Indian Institute of Technology Gandhinagar

DRONE PROJECT

ME 399: "Drone design, Fabrication, and Control using Mission Planner"

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Outline

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Introduction

In the course project, our primary objective was the comprehensive construction and operation of a drone, encompassing both manual and autonomous flight modes. The project involved meticulous decision-making in selecting key components such as motors, propellers, and batteries to optimize thrust and ensure efficient battery usage, aiming for a minimum flight time of 7 minutes. This initial phase culminated in the assembly of these components into a fully functional drone.

The power distribution within the drone system was a crucial aspect, with power originating from the battery and flowing through a distribution board to the Electronic Speed Controllers (ESCs) and motors. A dedicated APM connector facilitated a separate power supply to the Pixhawk, while a buck converter (5V) ensured the Raspberry Pi received the appropriate voltage, addressing the variance in power levels within the distribution board. Following the successful integration of these components, the drone was prepared for flight.

Subsequent calibration procedures included synchronizing the radio controller with motor speed, as well as calibrating all ESCs and GPS using Mission Planner. Six distinct operating modes were configured on the radio controller, enabling both manual and autonomous control. Notably, the implementation of Failsafe conditions was paramount, ensuring that if the drone's battery dropped below a specified threshold, it would autonomously return to its launch position.

The incorporation of a Geo-fence condition added an additional layer of control, restricting the drone's movement to a predefined area and preventing erratic behavior. Although our project aimed to integrate a Raspberry Pi and camera module for live feed capabilities, time constraints, and equipment unavailability limited this aspect. However, we view these elements as potential avenues for future enhancement and development.

In summary, our project journey involved meticulous component selection, systematic power distribution, thorough calibration, and successful implementation of Failsafe and Geo-fence measures, resulting in the successful manual and autonomous flight of the drone. While certain planned elements, such as the Raspberry Pi and camera integration, remain unexplored due to time constraints, they present exciting prospects for future iterations of our project.

Components

1. Landing Gears - [Link]
   - These were used to land the drone safely and increase the height of the drone from the base.

2. Battery - [Link]
   - Used to Power up the Drone.

3. Body Frame - [Provided]
   - It consists of 4 arms and a pair of bases to hold the arms.

4. Battery Voltage Indicator - [Provided]
   - Used to get the visual of battery voltage for each cell and combined battery.

5. Buck Converter (5V) - [Link]
   - Used to power up Raspberry Pi directly from the battery.

6. ESCs - [Provided]
   - To control the speed of the motors.

7. Motors - [Link]
   - 4 Motors are used to spin the 4 propellors.

8. Propellers - [Link]
   - 4 propellers are used to lift the drone.

9. APM Connector-[Link]
   - To power up the motors and Pixhawk through the battery.

10. Pixhawk 2.4.8 - [Link]
    - Flight controller for our drone.

11. Buzzer - [Provided with Pixhawk]
    - To provide an audio response to any changes made in Pixhawk.

12. Safety Switch - [Provided with Pixhawk]
    - To arm the motors and make the drone ready to fly.

13. Radio Controller and Reciever - [Link]
    - To control the drone remotely.

14. GPS - [Link]

- Used to know the drone's location as we were flying the drone autonomously.

