SD35

Collaborative End-of-arm screwdriver tool

User manual v0.3 (original, en)

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Table of contents

1 Introduction

SD35 is compatible with the Universal Robots e-series and can be mounted on the UR3e, UR5e, UR10e and UR16e Robots.

1.1 Scope of the Manual

This manual covers the SD35 collaborative screwdriver and its components with described software versions:

Name	Software version
URCap	**V0.2.2**

Name	Software version
SpinBridge	**V0.1.0**

Name	Software version
SD35	**V0.1.0**

1.2 Copyright Statement

2 Technical Datasheet

Bit drive	¼"/6.35 mm hexagonal 50mm
Screw capacity	M2-5
Screw length within full safety	35 mm
Torque range	0.8 -3.5 Nm
Speed range	100-750 rpm
Power supply	48 V dc, 10A
Motor power	70W (continuous)
Temperature range	0-50°
Buttons	1 x Freedrive button (blue) 1 x Configurable button (metal)
Light signaling	LED strip - RGBW
Screw detection	Integrated in safety shield, patented technology
Tool changer	Included, "SpinMount"
Mechanical interface	ISO 9409-1, type 50-4-M6
Electric interface	8-pole M12 (signal) 4-pole M12 (power) 8 x digital input 8 x digital output (npn/pnp 24V)
Digital interface	URCap (URSoftware ≥ 5.9) UR scripts Ethernet socket (Modbus TCP) 24V I/O (PNP input/output)
IP Classification	IP53
Dimension (safety shield fully extended)	54 x 325 x 159 mm
Safety shield diameter	Ø15 mm
Weight	2.39 kg
ESD safe	Yes

3 Safety

You must read, understand, and follow all safety information in this manual and in the Universal robots' manual. You must also follow manuals for all associated equipment, if in use, before initiating robot motion. Failure to comply with safety guidelines could result in death or serious injury.

The information in this manual does not cover designing, constructing, and running a complete robot solution, nor does it cover other external equipment that can influence the safety of the complete robot system.

The complete robot system must be designed and installed in accordance with the safety requirements, set forth in the standards and regulations of the country where the robot and tool are installed. The robot integrator or user are responsible for that, including but not limited to:

a. Performing a risk assessment for the complete robot system e.g., in accordance with ISO12100
b. Interfacing other machines and additional safety devices if defined by the risk assessment
c. Setting up appropriate safety settings in the robot software
d. Ensuring that the user cannot unintentionally modify any safety measures
e. Validating that the total robot system is designed and installed correctly
f. Specifying instructions for use
g. Marking the robot installation with relevant signs and contact information of the integrator
h. Collecting all documentation in a technical file; including the risk assessment and this manual

Any safety information provided in this manual must not be construed as warranty, by Spin Robotics Aps that the robot application will not cause injury or damage, even if robot application complies with all safety instructions. Spin Robotics Aps disclaims all liability if any of Spin Robotics tools are damaged, changed or modified in any way. Spin Robotics Aps cannot be held responsible for any damages caused to any of Spin Robotics tools, the robot, any other equipment, or humans due to programming errors or malfunctioning of any of Spin Robotics tools.

3.1 Intended Use

SD35 is intended to be used as end-of-arm tooling on industrial robots in automatic screw-assembly applications. Screwdriving applications are defined by applications where threaded objects are used for fastening parts. The tool is made for indoor and dry operating conditions, limited to a temperature range of 0-50°.

Any use or application deviating from intended use is deemed to be impermissible misuse. This includes, but is not limited to:

- Use in potentially explosive atmospheres
- Use in medical and life critical applications
- Use before performing a risk assessment
- Use outside the permissible operational conditions and specifications
- Use close to a human's head, face and eye area

- Use in other applications then screwdriving e.g., polishing, grinding, de-burring applications

3.2 General Safety Instructions

Generally, all national regulations, legislations, and laws within the country of installation must be observed. Integration and use of the product must be done with the precautions explained throughout this manual. Particular attention must be paid to the following warnings:

• You must not power-on SD35 if it is/has been exposed to condensing conditions. If condensing conditions appear during transport or storage, the product must be placed between 20 and 40 Celsius degrees for 24 hours before power is applied or before connected to a robot.

• It is recommended that the use of SD35 follows these standards:

- **ISO 10218-2**
- **ISO 12100**
- **ISO/TR 20218-1**
- **ISO/TS 15066**

Always ensure to power off the SD35 tool and SpinBridge while working/installing the physical installation.

3.3 Risk Assessment

The robot integrator must perform a risk assessment of the complete robot application. SD35 is only a component in a robot application. Safe use of SD35 relies on the integrators ability to design a safe robot application.

SD35 is designed with features especially suitable for collaborative applications:

- Smooth and rounded design without any sharp edges or pinch points.
- Linear compliance and build in certified safety sensor.
- Safety shield shielding the rotating bit and pointy screws thereby protecting humans from sharp, rotating elements.
- Light and sound signals making tool operations more predictable.

Spin Robotics have identified the potential hazards listed below as significant hazards that must be addressed by the integrator:

- Injuries due to collisions between humans and robot, tool, or other obstacles.
- Minimizing the risk that human limbs can be placed at the screw action positions.
- The robot installation is placed too close to large obstacles e.g., walls and other machines resulting in humans is wedged in between the robot and the obstacle.
- Consequences if SD35 cable get stuck to equipment/personal.
- Consequences due to lose bolts not tightened correctly.

Before start using the SD35 screwdriver tool in a collaborative application together with a Universal Robot, please **insure** the following:

- Ensure that the SpinMount tool flange is fastened sufficient, the supplied M6 screws are used and that the small Ø6 dowel pen is used together with the four M6 screws
- Ensure that no electrical wires are modified
- Robot speed is set to maximum 250 mm/s when approaching the screw location.
- Ensure that the front LED of the SD35 is enabled. (Blinking yellow when the robot is moving).
- Ensure that the S1 variable at the Insert Screw program node in the URCap is set no higher than 6 mm to avoid danger of crushing body parts between the SD35 tool and object. See description in 3.4.1
- The safety shield is not removed and are functioning.
- Ensure that screw longer than 40 mm is not used in collaborative applications where no additional safety system is utilized. See description in 3.4.1.
- Ensure that the programmed robot paths are not moving the tool in a height where the tool can be near a human head
- Ensure that the screwdriver approaches the screw insertion position perpendicularly (90 degrees), in the trajectory of the z-axis to avoid contact with sharp edges of the safety shield. See description in Section 3.4.3.
- Ensure that the included cable binders are used to fasten the power and signal cable to the robot arm to avoid human arms and head to be entangled between the robot and cables
- Ensure that the Safety cable is correctly installed between the SpinBridge and the robot controllers Emergency stop input terminals.

Before start using the SD35 screwdriver tool in a collaborative application together with a Universal Robot, the robot integrator **could** consider the following:

- Setting up safety zones in the Universal robot software that minimizing dangerous robot trajectories by setting safety planes. Please see the Universal Robot Manual for further instructions.
- Add extra safety sensors in fixtures and other equipment to avoid the robot to run without a product is ready in the fixture. This avoids human limbs getting crushed due to missing parts.
- If dangerous robot trajectories cannot be avoided ensure that the user of the robot uses other safety measures like eye protection and/or helmet and that humans are protected to get close to the robot during the dangerous robot movements.

Video tutorials with recommendations for installing a collaborative safe installation are found at https://spin-robotics.com/ and https://www.youtube.com/channel/UCmKWd0ZAnIr_86hfnB9we4g

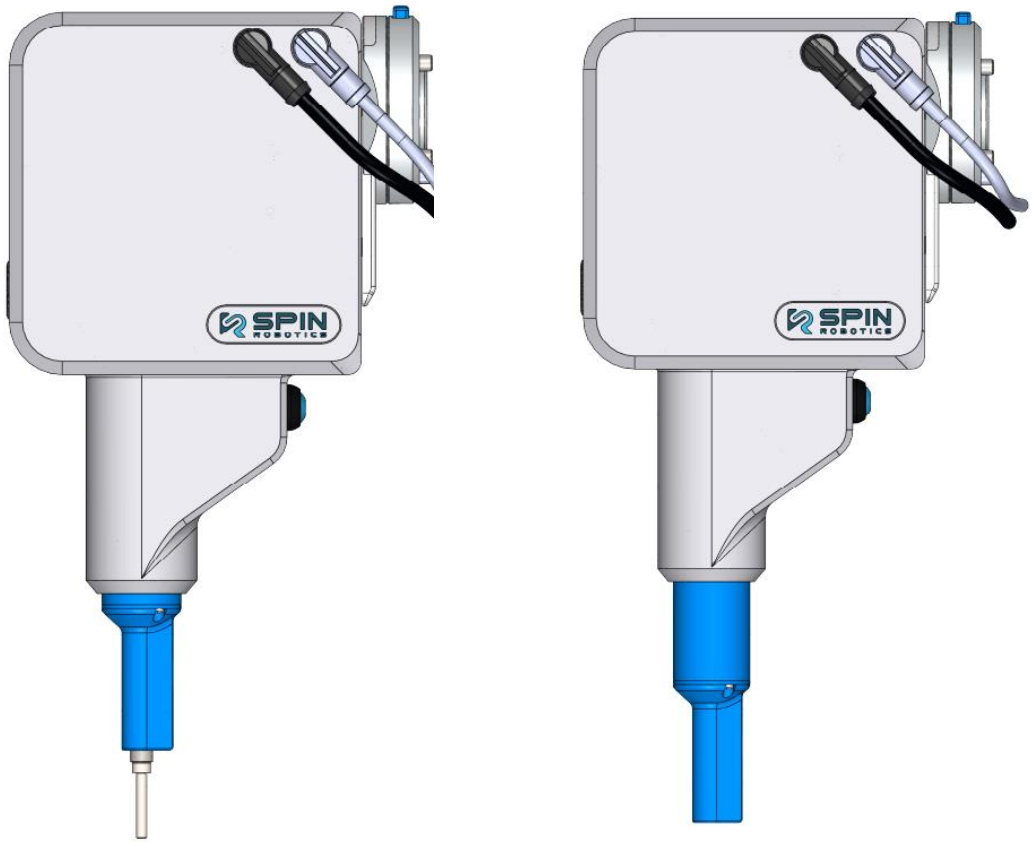
The SD35 tool has been tested in accordance with the ISO/TS15066 technical specification to ensure that the defined force impact limited in ISO/TS15066 is not exceeded. Based on these measurements it is recommended that the robot speed is not exceeding 250 mm/s when the tool approaching the screw insertion position to avoid exceeding the maximum allowed forces defined in ISO/TS15066. All technical reports from the impact force test can be found at https://spin-robotics.com/

3.4 SD35 Safety Features

3.4.1 Spin Robotics Safety Shield

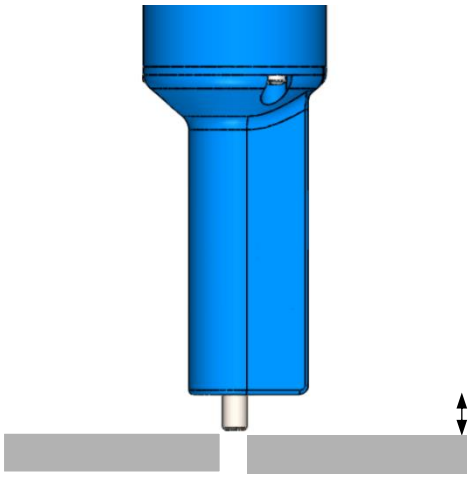
The SD35 collaborative screwdriver has been designed such that the screw and the bit are always covered by the Spin Robotics safety shield to enhance safety for the user.

NOTE: As noted in the technical datasheet (Chapter 2), the maximal screw length within safety is 40 mm. The screw length is adjusted in the SpinInterface. See Section 7.1.2.



The shield retracts itself at 6 mm above the surface (see image below), during the screw insertion. Because hands and fingers are thicker than 6 mm, this ensures safety of operators working with the screwdriver.

Warning: If the distance for the safety shield retraction [S_1] is set to more than 6 mm there are potential risk for crush hazard.



S_1 – Max. 6mm

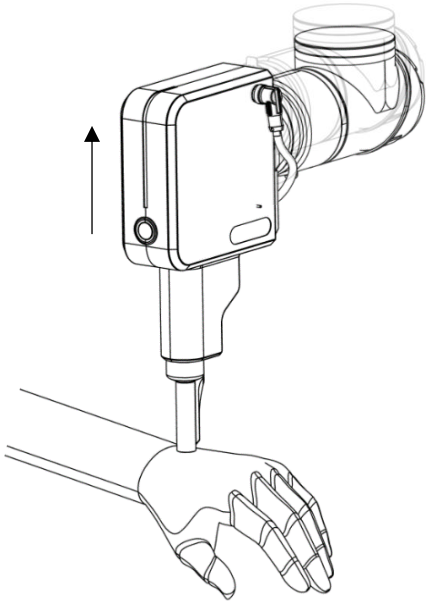
Note: If the distance for the safety shield retraction [S_1] is set to more than 6 mm (e.g. 9 mm above surface), the Spin Robotics URCap will file a pop-up window, which will ask you to confirm that you are disabling this safety feature

By clicking **Yes**, you agree to the warning and limited safety of the tool. This will display a warning sign next to the field Distance [S1].

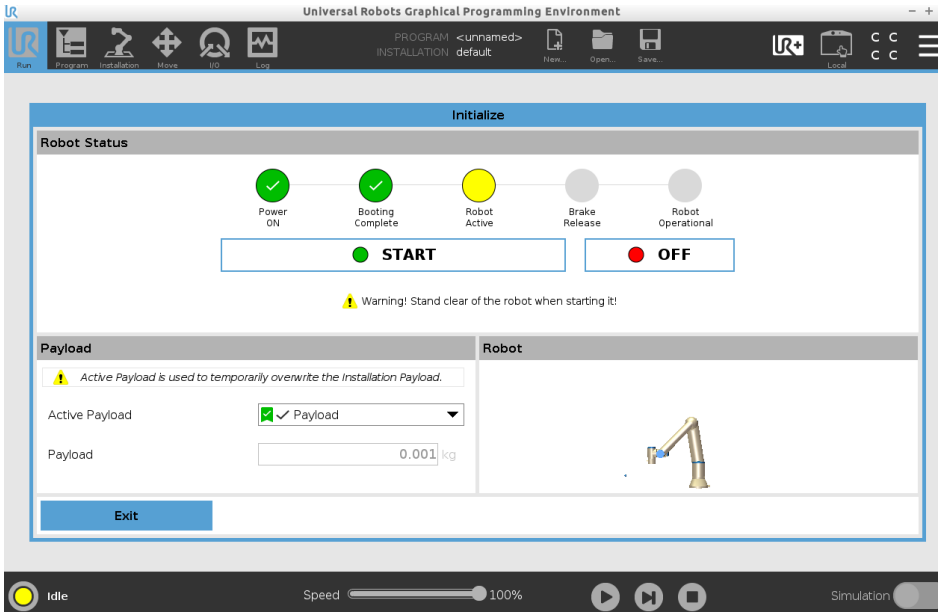
3.4.2 Safety Sensor

SD35 features a built-in performance level D safety sensor. If SD35 approaches the screw insertion point and experiences unexpected force of ≥ 45 N in the vertical direction, it will trigger an emergency stop. The safety system is a mechanical sledge system that will push up the tool during robot motion. If the tool is pushed more than 10 mm the robot motion and the SD35 tool will shut off.

Warning: Do not install the SD35 in a collaborative application without installing the safety cable between the robot controller and the Spin Bridge. See how to install it in Section 4.2.5



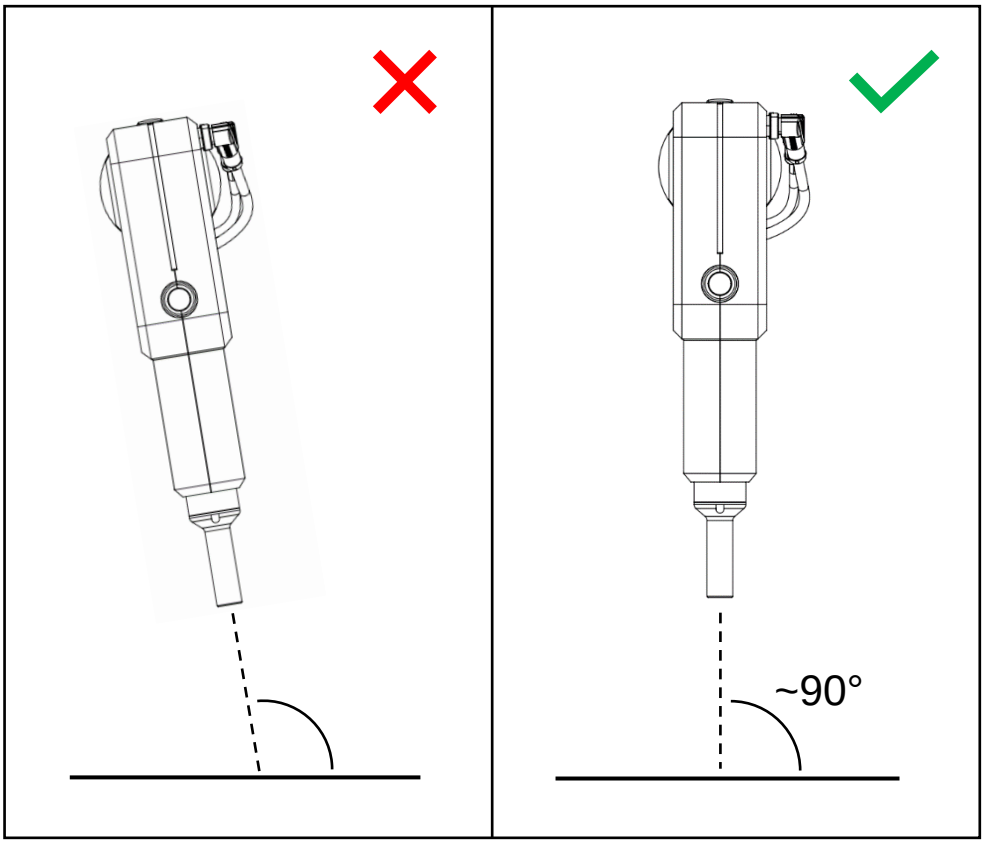
If this happens, remove tour hand and reinitialize the robot by clicking ok “Go to initialization screen” and press “Start”



3.4.3 **Programming Safe Robot Trajectories**

To ensure that the forces during a potential impact between the SD35 tool and a human part is not exceeding the force impact limits defined in ISO/TS15066 it is important that the approach movement is programmed such that the tool is perpendicular (90 degrees) to the screw insertion plane.

In this way the impact from the safety shield is decreased because the surface area of the tool tip is kept as large as possible.

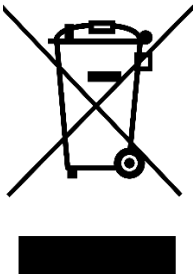


3.1 Environmental Safety

Spin Robotics' products must be disposed in accordance with the applicable national laws, regulations, and standards.

The product is produced with restricted use of hazardous substances in electrical and electronic equipment to protect the environment as defined by the EU RoHS directive 2011/65/EU. These substances include lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers, bis(2-ethylhexyl) phthalate, butyl benzyl phthalate, dibutyl phthalate and diisobutyl phthalate.

Observe national registration requirements for importers according to EU WEEE Directive 2012/19/EU.



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4 Installation of Hardware

General product details and environmental conditions are found in the Technical Sheet in Section 2.

4.1 Overview

For successfully install the SD35 screwdriver tool the following step is required

1) Mounting the SD35 tool at robot
2) Installing the SpinBridge box
3) Wiring power + signal cables between the SD35 tool and the SpinBridge
4) Wiring safety cable + Ethernet cable between the SpinBridge and the robot controller
5) Installing the Spin Robotics URCap

4.1.1 Included Hardware

When you receive the product, the following is included:

- 1 x SD35 collaborative screwdriver
- 1 x SpinBridge
- 1 x SpinMount
- 6 x Magnetic bit holders + Allen key
- 4 x Extra set/grub screws
- 1 x Teach-pen
- 4 x M6 Unbraco screws + Allen key
- 1 x 3m M12 shielded signal cable
- 1 x 3m M12 shielded power cable
- 1x Safety IO cable
- 1 x Ethernet cable
- 220 V cable – power supply (voltage based on country)
- 4 x Velcro cable straps
- USB stick
    - Spin Robotics URCap
    - User manual

4.2 How to install

Unpack the box and make yourself familiar with the components inside of it.

4.2.1 Quick Changer Mounting

1. Place the supplied dovel pin (A) inside of the UR flange so that you can easily find the right position for the SpinMount. *Note: It is important to mount is correctly to use the predefined Tool Center Point (TCP) in the URCap.*
2. Mount the SpinMount (B) (robot side) on the robot using the four supplied M6 unbraco screws (C) and the allen key, as shown on the picture below. Use 10 Nm tightening torque.

