Circuit Design Document

Cement Mixer Monitoring System

1. Introduction

This document outlines the circuit design and setup of the Cement Mixer Monitoring System, which consists of two ESP8266-based sensor circuits developed to monitor both motion and power consumption of cement mixers.

- Motion Monitoring Circuit (MPU6050): Captures angular velocity and acceleration.
- Current Monitoring Circuit (SCT013): Measures real-time current draw.

These circuits were prototyped on breadboards and later intended for PCB-based deployment.

2. Components Used

2.1 MPU6050 + ESP8266

- ESP8266 NodeMCU
- MPU6050 Sensor
- LED
- 1.6k Ohm Resistor
- 9V Battery
- 9V Battery Snap
- Jumper Wires
- Breadboard
- USB Cable

2.2 SCT013 + ESP8266

- ESP8266 NodeMCU
- SCT-013 Current Sensor
- 3.5mm Jack Breakout Adapter
- 10uF Non-polarized Capacitor
- 2 x 10k Ohm Resistors
- LED
- 1.6k Ohm Resistor
- 9V Battery
- 9V Battery Snap
- Jumper Wires
- Breadboard
- USB Cable

3. Circuit Connections

3.1 MPU6050 + ESP8266

- ESP8266 Power:
    - 9V Battery Red Snap (Positive) to ESP8266 NodeMCU Vin pin.
    - 9V Battery Black Snap (Negative) to ESP8266 NodeMCU GND pin.
- MPU6050 Sensor:
    - MPU6050 SCL to ESP8266 NodeMCU D1 pin (GPIO5).
    - MPU6050 SDA to ESP8266 NodeMCU D2 pin (GPIO4).
    - MPU6050 VCC to ESP8266 NodeMCU 3V3 pin.
    - MPU6050 GND to ESP8266 NodeMCU GND pin.
    - MPU6050 AD0 (optional) usually left floating for default address (0x68).
- LED:
    - LED Long Leg (Anode) to ESP8266 NodeMCU D4 pin (GPIO2).
    - LED Short Leg (Cathode) to one leg of the 1.6k Ohm resistor.
    - Other leg of the 1.6k Ohm resistor to ESP8266 NodeMCU GND pin.

3.2 SCT013 + ESP8266

- ESP8266 Power:
    - 9V Battery Red Snap (Positive) to ESP8266 NodeMCU Vin pin.
    - 9V Battery Black Snap (Negative) to ESP8266 NodeMCU GND pin.
- SCT-013 Sensor & Adapter:
    - SCT-013's 3.5mm jack plugs into the input jack of the 3.5mm breakout adapter.
- SCT-013 Adapter to ESP8266:
    - Adapter's 'L' (Left) output to one leg of the 10uF Non-polarized Capacitor.
    - Adapter's Ground output to ESP8266 NodeMCU GND pin.
    - Adapter's 'R' (Right) output remains unconnected.
- ADC Bias Circuit (for SCT-013):
    - One 10k Ohm Resistor from ESP8266 NodeMCU 3V3 pin to a common point.
    - The other 10k Ohm Resistor from the common point to ESP8266 NodeMCU GND pin.
    - The common point (where the two 10k Ohm resistors meet) to ESP8266 NodeMCU A0 pin.
    - The other leg of the 10uF Non-polarized Capacitor (from the adapter 'L' output) to the same common point (A0).
- LED:
    - LED Long Leg (Anode) to ESP8266 NodeMCU D4 pin (GPIO2).
    - LED Short Leg (Cathode) to one leg of the 1.6k Ohm resistor.
    - Other leg of the 1.6k Ohm resistor to ESP8266 NodeMCU GND pin

4. Assembly Notes

Platform Used: Breadboard

Microcontroller: ESP8266 NodeMCU

Sensor Mounting: Double-sided tape was used to mount the MPU6050 to a rotating part of the mixer. The SCT013 sensor rested securely on the ground with the appropriate wire passed through.

Power Supply: 9V batteries were used via battery snap connectors. Power stability was sufficient for periodic deployments, although LiPo batteries are planned for future use.

LED Indicators:

- External Red LED: Shows power status (always ON when powered).
- Internal Blue LED (on ESP8266): Indicates Wi-Fi activity and data transmission.

5. I2C and Analog Configuration

MPU6050: Communicates via I2C protocol with the ESP8266. Default I2C pins are used (typically D1 - SCL, D2 - SDA).

SCT013: Connected to the analog pin A0 of the ESP8266 for RMS current sampling. Burden resistor was integrated inside the sensor module used.

6. Data Handling and Transmission

The MPU6050 circuit transmits:

- Angular velocity: gyroX_dps, gyroY_dps, gyroZ_dps
- Acceleration magnitude: accel_euclidean_sum

The SCT013 circuit transmits:

- RMS current: Irms via the field5 JSON field

Data is sent via HTTP POST requests to a Flask server running locally.
Transmission interval: Every 5 seconds

7. Testing and Debugging

Each circuit was tested manually before deployment by monitoring the serial output via USB and ensuring data appeared correctly on the receiving end.

Both circuits include debug print statements for connection status, sensor readings, and HTTP responses.

8. Known Issues and Future Enhancements

- Stability: The MPU6050 module, being unsoldered, occasionally returns unstable or zero values. Soldering is recommended for production setups.
- Battery Life: 9V batteries deplete quickly during constant operation. LiPo or USB power banks are better long-term options.
- Data Access: During logging, the CSV file should not be opened in Excel, as it locks the file and prevents data from being written.
- Improvement: A future PCB version could include mounting holes and improved power routing.