15. GPS Stand - [Link]
    - Used to attach the GPS at a certain height to avoid any communication issues with Pixhawk.

16. Raspberry Pi - [Link]
    - Used for image processing and ROS implementation.

17. Camera - [Link]
    - Used for capturing the video.

18. Zip Ties - [Link]
    - Used to tie all the components together perfectly.

19. XT 60 Connector - [Link]
    - Used to connect the battery terminal with the Powerboard.

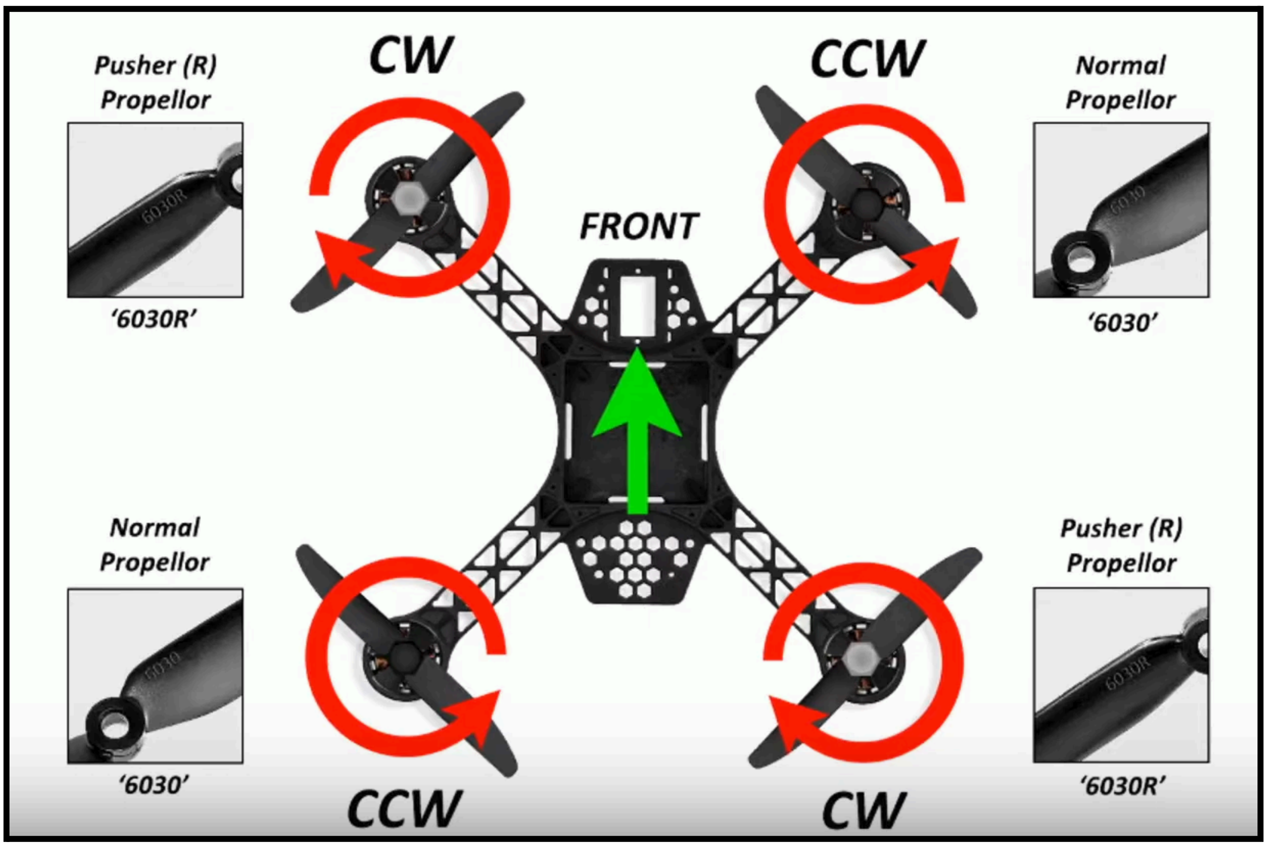
20. CAD files of Battery case, Pixhawk, and Raspberry Pi stand - 3D Printed
    - Used to hold the components.

Steps to fabricate a drone

Assembly of different components [Link]

To commence the assembly process, carefully follow the instructions outlined in the provided video. Pay close attention, particularly when affixing the propellers to the drone, as this step requires precision. Refer to the accompanying image, which clearly indicates that propellers marked with an 'R' should be attached for clockwise rotation, while those marked with an 'L' should be affixed for counter-clockwise rotation.

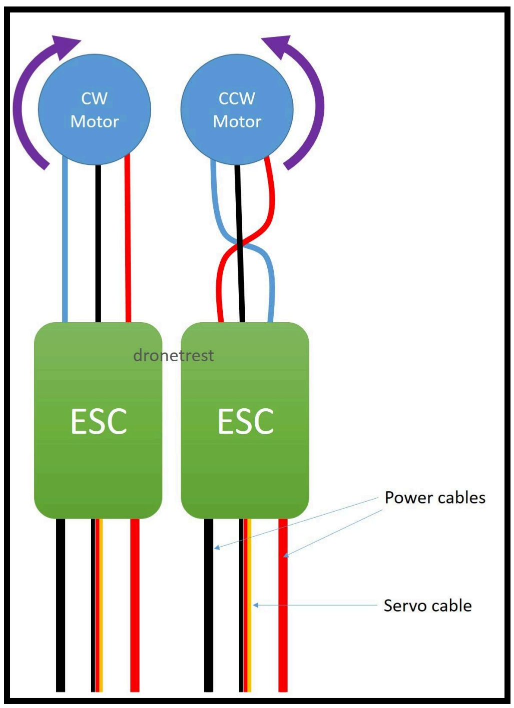
Ensure a secure attachment of all components by utilizing zip ties and double-sided tape. This meticulous approach not only enhances the stability of the assembly but also contributes to the overall functionality of the drone.



