# Series 1780 test stand V2

## Typical uses

- Outrunner brushless motor characterization
  - 25kgf / 0-100A
  - 40kgf / 0-150A
  - 75kgf / 0-500A
- Propeller characterization up to 70”
- Battery characterization
- ESC characteristization
- Propeller icing test
- Servo testing and control
- Endurance testing
- Quality testing
- Drone structure optimization
- Flight simulation and replication
- Motor heat testing
- Drone propulsion system maintenance

Figure 1: Series 1780 Test Stand 75 kgf Single-Motor

## Features list

- Direct measurements
  - Torque
  - Thrust
  - Voltage
  - Current
  - Optical RPM
  - Temperature
  - Airspeed
- Derived measurements
  - Motor efficiency
  - Propeller efficiency
  - System global efficiency
- Hardware:
  - Load measurement unit (LMU) factory calibrated
  - Supports multiple setups: single motor, coaxial back-to-back, face-to-face and offset
  - DAQ system with galvanic isolation and shielded electronics
  - Ground railing system and support structure
- Software:
  - ESC manual control
  - Real time data-acquisition
  - Automatic test and control
  - Powerful scripting engine
  - External cutoff switch and buzzer
  - Load cell overload alarm and cutoff


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## Technical specifications

**Table 1:** Design specifications for the series **1780 single-motor (25kgf - 100A)**

| Specification | Min. | Max. | Tolerance | Unit |
|---|---|---|---|---|
| Thrust | -25 | 25 | ±0.5% | kgf |
| Torque | -12 | 12 | ±0.5% | Nm |
| Voltage | 0 | 60 | ±0.5% | V |
| Current | 0 | 100 | ±1% | A |
| Angular speed* | 0 | 190k | - | RPM |

*Optical RPM.

**Table 2:** Design specifications for the series **1780 single-motor (40kgf - 150A)**

| Specification | Min. | Max. | Tolerance | Unit |
|---|---|---|---|---|
| Thrust | -40 | 40 | ±0.5% | kgf |
| Torque | -18 | 18 | ±0.5% | Nm |
| Voltage | 0 | 60 | ±0.5% | V |
| Current | 0 | 150 | ±1% | A |
| Angular speed* | 0 | 190k | - | RPM |

*Optical RPM.

**Table 3:** Design specifications for the series **1780 single-motor (75kgf - 500A)**

| Specification | Min. | Max. | Tolerance | Unit |
|---|---|---|---|---|
| Thrust | -75 | 75 | ±1% | kgf |
| Torque | -48 | 48 | ±1% | Nm |
| Voltage | 0 | 100 | ±0.5% | V |
| Current | 0 | 500 | ±1% | A |
| Angular speed* | 0 | 100k | - | RPM |

*Optical RPM.


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**Table 4:** Design specifications for the **series 1780 coaxial (25kgf - 100A)**

| Specification | Min. | Max. | Tolerance*** | Unit |
|---|---|---|---|---|
| Thrust side A* | -25 | 25 | ±0.5% | kgf |
| Thrust side B | -25 | 25 | ±0.5% | kgf |
| Torque side A | -12 | 12 | ±0.5% | Nm |
| Torque side B | -12 | 12 | ±0.5% | Nm |
| Voltage side A | 0 | 60 | ±0.5% | V |
| Voltage side B | 0 | 60 | ±0.5% | V |
| Current side A | 0 | 100 | ±1% | A |
| Current side B | 0 | 100 | ±1% | A |
| Angular speed** | 0 | 190k | - | RPM |

* Each side represents one motor and one propeller. The system can acquire data for both A and B sides in order to calculate a global performance.
** Optical RPM included.
*** This is the non-linearity of the rated output, meaning thrust accuracy over the entire range is ±0.005 * 25kg = ±125g.

**Table 5:** Design specifications for the **series 1780 coaxial (40kgf - 150A)**

| Specification | Min. | Max. | Tolerance*** | Unit |
|---|---|---|---|---|
| Thrust side A* | -40 | 40 | ±0.5% | kgf |
| Thrust side B | -40 | 40 | ±0.5% | kgf |
| Torque side A | -18 | 18 | ±0.5% | Nm |
| Torque side B | -18 | 18 | ±0.5% | Nm |
| Voltage side A | 0 | 60 | ±0.5% | V |
| Voltage side B | 0 | 60 | ±0.5% | V |
| Current side A | 0 | 150 | ±1% | A |
| Current side B | 0 | 150 | ±1% | A |
| Angular speed** | 0 | 190k | - | RPM |

* Each side represents one motor and one propeller. The system can acquire data for both A and B sides in order to calculate a global performance.
** Optical RPM included.
*** This is the non-linearity of the rated output, meaning thrust accuracy is ±0.005 * 40kg =±200g.


