UNIVERSITY OF CALIFORNIA
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EEECS100/42, Fall 2009 **T. K. Gustafson**

NAME(PLEASE PRINT CLEARLY):
S.I.D. :
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Due : Oct 7 at lecture

Problem Set No. 3

Based upon Chapter 14 of Hambley, further use of LTSpice and $r_c = 1/(pC)$, $r_l = pL$, the resistance operators for the capacitor and inductor .

Problem Number one) The logarithmic amplifier
a) Many times we wish not that the output signal of a system be proportional to the input, but that it be the logarithm of the input. A real (versus ideal as in the last problem set) diode can do this because it depends exponentially on the voltage for a forward bias (applied voltage) not the straight line characteristic along $v = 0$ which we used. Do Hambley problem 14.12 which addresses this.
b) Show that part a) is correct by simulating with LTSpice. Use $I_s = 9.5\ 10^{-15}$ A, $n = 1$, $V_T = kT/q$, where k is Boltzmann's constant $k = 1.38\ 10^{-23}$ J/K and $q = 1.6\ 10^{-19}$ Coulomb is the charge on the electron. Take $T = 300$ K. Plot from $v_{in} = .06$ V to .8 V. Use the LT1124 Op Amp.
c)What is the value of the offset voltage for the Op-Amp?

Problem Number two) Learning to use LTSpice- Sinusoidal analysis
In the last problem set we considered the R-C circuit. In particular we looked at the transient response of the capacitor voltage when the circuit was excited with a rectangular pulse. Now we look at the voltage v_c when excited with a signal $v_s(t) = sin(\omega t)$, and $\omega = 2\pi f$, f being the frequency. We wish to vary the frequency from a small value to some value much greater than $1/RC$. If we assume $v_c(t) = V_c sin(\omega t + \phi)$ we wish to plot V_c and ϕ as a function of the frequency f.
a) Using LTSPice for the R-C circuit of Problem Set 2, plot V_c and ϕ as a function of frequency ($\omega/2\pi$) over the range .1 Hz to 1 MHz. Use a resistor value of 1 kΩ and a capacitor value of 1μ F. Ask for an octave sweep from 1 to 10^6 Hz. Specify 100 points per octave. The plot of $|V_c|$ should be in dB, that is 20 $lg|V_c|$ versus lg f
b) By what factor (in dB) is $|V_c|$ reduced from its low frequency value at $f = 1/(2\pi RC)$? What is ϕ at this frequency?
c) Show that $|V_c| = \frac{1}{\sqrt{1+(\omega RC)^2}}$. What is the slope of 20 lg $|V_c|$ versus lg ω for $\omega >> 1/RC$ (give it in dB / decade) ?
d) Show that $\phi = tan^{-1}(\omega CR)$.

Problem No 3) Ideal Operational Amplifier
Problem 14.32 of the text

Problem No 4) Ideal Operational Amplifier
Problem 14.34 of the text

Problem No 5) Review Problem on the differential Operator
$p = \frac{d}{dx}$ voltage divider
A resistor (R), an inductor (L), and a capacitor (C) are connected in series and a voltage source $v_s(t)$ excites the series connection. The capacitor is initially uncharged and the inductor current is initially zero.
a) Using the voltage divider, express the voltage across the capacitor $v_c(t)$ as a function of p.
b) What is the value of $v_c(t)$ when $v_s(t) = V_{cc}$, a constant?
c) What is the value of $v_c(t)$ when $p- > \infty$. What sort of initial excitation $v_s(t)$ would give this response?

Problem No 6) Review Problem on KCL and KVL
Problem 1.67 of Hambley

Problem No 7) Review Problem on Thevenin and Norton
Problem 2.80 of Hambley