Connection of different components [Link]

The electrical connection of various components is a crucial phase in the assembly process, requiring meticulous attention to detail. Follow these steps for a seamless integration:

1. **Power Board Connection:** Properly solder the mains and Electronic Speed Controllers (ESCs) wires to the power board. This step is pivotal, as a precise soldering job ensures minimal power loss, optimizing the overall performance.
2. **Motor to ESCs Connection:** Connect the motors to the ESCs by considering the clockwise and counterclockwise rotation directions. Adjust the positive and negative terminals according to the arrangement of your propellers. This alignment is essential for the drone's correct rotational functionality.



3. **Pixhawk Connection [Pixhawk]:** Connect the Pulse Width Modulation (PWM) pins to the main output pins of the Pixhawk controller as demonstrated in the instructional video. Note that the negative terminal is oriented upwards, the positive downwards, with the communication wire in between.
4. **Receiver and GPS Connection:** Establish a connection between the receiver and Pixhawk using jumper wires. Ensure the receiver's positive terminal is upward, followed by the communication wire and negative wire. For GPS connectivity, link the GPS to the designated pins on the Pixhawk, and connect the I2C pin to the respective terminal. Additionally, attach the buzzer to the designated terminal on the Pixhawk.
5. **Power Distribution Board and APM Connector:** Connect the mains wires of the power

distribution board to the APM XT60 connector for efficient power distribution within the system.

6. **Buck Converter Connection:** Connect the main terminal of the buck converter to the mains of the power board. Utilize the other two terminals to supply power to the Raspberry Pi's 5V and ground pins after adjusting the voltage from 12V to 5V using the converter's adjustment knob.
7. **Raspberry-pi connection[Link]:** To connect the rasberry pi with PDB, we need to connect it with a buck converter as it operates with 5v. The TX and RX pin of raspi will be connected to pixhawk to communicate with pixhawk. We can take raspi data separately from the raspi visual software PuTTy.

For a comprehensive understanding and seamless execution, it is recommended to follow the outlined steps in the accompanying video tutorial, ensuring accurate and efficient assembly of the drone's electrical components.

Radio setup [Link]

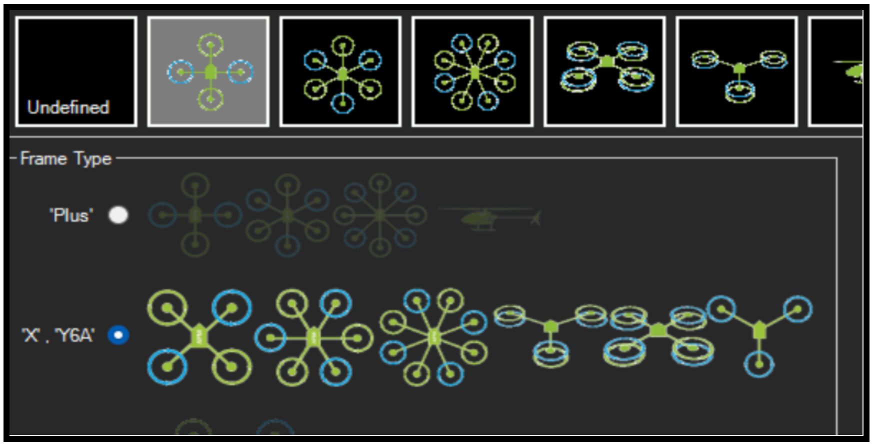
To program the FlySky FS-i6 transmitter, diligently follow the comprehensive steps outlined in the provided instructional video. Begin by navigating through the programming sequence as demonstrated, adhering to each step meticulously.

In addition to the prescribed steps, a crucial enhancement involves enabling the PPM (Pulse Position Modulation) output in the radio controller. To achieve this, access the RX setup menu on the radio controller and proceed to the PPM output settings. Here, enable the PPM output option to establish a seamless connection with the receiver. This pivotal step ensures effective communication between the transmitter and receiver, fostering a synchronized and responsive interaction essential for the optimal performance of the drone.

