Sensapex uMp micromanipulation system

Operating manual

Rev 2.0
4th June 2024

Sensapex Oy
Teknologiantie 13
Email: support@sensapex.com
www.sensapex.com

Disclaimer

Best efforts have been made to ensure that information contained in this manual is accurate. Latest version of this manual is available at: www.sensapex.com/support. We accept no responsibility for any errors or omissions, and we reserve the right to modify specifications, design, characteristics and products at any time without obligation.

The uMp micromanipulation system is designed for positioning microelectrodes, micropipettes or microtools with sub-micrometer resolution over distances of millimeters. The positioning typically takes place under visual control using a microscope. No other use is recommended.

- Product is not a medical device. It should be used only for non-human research.
- Any misuse will be the sole responsibility of the user/owner. Sensapex assumes no implied or inferred liability for direct or consequential damages from this product if it is operated or used in any way other than for which it is designed.

Safety warnings ⚠

- Use only the power supplier and cables provided by Sensapex. Always use grounded mains supply.
- Do not expose the product to liquid spills or moisture to prevent fire or shock hazard.
- This instrument contains no user-serviceable parts or components. Do not try to open or attempt to repair the instrument.

Precautions

Failure to comply with any of the following precautions may damage the product.

- uMp micromanipulation system is a sensitive research instrument. Handle and operate it according to instructions in this manual and with care to avoid damage.
- Do not operate if there is any obvious damage to the product.
- Do not operate near flammable materials or expose it to corrosive materials. Use of any hazardous materials with the product is not recommended and is the sole responsibility of the user.
- Be cautious and protect yourself against injury from microelectrodes or micropipettes. Note that pressure injections may cause pipette to shoot off from the holder. Use safety glasses and other protection if required for safety.
- Retain the original packaging for possible future transport of the product.
- To clean the micromanipulation system components, gently wipe them with a clean and dry or slightly water dampened cloth. Do not submerge in water or other cleaners or solvents.

Environmental ratings

- The micromanipulation system is designed for typical laboratory conditions.
- The system should be operated only in the temperature range of 15 °C to 40 °C. The maximum allowed relative humidity is 80 % at 5 °C to 31 °C and decreasing linearly from 80 % to 50 % between 31 °C and 40 °C.
- Mains supply-voltage must not fluctuate more than ±10%. The presence of typical transients on the mains supply, e.g. those of installation or overvoltage, are category II.
- Pollution degree II

1 Introduction 4
2 Warranty 4
3 Installation 4
3.1 Arrival inspection 4
3.2 General recommendations 5
3.3 Micromanipulator handedness 5
3.4 uMp micromanipulator axes definitions 5
3.5 Installing uMp micromanipulators using different stand options 5
3.6 Adjusting uMp-3 x-axis or uMp-4 D-axis vertical offset and tilt angle 6
3.7 Installing an amplifier head-stage using the uMp-DVT 7
3.8 Installing a rod with uMp-RHL 8
3.9 Grounding the manipulator 8
3.10 Connecting the products and powering ON the system 8
3.11 Calibrating the micromanipulators 9
4 uMp micromanipulation system operation 9
4.1 Powering ON – OFF the system 9
4.2 uMp-RW3 | uMp-RW4 9
4.3 uMp-TSC2 main view 10
4.4 Basic micromanipulator operation 11
4.5 Setting and using Home and Target positions 11
4.6 Changing between absolute and relative coordinates 11
4.7 Virtual axis 12
4.8 PEN speed 12
4.9 Single axis view with programmable automated stepping 12
4.10 Pipette or probe change 13
4.11 uMp-TSC2 Sleep mode 13
4.12 Charging uMp-HUB batteries 13
4.13 Updating firmware 13
5 uMp-TSC2 Main menu 13
5.1 Rotary wheel unit configuration 14
5.2 Movement sequences 14
5.3 Device group configuration 15
5.4 Classic move control 15
5.5 Dark mode 15
5.6 Confirmation dialogs 15
5.7 Reset uMp-TSC settings 15
5.8 About 16
6 Manipulator settings menu 16
6.1 Setup 16
6.1.1 Device ID 16
6.1.2 Device name 17
6.1.3 Calibrate zero position 17
6.1.4 Calibrate load 17
6.1.5 Poll axis angle 17
6.1.6 Test run 17
6.1.7 Virtual axis settings 17
6.2 Advanced settings 18
6.2.1 Simultaneous axes movement 18
6.2.2 Axis drive order 18
6.2.3 Enable range limits 18
6.2.4 Soft Start 18
6.3 Manipulator info 19
6.4 Add-on Features (Legacy) 19
7 Micromanipulator handedness and stand re-adjustments 19
7.1 Micromanipulator handedness reconfiguration 19
7.2 uMp-ROT handedness re-configuration 21
7.3 uMp-SLD locking tightness re-adjustment 21
8 Maintenance and troubleshooting 22
8.1 None or some manipulators connected to the system are available for control 22
8.2 Pipette tip is drifting 22
8.3 Manipulator axis does not move or moves only over partial range 22
8.4 Products got exposed to accidental liquid spill 22
9 Specifications 23
10 Manufacturers declaration of conformity 24

1 Introduction

Sensapex uMp micromanipulation system is based on patented piezo and motion control technologies to provide leading positioning accuracy and stability in compact size.

The uMp micromanipulation system includes uMp-TSC2 touch screen controller, uMp-RW3 or uMp-RW4 rotary wheel unit, uMp-HUB or uMp-HUB lite hub and one or more uMp-3 or uMp-4 micromanipulators. uMp-HUB also provides battery operation option. Each uMp-HUB or uMp-HUB lite enables adding four micromanipulators to the system.

There is no practical limit how many uMp-HUB or uMp-HUB lite and micromanipulators one system can have. A selection of standard accessories is provided to support most typical applications with the products.

Figure 1. uMp micromanipulation system main products.

2 Warranty

uMp micromanipulation system products have two (2) years limited warranty. The limited warranty terms are defined in the Sensapex general sales terms, which are available at our website:

- USA: https://www.sensapex.com/sensapex-terms-and-conditions-us/
- Rest of the world: https://www.sensapex.com/sensapex-terms-and-conditions/

3 Installation

Do not dismantle, loosen, or remove any of the screws or parts that are not indicated in this manual to be operated by the customer during normal use. Doing so will void the warranty and may require returning the product to Sensapex for service.

3.1 Arrival inspection

Please store the original packaging in case it ever becomes necessary to ship products again. Improper packaging is a form of abuse and, as such, will void the warranty for possible shipping damage.

- Please notify Sensapex or your local distributor immediately if the outside of the package is damaged.
- Carefully unpack all the items and verify that you have received all the parts specified in your order and packing slip.
- Please contact Sensapex or your local representative if any of the ordered parts are missing or if you have any concern regarding possible shipping damage.

3.2 General recommendations

Please follow these general recommendations during the installation:

- Manipulators are designed to install upright on a stable, flat, and clean surface.
- Handle the manipulators with care, preferably by holding them from the back of the body (part where indicator LED is located) to avoid excessive loading to any of the axes.
- For best stability, install manipulators close to the sample and ensure that cables and tubing are organized with drag relief (while having enough slack for free axes movements).

3.3 Micromanipulator handedness

uMp micromanipulators can be used in right- or left-handed configuration (pictures in this manual show right-handed uMp-3 manipulator). Typically, right-handed manipulators are installed on the right side and left-handed on the left side of the sample.

- For right-handed configuration, x-axis attachment surface is facing towards you when the manipulator is placed on the right-hand side of the sample.
- For left-handed configuration x-axis attachment surface is facing towards you when the manipulator is placed on the left-hand side of the sample.
- Handedness can be reconfigured at any time as instructed in 7.1.
    - Configure the right-handed manipulators with odd and left-handed manipulators with even device ID numbers (6.1.1). The y-axes of the manipulators installed at the opposite sides will then move in same direction (towards – away from user) when rotating wheel of the uMp-RW3 or uMp-RW4 in same direction.

3.4 uMp micromanipulator axes definitions

Axes naming conventions used with uMp micromanipulation systems are as follows (see Fig 2):

- x-axis moves pipette back-and-forth
- y-axis moves pipette towards-away of the user when installed left or right from the sample
- z-axis moves pipette up-down
- D-axis is in the uMp-4 micromanipulator the 4th physical axis that is aligned with the pipette and adjustable from 0 to 90-degree angle.
- D-axis in uMp-3 micromanipulator is a virtual 4th axis, which is either horizonal if x-axis is tilted and thus aligned with the pipette axis (“True approach”) or diagonal in case x-axis is horizontal and pipette is mounted in angle to it (“Diagonal approach).

