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A Solar Backup Powered Unmanned Areal Vehicle For Industrial And Power Plant Applications

A Mini project Report submitted in partial fulfilment of the requirements for the award of degree of

BACHELOR OF TECHNOLOGY

In

ELECTRICAL AND ELECTRONICS ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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An Autonomous Institute Affiliated to JNTU-GV, Vizianagaram

(Accredited by NBA, NAAC with 'A' Grade & ISO 9001:2008 Certified Institution)

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CERTIFICATE

This is to certify that the Mini project report entitled "***A Solar Backup Powered Unmanned Areal Vehicle For Industrial And Power Plant Applications***" submitted by **G Sai tharun(21341a0226),K. Anasuya Samhita (21341a0253),D. Honey (21341a0237),K. Nithin (21341a0245),B. Mohith (21341a0216),Ch. Harika (21341a0218),** has been carried out in partial fulfilment of the requirements for the award of degree of **Bachelor of Technology** in **Electrical and Electronics Engineering** in **GMR Institute of Technology**, An Autonomous Institute Affiliated to JNTU-GV, Vizianagaram, is a record of bonafide work carried out by him under my guidance & supervision.

The results embodied in this report have not been submitted to any other University or Institute for award of any degree.

Signature of the guide	Signature of the H.O.D
Dr. V. Manoj	**Dr. P Ramana**
Assistant Professor	**Professor & HOD**
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ABSTRACT

This project presents the design and implementation of a solar backup powered Unmanned Aerial Vehicle (UAV) tailored for industrial and power plant applications. The UAV is equipped with solar panels to harness solar energy and serve as a sustainable backup power source, ensuring continuous operation even in remote or off-grid locations. The system integrates advanced propulsion and control systems to enable autonomous flight, with the ability to navigate complex industrial environments and perform various monitoring and inspection tasks. By leveraging renewable energy and autonomous capabilities, the UAV offers a cost effective and environmentally friendly solution for enhancing operational efficiency and safety in industrial settings. This project aims to demonstrate the feasibility and effectiveness of solar-powered UAVs for industrial applications, highlighting their potential to revolutionize various sectors by providing reliable and sustainable aerial monitoring and inspection capabilities. This project proposes the development of a novel drone equipped with a hybrid power system combining solar panels and a battery. This project aims to contribute to the field of long endurance and sustainable drone technology. The integration of renewable energy sources with unmanned aerial vehicles (UAVs) has become an innovative approach to address sustainability and operational challenges in various industries, particularly in industrial and power plant applications. The Solar backup powered Unmanned Aerial Vehicle (UAV) represents a cutting-edge solution that harnesses solar energy to provide backup power and extend operational capabilities in remote or challenging environments.

Key words: Drone, Solar Panels, Industries, Power Plants, Thermal Image, solar back up.

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CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION TO PROJECT

A solar backup-powered unmanned aerial vehicle (UAV) tailored for industrial and power plant applications holds promise in enhancing operational efficiency. Equipped with solar cells integrated into its surface, this UAV harnesses solar energy during daylight hours, ensuring sustained flight capability. Concurrently, lithium batteries housed within the wing structure are charged, providing energy for nocturnal operations. However, optimizing the structural system of such a UAV to enable prolonged flights presents a significant challenge. While topology optimization has been widely employed in aircraft design to reduce weight, its application to solar-powered UAVs has primarily focused on energy management rather than structural considerations. Existing approaches often overlook the mechanical properties of lithium batteries, treating them merely as concentrated masses or disregarding their mechanical behaviours altogether. To address this gap, an integrated optimization scheme is proposed to synchronize component layout and structural topology design. By considering lithium battery packages as integral structural components, this approach aims to maximize the load-carrying potential of the system. Furthermore, advancements in modelling techniques, such as level set models, enable more accurate representation of component shapes and topological changes. Recent extensions of integrated optimization, including feature-driven design and smart structure system design, offer further avenues for refining UAV structural systems. In this study, the integrated optimization concept is extended to develop effective wing beam structure systems for a solar backup-powered UAV tailored for industrial and power plant applications, accounting for geometric nonlinearity and diverse periodic structural configurations.Creating a solar backup-powered unmanned aerial vehicle (UAV) tailored for industrial and power plant applications represents a significant advancement in autonomous technology.

Currently, most plant protection drones operate with semi-autonomous control systems, which often struggle to maintain flight stability within complex farmland environments. Developing plant protection drones with robust and reliable control systems remains a primary focus within the industry. The Pixhawk open-source flight control system is renowned as the "Android" of the UAV industry, with its PX4 firmware widely used. One notable feature is its support for Morb (Micro Object Request Broker), a message mechanism enabling multiple processes to exchange and share data efficiently.

The advent of solar backup-powered unmanned aerial vehicles (UAVs) tailored for industrial and power plant applications marks a significant stride in autonomous technology. These UAVs, designed to operate without human pilots onboard, hold immense potential for enhancing efficiency and productivity in industrial and power plant settings. One critical aspect of such UAVs is the development of robust and reliable control systems, ensuring stable flight performance amidst the complexities of industrial environments. Traditionally, plant protection drones in agricultural settings have operated with semi-autonomous control systems, facing challenges in maintaining flight stability, particularly in intricate farmland environments. However, adapting and refining these control systems for industrial and power plant applications necessitates a rigorous focus on stability and reliability.

The Pixhawk open-source flight control system emerges as a key player in this domain, often likened to the "Android" of the UAV industry. Leveraging its PX4 firmware, Pixhawk offers extensive capabilities, including support for Morb (Micro Object Request Broker), a messaging mechanism facilitating seamless data exchange between multiple processes. This study embarks on investigating the control system architecture for solar backup-powered UAVs intended for industrial and power plant applications, with a primary emphasis on Pixhawk-based systems. Specifically, it aims to establish efficient communication channels between the flight control system and auxiliary components, such as the spray system, crucial for tasks like Transmission line inception & power plant inception environments. By addressing these challenges, this research endeavours to enhance the stability, reliability, and overall performance of solar backup-powered UAVs in industrial and power plant contexts.

CHAPTER-2

LITERATURE REVIEW

Autonomous UAV quadcopters have garnered significant attention in recent years due to their versatility and potential applications in various fields including surveillance, agriculture, and search and rescue operations. The Pixhawk controller has emerged as a popular choice among researchers and developers due to its open-source nature and robust capabilities for controlling unmanned aerial vehicles. This literature review aims to provide an overview of the development of autonomous UAV quadcopters utilizing the Pixhawk controller and the methodologies employed for flight data acquisition [1].

The Pixhawk controller is a widely used open-source autopilot system designed for autonomous aerial vehicles. It provides a comprehensive set of features including GPS navigation, waypoint following, and stabilization algorithms, making it suitable for a wide range of UAV applications. Its modular design allows for easy integration with various sensors and peripherals, enabling developers to customize the platform according to their specific requirements. Numerous studies have demonstrated the successful development of autonomous UAV quadcopters using the Pixhawk controller as the central component. Researchers have focused on implementing advanced control algorithms such as PID (Proportional-Integral-Derivative) control, MPC (Model Predictive Control), and reinforcement learning to achieve stable and agile flight performance. These algorithms enable the quadcopters to autonomously navigate through complex environments, avoid obstacles, and perform precise manoeuvre's.

Flight data acquisition is essential for evaluating the performance of autonomous UAV quadcopters and refining control algorithms. Various sensors, including gyroscopes, accelerometers, magnetometers, barometers, and GPS, along with pulse width modulation (PWM) signals, have been utilized to capture quadcopter attitudes during flight. This rich dataset provides valuable insights into quadcopter dynamics and can serve as a basis for further research in autonomous navigation and control. The future trajectory of this research aims to implement autonomous quadcopters in specific agricultural tasks such as surveillance, fertilizing, and pest control. Additional hardware components, including cameras and actuators, will be integrated to facilitate task execution. Image processing algorithms will also be employed to enhance agricultural surveillance capabilities, enabling the detection and monitoring of crop health, pest infestations, and environmental conditions.

