Journal of Mechanical and Construction Engineering, 2024,
Vol. 04, Iss. 01, S. No. 038, pp. 1-8
ISSN (Online): 2583-0619

Design and Fabrication of FPV Racing Drone

Waqar Ahmed Siddiqui[1], M. C. Srivastava[2] Sumit Krishnan[3] Vivek Verma[4]

[1,2,4]Department of Aerospace Engineering, Amity School of Engineering and Technology, Amity University, Uttar Pradesh, Lucknow Campus
[3]Drone Instructor, Indian Drone Academy Pvt. Ltd, Hyderabad, India
swaqar7388@gmail.com[1], mcsrivastava@lko.amity.edu[2], sumitkrishnan99@gmail.com[3], vverma@lko.amity.edu[4]

How to cite this paper: W. A. Siddiqui, M. C. Srivastava, S. Krishnan and V. Verma, "Design and Fabrication of FPV Racing Drone," *Journal of Mechanical and Construction Engineering (JMCE), Vol. 04, Iss. 01, S. No. 038,* pp. 1–8, 2024.

https://doi.org/10.54060/a2zjournals.jmce.38

Received: 27/06/2023
Accepted: 25/07/2023
Online First: 30/11/2023
Published: 25/04/2024

Abstract

This research focuses on the designing aspects of a first-person view (FPV) Drone. An FPV drone is an unmanned aerial vehicle (UAV) that transmits Hawkeye's view to the ground control station. It's called a Hawkeye similar to the view that an eagle gets when it flies. It is also recognized for its dynamic behavior, the ease and flexibility of maneuvering. The response time of the FPV drone is quite remarkable for the purpose it serves. We have worked on the SP3 F3 racer Flight controller which is known for its extreme autopiloting and stability. Designing, developing, and simulating such a dynamic drone was a challenging task done with ease. It has a range of about 3 KM and a flight time of 11-12 minutes on (not so vigorous) flying conditions.

Keywords

First-Person View, UAV, Hawkeye view

1. Introduction

UAV's have been in existence ever since humans existed. Initially it was not easy and possible to control them because there was nothing there such as electronic or radio signals. First, we must get aware of the dictionary meaning of the term "Drone". The sound emitted by a colony of bees is known as drone. We may connect it as the sound which we hear near any

drone is very similar to the sound created by them. As discussed earlier, drone is nothing, but a radio controlled unmanned aerial vehicle which has been in existence since first world war happened. At that time air balloons were used to destroy the enemy army. The army used to fill the balloons with the explosives and made them to burst in enemy's zone. Although this trick sometimes damaged their own armies because the balloons used to fly in the direction of wind, which is uncontrollable. They had to drop this idea and move on towards the controlling on unmanned aerial vehicle. Therefore, it became the need of an hour to move towards the improvement of communication with the UAV to meet the current needs. the quick development of UAV's was observed during the era of first world war. The first pilotless airplane was built, and the radio controllability was mastered, which resulted in the guidance of missiles to the expected and desired target. Also, the drone technologies emerged until the second world war, but real boom was seen after the 90's. As a consequence, drones were more and more vital used in wars. Even India imported drones from Iraq during the Kargil war. Sir Abraham Karem is said to be the father of drones. He was an aeronautical engineer by profession and had a very keen interest in aircrafts since childhood.

As we all know about the emerging utilities of unmanned aerial vehicles in different sectors such as governmental, defense, agricultural, private, rescue, non-governmental levels, this industry has acquired a lot of attention and empathy from people. How so ever it is obvious that this drone industry has good control and command over the environmental friendly development and creations [1]. As a result the growth in this industry can be witnessed by all of us. There are a lot of job opportunities produced by this industry and also the government is taking good initiatives to promote the growth of start ups as well as in individual. In India 7 government is aiming to make India a 'drone hub'. Dedicated airspace differing all the flying zones so that safety and privacy is insured has been launched by the government of India. If we talk about the stats conducted by different bodies, the up-standing worth of this industry is $29.86 billion in 2022 and totalling all the initiatives made by the government, individuals and start up India stands with a total market worths $ 50 million during the financial year 2022.

With the time passing by and seeing this drastic growth in the unmanned aerial vehicle industry, all national and international governing agencies like Federal aviation authority (FAA), international civil aviation organization (ICAO), and the directorate general of civil aviation (DGCA) and many more have released many rules and regulations that everyone has to comply with. The UAV's have been categorized on the basis of many factors such as size, weight, configuration, purpose etc. on the basis of these configurations, if the weight exceeds 2 kg the user needs a RPAS license issued by the directorate general of civil aviation. If the drone is used for commercial purpose this license becomes mandatory else under some circumstances one can operate the drone with the consent of some regulating authority in that area such a local police.

