Sensapex uMp micromanipulation system

Operating manual

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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 microscope. 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 grounded mains supply that meets the product specifications.
- Do not expose the product to liquid spills or moisture to prevent fire or shock hazard.
- Use only the charger and cables provided by the Sensapex.
- Do not attempt to replace the battery inside the touch screen control unit or hub

Precautions

Failure to comply with any of the following precautions may damage the product
- 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
- uMp micromanipulation system is a sensitive research instrument. Handle and operate it according to instructions in this manual and 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 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

Sensapex uMp micromanipulators provide high stability and performance in compact size. They are based on patented linear piezo drives, which are operated under 5 nm resolution closed loop control. The mechanical design is based on high quality aluminum and steel alloys for optimal stiffness to weight ratio. Mechanical parts are electrically grounded throughout the manipulator.

The uMp micromanipulation system typically includes touch screen control (uM-TSC) unit, rotary wheel remote interface (uM-RW3|4) and triple (uMp-3) or quad (uMp-4) axis micromanipulator(s) (Fig 1, left). Control hub uM-HUB is also needed for systems that includes more than two micromanipulators (Fig1, right). Selection of standard options and accessories are provided to customize system for your application.

Figure 1. uMp micromanipulation system overview

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/support.

2 Installation

2.1 Product registration and extended warranty

Two (2) year limited warranty is provided for the users who register their product(s) to us within 30 days from receiving the delivery. Otherwise one (1) year warranty applies.

Registration is done with free PC-Suite software that can be downloaded from: www.sensapex.com/support/pc-suite. Pleas have serial number of each product available during the registration process.

2.2 Arrival Inspection

Instructions for arrival inspection:
1.	Please notify Sensapex or your local distributor immediately if the outside of the package is damaged.
2.	Carefully unpack all the items and verify that you have received all the parts specified in your order and packing slip.
3.	Please contact Sensapex or your local representative if any of the ordered parts are missing or if you have any concern regarding possibly shipping damage.

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 POSSIBLY RESULTING SHIPPING DAMAGE.

2.3 General recommendations

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.

Please ensure that following general requirements are met:

- Manipulators should be installed on a stable, flat and clean surface.
- Adapters or third-party products attached to manipulators must have flat and clean mounting surface.
- Manipulators are designed to install upright on the horizontal surface. Please contact Sensapex if you plan other installation options.
- Always handle the manipulator by holding from back of the body (part where indicator LED is located) or from docking base. Handling and holding manipulator from axes may cause bearing damage.

For best performance and stability:

a. Install manipulators rigidly to the same stable stage or platform as sample.
b. Install manipulators as close to the sample as possible.
c. Organize cables and tubing with firm drag relief while maintaining enough slack for free manipulator movements.
d. Electrically ground manipulators from designated grounding point to prevent them acting as antenna for ambient noise.

HEADSTAGE CABLE AND/OR SUCTION TUBING DRAG EXPLAIN OVER 90 % OF REPORTED DRIFT AND VIBRATION ISSUES OF THE MICROELECTRODE TIP (SEE SECTION 6 FOR FURTHER INFORMATION).

The axis conventions used throughout this manual are as follows:

- x-axis moves pipette back-and-forth (axial movement with true approach)
- y-axis towards-away of the user (lateral movement)
- z-axis up-down (vertical movement)
- D-axis is physical 4th axis or diagonal virtual
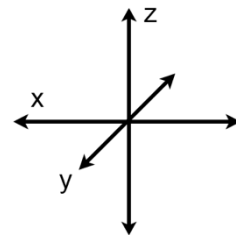
2.4 True approach vs. diagonal virtual approach

True approach is installation geometry where final approach is done using x-axis that is tilted in comparison to the horizontal plan and microelectrode is installed aligned with it. This is especially important and recommended in any experiment where targeted cells are not right at the surface and the pipette tip is driven inside the sample. The virtual axis can be used to move orthogonally along the horizontal plane (Fig. 2, left).

Orthogonal installation geometry with x-axis in 0 degrees to horizontal plane requires using virtual diagonal approach to move the pipette along its' axis (Fig 2, right). This approach is recommended in cases where final approach is done in orthogonal coordinates (typically vertically).

NOTE that the angle of electrode needs to be manually measured and set in diagonal approach
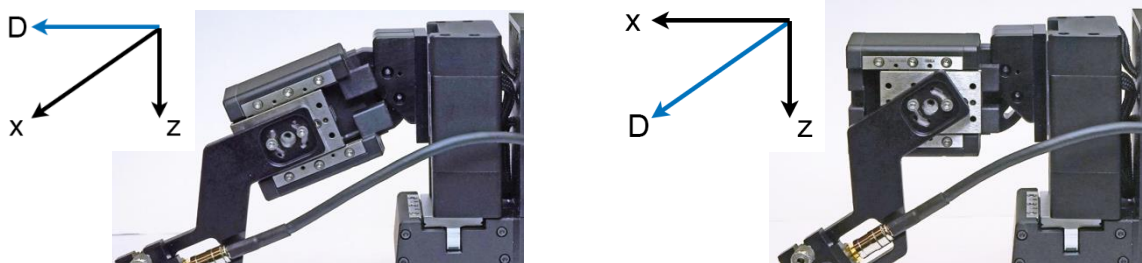
Figure 2. True and diagonal approaches; D defines virtual axis

2.5 Installing uMp manipulator with docking base

Please visit also our website to view installation tutorial videos: www.sensapex.com/support

1. Find right installation position by taking manipulator in hand and simulate alternative installation positions and approach angles. Each axis should be in the middle of its range. Attaching head-stage or microelectrode to manipulator helps to find right installation position.
2. Select threaded hole from stage/platform that is closest to center of the preferred position.
3. Micromanipulator is shipped with docking base attached. Unlock manipulator from its docking base by turning the locking knob 90 degrees using supplied tool (Fig 3., middle).
4. 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 (Fig 3., left). Use M6 or ¼ inch bolt supplied with the manipulator to attach docking base. Tighten lightly to allow sliding and turning the base on the platform.
5. Slide the manipulator to the docking base and fine tune exact position and orientation of the docking base by sliding/rotating it. Carefully remove the manipulator without moving the docking base and tighten the installation bolt firmly.
6. Slide the manipulator to docking base (Fig 3., right) and lock it by turning the knob 90 degrees. Test that installation is mechanically solid by gently trying to move the manipulator from the back-cover.
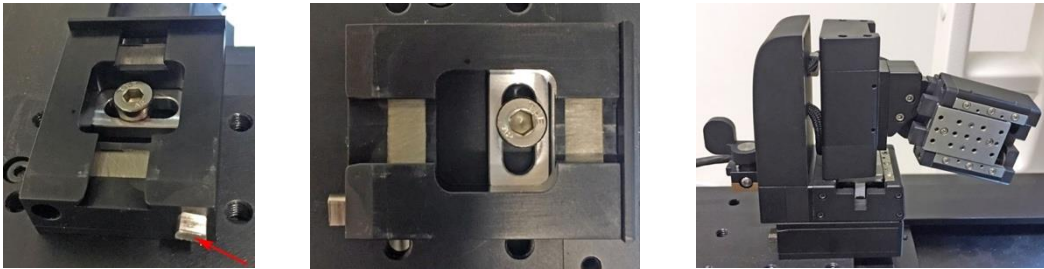
Figure 3. Installing uMp with docking base

