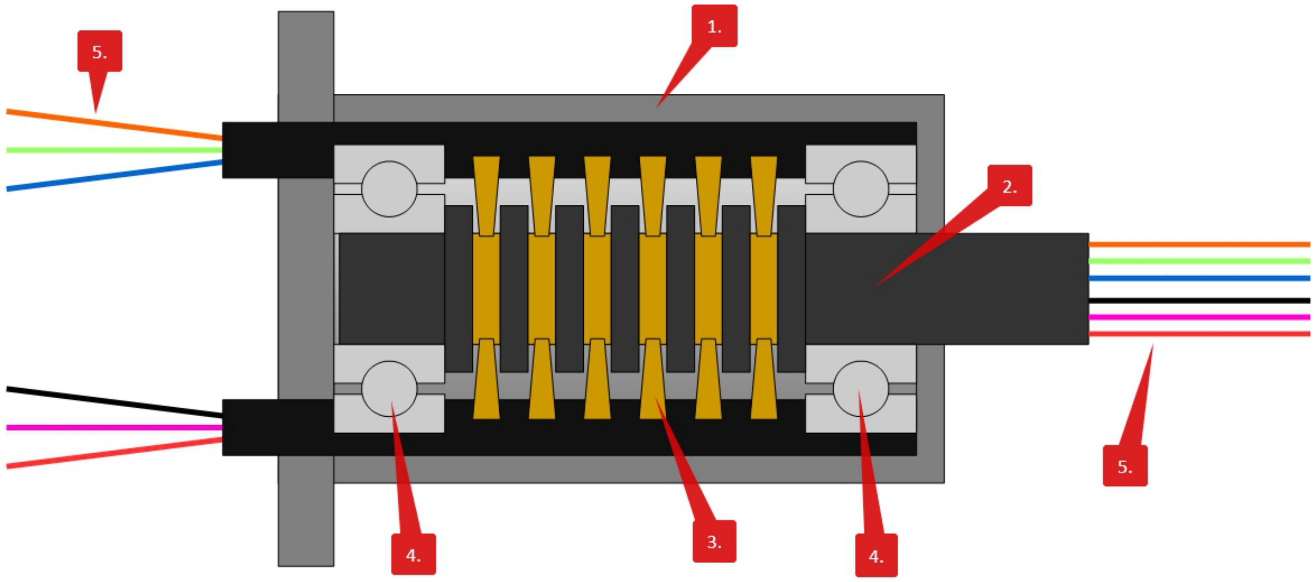
Testing slip rings

Any system with rotating parts or parts that change position during operation encounters the challenge of transmitting signals and power through movable connections. This issue has long been addressed, and leading manufacturers produce various devices for transferring electrical, pneumatic, and hydraulic media through such connections. There are also combined devices containing multiple lines for different media types.

