**Lab 6C: Non-inverting amplifier, summing amplifier**

**Objectives**

1) Investigate the non-inverting amplifier – its topology, advantages, and disadvantages

2) Investigate the summing amplifier – its topology and applications

3) Optional: investigate the difference amplifier – its topology and applications

**Part 1: single input circuits –non-inverting amplifier**

**Procedure:** construct the following non-inverting amplifier circuit. Implement the input voltage source Vs with a function generator. Then implement Vs again with a potentiometer and the power rails. See more details below.

A diagram of a circuit

Description automatically generated

**Derive:** the gain formula (based on Rf and R1) of this non-inverting amplifier. Then verify the gain with the actual measurements below.

**Measure and record:** For the source signal Vs, investigate both AC and DC signals. For the AC input, use a function generator (1kHz, 0.2Vpp, 0Vdc). Record the superimposed input and output waveforms. For the DC input, use a potentiometer and the power rails to implement Vin (±0.1V, ±0.2V, ±0.5V, ±1V, ±1.3V, ±1.4V, ±1.5V, ±1.6V, ±2V, and ±3V). Measure the corresponding output voltages of Vout. Plot the VTC.

**Determine** the gain Vout/Vin

**Discuss:** The **advantages and disadvantages** of the non-inverting amplifier topology

**Discuss:** If R1 approaches infinity and Rf approaches zero, the circuit becomes what topology? Explain this with the non-inverting amplifier’s gain formula.

**Explore:** How would you modify the non-inverting amplifier circuit above to achieve a positive gain of less than one? Sketch a circuit diagram to explain your solution. (Hint: use some method to reduce the voltage at the op amp’s positive signal input.)

Part 1: non-inverting amplifier data table:

|  |  |
| --- | --- |
| Derive the gain formula |  |
| Theoretical gain |  |
| Superimposed input and output waveforms at saturation |  |
| Plot the VTC (including saturation) |  |
| Measured gain |  |
| Advantages and disadvantages of this non-inverting amplifier |  |
| If R1 approaches infinity and Rf approaches zero, the circuit becomes what topology? Use the gain formula to explain. |  |
| How would you modify the non-inverting amplifier circuit to achieve a positive gain of less than one? Sketch this circuit. |  |

**Part 2: multiple input circuits – summing amplifier; difference amplifier (optional)**

Construct the following summing amplifier circuit

Diagram, schematic

Description automatically generated

**Derive:** Use the superposition principle to derive the gain formula (based on Rf, R1, and R2) of this summing amplifier, and verify it with the actual measurements below.

**Measure and record:** Set the first input Vin1 as a 1kHz, 200mVpp, 0Vdc sinusoidal signal. Set the second input Vin2 as a 2V DC signal. Record the waveform of the output signal. Analyze this output signal to identify its AC signal voltage and its DC offset voltage.

**Discuss:** Why is this amplifier called the summing amplifier?

**Discuss:** Can you produce a positive DC offset to the output signal? If so, how?

**Explore (optional):** Add a 1k resistor between the op amp’s positive signal input and ground. Does this change the op amp’s signal output? What may be a good reason for adding this 1k resistor?

Part 2: summing amplifier data sheet

|  |  |
| --- | --- |
| Derive the gain formula |  |
| Record the output waveform |  |
| Output’s AC signal voltage |  |
| Output’s DC offset voltage |  |
| Why is this amplifier called the summing amplifier? |  |
| How do you implement a positive DC offset to the output signal? |  |
| (Optional) Add a 1k resistor between the op amp’s positive signal input and ground. Does this change the op amp’s signal output? What may be a good reason for adding this 1k resistor? |  |

**Optional: difference amplifier (not graded)**

Construct the following circuit – the general form of the difference amplifier circuit

Graphical user interface, diagram, schematic

Description automatically generated

**Derive and verify:** Use the superposition principle to derive the gain formula (based on Rf, R1, R2, and R3) of this difference amplifier, and verify it with the actual measurements below.

**Measure and record:** Set the first input Vin1 as a 1kHz, 200mVpp, 0Vdc sinusoidal signal. Set the second input Vin2 as a 2V DC signal. Record the waveform of the output signal. What is this output signal’s AC signal voltage DC offset voltage?

**Discuss:** Why is this amplifier called the difference amplifier?

**Discuss:** Can you add a negative DC offset to the output signal?

**Data tables and scope image captures**

Part 1: non-inverting amplifier data table:

|  |  |
| --- | --- |
| Derive the gain formula |  |
| Theoretical gain |  |
| Superimposed input and output waveforms at saturation |  |
| Plot the VTC (including saturation) |  |
| Measured gain |  |
| Advantages and disadvantages of this non-inverting amplifier |  |
| If R1 approaches infinity and Rf approaches zero, the circuit becomes what topology? Use the gain formula to explain. |  |
| How would you modify the non-inverting amplifier circuit to achieve a positive gain of less than one? Sketch this circuit. |  |

Part 2: summing amplifier data sheet

|  |  |
| --- | --- |
| Derive the gain formula |  |
| Record the output waveform |  |
| Output’s AC signal voltage |  |
| Output’s DC offset voltage |  |
| Why is this amplifier called the summing amplifier? |  |
| How do you implement a positive DC offset to the output signal? |  |
| (Optional) Add a 1k resistor between the op amp’s positive signal input and ground. Does this change the op amp’s signal output? What may be a good reason for adding this 1k resistor? |  |