2.6 Installing uMp micromanipulator with uMp-EXM

1. uMp-EXM is shipped with docking base installed and detached from the manipulator. It is pre-set at factory for that specific manipulator (tools for re-setting are included in the delivery).
2. Follow steps 1 and 2 in 2.4.
3. Unlock docking base lock by turning the locking lever at the back of the uMp-EXM by 90 degrees (Fig. 4, left).
4. Follow steps 4 and 5 in 2.4. Note that it is possible to further secure installation by attaching uMp-EXM with second screw through the groove at the uMp-EXM bottom plate.
5. Slide the micromanipulator to docking base and lock it by turning lever at the back of the uMp-EXM by 90 degrees (Fig 4, right).
6. Ensure that the locking lever of the pick-up module is facing directly back, slide the pick-up module against the manipulator and lock by turning the lever in the module.
7. Unlock manipulator from the docking base by turning the locking lever at the back of the uMp-EXM and test functionality of the slide and flip | rotate mechanisms. Note that adding headstage and other heavier tools to manipulator may require tilt offset adjusting (see 5.3 Re-setting uMp-EXM alignment section for further instructions).

Figure 4. Electrode exchange module installation
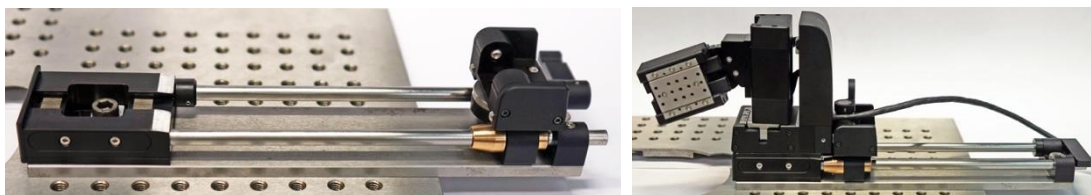
2.7 Adjusting x-axis angle

1. Support x-axis by hand and loosen two locking screws (Fig. 5, left).
2. Adjust the angle to preferred setting and tighten the locking screws.
3. Poll axis angle feature in the Setup section of the Manipulator settings menu shows current angle measured by the sensor in x-axis; feature should be switched off after installation (Fig. 5, right).
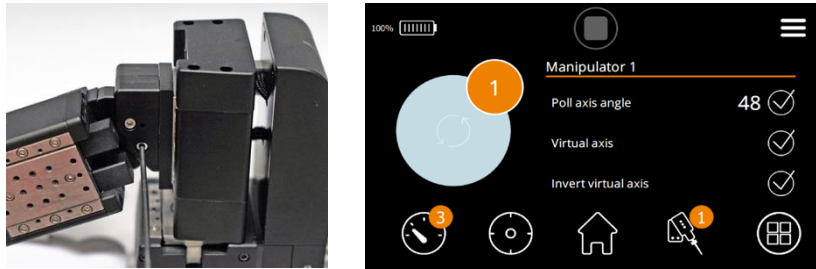
Figure 5. Adjusting approach angle

2.8   Installing head-stage or microelectrode holder

ONLY USE SCREWS SUPPLIED WITH SPECIFIC ADAPTER. TOO LONG SCREWS CAN CAUSE PERMANENT DAMAGE.

Standard accessories are available to install most common amplifier head-stages or microelectrode holders to the manipulator. Use uMp-DVT adapter to attach head-stage with dove-tail fitting to manipulator (custom adapter plates are available for other type of fittings):

1. The manipulator comes with shield plate attached on X-axis, which protects underlying mechanics and provides versatile options for attachments (Fig. 6, top left)
2. To attach uMp-DVT, first add axle of the adapter to shield plate. It supports angle adjustment of the attached head-stage or uMp-MPR in relation to the x-axis (Fig. 6, top right). Tighten gently without tools.
3. Add uMp-DVT adapter with two screws provided. Please note that screws should be placed in threads on opposite corners of the slots and in configuration that enable rotating uMp-DVT in right direction (Fig. 6 bottom left).
4. Loosen locking screw of the uMp-DVT dove tail adapter. Slide head-stage to adapter and tighten locking screw.
5. Attach adapter with head-stage mounted on it to manipulator X-axis. Adjust the position of the head-stage in the uMp-DVT adapter by sliding it as back as possible in the adapter without rear end of the head-stage colliding with the micromanipulator when moved over whole range.

MINIMIZING DISTANCE BETWEEN THE MICROELECTRODE TIP AND THE MANIPULATOR INSTALLATION POINT MAXIMIZES STABILITY.
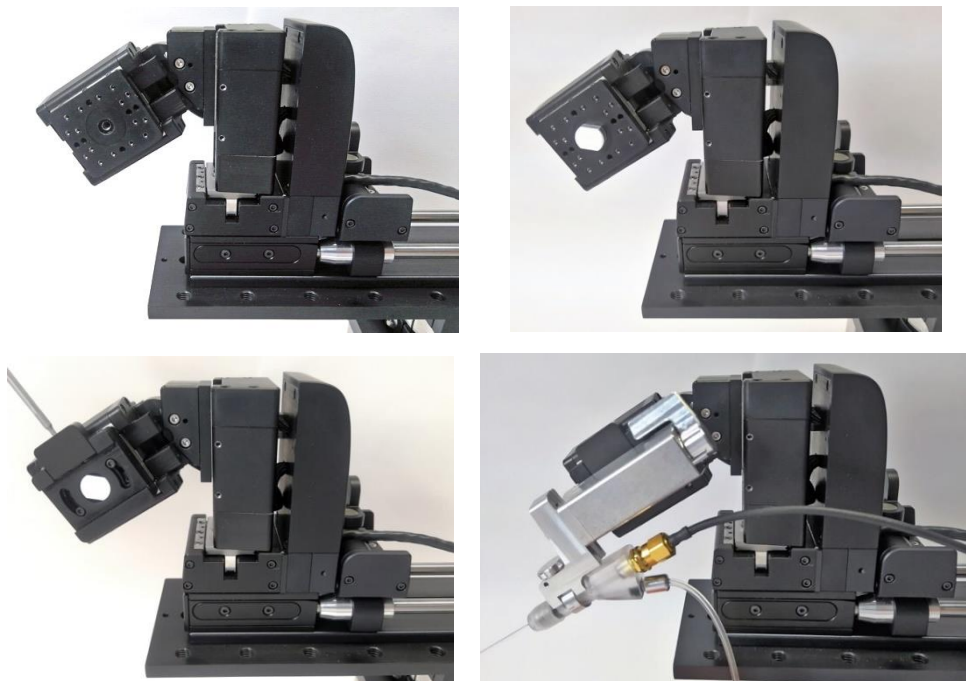

Figure 6. Installing, uMp-DVT and uMp-MPR adapters

![Sensapex logo]

uMp-MPR can be used to attach microelectrode holder or any other rod like tool holder to micromanipulator:

1. Loosen locking screw of the uMp-DVT dove tail adapter. Slide the uMp-MPR and tighten locking screw (Fig 6. bottom right).
2. Offset of the end piece of uMp-MPR can be adjusted vertically to support different approach angles.
3. Please use ring collar with uMp-MEH (Fig. 6, bottom right) and multipurpose front end in attaching other type of holders or rods.
4. Ensure that microelectrode holder or rod is installed as back as possible in the adapter without rear end of the head-stage colliding with the micromanipulator when moved over whole range (shorten rod if needed).

