BENG 186B Winter 2014

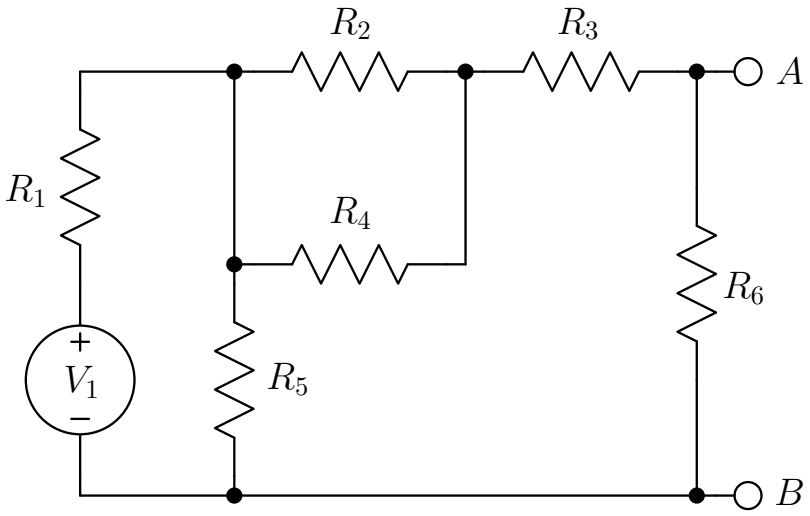
Quiz 1

Wednesday, January 22, 2014

Last Name, First Name: _____

- This quiz is closed book and closed notes. You may use a calculator for algebra and arithmetic.
- This quiz has 12 pages, including this cover sheet. Do not attach separate sheets. If you need more space, use the back of the pages.
- Circle or box your final answers and show your work on the pages provided.
- There are 4 problems. Points for each problem are given in **[brackets]**. There are 100 points total.
- You have 50 minutes to complete this quiz.

1. **[25 pts]** Consider the circuit below.



$V_1 = 10\,\text{V}$
$R_1 = 20\,\text{k}\Omega$
$R_2 = 40\,\text{k}\Omega$
$R_3 = -30\,\text{k}\Omega$
$R_4 = 120\,\text{k}\Omega$
$R_5 = 100\,\text{k}\Omega$
$R_6 = 25\,\text{k}\Omega$

(a) You measure the voltage between the terminals A and B with a voltmeter. What voltage does the voltmeter read? Assume the voltmeter has infinite input impedance. (*Hint:* Simplify your circuit as much as possible before delving into any equations.)

(b) What is the output impedance between terminals A and B?

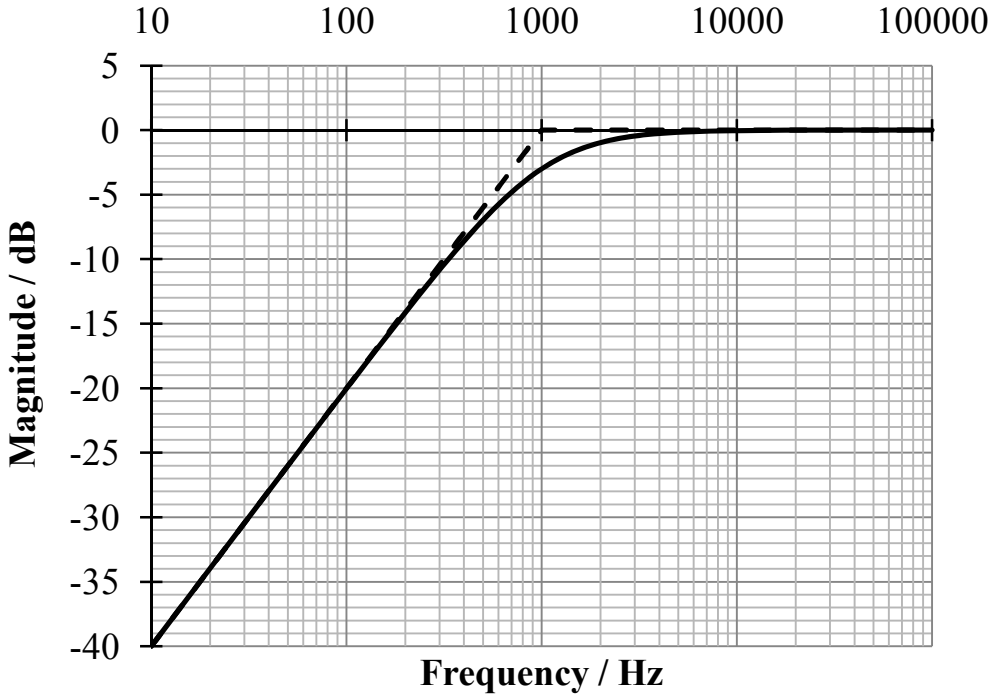
(c) You have three different loads you wish to test by attaching to terminals A and B, listed below. You test each load individually, and you wait for a long time after attaching the load before you perform measurements. For each load, predict the measured voltage across the load, the measured current through the load, and the measured power consumed by the load.

