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Design of Weight Lifting Quadcopter using Flight Controller

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ABSTRACT: A quadcopter can achieve vertical flight in a stable manner and used to moniter or collect data in specific region such as Loading a mass. Technological advances have reduce the cost and increase the performance of the low power microcontrollers that allowed the general public to develop their own quadcopter. The goal of this project is to build, modify and improve an existing quadcopter for stable flight with specific load and perform autocommands, such as auto landing.

KEYWORDS: Quadcopter

I.INTRODUCTION

Drones also called unmanned aerial vehicles (U AVs), have no human pilot onboard, and instead are either controlled by a person on the ground or autonomously via a computer program. These stealth craft are becoming increasingly popular, not just for war and military purposes, but also for everything from wildlife and atmospheric research to disaster relief and sports photography. Drones are becoming the eyes and ears of scientists by surveying the ground for archaeological sites, signs of illegal hunting and crop damage, and even zipping inside hurricanes to study the wild storms. You can even rent a personal drone to soar above the horizon and snap a photo or video. Our news and features will cover developments in drone technologies, innovative uses for drones and how drone use will impact society.

Current drones can be categorized on the basis of the number of propellers (tri copters, quadcopters, hexacopters, octa-copters), size (nano, mini, regular size, large), and range (very close range, close range, short range, mid-range, endurance) but we think that several upcoming drones have and would have many interesting functional features, which might be better ways of classifying. Drone hardware includes a frame, propellers, batteries, transmitters and receivers, electronic speed controllers (ESC's), motors and a flight controller interfaced with certain electronic devices like gyro-meters and accelerometers, just to name a few things. To control the hardware, electronic modules like Arduino, Raspberry Pi could also be used for self-programming.

II.PRINCIPLE

Drones use rotors for propulsion, rotor as a fan, because they work pretty much the same. Spinning blades push air down. which means that as the rotor pushes down on the air, the air pushes up on the rotor. This is the basic idea behind lift, which comes down to controlling the upward and downward force. The faster the rotors spin, the greater the lift, and vice-versa.

A quadcopter is very agile machine which is capable of six degrees of freedom. The rotors are all connected to their individual motor which allow them to move at different speeds, allowing each rotor to provide thrust and torque. two rotors will rotate clockwise and the other two counter clockwise-which makes the net torque zero.

III. BLOCKDIAGRAM AND WORKING

The movement on the remote control sticks, sends signals to the central flight controller. This central flight controller sends this information to the Electronic Speed Controllers (ESCs) of each motor, which in turn directs its motors to increase or decrease speed.

Remote Control Stick Movement → Central Flight Controller → Electronic Speed Control Circuits (ESCs) → Motors and Propellers → Quadcopter Movement or Hover.

