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REPORT ON **SPI MULTI-SLAVE SETUP FOR DUAL MOTOR SPEED CONTROL**

UNDER THE GUIDANCE OF
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INDEX

S. No	Topics	Page No.
1.	Abstract	1
2.	Introduction	1
3.	Background	1-4
4.	Requirements	5
5.	Hardware Design	5
6.	Procedure	5
7.	Results	6
8.	Conclusion	8
9.	Appendices	8

SPI Multi-Slave Setup for Dual Motor Speed Control

ABSTRACT

This report presents the design and implementation of an SPI-based control system for dual DC motor speed control using the ARM LPC2148 microcontroller, known for its high-performance ARM7TDMI-S core and versatile peripheral interfaces. On the transmitter side, the LPC2148's Analog to Digital Converter (ADC) is employed to enable a potentiometer for adjusting the Pulse Width Modulation (PWM), which controls the speed and direction of two distinct motors. An external interrupt, triggered via a push button on the master board, switches control between the two motors. Each motor is controlled by a slave microcontroller, with PWM signals driving chopper circuits comprising HCPL3120 opto-isolators and IRF840 MOSFETs. SPI communication is established using the serial clock (SCK), slave select (SS), MOSI, and MISO lines in a multi-slave configuration, ensuring reliable and efficient data transfer for synchronized motor operation.

Keywords: ARM, LPC2148, Pulse Width Modulation (PWM), Analog to Digital Converter (ADC).

1. INTRODUCTION

DC motor control is a cornerstone of power electronics and drives, essential for applications requiring precise and efficient speed and torque management. In industrial automation, electric vehicles, and robotics, efficient handling of motor speed directly impacts performance, energy consumption, and system reliability. This project integrates the capabilities of the LPC2148 microcontroller with advanced power electronics techniques to implement an SPI-based dual DC motor control system. Utilizing a multi-slave configuration, the system controls two distinct motors, with external interrupts triggered by a push button to switch between motors dynamically.

Efficient motor speed handling is achieved by dynamically adjusting the PWM pulse width through the LPC2148's ADC, using a potentiometer on the transmitter side. This allows for fine-grained control over motor speed and direction, catering to varying load conditions and operational requirements. The PWM signals are processed by individual chopper circuits, incorporating HCPL3120 opto-isolators for electrical isolation and IRF840 MOSFETs for high-speed switching. This setup ensures minimal power loss, improved motor efficiency, and enhanced system safety.

SPI communication, established through SCK, SS, MOSI, and MISO lines, ensures reliable and fast data transfer between the master and the two slave microcontrollers. The ability to efficiently manage motor speed across two independent motors not only optimizes energy usage but also extends motor lifespan, showcasing the synergy between embedded systems and power electronics in modern drive applications.

2. BACKGROUND

The Serial Peripheral Interface (SPI) is a synchronous communication protocol widely used for short-distance communication in embedded systems. It operates in a master-slave configuration, where the master device initiates and controls communication, while the slave devices respond to the master's commands.

