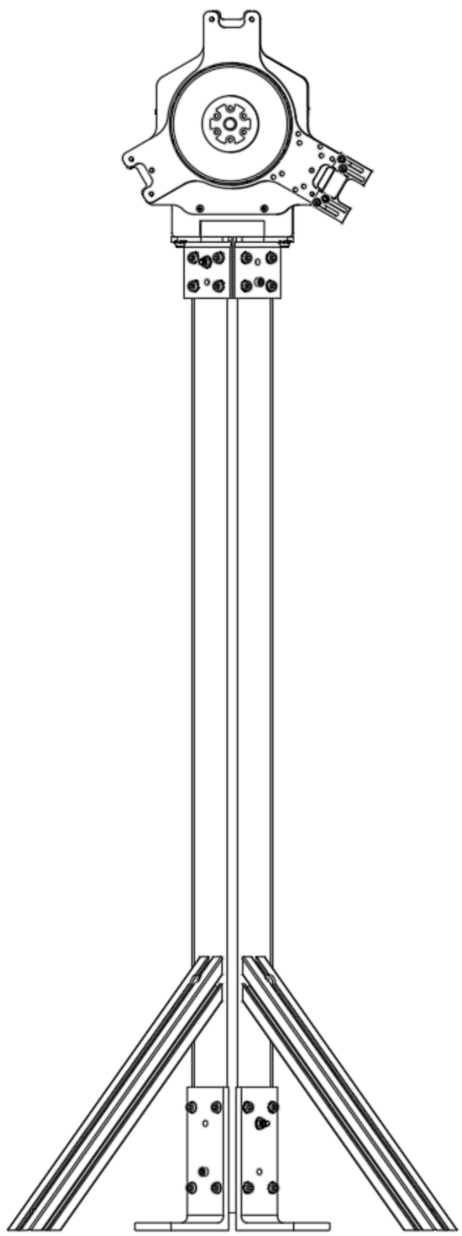
Flight Stand 150 User Manual



Tyto Robotics
B1 - 80 rue Adrien Robert • Gatineau, QC, Canada J8Y 3S2

sales@tytorobotics.com
tytorobotics.com • 1-844-722-8378

Table of contents

Chapter 1. Item Checklist and Safety Rules

Section 1.1 Introduction and Item Checklist

The Flight Stand 150 allows the user to test powertrains producing up to 150 kgf of thrust and 150 Nm of torque. It can measure voltage up to 180 V and direct current up to 500 A.

Reminder: a minimum of **two people** are required for this assembly.

You may use the following item checklist to verify the items inside the box.

	Flight Stand 150 Pro
Flight Stand 150 Pro - Main Box SKU#CNGP	1x SKU#NFLU - Flight Stand 150 Pro - Force Measurement Unit 150 kgf - 150 Nm
	1x SKU#WCAL - Flight Stand 150 Pro - Electrical Measurement Unit 180 V - 500 A
	1x SKU#JHJM - Flight Stand 150 Pro - Motor Mounting Plate
	1x SKU#AALJ - Flight Stand 150 Pro - Auxiliary Components Box
Flight Stand 150 Pro - Stand beam SKU#DMCV	2x SKU#ZBMK - Flight Stand 150 Pro - 45 degree long support
	1x SKU#ZVQD - Flight Stand 150 Pro - Square tube
Flight Stand 150 Pro - Stand fixtures SKU#WJRU	1x SKU#KDNN - Flight Stand 150 Pro - Stand fastener bag
	4x SKU#FCQD - Flight Stand 150 Pro - Lower fixation L-bracket
	4x SKU#QHXS - Flight Stand 150 Pro - Upper fixation L-bracket
Flight Stand Sync-Hub SKU#WMHX	1x SKU#GXYY - Flight Stand Sync Hub
	1x SKU#WQFF - 9V, 2A power adaptor in box
	1x SKU#RKVR - USB cable type A/B 1.8 m
	1x SKU#CLHV - Sync cable

Section 1.2 General Safety Rules

Always put safety first! It is your responsibility!

It is important to stay alert when working with a thrust stand. The Flight Stand has been tested to 150 kgf of thrust and 150 Nm of torque. However, it needs to be used in a safe environment for the operators, such as an enclosure. Any abuse or misuse of the stand may result in damage to the equipment or injury to the users.

To ensure safety, please follow these instructions:

1. Wear safety goggles during a test.
2. Wear gloves during assembly of the Flight Stand
3. Make sure you have all the components and tools needed before construction.
4. Inspect all fasteners before every experiment and as often as possible.
5. Do not place the Flight Stand near the presence of flammable liquids or gases.
6. Always keep your work area clean, do not work on surfaces that are dirty with oil. Small metal chips may be blown up and hit the propeller by accident. Clean your testing room before every test.
7. Respect Murphy's law. If you think something might go wrong, it will.
8. Make sure you are dressed for safety. Do not wear jewelry or long clothing when operating the tool. Tie long hair before a test.
9. Do not let children near the Flight Stand.
10. Do not use or assemble the tool alone.
11. Do not substitute parts or modify the instrument.
12. Always disconnect the power source AND wait for the voltage to go below 30 V before approaching the Flight Stand (or opening the door of the enclosure).
13. Do not store anything near or above the Flight Stand, especially when performing a test.
14. Do not stay in the plane drawn by the spinning propeller or directly behind it. This is where small parts are most likely to be ejected by the propeller.

Chapter 2. Installation Guide

Section 2.1 Stand Assembly

Open the following boxes and find these items:

- Flight Stand 150 Stand Beam - Square Tube
- Flight Stand 150 Stand Fixture - Lower L bracket x 4
- Flight Stand 150 Stand Fixture - Upper L bracket x 4
- Flight Stand 150 Main Box - 45 degree support 480 mm long x 2
- Flight Stand 150 Main Box - Auxiliary Box:
    - Stand Fastener Bag
    - Hand Tool Bag

You may install the stand with the items listed above:

Step 1: Place the stand on flat ground and install four lower L-brackets as indicated in Fig. 1.:

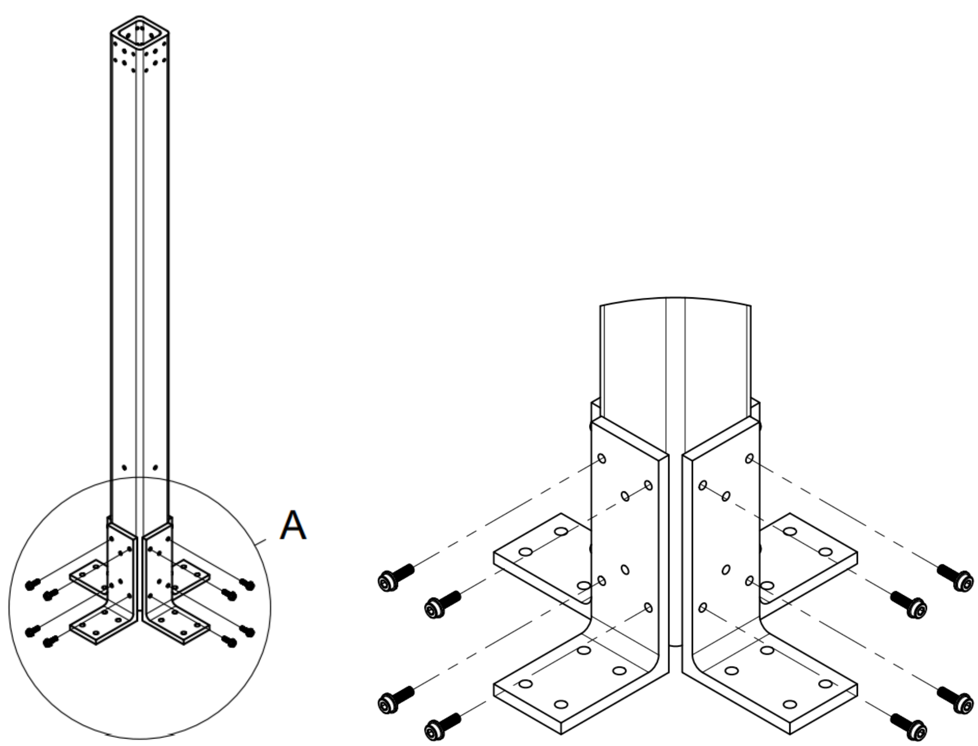


Fig. 1. Stand Assembly - Lower Section with L-Brackets

Fastening torque:

- M6 - 16 mm flange socket head screw: 15 Nm

Step 2: Reinforce the lower structure with long bolts

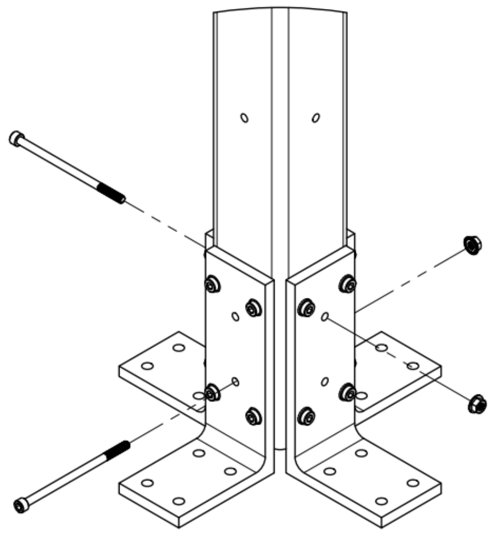


Fig. 2. Stand Assembly - Lower Section with Reinforcement Bolts

Use two M6 - 110 mm socket head screws and two M6 flange serrated lock nuts crossing each other, as shown in Fig. 2., to better distribute the mechanical stress to four L-brackets.

Fastening torque:

- M6 - 110 mm screw and nut: 13 Nm

Step 3. Install the 45-degree support beams to the stand

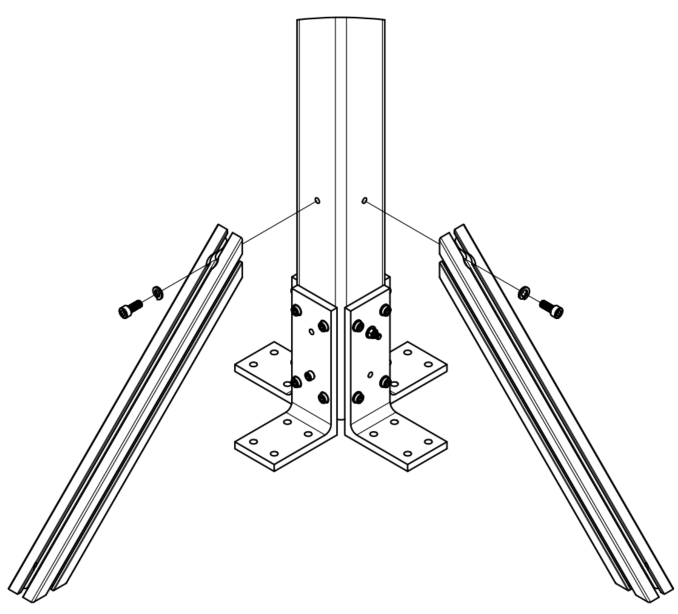


Fig. 3. Stand Assembly - Lower Section with 45-Degree Support Beams

The 45-degree support beams can be installed on any of two surfaces adjacent to each other on the stand, this applies to both Single motor and Dual motor setups. Use the M8 screws and lock washer to fix the support onto the stand.

