

**Physics 281**  
**EXPERIMENT 7**  
**I-V Curves of Non linear Device**

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Bring a diskette to save your data.

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**OBJECT:**

To study the method of obtaining the characteristics of a non linear device, and to learn the rectifying feature of the diodes.

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**APPARATUS:**

Diode, adjustable DC power supply, resistor (200 ohms or so), computer and interface, voltage and current sensors.

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**THEORY:**

Resistors and capacitors that we studied in the previous experiments are called linear devices because the voltage across such a device is linearly proportional to the current passing through it. However, many devices that play important roles in electronics are non linear devices. Indeed, physics would be dull and life most unfulfilling if all physical phenomena were linear. As a matter of fact, a linear device is linear only under certain conditions and within certain limits, as we saw in the experiment of temperature dependence of resistance. In this experiment we will study one of the simplest but not the least important non linear device -- a diode, and obtain the I-V curve of it.

A diode is made of two pieces of semiconductors, an n-type semiconductor and a p-type semiconductor, in direct contact. The n-type semiconductor is electron-rich while the p-type is hole-rich. The region in which the semiconductor change from p-type to n-type is called a junction. This junction creates a potential barrier that favors the current to run one way and impede it to run the opposite way. When the positive terminal of a battery is connected to the p side of the junction, the current can easily pass through and the diode is said to be forward biased. If the positive terminal of the battery is connected to the n side, however, it is very difficult for the current to pass and the diode is said to be reverse biased. The direction of bias is usually marked on the casing of the device or by the asymmetrical shape of the casing itself.

Figure 1 shows the characteristics of a typical diode. It is a plot of the current versus the voltage. When the voltage is forward biased, the voltage across the diode is very small, about 0.5 volts for the germanium diode and about 0.7 volts for the silicon diodes. (The voltage drop across a diode is more important than its resistance in most applications.) The working current of a diode changes dramatically, ranging from less than one mA to more than a kA, depending on its application. When the diode is reverse biased, the current is very small, usually less than 100  $\mu\text{A}$  for germanium diodes and less than 10  $\mu\text{A}$  for silicon diodes, as long as the voltage is less than the avalanche breakdown voltage. If the reverse voltage exceeds the avalanche voltage, the current would increase dramatically like the snow current running down hill in an avalanche, and it usually kills the diode. It is therefore to stay safely below the avalanche voltage in your applications. The breakdown voltage is listed in the semiconductor catalogue books and should be on the data sheets attached to the purchased diode.

There is, however, a special type of diodes known as Zener diodes capable of recovering from the avalanche if the current is kept too great. It is used to provide voltage references because the avalanche voltage across a Zener diode is relatively stable within a great range of current. The maximum allowed operating current of a Zener diode is specified in the catalogue books or the data sheets.

The most important application for the regular diodes is rectification. A rectifier is a device that turns an AC voltage into a DC voltage, which we will study in the next experiment.

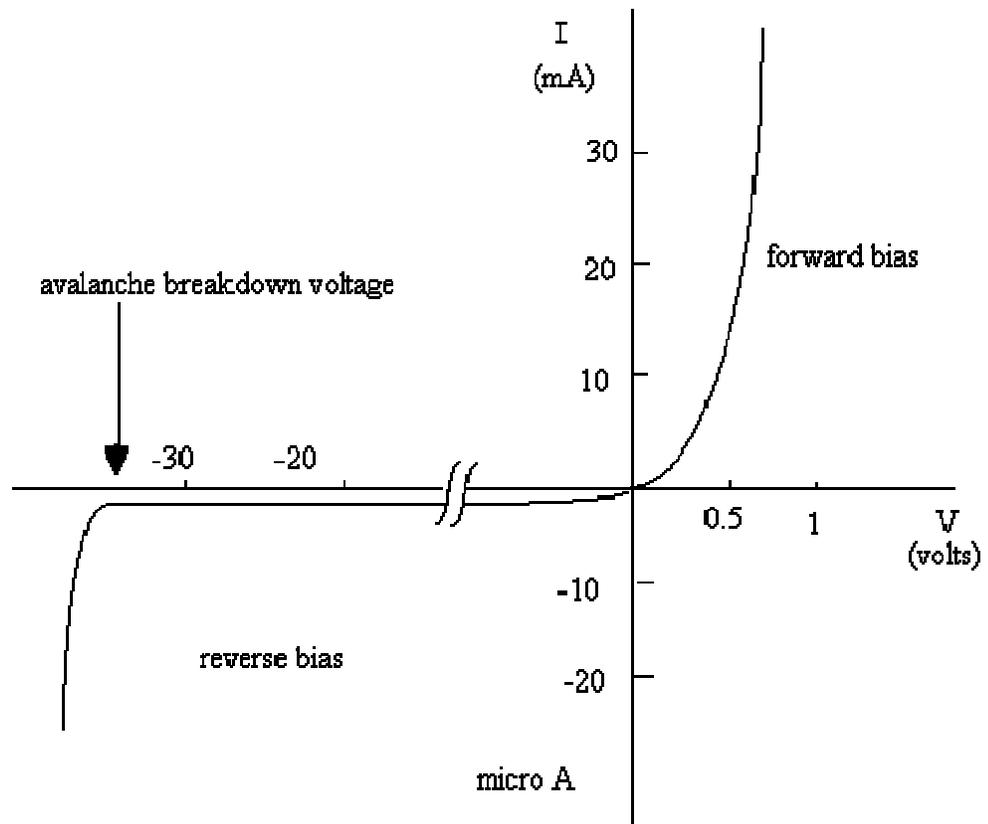


Figure 1

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**PROCEDURE:**

1. Construct a circuit shown in Figure 2 and set up the computer system for the I-V Curve experiment.

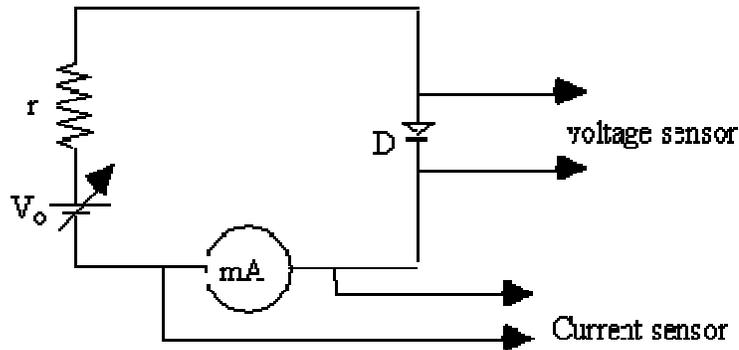


Figure 2

2. Turn on the power supply and give a voltage of about one volt. If the current is practically zero, then reverse the diode to forward bias it. The forward current should be a few mA depending on the resistance of the resistor.

3. Whence the diode is forward biased, then start from zero voltage and gradually increase to 5 Volts. The data should be automatically collected and a curve shown on the screen.

4. Try to fit the curve into an exponential function and get the parameters. Include not only the straight part, but almost the whole length of the curve in your curve fitting.

5. Now reverse the diode so that it is reverse biased. Repeat steps 3 and 4. Remember to keep the voltage below 5 V. The current should be practically zero since the current sensor is not sensitive enough to detect a current less than 1 mA. Get a hard copy of the plot, but you do not have to do curve fitting for the reverse biased data.

6. Save your numeric data on a diskette for both forward and reverse bias curves.

## DATA ANALYSIS

1. Make a plot manually or on EXCEL to combine the forward biased and the reverse biased data and make a single plot. This is characteristics curve of the diode.

2. Answer the questions

1. How well does the data fit to the exponential function ?

2. Can you come up with an idea to make use of the characteristics of the diode?

Reminder: Check you math, check the units, check your graph, do not forget to follow the format for your lab report (see syllabus).