An Owl cannot fly without ...

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Flight Feathers

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MEETINGS

FIRST SATURDAY OF THE MONTH AT 11AM

NO MEETINGS JULY/AUGUST

NEXT MEETING:

OCT 1st

EMERGENCY CALLS FROM OUR FIELD

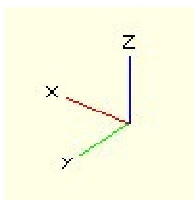
352-485-5111

2023
WISE OWLS

RON SANDERS
PRESIDENT & TREASURER
~
RICHARD GIBSON
VICE PRESIDENT
~
GILBERT PRIEUS
SECRETARY
~
ART SCHEURER
SAFETY COORDINATOR & FIELD MARSHALL
~
BRET MARTIN
FERNANDO MESA
AMA INTRO PILOT INSTRUCTORS

Meeting News – The meeting this month did not take place due to lack of a quorum. Weather event kept all but two members away.

To provide some newsletter content this month I'm presenting an article on another subject dear to the hearts of electric flyers.



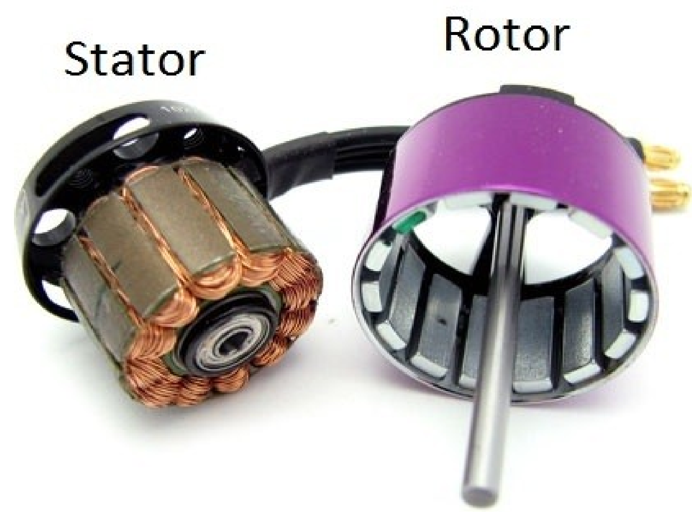
The Scientist Corner

Ed Centanni

Electronic Speed Controls (ESC)

The Electronic Speed Control (ESC) is an electronic device used to control the speed of a 3 phase direct current brushless motor. These are the types of electric motors commonly used in model aircraft and multi-rotor aircraft (drones). Most ESCs can use batteries or power sources that fall within a range of voltages – typically from 5 to 18 volts or 2S to 6S lithium based batteries. Some more powerful ESCs can use higher voltages. The most important spec for an ESC is it's amp rating. This can be anywhere from ½ amp for small micro aircraft up to a hundred or more amps for very large motors.

The ESC has three thick wires to control the motor, two thick wires that are connected to a power source – usually a battery, and a set of smaller wires that are connected to a signal (usually from a receiver or flight controller) that controls the motor speed.

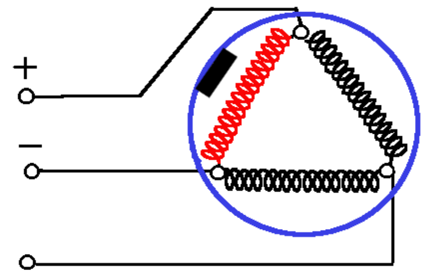


Brushless motors have permanent magnets mounted in a rotating housing called a rotor that encircles and revolves around a stationary motor armature called the stator.

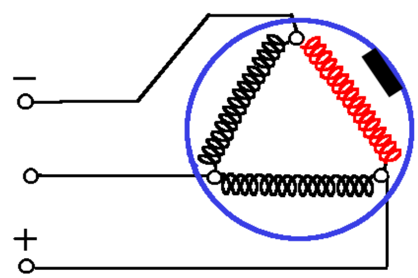
The ESC has a computer controlled set of solid state electronic switches that are attach to the three wires controlling the brushless motor. The wires connect to a set of inductors – coiled wires – that make up the stator. The computer controls the switches to puts the correct voltage on the correct wire at the right time to keep the ring and it's magnets spinning continuously.

How the ESC works: Some of you will recall the following from a previous article on electricity.