DRAG FROM THE HEADSTAGE CABLE OR TUBING EXPLAIN OVER 90 % OF REPORTED PERFORMANCE OR DRIFT ISSUES. ALWAYS ENSURE THAT THE DRAG IS RELIEVED BY ATTACHING THEM FIRMLY WITH ENOUGH SLACK FOR FREE MOVEMENTS (SEE SECTION 6 FOR FURTHER INSTRUCTIONS).

2.9   Wiring up the system

- Plug micromanipulator(s) to uMp-TSC control unit. The connectors will auto-lock when properly in place. To remove, press locking mechanisms at two sides of the connector.
- In case system includes more than 2 micromanipulators, connect micromanipulators to uMp-HUB and then connect uMp-HUB to uMp-TSC using provided Ethernet cable.
- In case more than 6 manipulators are used or PC control is used together with uMp-HUB, connect micromanipulators to uMp-HUB(s), connect uMp-HUB(s) and PC to any standard Ethernet router/switch and router/switch to uMp-TSC.
- Connect uMp-RW3|4 with provided USB cable to uMp-TSC.
- Ground **EACH** micromanipulator in the system from the point shown in Fig. 7 by putting ground wire under cap of the M2 screw.
- Turn on uMp-TSC control unit. The micromanipulator settings menu should display ID number of each manipulator connected to the system.
- In case all micromanipulators are not shown, unplug all manipulators and check their ID number one by one to verify they are all unique (see section 6 for further troubleshooting instructions)
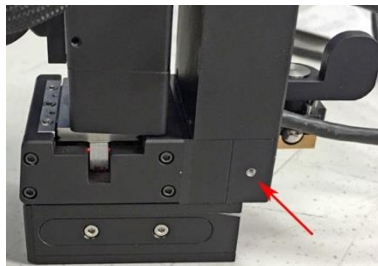

Figure 7. Micromanipulator grounding point

2.10   Calibrating the system after first installation

ALWAYS REMOVE THE MICROELECTRODE 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.

CALIBRATIONS ARE MANIPULATOR SPECIFIC AND NEED TO BE PERFORMED FOR EACH MANIPULATOR INCLUDED IN THE SYSTEM.

Calibrate position function is used to establish absolute position information for the closed loop control of each axis by driving them one at the time against mechanical end of their range. Function is completed by driving each axis to their Home memory position sequence.

The absolute position information is maintained in normal use. Run Calibrate position function again in case manipulators are accidentally moved manually (=by hand) when they are switched off. To perform calibration:

- Go to Setup section of the Manipulator settings menu. All the connected manipulators are displayed by their ID numbers. Do calibrations for each micromanipulator, by selecting them one at the time (Fig. 8).
- Press Calibrate positions command. Pop up dialog shows up to confirm executing command for just the selected manipulator or to all connected manipulators at the same time.
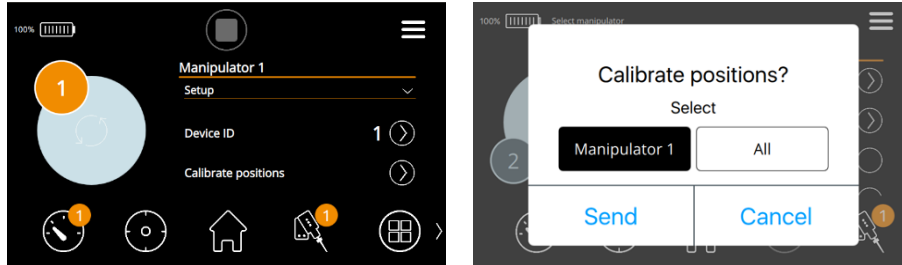

Figure 8. Calibrate positions and load.

Calibrate load function is used to establish default control parameters of the piezo drives to installation specific loading conditions. It must be always performed after first installation and in case loading conditions change significantly (different type of head-stage or microelectrode holder is used or x-axis angle setting in changed). To perform load calibration:

- Go to Setup section of the Manipulator settings menu. All the connected manipulators are displayed by their ID numbers. Do calibrations for each micromanipulator, by selecting them one at the time.
- Select Calibrate load function from the Manipulator settings menu. Start function by confirming execution from pop-up dialog.

EACH SPEED SETTING IS CALIBRATED ONE AT THE TIME, WHICH WILL TAKE SEVERAL MINUTES. IT IS NORMAL TO HEAR AUDIBLE SOUND DURING THE PROCESS.

3   uMp micromanipulation system basic features

3.1   uM-RW3|4

Each wheel of the rotary wheel remote unit uMp-RW3 (Fig 9, left) or uMp-RW4 (Fig 9, right) controls one of the manipulator axes (settings are fully configurable by uMp-TSC). Two uMp-RW3|4 can be connected to uMp-TSC to support operating two micromanipulators manually at the same time. Functionalities:

- Pair of push buttons on the left side of uMp-RW3|4 increase or decrease speed setting and pair of push buttons on the right side select micromanipulator with larger or smaller device ID
- 4th wheel can be used to control the 4th axis of uMp-4 or virtual axis of uMp-3 manipulators.

Figure 9. uMp-RW3 and uMp-RW4

3.2   uMp-TSC main view

The TSC provides real-time position information and quick buttons for most commonly used features. It also includes versatile configuration options to customize the control of system according to your preferences.

Main view displays current position information for all axes in micrometers. It also includes quick buttons on the bottom that are in two tow pages.

