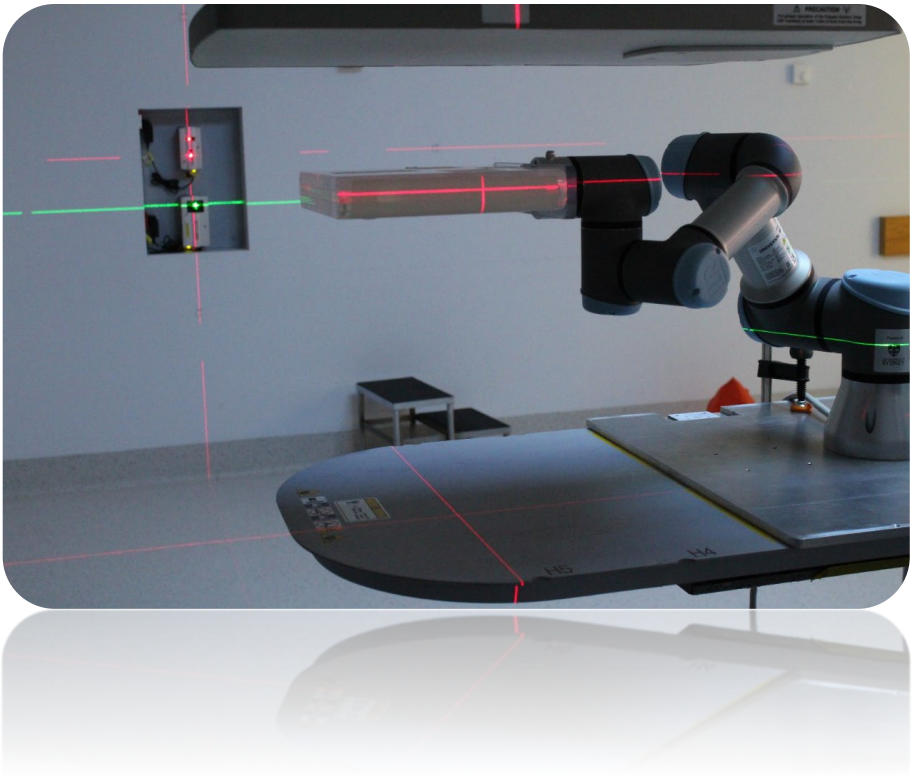
# Robotic Motion Phantom Controller Guide (UR16)



# Robot Transport Checklist

- Carry case
- Robot
- Base plate
  - 4x M6 screws
  - Mount gripper plate
- Phantom
  - Screws that attach phantom to robot
- Robotic controller
  - Attached tablet
  - Power cable
  - Robot connection cable
- Ethernet cable (connects the robotic controller and the PC)
- PC containing the robot software
  - PC Charger
- *Optional:* Robotic Motion Phantom Getting Started Guide

# Warnings

1. Make sure that the robot arm, the end effector and the phantom are properly and securely bolted in place.

    - Remember it's typically a two person job.

    - When attaching a phantom, make sure to park the robot so that it does not move to prevent any unplanned motion.

2. Make sure the robot arm has ample space to operate freely.

    - In certain situations, it can move fast, so be careful and handle accordingly.

3. Make sure to warn people to keep their heads and faces outside the reach of the operating robot or robot about to start operating.