Fastening torque:

- M8 - 20 mm socket head screw: 25 Nm

Step 4A. Install four upper L-brackets to the stand [Single motor setup]

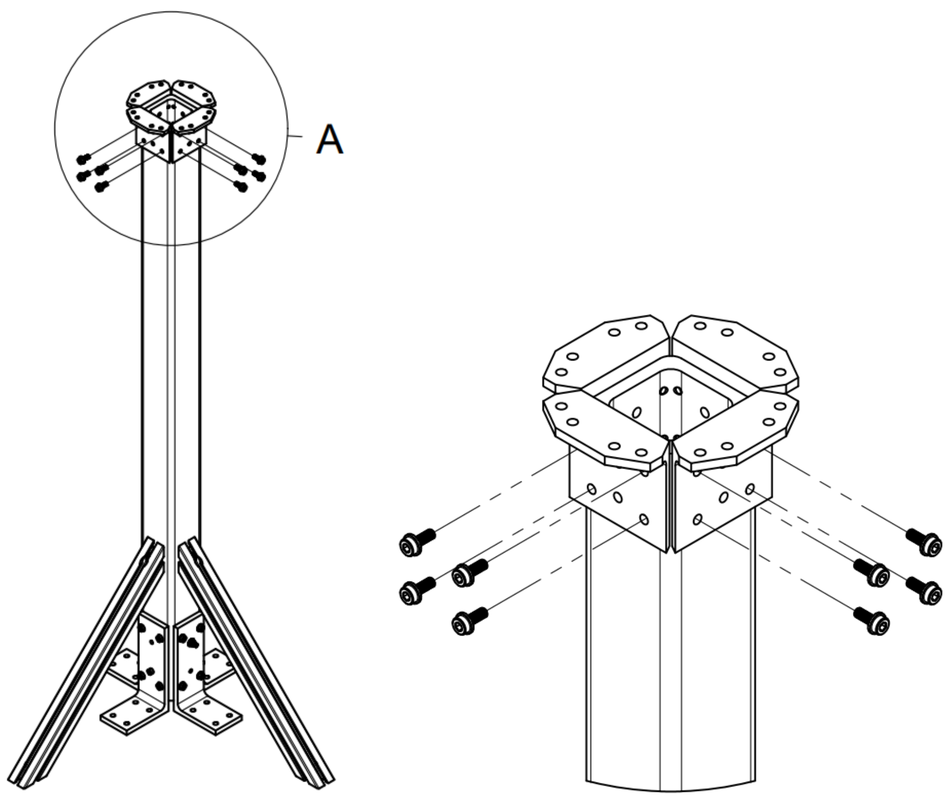


Fig. 4. Stand Assembly - Upper Section with four L-Brackets

Use all four upper L-brackets and sixteen M6 - 16 mm flange socket head screws on the upper section of the stand.

Fastening torque:

- M6 - 16 mm flange socket head screw: 15 Nm

Step 4B. Install two upper L-brackets to the stand [Dual motor setup]

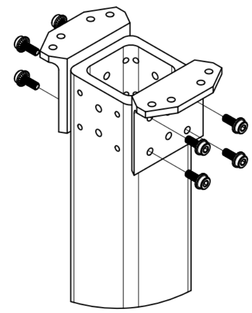


Fig. 5. Stand Assembly - Upper Section with two L-Brackets

This method is only recommended for dual-motor testing, which requires a tight distance between two propellers. Having the rotating surface parallel to the stand can create more drag thus affecting the test data.

Fastening torque:

- M6 - 16 mm flange socket head screw: 16.5 Nm

Step 5. Reinforce the upper structure with long bolts

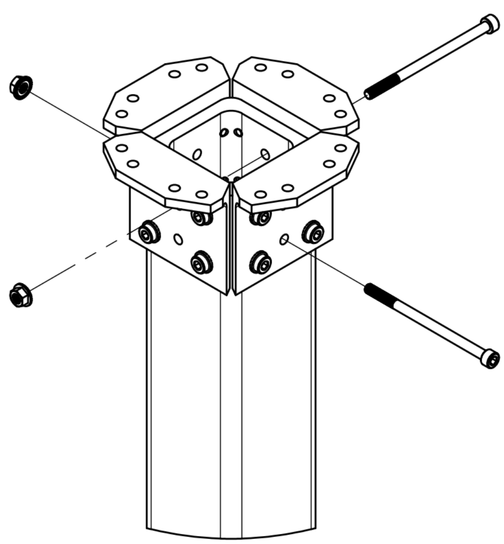


Fig. 6. Stand Assembly - Upper Section with Reinforcement Bolts

Similar to step 2, use two M6 - 100 mm socket head screws and two M6 flange serrated lock nuts to reinforce the upper L-brackets. If building a dual motor setup, you may have these two bolts parallel to each other to reinforce two L-brackets.

Fastening torque:

- M6 - 100 mm screw and nut [Single motor, two bolts perpendicular]: 13 Nm
- M6 - 100 mm screw and nut [Dual motor, two bolts parallel]: 15 Nm

Section 2.2 Ground Assembly

Once finished with the stand assembly, you may place the stand in the designated testing area. Due to the high amplitude dynamic loads generated by the propeller, it is mandatory to fix the stand to a concrete floor with anchors or bolts. The lower L-brackets and the 45-degree supports provide the possibility to use metric M8 and imperial 5/16” fasteners. Choose the best setup for you according to the equipment available. Please keep in mind that you are responsible for making sure the pulling or shearing forces do not exceed the safety limit of the selected fasteners. Perform the necessary calculations before you begin testing.

❗❗❗IMPORTANT❗❗❗

The stand has to be attached to a solid ground surface such as concrete. A soft ground has the risk of causing important vibrations at some rotation speed. This could damage the load cell which would require a replacement and a recalibration.

Stop the test and check the installation if you notice unusual vibration. Contact support in case of doubt. More information about vibrations is available here.

For dual motor testing, which requires a variable axial or radial distance between powertrains, you must design ground fixtures that provide sufficient damping and strength to resist high bending moment and vibration. If using the T-slotted aluminum rails, please note that the single beam profiles will not be sufficient in terms of strength and you must use double or quadruple profiles. All ground fixtures, regardless of material or profile, must be firmly fixed to the concrete flooring by anchors or concrete bolts. Failure to do so may result in severe vibration and damage to the Force Measurement Unit.

Section 2.3 Force Measurement Unit (FMU) and Motor Mounting

Retrieve the following items from the main box:

- Flight Stand 150 Force Measurement Unit
- Flight Stand 150 Motor Mounting Plate
- Flight Stand 150 Auxiliary Components Box
    - FS150 Motor Mounting Fastener Bag
    - FS150 FMU Stand Fastener Bag
    - Threadlocker, Loctite 242
    - FS150 Optical Probe Fasteners Bag
    - FS150 Optical RPM Probe Bag
    - Tie-wrap 0.1" Width, 8" Long, Black
    - Hook and Loop Cable Ties 11" Overall Length
    - FS PT-100 Temperature Sensor Bag

You may use the quick installation guide inside the box or continue with this document:

Step 1. Install the FMU on four upper L-brackets on the stand [Single motor]

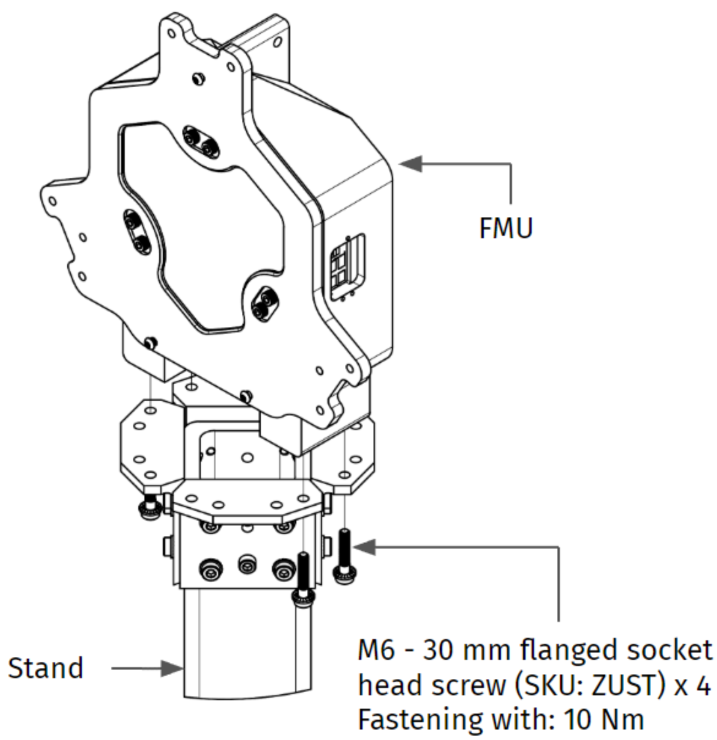


Fig. 7. FMU On the Stand - At a 45 Degree Angle

Placing the Force Measurement Unit at a 45 degree angle to the stand can reduce the drag effect from the airflow. It is recommended to have the FMU's front side facing the 45-degree supports, as shown in Fig. 8. When testing, it is suggested for those two 45-degree supports to work in tension mode in order to avoid buckling.

