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JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING

JSS SCIENCE AND TECHNOLOGY UNIVERSITY MYS

Branch: Electronics and Communication Engineering (4th Semester)

Section: A Subject: Microcontrollers and embedded systems

Event-2 Synopsis

Topic: **Design and Implementation of a Flight Controller for Active Fin Stabilization in High-Speed Rocketry (AFCS)**

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Introduction:

In high-speed rocketry, stability and accurate trajectory control are crucial for performance and safety. Passive stabilization using fixed fins is often insufficient in the presence of crosswinds or trajectory disturbances. To address this, Active Fin Control Systems (AFCS) are developed to dynamically adjust fin angles during flight using real-time sensor data and onboard processing. This project focuses on the design and implementation of a compact, efficient flight controller capable of driving fin-mounted servos in response to orientation changes, improving stability and flight accuracy in amateur or research rocketry.

Components Used:

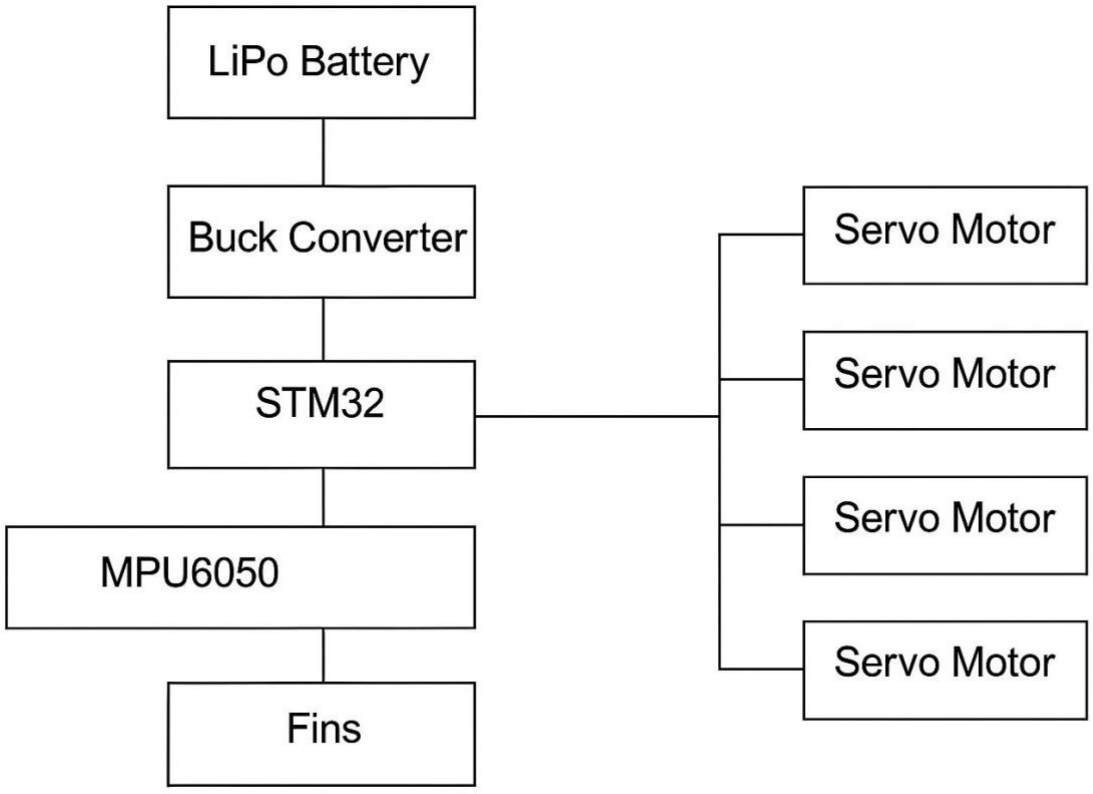
Component	Function
STM32F411 Black Pill	Main flight controller for real-time processing
MPU6050	6-axis IMU for gyroscope and accelerometer data
BMP180	Barometric pressure sensor for altitude
Sg90 Servos	Actuate fins based on controller output
3.3V Regulator	Voltage regulation for sensors and STM32
Lion Battery (3.7v 2S)	Power source
Buck Converter (7V op)	Servo power regulation

Method of Implementation:

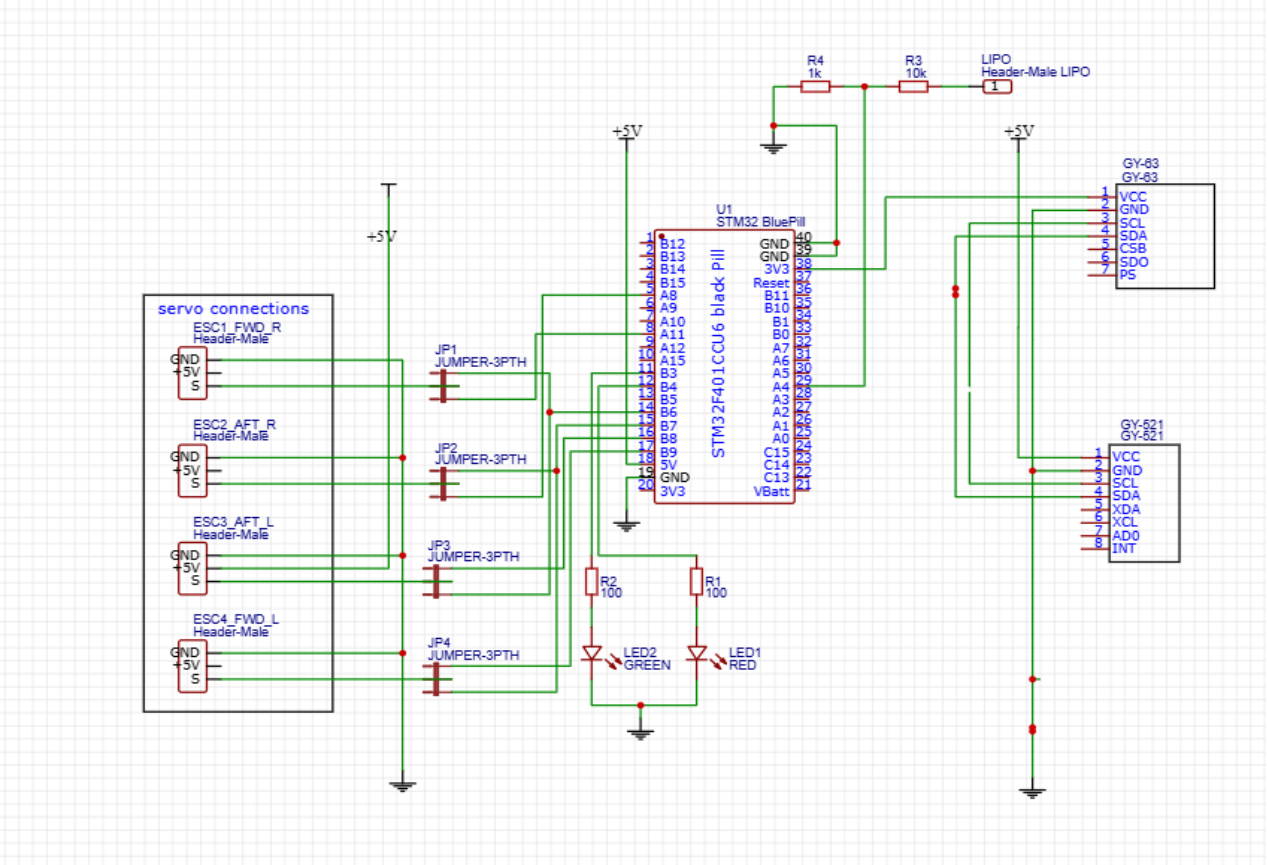
1. **Sensor Initialization:** The MPU6050 and BMP180 are initialized on I2C. The IMU continuously streams orientation (pitch, roll, yaw) and acceleration data.
2. **Orientation Estimation:** A complementary filter or Kalman filter is used to estimate accurate angular positions.
3. **Control Algorithm:** A PID controller calculates required servo movements to counteract any deviation from a stable flight path.

4. **Servo Actuation:** Calculated correction signals are sent as PWM outputs to control the angular position of the fins via servos.

Logic Diagram:



Circuit Diagram:



Expected Output:

- Real-time stabilization during rocket flight.
- Accurate telemetry and sensor data
- Fin movements in response to changes in pitch/roll to counteract trajectory deviations.
- Improved flight path accuracy and reduced wobbling.

Applications:

- Pitch and yaw controls in rockets
- Used in sounding rockets for mitigation of weather cocking

Conclusion:

The Active Fin Control System enhances the aerodynamic stability and accuracy of high-speed rockets through real-time feedback and fin adjustments. With reliable IMU data processing and responsive PID-controlled servo actuation, the system mitigates disturbances during flight. This project bridges embedded systems, control theory, and aerodynamics to create a robust and scalable flight stabilization platform for model rocketry and experimental aerospace applications.

References:

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3. InvenSense MPU6050 Product Specification

   https://partsearch.io/invensense/mpu-6050/

4. Bosch BMP180 Datasheet

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