



## Laboratory Assignment Number 7 for ME 218b

Pre-Lab Due by 11:59 pm on January 28, 2026

Due by 5:00 pm on January 30, 2026

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### Goals:

In this lab you will explore the behavior of a DC motor being driven by Pulse Width Modulation (PWM) using a Drive-Brake mode. You will also gain experience implementing closed loop speed control of the DC motor.

### Part 0: Pre-Lab

#### Background:

The pre-lab should be completed after you have read through the entire lab assignment, but before you go into the lab to begin your work there. Completing the pre-lab, which can be done without any special tools or resources, will allow you to be most efficient with your time in the lab. We judge the pre-lab submission based on a reasonable effort in pre-lab document submitted.

#### Assignment:

- 0.1) Design a circuit to drive the DC motor bi-directionally using Drive-Brake mode using an L293NE (or SN754410) as the drive stage with a motor voltage of 5V. The schematic should be created in KiCad.
- 0.2) Figure out how you will measure the electrical time constant of the motor as requested in Part 1.1. Include a circuit diagram of the measurement circuit.
- 0.3) Design the software that you will use for Part 1. Include pseudo code for program(s).
- 0.4) Design the software that you will use for Part 2. Include pseudo code for program(s).

#### In the report:

Include your answers to all of the sections of the pre-lab.

Pseudocode for part 1

Time Constant Measurement Service (Part 1.1)

RUN FUNCTION:

INPUT: ThisEvent

Switch on CurrentState:

Case IDLE:

If ThisEvent is ES\_NEW\_KEY (e.g., 't' for toggle start):

Start ES\_Timer (e.g., TOGGLE\_TIMER) with desired half-period

(e.g., 1ms for a 500Hz square wave to start)

Set RA2 HIGH

Set PinState to HIGH

Transition to TOGLLING state

Case TOGLLING:

If ThisEvent is ES\_TIMEOUT from TOGGLE\_TIMER:

Toggle PinState

Write PinState to RA2

Restart TOGGLE\_TIMER with same period

If ThisEvent is ES\_NEW\_KEY (e.g., 's' for stop):

Stop TOGGLE\_TIMER

Set RA2 LOW

Transition to IDLE state

If ThisEvent is ES\_NEW\_KEY (e.g., '+' or '-'):

Adjust timer period up or down

Print new frequency to terminal

Return ES\_NO\_EVENT

## Motor Control Service (Parts 1.2, 1.3)

## Init function

```

// Initialize Direction Control Pin (RB2, IN 1A)
Disable analog on RB2 (ANSB2 = 0)
Set RB2 as output (TRISB2 = 0)
Set RB2 = 0 (default forward direction)

// Initialize Direction Input Pin (RA1)
Disable analog on RA1 (ANSA1 = 0)
Set RA1 as input (TRISA1 = 1)

// Initialize ADC for potentiometer on AN0
Call ADC_ConfigAutoScan(BIT0HI)

// Initialize PWM (OC4 on RB13, using Timer2)
Call InitPWM() (From previous lab)

// Initialize Input Capture (IC2 on RB9, using Timer3)
Call InitInputCapture() (From previous lab)

// Start periodic timer for ADC reading (10 Hz)
ES_Timer_InitTimer(MOTOR_TIMER, ADC_UPDATE_TIME)

```

```

// Post ES_INIT
Post ES_INIT to self
Return TRUE

```

## Run function

```

INPUT: ThisEvent
ReturnEvent = ES_NO_EVENT

```

Switch on ThisEvent.EventType:

```

Case ES_TIMEOUT:
If ThisEvent.EventParam == MOTOR_TIMER:

    // --- Read Potentiometer ---
    // --- Calculate Duty Cycle ---
    // Map ADC (0-1023) to duty cycle register value (0-PWM_PERIOD)
    DutyCycleReg = (adcResult[0] * PWM_PERIOD) / 1023