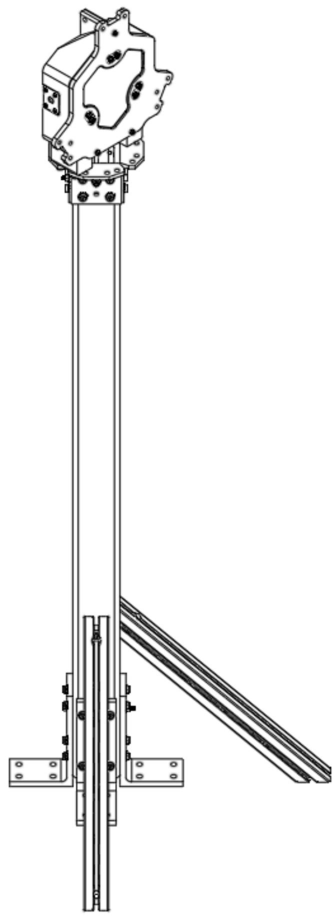


Fig. 8. FMU On the Stand - Overview for Single Motor Setup

Step 1B. Install the FMU on two upper L-brackets on the stand [Dual motor]

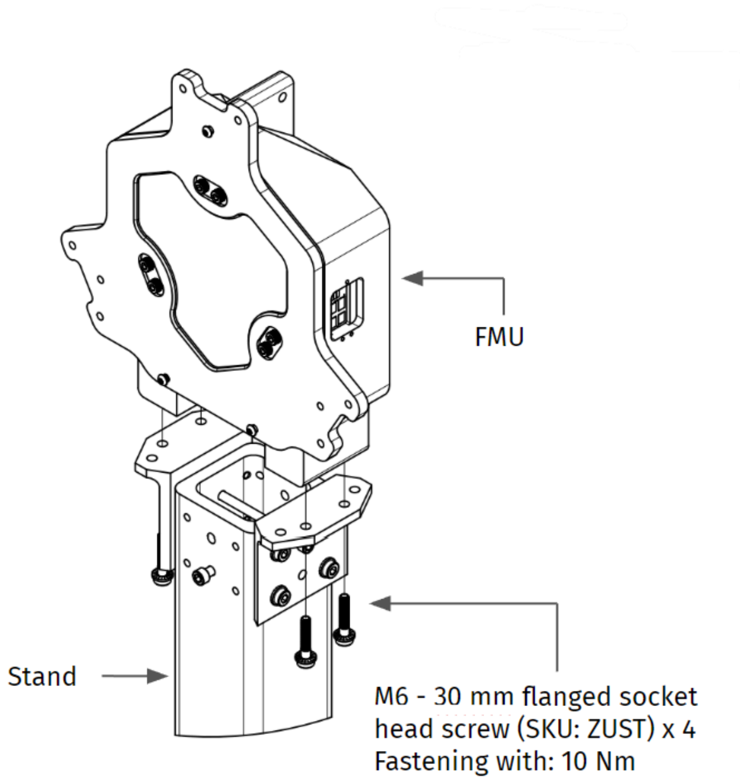


Fig. 9. FMU On the Stand - At a 90 Degree Angle

Placing the Force Measurement Unit on only two upper L-brackets will increase the drag and this method is only recommended for dual motor testing, which requires a tight distance between two propellers.

When testing with two stands and two FMUs back to back with each other, it is important to make sure that all four sides of the two stands: front, back, left, right, are assembled with the 45-degree support beams, as shown in Fig. 10., to provide as much strength in all directions as possible.

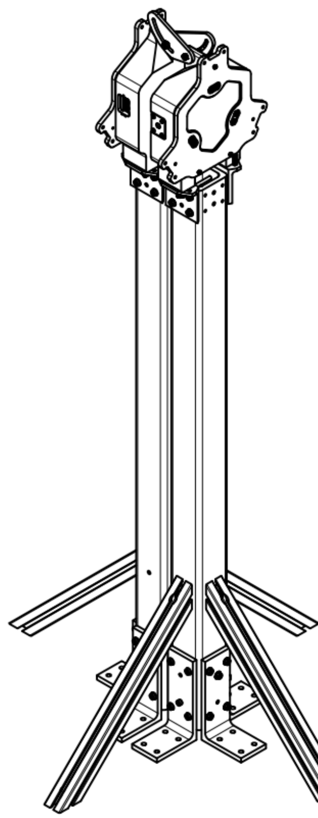


Fig. 10. FMUs On the Stands - Overview for Dual Motor Setup

Before Step 2, we recommend installing the motor on the motor mounting plate first. Fully tighten the fasteners on the motor with an adequate torque. If you wish to install the PT-100 temperature sensor inside the motor's chamber, you may apply the sensor at this step, with thermal glue.

When using an out-runner brushless motor, please install the motor on the indicated side of the mounting plate. See the laser engraving on the plate for more information.

Step 2. Install the optical RPM probe, the standoffs, and the positioning pins on the motor mount

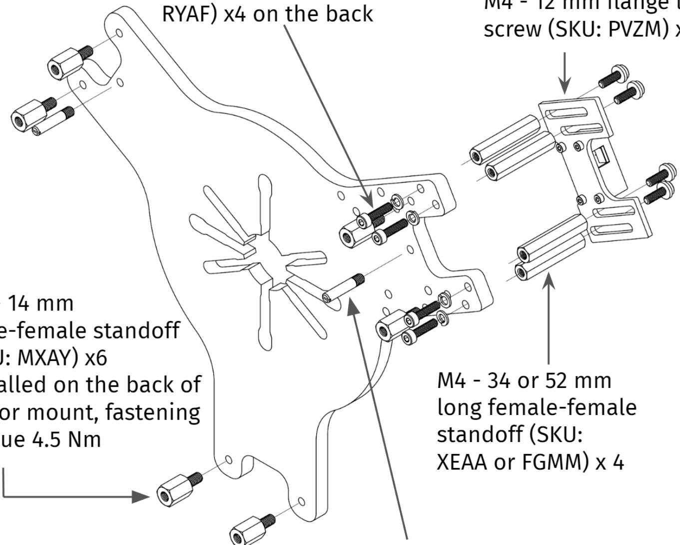


Fig. 11. Motor Mount - Optical RPM Probe and Standoffs

First, install the six M5 male-female standoffs and two M5 - 25 mm threaded pins on the opposite side of the motor. The standoffs require a tightening torque of 4.5 Nm.

Install the optical RPM probe on the same side of the outrunner motor, using the standoffs and fasteners provided in the bag. Several lengths of M4 female-female standoffs were provided so that you can adjust the position of the optical RPM probe in order to adapt to your motor’s height.

Apply loctite to the fasteners on the optical RPM probe.

Before step 3, please make sure that the motor is properly fixed on the motor mount with sufficient fastening torque. Do not put the propeller on the motor before this step, and have at least two people working on the next step.

Step 3. Install the Motor Mount sub-assembly onto the FMU

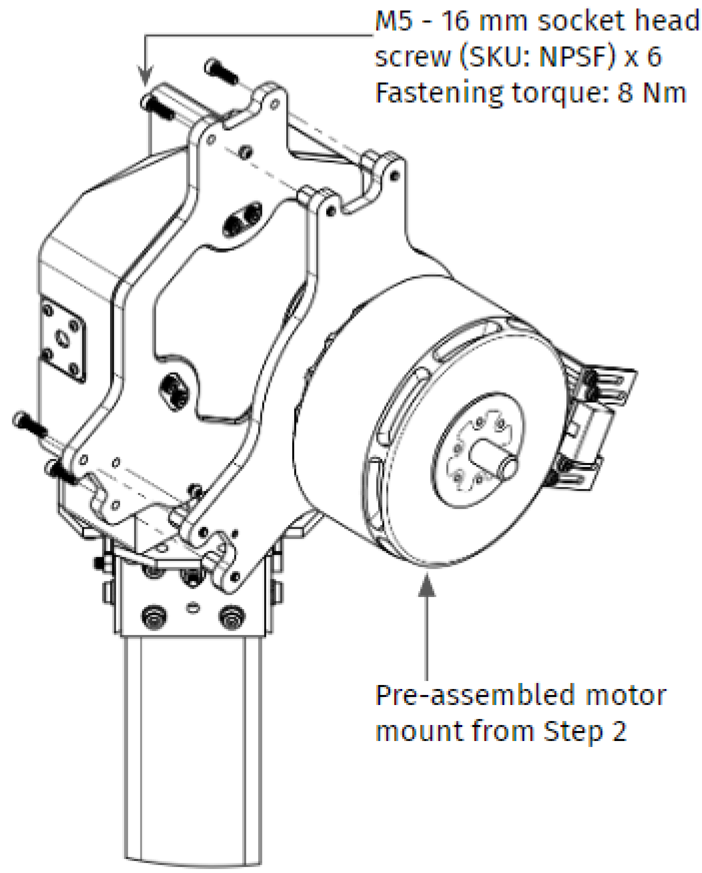


Fig. 12. Motor Mount - FMU Assembly

Align the motor mount assembly using the M5 threaded pins with the holes on the FMU front plate. Once aligned and positioned on the FMU, use the M5 - 16 mm socket head screws to fix the assembly with the M5 male-female standoffs, at the back of the motor mount. Fasten the screws with 8 Nm of torque.

Step 4. Use the Steelwriter pen provided in the auxiliary box to paint black and white sections on the rotor, as shown in Fig 13. The length of the white segment, indicated as L, should be at least 30 mm. Even if the rotor has black anodized aluminum, we recommend to paint it black anyway as any reflective surface may affect the infrared sensor. The black and white division should pass in front of the optical probe once per revolution.

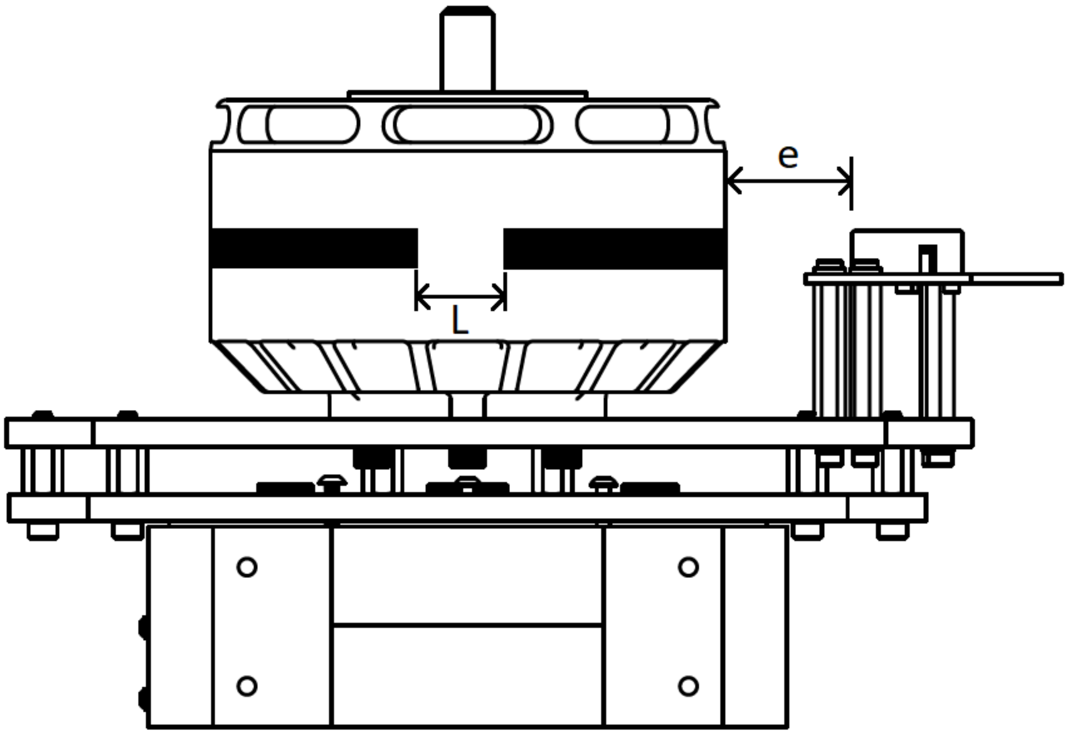


Fig. 13. Motor Mount - FMU Assembly

Alternatively, you may also attach a white or brightly colored piece of tape to the casing of the motor. However, if you are planning to perform endurance testing which lasts more than 15 mins, or using the stand in the pusher mode, we recommend to not use the tape for these applications.