The main objective of this project is to study and analyse the behaviour of a FPV drone built from very first thing to the final thing like making it from scratch. Although, to stay stuck to the main motive of this project there are some other missions to be accomplished and completed along with: Choosing all the parts that are responsible for the smooth flying of the Quadcopter. The study of compatibility of different equipments and accessories used to build this FPV quad copter. Installation of each component on their right and respective place and to calibrate them such as ESC, Flight controller, etc. To make the machine stable and airborne by working and tuning the flight controller. Implementation and study of vehicle dynamics, where we have discussed the proportional, integral and derivative factors to better study the performance of this airborne machine [2]. Flight dynamics of this machine have also been discussed. Analyzing and making a match between the practical and theoretical results which have been obtained after analysis (theoretical and practical) and changing the things accordingly so that we get a smooth flight. Based on all the results obtained, suggest new ways which can improve the flight time and aerodynamics of the Quadcopter [3-10]. Also, we have added an FPV system which enables us to receive live video from the drone to our ground control station. A simulator where we can learn the operation and methods of flying of drone[2-5].

Aircrafts fascinates, and every time we see an airplane flying in the sky, we feel amazed at how such a big machine is airborne, keeping all the physics and theories aside how a body can weighing in tons can fly in the sky that too for so long. these

were a few questions which we always have in my mind while we were young. My father being an 8 aircraft maintenance engineer used to take me to hangars and maintenance areas where I used to see aircrafts and helicopters and once he explained to me the theory of lift and how an aircraft flies, it was at this moment that I decided to pave my career in this field. Also during my school time, I made a project named Hero's Aelopile which is an example of newtons third law and how thrust works since then I have been reading articles and books which were about aircrafts. These little life happenings have been very helpful in motivating me to the stage in life where I can spend my knowledge and learn more and more everyday by exploring the new things. Furthermore, during the last decades we have all seen the progress and changes in the field of midea and photography everyone gets fascinated by high-definition videos with more and more frame rates. So if we have to shoot a video of a car race so obviously our drone needs to chase the cars with the equivalent speed which can be provided by the quadcopter which is been built from the very scratch.

Figure 1. Work distribution

2. Methodology

To obtain the objectives, the way and method that will be followed consists of firstly making a deep analysis of market which will to the selection of components of the vehicle. Along with the market study an industry expert will be reached out by me so as to do all the things under his guidance and supervision. After the successful assembly of the quadcopter, a few tests will be carried out to check the desired operation of our quad copter. It will be flown on different proportional, integral and derivative values until we get to see a no-perturbation flight .In order to fulfil that purpose, a number of flight tests will be carried out. Theoretical Euler Lagrange theorems will be employed to get the closest values of the quadcopter's equations of motion and flight dynamics. While working on such long projects which involve a long number of operations time management becomes very important, time management ensures the success of project within a deadline and with no unexpected errors. With this regard the weekly progress report has been made in which the detailed work plan of the ongoing week and upcoming week is mentioned. With the help of this, we can break the work in different sections, kindly refer the diagram to have better understanding of time plan.

2.1. State of the art

The category that matches it best, in accordance with this project and the primary function of the vehicle, inspection, which simply calls for it to have a camera, is SUA. By taking a deeper look at this division, a subcategory where UAVs are classified according to their geometry is discovered. The three most popular types of unmanned aerial vehicles (UAVs) in this class of multirotors are the quadcopter, hex copter, and octocopter.

2.2. Software

A perfect synergy between the hardware and the software is required in order to achieve a fully autonomous unmanned aerial vehicle that is capable of completing the assigned task. The "flight controllers," also known as the "neuralgic centre" carrying out various directives, are the result of this significant collaboration. Their functioning combines the use of physically carry output. There are two primary kinds of software when it comes to property ownership issues: open source and proprietary software. The primary distinction between the two is that, in the first, the original source code is made available for use and advanced users are given the ability to add later modifications, whereas in the second, the software development business controls the original source code and offers the option to use it with certain limitations. common hardware/software solutions, despite the fact that there are numerous options currently on the market.