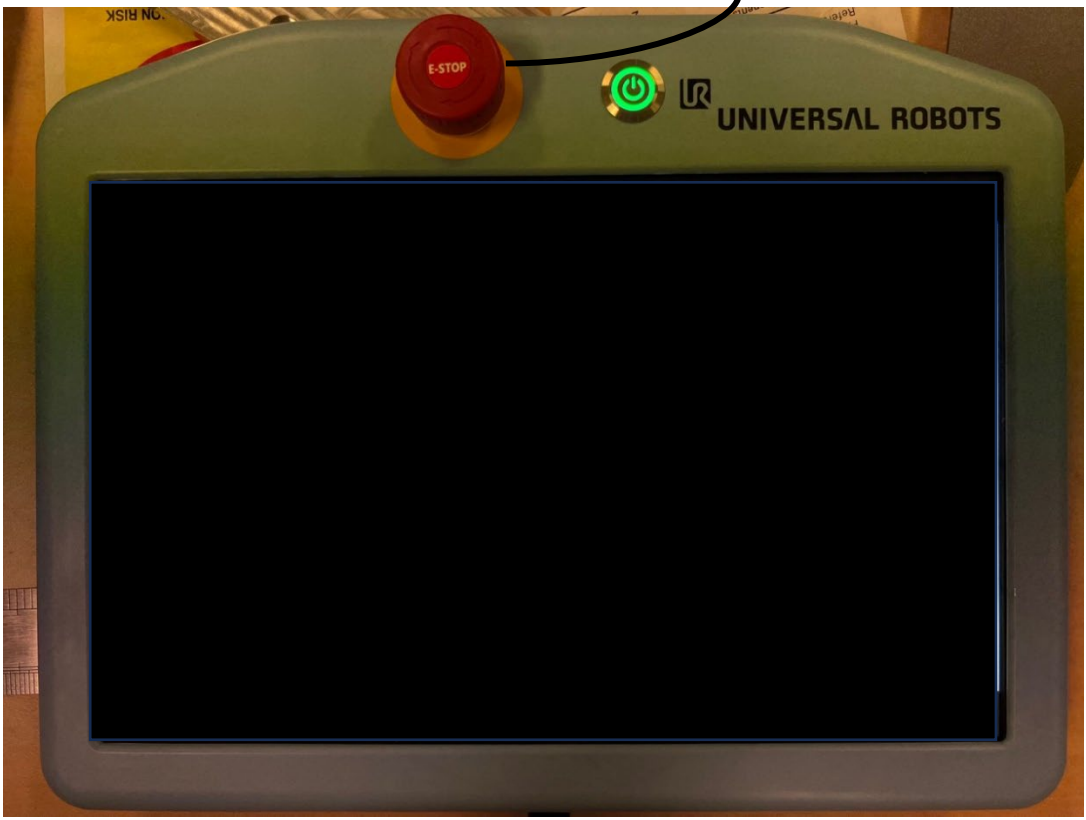
4. Enter the correct weight of the phantom into the controller and the code.

5. Never use the robot if it is damaged, for example if joint caps are loose, broken or removed.

6. If you are using a new motion trace, it is highly recommended to test the new trace.

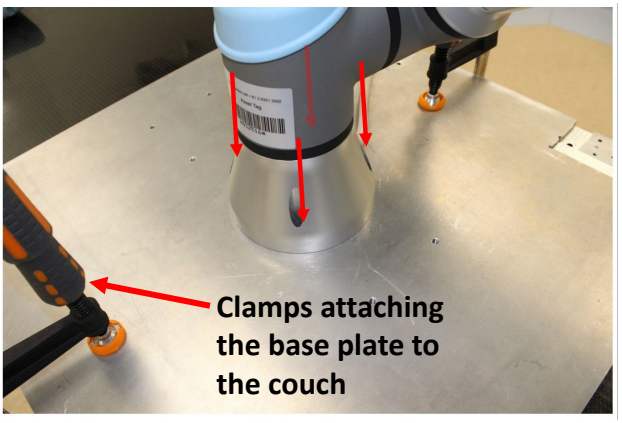
# NOTE!!!

If any unplanned robot movement happens, press the **E-STOP** button on top of the controller! The robot will stop immediately.