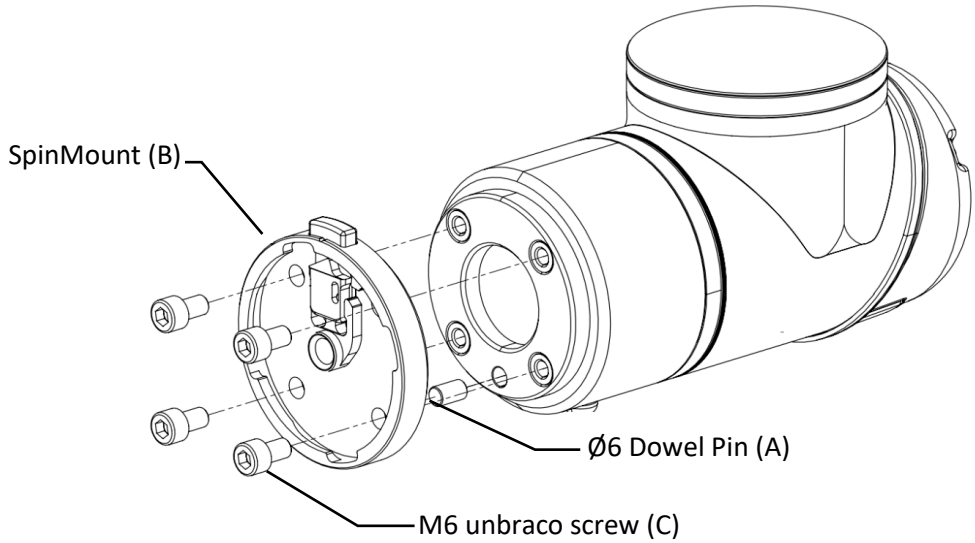


Figure 1 - SpinMount installation

4.2.2 Mount the tool

1. Push and rotate the SD35 in clockwise direction until you hear a ‘click’.

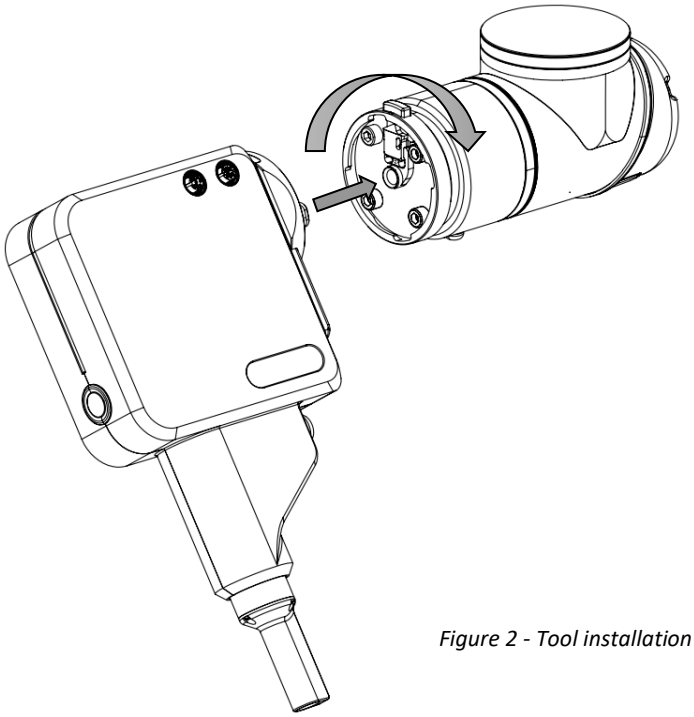
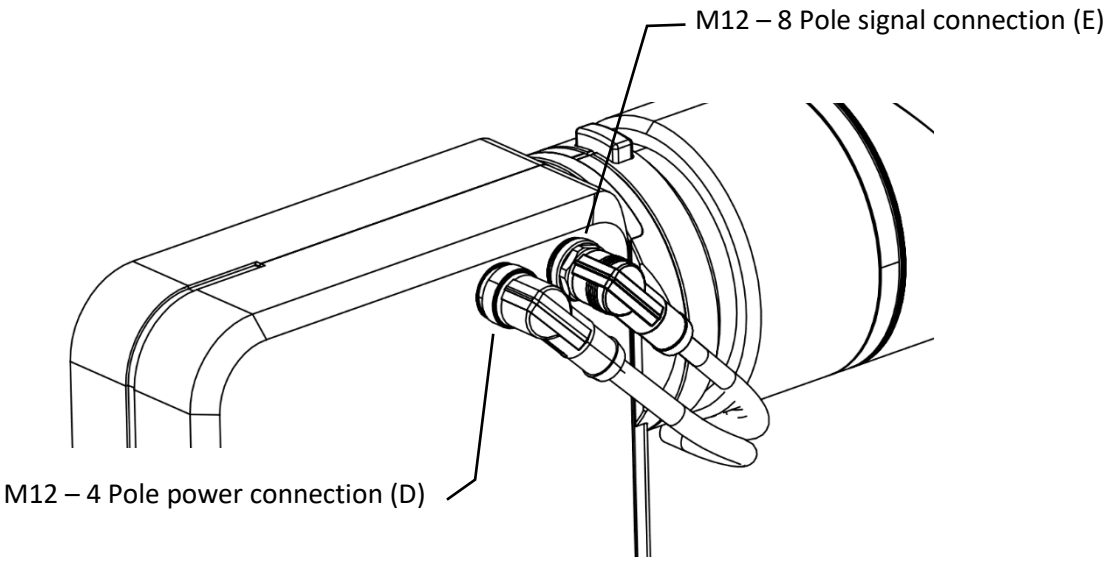


Figure 2 - Tool installation

4.2.3 Connect the Cables to the Tool

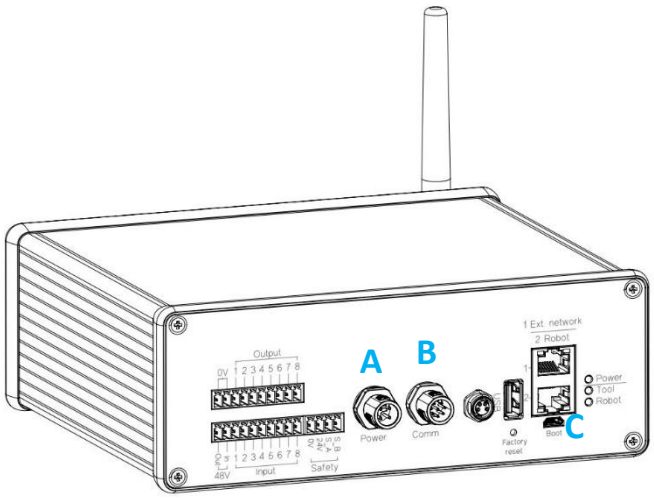
1. Connect the M12 – 4 Pole power cable (D) to the front port as shown on the picture.

2. Connect the M12 – 8 Pole signal cable (E) to the back port as shown on the picture.
3. Fasten cables on the robot by using supplied Velcro straps. Add extra bending radius to not damage the cables during robot motion. Do not fasten the cables tens to the robot but add extra cable length near all robot joints.



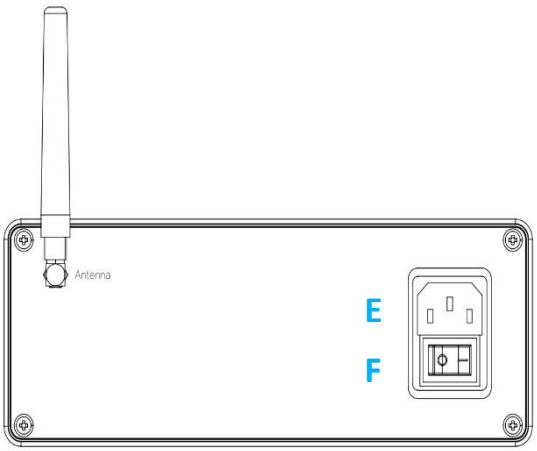
4.2.4 Connect Cables to SpinBridge

1. Connect the cables from SD35 to the SpinBridge:
    a. Connect the power cable to the left port (A) - Power.
    b. Connect the signal cable to the right port (B) - Comm.
    c. Connect the Ethernet cable to the lower Ethernet port (C) at the SpinBridge



NOTE: Remember to insert the Ethernet connected to the robot controller in the lower Ethernet plug (C) in the SpinBridge. The upper Ethernet plug is for external communication.

2. Mount the Antenna (D) at the back of the SpinBridge.



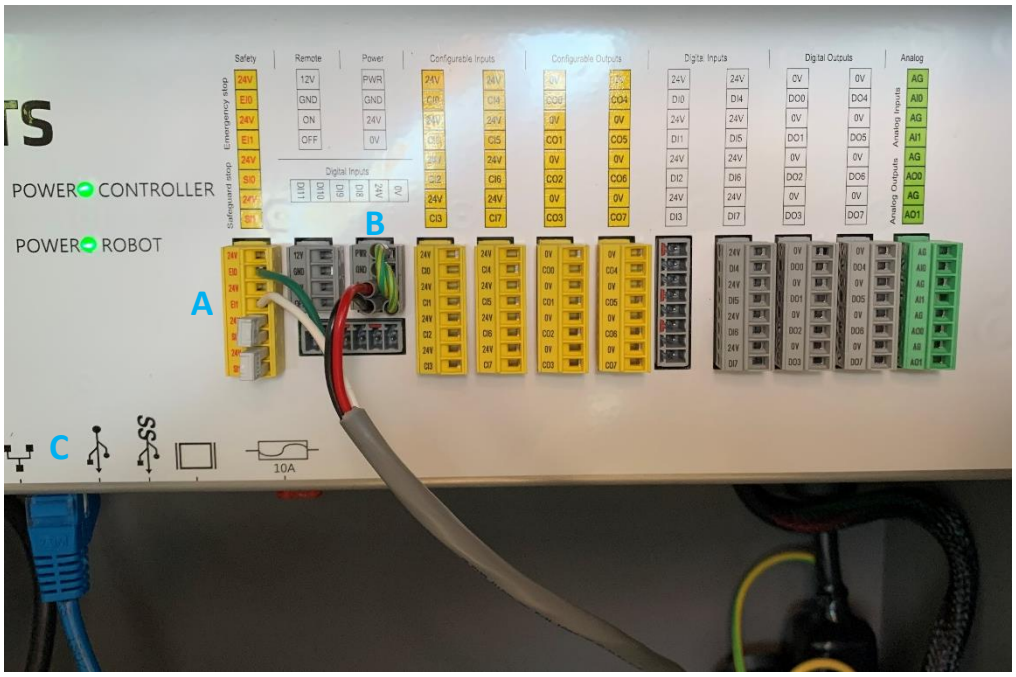
3. Plug in the main power cable (E)
4. Place the Spin Bridge next to the robot controller to keep it secure
5. When all cables incl. the safety cable (Section 4.2.5), turn on the power switch (F)

4.2.5 Connect Safety and Ethernet Cable to the UR Controller

Warning: Do not install the SD35 in a collaborative application without installing the safety cable between the robot controller and the Spin Bridge.

For ensuring that the robot stops when the internal safety system in the SpinBridge safety output much be connected to the robot controller emergency stop terminal (EI0, EI1).

1. Connect the Safety cables black plug to the Safety input connector at the SpinBridge (4-pin Safety input).
2. Connect the yellow plug of the safety cable to the Universal Robots emergency input in the e-series controller (A)
3. Connect the gray plug of the safety cable to the Universal Robots 4 pin power plug (B)
4. Connect the Ethernet cable to the Ethernet port in the robot controller (C)



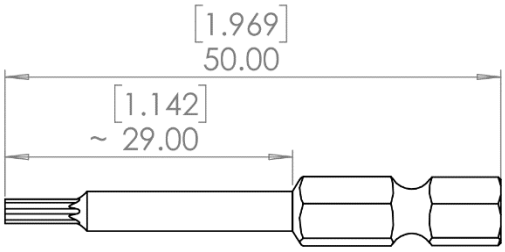
4.3 Mounting Magnetic Screw Holder

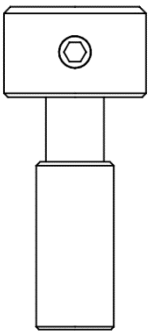
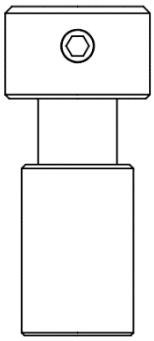
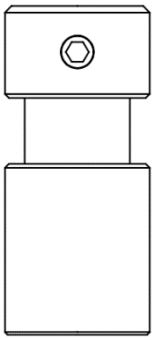
This sub-chapter explains the correct mounting of a 'magnetic screw holder' and bit.

To select the correct magnetic screw holder, see the table below.

The tool and the magnetic screw holders are compatible with ¼"/6.35mm bits with a total length of 50mm. Bits can be purchased by contacting the vendor which the tool has been purchased from or from local wholesales.

Table 1 - Magnetic screw holder and bit compatibility



Magnetic screw holder size		 S		 M		 L	
Inner diameter ød [mm]		2.5	3	4	4.5	5	6
Outer diameter ØD [mm]		6		8		10	
Typical screw size		M 1.6-3		M 3-4		M 4-5	
Torx			TX 4-9	TX 10-15	TX 20		TX 25-30
Hex socket				2-3		4	5-6
Phillips		PH 0			PH 1		PH 2
Pozidriv					PZ 1		PZ 2

NB: The inner diameter (ød) of the magnetic screw holder, needs to match the outer diameter of the bit shaft for a secure and precise fit.

4.3.1 Detailed Overview of Bit Holder

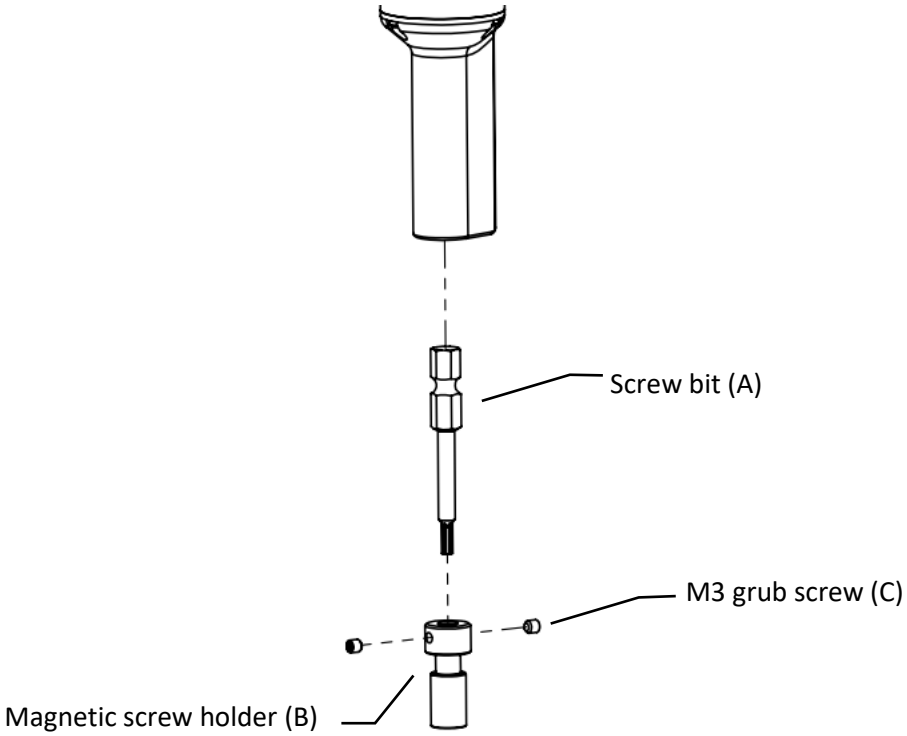
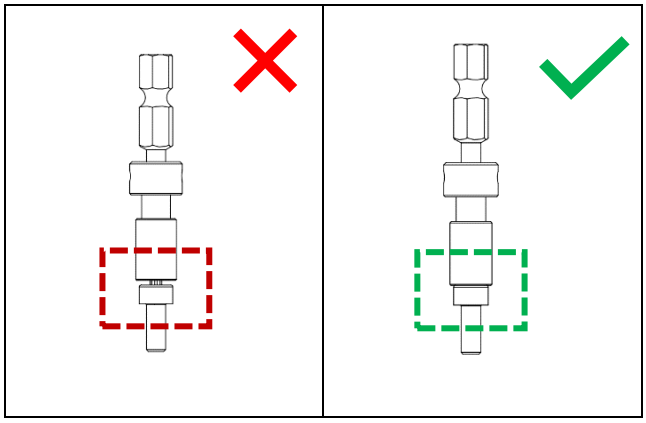


Figure 3 - Magnetic screw holder installation

1. Insert your screw bit (A) into the supplied magnetic screw holder (A).
2. Before fastening the bit inside the screw holder, check that the screw surface meets the magnetic ring on the screw holder (see picture below).
    a. Make sure that the bit is inserted as far as possible into the screw without resting on the bottom of the slot.
    b. Check that the screw is centered.



3. Make sure to tighten the two M3 grub screws (C) on the sides. It is recommended to apply a medium strength Loctite to the M3 grub screws for secure assembly.

4. The bit including the magnetic screw holder can now be inserted into the end of the SD35 where it is held firm by a locking mechanism.
5. The bit can be released in the SD35 tool with a gentle pull.

5 Software Setup

5.1 Setting Up the Network

For the robot and SpinBridge to communicate they need to be on the same network, currently we only support a static setup, so change the robots IP settings to the following:

IP: 192.168.37.100

Subnet: 255.255.255.0

Gateway: 192.168.37.1

NOTE: The SpinBridge needs to know the IP of the robot. We expect it to be 192.168.37.100, but if for some reason the robot needs a specific IP you can tell the SpinBridge on what IP it can find the robot in the SpinInterface – Settings – Network.

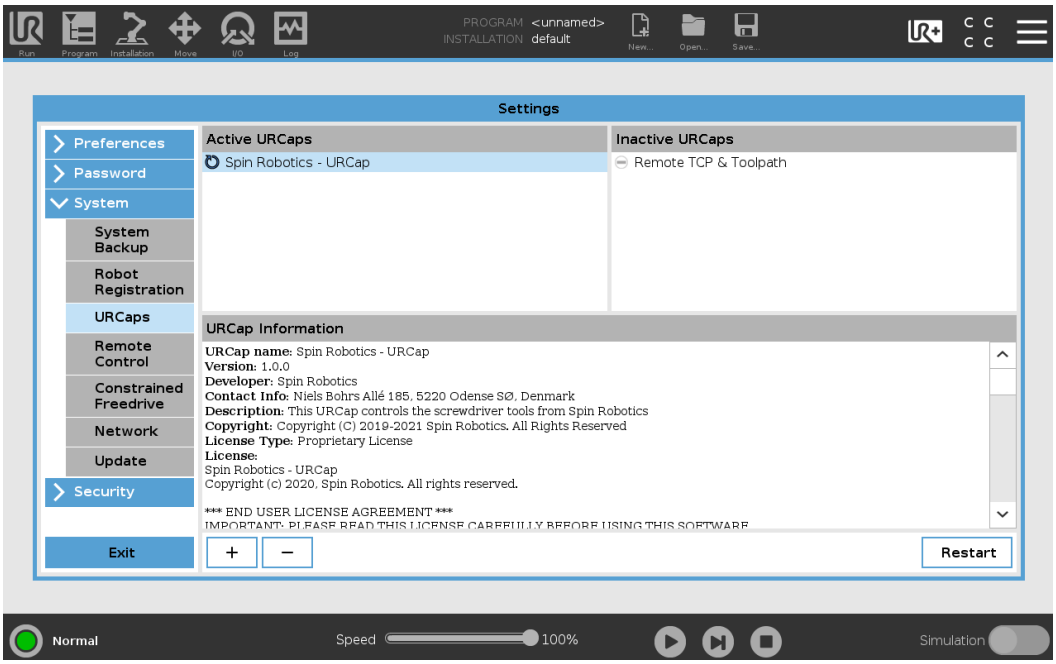
5.2 Installing Spin Robotics URCap

NOTE: The minimum UR PolyScope **version** is **5.10**. If your robot has installed a UR Polyscope version 5.9 or lower, please update UR Polyscope

1. Use the **Spin Robotics USB** that is provided in the package to install the Spin Robotics URCap by inserting it into the UR Teach Pendant as shown below.

2. On the right side of the screen, find the **Burger menu** and click on **Settings**. Select **System** on the left side of the screen and click **URCaps**.

3. Press the **+ sign** to search for the Spin Robotics URCap. Select the **USB stick** and click on **Spin Robotics URCap**. Press **open, wait** for the URCap to show as active and press **restart**.



4. The URCap is ready when the robot has rebooted. Now, initialize the robot.

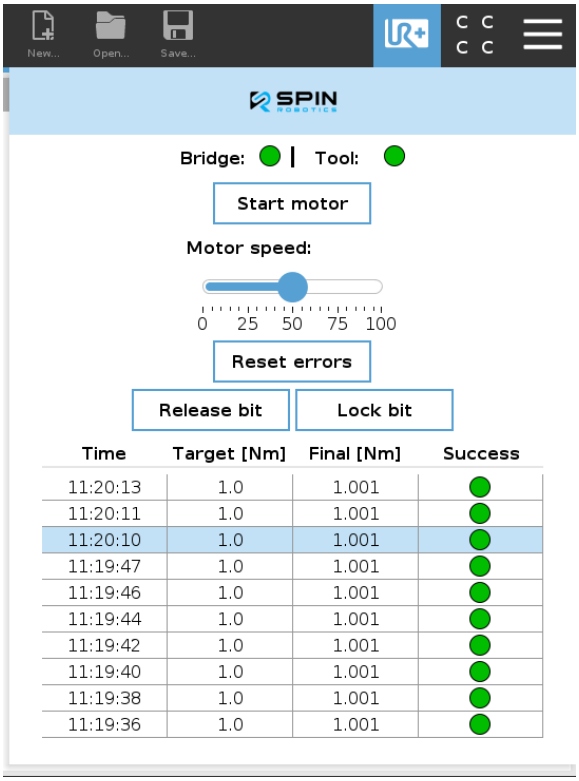
5.3 Uninstalling Spin Robotics URCap

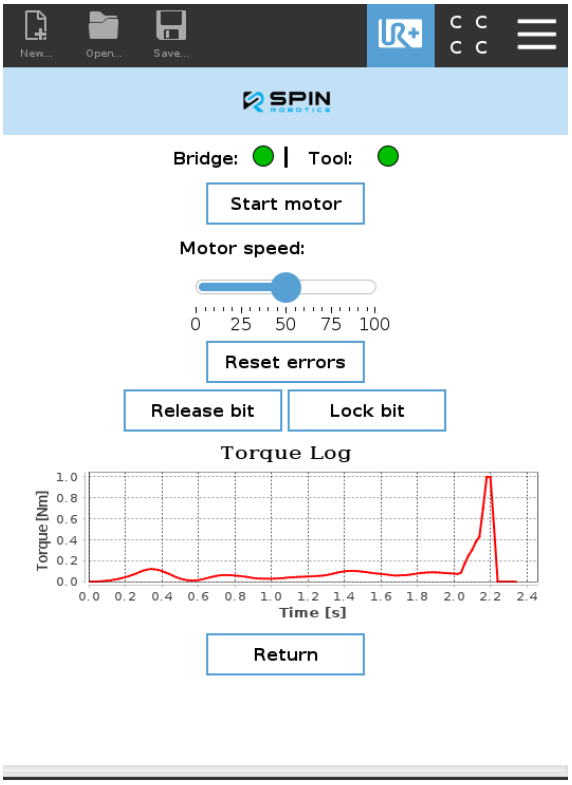
1. On the right side of the screen, find the **Burger menu** and click on **Settings**. Select **System** on the left side of the screen and click **URCaps**.
2. Select the Spin Robotics URCap and press the **– sign.**
3. Restart and re-initialize the robot.

5.4 URCap Toolbar

1. Click on the button UR+ in the upper-right corner to open the Spin Robotics URCap toolbar.
2. Here you can see the connection status of the robot to the SpinBridge and SD35 tool marked by either green (connected) or red (disconnected).
3. To start the screwdriver in freerun press the **Start motor** button. The speed of the screwdriver in freerun can be changed by the **Motor speed** slider.
4. The **Reset errors** button resets errors on the tool. If the tool LED is still red after pressing the **Reset errors** button, then refer to the SpinInterface.
5. To release and lock the bit in the screwdriver use the **Release bit** and **Lock bit** buttons. These buttons are only available, when there is a connection to the SpinBridge and tool.
6. The table in the bottom of the toolbar shows the log of the last 10 screws that have been inserted. The first column shows at what time the screw was inserted. The second column shows the target. This could be torque in Nm or distance in mm. The third column shows the actual torque or distance achieved for the given screw insertion in Nm or mm. The final column shows whether the insertion was successful or not. A successful insertion is shown by a green icon and an unsuccessful insertion with a red icon.

