Sensapex uMp micromanipulation systems

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 a microscope. No other use is recommended.

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

Safety warnings ⚠

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

Precautions

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

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

Environmental ratings

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

1 General

Sensapex uMp micromanipulation system is based on patented piezo and motion control technologies to provide leading positioning accuracy and stability in compact size. Importantly, Sensapex micromanipulation systems are easy to install and use even without previous experience with the micromanipulators.

The uMp micromanipulation is operated with stand-alone uMp-TSC2 touch screen controller, uMp-RW3 or uMp-RW4 rotary wheel unit and uMp-HUB lite manipulator connection hub. uMp-HUB is a hub variant that provides battery operation option.

There is no practical limit how many hubs and manipulators one micromanipulation system can have. A selection of standard accessories is provided to support most typical applications with the products.

Figure 1. uMp micromanipulation system controllers with uMp-3 manipulator.

1.1 Warranty

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

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

1.2 Arrival inspection

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

- Please notify Sensapex or your local distributor immediately if the outside of the package is damaged.
- Carefully unpack all the items and verify that you have received all the parts specified in your order and packing slip.

- Please contact Sensapex or your local representative if any of the ordered parts are missing or if you have any concern regarding possible shipping damage.

1.3 No self-repairs allowed

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

1.4 General installation recommendations

- Manipulator systems are designed to install upright on a stable, flat, and clean surface with 25 mm or ¼" thread pattern.
- Handle the manipulators with care, preferably by holding them from the back of the body (part where indicator LED is located) to avoid excessive loading to any of the axes.
- For best stability, install manipulators close to the sample and ensure that cables and tubing are organized with drag relief (while having enough slack for free axes movements).

2 uMp-3 or uMp-4 micromanipulation system installation

uMp-3 (or uMp-4) micromanipulation system main products are shown in Figure 2:

1. uMp-TSC2 touch screen controller.
2. uMp-RW3 rotary wheel unit.
3. uMp-HUB lite manipulator connection hub.
4. uMp-3 motorized 3-axis manipulator.
5. uMp-MBS simple mounting base (included with the uMp-3 and uMp-4 manipulators)
6. uMp-DVT dovetail holder for patch clamp head-stage.
7. uMp-RHL rod holder.

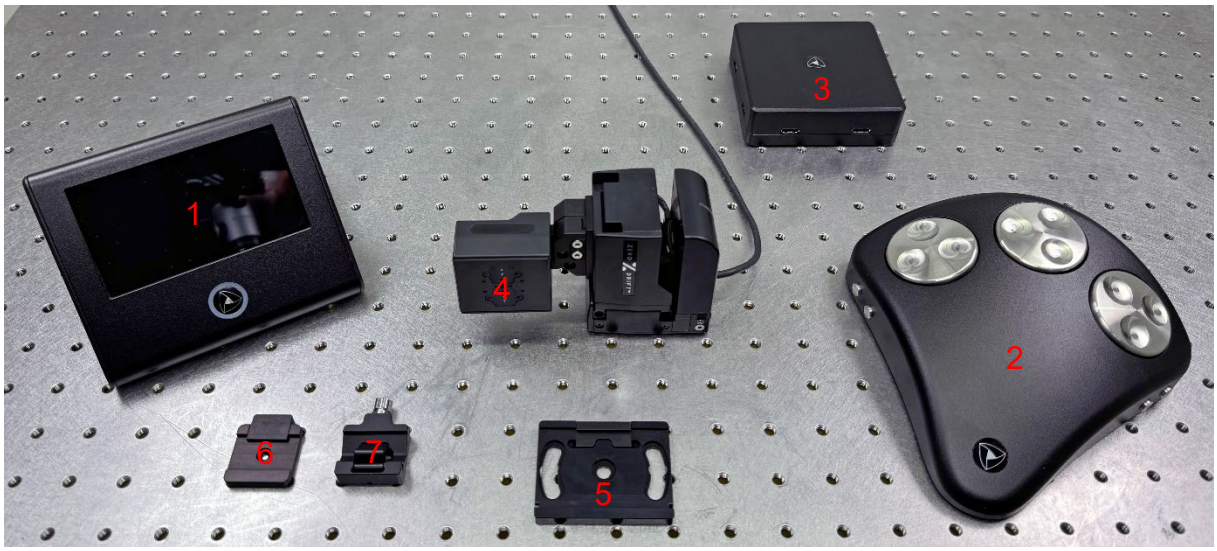


Figure 2. uMp-3 micromanipulation system.

2.1 Micromanipulator handedness

uMp-3 and uMp-4 micromanipulators can be used in right- or left-handed configuration (pictures in this manual show right-handed uMp-3 manipulator). Typically, right-handed manipulators are installed on the right side and left-handed on the left side of the sample.

- For right-handed configuration, x-axis attachment surface is facing towards you when the manipulator is placed on the right-hand side of the sample.

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

2.2 uMp-3 and uMp-4 micromanipulator axes definitions

Axes naming conventions are as follows (see Figure 3):

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

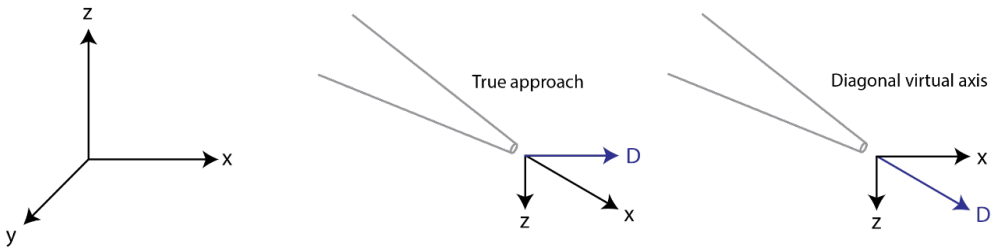


Figure 3. Left, uMp-3 micromanipulator axes definitions. Right, virtual axis D in true or diagonal approach.

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

2.3 Installing uMp micromanipulators using different stand options

The uMp-3 or uMp-4 micromanipulator comes with simple mounting base (uMp-MBS, Figure 1) that enables attaching manipulator firmly on a stage or post.

In addition, three different modular stand options are available that allow retracting the pipette sufficiently far away from the sample for convenient and safe handling (Figure 4). All products include sufficient standard metric and imperial screws for the installation.

Figure 4. uMp micromanipulator stand modules (from left to right): uMp-ROT rotation, uMp-FLP back-flip and uMp-SLD slide stands.

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

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

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

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

To adjust vertical offset (Figure 5):

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

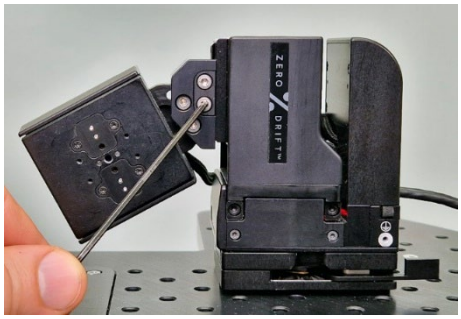


Figure 5. x / D axis offset adjustment mechanism screws (pointed and the one above)

To adjust x- / D-axis tilt angle (Figure 6):

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

Figure 6. X / D-axis angle adjustment mechanism screws (pointed and one below it).

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

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

uMp-DVT enables mounting of most common patch clamp amplifier head-stages (Figure 7):

1. To maximize stability, minimize the distance between the pipette tip and manipulator installation point within the pipette access and usability limitations.
2. For True approach
    a. Insert the provided dowel pins to the micromanipulator's x / D-axis: Figure 7 (1). These pins will ensure that the uMp-DVT is aligned parallel with the axis movement direction.
    b. Attach uMp-DVT in place using the pins for guidance: Figure 7 (2).
    c. Secure uMp-DVT in place with the provided screw: Figure 7 (3).
3. For Diagonal approach
    a. *Do not insert the dowel pins*.

b. Place uMp-DVT against the x- / D-axis and pre-tighten the attachment screw so that it is still possible to rotate the uMp-DVT.
c. Rotate uMp-DVT to the preferred approach angle and tighten the screw.

4. Open the dove tail clamping piece screw from the uMp-DVT: Figure 7 (4).
5. Slide the head-stage to the dove tail fitting: Figure 7. (5).
6. Tighten the clamping piece screw.
7. Organize head-stage cable and tubing with a drag relief to avoid drift through cable tension being transferred to the head-stage.

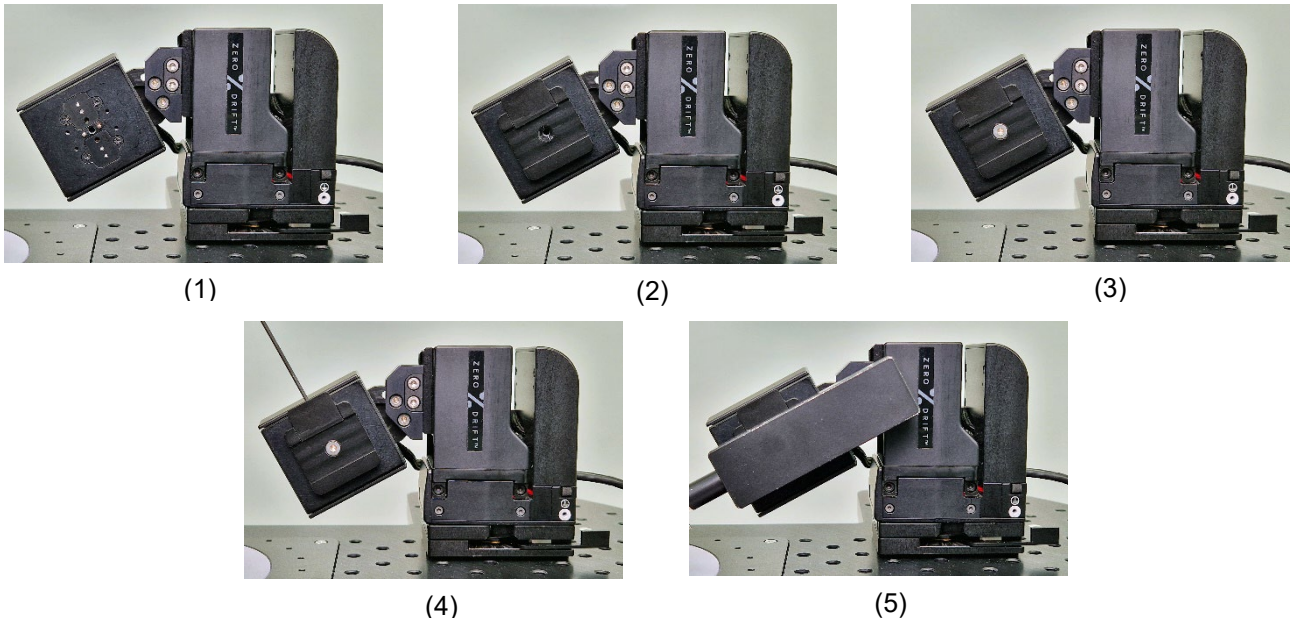


Figure 7. Step-by-step instructions for mounting a head-stage with uMp-DVT

2.6 Installing a rod with uMp-RHL

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

uMp-RHL enables mounting 4 – 10 mm diameter rods to the micromanipulator (Figure 8):

