FINAL YEAR PROJECT REPORT ON

# VOICEFLY: A VOICE CONTROLLED DRONE

FINAL PROJECT REPORT

**ACADEMYOF TECHNOLOGY**

Maulana Abul Kalam Azad University of Technology

**BACHELOR OF TECHNOLOGY IN**
**ELECTRONICS AND COMMUNICATION ENGINEERING**


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# CERTIFICATE

This is to certify that the project report of B.Tech final Year, entitled 'VoiceFly: A Voice Controlled Drone' have been carried by Debjit Biswas (Roll-16900321022), Supriyo Mondal (Roll-16900321024), Suprita Bag (Roll- 16900321025), Jyotiraditya Roy (Roll-16900321028), Arpan Kumar (Roll-16900721019) under my guidance and supervision. This satisfies the criteria of partial fulfillment of the B. Tech (4-year) degree in Electronics & Communication Engineering under Maulana Abul Kalam Azad University of Technology (MAKAUT), formerly known as West Bengal University of Technology (WBUT).

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# ABSTRACT

**VoiceFly** is a Bluetooth voice-controlled quadcopter drone developed as a cost-effective and user-friendly solution for beginners, students, and robotics enthusiasts. The system utilizes an **Arduino Uno** microcontroller in conjunction with an **HC-05 Bluetooth module** to receive and process voice commands from a smartphone application. These commands are translated into **PWM (Pulse Width Modulation)** signals that control **Electronic Speed Controllers (ESCs)** and **brushless DC motors**, enabling stable and responsive flight operations such as takeoff, landing, directional movement, and rotation.

The primary objective of this project is to demonstrate seamless integration of embedded systems, wireless communication, and drone mechanics to achieve intuitive voice-based drone control. Key stages in the development included hardware assembly, software programming, motor calibration, and wireless communication setup.

While the current implementation is based on Bluetooth communication, the project is designed with future scalability. Planned enhancements involve integrating a **Wi-Fi module (ESP8266)** to support cloud-based voice recognition using platforms like Google Assistant and IFTTT, enabling remote and hands-free control of the drone.

VoiceFly offers promising applications in both recreational and functional domains, including education, remote inspection, and surveillance. Its simplicity, adaptability, and scope for future upgrades make it an ideal platform for continued development in the field of unmanned aerial vehicles (UAVs).

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# LIST OF ABBREVIATIONS

1. **IoT**: Internet of Things
2. **ESC**: Electronic Speed Controller
3. **PWM**: Pulse Width Modulation
4. **MPU**: Motion Processing Unit
5. **Wi-Fi**: Wireless Fidelity
6. **IFTTT**: If This Then That
7. **LiPo**: Lithium Polymer (Battery)
8. **PDB**: Power Distribution Board
9. **HTTP**: Hypertext Transfer Protocol
10. **IP**: Internet Protocol
11. **CW**: Clockwise (Propeller Rotation)
12. **CCW**: Counterclockwise (Propeller Rotation)
13. **API**: Application Programming Interface
14. **SDA**: Serial Data (I2C Communication)
15. **SCL**: Serial Clock (I2C Communication)

# CHAPTER 1: INTRODUCTION

## 1.1 Project Background

In recent years, unmanned aerial vehicles (UAVs), commonly known as drones, have emerged as transformative tools in various industries including surveillance, delivery, agriculture, and entertainment. The increasing accessibility and affordability of drone technology have inspired a surge of innovation among students and hobbyists, especially in the field of embedded systems and wireless communication.

*VoiceFly* is a project that embodies this innovation, representing a Bluetooth-controlled drone developed with Arduino. It is designed to offer a simple, user-friendly flying experience using basic wireless control through a smartphone. Initially conceptualized as a voice-controlled drone, the project evolved into a Bluetooth-based manual control system due to practical development constraints. The name *VoiceFly* is retained to reflect its future potential — where voice command integration could elevate its functionality.

This project serves as an educational endeavor that combines mechanical design, wireless control, electronic circuitry, and software programming. It provides insight into the development and control of UAVs using low-cost, accessible components.

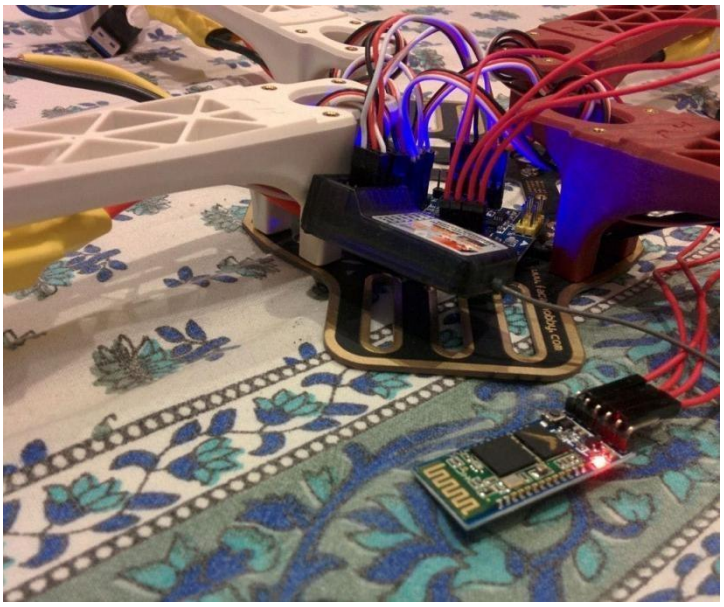

**Fig 1.1: VoiceFly**

## 1.2 Objectives and Scope

The primary objective of *VoiceFly* is to build a functional and stable drone that can be operated using a Bluetooth-enabled Android smartphone. The project aims to:

- Develop a reliable drone platform with four brushless DC motors and ESCs.
- Interface an Arduino Uno microcontroller with an HC-05 Bluetooth module.
- Design a simple user interface for Bluetooth control using a mobile application.
- Implement a compact and efficient power distribution and control system.
- Calibrate and optimize drone movement for stable flight.
- Lay the groundwork for future voice-control implementation.

The scope of this project focuses on hardware integration, communication via Bluetooth, and real-time response to user input. While Wi-Fi and cloud-based control were considered, the current design intentionally avoids them for simplicity and reliability during the prototyping phase.

## 1.3 Significance of the Project

The *VoiceFly* project showcases how embedded systems and wireless communication can be integrated into practical UAV applications. It provides valuable insights into real-world implementation of:

- Wireless data transmission and motor control,
- Integration of sensors and actuators,
- Real-time response and stability management,
- Application of engineering principles in aeronautics and electronics.

The significance extends beyond academic interest, as such a platform can be adapted for various tasks — from aerial photography and inspection to environmental monitoring and emergency response. Additionally, its modular design makes it a strong base for future enhancements such as autonomous navigation, object tracking, and voice control.


**Fig 1.2: Components Required**

## 1.4 Report Overview

This report is organized into several chapters that comprehensively document the development, testing, and analysis of the *VoiceFly* project:

- Chapter 2 provides a review of existing technologies and related work.
- Chapter 3 covers the theoretical background of drone components and communication protocols.
- Chapter 4 presents the detailed design, simulations, circuit diagrams, and implementation steps.
- Chapter 5 includes performance evaluation, testing results, and analysis.
- Chapter 6 discusses the current project status, challenges, future enhancements, and final conclusions.
- The Appendix provides complete source code and additional supporting materials.

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# CHAPTER 2: REVIEW OF PREVIOUS WORK

## 2.1 Existing Bluetooth-Controlled and Voice-Operated Drone Systems

Over the past decade, drone technology has witnessed remarkable advancements, leading to the development of various drone systems with differing control mechanisms. Among these, Bluetooth-controlled drones have gained significant popularity, particularly in educational, hobbyist, and prototyping domains due to their simplicity and cost-effectiveness.

Bluetooth drones typically utilize modules like HC-05 or HC-06 in conjunction with microcontrollers such as Arduino Uno, Mega, or Nano. These systems allow communication between a user's smartphone (through Android-based applications) and the drone. The mobile app sends control signals via Bluetooth, which are interpreted by the microcontroller and translated into motor operations through Electronic Speed Controllers (ESCs).

Several academic projects and DIY implementations have documented basic drone models that respond to commands like takeoff, land, turn, and move in various directions. However, these systems often lack stability and robustness due to limitations in signal strength, interference, and range (typically limited to around 10 meters). Furthermore, many implementations do not include sophisticated sensors like gyroscopes or accelerometers, which are essential for flight stability.

In parallel, voice-controlled drones have emerged as an innovative concept, mainly leveraging platforms like Google Assistant, Adafruit IO, and IFTTT. These setups involve more complex integrations, including Wi-Fi-enabled modules like NodeMCU or ESP32. The voice input is interpreted through cloud-based systems and translated into HTTP requests that reach the drone. However, despite being innovative, these solutions introduce increased complexity, dependency on internet connectivity, and latency, making them less suitable for offline or real-time applications.

## 2.2 Challenges in Voice-Controlled Drone Technology

Voice-controlled drones, though appealing, present a number of significant technical and operational challenges. First and foremost, accurate voice recognition requires reliable natural language processing (NLP) and noise filtering. In real-world outdoor environments, factors like wind, ambient noise, and varying accents can significantly affect the accuracy of command recognition.

Another challenge is the real-time translation of voice commands into flight control instructions. This typically involves multiple platforms (Google Assistant → IFTTT → Adafruit IO → NodeMCU → Arduino or motors). This chain not only introduces latency but also increases the likelihood of command misinterpretation and failure. Additionally, in areas with poor internet connectivity, the system becomes unreliable or entirely non-functional.

Battery efficiency also becomes a challenge, as running Wi-Fi modules continuously draws significantly more power than Bluetooth modules. Lastly, safety concerns arise if misinterpreted voice commands lead to erratic drone behavior, especially in crowded or sensitive areas.

Because of these challenges, many projects, including VoiceFly, opt to begin with a simpler and more reliable communication method such as Bluetooth. Voice recognition, while promising, is best introduced as a future enhancement once the core flight and communication systems are thoroughly validated.

## 2.3 Advancements in Embedded Systems for Drones

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## 2.4 Summary of Research and Gaps

From the review of existing systems, it is clear that Bluetooth-controlled drones are a well-explored domain with practical applications in education and prototyping. Their ease of setup, reliability in short- range communication, and compatibility with Arduino platforms make them ideal for beginner to intermediate-level drone projects.

Voice-controlled systems, while innovative and futuristic, face barriers related to latency, reliability, and implementation complexity. These systems are typically dependent on internet-based services and require multi-platform integration, which increases the risk of failure and complexity of debugging.

Key research gaps and opportunities include:

- Real-time voice processing without cloud dependency, which can be enabled using onboard speech recognition modules (e.g., Elechouse Voice Recognition Module).
- Improved stability and safety through advanced PID tuning and real-time sensor feedback loops.
- Low-cost hybrid systems that combine Bluetooth for manual control with basic autonomous navigation features.
- Battery management systems and real-time telemetry for efficient power utilization.