- Swipe quick button area left/right to change between two quick button views
- 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
- Yellow line below the virtual axis icon indicates that feature is on.
- Lightning icon is displayed when charging battery: White = charging; Blinking White-Green-Red = low batter warning
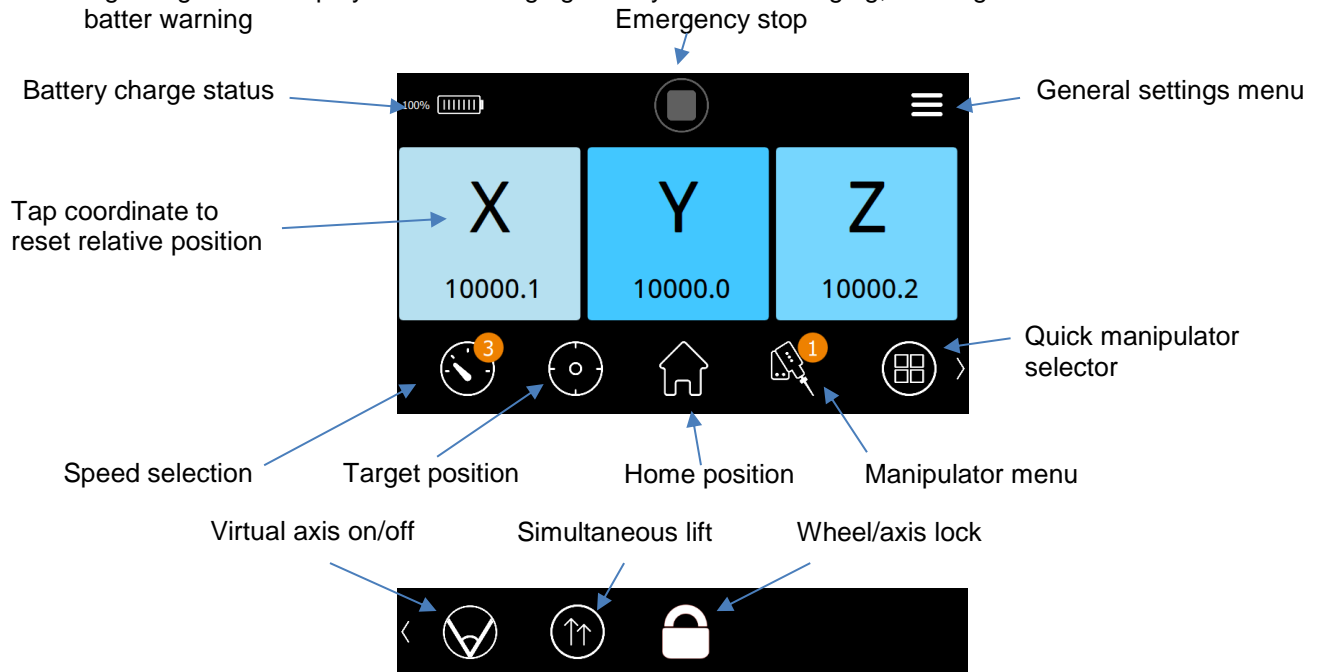

Figure 10. uMp-TSC main view

3.3   Positioning microelectrode

Use rotary wheels of the uMp-RW3|4 to control each of the axes individually (the wheel – axis configurations and positioning directions are customizable; see 4.1.1).

3.4   Changing speed

In addition to using uMp-RW3|4 push buttons, speed symbol at the uMp-TSC enables selecting any speed. Additional features:

- Continuous low speed from Manipulator settings menu, advanced settings is selected by default for optimal smoothness with speeds 1 and 2 in most installations (audible sound in this mode is normal). Unselecting this option leads to different control logic with burst like stepping, which may in some applications give more precise control feeling.
- Stepping mode (Fig. 11.) enables taking incremental steps of specific amplitude or speed.
    - Enter stepping mode for specific axis by pressing that field in uMp-TSC longer than 1 second
    - Use amplitude and speed symbols to configure stepping parameters
    - Up and down arrows execute one step forward/backward.
    - Tapping coordinate display resets display to show relative position information; tapping again recovers absolute coordinates
    - Pen speed activates open loop mode, where thrusts are taken with maximum acceleration and actual distance of individual steps may vary (actual position is displayed accurately).
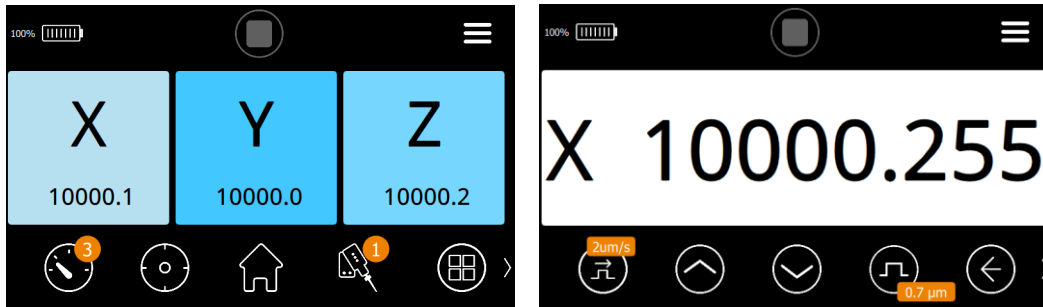
Figure 11. Stepping mode.

3.5   Selecting manipulator

Use uMp-RW3|4 push buttons or activate quick selection view from main view symbol (Fig 12).
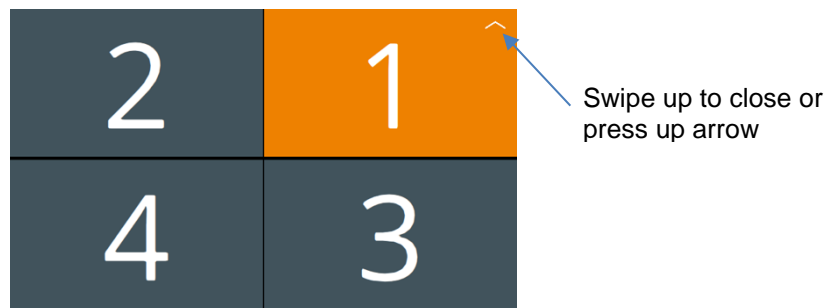

Swipe up to close or press up arrow

Figure 12. Manipulator quick selection view

3.6   Operating memory positions

- Press home or target icon shortly to drive manipulator to pre-set home or target coordinates.
- Press and hold target or home memory position symbols longer than one second to save current position as new memory position.
- Pop up dialog enables defining positioning speed.

3.7   Setting and operating virtual axis

Please note that virtual axis is optional feature and needs to be purchased separately. In case it is not purchased, the selection is not available in the Manipulator settings menu.

- Activate virtual axis from Micromanipulator settings menu -> Virtual axis settings (Fig 13, left) or by using quick button of main view (Fig 10; yellow line below quick button symbol indicates that virtual axis is on)
- Set virtual axis angle:
    - Currently defined value shown is displayed with angle measured with x-axis sensor in parenthesis.
    - For true approach (see 2.3), typically sensor angle provides correct setting to be used.
    - For virtual diagonal approach (see 2.3), angle of the microelectrode needs to be measured and set manually
    - Angle can be manually fine tuned with 0.1 degrees increments if needed. (Fig 13, middle)
- Activate 4th wheel for virtual axis feature to use fourth wheel of uMp-RW4 to control virtual axis with triple axis uMp-3 manipulators (Fig. 13, right)

Figure 13. Virtual axis

3.8   Activating recording mode

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

- Dims display and disables wheel unit to avoid unintended operation.
- Powers off piezo motors from micromanipulators.
- Saves battery for extended usage time before charging.

3.9   Exchanging microelectrode

Preparations before electrode exchange:

- Save safe position far away from sample as home position before starting experiments.
- Save target position closer to target so that pipette tip is in field of view, but with enough clearance to accommodate varying microelectrode lengths

To exchange microelectrode:

- Use home position to retrieve microelectrode from sample
- Unlock manipulator from docking base and slide | rotate | flip for easy access to microelectrode holder
- Change microelectrode, slide manipulator back to docking base and lock it
- Use target position to drive microelectrode to field of view for final positioning

3.10   Charging batteries

Plug in the charger to uMp-TSC charging port. The system can be operated with charger plugged, but battery operation is recommended for the most sensitive measurements and to extend battery life time.