Step 5. Adjust the position of the optical probe to make sure that the distance between the infrared sensor and the rotor, indicated as “e” in Fig 13, is 5 to 15 mm.

Step 6. Install the propeller on the motor.

Section 2.4 Installation of the Electrical Measurement Unit (EMU)

For this step, you need :

- Flight Stand - Electrical Measurement Unit (SKU: WCAL)

Open the EMU box, take out the EMU and read the installation guide.

Step 1. Install the EMU on any solid surface.

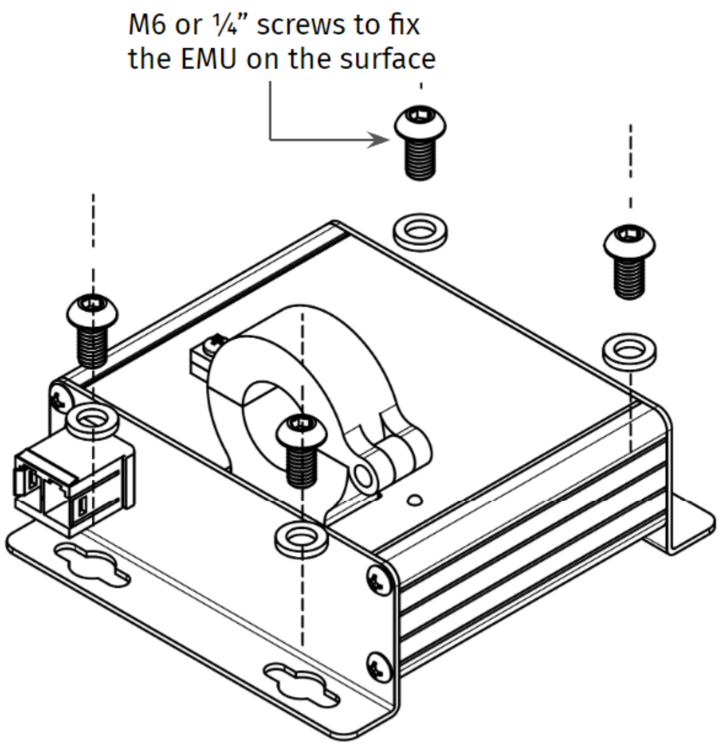


Fig. 14. EMU Installation

Ideally, the EMU will be as close to the ESC as possible. Therefore, we suggest installing it next to the stand.

You must install the EMU on a secured surface, with M6 or ¼” screws, according to the equipment you have available. Please take note that during dynamic testing, strong airflow may create low-pressure that may blow up any unsecured items. Any movement to the EMU can affect its current measurements. We recommend fixing it to the ground, or to a wall, or on top of a piece of metal or plywood, and secure the whole fixture with ground screws, anchors, or counterweights.

Section 2.5 Wiring and Cable Connection

You may now start connecting the cables and wires for the Flight Stand.

To start, you need :

- 1 x SKU#: WMHX - Flight Stand - Sync Hub

Step 1. Power up the Sync hub with the 9 V, 2 A power adaptor, and connect the USB between the sync hub and your PC.

Step 2. Connect the M8 cable between the Force Measurement Unit and the sync hub.

Step 3. Connect the M8 cable between the Electrical Measurement Unit and the sync hub.

Open the Flight Stand Software to see if the Force Measurement Unit and Electrical Measurement Unit are detected. You will see a green icon with the name and serial number on the connectivity panel of the software.

Prepare the power source, such as a power supply or battery pack that will be used for the test. It is your responsibility to choose the correct rating for the cables and connectors.

Step 4. Feed the positive wire through the hall sensor. For best measurement, the red and the black wire should not be close to each other. This step will allow the Hall Sensor to measure the DC current input to the ESC.

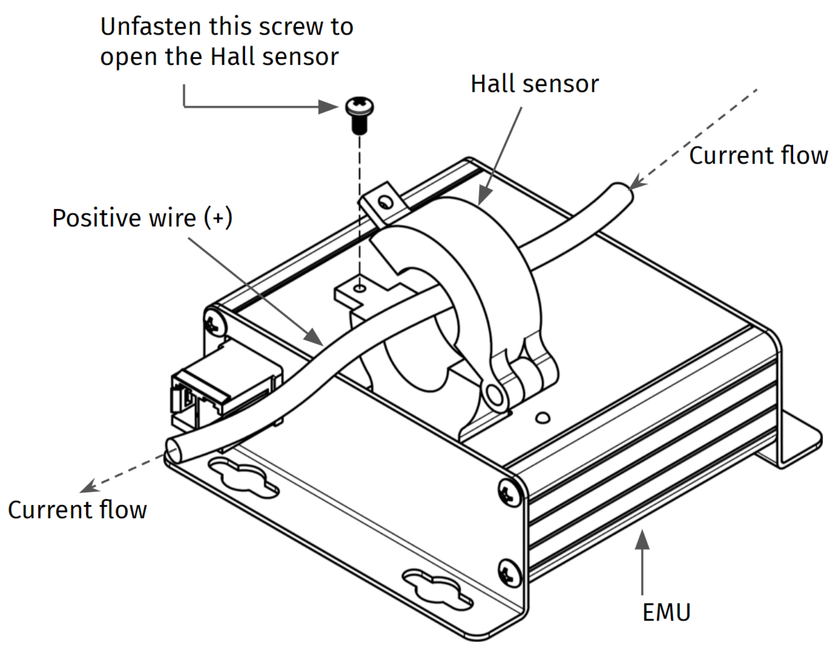


Fig. 15. EMU Wire Installation.

Step 5. Strip the power cord ends and connect them to the voltage measurement port as shown below:

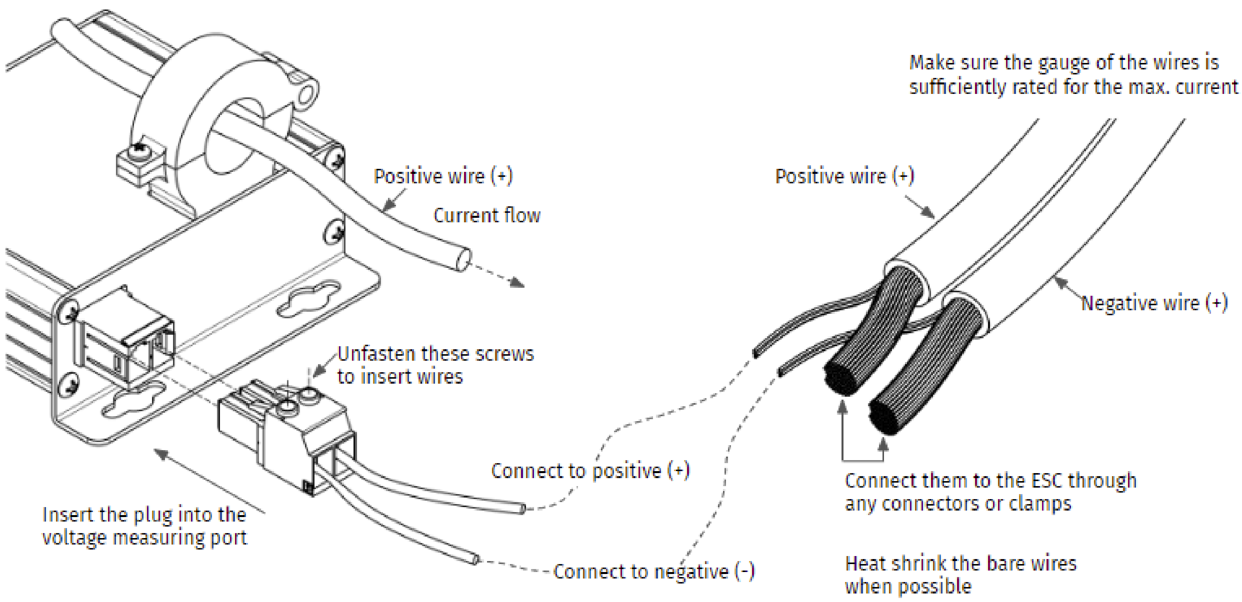


Fig. 16. Voltage Measurement Port Installation

Step 6. On the FMU check the connections between :

- The optical RPM probe to the FMU, using the JST 3-pin wire supplied within the optical RPM probe bag
- Any PT-100 temperature sensor to the TEMP 1 or TEMP 2 ports
- The ESC PWM input to the ESC port on the FMU

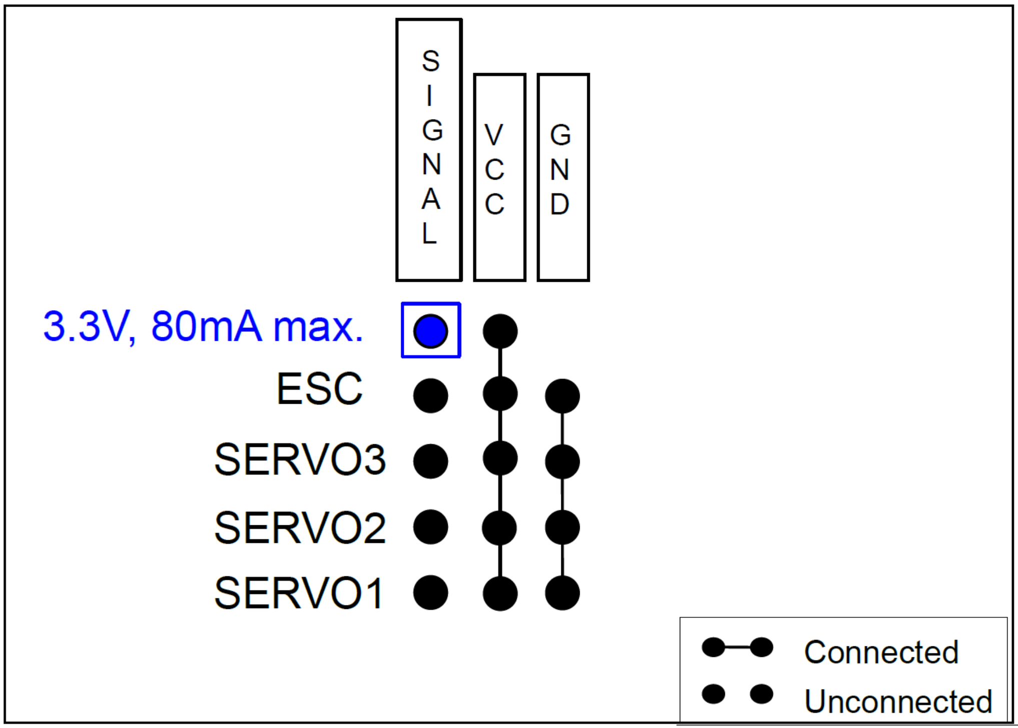
Step 7. On the motor, check the power wires and the ESC connection.

