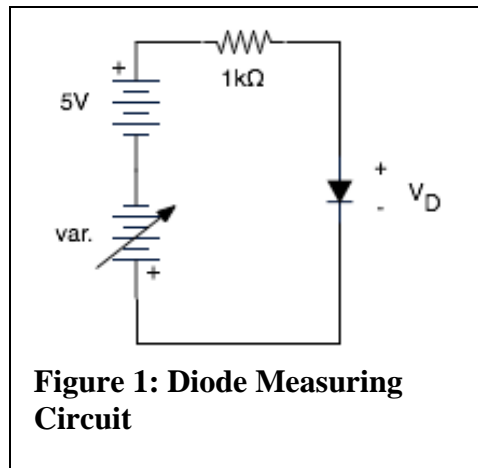


## Diodes

### V-I Characteristics – signal diode

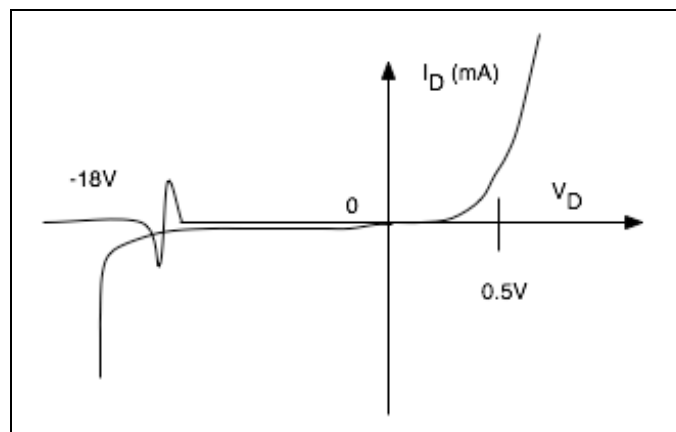
Measure the voltage-current characteristic of a standard signal diode, the 1N914, using the circuit shown in Figure 1 below. The purpose of the back-to-back power supplies is to facilitate measurements near zero supply voltage. Plot the V-I



**Figure 1: Diode Measuring Circuit**

characteristic to show the rapid rise in forward current when the forward voltage approaches 0.7 volts. It should look something like the curve in Figure 2.

Notice that the current in milliamperes is given by the voltage across a 1kΩ resistor as measured in volts. Therefore, you can measure  $I$  vs.  $V$  by connecting a digital voltmeter alternately across the resistor and the diode. In a moment you will use a LabView



**Figure 2: Diode Characteristic Curve**

program to repeat this measurement of  $I$  vs.  $V$ .

### Temperature dependence

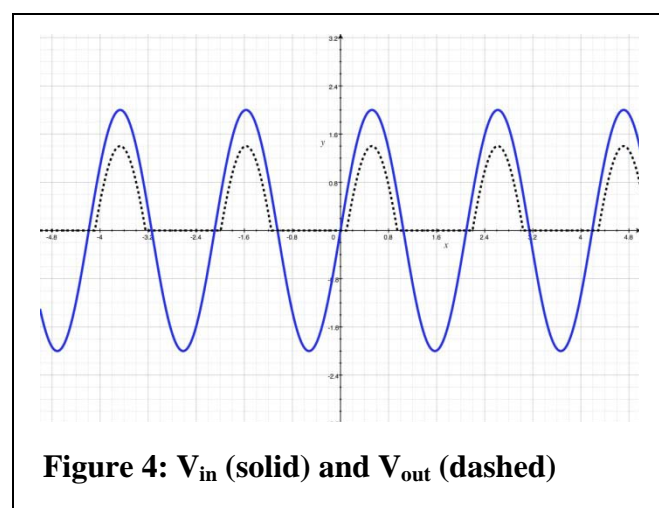
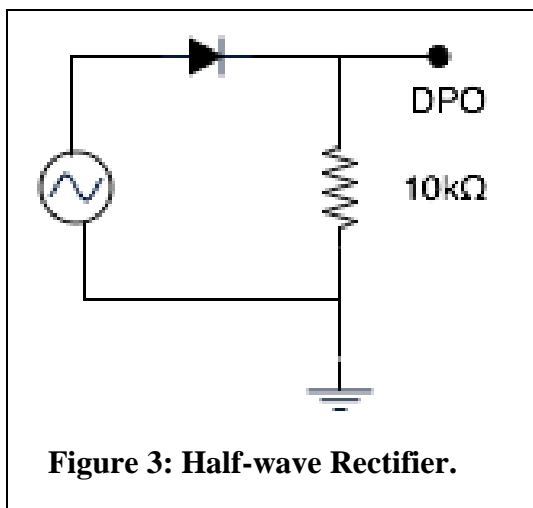
Reverse bias the diode with  $\sim -20$  V and observe the reverse current (should be about  $0.2 \mu\text{A}$ ). Touch a hot soldering iron to the metal lead close to the diode and note the percentage change in reverse current. There is a big effect because the minority carriers that transport the reverse current are thermally generated. Now bias the diode in a forward direction to get a forward current of about  $0.2$  mA. Repeat the heat treatment and observe the change in current.

