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# Construction and Development of an Industrial FPV Drone

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**Abstract**

This project develops an FPV industrial aircraft combined with advanced flight control, data monitoring in real time and a miniature robot arm for accurate industrial tasks. It improves safety and operates in dangerous environments by combining air monitoring with direct physical intervention. Its creative dual system architecture operates from advanced navigation and communication technologies to provide strong and reliable performance.

**Résumé**

Ce projet développe un drone industriel offrant une vue à la première personne et intégrant des commandes de vol sophistiquées, une surveillance continue des données et un minuscule bras robotique pour effectuer avec précision des opérations sur site. Il améliore la sécurité en intervenant dans des milieux risqués grâce à une combinaison de supervision aérienne et d'intervention physique directe au besoin. Son architecture duale innovante, basée sur des technologies de navigation et de communication de pointe, assure des performances robustes et fiables optimisant à la fois la détection environnementale et l'exécution de tâches critiques.

**ملخص**

يهدف هذا المشروع إلى تطوير طائرة بدون طيار صناعية بتقنية تدمج بين التحكم المتقدم في الطيران، ورصد البيانات في الوقت الحقيقي، وذراع روبوتي صغير لأداء المهام الصناعية بدقة. يعزز المشروع السلامة والكفاءة التشغيلية في البيئات الخطرة من خلال الجمع بين المراقبة الجوية والقدرة على التدخل الفيزيائي المباشر. تعتمد هندسته المبتكرة ذات النظامين على تقنيات الملاحة والاتصالات المتطورة لتوفير أداء قوي وموثوق

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# Table of abbreviations

| | |
|---|---|
| **FPV** | First Person View |
| **Elrs** | ExpressLRS (Express Longe Range System) |
| **Lora** | Longe Range |
| **UAV** | Unmanned Aerial Vehicle |
| **GPS** | Global Positioning System |
| **LiDAR** | Light Detection and Ranging |
| **LiPo** | Lithium Polymer (battery) |
| **FC** | Flight Controller |
| **ESC** | Electronic Speed Controller |
| **BAT** | Battery |
| **VTX** | Video Transmitter |
| **CAM** | Camera |
| **PROPS** | Propellers |
| **OLED** | Organic Light-Emitting Diode |
| **LCD** | Liquid Crystal Display |
| **TFT** | Thin-Film Transistor |
| **RTH** | Return to Home |
| **SD CARD** | Secure Digital Card |

**Key Words**

- Industrial FPV Drone
- Flight Control System
- Industrial Applications
- ExpressLRS
- Miniature Robotic Arm
- Sensor Integration
- Real-Time Telemetry
- Two Separate systems
- Autonomous Navigation
- Data Monitoring
- LoRa Communication
- Safety and Efficiency

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# GENERAL

# INTRODUCTION

# Introduction

Drone or unmanned aerial vehicle (UAV) is a remote or autonomous operational aircraft for tasks such as photography, surveillance, and disaster management. They use robotics, sensors and wireless communications and work in harsh environments. With characteristics such as GPS and real-time data transmission, drones improve efficiency, security and decision-making in the private and industrial sectors. [1]

Industrial drones are UAVs specializing in critical tasks such as infrastructure inspection, agriculture, logistics and more. Equipped with Lidar, Thermal and Advanced sensors, it is characterized by accurate and permanent operation. In contrast to the consumer model, they prioritize robustness, payload capacity and compliance. However, focusing on passive data collection limits physical interactions. This is the gap that is integrated by integrating robotic arms and combining aviation and mechanical skills. [2]

Industrial FPV drone projects combine agile air mobility and the ability to interact directly with their surroundings, using miniature robots to perform physical tasks in dangerous industrial environments. This dual ability improves security and operational efficiency by reducing the need for human presence in dangerous areas, while simultaneously enabling accurate interventions such as testing and sample acquisition. Equipped with advanced sensors and remote-control capabilities, drones can operate autonomously or through pilots and complex environments for continuous monitoring, allowing them to navigate rapid responses where traditional methods are impractical.

The project addresses key issues, including decision-making, real-time decisions, accurate environmental analysis, and effective payload management. By integrating the latest technologies, Industrial FPV Drone aims to determine new benchmarks for industrial security and operational performance, paving the way for future advancements in aviation robotics and automated industrial applications.

The structure of this paper consists of several comprehensive chapters. Chapter 1 includes a summary of the literature covering the development of drones, state-ART industrial UAVs, and integration of manipulator arms on air platforms. Chapter 2 discusses FPV shooting designs, including technical specifications, component selection, and global architecture diagrams that explain the connections between hardware and software interfaces. Chapter 3 focuses on the development of miniature arms dealing with kinematics, mechanical and electronic design and control strategies for effective integration. Also covers the implementation and test phases, including system assembly, calibration, performance evaluation, and analysis of results.

The document finally concludes with a brief conclusion section.

# CHAPTER ONE

## Literature Review

# Chapter One: Literature Review

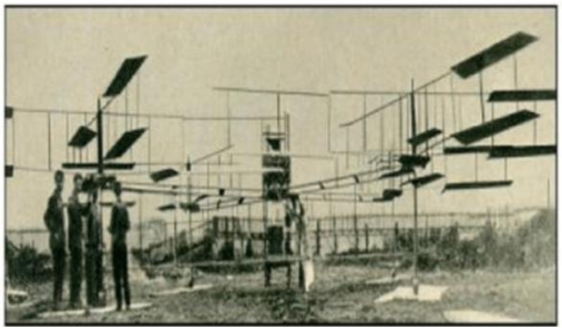
## I. History and Evolution of Industrial Drones

The history of industrial drones is a testament to the rapid advancements in aviation, robotics, and telecommunications. From their early military origins to their current industrial applications, drones have transformed significantly. [3]

### a. Early Developments (1898s–2000s)

Nikola Tesla has showcased the first radio-controlled boat, a 3-foot-long prototype that demonstrated the potential for remotely controlled vehicles. This innovation laid the groundwork for future UAV development. [4]

- **1907:** The first unmanned aircraft developed by Breguet Aviation the **Gyroplane,** an early French quadcopter rotary winged aircraft. [5]



*Figures I.1: Breguet Aviation Gyroplane 1907*

- **1930s–1940s**: the invention of military drones, such as the **Radioplane OQ-2**, that were used for target practice during World War II. [6]

*Figures I.2:The Radioplane QQ-2*

- **1960s:** The **Ryan Model 147 "Lightning Bug"** was a jet-powered UAV developed for high-risk reconnaissance missions. Used extensively during the Vietnam War, it pioneered modern aerial surveillance and electronic warfare. [7]

*Figures I.3:Ryan Model 147*

- **2000s:** Drones were introduced the consumers by companies likes DJI for photography and videography purposes. [8]

*Figures I.4:DJI Consumers drones*

**b. Shift to Industrial Applications (2010s):**

- **2010:** The Federal Aviation Administration) began issuing commercial drone permits in the U.S., paving the way for industrial use. [9]
- **2013:** Amazon announced its **Prime Air** delivery drone program, for delivering consumers packages and online orders. [10]

*Figures I.5:Amazon Prime Air delivery service drone*

- **2015:** DJI released the **Matrice 100**, a customizable drone platform used for industrial uses and research purposes. [11]

*Figures I.6:Matrice 100 DJI*

- **2018:** The introduction of the First-Person View (FPV) drones with low-latency video transmission enabled precise control in complex environments. [12]

*Figures I.7:First Person View Drone*

**c. Current Trends (2020s):**

- **2020:** The COVID-19 pandemic accelerated drone adoption for contactless delivery and medical supply transport.
- **2022:** New Autonomous drone used AI and machine learning to operate drones, such as beyond-visual-line-of-sight (BVLOS) flights that are used for long distances operations. [13]

*Figures I.8:BVLOS drones*

- **2023:** The integration of 5G connectivity improved real-time data transmission, making drones more reliable for industrial tasks.

## II. Existing Technologies

Industrial drones rely on a combination of cutting-edge technologies to perform complex tasks efficiently and safely.

### I. Navigation Systems:

- **GPS (Global Positioning System):** Widely adopted in the 2000s, GPS allows drones to navigate with meter-level accuracy.
- **LiDAR (Light Detection and Ranging):** Introduced in the 2010s, LiDAR used in drones to create 3D maps to avoid obstacles in real-time.
- **Ultrasonic Sensors**: Used for proximity detection, especially in indoor environments where GPS signals are weak.

### II. Communication Systems:

- **Radio Frequencies:** Early drones relied on analog radio systems, but digital systems like DJI Lightbridge (2014) improved signal stability.
- **5G Connectivity:** Rolled out in the late 2010s, 5G enables high-speed, low-latency communication for real-time control and data transfer.

### III. Power Systems:

- **Lithium-Polymer (LiPo) Batteries:** Introduced in the 2000s, LiPo batteries provided higher energy density, extending flight times.
- **Hybrid Power Systems**: Emerging in the 2020s, hybrid systems combine electric motors with internal combustion engines for longer endurance.

### IV. Payload Systems:

- **Modular Designs:** Companies like Parrot introduced modular payload systems in the 2010s, allowing drones to carry cameras, sensors, and other equipment.
- **Miniature Manipulator Arms:** Developed in the late 2010s, these arms enable drones to perform physical tasks such as lifting.

## III. FPV Drone Systems

An FPV (First Person View) system enables the live streaming of video from the camera mounted on an FPV drone to your FPV goggles. This immersive experience simulates the feeling of sitting in the aircraft’s cockpit while piloting it from the ground.

**a. Components of FPV Systems:**

- Cameras
- Transmitters and Receivers
- Goggles and Monitors

**b. Applications:**

- Inspection
- Search and Rescue
- Precision Agriculture
- Infrastructure Inspection
- Manufacturing

## IV. Comparison of similar technologies

Over the past decade, drone technology has advanced significantly, making drones inexpensive and increasingly common in both professional and civil environments. The huge takeoff of drones means that there are a large number of different types of drones available, but different types of UAVs are used for various purposes.