Calibration with Mission Planner

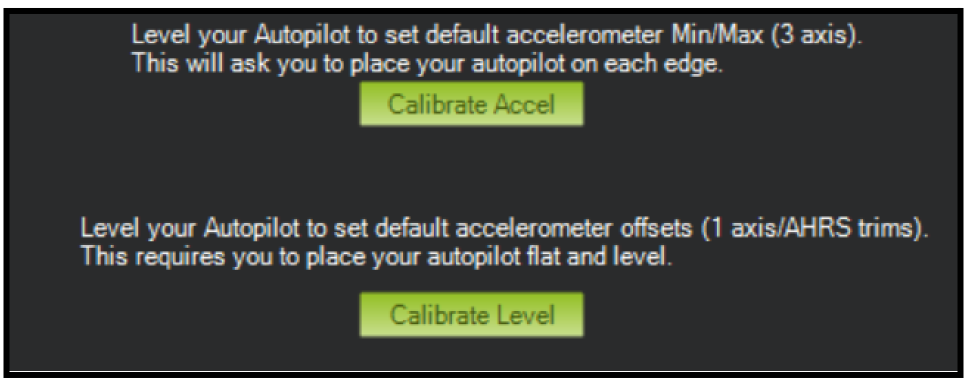
First download Mission planner(version - 1.3.79.1) from Microsoft store. After installation, launch the application and establish a connection with the Pixhawk controller using a USB Type-B cable. Subsequently, proceed to calibrate each drone component by following the prescribed steps.

- Choose the frame types in the Mandatory Hardware section of the Setup in Mission planner.



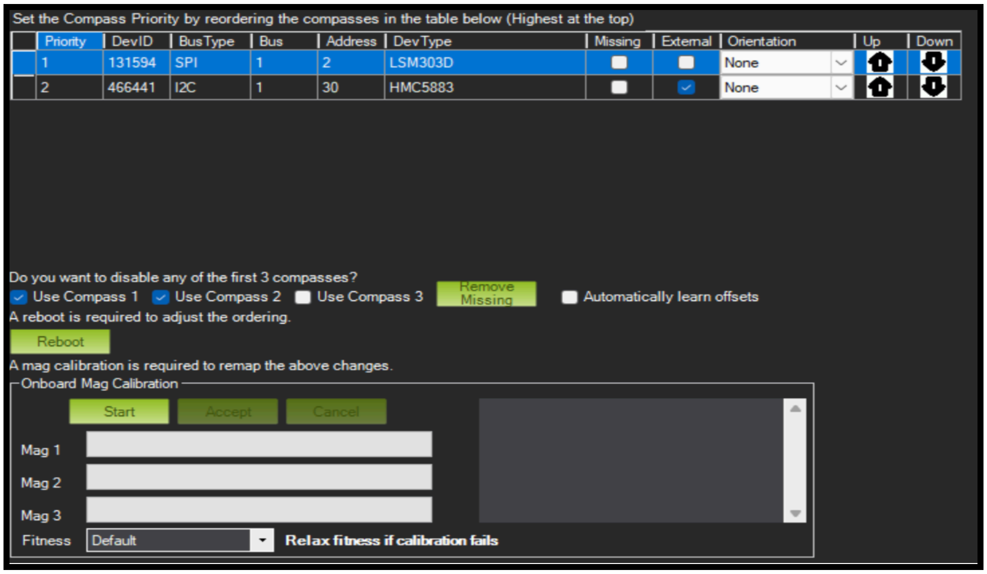
- <u>Accelerometer Calibration</u>

  Do calibration of accelerometer according to the video.



