MMU MULTIMEDIA UNIVERSITY FACULTY OF ENGINEERING

Inquire, Inspire and Innovate

A Servo Controller for Brushed DC Motor

Presented by:

Bashir Tawfig Bashir Abugharsa

(1181102921)

Supervisor:

Dr. Lo Yew Chiong

Moderator:

Dr. Cham Chin Leei

TABLE OF CONTENT

Background Overview

- Brushed DC motors are integral in mechanical systems evolution due to their simple structure and cost-effectiveness.
- They are favored for their DC power source. These motors are popular in mass-produced products.
- However, advanced applications require precision that exceeds basic controller circuit capabilities.
- Servo Controller Solution offers refined motor control via feedback mechanisms for precise operation.

Problem Statement

- **Precision Limitation:** The basic mechanical design of Brushed DC motors hinders precise control using just standard driver circuits.

- **Performance Variables:** External factors like load changes affect motor performance, which is unaddressed by simple drivers.

Project Scope

Goal: Develop a servo controller to improve the precision of brushed DC motors in speed and positioning.

Driver Circuit Design: Create a PWM-controlled circuit using a microcontroller for speed and direction control.

PID Control System: Implement a PID closed-loop control integrated with the driver circuit for more precise control.

Dynamic Performance: Ensure that the motor consistently follows precise movement while automatically adjusting for variations in load.

Project Objectives

User-Interactive Control: Implement a serial communication interface with servo controller.

Accurate Speed & Position Management: Develop a closed-loop system utilizing optical encoder feedback for precise motor handling.

Real-Time PID Control: Engineer a PID system for stable and accurate motor response.

Adaptive System: Establish a tuning methodology for optimal performance under diverse conditions and uses.

Literature Review

Motor Driver Circuit Design

Ayyanathan and Mariyammal[1] explore the use of Pulse Width Modulation (PWM) for controlling DC motor speed, employing an AT89S52 microcontroller and L293D IC. This method excels in providing precise speed and direction control over small DC motors in a cost-effective manner. However, the reliance on L293D IC limits its applicability to small motors, posing a challenge for more complex operational contexts.

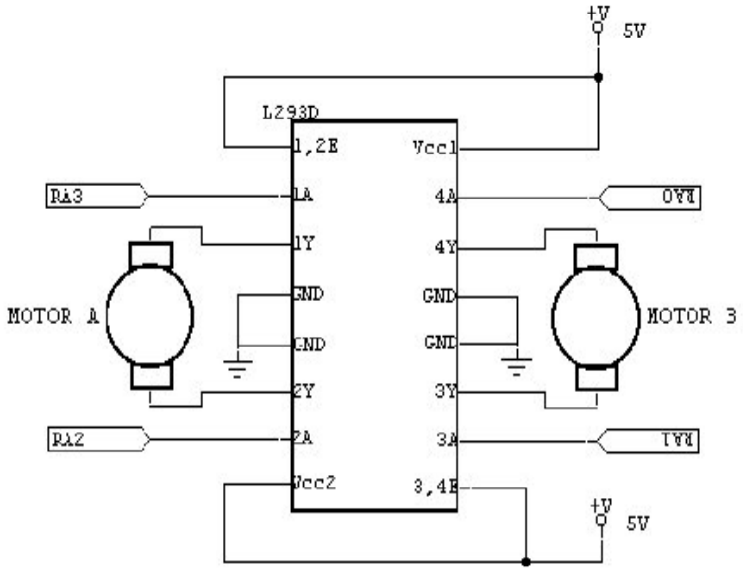


Figure 1: Motor Driving IC

Literature Review

Motor Driver Circuit Design

V. Gupta [2] designed H-bridge motor driver circuit for wheeled mobile robots. The use of BJTs in this design provides a cost-effective solution, however, it falls short in terms of efficiency and power management compared to MOSFETs, which could affect its performance in more demanding robotic applications.

