Lab #1 Diode Characterization

Part 1

Read Graymark 808 Manual
Input Circuitry – pages 13-16
Construction - pages 17-19

Perform Ac measurements pages 20-21
Your lab report should contain Figure 35

Part 2

We will also perform a modified Experiment 3 Silicon Diodes(written by Hambley for our textbook).

Read Theory section.

Replace the Procedure in Experiment 3 with the following procedure –

1) Measure the voltage and current through a signal diode (Use a 1N4148 from your GrayMark kit — these are also available in the instrument room).

   You may use either of three methods to measure the v-i characteristics:
   (a) use a DMM to measure voltage and current as shown in Figures 1 and 2 of Experiment 3;
   (b) use the LabVIEW VI which was demonstrated by Mike Rossiter in the lab (this will shortly be on the Web site); or
   (c) use the transformer/resistor/oscilloscope curve tracer which was discussed in the lab recitation.
   The choice is yours.

2) Repeat 1) for a power diode. Use a 1N4001 from your GrayMark kit (also available from the instrument room).

3) Repeat 1) for a zener diode. Several different zener diodes will be available in the instrument room.

4) Connect the circuit in Fig.3 and apply voltages from -2 to 2 volts to the input,in 0.2 volt increments.With the digital voltmeter,measure and record the output voltages,again to 3 significant figures.This circuit is called a "limiter."It permits small input voltages to pass without attenuating them at all,but it limits the output to at most about ±0.7 volt with large input voltages.Note that in the crude

approximation this circuit would not work at all;the two ideal diodes "back to back"would simply constitute a short to ground and the output would always be zero.

Replace the Assignment in Experiment 3 with the following Assignment –

Using your measurements for Parts (1), (2) and (3) plot the output voltages ,(Y axis),as a function of the input voltages ,(X axes). Compare these plots with the crude and standard diode approximations discussed in Experiment 3.

For the data from Parts 1) and 2) compute the differential resistance of the diode from equation (3-2) by taking differences between successive data points for ΔV and ΔI. Plot the differential resistance (Y axis)as a function of the current (X axis)through the diode. The current used in this plot should be the average of the two successive values that form ΔI. For comparison also plot equation (3-3) on the same graph. How does your plot of differential resistance compare with the theoretical approximation in equation (3-3)?

Plot your results from Part (4)

EXPERIMENT 3

SILICON DIODES

OBJECTIVE

To study the characteristics and applications of silicon diodes.

THEORY

Diodes are **nonsymmetrical** electrical devices. They conduct better when one end, called the **anode**, is positive with respect to the other end, called the **cathode**. Physical diodes are often marked with a line, like a minus sign, at the cathode, signifying that the diode will conduct better when this end is more negative than the other end. The symbol for a diode contains an arrowhead pointing from the anode to the cathode, which is the direction in which the current preferentially flows.

There are several useful approximations to describe the operation of diodes in circuits:

1) Crude. The diode is a short circuit, like a closed switch, when voltage is applied in the forward direction, and an open circuit, like an open switch, when the voltage is applied in the reverse direction. This is also called the "ideal diode" approximation, and is usually a good starting point in understanding a new circuit.

2) Standard. The diode is a 0.7 volt source, with no series resistance, when voltage is applied in the forward direction, and an open circuit when the voltage is applied in the reverse direction. This somewhat better approximation tries to account for the voltage drop across the diode when current is flowing through it in the forward direction by saying that the voltage across the diode is always exactly 0.7 volts.

3) Theoretical. Theoretically, the current through many silicon diodes at room temperature is related to the voltage across them by the equation

$$I = I_0\left(e^{\frac{V}{kT}} - 1\right) \approx I_0 \; e^{\frac{V}{26mV}} \qquad (3-1)$$

where k is Boltzman's constant, T is the absolute temperature, and I_o is the "leakage" current when the diode is reverse biased. This approximation implies a theoretical value for the differential resistance of the forward conducting diode. The differential resistance of the diode, *r*, which is also called the "ac" resistance, relates the change in voltage to a change in current:

$$r_d = \frac{\delta V}{\delta I} \qquad (3-2)$$

where δV and δI are small changes in the voltage and current in the diode from its operating point. For many silicon diodes at room temperature *r* is given approximately by

$$r = \frac{26mV}{I} \; ohms \qquad (3-3)$$

where I is the current in amps flowing through the diode. This resistance is often only a few ohms. It is in series with the 0.7 volts already present in the standard approximation.

The current - voltage characteristics of the three models are shown with the figures.

