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DESIGN & FABRICATION OF MULTI-PURPOSE DRONE

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ABSTRACT

Quadcopters are capable of stable vertical flight and can be used to track or collect data in a specific area within its application. Microcontrollers of low power in this modern world where the advancement in technology is reaching new heights are easily available and are of low cost, which allows the general public to create their own quadcopter. The aim of this project is to create a user-friendly drone which when needed can be used by anyone especially in these pandemic times to help the people in need. The project made use of quadcopter package, which comes with a frame, motors, esc and sensor boards, and also includes the batteries, transmitter & receiver, GPS module. Each part was checked and was made sure that it's working properly before its assembly. [1] With the situation getting worsen day by day, it is not even possible for the frontline health workers to go into the containment zones to supply the essentials. The major purpose of making this drone was to help the people in red zones which will ultimately reduce the burden on the frontline workers. The majority of the project's objectives were met, resulting in a secure and manoeuvrable quadcopter.

Keywords: Quadcopter, Transmitter & Receiver, Motors, Battery.

I. INTRODUCTION

A quadcopter, or multi-rotor, or drone, or quadrotor, is a basic flying mechanical vehicle that has four arms, and in each arm there's a motor connected to a propeller. Multi-copter with three or more arms are moreover conceivable, but works on the same vital as a quadcopter. In quadcopter, two of the rotors turn clockwise and the other two rotates in counter clockwise direction. Because of motors spinning in opposite direction the net torque at the center of quadcopter is zero, which means there is zero angular acceleration. For the quadcopter to fly the vertical force is increased by increasing the speed of all the motors by the same amount. As this vertical force crosses the gravitational force of the earth the quadcopter begins to fly. [2]

II. PROPOSED MODEL

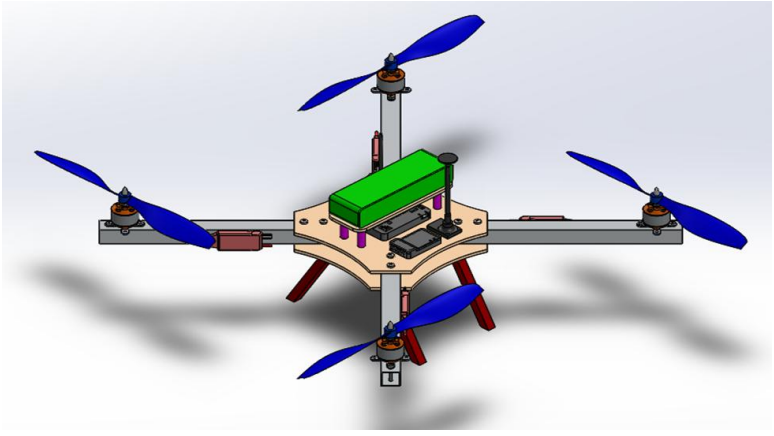

Figure 1: Isometric view of quadcopter

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Figure 2: Actual frame

III. COMPONENTS USED

The major components used during making of this quadcopter are described below:

FRAME: The construction holds all the components used in the quadcopter at the housing. It is intended to be solid and lightweight. To choose the suitable casing for the copter there are three factors to be considered namely weight, size and material used. The material used for making the frame should be strong enough to absorb the motor vibrations. Commonly used material for making frame are Carbon fiber, aluminium, and wood. The material used for making our housing is wood and arms is made of aluminium.

MOTORS AND PROPELLERS: Motors are used to spin the propellers. A quadcopter has 4 propellers of which two turn clockwise and the other two turn counterclockwise. The motors used is 2212 920KV Brushless motor and the propellers is Orange HD Propellers 1045(10*4.5).

ELECTRONIC SPEED CONTROLLER: ESC gives the signal to the motors how fast it should move at any instant of time. It provides high resolution 3 phase AC power to the motor. The ESC used is Emax BLHeli Series 30A.

FLIGHT CONTROLLER: It is generally referred as brain of the quadcopter because all the desired activities that are performed by the quadcopter is done by the flight controller. It is a circuit board that is having a number of sensors attached with it which detects the position of drone as well as the user's feed. The flight controller used for our model is APM 2.8.