Several studies have explored the integration of UAV technology into agriculture, highlighting its potential to increase efficiency, reduce resource consumption, and improve crop yields. For instance, UAVs equipped with multispectral and thermal imaging sensors have been used to assess crop health, identify areas requiring irrigation or fertilization, and detect pest infestations. Autonomous navigation capabilities enable UAVs to autonomously survey large agricultural areas, providing farmers with valuable insights for informed decision-making [1].

Solar photovoltaic (PV) power plants play a crucial role in the renewable energy landscape, and efficient monitoring is essential for maximizing their performance and lifespan. This literature review explores the advancements in drone technologies and their applications in the intelligent monitoring of solar PV power plants [2]. Advancements in Drone Technologies: Recent years have witnessed significant advancements in drone technologies, enabling them to be employed for a wide range of applications, including aerial inspections and monitoring. These advancements include improvements in flight stability, battery life, payload capacity, and sensor technology. Miniaturized yet powerful sensors, such as high-resolution cameras, thermal imaging cameras, LiDAR (Light Detection and Ranging) sensors, and multispectral sensors, have become integral components of drones for collecting comprehensive data during inspections. Drones offer several advantages for monitoring solar PV power plants, including cost-effectiveness, efficiency, and the ability to access hard-to-reach areas. Intelligent monitoring with drones involves various tasks such as site surveying, installation monitoring, defect detection, performance analysis, and predictive maintenance. High-resolution imagery captured by drones allows for detailed analysis of solar panel condition, identifying potential issues such as cracks, hotspots, soiling, or shading that may affect performance.

Several studies have demonstrated the effectiveness of drones in monitoring solar PV power plants. For instance, research by Li et al. (2020) utilized drones equipped with thermal imaging cameras to detect cell-level defects in solar panels, enabling targeted maintenance interventions. Similarly, the work of Zhang et al. (2019) employed LiDAR-equipped drones for accurate site mapping and layout optimization of solar PV installations, leading to improved energy production. Drones have emerged as powerful tools for the intelligent monitoring of solar photovoltaic (PV) power plants, offering advantages in cost, efficiency, and accessibility. Advanced sensor technologies integrated into drones enable comprehensive data collection, analysis, and actionable insights for optimizing the performance and maintenance of solar PV installations.

High-resolution cameras provide detailed imagery of solar panels, facilitating visual inspections and defect detection. Thermal imaging cameras detect temperature anomalies, such as hotspots caused by faulty cells, allowing for targeted maintenance interventions. LiDAR sensors offer accurate 3D mapping of solar PV sites, aiding in layout optimization and volume measurements. Multispectral sensors capture data across various wavelengths, enabling assessment of vegetation health, soil moisture levels, and environmental conditions surrounding the solar PV plant. Artificial intelligence and data analytics play a crucial role in processing large datasets collected by drones. Machine learning algorithms automate defect detection, predictive maintenance, and performance optimization of solar PV systems, enhancing operational efficiency and reliability.

Studies by Li et al. (2020) demonstrated the effectiveness of drones equipped with thermal imaging cameras in detecting cell-level defects, while research by Zhang et al. (2019) utilized LiDAR-equipped drones for accurate site mapping and layout optimization of solar PV installations. These advancements underscore the transformative potential of drone technologies in intelligent monitoring and management of solar PV power plants, contributing to the transition towards sustainable energy solutions [2].

The Pixhawk controller, an open-source autopilot system, has become a popular choice for controlling UAVs due to its robust features and flexibility. It offers a wide range of functionalities, including GPS navigation, waypoint following, and stabilization algorithms. Its modular design allows for seamless integration with various sensors and peripherals, enabling developers to customize the platform according to specific application requirements. Researchers and developers have focused on implementing advanced control algorithms to enable autonomous navigation and operation of UAV quadcopters. These algorithms, such as Proportional-Integral-Derivative (PID) control, Model Predictive Control (MPC), and reinforcement learning, enable the quadcopters to navigate through complex environments, avoid obstacles, and perform precise maneuvers autonomously. Additionally, machine learning techniques are being explored to enhance the quadcopters' ability to adapt and learn from their environment.

Challenges persist, as noted by Chen et al. (2018) in "Challenges and Solutions in the Development of UAV Plant Protection Systems." Payload capacity, flight endurance, and regulatory constraints remain significant hurdles. Integrating Pixhawk controllers while addressing these challenges requires innovative solutions and interdisciplinary collaboration. Looking ahead, opportunities lie in integrating Pixhawk controllers with emerging technologies such as artificial intelligence and machine learning. Li et al. (2022) emphasized the potential of these technologies to enable autonomous decision-making, adaptive control, and real-time data analytics, thereby enhancing the capabilities and efficiency of plant protection UAVs [4].

The design optimization of solar-powered drones involves intricate considerations of both the energy storage system and the structural topology to maximize efficiency and performance. This literature review examines recent advancements in the integration of batteries layout and structural topology optimization for solar-powered drones, focusing on methodologies, challenges, and potential applications [5].

Research by Wang et al. (2020) in "Optimal Battery Layout Design for a Solar-Powered Unmanned Aerial Vehicle" explored the optimal placement of batteries within the drone's structure. The study utilized computational optimization algorithms to determine the layout that minimizes weight while maximizing energy storage capacity. Results showed that strategically placing batteries near the centre of mass improved stability and flight endurance. Additionally, "Design Optimization of Battery Layout for Solar-Powered UAVs" by Li et al. (2019) emphasized the importance of balancing weight distribution and aerodynamic performance in battery layout design. The study proposed a multi-objective optimization approach considering factors such as drag reduction and structural integrity. The optimized layout resulted in improved energy efficiency and flight range.

In "Topology Optimization of Lightweight Structures for Solar-Powered Drones" by Zhang et al. (2021), structural topology optimization techniques were applied to design lightweight and robust drone frames. The study utilized finite element analysis and evolutionary algorithms to iteratively refine the structural topology, minimizing weight while maintaining structural integrity. The optimized designs demonstrated significant improvements in weight savings and mechanical performance. Furthermore, research by Liu et al. (2020) in "Topology Optimization of Solar-Powered Drone Wings for Enhanced Energy Harvesting" focused on optimizing wing structures to maximize solar energy harvesting. The study utilized computational fluid dynamics simulations and genetic algorithms to design wing shapes that maximize exposure to sunlight while minimizing aerodynamic drag. The optimized wing designs led to improved energy efficiency and extended flight endurance. Despite advancements, challenges remain in the integration of batteries layout and structural topology optimization for solar-powered drones. Integration of complex optimization algorithms with real-world design constraints requires computational resources and expertise. Furthermore, practical considerations such as manufacturing feasibility and regulatory compliance must be addressed.

Future research directions involve exploring advanced materials, such as carbon fibre composites and lightweight alloys, to further reduce weight and enhance structural performance. Additionally, advancements in additive manufacturing technologies enable the fabrication of complex geometries, facilitating the realization of optimized designs. The integration of batteries layout and structural topology optimization represents a promising approach to enhance the efficiency and performance of solar-powered drones. Recent research demonstrates the effectiveness of computational optimization techniques in designing lightweight, energy-efficient drone systems. Continued research and innovation in this field hold promise for advancing the capabilities of solar-powered drones and unlocking new applications in surveillance, environmental monitoring, and beyond.

