2.3.2

ICT ENABLED TEACHING SUPPORTIVE DOCUMENT

LAB MANUAL

DEPT OF PHYSICS (PG)

PG PHYSICS DEPARTMENT.

OP AMP - IC 741,

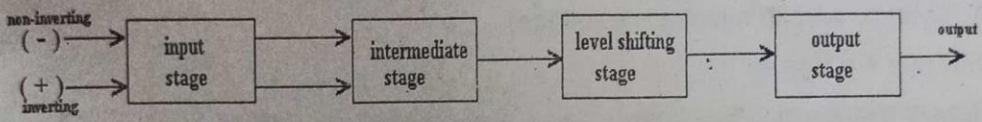
functioning, parameters and specifications

IC 741

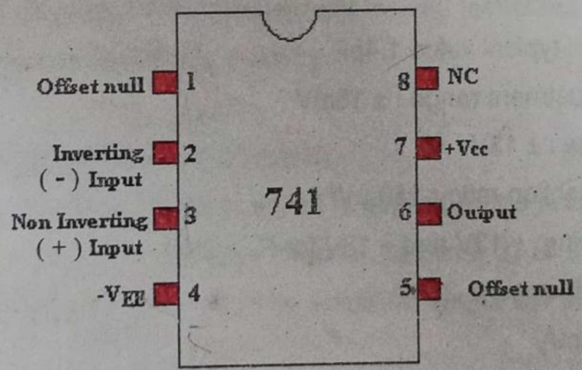
General Description:

The IC 741 is a high performance monolithic operational amplifier constructed using the planer epitaxial process. High common mode voltage range and absence of latch-up tendencies make the IC 741 ideal for use as voltage follower. The high gain and wide range of operating voltage provide superior performance in integrator, summing amplifier and general feed back applications.

Block Diagram of Op-Amp:



Pin Configuration:



Applications:

Used in AC and DC amplifiers, Active filters, Oscillators, Comparators, Regulators, Rectifiers, Integrators & Differentiators, Wave generators etc.

Features:

1. No frequency compensation required.
2. Short circuit protection
3. Offset voltage null capability
4. Large common mode and differential voltage ranges
5. Low power consumption
6. No latch-up

Specifications:

1. Voltage gain A = α typically 2,00,000
2. I/P resistance R_L = α Ω, practically 2MΩ
3. O/P resistance R =0, practically 75Ω
4. Bandwidth = α Hz. It can be operated at any frequency.
5. Common mode rejection ratio = α

   (Ability of op amp to reject noise voltage)
6. Slew rate + α V/μsec

   (Rate of change of O/P voltage)
7. When $V_1 = V_2$, V_D=0
8. Input offset voltage (Rs ≤ 10KΩ) max 6 mv
9. Input offset current = max 200nA
10. Input bias current : 500nA
11. Input capacitance : typical value 1.4pF
12. Offset voltage adjustment range : ± 15mV
13. Input voltage range : ± 13V
14. Supply voltage rejection ratio : 150 μV/V
15. Output voltage swing: + 13V and – 13V for R_L > 2KΩ
16. Output short-circuit current: 25mA
17. supply current: 28mA
18. Power consumption: 85mW
19. Transient response: rise time= 0.3 μs

    Overshoot= 5%

1. Inverting and Non inverting amplifier

Aim: - To construct inverting and non-inverting amplifier and to determine the voltage gain (closed loop gain)

Apparatus required:-

Sl.No	Equipment/Component name	Specifications/Value	Quantity
1	741 IC		1
2	Resistors	50kΩ, 470 kΩ	1 each
3	Regulated Power supply	(0-30V),1A	1
4	Multimeter	3 ½ digit display	2
6	Cathode Ray Oscilloscope	(0-20MHz)	1
7	Function Generator	(0-1MHz)	1

Theory:

Opamp is usually packed in an integrated circuit. Opamp is a high gain direct coupled differential amplifier. The closed loop voltage gain can be controlled by the feedback network the negative terminal of the input is known as the inverting terminal because the output will be 180 out of phase with the input. The positive terminal is known as non-inverting terminal because the output will be in phase with the input. Triangular symbol is used to represent the amplifier package.

The voltage gain of the inverting amplifier is given by

$V_{out} / V_{in} = Av = -R_F / R_S$.

The negative sign indicates Phase reversal of output.

For a non-inverting amplifier the input signal is applied to the non-inverting terminal of the opamp i.e. the input signal is fed to the plus terminal (terminal 3) of the opamp. The inverting terminal (terminal 2) is grounded through R_s. The amplified output will be in phase with the input signal.

