EE2019–Analog Systems and Lab: Tutorial 4

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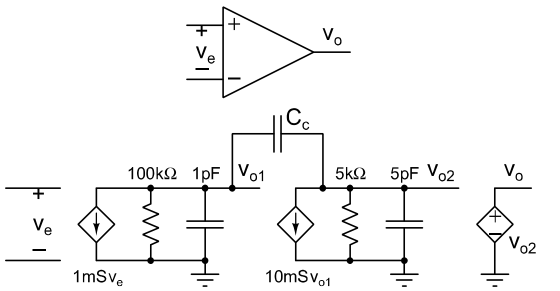

Figure 1: Circuit for problem 1

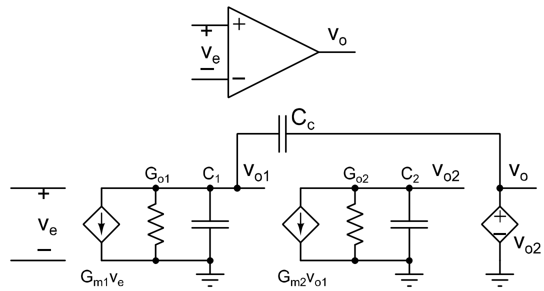

Figure 2: Circuit for problem 2

1. Fig. 1 shows the internal schematic of a Miller-compensated opamp. This opamp is used to realize a unity gain, non-inverting amplifier.

   - What is the phase margin?
   - Determine C_c so that the phase margin is 60°.
   - If the same opamp is used without any change to realize an inverting amplifier of gain -4, what are the phase margin and the closed loop bandwidth?
   - Re-design the opamp (value of C_c) so that when an inverting amplifier of gain -4 is realized using it, the phase margin is 60°. Compare the three cases wrt the following aspects: (a) Closed loop bandwidth, (b) phase margin, (c) phase lag contributed by the right-half-plane zero at the unity loop gain frequency.
   - Compare the bandwidths you obtain to the ones in the previous tutorial in which you simply increased C_1.

   While determining the unity loop gain frequency, phase margin, and C_c, do the calculations with and without the approximation $C_c \gg C_{1,2}$.

2. Determine the transfer function of the opamp in Fig. 2. How does it differ from the conventional Miller compensated opamp in the previous problem?

3. It is common to approximate the unity loop gain frequency as $\omega_{u,loop} \approx L_0 p_1$ where L_0 is the dc loop gain and p_1 is the dominant pole. If the loop gain is a second order function $L(s) = L_0/(1 + s/p_1)(1 + s/p_2)$, determine the exact unity loop gain frequency and the phase margin for the following cases: (a) $p_2 = 4L_0p_1$, (b) $p_2 = 2L_0p_1$, and (c) $p_2 = L_0p_1$. Compare them to the values obtained using the approximation above. $L_0 \gg 1$.

   (This approximation is very commonly used for hand calculations, but you should know how much error you end up with while doing so.)

Problem 4

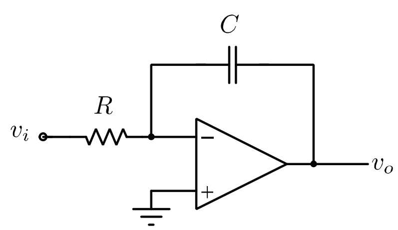

Figure 1: Circuit for Problem 1.

Fig. 1 shows an integrator. The opamp is ideal. The capacitor is initially uncharged. $v_i = \sin(\omega_o t)u(t)$, where $\omega_o = 1/RC$ and $u(t)$ is the unit step function. Draw to scale, on the same graph, v_i and v_o. Repeat with $v_i = \cos(\omega_o t)u(t)$.

