1) **Project Reference Number**: 46S_BE_3045
2) **Title of the project:** AUTONOMOUS AERIAL SYSTEM FOR AGRICULTURE PURPOSE.
3) **Name of the College & Department:** Acharya Institute of Technology, Department of Mechatronics Engineering
4) **Name of the students & Guide(s)**:
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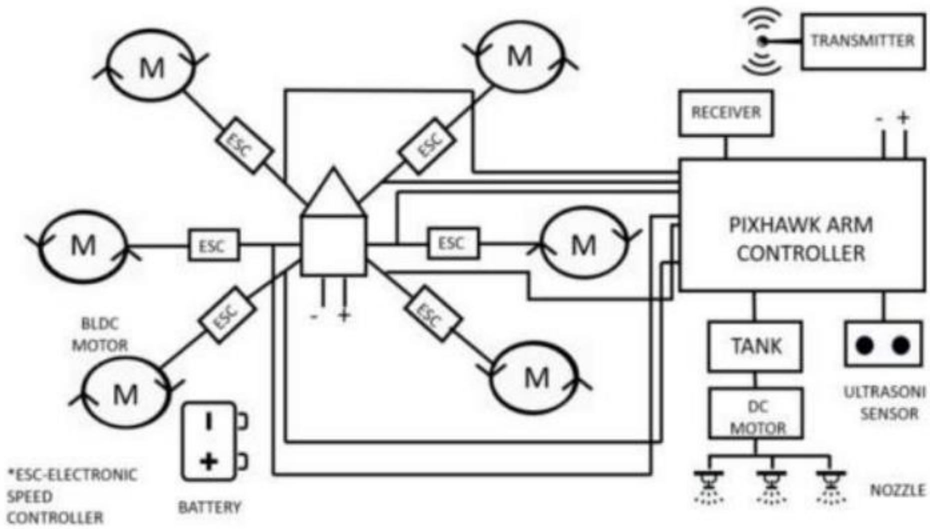
5) **Keywords:**
    - Autism
    - Agriculture
    - Airborne
    - Unmanned aerial vehicle
    - Autonomous flight
    - Communication
6) **Introduction:**
    Digital technologies are used to connect agricultural goods from pasture farms to consumers is known as digital farming. Digital farming also combines the latest and most powerful technologies into a single system to empower farmers and other agricultural value chainoperators to increase production. The drone can be controlled autonomously using flight control software or manually using the transmitter. Farmers are reaching out to agricultural drone technology to help mitigate the problems of supply not meeting up with the demand of crop production. In the case of small, inexpensive electrically actuated UAVs when mechanical complexity is a disadvantage, Hexadrotors compare favorably to classic Hexacopter design. Small UAVs can be constructed relatively easily and cheaply incorporated with sensors and microcontrollers. “UAV Hexacoptor applications will require a high level of controllability and flying.
7) **Objectives:**
    - Designing the prototype model of drone.
    - By considering various parameters.
    - Calibrating an Autonomous system into Drone for operation.
    - Designing a pesticide sprayer.
    - sprayer which is attached to the drone and calibrating.
    - Proccessing all at once with out error.

8) Methodology:



The main goal of this research is to create an effective hexacopter system with a built-in payload configuration. The remote control can be used to activate the spraying mechanism. Figure 1 shows the system's whole building block. To build the physical model of drone these were some of the steps which were followed, which are given below:

1. **Estimation of weight**
2. **Hexacopter design**
3. **Sprayer building and assembly**

Estimation of weight

Finding the aircraft's weight is required before developing the prototype. Even if the component's weight is fixed, if we add the additional component, the aircraft's weight will change. Below is a list of each component's weight.

