HOCHSCHULE RHEIN-WAAL
Rhine-Waal University of Applied Sciences

LAB REPORT

Course “Microelectronic Control Systems”, EL_5_2312

Winter Semester 2024/25

Lab 4
Levitating Magnet

Author: Caleb A Moyou Noutsa

Student ID: 30597

Course of study: EL

Submission date: 24.11.2024

Re-submission date: NA

Task 1

The objective of this lab was to design, implement, and test a control system for a levitating magnet. The system uses a Hall Effect Sensor to measure the magnet's position and adjusts the power to an electromagnet to maintain the magnet in a stable levitating position.

Control Algorithm

The PD controller consists of the following components:

1. Proportional Term:
    - Corrects the position of the magnet based on the difference between the target position (aim) and the current position (current).
    - Formula: Proportional term=Kp*error, where
        - Error = current – aim
2. Derivative Term:
    - Damps oscillations by responding to the rate of change of the error.
    - Formula: Derivative term =Kd * derivative,
        - Derivative = error - last
3. Control Signal:
    - Combines the proportional and derivative terms to compute the output power for the electromagnet.
    - Formula: output = (Kp * error) + (Kd * derivative)

4. Output Clamping:
    - The control signal is constrained within the valid range of $0 \leq$ output ≤ 255 to ensure compatibility with the PWM signal for the electromagnet.

Key Features

1. Calibration:
    - The system calibrates the Hall Effect Sensor during initialization to map its full range of readings.
    - A loop adjusts the magnet power incrementally while recording sensor data.
2. Real-Time Feedback:
    - The control loop continuously adjusts the electromagnet's power to stabilize the magnet at the target position.
3. LED Indicators:
    - Red and green LEDs provide visual feedback on the magnet's position relative to the target.

PD Control Loop

- The control loop calculates the error between the current and target positions.
- It adjusts the magnet power using the PD control formula:
    - Kp * error
    - Kd * (error - last)

- The power is updated in real time to maintain the magnet's position.

```
for(;;){
        current = hall_get();
        error = current - aim;
        last = error;
        derivative = error - last;

        output = (Kp * error) + (Kd * derivative);

        if (output > 255) output = 255;
        if (output < 0) output = 0;


        if( current > aim)
            led_red(1);
        else
            led_red(0);

        if( current < aim)
            led_green(1);
        else
            led_green(0);

        magnet_set(output);
        hall_setmagpower(output);
        last = error;
    }
```

LED Feedback

- **Red LED**: Turns on when the magnet is above the target position.
- **Green LED**: Turns on when the magnet is below the target position.

```
if( current > aim)
            led_red(1);
        else
            led_red(0);

        if( current < aim)
            led_green(1);
        else
            led_green(0);
```

Controller Parameters

- Kp = 12: Provides sufficient responsiveness to error while maintaining stability.
- Kd = 1: Adds damping to reduce oscillations.

```
uint8_t current = 0;
    uint8_t Kp = 12;
    uint8_t Kd = 1;
    int16_t error = 0, last = 0, output = 0, derivative = 0;
```

Challenges Encountered

1. **Magnet Instability**:
   - Initial instability was observed due to inadequate proportional gain (Kp).
   - Solution: Increased Kp to 12 to improve responsiveness.
2. **Oscillations**:
   - Excessive oscillations were caused by a lack of damping.
   - Solution: Introduced a derivative term with Kd = 1.

Results

Observations:

1. The magnet successfully stabilizes at the target position (aim = 123).
   ```
   aim = 123;
   ```
2. LEDs provide real-time visual feedback on the magnet's position.
3. The PD controller effectively compensates for disturbances, keeping the magnet stable.

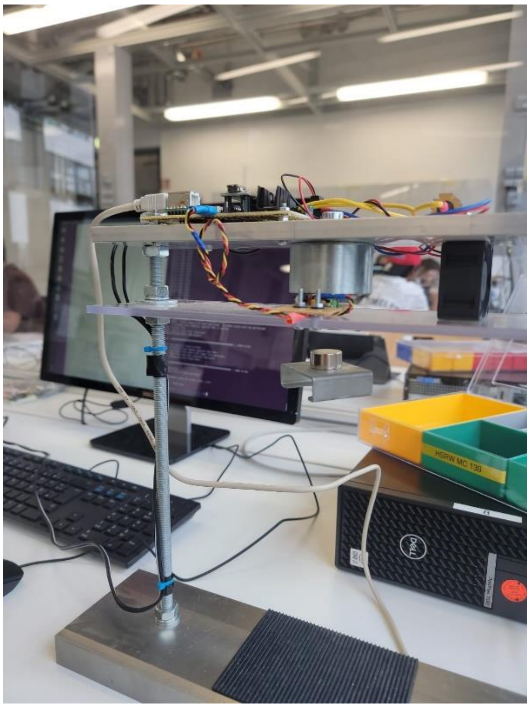

Figure 1: levitating magnet setup with the magnet seen floating.