CMPE 460 Laboratory Exercise 6

PWM & DC Motors & Servo Motors

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By submitting this report, you attest that you neither have given nor have received any assistance (including writing, collecting data, plotting figures, tables or graphs, or using previous student reports as a reference), and you further acknowledge that giving or receiving such assistance will result in a failing grade for this course.

Your Signature: ______________________________

Description

This laboratory exercise looked at implementing drivers for three different types of motors. The DC, servo and stepper motors. The DC motor operates by simply passing current through the motor. The direction of current will determine the direction that the motor will spin. The speed of a DC motor may be controlled by pulsing the voltage across the two terminals at various rates. The servo motor will hold its position given a PWM signal. Usually servo motors will operate at a single PWM frequency and between a minimum and maximum duty cycle. The duty cycles inside this range will control the position of the servo motor. A stepper motor is a motor that will operate with multiple inductors placed around the rotor. By pulsing these inductors in a certain order, the magnetic field generated will cause the rotor to rotate by a certain amount. Stepper motors may also be held in place in a closed loop fashion by providing active feedback against a load to hold the rotor at a certain position. This makes stepper motors a great choice for a kinematic robot that requires precise moving with high holding torque.

Wiring diagrams

DC motor

Because a DC motor will require a high amount of current that the microcontroller (MC) cannot viable provide, the DC motor must be isolated from the MC in a fashion that can also be controlled by the MC. To do this, an H-bridge array is used. The H-bridge array will allow the MC to switch the high voltage power supply (Vcc2) onto the motor terminals (1Y, 2Y).

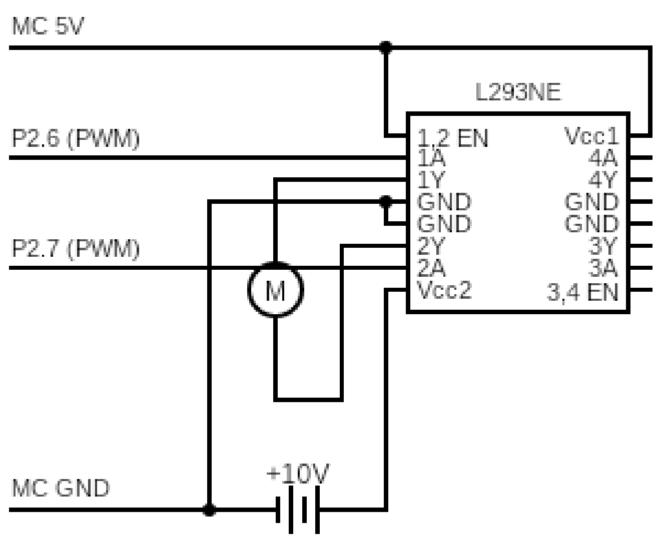


Figure 1: DC Motor wiring.

Figure 1 shows the wiring required to get the MC and the L293NE H-bridge array to control a DC motor. The inputs, 1A and 2A, will switch 0 V or 10 V onto their corresponding outputs, 1Y and 2Y, depending on the inputs logic level. To allow the motor to spin, one of the terminals should be raised to 10 V while the other should be grounded to 0 V. The speed of the motor can be controlled by pulsing the input line using a PWM signal. Varying the duty cycle will vary the resultant speed of the motor.

Notice that Figure 1 connects ground of the motor controller to the ground of the power supply. This will allow the reference voltage of the H-bridge logic (and output low) to match the ground on the power supply. The DC motor will not work without this connection.

Stepper motor

Like the DC motor, the stepper motor requires current isolation between the micro controller and the motor coils. To achieve this, a Darlington array is used. A Darlinton array can act as a current amplifier which can power the each coil on stepper motor.

