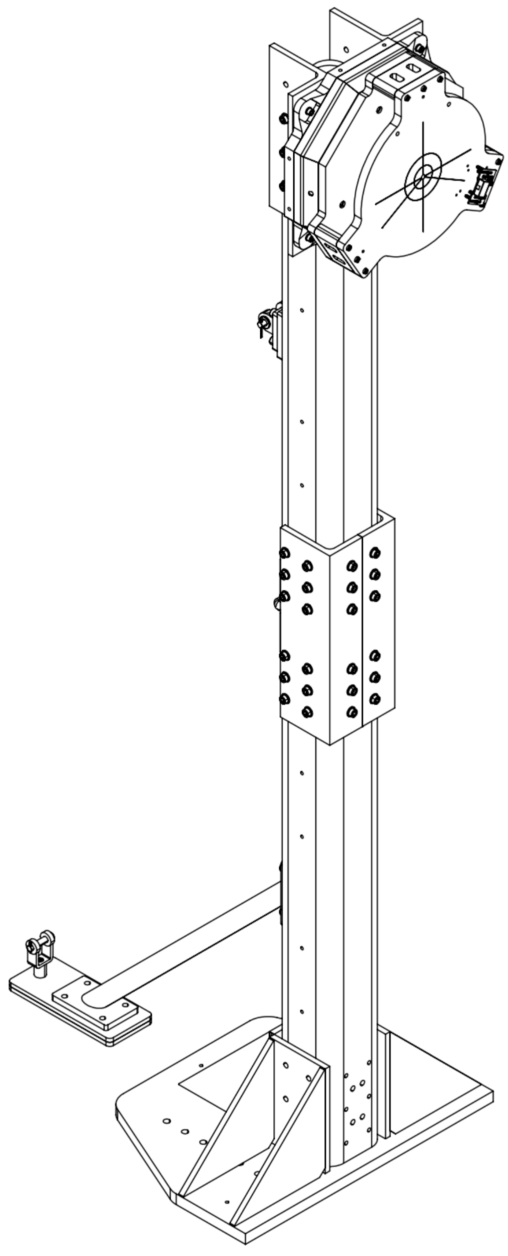
Flight Stand 500 User Manual



The image above represents the fully assembled Flight Stand 500

Table of contents

Chapter 1: Introduction

This is the user manual for customers who have purchased the **Flight Stand 500**. The goal of this user manual is to present all the necessary information for preparing and assembling the stand.

The user manual for the Flight Stand 500 is regularly updated. To ensure you have accurate up-to-date information, look for the latest PDF copy on our website: https://www.tytorobotics.com/blogs/manuals-and-datasheets/flight-stand-500-datasheet-and-manual

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IMPORTANT!

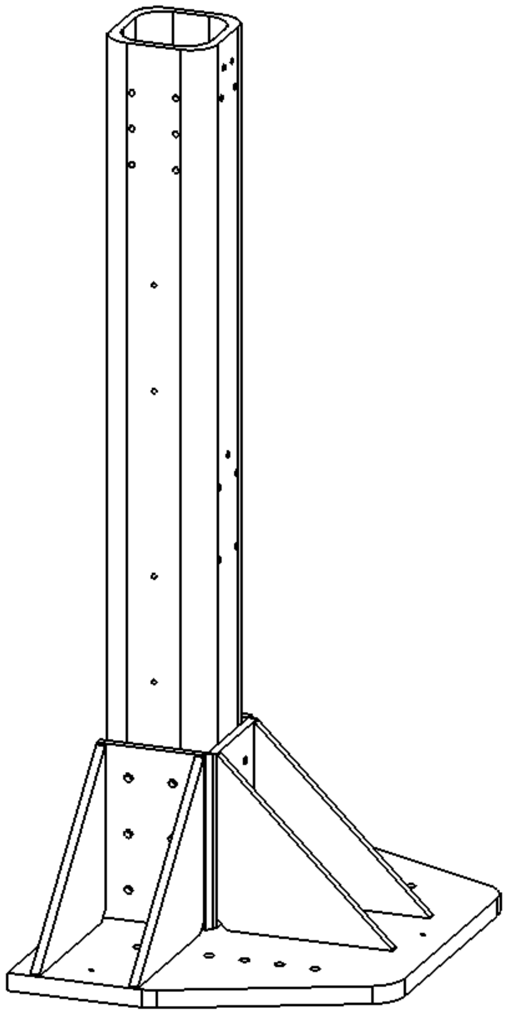
We highly recommend that all operators who will be working with this thrust stand read this user manual carefully in its entirety before carrying out any operation on the Flight Stand 500.

Please be aware that failure to adhere to the guidelines in this user manual can lead to testing inaccuracies, malfunction of the dynamometer, significant injuries, or even fatal consequences for the operator.

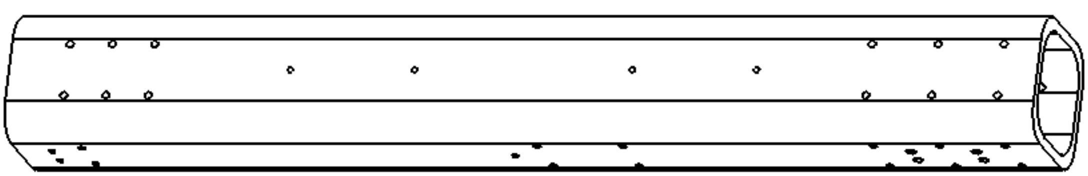
In this manual, any text following a # represents the Tyto Robotics SKU# for this item. You may refer to this code to order spare parts or to locate malfunctioning parts in the event that you need technical support.

The force measurement unit, the 500 kgf - 1500 Nm (#FNRK), is extremely sensitive to any external forces outside its rated output. It comes in a protective casing that you should hold on to. Do not take it out of the casing until you are ready to mount it onto the stand. When you dismount the force measurement unit from the stand, return it to the protective casing.

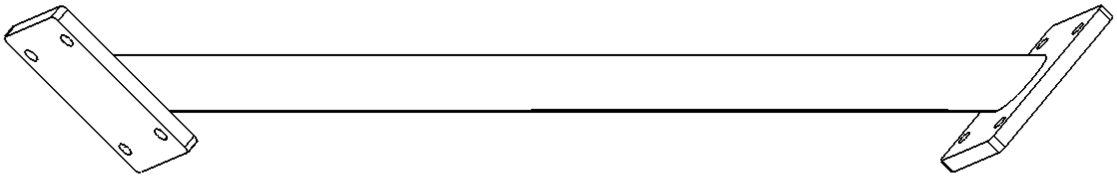
Item checklist for Flight Stand 500



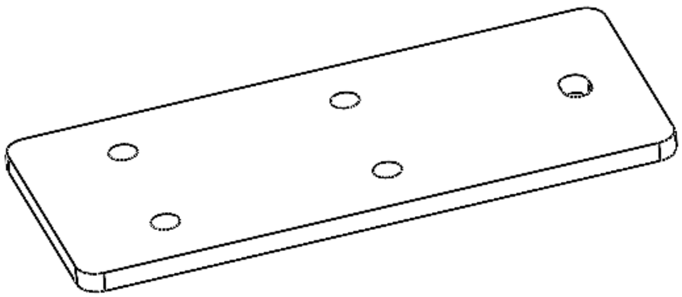
1 x QWWT - Flight Stand 500 Lower Base



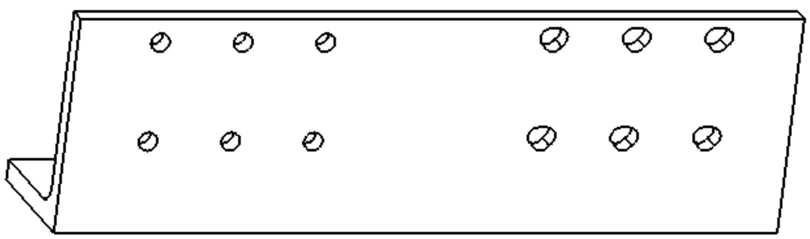
1 x MRRH - Flight Stand 500 Upper Tube



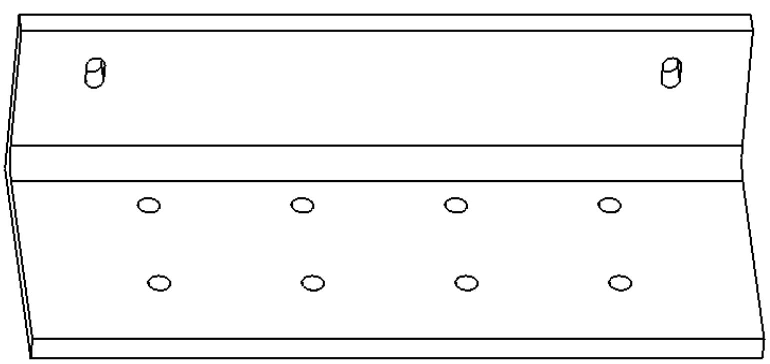
1 x TLDT - Flight Stand 500 45-degree Retention Arm



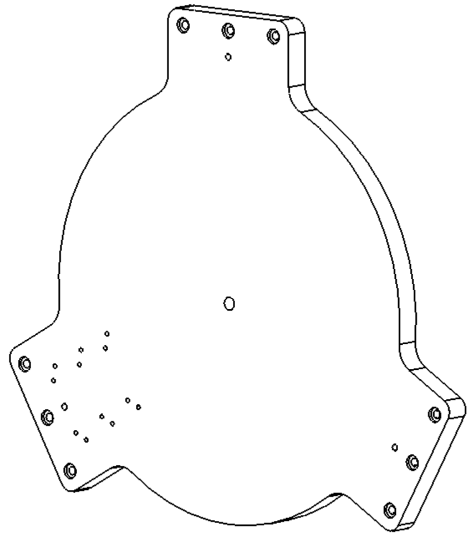
2 x TBMB- Flight Stand 500 45-degree Support Ground Spacer



2 x VYLY - Flight Stand 500 Middle L-bracket



2 x QXZS - Flight Stand 500 Upper L-bracket



1 x SKXG - Flight Stand 500 Motor Mounting Plate

1 x BRKC - FS500 accessories box	FS500 Hardware Bag A (SKU: BSBV)	1 x XMKA - Upper Clevis Bracket 2-1/2" Bore
		1 x DDZD - Clevis adaptor plate
		3 x HJLX - SHCS M10 x 1.5mm, 30mm long
		4 x YNXA - Steel eye bolt M8 x 1.25 - 16 mm Length
		4 x XVHB - SHCS M12 x 1.25 mm, 30 mm Long
		2 x YBPS - Nylon Sleeve Bearing 1/2" Shaft, 3/4" Housing
	FS500 Hardware Bag B (SKU: JMJK)	4 x ZEGX - SHCS flanged M10 x 1.5mm, 30mm long
		1 x HLEA - Lower Clevis 1/2"-20 Thread 1/2" pin (includes a pin and a cotter pin)
		1 x CQBH - SHCS 1/2"-20 Thread Size, 1-3/4" Long
		2 x PEZJ - bridge handles M8 - 149mm (Black)
		4 x UYKY - SHCS M8-20mm - 12.9 alloy steel
	FS500 Hardware Bag C (SKU: CEZK)	3 x VJQT - Extension spacer for motor mount
		9 x EJAR - M6-35mm zinc-plated Alloy Steel

	FS500 Hardware Bag D (SKU: QXDS)	8 x ZEGX - SHCS flanged M10 x 1.5mm, 30mm long
		1 x PMGX - Stand Hinge
		1 x GHGY - Precision Clevis Pin 1/2" Diameter 3" Length
		2 x BGAJ - Cotter Pins 1/8" Diameter, 1-1/2" Long
	FS500 Hardware Bag E (SKU: PFPG)	36 x ZEGX - SHCS flanged M10 x 1.5mm, 30mm long
	FS500 Hardware bag F (SKU: HRES)	12 x ZEGX - SHCS flanged M10 x 1.5mm, 30mm long
		4 x CFRT - SHCS M8 x 1.25mm, 50mm long
		4 x QCPU - Nylon-Insert Flange Locknut Class 10, M8 x 1.25mm
		4 x BNEC - M8 washer 18-8 stainless steel
		9 x EJAR - M6-35mm zinc-plated Alloy Steel
	1 x CAEZ - Optical RPM Probe Bag (SKU: CAEZ)	
	1 x WMPW - Optical Probe Fasteners Bag (SKU: WMPW)	
	1 x WKVQ - FS PT-100 Temperature Sensor Bag (SKU: WKVQ)	
	1 x CMTP - Steelwriter paint pen 5 mm Nib, color Black	
	1 x UPAS - Steelwriter paint pen 5 mm Nib, color White	
	1 x MKQQ - Threadlocker, Loctite® 242, 0.34 oz.	

Additional tools and materials needed for the FS500 assembly

You will need to acquire these tools and materials prior to the installation of your Flight Stand 500.

A Linear Actuator, the specifications are detailed in the "LINEAR ACTUATORS - FLIGHT STAND 500" sheet.

Lifting equipment that you may need for the assembly:

- Gantry Crane
- Hoist Pulley
- Ladder or vertical platform
- Linear actuator
- Heavy-duty tripod support
- Eyebolts and quicklinks

fig 1.2.1: Gantry crane

fig 1.1.2: linear actuator

fig 1.2.3: example of a 130 Nm torque wrench

Tools that you may need for the assembly:

- M12 or ½" anchors and screws
- M10 or ⅜" anchors and screws
- Metric and Imperial Allen keys
- Metric and Imperial socket set
- Torque wrench (130Nm)
- Heavy duty tripod support

Chapter 2: General Safety Rules

Always put safety first! It is your responsibility.

ATTENTION!

Some of the parts in this assembly weigh more than 100 kg or 220 lbs, and must be manipulated with a crane, extreme caution is advised.

It is crucial to remain vigilant and understand the function of each component. Please ensure that you and all colleagues who will operate the Flight Stand 500 have thoroughly read this guide before use.

Refer to the subsequent chapters of this manual for detailed assembly instructions.

These instructions are intended for both operators and maintenance staff and must be adhered to during all operations, services, testing, and repairs of this instrument.

To ensure safety, follow these instructions:

1. Wear safety shoes at all times.
2. While working on the assembly, wear a safety helmet, glasses, and gloves.
3. Never wear gloves while manipulating the crane or using an electric screwdriver.
4. Before assembly, make sure all your tools are in good condition and don't need to be replaced.
5. Never go under the stand during the stand-up phase.
6. Make sure to use properly rated cables for power.
7. Do not use power tools in the presence of flammable liquids or gasses.
8. Always keep your work area clean; do not work on surfaces that are dirty with oil. Small metal chips may be blown around and hit the propeller by accident. Clean your testing space before every test.
9. Respect Murphy's law. If you think something might go wrong, it will.
10. Make sure you are dressed for safety. Do not wear jewelry or inappropriate clothing when operating the tool.

11. Do not allow children to be around the Flight Stand 500.
12. Never force the tool to do a job for which it was not designed or is outside its specifications. Using the tool outside of its official specifications will void the warranty and is at your own risk.
13. Do not use or assemble the tool alone.
14. Do not substitute parts or modify the instrument.
15. Always disconnect the power source and make sure there is no remaining power before making adjustments, changing parts, and cleaning or working on the tool.
16. Do not store anything near or above the tool.
17. Always keep your tools clean and in good working order.
18. Do not operate the tool if you are under the influence of drugs, alcohol, or medication that may affect your ability to properly use the tool.
19. Do not open and touch the electrical circuits inside the enclosures (power and control console, Sync Hub, dynamometer circuit). Do not change or modify the electrical circuit.
20. For the installation of the components in the Flight Stand 500, always refer to the proper chapter in this manual. Always use the supplied fasteners and a torque wrench when specified. Always check the fasteners before running a test.
21. If you are using your own fixtures to support the measurement tool, make sure they are rigid and solid enough to support your loads.
22. Ground railing systems and enclosures must be properly secured to the ground.
23. Use the included lock washers; they are important because of the high vibration from the propulsion system.

Chapter 3: Ground mounting

IMPORTANT!

You should prepare and assign the test area before assembling the Flight Stand 500.

Please refer to the hole pattern drawing below to design your test area.

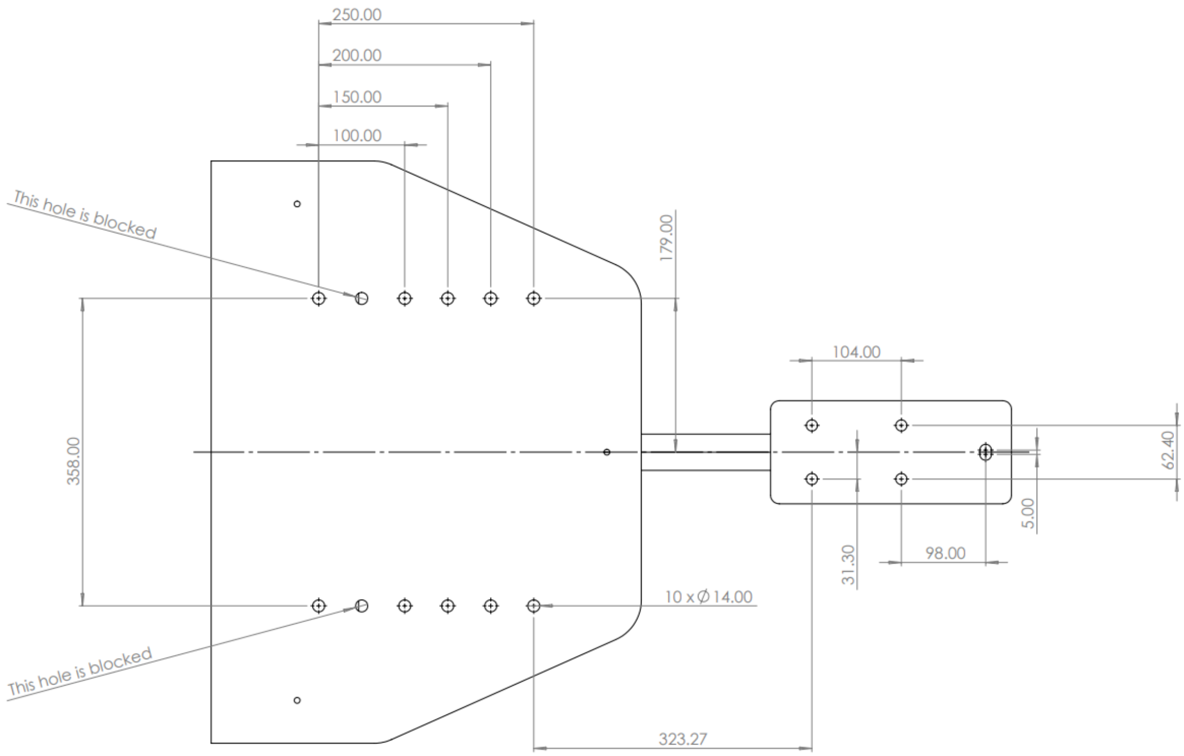


Fig 1.3.1: Hole pattern

Parts required for this step:

- Impact drills and drill bits for concrete
- Anchors and adhesive
- Assorted shims

3.1 Directly fix the stand on the concrete floor

The first approach for creating the hole pattern involves directly tracing the holes onto the ground using the components that will be mounted onto it. Subsequently, utilize anchors suitable for concrete to install tapped inserts, ensuring convenient attachment of the stand. It is strongly advised to engage a civil engineer to verify the structural integrity. The selected anchors should resist the pulling forces and lateral forces generated by the powertrain. Please refer to the “PULLING FORCES - FLIGHT STAND 500” document for more details.