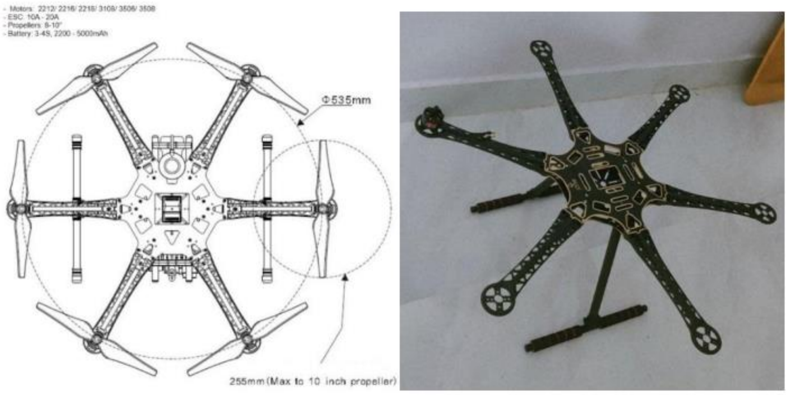
Component used	**Quantity**	**Total Mass (kg) (approx)**
Motor	6	0.42
ESC	6	0.12
Battery 5400 mh	1	0.13
Pixhawk 2.4.8 and receiver	1	0.03
Propeller	5	0.02
Telemetry module	1	0.05
Carbon fibre material frame	1	0.25
Pestiside sprayer tank	1	0.25
Pump	1	0.13
Bolts and Wires	10	0.05
Total weight		1.70

Weight Estimation Table

This weight is believed to be about correct by taking into account the thrust-producing motors that must lift both the aircraft and the payload. It is presumable that 1L of pestiside can be hoisted.

Hexacopter design

In terms of weight and physical strength, the choice of hexacopter frame is crucial. The frame in the suggested concept is made of PCB board, while the landing gear is made of carbon fibre for increased strength, durability, and lightness. In figure 4, the framework is displayed. The motors that are chosen are crucial since they determine how much cargo the drone can lift steadily. The BLDC motors and the flight controller should be compatible with the electronic speed controllers you choose. We can choose the payload weight based on the motor ratings and thrust output.



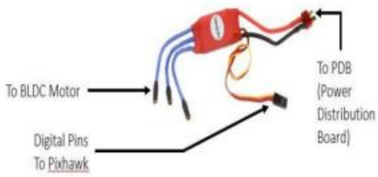
Frame construction

All six of the hexacopter's arms are attached to the top PCB. The bottom PCB is attached with landing gear and squishy pads that will retain the battery mount and serve as shock absorbers. Finally, top and bottom PCBs are joined together in the drone frame assembly, as can be seen.

Motor and electronic speed controller mounting

The motor layout is shown in the figure. The six BLDC motors are mounted to the six arms of the frame. There are three clock wise (CC) and three counters clock wise (CCW) motors which will create net forces acting on a body should be zero.

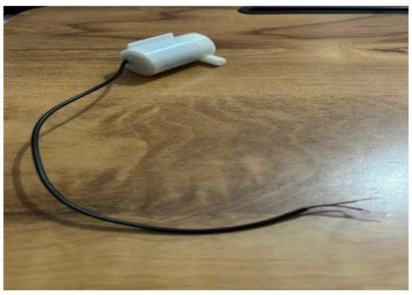
The speed of the motor is regulated using an Electronic Speed Control system (ESC) and is depicted in figure . This ESC provides electric dynamic braking to the system. It also takes care of reversal of directions in the system by reversing the direction of rotation of the motor. The six ESC are soldered to Power Distribution Board (PDB). The output wires which are to be connected to the BLDC motors. There are also digital pins in each ESC connected to pixhawk to control the speed of the motor. The frame with ESC mounted is shown in figure.



Drone Frames under various Angles

Sprayer building and assembly

The sprayer system for the drone is made up of a dc pump, tank, controller, and nozzles. To ensure that the drone is steady even after attachment, the sprayer system should be fastened to it. The controller will switch on or off the pump depending on the signal it gets from the user end. The pump starts up and sprays the fertilisers through nozzles when the switch is turned on. Figure depicts components of spraying system.



Components of Pesticide Sprayer

Calibration of Pixhawk of Drone using Mission Planner:

The calibration of our drone is done based on our requirement for making the drone to fly autonomously. Here are some of the calibration modifications which we have done:

Selecting the drone configuration

The Pixhawk must first be reset before the hexacopter configuration can be installed. The firmware for hexacopter is then installed. Here, the Pixhawk must have hexacopter added in order to achieve the UAV configuration, and the parameters must be altered to get the traditional UAV configuration. The Pixhawk must first be reset, linked to the PC, and then the mission planner must be opened in order to accomplish this. Installing the hexacopter configuration, as seen in the image, is the last stage.