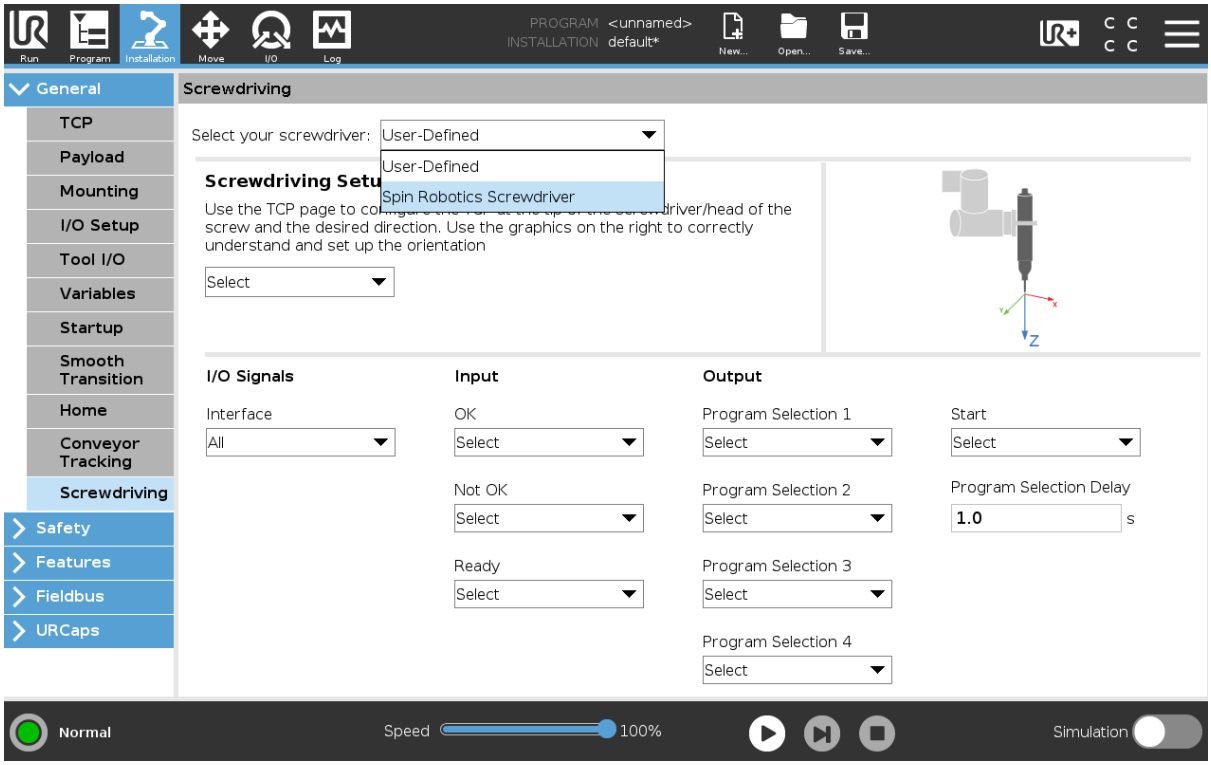
7. If a row is pressed, then the entire torque graph of the given insertion is shown. To return to the log press the return button.





5.5 Spin Robotics URCap Setup

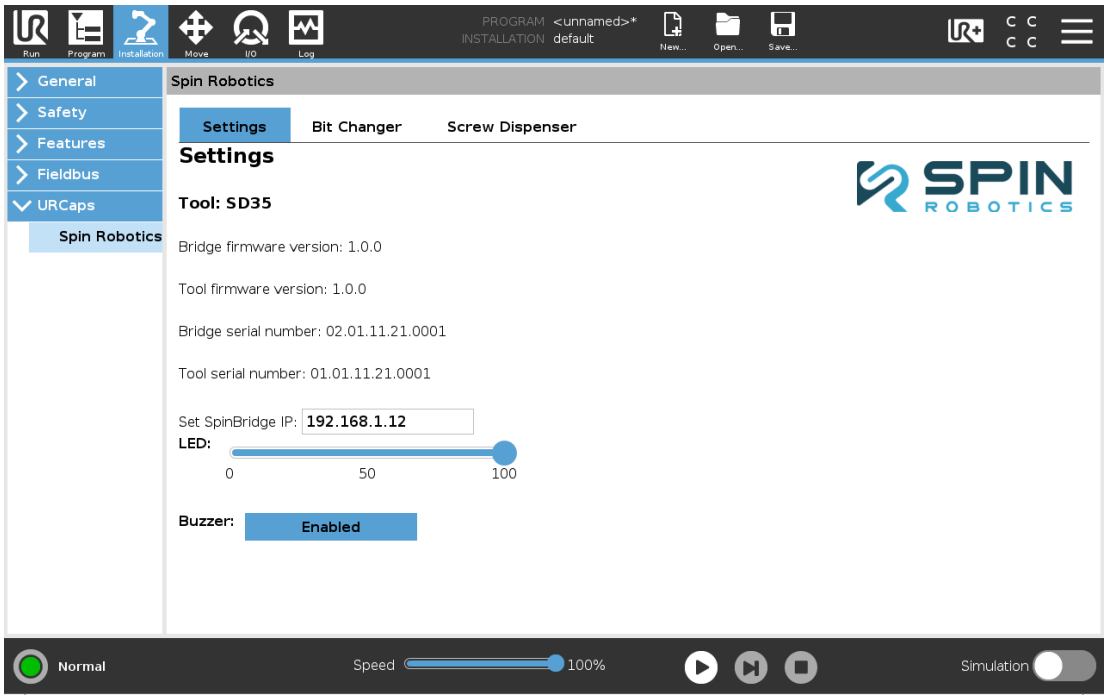
1. Click on the **Installation** button  on the upper left side of the screen.
2. Then in the **General** tab select **Screwdriving** and in the **Select your screwdriver** drop down menu select **Spin Robotics Screwdriver** as shown in the figure below.



3. Next, choose **URCaps** from the menu on the left and choose **Spin Robotics**.
4. The Spin Robotics Setup is divided into three sections: **Settings, Bit Changer** and **Screw Dispenser**.

5.5.1 Settings

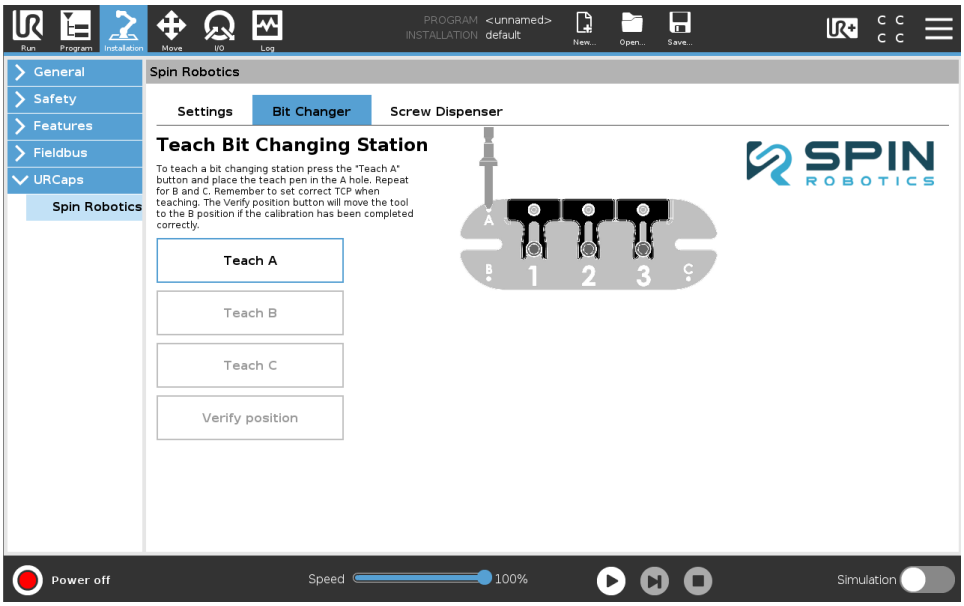
1. The SpinBridge **firmware** as well as the SD35 firmware version are shown here.
2. On the slider below, you can set up the **LED intensity** of the front LED strip on SD35.
3. By clicking on the **Buzzer** button you either enable or disable SD35's sound.



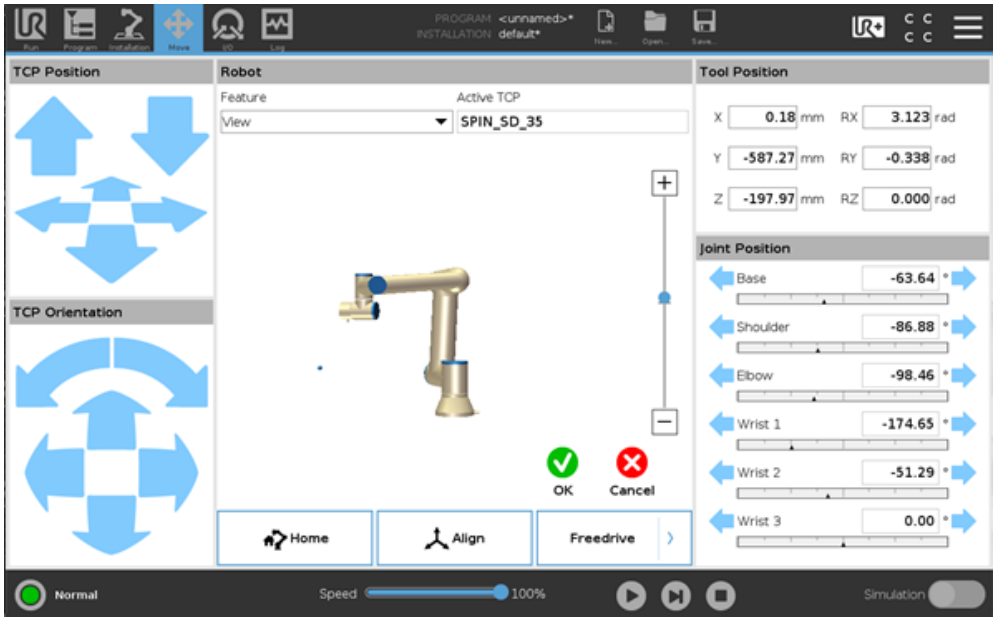
NOTE: To save your changes, click on the **Save** icon above and save the installation. Otherwise, the settings will only apply in this session and will disappear once the Teach Pendant is turned off.

5.5.2 Installation (Automatic Bit Changer)

1. This is where the position of the **Automatic bit changer** (optional accessory) is set up.
2. In order to set up the Automatic bit changer, you have to teach the A, B and C points of the Automatic bit changer with the provided teach pen.



3. To record the Automatic bit changer's position in the URCap, click on the button **Teach A** to record the point A on the Automatic bit changer's plate.

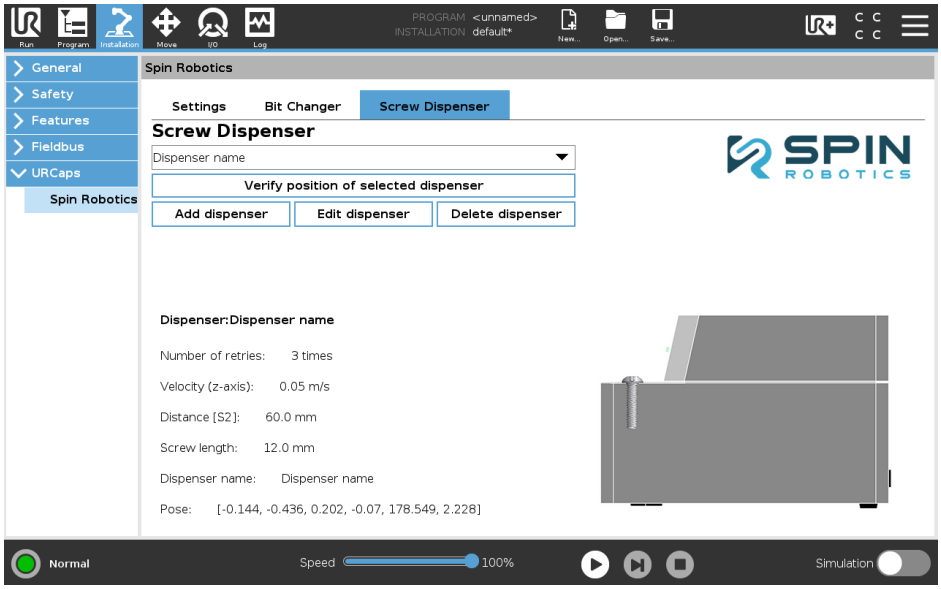


4. Using the teach pen inserted in SD35 (follow the manual for Automatic bit changer), pressing the free-drive button in the back of SD35, guide SD35 to the point A in the Automatic bit changer plate. Insert the tip of the teach pen, into the middle of the point A.
5. Click on the **Align** button and hold down the button **Move robot to: Aligned Z-Axis** to align the tool with the vertical Z axis.
6. By pressing the **OK** button , confirm the recorded point.
7. Repeat the same (step 3-6) with the point B and C, clicking on the button **Teach B** and **Teach C**.
8. To check that you programmed the right position of the Automatic bit changer, you can press the button **Move to feature**.
9. The tool will move to the position of the point B if **programmed correctly**.

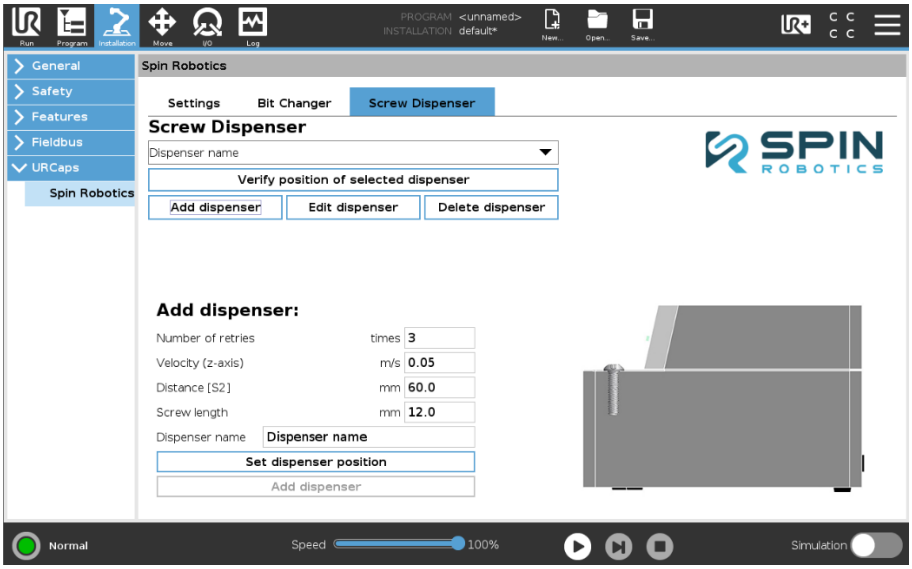
NOTE: To save your changes, click on the **Save** icon above and save the installation. Otherwise, the settings will only apply in this session and will disappear once the Teach Pendant is turned off.

5.5.3 Screw Dispenser

1. This is where the position of the **Screw dispenser(s)** (optional accessory) is set up, edited or deleted.



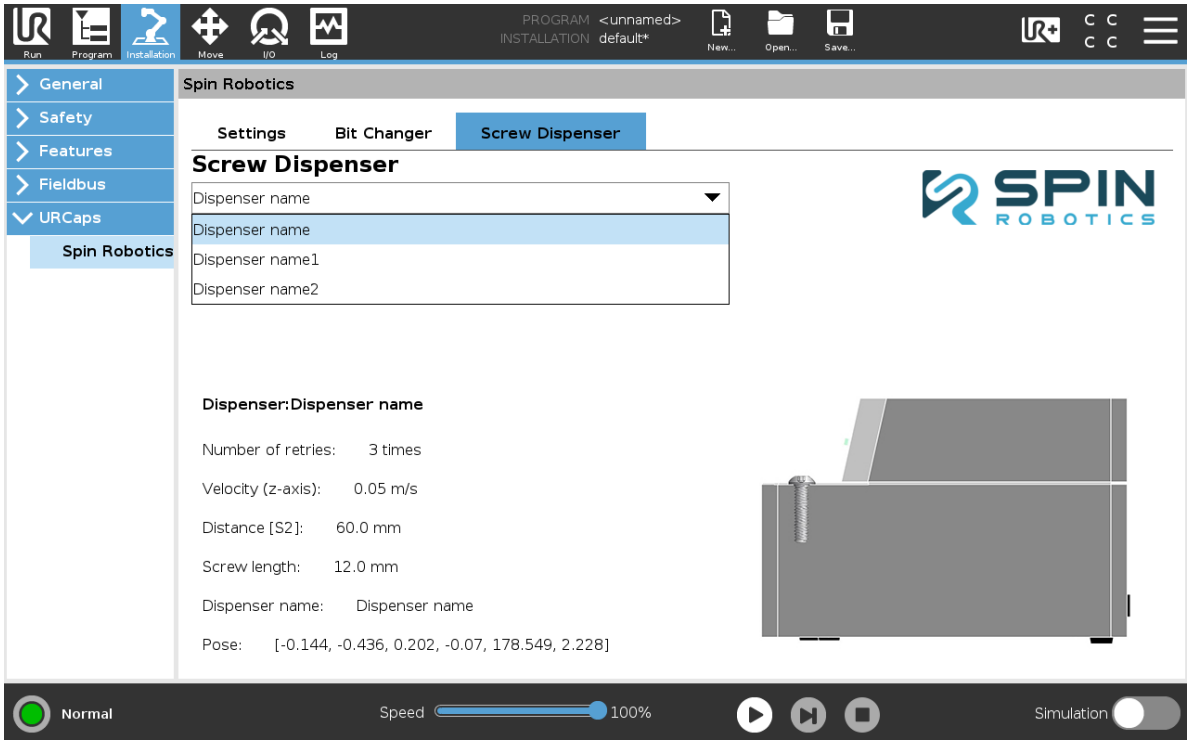
2. To add a new dispenser, click on the button **Add dispenser.**



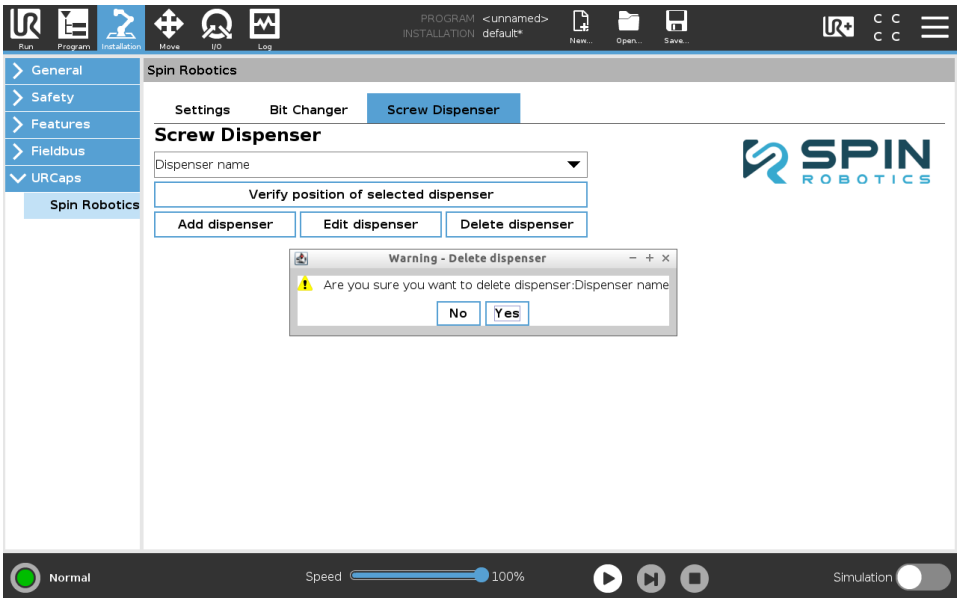
3. Fill in the required **input fields** with:
    a. **Number of retries** – meaning how many times will SD35 try to pick up a screw if it is not successful. If the number of retries is exceeded, SD35 will stop.
    b. **Velocity (z-axis)** – the speed with which SD35 descends vertically down to pick up a screw.
    c. **Distance** – the distance above the screw dispenser from which the command for SD35 "pick a screw" applies. From this distance, the tool will follow the speed you set in the field above - Velocity.
    d. **Screw length** – The length of screws that are dispensed by the screw dispenser.
    e. **Dispenser name** – Choose a name for your dispenser to differentiate it in case you work with multiple dispensers.

NOTE: Default settings are already pre-filled in all five fields.

4. Press the button **Set dispenser position** to record the Screw dispenser's position in the URCap.
5. Using the teach pen inserted in SD35, pressing the free-drive button in the back of SD35, guide SD35 to a screw that is presented by the screw dispenser.
6. Insert the tip of the teach pen into the head of the presented screw.
7. Click on the **Align** button and hold down the button **Move robot to: Aligned Z-Axis** to align the tool with the vertical Z axis.
8. By pressing the **OK** button , confirm the recorded location.
9. To finalize the screw dispenser's set up, click on the button **Add dispenser.**
10. The screw dispenser has been recorded and should appear in the drop-down menu above with its embedded parameters.
11. Click the button **Verify positioning of the screw dispenser** to see if it has been set up correctly.



12. To edit an existing dispenser, select a dispenser from the drop-down menu and press the **Edit dispenser** button. Now you can edit the dispenser, that you selected in the drop-down menu.
13. To delete a dispenser, select a dispenser from the drop-down menu and press the **Delete dispenser** button.
14. Confirm the screw dispenser's deletion by clicking the button **Yes** on the little pop-up screen. This will delete the selected dispenser from the drop-down menu.



NOTE: To save your changes, click on the **Save** icon above. Otherwise, the settings will only apply in this session and will disappear once the Teach Pendant is turned off.

6 Control

6.1 URCap Commands

NOTE: Before starting to make a program in the Spin Robotics URCap, you must:

a) Set up your Screw dispenser and optionally your Automatic bit changer in the Installation section  of the URCap (see chapter 5.5),
b) Create a new part in the SpinInterface software (see chapter 8.2.2).

1. To create a command for the robot, click on the button **Program**  in the upper left corner.
2. Select **URCaps** from the list of options on the left.
3. You will see all 4 commands for the SD35: Pick Bit, Pick Screw, Insert Screw and Place Bit.