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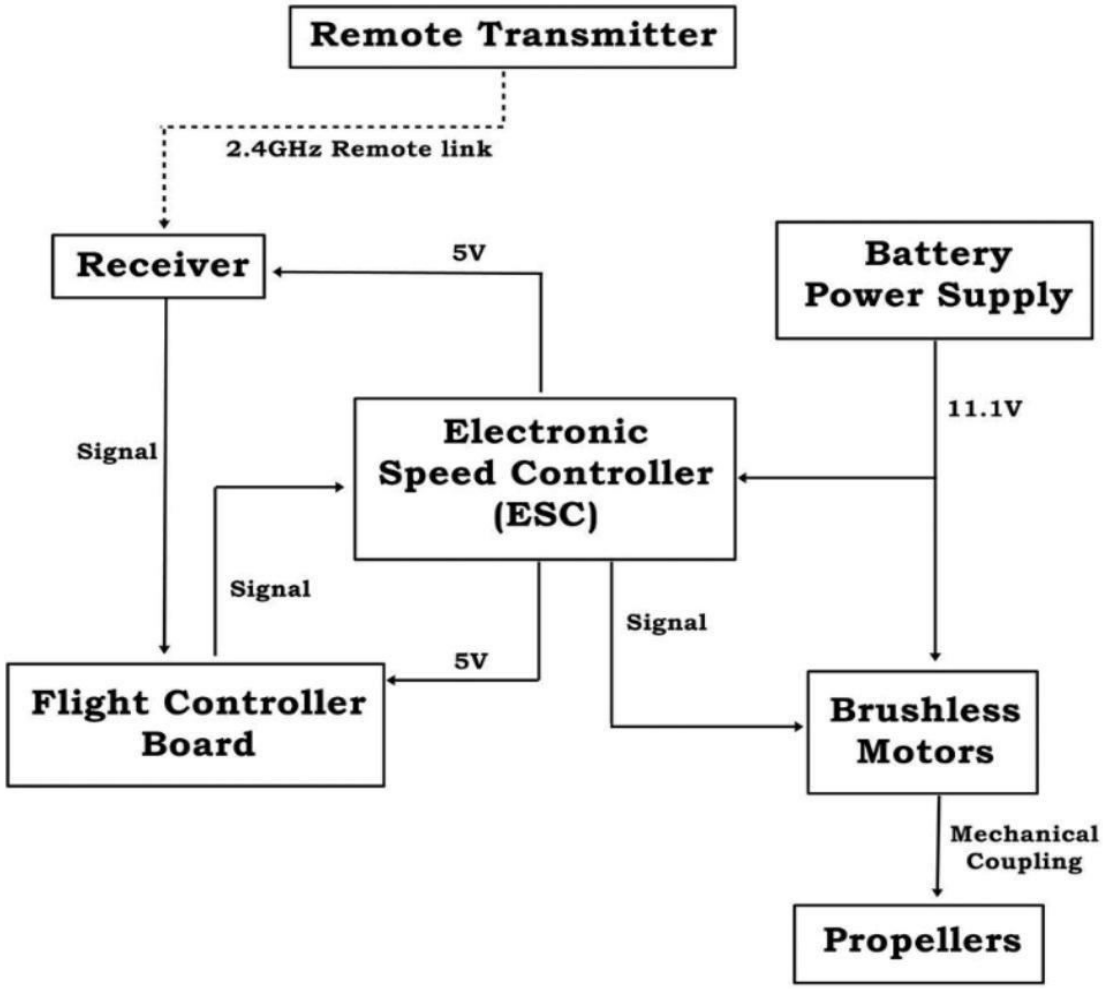

Fig. 1. Block DIAGRAM

IV. COMPONENTS

Motor

Every quadcopter would use BLDC (Brushless DC motors). With multi rotors, it's important to maintain the thrust to weight ratio to be at least 2. It is to make sure that your motors can produce around double thrust than the total weight of your drone. Or in other words, your drone should be able to hover at half throttle.

Kv is not a rating, but it is a motor constant and is taken to be the RPM/Volt of an unloaded motor. The Kv constant tells that how fast the motor will rotate when 1 volt is applied. This means that if 2 Volts is applied, the motor will rotate twice the value of Kv. Brushless DC motors are used as they have very high power density (in terms of size and weight), are incredibly efficient and can spin really fast with precisely controlled speed. Moreover, they're inexpensive to manufacture.

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ESC (Electronic Speed Controller)

It drives the brushless motor by providing the appropriate level of electrical power by converting the PWM signal from the receiver.

BEC(Battery Elimination Circuit) is a voltage regulator that converts the voltage from LiPo battery to a lower voltage to control the supply. Usually, BEC is built into ESC eliminating the need for another battery to power the 5V electronic devices. UBEC (Universal BEC) is used when ESC doesn't have built-in BEC. They generally are more reliable, more efficient and able to provide more current than BEC. The UBEC is connected in a similar way as the ESC i.e. directly to the main battery of the multi-copter.