ONLY USE THE ORIGINAL CHARGER AND USE ONLY EARTHED MAINS OUTLETS FOR CHARGING.

3.11   Updating firmware

Firmware of the products can be updated using the uMp-TSC or PC Suite. PC Suite works in more general due to IT settings in the internet connections that prevent uMp-TSC to access internet directly. Please follow instructions in the PC Suite help on how to update firmware using it.

To update firmware directly with uMp-TSC without computer.

1. Plug uMp-TSC to internet using Ethernet cable to automatically retrieve the latest firmware from Sensapex server. ***NOTE direct internet access is required without proxy or firewall settings that prevent access.***
2. Select Upgrade software from Software settings menu.
3. Press check for new updates button and update if new version is found.

UPDATE WILL BE MADE ONLY FOR THE MANIPULATOR THAT IS CURRENTLY SELECTED (DEVICE 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.

3.12   Powering off the system

Press the push button at the TSC front panel longer than 2 seconds to completely power off the system (confirmation dialog appears if dialogs are enabled). Powering system back on requires another long press.

4   uMp-TSC user interface menu

Enter and exit the main menu pressing the menu symbol or Done at the top right corner.

- About menu item displays information on current uMp-TSC software version.

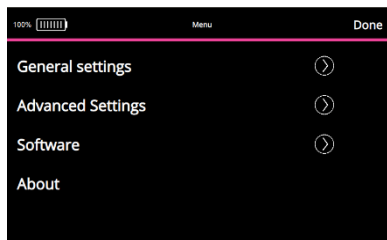*GENERAL SETTINGS ARE GLOBAL AND COMMON TO ALL MANIPULATORS.*

Figure 14. Main menu and general settings menu

4.1   General settings

General settings enable tailoring the user interface to your needs.
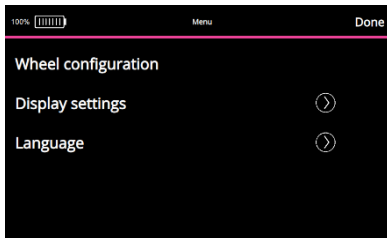

Figure 15. Main menu and general settings menu

4.1.1   Wheel configuration

Re-configure wheel to axis mapping and rotation direction to axis movement direction, by tapping related symbols in the Wheel configuration settings menu (Fig. 16).
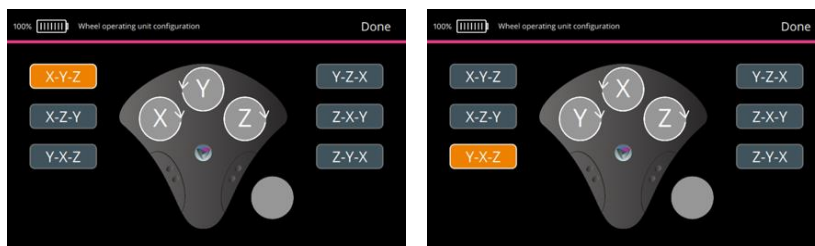

Figure 16. General settings menu

4.1.2   Display settings

- Brightness setting can be used to adjust display Brightness.

- Power saving setting defines time of inactivity after which the sleep mode is activated. Sliding the timer all the way to right will disable automated sleeping.). Pressing the uMp-TSC front panel button will wake up the system from sleep mode.

4.2   Advanced settings menu

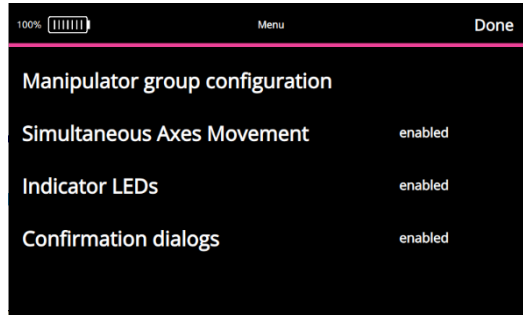Advanced settings menu provides settings that are less often adjusted after initial installation.

Figure 17. Advanced settings menu

4.2.1   Manipulator group configuration

Proprietary local area network (LAN) architecture is used in the uMp micromanipulation system. It makes possible to add unlimited number for manipulators to system, but it also means that all devices connected to same LAN can communicate with each other. For example, depending on the IT infrastructure in your lab, if uMp-TSCs are connected to LAN using Ethernet cables, each of them may be able to communicate with all manipulator systems in the lab or in different labs at the department. Manipulator group configuration setting can be used to prevent accidental control across different systems (Fig. 18):

- Configure system so that the manipulators that are meant to be controlled in the system are selected under the Own group.
- Listened group shows manipulators in group X within the LAN. You can use this to move your manipulators into Group X and then change own group. After that you can move your devices back to own group.
- If needed, use arrows between to include only manipulators that should be controlled in the Own group. Identity of each manipulator can be confirmed by serial number marked to the manipulators.
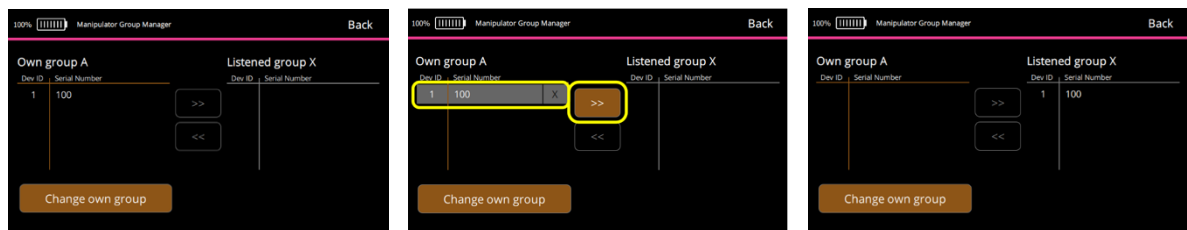

Figure 18. Manipulator group configuration

4.2.2   Simultaneous Axes Movement

Activating Simultaneous Axes Movement setting will move all the axes simultaneously during memory position functions, where as disabling it will move one axis at the time as defined in the Micromanipulator settings menu -> Manipulator drive config setting.

PLEASE NOTE THAT SIMULATENOUS MOVEMENT MAY LEAD TO COLLISION OF PIPETTE TIP TO CHAMBER OR OBJECTIVE FOR EXAMPLE WHEN RETURNING TO HOME POSITION

4.2.3 Indicator LEDS

Indicator LEDs setting defines if indicator LEDs of the manipulators are enabled or disabled.

4.2.4 Confirmation dialogs

Confirmation dialogs setting determines if dialog pop-ups are displayed when operating uMp-TSC functions.