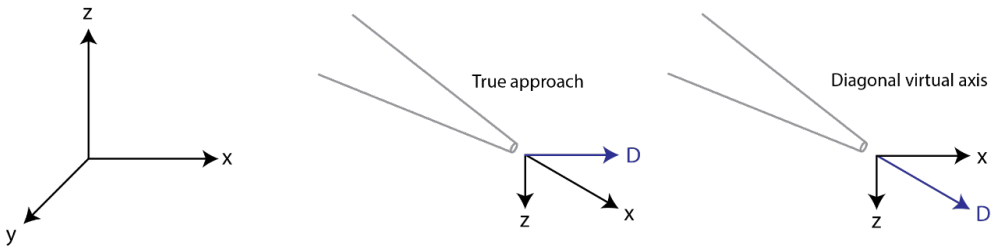


Figure 2. Left, uMp-3 micromanipulator axes definitions. Right, virtual axis D in true or diagonal approach.

In general Sensapex recommend using the True approach, which is especially beneficial when the pipette or probe is driven deeper to the sample. However, both alternatives are used successfully, and the choice is largely a matter of preference.

3.5 Installing uMp micromanipulators using different stand options

The uMp-3 or uMp-4 micromanipulator comes with simple mounting base (uMp-MBS) that enables attaching manipulator firmly on a stage or post.

In addition, three different modular stand options are available that allow retracting the pipette sufficiently far away from the sample for convenient and safe handling (Fig 3). All products include sufficient standard metric and imperial screws for the installation.

Figure 3. uMp micromanipulator stand modules (from left to right): uMp-ROT rotation, uMp-FLP back-flip and uMp-SLD slide stands.

Videos providing step-by-step instructions how to install uMp micromanipulators with different stand options can be found from links below (available at Sensapex Youtube channel):

- Modular stand concept: https://www.youtube.com/watch?v=I5A0Vla2vlU
- Installation of uMp-ROT stand: https://www.youtube.com/watch?v=NK93a7DKluM
- Installation of uMp-SLD stand: https://www.youtube.com/watch?v=JYi4Gfjjwow
- Installation of uMp-FLP stand: https://www.youtube.com/watch?v=b43Gw2ruAaE
- Post installation with uMp-MBS and uMp-FLP: https://www.youtube.com/watch?v=G0X6Vfwliq0

3.6 Adjusting uMp-3 x-axis or uMp-4 D-axis vertical offset and tilt angle

Both uMp-3 and uMp-4 micromanipulators have screw-locked mechanisms that allow adjusting the vertical offset and tilt angle of the x- / D-axis relative to the horizontal plane. Always support the x- or D-axis by hand throughout the adjustment process.

To adjust vertical offset (Fig 4):

1. Loosen two locking screws.
2. Slide x / D-axis up-down along the z-axis to find the right offset for the installation.
3. Tighten the two locking screws.

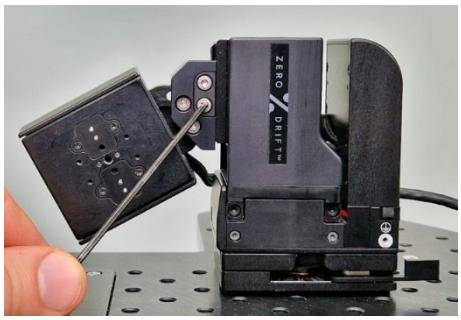


Figure 4. x / D axis offset adjustment mechanism screws (pointed and the one above)

To adjust x- / D-axis tilt angle (Fig 5):

1. Loosen the two locking screws.
2. Adjust tilt angle to find optimal approach angle for the pipette.
3. Enabling the *Poll axis angle* feature from the uMp-TSC2 *Manipulator Settings* menu shows the current angle measured by the integrated sensor (see 6.1.5).
4. Tighten the two locking screws.
5. Disable *Poll axis angle* feature.

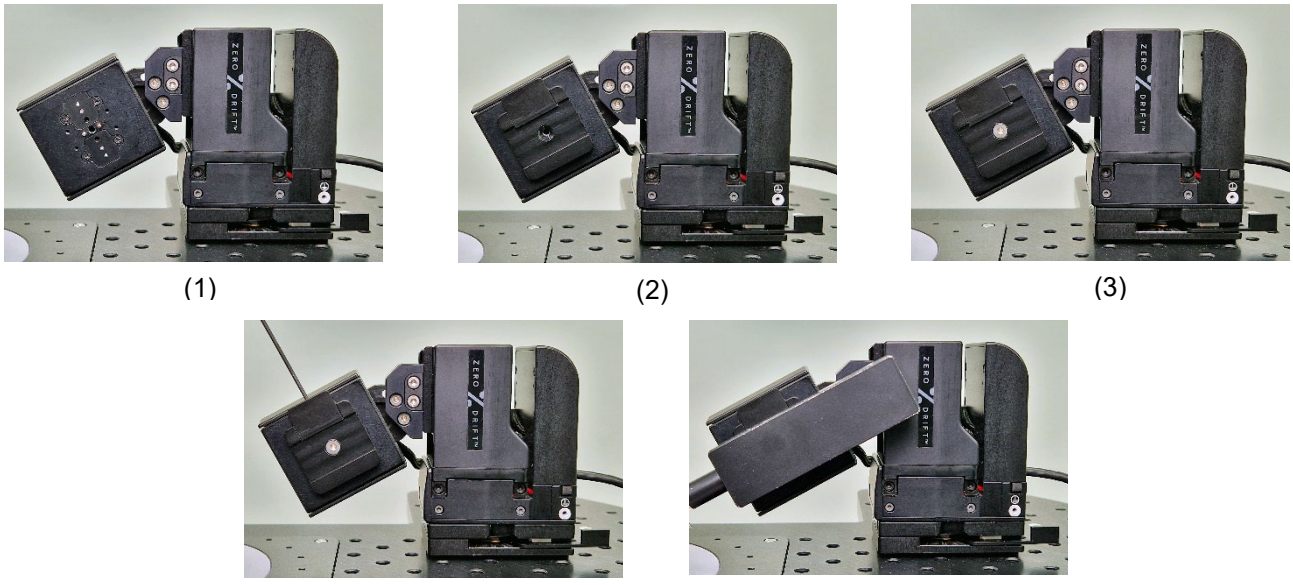
Figure 5. X / D-axis angle adjustment mechanism screws (pointed and one below it).

3.7 Installing an amplifier head-stage using the uMp-DVT

Only use the screws and dowel pins supplied with the uMp-DVT.

uMp-DVT enables mounting of most common patch clamp amplifier head-stages (Fig 6):

1. To maximize stability, minimize the distance between the pipette tip and manipulator installation point within the pipette access and usability limitations.
2. For True approach
    a. Insert the provided dowel pins to the micromanipulator's x / D-axis: Fig. 6 (1). These pins will ensure that the uMp-DVT is aligned parallel with the axis movement direction.
    b. Attach uMp-DVT in place using the pins for guidance: Fig. 6 (2).
    c. Secure uMp-DVT in place with the provided screw: Fig 6 (3).
3. For Diagonal approach
    a. *Do not insert the dowel pins*.
    b. Place uMp-DVT against the x- / D-axis and pre-tighten the attachment screw so that it is still possible to rotate the uMp-DVT.
    c. Rotate uMp-DVT to the preferred approach angle and tighten the screw.
4. Open the dove tail clamping piece screw from the uMp-DVT: Fig. 6 (4).
5. Slide the head-stage to the dove tail fitting: Fig 6. (5).
6. Tighten the clamping piece screw.
7. Organize head-stage cable and tubing with a drag relief to avoid drift through cable tension being transferred to the head-stage.



(1) (2) (3)

(4) (5)

Figure 6. Step-by-step instructions for mounting a head-stage with uMp-DVT

3.8 Installing a rod with uMp-RHL

Only use the screws and dowel pins supplied with the uMp-RHL.

uMp-RHL enables mounting 4 – 10 mm diameter rods to the micromanipulator (Fig 7):

1. To maximize stability, minimize the distance between the sample and manipulator installation point within the usability limitations.
2. For True approach
    a. Insert provided dowel pins to the micromanipulator x / D-axis (Fig 7, left). These pins will ensure that the uMp-RHL is aligned parallel to the axis motion.
    b. Secure the uMp-RHL in place using the provided screw (Fig 7, middle).
3. For Diagonal approach
    a. *Do not insert the dowel pins*.
    b. Place uMp-RHL against the x- / D-axis and pre-tighten the attachment screw so that it is still possible to rotate the uMp-RHL.
    c. Rotate uMp-RHL to the preferred approach angle and tighten the screw.
4. Open the uMp-RHL clamp by using the thumb screw.
5. Place / slide rod to the uMp-RHL (Fig 7, right).
6. Tighten the clamping piece using thumb screw.
7. Organize any wires and cables to avoid drag.

