UNIVERSITY OF UTAH
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ECE 2280

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1/08

Lab #3 {50 pts} Diodes

OBJECTIVES:

- Understand the basic operation and characteristics of a diode.
- Understand basic circuits containing a diode.

PARTS LIST:

? (4) silicon diodes (ex. 1N4001, 1N4004, etc.)
? 10k Potentiometer
? A couple capacitors (low value, medium value, large value)

PRE-LAB: Read Experiments

BACKGROUND INFORMATION:

Discussion about use of diodes, half-wave rectifiers, and Multimeter Testing.

Use of diodes

Diodes are mostly used in practice for emitting light (as LEDs) or controlling voltages in various circuits. The best way to think about diodes is to first understand what happens with an ideal diode and then to extend that knowledge to the real-world applications.

An ideal diode has an infinite resistance when the voltage across it is less than its "threshold voltage" and zero resistance when the voltage is greater than the threshold. The threshold voltage is just a characteristic of each individual diode (i.e. every silicon diode should have about the same threshold voltage whereas an LED may have a different threshold voltage). This threshold voltage concept comes from the fact that a diode is just a pn junction; the threshold voltage is defined by the concentration of donors and acceptors in the junction (Don't feel bad if you haven't studied *pn* junctions before; it is not crucial for this lab).

Given the above assumptions, we conclude that the I-V graph for an ideal diode should look like:

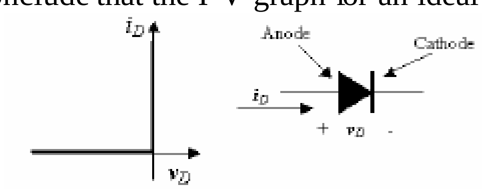


Fig. 2: Ideal Diode IV Curve and Schematic

In **Fig. 2**, the threshold voltage (i.e. the voltage when the slope of the line changes from 0 to ∞) is 0V. In the real-world the threshold voltage will be some positive voltage. For the diodes we will use in this lab, all threshold voltages will be positive (Zener diodes also have a low reverse threshold).

Half-Wave Rectifier

The half-wave rectifier is a circuit that allows only part of a sinusoidal input signal to pass. The circuit is simply the combination of a single diode in series with a resistor (see **Fig. 1**), where the resistor is acting as a load.

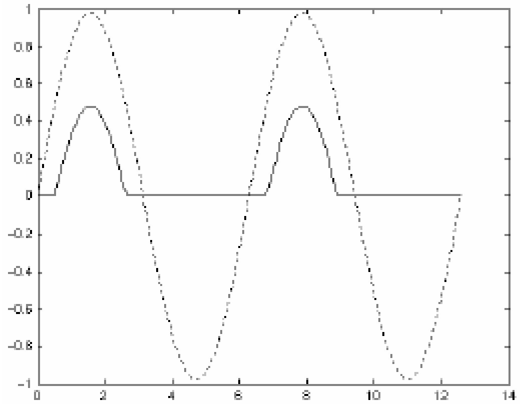


Fig. 3: Half-Wave Rectifier, Voltage vs Time

We see that the output voltage across the load is the input voltage minus the threshold voltage (this only holds when the input voltage is greater than the threshold voltage). Here, the threshold voltage is set to about 0.5 volts (can you see why?). We see that when the input voltage is not greater than the threshold voltage, we get zero voltage out. This makes sense if we look at **Fig. 2**.

Observations:

- We see that when the input voltage is less than the threshold voltage (and thus the voltage across the diode is less than the threshold voltage), we get zero current through the diode and the load (see **Fig. 2**).

- We see that when the input voltage is greater than the threshold voltage, any current can pass through the diode.

For the Half-Wave Rectifier the diode acts as a switch (see the bullets below for the switching conditions).

Switching Behavior:

- Off Condition: input voltage < threshold voltage. No current passes through the diode.
- On Condition: input voltage $\geq$ threshold voltage. Any current can pass through the diode.

For example, let's make the input voltage of five volts and a threshold voltage that we look up to be 2 Volts (which is just the voltage across the diode). Then, we know that there are 3 V across the resistor. The diode is on and current is passing through the diode.

<u>Multimeter diode test</u>

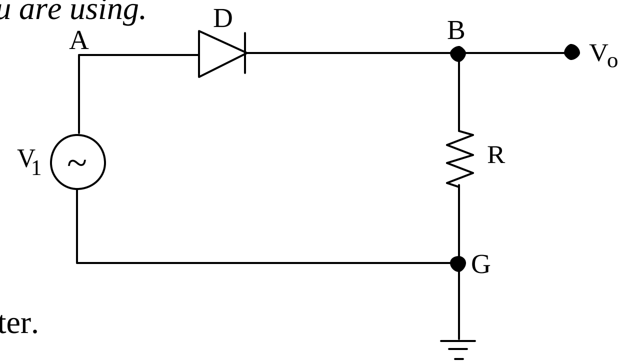
Most multimeters won't forward bias a diode in the regular ohmmeter setting. The ohmmeter just doesn't put out enough voltage to overcome the diode's forward voltage drop. Therefore, multimeters won't show significant conductivity in either diode direction. Try it yourself and see. Set the bench multimeter to the ohmmeter setting. Measure the resistance of a diode in both directions. A little problematic isn't it? You may find that your own body's conductivity is better than the diode's. Just hold the metal tips of the two meter probes in your two hands to see what I mean.

Most multimeters provide a special ohmmeter setting to measure diodes, usually marked with a small diode symbol. In this setting they use a high enough voltage to turn the diode on. Look for a diode symbol on your meter and set the meter to that position (It's a blue shift setting on the HP meter). Now the meter will test diodes.

