



# Series 1780 75 kgf Test Stand User Manual

**Manual SKU#: ZXMJ**

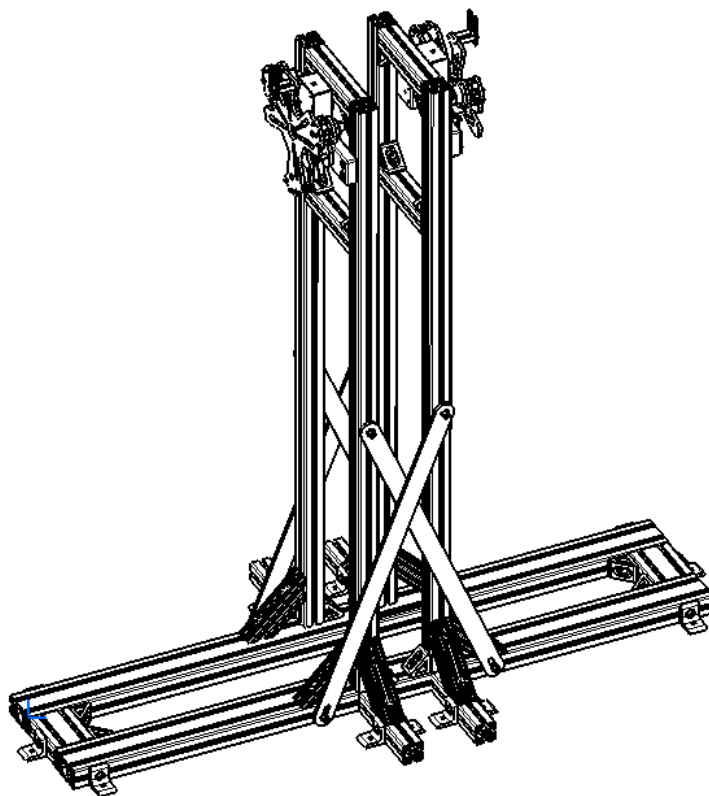


Image above shows the Series 1780 Test Stand 75 kgf - 500 A: Coaxial.

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# Chapter 1: Introduction

This is the user manual for customers who have purchased the **Series 1780 Test Stand 75 kgf - 500 A**. The goal of this user manual is to present all the important information about preparing, assembling, and using this test stand. If you need the user manual for the Series 1780 Test Stand 25 kgf V1, the V2 25 kgf - 100 A, or the 40 kgf - 150 A, contact us at [support@tytorobotics.com](mailto:support@tytorobotics.com).

The user manual for the Series 1780 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-datasheet/series-1780-manual-datasheet>

We have also developed an instructional video that follows the procedure for assembling the test stand, available here: <https://www.youtube.com/watch?v=zM1G4r1fITk>

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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 Series 1780.**

Note that not following the instructions in this user manual may result in testing errors, malfunction of the test stand, serious injuries, or death of 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 when you need technical support.

The Series 1780 test stand contains several major units: the load measurement unit(s), the power and control console(s), the main board, and the ground and stand structure. Every box may contain one or multiple bags of fasteners. Keep them inside the boxes until you need to use them.

The load measurement unit, the 75 kgf - 48 Nm A side (#FVET) and B side (#JTJB), is extremely sensitive to any external forces outside its rated output. The load measurement unit comes with a protective shell in its own boxes. Do not take it out until you need to mount it onto the support. When you unmount the load measurement unit from the support, place it back into the protective casing. For further information about how to store this unit to keep a valid warranty, refer to section 4.2.1 of this manual.

## 1.1 Item checklists for the test stand

Before you use these checklists, verify which configuration you purchased from us. If unsure, contact us.

### 1.1.1 Series 1780 Test Stand 75 kgf - 500 A: Single motor (SKU#: KURKE)

Ensure the following items are in the carton:

- Load measurement unit 75 kgf - 48 Nm: side A (SKU#: FVET) x 1
- Mono main board V2 (SKU#: RHGQ) x 1
- Main board power adapter (SKU#: PGAC) x 1
- Power and control console 100 V - 500 A: A side (SKU#: EMDG) x 1
- Accessories and fasteners for assembly box (SKU#: BCJE) x 1
- Heavy load motor mount V2 (SKU#: XSWU) x 1
- Temperature probe (SKU#: JTKB) x3
- Pressure probe (SKU#: BJPK) x1
- General user manual 75kg (SKU#: ZXMJ) x 1

The following items will be in separate boxes:

- Stand structure box (SKU#: TJLD) x 1
- Ground structure box (SKU#: YXHR) x 1

### 1.1.2 Series 1780 Test Stand 75 kgf - 500 A: Coaxial (SKU#: KXQVH)

Ensure the following items are in the carton:

- Load measurement unit 75 kgf - 48 Nm: side A (SKU#: FVET) x 1
- Load measurement unit 75 kgf - 48 Nm: side B (SKU#: JTJB) x 1
- Dual main board V2 (SKU#: GPDE) x 1
- Main board power adapter (SKU#: PGAC) x 1
- Power and control console 100 V - 500 A: side A (SKU#: EMDG) x 1
- Power and control console 100 V - 500 A: side B (SKU#: GCQH) x 1
- Accessories and fasteners for assembly box (SKU#: BCJE) x 1
- Extra fastener box for coaxial (SKU#: PNWW) x 1
- Heavy load motor mount V2 (SKU#: XSWU) x 2
- Temperature probe (SKU#: JTKB) x6
- Pressure probe (SKU#: BJPK) x1
- General user manual 75kg (SKU#: ZXMJ) x 1

The following items will be in separate boxes:

- Stand structure box (SKU#: TJLD) x 2
- Ground structure box (SKU#: YXHR) x 1

### 1.1.3 Accessories

If you purchased any of these accessories, you can find them in the main carton that came with your Series 1780 Test Stand:

- Series 1780 calibration checker bar (SKU#: QPZG)

The Series 1780 Test Stand 75 kgf - 500 A is a stand-alone product. It includes the necessary fasteners, stand, and ground structure. You **DO NOT** need the ground railing system for this version of the test stand.

## Chapter 2: General Safety Rules

### **Always put safety first! It is your responsibility.**

It is extremely important to stay alert and know how each item works. Read this part yourself, and make sure all your colleagues who will be working on the Series 1780 have carefully read this guide before using the test stand.

Refer to upcoming chapters in this manual for assembly instructions.

The following instructions apply to both operating and maintenance personnel and must be followed during all phases of operations, service, testing, and repair of this instrument.

### **To ensure safety, follow these instructions:**

1. Before construction, make sure all your tools are in good condition and don't need to be replaced.
2. Inspect all fasteners before every experiment. Use a thread locker when replacing bolts.
3. Make sure to use properly rated cables for power.
4. Do not use power tools in the presence of flammable liquids or gases.
5. 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.
6. Respect Murphy's law. If you think something might go wrong, it will.
7. Make sure you are dressed for safety. The load cell parts may be sharp, so wear gloves all along the assembly. Do not wear jewelry or inappropriate clothing when operating the tool.
8. Do not allow children to be around the Series 1780 test stand.
9. 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 done so at your own risk.
10. Do not use or assemble the tool alone.
11. Do not substitute parts or modify the instrument.



12. Always disconnect the power source before making adjustments, changing parts, and cleaning or working on the tool.
13. Do not store anything near or above the tool, especially when it is in use.
14. Always keep your tools clean and in good working order.
15. 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.
16. Do not open and touch the electrical circuits inside the enclosures (power and control console, main board, force sensor circuit). Do not change or modify the electrical circuit.
17. Respect the manufacturer's specification concerning the power, voltage, and current of the motors that you use on the Series 1780 Test Stand.
18. Make sure you are running all your tests in a safe space. The tool should be fenced off so unsuspecting personnel cannot enter the test area. Build a safety cage around the test area. Before a test, assume the propeller will break, and check whether there is a risk of injury from debris bouncing directly off the propeller or off the walls.
19. The safety cage or the enclosure should be suitably rated for containing a propeller failure. It should also protect operators in case the Series 1780 comes apart (loose screw or mechanical failure).
20. Make sure nobody is in the room or near the propeller when the motor tested is powered.
21. Wait for the propeller to stop spinning and the voltage measured at the ESC to be 0 V before accessing the testing area.
22. Make sure all the parts have time to cool down after all tests, unless this is part of the test design. The motor, ESC, batteries, and wires may be hot. Keep a fire extinguisher available.
23. Make sure a protective surface is between you and the propeller during a test. Wear protective glasses at all times while in the testing room.
24. For the installation of the components in the Series 1780, always refer to the proper chapter in this manual. Always use the supplied fasteners and a torque wrench when specified. Confirm the structure's rigidity every time before any tests.

25. Unbalanced propellers and extreme vibrations can lead to fatigue failure of some aluminum components and/or the load cells. Ensure the unit is completely enclosed in the safety area, and inspect all parts before performing a test.
26. Note that unbalanced propellers may cause resonances and powerful vibrations which may result in structure failure and can endanger someone. If you find your structure vibrating due to resonances, stop the test immediately.
27. If you are using your own fixtures to support the measurement tool, make sure they are rigid and solid enough to support your loads.
28. Ground railing systems and enclosures must be properly secured to the ground.
29. Do not approach the Series 1780 before cutting off the power to the motor.
30. Use the included lock washers; they are important because of the high vibration from the propulsion system.

## Chapter 3: Ground Mounting and Enclosure

### **IMPORTANT!**

You should prepare and assign the test area before assembling the Series 1780 Test Stand.

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### 3.1 Mounting options

#### **IMPORTANT!**

Using no fixture or leaving the Series 1780 improperly secured may cause injury, death, permanent damage to the load measurement unit, or damage to your facility. Check the safety guide for more information.

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#### 3.1.1 With concrete screws

The preferred mounting method is on a concrete floor with concrete screws. Make sure to use the given number of L-brackets to fix the ground structure:

- Single motor: 10 L-brackets
- Coaxial: 14 L-brackets minimum, supplied 16

We recommend to use the concrete screws with the following specifications:

- 5/16" hex washer head with a minimum length of 2-1/2" or M8 cap or flanged head with a minimum length of 60 mm
- Made of carbon steel
- Rated for concrete, brick, and hollow block application
- A pull-out rating of at least 100 kgf (220 lbf) each

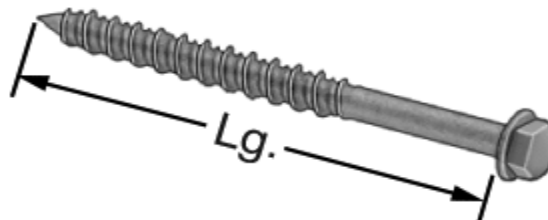


Fig. 3.1 Example of the concrete screws

Follow the manufacturer's installation instructions for the concrete screws.

### 3.1.2 Plywood on the floor

If your facility does not allow you to drill into the concrete flooring, you may use a large piece of plywood and place heavy weights at each corner of the plywood along with rubber pads to increase friction between the plywood and the floor. There is a high bending moment at the base of the tool, so make sure to use washers and sufficiently thick plywood to handle it. The screw heads can easily break through the plywood under a heavy load.

**It is your responsibility to make the base of your structure suitable for supporting the Series 1780.**

To use the plywood, make sure to have enough counterweights on each corner of the plywood.

#### Example

Build a 3 x 1.7 m plywood panel (at least 40 mm thickness). The density of plywood is about  $680 \text{ kg.m}^3$ , so your total weight should be close to 160 kg (140 kg of plywood and 20 kg for the structure). We suggest drilling at least eight holes in the panel and fix it onto levelling mounts to place it flat on the floor, as shown in Fig. 3.2 and Fig. 3.4:

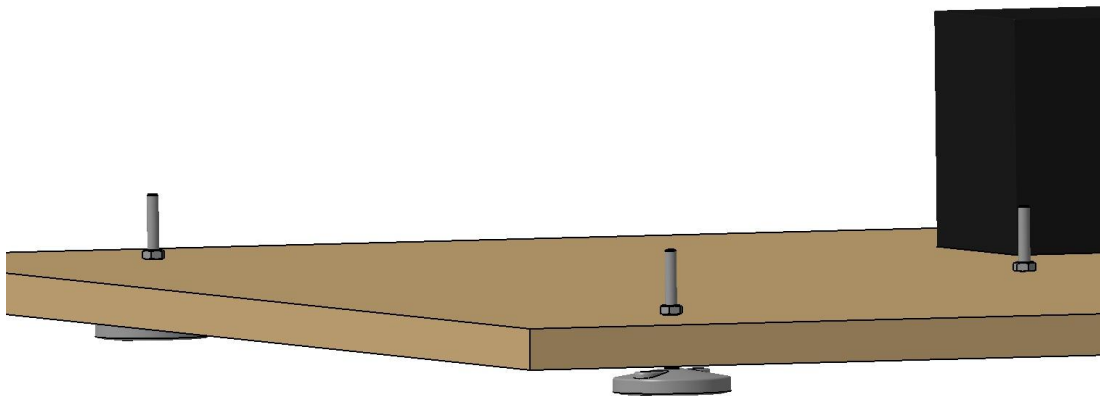


Fig. 3.2: Levelling mounts on the plywood

#### IMPORTANT!

For reference only, you may adjust the dimension and position of the counterweights according to your lab size. Run proper calculations!

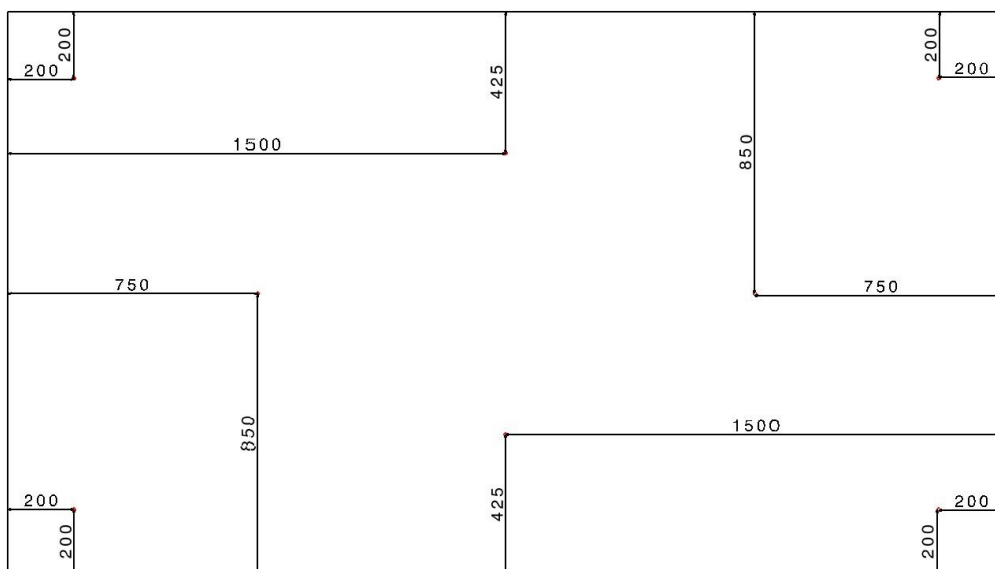


Fig. 3.3: Location of holes for the levelling mounts (dimensions in millimeters)

In addition to a levelling mount, our calculations suggest using four counterweights of 40 kg each. You could place your weights at the four corners of the tool, as shown in Fig. 3.4. The farther away these weights are from the stand on the plywood, the more stable the whole ground fixture will be. Make sure your propellers and airflow will not interfere with these weights.

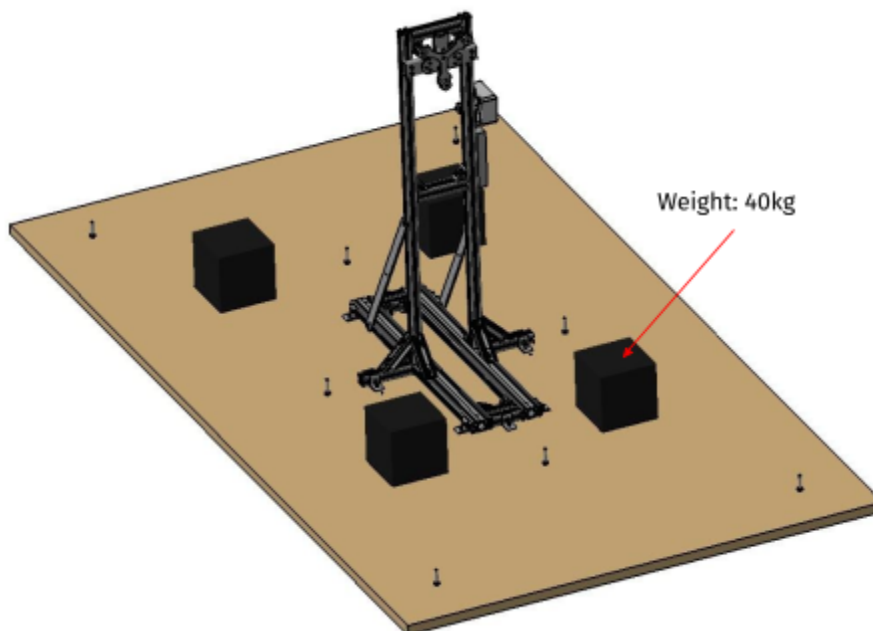


Fig. 3.4: Placing the counterweights on the plywood

To finish the installation of the plywood panel, you will also need to drill holes in the panel at the location of the L-brackets. You may drill these holes after building the ground metal structure, as detailed in Chapter 4.1.2. It will be easier to drill these holes after the L-brackets are installed on the structure.

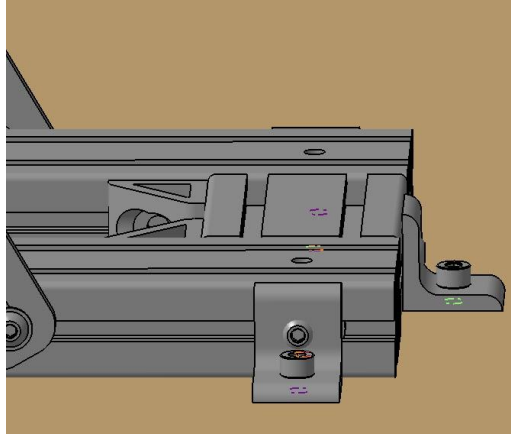


Fig. 3.5: Attached L-bracket on the plywood

The L-brackets can be used for M8 or 5/16" screws and bolts. If feasible, add lock washers to avoid screws being loosened due to vibration.

## 3.2 Build your own enclosure

### **IMPORTANT!**

Having the propeller spinning in an open area and running tests without a proper casing, duct, cage, or enclosure can be extremely dangerous to the operators and the facility.

You must have strong enough material for the enclosure, especially in the plane of the spinning propellers. The material should be capable of absorbing the energy from the debris of propellers.