The stand has 11 through holes of size 14 mm, which fit M12 or ½” anchors; and 4 through holes of size 11.5 mm, which fit M10 or ⅜” anchors.

3.2 Mounting on a rail chassis

The alternative and preferred mounting technique involves using beams. The holes are drilled into the beams and the load is distributed in the concrete. The following figure demonstrates Tyto’s design of ground rails using H beams. Please note that such H profiles may differ in different regions or countries. A mechanical engineer shall select the available profile and perform the necessary calculations and analysis for the design and manufacturing of the ground beams. The beams should be securely fixed into the ground using anchors or similar concrete ground fixtures.

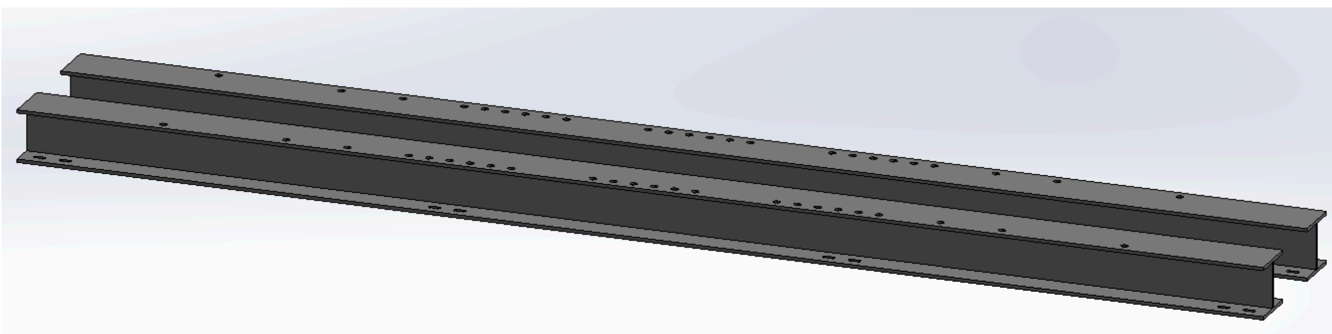


fig 3.2.1: an example of suitable H-beams

Chapter 4: Stand assembly

Step 1 : Pre-assembly preparation

- [ ] Form a team of at least three people
- [ ] Wear safety shoes, goggles, helmets
- [ ] Prepare a crane with a hoist pulley, and optionally a pallet jack or a platform cart
- [ ] Prepare a ladder or vertical platform
- [ ] Prepare a heavy-duty tripod support
- [ ] Prepare cutters, pliers, allen keys, hex sockets, torque wrench
- [ ] Open the accessories box and take out the fastener bags
- [ ] [NO ACTUATOR] Prepare two extra eye bolts and nuts (M6, M8, 1/4 inch, 3/8 inch) with a thread of minimum 25 mm or 1 inch

Step 2 : Install the Lower Base

Parts required for this Step:

- Lower base (#QWWT)
- 2 x 45-degree support ground spacer (#TBMB)
- 45-degree Retention arm (#TLDT)
- 2 x Stand L-Plate med (#VYLY)
- FS500 Hardware Bag A (#BSBV)
- FS500 Hardware Bag B (#JMJK)

ATTENTION: heavy lifting, structure weights 180 kg

- [ ] Install two eye bolts on the Lower Base (#QWWT)

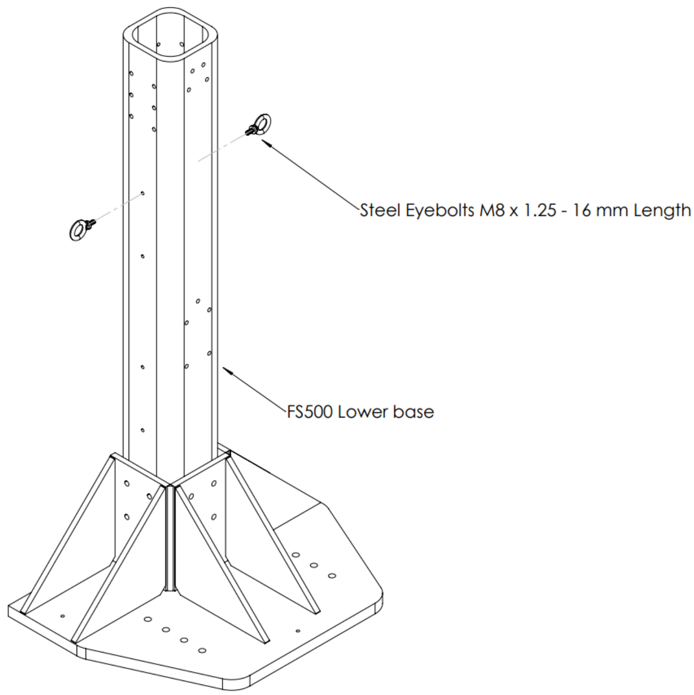


Fig 4.2.1: eye bolts mounting

- [ ] Use the hoist and chain sling to lift the Lower Tube and place it in the assigned position either directly on the floor or on the ground base; if you need to move it a fair distance, place the Lower Tube on a platform cart or pallet jack to move it around in your lab
- [ ] Once the holes on the Lower Tube align with the anchors or mounting features on the ground rails, lower it so it sits flat on the surface
- [ ] Fasten the ten screws (M12 or 1/2 inch socket head screws, yours to prepare) to fix the Lower Tube on the anchor, or on the ground base, **TORQUE: 130 Nm**

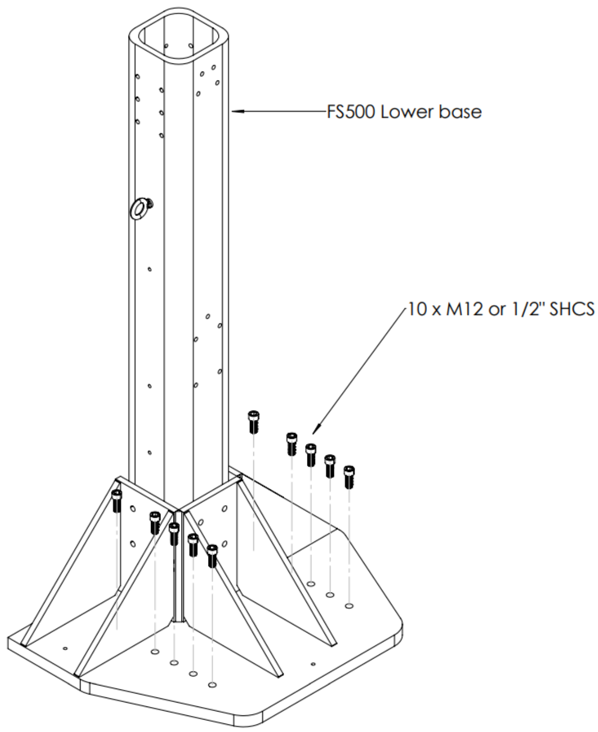


Fig 4.2.2: Lower Base fixing

- ☐ Take out the 45-degree retention arm (#TLDT) with the two 45-degree support ground spacers (#TBMB), align them on the concrete floor or ground base; slightly fasten the screws (M10 or 3/8 inch socket head screws, yours to prepare) to fix the 45-degree retention arm on the anchor, or on the ground base
- ☐ Adjust the position of the 45-degree retention arm to align the upper end of it with the Lower Tube, use four SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) to fix them together, **TORQUE: 75 Nm**; in case there is a visible gap between these two parts, add shims accordingly
- ☐ Fasten the screws at the bottom of the 45-degree retention arm on the anchor

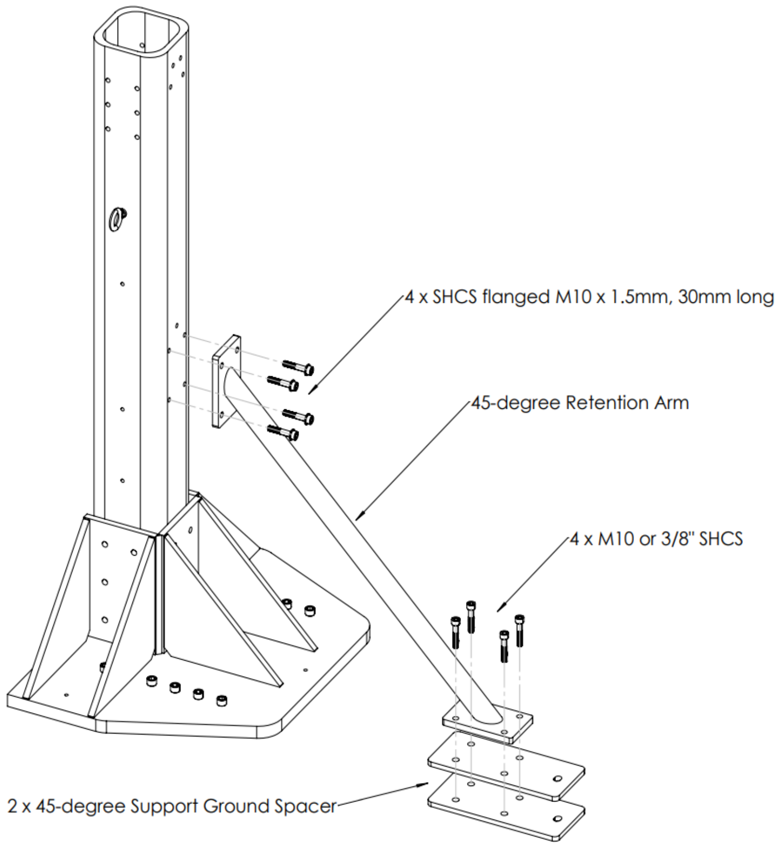


Fig 4.2.3: 45-degree retention arm and spacers mounting

- [ ] Use 1/2"-20 Thread Size set screw, or a male-male thread adapter (M12 or 1/2 inch, yours to prepare) to fit on the one remaining hole on the retention plate, and install the Lower Clevis (thread: ½”-20) on the retention plate; when installing the Lower Clevis, add shim, flat washers, or rubber washer accordingly to adjust the orientation of the clevis so that the pin can be perpendicular to the actuator’s axis; you may use a socket head screw if installing the whole stand on rails

- [ ] Put the ½” pin and the cotter pin for the Lower Clevis

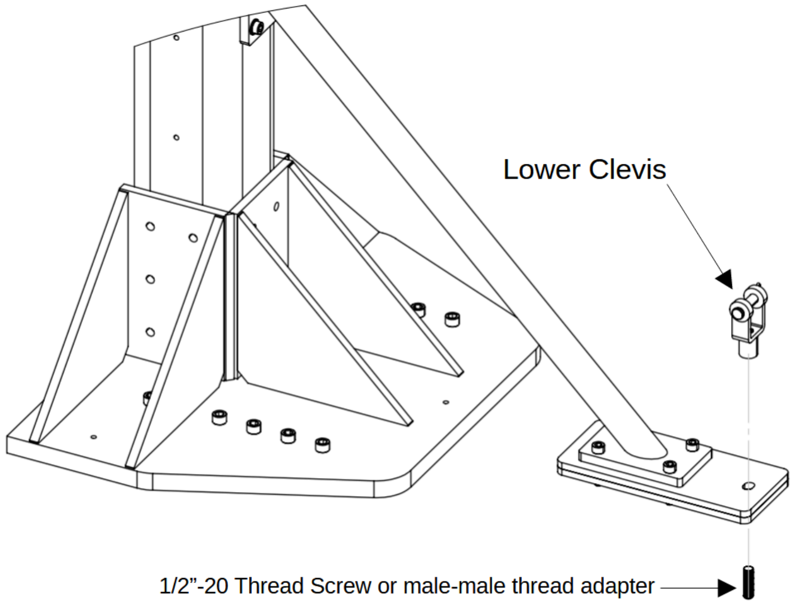


Fig 4.2.4: Lower Clevis fixing

Step 3 : Prepare the FMU

Parts required for this Step:

- FS500 Hardware Bag C (#CEZK)
- Force Measurement Unit

- [ ] Take the FMU from the protective case and lay it flat on a working table
- [ ] Keep the orange bridge handles on the FMU
- [ ] Insert three Extension Spacers for motor mount (#VJQT) by aligning the square holes on the upper plate of the FMU
- [ ] Use nine SHCS M6-35mm (EJAR) to fix the Spacers on the FMU, **do not fully tighten these screws**

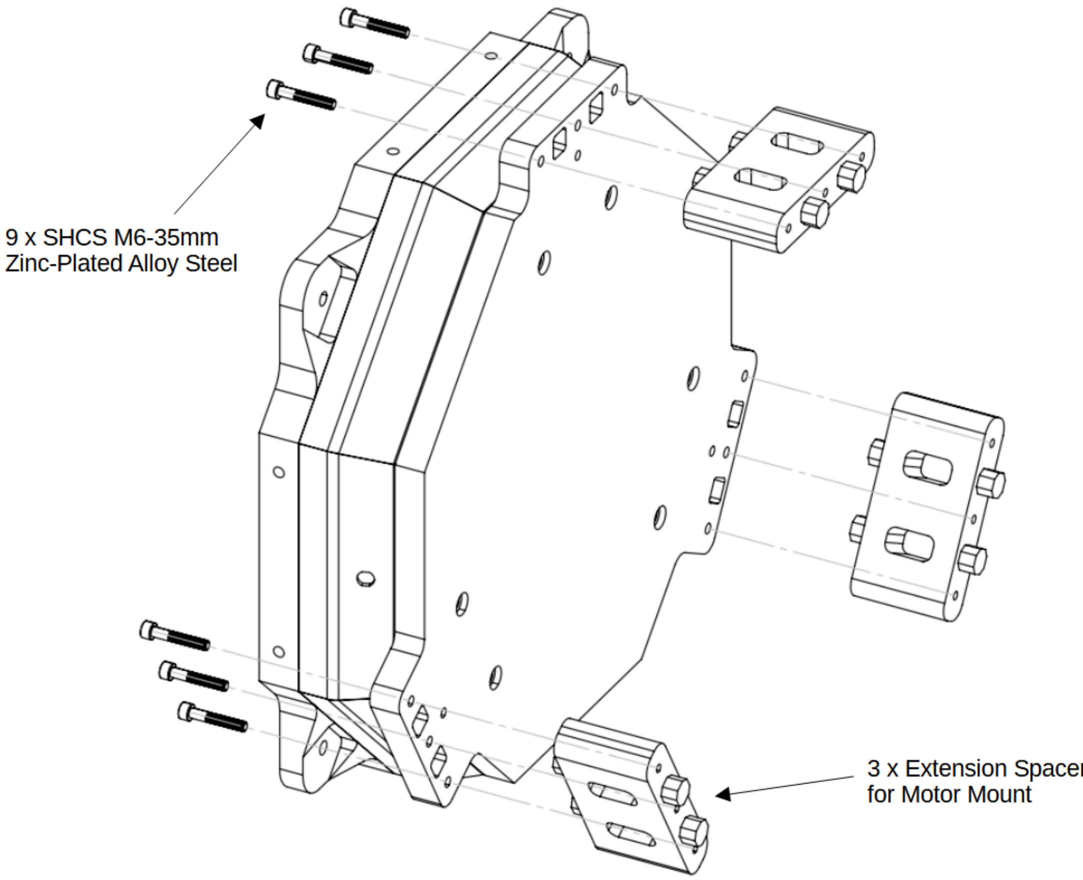


Fig 4.3.1: Extension Spacers mounting on the FMU

- [ ] Do not put the motor mounting plate on the spacers

Step 4 : Install the Upper Tube

Parts required for this Step:

- Upper Tube (#MRRH)
- FS500 Hardware Bag A (#BSBV)
- FS500 Hardware Bag D (#QXDS)
- FS500 Hardware Bag E (#PFPG)
- FS500 Hardware Bag F (#HRES)

ATTENTION: you must secure your Lower Tube on the floor before this operation; wear a helmet and never work under the lifted tube

- ☐ Use any equipment to move the Upper Tube (#MRRH) near the installation site, lay it flat on the floor with D-side facing up
- ☐ Install the Stand Hinge (#PMGX) using four SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) on the Upper Tube, keep the hinge in position **without tightening the screws**
- ☐ Install the two Upper L-Brackets (#QXZS) using twelve SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX), then use the ground to align the flat surface of the L-brackets with the B-side of the Upper Tube; **TORQUE: 75 Nm**
- ☐ Flip the Upper Tube twice to make side B facing up (hinge will be facing the bottom)
- ☐ Remove the M8 eye bolts from the Lower Tube and put them on the Upper Tube, install all four of them symmetrically on the Upper Tube