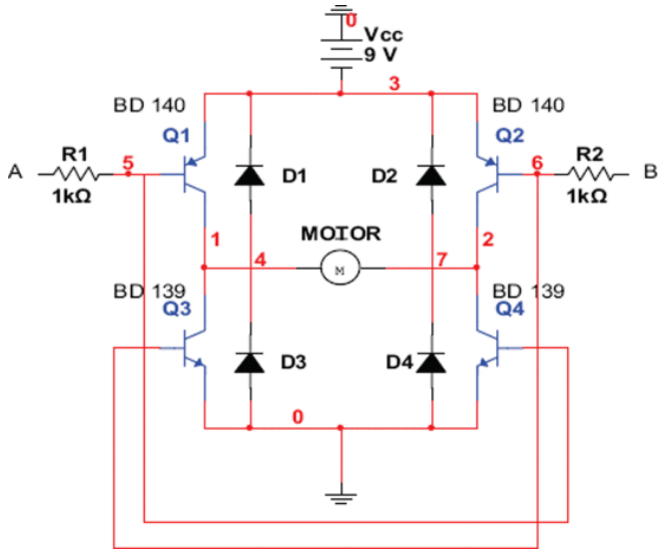


Figure 2:H- Bridge Motor Driver Circuit

Literature Review

PID Controller Design

X. Zhang [3] used fuzzy logic with PID control to enhance the system's adaptability and robustness. However, the use of fuzzy logic adds computational complexity.

Z. Adel, A. A. Hamou, and S. Abdellatif implemented a real-time PID control system on an Arduino Mega 2560, complemented by MATLAB for interface and real-time monitoring. However, their reliance on a speed sensor may limit the system's precision for applications demanding high accuracy.

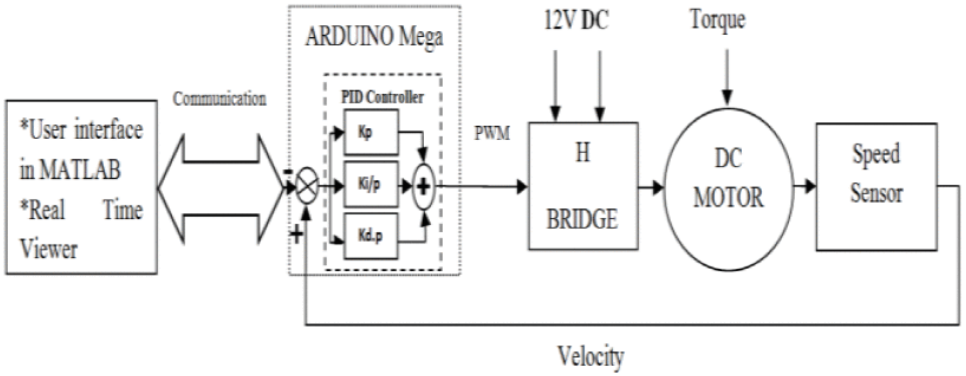


Figure 3: A Closed-loop Motor Speed Control

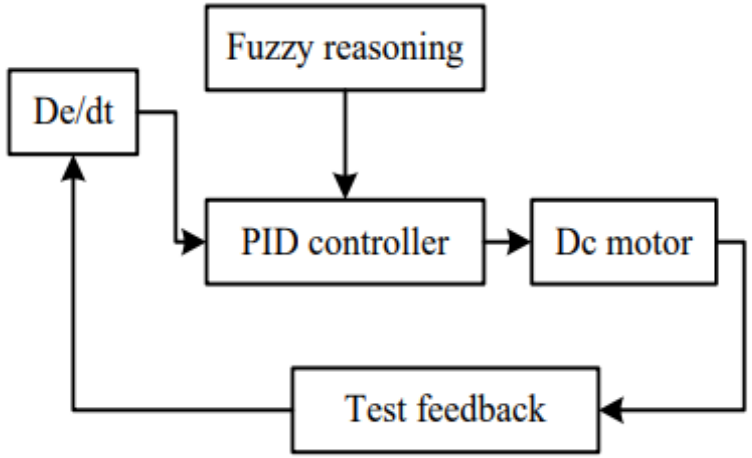


Figure 4: A Closed-loop Motor Speed Control

Methodology

- **Brushed DC Motor Driver Circuit**
- **Microcontroller Firmware**
- **Main Components**
- **Tools**

Methodology

Brushed DC Motor Driver Circuit

H-Bridge Configuration: Utilizes four power MOSFETs to form the brushed DC motor driver circuit.

