EE 360 Circuits & Electronics Lab. #8

OP-AMP Circuits

Lab Date: April 18, 2001

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ABSTRACT

Three different Operational Amplifier circuits with certain voltage and resister values were given in the pre-lab section, and the output voltage was calculated. In the same way, three different experimental circuits using the op-amp were constructed, and each circuit was measured its output voltages. Finally, the output voltages from pre-lab and lab section were compared.

OBJECTIVE

The purpose of this laboratory was to become familiar with the use of the operational amplifier and to construct a circuit in order to determine the effects of an op-amp on a circuit. Finally, the results from the pre-lab calculations and the experimental results were compared.

PROCEDURE

The first step of this lab was the pre-lab section had to be done. The objective of the pre-lab was to calculate the output voltages of the three different circuits given each being the non-inverting amplifier, inverting amplifier, and the summing amplifier. The calculations below were done for the three different circuits. All of the op-amps were supplied plus and negative fifteen volts to at the power supply terminals.

Using the fact that the current going into the op-amp is 0ampere, so KCL and the voltage divider rule was used to find the output voltage of the non-inverting amplifier, which experimental circuit is shown in Fig 1.

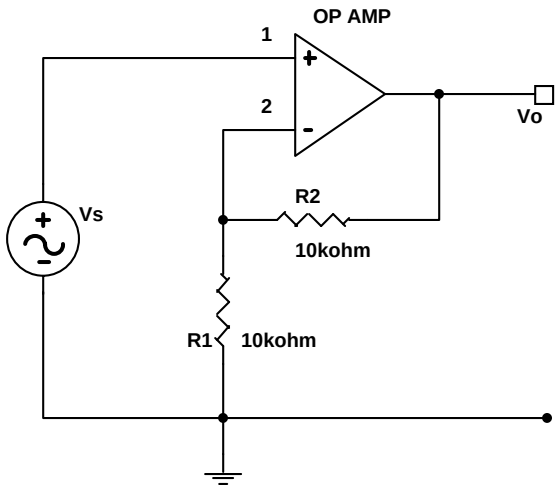

Fig 1. Experimental circuit. (#1 Non-Inverting Amplifier)

Following calculation was performed.

$$V_S = V_+ = V_-$$

$$i_f = i_s$$

$$\frac{V_o - V_-}{10K} = \frac{V_-}{10K}$$

$$V_o = 2V_-$$

Therefore, this non-inverting amplifier was assumed that voltage output was twice of the signal voltage, and it would not change its phase.

For the inverting amplifier, the KCL was applied to find the output voltage, which experimental circuit is shown in Fig 2.

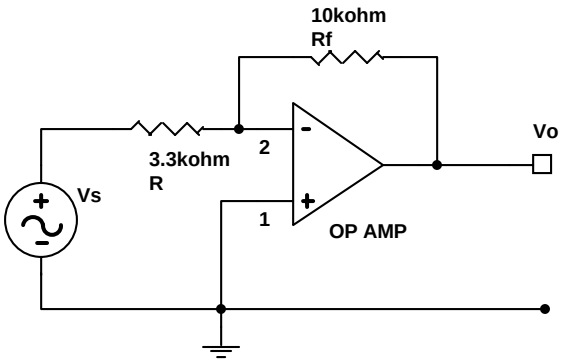

Fig 2. Experimental circuit. (#2 Inverting Amplifier)

Following calculation was performed.

$$V_o = -\frac{R_f}{R}V_S = -\frac{10K}{3.3K}V_S = -3.03Vs$$

Therefore, this inverting amplifier was assumed that voltage output was negative of 3.03 of the signal voltage, and it would change its phase.

(During the lab section, because of the difficulty of making stabilized inverting circuit, the feedback resistor, R_f, was switched from 10K to 5K; thus, the voltage output was assumed negative 1.52 of the signal voltage.)

$$V_o = -\frac{R_f}{R}V_S = -\frac{5K}{3.3K}V_S = -1.52Vs$$

The summing amplifier calculation was the variation of the inverting amplifier where the KCL was applied for both input voltages and added together, which experimental circuit is shown in Fig 3.