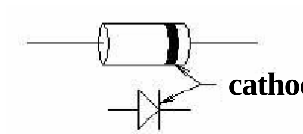
Most meters will show volts or mV (rather than Ω) when connected to the diode the right way. This indicates the forward drop across the diode at some low current and can be useful when comparing diodes. This test is also useful to see if the diode is not working correctly to see if the diode has been "blown".

EXPERIMENT 1 Half Wave Rectifier: (20 pts)

IMPORTANT: *Do not exceed the power rating for the diode you are using.*



Procedure:



1. (20 pts) Rectifier Testing

(1a) (3 pts) Select a diode and test it using the multimeter to verify it should operate correctly(use the diode setting).

(1b) (2 pts) Build the circuit in Fig. 4 using a 10k potentiometer.

(1c) (12 pts) Apply a 100Hz sine wave with 5V peak as the input.

Fig. 4 Basic Rectifier Circuit

- Using the oscilloscope, measure the signals at nodes A and B.
- Compare the voltage values at A and B with Fig. 3.25(d) *{Shown below}* from the textbook.
- Estimate the diode voltage drop at the peak of the output, V_{DO}, and compare it to the datasheet for the diode.
- Adjust the potentiometer turned all the way to one side and observe the signals at nodes A and B.
- Adjust the potentiometer all the way to the other side and observe the signals at nodes A and B.
- What effect does the R have?

(1d) (3 pts) Switch the generator to a square-wave output. Notice the direct effect of the diode drop.

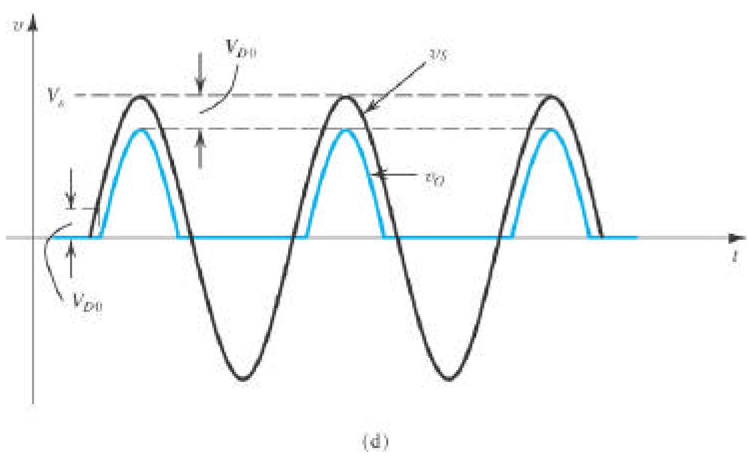


Fig. 3.25(d) { *Sedra and Smith, Microelectronic Circuits, 5th edition* }

EXPERIMENT 2 Diode Bridge(Full Wave): (30 pts)

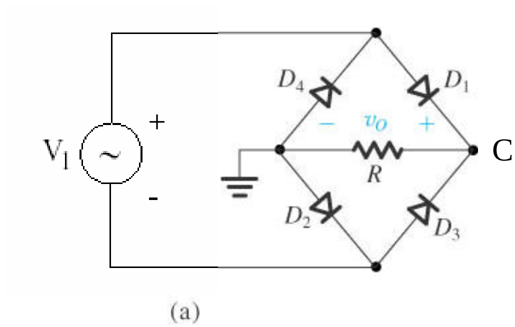


Fig. 5 Diode Bridge Rectifier

(2a) (5 pts) Expand Fig. 4 into the diode bridge shown in Fig. 5 on your breadboard. (Add D2-D4 diodes)

(2b) (5 pts) Apply a 100Hz sine wave with 5V peak as the input.

- Using the oscilloscope, measure the signal at node C.
- Compare the measurement with Fig. 3.27(b) *{Shown below}* from the textbook.

(2c) (10 pts)

- Adjust the potentiometer all the way to one side and observe the signal at node C.
- Adjust the potentiometer all the way to the other side and observe the signal at node C.
- What effect does the R have? Sketch appropriate graphs if necessary.

(2d) (10 pts)

- Place a capacitor with a small value in **<u>parallel</u>** with the resistor, R. Observe signal at node C.
- Replace the capacitor first with a medium value and then with a large value for C. Observe the signals at node C.
- Explain in detail how the capacitor works in the circuit. (You can refer to Sec. 3.5.4 of your book)

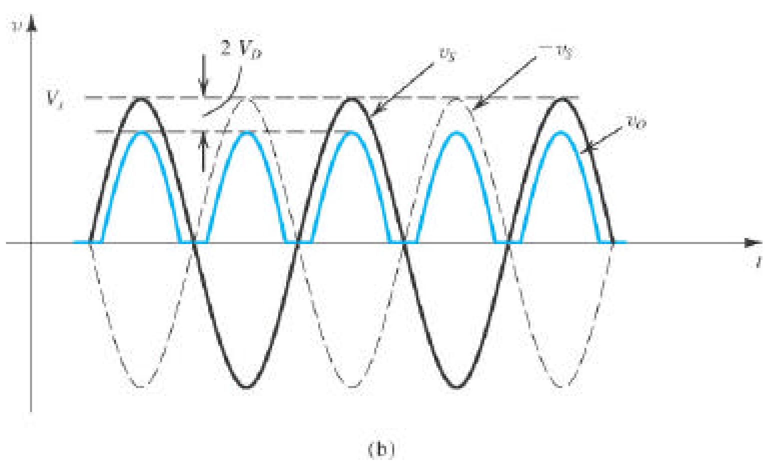


Fig. 3.27(d) { *Sedra and Smith, Microelectronic Circuits, 5th edition* }

<u>NOTE:</u> This concept is half of your first design project. This creates one side of your rail voltage.