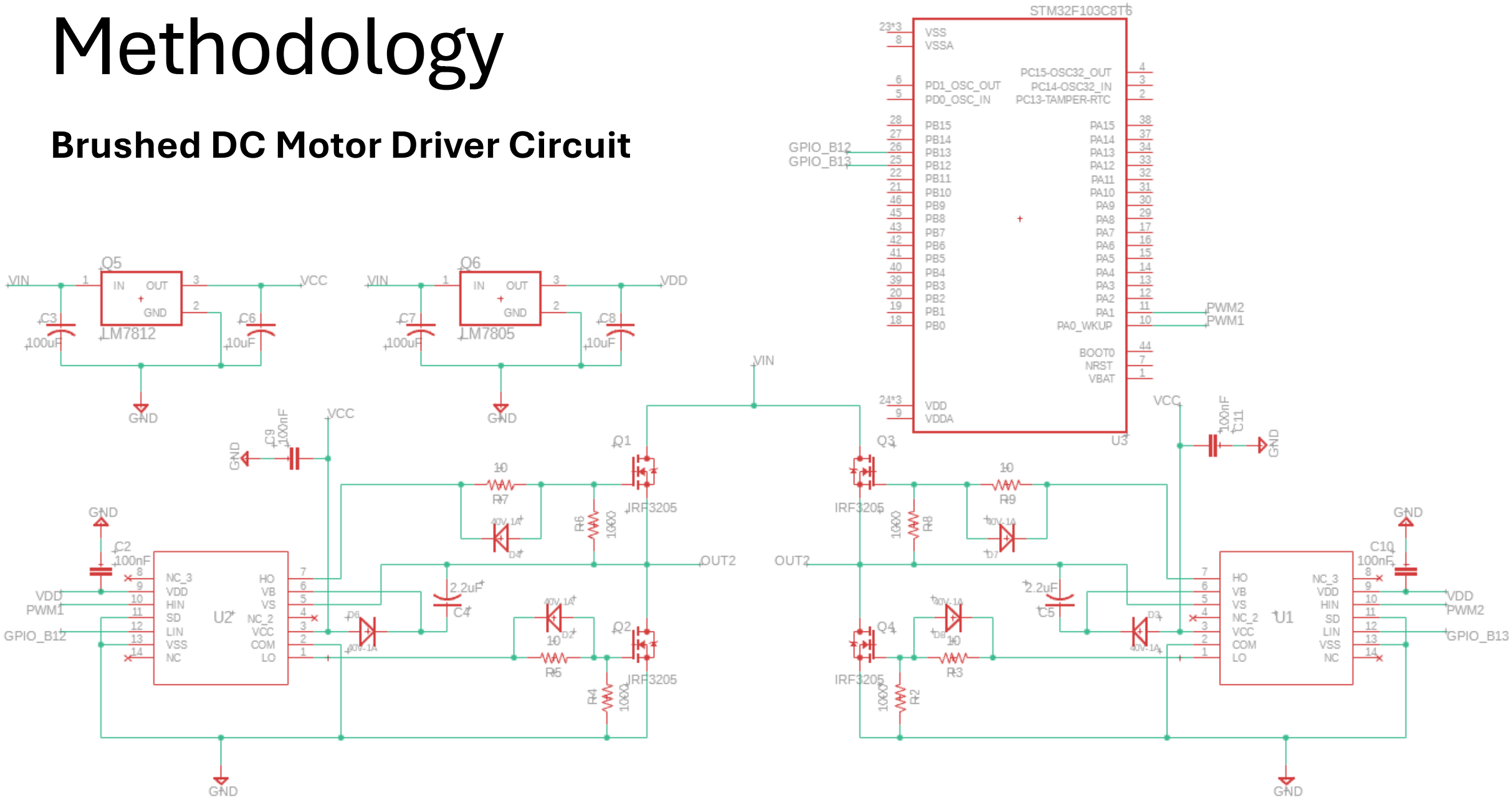
Motor Control: H-Bridge circuit controls motor direction and speed via a PWM signal.

PWM Generation: A microcontroller is used for generating the PWM signal required for motor control.

Gate Driver IC: Manages the operation of MOSFETs.

