19CSE303: Embedded Systems

PROJECT REPORT

PWM-based DC Motor Speed Control

GROUP MEMBERS:

Gowri Vinod : AM.EN.U4CSE21226

Sabarinath U : AM.EN.U4CSE21249

Gaadha V S : AM.EN.U4CSE21222

Hemanth Lakshman : AM.EN.U4CSE21227

Keshagni Vikranth Goud : AM.EN.U4CSE21276

1. Abstract

This project revolves around the implementation of Pulse Width Modulation (PWM) to regulate the speed of a DC motor using an LPC microcontroller. The system utilizes different PWM duty cycles generated by the LPC microcontroller to control the motor's speed. Key components such as the LPC2148 microcontroller, push buttons, optoisolator, Darlington transistor (TIP122), and various passive components are employed for precise speed control. The project explores the principles of PWM and motor control, providing insights into the modulation of pulse width to efficiently manipulate DC motor speed.

2. Introduction

1.1 Background

In the dynamic realm of electronics and automation, precise control over the speed of DC motors holds paramount importance. The ability to modulate motor speed not only finds applications in industrial automation but also in consumer electronics, automotive systems, and smart home technologies. This project delves into the implementation of Pulse Width Modulation (PWM) as a robust technique for controlling the speed of a DC motor. By utilizing an LPC microcontroller, this endeavor aims to provide a comprehensive understanding of PWM principles and their practical applications.

3. Objectives

The primary objectives of this project are to:

- Develop a PWM-based system for controlling the speed of a DC motor.
- Utilize the LPC2148 microcontroller, push buttons, optoisolator, Darlington transistor (TIP122), and various passive components for precise speed control.
- Investigate the principles of PWM and motor control to manipulate DC motor speed efficiently.
- Implement the project as an educational tool to enhance understanding of microcontroller programming and hardware interfacing.
- Explore diverse applications, ranging from industrial automation to smart home integration, showcasing the versatility of PWM-based motor control.

4. Project Components

I. LPC2148 (microcontroller)

The LPC2148 microcontroller serves as the brain of the project, providing the computational capabilities necessary for precise motor control. This 8-bit microcontroller operates at a clock frequency of [specify the frequency], featuring programmable flash memory, EEPROM, and various communication interfaces. Its role in the project is to execute the programmed logic for generating PWM signals based on user input and controlling the speed of the DC motor.

II. Push Buttons

Two push buttons, namely "Fast" and "Slow," are strategically integrated into the system to allow user interaction. The purpose of these push buttons is to trigger different PWM duty cycles when pressed. The "Fast" button signals the microcontroller to generate a PWM signal with a 100% duty cycle, leading to maximum motor speed. In contrast, the "Slow" button instructs the microcontroller to produce a PWM signal with a 50% duty cycle, resulting in a slower motor speed. This user-friendly interface enhances the educational aspect of the project, providing a hands-on experience in motor speed control.

III. Optoisolator

The optoisolator plays a crucial role in ensuring the single-direction operation of the motor. Acting as an interface between the microcontroller and the motor control circuitry, the optoisolator electrically isolates the two sections, preventing any potential damage or interference. This component enhances the overall safety and reliability of the system by effectively controlling the direction of the motor based on the PWM signals generated by the microcontroller.

IV. Darlington Transistor (TIP122)

The Darlington transistor, specifically the TIP122 model, is employed to amplify the PWM signals and drive the DC motor. With its high current gain and capability to handle larger loads, the TIP122 ensures efficient and controlled power delivery to the motor. Details of the transistor's specifications, including its current and voltage ratings, are crucial for understanding its contribution to motor speed control. Its role is to translate the low-power PWM signals into a higher-power output necessary for driving the DC motor at varying speeds.

V. DC Motor (12V Rating)

The DC motor used in the project is rated at 12V, making it suitable for the specified power supply. This motor's voltage rating is a critical parameter influencing its speed characteristics. Its relevance to the project lies in its responsiveness to the manipulated PWM signals, allowing for the adjustment of speed based on the duty cycle applied. Understanding the motor's specifications is essential for predicting its behavior under different operating conditions.

VI. Other Passive Components

Several passive components contribute to the overall functionality and stability of the system:

Decoupling Capacitor: Placed across the motor, this capacitor helps reduce electromagnetic interference (EMI) generated by the motor, ensuring a steady and interference-free operation.

