Routing cables between rotating parts of the gimbal

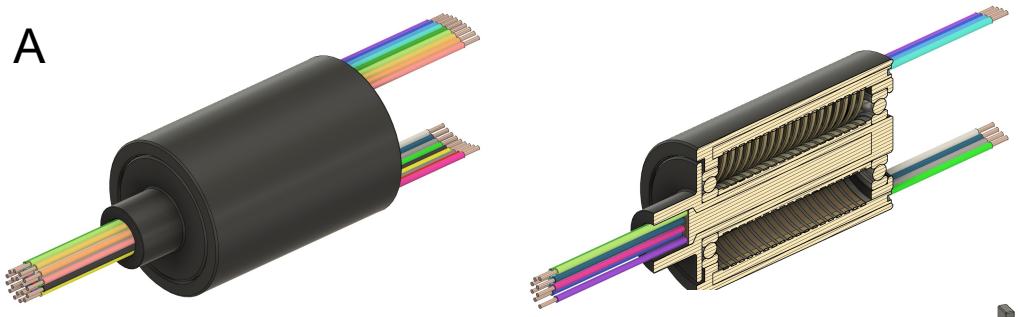
Introduction

During the development of systems of any complexity, there comes a point when it is necessary to determine the method for routing cables through moving joints of the gimbal frame. This brief guide provides a simplified demonstration of the routing methods used in real systems, outlining the main advantages and disadvantages of each method. We cannot guarantee the superiority of one routing method over another, but will provide a detailed description of key considerations.

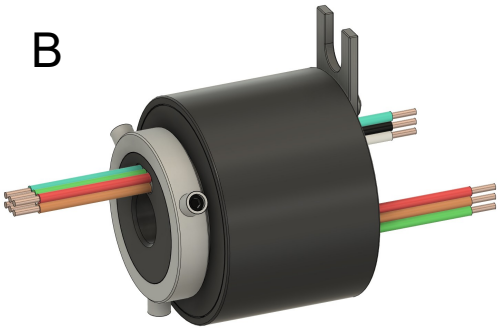
The SimpleBGC32 stabilization system is compatible with a variety of encoders available on the market. The list of supported encoders is regularly updated and can be found in our encoder manual.

Devices that enable the transmission of electrical signals (and more) from one rotating part to another are called slip rings. Detailed information on their design, operational features, and tests of available models can be found in this article.
Let us consider the main types of slip rings used in modern devices. There are also other types of slip rings that differ by the medium and method of electrical signal transmission, but they are less common:

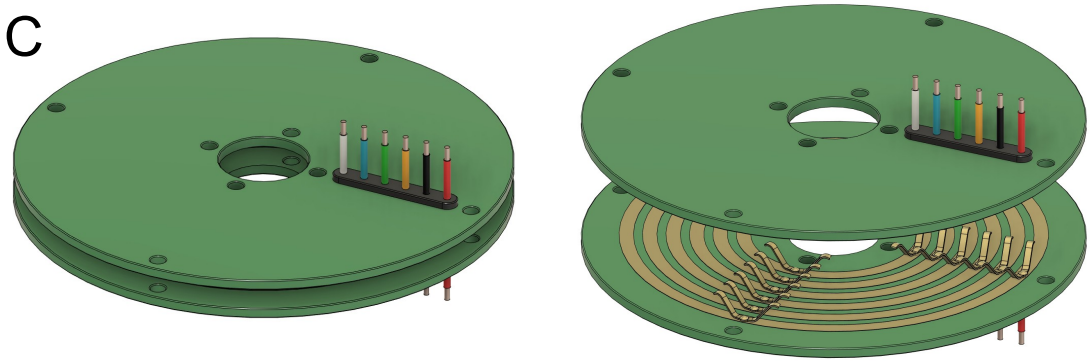
A) Capsule slip ring;