Selecting the configuration

Changing the parameters

There are a few settings that need to be altered after the hexacopter configuration has been installed. Basically, the parameters that are present when the fixed wing is installed have default values. These factors are crucial for the UAV's development. Only a few parameters are mentioned in this report, and those parameters are.

Q_ENABLE: Enables Hexa Plane

This makes it easier to configure drones on Hexacopter aircraft. The quad copter is enabled if the value is set to 1. The UAV auto is enabled if it is set to 2. It is displayed in the table below.

value	function
0	disable
1	enable
2	Enable UAV auto

The parameter's value that has been used is 1-Hexa plane is enabled

CAN_P1_driver: Index of virtual driver to be used with physical CAN interface.

If this option is enabled, then CAN buses might be used.

Value	Meaning
0	Disabled
1	First driver
2	Second driver
3	Third driver

CAN_P2_DRIVER: Index of virtual driver to be used with physical CAN interface.

It is like the previous one

Value	Meaning
0	Disabled
1	First driver
2	Second driver
3	Third driver

GPS_TYPE: 1st GPS type

Type of the GPS:

Value	Meaning
0	None
1	AUTO
2	uBlox
5	NMEA
6	SiRF
7	HIL
8	SwiftNav
9	DroneCAN
10	SBF
11	GSOF
13	ERB
14	MAV
15	NOVA
16	HemisphereNMEA

The parameter that has been given is 9 that is Drone Can

BRD_SAFETYENABLE:

During startup, the safety switch's state is controlled by the BRD_SAFETYENABLE parameter. The safety switch will boot in a flashing safe state when the value is set to 1, which is the default. When it is set to 0, the safety switch is turned off. If this parameter is enabled, the safety switch can be used to activate Pixhawk and perform a specific function.

Value	function
0	disable
1	enable

The parameter has been disabled because every time the safety swich should be used to calibrate the ESCs by disabling this the tasks becomes much easier.

ARSPD_TYPE: Airspeed type

Type of airspeed sensor

Value	Meaning
0	None
1	I2C-MS4525D0
2	Analog
3	I2C-MS5525
4	I2C-MS5525 (0x76)
5	I2C-MS5525 (0x77)
6	I2C-SDP3X
7	I2C-DLVR-5in
8	Drone CAN
9	I2C-DLVR-10in
10	I2C-DLVR-20in
11	I2C-DLVR-30in
12	I2C-DLVR-60in
13	NMEA water speed
15	ASP5033
100	SITL

The parameter that has been given is 8 that is Drone Can

Q_M_PWM_MAX: PWM output maximum

This parameter is used to set the PWM value which will be in microseconds. This will be the maximum output to the motors.

Range	Units
0 to 2000	PWM in microseconds

The maximum PWM value that is given to the Pixhawk is 1900

Q_M_PWM_MIN: PWM output minimum

The value of the PWM, which will be in microseconds, is configured using this parameter. This will be the motors' bare minimum output.

Range	Units
0 to 2000	PWM in microseconds

The minimum PWM value that is given to the Pixhawk is 1100

ARMING_REQUIRE: Require Arming Motors

Motors won't start until a few conditions are satisfied. If the value is set to 0, the prerequisites are not checked and the motors can be quickly and simply armed. The rudder stick is used to arm the motors when the value is set to 1. If the number 2 is set, the motors can be armed or disarmed using the rudder stick, but when they are disarmed, the motor delivers a PWM value of 0. The Pixhawk needs to be restarted if the value is set to 0.

Value	Meaning
0	Disabled
1	minimum PWM when disarmed
2	0 PWM when disarmed

The parameter value that is provide is 2 that is there will be no PWM value that goes to the motors when disarmed.

ARMING_RUDDER: Arming with Rudder enable/disable.

