Basic components of Drone

The main parts are:

1. Motors(BLDC)
2. Propellers
3. ESC'S
4. Flight controller
5. Transmitter box and Receiver
6. Battery
7. Frame
8. Power Distribution Board
9. GPS
10. Sensors
11. Landing gears

1.Brushless motors:

A **Brushless DC motor** (also known as a **BLDC motor** or **BL motor**) is an electronically commuted DC motor which does not have brushes. The controller provides pulses of current to the motor windings which control the speed and torque of the synchronous motor.

These types of motors are highly efficient in producing a large amount of torque over a vast speed range. In brushless motors, permanent magnets rotate around a fixed armature and overcome the problem of connecting current to the armature. Commutation with electronics has a large scope of capabilities and Flexibility. They are known for smooth operation and holding torque when stationary.

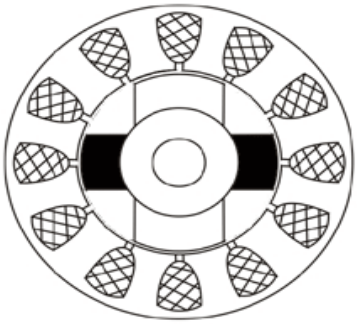
Before explaining the working of a brushless DC motor, it is better to understand the function of a brushed motor. In brushes motors, there are permanent magnets on the outside and a spinning armature which contains electromagnet is inside. These electromagnets create a magnetic field in the armature when the power is switched on and help to rotate the armature.
The brushes change the polarity of the pole to keep the rotation on of the armature. The basic working principle for the brushed DC motor and for brushless DC motor are same i.e. internal shaft position feedback.

Brushless DC motor has only two basic parts: rotor and the stator. The rotor is the rotating part and has rotor magnets whereas stator is the stationary part and contains stator windings. In BLDC permanent magnets are attached in the rotor and move the electromagnets to the stator. The high power transistors are used to activate electromagnets for the shaft turns. The controller performs power distribution by using a solid-state circuit.

Basically, BLDC are of two types, one is **outer rotor motor** and other is **inner rotor motor**. The basic difference between the two is only in designing, their working principles are same.

Inner Rotor Design

In an inner rotor design, the rotor is located in the centre of the motor and the stator winding surround the rotor. As the rotor is located in the core, rotor magnets do not insulate heat inside and heat get dissipated easily. Due to this reason, inner rotor designed motor produces a large amount of torque and validly used.



Inner Motor

Outer Rotor Design

In outer rotor design, the rotor surrounds the winding which is located in the core of the motor. The magnets in the rotor trap the heat of the motor inside and do not allow to dissipate from the motor. Such type of designed motor operates at lower rated current and has low cogging torque.

Outer Motor

Advantages of Brushless DC Motor

The advantages of a BLDC motor are:

1. Brushless motors are more efficient as its velocity is determined by the frequency at which current is supplied, not the voltage.
2. As brushes are absent, the mechanical energy loss due to friction is less which enhanced efficiency.
3. BLDC motor can operate at high-speed under any condition.
4. There is no sparking and much less noise during operation.
5. More electromagnets could be used on the stator for more precise control.
6. BLDC motors accelerate and decelerate easily as they are having low rotor inertia.
7. It is high performance motor that provides large torque per cubic inch over a vast sped rang.
8. BLDC motors do not have brushes which make it more reliable, high life expectancies, and maintenance free operation.
9. There is no ionizing sparks from the commutator, and electromagnetic interference is also get reduced.
10. Such motors cooled by conduction and no air flow are required for inside cooling.

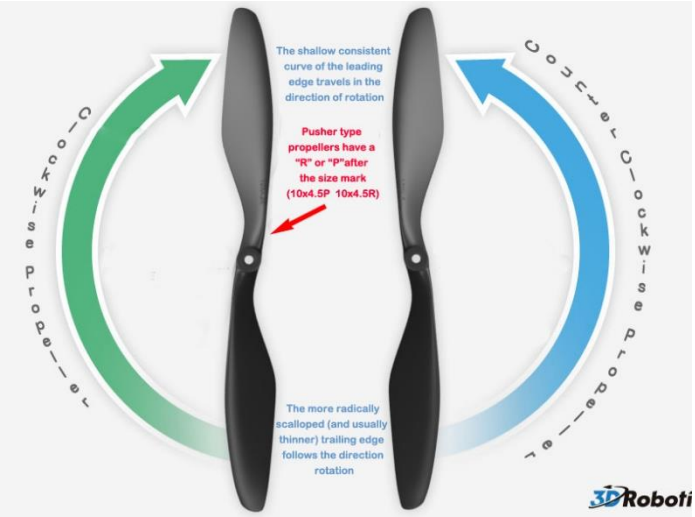
Disadvantages of Brushless DC Motors

The disadvantages of a BLDC motor are:

11. BLDC motor cost more than a brushed DC motor.
12. The limited high power could be supplied to BLDC motor, otherwise, too much heat weakens the magnets and the insulation of winding may get damaged.

