EE351 Laboratory Exercise 1
Diode Circuits

revised July 19, 2009

The purpose of this laboratory exercise is to gain experience and understanding working with diodes. Focus on taking good data so that the plots and calculations you will do later will be meaningful.

1.0 Rectifiers for Power Supplies

The signal generator is going to be used to mimic a 4 volt, 20 mA transformer with 25% regulation. The signal generator should be set to a sine wave frequency of 60 Hz and an open circuit output level of 14.15 Vpp as measured on the oscilloscope (this should be 2.50 Vrms into 50 Ohms as indicated on the amplitude setting of the signal generator).

1.1 Build the circuit in Figure 1 but omit the capacitor for the time being. Use 1K for R.

1.2 Observe the half-wave signal on the oscilloscope. This is indicating that the diode is conducting for only a single direction of current.

1.3 Add a 47 uF capacitor across R and observe that the waveform is much smoother now. Note that the diode is only conducting for the period when the output voltage is rising. Observe the distortion of the applied waveform on channel 1 of the oscilloscope during the charging period.

1.4 Measure the average DC output voltage, the minimum DC voltage, and the maximum DC voltage. Compute the peak-peak ripple voltage and divide by 3 to estimate the rms value. Then compute the percent ripple by dividing the rms ripple by the DC average voltage and multiplying by 100. Compute the power delivered to the load resistor.

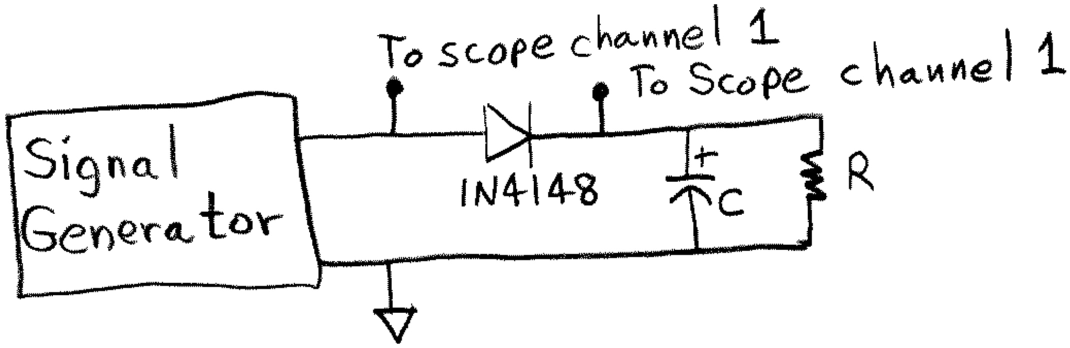

Figure 1: Half-wave rectifier

1.5 Replace R with 10K and repeat step 1.4. Note that the DC output voltage is higher and the ripple is lower but the output power is also lower.

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1.6 Build the full-wave rectifier circuit in Figure 2. Initially use a load resistor of 1 K and no capacitor. Note that the signal generator must be floating. No other connection such as Sync can be made for this part of the experiment to work.

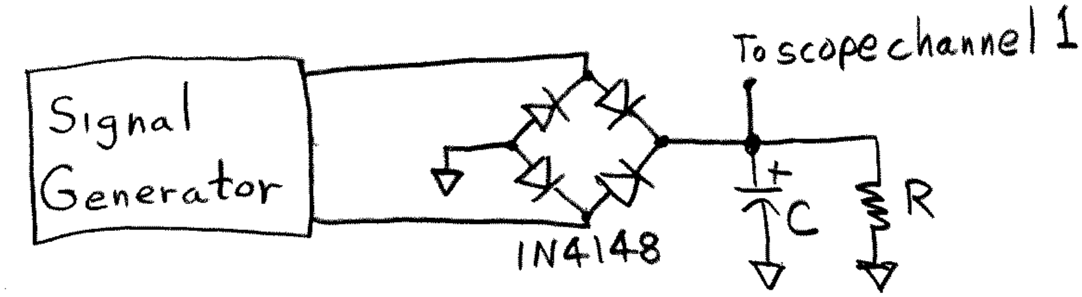

Figure 2: Full-wave Rectifier

1.7 Add a 47 uF capacitor across R and observe that the waveform is much smoother now. Note that the diode is only conducting for the period when the output voltage is rising.

1.8 Measure the average DC output voltage, the minimum DC voltage, and the maximum DC voltage. Compute the peak-peak ripple voltage and divide by 3 to estimate the rms value. Then compute the percent ripple by dividing the rms ripple by the DC average voltage and multiplying by 100. Compute the power delivered to the load resistor.

1.9 Replace R with 10K and repeat step 1.8. Note that the DC output voltage is higher and the ripple is lower but the output power is also lower.

1.10 Simulate both circuits using rectifier_filter.xls with parameters: 60 Hz, 4 Vrms, 0.02 Amperes, 25% regulation and 47 uF and 1K. Use 0 degrees starting phase and 2 cycles per plot. Use mode = 1 for half-wave and 3 for full-wave bridge. Use 0.75 volts for the diode junction and 4 ohms bulk resistance. Adjust the starting voltage until it is equal to the ending voltage. Compare the simulation results with the actual measurements.

