OPAMP (operational amplifier)

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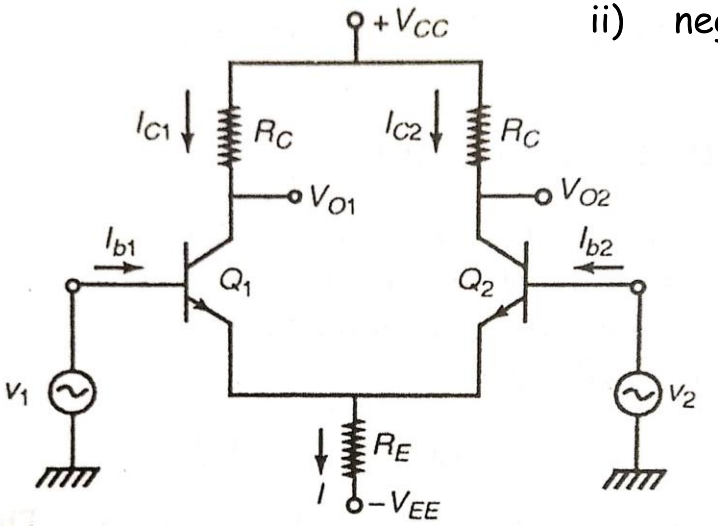
What is opamp?

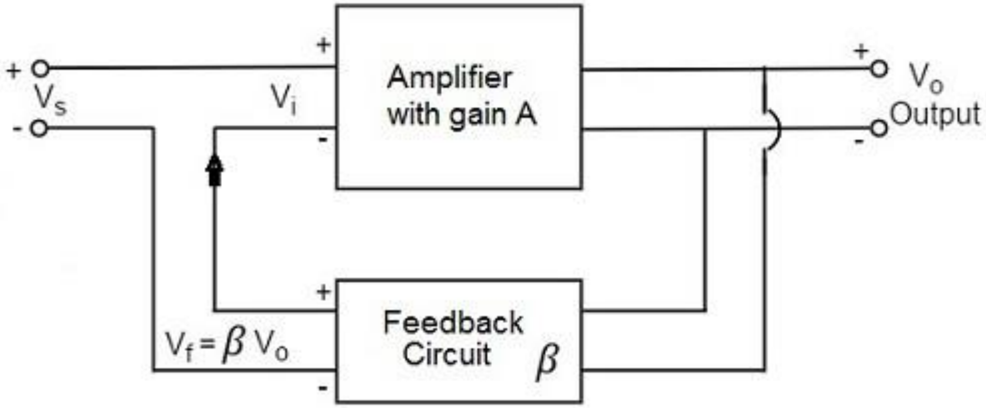
Opamp is a high gain direct couple amplifier whose response characteristics are externally controlled by negative feedback arrangement.

Feedback? A portion of output signal of an amplifier is feedback and superimpose on the input signal.

i) Positive feedback: if the feedback component adds to the i/p signal is in phase with the input signal.

ii) negative feedback: if the feedback component subtracts to the i/p signal is in phase with the input signal.





Why "operational"?

it perform mathematical operation like addition, subtraction, integration, differentiation etc.

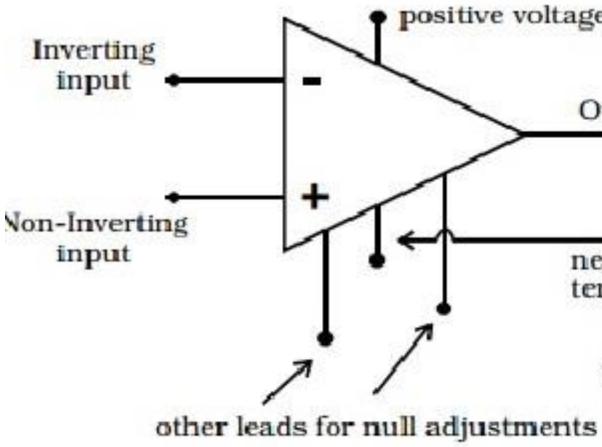
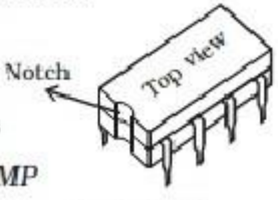
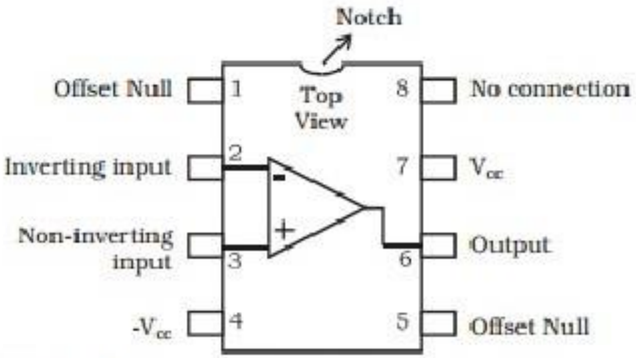


