QUADCOPTER:

DESIGN,

CONSTRUCTION, TESTING

A PROJECT REPORT

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This is to certify that the project report entitled Title " **Quadcopter : Design, Construction , Testing"** submitted by **MS K.Srilakshmi** to the Institute of Aeronautical Engineering , Hyderabad in partial fulfillment of the requirements for the award of the Degree Bachelor of Technology in Branch in AERONAUTICAL is a bonafide record of work carried out by her under my guidance and supervision .The contents of this report, in full or in parts, have not been submitted to any other Institute for the award of any Degree.

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APPROVAL SHEET

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ABSTRACT

In this project, A quadcopter is being designed which can cover a range of 1000 meters and can lift a payload of 0.5kg. By using software like Catia, Solid Works. The reason behind to choose this Specific Project Because Unmanned Aerial Vehicles (UAVs) like drones and quadcopters have revolutionised flight They help humans to take to the air in new, profound ways. For construction of it using simple fabrication Techniques and for basic flight control of the quadcopter is tested by PID (Proportional-Integral-Derivative) tuning and flying the quadcopter.

Quadcopter also known as quadrotor is the next form of helicopters having more dynamic stability than helicopters. They play a predominant role in different areas like surveillance, military operations, fire sensing and some important areas having many complexities. In this project a simple quadcopter has been designed. The details of design and analysis results including the avionics and power plant selection are described in this project report.

Keywords: Proportional-Integral-Derivative; quadcopter; drone; UAV

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LIST OF ABBREVIATIONS

ANSYS–Analysis System

CATIA–Computer Aided Three Dimensional Interactive Application

PID- Proportional-Integral-Derivative

ESC-electronic speed controller

Chapter-1

1 INTRODUCTION

1.1 BACKGROUND:

The first quadcopter was the Omnichen 2, invented in 1920 by Etienne Omnichen. This craft made 1000 successful flights and flew a recorded distance of 360 meters. Then the convert a wings model a quadcopter designed by Dr. George E. Bothezat, appeared in 1956. Nowadays there is an incredible evolution in 21st century in quadcopters. To introduce more robust controllers and modeling, techniques, Universities, students and researchers are working continuously, so that they can provide detailed and accurate representations of real life quadrotors. Nikita Guliaev (2017) explained the view of quadcopters price. In department stores and specialized shops, the average consumer can now purchase a quadcopter of the approximate size. The prices for such aerial craft range is very high.

1.2 INTRODUCTION:

The multi-rotor aerial automobiles have discovered a extensive area of packages within side the regions of police and navy surveillance, open area exploration, looking and rescue, aerial filming, programs delivering, etc. The associated studies regions entails aeronautics, mechatronics, dynamical systems, computerized manipulate, sign processing, Wi-Fi communication, etc. The hobbyists marketplace and the academicals hobby has promoted the expenses discount of sensor, actuators and the improvement of digital embedded gadgets committed to those aerial automobiles. The major hobby of the robotic manipulate network is to layout manipulate techniques to recognize self-sufficient flight following pre-programmed trajectories within side the space, changing the multi-rotor platform, pushed to begin with via way of means of a radio manipulate, in a totally Unmanned Autonomous Vehicle (UAV). The quad-rotor setup is the principle multi-rotor configuration studied within side the manipulate literature because of the simplicity of the modeling and manipulate admire to different structures and due to the fact has the ability to recognize competitive maneuvers like turn

behaviors. It is composed on 4 electric rotors with propellers installed on the ends of a cross-form structure. The dynamical configuration lets in the take off and land maneuvers in decreased spaces, hover above goals and the omnidirectional movement within side the space.

The actuators which reason excessive electric modern spending decdecreasee sensible flight time, typically in various 12 to 18 mins in business systems (Aranda, 2014). Also, multi-rotor aircrafts are regarded to be unstable, situation to results of vibration and noise all the time, and the dynamical manipulate turns into complicated if the results of air turbulence, propellers deflection and different perturbations are integrated into the dynamical under actuated machine model.

The cell insurance the use of unmanned aerial vehicles (UAVs) is gaining interest from studies network and telecom enterprises with the fast deployment of the Internet of things (IoTs). For collection/dissemination of data, IoTs-primarily based totally cell technologies anre being provided. For provision of offerings in wider insurance area, the cell networks are augmented with UAVs. UAVs are the trustable answer for enhancing of the efficiency, decorate throughout, fee and boosting capacity. These UAVs are briefly deployed within side the air to cowl a place in which the person call for is improved or within side

The case of screw ups or to offer connectivity in regions in which everlasting infrastructure isn't presently possible. Tis additionally consists of regions in which physical infrastructure is available, however the person density could be very high (event, stadium, etc.).

Tendencies of UAVs now no longer simplest offer the answer however additionally offer the burden balancing, and without problems cowl the most traumatic vicinity. For this purpose, an efficient technique and mechanism is required. Previously, Cell on Wheel (COW) is used as a brief answer wherein a vehicle became designed to hold a cellular microcellular base station This answer became evolved together with the Telstra Next Generation deployment plan to increase the insurance vicinity to cowl any occasion or emergency. There are few conditions wherein the cow ought to fail, as an instance in regions of herbal catastrophe in which the street infrastructure important for displacement isn't to be had. the primary motive for UAVs as a favorable answer for a huge variety of community programs is the capacity of its loose and impartial movement, to any tough to attain regions. These UAVs are provided with the base station (BS) hardware, and those act as a flying BS, growing an appealing

alternative to predictable roof or pole connected base stations. In radio conversation, the BS is a Wi-Fi conversation station hooked up at a fixed place and used to attach as part of Wi-Fi phone schemata BS relays the conversation, message and information to base stations in different cells via way of means of the Wi-Fi, cable conversation or thru a cable community or thru a mixture of Wi-Fi and cables. the placement of those UAV-primarily based totally BS in a microcell community with the intention to get most fulfilling insurance vicinity in which the person aren't desk bound is a tough task. Providing excellent placement even as preserving the range of UAVs most fulfilling is tough to achieve. Multiple answers for this hassle are mentioned within side the literature, in which majority have targeted on provision of the strength efficient answers for placement of UAVs.Among them, very much less interest has been paid in the direction of strength conscious answers and additionally; such answers have simplest taken into consideration implicit usage of strength to estimate the to be had strength. However, the express utilization of UAV strength has now no longer been addressed yet, which additionally has excessive effect at the UAV survivability.