1. To maximize stability, minimize the distance between the sample and manipulator installation point within the usability limitations.
2. For True approach
   a. Insert provided dowel pins to the micromanipulator x / D-axis (Figure 8, left). These pins will ensure that the uMp-RHL is aligned parallel to the axis motion.
   b. Secure the uMp-RHL in place using the provided screw (Figure 8, middle).
3. For Diagonal approach
   a. *Do not insert the dowel pins*.
   b. Place uMp-RHL against the x- / D-axis and pre-tighten the attachment screw so that it is still possible to rotate the uMp-RHL.
   c. Rotate uMp-RHL to the preferred approach angle and tighten the screw.
4. Open the uMp-RHL clamp by using the thumb screw.
5. Place / slide rod to the uMp-RHL (Figure 8, right).
6. Tighten the clamping piece using thumb screw.
7. Organize any wires and cables to avoid drag.

Figure 8. Step-by-step instructions for attaching a rod to uMp-3

2.7 Grounding the manipulator

uMp micromanipulators are fitted with an integrated grounding skeleton throughout the product. Use the specified grounding position to ground each manipulator with an M2 screw (Figure 9). Do not daisy chain the micromanipulator ground wires.

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

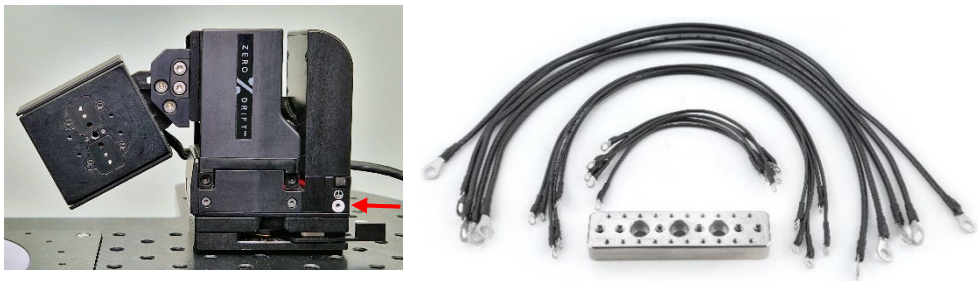


Figure 9. Left, red arrow marks the dedicated grounding point. Right. Sensapex grounding kit.

2.8 Connecting the products and powering ON the system

uMp micromanipulation system connection scheme is shown in Figure 10. Follow steps below to connect and power ON the products:

1. Connect uMp micromanipulators to uMp-HUB or uMp-HUB lite. The connectors will auto-lock when properly in place. To unlock, pinch the locking mechanisms on both sides of the connector. Each uMp-HUB or uMp-HUB lite enables adding four more uMp micromanipulators to the system.
2. Connect uMp-RW3 or uMp-RW4 rotary wheel unit(s) to uMp-TSC2 with the provided USB cable. uMp-TSC2 supports up to two uMp-RW3 or uMp-RW4 rotary wheel units.
3. Connect uMp-HUB or uMp-HUB lite to uMp-TSC2 with ethernet cable. A PC can be also connected to the system using ethernet cable via uMp-TSC2 or network switch.
4. Connect the provided power supplies to the uMp-TSC2 and uMp-HUB or uMp-HUB lite.
5. Power on the uMp-HUB or uMp-HUB lite using the push button.
6. uMp-TSC2 will automatically power on when plugged to its power supplier for the first time. After that it can be powered ON – OFF by long-pressing the button below screen.

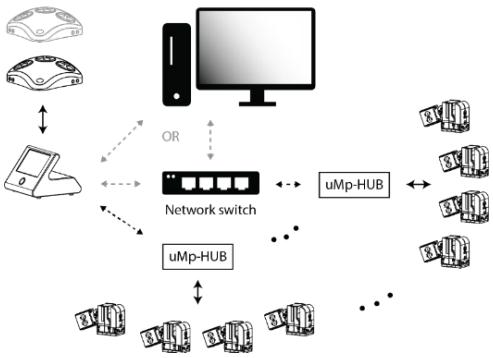


Figure 10. uMp micromanipulation system connections.

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

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

2.9 Calibrating the micromanipulators

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

3 In vivo micromanipulation system installation

In vivo micromanipulation system is based on a novel spherical coordinate system concept, which keeps the probe tips at the same relative position to the sample regardless of the probe approach angle. This allows a high local density of probes to be positioned in the sample. The system is also easy and intuitive to use.

In vivo micromanipulation system includes the following main products (Figure 11):

1. uMp-TSC2 touch screen controller.
2. uMp-RW3 rotary wheel unit.
3. uMp-HUB lite manipulator connection hub.
4. uMp-3 NP in vivo micromanipulation system tailored motorized 3-axis manipulator.
5. uMp-RNG table mounting ring segments (“RNG” from here on).
6. uMp-ARM manipulator mounting arms (“ARM” from here on).
7. uMp-SLF-90 manipulator mounting shelf (“SLF” from here on).
8. uMp-RHL rod holder.
9. Sensapex Neuropixels holders.

Figure 11. In vivo micromanipulator system overview

The RNG ring segments act as guides for the manipulator ARMs, allowing easy adjustment of the probe azimuth angle. The manipulator mounting shelves slide smoothly in the ARMs, allowing easy adjustment of the probe elevation angle. Stand-alone controllers provide full control of the motorized micromanipulators and tailored automation features, such as automated slow probe insertion. Standard accessories are available for mounting Neuropixels, Neuronexus and other common silicone probes to the manipulators.

In vivo micromanipulation system installation video: https://www.youtube.com/watch?v=LUbqXg0b6So

3.1 Axes and angle definitions

Axes of the in vivo micromanipulation system are defined as follows:

- x-axis moves probe pipette towards or away from the sample, along the probe axis.
- y-axis moves probe backwards and forwards roughly in parallel to the RNG
- z-axis moves probe backwards and forwards roughly in parallel to the ARM

Spherical coordinate system angles and their relation to the RNG and ARM are shown in Figure 12.

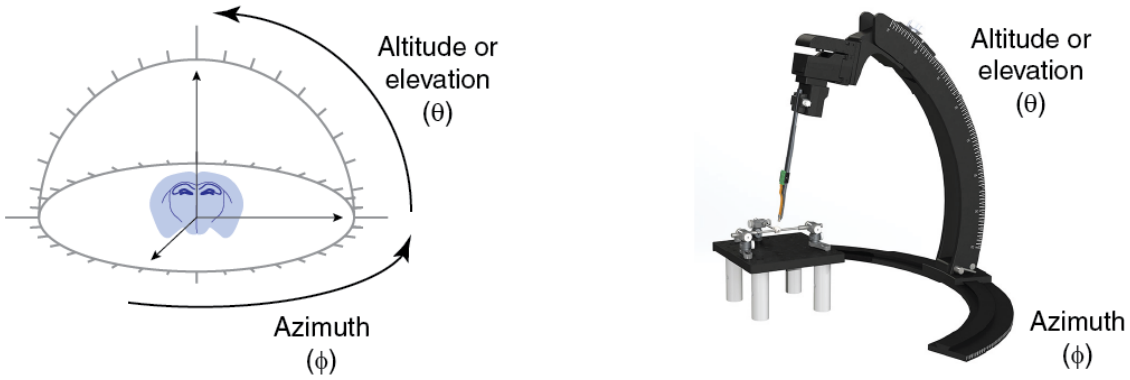


Figure 12. Axes and angle definitions for the in vivo micromanipulator system

3.2 Sample location in the system

Sample is placed to the nominal center of the spherical coordinate system, which is at the center of RNG radius and at 147 mm height from the installation surface (Figure 13).

Simplest way to lift the sample to right height is to place the stereotaxic head-mount platform on top of standard optical posts of right length (min 1” diameter recommended). In case the experimental setup involves large behavioral apparatus, such as treadmill, the RNG segments can be placed on top of suitable size optical posts (preferably one 1.5” post under each screw mounting slot).

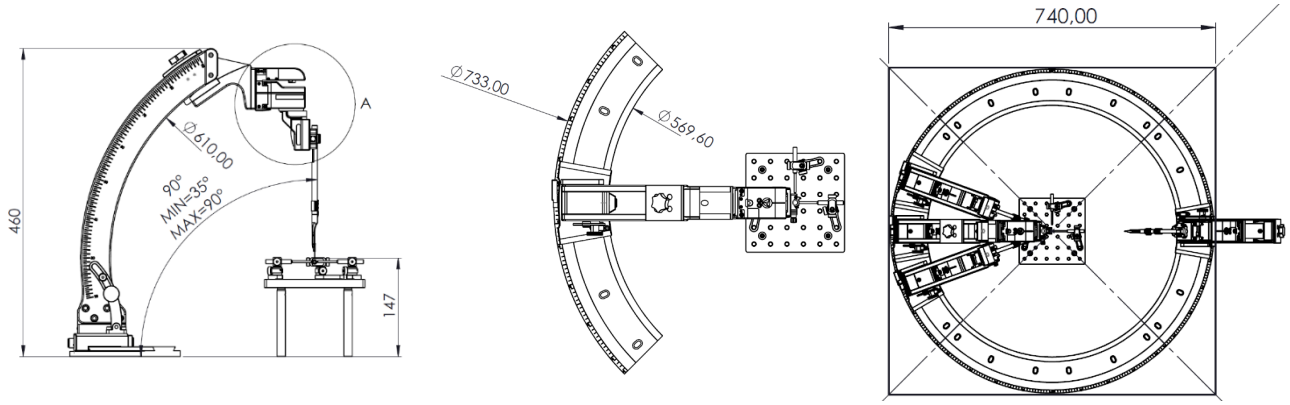


Figure 13. In vivo micromanipulation system sample placement

3.3 Installing the RNG segments

The RNG segments are mounted to an optical breadboard or table using the provided M6 or ¼" screws. The elongated holes allow mounting on both metric and imperial threaded surfaces. Figure 14 shows a single RNG segment that corresponds to 90 degrees in azimuth angle.

