DESIGN AND FABRICATION OF AN UNMANNED AERIAL VEHICLE

A project report submitted in fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

MECHANICAL ENGINEERING

and

Master of Technology

in

Mechatronics and Automation

by

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CERTIFICATE

This is to certify that the project entitled **"Design and Fabrication of an Unmanned Aerial Vehicle"**, being submitted by **Geet Amrit (Roll No.-710ME4082)**, has been carried out under my supervision in fulfilment of the requirements for the degree of Bachelor of Technology in Mechanical Engineering and Master of Technology in Mechatronics and Automation during the session 2014-2015 in the Department of Mechanical Engineering, National Institute of Technology, Rourkela.

To the best of my knowledge, this work has not been submitted to any other University/Institute for the award of any degree or diploma.

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Last but not the least my greetings to all my friends and family members who stood beside and encouraged me in achieving this wonderful feat.

ABSTRACT

The military utilization of Unmanned Aerial Vehicles (UAVs) has improved effectively day by day due to their capacity to carry out the desired work in hazardous and hostile environments while keeping their human administrators at a protected distance. The bigger UAVs likewise give a reliable long span, cost effective platform for observation and in addition weapons. They have been developed to be transformed into an imperative apparatus for the military. The question postured for the project was whether small UAVs additionally had utility in military and business/mechanical applications. It was proposed that smaller UAVs can serve more strategic operations, for example, seeking a village or a building for adversary positions and in addition for completing little scale transportation and conveyance meets expectations in different businesses and marketing endeavors. To accept this suspicion and considering various UAV outlines it was chosen to outline and create a Quadcopter. In this project the primary point is to build up a quadcopter that can be controlled by a straightforward flight controller. With a high payload limit this can be utilized for doing transportation and in addition outside observation as well as surveillance.

CONTENTS

NOMENCLATURE

P	-	Power [W]
rpm	-	Revolutions per minute [in thousands]
P_C	-	Propeller Constant
pf	-	Power Factor
Kv	-	rpm constant of a BLDC motor [rpm/V]
T	-	Thrust [N]
D	-	Diameter of the Propeller [m]
v	-	Velocity of air at the propeller [m/s]
Δv	-	Velocity of air accelerated by propeller [m/s]
ρ	-	Density of air [1.225 kg/m^3]
m	-	Weight generated by each motor and propeller [kg]
m_t	-	Total weight generated by the four motors and propellers [kg]
g	-	Acceleration due to gravity [m/s^2]
t	-	Time [min]
I	-	Total current drawn from the motor [Amp]
BP	-	Battery Power [AH]
T_f	-	Time of Flight [min]

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CHAPTER 1: INTRODUCTION

An unmanned aerial vehicle (UAV), prevalently known as a drone is essentially an airplane without a human pilot onboard. International Civil Aviation Organization (ICAO) groups unmanned airplane into two major categories

1. Autonomous aircraft

Autonomous aircraft are those airplanes which complete the predetermined assignment by its own or through a method of choice making pre-programmed into it.

2. Remotely guided aircraft

Remotely guided aircraft are those airplanes which require an outside controller or joystick to do the required task or as such it can be considered as a manually controlled airplane.

A quad copter, additionally called a quad rotor helicopter, is boosted and pushed by four rotors. Quad copters are delegated rotorcraft, instead of a fixed wing airplane because their lift is produced by a set of rotors (vertically arranged propellers). Unlike most helicopters, quad copters utilize two sets of similar propellers with fixed pitch. Out of the four propellers, two are clockwise (CW) and the other two are counter-clockwise (CCW). These basically use the RPM variation to regulate the lift as well as the torque. The movement control of the vehicle is accomplished by changing the revolution rate of one or more rotor discs, consequently transforming its torque load and thrust characteristics.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

To carry out the design and develop the control circuit of a quad copter several theoretical and practical techniques are reviewed by referring to a number of research papers.

2.2 Technology development

Ashfaq Ahmad Mian et.al. [1] carried their work on a nonlinear model as well as control technique for a quad copter with 6-DOF. The nonlinear model is basically in view with the Newton-Euler equation. The model derivation revolves around determining the mathematical formulation of movement of the Quad-copter in the three dimensional space and looking to imprecise the actuation force through development of electric motor dynamics as well as the aerodynamics coefficients. The inferred model is quite unstable dynamically. Hence, a nonlinear control methodology is finalised for the same. Adequacy of the control configuration plan is demonstrated through the nonlinear simulations.

Achtelik et.al. [2] finished research on visual following control of quad copter using the stereo camera method. The development of a quad copter is controlled in perspective of visual input and estimation of inertial sensor. In this examination work, dynamic markers were finely planned to improve perceivability under distinctive perspectives furthermore to guarantee vigor towards aggravations in the photo based stance estimation. Additionally, position- and heading controllers for the quad were completed to show the limit of the framework. The exhibitions of the controllers were further improved by the use of inertial sensors of the quad copter. A shut circle control structure is successfully coordinated in this exploration.

Santos et.al. [3] inquired about on clever fluffy controller of Quad-copter. The point of their work was to portray a clever framework which utilizes fluffy rationale to control a quad-rotor. It has six degrees of opportunity, three of them regarding the position: flat segment, vertical part and the stature and the staying three are connected with the introduction: Roll, Pitch and Yaw. A control framework is created utilizing fluffy and realized to order a re-establishment model of the quad-copter. The inputs are the estimations of the pitch, move yaw and tallness. The yields are the force created from each of the four rotors . Reenactment results show the capability of this keen control strategy.