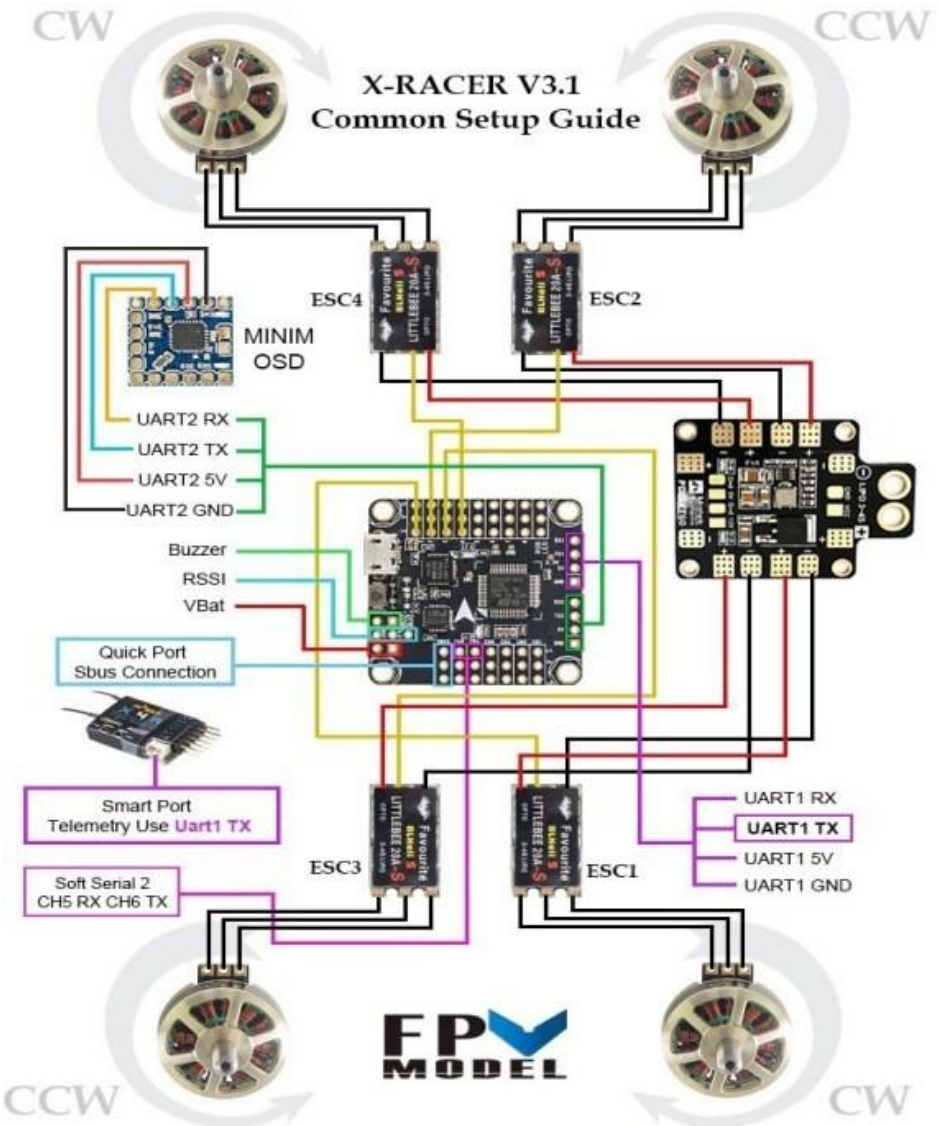

Figure 2. FPV Model

2.3. Flight board

With the use of a next-generation CPU and tried-and-true sensors, the SP Racing F3 Flight Controller ARCO was created to deliver outstanding flight performance in a compact and incredibly light form factor. This flight controller has a tonne of unique features, starting with a next-generation STM32 F3 CPU with a faster ARM-Cortex M4 core and hardware floating point unit for effective flight calculations. Additionally, it has a large-capacity black box flight log recorder that you can use to optimise your tune without having to make any educated guesses. extra built-in sensors for altitude and direction, together with a barometer positioned on the board's bottom for simple wind isolation, are some extra fantastic features. An output specifically for programmable LEDs that is excellent for 12 orientation both night flying and racing. All functionalities are supported simultaneously by the no-compromise I/O. Between Acro and the Deluxe edition, there are some differences: Acro: The typical racing/acro flying model. Deluxe: Extra sensors for direction and altitude. The flight control (FC) software used by F3 is free and open-source, with a vibrant user and developer community. Because it is open- source, you may add to the system. The creators and community of Cleanflight have reviewed and updated the comprehensive documentation that is included with the software. No more rumours or hearsay. Links to the handbook are available at http://cleanflight.com. Downloadable PDF versions are available from the GitHub releases pages. Make sure to consult the handbook that corre-sponds to the firmware version you are using.

