

Sensapex μ Mp micromanipulation system

Operating manual

Rev. 1.0

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Disclaimer

Best efforts have been made to ensure that information contained in this manual is accurate. We accept no responsibility for any errors or omissions, and we reserve the right to modify specifications, design, characteristics and product at any time without obligation.

The uMp micromanipulation system is designed for positioning microelectrodes, micropipettes or microtools in three-dimensional space with sub-micrometer resolution over distances of millimeters. The positioning takes place under visual control using microscope and the target as well as the microelectrode are located within the microscope's field of view. No other use is recommended.

- Product is not a medical device. It should be used only for non-human research.
- Do not open or attempt to repair the instrument to avoid risk of injury from electrical shock.
- 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 the charger only with properly grounded mains supply that meets the product specifications.
- Do not expose the product to liquid spills or moisture to prevent fire or shock hazard.
- Always use only the cables provided by the Sensapex to comply with CE electromagnetic immunity and interference standards, and to minimize electrical noise to other equipment in the laboratory.
- Do not position equipment in such a way that it is difficult to operate the disconnecting device(s)
- Do not attempt to replace the battery inside the touch screen control unit and/or hub

Precautions

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

- The product is designed for operation in a laboratory environment in room temperature.
- Operate this product only according to the instructions included in this manual.
- 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 sole responsibility of the user.
- Do not attempt using any other charger than the one provided by Sensapex
- 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
- Handle and operate the micromanipulator with care to avoid damage
- This instrument contains no user-serviceable parts or components. Do not try self-repair. This product should be serviced and repaired only by Sensapex.
- 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 has been tested for use up to 2000 m elevation.
- The system should be operated only in 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 should not fluctuate more than $\pm 10\%$. The presence of typical transients on the mains supply, e.g. those of installation or overvoltage, are category II.
- Pollution degree II

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1 General information

1.1 Introduction

Sensapex uMp micromanipulators provide high stability and performance in compact size. They are based on patented linear piezo drives, which are operated under real time closed loop control. The mechanical design is based on aerospace quality aluminum alloys for optimal stiffness to weight ratio. Mechanical parts are electrically grounded throughout the manipulator. High precision stainless steel crossed roller bearings are used to ensure accurate linear movement.

The micromanipulators are typically used in biomedical research to position a microelectrode or micropipette. In addition, the micromanipulator is suitable for many other applications where high precision positioning is required.

We provide two (2) year limited warranty for the users who register their product to us within 30 days from shipping (see our website or contact us at support@sensapex.com for further information). Otherwise one (1) year warranty applies.

1.2 About this manual

The uMp-series micromanipulator system is comprised of Touch Screen Control (TSC) unit, Rotary Wheel remote interface (RW) and triple or quad axis micromanipulator(s). Selection of modular options and accessories are provided for easy installation and use.



Figure 1. Overview of the uMp micromanipulation system

This manual provides information on how to install and operate the micromanipulation system. It also includes troubleshooting guide in case of unexpected problems. The manual is updated regularly. Please visit our website for the most recent version: www.sensapex.com. We are also always available in case you have any questions or concerns (support@sensapex.com).

2 Installation

2.1 Arrival Inspection

The micromanipulation system has been carefully packaged to avoid shipping damage. Please notify us or your local distributor immediately if the outside of the package is damaged. If the package is externally undamaged, carefully unpack all the items and verify that you have received all the parts specified in your order. Please contact Sensapex or your local representative if any of the ordered parts are missing.

NOTE Micromanipulator(s) and electrode exchange modules are delivered pre-configured either as left or right-handed version based on the information available on the order. Handedness is customer re-configurable at any time.

CAUTION Please keep the original packaging and use it if it ever becomes necessary to transport micromanipulation system to another location. Improper packaging is a form of abuse and, as such, can void the warranty if shipping damage is sustained because of such packaging.

2.2 Installation instructions

2.2.1 General recommendations

Your product is inspected and tested before the shipment to meet the specifications. In case unexpected problems occur despite of following instructions in this manual, please contact Sensapex or your local representative for further instructions. Please always provide picture of the installation when contacting us for support.

The micromanipulator should be mounted on a stable, flat and clean surface. In addition, the surfaces of the adapters and attached third-party products should be flat and clean. For best stability ensure that the microscope and/or specimen holder are mounted rigidly to the same solid and stable surface as the micromanipulators. The micromanipulators are designed to install upright on the horizontal surface. Please contact Sensapex if you plan other installation options.

The micromanipulator is designed using corrosion resistant materials for tolerance against corrosive substances, such as saline solutions. The micromanipulator should be immediately and carefully cleaned if exposed to small spill of corrosive fluids or aerosols. In case major spill occurs that causes solution to go inside the axes, please switch off the control unit immediately and contact Sensapex to arrange service. Care should also be taken to avoid introducing particles to the bearings, which may prevent normal function. Sensapex assumes no responsibility for damage caused by a failure to conform to these recommendations.

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

2.2.2 Installing uMp manipulator with docking base

The micromanipulators are designed to be installed using M6 or ¼ inch bolts. It is sufficient to use only one bolt for secure mounting on flat and clean surface. Below is step-by step process how to install manipulator using its docking base.

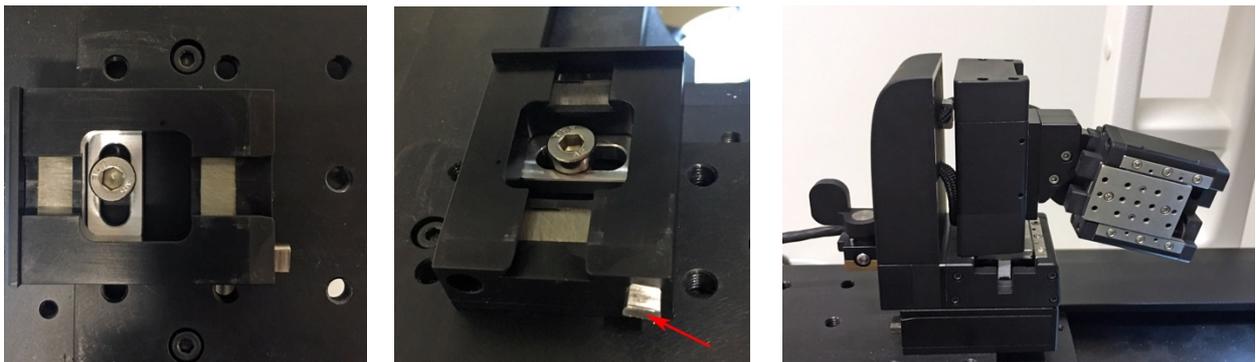


Figure 2. Installing docking base

1. Before installation, take manipulator in your hand and model various positions in the setup to decide what position and approach angle works best for the planned experiments. It may be necessary to attach for example head-stage with pipette holder to manipulator to aid finding right position. Manipulator axes should be in the middle of their range during while searching for right position to maintain full operating range after installation. After position is found, select threaded hole for the installation that will be below and at the center of the manipulator.

2. Micromanipulator is shipped with docking base attached. First step is to unlock manipulator from its docking base by turning the locking knob 90 degrees using supplied key or pliers.
3. Move slot inside the docking base to center of its adjustment range and place the docking base so that selected installation thread is in the middle of the slot. Use M6 or ¼ inch bolt to attach docking base. Tighten very lightly to allow sliding and turning the base on the platform.
4. Slide manipulator to the docking base and fine tune exact position and orientation of the docking base. Remove manipulator without moving the base and tighten the installation bolt firmly.
5. Slide manipulator to docking base and lock it by turning the locking knob back to locking position. Test that installation is mechanically solid by gently trying to move the manipulator from the back-cover (there should be no mechanical slack).

2.2.3 Installing uMp-EXM electrode exchange module

uMp-EXM electrode exchange module is offered as an option to provide easy to use coarse movements to clear the microelectrode from the sample for convenient exchange. Below is step-by step process how to install the exchange module. Note that the manipulator should be locked to the docking base during the installation and it is important to follow the exact installation order to ensure proper alignment and performance.

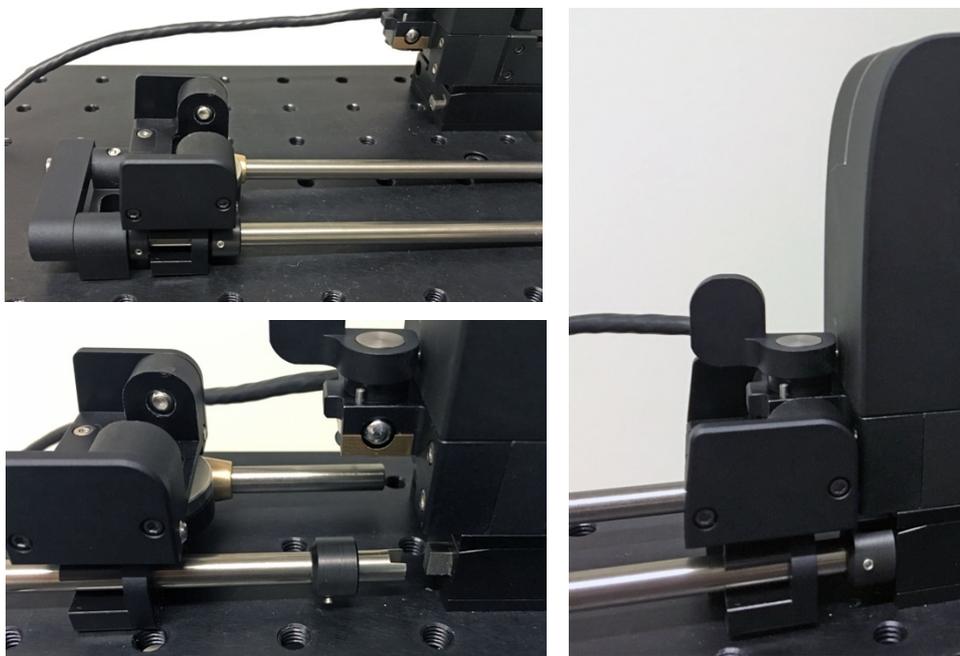


Figure 3.1. Electrode exchange module installation

1. Ensure that manipulator is locked to docking base and pick-up module locking lever is in unlocked position (=lever pointing back). Fig. 3.1., left top shows module as shipped. Please loosen set screw in collar that is in front of the pick-up unit and ensure that locking lever at the back is in lock position as in the picture. Slide the round ended rod to hole in the docking base and slotted rod to its counterpart at the docking base. Ensure that slotted part is pushed all the way in to the counterpart and then slide collar to cover the connection so that it is pushed all the way against the docking base. Ensure that set screw is pointing towards you as in the picture and tighten it. Note that locking collar should be oriented so that the wedged end of it is facing back.