### V-I characteristics of diodes using LabView

Repeat the measurement of  $I$  vs.  $V$  for a standard signal diode using the LabView program, *I\_vs\_v*, employing a  $1\text{k}\Omega$  resistor for the standard within the measurements. To find instructions on connecting the LabView board to your circuit, make selections within the program: File-> VI Properties-> Documentation. Make sure that the wire connections between the LabView circuit board and your protoboard are correct, including polarities. The LabView board does not only facilitate readout, but also provides a voltage source for your measurements. The measurements are activated with the 'Run' button. Make a printout of the generated curve and insert into your lab notebook.

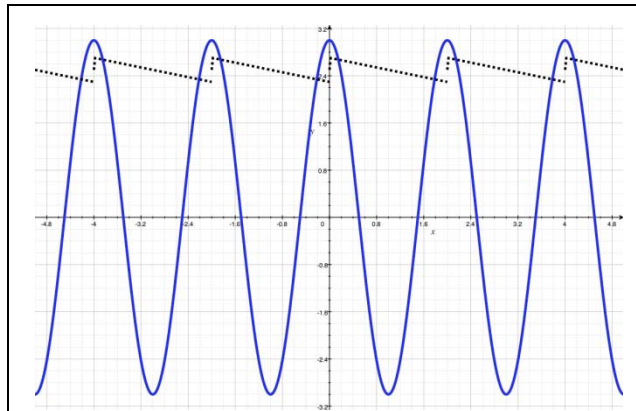
Use next LabView to measure the V-I characteristic for a Zener diode, the 1N4734, which has a Zener voltage of  $5.6$  V. (Note: In the forward condition, current flows out of the terminal labeled with the band marking cathode.) Plot the V-I characteristic using the LabView program and note the dramatic increase in reverse current when the reverse voltage reaches  $5.6$  volts. A Zener diode, biased at this breakdown condition, is a stable voltage reference because the voltage does not change much even though the current may change. Make a printout of the curve and insert it into your lab notebook.

### The Half-Wave Rectifier

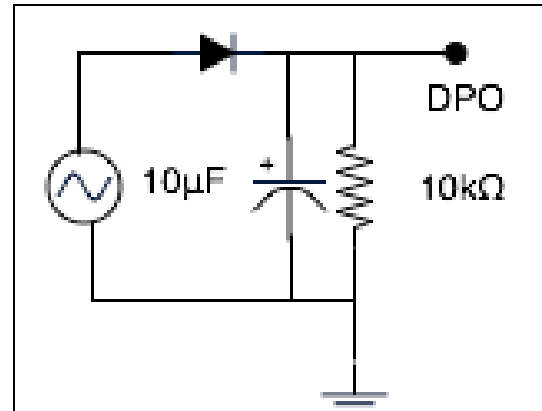


The basic half-wave rectifier with resistive load looks like the circuit in Figure 3. The Input and Output waveforms are shown Figure 4.

The half-wave rectifier with filter capacitor and resistive load is shown in Figure 6 with the input and output waveforms in Figure 5.



**Figure 5: Input (solid) & output (dashed) waveforms**



**Figure 6: Half-wave rectifier with capacitor.**

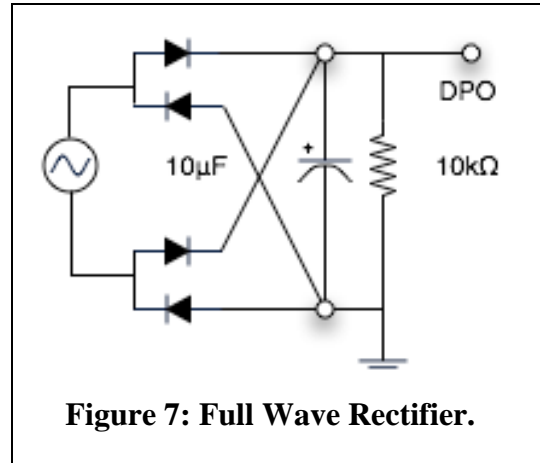
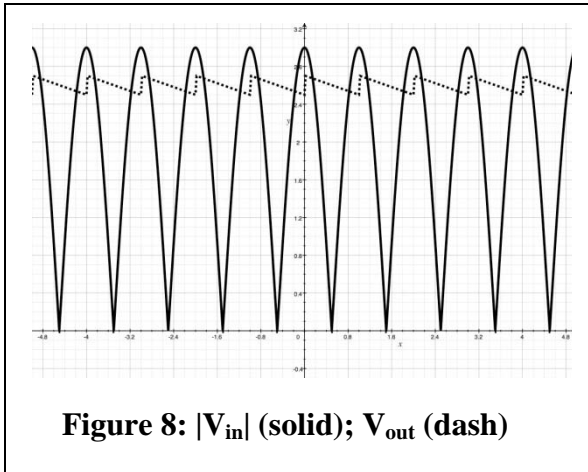
The capacitor is electrolytic. You *must* obey the polarity markings when you connect this capacitor in the circuit. For an electrolytic capacitor, an incorrect connection will lead to a malfunction and quite possibly to a destruction, if the connection is not corrected quickly.

