UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE 105 Lab Experiments

Fall 2022

Experiment 3: Diodes, LEDs, Photodetectors

Logistics

- Assigned date: **Week of October 3, 2022**
- Due date: **Week of October 10, 2022** at start of YOUR lab section
- Deliverables: An **individual** typed lab report and Pre-lab report per student. Be sure to include each partner's name. Follow the Lab Report Guideline Handout on bCourses.

1 Objective

In this lab, you will use examine diodes and LEDs. In addition you will explore using LEDs and photodiodes to make a transmitter and receiver, respectively. We will build an electrical receiver that will amplify the received signal to drive another LED. The datasheets of the LEDs and the photodiode are on bCourses.

2 Materials

Each lab workstation has the necessary test equipment and breadboards. You will also need the components listed in Table 1. *Note: Be sure to answer the questions on the report as you proceed through this lab. The report questions are labeled according to the sections in the experiment.*

Component	Quantity
51 Ω resistor	1
100 Ω resistor	1
100 kΩ resistor	1
1 nF capacitor	1
1 µF capacitor	1
10 µF capacitor	1
Pre-lab value resistor	1
1N4148 diode	1
WP7113IT Red LED	1
TEFD4300 Photodiode	1
WP7113GT Green LED	1
10 µF capacitor	2
LM741 op-amp	1

Table 1: Components used in this lab

3 Procedure

In this lab we will be exploring various applications of diodes, as rectifiers, LEDs, and photodiodes. We will also use our experience with op-amps to build a transmitter/receiver circuit.

3.1 Diode Half-Wave Rectifier

1. Build the half-wave rectifier shown in Figure 1 with the 1N4148 diode.
2. Connect **TWO** oscilloscope probes: one to measure the input voltage and one to measure the voltage across the load resistor.
3. Apply a 100 Hz sinusoid to your rectifier and attach it to a 1 kOhm resistor load. Starting from 100 mVpp, vary the amplitude applied until you see a 250 mV signal at the output on the oscilloscope.

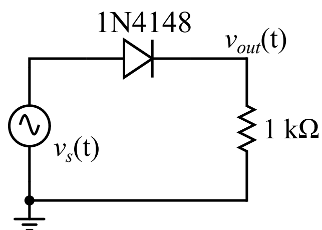

Figure 1: Half-wave rectifier circuit.

Q 3.1.1:

(a) What output waveform do you see? Take a screenshot from the oscilloscope showing both the input and output voltages in one picture.

(b) What applied voltage led to a 250 mV output?

(c) Estimate the forward voltage drop of the diode from your input and output voltage waveforms. (Compare to the datasheet as a sanity check.)

(d) Is the waveform exactly half a sinusoid? Why or why not?

For the remaining parts keep the amplitude of the signal generator at the value found in the previous part.

4. Now add a 1 μF capacitor in parallel with the resistor load. Vary the frequency from 100 Hz to 5 kHz.

Q 3.1.2:

As you vary the input frequency, what happens to the amplitude and shape of the output voltage waveform with the parallel capacitor? Why?

5. Remove the 1 μF capacitor and connect a 10 μF capacitor in parallel with the load. Starting at 100 Hz, vary the input voltage frequency until you see the output voltage change shape. Record the frequency where the change happens.

Q 3.1.3: At what frequency does the output voltage waveshape begin to change?

6. Remove the 10 μF capacitor and connect a 1 nF capacitor in parallel with the load. Starting at 100 Hz, vary the input voltage frequency until you see the output voltage change shape. Record the frequency where the change happens.

Q 3.1.4:

(a) At what frequency does the output voltage waveshape begin to change?

(b) Based on the four circuits (no parallel capacitor and then three different parallel capacitor values, what does the capacitor do the output waveform? Explain why this is happening.

3.2 LED Transmitter

1. On your 6 V supply set a current limit to 30 mA. Increase the voltage to 0.5 V. Press 'Display Limits', and then Press 'Voltage/Current' to switch to current limit setting. The nominal value is 5 A; reduce it to 30 mA.
2. Build the circuit shown in Figure 2 with the DMM connected to measure the current through the LED.

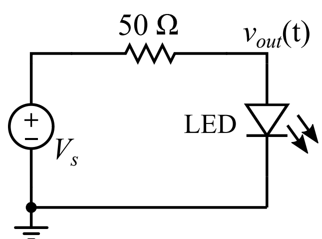

Figure 2: LED transmitter circuit.

Note that both the LED and the photodiode have indicate the anode and the cathode by using different pin lengths: anode is the longer lead, cathode is the shorter lead.

3. ***SLOWLY*** increase the dc supply voltage until you achieve a 20 mA current through the LED. Record this DC voltage. ***DO NOT go beyond 20 mA through the LED.***

Q 3.2.1: What DC input voltage is required to get 20 mA through the LED?

