GLP-F020

اسم القسم: هندسة تقنيات الأجهزة الطبية / اسم المختبر: النظم الالكترونية الطبية / المرحلة: الثالثة / رمز المختبر: BL 406

سجل التجارب للعام الدراسي 2023-2024

Experiment No.1: Operational Amplifiers

Objectives:

The objective of this experiment is to study operational amplifiers (op-amp) and its applications. We will be familiar with some basic op-amp circuits, including the most common types, i.e., the inverting, and non-inverting amplifiers.

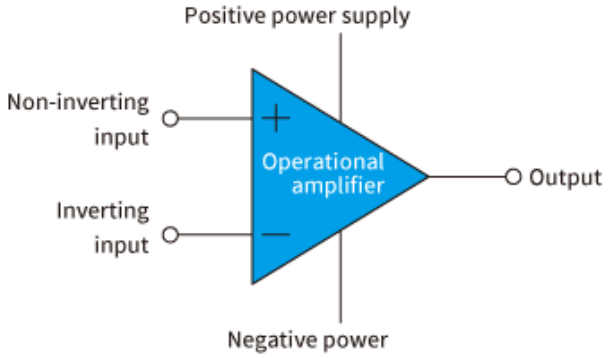
Introduction:

An Operational Amplifier, or op-amp for short, is fundamentally a voltage-amplifying device designed to be used with external feedback components such as resistors and capacitors between its output and input terminals. These feedback components determine the resulting function or "operation" of the amplifier and by virtue of the different feedback configurations whether resistive, capacitive, or both, the amplifier can perform a variety of different operations, giving rise to its name of "Operational Amplifier".

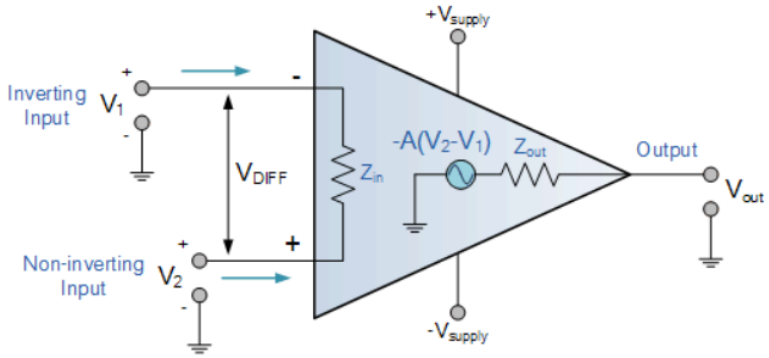
An *Operational Amplifier* is a three-terminal device that consists of two high-impedance inputs. One of the inputs is called the Inverting Input, marked with a negative or "minus" sign, (–). The other input is called the Non-Inverting Input, marked with a positive or "plus" sign (+).

A third terminal represents the operational amplifier's output port which can both sink and source either a voltage or a current. In a linear operational amplifier, the output signal is the amplification factor, known

as the amplifier gain (A) multiplied by the value of the input signal, and depending on the nature of these input and output signals, there can be four different classifications of operational amplifier gain.



Equivalent Circuit of an Ideal Operational Amplifier:



➢ Op-amp Parameter and Idealised Characteristic

- **Open Loop Gain, (A_{vo})**
  - **Infinite** – The main function of an operational amplifier is to amplify the input signal and the more open loop gain it has the better. Open-loop gain is the gain of the op-amp without positive or negative feedback and for such an amplifier the gain

will be infinite but typical real values range from about 20,000 to 200,000.

- **Input impedance, (Z_{IN})**
  - **Infinite** – Input impedance is the ratio of input voltage to input current and is assumed to be infinite to prevent any current from flowing from the source supply into the amplifier's input circuitry ($I_{IN} = 0$). Real op-amps have input leakage currents from a few pico-amps to a few milli-amps.

