AUTONOMOUS FLYING OF UAV WITH MACHINE LEARNING AND MAVLINK COMMUNICATION

Submitted by

Muntasir Muhit

191-35-399

Department of Software Engineering

Daffodil International University

Supervised by

Kaushik Sarker

Associate Professor & Associate Head

Department of Software Engineering

Daffodil International University

This project report has been submitted in fulfillment of the requirements for the Degree of Bachelor of Science in Software Engineering.

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APPROVAL

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This project titled on "**AUTONOMOUS FLYING OF UAV WITH MACHINE LEARNING AND MAVLINK COMMUNICATION**", submitted by **Muntasir Muhit (ID: 191-35-399)** to the Department of Software Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Software Engineering and approval as to its style and contents.

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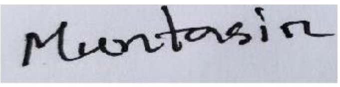
DECLARATION

It hereby declares that this thesis has been done by Muntasir Muhit under the supervision of Kaushik Sarker, Assistant Professor & Associate Head, Department of Software Engineering, Daffodil International University it also declares that neither this report nor any part of this . Has been submitted elsewhere for award of any degree.



Student Name: Muntasir Muhit

Student ID: 191-35-399

Batch: 28th

Department of Software Engineering

Faculty of Science & Information Technology

Daffodil International University

Certified By:

Kaushik Sarker

Assistant Professor & Associate Head

Department of Software Engineering

Faculty of Science & Information Technology.

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ABSTRACT

In the era of automation everything is crawling towards it. UAV is one of them. There are many UAV from low to high range but many developing teams are developing fully autonomous UAV but they are facing huge obstacles for the costly hardware. So, I have come wit the idea of automation of low cost UAV with implementing of Machine Learning and OBC(On Board Computer) by communicating through MAVLink Protocol. As we are working on same platform with different area for that the UAV needed to be automated. Nowadays UAVs are being used for mapping, infrastructure analysis, navigation, food and package delivery, photography and film making, pest spraying and much more. Also during early 2019 we have seen voice controlled automation devices taking over our daily lives, providing automation to our day to day routine. This paper fully describes the design and implementation of an AAV which can fly autonomously and can work with multiple missions.

Keywords: Pixhawk, Raspberry Pi, Motor, Raspbian Headless Buster, Mission Planner, PDB, Tx, Rx, Propellers, Frame, Antenna, GPS,

1. INTRODUCTION

1.1) Background

Our university has a large area of 155 acer. So, if there is any kind of accident happens, we can't detect it fast even our instinct don't. So, an UAV can solve the problem. If we use a car or other method to detect the early warning system it faces many obstacles but An UAV has no obstacles also it can hover on a selected or given way point. In this circumstance of early detection system needed an autonomous UAV for long endurance and hovering capability.

1.2) Motivation of the Research

In the era of automation everything is crawling towards it. UAV is one of them. There are many UAV from low to high range but many developing teams are developing fully autonomous UAV but they are facing huge obstacles for the costly hardwares. So, I have come wit the idea of automation of low cost UAV with implementing of Machine Learning and SBC(Single Board Computer) by communicating through MAVLink Protocol. As we are working on same platform with different area for that the UAV needed to be automated.

1.3) Objective

- It can fly autonomously.
- Less human efforts to operate.
- Low cost than industrial UAV's.
- It can do the job much faster.
- It can hover longer.
- It is a modular designed UAV to attach various modules according to the operation.
- It is also very useful for holding heavy objects up to 2kg.
- This UAV is very useful in disastrous situations.

1.4) Scope of the UAV

- The UAV can fly autonomously
- GCS monitoring and mission monitoring
- Less human effort
- Global mapping through GPS
- Weather proof
- SBC and FMU combined control

The main goal of this project was to design and implement an autonomous aerial vehicle (AAV) which can fly without radio transmission. It can just take the input from the SBC and takeoff for the mission given. Suppose you want to monitor an isolated area where road vehicle can go further and heavy arial vehicle is expensive to hire or monitor with so you can just make command for the AAV to hover on the right spot to monitor and it will much faster and cheap. AAV can collect and transmit data wirelessly. It also faster to detect any accident as like as unexpected fire in forests, high rise buildings, power transmission towers etc.. Multi modular work can be done with this AAV

1.5) Methodology

The components used in this AAV are UAV frame(Carbon frame), ESC(Electronic speed controller) 30 amp(Dshot 600 protocol), Flight Controller(Radolink Pixhawk), GPS(Radiolink SE100 Ublox-M8N), Higher KV motor(620Kv), 4000 MAH Li-on(Lithium Ion) Battery, Battery Power Monitoring Module Raspberry Pi cam(V1.1)[for future work], Skydroid T10 Transmitter (full range: 10km, operational: 5km), Skydroid M12 Long-range Receiver with high gain 6dbi Antenna(supports PPM and S-Bus protocol), RaspberryPi 3b+For programming and parameter settings there are multiple software and editor used Raspbian Buster Headless OS, Ardupilot Mission Planner, Notepad++, Pycharm.