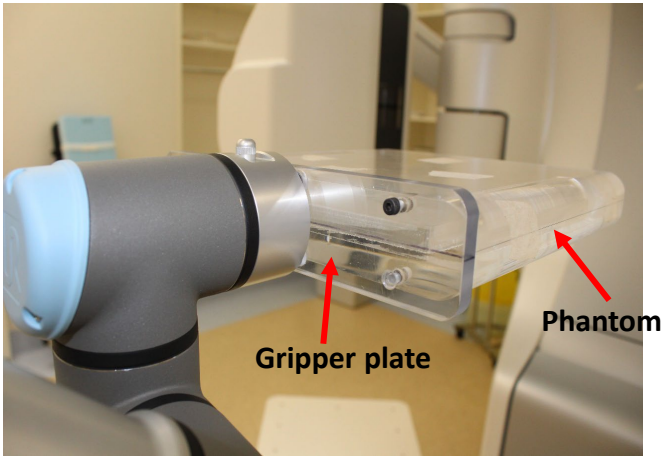


# Setting up the Robotic Motion Phantom

1. Mount base plates to the couch using clamps and mount robot to base plate using the black M6 screws.




2. Mount the gripper plate/end effector to the tool flange using the silver M6 screws, then attach phantom to gripper plate using the plastic screws.

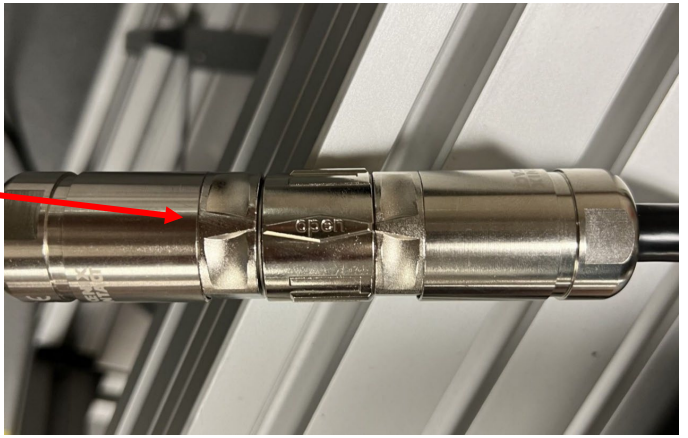


# Powering up the Robotic Motion Phantom

1. Connect the cable to connect the robotic controller with the robot. When the arrows on both ends point to OPEN, the cable is unlocked. To lock it, move the latch from this position. Connect the other end of the cable to the controller ensuring that it is securely latched (underside of the power supply).

