



UNDERGRADUATE PROJECT REPORT

ON

Aerial Agricultural Vehicle

Submitted By

Mehedhi Hassan (ID:2013-3-80-009)

Md Shihab Uddin (ID:2013-3-80-034)

Submitted to the

Department of Electrical and Electronic Engineering

Faculty of Science and Engineering

East West University

In partial fulfillment of the requirements for the degree of Bachelor of Science in

Electrical and Electronic Engineering

(B.Sc. in EEE)

Summer, 2018



UNDERGRADUATE PROJECT REPORT

ON

Aerial Agricultural Vehicle

Submitted By

Mehedhi Hassan (ID:2013-3-80-009)

Md Shihab Uddin (ID:2013-3-80-034)

Submitted to the

Department of Electrical and Electronic Engineering

Faculty of Science and Engineering

East West University

In partial fulfillment of the requirements for the degree of Bachelor of Science in

Electrical and Electronic Engineering

(B.Sc. in EEE)

Summer, 2018

Approved By

Fakir Mashuque Alamgir
Project Advisor
Assistant Professor, Department of EEE, EWU

Dr. Mohammad Mojammel Al-Hakim
Chairperson, Department of EEE, EWU

Acknowledgment

At first, we would like to thank the Almighty for giving us enough courage, scope, potential, and intelligence to complete the project. Then we are grateful to our parents for their nonstop support. Today we are here only because of them.

We are grateful to our supervisor Mr. Fakir Mashuque Alamgir, Assistant Professor, Department of Electrical and Electronic Engineering (EEE), East West University (EWU), Dhaka. He gave us regular guidance, valuable suggestions, and constant support during the project work. He inspired us a lot and gave us new ideas to implement on our project.

We would also like to thank the chairperson Dr. Mohammad Mojammel Al-Hakim, Professor Department of Electrical and Electronic Engineering (EEE), East West University (EWU), Dhaka.

At last, we want to thank our parents, well-wishers, and friends for their moral support and helpful discussion during the project work.

INDEX

ABSTRACT.....	1
CHAPTER 1: INTRODUCTION.....	2
1.1 Background	3
1.2 Report Organization	3
CHAPTER 2: HARDWARE AND SOFTWARE.....	4
2.1 Hardware	4
2.1.1 4200mAh 30C 11.1v Lipo Battery	4
2.1.2 APM 2.8 Flight Controller.....	5
2.1.3 NEO-6M GPS(Global Positioning System) Module.....	6
2.1.4 ESC(Electronic Speed Control) 20A.....	7
2.1.5 1400KV Brushless Outrunner Motor	8
2.1.6 Servo Motor MG996	9
2.1.7 X-525 Glass Fiber Frame	10
2.1.8 Power Distribution Board.....	11
2.1.9 Propeller 10x4.5"	12
2.1.10 6CH Remote Control.....	13
2.1.11 FPV Camera transmitter and receiver	14
2.2 Software	15
CHAPTER 3: SYSTEM RUNNING PROCESS.....	16
3.1 Block Diagram of the System	18
3.2 Working Principle	19

CHAPTER 4: CONCLUSION	22
4.1 Features	22
4.2 Drawback	22
4.3 Future Work	22
4.4 Discussion	23
4.5 Project Demonstration.....	23
REFERENCES	28

LIST OF FIGURES

Figure 2.1 : 4200mAh 30C 11.1v Lipo Battery	4
Figure 2.2 : APM 2.8 Flight Controller	5
Figure 2.3 : NEO-6M GPS(Global Positioning System) Module	6
Figure 2.4 : ESC(Electronic Speed Control) 20A	7
Figure 2.5 : 1400KV Brushless Outrunner Motor	8
Figure 2.6 : Servo Motor MG996	9
Figure 2.7 : X-525 Glass Fiber Frame	10
Figure 2.8 : Power Distribution Board	11
Figure 2.9 : Propeller 10x4.5"	12
Figure 2.10 : 6CH Remote Control	13
Figure 2.11 : FPV Camera transmitter and receiver	14
Figure 2.12 : Mission Planner software interface	15
Figure 3.1 : Drone top view	16
Figure 3.2 : Drone side view.....	17
Figure 3.3 : 6CH Transmitter.....	17
Figure 3.4 : FPV Camera Receiver with Smartphone.....	18

Figure 3.5 : Total system block diagram.	19
Figure 3.6 : Throttle and Yaw movement of Drone	20
Figure 3.7 : Roll and Pitch movement of Drone	20
Figure 3.8 : Flow chart of the total system	21
Figure 4.1 : Arming of the drone by transmitter	23
Figure 4.2 : Takeoff	24
Figure 4.3 : Right movement	24
Figure 4.4 : Left movement	25
Figure 4.5 : Forward movement	25
Figure 4.6 : Backward movement	26
Figure 4.7 : Live video streaming	26
Figure 4.8 : Spraying	27
Figure 4.9 : Landing	27

ABSTRACT

The main purpose of our project is to monitor and apply pesticides in the agriculture fields. Currently, 36.50% of global crop production is lost due to disease, pests, and weeds [1]. Following the report of ACCII (Associated Chambers of Commerce and Industry of India), annual crop losses due to pests and diseases amount to Rs.50,000 crore which is approximately \$500 billion [2]. It is a significant loss for a country. Pest and disease attack is one of the major problems. The number of disease and pest attack is increasing day by day. This attack could be reduced if the farmers monitor their field sincerely and apply pesticides in a proper way. That is why we are making this project so that we can reduce the number of disease and pest attack. We collect the data of some common disease and pest. We noticed that the farmers are applying pesticides improper way. We designed our system very carefully so that farmers can monitor their field easily and apply pesticides in a proper way. Our system is capable of controlling the damage of crops and bad effect on the environment and human health.

KEYWORDS : Agricultural drone, Pesticides spraying, Aerial monitoring, Agricultural disease and pest control.

