ENEE 307 Laboratory#6 (Operational amplifier circuits)

This laboratory is to experiment with the basic functions of an opamp (operational amplifier). The circuits to be built are amplifiers, active filters, and oscillators.

![Diagram of LF353, J-FET input operational amplifier](image)

Fig. 1: The pin assignment of LF353, J-FET input operational amplifier.

A. Pre-laboratory work

1. Study chapter two on the basic functions of an opamp (operational amplifier). Understand the meaning of the “virtual ground,” “infinite input impedance,” and “zero output impedance.”

2. Use PSPICE to simulate the Bode plots of the “open loop” situation. This is the case where the opamp is powered, within input ac excitation, but the output is left open --- there is no feedback to the input terminals. Plot (1) $20\log_{10}|A_v(\omega)|$ versus $\log_{10}(\omega)$, where gain is defined to be $V_{out}/V_{in}$, as well as (2) Phase($A_v(\omega)$) versus $\log_{10}(\omega)$. Sweep the frequency from dc to 1MHz.

3. Refer to the circuit shown in Fig. 2.7, design an inverting amplifier with a gain of $-10$. Use PSPICE to simulate the Bode plots --- $20\log_{10}|A_v(\omega)|$ versus $\log_{10}(\omega)$, as well as Phase($A_v(\omega)$) versus $\log_{10}(\omega)$. Cover a wide enough range, so that you can show the 3dB corner frequency. What is the bandwidth of this amplifier?
4. Simulate for the input impedance, as a function of frequency. The simulation is already done in step 3 above, and the quantity to show is the ratio between the input voltage and the input current, i.e., the current flowing through $R_1$ into pin 2.

5. Simulate for the output impedance.

6. Refer to Fig. 2.12, repeat your simulation effort and design a non-inverting amplifier with gain=+10. Obtain (a) Bode plots; (b) input impedance; and (c) output impedance.

7. Refer to Fig. 2.14, repeat your simulation effort and design a buffer amplifier with gain=+1. Obtain (a) Bode plots; (b) input impedance; and (c) output impedance.

8. For each of the above amplifiers (inverting, non-inverting, and buffer), compare the amplitude Bode plots with the “open loop” gain. Itemize your observation: what are the differences. Explain the reason behind the differences.

9. Refer to Fig. 2.39. Design an integrator. Set the RC time constant to be, e.g., 1 second. (Your choice.) Simulate and obtain the output voltage as a function of a square wave input. (Determine the amplitude and frequency of your square wave.) Derive the integration function. Discuss your choice of the value of the resistance and the capacitance.
10. Refer to the active low pass filter shown in the top row in Figure 12.13. Design one that has the corner (−3dB) frequency of 10kHz. Simulate and obtain the Bode plots. Compare with the results given in the textbook. Understand its function.

11. Follow the circuit shown in Fig. 13.24, use the values given in EXERCISE 13.16, PSPICE simulate the astable multivibrator. The values given are: $R_1=100$ kohm, $R_2=R=1$ Mohm, and $C=0.01\mu F$. Find the frequency of this oscillation. Assume your dc supply voltages.

B. What to do in the laboratory
   1. Measure the “open loop” gain of LF353, as a function of frequency.
2. Construct the inverting amplifier with a gain of $-10$. Measure the gain and phase, and collect enough data for Bode plots.

3. Construct the integrating amplifier. Measure the output voltage as a function of a square wave input. Change the amplitude and the frequency to verify your expectation. Compare with your simulation results and collect data for post-lab report.

4. Construct the low pass filter. Measure the output voltage as a function of a square wave input. Compare with your simulation results and collect data for post-lab report.
5. Construct the astable multivibrator. Measure the output voltage as a function of time. Compare with your simulation results and collect data for post-lab report.

C. Post-laboratory report questions, in addition to your report on data and your additional observation
1. The usual format: Present data. Arrange the order, so that your report shows your good understanding to the subject.
2. Add your own observations, comments, and suggestions.