The multi-rotor helicopter has skilled a superb improvement over final decade, the maximum usually used and studied one is the quadcopter which is likewise referred to as a quadrotor. It has drawn plenty interest from engineers and researchers because of its easy mechanical shape and a large boom in applications. Recently, the quadcopter will become one of the maximum famous studied structures on top of things area. It severs as an incredible test-mattress for investigating the conduct of multiple input multiple-output (MIMO) structures. In general, there are sorts of quadcopter configuration, which can be the plus and go systems respectively. In this paper, the dynamics modelling and controller layout are primarily based totally at the latter shape. The quadcopter is visible as an under-actuated gadget which has six stages of freedom (3 translational and 3 rotational), however with simplest 4 impartial inputs (the rate of every motor), this brings the robust coupling of rotational and translational dynamics. Due to the under-actuated houses of quadcopters, keeping its balancing kingdom or a favored mind-set will become greater challenging. Therefore, the manage set of rules layout could be very crucial and modelling a greater practical dynamic version of a quadcopter is likewise crucial. Over the final decade, numerous manage methodologies have been proposed to analyze the mind-set manage hassle of unmanned aerial vehicles (UAV). Both linear and nonlinear manage schemes are involved. In the version-primarily based totally PD and Linear

Quadratic Regulator (LQR) manage schemes are carried out to an indoor micro quadcopter. The PID set of rules in 3 systems are taken into consideration to formulate the manage tasks, PID, PI-D and I-PD controllers are as compared and tested with appreciate to the first-rate overall performance. Optimized PID manage approach is proposed, simulations are accomplished with appreciate to optimized PID and Back-step controller. Other sorts of manage techniques also are referred to in inclusive of H infinity, linear quadratic most effective manage, back-stepping manage, sliding mode manage and so on. Many humans have emphasized the deserves of PID manage approach of their papers, and it's far genuine that the PID manage method has been extensively used in lots of regions and offers a powerful overall performance in controlling risky structures. Nonetheless, the downside of PID manage approach is while the disturbance effects a massive blunder within side the gadget, the brief reaction of structures in phrases of settling time, overshoots and steady-kingdom reaction might be compromised which provides a weaker robustness. Especially within side the quadcopter gadget, the outside disturbances constantly reason a massive monitoring blunders, which increases the problem of controller layout. Hence, a sturdy cascade PID set of rules is proposed to enhance the stableness via way of means of reducing the gadget sensitivity to the outside disturbances. In addition, the mathematical fashions of quadcopter dynamics are generally derived from Euler-Lagrange or Newton-Euler methods, the latter is hired and the dynamics of vehicles are taken into consideration at some stage in the modelling for optimum accuracy and feasibility.

The navy use of unmanned aerial vehicles (UAVs) has grown due to their cap potential to function in risky places whilst preserving their human operators at a secure distance. The large UAVs additionally offer a dependable lengthy duration, fee powerful, platform for reconnaissance in addition to weapons. These UAVs are designed with exceptional filters such as adaptive high-benefit prolonged Kalman filter (AEKF), fee reference particle filter (CRPF) technique in estimating 1-D “tilt” with “Accelerometer” and “gyroscope” sensors for huge perturbations. Some quad-copters had been layout with sturdy manipulate regulation to make the elevation & pitch angles of the 3-DOF helicopter nearly song the time-various reference indicators that belong to a hard and fast own circle of relatives of characteristic of time. Also

new adaptive regulation for mind-set monitoring prolonged kingdom observer (ESO) had been evolved for powerful repayment for the outside disturbances & uncertainty in inertial matrix. Some quad-copters had been designed with Unscented Kalman filter (UKF) and an IMU with three-axis accelerometers, gyro meters & magnetometers with GPS receiver for mind-set angles estimation. Some designs had been with imaginative and prescient device the usage of camera, monitoring the item the usage of picture processing & additionally calculating distance among unmanned air automobile & floor goal to manipulate the UAV the usage of computer. Also a few quad-copters had been designed to the map or tracking the regions in risk zones, catastrophe regions, etc. These structures had been designed with payload of GPS, CCD cameras, laser scanner established on it. The layout stuck our hobby is the smaller UAVs can serve greater tactical operations consisting of looking a village, rivers, surveillance, monitoring for enemy positions, film shootings, etc. Smaller UAVs, at the order of a pair toes in length, need to be capable of manage navy tactical operations in addition to the rising business and commercial programs It became consequently an automobile within side the one foot in length with bearable payload of GPS, video camera, ZigBee ARM processor established on it that stuck our hobby. Although maximum of the huge navy UAVs are constant wing aircraft, we felt that small UAV need to have extra maneuverability and versatility because it became in all likelihood to be beneficial for a broader variety of programs than the bigger or smaller versions. The quadcopter will meet the aim of manufacturing a small UAV that might carry out beneficial missions in each navy and business arenas, time and investment constraints, battery backup compelled to layout a UAV to satisfy the purposeful necessities however now no longer to meet harsh environmental situations consisting of the ones encountered throughout navy missions. However, UAV layout truly will be re-applied with more modern and greater sturdy era which might permit it for use for navy functions, surveillance & goal monitoring.

The every-day growing human populace represents a pretty annoying and crucial venture for farmers, agronomists, and scientists in general. In order to have the ability to deliver the destiny meals demand, full-size enhancements ought to be completed in genomics, plant body structure and farming strategies. In reaction to that need, precision agriculture which is a control approach that makes use of statistics era to carry statistics from more than one reasserts to undergo on selections related to crop production" has emerged. The conventional imaging

supply for precision agriculture is satellite, however recently, the unmanned aerial systems (UAS) are getting the favored supply due to a type of benefits that they offer: better spatial and time resolutions, decrease costs, amongst others. Colombian farmers are actually privy to the significance of the use of real-time sensing strategies to enhance on farming techniques and processes. Several precision agriculture programs have emerged over the last decade. Gehrke and Greiwe connected a multispectral and a RBG cameras (ADC Lite and Sigman DP1 respectively) to an UAV (MR-X8) so as to gain 4-channel snap shots. Within their consequences they observed geometric balance issues because of the vibration of the platform. Using the identical multispectral digital digicam and a distinct UAV (Arknos), Garca and Herrera monitored sugarcane in Colombia and concluded that the received snap shots from the digital digicam had been beneficial to generate near-infrared mosaics, which they used to compute multiple plant life indexes (NDVI and SAVI) for biomass estimation. Stroppiana etal.