Jun Li et.al. [4] carried out research to break down the dynamic attributes and proportional-integral-derivative controller of a Quad-copter. This paper depicts the model of the quad-copter and investigates the dynamic model of the same. This paper additionally creates a blueprint of the controller which expects to manage the stance (orientation as well as position) of the 6-DOF Quad-copter. Thirdly, the dynamic model is executed in Mat lab simulation, and the parameters of the PID controller are acquired according to the simulation results. Finally, a quad-rotor with PID controllers is drafted. The consequences of flying trial demonstrate that powerful stabilisation of the quad-rotor can be achieved using the PID controllers.

Unmanned Aerial Vehicle frameworks require productive mission execution, which is dependent on errand arranging and control. Simi et.al. [5] proposed an undertaking distribution calculation for a multi-UAV sensor framework for identifying thorium intensities in the beachfront districts of India. Power mindful coordination and arranging strategy is used to encourage the activities of various UAVs. Dependent upon the availability of benefits in every detecting UAV unit, each UAV begins a task booking calculation and spreads its remaining errands quickly to diverse UAVs. The control station sends control information to the UAVs and gets the ensed parameters close by the range information from each UAV. The assignment distribution calculation was imitated adequately using an arrangement of static bits. The framework was more effective and capable with the use of this undertaking allotment calculation, as needs be adding to improved mission execution in UAV frameworks.

Md. R Haque et.al. [6] researched and represented quadcopter as a low weight and low cost self-ruling flight equipped for conveying package ordered by online by utilizing an android gadget as its center on-board processing unit. This quad by taking after Google map can find and explore destination. This paper exhibits the quadcopter's capacity of conveying the ordered package and returning to the original position. The promising consequence of this method empowers future research on utilizing quadcopter for delivering packages.

Zhijun Bai et.al. [7] built up an indoor navigation system without the help of a GPS and the system is completely autonomus. In order to stabilise the airplane a stance sensor is used. The SLAM (Simultaneous Localisation and Mapping) and route planning in obscure territory was carried out with the help of a two dimensional lidar. An aligned monocular camera is being utilized to perceive distinctive imprints to help the vehicle to infiltrate the target location. The test outcome demonstrated that the indoor self-governing navigation technique based on lidar for quadcopter is possible and effective.

Unmanned elevated vehicles (UAVs) can help with oceanic search operations carried out by the coast guards by flying with a helicopter and utilizing the infrared cameras in order to scan for the targets inside the water. Present days flight patterns for carrying out the search operations contain unexpected turns that can only be accomplished by a helicopter but was impossible to be done by an UAV. Thus, there was a requirement for developing an UAV-assisted search in path planning and control that helps an UAV to track a specific helicopter carrying out such moves while keeping up the sensor reportage and safety of all other airplanes. Ryan et.al. [8] proposed a feasible algorithm for path planning integrated with an autopilot system. It comprises of four modes and each of the modes has a related domain of application. Every mode is designed to impart both safety as well as contiguous sensor reportage between the UAV and the manned helicopter. Simulations were carried out using a non-linear model of an UAV and a commercially used autopilot system predominantly in the control loop. While performing the simulations, the coveted trajectories were summoned to the autopilot system as a series of waypoints. But, the UAV was not able to track precisely the trajectories, which resulted into certain oscillatory paths with erratic lengths. Thus, the analytic verifications of the tracking errors convergence as well as safety don't apply.

Razieh Nabi-Abdolyousef et. al. [9] introduced an offline path planning technique in 3D space for a surveillance aerial vehicle. In this system, the aerial vehicle should visit specific points on the path, and the crash between the vehicle and the fixed obstacle must be avoided. To accomplish the mission, to begin with, the path is created utilizing B-splines. At that point, the feasibility of tracking the designed path for the vehicle is considered by investigating the vehicle's dynamic limitations, for example, limitations on deflections of control surfaces. The analysis is upheld by a simulation. Potential extension of the proposed analysis to various aerial vehicles has been additionally examined in this research paper.

A.Arun et. al. [10] dealt with an UAV which is fit for autonomous explore in order to geo-localise ground targets which are arbitrarily distributes. The aerial robot captured the video. Successive comparisons of frames of the video are done to extract the three dimensional scene points. Certain choice making standards were outlined which is being utilized for navigation. While navigating autonomously, the target geo-localisation system utilizes a camera located at the bottom point so as to discover ground coordinates of the target. This assignment is accomplished by first enrolling the sequence of the video acquired from the robot with aerial pictures of the region taken by the robot. At that point transformation of geometric coordinate is immediately performed from the aerial pictures to the video sequence frames. By utilizing the sequence of the video caught by the robot, both autonomous navigation and the coordinates of self-assertive ground target can be deduced efficiently and effectively. The significant utilization of work is in the search operation.

S.Aravindan et.al. [11] assessed the position of a low height airborne robot using quaternion theory and Kalman channel strategy. At first using the quaternion speculation, the quaternion rates are made plans to compute the vector quaternion and it is used to learn the quaternion move framework. Subsequent to recognizing these parameters the state variable assignment is made by the movement out of the flying robot. While planning the scientific mathematical statement, the elevation of the elevated robot is taken stunningly low and fourteen variables are considered to add to this comparison. From that point on the Kalman channel system is used to gage the state capacity remembering the deciding objective to focus the definite position and velocity of the ethereal robot.