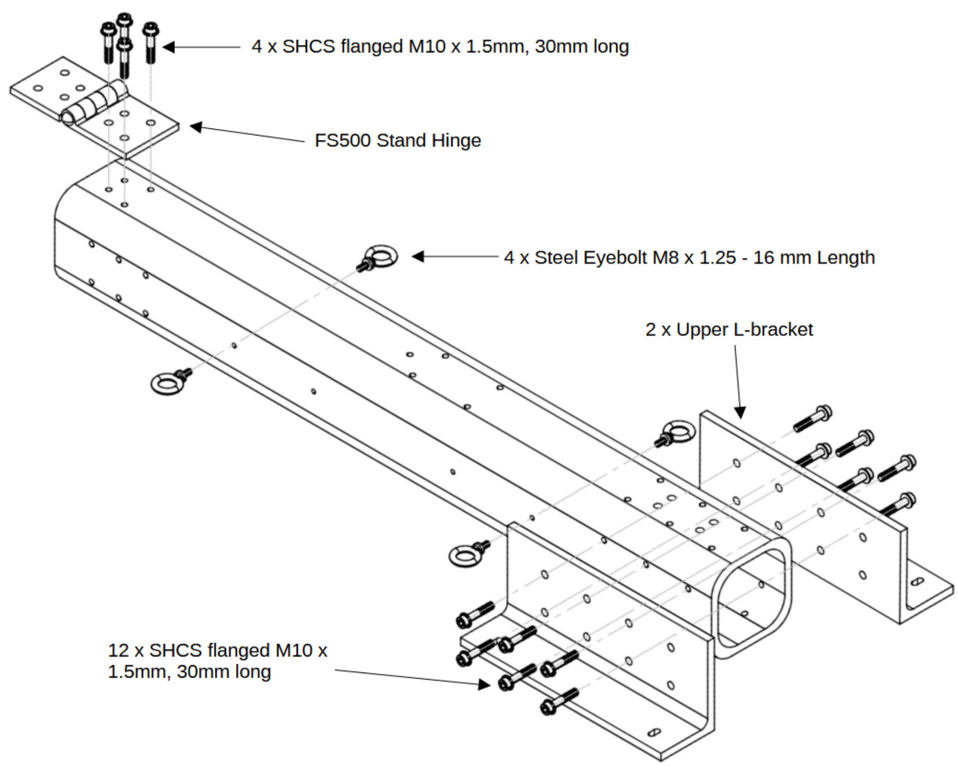


Fig 4.4.1: Hinge, eye bolts and Upper L-Brackets mounting on the Upper Tube

- ☐ Attach the chain sling to all four eye bolts on the Upper Tube
- ☐ Slightly lift the whole assembly of the Upper Tube
- ☐ Manually insert four SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) to fit the

hinge on the Lower Tube, **do not fully tighten the screws**

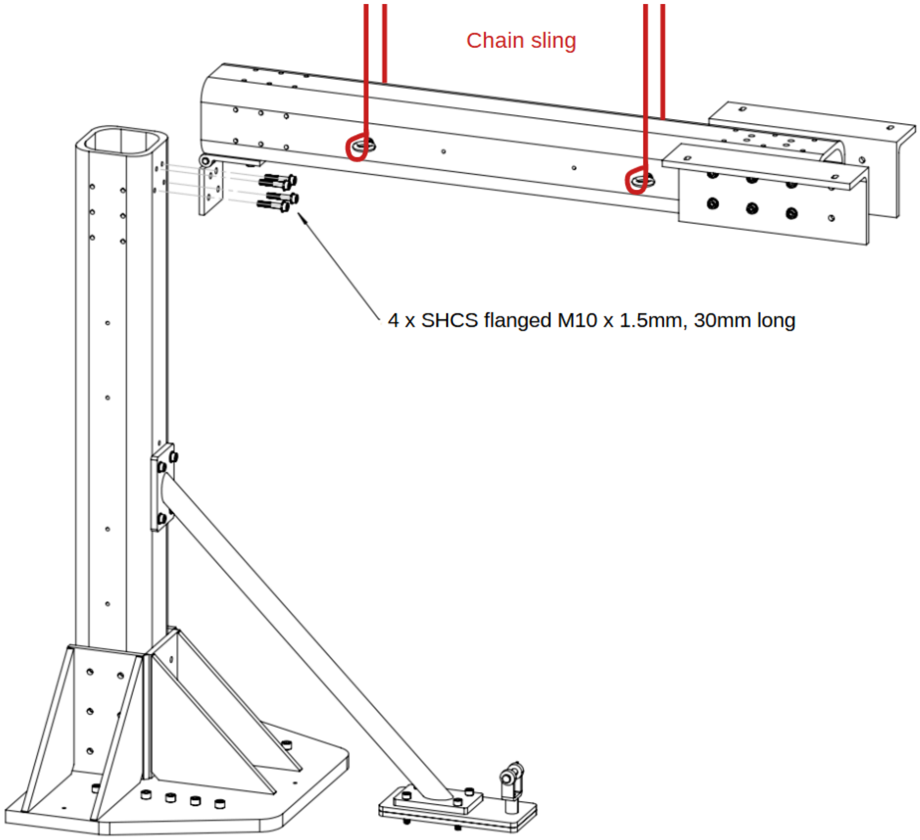


Fig 4.4.2: Upper Tube mounting on the Lower Base

- [ ] Install the two Middle L-brackets (#VYLY) using eighteen SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX), and eighteen M10 oversized flat washers on the Lower Tube to avoid the Upper Tube overrunning while being lifted up; **do not fully tighten these screws**

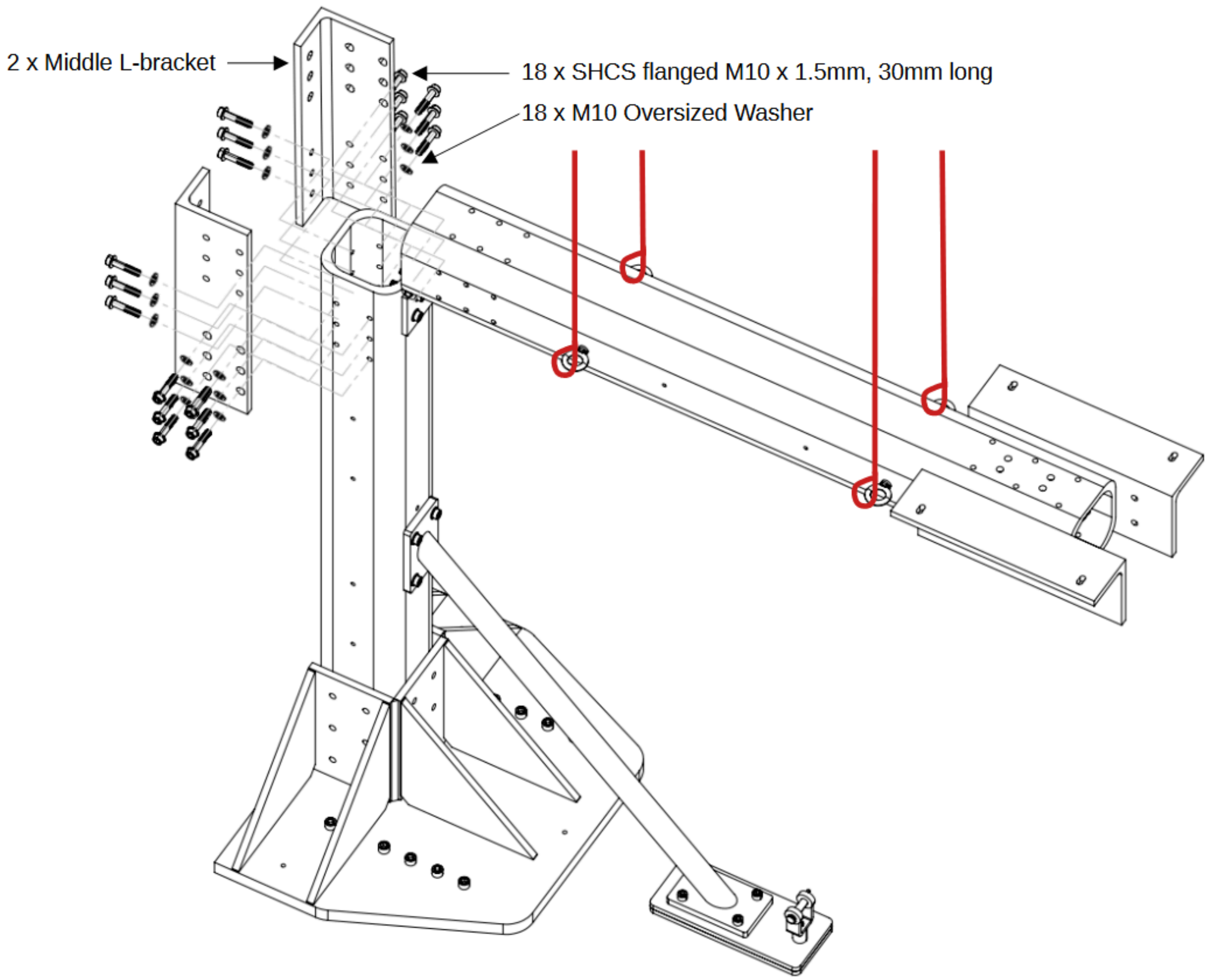


Fig 4.4.3: Middle L-Brackets mounting

- [ ] As the hinge works as a temporary supportive point, rotate the Upper Tube upward so that you may remove the two hooks or the quick links on the two eye bolts that are closer to the hinge; add the tripod support if necessary

- [ ] Keep the hoist pulley and chain sling attached to the other two eye bolts at the far end of the Upper Tube

- [ ] Remove the two eye bolts that are closer to the hinge, and then install the two black bridge handles (#PEZJ) using four SHCS M8-20mm - 12.9 alloy steel screws (#UYKY) at the same location

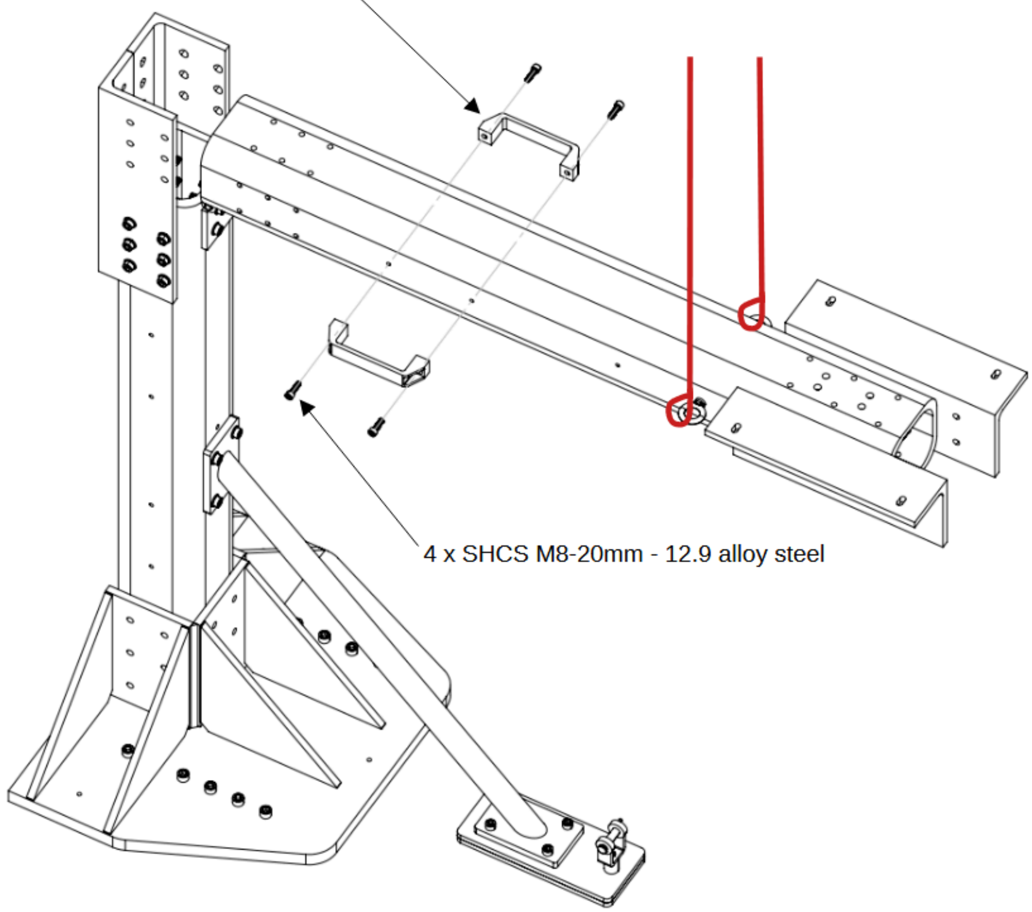


Fig 4.4.4: bridge handles mounting on the Upper Tube

- [ ] Continue to rotate the Upper Tube upward using the hoist pulley until it reaches its maximum height, or until the Upper Tube reaches about 15 to 20 degrees from vertical
- [ ] Two operators on the left and right have to give a final push to the Upper Tube through the handles to make it fully vertical
- [ ] Take eighteen SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) and eighteen M10 oversized flat washers and attempt to fit them between the Upper Tube (#MRRH) and Middle L-brackets (#VYLY); they may not all fit at once; adjust the position and orientations of the Middle L-brackets, the hinge with the Upper and Lower Tubes, so that all forty-four screws (twelve each on side A, B, and C with the Middle L-brackets, eight on side D with the hinge) can fully fit on the whole stand

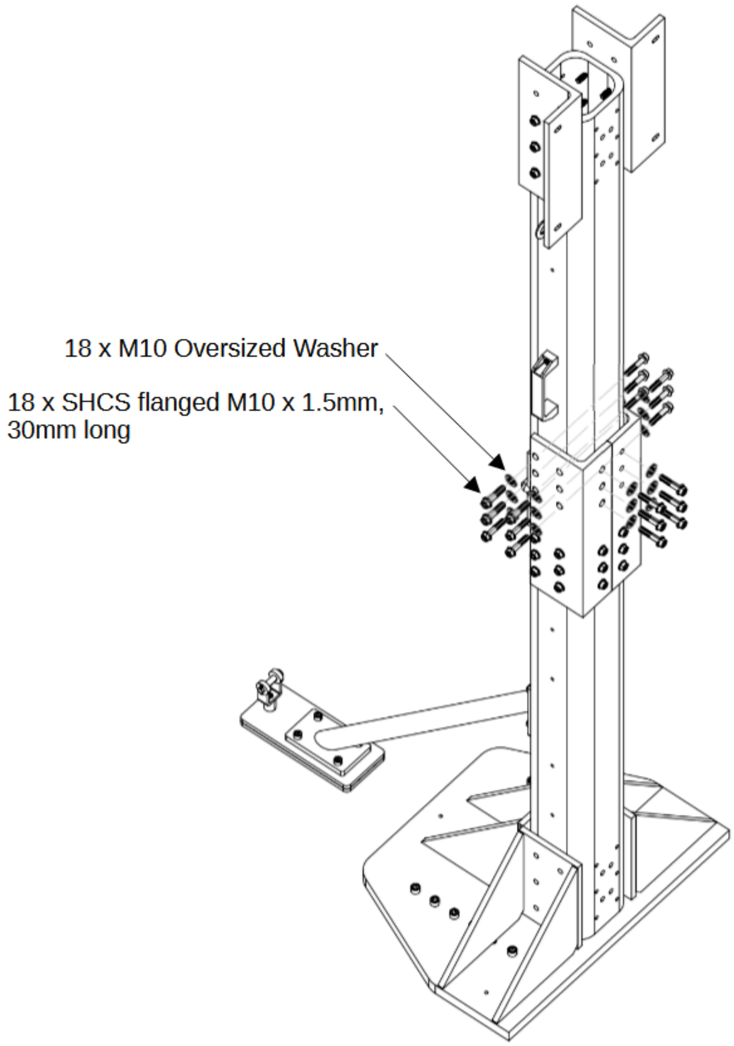


Fig 4.4.5: Middle L-Brackets adjusting o the Upper Tube

- ☐ Fully tighten all eight SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) on the hinge, **TORQUE: 75 Nm**
- ☐ Fully tighten all bottom eighteen SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) between the Lower Tube and the Middle L-brackets, **TORQUE: 75 Nm**
- ☐ Do not fully tighten the screws between the Middle L-brackets and the Upper Tube

OPTIONAL: USING THE ACTUATOR

You may skip the following steps if you are not using the linear actuator

- ☐ Install the clevis adaptor plate (#DDZD) on the Upper Tube using three SHCS M10 x 1.5mm, 30mm long screws (#HJLX) on side D, **TORQUE: 75 Nm**

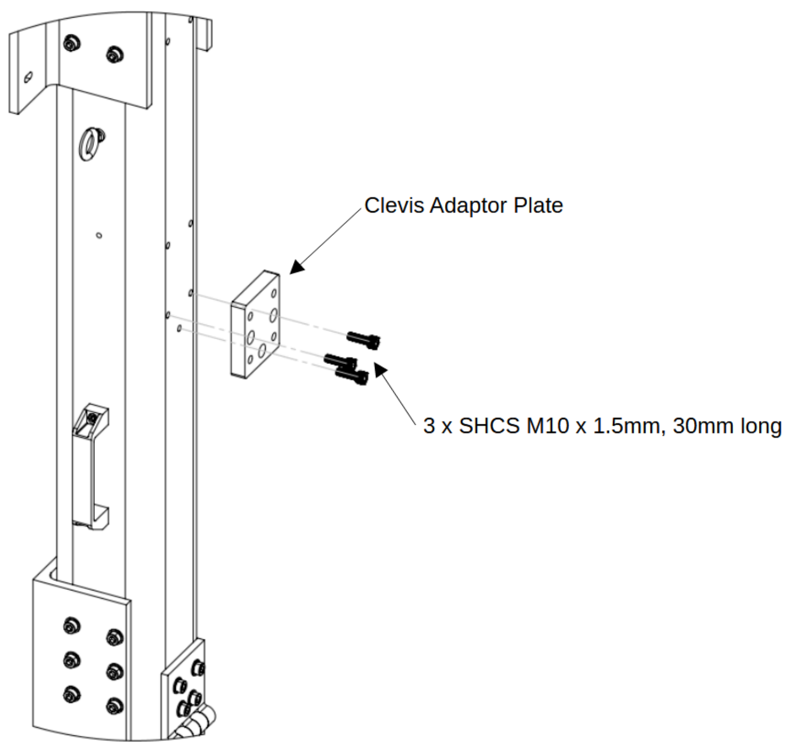


Fig 4.4.6: Clevis adaptor plate mounting

- ☐ Install the Upper Clevis (#XMKA) on the clevis adaptor plate (#DDZD) using four SHCS M12 x 1.25 mm, 30 mm long screws (#XVHB) **TORQUE: 130 Nm**
- ☐ Insert two nylon sleeve bearings (½” shaft, ¾” housing, SKU#: YBPS) on the Upper Clevis

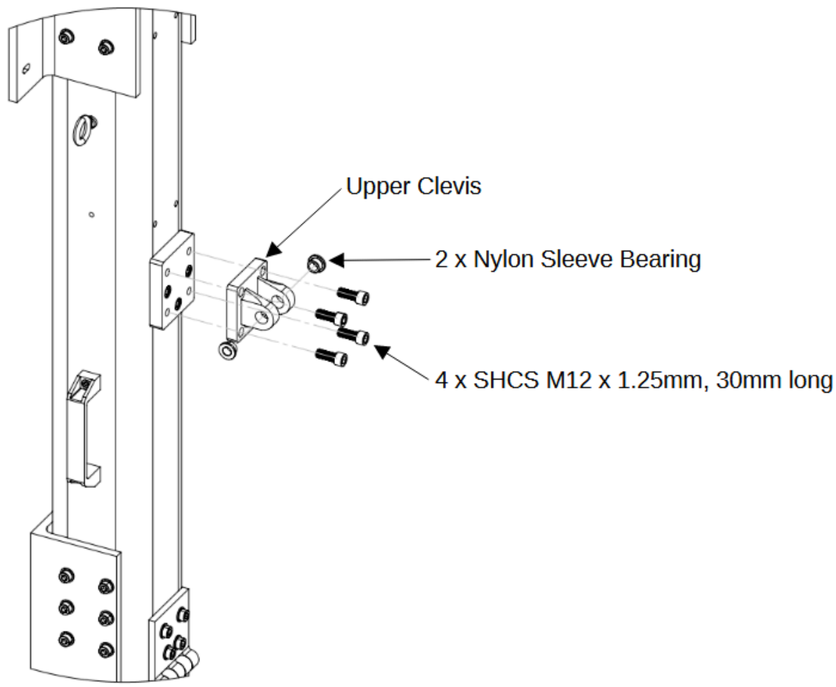


Fig 4.4.7: Upper clevis mounting

- [ ] Remove the pins on the Lower Clevis
- [ ] Place the rear attachment of the actuator on the Lower Clevis, insert the pin and then lock it with the cotter pin
- [ ] Power up the linear actuator
- [ ] Extend the stroke rod until the front attachment of the actuator reaches the Upper Clevis, insert the precision clevis pin 1/2" Diameter 3" length with 1/2" pin (#GHGY) and then lock it with one cotter Pin 1/8" Diameter, 1-1/2" long (#BGAJ)