**a. Multi-rotor drones:** Used in Photography, videography and inspection, they are easy to control and comes in low prices however, they have big disadvantages such as limited flying time and small payload capabilities. [14]

*Figures I.9:Multi rotor Drones*

b. **Fixed-wing drones:** Delivers long flying time, more stability and heavier payload, used for agriculture, mapping and surveillance, however they are much more expansive and requires more control training. [15]

*Figures I.10:Fixed wing drones*

c. **Single-rotor helicopter drones:** Used for aerial LiDAR and laser scanning, thay have an advantage of long endurance (with gas power) and heavier payload capability, still they are more dangerous, more expansive and requires advanced draining. [16]

*Figures I.11:Single rotor helicopter drones*

d. **Fixed-wing hybrid VTOL drones**: fixed-wing hybrid VTOL drones refer to fixed-wing aircraft that have been modified to take off and land vertically. They combine the long-range and flight time of fixed-wing UAVs with the vertical takeoff capability of rotary-wing devices. [17]

*Figures I.12:Fixed wing hybrid drones*

## V. Advantages and Limitations of Current Industrial Drones

UAVs have been helping in various industrial, surveillance and military uses, yet they do not come without challenges, understanding pros and cons is necessary for further developments and technology advancing,

**a. Advantages:**

- Reducing operational costs by automating tasks like inspection and surveying. [18]
- In safety, they eliminate the need for human workers in dangerous environments, such as high-altitude inspections or disaster zones.
- Drones can complete tasks faster than traditional methods, such as mapping large areas in minutes. [19]
- hey can be equipped with various payloads, including cameras, sensors, and manipulator arms, for diverse applications.

**b. Limitations**:

- Most drones have limited battery life, typically 20–40 minutes, restricting their operational duration. [20]
- Industrial drones can only carry lightweight equipment, limiting their functionality for heavy-duty tasks. [21]
- Drones are often unable to operate in adverse weather conditions like heavy rain or strong winds.
- Strict regulations, especially for BVLOS operations, can hinder widespread adoption.

## VI. Legal and Regulatory Framework

The rapid adoption of industrial drones has prompted governments worldwide to establish regulations ensuring safety, privacy, and security.

### VI.1 Key Regulations:

- **FAA (Federal Aviation Administration, USA):** Requires commercial drone operators to obtain a Part 107 certification and restricts BVLOS operations unless granted special waivers. [22]
- **EASA (European Union Aviation Safety Agency**): Classifies drones based on risk levels (Open, Specific, Certified categories) and mandates remote ID and geo-awareness systems for most drones. [23]

### VI.2 Challenges in Regulation:

The integration of Unmanned Aerial Vehicles (UAVs) into various sectors has introduced several regulatory challenges that need to be addressed to ensure safe and ethical operations.

**a. Privacy Concerns:**

- The increasing use of drones equipped with cameras raises concerns about surveillance and data protection.
- Strict regulations, such as the GDPR in Europe and privacy laws in the United States, impose restrictions on the collection and storage of images and videos captured by drones.
- Obtaining prior authorization or informing individuals before filming may limit certain industrial and commercial applications.

**b. Airspace Integration**

- Ensuring the safe coexistence of drones and manned aircraft remains a significant challenge.
- Drones must be integrated into Unmanned Traffic Management (UTM) systems to avoid collisions and ensure efficient tracking.
- The introduction of Detect and Avoid (DAA) systems is essential to enable Beyond Visual Line of Sight (BVLOS) flights.
- The increasing density of drones in urban areas raises the risk of incidents, requiring stronger coordination with aviation authorities.

**c. Global Harmonization**

- Differences in regulations between countries complicate the international use of drones. [24]
- The lack of a universal standard for drone certification and operation prevents seamless adoption of technologies across different markets.

- Some regions impose stricter restrictions (such as flight bans over public areas in China or certification requirements in Europe), making it difficult for manufacturers and operators to adapt.
- Initiatives like those led by the International Civil Aviation Organization (ICAO) aim to create a global regulatory framework, but adoption remains slow and varies by jurisdiction.

**d. Cybersecurity and Hacking Risks**

- Drones connected to wireless networks are vulnerable to cyberattacks. [25]
- Hackers could potentially take control of a drone remotely, compromising critical missions, especially in defense and industrial applications.
- Implementing encryption protocols and firewalls is essential to ensure secure communication between the drone and its control station.

**e. Environmental and Safety Regulations**

- The environmental impact of lithium batteries used in drones raises sustainability concerns. [26]
- Some countries impose strict regulations on battery management and recycling to reduce pollution and the risk of explosions.
- The development of dedicated air corridors for drones in urban areas is becoming a key issue to minimize noise pollution and safety hazards.

# CHAPTER II:

# Description to the FPV Industrial Drone

# Chapter Two: Description to the FPV Industrial Drone

## I. Introduction:

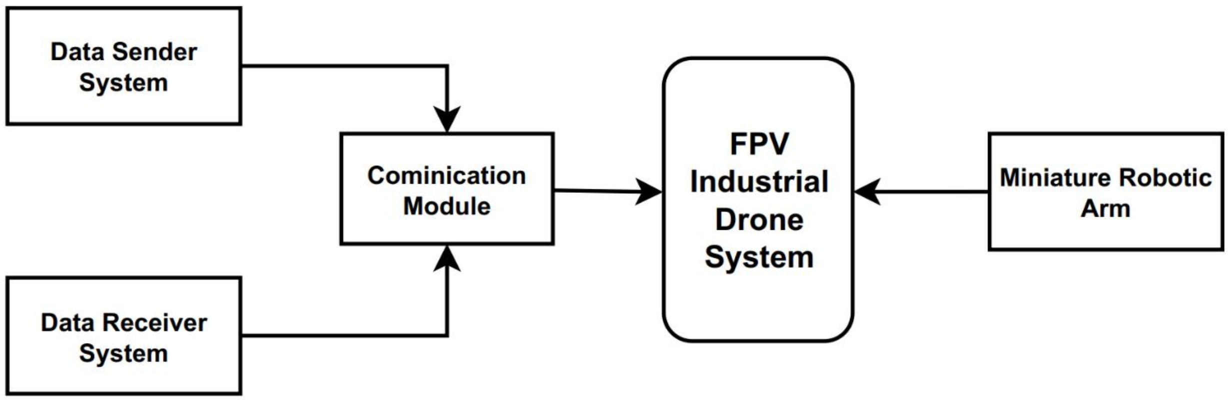
This chapter describes the general design and functional architecture of industrial FPV drones. The project is based on the conception of dual systems: A system specializing in flight control and maneuverability, and a system dedicated to data collection and communication. Additionally, the drone includes miniature robotic arms that allow for direct physical interaction with the surroundings. Together, these subsystems work together to provide a multi-purpose, powerful platform suitable for complex industrial operations in hazardous environments.

### I.1 Description of FPV Drone

The Industrial FPV drones are advanced unemployment systems for dangerous industrial environments. Integrate two core systems. Integrates agile, stable navigation (autonomous suspension, obstacle avoidance, etc.) and real-time data processing systems that collect, analyze and analyze environmental data (gas leaks, structural integrity, etc.). This dual architecture ensures accurate air mobility and immediate transmission of operator implementation knowledge, improving situational awareness and security. [27]

Miniature robotic arms allow physical tasks such as sample collection and equipment adjustment, minimizing human exposure. The fusion of air mobility with mechanical skills allows drones to streamline high-risk workflows in offshore testing or disaster responses.

Combining versatility, analytics, and robotics, it reclassifies industrial security, empowering independent execution of complex tasks in dangerous settings.




*Figures II.1: Main System Diagram*

### I.2 FPV Flight Drone System

The core of the drone is the FPV industry drone system. This also ensures agile and stable flight in challenging environments. The system integrates advanced flight control and navigation features to maintain improved position, maintaining height control and secure returns at home. The combination of robust control algorithms and valid real-time video transmissions allows the drone to provide high situational awareness for remote pilots. The system is developed for efficiency and stability.

### I.3 Miniature Robotic Arm

A key innovation of this project is the incorporation of a miniature robotic arm that extends the drone’s functionality beyond aerial surveillance. This arm is designed to perform sensitive operating tasks such as sample collection, equipment testing, and minor maintenance processes. Integration into drone platforms allows for accurate interaction with the industrial environment, reducing the risks of human operators. The design focuses on achieving ample freedom and precise control, allowing the arm to perform tasks with high accuracy and reliability.

### I.4 Data Monitoring System

By addition the flight system, the data monitoring system is responsible for monitoring and transmitting important environmental information in real time. In its core, the system uses a dedicated microcontroller to aggregate sensor data, including gas levels, temperature, air humidity, and pressure measurements. The wireless communication module is displayed in remote monitoring and control for the board as a user-friendly interface for mobile use and enables long distance data transmission. This integrated approach ensures that operators receive knowledge that can be implemented quickly and improve operational efficiency and security in industrial environments.

## I.5 Microcontrollers:

The industrial FPV drone relies on two key microcontrollers. The SpeedyBee F405 flight controller, powered by the STM32 processor, manages flight stability, navigation, and sensor integration. For data processing, the ESP32 WROOM32 handles real-time sensor acquisition and long-range communication via LoRa, and receives and displays data on the ground. This separation enhances system performance, ensuring efficient flight operations and reliable environmental monitoring.

### I.5.1 Benefits of using this Microcontrollers in FPV Industrial Drone:

Integrating the SpeedyBee F405 flight controller and the ESP32 microcontroller into our industrial FPV drone project offers several key advantages:

- **Cost-Effectiveness:** Both the SpeedyBee F405 and ESP32 are recognized for their affordability, providing high-performance capabilities without inflating project costs.
- **Flexibility:** The ESP32 supports various programming environments, including Arduino IDE, MicroPython, allowing for adaptable and customizable development tailored to specific project requirements.
- **Open-Source Community Support**: Both microcontrollers benefit from extensive open-source communities, offering a wealth of libraries, tutorials, and forums.
- **Integration Capabilities:** The ESP32's compatibility with various communication protocols enables seamless integration with other systems.
- **Energy Efficiency:** The ESP32 is designed with energy-saving features, making it ideal for applications requiring continuous operation with minimal power consumption.

