

Amplification

Objective

The objective of this lab is to demonstrate the basic characteristics an Op amplifier.

Equipment List

- Computer running Windows (NI ELVIS installed)
- National Instruments DAQ board (inside computer).
- General purpose Op-Amp (e.g. 741 op-amp)
- Assortment of resistors (10k Ω , and 100k Ω)
- Wires for connecting the previous equipment together.

Introduction

In this experiment, we will assume that the supply voltages for all op-amp circuits are +15 and –15 volts.

Operational Amplifiers or op-amps are the heart and soul of all modern electronic instruments. Their flexibility, stability and ability to execute many functions make op-amps the ideal choice for analog circuits. Historically, op-amps evolved from the field of analog computation where circuits were designed to add, subtract, multiply, integrate, differentiate etc. in order to solve differential equations found in many engineering applications. Today analog computers have been mostly replaced by digital computers; however the high functionality of op-amp circuits remains its legacy and op-amps are found in countless electronic circuits and instruments.

The op-amp is basically a very high gain differential amplifier with bipolar output. The op-amp transfer curve states that the output voltage, V_{out} is given by

$$V_{out} = -A (V_- - V_+) = -A (\Delta V) \quad (1)$$

where A is the open loop gain, V_- is the inverting input voltage and V_+ is the non-inverting input voltage. The negative sign in front of the gain term (A) inverts the output. The gain (A) can be defined as the ratio of the magnitude of the output voltage (V_{out}) to the input difference voltage ΔV . In practical op-amps, the gain can be from 10,000 to 20,000,000. Only a very small input signal is required to generate a large output. For example, if the op-amp gain is one million, a 5 microvolt input would drive the op-amp output to 5 volts.

Most op-amps are bipolar. This means that the output can be a positive or negative signal. As a result, two power supply voltages are required to power the op-amp.

The output voltage can never exceed the power supply voltage. In fact the rated op-amp output voltage (V_{\max}) is often a fraction of a volt smaller than the power supply voltage. This limit is often referred to as the + or – rail voltage.

Figure 1 show diagram of 741 in 8-pin DIL.

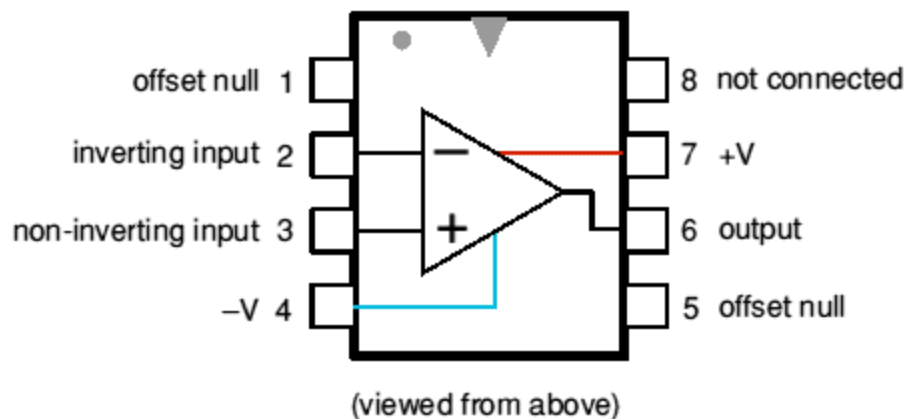


Figure 1. 741 in 8-pin DIL (Dual In Line) pack diagram

Inverting Amplifier

The circuit shown in Figure 1 is probably the most common op-amp circuit. It demonstrates how a reduction in gain produces a very stable linear amplifier. A single feedback resistor labeled R_f is used to feed part of the output signal back into the input. The fact that it is connected to the negative input indicates that the feedback is negative. The input voltage (V_i) produces an input current (i_i) through the input resistor (R_i). Note the differential voltage (ΔV) across the amplifier inputs (-) and (+). The plus amplifier input is tied to ground.