Optimizing the layout of integrated batteries and the structural topology is critical for maximizing the performance and efficiency of solar-powered drones. Research by Wang et al. (2020) focused on optimizing battery layout, employing computational algorithms to minimize weight while maximizing energy storage capacity. Their study demonstrated that strategically placing batteries near the center of mass improved stability and flight endurance.Similarly, Li et al. (2019) explored battery layout optimization considering factors such as weight distribution and aerodynamic performance. Their multi-objective optimization approach resulted in improved energy efficiency and flight range by balancing drag reduction and structural integrity.Structural topology optimization techniques have also been applied to design lightweight and robust drone frames. Zhang et al. (2021) utilized finite element analysis and evolutionary algorithms to refine structural topology, minimizing weight while maintaining strength. Their optimized designs showed significant improvements in weight savings and mechanical performance.

Additionally, Liu et al. (2020) focused on optimizing wing structures for enhanced solar energy harvesting. and addressing practical considerations like manufacturing feasibility. Future research may involve exploring advanced materials and additive manufacturing techniques to further enhance drone performance and efficiency in various applications [5].

CHAPTER-3

INTRODUCTION TO DRONE

3.1 DESCRIPTION

A drone is an unmanned aircraft. Drones are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously using software-controlled flight plans in its embedded systems, that work in conjunction with onboard sensors and a global positioning system (GPS). Drones have two basic functions: flight mode and navigation. To fly, drones must have a power source, such as battery or fuel. They also have rotors, propellers and a frame. The frame of a drone is typically made of a lightweight, composite material to reduce weight and increase maneuverability. Drones require a controller, which lets the operator use remote controls to launch, navigate and land the aircraft. Navigational systems, such as GPS, are typically housed in the nose of a drone. The GPS on a drone communicates its precise location to the controller. An onboard altimeter can communicate altitude information. The altimeter also helps keep the drone at a specific altitude if the controller designates one. Drones can be equipped with sensors, including ultrasonic, laser or lidar distance sensors, time-of-flight sensors, chemical sensors, and stabilization and orientation sensors. Visual sensors offer still and video data. Red, green and blue sensors collect standard visual red, green and blue wavelengths, and multispectral sensors collect visible and nonvisible wavelengths, such as infrared and ultraviolet. Accelerometers, gyroscopes, magnetometers, barometers and GPS are also common drone features. For example, thermal sensors make possible surveillance and security applications, such as livestock monitoring and heat-signature detection. Hyperspectral sensors help identify minerals and vegetation, and are ideal for use in crop health, water quality and surface composition.

3.2 APPLICATIONS OF DRONE

A commercial drone has an end-to-end connection via wireless, from user to controller. An industrial UAV, however, much like any other device in the IoT web, communicates directly to an industrial control system such as the Supervisory Control and Data Acquisition or SCADA. Some of the parameters measured by the mounted IoT sensors are temperature, humidity, atmospheric pressure, motion, electric & magnetic field strength, coronal arc discharge, cell phone signals, and methane levels. These sensors communicate directly with the utility's core communication network. This level of integration requires bidirectional communication transmission security and logical protocol synchronization. UAS' can do aerial imagery, visual imagery, thermal imagery and even radio-frequency imagery of factory stations and substations. However, drone imagery and drone airspace regulations vary from nation to nation and generally face severe restrictions as most processor-powered systems can be hacked into. Using the measurements gathered by IoT sensors as a novelty is of great significance to the success of the factory. Widespread adoption and integration across major automation markets, such as mining, energy & utilities, agriculture, oil & gas, infrastructure, emergency response, and life sciences calls for intelligent solutions that combine UAV hardware and automation software to deliver tangible results at scale. This has prompted the automation industry and drone manufacturers to look for a disruptive technology that will liberate the UAV: namely, high-speed data analytics combined with Industrial IoT, cybersecurity, and sensor-mounted drones. In order to use this integration in UAV applications, the standards & guidelines which can incorporate advanced technologies into procedures and practices need to set up. Engineers and scientists are already working on drones of varying capabilities which, much like military drones, would be operated from a ground station. The station will gather real-time measurements and sensor data from other fixed and mobile platforms.

3.3 PARTS USED IN DRONES

Drones are small or unmanned areal vehicles (UAVs). They're unique in that they can drive remotely and autonomously, and they're capable of maintaining a controlled, sustained level of flight.

3.3.1 F450 FRAME

This is standard quadcopter frame made from advanced engineering materials, for maximum strength and least weight. The main frame is glass fiber while the arms are constructed from ultra durable nylon. It weighs around 280g only. The kit requires assembly and comes with center plates with integrated power distribution PCB to power the ESCs from the battery. The arms are easily replaceable and come in red and white colors providing better orientation during flight. The center plate supports standard 50mm controller boards like MK, KK, FF, MWC

Features

- Built from quality glass fiber and nylon
- Integrated PCB connections for direct connection of your ESCs to the battery
- Coloured arms help you to keep track of the copters orientation during flight

- Large Center plate allows mounting of gimbals and camera for FPV and aerial photography
- Offers simple and quick assembly and repairing
- The center plate supports standard 50mm controller boards like MK, KK, FF, MWC
- It weighs around 280g only

It weighs around 280g only. The kit requires assembly and comes with center plates with integrated power distribution PCB to power the ESCs from the battery. The arms are easily replaceable and come in red and white colors providing better orientation during flight. This is standard quadcopter frame made from advanced engineering materials, for maximum strength and least weight. The main frame is glass fiber while the arms are constructed from ultra durable nylon

Fig 3.1:- drone F20 quadcopter frame

3.3.2 1400KV BLDC MOTORS

A 1400 KV BLDC motor is a brushless DC motor, specifically designed for powering multirotor applications like quadcopters and hexacopters , expand more Here's a breakdown of its key characteristics:

KV Rating

- KV stands for Kilovolts (KV). expand more In a BLDC motor, it refers to the RPM (Revolutions Per Minute) generated per Volt applied , expand more So, a 1400 KV motor will spin at 1400 RPM for every Volt of electricity supplied. expand more

Fig3.2: BLDC motor

3.3.3 ESC (ELECTRONIC SPEED CONTROLLER)

The Simonk 30A ESC is an Electronic Speed Controller (ESC) which is used to drive brushless DC drone motors and is capable of supplying current up to 30A. The 30A Simonk controller is made for quadcopters and multicopters to provide faster and better motor speed control. This ESC 30A features a battery eliminator circuit (BEC) that provides 5V and 2A to the receiver or flight controller, so an extra battery to power those is not needed. These electronic speed controllers are best used with A2212 BLDC motors of 1000kv, 1400kv, and 2200kv.

CONNECTIONS

- **Power:** Red - 7.4V to 14.8V
  Black - GND
- **Servo:** Yellow - Throttle Input
  Red - 5V, 2Amp Out
  Brown - GND
- **BLDC Motor:** 3 Blue Wires - BLDC ESC Connections

Fig 3.3:- ESC (Electronic speed controller for BLDC motor)

3.3.4 LIPO BATTERY (3300 mAH)

Orange 3S 35C/80C Lithium polymer 3300mah battery Pack (LiPo) is known for its performance, reliability, and price. So it's no surprise to us that the Orange lipo battery is useful in drones or any other multirotor systems; likewise, health & fitness devices. The 3300mAh battery Pack (LiPo) delivers full capacity at a price everyone can afford; likewise, we assure a quality product and the best customer support. The Orange 3S 35C/80C 3300mAh battery Pack (LiPo) is available with heavy-duty discharge leads; above all, it minimizes resistance and sustains high current loads. Orange batteries stand up to the punishing extremes of aerobatic flight and RC vehicles. Each pack is available with plating of gold on connectors and JST-XH style balance connectors. The assembling of all Orange Lithium Polymer battery packs is done using IR match cells, in addition, to provide high reliability.

