

Series 1780 Dynamometer V2 Datasheet

Typical use

- Outrunner brushless motor characterization
 - 25 kgf / 0-100 A
 - 40 kgf / 0-150 A
 - 75 kgf / 0-500 A
- Propeller characterization up to 70"
- Servo testing and control
- Endurance testing
- Factory testing



Features list

- Direct measurements
 - Torque
 - Thrust
 - Voltage
 - Current
 - Optical RPM
 - Temperature (three ports for each load measurement unit)
 - Airspeed (add-on required)
- Derived measurements
 - Motor efficiency (%)
 - Propeller efficiency (g/W)
 - System global performance
 - (for two-motor setups)
- USB interface
- ESC manual control
- Load cell overload alarm and cutoff
- Automatic tests and recording
- Galvanic isolation
- Output data to CSV files
- Real-time sensor plots
- Powerful scripting engine
- Support for temperature probes
- Support for airspeed probes
- External cutoff switch and buzzer
- Factory calibrated
- Support multiple setups: single motor, coaxial back-to-back, and coaxial face-to-face

Technical specifications

Table 1: Design specifications of the Series 1780 Single-motor (25 kgf - 100 A) version.

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 of the Series 1780 Single-motor (40 kgf - 150 A) version.

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 of the Series 1780 Single-motor (75 kgf - 500 A) version.

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 of the Series 1780 Coaxial (25 kgf - 100 A) versions.

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.

**** This table applies to both Basic coaxial and Ultimate coaxial

Table 5: Design specifications of the Series 1780 Coaxial (40 kgf - 150 A) versions.

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.

**** This table applies to both Basic coaxial and Ultimate coaxial

Table 6: Design specifications of the Series 1780 Coaxial (75 kgf - 500 A) versions.

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.

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 25 kgf - 100 A: Basic 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.

Software features list

- 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
 - And more with our scripting engine...
- User scripts with documentation

Hardware

The RCbenchmark dynamometer 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 1 and Figure 2 show an overview of the important components of the tool.

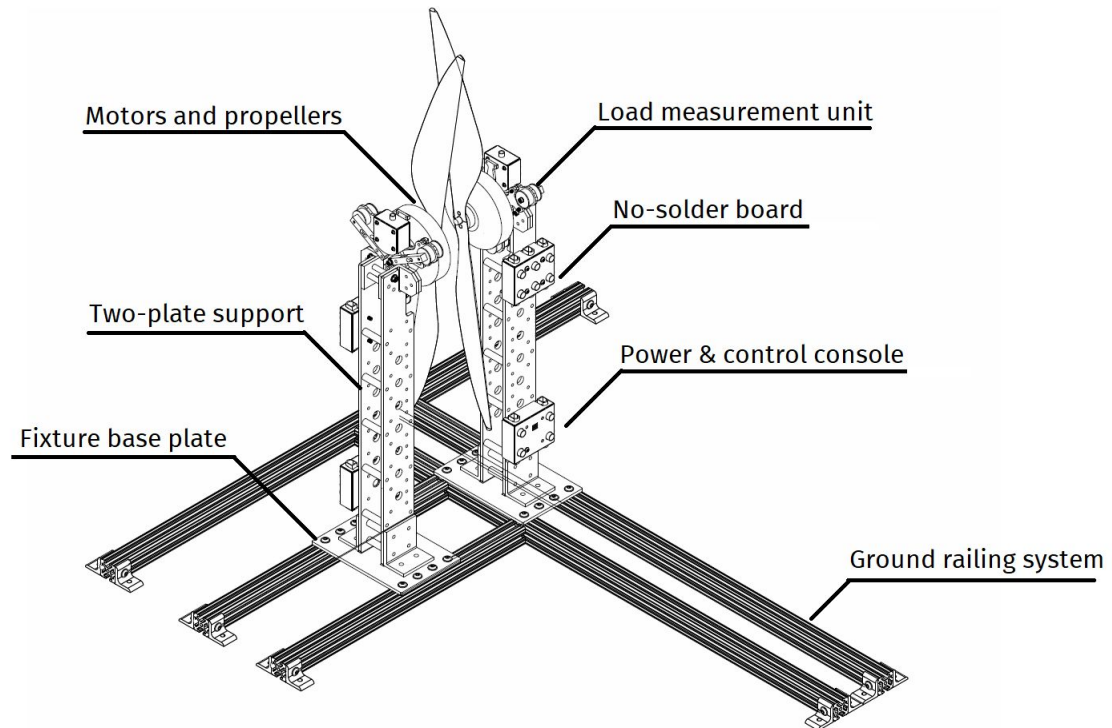


Fig. 1: Hardware overview for 25kgf and 40kgf versions

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 cycle 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 have different size and pitch.