2.Propellers:

Propellers convert the rotational motion into thrust and its working principle is based on Bernoulli's principle and Newton's third law of motion. In the Quadcopter, a total of four propellers is used out of which two move in the clockwise direction while two moves in the anti-clockwise direction.



Propellers are categorized on the basis of length and the pitch. Pitch is the distance travelled by drone in one single prop rotation. If the propeller is given having the characteristic 10x4.5, it means that the length is 10 inches while the pitch is 4.5. More torque is produced by the propellers of lower pitch and hence can operate on less current whereas for a high pitch propeller, more air will get displaced and this will result in a turbulent motion. Due to this, the drone would shake while hovering. Thus, a lower pitch propeller is recommended.

The variation in speed of the quadcopter is easier in the case of small propellers but in the case of large propellers, it takes a little time to change the speed. Also, the drone with small props uses high RPM motor and the blades spin rapidly to make UAV fly. However, it is noteworthy that a motor having less kV is used for operating the larger propellers otherwise motor may burn due to excessive heat produced.

There are 5 main variables that need to be considered when choosing a multirotor propeller:

- Size
- Pitch
- Blade Configuration
- Material (Durability)
- Design (Efficiency)

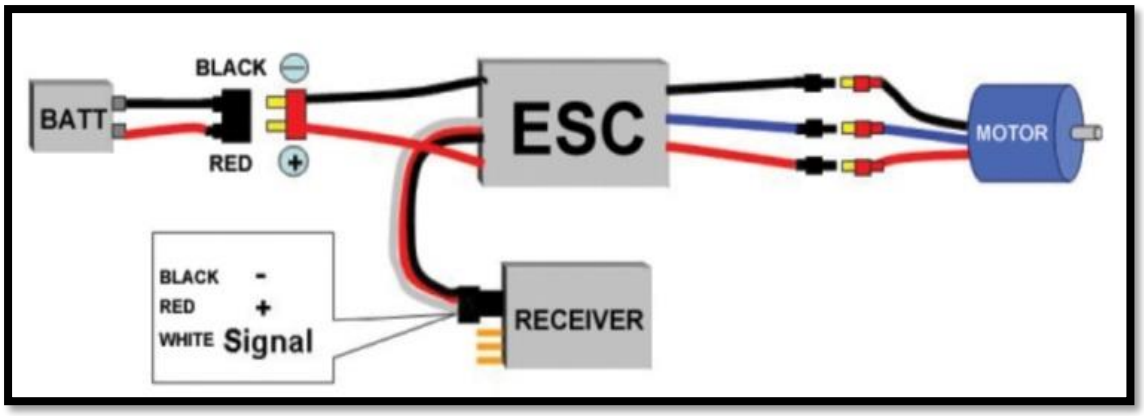
Types of Propellers Used:

Plastic Propeller: These are lightweight and Inexpensive but have balancing issues and produces more sound and vibrations.

Carbon Fibre Propeller: These Props are lighter in weight, strong, more balanced and produces lesser vibration and sound but it is expensive and provides lower thrust than plastic.

3.Electronic speed controller:

The term ESC stands for an electronic speed control is an electronic circuit used to change the speed of an electric motor, its route and also to perform as a dynamic brake. These are frequently used on radio controlled models which are electrically powered, with the change most frequently used for brushless motors basically providing an **electronically produced 3-phase electric power** low voltage source of energy for the motor. An ESC can be a separate unit which lumps into the throttle receiver control channel or united into the receiver itself, as is the situation in most toy-grade R/C vehicles. Some R/C producers that connect exclusive hobbyist electronics in their entry-level vehicles, containers or aircraft use involved electronics that combine the two on a sole circuit board.



Types of an Electronic Speed Controller

There is two kinds of electronic speed controller based on the specific requirements, you can acquire the exact one existing in RC Models shops such as brushed ESC and brushless Electronic Speed Control.

Brushed ESC:

Brushed ESC is the first electronic speed controller, which has been around for several years. It is very cheap to use in various RTR electric RC vehicles.

Brushless ESC:

Brushless ESC is the modern advancement in technology once it comes to Electronic Speed Controls. It is also a bit more costly. Connected to a brushless motor, it carries more power higher performance as compared to the brushed ones. It can also last a longer period of time.

4.Flight Controller:

A flight controller (FC) is a small circuit board of varying complexity. Its function is to direct the RPM of each motor in response to input. A command from the pilot for the multi-rotor to move forward is fed into the flight controller, which determines how to manipulate the motors accordingly.

The majority of flight controllers also employ sensors to supplement their calculations. These range from simple gyroscopes for orientation to barometers for automatically holding altitudes. GPS can also be used for auto-pilot or fail-safe purposes. More on that shortly.