Figure 7. Step-by-step instructions for attaching a rod to uMp-3

3.9 Grounding the manipulator

uMp micromanipulators are fitted with an integrated grounding skeleton throughout the product. Use the specified grounding position to ground each manipulator with an M2 screw (Fig 8). Do not daisy chain the micromanipulator ground wires.

We recommend using Sensapex grounding accessories, which are optimized for low electrical impedance while keeping cables flexible. They are also robust to corrosion.

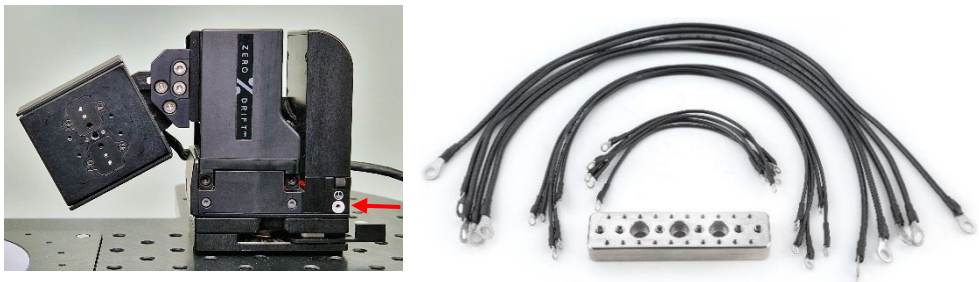


Figure 8. Left, red arrow marks the dedicated grounding point. Right. Sensapex grounding kit.

3.10 Connecting the products and powering ON the system

uMp micromanipulation system connection scheme is shown in Figure 9. Follow steps below to connect and power ON the products:

1. Connect uMp micromanipulators to uMp-HUB or uMp-HUB lite. The connectors will auto-lock when properly in place. To unlock, pinch the locking mechanisms on both sides of the connector. Each uMp-HUB or uMp-HUB lite enables adding four more uMp micromanipulators to the system.
2. Connect uMp-RW3 or uMp-RW4 rotary wheel unit(s) to uMp-TSC2 with the provided USB cable. uMp-TSC2 supports up to two uMp-RW3 or uMp-RW4 rotary wheel units.

3. Connect uMp-HUB or uMp-HUB lite to uMp-TSC2 with ethernet cable. A PC can be also connected to the system using ethernet cable via uMp-TSC2 or network switch.
4. Connect the provided power supplies to the uMp-TSC2 and uMp-HUB or uMp-HUB lite.
5. Power on the uMp-HUB or uMp-HUB lite using the push button.
6. uMp-TSC2 will automatically power on when plugged to its power supplier for the first time. After that it can be powered ON – OFF by long-pressing the button below screen.

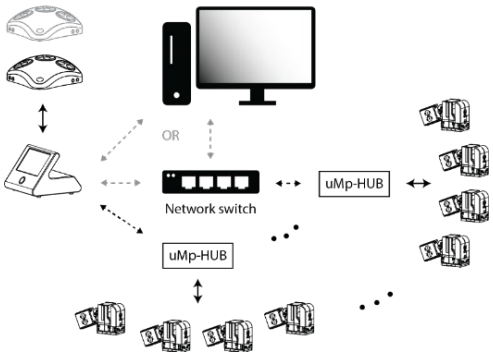


Figure 9. uMp micromanipulation system connections.

Verify that each of the connected micromanipulators is available for control and has a unique device ID. See 6.1.1. for further instructions in case not all manipulators are detected and shown by uMp-TSC2.

Please see the PC connection quick guide that is available at our website for further information: https://sensapex.com/support/umx-software/

3.11 Calibrating the micromanipulators

Calibrations are essential to establish an absolute coordinate system, as well as to optimize control parameters of a specific installation for best performance. Calibrations are micromanipulator-specific and need to be done for each micromanipulator. See 6.1.3. for *Calibrate zero position* and 6.1.4. for *Calibrate load* instructions.

4 uMp micromanipulation system operation

4.1 Powering ON – OFF the system

It is important to power off the micromanipulation system by first powering off the uMp-TSC2, which will save the current absolute coordinates to the micromanipulators' permanent memory. After that the micromanipulators can be powered off by switching off the uMp-HUB or uMp-HUB lite.

Correct powering off sequence avoids the need to re-do *Calibrate zero position* unless the micromanipulator axes are moved manually while being powered off.

4.2 uMp-RW3 | uMp-RW4

Each wheel of the rotary wheel remote unit uMp-RW3 (Fig 10, left) or uMp-RW4 (Fig 10, right) controls one of the manipulator axes (settings are fully configurable using the uMp-TSC2). A total of two uMp-RW3 or uMp-RW4 can be connected to the uMp-TSC2 to support operating two micromanipulators or other Sensapex products at the same time.

Functionalities:

- Pair of push buttons on the left side increase or decrease speed setting.
- Pair of push buttons on the right side allowing cycling through the selected manipulators by selecting the one with the next larger or smaller device ID.
- 4th wheel can be used to control the D-axis of the uMp-4 or virtual axis of the uMp-3 manipulators.

Figure 10. uMp-RW3 and uMp-RW4

4.3 uMp-TSC2 main view

The uMp-TSC2 provides real-time position information and quick buttons for the most commonly used features. It also includes versatile configuration options to customize the usability according to use preferences.

Layout and functionalities of the main view (Fig. 11):

- Many of the user interface symbols have further functionalities available by pressing the symbol for longer than 2 seconds.
- Left part of the display shows Sensapex products that are connected to the uMp-TSC2 (in this case micromanipulators).
    - Area can be hidden and recovered by orange arrow symbol.
    - Cogwheel under the micromanipulator symbol opens *Manipulator settings* menu, which includes micromanipulator specific functions and configuration options.
    - Adding more Sensapex devices to the same control system would show the connected devices in this area (e.g. uMs microscopes or uMc automated pressure controllers).
- *Main menu* can be accessed from symbol at top right corner.
- Selected uMp-RW3 or uMp-RW4 rotary wheel unit is indicated at top left corner.
- Real-time position of each axis is shown in micrometers: XYZ for uMp-3 or XYZD for uMp-4.
- The bottom area provides quick buttons: swipe left/right to change between the two tow pages.
- Emergency stop symbol at the bottom left corner will turn red whenever any of the manipulators connected to the system is moving (or any other connected Sensapex device is moving). Pressing the symbol will immediately stop all manipulators connected to the system (and other Sensapex devices).