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**Table 6:** Design specifications for the **series 1780 coaxial (75kgf - 500A)**

| Specification | Min. | Max. | Tolerance*** | Unit |
|---|---|---|---|---|
| Thrust side A* | -75 | 75 | ±1% | kgf |
| Thrust side B | -75 | 75 | ±1% | kgf |
| Torque side A | -48 | 48 | ±1% | Nm |
| Torque side B | -48 | 48 | ±1% | Nm |
| Voltage side A | 0 | 100 | ±0.5% | V |
| Voltage side B | 0 | 100 | ±0.5% | V |
| Current side A | 0 | 500 | ±1% | A |
| Current side B | 0 | 500 | ±1% | A |
| Angular speed** | 0 | 100k | - | RPM |

* Each side represents one motor and one propeller. The system can acquire data for both A and B sides in order to calculate a global performance.
** Optical RPM included.
*** This is the non-linearity of the rated output, meaning thrust accuracy is ±0.01 * 75kg = ±750g.


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For applications where humans may be endangered by the motors and propellers tested, flight testing must be performed to validate the test assumptions.

The tolerance in the table only represents non-linearity. There is also hysteresis and creep in the measurement error. For more details and explanations, please refer to appendix A at the end of this datasheet.

The sampling rate depends on your computer (50Hz+).

The load, power and optical RPM measurement units from side A and side B share the same design parameters. Thus, for the Series 1780 Coaxial, users can expect a maximum overall thrust and torque of twice the rated output of each measurement unit. For example, when you purchase the Series 1780 Dynamometer 25kgf - 100A: Coaxial, you can expect to measure up to 50kgf for your dual-motor setup and up to 200A for the global power output.

**Software features**

- Real-time graphs
- Manual motor control
- Manual servo control
- Safety cutoffs based on any measured data
- Data recording to CSV file
- Database upload and auto-plot
- Automated tests
  - Ramps
  - Steps
  - Measure the number of poles
  - Endurance testing
  - Constant thrust testing
  - Flight replication
  - And more with our scripting engine...
- User scripts with documentation

# Hardware

The RCbenchmark Series 1780 is designed to greatly reduce the time required for characterizing and testing high power brushless motors and large propellers while obtaining precise and accurate results. Figure 2 and Figure 3 show an overview of the important components of the tool for different configurations and ratings.

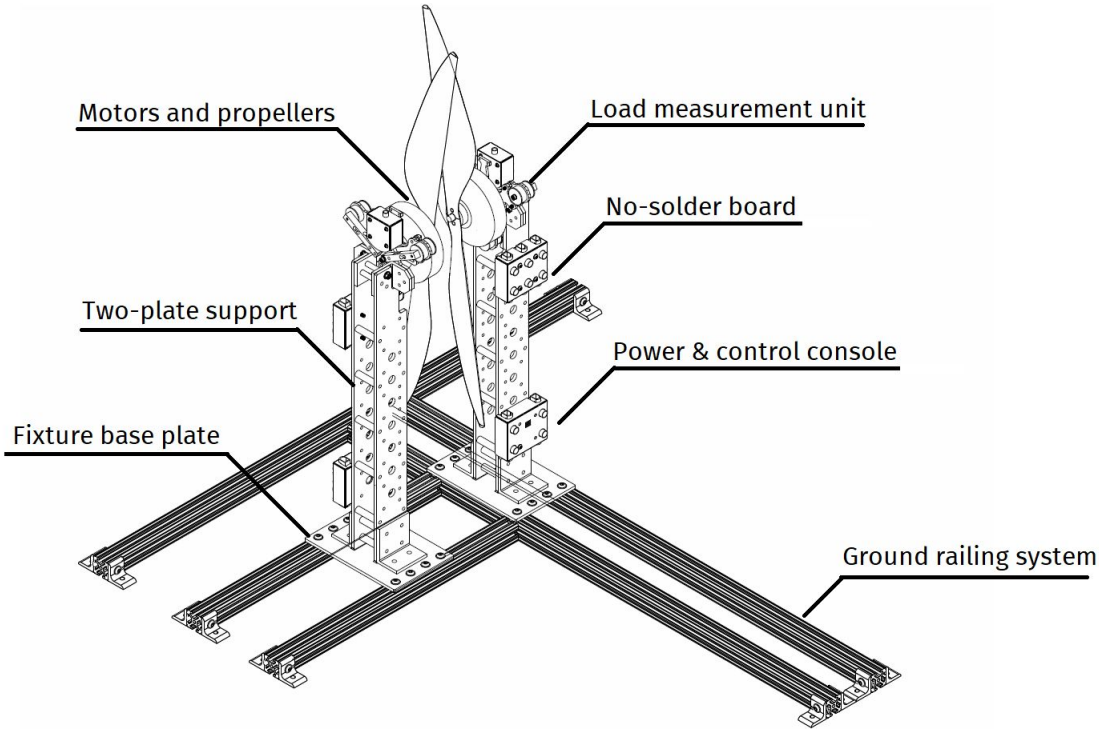


Figure 2: Series 1780 Test Stand 25/40 kgf Coaxial (propeller face-to-face mode)

For a given voltage, brushless motor speed is a function of two variables: the mechanical load (in Nm), and the input (which can be measured in duty cycles or percentage of the maximum command sent to the ESC). The motors are characterized by changing the input from the software and by changing the load with multiple propellers. The load changes as the propellers vary in size and pitch.

