UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE 105 Prof. Pister
Spring 2011

Homework Assignment #3

Due in the 105 box on the 2nd floor of Cory, 5pm Friday 2/4/2010

1. [30] "**No calculator**" questions. You should be able to answer these quickly without using a calculator.

a) A junction is doped with N_A=1e15 boron atoms per cc, and N_D = 1e14 arsenic atoms per cc. Calculate the built-in potential at room temperature.
b) In the previous junction, if the doping on one side of the junction is increased by 10x, how does the built-in potential change at room temp?
c) In the previous junction running at a particular bias voltage, if the hole current across the junction is 1mA, what is a rough estimate for the electron current?
d) if the temperature changes by +/- 30C around room temperature, what is the percentage change in the built-in potential for any semiconductor diode?
e) You have a diode with IS = 1e-16. What is the current with an applied voltage of 300mV? What is the voltage with an applied current of 1uA?
f) If you have ten identical diodes, and each one passes 1mA when biased at 0.7V,
   i) what current will be conducted at 0.7V with all diodes in parallel?
   ii) what current will be conducted at 0.7V with all diodes in series?
   iii) what voltage will be necessary to achieve 1mA with all diodes in parallel?
   iv) what voltage will be necessary to achieve 1mA with all diodes in series?

2. [20] You bias a diode at 600mV with a current of 26uA at room temperature, and then apply a 10mV sinusoidal signal.
   a. Write an exact expression for the output current. Calculate the maximum and minimum currents through the diode with this bias. (You may use some silicon devices to do this calculation)
   b. Estimate the small signal resistance, r_d, of the diode at this bias point (Id=26uA). You should be able to do this without a calculator.
   c. Calculate the small signal current through the diode
   d. Compare the large-signal calculation from part a to the linearized estimate of total current (bias current plus small-signal current from part c). What is the % error?
   e. Would your error be this small if you had used a 100mV sinusoidal signal? What about a 1V sinusoidal signal?
3. [50] The voltage doubler circuit in Figures 3.57 and 3.58 can also be used as a low cost power supply for small loads. Assuming a 110VAC 60Hz input, C1=100nF, a 3V Zener diode on the output, and steady-state operation:
   a. Sketch a cycle or two of the waveforms at the input, X, and the output. Clearly label your axes!
   b. Estimate the charge on the right plate of C1 when Vin is at its minimum, 3V, and at its maximum.
   c. Describe where that charge comes from, and where it goes.
   d. Calculate the current through the Zener diode.
   e. Use spice to verify parts a and d, and turn in your plots.