PART3: BASIC APPLICATIONS OF OPERATIONAL AMPLIFIERS

In this section some applications of Op-Amps are analyzed.
Take Op-Amp supply voltage as $+V_{cc}=15V$ and $-V_{cc}=-15V$. Make sure that the voltage levels are accurate to the first decimal point.

(A) Inverting Amplifier

PROCEDURE:

1. Analyze the inverting amplifier circuit shown in Figure 4 and prove that ,

$$\frac{V_{out}}{V_{in}} = -\frac{R2}{R1}$$

   You have to use Kirchhoff's Current Law at the nodes of the circuit (*use Nodal Analysis*). Also state all the assumptions you made (*Find out whether the requirements to apply Golden Rules are met in the Circuit before you apply those rules*).

2. Connect the circuit in the breadboard and apply a $1V_{pp}$ sinusoidal signal(V_{in}) for frequencies; 50Hz, 100Hz, 500Hz, 1kHz, 10kHz, 50kHz, 100kHz and 500kHz and observe the output waveform (Take $R_2=10k\Omega$ and $R_1=1k\Omega$).
   You have to observe the inversion caused by the amplifier using the Dual Channel mode in the oscilloscope.
   Note: You may have to adjust amplitude of your input signal source for different frequencies since the output amplitude of some signal generators varies with frequency even though you don't adjust the amplitude knob.

3. Then tabulate the following parameters at each of the above frequencies.
   V_{in} (peak to peak), V_{out} (peak to peak), Voltage Gain
   Plot input and output waveforms for 1 kHz signal.

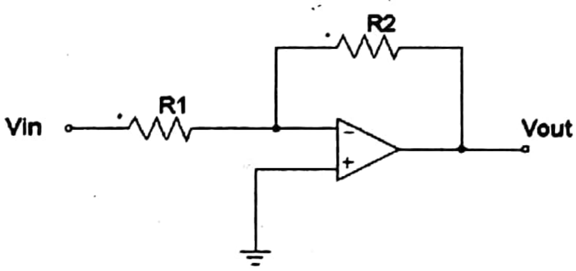

Figure 4. Inverting Amplifier

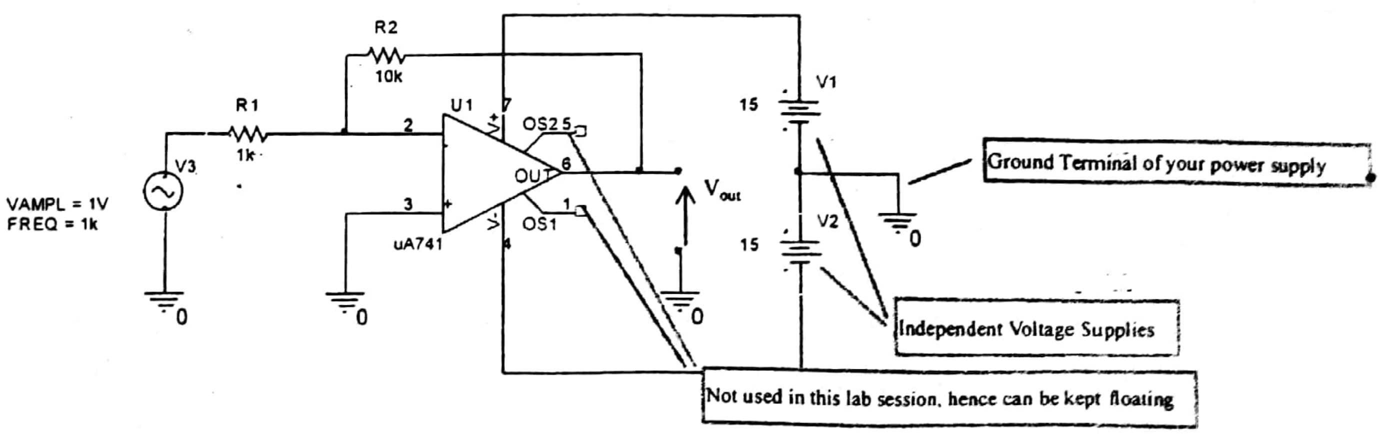

Figure 5. Practical circuit configuration for Inverting Amplifier Design

(B) Non-Inverting Amplifier

PROCEDURE:

1. Analyze the non-inverting amplifier circuit shown in Figure 6 and prove that ,

$$\frac{V_{out}}{V_{in}} = 1 + \frac{R2}{R1}$$

   State all the assumptions you made. (*Find out whether the requirements to apply Golden Rules are met in the Circuit before you apply those rules*)

2. Connect the circuit in the breadboard and apply a 1V_{pp} sinusoidal signal(V_{in}) for frequencies; 50Hz, 100Hz, 500Hz, 1kHz, 10kHz, 50kHz, 100kHz and 500kHz and observe the output waveform (Take R_2=10kΩ and R_1=1kΩ).