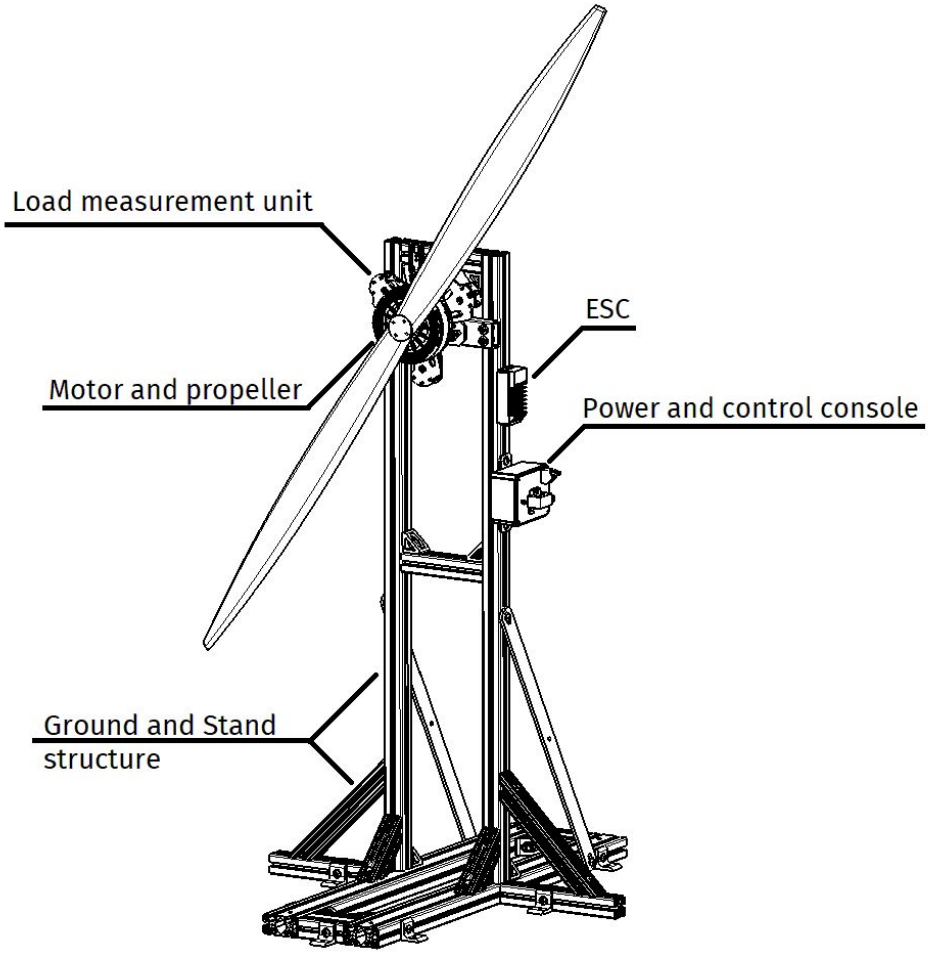


Figure 3: Series 1780 Test Stand 75 kgf Single-Motor

**Mountings and assemblies**

The load measurement unit is pre-assembled and calibrated before its shipment. Users will need to fix in place the unit support structure and finish assembling it with the motor mount, the optical RPM probe, and other electrical components. Detailed instructions are provided in the user manual.

It is highly recommended to use the supports provided to hold the load measurement units. Six holes for M5 bolts on the load measurement unit are reserved for support. All necessary fasteners and hand-tools for mounting and assembling were included in all variants of the Series 1780.

## Configurations

The Series 1780 is designed to be modular. Those modules can be replaced or reconfigured to adapt to different testing needs. Currently, you can order the Series 1780 test stand in two different configurations: single-motor or coaxial. Both configurations are available in three different thrust and torque ratings: 25kgf / 12Nm, 40kgf / 18Nm, 75kgf / 48Nm