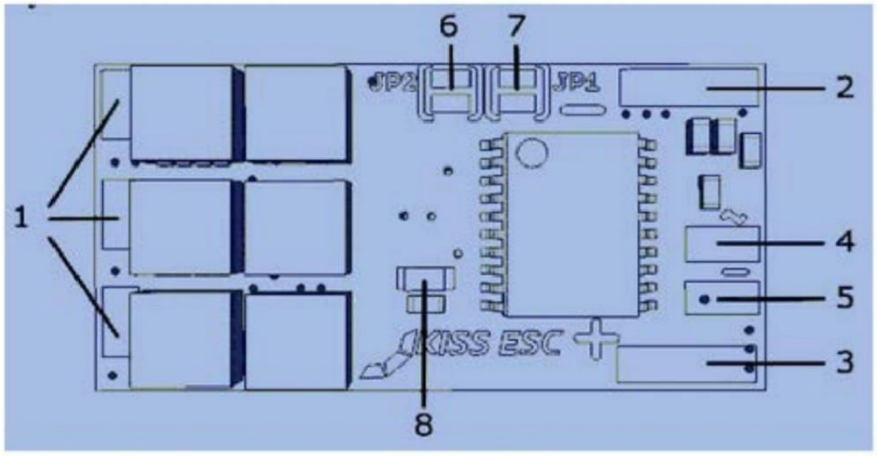

Fig. 2. ESC Construction

1. Solder pads for the 3-BLDC motor phases
2. Negative (-) LIPO connections
3. Positive (+) LIPO Connection
4. Servo signal or input of the PWM signal
5. GND reference of PWM Signal
6. Solder jumper, for altering the direction of Rotation (CW/CCW)
7. Solder jumper, for varying the type of the PWM input signal
8. State LED

The controllers switching connection to the motor connected and disconnected around 2 000 times per second by Pulse Width Modulation (PWM). MOSFET transistor is used as a switch instead of a mechanical switch. The speed of switching is fast and motors cannot detect it. It leads to the motors averages these pulses out. If there is 24V battery connected, only half of the time, the motor sees the battery like 12 V and goes at half speed. The speed of switching also affects the motor inductance, which keeps the motor current flowing constantly. However, that current is only flowing for half the time from the battery, so the battery current will be half the motor current.

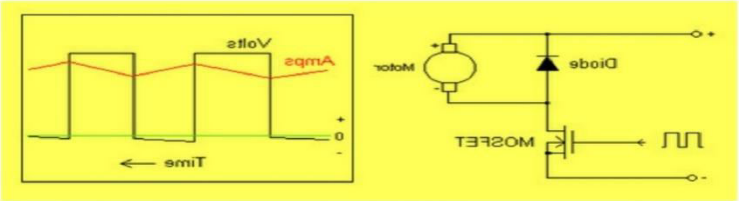

Fig. 3. ESC Electric Scheme

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Propeller

The main purpose of propellers is generating torque and thrust. Thanks to this are possible for quadcopter flying and manoeuvre.

Propellers convert the rotational motion into thrust and it's 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 traveled by drone in one single prop rotation. If the propeller is given having the characteristic 10 x 4.5, 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.

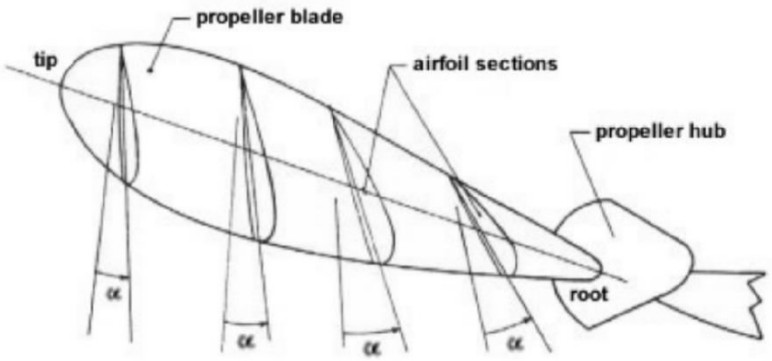

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Fig.4. Propeller Construction

Body Frame

An FPV Drone Frame is like a suit of armour for all of the sensitive electrical components that constitute a quadcopter. It is essential that a frame is as durable and rugged as possible.

The materials for the frames are fiberglass (G10), carbon fiber and aluminium, but the thing that matters the most is how well the frame is designed. For different tasks, the differently sized frame is preferred like for Aerial cinematography, Drone must be big enough to lift a specific camera with tall landing gear and for Sports, Super light-weight and extremely stiff for crisp and responsive control.