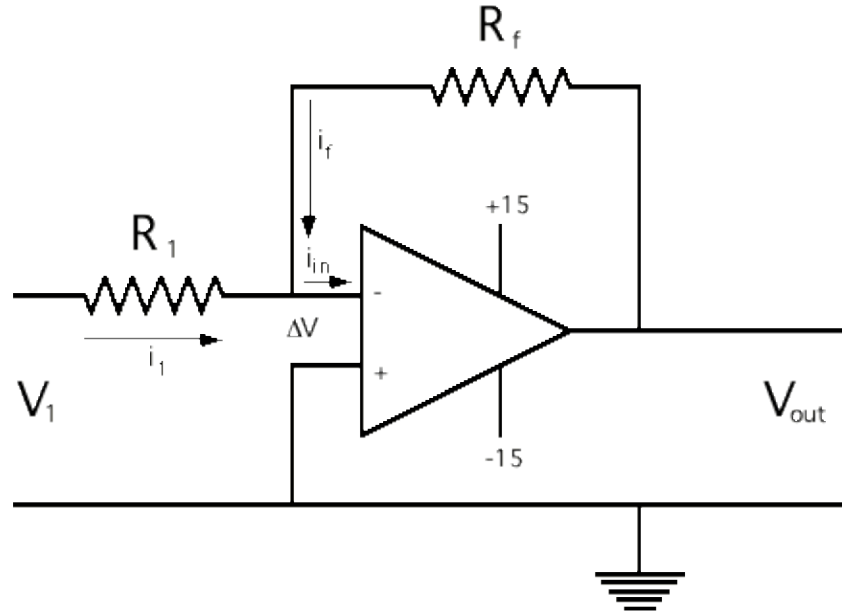


Figure 2. Schematic Diagram for an Inverting Op-Amp Circuit

$$V_{out} = - (R_f / R_1) V_1 = - (G) V_1$$

The ratio (R_f / R_1) is called the closed loop gain (G) and the minus sign tells us that the output is inverted. Note that the closed loop gain can be set by the selection of two resistors, R_1 and R_f .

Procedure

Test Circuit: Inverting Op-Amp Circuit

- On your NI ELVIS Prototyping build the inverting amplifier circuit shown in Figure 2 (shown pictorially in Figure 4).
 - Connect the **+15V DC Power Supply** of the Prototyping Board to the outer Rail closest to the Op-Amp's **Pin 7** on the breadboard.
 - Connect the **-15V DC Power Output** of the Prototyping Board to the outer Rail closest to the Op-Amp's **Pin 4** on the breadboard.
 - Connect the **AIGND** of the Prototyping Board to the inner Rail closest to the Op-Amp's **Pin 3** on the breadboard.
 - Connect the Function Generator **FUNC OUT** to the input of the op-amp circuit.
 - Connect the Oscilloscope **CH A+** to the input of the op-amp circuit.

- Connect the Oscilloscope **CH B+** to the OUTPUT **Pin 6** of the op-amp.

