UNMANNED AERIAL VEHICLE CONTROL DESIGN

Project Report submitted in partial fulfillment of the requirement for the degree

Of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

By

Anubhav Mathur (141003)
Franco Bhalla (141010)
Rachit Saini (141011)

UNDER THE GUIDANCE OF

Mr. Mohit Garg

Assistant Professor (ECE Department)

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

May 2018

Table of contents

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
(Established by H.P. State Legislative vide Act No. 14 of 2002)
P.O. Waknaghat, Teh. Kandaghat, Distt. Solan - 173234 (H.P.) INDIA
Website: www.juit.ac.in
Phone No. (91) 01792-257999
Fax: +91-01792-245362

CERTIFICATE

This is to certify that the work reported in the B.Tech project report entitled **"UNMANNED AERIAL VEHICLE CONTROL DESIGN "** which is being submitted by **ANUBHAV MATHUR(141003) FRANCO BHALLA(141010) RACHIT SAINI(141011)** in fulfillment for the award of Bachelor of Technology in Electronics and Communication Engineering by the Jaypee University of Information Technology, is the record of candidate's own work carried out by him/her under my supervision. This work is original and has not been submitted partially or fully anywhere else for any other degree or diploma.

Mr. Mohit Garg
Assistant Professor (Grade I)
Department of Electronics & Communication Engineering
Jaypee University of Information Technology, Waknaghat,

DECLARATION BY THE SCHOLARS

We hereby declare that the work reported in the B-Tech project report entitled **"UNMANNED AERIAL VEHICLE CONTROL DESIGN"** submitted at **Jaypee Univeristy of Information Technology, Waknaghat India** is an authentic record of our work carried out under the supervision of Mr. Mohit Garg (Assistant Professor Grade I). We have not submitted this work elsewhere for any other degree or diploma.

Name of the scholars:

Anubhav Mathur(141003)

Franco Bhalla(141010)

Rachit Saini(141011)

Department of Electronics and Communication

Jaypee University of Information Technology

Waknaghat, India

Date:May 11,2018

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our supervisor **Mr. Mohit Garg**, Assistant Professor (Grade-1), for his supervision, encouragement, and support which has been instrumental for the success of this project. It was an invaluable experience for us to be one of his students. Because of his, we have gained a careful research attitude. Thanks to those who are also the part of this project whose names could have not been mentioned here.

Anubhav Mathur (141003)

Franco Bhalla (141010)

Rachit Saini (141011)

List of Abbreviations

AUV	Autonomous Underwater Vehicle
GNC	Guidance, Navigation and Control
HIL	Hardware in the Loop
LOS	Line of Sight
LP	Low Pass
NED	North-East-Down
NED	North-East-Down
PID	Proportional-Integral-Derivative
SMC	Sliding Mode Control
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UDP	User Datagram Protocol
VTOL	Vertical Take Off Landing

List of figures

Abstract

A Quadcopter also called a Quadcopter helicopter or Quadcopter is a multirotor helicopter that is uplifted and pushed by four rotors. Quadcopters for the most part utilize two sets of indistinguishable settled pitched propellers; two clockwise (CW) and two counterclockwise (CCW). In late 2000s, progresses in gadgets permitted the generation of shabby lightweight flight controllers, acclemoters (IMU), worldwide situating framework and cameras. This brought about the Quadcopter arrangement getting to be prominent for little unmanned ethereal vehicles. With their small size and flexibility, these Quadcopters can be flown inside and in addition outside.

Automatons are of various kinds and have diverse setups for instance, bicopters, tricopters, UAV, hexacopter, octocopters, and so on. They have diverse utilizations and as needs be individual designs are utilized. Hexacopter and Octocopters have better dependability and yaw designs. Control of movement of vehicle is accomplished by adjusting the pivot rate of one or engine plates.

Our venture will exhibit a plan of a direction and control framework to use on air ships, basically on UAVs. The control techniques are Proportional-Integral-Derivative (PID) and sliding mode control. The last controller is nonlinear and more powerful than the PID. Sliding mode may be utilized for pitch and height control, while PID will deal with turning control and in addition pitch and elevation. The autopilot configuration should deal with shifting payload and wind. The direction framework will make a way for the UAV to take after in light of waypoints given. The exhibited techniques are actualized on MATLAB. We will utilize the ODE 45, ODE23 solver on MATLAB to tackle the differential conditions utilized as a part of finding the direction of the Quad copter

After learning how to simulate the working of a quadcopter we shifted our focus to making one. We gathered information from several websites and also referred to various IEEE papers to know what equipment is required to make a quadcopter. The comparisons between the simulated model and the hardware were made and thus a real understanding of the working of a quadcopter could be achieved.

CHAPTER 1
INTRODUCTION

There are numerous different suppositions of what an Unmanned Aerial Vehicle (UAV) is. Numerous trust that they are utilized for military purposes, however this is a long way from reality. An Unmanned airborne vehicle(UAV), additionally know as an unmanned airplane system(UAS), remotely guided aircraft(RPA) or unmanned air ship, is a machine capacities either by the remote control of a pilot or pilot(called a Combat System Officer on UAVs). The most essential definition of a UAV is that it is an aeronautical vehicle without a pilot, Unmanned Aerial Vehicle System Association Without pilot implies that the flying vehicle don't have a pilot on load up nor a pilot on the ground in a control focus, alluded to as a Ground Control Station. On the off chance that the flying vehicle has a pilot on ground who can speak with the vehicle, it is alluded to as an Unmanned Aerial System (UAS). The UAV is prearranged and should do the task and return without human obstruction, while a UAS is remotely worked amid the activity. In the lexicon, the UAV is defined as: A fueled, aeronautical vehicle that does not convey a human administrator, utilizes streamlined powers to give vehicle lift, can fly self-rulingly, can be superfluous or recoverable, and can convey a deadly or nonlethal payload. Ballistic or semi ballistic vehicles, voyage rockets, and big guns shots are not viewed as unmanned elevated vehicles.

1.1 <u>Motivation & Objective behind this project</u>

Unmanned flying vehicles (UAVs) are ending up increasingly well known in a wide field of utilizations these days. Despite the fact that being produced for the most part for military purposes previously, it winds up evident that there are a great deal of different regions where they may demonstrate helpful. Think about agribusiness for instance, where they might be utilized for field perceptions or for chemicals circulation. They can watch over wide woodland regions as a fireguard, or they can be utilized for traffic perception in the urban communities. In cartography, little UAVs may be utilized for programmed scene capturing, being considerably more cost-efficient contrasted and conventional elevated snap shooting. UAVs are moreover particularly captivating for the academic research, as they can be utilized for different purposes - as flying labs, demonstrating ground for control calculations, or as a training apparatuses for understudies. To make a UAV fly it needs an autopilot.

Through this project we desire to understand the dynamics of an Unmanned Aerial Vehicle (quadcopter here). From the very beginning the objective was to apply our knowledge of ‘Control Systems’ and ‘Robotics’.

Initially, the aim of this project was to find a perfect mathematical model for such a device and then develop an entire control architecture which would allow the quadcopter to fly independently. The plan was to simulate the working of a quadcopter with the help of MATLAB and then comprehend the results obtained.

After having finished the simulation our next objective was to make our own quadcopter and closely study the hardware used in making one.

1.2<u>Literature review</u>

Paper 1[1]:-

Tested that the model of a Quadcopter is nonlinear and powerfully flimsy because of the abnormal state of framework nonlinearity and outside unsettling influences. So he utilizes a strong second request sliding mode controller for height following of a Quadcopter. The controller is determined utilizing Lyapunov security approach and demonstrated hypothetically asymptotic solidness. The execution of proposed control strategy is assessed by contrasting the execution and traditional sliding mode control from the writing. It is exhibit that the proposed second request sliding mode control enhances the following control execution with better transient exhibitions..