### I.5.2 Communication modules:

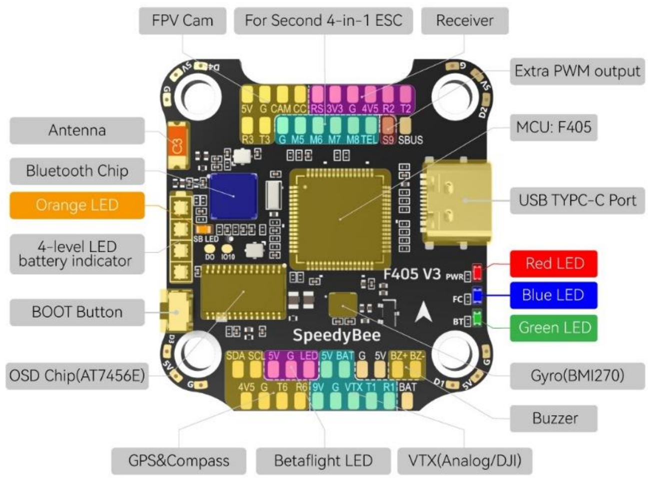
In our industrial FPV drone project, several communication modules are used to ensure efficient data transmission and control.

- The LoRa Ra-02 SX1278 module works at 433MHz, facilitating long-range data communication.
- For the flight control, the SpeedyBee Nano 2.4GHz ExpressLRS receiver and the RadioMaster Pocket ExpressLRS 2.4GHz transmitter provide a reliable control link.
- Additionally, the AKK Race ranger video an analog transmitter guarantees real-time video transmission to the FPV goggles, enhancing the pilot's situational awareness.

# II. Components used in the project:

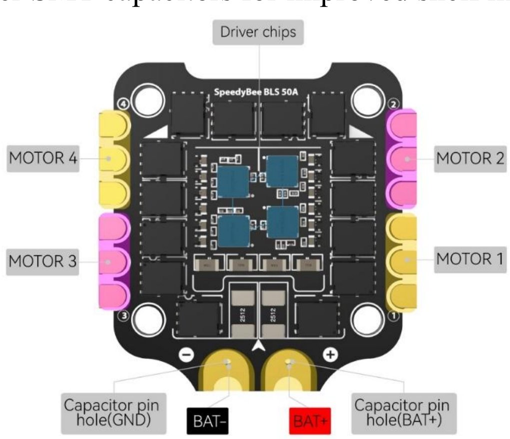
## II.1 In FPV Drone and Miniature Arm:

- ***SpeedyBee F405 V3 Flight Controller***: is a versatile, high-performance component that exemplifies the intersection of accessibility and advanced engineering in modern drone systems. Its robust feature set, coupled with its ease of use, makes it a pivotal tool for both enthusiasts and professionals seeking to push the boundaries of aerial innovation. As drone technology continues to evolve, the F405 V3 stands as a testament to the importance of reliable, adaptable, and user-centric design in shaping the future of unmanned flight. [28]




*Figures II.2: Flight Controller*

- ***SpeedyBee Blheli-S 50A 4-in-1 ESC*:** is an electronic speed controller with a high-performance controller designed for drone applications. It supports 3-6 LIPO batteries and provides 50A continuous current per channel with a burst current of 55A (5 seconds). Equipped with robust BB21-MCU- and BLHELI_S firmware, it ensures smooth and responsive engine control. ESC has TVS protection diodes and high-quality Japanese-made TDK filter filter SMT capacitors for improved shelf life and flight performance.

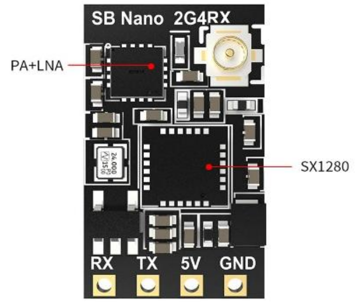



*Figures II.3: 50A 4in1 ESC*

- ***The X2807 1300KV Motors:*** are powerful brushless motors designed for 7-inch FPV drones. With their 1300KV rating, they provide a perfect balance of speed and torque, making them ideal for long-range flights. Their durable build and reliable performance ensure stability and responsiveness, making these motors a great match for 7-inch frames.

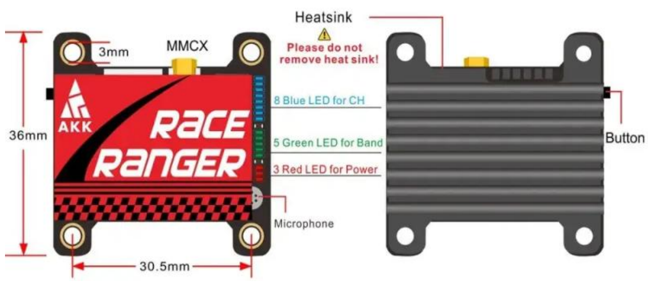

*Figures II.4: Brushless Motors*

- ***SpeedyBee 2.4GHz ELRS Receiver:*** is a lightweight, high-performance receiver using the **ExpressLRS** protocol for ultra-low latency and long-range communication. Ideal for FPV drones, it offers robust signal reliability, easy integration, and firmware update support, making it perfect for both racing and long-distance flights. Compatible with ELRS-enabled systems, it ensures precise control and enhanced flight performance. [29]




*Figures II.5:Elrs Reciever*

- ***The AKK Race Ranger VTX:*** is a compact and powerful video transmitter for FPV drones, delivering clear, real-time video for an engaging flying experience. With adjustable power up to 1600mW, Smart Audio for easy setup, and a wide voltage range (7-24V), it's perfect for racing and freestyle. Its lightweight design and effective cooling make it a reliable choice for smooth, high-quality video feeds. [30]




*Figures II.6: Video Transmitter (VTX)*

- ***The Caddx Ant Nano FPV Camera:*** is a small, lightweight Analog camera designed for FPV drones, offering clear video for an exciting flying experience. With its compact size, it fits easily into tight spaces while delivering great image quality, even in low light. Perfect for both beginners and experienced pilots, it’s a reliable choice for filming smooth, real-time footage during fast-paced flights. [31]

*Figures II.7: FPV Camera*

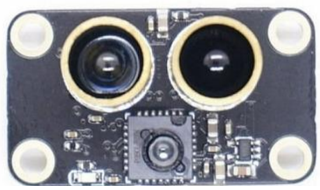
- ***The YR50B_S Finder (Buzzer):*** is a small, lightweight device designed to help you locate your drone if it crashes or gets lost. With a loud, attention-grabbing sound, it makes finding your drone quick and easy, even in tall grass or dense areas. Its simple plug-and-play design works with most flight controllers, making it a handy tool for any FPV pilot. [32]

*Figures II.8: FPV Finder (Buzzer)*

- ***The HGLRC M100 5883 GPS and Compass:*** are compact and reliable modules that improve the navigation capabilities of your drone. With a highly sensitive GPS, it offers accurate positioning and stable flight performance, and the integrated compass ensures accurate address information.Perfect for FPV pilots who want to return home or add features such as waypoint navigation to their drone. [33]


*Figures II.9: FPV GPS and Compass*

- ***The MTF01 Optical Flow and LiDar Sensor:*** is a compact, multi-sensor module integrating LiDAR and optical flow technologies to enable precise environmental perception for drones and robotic systems. Its LiDAR component provides level altitude hold and obstacle detection, while the optical flow sensor ensures stable surface-relative positioning, even in GPS-denied indoor environments. It is designed for industrial applications. [34]

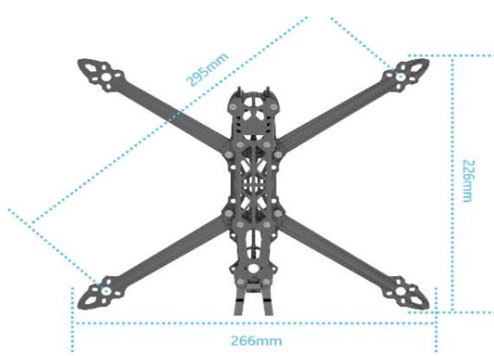


*Figures II.10:Optical Flow and LiDar Sensor*

- ***The LED Strip:*** is a simple yet effective way to add visibility and style to your drone. With bright, customizable lights, it helps you keep track of your drone during flights, especially in low-light conditions. Easy to install and lightweight, it's practical addition for both day and night flying.


*Figures II.11:FPV Led Strip*

- ***Mark4 7-inch frame:***is the robust and lightweight frame of a 7-inch FPV drone, perfect for long distances and freestyle flies. The durable construction of carbon fiber ensures strength and reliability, and a well-thought-based design allows for simple component assembly and optimal airflow. With elegant aerodynamic shapes, it is built for high-speed flights and hard landings. [35]




*Figures II.12:FPV Drone Frame*

- ***The 7x3.7x3 Props (7037 3-Blade):*** are high-performance propellers designed for 7-inch FPV drones. With their three-blade design, they offer a perfect balance of thrust, efficiency, and responsiveness, making them ideal for both long-range flight. I chose 3-blade props over 2-blade or 4-blade options because they provide better stability and control in windy conditions, while still maintaining good efficiency and flight time compared to 4-blade props, makes them a great choice for a smooth flying experience.


***Figures II.13:7inch propellers***

- ***The MG90S Servo Motors:*** are compact, lightweight, and reliable servos perfect for small-scale projects like miniature robotic arms. With their precise control, strong torque, and smooth movement, they offer excellent performance for tasks requiring accuracy and flexibility. Their affordability and durability make them a great choice for hobbyists and engineers working on robotics or DIY projects. [36]


***Figures II.14: MG90s Servo***

- ***The Lipo Battery 1480MAH 6S 150C:*** is a powerful FPV drone high performance battery. The 6-cell configuration and 150°C discharge rate provide exceptional performance and response capabilities, ensuring high-speed flight and demanding operation. The 1480 MAH capacity balances flight time and weight, ensuring that the drone remains agile and provides ample energy for exciting sessions. This is a reliable option for pilots who need high power and consistent performance. [37]


***Figures II.15: LiPo Battery***

- ***The 6S2P lithium-ion battery:*** is built using 12 cells of the LIR-18650 3.7 V 2800 mAh to provide a robust, energy density performance solution for a 7-inch drone. The 6S2P configuration provides large capacity (5600 MAH) and stable voltage output and balance. This is perfect for long distance flights. Lithium-ion chemistry guarantees lighter weight and greater energy efficiency than traditional LIPO batteries, while the 2800 MAH cell offers reliable performance and extended flight time. This battery is a good choice for pilots who prioritize endurance and efficiency of drone constructions.