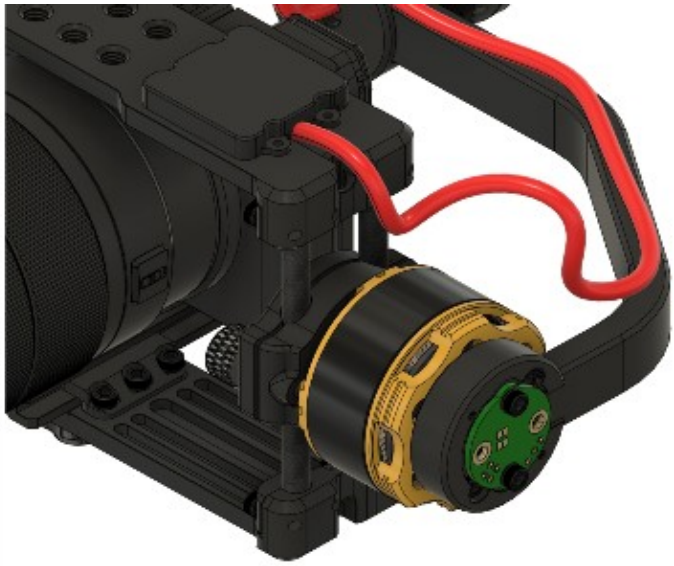
B) Through hole or through bore slip ring. The design is similar to the previous type but includes a through-hole for the shaft;



C) Pancake or PCB slip rings. Typically, these consist of two printed circuit boards with conductors, where one of the boards contains sliding contacts.



Motor with solid shaft

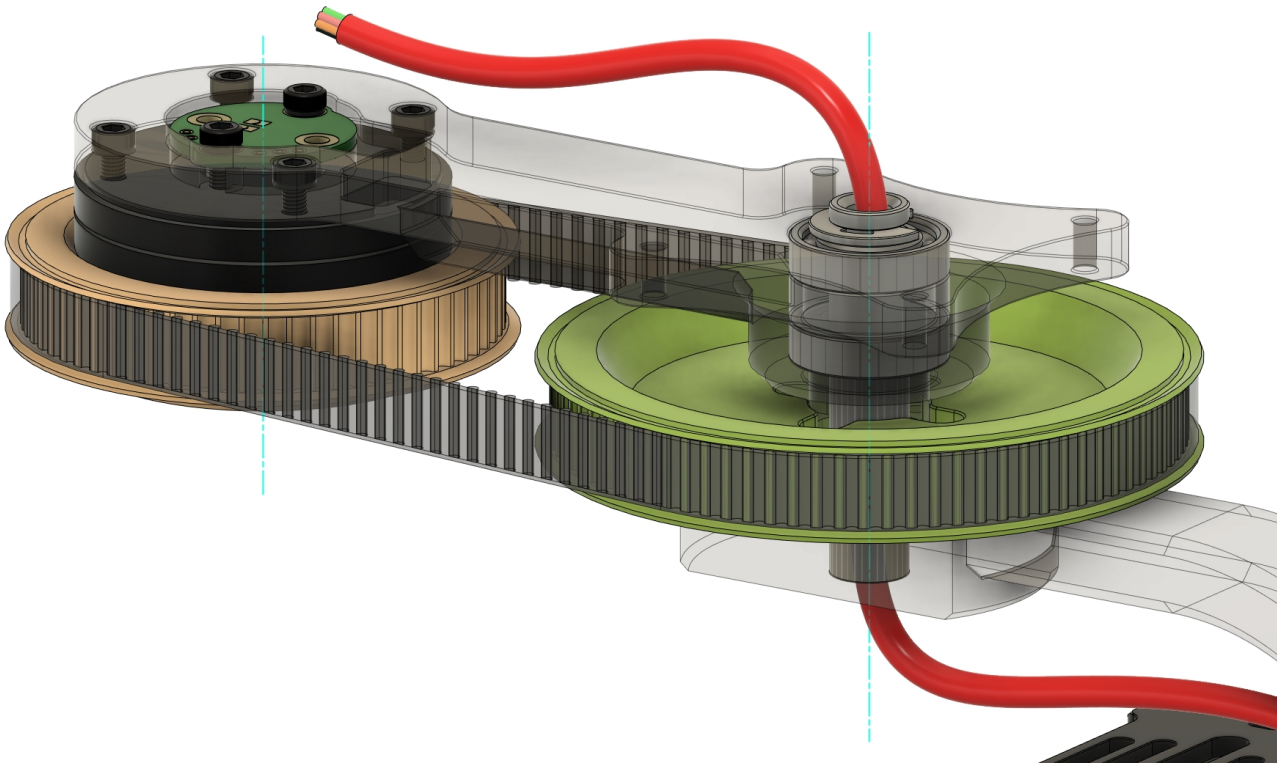


Left - Without encoder, Right - With an AS5048 magnetic encoder. Description:

- The simplest, basic option. It has a slight complexity in manufacturing;
- A simple modification of the gimbal for using encoders is possible, but direct access to the motor shaft is required. The motor must have a protruding shaft for reliable attachment of the encoder actuator;
- The angle of rotation of the shaft depends on the length reserve and flexibility of the cable. If many lines need to be routed and only a thick cable is suitable, consider using a flat multi-strand cable. The cable can be twisted into a spiral; if the cable is too soft and does not hold the spiral shape, a retaining element (for example, a 3D-printed spiral) can be added and secured to the cable;
- The excess length of the cable for rotation must be limited by securing the entire cable to the frame of the suspension, leaving the excess for movement free. This method of fixation reduces the likelihood of cable insulation rubbing against parts of the suspension. Additionally, it is necessary to use a nylon (or metal) sleeve to protect the wires of the cable for reliable fixation. In the area of excess length for rotation, a sleeve may not be used, or a sleeve made of a more flexible material can be used;
- Difficulties may arise in adjustment due to the bending force of the cable during rotation, which is particularly relevant for small gimbals with lightweight cameras. When using multi-stranded cables, the motors will require additional power to bend the cable and to keep the axis from shifting when the cable is straightened; this should be taken into account when configuring the Power parameter in GUI;
- Increasing the cable length can become a source of interference for noise-sensitive digital lines,

such as I2C. Test the system's operation in various modes. In the presence of high noise levels, any errors will be recorded by the error counter, which can be monitored in the Debug tab → Request state.

The motor, along with the encoder, is positioned externally and drives a hollow shaft through a reducer. This example features a belt drive and a magnetic encoder AS5048:



Description:

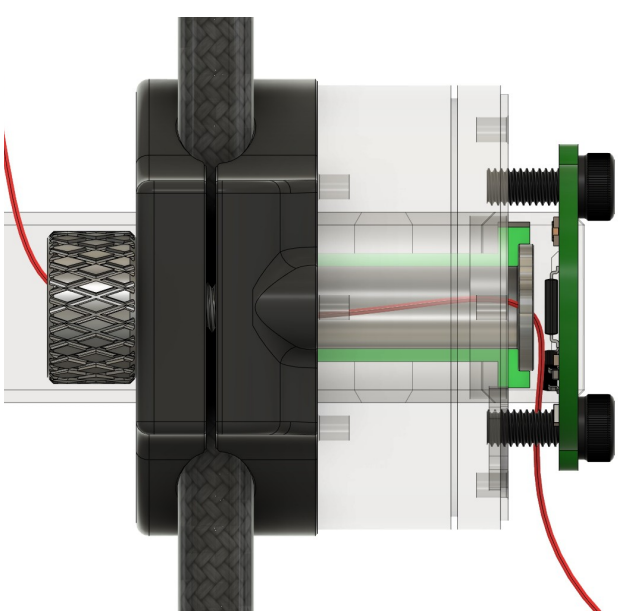
- The choice of reducer gear type depends on the design of the gimbal;
- The method is demanding on the quality of the gearbox, requiring minimal play between the gears or proper tensioning of the drive (toothed) belt. Generally, multi-stage gearboxes are not recommended for stabilization systems, as the play between the gears increases with each subsequent stage, with the exception of wave gearboxes. For belt drives, high-quality toothed belts designed for heavy loads should be used (often with part numbers starting with HTD or HTT). Belts for light loads, such as those from 3D printers, may stretch under sudden loads, adversely affecting stabilization quality;
- A motor with a built-in encoder or an external encoder with the actuator fixed to the motor shaft can be used. The actuator of the external encoder may also have a separate reducer driven by the motor or the axis shaft of the gimbal — in this case, the recommendations for gearboxes described above apply;

