



F. Y. B. Tech Academic Year 2021-22

Trimester:I

Subject: Basics of Electrical and Electronics Engineering

Name -----

Division -----

Roll No -----

Batch -----

Experiment No: 5

Name of the Experiment: Design of inverting and non-inverting amplifiers using OPAMP.

Performed on: -----

Submitted on: -----

Aim: Design of inverting and non-inverting amplifiers using OPAMP.

Prerequisite:

- Understanding of ideal and practical parameters of OPAMP

Objectives:

- To get familiar with OPAMP as an amplifier
- To identify the pins of an OPAMP such as LM 741
- To measure gain of OPAMP and compare it with theoretical value
- To understand the different configurations of OPAMP

Components and equipment required:

Function generator, CRO, regulated power supply, resistors, capacitors, OPAMP LM741 circuit board, connecting wires, etc.

Theory:

An ‘ideal’ or perfect operational amplifier is a device with certain special characteristics such as infinite open-loop gain A_o , infinite input resistance R_{in} , zero output resistance R_{out} , infinite bandwidth and zero offset (the output is exactly zero when the input is zero). The amplified output signal of an operational amplifier is the difference between the two signals applied to the two inputs. The most commonly available and used of all operational amplifiers in basic electronic circuits is OPAMP 741. The basic symbol of OPAMP is shown in Fig. 7.1 and detailed pin diagram of general purpose OPAMP 741 is shown in Fig. 7.2.

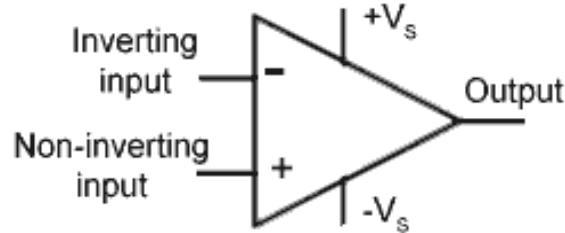


Fig.7.1 Symbol of OPAMP

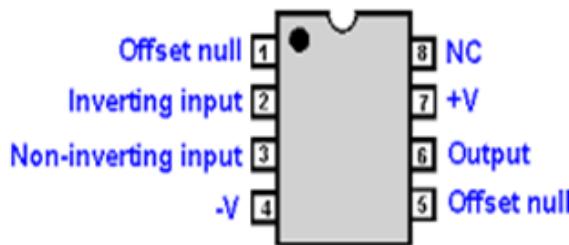


Fig.7.2 Pin diagram of OPAMP 741

Open Loop Gain, (A_{VL}) of an ideal operational amplifier can be very high, as much as 1,000,000 (120 dB) or more. However, this very high gain is of no real use as it makes the amplifier both, unstable and hard to control as the smallest of input signals, just a few microvolts, (μV) would be enough to cause the output voltage to saturate and swing towards one or the other of the voltage supply losing complete control. As the open loop gain of an operational amplifier is extremely high, we can therefore afford to lose some of this high gain by connecting a suitable resistor across the amplifier from the output terminal back to the inverting input terminal to reduce and control the overall gain of the amplifier. This then produces an effect known commonly as negative feedback, and thus produces a very stable operational amplifier.

Table 7.1 Ideal and practical characteristics of OPAMP 741

Sr. No.	Parameter	Ideal	General purpose 741 Op-Amp
1	Open-loop voltage gain, $G_O(V/V)$	∞	2,00,000
2	Input impedance, $Z_{in}(\Omega)$	∞	2 M Ω
3	Output impedance, $Z_o(\Omega)$	0	75 Ω
4	Input Offset current, I_{io} (nA)	0	20 nA
5	Input Bias current, I_{ib} (nA)	0	80 nA
6	Input Offset voltage, V_{io} (mV)	0	2 mV
7	Slew rate, SR (V/ μs)	∞	0.7 V/ μs
8	CMRR	∞	90 dB
9	SVRR / PSRR	∞	96 dB

10	Bandwidth BW	∞	1 MHz
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Negative Feedback is the process of feeding back a fraction of the output signal back to the input, but to make the feedback negative, we must feed it back to the negative or inverting input terminal of the OPAMP using an external feedback resistor called R_f . This effect produces a closed loop circuit to the amplifier resulting in the gain of the amplifier now being called its closed-loop gain. The closed-loop inverting amplifier uses negative feedback to accurately control the overall gain of the amplifier, improves input output impedance, increases the bandwidth but at a cost of reduction of the amplifiers gain. The ideal and practical characteristics of an OPAMP IC 741 are given in Table 7.1. Using negative feedback OPAMP can be used as an inverting and non-inverting amplifier.

Inverting Amplifier:

An inverting-amplifier circuit is built by grounding the positive input of the operational amplifier and connecting resistors R_1 and R_2 , called the feedback networks, between the inverting input and the signal source and amplifier output node, respectively as shown in Fig. 7.3. The analysis of the circuit is performed by relating current I_i with I_f and then calculating the output voltage V_o . Gain of the amplifier is given by:

(7.1)