CHAPTER 1: INTRODUCTION

Now a day cultivating crop is commercially increasing day by day. But the problem is it requires a huge manpower to maintain an agriculture field. Also, it's costly to maintain this amount of manpower. Farmers have always needed accurate and up-to-date information on the health of their crops and the environmental condition of the land. Among various ideas, we chose this project (Aerial Agricultural Vehicle) which will helps farmers in agriculture purpose. It will also reduce the amount of cost. Aerial Agricultural Vehicles basically low-cost drones with higher and advanced sensors and imaging capacities [3]. This project will help farmers to easily manage their fields. It is really hard for an individual farmer to manage the whole fields. It will waste his time and energy both. So we try to solve this problem for farmers. We design a drone which will change the substance of cultivating and development heavily. These drones have the ability to check storm damage, monitor crop progress, apply pesticides, and make sure that both crops and herds are healthy [3]. Also, farmers can identify Issues like crop growth, nutrient deficiency, water abundance, disease attacks and insect infestation [4]. The data collected by the drone images would help farmers to decide the perfect time to irrigate, apply fertilizers and pesticides [4].

1.1 Background

Agriculture is the most important sector of Bangladeshi economy. It contributing 19.6 percent to the national GDP (Gross domestic product) of our country and providing employment for 63 percent of the population [5]. But insect infestation and disease attacks are the main challenges in the agricultural sector. The number of disease and pest attack in agricultural sector significantly increases in Bangladesh over the past few years. Following a research conducted by the World Bank, agriculture has been highly susceptible to crop pest attacks and diseases. Conservative estimates of annual crop losses due to disease, pests, and weeds are 36.50% [1]. A proper estimation of the economic loss in the agricultural sector due to disease and pest attack in Bangladesh would surely reflect the considerable loss of addition to GDP. According to a research economic losses to developing countries each year, equating to 1.8% - 2.2% of total agricultural GDP [6]. For a developing country like Bangladesh, it is unacceptable.

1.2 Report Organization

In chapter-2, we have discussed about the software and hardware equipment that we have used in the project to construct the device. In Chapter-3, we have discussed about the block diagram and the working principle of the device. In Chapter-4, we have discussed about the features, drawbacks, discussion, and project demonstration about the device.

CHAPTER 2: HARDWARE AND SOFTWARE

In this project, we have used different types of hardware and software. 4200mAh Battery, APM 2.8 Flight Controller, GPS(Global Positioning System) Module, ESC(Electronic Speed Controller), Brushless Motor, Servo Motor, 6CH Receiver and Transmitter, FPV Camera Transmitter and Receiver, Propeller are the main hardware. Mission Planner is mainly used in this project as software.

2.1 Hardware

2.1.1 4200mAh 30C 11.1v Lipo Battery



Figure 2.1 : 4200mAh 30C 11.1v Lipo Battery [7]

Higher charge voltage than standard lipos. Perfect for high-performance models. Higher capacity than comparable size packs. Heavy duty silicone wire discharge leads. Rechargeable battery [7].

Specifications :

- Brand: Wild Scorpion
- Battery capacity: 4200mAh
- The discharge rate: 30C
- Max charging rate: 10C
- Battery section: 3S(11.1V)

- Dimension: 135.4 * 42.3 * 25.6mm (5.33 * 1.66 * 1.0 inch)
- Weight: Approx.316g (11.15 oz)
- Charge Plug: JST-XH
- Discharge Plug: TReference

2.1.2 APM 2.8 Flight Controller



Figure 2.2 : APM 2.8 Flight Controller [8]

The APM 2.8 flight controller is a professional quality IMU(Inertial Measurement Unit) autopilot that is based on the Arduino Mega platform. This autopilot can control fixed-wing aircraft, multi-rotor helicopters, as well as traditional helicopters. It is a full autopilot capable for autonomous stabilization, way-point based navigation and two-way telemetry with XBee wireless modules. Supporting 8 RC channels with 4 serial ports. ArduPilot Mega consists of the main processor board and the IMU shield which fits above or below it [8].

Specifications :

- Arduino Compatible
- Includes 3-axis gyro, accelerometer, and magnetometer, along with a high-performance barometer
- Onboard 4 Megabyte Dataflash chip for automatic data logging.
- Optional off-board GPS, uBlox LEA-6H module with Compass.

- One of the first open source autopilot systems to use Invensense's 6 DoF Accelerometer/Gyro MPU-6000.
- Barometric pressure sensor upgraded to MS5611-01BA03, from Measurement Specialties.
- Atmel's ATMEGA2560 and ATMEGA32U-2 chips for processing and USB functions respectively.

2.1.3 NEO-6M GPS(Global Positioning System) Module



Figure 2.3 : NEO-6M GPS(Global Positioning System) Module [10]

The NEO-6M GPS module appears in the figure underneath. It accompanies an outside radio wire and doesn't accompany header pins. In this way, you'll have to get and patch a few. The NEO-6M GPS module is likewise good with other microcontroller boards. The NEO-6M GPS module has four pins: VCC, RX, TX, and GND. The module speaks with the Arduino through serial correspondence utilizing the TX and RX pins, so the wiring couldn't be less complex [10].

Specifications :

- Dimension: 22mmX30mm
- Height: 13mm

- Hole dia.: 3mm
- Weight: 12g

2.1.4 ESC(Electronic Speed Control) 20A

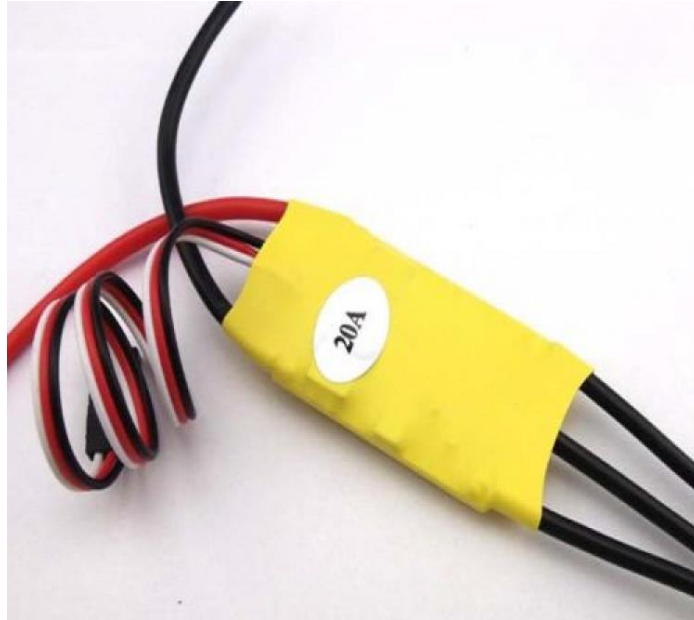


Figure 2.4 : ESC(Electronic Speed Control) 20A [10]

