Indian Institute of Technology, Delhi
EEL 101: Fundamentals of Electrical Engineering
Practice Problems, 25th April, 2008

1. Consider a solenoid with 500 turns of copper winding, and a core of silicon sheet steel. The radius of the core is 1 cm, and the solenoid is 10 cm long.

   (a) Find the mmf generated across the solenoid for a current of 1 A.

   (b) Silicon sheet steel has a magnetization characteristic given approximately by:
   $$B = B_0 \cdot (1 - e^{-H/H_0})$$
   where $B_0 = 1.35$ Tesla, and $H_0 = 169$ Amp-turns/meter. Find the magnetic flux density through the solenoid as a function of the current.

   (c) Apply Faraday's Law and find the back emf generated across the solenoid as a result of a changing current through the solenoid.

   (d) Find the inductance of the solenoid as a function of the current.

   (e) Consider a series R-L circuit as shown in Fig. (a). Write out a differential equation relating $v_R(t)$ and $v(t)$. Re-write the equation if the inductor is the solenoid, whose inductance is as derived in part (d). How will you solve this equation?

   (f) Suppose $v(t)$ is a sinusoid, given by $v(t) = v_0 \cos(\omega t)$. As ω increases, the impedance offered by the inductor increases. As a result, the amplitude of $i(t)$ decreases. Make approximations to the above equation, when the amplitude of $i(t)$ is small. you observed in the laboratory?

2. A certain three-terminal device has been invented. The three terminals of this device are named A, B, and C. The device behaves in the following fashion:
   $$I_A = \alpha \cdot V_{AC}^2 \cdot (1 + \beta/I_B)$$
   $$V_{BC} = \gamma \cdot e^{V_{AC}/\delta} \cdot I_B$$

   (a) What are the units of α, β, γ, δ, respectively?

   (b) What kind of controlled-sources are in this device? (VCVS/CCCS etc.)

   (c) Draw the small signal model for this device, and find the expressions for the small signal parameters that you need.

3. Consider the two wattmeter method of power measurement for a three phase balanced load. The star-connected load has an inductor, L, in parallel with a resistor, R. The voltages $|V_{RN} = |V_{YN}| = |V_{BN}| = V_0$.

    (a) Find $\overline{I_R}$. Find $\overline{I_Y}$, $\overline{I_B}$ assuming that the Y phase lags the R phase by 120^0.

    (b) Assume that the Y phase lags the R phase by 120^0. Find $\overline{V_{RY}}$ and $\overline{V_{BY}}$.

    (c) Find an expression for the readings of each of the two wattmeters.

    (d) If V_0=220 Volts, $R = 100\Omega$, and the frequency of the power supply is 50 Hz, plot the wattmeter readings as a function of the inductance, L.

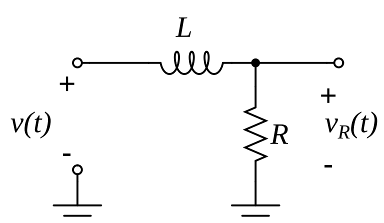
    (e) Repeat the last four steps, assuming that the Y phase leads the R phase by 120^0.

4. (a) In Fig. (b), first find the impedance offered by the network shown in the dashed region, as a function of ω.

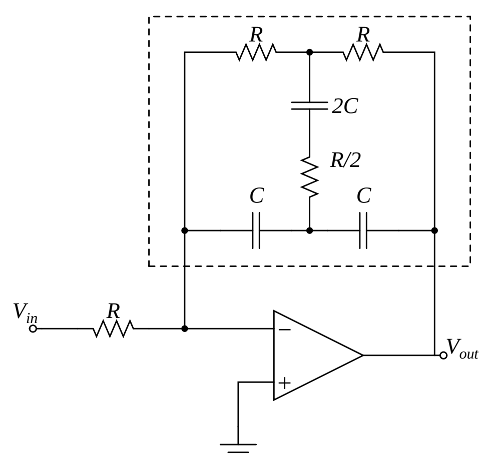
    (b) Find the gain, $V_{out}(j\omega)/V_{in}(j\omega)$ for the opamp circuit.

    (c) Plot the magnitude of the gain as a function of ω. For the plot, assume $R = 1k\Omega$, $C = 1\mu$Farad.

    (d) What kind of filtering does this circuit offer? Explain intuitively why the plot you have drawn is correct.



(a)



(b)