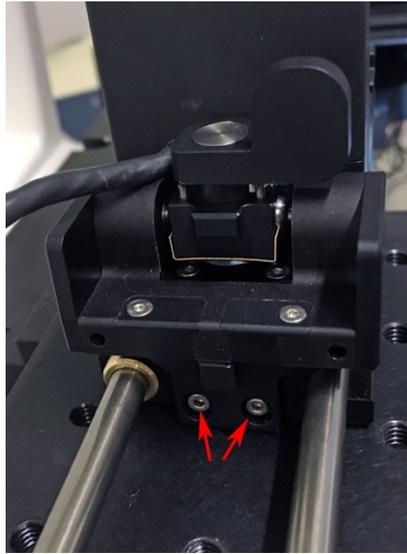


Figure 3.2. Pick up module alignment

2. Ensure that two set screws adjusting tilt angle (Fig. 3.4) are backed out so that they are not extending beyond the manipulator facing surface (default when shipped). Also ensure that screws marked with red arrows are loose (default when shipped). Push the pick up module against the manipulator and lock it to manipulator by turning the lever to point to the right as in Fig 3.2. Gently tighten gradually the two screws one at the time until both of them are firmly tight. This aligns the pick-up module with the installation geometry to allow smooth entry to and exit from the docking base.

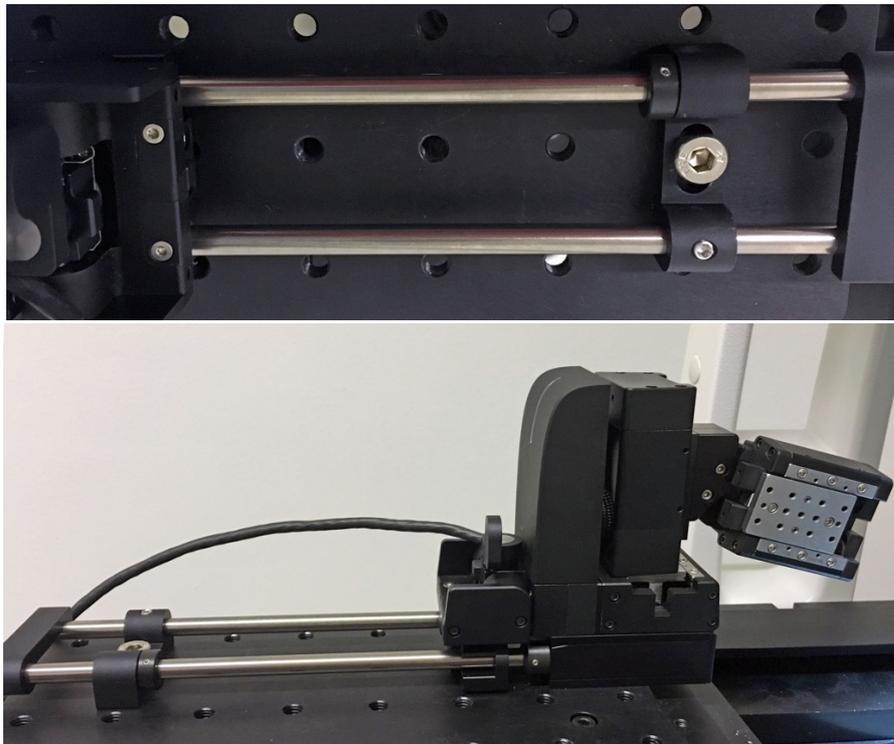


Figure 3.3. Attaching EXM module to stage / platform

3. Loosen set screw in the clamping piece that is locking the rod and set screw from the collar that is against the mounting piece. Slide the mounting piece over the thread that is closest to its default position. Ensure that rods are aligned with the docking base; rods are self-aligning after pick-up module is locked. Do not force rods away from mid position while finding the thread for attachment. Attach mounting piece to stage / platform using M6 / ¼ inch bolt and tighten firmly. Push locking collar back

against the mounting piece to secure rod from detaching from the docking base and tighten the set screw. Tighten also set screw on the mounting piece that locks round ended rod. Note that if rods are not aligned with the docking base the manipulator cannot enter / exit docking base smoothly.

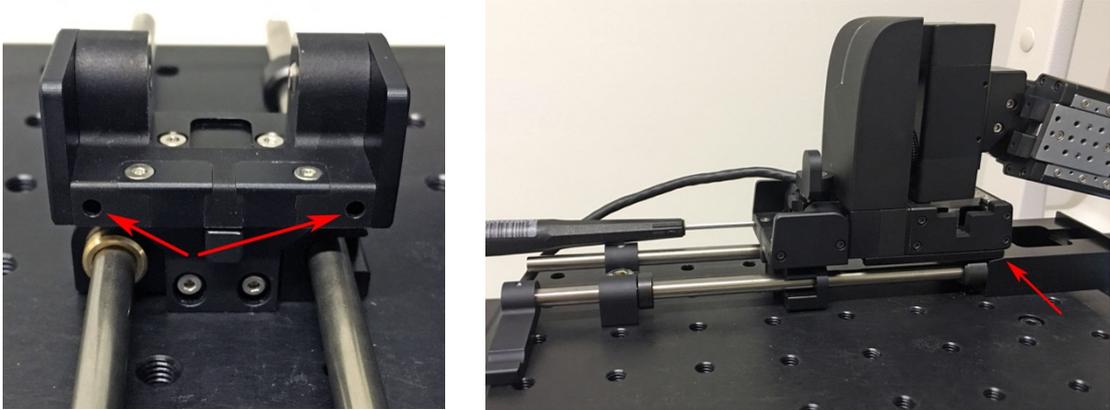


Figure 3.4. Tuning manipulator tilt angle while carried by the pick-up module

4. Horizontal tilt angle needs to be adjusted for smooth entry / exit to docking base. Two set screws that define this angle can be adjusted from the holes marked in red arrows in Fig. 3.4., left. To adjust, unlock docking base by turning the lever at the back, slide manipulator out from docking base so that its front edge is at the point where sloped entrance becomes flat. Adjust with using only other set screw first. Loosening the screw will lower the front end of the manipulator and tightening will lift it up. Right adjustment is such that front edge of the manipulator is just above the level of the docking base flat surface; if front end is too high the manipulator will not enter / exit docking base smoothly. After right adjustment is found, gently tighten the other set screw that it is just in touch with the manipulator but does not start to lift its front edge.

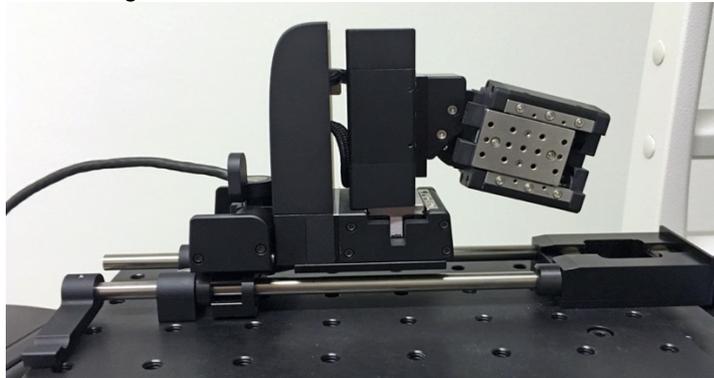


Figure 3.5. Tuning manipulator tilt angle in pick-up module

5. Test that the manipulator can enter and exit the docking base smoothly. If not, first check the tilt angle and adjust again if needed (step 4). If that doesn't help, re-check rod alignment (step 3). If that doesn't help, re-check pick-up unit alignment (step 2). Note that you need to re-do steps 3 and 4 if the pick-up unit alignment needs to be re-adjusted.

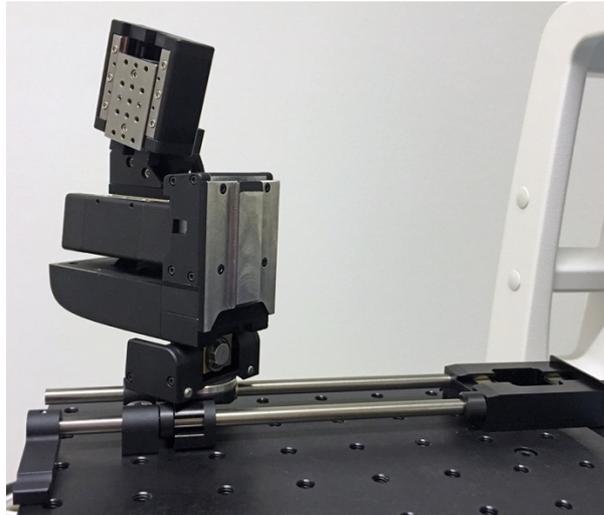


Figure 3.6. Tuning manipulator tilt angle in pick-up module

6. Test that flip and rotate mechanisms also work smoothly.

2.2.4 Installing head-stage / electrode holder

Accessories are provided to install most common amplifier head-stages, microelectrode holders or other microtools to the manipulator. Attaching various accessories using standard adapters is similar procedure and instructions below show it for the HSA type dove-tail adapter, which is compatible with most modern amplifier head-stages.

NOTE. Only use screws supplied with specific adapter. Too long screws can collide with piezo drive mechanisms and compromise function, possibly causing permanent damage.

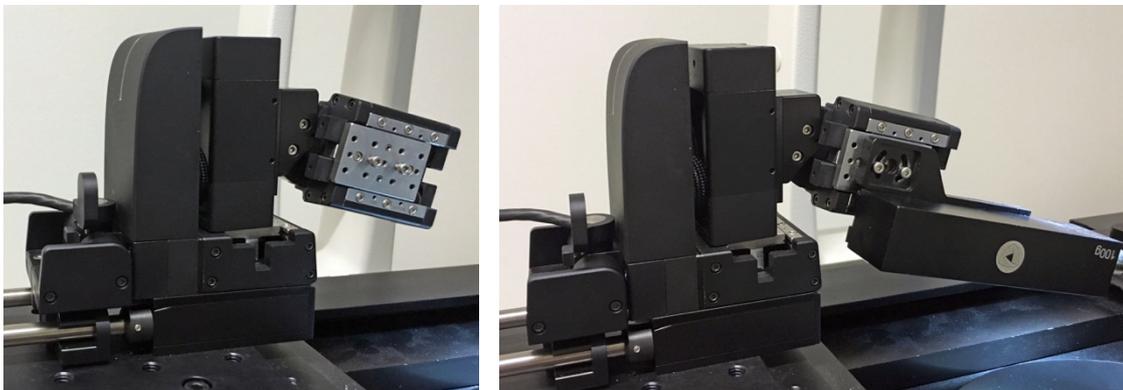


Figure 4. Attaching head-stage to manipulator

1. Fig. 4, shows screws attached to threads that should be used to adapters on x-axis.
2. Picture on the right shows HSA adapter with mock-up headstage attached to the manipulator. Depending on the head-stage it may be easier to first mount just the adapter to manipulator and then attach head-stage or to first attach headstage to the adapter.