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Quadcopters (or greater typically multi-rotors) have emerge as a pervasive technology, whether or not for recreation, photographic observation, package deal delivery, agricultural tracking or different uses. Their flight overall performance has advanced on a instead ad-hoc basis, depending closely on stabilization and flight controls using miniaturized Inertial Measurement Units (IMUs) and easy remarks controls. However, those flight manage programs are more often than not primarily based totally on easy unmarried rotor aerodynamic fashions at low speeds, so lack constancy for complete multi-rotors and ignore complicated aerodynamic interactions. This deficiency can also additionally motive deviations in deliberate trajectories and sudden behaviors with multi-rotor drones. Therefore, progressed overall performance can be feasible with a greater detailed information of the static and dynamic aerodynamic conduct of those vehicles.

The chief Objective of us is to Design, Construct, Test and Demonstrate Quadcopter that can perform various tasks and can easily manufacture with as less price as possible.

Chapter 2

2.1 LITERATURE REVIEW

Micro Aerial Vehicles are light weight flying machines, so they gained a lot of popularity in the past few years. These copters can do variety of tasks like in the fields of search and rescue, industrial inspection or observation. And for other applications for the small and light-weight flying platforms are in the computing power of micro controllers, MAVs can be used for a wide variety of experiments. In the field of navigation and sensor data fusion or flight control. For MAVs it is not necessary for a legal permission. And less effort is required for experiment. The control of the copter is done only by changing the rotation of propellers. The idea behind this method is to linearism the system for the entire operating rang without neglecting nonlinear effects.[1]

Disaster management, land slide, earthquakes management etc. We examine the fields or targeting or tracking the enemies at different locations or camps. But many UAVs are composed with fixed wings and size, but this paper discuss about the quad-rotor UAV which is optimal in size as per requirement of operation This paper discusses about how the drones are used for the military security, surveillance, and type of payload carrying by it. The quad-copter will be needed many sensors, gyroscopes, altimeter, magnetometer etc. with high-gain extended Kalman filter (AEKF), cost reference particle filter (CRPF) approach in estimating 1-D “tilt” with “Accelerometer” and “gyroscope” sensors for large perturbations. Many high-tech devices are installed in this UAV. For such many requirements, this paper concentrated on Graphical user interface (GIU), this GIU enables the operator or controller of the UAV to get better pictures, video, location information.[2]

Standard flight operations like takeoff, land, hover by controlling thrust over the propellers which in turn controlled by voltage applied. During takeoff all rotors rotates in clockwise direction, here clockwise direction rotation gives positive thrust, during hovering net thrust should be zero so a pair of rotors rotates in opposite direction but the magnitude of rotation is same, thrust and voltage are directly related, the amount voltage required for require

thrust is calculated by the formula. Pitch angle is measured with respect to the Y-axis, roll angle is measured with respect to the X-axis.[3]

From past few years there is wide different work in developing autonomous Micro Aerial Vehicles (MAV's). MAV's are more effective like light weight, small in size And their aerodynamics characteristics, MAV's are more flexible, maneuverable, easy To use and safe to interact or study. The introduction of low cost MAV's are made a Revolution for rapid prototyping and testing of innovative techniques to support Autonomous behavior. The MAV's are became for important in the commercial Market, MAV's are widely using many applications like military, civilian missions, Including surveillance operations, exploration, weather observation, disaster relief Coordination and civil engineering inspections. The UAV's are generally used in any Situations in which it would be difficult or dangerous to send any humans, similarly MAV's are used to do same operations. The reduced MAV's are they can use to Replace the large unmanned vehicles. When we compare with any other drones or UAV's, MAV's are unique in Characteristics that make devising algorithms for autonomy challenging (Bacharach et Al, 2010). Firstly, these vehicles are difficult to control as they are unstable system with speed dynamics. Secondly, the reduced size and light weight, then the MAV's Are not sustain more payloads the its leads to restriction of payloads the its reduced The power computation as well as noisy and limited sensors. Thirdly, the life of Battery we use is very short nearly in few minutes to around hours its effect the Continuous flight time period. From all this factors we came to know that MAV's Have little stability and information is getting changing rapidly and decisions on what Action to be performed must make in minutes. For modeling effective MAV's we must Manage the uncertainty, restricted resources and tight deadlines is most crucial for Autonomous and intelligent MAV. The automated planning technology is suited to fit Out MAV's with the strategic ability to meet the mission goals within the limits of the physical characteristics.[4]

Copters that are more dynamically stable than helicopters are our quadcopter. Payload carrying, crop-spraying, surveillance, military, photography, etc. are major roles played by quad copters. The major disadvantages of Quadcopter are it is costly and there are topological limitations. Quadcopter Flight dynamics include Bernoulli's principle, Newton's third law.

Thrust is the Normal force to propellers creating forward motion this is calculated by the formula T=ρAVr2.During takeoff and Landing mode copter follows translational motion and during hovering is done by making net thrust on frame be zero. The Quadcopter electronic components are motors, propellers, Electronic speed controller, Battery, Flight controller, Transmitter, and Receiver. The materials used for the frame construction are aluminum, balsa wood, Carbon fiber, most preferable one is aluminum because it is light, malleable, on magnetic, on flammable, strong and more resistant to corrosion. The design of quadcopter can be proved to be safer by doing Static structural analysis, Modal analysis, and Harmonic analysis on frame material. [5]

Past few decades' multi-rotor is made a remarkable development over the world, the most commonly used and studied one is quad copter which is also known as a quad rotor. The quad rotor is made revolution in engineering and researches due to simple mechanical structures and most used applications. From past few years' quad rotors become most popular studied system in control area. It's give the evidence for investigating the behavior of multiple-input multiple –output (MIMO) systems. Generally, there are two type of quad copter configuration, which are the plus and cross structures respectively. Now we are discussing about latter structure based on the dynamics modeling and controller design. Basically the quad copter is seen as an under-actuated system which has six degrees of freedom (three translational and three rotational but only four independent inputs (rotors speeds), thus creates an under-actuated system) this brings the strong coupling of translational dynamics and rotational. Because of under actuated properties of quad copters, maintaining its balancing state or required attitude becomes more complex. Thus the control algorithm design is very important and modeling a real model of a quad copter is important.

