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Pre-Lab 1

Op-Amps

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Chapter 1

Overview

1.1 Objective

The purpose of this lab is to understand the behavior of operational amplifiers (a.k.a op-amps) by conducting AC Sweep/Noise analysis, plotting input-output graphs at varying frequencies, and designing a non-inverting amplifier circuit with a gain of 4.

1.2 Equipment

- Breadboard
- Oscilloscope
- Function Generator
- Multimeter
- LM741 Op-Amp
- Resistors ($1k\Omega$, $10k\Omega$)
- Capacitor ($100nF$)

Chapter 2

Procedure

2.1 AC Sweep/Noise Analysis

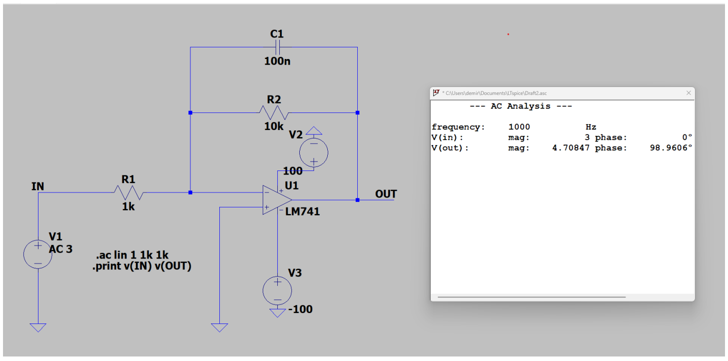

Figure 2.1: AC Analysis Circuit

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Frequency	1kHz	
V_{in}	mag: 3	phase: 0°
V_{out}	mag: 4.70847	phase: 98.96°

Table 2.1: AC Analysis Results

From the results, we can make these observations:

- **Magnitude:** The gain og the circuit is approximately 1.57 at $1kHz$.
- **Phase:** The input signal has a phase of 0°, while the output signal exhibits a phase shift of 98.96°. This significant phase shift is typical in op-amp circuits operating at high frequencies. As the frequency increases, op-amps tend to introduce phase shifts due to internal capacitances and feedback delays. A shift of approximately 99° suggests that the circuit is approaching the higher end of the op-amp's bandwidth, which leads to a lag in the output signal.

2.2 Frequency Response Analysis

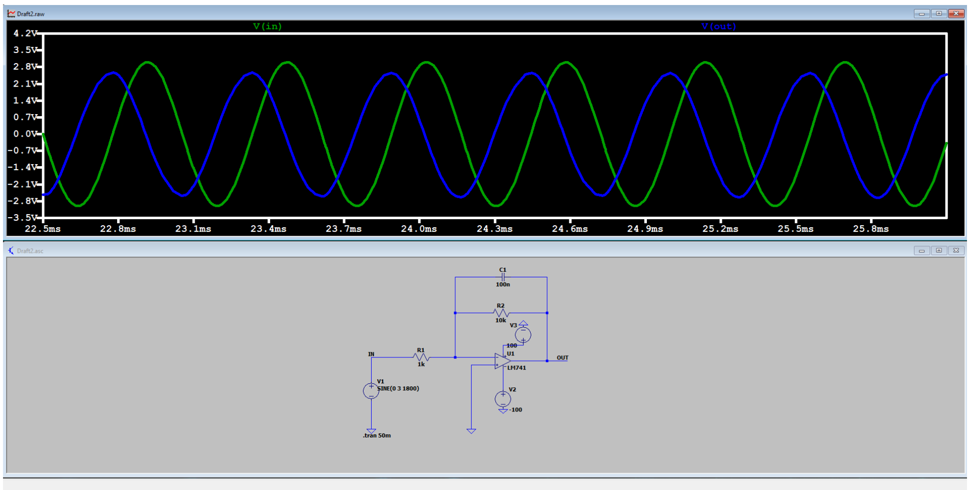

Figure 2.2: Frequency Response Analysis Circuit @ 1.8kHz

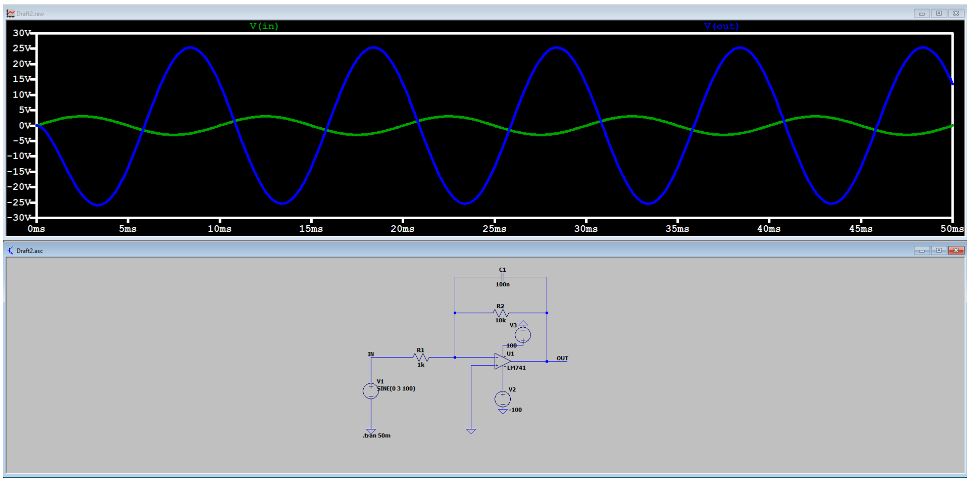

Figure 2.3: Frequency Response Analysis Circuit @ 100Hz

At lower frequencies, op-amp behaves as expected. However, at higher frequencies, output starts to lag behing the input due to phase shifts, and the amplitude decreases, indicating a drop in gain as the op-amp bandwidth is exceeded.