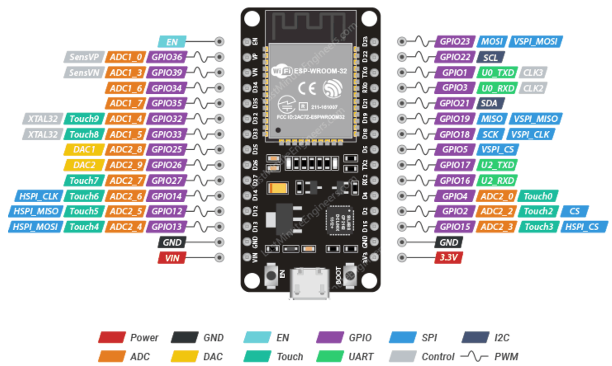

*Figures II.16: 6S-2p Lithum-Ion Battery*

- ***The RadioMaster Pocket ELRS remote controller:*** is a compact, high-performance transmitter designed for precision and reliability. It features ExpressLRS (ELRS) technology, delivering ultra-low latency and long-range communication, making it ideal for demanding applications like industrial drones. Its ergonomic design ensures comfortable operation, while its intuitive interface allows seamless control of flight systems and onboard equipment. The Pocket ELRS combines advanced functionality with portability, making it a versatile tool for both professional and hobbyist use. [38]


*Figures II.17: RadioMaster Pocket ELRS Remote Controller*

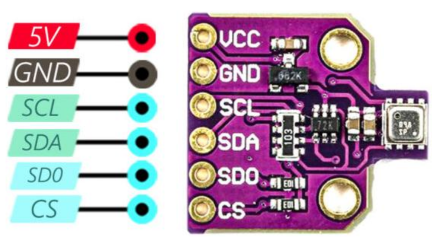
## II.2 In The Data Monitoring System:

- ***Esp32 Wroom32 Board***: Is a compact yet potent microcontroller with built-in Wi-Fi and Bluetooth connections, making it the perfect option for creating embedded and Internet of Things (IoT) applications. The ESP32 delivers significant processing power and versatility at a reasonable cost because to its dual-core processors and a range of input/ output connectors. [39]



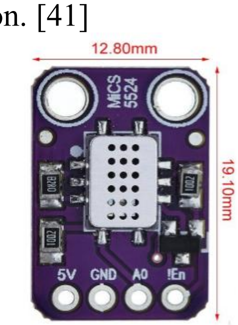

*Figures II.18: Esp32 Wroom32 Board*

- ***BME680 Sensor:*** is a versatile environmental sensor that measures temperature, humidity, barometric pressure, and air quality (VOC gas levels). Compact and energy-efficient, it's perfect for drones or IoT devices, providing accurate data for environmental monitoring. Its ability to track multiple parameters in one small package makes it a valuable tool for projects requiring detailed environmental insights. [40]



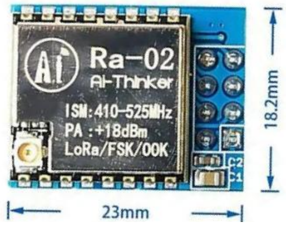

*Figures II.19: BME680 Sensor*

- ***MICS-5524 Sensor:*** is a compact gas sensor designed to detect a variety of gases, including carbon monoxide, nitrogen dioxide, and alcohol. With its small size and low power consumption, it's ideal for air quality monitoring, safety systems, or environmental projects. Its reliable performance and sensitivity make it a practical choice for applications requiring precise gas detection. [41]



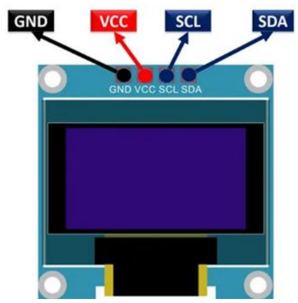

*Figures II.13: MiCs 5524 sensor*

- ***The RA02 SX1278 LoRa Module:*** is a long-range communication module designed for reliable, low-power data transmission over long distances. Operating at 433MHz, it uses LoRa technology to provide excellent signal penetration and resistance to interference, making it ideal for remote monitoring, and drone telemetry. Its compact design and efficient performance make it a great choice for applications requiring stable, long-distance communication. [42]




*Figures II.2114:LoRa Module*

- ***I2C OLED 0.96 inch display***: is a small and energy efficient screen that is perfect for displaying real-time data in compact projects. High contrast and clear viewpoint makes it ideal for drones,or IoT devices that display information such as sensor values, battery status and more. The I2C interface makes it easy to connect and use. [43]




*Figures II.22:Oled Display*

- ***I2C LCD***: is a simple, versatile display module used by the I2C communication protocol and can be easily connected and used with microcontrollers.Perfect for displaying text, numbers, or basic graphics in projects enviromment monitoring, with low power consumption and a simple setup.

- ***GMT020-02 TFT SPI Display (2.0 inch):*** is a lively colored screen screen for projects that require detailed images. It is ideal for displaying graphics, text, or real-time data on drones,or DIY electronics, as it uses the SPI interface to provide quick and efficient communication. [44]


*Figures II.23:SPI TFT Display*

# CHAPTER III:

# Building and Testing The Industrial Drone

# Chapter III: Building and Testing the Industrial Drone

## I. FPV Industrial Drone System Introduction

This section provides an overview of an integrated system that applies an industrial FPV drone and combines three core components: flight system, miniature robot arm, dual channel data monitoring system. The flight system ensures stable agile navigation using GPS and LIDAR for autonomous functions such as position hold and return to home paired with real-time control via radio master bag transmitter for accuracy in complex environments.

The drone's robotic arm enhances functionality by enabling physical interactions such as sample collection and equipment inspections. Integrated directly with the flight controller, the arm operates in sync with the drone's movements, maintaining stability during tasks. This allows the drone to not only conduct aerial surveys but also perform hands-on operations when required.

For data monitoring, sensor information is wirelessly transmitted via LoRa to the ground station, where it is visualized through the Blynk app and a dedicated web interface. This dual-path IoT architecture ensures real-time environmental tracking and rapid decision-making, critical for maintaining safety and optimizing efficiency in industrial settings.

### I.1 Main Control System:

The industrial FPV drone's control architecture combines remote operation with visualiza-tion of IoT control data.Flight and robotic arm functions are managed via a Radio-Master Pocket ELRS transmitter, which sends low-latency commands to the flight controller for pre-cise, stable maneuvering in dynamic environments.

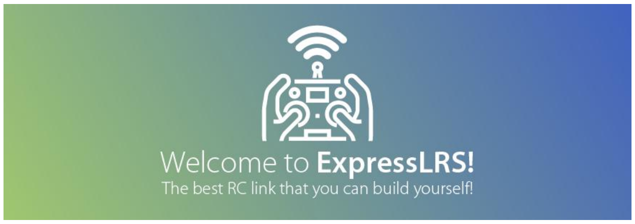
At the same time, the Blynk app and web interface provide remote access to real-time sensor data such as environmental metrics and system health enabling operators to monitor conditions and make informed decisions. This dual-layer approach integrates manual control and automated data processing, ensuring seamless interaction between the drone's physical actions and its digital feedback loop. The synergy of these elements creates an adaptable, user-centric platform primed for scalable industrial use and future innovation.

- **Fpv Drone Control System:**

Express-LRS (ELRS) Protocol Overview: Express-LRS (ELRS) is an open-source, high-performance radio control link designed for applications such as FPV drone racing and other remote-controlled activities. [45]

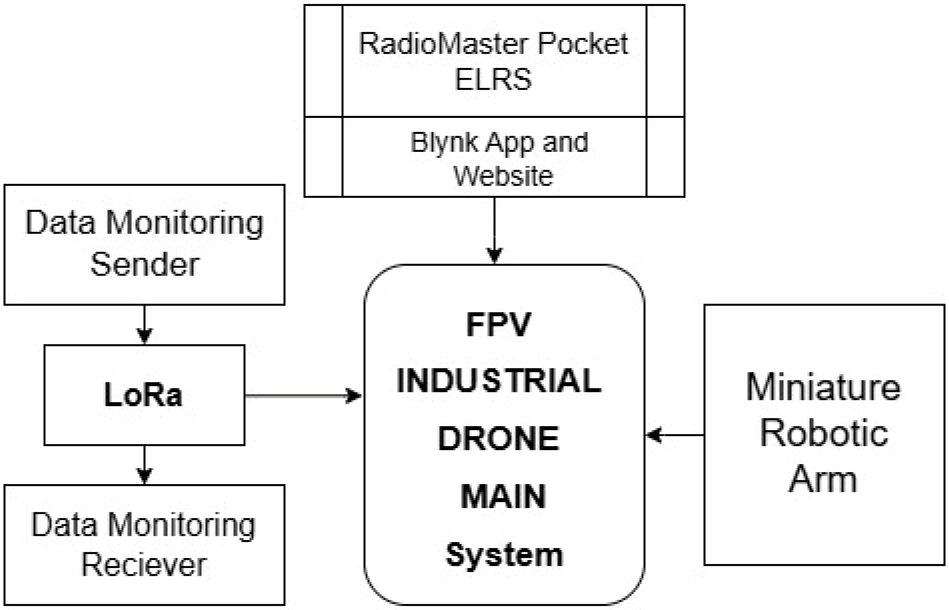
As an open-source project, ELRS benefits from continuing contributions from the global community of developers and users. This collaborative approach ensures regular updates, feature capabilities and robust support for a variety of hardware platforms.

In Summary is Express-LRS, providing a efficient radio control solution that meets the requirements of modern FPV pilots and remote controls.



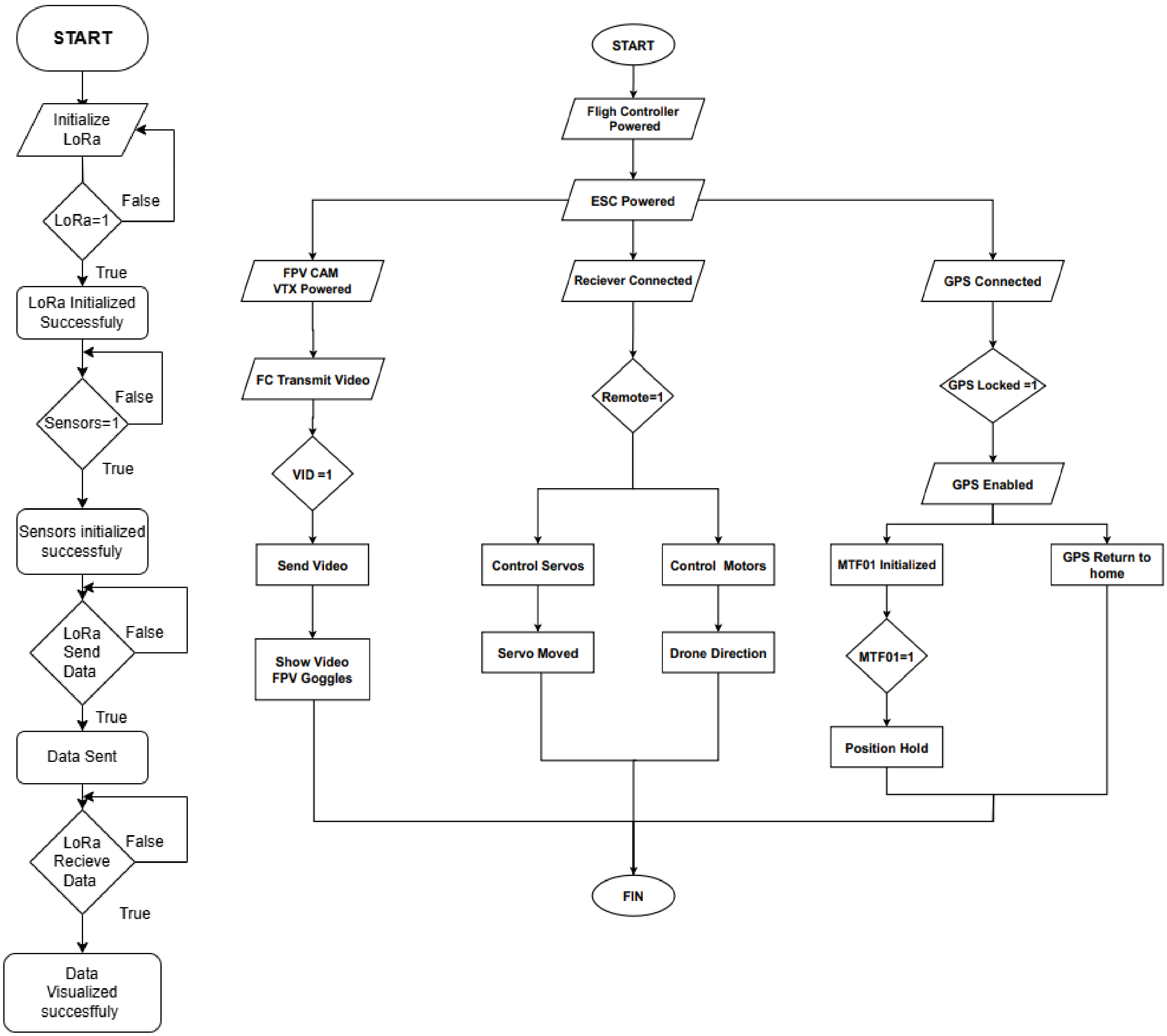

*Figures III.1:Express-LRS Protocol*

## I.2 Main System Diagram:




*Figures III.2:FPV Main System Circuit Diagram*

## I.3 Main System Algorithm:




*Figures III.3: Main System Circuit Algorithm*

## II. FPV Flight System

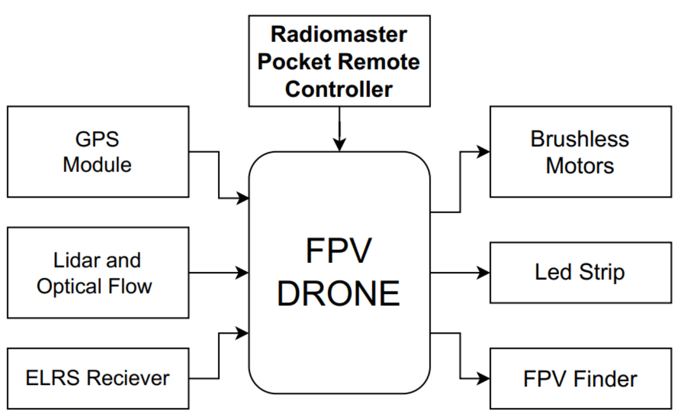
Our industrial FPV drone`s flight system integrates a high-performance flight controller with advanced sensors to ensure precise, stable operation. At its core is the MTF01 sensor—a dual LiDAR and optical flow unit—that provides accurate altitude hold, and position stabilization, even in GPS-denied environments. A constant GPS module improve outdoor navigation, while an inertial measurement unit maintains real-time balance and orientation. The drone is built on a robust carbon fiber frame and powered by high-efficiency brushless motors that deliver the thrust required for agile maneuvers. For real-time visual feedback, a high-definition camera paired with a video transmitter (VTX) provides clear imagery to the ground station. This control is guaranteed by the Radio Master Bag Transmitter using the Express-LRS protocol for long-distance, low-latency communication, and optimized LIPO battery configuration. Together, these components create good systems that meet the requirements of industrial application requirements with reliability, mobility and stability.

- **Built-in Sensors:**

Our flight controller integrates a BMI270 IMU and an SPL06 barometer to ensure precise and stable flight. The BMI270 delivers accurate measurements of acceleration and rotational movement across three axes, while the SPL06 provides reliable atmospheric pressure data for precise altitude estimation. Together, they form the backbone of our advanced navigation and stabilization system.

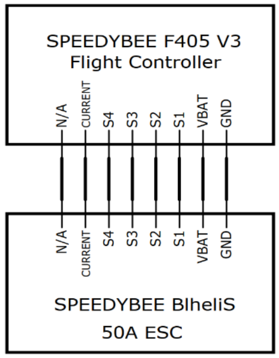

*Figures III.4:FPV Drone Sensors*

### II.1 Flight System Circuit Diagram:



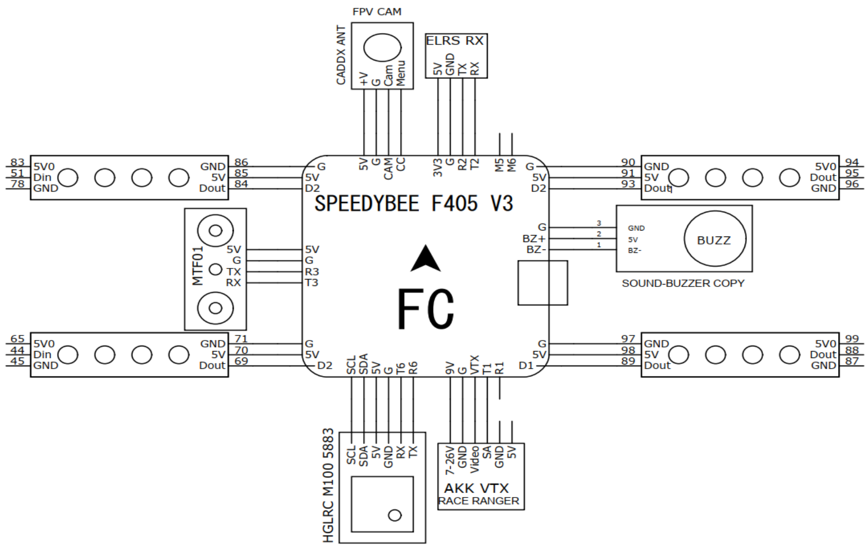

*Figures III.5:Flight System Circuit Diagram*

## II.2 Flight System Circuit:



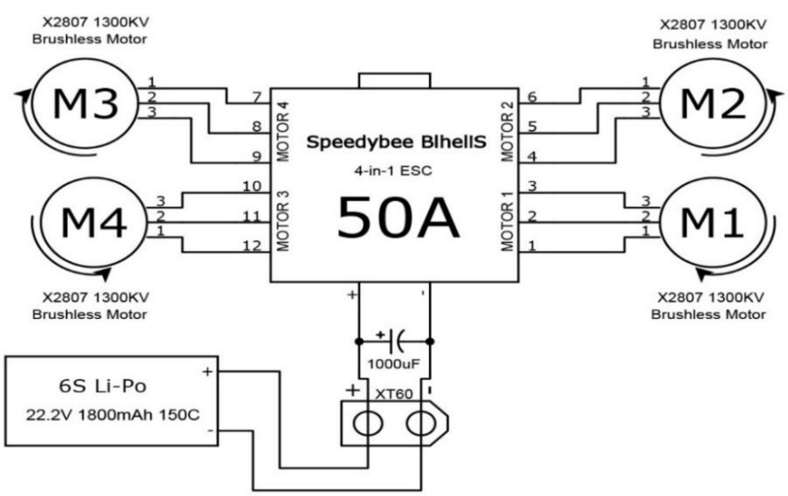

*Figures III.6 :Flight System Circuit*

- **Flight Controller Circuit Design:**



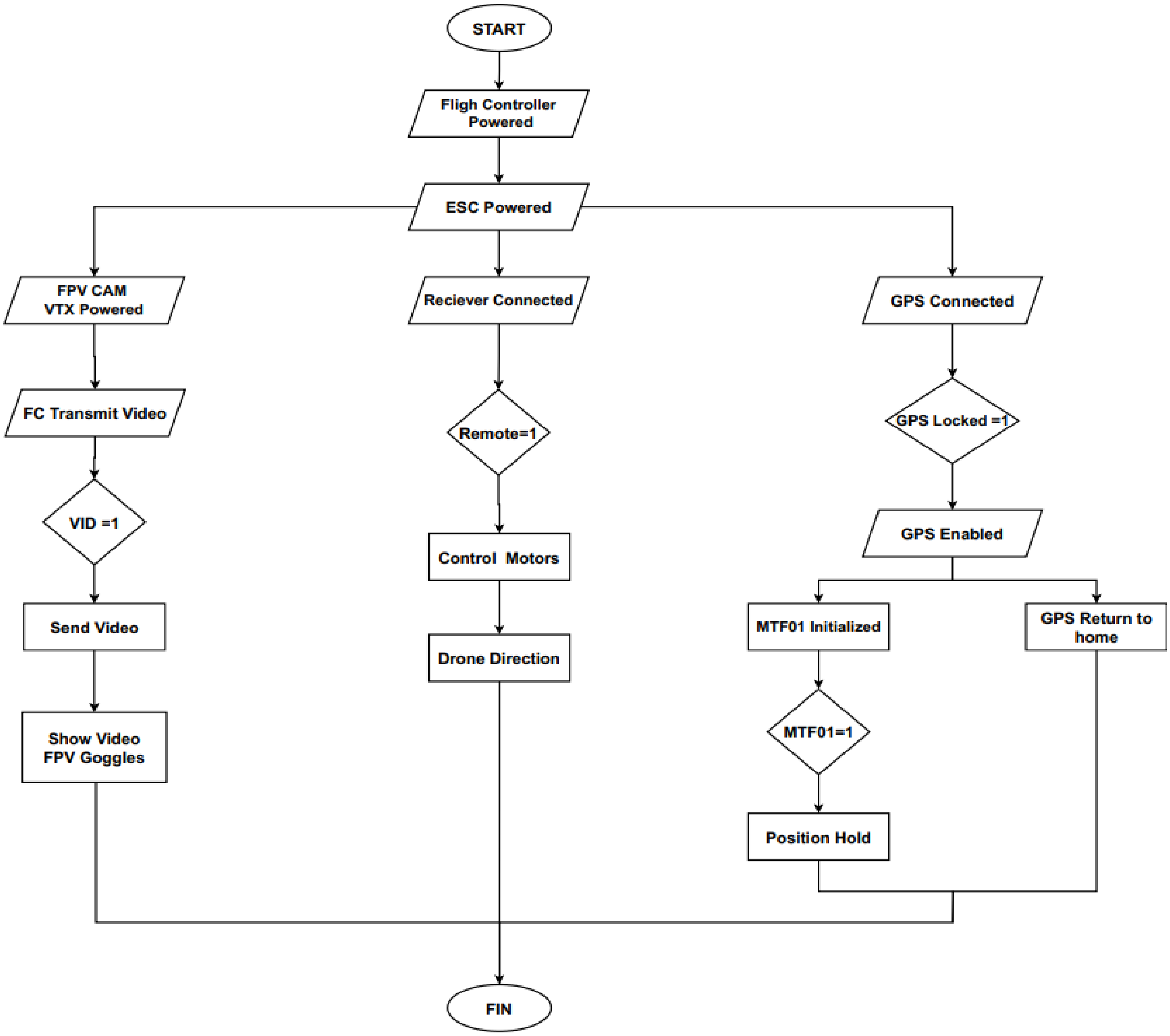

*Figures III.7:FPV Flight Controller System Circuit Design*

- **ESC Circuit Design**




*Figures III.8: FPV Flight System ESC Circuit Design*

## II.3 Flight System Circuit Algorithm:

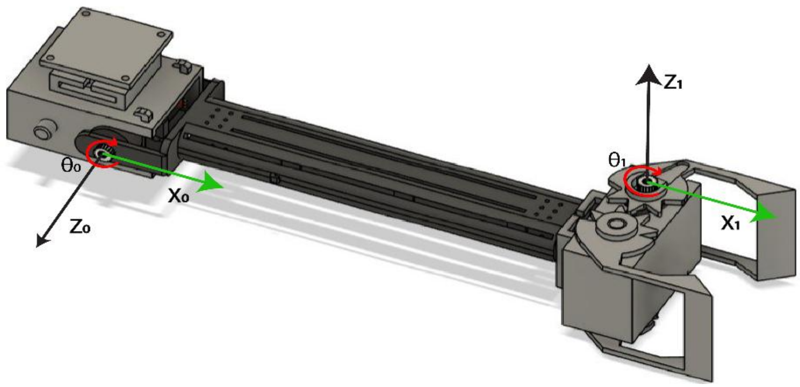



*Figures III.9:Flight System Circuit Algorithm*

## III. FPV Miniature Robotic Arm:

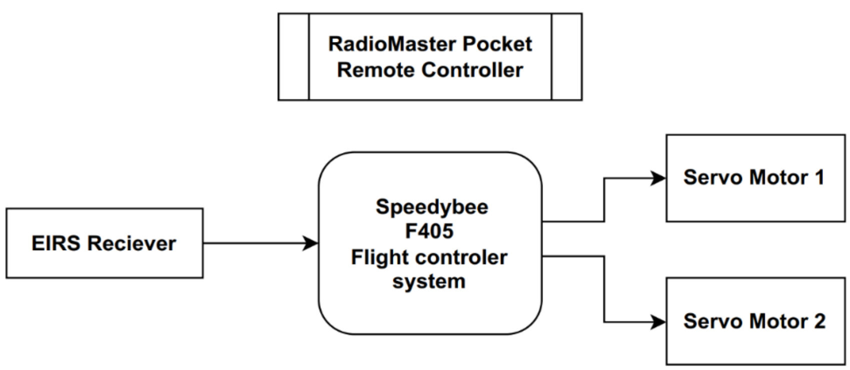
The miniature robot arm integrated into the drone is designed for precision operations and enables tasks such as object collection, sample collection, and on-site inspection. The ARM was developed using Autodesk Fusion 360 to maintain an optimal balance of strength and weight, and is equipped with a high-precision MG90S servo connected to each other with the flight controller to ensure synchronized movement with the overall flight dynamics of the drone. Control of the robotic arm is achieved by an ELRS receiver that allows for long range via a Radio-Master pocket transmitter. With dedicated servos managing both the arm's articulation and the gripper's action, the system is capable of executing fine, controlled movements to securely hold and handle objects with precision, improving use in industrial environments where drones are challenging.

- **Miniature Robotic Arm Axes:**



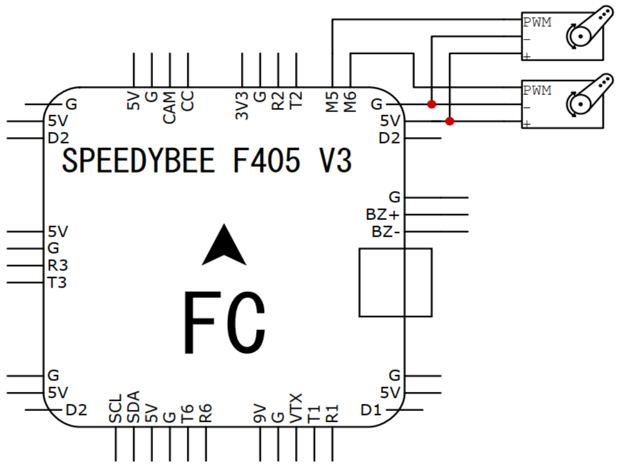

*Figures III.10:Robotic Arm Axes*

### III.1 Miniature Robotic Arm Diagram:



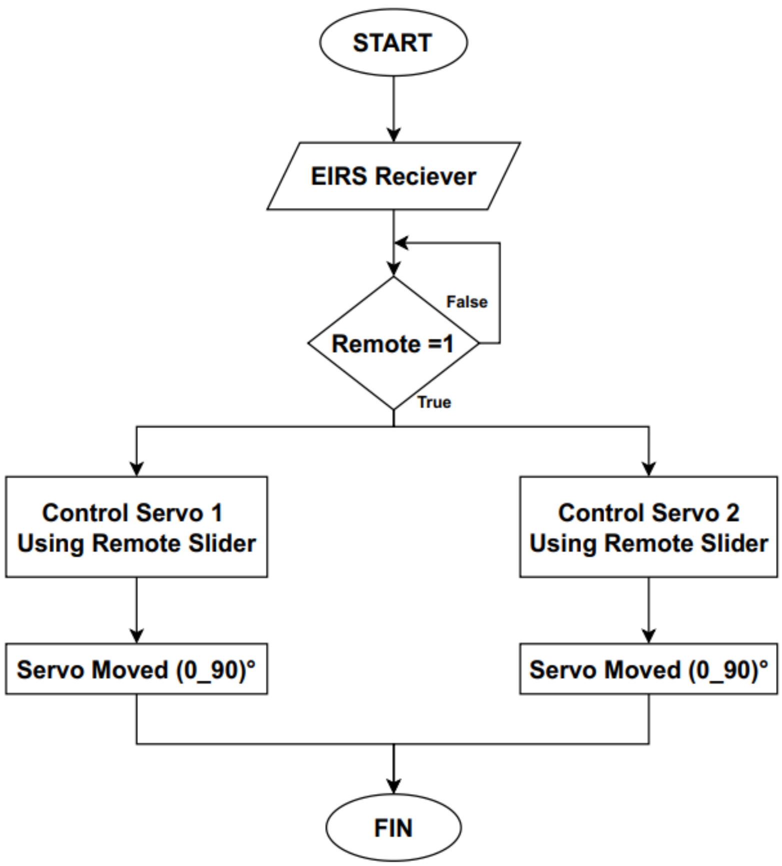

*Figures III.11:Robotic Arm Circuit Diagram*

## III.2 Miniature Robotic Arm Circuit Design:




*Figures III.12:Robotic Arm Circuit Design*

## III.3 Miniature Robotic Arm Circuit Algorithm:




*Figures III.13:Miniature Robotic Arm Circuit Algorithm*

## VI. Data Monitoring System:

Our Industrial FPV data monitoring system is designed to monitor the environment quickly, reliable and complete. Data sender on the board, powered by ESP32 microcontroller, collect important sensor data from BME680 sensor and MICS sensor, temperature, humidity, pressure and dangerous gas levels. This information is sent extensively through the LORA SX1278 module. this ensures minimal latency and high reliability even in difficult conditions. On the Ground station, the second ESP32 processes the received data. This is displayed on the LCD, archived on the SD card for subsequent analysis, and visualized via the Blynk app and website when connected to the Wi-Fi at the same time. This integrated approach not only optimizes data collection and data monitoring, but also improves operational efficiency and security for industrial applications.

### VI.1 Data Reception using Blynk System

The Blynk Monitoring System enables real-time data visualization and remote control using a WiFi-connected ESP32 microcontroller. Its key capabilities include: [46]

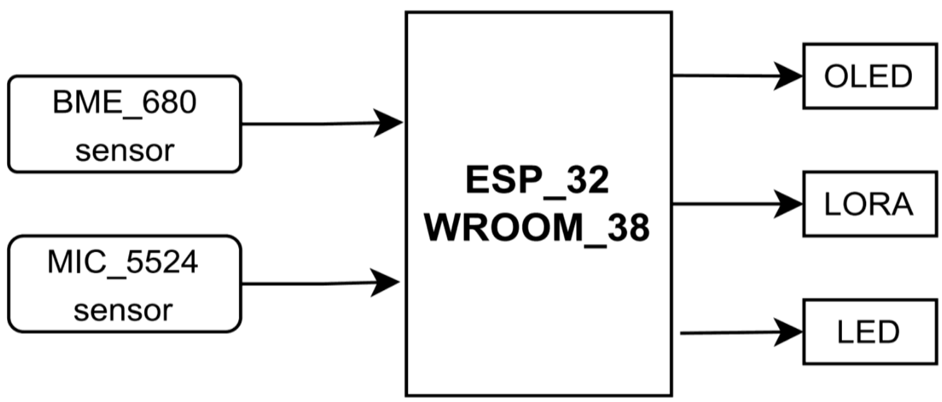
- **High-Speed Data Transmission:** WiFi ensures rapid and stable communication, allowing near-instant updates on sensor readings and system status.
- **User-Friendly Interface:** The Blynk app provides an intuitive dashboard with customizable widgets for displaying environmental data, such as gas concentration, temperature, and humidity.
- **Remote Access & Control:** Users can monitor sensor data and control connected devices from anywhere, enhancing flexibility and responsiveness.
- **Efficient Data Logging:** Blynk stores historical data, enabling analysis and trend tracking for better decision-making.
- **Multi-Device Integration:** The system can be expanded to work with multiple IoT devices, ensuring scalability for industrial applications.

This system enhances real-time monitoring efficiency, making it ideal for industrial drone applications requiring rapid data processing and visualization.


*Figures III.14:Blynk Monitoring System*

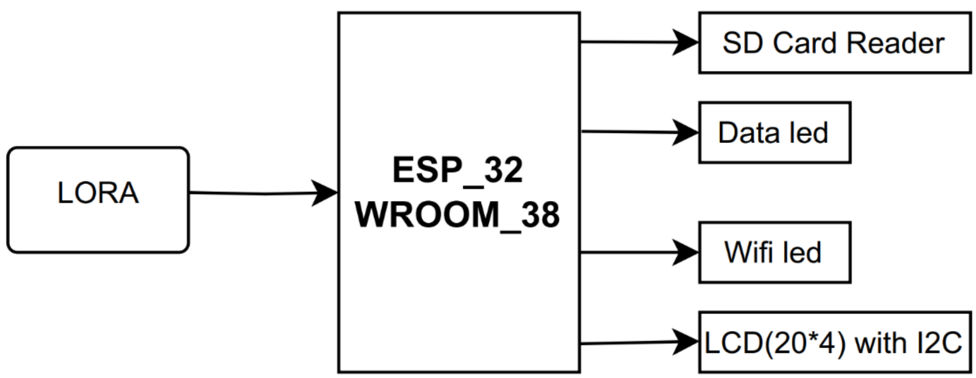
### VI.2 Data Monitoring System Diagram:

- **Data Sender Circuit Diagram**




*Figures III.15:Data Sender Circuit Diagram*

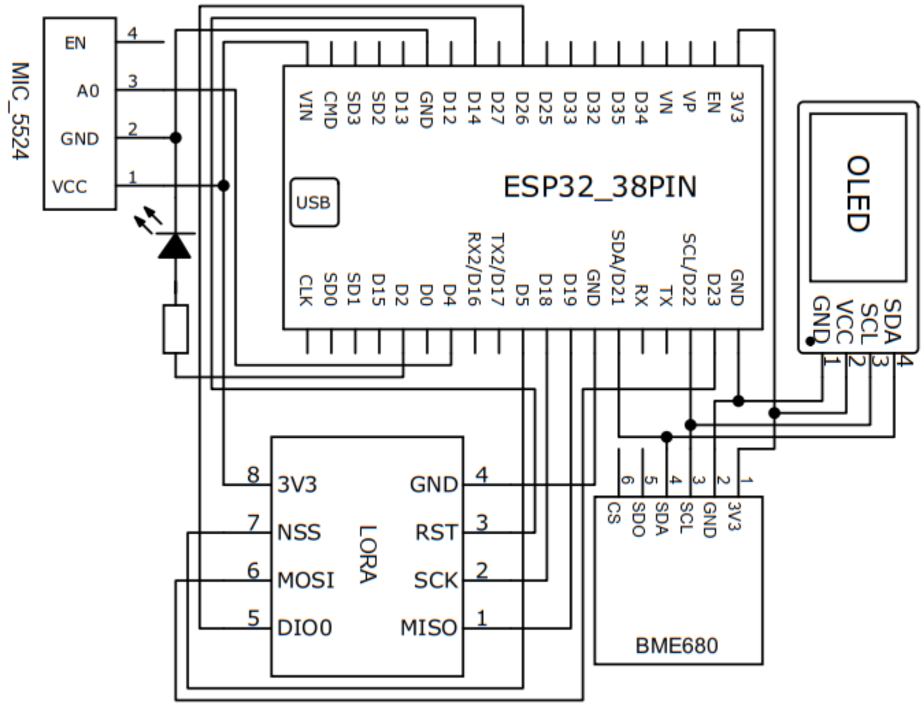
- **Data Reciver Circuit Diagram**




*Figures III.16:Data Reciever Circuit Diagram*

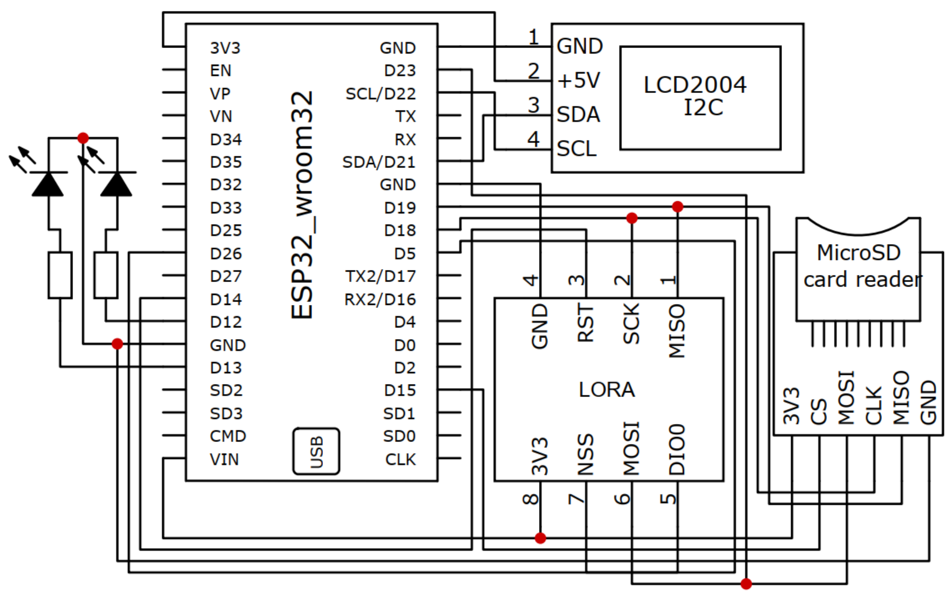
## VI.3 Data Monitoring System Circuit Design