Over the many decades, the different types of control methods have been came into act for attitude control problem of unmanned aerial vehicles (UAV). The both linear and nonlinear control schemes are used. In the model –based PD and Linear Quadratic Regulator (LQR) control schemes are used to an indoor micro quad copter. The PID algorithms in three structures are used to formulate to control tasks used PID, PI-D and I-PD controllers to the best output. Optimized PID control method is used in, control method is used two simulations are

performed with respect to optimized PID and Back- step controller. Other types of control strategies are also used in such as H infinity, linear quadratic optimal control, back-stepping control, sliding mode control etc.

Many of us are excited about the advantages of PID control method, and the PID control technique has been used in many applications .But the drawback of PID method is when the disturbance results a large error in the system, the transient response of systems in terms of settling time, overshoots and steady state response will be compared which presents a weaker robustness .Whereas quad copter system, the external disturbances always cause a large tracking error, which raises the difficulty of controller design. Hereby, a robust cascade PID algorithm is proposed to improve the stability by lowering the system sensitivity to the other components. The mathematical models of quad copter dynamics are usually derived from different types of methods like Euler-Lagrange or Newton-Euler methods, the latter is employed and dynamics motors are taken into account during the modeling for maximum accuracy and feasibility. In section III, PID controller is developed based on the linear model of the system. Section IV, simulations of cascade PID and parallel structure PID controllers are operated.[6]

We consider a larger architecture design for our Quadcopter Swarm and fly in dense formation indoors. The more number of small vehicles inspires novel design for estimating and communication or localizing. For localizing we develop a system to reliable track many small firm bodies with same motion-capture marker system. Our communication system sends only one-way data flow and supports a large number of vehicles to operate. With this communication system we can achieve the reliable flight with accurate localizing with minimum errors like < 2cm mean position error by using the majority of computational works like senior fusion, controls and path trajectory estimations. By using 49 Swarms Nano Quadcopter we estimating and tracking the performance in empirical fashion.

Here came to know that architecture system strength, dynamic control and synchronized system of large indoor Quadcopter swarms. By using of little bit of radio bandwidth are we can achieve the rich path trajectory planning and solutions to the uncertainty that we are facing before. For our 49 swarm vehicles we use 3 radios and we get the latency

below 30ms, and flight maneuvering on board states the estimated with mean tracking error of 2cm[7]

Quadcopter is a special kind of vehicle, which can be implemented in different applications (emergency response, pollution detection, crop spraying, Police department etc.). It has four propellers and their configuration maybe either in PLUS or CROSS. By increasing or decreasing speeds of propellers we can Throttle, Roll, Pitch and Yaw. Linear type control algorithm PID (Proportional Integral Derivative) which is mostly used in Robotics and Automation industry has three control parameters P-proportional, I-Integral-Derivative. The advantage of the linear control is that it is intuitive and easy to synthesize, but it cannot handle the constraints directly and may not be valid for large operation range since it is designed around a fixed operating point. The main components of our Quadcopter are Sensors, motors, GPS, Microcontroller, power supply, Telemetry devices.

LIPO battery, four brushless DC motors (BLDC), controller board, four propellers, a video camera, sensors constitute structure of quadcopter. Quadcopter system works on the principle of air lifting phenomena with high pressure.[8]

In this chapter some standard papers published in the journals are briefly explained which are useful for the proposed design.

2.2 PROBLEM DEFINITION:

There are many applications of UAV's because of its capability to fly where a human cannot go easily like any fire accident, or to capture the view of any landscape etc., but if the payload capacity, range, endurance is increased and cost is decreased then it will be more efficient.

2.3 OBJECTIVES AND OUTCOMES:

Objective of our project is to design a simple copter which can be easily fabricated, such a design which gives less aerodynamic drag, and able to carry the maximum payload and also is to maintain maximum strength to thrust ratio.

The outcome of this project is quadcopter capable to land smoothly and can achieve its goal efficiently

2.4 METHODOLOGY:

We have designed a simple quadcopter as shown in figure 1 using solid works software which is of 20 cc volume and weighs of 2263.72 grams and can lift up to 10000 grams, that is we have assumed thrust to weight ratio as 4:1. this design of quadcopter has 278681.41 square mm surface area.

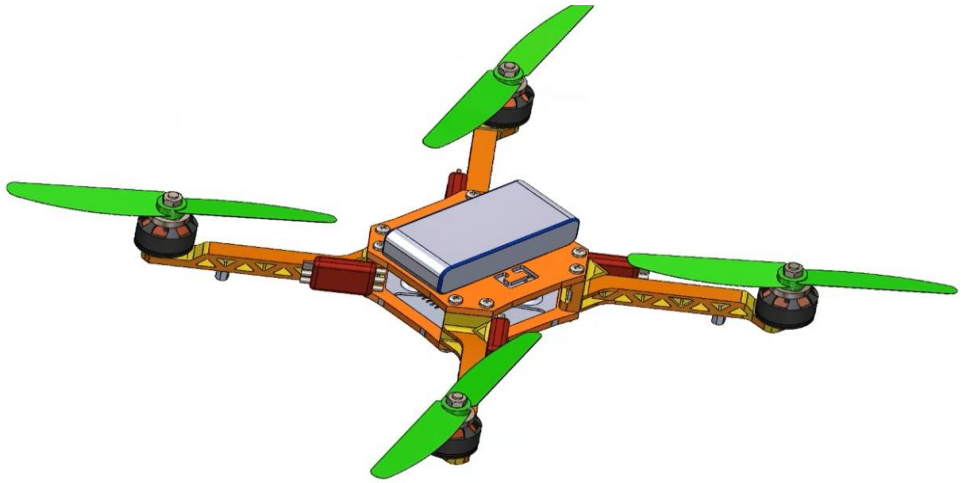

Figure 1 :-Modal of quadcopter

We opted for True 'X' configuration, because it is thin, strong and can withstand deformation due to loads and also it is light in weight**.** This frame offers equal stability on all axes as it is completely symmetrical, giving marginally good flight characteristics.

The frame of quadcopter can be made from aluminum, carbon fiber or balsa wood. The comparison among various Properties of these materials are listed below.

