UCSD, ECE65, Winter 2013

Lab 2: Diode iv Characteristics, Zener Diode

Experiment 1: General Purpose diode *iv* Characteristics

One way to measure the *iv* characteristics of an element is to apply a know voltage to the element and measure its current. By repeating these measurements at different voltages we arrive at the *iv* characteristics. This experiment shows how we can measure/plot the *iv* characteristics of an element (a 1N4148 diode in this case) on the scope. It uses the (x vs y) capability of the scope which plots v_1 versus v_2 where v_1 and v_2 are voltages on scope channels 1 and 2, respectively.

Because scope only measures voltages, we need to "convert" the diode current into a voltage that the scope can measure by adding a resistor R in series with the diode as is seen in Fig. 1 below ($i_D = i_R = v_R/R$). Furthermore, in order to "see" the plot on the scope, the plot should be refreshed continuously (*i.e.,* we need to use a periodic input voltage).

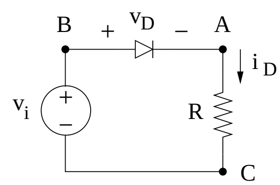


Fig. 1

PSpice Simulation: Simulate circuit of Fig. 1 with v_i being a 1-kHz triangular wave with a peak to peak value of 10 V and a DC offset of zero (*i.e.,* input signal ranges from −5 to +5 V). Run the simulation for three periods.

1) Plot v_D and v_R as functions of time.

2) Plot $i_D = v_R/R$ as a function of v_D. On your plot, identify forward-bias and reverse-bias regions.

Lab Exercise: It turns out that the circuit of Fig 1 will not work in the lab and we need a more complicated circuit. To understand why, build the circuit of Fig. 1. v_i is supplied by the function generator and is a 1-kHz triangular wave with a peak to peak value of 10 V and a DC offset of zero (similar to PSpice simulation). Scope should be in its default mode of showing channel traces as functions of time.

1) Use scope probe for channel 2 to view v_R (i.e., attach scope ground to point C and probe to point B). Compare with your PSpice simulation.

2) Try to simultaneously read v_D on channel 1 of scope. What happens to channel 2 trace. Explain your why this set up does not work while PSpice gives the correct answer.

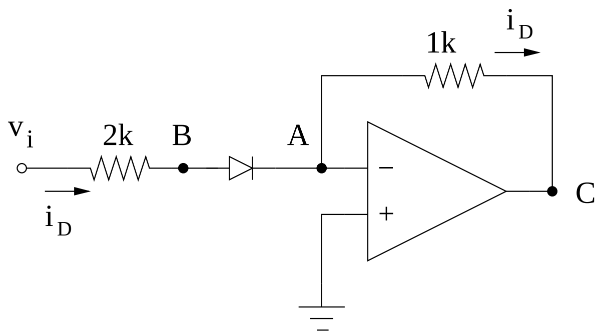


Fig. 2

3) Build the circuit of Fig. 2 above with a 741 OpAmp chip. The chip should be powered with ±15 V supplies. You will work with OpAmp in ECE100. This type of chip has two important properties which are relevant to this experiment. One, the current flowing into chip input terminals (marked by − and + signs) is very small and can be ignored. Second, if we operate this chip in the negative feedback mode (as is done in the circuit of Fig. 2), the voltages at "inverting" terminal (marked by −) and "non-inverting" terminal (marked by +) are almost equal.

Set the function generator to produce a 1 kHz triangular wave with a peak to peak value of 10 V and a DC offset of zero. Attach the scope ground to the non-inverting terminal of the OpAmp which is grounded (inverting and non-inverting terminals have the same voltage and, thus, point A is effectively grounded). Attach Channel 1 probe to point B (so Channel 1 reads v_D) and Channel 2 probe to point C (which will read $10^3 i_D$). Printout the traces and compare the results to your simulations. Explain why this circuit works.

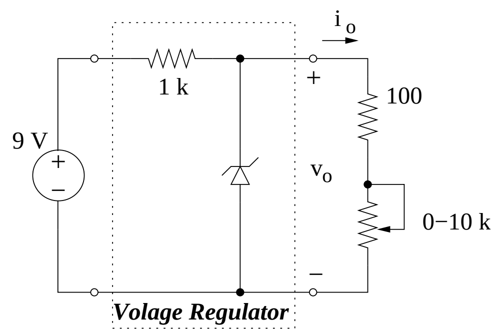
4) Set the function generator so that the signal amplitude is zero. Set the scope of show (x vs y). Set both channels to 1 V/division. Scope should show one point. Move the point such that it is at the lowest, right-most voltage division marks on the scope. Slowly increase the amplitude of the input. The scope shows the $i-v$ characteristics of the diode. Increase the amplitude of input wave until the the diode iv curves "fills" the scope display. Print out the scope output and mark and label the axes.

5) Explain why this set up works.

6) What is the funciton of 2 k resistor?

Experiment 2: Zener Diode Power Supply

Set up the circuit below with a 1N5232B Zener diode ($V_Z = 5.6$ V). In this circuit, the 9-V supply represents the "unregulated voltage." The elements in the box (1 kΩ resistor and the Zener diode) form the regulator circuit. The combination of the variable resistor (potentiometer) and 100 Ω resistor, represents the "load" in this circuit (call their combination R_L). With varying the resistance of the potentiometer, we can draw different amount of current from the regulator circuit. What is the purpose of the 100 Ω resistor?



Circuit Analysis: Using a "Constant voltage" model for the Zener region, calculate the output voltage of the regulator (v_o) as a function of its output current (i_o). Estimate the maximum load current for the circuit to act as a voltage regulator.

PSpice Simulation: Simulate the circuit with PSpice with R_L (combination of the potentiometer and 100 Ω resistor) as a parameter with a range of 100 Ω to 10 kΩ (do NOT include the 100 Ω resistor in your simulation!). Plot v_o versus i_o and compare with your analytical results.

Lab Exercise: Assemble the circuit. Start with the potentiometer set at maximum resistance (*i.e.,* about 10 kΩ). Measure the load current and the load voltage. Then, vary the potentiometer resistance and measure the load voltage for a range of load currents. Plot v_o, versus i_o. Compare with your circuit analysis and PSpice simulation and explain the results (specially the observed slight drop in v_o when i_o is increased).