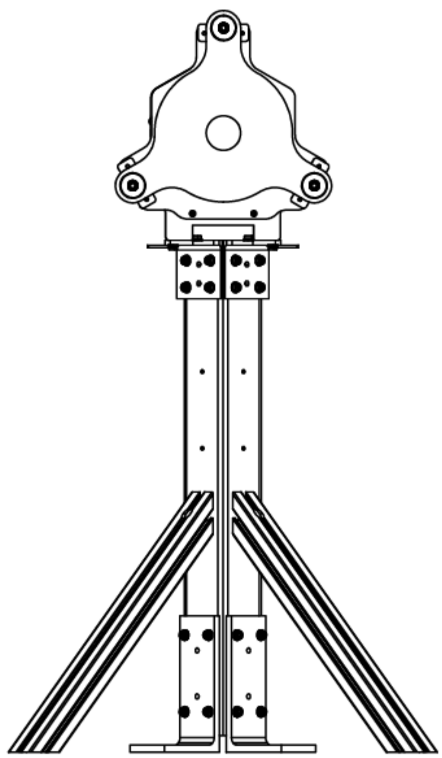
Flight Stand 60 User Manual

Version 1.0



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Section 1.1 Introduction and Item Checklist

The Flight Stand 60 Engine Test Stand allows users to test gas engines and propellers producing up to 60 kgf of thrust and 30 Nm of torque. It can measure a fuel flow rate from 20 ml/min to 800 ml/min.

The Flight Stand 60 Engine Test Stand can be used indoors or outdoors. When using the stand indoors, you must direct the products of the exhaust or canisters of the engine outside the building. If using the stand outdoors, note that the sensors and data-acquisition unit can not be operated under rainy, snowy, or icing conditions.

IMPORTANT: a minimum of **three people** are required to complete this assembly.

You may use the following item checklist to verify the contents of the product boxes.

	Flight Stand 60 Engine Test Stand
Flight Stand 60 Engine Test Stand - Main Box SKU#4A4Q	1x SKU#ZFGZ - Flight Stand 60 - Force Measurement Unit 60 kgf - 30 Nm
	1x SKU#FP37 - Flight Stand 60 - Auxiliary Sensor Box
	1x SKU#J4N8 - Flight Stand 60 - Motor Mounting Plate
	1x SKU#E6NC - Flight Stand 60 - Auxiliary Components Box
Flight Stand 60 - Stand SKU#8PF7	2x SKU#ZBMK - 45 degree 480 mm long support
	1x SKU#F6JD - Flight Stand 60 - Square tube
Flight Stand 60/150 Pro - Stand fixtures SKU#WJRU	1x SKU#KDNN - Flight Stand 60/150 Pro - Stand fastener bag
	4x SKU#FCQD - Flight Stand 60/150 Pro - Lower fixation L-bracket
	4x SKU#QHXS - Flight Stand 60/150 Pro - Upper fixation L-bracket
Flight Stand 60 Fiber Optic Sensor Kit SKU#9F8D	1x SKU#BFXA - Fixture parts of Flight Stand 60/150
	1x SKU#CDAK - Engine testing fiber optic
	1x SKU#X9Q4 - Optic fiber sensor amplifier
	1x SKU#H9KC - Optic fiber converter
Flight Stand DAQ Kit SKU#RJ3F	1x SKU#BYCE - Flight Stand DAQ
	1x SKU#WQFF - 9V, 2A power adaptor in box
	1x SKU#RKVR - USB cable type A/B 1.8 m
	1x SKU#M84P - Sync cable 4 ft
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 outdoors up to 60 kgf of thrust and 30 Nm of torque with real engines. It must always be used in a safe environment and operators must maintain a far enough distance from the work station to ensure safety in the case of an engine or propeller failure. Any abuse or misuse of the stand may result in damage to the equipment or injury to the operators.

To ensure safety, please follow these instructions:

1. Never work alone.
2. Always test in an area designed to safely withstand a catastrophic propeller failure.
3. Know the limits of the engine, the propeller, and the tool. Never overload them.
4. Tighten the fasteners to the rated torque.
5. Do not substitute parts or modify the test stand.
6. Keep the test area clean, propellers can create suction and damage equipment or hurt people.
7. Use the properly rated fuel and oil, as well as the correct ratio of oil/gas.
8. Stay away from the Flight Stand when a test starts.
9. Electrically cut off the ignition power when approaching the stand for any reason.
10. Stop the test immediately when you observe significant vibration.
11. After any test, let the engine cool down before performing any intervention.
12. If unsure, contact our technical support team or the engine's manufacturer.

Chapter 2. Installation Guide

Section 2.1 Stand Assembly

Open the following boxes and retrieve these items:

- Flight Stand 60 Stand Beam - Square Tube
- Flight Stand 60/150 Stand Fixture - Lower L bracket x 4
- Flight Stand 60/150 Stand Fixture - Upper L bracket x 4
- Flight Stand 60/150 - 45 degree support 480 mm long x 2
- Flight Stand 60 Main Box - Auxiliary Box:
    - Stand Fastener Bag
    - Hand Tool Bag

You will use the items listed above to install the stand:

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

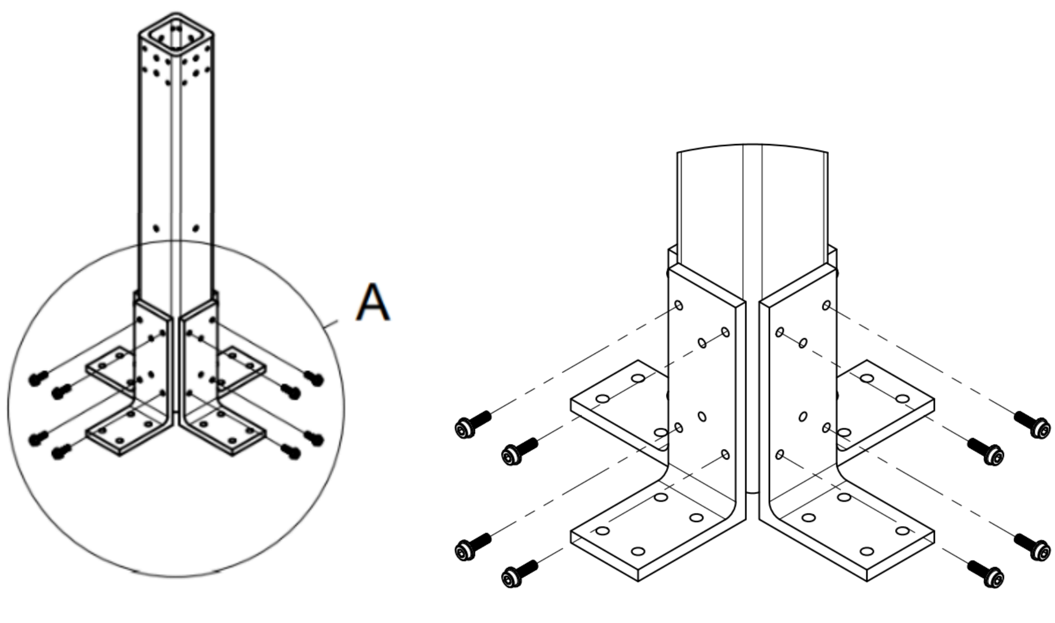


Fig. 1. Stand Assembly - Lower Section with L-Brackets

Fastening torque:

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

Step 2. Reinforce the lower structure with long bolts

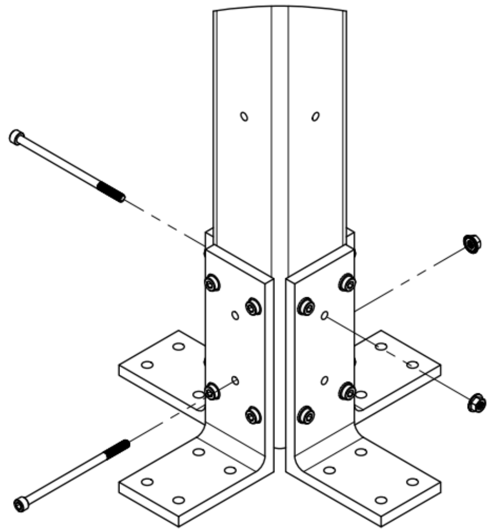


Fig. 2. Stand Assembly - Lower Section with Reinforcement Bolts

Install two M6 - 110 mm socket head screws and two M6 flange serrated lock nuts (Fig. 2.) Install them on adjacent sides to distribute the mechanical stress across the four L-brackets.

Fastening torque:

- M6 - 110 mm screw and nut: 13 Nm

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

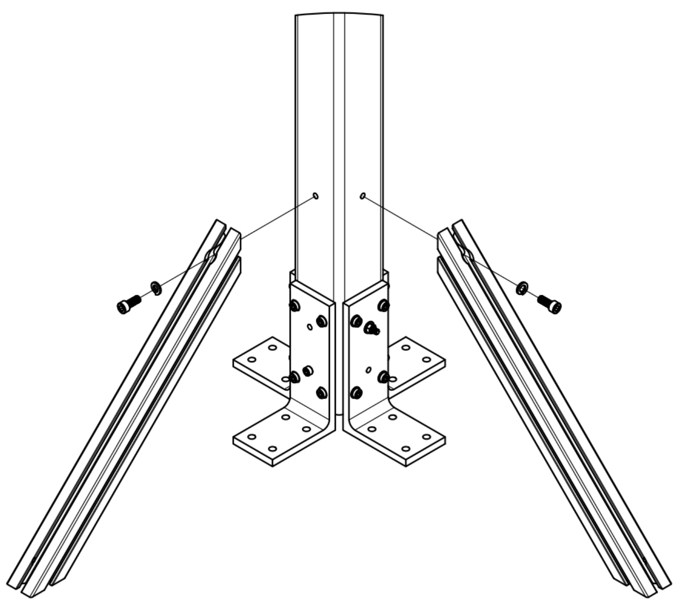


Fig. 3. Stand Assembly - Lower Section with 45-Degree Support Beams

The 45-degree support beams can be installed on any of two surfaces adjacent to each other on the stand. When placing the stand, the 45-degree support beams must be oriented on the opposite side as the engine. 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 4. Install four upper L-brackets to the stand.

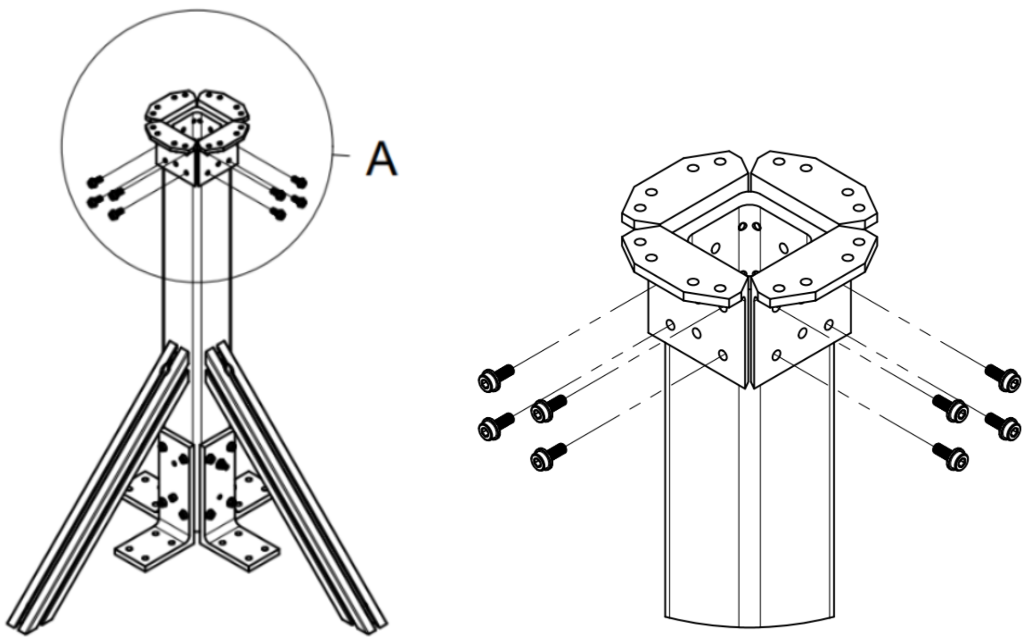


Fig. 4. Stand Assembly - Upper Section with four L-Brackets

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

Do not install the reinforcement bolts on the upper section, as you will use these holes to affix the fiber optic RPM sensor at a later step.

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 properly to a ground structure. Under most circumstances, where the engine shall be tested outdoors, we recommend building a ground base with metal profiles like those shown in the image below:

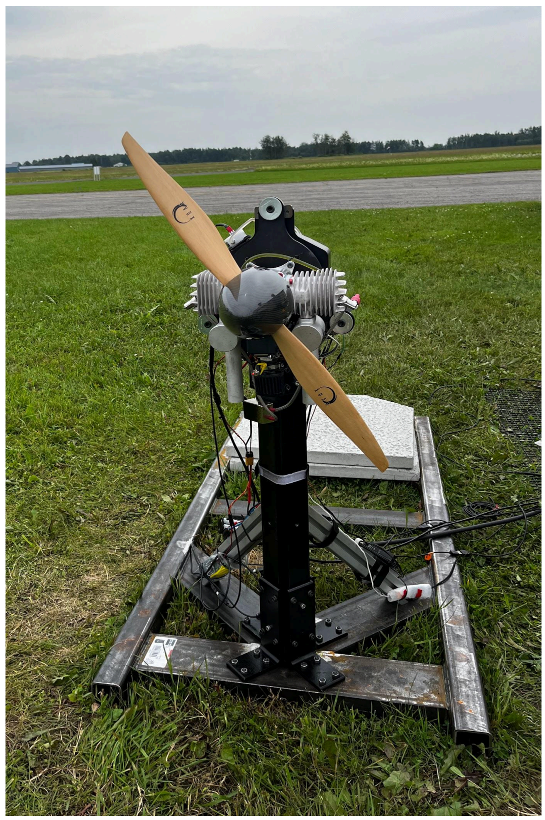


Fig. 5. Ground base for engine test stand

Tyto Robotics does not sell or supply this ground base assembly. You will need to design and build a ground structure with components available in your local market. Make sure to carefully perform calculations for stress, length of the rails, and the total mass required for the counterweights.

The lower L-brackets and the 45-degree supports are compatible with both metric M8 fasteners and imperial 5/16” fasteners.

❗❗❗IMPORTANT❗❗❗

The stand has to be placed in a vacant area without rocks or stones. Make sure to use sufficiently heavy counterweights if you place the stand and ground structure on grass. Fully tighten all fasteners to the recommended torque as severe vibration can damage the load cell, which would require a replacement and/or recalibration.

If you notice unusual vibration, stop the test by cutting off power to the ignition unit and check your setup. Make the stand base sufficiently rigid. Contact support in case of doubt.

Section 2.3 Force Measurement Unit (FMU) and Motor Mounting

Retrieve the following items from the main box:

- Flight Stand 60 Force Measurement Unit
- Flight Stand 60 ICE Engine Mounting Plate
- Flight Stand 60 Auxiliary Components Box
    - FS60 Engine Mounting Fastener Bag
    - FS60 FMU Stand Fastener Bag
    - Tie-wrap 0.1" Width, 8" Long, Black
    - Hook and Loop Cable Ties 11" Overall Length

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, please make sure that the front plate is installed on the opposite side as the 45-degree support beams.