2.4.1 Quadcopter frame:

Quadcopter frame The frame of quadcopter can be made from aluminum, carbon fiber.

The comparison among various Properties of these materials are listed in table1.

Table 1:-The comparison among various Properties of these materials

property	Aluminum alloy	carbon
Young's modulus	70	70
Poisson's ratio	0.33	0.1
Ultimate tensile strength	550	600
Ultimate compressive strength	469	570
Density	2.86	1.6

Aluminum alloy is light and strong material, which dissipates heat well, and is relatively inexpensive compared to the other available options. Having Malleability, or the ability to be shaped. No sparking, so it's ideal for use near flammable substances. Resistant to corrosion, this makes it ideal for use outdoors. Nonmagnetic, hence it is not affected by electromagnetic forces. Thus Aluminum is a material which is used for arms and the center plate. The cad assembly model for quadcopter is shown in following fig. The Aluminum frame of the vehicle is subjected to following analysis-

1.Structural Analysis

2.Modal Analysis

with both the materials aluminum alloy and carbon

TABLE 2:-STRUCTURAL ANALYSIS OF FRAME WITH ALUMINUM ALLOY FRAME.

Aluminum alloy	Total deformation	X deformation	Y deformation	Z deformation

maximum	0.0081104	0.00069004	0.0004696	0.0001895
minimum	0	-0.000007	-0.0001487	-0.0027677

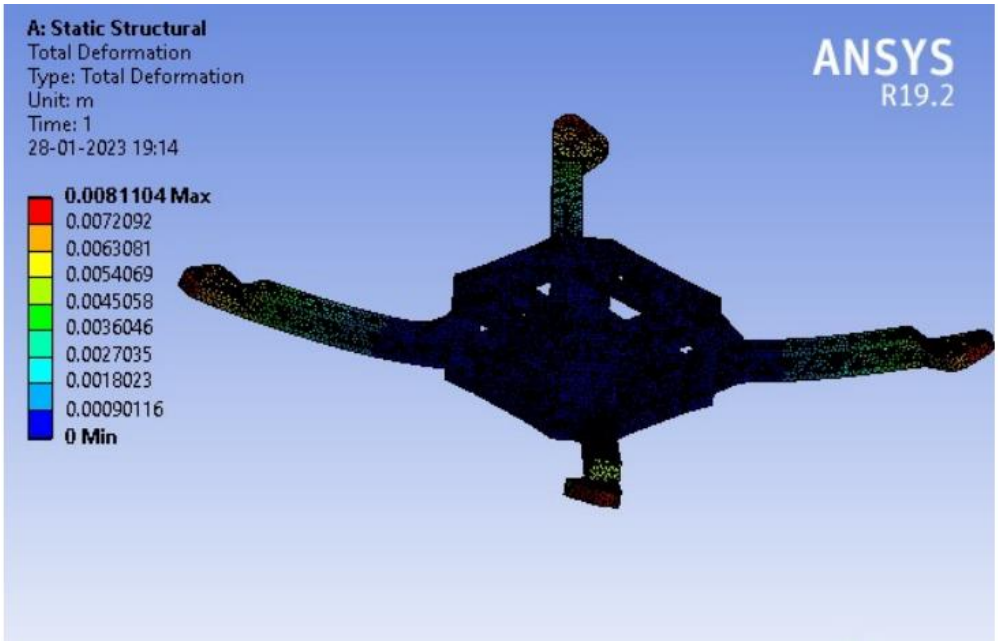

FIGURE 2A:-STRUCTURAL ANALYSIS

Figure 2A shows the structural analysis of quadcopter modal with alluminium alloy frame

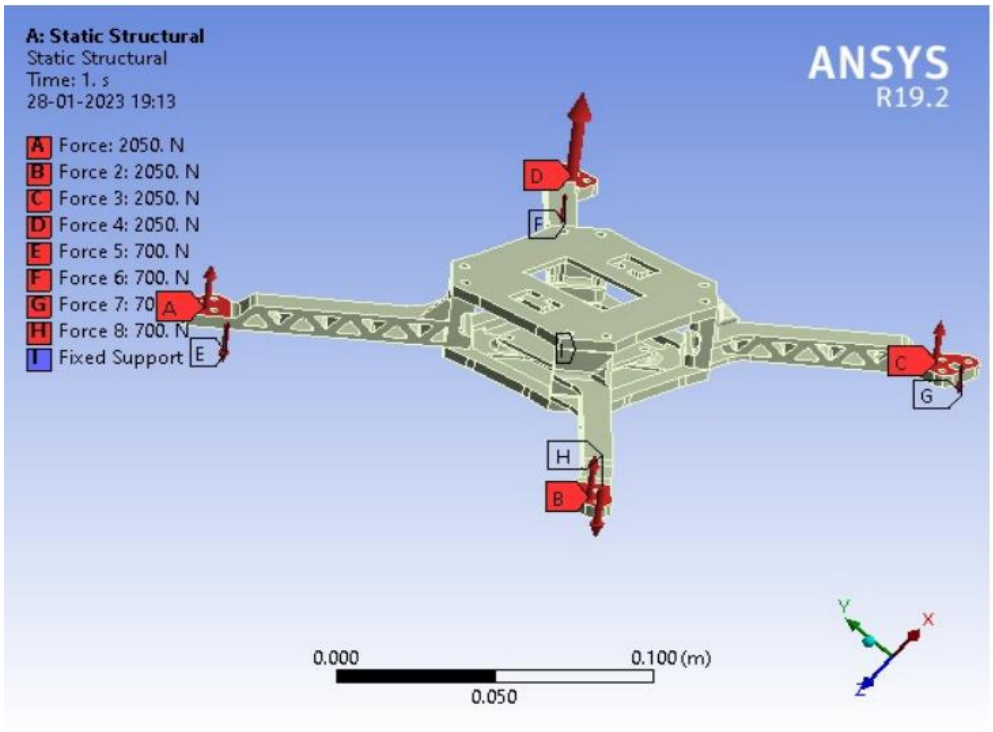

FIGURE 2B:-STRUCTURAL ANALYSIS

sFigure 2B shows the forces acting on the frame of quadcopter modal

TABLE 3:- STRUCTURAL ANALYSIS OF FRAME WITH CARBON FRAME.

