BENG 186B Winter 2011

Quiz 1

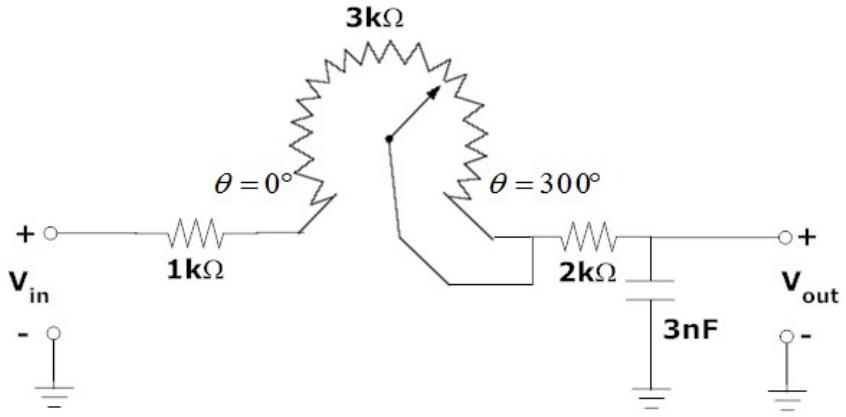
January 21, 2011

NAME (Last, First): _____

- This quiz is closed book, closed note, you may use a calculator for algebra.
- Circle your final answers in the space provided; show your work only on the pages provided.
- Do not attach separate sheets. If you need more space, use the back of the pages.
- Points for each problem are given in [brackets], 100 points total. The quiz is 50 minutes long.

1	/25
2	/25
3	/25
4	/25
Total	/100

1. [**25 pts**] A variable low-pass filter is implemented with a turn potentiometer as shown. The total resistance of the potentiometer is 3kΩ and is linearly distributed over the range of angle θ from 0° to 300°.

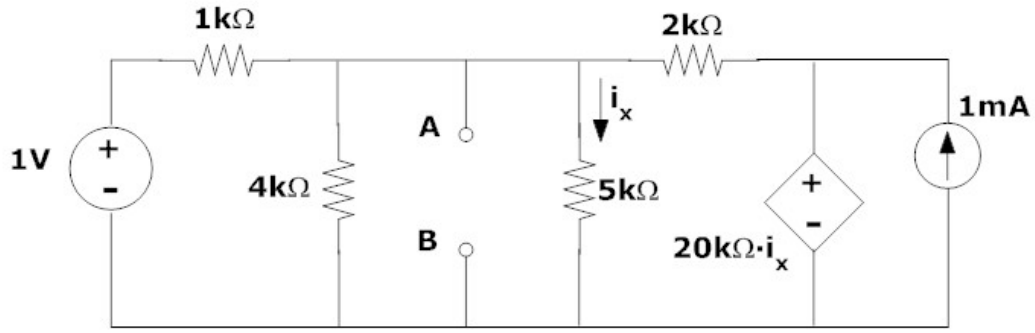


   a. Derive the transfer function of $V_{out}(j\omega)/V_{in}(j\omega)$ in terms of θ in degrees (0° ≤ θ ≤ 300°). [10 pts]

(1. continued)

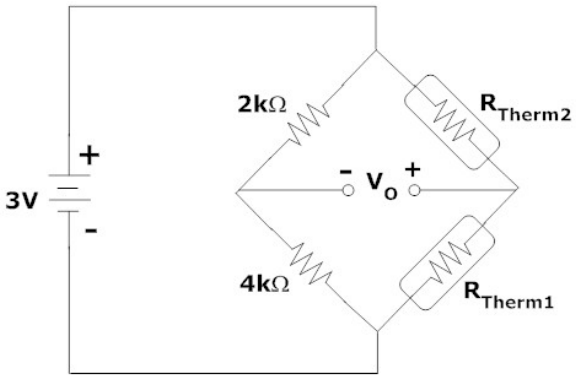
b. Derive the cut-off frequency f_C of the low-pass filter as a function of θ, and sketch this function $f_C(\theta)$ for $0° \leq \theta \leq 300°$. Label the axes and indicate numerical values for $\theta = 0°$ and $300°$. [15 pts]

2. [**25 pts**] Find the Thevenin equivalent between points A and B.



(2. continued)

3. [**25 pts**] A Wheatstone bridge with two thermistors implements a temperature sensor as shown. T is temperature in degrees Celsius (°C), and $R_{Threrm1}$ and R_{Therm2} are the thermistor resistances in Ohms as a function of T as given below.



$$R_{Therm2} = R_2 \cdot \left(1 + \alpha_2 T\right)$$
$$R_2 = 1k\Omega$$
$$\alpha_2 = -0.02/°C$$

$$R_{Therm1} = R_1 \cdot \left(1 + \alpha_1 T\right)$$
$$R_1 = 2k\Omega$$
$$\alpha_1 = 0.01/°C$$

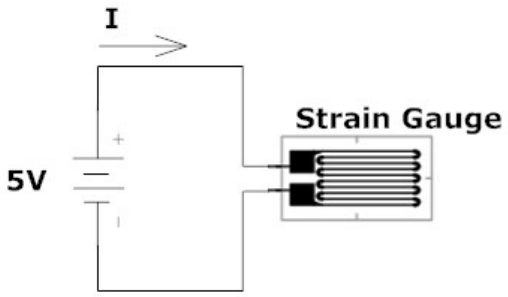
a. Derive the output voltage V_O as a function of T. [10 pts]

(3. continued)

b. Write the sensitivity of dV_o/dT. Does it depend on T? [10 pts]

c. Give values for the output voltage V_O at -10°C and at +25°C. [5 pts]

4. [**25 pts**] A strain gauge is used as a uniaxial stress transducer as shown. The strain gauge is subjected to tensile stress, and the current through the strain gauge is measured at constant voltage. Assume that the strain gauge has nominal resistance $R_G = 10k\Omega$, gauge factor G = 50, and Young's modulus E = 10kPa.



   a. Find the sensitivity $\Delta I/\sigma$, where ΔI is the change in output current in units A, and σ is the stress in units Pa. [15 pts]

(4. continued)

b. Find the output current I for $\sigma = 0$ and 10 Pa. [10 pts]