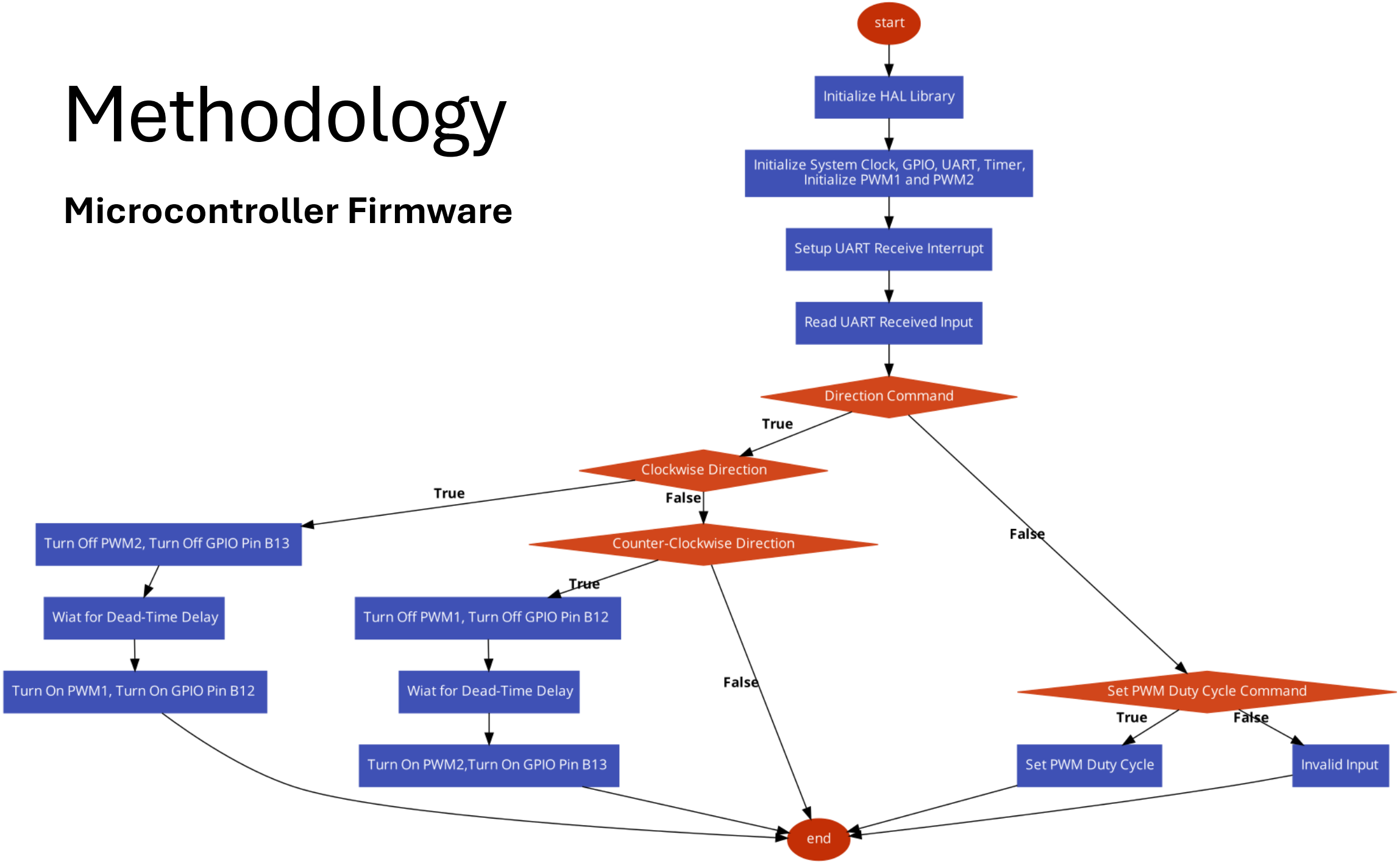
Methodology

Brushed DC Motor Driver Circuit



Methodology

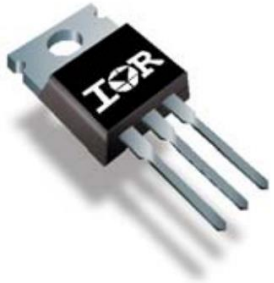
Microcontroller Firmware



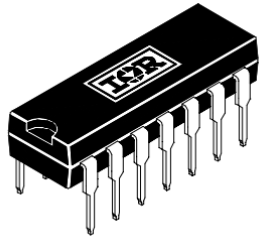
Methodology

Main Components

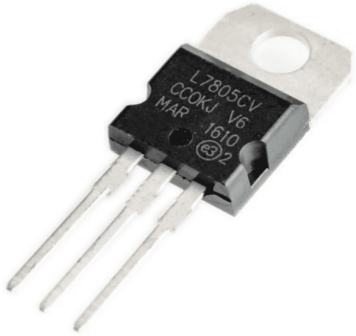
IRF3205 N-channel MOSFET



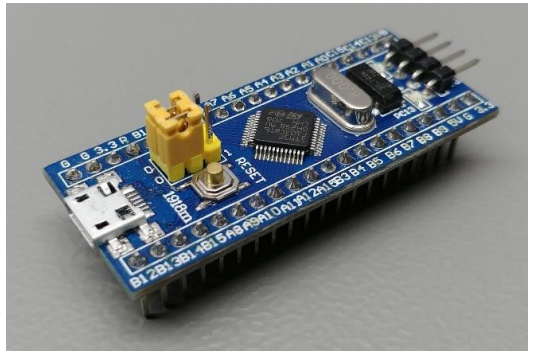
IR2110 MOSFET Gate Driver:



LM7805 & LM7812 Fixed Voltage Regulator