Step 8. On the Stand, use the cable ties to secure all loosen cables to the stand except for the three-phase wires between ESC and motor.

Step 9. Perform a test run at a lower voltage, confirm the rotation speed direction, and then fully tie-wrap all cables.

Note: The control pins on the FMU are ordered: Servo 1, Servo 2, Servo 3, ESC.

Here is the pinout diagram of the ESC (Electronic Speed Controller) breakout board. Please examine the diagram and silk screens closely to familiarize yourself with the layout and functionalities of the various pins:



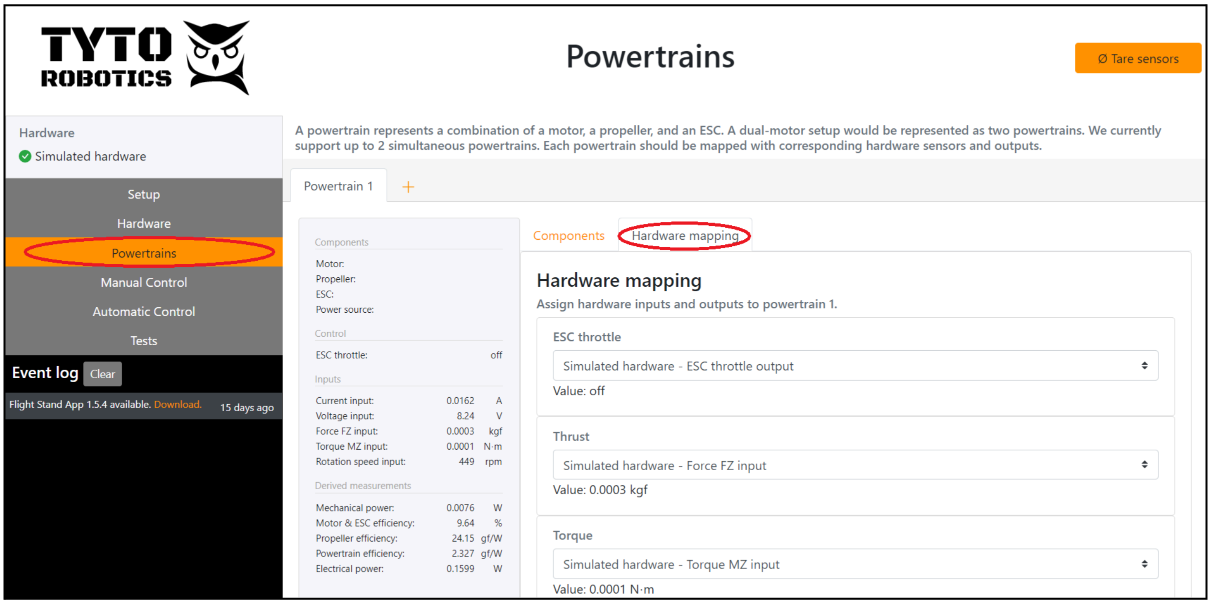
1. 3.3V Pin: You will find a single 3.3V pin, which is used to supply a constant voltage of 3.3 volts (80mA max.). Most ESCs work with 3.3V.
2. Ground Pins: All ground pins on the board are interconnected, providing a common ground reference.
3. VCC Pins: There are four VCC pins that are interconnected but do not carry any voltage by default. This unique design feature allows you the flexibility to supply your preferred VCC voltage to the ESC or Servo. You can power the VCC rail from the 3.3V pin (80mA max), from an ESC with a BEC, or from an external power supply. To power the VCC rail with 3.3V, connect the two top pins together.

If your ESC is not working, it may be because it is not receiving power. See point 3 above

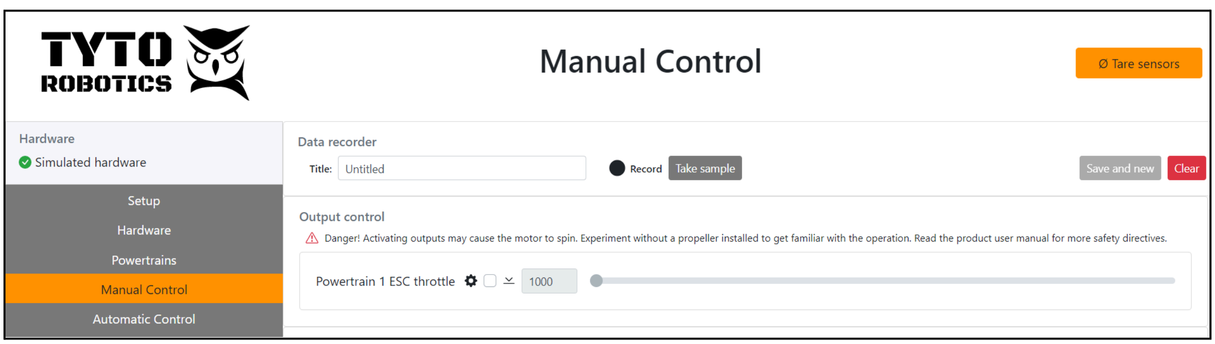
Chapter 3. Software Setup

Section 3.1. Software Setup and Test Run.

Step 1. Go to the “**Powertrains**” tab, and then “**Hardhare mapping**” to define powertrain components.
Step 2. Leave the test place and close the enclosure.



Step 3. Turn on the power and do a quick low-speed test run to determine the rotation direction using manual control. If the rotation direction is wrong, turn off the power and switch 2 cables on the three-phase between ESC and the motor. Then re-run the quick test.



Step 4. Check if every sensor works properly by watching values on the software.

Turn off the power. And tie wrap all cables the three-phase between ESC and motor included.

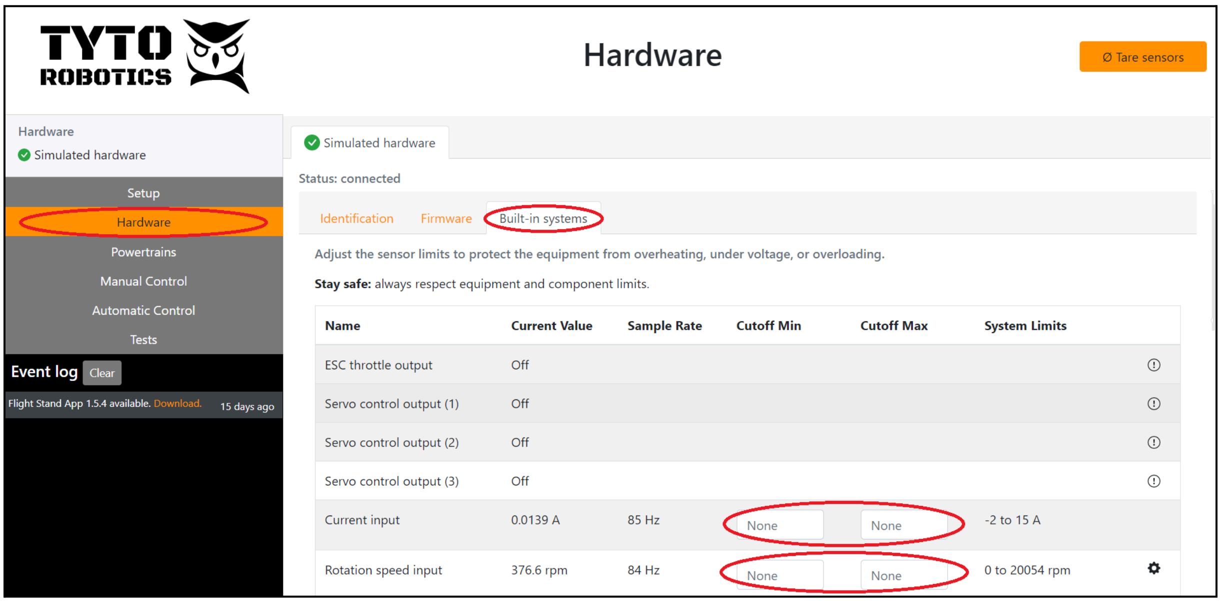
Chapter 4. Testing

Section 4.1. Manual Test

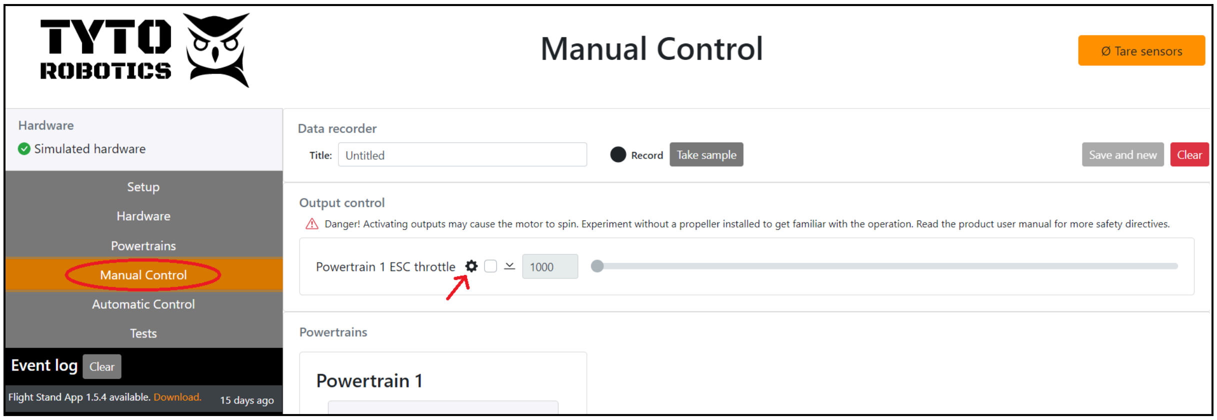
<u>You have to do these steps before each test :</u>