Diode (1N4004): The diode serves as a protective component, preventing voltage spikes or reverse currents that may occur during motor operation.

Resistors: Various resistors are strategically placed in the circuit to limit current, adjust voltage levels, and ensure proper functioning of the components.

VII. Power Supply

The power supply forms the backbone of the entire system, providing the necessary voltages for both the microcontroller and the DC motor. A stable 12V supply is crucial for the motor's optimal performance, while a 5V supply powers the microcontroller and associated circuitry. The power supply requirements play a pivotal role in ensuring the reliable and sustained operation of the entire motor control system.

5. Hardware Simulation Tools

I. Proteus

Proteus is utilized for virtual hardware simulation and testing. This tool enables the creation of a dynamic electronic circuit, including all project components. It provides a real-time simulation environment, allowing for the observation and analysis of PWM signal generation, motor control, and overall system behavior. Proteus accelerates development by minimizing the need for physical prototypes and aids in identifying and resolving potential issues before hardware implementation.

II. LPC Microcontroller Model

The LPC microcontroller model within Proteus accurately emulates the LPC2148 microcontroller used in the project. This emulation enables the execution of programmed code within the simulated environment, providing insights into the microcontroller's response to user inputs, PWM signal generation, and motor speed control. The model ensures precise representation of timing, communication, and computational aspects, facilitating efficient code validation and seamless integration with other hardware components. The use of Proteus and the LPC microcontroller model streamlines the design process, enhancing reliability and efficiency in project development.

6. Software Tools

I. Keil IDE

Keil IDE is the programming environment for the LPC2148 microcontroller. It facilitates the development of code that controls PWM signal generation and motor speed. Keil's integrated development environment streamlines code writing, debugging, and compiling, ensuring efficient programming for the microcontroller.

II. Proteus (Software)

Proteus remains instrumental in the project by providing a virtual platform for hardware simulation. It allows for the comprehensive testing of the entire circuit, including the microcontroller, push buttons, and motor control components. Proteus ensures a real-time simulation experience, aiding in the identification and resolution of issues before physical implementation. Its role is pivotal in minimizing development time and optimizing the performance of the designed system.

7. Project Concept

I. Speed Control Mechanism

The speed control mechanism relies on manipulating the Pulse Width Modulation (PWM) signal with varying duty cycles. PWM involves altering the width of the signal's pulses while keeping the frequency constant. In this project, different duty cycles are applied to the PWM signal generated by the microcontroller. A 100% duty cycle, triggered by the "Fast" button, results in maximum motor speed, while a 50% duty cycle, activated by the "Slow" button, leads to a slower motor speed. By adjusting the pulse width, the average power delivered to the motor is controlled, allowing for precise speed regulation.

II. Push Button Operation

The push buttons, "Fast" and "Slow," play a crucial role in user interaction and speed control. Pressing the "Fast" button signals the microcontroller to generate a PWM signal with a 100% duty cycle, instructing the motor to operate at its maximum speed. Conversely, pressing the "Slow" button triggers the microcontroller to produce a PWM signal with a 50% duty cycle, resulting in a slower motor speed. This user-friendly interface not only enhances the educational aspect of the project but also demonstrates the practical application of PWM in controlling motor speed based on user input.

III. Additional Notes

Optoisolator

The Optoisolator is incorporated to ensure the single-direction operation of the motor. Serving as an interface between the microcontroller and the motor control circuitry, the Optoisolator electrically isolates these components. This isolation prevents potential damage or interference, enhancing the safety and reliability of the system. The Optoisolator is integral to controlling the direction of the motor based on the PWM signals generated by the microcontroller.

Decoupling Capacitor

A decoupling capacitor, strategically placed across the motor, is employed to reduce electromagnetic interference (EMI) generated during motor operation. This capacitor aids in maintaining a steady motor speed by minimizing the impact of electrical noise and fluctuations. Its presence ensures the system's stability and reliability, contributing to the overall efficiency of the PWM-based motor control.

