

Lab 03

Operational Amplifier

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Lab Location

Sensor & Instrumentations Lab

Lab Outcomes:

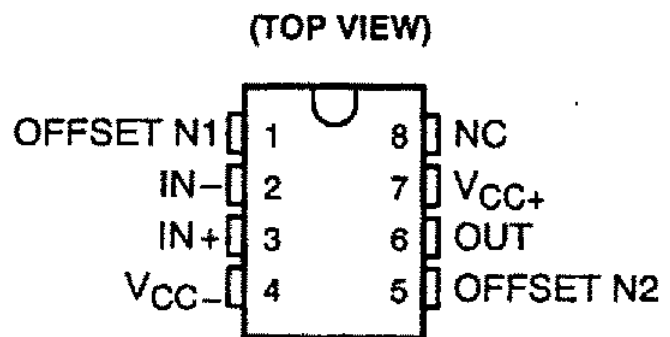
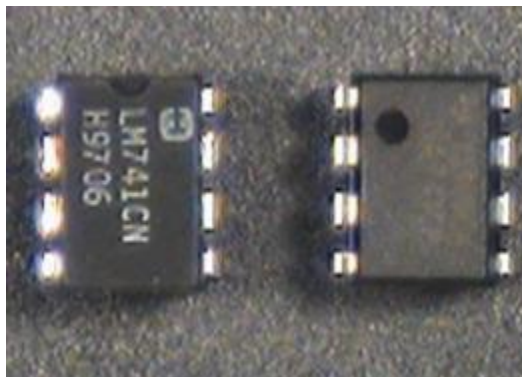
By the end of this lab, students should be able to:

1. Experimental setup for operational amplifier with LM741
2. Develop a circuit op-amp circuit based on desired output

1.0 Operational Amplifier

In real world, how adding and subtracting numbers are achieved? In other words, what is the physical device that adds two numbers! What is the physical device that subtracts two numbers? Furthermore, is there any device that multiplies a number?

Most of the time, operational amplifier is called op-amp. The IC picture and the pin connecting diagram for the most popular op-amp (741) are shown in Figure 1.



¹ I know some of you will say that calculator adds two numbers! What I mean here is how calculator adds two numbers!

Figure 1: Picture of 741 Op-amp and its pin connecting diagram

Notice that the op-amp requires additional power supply V_{CC+} and V_{CC-} . This is because op-amp is an active electrical component. Passive electrical components such as resistor, capacitor and inductor do not require additional power supply. Figure 2 presents the schematic diagram of an operational amplifier.

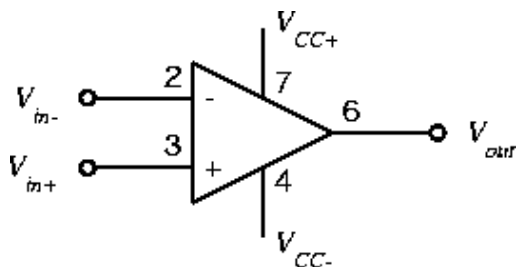


Figure 2: Schematic diagram of an op-amp

Here are the descriptions for each pin.

- Pin 1: We will not use.
- Pin 2: The negative input pin. It is called the inverting terminal. In the schematic, it is represented by the minus symbol inside the triangle.
- Pin 3: The positive input pin. It is called the non-inverting terminal. In the schematic, it is represented by the plus symbol inside the triangle.
- Pin 4: This pin is connected to -15V.
- Pin 5: We will not use.
- Pin 6: The output pin.
- Pin 7: This pin is connected to +15V.
- Pin 8: Not used.

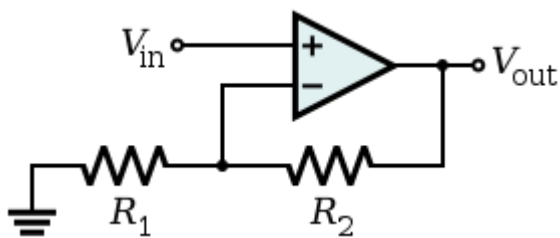
The basic assumptions for the op-amp are (Nise 2004):

1. Differential input: $V_{in+} - V_{in-}$
2. High input impedance: $Z_i = \infty$
3. Low output impedance: $Z_o = 0$
4. High constant gain amplification: $A = \infty$
5. The output: $V_{out}(t) = A(V_{in+} - V_{in-})$

In your class lectures during electronic subject, you have studied the concept of an op-amp and have derived the relationship between the input and the output voltage for two different op-amp configuration namely inverting and non-inverting configurations. In this lab, we are going to practically build the op-amp circuit applications.

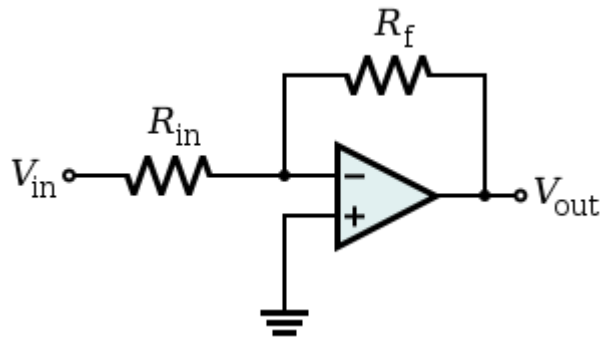
2.0 Basic Single Stage Amplifier

Non-inverting amplifier



$$V_{out} = V_{in} \left(1 + \frac{R_2}{R_1} \right)$$

Inverting amplifier



$$V_{out} = -V_{in} (R_f / R_{in})$$

3.0 Experimental setup

Based on your previous knowledge, you are required to design a circuit that meet the condition:

$$V_{out} = 10 V_{in}$$

741 Op-amp require V_{cc+} and V_{cc-} supply in order to make it operate. In order to achieve that, we can build a virtual ground circuit. The detail of virtual ground circuit will be discussed in the lab. Happy experimenting!!

4.0 Lab Activities

- 1) You are required to submit the details calculation involve in the lab on how to implement operational amplifier circuit for $V_{out} = 10 V_{in}$ for both Non-Inverting and Inverting Amplifier.
- 2) Record at least 5 readings of Op-Amp output and plot the graph of V_{out} against V_{in} for both Non-Inverting and Inverting Amplifier.

References

1. http://en.wikipedia.org/wiki/Operational_amplifier
2. <http://tangentsoft.net/elec/vgrounds.html>
3. Lab Sheet BMM2413 Electronics Lab 01 Operational Amplifier
4. National Semiconductor LM741 Datasheet
5. Norman S. Nise, 2004. **Control Systems Engineering Fourth Edition**, John Wiley & Sons, Inc.
6. <http://hyperphysics.phy-astr.gsu.edu/HBASE/electronic/opampvar2.html>
7. <http://www.bcael.com/opamp.htm>