With a proper flight controller setup, a pilot's control inputs should correspond exactly to the behaviour of the craft. Flight controllers are configurable and programmable, allowing for adjustments based on varying multi-rotor configurations. Gains or PIDs are used to tune the controller, yielding snappy, locked-in response. Depending on your choice of flight controller, various software is available to write your own settings.

Many flight controllers allow for different flight modes, selectable using a transmitter switch. An example of a three-position setup might be a GPS lock mode, a self-levelling mode, and a manual mode. Different settings can be applied to each profile, achieving varying flight characteristics.

Multiple flight modes are available: GPS lock, altitude lock, orientation mode (moving forward always happens away from take-off point, regardless of craft rotation), and a non-stabilized manual mode.

The Naza's are the ultimate hobby flight controllers, with a multitude of features, optimized ease of use, and relatively straightforward setup.

5.Transmitter:

In electronics, a transmitter or radio transmitter is an electronic device which generates a radio frequency alternating current. When a connected antenna is excited by this alternating current, the antenna emits radio waves. The number of channels transmitters have determines the number of controls it is having. So a 4-channel radio will be able to control 4 different things whereas a 6-channel radio will be able to control 6 controls.

For a quadcopter, a minimum of 4 channels is required, not because of the 4 motors but because of the 4 different controls required to fly the quadcopter.

These controls are Throttle (how fast the motors are spinning), Pitch (tilting the multi-copter forwards and backward), Roll (tilting the multi-copter to either side), Yaw (rotating the multi-copter on its axis).

Receiver:

The receiver is an electronic device used to receive radio waves and convert the information to a usable form.

Types of receivers:

PWM receivers: PWM(Pulse Width Modulation) receivers use one servo wire for each channel. So for 4 channels, 4 servo wires are used going to the channel's port on the receiver. PWM receivers are comparatively large because of so much wiring.

PPM receivers: PPM(Pulse Position Modulation) sends multiple PWM signals through a single wire in succession. PPM is preferable because in this only a single wire is required and it can carry all the Channel signals required with the maximum of 8 channels and is very useful in small, clean builds.

SBUS receivers: SBUS is a serial connection and this also uses just a single wire and is much faster. It is a preferable choice of the Drone users.

6. Battery:

In drones, lithium polymer battery is being used and mAh is used to describe the total amount of energy a battery can store at one time. A battery rated at more mAh will give power for a longer amount of time, given the same

usage pattern but have a drawback of much weight and larger size. As the battery gets larger, the increase in flight time becomes lesser effective and eventually, a point is reached when no more flight time is increased with the size. This is mainly caused by the weight of the battery and hence agility of drone is reduced.

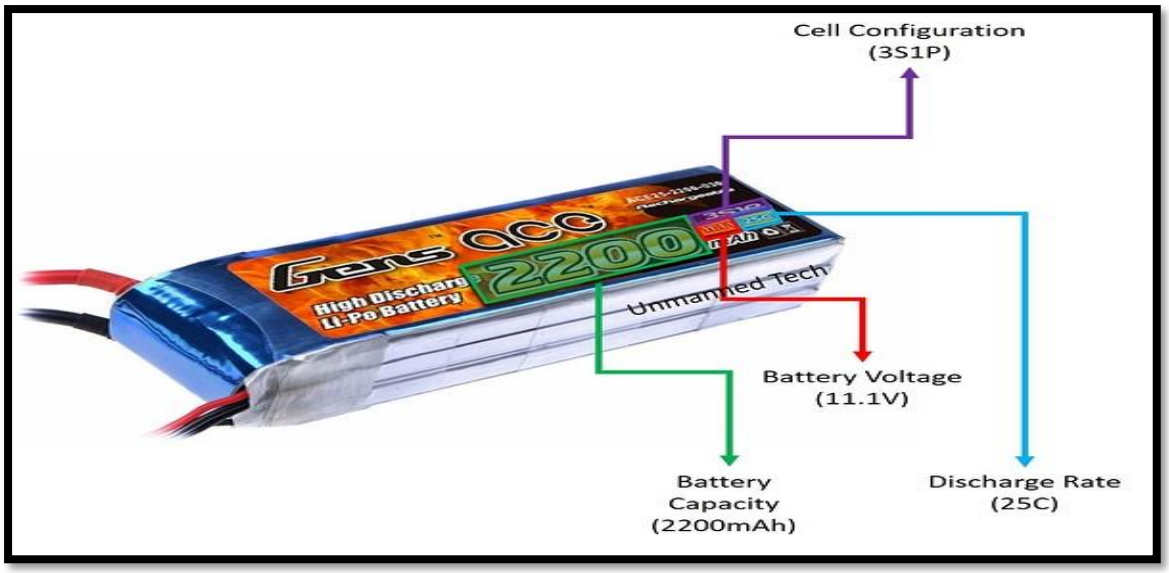
Max Current Draw:

Max current supplied by the battery to the motors when the current draw is at 100% throttle,

Can be calculated by this formula:

Max current = capacity * C-rating

The battery is the part of the drone that makes all actions and reactions possible. Without the battery, the drone would have no power and would therefore not be able to fly. Different drones have different battery requirements. Smaller drones may need smaller batteries due to the limited power needs. Bigger drones, on the other hand, may require a bigger battery with a larger capacity to allow it to power all the functions of the drone. There is a battery monitor on the drone that helps in providing battery information to the pilot to monitor the performance of the battery.



