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EGR 24L Introduction of Circuit Analysis Laboratory

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Lab#6C
Non-inverting amplifier, summing amplifier.

Introduction:

In this laboratory experiment, our goal is to delve into the characteristics and practical applications of non-inverting amplifiers and summing amplifiers. By grasping the underlying principles of these configurations, we aim to acquire the expertise needed to design and implement these circuits for a variety of real-world purposes. Through hands-on experimentation and thorough analysis, our objective is to deepen our understanding of the distinctive features and advantages that non-inverting and summing amplifiers bring to the field of analog signal processing. Operational amplifiers (op-amps) serve as versatile foundations in the realm of analog electronics, finding application in a multitude of scenarios. Specifically, non-inverting amplifiers and summing amplifiers play crucial roles in signal processing, providing engineers and researchers with potent tools for amplification and signal manipulation.

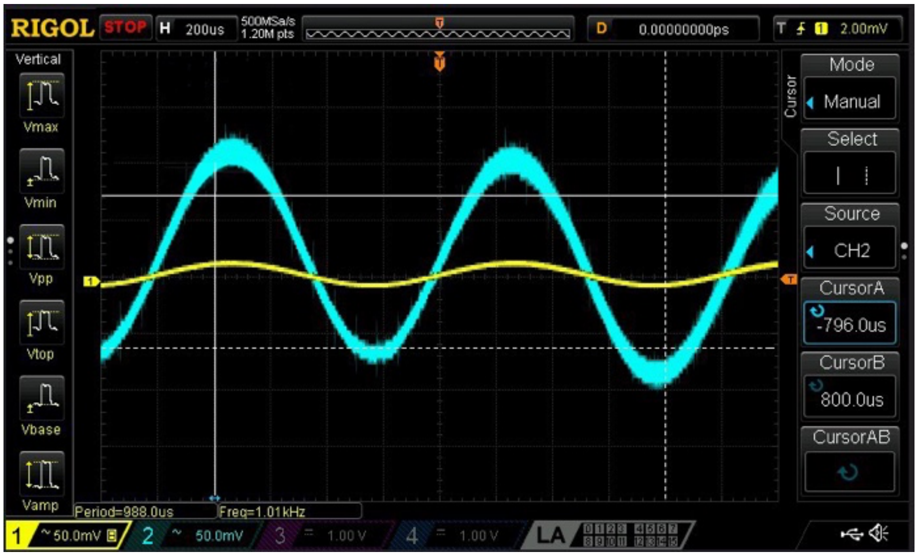
A notable feature of the non-inverting amplifier lies in its adjustable gain, determined by the ratio of feedback and input resistors. This adaptability empowers engineers to customize the amplifier's performance to suit specific application requirements. Additionally, the non-inverting configuration typically showcases high input impedance, effectively minimizing loading effects on the signal source. Moving on to the summing amplifier, it represents an essential op-amp circuit that broadens the versatility of operational amplifiers into the domain of signal mixing and summation. This configuration allows for the amalgamation of multiple input signals, each with different weights, to generate a single output signal. The summing amplifier proves particularly valuable in applications demanding the aggregation of signals, such as in audio mixing consoles or control systems. Overall, this experiment seeks to provide a comprehensive exploration of these amplifier configurations, shedding light on their functionalities and applications in the broader context of analog signal processing.

Procedure:

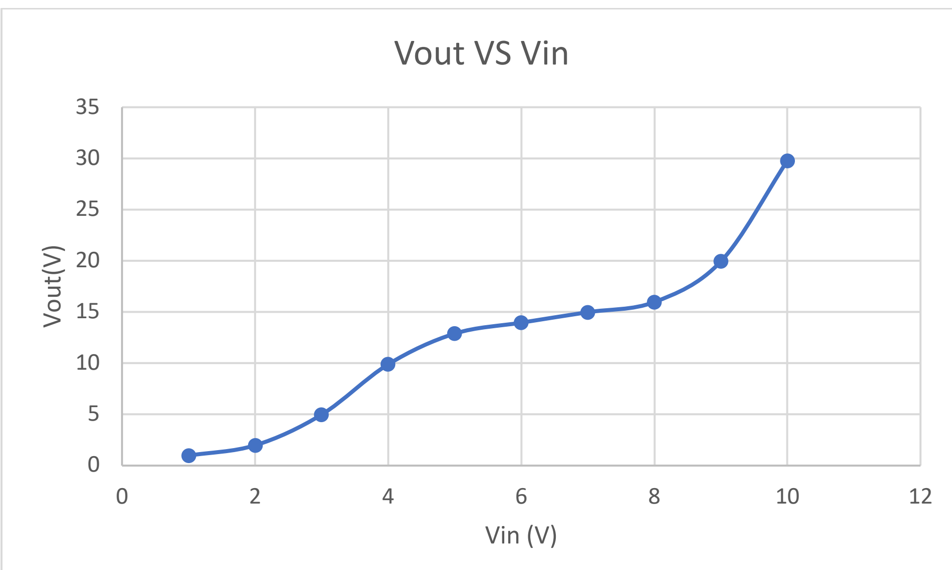
1. In the part1, we are constructing a non-inverting amplifier circuit follow the instruction on the spec sheet. Next, we increase the Voltage input by .1V by using potential meter and we record the voltage output which corresponding to Vin. In additional, we connected function generator and oscilloscope to the circuit to see the relationship between Vin, Vout.