Fig 3.4 :- 3300mah Lipo Battery

3.3.5 FLIGHT CONTROLLER (PIXHAWK 2.4.8)

This Pixhawk flight controller is the brain of a drone, keeping it stable and responding to pilot commands. It uses ArduPilot software (version 2.4.8), which is like its operating system. While reliable, this software version might be outdated. Newer versions likely offer better performance and bug fixes. Think of it as a smartphone - you'd want the latest software for best results.

Fig 3.5 :- Pixhawk 2.4.8 Flight controller

3.3.6 POWER MODULE

Pixhawk Power Module V6.0 Output BEC 3A XT60 Connector 28V 90A. A battery Eliminator circuit is a type of voltage regulator.it is used to prevent high voltage towards the Esc's and pass the required voltage which is essential. As modern RC airplanes use high voltage batteries, it allows you to run your receiver, servos, and other accessories from your main battery without using a separate lower voltage one.

The **APM 2.5.2/2.6/2.8** Pixhawk Power Module is a simple way of providing your **APM 2.5** with clean power from a LiPo battery as well as current consumption and battery voltage measurements, all through a **6-pos** cable. The on-board switching regulator outputs **5.3V** and a maximum of **2.25A** from a **2S-6S LiPo battery.** The Power Module comes completely assembled with "Deans" or "T" connectors, and wrapped in shrink tubing for protection. Also, the circuit detects a sensing current around **90 A**.

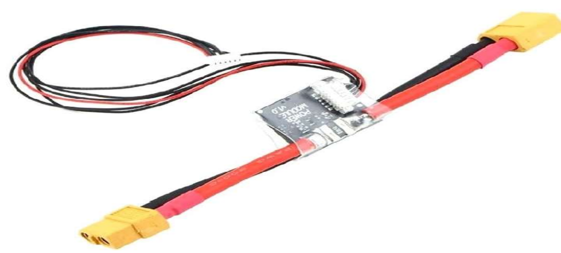

Fig 3.6 :- Power Moduule

3.3.7 GPS MODULE FOR PIXHAWK

This is a new generation NEO-M8N High Precision GPS Module with Built-in Compass for PIXHAWK and APM FC (**Ready to connect to PIXHAWK FC**) with onboard Compass, low power consumption, and high precision, the ultimate accuracy is 0.6 meters, actually almost 0.9 meters, greater than the previous generation NEO-7N 1.4-1.6 meters accuracy, support GPS/QZSS L1 C/A, GLONASS L10F, BeiDou B1 protocol, and mode or more. Additionally, you can connect the same module to APM Flight Controller just after swapping the extra 5-pin connector provided in Package. So if you want GPS telemetry for your FPV flying or camera ship? This new generation GPS NEO-M8N is the answer. Capable of accuracy between 0.6 and 0.9 meters it is a significant improvement over previous models. Sattelite searching and acquisition is very fast, generally taking around ten seconds to locate and acquire up to 6 satellites. It also has a built-in compass with a 10Ghz refresh rate and a low noise figure which ensures this GPS module offers excellent performance.

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Fig 3.7 : GPS module for Pixhawk

3.3.8 SAFETY SWITCH AND BUZZER

Pixhawk Passive Buzzer and Switch buzzer have two main products one is the passive buzzer and the other is Flight Controller E-Switch. The Passive buzzer has a JST-SH connector on one side that plugs directly into the Pixhawk.Once connected you will be able to hear different sounds that relate to different modes!

The Pixhawk Flight Controller E-Switch Module enables you to arm/disarm your board at a moment’s notice. This comes with a three-position JST-SH connector.

Fig 3.8: Safety Switch & Buzzer

3.3.9 PROPLLER SET

This 1045 propeller can be used with brush less motors with a 800-2200 kV rating. With a low kV motor(800 – 1400 kV), this propeller offers smooth flights with longer flight times perfect for FPV and aerial photography. With a high kV motor (more than 1200 kV) this propeller offers fast flights perfect for acrobatic flights.

This propeller can be used with our A2212 1000KV, 1400KV, 1800KV and 2200kV motors and our 30A ESC.

Note: Buy additional propellers than required on your multirotor as propellers are regularly broken during flight crashes

Fig 3.9:- Propller set CW & CCW

3.3.10 FLYSKY FS-I6 2.4G 6CH PPM RC TRANSMITTER WITH FS-IA6B

When using a drone, a transmitter is one of the most important components. You can't fly a multirotor without it because it uses radio signals to send commands wirelessly to a Radio Receiver, which is connected to an aircraft or multirotor that is being remotely controlled.

This is the FlySky FS-i6 2.4G 6CH PPM RC Transmitter With FS-iA6B Receiver. It is a great entry-level radio for those just starting in the field of drones flying.

Above all, you get a slim, modern radio transmitter that fits nicely in your hands and weighs just under 400 gm. It won't test your arm stamina on those long flights. This radio is also really practical with a 3-position switch. It has two adjustable knobs for flight modes/ multiple flap positions.

You will get the new FS-iA6B receiver with this kit. It comes with a dual antenna for excellent reception and interference rejection capabilities.

Each transmitter has a unique ID and so when binding; the receiver remembers this ID and accepts data from that transmitter only. This avoids picking up other transmitter signals and dramatically decreases inference and increases safety.

Fig 3.10 :- Signal Transmitter

Fig 3.11:- Receiver

CHAPTER-4

CONTROLLER & SOFTWARE USED IN DRONE

4.1 FLIGHT CONTROLLER

The flight controller used in the drone for this project is PIXHAWK 2.4.8 Drone Flight Controller PX4 32 Bit Autopilot.

Fig 4.1: Pixhawk flight controller (v 2.4.8)

4.2 FLIGHT CONTROLLER SPECIFICATIONS

4.2.1 PROCESSOR

1. 32bit STM32F427 Cortex M4 core with FPU.
2. 32-bit STM32F103 failsafe co-processor.
3. 168 MHz.
4. 128 KB RAM.
5. 2 MB Flash.

4.2.2 SENSORS

1. ST Micro L3GD20H 16 bit gyroscope.
2. ST Micro X4HBA 303H 14-bit accelerometer/magnetometer.
3. Invensense MPU 6000 3-axis accelerometer/gyroscope.
4. MEAS MS5607 barometer.

4.2.3 INTERFACES

1. 5x UART (serial ports), one high-power capable, 2x with HW flow control.
2. 2x CAN (one with an internal 3.3V transceiver, one on expansion connector).
3. Spektrum DSM / DSM2 / DSM-X® Satellite compatible input.
4. Futaba S.BUS® compatible input and output.
5. PPM sum signal input.
6. RSSI (PWM or voltage) input.
7. I2C.
8. SPI.
9. 3.3 and 6.6V ADC inputs.
10. Internal micro USB port and external micro USB port extension.