1.6) Block Diagram

The block diagram of our work is as shown in Figure

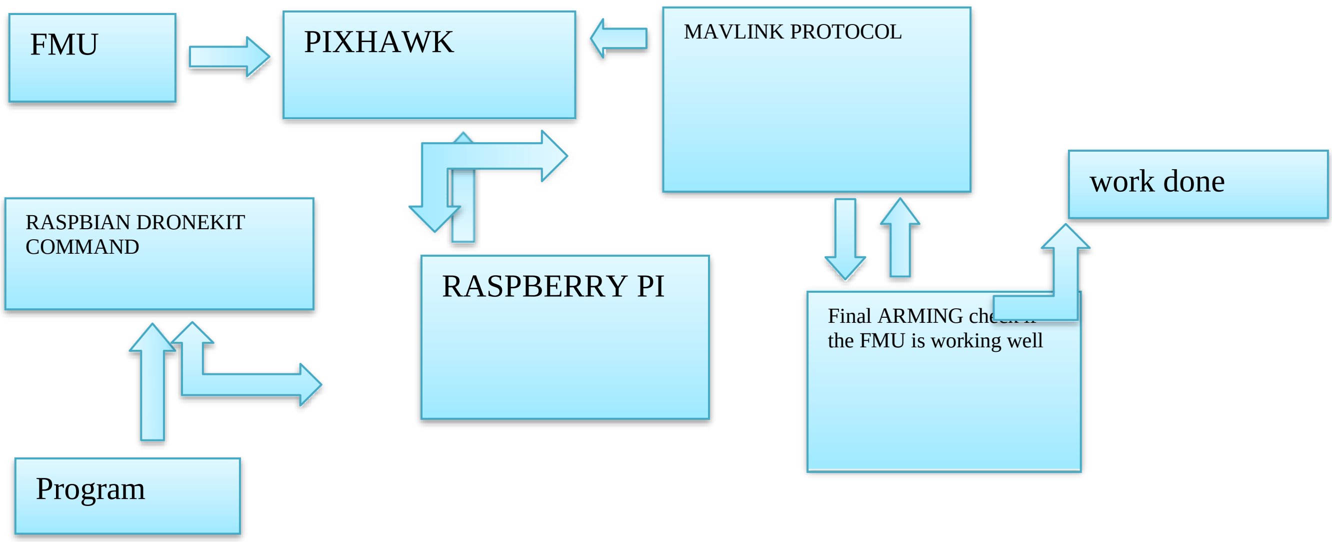


Fig. 1-1. Block Diagram

1.7) Working of the UAV

The UAV is operated through GCS(Ground Control Station), so we can command multiple UAV through GCS with out radio transmission. It can take command from GCS and work along with the mission uploaded. Though it operated by SBC (Raspberry Pi) so there is less human effort to be added. Multiple mission can be operated by the UAV.

1.8) Purpose of the UAV

This UAV is mainly designed to detect fire in forests, high rise buildings and high rise towers. This vehicle is powered with SBC and FMU with a stable configuration. There are many types of UAV in the world but most of them are radio controlled. Thus our country is a small area with a vast population so an UAV can be use for various operations so, this AAV(Automated Arial Vehicle) can be a breakthrough in the "Fourth Industrial Revolution" in Bangladesh.

2. LITERATURE REVIEW

2.1) Background

In this cutting-edge world, robotics is a modern field of advanced innovation that pushes the traditional engineering boundaries toward the modern era of automation. For a thoughtful understanding of the complexity of robots and their applications in everyday life requires learning of electrical, mechanical engineering, basic science, and software. Numerous industrial tasks have been carried out such as pick and place operation, assembly operation at the manufacturing plant, welding and spray painting in automobile industry, army, home, as well as in a medical application for surgery by several advanced robotic systems.

3. COMPONENTS ASSEMBLING

3.1) Approach

We used PIXHAWK which is F4 based ARM 32 processor implemented FMU with ARM 32 F100 series I/O co-processor. Internal sensors are Magnetometer(IST8310), Barometer(MS5611), Gyro(MPU6000).

PIXHAWK comes with pre-programmed firmware we need to set up the flight parameters, PID values, FMU configuration, GPS configuration, Serial port configuration, PPM or S.Bus signal configuration, ESC signal protocol(Dshot[300-1200].OneShot,PWM,SingleShot,Opto), Battery Voltage Monitoring configuration

For this UAV to be automated we need to program these parameters first otherwise it won't fly stable. For configuration of the PIXHAWK we need "Mission Planner" also we need to configure the serial port 2 baud rate and protocol to SERIAL2_BAUD= 921600 and SERIAL2_PROTOCOL=2 and also for Raspbian buster OS we need to set the file log type to LOG_BACKEND_TYPE=3.

Fig. 3-1. Whole UAV

3.2) part of the UAV arm

Fig. 3-2. PDB mounting in UAV frame

3.3) PDB attaching in frame

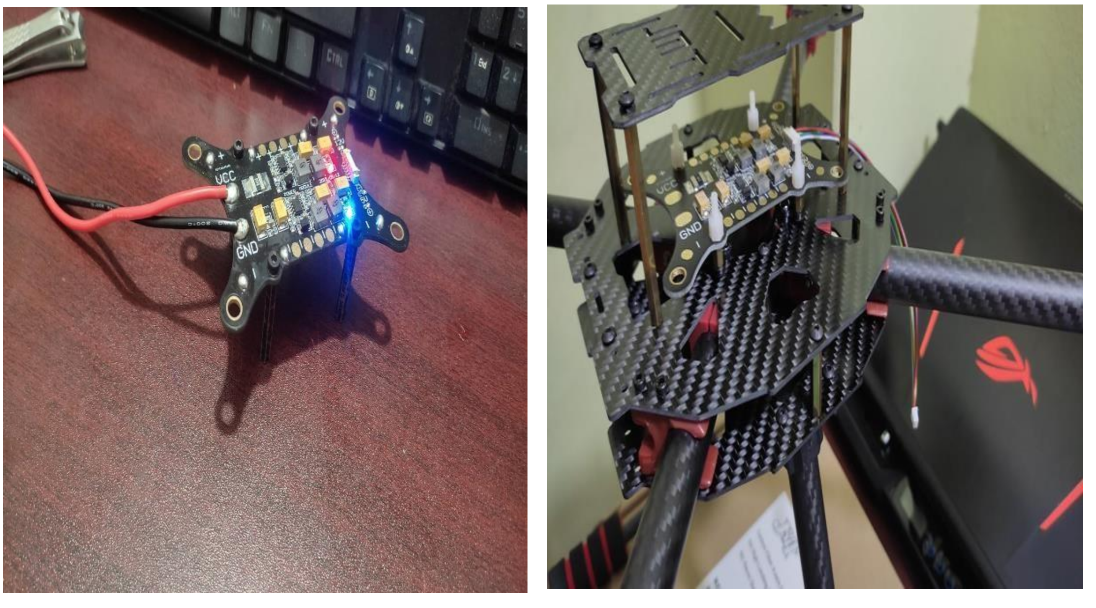


Fig. 3-3. PDB mounting in UAV frame

PDB is used for distribute the correct voltage to the GPS, FMU, Raspberry Pi, Tx, Rx, ESC