In order to run the motors, they must first be armed. By connecting the Pixhawk to the mission planner and then forcing the motors to be armed using the software, the arming can be accomplished in a variety of ways. The motors can also be armed via the rudder input technique. In the table, 3 values are displayed. The software ought to arm the motors if the value 0 is written to the Pixhawk. The motors can be armed, but not disarmed, if Pixhawk is given the value 1. The motors can be armed and disarmed using rudder input if the value 2 is provided. Only when the throttle input is zero does it operate. To arm the motors, move the throttle to zero and move rudder input to right. In order to disarm move the throttle to left.

Value	Meaning
0	Disabled
1	Arming Only
2	Arm Or disarm

The value that has been given is 2 Arm or disarm.

Q_ESC_CAL: ESC Calibration

The UAV motors' throttle range is calibrated using this. Prior to using, please read https://ardupilot.org/plane/docs/quadplane-esc-calibration.html. On each boot, this value is automatically reset to 0. Only the QSTABILIZE mode affects this setting. while set to 1, all motors' output will come from the throttle stick while they are activated and will be zero when they are not. When set to 2, all motors' output will be at its maximum when activated and zero when deactivated. Before usage, make sure all propellers are removed.

Value	Meaning
0	Disabled
1	Throttle Input
2	Full Input

The value used is 1- throttle input.

Correction and calibration of each component Accelerometer Calibration:

Why accel calibration is done:

The sensitivity calibration of accelerometers needs to be done properly in order to provide accurate data and span the right frequency range.

Procedure:

Click on calibrate accel to begin the calibration process. The mission planner will specify which axes need to be calibrated and in what order, thus calibration must be performed properly.

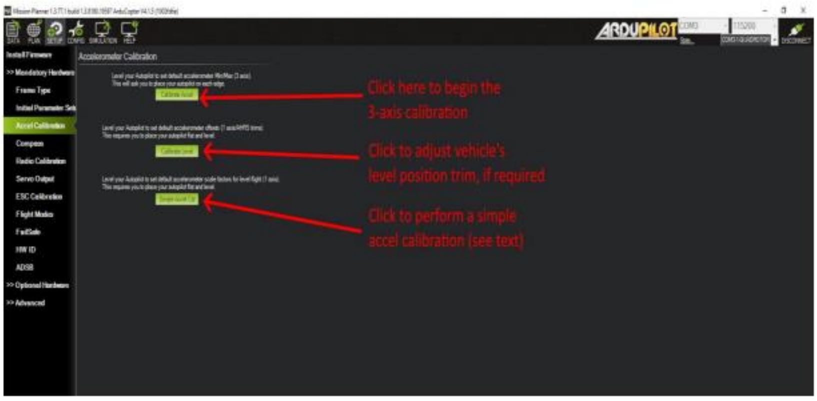
• To calibrate, Pixhawk is aligned along several axes.

• The calibration positions include level, on its back, and on its right and left sides, with the nose up or down.

• After hitting the key for each phase, the UAV must remain motionless for a certain period of time. The key needs to be depressed after each alignment in order for the acceleration calibration to be finished.

• The Pixhawk is calibrated while mounted on a UAV.

Software will display the calibration results after it is finished.



Accel Calibration

Calibration of Radio:

Using the RC transmitter, the pilot can control the aircraft, select the flight mode, and activate or deactivate auxiliary functions. Here, the aircraft's flight modes have been controlled and changed using an FS-i6 radio transmitter. The aeroplane and Pixhawk could suffer some harm if the throttle and other controls are not calibrated. The mission planner can be used to set the minimum, maximum, and trim values for the RC input during calibration.

Radio transmitter Setup

• Verify that the battery is unplugged and that the RC receiver is attached to Pixhawk.

• After that, all trim must be placed in the centre with no additional trim input.

• Attach the Pixhawk to the computer, then launch the mission planner. then start the calibration by going to the necessary hardware.

• Prior to that, some RC channels should be assigned; they are listed below.

Channel 1 must be controlled by a roll stick, while Channel 2 by a pitch stick, Channel 3 by a throttle stick, Channel 4 by a yaw stick, and Channel 6 by a tuning knob.

• Two- or three-position switches are used to regulate all of the from channels 7 to 12.