STM32f103 Microcontroller



Methodology

Hardware Tools

Hantek Oscilloscope / Multimeter

Adjustable DC Power Supply

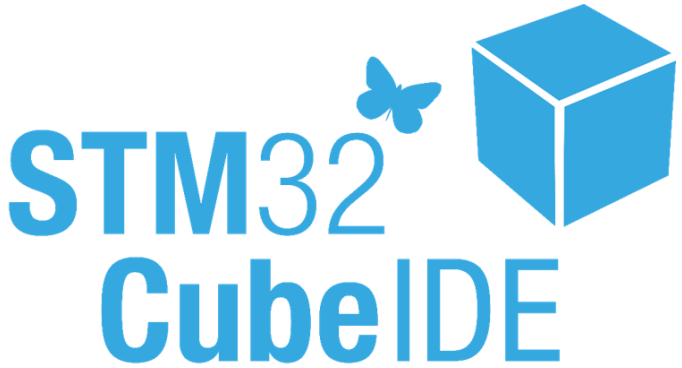
ST-Link Programmer

USB to TTL Adapter

Methodology

Software Tools

STM32CubeIDE



Arduino IDE Serial Monitor

Autodesk Fusion 360

Future Implementation (FYP 2)

1

Develop a real-time PID control system.

2

Use Optical Encoder as feedback loop.