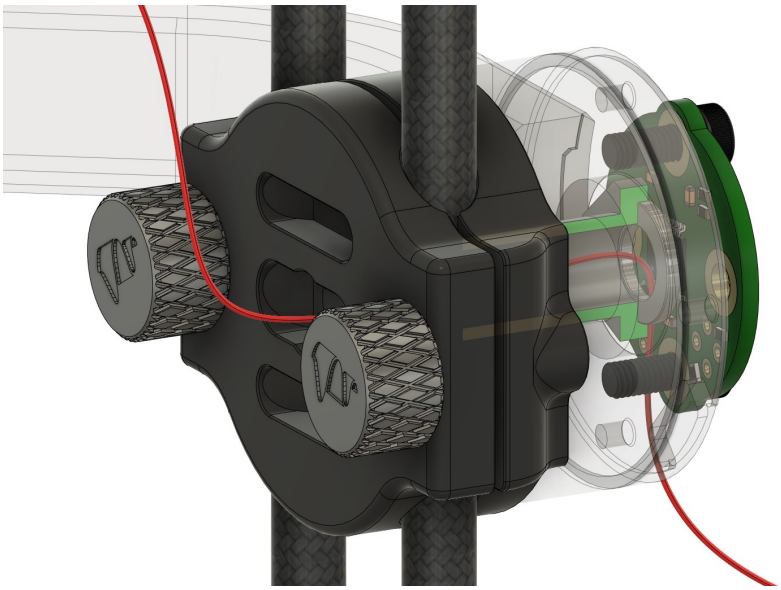
- A high-quality shaft is required for the gimbal axis; it should not bend under the weight of the frame with the load. Secure mounting of the shaft to the gimbal frame and high-quality bearings (for the rotating side) are essential;
- The type and size of the slip ring depend on the diameter of the hollow shaft and the design of the gimbal. It is important to select a slip ring with acceptable current parameters. Otherwise, the slip ring may quickly fail;
- In a standard slip ring design without isolated or shielded lines, there may be crosstalk from power lines to signal lines. In this case, alternating the signal lines and power lines can help (a method suitable for ordinary cables).

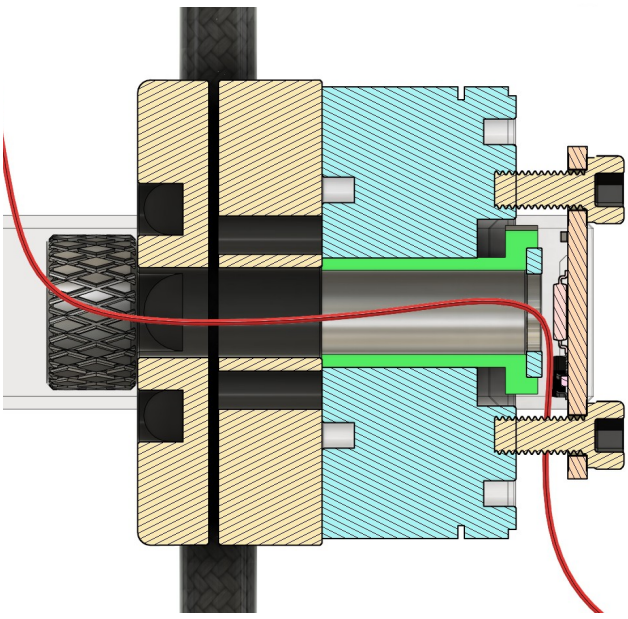
Motor with hollow shaft

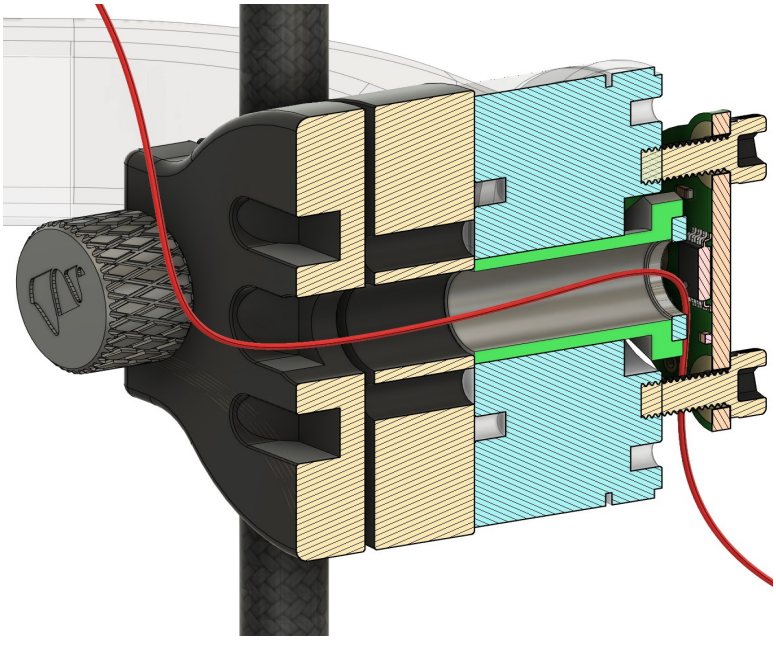
Motor with a hollow shaft and a magnetic encoder