At least three mounting holes should be used, though using all six will provide the best stability.

Figure 14. uMp-RNG table mounting ring segment

If three or four RNG track segments are installed, they can be aligned against each other, with care taken to ensure a smooth transition between segments. Alternatively, the uMp-INK installation aid system can be used to help with the alignment (Figure 15), which is also recommended when using two RNG segments:

- Place the RNG segments on the table with screws in place but not tightened.
- Screw the long guide rods to the center disk. Ensure they go all the way so that the end of the rod is mounted against the flat surface at the disk.
- Adjust the RNG positions until all alignment kit guide rods are in solid contact with the RNG.
- Tighten the mounting screws while ensuring that the guide pins stay in solid contact.

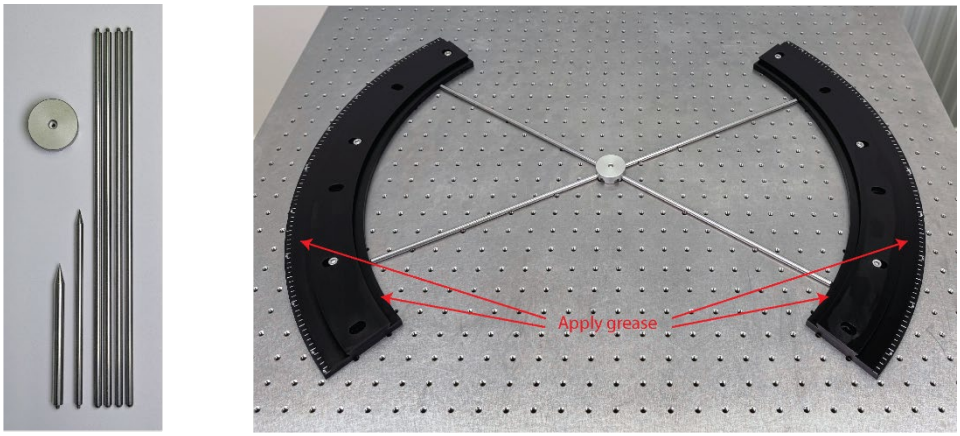


Figure 15. Using the installation aid system

Once the RNG segments are installed, thinly apply the provided grease to the full length of the contact surfaces marked with arrows in Figure 15.

3.4 Installing the ARMs

Carefully unpack the ARM modules. Confirm that the ARM locking lever is pointing all the way left, which is the unlocked position (Figure 16). Slide each ARM onto the desired RNG segment and move it back-forth over the full RNG segment length to spread the grease evenly. Wipe off excess grease.

Re-adjust the RNG alignment in case the ARM does not slide smoothly over the joining RNG segments.

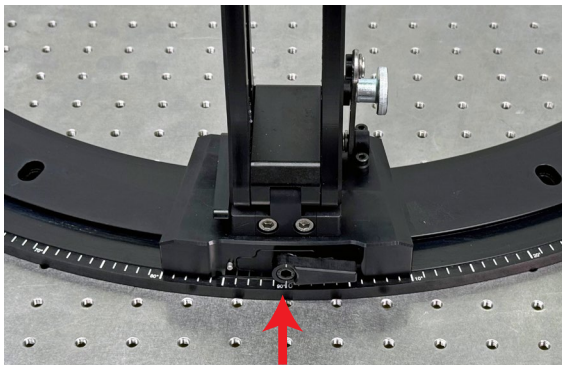


Figure 16. ARM locking lever (locked in the picture).

Flip the ARM locking lever all the way to right to lock ARM to RNG. Only gentle force is needed to operate the lever for reliable and firm locking – do not overtighten.

Follow the instructions below to re-adjust the locking lever, in case the ARM does not lock properly or operating the lever requires large force:

- Use 2 mm Allen key to loosen the screw that locks the lever to its axel (Figure 17, left).
- Turn the lever all the way to right against end stop.
- Use 5 mm Allen key to loosen the axel screw if operating the lever takes high force or tighten it in case the ARM does not lock to RNG properly (Figure 17, right).
- Use 2 mm Allen key and re-tighten the lever locking screw (Figure 17, left)

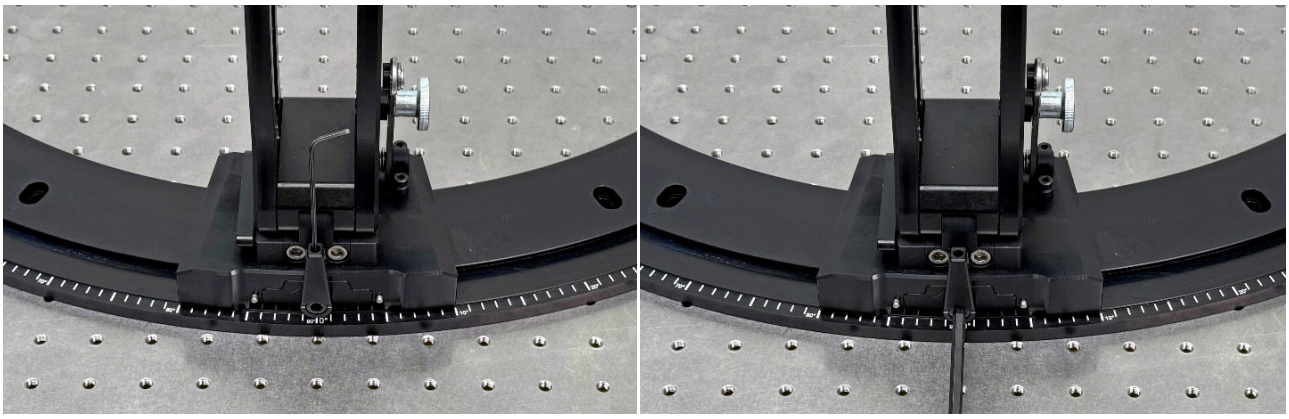


Figure 17. ARM locking lever adjustment (locked in the picture).

- The end stopper screw for the back folding can be freely (Figure 18, right), but it is recommended to adjust it so that the ARM turns beyond its center of mass to reach stable state.
- The knurled knob (Figure 18, right) allows temporarily locking the ARM in any position over its full folding range, which may be needed e.g. in case a spatial constraint prevents folding the ARM back until it reaches a stable state.

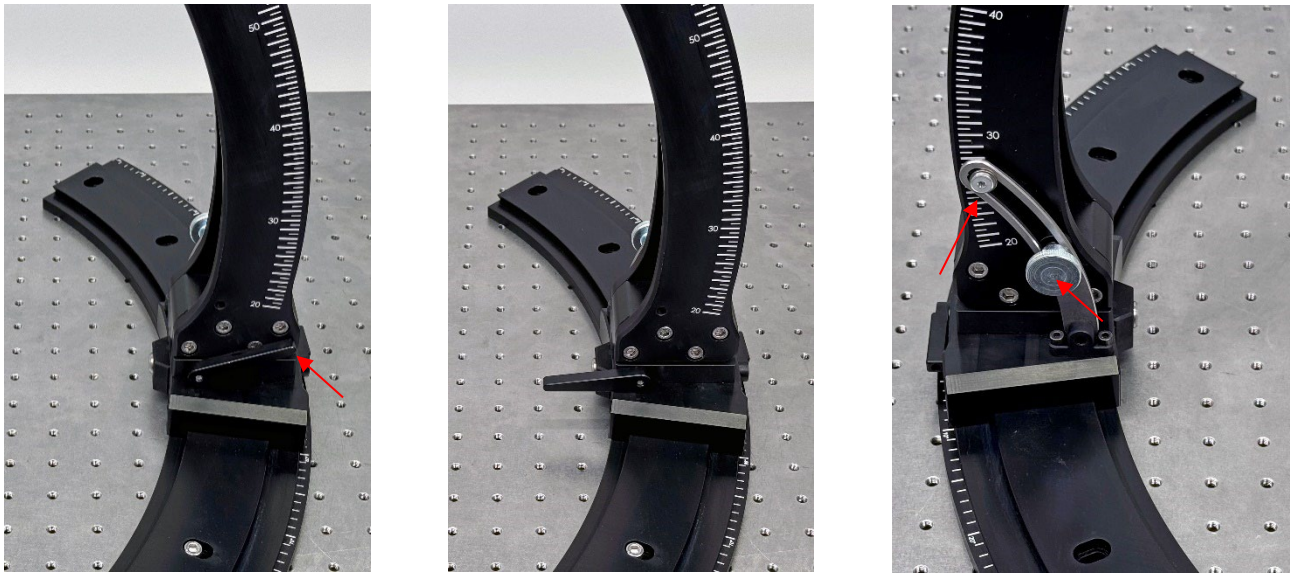


Figure 18. Adjusting the ARM back folding mechanism.

3.5 Installing manipulator to the ARM

Always handle the manipulator from its body to avoid excessive loading to the bearings. Be careful not to drop the manipulator to the table, as it is likely to cause permanent damage to the manipulator axes (requiring factory service).

The ARM is delivered by default with one uMp-SLF-90 shelf installed on it. The SLF and thus the probe elevation angle can be adjusted by loosening the knob at the back of the SLF (Figure 19). The elevation angle is laser marked to the ARM to allow easy angle read-out and adjustment. Tighten the knob after the preferred angle is set. Only gentle tightening is required for secure locking.

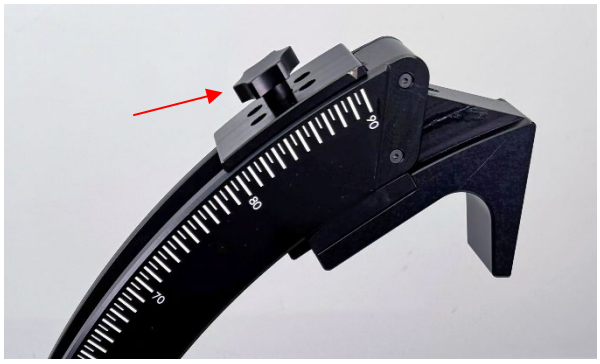


Figure 19. uMp-SLF-90 manipulator mounting shelf.