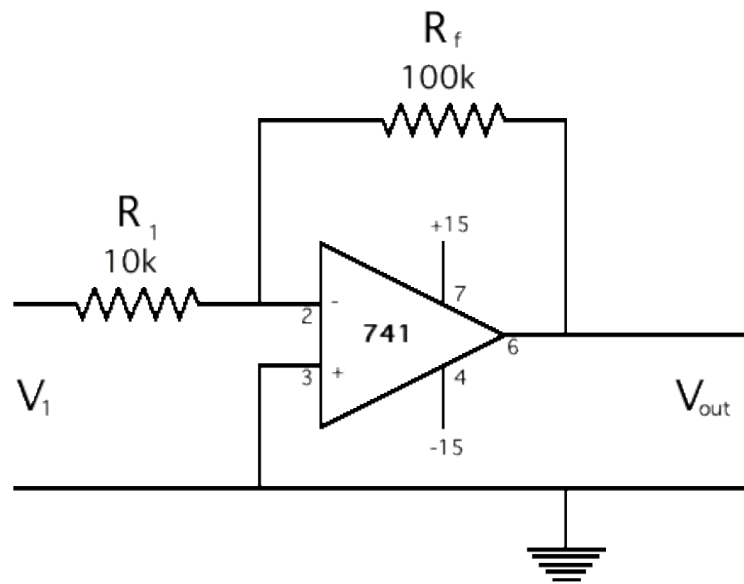


Figure 3. Schematic Diagram for Inverting Amplifier with Gain of 10

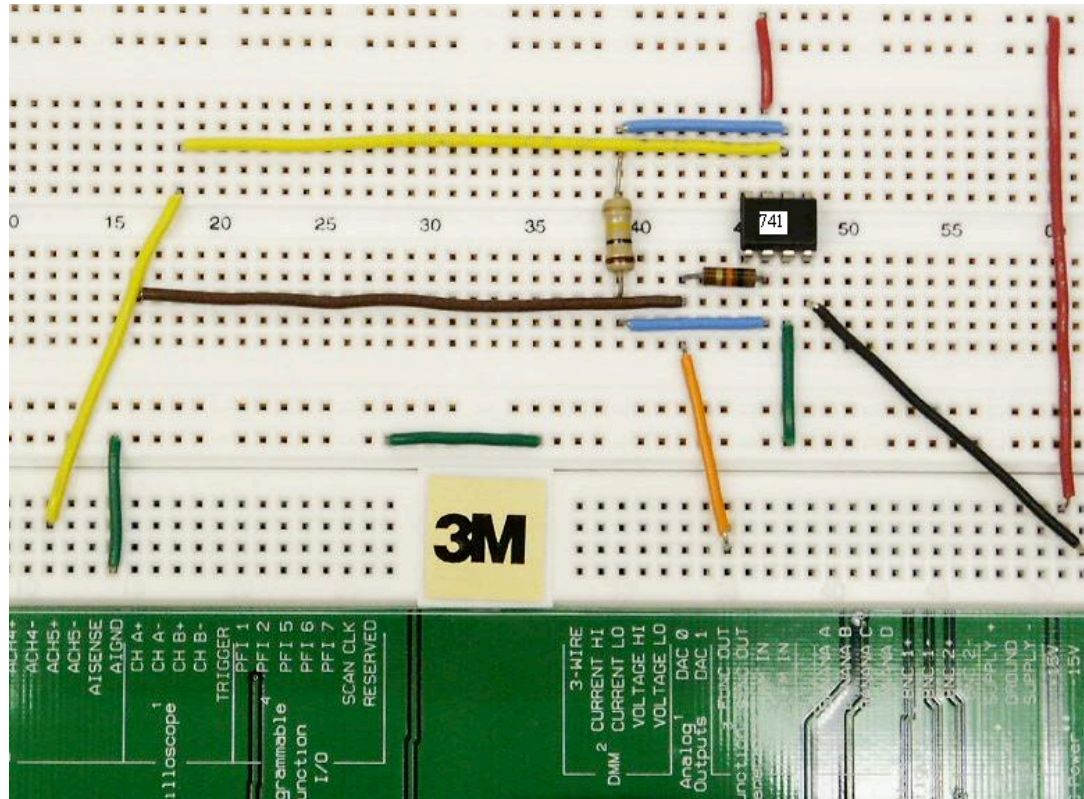


Figure 4. Component Layout for an Inverting Op-Amp Circuit

2. Turn on the NI ELVIS Benchtop Workstation, select **Start»Programs»National Instruments»NI ELVIS 1.0»NI ELVIS**, or select **NI ELVIS on the desktop**. Turn on the **Prototyping Board Power**.
3. Then open **Function Generator**. Select sine wave, and set frequency to 1 kHz, Peak Amplitude to 0.25V. And click **On** on the **Function Generator** panel, as shown in figure 5.

