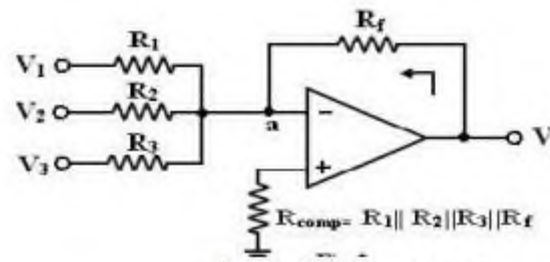
Adder:

Op-amp may be used to design a circuit whose output is the sum of several input signals.Such a circuit is called a summing amplifier or a summer or adder.An inverting summer or a non-inverting summer may be discussed now.

Inverting Summing Amplifier:



inverting summer

A typical summing amplifier with three input voltages V_1, V_2 and V_3 three input resistors R_1, R_2, R_3 and a feedback resistor R_f is shown in figure 2.The following analysis is carried out assuming that the op-amp is an ideal one, AOL= ∞.Since the input bias current is assumed to be zero, there is no voltage drop across the resistor R_{comp} and hence the non-inverting input terminal is at ground potential.

$$I= V_1/R1+V_2/R2\ldots..+Vn/Rn;$$

$$Vo= - R_f$$

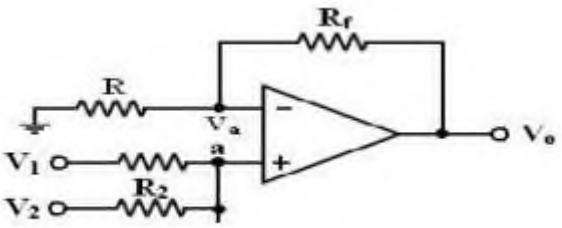
$$I=Rf/R(V_1+V_2+\ldots.V_n).$$

To find R_{comp}, make all inputs $V_1 = V_2 = V_3 = 0$.

So the effective input resistance $R_i = R_1 \| R_2 \| R_3$.

Therefore, $Rcomp = R_i \| R_f = R_1 \| R_2 \| R_3 \| R,f$.

Non-Inverting Summing Amplifier:



Non inverting summer

A summer that gives a non-inverted sum is the non-inverting summing amplifier of figure Let the voltage at the (-) input terminal be Va. which is a non-inverting weighted sum of inputs.

Let $R_1 = R_2 = R_3 = R = R_f/2$, then $V_o = V_1+V_2+V_3$

Subtractor using Operational Amplifier

If all resistors are equal in value, then the output voltage can be derived by using superposition principle.

Subtractor:

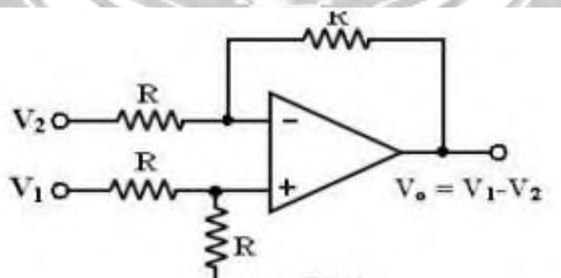


Fig 4

Subtractor

A basic differential amplifier can be used as a subtractor as shown in the above figure. If all resistors are equal in value, then the output voltage can be derived by using superposition principle.

To find the output V_{01} due to V_1 alone, make $V_2 = 0$.

Then the circuit of figure as shown in the above becomes a non-inverting amplifier having input voltage $V_1/2$ at the non-inverting input terminal and the output becomes

$V_{01} = V_1/2(1+R/R) = V_1$ when all resistances are R in the circuit.

