Presentation Topic

Name of the course:- Basic Electronics Engineering

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(NBA and NAAC accredited, ISO 9001:2015 certified)

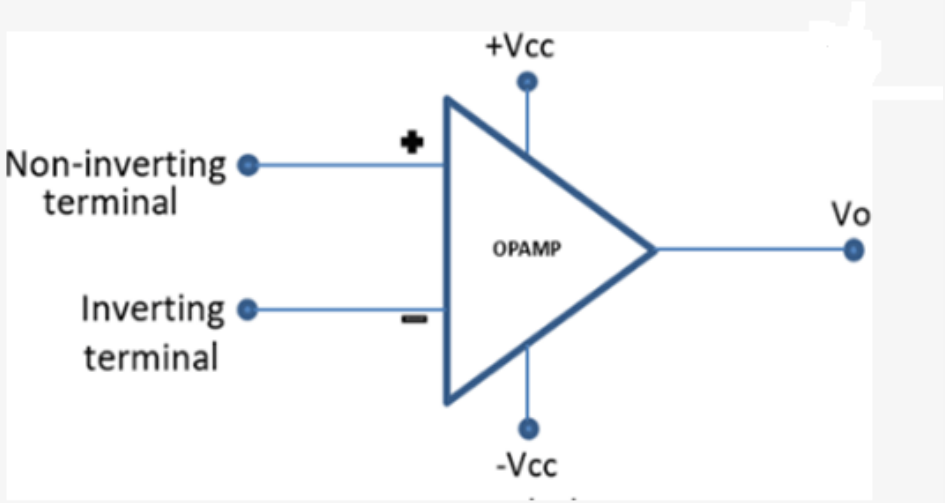
Unit 4:Linear Integrated circuit

- Introduction to operational amplifiers
- Block diagram of OP-AMP
- Ideal characteristics of OP-AMP
- Positive feedback and Negative feedback
- Inverting & Non inverting Amplifier
- Comparators
- Summing amplifier
- Difference amplifier

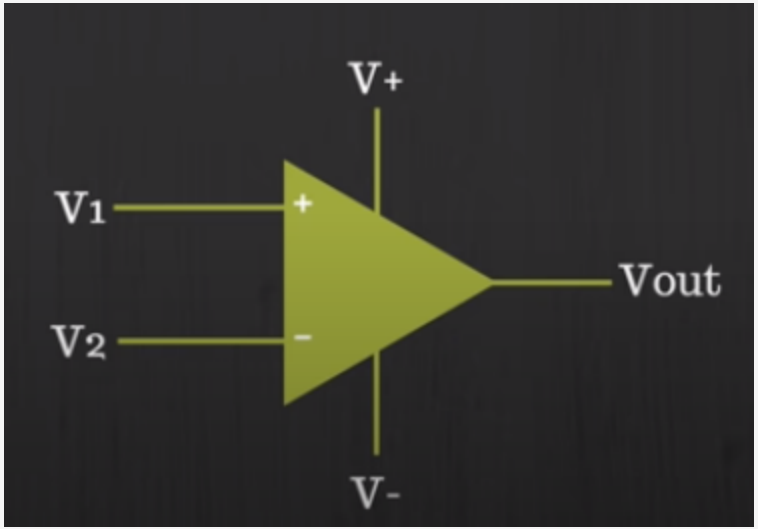
Introduction to operational amplifier

- The basic job of operational amplifier is to amplify the signal .
- Op-amp circuit is built using different capacitors and registers.
- Op-amp is able to perform different mathematical operations such as addition, subtraction, differentiation and integration.

Symbol of OPAMP



Symbol of op-amp



- V1: Non-inverting input
- V2:inverting input
- V+:positive power supply
- V-: negative power supply
- Vout:Output of opamp

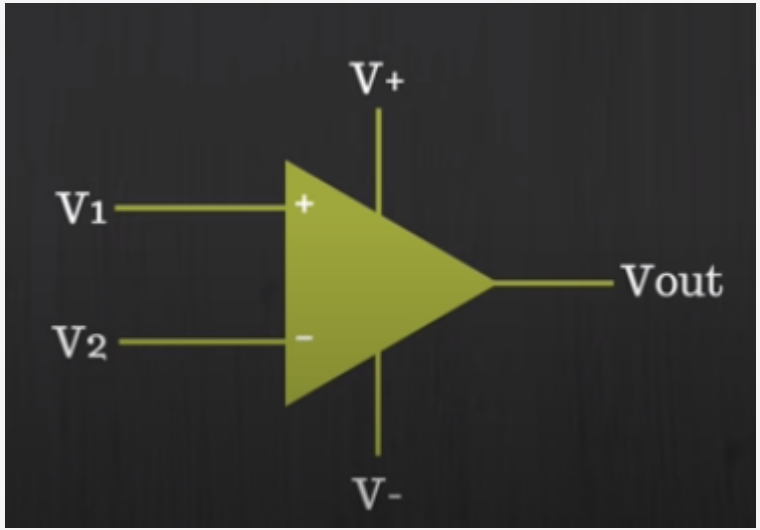
Op-amp ,a kind of differential amplifier

- It amplifies difference between two Inputs.
- Suppose A is gain of op-amp.

Then

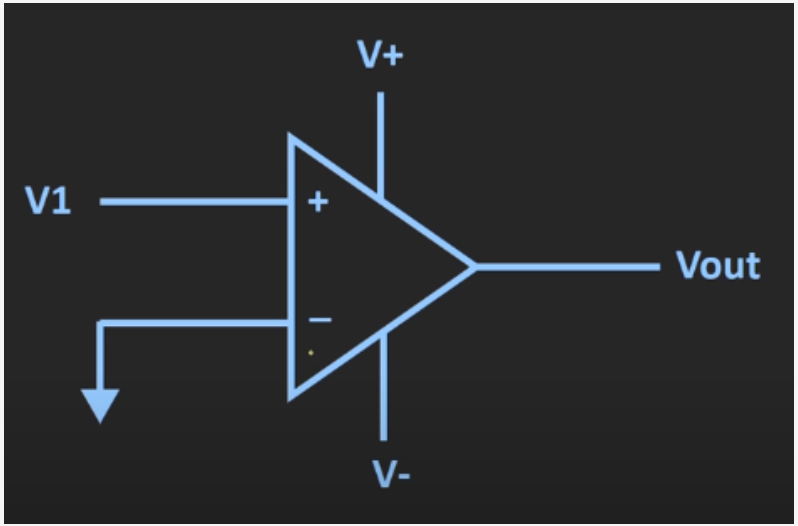
Vout=A(v1-v2)

- Op-amp is high gain amplifier .
- Gain in the range of 10^5 to 10^6.