Paper 2[2]:-

In this they proposed that a Quadcopter is nonlinear, coupled and insecure framework. Two control plans, specifically back stepping and sliding mode, have been connected to get wanted direction following by Quadcopter. They display the relative execution consequences of Quadcopter under two control plans.

Paper 3[3]:-

In this, a moment arranges sliding mode control (SMC) is suggested to increase the execution of Quadcopter. The sliding surface of the proposed controller rests on the corresponding vital subordinate (PID) progression. The control law is inferred based on the Lyapunov solidness hypothesis, which ensures that all the framework state directions reach and remain on the sliding surfaces. The proposed control technique is contrasted and ordinary sliding mode control. It is exhibited that the proposed PID-based second-arrange sliding mode control enhances the execution of Quadcopter with better elevation following particular and quicker joining while at the same time keeping up dependability even after the event of outside aggravations and parameter vulnerabilities.

CHAPTER 2

DYNAMIC MODELLING OF QUADCOPTER

We initially needed to portray the introduction and the material science behind the Quadcopter flight. A quadcopter is inalienably an exceptionally precarious framework. Anybody endeavoring to control a quadcopter with manual information sources just and no mentality sensor mix would rapidly find that adjusting the flying machine is practically unthinkable.

2.1 DETERMINING QUADCOPTER ORIENTATION

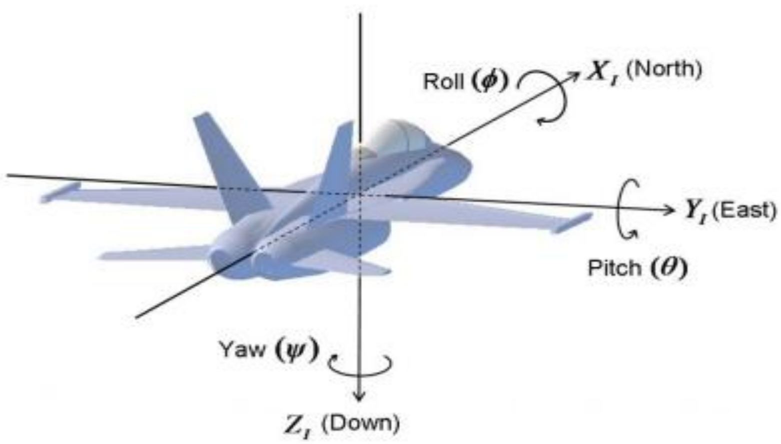


Figure 1: Inertial Frame of a Free Body

Keeping in mind the end goal to balance out the Quadcopter, it is first urgent to decide the flying machine introduction (additionally called state of mind) with respect to the settled inertial edge of the earth. This inertial casing is appeared in Figure 10, and comprises of 3 orthogonal tomahawks (North, East, and Down) and the rotations about these tomahawks (Roll, Pitch, and Yaw).

With a specific end goal to accomplish stable flight, the roll and pitch tomahawks should first be balanced out. On the off chance that these tomahawks are not legitimately controlled, the Quadcopter will instantly tip over and be not able fly. The yaw hub should likewise be generally steady for the Quadcopter to be controllable, yet is less basic.

2.2. THE PHYSICS OF QUADCOPTER FLIGHT

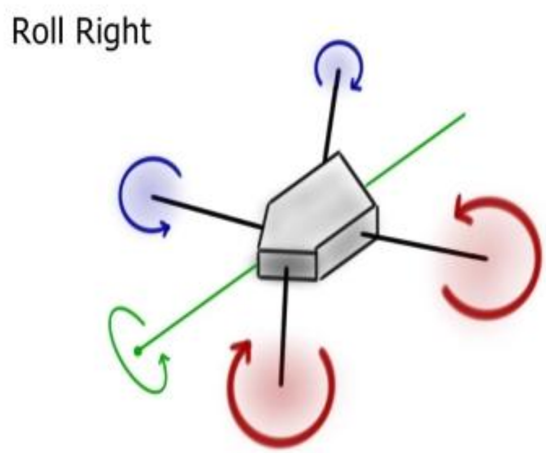
Before we leave upon a venture as mind boggling as this one, it is helpful to have a comprehension of the hypothetical underpinnings included. I think it is important to have no less than an essential comprehension of the material science of Quadcopter flight. While it is unquestionably conceivable to just take after an arrangement of bearings for building and flying a multirotor, it will be much clearer, and more important, on the off chance that you can disclose to yourself the reason behind each progression. There is a colossal measure of material science engaged with multirotor flight, and we are just going to skim the surface in this report. Here we will center around the material science engaged with moving the multirotor which includes modifying the adjust of powers following up on the art.

2.2.1 STEERING

While flying a multirotor, it is quite important to note how it moves and how it is that we are going to control it. Behind all the multirotor developments there is a role of the rotational speed of the engines. Just by changing the relative rates of the engines in the correct proportion and remembering that it is the rotational speed of the engines that decide how much lift each of the prop delivers, the controller of the flight can make the multirotor pivot around any of the direction (move, pitch and yaw) and also make the multirotor pick or drop height.

2.2.2 ROLL AND PITCH

To turn the multirotor about the roll or pitch tomahawks, the flight controller makes engines on one side speedier than on the other this lifts one part of the multirotor higher than the other side hence making it tilt to that side. In the same way to make the quadcopter move towards the right the flight controller makes the two engines on the left side to turn quicker than the engines on the correct side, which will lift the left side more than the correct side which will ultimately result in the right tilting of the multirotor. Similarly to make a quadcopter pitch down the controller of the flight makes the two engines on the back of the art turn faster then the two engines on the front.



.

Figure 2: Left or right roll of quadcopter by adjusting the relative speeds

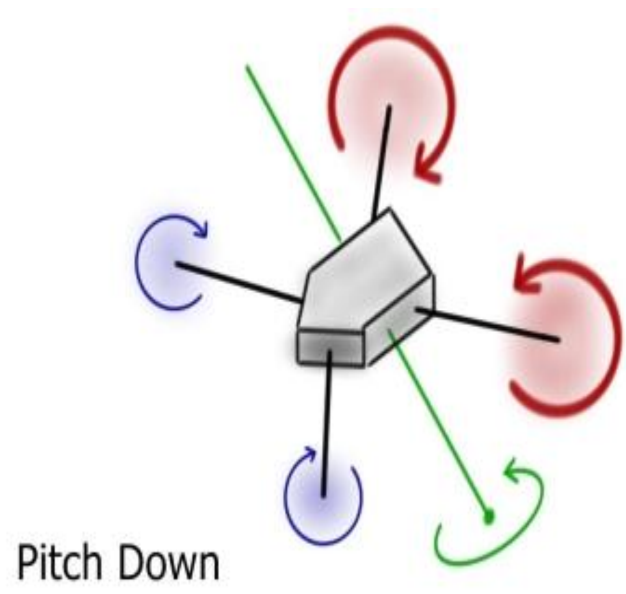


Figure 3: Pitch up and down of quadcopter by adjusting the relative speeds

2.2.3 YAW

Managing the multirotor revolution about the yaw hub is more mind boggling than managing its turn about the roll or pitch tomahawks. To start with, how about we talk about how we forestall pivot about the yaw hub. When collecting and programming multirotor, we set up the engines with the goal that each engine turns the other way than its neighbors.