To install the uMp-3 NP manipulator to ARM:

1. Install the uMp-MBS to the SLF. Confirm first that the uMp-MBS end stopper screw is pointing downward (Figure 20, center). Change the stopper screw to another end if needed.
2. Push uMp-MBS against the side and back stoppers of the SLF (Figure 10, left), and secure it in place with two M6 mounting screws using the 4 mm hex key (Figure 10, center). Ensure that the uMp-MBS stays against the stoppers during the screw tightening to ensure proper alignment.
3. Loosen the dovetail clamp screw of the uMp-MBS with 1.5 mm hex key.
4. Carefully slide the uMp-3 NP manipulator to the uMp-MBS until it hits the end stopper screw and secure it in place by tightening the dovetail clamp screw. ***Confirm that the manipulator is firmly attached before letting it go.***

5. Confirm visually or by measuring that the uMp-3 NP and SLF are accurately aligned.
6. Follow chapters 2.7 – 2.9 for wiring the system, to power one and to perform calibrations.

Figure 20. Mounting the uMp-3 NP manipulator to ARM.

3.5.1 Installing uMp-SLF-15 shelf variant

The uMp-SFL-15 manipulator mounting shelf variant enables placing two manipulators in the same arm with minimum 15 degrees separation (Figure 21). Using the uMp-SLF-15 requires re-configuring standard uMp-3 NP manipulator with a dedicated x-axis stacking adapter.

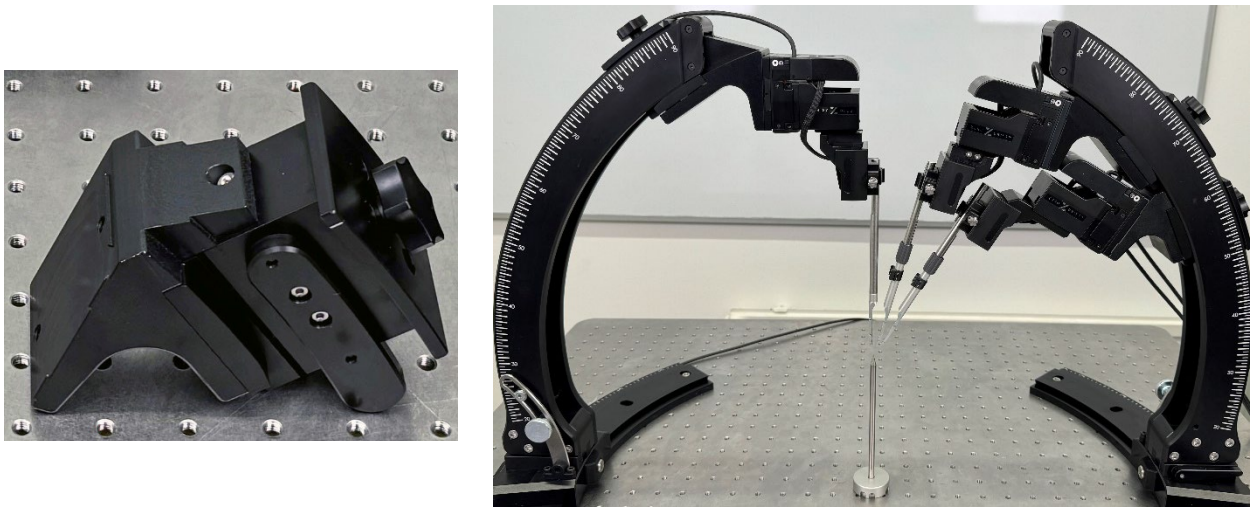


Figure 21. Left, uMp-SLF-15. Right, system with a manipulator in right ARM installed with the uMp-15-SLF.

To install uMp-SLF-15 shelf to an existing ARM:

A. Lower the uMp-SLF-90 in elevation angle for easy access to the ARM end-cap.
B. Detach the ARM end-cap by loosening 4 screws and sliding it off from the ARM (Figure 22).
C. Slide the uMp-SLF-90 off from the ARM.
D. Slide the uMp-SFL-15 to the ARM towards lower elevation angle range.
E. Slide the uMp-SLF-90 back to the ARM.
F. Attach end-cap back with 4 screws.
G. Confirm that both shelves are sliding smoothly in the ARM.

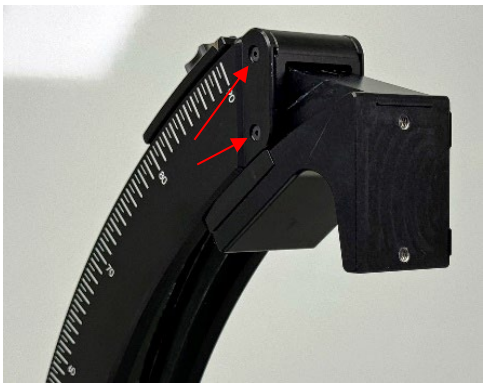


Figure 22. ARM end cap screws.

To convert standard uMp-3 NP to uMp-SLF-15 variant (Figures 23-25):

A. Loosen and remove two screws from the back of the x-axis (save screws for later).
B. Loosen two captive screws from the x-axis backside parallel to the axis.
C. Loosen two screws from the side of the x-axis stacking piece and slide the stacking piece away from the manipulator body.

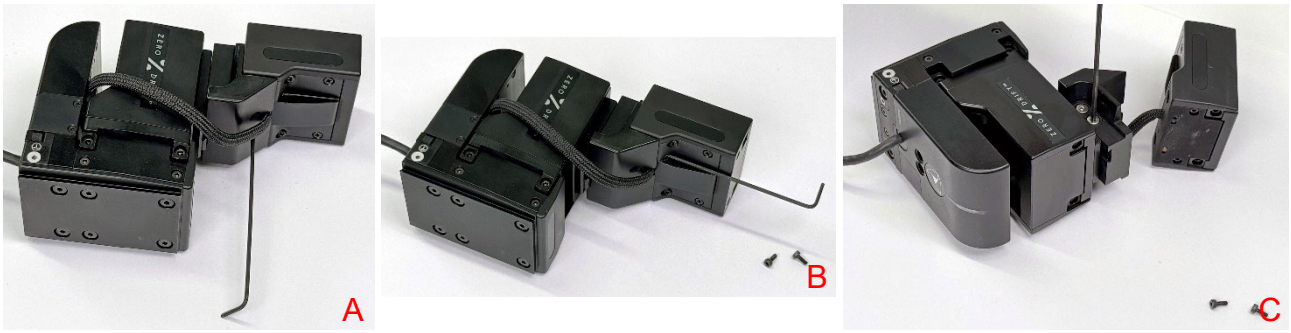


Figure 23. First three steps of uMp-3 NP reconfiguration.

D. Loosen four screws from the dove tail stacking plate attached to manipulator z-axis.
E. Remove the dove tail stacking plate from the manipulator body. Ensure that the dowel pins remain at the manipulator's z-axis. Store the dove tail plate, its mounting screws and stacking piece.
F. Take out uMp-SLF-15 specific x-axis stacking piece and 4 screws that come with it.

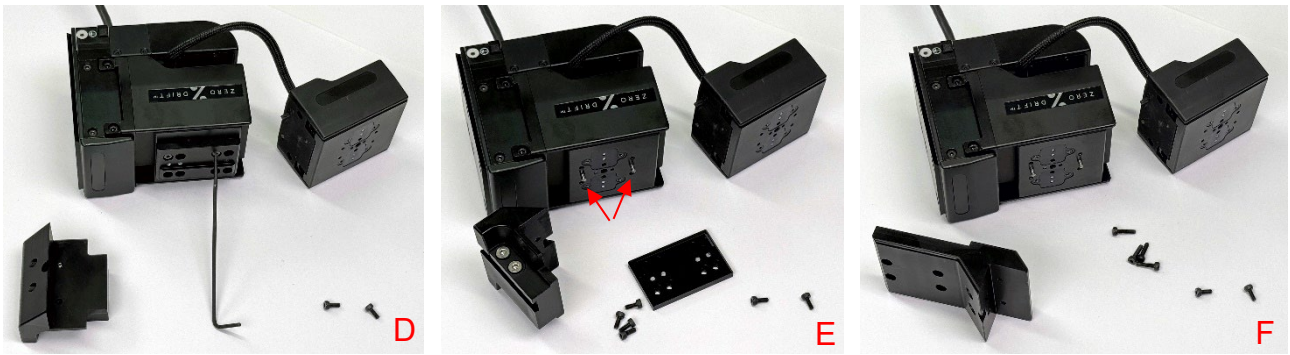


Figure 24. Next three steps of uMp-3 NP reconfiguration.

G. Place uMp-SLF-15 x-axis stacking piece against the manipulator's z-axis using the dowel pins as guides. Mount in place with 4 screws.
H. Place x-axis against the stacking piece and tighten two screws from the bottom side (screws from step A). Leave screws slightly loose to allow x-axis to move against the stacking piece.

I. Tighten two captive screws of the x-axis (ones in step B). Leave screws slightly loose to allow x-axis to move against the stacking piece. Firmly tighten the screws of step H and then captive screws.

Figure 25. Final three steps of uMp-3 NP reconfiguration.

3.6 Installing uMp-RHL to uMp-3 NP

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

1. Insert provided dowel pins to the micromanipulator x-axis (Figure 16, left).
2. uMp-RHL has two alternative positions in the x-axis. Place the uMp-RHL to front position and secure in place using the provided screw (Figure 16, center). Confirm visually or by measuring that the uMp-RHL and x-axis are accurately aligned.
3. Open the uMp-RHL clamp by using the thumb screw and place / slide rod to the uMp-RHL.
4. Tighten the clamping piece using thumb screw. Use provided special tool to help firm clamping.

