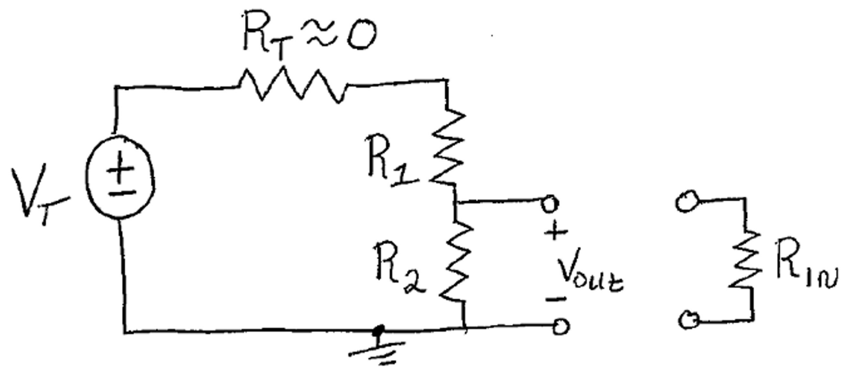
Homework 4

Friday, March 5, 2021 1:51 PM

"I pledge my honor I have abided by the Stevens Honor system."

- Alex Haskins

1. A sensor has a Thevenin equivalent circuit with V_T and R_T. This sensor is connected to a two-resistor attenuator as shown below.



The output of this two-resistor attenuator (V_{out}) is to be connected to the input of a measuring instrument which has an input resistance given by R_{in}. This problem examines the design of the attenuator and the loading error in V_{out} due to the input resistance R_{in}. To simplify the analysis, we can assume that R_T is small and can be neglected in this problem. Thus, for this problem, we can assume R_T is zero. The value of V_T is equal to 3 Volts.

a. **Attenuator Design**; Determine the values of R_1 and R_2 which will satisfy the following two requirements.
   i) The current flowing through both R_1 and R_2 before connecting to R_{in} should be 0.01 ma. (Hint; use Ohm's Law).
   ii) V_{out} before connecting to R_{in} should equal $(0.4)\cdot V_T$.

$V_T = 3\text{ V.} \quad R_T \approx 0\ \Omega$

$.4(3) = (.01\times10^{-3})R_2$

$R_2 = 120{,}000\ \Omega$

$V_T = I(R_1 + R_2)$

$3 = (.01\times10^{-3})(R_1 + 120{,}000)$

$R_1 = 180{,}000\ \Omega$

b. **Determining the input resistance R_{in};** Using the correct values for R_1 and R_2 from part (a) of this problem, determine the minimum value of R_{in} for a loading error of $(0.02)\cdot V_T$. (Hint; to simplify the analysis, I suggest you solve for "R_{eq}" first. Once you have solved for R_{eq}, you can solve for R_{in}).

$.4V_T - .02V_T$

$1.4 - .06 = 1.34$

$R_{eq} = \dfrac{R_2 R_{in}}{R_2 + R_{in}}$

Loading Error $= V_{Before} - V_{After}$

$1.34 = V_{Before} - \dfrac{R_{eq}}{R_{eq}+R_1}(V_T)$

$1.34 = 1.4 - \dfrac{R_{eq}}{R_{eq}+180{,}000}(3)$

$-.06 = - \dfrac{R_{eq}}{}$

$R_{eq} + R_1$

$$\frac{-.06}{3} = -\frac{R_{eq}}{R_{eq}+180,000}$$

$$-.02\,R_{eq} - 3,600 = -R_{eq}$$

$$R_{eq} = 3,673.47\,\Omega$$

$$3,673.47 = \frac{(120,000)R_{in}}{120,000 + R_{in}}$$

$$440,816,327 + 3,673.47\,R_{in} = 120,000\,R_{in}$$

$$116,326.53\,R_{in} = 440,816,327$$

$$R_{in} = 3,789.47\,\Omega$$

2. Please refer to the two graphs on slide 61 in our Lecture Notes for Chapter Three. (The title of the slide is *Example 6.1*). The two graphs given on this slide are the graphs of the magnitude and phase of the transfer function for a filter.
   a. Is this filter an active or a passive filter? Why?

      This is an active Filter because it also amplifies input voltages.

   b. Is this filter a high-pass, bandpass, or low-pass filter? Why?

      This is a low-pass Filter, for the values to the left of f_c are not 0 but they are 0 to the right.

   c. What is the cut-off (or corner) frequency of this filter?

      $f_c \approx 2500$ Hz, Above this value $H(f) = 0$.

   d. You are given the following input voltage. Determine the output voltage of the filter.

$$V_{in}(t) = (7.87)\cdot\cos(4000\pi t - 15.8°)$$

$7.87 \angle 15.8°$

$f = 2000$ Hz : $H(f) = 2$ and $\angle H(f) = 60°$

$f = 2000\ Hz$; $H(f) = 2$ and $\angle H(f) = 60^\circ$

$$V_{out} = V_{in}\,(H_f) = 7.87\angle 15.8^\circ \cdot 2\angle 60^\circ = 15.74\angle 75.8^\circ$$

$$V_{out} = 15.74\cos\left(4000\pi t - 75.8^\circ\right)$$