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### 3.2.1 Design and build your own enclosure

For security reasons, the following points are important:

- Your enclosure is large enough to hold your propellers
- Easy access to any operator for future installation
- Emergency exits are not blocked
- The panel walls can absorb energy from debris
- The room has enough room for the downwash

Before starting to design the enclosure, know what size propellers you are planning to test. Generally, you should leave at least 12" (300 mm) between the propeller's blade tips and all panel walls made of mesh. Solid panels should be at least one radius away from the tip of the propeller.

For example, if you are planning to test a 60" propeller, you should design your safety cage at least 84" wide and 84" high if the wall is mesh. And you should design the enclosure at least 120" wide if the wall is concrete or plywood.

We also recommend having the downwash clearance be five times the maximum propeller diameter. Downwash can generate severe turbulence and affect the accuracy of thrust and torque measurements.

Do not place the stand horizontally because the operators would be more likely to be in the rotation plane of the propeller.

When possible, we always suggest having the thrust stand in its own room and not share the space with other test equipment. All operators will vacate from the enclosure or the whole testing room when the power is turned on. The power supply must be located outside the enclosure.

## Chapter 4: Series 1780 Installation

We suggest assigning and preparing the safety area and building the enclosure prior to the assembly and installation of the 75 kgf - 500 A version of the Series 1780, refer to the previous section for installing the tool on the ground.

In this chapter, we will present a guide for installing the Series 1780 Test Stand. Every section in this chapter represents the suggested procedure for assembling and installing the Series 1780. Follow the sequence accordingly, and do not bypass any operations.

When you are ready to start with the Series 1780 installation, first, prepare the correct tools for the operations. You can find inside the package a bag of hand tools (SKU#: AMXZ) in the fixture and fastener box (SKU#: BCJE), which includes several sizes of Allen keys and wrenches. If you are using your own tools, make sure to have the proper drive sizes.



Fig. 4.1: Allen key



Fig. 4.2: Wrench

Follow these steps to install the Series 1780:

1. Ground and stand support
2. Load measurement unit
3. Motor, motor mount, and optical RPM probe
4. Power and control console
5. Main board



## 4.1 Ground and stand support

The support is the largest mechanical structure of the Series 1780. It is designed to be placed on the ground and to support and sustain all loads generated by the motors and propellers. You may also use it to fix the ESC and the power and control console on it.

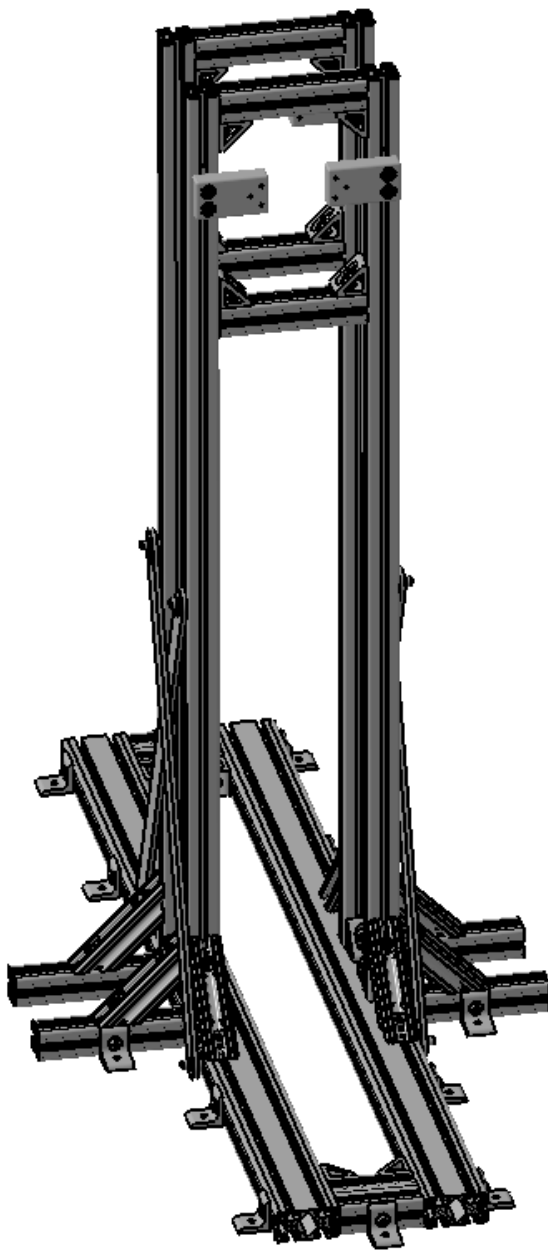


Fig. 4.3: 75 kgf coaxial version ground and stand support

## IMPORTANT!

This structure was carefully designed, calculated, and tested to hold loads and vibrations from one or two propellers producing the maximum rated thrust. You must follow the instructions to properly assemble the structure and firmly tighten all the supplied fasteners. Missing parts or loose fasteners are very dangerous during a test.

### 4.1.1 What's included and where to find the parts

When you have the Series 1780 Test Stand 75 kgf - 500 A: Single motor, you will use the following list of boxes to start the assembly:

Item name	Item SKU	Qty
Ground structure box	YXHR	1
Stand structure box	TJLD	1
Fixture and fastener box	BCJE	1

When you have the Series 1780 Test Stand 75 kgf - 500 A: Coaxial, you will use the following list of boxes to start the assembly:

Item name	Item SKU	Qty
Ground structure box	YXHR	1
Stand structure box	TJLD	2
Fixture and fastener box	BCJE	1
Extra fastener box for coaxial	PNWW	1

Retrieve the hand tools immediately from the fixture and fastener box (#BCJE):

#### Hand tools bag (SKU#: AMXZ)

Item name	Item SKU	Qty
Allen key 3/16"	TRHE	1
Allen key 1/4"	QYHR	1
Allen key 4 mm	5WUH	1
Wrench 8 mm x 10 mm	9AGF	1

To avoid mistakes using the wrong screws in the Series 1780 assembly, keep the fasteners in the bags until you need them. Keep all the empty fastener bags in case you need to disassemble the structure so you can place the fasteners back in the appropriate bag.

#### 4.1.2 Assembly of the ground structure

Note that both versions of the 75 kgf - 500 A thrust stand use the same ground base. Retrieve the following items from the boxes:

Item name	Item SKU	Qty	Located in (SKU# if exist)
T-slotted double frame 4' long	VYTV	2	75 kgf ground structure box (#YXHR)
T-slotted double frame 4" long	WHXZ	2	Fixture and fastener box (#BCJE)
L bracket	KPHT	2	Fixture and fastener box (#BCJE)
Gusset bracket	YKPV	4	Fixture and fastener box (#BCJE)
Beam fastener bag	WVKM	1	Fixture and fastener box (#BCJE)

You will need these items from the **beam fastener bag (#WVKM)**:

Item name	Item SKU	Qty
Button head 5/16"-18 screw 11/16" long	KEDB	10
End-feed T-nut 5/16"-18	YREC	10

To start:

- ☐ Take two T-slotted double beams 4" (#WHXZ) out of the fixture and fastener box (#BCJE).
- ☐ Take two T-slotted double beams 4' (#VYTV) out of the ground structure box (#YXHR).
- ☐ Place these four T-slotted frames (#WHXZ and #VYTV) on a worktable.
- ☐ Take ten button head 5/16"-18 screws (#KEDB) and ten end-feed T-nuts (#YREC) out of the beam fastener bag (#WVKM).



Fig. 4.4: L-bracket

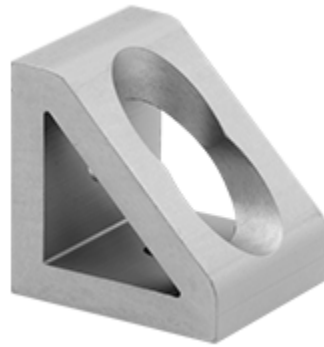


Fig. 4.5: Gusset bracket

- ❑ Take four gusset brackets (#YKPV) and two L-brackets (#KPHT).
- ❑ Fix on one short side of the T-slotted double beam 4" (#WHXZ) two gusset brackets (#YKPV) with button head 5/16"-18 screws (#KEDB) and T-nut fasteners (#YREC), shown in Fig. 4.6.
- ❑ On another single side, fix an L-bracket (#KPHT) at the middle of the T-slotted double beam 4" (#WHXZ) with the button head 5/16"-18 screws (#KEDB) and T-nut fasteners (#YREC), as shown in Fig. 4.6.

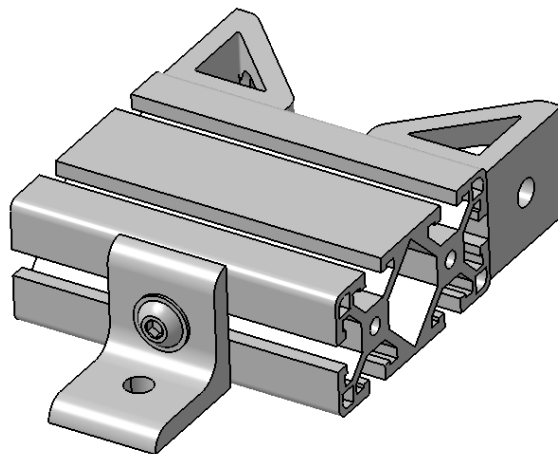


Fig. 4.6: Two gussets (#YKPV) and one L-bracket (#KPHT) attached to the T-slotted double frame 4" (#WHXZ)

- ❑ Make the second assembly, as shown in Fig. 4.6, with the supplied components.
- ❑ Attach the assemblies from the last step at each end of the two T-slotted double beams 4' (#VYTV), connect and close the structure with button head 5/16"-18 screws (#KEDB) and T-nuts (#YREC), as shown in Fig. 4.7.

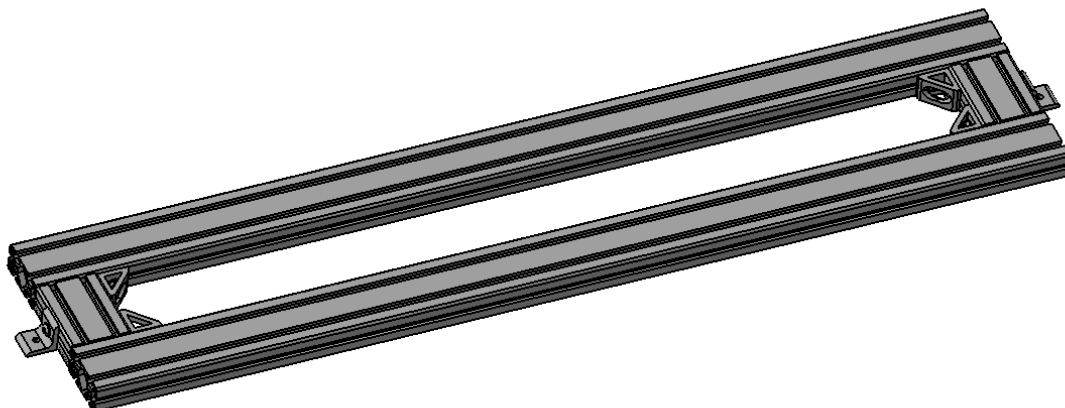


Fig. 4.7: Attaching T-slotted frame 4' (#VYTV) to T-slotted frame 4" (#WHXZ)

- ❑ Finish assembling the ground structure.
- ❑ Apply fasteners and T-nuts on only one side of the L-brackets, as shown in Fig. 4.7, because you may need the free end to attach the ground structure to the flooring.

### 4.1.3 Assembly of the stand structure

The stand structure on the Series 1780 Test Stand 75 kgf - 500 A is mostly identical to each measurement chain. If you have purchased the coaxial version, simply repeat all the steps in this section to build the second copy.

Retrieve the following items from the boxes:

Item name	Item SKU	Qty	Located in (SKU# if exist)
T-slotted single frame 4' long	HJXQ	2	75 kgf stand structure box (#TJLD)
T-slotted single frame 7" long	NWGF	4	75 kgf stand structure box (#TJLD)
Aluminum support rod	PFUP	2	75 kgf stand structure box (#TJLD)
Gusset bracket	YKPV	6	Fixture and fastener box (#BCJE)
Diagonal beam 6" with fasteners	QFGJ	4	Fixture and fastener box (#BCJE)
Rod fastener bag	SXFA	1	Fixture and fastener box (#BCJE)
Beam fastener bag	WVKM	1	Fixture and fastener box (#BCJE)

If you are building the second copy for the coaxial, you may need to retrieve these items from other boxes dedicated for coaxial assemblies:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Gusset bracket	YKPV	6	Extra fastener box for coaxial setups (#PNWW)
Diagonal beam 6" with fasteners	QFGJ	4	Extra fastener box for coaxial setups (#PNWW)
Rod extra fastener bag	METT	1	Extra fastener box for coaxial setups (#PNWW)
Beam fastener bag	GKDN	1	Extra fastener box for coaxial setups (#PNWW)

You will need these items from the **beam fastener bag (#WVKM)**:

Item name	Item SKU	Qty
Button head 5/16"-18 screw 11/16" long	KEDB	12
End-feed T-nut 5/16"-18	YREC	12

You will need these items from the **rod fastener bag (#SXFA)**:

Item name	Item SKU	Qty
Socket head 5/16"-18 screw 3/4" long	PKJK	2
Split lock washer 5/16"	QTAS	2
End-feed T-nut 5/16"-18	YREC	2

You will need these items from the **coaxial extra beam fastener bag (#GKDN)**:

Item name	Item SKU	Qty
Button head 5/16"-18 screw 11/16" long	KEDB	10
End-feed T-nut 5/16"-18	YREC	10

you will need these items from the **coaxial rod extra fastener bag (#METT)**:

Item name	Item SKU	Qty
Socket head 5/16"-18 screw 1" long	JYBC	2
Split lock washer 5/16"	QTAS	2
Spacer 1/4" height	LKVJ	2
End-feed T-nut 5/16"-18	YREC	2

To start the assembly, follow these steps:

- ☐ Retrieve two T-slotted single beams 7" long (#NWGF) and two T-slotted single beams 4' long (#HJXQ).
- ☐ Place these four T-slotted frames (#NWGF and #HJXQ) on a worktable.

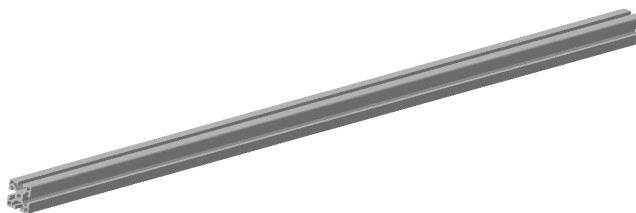


Fig. 4.8: T-slotted frame 4' long (#HJXQ)

- ☐ Retrieve eight end-feed 5/16"-18 button head screws 11/16" long (#KEDB) and eight end-feed T-nuts 5/16"-18 (#YREC).
- ☐ Take four gusset brackets (#YKPV).

- ❑ Use two button head screws (#KEDB) and two T-nuts (#YREC) to connect one gusset bracket (#YKPV) with the 7" beam (T-nut inside the slot of the T-slotted beam). Do not fully tighten the fasteners. You may slide the gusset, screw, and T-nut while loose, as shown in Fig. 4.9.

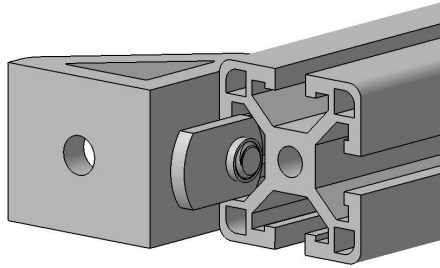


Fig. 4.9: Insert the screw (#KEDB) through the gusset bracket (#YKPV) and reach the nut (#YREC).

- ❑ Repeat the previous step on the other side of the 7" beam (#NWGF). Repeat to build the second one. Once finished, slide the 7" beam into the 4' single beam (#HJXQ).
- ❑ Fully connect the 4' and 7" beams, as shown in Fig. 4.10, with the last four fasteners (#KEDB); gently fasten, but do not fully tighten the screws and the T-nuts to keep everything in place.



Fig. 4.10: Vertical section of the stand

- ❑ Place the structure flat on a worktable.
- ❑ Take four diagonal beams 6" long (#QFGJ), with its screws and nuts already assembled on the beam, and two gusset brackets (#YKPV). Then, take the remaining four button head 5/16"-18 screws (#KEDB) and end-feed T-nuts 5/16"-18 (#YREC) out of the beam fastener bag (#WVKM) or the coaxial extra fastener bag (#GKDN).



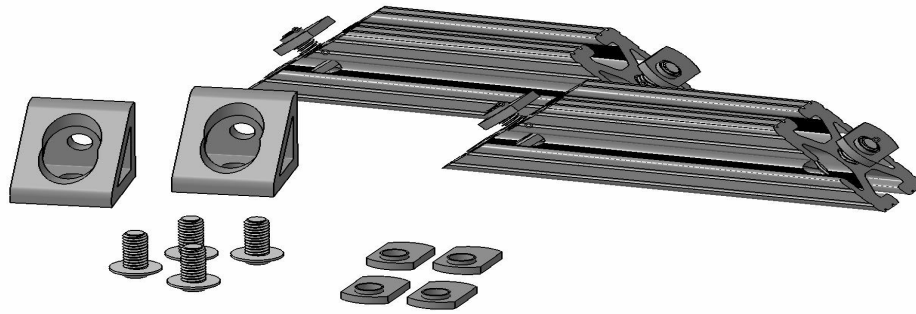


Fig. 4.11: Beams, gusset brackets, screws, and T-nuts for the next assembly

- ❑ On the assembly from Fig. 4.10, use one button head 5/16"-18 screw (#KEDB) and one end-feed T-nut 5/16"-18 (#YREC) to join the gusset bracket (#YKPV) to a T-slotted beam 4' (#HJXQ).
- ❑ Repeat the last step with the second T-slotted beam 4' (#HJXQ) in the back of the beam, as shown in Fig. 4.12.
- ❑ On the opposite side of the gusset brackets, join the 6" diagonal beams (#QFGJ) in the T-slotted single frames 4' (#HJXQ) with the screws and T-nuts, as shown in Fig. 4.12. Leave the other end of the diagonal beams free for future purposes.



Fig. 4.12: Bottom side of the stand

- ❑ Take two aluminum rods (#PFUP) out of the box.
- ❑ Fix one aluminum rod (#PFUP) with one socket head 5/16"-18 length 3/4" screw (#PKJK) and one end-feed T-nut 5/16"-18 (#YREC) on the 4' T-slotted beam (#HJXQ). Use the **slot** end of the rod to fix it to the stand.
- ❑ Repeat the last step on each T-slotted single beam 4' (#HJXQ), as shown in Fig. 4.13.