Radio setup

Calibration:

Use of mission planning software is required for calibration following radio transmitter setup. The procedures are outlined below.

• Select Initial setup/mandatory hardware/radio calibration from the Mission Planner software.

• The radio calibration will then begin when you select the bottom-right option to calibrate the radio.

• It is necessary to adjust the sticks to their minimum and maximum positions before calibrating. In the same way, move the switches. As seen in the figure below, a red line indicating the maximum and minimum values will appear.

• The software will typically display the data summary. The values are between 1100 an1900.

Calibration of Radio

Calibration of ESC:

The ESCs are the electronic speed controllers that regulate the motors' rpm, as it was described above in the components. The motors won't work without the ESCs being calibrated, and as a result, a constant beep will indicate that the ESCs are out of calibration. Our most challenging task while developing the UAV was calibrating the ESCs.

The calibration of the ESCs must be completed once the inputs have been set.

First, remove the brushless motors' propellers.

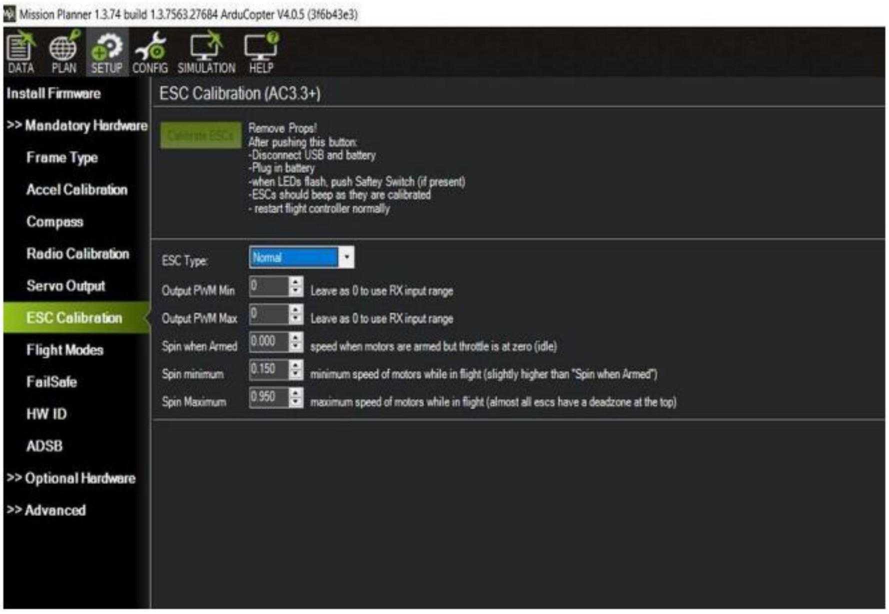
Step 2: Disconnect the battery and USB after maintaining the throttle at its highest setting.

Step 3: Connect the power source for the battery.

Step 4: Press the Pixhawk's safety switch as soon as the LED starts to flash.

Step 5: When the ESC begins to beep, they have been calibrated.

STEP6: Restart the Pixhawk normally in step 6 to complete the calibration.



ESC calibration

Calibration of Compass and GPS:

Use Mission Planner to calibrate a UAV's compass by following these steps:

• Connect your UAV: Ensure that Mission Planner can communicate with your UAV via a USB cable or telemetry link. Make sure the UAV is turned on and the connection is secure.

Open Mission Planner (OMP)

Open Mission Planner on your computer, then attach your UAV to it. Await the software to identify the car and show the telemetry data.

• Open the menu for Initial Setup:

Click "Initial Setup" on the Mission Planner's top menu bar. There will be a drop-down menu.Choose Compass Calibration:

In the sub-menu, select "Compass Calibration." This will open the compass calibration wizard.

 Follow the instructions:

Mission Planner will guide you through the calibration process step by step. Make sure to carefully read and follow the instructions provided on the screen.

• Choose the right compass: The calibration wizard will ask you to choose the compass you want to calibrate if your UAV has more than one. Select the compass that has to be calibrated.