```

```
// Calculate percentage for display
CurrentDutyCyclePercent = (adcResult[0] * 100) / 1023

// --- Read Direction Input ---
DirectionInput = Read PORTAbits.RA1

// --- Apply Direction and Duty Cycle ---
If DirectionInput == 0:    // Forward
    Set IN_1A (RB2) = 0
    Set OC4RS = DutyCycleReg
Else:                      // Reverse
    Set IN_1A (RB2) = 1
    // Invert duty cycle for Drive-Brake with IN1A=1
    Set OC4RS = PWM_PERIOD - DutyCycleReg

// --- Calculate and Print RPM ---
// Safely read volatile period (disable interrupts briefly)
__builtin_disable_interrupts()
PeriodSnapshot = CurrentPeriod
__builtin_enable_interrupts()

If PeriodSnapshot > 0:
    RPM = RPM_NUMERATOR / PeriodSnapshot

    // Print for data collection (CSV format)
    Print "%d, %d\r\n", CurrentDutyCyclePercent, RPM
Else:
    // Motor stopped or no encoder pulses
    Print "%d, 0\r\n", CurrentDutyCyclePercent

// Restart timer
ES_Timer_InitTimer(MOTOR_TIMER, ADC_UPDATE_TIME)

Default:
    // Ignore other events

Return ReturnEvent
```

Pseudocode for part 2 modification to motor service from part 1

New init function

Save Priority to MyPriority

// Initialize Direction Control Pin (RB2, IN 1A)

// Initialize ADC for potentiometer on AN0

// Initialize PWM (OC4 on RB13, using Timer2)

Call InitPWM()

// Initialize Input Capture (IC2 on RB9, using Timer3)

Call InitInputCapture()

// Initialize Timing Pin for ISR measurement (Part 2.5)

Set TIMING\_PIN\_TRIS = 0 (output)

Set TIMING\_PIN = 0 (initially low)

// Initialize Control Loop Timer (Timer4)

Call InitControlTimer()

// Print startup message

// Start periodic timer for ADC/reporting (10 Hz)

ES\_Timer\_InitTimer(MOTOR\_TIMER, ADC\_UPDATE\_TIME)

Post ES\_INIT to self

Return TRUE

New run function

Switch on event type:

Case ES\_TIMEOUT:

If ThisEvent.EventParam == MOTOR\_TIMER:

// --- Read Potentiometer for Speed Command ---

Declare adcResult[1]

ADC\_MultiRead(adcResult)

```
// Map ADC (0-1023) to commanded RPM
float NewTargetRPM = (float)adcResult[0] * MAX_COMMANDED_RPM / 1023.0
```

```
// Update target RPM (used by control ISR)
```

```
TargetRPM = NewTargetRPM
```

```
// --- Print for monitoring (CSV format) ---
```

```
Print "%.1f, %.1f, %.1f, %.1f\r\n",
      TargetRPM, CurrentRPM, LastRPMError, RequestedDuty
```

```
// Restart timer
```

```
ES_Timer_InitTimer(MOTOR_TIMER, ADC_UPDATE_TIME)
```

Default:

```
// Ignore other events
```

```
Return ReturnEvent
```

Control loop isr, priority 5 lower than encoder isr

```
// Clear interrupt flag first
IFS0CLR = _IFS0_T4IF_MASK
```

```
// Raise timing pin on entry (for Part 2.5)
```

```
TIMING_PIN = 1
```

```
// --- Local variables (static for speed) ---
```

```
static float RPMError
static uint32_t ThisPeriod
static float Rpm
```

```
// --- Get Current Motor Speed ---
```

```
ThisPeriod = CurrentPeriod
```

If ThisPeriod > 0:

```
Rpm = PER2RPM / ThisPeriod
```

Else:

```
Rpm = 0
```

```
// --- Calculate Error ---
```

```
RPMError = TargetRPM - Rpm
```

```
// --- Accumulate Error for Integral ---
SumError += RPMError

// --- Calculate Requested Duty Cycle (PI Control Law) ---
RequestedDuty = (pGain * RPMError) + (iGain * SumError)

// --- Clamp Output and Apply Anti-Windup ---
If RequestedDuty > 100:
    RequestedDuty = 100
    SumError -= RPMError // Anti-windup: undo the accumulation

Else If RequestedDuty < 0:
    RequestedDuty = 0
    SumError -= RPMError // Anti-windup: undo the accumulation

// --- Update for display ---
LastRPMError = RPMError
CurrentRPM = Rpm

// --- Apply Duty Cycle to PWM ---
Call SetDuty(RequestedDuty)

// Lower timing pin before exit (Part 2.5)
TIMING_PIN = 0
```

