Julia Laine

Lab 02

8/29/24

Partner: Geetika Chitturi

Section: 20008-009

AD2 Serial number: 210321AA2E82

Abstract

In this lab, 3 circuits were constructed using an AD2, breadboard, power supply, and digital multimeter. The purpose of the lab was to demonstrate the different applications of MOSFETs. The first circuit was used to generate a V_{GS} and I_D I-V characteristic curve. It was successful in generating the curves for each mode. The second circuit controlled a motor using the function generator on the AD2 and later a potentiometer. It was successfully completed and controlled the motor. It showed the relationship between motor RPM and duty cycle. The last circuit was a PWM generator to control a motor. It was created by using a LM555 and a MOSFET to create a PWM wave. It was successful and demonstrated the relationship between Vcontrol and motor speed.

Task 1

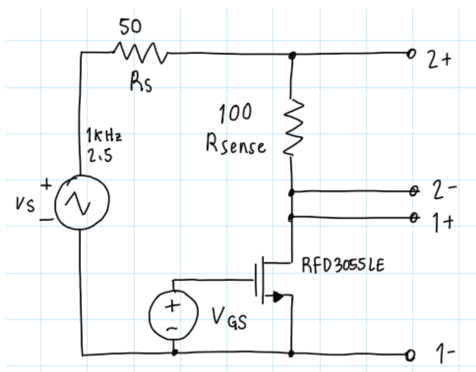
Objective

The objective of this task is to demonstrate V_{GS} and I_D I-V relationship curves in practice.

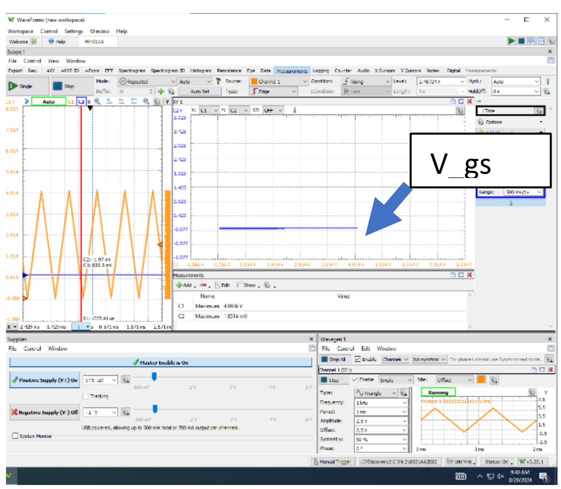
Procedure

The circuit shown below in results was built. An AD2 was used to measure the outputs and connected to the 2+, 2-, 1+, 1- channels. The oscilloscope on the AD2 was configured to measure the XY mode to generate the IV characteristic of the MOSFET. Screenshots were taken and labeled. Power dissipated was estimated from the screenshots. Afterwards, R_DS was found on the datasheets and compared to the found R_DS.