This is an electronic circuit that controls and directs the speed of an electric motor. It might likewise give turning around the motor and dynamic braking. Smaller than normal electronic speed controls are utilized as a part of electrically powered radio controlled models. Full-size electric vehicles additionally have systems to control the speed of their drive motors [10].

Specifications :

- Constant Current: 20A
- Burst Current: 25A
- Battery: 2-4S Lipoly / 5-12s NiXX
- BEC: 5v / 3A
- Motor Type: Sensorless Brushless
- Size: 54 x 26 11mm
- Weight: 30

2.1.5 1400KV Brushless Outrunner Motor



Figure 2.5 : 1400KV Brushless Outrunner Motor [11]

This is a brushless outrunner motor particularly made to control quadcopters and multirotors. It is a 1400kV motor. It gives elite, superpower and brilliant efficiency. These motor are ideal for medium size quad-copters with 8-10 inches propellers. Use this to build powerful and efficient quad-copters [11].

Specifications :

- KV: 1400
- No load Current : 10 V : 0.5 A.
- Current Capacity: 12A/60s
- No Load Current @ 10V: 0.5A
- No. Of Cells: 2-3 Li-Poly
- Motor Dimensions: 27.5 x 30mm
- Shaft Diameter: 934;3.17mm
- Shaft diameter: 3.175mm.
- Minimum ESC Specification: 18A (30A Suggested)
- Thrust @ 3S with 1045 propeller: 1000gms approx

- Thrust @ 3S with 0945 propeller: 650gms approx
- Thrust @ 3S with 0845 propeller: 550gms approx

2.1.6 Servo Motor MG996



Figure 2.6 : Servo Motor MG996 [12]

It is basically an upgraded version of the famous MG995 servo, and features upgraded shock-proofing and an updated PCB and IC control framework that make it significantly more exact than its predecessor. The gearing and motor have additionally been moved up to enhance dead data transfer capacity and centering. This high-torque standard servo can turn around 120 degrees (60 toward every path) [12].

Specifications :

- Brand : Tower pro
- Modulation : Digital
- Torque : 4.8V: 130.54 oz-in (9.40 kg-cm)
6.0V: 152.76 oz-in (11.00 kg-cm)
- Speed : 4.8V: 0.19 sec/60°
6.0V: 0.15 sec/60°
- Weight : 1.94 oz (55.0 g)
- Dimensions : Length:1.60 in (40.7 mm)

Undergraduate Project Report

- Width : 0.78 in (19.7 mm)
- Height : 1.69 in (42.9 mm)
- Gear Type : Metal
- Rotation/Support : Dual Bearings
- Pulse Cycle : 1 ms
- Connector Type : JR

2.1.7 X-525 Glass Fiber Frame



Figure 2.7 : X-525 Glass Fiber Frame [13]

It is basically a body frame which is made by SS pipe. It will carry the whole component of our drone [13].

Specifications :

- Width: 600mm
- Motor Bolt Holes: 14~30mm

2.1.8 Power Distribution Board



Figure 2.8 : Power Distribution Board [14]

This Power Distribution Board can be used with any frame. It distributes power from the flight battery to ESCs to power the Quad's motors. This power distribution board provides a tidy plug and play solution to power our speed controllers. Simply use 3.5mm male connectors on our ESCs and plug a battery in using the (optional) pre-soldered XT60 male connector. The board also features a 2 pin, JST size auxiliary power out port that is perfect for powering LEDs or any accessories fitted to the drone [14].

Specifications :

- Current: 4 x 20A Outputs (MAX)
- Power Input: XT60 with 12AWG wire
- Motor output: 4 x 3.5mm Female bullet plug
- Aux output: 2 pin JST compatible
- Weight: 27.3g (including wires)

2.1.9 Propeller 10x4.5"



Figure 2.9 : Propeller 10x4.5" [15]

A propeller is a device with blades which is attached to aircraft. The engine makes the propeller spin round and causes the aircraft to move. Here we used 10inch (25cm) diameter 4.5inch (11cm) pitch matched pair of pusher and puller propellers. It is most suitable for our drone [15].

Specifications :

- Type: Pusher and Puller pair of propellers
- Diameter: 10inch (25cm)
- Pitch: 4.5inch (11cm)
- Weight: 13gms
- Supported motor shafts: 3mm, 3.2mm, 4mm, 5mm, 6mm, 6.35mm, 7.95mm

2.1.10 6CH Remote Control



Figure 2.10 : 6CH Remote Control [16]

Super active and passive anti-jamming capabilities, Very low power consumption, High receiving sensitivity, 8 model memory, digital control Can be programmed by PC with included software [16].

Specifications :

- Transmitter/Receiver: 2.4GHz
- Mode type: Airplane, Helicopter, Glider
- Stick mode: Left Hand or Right Hand
- Modulation: Frequency Modulation
- Antenna length: 115cm/26mm
- Code type: PPM/GFSK
- Power: 12V DC
- Certificate: CE FCC
- RF power: Less Than 0.8w
- Item weight: 575g

- Item dimension: 180x220x70mm

2.1.11 FPV Camera transmitter and receiver



Figure 2.11 : FPV Camera transmitter and receiver [17]

Here we use 700TVL 1/3 CMOS FPV Camera. This camera is small and light. This FPV camera is mounted onto a drone to send real-time video down to the ground using a video transmitter. The FPV camera allows us to see where the drone is flying and what it is seeing as if it had its own eyes. Depending on the drone, the FPV transmitter will send the live video signal to our Remote Control screen, monitor, smartphone device. FPV cameras allow us to fly higher and further with some of the latest drones being able to fly up to a limited range using FPV technology [17].