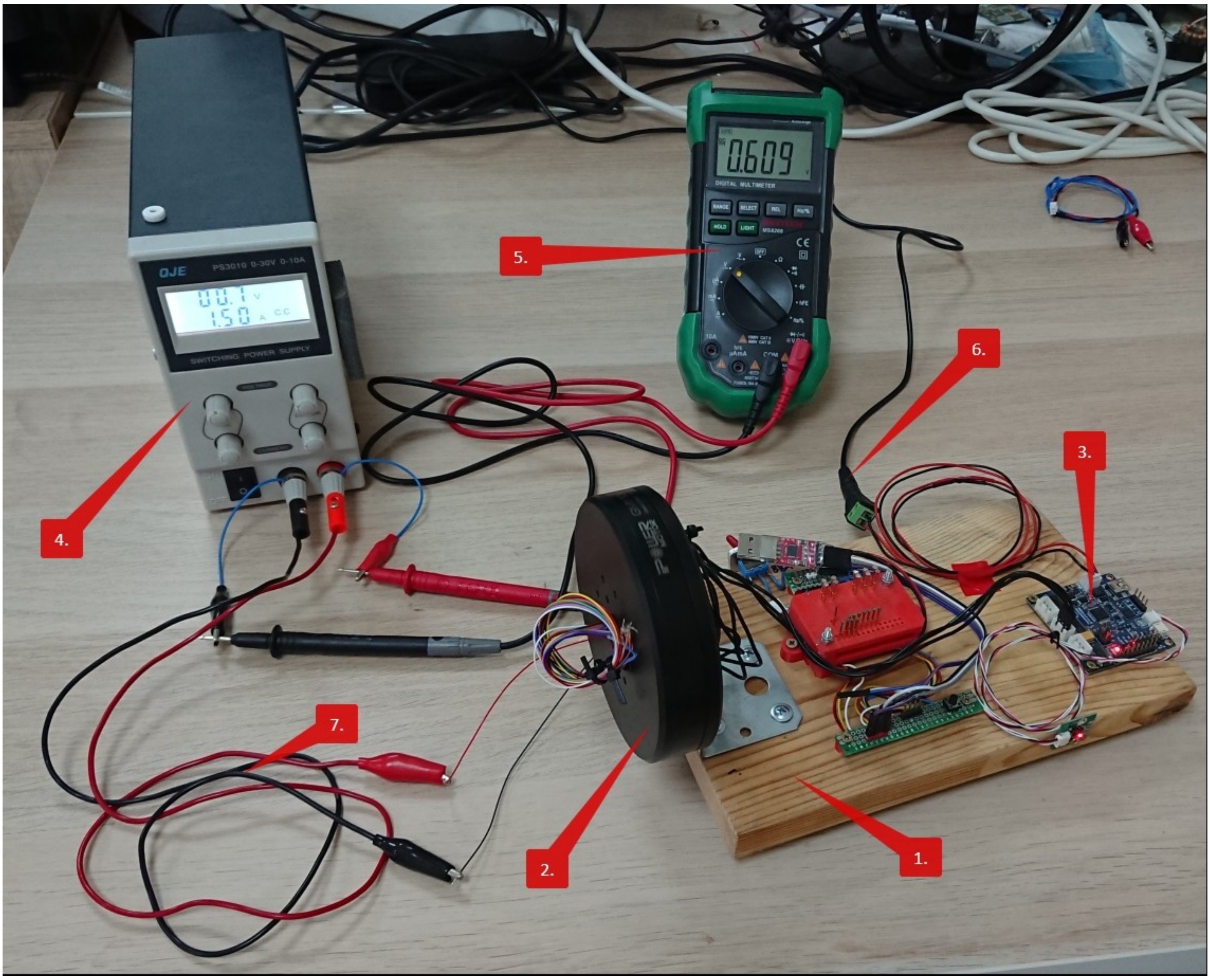
In our case, where the goal is to provide infinite rotation of the gimbal parts relative to each other, we require a unit called a *slip ring* for electrical signals. This device, consisting of a stationary part - stator (1) typically integrated with the main housing, a rotating part - rotor (2), brushes (sliding contacts) (3), bearings (sliding or rolling) supporting the rotor within the housing (4), and free wires (5) for connecting external devices, ensures seamless signal transmission across the rotating components.



It is worth noting that standard slip ring brushes and the rotor's brush-contacting surface are typically made of beryllium bronze, while high-quality slip rings use gold-plated friction parts. The bearings also depend on the slip ring's price, with rolling bearings being more common.