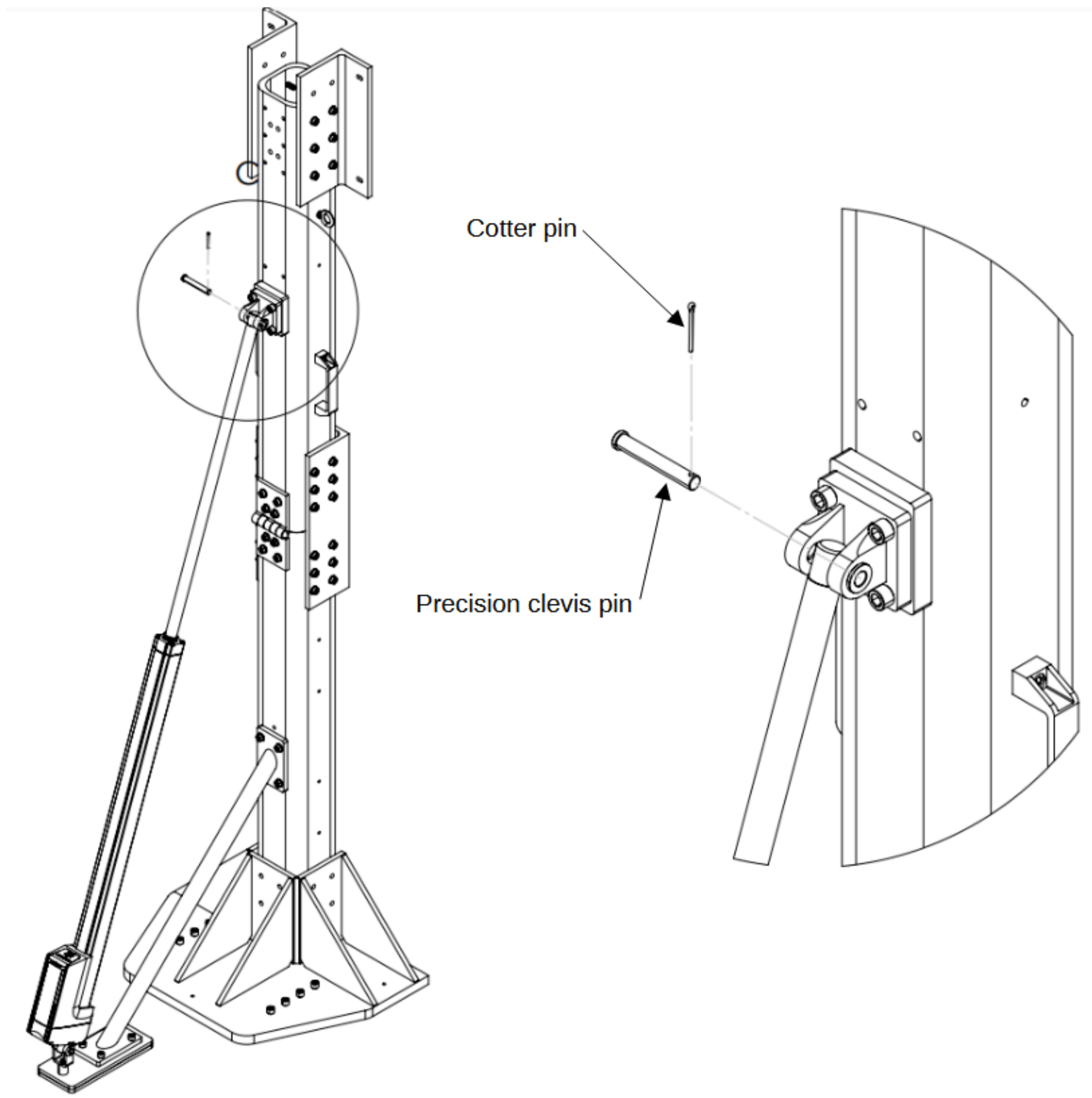


Fig 4.4.8: Linear actuator securing

- ☐ Make sure again all screws on the hinge are fully fastened, the cotter pins are secured on both ends of the actuators
- ☐ **Remove** all upper eighteen SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) and all eighteen M10 oversized flat washers between the Upper Tube and the Middle L-brackets

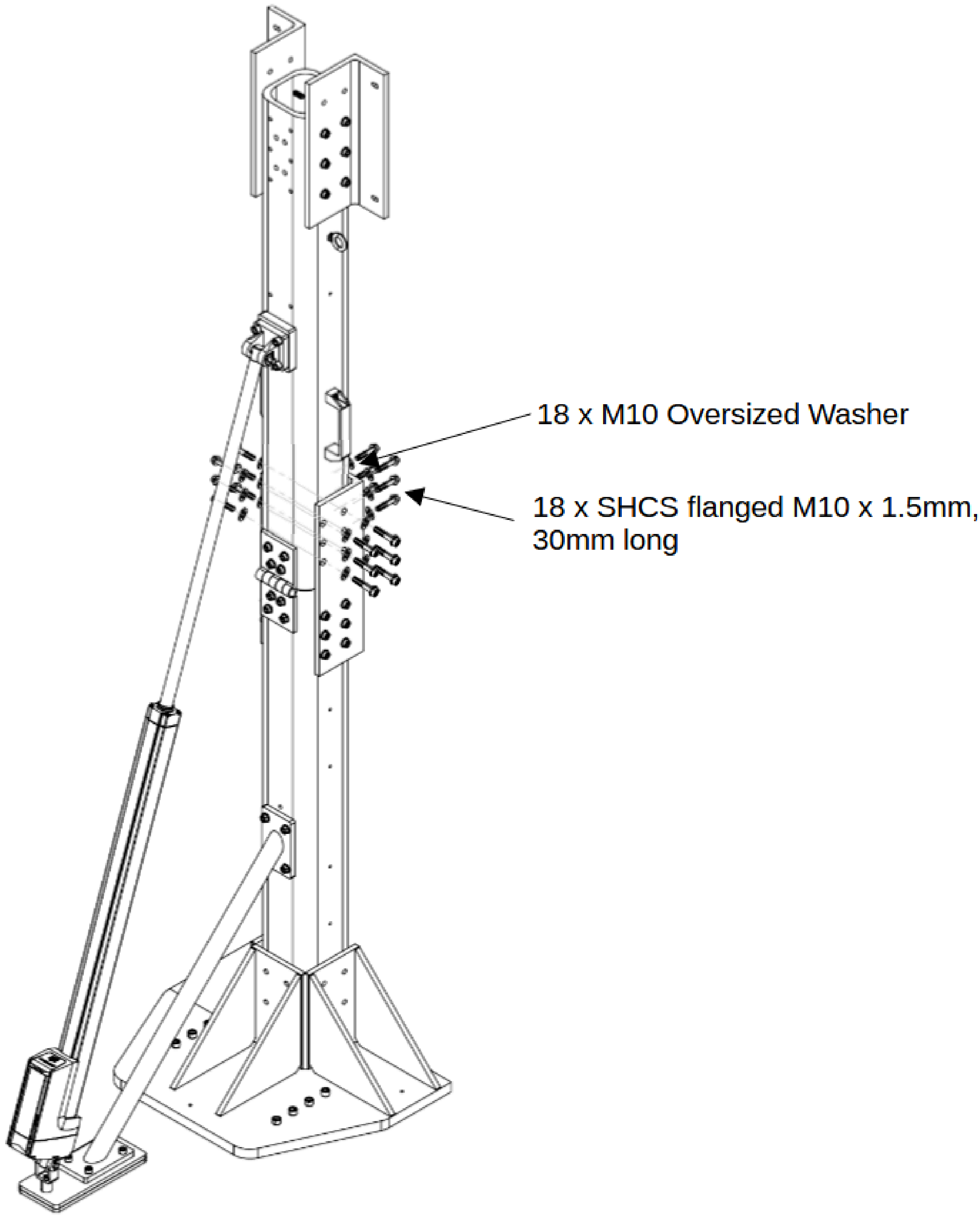


Fig 4.4.9: M10 Screws removal

- [ ] Slowly retract the linear actuator to start lowering the Upper Tube. You should simultaneously lower the chain sling on the hoist pulley to provide a back-up force; rotate the Upper Tube for around 45 degrees

- ☐ Place the tripod support near the rear attachment point of the actuator, at a height about 5 to 10 cm (2 to 4 inches) higher than the lowest position the actuator will reach
- ☐ Continue to retract the linear actuator until the Upper Tube sits safely on the tripod

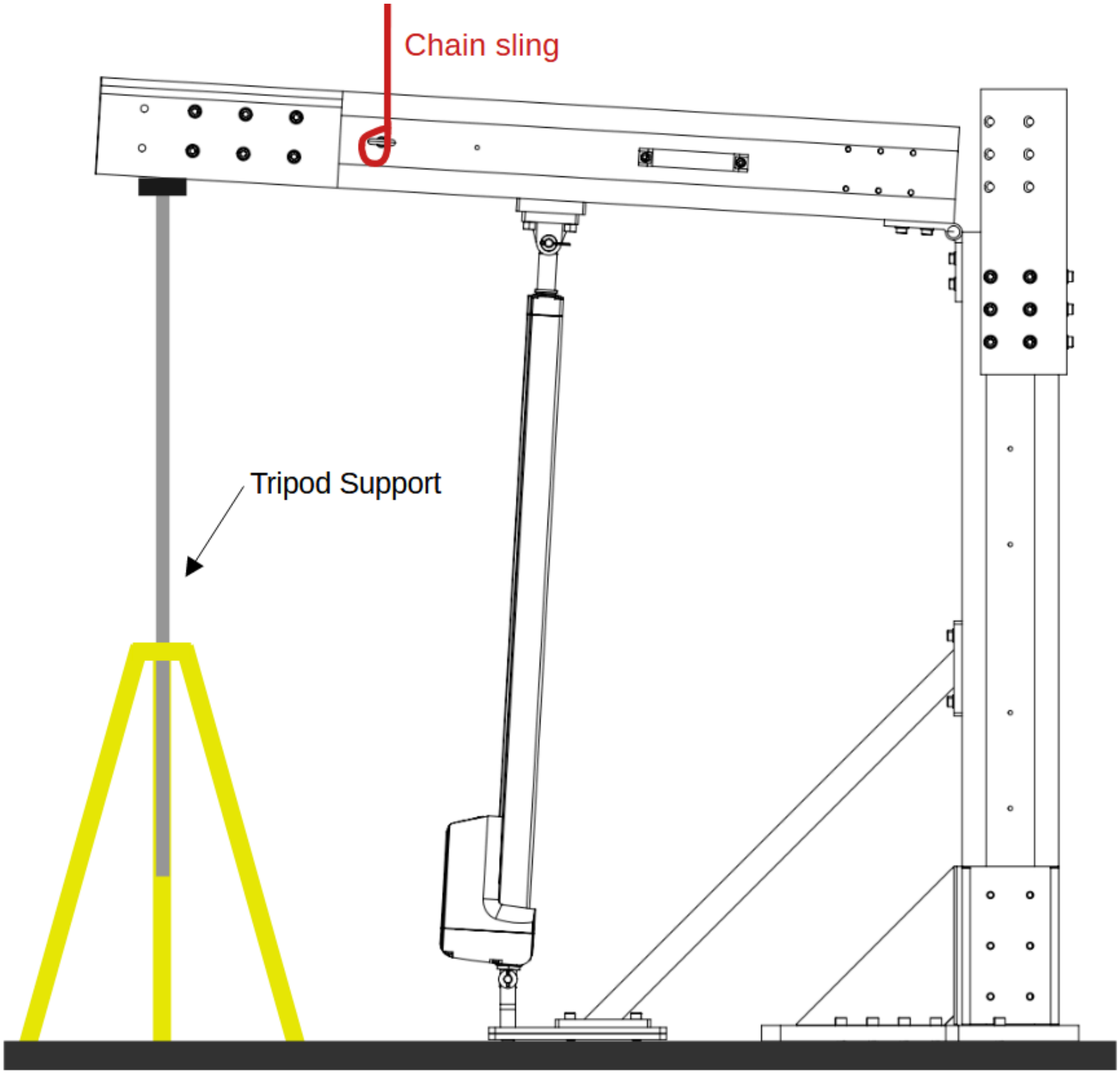


Fig 4.4.10: 45-Degree stand position

- ☐ Detach the hooks or the quicklinks from the chain sling with the eye bolts on the Upper Tube, also remove the bridge handles

Step 5A: Install the FMU on the stand (without actuator)

Parts required for this step:

- FS500 Hardware Bag E (#HRES)

After Step 4, you should have the Upper Tube sitting vertically on the Lower Tube without using the actuator

- [ ] Tighten all eighteen SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) between the Upper Tube and the Middle L-brackets, **TORQUE: 75 Nm**
- [ ] Climb up and detach the hooks or the quicklinks from the chain sling with the eye bolts on the Upper Tube, also remove the bridge handles
- [ ] Lay the FMU flat on the table, rotate it horizontally until the panel for the M8 COM cable is on the left, and the panel for the RPM and PWM control ports are on the right
- [ ] Remove the orange bridge handles on the left and right side of the panel
- [ ] Install a total of four M8 eye bolts (#YNXA): one at front-left, one at front-right, two at the rear panels

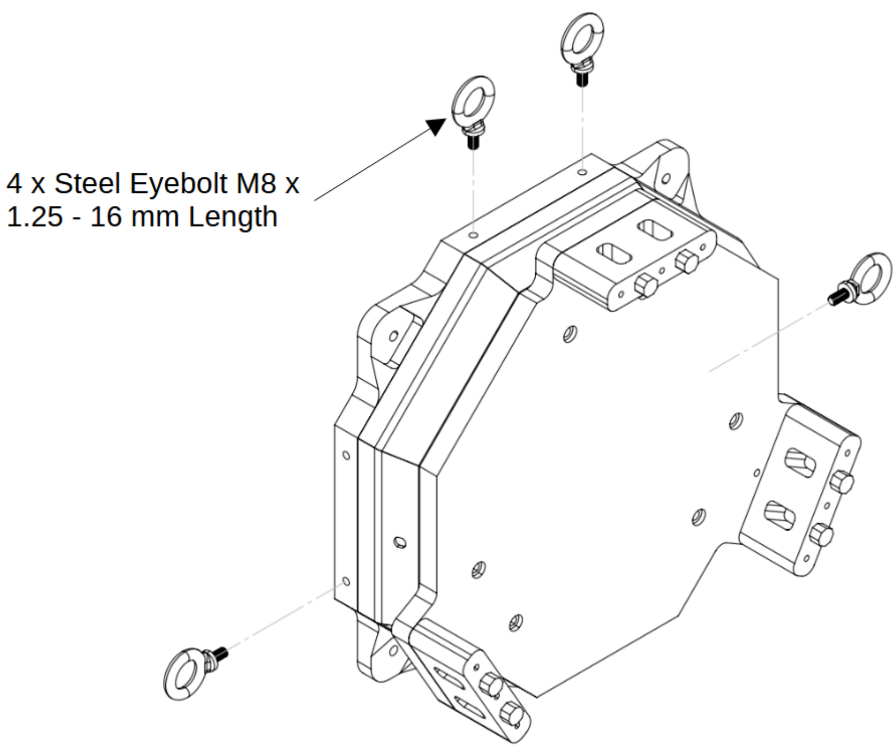


Fig4.5A.1: eye bolts mounting on the FMU

- [ ] Move the FMU carefully and attach those four eye bolts to the chain sling through hooks or quicklinks, make sure the chains are longer for the two eye bolts that are further away from the pulley

- [ ] Slowly lift up the FMU with the pulley until it reaches the height of the Upper L-Bracket

- [ ] Climb up and install the FMU on the Upper L-Bracket using four SHCS M8 x 1.25mm, 50mm long screws (#CFRT), four M8 washer 18-8 stainless steel (#BNEC) and four Nylon-Insert Flange Locknut Class 10, M8 x 1.25mm (#QCPU) , **TORQUE: 38 Nm**

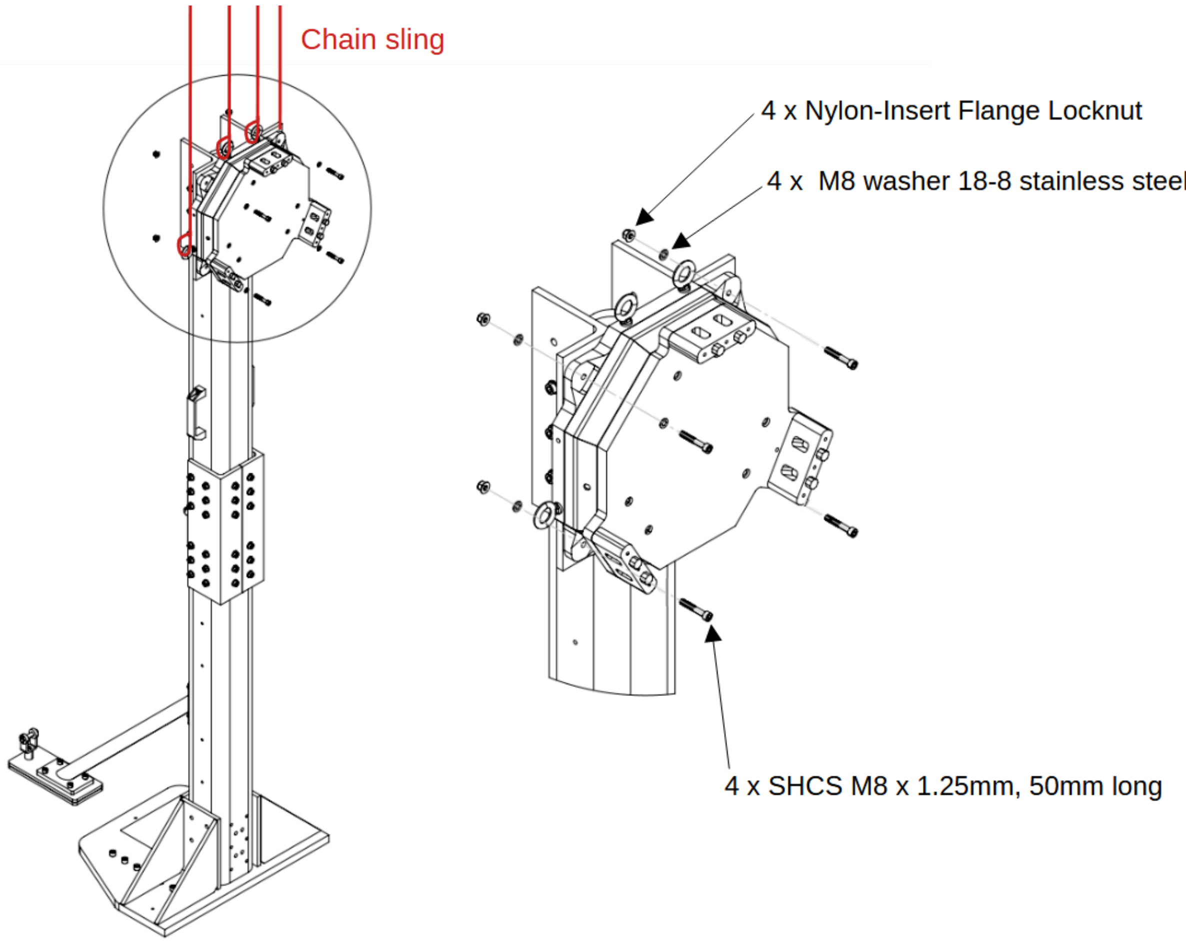


Fig 4.5A.2: FMU mounting on the Upper Tube

- [ ] After fully tightening the fasteners, detach the chain sling from the eye bolts, then remove the eye bolts on the FMU