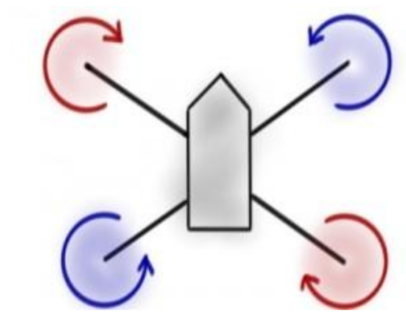


Figure 4: Configuring each motor to spin in the opposite direction

At the point when a propeller rotates for instance, clockwise, conservation of rakish force suggested that the body of the quadcopter will incline to turn counter-clockwise. This is because of Newton's third law of movement, "for each movement, there is an identical and inverse response." The body of the multirotor will incline to turn near the path inverse the rotational route of the propellers. Every one of the Quadcopters four rotors inclines to make the multirotor turn the different way than their turn. So by proper using the sets of rotors to turn it into inverse ways, we can keep the multirotor from turning about the yaw pivot.

So in this way, when we really need the multirotor to focus about the yaw hub, the flight controller will back off opposite sets of engines in context to the next combine. This tends the precise force of the two sets of props to not to be again in adjusting and the art pivots. We can construct the multirotor pivot in either heading by backing off various sets of engines.

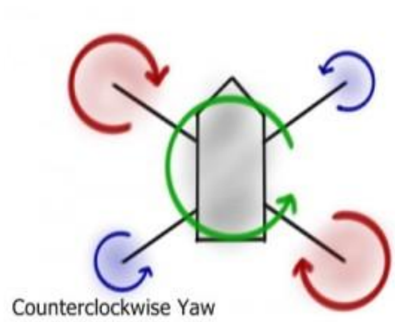


Figure 5: The clockwise-rotations of motors are faster than the counter-clockwise rotation of motors

2.2.4 HOVERING/ALTITUDE CONTROL

To assemble the multirotor drift, which tends the multirotor to stand or fly on consistent height without pivoting in the direction of any path, adjusting of powers is required. Throwing a touch of math into the photo now, the power of gravity backing up on the multirotor is equivalent to the mass of the multirotor times gravitational speeding up. The lift delivered by the multirotor is equivalent to the whole of the lift created by every one of the rotors. In this manner, if the power of gravity measures up to the power of the lift created by the engines, the multirotor will keep up a consistent height. To climb or drop, consequently, the flight controller upsets this adjusts. In the event that the lift created by the multirotor is more noteworthy than the power of gravity, the art will pick up elevation. In the event when the opposite is valid, that is, if the lift proposed by the multirotor is not as much as the power of gravity backing up on the multirotor, at that point the multirotor will fall.

2.2.5 MOVEMENT

We've already discussed how, by altering the relative velocities of the engines, the flight controller can construct the multirotor tilt. The causes we need to have the potential to tilt the multirotor is that tilting the multirotor makes it move. By inclining the multirotor in various ways, it can be made to advance, in reverse, left, or right.

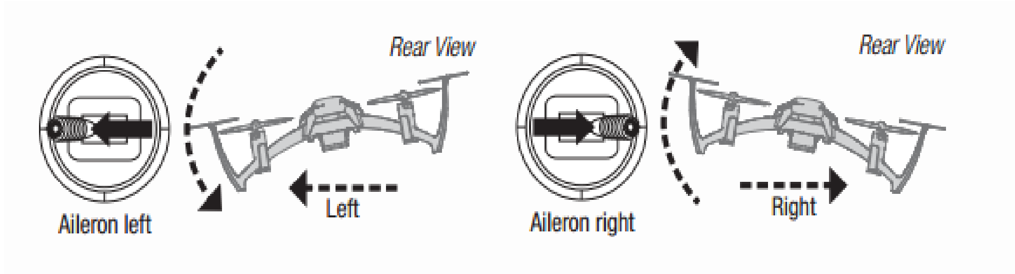


Figure 6: A quadcopter rotating left and right.

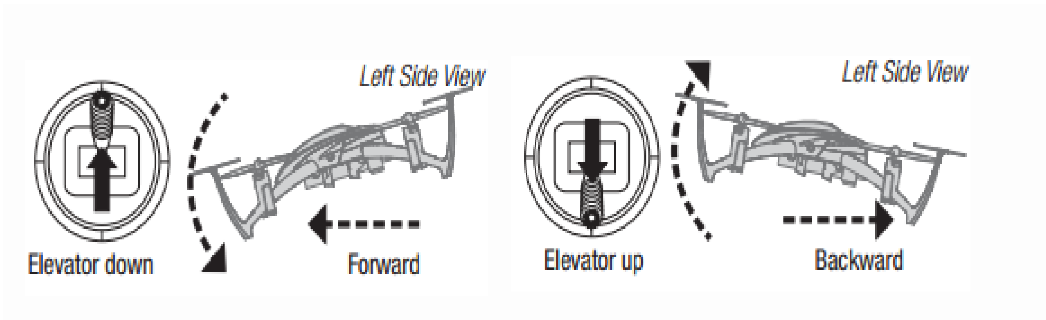


Figure 7: A quadcopter propelling forwards and backwards.

2.3 MATHEMATICAL MODEL

Dynamics of quadcopter using Euler-Lagrange Formalism are presented. Defining E = [e_x, e_y, e_z], the Earth fixed frame and B = [x,y,z], the Body fixed frame. Let Φ, θ & Ψ represent the Euler angles; the outputs of the system are x, y & z, which are positions of the center of gravity of the quadcopter; the p, q and r denote its angular velocities in body-frame and F_i (i=1,2,3,4) is the thrust force produced by each propeller . The orientation of UAV quadcopter is shown in fig.1.

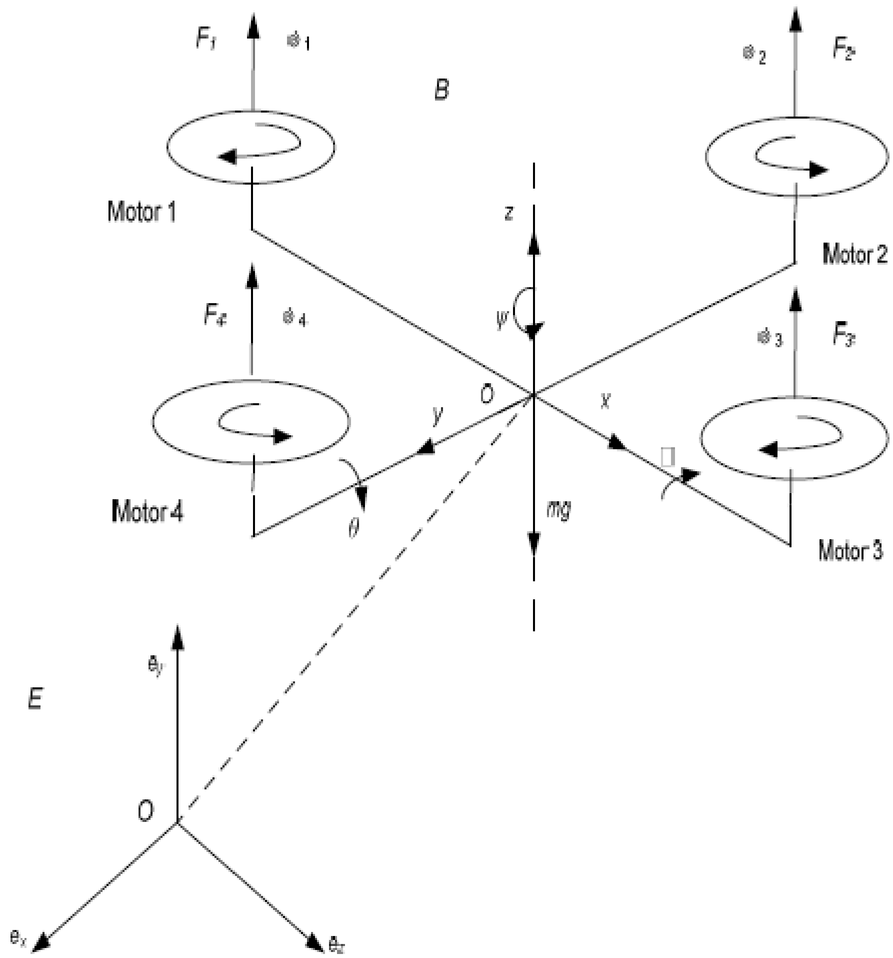


Figure 1: UAV Quadrotor

The dynamical model of quadcopter with x,y and z motions as a consequence of roll, pitch and yaw rotation, can be expressed as:

$$
\begin{aligned}
\ddot{\emptyset} &= \dot{\theta}\dot{\varphi}\left(\frac{I_y - I_z}{I_x}\right) - \frac{J_r}{I_x}\dot{\theta}\Omega + \frac{l}{I_x}U_2 - \frac{K_1 l}{I_x}\dot{\emptyset} \\
\ddot{\theta} &= \dot{\emptyset}\dot{\varphi}\left(\frac{I_z - I_x}{I_y}\right) - \frac{J_r}{I_y}\dot{\emptyset}\Omega + \frac{l}{I_y}U_3 - \frac{K_2 l}{I_y}\dot{\theta} \\
\ddot{\varphi} &= \dot{\emptyset}\dot{\theta}\left(\frac{I_x - I_y}{I_z}\right) + \frac{l}{I_z}U_4 - \frac{K_3 l}{I_z}\dot{\varphi} \\
\ddot{z} &= -g + (cos\emptyset\ cos\theta)\frac{1}{m}U_1 - \frac{K_4 l}{m}\dot{z} \\
\ddot{x} &= (cos\emptyset\ sin\theta\ cos\varphi + sin\emptyset\ sin\varphi)\frac{1}{m}U_1 - \frac{K_5 l}{m}\dot{x} \\
\ddot{y} &= (cos\emptyset\ sin\theta\ sin\varphi - sin\emptyset\ sin\varphi)\frac{1}{m}U_1 - \frac{K_6 l}{m}\dot{y}
\end{aligned} \tag{1}
$$

where, I_x, I_y, I_z, g and m are physical parameters, K_i denote the positive drag coefficients, defined in table 1.1.Where, U_2 and U_3 are the roll and pitch inputs; the U_1 is total thrust on the body in the z-axis; $U4$ is the yawing moment and Ω a disturbance, obtaining:

$$
\begin{aligned}
U_1 &= b(\Omega_1^2 + \Omega_2^2 + \Omega_3^2 + \Omega_4^2) \\
U_2 &= b(\Omega_2^2 + \Omega_4^2) \\
U_3 &= b(\Omega_3^2 + \Omega_1^2) \\
U_4 &= d(\Omega_2^2 + \Omega_4^2 - \Omega_1^2 - \Omega_3^2)
\end{aligned}
$$

For the simulation exercise, physical parameters have been taken from:

Table 1.1

Symbol	Definition	Value
m	Mass	.23kg
l	Arm length	0.23 m
I_z	Moment of Inertia along z axis	1.3e-2 kgm^2
I_y	Moment of Inertia along y axis	7.5e-3 kgm^2
I_x	Moment of Inertia along x axis	7.5e-3 kgm^2
b	Drag coefficient	7.5e-7 Nms^2
d	Lift coefficient	3.13e-5 Ns^2
J_r	Rotor inertia	6e-5 kgm^2
g	Acceleration of gravity	9.8 m/s^2
$K_1 = K_2 = K_3$	Positive constants	0.01Ns/m
$K_4 = K_5 = K_6$		0.012Ns/m

The dynamic model proposed in equation set (1) can be communicate in state space form X =f(X,U) by introducing state vector as

$$X^T = [\emptyset, \dot{\emptyset}, \theta, \dot{\theta}, \varphi, \dot{\varphi}, z, \dot{z}, x, \dot{x}, y, \dot{y}].$$
$$x_1 = \emptyset\ , \qquad x_2 = \dot{x}_1 = \dot{\emptyset}, \qquad x_3 = \theta, \qquad x_4 = \dot{x}_3 = \dot{\theta},$$
$$x_5 = \varphi, x_6 = \dot{x}_5 = \dot{\varphi}, x_7 = z\ ,\ x_8 = \dot{x}_7 = \dot{z}, x_9 = x,$$
$$x_{10} = \dot{x}_9 = \dot{x}, \quad x_{11} = y\ , x_{12} = \dot{x}_{11} = \dot{y}$$
$$(2)$$

From equations (1) and (2) the dynamics is formulated as x=f(X,U).

$$= \begin{pmatrix} x_2 \\ x_4 x_6 a_1 + x_4 a_2 \Omega + b_1 U_2 - d_1 \\ x_4 \\ x_2 x_6 a_3 + x_2 a_4 \Omega + b_2 U_3 - d_2 \\ x_6 \\ x_4 x_6 a_5 + b_3 U_4 - d_3 \\ x_8 \\ -g + (cos x_1\ cos x_3)\frac{1}{m} U_1 - d_4 \\ x_{10} \\ u_x \frac{1}{m} U_1 - d_5 \\ x_{12} \\ u_y \frac{1}{m} U_1 - d_6 \end{pmatrix} \qquad (3)$$

where

$$a_1 = (I_y - I_z)/I_x \qquad a_2 = -J_R/I_x$$
$$a_3 = (I_z - I_x)/I_y,\ a_4 = -J_R/I_y \quad a_5 = (I_x - I_y)/I_z$$

and

$$b_1 = l/I_x,\ b_2 = l/I_y,\ b_3 = l/I_z,\ d_1 = \frac{K_1 l}{I_x} x_2,\ d_2 = \frac{K_2 l}{I_y} x_4,$$
$$d_3 = \frac{K_3 l}{I_z} x_6,\ d_4 = \frac{K_4 l}{m} x_8,\ d_5 = \frac{K_5 l}{m} x_{10},\ d_1 = \frac{K_6 l}{m} x_{12}$$

and

$$u_x = cos x_1\ sin x_3\ cos x_5 + sin x_1\ sin x_5$$
$$u_y = cos x_1\ sin x_3\ cos x_5 - sin x_1\ cos x_5$$

The vertical data force U_1 is used to stabilize the altitude of quadcopter. By the position subsystem crave roll and pitch angle are formed and control inputs U_2, U_3 & U_4 are used to stabilize the quadcopter.

CHAPTER 3

CONTROL TECHNIQUES & SIMULATION TECHNIQUE

3.1 CONTROL TECHNIQUES

PID Control it is really a three section framework:

Proportional: the primary capacity of the relative compensator is to present a pick up that is corresponding to the blunder perusing which is made by framework's yield and info.

Derivative: in a unitary input framework, the subsidiary compensator will present the subordinate of the blunder flag increased by K_D .At last, the incline of the blunder flag's waveform is the thing that will yield. Its primary reason for existing is that of enhancing the transient reaction of the general shut circle framework.

Integral: in a unitary input framework, the indispensable compensator will present the vital of the blunder flag increased by K_I ..This implies area under the blunder flag's bend will influence the yield flag. We will demonstrate this later, however note that this feature of the controller will enhance the enduring state blunder of general shut circle framework.