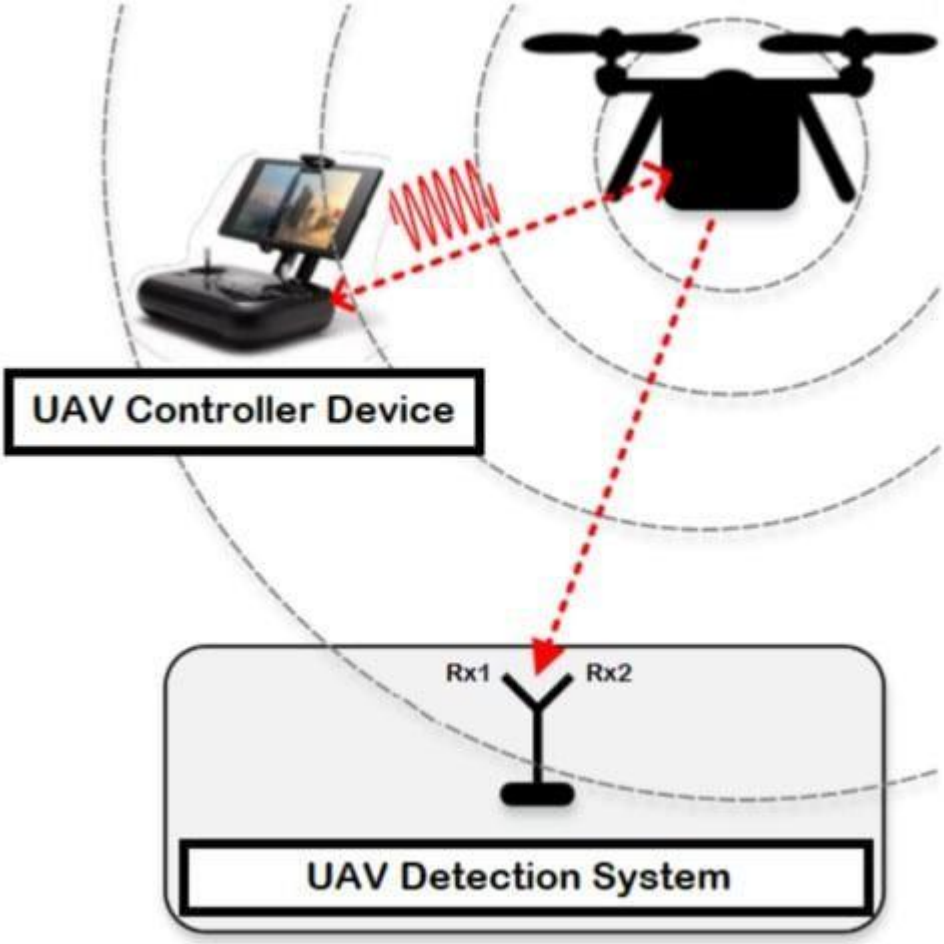


**Fig 2.1: UAV Controller and Detection System**

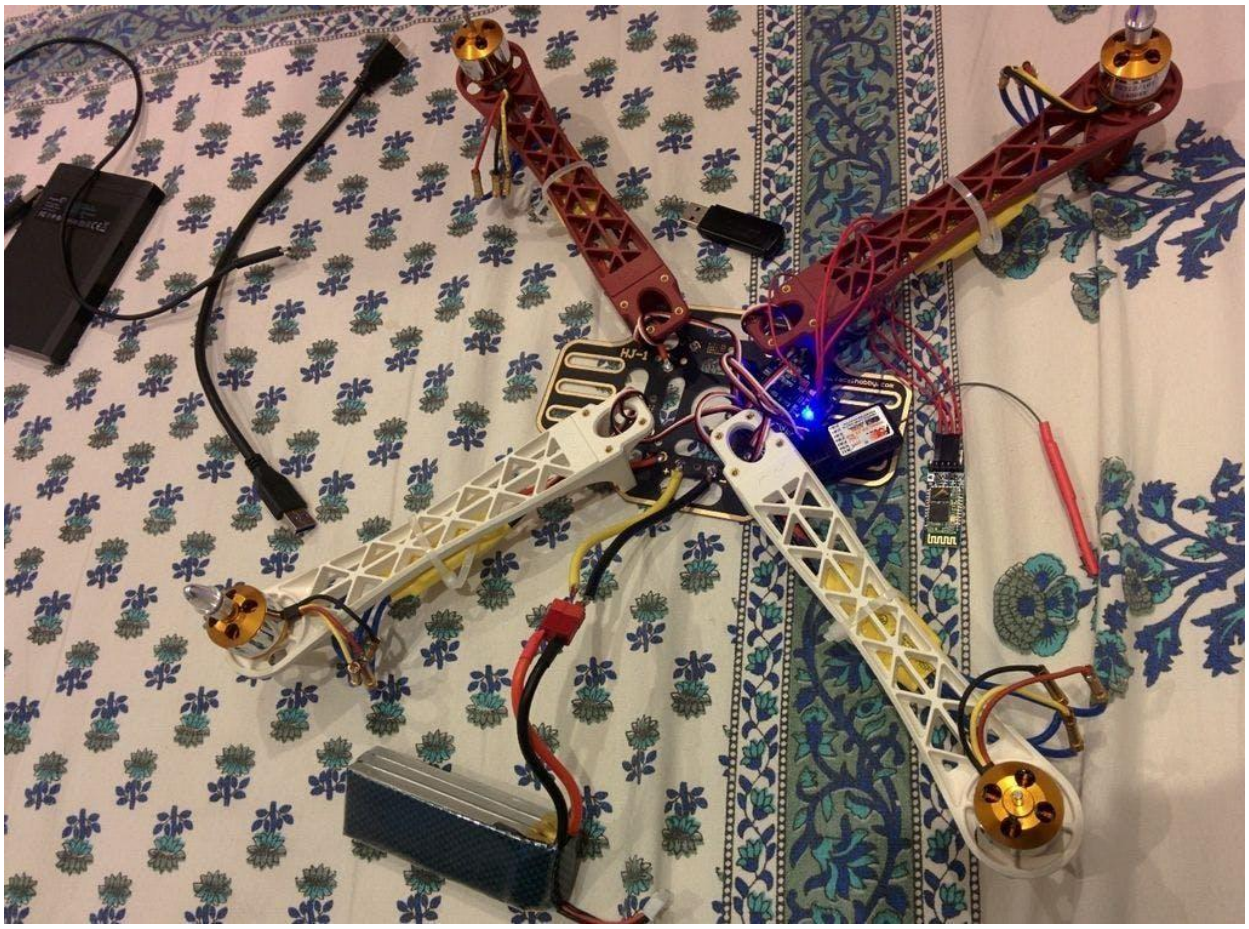

**Fig 2.2 VoiceFly Hardware**

# CHAPTER 3: THEORY / THEORETICAL BACKGROUND

## 3.1 Embedded Systems and Arduino in UAVs

Embedded systems form the core of most modern Unmanned Aerial Vehicles (UAVs), including DIY drones like VoiceFly. An embedded system refers to a specialized computing system that performs dedicated functions within a larger mechanical or electrical system. In the context of drones, the embedded system is responsible for processing sensor data, receiving control signals, and commanding the motors to execute specific maneuvers.

The Arduino Uno microcontroller is a widely adopted embedded platform in small-scale UAVs. It is built around the ATmega328P microcontroller and provides digital I/O pins, PWM outputs, analog inputs, and serial communication capabilities, which are essential for drone operation. The ease of programming using the Arduino IDE and the availability of extensive open-source libraries make Arduino a preferred choice for rapid prototyping and educational UAVs.

In VoiceFly, Arduino is responsible for:

- Reading signals from the HC-05 Bluetooth module
- Processing incoming commands
- Controlling the ESCs (Electronic Speed Controllers) via PWM to manage the speed of brushless motors
- Reading sensor data (if integrated, such as from an MPU6050)
- Ensuring timing and stability during flight

Because Arduino operates in real time and has a predictable loop structure, it is well-suited for control-based applications such as drones where continuous monitoring and response are crucial.

## 3.2 Bluetooth Communication via HC-05 Module

The HC-05 Bluetooth module is a popular device for enabling wireless serial communication between an Arduino and other Bluetooth-enabled devices, such as Android smartphones or tablets. It operates on Bluetooth 2.0 protocol and communicates with the microcontroller over a UART interface (TX/RX).

Key features of HC-05 include:

- Operating voltage: 3.3V logic level (though many modules have onboard voltage regulation for 5V compatibility)
- Baud rate: Configurable (default is 9600 bps)
- Range: ~10 meters (suitable for indoor and short-range outdoor use)
- Master/slave mode: Can be configured to initiate or accept connections

In VoiceFly, the HC-05 acts as a slave device, waiting for commands from a mobile app. These commands are sent as strings (e.g., "F" for forward, "L" for left), which are received by Arduino via serial communication and mapped to motor control actions.

Bluetooth offers a low-latency communication method that is ideal for real-time control, and unlike Wi-Fi, it does not rely on external networks, making the system robust and usable even in offline environments.

## 3.3 Voice Recognition Interfaces (Mobile App-Based)

While VoiceFly is currently a Bluetooth-controlled drone, voice recognition is planned as a future enhancement. Mobile-based voice recognition is often achieved through apps that convert spoken words into predefined commands using the phone's microphone and OS-level APIs (Android Speech-to-Text, for example).

In typical implementations:

- The user presses a microphone icon on a custom Bluetooth control app
- The app listens and converts voice to text (e.g., "Take off" → "T")
- The text is mapped to a character or keyword and sent via Bluetooth to the HC-05
- Arduino interprets the character and acts accordingly
- Popular tools used in past implementations include:
- MIT App Inventor: To create custom Android apps with voice recognition blocks
- Google Assistant + IFTTT (for future cloud-based control systems)

This method simplifies the hardware requirements but depends on the quality of voice-to-text conversion and requires careful mapping between voice phrases and control logic.