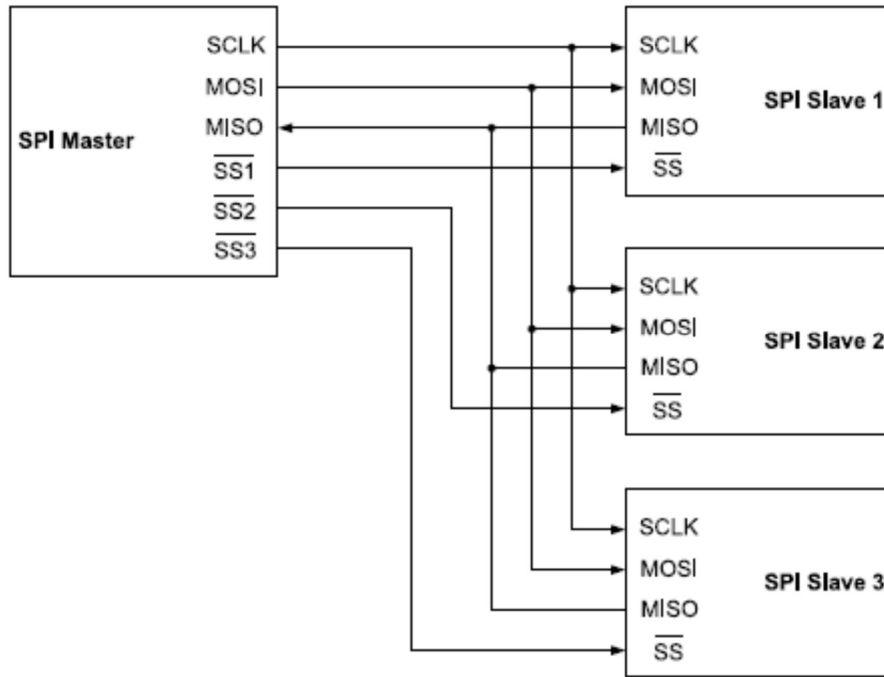


Figure 1 SPI Master Connected to Three SPI Slaves

SPI uses four key signals:

- *SCK (Serial Clock)*: This is a serial clock signal that is transmitted by the bus master to the slave device(s).
- *MOSI (Master Out Slave In)*: The data from a master to a slave device, is transmitted using Master- Out-Slave-In (MOSI) data line.
- *MISO (Master In Slave Out)*: The data to a master device from a slave, is transmitted using Master- In-Slave-Out (MISO) data line.
- *SS (Slave Select)*: This signal is used to select or enable a slave device for SPI communication. This signal is active low i.e., a logic low on this line enables the device for SPI communication.

In operation, data is shifted out of the master and into the slave, and vice versa, on the rising or falling edges of the clock signal. This full-duplex communication makes SPI highly efficient for real-time control applications. SPI supports high data transfer rates, making it ideal for quick updates to control signals, which is essential for dynamic motor speed and direction adjustments. Its straightforward structure simplifies the integration of microcontrollers with motor driver circuits, ensuring efficient communication and control.

2.1. LPC2148 MICROCONTROLLER

The LPC2148 microcontroller, based on the ARM7TDMI-S core, is widely used in embedded applications for its computational efficiency and peripheral support.



Figure 2 NGX ARM7 LPC2148 Development Board

Key features relevant to this project include:

- *PWM (Pulse Width Modulation)*: The LPC2148 provides multiple PWM channels, enabling precise control over motor speed and direction by modulating the duty cycle of the signal.
- *ADC (Analog-to-Digital Converter)*: The built-in ADC modules allow real-time conversion of analog inputs, such as the potentiometer position, to digital signals for processing.
- *SPI Interface*: Supports efficient communication with external devices like motor drivers, ensuring seamless integration in control systems.

2.2. DC MOTOR CONTROL

A DC motor converts electrical energy into mechanical motion, with speed proportional to the applied voltage. By adjusting the voltage or current, the motor's speed and direction can be precisely controlled. PWM is a common method used to achieve this, where the average voltage applied to the motor is controlled by varying the duty cycle of a digital pulse.

In this project, the PWM signals are generated using the LPC2148 microcontroller (slave) based on the analog voltage fed to the analog to digital converter of LPC2148 microcontroller (master) and transmitted via SPI to control a motor using the driver circuit. The motor driver circuit includes:

HCPL3120 Opto-Isolator: Provides electrical isolation between the control circuit and the high-power motor, ensuring safety and noise immunity.

IRF840 MOSFET: Acts as a high-speed switching device in the chopper circuit, efficiently driving the DC motor.

The SPI protocol facilitates smooth and reliable data transfer between one microcontroller to another, enabling real-time adjustments to motor speed. This integration demonstrates the effectiveness of SPI in implementing efficient and responsive motor control systems.