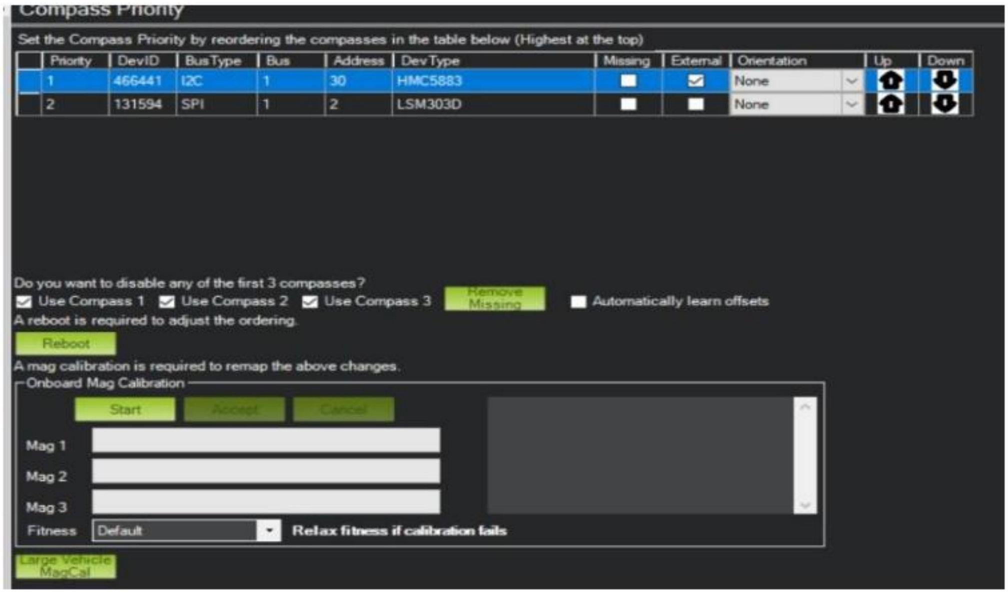
• Rotate the UAV: To rotate the UAV in all three directions (pitch, roll, and yaw), follow the on-screen instructions. The needed rotation direction and speed for each axis will be displayed by Mission Planner.

• Finish the calibration

As directed, keep rotating the UAV until the calibration progress reaches 100%. When the calibration is finished, Mission Planner will notify you and display the calibration status.

• Check the performance of the compass: After calibration, make a few test flights to check thecompass. During the flights, pay attention to the stability and correctness of the heading information displayed in Mission Planner.

It's important to keep in mind that the procedures listed here are only a broad outline, and depending on the version you are using, Mission Planner's specific options and interfaces may differ slightly. For exact directions specific to your programme version, always consult the Mission Planner literature or user manual



Compass and Gps Calibration

Applying the Flight Modes

The flying modes of a UAV aircraft have a significant impact on the control of its behaviour and capabilities. They enable the pilot or autonomous flight control system to select from a variety of flight behaviours, providing manual control, stabilisation, autonomous navigation, and specialist mission responsibilities. The autonomous flight mode is briefly described here, along with a more thorough explanation of the three modes you mentioned (HOVER, Q STABILISE, and FBWA):

HOVER (Hover Mode):

In this mode, the UAV aircraft hovers steadily over its location. It uses the onboard sensors, which include accelerometers, gyroscopes, and barometers, to maintain stability and altitude. This mode is particularly useful for tasks where the aircraft must remain motionless in the air, such as aerial photography or surveillance.

Q STABALIZE (Quadplane Stabilize Mode):

The Q STABILISE mode can only be used by UAV aircraft that can transition between fixedwing flight and vertical takeoff and landing (UAV). In this mode, the UAV aircraft operates as a multirotor (quadcopter-like) device. It maintains stability and attitude control by making use of all available control surfaces and motor outputs. This mode is typically used when switching between vertical flight and forward flight.

FBWA (Fly-By-Wire A):

A UAV can fly like a conventional fixed-wing aeroplane thanks to a fixed-wing flying mode dubbed FBWA. According to the configuration, the aircraft's roll and pitch can be controlled by the pilot or autonomous flight control system using the control surfaces (ailerons and elevators), but not its throttle or yaw. Longer flights or missions frequently involve efficient and precise forward flight, which is possible when using the FBWA mode.