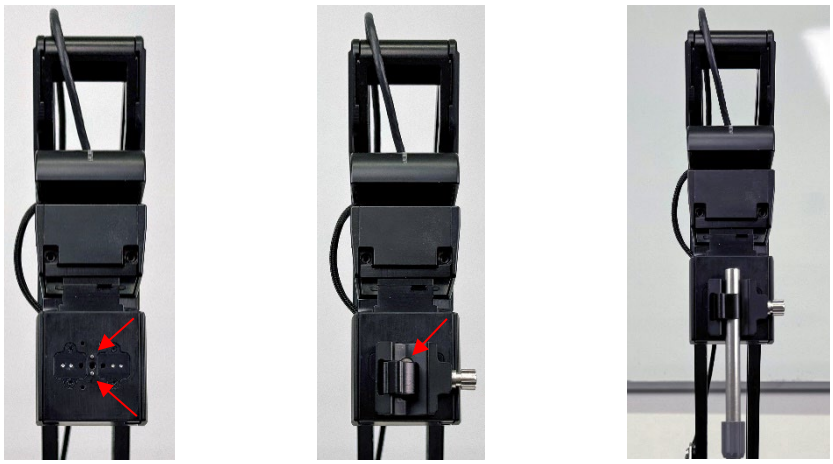


Figure 26. Installing uMp-RHL.

3.7 Operating uMp-NPH-S and uMp-NPH-2S adapter heads

Pre-adjust the uMp-NPH-S or uMp-NPH-2S adapter head by following the steps below (Figure 27):

A. Loosen front and rear set screws until there is no contact with the fork.
B. Tighten the rear screw until it touches the fork.
C. Tighten rear screw further according to instructions below – DO NOT OVERTIGHTEN.
    - uMp-NPH-S for Neuropixel V1.0 probe: 0.5 - 1 round
    - uMp-NPH-2S for Neuropixel V2.0 probe: 0.5 - ¾ round
D. Tighten the front screw until it touches the fork.

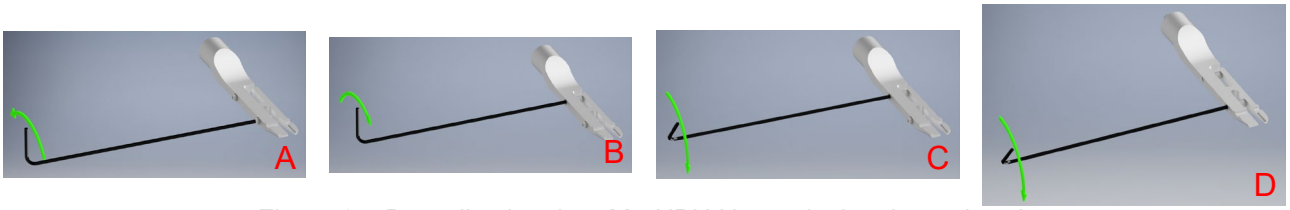


Figure 27. Pre-adjusting the uMp-NPH Neuropixels adapter head.

Mounting the probe:

1. Open the clamp by tightening front screw with ¼ turn (Figure 28, left, green arrow).
2. Slide the Neuropixels probe dove tail cap to adapter head from front to back (Figure 28, right).
3. Release front screw so that it is not in contact with the fork (Figure 28, left, red arrow).

Always confirm that the probe is firmly attached before letting go of the probe. If it is not firmly attached, release the front screw further and/or review the pre-adjustment instructions.

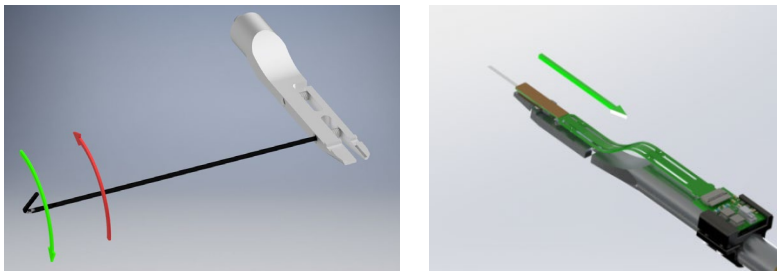


Figure 28. Mounting Neuropixels probe to adapter head.

3.8 Adjusting the Neuropixels probe spin angle

uMp-NPR-200S has a spin angle adjustment mechanism that enables pre-setting the specific spin angle around the long axis of the probe. Follow steps below to install the adapter head and to adjust spin angle:

A. Tighten the uMp-NPR-200 spin angle adjustment mechanism nut.
B. Screw the uMp-NPH-S or uMp-NPH2S Neuropixels adapter head to the uMp-NPR-200S.
C. Loosen the spin angle adjustment mechanism nut.
D. Adjust the spin angle and tighten the adjustment mechanism nut.

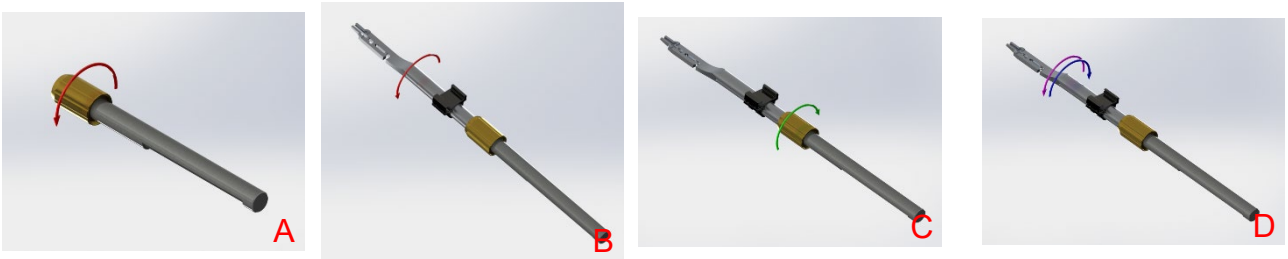


Figure 29. Installing and adjusting the adapter head spin angle.

The spin adjustable uMp-NPR-200S has slotted back-end for repeatable orientation when placed to uMp-RHL and to allow controlled back-forth sliding for manual probe retraction when slightly loosening the uMp-RHL clamping screw. Place the slotted surfaces of the uMp-NPR-200S against the uMp-RHL (Figure 30).

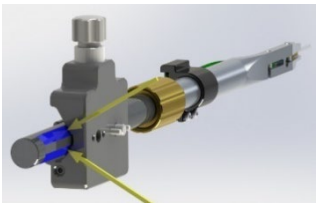


Figure 30. uMp-NPR-200S alignment and slide surfaces.

3.9 Confirming the system alignment

Installation aid kit (Figure 5) allows to confirm and re-adjust the system alignment. Aim is that all probes are pointing at the nominal center of the system. For this, the alignment pin is inserted into the center disc of the aid and the mock-up alignment rods inserted in the uMP-NPR-200S (Figure 31). Fine tune the alignment until all probes point to the same center point and keep on tracking it while the azimuth and elevation angles are adjusted.

Please note that the alignment does not need to be 100 % perfect. 20 mm positioning range per manipulator axis provides means to compensate for the minor alignment deviations by linear off-set adjustments, which can be an be stored e.g. as HOME position in the uMp-TSC2.

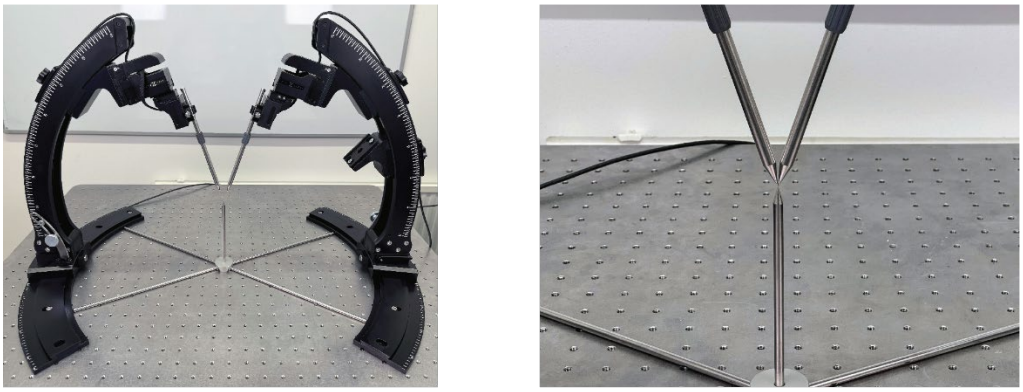


Figure 31. Confirming the system alignment.

4 uMp micromanipulation system control

4.1 Powering ON – OFF the system

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

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

4.2 uMp-RW3 | uMp-RW4

Each wheel of the rotary wheel remote unit uMp-RW3 (Figure 32, left) or uMp-RW4 (Figure 32, right) controls one of the manipulator axes (settings are fully configurable using the uMp-TSC2). A total of two uMp-RW3 or uMp-RW4 can be connected to the uMp-TSC2 to support operating two micromanipulators or other Sensapex products at the same time.

Functionalities:

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

Figure 32. uMp-RW3 and uMp-RW4

4.3 uMp-TSC2 main view

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

Layout and functionalities of the main view (Figure 33):

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

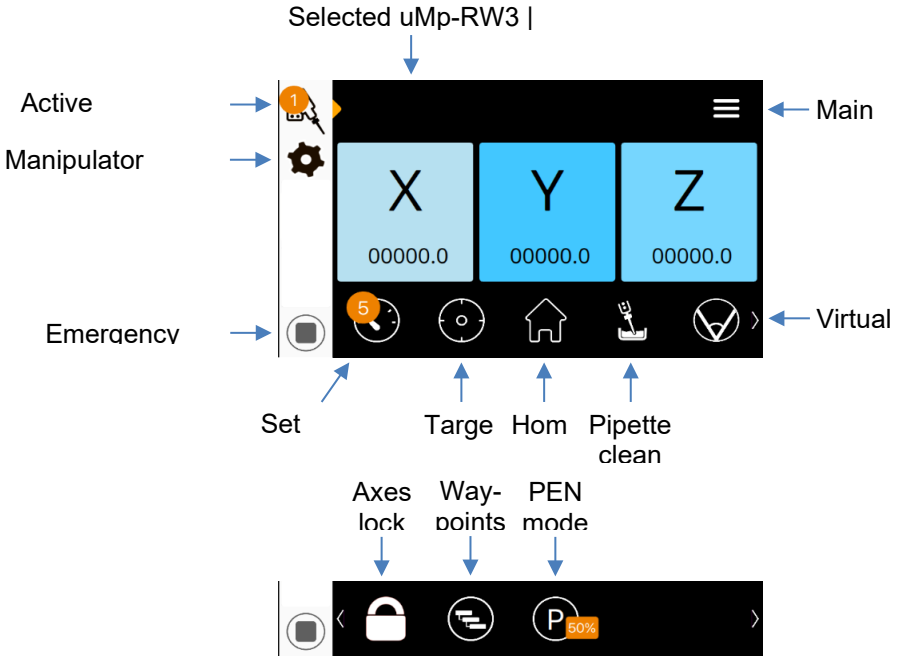


Figure 33. uMp-TSC2 main view

4.4 Basic micromanipulator operation

- Use rotary wheels of the uMp-RW3 or uMp-RW4 to move each of the axes individually.
  - The wheel – axis configurations and positioning directions are customizable (see 5.1.1).
- Use uMp-RW3 or uMp-RW4 push buttons on the right side or press manipulator symbol in the uMp-TSC2 main view to change between different manipulators (Figure 34, left)
  - It is possible to tap any of the shown devices to select it
  - Each micromanipulator has an indicator LED at its back which indicates active device. Light will change to green when the micromanipulator is moving.
- Use uMp-RW3 or uMp-RW4 push buttons on the left side or press the speed selection symbol in the uMp-TSC2 main view to change the speed setting (Figure 34, right)
  - It is possible to tap any of the speed settings to select it.
- Turning the wheel slower than a certain threshold will cause undesired start-stop movement
  - This indicates that the current speed setting is too high for the desired movement speed
  - Switch to smaller speed setting and rotate wheel faster for continuous movement