Figure 4: Series 1780 Single-Motor Testing Mode

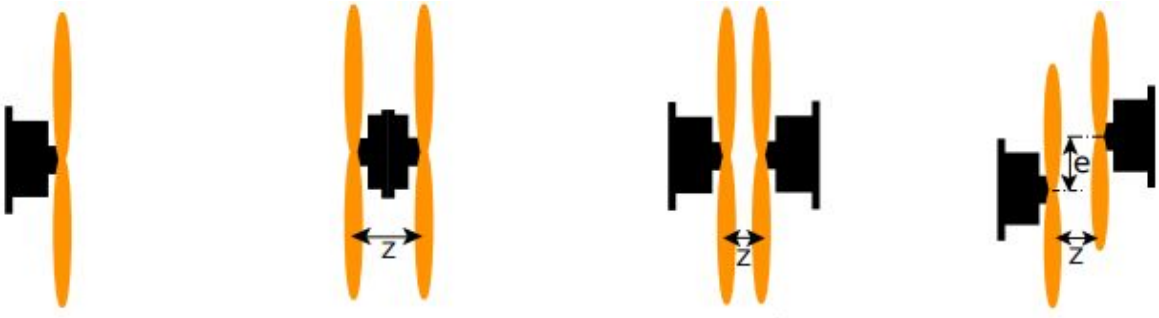


Figure 5: Series 1780 Coaxial Testing Modes

Both configurations share mostly the same hardware, except that the coaxial contains two times more hardware than the single-motor configuration. The coaxial configuration can be used to test different setups: single motor, two motors back-to-back, two motors face-to-face, and two motors offset. When testing two motors, coaxial configurations will allow motor control and data processing for two motors simultaneously. When testing in a coaxial back-to-back configuration, the minimum distance between the backs of the motors is: 100.34mm for the 25kgf or 40kgf rated stands and 298.106mm for the 75kgf rated stand.

All RCbenchmark Series 1780 test stands are calibrated before the product's shipment. Upon receiving the product, you may mount the unit onto the test bench and start testing right away.

**Compatible motors**

The motor mounts for the Series 1780 are compatible with most brushless motors for UAVs on the market. They contain three major features:

1. Attachment points to install the motor mount to the load measurement unit with the standoffs and M5 nuts.

2. Two tapped holes to install the optical probe to the motor mount with the supplied spacers and M4 screws.

3. For the 25kgf and 40kgf versions, the motor can be mounted directly on the motor mount with M3, M4, M5, M6 screws. The screws go through slots. There are slots at 0, 90, 120, 180, 240 and 270 degrees in order to adapt to multiple motor geometries. For inrunner motor testing, there is also a center hole of $\phi$15 that allows a rotating shaft through the plate.