Therefore, it is mathematically shown as:

Compensation	Time Domain	S-Domain
PID Controller	$K_P e(t) + K_D \frac{d}{dt} e(t) + K_I \int_0^t e(x)d(x)$	$K_P + K_D s + \frac{K_I}{s} = \frac{K_P s + K_D s^2 + K_I}{s}$

For no reason then again simplicity, one will see why the s-domain is solely used once analyzing or planning analogous systems - operating with fractions is often easier than doing integration and/or derivatives. If we have a tendency to currently take what we've got delineate as a pelvic inflammatory disease controller and apply it to work one, our diagram can currently agree one thing like what you see in Figure one.1 below.

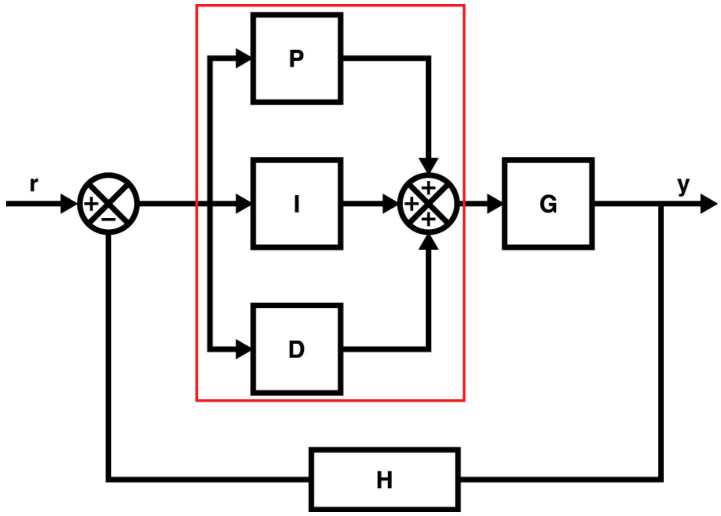


Figure 8: PID Block Diagram

Steady-state error Analysis:

$$e(\infty) = e_{step}(\infty) = \frac{1}{1+K_p} \text{ where } K_p = \lim_{s\to 0} G(s)$$

$$e(\infty) = e_{ramp}(\infty) = \frac{1}{K_v} \text{ where } K_v = \lim_{s\to 0} s \cdot G(s)$$

$$e(\infty) = e_{parabola}(\infty) = \frac{1}{K_a} \text{ where } K_a = \lim_{s\to 0} s^2 \cdot G(s)$$