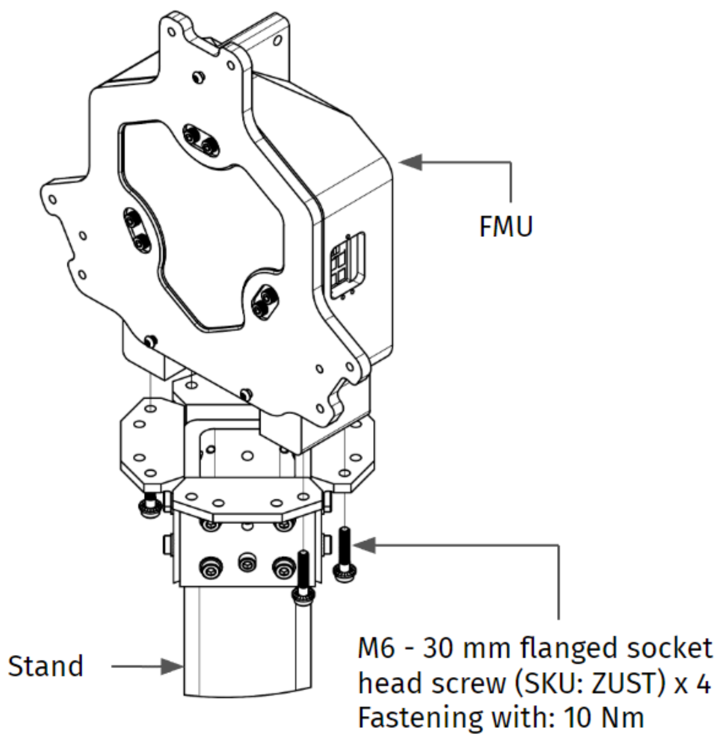


Fig. 6. FMU on the Stand

Step 2. Open the motor mounting plate fastener bag (SKU: A8AJ) and retrieve the three metal spacers, then install those on the FMU with six M5 - 15 mm SHCS:

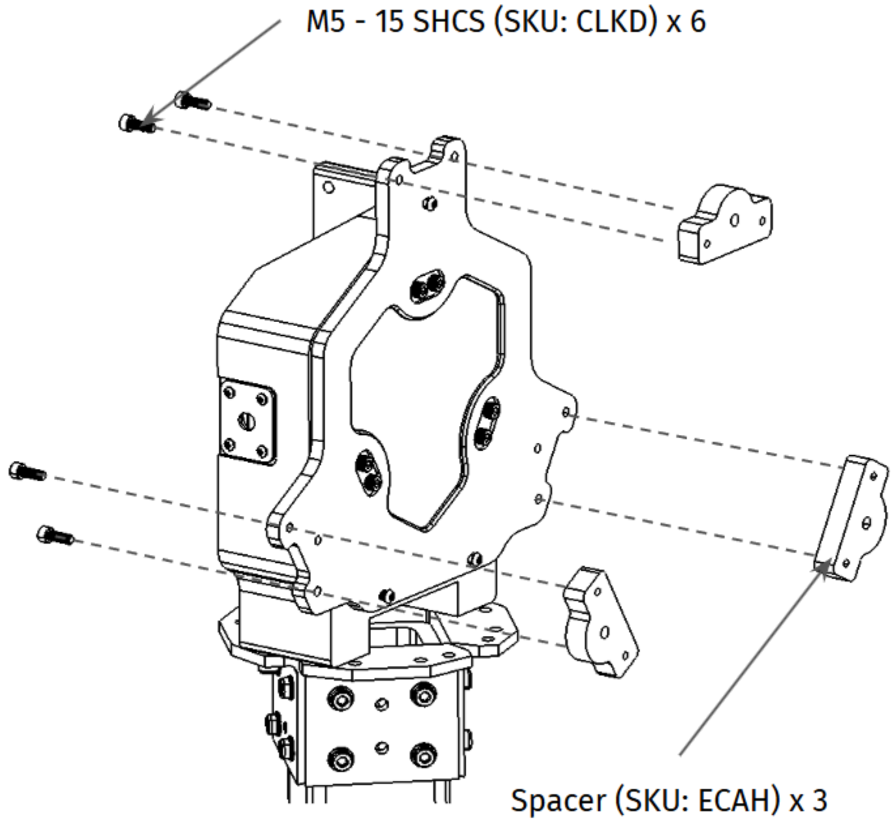


Fig. 7. Install spacers on the FMU

Fastening torque:

- M5 - 15 mm socket head screw: 10 Nm

Step 3. Drill holes on the engine mounting plate and then install the engine on the plate.

The plate thickness is 9.53 mm (3/8 inches), we suggest confirming the engine's mounting points, and then marking the plate before drilling the holes. Most engines do not share the same mounting features. You may contact our sales team to purchase more engine mounting plates if you need multiple plates for different engines with different mounting points.

Some engines may require extra clearance for their canisters or exhausts, especially at the location where the vibration dampers are located with the 19.3 mm through holes. You may add spacers between the engine and the mounting plate if necessary. We recommend performing a test fit before putting the engine on the stand.

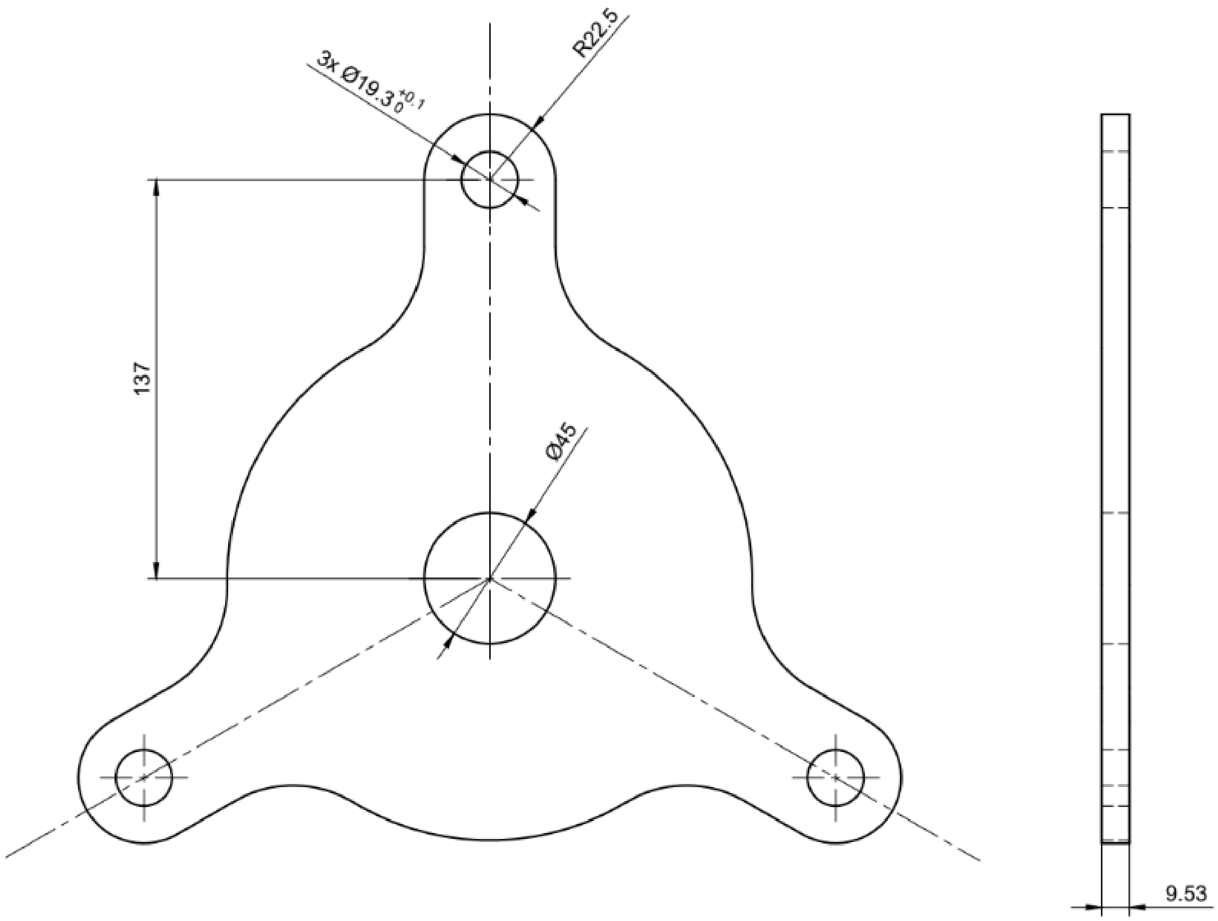


Fig. 8. Engine mounting plate

Step 4. Insert the vibration dampers onto the engine mounting plate.

We have provided three ratings of vibration dampers in the accessory box:

- Soft - for axial load up to 40 lbsf (18.1 kgf): RED DOT, 26830-1
- Medium - for axial load up to 90 lbsf (40.9 kgf): YELLOW DOT, 26831-1
- Hard - for axial load up to 140 lbsf (63.6 kgf): GREEN DOT, 26844-1

We recommend using the soft ones for engines smaller than 120 cc; and using the hard ones for engines larger than 200 cc.

You may apply grease to insert the male stud section of the vibration damper into the 19.3 mm hole on the engine mounting plate.

NOTE: the vibration damper requires a press fit to enter the 19.3 mm hole, please apply lubrificator accordingly.

Step 5. Installing the engine mounting plate already assembled with the engine and the vibration dampers on the FMU, with three M8 - 45 socket head cap screws.

IMPORTANT: the engine and its exhausts should have been installed on the engine mounting plate before this step.

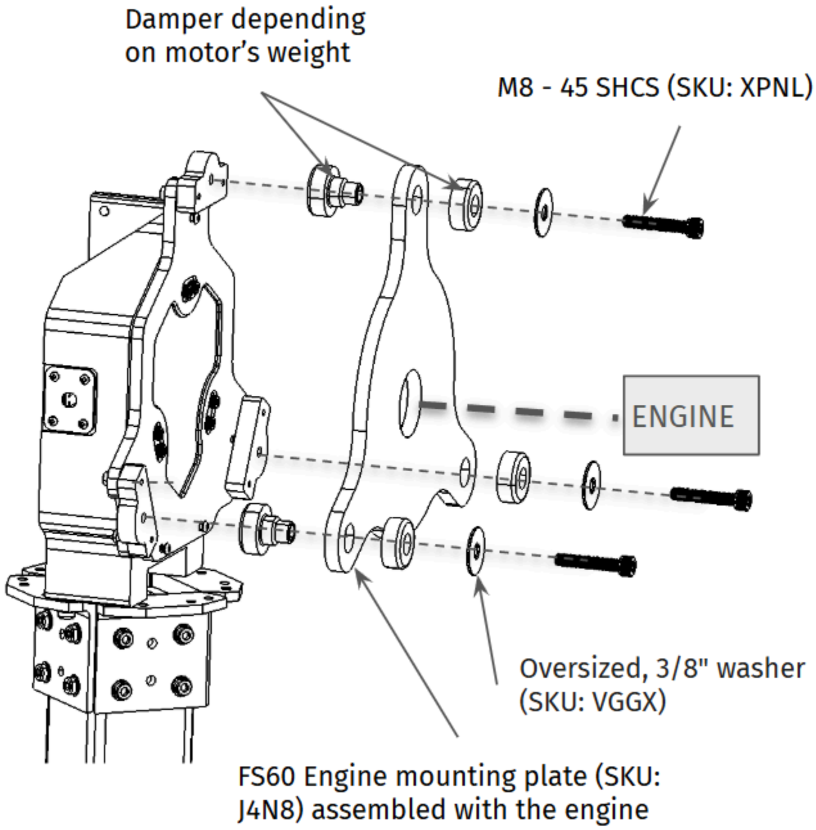


Fig. 9. Mount the engine mount with engine and vibration dampers

Fastening torque:

- M8 - 45 mm socket head screw: 30 Nm

Section 2.4 Installation of the Fiber optic RPM sensor

Retrieve the following items from the Flight Stand 60 Fiber Optic Sensor Kit (SKU: 9F8D):

- Fixture parts for Flight Stand 60/150
- Fiber optic for engine testing
- Protective tube for engine testing
- Fiber optic amplifier
- Fiber optic converter unit

You will also need to retrieve one 15 ft audio jack cable from the auxiliary box.

NOTE: The Flight Stand 60 and the Flight Stand 150 share the same fixture of the fiber optic, but the fiber sensor is different between gas engine and electrical powertrain.

IMPORTANT: The fiber **cannot** be bent to a radius under 40 mm or it will severely damage the quality of the signal!

Step 1. Install the arm holder (SKU: NCYP) on the Upper L-brackets of the stand with two M6 x 110 screws, two washers, and two hex nuts.

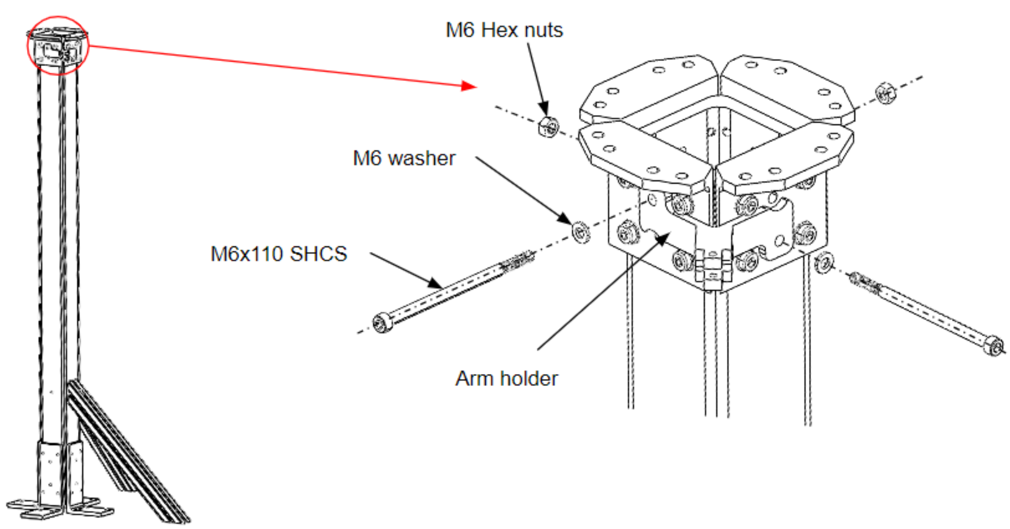


Fig. 10. Fiber arm holder on the Flight Stand 60 / 150

Step 2. Insert the arm into the arm holder, and then add the sensor holder on the arm and then tighten it by using M4 x 20 button head screws and M4 Lock nuts, as shown in Fig. 11.