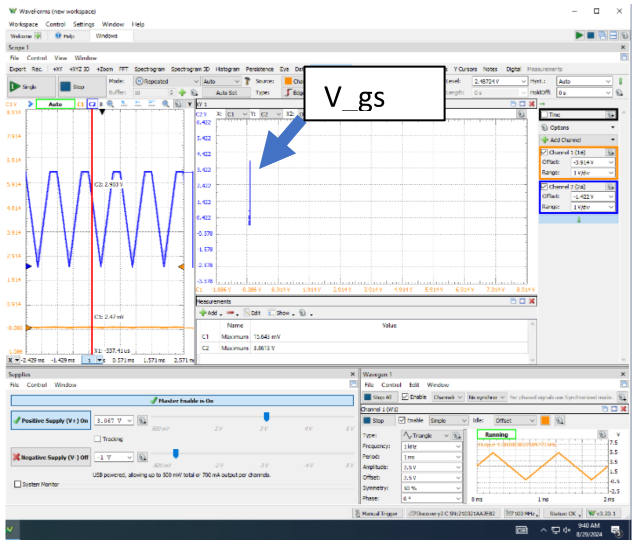
Results



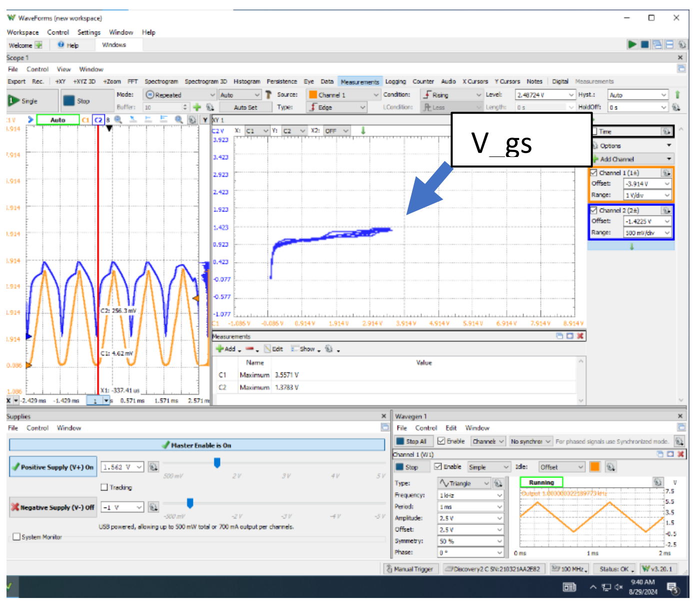
Circuit diagram graph



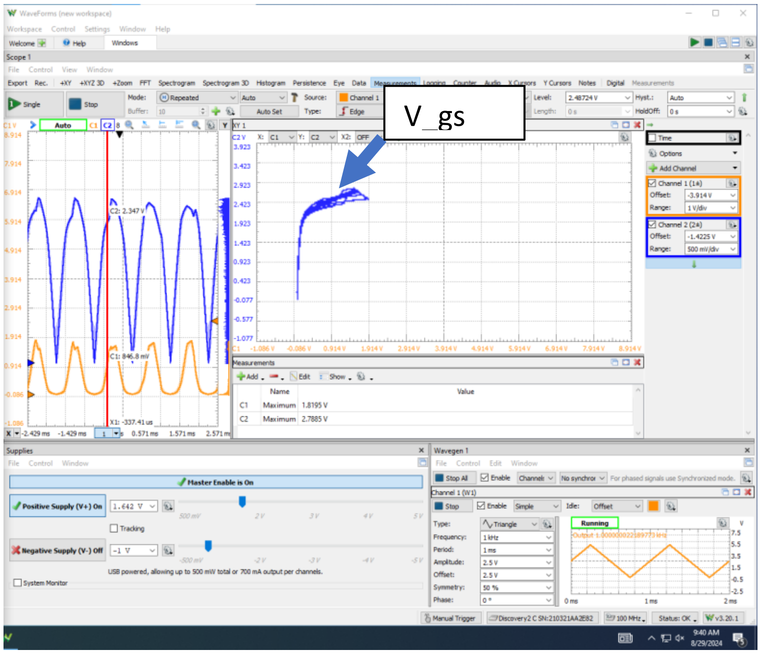
AD2 graphs at cutoff



AD2 graph at linear



AD2 graph at saturation (1)



AD2 graph at saturation (2)

Power estimate

$$P = \frac{V^2}{R}$$

Cutoff:

$$P = \frac{V^2}{R} = \frac{.002^2}{100} = 4 * 10^{-8} W$$

Triode:

$$P = \frac{V^2}{R} = \frac{3.8613^2}{100} = .149\ W$$

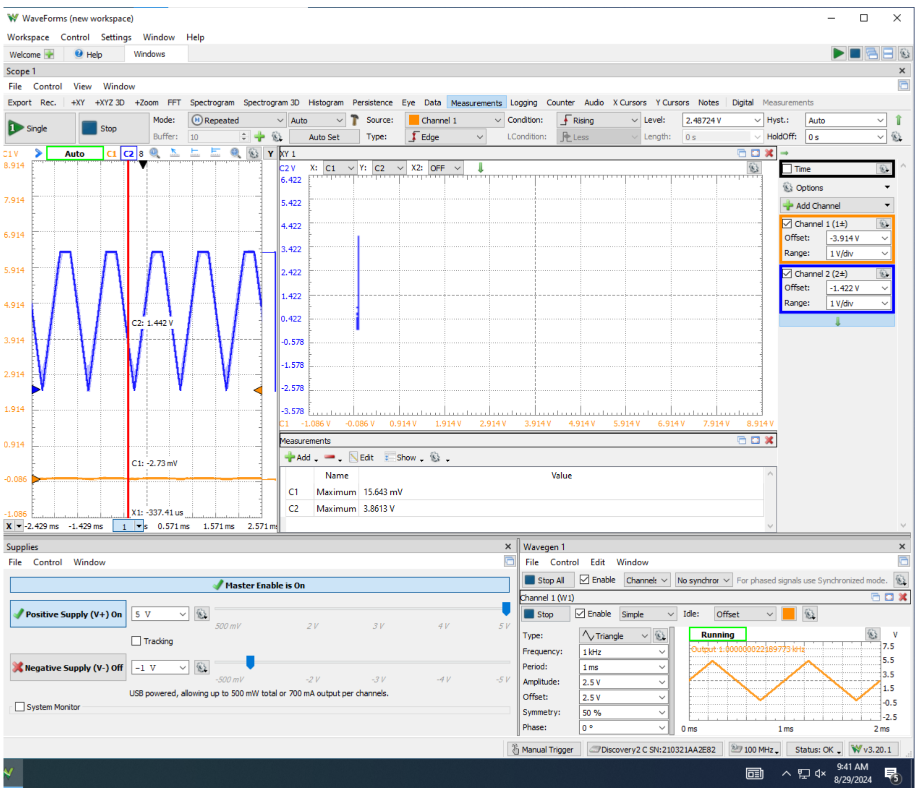
Sat 1:

$$P = \frac{V^2}{R} = \frac{1.3783^2}{100} = .0189\ W$$

Sat 2:

$$P = \frac{V^2}{R} = \frac{2.789^2}{100} = .0778\ W$$

The most power is dissipated in triode while the least power is dissipated in cutoff. As V_{GS} increases, power dissipated increases.



V_GS at 5v

V_DS Estimation in Linear

$$I_D = \frac{3.8613\ V}{100\ Ohms} = .0386\ A$$

$$\frac{V}{I} = \frac{.015\ V}{.0386\ A} = .387\ Ohms = R_{DS}$$

Comparison to datasheet

Datasheet RDS on: .107 Ohms

Found RDS: .387 Ohms

Conclusion

The experiment was semi successful. The V_{GS} and I_D I-V relationship curves were accurate and showed the graphs seen in the textbook in person. It was “semi” successful because the found RDS was more than 3x higher than the RDS on the datasheet. This may be because of the difference in voltages used to find the RDS.

Task 2

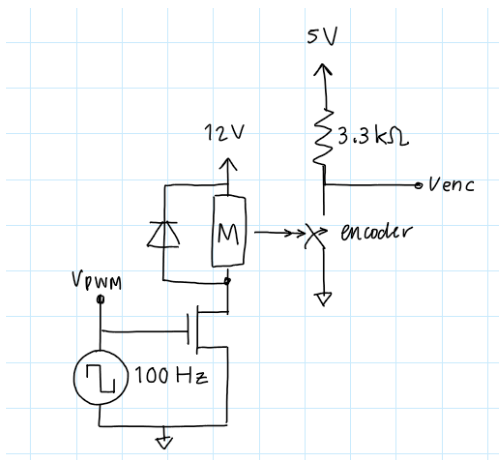
Objective

The objective of this task is to control a motor by using a PWM wave.

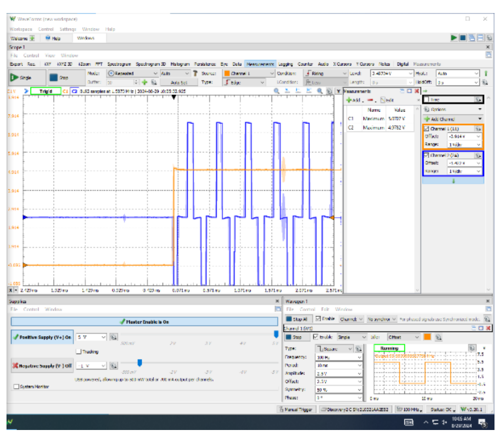
Procedure

First the circuit shown below in the results section was constructed. An AD2 was setup to output the waveforms and record frequency and current. From this, the power consumed and RPM were found. The duty cycle vs motor RPM graph was created to compare the two values.