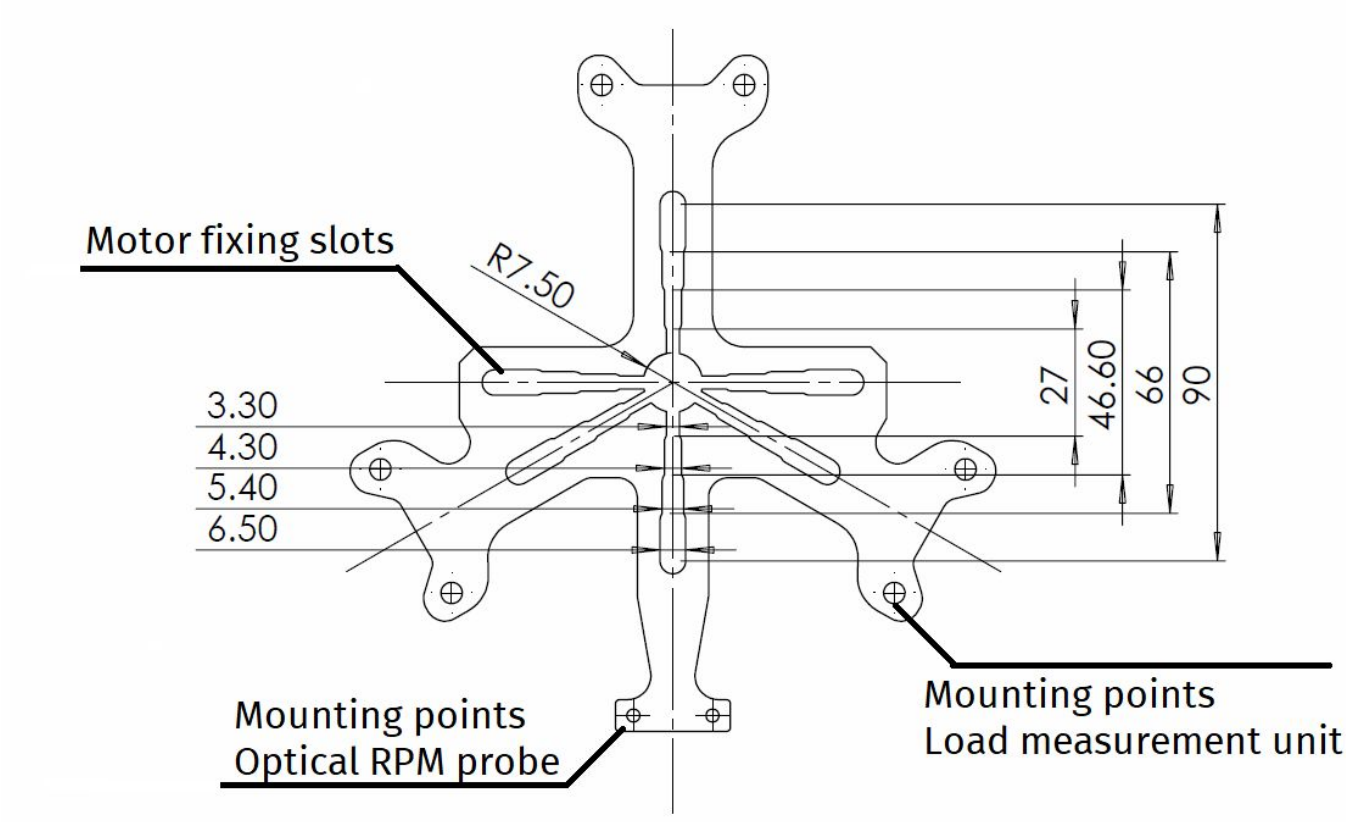


Figure 6: Series 1780 25 kgf / 40 kgf Motor Mount



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For the 75kgf version, the motor can also be mounted directly on the heavy-load motor mount with M5, M6, M8 and M10 screws. This motor mount is specially designed for the 75kgf version, as it can support the higher thrust and torque generated by the motors. The screws go through slots. There are slots at 0, 90, 120, 180, 240 and 270 degrees in order to adapt to multiple motor geometries. For inrunner motor testing, there is also a center hole of $\phi$30 that allows a rotating shaft through the plate.

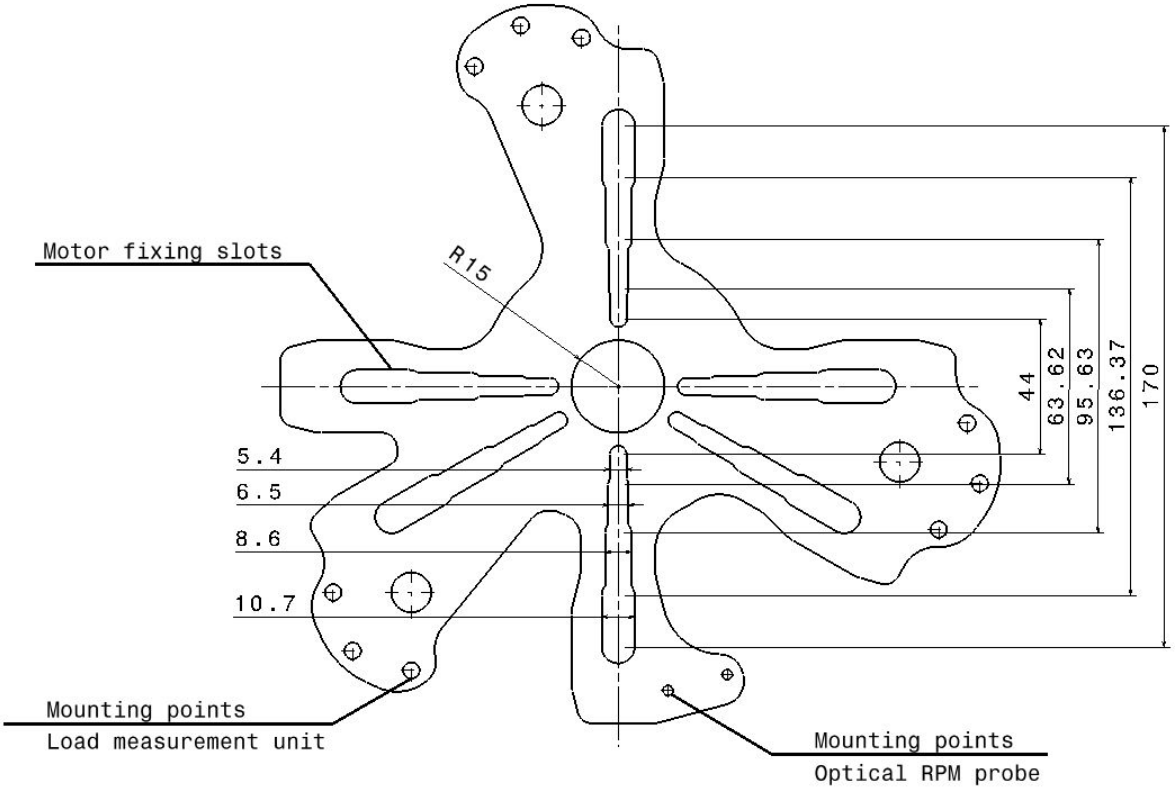



Figure 7: Series 1780 75 kgf Motor Mount

If necessary, customers who purchased the Series 1780 Test Stand 75kgf - 500A can still use the thinner and smaller motor mount from the 25kgf and 40kgf.