NOTE Close up installation provides highest mechanical stability. Minimizing minimize the distance between the microelectrode tip and the manipulator installation point will maximize stability.

NOTE Drag from the head-stage cables or tubing are most common reason for performance issues, drift and mechanical artifacts. Always ensure that the drag is relieved by organizing them. For example, head-stage cable should be attached firmly to somewhere above the micromanipulator so that it curves down neatly at the level of the x-axis with enough slack for

free movements. Please contact us if you have any questions or concerns how to optimally arrange cables or tubing in your installation.

2.2.5 Adjusting approach angle

Two commonly used geometries for approaching the target are:

1. True approach angle where microelectrode is installed parallel to the x-axis and x-axis is mechanically tilted to preferred approach angle. Moving the x-axis will move the microelectrode in approach angle. Virtual axis feature is offered to enable moving microelectrode horizontally back- and forth in stage / platform plane by moving x- and z-axis together (see 3.2.1.4).
2. In diagonal approach the x-axis is set to 0 degrees (parallel to stage/platform) and the microelectrode is installed in an angle relative to x-axis. Inverse virtual axis feature can be used to move the x- and z-axis together so that microelectrode is moving parallel to its installation angle (see 3.2.1.4).

For true approach angle, loosen two screws from the x-axis tilt adjustment piece, adjust the angle to preferred setting and tighten the screws (Fig. 5). Poll axis angle feature in the TSC Manipulator setting menu shows the tilt angle during the adjustment (see 3.2.1.3).

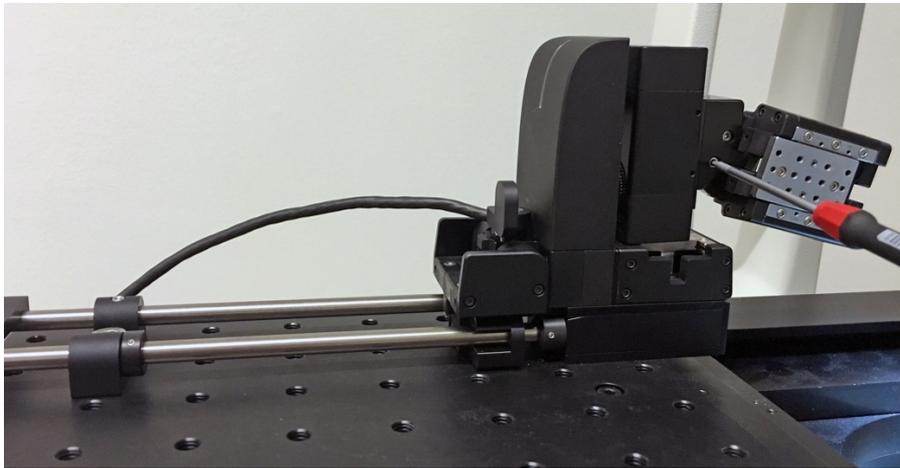


Figure 5. Adjusting approach angle

2.2.6 Re-configuring manipulator handedness

2.2.6.1 Micromanipulator

Handedness is determined by the orientation of the x-axis relative to the micromanipulator:

1. 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.
2. 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 (see Fig. 5).
3. It is also possible to configure manipulator to have x-axis attachment surface facing up (Fig. 6.2.), which requires using one additional attachment plate between the x-axis and tilt angle adjustment module.

To change from right to left-handed, or vice versa, loosen pair of screws pointed with arrows in Fig. 6.1, left. Drive y-axis to the other extreme and unscrew the cable clip to release x-axis cable from the manipulator body. Flip the x-axis around and loop the x-axis cable to other side of the z-axis. Attach cable and x-axis in reverse order using the same screws.

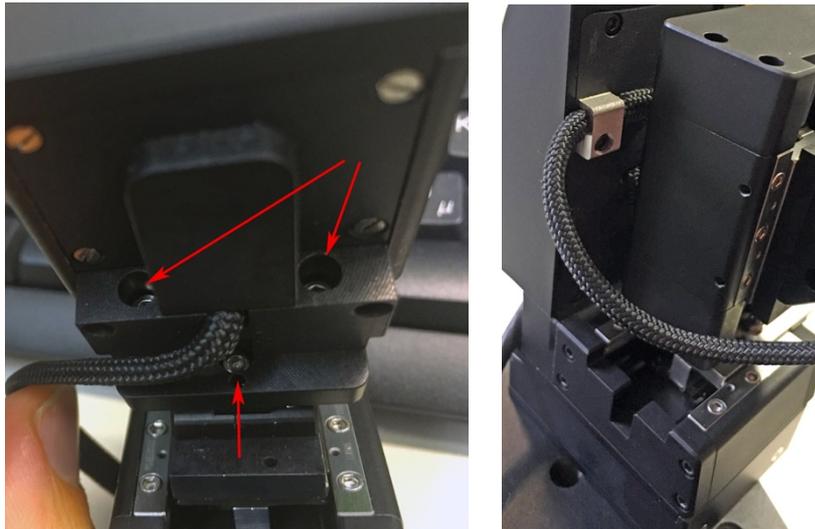


Figure 6.1. Re-configuring handedness

To attach x-axis its attachment side up, loosen the pair of x-axis attachment screws as instructed above. Attach the adapter plate to back end of the x-axis so that thicker part facing backside of the axis (Fig. 6.2. bottom, left). Then attach adapter plate with the x-axis to the tilt adjustment piece using the two screws (Fig 6.1. single arrow behind x-axis cable and arrow in Fig. 6.2. bottom right).

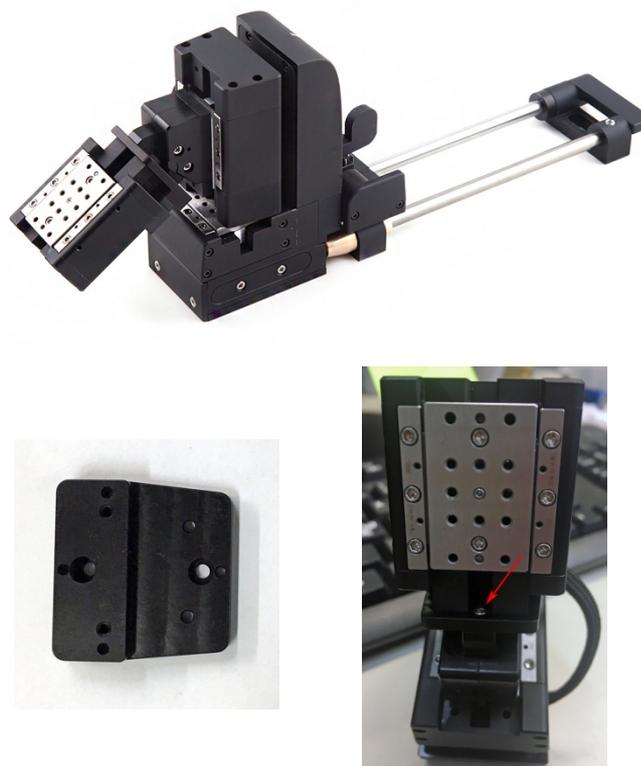


Figure 6.2. X-axis up configuration

2.2.6.2 Exchange module handedness reconfiguration

If the exchange module rotation mechanisms is used for the electrode exchange its rotation direction need to be reconfigured when changing the manipulator's handedness (Fig 6.3).

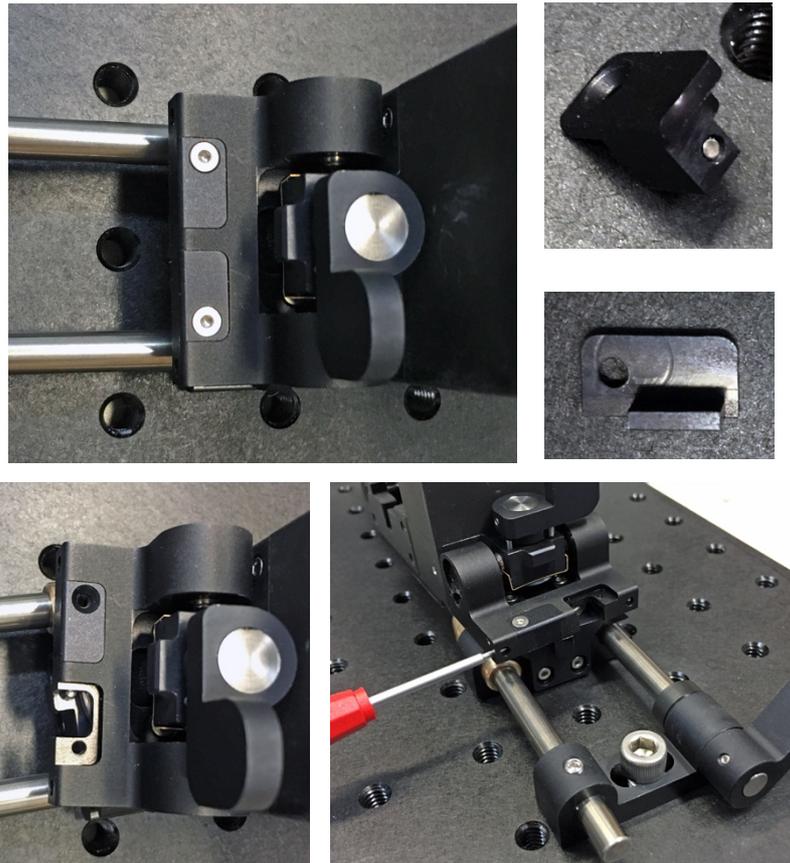


Figure 6.3. Rotate direction reconfiguration

Lock the pick-up module to manipulator, unlock the docking base and pull manipulator out of the docking base. Unscrew two screws that hold the adjustment and cover pieces (Fig. 6.3. top row, 1.3 mm hex key). Use spare adjustment piece supplied with the module for the other handedness, loosen the set screw so that the end of it is at the level of the piece and attach it to the slot that originally had the cover piece. Attach also spare cover piece with different handedness. Gradually tighten the set screw until the center of the manipulator is aligned with the center of the docking base. Test that manipulator can enter and exit the docking base smoothly.