3.2 **SIMULATION RESULTS**

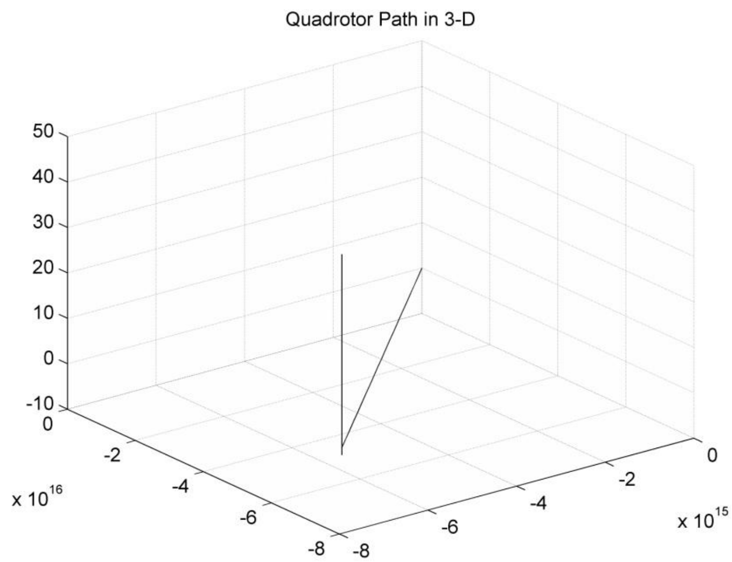


Figure 9–Quadcopter path in 3-D

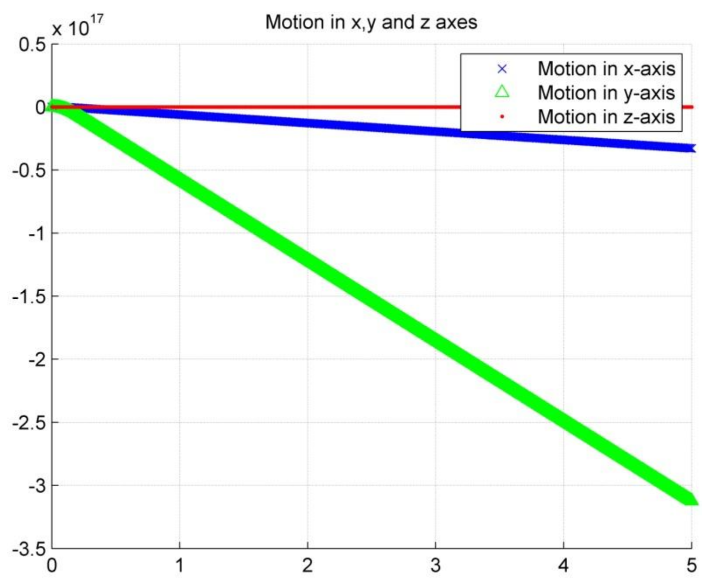


Figure 10–Motions in x,y and z axes

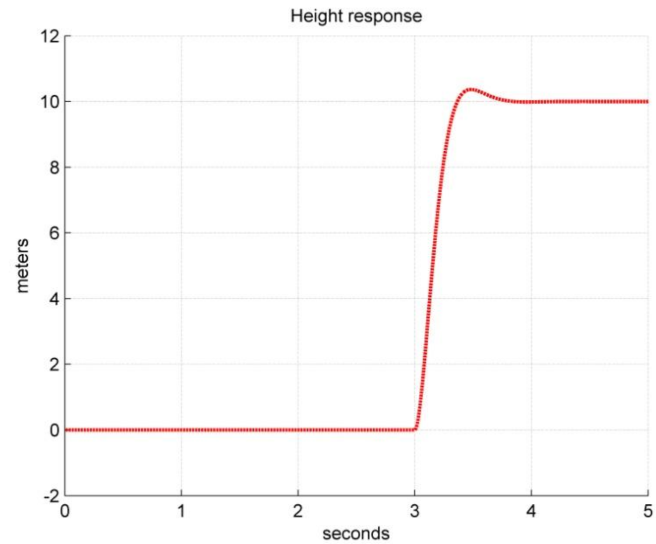


Figure 11 –Height response

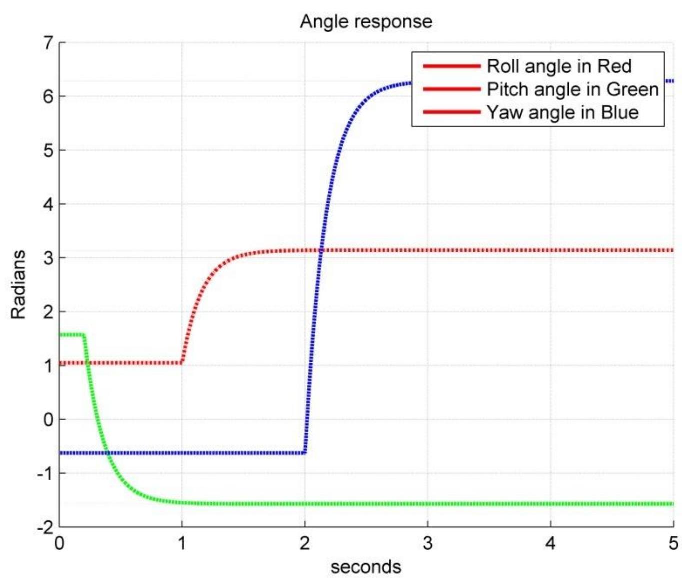


Figure 12–Angle response

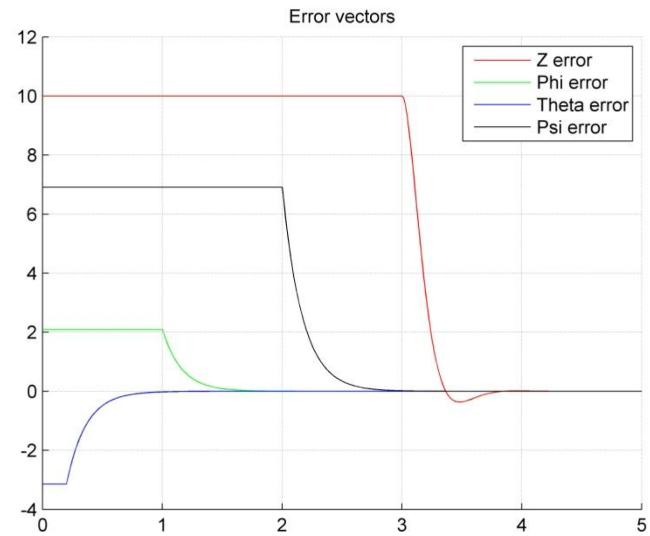


Figure 13- Error vectors

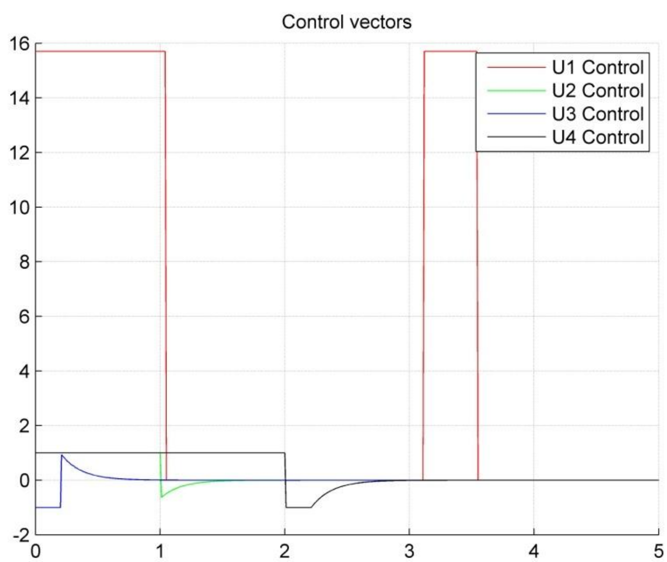


Figure 14– Control vectors

CHAPTER 4

QUADCOPTER COMPONENTS & HARDWARE DESIGN

4.1 QUADCOPTER FRAME

Similarly as critical as great gadgets, multi-rotors rely upon durable, lightweight frames for mounting parts. There are innumerable casing plans of differing shapes, measurements, and materials. A standout amongst the most widely acknowledges materials for multi-rotor outlines are carbon fiber. The main catch is that carbon fiber is known to square radio signs, which is clearly not monitor for a side interest that relies upon various transmissions. It can be utilized however, and is frequently.

The edge must be sufficiently extensive to enable every one of the four propellers to rotate without impact, yet should not be too substantial and subsequently too overwhelming for the engines.

Figure 15: A Quadcopter

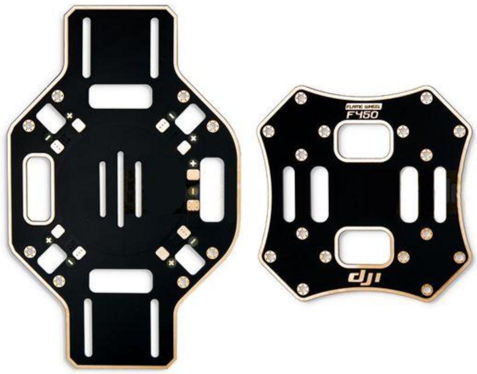


Figure 16: F450 Quadcopter frame

4.2 MOTORS

Engines utilized nowadays are only of the "brushless" assortment. That likens to insignificant grinding. A barrel shaped shell of magnets pivots on exactness direction around a center of firmly and flawlessly wound wire. The engines turn the propellers to give the Quadcopter lifting push. Quadcopters only utilize brushless DC engines (BLDC), as they give push to-weight quantity better than brushed DC engines. Be that as it may, they require more intricate speed controllers.

Figure 17: 850Kv Brushless Motor

4.3 PROPELLERS

The assortment of propellers is seemingly more prominent than some other segment we talk about; materials, measurements, and value traverse a mind-bogglingly wide range. For the most part, less expensive props are less exactly fabricated and more inclined to making vibration.

Figure 18: Propellers (10*4.5)

The first is length, typically given in inches. The higher the Kv of your engines, the lesser your props should be. Lesser props consider more prominent velocities, however decreased effectiveness. A bigger prop setup (with correspondingly-low Kv engines) is less demanding to fly consistently, utilizes less present, and lifts more weight.

4.4 ELECTRONIC SPEED CONTROLLER

Each engine needs an individual electronic speed controller (ESC for short). These speed controllers admit summons as PWM flags and yield the suitable engine speed likewise. Each ESC has a present rating, which showed the most extreme current that it might give the engine without overheating. Fitting ESCs must be guaranteed that they can give enough current to the engines.

Figure 19: Programmable Electronic Speed Controller (25 Amps)

ESC invigorate rates fluctuate. For multi-rotors, given the adjust of numerous engines basic to the specialty's capacity to remain airborne, high invigorate rates are more essential than numerous different interests where ESCs are utilized.

4.5 BATTERY

The battery gives electrical power to the engines and every lone electronic part of the airplane. Lithium Polymer (LiPo) batteries are used solely, in light of the fact that they have high particular vitality. LiPo batteries have a limit rating and release rating. The limit rating, in milliamp-hours (mAh) demonstrates how much current the battery may yield for 60 minutes.

Figure 20: 2200mAh LiPo Battery

4.6 RADIO RECIEVER AND TRANSMITTER

The radio collector (Rx) gets radio signals from a RC transmitter and proselytes them into dominance signals for each and every control channel. Present day RC collector's work on a 2.4 GHz radio repetition, while more orthodox Rx units frequently utilized 72 MHz frequencies. Rx units may have as few as 4 channels, yet numerous have more channels for extra control alternatives. We chose 6 Channel Radio CT6B made by FlySky[8] for this task. It is a passage level 2.4 GHz radio framework offering the dependability of 2.4 GHz flag innovation and a collector with 6 channels.

- **Channels**: 6 Channels
- **Model Type**: fixed-wing/glider/helicopter
- **RF range**: 2.405-2.475Ghz
- **Bandwidth**: 500Khz

Figure 21: CT6B 6 Channel Receivers and Transmitter

4.7 ARDUPILOT 2.6

ArduPilot is an, unmanned open source vehicle Autopilot Software Suite,[1] equipped for controlling self-ruling:

- Boats
- Helicopters
- Antenna trackers
- Multirotor rambles
- Fixed-wing and VTOL air ship
- Ground meanderers
- Submarines

This variant is prepared to use, with no get together required. It enables the client to turn any settled, rotational wing or multirotor vehicle into a completely independent vehicle; equipped for performing customized GPS missions with waypoints. This amendment of the board has no installed compass, which is intended for vehicles where the compass ought to be set as a long way from power and engine sources as conceivable to stay away from attractive impedance. This is intended to be utilized with the 3DR uBlox GPS with Compass, so this GPS/Compass unit can be ascend further from commotion sources than APM itself.