Results



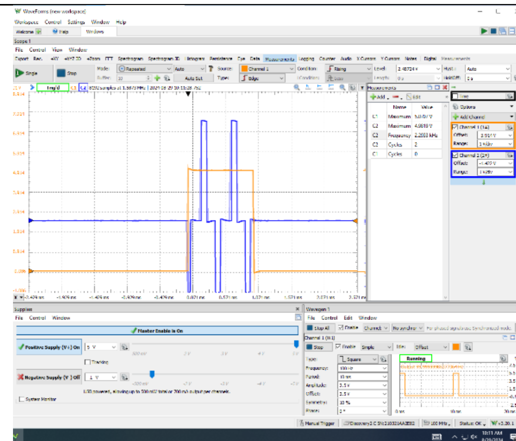
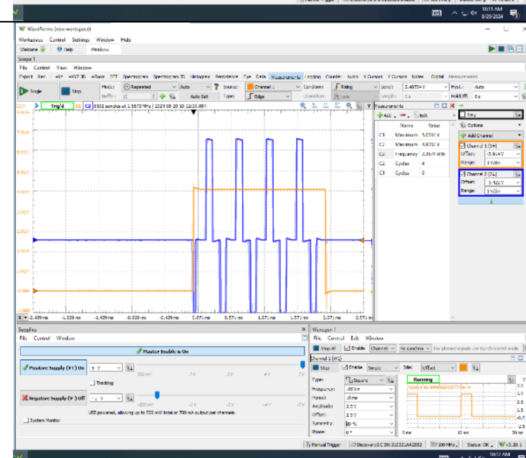
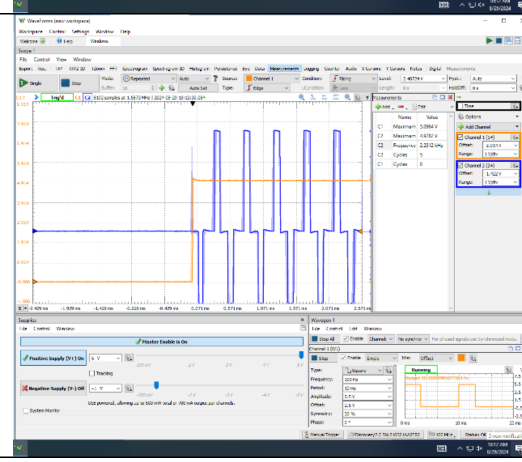
Circuit Diagram

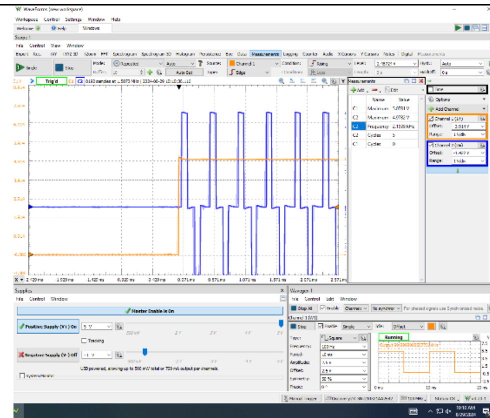
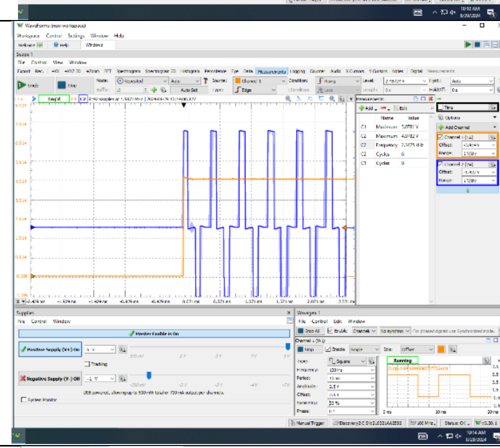
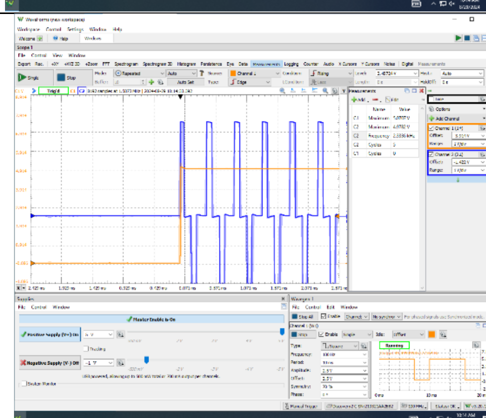
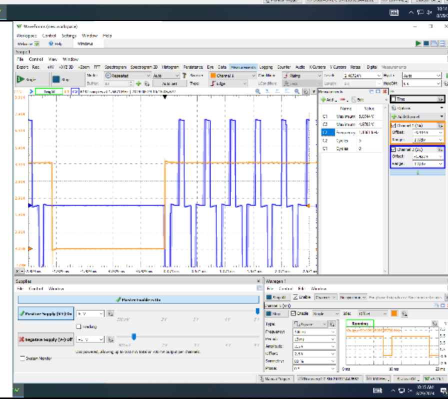


