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EECS 42 – Introduction to Electronics for Computer Science

Spring 2003, Prof. A. R. Neureuther
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Problem Set # 11 Due 4:30 PM May 8th, 240 Cory

Reading: Week 14# Diodes and MOS Devices, S&O 13.1-13.2, 518-526.

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) $I_{DIODE}(V) = 10^{-14}A(e^{(V/0.025)} - 1)$
b) The Current versus Voltage for a 1.5V battery and a 390 Ω resistor connected across the diode such that current will flow. (This is the load line from $|I_{SC}|$ to V_{OC}).
c) Find by reading your graph $I_{Diode} = I_{Thevenin\_Equivalent\_Circuit}$.
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 = 1kΩ. **Use the Large Signal Model.**

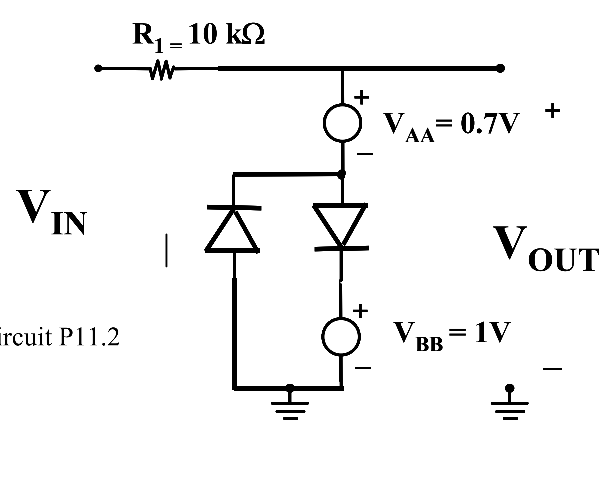
a) Sketch an arbitrary waveform of your choice versus time that takes on all values from –10V to +10V.
b) Sketch the output of circuit P11.2.
c) Show how a sinusoid V(t) = 10Vsin((1000)2πt) is converted into a digital signal.

11.3 Sheet of conducting material. A 100nm (0.1 μm) thick layer of silicon contains 10^{13} **cm^{-2}** n-type dopant ions that are ionized and thus produce electrons that act as carriers. Assume that the mobility is 400 cm^2/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 resitivity/thickness.
d) Determine the resistance of a layout that is 3 μm (L) long by 0.2 μm wide (W).

11.4 MOS Parameters. An NMOS device has a 10 nm thick oxide gate. Positive gate voltage in excess of V_T = 1V produces mobile electrons under the gate. Assume W = 1μm and L = 0.25 μm.

a) Find the capacitance per unit area $C' = \varepsilon_R\varepsilon_0/t$. Where $\varepsilon_R = 3.9$, $\varepsilon_0 = 8.85 \times 10^{-14}$ 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} = 3V.
d) Determine the the number of mobile electrons under the gate when V_{GS} = 3V.
e) Using the approach in Problem 11.3 and a mobility of 1000 cm^2/Vsec, find the sheet resistance and resistance.
f) Using V_{D_SAT} = 1V, find k_D.



Circuit P11.2