications. The best practice would be to send it back to us for recalibration.

7 Example Programs

7.1 Follow Line (follow_line_bota.urp)

This program is a basic example for contour following for processes like polishing and grinding. It uses the **F/T sensor: Find Surface** node to establish gentle contact with a surface. Afterwards, the force control capability of UR with the external FT sensor are used to follow the surface and apply a constant force.



7.2 Tool Load Identification (tool_load_identification_bota.urp)

This program shows how to use the **F/T sensor: Compensate Tool Load** node. This node performs an identification motion to estimate the tool load and the sensor bias. The identification motion is defined by three user defined waypoints. It is important to choose three waypoints with distinct orientation. If possible, at each waypoint should a different sensor axis be aligned with gravity. After the identification motion, the mass and center of gravity of the target payload is set. The identified values are printed in the log as well. In this example program the hand guiding is activated after identifying the tool load.