VE215 Fall 2017

Lab 2[1]: Op Amp Lab

Manual

I. Goals

i. Learn how to build and test a variety of circuits based on LM 741 Op Amp chip: non-inverting and inverting amplifiers with fixed gain.
ii. Measure the gain of the amplifier and compare it with theoretical calculations.
iii. Determine the saturated output voltage of the amplifier.

II. Introduction

Operational amplifiers (Op Amps) are integrated circuits (ICs) used in many applications. In this lab, you will build and study LM741.

2.1 Op Amp terminals

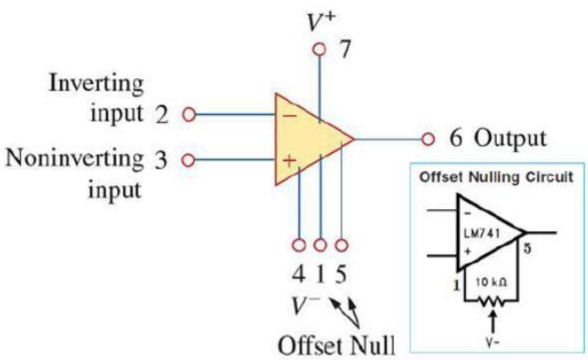


Figure 1. Circuit symbol of a typical op amp.

In Fig1, there are:

Two terminals for input signals: inverting (labeled -) and non-inverting (labeled +)

A terminal for the output signal

Two terminals for the power supply voltages: positive +Vcc and negative –Vcc. (e.g. In this lab, set +Vcc = 5V; -Vcc = -5V.)

Accordingly,, for LM741 op amp chip you see in reality, the pin numbers are shown in Fig2:

[1] This lab manual is based on *Circuits Make Sense*, Alexander Ganago, Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor.

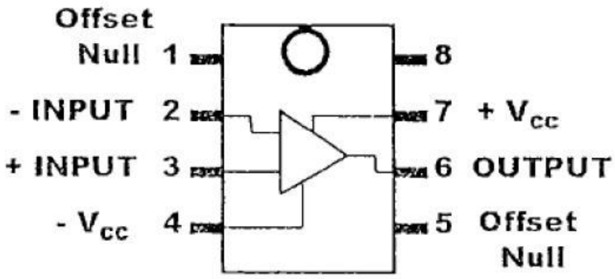


Figure 2. Pin numbers for LM 741 op amp

Note:

Pin #8 is not connected; pins #1 and #5 are not used in this lab.

Do not mistake the connections of input signals (# 2 labeled –and #3 labeled+) for the connections to the power supply (#4 for $-V_{CC}$ and #7 for $+V_{CC}$).

Make sure you connect the grounds of oscilloscope, function generator and DC source together.

2.2 The gain of amplifier circuits

The amplifier circuits are characterized by their gain values. The voltage gain is the ratio of output voltage to the input voltage in the circuit:

$$Voltage\ Gain = \frac{Output\ Voltage}{Input\ Voltage}$$

In the lab, you can use oscilloscope to measure the input and output peak-to-peak (ppk) amplitudes of the signals through two channels at the same time.

2.3 Inverting amplifier

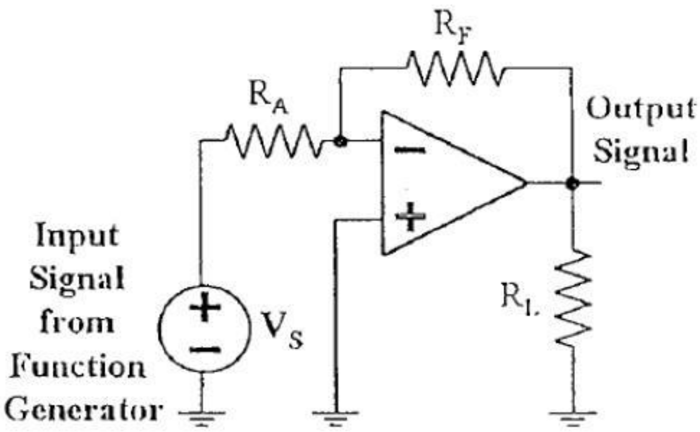


Figure 3. Inverting amplifier.

For inverting amplifier, the theoretical gain should be:

$$Gain = \frac{V_{output}}{V_s} = -\frac{R_F}{R_A}$$

2.4 Non-inverting amplifier

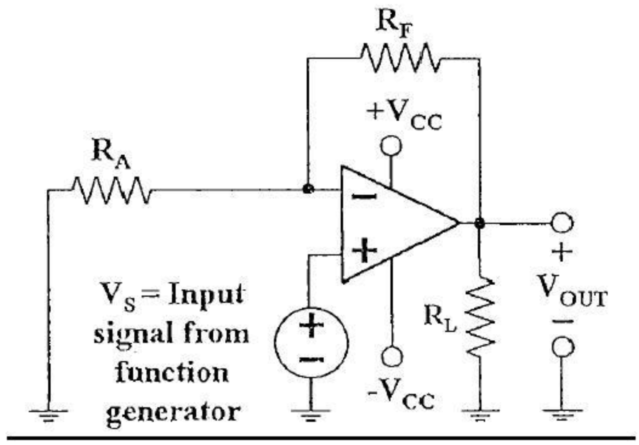


Figure 4. Non-inverting amplifier.