3. REQUIREMENTS

Component	Quantity
LPC2148 Boards	3
IRF840 MOSFET	2
HCPL3120	2
DC Motor	2
Bread board	3
Regulated Power Supply	2
Connecting Wires	As Reqd

4. HARDWARE DESIGN

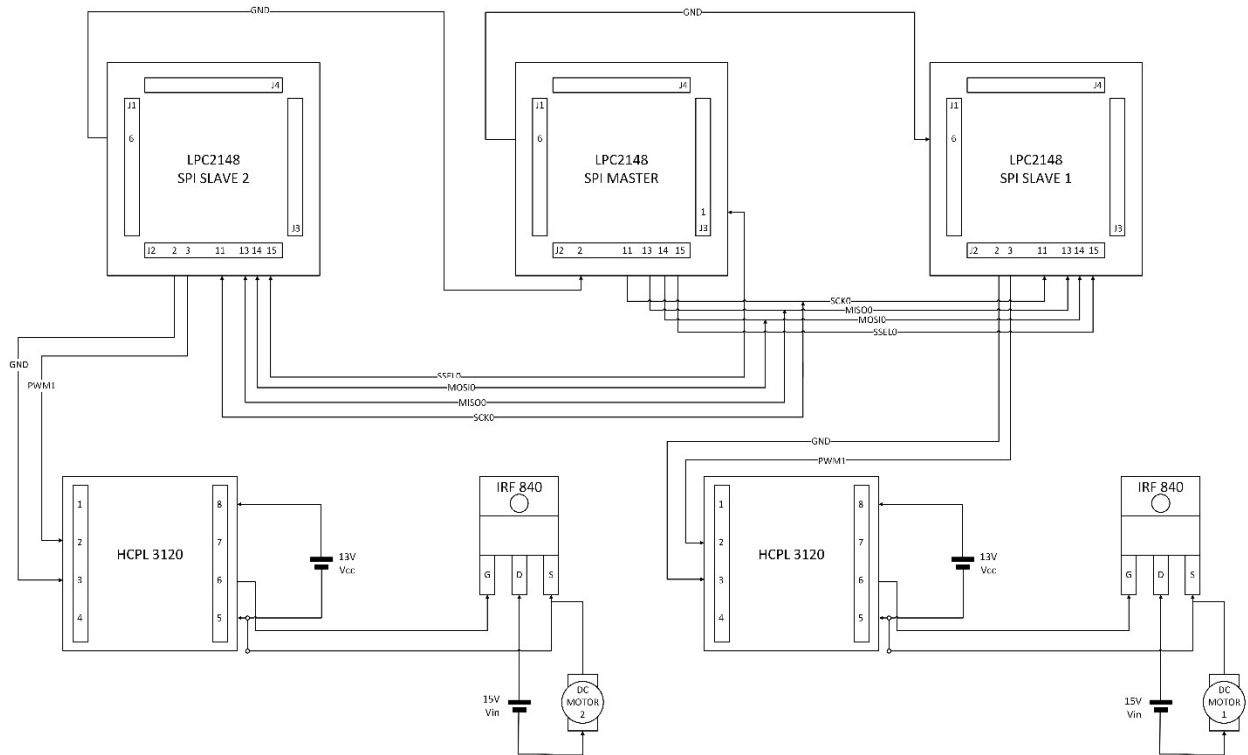


Figure 3 Connection Configurations

5. PROCEDURE

- Place two LPC2148 microcontrollers on separate development boards, designating one as the SPI Master and the other as the SPI Slave.

- Connect SCK0 (Serial Clock) PIN 11 of the master to the breadboard and then take it to PIN 11 of both the slaves.
- Connect MISO (Master In Slave Out) PIN 13 of the master to the breadboard and then take it to PIN 13 of both the slaves.
- Connect MOSI (Master Out Slave In) PIN 14 of the master to the breadboard and then take it to PIN 14 of both the slaves.
- Connect SSEL0 (Slave Select) PIN 15 of the master to PIN 15 of the slave1 and PIN 1 from J3 Junction of the master to PIN 15 of slave 2.
- Ensure a common ground is established between the master and slave microcontrollers.
- Initialize the ADC module on the master to read the potentiometer's analog voltage.
- Configure the PWM module to output the signal to the HCPL3120 opto-isolatoras displayed in Figure 3
- Power the HCPL3120 opto-isolator with a 13V supply and connect its output to the gate of the IRF840 MOSFET for both the chopper circuits.
- Wire the MOSFET in a chopper configuration, with the drain connected to the DC motor and the source to ground.
- Supply 15V to the motor through the MOSFET's drain terminal.
- Verify that the chopper circuit modulates the motor's speed according to the PWM signal.