2.3 Non-Inverting Amplifier Design

For non-inverting amplifier design, we need to calculate the resistor values for the desired gain. The formula for calculating the resistor values is given below:

$$4 = 1 + \frac{R_f}{R_1} \Rightarrow \frac{R_f}{R_1} = 3$$
$$R_f = 3k\Omega, R_1 = 1k\Omega$$

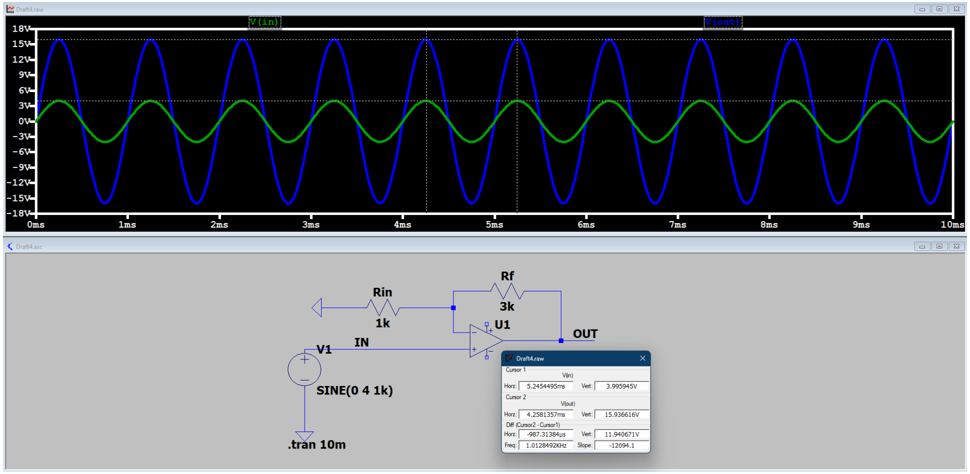

Figure 2.4: Non-Inverting Amplifier Circuit @ 4V1kHz

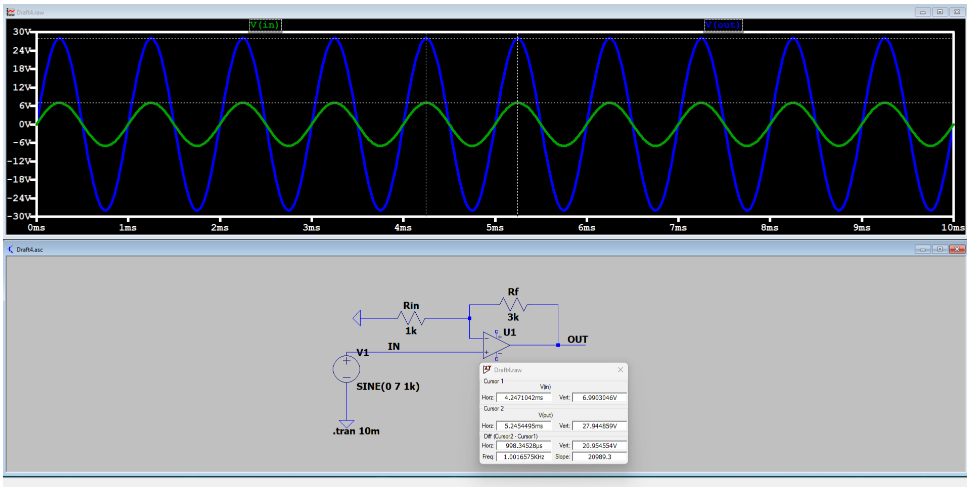

Figure 2.5: Non-Inverting Amplifier Circuit @ 7V1kHz

As we increase the voltage, the output voltage also increases. This is because the gain of the circuit is 4.

Chapter 3

Discussion

- **P1 Observations:** The AC Sweep analysis demonstrated that the op-amp maintained stable gain at low frequencies but began to attenuate as the frequency approached 1 kHz.
- **P2 Observations:** The Frequency Response analysis showed that the op-amp maintained stable gain at low frequencies but began to attenuate as the frequency approached 1 kHz.
- **P3 Observations:** The non-inverting amplifier design performed well, maintaining a gain of 4 as expected

Chapter 4

Conclusion

The lab successfully demonstrated key characteristics of op-amps, including frequency response and voltage saturation effects. Analytical calculations closely matched experimental results, confirming the accuracy of the models used to predict op-amp behavior. Understanding these characteristics is essential for designing reliable op-amp circuits in practical applications.