

# PHYSICS 1040L LAB

## LAB 7: DIODE POWER SUPPLY

**Object:** To determine how a diode power supply works and to measure its ripple factor.

**Apparatus:** Diode power supply board, Multimeter, Waveform generator, voltage probes, and Oscilloscope.

**Theory: AC Voltage and Current:** In many applications of electricity alternating currents (AC) and alternating voltages are used. If one places a voltage which varies sinusoidally with time across a load, then the current through that will also vary sinusoidally with time:

$$V = V_0 \sin(\omega t) \quad \text{and} \quad (1)$$

$$I = I_0 \sin(\omega t + \phi) \quad (2)$$

where the zero subscripts refer to maximum values,  $\omega$  is the frequency,  $t$  is the time, and  $\phi$  is the phase difference between the voltage and current. In many cases, as in this one,  $\phi$  is zero. Frequently, one would like to use a direct current when the most convenient electrical power source is AC. Then one desires to convert AC to DC. A diode is a device which may be used to convert AC to DC.

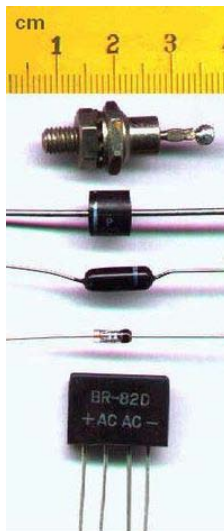
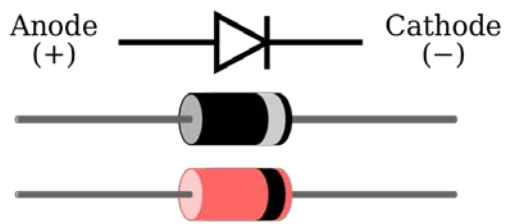


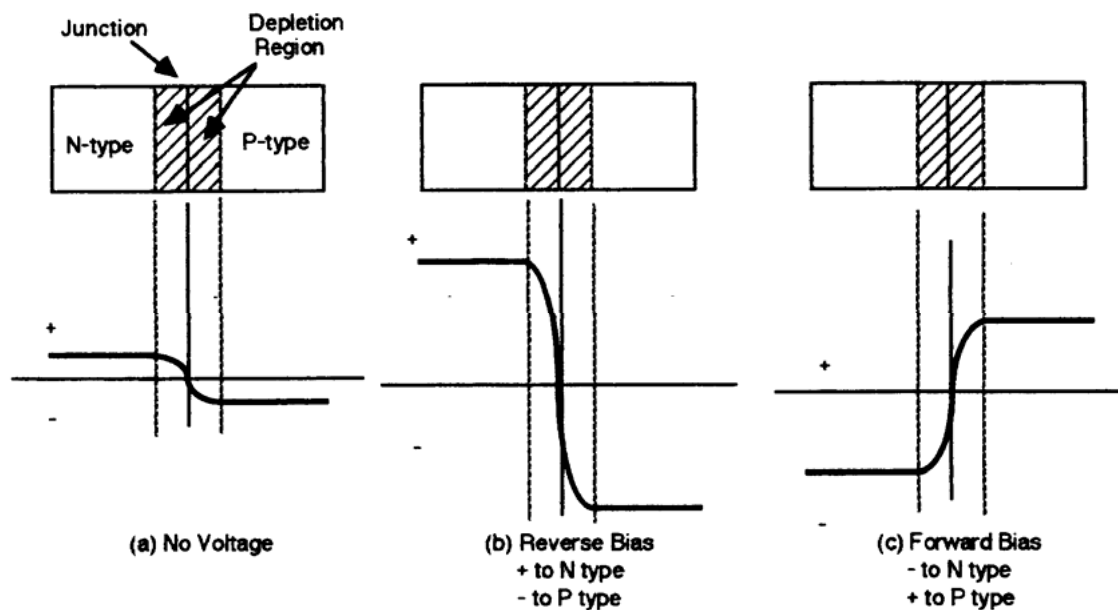
Figure 1: Various semiconductor diodes. Bottom: A bridge rectifier. In most diodes, a white or black painted band identifies the cathode terminal, that is, the terminal that conventional current flows out of when the diode is conducting

Figure 2: Typical diode packages in same alignment as diode symbol. Thin bar depicts the [cathode](#).