2.2.7 Connecting micromanipulators to the control unit

Turn on TSC by pressing the button and wait that main view is displayed (Fig. 9). Connect manipulator(s) one at the time to the TSC and/or hub if more than 2 manipulators are included in the system (in that case plug in hub first to TSC). The connectors will auto-lock when properly in place and they can be removed by pressing in locking mechanisms at two sides of the connector. The manipulators will appear in the Manipulator setting menu (Fig. 13) and they should have different ID numbers. If needed, configure ID of specific manipulator by using Device ID setting in the micromanipulator menu.

NOTE Ground all micromanipulators from the grounding point (Fig. 7) to setup main ground with ground wire by using M2 screw.

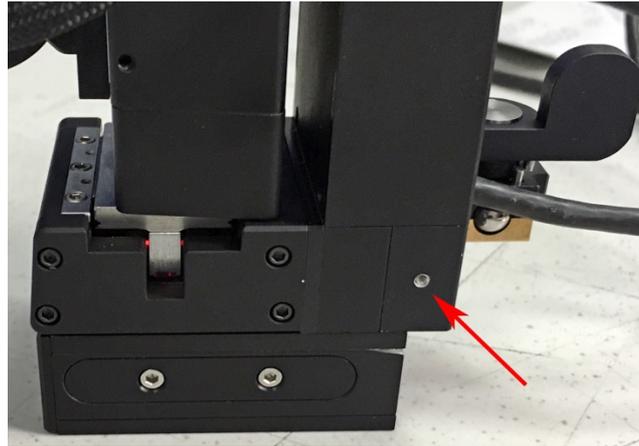


Figure 7. Micromanipulator grounding point

3 Using micromanipulation system

The touch screen control (TSC) unit and rotary wheel interface (RW) provide ergonomic and intuitive interface for the precise positioning (Fig. 8). This section provides brief instruction to help you getting started with the system after installation.



Figure 8. Left, Touch screen control unit; right, 3 wheel rotary wheel remote interface

To start operation, confirm that all manipulators in the system are installed and configured according the instructions in section 2. Plug the RW to the TSC using the USB cable that is supplied. Press the button in the TSC front panel to power it on and wait until main view is shown (Fig. 9). Confirm from the Manipulator settings menu (Fig. 13.) that all manipulators connected to your system are available there for selection. Please follow the instructions in this section to complete initial installation and always practice with mock-up use before working with the real samples and/or microelectrodes.

3.1.1 Overview of the control interfaces

Main products included in the system are triple axis uMp-3 or quad axis uMp-4 micromanipulator(s), touch screen control unit (uM-TSC) and rotary wheel remote interface (uM-RW3 | -RW4). In addition, 1-to-4 connector hubs are supplied with a system that have more than two micromanipulators, which also include extra batteries to maintain battery operation usage time in larger systems.

Each wheel in the RW controls one of the manipulator axis. The axis conventions are following: x-axis moves the microelectrode back-and-forth (axial movement), y-axis towards-away of the user (lateral movement) and z-axis up-down (vertical movement). The RW is available also as 4 wheel version (uM-RW4), where 4th wheel can be used to control the 4th axis in the quad axis manipulators or virtual 4th axis in the triple axis manipulators.

It is possible to connect two RW to one TSC to enable operating two micromanipulators with both hands at the same time. RW also has quick buttons on the left side to increase / decrease the speed and on the right side to change manipulator that is currently controlled.

The TSC provides real-time absolute position information in all axes and quick buttons for often required features. It also includes versatile configuration options to reconfigure the system according to your preferences.

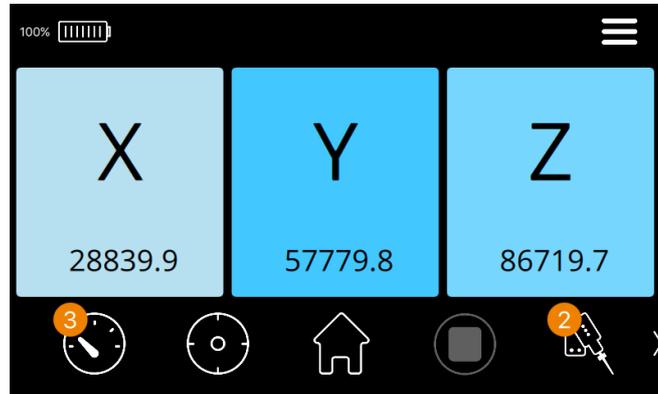
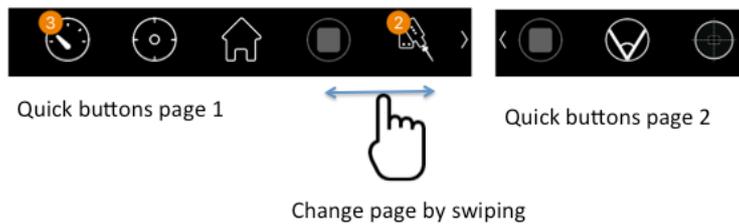


Figure 9. Touch screen unit main view

Main view shown in the Fig. 9 shows current absolute position information for all axes in micrometers. It also includes quick buttons on the bottom that are located in two tow pages. To activate another tow page, use the swipe gesture over the quick buttons area.



	<p>Speed selection view.</p>
	<p>Target memory position. Press and hold will save the current position as target position.</p>
	<p>Home memory position. Press and hold will save the current position as home position.</p>

	<p>Emergency stop symbol will turn red when any of the manipulators connected in the system are moving. Pressing the symbol will immediately stop all manipulators connected to the system.</p>
	<p>Opens Manipulator settings menu. Currently active manipulator ID number is displayed next to symbol.</p>
	<p>Virtual axis toggle for the active manipulator. Yellow line below the icon shows if the virtual axis is on.</p>
	<p>Menu button at the right top corner opens general settings menu.</p>
	<p>Battery status is show as graphical bar and in percents.</p>
	<p>Charging indicators. White = charging; Blinking White-Green-Red = low batter warning.</p>

3.1.2 Calibrating the system after first installation

uMp micromanipulation system is highly accurate research instrument, which needs to be calibrated to your installation specific conditions for optimal performance. This can be done with two simple steps explained in this chapter.

NOTE that calibrations are manipulator specific and need performed for each manipulator in the system.

CAUTION Always remove the microelectrode before calibration procedure to avoid collision and damage to electrode or sample. Also make sure that each micromanipulator in the system has enough clearance to complete the initialization movements over their full range.

3.1.2.1 Calibrate absolute position information

Go to Manipulator settings menu by pressing the manipulator symbol in the bottom right corner. All the connected manipulators are displayed by their ID numbers. Perform Calibrate position for each of them by first selecting the manipulator form symbol on the left side of view (=ID number) and then tapping arrow next to the Calibrate position command. Pop up dialog shows up, which allows executing command for just the selected manipulator or to all of them at once.

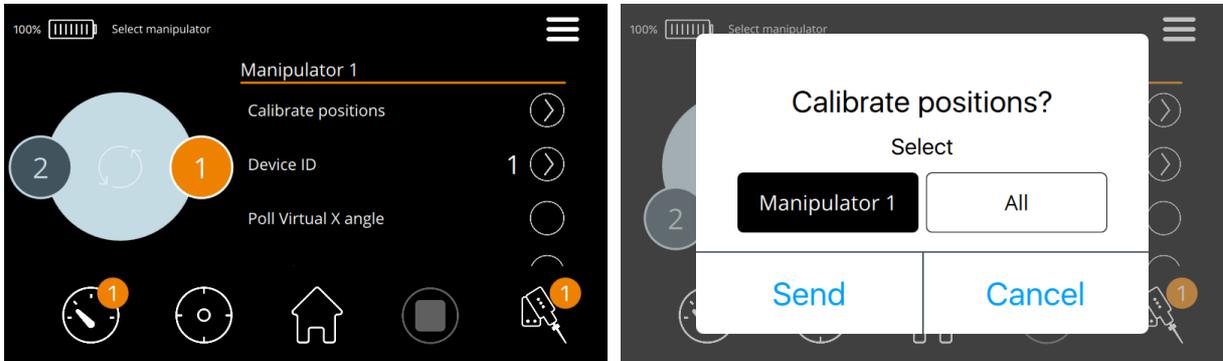


Figure 10. Calibrate positions

The Calibrate position will drive each axis one at the time against their mechanical end of range to establish absolute zero coordinates.

NOTE This feature needs to be executed during first installation and if manipulators are moved manually (=by hand) when they are switched off. In normal operation the absolute position information is maintained.

3.1.2.2 Calibrate load

This feature is used to adjust default control parameters of the piezo drives to specific loading conditions in the installation. It must be always performed after first installation for each manipulator. It should be also performed again in case manipulators' loading conditions change significantly, for example by changing the approach angle. Select Calibrate load function from the Manipulator settings menu and start routine by tapping the arrow symbol. Dialog will pop up that need to be confirmed to execute feature (Fig. 13.).

NOTE that each speed setting is calibrated one at the time, which will take several minutes. It is normal to hear audible sound during the process.

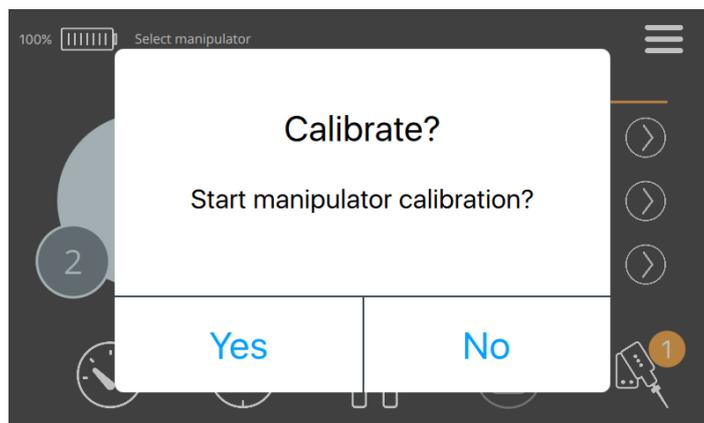


Figure 11. Calibrate load

3.1.3 Basic operation

To position microelectrode use rotary wheels of the RW to control each of the axes individually. The wheel – axis configurations and positioning directions are customizable (see 3.2.4.1).