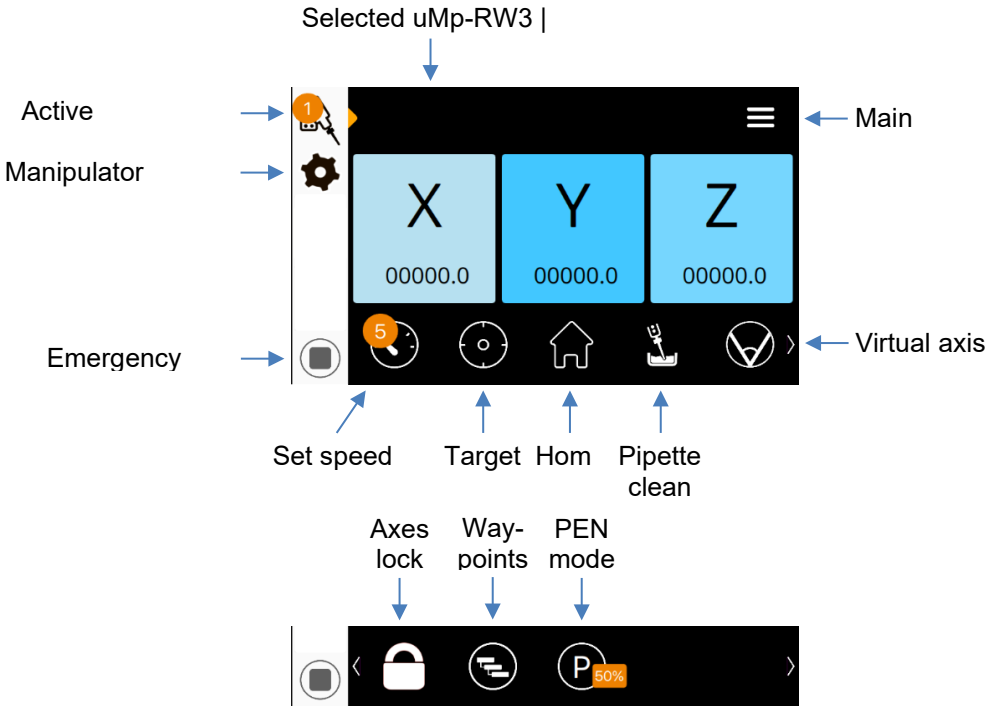


Figure 11. uMp-TSC2 main view

4.4 Basic micromanipulator operation

- Use rotary wheels of the uMp-RW3 or uMp-RW4 to move each of the axes individually.
  - The wheel – axis configurations and positioning directions are customizable (see 5.1.1).
- Use uMp-RW3 or uMp-RW4 push buttons on the right side or press manipulator symbol in the uMp-TSC2 main view to change between different manipulators (Fig 12, left)
  - It is possible to tap any of the shown devices to select it
  - Each micromanipulator has an indicator LED at its back which indicates active device. Light will change to green when the micromanipulator is moving.
- Use uMp-RW3 or uMp-RW4 push buttons on the left side or press the speed selection symbol in the uMp-TSC2 main view to change the speed setting (Fig 12, right)
  - It is possible to tap any of the speed settings to select it.
- Turning the wheel slower than a certain threshold will cause undesired start-stop movement
  - This indicates that the current speed setting is too high for the desired movement speed
  - Switch to smaller speed setting and rotate wheel faster for continuous movement

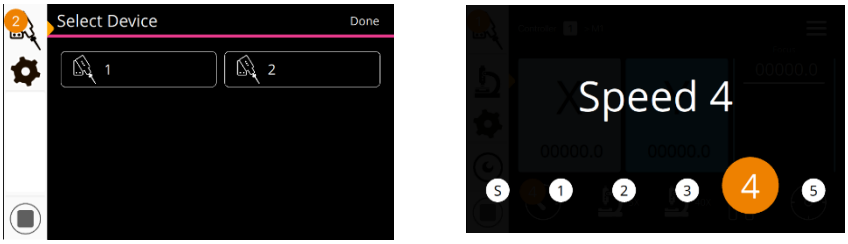


Figure 12. Left, manipulator selection. Right, speed setting selection.

4.5 Setting and using Home and Target positions

- Tap the *Home* or *Target* symbol shortly to drive manipulator to pre-set home or target position.
- Long press *Home* or *Target* position symbol to save current position as new memory position.
- A pop-up dialog enables defining the positioning speed and confirming execution (Fig 13).

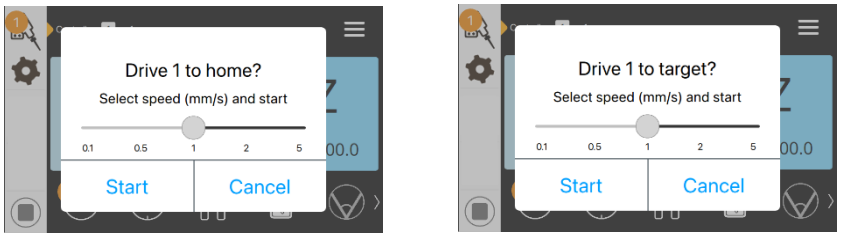


Figure 13. *Home* and *Target* memory positions

4.6 Changing between absolute and relative coordinates

Tap any of the axis display areas to toggle between absolute and relative coordinates:

- Relative position mode is indicated by open circle at the top right corner of the axis information area (Fig 14, middle)
- In case relative position mode is entered first time, it will reset it to zero.
- If relative position is set earlier, position relative to that earlier set position is shown.
- To reset the relative position reference (i.e. to re-zero), long-press the open circle symbol and confirm in the pop-up dialog (Fig 14, right)

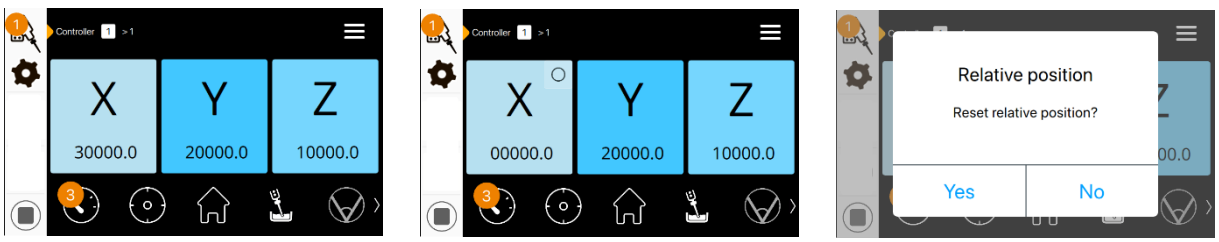


Figure 14. Relative coordinates

4.7 Virtual axis

The virtual axis can be enabled from the main view quick button or from the *Manipulator settings* menu (Fig. 15). Configuration:

- True approach (see 3.3) is used by default:
    1. Use *Virtual axis angle* setting to define the angle of the x-axis (relative to horizontal plane).
    2. The current setting is shown in parenthesis together with the angle x-axis sensor.
    3. Usually, the measured angle works well but a pop-up dialog enables further adjustment.
- *Diagonal approach* (see 3.3) is used by enabling that option:
    - The angle between the pipette and horizontal plane needs to be measured and set manually.
- By default, the wheel defined to operate x-axis will operate the virtual axis.
- *4th wheel for virtual axis* enables controlling the virtual axis with the 4th wheel of the uMp-RW4.
- The two axes linked to create the virtual axis stop in case either one reaches the end of its range.

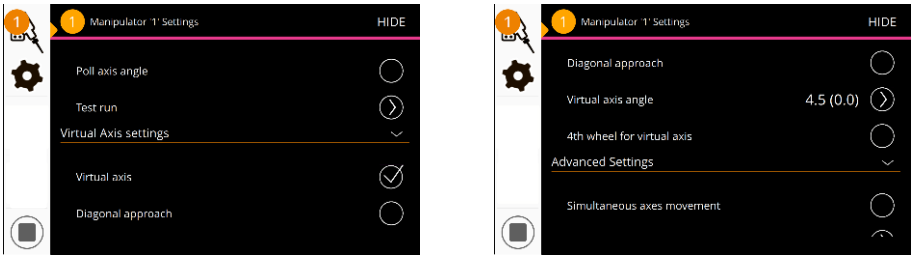


Figure 15. Virtual axis settings

4.8 PEN speed

PEN mode is a special speed setting tailored to penetrate a cell membrane by high acceleration and small amplitude stabs, often used in recordings with sharp electrodes. It operates in open-loop mode, which means that distance travelled by each PEN mode stab will vary. The integrated position sensors measure the current position in real-time, which is displayed at the uMp-TSC2 and enables tracking the movements during the PEN mode use.

- PEN mode stabs can be executed by rotating the uMp-RW3 or uMp-RW4 wheels. There is dead-time between two subsequential PEN stabs to allow taking them in controlled manner one by one.
- PEN mode can also be operated from the single axis view (see 4.9).
- Long-pressing PEN mode symbol opens dialog that allows adjusting the distance travelled during each stab. The recommendation is to start with small values and increase if needed.

4.9 Single axis view with programmable automated stepping

Single axis view can be used to configure and perform automated positioning steps of certain size and with certain speed, e.g. to insert microelectrodes or probes to the sample at a very slow speed or for taking dedicated small steps in blind patch-clamp recordings.