3

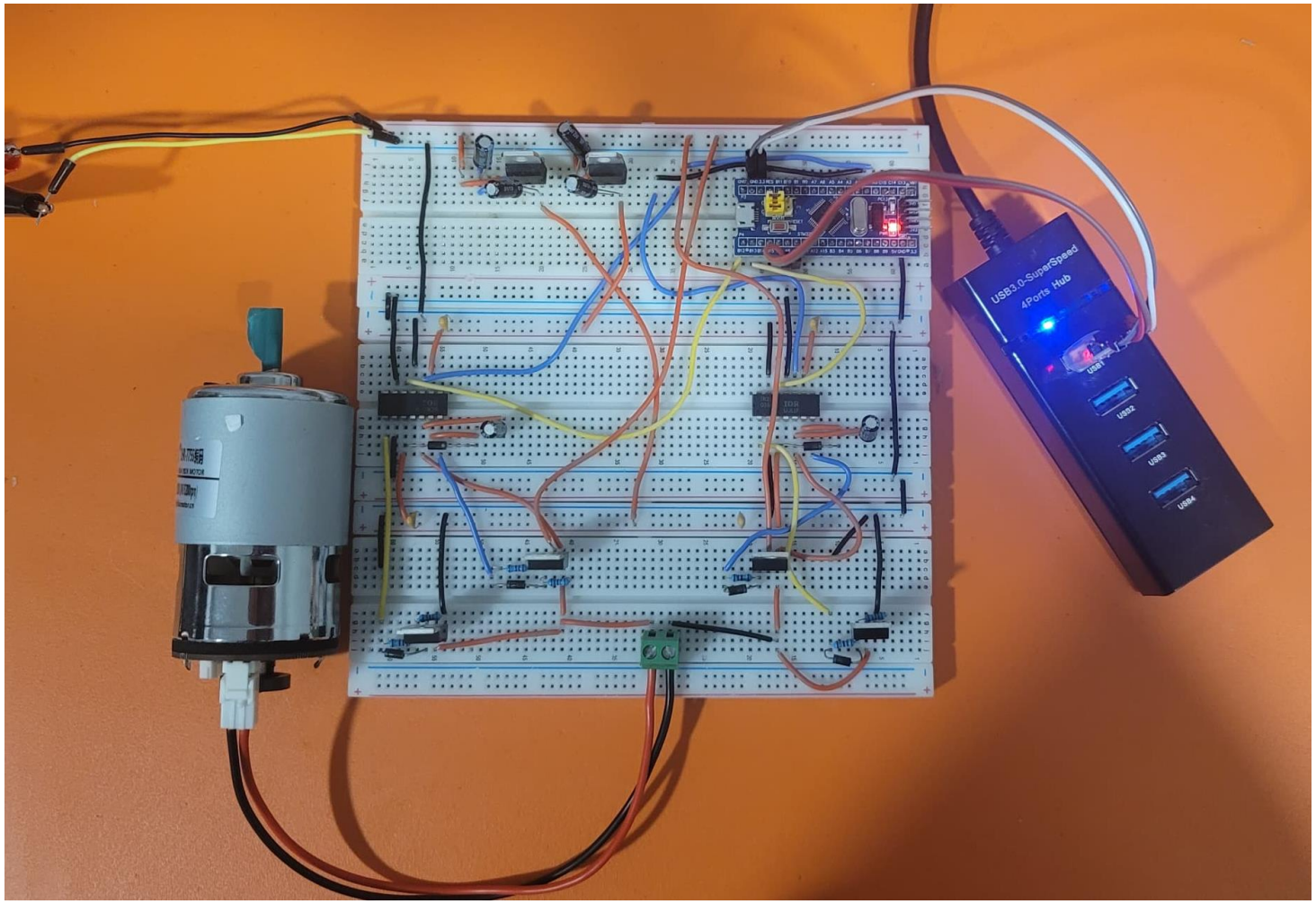
Precisely adjust the PID controller for optimal speed and position accuracy.

4

Design a PCB for the motor driver circuit.