4.3 PIXHAWK PINOUT CONNECTIONS PORTS

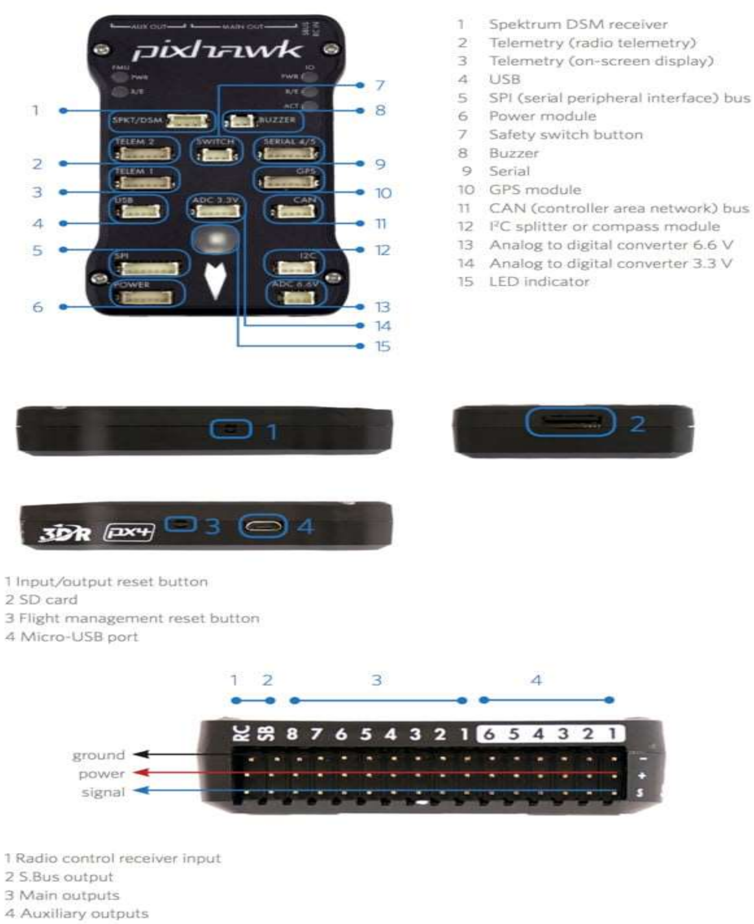

Fig 4.2: Port details of Pixhawk controller

4.3.1 TOPSIDE

Port 1: Spektrum DSM Receiver. This port is used for connecting Spektrum and DSM telemetry radios for data transmission

- **Port 2: Telemetry (Radio Telemetry)** This port can be used for telemetry radios or other serial communication
- **Port 3: Telemetry (On-screen Display)** . This port can be used for telemetry radios or other serial communication.
- **Port 4: USB** . This port is used to connect the Pixhawk to a computer for configuration and data transfer.
- **Port 5: SPI (Serial Peripheral Interface Bus)** . This port allows you to connect SPI compatible peripherals.
- **Port 6: SPKT/DSM** . This port is used for connecting Spektrum and DSM telemetry radios for data transmission, similar to Port 1 .
- **Port 7: Power Module** This 6-pin port connects to your power module (PM) which distributes power from your battery to the Pixhawk and other electronics.
- **Port 8: Safety Switch Button** . This button is used to arm and disarm the flight controller.
- **Port 9: Buzzer** . This port connects a buzzer that can be used to provide audio alerts.
- **Port 10: GPS Module** . This port is used to connect a GPS unit, typically with an integrated compass. A 6-wire cable is usually included for this connection.
- **Port 11: CAN (Controller Area Network) Bus** . This port allows you to connect CAN compatible peripherals.
- **Port 12: PC Splitter or Compass Module** . This port can be used to connect a splitter cable for connecting additional peripherals or an external compass .
- **Port 13: Analog to Digital Converter 6.6 V**. This port provides analog to digital conversion for voltage sensors up to 6.6V.
- **Port 14: Analog to Digital Converter 3.3 V** . This port provides analog to digital conversion for voltage sensors up to 3.3V .
- **Port 15: LED Indicator**. This LED indicates the status of the Pixhawk .

4.3.2 BOTTOM SIDE

- **Port 1: Input/Output Reset Button** . This button is used to reset the Pixhawk to its default settings .
- **Port 2: SD Card**. This port is used for an SD card for data logging .

- **Port 3: Flight Management Reset Button**. This button is used to reset the flight management software to its default settings.
- **Port 4: Micro-USB Port** This port can be used to connect the Pixhawk to a computer for configuration and data transfer, similar to the USB port on the topside

4.3.4 LEFT SIDE

- **Ports 1-4: Radio Control Receiver Input** . These ports are used to connect your receiver which provides control signals from your transmitter.
- **Ports 5-8: S.Bus Output**. This port can be used to connect S.Bus compatible peripherals
- **Ports 9-12: Main Outputs** These ports are used to connect to electronic speed controllers (ESCs) for controlling brushless motors.
- **Ports 13-14: Auxiliary Outputs** . These ports can be used for servos or configured as digital inputs/outputs.

4.4 SOFTWARE USED FOR DRONE

Mission Planner, a ground control software application used to configure and manage autopilot systems for unmanned aerial vehicles (UAVs). Text overlaid on the bottom portion of the logo reads “Mission Planner,” followed by the version number “Version: 1.3.81” and “by Michael Obome”

Fig 4.3: Software used

4.5 UPDATING SOFTWARE IN PIXHAWK FLIGHT CONTROLLER

4.5.1 CONNECT THE PIXHAWK CONTROLLER TO SOFTWARE

- Take a Micro USB port and connect it to the laptop and to the flight controller by using that cable

- Ater that open your laptop and search for COM ports in device manager after that open Misson planner software and connect by selecting the appropriate connection

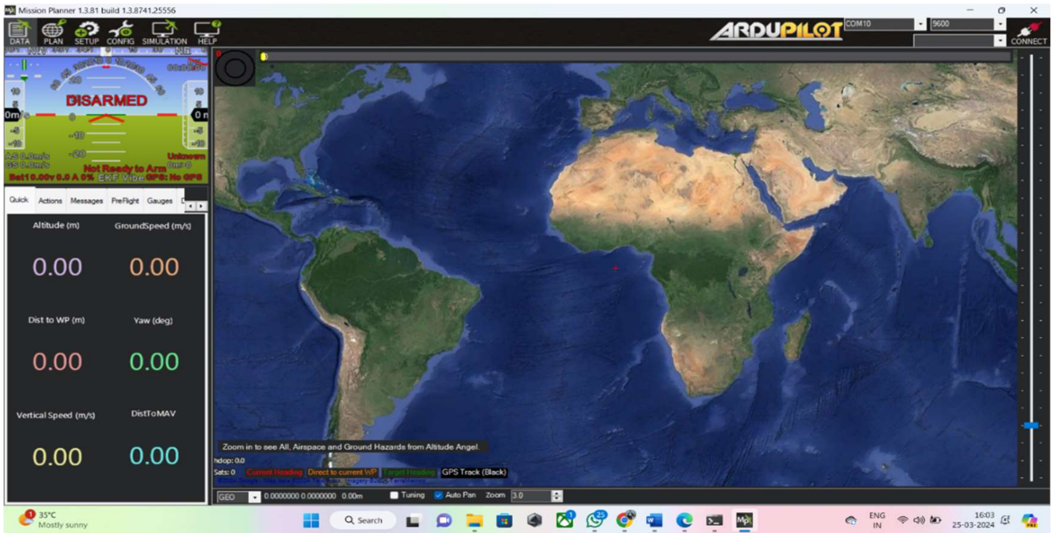

Fig 4.4: Connect the Pixhawk controller to software interface

4.5.2 FIRMWARE FLASHING

After downloading the appropriate ArduPilot firmware for Pixhawk 2.4.8 [1].Mission Planner allows you to flash this firmware onto your Pixhawk flight controller. This essentially uploads the software (flight code) that controls the Pixhawk's functionalities. Since we are preparing the Quadcopter we need to install 4 (Quad) Firmware to PIXHAWK flight controller.