Non-Inverting Terminal of Op-amp

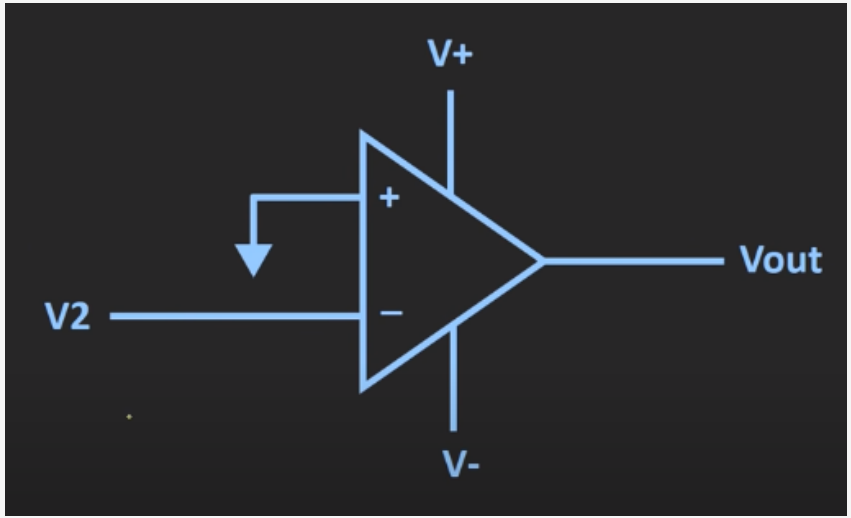
- Non-inverting Op-amp



- Sinusoidal input is applied at v1,
- Amplified Output will be in phase with input sinusoidal wave .
- Hence non-inverting terminal

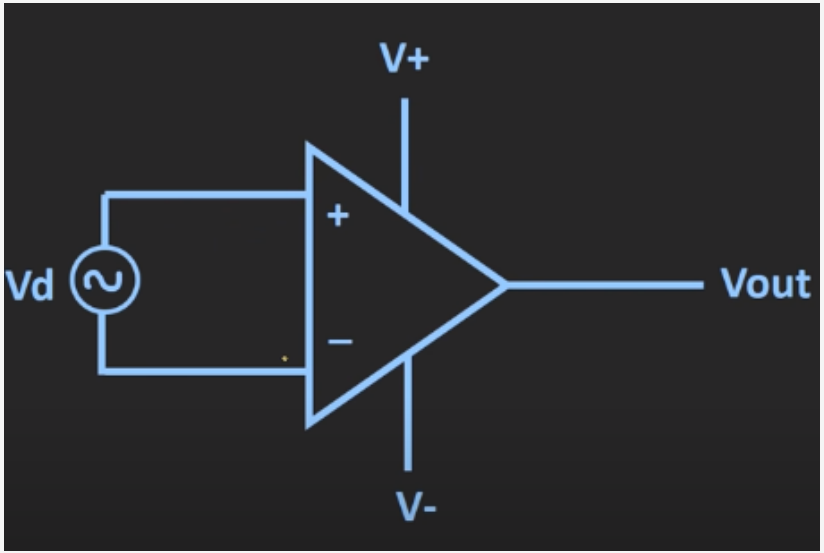
Inverting Terminal of Op-amp

- Inverting Op-amp



- Sinusoidal input is applied at v2,
- Amplified Output will be 180 degree out of phase (i.e.Inverted)
- Hence inverting terminal

Operational Amplifier



- Vd is input voltage applied between two terminals .
- A:open loop gain of op-amp
- (open loop because output is not fed back to input)
- Then vout= A*Vd

Operational Amplifier

- As gain high 10^5 to 10^6
- Consider A=10^5

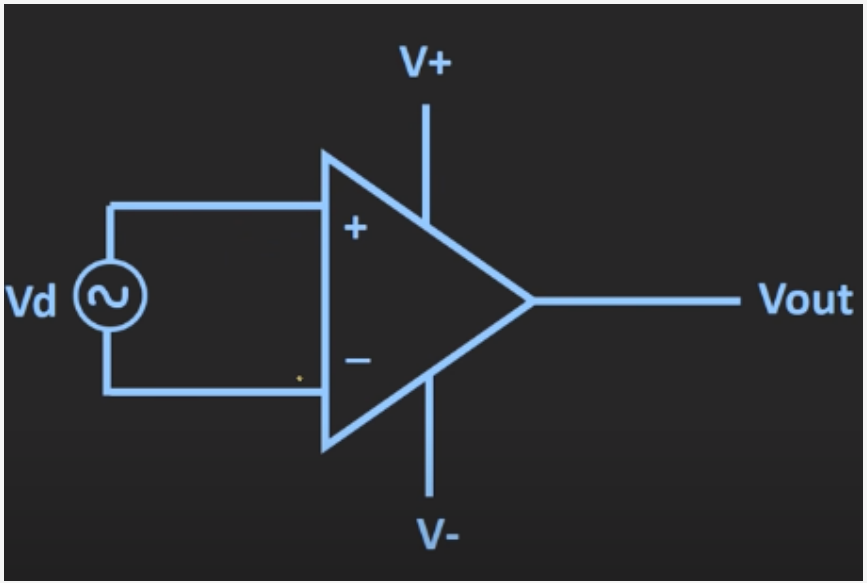
➢If Vd=1mv

➢Vout=100v (theoretically)