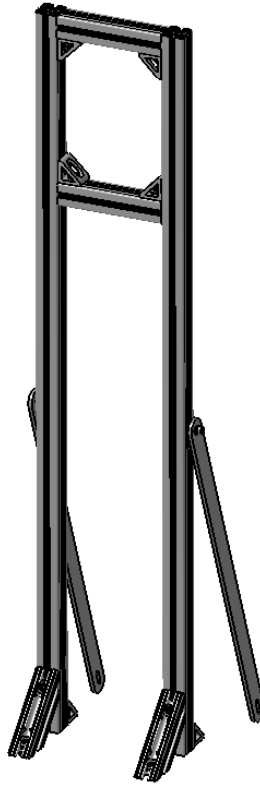


Fig. 4.13: Vertical part of the stand with two support rods

- ❑ Make sure that the 6" diagonal beam (#QFGJ) is on the opposite side of the support rod (#PFUP).
- ❑ Take another two diagonal beams 6" (#QFGJ) and two T-slotted single frames 7" (#NWGF).
- ❑ Connect the 4' T-slotted beam (#HJXQ) and the T-slotted single beam 7" (#NWGF) with the diagonal beam 6" (#QFGJ), and, with the given fasteners, attach to the diagonal beam (#QFGJ).
- ❑ Do not fully tighten the screws on the diagonal beams because you may need to adjust the position later when installing it onto the ground structure.
- ❑ Repeat the last step for the other side of the 4' beam, as shown in Fig. 4.14.



Fig. 4.14: Diagonal beam 6" (#QFGJ) attached to the T-slotted frame 4" (#HJXQ) and 7" (#NWGF)

When you have the **coaxial version** of the stand and need to construct the second copy of the stand structure, note that the support rod requires a 1/4" spacer to avoid interference with the first stand. The screws have already been extended; thus you may easily fix the rod with an extra spacer. Fig. 4.15 shows a more detailed drawing.

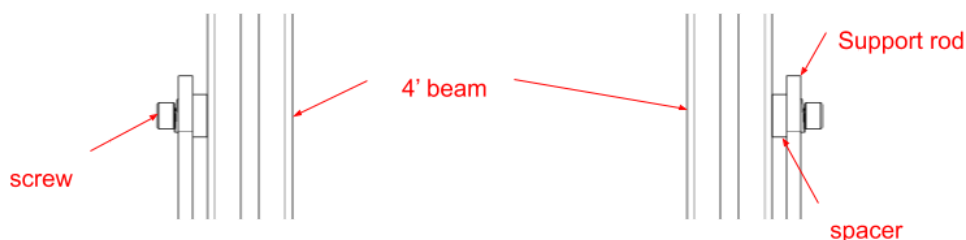


Fig. 4.15: Use spacers (#LKVJ) and 1" screws (#JYBC) to connect the rod (#PFUP) to the 4" beam (#HJXQ).

#### 4.1.4 Ground and stand structure assembly for single motor

Follow this section if you have the single-motor version of the thrust stand.

Retrieve the following items from the boxes:

Item name	Item SKU	Qty	Located in (SKU# if exist)
L-bracket	KPHT	8	Fixture and fastener box (#BCJE)
Rectangular block profile	LZWT	2	Fixture and fastener box (#BCJE)

You will need the rest of the items from the **beam fastener bag (#WVKM)**:

Item name	Item SKU	Qty
Button head 5/16"-18 screw 11/16" long	KEDB	8
End-feed T-nut 5/16"-18	YREC	8

You will need the rest of the items from the **rod fastener bag (#SXFA)**:

Item name	Item SKU	Qty
Socket head 5/16"-18 screw 3/4" long	PKJK	2
Split lock washer 5/16"	QTAS	2
End-feed T-nut 5/16"-18	YREC	2

You will need all the items from the **profile block fastener bag (#QSCV)**:

Item name	Item SKU	Qty
Socket head 5/16"-18 screw 1" long	JYBC	4
Split lock washer 5/16"	QTAS	4
End-feed T-nut 5/16"-18	YREC	4

**You will need at least TWO people to finish the following work.** To start the assembly, follow these steps:

- ❑ To connect the upper and lower part, place the stand structure that you built previously in the middle of ground structure, as shown below in Fig. 4.16.
- ❑ Insert two T-nuts into the the outer slot facing up of each 4' double beam (#VYTV) to reserve for the future fixation of the 6" diagonal beam and the gusset bracket. You may also keep the T-nuts loosened on the stand structure and slide the whole structure into the base structure.

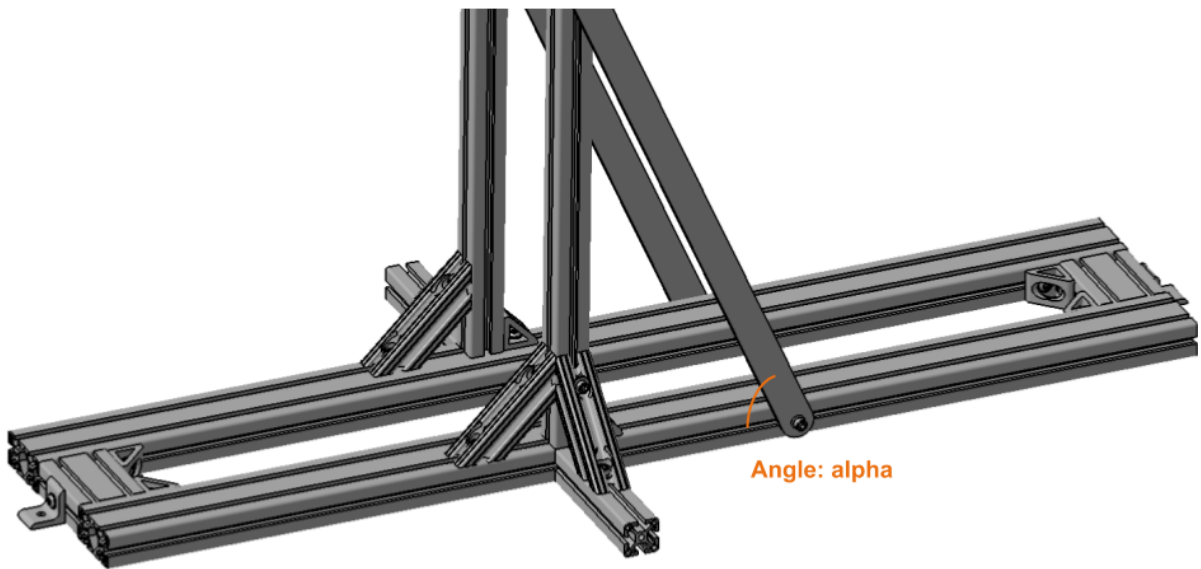


Fig. 4.16: Gather your two previous assemblies.

- ❑ Insert one socket head 5/16"-18 3/4" length screw (#PKJK) into the free side of the aluminum rod (#PFUP) and then connect it to one end-feed T-nut 5/16"-18 (#YREC) inserted into the T-slotted 4' double beam (#VYTV) on the side. Repeat for the other side.
- ❑ **ATTENTION:** The angle ( $\alpha$ , as shown in Fig. 4.16) between the aluminum side rod and the ground must be between 50 and 60 degrees to minimize the buckling effect and the load on the structure.
- ❑ Take all the L-brackets (#KPHT) out of the fixture and fastener box (#BCJE).
- ❑ Take eight button head 5/16"-18 screws (#KEDB) and eight end-feed T-nuts 5/16"-18 (#YREC).

- ❑ Insert one button head screw (#KEDB) into one L-bracket, and connect the other side with one end-feed T-nut 5/16"-18. Leave the other side of the L-bracket free. Repeat this step for all L-brackets.
- ❑ Insert and attach these four L-brackets on each side of the support and four on both parts of the T-slotted frame 7" (#NWGF).
- ❑ All eight L-brackets plus the two already installed on the 4" double beam should now be in place. See Fig. 4.17.

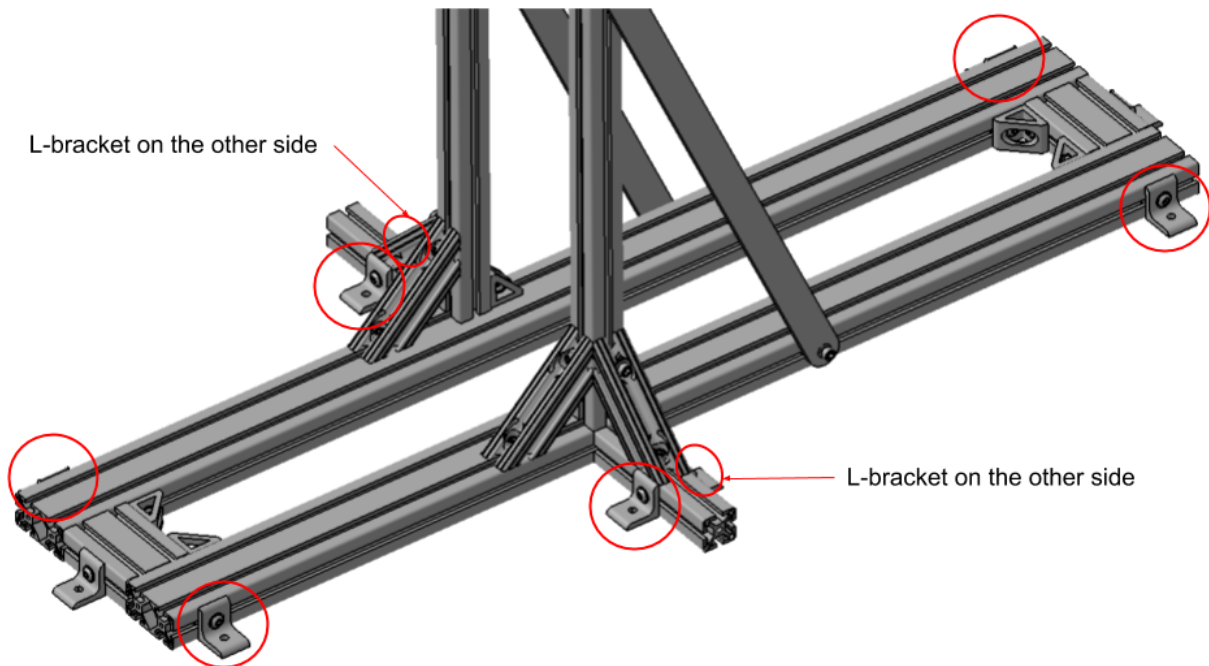


Fig. 4.17: Insert and attach the L-brackets (#KPHT) and rods (#DUSQ) to the support.

- ❑ Tighten all fastener screws with Allen key 3/16" (#TRHE).
- ❑ Take two rectangle block profiles (#LZWT) out of the fixture and fastener box (#BCJE).
- ❑ Take all items out of the profile plate fastener bag (#QSCV).
- ❑ Use the two end-feed T-nuts 5/16"-18 (#YREC) to connect through the hole on the rectangular block (#LZWT) with two 5/16"-18 1" long screws (#JYBC) and two split lock washers 5/16" (#QTAS). Do not fully tighten the screws because you will need to slide the rectangular blocks into the slots later. Repeat for the second hole, as shown in Fig. 4.18.

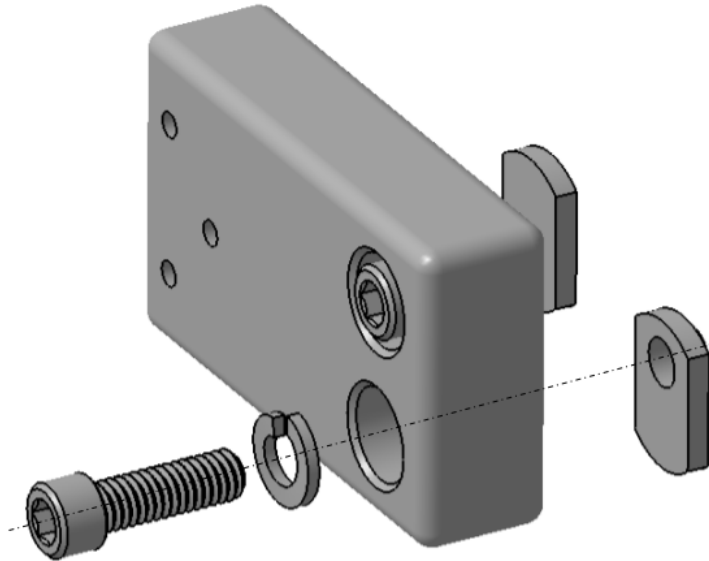


Fig. 4.18: Insert screws (#JYBC) through washers (#QTAS) to the T-nut (#YREC).

- ❑ Repeat the last steps for the second rectangular block profile (#LZWT).
- ❑ Insert and slide in this assembly on the T-slotted frame 4' (#HJXQ) with Allen key 1/4". Try to keep both blocks at the same height, and do not fully tighten the 5/16"-18 socket head screws until you place the load measurement unit onto the support. Install these two blocks on the same side of the 6" diagonal beam, opposite the support rod.

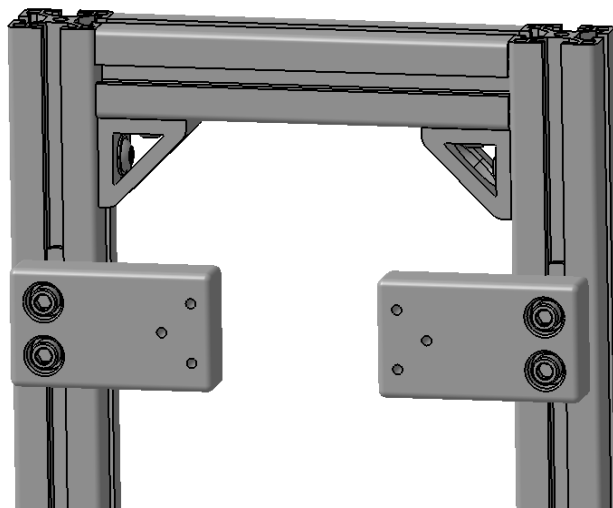


Fig. 4.19: Rectangle profile (#XLGF) attached to T-slotted frame 4' (#HJXQ)

- ❑ Double-check that the other fasteners are mounted on the support and that they are well tightened.
- ❑ Under some circumstances, the load measurement unit may need extra adjustment to be mounted on the support. If necessary, slightly loosen the screws from the 7" and the rectangular tube to adjust clearance.
- ❑ Move the completed structure to the assigned area.
- ❑ Now, drill the holes on the ground or on the plywood with the L-brackets in place.

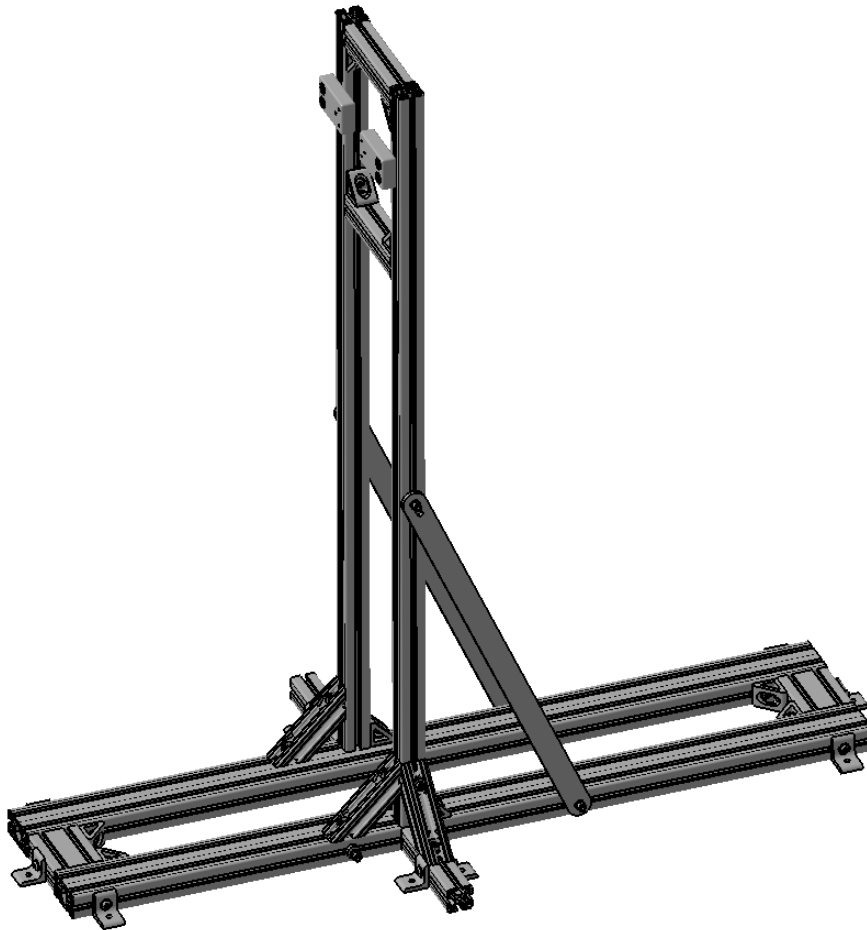


Fig. 4.20: Assembled support for single-motor setup



### IMPORTANT!

Make sure that all fasteners are properly tightened, and recheck regularly. All connections through T-nuts (#YREC) must be verified before starting a new test.

## 4.1.5 Ground and stand structure assembly for coaxial

Follow this section if you have the coaxial version of the thrust stand.

Retrieve the following items from the boxes:

Item name	Item SKU	Qty	Located in (SKU# if exist)
L-bracket	KPHT	8	Fixture and fastener box (#BCJE)
L-bracket	KPHT	6	Extra fastener box for coaxial setups (#PNWW)
Rectangular block profile	LZWT	2	Fixture and fastener box (#BCJE)
Rectangular block profile	LZWT	2	Extra fastener box for coaxial setups (#PNWW)

You will need the rest of the items from the **beam fastener bag (#WVKM)**:

Item name	Item SKU	Qty
Button head 5/16"-18 screw 11/16" long	KEDB	8
End-feed T-nut 5/16"-18	YREC	8

You will need the rest of the items from the **coaxial extra beam fastener bag (#GKDN)**.

Item name	Item SKU	Qty
Button head 5/16"-18 screw 11/16" long	KEDB	8
End-feed T-nut 5/16"-18	YREC	8

You will need the rest of the items from the **rod fastener bag (#SXFA)**:

Item name	Item SKU	Qty
Socket head 5/16"-18 screw 3/4" long	PKJK	2
Split lock washer 5/16"	QTAS	2
End-feed T-nut 5/16"-18	YREC	2

You will need the rest of the items from the **coaxial rod extra fastener bag (#METT)**:

Item name	Item SKU	Qty
Socket head 5/16"-18 screw 1" long	JYBC	2
Split lock washer 5/16"	QTAS	2
Spacer 1/4" height	LKVJ	2
End-feed T-nut 5/16"-18	YREC	2

You will need all the items from the **profile block fastener bag (#QSCV)**:

Item name	Item SKU	Qty
Socket head 5/16"-18 screw 1" long	JYBC	4
Split lock washer 5/16"	QTAS	4
End-feed T-nut 5/16"-18	YREC	4

**You will need TWO people to finish the following work.** To start the assembly, follow these steps:

- ☐ To connect the upper and lower parts, you will need to install two stand structures onto one ground structure.
- ☐ If you are planning to test face-to-face setup, refer to Fig. 4.26 for an overall outlook. You may follow the instructions for the back-to-back setup below because both setups are similar, except for the positions and orientations of the two stand structures.