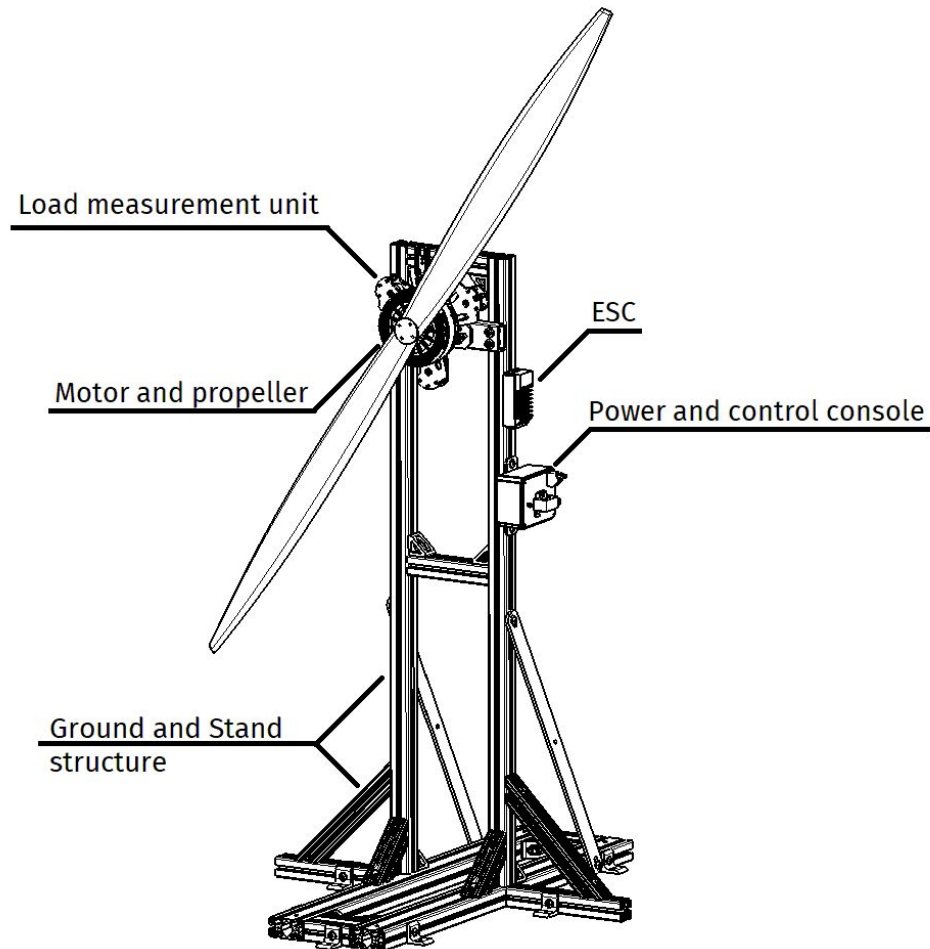


Fig. 2: Hardware overview for 75 kgf version

Mountings and Assemblies

The load measurement unit is pre-assembled and calibrated before its shipment. Users will need to fix 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 given supports 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 dynamometer in three different configurations: Single-motor, Basic coaxial and Ultimate Coaxial for the **25 kgf - 100 A** and **40 kgf - 150 A**.

