

Lab Experiments for Op Amps

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1 Basic Op-Amp Circuits

Objectives

1. To study the ac characteristics of the non-inverting op-amp configuration.
2. To study the ac characteristics of the inverting op-amp configuration.
3. To observe the 180° phase shift associated with the inverting op-amp configuration.
4. To simulate non-inverting and inverting op-amp circuits using available software.

Equipment

- 8 Resistors: $1\text{ k}\Omega$, $10\text{ k}\Omega$, $33\text{ k}\Omega$, $39\text{ k}\Omega$, $68\text{ k}\Omega$, $180\text{ k}\Omega$, $220\text{ k}\Omega$, $820\text{ k}\Omega$
- 1 LM741 operational amplifier

Information

The basic non-inverting op-amp configuration is shown in Figure 1-1. The operational amplifier itself, within the triangle, has a very large open loop voltage gain, a reasonably high R_i and a fairly low R_o . These are all desirable characteristics. Resistors R_1 and R_2 are feedback resistors which generally improve the amplifier's characteristics at the expense of voltage gain. At the same time, the voltage gain is stabilized to a particular value, which is also a desirable characteristic.

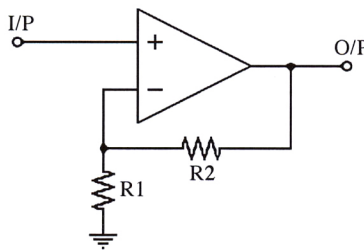


Figure 1-1. Basic Non-Inverting Amplifier

The op-amp with feedback will have characteristics determined mostly by the two external resistors. The characteristics of the non-inverting op-amp are given in Equations 1-1, 1-2 and 1-3.

$$R_i = \infty \Omega \quad \dots \dots \dots \text{Equation 1-1}$$

$$R_o = 0 \Omega \quad \dots \dots \dots \text{Equation 1-2}$$

$$A_v = \frac{R_1 + R_2}{R_1} \quad \dots \dots \dots \text{Equation 1-3}$$

Sometimes an additional resistor is connected from (+) to ground in order to set the input resistance to a specific value. A very common configuration of the non-inverting op-amp is the “buffer” amplifier used to isolate stages. The buffer is made by replacing R2 in Figure 1-1 with a short circuit, and replacing R1 with an open circuit. Equation 1-3 will show that this will provide a voltage gain of exactly one.



Figure 1-2. Basic Inverting Amplifier

Figure 1-2 illustrates the basic inverting op-amp configuration. Again, the characteristics are determined largely by the external biasing resistors, and are given in Equations 1-4, 1-5 and 1-6.

$$R_i = R_1 \quad \dots \dots \dots \text{Equation 1-4}$$

$$R_o = 0 \Omega \quad \dots \dots \dots \text{Equation 1-5}$$

$$A_v = \frac{-R_2}{R_1} \quad \dots \dots \dots \text{Equation 1-6}$$

Integrated Circuit Measurement Precautions

1. Set DC power supply voltages without any circuitry connected, then turn the supplies OFF.
2. Connect the circuit under test. If a generator is connected, be sure it is turned OFF.
3. Carefully double-check all connections, then switch the DC power supplies ON.
4. After confirming correct DC operation, the generator may be switched ON.
5. To make a circuit change, turn the generator OFF first, then turn the DC supplies OFF.

Circuit Simulation

If circuit simulation software is not available, the student may complete the required theoretical calculations for R_i , R_o and A_v below using formulae presented earlier.

1. Simulate the circuit of Figure 1-3 using available software. Use a generator set to 100 mV and 1.0 kHz.
2. Complete the circuit measurements of V_g , V_i , V_o and V_{oc} required to calculate R_i , R_o and A_v as required for Table 1-1.

Table 1-1. Non-Inverting Amplifier Simulator Measurements

V_g	V_i	V_o	V_{oc}	R_i	R_o	A_v

3. Simulate the circuit of Figure 1-4 using software. Use a generator set to 500 mV and 1.0 kHz.
4. Complete the circuit measurements of V_g , V_i , V_o and V_{oc} required to calculate R_i , R_o and A_v as required for Table 1-2.