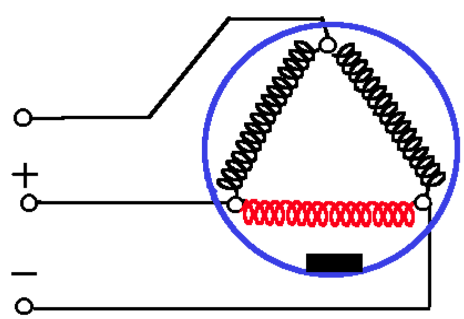
Here's a symbolic picture of a brushless motor. There are coils in the center of it surrounded by a ring of magnets that spin and are connected to a propeller. To keep things simple, in the following examples I am showing only one magnet in the spinning ring and it's position at each phase.



In phase one the first coil is activated to provide a magnetic field and the magnet is attracted to it spinning the ring for a 1/3 revolution.



In phase 2 the second coil is activated. The magnet is attracted to it and it spins the ring for the second 1/3 revolution.



Finally in phase 3, the third coil is activated and the magnet spins the ring to the final third of the revolution. The three phases repeat over and over to spin the ring, the attached shaft and the mounted propeller.

Additionally ESCs controller wires can switch from outputting voltage to sensing voltage. That allows the ESC to sense when a magnet is passing by a stator coil and gives the computer the means to synchronize the drive pulses accurately to give best performance and efficiency.

ESC BECs: ESCs usually, but not always have a BEC – Battery Eliminator Circuit. Thats a name held over from fuel powered models where servos and receivers are powered by batteries. An ESC BEC is simply a 5V power supply incorporated into the ESC circuitry that supplies power to the servos, receivers, retracts, etc and thus eliminating the need for a separate low voltage battery. The power wire is usually connected as the third wire in the throttle control wire. BECs are usually one of two types – linear and switching. Linear BEC use a power transistor to act as a variable resistor to maintain a constant voltage under changing load demands. That means it heats up under heavy current load or if the input battery voltage is much higher than 5 volts.

To get around these issues in larger, more powerful ESCs, some ESCs use a switching BEC. This is a much more efficient, and cooler operating BEC that uses a pulsed output. To keep output steady a filter is connected between the output and the load to smooth out the pulses to a steady regulated voltage. The down side is that some radio frequency (RF) interference may be generated and find it way into signal wires. Good RF design is important to minimize this.

In aircraft that use multiple ESCs, BEC type becomes important. Linear BECs can be paralleled together – no special wiring needed for connecting the throttle controls in parallel. Switching BECs should NOT be paralleled or connected together. The circuitry samples the voltage at a set rate and switching BECs will fight each other trying to regulate each others voltage at the wrong time.

A third type of BEC is no BEC at all. These are useful in aircraft with flight controllers – multi-rotors. These are usually called OPTO ESCs. OPTO is short for optoisolator. The throttle input is electrically isolated from the throttle by a type of component called an optoisolator. The throttle signal transfer is performed by a LED shining on a photo transistor, thus the name opto (optical) isolator. This is useful when the throttle control is a flight controller and power is supplied by a separate or stand-alone BEC.

ESC Common features: Most ESCs have some common features such as throttle range calibration, braked stop, low voltage actions and thresholds, start up speed, battery type (LI or NI) and motor sync speed. The means to set these parameters can be from a USB connection, a special programming card, or from the RC controller depending on the ESC set up features and manufacturer.

Throttle range calibration – lets you set the ESC input range to match your transmitter throttle control range

Brake – brakes the motor on throttle shut off to help folding propellers fully retract.

Low battery voltage actions -- Set what happens (Cutoff mode) – stop motor, reduced throttle – and at what voltage (Cutoff threshold) to take such action.

Start up speed – if the motor is connected to a gearbox (helicopter) a fast throttle up could strip gears. A slow throttle up setting will help prevent damage.

Sync speed or timing – most motors can use the default setting, however some motors with more poles in the stator can benefit from higher timing settings. Your mileage may vary.

Temperature shutdown – If the ESC overheats from prop/motor mismatch or other conditions it can be set to either reduce power to help cool down or shut down the motor completely.