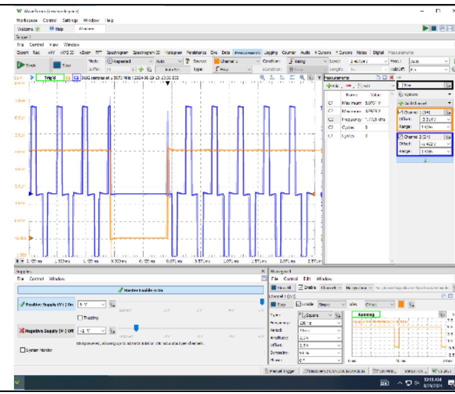
100 Hz 0-5V square wave with Duty Cycle of 50%

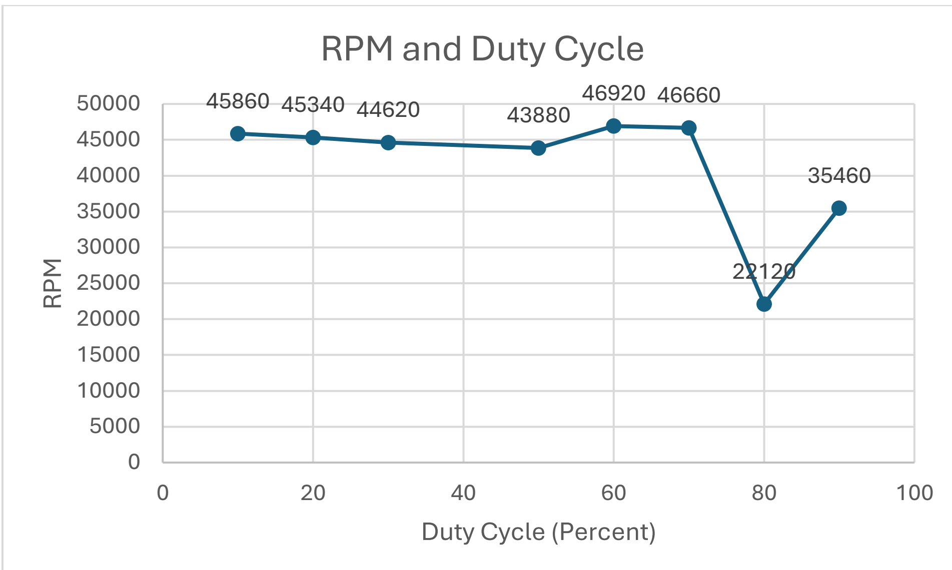
Orange: pin 5 (V_ctrl)