Problem 5

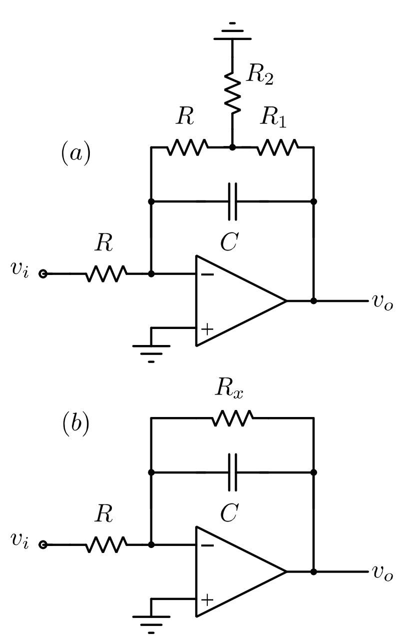

Figure 2: Circuit for Problem 2.

All opamps are ideal in Fig. 2. Determine the dc gain and 3-dB bandwidth of the circuit of Fig. 2(a). What R_x should be chosen in the circuit of Fig. 2(b) to obtain the same transfer function?

Evaluate R_x in the limiting case when $R_1, R_2 \ll R$. What might be the utility of the T-network in Fig. 2(a)?

Problem 6

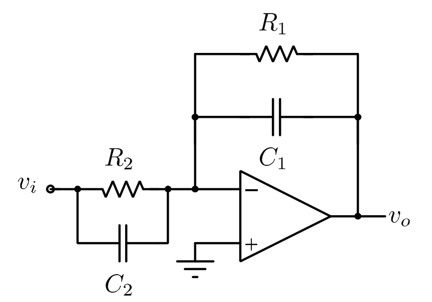

Figure 3: Circuit for Problem 3.

Determine the transfer function of the circuit of Fig. 3. Sketch a Bode plot.

Problem 7

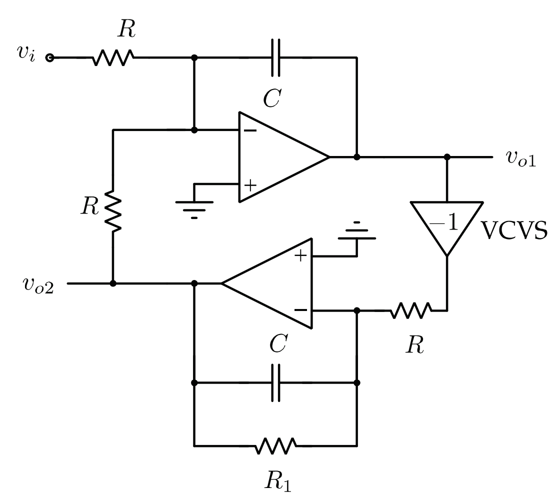

Figure 4: Circuit for Problem 4.

The opamps are ideal. Determine the transfer functions from the v_i to v_{o1} and v_{o2}.

Problem 8

The opamps are ideal. The initial conditions are marked. Plot the waveforms v_{o1} and v_{o2}.

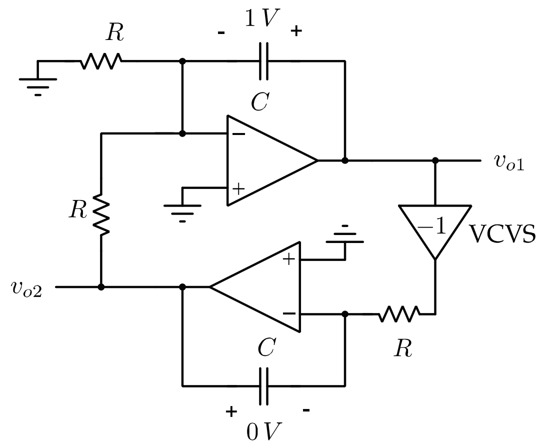

Figure 5: Circuit for Problem 5.

Problem 9

Consider the integrator of Fig. 1. The opamp is not ideal, but has a frequency dependent gain determined by GB/s, where GB denotes its gain-bandwidth product. Determine the integrator's transfer function, when a nonideal opamp is used.

Problem 10

Use the results of Problem 6 to evaluate the transfer function of the circuit of Fig. 4 when the opamps have a finite gain-bandwidth product. The VCVS can be assumed to be ideal.