6. RESULTS

6.1. HARDWARE IMPLEMENTATION

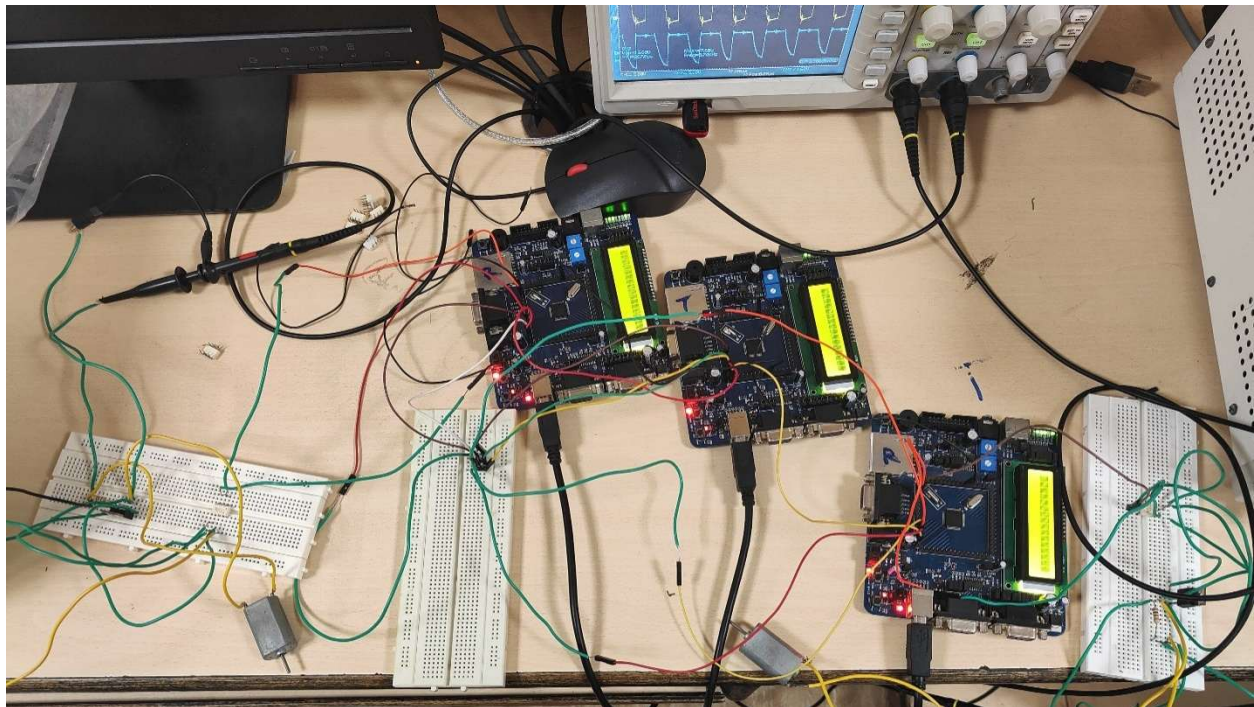


Figure 4 Board Connected to Chopper Circuit

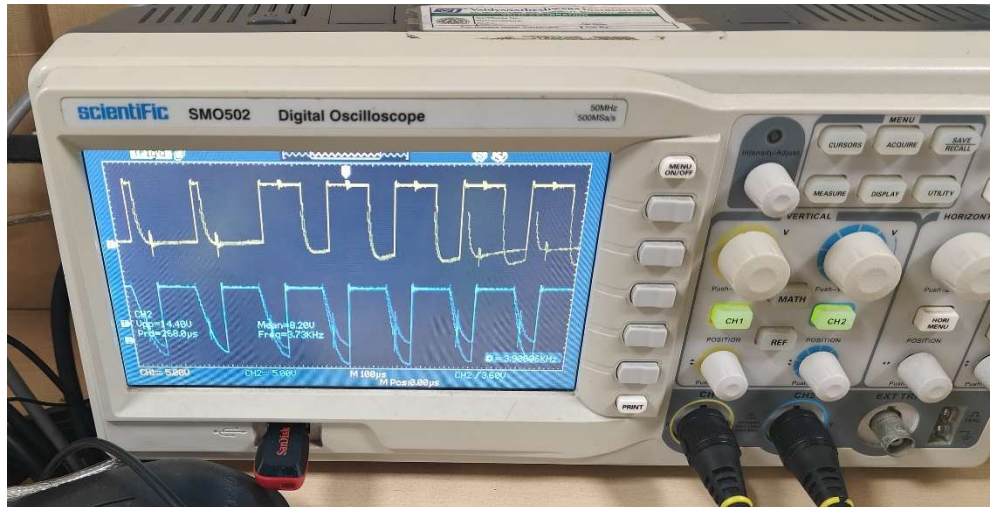


Figure 5 DSO Output Waveforms

6.2. OBSERVED WAVEFORMS

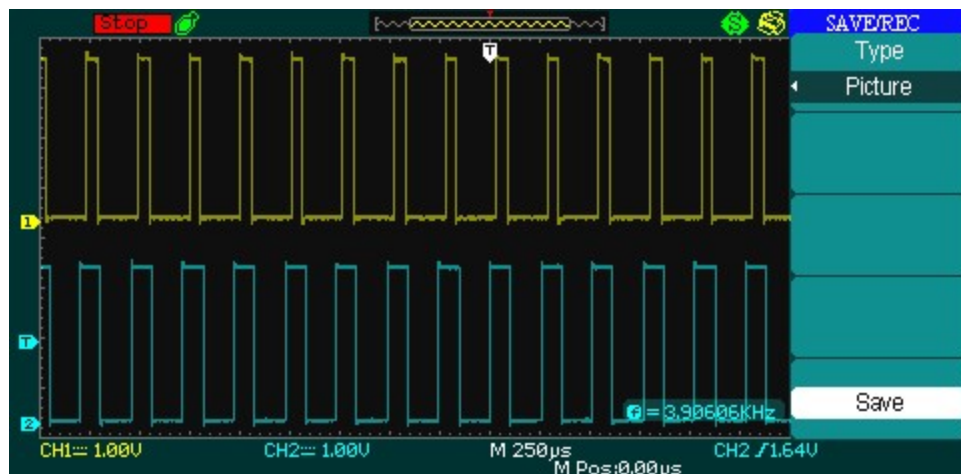


Figure 6 Output Observed Across the Slave Board

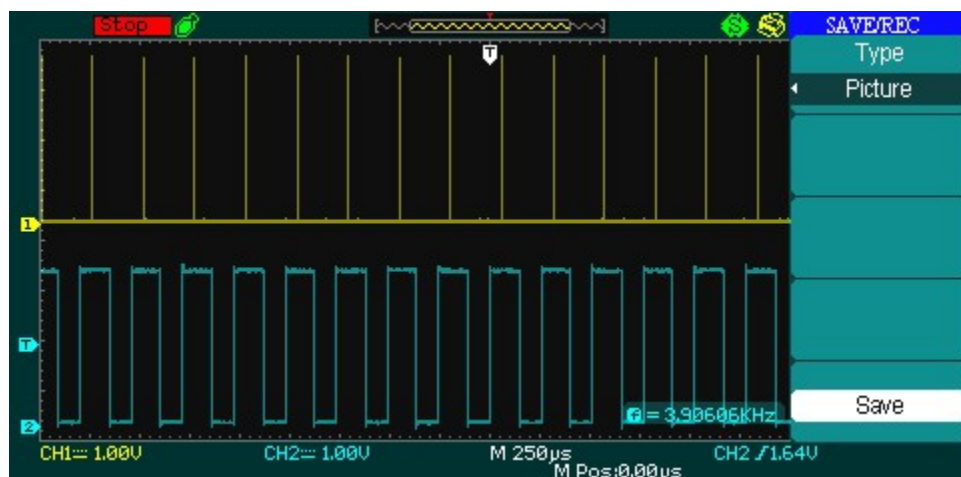


Figure 7 Output Observed Across the Load

7. CONCLUSION

The implementation of an SPI-based dual DC motor control system using LPC2148 microcontrollers demonstrates an efficient