	Total deformation	X deformation	Y deformation	Z deformation
maximum	0.024486	0.020758	0.014256	0.0005198
minimum	0	-0.00021054	-0.00033348	-0.0080190

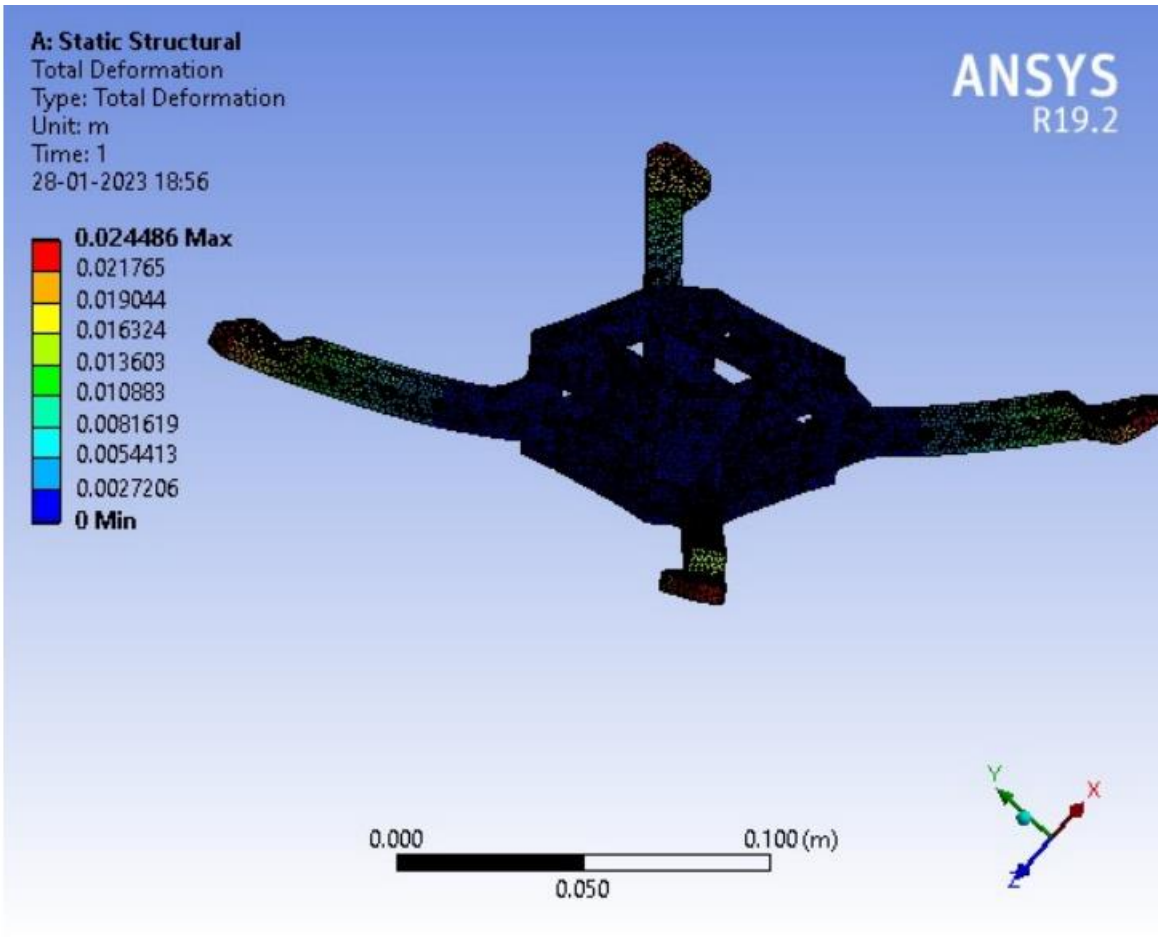

FIGURE 2C:-STRUCTURAL ANALYSIS

Figure 2c shows structural analysis of quadcopter frame made of carbon

TABLE 4:- MODAL ANALYSIS OF ALUMINUM ALLOY FRAME.

Aluminum alloy	Total deformation	X deformation	Y deformation	Z deformation
maximum	9.8994	0.0722	7.9727	5.627
minimum	0.	-4.922	-0.0799	-7.2086