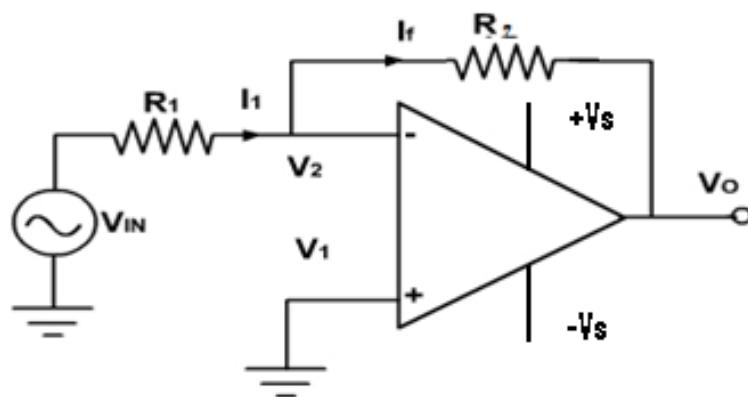


Fig. 7.3 Inverting amplifier configuration of an OPAMP

Non-Inverting Amplifier:

The operational amplifier can also be used to construct a non-inverting amplifier with the circuit indicated in Fig. 7.4. The input signal is applied to the positive or non-inverting input terminal of the operational amplifier, and a portion of the output signal is fed back to the negative input terminal. Analysis of the circuit is performed by relating the voltage at V_2 to both the input voltage V_{in} and the output voltage V_o . Gain of the amplifier is given by:

(7.2)

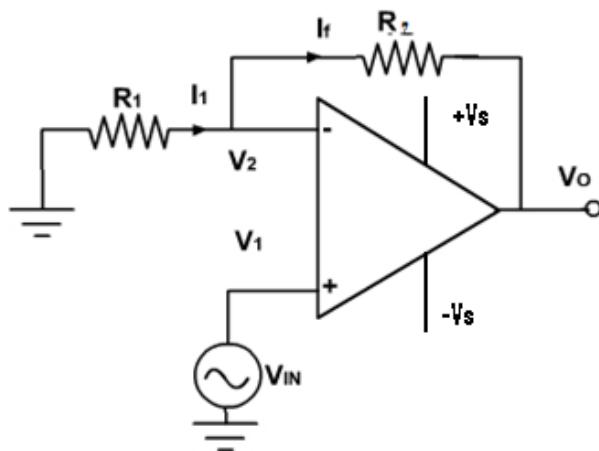


Fig. 7.4 Non-inverting amplifier configuration of an OPAMP

Procedure:

1. Connect the circuit for inverting amplifier as shown in the circuit diagram.
2. Select resistors R_1 and R_2 provided on the circuit board.
3. Set $+V_s$ to $+15$ V and $-V_s$ to -15 V by using the dual power supply and switch on the supply.
4. Apply sine wave input in the range of 500 mV to 1 V using signal generator.
5. Measure the peak to peak input and output voltages on CRO.
6. Calculate theoretical gain value using Eq. 7.1 for inverting amplifier and Eq. 7.2 for non-inverting amplifier and compare it with the experimental value obtained by dividing output voltage by the input voltage.
7. Draw input and output waveforms on the graph sheet.
8. Observe outputs of the amplifier circuit using different values of R_1 and R_2 .
9. Repeat steps 2 to 8 for non-inverting amplifier configuration.

Observation Table:

1. Inverting Amplifier(AC input)

Sr. No.	Input Voltage V_{in}	R_1	R_2	Output Voltage V_o	Gain (Practical) V_o / V_{in}	Gain (Theoretical) $-R_2 / R_1$
1	200mv	10 KΩ	100 KΩ	20 V	-10	-10
2	300mv	20 KΩ	80 KΩ	12 V	-4	-4
3	400mv	10 KΩ	30 KΩ			-3
4	1v	15 KΩ	75 KΩ			-5
5	2v	10 KΩ	60 KΩ			-6

1. Inverting Amplifier(DC input)

Sr. No.	Input Voltage V_i (DC)	R_1	R_2	Output Voltage V_o	Gain (Practical) V_o / V_{in}	Gain (Theoretical) $-R_2 / R_1$
1	200mv	10 KΩ	100 KΩ	20 V	-10	-10
2		20 KΩ	80 KΩ	12 V	-4	-4
3		10 KΩ	30 KΩ			-3
4		15 KΩ	75 KΩ			-5
5	1.5v	10 KΩ	60 KΩ			-6

2. Non-Inverting Amplifier (AC Input)

Sr. No.	Input Voltage $V_{in(AC)}$	R_1	R_2	Output Voltage V_o	Gain (Practical) V_o / V_{in}	Gain (Theoretical) $1 + (R_2 / R_1)$
1	200mv	10 KΩ	100 KΩ	22 V	11	11
2	300mv	20 KΩ	80 KΩ			5
3	400mv	10 KΩ	30 KΩ			4
4	1v	15 KΩ	75 KΩ			6
5	2v	10 KΩ	60 KΩ			7

1. Non-Inverting Amplifier (DC Input)

Sr. No.	Input Voltage V_{in}	R_1	R_2	Output Voltage V_o	Gain (Practical) V_o / V_{in}	Gain (Theoretical) $1 + (R_2 / R_1)$
1	200mv	10 KΩ	100 KΩ	22 V	11	11
2		20 KΩ	80 KΩ			5
3		10 KΩ	30 KΩ			4
4		15 KΩ	75 KΩ			6
5	1.5v	10 KΩ	60 KΩ			7



Note: Students are instructed to do all the necessary calculations on separate sheets.

Conclusion:

Post Lab Questions:

1. What is an operational amplifier?
2. Write applications of positive feedback and negative feedback in OP AMP.
3. Write gain equation for inverting and non-inverting amplifiers of OPAMP?
4. What is OPAMP adder, OPAMP subtractor circuit?

Additional links for more information:

- <http://dei.vlab.co.in/?sub=22&brch=60&sim=1119&cnt=2>
- <http://www.ti.com/lit/ds/symlink/lm741.pdf>