Result and Discussion

- **Brushed DC Motor Driver Circuit**



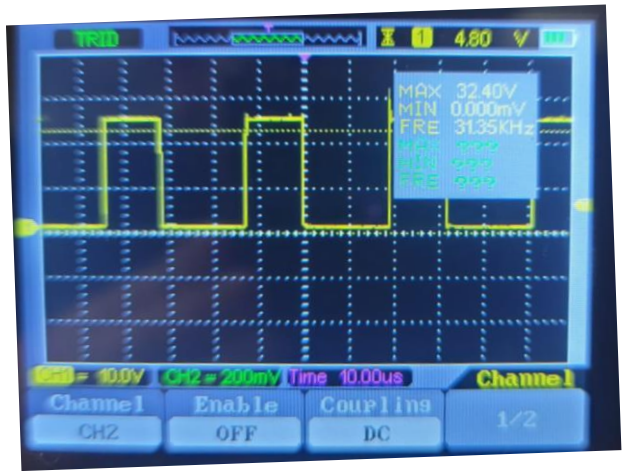
Result and Discussion

Motor at 40% PWM Duty Cycle

Microcontroller

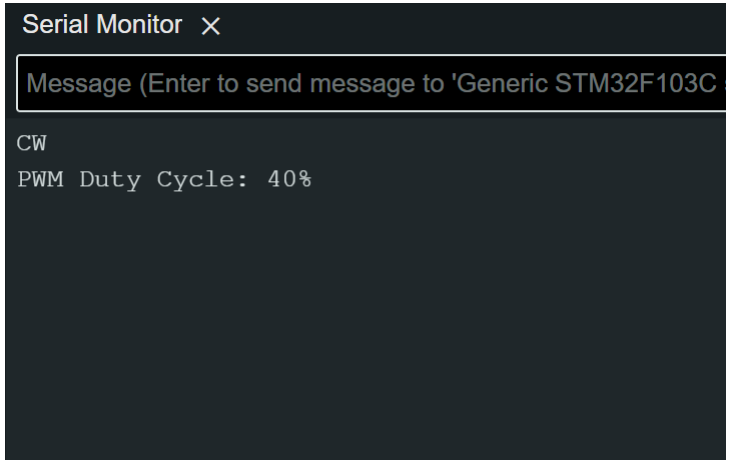
High Side MOSFET VGS

Brushed DC Motor



Low Side MOSFET VGS

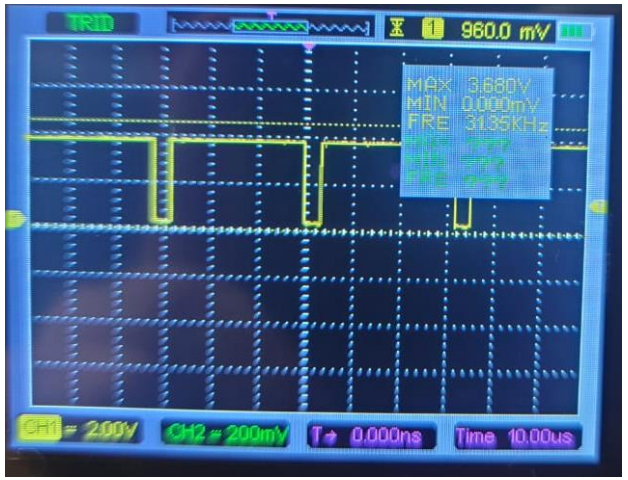
Serial Monitor



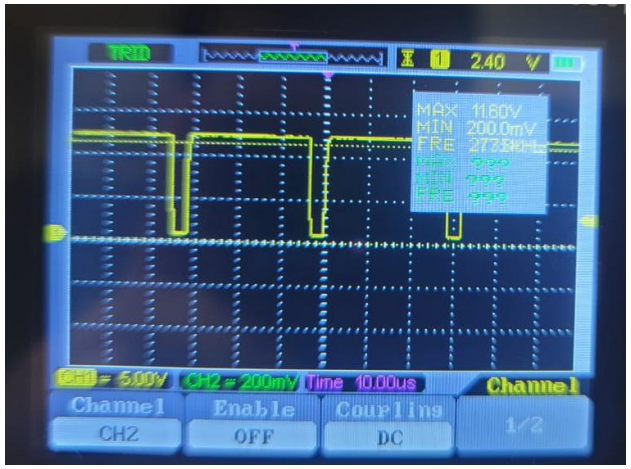
Result and Discussion

Motor at 90% PWM Duty Cycle

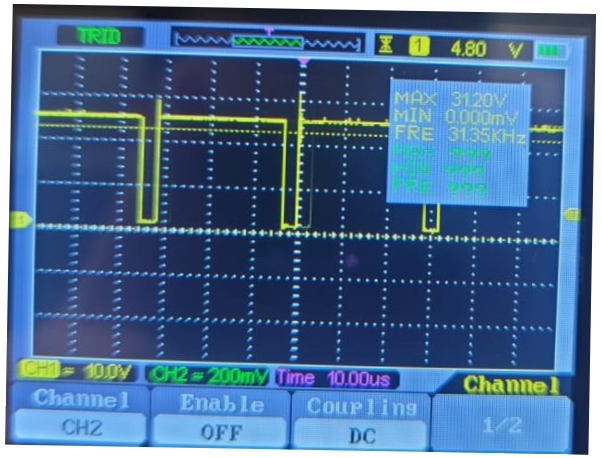
Microcontroller



High Side MOSFET VGS

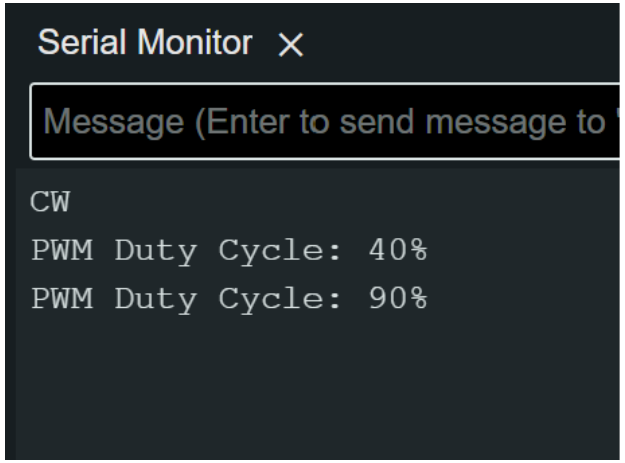


Brushed DC Motor



Low Side MOSFET VGS

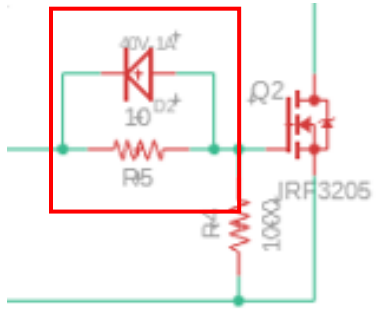
Serial Monitor



Result and Discussion

MOSFET Gate Discharge Time Diode

From the oscilloscope readings, it's evident that incorporating a diode at the MOSFET gate impacts the gate discharge time. With the diode in place, the gate discharges in about 300ns. Conversely, removing the diode results in a longer discharge time of 400ns. Therefore, the inclusion of a diode at the MOSFET gate contributes to a slight improvement in the gate's discharge efficiency.



Gate Discharge Time with Diode

Gate Discharge Time without Diode

Project Timeline

Project Budget

Part Name	Quantity	Unit Cost (RM)
LM7805 Voltage Regulator	1	0.80
LM7812 Voltage Regulator	1	0.80
IR2110 MOSFET Gate Driver	2	3.59
IRF3205 Power MOSFET	4	3.50
STM32F103C8T6 Blue Pill Board	1	16.90
Metal Film Resistors	8	0.10
1N5819 Diode	6	0.20
2.2uF 50V Capacitor	2	0.10
10uF 50V Capacitor	2	0.10
100uF 25V Capacitor	2	0.10
100nF Ceramic Capacitor	4	0.10
Breadboard	3	3.60
Total		53.48

Summary