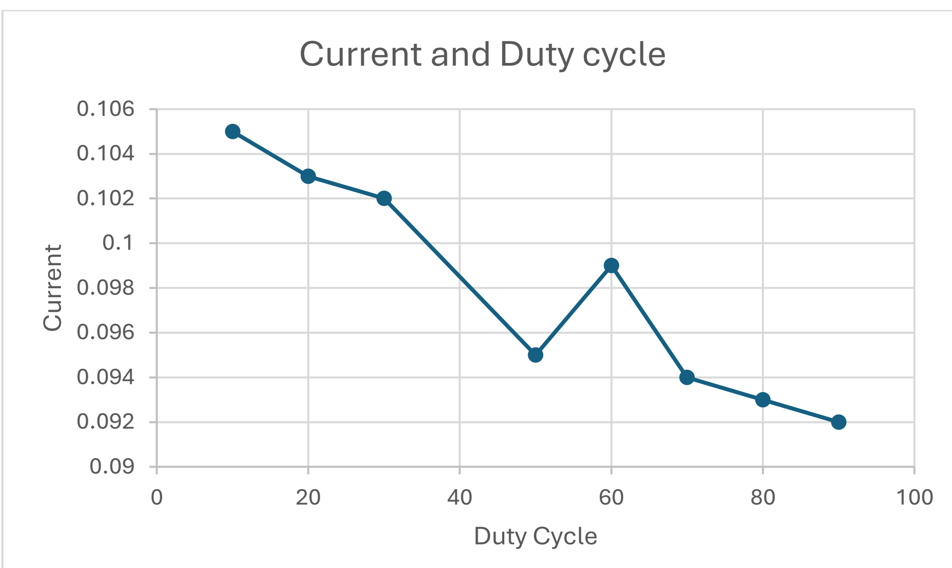
Blue: encoder on motor

Duty cycle (%)	Frequency Hz	RPM Hz * 60	Average Id (A)	Power consumed (Id^2/3300)	Image
10	764.333333	45860	0.105	3.34091E-06	
20	755.666667	45340	0.103	3.21485E-06	
30	743.666667	44620	0.102	3.15273E-06	

50	731.333333	43880	0.095	2.73485E-06	
60	782	46920	0.099	0.00000297	
70	777.666667	46660	0.094	2.67758E-06	
80	368.666667	22120	0.093	2.62091E-06	

90	591	35460	0.092	2.56485E-06	





I expected the RPM to increase as the duty cycle increased since there would be voltage supplied to the motor for a longer time. It looks like I was wrong, and it remained about the same with a dip at 80% duty cycle. I would repeat this portion to double check my calculations, but I do not have a motor.

Conclusion

This task was successful since the motor was successfully controlled using the PWM wave generated by the AD2 and the potentiometer. The RPM and duty cycle graph may not be accurate due to incorrect frequency measurements. The frequency measured on the AD2 may have been the incorrect channel. The duty cycle and current graph may also not be accurate since it has a large spike at 60% duty cycle. The I values were not accurate to high degrees and my lab partner and I did the best we could to get a reasonable value of I.

Task 3

Objective

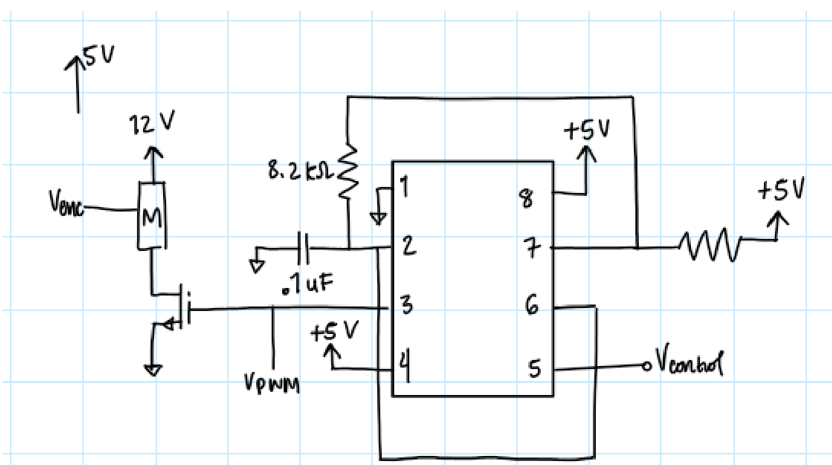
The objective of this task was to generate our own PWM waves to control a motor without using the function generator.