ESC Computer Software: The computers on most ESCs can host different software for special purposes. The most common software designed for ESCs are ordinary or traditional, SimonK, and BLHeli. SimonK and BLHeli are open source software freely available to anyone and if you're so inclined you can modify them. Most ESCs have either a boot loader connection or solder pads to connect the ESC to a computer from which you can load software onto the ESC.

Traditional or ordinary software: This is the software that comes on most ESCs not specifically labeled to have other custom software. It works just fine with fixed wing type airplanes. All ESCs monitor the speed of the motor at a designated monitor refresh rate and adjust the power to keep it at the given power level. Traditional or ordinary software has a normal motor refresh rate sufficient for airplane power needs.

SimonK software has a faster motor refresh rate. This provides better control, faster throttle response and more "locked in" flight control for multi-rotor aircraft. Settings are standardized for off-the-shelf installs for Multi-rotors. ESCs that use SimonK and other advanced ESC software MUST be electronically capable of supporting the faster refresh rate commanded by the software.

BLHeli is similar to SimonK in terms of faster refresh rate but the settings are more customizable. BLHeli is also said to work better with lower KV motors used with larger multi-rotors. BLHeli also supports **OneShot control protocol** that is an ESC option. Smaller racing multi-rotors require very quick, precise and wide range throttle control. OneShot is a more advanced throttle control signal protocol that provides more efficient, and faster throttle control than the usual pulse width modulation. It is also a synchronous protocol for better reliability. It requires a OneShot capable flight controller to communicate to the ESC.

Effect of wire length: The length of the large ESC wires – power, and motor control – is important. There are three things effected by long wires on an ESC: RF interference, resistance, and back voltage. The electricity going through these wires is typically high amperage pulses.

Lenz Law: The direction of current induced in a conductor by a changing magnetic field due to Faraday's law of induction will be such that it will create a magnetic field that opposes the change that produced it. That means that a long wire (read more inductance) will resist the change of current in it by generating a back voltage to oppose the change. The longer the wire the more the inductance. High amperage pulses are the ultimate in changing current, going from zero to max in nanoseconds.

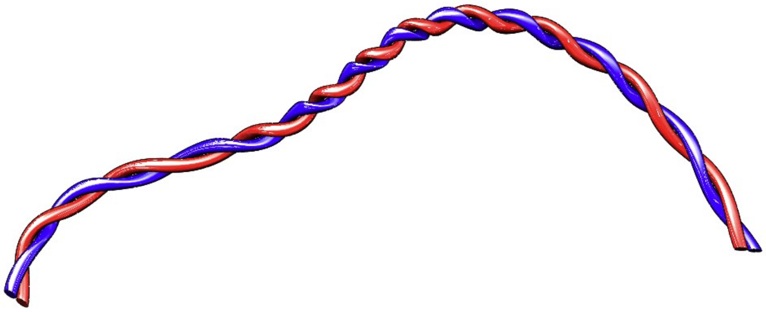
Imagine some old plumbing that is not well secured in position. When you run the water wide open and suddenly shut the valve, the momentum of the water tries to keep the it moving and creates a local high pressure wave at the valve end of the pipe. The pipe moves and bangs against anything close to it. Now imagine the racket if the valve is open and shut hundreds or thousands of times per second?

A similar thing happens with the electric current in the power supply wires of the ESC, but instead of a pressure wave we have a voltage spike caused by a magnetic field instead of momentum. That's called back voltage and if it's large enough it can damage the ESC or the spike filter components of the ESC. Avoid adding long power supply wires on the ESC. If you must then connect multiple 220uF capacitors in parallel to the wires close to the ESC. The battery itself is a large capacitor.

The length of the motor control wires are not so critical. These are connected to the stator coils which are pretty long themselves. You can usually add up to 6" of length to these without any problems. You can shorten them as well.

The other problem with longer wires is resistance. Some tests were done with small ESCs that were factory installed with small wires. Thrust and flight time were measured before and after installing larger diameter – lower resistance wires. The results was 25% more thrust and longer flight times since the same airspeed could be maintained with lower throttle setting. If you do need longer wires try to make them bigger (lower gauge) to minimize resistance.

Finally there's RF interference. Again lower gauge wire can help but there's another trick. Simply twist the wires together.



The two wires will be in close proximity, separated by the wire insulation. That makes the wire a long skinny capacitor that will filter out the RF signals in the wire. The same can be done on the motor side as well.