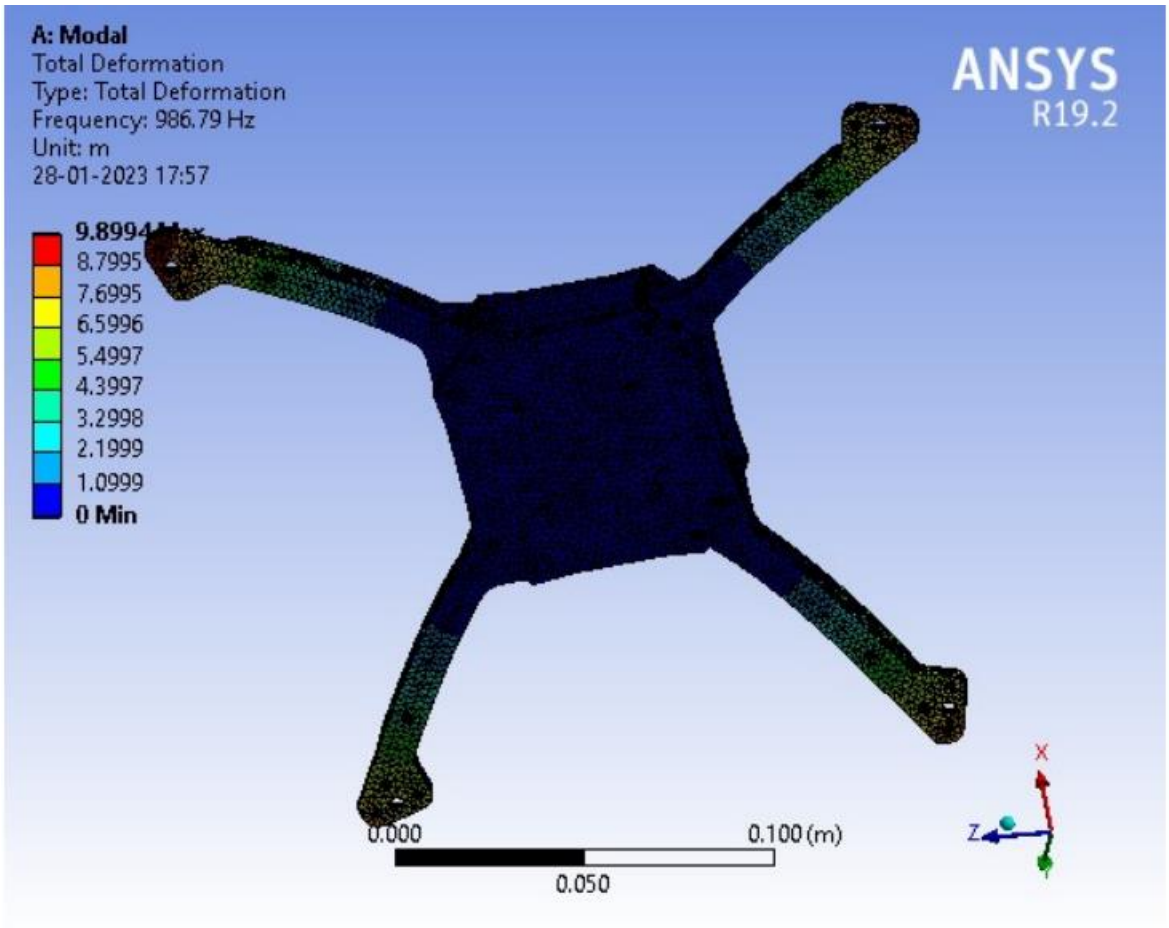

FIGURE 3:-MODAL ANALYSIS

Figure 5 shows the modal analysis of quadcopter frame made of alluminium alloy at a frequency of 986.79 hz

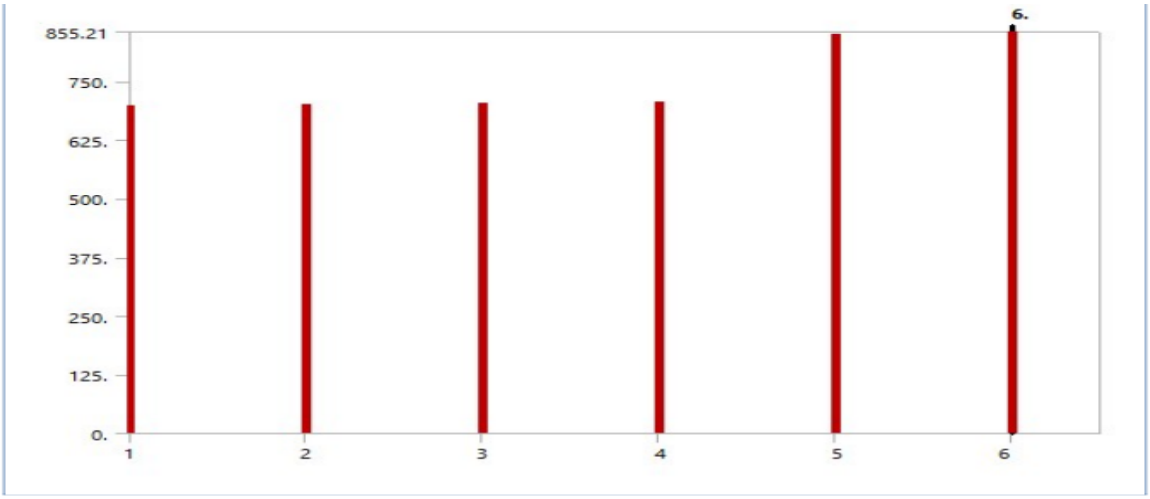

FIGURE 4:- MODES AND FREQUENCIES(X-MODES,Y-FREQUENCY)

TABLE 5 :-MODAL ANALYSIS OF CARBON FIBER FRAME.

mode	frequency
1	697.65
2	699.56
3	703.36
4	704.56
5	849.2
6	855.2

From the figure 6 and table 5 we can find the frequencies at diferent modes,the highest frequency is at mode 6 and then in mode 5 the lowest frequency is at mode 1 and mode 2.

Chapter 3

3.1 IMPLEMENTION:

We have implemented our design by selecting the various avionics required to fabricate our product.

3.2 POWER PLANT SELECTION

We have selected Brush less DC(BLDC) Motor because they have superior thrust to weight ratio compared to brushed motors. We have shortlisted two types of motors as can be seen in table 6 which are suitable for our requirements. F100 of brand Motors which can provide 2400 N thrust with 1350 kv. Here, The Kv rating refers to the number of revolutions per minute a motor with no load will turn when 1 volt is applied to it. The value is often reported in terms of Kv, i.e. 1350 RPM/V = 1350 Kv. Therefore, if a 100 Kv motor was connected to a 20 V battery, it would spin at 27000 RPM. Low Kv motors operate at lower RPMs and produce more torque, ideal for larger propellers. High Kv motors operate at higher RPMs and are ideal for low torque, small, and fast spinning propellers.

TABLE 6 :-POWERPLANT SELECTION

Motor	F100 	ECO II SERIES 2207 
KV	1350	1700
Weight (kg × 10^3)	0.0665	0.0334
Rated Voltage (LiPo)	5-6S	3-6S
Peak Current	61.65A	38A

(10s)		
brand	Tmotors	Emax
Idle Current (10V)	1.5A	1.2A
Cost (₹)	3000	1649

Motor	F100			ECO 11 SERIES		
Throttle (%) Parameter	50	70	100	50	75	100
Thrust (kg)	1.1151	1.97225	2.46779	0.500	0.700	1.980
Voltage (V)	20.76	20.37	19.84	25.2	25.2	25.2
Current (A)	14.88	35.76	61.65	4.9	7.9	35.8
Power (W)	308.85	728.65	1223.32	123.48	199.08	902.18
Efficiency (T/P)	3.61	2.71	2.02	4.05	3.52	2.19

Another motor we selected belongs to Emax brand, Eco series II 2207 of 1700kv which can produce a maximum of 1900 thrust. Finally we selected F100 motor because the other one has a disadvantage even though it can produce maximum thrust but at only 100% throttle, at 75% throttle it is not producing enough thrust so we decided to go for F 100 motor.