Specifications :

- Sensor: 1/3" CMOS > 700TVL
- Format: NTSC/PAL
- Horizontal Resolution: 700TVL
- Lens: 2.6mm IR coated
- Field of View: 127° diagonal 160° horizontal (ideal for a fixed camera)
- Input Voltage: DC 3.6~5.5V (powered from VTX)
- Power consumption: 60mA @ 5V

- Operational temperature: -20~70°C
- Connector Type: Mini Molex type plug
- Dimensions: 29 x 24 x 17mm
- Weight: 9.3g

2.2 Software

Here we used Mission Planner software for our drone project. Mission Planner is a full-featured ground station application for the ArduPilot open source autopilot project. It is a ground control station for Plane, Copter, and Rover. It is compatible with Windows only (although it can be run on Mac using mono). Mission Planner can be used as a configuration utility or as a dynamic control supplement for Our autonomous vehicle set up as well as pre-flight mission planner, in-flight monitoring, and post-flight log file analysis [18].

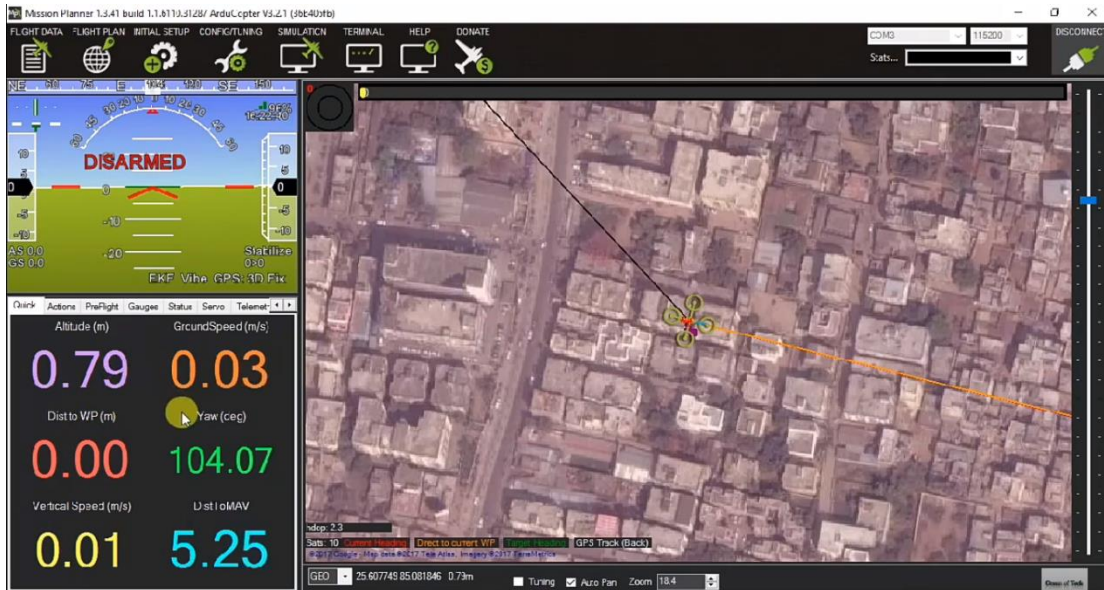


Figure 2.12 : Mission Planner software interface [18]

CHAPTER 3: SYSTEM RUNNING PROCESS

Our project has two parts. One is the Drone with the Sprayer and another is the 6CH Transmitter with the FPV Camera Receiver. People will use the 6CH Transmitter to control the Drone and the Sprayer. Through the FPV Camera Transmitter, video data will be transmitted and the FPV Camera Receiver will receive the video data. Video data will be displayed in the Smartphone display by using an app.

