Section	LA1
Bench No.	5

ECE110 Introduction to Electronics

Experiment 7: Motor-Driven Circuit

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This part is reserved for your instructor

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Instructor Signature	
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Experiment 7: Motor-Driven Circuit

Laboratory Outline

In previous lab, you constructed a square wave signal with an adjustable duty cycle signal. And in lab 2 and 3, you used different resistances to attempt to balance the speed of your two wheels. While this method was effective, it also had a very low power efficiency, and the motor was prone to stalls if attempting to significantly reduce the speed.

In this experiment, we will implement a method that utilized the MOSFET-based motor drives for high efficiency and use time-varying signal to control for high-motor torque and lower risk of motor stalling. A single potentiometer allows for a simple method of adjustment to make the car run a straight path.

Learning Objectives

- Learn the basic function of MOSFET
- Build a motor-driven circuit for improved engineering design though the use of MOSFET

Voltage-divider-based motor-drive circuit

Build the motor control circuit shown in Figure 1 using the 30N06 n-channel MOSFETs from your kit. Use the $1k\Omega$ potentiometer from your kit as well. The potentiometer is blue and has 102 printed on the side, meaning its value is 10 + two more 0s to give a value of 1000 Ω $(10 \times 10^2\Omega)$ from end to end. The knob controls a "wiper" that changes the location of the middle lead causing the values of R_1 and R_2 to change in relation to each other, that is, the wiper provides a single moveable "tap" dividing the resistor into two smaller resistors. Because it is formed from a single fixed-value resistor, in this case 1k Ohms, it must be true that $R_1 + R_2 = 1k\Omega$ always.

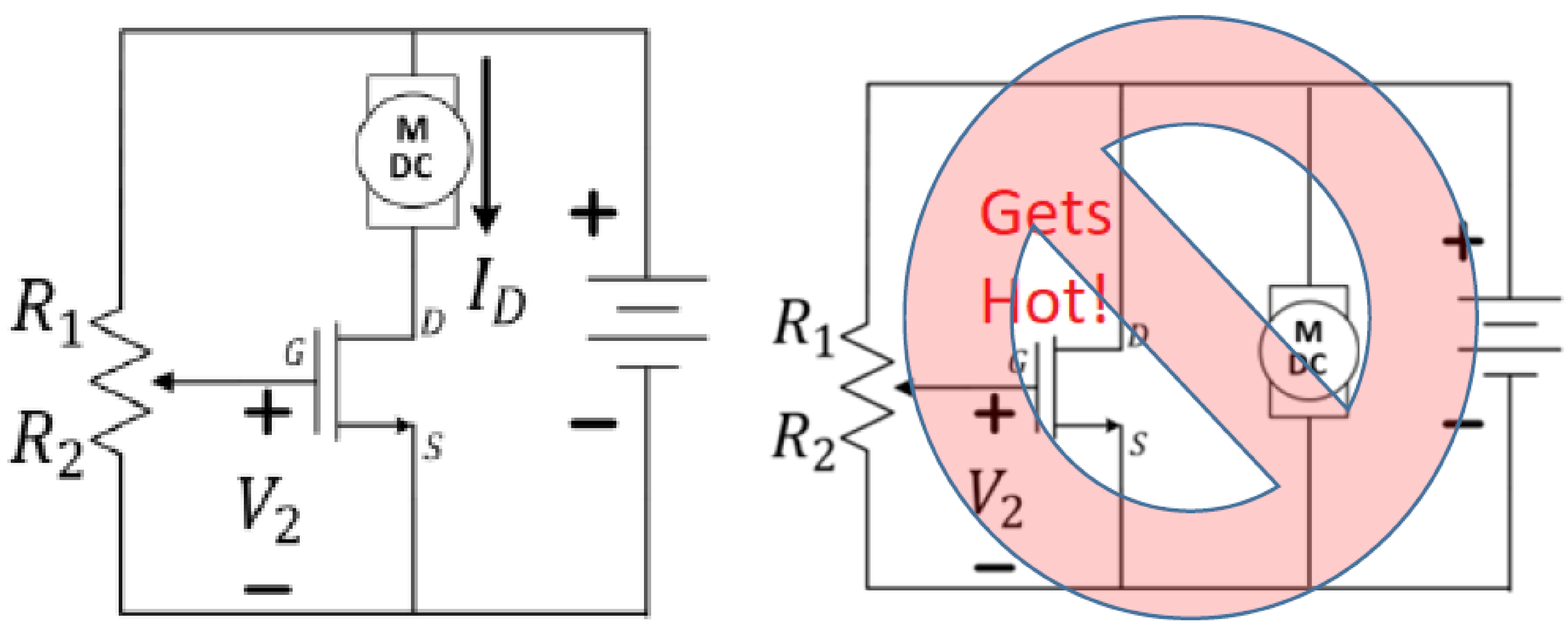

*Figure 1:The voltage-divider-based motor-drive circuit(on the left).**Avoid the wiring mistake on the right!**.*

In this design, **the MOSFET acts as a switch**. There is a high impedance (think "resistance") looking into the gate ("G") pin and therefore the voltage-divider circuit on the left is relatively unaffected by the presence of the MOSFET and can be analyzed as though the rest of the circuit were not present. However, the MOSFET monitors the "output" of the voltage divider and behaves like a switch. When the voltage, V_2, across R_2 becomes high enough, current I_D will begin to flow driving the motor. When the voltage across R_2 is small, the current will be zero and the motor will be stopped.

