Quad-Copter

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***Abstract*— The project goal was to design an autonomous Quadcopter capable of self-sustained flight while utilizing a microcontroller. The Quadcopter was designed to be small enough so that costs would be minimized, which is why small motors and propellers are being used. While a microcontroller, accelerometer, and gyroscope are communicating between each other to maintain control.**

I. Introduction

The multirotor helicopter also known as quad rotor is equipped with four rotors to creat lift. It is a true helicopter in that lift force is created by narrow chord horizontally rotating air foils. The quadcopter existence since the 1920s when early manned version named the De Bothezat helicopter was build and successfully flown. First developed and prototypes under U. S Army contract with the De Bothezat.

II. Quadcopter

The Quadcopter is one of the most complex flying machine due to versatility to perform many type of task. Classical Quadcopter are usually equipped with a four rotors. Quadcopter are symmetrical vehicles with four equally sized rotors at the end of four equal length rods.

Fig. 1 Quadcopter.

III. Block diagram

The four motors are controlled by the quad copter controller with the use of ESC cable. The Hall Effect sensors feedback the error signal to the controller and the controller will produce its equivalent output to minimize the error, ESC cables are used to drive the motors.

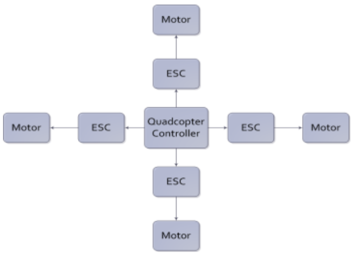

Fig. 2 Quadcopter Block Diagram.

IV. Quadcopter movements

An aircraft in flight is free to rotate in three dimensions pitch, nose up or down about an axis running from wing to wing yaw, nose left or right about an axis running up and down and roll, rotation about an axis running from nose to tail. The axes are alternatively designated as lateral, vertical, and longitudinal. These axes move with the vehicle and rotate relative to the Earth along with the craft. These definitions were analogously applied to spacecraft when the first manned spacecraft were designed in the late 1950s.

Sr.no	Quadcopter Movement		
	Name	Axis	Description
1	YAW	Vertical	Rotation around the vertical axis that results in a turn to left or right..
2	PITCH	Lateral	Rotation around the lateral axis that result in climb or descent.
3	ROLL	Longitudinal	Rotation around the longitudinal axis that results in straight line roll but no turn to either side.

a. *Yaw (right/left)*

The vertical yaw axis is defined to be perpendicular to the wings with its origin at the center of gravity and directed towards the bottom of the aircraft. Yaw moves the nose of the aircraft from side to side. A positive yaw, or heading angle, moves the nose to the right. The rudder is the primary control of yaw.

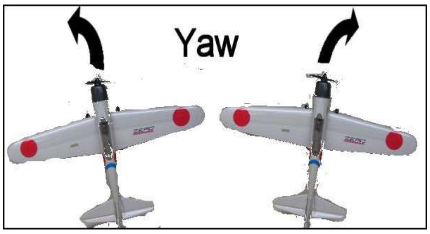

Fig. 3 Yaw (right/left)

b. *Pitch*

The pitch axis passes through the plane from wing tip to wing tip. Pitch moves the aircraft's nose up and down. A positive pitch angle raises the nose and lowers the tail. The elevators are the primary control of pitch.

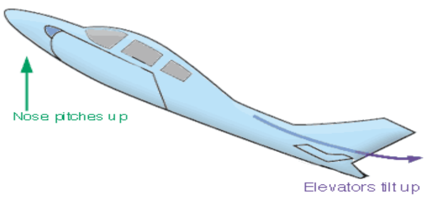

Fig. 4 Pitch

c. Roll

The roll axis (or longitudinal axis) passes through the plane from nose to tail. The angular displacement about this axis is called bank. The pilot changes bank angle by increasing the lift on one wing and decreasing it on the other. A positive roll angle lifts the left wing and lowers the right wing.

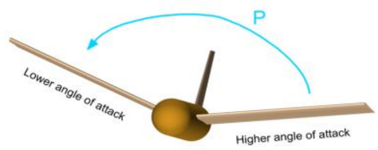

Fig. 5 Roll

V. BRUSHLESS MOTOR

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors) are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor. In this context AC (alternating current) does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. Additional sensors and electronics control the inverter output amplitude and waveform (and therefore percent of DC bus usage/efficiency) and frequency (i.e. rotor speed).

Brushed DC motors develop a maximum torque when stationary, linearly decreasing as velocity increases. Some limitations of brushed motors can be overcome by brushless motors they include higher efficiency and a lower susceptibility to mechanical wear. These benefits come at the cost of potentially less rugged, more complex, and more expensive control electronics.

A typical brushless motor has permanent magnets which rotate around a fixed armature, eliminating problems associated with connecting current to the moving armature. An electronic controller replaces the brush/commutator assembly of the brushed DC motor, which continuously switches the phase to the windings to keep the motor turning. The controller performs similar timed power distribution by using a solid-state circuit rather than the brush/commutator system.

When converting electricity into mechanical power, brushless motors are more efficient than brushed motors. This improvement is largely due to the brushless motor's velocity being determined by the frequency at which the electricity is switched, not the voltage. Additional gains are due to the absence of brushes, which reduces mechanical energy loss due to friction. The enhanced efficiency is greatest in the no-load and low-load region of the motor's performance curve. Under high mechanical loads, brushless motors and high-quality brushed motors are comparable in efficiency.