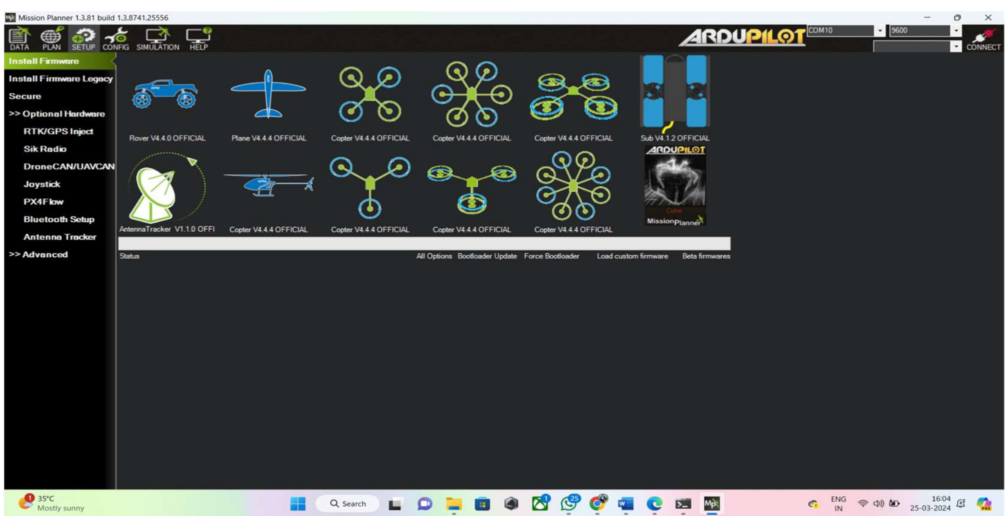

Fig 4.5: Firmware Flashing

4.5.3 MANDATORY HARDWARE SETUP

Mission Planner provides a user interface to configure various settings related to your specific quadcopter setup. This includes

- **Motor Configuration:** You'll define the motor layout (e.g., X configuration), specify motor directions (clockwise/counter-clockwise), and calibrate the Electronic Speed Controllers (ESCs) that control the motors.
- **Receiver Calibration:** You'll calibrate your Radio Control (RC) receiver to ensure proper control signal inputs from your transmitter.
- **Sensor Calibration:** Mission Planner helps calibrate sensors like the accelerometer, gyroscope, compass, and barometer for accurate flight data.

4.5.3.1 ACCEL CALIBRATION

In this Accel calibration we are going to calibrate the levels of drone i.e: level, left, right, Nose Up ,Nose Down, reverse. This helps the drone controller to knowing its level

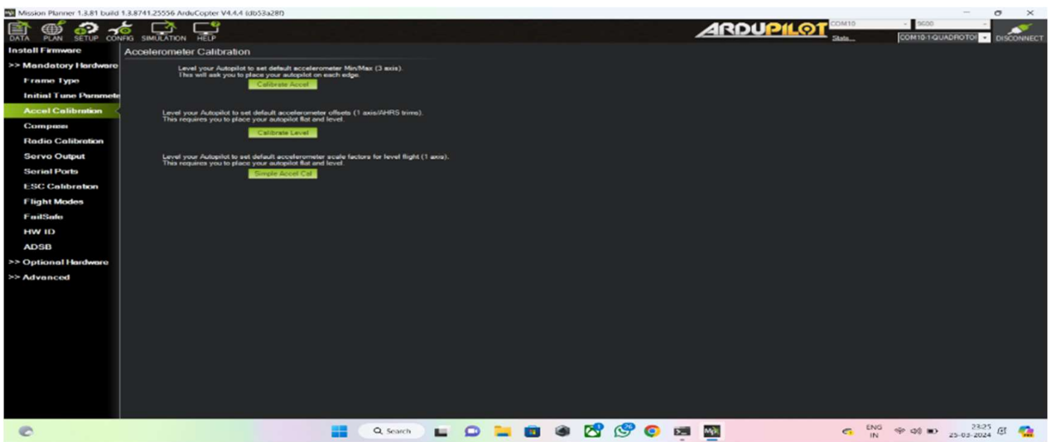

Fig 4.6: accel calibration (Before)

Fig 4.7: accel calibration (completed)

4.5.3.2 GPS COMPASS CALIBRATION

In this GPS Compass calibration we need to calibrate the Compass for Mag 1 & 2 by rotating the drone in all directions we can calibrate this compass

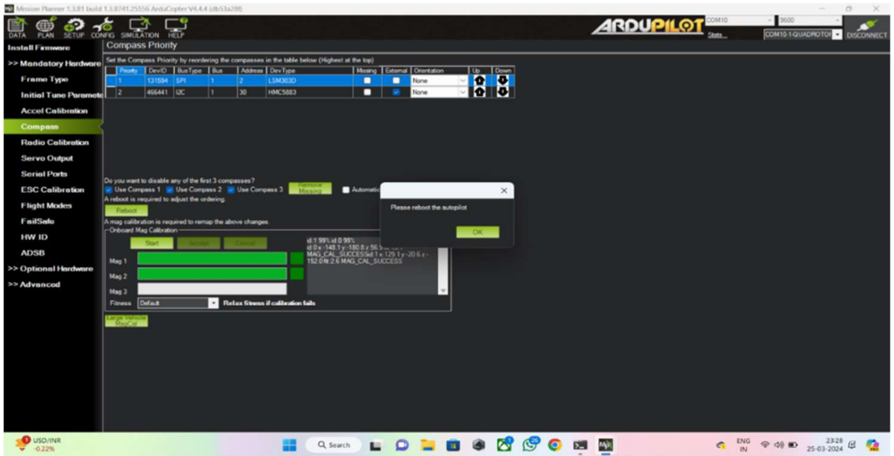

Fig 4.8: GPS calibration

4.5.3.3 RADIO CALIBRATION

This radio calibration calibrates our Radio that is our remote to our flight controller through receiver. Here we need to calibrate the throttle and directions and all pins that is working or not all ports are we need to calibrate by using this radio calibration.

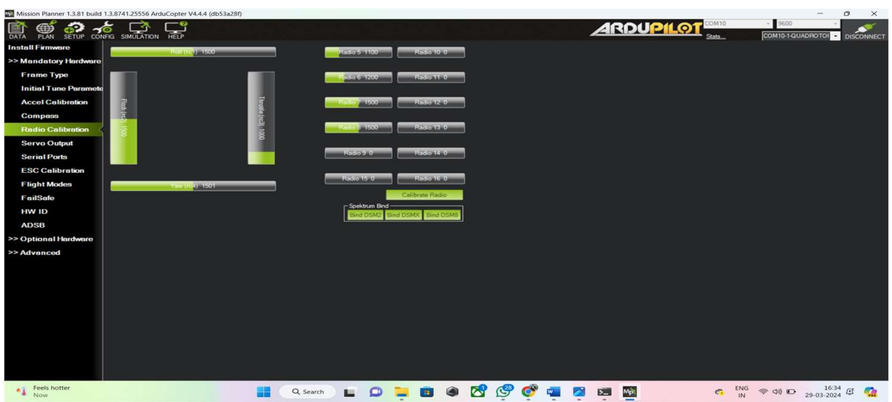

Fig 4.9: Radio (Remote) Calibration

4.5.3.4 ESC CALIBRATION

- Electronic speed controllers are responsible for spinning the motors at the speed requested by the autopilot. Most ESCs need to be calibrated so that they know the minimum and maximum PWM values that the flight controller will send.
- We can calibrate the ESC as mentioned in the below picture.

