TWO TERMINAL DEVICES - PRINCIPALLY DIODES

This experiment is an introduction to electronics components. In performing this experiment you will learn about the current-voltage characteristics of the most simple of the electronic building blocks, the diode. In addition, you will learn a technique for easily measuring the current-voltage characteristics of a device.

Theory:

For any two-terminal device, such as a resistor, capacitor, diode, battery, etc., a full useful description of its operation is given in some form which relates the current through the device to the voltage across it. Such a relationship is expressed in various ways. For example, for a pure resistor, a single number, R, the resistance, plus Ohm's law, fully express the current-voltage relationship (v=iR). Similarly, for a pure capacitor, the single number C, the capacitance, plus a differential relationship give the characteristics. For other devices, like diodes, the relationship is a bit more complicated, and often more than one number, or even a graph relating i to v, is necessary to provide the description.

The form of the relationship between i and v for diodes is adequately covered in the cited references.

Measurement Technique:

The most direct means of measuring the characteristics of a two terminal device of the type we are considering in this experiment is illustrated in Fig. 1.





In this case, R is used to set the voltage applied to the device, and then a voltmeter and an ammeter are used to measure the voltage across and the current flowing through the device. **This technique is satisfactory, but slow. We shall not use it.**



The method you will use for measurement of the characteristics of the device is illustrated in Fig. 2.



In this circuit, a continuously varying voltage of 6.3 V RMS (8.9V amplitude) is applied to the device by the transformer. This voltage continuously swings from +8.9V to -8.9V. The current through the device is measured by reading the Y deflection of the oscilloscope (CRO in Figure 2), which reads the voltage across R_2 , which is (i R_2). The voltage across the device is measured by reading the X deflection of the oscilloscope, which is slightly in error since the deflection is actually ($v_{device} + iR_2$). It is important that i R_2 be sufficiently less than v_{device} for this technique to work well. Thus the oscilloscope gives a direct graphical plot of i_{device} vs v_{device} . The values of R_2 should be chosen small enough that (iR_2) is sufficiently less than v_{device} , but large enough that it is possible to get an adequate Y deflection. For this experiment you will use $R_2 = 4.7\Omega$.

An extra resistor, R_1 , has been included in the circuit in order to protect the device. This resistor should be chosen large enough to limit the maximum current that can be passed through the device, but small enough to permit adequate voltage or current to be built up for measurement.

In this experiment, you should use the oscilloscope with the vertical sensitivity set to about 0.1 volts/cm and the horizontal sensitivity set to about 1 or 2 volts/cm. If the curves are not displayed well using these sensitivities, then choose appropriate values.

The Experiment

- 1. Check the vertical and horizontal sensitivities of the oscilloscope in the Y vs. X mode and set the zeros.
- 2. Connect the circuit in Fig. 2. Measure the characteristic (i vs v) curves for the various devices provided and outlined in Table 1. Sketch the curves obtained in your lab report, or print the oscilloscope screen indicating the positions of the zeros of X and Y. Also, indicate actual value of current on the Y axis of the curves. Table 1 gives a list of the best values to use of protective resistor R₁.

DEVICE	R ₁ (ohms)	Comment
1. Short Circuit	100	Why is the line not vertical?
2. 47 ohm Resistor	100	Particularly note the slope of the trace.
3. 1000 ohm resistor	100	
4. 47 ohm resistor in series with a 1 1/2 volt dry cell in both the positive and the negative direction.	100	Compare the trace with that for the 47 ohm resistor
5. Germanium Diode	100	Note the slopes, intercepts, and points of bending of the curves. Compare the 4 diodes to each other and to the theory.
6. Silicon Diode	100	
7. One Section of a Selenium Rectifier	100	
8. Diode Vacuum Tube*	0	
9. Zener Diode	100	Note the two fixed voltages of the diode.
10. Thermistor	50	Note the effect of touching the glass bead. Why?

Table 1

***NOTE:** The vacuum diode has 4 connections. Two are the anode and cathode (as with the other diodes) and the other two are "HEATER" leads which require 6.3 volts across them in order that the cathode may be heated so that the diode may function.

- 3. Using the ohmmeter function of a multimeter, measure the "resistance" of each of the devices you measured in part 2, making the connections in both possible directions. Interpret your readings in the light of the observations in part 2, and with reference to how an ohmmeter works. Discuss the question of "what is the ohmmeter really measuring?" with your demonstrator. You may develop a better understanding of this question on using a variety of ohmmeter ranges and by using a couple of different types of ohmmeters.
- 4. If time permits, it would be interesting to look at the i-v curves of any other components that you can obtain. This could include inductors capacitors any pair of terminals of transistors, etc.

<u>References</u>: *L.R. Fortney: Principles of Electronics: Analog and Digital*, Harcourt, Brace, Jovanovich Publ. 1987

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