- ❑ Insert four T-nuts (#YREC) into the outer T-slots facing up on each 4' double beam (#VYTV) to allow future attachment of the 6" diagonal beam and the gusset bracket of the stand structure.



Fig. 4.21: Coaxial assembled support: base section

- ❑ Use the fasteners on the 6" diagonal beams to attach the stand structure to the ground structure. Tighten the screws and the T-nuts connected to the diagonal beams and the gusset brackets on each stand.
- ❑ Insert two T-nuts (#YREC) on each outer side of the 4' double beam (#VYTV) to attach the horizontal end of the support rod (#PFUP). Note that the rod on one stand will overlap on the other for back-to-back installation. You may use the 5/16"-18 socket head 3/4" length (#PKJK) and 1" length (#JYBC) screws plus the 1/4" spacer (#LKVJ) from the rod fastener bag (#SXFA & #METT) to install both rods in place.
- ❑ Take eight L-brackets (#KPHT) out of the fixture and fastener box (#BCJE) and four L-brackets (#KPHT) out of the coaxial extra fastener box (#PNWW).
- ❑ Use the button head 5/16"-18 screws (#KEDB) and the end-feed T-nuts 5/16"-18 (#YREC) to connect the L-brackets on one side.
- ❑ Slide eight L-brackets (side with the T-nuts) into the T-slotted frame on the ground structure 4' double beam (#VYTV). Depending on whether you wish to test back-to-back or face-to-face setup, you may place these L-brackets along the full length of the 4' double beam. Make sure to have at least one L-bracket at each end of the 4' double beam, as shown in Fig. 4.21.



- ❑ Slide four L-brackets into the T-slotted frame 7" (#NWGF) on the left and right side. Do this for **ONLY ONE** stand that you wish to completely fix to the ground. Do NOT install the L-brackets to another stand because you may need to allow free linear movement to adjust the axial distance. See Fig. 4.22:

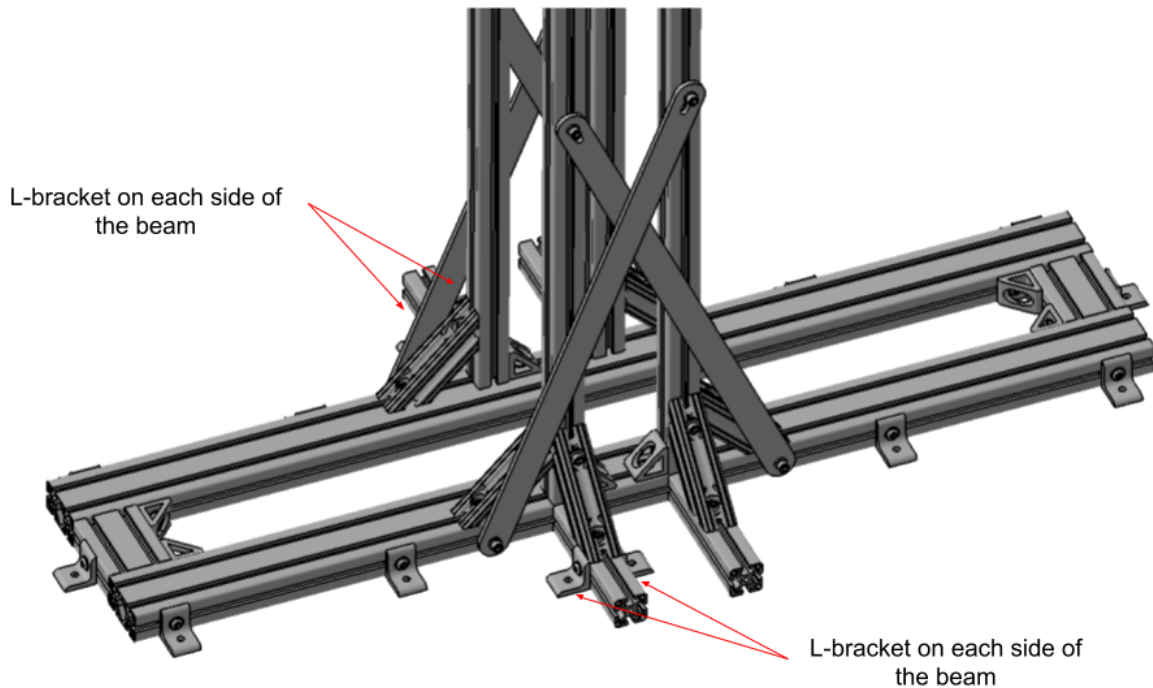


Fig. 4.22: Attach L-brackets (#KPHT) to the support.

- ❑ We recommend the angle  $\alpha$  between the rod and the ground base support to be at least 55 degrees and up to 68 degrees. See Annex 1 for the recommended value when testing specific diameters of propellers.
- ❑ Tighten all the fastener screws with Allen keys.
- ❑ Take four rectangle block profiles (#LZWT) out of the fixture and fasteners box (#BCJE) and the Coaxial Extra Fastener Box (#PNWW).
- ❑ Take all the items out of the profile plate fastener bag (#QSCV).
- ❑ Use the two end-feed T-nuts 5/16"-18 (#YREC) to connect through the hole on the rectangular block (#LZWT) with two 5/16"-18 1" long screw (#JYBC) and two 5/16" split lock washers (#QTAS). Do not fully tighten the screws because you will need to slide the rectangular tube profile into the slots later. Repeat for the second hole, as shown in Fig. 4.23.

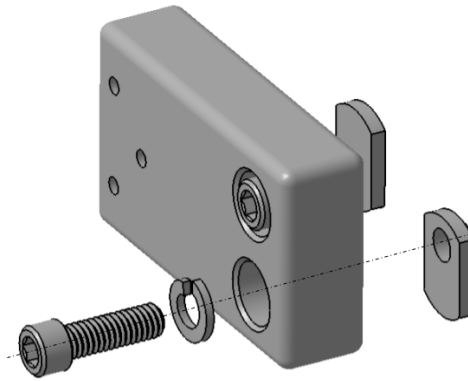


Fig. 4.23: Insert screws (#JYBC) through washers (#QTAS) to the T-nuts (#YREC).

- ❑ Repeat the last steps for the rest of the rectangular block profiles (#LZWT).
- ❑ Insert and slide in this assembly on the T-slotted frame 4' (#HJXQ), both facing out. Try to keep all four blocks at the same height. Do **NOT** fully tighten the 5/16"-18 socket head screws until you place the load measurement unit onto the support.

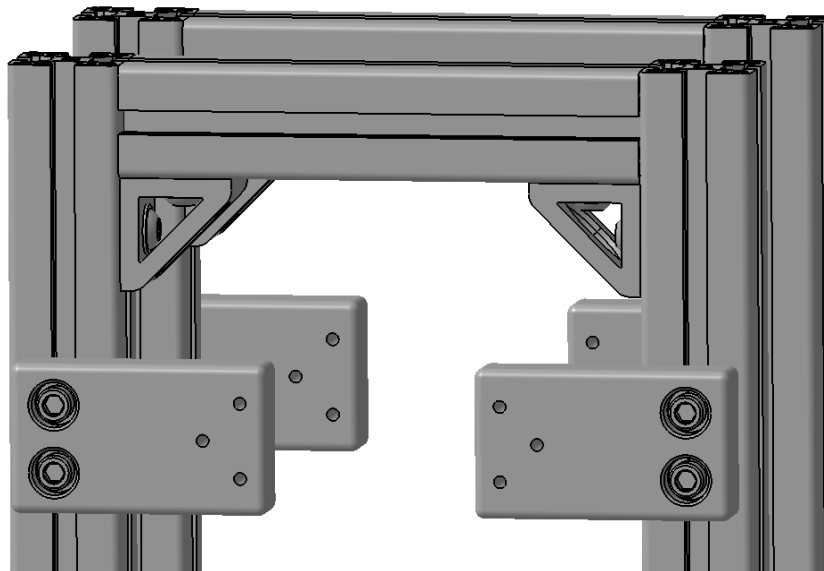


Fig. 4.24: Rectangle profile (#XLGF) attached to T-slotted frame 4' (#HJXQ)

- ❑ Double-check whether other fasteners are mounted on the support and whether they are well tightened. Make sure NOT to fully tighten the 5/16"-18 1" socket head screws because you may need some clearance to install the load measurement unit in the next step.
- ❑ Do the same step for the second stand structure.

- ❑ Under some circumstances, the load measurement unit may need extra adjustment to be mounted on the support. Leave these fasteners a little loose before the completion of Section 4.3.
- ❑ Move the completed structure to the assigned area.
- ❑ Now, drill the holes on the ground or on the plywood with the L-brackets in place.

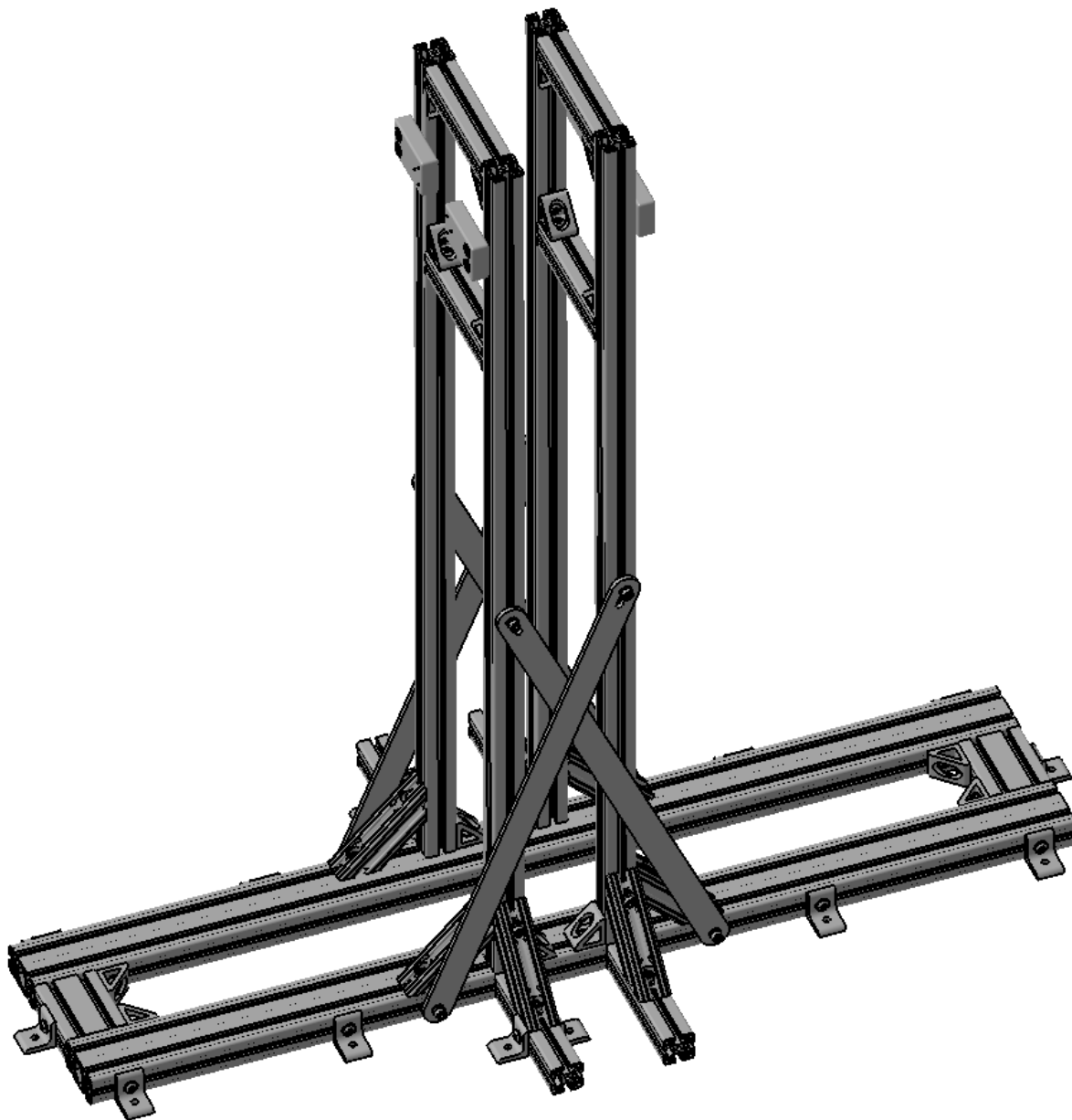


Fig. 4.25: Assembled support for coaxial back-to-back setup

- ❑ If you are trying to build the support for the coaxial face-to-face, its setup is similar to the current setup, except two stand structures will be facing each other separated by a greater distance.
- ❑ Always keep one stand's 7" side beams free of L-brackets because you may need to adjust the axial distance. When necessary, you may swap the T-nuts between the L-brackets on the ground and the support rod to allow extra movement. See Fig. 4.26.



Fig. 4.26: Assembled support for coaxial face-to-face setup

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### **IMPORTANT!**

Make sure that the designated fasteners are properly tightened, and recheck regularly. All connections through T-nuts (#YREC) must be verified before starting a new test.

## 4.2 Load measurement unit

The load measurement unit is a key component of the Series 1780. It measures the thrust and torque of the motors and propellers. It is extremely sensitive to impact and overload.



Fig. 4.27: Load measurement unit assembly

The unit provides mounting points to connect with the stand structure and to attach the motor mount plate. It also has two cables: one for the force sensor and the other for the optical RPM sensor.

### 4.2.1 Storage, calibration, and warranty

#### **IMPORTANT!**

The LMU is a high-precision instrument and is very delicate. Impact and excessive force applied on the load measurement unit will cause permanent damage to the load sensors!

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The Series 1780 load measurement unit comes in a case to protect the unit from impact during shipping and while not in use. We recommend keeping the load measurement unit inside the package until you need to mount it onto the support.



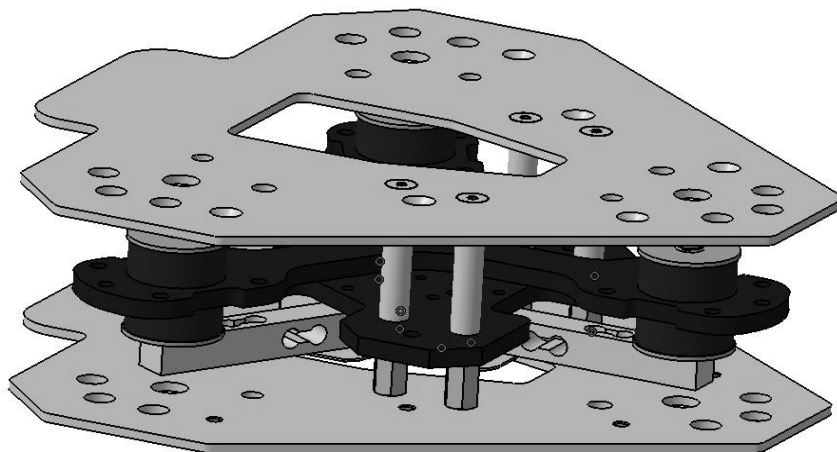


Fig. 4.28: Load measurement unit inside the protective case

Keep all the components of the protective case together. If repairs are necessary, ship the unit back with the casing. If you are not able to ship the load measurement unit back with the protective casing for repair or recalibration, we will return the unit with a new protective casing and apply a charge.

---

**IMPORTANT!**

Do not tamper with any screws sealed in orange or black paint on the load measurement unit because a recalibration of the whole unit will be needed upon reassembly. Your test results will be affected if the calibration data is not valid. Currently, the load measurement unit can be only recalibrated in a Tyto Robotics facility. Contact us for a quote when needed.

#### 4.2.2 What's included

For the Series 1780 Test Stand 75 kgf - 500 A: Single motor (SKU#: KURKE), you will receive one load measurement unit 75 kgf - 48 Nm in the box:

Item name	Item SKU	Qty
Series 1780 load measurement unit 75 kgf - 48 Nm: side A	FVET	1

For the Series 1780 Test Stand 75 kgf - 500 A: Coaxial (SKU#: KXQVH), you will receive two load measurement units 75 kgf - 48 Nm in the box:

Item name	Item SKU	Qty
Series 1780 load measurement unit 75 kgf - 48 Nm: side A	FVET	1
Series 1780 load measurement unit 75 kgf - 48 Nm: side B	JTJB	1

#### 4.2.3 Mounting the load measurement unit to the stand

##### **IMPORTANT!**

Do not start this step until you have assembled the stand structure and installed it onto a ground fixture that can firmly hold the Series 1780 test stand.

If you are building a single-motor setup, retrieve the following equipment:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Assembled stand	N/A	1	Done previously
Load measurement unit: side A	EXBE	1	Packed load measurement unit box (#FVET)
LMU fastener bag	VQMD	1	Fixture and fastener box (#BCJE)

If you are building a coaxial setup, retrieve the following equipment:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Assembled stand	N/A	1	Done previously
Load measurement unit: side A	EXBE	1	Packed load measurement unit box A (#FVET)
Load measurement unit: side B	USMX	1	Packed load measurement unit box B (#JTJB)
LMU fastener bag	VQMD	2	Fixture and fastener box (#BCJE) and Coaxial extra fastener box (#PNWW)

Inside the load measurement unit LMU fasteners bag (#VQMD), you will find:

Item name	Item SKU	Qty
SHC Screw M5 x 0.8 mm - 25 mm	YBJA	4
SHC Screw M5 x 0.8 mm - 40 mm	QACR	2
M5 split lock washer	T9DQ	6
Aluminum spacer 15 mm	UGFD	2
Mechanical safety stop	YFXL	1

### IMPORTANT!

Make sure to properly attach the stand to the floor before placing the load measurement unit onto the stand. Fallen stands can cause injuries or damage to the load measurement unit.

- 
- ☐ Open the packed load measurement unit side A (#FVET) or side B (#JTJB).
  - ☐ Remove the flat head screws.

