Series 1780 Test Stand Datasheet

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Introduction

The Series 1780 Test Stand is the perfect tool for characterizing the propulsion systems of medium and large drones. The stand supports single motor or coaxial testing in several configurations. It comes in three convenient sizes to suit your testing needs:

- 25 kgf / 12 Nm / 0-100 A
- 40 kgf / 18 Nm / 0-150 A
- 75 kgf / 48 Nm / 0-500 A

Description

The stand was built with the needs of drone designers in mind, taking into consideration the features that would simplify testing. The stand comes with easy to use software controlled manually or with custom pre-written scripts for automated testing. Data can be viewed in real-time then exported to a .csv file once tests are completed. An external cutoff switch and load cell overload alarm offer enhanced safety and peace of mind.

The stand supports multiple configurations such as: single motor, coaxial back-to-back, coaxial face-to-face and coaxial offset. We also offer a ground railing system and support structure to help secure the stand in your work area, and airspeed and temperature probes to cover all aspects of characterization.

Measured Data:

- Thrust
- Torque
- Optical RPM
- Current
- Voltage
- Temperature
- Wind velocity

Computed Data:

- Mechanical power
- Electrical power
- Motor efficiency
- Propeller efficiency
- Overall system efficiency

Applications

- Outrunner brushless motor characterization
- 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

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Technical Specifications

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

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 (40 kgf - 150 A)**

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 (75 kgf - 500 A)**

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.

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

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 * 25 kg = ±125 g.

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

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 * 40 kg =±200 g.

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

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 * 75 kg = ±750 g.

***The tolerance in the tables above only represent 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 (50 Hz+).

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 25 kgf - 100 A: Coaxial, you can expect to measure up to 50 kgf for your dual-motor setup and up to 200 A for the global power output.

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

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.

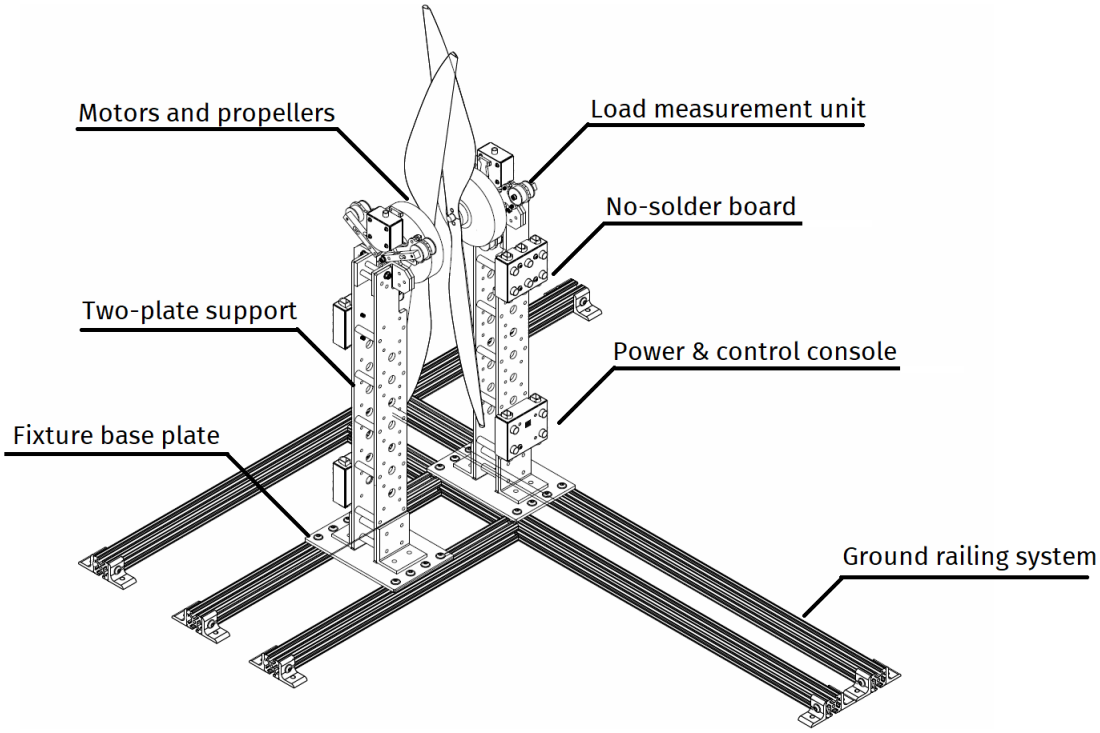


Figure 2: Series 1780 Test Stand 25/40 kgf Coaxial (propeller face-to-face mode)

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.