4.3 Software menu

Software settings menu enables managing software versions and beta features available to uMp micromanipulator system products (Fig. 19).
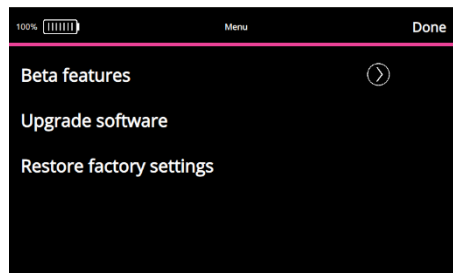
Figure 19. Software settings menu

4.3.1 Beta features

SENSAPEX TAKES NO RESPONSIBILITY FOR BETA FEATURE FUNCTIONALITY OR PERFORMANCE

Beta features may be available at the time. These are features under development often 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 cannot not produce any harm.

- Beta features can be activated from general settings menu (confirming pop-up disclaimer required)
- Beta features may appear in General settings or Manipulator settings menus, depending if they are manipulator specific.

Current beta features available:

- Take step protocol is modified control logic for controlling manipulators with uMp-RW3, where rotation speed of the wheels affects the positioning speed. This has been requested and considered by some customers as more intuitive and dynamic way to control the manipulator instead of default non-dynamic logic.

4.3.2 Upgrade software

Upgrade software menu enables updating the firmware to uMp-TSC, uMp-RW3 | 4 and to uMp-3 | 4 micromanipulators. Please see 3.11. for further instructions.

4.3.3 Restore factory settings

Restore factory settings can be used to restore uMp-TSC configuration to default settings.

4.4 Manipulator settings menu

Settings at the Manipulator Settings Menu are manipulator specific and need to be configured to each manipulator separately by first selecting the micromanipulator to be configured (see Fig. 20 for menu layout).
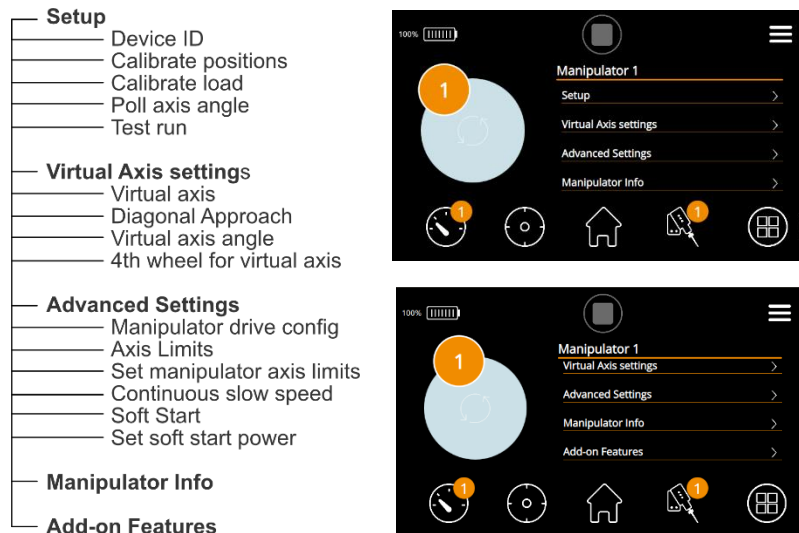
Figure 20. Manipulator settings menu

- Enter and exit the menu by pressing the manipulator quick button / symbol
- Connected manipulators are displayed by their ID numbers.
  - Tap number to select any of them
  - Symbols can be moved around circle to match installation layout. Pressing the arrow symbol in the center will reset to factory default layout.
- Manipulator info section displays manipulator specific information, such as serial number and current firmware version

4.5   Setup

Setup menu includes functions required during the installation. Please see chapter 2. for further instructions how to use them.

- Test run function can be used to drive each axis back and forth over whole range with many cycles. This feature may be needed as part of troubleshooting process.

- Change device ID feature is used to change device ID of specific manipulator:
  - For new systems, the device IDs are factory configured to recommended settings.
  - Odd numbers are recommended for right-handed manipulators and even numbers for left handed manipulators
  - To add manipulators to existing system:
    - Review device IDs of manipulators in the existing system.
    - Disconnect all other manipulators from uMp-TSC or uMp-HUB
    - Add new manipulator to uMp-TSC or uMp-HUB
    - If needed, change device ID to be different from other manipulators
    - Connect all manipulators back to uMp-TSC or uMp-HUB

EACH MANIPULATOR CONNECTED TO THE SYSTEM MUST HAVE UNIQUE DEVICE ID.

4.6   Virtual axis settings

Virtual axis settings is available when the optional Virtual axis feature is purchased to selected manipulator. See 3.7. for further information.

4.7   Advanced settings

Virtual axis settings is available when the optional Virtual axis feature is purchased to selected manipulator. See 3.7. for further information.

4.7.1   Manipulator drive config

Manipulator drive config settings enables defining the order for axes movement during the memory position driving (assuming Simultaneous Axes Movement is disabled, see 4.2.2). To change the order from default settings:

- Press reset button
- Tap the axis names in the preferred order.
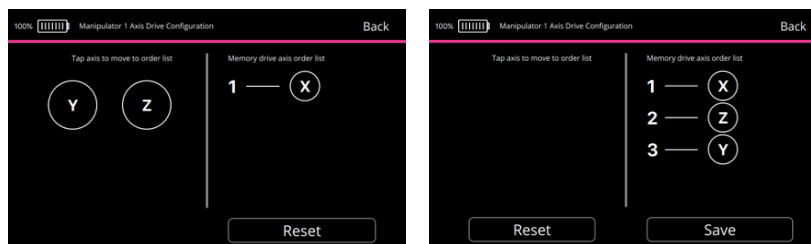- Press save button to save new configuration

Figure 21. Manipulator drive config

4.7.2   Axis Limits

Axis Limit settings can be used to limit positioning range from the full range for example to prevent collision to the dish bottom with the microelectrode (Fig. 22). To set the limits:

- Tap Set manipulator axis limit symbol to open configuration interface
- Select the axis and limit you want to configure.
- Use uMp-RW3|4 wheels to move each axis of manipulator to preferred limits and press Set button to set them one at the time. Current coordinates are shown in the middle section. Alternatively, arrow buttons can be used to adjust selected limit.
- Reset button can be used to remove all limits.
- Colored lines below each axis indicate the allowed range in blue and limited range in red color
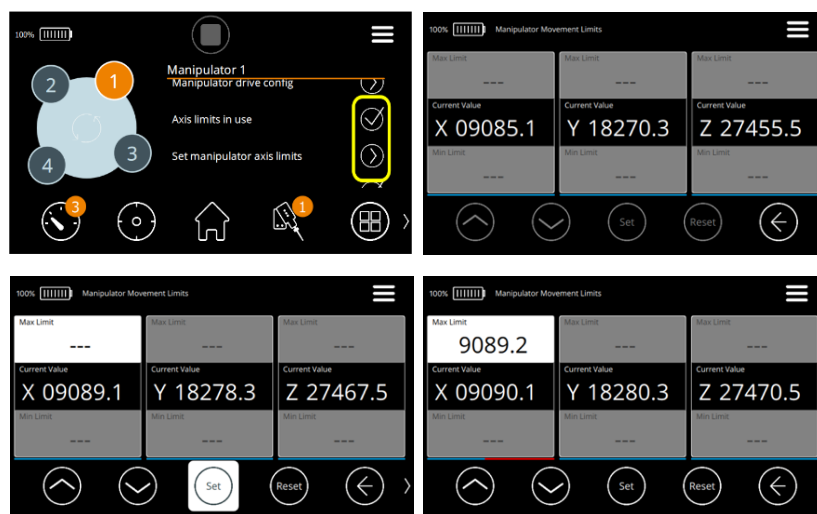

Figure 22. Axis limit configuration

4.7.3 Continuous slow speed

Continuous slow speed setting is selected by default and recommended for most applications to minimize positioning related vibrations for speeds 1 and 2. It implements continuous pulsing control logic for speeds 1 and 2, which reduces the basic control frequency to lower values and thus also to audible frequencies. It is possible to quickly toggle on/off this setting and test the effect on the positioning performance in your application.