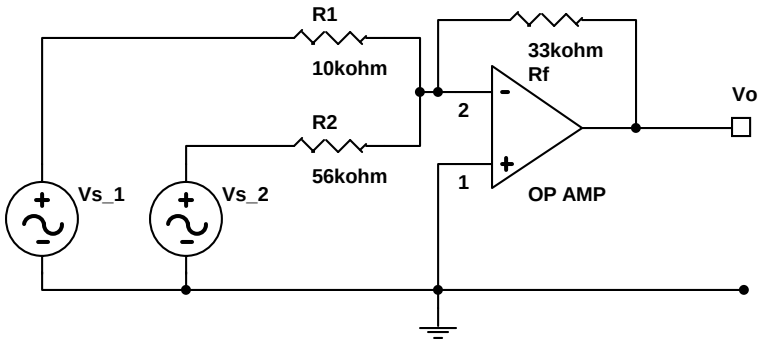

Fig 3. Experimental circuit. (#3 Summing Amplifier)

Following calculation was performed.

$$V_o = -\frac{R_f}{R_1}V_{S1} - \frac{R_f}{R_2}V_{S2} = -\frac{33K}{10K}V_{S1} - \frac{33K}{5.6K}V_{S2} = -3.3V_{S1} - 5.9V_{S2}$$

If the signal voltage V_{S1} and V_{S2} were same, following relationship was figured out.

$$V_{S1} = V_{S2} = V_S$$

$$V_o = -\frac{R_f}{R_1}V_S - \frac{R_f}{R_2}V_S = -\left(\frac{33K}{10K} + \frac{33K}{5.6K}\right)V_S = -9.2V_S$$

The experiment involved three parts in setting up three different circuits. For the inverting and the summing amplifier, the output voltage was expected to be negative since the two circuits work in inverting the input voltage sign. The output voltages were measured using a voltmeter in the point marked Vo on the diagrams in the previous pages. In all three circuits, an operational amplifier was used, and it had a set up. Once again, in order to have the circuit work, a 15V power supply was connected to the +Vcc and -Vcc part of the op-amp making the output voltage maximum as 15V.

Knowing those calculated values, the real experiment was performed. The experimental circuits were constructed on the protoboard. The experiment was consists of three parts. Part 1 was to measure the input and output voltage of the non-inverting amplifier (Fig 1). Part 2 was to measure the input and output voltage of the inverting amplifier (Fig 2), and part 3 was to measure the input and output voltage of the summing amplifier (Fig 3). Finally, the experimental and calculated values were compared.

RESULTS

		Pre-lab Values	Experimental Results	Error %
Part 1. Non-Inverting Amp.	Vin	**(6.3V)**	**6.3V**	**-----**
	Vout	**(12.6V)**	**12.6V**	**0.0%**
Part 2. Inverting Amp.	Vin	**(5.0V)**	**5.0V**	**-----**
	Vout	**(-7.6V)**	**-7.7V**	**1.3%**
Part 3. Summing Amp.	Vin_1	**(1.0V)**	**(1.0V)**	**-----**
	Vin_2	**(1.0V)**	**(1.0V)**	**-----**
	Vout	**(-9.2V)**	**-9.3V**	**1.1%**

DISCUSSIONs

In examining the results and comparing the values, the experimental results met the expected values to a reasonable amount. The expected output voltages in the pre-lab were 12.6V (@ Vin = 6.3V), -7.6V (@ Vin = 5.0V), and -9.2V (@ Vin = 1.0V each) where the experimental measurements were 12.6V, -7.7V, and -9.3V, respectively. The experimental values had low error values of 0.0%, 1.3%, and 1.1% respectively compared to the theoretical calculated value. This was assumed that these low values indicated the success of this experiment. In the case of the inverting and summing amplifier, the values were expected to be inverted, and examining the results this could be seen by the difference in the sign of the input and output voltages. The major source of error that might account for these slight errors that did not match the pre-lab values might be the voltage source calibrated with a slightly off value from the design. Since the value slightly fluctuated as it was calibrated, setting the voltages to exactly. From having the voltage values off of 0.2 to 0.3V, the volts had a possibility to affecting the final results.

CONCLUSION

Overall, in observing the results and the error calculations in the discussion section, this laboratory was a success where the experimental values met the pre-lab values. The laboratory showed how the operational amplifier comes in act with the circuit and how it affects the output voltages of a circuit. Although some sources of error might have affected to this experiment, in a broad sense with the low error in the experiment results, the experiment was successful in meeting its objectives.