3.4) GPS mounting

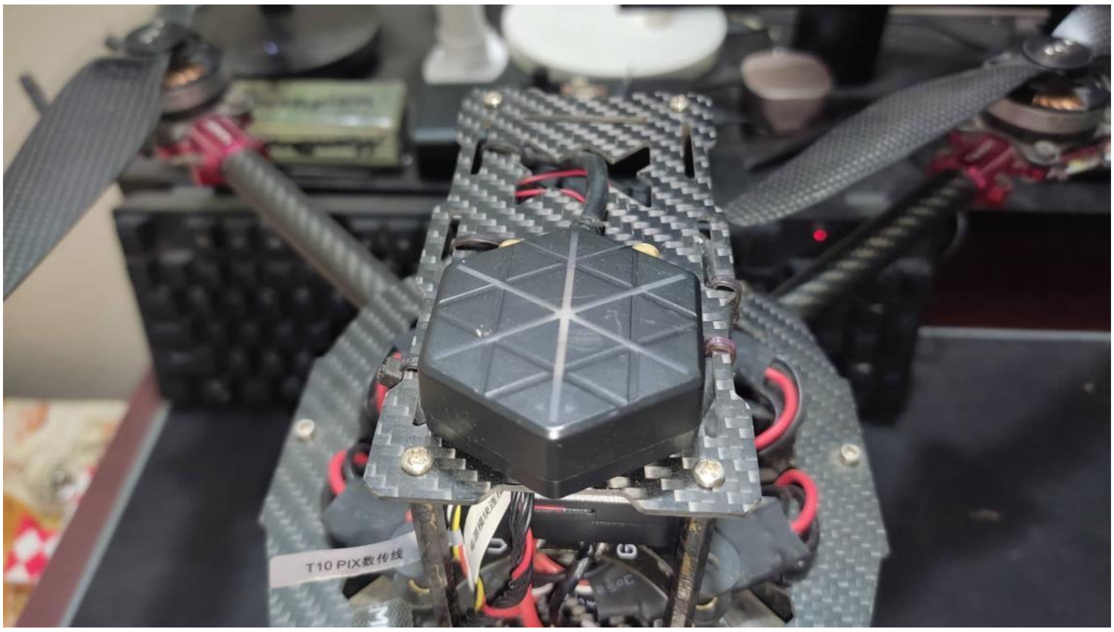


Fig. 3-4. GPS attaching

GPS is very important component for this UAV. GPS is used for real time positioning data and hover on a precise point and also indicate true NORTH according to earth.

3.5) Motor Mounting with propeller of UAV

Fig. 3-5. Mounting motor and propeller on UAV arm

Motor creates thrusts along with propeller

3.6) ESC attaching

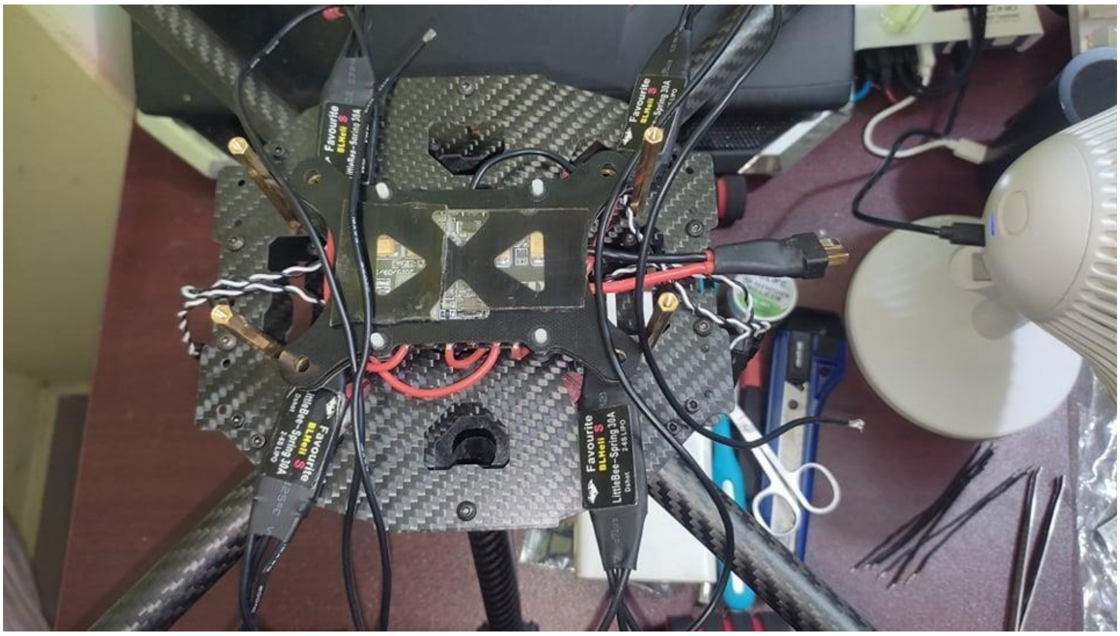


Fig. 3-6. ESC soldering and connecting with motors

ESC provide the right amount of voltage along with the chosen protocol from PDB and Battery to motor

3.7) 3DR Power Module attaching

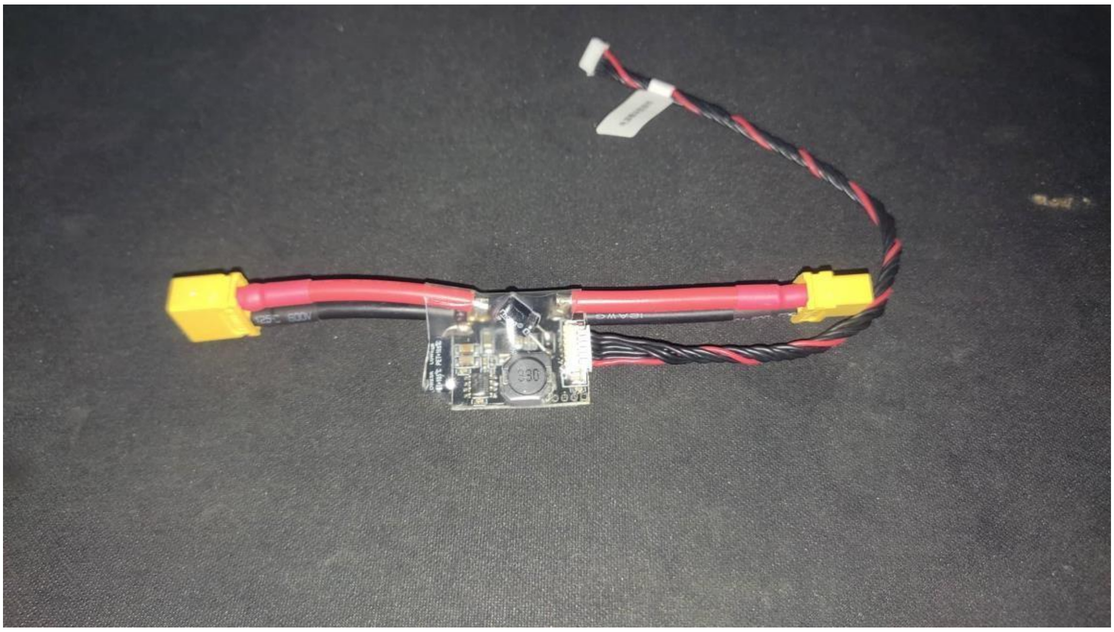


Fig. 3-7. Power module

Power module provide the correct voltage to the PIXHAWK (FMU) and also communicate with PIXHAWK for voltage monitoring.