2.0 Forward bias measurements

2.1 Build the circuit in Figure 3. The 1K resistor is used to measure the current through the diode and the different values of R1 are used to broaden the adjustment range of the power supply so that setting the various diode currents in later steps is easier.

2.2 Accurately measure and record the actual value of the 1K resistor and use this value in computing the diode current in the next step. The diode current is determined by measuring the voltage drop across this resistor and using Ohm’s law to compute the current. For example, a 1 Volt drop would be a current of 1 mA.

2.3 Using 100K for R1, adjust the power supply to obtain nominal diode currents of 5, 10, 20, 50, and 100 uA and record the voltage across the diode for each of these currents. Note: Nominal means generally close to but without a definite tolerance. Do not waste time trying to adjust the current to exactly 50.00000 microamperes for example. All you need is a current generally close to 50 microamperes (say within ten percent). Record the actual current and actual voltage and your data is fine.

2.4 Using 10K for R1, adjust the power supply to obtain nominal diode currents of 0.2, 0.5, and 1.0 mA and record the voltage across the diode for each of these currents.

2.5 Using zero Ohms for R1, adjust the power supply to obtain nominal diode currents of 2.0, 5.0 and 10.0 mA and record the voltage across the diode for each of these currents.

2.6 Plot the data collected in steps 2.3 through 2.5 using your actual currents and voltages. Make two different plots. One plot should indicate linear voltage (x axis) and linear current (y axis) – this should resemble the diode current versus voltage plot in the text. The other plot should use a logarithmic axis for current (x axis) and a linear axis for voltage (y axis) – hint: this should be a fairly straight line – do not compute the log of current, plot the data on a log axis. Use Excel and select the XY scatter plot function.

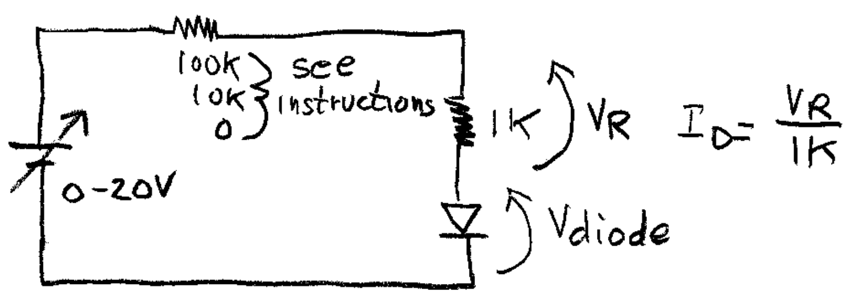

Figure 3: Measuring diode current versus voltage

3.0 Use of a diode as a signal clipper or limiter

3.1 Build the circuit in Figure 4.

3.2 Vary the 0 - 6 Volt power supply and note that the signal on the oscilloscope is limited or clipped. Neatly draw and label some example waveforms or use a data file from the scope.

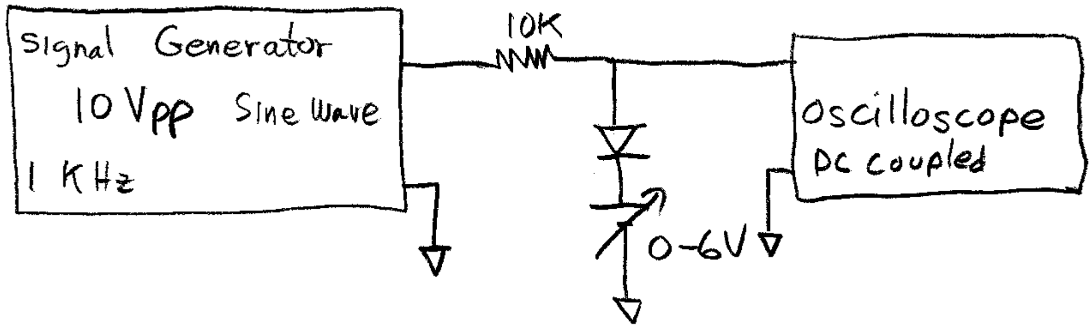

Figure 4: Diode clipper

4.0 Use of the diode as a signal clamper.
Note: a clamper is also known as a DC restorer in repetitive pulse waveform applications such as video.

4.1 Build the circuit in Figure 5.

4.2 Vary the output of the signal generator from 1 to 10 Volts peak-peak and note that the most negative portion of the waveform on the oscilloscope is approximately negative 0.6 Volts independent of the input amplitude. Neatly draw and label some example waveforms.

