MAE140 - Linear Circuits - Fall 20
Midterm #2, November 24

Instructions

(i) Prior to the exam, you must have completed the Academic Integrity Pledge at `https://academicintegrity.ucsd.edu/forms/form-pledge.html`

(ii) The exam is open book. You may use your class notes and textbook.

(iii) Collaboration is not permitted. Your answers must be the result only of your own work.

(iv) The exam has 3 questions for a total of 24 points.

(v) You have from 2:00pm to 3:20pm. Please allow sufficient time to post your answers in Canvas.

(vi) If there is any clarification needed, post your question in the "Discussions" tab of the class Canvas webpage ("Clarifications on question statements of midterm2")

Good luck!

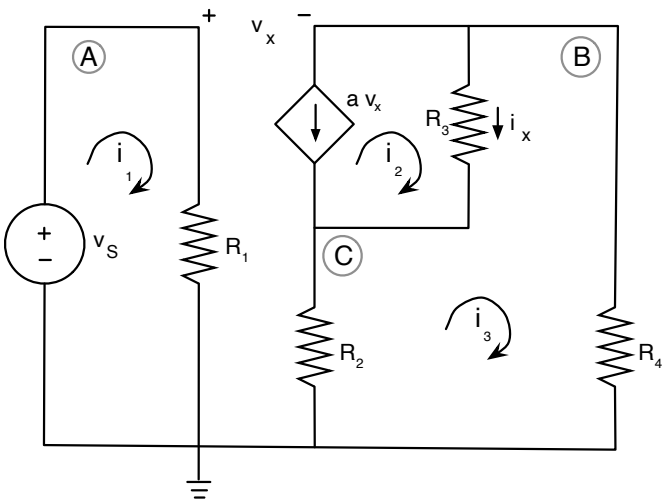

Figure 1: Circuit for Question 1.

1. **Circuit analysis with dependent sources**

   Part I: [6 points] Formulate node-voltage equations for the circuit in Figure 1. Use the node labels provided in the figure. Clearly indicate the final equations and circuit variable unknowns. Make sure your final answer has the same number of independent equations as unknown variables (notice the presence of the dependent source). No need to solve any equations!

   Part II: [2 points] Express the current i_x and the mesh currents i_1, i_2, i_3 in terms of node voltages.

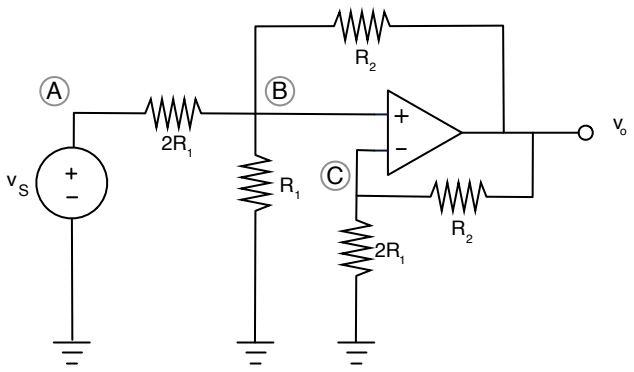

Figure 2: Circuit for Question 2.

2. **OpAmp circuit analysis**

   Part I: [6 points] Two engineers computed two different expressions for input-output relationship for the circuit in Figure 2. One computed

$$v_o = \frac{2R_1 + R_2}{R_1} v_s$$

   and the other computed

$$v_o = \frac{2R_1 + R_2}{4R_1} v_s$$

   Use node-voltage analysis to determine which one was right.

   Part I: [2 points] If the Op-Amp is connected to an external power supply with $+v_{CC} = 6V$ and $-v_{CC} = -6V$, and $R_1 = R_2 = 10\,K\Omega$, what is the range of v_S so that the Op-Amp does not saturate?

3. **OpAmp design**

   Consider the operation

$$v_o = 2v_{\text{in}} - 27$$

   In your toolbox, you only have the input voltage source v_{in}, a voltage source of 9V, and many $10\,K\Omega$ resistors (as many as you need).

   Part I: [4 points] Design a circuit that implements this operation using two inverting op-amps and one inverting summer.

   Part II: [4 points] Design a circuit that implements this operation using only one op-amp.