Lab Session 13
Inverting and Non-Inverting Amplifiers behavior of Operational Amplifier

Objective

In this lab, Inverting and Non-Inverting Operational Amplifier circuits will be investigated.

Material and Equipment

- Resistor 1 kΩ
- Resistor 3.3 kΩ
- Resistor 1.5 kΩ
- Operational Amplifier LM 741
- 2 DC power supply, 0...15 V
- 1 Oscilloscope

Theory

1) Op-Amp Basics

The operational amplifier is one of the most useful and important components of analog electronics.

They are widely used in popular electronics. Their primary limitation is that they are not especially fast: The typical performance degrades rapidly for frequencies greater than about 1 MHz, although some models are designed specifically to handle higher frequencies. The primary use of op-amps in amplifier and related circuits is closely connected to the concept of negative feedback. Feedback represents a vast and interesting topic in itself. However, it is possible to get a feeling for the two primary types of amplifier circuits, inverting and noninverting, by simply postulating a few simple rules (the "golden rules").

2) The Golden Rules

The other important fact about op-amps is that their *open-loop gain* is huge, in which there is no feedback loop from output back to input. A typical open-loop voltage gain is ~ 10^4 - 10^5. By using negative feedback, we throw most of that away!

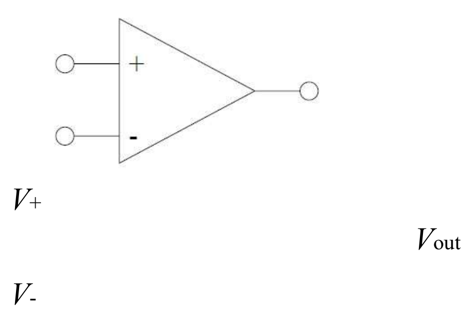

Figure 13.1: Operational amplifier.

The golden rules are idealizations of op-amp behavior, but are nevertheless very useful for describing overall performance. They are applicable whenever op-amps are configured with negative feedback, as in the two amplifier circuits discussed below. These rules consist of the following two statements:

1. The voltage difference between the inputs, $V_+ - V_-$, is zero. (Negative feedback will ensure that this is the case.) ➔ $\boldsymbol{V_+ = V_-}$.

2. The inputs draw no current. (This is true in the approximation that the Z_{in} of the op-amp is much larger than any other current path available to the inputs.)

When we assume ideal op-amp behavior, it means that we consider the golden rules to be exact. We now use these rules to analyze the two most common op-amp configurations. ➔ $\boldsymbol{I_+ = I_- = 0}$.

3) Inverting Amplifier

The inverting amplifier configuration is shown in Fig. 13.2. It is "inverting" because our signal input comes to the "−" input, and therefore has the opposite sign to the output. The negative feedback is provided by the resistor R_2 connecting output to input.

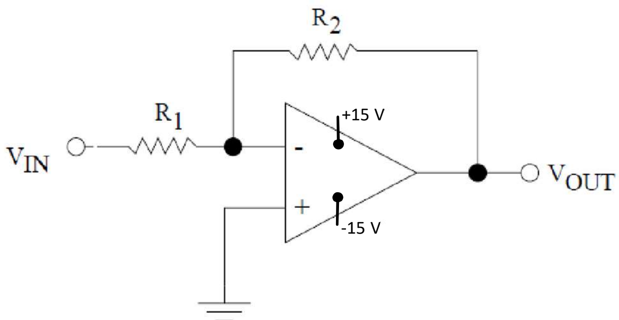

Figure 13.2: Inverting amplifier configuration.

We can use our rules to analyze this circuit. Since input + is connected to ground, then by rule 1, input − is also at ground. For this reason, the input − is said to be at *virtual ground*. Therefore, the voltage drop across R_1 is $v_{in} - v_- = v_{in}$, and the voltage drop across R_2 is $v_{out} - v_- = v_{out}$. So, applying Kirchoff's first law to the node at input −, we have, using golden rule 2:

$$i_- = 0 = i_{in} + i_{out} = v_{in}/R_1 + v_{out}/R_2 \text{ or}$$
$$G = v_{out}/v_{in} = -R_2/R_1$$

4) Non-inverting Amplifier

This configuration is given in Fig. 3. Again, its basic properties are easy to analyze in terms of the golden rules.

$$v_{in} = v_+ = v_- = v_{out}\left[\frac{R_1}{R_1 + R_2}\right]$$

Where the last expression is from our voltage divider result. Therefore, rearranging gives

$$G = v_{out}/v_{in} = \frac{R_1 + R_2}{R_1} = 1 + \frac{R_2}{R_1}$$

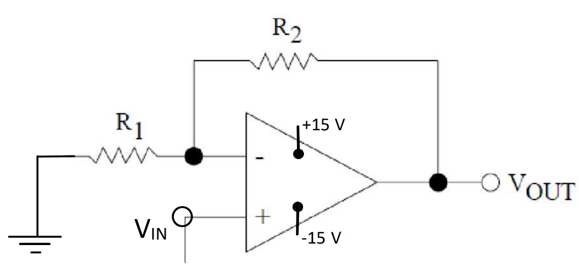

Figure 13.3: Non-inverting amplifier configuration.

Procedure

A. Inverting Amplifier

1) Set up the circuit of the figure.2, where R_1=1 kΩ, R_2=1.5 kΩ and V_{IN} is a sinusoidal signal having a frequency f = 1 kHz

2) Vary the input amplitude V_{inMax} and measure the output amplitude V_{outMAX}, using the oscilloscope, to feel the table below.

V_{inMax} (V)	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2
V_{outMax}(V)											

Table13.1

B. Non-Inverting Amplifier

1) Set up the circuit of the figure.3, where R_1=1.5 kΩ, R_2=3.3 kΩ and V_{IN} is a sinusoidal signal having a frequency f = 1 kHz.

2) Vary the input amplitude V_{inMax} and measure the output amplitude V_{outMAX}, using the oscilloscope, to feel the table below.

V_{inMax} (V)	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2
V_{outMax}(V)											

Table 13.2

Conclusions & Comments:

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