Step 5B: Install the FMU on the stand (with actuator)

After Step 4 with the actuator, you should have the Upper Tube sitting almost horizontally on the tripod support

- [ ] Keep the orange handles on the FMU
- [ ] With two operators working together, one holding each side of the FMU with the handle, move and make the FMU sit flat on the Upper L-Brackets on the Upper Tube. Quickly insert 4 four SHCS M8 x 1.25mm, 50mm long screws (#CFRT) between the FMU and the Upper L-Brackets to secure the FMU's position
- [ ] Tighten the four SHCS M8 x 1.25mm, 50mm long screws (#CFRT), four M8 washer 18-8 stainless steel (#BNEC) and four Nylon-Insert Flange Lock Nut Class 10, M8 x 1.25mm (#QCPU) , **TORQUE: 38 Nm**

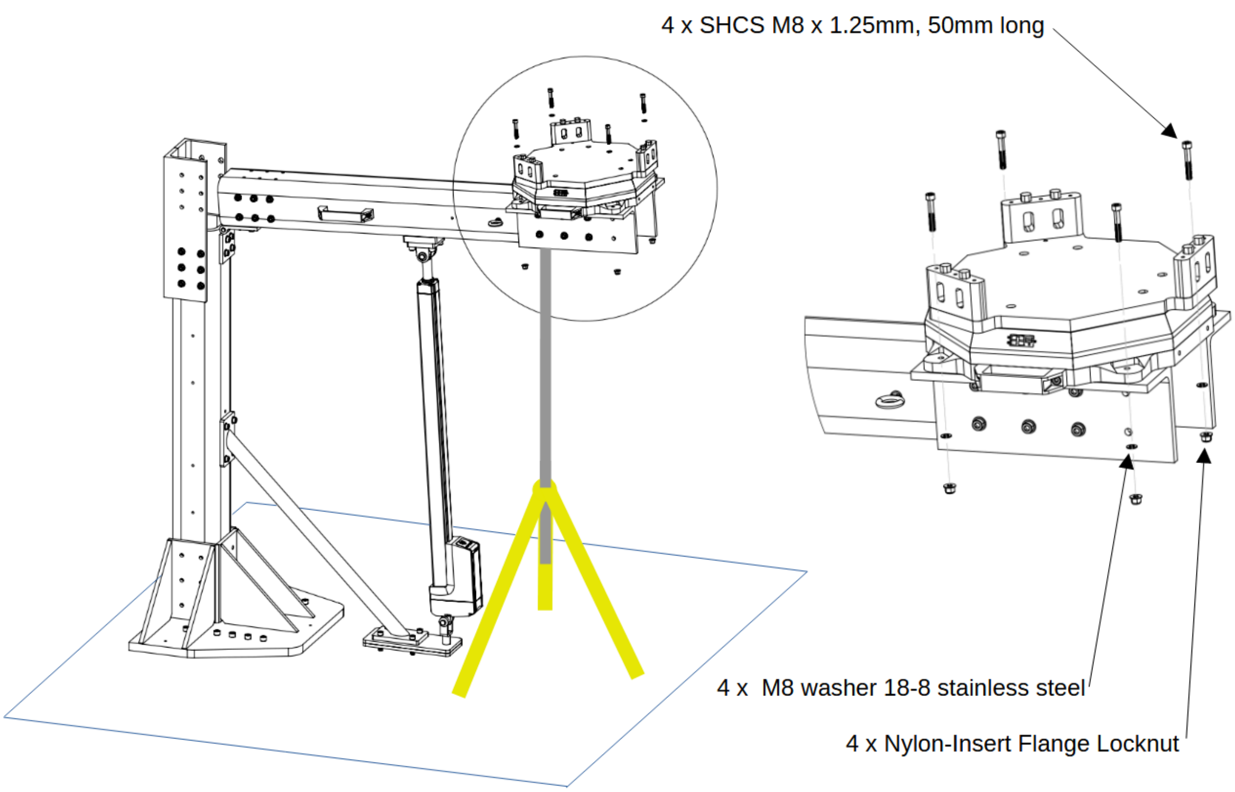


Fig 4.5B.1: FMU fixing on the Upper Tube

- [ ] Remove the handles from the FMU once it is fully installed on the stand

Step 6A: Install the motor and the motor mount (without actuator)

Parts required for this Step:

- FS500 Hardware Bag F (#PFPG)
- FS150 Optical RPM Probe Bag (#CAEZ)
- FS150 Optical Probe Fasteners Bag
- Steelwriter paint pen 5 mm Nib, color Black (#CMTP)
- Steelwriter paint pen 5 mm Nib, color White (#UPAS)
- Threadlocker, Loctite® 242, 0.34 oz. (#MKQQ)
- 2 x Stand Connection L-plate FMU mono-ax (#QXZS)
- Motor mounting plate (#SHXG)

- [ ] Measure the mounting points of your brushless motor and drill holes on the motor mounting plate (#SHXG), make sure to properly align these holes with the center mark on the motor mounting plate; a small non-concentricity will generate errors in torque measurement.
- [ ] On the motor mounting plate, where the two crosses are engraved, drill two holes that won't block your motor's assembly for two eyebolts to lift up the motor mount (recommended drill size: 6.4 mm, 17/64", 8.5 mm, 11/32"; recommended eye bolts to use: M6, M8, ¼", ⅜").
- [ ] Install your motor on the motor mounting plate. We recommend using socket head screws with lock washers. Make sure to tighten all fasteners to the rated torque.
- [ ] Install the optical RPM probe (#PPKP) on the motor mounting plate, you may wish to use different locations depending on the diameter of the motor; and you may also select to use different length standoffs (SKU#: XEAA, FGMM, RYAF) depending on the height of the motor.
- [ ] Apply loctite to all fasteners used for fixing the optical RPM probe, severe vibration could loosen these fasteners.
- [ ] Use the Steelwriters (#CMTP, #UPAS) to paint black-white divisions on the rotor.
- [ ] Use two eye bolts that have a long enough thread, minimum 1 inch or 25 mm, and fix them with nuts in the two holes marked as "Drill for Lifting".

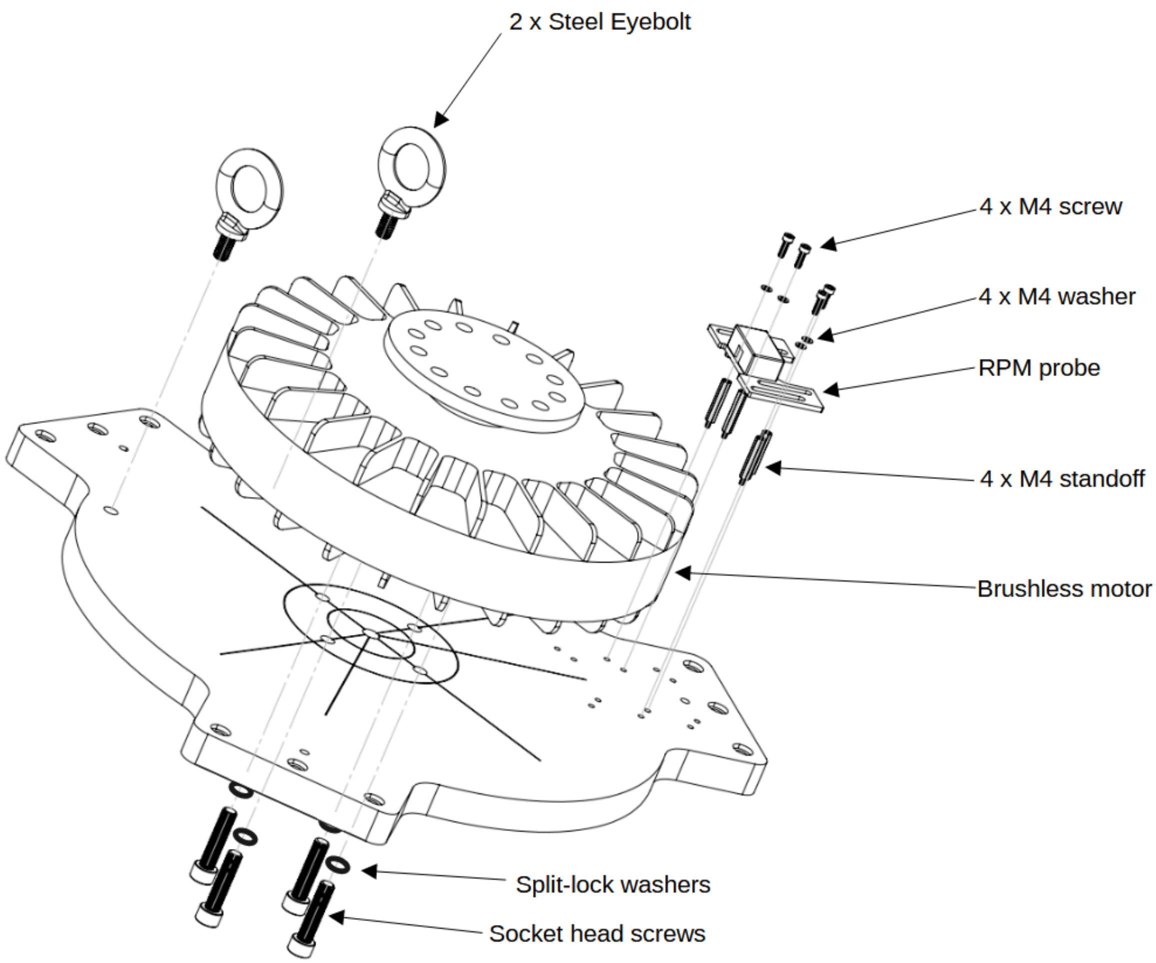


Fig 4.6A.1: Mounting the RPM Probe and eye bolts on the motor mounting plate

- ☐ Move the motor mounting plate and the brushless motor assembly near the stand.
- ☐ Attach the chain sling to the two eye bolts with hooks or quicklinks, hold it steady and avoid swinging. Gradually raise the motor mounting plate to the height of the Force Measurement Unit.
- ☐ One operator shall climb up and then manually align the square holes on the motor mounting plate with the spacers on the FMU.
- ☐ Use nine SHCS M6-35mm Zinc-Plated Alloy Steel (#EJAR) to fix the motor mounting plate onto the spacers.

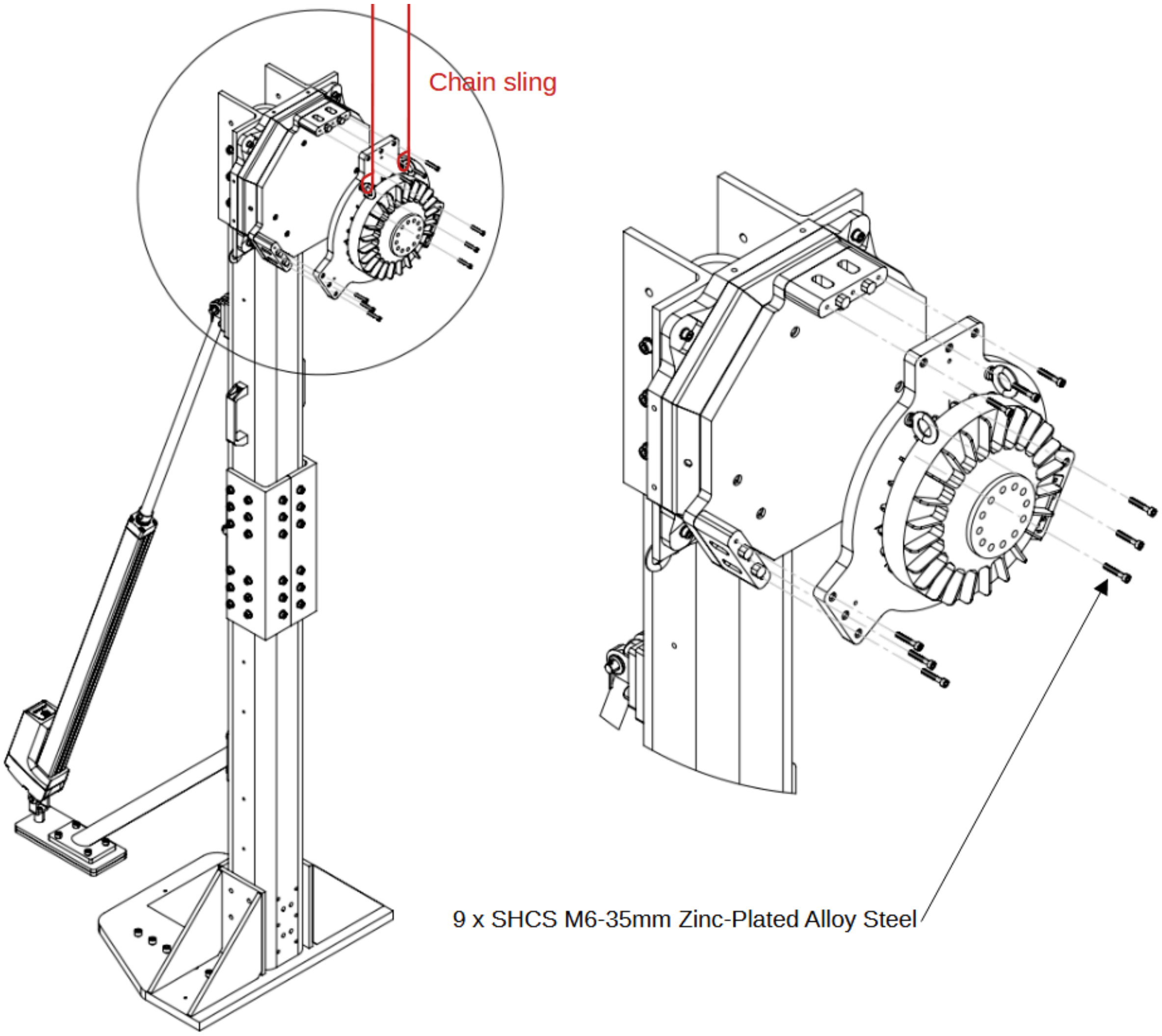


Fig 4.6A.2: Fixing the motor mounting plate

- ☐ Tighten the nine SHCS M6-35mm Zinc-Plated Alloy Steel on the motor mounting plate side, **TORQUE 15.7 Nm.**
- ☐ Tighten the nine SHCS M6-35mm Zinc-Plated Alloy Steel on the FMU side, **TORQUE 15.7 Nm.**

Step 6B: Install the motor and the motor mounting plate (with actuator)

- ☐ Install the motor on the motor mounting plate

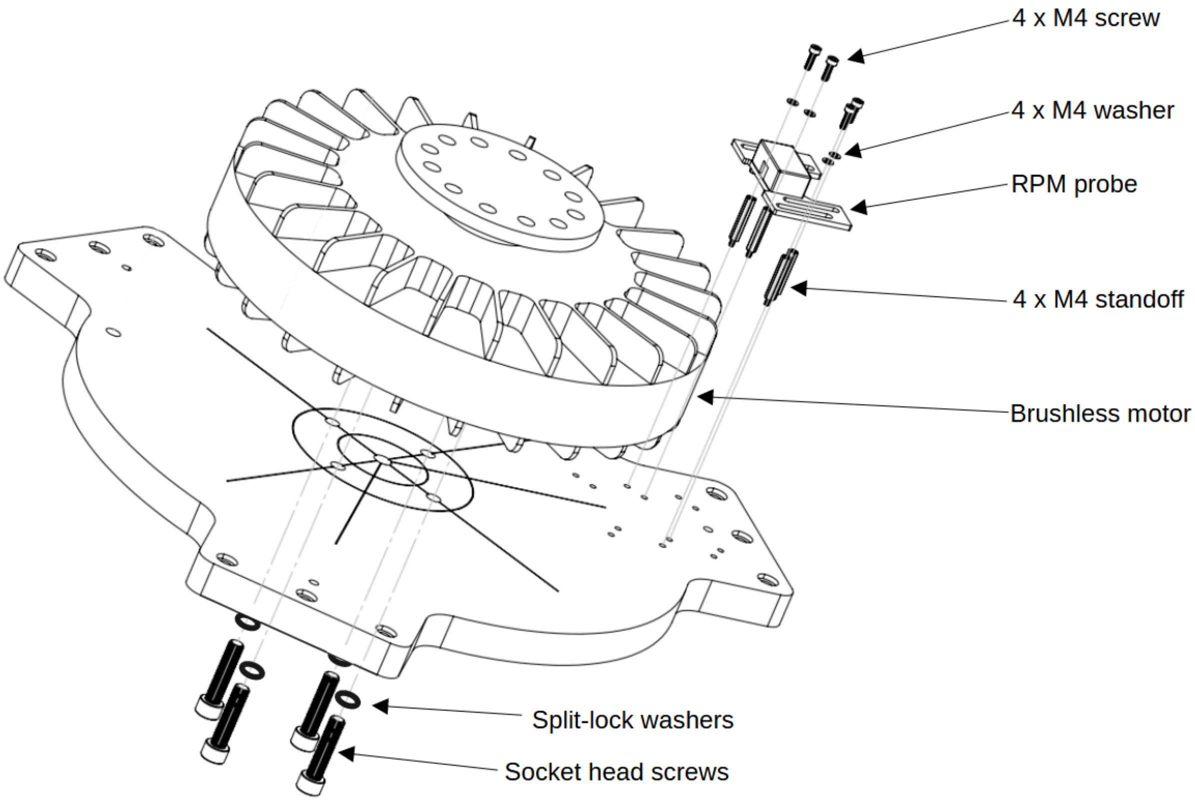


Fig 4.6B.1: Mounting the motor on the motor mounting plate

- ☐ Install the optical RPM probe (#PPKP) on the motor mounting plate. You may choose to use different locations depending on the diameter of the motor; and you may also choose to use different lengths of standoffs (SKU#: XEAA, FGMM, RYAF) depending on the height of the motor
- ☐ Apply Loctite to all fasteners used for fixing the optical RPM probe as severe vibration can loosen these fasteners
- ☐ Use the Steelwriters (#CMTP, #UPAS) to paint black-white divisions on the rotor, when having more than 1 black-white divisions, make sure that they are equally spaced
- ☐ Two operators shall work together, one holding each side of the motor mounting plate and keeping the plate relatively flat.
- ☐ Place the motor mounting plate on the spacers by aligning the square holes of the motor mounting plate with the spacers.
- ☐ Use nine SHCS M6-35mm Zinc-Plated Alloy Steel (#EJAR) to fix the motor mounting plate onto the spacers.