The aim of the customary aerodynamic control is to change the aerial vehicle attack angle by angular movement prompted by a moment, which is created by redirecting its control surfaces, to make it able to generate pneumatic lift and acquire the normal lateral acceleration. However Wang Zheng-jie et.al. [12] dealt with a manoeuvring process which will bring about a postponement in the sending and directing of command signals. Compared with the aerodynamic control mode, in the direct lateral thrust control mode, the lateral control jet engine is used to generate control force and torque. Thus, in this paper a joined control method of lateral thrust and aerodynamic force is proposed to take care of the issue of fast reaction and high accessible overload. In the first place, the control plan is built up utilizing the aerodynamic optimized control as the principle input and the response jet control framework (RCS) as the auxiliary input. At that point the dynamics and kinematics mathematic model of the aerial vehicle is built taking into account the direct lateral thrust control. As the last step, going for the undertaking of terminal phase of the aerial vehicle to attack the objective target from the top, the joined control system is composed by fuzzy adaptive algorithm. Simulation results show that the overload needed under the combined control is lower than that under the aerodynamic optimized control. So this consolidated control system can fulfil the prerequisites of the aerial vehicle overload better than the conventional mode does.

CHAPTER 3: WORKING PRINCIPLE

3.1 Quadcopter Movement Mechanisms

Quadcopter is a small unmanned aerial vehicle comprising of four propellers that are joined to every rotor arranged at the quad's cross frame. The fixed pitched rotors are utilized to control the quadcopter movement. The four rotors are not dependent on each other regarding speed, pitch, yaw and roll. On account of this, the quadcopter can be controlled easily with no aggravations. The yaw, pitch and, roll characteristics are illustrated in the Figures 3.1, 3.2 and 3.3 respectively.

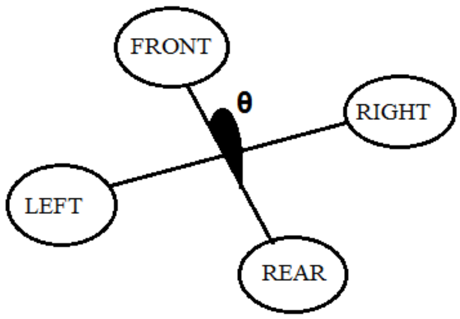

Figure 3.1: Direction of Pitch of Quadcopter

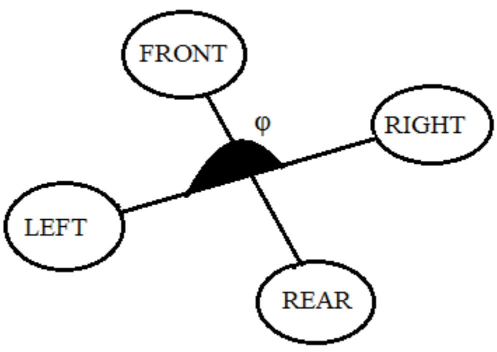

Figure 3.2: Direction of Roll of Quadcopter

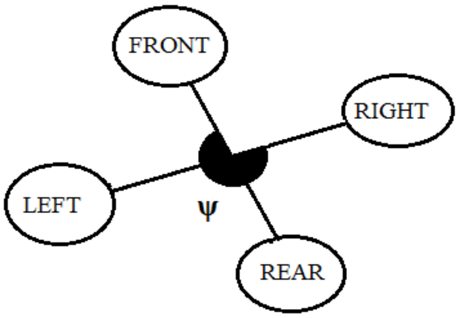

Figure 3.3: Direction of Yaw of Quadcopter

A Quadcopter has four input forces and these forces are essentially the thrust created by the propeller associated with the rotor. The movement of the quad can be controlled by controlling the thrust created and these are controlled by the pace of the rotors.

3.2 Take-off and landing mechanism

The Take off motion of a quadcopter is fundamentally characterized as the lift up from the ground to float in the air all around and landing is the exact inverse. Take off is essentially controlled by increasing the speed of the four rotors all the while and landing by diminishing the same. The takeoff and landing motion of a quadcopter are illustrated in Figure 3.4 and 3.5 respectively.