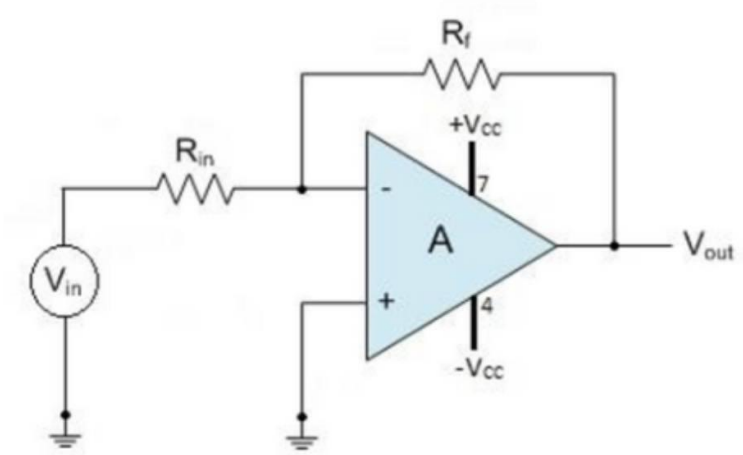
- **Output impedance, (Z_{OUT})**
  - **Zero** – The output impedance of the ideal operational amplifier is assumed to be zero acting as a perfect internal voltage source with no internal resistance so that it can supply as much current as necessary to the load. This internal resistance is effectively in series with the load thereby reducing the output voltage available to the load. Real op-amps have output impedances in the 100-20kΩ range.

- **Bandwidth, (BW)**
  - **Infinite** – An ideal operational amplifier has an infinite frequency response and can amplify any frequency signal from DC to the highest AC frequencies so it is therefore assumed to have an infinite bandwidth. With real op-amps, the bandwidth is limited by the Gain-Bandwidth product (GB), which is equal to the frequency where the amplifier gain becomes unity.

- **Offset Voltage, (V_{IO})**
  - **Zero** – The amplifier's output will be zero when the voltage difference between the inverting and the non-inverting inputs is zero, the same, or when both inputs are grounded. Real op-amps have some amount of output offset voltage.

Inverting Operational Amplifier:

The inverting operational amplifier is a constant or fixed-gain amplifier producing a negative output voltage as its gain is always negative.