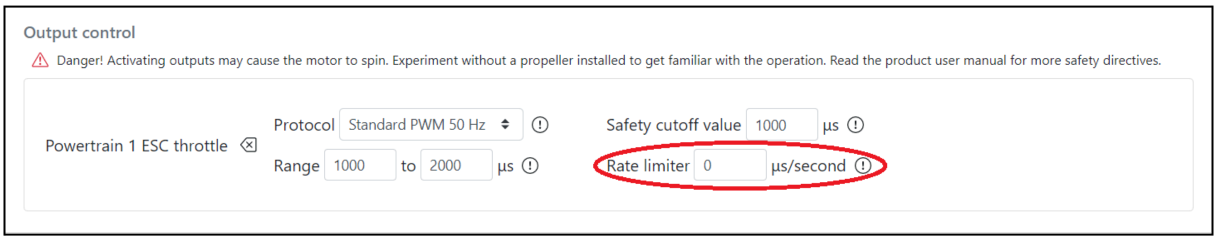
Step 1. Do a thorough **ground inspection** and remove anything you find that could fly off or away, especially small parts.

Step 2. Select safety limits in the software:

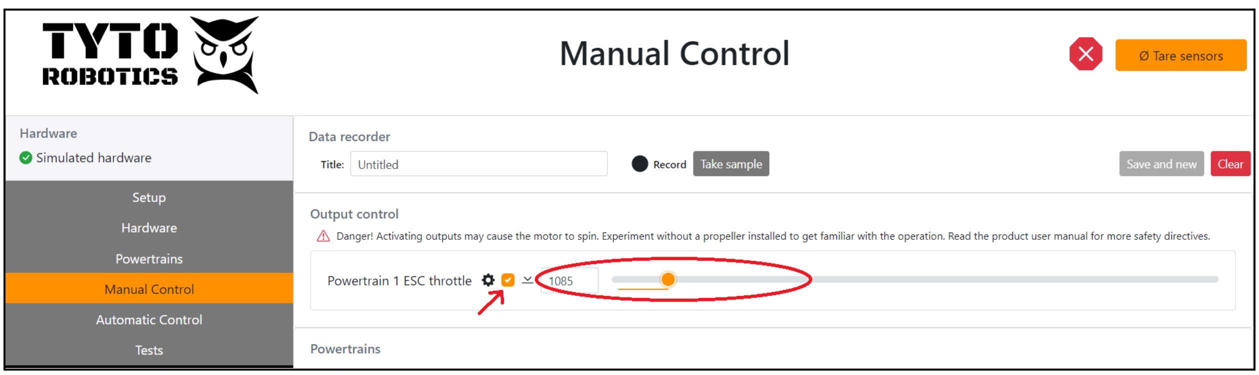


Step 3. Select the rate limiter setting:

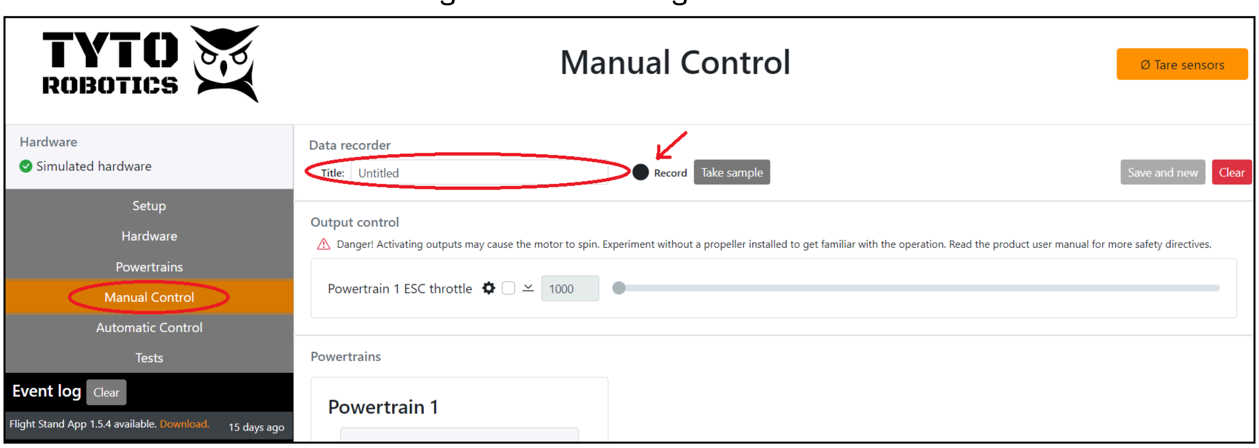




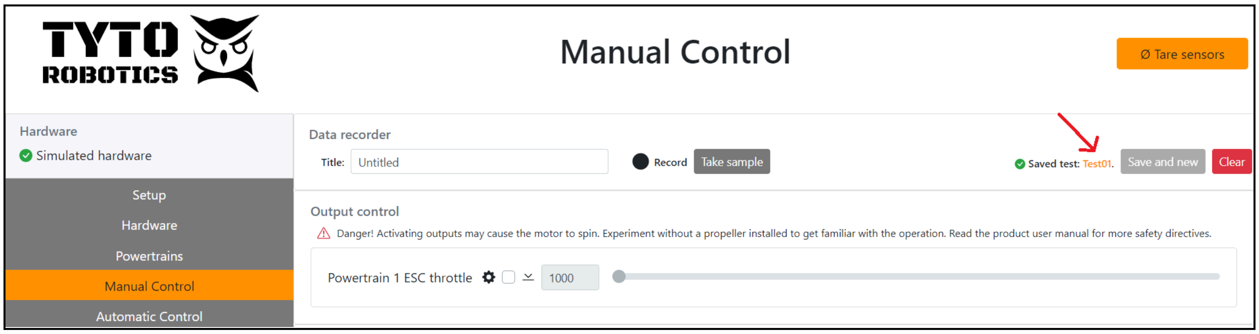
Step 4. You can now start the test by turning the power on, naming and starting the test.



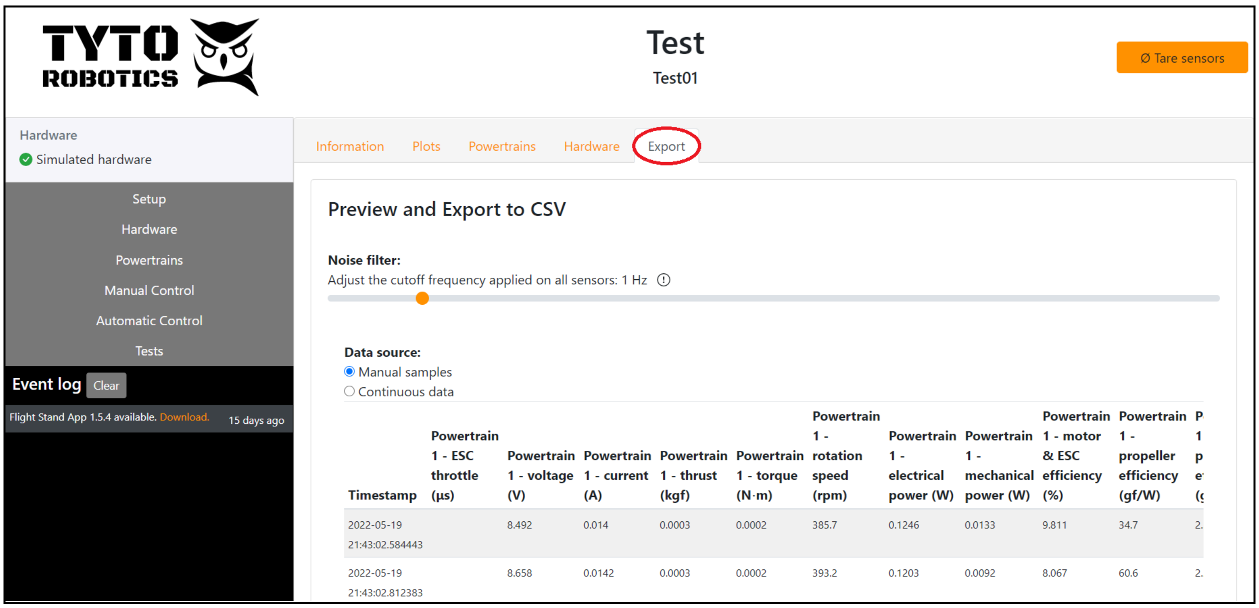
Use the manual control tab during the test to change the RPM.

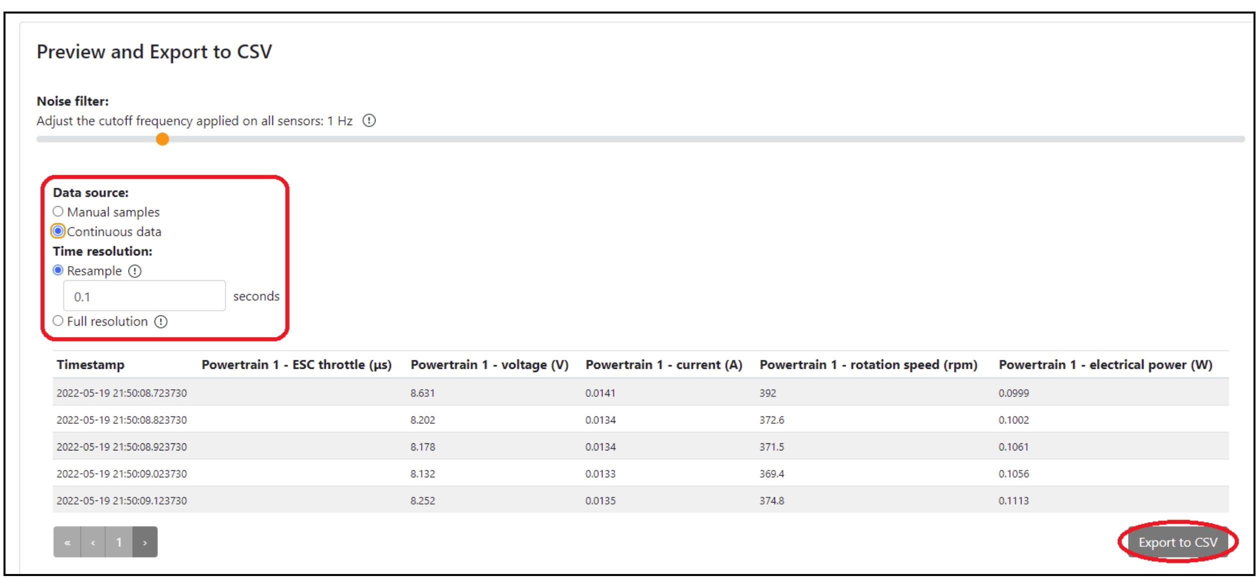


Step 5. Once you've done you can stop the motor, then record and turn the power off.



