A SECOND YEAR MINI PROJECT REPORT ON

CONTROLLING BLDC MOTOR USING PID FOR SINGLE AXIS DRONE

BACHELOR OF TECHNOLOGY

IN

ROBOTICS & AUTOMATION

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BUDGET OF THE PROJECT

Sr. No.	Description of part with Specification	Quantity (no's)	Price/item (₹)	Total cost (₹)
1	ESC	3	396	1190
2	UNO ARDUINO WITH CABEL	1	575	575
3	CONNECTORS	1	152	152
4	BULLET CONNECTORS	10	21	210
5	BLDC MOTORS	2	380	760
6	MPU 6050	1	115	115
7	XT 60 CONNECTOR	4	55	220
8	SMPS	1	700	700
9	BATTERY	1	1	1500
10	PROPELLER	1	150	300
11	MISCELLANEOUS	-	-	500
			TOTAL	5722

1. INTRODUCTION

In recent years, the proliferation of unmanned aerial vehicles (UAVs), commonly known as drones, has transformed various industries by providing cost-effective solutions for tasks ranging from aerial photography to surveillance and agriculture. Among the multitude of drone configurations, single-axis drones have emerged as a specialized platform for applications that prioritize precise positioning and stability along a single axis of motion. However, achieving optimal control of single-axis drones presents unique challenges, particularly in controlling the propulsion system's Brushless DC (BLDC) motors to ensure smooth and stable flight.

BLDC motors offer numerous advantages over traditional brushed DC motors, including higher efficiency, lower maintenance requirements, and increased power density. Leveraging these benefits, coupled with advanced control techniques, holds the key to unlocking the full potential of single-axis drones in various industries. One such control strategy that has garnered considerable attention is the Proportional-Integral-Derivative (PID) control method, renowned for its ability to regulate motor speed or position with precision and stability.

The integration of PID control with BLDC motors for single-axis drone applications represents a promising avenue for enhancing flight stability, maneuverability, and overall performance. By dynamically adjusting the motor's speed or position based on feedback from onboard sensors, PID controllers can effectively counteract disturbances and maintain the desired flight trajectory even in challenging environmental conditions.

Despite the potential benefits, implementing PID control for BLDC motors in single-axis drones poses several technical and practical challenges. These include the selection and tuning of PID controller parameters, integration with the drone's control system architecture, and real-time responsiveness to changing operating conditions. Addressing these challenges requires a systematic approach, combining theoretical analysis, experimental validation, and iterative refinement of control algorithms.

This report aims to explore the feasibility and effectiveness of controlling BLDC motors using PID for single-axis drone applications. By examining the underlying principles of BLDC motor control, PID control theory, and relevant literature on drone technology, we seek to identify the key factors influencing the performance of PID-controlled BLDC motors in single-axis drones.

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We aim to develop an optimized PID control system for controlling a Brushless DC (BLDC) motor in a single-axis drone using an Arduino microcontroller and a gyroscope sensor. The goal is to achieve stable and precise motor control, enabling smooth and responsive drone operation in dynamic environments.

In the subsequent sections, we delve into the literature review to contextualize our research within the broader domain of BLDC motor control and PID-based drone applications. We then articulate the problem statement and objectives guiding our investigation, followed by a detailed methodology outlining our experimental approach and data analysis procedures.