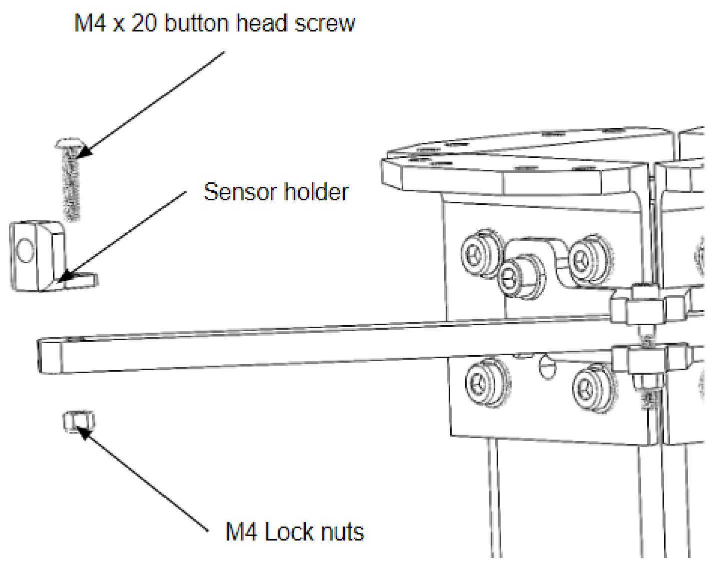


Fig. 11. Fiber sensor holder on the arm on the Flight Stand 60 / 150

Step 3. Insert the fiber optic sensor in the sensor holder.

Step 4. Tighten the M6 split lock washer by screwing the M6 steel hex nut on the external threading of the fiber optic sensor; apply adequate torque but **avoid applying excessive torque** to the nuts as it may damage the thread on the fiber head.

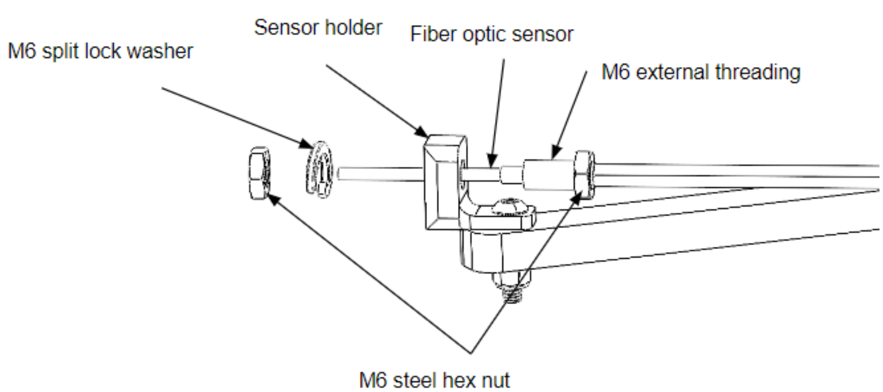


Fig. 12. Fiber optic sensor on the sensor holder on the Flight Stand 60 / 150

Step 5. Add the protective tube for the fiber optic, this will help the fiber to resist heat up to 130 degrees celsius.

Step 6. Adjust the sensor, so the light beam is as orthogonal as possible to the propeller. Maintain a distance L of around 30 mm.

NOTE: the propeller may have a significant pitch or curve, especially close to the center of the rotor, so make sure the closest point between the propeller and the fiber head is around 30 mm, and the furthermost point can be higher.

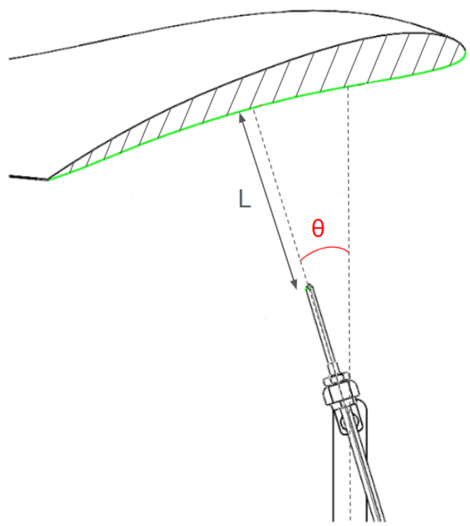


Fig. 13. Fiber optic sensor's position on the Flight Stand 60 / 150

Fig. 14. Fiber head at around 30 mm from the prop at the closest

Step 7. Install the amplifier holder on the support holder (SKU: 4XQE) with the M3 x 12 button head screws and the M3 lock nuts.

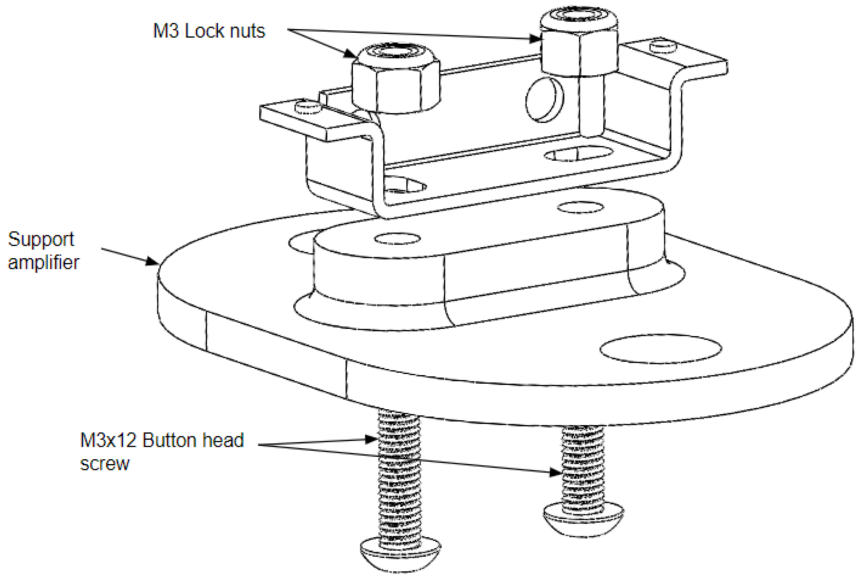


Fig. 15. Assembly of the support amplifier for the Flight Stand 60 / 150

Step 8. Add two M8 T-nuts into the 45-degree supports of the Flight Stand 60 / 150. Place the assembled amplifier support on the rails with the T-nuts and two M8 x 16 flanged button head screws.

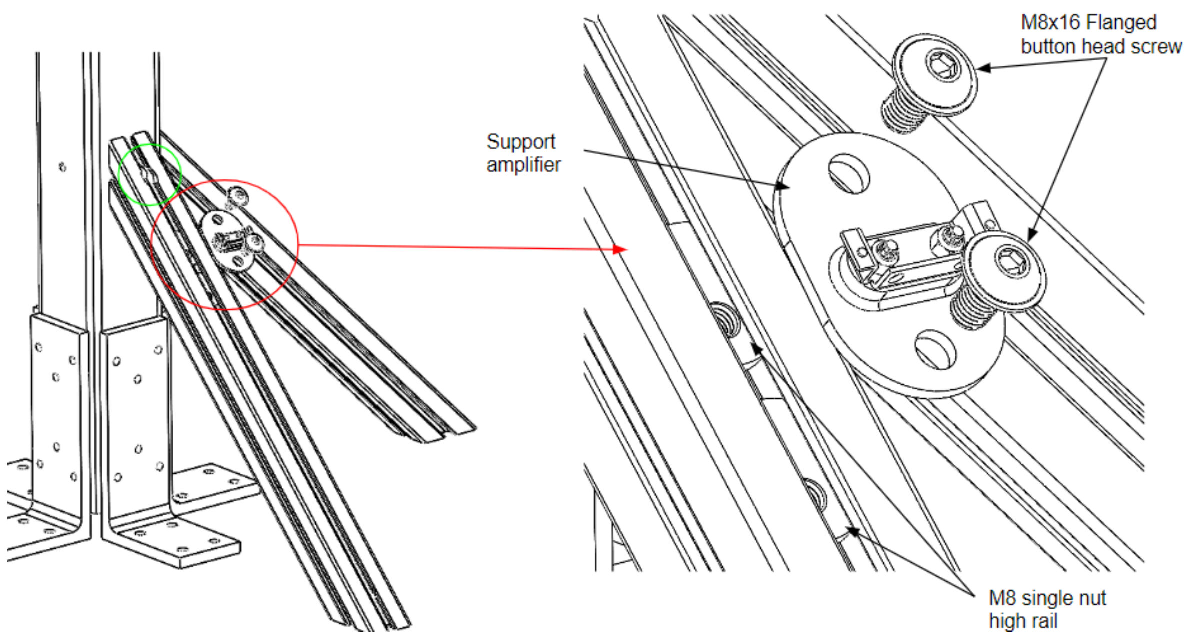
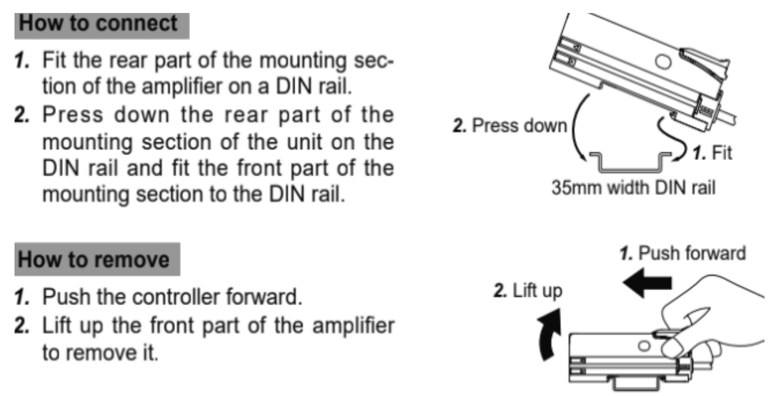


Fig. 16. Support amplifier on the Flight Stand 60 / 150

Fig. 17. Fiber optic amplifier on either of the 45-degree support

Step 9. Follow these instructions to mount the digital amplifier on the bracket (DIN rail) and connect the fiber cable linking the sensor to the digital amplifier.



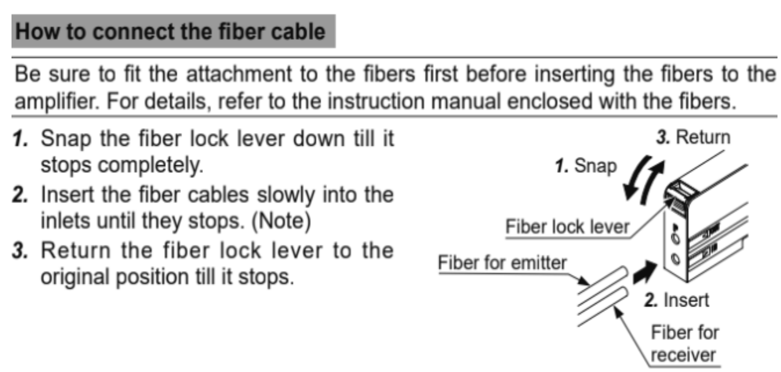
How to connect

1. Fit the rear part of the mounting section of the amplifier on a DIN rail.
2. Press down the rear part of the mounting section of the unit on the DIN rail and fit the front part of the mounting section to the DIN rail.

How to remove

1. Push the controller forward.
2. Lift up the front part of the amplifier to remove it.

Fig. 17. Mount the amplifier on a DIN rail



How to connect the fiber cable

Be sure to fit the attachment to the fibers first before inserting the fibers to the amplifier. For details, refer to the instruction manual enclosed with the fibers.

1. Snap the fiber lock lever down till it stops completely.
2. Insert the fiber cables slowly into the inlets until they stops. (Note)
3. Return the fiber lock lever to the original position till it stops.

Fig. 18. Connect the fiber cables on the amplifier

Step 10. Connect the electric cable Panasonic CN-73-C5 to the digital amplifier.

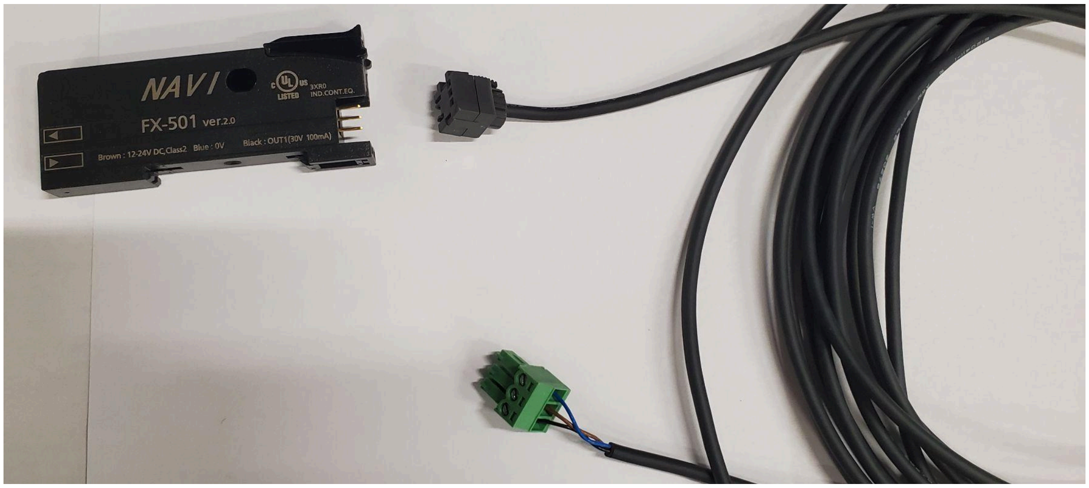


Fig. 19. Connection of the electrical wire to the amplifier

Step 11. Connect the screw terminal to the signal conditioning circuit.

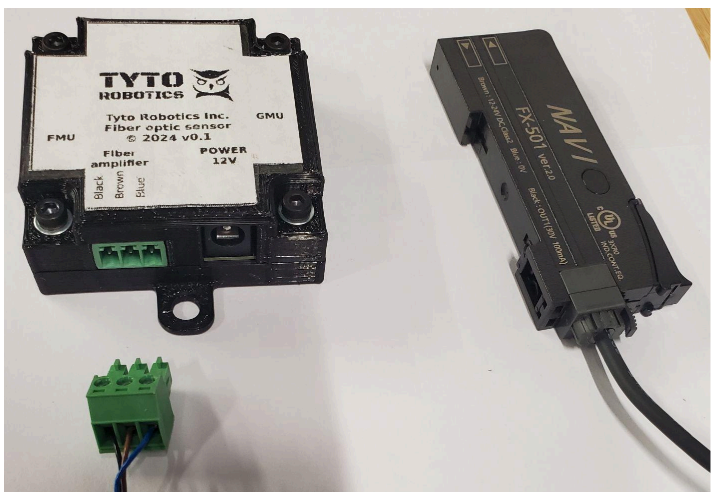


Fig. 20. Connection of the screw terminal to the signal conditioning circuit

Step 12. Plug in the **12 V** power supply cable to the signal conditioning circuit; a wrong power supply voltage can trigger faulty results

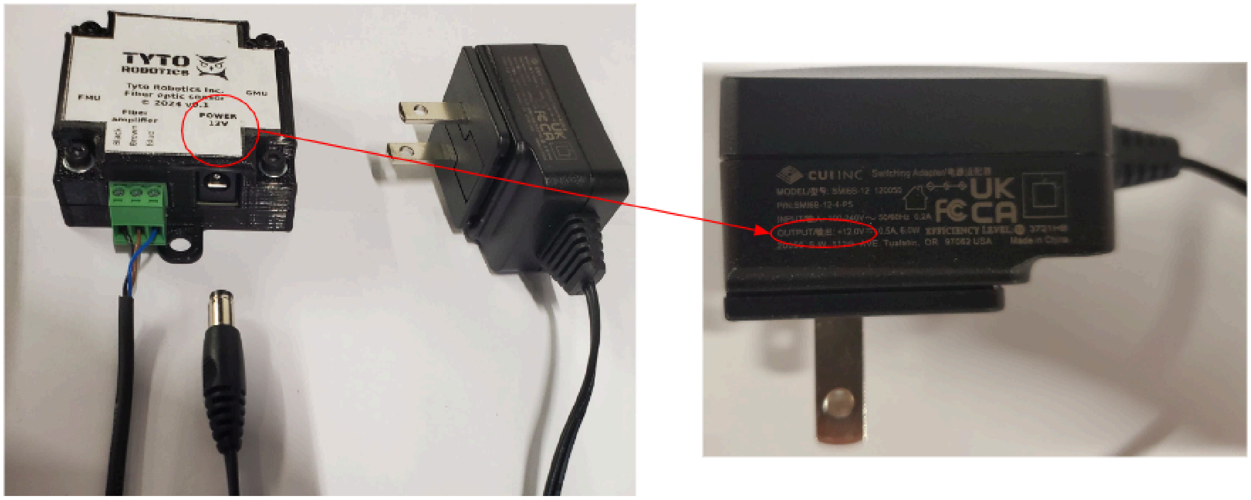


Fig. 21. Connection of the **12 V** power supply to the signal conditioning unit

Step 13. Use the audio jack cable to connect the fiber optic converter unit to the Flight Stand DAQ - **RPM port #1** (we supplied a 15 ft long audio jack cable so you may place the converter unit closer to the stand while keeping the DAQ unit close to your work station).