To change the speed press buttons located at the left side of the RW. Upper button will increase the speed setting and lower button will reduce the speed setting. Pressing the quick button in the TSC main view also enables selecting any available speed. Fastest speeds 4 and 3 are designed for approaching the target and 1, 2 and snail for the final approach.

Stepping mode (Fig. 12.) enables taking incremental steps for example to drive extracellular electrode forward in tissue with certain increments. Selected speed that is at the lower left corner determines stepping speed. Using the Pen speed activates open loop mode, where thrusts are taken with maximum acceleration for example try to impale cells for the intracellular recordings or in microinjections. In the open loop mode, the actual distance of individual thrusts may be different than set value and may vary between thrusts. However, position information shown in display is always accurate.

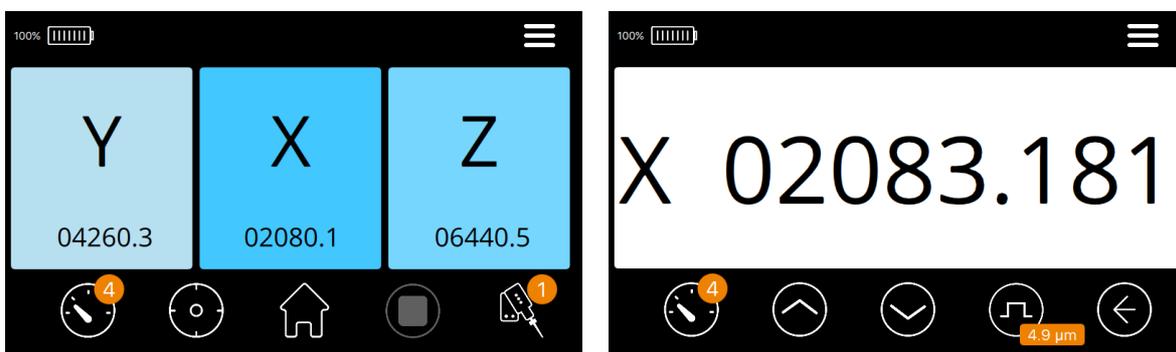


Figure 12. Stepping mode

Preferred step size can be specified using step symbol (range 0.1 – 10 μm). Up/down arrow symbols are used to step forward or backward. It is possible to reset the x-axis coordinate by tapping the number. Arrow to left symbol can be used to return to main view.

Micromanipulator can be selected by pressing buttons on the right side of the RW. Upper button will go to larger manipulator ID and lower button to smaller ID number. It is also possible to select any manipulator that is connected to the system by pressing its ID at the Manipulator settings view.

Home & Target memory positions can be used for example for convenient electrode exchange. Press the home (=home symbol) or target (cross hair symbol) quick buttons to perform memory positioning. Pressing symbol longer than one second will save the current location to that quick selection. Pop up dialog is shown when activating the command, which also enables selecting the speed that is used to perform memory position drive.

Displayed axis values can be reset by tapping the axis symbol. Tapping again will recover absolute coordinate.

Emergency stop symbol is red in case any of the manipulators in the system is moving and pressing it will immediately stop all the manipulators in case there is for example collision risk during memory position operation.

Virtual axis can be toggled on/off by using the dedicated quick button that is available at second quick button bar view (see 3.2.1.4. for further instructions how to set up virtual axis).

To perform measurement press button in touch screen controller to activate recoding mode, which puts the system to sleep. This way accidental movement of the RW wheels will not cause movements. Using the recording mode when not positioning the manipulators actively also significantly increases battery usage time. Normal operating mode can be quickly recovered by pressing the button again.

To change the microelectrode use home position to return to safe position away from the sample. Lock the pick-up module to manipulator and unlock the docking base. Slide manipulator back from the docking base and flip/rotate the manipulator for easy access to electrode. Rotate/flip manipulator back to working position

and slide it to docking base. Lock the docking base, unlock the pickup module and use target position to return microelectrode to field of view close to sample. Note that the micromanipulators should be always handled with care to avoid manually moving the axes.

To charge battery simply plug in the charger to TSC. **CAUTION The charger should be connected to earthed mains outlet only.** The system can be operated with charger plugged but for the most sensitive measurements it is recommended to use battery operation to eliminate possibility of 50/60 Hz noise. Operating the system with charger always plugged in has also negative impact on the battery performance over time (like for example in laptops).

To completely power off the system keep the button in the TSC front panel pressed for longer than 3 seconds. Powering back on requires another long press.

3.2 Description of the TSC menus

3.2.1 Manipulator settings menu

Manipulator specific configurations and features are included in this menu. Enter and exit the menu by pressing the symbol in the bottom right corner.

NOTE settings are manipulator specific and need to be changed to all manipulators by first selecting the manipulator to be configured.

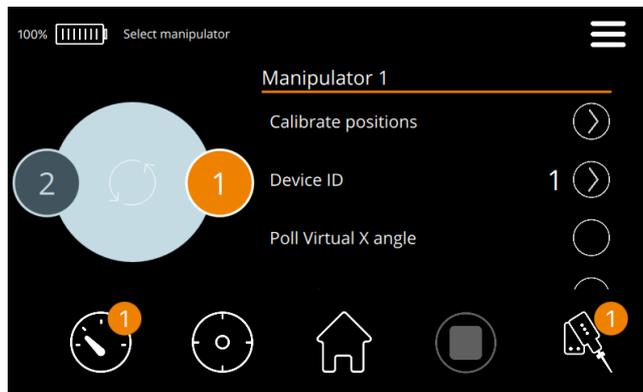


Figure 13. Manipulator settings menu

All the connected manipulators are displayed by their ID numbers on the left. You can select any of them from by tapping the number. It is also possible to organize ID numbers to layout that is matching with the installation layout by dragging the symbols around the circle. Pressing the arrow symbol in the center will reset the default layout.

3.2.1.1 Calibrate positions

This feature is used to establish absolute positioning information for each axis by driving them one at the time against mechanical end of range (Fig. 10). This will be done in the following order: first retracting x-axis, then moving y-axis all the way to the front and lifting z-axis all the way up and. After this the axis are returned to the Home memory position using reverse sequence. Dialog pops up before running the feature to prevent accidental use. It also enables choosing if the feature is performed for just the selected manipulator or all manipulators connected to the system.

CAUTION Always remove the microelectrode before running this feature to avoid collision and damage to electrode or sample. Also make sure that each micromanipulator in the system has enough clearance to complete the initialization movements.

NOTE This feature needs to be executed during first installation and if manipulators are moved manually (=by hand) when they are switched off. In normal operation the absolute position information is maintained.

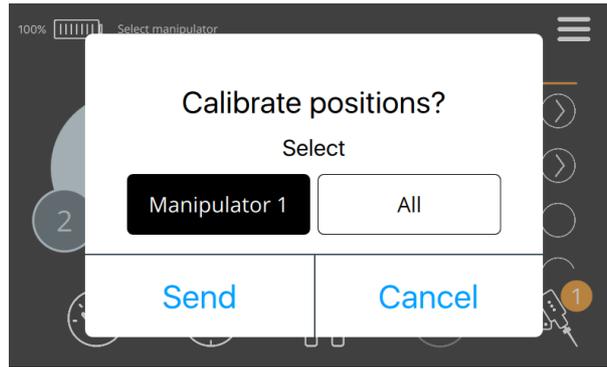


Figure 14. Calibration position dialog

3.2.1.2 Changing device ID

This feature can be used to change device ID of any manipulator connected to the system. It may also be needed when add-on manipulators are added to the system after initial installation. By default, multiple manipulator systems are delivered from factory pre-configured so that each manipulator has different ID.

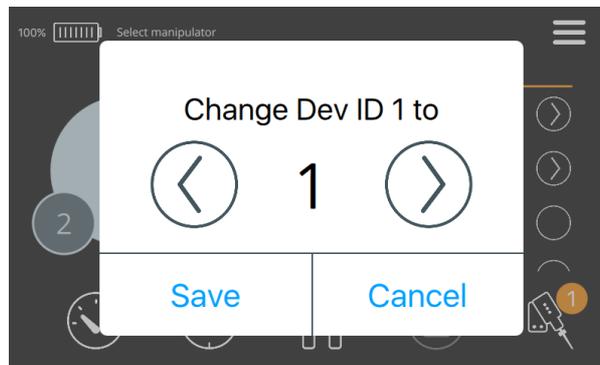


Figure 15. Changing device ID

3.2.1.3 X-axis tilt angle read-out

This feature enables constantly polling the sensor in x-axis, which is measuring the tilt angle to help installing the manipulators with specific approach angles (Fig. 11). After enabling the current angle is shown next to menu item. Feature should be switched off when not needed anymore to avoid unnecessary polling of the manipulators (saves some resources).

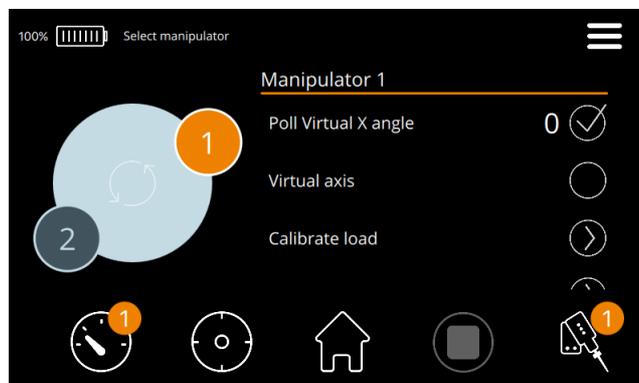


Figure 16. Polling x-axis angle

3.2.1.4 Virtual axis

The virtual axis feature enables moving the microelectrode tip in the horizontal plane when x-axis is tilted for true approach angle (Fig. 5). To set up virtual axis, select Virtual axis angle and adjust according to installation (Fig. 17). Value shown is the current setting and value measured value from the tilt angle sensor is shown in the parenthesis. If virtual plane is not totally horizontal when observing the microelectrode tip, it is possible to fine tune the setting 0.1 degree at the time until the plane is correct. Virtual axis can also be toggled on / off from main view quick button (see 2.3.1). In case 4 wheel RW is used together with triple axis manipulators, the 4th wheel will operate the virtual axis.