For non-inverting amplifier, the theoretical gain should be:

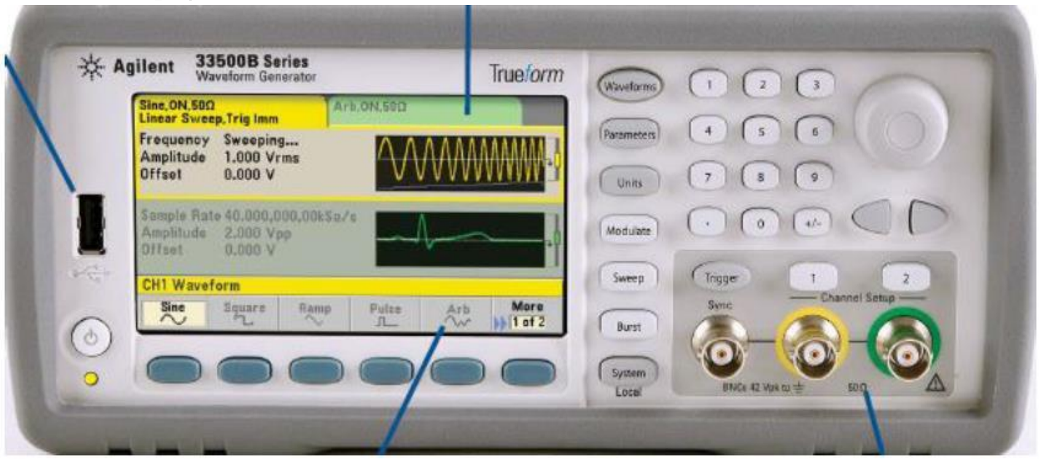
$$Gain = \frac{V_{output}}{V_S} = 1 + \frac{R_F}{R_A}$$

III. Apparatus

Apart from the DC source you are already familiar with in Lab 1, we are going to use function generator and oscilloscope this time.

3.1 Function generator

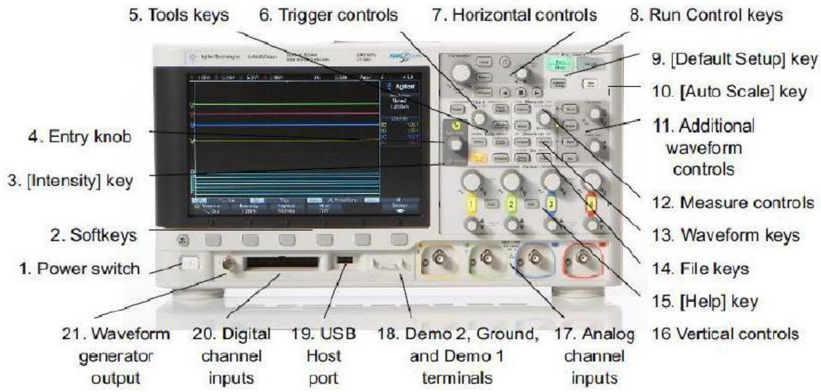
Check the next page about the main buttons we would use



- "Parameter": to change the amplitude, frequency of wave to generate. **Note:** The amplitude here equals to half of the pp value (i.e. If you set a wave whose amplitude is 100mV, the measured pp value would be 200 V_{pp} where the subscript pp means peak to peak value).

  "1"/ "2": to switch on the channel.