2. Connect robot power supply to power.

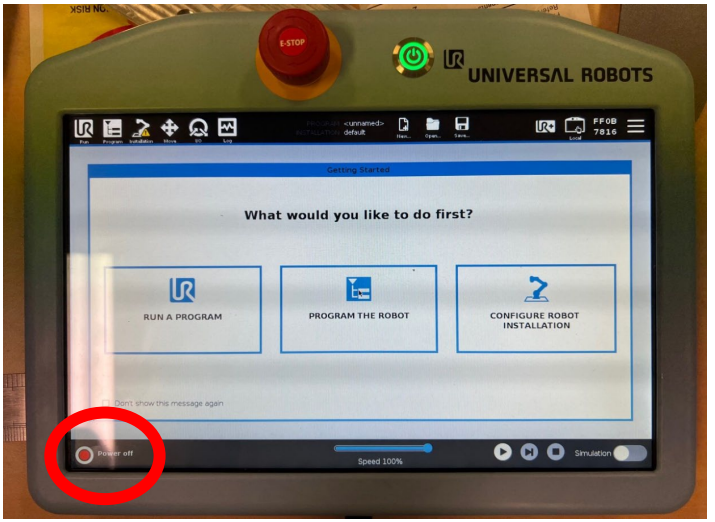
Unlocked




Locked

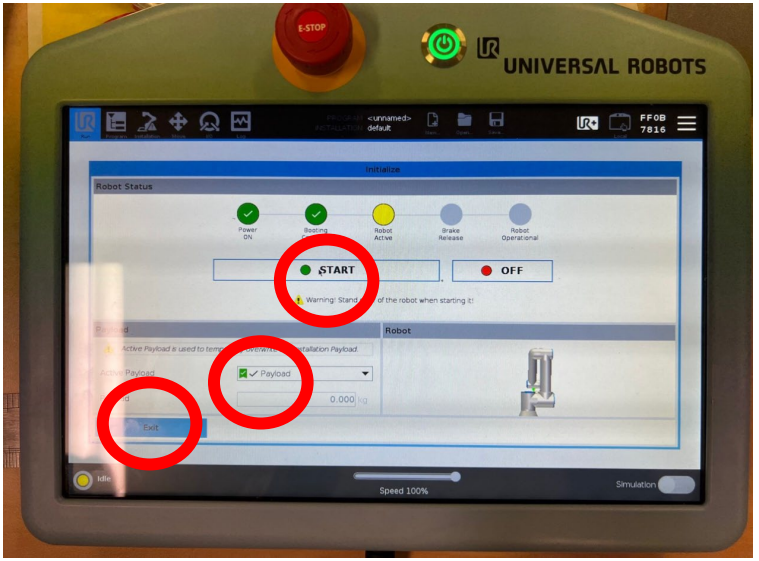
3. Press the start button. Ensure E-stop is released and wait for the application to boot up.


4. It brings up this window. Click on ‘Power off’.



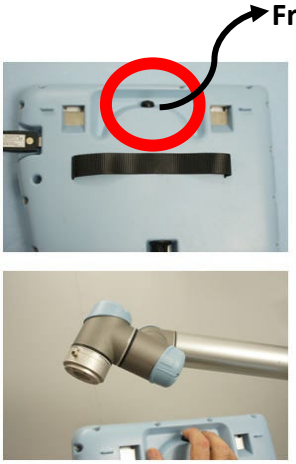
5. Press ‘ON’ and wait until it shows ‘START’.


6. Click on ‘START’ (you will hear the robot brakes are released), add payload and then click on Exit.

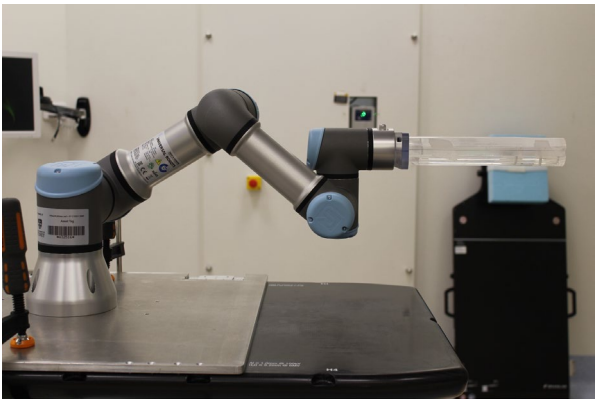


# Positioning the phantom to the treatment isocentre:

1. Use the Freedrive button on the back of the robot tablet to move into the starting position.

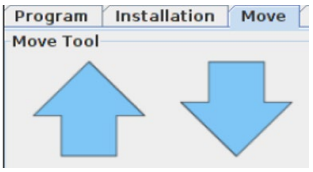


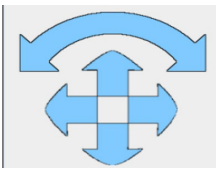


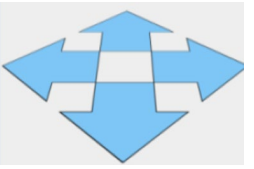



The figure above shows the most optimal position to use the robotic motion phantom when running motion traces. Placing the shoulder up and the elbow down allows adequate flexibility and range of motion. The Elbow joint can even be moved further down and closer to the shoulder if needed for even more range of motion. To move the robot, hold the free drive button on the tablet. **Important: If the phantom is attached you will need to support the phantom before pressing the free drive button. Failure to do so will cause the phantom to drop and collide with the couch.**