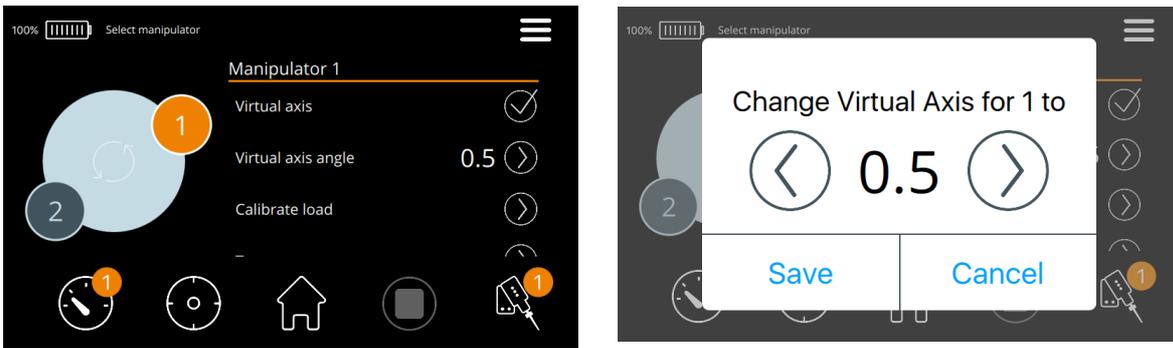


Figure 17. Virtual axis

Invert virtual axis feature can be used for diagonal approach in the installations where x-axis is horizontally in 0 degrees and just the microelectrode is tilted to specific angle. Here the angle of the microelectrode in comparison to horizontal 0 degrees need to be manually measured and set.

3.2.1.5 Calibrate load

This feature is used to adjust default control parameters of the piezo drives to specific loading conditions in the installation. It must be always performed after first installation and if loading conditions change, for example by changing the approach angle significantly. Dialog will pop up that need to be confirmed to execute feature (Fig. 18).

CAUTION Always remove the microelectrode executing Calibrate load, which will drive each of the axes close to their extremes, to prevent collision and damage. Also make sure that each micromanipulator in the system has enough clearance to complete calibration routines.

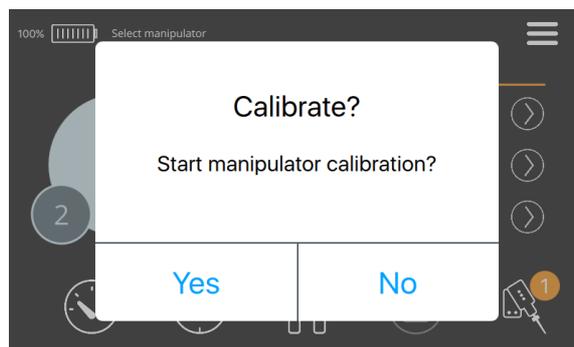


Figure 18. Calibrate load

3.2.2 Operating range limits

This feature allows user to set movement limits to each axis for example to prevent collision to the dish bottom with the microelectrode. Limits can be activated by pressing 'Axis limit in use' selection (1). After that limits can be set for each axis by pressing (2) and using the configurator interface.

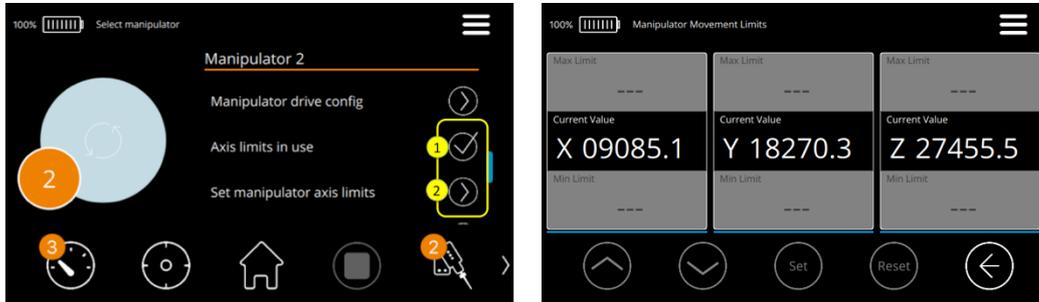


Figure 19. Axis limit configuration

First select the axis and limit you want to configure. Then use RW wheels to get to that limit and press Set button to set it (current coordinates will show in the middle section). Reset button can be used to remove all limits. It is also possible to tune the set values by using the arrow buttons when the limit field is selected. Colored lines below each axis show the allowed range in blue and limited range in red color.

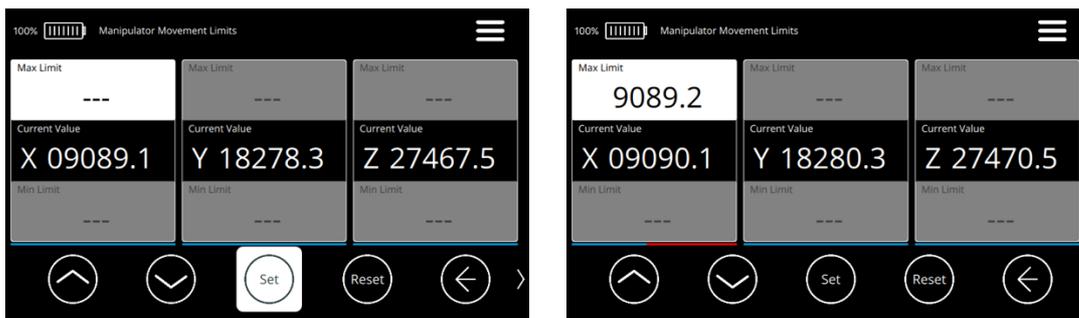


Figure 20. Setting axis limits

3.2.3 Advanced and beta features

3.2.3.1 Test run

Test run feature will drive each axis back and forth over whole range with selected cycle times. This feature may be needed as part of troubleshooting and service processes.

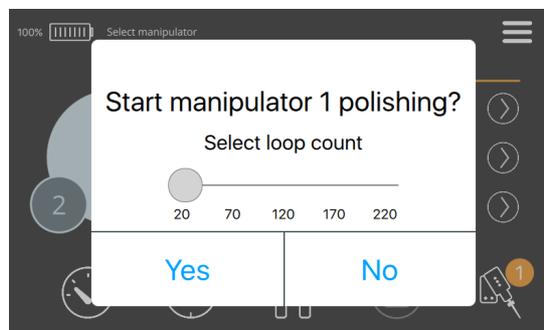


Figure 21. Test run

3.2.3.2 Axes drive order configuration

This feature enables defining any order for sequential positioning of the axes for example during the memory position functions (default is x-y-z). To reconfigure, first press reset button, then tap the axis names in the preferred order and finally press save button to save new configuration. Run Calibrate position feature to confirm the suitability of the new order.

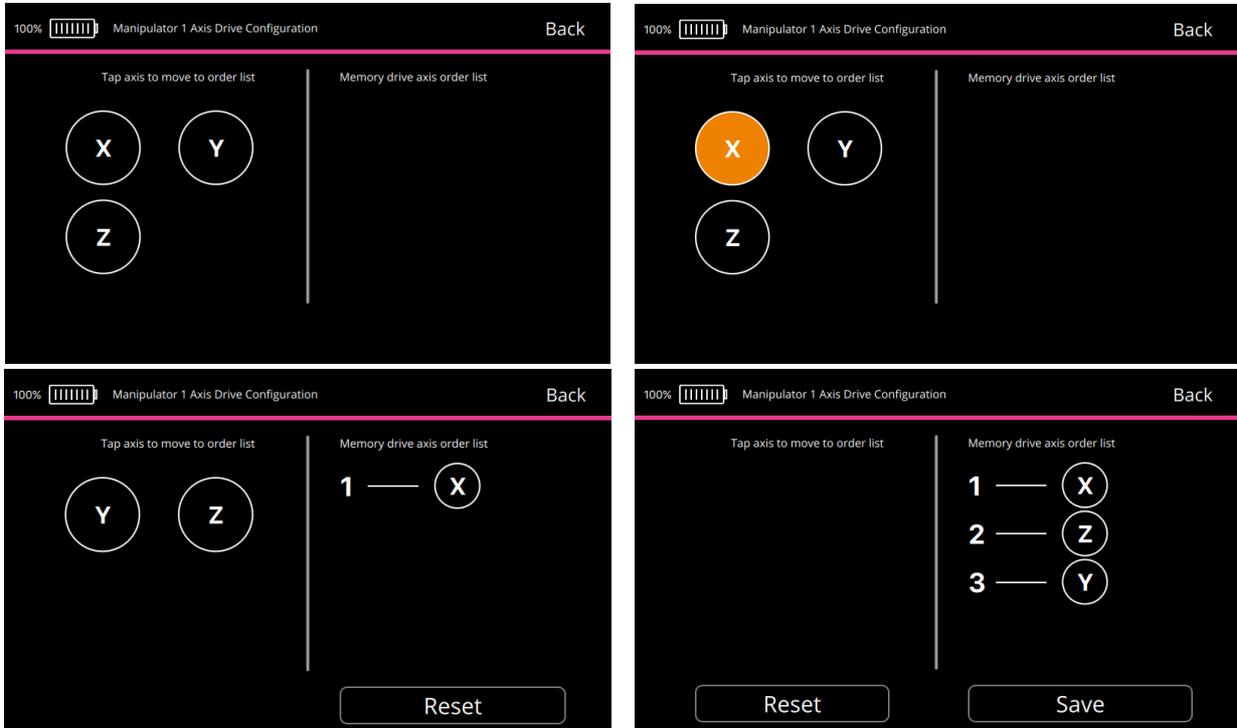


Figure 22. Configure axes drive order

3.2.3.3 Manipulator info

Manipulator info section at the bottom of the Manipulator settings menu shows manipulator's current firmware version.

3.2.3.4 Beta features

Beta features may be available at the time. These are features under development based on customer feedback. Beta features are not fully developed or tested. If you are interested in testing them, always test them in safe environment where possible malfunctioning does not produce any harm.

CAUTION Sensapex takes no responsibility for the functionality or performance of the beta features.



Figure 23. Beta features

To use beta features, first activate Beta features selection from main menu and confirm the pop-up dialog. As an example, Custom low speed selection is currently available under Manipulator settings menu, which is new control logic being developed for the speed 2 (optimization of vibration vs. audio sound performance).

3.2.4 General settings menu

General settings menu includes features that enable configuring the usability of the system and that are common to all manipulators. Enter this view by pressing the General settings symbol in top right corner of main view.