Single axis view (Fig 16) can be accessed by long pressing the axis display area in the main view:

- Tap speed setting symbol at left corner to define positioning speed for the automated step.
- Tap step length setting to define distance travelled during the automated step.
- Plus and minus signs execute defined automated incremental or decremental position steps.
- Relative position feature is available also at the single axis view (see 4.6)
- In case PEN speed setting is selected, plus and minus signs execute PEN mode stabs

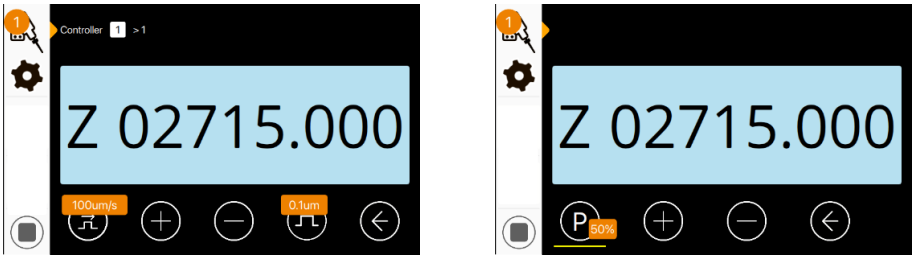


Figure 16. Single axis view

4.10 Pipette or probe change

Preparations before pipette or probe change:

- Save a safe to handle position far away from sample as *Home* position before starting experiments.
- Save a *Target* position closer to the target so that pipette or probe tip is in field of view, but with enough clearance to accommodate varying pipette or probe lengths.

To change pipette or probe:

- Use *Home* position to retrieve pipette or probe from sample.
- Operate manipulator stand to slide, flip and/or rotate the manipulator to retract pipette for handling.
- Change the pipette or probe and return manipulator stand to its working position.
- Use *Target* position to drive the pipette or probe to the preset position close to the sample.

4.11 uMp-TSC2 Sleep mode

Sleep mode can be activated by pushing the push button at the uMp-TSC2 front panel and is recommended to be used during experiments. Pushing button again will return normal operating mode. Sleep mode will:

- Dims the display and disables the rotary wheels to avoid unintended operation.
- Sets the piezo motors and motion controller to passive state in the micromanipulator.

4.12 Charging uMp-HUB batteries

Only use the original charger and use only earthed mains outlets for charging.

Plug the charger into the uMp-HUB charging port. uMp-HUB can be operated normally during charging. Battery operation is recommended for the most sensitive measurements if electrical noise from using mains supply is otherwise an issue.

4.13 Updating firmware

We recommend updating firmware regularly.

Please let us know if you observe software bugs so that we can fix them promptly. New features are also introduced at the times, which are available through firmware updates.

uMp-TSC2 and uMp-3 or uMp-4 firmware can be updated using a dedicated software tool that is available at the Sensapex website for downloading. Please use the link below to download the document that includes the download link and provides step-by-step instructions how to use the tool:

https://sensapex.com/wp-content/uploads/downloadable-files/2023/08/uMx-firmware-update-tool_v2.2.pdf

- Please note that the firmware of each manipulator needs to be updated one at a time.
- Please review the quick connection guide in case the firmware update tool does not find the products that are connected to the micromanipulation system: https://sensapex.com/wp-content/uploads/2023/07/PC-connection-quick-sheet-v2.pdf

5 uMp-TSC2 Main menu

uMp-TSC2 *Main menu* can be entered by tapping the menu symbol from top right corner of the main view. *Main menu* structure is shown in Fig 17.

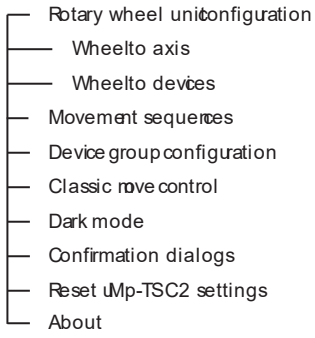


Figure 17. uMp-TSC2 Main menu

5.1 Rotary wheel unit configuration

Enter *Rotary wheel unit configuration* menu. *Wheel to axis* configurator defines which wheel of the uMp-RW3 or uMp-RW4 is operating which axis, as well as movement vs. wheel rotation direction (Fig 18).

- Tap different configuration alternatives for wheel-to-axis mapping.
- Tap wheel symbols to reverse movement vs. wheel rotation direction.

Wheel to devices configurator defines which micromanipulators are controlled by which uMp-RW3 or uMp-RW4 rotary wheel unit (Fig 18). A common use case for multiple uMp-RW3 use is to configure one wheel unit for the micromanipulators and second to control microscope focus and xy-stage in Sensapex uM Patch systems. Follow the instructions provided in the configurator view.

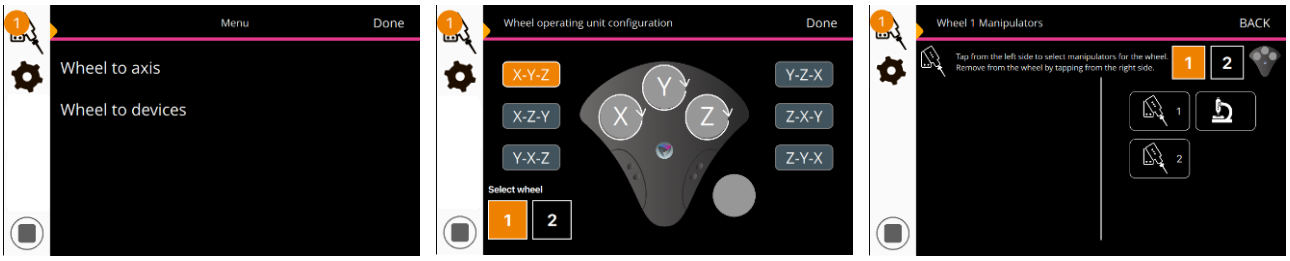


Figure 18. Rotary wheel unit configuration

5.2 Movement sequences

Movement sequences is a configurator (Fig. 19) that enables setting a list of XYZ(D) coordinate waypoints that can be then moved through with specified speed per waypoint as a complete sequence.

- Each waypoint is set by moving the micromanipulator to preferred position and setting it as waypoint.
- In case position between two waypoints differs in more than one axis, the *Axis drive order* setting (*Manipulator settings* menu) defines the order for which the axes are moved. In case *Simultaneous axes movement* option is enabled in the manipulator settings menu, all axes will move simultaneously.

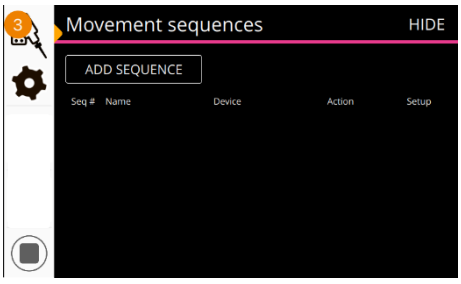


Figure 19. Movement sequences

5.3 Device group configuration

Patented network control architecture is used in the uMp micromanipulation system. It makes it possible to add a practically unlimited number for manipulators to system, but it also means that all devices connected to the same network can communicate with each other. For example, depending on the IT infrastructure, if several uMp-TSC2s are connected to same network, each of them is able to communicate with all micromanipulator systems in the network.

Device group configuration setting can be used to define different micromanipulation systems to different control groups to prevent accidental control across different systems (Fig. 20).

1. Start by tapping Scan all groups, which will list all the Sensapex devices connected in the same network (incl. uMs microscopes and uMc automated pressure controllers if they exist). List shows serial numbers of each product, which can be used to identify specific device.
2. If the list includes devices that are not part of the system that uMp-TSC2 is meant to control, change uMp-TSC2 group to a different and unused group by tapping Change own group button.
3. Select micromanipulators that are connected to your uMp-TSC2 and press Move to own group button. This will move them to your uMp-TSC2 new control group.
4. Restart by power off-on the products that were re-configured (see 4.1).

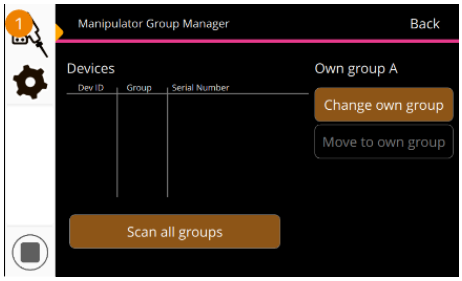


Figure 20. Manipulator group manager interface

5.4 Classic move control

Classic move control defines if the uMp-RW3 or uMp-RW4 wheel rotation speed affects the micromanipulator's movement speed.

- *Classic move control* is disabled by default. In this configuration, the manipulator's movement speed varies based on how fast the wheel rotates, which is typically considered to be intuitive.
- Enabling *Classic move control* sets the movement speed constant for a given speed setting, regardless of how fast the wheel is rotated.
- Regardless of the mode, always move to slower speed setting in case the movement does not remain continuous due to too slow wheel rotation.

5.5 Dark mode

Dark mode setting defines if the LED light around the uMp-TSC2 button and the indicator LEDs at the back of the manipulators get turned on. Please note that the red LEDs inside the manipulator axes are not dimmed by this, as they are essential for proper operation of the manipulator.

