Electronics classwork 4, 27th January 2005

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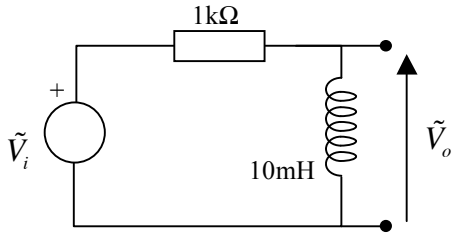
1. For the circuit below find the relationship between input and output voltages $\tilde{V}_o/\tilde{V}_i$ (the transfer function) that is valid for all frequencies, ω. [Hint: use symbols rather than component values for as much of your working as possible]



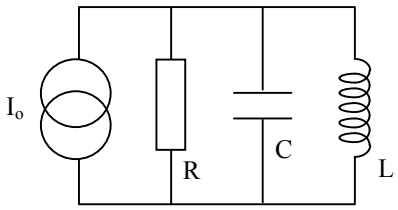
   (a) Find the asymptotic forms of this equation that are valid as ω→0 and ω→∞. Sketch these asymptotic lines on an amplitude Bode plot ($20\log_{10}[|\tilde{V}_o/\tilde{V}_i|]$ versus $\log_{10}[\omega]$) giving their slopes where appropriate.

   (b) Identify the 3dB point on the Bode plot from where your two asymptotes cross and calculate the angular frequency, ω_{3dB}, and frequency, f_{3dB}, at which this occurs. What is the phase difference between the input and output voltages at this point?

   (c) Complete your Bode plot by sketching the full form of the transfer function that must hit the asymptotes at their limits and pass through the 3dB point.

   (d) The circuit is to be used as a filter to reject unwanted signals, identify the function the circuit performs in this respect.

2. The circuit below is used to provide a large oscillating magnetic field in the inductor that is used to power a second piece of equipment across an air gap by magnetic induction. The circuit is driven by a current source I_o that can deliver up to 100mA at the desired frequency of 125kHz and has a parallel impedance of R=100Ω.



   (a) Obtain an expression for combined parallel complex impedance of the three circuit elements.

   (b) Hence obtain an expression for the complex voltage $\tilde{V}$ that appears across the three circuit elements.

   (c) Show that the current through the resistor can be written in the form:

$$\tilde{I}_R = \frac{\tilde{V}}{R} = \tilde{I}_o \frac{A\omega}{1 + j\frac{\omega}{\omega_o Q} - \frac{\omega^2}{\omega_o^2}}$$

and obtain expressions for A, Q and ω_o in terms of the circuit elements.

(d) If the circuit is designed to resonate at a frequency of 125kHz and the inductor is measured to have a value of L=3.5μH. What value of capacitance C is required to meet this specification. What is the resulting value of Q.

(e) At resonance calculate the voltage $\tilde{V}$ and hence the current in each of the three components.

(f) If the circuit were built without the capacitor, what would the current source have to provide in order to generate the same magnetic field in the inductor.

3. For the circuit in question 2 sketch the amplitude Bode plot for $\left|\tilde{I}_R/\tilde{I}_o\right|$. [Hint start by sketching the high and low frequency asymptotes. Then add the value of $\left|\tilde{I}_R/\tilde{I}_o\right|$ at resonance before sketching in your line that should approach the asymptotes at high and low frequencies and pass through the value at resonance]