3.8) Raspberry Pi Mounting

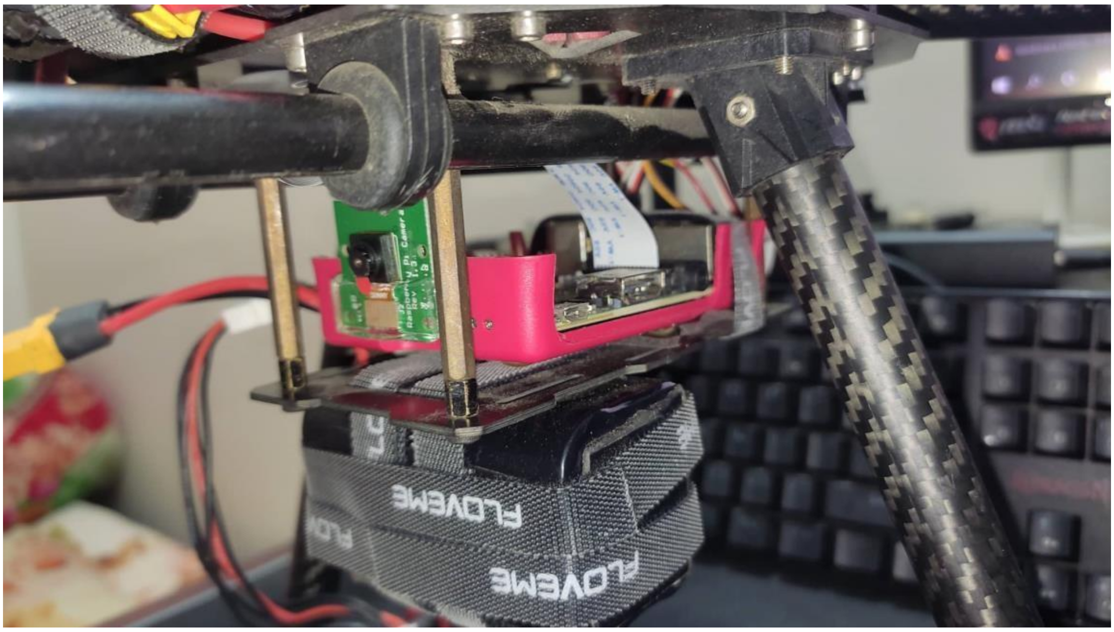


Fig. 3-8. Raspberry Pi 3B+

Raspberry Pi to program automation of the UAV.