2. LITERATURE REVIEW

SR NO	AUTHOR NAME	TITLE	OBJECTIVE	METHODOLOGY	ACCURACY /RESULTS
1.	Ahmed K. Hassan, Fayez F. Areed	Brushless DC Motor Speed Control using PID Controller, Fuzzy Controller, and Neuro Fuzzy Controller	To Investigate the feasibility and effectiveness of using PID control for stabilizing and controlling BLDC motors in single-axis drone applications.	Discussion of the process for selecting and tuning PID controller parameters to optimize motor control performance. Discussion of the performance metrics used to evaluate the effectiveness of the PID control system, such as settling time, overshoot, and tracking accuracy.	PID controller has a moderate response with 10% load from rated torque. Fuzzy controller has a good response with the same 10% load from rated torque.it has a rise time 0.00977 sec. which is longer slightly than PID controller
2.	Y.Narendra Kumar, P.Eswara Rao, Vijay Varma	Speed Control of BLDC Motor Drive By Using Pid Controllers	In this paper PID controller is implemented with speed feedback loop and it is observe that torque ripples are minimized. Simulation is carried out using MATLAB / SIMULINK	Design and assemble a test setup comprising a BLDC motor, appropriate sensors for shaft position sensing, and an electronic controller. Develop a PID control algorithm tailored to regulate the speed or position of the BLDC motor effectively.	By comparing the performances of Permanent-magnet brushless dc motor with PI and PID controller it is concluded that PID response gives high efficiency. Due to this high efficiency, higher torque will be produced in low-speed range, and it has high power density, low maintenance and less noise than other motors.
3.	S. Srikanth; G. Raghu Chandra	Modeling and PID Control of the Brushless DC Motor with Generic Algorithm	This research aims to develop a comprehensive BLDC motor control model, focusing on position control. To improve upon conventional PID controller tuning, we propose utilizing Genetic Algorithm.	Develop a mathematical model of the BLDC motor system, considering factors such as motor dynamics, electrical characteristics, and mechanical properties. Implement a Genetic Algorithm optimization framework to search for optimal PID controller gains. Define the fitness function based on control system performance metrics, such as settling time, overshoot, and steady-state error.	Simulation results showed that PID control tuned by GA provides more efficient closed loop response for position control of BLDC motor

3. PROBLEM STATEMENT AND OBJECTIVES

PROBLEM STATEMENT:

The integration of brushless DC (BLDC) motors in single-axis drones poses a significant challenge in achieving stable and precise control, particularly in dynamic environments. Although proportional-integral-derivative (PID) controllers are commonly used for motor control due to their simplicity, the optimal tuning of PID parameters for BLDC motors in single-axis drone applications remains a complex and unresolved issue. The lack of a systematic approach for determining the optimal PID gains results in suboptimal performance, leading to issues such as oscillations, overshooting, and poor responsiveness.

Furthermore, the unique dynamics and operational constraints of single-axis drones necessitate specialized control strategies to ensure smooth and accurate motor control. Factors such as varying payload weights, aerodynamic disturbances, and environmental conditions further complicate the control problem, requiring robust and adaptive control algorithms.

Hence, there is a pressing need to develop an optimized PID controller specifically tailored for controlling BLDC motors in single-axis drone applications.

OBJECTIVES:

1. To understand how the PID Works inside the drone
2. To interface the two BLDC motor with ESC and Two ESC with Microcontroller.
3. To interface the MPU6050 with Microcontroller. The MPU6050 acts a Sensor.
4. To assemble the above connections and give signal to the controller to control the movement of the BLDC motor. Controls the motor with the help of PID.
5. To Ensure stable and precise control of the BLDC motor to maintain the drone's stability during flight.

4. METHODOLOGY

1. System Identification:

Collecting data from the BLDC motor and gyroscope sensor to characterize the system dynamics.
Conducting system identification techniques such as step response analysis or frequency response testing to model the motor and drone dynamics.

2. **Feedback from Sensor:**

Utilizing a gyroscope sensor to measure the drone's angular position and velocity.
Implementing sensor fusion algorithms to combine gyroscope data with accelerometer readings for accurate orientation estimation.

3. Feedback Sensor Processing:

To Process sensor data using appropriate filtering and signal processing techniques to remove noise and extract relevant information.

4. PID Controller Design:

Obtain the values from inbuilt PID controller to regulate the BLDC motor's speed or position based on feedback from the gyroscope sensor.
Use the identified system model to guide the selection of PID controller parameters (proportional, integral, and derivative gains).

5. PID Tuning:

Employing Auto-tuning algorithms to optimize PID controller parameters.
Conduct experiments to validate the performance of different PID parameter sets and select the optimal tuning configuration.

6. Controller Implementation:

Implement the PID values on an Arduino microcontroller platform to execute real-time motor control.
Interface the Arduino with the gyroscope sensor to receive feedback data and adjust motor commands accordingly.

7. Closed-Loop Control:

This forms A closed-loop control system where the PID controller continuously adjusts the motor's speed or position based on feedback from the gyroscope sensor.