Procedure

First the circuit shown below was constructed. The circuit's inputs were connected to an AD2's waveform outputs. The outputs of the circuit were connected to the oscilloscope on the AD2. The V_control was changed by changing the DC offset of a waveform on the AD2. The duty cycle and motor speed were recorded. Then the function generator was replaced with a potentiometer that changed the speed of the motor. This was verified by turning the potentiometer to both ends and it was full speed on one end and off at the other. Finally, a model for Vcontrol and speed was developed.

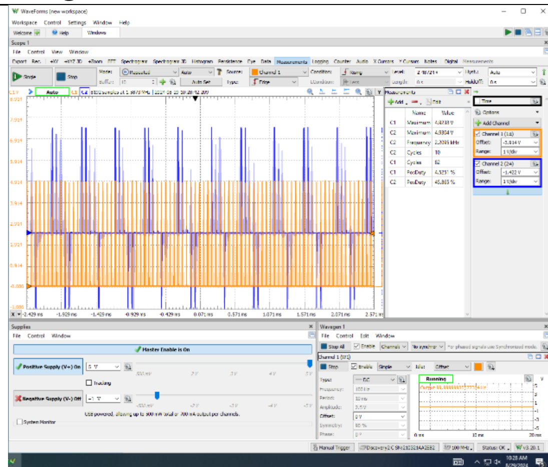
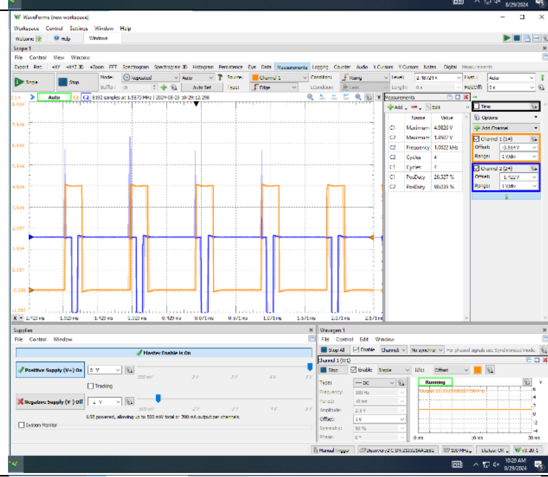
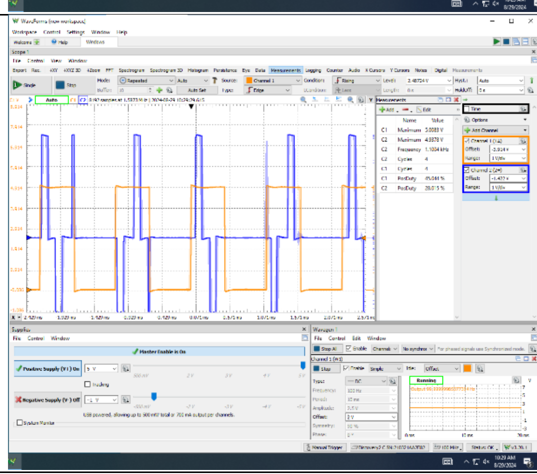
Results