2. In the Part 2, we constructed a summing amplifier circuit following the spec sheet. In this part also set up function generator to 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.

Data:



RIGOL
STOP
H 200us
500MSa/s
1.20M pts
D 0.00000000ps
T 2.00mV
Vertical
Vmax
Vmin
Vpp
Vtop
Vbase
Vamp
Cursor
Mode
Manual
Select
Source
CH2
CursorA
-796.0us
CursorB
800.0us
CursorAB
Period=988.0us
Freq=1.01kHz
1 50.0mV
2 50.0mV
3 1.00 V
4 1.00 V
LA

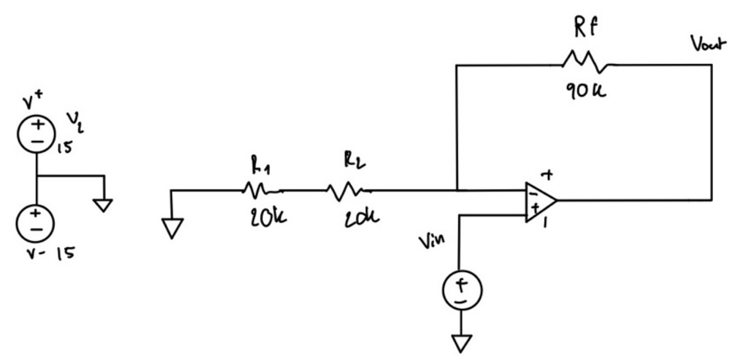


Vout VS Vin
Vout(V)
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
Vin (V)

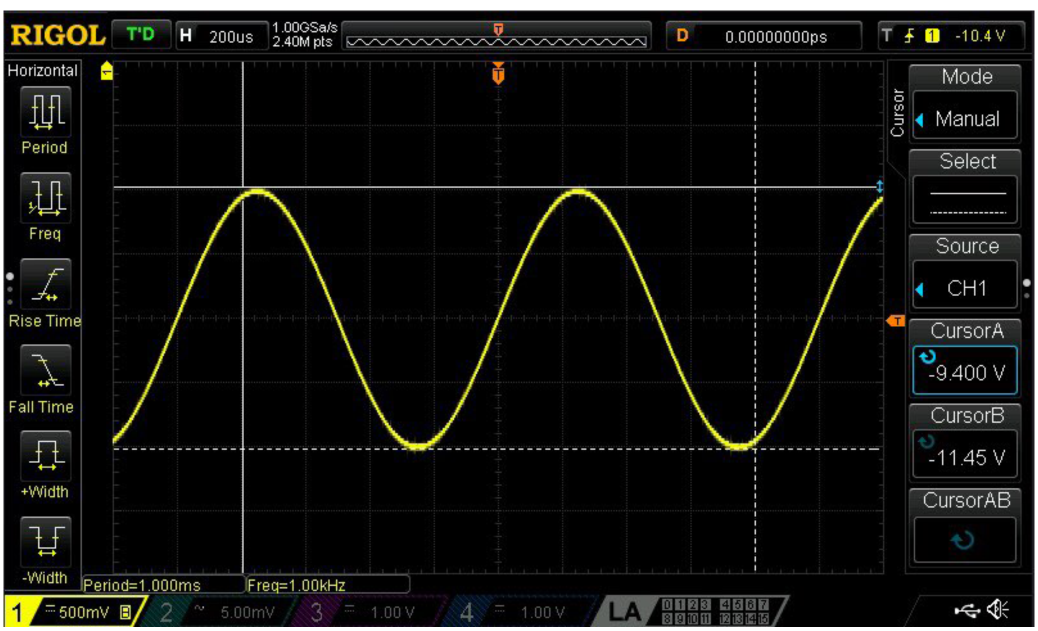
Part 1: non-inverting amplifier data table:

<table>
<tr><td>Derive the gain formula</td><td>$$Av = 1 + \frac{Rf}{R1} \rightarrow \frac{Vout}{Vin} = 1 + \frac{Rf}{R1} \rightarrow \mathrm{Vout} = (1 + \mathrm{R1Rf}) \cdot \mathrm{Vin}$$</td></tr>
<tr><td>Theoretical gain</td><td>
<table>
<tr><td>Vout(V)</td><td>1</td><td>2</td><td>5</td><td>10</td><td>13</td><td>14</td><td>15</td><td>16</td><td>20</td><td>30</td></tr>
<tr><td>Vin(V)</td><td>±0.1</td><td>±0.2</td><td>±0.5</td><td>±1</td><td>±1.3</td><td>±1.4</td><td>±1.5</td><td>±1.6</td><td>±2V</td><td>±3V</td></tr>
</table>
</td></tr>
<tr><td>Superimposed input and output waveforms at saturation</td><td>See the graph above</td></tr>
<tr><td>Plot the VTC (including saturation)</td><td>See the graph above.</td></tr>
<tr><td>Measured gain</td><td>
<table>
<tr><td>Vout(V)</td><td>.98</td><td>1.98</td><td>4.98</td><td>9.89</td><td>12.89</td><td>13.96</td><td>14.98</td><td>15.97</td><td>19.94</td><td>29.78</td></tr>
<tr><td>Vin(V)</td><td>±0.1</td><td>±0.2</td><td>±0.5</td><td>±1</td><td>±1.3</td><td>±1.4</td><td>±1.5</td><td>±1.6</td><td>±2V</td><td>±3V</td></tr>
</table>
</td></tr>
<tr><td>Advantages and disadvantages of this non-inverting amplifier</td><td>Advantages are Positive Gain (positive voltage gain without inverting the input signal.), Simple Design, High input Impedance (exhibits high input impedance, reducing loading effects on the signal source.), Adjustable Gain and Preservation of phase.

Disadvantages are Limited Voltage Range (The output voltage is limited by the power supply voltages, and saturation can occur if input signals push the output beyond these limits), Complexity for High gains (Achieving very high gains may require precision resistors, leading to increased complexity and cost.), Nosie sensitivity (Susceptible to noise in the input signal, especially in high-gain configurations)</td></tr>
<tr><td>If R1 approaches infinity and Rf approaches zero, the circuit becomes what topology? Use the gain formula to explain.</td><td>$$Av = 1 + \frac{Rf}{R1} \rightarrow Av = 1 + \frac{0}{\infty} \rightarrow therefore\ Av = 1$$
This means that the voltage gain (AvAv) is equal to 1, indicating unity gain. In other words, the output voltage closely follows the input voltage without</td></tr>
</table>

	amplification. The configuration resembles a voltage follower or unity-gain buffer. In practical terms, a voltage follower is useful when you need to match impedances or isolate a high-impedance source from a low-impedance load. It is often employed to minimize loading effects and maintain signal integrity in various electronic circuits.
How would you modify the non-inverting amplifier circuit to achieve a positive gain of less than one? Sketch this circuit.	 Connect resistor as series on positive signal in op amp would reduce overall voltage to make it smaller or by putting the bigger resistor value on positive signal in op amp would also work the same way.

Part2:



(The image is modified with photoshop due to we bring the OP-Amp home we don't have the oscilloscope, but using some hand calculate data we can obtain expected the Sine graph in this way.)

Part 2: summing amplifier data sheet

Derive the gain formula.	$$A = -\frac{Rf}{R1}$$ $$Therefore, Vout = -\left(\frac{Rf}{R1}\right) * V1 - \left(\frac{Rf}{R2}\right) * V2$$
Record the output waveform.	See above
Output's AC signal voltage	The output AC signal is -9.4V
Output's DC offset voltage	The output DC signal is 2V
Why is this amplifier called the summing amplifier?	The summing amplifier gets its name because it adds or sums multiple input voltages with different weights to produce an output voltage. It's commonly used for combining or summing signals in electronic circuits, making it useful in applications like audio mixing.
How do you implement a positive DC offset to the output signal?	1. User an inverting amplifier circuit 2. Connect DC voltage source (Voffset) inseries with input signal. 3. Adjust resistor values to control amplification
(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?	Adding a 1k resistor between the op-amp's positive signal input and ground won't significantly change the op-amp's signal output. The resistor is often added to provide a DC bias path for the input and stabilize the input common-mode voltage, preventing saturation and distortion in certain amplifier configurations.

Conclusion:

This laboratory experiment aimed to investigate the characteristics and performance of non-inverting and summing amplifiers. The non-inverting amplifier demonstrated its ability to amplify an input signal while preserving its phase, confirming its functionality as a voltage amplifier. The experimental results closely matched the theoretical predictions, indicating that the non-inverting amplifier design was successful. Furthermore, the summing amplifier was examined to understand its capability to combine multiple input signals with appropriate weighting factors. The observed output voltages aligned with the calculated values based on the circuit design, affirming the summing amplifier's accuracy in producing a weighted sum of input voltages. Although we did not achieve the result in the second part of the lab as we expected.

In summary, the successful implementation and analysis of the non-inverting and summing amplifiers have provided valuable insights into the principles of amplifier circuits. This experiment not only enhanced our understanding of amplifier functionality but also emphasized the importance of theoretical concepts in practical circuit design and analysis.