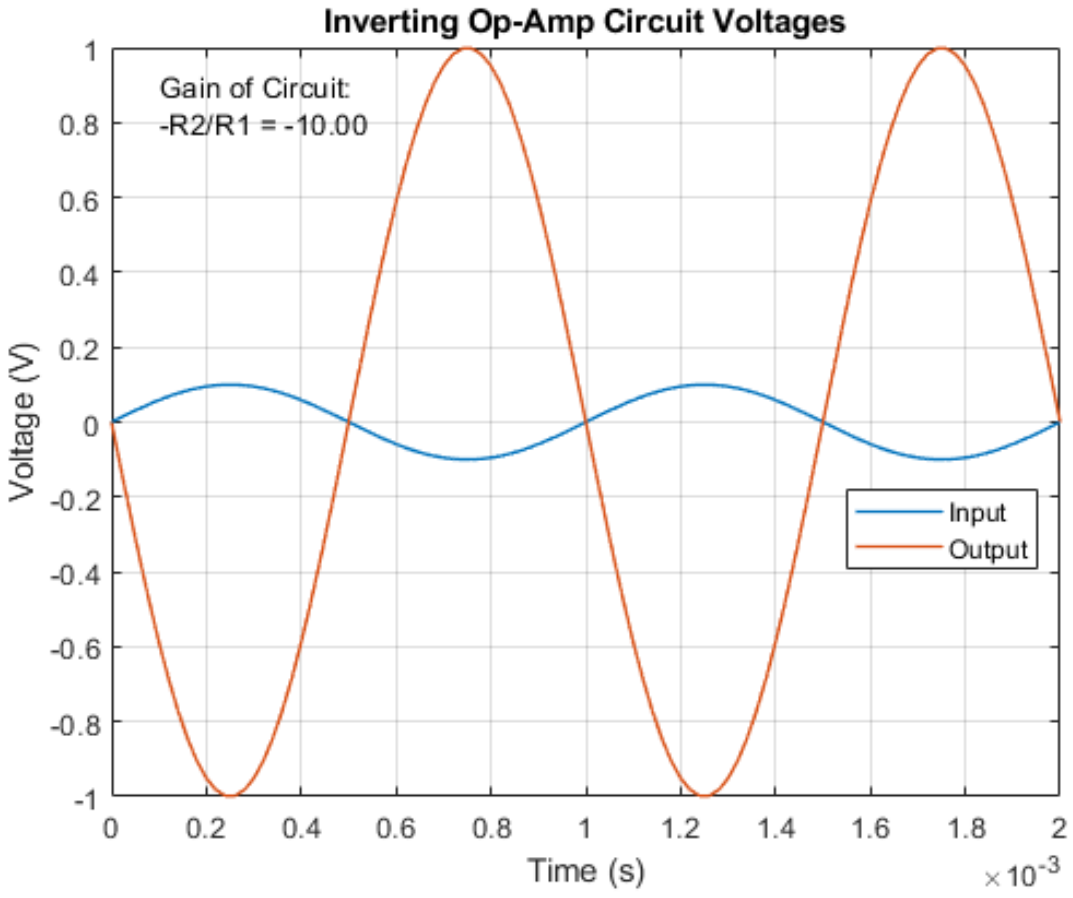


Procedure:

1. Connect the $(+A_C)$ source to the positive terminal of R_1 and the negative terminal of R_1 to the inverting terminal op Op-amp.
2. Connect R_f between inverting and V_{out} terminals of Op-amp.
3. Connect +dc source to +Vcc and –dc to –Vcc.

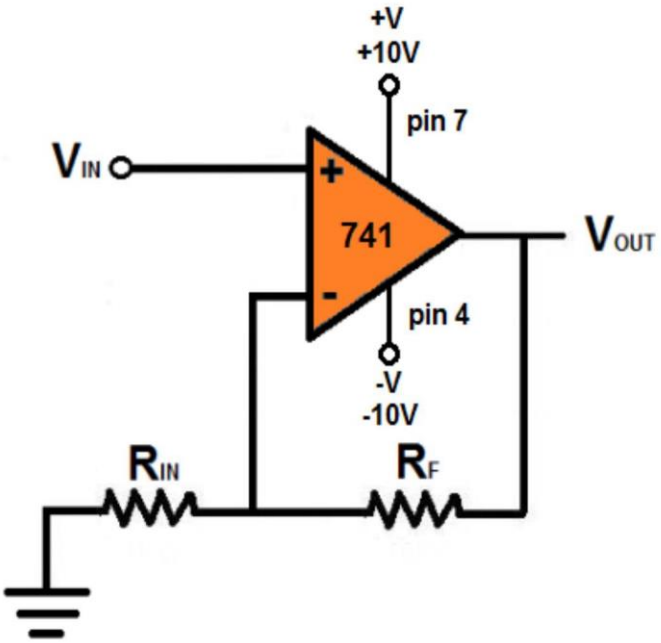
4. Connect the Non-inverting terminal of Op-amp to the ground.
5. Connect the $(-A_C)$ to the ground.
6. Connect the first channel of the oscilloscope to the inverting terminal of Op-amp and ground.
7. Connect the second channel of the oscilloscope to V_{out} terminal of Op-amp and ground.

The output will be as seen in the figure below.



Non-inverting Operational Amplifier:

In a non-inverting operational amplifier configuration, the input voltage signal, (V_{IN}) is applied directly to the non-inverting (+) input terminal which means that the output gain of the amplifier becomes "Positive" in value in contrast to the "Inverting Amplifier" circuit we saw in the last tutorial whose output gain is negative in value. The result of this is that the output signal is "in-phase" with the input signal.