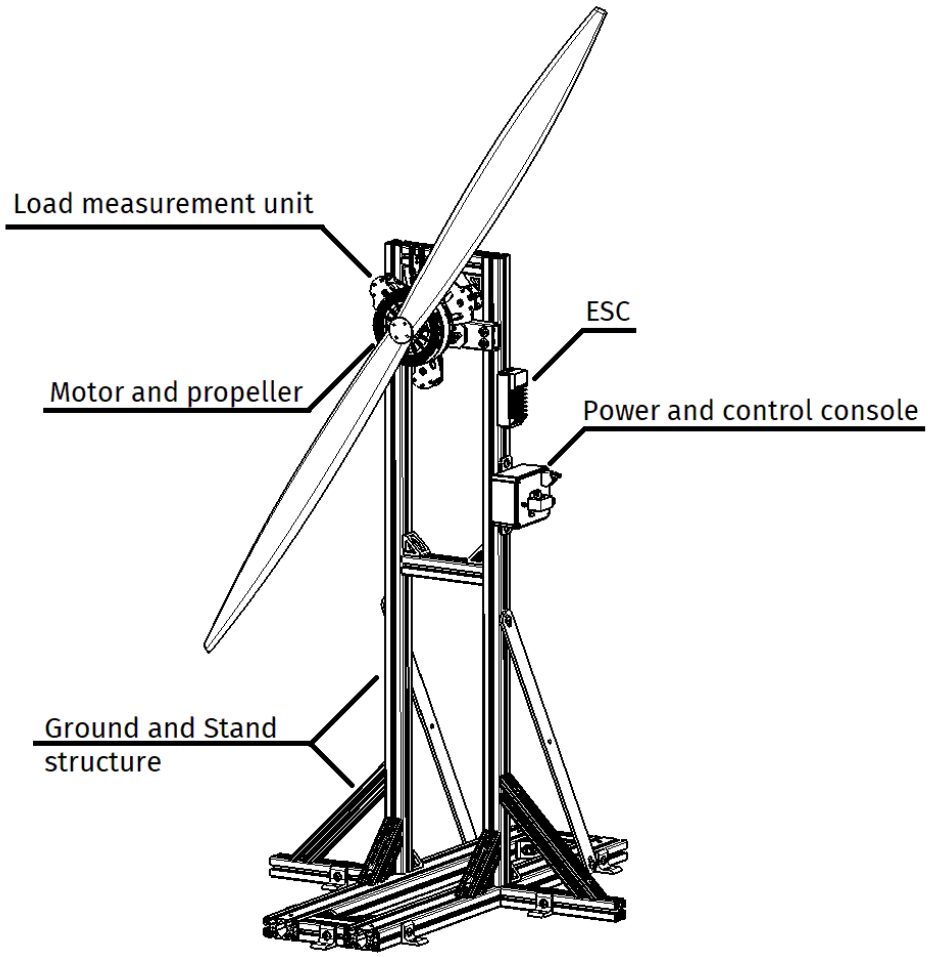


Figure 3: Series 1780 Test Stand 75 kgf Single-Motor

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: 25 kgf / 12 Nm, 40 kgf / 18 Nm, 75 kgf / 48 Nm

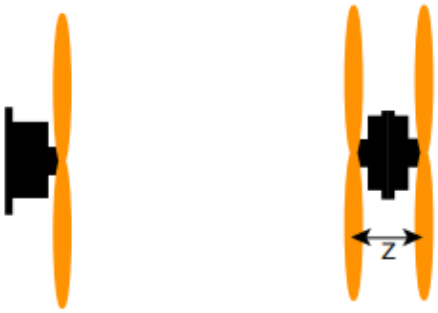


Figure 4: Series 1780 Single-Motor Testing Mode

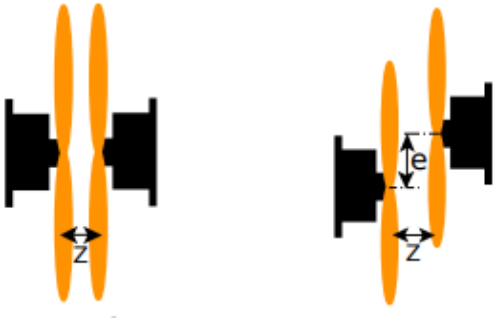


Figure 5: Series 1780 Coaxial Testing Modes

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:
100.34 mm for the 25 kgf or 40 kgf rated stands and 298.106 mm for the 75 kgf 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.

