LAB 2.1

Inverting Op-Amp Configuration

[See Section 2.2, p. 58 of Sedra/Smith]

OBJECTIVES:

To study an operational amplifier and an inverting amplifier by:

- Completing the analysis of the circuit and selecting resistors that satisfy design specifications for two values of voltage gain.
- Simulating the circuits to compare the results with the paper analysis.
- Implementing the circuits in an experimental setting, taking measurements, and comparing circuit performance to theoretical and simulated results.

MATERIALS:

- Laboratory setup, including breadboard
- 1 741-type operational amplifier (obtain its datasheet)
- Several wires and resistors of varying sizes

PART 1: DESIGN AND ANALYSIS

Consider the circuit shown in Figure L2.1:

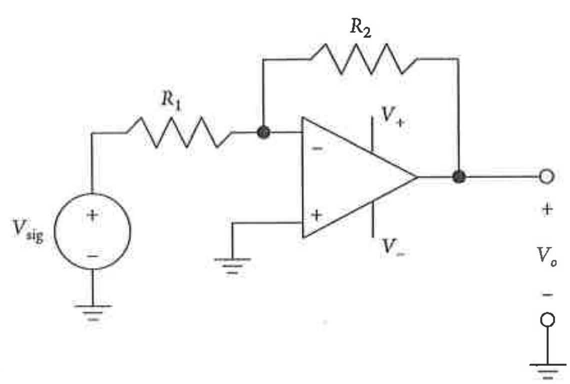

FIGURE L2.1: Inverting amplifier circuit. See Fig. 2.5, p. 59 S&S.

Design two versions of the circuit in Figure L2.1: one that achieves $A_v = -10$ V/V, and one that achieves $A_v = -100$ V/V. Assume a 1-kHz input waveform v_{sig} of

PART 4 [OPTIONAL]: EXTRA EXPLORATION

- In your measurement setup, gradually increase the frequency of the input sine wave until the output's amplitude is about 70% of what it was at lower frequencies. At what frequency does this happen? This represents the –3-dB frequency of the circuit.
- In your measurement setup, gradually increase the amplitude of the input sine wave until the output becomes distorted. At what amplitude does this begin to happen? Can you explain this phenomenon?

50 mV_{pk-pk}. Your circuit may only draw up to 50 μA of current from v_{sig} (it will draw more from V_+ and V_-). Use supplies of $V_+ = -V_- = 15$ V.

Hand calculations

- Sketch the circuit in your lab book, clearly labeling the op-amp terminals.
- What values of R_1 must you use to satisfy the current constraint? What is the input resistance of the circuit?
- What values of R_2 do you need to use to meet the two gain specifications? Is the problem completely specified?

Simulation

- Simulate both circuits using a transient simulation with a 50-mV_{pk-pk} 1-kHz input sine wave v_{sig}. In your simulations, assume that your input voltage source v_{sig} has an output resistance of 50 Ω. Use values of R_1 and R_2 based on your preceding calculations.
- Plot the input and output waveforms. What is the DC voltage at the inverting terminal of the op-amp?
- What are the simulated voltage gains of your circuit?

PART 2: PROTOTYPING AND MEASUREMENT

- Assemble the circuit with $A_v = -10$ V/V onto a breadboard. Do not include the 50-Ω output resistance of v_{sig}.
- Using a digital multimeter, measure the DC voltages at the input, output, and inverting terminal, while leaving the input tied to ground.
- Using a function generator, provide a 1-kHz 50-mV_{pk-pk} sine wave to the input. Using an oscilloscope, observe the output voltage waveform.
- Using a power supply, provide a DC input to the circuit in increments of 0.1 V, from –1 V to +1 V. Record the values of v_O and plot your results.
- Repeat the measurements for the gain $A_v = -100$ V/V, but this time sweeping the DC input to the circuit in increments of 0.01 V, from –0.1 V to +0.1 V.
- Using a digital multimeter, measure all resistors to three significant digits.

PART 3: POST-MEASUREMENT EXERCISE

- For both circuits, calculate the voltage gains you obtained in measurement. Explain any discrepancies between the experiments, simulations, and hand analysis.
- Recalculate the theoretical gains of the circuit using the measured resistor values. Are the recalculated values closer to your measured gains?