Use a 10 V peak-to-peak 60-Hz signal from a generator as the source.

- Begin with the capacitor disconnected. Observe the half-wave rectified pattern on the oscilloscope. Verify that the frequency of the pattern is 60 Hz.
- Add the 10- $\mu$ F capacitor, getting the polarity right, but remove the load resistor. Observe how the capacitor integrates the rectified power to make a smooth DC source. We might imagine using such a source to power some electronics that need a stable source.
- Add the resistive load back into the circuit and see how the load causes the output of the power supply to “ripple”. You may need to AC-couple the scope and to increase the gain in order to see the ripple well. Verify that the frequency of the ripple is 60 Hz. Use the “Measure” or “Cursor” utilities of the scope to examine the phase of the ripple with respect to the phase of the input AC voltage. Over what phase range of the AC input signal does the capacitor charge?

### **The Full-Wave Rectifier**

The full-wave rectifier, with filter capacitor and resistive load, is shown in Figure 7, with the input and output waveforms in Figure 8.



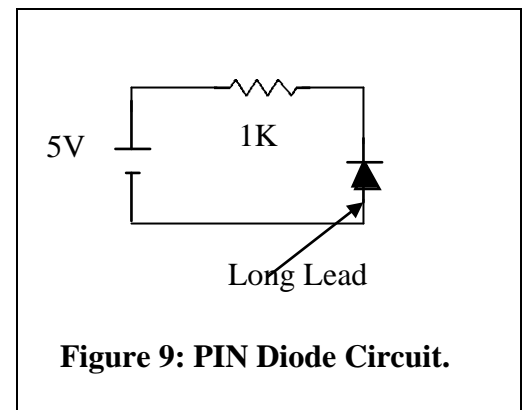
Build the circuit above. Use a 10-V peak-to-peak 60-Hz signal as the source.

- Begin with the capacitor disconnected. Observe the full-wave rectified pattern on the oscilloscope. Verify that the frequency of the pattern is 120 Hz. [Note: Because the two channels of your oscilloscope have a common ground, it is not possible to view both the input and the output of the rectifier at once.]
- Add the 10- $\mu$ F capacitor, getting the polarity right, but remove the load resistor. Observe how the capacitor integrates the rectified power to make a smooth DC source.
- Add the resistive load back into the circuit and see how the load causes the output of the power supply to “ripple.” Verify that the frequency of the ripple is 120 Hz.
- Increase the resistive load by making the resistor 47k $\Omega$  instead of 10k $\Omega$ . Observe that the ripple decreases. Once again you may need to AC-couple and to increase the magnification of the DPO.

Explain the advantage of the full-wave over the half-wave rectifier in making a stable power supply. In fact, neither supply is very good. Both are unregulated. Regulated power supplies will be studied in a later lab.

### The PIN Diode

The PIN diode has intrinsic (i.e. not doped) material (I) in the junction between P and N type material. It makes a fast photo diode, wherein minority carriers are generated by photons. Because the photoeffect depends upon minority carriers, the diode is biased in the reversed condition for a normal operation as a light-sensitive device. Use the PN323D PIN diode in the circuit of Fig. 9 to show a large increase in diode current when a bright lamp is brought close to the diode. Assess effect of an elevated temperature on the reverse current. Reverse the diode to attempt to find the effect of light on the diode current in the forward-biased condition.



### The Seven-Segment Display

The seven-segment display uses 8 light-emitting diodes, including one for the decimal point. The LN516RK (alternatively LA601VL) is a common cathode device, as shown in Fig. 11. The connections for the pins (view from above) of LN516RK are shown in Fig. 10.

Use the circuit in Fig. 12 to turn on segments of the display and verify validity of the diagram in Fig. 10. Ask your instructor to sign off on the proper operation of your circuit testing this display.

