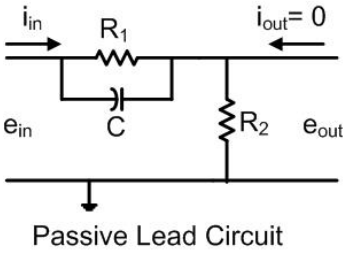
MEEN 2210 Electromechanical Engineering Systems Spring 2011

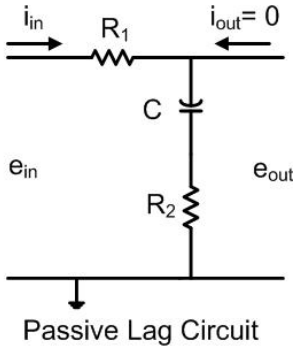
Problem Sets #3 and #4 Due Class Period # 9 February 16, 2011

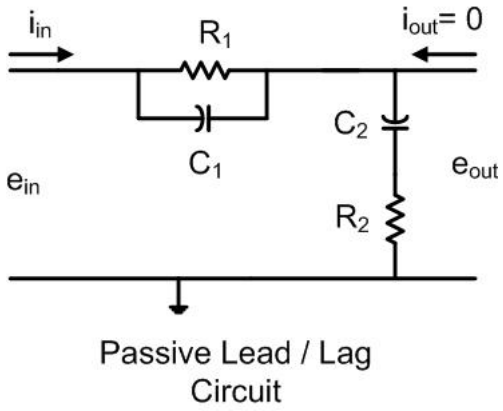
1. The following experimental data represents the unit step response of an electrical system. Can the system be modeled as a 1st-Order Dynamic System? If so, what is the time constant τ and the steady-state gain K of the system?

t (s)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
e_{out} (V)	0.0	1.4	2.3	3.0	3.6	4.1	4.2	4.6	4.7	4.8	4.9

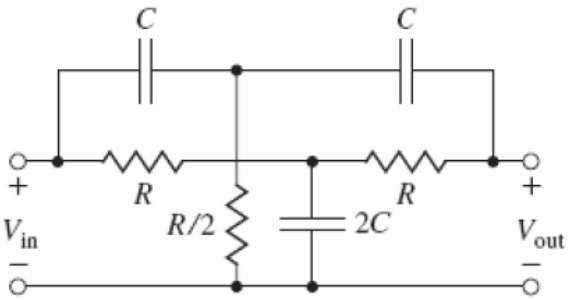
2. Derive the mathematical models (i.e., equations of motion and transfer functions) for the passive lead circuit, the passive lag circuit, and the passive lead/lag circuit shown in the figures, first from the application of first principles (e.g., KVL, KCL) and then using the impedance concept. The input is the voltage e_{in} and the output is the voltage e_{out}. Assume no loading is taking place, i.e., $i_{out} = 0$.





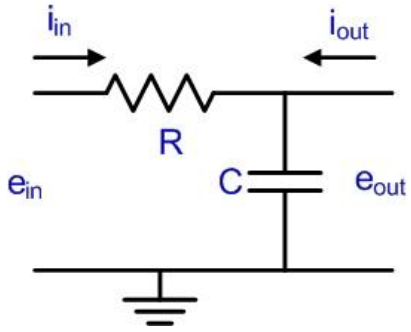


3. Derive the mathematical model (i.e., equation of motion and transfer function) for the notch circuit shown in the figure, first from the application of first principles (e.g., KVL, KCL) and then using the impedance concept. The input is the voltage V_{in} and the output is the voltage V_{out}. Assume no loading is taking place, i.e., $i_{out} = 0$.



4. Using KVL and KCL, together with the constitutive element relations for R and C, show that the complete mathematical model for the RC circuit shown is given by:

$$\begin{bmatrix} e_{out} \\ i_{out} \end{bmatrix} = \begin{bmatrix} 1 & -R \\ CD & -(RCD+1) \end{bmatrix} \begin{bmatrix} e_{in} \\ i_{in} \end{bmatrix}$$



Is this representation the same as $\begin{bmatrix} e_{in} \\ i_{in} \end{bmatrix} = \begin{bmatrix} RCD+1 & -R \\ CD & -1 \end{bmatrix} \begin{bmatrix} e_{out} \\ i_{out} \end{bmatrix}$? Show details.

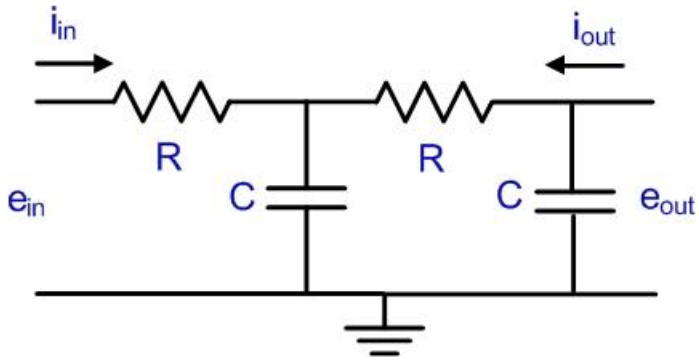
5. The circuit shown consists of two identical RC circuits connected in series. Since the transfer function for a single unloaded ($i_{out} = 0$) RC circuit is given by

$$\frac{e_{out}}{e_{in}} = \frac{1}{RCD+1}$$

when two RC circuits are connected in series, the overall transfer function should be

$$\frac{e_{out}}{e_{in}} = \left(\frac{1}{RCD + 1} \right)^2$$

Is this correct? Why or why not? Explain. Find the overall transfer function first by using first principles applied to the complete system and second by using the matrix representation given in problem #3. Compare your answer to the above result.



Can you make any general statement about connecting two electrical systems (or any two dynamic systems) in series?