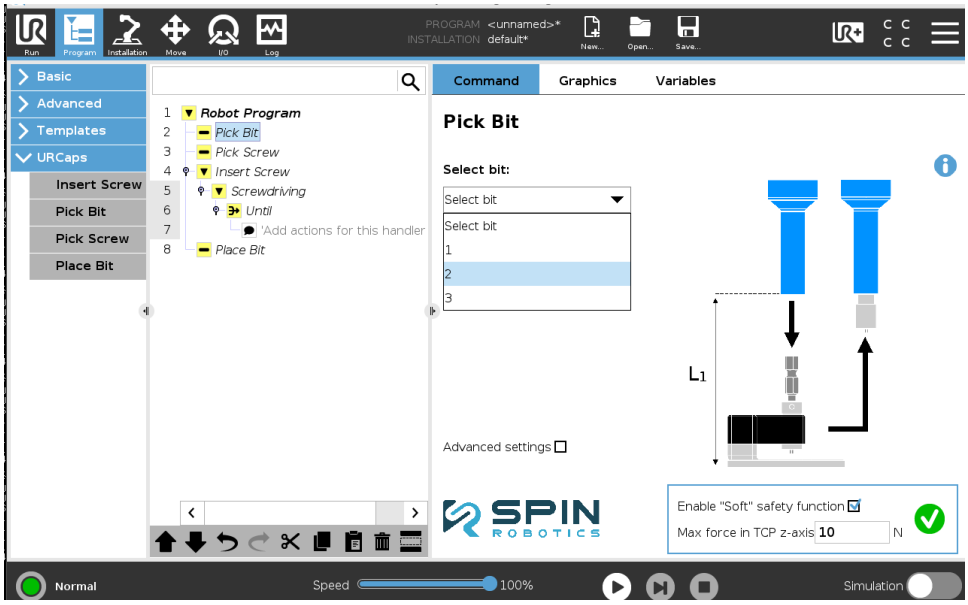
6.1.1 Pick Bit

1. On the left bar, click the button **Pick Bit**.
2. From the drop-down menu, select which bit is to be picked by the SD35.

NOTE: The bit number 1,2 or 3 is written correspondingly on the Automatic bit changer station.

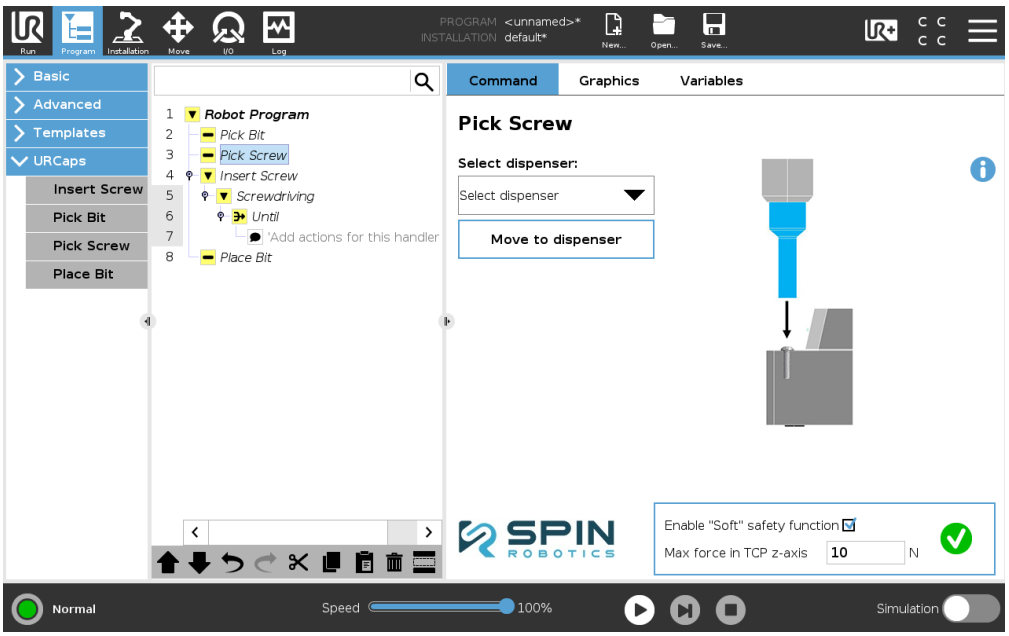
3. By pressing the button **Advanced settings,** you can customize the velocity and the distance at which the command takes over.
   Velocity (z-axis) – the speed with which SD35 descends vertically down to pick up the bit and shifts up again (shown by black arrows)
   Distance – the distance above the Automatic bit changer from which the command for SD35 "pick a bit" applies. It is the distance from the tool's TCP to the Automatic bit changer's plate, here the tool will follow the speed you set in the field above - Velocity.
4. In the right bottom corner, leave the box with a check if you wish to **enable "soft" safety feature for the tool when it vertically descends towards the bit**. This will make sure that when the tool recognizes a maximum force which is adjustable in the field **Max force in TCP z-axis**, it will counteract its movement, freeing an object that it was pressing onto.

NOTE: The recommended value of the field Max force in TCP z-axis is 10 N equaling to the screwdriver tip applying a pressure of 1 kg.



6.1.2 Pick Screw

1. On the left bar, click the button **Pick Screw**.
2. From the drop-down menu, **select a dispenser** from which SD35 should take screws.



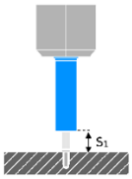
3. Click on **Verify positioning** button to see if the screw dispenser has been set up correctly.
4. In the right bottom corner, leave the box with a check if you wish to **enable "soft" safety feature for the tool when it vertically descends towards the screw**. This will make sure that when the tool recognizes a maximum force which is adjustable in the field **Max force in TCP z-axis**, it will counteract its movement, freeing an object that it was pressing onto.

NOTE: The recommended value of the field Max force in TCP z-axis is 10 N equaling to the screwdriver tip applying a pressure of 1 kg.

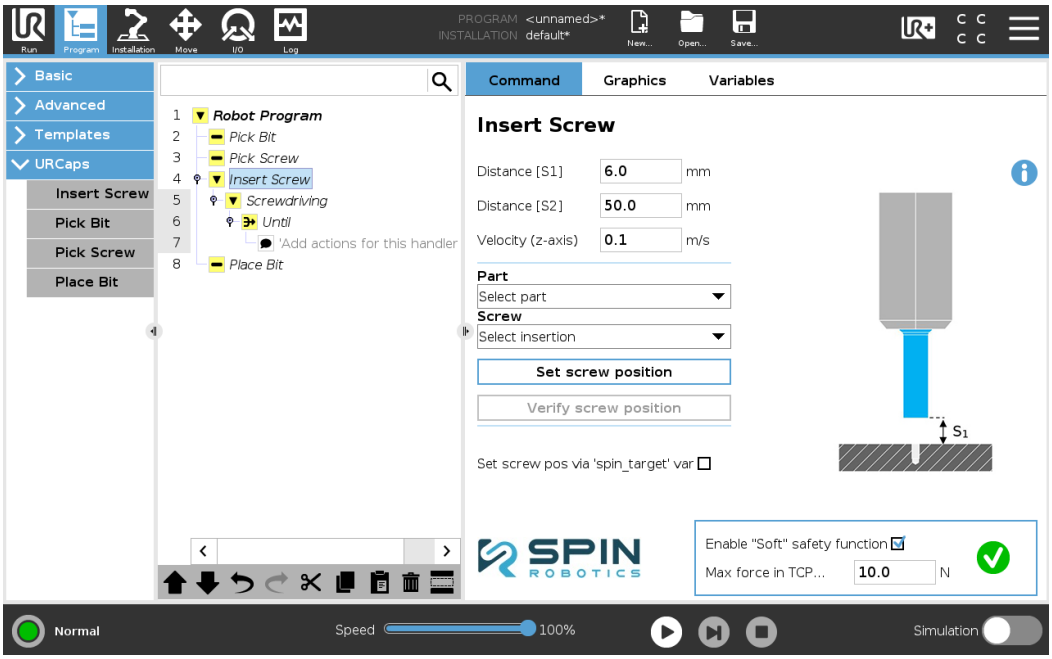
6.1.3 Insert Screw

NOTE: To insert a screw into your part, the part and screws must be recorded in the SpinInterface. To create a new part and define your screws in the SpinInterface software, follow chapter 8.2.2 and chapter 8.2.3).

1. On the left bar, click the button **Insert Screw**.
2. There will be three fields that can be adjusted manually, yet the default values should be sufficient for most applications:



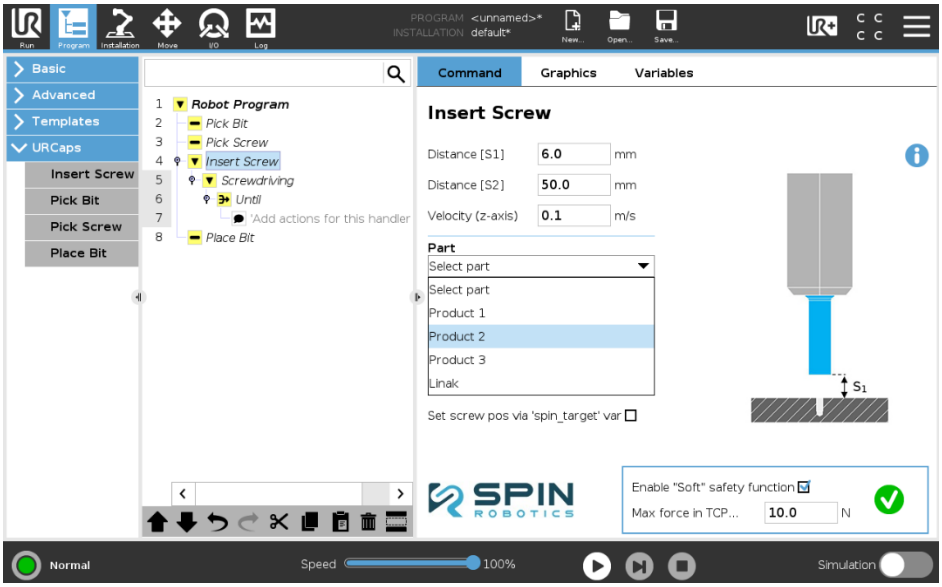
   a. The field **Distance [S2]** – the distance at which the insert screw command takes control and SD35 moves towards the insertion location with the protective shield covering the screw. The distance is measured vertically from the insertion point.
   b. The field **Distance [S1]** - the distance at which the protective shield retracts itself. The distance is measured vertically from the insertion point.
   c. **Velocity (z-axis) –** the speed at which SD35 moves from point [S2] to [S1].¨



3. In the right bottom corner, leave the box with a check if you wish to **enable "soft" safety feature for the tool when it vertically descends towards the insertion point**. This will make sure that when the tool recognizes a maximum force which is adjustable in the field **Max force in TCP z-axis**, it will counteract its movement, freeing an object that it was pressing onto.

NOTE: The recommended settings for Velocity and Distance are set by default but can be changed based on your application. The recommended value of the field Max force in TCP z-axis is 10 N equaling to the screwdriver tip applying a pressure of 1 kg.

4. Under the title **Part**, open a drop-down menu and select the desired part that you have previously set up in the SpinInterface.



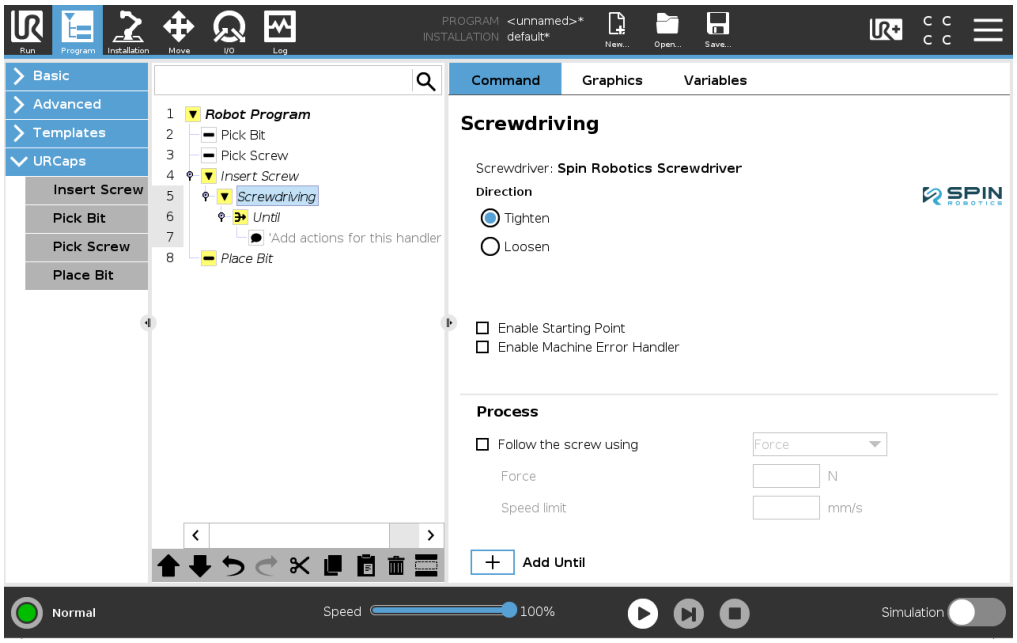
5. Under the title **Screw**, open the drop-down menu and select the screw you wish to insert. Only the screws within the chosen Part will be available for selection.

6. Press the button **Set screw position.**
7. Using the teach pen inserted in SD35, pressing the free-drive button in the back of SD35, guide the teach pen into the head of the screw of a finished product.
8. Click on the **Align** button and hold down the button **Move robot to: Aligned Z-Axis** to align the tool with the vertical Z axis.
9. By pressing the **OK** button 

, confirm the recorded location.
10. When the screw position has been set, the button **Verify screw position** will get enabled.
11. ***Alternative to step 6-10:*** By ticking off the button **Set screw pos via 'spin_target' var**, you choose to set the screw position via a global variable.

Setting the screw position via ‘spin_target’ is applicable if the screw position is already known from for example a camera or calculating the screw position. You must tell the robot the screw position by setting the global variable ‘spin_target’. The variable ‘spin_target’ is the same for all Insert Screw nodes and must therefore be set between Insert Screw nodes if multiple Insert Screw nodes are used in the same program.

12. If the position is correct, click on the node **Screwdriving** which is under the node Insert Screw in the command tree.



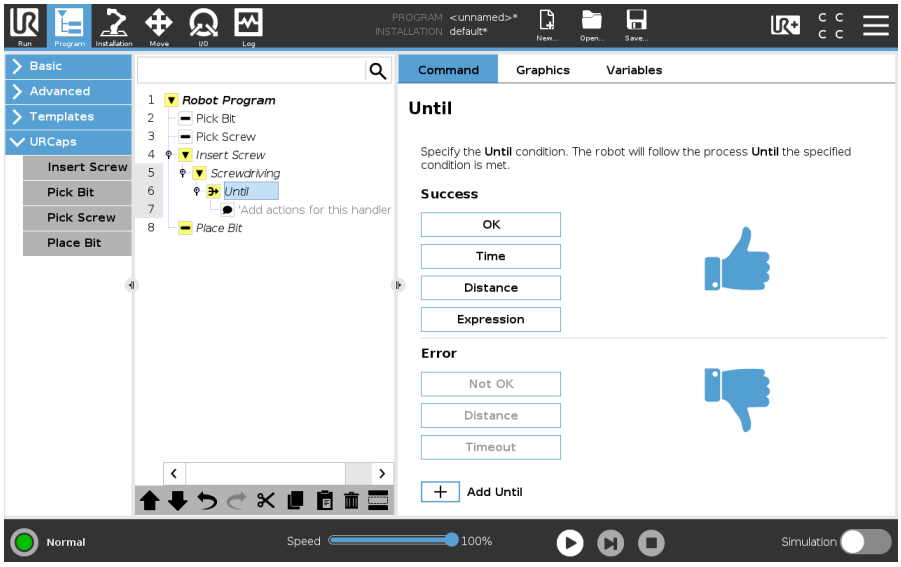
13. Here you can choose whether you want SD35 to **tighten** or **loosen** the screw.

NOTE: Make sure to leave the buttons enable a starting point and machine error handler unchecked.

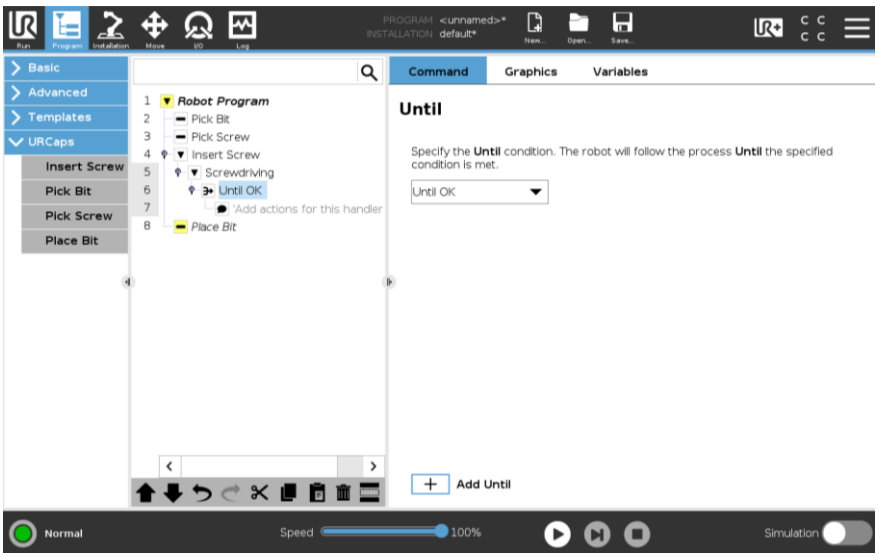
14. The field **Follow the screw using checkbox** must be ticked and **Force** must be chosen in the drop-down menu.
15. Fill in the two fields: **Force** and **Speed limit**.

NOTE: The recommended settings by Spin Robotics are 20N for Force and 15 mm/s for Speed but you might need to adjust this based on your application.

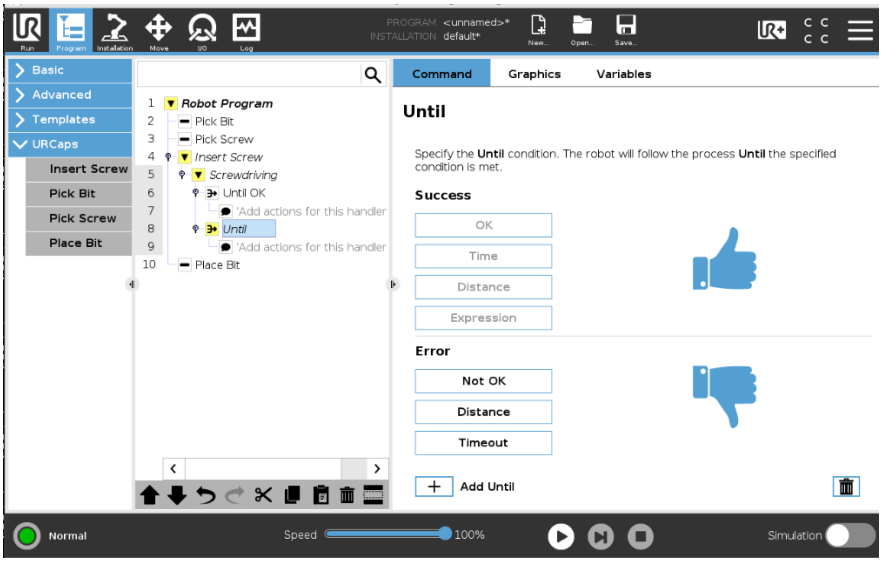
16. Click on the node **Until** in the command tree.



17. Under **Success**, select the **OK** button. This enables you to insert sub-commands that are to be executed if the screw insertion has been completed successfully.



18. Click on the button below, **Add Until** [+].
19. This will open a new **Until** command line.



20. Here you must choose in the section **Error** the button **Not OK.** This enables you to insert sub-commands that are to be executed if the screw insertion has not been completed successfully.

6.1.4 Place Bit

1. On the left bar, click the button **Place bit**.

2. From the drop-down menu, **select a bit** (1,2 or 3) in the Automatic bit changer station where SD35 will place the bit.

NOTE: The bit number 1,2 or 3 is written correspondingly on the Automatic bit changer station.

By pressing the button **Advanced settings** you can customize the velocity and the distance at which the command takes over.

Velocity (z-axis) – the speed with which SD35 descends vertically down to place a bit and shifts up again (shown by black arrows)

Distance – the distance above the Automatic bit changer from which the command for SD35 “place a bit” applies. It is the distance from the tool’s TCP to the Automatic bit changer’s plate, here the tool will follow the speed you set in the field above - Velocity.

6.2 Application Example – Simple Insertion

Here you can see a full URCap Program for a screw process with a bit change and two types of screws:

```
1  Robot Program
2    Pick Bit
3    MoveJ
4      Waypoint_1
5    Pick Screw
6    MoveJ
7      Waypoint_1
8    Insert Screw
9      Screwdriving
10       Until OK
11         'Add actions for this handler below'
12         Wait: 0.01
13         MoveL
14           Direction: Base Z+
15             Until distance: 20 mm
16       Error: Not OK
17         'Add actions for this handler below'
18         Wait: 0.01
19         MoveL
20           Direction: Base Z+
21             Until distance: 20 mm
22         Popup: error
23   MoveJ
24     Waypoint_1
25   Place Bit
26   Pick Bit
27   MoveJ
28     Waypoint_2
29   Pick Screw
30   MoveJ
31     Waypoint_2
32   Insert Screw
33     Screwdriving
34       Until OK
35         'Add actions for this handler below'
36         Wait: 0.01
37         MoveL
38           Direction: Base Z+
39             Until distance: 20 mm
40       Error: Not OK
41         'Add actions for this handler below'
42         Wait: 0.01
43         MoveL
44           Direction: Base Z+
45             Until distance: 20 mm
46         Popup: error
47   MoveJ
48     Waypoint_2
49   Place Bit
50   Halt
```

Line 2: SD35 travels to the Automatic bit changer and the command *Pick Bit* is executed.
Line 3-4: SD35 moves to a programmed Waypoint 1 that is set to optimize the tools trajectory.
Line 5: SD35 travels to the screw feeder and the command *Pick Screw* is executed.
Line 6-7: SD35 moves back to a programmed Waypoint 1.

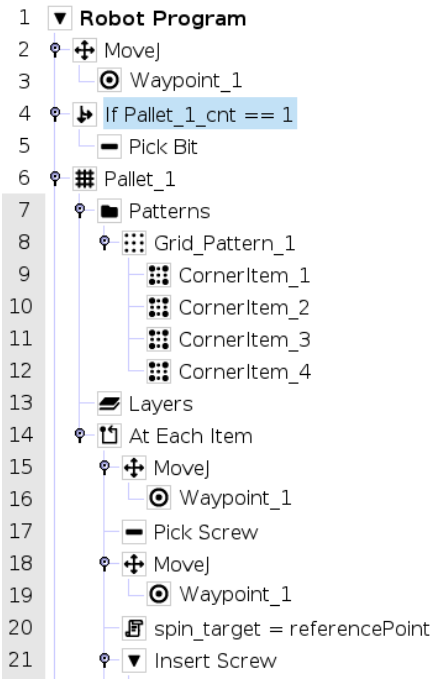
Line 8-15: SD35 approaches the screw location to execute the command *Insert Screw.* After successfully executing the command, SD35 will wait for 0.01 seconds to make sure that the command has been finished. Then it will move upwards by 20 mm.