The example uses a ring magnet and the AS5048 encoder. The magnetic encoder requires the installation of a chip above the magnet, with a gap of no more than 2 mm between the chip casing and the cylindrical magnet. Routing the cable through the hollow shaft (the cut is painted green) will require a ring magnet, but on the encoder side, the cable can only be routed through the gap between the magnet and the chip casing. To increase the gap, it is possible to replace the manufacturer-recommended magnet with a more powerful one. However, it is essential to thoroughly test the encoder's operation and verify the accuracy of the data produced by the encoder.





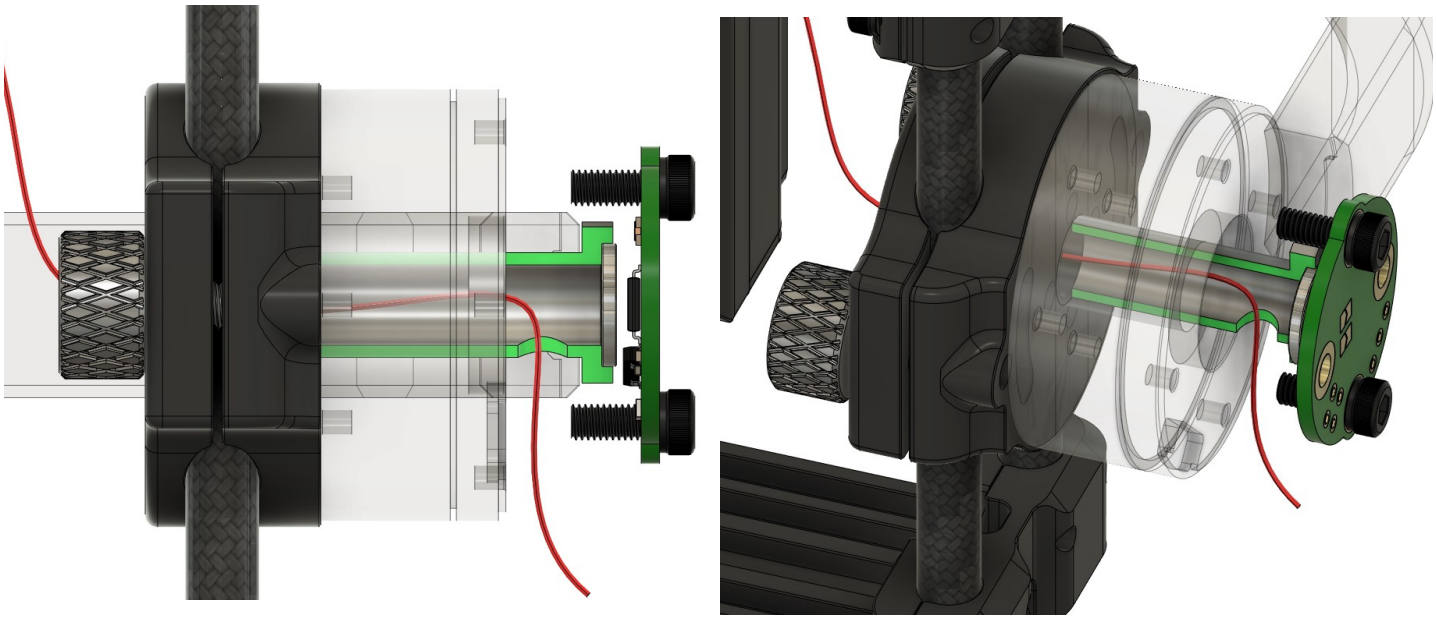




Description:

- The angle of rotation of the shaft depends on the cable length reserve and the cable's flexibility. The space for the cable is limited, and this solution is suitable if the shaft does not allow for 360-degree rotation or more;
- This method of cable routing explains the basic principle but is poorly suited for use without an extended hollow shaft or slip ring;
- High currents flowing through wires located near the magnetic encoder can affect the operation of the encoder and create interference with other digital signals.