4.7.4 Soft Start

Soft start setting is selected by default and is recommended to reduce movement start related accelerations when changing positioning direction and thus minimize related vibrations. It is possible to quickly toggle on/off this setting and test the effect on the positioning performance in your application.

- Set soft start power is setting that controls the acceleration reduction. The larger the value, the larger the allowed acceleration

4.7.5 Add-on Features

Add-on Features menu displays optional features that have been purchased and activated to the selected micromanipulator (see Fig. 23 as an example for virtual axis feature pack).
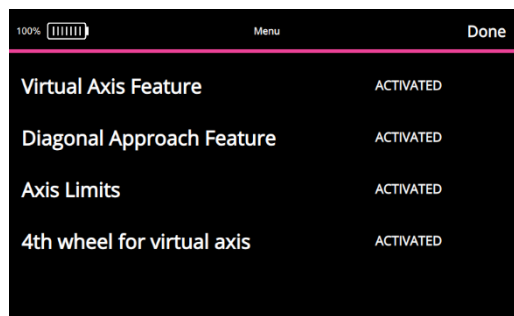

Figure 23. Virtual axis add-on feature

5 Reconfiguring handedness and re-adjusting uMp-EXM

## 5.1   Micromanipulator handedness reconfiguration

Micromanipulator handedness is determined by the orientation of the x-axis relative to the micromanipulator:
- 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.
- It is also possible to configure manipulator to have x-axis attachment surface facing up.
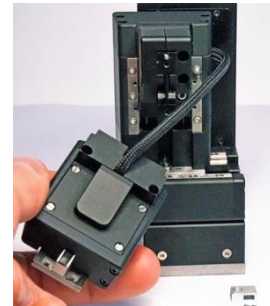
Follow six step process to reconfigure manipulator from right to left-handed, or vice versa:
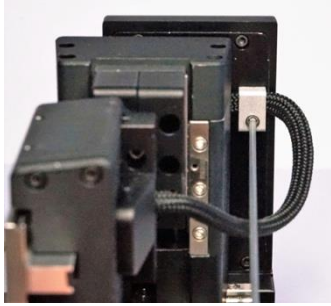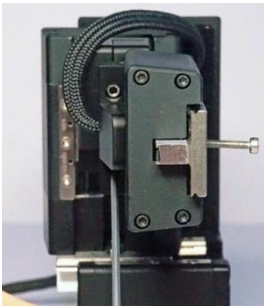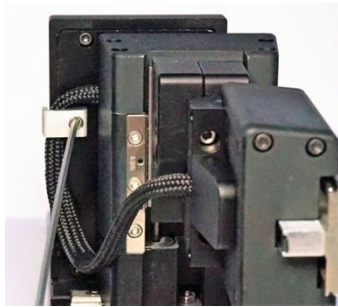
1. Release the M2 screw of cable
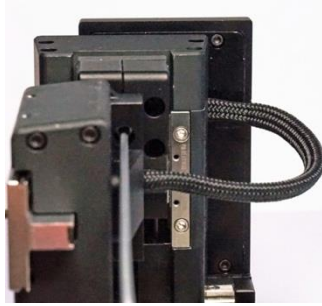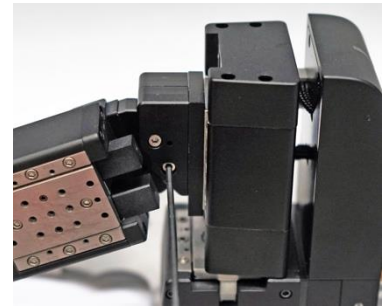

2. Open two M2x8 screws

3. Detach x-axis by pulling

4. Flip x-axis, push in place and attach with two M2x8 screws

5. Flip cable to back side of x-axis and attach cable clip. NOTE cable must be centered in the groove to avoid pinching

6. Unscrew angle adjustment screws from previous side; screw back to new side

Follow step below to reconfigure to attachment side up configuration:
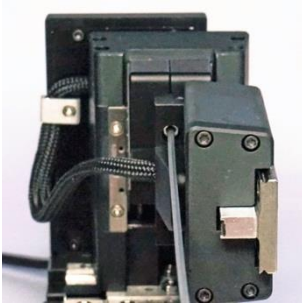
1. Open two M2x8 screws and detach x-axis by pulling

2. Find flip plate, two M1.6x3 and two M2x3 screws (delivered with manipulator)
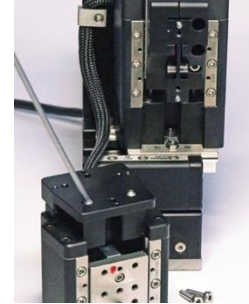
3. Attach flip plate to x-axis with two M1.6x3 screws

4. Attach two M2x8 screws to flip plate from other side

5. Attach x-axis to angle adjustment unit with two M2x3 screws

6. Manipulator in attachment side up configuration.

5.2 uMp-EXM handedness reconfiguration

Handedness of the uMp-EXM is matched to the manipulator that was delivered with it. Right-handed uMp-EXM rotates counter clockwise and left-handed clockwise. Please follow steps below to re-configure uMp-EXM:
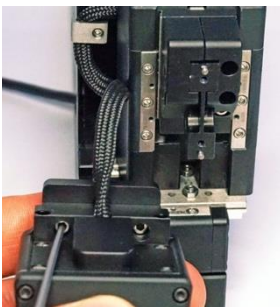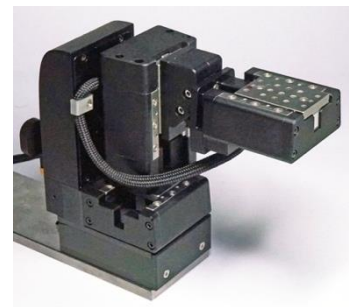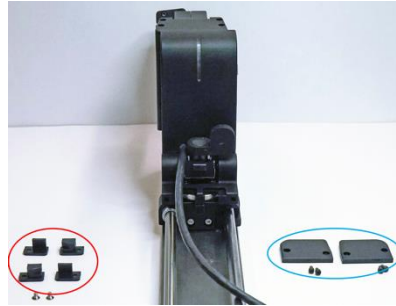

1. Remove side plates from pick-up module with supplied hex key.

2. Remove cover and constraint pieces (red circle) by opening phillips head screws located on top side of the pick-up module. Open set screw of the constrain piece with 0.9 mm hex key until flush with outer surface to release the part.
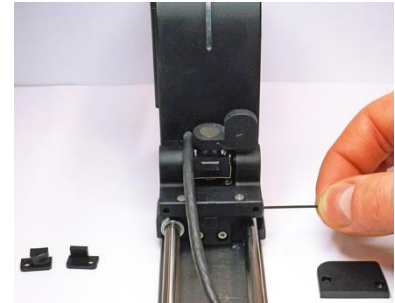
3. Attach cover and constrain pieces of new handedness and set rotation limit of the constrain piece until manipulator is exactly centered within the docking base.