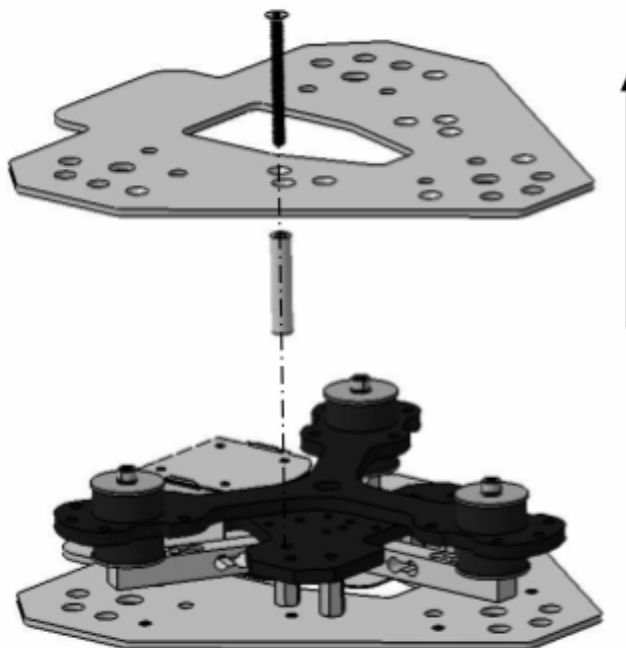


Fig. 4.29: Removal of the protective metal plate

- ❑ Separate the load measurement unit (LMU) from its protective case.
- ❑ Handle the load measurement unit with care and take it to the stand.

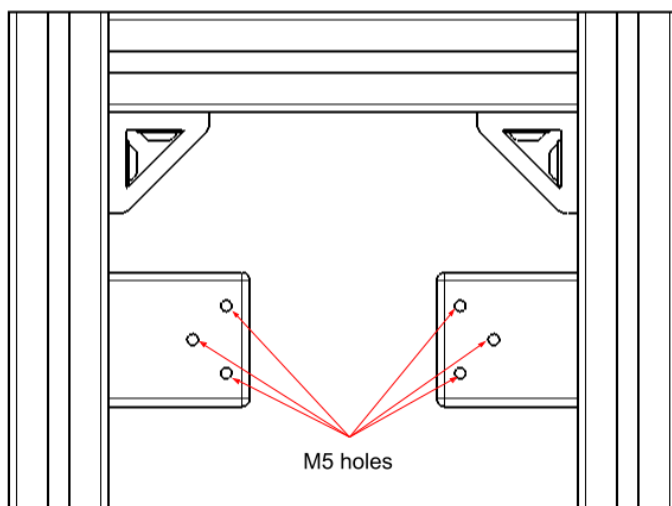


Fig. 4.30: Align the load measurement unit with the block with the highlighted holes.

- ❑ Place the load measurement unit (#EXBE or #USMX) onto the rectangular block profile, aligning these upper and lower holes, as shown in Fig. 4.30.

- ❑ In some cases, you may need to adjust the position of the rectangular block profile to have enough clearance to install the load measurement unit. Adjust the position by loosening screws when necessary. Work with another person because the position of the load measurement unit may need to be maintained while the unit is being adjusted.
- ❑ Use four M5 socket head screws - 25 mm (#YBJA) and four M5 split lock washers (#T9DQ) to attach the load measurement unit completely, using the two upper and lower holes, as shown in Fig. 4.31.

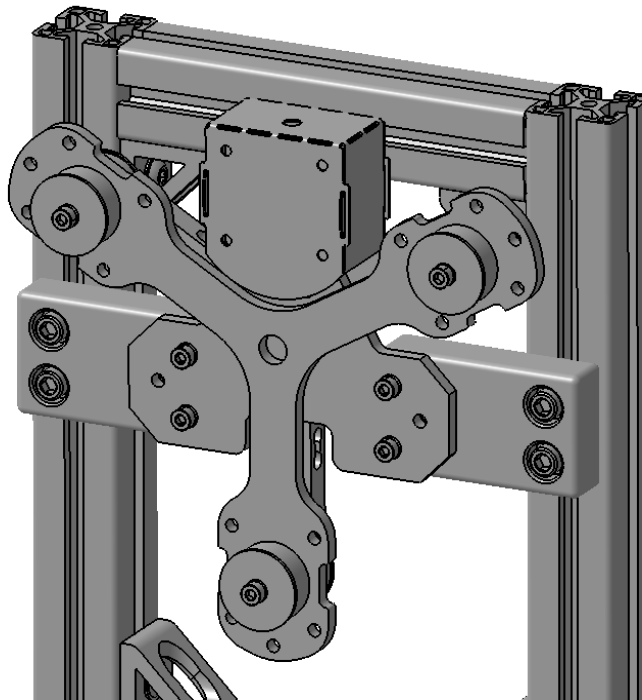


Fig. 4.31: Use four M5 - 25 mm screws to attach the LMU onto the stand (rectangular block).

- ❑ Take out the mechanical safety stop (#YFXL), two 15 mm aluminum spacers (#UGFD), and two socket head M5 - 40 mm screws (#QACR) from the fastener bag.
- ❑ Install the mechanical safety stop (#YFXL) on top of the load measurement unit's upper plate with the 15 mm aluminum spacer.
- ❑ Use two M5 - 40 mm screws (#QACR) and two M5 split lock washers (#T9DQ) to attach the stop to the rectangular profile (#LZWT), as shown in Fig. 4.32.

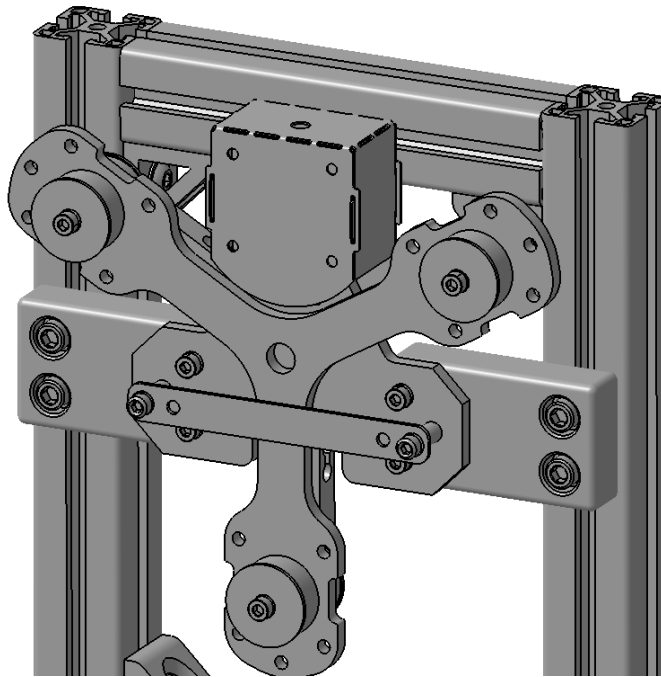


Fig. 4.32: Installation of the mechanical safety stop

- ❑ Now, fully tighten all the M5 screws and the 5/16"-18 screws.
- ❑ We suggest tightening the load measurement unit on the rectangle profile first, to ensure the fit of the unit. Then, tighten the rectangle block profile onto the T-slotted frame. **Tighten all the screws in a diagonal order.**

**IMPORTANT!** The purpose of the mechanical safety stop is to prevent the propeller/motor from falling on the ground in the event of a load cell mechanical failure. The tool was designed and tested to prevent this from happening, but, under a strong overload, all three load sensors may break simultaneously, causing the motor plate to detach. In the event of a load sensor failure, the propeller could still hit the stand structure and shatter.

- ❑ The mechanical safety stop can be moved to a higher or lower position in case the cable outlet from the motor interferes with the stop. Avoid direct contact of this stop with any wiring because it may cut the shield and short the ESC.
- ❑ If the coaxial version thrust stand is being used, simply repeat all the previous steps in this section to install the second load measurement unit onto the stand.

#### 4.2.4 Dismounting the load measurement unit from the support

The load measurement unit will need to be put back in the protective casing if you need to do any of the following:

- Change the setup
- Move the test stand to another location
- Stop using the Series 1780 for a long time (to avoid damaging the load cell by mistake)
- Return the unit for repair, recalibration, or upgrade

In case you need to dismount the load measurement unit, first, find the protective casing (see Section 4.2.1) in the original package. Build the casing with the metal plates and the standoffs and put the load measurement unit properly inside.

Use caution when you remove the fasteners because the load measurement unit is sensitive and any sudden impact can damage the load sensor. Loosen the M5 screws from the rectangular block profile only when it is safe to do so. Have a second person help you hold the load measurement unit when loosening the screws.

After removing the load measurement unit from the support, place it back onto the protective case, aligning with the hex standoffs. Close the casing with the spacers and the second metal plate, and fasten the M5 flat head screws properly to make sure the load measurement unit is well protected inside.

Keep the unit inside the casing until you need it.

### 4.3. Motor, motor mount, and optical RPM probe

The motor mount plate is an important component for the Series 1780 Test Stand. It is a connection between the motor and the load measurement unit. It transfers thrust and torque and provides multi-adaptive mounting points to attach the motors, and the optical RPM probe. It can also be used for the calibration checker bar.

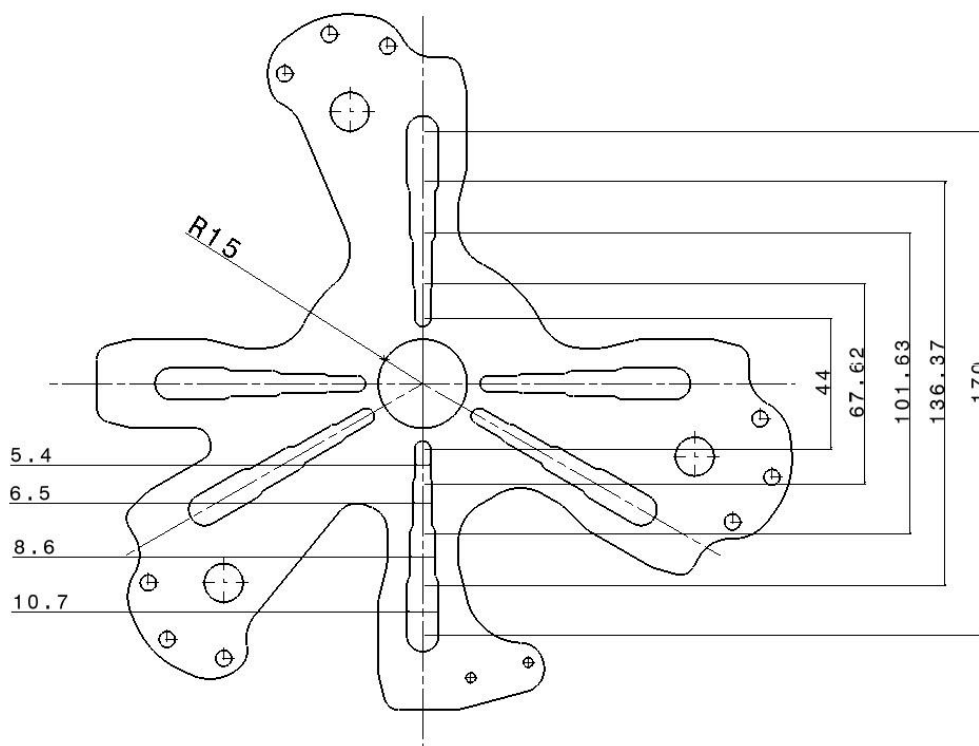


Fig. 4.33: General purpose motor mount slot features (all annotations in millimeter)

Make sure to install the motor and the optical RPM probe on the motor mount before mounting the whole structure onto the load measurement unit.



### 4.3.1 What's included

With the Series 1780 Test Stand 75 kgf - 500 A: Single motor (SKU#: KURKE), you will receive one motor mount plate and one optical RPM probe:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Heavy load motor mount	XSWU	1	Main carton box
Optical RPM probe V2.2: A	ZZJB	1	Mono main board box (#RHGQ)
Optical probe fastener and spacer kit	JRXA	1	Mono main board box (#RHGQ)

With the Series 1780 Test Stand 75 kgf - 500 A: Coaxial (SKU#: KXQVH), you will receive two motor mount plates and two optical RPM probes:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Heavy load motor mount	XSWU	2	Main carton box
Optical RPM probe V2.2: A	ZZJB	1	Dual main board box (#GPDE)
Optical RPM probe V2.2: B	QRQW	1	Dual main board box (#GPDE)
Optical probe fastener and spacer kit	JRXA	2	Dual main board box (#GPDE)

### 4.3.2 Install your motor onto the motor mount

You will have to prepare your own motor to be tested. Also, you will need to prepare your own fasteners to attach the motor to the motor mount.

The motor mount plate, as shown in Fig. 4.33, features several widths of slots for M5, M6, M8, and M10 screws at a 0, 90, 120, 180, 240, and 270 degree circular pattern.

If your motor supports more than one type of mounting point, we always recommend using the largest point possible. For example, if your motor has M5 holes at diameter 40mm and M6 holes at diameter 50mm, we suggest using the M6 holes.

We highly recommend adding washers between the motor plate and the screw heads used to install your motor.

### IMPORTANT!

Tighten all screws for your motor at the time you mount it on the metal plate. You **CANNOT** reach these screws once the motor plate is mounted on the load measurement unit.

### 4.3.3 Install the optical RPM probe on the motor mount

The optical RPM probe reads the rotation speed of your motor. You will need to prepare the following materials to install the optical RPM probe:

Item name	Item SKU	Qty
Optical RPM probe V2.2: A or Optical RPM probe V2.2: B	ZZJB or QRQW	1
Optical probe fastener and spacer Kit	JRXA	1

Each bag in the optical probe fastener and spacer kit (SKU#: JRXA) contains the following:

Item name	Item SKU	Qty
Spacer 4.76 mm long	GFRE	2
Spacer 12.70 mm long	9R8L	2
Spacer 22.23 mm long	PD8E	2
Spacer 33.34 mm long	YE4H	2
Spacer 38.10 mm long	TFQM	2
M4 x 12 mm socket head screw	QTBR	2
M4 x 20 mm socket head screw	QCBP	2
M4 x 30 mm socket head screw	KRJC	2
M4 x 40 mm socket head screw	YJKT	2
M4 x 50 mm socket head screw	FL9D	2
M4 black plastic washer	7EB9	2

It is not necessary to use all the fasteners and spacers indicated above to install the optical RPM probe. Choose only one format of spacer and one length of M4 screw that can provide the perfect height for the optical probe to approach the motor.

Choose from one of the pairs below according to your motor's height:

- 4.76 mm spacer – M4 x 12 mm screw
- 12.70 mm spacer – M4 x 20 mm screw
- 22.23 mm spacer – M4 x 30 mm screw
- 33.34 mm spacer – M4 x 40 mm screw
- 38.10 mm spacer – M4 x 50 mm screw

Follow these instructions to install the optical probe onto the motor mount:

- ☐ Apply black electrical tape (prepared by you) to reflective logos on the rotor of the motor to be tested.
- ☐ Apply the supplied reflective tape on any part of the rotor of your motor. The length of the reflective tape should be longer than 10 mm. For motors that have a larger diameter, put a longer tape on the motor for measuring the RPM. Note that, if you run out of the reflective tape we provided, use any white electrical tape as an alternative.
- ☐ Select a pair of spacers and screws that correspond to the height from the motor mount to the reflective tape.
- ☐ Place the M4 screws and M4 black plastic washers through the slots on the optical RPM probe. Then, put the aluminum spacers on the other side of the circuit. Slightly fasten the screws into the tapped holes on the motor mount.

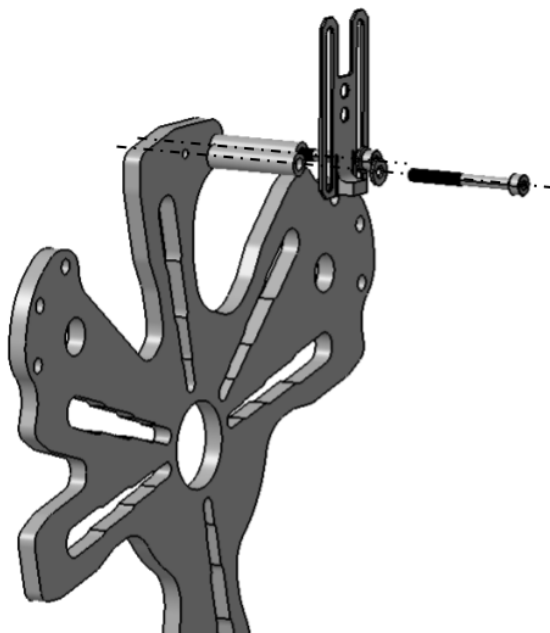


Fig. 4.34: Connection of the screw, washer, spacers, and optical probe to the motor mount

- ❑ Adjust the radial distance between the sensor head of the probe and the rotor edge, using the slots on the circuit. Make sure the gap between the optical sensor and the motor, shown as  $e$  in Fig. 4.35, is according to the specification.

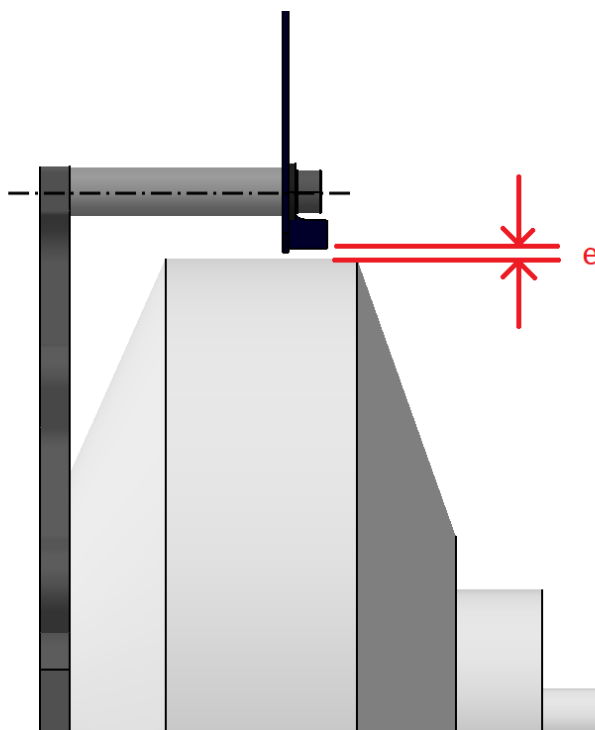


Fig. 4.35: Gap control between the probe and the motor

- ❑ The recommended gap distance (e) between the motor and the probe is:
    - 2-5 mm for optical RPM probe V2.2
  - ❑ Once the probe reaches the appropriate distance from the motor, fully tighten all the screws with an Allen key.
- 

**IMPORTANT!**

The distance between the motor and the head of the optical sensor is important. It must be kept under a certain distance for the optical sensor to work effectively.

The optical probe is very close to spinning parts. Check that fasteners are tight before every test to prevent the optical probe from slipping and colliding with the rotor.

#### 4.3.4 Install the motor mount assembly on the load measurement unit

Once you finish putting the motor and the optical probe on the motor mount, you can now install the whole assembly onto the load measurement unit.

#### IMPORTANT!

We recommend mounting the propeller after the motor is installed and firmly attached onto the load measurement unit.

Check that the motor screws have been well fastened before this operation. They will not be accessible after the assembly is installed on the load measurement unit. Check the torque specifications provided by your motor's manufacturer.