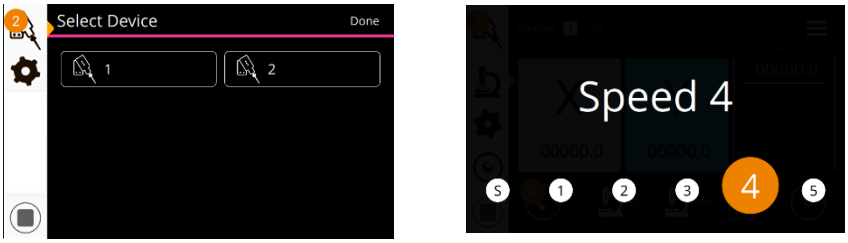


Figure 34. Left, manipulator selection. Right, speed setting selection.

4.5 Setting and using Home and Target positions

- Tap the *Home* or *Target* symbol shortly to drive manipulator to pre-set home or target position.
- Long press *Home* or *Target* position symbol to save current position as new memory position.
- A pop-up dialog enables defining the positioning speed and confirming execution (Figure 35).

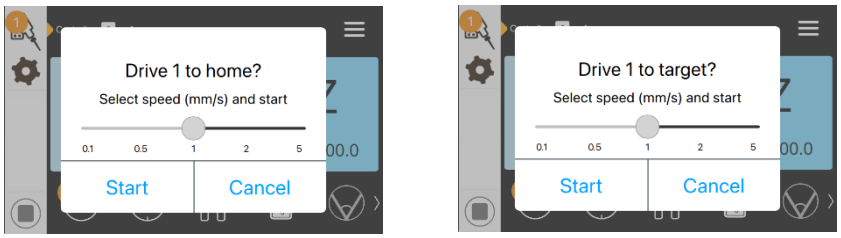


Figure 35. *Home* and *Target* memory positions

4.6 Changing between absolute and relative coordinates

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

- Relative position mode is indicated by open circle at the top right corner of the axis information area (Figure 36, middle)
- In case relative position mode is entered first time, it will reset it to zero.
- If relative position is set earlier, position relative to that earlier set position is shown.
- To reset the relative position reference (i.e. to re-zero), long-press the open circle symbol and confirm in the pop-up dialog (Figure 36, right)

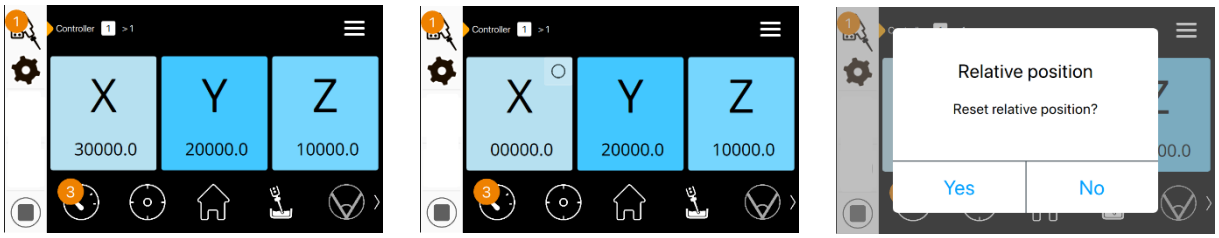


Figure 36. Relative coordinates

4.7 Virtual axis

The virtual axis can be enabled from the main view quick button or from the *Manipulator settings* menu (Figure 37). Configuration:

- True approach (see 2.2) is used by default:
  1. Use *Virtual axis angle* setting to define the angle of the x-axis (relative to horizontal plane).
  2. The current setting is shown in parenthesis together with the angle x-axis sensor.
  3. Usually, the measured angle works well but a pop-up dialog enables further adjustment.
- *Diagonal approach* (see 2.2) is used by enabling that option:
  - The angle between the pipette and horizontal plane needs to be measured and set manually.
- By default, the wheel defined to operate x-axis will operate the virtual axis.
- *4th wheel for virtual axis* enables controlling the virtual axis with the 4th wheel of the uMp-RW4.
- The two axes linked to create the virtual axis stop in case either one reaches the end of its range.

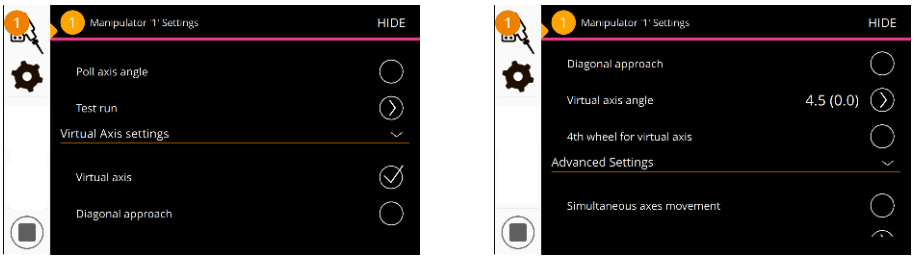


Figure 37. Virtual axis settings

4.8 PEN speed

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

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

4.9 Single axis view with programmable automated stepping

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

Single axis view (Figure 38) can be accessed by long pressing the axis display area in the main view:

- Tap speed setting symbol at left corner to define positioning speed for the automated step.
- Tap step length setting to define distance travelled during the automated step.
- Plus and minus signs execute defined automated incremental or decremental position steps.

- Relative position feature is available also at the single axis view (see 4.6)
- In case PEN speed setting is selected, plus and minus signs execute PEN mode stabs

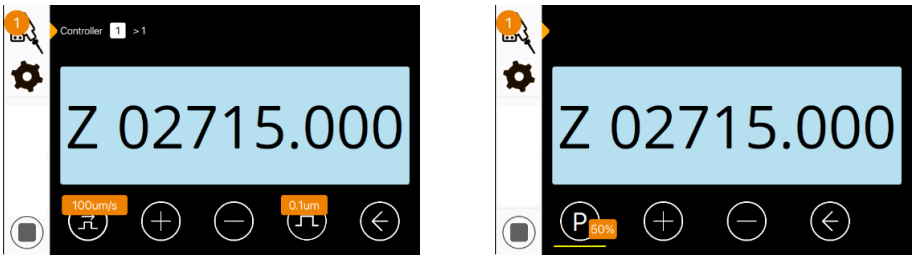


Figure 38. Single axis view

4.10 Pipette or probe change

Preparations before pipette or probe change:

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

To change pipette or probe:

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

4.11 uMp-TSC2 Sleep mode

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

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

4.12 Charging uMp-HUB batteries

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

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

4.13 Updating firmware

We recommend updating firmware regularly.

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

uMp-TSC2 and uMp-3 or uMp-4 firmware can be updated using a dedicated software tool that is available at the Sensapex website for downloading. Please use the link below to download the document that includes the download link and provides step-by-step instructions how to use the tool:
https://sensapex.com/wp-content/uploads/downloadable-files/2023/08/uMx-firmware-update-tool_v2.2.pdf

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

5 uMp-TSC2 Main menu

uMp-TSC2 *Main menu* can be entered by tapping the menu symbol from top right corner of the main view. *Main menu* structure is shown in Figure 39.

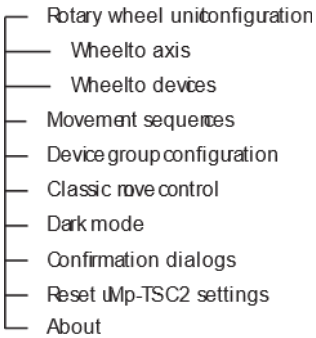


Figure 39. uMp-TSC2 Main menu

5.1 Rotary wheel unit configuration

Enter *Rotary wheel unit configuration* menu. *Wheel to axis* configurator defines which wheel of the uMp-RW3 or uMp-RW4 is operating which axis, as well as movement vs. wheel rotation direction (Figure 40).

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

Wheel to devices configurator defines which micromanipulators are controlled by which uMp-RW3 or uMp-RW4 rotary wheel unit (Figure 40). A common use case for multiple uMp-RW3 use is to configure one wheel unit for the micromanipulators and second to control microscope focus and xy-stage in Sensapex uM Patch systems. Follow the instructions provided in the configurator view.

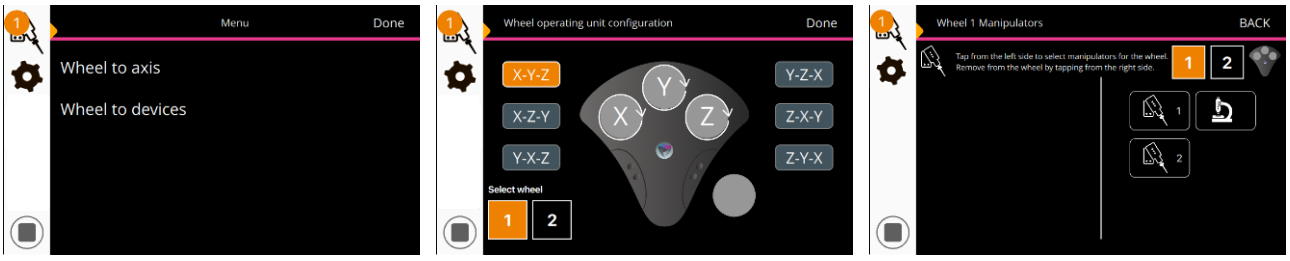


Figure 40. Rotary wheel unit configuration

5.2 Movement sequences

Movement sequences is a configurator (Figure 41) that enables setting a list of XYZ(D) coordinate waypoints that can be then moved through with specified speed per waypoint as a complete sequence.

