Wheel Speed Measurement and Control System Using Hall Effect Sensor and PID Control

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***Abstract*— This project focuses on the development of a smart wheel speed control system. It involves taking user input for the desired speed and using a Hall effect sensor and PID control to set the wheel's speed equal to this desired speed. The project aims to demonstrate an efficient and reliable method for controlling wheel speed in various applications, such as vehicles, conveyor belts, and machinery.**

I. AIM

The primary objectives of the project are to minimize the time taken to reach the desired speed and to minimize the speed error once the desired speed is reached.

II. MATERIAL REQUIRED

A list of components used in the project is given below:

- Arduino UNO
- Hall Effect Sensor
- Brushless DC Motor
- Motor Shield
- 12 V DC Adapter
- Jumper Wires
- Wheel
- Magnets

III. INTRODUCTION

Our project uses the property of a Hall effect sensor to measure the current speed of the wheel and a motor shield to control the power of the motor, thereby controlling the speed of the wheel. Our project also uses Arduino library <AFMotor.h> for using motorshield.

IV. THEORY

A. Hall Effect Sensor

After researching the Hall effect sensor, we got to know about its functionality and accuracy. The Hall Effect sensors are integrated circuits that transduce magnetic fields and change their response voltage according to changes in magnetic fields.

Figure 1 Hall Effect Sensor[1]

B. *Motor Shield*

A motor shield is a device that controls the speed and direction of a motor. It has the capacity to control motors. For each motor, it has two pins. If we interchange the pins, the motor will rotate in the opposite direction.

Figure 2 Motor Shield[2]

C. *Brushless DC Motor And Adapter*

Our project uses a 3000 Rpm brushless DC motor. As the name indicates, it uses a direct current source. The rotational speed of BLDC motors is proportional to the power supply voltage, So we can control it with a motor driver that regulates the power supply.

Figure 3 Brushless DC Motor[4]

D. *PID Control*

The PID (Proportional-Integral-Derivative) controller is a feedback control loop mechanism widely used in control systems. It continuously calculates an error value as the difference between a desired setpoint (the user input speed) and a measured process variable (the speed of the wheel). The controller attempts to minimize the error by adjusting the control input (the motor speed).

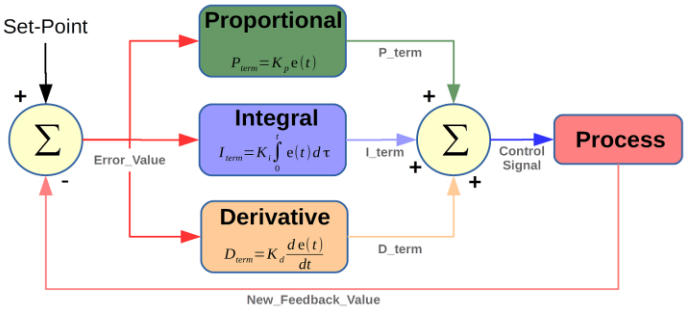

Figure 4 PID FLOW DIAGRAM[3]

V. PROCEDURE

i. Knowing how a Hall effect sensor works, two magnets are stuck on the outer surface of the wheel. Their position is on the two ends of the diameter of the wheel. The polarity of both magnets is opposite. This is done to get a significant change in the magnetic field when the motor rotates.

ii. The hall effect sensor is placed at the front of the wheel. Its orientation is such that the direction of the magnetic field and the direction of the hall effect sensor are perpendicular to each other.

iii. The BLDC motor is connected to the motor shield, and the motor shield is connected to the DC power supply and Arduino UNO. The DC power supply is coming from a DC power adapter.

iv. After this circuit setup, we coded it in Arduino for PID control and motor shield

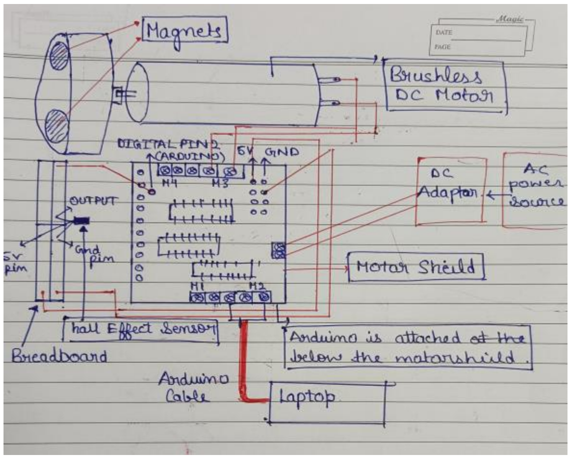

Figure 5 Circuit diagram

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VI. DISCUSSION

Now, after connecting the circuits and doing the code for PID control and motor shield, our project is working. After setting the desired speed, the motor's maximum speed slowly decreased to the desired speed. Now, moving towards our objective to minimize the time taken to reach the desired speed and to minimize the speed error while moving at the desired speed. For this, we need to set the correct values of Kp, Kd, and Ki, which are constants of proportionality, derivative, and integral, respectively.

a) Kp: Increasing this constant decreases the reaction time when responding to changes in a magnetic field.
b) Kd: Increasing this constant increases the damping effect, thereby reducing the oscillating and stabilizing of the system.
c) Ki: Increasing this constant increases the effect of past error values, which helps us to eliminate the speed error while moving at the desired speed.

So, after discussing and trying to hit the trial method, we found values of all three constants, which were giving correct results to an extent.

VII. RESULTS

After experimenting with different values of Kp, Kd, Ki, We finally got our Kp=0.08, Kd=0.01 ,.Ki=0.08. In our experiment, we set our desired speed at 200 rev/sec and got average error as 10 rev/sec/

VIII.CONCLUSIONS

Our project worked correctly and gave readings of the wheel's speed correctly. We can say that the readings of hall effect sensors are accurate and can be used in precise calculations. Also, using the PID control system, we can get the desired output using concepts of oscillations, damping, and error analysis. By calculating suitable values of Kp, Kd, Ki we can minimize the steady-state error.

IX. APPLICATIONS

a) Automotive Industry: The system can be used in vehicles for precise speed control, such as in cruise control systems.
b) Industrial Automation: It can be used in conveyor belts and machinery to control the speed of rotating parts.
c) Robotics: The system can be integrated into robotic systems to control the speed of wheels or other moving parts.
d) Electric Mobility: In electric vehicles, the system can be used to control the speed of motors for efficient and safe operation.

X. REFERENCES

[1] Everything You Need To Know About Hall Effect Sensors | RS | RS (rs-online.com)

[2] Robotbanao L293D Motor Driver Shield For Microcontrollers-4 Channel Driver-Bipolar Pulse-Width-Method(PWM) : Amazon.in

[3] PID Controller: Types, What It Is & How It Works | Omega

[4] Brushless DC electric motor - Wikipedia

[5]Basics of PID Controllers: Working Principles, Pros & Cons (integrasources.com)