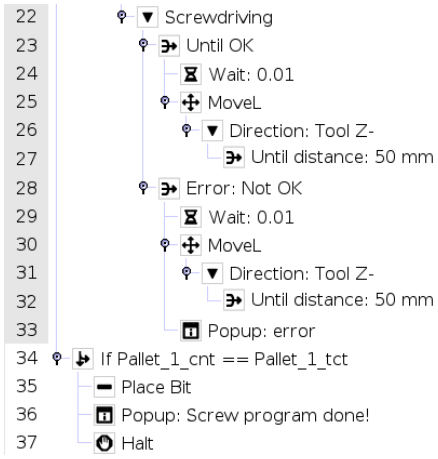
NOTE: If *Wait: 0.01* is not programmed, the URCap can run into a mistake, believing it is still executing a screwdriving command and it might ignore to move upwards by 20 mm.

Line 16-22: If the command *Insert Screw* has not been executed successfully, SD35 will wait 0.01 sec and move upwards by 20 mm, showing an error in a window popup.
Line 23-25: SD35 moves over the Waypoint 1 to the Automatic bit changer to execute the command *Place Bit.*
Line 26: SD35 travels to a different position at the Automatic bit changer and the command *Pick Bit* is executed. This time, SD35 takes a different bit, which is specified inside the command set up.
Line 27-28: SD35 moves to the waypoint 2 set on the way to a second screw feeder.
Line 29-31: SD35 executes the command *Pick Screw* at the second screw feeder and moves back to the waypoint 2.
Line 32-39: SD35 approaches the screw location to execute the command *Insert Screw.* After successfully executing the command, SD35 will wait for 0.01 seconds and move upwards by 20 mm.
Line 40-46: If the command Insert Screw has not been executed successfully, SD35 will wait 0.01 sec and move upwards by 20 mm, showing an error in a window popup.
Line 47-50: SD35 moves over the waypoint 2 to execute the command *Place Bit* and stops.

6.3 Application Example – Screw Insertion with Variable Pose

Here you can see a full URCap Program for a screw process where the position of the screw insertion is set by the 'spin_target' variable. This program utilizes the pallet node from Universal Robots to insert screws into a grid.





Line 2-3: SD35 travels to a waypoint above the workspace.
Line 4-5: SD35 moves to pick up the relevant bit for this program, but only if the pallet count is 1. This is only the case for the first insertion.
Line 6-13: Here the pallet is created. This is done by following the wizard, when the node is created. When teaching the corner items, insert the teach pen into already inserted screws in the corners of the grid.
Line 14-33: These are the actions that are performed for every insertion point in the palletizing operation.

Line 15-16: SD35 moves to a waypoint above the workspace to make a safe trajectory.
Line 17: SD35 moves to a dispenser and picks up a screw.
Line 18-19: SD35 moves to a waypoint above the workspace to make a safe trajectory.
Line 20: The variable 'spin_target' is set to 'referencePoint', which is the position of the hole that a screw is to be inserted into
Line 21-27: SD35 approaches the screw location to execute the command *Insert Screw.* After successfully executing the command, SD35 will wait for 0.01 seconds and move upwards by 500 mm.
Line 28-33: If the command Insert Screw has not been executed successfully, SD35 will wait 0.01 sec and move upwards by 20 mm, showing an error in a window popup.

Line 34-37: If the current pallet count is equal to the total pallet count the SD35 will place the bit back into the automatic bit changer and a popup will be shown telling the user that the program finished successfully.

6.4 URScript Commands

The entire set of URScript functions can be found in the urcap in /com/spin/urcap/URScript/ScrewdriverFunctions.script.

6.4.1 URScript Functions for Program Nodes

The following URScript functions are the functions used by the program nodes.

spin_pick_bit(bit_nr, app_offset, std_vel, fixture, force, safety)

The function to pick a bit:

- bit_nr is the bit number of the changing station. Can only be 1, 2 or 3.
- app_offset is the approach offset in meters. This has to be above 0.055

- std_vel is the velocity that the robot moves with whilst moving through the black arrows
- fixture is the coordinate frame of the bit changing station. This is taught in the bit changer tab
- force is the force threshold in Newton. If this threshold is surpassed whilst moving towards the bit the tool will return to the approach offset and try again. It will try 3 times before failing
- safety is a boolean telling if the soft safety feature should be on or off

spin_place_bit(bit_nr, app_offset, vel, fixture, force, safety)

The function to place a bit:

- bit_nr is the bit number of the changing station. Can only be 1, 2 or 3.
- app_offset is the approach offset in meters. This has to be above 0.055
- std_vel is the velocity that the robot moves with whilst moving through the black arrows
- fixture is the coordinate frame of the bit changing station. This is taught in the bit changer tab
- force is the force threshold in Newton. If this threshold is surpassed whilst moving down in front of the bit changing station the tool will return to the approach offset and try again. It will try 3 times before failing
- safety is a boolean telling if the soft safety feature should be on or off

spin_pick_up_screw(p, name, nrOfRetries, velZ, screwLength, offsetS, force, safety)

The function to pick a screw:

- p is the pose of the screw
- name is the name if the dispenser
- nrOfRetries is how many times the tool will try to pick a screw before an error is thrown
- velZ is the velocity of picking up a screw
- screwLength is the length of the screw in meters
- offsetS is the distance above p in meters that the approach will begin from
- force is the force threshold in Newton. If this threshold is surpassed whilst moving down towards the screw the tool will return to the approach offset and try again. It will try 3 times before failing
- safety is a boolean telling if the soft safety feature should be on or off

spin_approach_screw_insertion(p, offsetS1, offsetS2, velZ, screwLength, force, safety)

The function to approach a screw insertion:

- p is the pose of the fully inserted screw
- offsetS1 is the offset from p where the protective shield will retract in meters. This can only be between 0.003 and 0.016
- offsetS2 is the offset from p where the node takes control in meters. This con only be a positive value

- velZ is the velocity that the tool moves from S2 to S1
- screwLength is the length of the screw in meters
- force is the force threshold in Newton. If this threshold is surpassed whilst moving down towards the screw the tool will return to the approach offset and try again. It will try 3 times before failing
- safety is a boolean telling if the soft safety feature should be on or off

6.4.2 Low-level URScript Functions

The following URScript functions are functions used within the program nodes.

spin_reset_errors()

Resets tool errors. If errors are not resolved from this function, then refer to the SpinInterface

spin_motor_start(direction, rpm)

Starts the screwdriver with a given direction and rpm. Direction is to be set to 0 or 1, where 0 is clockwise and 1 is counterclockwise.

spin_motor_stop()

Stops the screwdriver.

The following functions are all to control the safety shiels (ss).

spin_ss_command(command, position)

Moves the shield. Command is an int that determines how the shield moves. Position is a position of the shield in mm and is only used for some commands but needs to be set every time the function is called.

0 – stops the shields movement

5 – homes the shield

10 – locks bit. The position that is moved to is also the home position

11 – releases bit

12 – covers bit

13 – moves pos past the bit. Is typically used to cover a screw. If pos is equal to the screw length in mm the screw will be covered

14 – moves pos relative to the current position of the shield

15 – moves shield to the absolute value of pos

30 – moves shield downward for position

31 – moves shield upwards for position

40 – robot follow. The shield will read the velocity of the robot and try to move with the opposite velocity. This is a mode that is entered. To exit this mode send a 0 command.

spin_ss_move_home()

Locks the bit.

spin_ss_move_bit_release()
Releases the bit.

spin_ss_move_bit_cover()

Covers the bit with the shield.

spin_ss_move_screw_cover(screw_length)

Covers a screw with a length of screw_length in mm.

spin_ss_home()

Homes the shield.

spin_ss_robot_follow()

Robot follow. The shield will read the velocity of the robot and try to move with the opposite velocity. This is a mode that is entered. To exit this mode send a 0 command.

spin_ss_stop()

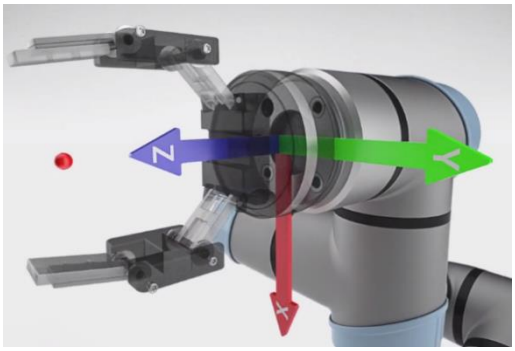
Stops the shields movement.

spin_led_intensity(intensity)

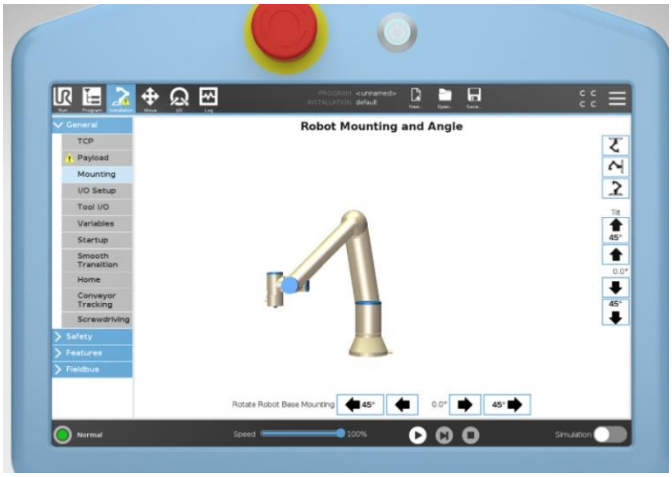
Sets the intensity of the LED in the range 0-100.

6.5 TCP Configuration

1. For the robot to work optimally, you will need to configure the position of the tool center point (TCP). TCP is the tip of the SD35 screwdriver's bit.
2. The robot needs to know the position of the TCP relative to the center of the UR tool flange. This is done by setting three coordinates: X, Y and Z in the URCap.



3. To configure the TCP, start by clicking the Installation button  in the upper left corner.
4. Choose the TCP button from the left menu.



6.5.1 Default TCP

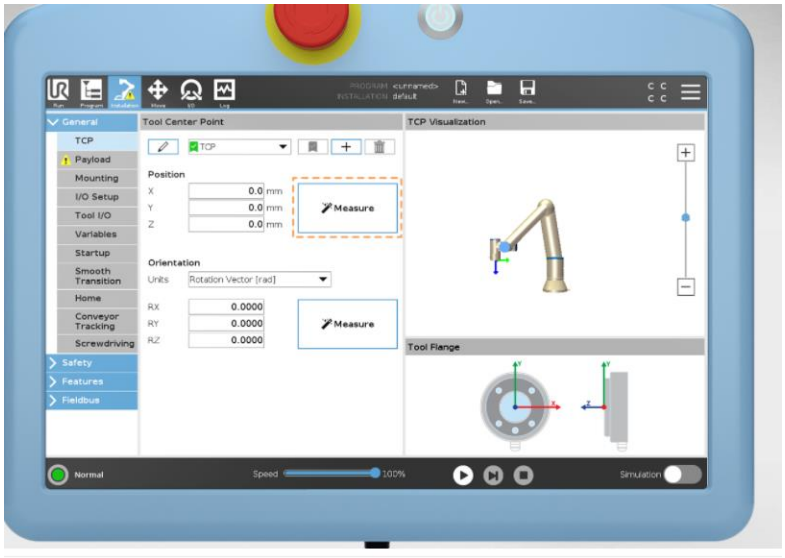
• Spin Robotics has configured the correct TCP for SD35 when mounted on the robot.

1. To select the default TCP, open the drop-down menu and select the "SPIN_SD_35".
2. Set it as the default TCP by clicking on the check mark.
3. Once that is done, it will show the TCP as default by having a green tick mark next to it.

NOTE: These coordinates are relevant when the SD35 is mounted directly on the flange, using the supplied SpinMount tool changer.

6.5.2 Automatically Measure TCP

• You can also choose to automatically measure the TCP by clicking on the button **Measure**.



1. To enter a new TCP, press the + button next to the drop-down menu. This will create a new TCP.
2. Click on the button Set point 1 and bring SD35's TCP to a pre-determined reference point – e.g. a sharp corner.
3. Click the button OK 

to save the location.
4. Repeat this procedure also with the point 2, 3 and 4 where the SD35 approaches the object from different directions.
5. Click on the button Set 

.
6. Using the four points, the system has now calculated the TCP automatically.
7. Under the **Orientation**, make sure to select RPY [°] in the drop-down menu and change the rotation around the X axis (**RX line**) by 90 degrees.
8. Make sure to press the check button to select this TCP as default.

7 SpinInterface

7.1 Ethernet Setup

You have two options to access the SpinInterface, either through a hotspot or connect the Ext. Network port to a network of your choice.

Hotspot details:

- Name: SpinBridge-xxxx, where the x's is the last four digits in the serial number.
- Password: spinbridge
- SpinInterface can be accessed through a browser on the address: "10.42.0.1"

If the SpinBridge is connected to a network that you manage, the SpinInterface can be accessed through the DNS name in a browser:

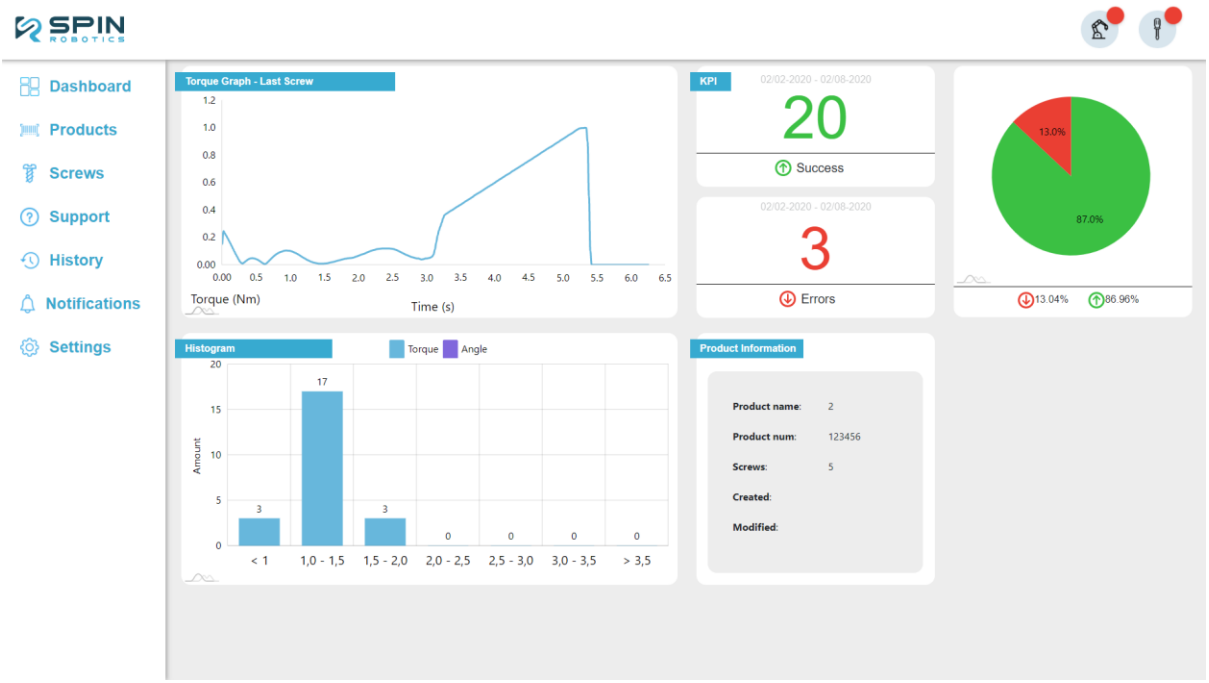
- "SpinBridge-xxxx:80", where the x's is the last four digits in the serial number.

7.1.1 Dashboard

Once you open the SpinInterface, you will see the main Dashboard screen.
In the upper right corner, you can see two buttons that will always appear throughout the Interface:

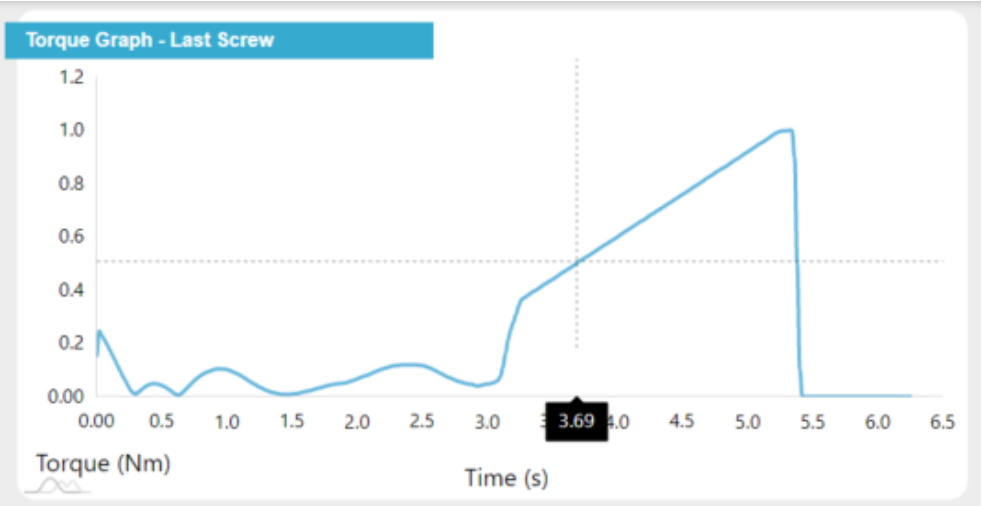
a) Connectivity to the robot - signaling green if the robot is connected, signaling red if the connection is lost.

b) Connectivity to SD35 - signaling green if SD35 is connected, signaling red if the connection is lost.

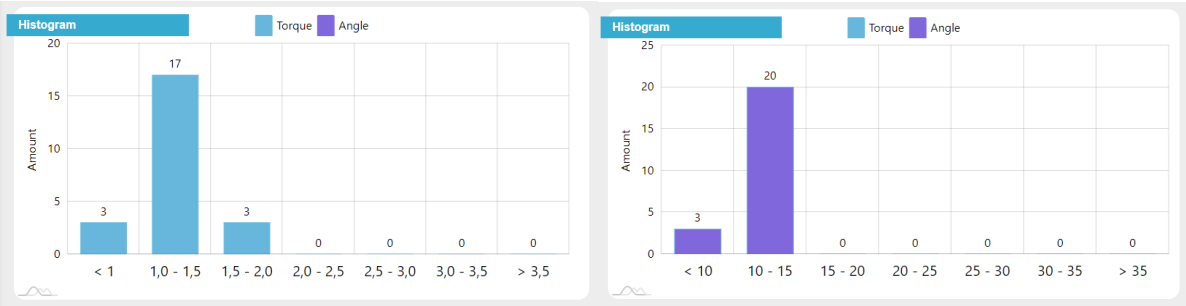


1. On the upper left side of the Dashboard screen, you will see a **Torque Graph.** This graph shows torque of the last screw that was inserted.
   - The vertical (y) axis represents torque in Newton-meters (Nm) while the horizontal (x) axis represents time in seconds (s).

- You can follow the precise values of the screw insertion by hovering over a desired point on the curve.
- By clicking and dragging the mouse from one point to another on the curve, you can zoom in on a certain time frame.

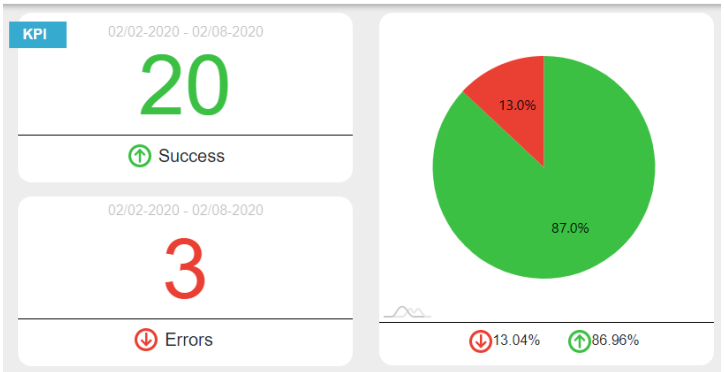


2. On the bottom left side of the Dashboard screen, you can see a **Histogram.** This histogram gives an overview of how many screws were inserted under a certain torque and angle.



- The vertical (x) axis shows the screws inserted while the horizontal (y) axis shows a corresponding torque or angle range.
- You can switch between the torque and rotations histogram by clicking on the blue and purple button above the graph.

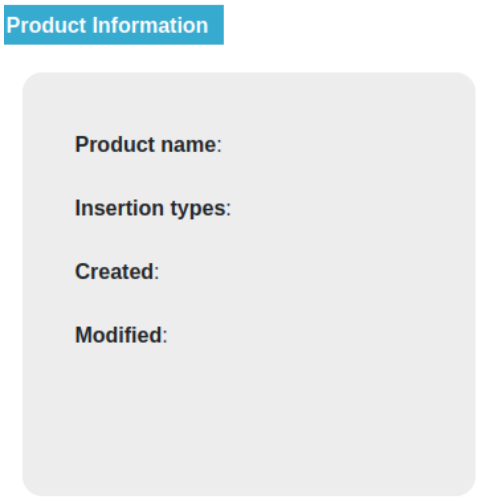
3. In the upper right corner, you will see the ***Success* rate** of all your screwdriving processes.



- The green number indicates the number of successfully inserted screws.

- The red number indicates the number of errors, screws that were inserted incorrectly.
- The pie chart on the very right indicates the percental share of errors (marked red) compared to the number of successfully inserted screws (green).

