ECE 2274
Pre-Lab for Experiment # 4
Diode Basics and a Rectifier
Completed Prior to Coming to Lab

Part I – I-V Characteristic Curve

1. Construct the circuit shown in figure 4-1. Using a DC Sweep, simulate the current-to-voltage characteristic of a diode.

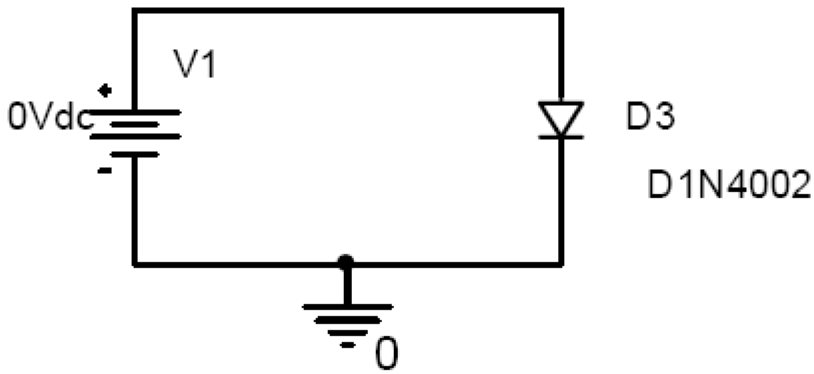

Figure 4 – 1

a. Select VDC for your input voltage supply.

b. Select diode 1N4002 (D1N4002) from the parts list.

c. Place a current probe in series with the diode, so that you can measure the diode current as a function of diode voltage.

d. Set the start value to 0V and the end value to 800mV for the DC Sweep analysis. The plot obtained is called the I-V characteristic curve.

e. Print and label your graph to turn in as part of your pre-lab.

f. Click on the diode symbol in your schematic to highlight it. Then, go to EDIT/Pspice Model. Determine Vj, N, and Rs, which are the turn-on voltage, non-ideality factor, and forward-bias series resistance. Record these values.

2. Change the diode to a 1N914 (D1N914) model. Repeat the DC Sweep simulation. Print and label your graph to turn in. What changes do you notice and explain how the different values for Vj, N, and Rs influence the I-V characteristics?

Revised: Summer 2010

Part II – Half-Wave Rectifier

3. Figure 4-2 shows a half-wave rectifier. Build a half-wave rectifier in PSpice using the D1N4002 diode.

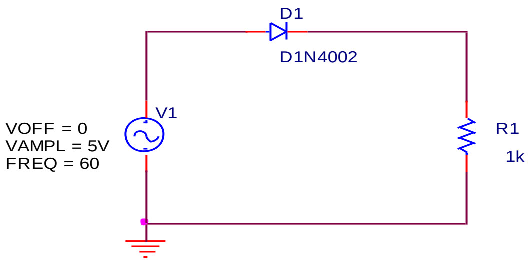

Figure 4-2: A half-wave rectifier

a. Set the attributes to the source, part VSIN, as follows:

i. VOFF = 0V

ii. VAMPL = 5V

iii. FREQ = 60 Hz

b. Choose a resistor value that is relatively large (>500Ω) from the list of 5% tolerance resistors. **Do not use the default value of 1kΩ for the resistance.**

4. Run a transient simulation to measure the voltage across the source and the resistor using a time span equal to at least one full cycle of the input voltage.

a. Does the output voltage across the resistor match the input voltage in the positive domain? Why or why not?

b. Find and record the maximum value of the voltage over the resistor.

c. Print and label your graph to turn in.

5. Using a DC Sweep, simulate the output voltage of a half-wave rectifier. Run the sweep over the part VSIN from -5V to +5V. The plot obtained is called the voltage transfer function. Print and label your graph to turn in.

$$V_{TF} = V_{OUT} / V_{IN}$$

6. Using the half wave rectifier Fig 4-3, design a circuit in which a capacitor is in parallel with R1 such that the ripple voltage, Vr, is 0.5V. Assume that Von = 700mV for the D1N4002. *You may need to use more than one*. Be sure to show all your work. T is the period of the waveform and it will be different for have-wave and full-wave circuits. Solve for C.

$$V_r = (V_{AMPL} – V_{drop})(1- e^{-T/RC})$$

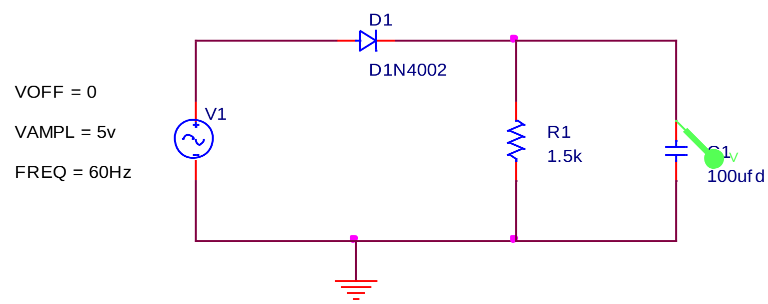

Fig. 4-3

a. Verify your design using a transient simulation.

b. Print out the simulation results to turn in.