PROCEDURE

1) Connect the circuit in Fig. 1, and apply voltages varying from -10 to 10 volts to the input, in one volt increments. With the digital voltmeter, measure and record the output voltages. *How do your results compare with the crude approximation? How do they compare with the standard approximation?*

2) Connect the circuit in Fig. 2, and apply voltages from -10 to 10 volts to the input, in one volt increments. With the digital voltmeter, measure and record the output voltages. Since the output does not change much, be sure to measure to three significant figures. *How do your results compare with the crude approximation? How do they compare with the standard approximation?*

3) Connect the circuit in Fig. 3 and apply voltages from -2 to 2 volts to the input, in 0.2 volt increments. With the digital voltmeter, measure and record the output voltages, again to 3 significant figures. This circuit is called a "limiter." It permits small input voltages to pass without attenuating them at all, but it **limits** the output to at most about ± 0.7 volt with large input voltages. Note that in the crude approximation this circuit would not work at all; the two ideal diodes "back to back" would simply constitute a short to ground and the output would always be zero.

ASSIGNMENT

Using your measurements for Figs. 1, 2, and 3, plot the **output voltages**, (Y axes), as a function of the **input voltages**, (X axes). On the same plots, show the outputs that would be expected in the crude and standard approximations.

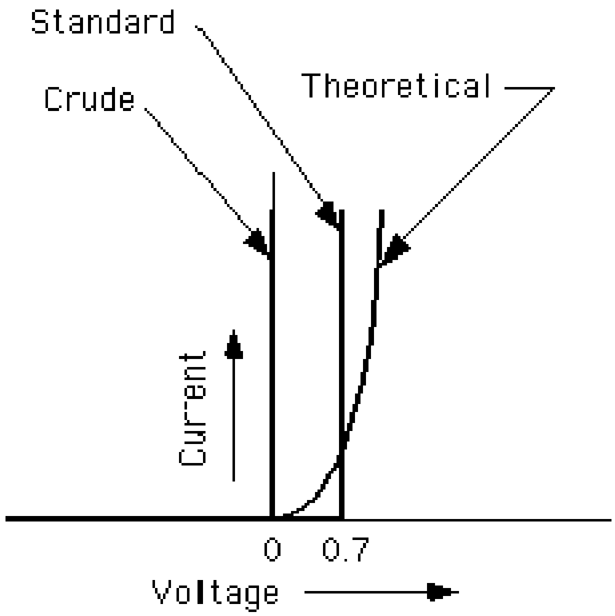
Use the data from the part 2 to compute the current flowing through the diode. This is the same as the current flowing through the 1 kΩ resistor, since there is no place else for that current to flow. The current through the 1 kΩ resistor may be computed, using Ohm's law, from

$$I = \frac{(V_{in} - V_{out})}{1\ k\Omega} \qquad (3-4)$$

Plot the **current** flowing through the diode (Y axis) as a function of the output voltage, which is the **voltage across the diode** (X axis). On the same plot show the current - voltage relationship expected in the standard approximation. *What is the maximum voltage difference between your experimental data and the standard approximation?*

Using the same data, compute the differential resistance of the diode from equation (3-2) by taking differences between successive data points for ΔV and ΔI. Plot the differential **resistance** (Y axis) as a function of the **current** (X axis) through the diode. The current used in this plot should be the average of the two successive values that form ΔI. For comparison, also plot equation (3-3) on the same graph. *How does your plot of differential resistance compare with the theoretical approximation in equation (3-3)?*

Figures



Diode Models

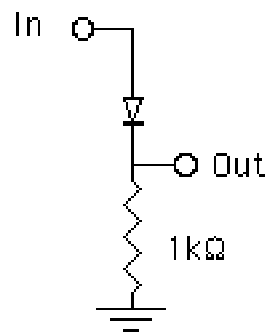


Figure 1

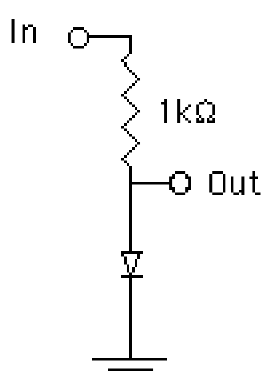


Figure 2

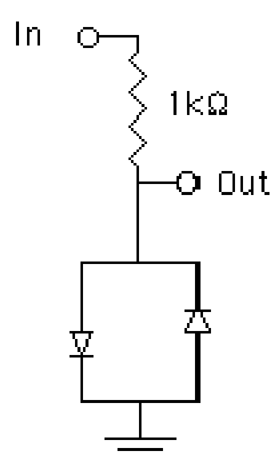


Figure 3