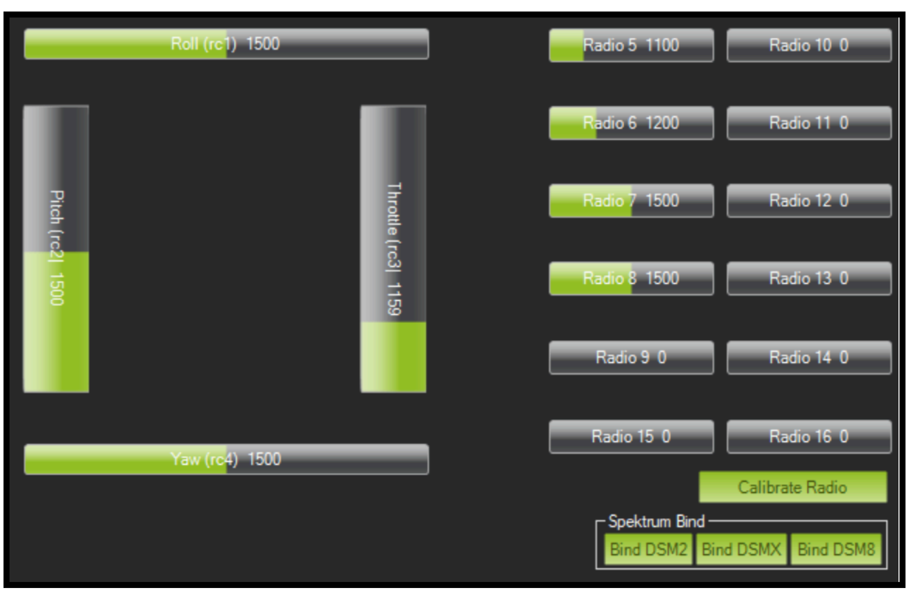
- <u>Compass Calibration</u>

  This can also be done simply by the instruction in the video. Do not forget to reboot after calibration of the compass.



- <u>Radio Calibration</u>

  Initiate the calibration process by powering on the flight controller and ensuring all control sticks are positioned according to the instructions provided in the accompanying video. Subsequently, proceed to calibrate the radio by moving each stick to its maximum position as directed. During this calibration phase, take note of the throttle's minimum and maximum positions. These recorded values are pivotal for the subsequent Electronic Speed Controller (ESC) calibration using the Mission Planner.

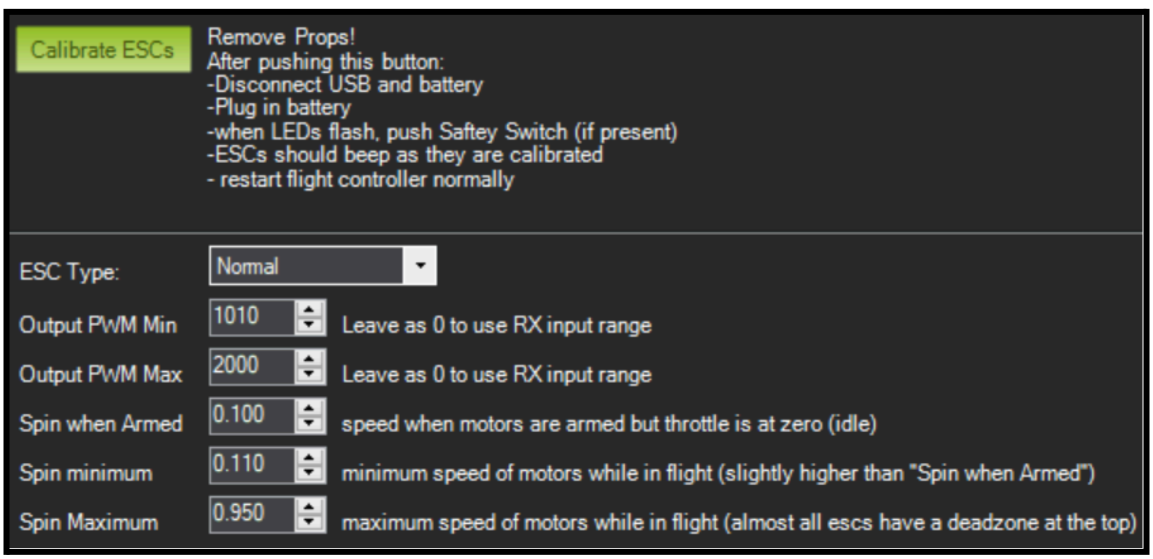


- <u>ESCs Calibration</u>

To calibrate escs follow the following steps rather than following any video:

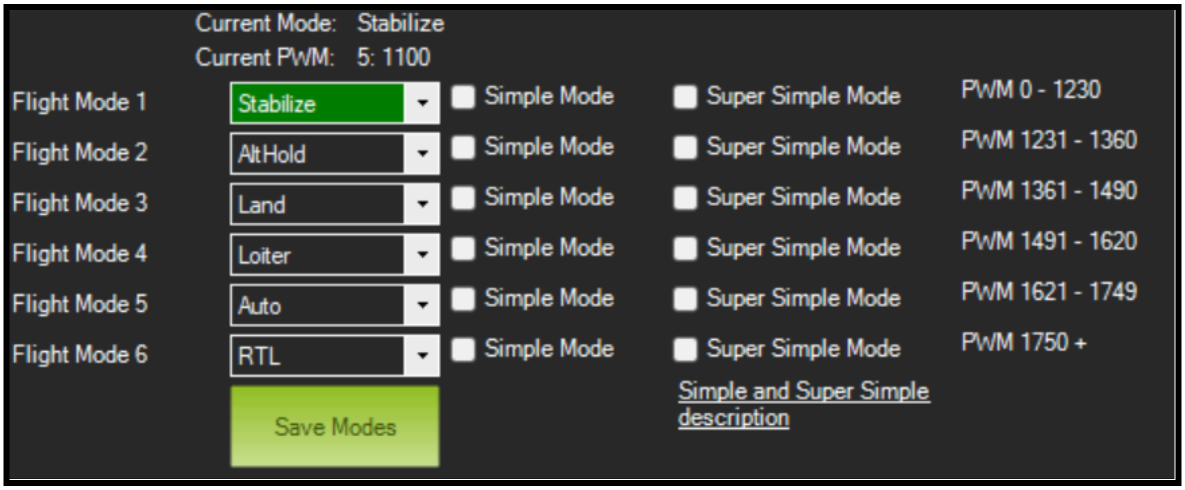
- Remove Props from the drone
- Ensure the radio controller is switched off.
- Set the Output PWM Min parameter to the min value of throttle and Output PWM Max parameter to the max value of throttle and adjust other parameters as instructed in image below.
- Push the Calibrate ESCs button in the mission planner(shown in below picture).
- Now disconnect both the USB and drone's battery.
- Plug in the battery again and wait for a while until the combination of Red,Blue and Green light appears on the pixhawk. Once blinking of these colors appear on pixhawk then push the safety switch of the drone to start the calibration of all escs. ESCs should beep as they are calibrated. You will hear the sound of beeping twice or thrice.
- After that again remove and connect the battery and then connect the pixhawk with a mission planner to complete the process.

Following these steps ensures a thorough and accurate calibration of all ESCs, contributing to the optimal performance of the drone.



- Flight Modes

  Proceed to the radio controller to configure and save the desired flight modes. Currently, the following modes are available on the radio. Ensure to customize and save these modes for optimal drone operation.



Explanation of Flight Modes:

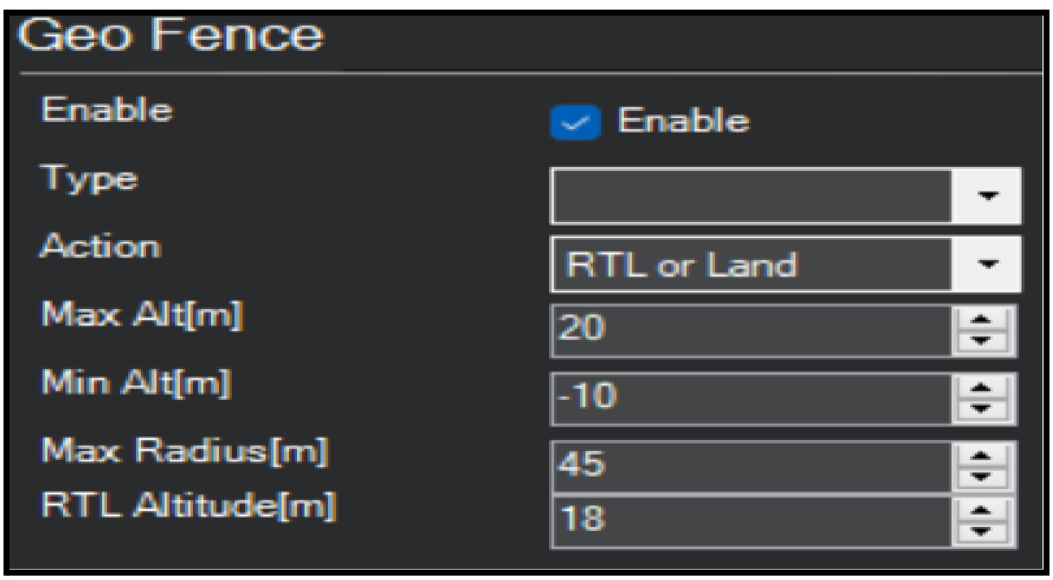
- ☐ **Stabilize Mode:** In this mode, the drone maintains a stable and level orientation when the pilot releases the controls. It is ideal for beginners and provides a straightforward manual control experience.
- ☐ **AltHold Mode:** Altitude Hold mode enables the drone to automatically maintain a constant altitude. This is particularly useful when you want the drone to hover at a specific height without continuous input.
- ☐ **Land Mode:** When activated, Land mode instructs the drone to descend and land at its current location. It's a convenient mode for safely bringing the drone back to the ground.
- ☐ **Loiter Mode:** Loiter mode combines GPS information to enable the drone to hold its position and maintain a steady hover. It is useful for capturing stable aerial footage or waiting in a specific location.
- ☐ **Auto Mode:** Auto mode allows the drone to follow a pre-programmed flight path autonomously. Waypoints are set, and the drone navigates through them, making it suitable for surveying or mapping tasks.
- ☐ **RTL (Return to Launch) Mode:** When triggered, RTL mode directs the drone to automatically return to its initial takeoff position. This is a crucial safety feature and is activated in emergency situations or when the pilot wants the drone to return to a designated home point.