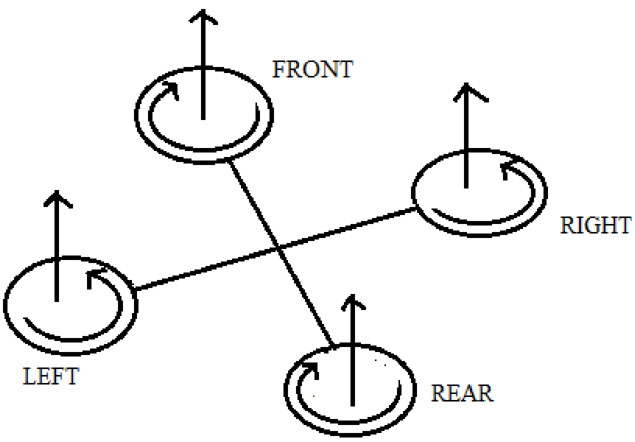

Figure 3.4: Take off motion of Quadcopter

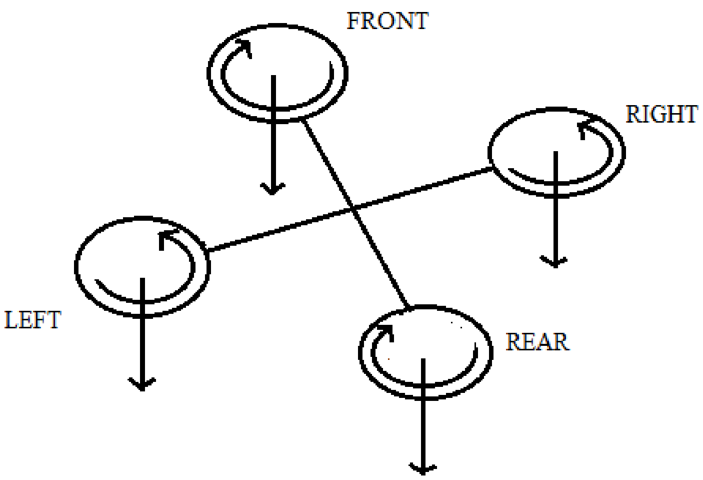

Figure 3.5: Landing motion of Quadcopter

3.3 Forward and backward motion mechanism

Forward movement is controlled by boosting the velocity of the rear rotor while the backward movement is by diminishing the same. Changing the rotor speed will influence the pitch angle which turn controls the quad movement in forward and reverse direction. The forward and the backward motions of a quadcopter are illustrated in Figure 3.6 and 3.7 respectively.

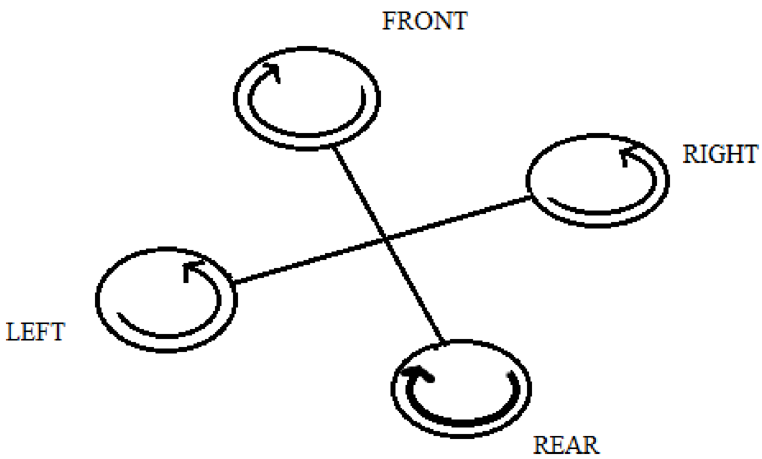

Figure 3.6: Forward motion of Quadcopter

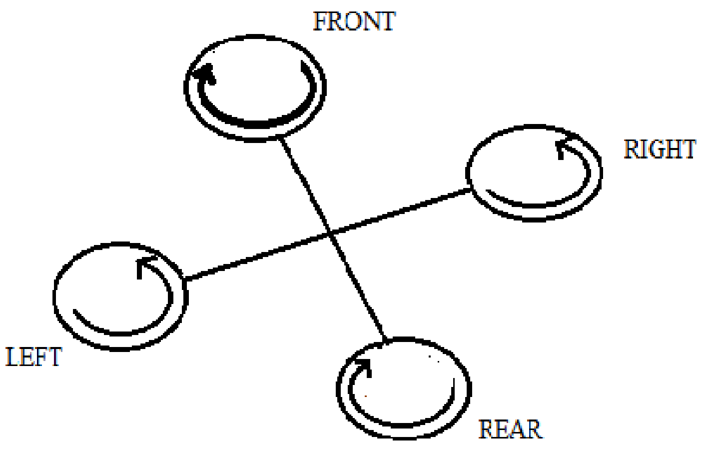

Figure 3.7: Backward motion of Quadcopter

3.4 Leftward and Rightward motion

For controlling the leftward and rightward motion of the quadcopter the yaw angle must be varied. The angle of yaw can be controlled by boosting the anti-clockwise rotor speed while diminishing the clockwise rotor speed or the other way around. The leftward and rightward motions of a quadcopter are illustrated in Figure 3.8 and 3.9.