## Diodes:

A diode may be thought of as a one-way current valve. That is, it will allow current to flow through it in one direction but not in the other. The ideal diode, therefore, would have an infinite resistance in one direction and zero resistance in the other.



Figures: 3A, 3B and 3C

A real diode, such as a semiconductor diode falls somewhat short of this ideal behavior. A real diode is made of two different types of semiconducting materials. On one side is n-type material which is doped (impurities implanted) with an element which causes it to have free conduction electrons. The other side is p-type material which has holes into which electrons may fit. When a voltage is placed across either of these materials, the electrons or the holes move in response to the electric field and thus current flows. A diode is formed of a junction of p-type and n-type material. At the junction electrons migrate from the N-type into the P-type material, filling holes. The result of this is that P-type material becomes negatively charged and the N-type material becomes positively charged. Electrons are

attracted to the N-type material and holes repelled. This leaves a "depletion region" near the junction with no free charge carriers present, creating a potential barrier which inhibits the further migration of charge (i.e., current). (See Figure 3a). If a voltage is applied across the diode with the positive terminal connected to the N-type and the negative terminal to the P-type material, the natural polarities are strengthened, increasing the height of the potential barrier and preventing the passage of charges across the depletion region (Figure 3b). If the voltage is now connected in the opposite direction, the potential barrier is lowered and charges may cross the depletion region (Figure 3c). Thus, current will pass through the diode only when the P-type side is positive with respect to the N-type side.

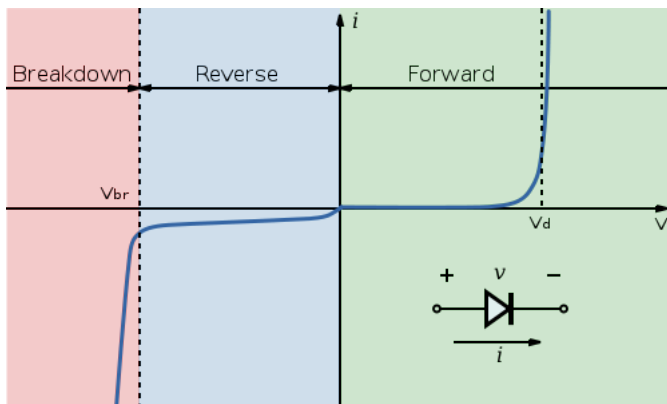


Figure 4: I–V characteristics of a p–n junction diode (not to scale—the current in the reverse region is magnified compared to the forward region, resulting in the apparent slope discontinuity at the origin; the actual I–V curve is smooth across the origin).

## Diode Power Supply:

A diode power supply consists of two diodes connected so that current is passed through one when the AC voltage is positive and through the other one when it is negative. These are connected to a load resistor so that current from each of them is always in the same direction. It is now a pulsating DC current. A capacitor is usually placed in parallel with the load resistor to "smooth" the current leaving only a "ripple" on the DC voltage. Below is an example of one type of circuit which will accomplish this task. Sketch the current path when point 1 is positive and 2 is negative. Then sketch the path when 1 is negative and 2 is positive. Does the current flow through the load resistor in the same direction in both cases?