- <u>Fail-Safe</u>

  Configure the failsafe parameters to ensure that your drone initiates a proper landing when the battery voltage reaches a critically low level.

- Geo-Fence[Link]

  In alignment with the instructions provided in the accompanying video, establish the following parameters to define a geo fence for your drone, ensuring it remains within the desired range. This critical configuration guarantees that the drone operates within specified geographical boundaries, enhancing safety and control during flight.



How to choose essential components

The primary and foundational step in component selection for constructing a drone involves finding the **optimal combination of motors, propellers, and batteries.** It is crucial to strike a balance between battery capacity and weight, considering the trade-off between achieving desired **flight time and ensuring the drone's ability to lift off.** Key parameters such as the complete setup's weight (including the battery), motor thrust capability, and propeller pitch play pivotal roles in this selection process.

Adjusting propeller length and pitch allows for fine-tuning the thrust criteria. For instance, a battery with a capacity of 10000 mAh and a weight of 650gm, coupled with motors capable of providing 1024g of thrust each, yielded a theoretical flight time of approximately 7 minutes when operated at full thrust. This theoretical estimation was subsequently verified during practical operations.

Moving on to Electronic Speed Controllers (ESCs), their selection is contingent upon the specifications of the chosen motors. It is imperative that the **amps rating of the ESCs equals or exceeds the amp rating of the motors.**

For the flight controller, a general Pixhawk model, such as the **Pixhawk 2.4.8**, proves versatile and suitable for various tasks. The specific requirements and specifications of the Pixhawk can be referenced from the **official website**.

Choosing a **GPS module is task-dependent**, with precision directly impacting the cost. While a high-precision GPS may be necessary for certain applications, **a standard GPS module like the M8N suffices for general purposes. Mounting the GPS slightly above the Pixhawk, with the aid of a GPS stand, minimizes signal interference.**

When utilizing a standard power distribution board (PDB) as the base plate, an **APM converter** becomes essential. This three-port device connects to the battery and efficiently distributes power to both the Pixhawk and PDB separately. The PDB receives power through an **XT60 connector**, establishing a crucial link between the APM and PDB.

Integrating a Raspberry Pi into the setup necessitates a **buck converter (5V)** to power the Pi from the PDB, aligning the voltage discrepancy between the **PDB's 11.1 volts and the Pi's 5 volts.**

Components like a **safety button, buzzer, and battery voltage indicator** contribute significantly to safety and monitoring. The voltage indicator facilitates cell voltage checks, while the safety buzzer signals when the battery voltage falls below a specified threshold. Configurable parameters for these components can be set using Mission Planner.

In conclusion, for manual drone control, a **radio controller (RC) and receiver** are indispensable. The receiver connects to the Pixhawk, translating manual commands from the RC into actions. A standard RC commonly used in drone applications suffices for this purpose.

This comprehensive overview encapsulates the essential parameters in component selection, providing a detailed understanding of each component's role and the criteria governing their choice.

How to fly a drone

Flying a drone using a remote control (RC) can be an exciting experience. Here's a step-by-step guide to help you get started:

1. **Understand the RC controls:** Before you begin, it's crucial to understand the drone's RC control thoroughly. It contains specific instructions for your drone model.

2. **Charge the Drone and Controller:** Ensure that your drone and the RC controller are fully charged.

3. **Find a Suitable Location:** Choose an open area free from obstacles and interference for your first flight.

4. **Inspect the Drone:** Check for any damage and ensure that all parts, especially propellers, are securely attached.