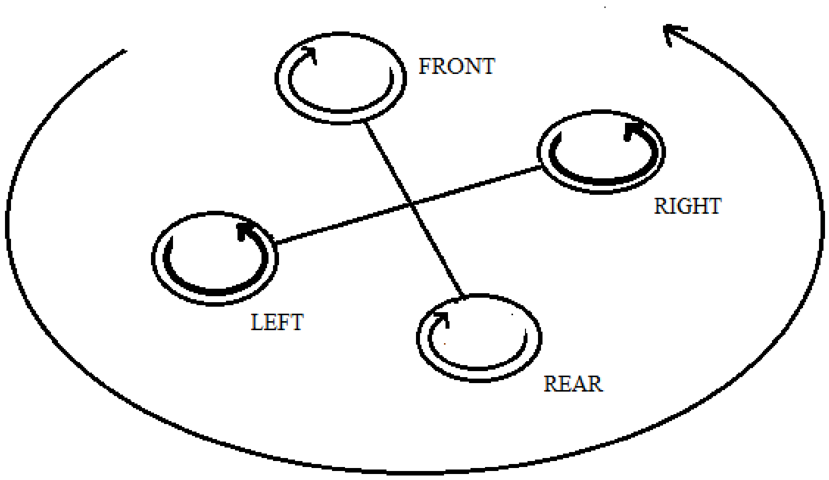

Figure 3.8: Leftward motion of Quadcopter

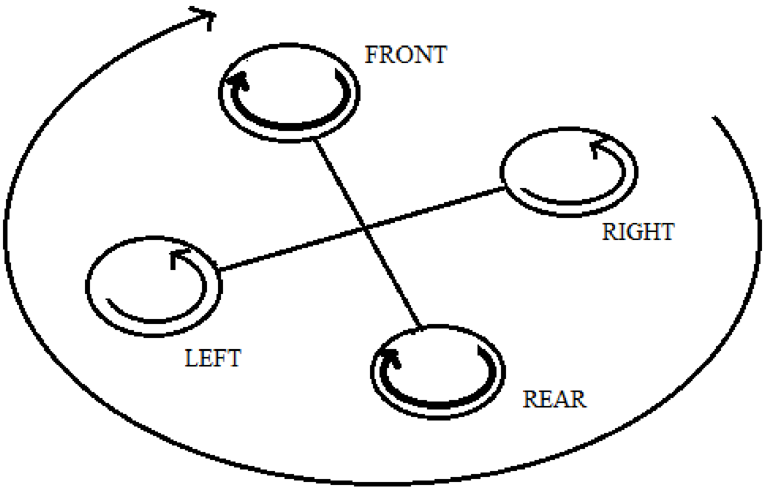

Figure 3.9: Rightward motion of Quadcopter

3.5 Hovering or static position

The hovering or static position of the quadcopter should be possible by two sets of rotors pivoting in clockwise and counter clockwise directions respectively with same velocity. The two sets of rotors turning in clockwise and anti-clockwise directions will result in the sum total of the reaction torque to be zero and therefore keeping the quadcopter in floating position.

CHAPTER 4: WEIGHT ESTIMATION

4.1 Weight estimation

Weight Estimation is an important parameter for any design as it will help us in understanding the stability of the model.

Sl. No.	Name of the Component	Number of Components	Weight of each Component	Total Weight
1	Quadcopter Frame	1	300 g	300 g
2	BLDC Motor	4	80 g	320 g
3	Battery	1	380 g	380 g
4	ESC	4	30 g	120 g
5	Propeller	4	15 g	60 g
6	Collet	4	5 g	20 g
7	LCD Flight Controller	1	35 g	35 g
8	Machine Screws, Standoffs and Wirings (Estimation)		200 g	200 g
				1435 g= 1.435 kg

Table 1: Weight estimation of the Quadcopter

CHAPTER 5: CALCULATION

5.1 Static Thrust calculation

Static thrust calculations are very much necessary in order to ensure the correct propellers and motors have been chosen. Static thrust is characterized as the measure of thrust developed by a propeller which is found stationary with respect to the earth. This estimation is especially critical for this project because the quadcopters are more prone to perform at low speeds in respect to the earth. This low-speed performance guarantees that the calculation of static thrust can be applied to an extensive range of flight conditions. Additionally, it is imperative to note that the last computations of static thrust are estimates and not real values.

The first step towards calculating the static thrust is by determining the power delivered by the motors to the respective propellers in terms of rpm. The empirical formula used to calculate the power is given by equation 1.

$$P = P_C * rpm^{pf} \qquad (1)$$

Where

P-Power [in W]

rpm- Revolutions per minute [in thousands]

P_C- Propeller Constant

pf- Power Factor

Since the DC motors are generally rated in Kv (rpm/V), the rotational speed at which maximum power can be attained is calculated by multiplying the motors Kv by half the voltage of the battery and then dividing the results by 2. This process is shown in Equation 2.

$$rpm_{maxPower} = \frac{Kv * 0.5 * \text{Battery Volts}}{2} \qquad (2)$$

So,$rpm_{maxPower}$=(1500*0.5*11.1)/2=4162.5

In this case the propeller constant P_C of a 10X4.5 propeller is 0.190 and a power factor is 3.3. The rotational speed is 4162.5 rpm, the calculation is as follows.

Power=$0.19*4.1625^{3.3}$=21 W.

The next step is to calculate the amount of thrust produced by the propeller. Equation 3 gives the thrust on the basis of the Momentum Theory.

$$T=\frac{\pi}{4}D^2\rho v\Delta v \qquad (3)$$

Where,
T=Thrust [in N]
D=Diameter of the Propeller [in m]
v=Velocity of air at the propeller [in m/s]
Δv=Velocity of air accelerated by propeller [in m/s]
ρ=Density of air [1.225 kg/m^3]

The velocity of the air at the propeller is given by v=½Δv of the total change in air velocity: Thus, equation 4 is derived.

$$T=\frac{\pi}{8}D^2\rho(\Delta v)^2 \qquad (4)$$

Equation 5 gives the power that is acquired by the propeller from the motor. Equation 6 gives the result of solving equation 5 for Δv and then substituting it into equation 4. This helps in elimination of Δv and thus, torque can be calculated easily.

$$P=\frac{T\Delta v}{2} \Rightarrow \Delta v=\frac{2P}{T} \qquad (5)$$

$$T=[\frac{\pi}{2}D^2\rho P^2]^{1/3} \qquad (6)$$

P=21W

D=10 inches=10*2.54=25.4cm=0.254m

ρ= 1.225kg/m^3

So, T= $[(3.14/2)*(0.254)^2*1.225*(21)^2]^{1/3}$

= $(54.747)^{1/3}$

=3.797 N

Finally, it is preferable to express the results of equation 6 in terms of mass. From Newton’s second Law, F=ma, we can derive the following equation.

$$m=\frac{1}{g}[\frac{\pi}{2}D^2\rho P^2]^{1/3} \qquad (7)$$

Where g=9.81m/s^2

So, m=3.797/9.81

=0.387 kg

For the four motors and propellers

Total Weight, m_t =4*m=4*0.387=1.55 kg

Solving for mass is useful for quadcopters because it can be directly related to the mass of the airplane. It can be clearly seen that the total weight of the four motors is approximately equal to that of the estimated weight. Hence, the selection of materials for carrying out this project work is satisfactory.

