Lab 3: Introduction to electronics

BE 107: Murray, Dickinson, & Kempes, Spring 2015

Written by David Flicker on April 15, 2015

Due at 10:30am on Tuesday, April 21, 2015

Introduction

In this lab we will explore basic analog electronics and how simple controls can generate complex behaviors. First, you will learn about two kinds of brightness sensors and determine how they are different. Then, you will build a Braitenberg vehicle, a simple vehicle that exhibits surprising, complex behaviors. Finally, you will drive the motor with a PWM signal to contrast the analog behavior with the digital behavior.

Part I

In this section, we will investigate the differences between the phototransistor and photoresistor. First, we need to build a light source. We will be using a breadboard for making connections in this lab. Here’s what a breadboard looks like.

![Figure 1: Breadboard layout](image)

The power rails on either side are entirely connected (the blue and red lines) while the numbered rows on the breadboard are connected (green lines).

Start by installing the AA rechargable batteries into the holder and plug the red wire (+) into the positive supply on the breadboard and the black wire (-) into the negative supply on the breadboard. Then, build the following circuit, figure 2, on one side on the breadboard using a resistance of 220 ohms to start. The shorter lead corresponds to the side with the line on the schematic.

Try turning the battery on and see if the LED lights. Once the LED is working, build the following circuit, figure 3, on the other side of the breadboard.First, use a resistance of 100K.

Point the LED at the phototransistor. Now turn on the LED and measure the output voltage of the circuit by measuring the voltage across the phototransistor.

Next, unpack your oscilloscope and follow the setup instructions. Then, connect your oscilloscope probe across the phototransistor. Turn on the LED by disconnecting and then lightly touching the power input to the LED (this is to make the connection as quickly and reliably as possible). Measure and save the fall time (ie how long the signal takes to transition from a high state to a low state) using the oscilloscope.
Change the LED resistance to 1K, 10K, and 100K and determine the output voltage at each resistance. Then, swap the phototransistor pullup resistor to 4.7K, and at LED resistances of 220 ohms, 1K, 10K, and 100K measure the output voltage.

Now, take out the phototransistor circuit and instead build the following circuit, figure 4, using the photoresistor. Use 100K again as the initial resistance.

Measure the output voltage across the photoresistor at LED resistances of 220 ohms, 1K, 10K, and 100K. Record the output voltage when the resistor connected to the photoresistor is changed to 4.7K ohms. Plot the output voltage for the photoresistor and phototransistor across the pullup resistor values and the LED resistances.
Part II

In this section, we will try to build a vehicle that drives itself using only light as a sensor called a Braitenberg vehicle. Build the following circuit, figure 5, on one of the two vehicles available in lab. The silver line on the diode corresponds to the line on the schematic. Looking at the transistor with the rounded face facing you, the terminals are from left to right collector, base, and emitter.

![Braitenberg vehicle schematic](image)

Figure 5: Braitenberg vehicle schematic

Turn on the battery back and watch as your vehicle avoids the light. Capture a video of your robot moving around on the table.

Optional: Try adding in a 10K resistor in series with the photoresistor or placing a piece of tape on top of the photoresistor. Note the differences in behavior in your vehicle.

Part III

In this section, we will build a circuit that drives a motor using pulse width modulation (PWM). Ask your TA for a comparator. On the vehicle build the following circuit, figure 6.

![Pulse width modulation drive schematic](image)

Figure 6: Pulse width modulation drive schematic
Note that the comparator has the following pinout, figure 7, (or what terminals do what).

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<thead>
<tr>
<th>8</th>
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<tr>
<td>6</td>
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Figure 7: Pinout numbers on the comparator

With the text on the MOSFET facing you, the pins from right to left are gate, drain and source. Turn on the function generator on the PicoScope software to generate a 1 KHz square wave with 50% duty cycle. Verify that the motor turns. Try varying the duty cycle and see how low the duty cycle can be before the motor will not start up.