2.4. Processor

There in the center of all F C may be a small processor that works onerous to stay you within the air, we tend to be solely very exploitation F3 or F4 chips thus suggested to selecting an F C with one in all these. We tend to don't seem to be very creating nevertheless. Lindesnes thirty-two boards are currently superannuated and cannot be supported by future software system updates.

3. Proposed Methodology and Implementation

To build the drone now you have an idea the kind of drone you would like, to choose the components the following next step is as follows. Person to person each build is going to carry but the basic pattern will be followed by all builds. Ill explain for each component what it does, you will have to make the choice and for spec-wise the bare minimum you should look.

3.1. Frame

Your beginning point is this. Everything you find along of all your components. The frame is mde up of carbon fiber and is very durable. It can bear heavy shocks and deal with the crack it will not easily break.

Figure 3. Frame of FPV

3.2. Quadcopter Brushless Motors

This area units the powerhouse that offer your quadcopter thrust to achieve your quads the insane speeds drones area units reach. Out there, there is a BLDC drone, the decision is very difficult. while selecting the motors this is to be kept in mind that our motors are capable enough to lift up more and more weight, that is they must produce enough of thrust, the power generated, and the rounds per minute produced. So here we are choosing a 2300 Kv Brushless D C motor (BLDC) to fulfil our purpose.

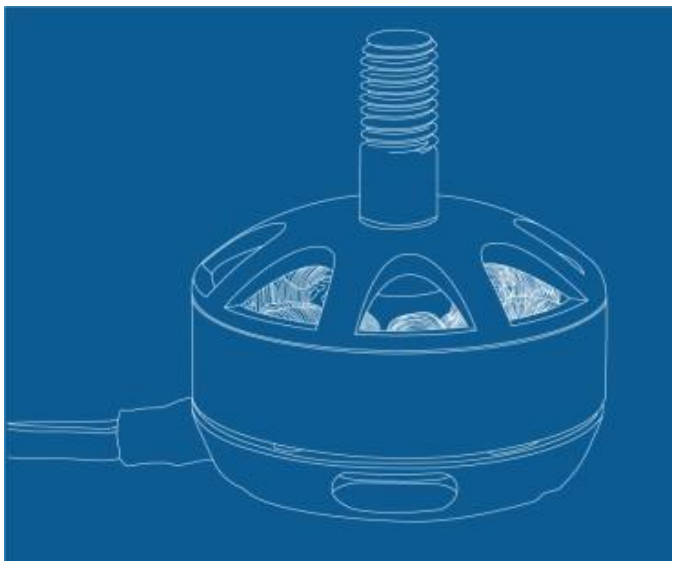

Figure 4. Brushless Motor

3.3. Sensors Type

FPV cameras are commonly equipped with either a Complimentary Metal Oxide Semiconductor or a Charged Couple Device image sensor. Complimentary Metal Oxide Semiconductor cameras are often less expensive and light, but they lack the capacity to respond fast to change in illumination. Because we regularly fly in the brilliant sun followed by the darker terrain, any loss of sight might lead to an accident.

4. Result and Discussion

The values do not correspond, as seen in Sub-Section when the Proportional, Integral and Derivative of both the vehicle and the theoretical model were tweaked. Despite this dissimilarity, each set of characteristics appears to serve its purpose. As a result, two case scenarios are offered to elucidate the cause of this phenomena and to ensure that no errors have occurred. On the one hand, the experimentally acquired PIDs are entered into Simulink, and the real vehicle's behavior is compared to that of the model. The theoretically derived PIDs, on the other hand, are put in the vehicle using beta flight to compare the theoretical and experimental responses.

4.1. Simulink PID Experiments

To recreate the same circumstance as the experiment one, the first-person view FPV quadcopter is initially flown with characteristics that improve its stability. Referring back to Table, these results are Proportional = 0.16, Integral = 0.49, Derivative = 0.039, Proportional = 0.163,Integral = 0.085, Derivative = 0.049 and P = 0.21, I = 0.0023, D = 0. Following that, the processors is accessible via betaflight to download the transmitter commands, which are then presented as inputs in Simulink. Fur-

thermore, the theoretical PIDs are replaced with the ones listed above, and the model is run. The 56 theoretical and desired angles are the consequences of this system. The betaflight graphs and the Simulink graph may be viewed in the graphs below.