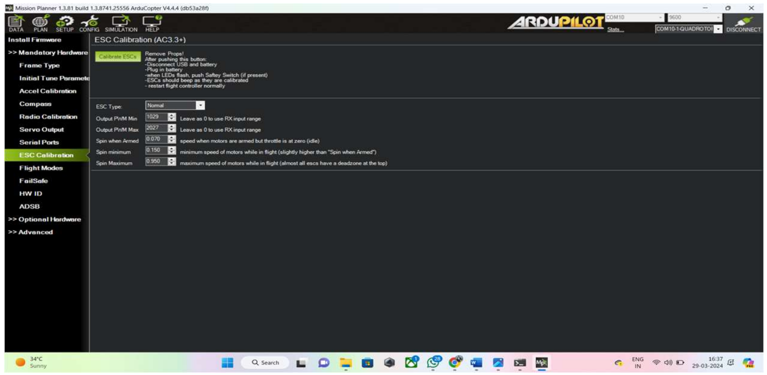

Fig 4.10 : ESC calibration

1.5.3.5 FLIGHT MODE SETUP

We can set upto 6 Flight mode setups Pixhawk offers various flight modes like Stabilize, RTL, Land, Acro, Autotune, and Loiter. Mission Planner allows you to configure these modes, including setting parameters like control responsiveness and altitude hold behavior.

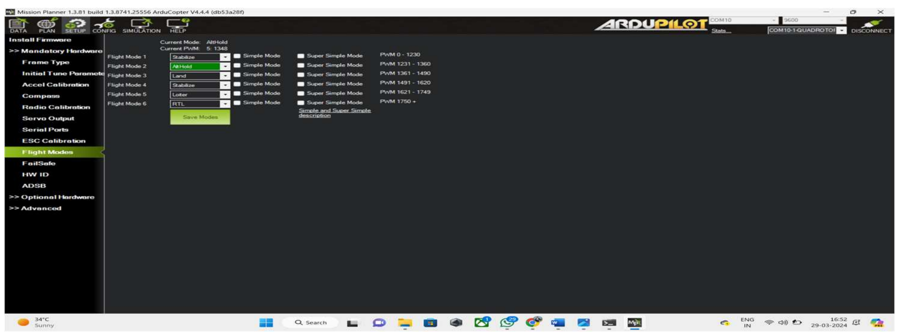

Fig 4.11 : Flight mode setup

4.5.3.6 FAIL SAFE SETUP

- Copter has a number of failsafe mechanisms to ease vehicle recovery/prevent wandering in the event that vehicle control is lost. The main failsafe topics are listed below.

Fig 4.12 : Fail safe setup

4. MISSION PLANNING (OPTIONAL)

While not essential for basic flight, Mission Planner allows you to create autonomous missions for your quadcopter. You can define waypoints (GPS coordinates) and set flight paths for the Pixhawk to follow automatically.

5. PRE-FLIGHT CHECKS & MONITORING

Mission Planner provides real-time data monitoring from the Pixhawk. You can check battery voltage, motor health, sensor readings, and other crucial parameters before flight to ensure everything functions properly.

CHAPTER-5

INTEGRATION OF DRONE TO SOLAR

5.1 INTRODUCTION TO SOLAR

Integrating solar panels into a drone is a fascinating way to extend flight time and create a more sustainable aircraft. Here is a breakdown of the process:

1. **Choosing Solar Panels:** Opt for lightweight, high-efficiency solar cells that can conform to the drone's body or wings.
2. **Positioning and Mounting:** Carefully plan the placement to maximize sunlight exposure while maintaining balance and aerodynamics. Secure the panels with a lightweight but strong framework.
3. **Electrical System Integration:** Connect the solar panels to a Maximum Power Point Tracker (MPPT) to optimize energy conversion. This charges the drone's battery or directly powers the motor depending on the design.
4. **Weight Management:** Every gram counts! Choose efficient components and minimize wiring to keep the overall weight gain minimal.
5. **Flight Control Adjustments:** The added weight from the solar panels may require adjustments to the drone's flight control software for optimal performance.

5.2 INTEGRATION OF SOLAR TO DRONE

Charging a LiPo (Lithium Polymer) battery using solar panels involves several steps and considerations. Firstly, we need to understand the components involved. Solar panels convert sunlight into electrical energy, which can then be used to charge the LiPo battery. However, solar panels produce direct current (DC) electricity, while LiPo batteries require direct current for charging but store energy as direct current. Therefore, you typically need a charge controller to regulate the flow of electricity from the solar panels to the battery. The charge controller serves several purposes. It regulates the voltage and current to prevent overcharging, which can damage the battery. It also ensures that the solar panel's output matches the voltage required by the battery, optimizing the charging process. When setting up your solar panel system, consider factors such as the panel's orientation and tilt angle to maximize sunlight exposure throughout the day. Ideally, you want the panels to face south (in the Northern Hemisphere) and be angled to capture the most sunlight.

Once solar panels are properly positioned and connected to the charge controller, the controller manages the flow of electricity to the LiPo battery. It monitors the battery's state of charge and adjusts the charging current accordingly. During the charging process, it's essential to monitor the battery's temperature. LiPo batteries can be sensitive to temperature fluctuations, and charging them at extreme temperatures can reduce their lifespan or even cause safety hazards. Some charge controllers include temperature sensors to prevent charging if the temperature is outside the safe range. it's also crucial to use the correct settings on your charge controller. Most controllers allow you to select the type of battery you're charging and adjust parameters such as charging voltage and current accordingly. Consult the manufacturer's specifications for both the LiPo battery and the charge controller to ensure compatibility and optimal settings.

Finally, remember that charging a LiPo battery with solar panels is a slow process compared to using a dedicated charger or mains electricity. It may take several hours or even days to fully charge the battery, depending on factors such as sunlight intensity and battery capacity.

In summary, charging a LiPo battery with solar panels involves connecting the panels to a charge controller, which regulates the flow of electricity to the battery. Proper positioning of the panels, monitoring of battery temperature, and correct settings on the charge controller are essential for safe and efficient charging.

5.3 SOLAR PANELS USED

For this project we are using 5V 100mA Mini Solar Panel 70x70mm size **,** Solar Panels take advantage of the sunlight, which is one of nature's most potent and free resources. They are today one of the most popular green energy sources and are employed in a variety of places, including our homes, street lights, and many other places.

Fig 5.1: Thin solar film

5.4 CHARGING MODULE USED

Here we are used CN3065 v1.0 Mini Solar Lipo Lithium Battery USB Charger Board Module 500mA. This is a supermini Solar Lipo charger based on the CN3065 - a single lithium battery charge management chip.

This Solar charger provides you with the ability to get the most possible power out of your solar panel or other photovoltaic device and into a rechargeable LiPo battery. Set-up is easy as well, just plug your solar panel into one side of the Solar charger and your battery into the other and you are good to start charging!

The output of the Solar Charger is intended to charge a single polymer lithium-ion cell. The load should be connected in parallel with the battery. By default, the Solar charge comes set to a maximum charge current of 500mA with a maximum recommended input of 6V (minimum 4.4V). It’s recommended that batteries not be charged at greater than their capacity rating.

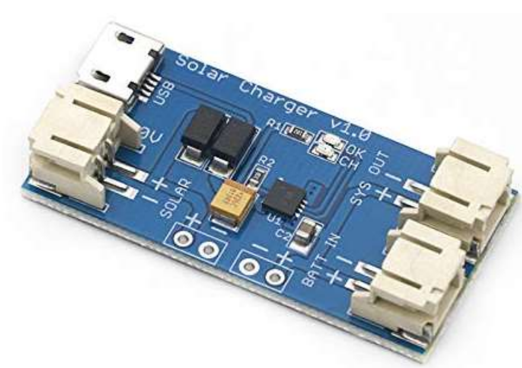

Fig 5.2: Mini Lipo solar charger module

The CN3065 v1.0 is a small solar lithium battery charger board module designed for charging lithium polymer (LiPo) batteries using solar power. It can charge batteries with a maximum current of 500mA. This module typically features a USB interface for easy connection to various power sources, including solar panels and USB ports. It's commonly used in small-scale solar-powered projects such as solar-powered gadgets, DIY solar chargers, and low-power applications where a compact and efficient charging solution is needed.