Airspeed and Temperature Probes - for 75kgf version only

The Series 1780 75 kgf single motor test stand comes with one airspeed pressure sensor and three (3) temperature probes. The Series 1780 75 kgf coaxial test stand comes with one airspeed pressure sensor and six (6) temperature probes. The airspeed pressure sensor has a measurement range of ±6.8 kPa and an accuracy of 1% FS when tared but not calibrated. The temperature probes measure temperatures from -10 °C to +120 °C with a ±0.5 °C accuracy from -10 °C to +85 °C. They have an 800 ms update rate.

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 2 5kgf and 40 kgf 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 ϕ15 that allows a rotating shaft through the plate.

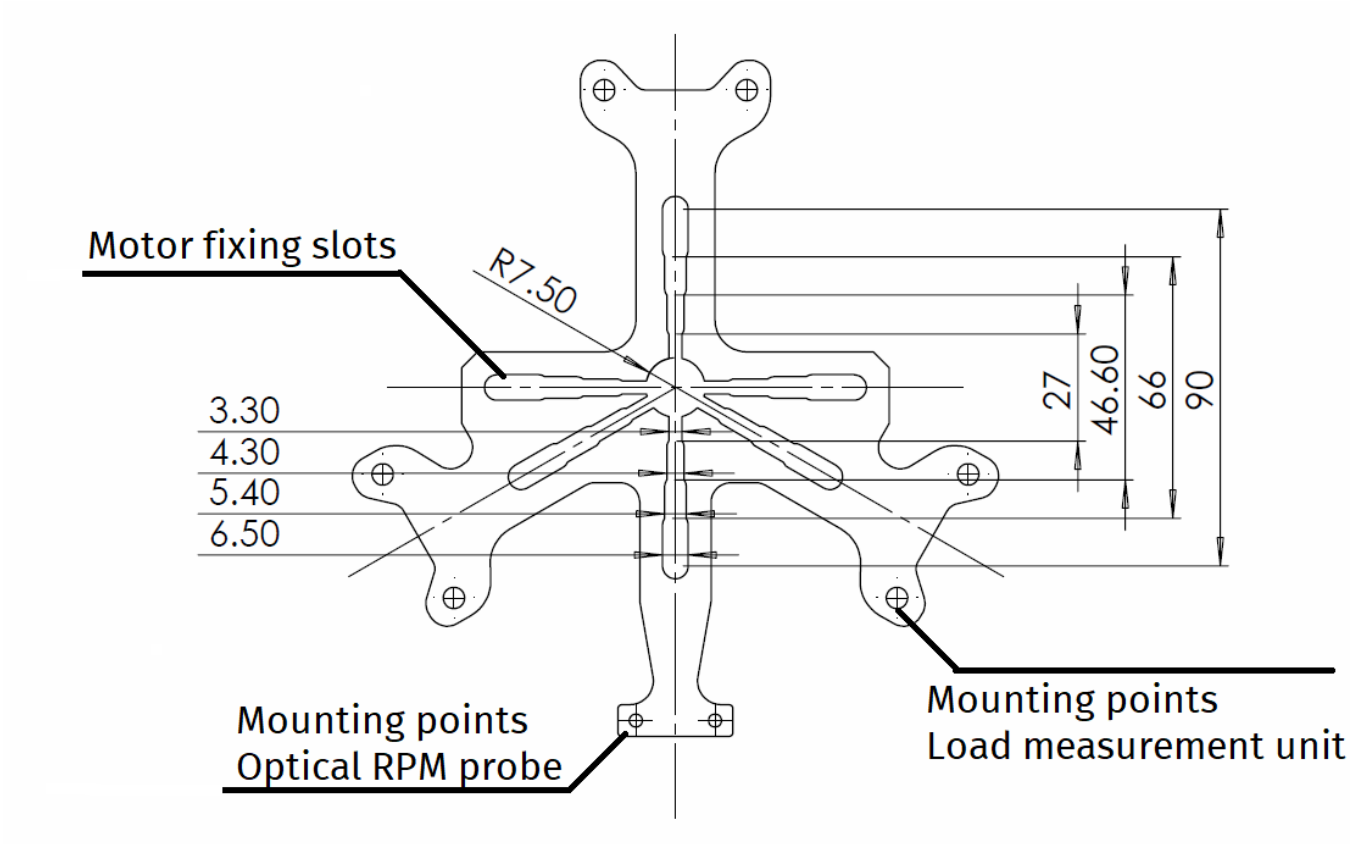


Figure 6: Series 1780 25 kgf / 40 kgf Motor Mount

For the 75 kgf 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 75 kgf 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 ϕ30 that allows a rotating shaft through the plate.

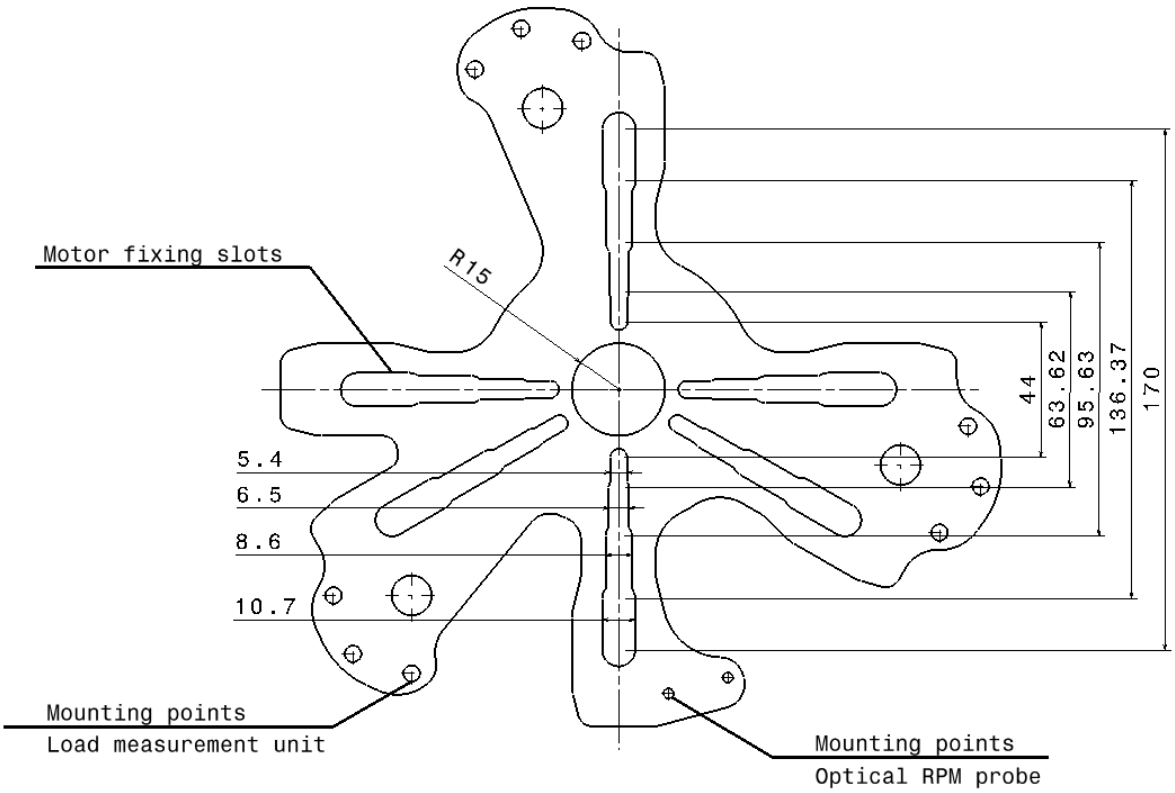


Figure 7: Series 1780 75 kgf Motor Mount

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

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.

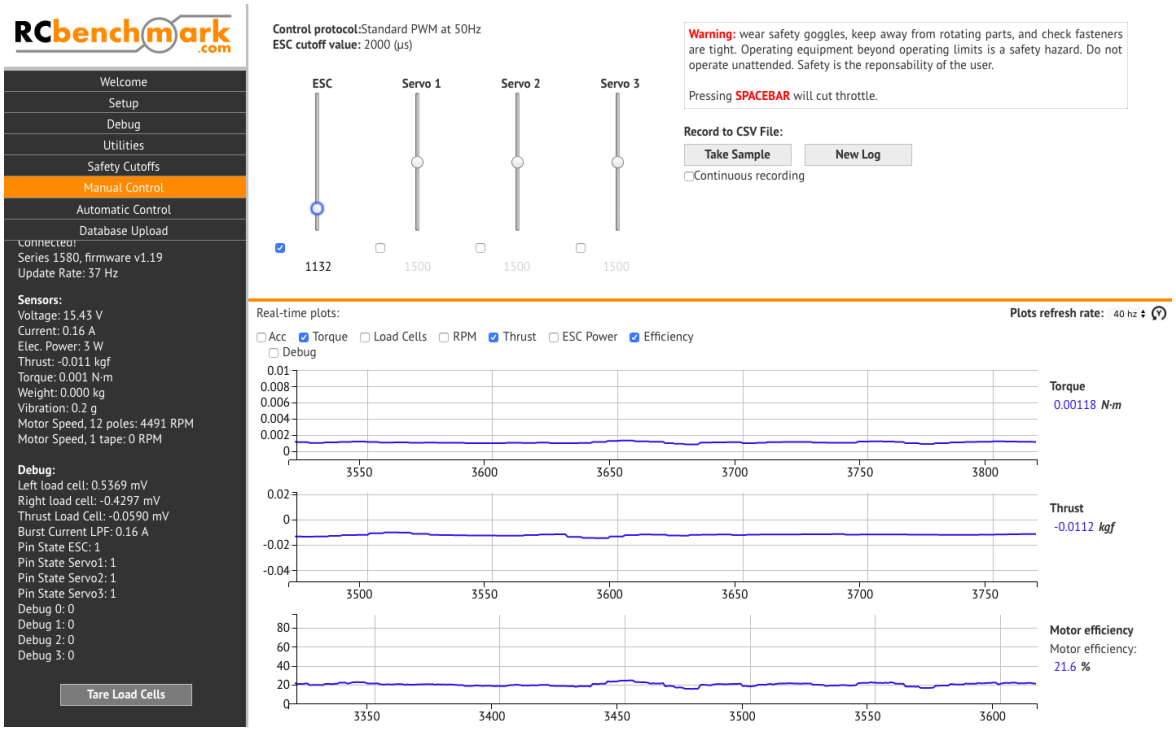
Software

Our open-source propulsion testing software is included with all test stands and allows you to control your propulsion system and record data easily.

The test stand can be controlled manually or automatically with Windows, Linux, Mac and Chrome OS. The interface displays sensor information in textual and graphical form, which can be recorded as single data points or continuous data. We provide pre-written test scripts, which you can then edit or you can write your own custom scripts.

Once the data is recorded, you can easily export it to a .CSV file, readable with most spreadsheet softwares. You can set-up your own working units, safety cut-offs and live plots to meet your needs. Your results will provide you with important information about propeller and motor efficiency as well as consumed power.

- Real time graphs
- Manual motor control
- Manual servo control (three channels)
- Calibration wizard
- Safety cutoffs based on any measured data
- CSV export
- Automated test
  - Ramps
  - Steps
  - Measure Kv
  - Measure number of poles
  - And more...
- User scripts with documentation



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Appendix A

1. Data Table

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

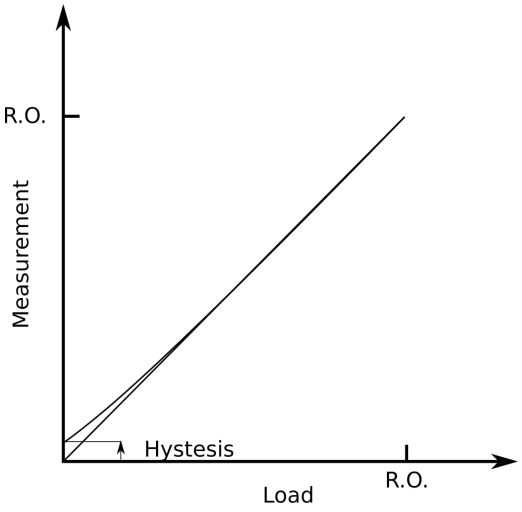
After calibration, our load measurement units are checked under static load to measure a 3 kgf, 5 kgf or 10 kgf load within 0.5% of the **measured** value. The values shown in Table 7 are maximum, and you will likely experience better results when testing.