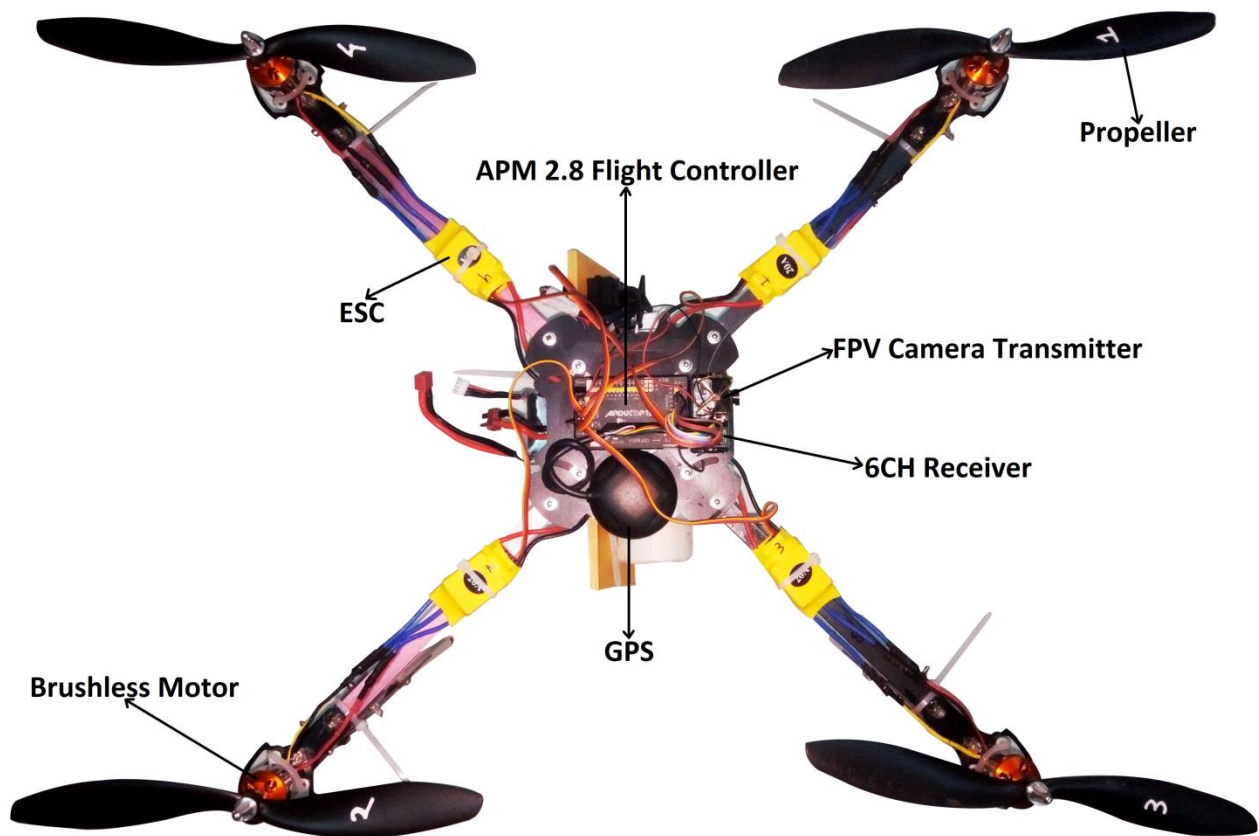


Figure 3.1 : Drone top view

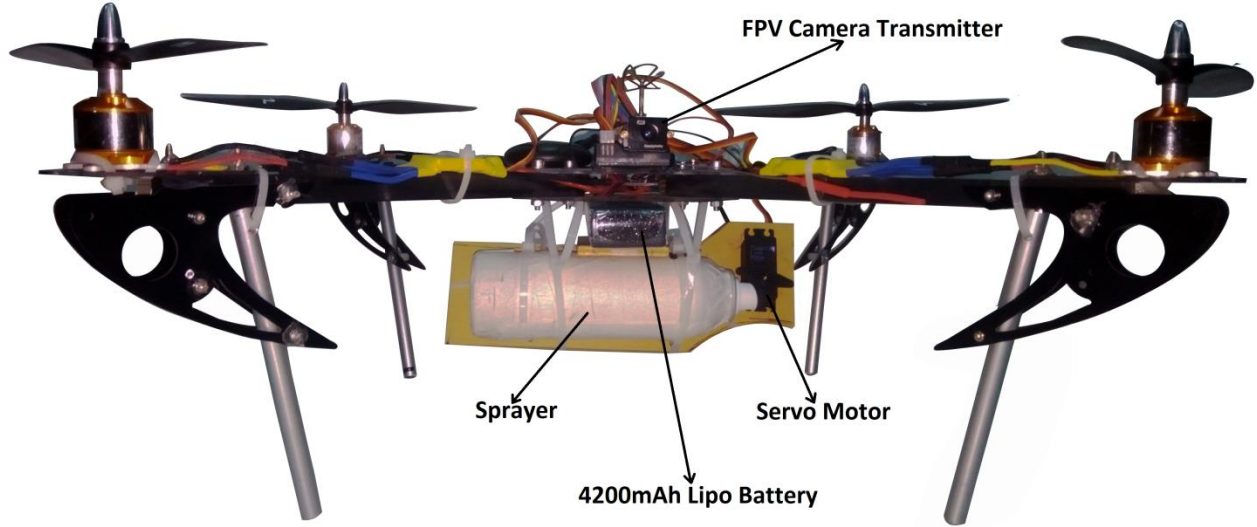


Figure 3.2 : Drone side view

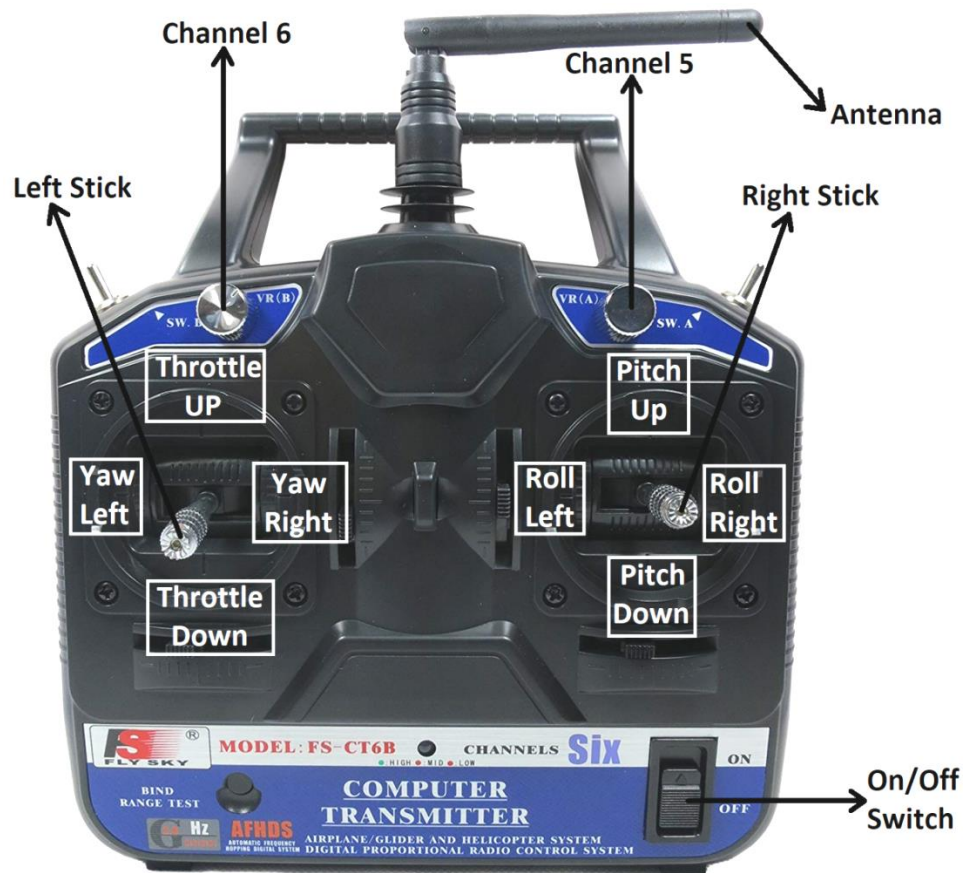


Figure 3.3 : 6CH Transmitter



Figure 3.4 : FPV Camera Receiver with Smartphone

3.1 Block Diagram of the System

The block diagram of the total system is shown in Figure 4.5, This is the proposed block diagram of the system. APM 2.8 Flight Controller is used as the processor of the system. GPS(Global Positioning System), ESC(Electronic Speed Controller), 6CH Receiver, FPV Camera Transmitter are connected with the APM 2.8 Flight Controller. GPS holds the Drone in a stable position and identifies the takeoff position so that it can automatically land on the takeoff position. 6CH Receiver is connected wirelessly with the 6CH Transmitter. The flying instructions are transmitted by 6CH Transmitter and received by 6CH Receiver, thus the drone movement is controlled. The Sprayer is connected with the Servo Motor and the Servo Motor is connected with the 6CH Receiver. The Sprayer and the Servo Motor is controlled wirelessly by the 6CH Transmitter. FPV Camera Transmitter is connected wirelessly with FPV Camera Receiver. The video data is transmitted by FPV Camera Transmitter and received by FPV Camera Receiver which is displayed in the Smartphone display by using an app. The Propeller is connected with the Brushless Motor and the Brushless Motor is connected with the ESC. The ESC converts the PWM signal from the APM 2.8 Flight Controller and drives the Brushless