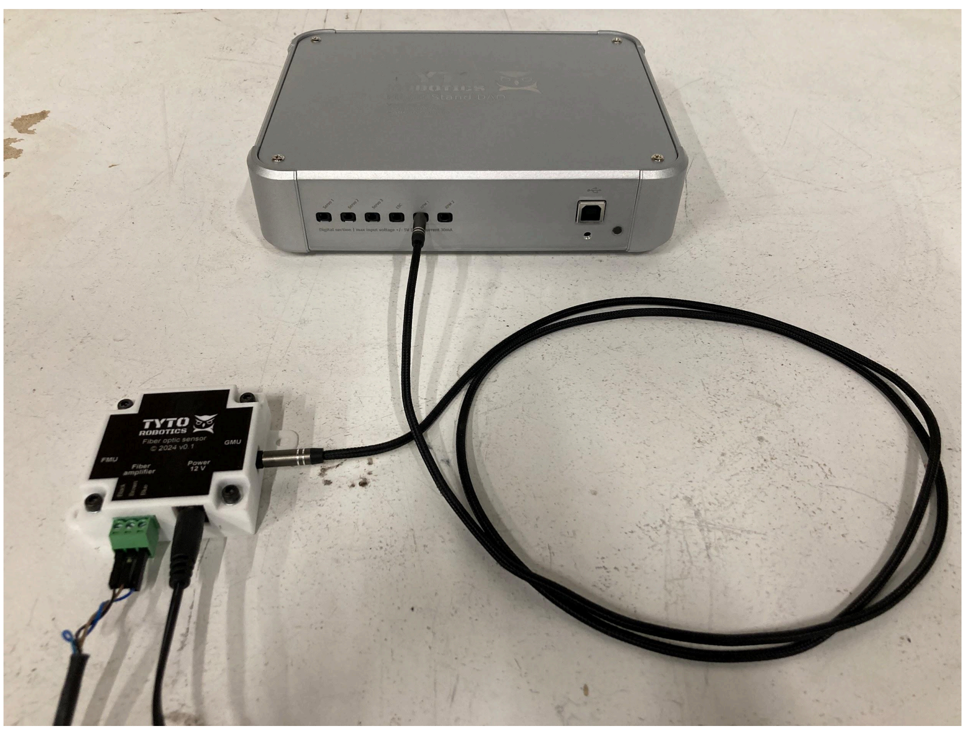


Fig. 22. Connection of the audio jack cable between the DAQ and the converter

NOTE: There is no need to connect the fiber optic RPM sensor to the FMU. Once you turn on the power, you will see the amplifier unit light up.

Section 2.5 Installation of the Fuel Flow sensor

Retrieve the following items from the Flight Stand 60 Auxiliary Sensor Box (SKU: FP37):

- Fuel flow sensor kit
  - Tyto Robotics' Fuel flow converter unit
  - Jeti fuel flow sensor and amplifier
  - Wires and screw terminals
- Fuel flow sensor and fuel tank support plate

Step 1. Open the fuel flow sensor kit, take out the support plate and place it flat on a work station as shown in the figure below:

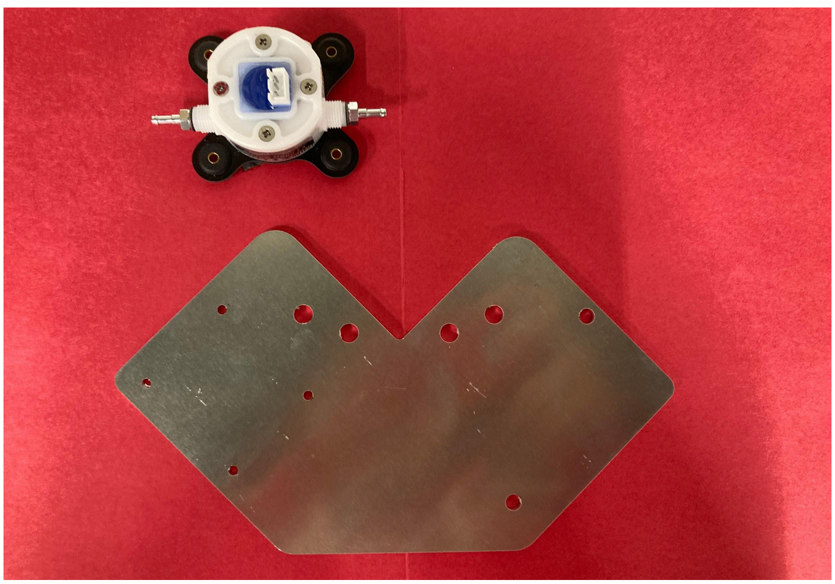


Fig. 23. Support plate with 6-holes on the left and 4-holes on the right

Step 2. Install the fuel flow sensor on the support plate with inlet on the left, and outlet on the right. Use the M3 screws and lock nuts, make sure to install the nuts on the same side as the flow sensor, as shown below:

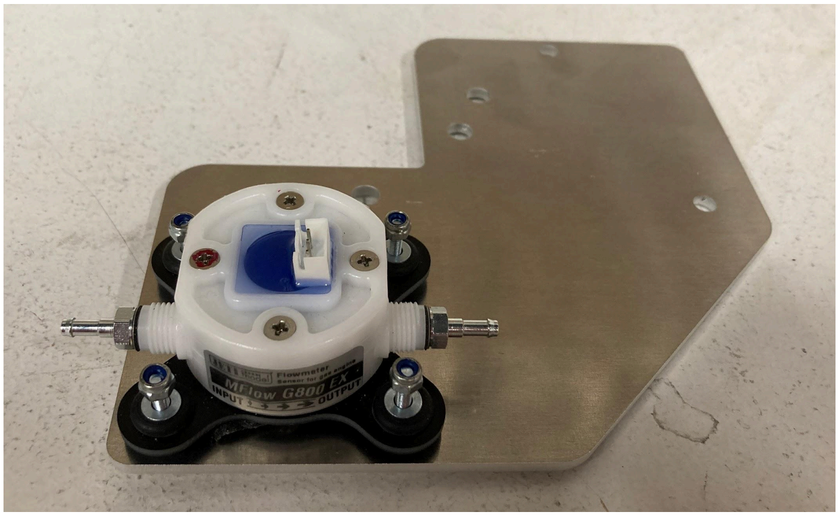


Fig. 24. Fuel flow sensor on the plate, inlet on the left, and outlet on the right

Step 3. Install the fuel flow converter unit on the support plate with two M5 - 10 mm button head screws and two M5 nuts.

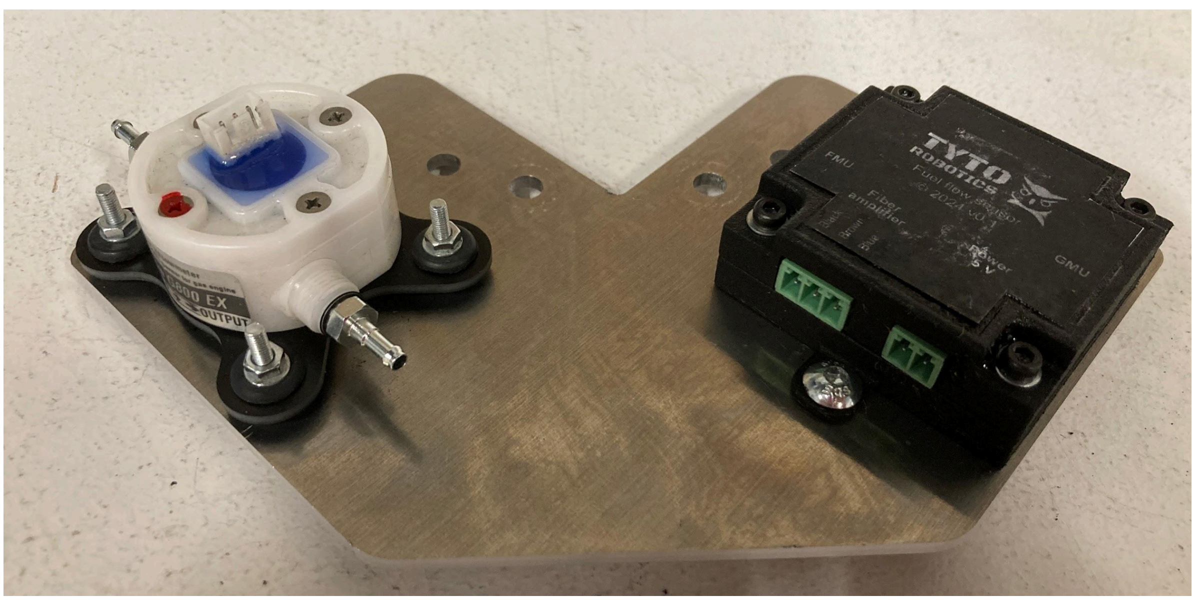


Fig. 25. Support plate with fuel flow sensor and fuel flow converter unit

Step 4. Prepare a 5 V DC power output to be connected to the converter unit with the 2-POS screw terminal; this can be any 5 V power adapter on the market, or a USB extension cord with the VCC and GND connected to the correct position on the screw terminal; make sure the screw terminal is fully tightened.

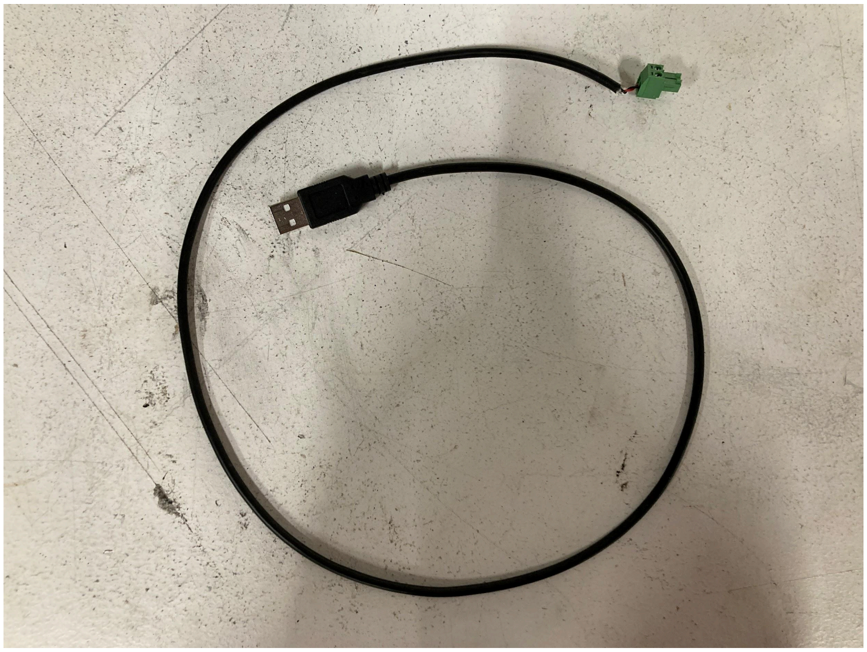


Fig. 26. USB cable with 5V and GND to the fuel flow converter unit

Step 5. Connect the Jeti amplifier unit with one side to the JST white header, and the other side's 2.54 mm header to the Brown - Red - Orange (BRO) input on the converter unit.

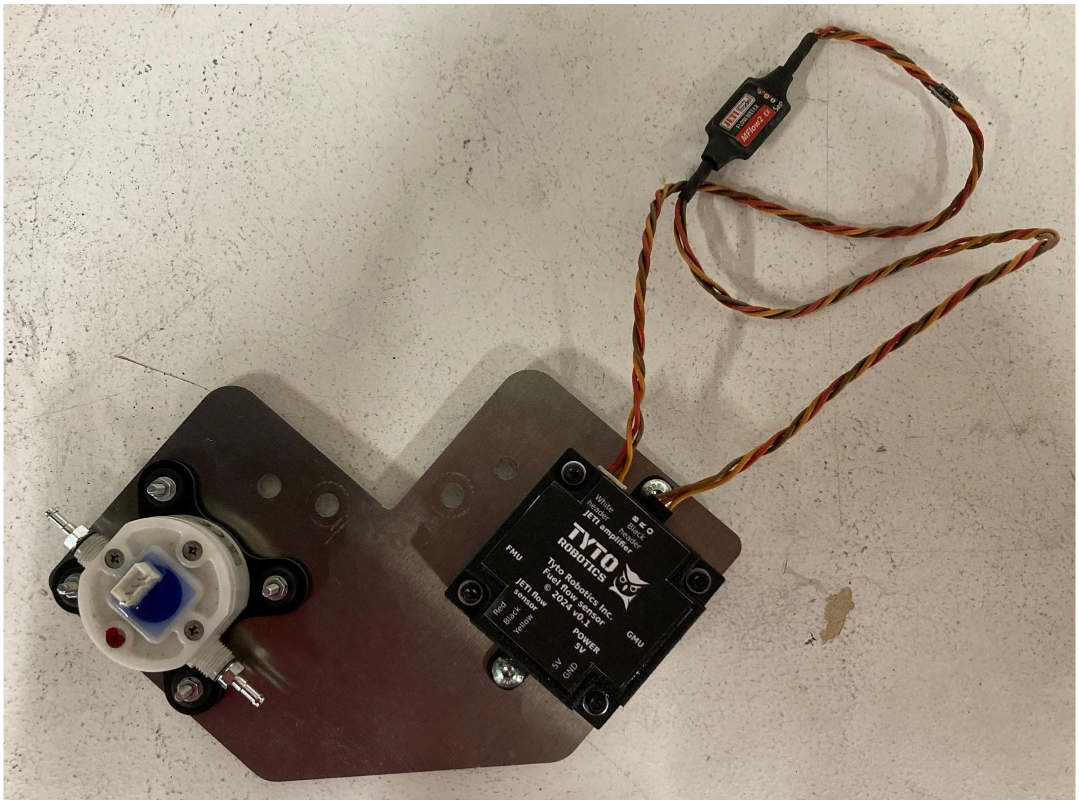


Fig. 27. Jeti amplifier interconnects on the fuel flow converter unit [B: Brown, R: Red, O: Orange]

Step 6. Connect the Jeti flow sensor with the fuel flow converter unit through Green-terminal-JST-cable (SKU: 47CG).