$V_{out} = [(R_F + R_S) / R_S] V_{in}$

Closed loop voltage gain $A_V = V_{out} / V_{in} = [(R_F + R_S) / R_S]$

$A_V = 1 + (R_F/R_S)$

Circuit diagrams:

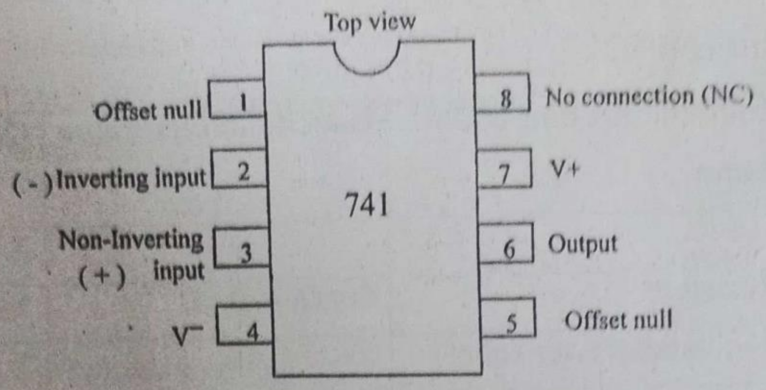


Fig.1: The pinout (base diagram) of a 8 pin IC-741

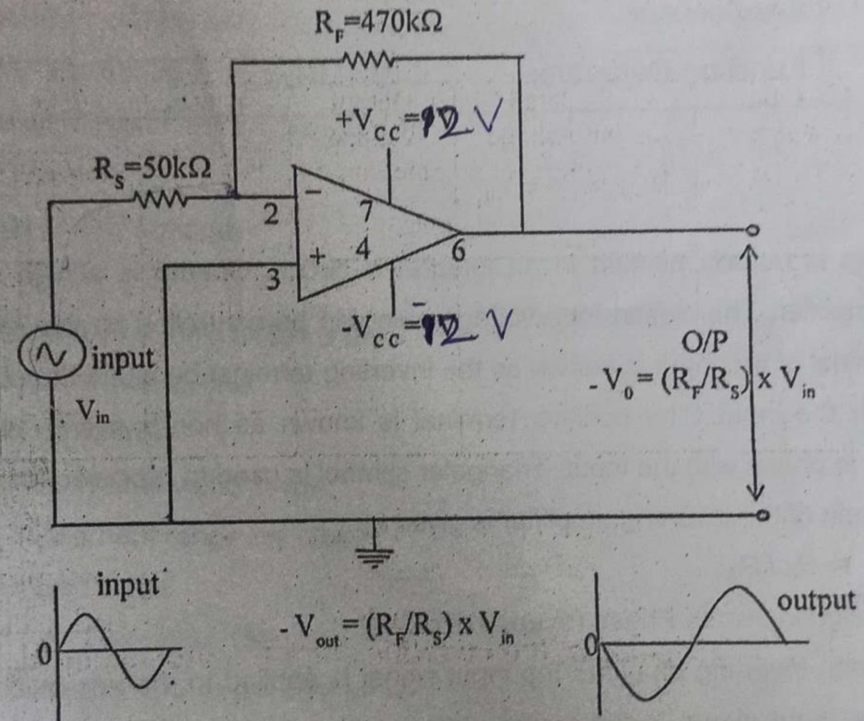


Fig.2: Inverting Amplifier

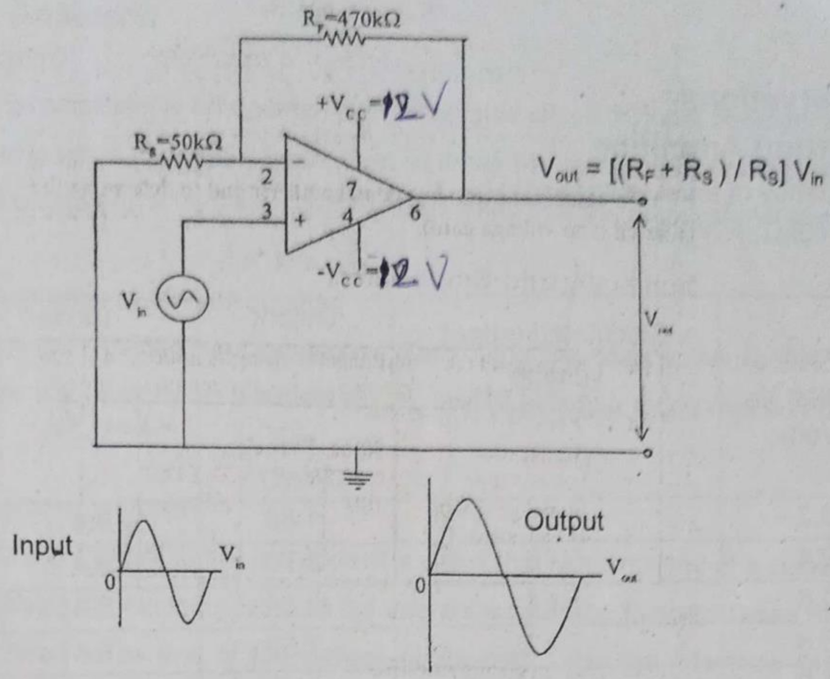


Fig.3: Non-inverting Amplifier

Procedure:

The fabrication of an inverting amplifier is done on the bread board. The positive terminal of the 12V volt dual supply is connected to terminal 7 and the negative terminal of the dual supply to terminal 4. The transistor R_S and R_F are connected as shown in the circuit. An input of about 0.5 volt is supplied to the opamp using a function generator. The output is obtained from terminal 6 with respect to ground.