- [ ] Tighten the nine SHCS M6-35mm Zinc-Plated Alloy Steel on the motor mounting plate side, **TORQUE 15.7 Nm**

- [ ] Tighten the nine SHCS M6-35mm Zinc-Plated Alloy Steel on the FMU side, **TORQUE 15.7 Nm**

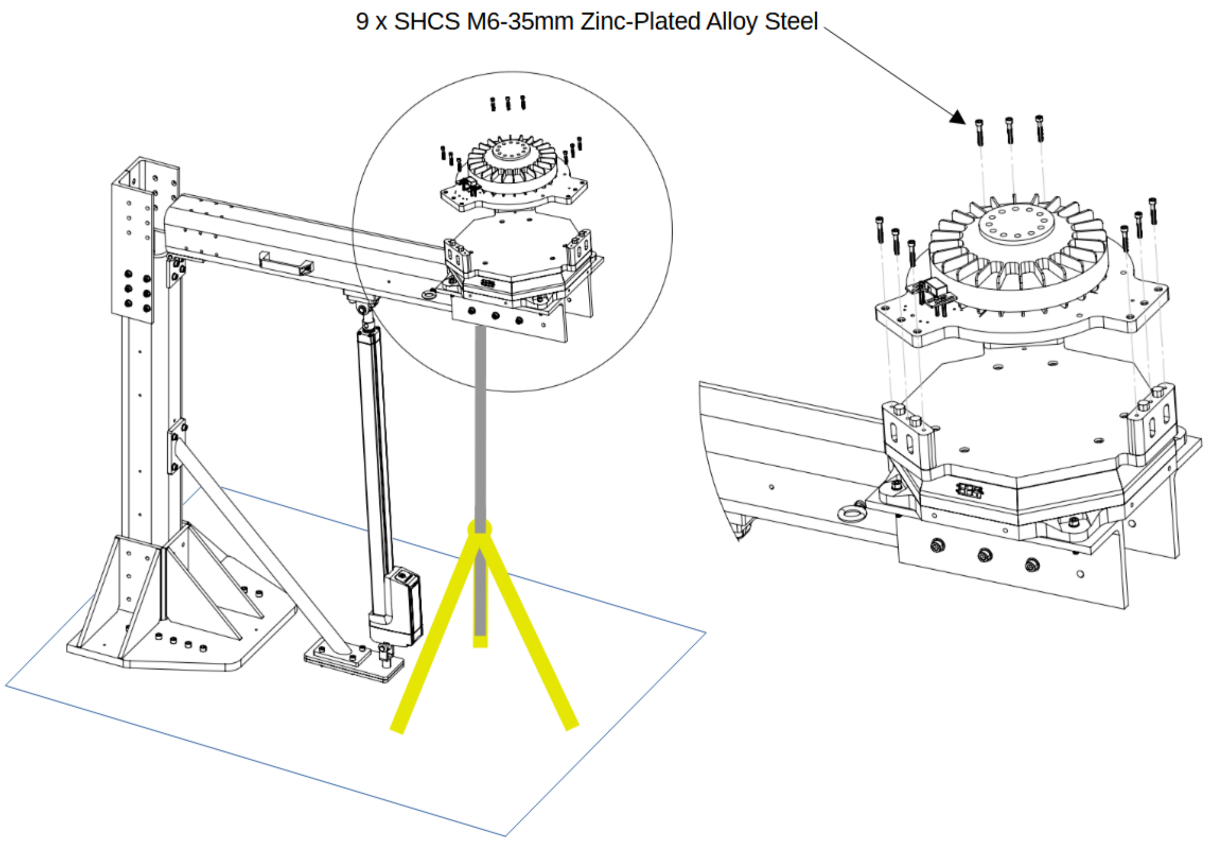


Fig 4.6B.2: Motor mounting plate fixing

- [ ] Power up the actuator

- [ ] Raise the Upper Tube until the Upper Stand is fully upright

- [ ] Shut down the power for the linear actuator

- [ ] Put the eighteen SHCS flanged M10 x 1.5mm, 30mm long screws (#ZEGX) and eighteen M10 oversized flat washers on the two Middle L-brackets and the Upper Tube. Tighten the screws to **TORQUE: 75 Nm**

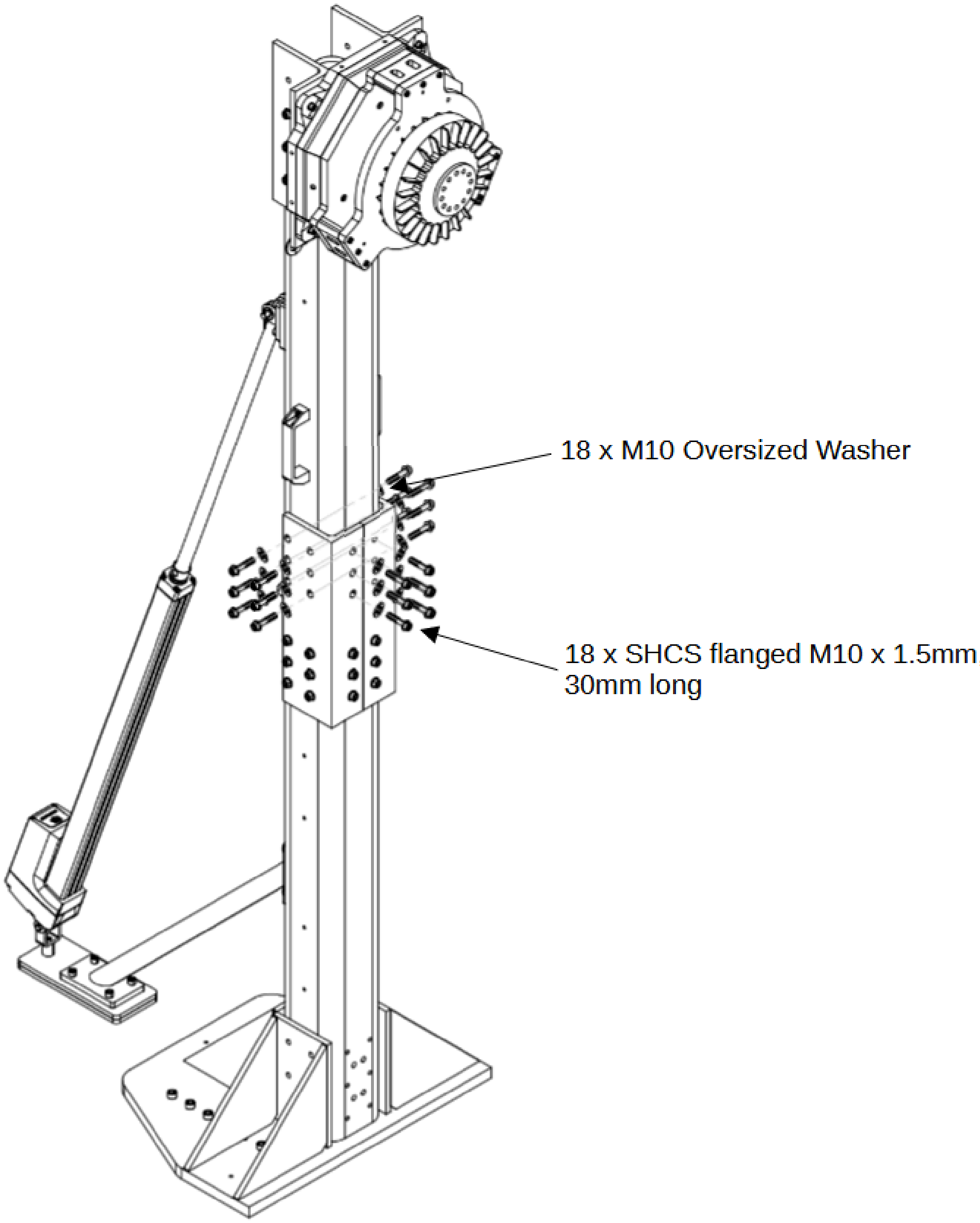


Fig 4.6B.3: Securing the Upper Tube

fig 4.6: Raised stand

Step 7: Three-phase wires

We recommend using ring terminals to connect the wires between the motor and the ESC

- [ ] Connect the heavy-duty wires one by one from the ESC to the brushless motor
- [ ] Fully tighten the screws and nuts through the ring terminals
- [ ] Use insulated tape to fully wrap the exposed metal on the ring terminals
- [ ] Use tie-wraps to tighten the three-phase wires between the ESC and the motor on the motor mounting plate; add cushions if necessary to avoid cable cuts by the sharp edge of the metal parts

Step 8: Final steps

We recommend installing the propeller when the stand is fully upright

- [ ] Prepare the spacers and fasteners for your propellers
- [ ] Climb up to the height of the FMU and install the propeller on the motor
- [ ] Apply adequate tightening torque on the fasteners of the propeller
- [ ] If you are using the linear actuator, remove the pins on the Upper Clevis and then retract the actuator to its minimum position. Completely remove the actuator from the stand
- [ ] Make sure that all fasteners are properly tightened to the rated torque, especially after each lift up / down of the Upper Tube
- [ ] Keep one or more M8 eye bolts on one side of the Upper and Lower Tube so that the three-phase wires can be secured with cable-ties or quicklinks
- [ ] Make sure that all loose objects are removed from on or around the stand

Chapter 5: Electrical wiring

The quality of the electrical wiring between the power source and the ESC, and between the ESC and the brushless motor, is extremely important to the safety of operating the Flight Stand.

Tyto Robotics doesn’t provide any electrical wiring to connect the powertrain components, it is your responsibility to choose the proper wire gauge according to the maximum power transmission current.

IMPORTANT!

Most of the powertrain components at this scale are operated under high voltage and high current. Therefore, you must properly secure all the wire connections. A faulty contact or a current leak can significantly degrade the Flight Stand measurements. We suggest using properly rated terminal blocks or distribution blocks as shown in Fig 5.1. Make sure to tighten the nuts on the lugs to maintain good contact.

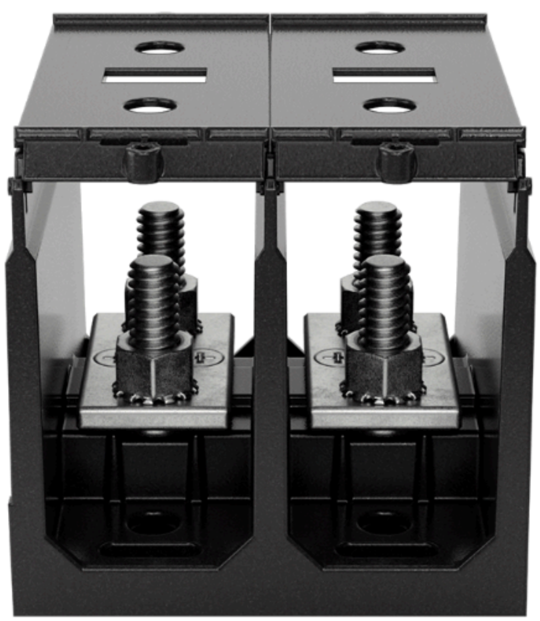


Fig. 5.1. Terminal blocks or distribution blocks

5.1 Voltage measurement

ATTENTION!

High voltage operation, make sure the power is shut down or the relay is open!

Parts required for this Step:

- High Voltage Electrical Measurement Unit
- Voltage measurement probe (2 polarities)

Tools required for this Step:

- Cutter and pliers
- Insulated tape
- Lugs and crimp (optional)

STEP 1. Take the banana connector wires out from the Electrical Measurement Unit box, keep the connector end and strip the other wire end;

STEP 2. Depending on the type of power source, you may solder or crimp the free end with the ring terminal according to the type of intermediate point;

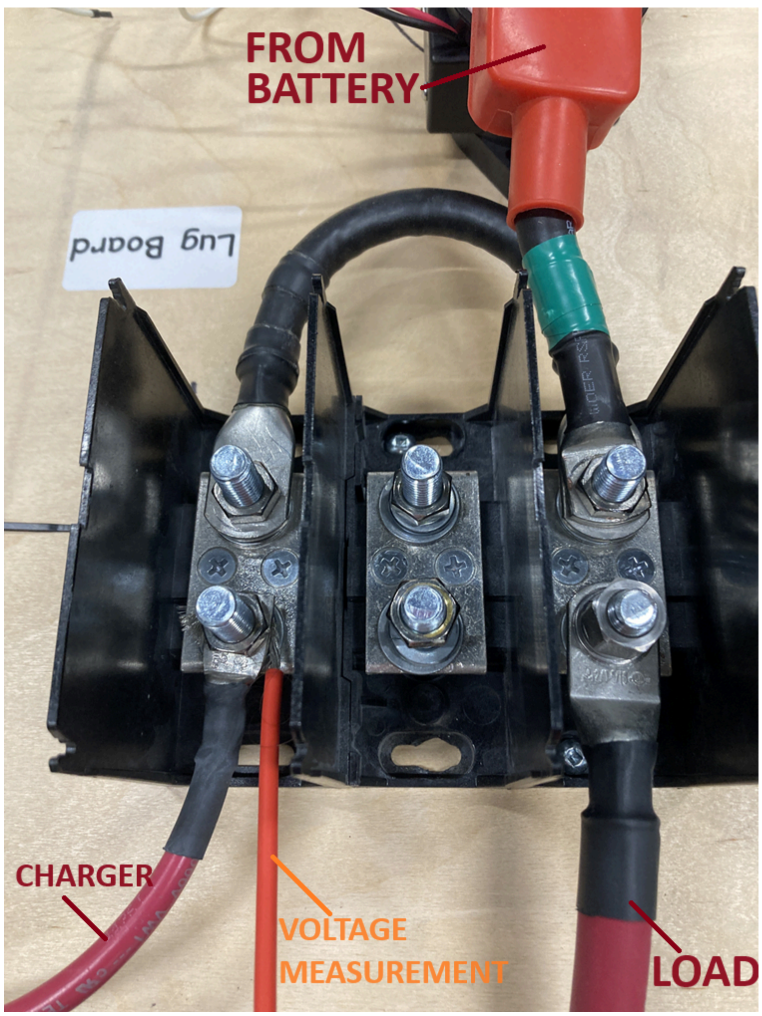


Fig 5.1.1: Terminal Block wiring

STEP 3. In our example, we stripped the end of the wire and clamped it with a nut on the distribution block. Make sure to tighten the nuts to the rated torque;

STEP 4. If you do not use a distribution block, you may also crimp the wire with a ring terminal and connect each wire to the proper polarity between the power source and the ESC; as the Flight Stand 500 may operate under high voltage, we do not recommend stripping the high-current power line and twisting the voltage measurement wire with it;

STEP 5. Connect the banana connector to the EMU following the color scheme for polarities;

STEP 6. Connect the M8 cable between the Electrical Measurement Unit and the Sync Hub; open the Flight Stand Software to see if the Electrical Measurement Unit is detected. You will see a green icon with the name and serial number on the connectivity panel of the software.

STEP 7. The voltage measurement may show 0 on the Flight Stand software when the real voltage is below 5 V. We suggest using the lowest possible voltage on your power source to perform a quick verification without rotating the motor;

Fig 5.1.2: Connect the banana connector to the EMU

5.2 Current measurement

STEP 1. Use a small screwdriver to unfasten the screw and open the Hall Sensor;

STEP 2. Feed the POSITIVE wire through the Hall sensor following the sign of current flow indicated on the sensor.

STEP 3. For best measurement, the red and the black wires should not be close to each other. This step will allow the Hall Sensor to measure the DC current input to the ESC.

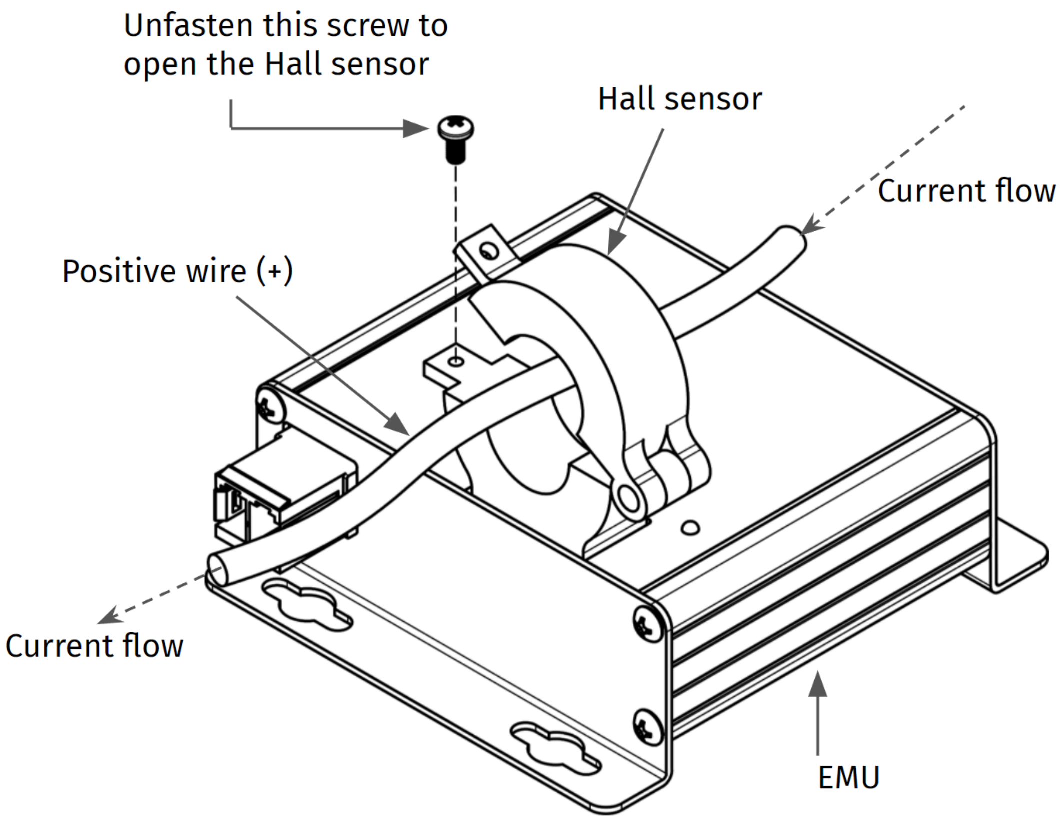


Fig 5.2.1: EMU current measurement setup

5.3 FMU Input/Output

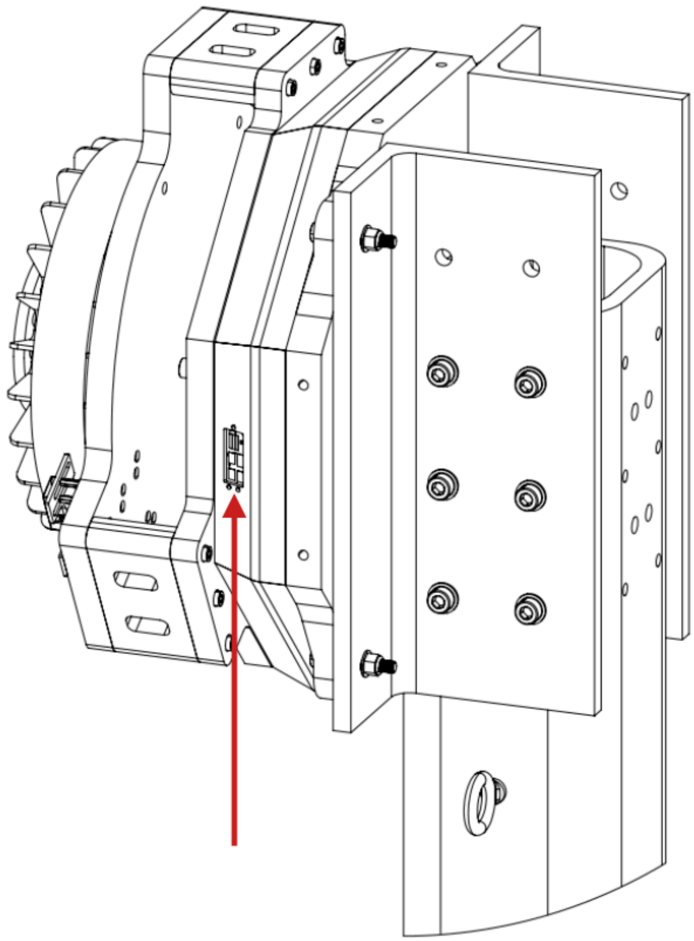


Fig. 5.3.1: Location of the breakout board

On the side of the FMU opposite the M8 connector, the breakout board is the Input / Output interface with the following ports:

- **ESC**: PWM port
- **S1**, **S2**, **S3**: Servo ports
- **RPM**: RPM probe port
- **Temp1**, **Temp2**: PT-100 ports
- **Temp IR**: IR sensor port

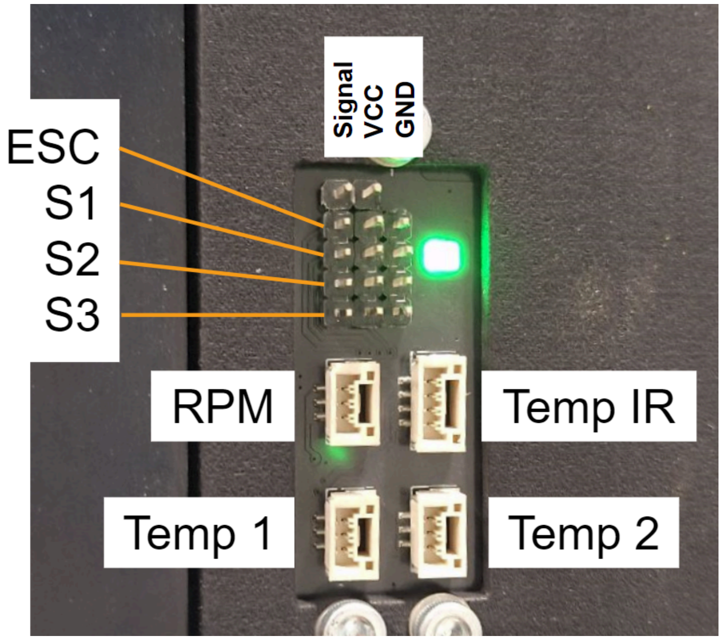


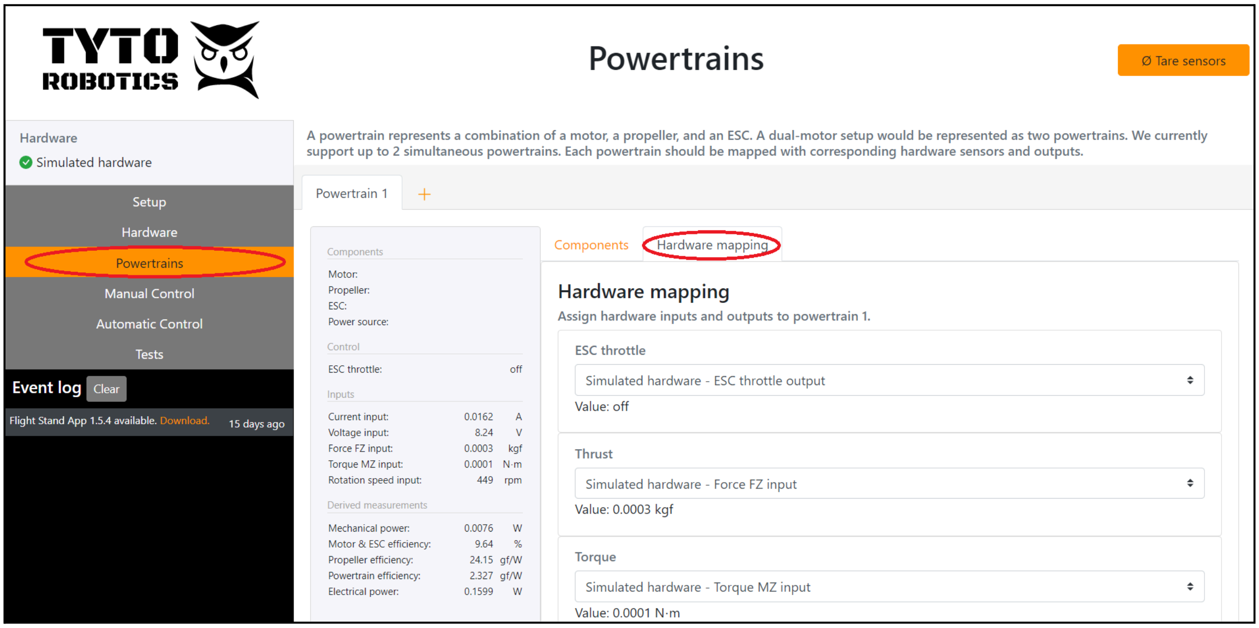
Fig. 5.3.2:. Breakout board layout

Chapter 6. Software Setup

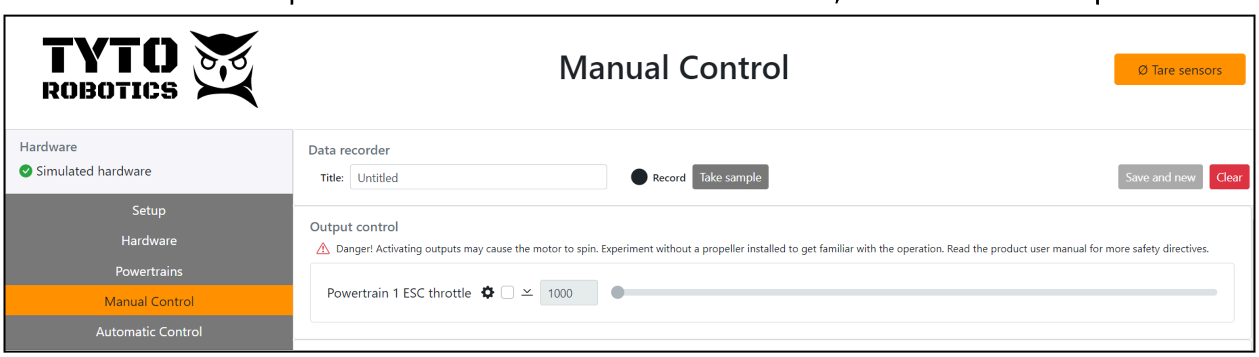
Visit www.tytorobotics.com to download the latest version of the Flight Stand Software.

6.1. Software Setup and Test Run

Step 1. Go to the "**Powertrains**" tab, and then "**Hardware mapping**" to map the powertrain components.
Step 2. Leave the testing space, ensuring everything within it is secured.



Step 3. Turn on your power source and run a short low-speed test in the manual control tab to determine the motor's direction of rotation. If the direction is wrong, turn off the power, switch 2 of the three-phase cables between the ESC and motor, then run another quick test.



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

Turn off the power. Tie wrap all cables, including the three-phases between ESC and motor.

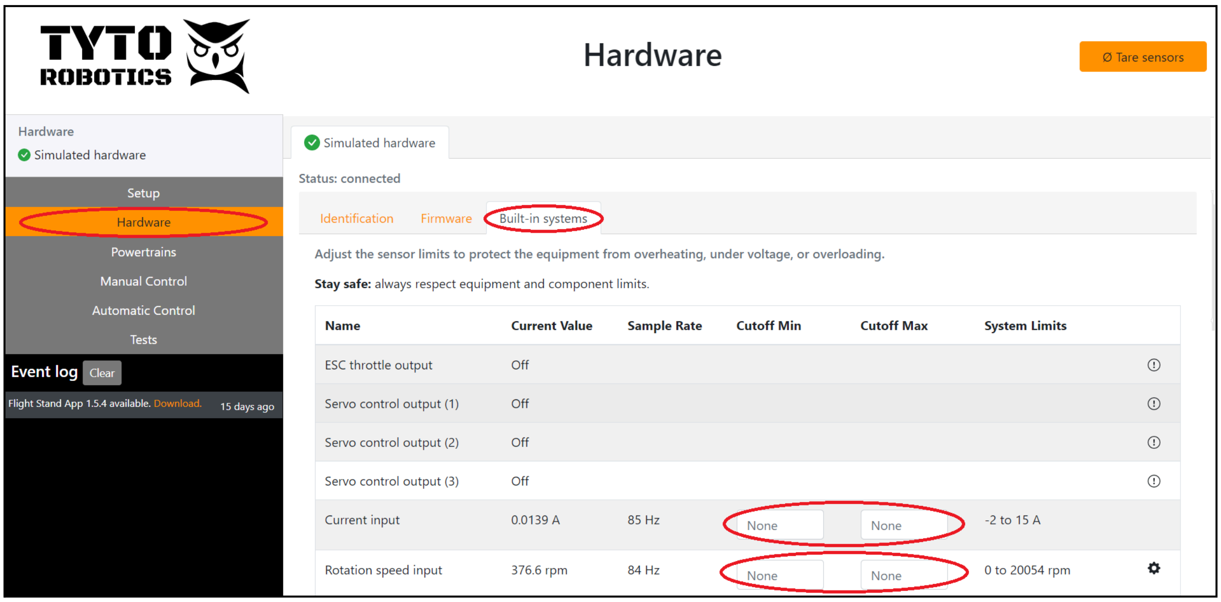
Chapter 7. Testing

7.1. Manual Test

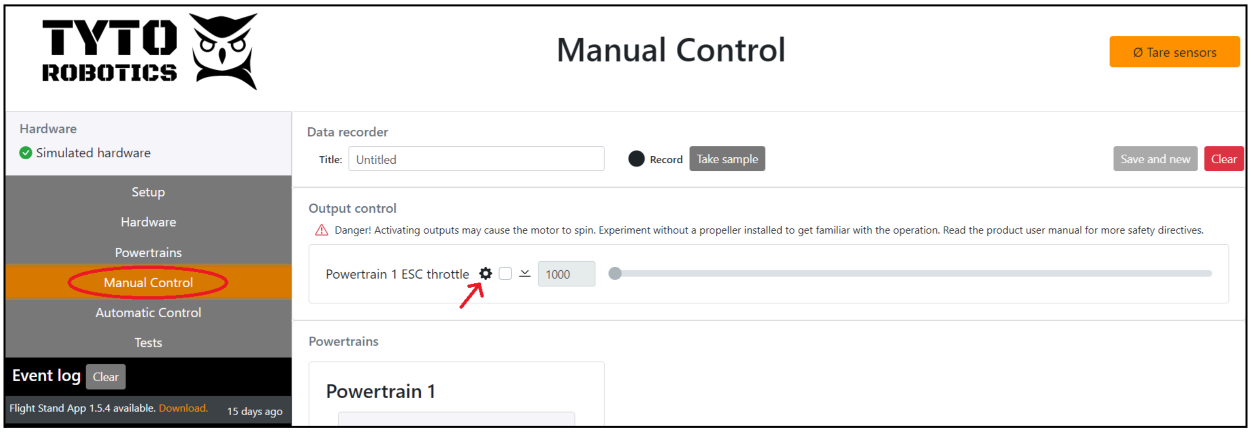
You must complete these steps before each test :

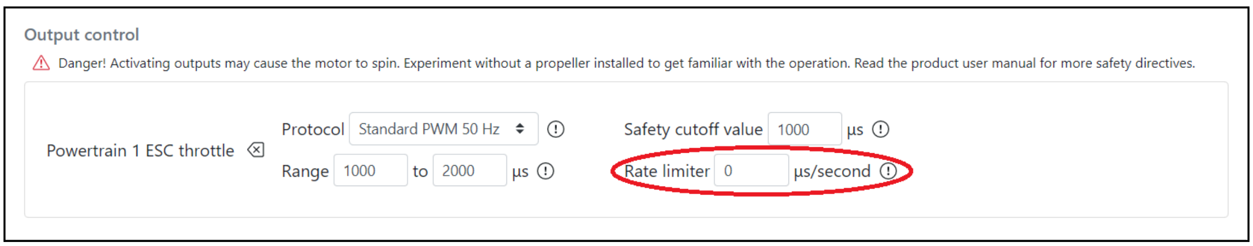
Step 1. Do a thorough **ground inspection** of the test area and remove anything that could fly off or away, especially small parts.

Step 2. Set your safety limits in the software:

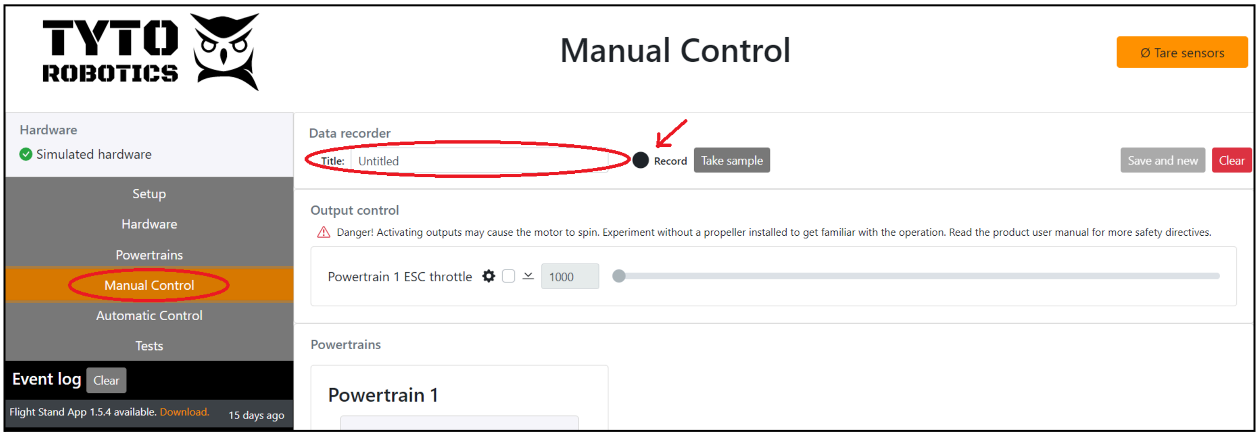


Step 3. Select the rate limiter settings:

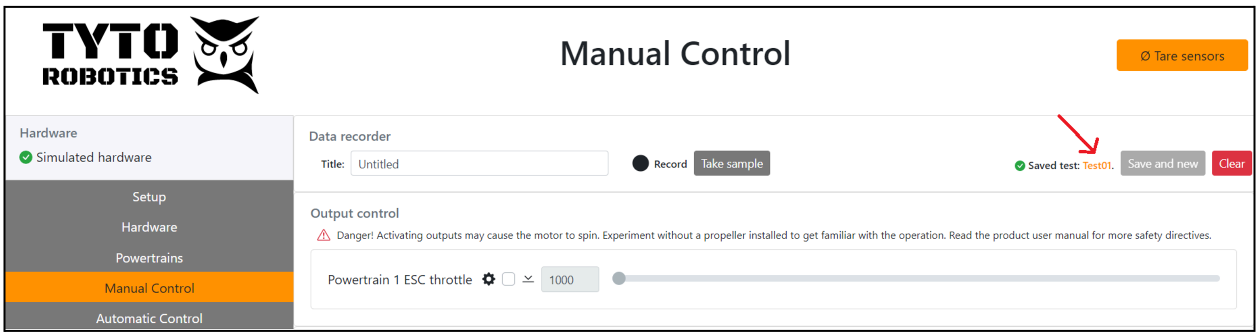




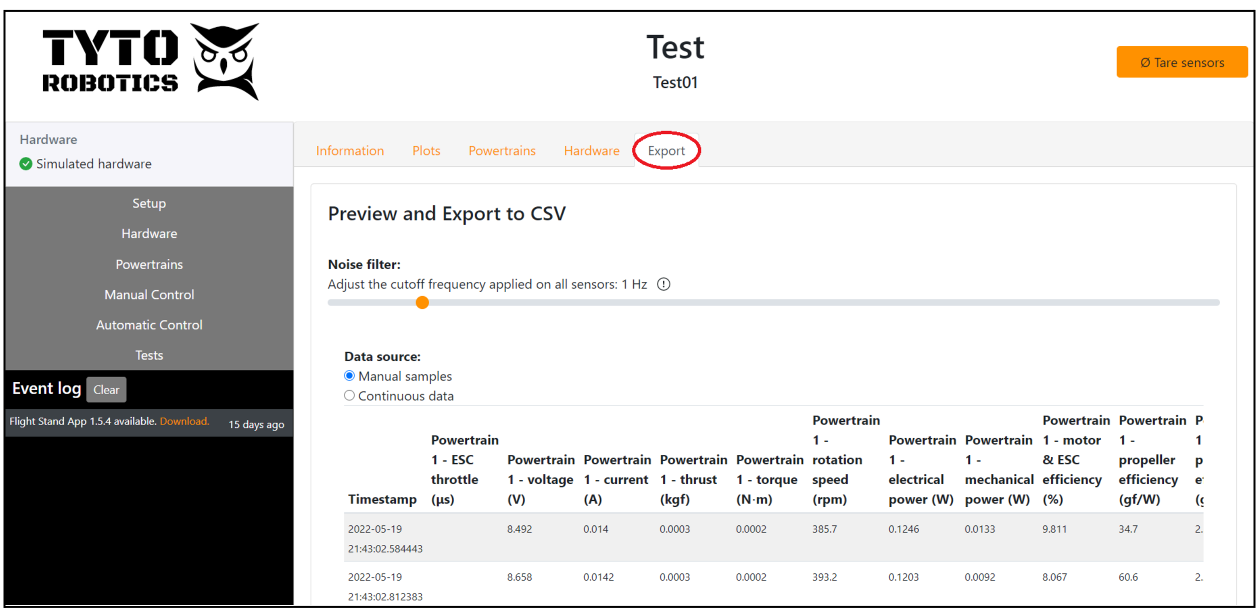
Step 4. You can now start the test by turning the power on, naming and starting the test by activating the ESC. Use the throttle slider in the manual control tab to control the RPM.

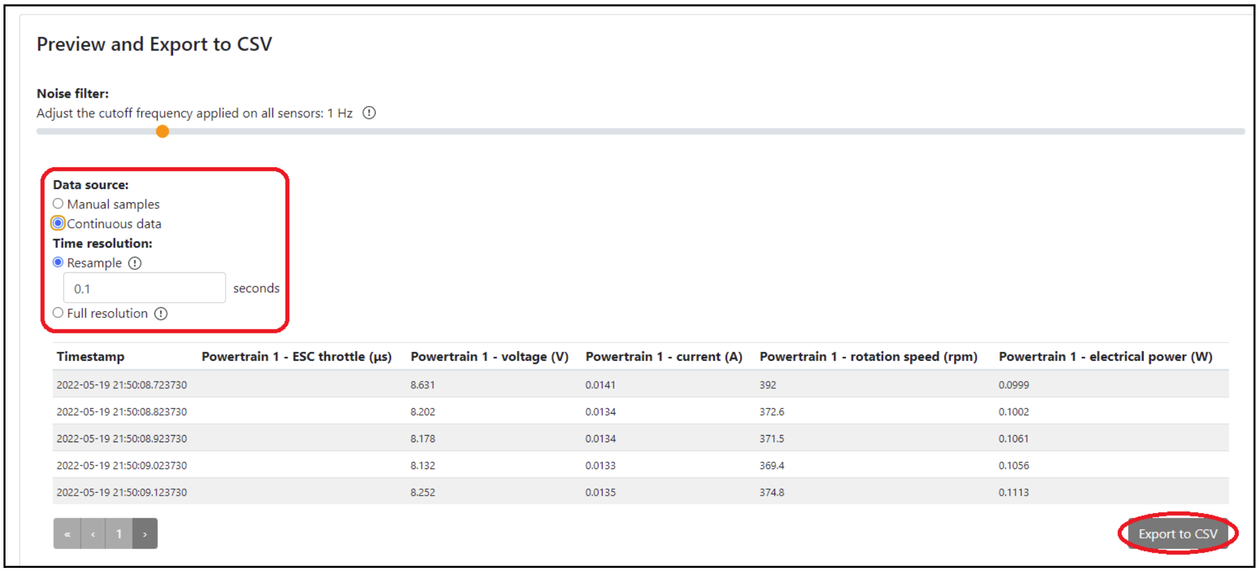


Step 5. Once your test is complete, stop the motor and recording, and turn the power off.