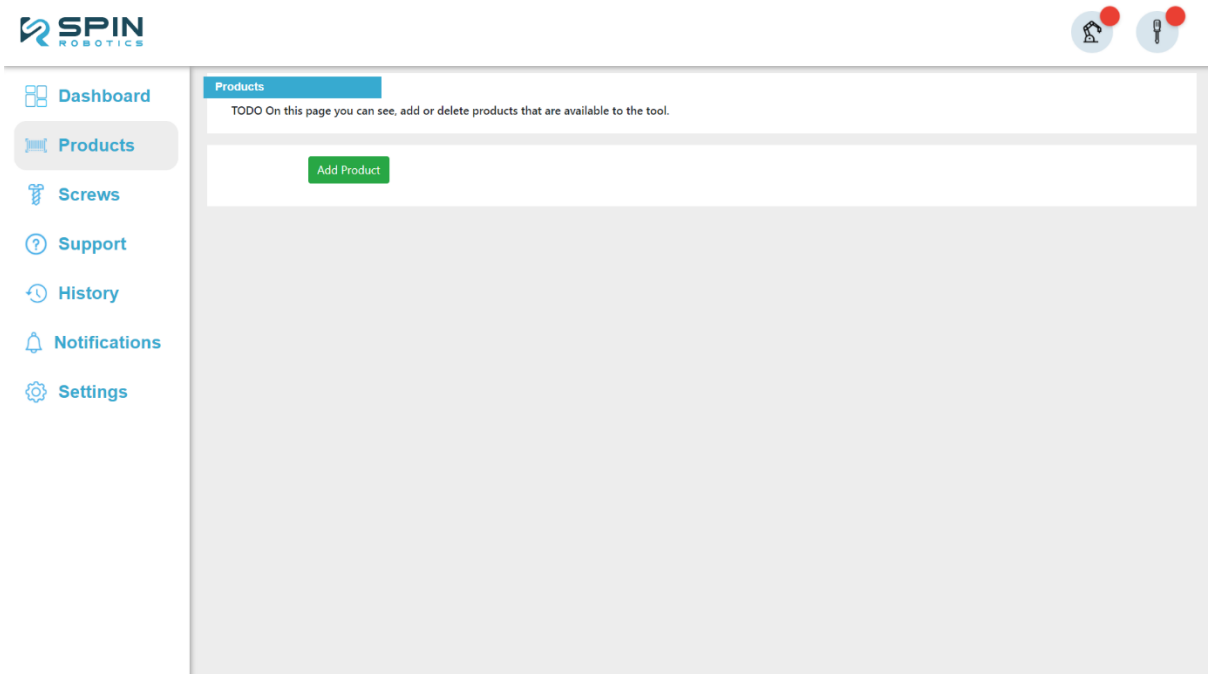
4. In the bottom right corner, you can see information about the latest **Part** in which you inserted screws.



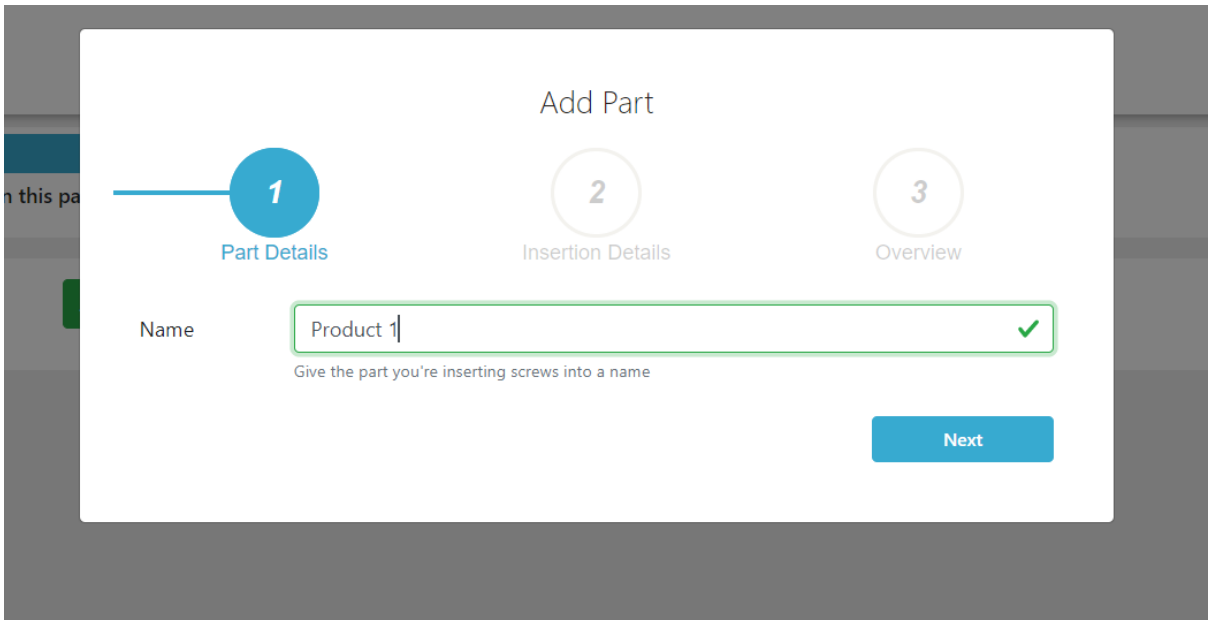
- The Product's name and number can be set up in the category Parts.
- The line Created and Modified shows when the Part was created and modified in the system.

7.1.2 Parts

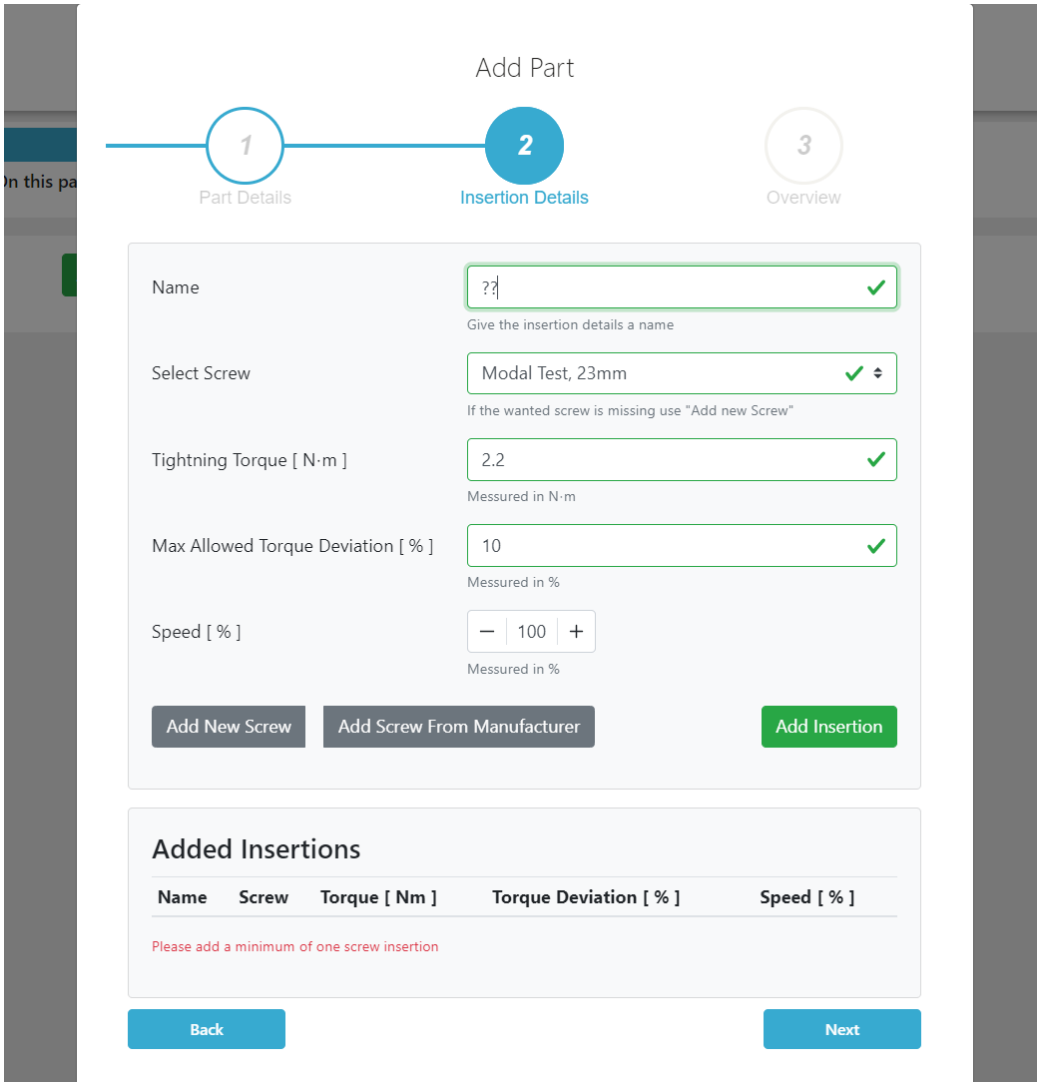
By clicking on the button Parts in the left side menu, you will get into a site where you can set up parts in which you insert screws.



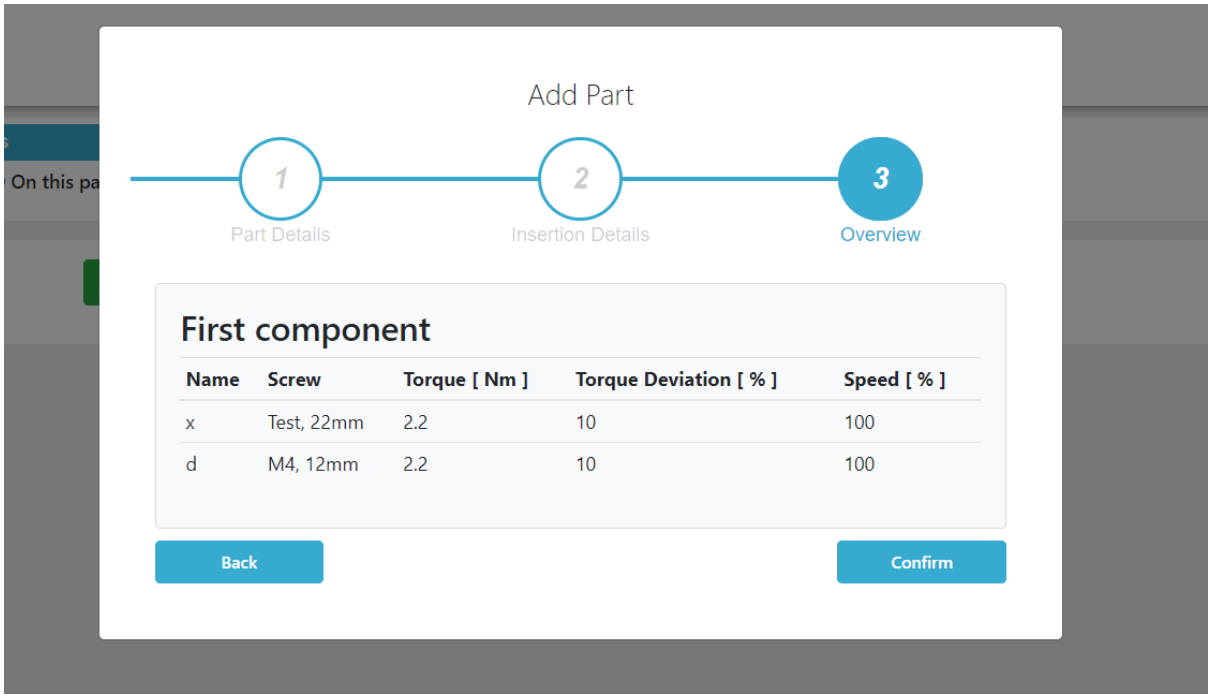
1. When you access this page for the first time, you will need to add your parts by clicking the green button **Add Part**.
2. A new window will open with a blank space for naming your part. When the name is typed in, the field will turn green, and you can click on the button **Next**.



3. The next step is to specify insertion details in each of the rows.



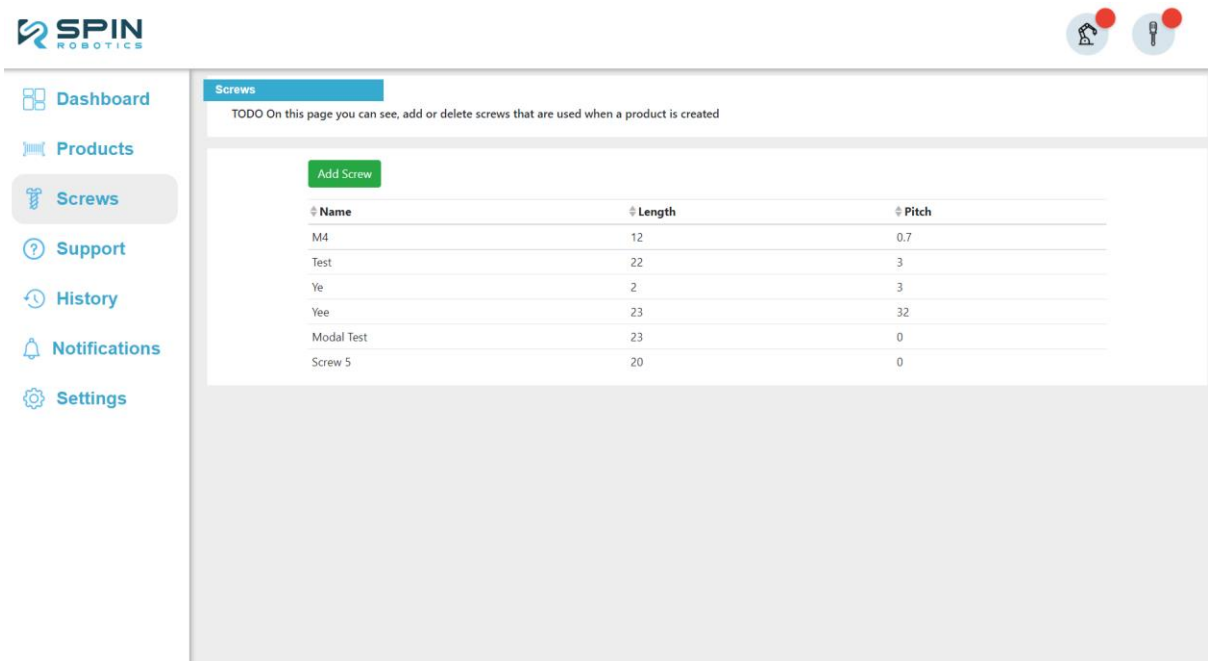
4. In the last step, Overview, you can either click on the button Back if you wish to edit some of the details or you can click on the button Confirm to save your part.



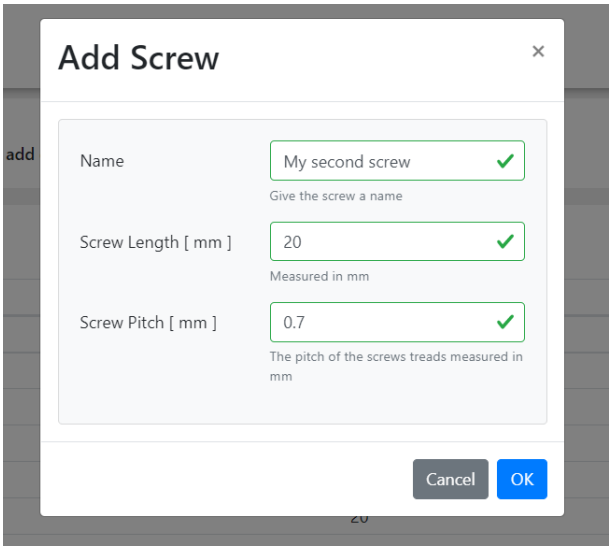
5. If you wish to switch to a previous section, Part or Insertions, click on the circle.
6. After confirming the part, you will be automatically taken back to the Part page where you will be able to see all your saved parts.

7.1.3 Screws

By clicking on the button **Screws** in the left side menu, you will get to a page where you can see, add or delete screws that are used in your parts. These screws then show up in the Parts configuration under Insertions when you click on **Select Screw.**



1. To add a new screw, click on the green button **Add Screw**.

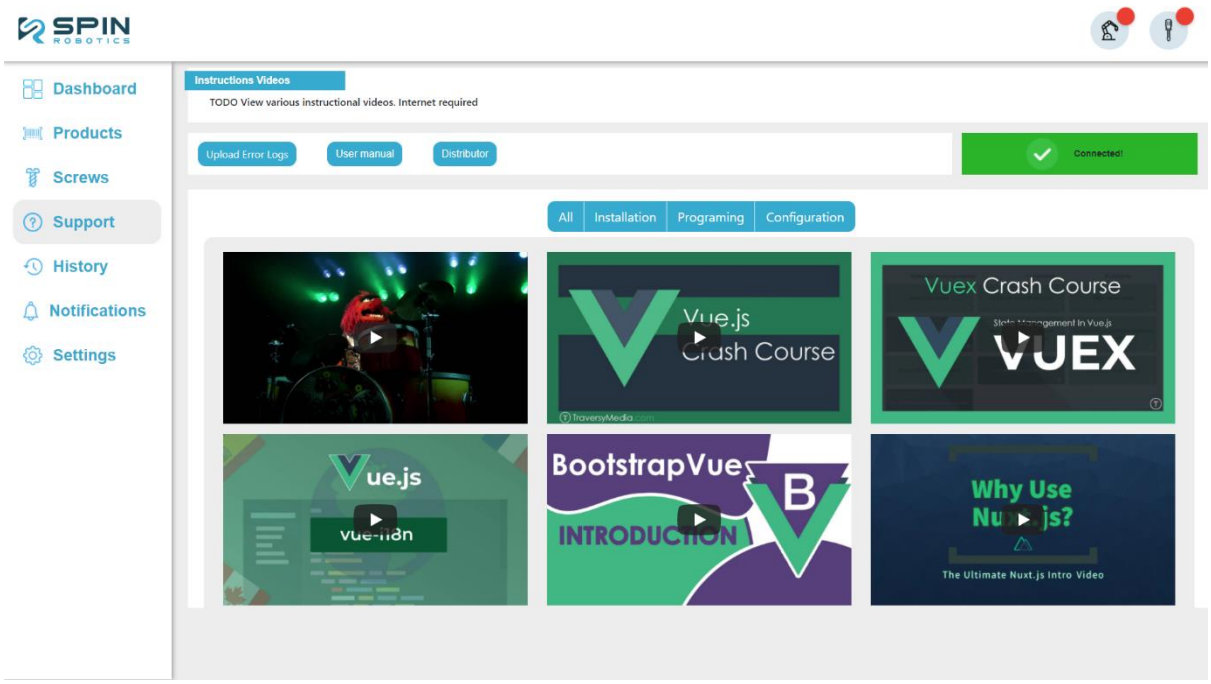


2. Fill in the required screw details and click on the blue button OK.
3. Now your newly added screw will show in the bottom of the list.
4. You can organize the list of screws by descending or ascending order based on the screw name or screw length.

7.1.4 Support

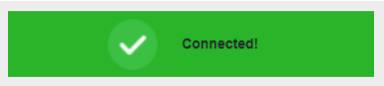
By clicking on the button Support in the left side menu, you will open a support page where you can play instructional video on how to, for example connect and set up SD35.

Internet connection is required on this sub-page.



1. Click on the button Send Error Logs to send the recorded errors to Spin Robotics.
2. Click on the button User Manual to open the SD35 manual on the Spin Robotics' website.

3. Click on the button Distributors to open a map of distributors on the Spin Robotics' website.
4. The green button Connected shows if the tool is connected to the internet.

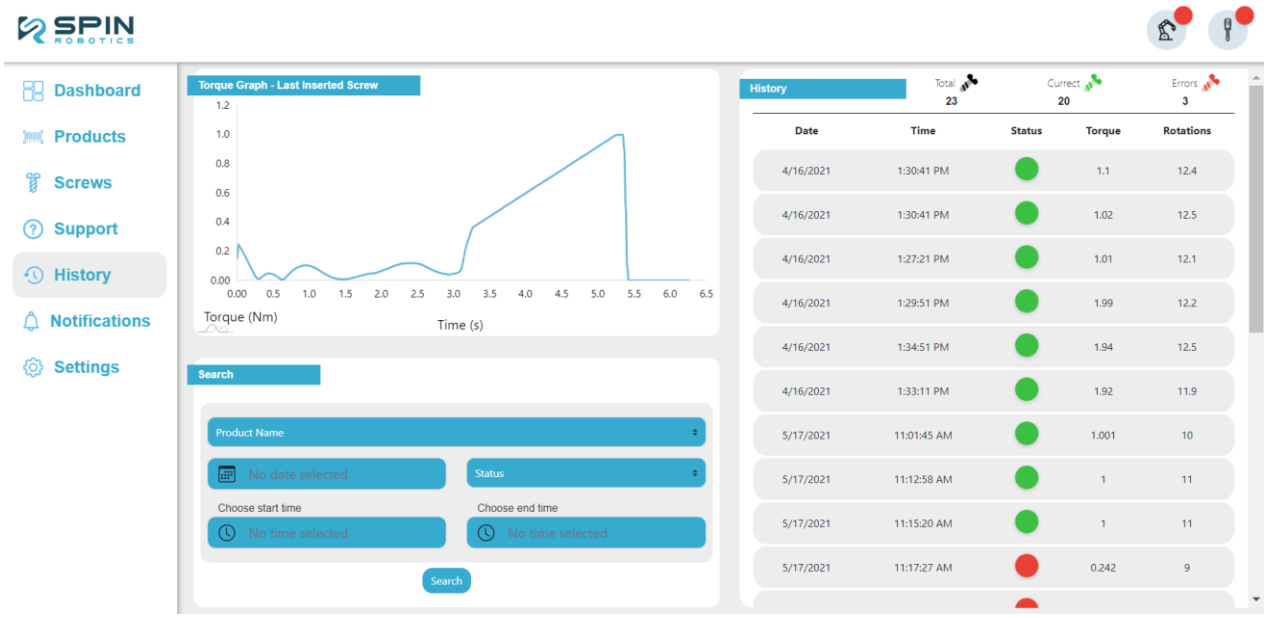


5. You can sort through the instructional videos by clicking on the different selections above the videos highlighted in blue.

7.1.5 History

By clicking on the button **History** in the left side menu, you will open a page where you can see recorded data from SD35.