3.9) GPIO pin configuration

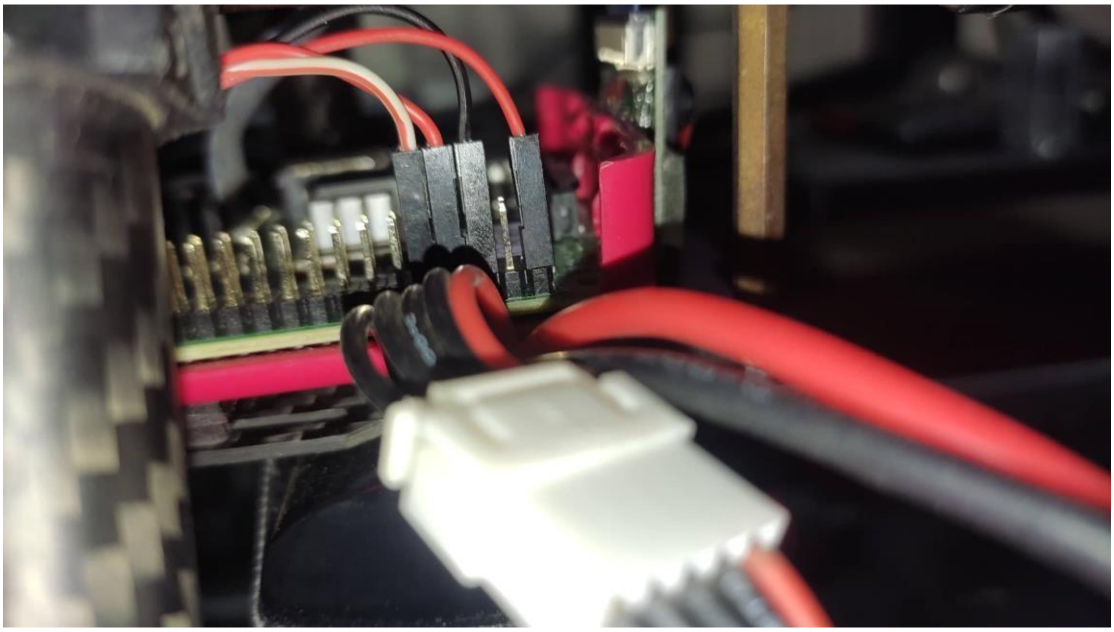


Fig. 3-9. Raspberry Pi GPIO pin configuration

3.10) High gain antenna mounting

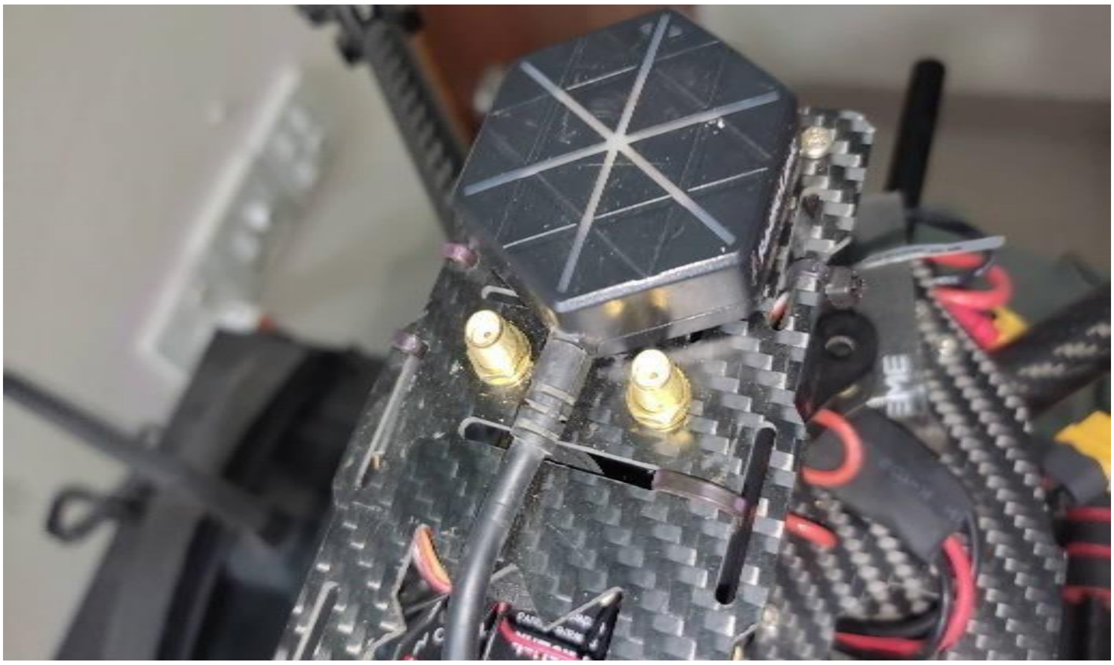


Fig. 3-10. 6 Dbi antenna

For long range communication

3.11) PIXHAWK configuration

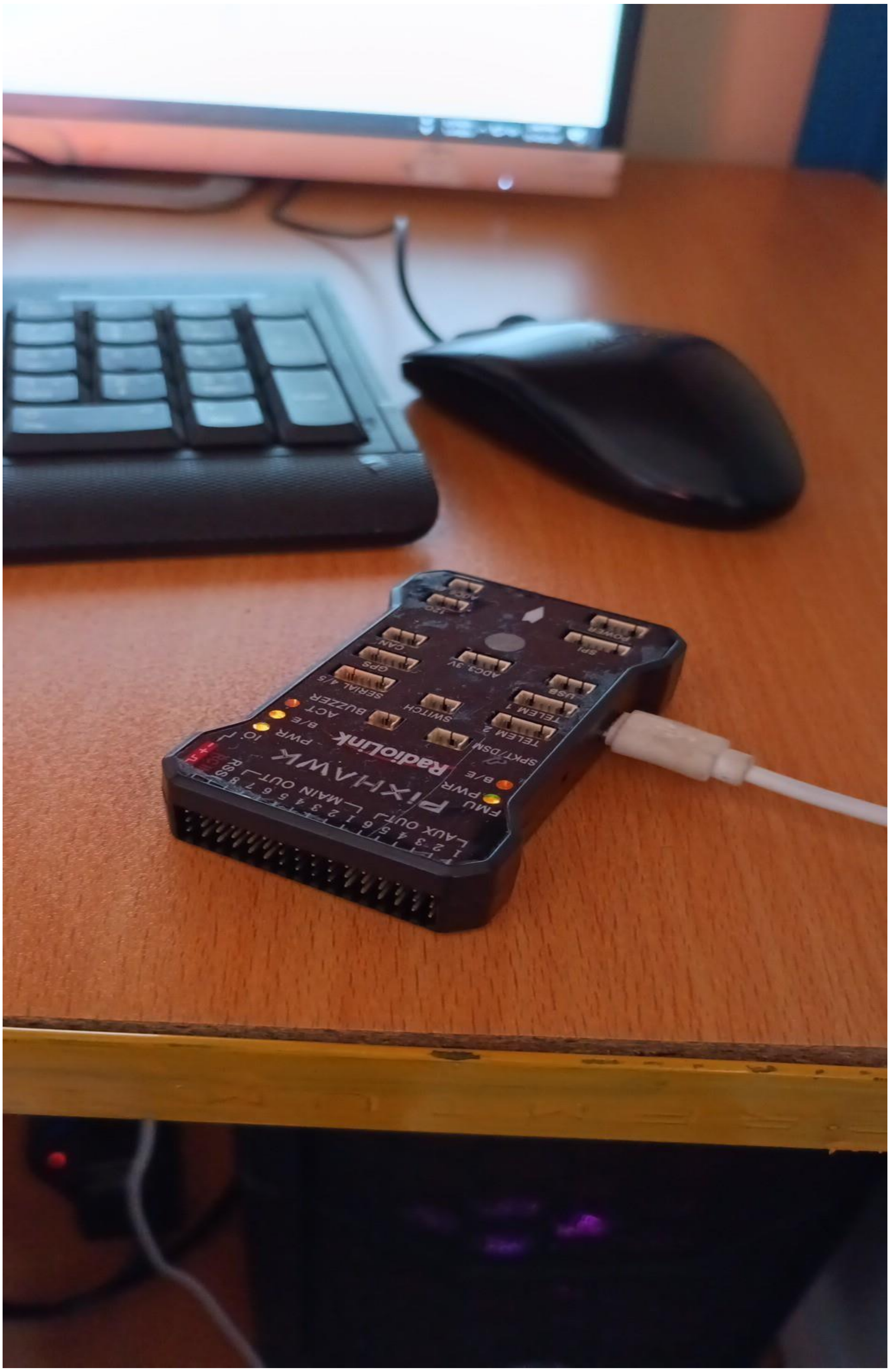


Fig. 3-11. Pixhawk configuring parameters

3.12) Mechanical Structure of the UAV

To build the UAV we used the lightweight carbon frame. PIXHAWK FMU for inertial navigation system and the internal flight management. We used the quadcopter structure and used 4*4 30A ESC and 620KV motor. To power up the whole UAV we mounted a PDB with battery also a battery voltage monitor 2*2 display. We used 1355 carbon propeller for maximum thrust. 6DBI antenna for long range connectivity. M12 receiver for the T10 transmitter has a range of 10KM uninterrupted. GPS M8N U-blox 20CM precise accuracy. Raspberry Pi B3+ for SBC controlling along with PIXHAWK.

3.13) Components Study

(i) Mechanical part
(ii) Programmable part

3.14) Mechanical Parts

a. Motor (TAROT 4006 4s KV: 620)
b. PDB (3DR analog)
c. Battery(4000 Mah Lithium Ion 21700 cell 4s 1p configuration)
d. Frame(Carbon Frame Foldable)

3.15) Motor (TAROT 4006 4s KV: 620)

Fig. 3-12. TAROT 4006

3.16) PDB(3DR analog)