5.3 Re-setting uMp-EXM alignment

The uMp-EXM is adjusted for the matched uMp manipulator at the factory. Adjustment depends on the load that is attached to the x-axis. In case manipulator does not enter and exit docking base smoothly, the tilt angle of the manipulator may need to be readjusted following steps below:
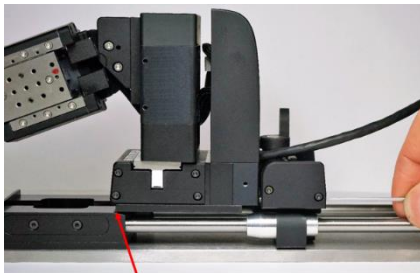
1. Open the docking base lock and slide manipulator so that front end is at the beginning of the bevelled part (see the picture).
2. Tighten or loosen the tilt-angle adjustment screw from one side with hex key to lift the front edge to right level (see the red arrow).
3. Tighten the other side adjustment screw to the same setting

In case tilt angle adjustment is not sufficient for smooth entry/exit from docking base, the uMp-EXM may need to be re-aligned with the docking base following step below:
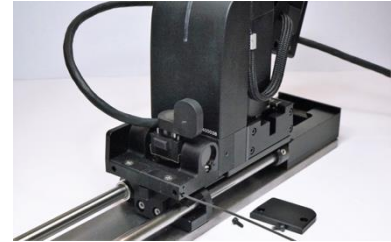
1. Lock manipulator to docking base and open pick-up module locking lever (blue circle).
2. Loosen both tilt adjustment screws until they form clear gap relative to manipulator (green arrows).
3. Loosen two screws with 1.5 mm hex key from the alignment adjustment (red circle); do not remove entirely.

4. Lock the pick-up module locking lever (blue circle)
5. Tighten alignment adjustment screws gradually one at the time until firmly tight (red circle)
6. Unlock manipulator from docking base and adjust tilt settings as described earlier.

7. Remove side plate from side opposite to rotation direction
8. Use 0.9 mm hex key to adjust rotation limit so that manipulator is exactly at the centre of the docking base when against the limit
9. Attach side plate and fine tune tilt adjustment if needed.

NOTE manipulator needs to be locked to the docking based during steps 1-5.

6   Maintenance and service

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.

The micromanipulation system has been tested at the factory before shipment to meet its specifications. Please review the troubleshooting section if problems occur after installing and using the system according to this manual. If problem persists please contact Sensapex ([support@sensapex.com)](mailto:support@sensapex.com) or your local representative for further instructions.

The micromanipulator is designed using corrosion resistant materials for tolerance against corrosive substances, such as saline solutions. In case small spill occurs, the micromanipulator should be immediately and carefully cleaned using damp cloth. 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.

IT IS RECOMMENDED TO UPDATE SOFTWARE REGULARLY. PLEASE LET US KNOW IF YOU OBSERVE SOFTWARE BUGS SO THAT WE CAN FIX THEM. WE COMMONLY INCLUDE NEW FEATURES TO NEW SOFTWARE RELEASES, WHICH IS ANOTHER BENEFIT TO KEEP YOUR SOFTWARE ALWAYS UPDATED.

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.

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

Fix: try restarting uMp-TSC by pressing button in the front panel over 2 seconds to power off-on. If it does not solve the issue, unplug all manipulators and plug them back one at the time and ensure that all manipulators have different device ID. See 4.3.3 for instructions how to reconfigure.

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 as advised later in this section. 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 or loading changes 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. The nanometer scale reading changes in uMp-TSC readings can occur despite of lack of linear movement from piezo drives for example due to minor changes in loading (e.g. head-stage or tubing pulling) or minor temperature changes (=fraction of degree of Celsius). The nanometer scale changes will not be relevant for most experiments. Movements and dimensional changes in nanometer scale occur constantly in the preparation and mechanical parts of your experimental setup (only manipulator will know/show it due to high accuracy closed loop control).

In case micrometer scale drifts in the pipette tip occurs, easiest way to eliminate micromanipulator as potential drift source is to reset axes readings in the uM-TSC display and see read-outs change in same scale while the pipette tip drift is observed. If not, drift source is something external to manipulator. Quite often it is due to the drift in microscope mechanics, optics or camera focus plane (=image is drifting although pipette tip is 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.**
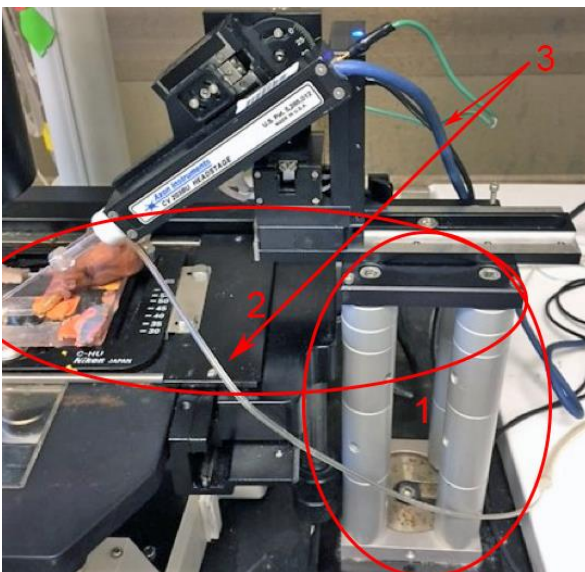
Case study for identifying typical issues

1 Manipulator is installed on tall pillar, whereas sample is on the microscope stage. Different mechanical installation framework leads to increased sensitivity to thermal drifts and vibrations. **Mounting directly to microscope stage would provide more stability (new stage would be needed in this case).**

2 Long distance from installation point to microelectrode tip provides long lever arms for thermal drifts and mechanical vibrations. **Mounting directly to microscope stage closer to the sample would improve stability.**

3 Headstage cable and tubing are dragging, which mediates ambient vibrations to headstage and pipette holder, as well as imposes manipulator and pipette holder to varying loading/torque that will cause microelectrode to drift. **Organizing cables and tubing, e.g. by fixing firmly somewhere above manipulator with enough slack, would improve stability.**

7   Specifications

uMp-3 triple axis micromanipulator

Positioning range:	20x20x20 mm^3 (x-y-z)
Resolution:	5 nm
Repeatability:	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)
Resolution:	5 nm
Repeatability:	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 versions available
Rotary optical encoder based wheels
USB connection to Touch screen control unit: 5 VDC, 0.2 A
Dimensions: 170x53x170 mm
Weight: 990 g

8 Limited warranty

Sensapex warrants that products conform to the published specifications and shall be free from defects in materials and workmanship when used according to this manual. 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.

9 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