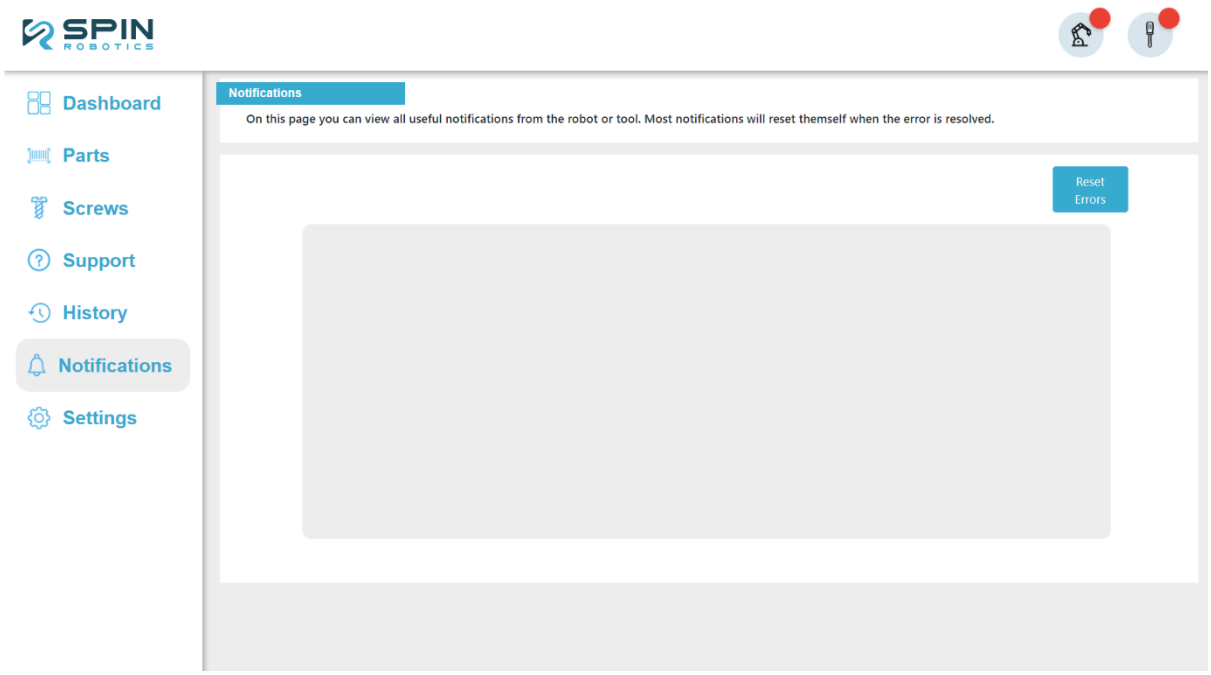
1. In the upper left corner, you can see the same torque graph as is shown on the Dashboard site. This graph shows torque of the last screw that was inserted.
2. Below the graph, you can **Search** for data from a specific screw by filtering through the options.



3. On the right side of the screen, you can see a detailed historic overview of total screws inserted, the number of correctly inserted screws and the number of errors.

4. In the lines below the overview, you can see the date, time, status, torque and rotations of each inserted screw.

7.1.6 Notifications



By clicking on the button **Notifications** in the left side menu, you will open a page where you can see notifications from the robot and SD35.

Once the error is resolved, the notification will disappear.

By clicking on the button **Resolve Errors**, the SpinBridge will try to resolve errors.

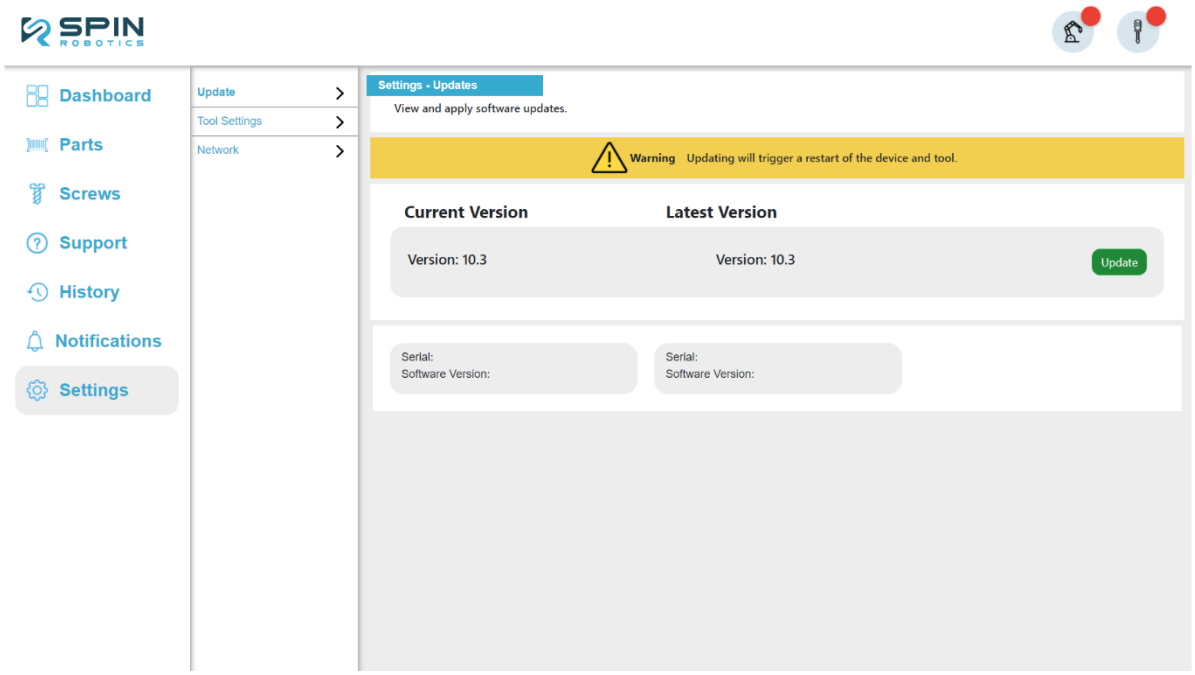
NOTE: If there is an error that you cannot resolve yourself, call the Spin Robotics tech support.

7.1.7 Settings

By clicking on the button **Settings** in the left side menu, you will open Settings configuration with three sub-options: Software Updates, Tool Settings and Network.

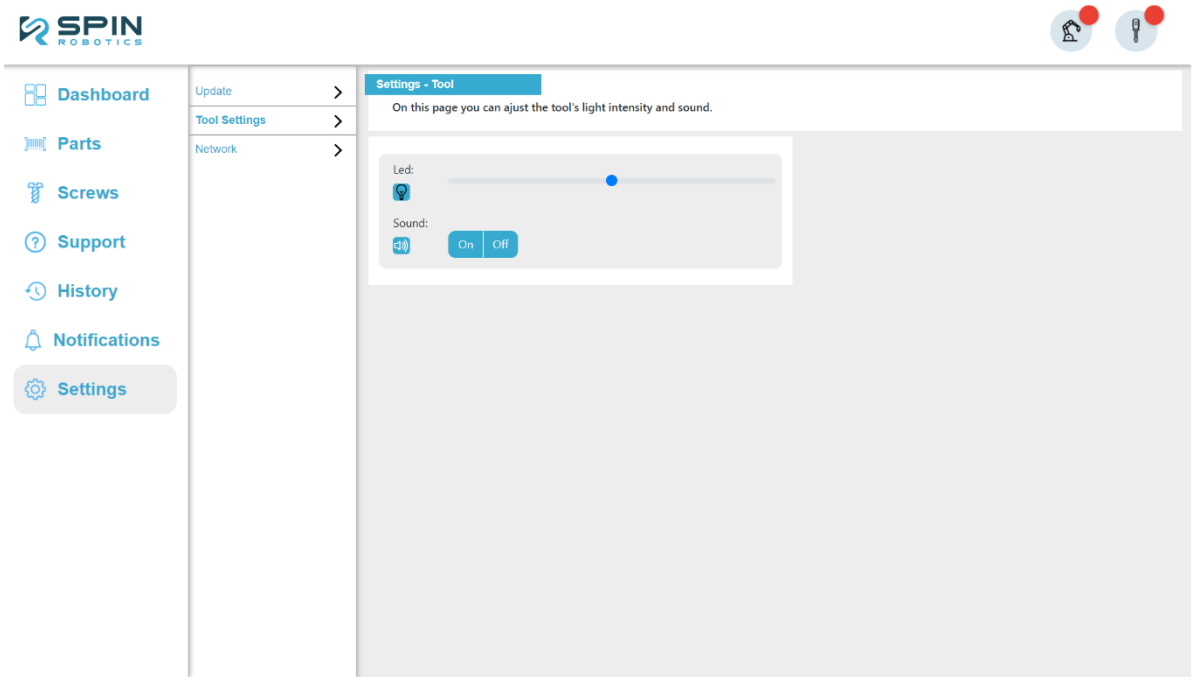
7.1.7.1 Software Updates

In this section, you will see the current software version and new software updates for the SpinBridge and SD35.
In case new updates are available, the button **Update** will have a green color. If there are no updates, it will stay gray.



7.1.7.2 Tool Settings

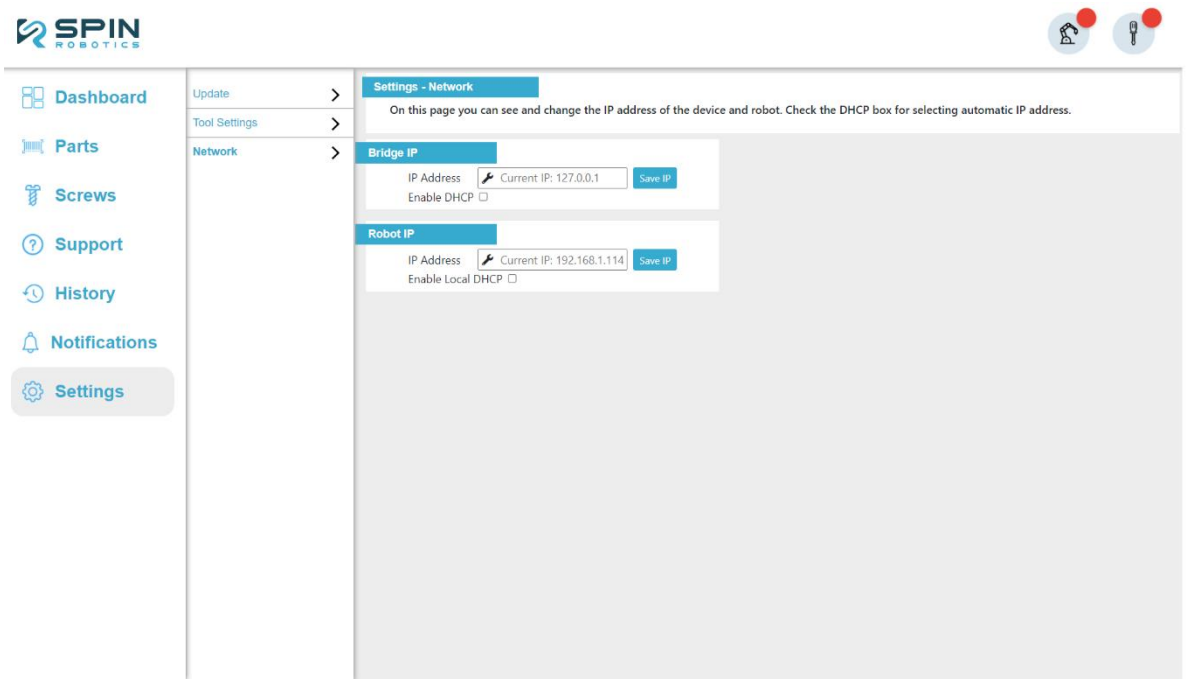
By clicking on the Tool Settings bar, you will be taken to a page where you can adjust the light intensity and switch on/off the sound of SD35.



7.1.7.3 Network Settings

By clicking on the bar Network Settings, you will get to a page where you can see and change the IP address of the SpinBridge and your robot.

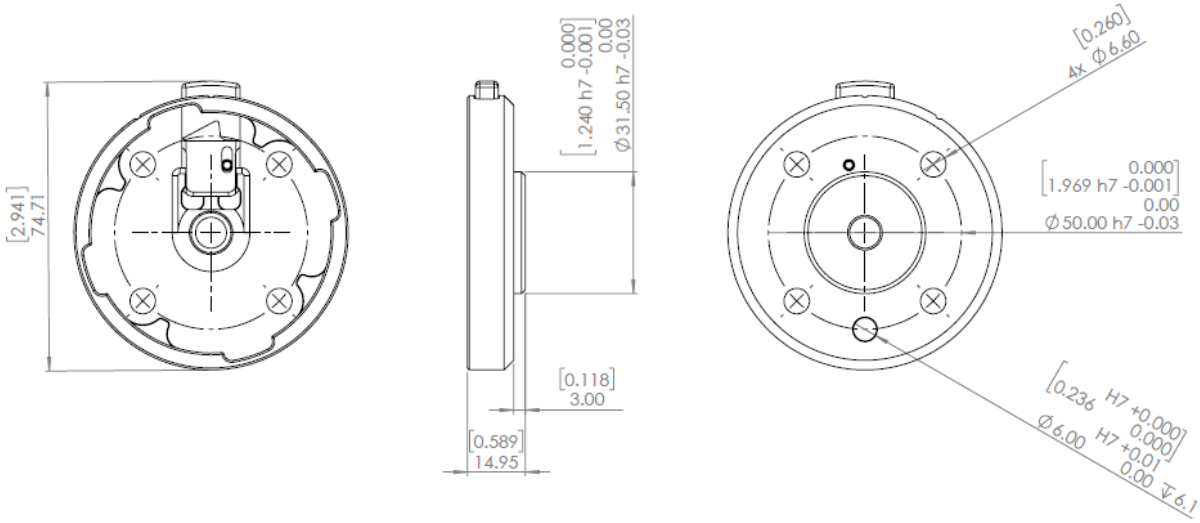
The configurable fields by both the Bridge and Robot are editable and show current IP addresses of the devices. By ticking the box Enable Local DHCP, you can select an automatic IP address.



8 Mechanical Specifications

8.1 Quick Changer Standard Interface

The mechanical mounting interface on the SD35 is a standard robot flange which complies with ISO 9409-1, Type 50-4-M6. Dimensions and tolerances are noted in mm/inches I the drawing below:



8.2 SD35 Dimensions

All dimensions are in mm/[inches].

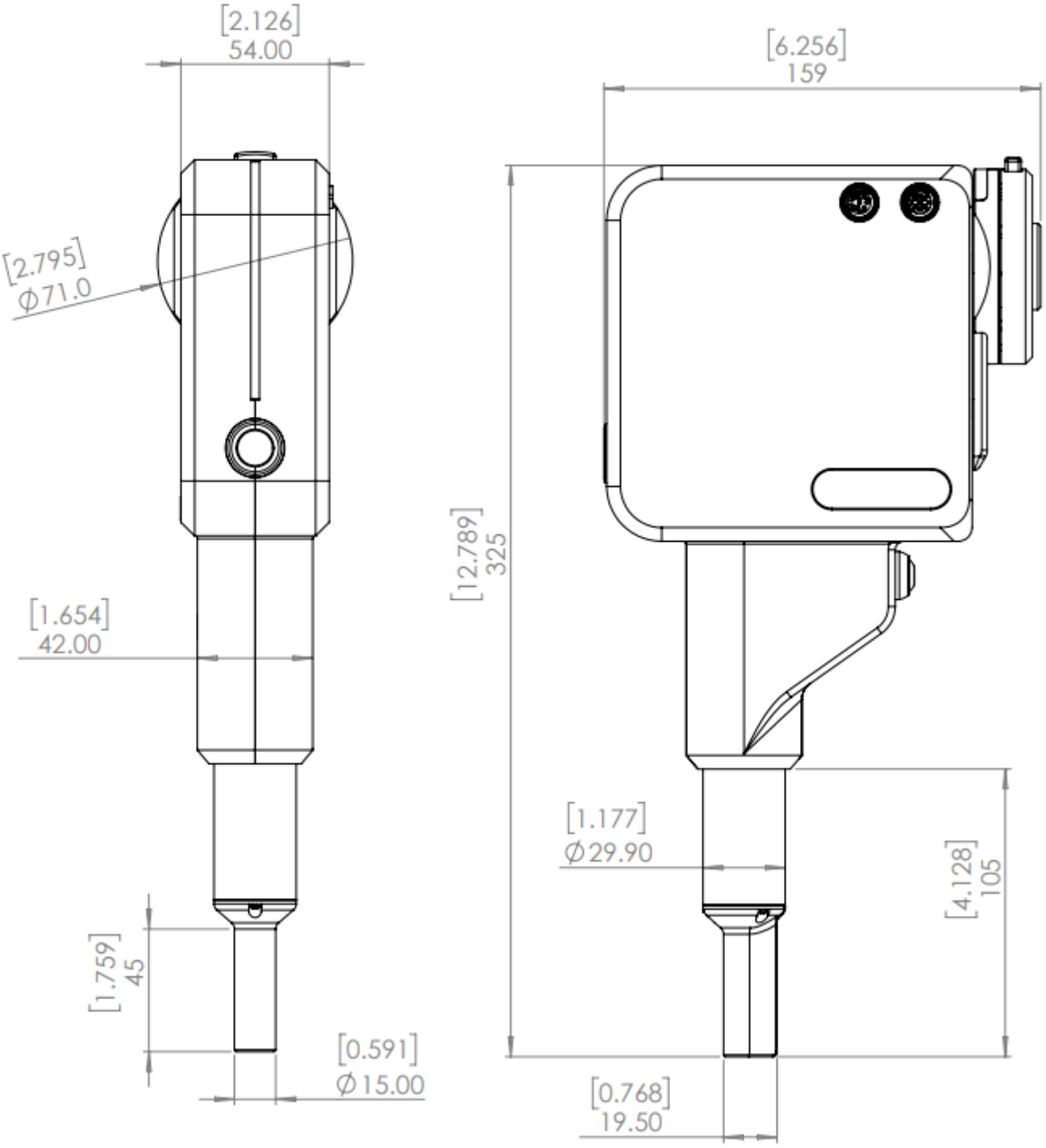


Figure 4 - SD35 dimensions - fully extended safety shield

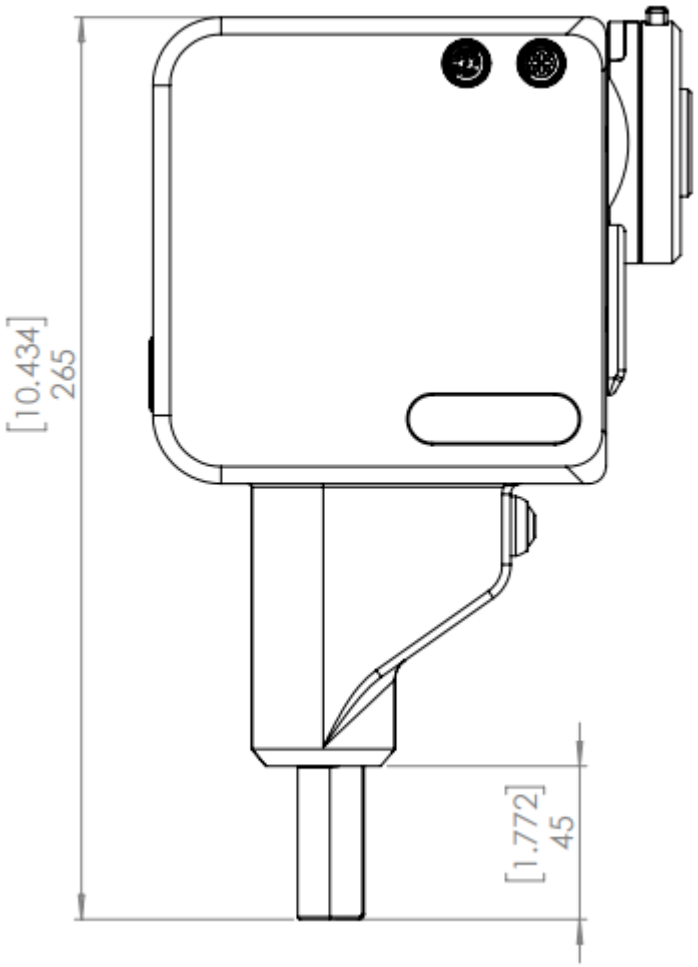


Figure 5 - SD35 dimensions - fully retracted safety shield

8.3 Tightening Torque

The SD35 is equipped with variable torque settings and has a torque range 0.8-3.5 Nm with a torque accuracy of ± xx tested according to manufacturer (or ISO5393).

Overheat protection, software, and built-in thermistor.

8.4 Moment of Inertia and Center of Mass

The coordinate system used for calculating the moment of inertia and center of mass for the screwdriver is shown in Figure 13. All values represent a configuration when the safety shield is in the fully retracted position.

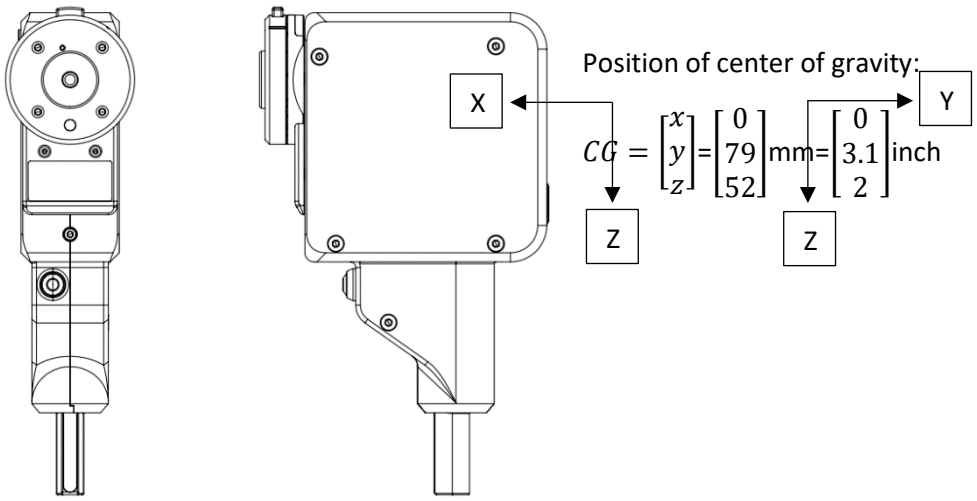


Figure 6 - Reference coordinate system

Mass moment of inertia:

$$I = \begin{bmatrix} I_{xx} & I_{xy} & I_{zz} \\ I_{yz} & I_y & I_{xx} \\ I_{zx} & I_{zy} & I_{zz} \end{bmatrix} = \begin{bmatrix} 16777 & -2 & 11997 \\ -2 & 35466 & 8 \\ 11997 & -8 & 19712 \end{bmatrix} kg * mm^2 = \begin{bmatrix} 57 & 0 & 41 \\ 0 & 121 & 0 \\ 41 & 0 & 67 \end{bmatrix} * lb * inch^2$$

8.5 Position of tool center point (TCP)

The TCP is defined at the tip of the screw bit.

Position of TCP:

$$TCP = \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 \pm 2 \\ 146.9 \pm 2 \\ 248.4 \pm 2 \end{bmatrix} mm = \begin{bmatrix} 0 \pm 0.08 \\ 5.78 \pm 0.08 \\ 9.78 \pm 0.08 \end{bmatrix} inch$$

8.6 Tool compliance and safety sensor

The tool is capable of both vertical and sideways operation. The maximum possible force that the bit can exert on a screw in axial direction, referred to as *axial force*, depends on the orientation of the tool as shown on the following table:

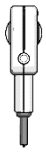
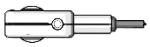
Orientation	Maximum axial force [N]
Vertical 	48 ± 3
Horizontal 	26 ± 3

Table 2 – Maximum axial force

If the force exceeds the max. axial force, the robot goes into safety stop.