7. Frame

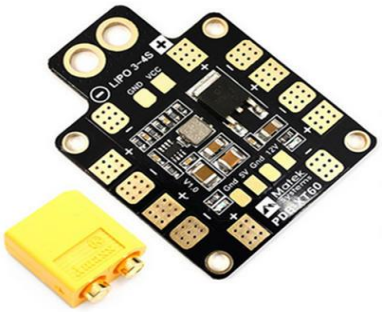
The Drone frame refers to the overall design and configuration of Drone. This is the first decision to be made when buying or designing a Drone, and has a large impact in the Drone's capabilities.

A DJI F450 is around 450 mm across, for example the F330 is 330 mm, and so on.

8. Power Distribution Board (PDB)

Power Distribution Board (PDB) is a printed circuit board that is used to distribute the power from your flight battery to all different components of the

multirotor. Prior to PDB's becoming common it was necessary to connect all the different components using wire and the result often resembled an octopus and weighed a considerable amount due to the amount of copper and solder joints in the wires.



9.GPS Module:

The GPS module is responsible for the provision of the drone longitude, latitude and elevation points. It is a very important component of the drone. Without the GPS module, drones would not be as important as they are today. The modules helps drone navigate longer distances and capture details of specific locations on land. The GPS module also help in returning the drone safely "home" even without navigation using the FPV. In most modern drones, the GPS module helps in returning the drone safe to the controller in case it loses connection to the controller. This helps in keeping the drone safe.

GPS stands for Global Positioning System. It is an American standard which provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. Often combines GPS receiver and magnetometer to provide latitude, longitude, elevation, and compass heading from a single device. GPS is an important requirement for waypoint navigation and many other autonomous flight modes. Without GPS drones would have very limited uses. Along with FPV, drones can navigate long distances and be used for exiting applications such as lidar and photogrammetry.

10.SENSORS:

In the broadest definition, a sensor is a device, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics.

TYPES OF SENSORS:

ACCELEROMETER:

The accelerometer measures the rate of change of the object's speed and tells whether the object is going up or down. It senses both static gravity acceleration and dynamic acceleration to detect the type of motion. The unit of measurement is meter per second square or g (9.8 m/s^2). It measures acceleration in three different axes(x, y, and Z-axes). The accelerometer senses

both linear motion and the direction of the ground by sensing the earth's gravitational pull.

GYROSCOPE:

The gyroscope measures the rate of rotation of an object about its axis which is measured in degrees per second or rotations per minute (RPM). It is mounted on the centre of the quadcopter in such a way that it is aligned with its axes and thus providing information about the orientation of the quadcopter. Three axes of rotations are measured (roll, pitch, and yaw).

INERTIAL MEASUREMENT UNIT (IMU):

For the accurate measurement of the orientation, velocity and the location of the quadcopter, IMU is used. It is a board in which both accelerometer and the gyro meter are combined to get much stability. To correct the errors in the gyroscope feedback, IMU may also contain a magnetometer.

BAROMETER:

The barometer is a pressure sensor that senses changes in air pressure and hence can be used to measure the altitude of the quadcopter as with an increase in the altitude the pressure decreases.

MAGNETOMETER:

It acts like a compass to measure the earth's magnetic field and serves the task of correcting the drift of the gyro and to serve as an ancillary to the GPS system.

DISTANCE:

Distance sensors are used for the much accurate reading of the altitude and to prevent the drone from Collison with any external obstacle. Generally, these distance sensors use the ultrasonic or light-based system.

11.Landing Gear

Some drones come with helicopter-style landing gears that help in landing the drone. Drones which require high ground clearance during landing will require a modified landing gear to allow it to land safely on the ground.

In addition to that, delivery drones that carry parcels or items may need to have a spacious landing gear due to the space required to hold the items as it touches the ground. However, not all drones require a landing gear.

Some smaller drones will work perfectly fine without a landing gear and will land safely on their bellies once they touch the ground. Most drones that fly longer and cover longer distances have fixed landing gears. In some cases, the landing gear may turn out to be an impediment to the 360 degrees view of the environment especially for a camera drone. Landing gears also increase the safety of the drone.