2. You can do small adjustments using the controls in the 'Move' tab as shown below.

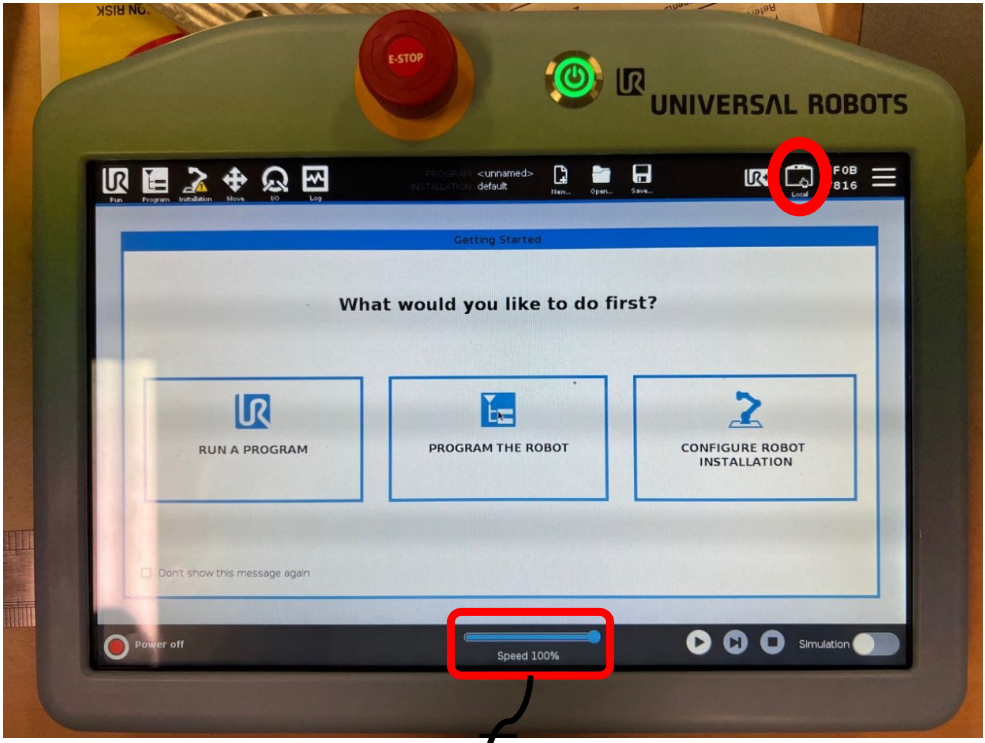




# Operating the robot using USYD software

1. Click on this and change this to ‘Remote Control’ to ‘Local’ to run the robot using the USYD developed code.




Do not change this. 100% is optimum for our purpose.

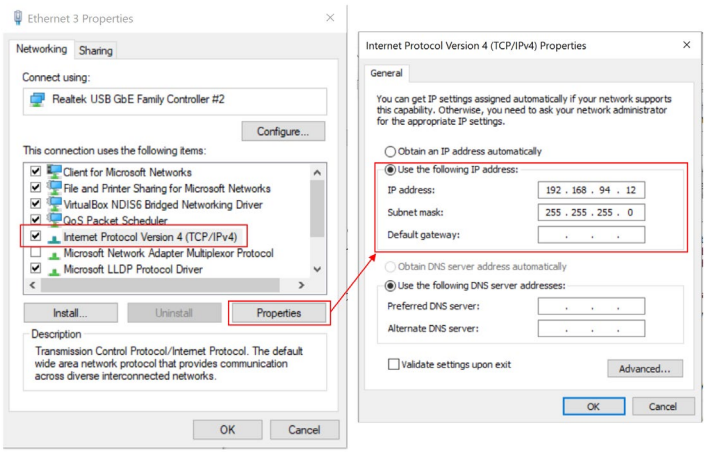
2. Connect a Cat5 network cable at the bottom of the controller with the USYD robot laptop.

3. Once the Ethernet cable is connected between the PC and the Robotic Controller, the IP address needs to be configured on the robot, software and PC.

- **PC:**

Go to *Control Panel* Under the *Network and Internet settings* → *Network Connections* → *Ethernet.* Right click *Ethernet* and then click *Properties*. Select *Internet Protocol Version 4 (TCP/IPv4)* and then click *Properties.* Setup the IP address and subnet mask.

- IP address
- Subnet mask



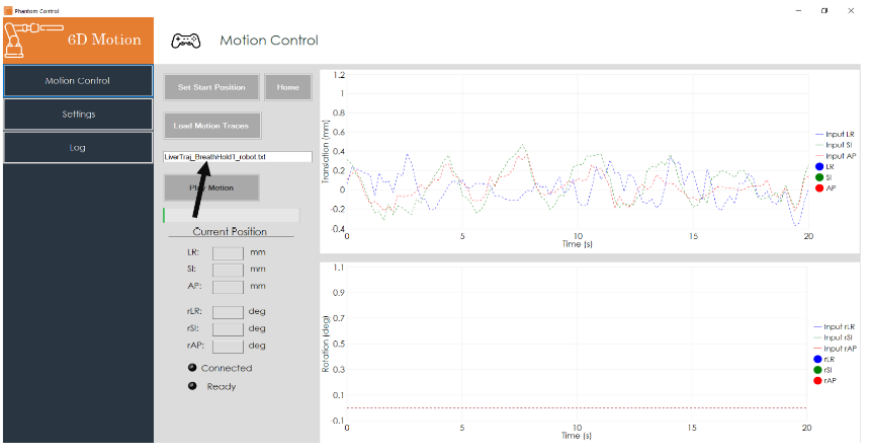

**Robot:**

Go to the *Setup Robot*, and select *Setup Network*. The setup:

- IP Address
- Subnet mask

The IP address should be in the same format as the PC: 192.168.94.x, and the subnet mask should be 255.255.255.0

# USYD robot software GUI guide



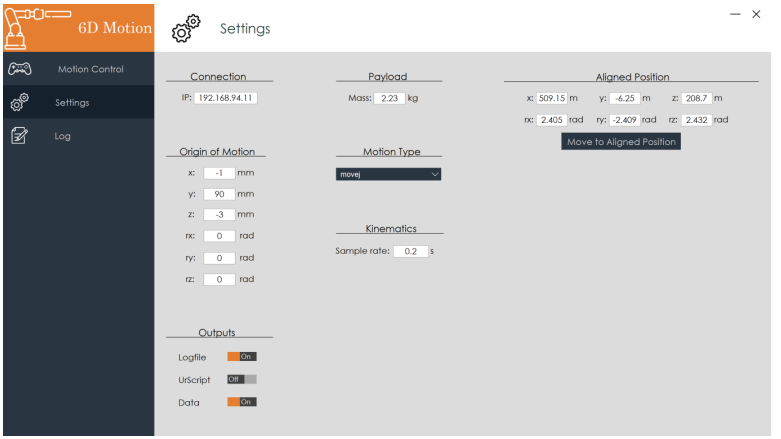

**Motion Control tab**
Opens controls to load traces and run motion.

**Settings tab**
Opens settings for robotic motion phantom.

**Log tab**
Opens log box to view status of robotic motion phantom.

First, go to the Settings tab and fix the parameters as described next.

# USYD robot software GUI guide




**Settings tab**

Opens settings for robotic motion phantom.

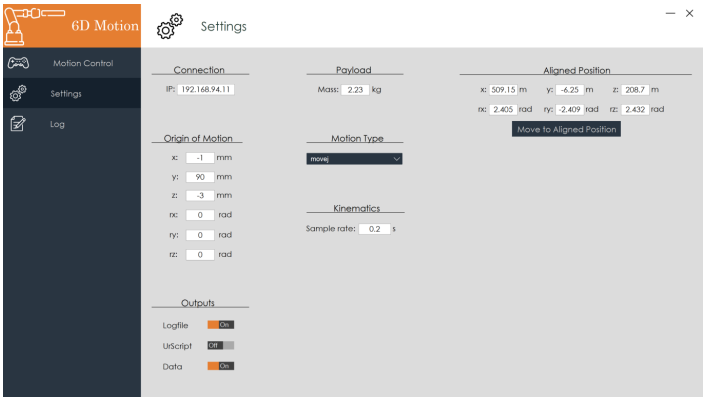
1. **Connection -** Input the IP address of the robotic controller for TCP/IP connection. IP address can be changed on the Teach Pendent under settings.