5.2 Time of Flight Calculation

The time of flight for the quadcopter is calculated using the empirical formula

t=BP*60*0.9/ I (8)

Where,
t- Time [in min]
BP-Battery Power [in AH]
I- Total Current drawn from the motor [in Amp]
0.9 is multiplied for considering 10% error.

In this case we are using a 3300mAH LiPo battery and 10*4.5 propellers.
Current needed for a 10*4.5 inch Propeller is around 3.2 A

So, Time of flight, T_f= 3.3*60*0.9/3.2=55 minutes

The time of flight is calculated theoretically is without considering the air resistance and without any payload.

CHAPTER 6: DESIGN AND SPECIFICATIONS

6.1 Quadcopter Frame

The frame is the essential skeletal structure of the Quadcopter. It is a tough 49.5 cm diameter outline with power tracks on PCB (Power Control Board) for straightforwardly joining ESCs to battery. This feature facilitates the electronic design and makes the platform more reliable.

Arms are comprised of ultra tough polyamide nylon. Arms have brass supplements with M3 screw threads. They can survive rehashed crashes without breaking.

The design of the bottom plate, top plate and the assembled frame of the quadcopter are shown in figure 6.1, 6.2 and 6.3 respecively.

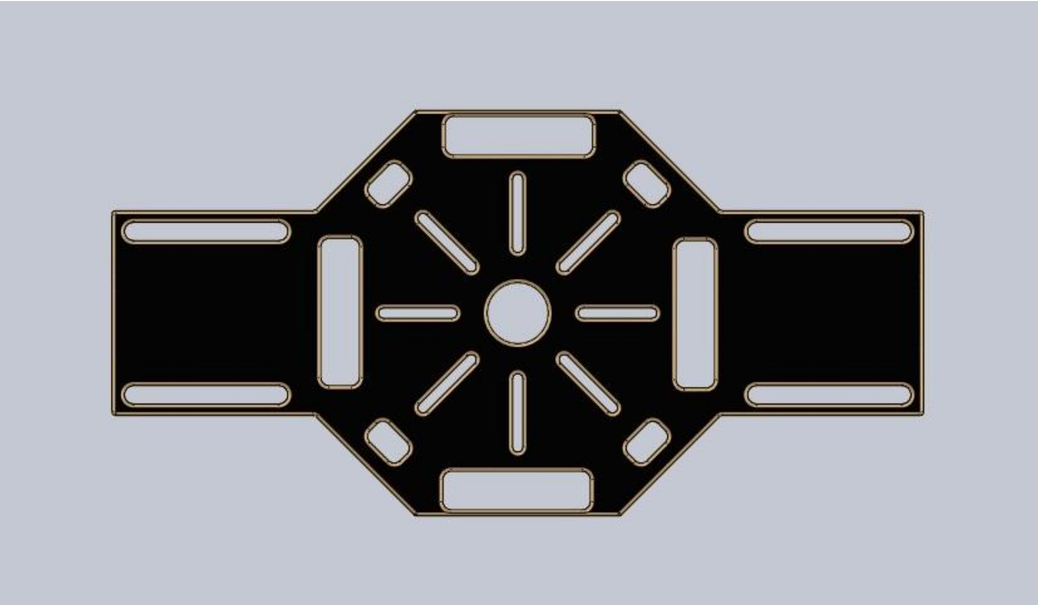

Figure 6.1: Design of Bottom Plate

Figure 6.2: Design of Top Plate

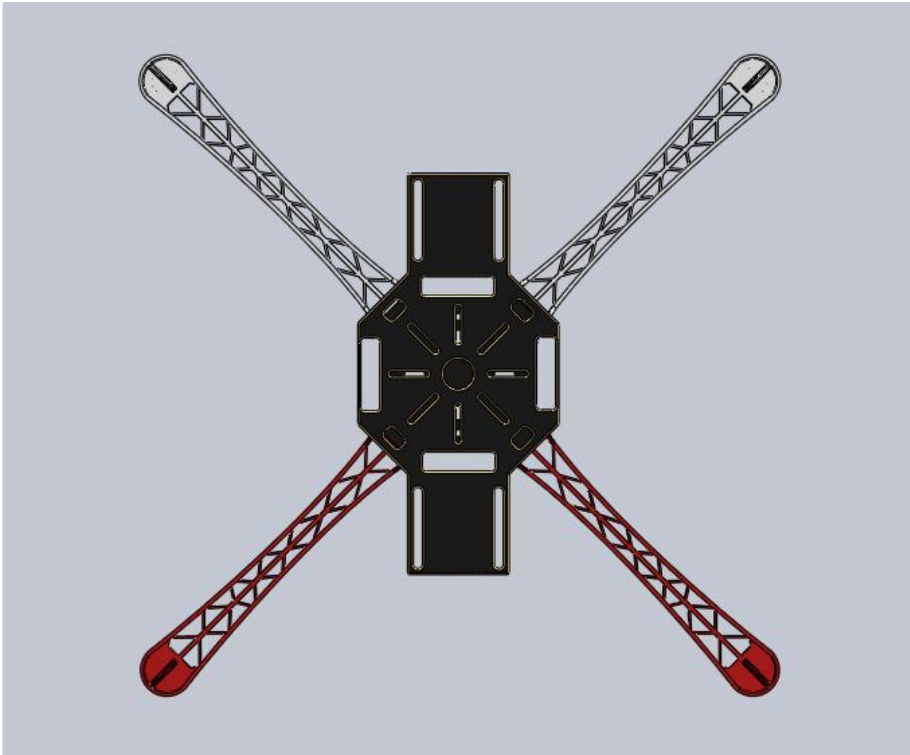

Figure 6.3: Assembled frame of the Quadcopter

6.2 Brushless DC Motor

Figure 6.4: Design of Brushless DC Motor

Brushless DC electric motors (BLDC motors) otherwise called electronically commutated motors (ECMs, EC engines) are the synchronous motors that are generally powered by a DC electric source. The rotor part of a brushless motor is a permanent magnet synchronous motor, however can likewise be a switched reluctance motor, or induction motor.

Brushless motors offer a few preferences over brushed DC motors

- It provides more torque per weight
- It provides more torque per watt (higher efficiency)
- Increased unwavering quality
- Diminished commotion
- It has longer lifetime (Brush and commutator disintegration is prohibitted)
