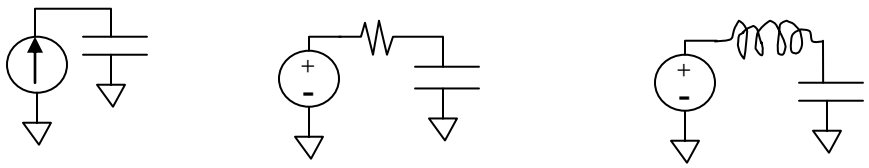
UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE 105 Prof. Pister
Spring 2011

Homework Assignment #4

Due in the 105 box on the 2nd floor of Cory, 5pm Friday 2/11/2010

Problem 1: On a single graph on a piece of graph paper, draw a linear voltage axis from 0 to 2V, and a linear time axis from 0 to 3ns and plot the time response of the following circuits:



a) a 1mA step function current source feeding a 1pF capacitor.
b) a 1kΩ resistor hooked to a 1V step function supply on one side, and a 1pF capacitor on the other.
c) a 1uH inductor (I'm not so good at drawing inductors) from a 1V step function supply feeding a 1pF capacitor.

Problem 2: Consider an NPN transistor with I_S=10 fA and a β of 100.
a) If the device is biased in the forward active region at room temperature, ignore the Early effect and calculate the base-emitter voltage required to get a collector current of 1uA. Don't use a calculator! What is the base current that corresponds to this bias point?

b) If V_A for this transistor is 50V, approximately what is the worst-case error in your calculations if this transistor is operating in a circuit powered by two AA alkaline batteries? (hint: alkaline batteries start life at 1.6V, and have useful storage down to around 0.9V)

c) Same as part (a), but 100uA collector current. Using the formulas derived in class, estimate the small signal input resistance, r_π, output resistance, r_o, and transconductance g_m at this bias point. No calculators! Draw the low frequency small signal model, labeling all currents, voltages, and components.

d) Assuming V_A=50V, use your calculator to calculate the base and collector currents at the following three bias points: (V_{BE}= 600mV, V_{CE}= 1V) , (V_{BE}= 601mV, V_{CE}= 1V), (V_{BE}= 600mV, V_{CE}= 2V)
and use only those currents and voltages to make your best estimate of the small signal input resistance, output resistance, and transconductance.

e) how do your answers in c) and d) compare? Why?

Problem 3: Draw the low-frequency small-signal model for a bipolar common-emitter amplifier with a resistive load. If V_{CC} = 11V and R_C=1MΩ what is the current necessary to achieve an output bias point of 10V? 1V? What are the small-signal values for g_m and r_o if the output bias point is 10V? 1V? What is the voltage gain, assuming that $V_A >> V_{CC}$, at an output bias point of 10V? 1V?