EE 140/240A Prof. Pister
Spring 2017

Homework Assignment #1

Due by online submission very very late Monday night 1/23/2017 (Tuesday at 9am)

1. A voltage source with a 1kΩ output impedance drives an amplifier with a 1nF input capacitance. At t=0, the voltage source jumps from 0 to 1V (a step input). Carefully sketch by hand the voltage seen at the input to the amplifier on three different time scales:
   a. 0 to 1 ms
   b. 0 to 1 μs
   c. 0 to 1 ns
2. By hand, sketch the response of the RC filter above to an input sine wave with a 1V amplitude and a frequency of 1kHz, 100kHz, 1MHz, 1GHz (Draw four separate plots. Draw the input for reference, and then the output, possibly with a different vertical axis. Label both axes in each plot)
3. You're standing on a big smooth hillside. Directly North the hill climbs up quite steeply, rising 50 cm for every step you take. Directly East the hill climbs gently, rising only 2 cm for every step you take. If you want to be 10 steps further north than you currently are, how far east do you have to walk in order to stay at the same altitude?
4. You have made a new three terminal device. Terminal A is grounded. Terminal B is the input. Terminal C is the output. The output current I_c is given by $I_c=f(V_{ba}, V_{ca})$. You measure an output current I_C at a certain bias point (V_{BA}, V_{CA}).
   a. Assuming that f is a smooth function (its derivatives exist), write an exact expression for how the current will vary for small changes to the input and output voltages around that bias point. Write those changes as i_b, v_b and v_c.
   b. Simplify your answer to the best linear approximation to f at the bias point (a plane through (V_{BA}, V_{CA}, I_C)).
   c. If you don't allow the output current to vary (you keep it fixed at I_C so $i_c=0$), write an equation for the output voltage as a function of the input voltage.
   d. Write your answer to the problem 1 using this same formalism.
   e. What is the gain of a common emitter amplifier with a current source load, using this same formalism?
5. Graph the magnitude of the impedance of the following elements and circuits by hand. Use a log/log scale, with the frequency axis varying from 1 to 10^{11} rad/sec, and impedance axis varying from 1 Ω to 10 GΩ.
   a. Resistors of magnitude 1kΩ, 1MΩ, 1GΩ and capacitors of 1 uF, 1nF, and 1pF; and inductors of magnitude 1mH, 1uH, 1nH (all 9 of these components should be on the same plot)
   b. The series combination of 10kΩ and 10pF
   c. The parallel combination of 10kΩ and 10pF
   d. The series combination of 10Ω and 10nH (real inductors always have series resistance)
   e. The parallel combination of the previous real inductor and 1pF (roughly what an LC tank in your cell phone looks like)
6. [ee240A] Using the datasheet from the vacuum tube (6 pages, 2.5 MB) Estimate g_m, r_o, and the maximum possible gain for the tube used with a constant current source bias of 100mA on the plate and -75 V bias on the grid. In a tube, the plate is sort of like the drain or collector of a transistor, and the grid is sort of like the gate or base. You will have to estimate some derivatives from the graph for this problem. (note: this was an IC prelim problem)