If you are planning to test motors outside of the specifications of this motor mount, we offer a service whereby we will build you a specialized motor mount for a reasonable fee. Please contact us with the dimensions and motor specifications. You can also manufacture your own mounting plate.

# Safety

Read the product manual for complete safety information.

Fast spinning propellers and motors can cause harm or even death of the user. Safety goggles must always be worn when testing. The software has automatic cutoffs based on the specifications of the device. These cutoffs can be limited even further by the user for enhanced safety, to prevent a propeller from spinning too fast or a motor from using too much current, for example.

The Series 1780 should be placed in a room separated from the operator. During the tests, no operator must be allowed to enter this room. Additionally, it is important to reinforce the walls, or have a safety cage alongside the propellers' spinning surface. These reinforced structures will protect the operator in case any moving components are damaged during operation.

It is highly recommended to use the proper fasteners provided in the package. Please follow the instructions to install and to tighten those fasteners according to the user manual.

Always check that the fasteners are fully tightened before running any tests. Also check the room to remove metal chips or small loose parts on the floor before the test. Operations related to the electrical system must be accomplished by qualified personnel only. Cut the power before connecting or disconnecting the components.

Please read the product's safety instructions to obtain complete information.

# Software

The software allows the user to control one or two motors simultaneously. It displays the sensor information in text and graphical form. The user can record all of the measured data with a single click or record continuously. The output is a csv file, which can be easily opened with a spreadsheet software or many other software packages.