8. Integration and Testing:

Integrate the PID-controlled BLDC motor and gyroscope sensor into the single-axis drone platform.
Conduct extensive testing to evaluate the performance of the control system under various conditions.

9. Validation and Optimization:

Validate the effectiveness of the PID control system by Iterating on the design and tuning of the control system based on testing results, optimizing performance for improved stability.

FLOWCHART:

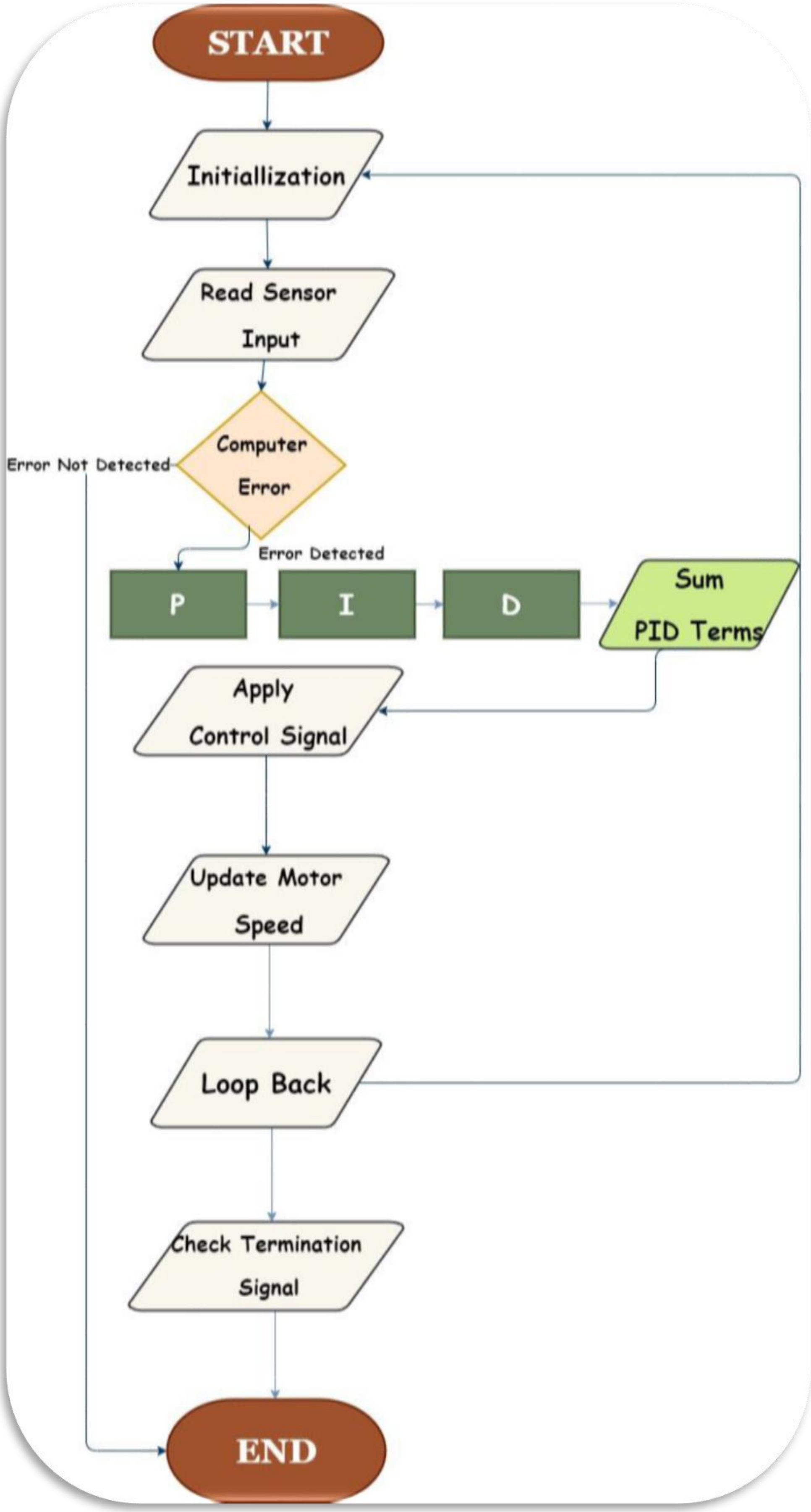

Figure 1: Flowchart

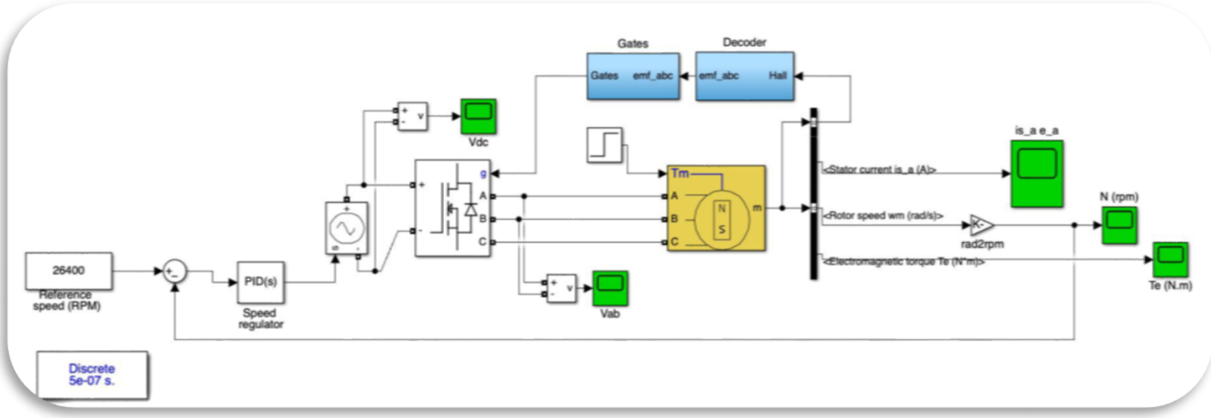

Figure 2: Simulink BLDC Motor Control

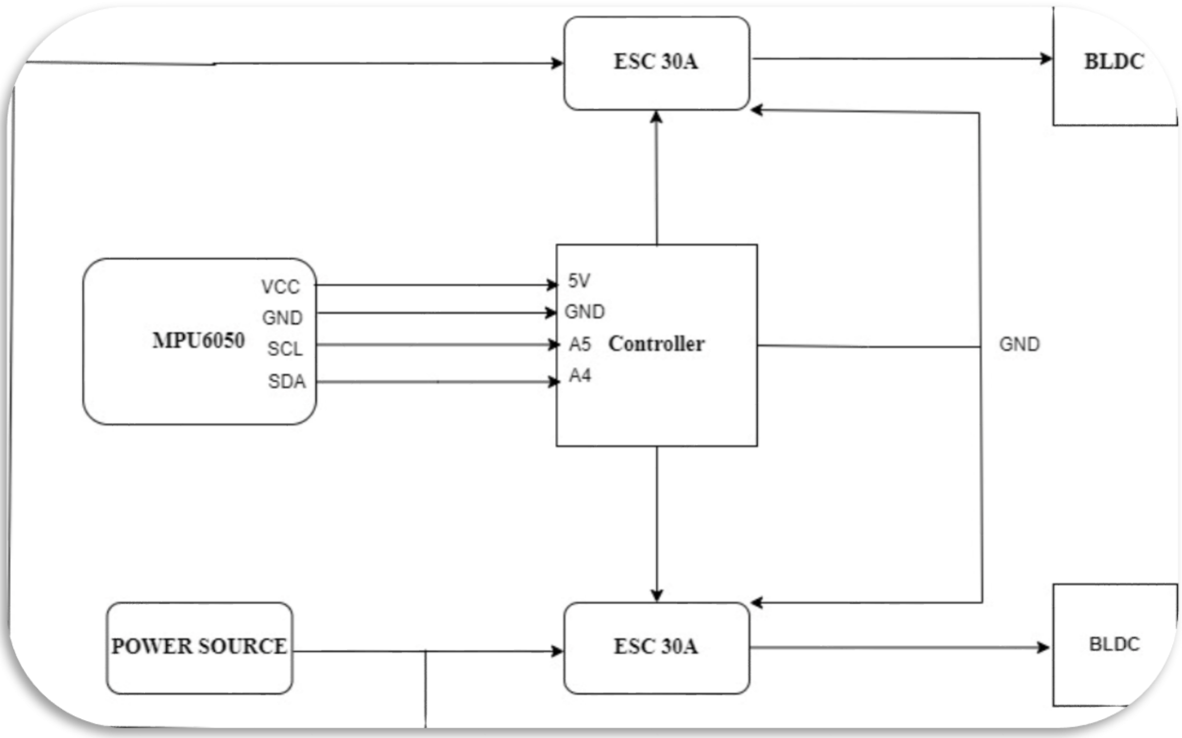

Figure 3: Block Diagram

5. RESULTS

Figure 4: Constructed Project Model

System Identification:
Understood the dynamics of BLDC motor and the drone's single axis. This includes determining the motor's response to various inputs and its transfer function.

Understood PID Controller Design:

- Proportional (P) Term: A response to the current error. Adjusting its gain to control the response speed.