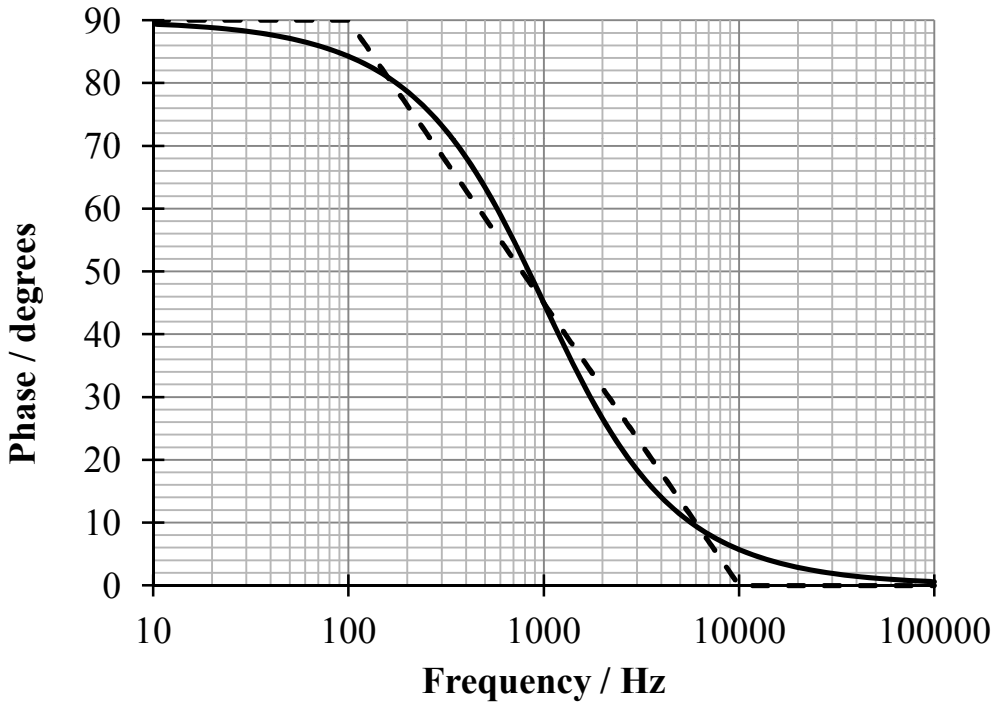
i. $10\,\mathrm{k}\Omega$ resistor

ii. $4.7\,\mu\mathrm{F}$ capacitor

iii. $220\,\mu\mathrm{H}$ inductor

2. **[30 pts]** The Bode plot of a particular first–order filter is shown below. The dashed lines are straight–line approximations of the actual plot (the solid curves).