3.3 AVIONICS SELECTION

3.3.1 ESC

The role of the ESC is to deliver power from the battery to the motor in a controlled manner. If you input 50% throttle on the controller, the ESC will deliver 50% power to the motor. One one end, the ESC has two wires to connect the battery, a red (positive) wire and a black (negative) wire. On the other end are three wires that connect the ESC to the coils of the brushless motor. If the motor spins in the wrong direction after connecting it to the ESC, switching any two of the wires will make it spin in the right direction

we have shortlisted two ESC's which are suitable for our requirements they are ALPHA 60A and other one is sky walker hobby wing,can be seen in table7 both can give 60 amperes of current and peak current of 80Amperes.finally we opted ALPHA esc because it has less weight compared to other.

TABLE 7:- ESC

ESC	ALPHA 60A 12S V1.2 	Skywalker hobby wing 
Continuous Current (A)	60A	60A
Peak Current (A)(10s)	80A	80A
Weight (g)	73g	100g
LiPo	6s LIPO	2-6S LIPO
Size (mm)	78.7*32.5*16.2	130*120*20

ESCs have a maximum voltage limit that may be given as a voltage range or a cell range: an ESC rated for 3S - 8S cells will support a voltage of 11.1 - 33.6 V. Some ESCs offer the option of changing the chemistry type and number of cells for automatic low voltage protection based on the battery's chemistry. The ESC may also let you set a switch-off voltage that will alert you when the battery voltage becomes too low (3.0 - 3.4 V). A low voltage cut-off (LVC) circuit senses the voltage drop as the battery discharges and sends a warning signal or commences an automatic shutdown procedure in response.

The ESC's current rating should be 10 - 20% higher than the motor's. This will prevent it from overheating and provide a bit of wiggle room when operating at max throttle. You do not want to go much higher than this range because if the ESC delivers a much higher current it could damage the motor. The ESC has two current ratings: continuous and burst. The continuous current is sustainable for prolonged periods of time and the burst current for short periods only.

When wiring ESCs into a quadcopter you can have one ESC for each motor or use a 4-in1 ESC with a single board and four motor connectors. Having four ECSs can help spread the load if the motors have a high power draw while a 4- in-1 ESC is a great option for saving space and limiting weight from hardware. ESCs often have a built-in battery eliminator circuit (BEC), which doesn't eliminate the need for a battery but acts as a voltage regulator to eliminate the need for a separate battery for on-board electronics. The power going through the BEC is dropped to a lower voltage, usually 5 V, which safely powers the receiver and any other devices on board.circuit including ESC and BEC is shown in figure7.

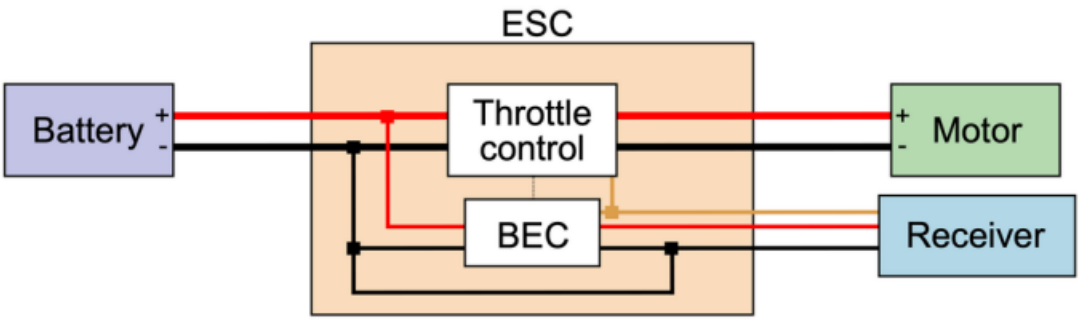

FIGURE 5:- DRONE POWER CIRCUIT INCLUDING AN ESC AND BEC[9]

3.3.2 BATTERY

The most common batteries in drones are lithium-based due to their high energy density compared to nickel cadmium or nickel metal hydride batteries. Lithium-polymer (LiPo)

batteries differ from other Li-Ion batteries because they are made of a porous/ gel-like compound instead of a liquid. LiPo batteries rival Li-Ion batteries in terms of energy density, but are especially popular because they are less likely to leak or combust. The energy density of LiPo batteries ranges from 140 - 265 Wh/kg in terms of weight and 250 - 730 Wh/L for volume. Volume energy density is important to consider when building a drone so the battery fits on the frame, but for performance calculations, the energy density by weight is more relevant. With higher density comes higher cost, so budgets may be a limiting factor.

The voltage rating of the battery will allow you to determine your motor speed and amperage. Since motors are rated in Kv with the unit RPM/Volt, the number of volts your battery can supply will determine how fast your motor will spin. You can cause damage to your circuit or even cause a fire if your voltage rating is too low or your current drawn is too high

TABLE 8:- BATTERY FOR QUADCOPTER

Orange polymer Battery pack	
Capacity (mAh)	4200
Voltage (V)	22.2
Discharge (C)	35
Weight (g)	621
Size (mm)	51*44*137
Cost (₹)	6399

We have selected orange polymer battery pack can be seen in table8 which is of 4200 mah and give 22.2 v that is it is a 6S battery and the discharge rate is 35C i.e.; The discharge rate or the C rating is a measure of how quickly the battery can safely discharge. If a battery has a C rating of 35 and a capacity of 4200 mAh/ 4.2 Ah, you could safely discharge it at 35 times the capacity of the battery, 35 x 4.2 = 147 Ah. With continuous power at that rate, the 4.2 Ah battery could be discharged in 1.7 minutes ((4.2 / 147) x 60 = 2.4). Batteries may also have a range or 'peak' discharge rate, where the battery may exceed its constant power output for a short period of time without overheating, such as during a sudden climb or correction. A higher C rating is great for applications like drone racing that require bursts of speed, since the battery can deliver the charge needed very quickly.

Battery capacity is given in mAh or Ah and can be used to estimate your flight time using equation 8. Battery capacity is more specifically defined as the number of hours of current or power the battery can provide. Common units are the ampere-hour (Ah) and the watt-hour (Wh). If a battery has a capacity of 1 Ah, you can draw 1 A of current for one hour. If the capacity is 1 Wh, the battery would provide 1 W of power for one hour.

CONCLUSION

A design of quadcopter is studied and the parts of quadcopter is fixed in this phase of project the flow analysis and the efficiency of quadcopter is concluded in the next phase of project.

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