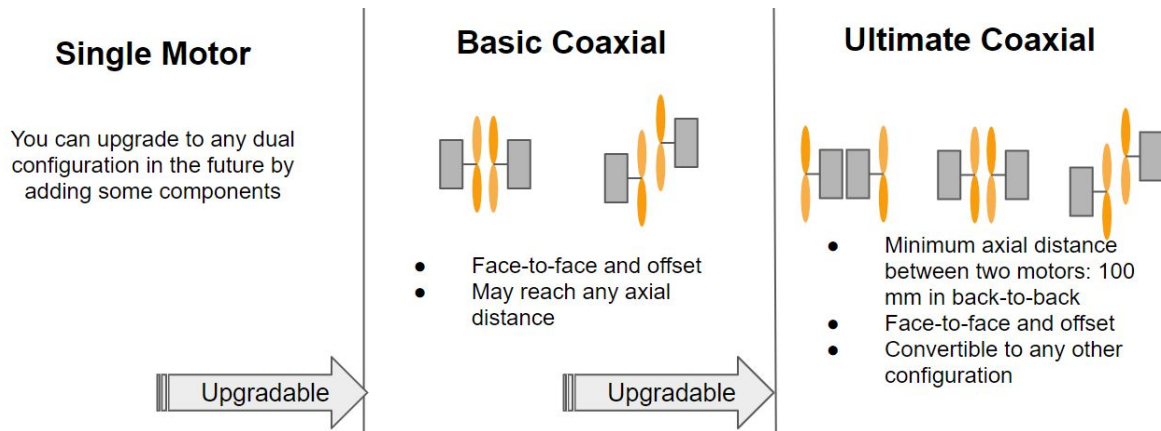


Fig. 3: Available configurations for 25 kgf and 40 kgf versions

All three configurations share mostly the same hardware, except that the Ultimate coaxial contains special mounting to connect two measurement units together. These configurations can be used to test different setups: one motor, two motors face-to-face, two motors offset and two motors back-to-back. When testing two motors, coaxial configurations with an upgraded data acquisition board will allow motor control and data processing for two motors simultaneously.

The power and control console, the optical RPM probe, the motor mounts and the fixtures are universal to all the configurations. It is possible to upgrade a configuration by purchasing extra components. Please contact the RCbenchmark technical support team for more details.

The Series 1780 Dynamometer **75 kgf - 500 A** also offers a single-motor version for one motor testing and a coaxial version for dual-motor testing. The coaxial version can support all the dual-motor setups: back-to-back coaxial, back-to-back offset, face-to-face coaxial and face-to-face offset.

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

Compatible Motors

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

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

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

For the 25 kgf 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, 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.