2. **Payload -** in kg. Maximum payload is 16 kg.

3. **Sample rate** - The sample rate defines the velocity and acceleration of the robotic phantom. The input sample rate should be the same as the input data sampling frequency. This will allow the robot to move from point *a* to *b* at the set input sampling time. The optimised interval is 0.2 sec.

4. **Turn on the Outputs**: Output files can be turned on and off. Logfile outputs a .txt of the logging information during a motion run. UrScript outputs what is sent to robotic controller for executed motion, this is in the robot API language. Data outputs the motion recoded from the robot as a .txt file in the format [Time (s) x (mm) y (mm) z (mm) rx (deg) ry (deg) rz (deg)] (space delimited). The output motion traces could be useful if any future debugging is needed.

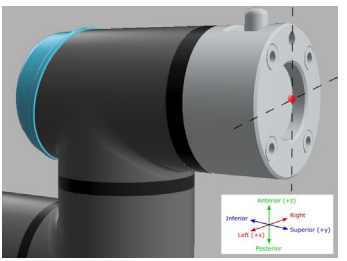
# USYD robot software GUI guide



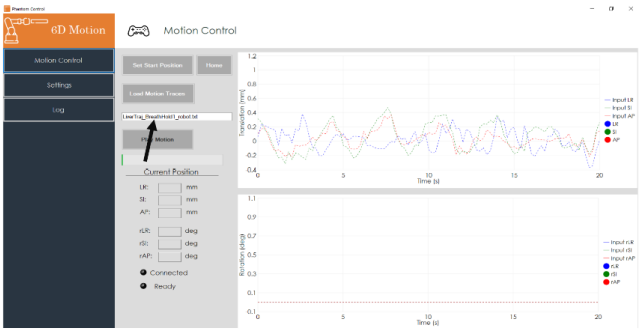

**Settings tab (continued)**

5. **Motion Type -** Two motion types can be run movej (default) and movel. Movej makes the robotic arm move from point a to b in the most efficient way when moving the joints on the arm. Movel makes the robotic arm move from point a to b linearly, i.e. the joints will move in a way that will force the phantom to move in a straight path.

6. **Origin of motion**: Default origin of motion is located at the centre of tool flange. This is only relevant if the robot is used to perform rotation. To move the origin of motion to the treatment isocentre, enter the x, y and z distances from the centre of the tool flange of the robot arm to the desired point on the phantom. **The z coordinate needs to be reversed as compared to IEC coordinate system. So, positive z is towards posterior direction. Everything else follows IEC coordinate system.**



# USYD software GUI guide



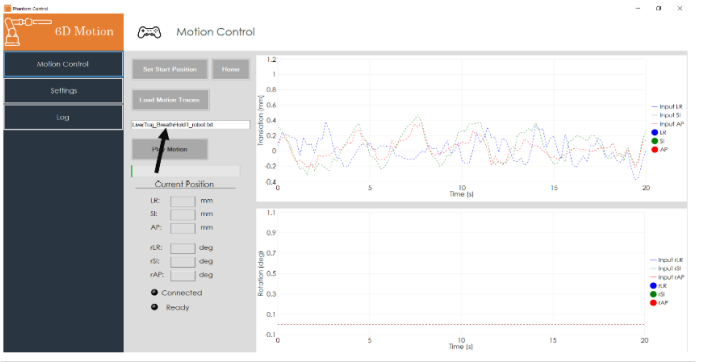

**Motion Control tab –** Once all the parameters are added in the Settings tab, switch to the Motion Control tab.

1. **Set Start Position -** Once the phantom is setup and aligned, click the *Set Start Position* button. This will first establish a connection with the robot and get the current (aligned) position of the phantom. This will activate the Home button (text will turn white). If a connection cannot be setup due to communication issues, those buttons won't be turned on (text will remain black). The software will log the connection error in the *Log* tab. Check the connections and try to assign a different IP to fix this.

2. **Home** – Click the Home button. The home button will send the robotic phantom back to the original start position which was set by the *Set Start Position* button. If the robot is repositioned and the *Set Start Position* is clicked again the new home position will be updated to the new position.

