

Name: _____

ECET 242 – Electronic Circuits

Lab 1
Electrical Characteristics of Silicon and Zener Diodes

Objective: Students successfully completing this lab exercise will accomplish the following objectives:

1. Learn the electrical characteristics of silicon and zener diodes.
2. Learn to identify diode operating points on a characteristic I-V curve using a load line.

Lab Report: An informal lab report will be required for this experiment. Turn in this handout with your collected data along with word-processed responses to all problems and discussion questions. Graphs should be constructed using a graphing software such as Microsoft Excel or Matlab. Reports will be due at the next lab session following the date on which the lab was performed.

Equipment:

Variable DC power supply	1 W, 10 Ω resistors (2)
Digital Multimeters (DMM) (2)	Breadboard
1N4004 silicon diode	Connecting leads
1N4737A zener diode	

Procedure 1: I-V Characteristics of a Silicon Diode

1. Examine the 1N4004 diode and identify the anode and cathode. The cathode is indicated by the silver polarity band. The anode is connected to the p-type silicon and the cathode is connected to the n-type silicon.
2. Connect two 1 W, 10 Ω resistors in parallel on the breadboard to make one 2 W, 5 Ω resistor. The added wattage capacity of combined resistors is needed for this experiment.

Connect the parallel combination of resistors in series with a 1N4004 diode and a DMM. Set the DMM to measure currents of up to 500 mA. Note that some of the DMM's have a 10 A input for currents exceeding 100 mA. Make sure to use the 10 A input if the DMM you are using has this feature.

3. With the power supply turned off, connect the 5 Ω resistor combo, 1N4004 diode, and ammeter in series with the power supply. Connect the circuit so that the diode is forward biased with the anode toward positive supply terminal and cathode toward negative supply terminal.
4. Turn the voltage knob of the power supply fully counter-clockwise to its minimum setting. Turn on the power supply. Connect the second DMM to measure diode voltage. Increase voltage of the power supply slowly so that you get a diode current of about 500 mA. For your own safety and to protect the test equipment, do not exceed 500 mA. In Table 1, record the diode voltage at this current.

Decrease the supply voltage until the diode current is 300 mA. Record the diode voltage at this current in Table 1. Repeat this process for diode currents of 200 mA, 100 mA, 50 mA, 20 mA, 10 mA, 5 mA, 2 mA and 1 mA.

Continue decreasing the supply voltage so that you achieve diode voltages of 0.5 V, 0.25 V and 0.1 V. Record the diode currents at these voltages in Table 1 also.

5. Set the voltage of the power supply so that the diode current is 300 mA. Record the voltage of the power supply below.

$$V_S = \underline{\hspace{2cm}}$$

Calculate the approximate diode current using the supply voltage above assuming $R = 5 \Omega$ and $V_{\text{Diode}} = 0.7 \text{ V}$.

$$I_{\text{Diode}} (\text{approximate}) = \underline{\hspace{2cm}}$$

Calculate the percent error between the approximate and measured currents using the formula below.

$$\% \text{ Error} = \left(\frac{\text{Approximate Value} - \text{Measured Value}}{\text{Measured Value}} \right) * 100\%$$

$$\% \text{ Error} = \underline{\hspace{2cm}}$$

Table 1: Voltage and Current Measurements for a Forward Biased 1N4004 Silicon Diode

Diode Voltage (V)	Diode Current (mA)
	500
	300
	200
	100
	50
	20
	10
	5
	2
	1
0.5	
0.25	
0.1	

6. Turn off the power supply and reverse the + and – leads of the power supply where they connect to your breadboard. Now the diode is reverse biased. Slowly change the diode voltage in -5 V steps from 0 to -30 V and record the resulting current in Table 2 below. Since the diode current is so low in reverse operation, you should use a μA scale on the DMM to record the current.

Table 2: Current Measurements for Reverse Biased a 1N4004 Silicon Diode

Diode Voltage (V)	Diode Current (mA)
0	
-5	
-10	
-15	
-20	
-25	
-30	

- Combine all measurements from Table 1 and Table 2 and use the data to plot an I-V characteristic curve of the silicon diode. Use the full range of diode voltages from -30 V in reverse operation to the maximum positive diode voltage in forward operation. Generate the plot using Microsoft Excel.