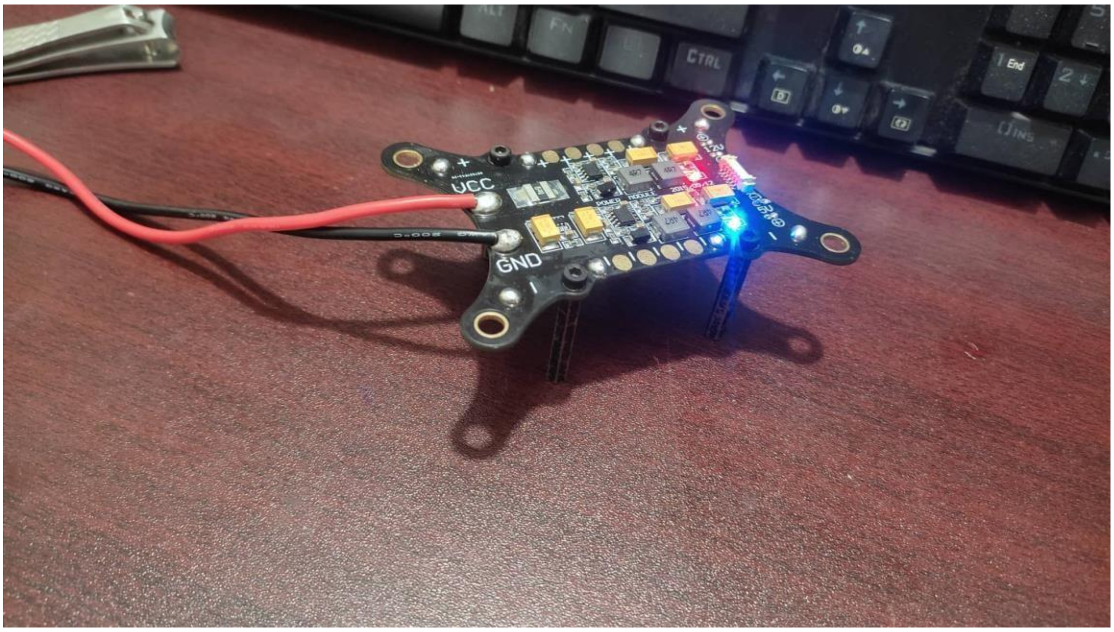


Fig. 3-13. PDB 3DR analog

3.17) Battery

Fig. 3-14. Lithium Ion Battery

3.18) Frame

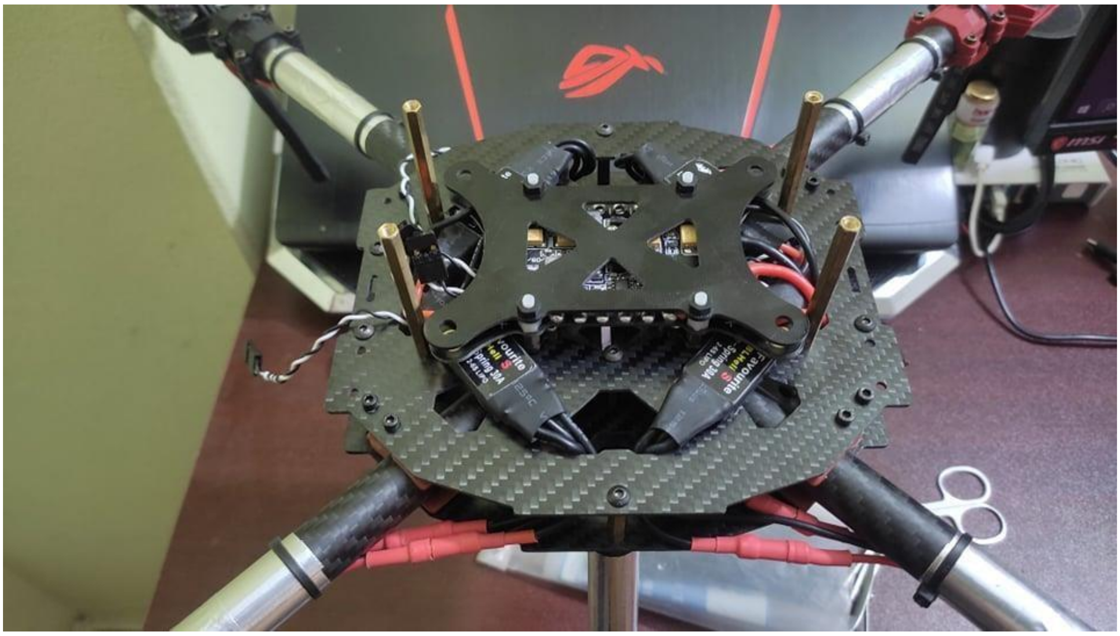


Fig. 3-15. CF Frame

3.19) Programmable parts

We use PIXHAWK as FMU and Raspberry Pi as SBC

3.20) SBC Raspberry Pi and Pixhawk(FMU)

PIXHAWK:

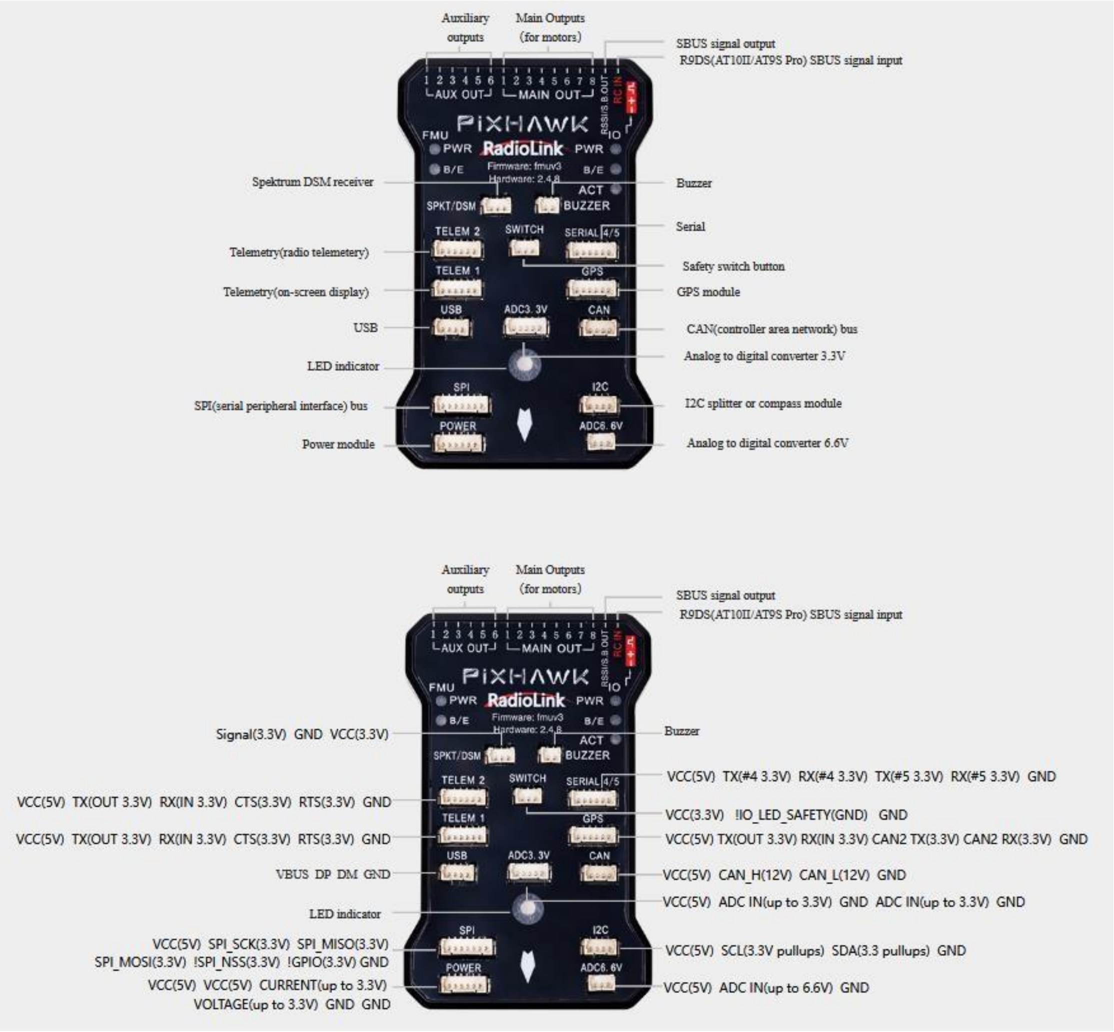


Fig. 3-16. PIXHAWK I/O ports

Fig. 3-16. Signal O/I ports

3.21) Raspberry Pi:

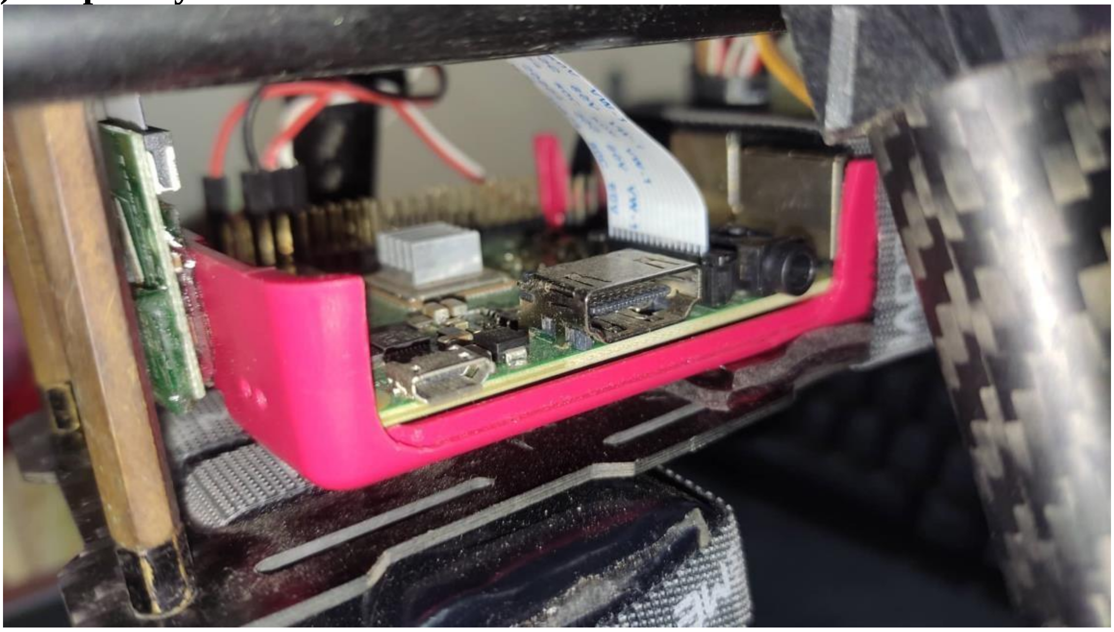


Fig. 3-16. Raspberry Pi 3B+

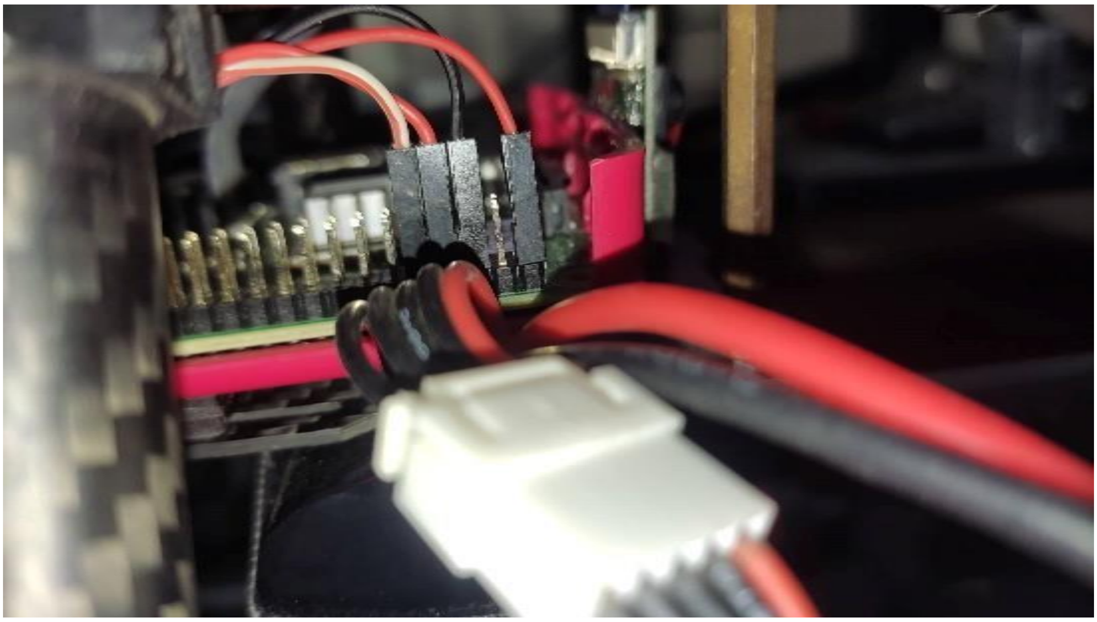
3.22) FUNCTIONAL DESCRIPTION

3.23) PIXHAWK :

3.24) UART serial TX Rx to Raspberry Pi GPIO PIN

- PIN 2: Vcc(5V) to Power PDB 3DR 5V output
- PIN 6: GND to PDB 3DR GND
- PIN 14: Tx(UART) to TELEMETRY SERIAL 2nd pin
- PIN 15: Rx(UART) to TELEMETRY SERIAL 3rd pin