Motor by providing the appropriate level of electrical power. DC Power is supplied to the APM 2.8 Flight Controller and the ESC through 4200mAh 11.1V Battery.

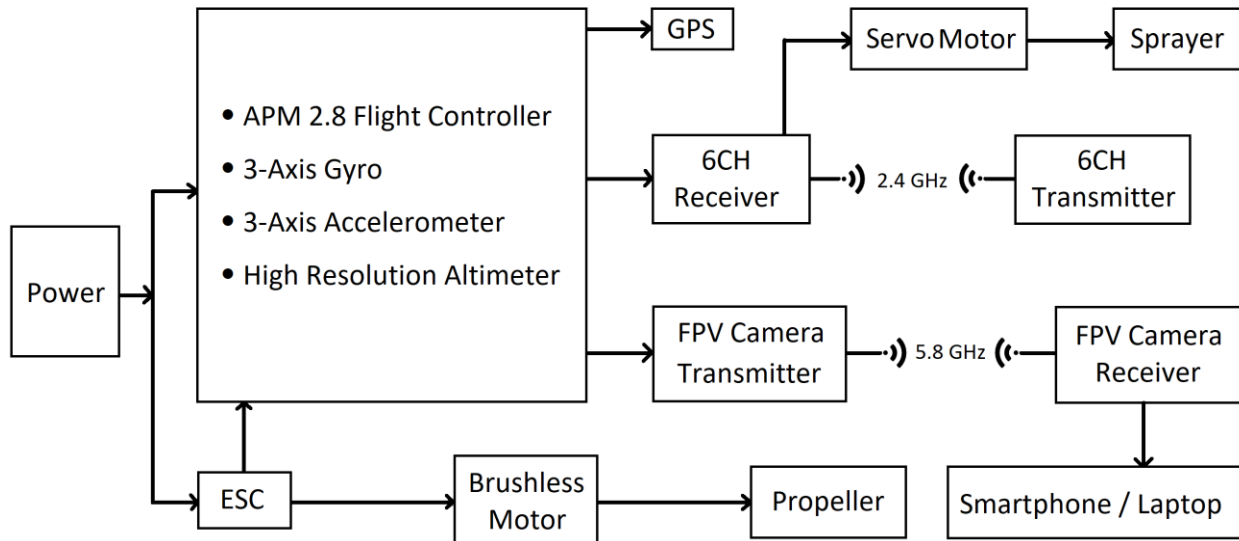


Figure 3.5 : Total system block diagram

3.2 Working Principle

The project has two parts. One is the Drone with the Sprayer and another is the 6CH Transmitter with the FPV Camera Receiver. After the drone is powered up, the flight controller activates with a sound and checks all the connections of the GPS, ESC, brushless motor, servo motor, FPV camera and the 6ch receiver. If all the connections are ok then it connects with the 6ch transmitter and the FPV camera receiver. The 6ch transmitter is then ready to control the drone's flying movement, modes and the sprayer connected with the servo motor. The left and right sticks of the 6ch transmitter control all the flying movement. The left stick controls two aspects of flying a drone which is the throttle and the yaw. The throttle is the movement of up and down. This control is on the y-axis. If the left stick is moved up and down, the drone will change its altitude. It is also used for takeoff and landing. The Yaw is the rotation of left and right. So, if the left stick is pushed on the x-axis left or right, it will make the drone rotate in that specific direction.