- Integral (I) Term: This term integrates the error over time, helping to eliminate steady-state error. Tune it to correct any bias in the system.
- Derivative (D) Term: This term predicts future error based on its rate of change. Use it to dampen the system's response and reduce overshoot.

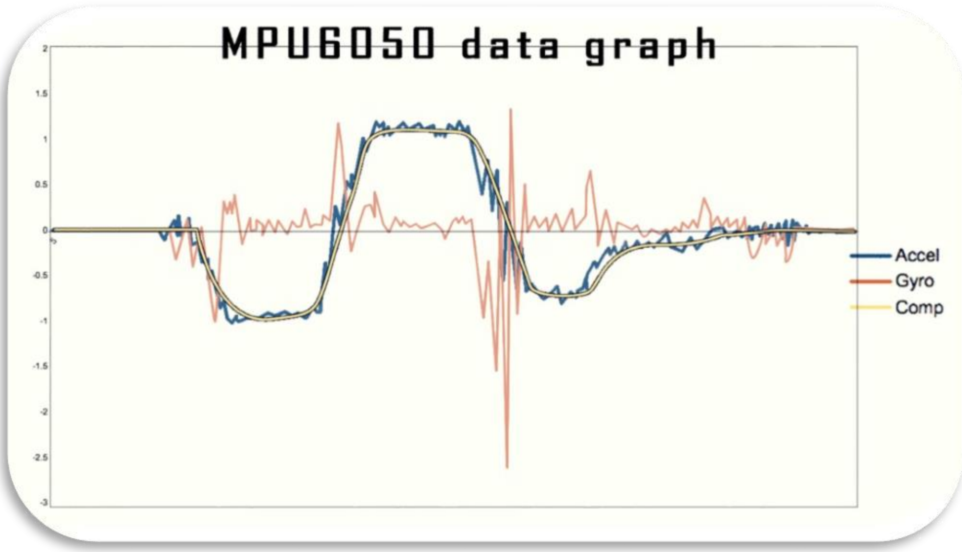

Figure 5: Generated Graph Data

6. CONCLUSION

- This project serves as a stepping stone for further exploration of drone flight control systems and PID control applications.

- Calibrating brushless motors is essential for smooth and efficient drone operation.

- PID control is a powerful technique for regulating systems to a desired state.

- We have implemented this project on one axis to understand how PID works in Drone further for future scope we can use it for two axis i.e in drone.

7. FUTURE SCOPE

The successful implementation of PID control for a single-axis drone opens up several avenues for future research and development:

- **Multi-axis Control:** Expanding the PID control system to manage multiple axes of movement would enable more complex maneuvers and flight patterns. This could involve synchronizing the control of multiple motors to achieve coordinated motion in two or three dimensions.
- **Advanced Control Algorithms:** Investigating alternative control algorithms, such as fuzzy logic, adaptive control, or model predictive control, could potentially improve the drone's performance in different operating conditions or environments.
- **Sensor Fusion:** Integrating additional sensors, such as inertial measurement units (IMUs), GPS, or cameras, can enhance the drone's perception and navigation capabilities. Sensor fusion techniques can combine data from multiple sources to improve position estimation, obstacle avoidance, and overall flight stability.
- **Autonomous Navigation:** Developing autonomous navigation algorithms that utilize PID control along with path planning and obstacle detection algorithms could enable the drone to operate independently and perform complex tasks without human intervention.

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