MAE140 Linear Circuits Quiz # 2 --- February 21, 2002

Instructions

This quiz is open book. You may use whatever written materials you choose including your class notes and the textbook. You may use whatever calculator you desire, provided it has no messaging communications capability, including infrared, radio and other wireless technology. These permissions should be taken to indicate the limited help that either written material or computational assistance is likely to provide --- please do not spend significant time looking up books or calculating. That is not what is being tested here. Marks are awarded for concepts and methods.

You should attempt to answer all of the three questions. They are equal value, although not necessarily equal difficulty.

You have 70 minutes. I do not expect many people to finish.

Please mark your papers with your name and student number.

Question 1 --- Circuit Analysis with Dependent Sources

Consider the circuit in Figure 1

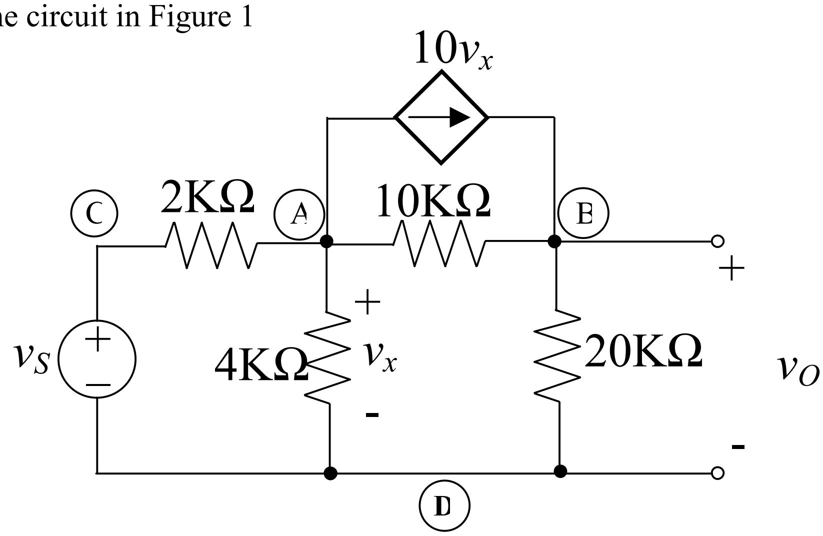

Figure 1

Compute the voltage gain $\frac{v_O}{v_S}$.

[I get approximately 10.]

Question 2 --- OpAmp Circuit Analysis

Consider the circuit depicted in Figure 2.

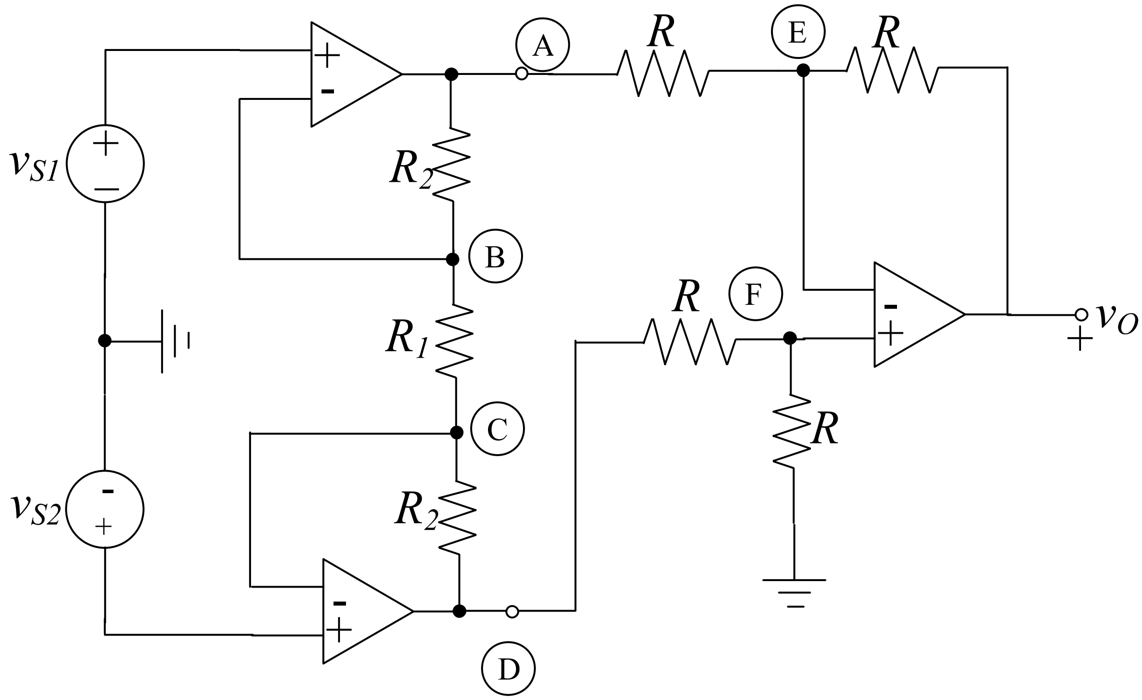

Figure 2

The objective is to show that the circuit is a differential amplifier whose input-output relationship is given by $v_O = K(v_{S2} - v_{S1})$ and to find the gain K in terms of the circuit elements.

(a) Write the node voltages at nodes B, C, E and F.
(b) Solve the node equations at E and F to show that $v_O = v_D - v_A$.
(c) Solve the equations at nodes B and C for v_A and v_D in terms of v_{S1} and v_{S2}.
(d) Substitute the results from part c into b and derive the overall input-output relationship.

[I get $K = (G_2 - 2G_1)/G_2$.]

Question 3 --- OpAmp Circuits

The Voltage Follower circuit shown in Figure 3 has the property that (provided we stay away from saturation and current limitations of the OpAmp) the output voltage, v_O, equals the input voltage, v_i, for any load R_L. That is, the load current, i_L, is maintained at such as level as to keep the output voltage equal to the input voltage. Thus, the Voltage Follower is an example of a voltage-controlled voltage source (VCVS).

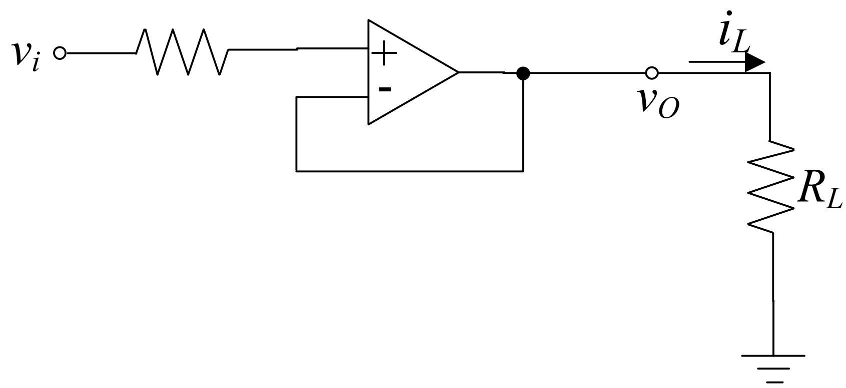

Figure 3 Voltage Follower (VCVS)

The non-inverting amplifier OpAmp configuration of Figure 4, has the property that

$$v_O = \frac{R_L + R_E}{R_E} v_i.$$

(a) Show that by fixing the resistor R_E this yields a current source into the load R_L of size $i_L = v_i / R_E$. Thus, the non-inverting amplifier is a voltage-controlled current source (VCCS). This was a homework problem Thomas & Rosa 4-29 (a).

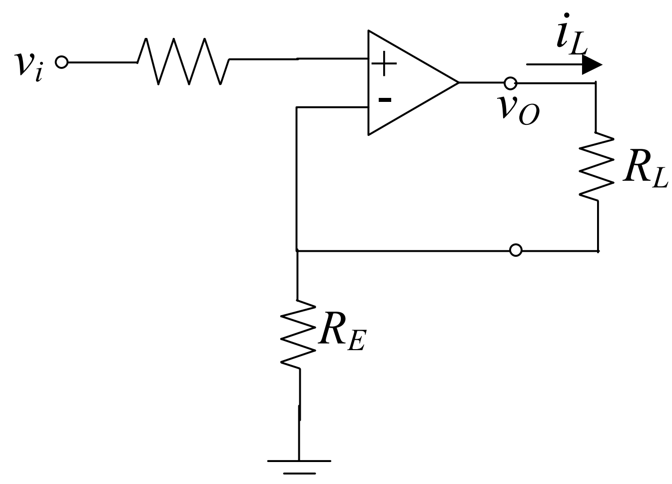

Figure 4 Non-inverting Amplifier (VCCS)

(b) Describe how to build a current-controlled voltage source (CCVS) and a current-controlled current source (CCCS) from OpAmp circuits. Specifically address how one might achieve various gain values and signs of the controlled sources. Further, discuss how the practical considerations needed to ensure that the device does not disturb the controlling current.

(c) Show that the Negative Resistance Converter circuit shown in Figure 5 achieves a voltage to current relation $\frac{v_{in}}{i_{in}} = -R_L$.

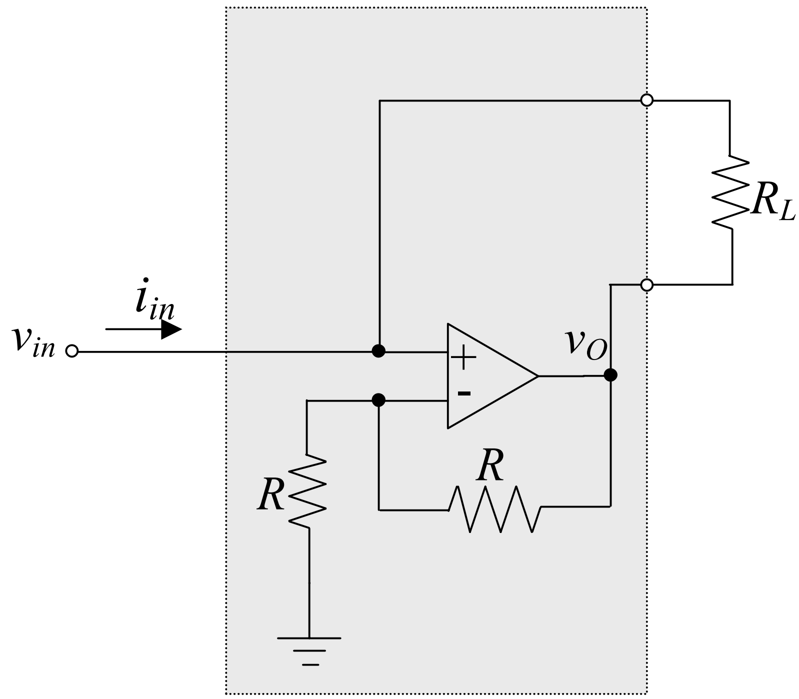

Figure 5 Negative Resistance Converter Circuit