Fig Symbol for OP-AMP



8-pin DIP



OP-AMP Pin-out configuration

IC 741

Characteristics of an ideal opamp:

i) Infinite voltage gain $(A_V = \infty)$

ii) Infinite input resistance $(R_i = \infty)$

iii) Zero output resistance $(R_o = 0)$

iv) Zero output voltage when input voltage is zero

v) Infinite bandwidth

vi) Characteristics not drift with temperature

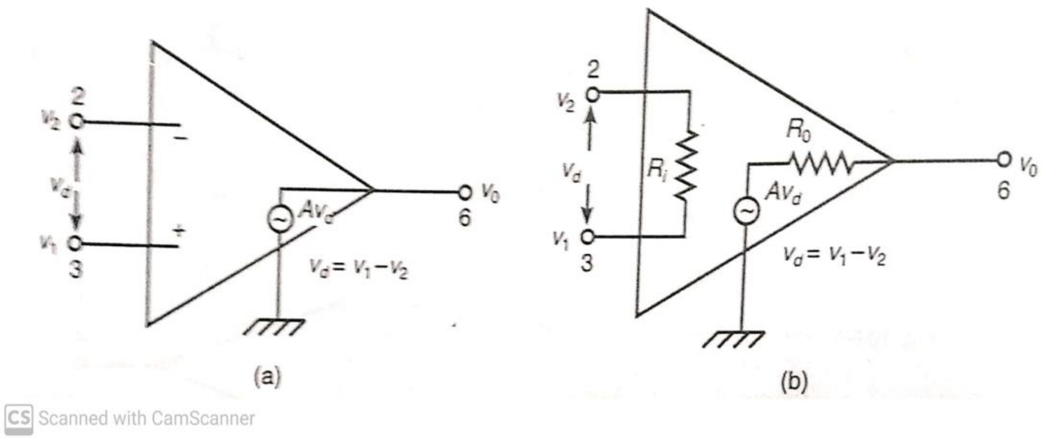
vii) Infinite CMRR

viii) Infinite slew rate

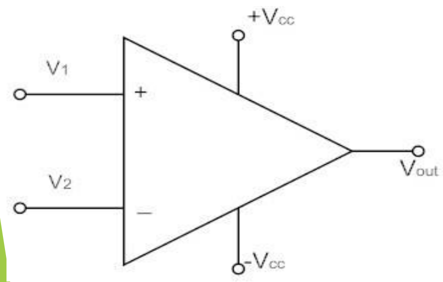
Practical opamp differ from ideal opamp:

Voltage gain 10^3 to 10^6
Input impedence, 150 KΩ to 100 MΩ
o/p impedence 0.75 to 1.00 Ω
BW finite, upto 100 KHz
Practical opamp don't have perfect balance

A.C. equivalent circuit of a) ideal opamp b) practical opamp



Common mode rejection ration (CMRR):



The difference of the input voltage, $V_d = V_1 - V_2$ ---(1)
Average of the input voltage, $V_C = \frac{V_1+V_2}{2}$ ---(2)
$V_0 = A_1V_1 + A_2V_2$---(3)
Solving eq (1) and (2)

$$V_1 = V_C + \frac{V_d}{2}$$

$$V_2 = V_C - \frac{V_d}{2}$$

Putting the value of V_1 and V_2 in eq (3) we get,

$$V_0 = A_1(V_C+\frac{V_d}{2}) + A_2(V_C-\frac{V_d}{2})$$
$$= \frac{1}{2}(A_1 - A_2)V_d + (A_1 + A_2)V_C$$
$$= A_dV_d + A_CV_C$$