8. CODE :

```
#include <lpc214x.h>


#define MOTOR_CONTROL_PIN  (1 << 21)  // Pin P0.21 for motor control
#define FAST_BUTTON_PIN    (1 << 15)  // Pin P0.15 for the Fast button
#define SLOW_BUTTON_PIN    (1 << 16)  // Pin P0.16 for the Slow button

void delay_ms(unsigned int count) {
   unsigned int i, j;
   for (i = 0; i < count; i++)
      for (j = 0; j < 10000; j++);
```

```
}

void initPWM() {
    PINSEL0 |= (1 << 10);  // Configure P0.21 as PWM output
    PWMPCR = (1 << 14);    // Enable PWM1
    PWMPR = 30;            // Set the PWM prescaler for a frequency of approximately 1 kHz
    PWMMR0 = 100;          // Set PWM period to 100 (adjust for desired frequency)
    PWMMR1 = 50;           // Set PWM duty cycle to 50 (adjust for desired duty cycle)
    PWMTCR = (1 << 1);     // Reset PWM TC and PR
    PWMTCR = (1 << 0);     // Enable PWM
}

void initButtons() {
    IODIR0 &= ~(FAST_BUTTON_PIN | SLOW_BUTTON_PIN);  // Set P0.15 and P0.16 as
input
}

int isFastButtonPressed() {
    return ((IOPIN0 & FAST_BUTTON_PIN) == 0);
}

int isSlowButtonPressed() {
    return ((IOPIN0 & SLOW_BUTTON_PIN) == 0);
}

int main() {
    initPWM();
    initButtons();

    while (1) {
        if (isFastButtonPressed()) {
            PWMMR1 = 100;  // Set PWM duty cycle to 100 for maximum speed
        } else if (isSlowButtonPressed()) {
            PWMMR1 = 50;   // Set PWM duty cycle to 50 for slower speed
        }

        delay_ms(100);    // Adjust the delay based on the application requirements
    }
}
```

9. OUTPUT:

10. Project Application

- Educational Tool:

Provides a practical demonstration of PWM-based motor speed control.
Enhances understanding of microcontroller programming and hardware interfacing.

- Industrial Automation:

Applicable in industries for controlling conveyor belt speeds, robotic arms, and other automated systems requiring precise motor control.

- Consumer Electronics:

Suitable for applications such as fan speed control in appliances, ensuring energy efficiency and noise reduction.

- Automotive Systems:

Implementation in automotive projects for controlling various motorized components, such as windshield wipers or seat adjustments.

- Smart Home Applications:

Integration into smart home systems for controlling the speed of smart blinds, curtains, or ventilation systems.

The project not only serves educational purposes but also presents practical applications in diverse industries, showcasing the versatility of PWM-based motor control in various real-world scenarios. The integration of hardware simulation tools like Proteus and software development tools like Keil facilitates a comprehensive learning experience and efficient project development.

11. Conclusion

In conclusion, this project on PWM-based DC motor speed control has successfully demonstrated the effective use of embedded systems and microcontroller programming. Under the guidance of our esteemed embedded systems teacher, Anu Chalil ma'am, we have achieved a comprehensive understanding of PWM principles and their practical application in motor control.

The key aspects of the project include the utilization of the LPC2148 microcontroller, push buttons, optoisolator, Darlington transistor, and other components to achieve precise motor speed control. The project's achievements lie in its educational value, offering hands-on experience in microcontroller programming and hardware interfacing, and its applicability in diverse industries such as industrial automation, consumer electronics, automotive systems, and smart home applications.

Future developments may focus on refining the system for specific industrial applications, incorporating advanced control algorithms, or exploring additional features for enhanced functionality. The success of this project lays a solid foundation for further exploration and innovation in the field of embedded systems and motor control.

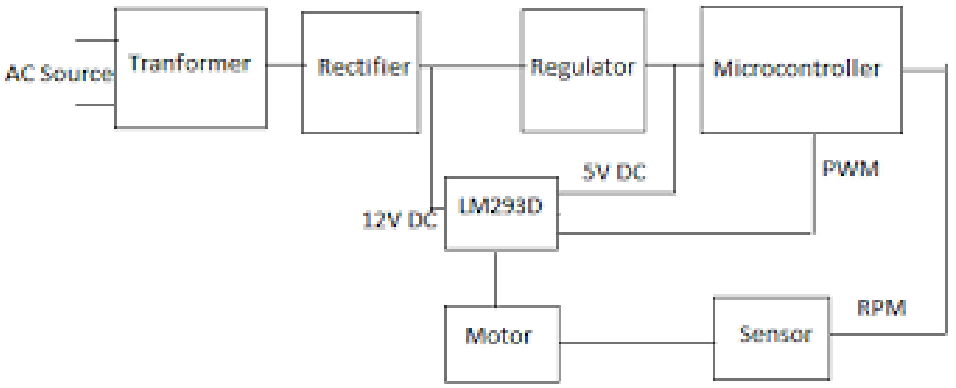
12. Acknowledgments

Special thanks to Anu Chalil ma'am for her invaluable guidance and dedication to embedded systems education. Gratitude to AVV for providing resources. Acknowledgment to peers and any other contributors for their support in making this project a success.