The input and the output voltage to the opamp is measured using a multimeter or volt meter or a CRO. The corresponding voltage gain V_{out} / V_{in} is calculated. The theoretical value of voltage gain is given by $-R_F/R_S$. The experiment is repeated for different input voltages.

The fabrication of the non-inverting amplifier is done using a bread board. The input is fed to the positive terminal (terminal 3) of the opamp. The inverting terminal (terminal 2) of the opamp is grounded through R_S. The output is in phase with the input. Measure the input and output voltages using a multimeter or voltmeter or CRO. The corresponding voltage gain V_{out} / V_{in} is calculated. The theoretical value of voltage gain is obtained from the equation.

$A_V = V_{OUT} / V_{IN} = 1 + [R_F / R_S]$

The experiment is repeated for various values of input voltages. We can also repeat the experiment by changing the values of R_F and R_S. We can perform the experiment by keeping the values of $R_F = R_S = 50k$. In this case the closed loop voltage gain is 2.

Observations

Inverting Amplifier

Frequency of input voltage=1kHz

R_F=470kΩ, R_S=50k Ω

Input Voltage V_{in} (Volt)	Calculated output voltage $V_{out} = -V_{in} (R_F / R_S)$ (Volt)	Output voltage measured V_{out} (Volt)	Closed loop gain	
			V_{out} / V_{in}	$-R_F / R_S$
0.2	-1.88	-1.88	- 9.4	- 9.4
0.4	-3.76	-3.76	- 9.4	- 9.4
0.6	-5.64	-5.64	- 9.4	- 9.4
0.8	-7.52	-7.52	- 9.4	- 9.4
1.0	-9.40	-9.40	- 9.4	- 9.4

Non- Inverting Amplifier

Frequency of input voltage=1kHz

R_F=470kΩ, R_S=50k Ω

Input Voltage V_{in} (Volt)	Calculated output voltage $V_{out} = [(R_F + R_S) / R_S] V_{in}$ (Volt)	Output voltage measured V_{out} (Volt)	Closed loop gain	
			V_{out} / V_{in}	$(1+R_F / R_S)$
0.2	2.08	2.08	10.4	10.4
0.4	4.16	4.16	10.4	10.4
0.6	6.24	6.24	10.4	10.4
0.8	8.32	8.32	10.4	10.4
1.0	10.4	10.4	10.4	10.4

Result

The voltage gains of the inverting & non-inverting amplifier are tabulated.

Questions & Answers:

1) What is an op-amp?

Ans: An operational amplifier (or an op-amp) is an integrated circuit (IC) that operates as a voltage amplifier. An op-amp has a differential input. That is, it has two inputs of opposite polarity. An op-amp has a single output and a very high gain, which means that the output signal is much higher than input signal.

2) Give the characteristics of an ideal op-amp:

Ans: Infinite voltage gain, Infinite input impedance, Zero output impedance, Infinite bandwidth, Zero input offset voltage (i.e., exactly zero out if zero in), Infinite common mode rejection ratio, Infinite slew rate.

3) What is virtual ground concept?

Ans: A virtual ground (or virtual earth) is a node of a circuit that is maintained at a steady reference potential, without being connected directly to the reference potential. In some cases the reference potential is considered to be that of the surface of the earth, and the reference node is called "ground" or "earth" as a consequence.

4) What is feedback? Which type of feedback is used in linear application?

Ans: An ideal opamp has infinite gain. It amplifies the difference in voltage between the + and - pins. Of course in reality this gain is not infinite, but still quite large The output of the opamp (at to some extents the input also) is constrained by the power supply, we can't get out more than the supply puts in. If we simply put signals into the opamp without feedback it would multiply them by infinity and get a binary output (it would saturate at the supply rails) So, we need some way of controlling the gain. That is what the feedback does.

The feedback (DC as well as AC) takes part of the amplified output from the input, such that the gain is constrained much more by the feedback network, which is predictable, and much less by the massive (and unpredictable) open loop gain.

Exercise:

1. Which type of feedback is used in linear application?
2. What is the necessity of negative feedback?
3. What are 4 building blocks of an op-amp?
4. How a non-inverting amplifier can be courted into voltage follower?

ATTESTED

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