Where A_d=$\frac{1}{2}(A_1 - A_2)$=voltage gain for difference signal
A_C=$(A_1 + A_2)$=common mode signal

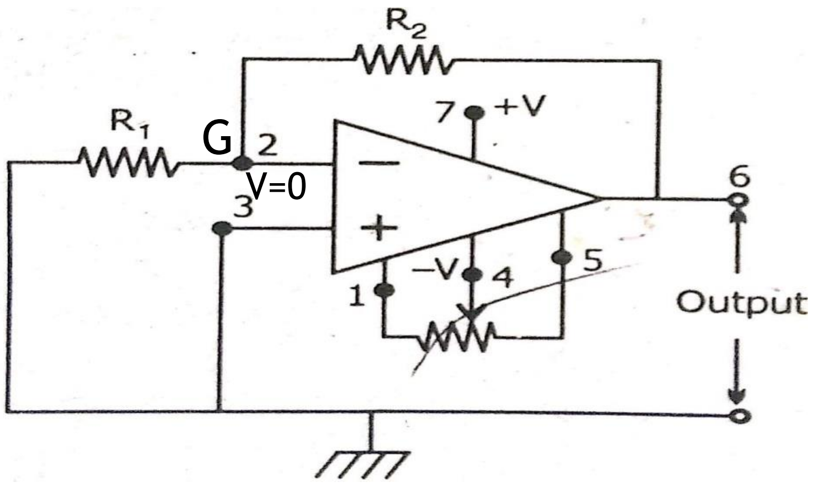
CMRR is the ration between the voltage gain for difference signal and common mode signal.

$$CMRR = \left|\frac{A_d}{A_C}\right|$$

Slew rate:

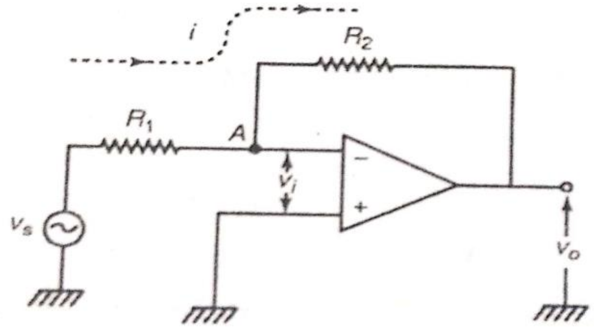
Maximum rate of change of output voltage per unit of time and is expressed in volt per microsecond
SR=$\frac{dV_0}{dt}$ v/μs

Opamp offset null adjustment:



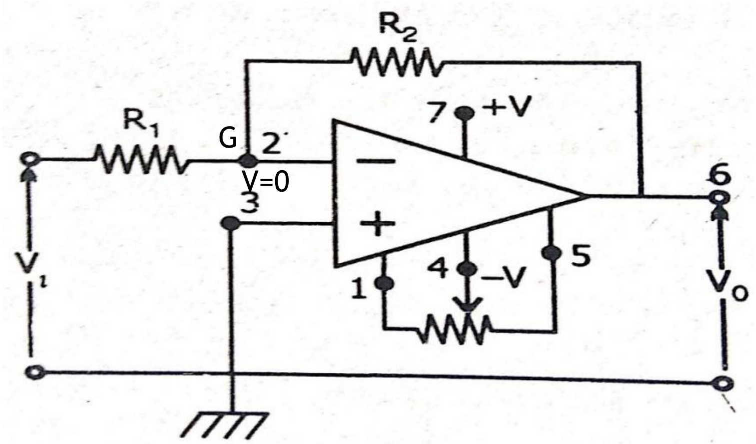
- For some application a small input input offset voltage effect the output voltage. So offset null adjustment are use to minimize the effect of input offset voltage.
- 10 KΩ potentiometer are connected to the pin 1 and 5 while the wiper is connected to −V dc supply.
- The potentiometer knob is adjusted to get zero output voltage.

