

Reaction Wheel-Based CubeSat Attitude Control System

1. Working Principle & Features

- **PID-Based Attitude Stabilization**

The CubeSat utilizes a real-time PID control algorithm to stabilize its orientation along three axes (X, Y, Z) using reaction wheels.

- **Triple BLDC Motor Configuration**

Each axis has a dedicated NEMA17 BLDC motor controlled via a VESC. The X-axis motor is directly managed by the Arduino Nano through UART, while Y and Z axes communicate via CAN bus.

- **Sensor Fusion with MPU9250**

The IMU provides 9-axis data, processed via the Madgwick filter on the Arduino Nano to derive precise orientation information for PID correction.

1. Components Used

- **Microcontroller**

Arduino Nano acts as the central processor for PID control and communication with peripherals.

- **Sensors**

- MPU9250: Real-time orientation data via I2C
- Hall Sensors (x3): Built-in RPM feedback from BLDCs
- NTC 10K Thermistors (x3): Temperature monitoring on motors

- **Actuators**

- NEMA17 BLDC Motors (x3): Sensored motors acting as reaction wheels
- VESCs (x3): Configured motor controllers for precise control

- **Storage**

Catalex MicroSD Card Module logs operational data via SPI.

1. System Behavior & Safety

- **Attitude Correction**

If misalignment is detected, PID control commands the motors until the orientation matches the setpoint.

- **Fault Handling**

In case of failure in Y or Z axis VESCs, the X-axis motor continues functioning. Faults

are logged for diagnosis.

- **Thermal Protection**

VESCs automatically slow down or shut off motors when temperature thresholds are reached:

- Warning: 80°C
- Cutoff Start: 80°C
- Cutoff End: 100°C

- **RPM, Voltage & Current Limiting**

VESC parameters are configured to prevent overdraw and ensure system safety.

1. Communication & Logging

- **CAN Communication Setup**

- VESC 0 (Master): CAN ID = 0, UART Enabled, Termination = Enabled
- VESC 1: CAN ID = 1, UART Disabled, Termination = Disabled
- VESC 2: CAN ID = 2, UART Disabled, Termination = Enabled

All VESCs have: Send CAN Status, Multiple VESCs, and CAN Forwarding enabled in VESC Tool.

- **Real-Time Data Logging**

Orientation, PID output, RPM, and temperature are logged for up to 24 hours.

- **Manual CSV Reset**

A push-button resets the .csv log without reprogramming the SD card.

1. Setup Instructions

- **Arduino Nano Setup**

- Upload PID control firmware
- Connect MPU9250 via I2C (A4/A5)
- Connect SD Module via SPI (D10-D13)
- Connect VESC UART via Software Serial (D8/D9)

- **VESC Configuration via USB & VESC Tool**

- Set CAN IDs and termination resistors
- Enable CAN features
- Set temperature cutoffs and current/RPM limits

- **Wiring Notes**

Ensure CANH and CANL lines are twisted pairs with proper termination. Use shielded wires for high-current and signal lines.