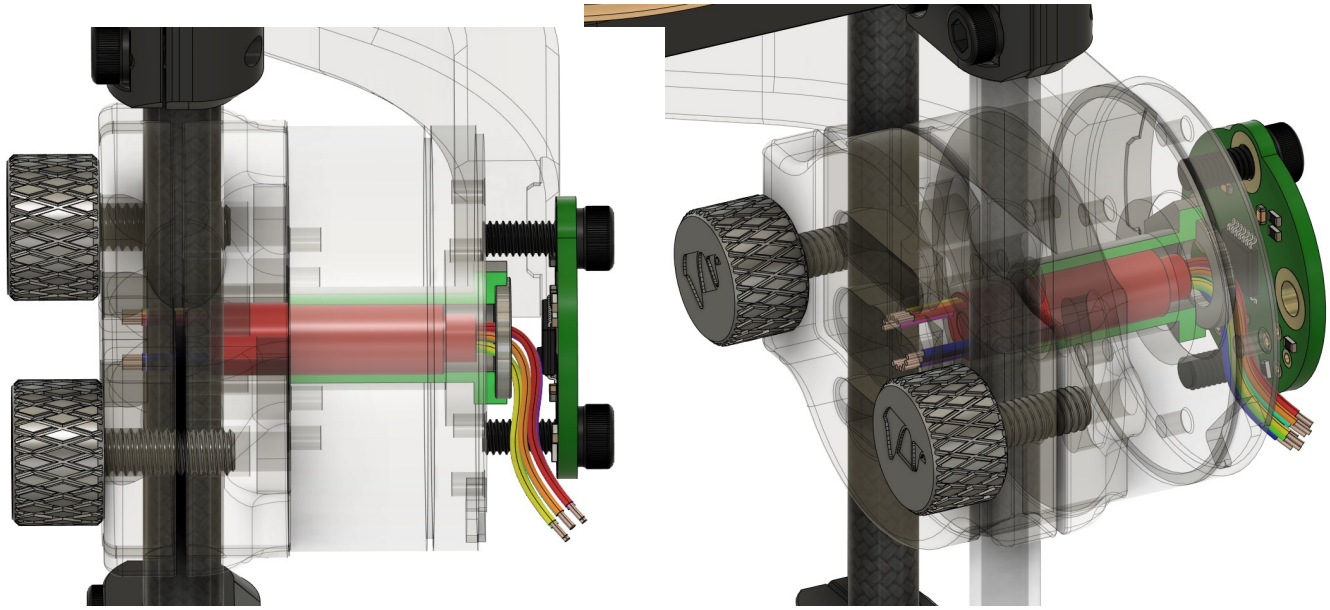
Motor with an extended hollow shaft and a magnetic encoder



Description:

- Practical implementation of the method described above. The angle of rotation of the shaft also depends on the cable reserve, but extending the shaft allows it to fit without requiring a gap between the magnet and the encoder;
- The method is also better suited for shafts that do not require rotation of 360 degrees or more;
- The currents flowing through the wires will be distanced from the sensitive magnetic encoder, but this comes at the expense of compactness in the moving assembly;
- Recommendations for the selection and routing of cables from the section "1. Motor with solid shaft" are also applicable here;