APM 2.6 is a correction of the APM that makes utilization of an outer compass. It has no on board compass, and is upgraded for vehicles where the compass ought to be put as a long way from power and engine sources as conceivable to maintain a strategic distance from attractive obstruction.

APM 2.6 is intended to be utilized with the 3DR GPS uBlox LEA-6 with Compass module. This module might be ascend further from commotion sources than the APM itself.

Digital Input Pins:

Pin 0 to 8: The APM2 has a pillar of simple statistics binds one side, marked A0 to A8 on the underside of the board. They are reachable as pin numbers 0 to 8 comprehensive in PIN factors.

Each one of these pins can take up to 5V and might be used for any wide easy information. They are generally used for velocity and sonar inputs.

Pin 12: controls administration connector current pin, acknowledges up to 5V, normally appended to 3DR power block with 17:1 scaling

Pin 13: controls administration connector voltage pin, acknowledges up to 5V, generally joined to 3DR power block with 10.1:1 scaling

Digital Output Pins:

The APM2 uses a similar positioning of 9 simple information pins as advanced output pins. They are designed as advanced output pins naturally when you begin to utilize them as computerized output.

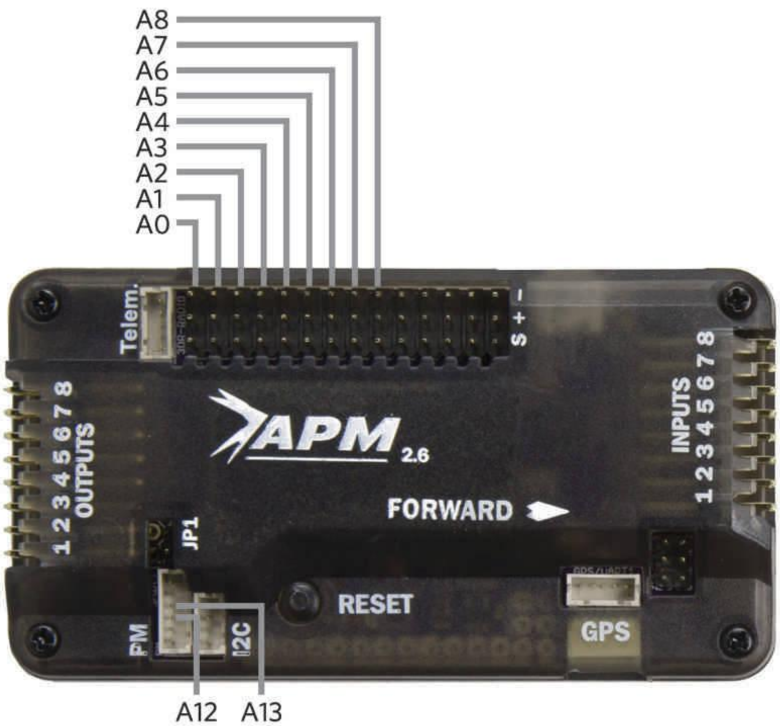


Figure 22 APM 2.6

4.8 GPS UBLOX 7M

Ublox Neo 7M GPS module that incorporates a HMC5883L advanced compass. The new Ublox NEO 7 arrangement is a high affectability, low power GPS module that has 56 channels and yields exact position refreshes at 10Hz. This GPS module additionally accompanies a formed plastic case which keeps the module ensured against the components making it perfect for use on your flying machine or Quadcopter.

This Ublox Neo 7M GPS module utilizes a dynamic hardware fired fix reception apparatus to give magnificent GPS flag which beats the more established Ublox Neo 6 arrangement modules. This Ublox Neo 7 module likewise incorporates a rechargeable reinforcement battery to take into account HOT begins and furthermore incorporates an i2c EEPROM to store the arrangement settings. Out of the case this GPS module is designed to keep running at 38400 Baud and is arranged to keep running with APM/Pixhawk frameworks. This GPS module incorporates two links, a 6pin connector for the GPS module and a 4 stick connector for the compass.

Figure 23 GPS UBLOX 7M

4.9 3DR POWER MODULE

Gives a stable 5.37V and 2.25 Amp control supply which diminishes the odds of a brownout permits checking of the battery's voltage and current and setting off an arrival to dispatch when the voltage turn out to be low or the aggregate power devour amid the flight approaches the battery's ability. Enables the autopilot firmwares to all the more precisely make up for the impedance on the compass from different segments.

The PM acknowledges a most extreme info voltage of 18V and greatest current of 90Amps. At the point when utilized with an APM the full 90Amp current detecting reach can be utilized, with the PX4/Pixhawks up to 60Amps can be estimated.

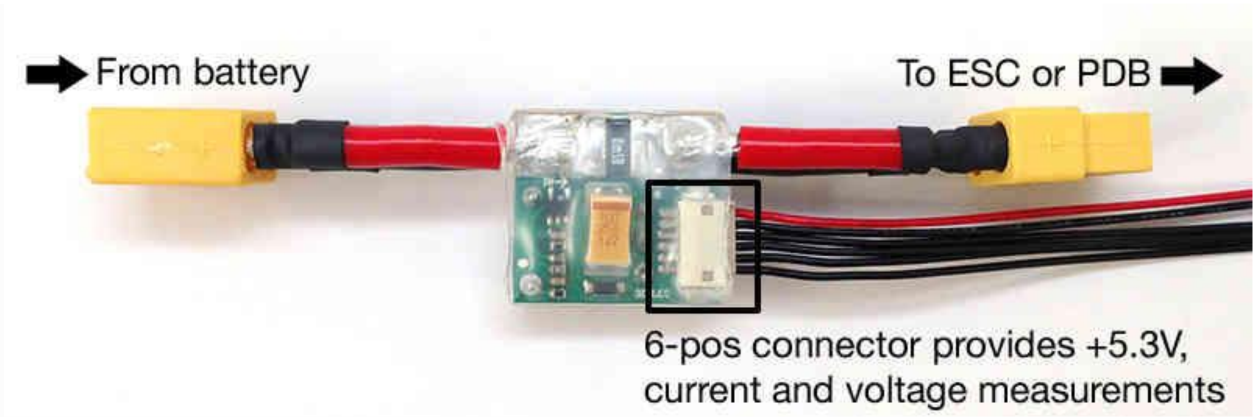


Figure 24 3DR Power Module

4.10 Mission Planner:

- The Mission Planner, made by Michael Oborne, completes significantly more than its name.
- Point-and-snap waypoint section, utilizing Google Maps/Bing/Open road maps/Custom WMS.
- Select mission orders from drop-down menus.
- Download mission log documents and investigate them.
- Arrange APM settings for your airframe.

- Interface with a PC pilot test program to make a full equipment on top of it UAV test system.
- See the yield from APM's serial terminal.