Step 7. Connect the 5 V power supply (USB or power adapter).

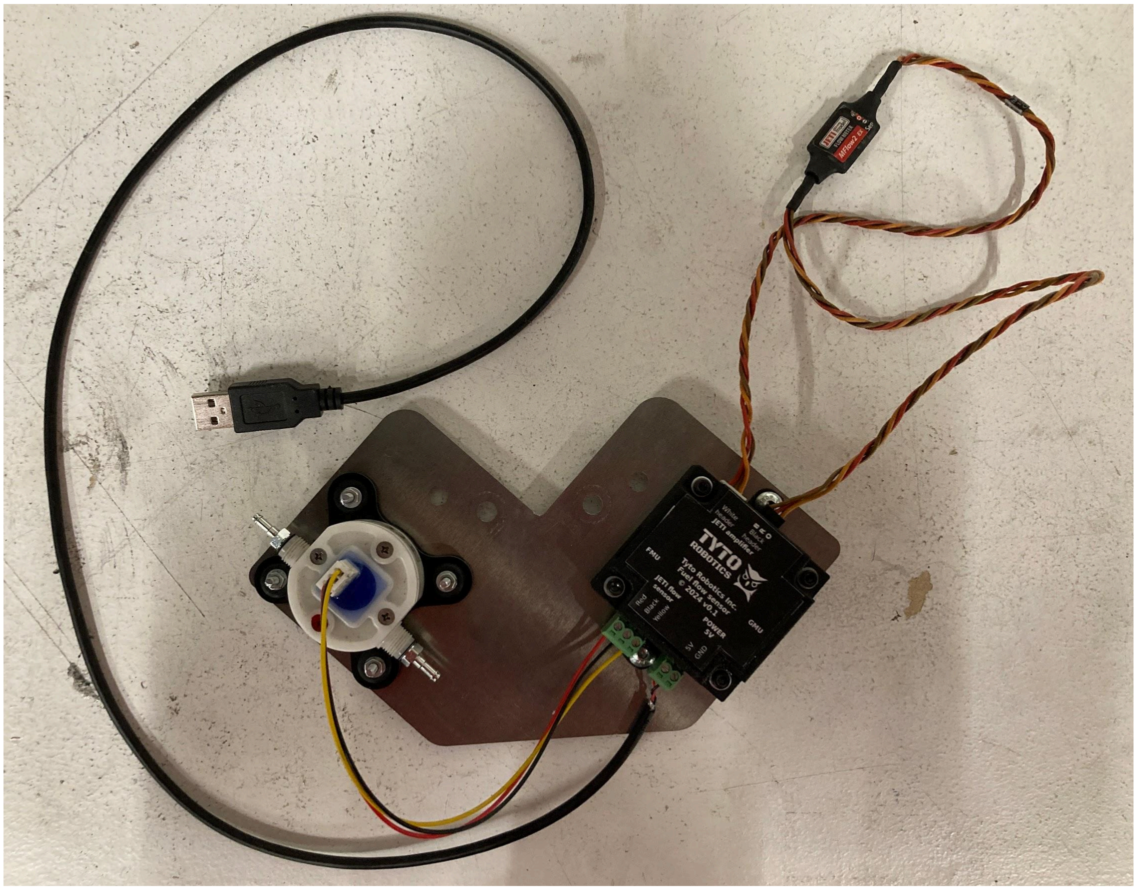


Fig. 28. Fuel flow sensor and converter unit fully installed and connected on the support plate

Step 8. Do not insert the fuel pipe until you are ready to install the fuel tank.

Step 9. Install the support plate assembled with the flow sensor and the converter unit on the Flight Stand 60 upper L-brackets, behind the FMU; make sure that the fuel flow converter and the fuel flow sensors are facing **downward** and you have an empty space on top of the plate behind the FMU; you may install the fuel tank on the plate afterwards.

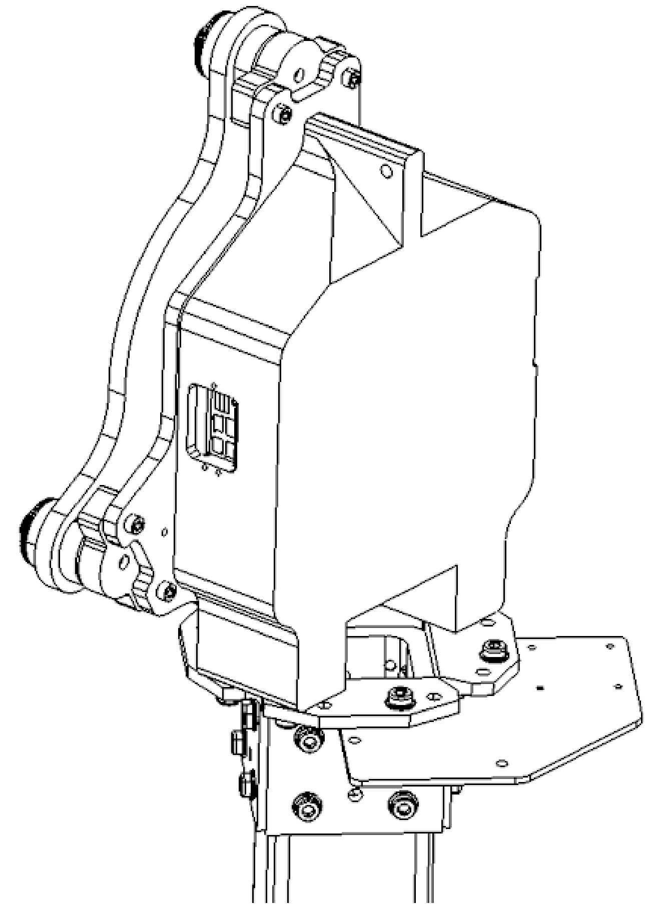


Fig. 29. Install the support plate with the sensors facing downward

Fastening torque:

- M6 - 30 mm flange socket head screw and nuts: 12 Nm

Step 10. Connect the fuel flow converter unit to the FMU (RPM port) on the side.

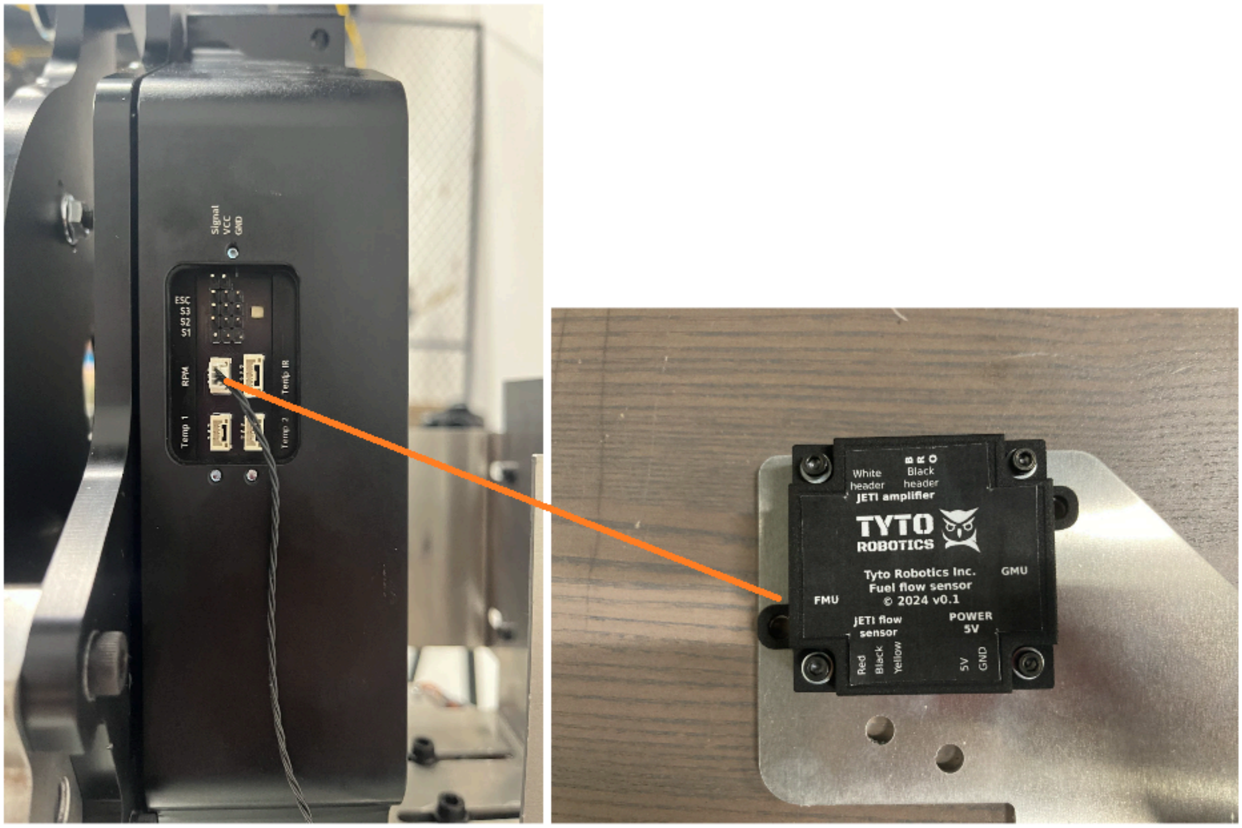


Fig. 30. Plug the 3-POS JST wire from the fuel flow converter to the FMU's RPM port

Step 11. (optional): You may design a custom support plate to enable you to mount your fuel tank on top of the fuel sensor support plate.

Fig. 31. Fuel tank sitting behind the FMU on custom support plate (not included)

Section 2.6 Installation of the thermocouples

The Flight Stand 60 includes two sets of thermocouples, if you wish to measure temperature at more than 2 locations, or need replacement parts, please contact our sales team.

Retrieve the following items from the Flight Stand 60 Auxiliary Sensor Box (SKU: FP37):

- Thermocouple probe bag
- Thermocouple sensor bag
- 15 ft audio jack cable

NOTE: the thermocouples may burn under a combination of high temperature, vibration, hot air, and hot oil inside the exhaust; consider the thermocouples as consumables and reserve a budget to replace them after every few hours of combustion tests.

The following steps show an **example** of how to install the thermocouples in the exhaust with the supplied sensors. Similarly, you may drill and place the thermocouples in the resonators or any location where you wish to measure the temperature.

Step 1. Drill a through hole in the exhaust that fits bolts smaller than M5 or equivalent imperial sizes.

Step 2. Pass an M3, M4, M5 bolt through the hole and fix it with a lock nut on the other side of the exhaust; use a flat washer to increase the mounting surface for the screw.

Fig. 32. A bolt that passes through the exhaust with lock nut

Step 3. Take the alligator clip thermocouple and clip it on the bolt inside the exhaust.

Fig. 33. Alligator clip thermocouple clipping on the bolt inside the exhaust

Step 4. Repeat the same step for the other exhaust.

Step 5. Connect the thermocouple's K type connector to the thermocouple conditioning unit.

Step 6. Connect the audio jack cable between the thermocouple conditioning unit and the Flight Stand DAQ, you can use any of the eight analog ports on the DAQ.

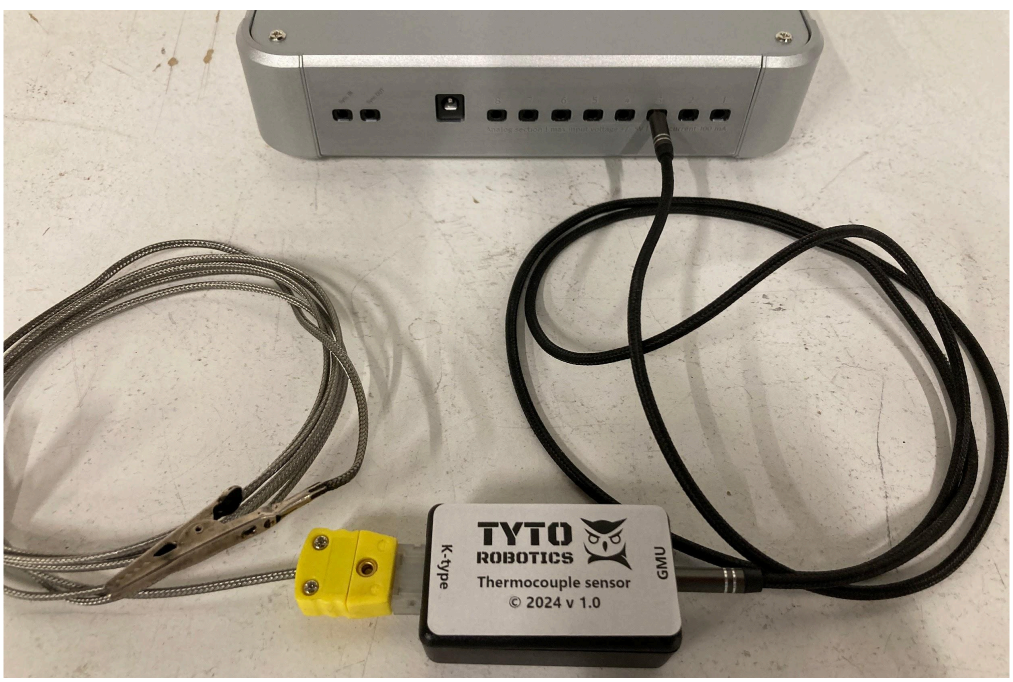


Fig. 34. Connect the thermocouple breakout to any analog port on the DAQ

In the case that you want to use your own thermocouples, simply purchase the ones with a K connector as shown in the figure below. Please make sure that the cable is made with a braided stainless steel cover to resist the high temperature inside the exhaust.

All K-type thermocouples are compatible with the Flight Stand DAQ and thermocouple breakout board. You may also need to calibrate your own sensor and enter the coefficient manually in the Input Transformations section of the Flight Stand software.

Fig. 35. Different K type thermocouples

Section 2.7 Installation of the pressure sensor

Retrieve the following items from the Flight Stand 60 Auxiliary Sensor Box (SKU: FP37):

- Airspeed pressure probe sensor bag
- 15 ft audio jack cable

NOTE: The pressure sensor kit does not include a pitot tube, so you will need to source your own. You will also need to design a fixture for the pitot tube to be mounted on the stand. The following steps show an example of how to connect the pitot tube and the pressure sensor.

Step 1. Prepare a fixture and install your pitot tube at the location where you wish to measure the airspeed.