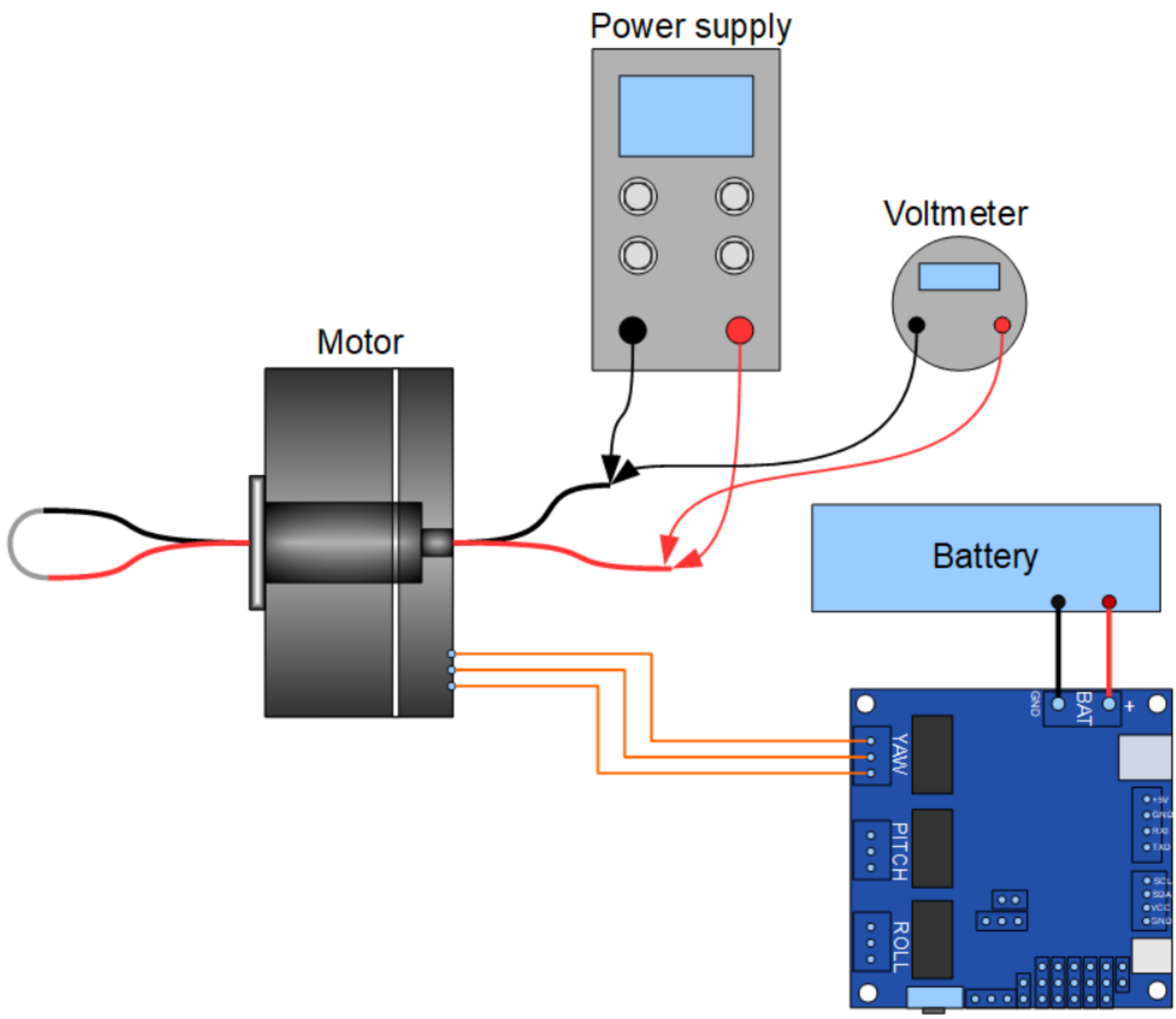
Slip rings come in various sizes, types, and designs. Generally, 7.9 mm slip rings are used for small gimbals, 12.5 mm for medium-sized ones, and 22 mm for large gimbals. Motor manufacturers often provide hollow shafts of appropriate diameters. There are also smaller slip rings, such as 6.5 mm or less, but making them reliable or with a high line count is challenging. Slip ring length varies with the number of lines, and many include a flange for mounting the stator or rotor.

Based on experience gained over the company's operational period and user recommendations, tests were conducted under conditions closely approximating real-world use. This resulted in the assembly of the following test setup:



The test setup consists of the following components:

1. Wooden platform for component mounting and stability;
2. Motor with an appropriate hollow shaft and mounting bracket;
3. SBGC32 controller for motor rotation;
4. Laboratory power supply with adjustable current control;
5. Multimeter in voltmeter mode to measure voltage drop;
6. Power source for the SBGC32 controller;
7. Set of standard wires for connections.



Test procedure

A motor with an appropriately sized hollow shaft was selected, and the slip ring was mounted. Wires were secured to prevent tangling during rotation. The remaining wires were arranged based on the motor's moving part dimensions.

On the slip ring's rotating part (rotor), driven by the motor, two arbitrary lines were connected. On the stationary side of the slip ring (stator), the same lines were connected to the positive and negative terminals of the power source. The power source had a sufficiently accurate built-in ammeter, eliminating the need for an external instrument. However, due to the internal voltmeter's lack of precision, an external multimeter was used.

Thus, current flowed through one line and then the other, returning to the power source. The voltage drop across wires outside the slip ring was about 0.1V and was accounted for in the test results.

Each test took approximately 3 hours on average per stage. In guaranteed operating mode (currents specified by the manufacturer), slip rings were tested for 5 hours. Slip ring models without manufacturer-guaranteed operating modes or extended operating times were tested based on wire and slip ring heating. Temperature was monitored using a thermal imaging camera.