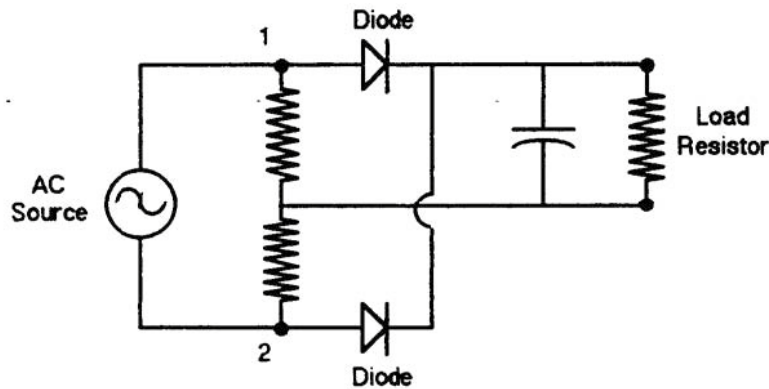


Figure 5: Diode power Supply

## Procedure and Data Analysis

1. Plug in oscilloscope into the AC outlet.(using ungrounded adapter! Very Important.)The oscilloscope is used for measuring input AC-voltage and output DC-voltage.

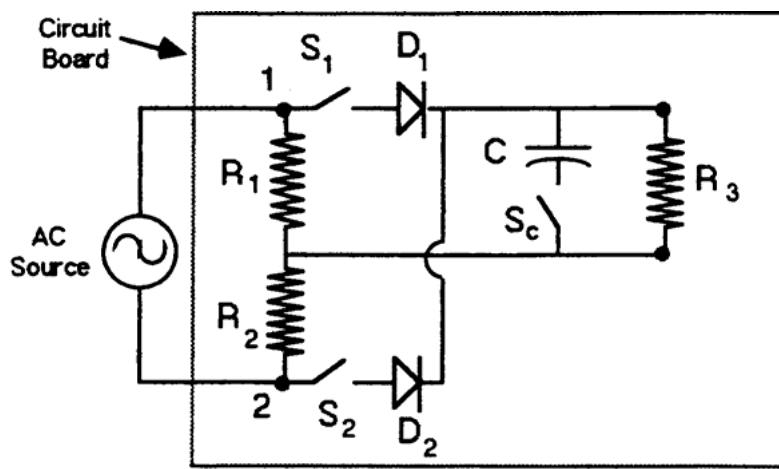


Figure 6. Circuit board arrangement.

2. With switch S1 closed and switches S2, and SC open, connect input from the signal generator AC voltage to terminals 1 and 2 on the diode power supply board.

3. Leave the **RED** and **Black** alligator clips attached to the two points during the whole experiment and leave them there.

The equivalent circuit for this configuration is shown in figure 7.

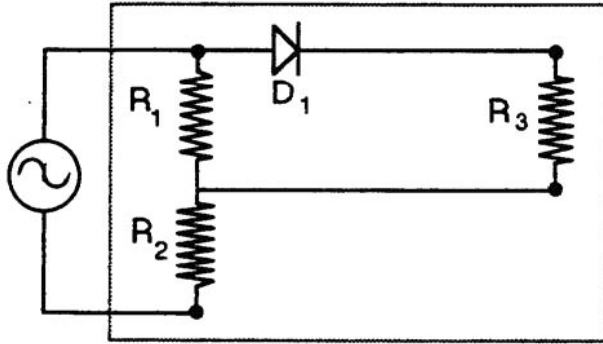


Figure 7: Equivalent Circuit with only Diode Number 1 switched into circuit.

4. Connect the ground and probe of the oscilloscope to terminals 1 and 2 as shown on your data page. Measure the supply voltage (Peak to Peak Voltage  $V_{pp}$ ). Adjust Volt/Div dial until the AC waveform fills the screen. Observe that it is sinusoidal and calculate the amplitude and RMS voltage of the sine function and also the input frequency.
5. Draw a sketch of the waveform in the proper place in your data table.

Note: There are three different voltages that can be measured or calculated in this experiment: Peak to Peak Voltage  $V_{pp}$ ,  $V_{\text{amplitude}}$  or  $V_{\text{max}}$  different expressions for the same voltage and equal to  $\frac{1}{2} V_{pp}$ , and  $V_{\text{RMS}}$ . Keep you reported voltages consistent in your data table.