AUTO (Autonomous Flight Mode):

The phrase "autonomous flight mode" refers to an operating mode in which the UAV aircraft automatically follows pre-established mission parameters and waypoints. The aircraft uses its onboard navigation system and flight controller to execute the flight plan in this mode. The flight controller is able to fly autonomously, maintain heading and altitude, and perform other duties that are unique to a given mission by utilising complicated algorithms and a range of sensors, including the GPS, barometer, and magnetometer. Autonomous flight mode is widely used for tasks like mapping, surveying, search and rescue, and other uses where precise and planned missions are required.

It's important to keep in mind that the availability and particular behaviour of flying modes may alter based on the flight controller and software being used with the UAV aircraft. Wellknown flight controllers like ArduPilot and PX4 typically offer the flying modes you mentioned, while other systems may offer additional or different flight modes based on their setups and capabilities.

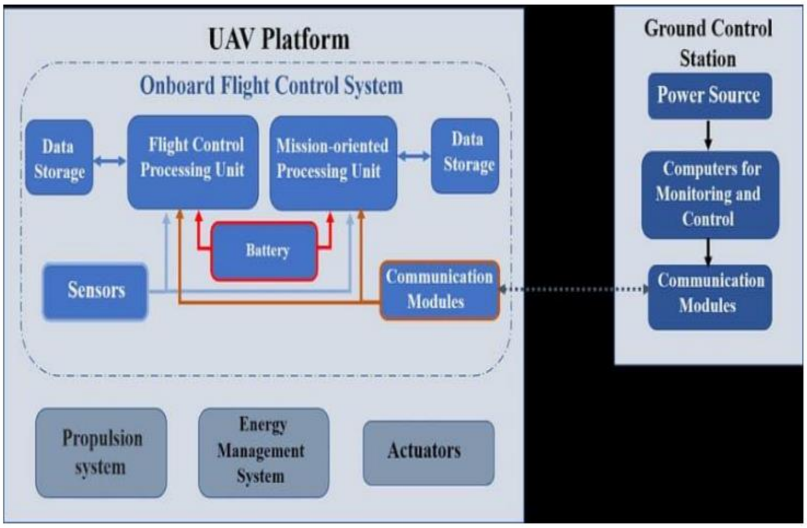
Installing Transmitter and Receiver

The receiver in use has six channels, as shown in the image, and is connected to pixhwak. The transmitter and receiver are initially coupled. The drone's receiver, which is also the transmitter, will receive the signal from the transmitter and transfer it to the flight controller. Here, the signal will be processed by the flight controller and sent to the electronic speed controller so that the motors' speeds can be changed.

Receiever

Block Diagram:

The overall methodology of this project can be summarized in the given block diagram which has each and every process:



9) RESULT AND CONCLUSION

After through research and vigorous testing of our drone we were able to complete the working model of the drone. Here are some of the steps which we followed to complete the project.

1. DESIGNING A DRONE

TASK 1: Selecting the components that are required for the drone.

TASK 2: Constructing the drone as per our required parameters.

TASK 3: Calibrating the motors and others devices if required.

TASK 4: Testing the drone for flight. Check for the errors and correct it and then test for flight.

2. DESIGNING PESTISIDE SPRAYER MODEL

TASK 1: Selecting the suitable design for making a model which is required.

TASK 2: Get the components required for making complete model.

TASK 3: Provide the connections from the pump from tank to nozzle spray.

TASK 4: Adjusted the model of tank with drone by taking suitable measures.

3. FINAL WORKING

TASK 1 : Calibrated all the components and checked whether the sensors are working or not.

TASK 2 : Then, if all components are calibrated, then take it for the testing.

TASK 3: IF errors were found and if components not calibrated, we checked the connections again and make it right again.

TASK 4: The drone is able to go to the selected area and do the required operations.

TASK 5: If the drone came correctly to the area where pest has to be sprayed, then pest spray is enabled on required area.

TASK 6 : After the pest is sprayed, the drone should come back to its original position.

Here are some of the images of our final model of the drone.

Top View of drone Front View

An effort is made to explain the UAV and its use in agriculture, which may use a variety of software and hardware to autonomously spray pesticides on crops.