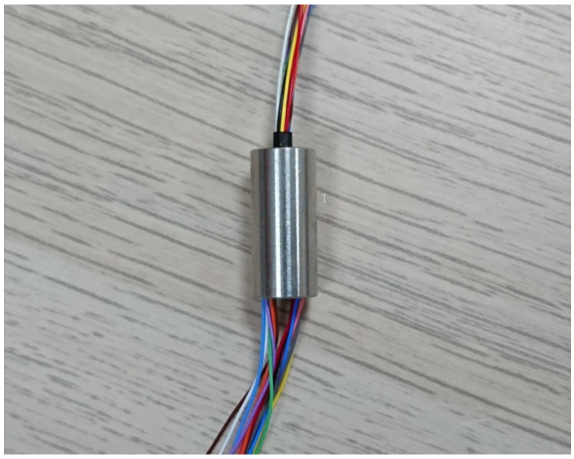
During testing, the slip ring was rotated by the motor, simulating actual gimbal operation where the motor also absorbs some slip ring heat, although it may heat up during operation. Cooling pauses were introduced between heat-inducing tests to allow the slip ring to return to normal temperature.

Test results and brief comments are provided below. The abbreviation U_p denotes the voltage drop across a single line.

Capsule Slip Ring M079-12 by SenRing

Diameter: 7.9 mm, 12 wires for 1A current, body height: 17.6 mm. Current measurements:

- *0.5A: U_p = 0.17V;*
- *1A: U_p = 0.38V;*
- *1.5A: U_p = 0.56V, heated to 43°C ;*
- *2A: U_p = 0.76V, instant heating to 46°C, peak mode.*



The slip ring performed exceptionally well, with a power reserve. The thin, flexible wires present additional challenges for currents above 1 A. The metal casing dissipates heat efficiently. No additional rotational resistance was observed, even after testing.

Capsule Slip Ring M125-12 (without flange) by SenRing

Diameter: 12.5 mm, 12 wires for 1A current, body height: 18.2 mm. Current measurements:

- *1A: U_p = 0.13V;*
- *1.5A: U_p = 0.29V;*
- *2A: U_p = 0.383V, slow heating to 46°C, did not heat further;*
- *2.5A: U_p = 0.5V, rapid heating to 47°C, reached 53°C after 3 hours, peak mode.*

A good slip ring that continued to function even during heating, with no significant increase in voltage drop. In guaranteed mode up to 1A, it operated normally at 2A. Some slight resistance to rotation was observed.

Capsule Slip Ring SNM022C-18 by SenRing

Diameter: 22 mm, 18 wires for 2A current, body height: 33 mm. Current measurements:

- *2A: U_p = 0.369V;*
- *3A: U_p = 0.5V, temperature remains normal, slight increase of 4-8°C.*

Testing was halted due to a significant increase in voltage drop, although the temperature remained stable. No resistance to rotation was observed.

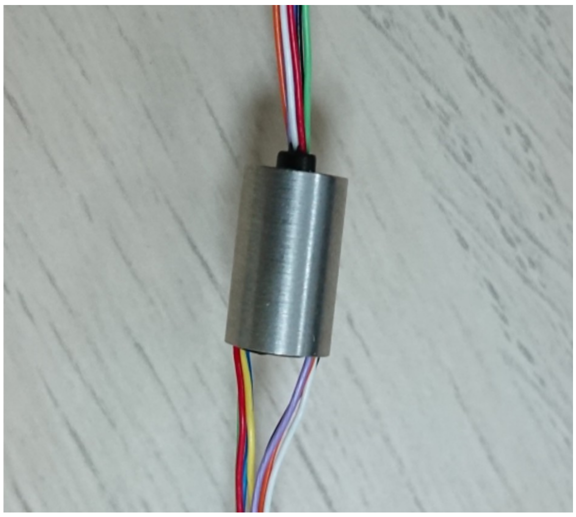
Miniature Contact Rings SRC012-12 by Prosper

Diameter: 12 mm, 12 wires for 2A current, body height: 13 mm, total height: 20 mm. Current measurements:

- *2A: U_p = 0.36V;*
- *2.5A: U_p = 0.41V;*
- *3A: U_p = 0.55V, heating to 36-42°C, wire cross-section is insufficient;*
- *4A: U_p = 0.8V, heating to 46°C in 30 seconds, peak mode.*

A good slip ring that heats slowly despite the plastic casing. The casing material is less flexible compared to SenRing slip rings. No resistance to rotation was observed.