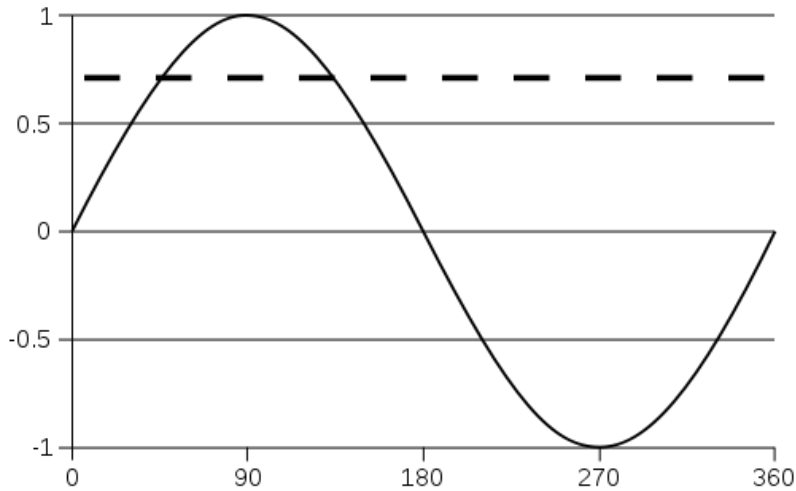


Figure 8: A sine wave, over one cycle (360°). The dashed line represents the root mean square (RMS)

$\frac{1}{\sqrt{2}} V_{\text{amplitude}}$  value at about 0.707 times  $V_{\text{amplitude}}$

6. Measure the voltage across terminals 1 and 2 with an **RMS AC voltmeter**. If it is an RMS Voltmeter, this is  $V_{\text{RMS}}$ . Then calculate the amplitude of the sinusoidal voltage.
7. Connect the ground and probe of the oscilloscope across Resistor R1, as shown on your data page. Measure the voltage (Peak to Peak Voltage  $V_{\text{pp}}$ ) across R1. Calculate  $V_{\text{max}}$  and  $V_{\text{RMS}}$  across R1.
8. Draw a sketch of the waveform in the proper place in your data table.
8. Measure the voltage across R1 with an **RMS AC voltmeter**. If it is an RMS Voltmeter, this is  $V_{\text{RMS}}$ . Then calculate the amplitude of the sinusoidal voltage.
9. Connect the ground and probe of the oscilloscope across Resistor R2, as shown on your data page. Measure the voltage (Peak to Peak Voltage  $V_{\text{pp}}$ ) across R2. Calculate  $V_{\text{max}}$  and  $V_{\text{RMS}}$  across R2.
10. Draw a sketch of the waveform in the proper place in your data table.
11. Measure the voltage across R2 with an **RMS AC voltmeter**. If it is an RMS Voltmeter, this is  $V_{\text{RMS}}$ . Then calculate the amplitude of the sinusoidal voltage.
12. The sum of the two voltages across R1 and R2 should equal the voltage measured across points 1 and 2.

13. Measure the waveform across  $R_3$  using the oscilloscope. Measure the DC voltage across  $R_3$  using the DC voltage setting on the multimeter.
14. Draw a sketch of the waveform in the proper place in your data table.
15. Jumper the other diode,  $D_2$ , into the circuit and repeat step 13. Figure 5 shows the equivalent circuit.

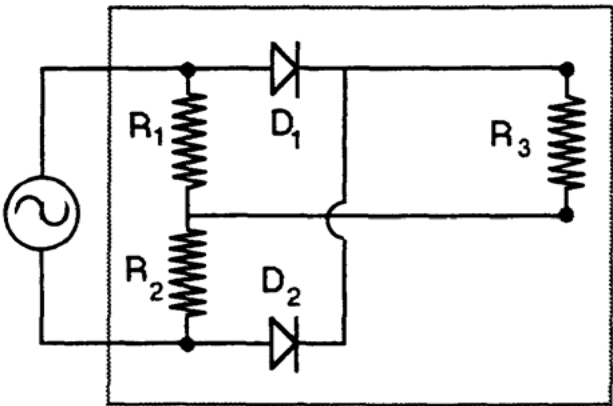


Figure 5: The equivalent circuit with both diodes in the circuit.