5.6 Confirmation dialogs

Confirmation dialogs setting determines if notification pop-ups are displayed when operating uMp-TSC2 functions (does not disable configuration or confirmation type dialogs).

5.7 Reset uMp-TSC settings

Reset uMp-TSC settings enables resetting the uMp-TSC2 defined software settings to factory default values (does not impact settings saved to the micromanipulators).

5.8 About

About menu provides information of the uMp-TSC2 product and its current firmware version (bolded in example below). An example of the information is provided below.

version **1.2.1.4-9 (c)** Sensapex
Product info
HNAME uMpTCU-11202201
SNO 11202001
PRODATE 08.11.2022
HWID 2.0
DHCP N/A
LOCAL **169.254.50.113**
Sensapex RWx 1.22.39.400 325F36503439
Proxy settings

The LOCAL IP address (bolded above) is the IP address that need to be set to the Sensapex firmware update tool should the uMp-TSC2 not be automatically detected by the update software.

6 Manipulator settings menu

Manipulator settings menu can be entered from the uMp-TSC2 main view cogwheel symbol. Settings in the *Manipulator settings* are micromanipulator specific and need to be configured to each manipulator separately by first selecting the micromanipulator to be configured. The *Manipulator settings* menu structure is shown in Fig 22.

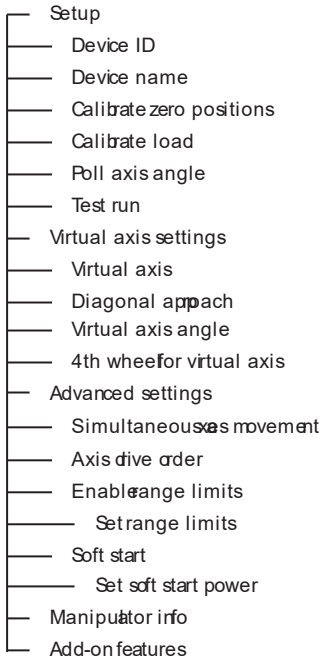


Figure 22. Manipulator settings menu

6.1 Setup

6.1.1 Device ID

Each Sensapex product that is controlled by the uMp-TSC2 or SDK for PC control needs to have unique device ID, which is used to identify and communicate with that product. The most common cause for reported connection issues comes from conflicting device IDs. The steps below instruct how to use *Device ID* settings to re-configure the device IDs:

1. Power off uMp-HUB or uMp-HUB lite.
2. Unplug all micromanipulators. Power-off whenever unplugging – reconnecting micromanipulators.
3. Connect each micromanipulator to the uMp-HUB or uMp-HUB lite one at a time and check device ID.

4. In case any of the micromanipulators have identical device ID's, change its ID to unique number.
5. Please note that rotary wheel vs. y-axis movement direction is mirrored between odd-even IDs. Odd numbers are recommended for right-handed and even numbers for left-handed manipulators.
6. After all micromanipulators have a unique ID, reconnect all at the same time to the uMp-HUB or uMp-HUB lite and confirm they are all detected and available for control.

6.1.2 Device name

Device name allows naming each manipulator. It is not used to identify the device for control purposes, which allows flexible naming. Please note that only the first two letters of the device name are displayed on the device icon in the main view, so limiting the names to two characters is recommended.

6.1.3 Calibrate zero position

Always remove pipettes or probes before Zero position calibration to avoid collision and damage. Ensure that each micromanipulator axis has enough clearance to complete the initialization movements over its full movement range.

Calibrate zero position will drive each of the micromanipulator axis against its mechanical end stop to establish the zero point of the absolute coordinate system. It is important that absolute position information is always correct because stored locations (e.g. *Home* and *Target* positions, but also *Waypoints*) are addressed in the absolute coordinate system.

Re-doing *Calibrate zero position* is not needed if the uMp micromanipulation system is powered off correctly (see 4.1) and if axes are not moved manually while being powered off.

Tap *Calibrate zero position* to start the calibration and confirm execution from the pop-up dialog. Wait until the calibration routine is finished before continuing use.

6.1.4 Calibrate load

Always remove pipettes and other microtools with negligible weight before calibration procedure to avoid collision and damage to electrode or sample. Ensure that each micromanipulator has enough clearance to complete the initialization movements over their full movement range.

Calibrate load will calibrate the default piezo-motor control parameters to specific installation and loading conditions. It is not necessary to re-do *Calibrate load* unless installation and loading conditions change.

To perform *Calibrate load*:

1. Perform first *Calibrate zero position* if there is any uncertainty on the correct absolute coordinates. *Calibrate load* will fail or may lead to wrong default parameters if it is performed without correct absolute coordinates.
2. Perform *Calibrate load* and confirm from the pop-up dialog.
3. Wait until the calibration routine is finished. It will take several minutes because the micromanipulator is moving each axis over its range with different speed settings.

6.1.5 Poll axis angle

Enabling *Poll axis angle* will measure and show the angle of the x- or D-axis relative to the horizontal plane using the sensor that is integrated to the x- or D-axis.

Disable Poll axis angle after use. It will otherwise cause an unnecessary increase in the communication traffic within the micromanipulator system.

6.1.6 Test run

Test run feature is sometimes used during the troubleshooting process. It enables repeated automated positioning of all micromanipulator axes over their full range.

6.1.7 Virtual axis settings

Virtual axis settings are used to set up the virtual axis (see 4.7. for further information).

6.2 Advanced settings

6.2.1 Simultaneous axes movement

Enabling *Simultaneous axes movement* setting will move all the axes simultaneously during the memory position functions like *Home* and *Target*. This may create risk for collisions, which is why the setting is disabled by default and axes are moved one at the time in the order that can be defined with the *Axis drive order* setting.

6.2.2 Axis drive order

Axis drive order setting opens a configurator view that enables defining the order for which individual axes are moved one at the time during the memory position driving, such as *Home* and *Target*. Setting is not relevant if *Simultaneous axis movement* is Enabled. To reconfigure the order (Fig. 23):

1. Tap Reset button.
2. Tap the axis names in the preferred drive order.
3. Tap Save button to save the new configuration.

Always validate the drive order setting first in mock-up use and safe conditions to avoid possible collisions and damage.

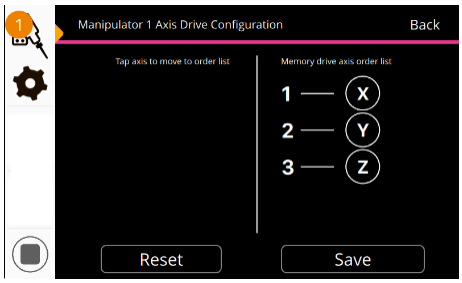


Figure 23. Axis drive order configuration

6.2.3 Enable range limits

Enable range limits feature allows limiting the active positioning range to be less than the full range. This may be helpful, for example, to prevent collision to the dish bottom with the pipette tip. Enabling this feature reveals the *Set range limits* setting, which is a configurator used to define the limits (Fig. 24):

1. Min and Max limits are set to each axis one at a time. The current axes positions are also displayed.
2. Tap the specific limit that you want to configure.
3. Use uMp-RW3 or uMp-RW4 to move the selected axis to the position where a specific limit should be set.
4. Tap Set button. Repeat for each limit.
5. Tap Reset button to reset all limits for re-configuration.

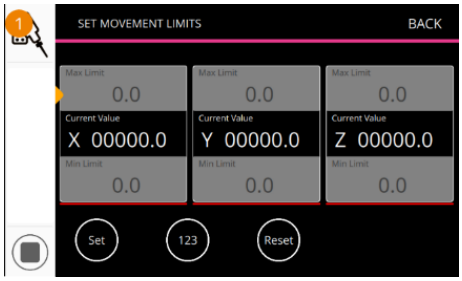


Figure 24. Range limit configuration

6.2.4 Soft Start

Soft start setting is enabled by default. It limits maximum acceleration when changing the movement direction to minimize vibrations that may otherwise occur at the pipette or probe tip.

Enabling the *Soft start* feature reveals the *Set soft start power* setting, which is used to adjust the acceleration limits. The larger the value, the less acceleration is limited.

Soft start mode is not recommended to be used with the Snail speed mode. Snail speed takes a very small number of positioning steps. It takes long time when operating from uMp-RW3 or uMp-RW4 wheels before Soft start related acceleration control gets relieved and movement starts.