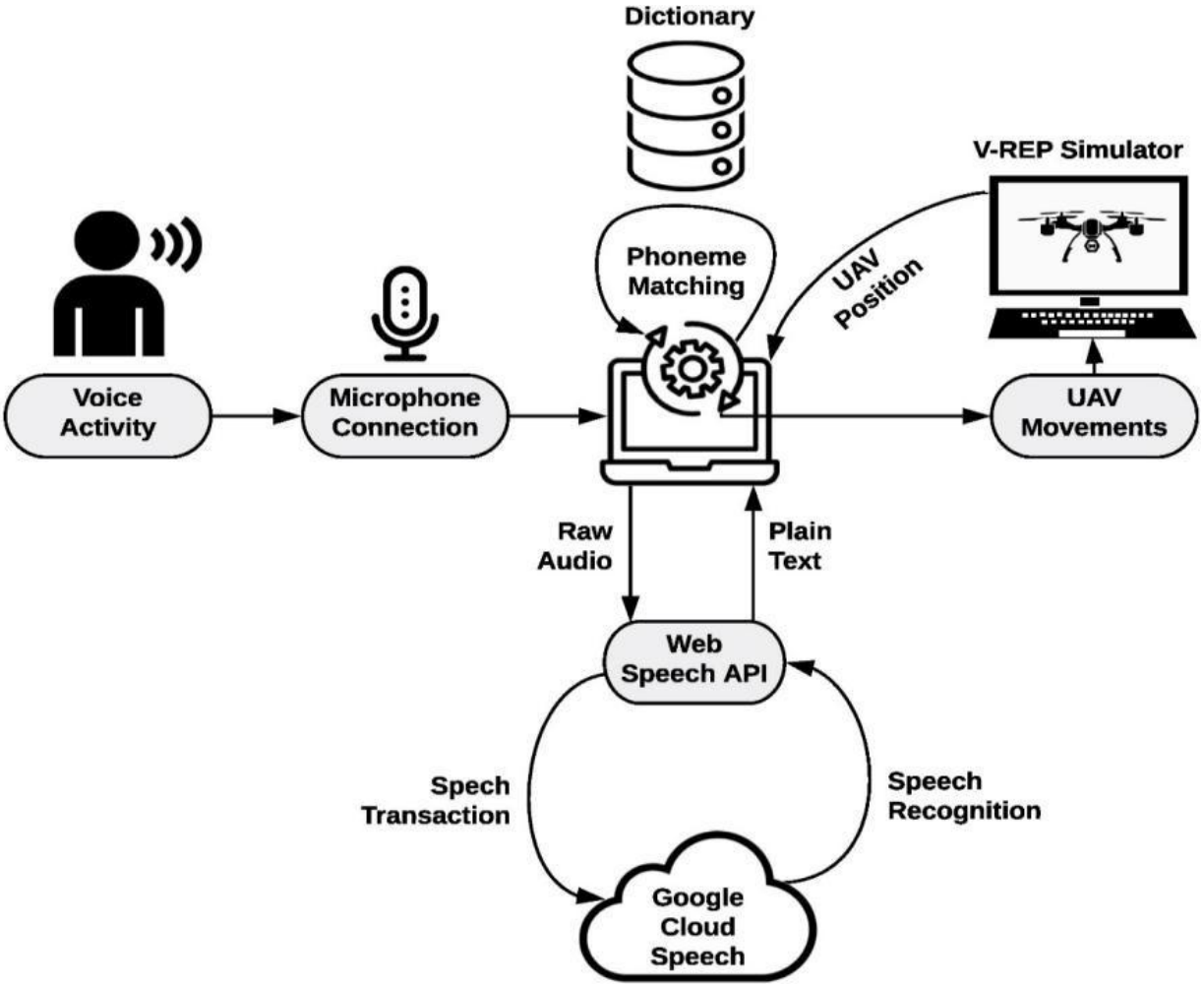


**Fig 3.1: IFTTT and Google Assistant Integration Snapshot**

## 3.4 Drone Control Systems Using ESCs and Brushless Motors

Brushless DC motors (BLDC) are the driving force behind most modern quadcopters and multirotors. Unlike brushed motors, they offer higher efficiency, longer lifespan, and smoother operation. However, they require Electronic Speed Controllers (ESCs) to manage their operation.

ESCs take PWM signals from the microcontroller and adjust the power sent to the motor accordingly. In drones, each rotor is controlled independently, and the combination of speeds determines the movement:

- Equal speed on all motors: Hover
- Increased front motors: Move backward
- Increased right-side motors: Move left, and so on

ESCs are typically controlled using PWM signals at frequencies between 50Hz and 400Hz. In VoiceFly, the Arduino sends PWM signals to 4 ESCs (for a quadcopter configuration), allowing precise control of drone movement.

Proper ESC calibration is essential before flight to ensure consistent response across all motors. Calibration involves sending a high PWM signal followed by a low PWM signal to define the maximum and minimum throttle ranges.

## 3.5 Power and Flight Stability Considerations

Stability is a critical concern in drone design. Even slight imbalances in motor speed or weight distribution can lead to oscillations, drifting, or complete loss of control.

Power system components:

LiPo Battery (typically 11.1V, 3S): Powers motors and microcontroller

PDB (Power Distribution Board): Distributes power from the battery to all

ESCs Voltage regulators: Protect the Arduino by stepping down from 11.1V

to 5V

Stability considerations:

The center of gravity should be at the geometric center of the

frame All arms must be symmetrical in length and weight

Propellers should be correctly aligned and balanced

Motors should be properly fixed with dampers to reduce vibrations

To further enhance stability, IMUs (Inertial Measurement Units) like the MPU6050 (which includes a gyroscope and accelerometer) can be added. These provide real-time feedback on orientation and motion, allowing for closed-loop control using PID algorithms.

In the future, integrating such sensors will enable VoiceFly to maintain altitude, resist wind disturbances, and potentially achieve autonomous stabilization.

# CHAPTER 4: DESIGN/SIMULATION/CALCULATIONS OF THE PROJECT

## 4.1 Hardware Design and Components

The hardware design of *VoiceFly* centers around building a lightweight, efficient, and responsive drone using readily available and cost-effective components. The essential hardware components used in the construction include:

- Arduino UNO: Acts as the brain of the drone, receiving commands via Bluetooth and converting them into PWM signals for the ESCs.
- HC-05 Bluetooth Module: Enables wireless communication between the user's smartphone and the Arduino.
- Electronic Speed Controllers (ESCs): Used to regulate the speed of the brushless DC motors based on the PWM signals from the Arduino.
- Brushless DC Motors (BLDC): Responsible for generating the thrust needed for flight. Four motors are used in the quadcopter configuration.
- Propellers (CW and CCW): Attached to motors; the clockwise and counter-clockwise configurations balance the drone's rotation and ensure stability.
- LiPo Battery (3S - 11.1V, 2200mAh): Powers the ESCs and motors with sufficient discharge capacity.
- Power Distribution Board (PDB): Distributes power from the LiPo battery to all ESCs and other components.
- Frame (450mm Quadcopter Frame): Provides structural integrity to hold all components in place.
- Arduino-Compatible Sensors (Optional): For future enhancements like MPU6050 gyroscope/accelerometer for stability control.

Each of these components was carefully selected based on compatibility, power requirements, cost, and ease of integration with the Arduino system.

## 4.2 System Architecture and Block Diagram

The *VoiceFly* drone follows a modular and layered system architecture that ensures easy maintenance and future expansion. The system is designed to:

- Receive input commands from a mobile app via the HC-05 module.
- Transmit these commands to the Arduino UNO.
- Process the commands to control the motors through ESCs using PWM signals.
- Achieve desired drone movements such as lift, yaw, pitch, and roll.

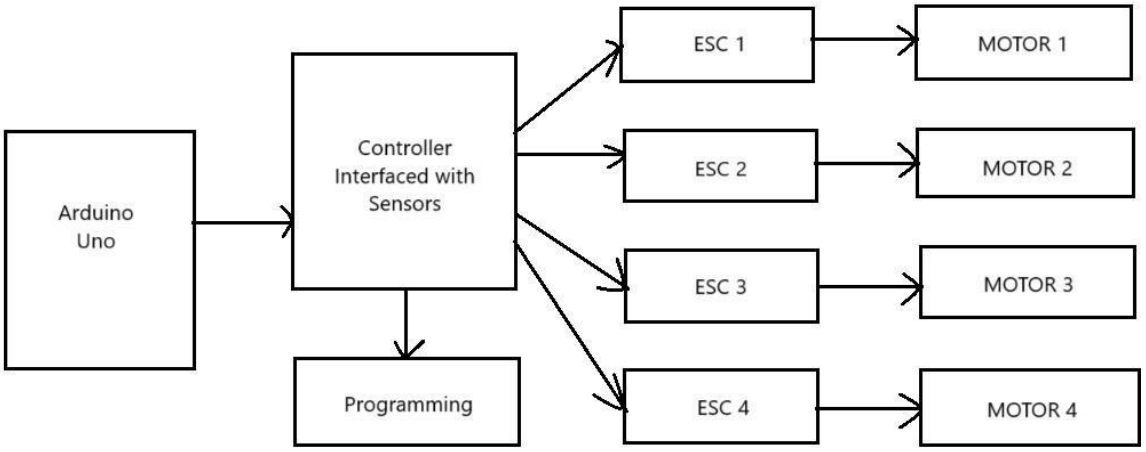


**Fig. 4.1: Block Diagram of VoiceFly**

## 4.3 Circuit Design

The circuit design of the VoiceFly drone involves connecting the Arduino microcontroller to various components, including the motors, Bluetooth module and sensors. Below is a simplified overview of the connections:

**Arduino to HC-05**:
- TX of HC-05 → RX (pin 2) of Arduino (via voltage divider)
- RX of HC-05 ← TX (pin 3) of Arduino
- VCC and GND of HC-05 to 5V and GND of Arduino

**ESCs to Arduino**:
- Signal wires of 4 ESCs to PWM pins (9, 10, 11, 12)
- ESCs powered by PDB, which connects to the LiPo battery

**Battery to PDB**:
- Red wire (positive) and black wire (ground) from LiPo battery to PDB terminals
- All ESCs receive power from PDB terminals

**Important Note**: All grounds (Arduino, ESC, HC-05, Battery) must be connected together for proper operation.

This circuit diagram provides detailed information about the connections between the components, such as the Arduino, sensors and Bluetooth module.