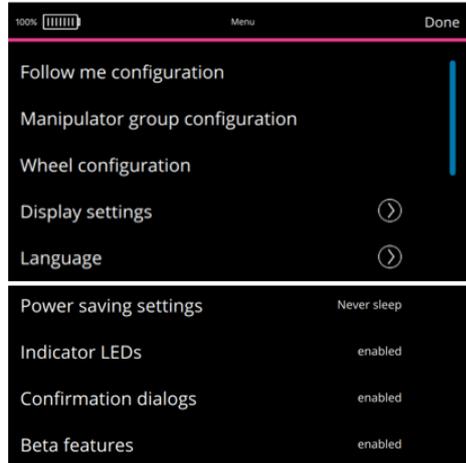


Figure 24. General settings menu.

3.2.4.1 Rotary wheel unit configuration

Wheel configuration settings enables selecting, which wheel controls which axis as well as configuring what direction each axis is moving when wheel is rotated clockwise.

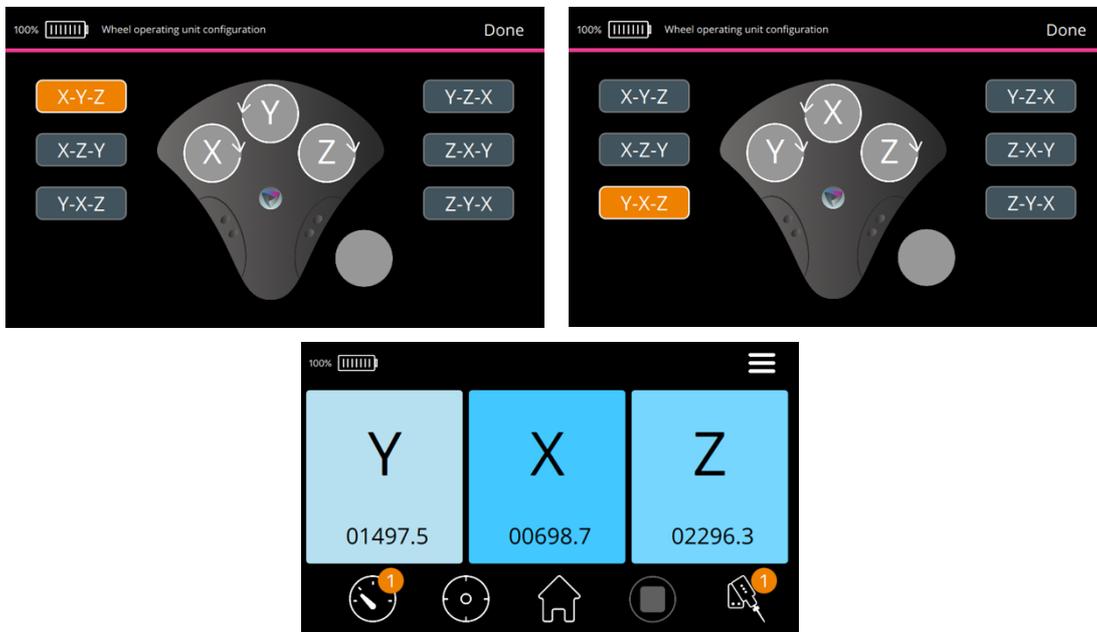


Figure 25. Wheel configuration menu

Select preferred configuration from the view by tapping it. Main view will be updated accordingly. Pressing the wheel symbols in the settings menu will change direction of the movement (direction of arrow over the wheel changes accordingly).

3.2.4.2 Display brightness

Brightness of the display can be adjusted from the Brightness menu.

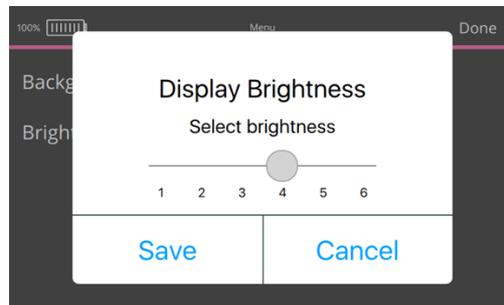


Figure 26. Display brightness menu

3.2.4.3 Language selection

Language selection menu includes different language variants of the interface. New languages will be gradually added on-need basis. Please contribute by sending us translation in your local language!

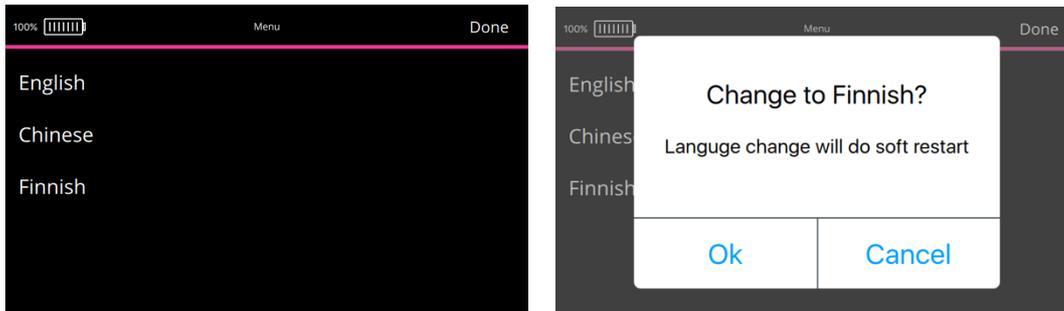


Figure 27. Language setting menu

3.2.4.4 Power saving

Power saving menu is used to set time of inactivity after which the micromanipulator system will go to sleep mode. Sliding the selector all the way to right will disable power saving mode. Pressing the button in the touch screen controller will return to normal operating mode from sleep.

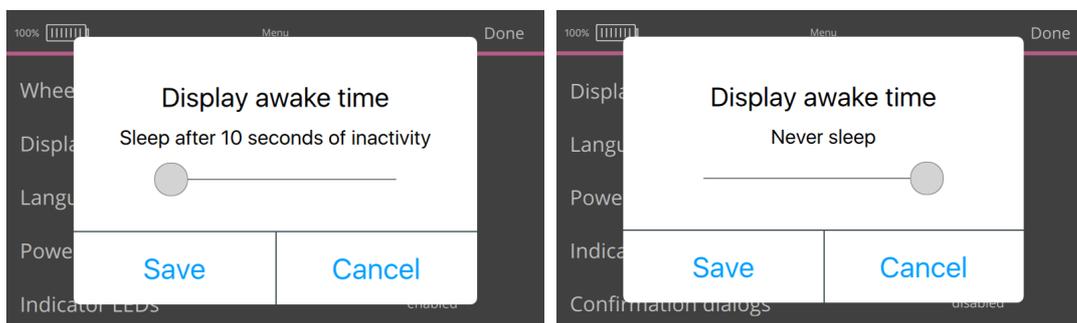


Figure 28. Power saving menu

3.2.4.5 Indicator LEDs

This setting allows disabling the indicator light from micromanipulators (for example during imaging).

3.2.4.6 Confirmation dialogs

This setting enables disabling pop up confirmation dialogs that are shown for example in memory position features.

3.2.5 Software settings

Software settings enable user to conveniently update the micromanipulator and touch screen control unit software. It also includes setting to factory reset touch screen controller settings.

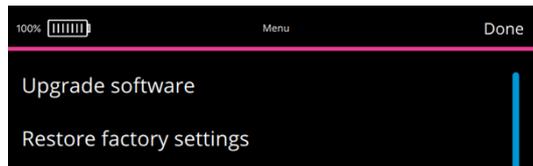


Figure 29. Software settings menu

3.2.5.1 Software update

Most convenient way to update micromanipulator and touch screen control unit software is to plug the TSC to internet using Ethernet cable, which enables automatically retrieving the latest software from the internet.

In case internet connection is not available, software update is also possible through USB memory stick. Please download latest software from our website, save them to the root of the USB memory stick and plug to control unit. After that process is the same as when updating over internet.



Figure 30. Software update

Press check for new updates button for the software update view. New update will be searched from the internet or from USB memory stick and updated if more recent version is found.

NOTE update will be made only for the manipulator that is currently selected (ID shows in the view). To update other manipulators in the system, first select the specific manipulator from Micromanipulator setting menu and repeat the update process.

3.2.5.2 Restore factory settings

Restore factory settings feature will reset the configurable features to default values as shipped originally from the factory. Following settings will be reset:

1. Language setting: english
2. Display brightness: 4
3. Power saving setting: 20 seconds
4. Confirmation dialogs: enabled
5. Axis drive order: x-y-z

3.2.6 Advanced and beta features

3.2.6.1 Manipulator group configuration

The micromanipulator system architecture is local area network (LAN) and thus it is possible to plug and play unlimited number of micromanipulators. It also means that in case your TSC is plugged to LAN with Ethernet cable (e.g. during firmware installation) the control unit will detect all the other manipulators that are connected to the same LAN. Depending on your IT system configuration, this may include other manipulators in different setups or in different labs.

In case relevant to your lab, it is possible to configure touch screen control unit to only listen and control manipulators that are physically connected to it. This can be done by manipulator group configuration setting.

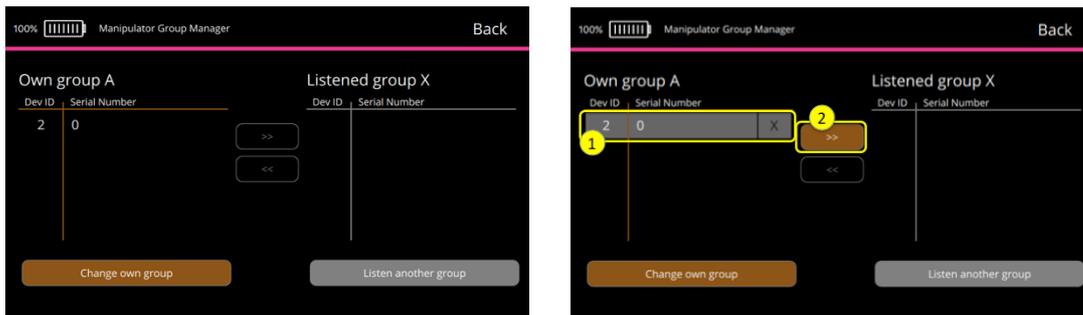


Figure 31. Manipulator group configuration

To configure, ensure that the manipulators that are meant to be controlled in the system are selected under the Own group. Listened group shows other manipulators within the LAN. Use arrows between two groups to include only the ones that should be controlled in the Own group. You can use serial numbers that are laser marked to each manipulator to confirm identity of each manipulator.