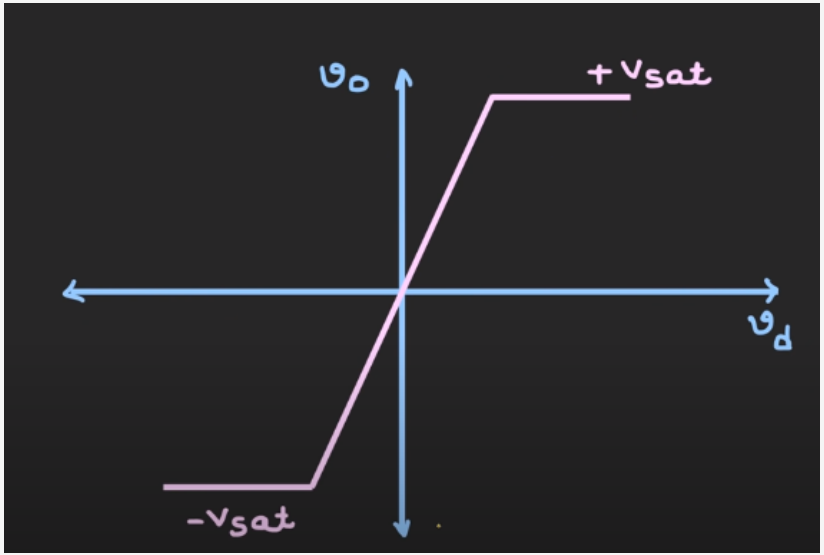
➢If Vd=1v

➢Vout=10^5v(theoretically)

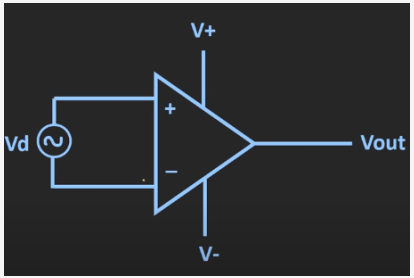
❖But it is not possible practically



Voltage transfer curve of op-amp



- X axis: input voltage, Vd applied between two input terminal
- Y axis: output voltage,Vo of op-amp
- Slope : gain A of op-amp



Voltage transfer curve of op-amp

- In open loop configuration ,

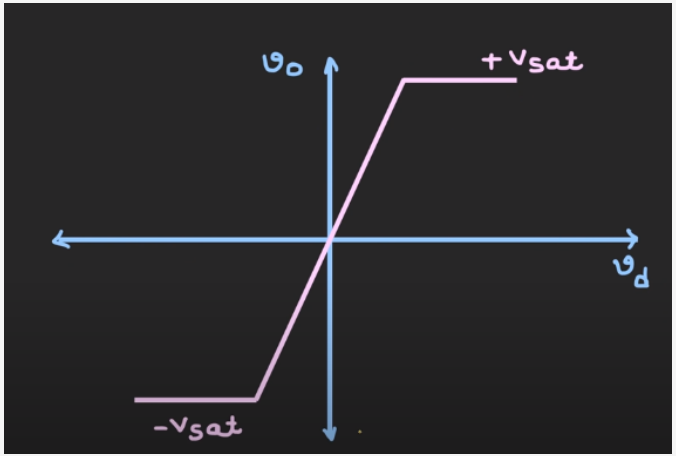
The output is saturated at +Vsat and –Vsat.

+Vsat < V+

-Vsat > V-

(value of V+ can be from +5v to +15v)

(value of V- can be from -5v to -15v)



OP-AMP

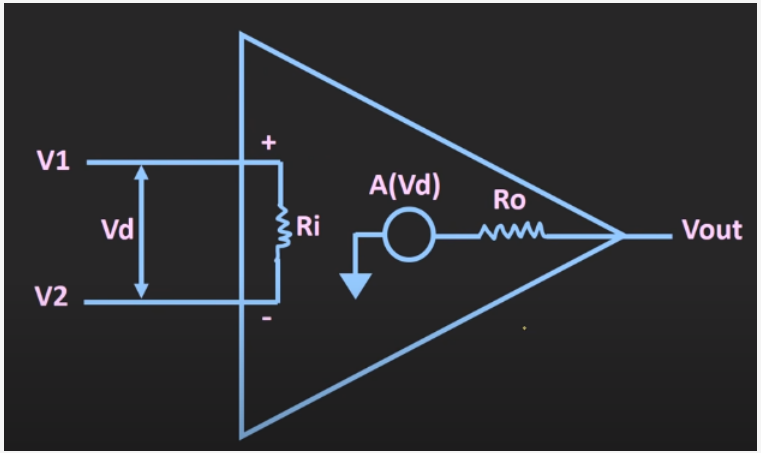
It can be used as

- comparator
- Adder
- Sub-tractor
- In filter circuit

Thus Op-amp is very versatile IC.

It is versatile because of its different characteristics.

Equivalent circuit of op-amp and characteristics of ideal op-amp



Characteristics of ideal op-amp

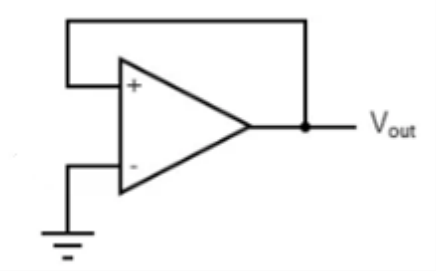
- Ri,Input resistance: infinite
- Ro,Output resistanec :zero
- Gain:infinite
- Bandwidth :infinite (accept signal of all frequencies)

Open and close loop configuration

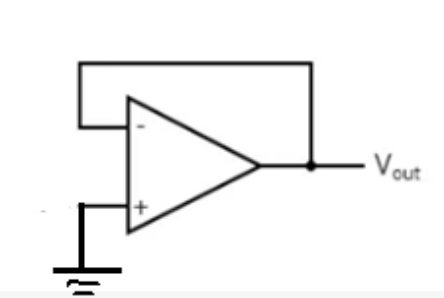
- If the feed back is not given it is called as open loop configuration.
- If the feedback is given it is called as close loop configuration.

