Problem Set # 11 Due 4:30 PM May 8th, 240 Cory

**11.1 Diode Equation.** On a sheet of graph paper plot the following two current versus voltage functions. Consider V going from 0 to 3V and I going from 0 to 2 mA.

a) \[ I_{\text{Diode}}(V) = 10^{-14} \text{A} \left( e^{V/0.025} - 1 \right) \]

b) The Current versus Voltage for a 1.5V battery and a 390 \( \Omega \) resistor connected across the diode such that current will flow. (This is the load line from \( I_{\text{SC}} \) to \( V_{\text{OC}} \)).

c) Find by reading your graph \( I_{\text{Diode}} = I_{\text{Thevenin_Equivalent_Circuit}} \).

d) Replace the diode equation with the large-signal diode model (0.7V) and find the current. How accurate is it?

e) Determine the current with the perfect rectifier model. How accurate is it?

**11.2 Diode Clipping.** Consider the diode clipping circuit P11.2 with \( R_1 = 1 \text{k}\Omega \). **Use the Large Signal Model.**

a) Sketch an arbitrary waveform of your choice versus time that takes on all values from –10V to +10V.

b) Sketch the output of circuit P11.2.

c) Show how a sinusoid \( V(t) = 10 \text{Vsin}((1000) \pi t) \) is converted into a digital signal.

**11.3 Sheet of conducting material.** A 100nm (0.1 \( \mu \text{m} \)) thick layer of silicon contains \( 10^{13} \text{ cm}^{-2} \) n-type dopant ions that are ionized and thus produce electrons that act as carriers. Assume that the mobility is 400 \( \text{cm}^2/\text{Vsec} \).

a) Find the density of electrons if the dopant is uniformly distributed.

b) Determine the conductivity of the material.

c) Determine the sheet resistance of the layer. (resistance = (L/W)(resistivity/thickness), and sheet resistance is the resistivity/thickness.

d) Determine the resistance of a layout that is 3 \( \mu \text{m} \) (L) long by 0.2 \( \mu \text{m} \) wide (W).

**11.4 MOS Parameters.** An NMOS device has a 10 nm thick oxide gate. Positive gate voltage in excess of \( V_T = 1 \text{V} \) produces mobile electrons under the gate. Assume \( W = 1 \mu \text{m} \) and \( L = 0.25 \mu \text{m} \).

a) Find the capacitance per unit area \( C' = \varepsilon_R \varepsilon_0 /t \). Where \( \varepsilon_R = 3.9 \), \( \varepsilon_0 = 8.85 \times 10^{-14} \text{ F/cm} \) and \( t \) is the oxide thickness. (be sure to convert everything to the same dimensional units: example cm.

b) Find the capacitance of the gate. (Likely few fF).

c) Determine the charge on the gate when \( V_{GS} = 3 \text{V} \).

d) Determine the the number of mobile electrons under the gate when \( V_{GS} = 3 \text{V} \).

e) Using the approach in Problem 11.3 and a mobility of 1000 \( \text{cm}^2/\text{Vsec} \), find the sheet resistance and resistance.

f) Using \( V_{D,SAT} = 1 \text{V} \), find \( k_D \).