- Ionizing sparks from the commutator are generally disposed, and there is also an overall diminishment of electromagnetic interference (EMI).
- As the rotor has no windings, they are not subjected to the action centrifugal forces, and as the windings are upheld by the housing, they can be cooled by the process of conduction, obliging no air flow inside the motor for cooling. This implies that the motor's internals can be completely encased and shielded from other outside matter.

6.2.1 Specifications of BLDC Motor

Sl.No.	Specification	Parameter
1	KV(rpm/v)	1300
2	Maximum Power	190W
3	Maximum Thrust	920 grams
4	Weight	53 grams
5	Shaft Diameter	3.175mm
6	Shaft Length	45mm
7	Battery	2S-3S Li-Po
8	ESC(A)	30A

Table 2: Specifications of BLDC Motors

6.2.2 Dimensions of BLDC Motor

Sl.No.	Dimensions	Parameter
1	Motor Diameter	28 mm
2	Motor Length	30 mm
3	Shaft Diameter	5 mm
4	Shaft Length	65.5 mm

Table 3: Dimensions of BLDC Motors

6.3 Propeller

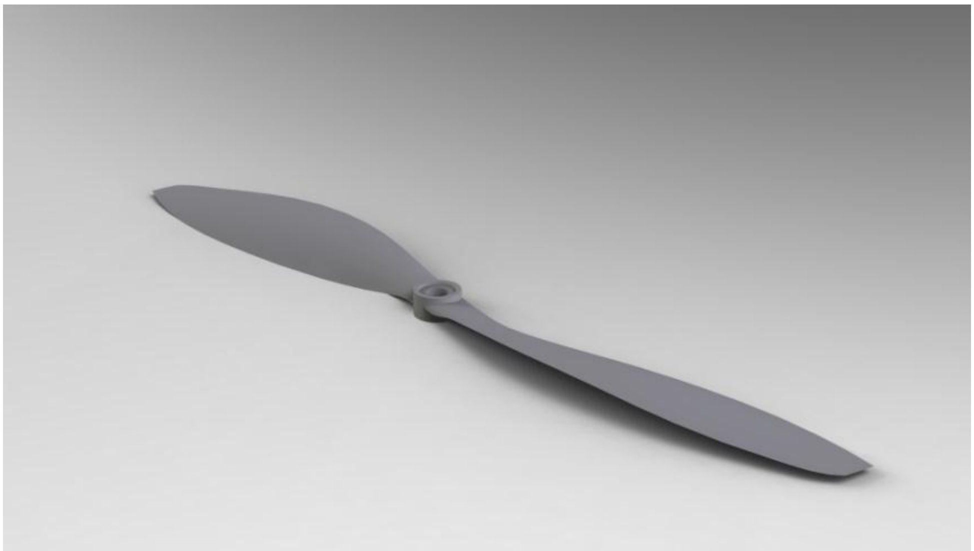

Figure 6.5: Design of Propeller

A propeller is a kind of fan that transmits power by changing the rotational movement into thrust. A pressure difference is created between the forward and back surfaces of the airfoil-shaped blade, and a fluid, (for example, air or water) is accelerated behind the blade. Propeller dynamics can be demonstrated by both Bernoulli's law and Newton's third law.

6.3.1 Specifications of the Propellers

Sl.No.	Specifications	Parameters
1	Type	Pusher and Puller pair of propellers
2	Diameter	10 inch (25 cm)
3	Pitch	4.5 inch (11 cm)
4	Weight	13 gms
5	Supported motor shafts	3mm, 3.2mm, 4mm, 5mm, 6mm, 6.35mm and 7.95mm

Table 4: Specifications of the propellers

6.4 Electronic Speed Controller (ESC)

This is completely programmable 30A BLDC ESC with 5V, 2A BEC (Battery Eliminator Circuit).This can drive motors with nonstop 30A load current. It has a tough construction with two different PCBs for controller and ESC power MOSFETs. It is additionally provided with heat sink on the MOSFETs for better heat dissipation. It can be controlled with a 3 Cell Lithium Polymer Battery. It has separate voltage controller for the microcontroller for giving great anti-jamming capacity.