4. Then tabulate the following parameters at each of the above frequencies.
   V_{in} (peak to peak), V_{out} (peak to peak), Voltage Gain
   Plot input and output waveforms for 1 kHz signal.

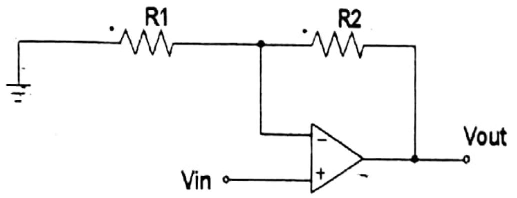

Figure 6. Non-Inverting Amplifier

(c) Adder (Summing Amplifier)

PROCEDURE:

1. Analyze the adder circuit shown in Figure 7 and prove that ,

$$V_{out} = -R_2\left(\frac{V_a}{R_a} + \frac{V_b}{R_b} + \frac{V_c}{R_c}\right)$$

   State all the assumptions you made (*Find out whether the requirements to apply Golden Rules are met in the Circuit before you use apply those rules*).

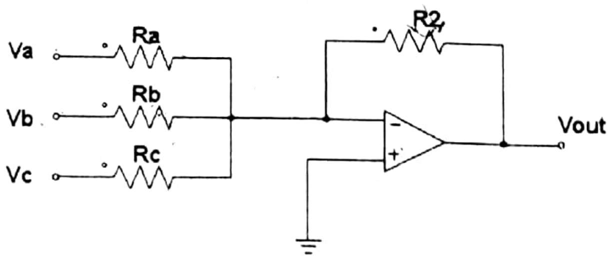

Figure 7. Adder (Summing Amplifier)

2. Connect the circuit in the breadboard without V_c and R_c such that $V_{out} = -R_2\left(\frac{V_a}{R_a} + \frac{V_b}{R_b}\right)$
   Then take R_2= R_a= R_b= 1kΩ such that $V_{out} = - \quad (V_a + V_b)$

3. (a) Take $V_a = V_b = 5V$ and observe the output
(b) Take $V_a = 5V$ and V_b as $1V_{pp}$ sinusoidal signal of 2 kHz and observe the output
(c) Plot input and output waveforms for steps (a) and (b)

(D) Comparator

PROCEDURE:

1. Analyze the comparator circuit shown in Figure 8 and understand its behavior.
Can you apply Golden Rules for this circuit for any purpose? Explain Why?

2. Connect the circuit in the breadboard and apply an input signal as shown in Figure 8.

3. Adjust the rheostat such that $V_+ = -15V$. Then gradually increase V_+ towards +15V using the rheostat.
Observe how the output waveform changes when you change V_+.
Plot the output waveforms for $V_+ = -12V$, -5V, 0V, +5V, +12V

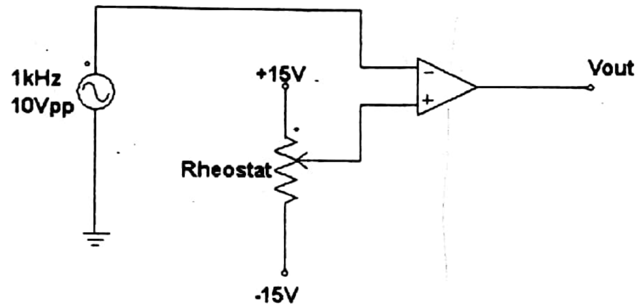

Figure 8. Comparator Circuit

DISCUSSION:

1. Draw the equivalent circuit (model) for an OP-Amp. It should include the terms Z_{in}, Z_{out}, A_v, V_+, V_- and V_{out}. State the ideal values for Z_{in}, Z_{out}, A_v
2. What is meant by the term *Virtual Earth* when an inverting amplifier is considered?
3. What is a *Unity Gain Buffer (Voltage Follower)*?
Explain its operation using your own words (also analyze the circuit and derive an expression for the output in terms of the input)
What are the practical applications of the unity gain buffer?
4. How would you build a Difference amplifier (to amplify the difference between two input signals) using an Op-Amp?
5. What are the practical limitations of *μA741* Op-Amp?

References:

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By Jacob Millman and C. Halkias
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