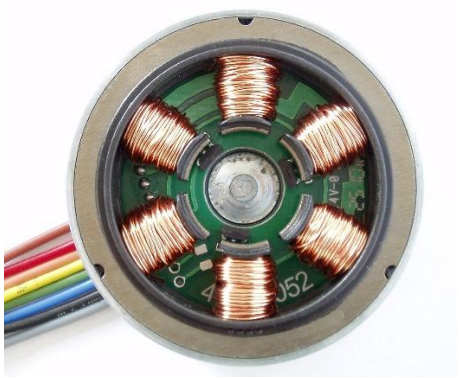
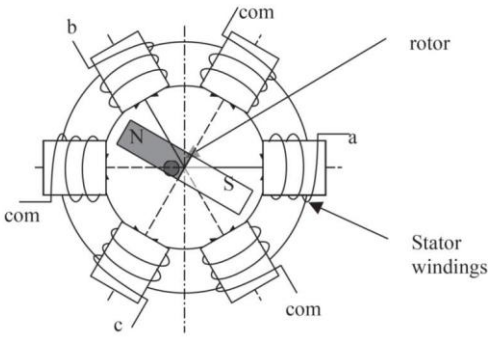
Brushless DC Motor – Construction

- A Brushless DC Motor (BLDC Motor) is an electric motor that runs on DC supply and uses **electronic commutation** instead of mechanical commutation as is the case with conventional DC Motors.

- Due to the absence of brushes and commutator as compared with conventional DC motors, BLDC Motors have advantages such as
  Higher efficiency
  Lower maintenance requirements
  Longer life
  More precise speed control
  Quieter operation
  Higher speed range
  Higher torque to weight or volume ratio
  Higher power density and smaller size

- The Stator of a BLDC Motor consists of a three-phase winding which is usually star connected type.



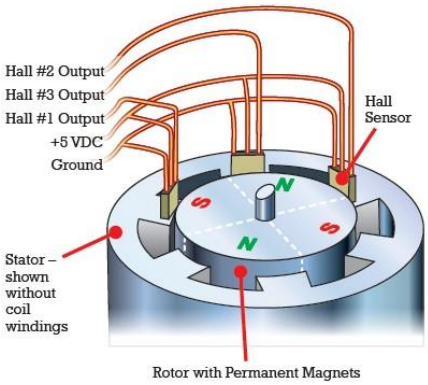


The Rotor of a BLDC Motor consists of permanent magnets usually made of

rare earth magnets. For e.g., Neodymium Iron Boron (NdFeB) magnets.

Brushless DC Motor – Hall Sensors

- Hall Effect sensors on brushless DC motors provide the position of the magnetic pole on the motor rotor (rotating element) relative to the motor phase coil windings on the motor stator (stationary element).



- The Hall Effect sensors are used to indicate which stator phase winding to energize to generate the maximum motor torque in the desired direction of rotation.
  The **Electronic Speed Controller (ESC)** is the essential electronic brain of a Brushless DC (BLDC) motor system. Its primary role is to convert the

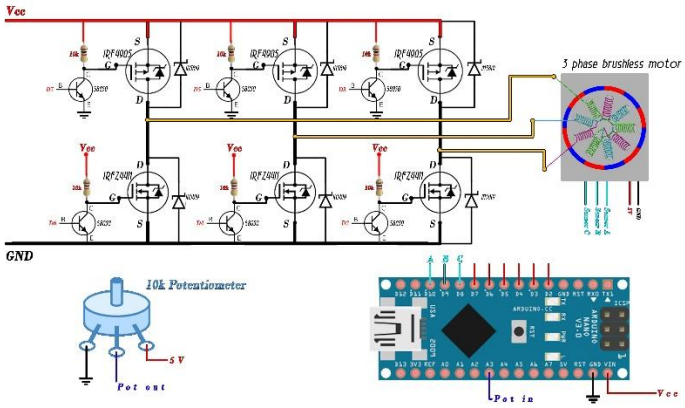
direct current (DC) power from a battery into a precisely timed, three-phase alternating current (AC) signal that drives the motor windings, replacing the mechanical commutation found in brushed motors

A BLDC ESC is a sophisticated piece of power electronics, typically comprising three main sections:

(i) Microcontroller unit
(ii) Power Stage (Inverter Bridge)
(iii) Gate Driver Circuit

Brushless DC Motor – Principle of Operation & Applications

The operation of a BLDC Motor is based on a sequence of events which are performed repeatedly by ESC. The events are as follows:



i) **Rotor position sensing** : Done using Hall Effect sensors which send the rotor position information in the form of digitally encoded data to microcontroller.

ii) **Electronic Commutation** : Based on Hall sensor data processed by the microcontroller, gate driver circuit turns ON/OFF relevant switches in the

Bridge Inverter so that at any point in time two out of three stator coils are energized.

iii) **Torque production & Rotation of the Rotor** :

The newly created stator poles (due to new phase being turned ON) creates torque which forces rotor magnets to align to a new position in the direction of rotation.

ESC continues to perform this sequence of events repeatedly, which continuously rotates the rotor in the desired direction

Comparison between Conventional (Brushed) DC Motor & BLDC Motor

Feature	Brushed DC Motor (BDC)	BLDC Motor (Brushless DC)
Efficiency	Moderate (Typically 50-80%). Energy is lost as heat/friction at the brushes.	**High** (Typically 80-90%). No friction or resistance losses from brushes.
Maintenance	**High/Regular**. Brushes and commutator wear out, requiring inspection, cleaning, and replacement.	**Low/Minimal**. Lifetime is limited mainly by the bearings.
Lifespan	Shorter (Limited by brush and commutator wear).	**Longer** (Due to no mechanical wear parts).
Speed	Lower Max Speed (Limited by brush arcing/contact at high speeds).	**Higher Max Speed** (No mechanical limitations).
Noise	Noisier (Acoustic noise from brush friction and electrical noise from sparking).	Quieter (No brush friction or electrical arcing).
Control	Simple (Direct control by varying voltage).	Complex (Requires an electronic controller/driver for commutation).
Initial Cost	**Lower** (Simpler construction).	**Higher** (Due to the required electronic controller).

BLDC Motors are ideal for applications requiring **high efficiency, long life, precise speed control, quiet operation, and higher power density** (more power for a smaller size).

Examples include Electric vehicles, Drones, Modern home appliances (like BLDC fans), Robotics, and Medical devices.