Fall | 2011

Experiment 6

LEDs and Zener Diodes

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I. OBJECTIVES

In this experiment you will learn how to:

- Investigate the characteristics of light emitting diodes (LEDs) and some of their applications.
- Investigate the characteristics of Zener diodes and calculate their voltage regulation.

II. MATERIAL AND PROCEDURE

A. LIGHT EMITTING DIODES

Procedure

A1. LED FORWARD CHARACTERISTICS

Connect the circuit of Fig. A-1 using the *red* light emitting diode (LED). Starting from a value of 0.5 V, increase V_S in steps of 0.1 V and measure the LED voltage and current for each V_S. Do not exceed 30 mA of current in the diode.

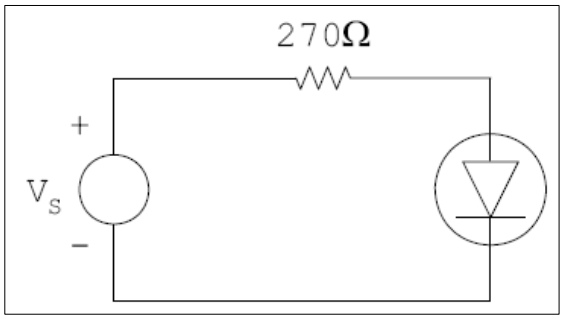

Figure A-1: LED Circuit

Exercise • Refer to in-lab 6 exercise A-1

A2. LED REVERSED CHARACTERISTICS

Repeat Part A.1 with the diode connection reversed. Plot the forward and reverse characteristics of the LED and determine the incremental resistance of the diode in the forward and reverse conducting regions.

Exercise • Refer to in-lab 6 exercise A-2

A3. LED CONDUCTION ANGLE

Connect the circuit of Fig. A-2 using the *red* LED. Carefully measure the voltage levels and conduction angles in the forward and reverse directions, using the oscilloscope.

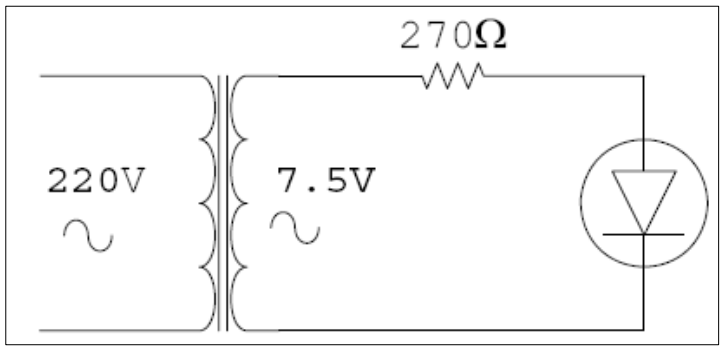

Figure A-2: LED Circuit using AC input

- Compare the measured values with those predicted from the value of VS and the diode characteristics.
- Calculate the power dissipated in the forward and reverse directions.

Exercise • Refer to in-lab 6 exercise A-3

Discussion on Part A

- If VS = 12 V DC, choose the series resistor to give 20 mA through the red LED. Draw the load line.
- In the circuit of Fig. A-2, does the power dissipated in the reverse direction serve any useful purpose? How can it be eliminated?

B. ZENER DIODES

B1. ZENER FORWARD VOLTAGE

Procedure

Connect the circuit shown in Fig. B-1 and measure V_Z when V_S is 15 V.

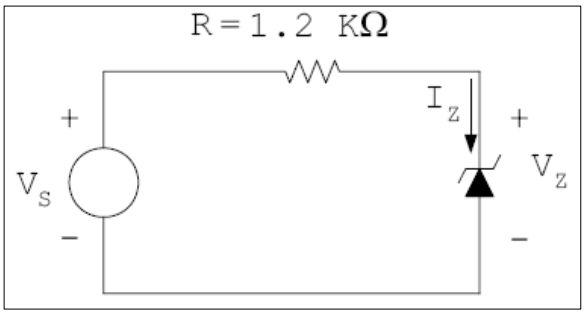

Figure B-1: Zener Diode Circuit

Exercise • Refer to in-lab 6 exercise B-1

B2. ZENER DIODE CHARACTERISTICS

Reduce the value of V_S in steps of 0.5 V, and measure V_Z and I_Z. Calculate the power dissipation in the Zener diode.

Exercise • Refer to in-lab 6 exercise B-2

B3. ZENER DIODE CHARACTERISTICS ANALYSIS

Plot a curve of I_Z versus V_Z.

- Calculate the value of the Zener resistance r_Z.
- What is the minimum value of V_S required to get Zener diode breakdown?

Take additional measurements around this minimum V_S to answer the following two questions:

- What is the value of the knee Zener voltage, V_{ZK}?
- What is the value of knee Zener current, I_{ZK}?

B4. ZENER DIODE LINE REGULATION

Apply a V_S of 3 VAC peak-to-peak with a frequency of 500 Hz, superimposed on a 12 V DC level. The resulting V_S is of the form $12 + 1.5\sin(1000\pi t + \varphi)$ Volts.

- Measure V_Z. What is the DC (average) value of V_Z?
- What is the AC component in V_Z?
- Find the line regulation of the Zener diode.

Note *The AC component in VZ can be calculated using the voltage divider formed by r_Z and the resistor R.*

$$\frac{AC\ Component\ in\ V_Z}{AC\ Component\ in\ V_S} = \frac{r_Z}{r_Z + R}$$

The line regulation is the ratio of the change in V_Z to the change in V_S, provided that the diode is in the Zener region.

Exercise • Refer to in-lab 6 exercise B-4

B5. ZENER DIODE LOAD REGULATION

With V_S = 12 V DC, connect a load resistor R_L ***in parallel*** with the Zener diode. Measure the Zener voltage, Zener current, and load current for the following values of RL: 56 KΩ, 22 KΩ, 10 KΩ, 4.7 KΩ, 2.2 KΩ, 1 KΩ, 680 Ω, 470 Ω, and 220 Ω.

- For what range of load resistors does the Zener diode regulate the load voltage?
- What is the load regulation of the Zener diode?

Note *The load regulation is defined as the ratio of the change in VZ to the change in I_{LOAD}, provided that the diode is in the Zener region.*

$$Load\ regulation = \frac{\Delta V_Z}{\Delta I_{load}}$$

Exercise • Refer to in-lab 6 exercise B-5

Discussion on Part B

- How is the maximum current in a Zener diode determined?
- How is the minimum current in a Zener diode determined?
- Show that for a Zener voltage regulator, the value of the resistor R should be chosen using the equation:

$$R = \frac{V_{smin} - V_{ZK} - r_z I_{ZK}}{I_{ZK} + I_{LOADmax}}$$

III. OUTCOMES

By the end of Experiment VI, students:

- Are familiar with LED characteristics
- Are familiar with Zener characteristics
- Are able to calculate the line and load regulation for a zener diode.