3. **Load Motion Traces** - Next click on the *Load Motion Trace* button. This will allow the user to load a .txt file in the following format [t x y z rx ry rz] with units of [sec mm mm mm deg deg deg], note this is space delimited not tab. The loaded trace name displayed on the left and the graph on the right. Note: If exporting the motion traces from MATLAB, using the *dlmwrite* function is recommended. e.g. *dlmwrite('output.txt',TraceArray,' ').* Depending on the trace length this might take a while (upto 4 mins for a 20 min long trace).

# USYD software GUI guide




**Motion Control tab (continued)**

**4. Play Motion -** Once the loaded trace is complete and the transformed motion is checked for irregular motion (singularity check, large motion check) the *Play Motion* button will become active. Clicking this will send the data to the robot and run the motion. The play icon will change to a stop icon and renamed to *Stop Motion*, clicking *Stop Motion* will stop the robot from moving. After a motion trace is completed click the 'Home' to bring the robot back to the Home position before loading another trace.

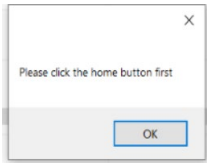
**5. Status Bar -** Provides an estimated status of progress of the motion that is running.

**6. Display LEDs -** Provide information if the robot and connected and ready for motion. If there is an issue with the motion such as a singularity or very large motion the Ready LED will be red and the Play button will become inactive. If both LEDs are green motion can be run.

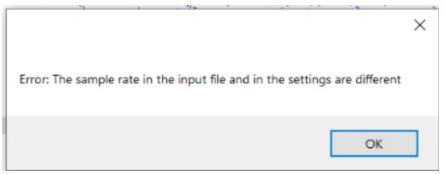
**7. Current Position Value Box -** Displays the current position of the robot when a motion trace is running.

# USYD software GUI guide (sample errors)

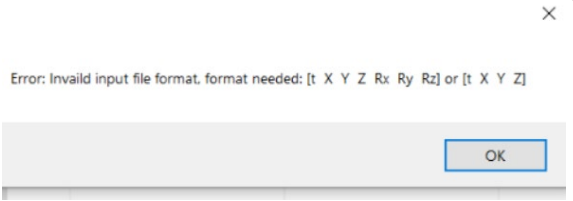
- The software will show an error if the Home button is not clicked before loading a new trace.




- The software will show an error if the input frequency in the robot trace and in the settings are different.

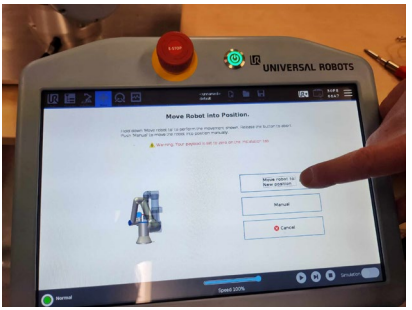



- The software will show an error if the input robot trace file format is wrong.



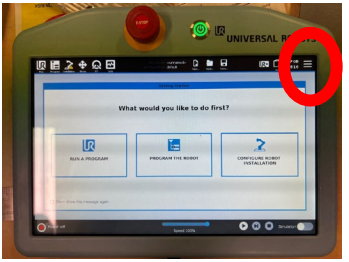
# Shutting down the robot

1. For pack up, on the robot tablet, Change ‘Remote Control’ to ‘Local’.
2. Click on the ‘Move’ tab.
3. Click and hold the ‘Move robot to new position’ and press ‘continue’.




4. The robot will go back to the below configuration.

5. To turn off the robot, click on this. It brings up a dialogue box and press ‘Shut down’.



## Coordinate System of Robotic Motion Phantom

The coordinate system of the robotic motion phantom is based on the *IEC 61217 Radiotherapy equipment – Coordinates, movements and scales*. The figure below depicts the coordinate system of the robotic motion phantom. All input motion traces should be placed in this reference frame. Note that, the coordinate system on the tablet is different to IEC 1217.