Part III – Full-Wave Rectifier

7. Build a full wave rectifier as shown in figure 4-4
   a. Assume Vr= 200mv, how does the voltage compare to that of the half-wave rectifier? Why has the ripple voltage changed?
      *HINT: Try taking the capacitor out and seeing how the rectified signal has changed. Compare the period of the two waveforms and take a look at the ripple formula.
   b. How does the maximum voltage output compare to that of part 6? Why has the maximum output voltage changed? This is related to the previous part.

R1= 1.5KΩ

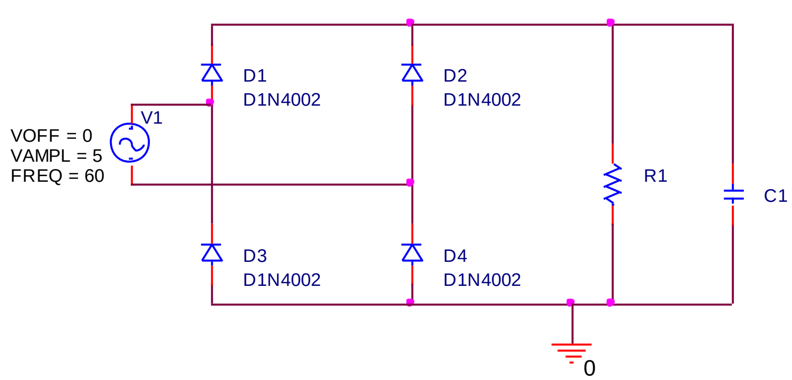

Figure 4-4: Full-Wave Rectifier

Pre-Lab Answer Sheet:

1.f. 1N4002 V_j __________ N __________ R_S __________

2. 1N914 V_j __________ N __________ R_S __________

What changes do you notice and explain the different values for Vj, N, and Rs influence the I-V characteristics?

4.a. Does input match output voltage? Why not?

4.b. Maximum voltage across resistor. __________

6. Capacitor which gives 0.5V ripple __________

7. a. How do the half-wave and full wave rectifier ripple voltages compare? Why?

7. b. How do the half-wave and full wave rectifier maximum voltages compare? Why?

Required Graphs:
1. DC sweep of 1N4002
2. DC sweep of 1N914
3. Transient of DR circuit
4. Voltage transfer function of half-wave rectifier
5. Transient of half-wave rectifier
6. Transient of full-wave rectifier

Lab Exercise
Experiment # 4
Diode Basics and a Rectifier

Part I – I-V Characteristic Curve

1. Using a curve tracer, determine the I-V characteristic of the diode that you actually use in the lab. Print out the characteristic curve to turn in with your Data Sheet.

Part II – Half-Wave Rectifier

2. Build the half-wave rectifier you designed in the pre-lab. Use the Varic and the 10:1 isolation transformer to create a ±5V sinusoidal source. Use the closest value resistor that is available in the lab. Record the resistor value in your Data Sheet.

    a) Measure the ripple voltage (Vr).

    b) Determine your percent error between your measured ripple voltage and the one expected from your design in pre-lab.

    c) Capture the waveform with about 2-3 periods use AC coupling.

3. Remove the capacitor from the circuit. Determine the maximum voltage across the resistor and compare it with the value you found in the pre-lab. Capture the waveform, remember to turn off AC coupling.

4. Using a digital multimeter, capacitance meter, and curve tracer determine the actual values for R1, C, and Von*.

    a. Using these values, recalculate the ripple voltage. Be sure to show all your work.

    b. Determine your percent error between your measured ripple voltage and the one that you just calculated.

*Note: One method to calculate Von is to extrapolate the linear section of the forward I-V characteristic to find the intersection of the linear portion of the I-V with the x-axis. The voltage at this intersection is Von.

Part III – Full-Wave Rectifier

5. Using the same valued capacitor and load, construct the full wave rectifier designed in the Pre-Lab. Again, use the Varic and the 10:1 isolation transformer to create a ±5V source.

    a. Measure the ripple voltage (Vr) and maximum voltage output

    b. How does it compare with the Pre-+Lab?

c. Again recalculate the ripple voltage using the actual values of C, R1, and Von.

d. Determine your percent error between your measured ripple voltage and the one that you just calculated

e. Capture the waveform with AC coupling selected.

6. What would be a benefit of using a half wave rectifier instead of a full wave? What would be a benefit of using a full-wave rectifier instead of a half wave? List a few of the pro’s and con’s to each design.

Data Sheet
Experiment # 4
Diode Basics and a Half-wave Rectifier

Part I – I-V Characteristic Curve

1. Print out the characteristic curve to turn in with your Data Sheet.

Part II – Half-Wave Rectifier

2. Standard capacitance nominal value: C = _____________

   a. V_{ripple} (measured) = _____________

   b. % error = _____________

3. Voltage without capacitor in circuit: V_{max} = ______________

   % error = ______________

4. Measured values:

R1 = ______________

C = ______________

Von = ______________

   a. V_{ripple} (calculated) = _____________

   b. % error = _____________

Part III – Full-Wave Rectifier

5. a. Ripple voltage _____________

   Maximum output voltage ______________

   b. % error form Prelab : _____________

c. Calculated ripple voltage: ____________

d. % error from calculated: ____________

6. Discuss Pro's and Con's to each the Full-Wave and Half-Wave rectifier

Required graphs:
1. I-V Characteristics curve
2. Scope capture of half-wave w/capacitor
3. Scope capture of half-wave w/out capacitor
4. Scope capture of full-wave