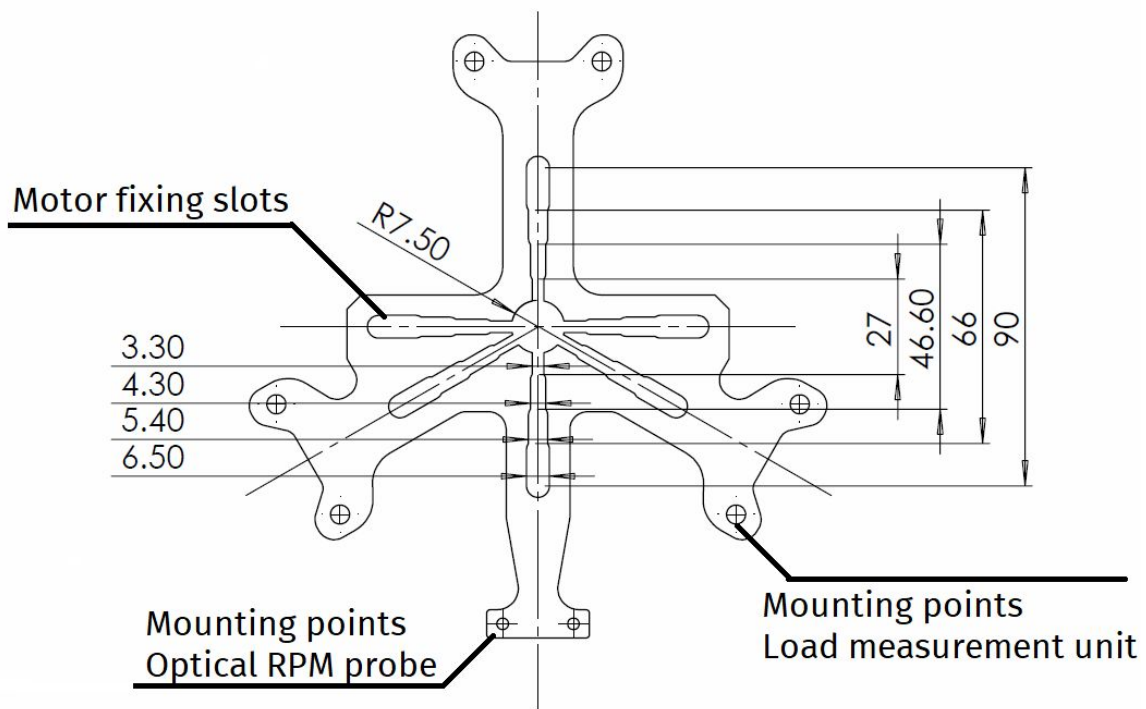


Fig. 4: Motor mount features for 25 kgf and 40 kgf

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,

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, 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.

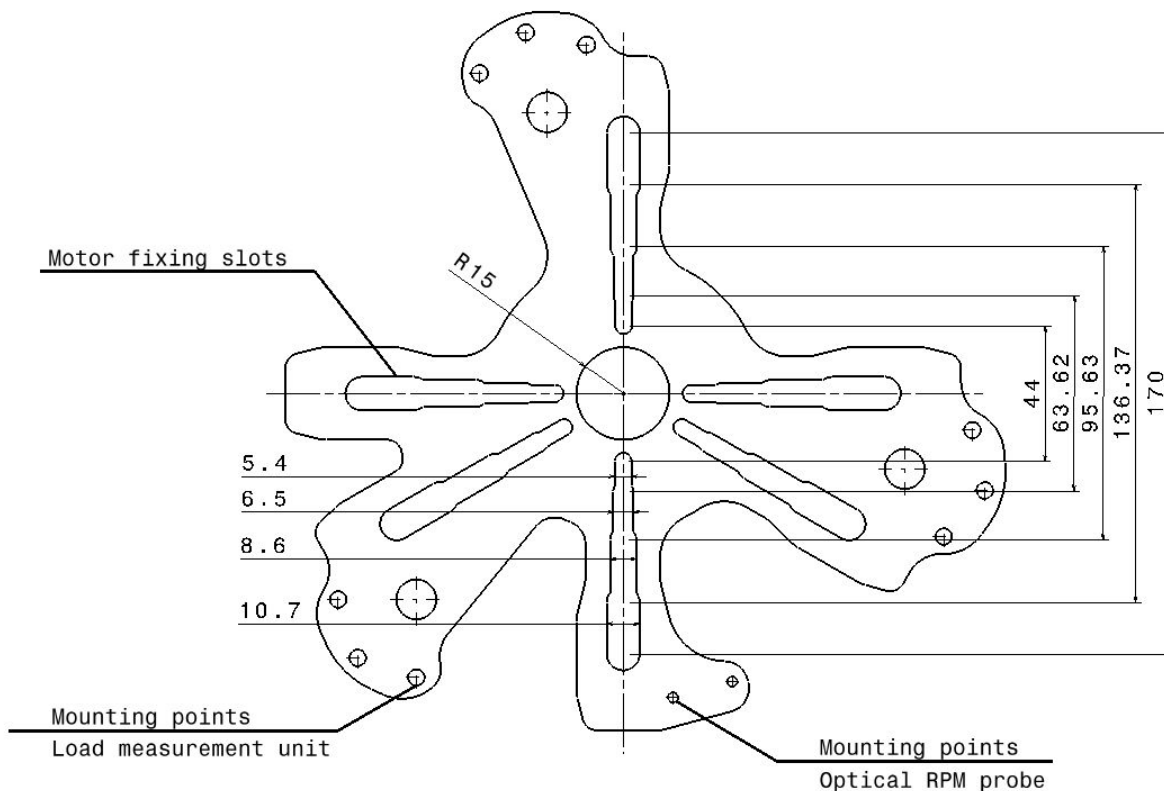


Fig. 5: Motor mount features for the 75 kgf version

If necessary, the customers who purchased the Series 1780 Dynamometer 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 out of the specification of this motor mount, we offer a service to build a specialized motor mount at a reasonable fee. Please contact us with the dimensions and motor specifications. You can also machine your own mounting plate.

Safety

Read the 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 further limited by the user to, for example, prevent a propeller from spinning too fast or a motor from using too much current.

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 that 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.