6.3 Manipulator info

“Manipulator info” shows information specific to the selected micromanipulator. Of specific relevance are the firmware version and serial number that are bolded in the example Manipulator info below.

uMp_v1.23.48.500
IP: 169.254.20.195
MAC: 70:B3:D5:45:D4:C3
SN: 11401219
HW: 3
DOM: 20220616
MCU: 0x450 2003

6.4 Add-on Features (Legacy)

Certain features that have been optional in the past are now included as standard features. This menu is maintained for legacy support reasons only.

7 Micromanipulator handedness and stand re-adjustments

7.1 Micromanipulator handedness reconfiguration

Please follow the step-by-step instructions below to reconfigure uMp-3 micromanipulator between right- and left-handed configurations. Procedure is the same for the uMp-4 manipulator, except that its D-axis orientation is reconfigured instead of the x-axis.

1. Detach x-axis cable clip from the manipulator body using 1.5 mm hex key (Fig. 25, left)
2. Unscrew 2 pcs of x-axis mounting screws using 1.5 mm hex key (Fig. 25, right)

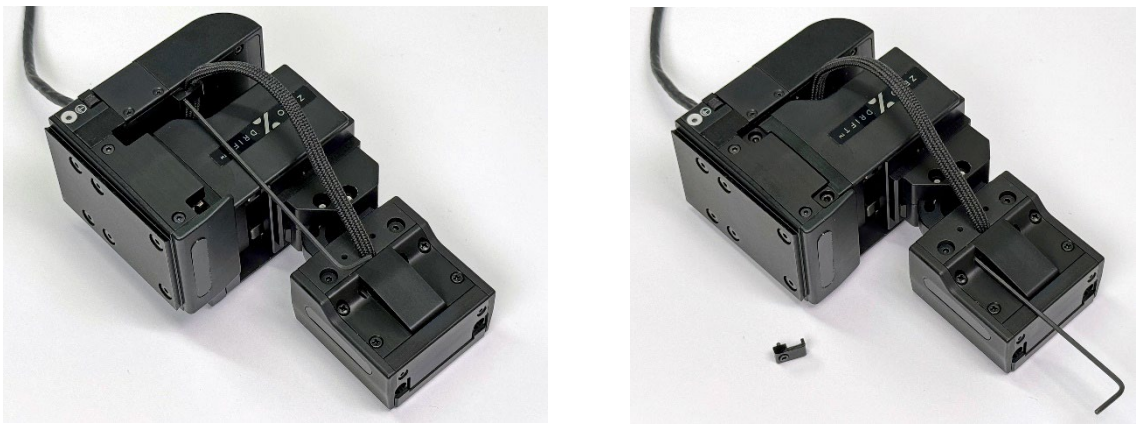


Figure 25. Remove x-axis cable clip and mounting screws.

3. After x-axis is detached from the micromanipulator (Fig 26, left), unscrew 2 pcs of angle adjustment locking screws all the way out using 2 mm hex key (Fig 26, right)

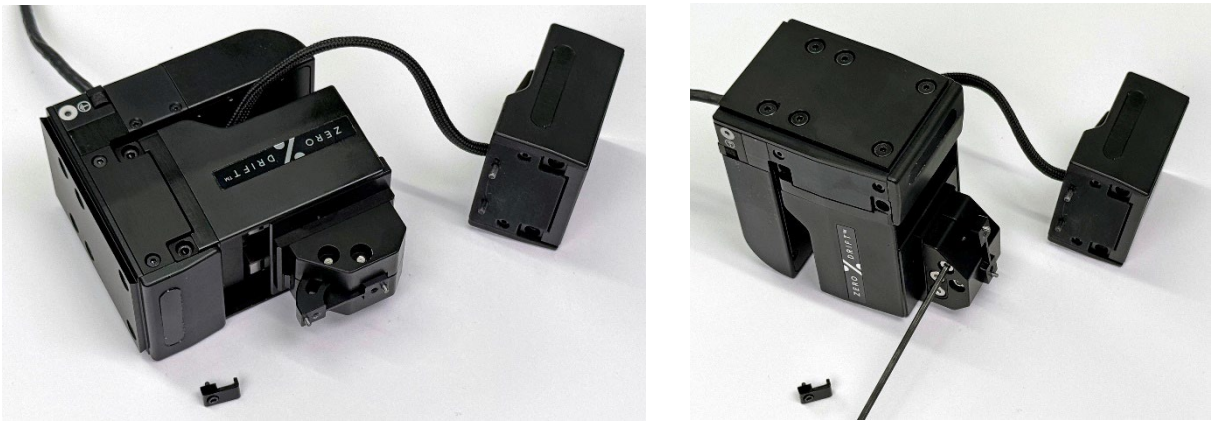


Figure 26. Remove angle adjustment locking screws

4. After completing steps 1-3 (Fig. 27, left), screw the 2pcs of angle adjustment locking screws back from the opposite side for left-handed configuration using 1.5 mm hex key. (Fig 27, right)

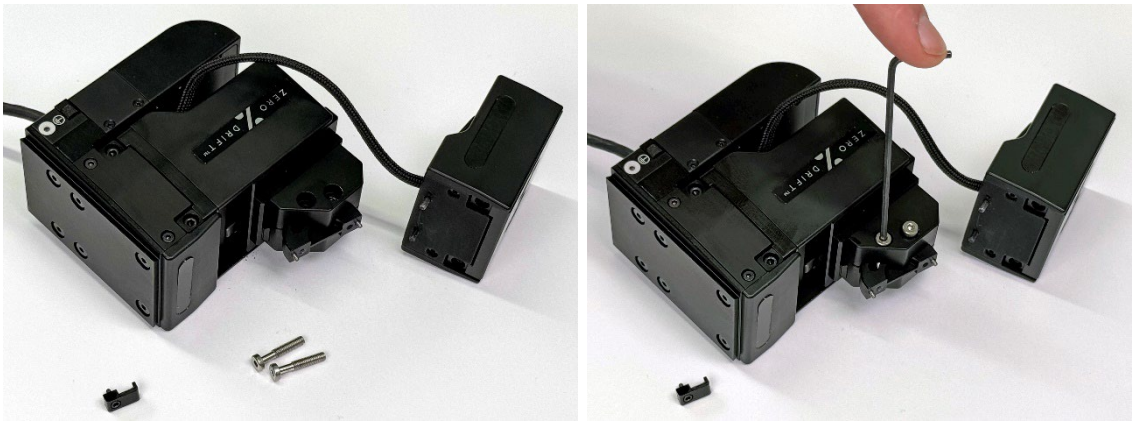


Figure 27. Insert angle adjustment locking screws.

5. Attach x-axis back to the micromanipulator in left-handed configuration with 2 pcs of x-axis mounting screws using 1.5 mm hex key (Fig. 28, left).
6. Secure x-axis cable to the manipulator body with cable clip by using 1.5 mm hex key. BE CAREFUL NOT TO PINCH THE CABLE WITH CABLE CLIP (Fig 28, right)

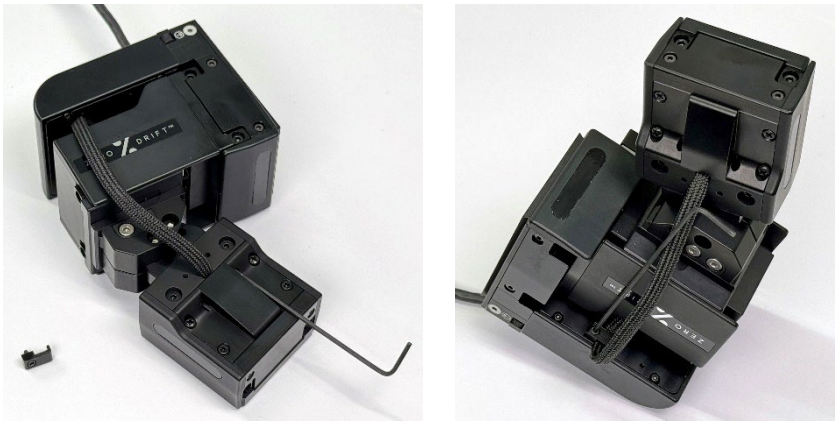


Figure 28. Re-attach x-axis and cable clip in left-handed configuration.

7.2 uMp-ROT handedness re-configuration

- For right-handed configuration, x-axis attachment surface is facing towards you when the manipulator is placed on the right-hand side of the sample. To make uMp-ROT right-handed:
    - Rotate stand to uncover dowel pin holes. Place the stopper pin to the hole marked with R.
- For left-handed configuration x-axis attachment surface is facing towards you when the manipulator is placed on the left-hand side of the sample. To make uMp-ROT left-handed:
    - Rotate stand to uncover dowel pin holes. Place the stopper pin to the hole marked with L.