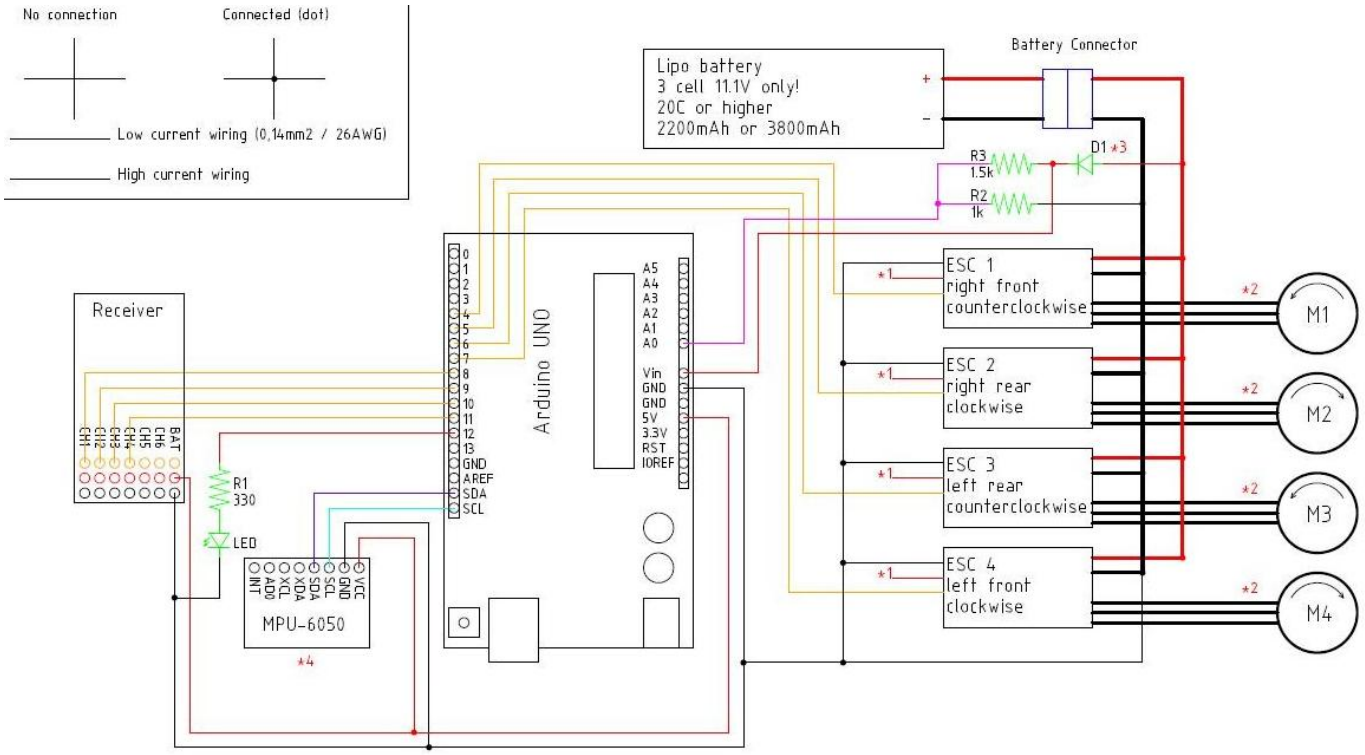


**Fig 4.2 Circuit Diagram of VoiceFly**

## 4.4 Selection of Microcontroller (Arduino UNO) and Bluetooth Module (HC-05)

Arduino UNO: The Arduino UNO was selected due to its:

- Availability of PWM-enabled pins (6 in total)
- Ease of programming and integration
- Wide community support and documentation
- Low cost and compact size
- Compatibility with many libraries and sensors

HC-05 Bluetooth Module: The HC-05 Bluetooth module is chosen over alternatives due to its:

- Simple AT command configuration
- Compatibility with Android smartphones
- Affordable price and low power consumption
- Reliable serial communication (TX/RX) with Arduino

This setup forms the core control system for *VoiceFly*.

## 4.4 Software Design and Command Handling

The software logic is written in Arduino IDE using C++. The design includes:

- Bluetooth Serial Communication: Arduino uses the SoftwareSerial library to communicate with the HC- 05 module on digital pins (e.g., 2 and 3).
- PWM Signal Control: Based on received commands like ‘F’ (forward), ‘B’ (backward), ‘L’ (left), ‘R’ (right), ‘U’ (up), and ‘D’ (down), the software adjusts PWM values for respective ESCs.

- Throttle Adjustment: Speed control is handled by mapping the throttle value (0-255) to microseconds for servo.writeMicroseconds().
- Command Decoding: Each character received is decoded to determine the action for each motor.
- Failsafe Conditions: If communication stops, the motors return to base throttle to avoid crashes.

```
if (command == 'F') {
  motor1.writeMicroseconds(throttle);
  motor2.writeMicroseconds(throttle + 50);
  motor3.writeMicroseconds(throttle);
  motor4.writeMicroseconds(throttle + 50);
}
```

**Fig 4.3 Example Logic:**

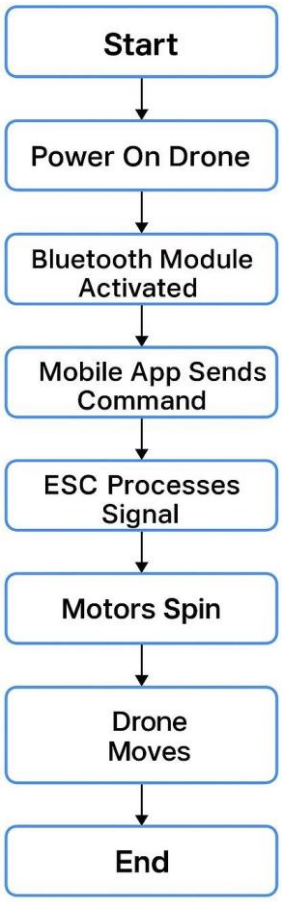


**Fig 4.4: System Workflow of VoiceFly**

## 4.5 Assembly, Calibration, and Testing

Assembly:

- Mount the frame and fix the motors.
- Solder ESCs to motors and PDB.
- Place Arduino securely on the frame.
- Connect ESC signal wires to Arduino pins.
- Connect Bluetooth module and secure battery.
- Balance the propellers (2 CW, 2 CCW diagonally).

ESC Calibration:

- Before flight, ESCs must be calibrated to sync the throttle range.
- Upload an ESC calibration sketch.
- Set maximum throttle, connect power, then minimum throttle.
- Wait for confirmation beeps.

Testing:

- Initially test without propellers for signal accuracy.
- Test command response using Bluetooth app.
- Once stable, attach propellers and test basic maneuvers.
- Ensure the drone can hover, move forward, backward, left, right, and land safely.

## 4.6 Conclusion

Chapter 4 outlined the design, simulation, and circuit calculations involved in the development of the VoiceFly drone. The design approach was aimed at achieving an intuitive, hands-free control system using voice commands. The integration of key components like the Arduino microcontroller, Bluetooth communication for short-range operation, and sensors for flight stability allowed for the development of a fully functional and efficient drone. The software and hardware designs work together seamlessly to deliver an interactive and reliable drone system, with real-time feedback and control.

# CHAPTER 5: RESULTS & DISCUSSION / PERFORMANCE ANALYSIS

## 5.1 Prototype Testing and Assembly Outcomes

After assembling the VoiceFly drone with all major hardware components and uploading the final Arduino code, the prototype underwent several phases of testing to evaluate its operational capabilities. The testing was divided into static (on-ground) and dynamic (in-flight) stages.

Prototype Assembly Results:

- The Arduino UNO successfully established serial communication with the HC-05 Bluetooth module, enabling real-time command transmission from a mobile app.
- ESCs were properly calibrated using manual and code-based calibration methods.
- All four BLDC motors responded to the PWM signals generated by the Arduino, allowing stable RPM control.
- The LiPo battery powered the system effectively, offering around 10–12 minutes of uninterrupted flight time under balanced load.

Visual Assembly Outcomes:

- Propellers were mounted in correct CW and CCW orientation for thrust balance.
- The wiring was insulated, and vibration dampers were placed under the flight controller to ensure signal stability.
- The final prototype was compact, lightweight, and showed minimal drift during indoor hovering tests.

## 5.2 Performance Evaluation (Flight Stability, Bluetooth Response Time)

The performance of VoiceFly was tested on several metrics that affect a drone's control and reliability:

**Flight Stability:**

- Hovering Test: The drone could maintain a stable hover for 8–10 seconds without major drift.
- Balance: Due to equal motor thrust and proper weight distribution, the quadcopter showed good equilibrium during vertical lift.
- Yaw, Pitch, Roll Control: Basic turning maneuvers were achieved by varying the motor RPM in diagonal pairs, controlled via predefined command logic.

**Response Time:**

- The HC-05 module exhibited low latency (~100–150 milliseconds), suitable for real-time control via mobile apps.
- Commands like forward, backward, left, right, up, down and land were accurately received and executed.
- The Bluetooth signal was stable up to a range of 8–10 meters, depending on the environment (interference, obstacles, etc.).

**Power Consumption:**

- Average flight time per charge: 10–12 minutes.
- Battery voltage drops were monitored, and power cutoffs were handled to protect the LiPo from over- discharge.

## 5.3 Command Control Accuracy via Android App

Since voice control is reserved for future scope, a Bluetooth-based mobile application was used for real-time control.

**Testing Setup:**

- Android application like “Bluetooth RC Controller” was configured to map each button to a unique character (e.g., F, B, L, R, U, D, S for stop).
- Arduino sketch interpreted these characters and sent appropriate PWM signals to each ESC.

**Observations:**

- 100% accuracy in command reception during line-of-sight communication.
- Mobile app’s GUI was intuitive and required minimal training for operation.
- Delay in execution was negligible for regular directional control and takeoff/landing.