3.3 Photodiode

1. Remove the ammeter connection from the LED transmitter circuit and replace it with a wire to connect the resistor and LED in series.
2. Connect the photodiode to another DC supply (Fig 3) with the ammeter in series to measure the current (Use the +25 V channel for the diode and leave the LED supply on the +6 V channel.)

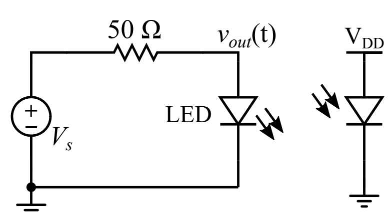

Figure 3: LED transmitter circuit.

3. Set V_{DD} to 5 V and find a distance between the photodiode and the LED that will result in photodiode current of 9.32 μA. *Note that the received light intensity is maximized when the LED and the photodiode are positioned "face to face" with their round sides.*

4. Now vary the supply voltage V_{DD} from 1 V to 10 V. Is the current dependent on the supply voltage?

Q 3.3.1: Is the current dependent on the supply voltage? Why or why not?

3.4 Receiver- DC and AC

Now, we will put the previous sections together to build a transmitter-receiver system, as shown in Fig. 4.

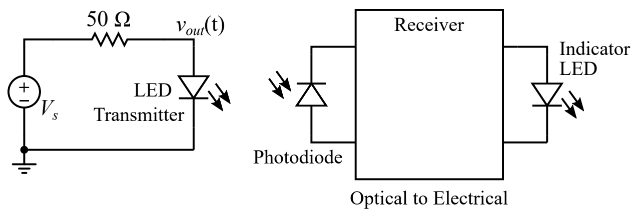

Figure 4: Transmitter and receiver block diagram.

1. Using the already-built LED transmitter from Section 3.2, build Receiver 1, shown in Fig. 5 with the green LED as the indicator LED. Keep the distance between the photodiode and the LED that will result in photodiode current of 9.32 μA. Use the R_f resistor value that matches your calculations in the pre-lab. You can use the same supply voltage for the photodiode and the opamp (why?).

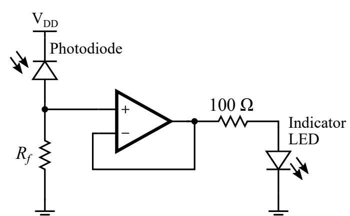

Figure 5: Receiver implementation 1.

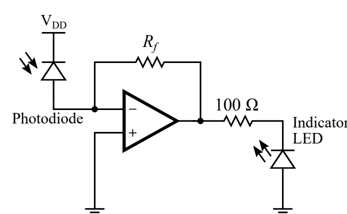

Figure 6: Receiver implementation 2.

2. Make sure that the indicator LED is ON. Measure and record the voltage on the indicator LED and the current through it.

Q 3.4.1: For DC Receiver 1, what is the voltage on the indicator LED and the current through it?

3. Remove the low voltage dc supply from the transmitter LED. Instead, we will use the function generator so supply an ac voltage. Set the function generator to HIGH-Z operation. Set the function generator to have a 0-V_s sine wave at 5 Hz, where V_s is the DC supply voltage that you measured in Section 3.2 (You will have to set the peak-to-peak voltage and the dc offset voltage appropriately.) Check the function generator output by measuring the output with a voltage probe on the oscilloscope.

4. Now connect the function generator instead of the DC supply-51 Ω resistor-combination (the function generator has an internal resistance of 50 Ω so we don't need an external one.)

5. Connect the oscilloscope probes to measure the function generator output waveform (i.e. the voltage across the transmitter LED) and the amplifier output waveform.

6. For fun: look at the output as you increase the frequency to the kHz and MHz range.

Q 3.4.2:

(a) Include a screenshot of the oscilloscope showing the transmitter LED and the amplifier output voltage waveforms with an input frequency of 5 Hz.

(b) Comment on what the transmitter and indicator LEDs do.

7. Rewire Receiver 1 into Receiver 2 (Fig. 6). Repeat steps 1-6.

Q 3.4.3:

(a) For DC Receiver 2, what is the voltage on the indicator LED and the current through it?

(b) Include a screenshot of the oscilloscope showing the transmitter LED and the amplifier output voltage waveforms.

(c) What differences did you notice between Receiver 1 and Receiver 2?

STOP: Make sure you get a GSI checkoff before you leave lab!

Report

Report Total is 100 points

Pre-Lab (**50 points**)

Post-Lab (**50 points**)

3.1.1a (**3 points**)
3.1.1b (**2 points**)
3.1.1c (**3 points**)
3.1.1d (**3 points**)
3.1.2 (**3 points**)
3.1.3 (**2 points**)
3.1.4a (**2 points**)
3.1.4b (**5 points**)
3.2.1 (**2 points**)
3.3.1 (**5 points**)
3.4.1 (**3 points**)
3.4.2a (**5 points**)
3.4.2b (**3 points**)
3.4.3a (**3 points**)
3.4.3b (**3 points**)
3.4.3c (**5 points**)