TRANSIMTTER & RECEIVER: Transmitter is used to control the drone. Transmitter transmit a signal which is received by the receiver which is situated at the flight controller. Before the use of transmitter & receiver it needs a binding which is done only once.

BATTERY: In most of the quadcopters LiPo batteries are used because it is lightweight, compact in size and provides higher specific energy as compared to other lithium batteries. Battery power determines the flight time so one has to choose the battery very carefully. Orange 5200mAh 3S 40C/80C is the battery used for this particular model. [3,4]

IV. DESIGN CALCULATION

For designing of the drone, one must decide which type of material to be used for building of frame. The frame of the quadcopter is core a part which is subjected to varying load and stress so it must be designed in such a way that it should bear the required load. In our case, we have used a combination of aluminuim and wood(hardener) as the frame should be tough and lightweight. Frame is an assembly of four arms (for quadcopter) with centre housing which consist of mid and lower base plates.

By considering all possible scenarios, we have selected wheel base diameter for this drone to be 600mm. Wheel base diameter is distance between end of one arm to end of another arms diagonally.

WOODEN PLATES	ALUMINIUM ARMS
Length=170mm	Length=240mm
Breath=170mm	Cross-section=20mmx20mm (square pipe)
Thickness=2mm	Thickness=2mm

The wooden plates have been cut in shape of irregular lamena so that minimum material is used.

Once above values are set, next step will be calculation of power, torque, speed and weight as these are the crucial factor to determine the efficiency of a drone.

SPEED:

It is usually measured in RPM. Higher is the speed, more the current it draws. It also depends on KV ratings as RPM is directly proportional to volts supplied. KV is defined as revolutions per volt.

Below is the details of motor and battery which we have used in our drone.

Motor specification:	Battery specification:	
Current: 12A	5200mAh LiPo 3S	
Battery: 2 or 3S	C-rating: 40C	
ESC: 18A (30A suggested)	Burst rating: 80C	
Thrust: 3S with 1045 propeller 800gm approx.	Dimension: 137x28x44(mm)	Manufacturer Catalogue
Input voltage: 16V(Max)	Weight-360gm	
Weight: 50gm approx.	Balance plug: JST XH	
	Discharge plug: XT-60 (60A)	
	Voltage: 11.1V	

RPM= KV x Volts

Max voltage= 3.7x 3 (3S is the No. of cells in a battery and each cell carry 3.7V)

= 11.1V

RPM=1000 x 11.1

= 11000rpm (single motor)

Since we are using quadcopter there are four motors. Therefore,

Total RPM= 4 x111000

= 44400rpm

We have to attain RPM in range of 25-35000, hence our RPM is sufficient for stable flight.

WEIGHT:

It is one of the most important parameters in designing of drone as many other factors like torque, power etc. directly or indirectly depends upon it. Below is the list of all parts and components weight.

Arms- 115gm=115 x 4= 460gm
Mid base plate- 47gm
Lower base plate-47gm
Top base plate-26gm
Bushing-3.1gm=3.1 x 4= 12.4gm
Landing gear-70gm=70 x 2= 140gm
Nuts, bolts, washers-60gm
Frame weight= 792.4~800gm
Electronic components-912gm
Hence, total weight will be frame weight plus weight of electronic components.
Total weight= 1712gm (approx.)

TORQUE:

The amount of thrust the motor are generating to lift the drone is known as torque. It depends upon the size of motors lesser is KV rating, greater is the torque.

Since our drone is freestyle and its aim is for transportation of goods. We can assume that equipments up to 1kg can mounted on it for transporting.

Self weight of drone= 1712gm
Weight of goods= 1000gm

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Actual/ Takeoff weight= 1712+1000= 2712gm or 2.712kg

Using 2212, 1000KV motors with 1045 propellers, (Note: 1mAh is milli ampere hour 1000mAh= 1Ah)

Max. continuous current discharge = C-rating x Capacity
= 40 x 5.2
= 208 Ahr

Max. continuous current = It is the maximum amount of current that battery could deliver before depleting.

Burst current discharge = 80 x 5.2
= 416Ahr

Burst current discharge = It is a current which a battery can discharge for a short period (say 10 sec)

Now, determining the current consumed by motors at full throttle

Current consumption of single motor = 12Ahr (full throttle)

Therefore, current consumed by four motors = 12 x 4
= 48Ahr

The motors together must produce thrust greater than the takeoff weight to hover the drone in air. Total weight that must be overcome is 2712g. Hence, each motor has to produce at least 700g of thrust to surpass takeoff weight.