Circuit diagram

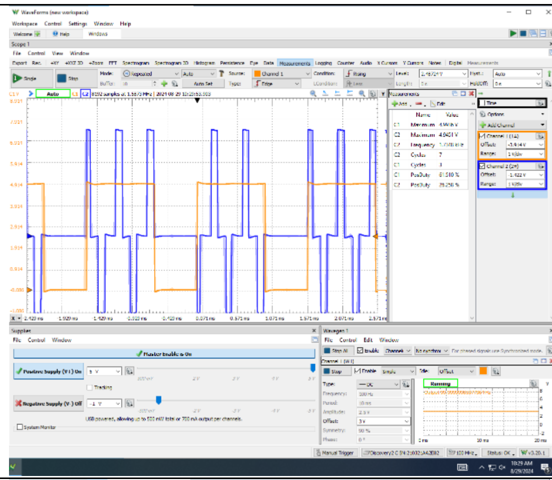
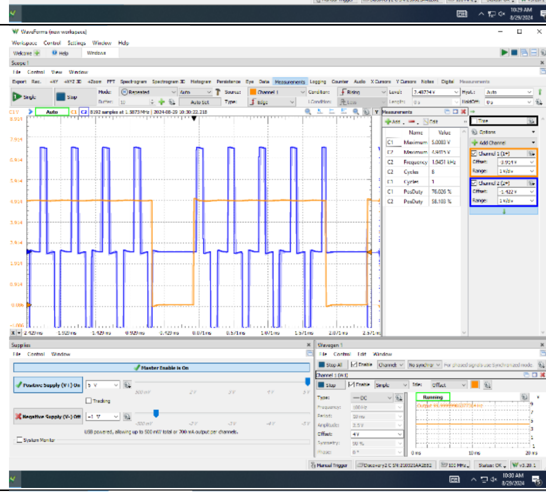
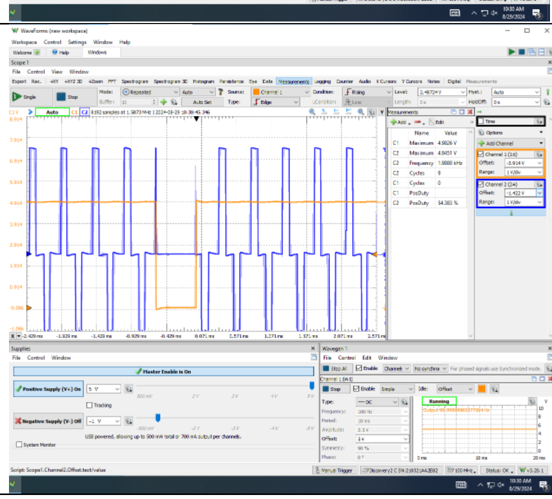


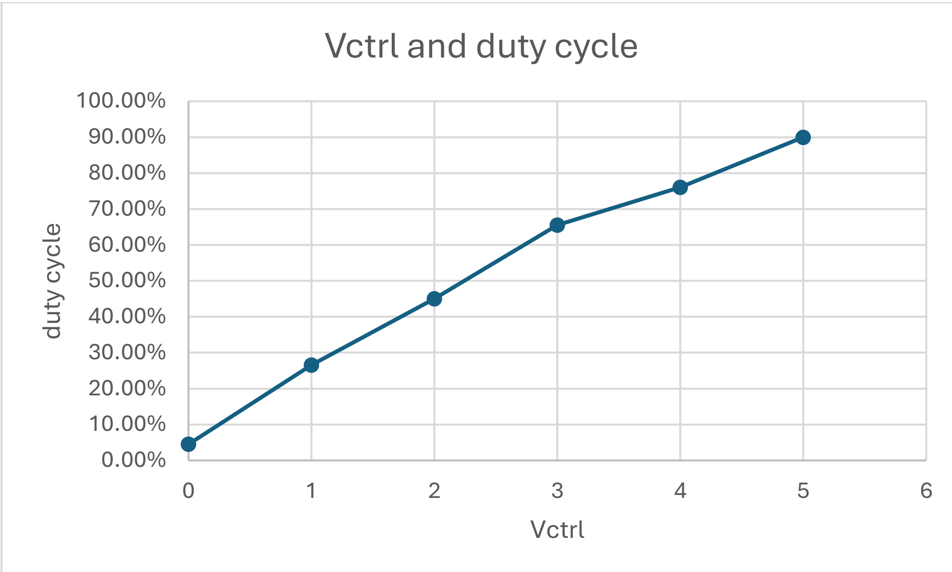
Julia Laine 20008-009 Lab02 9/5/24

Duty cycle of vpwm at each vctrl

Vctrl	Vpwm Duty Cycle	Image
0	4.5%	
1	26.53%	
2	45.04%	

Julia Laine 20008-009 Lab02 9/5/24

3	65.51%		
4	76.03%		
5	90%		



Model of Vcontrol and Duty cycle

As the Vcontrol increases, the duty cycle increases proportionally to it.

Conclusion

This task was successfully completed since the motor was controlled using the PWM circuit we made. The Vcontrol and duty cycle relationship graph makes sense to increase linearly.