Slip Ring IFlight 7.9 mm (for Motor 4108)



Diameter: 7.9 mm, 8 wires, current not specified, body height: 25 mm. Current measurements:

- *1A: U_p = 0.163V;*
- *1.5A: U_p = 0.26V;*
- *2A: U_p = 0.355V, heating wires to 46°C;*
- *2.5A: U_p = 0.46V, rapid heating to 52°C, current limit.*

The slip ring has a metal casing that efficiently dissipates heat to the motor, but the wire cross-section limits current; it's best not to exceed 1.5A per line. Overall, it is sufficient for systems with encoders.

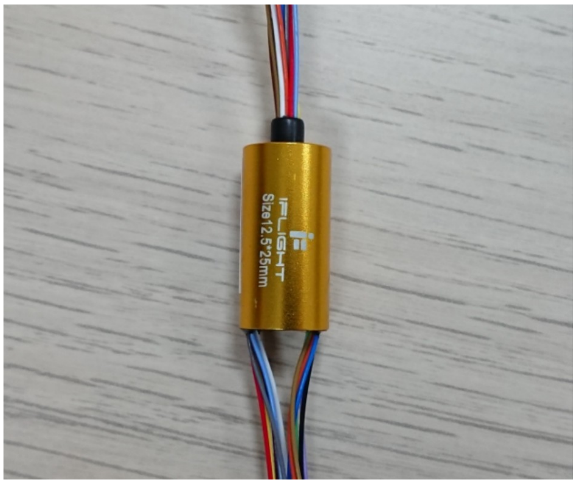
Slip Ring IFlight 12.5 mm

Diameter: 12.5 mm, 12 wires, current not specified, body height: 25 mm. Current measurements:

- *1.5A: U_p = 0.25V;*
- *2A: U_p = 0.475V, rapid heating of wires to 43°C.*

The slip ring exhibited an increasing voltage drop during operation, adding approximately 0.1V per channel over an hour. No overheating was observed, but noticeable resistance to rotation developed. It is not recommended for use due to reliability concerns.

Slip Ring IFlight 12.5 mm High Current



Diameter: 12.5 mm, 12 wires for 2A current, body height: 25 mm. Current measurements:

- *2A: U_p = 0.32V;*
- *3A: U_p = 0.53V, slow heating of wires to 43°C;*
- *4A: U_p = 0.75V, rapid heating to 56°C, peak mode.*

A good slip ring with a low price and metal casing. It can operate reliably in 2A+ mode. No more demanding expectations should be placed on it.

Slip Ring IFlight 6.5 mm (for Motor 2804)

Diameter: 6.5 mm, 8 wires, current not specified, body height: 28.4 mm. Current measurements:

- *0.5A: U_p = 0.12V;*
- *1A: U_p = 0.28V, heating wires to 42°C;*
- *1.5A: U_p = 0.291V, heating the slip ring to 46°C;*
- *2A: U_p = 0.398V, rapid heating to 52°C, current limit.*

The slip ring features thin wires with few metal strands inside. They are likely suitable for very small systems (e.g., for GoPro cameras), with current not exceeding 0.5A per line.

Slip Ring from Letus gimbal (SenRing)

The tested slip ring features two power lines, four weak lines, and a coaxial line (not included in the tests).

Power Line Measurements:

- *2A: U_p = 0.11V;*
- *3A: U_p = 0.151V;*
- *4A: U_p = 0.205V;*
- *5A: U_p = 0.27V, consistent heating observed, likely the limit for the power line.*

Weak Line Measurements:

- *2A: U_p = 0.1V;*
- *2.5A: U_p = 0.18V;*
- *3A: U_p = 0.21V, heating up to 45°C, at which point the test was concluded.*

Slip Ring Panlink PSR-F3-6 (Six Channels)

The label indicates a maximum of 2A. It features very long, thin wires. Current measurements:

- *1A: U_p = 0.285V;*
- *2A: U_p = 0.535V;*
- *3A: U_p = 0.855V, slow heating observed, reaching 67°C for the slip ring and 74°C for the wires. No further tests were conducted.*

This is a large slip ring designed for 22 mm with a limited number of channels. Based on the resistances observed, it can reliably handle currents up to 2A, but not beyond that.

Conclusion

Based on the test results, it is important to note that this article is for informational purposes only. The goal of this work was to provide users with an understanding of the practical differences between existing slip rings.

After testing with maximum currents, additional tests were conducted with the I2C and CAN buses connected. In most cases, the CAN bus, with a soldered terminator jumper on the endpoint device, performed excellently. However, the I2C bus exhibited numerous errors, indicating the need to implement standard error mitigation strategies and to replace the pull-up resistors on the I2C IMU side. Additionally, our I2C Extender board can help address these issues.