Prepare the following materials to carry out this operation:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Motor mount assembly with motor, optical RPM probe	N/A	1	Done previously
Load measurement unit assembly, installed on the support	N/A	1	Done previously
Motor mount fastener bag	VTBS	1	Fixture and fastener box (#BCJE) or Extra fastener box for coaxial setups (#PNWW)

If you have purchased the coaxial version of the thrust stand, you will find one motor mount fastener bag (#VTBS) in both fixture and fastener Box (#BCJE) and (#PNWW).



You can find the following items from the **motor mount fastener bag (SKU#: VTBS)**:

Item name	Item SKU	Qty
M5 x 12 mm socket screw	2HEX	9
M5 x 20 mm M-F standoff	CTKG	9
Split lock washer M5	T9DQ	9
M5 x 0.8mm serrated flange locknut	YTEX	18

To start the installation, follow these steps:

- ❑ Take out the nine socket head screws (#2HEX), the nine standoffs (#CTKG), and the nine split lock washers from the bag (#VTBS).
- ❑ Insert the M5 screws (#2HEX) and split lock washers (#T9DQ) through the nine holes of the load measurement unit.

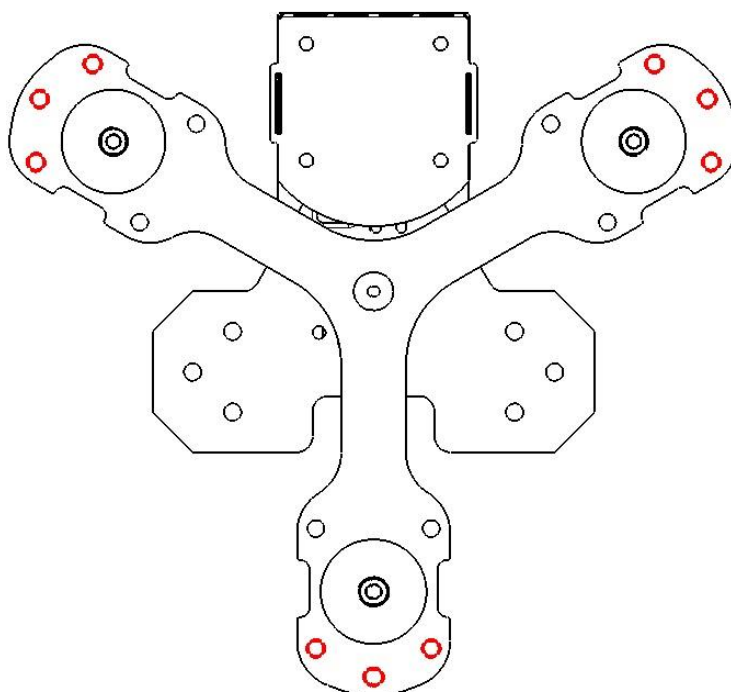


Fig. 4.36: Use the nine highlighted holes shown here to insert your screws and split lock washers.

- ❑ Insert the M5 screws in the female part of the nine M5 standoffs, and tighten them well, as shown in Fig. 4.37.

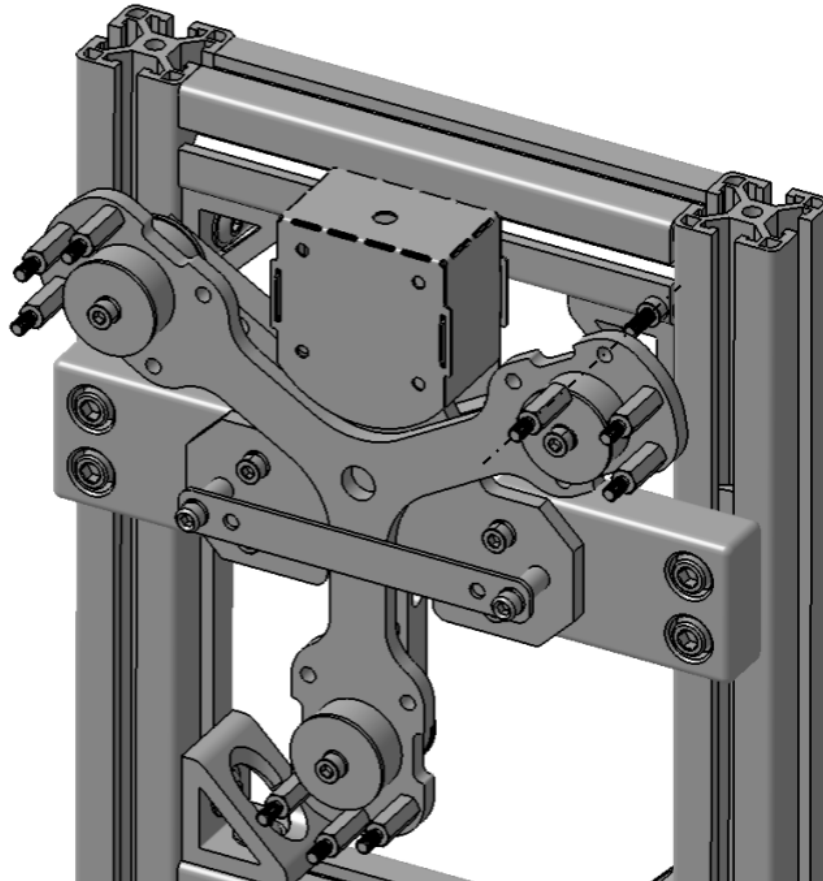


Fig. 4.37: Installation of the screws, washers, and standoffs to the load measurement unit

- ❑ Take out nine serrated locknuts (#YTEX) from the motor mount fastener bag (#VTBS).
- ❑ Take out the entire assembly of the motor mount with the motor and optical RPM probe.
- ❑ Align the nine M5 holes on the motor mount with the M5 male-female standoffs on the load measurement unit. See Fig. 4.38.
- ❑ In the motor mount fastener bag (#VTBS), we have supplied 18 serrated locknuts, use nine of them for this installation. You may use the other nine as replacement when necessary. We also suggest using the hex sockets if possible when you need to frequently change motors and propellers.



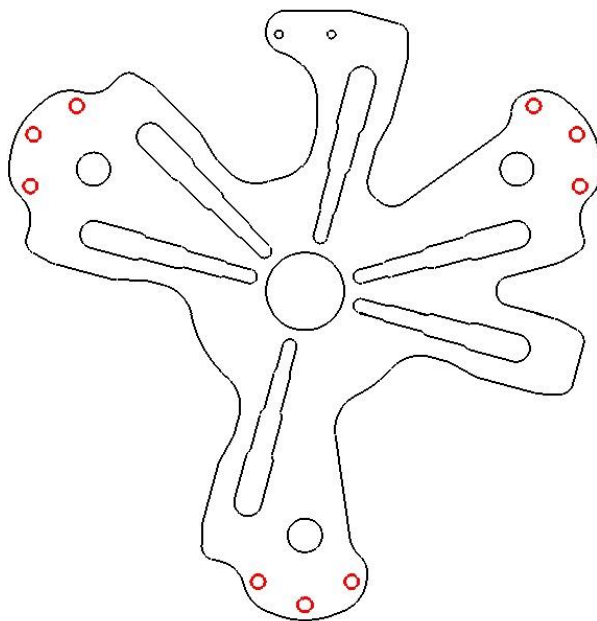


Fig. 4.38: Use the nine highlighted holes shown here to align with the load measurement unit

- ❑ Rotate the M5 flange locknut (#YTEX) into the male threaded standoffs to fasten the motor mount onto the load measurement unit, as shown in Fig. 4.39:

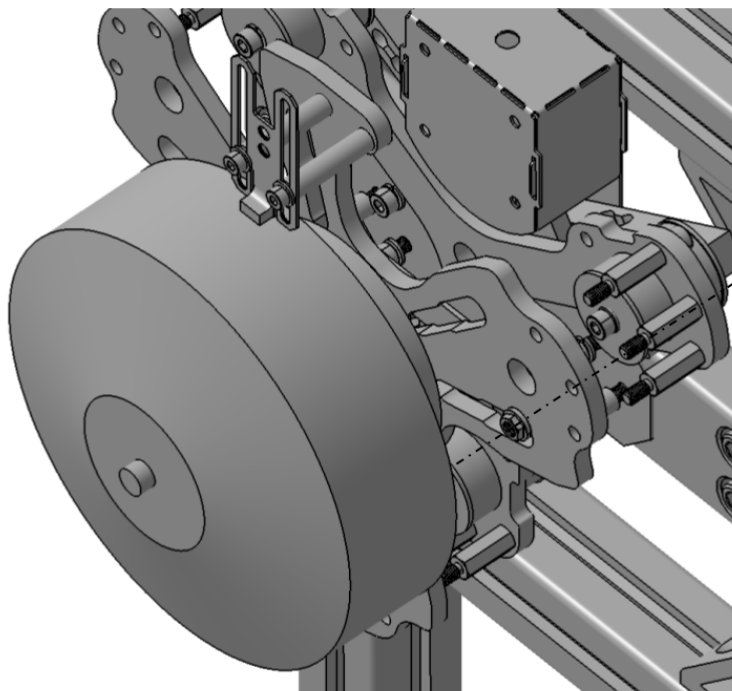


Fig. 4.39: Connection of load measurement unit to motor mount assembly using M5 nuts

- ❑ Repeat the previous step before tightening all the nuts.
  - ❑ Tighten all the nuts with the wrench, following a diagonal sequence. If you have hex socket 8 mm, use it because it may make it easier to tighten the serrated flange nuts (#YTEX).
  - ❑ If you have the coaxial version, simply repeat the previous steps in this section to install the motor mount onto the load measurement unit.
- 

**IMPORTANT!**

Every time, before you start a test, we highly recommend that you check the tightness of the fasteners on the motor mount for safety.

## 4.4 Power and control console

The maximum measuring voltage and current are 100 V and 500 A respectively.

Note that the Series 1780 power and control console can only be controlled and operated using the RCbenchmark GUI and the Series 1780 Test Stand hardware.

**IMPORTANT: SHUT THE POWER OFF** before working on the power console. Do not try to open the casing of the Series 1780 power and control console, as it may result in injury. Such an operation will void the warranty.

### 4.4.1 Introduction to the power and control console 100 V - 500 A

The design of the Series 1780 power and control console consists of three parts: current measurement, voltage measurements and the ESC signal output.

1. We provide a contactless hall sensor to measure the current. You must pass the DC power input cable through the sensor's opening to measure the current.
2. For the voltage measurement, you need to connect two thin wires, one to power and one to ground, to the terminal. Do not do the connection operation when the power is on.
3. The ESC control section provides two signal output ports to control the ESC or servo motor. The output signal is a PWM signal with 50 Hz frequency, from 1000 to 2000  $\mu$ s. Since some ESCs need to be calibrated before being functional. Be sure to read the user manual of your ESC.

### 4.4.2 What's included and where to locate the components

If you purchased the Series 1780 Test Stand 75 kgf - 500 A: Single motor (SKU#: KURKE), you received one power and control console 500 A: side A (SKU#: EMDG). You find these items in the box:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Series 1780 power and control console 500A: side A	ZSTS	1	#EMDG
S1780 test stand 75 kgf fasteners bag for power sensor	HGQX	1	#EMDG

If you purchased the Series 1780 Test Stand 75 kgf - 500 A: Coaxial (SKU#: KXQVH), you will receive one power and control console 500 A: Side A (SKU#: EMDG) and one power and control console 500 A: Side B (SKU#: GCQH). You will find these items in the box:

Item name	Item SKU	Qty	Located in (SKU# if exist)
Series 1780 power and control console 500 A: Side A	ZSTS	1	#EMDG
Series 1780 power and control console 500 A: Side B	FNXA	1	#GCQH
S1780 test stand 75 kgf fasteners bag for power sensor	HGQX	2	#EMDG & #GCQH

All the fasteners are included inside the fasteners bag (SKU#: HGQX). You will find the following items in the bag:

Item name	Item SKU	Qty
Button head 5/16"-18 screw 11/16" long	KEDB	2
End-feed fastener 5/16"-18 nut	YREC	2
5/16" washer	BLGN	4

#### 4.4.3 Attaching the power and control console to the stand structure

##### **IMPORTANT!**

Shut the power OFF before ALL operations.

To install other unit, follow the same steps:

- ☐ Take out the power and control console side A (#ZSTS) or side B (#FNXA) and the fasteners bag for power sensor (#HGQX).
- ☐ On the power and control console (#ZSTS or #FNXA), is a metal strip in the back with two holes. Screw one button head 5/16"-18 screw (#KEDB) with two washers (#BLGN) through each holes on the strip, and connect the other side with one end-feed T-nut 5/16"-18 (#YREC). Do it for both holes.

- ❑ When installing coaxial, make sure to place the correct side, A or B, of the power and control console to the corresponding load measurement unit side A and B. Do not keep the load measurement unit side A and power and control console side B on the same stand.
- ❑ Then, join the whole assembly into a T-slotted frames 4' long (#HJXQ) by inserting the T-nuts into the slot, as shown in Fig. 4.40.

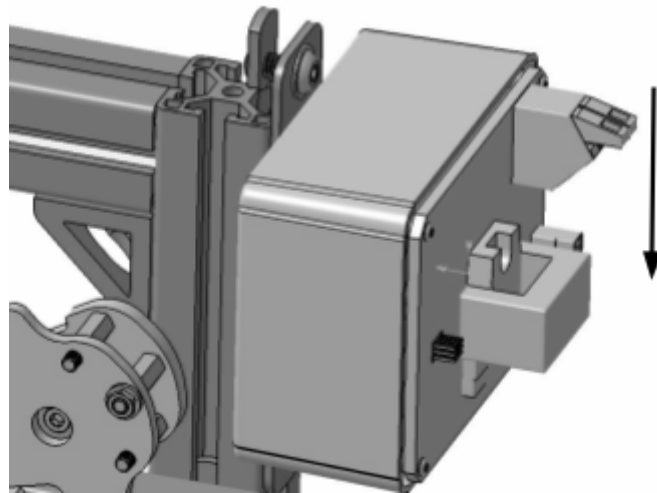


Fig 4.40: Join the power and control console to the support.

- ❑ Then, slide the power and control console along the beam, ensuring that you have enough space to attach the ESC above the console on the beam.

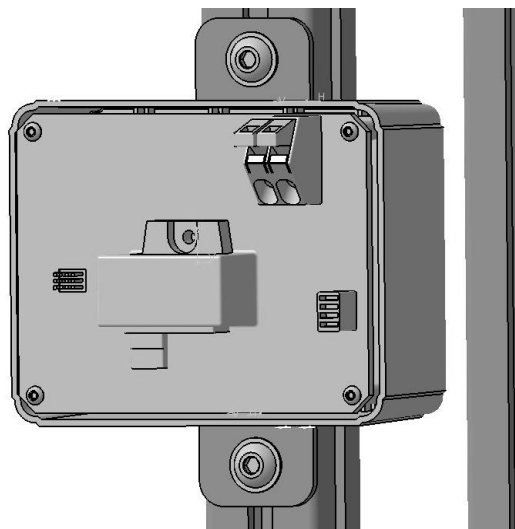


Fig. 4.41: Power and control console attached to the support

- ❑ Tighten all the 5/16"-18 screws when position.

#### 4.4.4 Attaching the ESC on the stand structure

Depending on the size, and the fixture pattern on the ESC, you may have a few options for attaching the ESC to the support frame. Here, we will show you an example. Inside the package of the main board, you will find reusable straps.

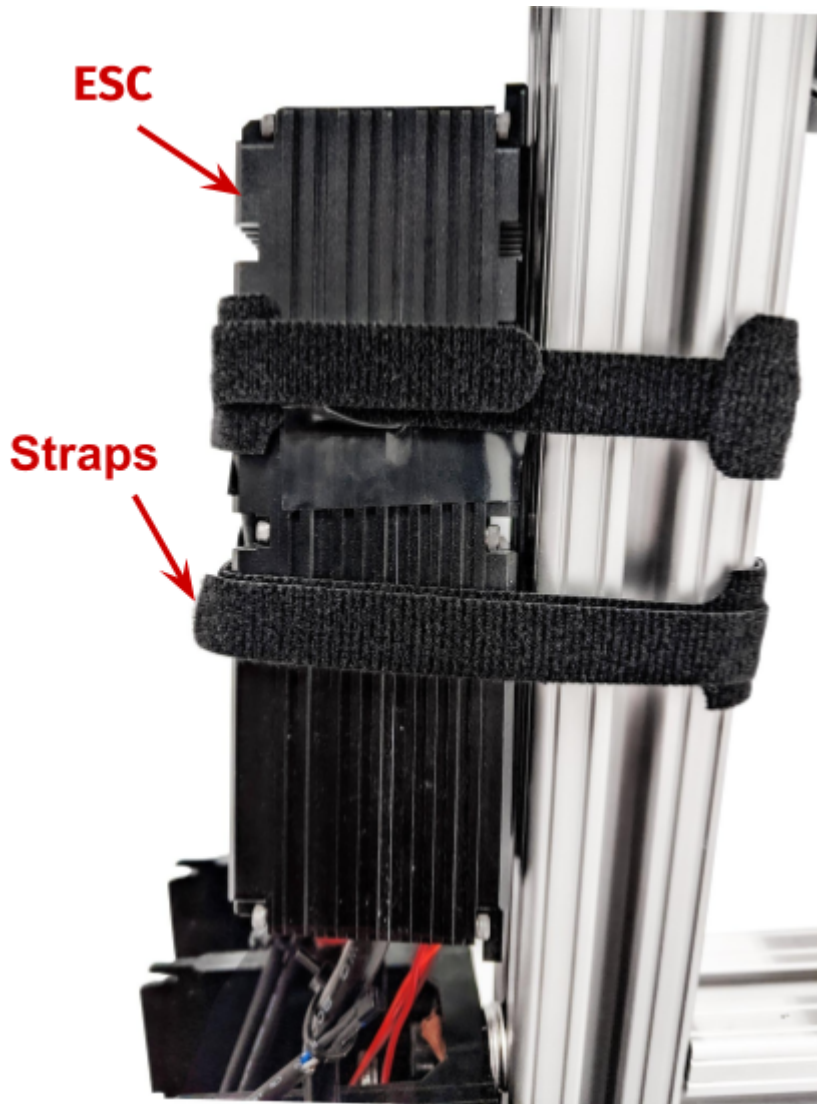


Fig. 4.42: Example of attaching the ESC to the 4' beam using straps

If one strap is not long enough, you can use two in-line to extend the total length. You will need to apply straps in several positions to ensure enough strength in holding the ESC on the support plate. Any loose objects may cause damage to your propeller.



## 4.5 Main board

The main board is the core component of the Series 1780 Test Stand. It performs data processing from all the sensors and signal processing for the output PWM to the ESC, and is the connection to a workstation for the GUI control.

There are two versions of the mainboards:

- Mono main board (SKU#: RHGQ): for one motor control and measurement
- Dual main board (SKU#: GPDE): for two motors control and measurement



Fig. 4.43: Photo of dual main board with USB cable and power adapter

The difference between the mono and the dual main board is the number of connectors supported. Bear in mind both versions have the same power adapter, USB connection cord, and the same mounting features.