3.2.6.2 Beta features

Beta features may be available at the time. Beta features are not fully developed or tested. If you are interested in them, please test them at your convenience in safe environment where possible malfunctioning does not produce any harm and let us know your feedback.

To use beta features, first activate Beta features selection from main menu and confirm the pop-up dialog. As an example, follow me feature may become available under Micromanipulator settings menu, which is new control logic tested for the speed 2 (optimization of vibration vs. audio sound performance).

3.2.6.2.1 Follow me beta feature

CAUTION Sensapex takes no responsibility for the functionality or performance of the beta features.

Follow me feature can be used to make micromanipulators to follow microscope stage movement so that the microelectrode tips remain in the field of view. It also enables making micromanipulators to follow each other for coordinated movements. Current implementation is built to work with Prior Scientific motorized stages that have ProScan III controller.

Connect Prior ProScan III controller to TSC using USB cable. Stage can be then selected and controlled by the RW the same way as micromanipulators and manipulators can be set to follow stage movements.

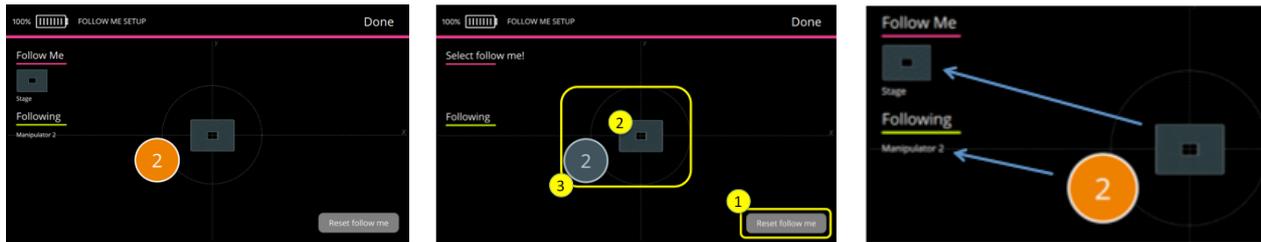


Figure 32. Follow me feature

To configure, first reset the current configuration. Then select who to follow by touching the stage symbol or manipulators if manipulators are following each other instead of following the stage. Select the followers in similar way. Note that it is possible at any time to reconfigure who to follow or who are following.

4 Maintenance and service

The micromanipulation system has been designed to be a reliable instrument. In case of troubles occur after installing and using the system according to this manual, please review the troubleshooting section and contact Sensapex or your local representative for further instructions. We are always happy to support our customers to be successful in their experiments!

NOTE It is always recommended to update software regularly to ensure the that latest versions are being used. Please let us know if you observe software bugs so that we can fix them. There will be also new features added in the software updates, which is another good reason to keep your software always updated.

NOTE Always take a picture of your installation and send it to Sensapex or your local representative when contacting for further instructions. In most cases problem can be solved by improving the installation.

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

4.1 Troubleshooting most common problems

Problem: more than one micromanipulator is connected to TSC but they are not shown in the Manipulator settings menu.

Fix: try restarting TSC by powering it off and powering back on by pressing button in the front panel over 3 seconds. If it does not solve the issue, unplug all manipulators and plug them back one at the time. Ensure that all manipulators have different device ID and reconfigure if needed.

Problem: manipulator axis does not move over the whole range or moves slowly.

Fix: most likely cause is excessive loading from the cable or tubing drag. Please organize cables / tubing to eliminate problem. Please send picture of the installation to Sensapex (support@sensapex.com) to confirm the installation.

Problem: movement of one axis causes correlated microelectrode tip movements in other axes or other movement artifacts are observed.

Fix: most likely causes are: (1) the microelectrode is colliding with an objective or chamber, (2) there are mechanically loose connection in the installation or (3) cable/tubing movements are causing the artifacts. Review if these could cause the problem and fix if needed.

Problem: pipette tip is drifting.

Fix: piezo drives are inherently drift free in micrometer scale. Note that nanometer scale changes in TSC readings can be cause by minor changes in loading, temperature changes etc. but those are rarely relevant in practice. Easiest way to eliminate micromanipulator as drift source is to reset axes readings in the display and see if they change while the pipette tip drift is observed. If not, drift source is something else in the installation.

Note that observed pipette tip drifting can often be due to the drift in microscope mechanics, optics or camera focus plane (=image is drifting although pipette tip is actually holding its position). Always investigate drift by having fixed target under the microscope and observe if relative position between that target and the microelectrode tip are changing.

5 Specifications

The micromanipulation system is designed to be used in laboratory environment in room temperature that is free from mechanical vibrations, electrical noise and transients. Specifications are presented for such environment.

- The system should be operated only in 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 should not fluctuate more than $\pm 10\%$. The presence of typical transients on the mains supply, e.g. those of installation or overvoltage, are category II.
- Pollution degree II

uMp-3 triple axis micromanipulator

Positioning range:	20x20x20 mm ³ (x-y-z)
Min. step size:	5 nm
Closed-loop control:	100 nm repeatability
Max. speed:	5 mm/s
Load:	0-150 g
X-axis tilt angle:	0 – 45 degrees*
Table mounting:	M6 ¼ inch bolt
Electrode exchange (add-on module):	slide + back-flip back-slide** side-rotate
Dimensions (WxHxL):	39x93x101 mm
Weight:	350 g
Electrical input:	12 VDC, max. 2 A

uMp-4 four axis micromanipulator

Positioning range:	20x20x20x20 mm ³ (x-y-z-D)
Min. step size:	5 nm
Closed-loop control:	100 nm repeatability
Max. speed:	5 mm/s
Load:	0-150 g
X-axis tilt angle:	0 – 90 degrees*
Table mounting:	M6 ¼ inch bolt
Electrode exchange (add-on module):	slide + back-flip back-slide** side-rotate
Dimensions (WxHxL):	39x114x101 mm
Weight:	410 g
Electrical input:	12 VDC, max. 2 A

uM-TSC touch screen control unit

Capacitive touch screen display
Easy speed adjustment and manipulator selection
Programmable memory positions
Supports two uMp-RW3 -RW4 interfaces
Supports max. 65536 manipulators*
Ethernet PC control interface
Charger input: 100-240 VAC, 50-60 Hz (grounded 3-prong mains outlet required)
Charger output: 24 VDC, 1 A
Batteries: Li-ion (rechargeable)
Dimensions: 120x95x123 mm
Weight: 850 g

*1-to-4 connector hubs are provided for multiple manipulator systems



The battery has built-in protection

uM-RW3 | RW4 remote wheel interface

3 and 4 wheel version available

Rotary optical encoder based wheels

USB connection to Touch screen control unit: 5 VDC, 0.2 A

Dimensions: 170x53x170 mm

Weight: 990 g

6 Limited warranty

Sensapex warrants that products conform to the published specifications and shall be free from defects in materials and workmanship under normal use, handling and service. The Limited Warranty is for one (1) year after the date of shipment. The Limited Warranty is extended to two (2) years with the same terms and free of charge if the product is registered to Sensapex within 30 days of the delivery.

Sensapex has no obligation under the Limited Warranty or otherwise, and this Limited Warranty does not apply to products if: (a) products are identified by as a pre-production product, alpha, beta or similar product or a prototype, (b) products includes specials, modifications, or customized items meeting the specifications provided by customer; (c) products are used in conjunction with equipment not provided by, or acknowledged as compatible by, Sensapex; (d) Sensapex determines that a problem is caused by accident, abuse, misuse, negligence, misapplication, fire, earthquake, flood, other force majeure event, failure of electrical power, the use of unauthorized parts or reagents, or unauthorized repairs or modifications; (e) Sensapex determines that a problem is caused during or as a result of shipment or relocation; (f) Sensapex logo or product serial numbers have been removed or defaced from the Product; or (g) a problem arises from or is based on Sensapex's compliance with customer's specifications.

To the extent the products are incorporated into any other instrument or device, Sensapex makes no representation with respect to the safety, efficacy, accuracy, reliability, use, or fitness for intended purpose of such integrated product. To the extent so incorporated into any other instrument or device, customer agrees to indemnify and hold Sensapex harmless from any claims, suits, liabilities, losses, damages, expenses (including reasonable attorneys' and experts' fees and expenses) and costs arising from or relating to any defects in and/or the use of integrated product to comply with any applicable laws or regulations.

Subject to customer's compliance with the procedure set forth in the limited warranty terms, Sensapex's sole obligation, and customer's exclusive remedy for any defective product, shall be limited, at Sensapex' option, to either repairing or replacing, free of charge for materials or labor, any products which are proved not in compliance with the Limited Warranty during the Warranty Period.

Products need to be transported for the service in its original shipping packaging. The cost of return shipment from customer to Sensapex is paid by customer and shipment from Sensapex to customer by Sensapex for the authorized service returns under limited warranty terms. If service is not under limited warranty or if the return is unauthorized the costs are paid both ways by the customer.

EXCEPT FOR THE LIMITED WARRANTY EXPRESSLY SET FORTH ABOVE, SENSAPEX MAKES NO WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THE PRODUCTS, AND EXPRESSLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THE LIABILITY OF SENSAPEX ARISING OUT OF SUPPLYING OF THE PRODUCT, OR ITS USE, WHETHER UNDER THE FOREGOING LIMITED WARRANTY, A CLAIM OF NEGLIGENCE, OR OTHERWISE, SHALL NOT IN ANY CASE EXCEED THE COST OF CORRECTING DEFECTS IN THE PRODUCT. ALL LIABILITY SHALL TERMINATE UPON EXPIRATION OF THE SPECIFIED WARRANTY PERIOD. THE FOREGOING SHALL CONSTITUTE THE SOLE REMEDY OF THE CUSTOMER. IN NO EVENT SHALL SENSAPEX OY BE LIABLE FOR CONSEQUENTIAL OR SPECIAL DAMAGES.

7 Manufacturers declaration of conformity

Manufacturer's Name: Sensapex Oy

Manufacturer's Address: Teknologiantie 13, 90590 Oulu, Finland
declares this product:

Product Name: uMp-series micromanipulation system
conforms to the following standards:

Low voltage directive 2006/95/EC: EN 61010-1:2010

EMC directive 2004/108/EC: EN 61326:2006; EN 55011:2009/CISPR 11:2009 (Class B, Group 1)

Best of our knowledge RoHS compliant (2006/95/EC)

WEEE directive 2002/96/EC

Batteries and Accumulators Directive 2006/66/EC

Supplementary Information: "The product complies with the requirements of the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC"

Date: 1.4.2016



Mikko Vähäsöyrinki, CEO
Sensapex Oy