- In conclusion, the project effectively developed a driver circuit for Brushed DC motors, allowing speed and direction control with PWM signal using microcontroller. Notably, the PID control aspect is planned for FYP part 2, promising to further refine motor operation. Future directions involve enhancing real-time control mechanisms, advancing the motor driver circuit design, and integrating optical encoder feedback for superior precision and performance.

Thank You

References

[1] Ayyanathan, Mariyammal. "DC Motor Speed Control Using PWM." 2018, vol. 3, pp. 2456-2165. [Online]. Available: https://www.researchgate.net/publication/338116979_DC_Motor_Speed_Control_Using_PWM

[2] V. Gupta, "Working and analysis of the H - bridge motor driver circuit designed for wheeled mobile robots," 2010 2nd International Conference on Advanced Computer Control, Shenyang, China, 2010, pp. 441-444, [Online]. Available: https://ieeexplore.ieee.org/document/5486818

[3] X. Zhang, "Design and implementation of fuzzy PID DC motor control system based on STM32," in 2023 IEEE International Conference on Control, Electronics and Computer Technology (ICCECT), Jilin, China, 2023, pp. 1129-1131, [Online]. Available: https://ieeexplore.ieee.org/document/10141000

[4] Z. Adel, A. A. Hamou and S. Abdellatif, "Design of Real-time PID tracking controller using Arduino Mega 2560for a permanent magnet DC motor under real disturbances," 2018 International Conference on Electrical Sciences and Technologies in Maghreb (CISTEM), Algiers, Algeria, 2018, pp. 1-5, [Online]. Available: https://ieeexplore.ieee.org/document/8613560