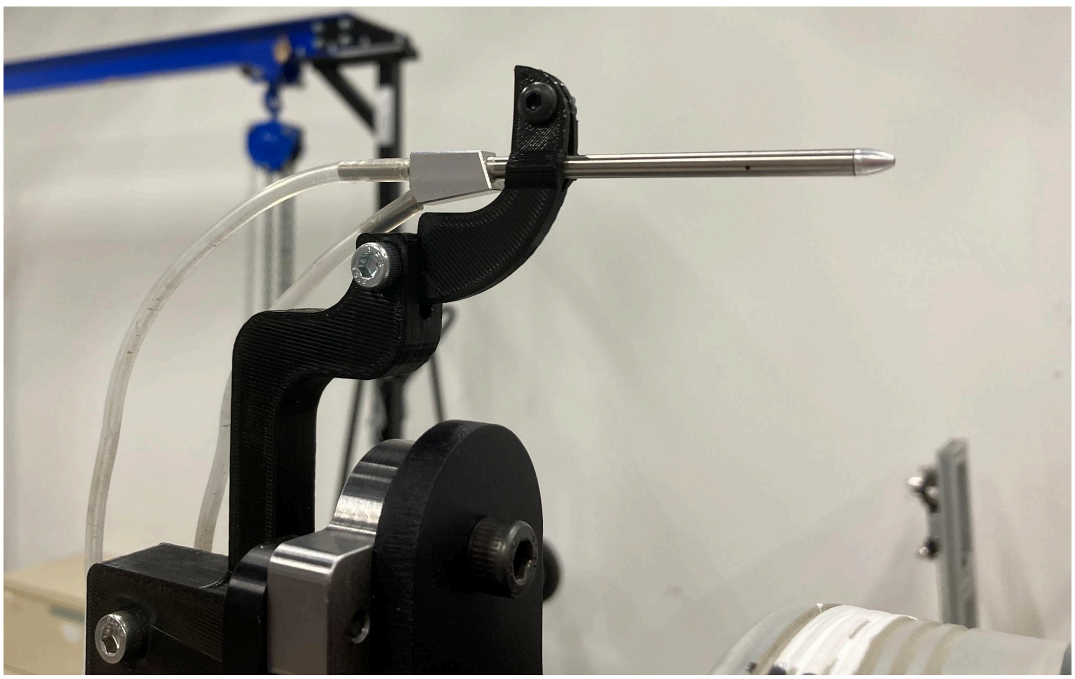


Fig. 36. Example of pitot tube and its fixture (yours to prepare)

Step 2. Connect the static pressure end of the pitot tube to either port on the pressure sensor.

Step 3. Connect the dynamic pressure end of the pitot tube to the other port of the pressure sensor.

Step 4. Connect the audio jack cable (15 ft) between the pressure sensor and the Flight Stand DAQ, you can use any of the eight analog ports on the DAQ.

Fig. 37. Connections of the pitot tube, pressure sensor, and the DAQ

Section 2.8 Sync Hub, DAQ, and PC

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

To start, you need:

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

Step 1. Power up both the Sync Hub and the DAQ with the 9 V, 2 A power adaptor for each and connect both devices via USB to one PC.

Step 2. Connect the M8 cable between the Force Measurement Unit and the Sync Hub.

Step 3. Connect the sync cable between the Sync Hub and the DAQ, it must be interconnected through the IN port on one device, and the OUT port on the other, for example:

- Sync Hub's sync OUT -> DAQ's sync IN
- Sync Hub's sync IN -> DAQ's sync OUT

Fig. 38. Sync Hub and DAQ connections with sync cable (IN to OUT), and each device's power source, plus USB connection to the PC

Step 4. If you are using a USB extension, make sure that the maximum length doesn't exceed 5 m, or use the USB hub with an external power supply.

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

When testing outdoors, it is mandatory for all personnel to stay a safe distance away from the stand. Prepare your work station with the control laptop in the safe zone, indicated below:

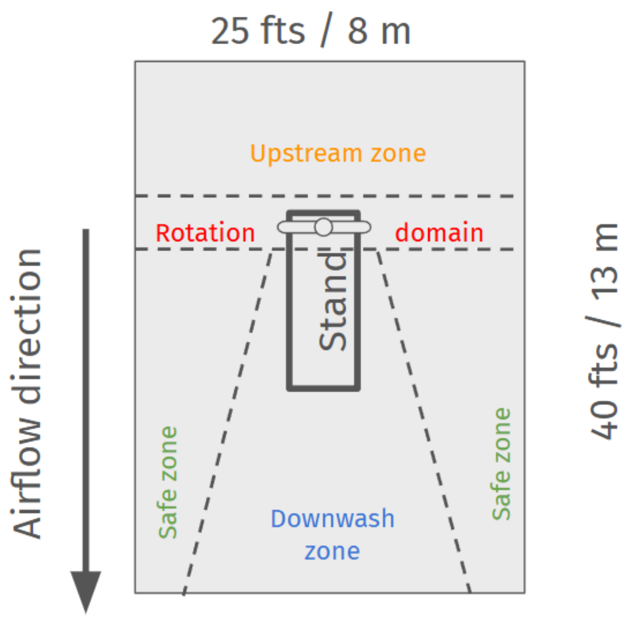


Fig. 39. Safe zone for the work station at your facility

Chapter 3. Sensor settings

Section 3.1 Fiber optic RPM settings

Once the fiber optic converter unit is powered with the 12 V power supply, the fiber amplifier will be lit up and you may start setting up the fiber sensor.

The following SETTINGS work for **OUTDOORS**.

Step 1. Press the «**MODE key**» to set L/D menu (Light/Dark).

Fig. 40. Light/Dark menu on the digital amplifier

Step 2. Press the «**DOWN key**» to activate L-on (Light-On) mode.

Fig. 41. Light-on selected in the L/D menu

Step 3. Press the «**SET key**» to confirm the settings.

Fig. 42. Setting Light-on validated in the L/D menu

Step 4. Press again the «**MODE key**» to CUST (customize) menu.

Fig. 43. CUST menu on the digital amplifier

Step 5. Press the «**UP key**» until you see «SPEd Std» appear on the digital display.

Fig. 44. «SPEdStd» selected in the CUST menu

Step 6. Press the «**SET key**» to confirm setting speed to standard (STD).

Fig. 45. «SPEdStd» validated in the CUST menu

Step 7. Press the «**MODE key**» one time to start PRO menu.

Fig. 46. PRO menu in the digital amplifier

Step 8. Press «**UP key**» several times until you see «PRO 6» appear on the digital display.

Fig. 47. «Pro6» selected in the PRO menu

Step 9. Press the «**SET key**» to enter settings under Pro 6.

Fig. 48. «Pro6» validated to open its sub-menu

Step 10. Press the «**UP key**» until you see on the digital display «PRO6 __Γ¯».

Fig. 49. «Pro6 __Γ¯» chosen in the «Pro6» sub-menu

Step 11. Press the «**SET key**» to confirm using sensing output mode.

Fig. 50. «Pro6 __Γ¯» validated

Step 12. Press the «**MODE key**» multiple times to exit the customized menu (until you see two numbers showing on the LCD).

Fig. 51. Exit of the customized menu

Step 13. Use the «**UP key**» or «**DOWN key**» to set the threshold to **20** (Note : *after 2s, the current value will automatically be set*).

Fig. 52. Setting of the threshold

Step 14. Once the fiber optic amplifier is set up, you may open the Flight Stand software and start to map the sensor to the data acquisition system.

Step 15. Go to Hardware Mapping tab -> choose the source of rotation speed from the parameter: FS-DAQ - Rotation Speed.

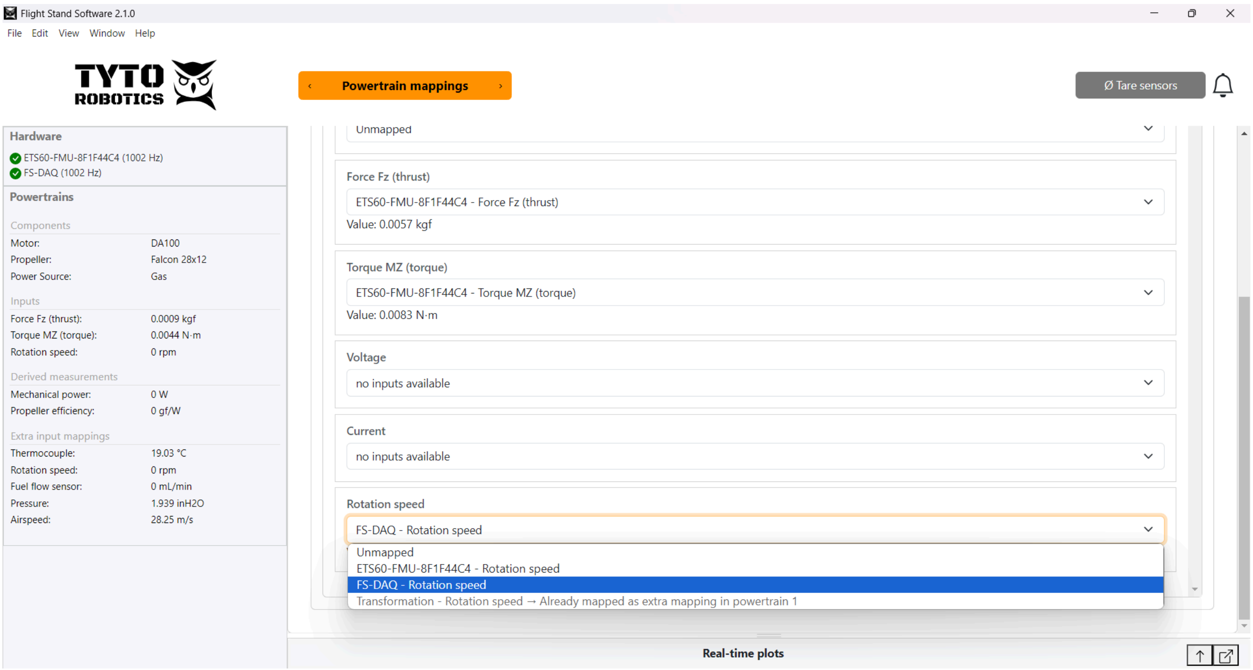


Fig. 53. Hardware mapping of the RPM sensor

Step 16. Go to Hardware tab -> FS-DAQ -> Built-in systems -> Rotation speed, click on the small gear button on the right and set the divider count as the **number of blades** of your propeller.

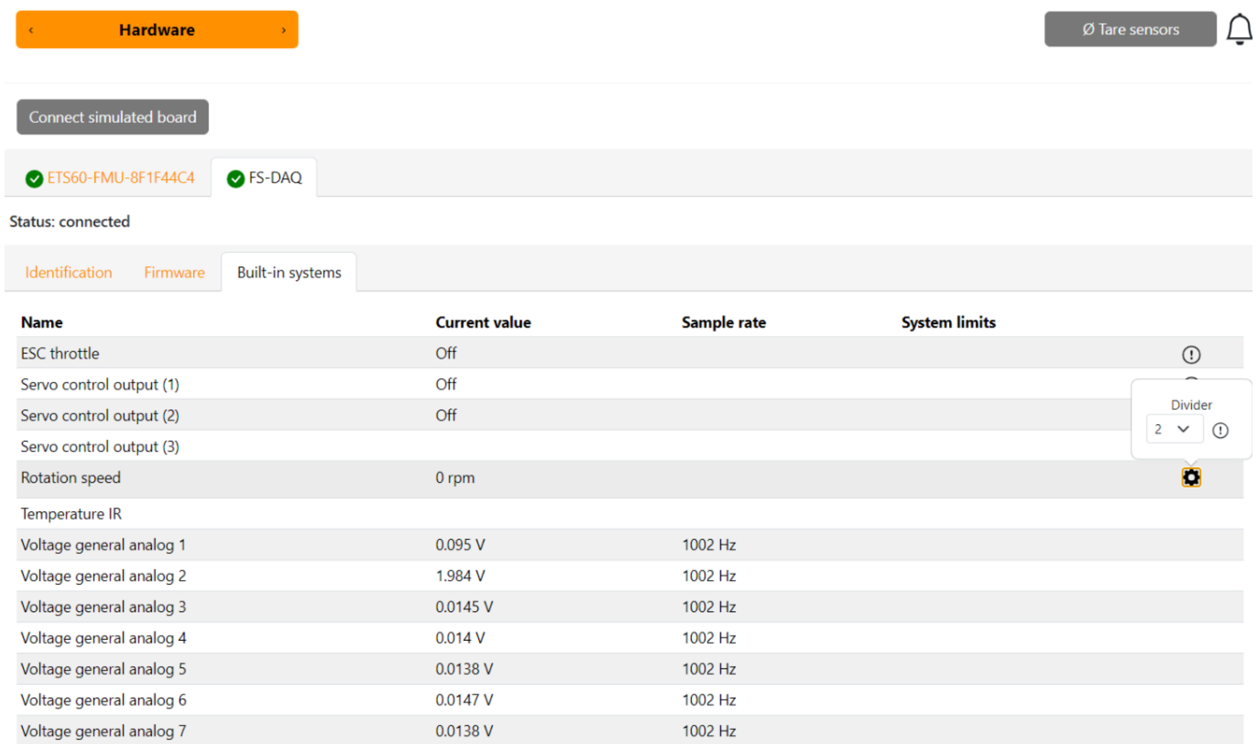


Fig. 54. Divider setting in the Flight Stand software

IMPORTANT: Each time a blade passes in front of the fiber head it will be counted; when you have a two-blade propeller, it counts two per revolution, thus you must set the divider to 2. If you have a three-blade propeller, it will be 3, and so on.

Step 17. Once you have the RPM reading on the screen, ask another operator to manually flip the propeller without the spark plug on the engine, you shall be able to see an RPM reading on the Flight Stand software.

Section 3.2 Fuel flow sensor settings

The sensor reads the flow rate as pulses and it has a lower limit of 20 ml/min. Please always plug the flow sensor converter in the **FMU's RPM port**. Even though it is also possible to plug it to the Flight Stand DAQ unit, we do not recommend doing so due to the limited cable length.

To set up the fuel flow sensor:

Step 1. Plug in the sensor and power it up with 5 V, then open the Flight Stand software.

Step 2. Go to the Hardware tab -> ETS60-FMU -> find Rotation speed, click on the smaller gear button on the right and set the divider to 1.

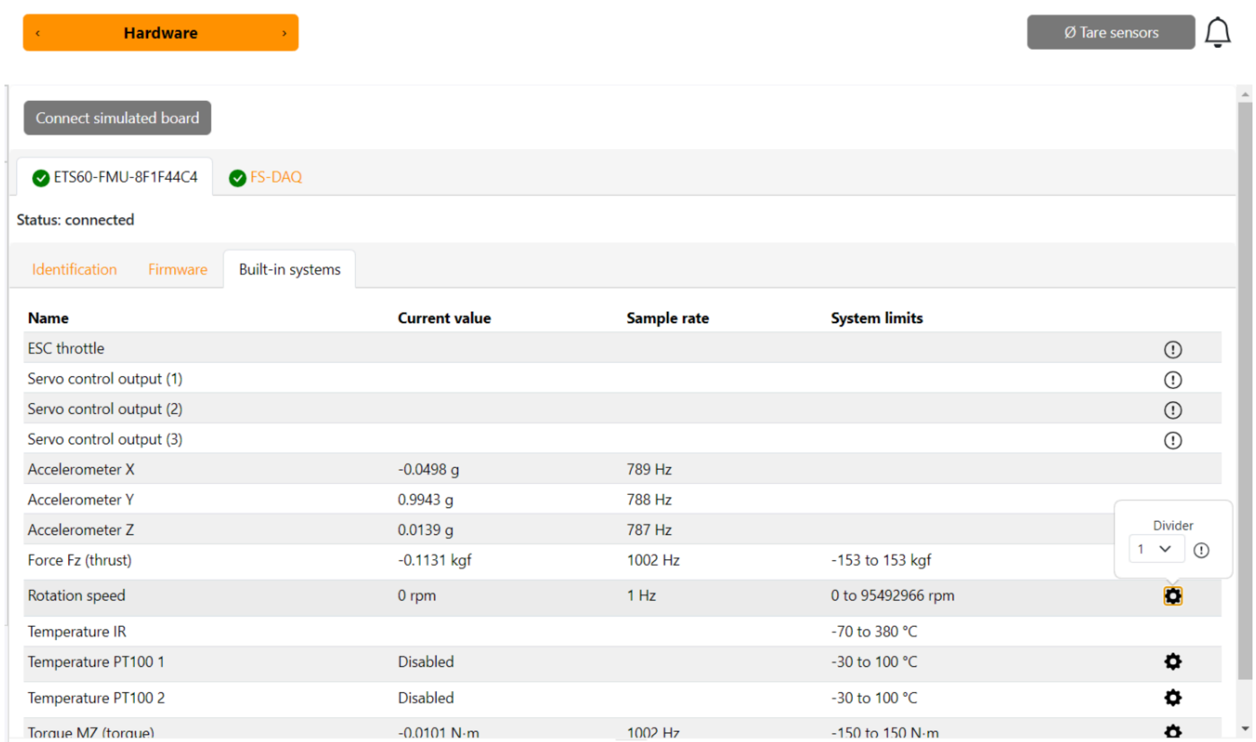


Fig. 55. Divider setting for flow rate sensor

Step 3. Then go to input transformation -> New, with the following information.