Positive feedback and Negative feedback

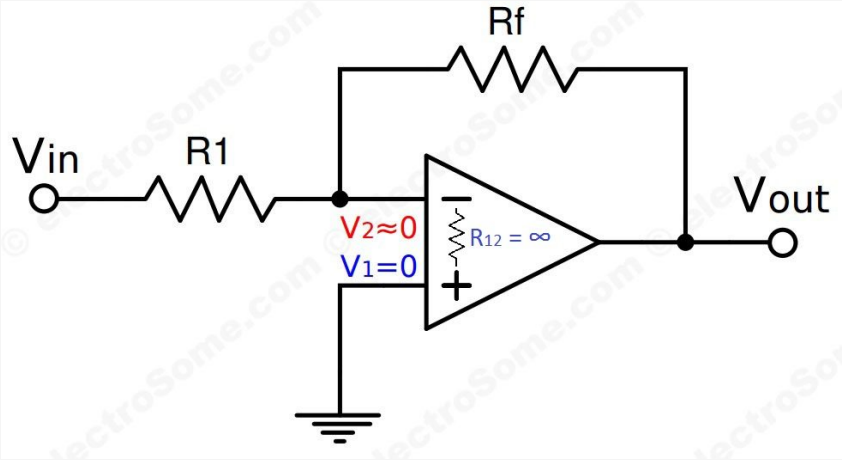
Positive feedback



Negative feedback



Concept of virtual ground

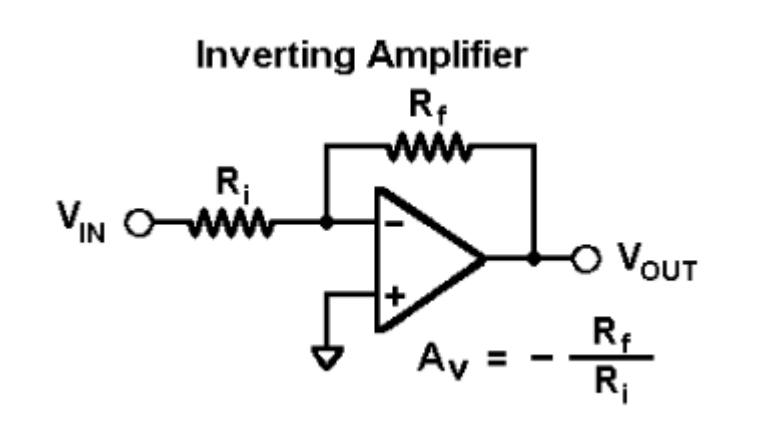


- This is known as inverting configuration of op-amp .(with negative feedback)
- Input impedance of op-amp is very high
- Hence op-amp never draws any current at it's input, hence input current is always zero.
- Iin =0 amperes
- For current to be zero the voltage Va must be zero, thus even though the input is applied , the inverting terminal behaves as ground terminal at node 'a'.
- This concept is known as virtual ground concept.

Inverting & Non inverting Amplifier

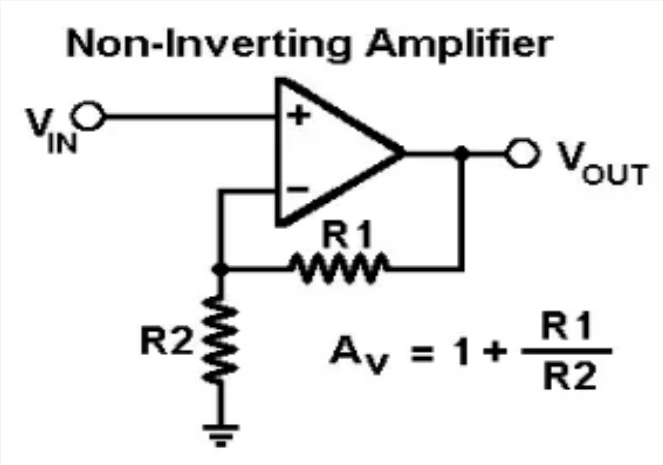
Inverting Amplifier (negative feedback)

Gain of inverting amplifier



Inverting Amplifier (negative feedback)

