Lab 3 – Prototype Phase 1

ECE 298 – S2021

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| Lab Section: | N/A | Group: | 90 |

# Part 1 – Pin Mapping

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| MCU Pin | Pin Mode | Functional Description |
| PA0 | TIM2\_CH1 | Outputs a PWM signal to the left DC Motor |
| PA1 | TIM5\_CH2 | Outputs a PWM signal to the right DC motor. |
| PA4 | GPIO\_Output | Outputs the first bit of 4 that is sent to the LCD in 4-bit mode. |
| PA5 | GPIO\_Output | Outputs the second bit of 4 that is sent to the LCD in 4-bit mode. |
| PA6 | GPIO\_Output | Outputs the third bit of 4 that is sent to the LCD in 4-bit mode. |
| PA7 | GPIO\_Output | Outputs the fourth bit of 4 that is sent to the LCD in 4-bit mode. |
| PA10 | GPIO\_Input | Controls the full system by turning it On/Off. |
| PB0 | GPIO\_Output | Outputs the E (enable) bit that is sent to the LCD in 4-bit mode. |
| PB1 | GPIO\_Output | Outputs the RS bit that is sent to the LCD in 4-bit mode. |
| PB2 | GPIO\_Output | Outputs the R/W (read/write) bit that is sent to the LCD in 4-bit mode. |
| PB3 | GPIO\_Output | Controls the red LED indicating battery voltage. |
| PB4 | GPIO\_Output | Controls the orange LED indicating battery voltage. |
| PB5 | GPIO\_Output | Controls the yellow LED indicating battery voltage. |
| PB6 | GPIO\_Output | Controls the green LED indicating battery voltage. |
| PB7 | GPIO\_Output | Controls the green LED indicating controller mode. |
| PB14 | GPIO\_Output | Selects the mux output controlling forward and backward rotation of the right DC motor. |
| PB15 | GPIO\_Output | Selects the mux output controlling forward and backward rotation of the left DC motor. |
| PC0 | ADC1\_IN10 | Analog to digital converter input of battery voltage. |
| PC1 | ADC1\_IN11 | Analog to digital converter input of speed control potentiometer. |
| PC2 | ADC1\_IN12 | Analog to digital converter input of steer control potentiometer. |
| PC6 | GPIO\_EXTI6 | Input of the left motor encoders’s Q1 output to sense rotation speed. |
| PC7 | GPIO\_Input | Input of the left motor encoders’s Q2 output to sense rotation direction. |
| PC8 | GPIO\_EXTI8 | Input of the right motor encoders’s Q1 output to sense rotation speed. |
| PC9 | GPIO\_Input | Input of the right motor encoders’s Q2 output to sense rotation direction. |

# Part 2 – MCU Resources

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| MCU Resource | Functional Description |
| TIM1 | Counts time until the last 1/24-th of a rotation occurred when sensing the Q1 voltage of the left DC motor encoder. |
| TIM2 | Generate PWM signal that is sent to control the left DC motor controller. |
| TIM4 | Counts time until the last 1/24-th of a rotation occurred when sensing the Q1 voltage of the right DC motor encoder. |
| TIM5 | Generate PWM signal that is sent to control the right DC motor controller. |
| ADC | Measures the analog voltage of the DC battery and potentiometer voltage division circuits on a scale of 0-3.3 V. |
| GPIO | Outputs digital signals to the LEDs, multiplexers, LED NFETs and LCD interfaces and receives input from the DC motor encoder’s outputs. |
| NVIC | Receives voltage from the DC motor encoder’s Q1 output to determine the rotation speed and direction of the motor. |

# Part 3 – Test Cases

## DC Motor control and interface

### Test Summary

The system involving the DC motor, DC motor encoder, DC motor controller, potentiometer steering and speed inputs has been tested with input/output test cases. The DC motor is controlled with a software-based PID controller that varies the duty cycle of the PWM signal that is input to each of the DC motor controllers. The set point of the PID control is set by the steering/speed potentiometer voltage divider ouput that is sensed by the ADC. The output of the DC motor encoder is then sensed by the MCU and the corresponding adjustments to the duty cycle are made. The LCD displays the sensed voltage. Due to the overshoot of the PID controller, there is an error of ~5% of the set-point RPM that is observed on the DC motors.

It should be noted that a 2-1 multiplexer is used to apply a backward rotation to the DC motor, the select pins of which are labelled AB1, and AB2 for the left and right motor respectively.

The following tests are displayed in the following section:

**Test 1: (forward steering)**

1. The controller is set to ON mode.
2. The speed input potentiometer is set to position 7, which corresponds to a maximum speed of 160 RPM
3. The steering input potentiometer is set to position 2, which corresponds to decreasing the left motor speed by 60% (turning left).
4. The sensed DC motor input is displayed on the LCD.

**Test 2: (backward steering)**

1. The controller is set to ON mode.
2. The speed input potentiometer is set to position 1, which corresponds to a speed of -320 RPM
3. The steering input potentiometer is set to position 9, which corresponds to decreasing the left motor speed by 80% (turning right while reversing).
4. The sensed DC motor input is displayed on the LCD.

**Test 3: (maximum speed)**

1. The controller is set to ON mode.
2. The speed input potentiometer is set to position 10, which corresponds to a maximum speed of 400 RPM
3. The steering input potentiometer is set to position 5, which corresponds to setting the speed on both the left and right motors to be the same.
4. The sensed DC motor input is displayed on the LCD.

Schematics and Simulations

**Test 1: (forward steering)**

The voltage of the steering/speed potentiometers is set:

Chart

Description automatically generated with medium confidence

The motor is fed a PWM which ramps up its speed to what is shown below:

Diagram, schematic

Description automatically generated

And the PC[6..9] pins are used to sense the rotation speed of the motors and set the duty cycle of the PWM pins in closed loop control. The LCD displays the corresponding mode and rotation speed:

Diagram, schematic

Description automatically generated

The test confirms the forward rotation and steering control is as designed, implemented with PID control of the PWM duty cycle fed to the DC motors.

**Test 2: (backward steering)**

The voltage of the steering/speed potentiometers is set:

Chart

Description automatically generated

The motor is fed a PWM which ramps up its speed to what is shown below:

Diagram, schematic

Description automatically generated

And the PC[6..9] pins are used to sense the rotation speed of the motors and set the duty cycle of the PWM pins in closed loop control. The LCD displays the corresponding mode and rotation speed:

Diagram, schematic

Description automatically generated

The test confirms the backward rotation and steering control is as designed, implemented with PID control of the PWM duty cycle fed to the DC motors.

**Test 1: (forward steering)**

The voltage of the steering/speed potentiometers is set:

Diagram, schematic

Description automatically generated

The motor is fed a PWM which ramps up its speed to what is shown below:

Diagram, schematic

Description automatically generated

And the PC[6..9] pins are used to sense the rotation speed of the motors and set the duty cycle of the PWM pins in closed loop control. The LCD displays the corresponding mode and rotation speed:

Diagram, schematic

Description automatically generated

The test confirms the maximum forward rotation and straight speed control is as designed, implemented with PID control of the PWM duty cycle fed to the DC motors.

## Battery sense and LED indicators

### Test Summary

### Schematics and Simulations

## Button Indication and response

### Test Summary

### Schematics and Simulations