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

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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 the given input. It determines how to manipulate the motors in accordance with the command from the pilot for the multi-rotor. It can also be self-programmed using an Arduino interfaced with the electronic components like gyrometer, accelerometer etc. or else a variety of pre-programmed highly stable flight controllers are available some of which are 3DR PixHawk, DJI A3, DJI NAZA-M V2, Lumenier LUX.

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 a transmitter 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.

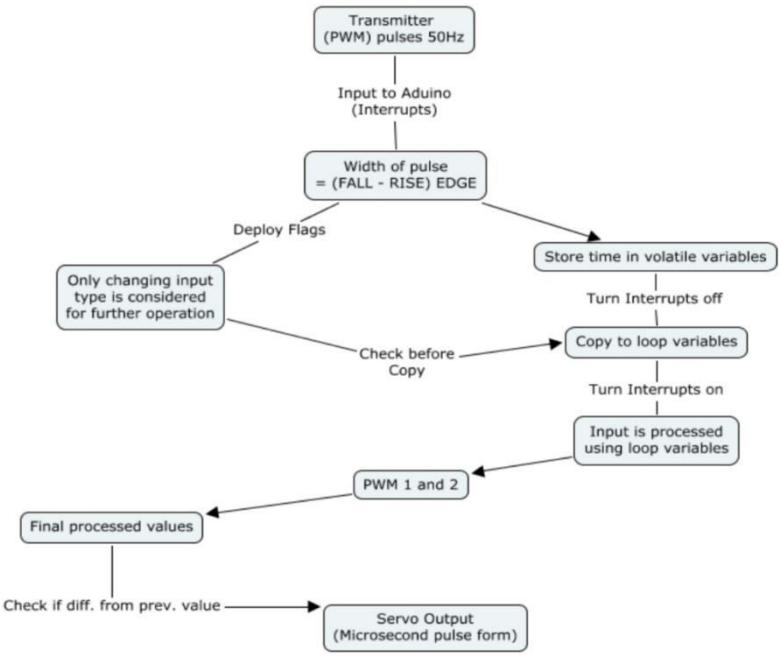

Fig. 5. complete block diagram for inputs from Transmitter and output to BLDC

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V. CALCULATION

1. Consider a weight (load) of 400 – 500 gms.
2. So Motor choose is BLDC motor of 1800kv which produce total thrust of 900gms.as two motor producing up thrust and two producing downthrust so, total thrust in upward direction is 1800gms.max.power 180w, shaft dia.5mm.
3. As motor gets choose ESC & Propellers are also choosen.
4. ESC is of 30Amp. as per motor. And weight is 22 gms of one.
5. Propellers are 1045 ie.10 x 4.5 inch(25 x11cm) pusher and puller propeller. Having weight 30 gms.
6. As it is quadcopter the frame used is cross shaped (X) having four arm or F450 frame of 220mm length,40mm width & weight 50gm.of one arm. So total weight of frame is 250 gms.
7. Flight controller used is KK 2.1.5 multi rotor LCD Flight controller because is has 6 channel to connect esc, camera etc.
8. Battery used is lipo as per motor. It is 11.1v 2200mAh lipo Battery, having weight 150-160 gms. it is 3s battery, the battery has 3.7V cells. Hence the voltage is 3.7 x 3=11.1V
9. The flying time is max. 15 min. As per battery capacity & performance.
10. The total weight of drone = 250gm(frame)+150gm(battery)=400 gm
11. Thrust produce by 2 motors are 2x900 =1800
12. As weight to thrust ratio is 1:2 so 1800 – 400=1400 gms
13. 1400- 900 =500gms
14. hence the Quadcopter is capable of carrying 400 – 500gms of extra weight(**load).**