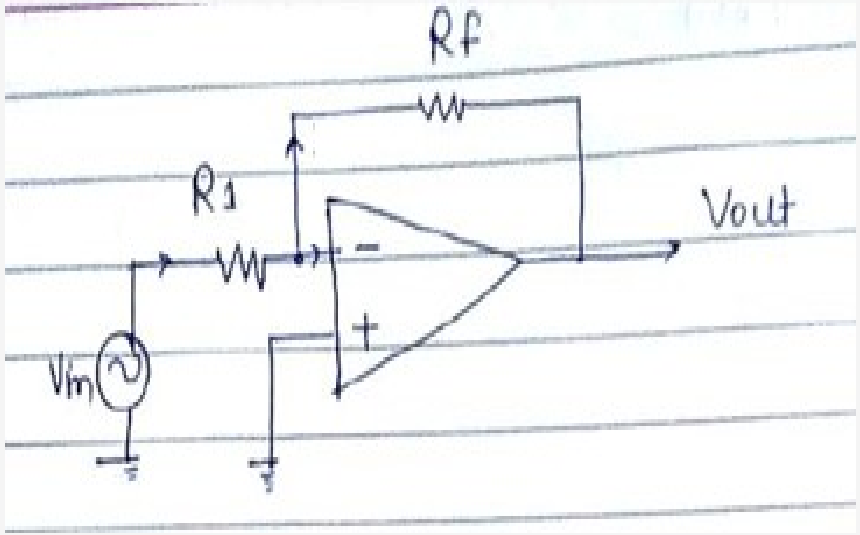
Gain of inverting amplifier



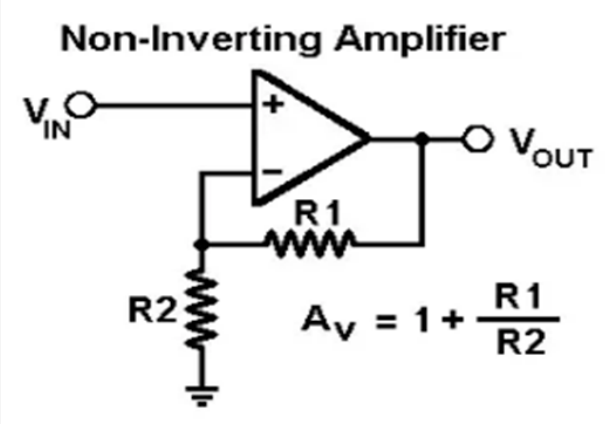
Ex:Find the gain and output voltage of op-amp .

- Given:
- Rf=2Kohm,
- R1=1Kohm,
- Vin=1V

- ans:-2V



Problem on gain of non-inverting op-amp



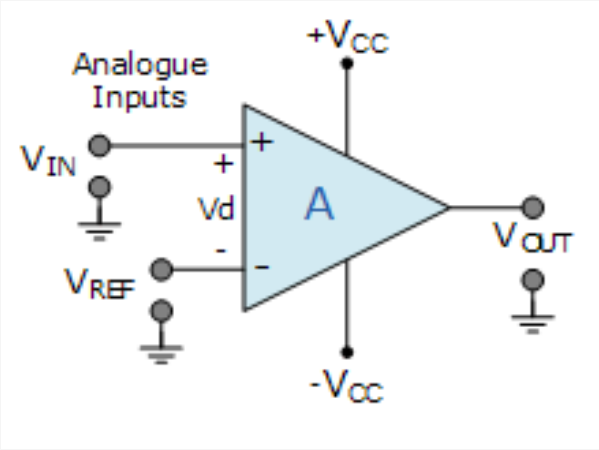
Problem:- In Above ckt i/p is 1V Sinusoidal
Rf = 2kΩ , R1 = 1kΩ
Find gain and o/p vtg.

Ans: Gain = 3
Vtg output = 3 volt.

Op-amp as comparator

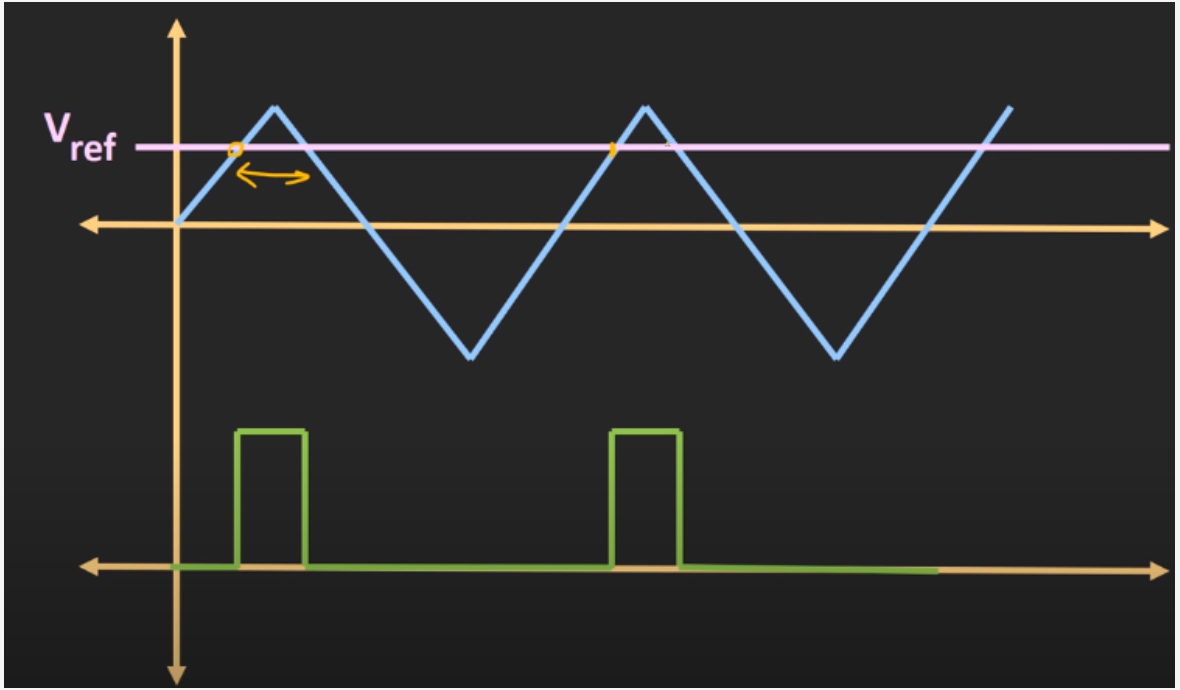
- The **Op-amp as a comparator** compares one analogue voltage level with another analogue voltage level, and produces an output signal based on this voltage comparison.
- Out of these two voltages ,One voltage is considered as reference voltage .
- When the applied input voltage is greater than the reference voltage,the output of op-amp is high.
- When the applied input voltage is less than the reference voltage,the output of opamp is low.

