Lab 2 Diode Characteristics

HEALTH AND SAFETY

Any laboratory environment may contain conditions that are potentially hazardous to a persons' health if not handled appropriately. The electrical engineering laboratories obviously have electrical potentials that may be lethal and must be treated with respect. In addition, there are also mechanical hazards, particularly when dealing with rotating machines, and chemical hazards because of the materials used in various components. Our objective is to educate all laboratory users to be able to handle laboratory materials and situations safely and thereby ensure a safe and healthy experience for all. Watch for posted information in and around the laboratories, and here on the class web site.

OBJECTIVES

The purpose of this lab is to study the characteristics and properties of diodes. Diode I-V curves will be plotted using Curve Tracers. The rectifier and filtering circuits are to be constructed using rectifier diodes and capacitors.

MATERIAL AND EQUIPMENT

Material	**Equipment**
1N4005 (rectifier diode)	Curve Tracer
1N4733 (zener diode)	HP Oscilloscope 54601: EE1659.XX
1N4148 (signal diode)	Agilent Signal Generator 33120A: EE1634.XX
Assorted Resistor(100, 10k ohms)	Power supply

PRE LAB

You have to complete it before the lab starts. Look up the characteristics of the 1N4005 diode by making a web search. The specifications for different kinds of diodes vary. Copy the maximum/minimum rates and the electrical characteristics of the specifications for the diode to your lab report as part of your lab report. Understand the terms used in the specifications.

THEORY

The simplest and most fundamental nonlinear circuit element is the diode. The diode is a device formed from a junction of n-type and p-type semiconductor material, shown in Figure 1(a). The lead connected to the p-type material is called the **anode** and the lead connected to the n-type material is the **cathode**, shown in Figure 1(b). In general, the cathode of a diode is marked by a solid line on the diode package, shown in Figure 1(c).

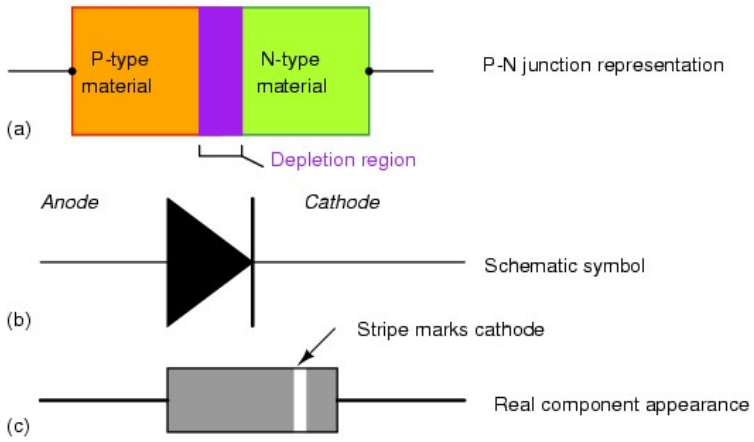

Figure 1: (a) PN-junction model, (b) schematic symbol, and (c) physical part for a diode. One of the primary function of the diode is the rectification. When it is forward biased (the higher potential is connected to the anode lead), it will pass current. When it is reverse biased (the higher potential is connected to the cathode lead), the current is blocked. The characteristic curves of an ideal diode and a real diode are seen in Figure 2.

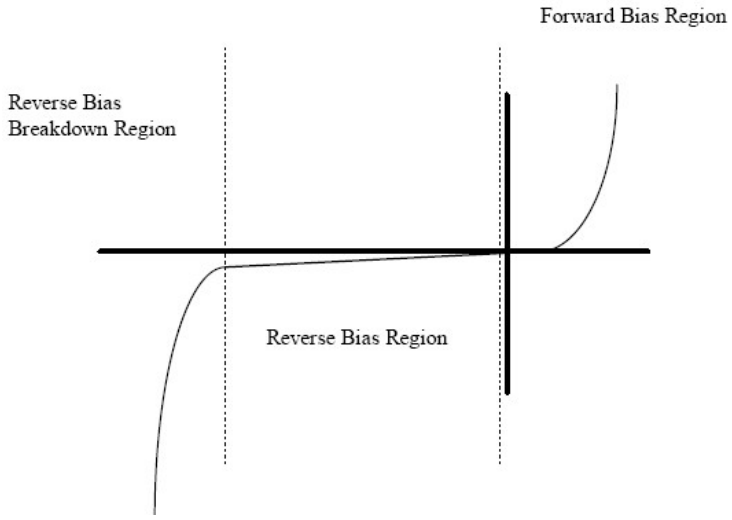

Figure 2: I-V curve for a real diode

The current i in the forward direction can be expressed in the following exponential relationship

$$i \cong I_S e^{v/nV_T} \qquad (1)$$

Where I_S usually called saturation current, is a constant for a given diode at a given temperature. It can be as low as 10^{-15} A. V_T is also a constant called thermal voltage, and it is given by

$$V_T = \frac{kT}{q} \qquad (2)$$

When analyzing circuits, the real diode is usually replaced with a simpler model. The simplest form, the diode is modeled by a switch (Figure 1-3). The switch is closed when the diode is forward biased and open when the diode is reverse biased.

PROCEDURE

1. Diode I-V Characteristics

A) Study 1N4005 rectifier diode

The I-V characteristics for the diode can be displayed using the Curve Tracer. Through the proper setup, the Y-direction can be used to display the current through the diode, and the x-direction can be used to display the voltage on the diode. Connect the diode properly to the Curve Tracer, make sure "C" terminal connected Anode of the diode and "E" to the Cathode. Study the I-V curve carefully and fill in the following table with appropriate values. Document the knee voltage of this diode in your report.

Points	Diode Voltage (V)	Diode Current (I)	Characteristic
1			OFF
2			OFF
3			Just turning on
4	0.6V		
5	0.65V		
6	0.70V		
7	0.75V		

B) Repeat the same procedure for 1N4148.

Points	Diode Voltage (V)	Diode Current (I)	Characteristic
1			OFF
2			OFF
3			Just turning on
4	0.6V		
5	0.65V		
6	0.70V		
7	0.75V		

C) Explain the differences of the data between 1N4148 and 1N4005 if applicable and document it in your final report. Hints: silicon diodes can be classified as signal diodes and rectifier diodes.

2. Half-Wave Rectifier Properties

The half-wave rectifying properties of the diode can be displayed using the circuit shown in Figure 3. Connect the circuit in Figure 1-5. Use R = 10k ohms and a 1N4005 diode. Set the signal generator so that it can provide an output as:

- Sinusoidal signal
- Amplitude: 3V p-p
- Frequency: 1kHz
- Output impedance: High Impedance

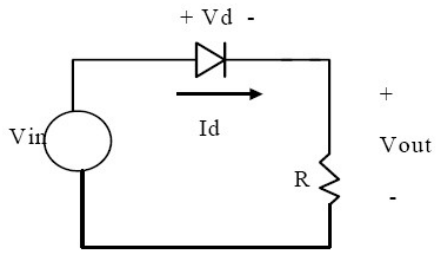

Figure 3: Schematic of the half-wave rectifier diode circuit

A) Display the waveforms for the input and output voltages (Vin and Vout) using an oscilloscope, make sure the ground terminals of the oscilloscope are always connected to the ground terminal of the signal generator. Sketch the waveforms in your lab report, and label the peak voltages of the waveforms.

B) Add one 2 μF capacitor in parallel with the 10k resistor, the other parts remain the same. Please notice the +, - signs on the capacitor if you use a polarized capacitor, make sure the polarization is correct, otherwise it may blow up. Display the input and output voltages waveforms and sketch in your report. Label the ripple voltage (peak-peak) in the waveform.

In your report, hand in the labeled waveforms obtained in (A) and (B). In addition, calculate the ripple voltage using the knowledge learned in the class and compare it to the experimental result.

3. Zener Diode Characteristics

The zener diode has the unique property of maintaining a desired reverse biased voltage. This makes it useful in voltage regulation. In this exercise, you are to tabulate the regulating properties of the Zener diode. Connect the circuit as shown in Figure 4, use 220 ohms resistor and 1N4733 zener diode.

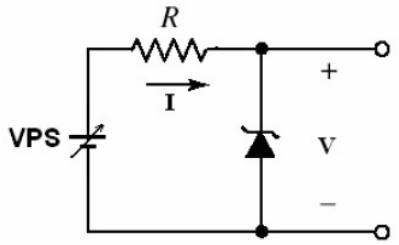

Figure 4: Zener diode voltage regulation

Measure the diode properties, by varying the input voltage and measuring the voltage across the diode and the current through the diode. Fill in the following table when you measure the voltage and current.

Points	Power supply voltage (V)	Diode Voltage (V)	Diode Current (I)	Regulating (Yes/No)
1	3.0			
2	4.5			
3	5.0			
4	5.5			
5	6.0			
6	6.5			
7	7.0			

LAB REPORT

Assuming that your instructor is a busy manager, submit a maximum 4-page brief report, including a coving page. Introduction and conclusion are not needed in this report. Look at lab procedures for detailed information about what you should submit.

Lab report marking scheme:

Pre-lab: 10%
Lab procedure: 90%
- Part 1: 30%, 1A (10%), 1B (10%), 1C (10%)
- Part 2: 40%, 2A (15%), 2B (15%), calculation (10%)
- Part 3: 20% , table

Total: 100%