Current consumption of one motor to produce 100g of thrust is 1.5A.

Amps(A)	Load(g)
12	800
x	100

x = 1.5A

To produce 700g of thrust current consumed by one motor is,
= 1.5 x 700/100 = 10.5Ahr

Current consumed by four motors = 4 x 10.5
= 42Ahr

Above is the current which is drawn by motors from battery to effective flying.

Next is the flight time, one may find out the flight time if current consumption of motors is derived.

Flight time is the actual time that the pilot can control or fly the drone.

It is determined by using a fomula, i.e

Flight time = (battery capacity x battery discharge/ Avg.Amp draw) x 60, minutes

Battery discharge = 80% (Note: We cannot drain the battery below 20% voltage as it will permanently damage it so effective capacity is only 80% is available for flight time.)

Avg. Amp draw = current consumed by motors + current consumed by other electronic components
= 42Ahr + 5Ahr
= 47Ahr

Therefore, Flight time = (5.2 x 80%/47) x 60
= 5.31 minutes

Henceforth, we can say that the thrust produce by motors is 3200g and load which the drone has to handle is 2712g including extra 1 kg for placing of goods.

Safe weight = 3200 – 2712
= 488g

The remaining 488g can taken as factor of safety.

POWER:

The power of the drone is determine in terms of ratio of max static output of motor divided by weight of quadcopter/drone.

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It is written as, total thrust/ total weight

Power = 3200/2712

= 1.18~1.2

Therefore, the power we are getting is 1.2 times more than the required value.

V. RESULTS AND DISCUSSION

The following results were obtained when the motor was tested at various parameters:

Table 1. Experimental Values

Motor	Type	Kv	Battery	Propeller
XXD	2212	1000	3S 5200 30C	1045
V	A	W	Thrust (gr)	g/W
12.45	2.00	24.90	200	8.03
12.42	2.85	35.40	250	7.06
12.39	3.38	41.88	290	6.92
12.34	4.39	54.17	360	6.65
12.27	6.58	80.74	465	5.76
12.23	7.61	93.07	545	5.86
12.15	10.01	121.62	650	5.34
12.05	12.53	150.99	750	4.97
11.98	14.76	176.82	825	4.67

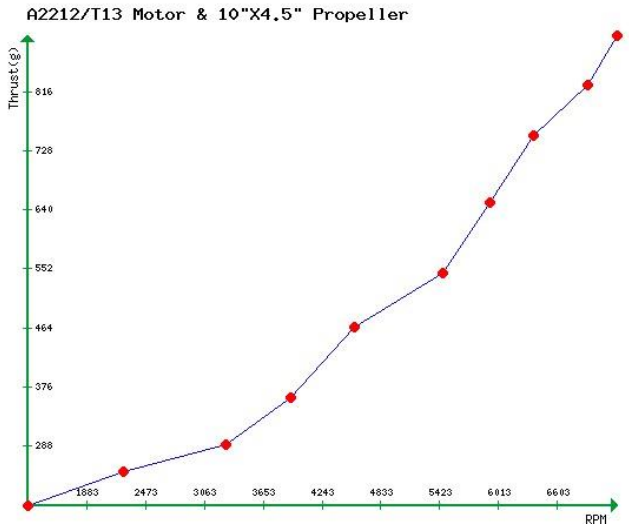

Figure 2: Graph of speed vs thrust

VI. CONCLUSION

This section discusses the salient features of the drone or the quadcopter which have many uses in practical application. The main purpose was to study the complete designing process of the quadcopter from the engineering view point and try to improve the balance and firmness. The frame of the drone was designed with the help of SolidWorks software which has a good rigidity and the size is also compatible with the specification of rotor and propeller used. In the near future, the quadcopter will become part of our daily lives, from the most basic things like delivery of groceries to the farmers manage the crops to ariel advertising to frequent use in military services and so on. With the project complete, with larger motors all that is necessary to achieve flight, replication is now relatively simple assuming all identical components. Hardware assembly and testing is all that would be necessary to create as many autonomous drones as desired.

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