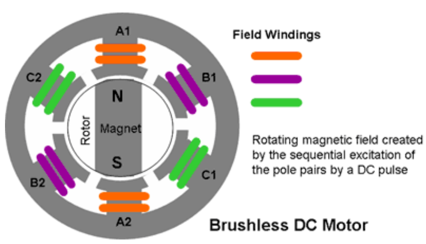

Fig. 6 Brushless motor.

VI. ELECTRONIC SPEED CONTROLLER.

An electronic speed control or ESC is an electronic circuit with the purpose to vary an electric motor's speed, its direction and possibly also to act as a dynamic break. ESCs are often used on electrically powered radio controlled models, with the variety most often used for brushless motors essentially providing an electronically generated three-phase electric power low voltage source of energy for the motor.

An ESC can be a stand-alone unit which plugs into the receiver's throttle control channel or incorporated into the receiver itself, as is the case in most toy-grade R/C vehicles. Some R/C manufacturers that install proprietary hobby-grade electronics in their entry-level vehicles, vessels or aircraft use onboard electronics that combine the two on a single circuit board.

Regardless of the type used, an ESC interprets control information not as mechanical motion as would be the case of a servo, but rather in a way that varies the switching rate of a network of field effect transistors, or FETs.The rapid switching of the transistors is what causes the motor itself to emit its characteristic high-pitched whine, especially noticeable at lower speeds. It also allows much smoother and more precise variation of motor speed in a far more efficient manner than the mechanical type with a resistive coil and moving arm once in common use.

Most modern ESCs incorporate a battery eliminator circuit (or BEC) to regulate voltage for the receiver, removing the need for separate receiver batteries. BECs are usually either linear or switched mode voltage regulators.

DC ESCs in the broader sense are PWM controllers for electric motors. The ESC generally accepts a nominal 50 Hz PWM servo input signal whose pulse width varies from 1 ms to 2 ms. When supplied with a 1 ms width pulse at 50 Hz, the ESC responds by turning off the DC motor attached to its output. A 1.5 ms pulse-width input signal drives the motor at approximately half-speed. When presented with 2.0 ms input signal, the motor runs at full speed.

ESC systems for brushed motors are very different by design; as a result brushed ESC's are not compatible with brushless motors. Brushless ESC systems basically drive tri-phase brushless motors by sending a sequence of signals for rotation. Brushless motors, otherwise called out runners or in runners, have become very popular with radio controlled airplane hobbyists because of their efficiency, power, longevity and light weight in comparison to traditional brushed motors. However, brushless AC motor controllers are much more complicated than brushed motor controllers.

The correct phase varies with the motor rotation, which is to be taken into account by the ESC: Usually, back EMF from the motor is used to detect this rotation, but variations exist that use magnetic (Hall Effect) or optical detectors. Computer-programmable speed controls generally have user-specified options which allow setting low voltage cut-off limits, timing, acceleration, braking and direction of rotation. Reversing the motor's direction may also be accomplished by switching any two of the three leads from the ESC to the motor.

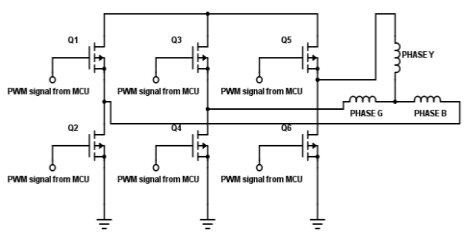

Fig.7 Electronic speed controller

VII. PROPELLER.

A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade.

An aircraft propeller or airscrew converts rotary motion from a piston engine, a turboprop or an electric motor, to provide propulsive force. Its pitch may be fixed or variable. Early aircraft propellers were carved by hand from solid or laminated wood, while later propellers were constructed of metal. Modern designs use high-technology composite materials.

The propeller attaches to the crankshaft of a piston engine, either directly or through a reduction unit. A light aircraft engine may not require the complexity of gearing, which is essential on a larger engine or on a turboprop aircraft.

A well-designed propeller typically has an efficiency of around 80% when operating in the best regime.The efficiency of the propeller is influenced by the angle of attack (α). This is defined as $\alpha = \Phi - \theta$, where θ is the helix angle (the angle between the resultant relative velocity and the blade rotation direction) and Φ is the blade pitch angle. Very small pitch and helix angles give a good performance against resistance but provide little thrust, while larger angles have the opposite effect. The best helix angle is when the blade is acting as a wing producing much more lift than drag. Angle of attack is similar to advance ratio, for propellers.

Fig.8 Propeller.

VIII. BATTERY

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated variously as LiPo, LIP, Li-poly and others), is a rechargeable battery of lithium-ion technology in a pouch format. Unlike cylindrical and prismatic cells, LiPos come in a soft package or pouch, which makes them lighter but also less rigid.

IX. PRESENT IMAGE

Fig.9 Present image of Quadcopter

X. FUTURE SCOPE

We can improved its performance by installing gyroscope sensors in it and try to stabilize it fully, we can use it without a remote control and make it fully automated as the controller is providing command signal to the motors of the Quadcopter. We can also mount a camera on Quadcopter and use it for traffic surveillance.

XI. CONCLUSIONS

Precise control must be maintained in real time over yaw, pitch, roll and altitude. This is far more complex than any ground-based vehicle. I believe that we can make it fully automated using feedback loop with controller and operate it without remote controller.

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