5. **Install the Battery:** Insert the fully charged battery into the drone.

6. **Turn on the Controller:** Switch on the RC controller before powering the drone. This ensures the controller binds with the drone.

7. **Turn on the Drone:** Power on the drone. Most drones have a specific procedure for this, often involving pressing and holding a button.

8. **Calibrate the Drone:** Many drones require calibration before flying, especially for the compass and gyroscopes. Refer to your manual for specific instructions.

9. **Understand the Controls:** Familiarize yourself with the RC controller. Typically, the left stick controls altitude and rotation, while the right stick controls forward/backward and left/right movement.

10. **Start with a Hover:** Gently push the throttle (usually the left stick) to lift the drone off the ground and let it hover a few feet above the ground. Practice maintaining a steady hover.

11. **Practice Basic Maneuvers:** Start with simple movements like moving forward, backward, left, and right. Then, practice turning and altitude adjustments.

12. **Use Beginner Modes:** If your drone has beginner modes like Alt Hold or Stabilize mode, use them to simplify your first flights.

13. **Be Aware of Battery Life:** Keep an eye on the drone's battery indicator. When it

is below a certain limit, it's time to land.

14. **Landing:** Reduce the throttle slowly to bring the drone down for a gentle landing, or put it into Land Mode to land the drone at its place. Also, one can apply RTL (Return to Launch) mode if the GPS is connected to safely land it back to its home position.

15. **Turn Off the Drone and Controller:** After landing, turn off the drone first and then the controller.

16. **Post-Flight Check:** Inspect your drone for damage after each flight.

17. **Flying with Waypoints**: If one would like to fly the drone through the waypoints given by Mission Planner then one should first arm the drone in Stabilize mode and slightly increase the throttle and then put it into the Auto mode.

    To generate the Waypoints through Mission Planner one can refer the following video - Link

Remember, drone flying often comes with legal regulations, including airspace restrictions, privacy laws, and specific flying rules. Always check and adhere to local laws and regulations when flying a drone. Additionally, practice makes perfect. The more you fly, the better you'll get at controlling your drone. Fly safe!

Videos or playlists link

- PX4 Offboard Control with ROS2 - https://www.youtube.com/watch?v=GxI5Ny1fyZc
- PX4 Mavros integration with Python - https://www.youtube.com/watch?v=jBTikChu02E
- How to connect Pixhawk with Raspberry Pi - https://www.youtube.com/watch?v=cZVNndOaYCE
- ROS2 in PX4 - https://www.youtube.com/watch?v=F5oelooT67E
- How to Setup Geo Fence - https://www.youtube.com/watch?v=I8EUIj3yz5c
- How to make drone and connect it with Mission Planner - https://www.youtube.com/watch?v=hE45exjXeUQ
- How to setup the drone and bind it with the receiver - https://www.youtube.com/watch?v=jY_wpxIKQss
- How the make and setup a drone and its connection - https://www.youtube.com/watch?v=SOP-u3H4buY
- Testing Videos Drive link - Videos

Do and Dont's

DOs

- Ensure proper soldering of wires with the Power Distribution Board(PDB).
- Propellers should be tightened to the extent that they should be intact at full throttle.
- Set the cell's lowest battery voltage to 2.8V in the battery voltage indicator and Failsafe.
- Tighten each component through zip ties.
- If you encounter any problems in your drone, then first check if there are any error messages showcased in Mission Planner.
- One should do the ESC calibration through Mission Planner only as it calibrates all the ESCs in one go.
- Conduct ground tests to ensure everything is working correctly before the first flight.
- Understand and comply with local drone laws, including where and when you can fly.
- Always keep the drone within your visual line of sight.
- Ensure you have a strong connection between the drone, controller, and any devices used.
- Start in open, unpopulated areas to practice your skills.
- Continuously learn about drone technology and piloting techniques.

DON'Ts

- Never use cellotapes to attach or bind any component in a drone.
- Propellers should not be tightened by hand.
- Never fly the drone without enabling the Failsafe protocol and Geofence.
- Never coil and bind the wires as they might break internally causing an unusual behaviour of the drone.
- Adding too much weight can affect flight performance and safety.
- Avoid using old or damaged parts, as they can fail mid-flight.
- Avoid using half charged batteries while flying a drone.
- Avoid flying in bad weather conditions like high winds or rain.
- Don't let the battery run too low during flight, which could lead to a crash.
- If there are connectivity problems, don't fly until they're resolved.