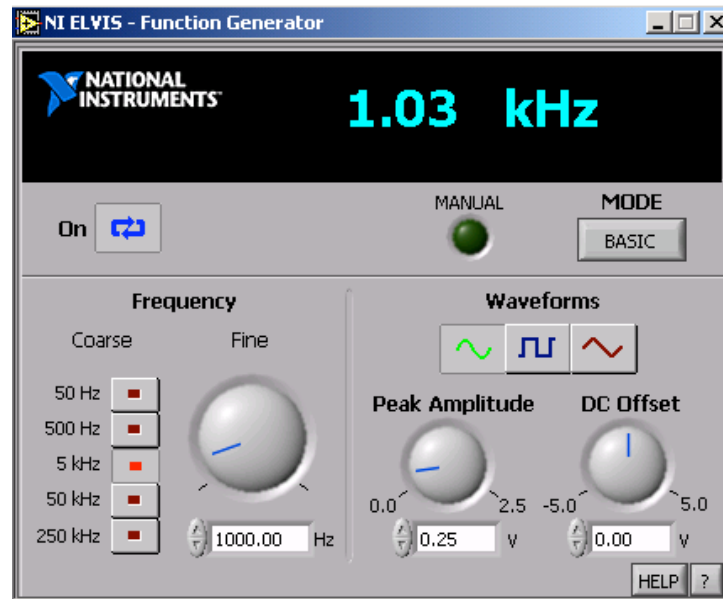


Figure 5. Funuction Generator

4. Open the **Oscilloscope**, Click on the **Run** button, and turn on Channel A and B. Set the **Source** of both channels as shown in figure 6. Both input and output signals are appeared. By click **MEAN**, adjust the **Position** and **Scale**, observe the Vp-p of both signals.

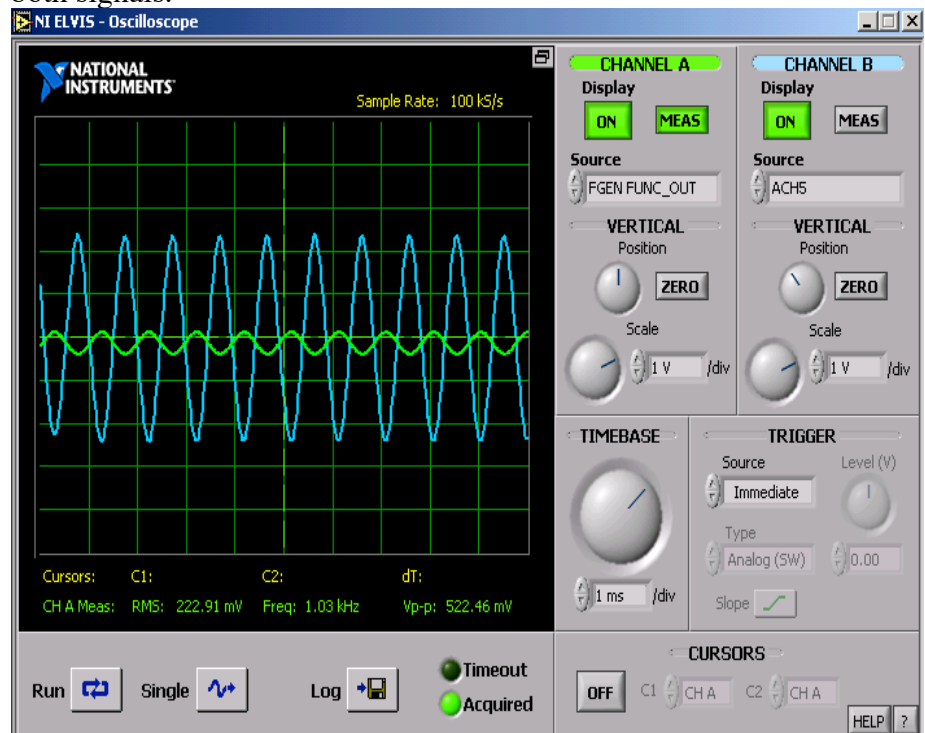


Figure 6. Oscilloscope

5. You can change the input signal levels, and observe the result output signal.
6. When finished testing different input voltages, let your instructor check your result.
7. Turn off the **Oscilloscope** and **Function Generator**. Turn off the Prototyping Board Power and System Power.