The Series 1780 main board provides high-quality connectors for connecting the power sensor, force sensor, control unit and other accessories. It also features buzzers for overload alert, a safety cutoff switch, and LED indicators, etc.

In this part, we will only present the installation of just the main board. For the cable connection of the mainboard, as well as the use of the buzzer and safety cut-off switch, refer to Chapter 5.

#### 4.5.1 What's included

You will have received the mono main board (SKU#: RHGQ) in the carton of the thrust stand Series 1780 Test Stand 75 kgf - 500 A: Single motor (SKU#: KURKE). You can find these items inside the package:

Item name	Item SKU	Qty
Series 1780 complete mono main board V2	BJXT	1
USB cable	JG3F	1
Optical RPM probe V2: A	ZZJB	1
Optical probe fasteners and spacers kit	JRXA	1
Cable tie 0.1" width, 8" long	YCRH	20

If you received the dual main board (SKU#: GPDE) in the carton of the thrust stand Series 1780 Test Stand 75 kgf - 500 A: Coaxial (SKU#: KXQVH), you can check these items inside the package:

Item name	Item SKU	Qty
Series 1780 complete dual main board V2	JAGY	1
USB cable	JG3F	1
Optical RPM probe V2: A	ZZJB	1
Optical RPM probe V2: B	QRQW	1
Optical probe fasteners and spacers kit	JRXA	2
Tie-wrap 0.1" width, 8" long	YCRH	40

If you are following the correct assembly procedure, the optical RPM sensor(s) inside the package should have already been retrieved and installed on the motor mount in the previous operation (marked grey in the table).



The USB cable is used to connect the main board with a PC, in order to allow communication and data processing on the RCbenchmark software. The cable ties can be used to tie up all the loose cables.

The power adapter is located in the main shipping carton box. The power adapter features several plugs commonly used in the world.

Item name	Item SKU	Qty
Main board power adapter	PGAC	1

#### 4.5.2 Installing the main board on the ground or on the stand structure

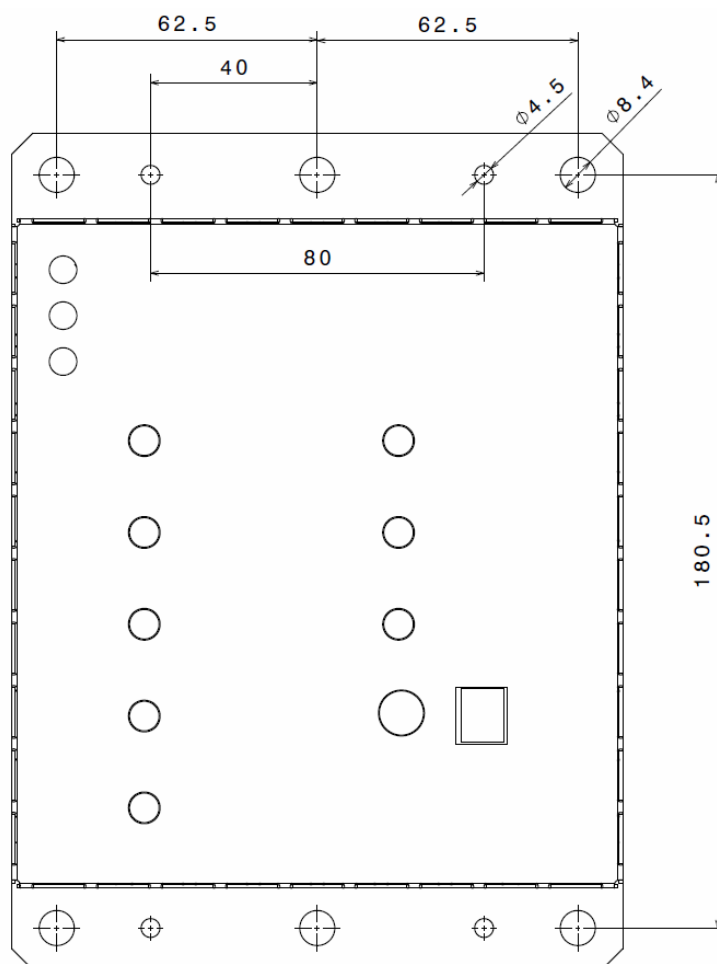


Fig. 4.44: Schematic drawing for main board mounting holes

You can use any of these holes to mount the Series 1780 main board onto the ground structure, the stand structure, or anywhere else. You will need to prepare your own fasteners. There are two types of holes you can choose:

- Diameter 4.5 mm – four holes on two sides, fit M4 and #8 fasteners.
- Diameter 8.4 mm – six holes in the center and two sides, fit M8 and 5/16" fasteners.

If you wish to attach the main board to the beams, use the extra 5/16"-18 button head screws and the T-nuts provided in the spare T-nuts and fastener bag (#PZKW), located in the fastener box (#BCJE or #PNWW).

Keep the main board close to the PC, and do not use simple USB extension cords to prevent voltage drops and freezing the communication. If necessary, to extend the distance between the main board and the PC, use USB hubs with an external power supply.

## 4.6 Tightening with a torque wrench

Once you have finished installing the Series 1780, check all the screws with a torque wrench. **Remember to tighten all the screws in a diagonal order.** You can use the following table to determine the torques needed:

Nominal size	Type of head	Profile	Torque (Nm)
M4	Socket	Normal	4–6
M5	Socket	Normal	10–12
5/16"-18	Socket	Normal	22–30
5/16"-18	Button flange	Normal	15–20

### IMPORTANT!

Because the T-nuts are short in threads compared to the normal nuts. We recommend regularly checking the 5/16"-18 socket head screws connected to the beams with the T-nuts. We suggest checking these screws before or after every test day, or every 2 hours of running time on the stand.

## Chapter 5: How to Connect Electrical Components

In this chapter, we present a guide for connecting all the electrical components together. Follow this guide carefully, and respect all the safety rules.

### 5.1 Electrical safety rules

- The main board is powered by a 5 V, 2 A power adapter, which is included in the package. Do not try to power the board by using other power supplies that output other voltages.
- The maximum measuring voltage of the Series 1780 75 kgf - 500 A power and control console is 100 V. Maximum continuous current input is 500 A.
- When connecting the power cable or bullet connectors on the power and control console, do not let the exposed metal of the wire touch the casing.
- Turn off the power supply or disconnect the battery when you are connecting the power wire to the Series 1780.

## 5.2 Sensor chain

### 5.2.1 Optical RPM probe and force sensor

Follow these instructions to connect the optical RPM probe:

- ❑ Connect the optical RPM probe cable to the connector on the metal box of the load measurement unit, marked optical probe, as shown in Fig. 5.1.

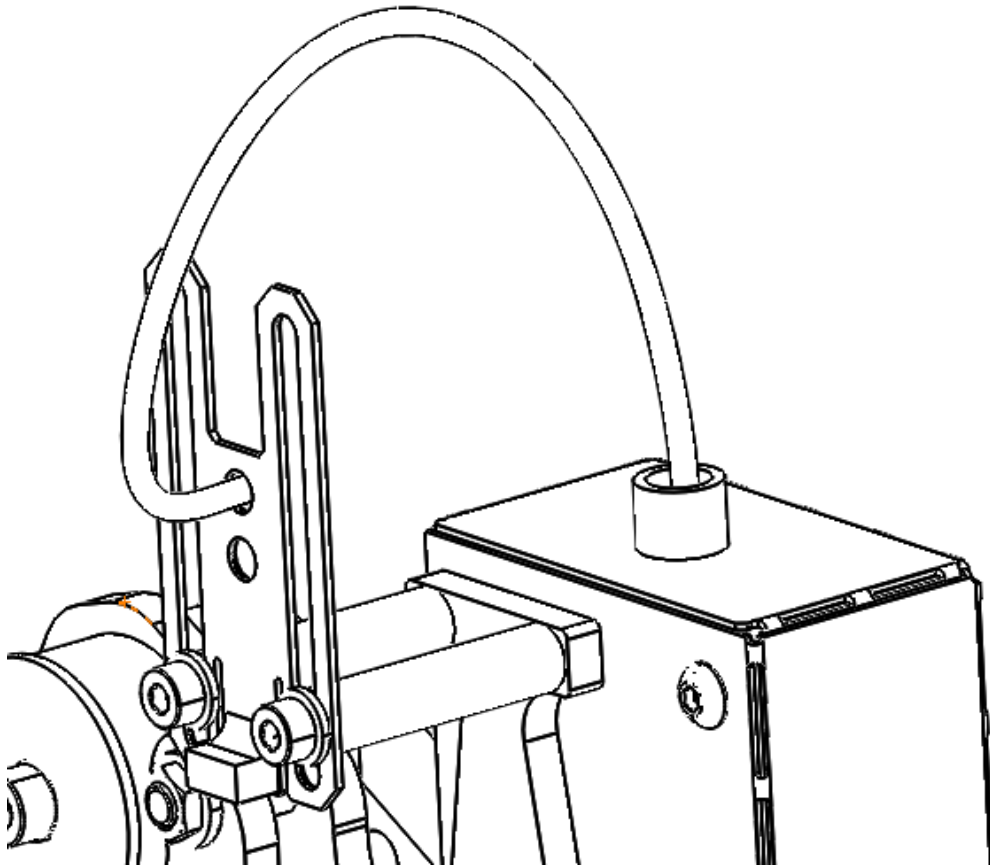


Fig. 5.1: Optical probe connected to the control console

- ❑ Connect the force sensor and optical probe COM cables to the main board at the correct connector location by following instructions on the main board. If you have a dual main board, make sure your cables are connected on the right side (A or B side).

## 5.2.2 Power sensor

To connect the wiring on the power sensor, follow the steps:

- ❑ Pass the positive wire of the ESC through the hall sensor on the power sensor to measure the current. Use two wires to make a connection between the positive and negative output on the power source and the voltage measurement connector on the power and control console for the voltage measurement. Put the power and control console as close as possible to your ESC, as shown in Fig 5.2.
- ❑ When putting the power wire through the hall sensor, please make sure the current flow is going in the direction of the arrow on the circuit board.
- ❑ Connect the power sensor COM cable to the main board at the correct connector location by following the label on the main board. If you have a dual main board make sure your cables are connected on the correct side (A or B).

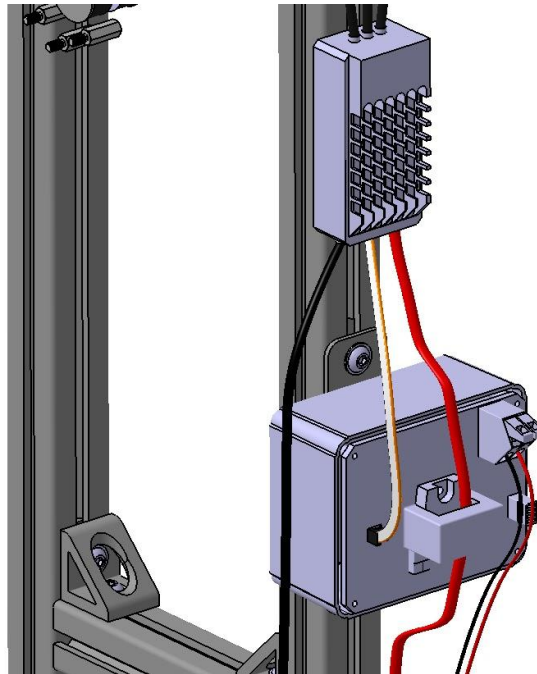


Fig. 5.2: Positive DC input passes through the opening of the current sensor.

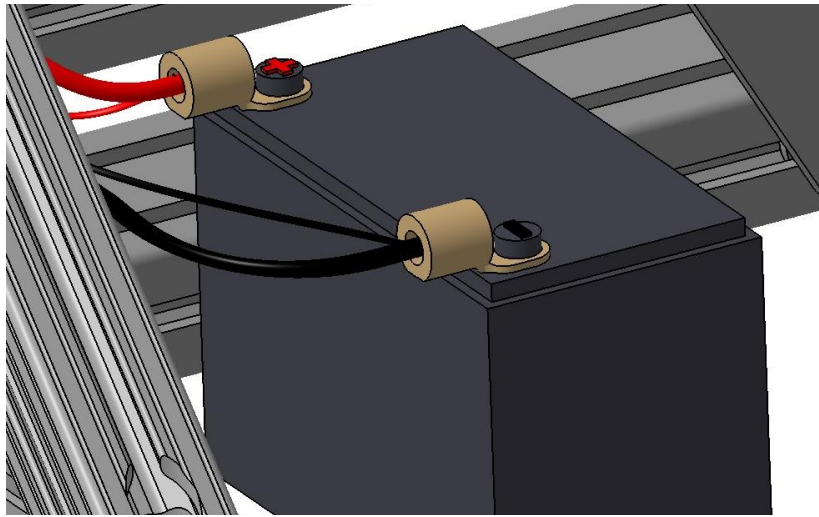


Fig. 5.3: Power source with the cable from the power sensor and ESC. The user is responsible for providing a power source with a suitable rating for the powertrain under test.

### 5.2.3 Temperature probe

Connect the temperature probe COM cable (additional purchase required) to the main board at the correct connector location by following the label on the main board. Use the thermal adhesive to attach the temperature sensor to the devices whose temperature you need to measure. There are additional instructions programmed into the software. Contact our technical team for more information.

### 5.2.4 Air-speed probe

The Series 1780 can be connected to one pressure probe (additional purchase required) for connecting to a wind tunnel Pitot tube. You should connect the pressure probe on the “Add-ons” port of the main board. After the probe is detected by the software, additional instructions will be available in the software.

## 5.3 Control chain

### 5.3.1 Power and control console

Connect the control COM cable to the main board at the correct connector location by following the label on the main board. If you have a dual main board, make sure the cables are connected on the right side (A or B).

Then, connect the ESC's control cable (small three pin connector) to the connectors available on the power and control console. Make sure to use the correct polarity and follow the pin assignment as printed on the casing.

If the ESC does not come with a battery elimination circuit (BEC), you can use the 5 V output in the jumper connector on the power and control console. Check the jumper position and internal connection diagram on the power and control console for the details.

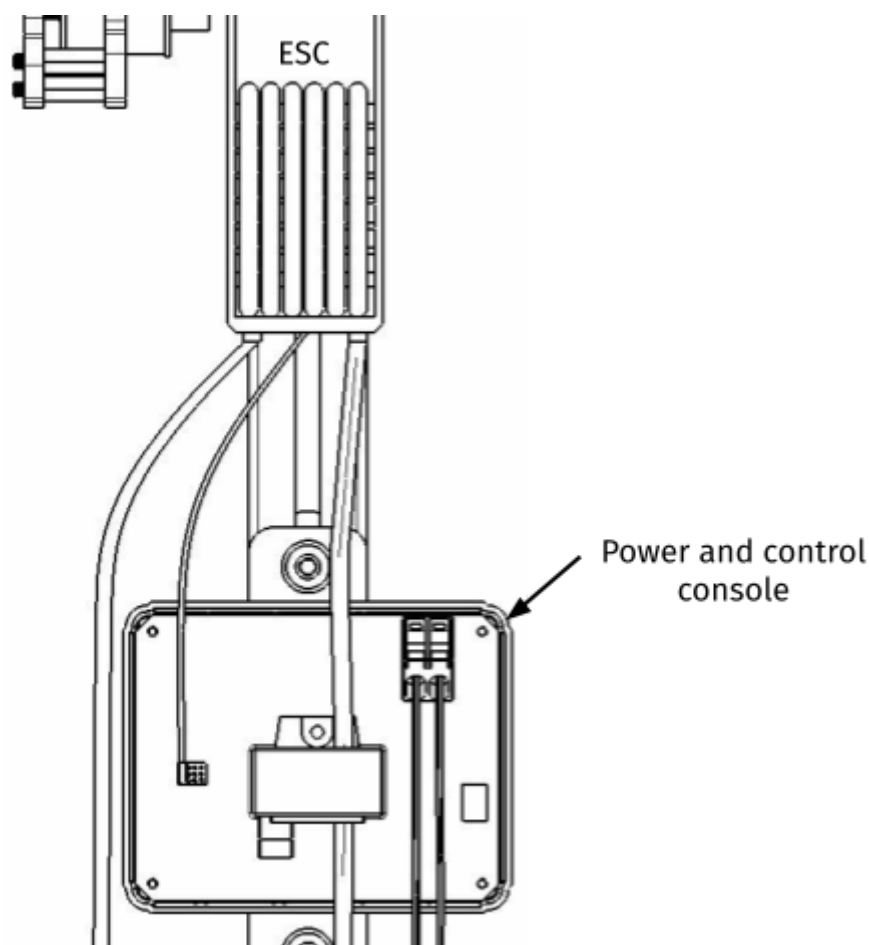


Fig. 5.4: Control chain between the ESC and power and control console

## 5.4 Main board and PC

### 5.4.1 Indicator lights

There are three different indicators on the Series 1780 main board: power, activity, and error.

- ❑ The power indicator LED will turn on when the main board is powered by the 5V power supply.
- ❑ The activity indicator LED will flash when the main board is communicating with the PC.
- ❑ The error indicator LED will flash when an error event happens and momentarily upon connection. If it continuously flashes, contact our technical support team.

### 5.4.2 Power and USB to your PC

Connect the power adapter and the USB cable to the main board. Then, connect the power adapter to an outlet with a suitable blade and the USB cable to your computer.

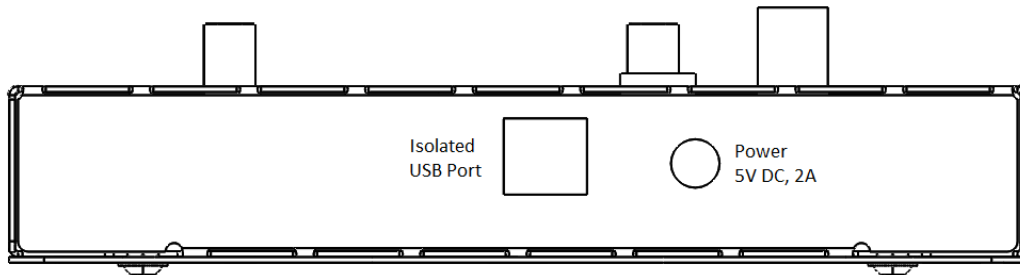


Fig. 5.5: Mono main board USB and power ports

### 5.4.3 Buzzer and safety cut-off switch

The buzzer and safety cut-off connector are embedded on the Series 1780 main board. The buzzer will sound in the following situations:

- One of the 12 strain gauges in the load cell is being overloaded. Stop applying force immediately to avoid permanent damage.
- The safety cut-off switch is triggered.