CHAPTER-6

RESULTS AND DISCUSSIONS

The development of a solar backup-powered unmanned aerial vehicle (UAV) tailored for industrial and power plant applications represents a significant leap forward in sustainable aerial technology. This innovative UAV design integrates several key features to enhance sustainability, operational efficiency, and monitoring capabilities in critical infrastructure sectors. First and foremost, the UAV's design incorporates solar panels on its wings, strategically positioned to maximize exposure to sunlight. These solar panels serve as the primary source of energy for the UAV, harnessing solar radiation to power its propulsion system and onboard electronics. By leveraging solar energy, the UAV reduces its reliance on traditional fossil fuels, minimizing carbon emissions and aligning with sustainability goals. This integration of renewable energy not only reduces the environmental footprint but also contributes to long-term cost savings by mitigating the need for frequent refueling or recharging. Complementing the solar power system, the UAV is equipped with a backup power system to ensure continuous operation, particularly during periods of limited sunlight or adverse weather conditions. This backup power system may consist of high-capacity batteries, fuel cells, or other energy storage solutions capable of providing sufficient power to sustain flight and operational tasks when solar energy alone is insufficient. The seamless integration of solar and backup power systems enhances the UAV's reliability and endurance, allowing it to fulfill its monitoring and surveillance duties without interruption.

In terms of design and functionality, the UAV boasts a robust payload capacity, enabling it to carry various sensors, cameras, communication equipment, and other payloads essential for industrial and power plant applications. High-resolution cameras and sensors facilitate real-time monitoring of critical infrastructure, enabling early detection of anomalies, leakages, or equipment malfunctions. Communication equipment ensures seamless data transmission between the UAV and ground control stations, enabling operators to receive telemetry data, control the UAV's flight path, and initiate emergency procedures if necessary.

Drones, particularly those powered by solar energy with backup systems, offer a myriad of applications in industrial and power plant settings, revolutionizing monitoring, maintenance, and safety protocols. These advanced UAVs integrate cutting-edge technology to enhance sustainability, operational efficiency, and data-driven decision-making in critical infrastructure sectors. One of the primary applications of solar backup-powered drones in industrial and power plant environments is aerial inspection and monitoring. Equipped with high-resolution cameras, thermal imaging sensors, and other specialized payloads, these drones provide real-time surveillance of equipment, structures, and facilities. From inspecting power lines, pipelines, and storage tanks to monitoring industrial processes and detecting leaks or abnormalities, solar backup-powered drones offer unparalleled visibility and insights into operational performance and asset integrity. The feasibility of the plant protection UAV control system underwent validation through two distinct tests. Initially, the focus was on evaluating the data transmission reliability between the flight control system and the spray system using serial communication. This alignment verified the robustness and reliability of communication between the Pixhawk flight control system and the sprinkler system facilitated through the serial port. Additionally, a practical assessment was conducted using a four-rotor UAV experimental platform built upon the Pixhawk flight control system. In this scenario, the SWG switch on the remote control was designated as the spray switch, corresponding to the receiver's 8 channels. A series of simulated spray experiments were then conducted within a 100-meter operational range. The results of these experiments confirmed the efficacy of the Pixhawk flight control system in analyzing the state of the spray switch and transmitting corresponding spray commands to the spray system within the designated range. Concurrently, the spray system successfully interpreted these instructions, executing the spraying function while maintaining a continuous balance in water volume to adhere to operational requirements. This comprehensive validation process underscores the reliability and effectiveness of the plant protection UAV control system, ensuring its suitability for practical deployment in real-world applications.

Furthermore, solar backup-powered drones play a crucial role in preventive maintenance and predictive analytics. By conducting routine inspections and collecting vast amounts of data, these drones enable predictive maintenance algorithms to identify potential equipment failures or performance degradation before they occur. This proactive approach minimizes downtime, extends asset lifespan, and reduces maintenance costs, ultimately enhancing operational efficiency and reliability in industrial and power plant facilities. Safety is another critical application of solar backup-powered drones in industrial settings. These UAVs can access hazardous or hard-to-reach areas, such as confined spaces, elevated structures, or areas with toxic chemicals, without exposing human workers to risk.

CHAPTER-7

CONCLUSION

The project began with an extensive literature review and feasibility study to assess the technical, economic, and environmental aspects of solar-powered UAVs. Based on the findings, the project objectives were defined, focusing on structural design, solar integration, backup power system development, autonomous navigation, and field testing.

KEY ACHIEVEMENTS

Structural Design: A lightweight and aerodynamic UAV structure was developed, incorporating advanced materials and design principles to optimize flight performance and payload capacity.

Solar Integration: High-efficiency solar panels were seamlessly integrated into the UAV's surface area, enabling continuous recharging of onboard batteries and extending flight endurance.

Backup Power System: A robust backup power system was engineered to ensure uninterrupted operation during low-light conditions or emergencies, enhancing reliability and mission capability.

Autonomous Navigation: State-of-the-art navigation and control algorithms were implemented, enabling autonomous flight, waypoint navigation, obstacle avoidance, and adaptive mission planning for efficient and safe operation.

Field Testing: Extensive field tests and demonstrations were conducted in real-world industrial and power plant environments to validate the UAV's performance, reliability, and suitability for various applications.

IMPACT AND SIGNIFICANCE

The Solar Backup Powered UAV project has significant implications for various industries and sectors:

Enhanced Safety: By providing remote monitoring and inspection capabilities, the UAV enhances safety by minimizing the need for manual interventions in hazardous environments.

Improved Efficiency: The autonomous operation and long flight endurance of the UAV increase operational efficiency, reduce downtime, and improve asset management practices.

Environmental Sustainability: Harnessing solar energy as the primary power source aligns with sustainability goals, reducing reliance on fossil fuels and minimizing the environmental footprint of aerial operations.

Technological Advancements: The project contributes to advancements in aerial robotics, renewable energy integration, and autonomous systems, paving the way for future innovations and applications.

CHALLENGES AND FUTURE DIRECTIONS

While significant progress has been made, several challenges and opportunities for future research and development remain:

Technological Advancements: Continued research and development are needed to enhance solar energy harvesting, battery storage, lightweight materials, and autonomous navigation algorithms.

Regulatory Considerations: Addressing regulatory challenges related to UAV operations, airspace integration, and safety regulations is crucial for widespread adoption and deployment.

Integration with IoT and AI: Integration with Internet of Things (IoT) devices, artificial intelligence (AI) algorithms, and data analytics platforms can further enhance the UAV's capabilities and performance.

Collaborative Partnerships: Collaborative partnerships with industry stakeholders, research institutions, and regulatory agencies are essential for fostering innovation, validating technologies, and accelerating market adoption.

In conclusion, the Solar Backup Powered Unmanned Aerial Vehicle project represents a significant advancement in the fields of aerial robotics and renewable energy integration. By leveraging solar energy and backup power systems, the project offers a sustainable and reliable solution for enhancing safety, efficiency, and environmental stewardship in industrial and power plant operations. While challenges and opportunities for improvement exist, the project lays a solid foundation for future research, development, and deployment of solar-powered UAVs in diverse applications, contributing to the advancement of technology and the well-being of society. The Solar Backup Powered UAV project exemplifies the potential of interdisciplinary collaboration and innovation in addressing complex challenges facing modern industries. With its blend of cutting-edge technology, environmental sustainability, and real-world applicability, the project underscores the importance of pushing the boundaries of science and engineering to create positive impact and drive progress in society.

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