16. Jumper the capacitor into the circuit and repeat step 13. Draw a sketch of the waveform in the proper place in your data table.

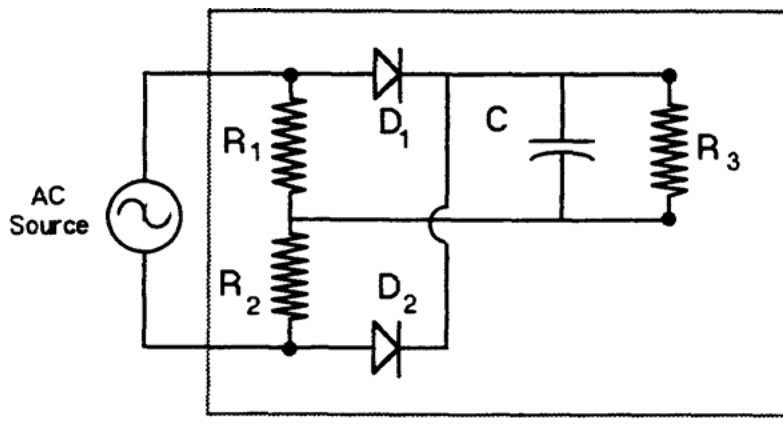


Figure 6: The equivalent circuit with both diodes and the capacitor in the circuit.

**17. Calculate the percentage of ripple,  $(AC \text{ Amplitude} / DC \text{ Voltage}) \times 100\%$ . As shown on your data page**

Figure 7: Alternating Current (green curve). The horizontal axis measures time; the vertical, current or voltage.

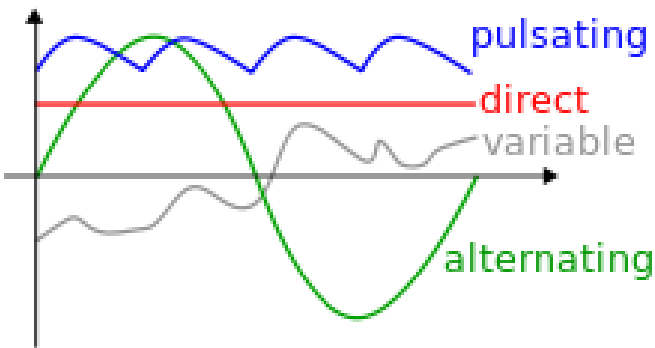


Figure 8: High voltage transmission lines deliver power from [electric generation](#) plants over long distances using alternating current. AC transmission is more efficient than DC transmission. Less energy is lost to heat using A.C. These lines are located in eastern [Utah](#).





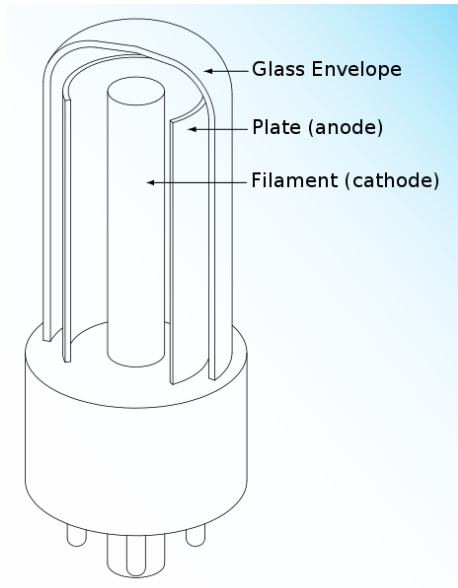


Figure 9: For many years from the early 1900's various electronic devices used glass tubes instead of semiconductors you can see on the first page of this handout.

Structure of a [vacuum tube](#) diode. The filament may be bare, or more commonly (as shown here), embedded within and insulated from an enclosing cathode.



1920 RCA UV199 Triode The first from RCA to be machine manufactured.



1933 RCA 83 Full Wave Rectifier with mercury vapor. This tube is equivalent to our circuit,

(No Capacitor for smoothing)

### Diode Power Supply Circuit Board