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

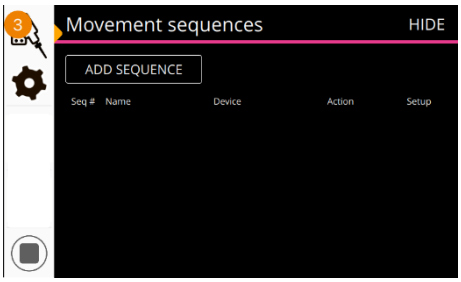


Figure 41. Movement sequences

5.3 Device group configuration

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

Device group configuration setting can be used to define different micromanipulation systems to different control groups to prevent accidental control across different systems (Figure 42).

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

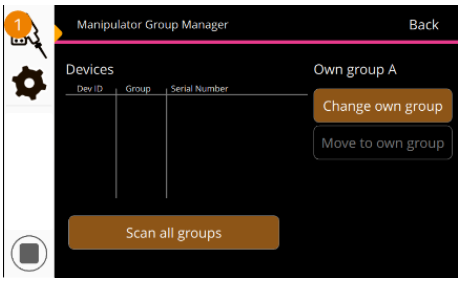


Figure 42. Manipulator group manager interface

5.4 Classic move control

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

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

5.5 Dark mode

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

5.6 Confirmation dialogs

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

5.7 Reset uMp-TSC settings

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

5.8 About

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

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

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

6 Manipulator settings menu

Manipulator settings menu can be entered from the uMp-TSC2 main view cogwheel symbol. Settings in the *Manipulator settings* are micromanipulator specific and need to be configured to each manipulator separately by first selecting the micromanipulator to be configured. The *Manipulator settings* menu structure is shown in Figure 43.

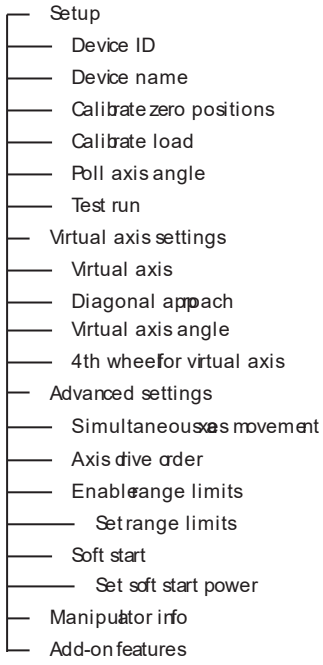


Figure 43. Manipulator settings menu

6.1 Setup

6.1.1 Device ID

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

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

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

6.1.2 Device name

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

6.1.3 Calibrate zero position

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

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

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

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

6.1.4 Calibrate load

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

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

To perform *Calibrate load*:

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

6.1.5 Poll axis angle

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

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

6.1.6 Test run

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

6.1.7 Virtual axis settings

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

6.2 Advanced settings

6.2.1 Simultaneous axes movement

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

6.2.2 Axis drive order

Axis drive order setting opens a configurator view that enables defining the order for which individual axes are moved one at the time during the memory position driving, such as *Home* and *Target*. Setting is not relevant if *Simultaneous axis movement* is Enabled. To reconfigure the order (Figure 44):

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

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

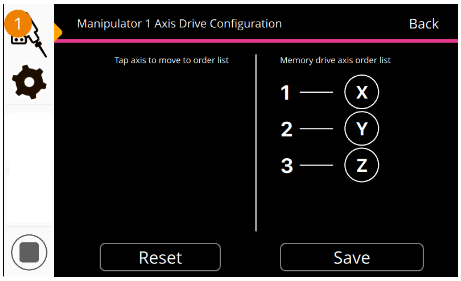


Figure 44. Axis drive order configuration

6.2.3 Enable range limits

Enable range limits feature allows limiting the active positioning range to be less than the full range. This may be helpful, for example, to prevent collision to the dish bottom with the pipette tip. Enabling this feature reveals the *Set range limits* setting, which is a configurator used to define the limits (Figure 45):

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

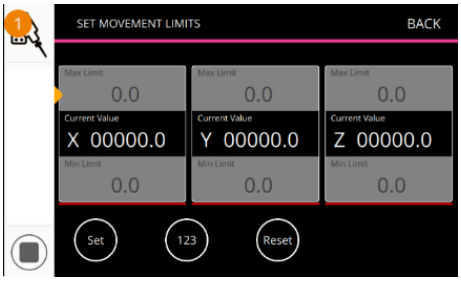


Figure 45. Range limit configuration

6.2.4 Soft Start

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

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

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

6.3 Manipulator info

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

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

6.4 Add-on Features (Legacy)

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

7 Micromanipulator handedness and stand re-adjustments

7.1 Micromanipulator handedness reconfiguration

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

1. Detach x-axis cable clip from the manipulator body using 1.5 mm hex key (Figure 46, left)
2. Unscrew 2 pcs of x-axis mounting screws using 1.5 mm hex key (Figure 46, right)

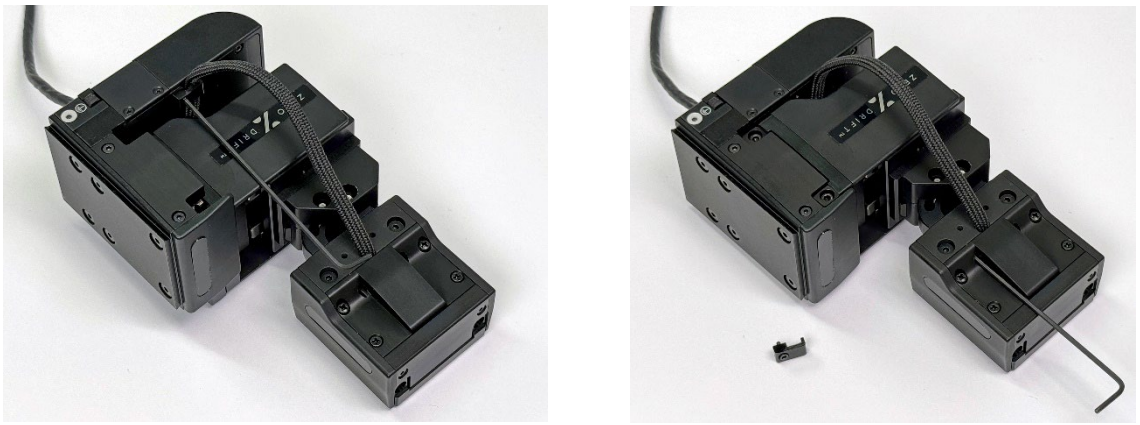


Figure 46. Remove x-axis cable clip and mounting screws.

3. After x-axis is detached from the micromanipulator (Figure 47, left), unscrew 2 pcs of angle adjustment locking screws all the way out using 2 mm hex key (Figure 47, right)

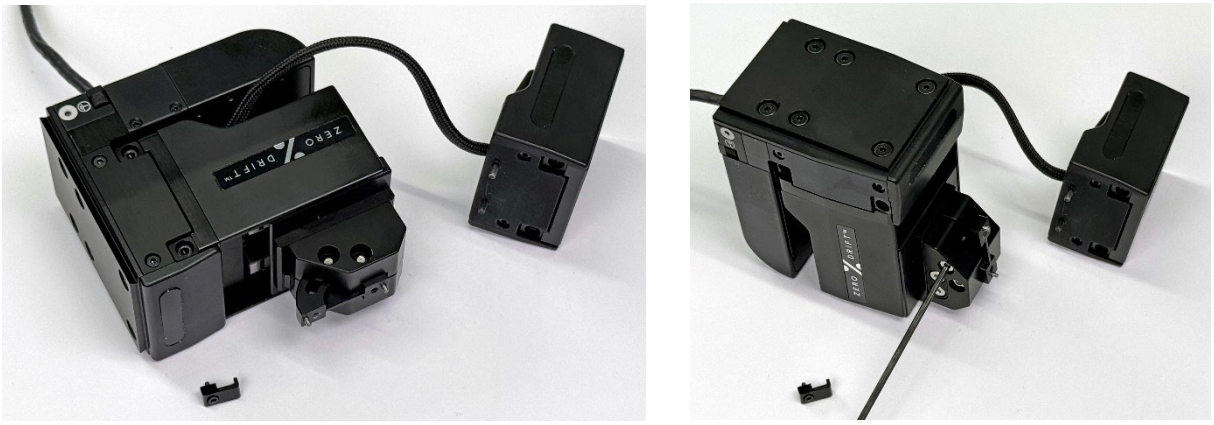


Figure 47. Remove angle adjustment locking screws

4. After completing steps 1-3 (Figure 48, left), screw the 2pcs of angle adjustment locking screws back from the opposite side for left-handed configuration using 1.5 mm hex key. (Figure 48, right)

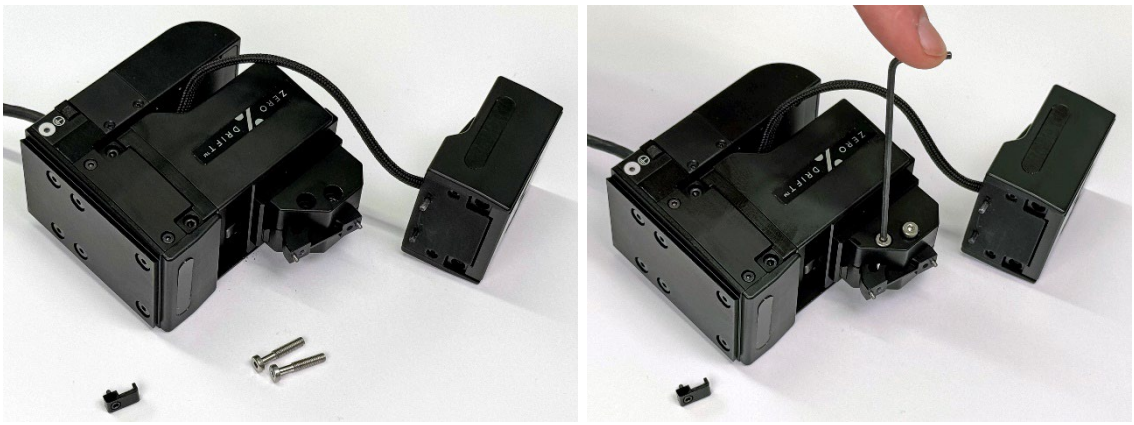


Figure 48. Insert angle adjustment locking screws.

