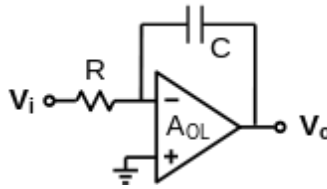


EECE 2412 – Homework 2 – Fall 2018

Due: Wednesday, September 26, 2018

- 1) Problem 2.25 on page 124 in the textbook (Allan R. Hambley, Electronics, 2nd edition, Prentice Hall, 1999).
- 2) Problem 2.45 on page 126 in the textbook. Plot the gain magnitude in decibels. Label the values of the low-frequency gain far below f_{BOL} and the unity-gain frequency (f_t).
- 3) Carefully read chapter 2 before starting to work on this problem, especially sections 2.6 and 2.11. Consider the op-amp circuit shown below.
 - a. Derive the equation for the closed-loop gain $A_{\text{CL}}(j\omega) = V_o(j\omega)/V_s(j\omega)$ 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 ($A_{\text{OL}} = \infty$). 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 5mV is applied at 100Hz. Assume that $C = 50\text{pF}$, $R = 50\text{k}\Omega$, and $A_{\text{OL}} = 10^4$.



- 4) An op-amp with a gain-bandwidth product of 20MHz is operated with a closed-loop gain of +100V/V using the non-inverting configuration in Fig. 2.11 in the textbook. What is the 3dB bandwidth with closed-loop operation? At what frequencies does the closed-loop amplifier exhibit phase shifts of -6° and -84° ?
- 5) An op-amp has a CMRR of 85dB and a differential voltage gain (A_d) of 102dB. A voltage of $v_1 = 110\mu\text{V}$ is applied to the non-inverting terminal, and a voltage of $v_2 = 40\mu\text{V}$ 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, and assuming that the common-mode gain is positive.
- 6) Set up the circuit in Fig. 2.59 (page 115) of the textbook in PSPICE with $\pm 15\text{V}$ 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. In PSPICE simulation setup, please pick following values: $R = 1\text{k}\Omega$, $T = 0.25$
 - 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 1V 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 35V 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) back to 1V, and increase its frequency to 613kHz**. 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 100mV, and keep its frequency at 613kHz. 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.