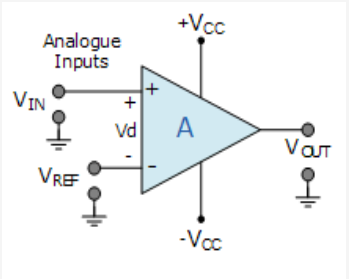
Op-amp as comparator



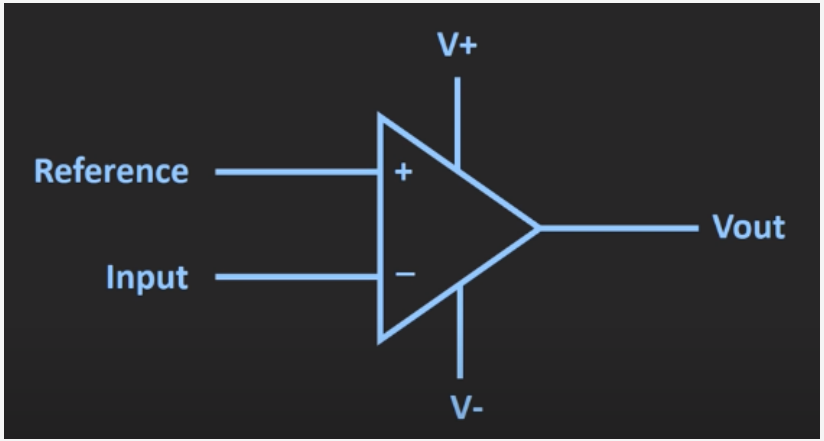
- When VIN>VREF, output will be high
- When VIN<VREF, output will be low .
- Shown here is the non-inverting comparator because the input is applied to the non-inverting terminal of op-amp.

Non-inverting Op-amp as a comparator



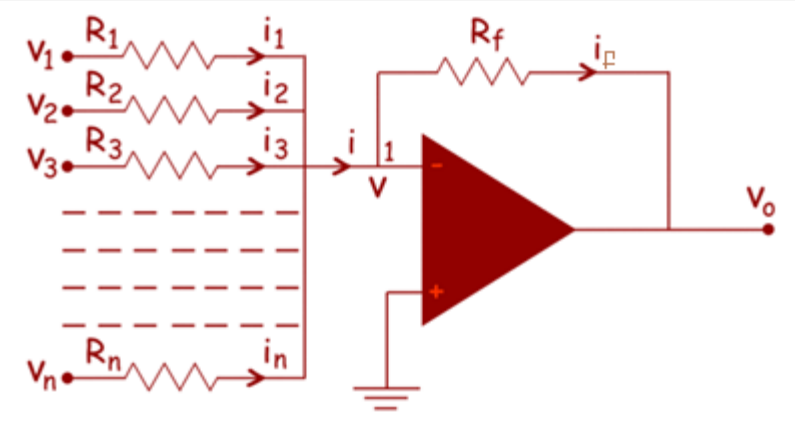


inverting op-amp as comparator



- Shown here is the inverting comparator because the input is applied to the inverting terminal of op-amp.

Inverting Op-amp adder



- Here, n numbers of input voltages are connected in parallel and given as input to the inverting terminal of op-amp.
- The non-inverting terminal of the op amp is connected to ground.

$$v_0 = -\left(\frac{R_f}{R_1}v_1 + \frac{R_f}{R_2}v_2 + \frac{R_f}{R_3}v_3 + \cdots\cdots\cdots + \frac{R_f}{R_n}v_n\right)$$

This indicates that output voltage v_0 is weighted sum of numbers of input voltages.

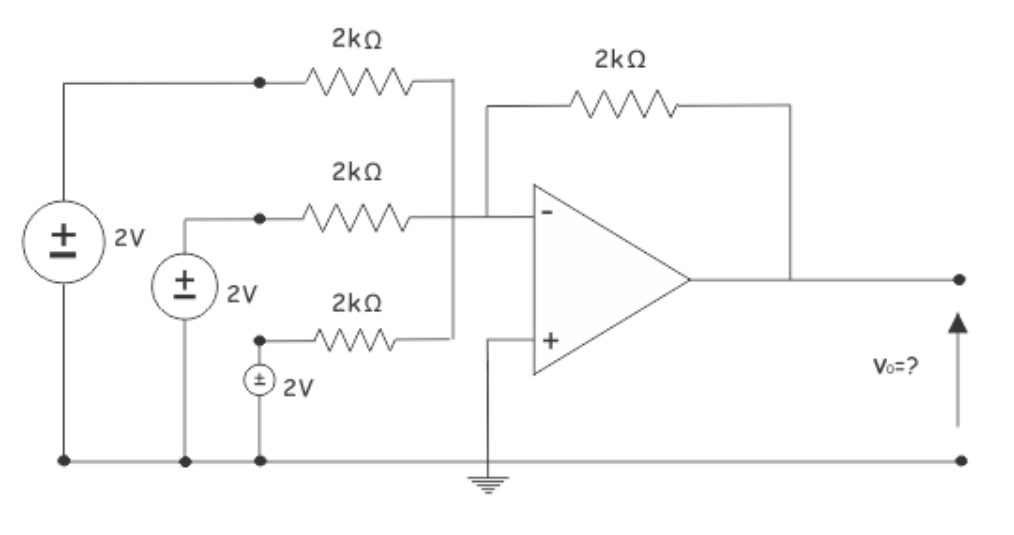
In above equation ,when all values of the resistances are made equal, (i.e.all input resistances and feedback resistance)It will have unity gain , thus it will act as adder.

$$v_0 = -\ (v_1 + v_2 + v_3 + \ldots\ldots + v_n)$$

(Note : As it is inverting summer the output of voltage adder will be out of phase with respect to the input by 180 degree)

Example on inverting op-amp summer

- If 3 input voltages are applied at inverting terminal .Find output voltage .