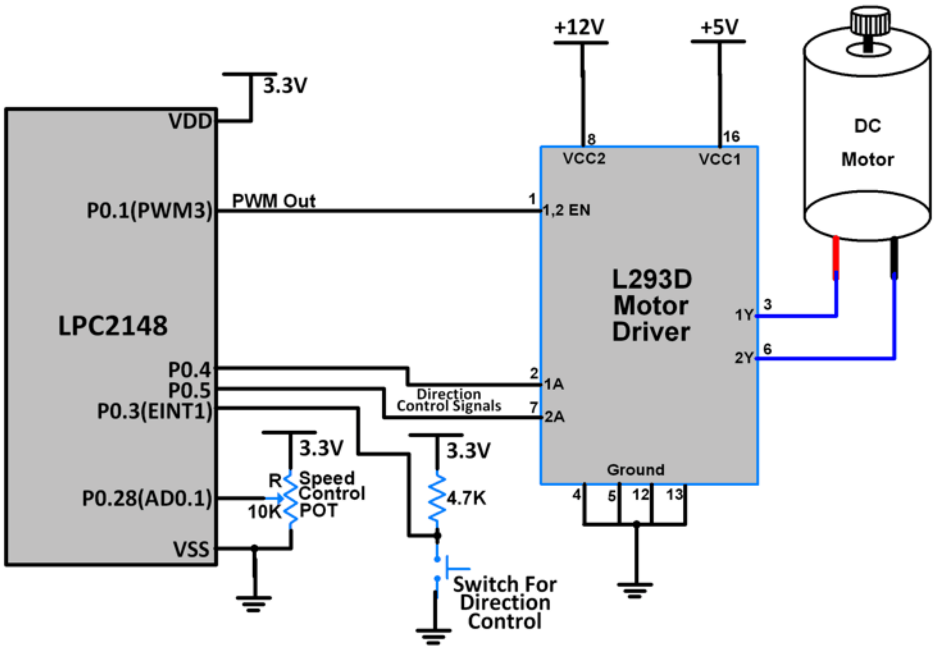
13. References

14. Appendix

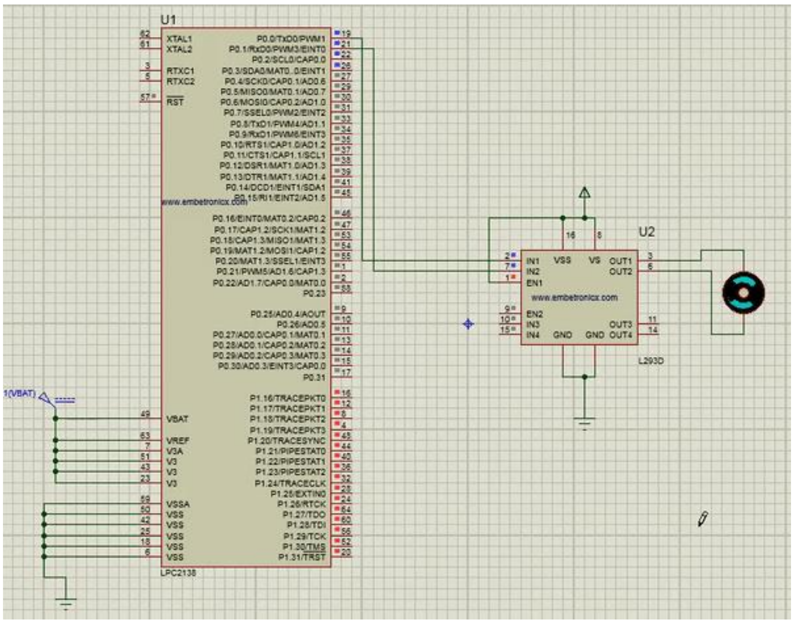
Block diagram



Circuit Diagram



Software


U1
U2
LPC2138
L293D