and reliable approach to managing the speed and direction of multiple motors. By leveraging the multi-slave configuration of SPI, the system ensures seamless and high-speed communication between the master and two slave modules. The integration of ADC for potentiometer input on the transmitter side, along with external interrupts to dynamically switch control between motors, provides real-time and flexible motor speed management. Each motor is controlled via a dedicated PWM signal processed by a robust chopper circuit, ensuring high efficiency and adaptability to varying load conditions.

This setup underscores the potential of SPI protocol and embedded systems in managing complex motor control tasks in power electronics and drives applications. The project paves the way for scalable, multi-motor control solutions that are well-suited for industrial automation, robotics, and other advanced mechatronics systems, where precision, efficiency, and reliability are paramount.

8. APPENDICES

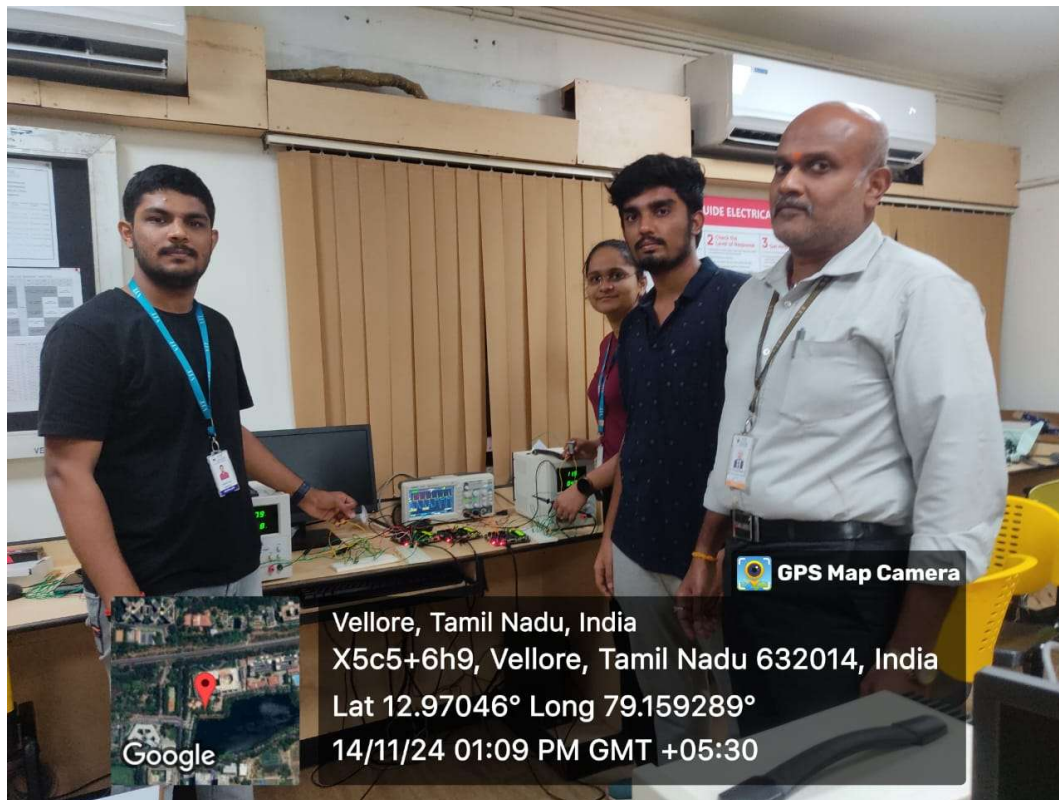


Figure 8 Contributors of the Work