We connected Pixhawk telemetry serial port 2 to Raspberry Pi GPIO pinout to



communicate with UART data transmission to Pixhawk through SSH with MAVLINK

Fig. 3-17. Raspberry Pi 3B+ GPIO pin attaching

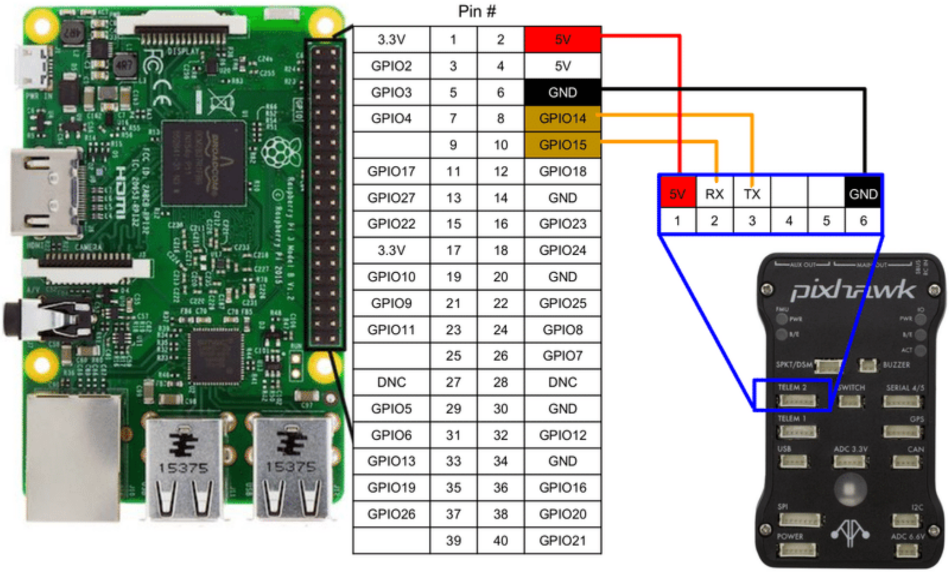


Fig. 3-18. Raspberry Pi 3B+ GPIO pin diagram

4. RESULTS AND DISCUSSION

4.1) Final output

This AAV can fly autonomously. It can take command from GCS through SSH raspbian OS. Having SBC controlled FMU will provide uninterrupted communication and better stability. There in no PID values needed to count the X, Y, Z axis stabilization for hovering. It can just take the position from the global true north along with the GPS and hover on given point. Less human effort needed to operate this vehicle.

Fig. 4-1. Final output - UAV

4.2) Learning Experience

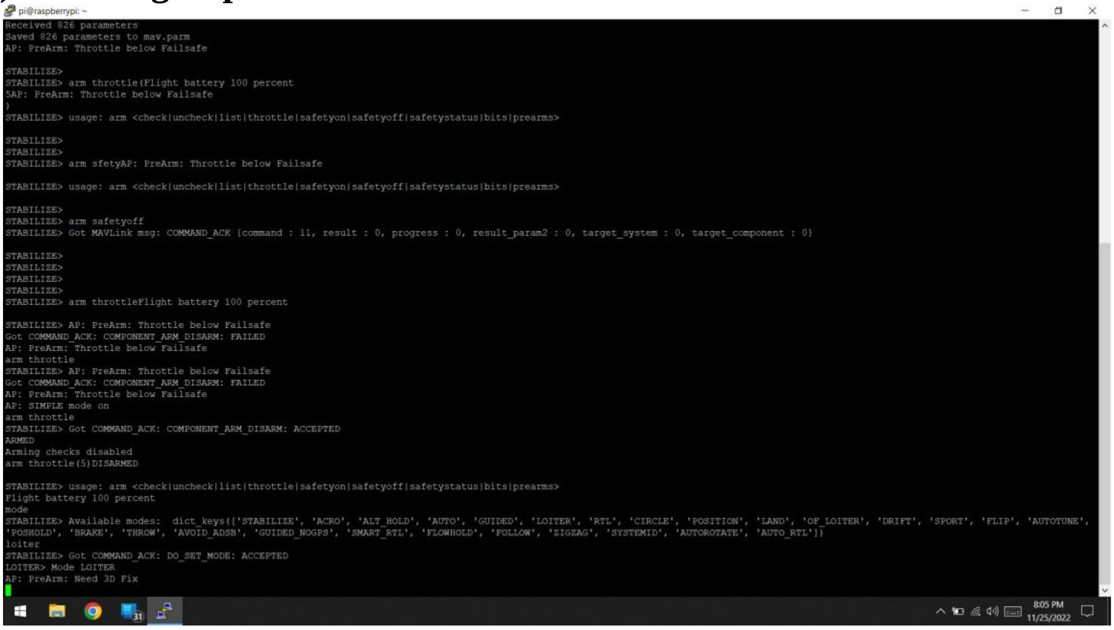


Fig. 4-2. First attempt to arming UAV .

We get many errors when we try for the first time to arm the UAV. We get multiple failsafe checks. After some researching we get the wright command to arm the UAV. After implementing the MAVLINK command at first we don’t know that the Raspberry Pi need some delay time to arm the UAV so we tried multiple command and got the PIXHAWK bricked. After getting the bricked FMU we flashed the FMU and re-programmed the FMU again and then we successfully armed the UAV.

4.3) System Working

In primary stage we tried to do the research if an UAV can be automated. Our goal is to automate an UAV to detect fire. Then we increased our curiosity and the capacity to make the UAV with powerful components. Now we made the UAV to presentable. 80% work is done on this project. We faced many problems to make the UAV automation. Thus Bangladesh is a densely populated country with a small area, so this UAV can do multiple operations as like as on air patrolling, forest monitoring, ration delivery in disastrous area, emergency medicine supply etc. Now days many countries uses UAV to spray and seeding in fields and it is faster than ever.

5. CONCLUSION

5.1) Conclusion:

(1) We can eliminate human life in risky missions

(2) We have to learn from our mistakes, we made many mistakes and corrected them while doing this project.

(3) Less human effort (only one person can control and command more than 200-400 UAV’s)

(4) Faster and less mentainance also weather proof.

(5) Reliable and cheap in many risky situation .

5.2) Future Works

In the future SBC operated UAV can be a shape shifting structured UAV by adding other thrusting component (As like as ION driver or Pulse jet engine). Also can be use for image recognition and LIDAR path detection for better stability and collision avoiding. Automated delivery system can be achieved by the UAV with image and INS(Internal Navigation System as like as GPS and GLONASS)