Use the oscilloscope to monitor V_2 as you adjust the potentiometer that determines the balance between R_1 and R_2 and, therefore, controls V_2.

Question 1: At what voltage V_2 does the motor begin to turn?

2.1V

Question 2: At what minimum voltage V_2 does the motor appear to run near full speed?

2.3V

Question 3: What is the voltage from drain-to-source at the same motor speed as in Question 2? (This will be useful later when estimating efficiency, η!)

680 mV

Question 4: Describe a procedure for determining the efficiency, η, of the voltage-divider controlled motor-drive circuit (Figure 1). Assume all power consumed by the motor is useful and all power used elsewhere is waste.

$$\eta = \frac{U_{battery} - U_{DS}}{U_{battery}} = 70.29\%$$

Slow the Motor

Use the function generator to slow the motor as shown in Figure 2 below. Use a square wave with **7V amplitude, 1kHz, and 3.5V offset**. Observe the voltage V_2 on the oscilloscope's Channel 1. Note that you will need to make sure the battery is ***only* connected between the motor and the source (S) pin of the MOSFET**. It should ***not*** be connected to the positive terminal of the function generator.

Change the duty cycle of the function generator from 20 to 50 to 80%. To do so, press **Shift**, then the key that says **%DUTY**. Adjust by turning the knob.

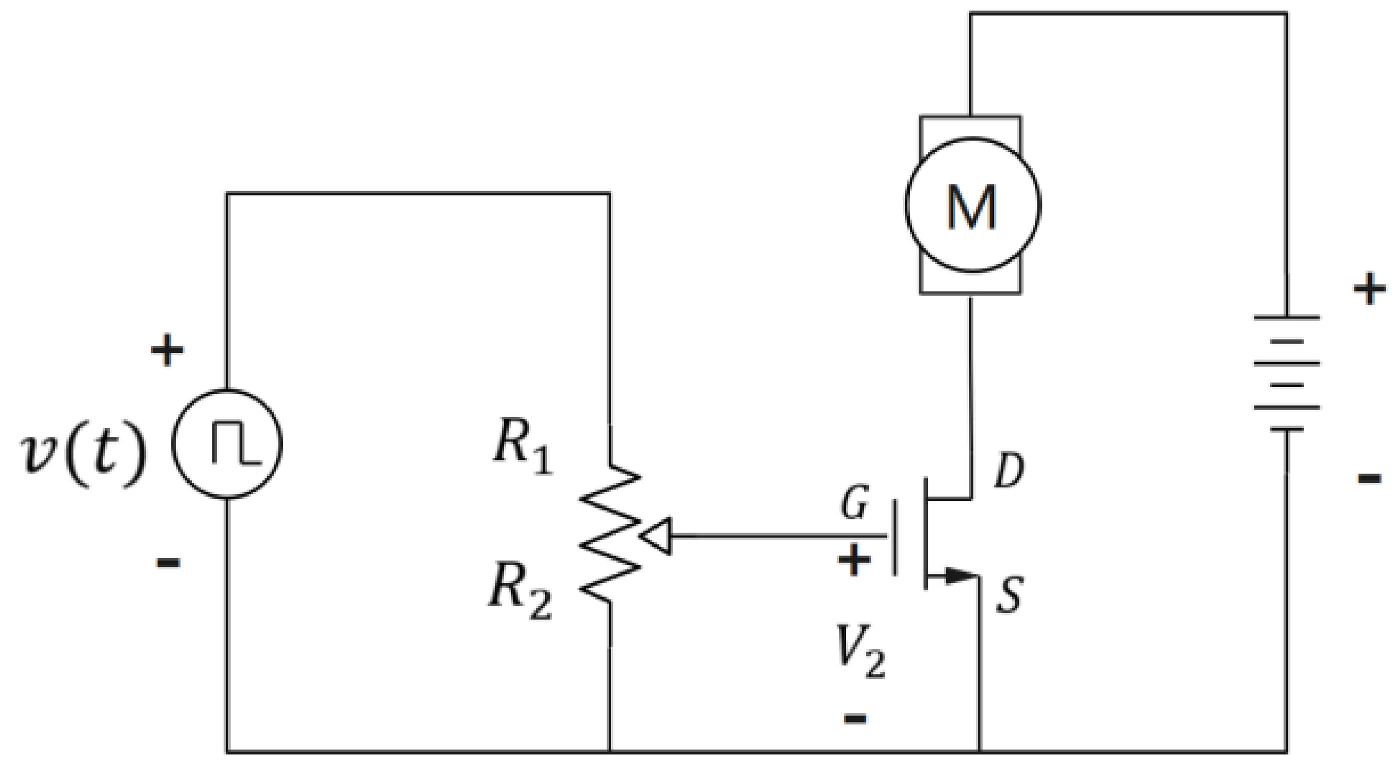

Figure 2: Slowing the motor speed in the motor-drive circuit

Question 5: Discuss the effect of duty cycle on the speed of the wheel.