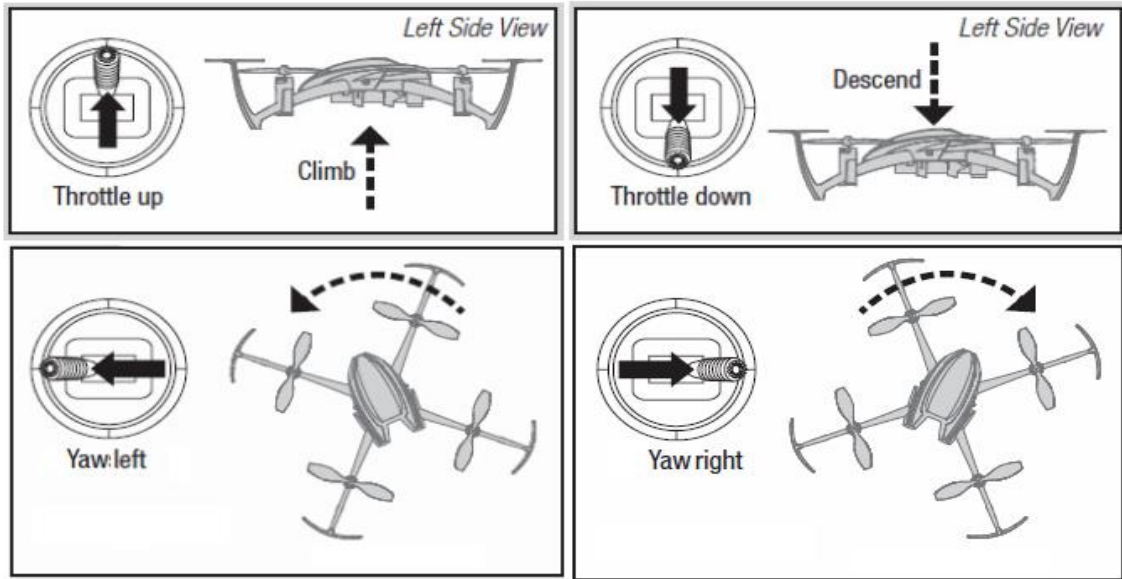


Figure 3.6 : Throttle and Yaw movement of Drone [19]

The right stick controls two aspects of flying a drone which is the roll and the pitch. The Roll is the movement of the drone to the sides. If the right stick is moved to the left or to the right, the drone will respectively roll in that particular direction. This movement doesn't change the altitude of the drone but it changes only the position on the x-axis. The Pitch is the movement of the drone forward and back. If the right stick is pushed up or down, the drone will respond by moving forward and back.

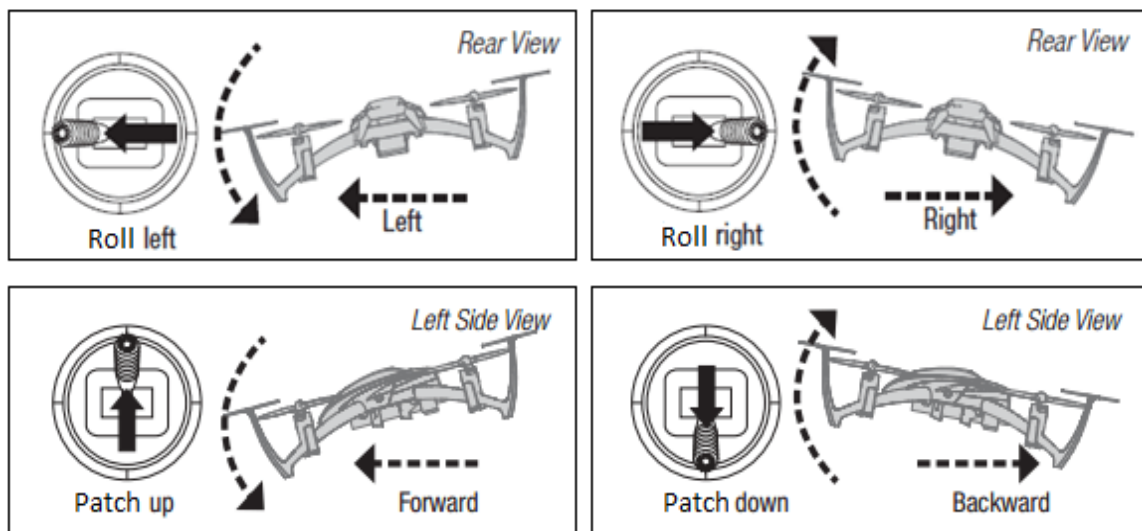


Figure 3.7 : Roll and Pitch movement of Drone [19]

The left knob(channel-6) of the 6ch transmitter controls the servo motor rotation by which the sprayer is operated. The right knob(channel-5) of the 6ch transmitter controls the flying modes. The Stable mode is the default mode of flying. The Altitude Hold mode is used to fly the drone in a stable height. The GPS mode is used to keep the drone in a stable position. The Return to Home mode brings the drone to the takeoff position and lands the drone automatically. The GPS and Return to Home modes are operated by the GPS device. The video data will be transmitted by the FPV camera and the video will be displayed on the Smartphone which is connected with the FPV camera receiver.

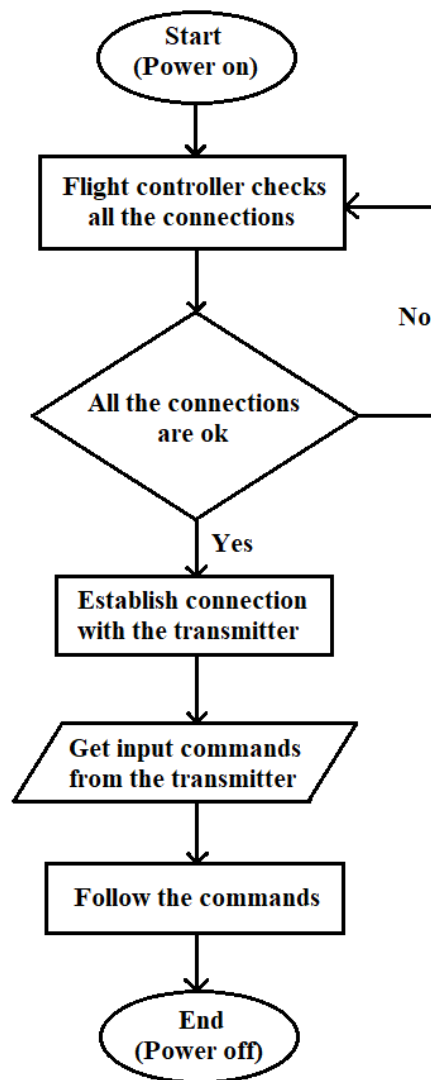


Figure 3.8 : Flow chart of the total system

CHAPTER 4: CONCLUSION

There are various types of features in our device. The device is easy to control. Our system has multiple functions, also have a video camera with transmitter and receiver. So the user can monitor their field very easily. We have faced various types of challenges during this project. We tried to minimize the problems. Since this was a prototype our focus was to build a model, which can help farmers to monitor their field and apply pesticides easily.