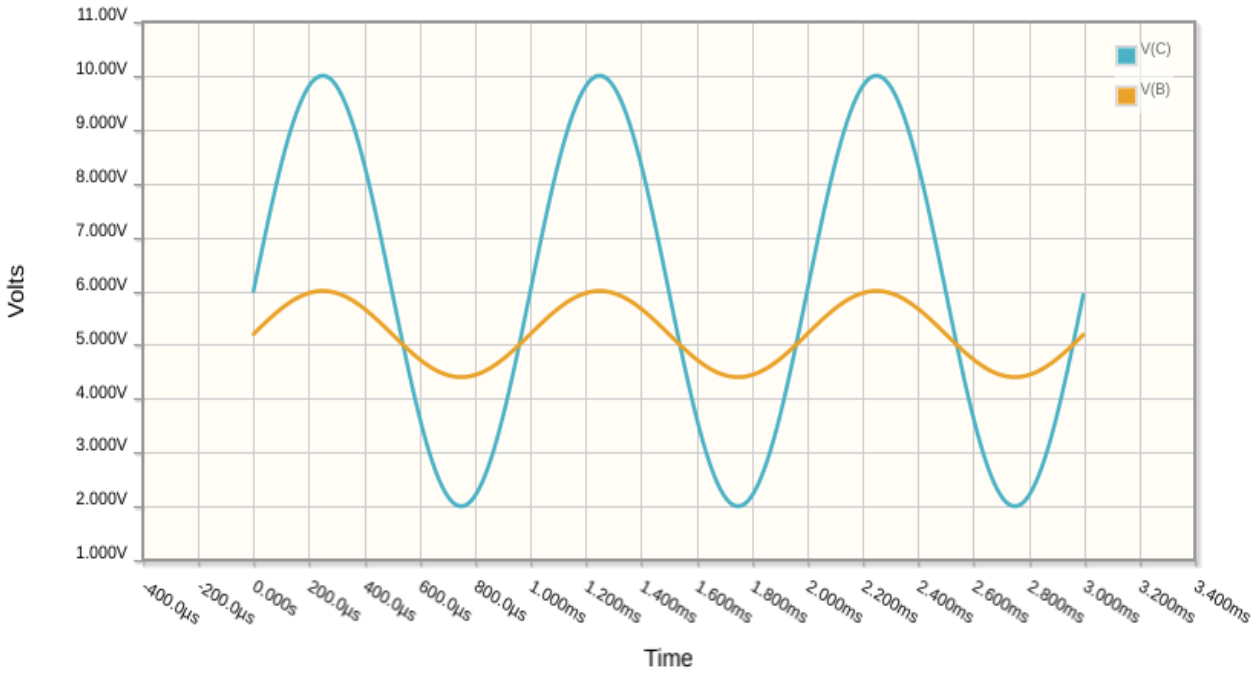


Procedure:

1. Connect the $(+A_C)$ source to the Non-inverting terminal op Op-amp and $(-A_C)$ to the ground.
2. Connect the positive terminal of R_1 to the ground and the negative terminal of R_1 to the inverting terminal op Op-amp.

3. Connect R_f between inverting and V_{out} terminals of Op-amp.
4. Connect +dc source to +Vcc and –dc to –Vcc.
5. Connect the first channel of the oscilloscope to the Non-inverting terminal of Op-amp and ground.
6. Connect the second channel of the oscilloscope to V_{out} terminal of Op-amp and ground.

The output will be as seen in the figure below.



Discussion:

1. What is an operational amplifier?
2. State assumptions made for analyzing ideal op-amp.
3. What is a voltage transfer curve of an op-amp?
4. Why open-loop op-amp configurations are not used in linear applications?
5. List the parameters that should be considered for ac and dc applications.
6. Define offset voltage as applied to an op-amp
7. What kind of negative feedback is present in a noninverting op-amp
8. What is an inverting amplifier?
9. What are the applications of an inverting amplifier?