5. Attach x-axis back to the micromanipulator in left-handed configuration with 2 pcs of x-axis mounting screws using 1.5 mm hex key (Figure 49, left).
6. Secure x-axis cable to the manipulator body with cable clip by using 1.5 mm hex key. BE CAREFUL NOT TO PINCH THE CABLE WITH CABLE CLIP (Figure 49, right)

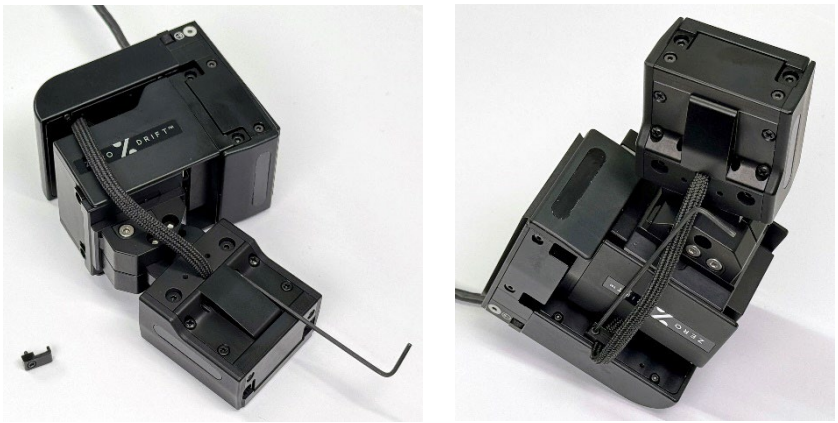


Figure 49. Re-attach x-axis and cable clip in left-handed configuration.

7.2 uMp-ROT handedness re-configuration

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

7.3 uMp-SLD locking tightness re-adjustment

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

1. Tightness is adjusted from the back of the uMp-SLD using two set screws shown in blue (Figure 50).

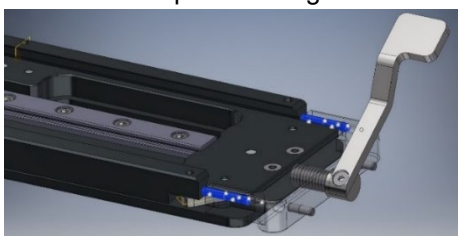
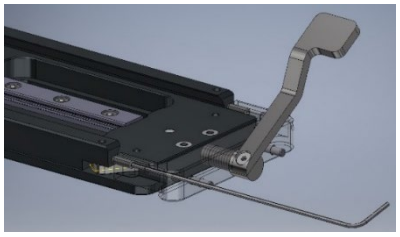
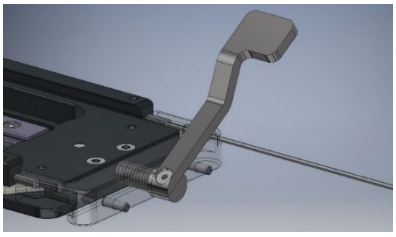


Figure 50. uMp-SLD locking adjustment screws shown in blue.

2. There are additional outer set screws that prevent unintentional adjustment changes. Use 0.9 mm Hex key to remove the outer screws from both sides of the locking lever to provide access for adjustments.
3. Use 0.9 mm hex key to tighten the locking mechanism by turning adjustment screws clockwise with same amount on both sides until the slide starts to brake when lever is approximately at 45 deg position (Figure 51).





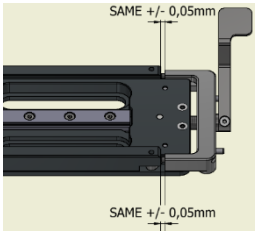


Figure 51. Adjusting locking screws.

4. Use calipers to measure the gap between slide rails and locking part to confirm the gaps on both sides are equal within +/-0,05mm (Figure 51, right).
5. Figure 31. Adjusting locking screws.
6. Test the uMp-SLD locking and sliding action. Tune the adjustment further if needed.
7. Screw the two outer screws back in place.

8 Maintenance and troubleshooting

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

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

Please review the common issues and their solutions. If it does not help and problem persists, please contact your local representative or Sensapex support for further instructions: support@sensapex.com. Please include

the respective product serial number, a brief description of the issue and possible circumstances leading to it when contacting support. A picture of the installation is often also required for troubleshooting.

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

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

8.2 Pipette tip is drifting

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

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

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

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

8.4 Probes are not accurately pointing to or holding their relative position to the sample when adjusting the azimuth and elevation angles in the in vivo micromanipulation system

Use installation aid kit to evaluate and improve the system alignment according to the steps below:

- Confirm that RNG segments are aligned correctly. Even small deviations can cause relatively large errors. Rotating the probe around azimuth angle by sliding the ARM around RNG segments is the easiest way to see if the individual RNG segments are pointing to the same center point. Note that RNG segments must have solid contact with all alignment guide rods when using the installation aid kit.
- Confirm that the uMp-MBS mounting bases are properly aligned with the side and back stoppers of the SLF and, thus, manipulator is aligned with the SFL and ARM.
- Confirm that the uMp-RHL is aligned with the manipulator x-axis. In case the dowel pins that guide the alignment are not snug fit to the holes in uMp-RHL, there may be minor wiggle room for the orientation. Confirm visually (or by measuring with calliber) that uMp-RHL and x-axis are aligned, re-adjust if needed.

Small deviation (couple of millimeters offset) from perfect system alignment is normal due to practically realistic manufacturing tolerances of the mechanical parts. These can be compensated for by the manipulator axes

and will remain the same unless the installation is changed. Since the experiments are always calibrated for the sample specific reference points (e.g. Lambda and Bregma), deviation will not reduce the overall probe placement accuracy based on classic stereotaxic coordinates or when using new brain atlas tools, such as Pinpoint.

8.5 Cleaning and re-lubricating the RNG and ARM sliding mechanisms

Cleaning and re-lubrication of the sliding mechanisms are needed in case the ARM is not sliding smoothly in the RNG segments or SLF is not sliding smoothly in the ARM.

- To clean and re-lubricate RNG, wipe off the old grease from the RNG sliding surfaces marked with arrows in Figure 5. Apply new grease and slide ARM around the RNG segments to spread the grease evenly. Wipe off excess grease.
- To clean and re-lubricate ARM, wipe off the old grease from the two inner grooves of the ARM where shelf is sliding (Figure 52).

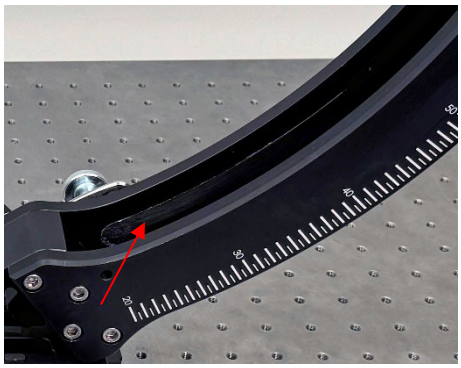


Figure 52. ARM slide mechanism cleaning and re-lubrication.

8.6 Probe or probe holder feels unstable

It is essential for stable recordings that the probe holder and probe is mounted firmly to the micromanipulator.

- Try gently wiggling the probe holder to confirm that it is held securely in place in the uMp-RHL. Tighten the uMp-RHL thumb screw further if needed by using the provided tool.
- Confirm that probe is securely clamped in the adapter head (see 3.7.).

8.7 Products got exposed to accidental liquid spill

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

9 Specifications

uMp-3, uMp-3 NP and uMp-4

Positioning range uMp-3 | uMp-4:	20x20x20 mm^3 (x-y-z) | 20x20x20x20 mm^3 (x-y-z-D)
Resolution:	5 nm
Repeatability:	100 nm
Max. speed:	5 mm/s
Max. payload:	150 g
X-axis tilt angle uMp-3 | uMp-4:	0 – 45 degrees | 0 – 90 degrees
Dimensions uMp-3 | uMp-4:	49x77x128 mm | 49x104x136 mm
Weight uMp-3 | uMp-4:	645 g | 894 g

uMp-RNG

Dimensions:	367x367x15 mm
Weight:	1500 g

uMp-ARM

Dimensions:	126x225x451 mm
Weight:	2400 g

uMp-TSC2

Capacitive touch screen display
Connects up to two uMp-RW3 | uMp-RW4
Requires uMp-HUB or uMp-HUB lite to connect micromanipulators
Two Ethernet ports to connect other Sensapex devices or PC

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

uMp-HUB lite

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

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

uMp-HUB

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

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


The battery has built-in protection

uMp-RW3 | uMp-RW4 rotary wheel interface

3 or 4 wheel versions
Two pairs of push buttons for speed and manipulator selection
USB connection to uMp-TSC2 (5 VDC, 0.2 A)

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

EU Declaration of Conformity

1. **Manufacturer**

   Sensapex Oy

   Teknologiantie 13

   90590 Oulu

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

3. **Object of the declaration**

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

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

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

and harmonised standards / technical specifications

EMC **EN IEC 61326-1:2021**

Emission requirements: EN 55011:2006, EN 61000-3-2:2019, EN 61000-3-3:2013

Immunity requirements according to Table 2 for equipment intended to be used in an industrial electromagnetic environment: Electrostatic discharge (ESD), Electromagnetic field, Power frequency magnetic field, Burst, Surge, Voltage dips & Short interruptions, Conducted RF

RoHS EN IEC 6300 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

MD EN ISO 12100 Safety of Machinery. General Principles for Design. Risk Assessment and Risk Reduction

5. **Signed for and on behalf of:**

Oulu 28.8.2024

Sensapex Oy

Mikko Vähäsöyrinki, General Manager