3.2 Oscilloscope

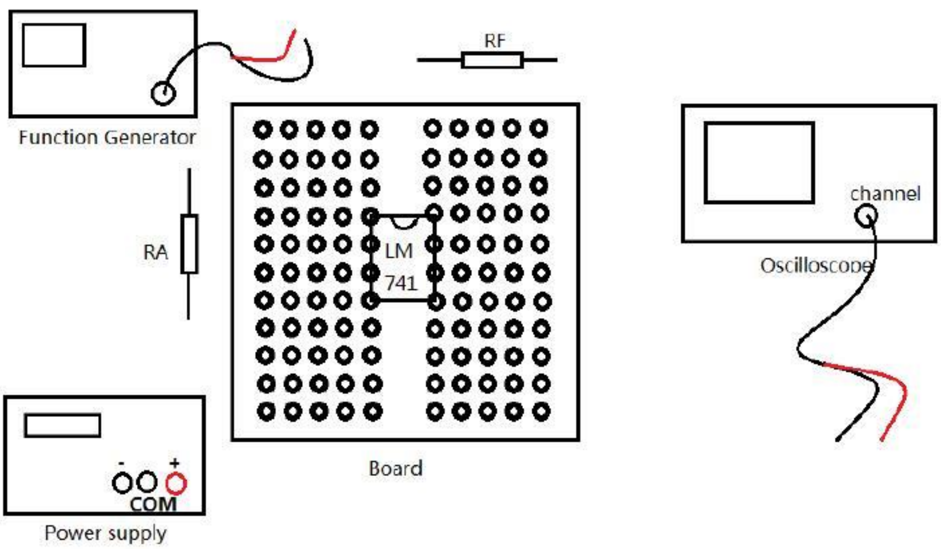


"Auto scale": to automatically achieve an output on the screen with proper scale
"Meas": to turn on the measurement of the wave
"1"/"2": to show or hide the wave you detecting through channel 1 or 2

IV. Pre-lab Assignment

<u>Finish it before labor you lose your score for this part.</u>

1. What would be the gain of a non-inverting amplifier if R_F=100 and R_A=50? What about an inverting amplifier? (Predict your theoretical result.)
2. What should be connected to pins #4 and #7 of LM741? What about #1 and #5?
3. Should the ground and "–Vcc" be connected together?
4. Connect the components to form a non-inverting amplifierfollowing the steps in procedure part. This question may save you a lot of troubles during the lab.

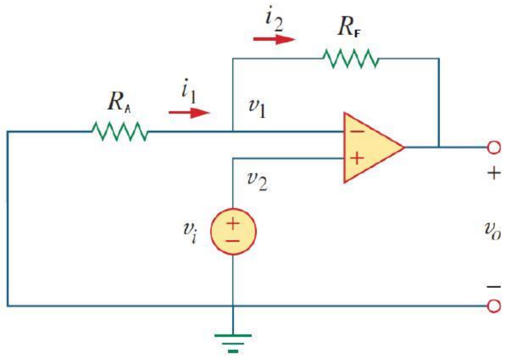


V. Procedure

5.1 Non-inverting amplifier

You are going to build a non-inverting amplifier in this part.

1. Build the circuit according to the figure below. (You may refer to Fig.2).R_F =100, R_A=50. Note:
   a) Use the power supply to provide $+V_{cc}$=+5V and $-V_{cc}$=-5V to the op amp.
   b) Use the **COM** port on the power supply as the **ground** in the schematic.

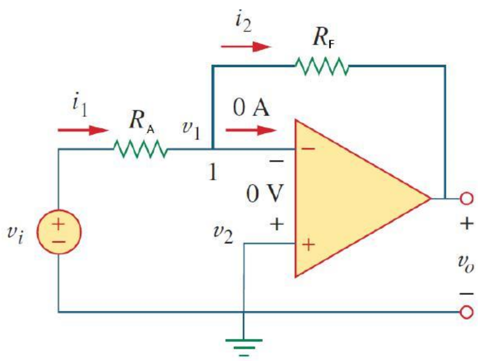


2. Use the function generator to generate a sine wave, and use it as the input voltage (V_i in the figure above). Set the initial amplitude of the sine wave to 0.1V_{pp}. Use the oscilloscope to measure the output voltage (V_o in the figure above).
3. Increase the input voltage by 0.1V_{pp} each time and record the corresponding output until the output voltage is saturate, which means the output voltage is not increasing any more as the input voltage increases.

5.2 Inverting amplifier

You are going to build an inverting amplifier in this part.

1. Build the circuit according to the figure below. (You may want to refer to Fig.2). RF =100, RA=50. Note:
   a) Use the power supply to provide $+V_{CC}$=+5V and $-V_{CC}$=-5V to the op amp.
   b) Use the COM port on the power supply as the ground in the schematic.



2. Use the function generator to generate a sine wave, and use it as the input voltage (v_i in the figure above). Set the initial amplitude of the sine wave to 0.1V_{pp}. Use the oscilloscope to measure the output voltage (v_o in the figure above).
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until the output voltage is saturate, which means the output voltage is not increasing any more as the input voltage increases.

VI. Post-lab

In your post-lab report, you are required to do the following things:

1. You have to give a plot which illustrates the relation between the input voltage and the output voltage ($v_{pp(out)}$ versus $v_{pp(in)}$).
2. Calculate the gain of your amplifier based on the data you gather during the lab and give a plot which illustrates the relation between the gain and the input. (gain versus $v_{pp(in)}$)
3. You may compare the difference between the expected gain and the measured gain and perform some error analysis.
4. Using Pspice to simulate the lab circuit is encouraged; bonus is available if you do it correctly.

Reference:

1. *Circuits Make Sense*, Alexander Ganago, Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor.