

# Lab Experiments for Devices

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# 1 Diode Biasing

## Objectives

1. To determine the condition of a diode through ohmmeter testing.
2. To identify the cathode and anode ends of a diode using the ohmmeter.
3. To verify forward and reverse bias conditions through voltage measurements on the device and circuit.
4. To find how closely a diode behaves like a switch.
5. To understand the effects upon a biased diode of varying other circuit parameters.
6. To simulate diode circuits using Electronics Workbench™ software running in a Macintosh™ or Windows™ environment, or other similar software.

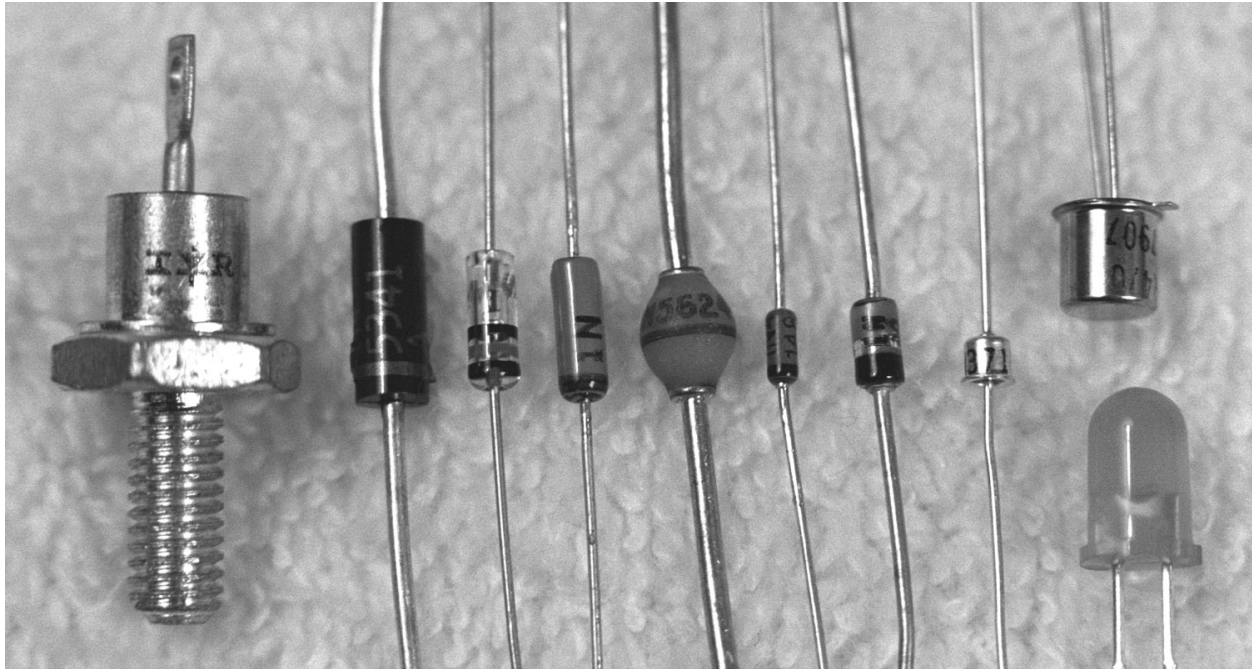
## Equipment

- 1 4.7 kΩ resistor
- 1 1N4004 silicon diode (or equivalent)
- 2 Diodes of any type

## Information

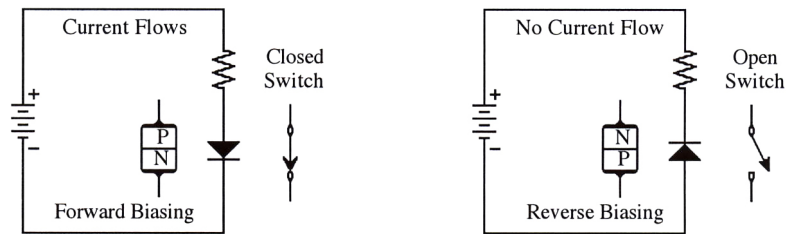
Since a diode allows current to flow in one direction only, it is always necessary to identify which end of the diode is the cathode and which end is the anode. The cathode end of the diode is usually identified with a colored band. Sometimes a diode's identification number is color-coded on the device and the color bands are printed on the cathode end. Often the diode's symbol is printed on the device.

Figure 1-1 illustrates several diodes and their marking systems.



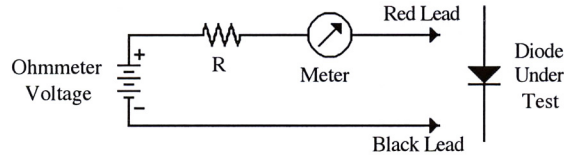
**Figure 1-1. Various Diode Identification Schemes**

In all diodes, the cathode end is the end which connects with the N-type semiconductor material, and the anode connects with the P-type material. When a diode is used in a completed circuit, with positive potential connected to P material and negative potential connected to N material, the diode is forward biased and may conduct current. An ideal diode when forward biased would behave like a closed switch. A diode is reverse biased when the positive potential connects to N material and the negative potential connects to P material. An ideal diode when reverse biased would behave like an open switch. These two biasing conditions are illustrated in Figure 1-2.



**Figure 1-2. Forward and Reverse Diode Biasing**

Of course, ideal diodes do not exist, so the forward resistance of the diode is not  $0 \Omega$ , but is a low resistance. Similarly, the reverse resistance is not  $\infty \Omega$ , but is a high resistance. The actual resistances may be measured with an ohmmeter, but this is often the source of some confusion. An equivalent ohmmeter circuit is shown in Figure 1-3.



**Figure 1-3. Ohmmeter Equivalent Circuit**

The actual meter movement may be represented as some resistance which could be lumped in with the “R” shown in Figure 1-3. If the test leads of the ohmmeter are connected to the diode as shown, the circuit is really a simple forward biased circuit as shown in Figure 1-2. What causes the confusion is that the equivalent ohmmeter voltage varies from one meter to another and also changes whenever the ohmmeter’s range is changed. This varies the amount of forward biasing applied to the diode, and thus varies the resulting resistance measurement, so the same diode might measure a forward resistance of  $95 \Omega$  on one range and  $260 \Omega$  on another range or on another meter. This is quite normal and, once understood, will not bother the technician.

The important things that must be known to take resistance measurements concern the ohmmeter’s test lead polarity, and the ratio of forward and reverse diode resistance. The technician should test the ohmmeter with a voltmeter to be sure of the test lead polarity, or else refer to the operating manual for the instrument. The actual measured forward or reverse resistance of a diode is not particularly important. What is important is that the resistance should be much higher in one direction than in the other, typically  $1 \text{ k}\Omega$  or less in the forward direction and  $1 \text{ M}\Omega$  or more in the reverse direction. The measurement of any semiconductor resistance will always depend upon the ohmmeter’s internal voltage.

## Circuit Simulation

1. Measure the forward resistance of a 1N914 diode using the multimeter in Electronics Workbench™. Connect a voltmeter in parallel with the diode as well so you can see the voltage which the meter causes to appear across the diode.
2. Adjust the multimeter “SETTINGS” so that the ohmmeter current is 0.1 mA. Record the voltmeter reading and the ohmmeter reading in Table 1-1 and on the Simulation Summary sheet.
3. Repeat for current settings of 1 mA and 10 mA.
4. Measure the reverse resistance of a 1N914 diode using the multimeter set for an ohmmeter current of 1.0  $\mu$ A and again for an ohmmeter current of 1.0 mA. Record in Table 1-1.

**Table 1-1. Diode Resistance Simulations**

Ohmmeter Current	Diode Voltage	Diode Resistance
0.1 mA		
1.0 mA		
10 mA		
1.0 $\mu$ A		
1.0 mA		

5. Simulate the circuits of Figures 1-4 and 1-5 using Electronics Workbench™. Record the resistor and diode voltages in Table 1-2.

**Table 1-2. Forward and Reverse Bias Simulations**

	Resistor Voltage	Diode Voltage
Forward Bias		
Reverse Bias		

## Procedure

### Diode Resistances

1. Use a voltmeter to measure the voltage across the test leads of your ohmmeter. Determine if the positive side of the ohmmeter voltage is connected to the red or (+) ohmmeter lead. Note your results below.

The red ohmmeter lead is the \_\_\_\_\_ (positive / negative) side of the ohmmeter voltage.

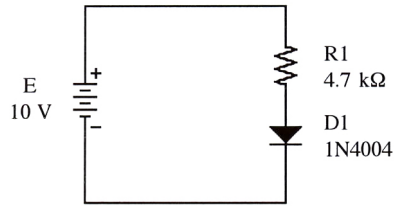
2. Select a 1N4004, or equivalent, diode. Measure the forward and reverse resistance of the diode using several different ohmmeter ranges. Record the ranges and resistance measurements in Table 1-3.

**Table 1-3. Diode Resistances**

Ohmmeter Range	Forward Resistance	Reverse Resistance

## Diode Forward Biasing

3. Connect the circuit of Figure 1-4, then adjust the power supply to 10 V.



**Figure 1-4. Forward Biasing Circuit**

4. Measure the voltage drop across the resistor and across the diode and record these measurements in Table 1-4.

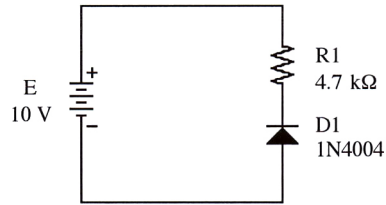
**Table 1-4. Forward Bias Measurements**

Diode Type	Voltage Across R1	Voltage Across D1
1N4004		
Closed Switch		

5. Repeat the measurements for Table 1-4 using two other PN diodes. They may be any silicon or germanium diodes, or even two more 1N4004 diodes.
6. Replace the diode with a closed switch or a short piece of hookup wire. Record measurements of the voltage across the resistor and across the switch in the bottom of Table 1-4.

## Diode Reverse Biasing

7. Connect the circuit of Figure 1-5, then adjust the power supply to 10 V.



**Figure 1-5. Reverse Biasing Circuit**

8. Measure the voltage drop across the resistor and across the diode and record these measurements in Table 1-5.
9. Repeat the measurements for Table 1-5 using two other PN diodes. They may be any silicon or germanium diodes, or even two more 1N4004 diodes.
10. Replace the diode with an open switch or simply remove the diode. Record measurements of the voltage across the resistor and across the switch in the bottom of Table 1-5.

**Table 1-5. Reverse Bias Measurements**

Diode Type	Voltage Across R1	Voltage Across D1
1N4004		
Open Switch		



# 1

## Simulation Summary

Name \_\_\_\_\_

---

1. Complete the simulation data required for Table 1-1 below.

Ohmmeter Current	Diode Voltage	Diode Resistance
0.1 mA		
1.0 mA		
10 mA		
1.0 $\mu$ A		
1.0 mA		

2. Complete the simulation data required for Table 1-2 below.

	Resistor Voltage	Diode Voltage
Forward Bias		
Reverse Bias		



# 1

## Data Sheet

Name \_\_\_\_\_

---

1. Complete the data required for Table 1-3 below.

Ohmmeter Range	Forward Resistance	Reverse Resistance

2. Complete the data required for Table 1-4 below.

Diode Type	Voltage Across R1	Voltage Across D1
1N4004		
Closed Switch		

3. Complete the data required for Table 1-5 below.

Diode Type	Voltage Across R1	Voltage Across D1
1N4004		
Open Switch		

## Questions

1. Refer to Table 1-3. Explain why the measured forward resistance depended on the ohmmeter range being used.
2. Refer to Table 1-4. Is 0.6 V a good approximation for the forward voltage across a silicon diode? Support your answer with data.
3. Refer to Table 1-4. Use your data to illustrate the contention that a forward biased diode acts like a closed switch.
4. Refer to Table 1-5. Use your data to illustrate the contention that a reverse biased diode acts like an open switch.