Procedure 2: I-V Characteristics of a Zener Diode

- Examine the 1N4737A zener diode. Identify the anode and cathode.
- Connect two 1 W, 10 Ω resistors in parallel on the breadboard to make one 2 W, 5 Ω resistor. Connect the parallel combination of resistors in series with a 1N4737A diode and a DMM. Set the DMM to measure currents of up to 500 mA. Make sure to use the 10 A input if the DMM you are using has this option.
- Turn off the power supply. Connect the 5 Ω resistor combination, the 1N4737A zener diode and an ammeter in series with the power supply. Connect the circuit so that the diode is forward biased.
- Turn the voltage knob of the power supply fully counter-clockwise to its minimum setting. Turn on the power supply. Connect the second DMM to measure diode voltage. Increase voltage of the power supply slowly so that you get a diode current of about 500 mA. For your own safety and to protect the test equipment, do not exceed 500 mA. In Table 3, record the diode voltage at this current.

Decrease the supply voltage until the diode current is 300 mA. Record the diode voltage at this current in Table 3. Repeat this process for diode currents of 200, 100, 50, 20, 10, 5, 2, and 1 mA.

Continue decreasing the supply voltage so that you achieve diode voltages of 0.5 V, 0.25 V and 0.1 V. Record the diode currents at these voltages in Table 3 also.

- Set the voltage of the power supply so that the diode current is 300 mA. Record the voltage of the power supply below.

$$V_s = \underline{\hspace{2cm}}$$

Calculate the approximate diode current using the supply voltage above assuming $R = 5 \Omega$ and $V_{\text{Diode}} = 0.7 \text{ V}$.

$$I_{\text{Diode}} (\text{approximate}) = \underline{\hspace{2cm}}$$

Calculate the percent error between the approximate and measured currents using the formula below.

$$\% \text{ Error} = \underline{\hspace{2cm}}$$

Table 3: Voltage and Current Measurements for a Forward Biased 1N4737A Zener Diode

Diode Voltage (V)	Diode Current (mA)
	500
	300
	200
	100
	50
	20
	10
	5
	2
	1
0.5	
0.25	
0.1	

13. Turn off the power supply and reverse the + and – leads of the power supply. Do not move the ground lead of the power supply. Now the diode is reverse biased. Slowly change the diode voltage in -2 V steps from 0 to -6 V and record the resulting currents in Table 4 below. Slowly increase the voltage beyond -6 V and record the resulting diode voltages at currents of -1, -10, -25, -75 and -100 mA.

Table 4: Current and Voltage Measurements for Reverse Biased a 1N4734A Zener Diode

Diode Voltage (V)	Diode Current (mA)
0	
-2	
-4	
-6	
	-1
	-10
	-25
	-50
	-75
	-100

14. Combine all measurements from Table 3 and Table 4 and use the data to plot an I-V characteristic curve for the zener diode. Generate the plot using Microsoft Excel.

Problems:

Solve each of the following problems on separate sheets of paper. Use Microsoft Excel to plot characteristic curves and load lines.

1. The 1N4004 diode can handle up to 1 A of continuous forward current. Graphically extend your 1N4004 diode I-V characteristic curve to 1 A. From the point where the extended graph intersects 1 A, determine the corresponding voltage required to generate this current. Record value below.

$$V_{\text{Max}} = \text{_____} \text{ V}$$

Compute the maximum allowable continuous forward power using the following equation and assuming $I_{\text{Max}} = 1 \text{ A}$:

$$P_{\text{Max}} = V_{\text{Max}} I_{\text{Max}}$$

$$P_{\text{max}} = \text{_____} \text{ W}$$

2. Suppose a 2 V DC power supply is connected in series with a 10Ω resistor and a forward biased 1N4004 diode. On the 1N4004 diode characteristic curve, draw the load line for the circuit and find the operating point. Label the operating point on the characteristic curve. According to the operating point on the curve, what is the diode current and voltage in this circuit? Repeat for a 20 V DC power supply connected in series with a 400Ω resistor.
3. Suppose a 10 V DC power supply is connected in series with a 100Ω resistor and a reverse biased 1N4737A diode. On the characteristic curve, draw the load line for the circuit and find the operating point. Label the operating point on the characteristic curve. According to the operating point on the curve, what is the diode current and voltage in this circuit?

Discussion Questions

Respond to each of the questions below on a separate sheet of paper. Use a word processor to record your answers in complete, well-written sentences.

1. What is a silicon diode? How does it work? What is it made of?
2. What are reverse and forward bias?
3. What are the characteristics of silicon diode current versus voltage?
4. What is a zener diode? How does it operate?
5. What are the characteristics of zener diode current versus voltage?