You can build your own safety switch by using the safety cut-off connector on the main board. When the wire is short, the cut-off of the Series 1780 will be triggered, and it will cut the signal output from the software to the ESC. This logic (short or open) can be inverted in the



RCbenchmark software. Remember that this is only a software cut-off; it will not cut power to the motors, only the control signal.

## 5.5 Cable management

For cable management, you can use the black and orange hook and loop cable ties (#LFYX) in the fixture and fastener box (#BCJE). If necessary, bundle the cables together with cable ties.

Before spinning a motor on the Series 1780 test stand, make sure all cables are secured. Avoid the cable touching any sharp edge on the stand because it may cut the shield due to vibration and short the component. Any cable that hits the spinning propeller may cause damage to the sensor, the propeller, or the whole facility.

## Chapter 6: Coaxial Testing (Two-Motors)

In this chapter, we introduce how to run tests for two motors or tests for a single motor when you have purchased the coaxial configurations. If you purchased the Series 1780 Test Stand: Single motor, you can bypass this chapter and move on to the next.

With the Series 1780 Test Stand 75 kgf - 500 A: Coaxial, you can do the following dual-motor setups:

- One motor
- Two motor face-to-face coaxial
- Two motor face-to-face offset: partial overlapping
- Two motor back-to-back coaxial
- Two motor back-to-back offset: partial overlapping

### 6.1 Two motors face-to-face

In this setup, you are able to adjust the axial distance by moving either side A or B assembled units. Keep in mind that only ONE side can be left free for axial movement because you may need to completely attach side A to the 7" single beams on the ground. In the demonstration, we have selected side B as the free-to-move unit.

**You will need at least two people to implement the movement.** When you need to adjust the axial distance, simply loosen the four pairs of fasteners on the 6" diagonal beams and the gusset brackets to allow free movement of the stand structure on the ground structure. You will also need to loosen the 5/16"-18 screws on the support rods to allow free movement.



Then, push or pull the whole stand structure slowly along the axis. Avoid applying force directly on the load measurement unit or the propeller, and use extra caution to avoid collision because it may damage the load measurement unit, motor, or propeller.

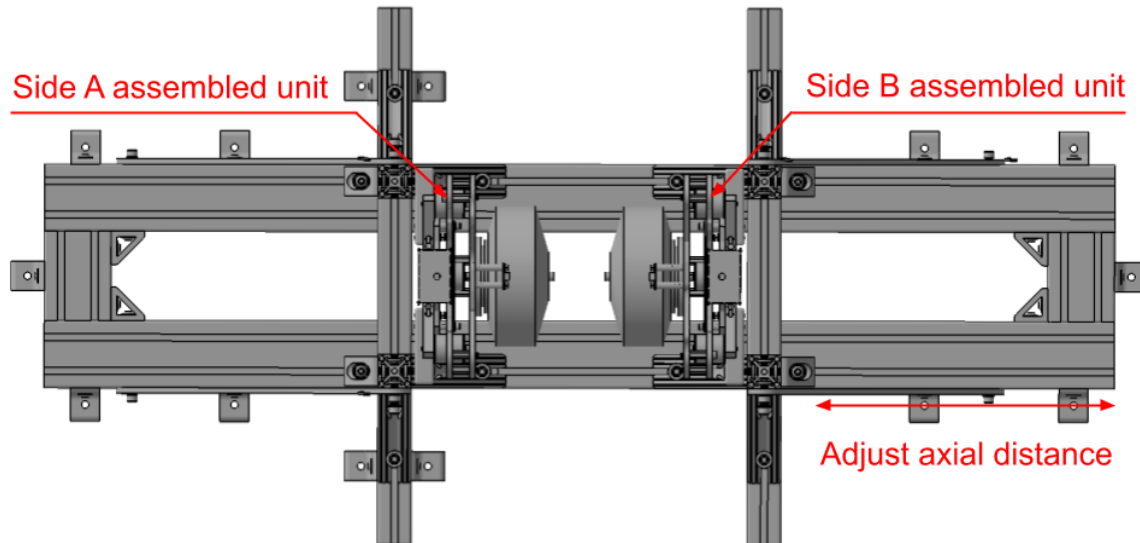


Fig. 6.1 Two motors face-to-face axial movement

Once the stand structure reaches the assigned position, refasten all fasteners with the Allen keys provided. For each stand, confirm that the support rods at the new position are between 50 and 60 degrees from the ground structure (Angle  $\alpha$ , shown in Fig. 6.2). Double-check the torque specifications for these fasteners, following those in the table in Annex 2.



Fig. 6.2: Angle  $\alpha$  (alpha) for each stand on a face-to-face setup

When you intend to run the offset and partial overlapping setup, you can slightly adjust the height of one load measurement unit on the stand. Doing so can provide a small adjustable radial offset for your overlapping tests.

Keep in mind that other sensors and control units also have sides A and B and should match the connections on the main board. Connecting load measurement unit side A and power control console side B on one stand may cause significant error in the derived efficiency.

Under certain circumstances, the COM cable may not be long enough for your application. All the electrical components in the Series 1780 support an extension cord. If you need this cord, contact our sales team by mentioning SKU# JCXK.

## 6.2 Two motors back-to-back

Similar to the face-to-face setup, this setup also allows axial distance adjustment by moving either side A or B of the assembled unit. Keep in mind that only ONE side can be left free for axial movement because you may need to completely attach side A to the 7" single beams on the ground. In the demonstration, we have selected side B as the free-to-move unit.

**You will need at least two people to implement the movement.** When you need to adjust the axial distance, simply loosen the four pairs of fasteners on the 6" diagonal beams and the gusset brackets to allow free movement of the stand structure on the ground structure. You

will also need to loosen the 5/16"-18 screws on the support rod to allow free movement. Then, push or pull the whole stand structure slowly along the axis, and use extra caution to avoid collision because it may damage the load measurement unit, motor, or propeller.

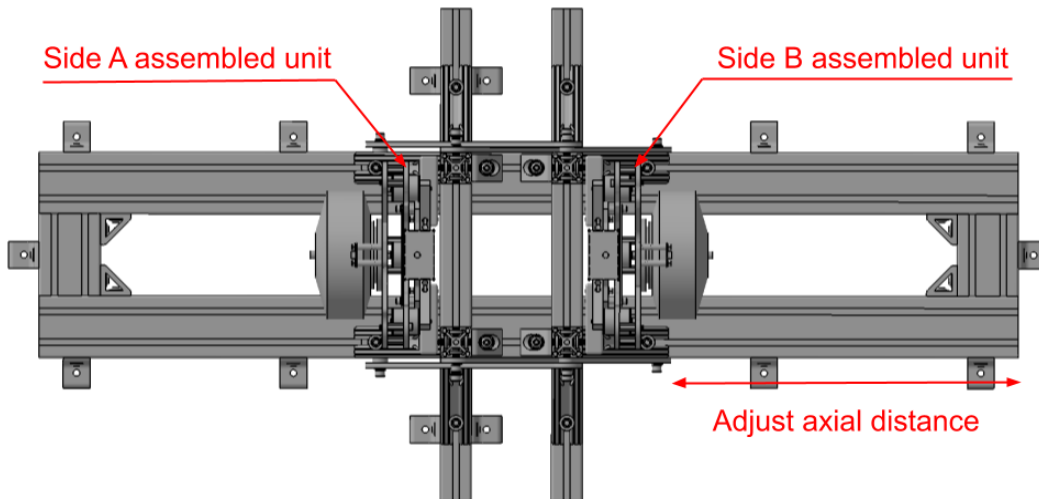


Fig 6.3: Two motors back-to-back axial movement

You will reach the minimum distance when two gusset brackets in contact with each other.

Once the stand structure reaches the assigned position, refasten all the fasteners with the Allen keys provided. For each stand, confirm that the support rods at the new position create the Angle  $\alpha$  to the ground structure following Annex 1. Double-check the torque specifications of these fasteners, following those in the table in Annex 2.

When you intend to run the offset and partial overlapping setup, you can slightly adjust the height of one load measurement unit on the stand. Doing so can provide a small adjustable radial offset for your overlapping tests.

## 6.3 Using coaxial to test one motor

It is totally feasible to use the Series 1780 Test Stand 75 kgf - 500 A: Coaxial to test only one motor. If you wish to test only one motor, we always recommend uninstalling the unused stand structure from the ground base.

If you wish to keep the unused stand on the ground structure, make sure that air flows from the unused stand towards the stand with the spinning motors and propeller. Placing obstacles in the upstream can produce less drag than placing them in the downstream. Always remove the load measurement unit and disconnect all the unused cords to avoid damage.

## Chapter 7: Using the RCbenchmark Software

In this chapter, we will present information about getting started using the RCbenchmark thrust-stand software (GUI).

Visit this link to download the latest version of the software:  
<https://www.tytorobotics.com/software>

We currently support the following operating systems:

- Windows
- Linux
- Mac

Once downloaded, open the installer, and follow the on-screen instructions. After installation, open the program, and you will see the Welcome tab (Fig. 7.1).

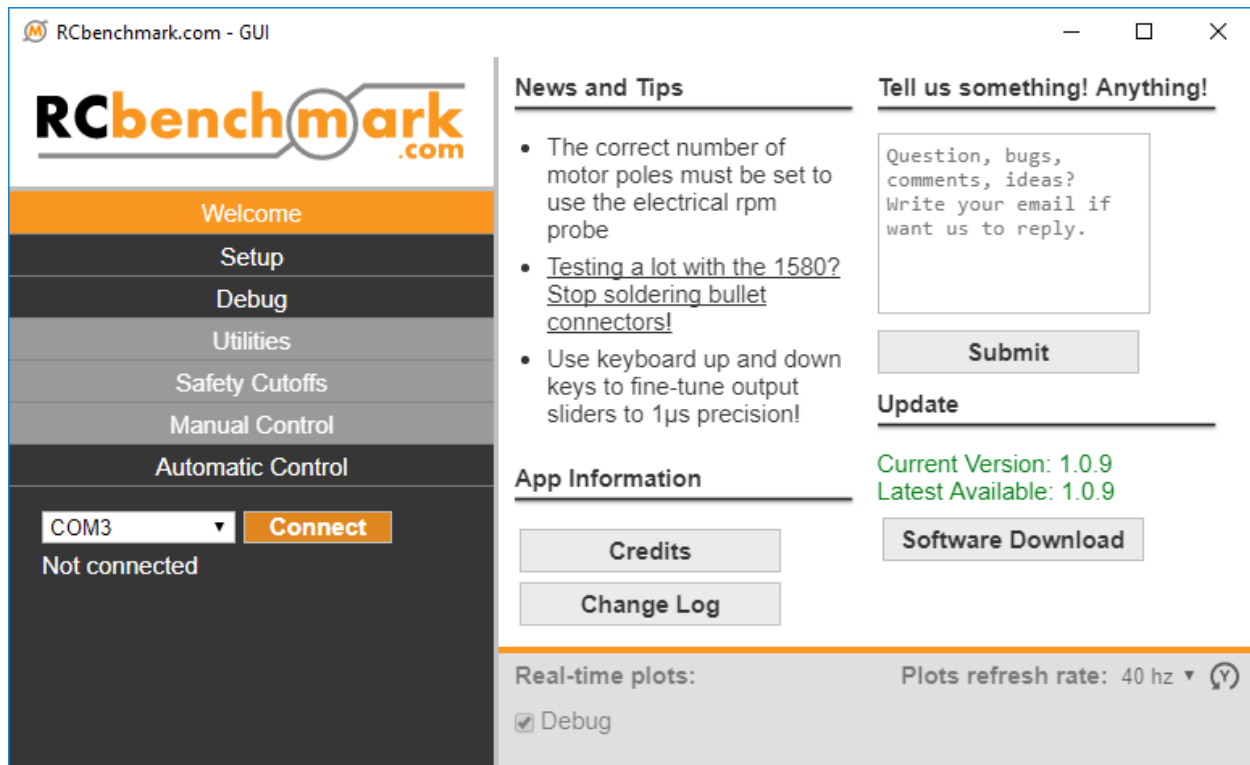


Fig. 7.1: Welcome tab of the RCbenchmark software

## 7.1 Connecting to the tool



Fig. 7.2: Connecting the tool

Fig. 7.2 shows the connection section of the software. Normally, you do not need to install any drivers for the tool to be detected. In Windows, you might have to wait a few minutes for the operating system to automatically download the driver in the background (an internet connection is required).

To confirm that the software detects the tool, connect the USB cable and the power adapter to the main board. When you do this, the COM port will automatically change to the newly connected tool. If you disconnect the USB cable, the COM port will switch back to the previously used port.

If the COM port does not automatically switch when connecting the tool, contact us or try troubleshooting driver issues:

<https://www.tytorobotics.com/blogs/software-troubleshooting/driver-issues>.

The product already comes preloaded with the correct firmware, but future GUI updates might require you to flash a new firmware. If a firmware update is necessary, the software will notify you. The process is simple; just follow the on-screen instructions.

We highly recommend that you watch our two introductory videos on using the software. They are only five minutes each and will teach you all you need to know to automate tests:

<https://www.youtube.com/watch?v=eA0wLIQhi70>.

The software was designed to be easy to use. If you need help understanding its features, email us at [support@tytorobotics.com](mailto:support@tytorobotics.com), and we will be more than happy to help you.

## Chapter 8: Upgrade, Warranty, and Technical Support

In this chapter, we present all necessary information regarding the after-sales services for the Series 1780 Test Stand. Use this information to contact our technical support team, purchase extra components, request a part repair or recalibration, or for any other inquiries.

### 8.1 Technical support

Tyto Robotics offers technical support for the Series 1780 Test Stand over the telephone and by email. If you prefer using emails, send your inquiry to: [support@tytorobotics.com](mailto:support@tytorobotics.com).

We will strive to find a solution within 24 business hours. If you prefer calling us by telephone, you can use these numbers:

+1-844-722-8378 (toll-free from North America)  
+1-819-665-2489

Our office is open Monday to Friday, from 9 a.m. to 5 p.m. EST/EDT, except Canadian and Quebec statutory holidays. We offer service in English, French, Cantonese, and Chinese Mandarin, depending on staff availability.

### 8.2 Upgrade your products

The Series 1780 Test Stand follows a modular design, so you will be able to add more features or upgrade your product. You may also upgrade from the single-motor to the coaxial version with the purchase of the extra components.

If you are planning to test in-runner motors, contact our technical support to order a special mount to adapt these motors.

### 8.3 Product's warranty

We hope you enjoy many sessions of successful tests with our tool. Nevertheless, some problems could arise that require repairs.

The Series 1780 provides a one-year warranty for repair and replacement. After this period, we will charge a fee for the repair, or you can purchase a new component from our online store or offline via quote.

However, Tyto Robotics does not bear responsibility for the damages caused by these situations:

- Overloading the load measurement unit
- Broken propeller hits the structure
- Overloading the sensors
- Applying power (voltage and current) out of the tool specification
- Opening the circuit casing
- Opening the load measurement unit
- Water damage
- Excessive exposure to dust
- Applying any unlock code in the software
- Using an unofficial firmware
- Testing outside of the supported range
- Deliberately damaging the product

If the test stand is damaged, you should stop using the Series 1780 and contact Tyto Robotics technical support for information about the repair and replacement.



## Annex 1. Support rod angle in coaxial setup

Suggested 650 mm rod placement angle (back-to-back setup): This angle is the one between the rod and the ground base support.

Diameter of the propeller (in.)	Minimum axial distance between two props (mm)	Suggested rod angle in back-to-back $\alpha$ (degree)
<48	280	>55
48–55	300	58
55–64	320	63
64–70	320	68

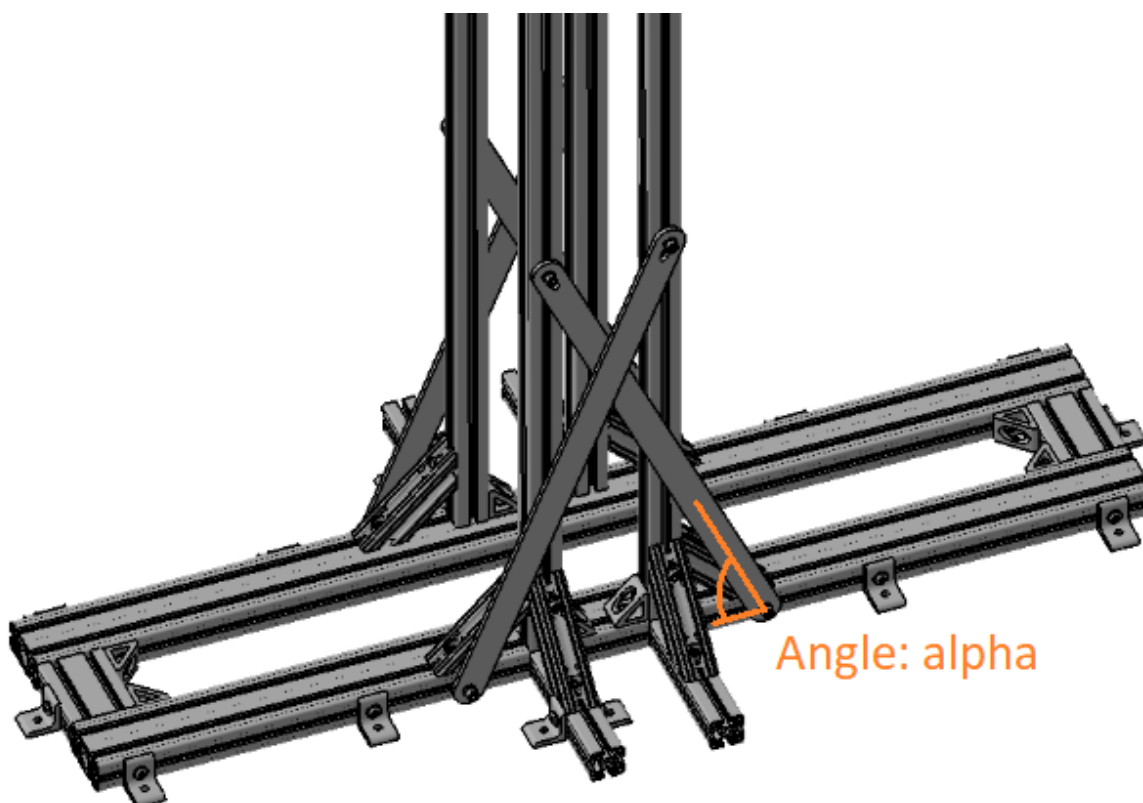


Fig. A1: Angle  $\alpha$  (alpha) between the rod and the ground structure in the back-to-back setup

## Annex 2. Suggested torque specifications

Tighten and verify all fasteners on the stand, the load measurement unit, the motor mounting with the torque specifications as follow:

Nominal size	Type of head	Profile	Torque (Nm)
M4	Socket	Cap screw	4–6
M5	Socket	Cap screw	10–12
M6	Socket	Cap screw	16 20
5/16"-18	Socket	Cap screw	22–30
5/16"-18	Button flange	Cap screw	15–20