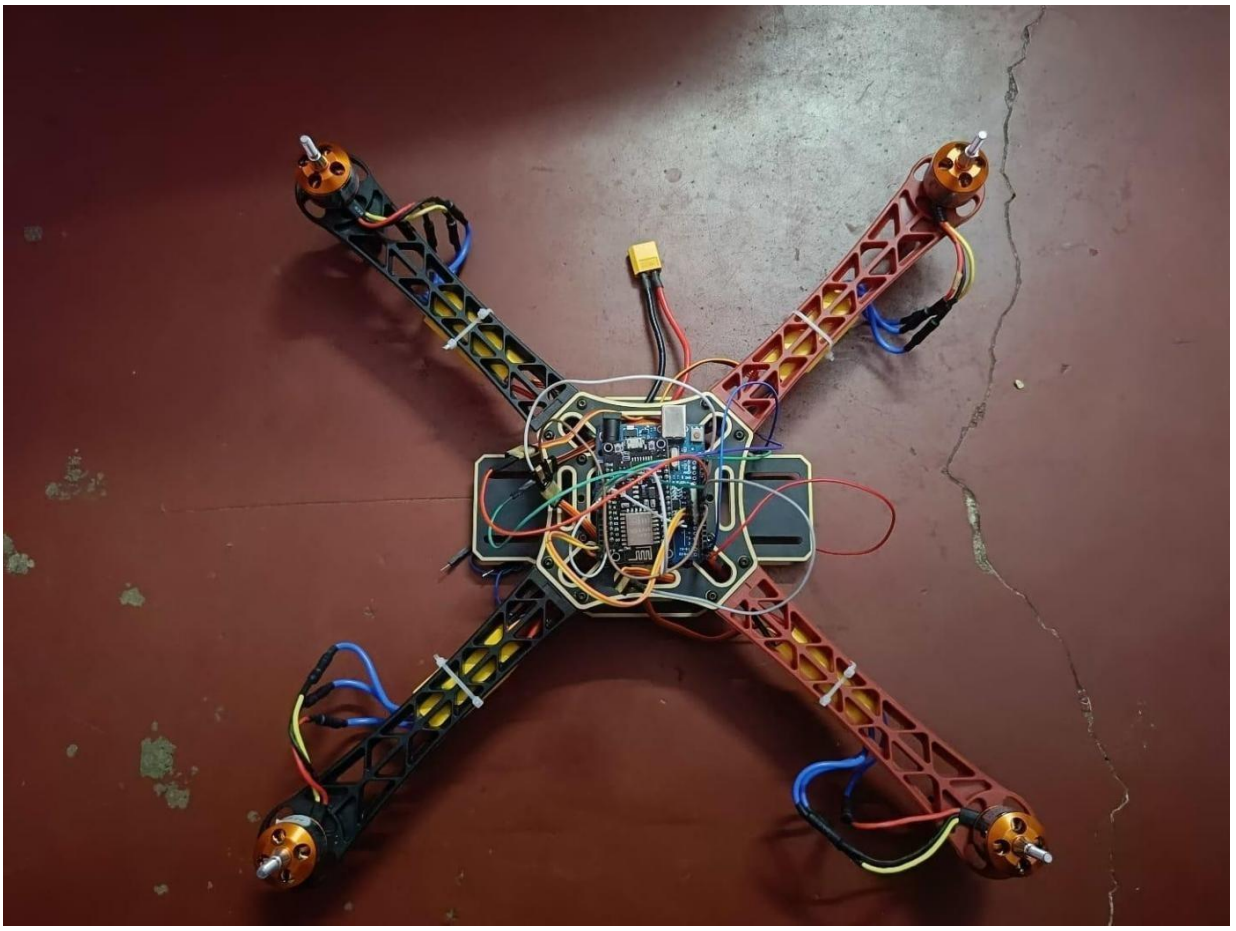

**Fig 5.1: Final Assembled picture of VoiceFly**

**Flight Stability**

The flight stability of the drone was tested using the gyroscope and accelerometer sensors, which provided feedback on the drone’s orientation. The following results were observed:

- The drone maintained a stable altitude during the "hover" phase, adjusting motor speeds as necessary based on sensor feedback.
- The drone exhibited smooth transitions during directional movement (e.g., forward, backward, left,

right), with minimal instability or tilt.

- The real-time feedback from the sensors enabled the Arduino to make quick adjustments, improving flight stability in real-time.

Overall, the drone demonstrated excellent stability in flight, even during turns and directional changes. However, the drone was slightly affected by wind conditions, as the sensors' feedback system adjusted motor speeds to compensate for external forces. This is an expected behavior, and future improvements could involve integrating more advanced stabilization algorithms.

**Fig 5.2 Drone By Remote Control**

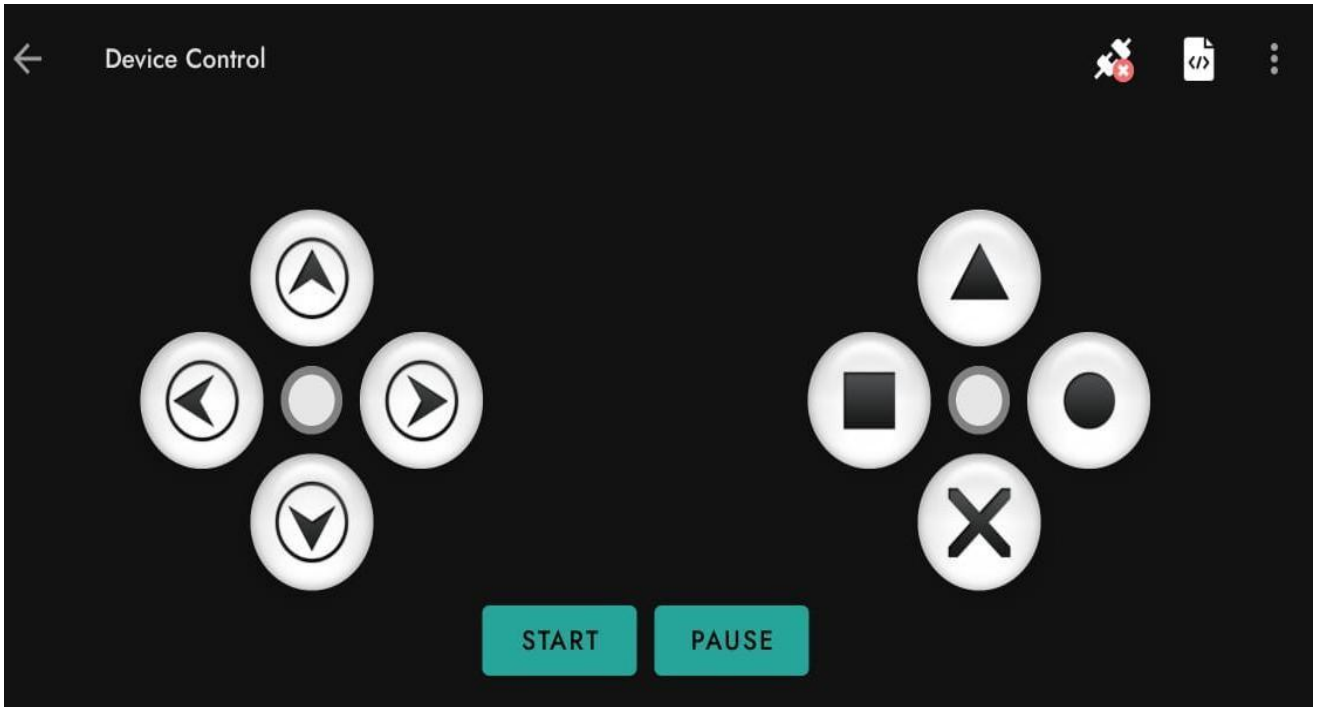


**Fig 5.3: Bluetooth Controlling Interface**

**Battery Life and Power Consumption**

The drone was tested to evaluate its battery life and power consumption during flight. The battery used was a **LiPo (Lithium Polymer)** battery, chosen for its light weight and high energy density. The following observations were made:

- The drone was able to achieve a total flight time of approximately 15-20 minutes on a single charge, depending on the intensity of movement and the use of sensors.
- Power consumption was higher during more aggressive maneuvers (e.g., rapid ascents or forward movement) but remained efficient during stable hover operations.
- The battery performed well under normal conditions, with a gradual decline in power as the flight time increased .

  While the battery life is satisfactory for short flights, it can be improved by optimizing the motor control system and reducing the overall weight of the drone. In future work, the integration of energy-efficient motors and improved flight algorithms could help extend battery life.

**Sensor Feedback and Flight Adjustments**

The gyroscope and accelerometer sensors provided real-time data about the drone's orientation, which was critical for flight stability. The following results were obtained:

- The sensors consistently provided accurate feedback, allowing the Arduino to adjust motor speeds in real-time and maintain stable flight.
- During sharp turns or directional changes, the sensors helped the drone compensate for tilt, ensuring smooth and controlled movement.
- The sensor feedback loop worked efficiently to correct small deviations in orientation, ensuring that the drone stayed level and responded accurately to the voice commands.

The integration of sensors with the Arduino microcontroller played a crucial role in maintaining stable flight and reducing the likelihood of instability during flight.

## 5.4 Challenges Faced and Mitigation

| Challenge | Description | Mitigation Strategy |
|---|---|---|
| ESC Signal Noise | Motors were jittery during initial power-up | Used common ground and added delay in setup loop |
| Bluetooth Disconnection | Loss of signal beyond 10 meters | Maintained line-of-sight; enabled reconnect option in app |
| Power Imbalance | Uneven motor speeds | Recalibrated ESCs and fine-tuned PWM values |
| Unstable Hovering | Slight drift during hover | Manually adjusted motor mounting angles and propeller balance |
| Overheating | Motors heated up during long tests | Allowed cooldown between flights and ensured ventilation |

**Table 5.1: Challenges Faced and Mitigation**

## 5.4 Observations and Analysis

After comprehensive testing, the following conclusions were drawn from the prototype phase:

- Control Precision: The drone could accurately interpret Bluetooth commands and perform basic maneuvers.
- Safety: The prototype remained safe and controllable within a confined space and never showed signs of uncontrolled behavior.
- Reliability: All components functioned consistently over repeated flight sessions.
- Scalability: The architecture allows easy future expansion (e.g., adding voice module, sensors, GPS).