Motor with a hollow shaft, slip ring, and magnetic encoder

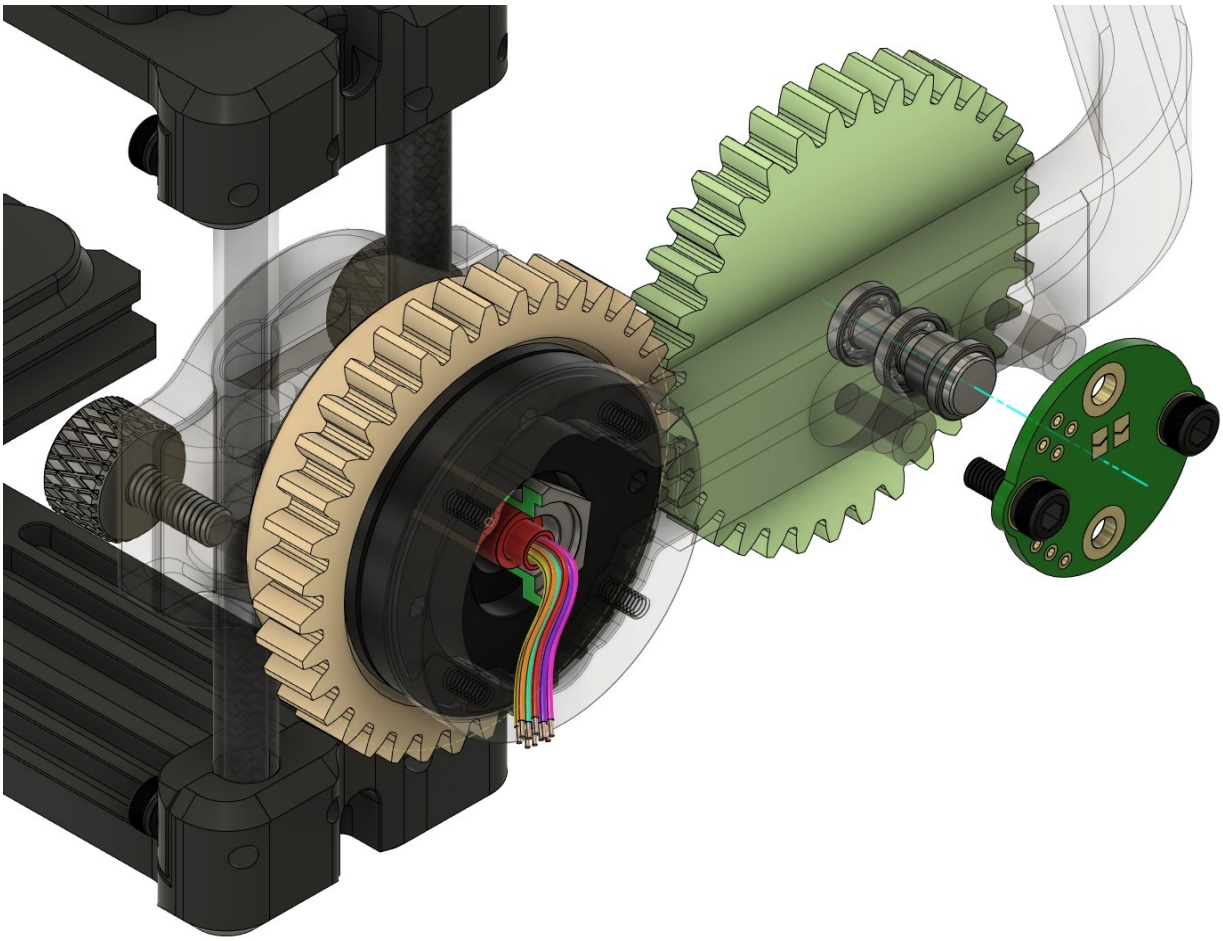


Description:

- The method follows that described in section A, but a slip ring (highlighted in red) is added to the motor's hollow shaft, and a ring magnet is used;
- The shaft can rotate 360 degrees; however, there are drawbacks related to the small clearance for the cable wires between the magnet and the encoder housing, as well as potential interference from currents in nearby wires;
- The method requires selecting a slip ring based on the permissible current load. High currents necessitate an increase in sliding contacts and wires leading to them, which increases the size of the component itself. It is possible to use several parallel lines to increase the current load, but it should be remembered that the number of lines must be increased for both incoming and outgoing currents;
- After selecting the slip ring, a motor with a hollow shaft of suitable or larger diameter (with a centering insert in the hollow shaft) will be required.

Motor with a hollow shaft and a slip ring

The AS5048 encoder is extended through a gearbox.