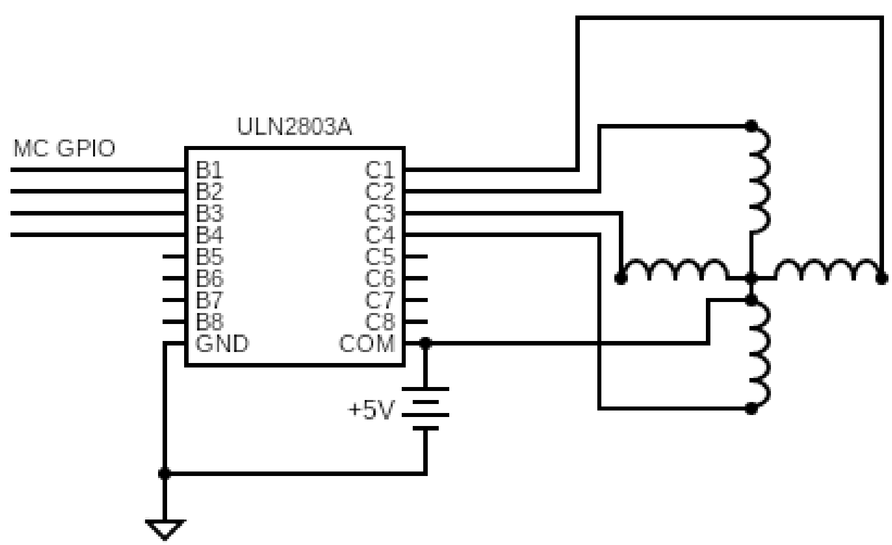
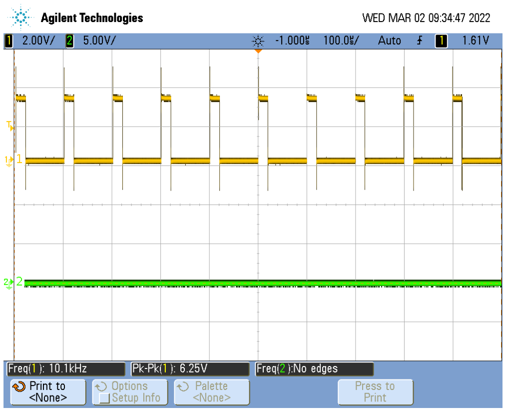


Figure 2: Stepper Motor wiring.

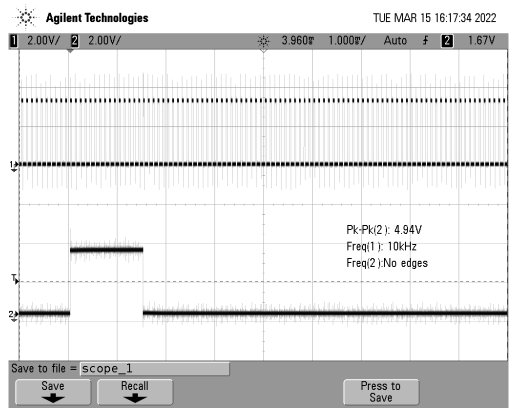
As shown in Figure 2, a darlington array integrated circuit is controlled directly by GPIO pins on the MC. The common line is connected to an external power source and output pin is connected to the respective input terminal of the stepper motor's coil.

Oscilloscope captures

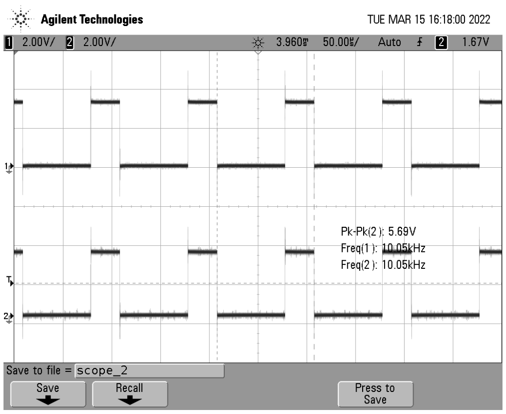
Oscilloscope captures were taken for Parts 1 (Figure 3a) and 4 (Figures