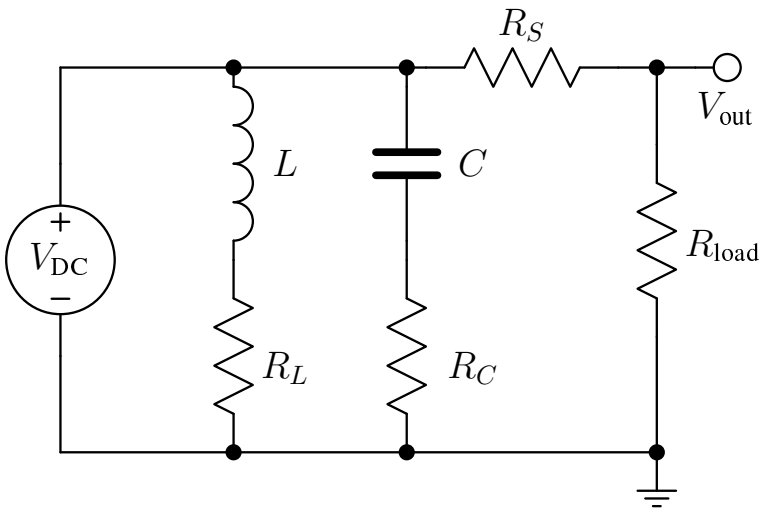
(a) What kind of filter is this? (*e.g.* low–pass, notch, etc.)

(b) Write down the cut-off frequency/frequencies of the filter.

(c) Write the transfer function $H(j\omega)$ of the filter, where j is the imaginary unit and ω is the radial frequency.

(d) You have a $0.01\,\mu$F capacitor and an extensive collection of resistors (*i.e.* any resistance value needed is available to you). Using only these components, draw a circuit that would produce the above transfer function. Label the input as V_{in} and the output as V_{out}. Label all components and their component values.

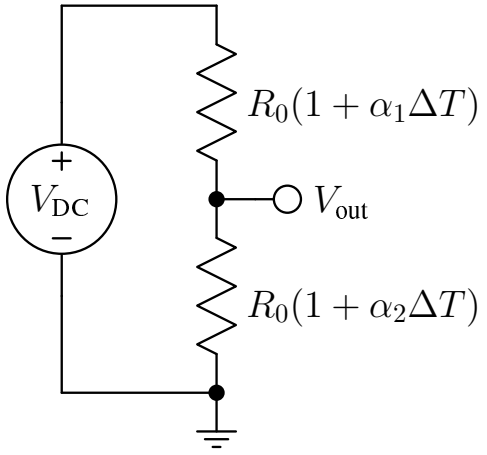
3. **[20 pts]** Consider the circuit below, driven by a constant (DC) voltage source V_{DC}, and loaded by a resistor R_{load}:



(a) Find V_{out} at steady–state.

(b) Find the power efficiency of the circuit at steady–state, defined as the ratio of power delivered to the load R_{load} over power supplied by the source V_{DC}.

4. **[25 pts]** Consider the temperature sensor below, which is made with two thermistors. The sensor outputs a voltage dependent on temperature. At room temperature, both thermistors have identical resistances $R_0 = 5000\,\Omega$. For this problem, assume no self–heating occurs.



$$V_{DC} = 5\,\text{V}$$
$$R_0 = 5000\,\Omega$$
$$\alpha_1 = -0.04\,^\circ\text{C}^{-1}$$
$$\alpha_2 = 0.04\,^\circ\text{C}^{-1}$$

(a) Find V_{out} as the temperature goes down $20\,^\circ$C from room temperature.

(b) Find the sensitivity of the temperature sensor.

(c) The temperature coefficients α_1 and α_2 are intrinsic to the thermistor material and usually cannot be changed to make the sensor more sensitive. Besides buying thermistors that are more sensitive, how else could you increase the sensitivity of the temperature sensor?