Description:

- This method expands the capabilities of method C by eliminating the issue of the small clearance for the cable between the magnet and the encoder housing;
- Requires a quality gear reducer (as in the example) or a belt drive; the performance of the encoder depends on the quality of the reducer;
- For a component with rotating parts, a housing is necessary to prevent the ingress of objects and parts of the suspension;
- This solution is suitable for large gimbals;
- Under the conditions described above, inexpensive magnetic, capacitive, and analog encoders will be suitable.

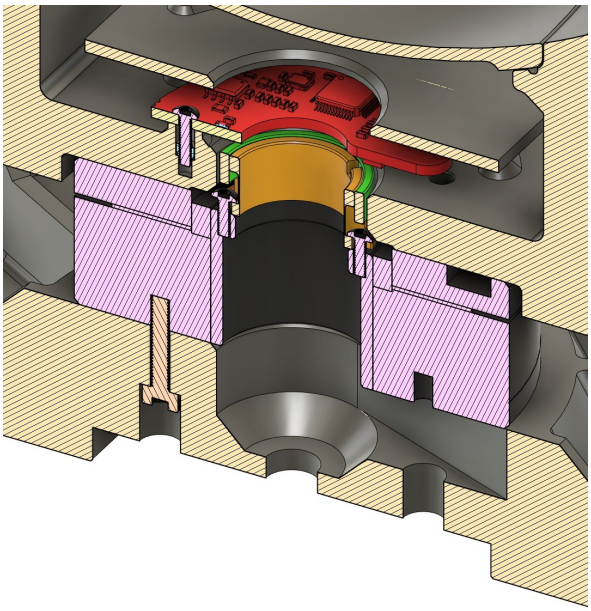
Encoders with a hollow shaft or with interchangeable actuator bushings

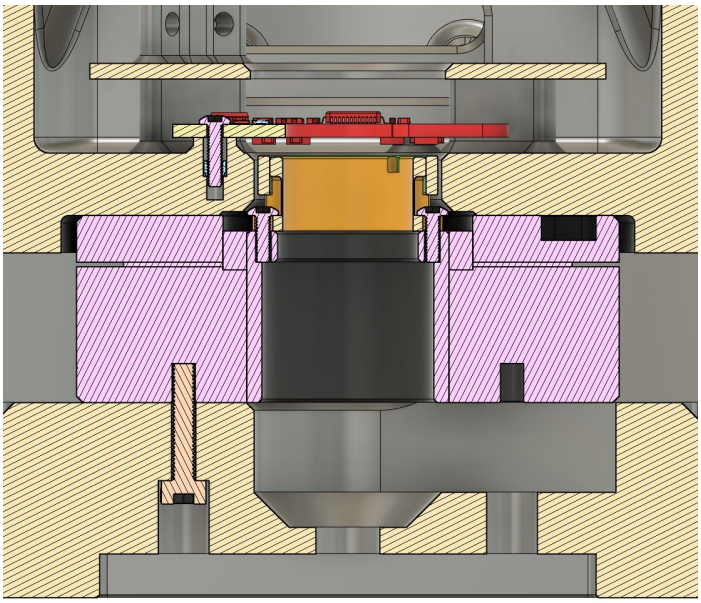
The SimpleBGC32 system supports encoders with a hollow shaft, such as the capacitive AMT203 and AMT222-223.

The encoder allows for the use of interchangeable bushings, and for secure attachment, it is recommended to design a bushing compatible with the hollow shaft of the chosen motor and the installation conditions of components in the designed system. It is important to note that the dimensions of the bushing are constrained by the diameter of the hole in the encoder; for example, the AMT203 has a hole in the mounting frame of 12.6 mm. Additionally, these dimensions impose limitations on the maximum diameter of the cable from the slip ring.

Motor with a hollow shaft, slip ring, and encoder with a ring actuator

The SimpleBGC32 system supports RLS Orbis, Zettlex, and other encoders. For example, let's consider the magnetic encoder from RLS Orbis (colored in red). The magnet holder is colored in orange, while the encoder's magnet is colored in green.





Description:

- Ring encoders are best suited for use in large or heavy systems, or when it is necessary to pass a thick cable through moving connections. However, such encoders require precise installation and adherence to the manufacturer's recommendations;
- In the illustration, the motor has an adapter for the precise and reliable installation of the encoder magnet. The adapter should be made from non-magnetic materials;
- The choice of motor depends on the type and size of the slip ring.