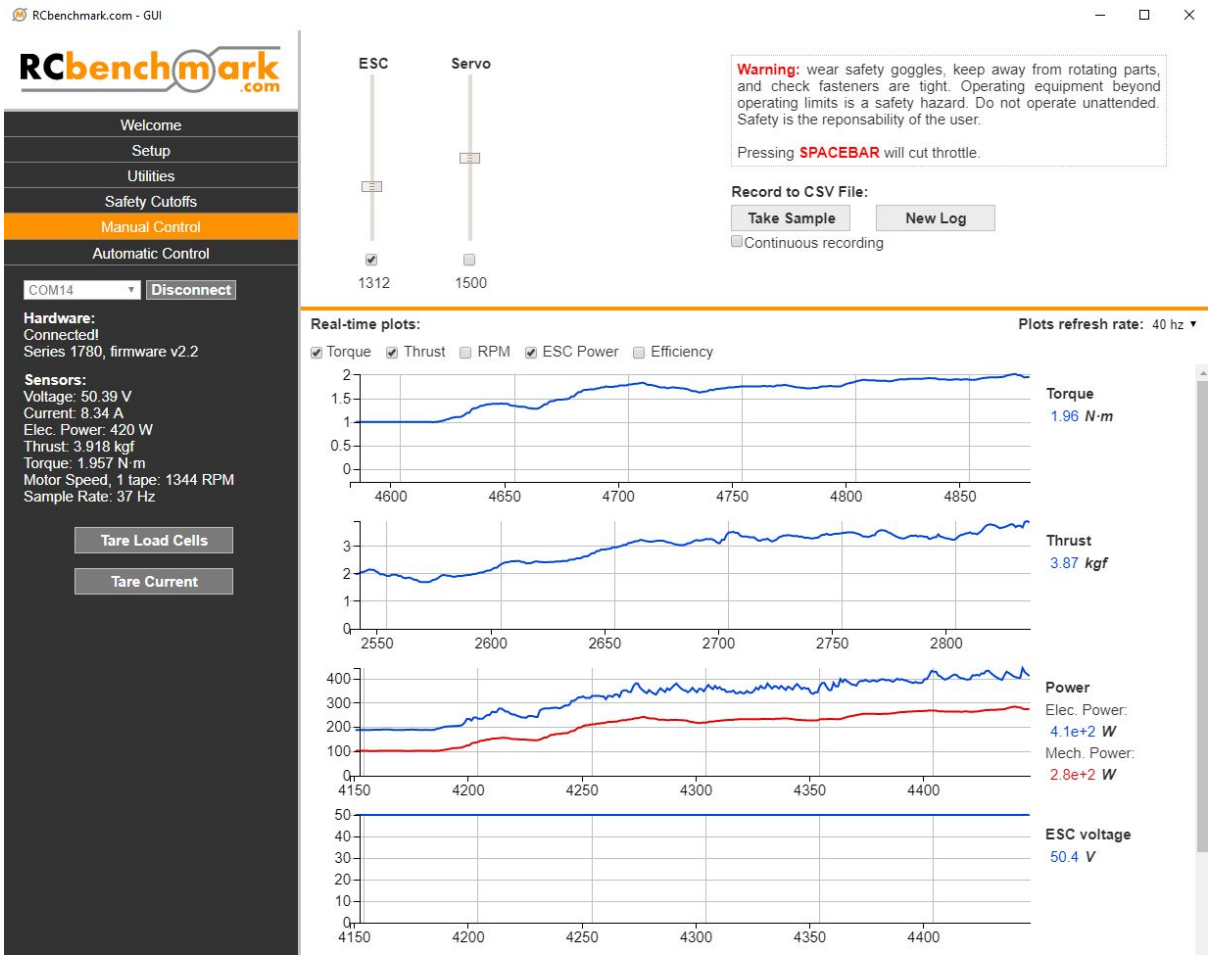



Figure 8: RCbenchmark Software

### Deployment and custom use

The software is open source. It is an app that runs on Windows, Linux and Mac. The firmware is written in C and the GUI is written in Javascript, which should be very simple to learn for users with C/C++ experience.

# Appendix A

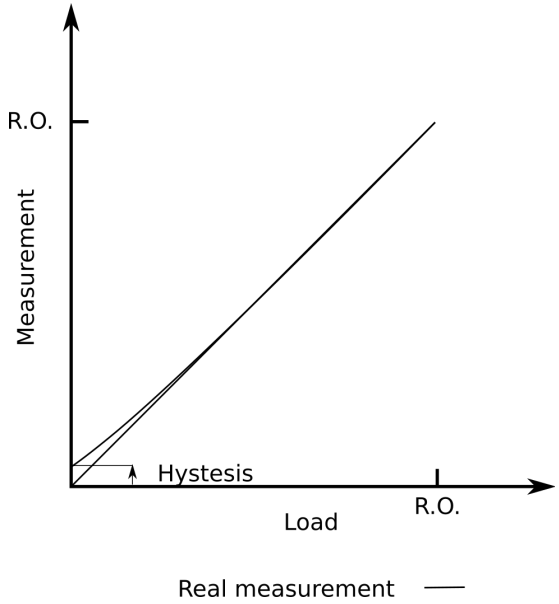
## 1. Data table

| Product name | Rated output (R.O.) | Non-linearity | Hysteresis | Creep (5 minutes) | Resolution |
|---|---|---|---|---|---|
| Series 1780 - 25Kgf | 25kgf | ±0.5% R.O. | ±0.12% R.O. | ±0.15% R.O. | <1g |
| | 12Nm | ±0.5% R.O. | ±0.16% R.O. | ±0.12% R.O. | <1mN |
| Series 1780 - 40Kgf | 40kgf | ±0.5% R.O. | ±0.12% R.O. | ±0.12% R.O. | <1g |
| | 18Nm | ±0.5% R.O. | ±0.16% R.O. | ±0.13% R.O. | <1mN |
| Series 1780 - 75Kgf | 75kgf | ±1% R.O. | ±0.12% R.O. | ±0.18% R.O. | <1g |
| | 48Nm | ±1% R.O. | ±0.16% R.O. | ±0.16% R.O. | <1mN |

After calibration, our load measurement units are checked under static load to measure a 3kgf, 5kgf or 10kgf load within 0.5% of the **measured** value. The values shown in Table 7 are maximum, and you will likely experience better results when testing.

## 2. Hysteresis

The hysteresis is the maximum measurement error after applying and removing a load equal to the rated output of the load measurement unit.

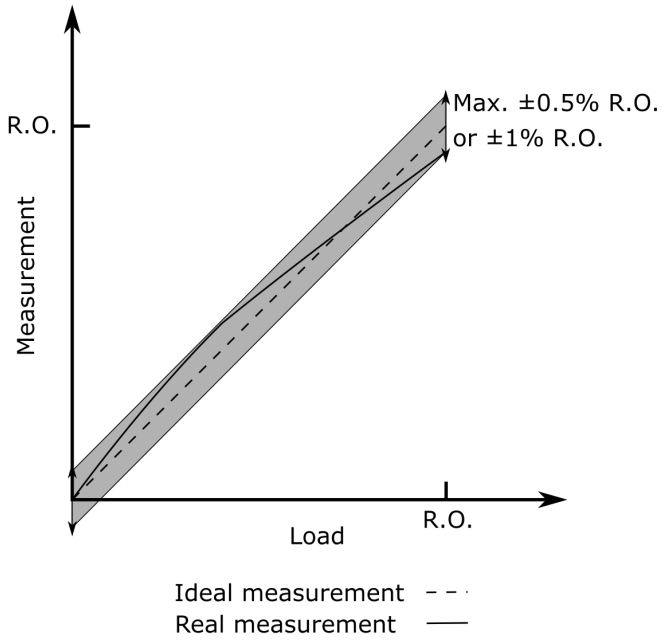



It is possible to minimize hysteresis with the following procedure:

1) Apply the full load to be measured then return to zero load
2) Tare the unit
3) Apply the full load to be measured and record the measurement