VI. FRAME DESIGN

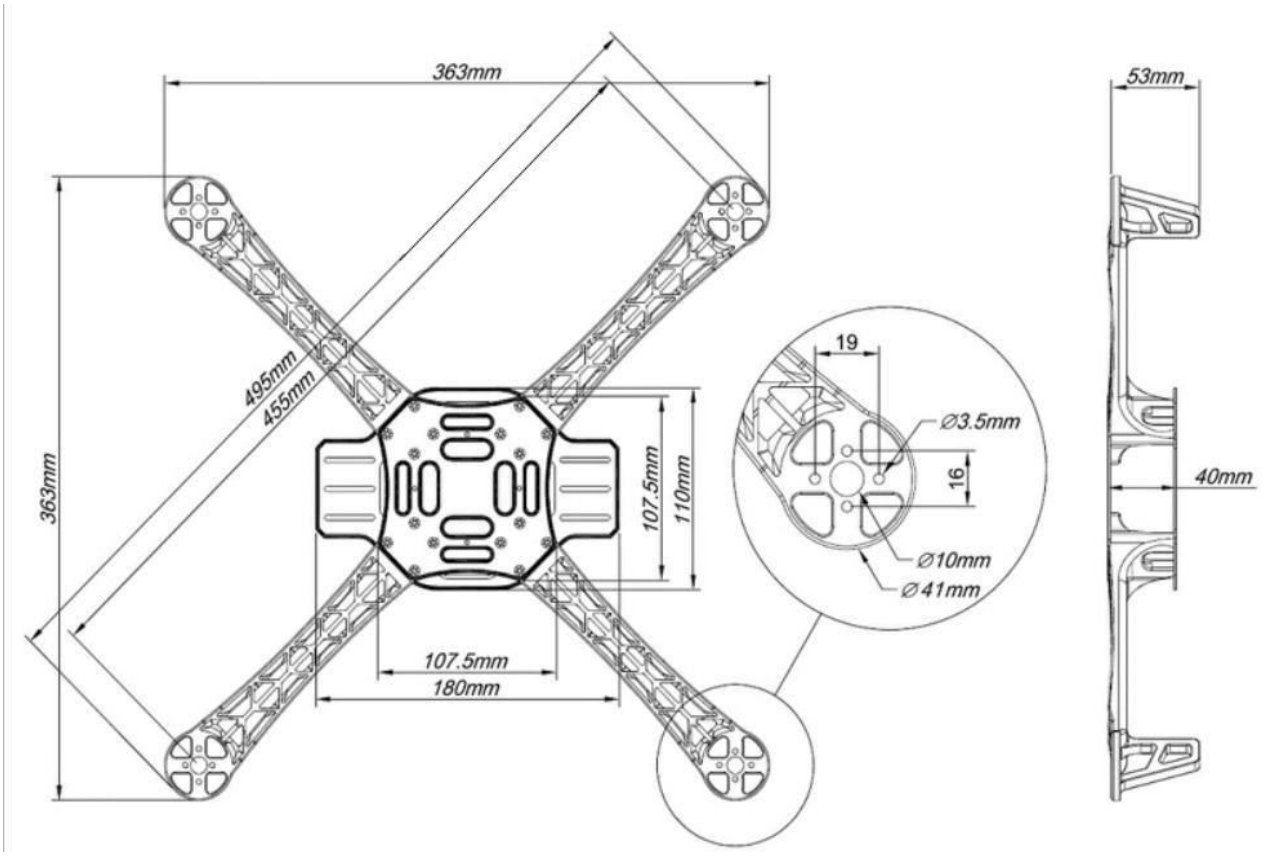

Fig. 6. Frame Design

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VII. APPLICATIONS

1. UAVs provide applications in aerospace.
2. civil for hobby and recreational use.
3. commercial aerial surveillance.
4. professional aerial surveying.
5. commercial and motion picture filmmaking.
6. Journalism.
7. search and rescue.
8. scientific research.
9. disaster relief.
10. Agriculture.
11. Construction.
12. passenger transport.

VIII. CONCLUSION

Drones or unmanned vehicles are an important part of human life, whether from the perspective of monitoring or handling with dangerous substances.

The paper offers an insight into the issue of understanding of quadcopter components and its selection for real drone. There are described basicprinciples of motors function, properties of propellers, ESC or flight controllers. Flight controllers are complex devices, specialized for their task. Their circuit contains sensory system and distributes control signals to each motor. However, there is another way to control drone. The universal microcontroller can be used to control it. It brings advantage to universality. The modular system can be created and modified in different ways according to the task. In this paper is used microcontroller Raspberry Pi 2B, which can provide enough performance to run control system for BLDC motors. It can work in the system itself with the sensory circuit or with the support of complex flight controller.

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