Step 6. Export the CSV file at the selected data acquisition.



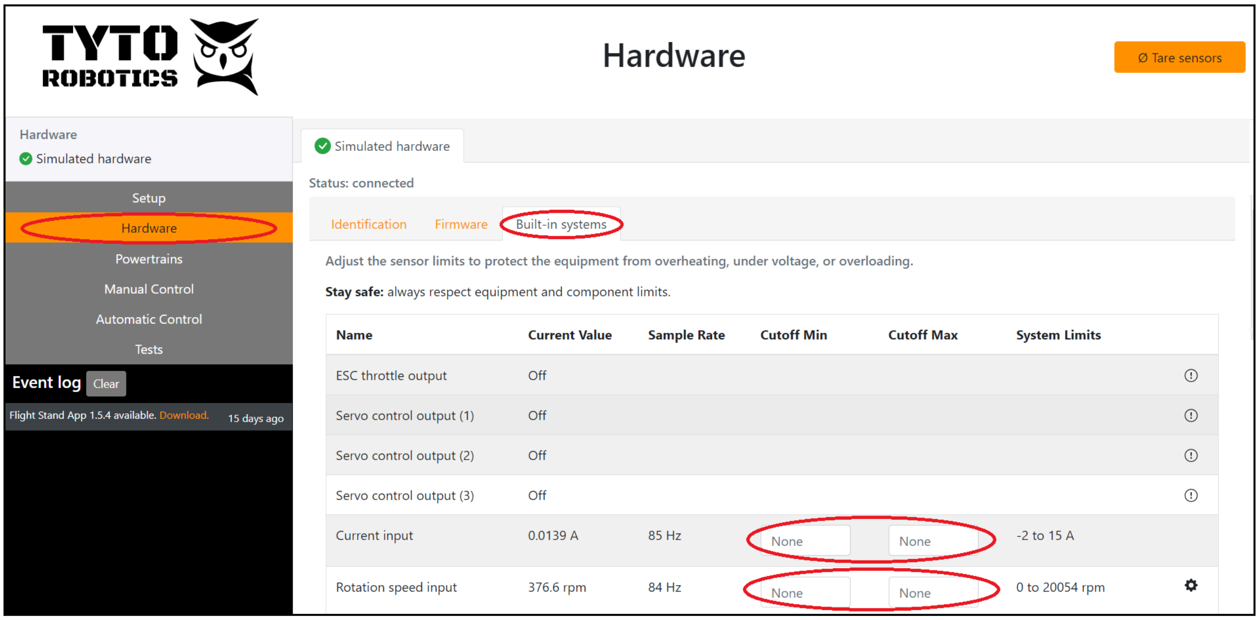


Section 4.2 Automatic test

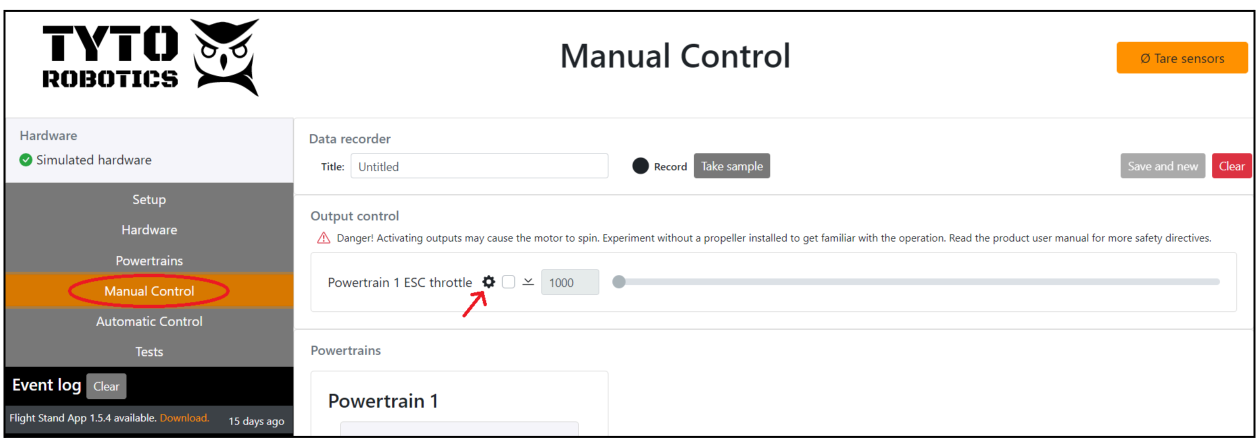
<u>You have to do these steps before each test :</u>

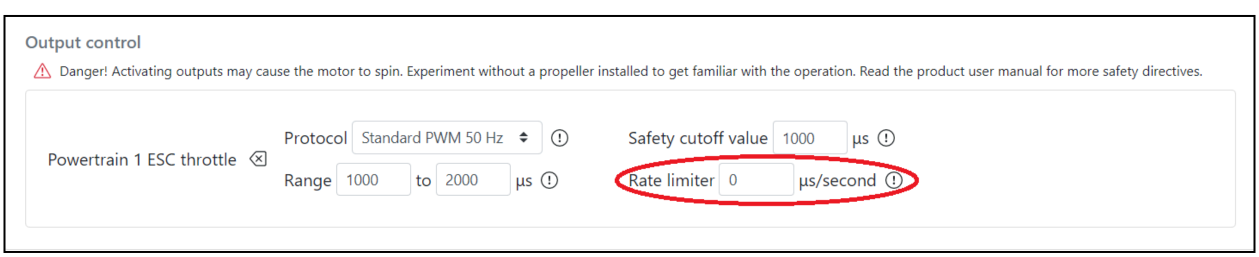
Step 1. Do a thorough **ground inspection** and remove anything you find, especially small parts.

Step 2. Select safety limits in the software:



Step 3. Select the rate limiter setting:

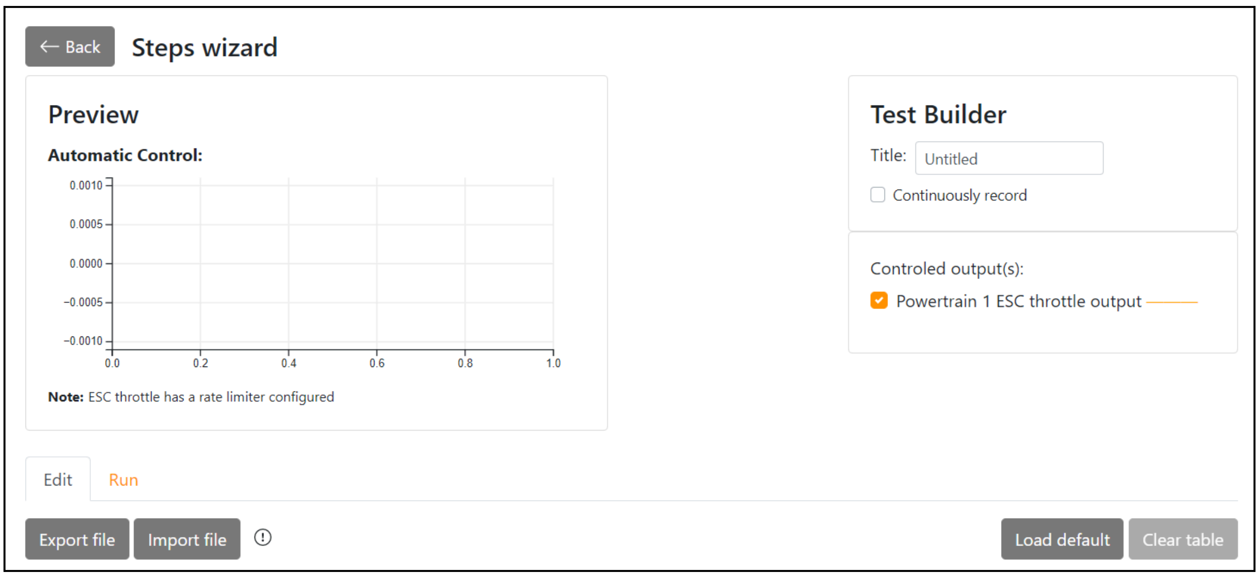


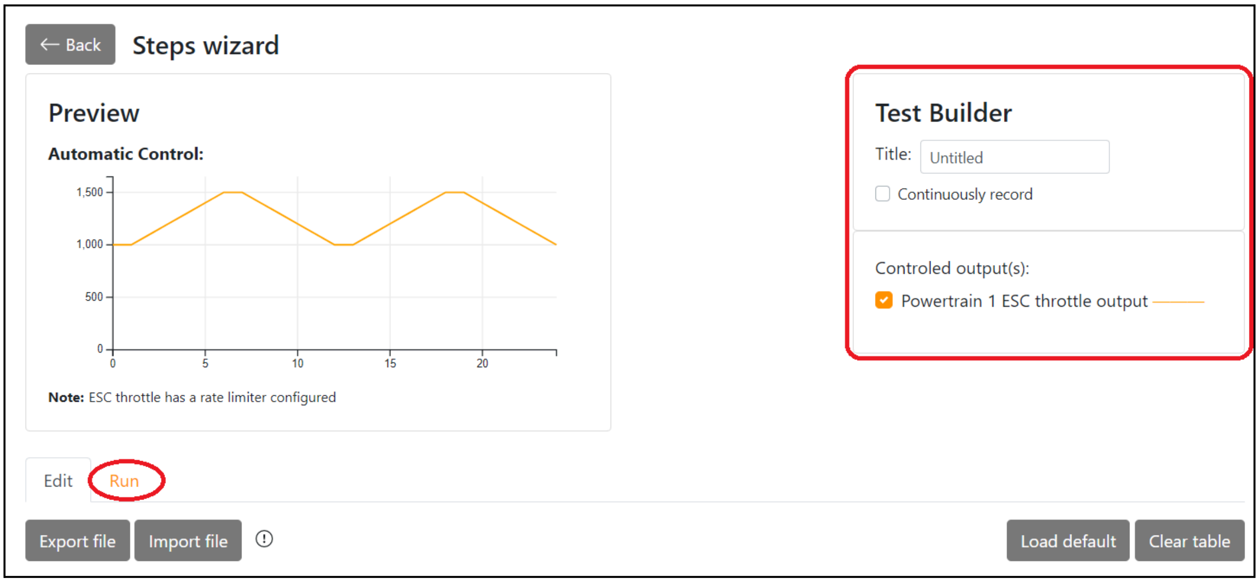


Step 4. Prepare the automatic control:

