EECE 2412 – Homework 2 – Fall 2016

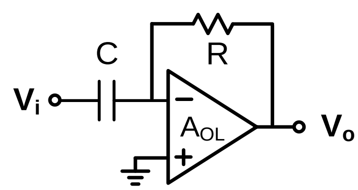
Due: Wednesday, September 28, 2016

1) Problem 2.47 on page 126 in the textbook (Allan R. Hambley, Electronics, 2nd edition, Prentice Hall, 1999). Assume that the gain bandwidth stated in the problem is in Hertz (i.e., 10^6 Hz).

2) The concepts related to this problem are explained in different parts of chapters 1 and 2 in the textbook. Finish reading both chapters completely before starting to work on this problem. An op-amp has a CMRR of 100dB and a differential voltage gain (A_d) of 80dB. A voltage of $v_1 = 120\mu V$ is applied to the non-inverting terminal, and a voltage of $v_2 = 80\mu V$ is applied to the inverting terminal.
   a. What is the differential input voltage?
   b. What is the common-mode input voltage?
   c. Determine the magnitude (not in decibels) of the amplifier's common-mode gain.
   d. Calculate the amplifier's output voltage under the given input conditions.

3) Problem 2.43 on page 126 in the textbook.

4) Consider the differentiator with an operational amplifier shown in the figure below.
 a. Derive the equation for the closed-loop gain $A_{CL}(j\omega) = V_o(j\omega)/V_s(j\omega)$ under the assumption that the op-amp has a finite DC gain of A_0, but is otherwise ideal.
 b. Find the closed-loop gain with an ideal op-amp ($A_{OL} = \infty$). Sketch the Bode plot (magnitude vs. frequency, phase vs. frequency). Label the slopes in the plot as well as the crossing point of the magnitude plot (y-axis in decibel scale) with the x-axis and the phase plot with the y-axis.
 c. Based on the gain equation in part a), what is the output amplitude if a sinusoidal input with an amplitude of 2mV is applied at 500Hz. Assume that $C = 20\mu F$, $R = 10k\Omega$, and $A_{OL} = 10^4$.
 d. Under the conditions in part c), what is the value of the circuit's closed-loop voltage gain in decibels?



5) Problem 2.60 on pages 128 in the textbook. Hint: This problem is very similar to example 2.10 (page 96) and exercise 2.16 (page 99) in the book.

6) Set up the circuit in Fig. 2.15 (page 74) of the textbook in PSPICE with ±15V supplies, and simulate it to make the assessments below. Make sure to use the uA741 op-amp model in the PSPICE library. Submit print-outs of the schematic and all mentioned plots with appropriate labels/annotations and the corresponding answers.
   a. Plot the AC gain (v_o/v_{in}) in dB vs. frequency, and plot the magnitude of the AC gain vs. frequency*. When setting up the AC simulation, use a logarithmic sweep with at least 10 points per decade. Label the 3dB corner frequency in both plots and provide the corresponding values of the gain (the magnitude, and the value in dB).
   b. Simulate the circuit with a sinusoidal input signal having an amplitude of 0.05V at 1kHz. Plot the input and output transient waveforms in the same figure**. Determine the gain based on the ratio of the amplitudes and the phase difference between the signals. Does the result agree with the theoretical expectation for the gain of this amplifier?

c. Simulate the circuit with a sinusoidal input signal with an amplitude of 0.5V at 1kHz. Plot the output voltage vs. time and explain any unusual characteristics of the waveform. Does the result agree with the practical expectation?
d. Change the amplitude of the sinusoidal input signal (transient simulation) to 0.5V, and increase its frequency to 100kHz**. Re-simulate the circuit, and plot the transient input/output voltages. Explain the result.
e. Change the amplitude of the sinusoidal input signal (transient simulation) to 0.05V, and keep its frequency at 7.2kHz. Re-simulate the circuit, and plot the transient input/output voltages. What is the gain now? Explain the result.

* In the AC simulation, make sure to select the appropriate start and end frequencies to see the complete frequency response.
** For the transient simulations, pick a run time (TSTOP) that allows you to view several cycles of the input/output waveforms. The maximum step time parameter in the transient simulation specifies the max. distance (in time) between simulation points. If you choose it to guarantee 50 or more points during one period of the input, then the input/output waveforms should appear smooth. If the output appears distorted, then you can also try increasing the number of points (decreasing the max. step time) to find out whether the limited simulation accuracy is the cause of the distortion. After changing the input signal frequency, you might have to change the max. time step as well in order to obtain better simulation results.