Concept of virtual ground:



- There is a virtual ground at the point A.
- The word virtual is used to imply that through the point A is effectively connected to ground, no current actually flows into this short.
- It is not actual ground. The concept of virtual ground makes the analysis and understanding of many OPAMP circuits very simple.

Inverting amplifier:



The current through R1 is, $\frac{V_i - V}{R_1}$

The current through R2 is, $\frac{V - V_o}{R_2}$

Due to virtual ground, $\frac{V_i - V}{R_1} = \frac{V - V_o}{R_2}$

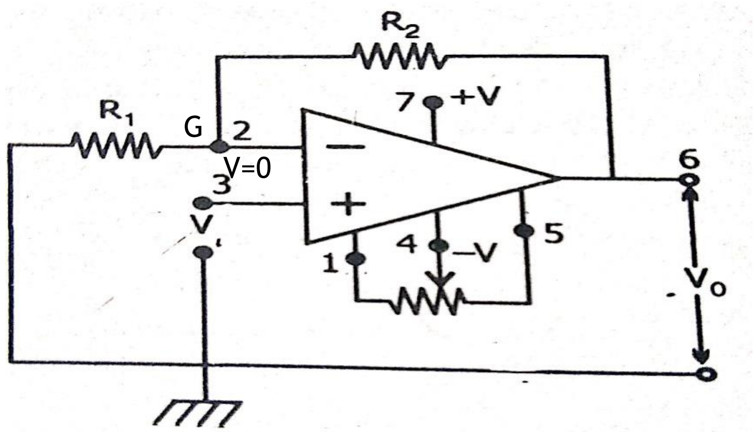
Or, $\frac{V_i}{R_1} = -\frac{V_o}{R_2}$

Or, $V_o = -\frac{R_2}{R_1} V_i$, expression of o/p voltage

Voltage gain, $A_V = \frac{V_o}{V_i} = -\frac{R_2}{R_1}$

The –ve sign signifies that the o/p voltage is inverted with respect to the input voltage.

Non-Inverting amplifier:



The current through R1 is, $\frac{0 - V_i}{R_1}$

The current through R2 is, $\frac{V_i - V_o}{R_2}$

Due to virtual ground, $\frac{-V_i}{R_1} = \frac{V_i - V_o}{R_2}$

Or, $\frac{-V_i}{R_1} = \frac{V_i}{R_2} - \frac{V_o}{R_2}$

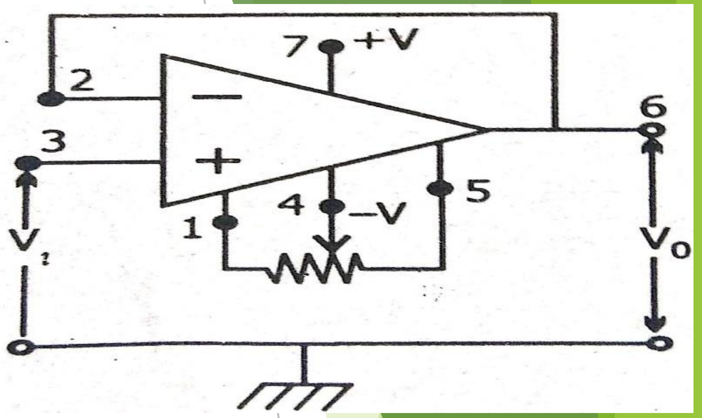
Or, $\frac{V_o}{R_2} = \frac{V_i}{R_2} + \frac{V_i}{R_1}$

Or, $V_o = \left(1 + \frac{R_2}{R_1}\right) V_i$, expression of o/p voltage

Voltage gain, $A_V = \frac{V_o}{V_i} = \left(1 + \frac{R_2}{R_1}\right)$

The +ve sign signifies that there is no phase difference between input and output.

Unity gain buffer:



$$A_V = 1 + \frac{R_2}{R_1}$$

As R_1=α and R_2=0

A_V=1

It allows the i/p voltage to be transferred to the o/p without any change.