Step 6. Export the CSV data file at your desired sampling rate.

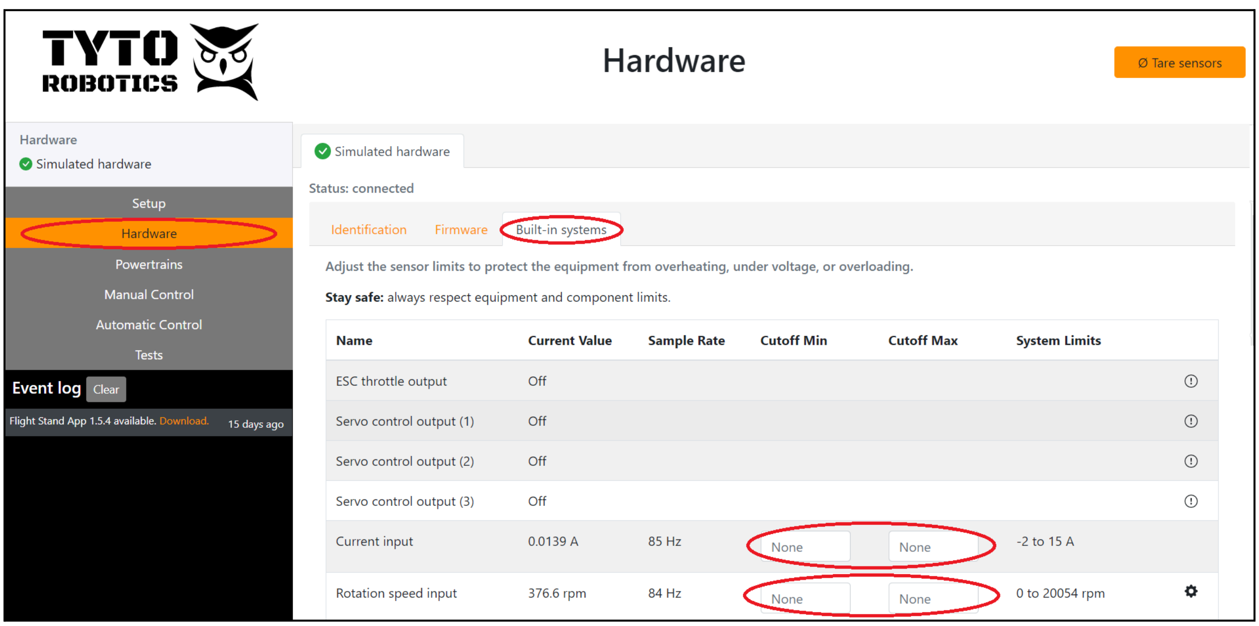




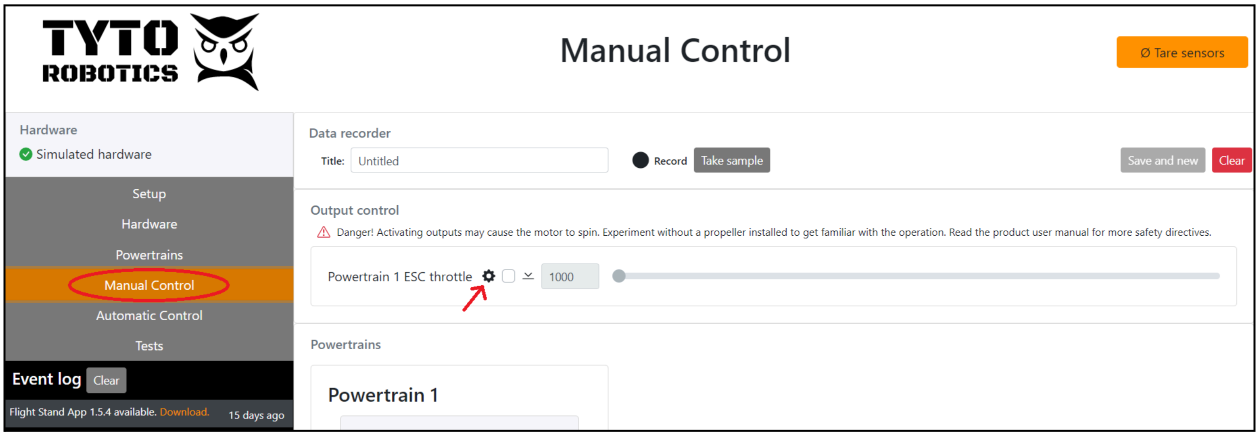
7.2 Automatic test

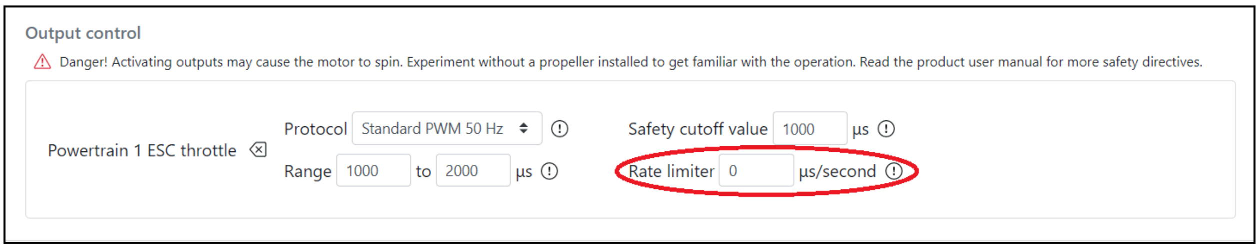
Step 1. Do a thorough **ground inspection** of the test area and remove anything that could fly off or away, especially small parts.

Step 2. Set your safety limits in the software:



Step 3. Select the rate limiter settings:

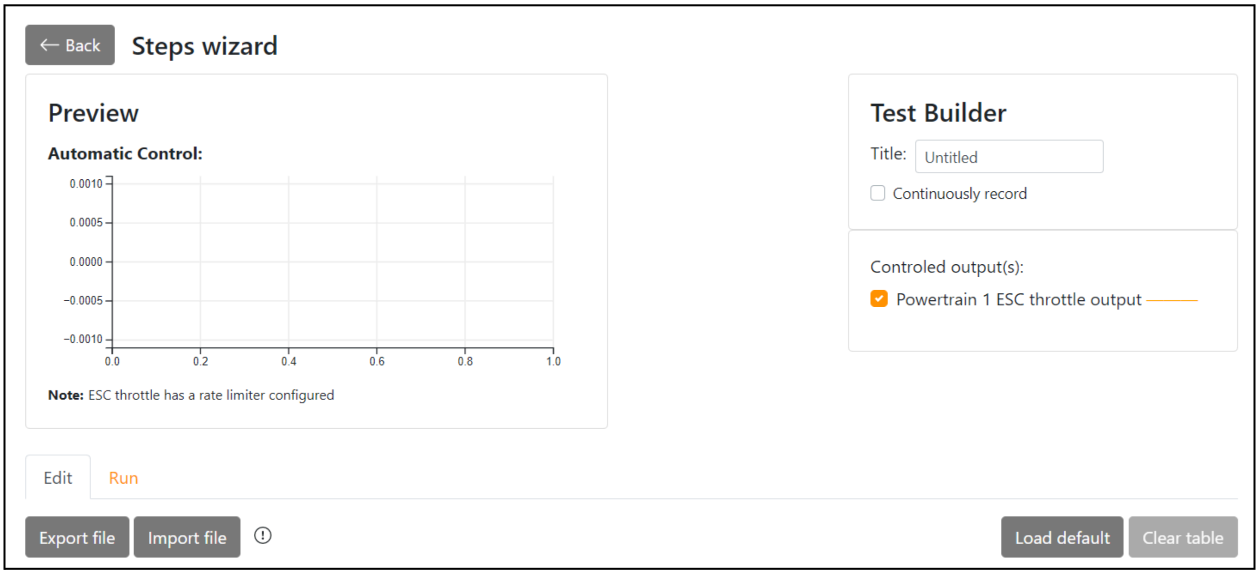

TYTO ROBOTICS
Manual Control
Tare sensors
Hardware
Simulated hardware
Setup
Hardware
Powertrains
Manual Control
Automatic Control
Tests
Event log
Clear
Flight Stand App 1.5.4 available. Download.
15 days ago
Data recorder
Title:
Untitled
Record
Take sample
Save and new
Clear
Output control
Danger! Activating outputs may cause the motor to spin. Experiment without a propeller installed to get familiar with the operation. Read the product user manual for more safety directives.
Powertrain 1 ESC throttle
1000
Powertrains
Powertrain 1

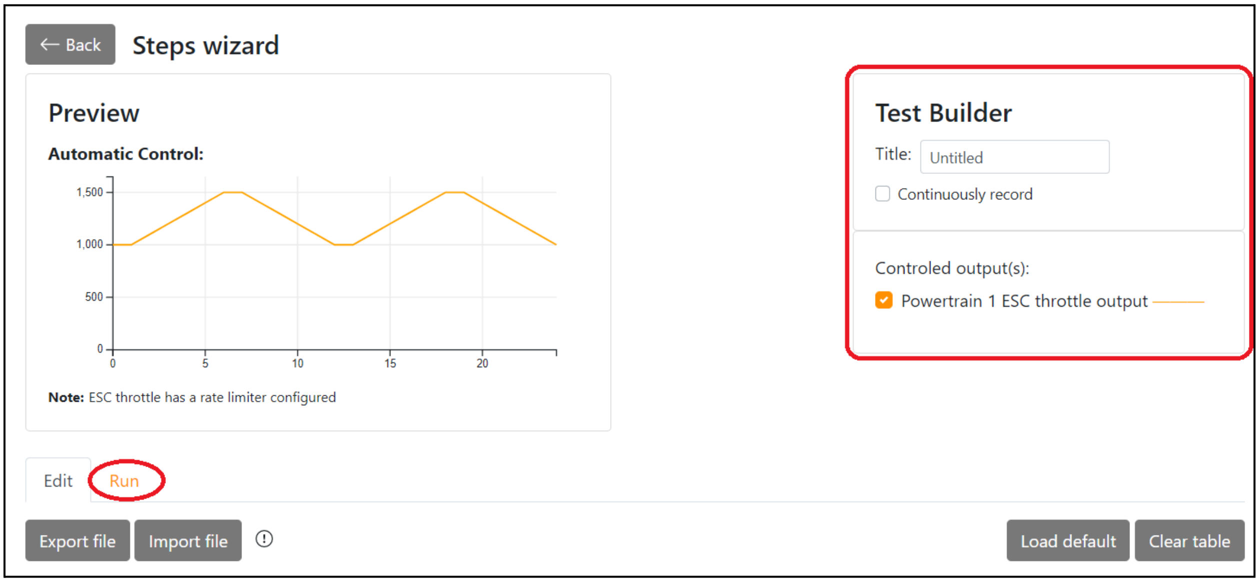

Output control
Danger! Activating outputs may cause the motor to spin. Experiment without a propeller installed to get familiar with the operation. Read the product user manual for more safety directives.
Powertrain 1 ESC throttle
Protocol
Standard PWM 50 Hz
Safety cutoff value
1000
µs
Range
1000
to
2000
µs
Rate limiter
0
µs/second

Step 4. Prepare the automatic control:

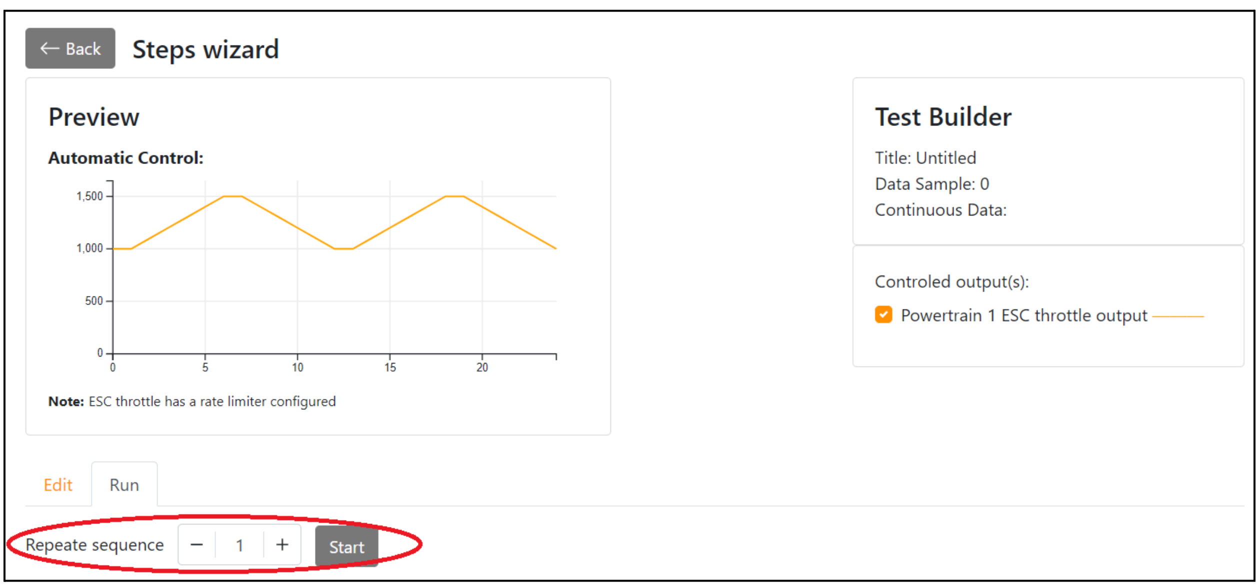
4.1 Select either Steps or Ramp depending on what type of test you would like to run.

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



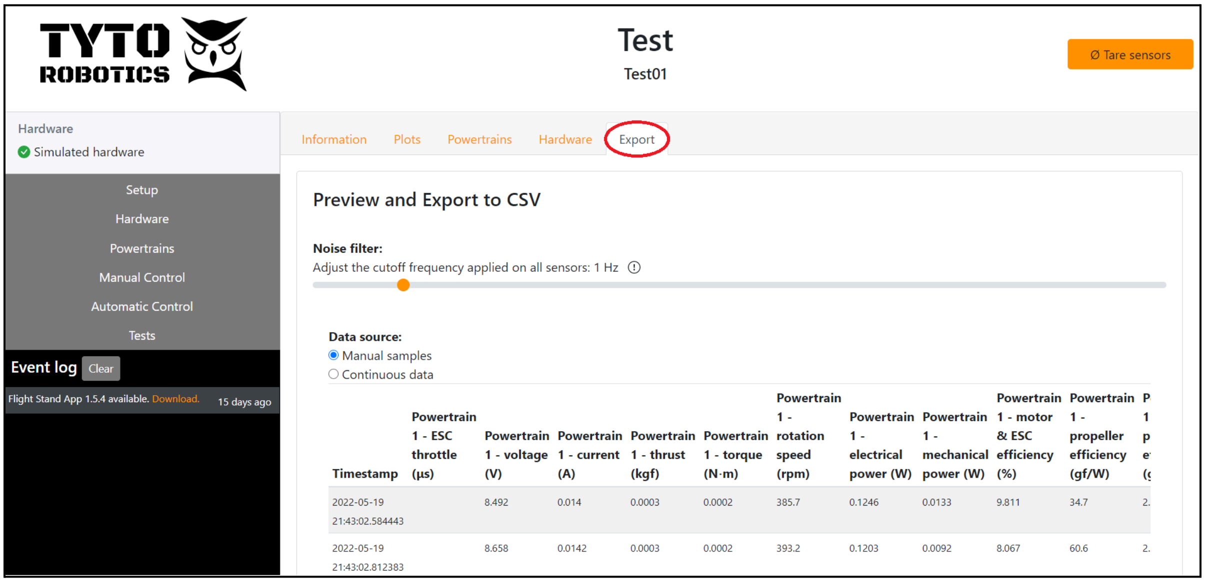


Step 5. Select the number of repeats you would like, then press Start to run the sequence.

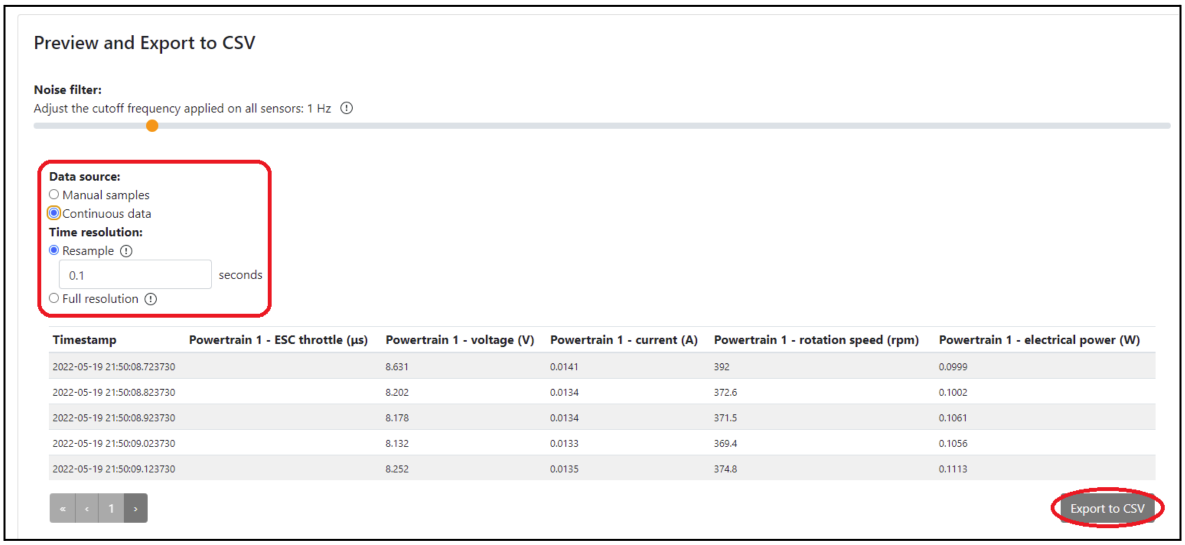


Step 6.

Once the test is finished, you can click “View saved test” to see the test recording.



Step 7. Export the CSV data file at your desired sampling rate.



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