- Name: Fuel Flow Sensor
- Unit type: Other: ml/min

Formula input:

- a: ETS60-FMU - Rotation speed
- Formula: 1.16*a
- System limits: 0 to 0

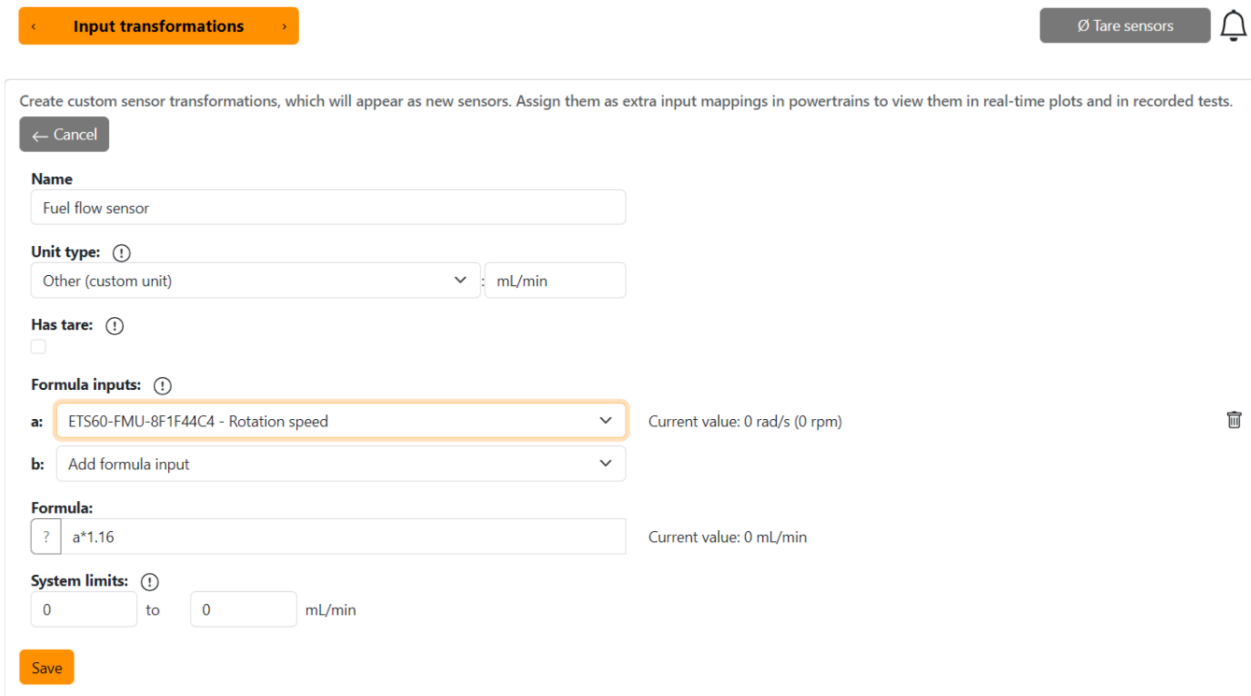


Fig. 56. Input transformation for flow rate reading

Step 4. Save the input transformation.

Step 5. Go to Powertrain mappings -> Powertrain 1 -> Extra mapping -> Add extra input/output -> Choose “Transformation - Fuel flow sensor” in the drop down menu.

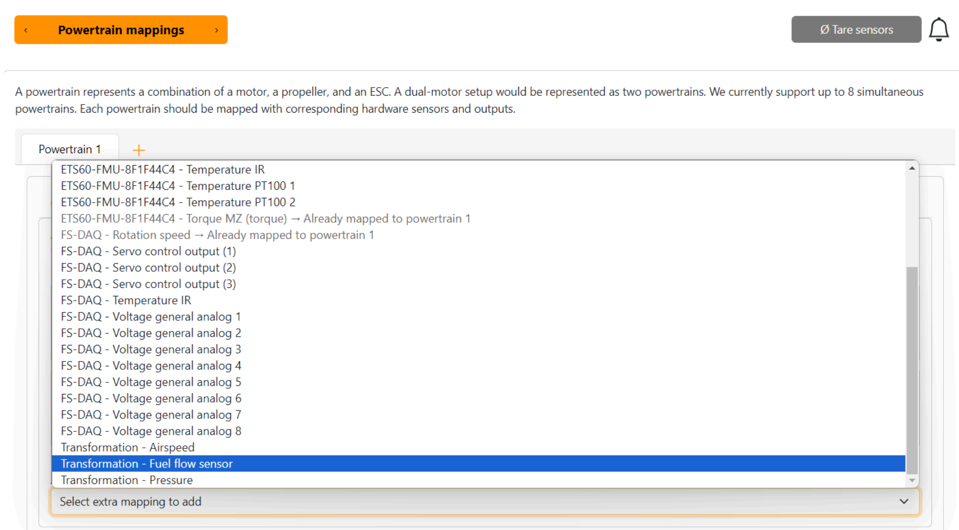


Fig. 57. Extra mapping of Fuel flow sensor in the software

Due to the nature of the combustion engines, the flow rate is never constant during a test. There can also be bubbles in the fuel lines if the watertight is not clamped tight enough. The reading of flow rate can display spikes from time to time.

If you observe excessive fluctuations on the flow rate data, you may also check the ground cable (GND) on the **green screw terminal - white JST wire** between your fuel flow sensor and the fuel flow converter unit.

Section 3.3 Thermocouple settings

Step 1. Open the Flight Stand software, and go to the Input Transformations tab.

Step 2. Add a new input transformation.

Step 3. Then go to input transformation -> New, with the following information:

- Name: Thermocouple (Add alias: Exhaust LEFT or RIGHT)
- Unit type: Temperature

Formula input:

- a: FS-DAQ - Voltage general analog # - enter the number of the port where you plugged the converter unit
- Formula: (1/0.005)*a+273.15
- System limits: 0 to 0

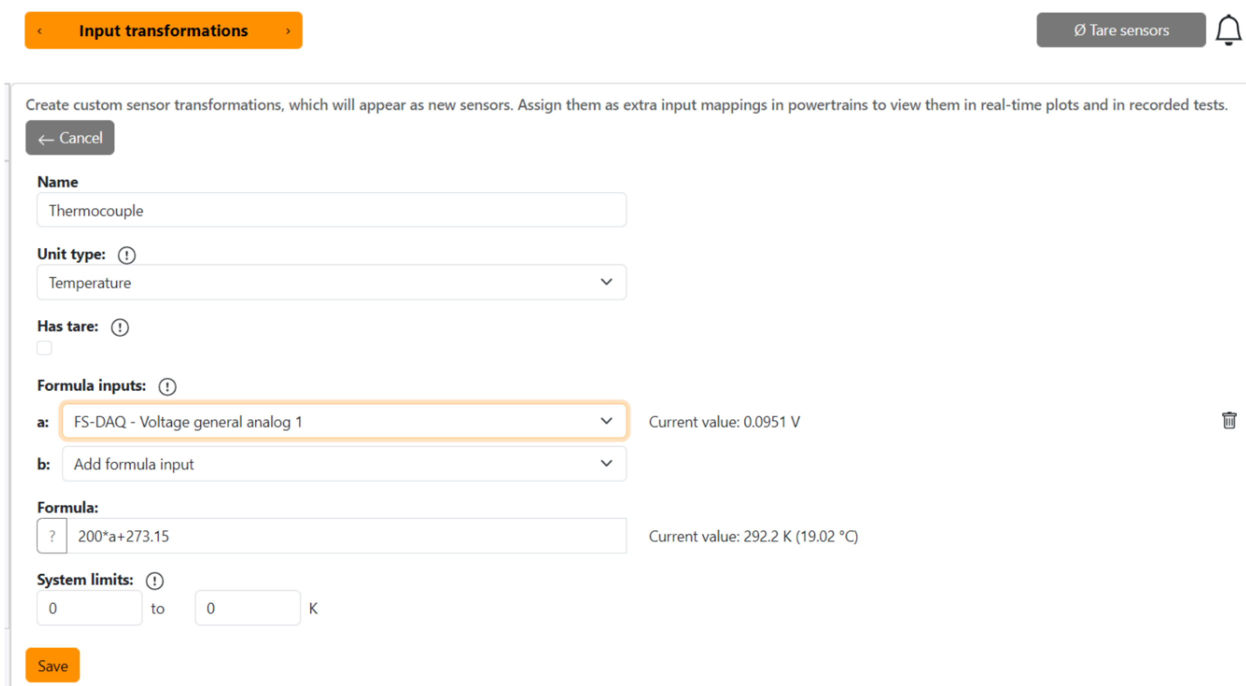


Fig. 58. Input transformation for thermocouple

Step 4. Save the input transformation.

Step 5. Repeat the same steps 1 to 4 for the other thermocouple(s).

NOTE: this equation only works for the thermocouple supplied by Tyto Robotics. If you use other thermocouples that have a different range, contact your sensor's supplier and enter the coefficient manually in the input transformation section.

Section 3.4 Pressure sensor settings

Step 1. Open the Flight Stand software, and go to the Input Transformations tab.

Step 2. Enter the first transformation for the pressure sensor:

- Name: Pressure
- Unit type: Other (custom unit): inH2O
- **Has tare: YES**

Formula input:

- a: FS-DAQ - Voltage general analog # - enter the number of the port where you plugged the converter unit
- Pressure: (a-0.25)*(4/(0.9*5))
- where variable *a* comes from the analog voltage of the Flight Stand DAQ unit where you plugged the sensor
- System limits: 0 to 0

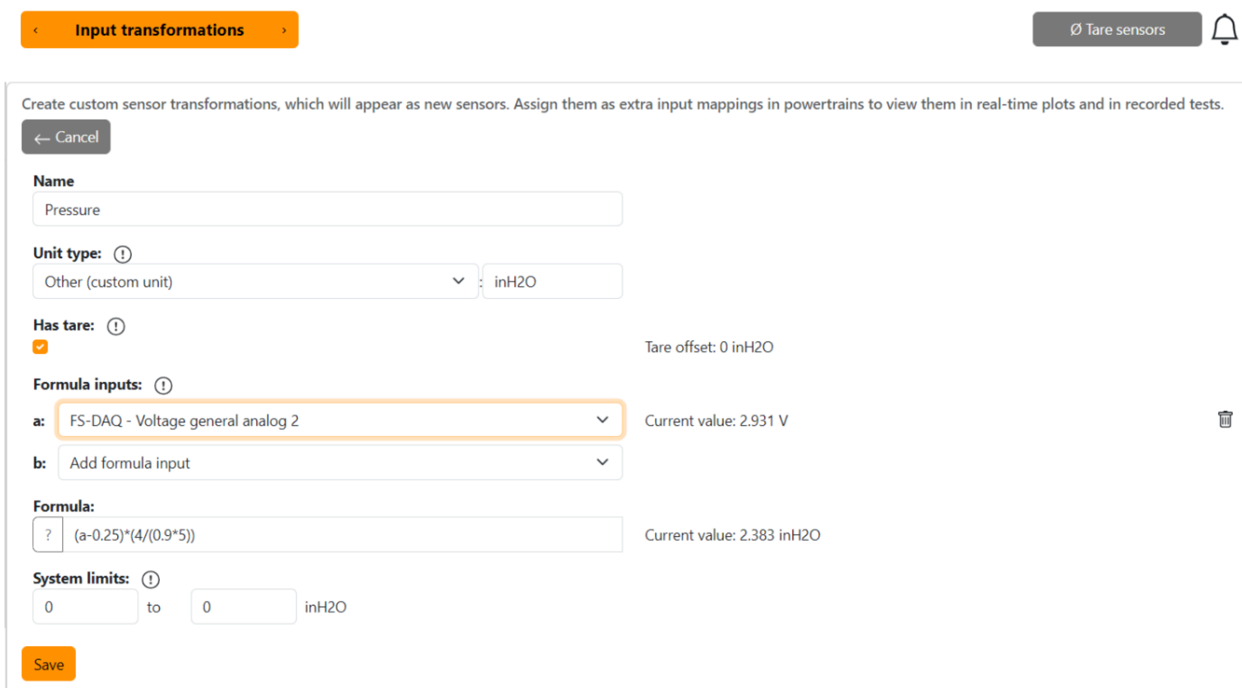


Fig. 59. Input transformation for pressure sensor

Step 3. Add a constant in the transformation for Air density:

- Name: Air density
- Unit type: Other (custom unit): kg*m-3

Formula input:

- a: N/A

- Formula: 1.293 [NOTE: you have to look for this value every day before launching a test as this value can vary with the real-time temperature and humidity in your region]
- System limit: 0 to 0

Use any online platform to obtain the real-time air density, by entering your local temperature, air pressure, and humidity.

Step 4. Enter the last transformation for Airspeed:

- Name: Airspeed
- Unit type: Other (custom unit): m/s

Formula input:

- a: Transformation - Pressure
- b: Transformation - Air density
- Formula: sqrt(((2*abs(a*248.84))/b)
- System limit: 0 to 0

In the figure below, we manually entered the air density as a constant of 1.209226; but we recommend using b as a saved constant and you may modify it easily.