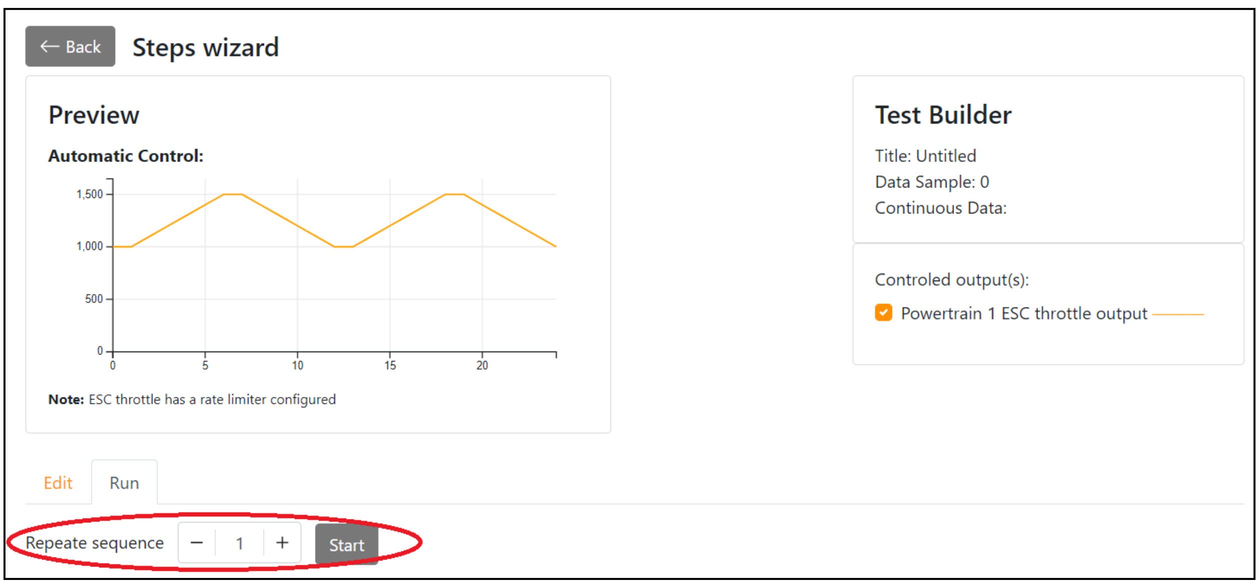
4.1 Select either Steps or Ramp depending on what type of test you want to run.

4.2 You can either import a CSV file, load default values or fill the table.

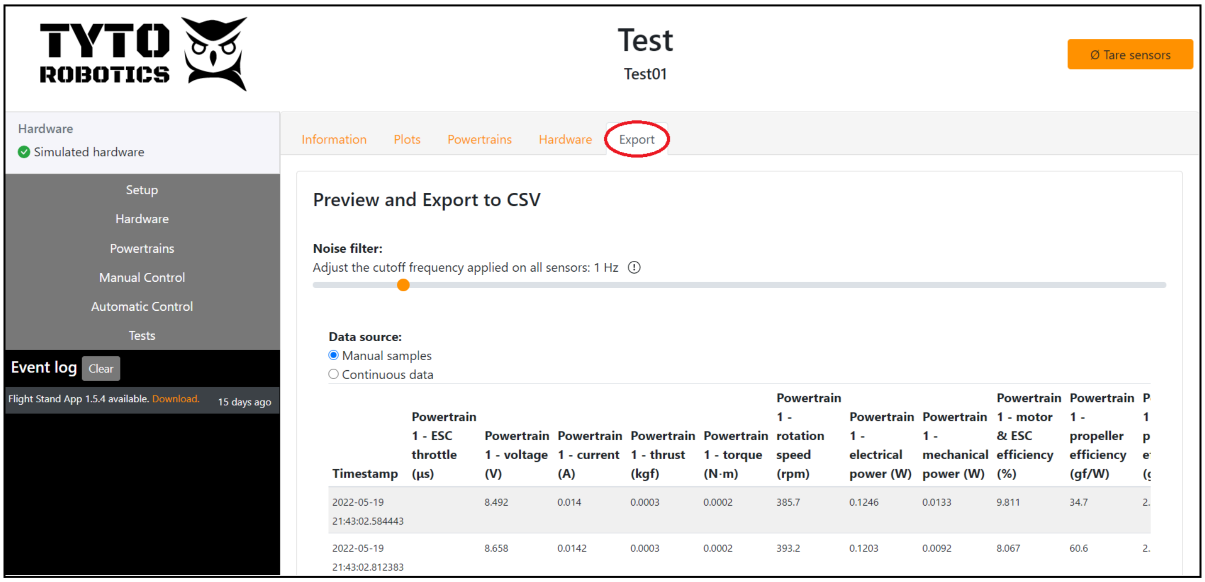




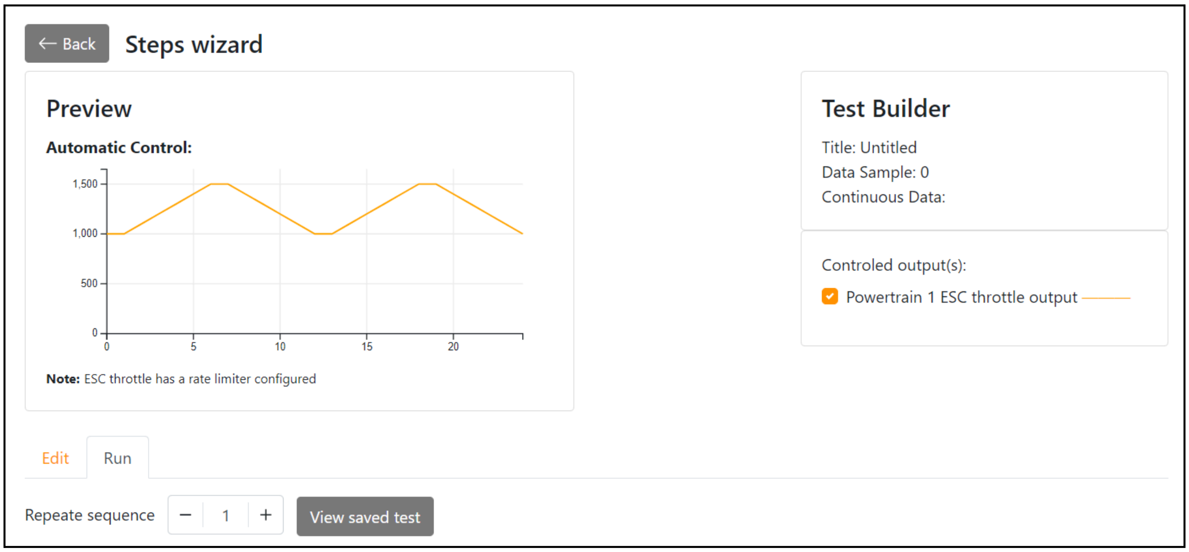
Step 5. Select the number of sequences you want, and then press start to run the sequence.

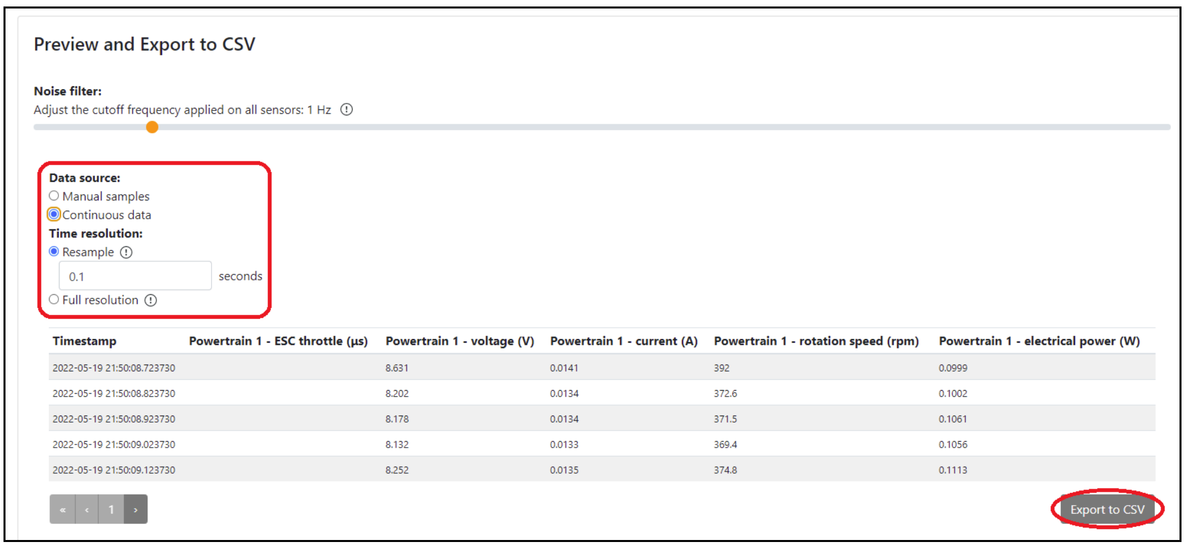


Step 6.
Once the test is finished, you can click “view saved test” to see the record you just made.



Step 7. Export the CSV file at the selected data acquisition.





Timestamp	Powertrain 1 - ESC throttle (µs)	Powertrain 1 - voltage (V)	Powertrain 1 - current (A)	Powertrain 1 - rotation speed (rpm)	Powertrain 1 - electrical power (W)
2022-05-19 21:50:08.723730		8.631	0.0141	392	0.0999
2022-05-19 21:50:08.823730		8.202	0.0134	372.6	0.1002
2022-05-19 21:50:08.923730		8.178	0.0134	371.5	0.1061
2022-05-19 21:50:09.023730		8.132	0.0133	369.4	0.1056
2022-05-19 21:50:09.123730		8.252	0.0135	374.8	0.1113