7.3 uMp-SLD locking tightness re-adjustment

uMp-SLD is adjusted at the factory for right tightness to hold the sliding part firmly in place when locked while enabling non-contact and frictionless slide operation. In case locking or sliding performance degrades over time, the uMp-SLD can be re-adjusted following the step-by-step instructions below.

7. Tightness is adjusted from the back of the uMp-SLD using two set screws shown in blue (Fig. 29).

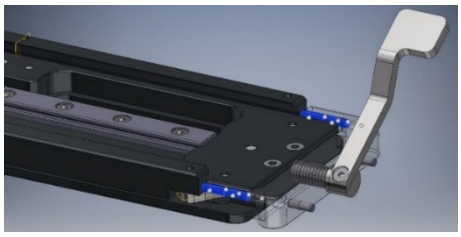


Figure 29. uMp-SLD locking adjustment screws shown in blue.

8. There are additional outer set screws that prevent unintentional adjustment changes. Use 0.9 mm Hex key to remove the outer screws from both sides of the locking lever to provide access for adjustments.
9. Use 0.9 mm hex key to tighten the locking mechanism by turning adjustment screws clockwise with same amount on both sides until the slide starts to brake when lever is approximately at 45 deg position (Fig. 30).

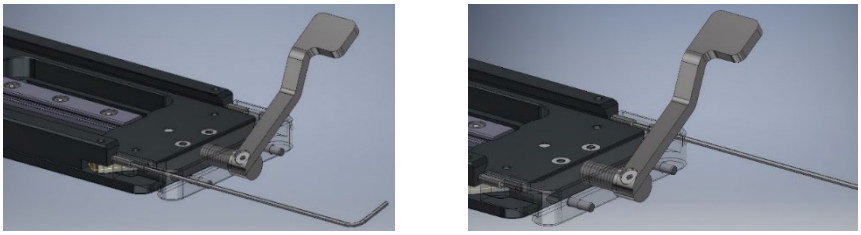


Figure 30. Adjusting locking screws.

10. Use calipers to measure the gap between slide rails and locking part to confirm the gaps on both sides are equal within +/-0,05mm (Fig. 31).

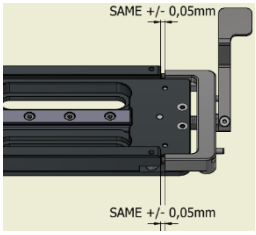


Figure 31. Adjusting locking screws.

11. Test the uMp-SLD locking and sliding action. Tune the adjustment further if needed.
12. Screw the two outer screws back in place.

8 Maintenance and troubleshooting

This instrument contains no user serviceable parts or components. Contact Sensapex or your local representative to arrange a service. Disassembling the product or attempting self-repair is prohibited and will void the warranty.

It is recommended to update the firmware regularly. Please let us know if you observe software bugs so that we can fix them.

Please review the common issues and their solutions. If it does not help and problem persists, please contact your local representative or Sensapex support for further instructions: support@sensapex.com. Please include the respective product serial number, a brief description of the issue and possible circumstances leading to it when contacting support. A picture of the installation is often also required for troubleshooting.

8.1 None or some manipulators connected to the system are available for control

- In case one but not all micromanipulators show up in the uMp-TSC2, some manipulators are likely to have the same device IDs that need to be re-configured. See 6.1.1. for instructions. If the manipulators are found to have no ID clashes, it is possible that they are configured to be in different device groups (see below).
- In case none of the micromanipulator show up in the uMp-TSC2, they are likely to be in different device group than uMp-TSC2. See 5.2.2. for instructions how to re-configure device group.

8.2 Pipette tip is drifting

Sensapex piezo technology provides inherently drift-free linear position control. The position is measured in real time with high precision linear encoders that are integrated to each axis. In case any drift in the axes would occur, it would be visible in the positions displayed at the uMp-TSC2 main view.

- Observe coordinates at the uMp-TSC2 during pipette tip observation to confirm that the micromanipulator axes are not drifting. A few hundred nanometers of change in position can be caused by e.g. minor temperature changes.
- Drifting at the pipette tip is often due to loading conditions changes. Common source is from the head-stage cable or tubing. Always fix the cables and tubing with drag relief.
- Another common drift source is the fluctuating temperature and/or air drafts around the setup, which should be minimized to the extent possible.
- Pipette tip may also occur if the pipette holder is unstable or worn-out.
- In some cases the observed drift is actually caused by drift originating from microscope xy-stage, recording chamber (temperature changes) or microscope objective/focus. In such cases, fix the origin for the problem to resolve it.

8.3 Manipulator axis does not move or moves only over partial range

- Confirm that there is no physical collision, payload of the manipulator is within the specifications and that there is no excessive load e.g. from dragging cables.
- In case no explanation is found from external conditions, please contact your local representative or Sensapex support for further instructions: support@sensapex.com

8.4 Products got exposed to accidental liquid spill

- In case a small spill occurs, the products should be immediately cleaned using a damp cloth.
- In case a major spill occurs, which may cause liquid ingress into the products, power off and unplug power suppliers from the system *immediately*. Contact your local representative or Sensapex to arrange service.

9 Specifications

uMp-3

Positioning range:	20x20x20 mm^3 (x-y-z)
Resolution:	5 nm
Repeatability:	100 nm
Max. speed:	5 mm/s
Max. payload:	150 g
X-axis tilt angle:	0 – 45 degrees
Dimensions:	49x77x128 mm
Weight:	645 g

uMp-4

Positioning range:	20x20x20x20 mm^3 (x-y-z-D)
Resolution:	5 nm
Repeatability:	100 nm
Max. speed:	5 mm/s
Max. payload:	150 g
X-axis tilt angle:	0 – 90 degrees
Dimensions:	49x104x136 mm
Weight:	894 g

uMp-TSC2

Capacitive touch screen display
Two pairs of push buttons for speed and manipulator selection
Connects up to two uMp-RW3 | uMp-RW4
Requires uMp-HUB or uMp-HUB lite to connect micromanipulators
Two Ethernet ports to connect other Sensapex devices or PC

Power supply (provided):	5 VDC, 3.6 A
Dimensions:	125x95x127 mm
Weight:	679 g

uMp-HUB lite

Supports connecting up to four uMp micromanipulators
Ethernet connection to uMp-TSC2 or PC

Power supply (provided):	24 VDC, 2.71 A
Dimensions:	95x95x30 mm
Weight:	259 g

uMp-HUB

Li-ion operated (rechargeable)
Supports connecting up to four uMp micromanipulators
Ethernet connection to uMp-TSC2 or PC

Power supply (provided):	24 VDC, 1.0 A
Dimensions:	95x95x52 mm
Weight:	513 g

The battery has built-in protection

uMp-RW3 | uMp-RW4 rotary wheel interface

3 or 4 wheel versions
USB connection to uMp-TSC2 (5 VDC, 0.2 A)

Dimensions:	170x53x170 mm
Weight (uMp-RW3 | 4):	1045 g | 1161 g

10 Manufacturers declaration of conformity

1. Manufacturer

Sensapex Oy
Teknologiantie 13
90590 Oulu
+358400240955
office@sensapex.com

2. This declaration of conformity is issued under the sole responsibility of the manufacturer

3. Object of the declaration

Brand name:	Sensapex
uMp micromanipulation system:	uMp-TSC2, uMp-HUB lite, uMp-RW3, uMp-RW4, uMp-3, uMp-3 NP, uMp-4

4. The object of the declaration is in conformity with the following directives

2014/30/EU	Electromagnetic Compatibility Directive (EMC)
2011/65/EU	Restriction of Hazardous Substances (RoHS) Directive
2006/42/EC	Machinery Directive (MD)

and harmonised standards / technical specifications

EMC	**EN IEC 61326-1:2021** Emission requirements: EN 55011:2006, EN 61000-3-2:2019, EN 61000-3-3:2013 Immunity requirements according to Table 2 for equipment intended to be used in an industrial electromagnetic environment: Electrostatic discharge (ESD), Electromagnetic field, Power frequency magnetic field, Burst, Surge, Voltage dips & Short interruptions, Conducted RF
RoHS	EN IEC 6300 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances
MD	EN ISO 12100 Safety of Machinery. General Principles for Design. Risk Assessment and Risk Reduction

5. Signed for and on behalf of:

Oulu 28.8.2024

Sensapex Oy

Mikko Vähäsöyrinki, General Manager