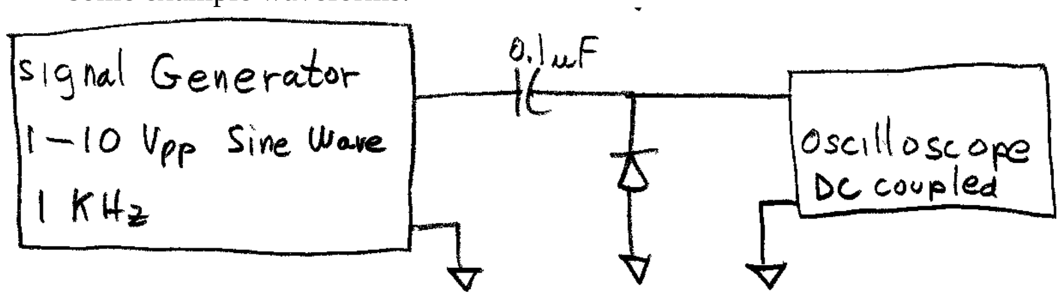

Figure 5: Clamping circuit

5.0 Use of diodes as an electronic switch

5.1 Build the circuit in Figure 6.

5.2 Connect point x to +20 Volts and observe that a signal is present on the oscilloscope. Observe that both diodes are forward biased.

5.3 Connect point x to -20 Volts and observe that no signal is present on the oscilloscope. Observe that both diodes are reversed biased.

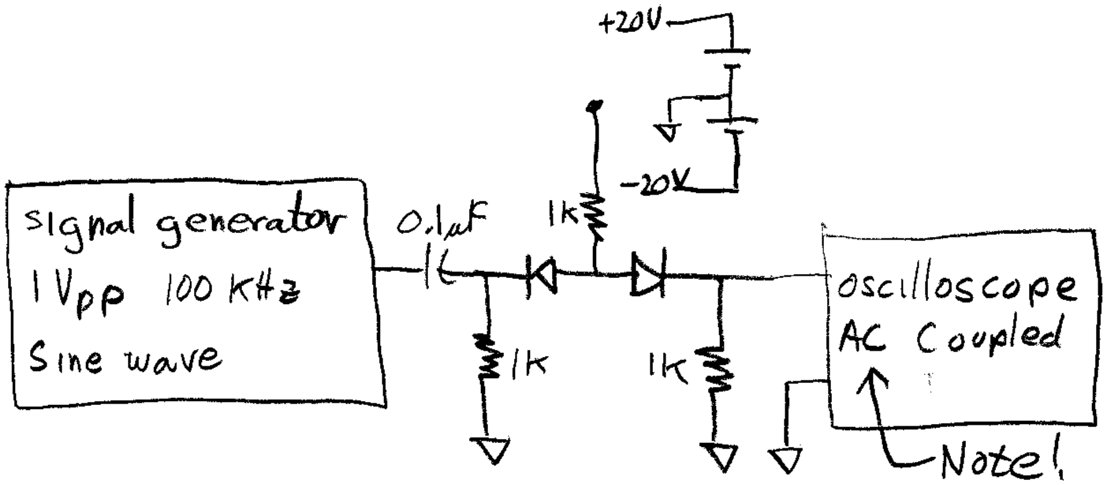

Figure 6: Electronic switch

6.0 Light-emitting diode (LED)

6.1 Build the circuit in Figure 7.

6.2 By measuring the voltage drop across the 1K resistor to measure current as in part 2, construct a table of voltage drops across the LED for the following nominal currents: 20 mA, 10 mA, 5 mA, 2 mA, and 1 mA. Note that the voltage drop is significantly more than a plain diode. Note that the light output of an LED is a linear function of the current through it.

6.3 Reduce the current to the minimum value for which light is barely visible from the LED and record this value. Note: if the room was dark and your eyes were dark adapted then a remarkably small current would produce enough light to be visible.

6.4 Adjust the current through the LED so that the light output in your opinion is "normal" for an instrument display. Record this value. Note: typical values used in instrument displays are in the 5 to 15 mA range with 10 being a common value. The light should be definitely visible but not so bright as to be harsh.

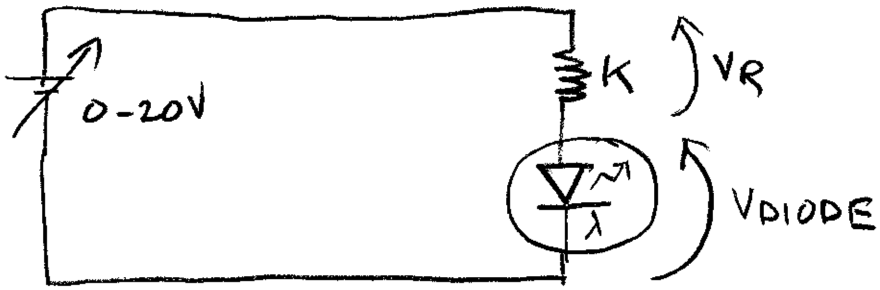

Figure 7: Light Emitting Diode circuit

7.0 Calculating diode parameters

7.1 Compute the junction constant, n, and the reverse saturation current, Is, for your diode in part 2. Use data for the nominal current values of 50 and 500 microamperes. If the lab was warm use 298K for the temperature. If the lab was chilly, use 295K for the temperature. The junction constant should be somewhere between greater than 1 and not much over 2. The reverse saturation current should be somewhere in the high picoampere to low nanoampere range. If either calculation is out of these ranges then check your calculations or check your data.