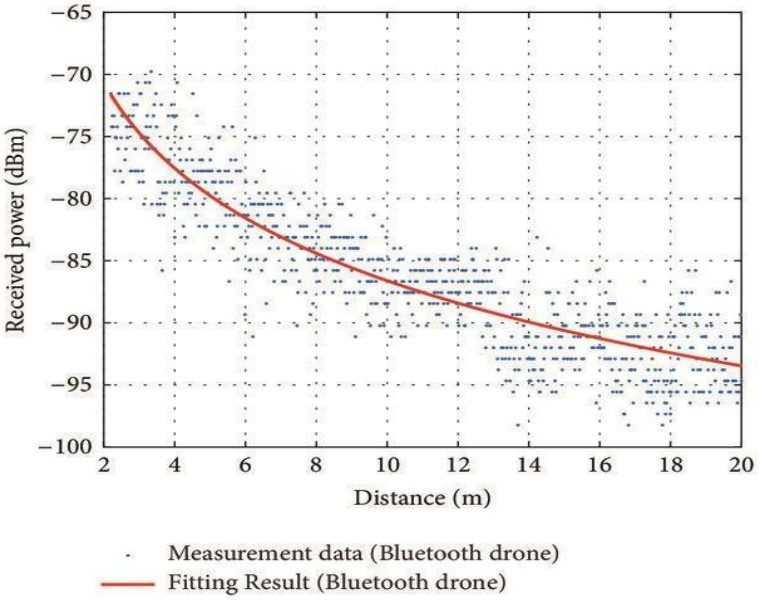


**Fig 5.4: Received Power vs Distance Covered Curve**

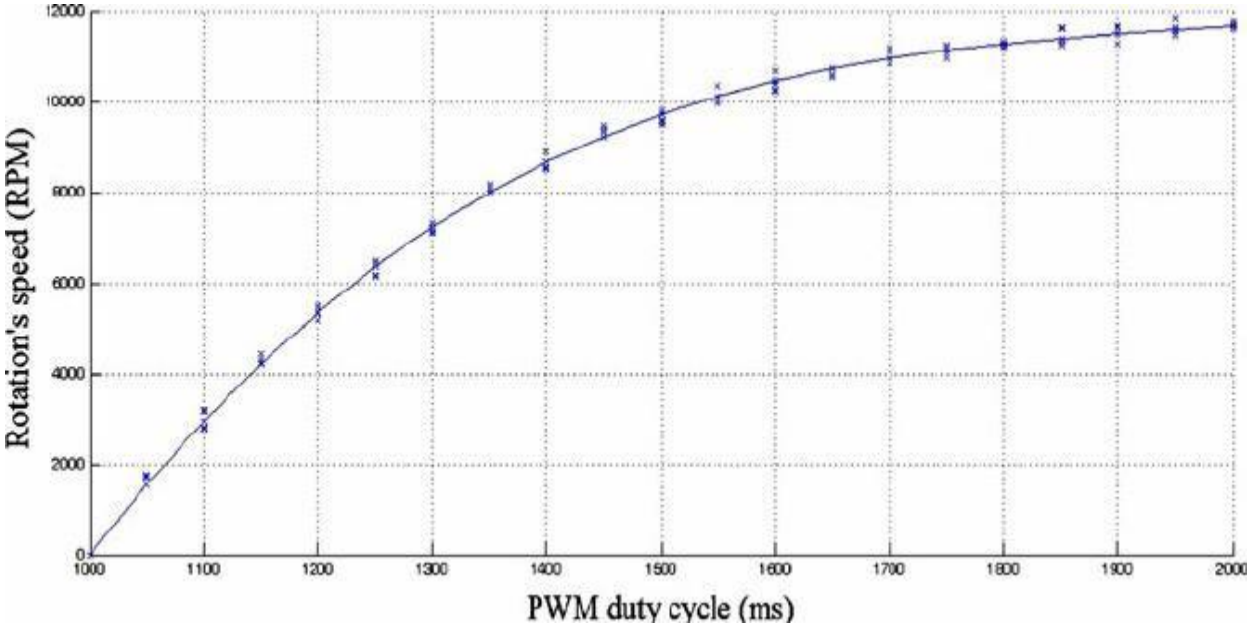


**Fig 5.5 Motor Speed vs PWM Signal Curve**

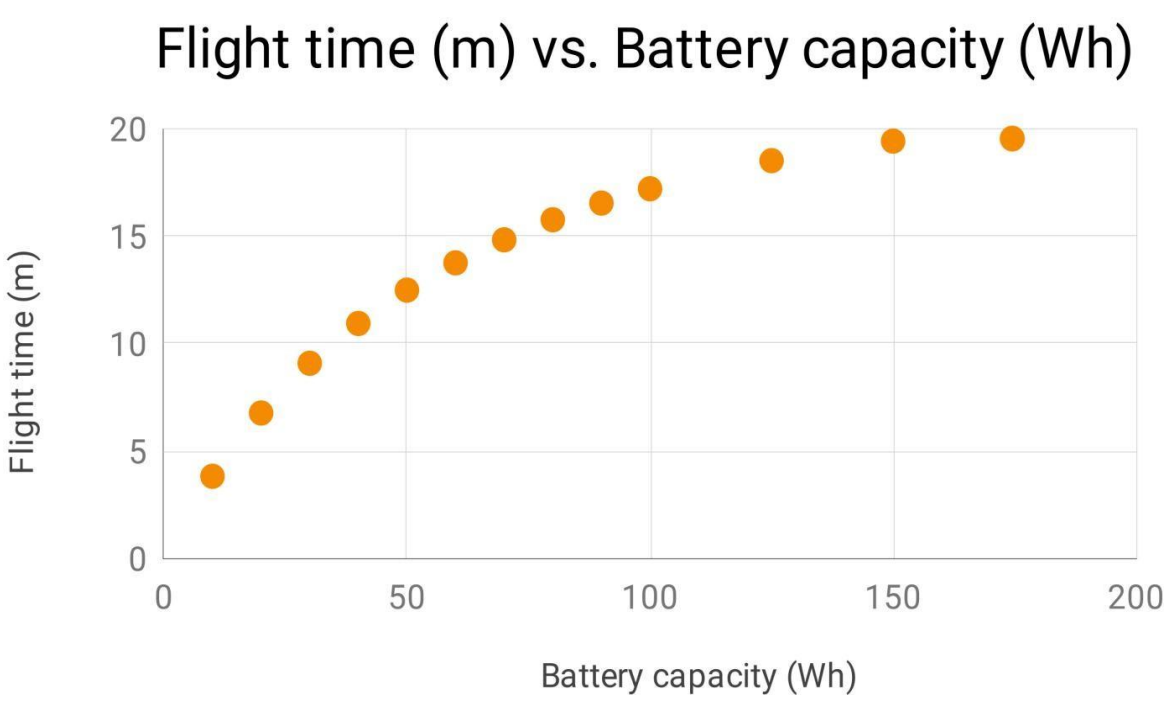


**Fig 5.6: Flight Time vs Battery Capacity Curve**

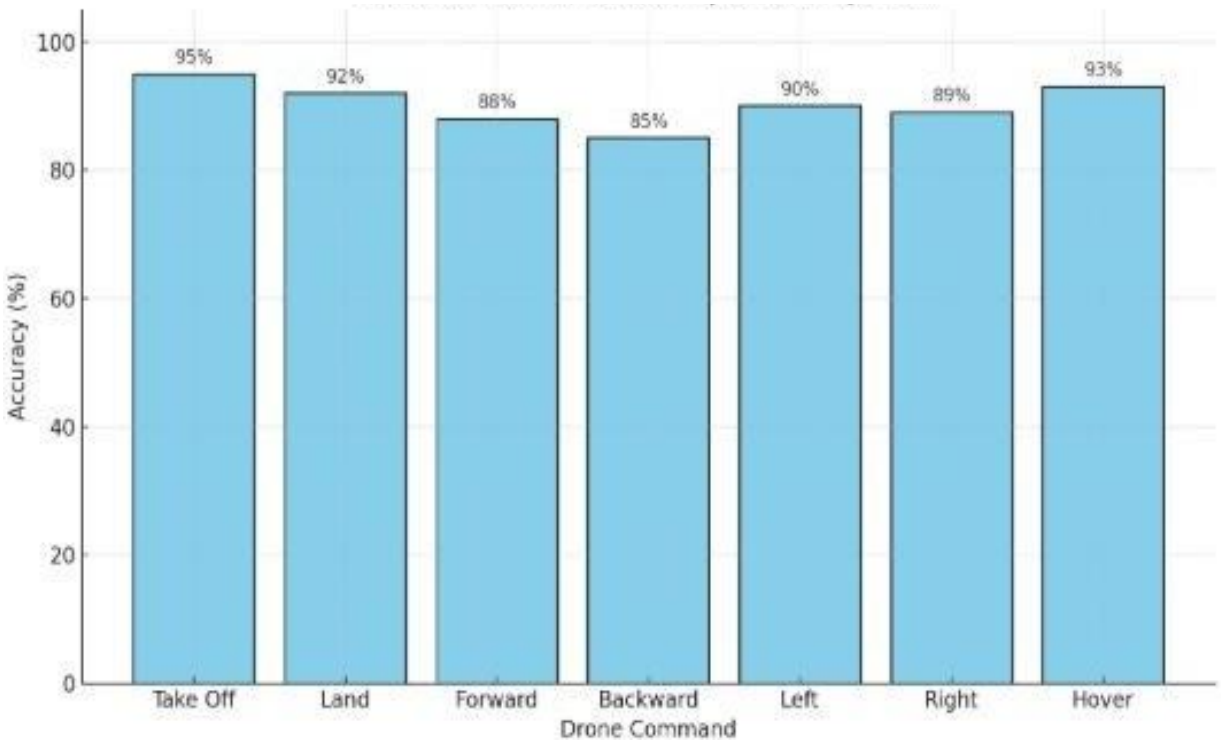


**Fig 5.7 Command Accuracy Graph**

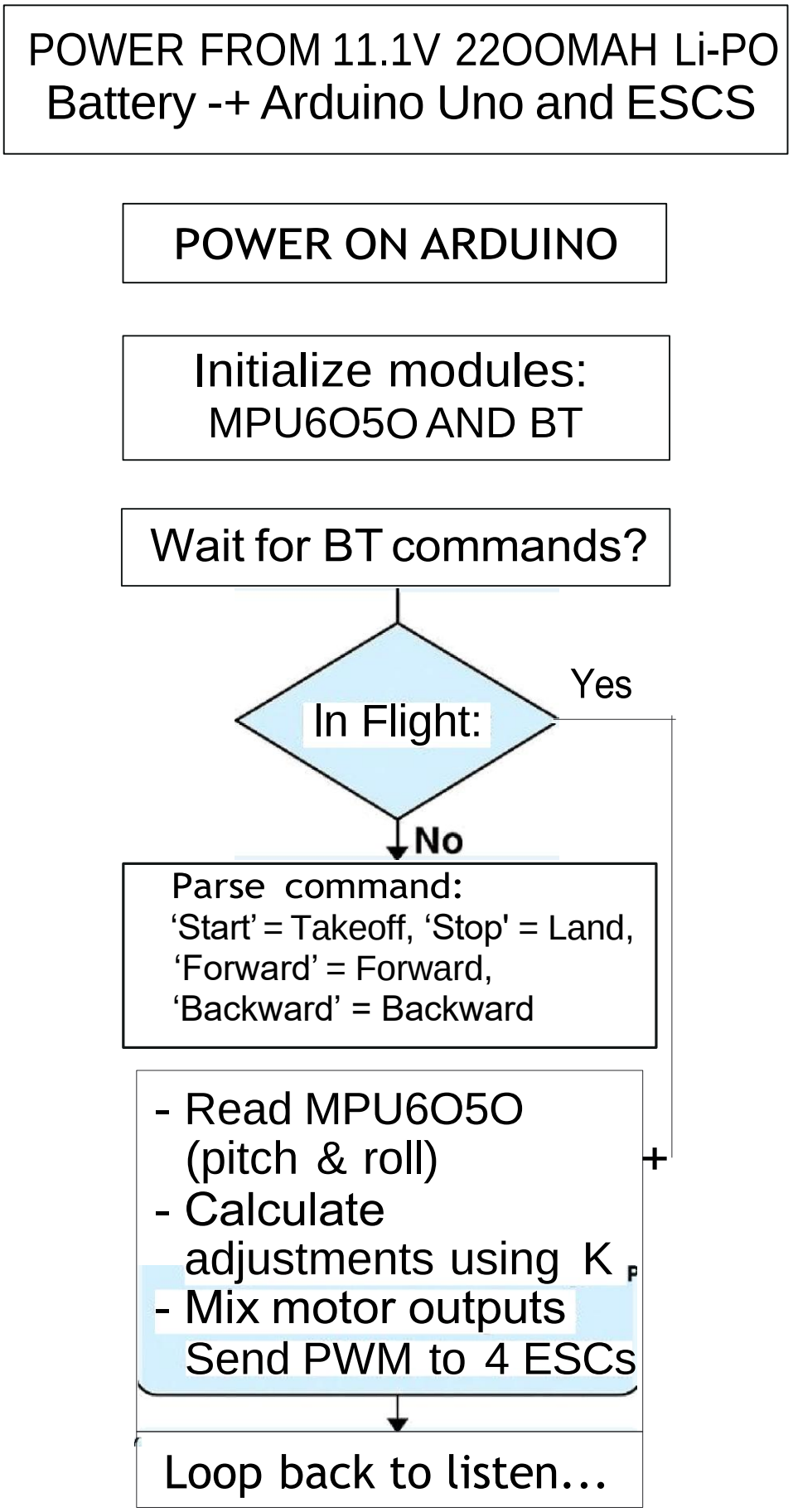


**Fig 5.8: Total Workflow Of VoiceFly**

## Table 5.2: Key Performance Metrics:

| Parameter | Measured Result |
|---|---|
| Average Flight Time | 11 minutes |
| Command Response Delay | < 150 ms |
| Effective Bluetooth Range | 8–10 meters |
| Hover Time (stable) | 6–8 seconds |
| ESC Calibration Error Rate | 0% after tuning |

# CHAPTER 6: CURRENT STATUS, FUTURE WORK AND CONCLUSION

## 6.1 Current Status (Bluetooth Functional, Flight Control Verified)

As of the latest phase of development, the VoiceFly drone prototype is fully functional using Bluetooth- based control through the HC-05 module and an Android smartphone application. All hardware components, including the Arduino UNO, Electronic Speed Controllers (ESCs), brushless motors, and the LiPo battery, have been successfully integrated and tested.