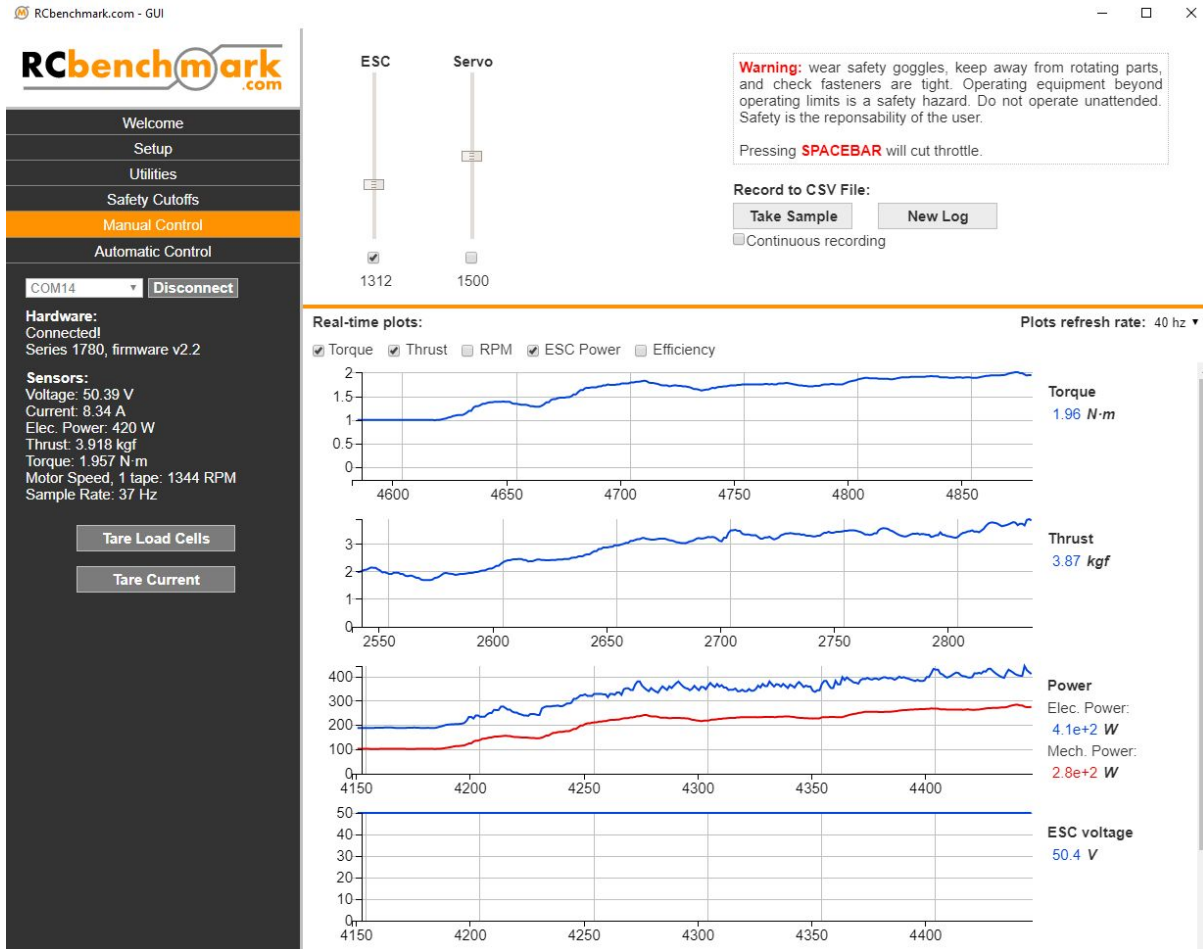


Fig. 6: RCbenchmark software

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 Mins)	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 mN
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 mN
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 mN

Table 7: Accuracy and resolution of the load measurement units

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 often experience better results when testing.

2. Hysteresis

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

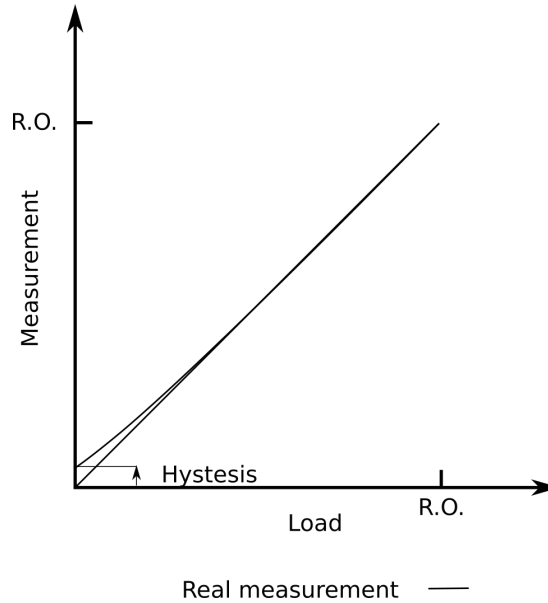


Fig. 7: Illustration of the hysteresis

It is possible to minimize hysteresis with the following procedure:

- 1) Reach the full load to be measured and return to zero load.
- 2) Tare the unit.
- 3) Reach 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.

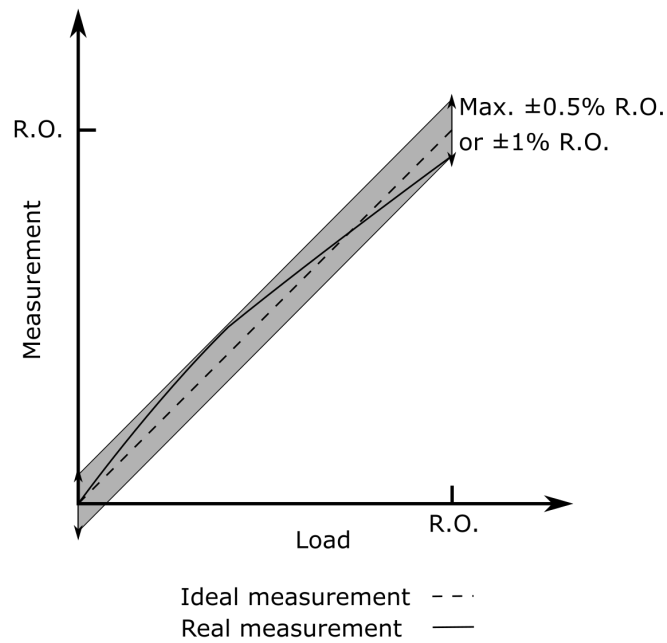


Fig. 8: Illustration of the maximum non-linearity error and of an example of a calibration curve.

4. Creep

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

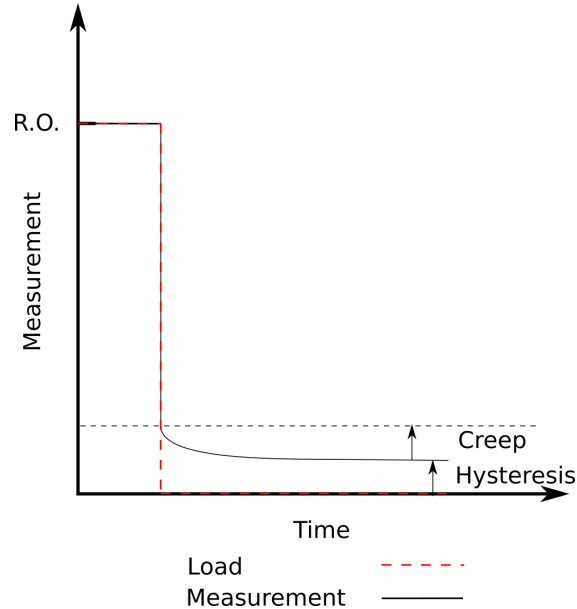


Fig. 9: Illustration of the creep

5. Note on measurement error

We do not recommend testing propellers with a maximum thrust under 25% of the full-scale rating. Aerodynamics 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 the user notes and controls all the test variables (room geometry, temperature, cable management...) and use a checklist for their tests.

During the production and calibration process, we can always find the results far superior to the maximum error values. All our load cells are tested after calibration, and we restricted the observed value from an M1 class 3 kg standard weight to be between 2.985 kg to 3.015 kg (0.5% of the measured value) while placing the LMU horizontally and applying the weight from the top. A similar requirement also applies to the torque section.

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 with your previous tests, and it can be used to calibrate the measurement to a specific air pressure and temperature.