6.4.1 Specifications of ESC

Sl.No.	Specifications	Parameters
1	Output Current	30A continuous; 35A for 10 seconds
2	Input Voltage	2-4 cells Lithium Polymer / Lithium Ion battery or 5-12 cells NiMH / NiCd.
3	Battery Eliminator Circuit	5V, 2Amp for external receiver and servos
4	Max Speed	2 Pole: 210,000rpm 6 Pole: 70,000rpm 12 Pole: 35,000rpm
5	Weight	22gms
6	Size	47mm x 27mm x 12mm

Table 5: Specifications of ESC

6.4.2 Features

1. It has high quality MOSFETs for BLDC motor drive.
2. It is equipped with a high performance microcontroller for best compatibility with all types of motors at greater efficiency.
3. It can be made fully programmable with any standard RC remote control.
4. It is provided with heat sink with high performance heat transmission membrane for better thermal management.

5. It has 3 start modes: Normal / Soft / Super-Soft, which is generally compatible with fixed wing aircrafts and helicopters.
6. The throttle range can be configured to be compatible with any remote control available.
7. It generally gives a smooth, linear and precise throttle response.
8. Protection from Low-Voltage cut-off
9. Over-heating is prohibited
10. It has a separate voltage regulator IC for the microcontroller to provide anti-jamming capability.
11. Supported Motor Speed (Maximum): 210000RPM (2 poles), 70000RPM (6poles), 35000RPM (12 poles)

6.5 Battery

It is a 11.1V, 3 Cell, 3300mAh, 20C Lithium Polymer battery which can give discharge current of 66 Amps. It is provided with a "T"type power connector as well as a 4 pin JST connector for charging. It is the most perfect battery for the quadcopter which obliges high current.

6.5.1 Specifications of Battery

Sl.No.	Specification	Parameter
1	Type of Battery	Lithium Polymer
2	Voltage of Battery	11.1V
3	Capacity of Battery	3300mAh
4	Number of cells in Battery	3
5	Maximum constant discharge current	66Amps (20C)
6	Maximum charging current	6.6Amps (2C)
7	Battery cut off voltage	9.9V
8	Weight of battery	201gms
9	Dimensions of battery	Length-14cm, Width-2.6cm, Height-4.2cm
10	Power Connector	‘T’ type female power connector with 4mm^2 multistrand copper wire
11	Charge connector	4pin JST connector

Table 6: Specifications of battery

6.6 LCD Flight Controller

It is a flight control board which is basically used for Quadcopters. Its intention is to stabilize the airplane amid flight. To carry out the same it takes the signal from the 6050 MPU gyro/acc (yaw, pitch and roll) and then passes the same to the Atmega644PA IC. The Atmega IC unit then processes these signals in accordance to the clients chosen firmware and the control signals are passed to the Electronic Speed Controllers (ESCs). These signals direct the ESCs to make fine acclimations to the motors rotational velocity which in turn helps to balance the aircraft.

The control board likewise uses signals from the radio systems receiver (Rx) and passes these signals to the Atmega644PA IC through the aileron, lift, throttle and rudder inputs. When these data has been processed the IC will send varying signals to the ESCs which in turn alters the rotational velocity of each motor to actuate controlled flight (up, down, backward, forward, left, right, yaw).

6.6.1 Specification of Multi-rotor LCD Flight Controller

Sl. No.	Specifications	Parameters
1	Size	50.5mm x 50.5mm x 12mm
2	Weight	21 gram (Inc Piezo buzzer)
3	IC	Atmega644 PA
4	Gyro/Acc	6050MPU
5	Auto-level	Yes
6	Input Voltage	4.8 V-6.0 V
7	AVR interface	Standard 6 pin
8	Signal from Receiver	1520us (5 Channels)
9	Signal to ESC	1520us

Table 7: Specifications of Multirotor LCD Flight Controller

CHAPTER 7: CONCLUSION AND FUTURE PLANS

The design of the Quadcopter was successfully carried out. It can be clearly seen that the total weight of the four motors is approximately equal to that of the estimated weight. Hence, the selection of materials for carrying out this project work is satisfactory. Fabrication of the Quadcopter using the above mentioned list of materials was also done successfully. The final assembled unit of the quadcopter is shown in Fig. 7.1.

Height of Flight	**Simulation Value**	**Experimental Value**	**Error (%)**
At 10m	4.50s	4.70s	4.4
At 20m	9.40s	9.70s	3.2
At 30m	12.30s	12.54s	1.9
At 40m	17.9s	18.4s	2.7
At 50m	23.41s	24.58s	4.9

Table 8: Time of Flight comparison at different distances

It can be clearly seen from Table 2 that the simulation value is less as compared to the experimental value. The reason behind this is because of the air resistance that the quadcopter encounter during the experimental flight. It can be concluded that the Quadcopter will be unstable for a certain range of flight, becomes stable at a height of 30-40 m and then it again becomes unstable as the height again increases.

Figure 7.1: Assembled unit of the Quadcopter

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