4.1 Features

There are a lot of features in the system. Those are as follow:

1. The system is very flexible.
2. The system can be used in any type of crop field.
3. Pesticides spraying and video monitoring can be done.
4. The DC power supply of the system is easily rechargeable and changeable.
5. The system is portable.
6. While flying the system can hold itself in a particular position.
7. If the system gets out of the transmitter range it will automatically return to takeoff position.
8. If low battery is detected while flying the system will automatically return to takeoff position.

4.2 Drawback

The quality of the sensors is very low as we have used prototype sensors. This is the only drawback of the project.

4.3 Future Work

As we have the data we will build an AI model and that will be uploaded to the server. Device will automatically fly, monitor and take efficient decision when and where to spray pesticides through Artificial Intelligence (AI) program. The present data will also be stored and password protected in the server. User can log in to the server using the password and see the data from anywhere in the world.

4.4 Discussion

We just made this device which can help the farmers to monitor and apply pesticides to reduce disease and pest attack. But a device can't completely clear all the disease and pest unless the farmers are well trained and apply pesticides perfectly. Owner of the land should have ensured that farmers are properly trained and apply pesticides sincerely. Also, the agriculture field officer should provide all information to the farmers and ensuring that the framers are using the best pesticides in the proper way.

4.5 Project Demonstration

We took the video shoot of our project on 20th August 2018 at 3 pm near aftabnogor ground. We took the shoots of arming, takeoff, movements, spraying, live video streaming, and landing.



Figure 4.1 : Arming of the drone by transmitter



Figure 4.2 : Takeoff



Figure 4.3 : Right movement



Figure 4.4 : Left movement



Figure 4.5 : Forward movement



Figure 4.6 : Backward movement



Figure 4.7 : Live video streaming



Figure 4.8 : Spraying



Figure 4.9 : Landing

REFERENCES

- [1] “Farmers' Training- Insect Pest and Crop Diseases,” LinkedIn SlideShare, 19-Aug-2015. [Online]. Available: <https://www.slideshare.net/Arpur/farmers-training-insect-pest-and-crop-diseases/1>
- [2] “India's Farmers Fighting Pests,” CropLife International. [Online]. Available: <https://croplife.org/news/keeping-indias-pests-in-line/>
- [3] “How Drones Came to Your Local Farm,” MIT Technology Review, 03-Feb-2015. [Online]. Available: <https://www.technologyreview.com/s/526491/agricultural-drones/>
- [4] “Drones used for first time in Bangladesh,” The Daily Star, 29-Mar-2015. [Online]. Available: <https://www.thedailystar.net/backpage/drones-used-first-time-bangladesh-4956>
- [5] “Bangladesh - Agriculture,” Encyclopedia of the Nations. [Online]. Available: <http://www.nationsencyclopedia.com/economies/Asia-and-the-Pacific/Bangladesh-AGRICULTURE.html>
- [6] “Five invasive pests cost African economy \$1 billion every year,” Diseases caused by phages. [Online]. Available: <https://www.cabi.org/news-and-media/2017/five-invasive-pests-cost-african-economy-1-billion-every-year/>
- [7] “Wild Scorpion 4200mAh 30C 11.1v Lipo Battery,” RC shop bd. [Online]. Available: <https://www.rcshopbd.com/product/wild-scorpion-4200mah-30c-11-1v-lipo-battery/>
- [8] “APM 2.8 ArduPilot Mega 2.8 Flight Control Board,” MYRCMART. [Online]. Available: <http://www.myrcmart.com/apm-28-ardupilot-mega-28-flight-control-board-straight-pin-free-vibration-damping-plate-p-8506.html>
- [9] “Guide to NEO-6M GPS Module with Arduino,” Random Nerd Tutorials. [Online]. Available: <https://randomnerdtutorials.com/guide-to-neo-6m-gps-module-with-arduino/>
- [10] “Electronic speed control,” Wikipedia, 27-Jul-2018. [Online]. Available: https://en.wikipedia.org/wiki/Electronic_speed_control
- [11] “1400kV Brushless Motor-India's DIY Electronics,” Probots Techno Solutions. [Online]. Available: https://probots.co.in/index.php?main_page=product_info&products_id=870

- [12] “Servo Motor Metal gear MG996R,” Arduino UNO - ePro Labs Wiki. [Online]. Available:
https://wiki.eprolabs.com/index.php?title=Servo_Motor_Metal_gear_MG996R
- [13] “X-525 Glass Fiber Frame Quadrotor,” X-525 FRAME QUADROTOR. [Online]. Available: http://bdspeedytech.com/index.php?route=product/product&product_id=655
- [14] “Hobby King Quadcopter Power Distribution Board,” Hobbyking. [Online]. Available: https://hobbyking.com/en_us/hobby-king-quadcopter-power-distribution-board.html
- [15] “10x4.5 inch (25x 11cm) Pusher and Puller Propeller Matched P,” Nex Robotics. [Online]. Available: <http://www.nex-robotics.com/products/multirotor-platforms/10x4-5-inch-25x-11cm-pusher-and-puller-propeller-matched-pair.html>
- [16] “FlySky 2.4G Fly-Sky (FS) CT6B 6-Channel,” HobbyPartz.com. [Online]. Available: <https://www.hobbypartz.com/79p-ct6b-r6b-radiosystem.html>
- [17] “Wide Angle Mini FPV Camera 1/3,” Hobbyking. [Online]. Available: https://hobbyking.com/en_us/wide-angle-mini-fpv-camera-1-3-cmos-700tvl-ntsc-pal.html
- [18] “Building Mission Planner with Visual Studio,” Introducing Copter - Copter documentation. [Online]. Available: <http://ardupilot.org/dev/docs/buildin-mission-planner.html>
- [19] “How to fly a Drone - Beginner Guide [2018],” Drone Nodes, 27-Mar-2018. [Online]. Available: <http://dronenodes.com/how-to-fly-a-quadcopter-beginner-guide/>