Figure 25 MISSION PLANNER

CHAPTER 5
WORK PROGRESS

The topic of the project was decided keeping in mind the feasibility of the work to be done, the ease and the learning that could be attained from it. We started off working towards it by learning the basics of the software used i.e. MATLAB. The Ordinary Differential Equations solver feature of MATLAB is what is used to achieve the mathematical model used to understand the dynamics of a quadcopter. For understanding the control and dynamics of the quadcopter, a basic review of the subjects Control Systems and Robotics was done and the topics that needed our attention were read thoroughly by each individual of the team. After going through the essential processes of reading through our course books for a better understanding, we looked for research papers on IEEE Xplore, Scribd etc. Websites like Couresera.org were visited to get the required study material for the same. An insight into the works of those who have simulated the working of the quadcopter in the past was gained as well. Research papers were thoroughly read by each member of the team as part of the literature review.

After gathering enough information and knowledge on the control design of an Unmanned Aerial Vehicle (UAV), we moved to the programming part for simulation on MATLAB. A Graphical User Interface (GUI) was created for the same to closely observe the working and movements of Unmanned Aerial Vehicle(UAV). The relevant codes for the same were searched on the internet and understood. Through all this, regular visits were made to our project guide who helped us on the intricacies of the project.

The simulation of the working of a quadcopter through MATLAB was achieved after rigorous research and efforts. The code is running and allows the user to input values of various parameters to study the movement of an Unmanned Aerial Control Vehicle.

After having learnt the software well and understood the basics of the movements of an Unmanned Aerial Vehicle for simulating its behavior on MATLAB, we planned to work on the hardware aspect of the project.

After learning how to simulate the working of a quadcopter we shifted our focus to making one. We gathered information from several websites and also referred to various IEEE papers to know what equipment is required to make a quadcopter. We went to Chandigarh and Delhi to buy the parts that would be used to make a quadcopter.

It took us about a month’s time to finish working on the hardware. The task was exciting as well as challenging in its own way. A GPS module was installed on the frame of the quadcopter so as to get the exact location of the quadcopter. The quadcopter is controlled with the help of a remote that uses various modes to control the flight of the quadcopter.

The project was completed by collective efforts of all three members of the group and by May 3 the project was completed.

CHAPTER 6

FUTURE SCOPE & CHALLENGES

Future Scope:

Aside from the customary utilization of a quadcopter for elevated photography, quadcopters have huge amounts of employments in building and the future could see the utilization of quadcopters in an extensive number of fields. Some of them could be:

Individual Transport: The thought is truly basic. You arrange your quadcopter, reveal to it where you need to go and permit the self-sufficient flight pilot to whisk you away to your picked goal.

Conveyance:

Several organizations' advances in ramble conveyance have been all around broadcasted. Regardless of whether that is on the grounds that they are a suitable business opportunity or essentially free promoting material is an alternate issue by and large. The greatest name in this rising space is online retail goliath Amazon. As a feature of its proposed flying conveyance benefit it has been trying automatons in the UK.

Challenges:

While doing the simulation and designing the structure of the quadcopter we encountered many challenges varying from learning to use MATLAB to assembling the various parts of the quadcopter to give it the perfect shape and balance. The challenges that we faced could be listed as:

Stability:

To get a fully stabilized flight that will permit the quadcopter to hover at a single location is one area where we faced the maximum number of difficulties. It is quite a task to create a perfectly balanced structure. It is tough to fly the quadcopter in small and bounded locations as the quadcopter doesn’t immediately start to fly upwards and takes a few seconds and a lot of adjustments to immediately start going in the desired direction.

Complex mathematical equations:

The mathematics involved in studying the dynamics of a quadcopter which includes the study of important characteristics related to the flight of a quadcopter (roll, pitch, yaw, MOI) is too complex for a layman to understand. To study those equations and get an understanding of them we had to revisit the topics we studied during first year.

Take off problems:

Our most recent problem which is still unsolved is that enough thrust not being generated to lift the Quadcopter from the ground. We figured out there is some problem in the thrust calibration which is not able to cope up with the weight of the Quadcopter.

CHAPTER 7

CONCLUSION

A quadrotor is a helicopter which has four similarly divided rotors, typically organized at the sides of a square body. With four autonomous rotors, the need for a swash plate instrument is lightened. The swash plate instrument was expected to permit the helicopter to use more degrees of opportunity, yet a similar level of control can be gotten by including two more rotors. Quadcopter control is an on a very basic level troublesome and intriguing issue. With six degrees of flexibility and just four autonomous sources of info, quadcopters are seriously under incited. To accomplish six degrees of flexibility, rotational and translational movement are coupled. The subsequent elements are very nonlinear, particularly in the wake of representing the entangled streamlined impacts. At long last, not at all like ground vehicles, quadcopters have next to no rubbing to keep their movement, so they should give their own damping with a specific end goal to quit moving and stay stable. Together, these elements make an exceptionally fascinating control issue. We have introduced an extremely rearranged model of quadcopter elements and plan controllers for our elements to take after an assigned direction.

The project is presently in the final design stages and we have completed several tethered test flights. We have resolved several issues encountered in this project to date, and we continue to work on the outstanding issues. When the fundamental flight control systems are complete, the Quadcopter will be okay for experimental missions. The project could go in a variety of directions since the platform seems to be as flexible as we initially intended. As a team, we can completely change what function it performs and we are able to integrate any technology that would prove to be useful. This project will clearly demonstrate the goals of proving that small scale UAVs are useful across a broad range of applications eg. the quadcopter could be loaded with a camera to capture images of the terrains it flies over. We started off by performing the simulation of the working of a quadcopter to understand the dynamics and related control movements of a quadcopter. We then put those results into use and designed a quadcopter that is working using an open-source, unmanned vehicle autopilot software suite namely, ArduPilot.

The project was completed in 2 phases.

First half saw us working on the simulation aspect using MATLAB through which we got the basic understanding of the dynamics of a quadcopter.

The second half was about designing the quadcopter with whatever means we had and it took us approximately 2.5 months to work upon the design and structure of the quadcopter.

REFRENCES

[1] HaiYang Chao,YongCan Cao, YangQuan Chen,"Autopilots for small unmanned aerial vehicles",International Journal of control automation systems,Volume 8, Issue 1,February 2010

[2] Siti Imane, Mjahed mostafa, Ayad Hassan, El Kari Abdelijalil,Complex System(WCCS), 2015, Publisher IEEE, 23-25 Nov 2015

[3] M. Liu, G. K. Egan, and Y. Ge, “Identification of attitude flight dynamics for an unconventional UAV,” Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems*, pp. 3243–3248, 2006.*

[4] Atheer L Salih, M. Moghavvemi, Haider A.F Mohamed 2 and Khalaf Salam, “Flight PID controller design for a UAV quadcopter”,Publisher IEEE 31 Dec 2010

[5] Paul Infant Teenu Mohandas, James M. Conrad,”Unmanned aerial vehicle evolution”,Publisher IEEE 10 May 2012.

[5] http://www.nesta.org.uk/drones-history-flying-robots

[6] http://blacktieaerial.com/the-physics-of-quadcopter-flight/

[7] http://www.me.psu.edu/sommer/me445/reports/Fa14.pdf

[8] https://www.scribd.com/document/335403008/Literature-Review

[9] https://link.springer.com/chapter/10.1007/978-3-319-00542-3_25

[10] http://wiki.theuavguide.com/wiki/PID_Controller

[11] http://diydrones.com/forum/topics/simple-matlab-simulation-of-a

[12] https://nicisdigital.wordpress.com/2013/01/11/pid-controller-in-matlab/

[13] http://wiki.theuavguide.com/wiki/PID_Controller

[14] https://rtime.felk.cvut.cz/~hanzalek/publications/Hanzalek07d.pdf

[15] https://nicisdigital.wordpress.com/2013/01/11/pid-controller-in-matlab/

[16] https://uknowledge.uky.edu/cgi/viewcontent.cgi?referer=https://www.google.co.in