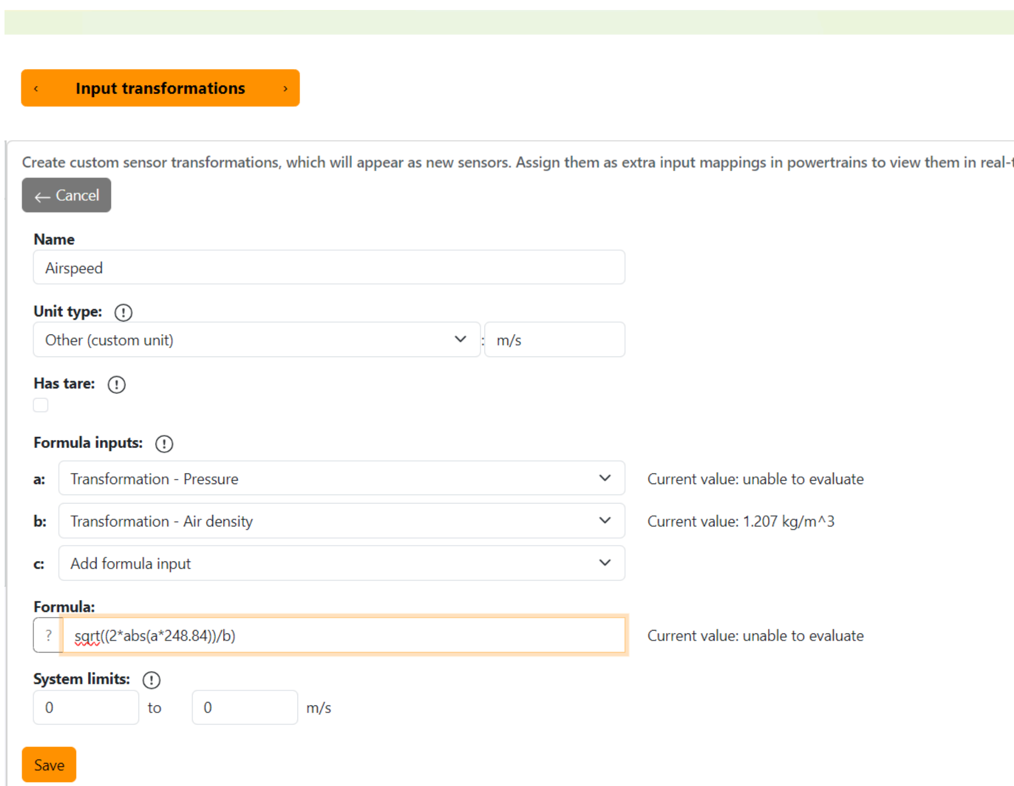


Fig. 60. Input transformation for airspeed with manually entered air density

Step 5. Save all transformation and check if you have all three transformations properly entered:

Input transformations

Create custom sensor transformations, which will appear as new sensors. Assign them as extra input mappings in powertrains to view them in real-time plots and in recorded tests.

Order	Name	Formula	Current value	System limits	Tyto Robotics	Delete
	Pressure	(a-0.25)*(4/(0.9*5))	Unable to evaluate	None	Yes	
	Air density	1.207	1.207 kg/m^3	None	Yes	
	Airspeed	sqrt((2*abs(a*248.84))/1.207)	Unable to evaluate	None	Yes	

Fig. 61. Three transformations for pressure and airspeed

Chapter 4. Engine setting

Every gas engine is different. Tyto Robotics does not provide technical support on the starting or operation of your engine, and you are responsible for the operational safety of the engine.

Section 4.1 Throttle control settings

You must prepare your own throttle control mechanism to be installed on the engine. Properly locate the throttle arm on the carburetor before starting your design. Check carefully whether the throttle arm can reach the minimum and maximum stroke of the engine.

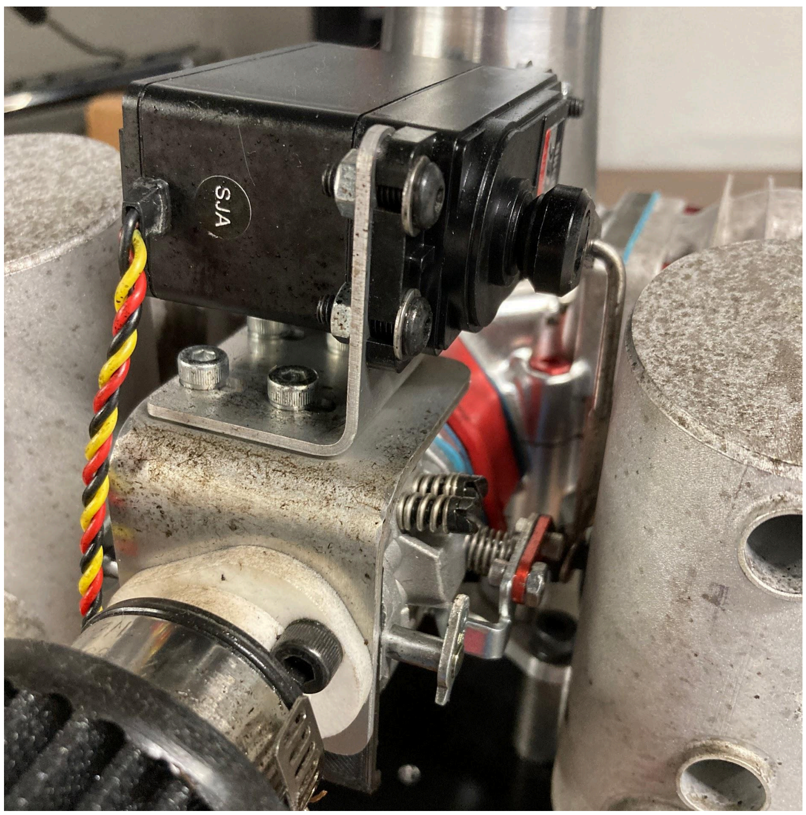


Fig. 62. Example of throttle control mechanism (yours to prepare)

You may use the Flight Stand software to control the gas engine. To do that, simply connect the servo motor that you are using with any of the three SERVO ports on the FMU.

NOTE: the servo ports on the FMU or on the DAQ can provide up to 80 mA of direct current, while many servo motors require up to 2 A. You may use the FMU or DAQ as the source of PWM signal, and power the servo up with an external power supply.

Always check and test the throttle before running a test to see if it can get to the minimum and maximum stroke. Most of the time the engine may not start simply because the throttle was not turned on. Perform a test of the throttle arm via the software every time before starting the engine.

Section 4.2 Spark plugs and ignition control unit

You may then prepare the ignition line for the engine.

Step 1. Attach the ignition control unit (ICU) to any safe place on or near your stand.

Step 2. Connect the spark plugs to the ignition control unit.

Step 3. Connect the Hall sensor to the shaft with the ignition control unit.

An ignition safety switch is important for any engine test. It will help you to quickly stop the engine at any time. We recommend using a long distance ON-OFF switch, a solenoid, or a relay between the power source and the ICU. The ICU may consume several amperes continuously, please prepare wires that are rated for such a use.

Step 4. Connect the ignition control unit with the safety switch, and then to the power source.

Step 5. Keep the ignition switch OFF until you are ready to run a test.

Section 4.3 Fuel line setting

You may then prepare the fuel line for the engine.

NOTE: set the throttle to OFF, close the CHOKE, and make sure the ignition unit is OFF when preparing the fuel line.

Step 1. You may place the fuel tank directly on the fuel tank and flow sensor support plate, right behind the FMU; you will need to make your own fixture to secure the fuel tank.

Fig. 63. Example of placing the fuel tank behind the FMU

Step 2. Prepare three sections of pipes to be connected:

- Fuel tank to oil filter
- Oil filter to fuel flow sensor
- Fuel flow sensor to carburetor on the engine

Step 3. Cut the pipes to the right length, and then drop in two clamps for each pipe, except the one that will go into the fuel tank.

Step 4. Prepare an oil filter and carefully check the inlet and outlet side.

Fig. 64. Fuel filter direction

Step 5. Plug a section of pipe to the inlet of the oil filter, and then drop the other end to the fuel tank; clamp the pipe to maintain the watertight on the filter.

Step 6. Plug another section of pipe to the outlet of the oil filter, and then connect the other end to the inlet of the fuel flow sensor; clamp the pipe on both ends to maintain the watertight.

Step 7. Plug the last section of pipe to the outlet of the fuel flow sensor, and then connect the other end to the oil inlet of the carburetor; clamp the pipe on both ends to maintain the watertight.

Step 8. Use a hand pump to supply fuel to the engine so that the engine can start; the engine will not start dry.

Section 4.4 Carburetor settings

Follow the instructions from the engine manufacturer to prepare the settings on the carburetor. If the engine was never broken in, you should carefully follow the guidelines for the adjustment of the low-speed needle in order to properly adjust the mix of the air and fuel for the first one to two hours of operation on the engine.

Properly identify the locations of the following components:

- Choke
- High-speed needle
- Low-speed needle

Check these settings before launching the test.

Chapter 5. Software

Section 5.1. Manual Test

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

Step 2: Open the Flight Stand software. Make sure you are familiar with the software, you can use these videos as a reference.

Step 3: Make sure you have the latest version of the software installed.

Step 4: In the left-hand panel, ensure the FMU and DAQ are connected, indicated by a green check mark.

Step 5: Navigate to the Powertrain Mapping tab and click on “Extra mappings”. Map the throttle control to the servo port where it is connected.

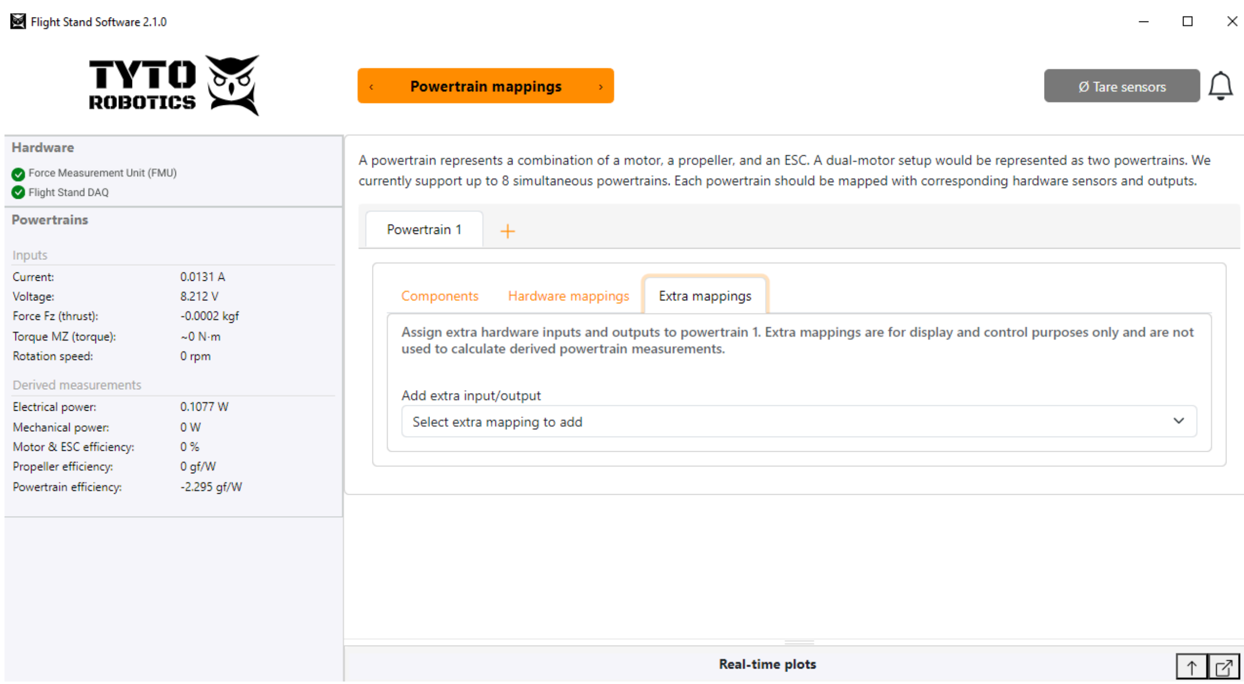


Fig. 65. Flight Stand software “Extra Mappings” section

Step 6: Navigate to the Manual Control tab of the software. Check the Output control box next to Powertrain throttle.

Step 7: Ensure your throttle has full range of motion. Test your throttle servo to confirm that it can reach full stroke. Use the toggle bar to ensure it can reach full left and right, all positions.

Step 8: Tare the sensors with the button in the top right of the software window.

Step 9: Put on your PPE and prepare to start your engine. We assume that you have already pumped the gas to the carburetor and finished all steps in Section 4 of this manual. Toggle the throttle bar to low speed.

Step 10: Confirm choke position and turn on the ignition unit. The ignition safety button should now be turned on.

Step 11: Use a starter to ignite the engine and let it idle.

Step 12: Keep the engine at medium speed if it is not yet broken in and check the colour of the smoke to see if your mixture is too lean or too rich.

Step 13: Start your test - use the throttle slider in the Manual Control tab to control the throttle of your engine.

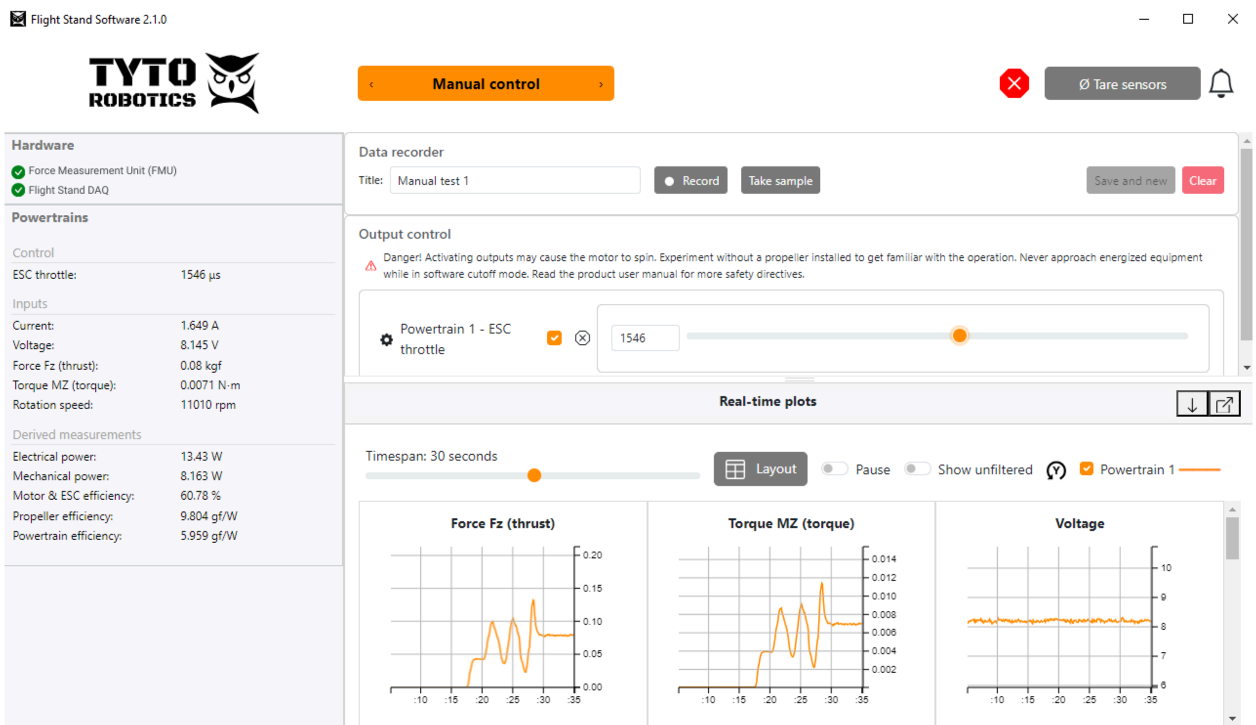


Fig. 65. Flight Stand software throttle slider in the Manual Control tab

Step 14: See our Flight Stand software user manual for instructions on more advanced tests.