The larger duty is, the faster the speed.

Question 6: Set a proper duty cycle(between 30%-70%), and use oscilloscope to measure the duty cycle and 0-to-peak amplitude of the function generator, calculate RMS voltage of V(t). Use these to predict the RMS voltage at the input(gate pin V_2) of the MOSFET. Show your work.

$RMS = 7\ V \cdot \sqrt{50\%} = 4.95\ V$

predict of $V_2 = 3V$

Question 7: Use the oscilloscope to measure the RMS voltage at each MOSFET gate (V_2). Place the black probes at the **negative** side of the battery and the red probes at the gate of each transistor in turn (Figure 3).

GS 1.75V

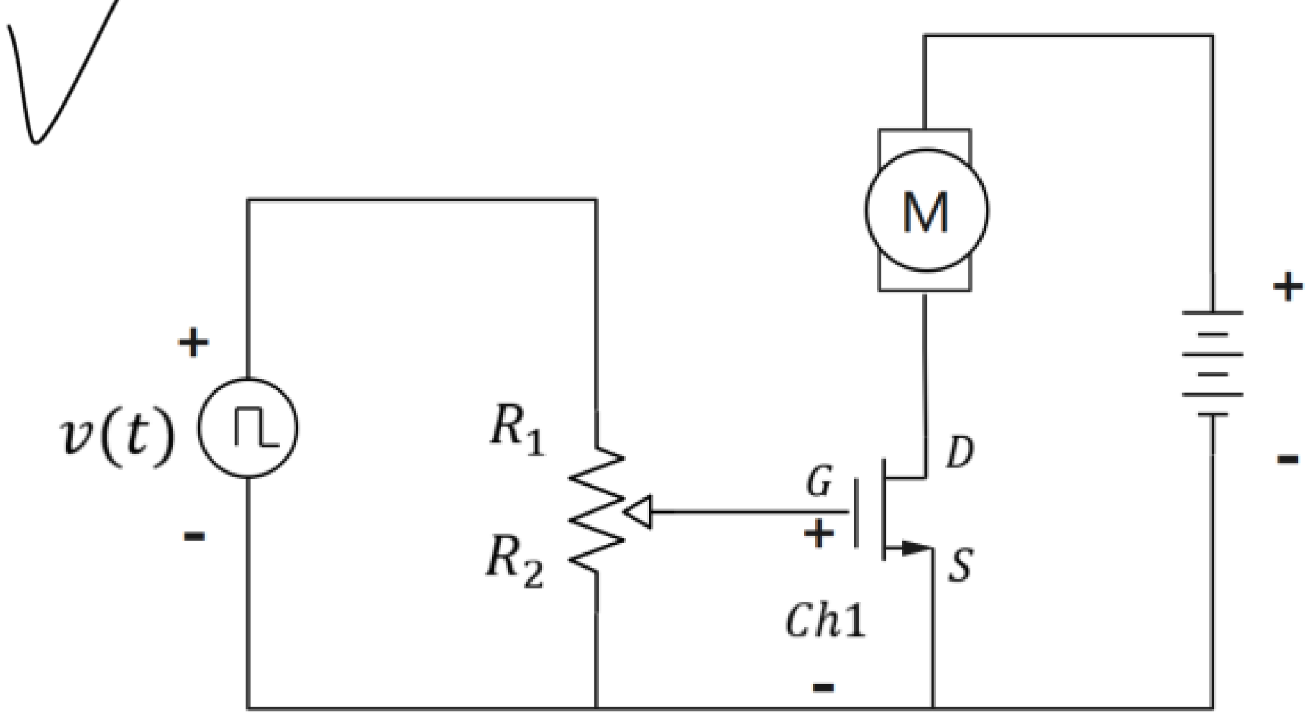

Figure 3: Using the oscilloscope to measure to the gates of the MOSFET

Question 8: State some fact to explain the difference between the estimated and measured RMS voltage.

There were voltage divided by other parts.

Question 9: We already learn to change the duty cycle of our own square-wave oscillator (lab 5). Considering the function of the square wave signal in this lab, what advantage(s) might that provide?

It can make the RMS easy to calculate.

Explore More! Modules

The instructor will provide you with their preferences for this week's ***Explore More! Modules***. Also, you can choose any modules **with your preference.** Remember, at the end of the semester, you will earn points towards your total semester lab score by having completed a minimum of 6 modules. If you wish to be eligible for a Course Aide position in the future, please consider doing more and impressing us with your command of the material and your ability to aid your classmates.