The use of UAVs to spray pesticides on farms has a number of benefits, including improved efficacy, economy, and accuracy. Farmers can cover huge areas fast and target particular regions that need treatment by employing specialised agricultural drones, minimising the need for pesticides and lowering the environmental effect. To maintain the legitimacy and security of the activities, it is crucial to follow legislation, pick the right pesticides, and stick to safety procedures. Following the spray application, evaluation and monitoring assist determine efficacy and make the required corrections for subsequent applications. UAV pesticide spray application can ultimately be a useful tool in contemporary precision agriculture, giving farmers a more effective and environmentally friendly method of crop protection.

However, compliance with rules, appropriate instruction, and consideration of safety measures are necessary for the successful application of UAV technology in agriculture. In order to protect the privacy and security of the data obtained by the drones, it's crucial to adhere to local regulations surrounding the use of UAVs and the application of pesticides.

We may anticipate further breakthroughs and advancements in the agriculture industry as UAV technology develops. The incorporation of AI, ML, and autonomous capabilities in UAVs has the potential to improve farming operations even more, boost output, and promote ecologically friendly and sustainable practises.

UAVs have generally shown to be useful instruments in contemporary agriculture, allowing farmers to make data-driven choices, increase productivity, and improve crop management techniques.

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10) Scope for future work

- Equipment: specialised agricultural drones outfitted with pesticide spraying systems are deployed. These drones are often equipped with a payload capacity to carry the required amount of insecticide, as well as a spray boom or nozzles for precision administration.
- Precision Application: UAVs make it possible to apply pesticides precisely and strategically, minimising the chance of overspraying or missing regions and maximising pesticide efficiency.
- Efficiency in Time and Labour: Using UAVs instead of manual spraying techniques allows for faster coverage of broad farmed areas, which saves time and labour in the application of pesticides.
- Accessibility: UAVs have the ability to enter fields that are challenging for conventional machinery to operate in, such as steep terrain or regions with impediments.
- Reduced Human Exposure: By deploying UAVs for pesticide spraying, the risk of employees being exposed to potentially dangerous chemicals is reduced.
- Uniform Coverage: UAVs can offer constant pesticide dispersion over the whole field, assuring uniform coverage, and lowering the risk of crop damage from inadequate or excessive pesticide application.
- Environmental effect: By eliminating overspray and drift, restricting chemical runoff, and focusing on specified treatment areas, UAVs with accurate spray systems can help reduce the environmental effect of pesticide use.
  Autonomous Aerial System for Agriculture Purpose
- Data Integration: Some cutting-edge UAV systems may work in conjunction with other technologies, such remote sensing and imaging, to collect information on crop health and insect infestations, allowing farmers to apply pesticides with precision.
- Planning and Mapping: Prior to submitting the application, a complete aerial map of the farmland must be created. This mapping procedure entails using advanced imaging techniques such as aerial photography or remote sensing to locate treatment sites and optimise drone flying trajectories.
- Pesticide Selection: The choice of pesticides should be carefully considered to ensure that they are appropriate for aerial application. To ensure the security and efficiency of the spraying operation, considerations such formulation, drift potential, and environmental impact must be made.
- Rules and permissions: Depending on the nation or location, there can be particular rules and permissions controlling the use of drones to spray pesticides. To maintain lawful and secure operations, compliance with these rules is crucial.
- Safety precautions: During UAV pesticide spray operations, appropriate safety procedures should be followed. To reduce the potential of contamination, this entails wearing personal protective equipment, keeping safe distances from people and animals, and following environmental regulations.

- Efficiency and Precision: Farmers may target certain regions, use less pesticides, and have a smaller environmental effect thanks to UAVs' precision spraying capabilities. Drones have the ability to be programmed to fly along predetermined routes, guaranteeing uniform coverage and minimising overlap.
- Monitoring and evaluation: It's crucial to keep an eye on the treatment's efficacy after the spray application. Ground surveys, remote sensing methods, or drones equipped with sensors can all be used to do this. Monitoring assists in determining the effectiveness of the pesticides and making any required modifications for subsequent applications.