- **Data Sender Circuit Design**




*Figures III.17:Data System Circuit Design*

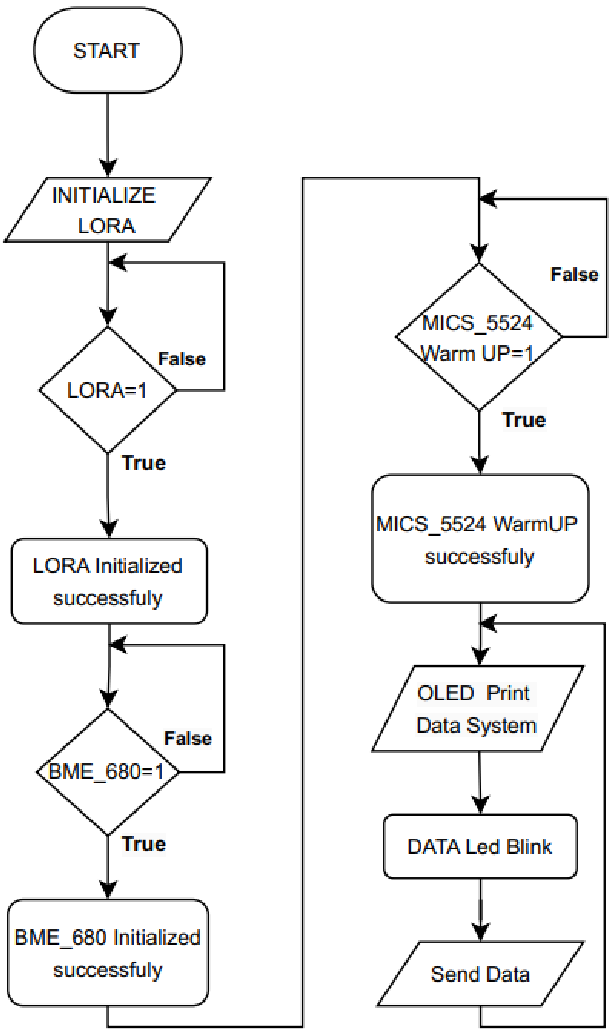
- **Data Reciever Circuit Design**



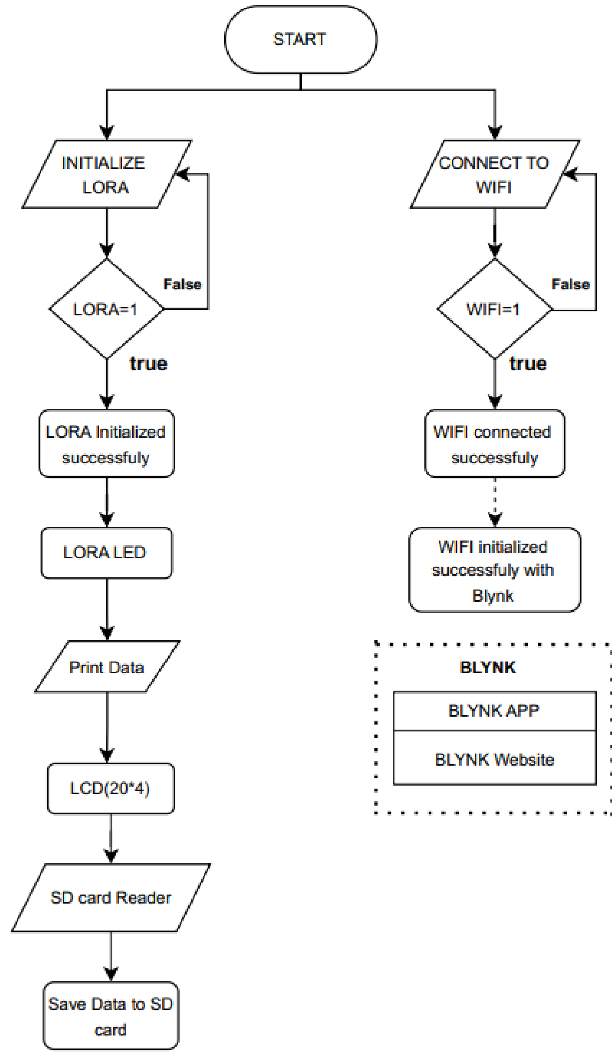

*Figures III.18:Data Reciever Circuit Design*

### VI.4 Data Monitoring System Circuit Algorithm

- **Data Sender Circuit Algorithm**
- **Data Reciever Circuit Algorithm**




*Figures III.19:Data Sender System Circuit Algorithm*




*Figures III.20:Data Sender System Circuit Algorithm*

## V. Test Results

In this section, we present the test results of the three key systems integrated into our industrial FPV drone:

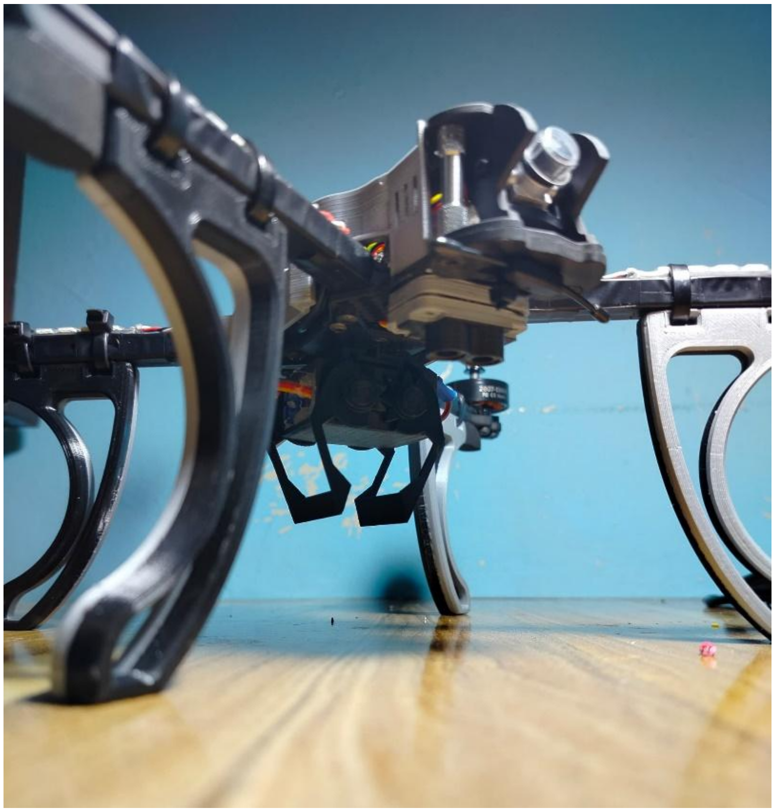
### V.1 Flight Control and Navigation System Test

- The SpeedyBee F405 flight controller was tested for stability, responsiveness, and sensor integration.
- The drone successfully maintained stable flight in manual and assisted modes, demonstrating precise control and smooth maneuverability
- The GPS module (HGLRC M100 5883) provided accurate positioning, essential for autonomous navigation.
- The AKK Race Ranger VTX enabled real-time FPV video transmission with minimal latency.


*Figures III.21:Industrial FPV Drone Systems*

### V.2 Miniature Robotic Arm Test:

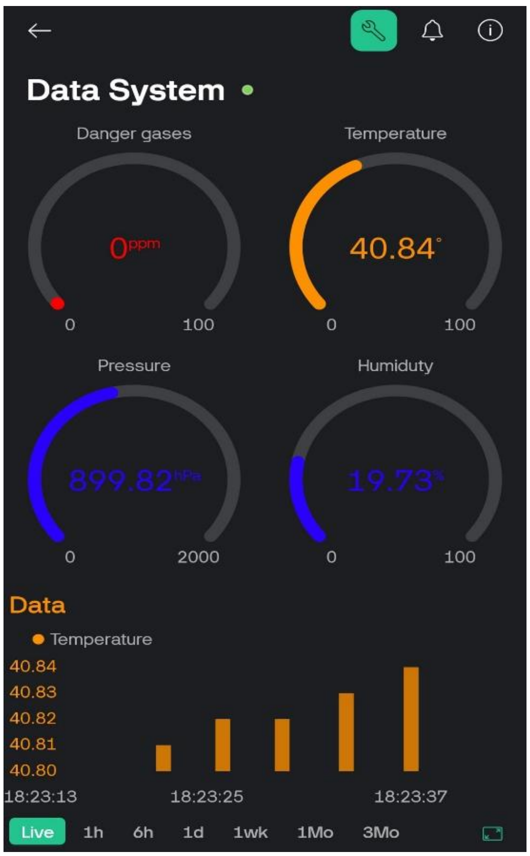
- The **3D-printed robotic arm**, controlled by **two SG90 servo motors**, was tested for precision and functionality.
- It successfully performed basic tasks such as object gripping and manipulation.
- **Servo response** times were optimized for smooth and stable operation, ensuring reliable performance in industrial applications.



*Figures III.22:Miniature Robotic Arm (Drone)*

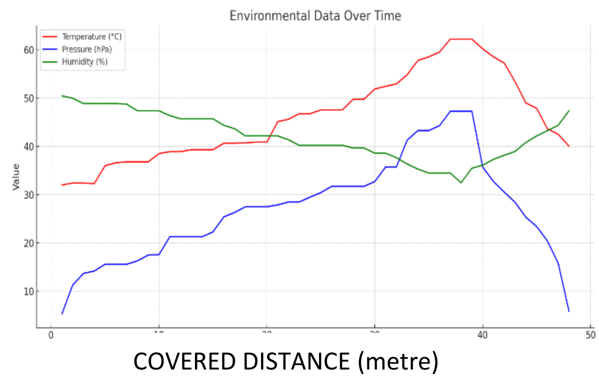
### V.3 Data Monitoring System Test:

- **LoRa Transmission Speed:** The LoRa RA-02 module enabled rapid and reliable long-range data transmission with minimal latency.
- **Sensor Sensitivity & Accuracy:** The BME and MiCS sensors provided high-precision environmental readings, ensuring reliable data acquisition.
- **Blynk Visualization:** Real-time data was displayed instantly on the Blynk platform, offering a fast and user-friendly monitoring interface.




*Figures III.23:Data Visualization using Blynk*

- **Sensors Data:**




*Figures III.24:Sensors Data*

# GENERAL CONCLUSION

# Conclusion

In Conclusion, this project is a cutting-edge development in industrial UAV technology. We develop a FPV drone that integrates advanced flight control real-time sensor data processing and a miniature robotic arm to carry out critical tasks in hazardous industrial environments. The core goal is to improve the overall safety and efficiency of operations with precise aerial monitoring and direct physical intervention. By using the latest navigation and communications technologies, our innovative design revolutionizes industrial automation and unmanned operations.

Our projects provide a versatile solution that greatly simplifies industrial enterprises by enabling remote inspection, accurate sample collection and target maintenance tasks. By combining an agile FPV flight with a miniature robotic arm, the system minimizes human risk, streamlines complex industrial processes, ultimately increasing operational efficiency and reducing costs.

The project has faced a number of challenges, including the complexity of integrating a number of systems while ensuring stability and efficiency. Energy management and calibration requires careful optimization to meet the industrial requirements and the prescribed constraints have added other limitations. Despite these obstacles, we have successfully refined the design to create a reliable and functional solution.

Future enhancements on our road-map are geared towards elevating the system's capability and flexibility. Also, we will add an AI-enabled camera that will allow it to detect and recognize objects in real-time, making it easier for people to work with it, and design a more advanced robotic arm, with greater degrees of freedom and a longer reach to perform multiple kinds of tasks for the hardware side, we look to upgrade to more powerful flight controllers like the Pixhawk 6X, as well as next gen dev boards like the Raspberry Pi 5 with its on-chip AI camera for processing power. We will also be improving our communication system with a Crossfire receiver to make link more resilient, and a Radio-Master TX16S remote for more control, and a transition from analog to digital video transmission using a DJI O4 Air Unit VTX, while the data system will benefit from the superior range and reliability of a LoRa Semtech SX1262 module.

After All This project has developed a multi -purpose FPV industrial aircraft with fast flight control, actual data collection and accurate Haptic feedback in a closed -loop system. The drones navigate and detect obstacles independently, using its micro arms to perform tasks safely in different environments. Despite technical and integration challenges, this achievement throws a solid basis for continuous innovation. Improvements in the future, such as AI compatible images, advanced flight controllers and improved media links, will optimize this system for new generation industrial UAV applications, improve safety and operational efficiency.

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