NB: Some screw types need higher axial force than others for the driving torque to transfer into the screw. If the force is too small, the bit will jump out of the screw-slot and start spinning freely. To avoid this, we recommend using vertical tool orientation for screws requiring larger axial force and change worn out bits regularly. *(Box market in a visual way)*

9 Electrical Specifications

NOTE: It is only possible to control the SD35 screwdriver tool through the SpinBridge box. A SpinBridge is ALWAYS required to use the system.

SD35 supports a wide range of control methods through the SpinBridge, making it suitable for all the following:

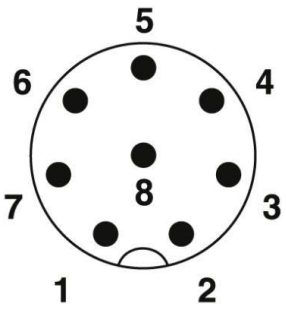
- Universal Robots - URCap and scripts
- Omron Techman - TMComponent
- Other Robots – Manual 24 V I/O control at the SpinBridge and Modbus TCP commands (port 1502)
- PLC – Manual 24 V I/O control and MODBUS TCP (RS485) commands (port 1502)

Power and communication are established with the SD35 via a 8-way communication cable and a 4-way power cable. The communication cable provides a 24V power supply to the screwdriver control system, serial RS485 communication to the SpinBridge and safety output signals from the internal safety system. The 4-way power cable supplies the main drive motor with 48V. During emergency stop the 48V supply are turned off by the SpinBridge.

A M12 8-way 3 m shielded communication cable and a M12 4-way 3 m shielded power cable a is supplied with SD35.

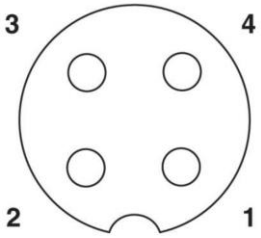
9.1 SD35 pinout interface

The table below illustrates the cable pinout at the SD35 tool input.



Signal connection pinout		
PIN	End of cable color	Signal
1	White	+24V – Robot/Safety supply (max. 2A)
2	Brown	+24V – Main power
3	Green	RS485 +
4	Yellow	RS485 -
5	Gray	SAFETY A
6	Pink	0V – Robot/Safety supply
7	Blue	GND – Main Power supply
8	Red	SAFETY B

Figure 7 - Pinout of the I/O Connector, Coding A



Power connection pinout		
PIN	End of cable color	Signal
1	Brown	+48V - Main power (max. 4 A)
2	White	+48V - Main power (max. 4 A)
3	Black	0V - Main power
4	Blue	0V - Main power

9.2 Status LED

A multicolor led status provides general information about the screwdriver status. **Error! Reference source not found.**

The meaning of the color signals is explained below.

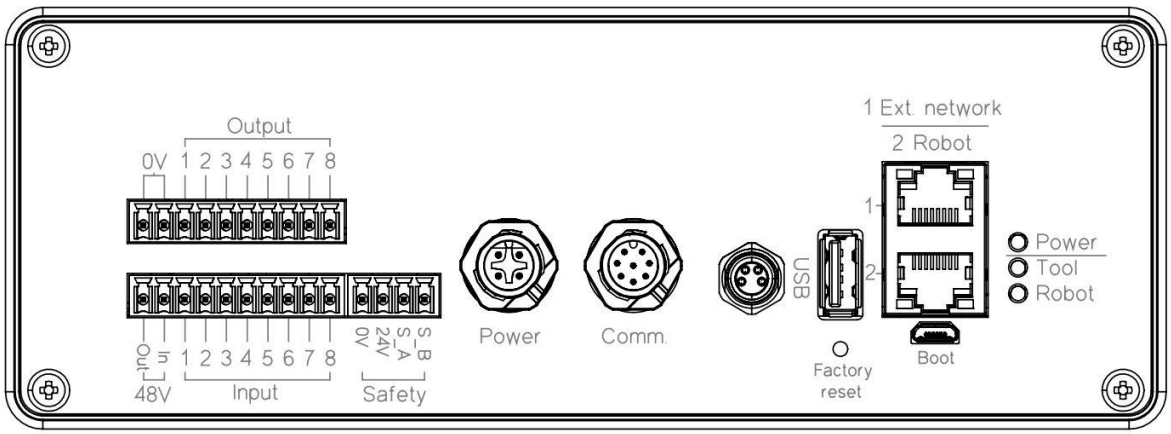
Color	State	Information
None	Off	Screwdriver is NOT supplied with power
White	On	Screwdriver is supplied with power. The robot is not moving
Yellow	Pulse	Robot is moving
Yellow	On - steady	Screwdriver motor is running
Green	On + buzzer (short beep)	Screw successfully inserted
Red	Blink + buzzer (long beep)	An error has occurred. See dashboard for further information.

Table 3 - LED color code

9.3 SpinBridge

The SpinBridge consists of the following electrical interfaces:

- 8 x 24V Digital inputs
- 8 x 24V Digital output
- 1 x 48V output and 1 x 48V input (SD35 drive motor supply)
- 2 x OSSD safety signal output & 24V/0V to supply the safety system
- 1 x M12 Power Connector to supply the SD35 drive motor with 48V
- 1 x M12 Communication connector to communicate with the SD35 tool
- 1 x USB 2.0 Host
- 2 x Ethernet ports
- 1 x USB Micro Slave (only used for factory software booting. DO NOT USE THIS)
- 3 x LED light indication



9.3.1 Digital Input & Output

The Spin

The safety cable for universal robots is wired as follows:

Color	Input	SpinBridge output
Green	EI0	Pin 3
White	EI1	Pin 4
Red	24V	Pin 2
Black	0V	Pin 1

Wiring

Ethernet cable

It is recommend to use the supplied 2M CAT- Ethernet cable

Power supply

10 Maintenance and Repair

All maintenance and repairs must be performed in compliance with this manual, including safety instructions.
Only authorized system integrators, or Spin Robotics, shall perform repairs. Unauthorized repairs can lead to warranty void.

Only use original spare parts.

- Always turn off the robot and screwdriver power supply before doing maintenance operations on the screwdriver.

The screwdriver requires only external maintenance, no maintenance is required on the inside. If in need of maintenance on the inside of the tool, please contact the vendor where the tool has been purchased. SD35 is not waterproof, proper cleaning should be done on the screwdriver with a dry cloth, with no chemicals, on monthly basis.

10.1 Screw Fix and Bit

Bit and fix for the screwdriver must be inspected visually monthly and after 50.000 cycles. If the screw fix is damaged due to misuse, it will be evident enough to be visually detected. In such cases, the screw fix must be replaced to avoid further damage to the tool.
Screw bit holder

Check inside the screw bit holder to ensure if there is any debris and make sure the magnetic interface is free of metal shavings and dirt, to ensure maximum grip of screws.

Replace bits if they show visible damage or wear. Inspect on monthly basis.

10.2 Calibration

The screwdriver has been calibrated at Spin Robotics to comply with the specifications in the technical sheet. In case of a calibration report is needed, please contact the vendor which the tool has been purchased.

11 Warranties

Patents

SD35 and other products of Spin Robotics are protected by several patents in global publication process. All manufacturers of copies and similar products violating patent claims will be prosecuted.

Product Warranty

Without prejudice to any claim the user (customer) may have in relation to the dealer or retailer, the customer shall be granted a manufacturer's warranty under the conditions set out below:

If a problem occurs with products and the problem is caused by manufacturing defects in material and workmanship, Spin Robotics will, at its discretion replace the Products in accordance with the warranty terms and conditions in accordance with Spin Robotics' Product warranty ("Product Warranty"). The Products are covered under the Product Warranty for i) a period of 12 months after delivery, or ii) a period of 15 months from the date the Products are shipped EXW (Incoterms 2020) from Spin Robotics' principal place of business in Odense, Denmark, or such shipping place as designated by Spin Robotics, or iii) a period of time until 1 million tightening cycles, whichever is first to occur (the "Warranty Period"). As far as applicable laws permit, the Warranty Period will not be extended or renewed due to subsequent exchange, resale, repair, or replacement of the products. Part(s) repaired or replaced during the Warranty Period will be warranted for: (a) the remainder of the original Warranty Period; or (b) 180 days from the date of repair or replacement, whichever is longer. Spin Robotics shall provide the necessary spare parts, while the customer (user) shall provide working hours to replace the spare parts, either replace the part with another part reflecting the current state of the art or repair the said part.

The Warranty does not apply to:

a. Products subjected to abnormal use or environmental conditions, accident, mishandling, neglect, unauthorized alteration, misuse, tampering improper installation or repair, or improper storage.
b. Damage resulting from or caused using any attachment, accessory, connection, extension, etc. attached to the Products.
c. Failure due to customer design, installation, programing and operating the Products outside the guidelines of Spin Robotics.
d. Products damaged by external conditions including, but not limited to, battery leakage, fire, water, or interruptions in electric power supply.
e. Down time, work stoppage, business interruption, loss of revenues or loss of anticipated savings, and loss of or damage to or corruption of data, due to Products failure.
f. Software.

Prior to shipping back, the product to Spin Robotics, the customer must get a Returned Material Authorization (RMA) from Spin Robotics. A Returned Material Authorization (RMA) form can be acquired by contacting the vendor which the tool has been purchased from. Under no circumstances whatsoever shall Spin Robotics be liable to any person, firm, or corporation for any special, indirect, or consequential damages, whether for breach of contract, negligence, misrepresentation or otherwise and whether resulting in lost profits, interest on money borrowed or invested, impairment of goods, work stoppage or otherwise, in any way arising out of the sale of any products or services by Spin Robotics to customer. The liability of Spin Robotics and the exclusive remedy of customer for any defect or breach or for any action relating to the

sale of any products or services by Spin Robotics to customer, whether based in contract, negligence, strict liability, tort, breach of warranty, or otherwise, is limited, at Spin Robotics' option, to repair or replacement of the defective goods or services or refund of the purchase price, therefore. The foregoing shall constitute the sole and exclusive liability of Spin Robotics and the sole and exclusive remedy of customer or anyone claiming on behalf of or through customer.

Disclaimer

Spin Robotics continues to improve reliability and performance of its products, and therefore reserves the right to upgrade the product without prior warning. Spin Robotics takes every care that the contents of this manual are precise and correct but takes no responsibility for any errors or missing information.

12 Certifications

Declaration, certificates and applied standards are listed in this chapter.

Applied Standards

Standards applied under the development of the product is listed in this section. When an EU Directive number is noted in brackets, it indicates that the standard is harmonized under that Directive.

ISO 12100:2010
EN ISO 12100:2010 (E) [2006/42/EC]
Safety of machinery – General principles for design – Risk assessment and risk reduction
The product is evaluated according to the principles of these standards.

ISO 10218-2:2011
EN ISO 10218-2:2011 (E) [2006/42/EC]
ANSI/RIA R15.06-2012
CAN/CSA-Z434-14
Robot and robotic devices – Safety requirements for industrial robots
Part 2: Robot systems and integration
The product is prepared for compliance with robot system requirements defined in the standards.

ISO/TS 15066:2016
RIA TR R15.606
Robots and robotic devices – Safety requirements for industrial robots – Collaborative operation
This is a Technical Specification (TS), **not** a standard. The product is prepared for easy integration in compliance with provisions in this Technical Specification, see, more in the safety chapter.

ISO/TR 20218-1:2018
Robotics – Safety requirements for industrial robots
Part 1: Industrial robot system end of arm tooling (end-effector)
This is a Technical Report (TR), **not** a standard. The product is designed according to principles in this Technical Report.

ISO 9409-1:2004 [Type 50-4-M6]
Manipulating industrial robots – Mechanical interfaces
The flange and tool changer on the SD35 conforms to type 50-4-M6 of this standard. Robots should also be constructed according to this standard to ensure proper fitting.

IEC 60529:2013
EN 60529/A2:2013
Degree of protection provided by enclosures (IP Code)
This standard defines enclosure ratings regarding protection against dust and water. SD35 is designed and classified with an IP rating according to this standard, see SD35 sticker.

IEC 61131-2:2007 (E)
EN 61131-2:2007 [2004/108/EC]
Programmable controllers
Part 2: Equipment requirements and tests

24V I/O signals in the SD35 control box are constructed for reliable communication with robots and PLC´s conforming to these signals.

IEC 61076-2-104:2014 [8-way, coding A, gold contacts]
EN 61076-2-104:2014 [8-way, coding A, gold contacts]
Connectors for electronic equipment
Part 2-104: Circular connectors – Detail specification for circular connectors with M8 screw- or snap-locking
The SD35 connector and the cable conforms to type 8-way, coding A, gold contacts, which is the highest quality rating defined in this standard. Mating operations: 100 times

ISO 13732-1:2006
EN ISO 13732-1:2008 [2006/42/EC]
Ergonomics of the thermal environment – Methods for the assessment of human responses to contact with surfaces
Part 1: Hot surfaces
The product is designed so that the surface temperature is kept under the ergonomic limits defined in this standard.

IEC 61000-6-2:2005
IEC 61000-6-4/A1:2010
IEC 61000-4-2
EN 61000-6-2:2005 [2004/108/EC]
EN 61000-6-4/A1:2011 [2004/108/EC]
EN 61000-4-2
Electromagnetic compatibility (EMC)
Part 6-2: Generic standards - Immunity for industrial environments
Part 6-4: Generic standards – Emission standard for industrial environments
The product is tested according to these standards.

EN 50370-2:2003
EN 50370-1:2005
Electromagnetic compatibility (EMC) – Product family standard for machine tools
Part 1: Emission
Part 2: Immunity
The product is tested according to these standards.

IEC 60068-2-1:2007
IEC 60068-2-2:2007
IEC 60068-2-27:2008
IEC 60068-2-64:2008
EN 60068-2-1:2007
EN 60068-2-2:2007
EN 60068-2-27:2009
EN 60068-2-64:2008
Environmental testing
Part 2-1: Tests – Test A: Cold
Part 2-2: Tests – Test B: Dry heat
Part 2-27: Tests – Test Ea and guidance: Shock
Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance
The product is designed to pass tests defined in these standards.

IEC 60664-1:2007
IEC 60664-5:2007
EN 60664-1:2007 [2006/95/EC]
EN 60664-5:2007
Insulation coordination for equipment within low-voltage systems
Part 1: Principles, requirements and tests
Part 5: Comprehensive method for determining clearances and creepage distances equal to or less than 2mm
The electrical circuitry of the product is designed in compliance with these standards.

UL 1740:2018 edition 4
Standard for Robots and Robotic Equipment
The product is designed to meet the requirements in both this and other relevant UL standards. For more information about UL compliance and field certification in US, contact your supplier.

ISO 5393:2017
Rotary tools for threaded fasteners – Performance test method
This standard defines test method for screwdriver tools. The SD35 has undergone this method to identify the torque repeatability of the tool.

ISO 20607:2019
Safety of Machinery – Instruction handbook – General Drafting Principles

Remember ESD standards for electronic equipment!!! ER det inkluderet I IEC 61000-4-2-ESD???

13 CE/EU Declaration of Incorporation (original)

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

The manufacturer:

Spin Robotics Aps
Niels Bohrs Allé 185
5220 Odense SØ
Denmark

declares that the product:

Type: Industrial Screwdriver Tool
Model: SD35
Generation: G1
Serial: SD35.6020.00000 - SD35.6020.99999

may not be put into service before the machinery in which it will be incorporated is declared in conformity with the provisions of Directive 2006/42/EC, including amendments, and with the regulations transposing it into national law.

The product is prepared for compliance with all essential requirements of Directive 2006/42/EC under the correct incorporation conditions, see instructions and guidance in this manual. Compliance with all essential requirements of Directive 2006/42/EC relies on specific robot installation and the final risk assessment.

Technical documentation is compiled according to Directive 2006/42/EC annex VII part B and available in electronic form to national authorities upon legitimate request. Undersigned is based on the manufacturer address and authorized to compile this documentation.

Additionally, the product declares in conformity with the following directives, according to which the product is CE marked:

2014/30/EU - Electromagnetic Compatibility Directive (EMC)
2011/65/EU – Restriction of use of certain hazardous substances (RoHS)

Relevant essential health and safety requirements of the following EU directives are also applied:

2014/35/EU - Low Voltage Directive (LVD)
2012/19/EU – Waste of Electrical and Electronic Equipment (WEEE)

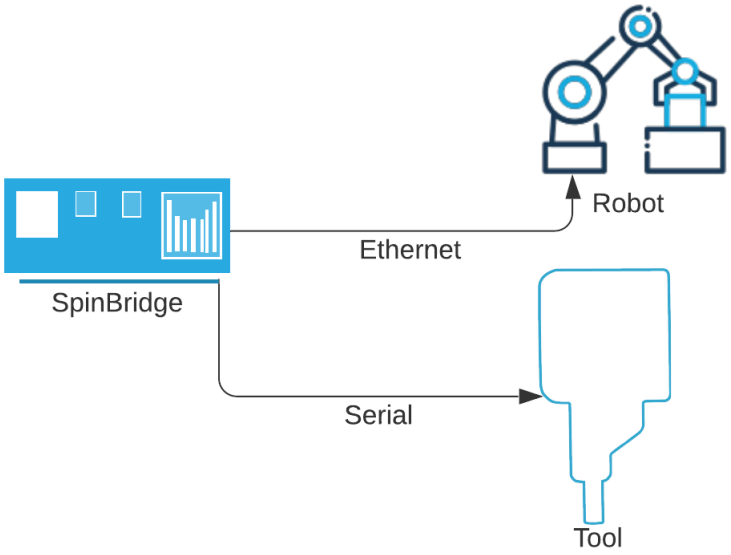
A list of applied harmonized standards, including associated specifications, is provided in this manual.

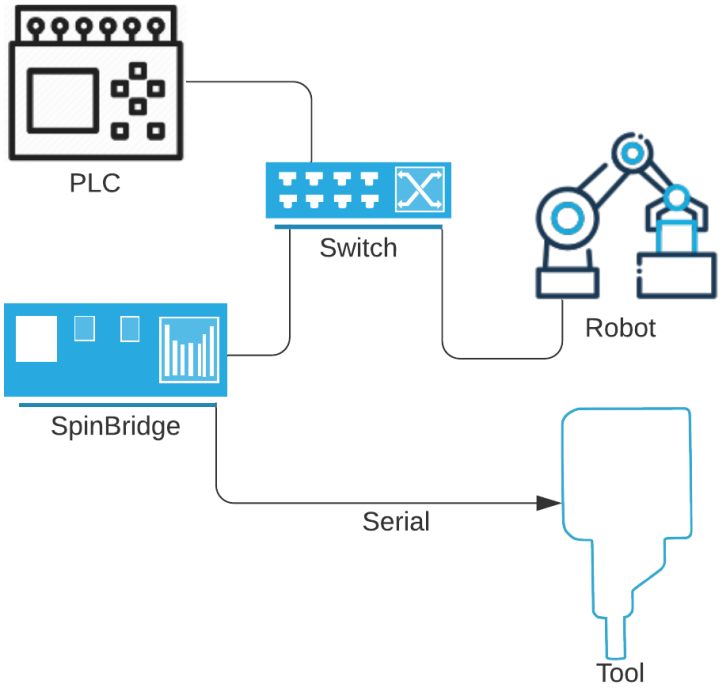
Odense, June 9th, 2021 Corporate Management

Thomas Sølund
Chief Technology Officer

14 Appendix A - Connect Additional Network Equipment to the Robot

This appendix will describe some of the ways one could setup this system with different kinds of network equipment, like a camera or a PLC.

<table>
<tr>
<td> 
</td>
<td>Default Setup described in this manual.

The ethernet port labeled Robot on the SpinBridge connected directly to the robot.
SpinBridge with static IP of 192.168.37.1
Robot with a static IP of 192.168.37.100.</td>
</tr>
<tr>
<td> 
</td>
<td>Possible setup with an additional network device.

The ethernet port labeled Robot on the SpinBridge connected to a switch which is then connected to the robot and the external device, PLC in this diagram.
SpinBridge with static IP of 192.168.37.1
Robot with a static IP of 192.168.37.100.

If the robot must use another IP than:
192.168.37.100
Please make sure that the IP of the robot is known to the system via. SpinInterface – Settings – Robot IP.</td>
</tr>
</table>

15 Appendix B – Error Codes

This appendix lists and describes all possible errors one can encounter while using this system.

Error code	Text	Description	Possible Solution
10	Robot - Interface Not Connected	Ethernet connection to the SpinBridge is faulty.	Make sure the network is setup correctly. Else restart the robot.
11	Robot - Modbus Not Connected	Serial connection to the SpinBridge is faulty.	Make sure the network is setup correctly.
12	Robot - Emergency Stop	Robot is in emergency stop.	Make sure all emergency stop buttons are unpressed, and the safety sensor on the tool is not exposed.
13	Robot - Security Stop	Robot security stop has been activated.	
14	Robot - Not Powered On	Robot not powered on.	Make sure the robot is powered on.
50	Tool - Not Connected	Tool not connected to SpinBridge.	Make sure the cables are connected correctly from the tool to the SpinBridge.
60-66	Range of errors.	Internal tool utilities errors.	Restart SpinBridge else contact support if problem presists.
80-93	Range of errors.	Internal drive motor errors.	Restart SpinBridge else contact support if problem presists.
83	Tool Motor - Temperature Too High	Drive motor temperature is too high.	Make sure the setup is properly ventilated.
100-116	Range of errors.	Internal safety shield errors.	Restart SpinBridge else contact support if problem presists.
130	Screw Program - Does Not Exist	Insertion missing under Parts on the SpinInterface.	Internal data error. Try to remake the Part.
131	Screw Program - Invalid	Faulty value on an insertion or part.	Check that Part and Screw are within supported parameters.
132	Screw Program - Invalid Type	Insertion type is not supported.	Internal data error. Try to remake the Part.
133	Screw Program - Type Not Implemented	Insertion type is not supported.	Internal data error. Try to remake the Part.
134	Screw Program - Tool Torque Log	?	
135	Screw Program - Undefined	Part or Insertion is faulty.	Internal data error. Try to remake the Part.

150	Screw Program - Start - Robot Force	?	
151	Screw Program - Start - Robot Position	?	
152	Screw Program - Start - Robot Speed	?	
153	Screw Program - Start - Timeout	?	
154	Screw Program - Start - Tool Speed	?	
155	Screw Program - Start - Tool Torque	?	
156	Screw Program - Rundown - Robot Position	?	
157	Screw Program - Rundown - Robot Speed	?	
158	Screw Program - Rundown - Timeout	?	
159	Screw Program - Rundown - Tool Speed	?	
160	Screw Program - Rundown - Tool Torque	?	
161	Screw Program - Tightening - Timeout	?	
162	Screw Program - Target - Angle	?	
163	Screw Program - Target - Position	?	
164	Screw Program - Target - Torque	?	
180	Screw Program - Loosen - Start Timeout	?	
181	Screw Program - Loosen -	?	

	Rundown Timeout		
182	Screw Program - Loosen - Rundown Robot Position	?	