2. Hysteresis

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

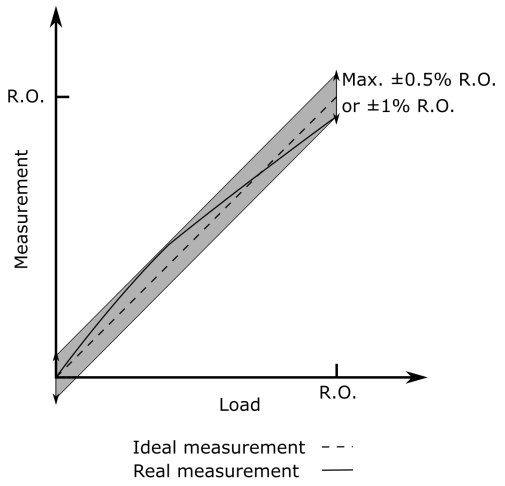
It is possible to minimize hysteresis with the following procedure:

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



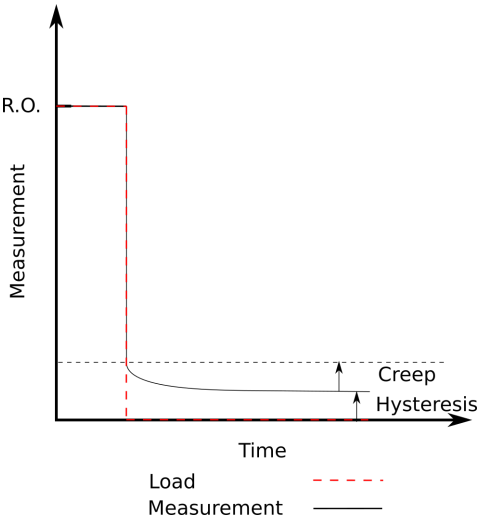
3. Non-linearity Error

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.



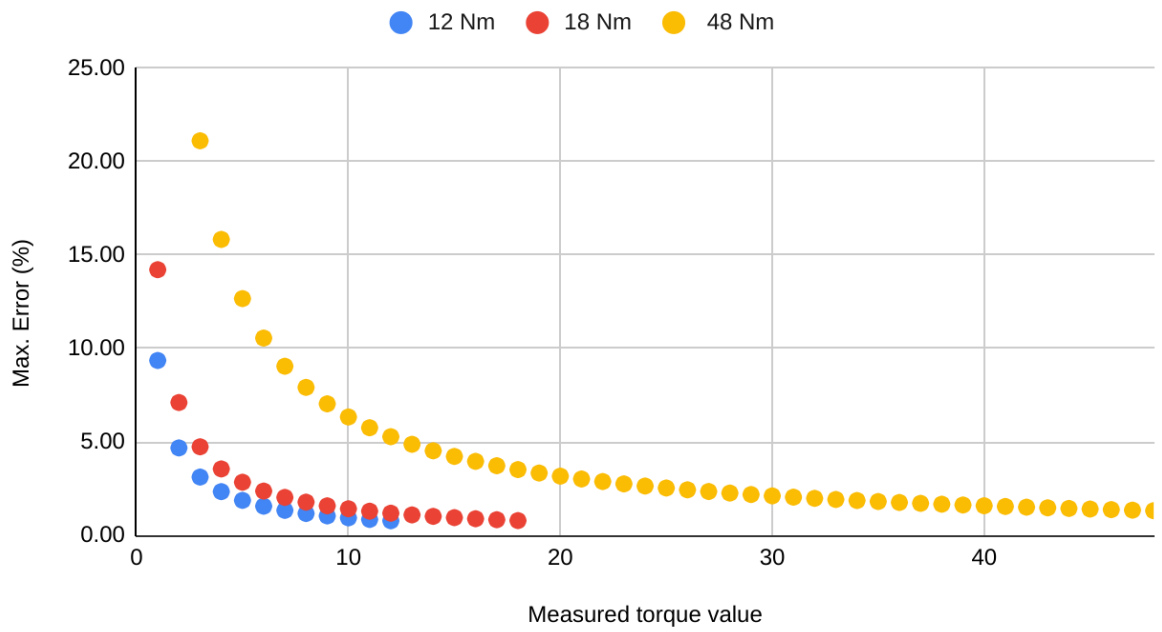
5. Note on Measurement Error

We do not recommend testing propellers with a maximum thrust under 25% of the test stand's rating. Aerodynamic effects, vibration 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, etc.) and use a checklist for tests.

During production, we always find the measured error to be far lower than the maximum anticipated error values. 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 3 kg standard weight for example, the measured load would need to be between 2.985 kg to 3.015 kg to pass the test. A similar requirement 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, propeller and 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