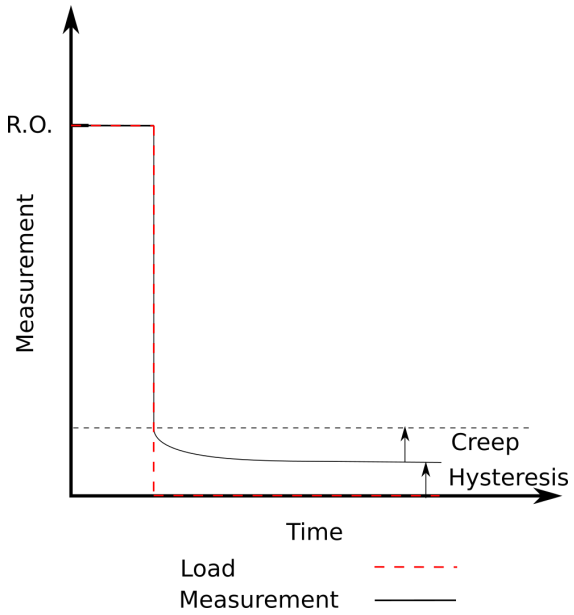
## 3. Non-linearity error

The nonlinearity error is the maximum deviation from the ideal measurement line. This error is for the worst-case scenario with high perpendicular load and torque. You will likely obtain a much lower measurement error.



## 4. Creep

Creep is the change in the measured value over time caused by a constant strain.



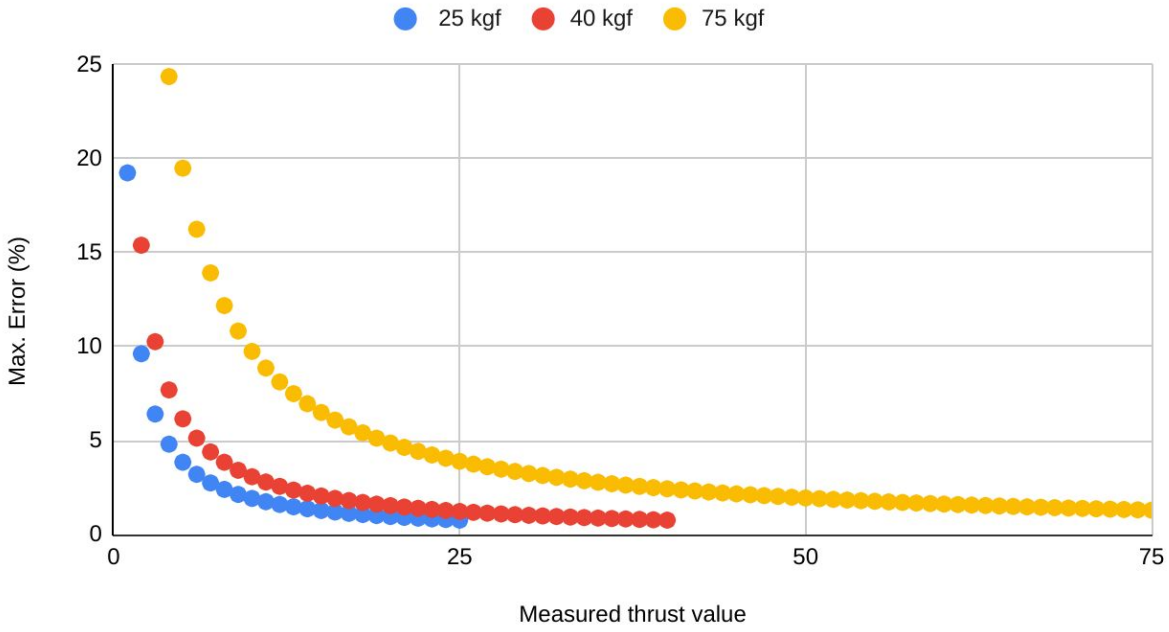

## 5. Note on measurement error

We do not recommend testing propellers with a maximum thrust under 25% of the full-scale rating. Aerodynamic effects, vibrations, and cables can affect the measurements of more than 0.5% of the full-scale rating. For useful, comparable and repeatable results, we recommend that you note and control all the test variables (room geometry, temperature, cable management...) and use a checklist for tests.

During the production and calibration process, we always find the measured erro to be far lower than the maximum anticipated error values. All our load cells are tested after calibration and we ensure that the observed load is within 0.5% of the true value when it is placed on the LMU from the top. For an M1 class 3kg standard weight for example, the measured load would need to be between 2.985kg to 3.015kg to pass the test. A similar requirement also applies to the torque calibration.

For highly accurate, comparable results, you can perform a standard test at the beginning of each test session using a motor, a propeller and a power supply reserved for calibration purposes. This calibration test can be used to check that there is no significant difference from your previous tests, and it can be used to calibrate the measurement to a specific air pressure and temperature.

## 6. Maximum thrust error on the measured value




## 7. Maximum torque error on the measured value