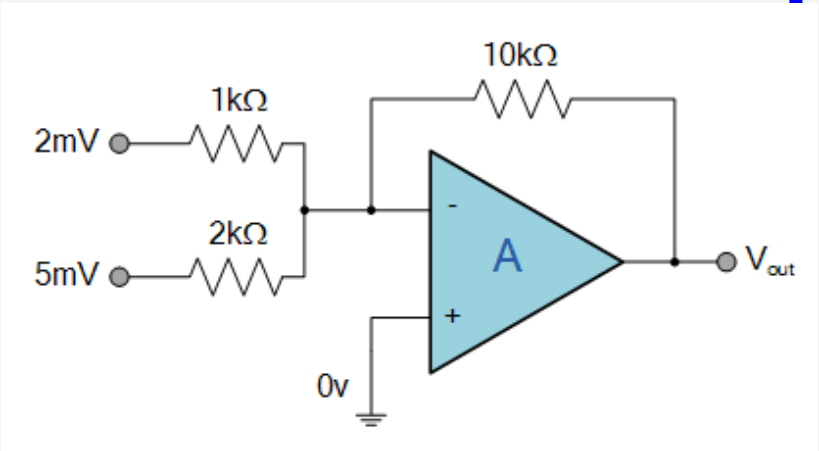
Example on inverting op-amp summer

- As per equation

$$v_0 = -\left(\frac{2k\Omega}{2k\Omega} \times 2V + \frac{2k\Omega}{2k\Omega} \times 2V + \frac{2k\Omega}{2k\Omega} \times 2V\right)$$
$$\Rightarrow v_0 = -(2V + 2V + 2V)$$
$$\Rightarrow v_0 = -6V$$

- Thus we obtained addition of all 3 voltages .

Example no.2

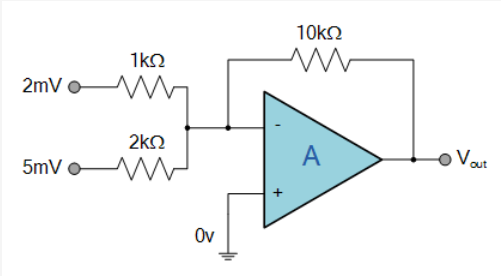


- Find the output voltage .
- As all the resistance values are not equal, the gain will not be unity.
- The output will not be -7mv.

Example no.2

By using the formula

$$v_0 = -\left(\frac{R_f}{R_1}v_1 + \frac{R_f}{R_2}v_2 + \frac{R_f}{R_3}v_3 + \cdots\cdots\cdots + \frac{R_f}{R_n}v_n\right)$$

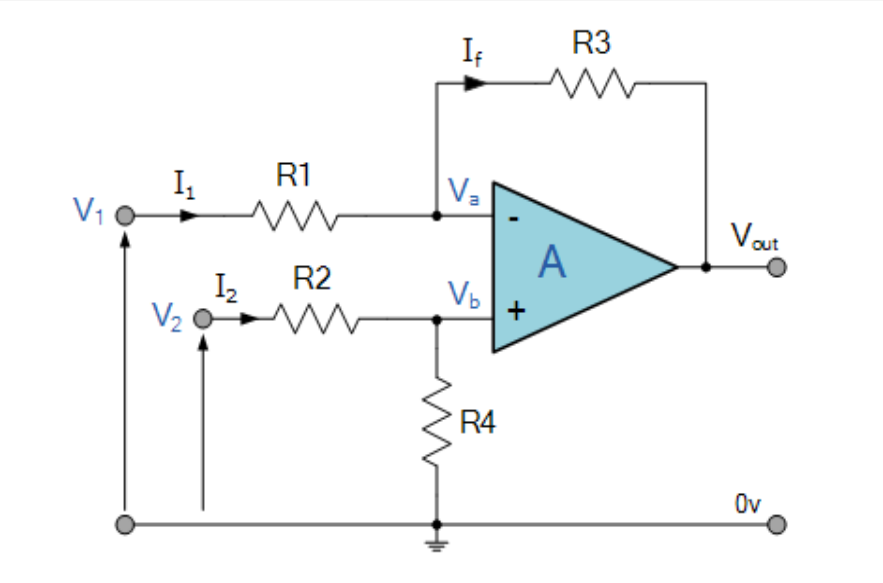


Vout= - 45Volts

Here it has given the weighted sum of all input voltages .

It is called as scaling summing amplifier.

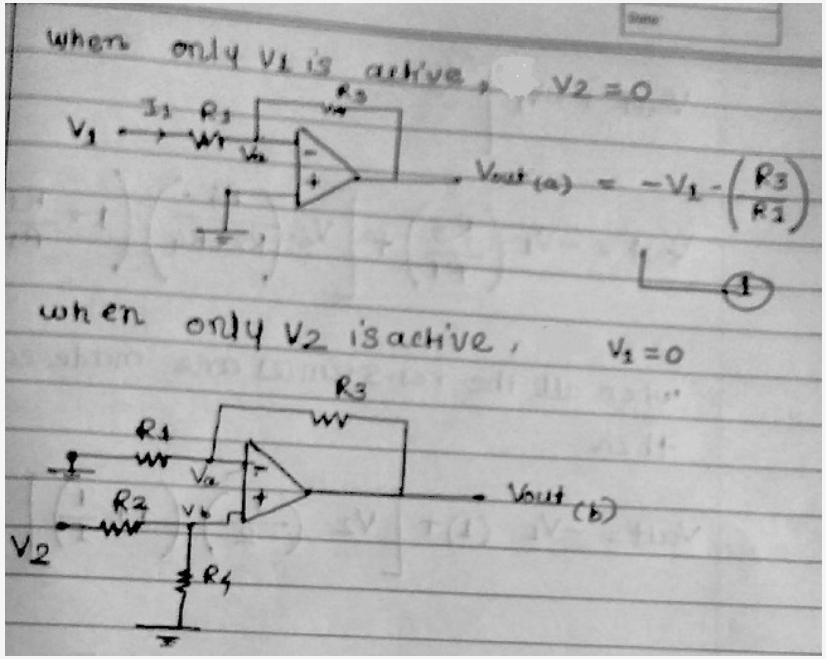
Op-amp as difference amplifier(sub-tractor)