Table 1-2. Inverting Amplifier Simulator Measurements

V_g	V_i	V_o	V_{oc}	R_i	R_o	A_v

Procedure

Non-Inverting Amplifier Measurements

1. Connect the circuit of Figure 1-3 using an 8-pin LM741 op-amp.

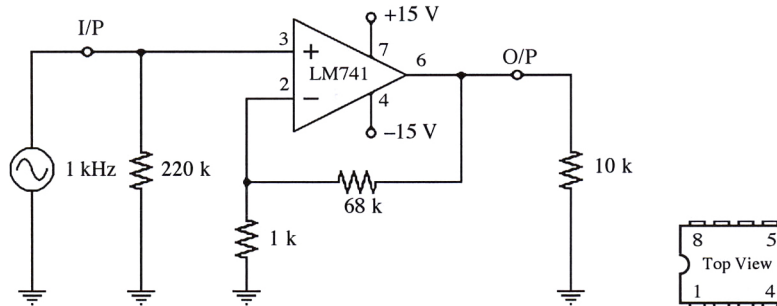


Figure 1-3. Non-Inverting Amplifier Circuit

2. Using a $180\text{ k}\Omega$ sensing resistor, and the techniques learned in earlier experiments, complete the four amplifier measurements required for Table 1-3. Use a generator frequency of 1 kHz.

Table 1-3. Amplifier Measurements

V_{oc}	V_o	V_g	V_i

3. Using the data measured in Table 1-3, calculate the amplifier characteristics required for Table 1-4.

Table 1-4. Amplifier Calculations

I_i	I_o	R_i	R_o	
A_{vo}	A_v	A_i	A_p	Units
				None
				dB

4. Check the input signal and the output signal simultaneously to make sure that there is 0° phase shift in this amplifier.

Inverting Amplifier Measurements

- Connect the circuit of Figure 1-4 using an 8-pin LM741 op-amp.

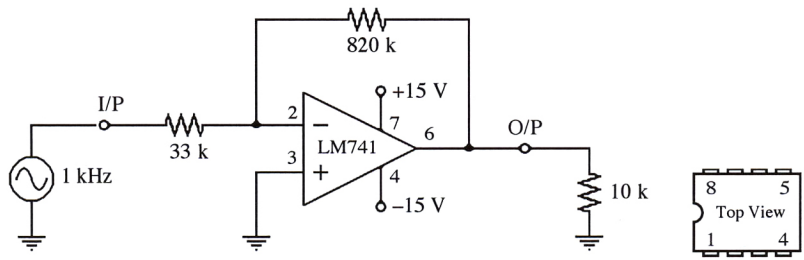


Figure 1-4. Inverting Amplifier Circuit

- Using a 39 kΩ sensing resistor, and the techniques learned in earlier experiments, complete the four amplifier measurements required for Table 1-5. Use a generator frequency of 1 kHz.

Table 1-5. Amplifier Measurements

V _{oc}	V _o	V _g	V _i

- Using the data measured in Table 1-5, calculate the amplifier characteristics required for Table 1-6.

Table 1-6. Amplifier Calculations

I _i	I _o	R _i	R _o

A _{vo}	A _v	A _i	A _p	Units
				None
				dB

- Check the input signal and the output signal simultaneously to make sure that there is 180° phase shift in this amplifier.
- If you have any time remaining, connect a buffer amplifier using the 8-pin LM741 op-amp, as described in the information section of this experiment.

1

Simulation Summary

Name _____

1. Complete the simulator data required for Table 1-1 below.

Vg	Vi	Vo	Voc	Ri	Ro	Av

2. Complete the simulator data required for Table 1-2 below.

Vg	Vi	Vo	Voc	Ri	Ro	Av

1

Data Sheet

Name _____

1. Complete the data required for Table 1-3 below.

Voc	Vo	Vg	Vi

2. Complete the data required for Table 1-4 below.

Ii	Io	Ri	Ro

Avo	Av	Ai	Ap	Units
				None
				dB

3. Complete the data required for Table 1-5 below.

Voc	Vo	Vg	Vi

4. Complete the data required for Table 1-6 below.

Ii	Io	Ri	Ro

Avo	Av	Ai	Ap	Units
				None
				dB

Questions

1. Refer to Table 1-3. Explain why the measurements of V_{oc} and V_o are the same, within measurement accuracy.
2. Calculate the theoretical R_i , R_o and A_v for the circuit of Figure 1-3 and compare these values to those determined from measurements.
3. Calculate the theoretical R_i , R_o and A_v for the circuit of Figure 1-4 and compare these values to those determined from measurements.
4. If you had time to complete step 9 of the procedure, describe your observations.