**Key Achievements:**

- Bluetooth Control: The drone responds accurately and reliably to directional commands such as *take off*, *land*, *move forward*, *backward*, *left*, and *right*.
- Flight Stability: During indoor testing, VoiceFly demonstrated stable lift and hover capabilities.
- System Reliability: With proper calibration, ESCs and motors worked in synchronization, providing efficient power distribution and maneuvering ability.
- User Interface: The mobile app used to transmit Bluetooth commands was simple, responsive, and compatible with multiple Android devices.

Overall, the core functionality of manual wireless control using Bluetooth has been validated, making VoiceFly ready for real-world demos, academic exhibitions, or as a foundation for more advanced upgrades.

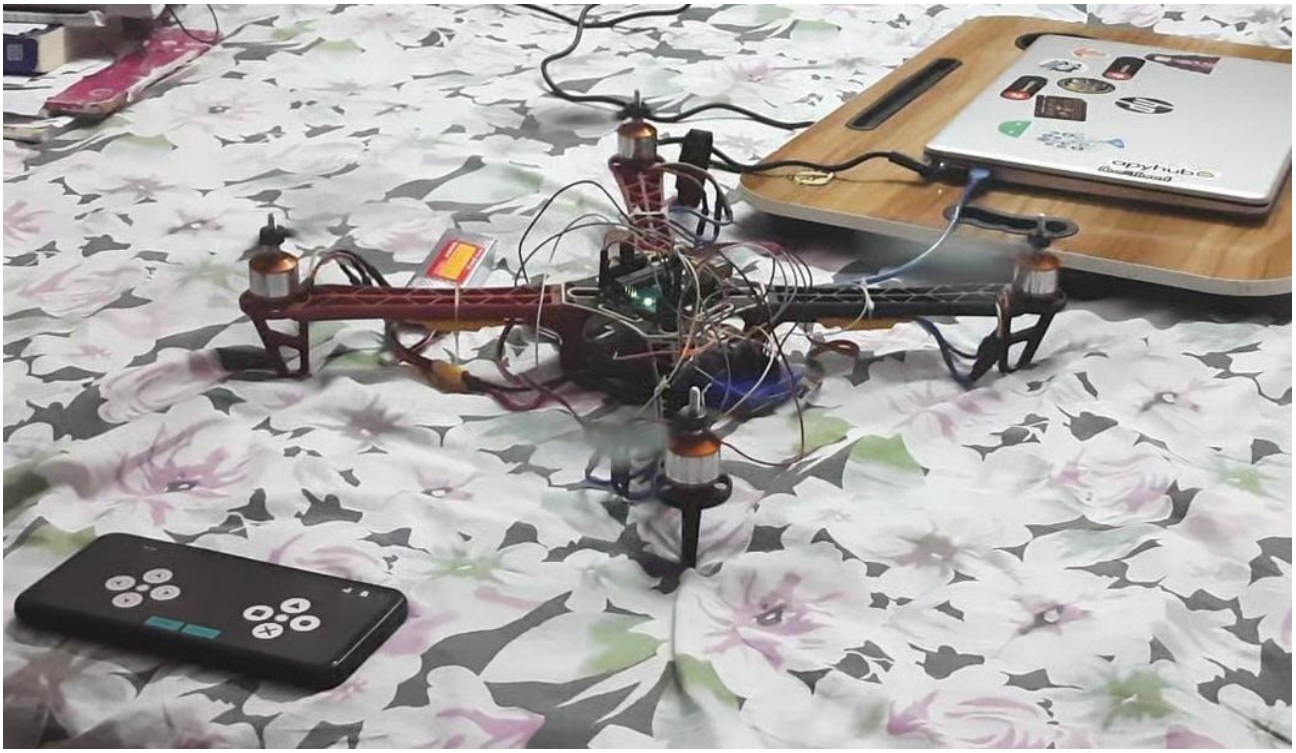

**Fig 6.1: Operational VoiceFly**

## 6.2 Future Enhancements (Autonomous Features, Sensor Integration)

While VoiceFly has achieved its foundational objectives, several enhancements are planned to take the project from a semi-manual system to an intelligent, semi-autonomous aerial platform. These future upgrades will improve versatility, usability, and autonomy.

### Voice Recognition Integration

- Goal: Enable users to control the drone using voice commands like *"take off"*, *"land"*, *"move forward"*, etc.
- Tools: Integration with Google Assistant, IFTTT, and voice-controlled Android apps.
- Implementation: Bluetooth app with speech-to-text capabilities, sending character codes to Arduino.
- Challenges: Requires accurate speech interpretation, noise filtering, and command confirmation logic.

### Sensor-Based Stability Enhancements

- Accelerometer: To maintain level flight and compensate for external disturbances.
- Ultrasonic Sensor: For auto-landing and obstacle avoidance at low altitudes.

### GPS Module Integration4

- To allow location tracking and waypoint navigation.
- Useful for autonomous missions or geo-fencing applications.

### IoT and Remote Monitoring

- Adding Wi-Fi modules like NodeMCU (for future scope) to enable web-based interfaces for drone telemetry, location, and battery data.
- Potential integration with cloud platforms (like Firebase or Adafruit IO).

### Android App Customization

- Develop a dedicated Android application with both manual and voice control UI, sensor data display, and custom command mapping.

### Improved Battery Life

Battery performance remains a limitation in most drone systems. Future improvements could focus on:

- **Energy-Efficient Motors**: Using more efficient motors to reduce power consumption.
- **Solar Charging Systems**: Adding lightweight solar panels for extended operational time.
- **Battery Management Systems (BMS)**: To optimize energy usage and prolong battery lifespan.

### Modular Design for Customization

Redesigning the drone with a modular structure would allow users to swap components, such as cameras, sensors, or batteries, based on specific needs. This approach would make the drone highly versatile and adaptable to a wide range of applications.

## 6.3 Commercial Use Potential

With some enhancements, VoiceFly can find meaningful application in both personal and professional settings:

**Educational & Research Applications:**

- Ideal for engineering students, hobbyists, and researchers to explore drone dynamics, embedded programming, and wireless communication.

**Surveillance & Inspection:**

- Can be used in indoor surveillance with minimal noise.
- Add-ons like a camera and ultrasonic sensors can turn it into a room-mapping robot.

**Healthcare and Emergency Use:**

- Voice-controlled flying platforms can help people with disabilities navigate or deliver small medical payloads in indoor environments.

**Agricultural and Industrial Monitoring (With Future Enhancements):**

- Integration with sensors and GPS may allow it to scan crop health or monitor closed industrial environments.

The potential expands significantly when the drone becomes semi-autonomous and voice-responsive, making it a viable low-cost platform for a wide range of niche markets.

## 6.4 Conclusion

The VoiceFly Bluetooth-controlled drone project has demonstrated how embedded systems, wireless communication, and mechanical design can be combined to build an interactive and responsive unmanned aerial vehicle. The use of Arduino UNO and the HC-05 Bluetooth module has proven to be a reliable foundation for low-cost, short-range drone control using a mobile phone interface.

The project accomplished all its core objectives, including:

- Stable wireless control through Bluetooth.
- Effective ESC and motor coordination.
- Proper drone balance and safe flight operation.
- Successful real-time testing with mobile app command inputs.

While current functionality is based on Bluetooth control, the system design has been planned to support future upgrades like voice recognition, Wi-Fi control, GPS navigation, and IoT data analytics. These enhancements will extend its application across multiple fields and bring the drone closer to a truly smart flying system.

In conclusion, VoiceFly is not just a project, but a scalable platform for future innovation in aerial robotics. It bridges the gap between theoretical embedded system knowledge and real-world engineering practices, offering a gateway to more complex and autonomous UAV developments.

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# APPENDIX

This appendix provides the essential codes required for implementing the Bluetooth- controlled drone project using Arduino UNO, HC-05 and MPU6050.