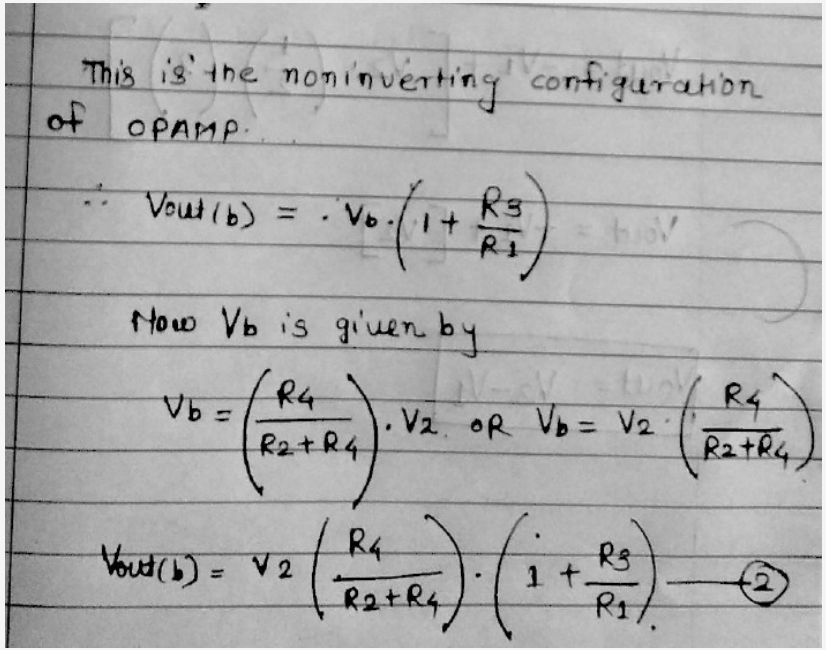


- This is the circuit for op-amp as substractor.
- To find the output voltage ,the superposition theorem is used.
- It states that, when there are multiple input sources, the output voltage of that circuit can be determined by summing the individual responses achieved by considering each voltage source acting separately.

Op-amp as difference amplifier(sub-tractor)

- By applying superposition theorem





Op-amp as difference amplifier(sub-tractor)...

- By adding equation 1 and 2

$$V_{out} = V_{out(a)} + V_{out(b)}$$

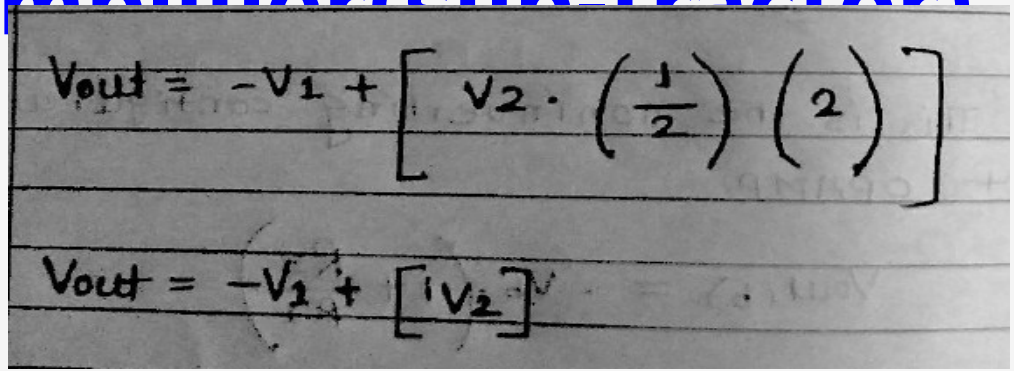
$$V_{out} = -V_1\left(\frac{R_3}{R_1}\right) + \left[V_2 \cdot \left(\frac{R_4}{R_2+R_4}\right)\left(1+\frac{R_3}{R_1}\right)\right]$$

when all the resistances are made equal then

$$V_{out} = -V_1\ (1) + \left[V_2 \cdot \left(\frac{1}{2}\right)\left(1+\frac{1}{1}\right)\right]$$

$$V_{out} = -V_1 + \left[V_2 \cdot \left(\frac{1}{2}\right)(2)\right]$$

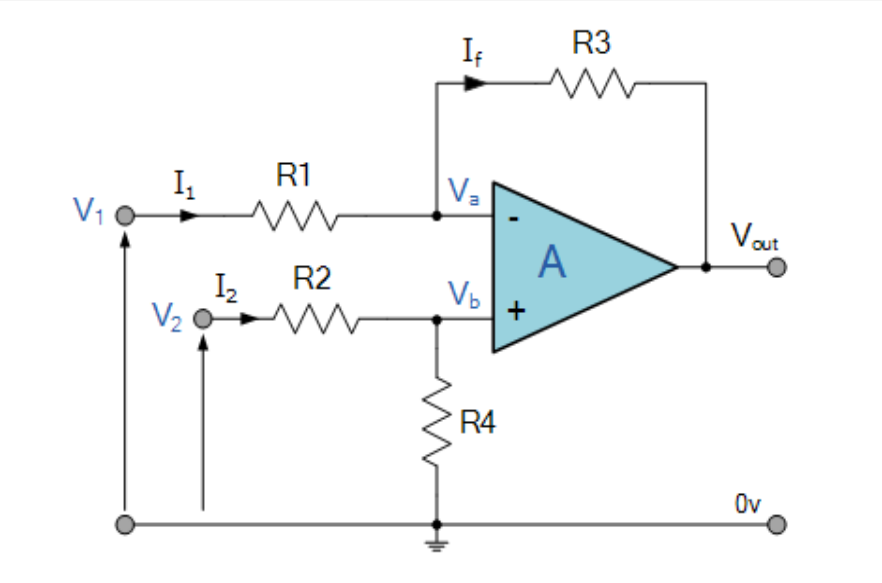
Op-amp as difference amplifier(sub-tractor)



$$Vout = V_2 - V_1$$

Thus op-amp will act as sub-tractor .

Ex on Op-amp as sub-tractor



- Find output voltage using superposition theorem.
- The values given are
- V1=2,V2=5
- R1=2 Kohm, R2=2 Kohm,
- R3=10 Kohm, R4=4 Kohm

Sol: when V1 is active ;Vout1=-10

When V2 is active ; Vout2=20

Adding Vout1 and Vout2

Vout =10

When all the resistances are made equal then

Vout= V2-V1

Vout=3

Thank you