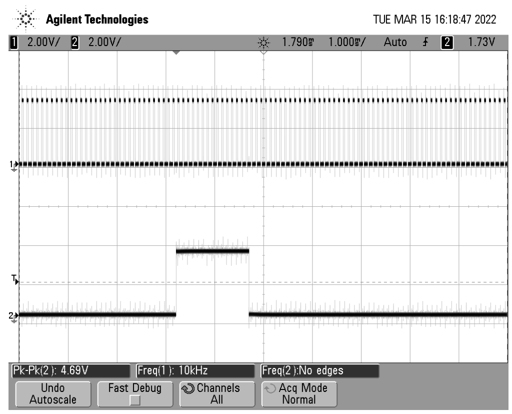
(a) 20% duty cycle on 10 kHz PWM



(b) Left motor at 30% (10 kHz) and servo at 7.5% (50 Hz) simultaneously



(a) Left and right motor at 30% (10 kHz) simultaneously



(b) Right motor at 30% (10 kHz) and servo at 7.5% (50 Hz) simultaneously

Description of code

There are two new modules written to support the DC and servo motors. The `pwm` module will implement the lower level hardware configuration of the TimerA. This module supports all TimerA pins (TA0-3 5-pins per timer). Any of the PWM pins may be selected via a `PwmPin` object that will select both the timer and the pin on that timer. During initialization the base frequency of the timer channel can be configured. During runtime, the duty cycle may be set using a floating point number from `0.0` to `1.0`.

The second module written to support this lab is the `dc` module. This module will simply wrap the `pwm` module to operate two pins, forward and backward. To control the direction and speed of the motor, a number between `-1.0` and `1.0` may be used where negative numbers will run the motor backward.

To time the speedup and slowdown of the motor in part 2, a Timer32 was configured to interrupt at 10 ms intervals and increment a state counter. The state counter would count from 0 to 100 controlling the speed of the motor. Once overflown, the counter would reset and place the system into deceleration mode. The system oscillated between acceleration and deceleration modes until a switch press toggles to system to an OFF state.

In-lab questions

1. Explain how to change speed and direction of turn of the DC motor.

   The speed of the motor can be changed by varying the duty cycle of the PWM signal. The direction of the motor can be changed by swapping the terminals on the motor (or by feeding a PWM signal into the other terminal).

2. Describe in your lab report an alternate method in your report that uses only one PWM line and one GPIO line.

   The PWM signal is connected to one terminal, the GPIO line to the other. To run the motor forward, drop the GPIO line to LOW and start the PWM signal with $duty\_cycle$. To run the motor backward, raise the GPIO line to HIGH and start the PWM signal with $1 - duty\_cycle$.

3. Which stepping mode does this code use?

   Full-step (low torque)

100 :1 gearbox

$15.45\ Nm \left(\frac{1}{100}\right) = \boxed{0.1545\ Nm}$

$2189.76 \left(\frac{1}{100}\right) = \boxed{2.18976\ oz\ in}$

6. $F_T = F_w + F_f$

$F_T = \frac{100kg}{4}(9.81)(\sin(\theta))$

$32\ oz.in \left(\frac{100}{1}\right) = 3200\ oz.in$

force !

$3200\ oz\ in \left(\frac{1}{8}\right) = \cancel{32} \cancel{400z}\ 400\ oz$

$= 40z \left(\frac{1\ lb}{16\ oz}\right)\left(\frac{1\ N}{0.225\ lb}\right)$

$= \cancel{111}\ N$

111.1

$111.11\ N = \frac{100kg}{4}(9.81)(\sin\theta)$

$\boxed{\theta = 26.94^\circ}$

Exercise 6: Motor Control

Student's Name: Andrei Tomban Section: 2

PreLab		Point Value	Points Earned	Comments
PreLab	Motor Calculations	10	10	CP 2/25
	H-Bridge Questions	10	10	

Demo		Point Value	Points Earned	Date
Demo	20% Duty Cycle at 10kHz	10	10	DY 2/25
	DC Motor Functionality	5	5	LJB 3/15/22
	Stepper Motor Functionality	5		
	Servo Motor Functionality	5	5	CB 3/15
	Simultaneous TI Car Motors-Servo Motor	15	15	DY 3/15

To receive any grading credit students must earn points for both the demonstration and the report.