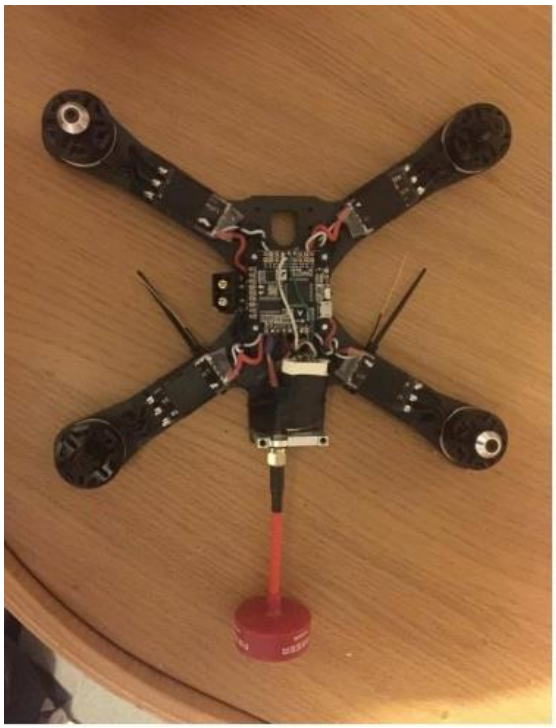

Figure 5. FPV Drone

5. Conclusions

We have learned about choosing the right components which matches the feasibility with other equipment after performing all the process from designing to fabrication to simulation and testing of an SP F3 Flight Controller-based FPV drone, we have also developed a very good understanding of design parameters such as flight time, thrust available, payload carrying capacity, maximum speed, endurance and range of the FPV drone. This project helped me to enhance my flying skills as FPVs require a very highly skilled drone pilot to maneuver. The project was all about building a drone which includes the all the design aspects such as the preliminary design, the conceptual design all the other concepts which should be kept in mind while designing a FPV drone. The theoretical and practical studies have been made, and all the vehicle's theoretical PIDs and practical PIDs are considered so that optimum efficiency data can be recorded. While designing an FPV drone stability is the main criterion. For a stable FPV drone to find the appropriate compatible components is extremely important. Also, PID tuning was done for stability. In the theoretical part, the quadcopter dynamics were studied with the help of Simulink and MATLAB. Finally, the FPV was assembled and a test flight was done, which was a success as the quadcopter was stable and flying very smoothly.

References

[1]. *"Boletín Oficial del Estado*," no. 252. 2014 https://www.boe.es/boe/dias/2014/10/17/

[2]. J. Gundlach, *Designing unmanned aircraft systems: A comprehensive approach*. American Institute of Aeronautics and Astronautics, 2012.

[3]. R. E. Hofer. "*Preliminary design of an unmanned aerial vehicle with application to photovoltaic farm inspection*",

2014.

[4]. J. R. Wertz, D. F. Everett, and J. J. Puschell, *"Space mission engineering: the new SMAD,"* Microcosm Press, 2011. https://astrobooks.com/spacemissionengineeringthenewsmadsme-smadwertzeverettpuschellavailablespring2011softcover.aspx

[5]. D. Norris, *"Build your own quadcopter,"* McGraw-Hill Education, 2014. https://www.asemanx.com/wp-content/uploads/2021/09/Build-your-own-quadcopter-power-up-your-designs-with-the-Parallax-Elev-8.pdf

[6]. S. Bouabdallah, *"Design and control of quadrotors with application to autonomous flying,"* PhD thesis, École Polytechnique federale de Lausanne, 2007. https://www.researchgate.net/publication/37439805_Design_and_Control_of_quadrotors_with_application_to_autonomous_flying

[7]. I. A. Manarvi, M. Aqib, M. Ajmal, M. Usman, S. Khurshid, and U. Sikandar, *"Design and development of a quad copter (UMAASK) using CAD/CAM/CAE,"* IEEE Aerospace Conference, 2013.

[8]. C. Robert, "*Flight stability and automatic control*", WCB/McGraw Hill, vol. 2, 1998.

[9]. C. Balas, *"Modelling and Linear Control of Quadcopter,"* PhD thesis, MS Thesis, Cranfield University, Cranfield, 2007. https://www.scribd.com/document/247123109/Modelling-and-Linear-Control-of-Quadcopter-SimuLINK#

[10]. R. W. Beard, *"Quadrotor dynamics and control,"* Brigham Young University, 2008 https://www.researchgate.net/publication/265825340_Quadrotor_Dynamics_and_Control