---

## Arduino Code for Voice Bluetooth-Controlled Drone (VoiceFly)

```
#include <Wire.h>
#include <Servo.h>
#include <MPU6050.h>
#include <SoftwareSerial.h>

MPU6050 mpu;
SoftwareSerial BT(2, 3);  // RX, TX for HC-05
Servo esc1, esc2, esc3, esc4;
// Throttle constants
const int minThrottle = 1000;
const int takeoffThrottle = 1300;
const int maxThrottle = 2000;
// State variables
bool escCalibrated = false;
bool escArmed = false;
bool motorsStarted = false;
int speedVal = 0;  // Current throttle/speed of motors

void setup() {
  Serial.begin(9600);
  BT.begin(9600);
  Wire.begin();
  mpu.initialize();
  esc1.attach(5);
  esc2.attach(6);
  esc3.attach(9);
  esc4.attach(10);
  speedVal = minThrottle;  // start at min throttle
```

```
  Serial.println(F("========== Drone Voice Control =========="));
  Serial.println(F("Serial commands:"));
  Serial.println(F(" - calibrate : Calibrate ESCs"));
  Serial.println(F(" - arm       : Arm ESCs"));
  Serial.println(F("Bluetooth commands:"));
  Serial.println(F(" - start     : Start motors"));
  Serial.println(F(" - stop      : Stop motors"));
  Serial.println(F(" - speed up  : Increase throttle"));
  Serial.println(F(" - speed down: Decrease throttle"));
  Serial.println(F("========================================="));
}

void loop() {
  // PC Serial commands for ESC calibration and arming
  if (Serial.available()) {
    String input = Serial.readStringUntil('\n');
    input.trim();
    input.toLowerCase();
    if (input == "calibrate") {
      calibrateESCs();
    } else if (input == "arm") {
      armESCs();
    }
  }
  // Bluetooth commands for controlling motors
  if (BT.available()) {
    String cmd = BT.readStringUntil('\n');
    cmd.trim();  // Remove whitespace/newline chars
    if (cmd.length() > 0) {  // Only process non-empty commands
      Serial.print(F("Bluetooth Command: "));
      Serial.println(cmd);
      handleBTCommand(cmd);
    }
  }
  if (motorsStarted) {
    stabilize();  // Optional MPU6050 stabilization placeholder
```

```
  }
}
// ESC Calibration process
void calibrateESCs() {
  Serial.println(F("Starting ESC Calibration..."));
  Serial.println(F(">>> Unplug the LiPo battery now. <<<"));
  delay(3000);
  Serial.println(F("Sending MAX throttle..."));
  setAllMotors(maxThrottle);
  delay(2000);
  Serial.println(F(">>> Plug in the LiPo battery NOW. ESCs will beep. <<<"));
  delay(5000);
  Serial.println(F(">>> Press ENTER to finish calibration and send MIN throttle <<<"));
  while (!Serial.available()) {
    // wait for user input on serial monitor
  }
  Serial.read();  // clear the serial buffer
  Serial.println(F("Sending MIN throttle..."));
  setAllMotors(minThrottle);
  delay(3000);
  Serial.println(F("Calibration complete! Type 'arm' to arm ESCs."));
  escCalibrated = true;
  escArmed = false;
  motorsStarted = false;
  speedVal = minThrottle;
}
// Arming ESCs (after calibration)
void armESCs() {
  if (!escCalibrated) {
    Serial.println(F("ESCs are not calibrated. Please type 'calibrate' first."));
    return;
  }
  Serial.println(F("Arming ESCs..."));
  for (int i = 0; i < 5; i++) {
    setAllMotors(minThrottle);
    delay(1000);
```

```
  }
  Serial.println(F("ESCs armed. Ready for commands."));
  escArmed = true;
  motorsStarted = false;
  speedVal = minThrottle;
}
// Set throttle for all motors
void setAllMotors(int throttle) {
  esc1.writeMicroseconds(throttle);
  esc2.writeMicroseconds(throttle);
  esc3.writeMicroseconds(throttle);
  esc4.writeMicroseconds(throttle);
}
// Stop motors gradually
void stopMotors() {
  for (int s = speedVal; s >= minThrottle; s -= 25) {
    setAllMotors(s);
    delay(100);
  }
  setAllMotors(minThrottle);
  speedVal = minThrottle;
  motorsStarted = false;
}
// Handle Bluetooth commands
void handleBTCommand(String cmd) {
  if (!escArmed) {
    Serial.println(F("ESCs are not armed. Please calibrate and arm first."));
    return;
  }
  if (cmd == "start") {
    motorsStarted = true;
    speedVal = takeoffThrottle;
    setAllMotors(speedVal);
    Serial.println(F("Motors started!"));
  }
  else if (cmd == "stop") {
```

```
    stopMotors();
    Serial.println(F("Motors stopped."));
  }
  else if (motorsStarted) {
    if (cmd == "speed up") {
      speedVal += 50;
      if (speedVal > maxThrottle) speedVal = maxThrottle;
      setAllMotors(speedVal);
      Serial.print(F("Speed increased to "));
      Serial.println(speedVal);
    }
    else if (cmd == "speed down") {
      speedVal -= 50;
      if (speedVal < minThrottle) speedVal = minThrottle;
      setAllMotors(speedVal);
      Serial.print(F("Speed decreased to "));
      Serial.println(speedVal);
    }
  }
}

// MPU6050 stabilization placeholder (future)
void stabilize() {
  // Here you can implement MPU6050-based stabilization if needed
}
```

## Android Bluetooth Command Mapping (Using App like "Bluetooth Electronics" or "BT Voice Control for Arduino")

| Button Label | Command Sent | Function |
|---|---|---|
| Forward | F | Moves drone forward |
| Backward | B | Moves drone backward |
| Left | L | Moves drone left |
| Right | R | Moves drone right |
| Up/Take Off | U | Drone takes off |
| Down/Land | D | Drone lands |
| Stop/Hover | S | Hover / Stop |

## MPU6050 Integration Code

```
#include <Servo.h>
#include <SoftwareSerial.h>
#include <Wire.h>
#include <MPU6050.h>

MPU6050 mpu;

Servo motor1, motor2, motor3, motor4;
SoftwareSerial BT(2, 3); // RX, TX

const int escPin1 = 5, escPin2 = 6, escPin3 = 9, escPin4 = 10;

int throttle = 1000;
bool escCalibrated = false;
bool escArmed = false;

float pitch, roll, yaw;

void setup() {
  Serial.begin(9600);
  BT.begin(9600);
  Wire.begin();

  mpu.initialize();
  if (!mpu.testConnection()) {
    Serial.println("MPU6050 connection failed");
    while (1);
  }
  Serial.println("MPU6050 connected");

  motor1.attach(escPin1);
  motor2.attach(escPin2);
  motor3.attach(escPin3);
  motor4.attach(escPin4);

  stopMotors();

  Serial.println("Type 'calibrate' then 'arm' via Serial to begin.");
}

void loop() {
  readMPU();

  // Serial commands for calibrate/arm
  if (Serial.available()) {
    String command = Serial.readStringUntil('\n');
    command.trim();
    if (command == "calibrate") calibrateESCs();
    else if (command == "arm") armESCs();
  }

  // Bluetooth/Voice commands
```

```
  if (BT.available()) {
    String btCmd = BT.readStringUntil('\n');
    btCmd.trim(); btCmd.toLowerCase();
    Serial.print("Bluetooth Command: "); Serial.println(btCmd);

    if (!escArmed) {
      Serial.println("ESCs are not armed.");
      return;
    }

    if (btCmd == "start") runMotors(throttle);
    else if (btCmd == "stop") stopMotors();
    else if (btCmd == "speed up") { throttle = constrain(throttle + 50, 1000, 2000); runMotors(throttle);
}
    else if (btCmd == "speed down") { throttle = constrain(throttle - 50, 1000, 2000);
runMotors(throttle); }
    else if (btCmd == "uplift") { throttle = constrain(throttle + 100, 1000, 2000); runMotors(throttle); }
    else if (btCmd == "land") { for (int t = throttle; t >= 1000; t -= 25) { runMotors(t); delay(100); }
stopMotors(); }
    else if (btCmd == "left") runMotors(throttle - 20, throttle + 20, throttle - 20, throttle + 20); // Roll
    else if (btCmd == "right") runMotors(throttle + 20, throttle - 20, throttle + 20, throttle - 20); // Roll
    else if (btCmd == "forward") runMotors(throttle + 20, throttle + 20, throttle - 20, throttle - 20); //
Pitch forward
    else if (btCmd == "backward") runMotors(throttle - 20, throttle - 20, throttle + 20, throttle + 20); //
Pitch back
  }

  // Stabilize if armed
  if (escArmed) stabilize();
}

// Reads pitch/roll from MPU6050
void readMPU() {
  int16_t ax, ay, az, gx, gy, gz;
  mpu.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);
  pitch = atan2(ax, sqrt(ay * ay + az * az)) * 180 / PI;
  roll = atan2(ay, sqrt(ax * ax + az * az)) * 180 / PI;
}

// Stabilization
void stabilize() {
  int correctionPitch = pitch * 2;
  int correctionRoll = roll * 2;

  int m1 = throttle - correctionPitch + correctionRoll;
  int m2 = throttle - correctionPitch - correctionRoll;
  int m3 = throttle + correctionPitch - correctionRoll;
  int m4 = throttle + correctionPitch + correctionRoll;

  runMotors(m1, m2, m3, m4);
}

// ESC functions
void calibrateESCs() {
  Serial.println("Disconnect battery, press Enter.");
```

```
  while (!Serial.available()) {}
  Serial.read();
  motor1.writeMicroseconds(2000);
  motor2.writeMicroseconds(2000);
  motor3.writeMicroseconds(2000);
  motor4.writeMicroseconds(2000);
  Serial.println("Connect battery, then press Enter.");
  while (!Serial.available()) {}
  Serial.read();
  stopMotors();
  escCalibrated = true;
  Serial.println("ESCs calibrated.");
}

void armESCs() {
  if (!escCalibrated) { Serial.println("Calibrate first."); return; }
  runMotors(1000); delay(2000); stopMotors();
  escArmed = true;
  Serial.println("ESCs armed.");
}

// Motor control
void runMotors(int t) {
  motor1.writeMicroseconds(t);
  motor2.writeMicroseconds(t);
  motor3.writeMicroseconds(t);
  motor4.writeMicroseconds(t);
}

void runMotors(int m1, int m2, int m3, int m4) {
  motor1.writeMicroseconds(constrain(m1, 1000, 2000));
  motor2.writeMicroseconds(constrain(m2, 1000, 2000));
  motor3.writeMicroseconds(constrain(m3, 1000, 2000));
  motor4.writeMicroseconds(constrain(m4, 1000, 2000));
}

void stopMotors() {
  runMotors(1000);
}
```

## Motor Calibration Code

```
  #include <Servo.h>

  // Create servo objects for each motor
  Servo escFL;
  Servo   escFR;
  Servo   escBL;
  Servo escBR;

  // Define throttle value
  int throttle = 1500; // Middle throttle for testing

  void setup() {
```

```
    Serial.begin(115200);
    Serial.println("Starting
    setup...");

    // Attach ESC signal wires to
    PWM pins escFL.attach(5);    //
    Front Left Motor escFR.attach(6);
                    // Front Right Motor
    escBL.attach(9);                //
    Back Left Motor
    escBR.attach(10); // Back Right
    Motor

    // Step 1: Send minimum throttle to arm ESCs
    Serial.println("Sending minimum throttle to arm
    ESCs..."); escFL.writeMicroseconds(1000);
    escFR.writeMicroseconds(1000);
    escBL.writeMicroseconds(1000);
    escBR.writeMicroseconds(1000);

    delay(3000); // Wait 3 seconds for ESCs to arm (VERY IMPORTANT)

    // Step 2: Set fixed throttle
    Serial.println("Setting motors to 1500 throttle...");
    escFL.writeMicroseconds(throttle);
    escFR.writeMicroseconds(throttle);
    escBL.writeMicroseconds(throttle);
    escBR.writeMicroseconds(throttle);

    Serial.println("Motors should now be spinning at medium speed!");
}

void loop() {
    // Do nothing in loop. Motors stay spinning.
}
```

## Calibration Notes

- Make sure to **calibrate each ESC** with its corresponding motor before the first flight.
- Use a **separate calibration sketch** or test setup to write full throttle (2000) and zero throttle (1000) signals to each ESC.
- Always test motors **without propellers** during programming and debugging