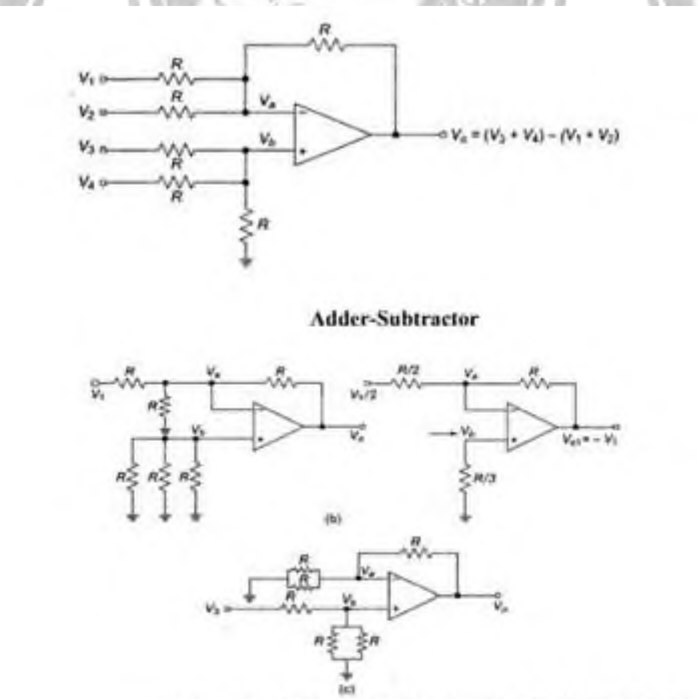
Similarly the output V_{02} due to V_2 alone (with V_1 grounded) can be written simply for an inverting amplifier as

$V_{02} = -V_2$

Thus the output voltage Vo due to both the inputs can be written as

$V_0 = V_{01} - V_{02} = V_1 - V_2$

Adder/Subtractor:



Adder-Subtractor

equivalent circuit for V2=V3=V4=0 and (c) for V1=V2=V4=0

It is possible to perform addition and subtraction simultaneously with a single op-amp using the circuit shown in figure 2.16.The output voltage Vo can be obtained by using superposition theorem. To find output voltage V_{01} due to V_1 alone, make all other input voltages V_2, V_3 and V_4 equal to zero.

The simplified circuit is shown in figure 2.17. This is the circuit of an inverting amplifier and its output voltage is, $V_{01}= -R/(R/2) * V_1/2= - V_1$ by Thevenin's equivalent circuit at inverting input terminal).Similarly, the output voltage V_{02} due to V_2 alone is,

$$V_{02} = - V_2$$

Now, the output voltage V_{03} due to the input voltage signal V_3 alone applied at the (+) input terminal can be found by setting V_1, V_2 and V_4 equal to zero.

$$V_{03}=V_3$$

The circuit now becomes a non-inverting amplifier as shown in fig.(c).So, the output voltage V_{03} due to V_3 alone is

$$V_{03} = V_3$$

Similarly, it can be shown that the output voltage V_{04} due to V_4 alone is

$$V_{04} = V_4$$

Thus, the output voltage Vo due to all four input voltages is given by

$$V_o = V_{01} = V_{02} = V_{03} = V_{04}$$

$$Vo = - V_1 - V_2 + V_3 + V_4$$

$$V_o = (V_3 + V_4) - (V_1 + V_2)$$

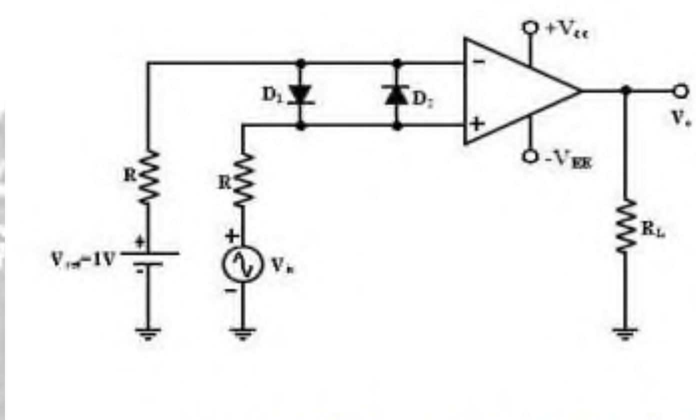
So, the circuit is an adder-subtractor.

Comparator

A comparator compares a signal voltage on one input of an op-amp with a known voltage called a reference voltage on the other input. Comparators are used in circuits such as,

- Digital Interfacing
- Schmitt Trigger
- Discriminator
- Voltage level detector and oscillators

Non-inverting Comparator:



non-inverting comparator circuit

A fixed reference voltage V_{ref} of 1 V is applied to the negative terminal and time varying signal voltage Vin is applied to the positive terminal.

When Vin is less than V_{ref} the output becomes V_0 at $-V_{sat}$

$$[V_{in} < V_{ref} \Rightarrow V_0\ (-V_{sat})].$$

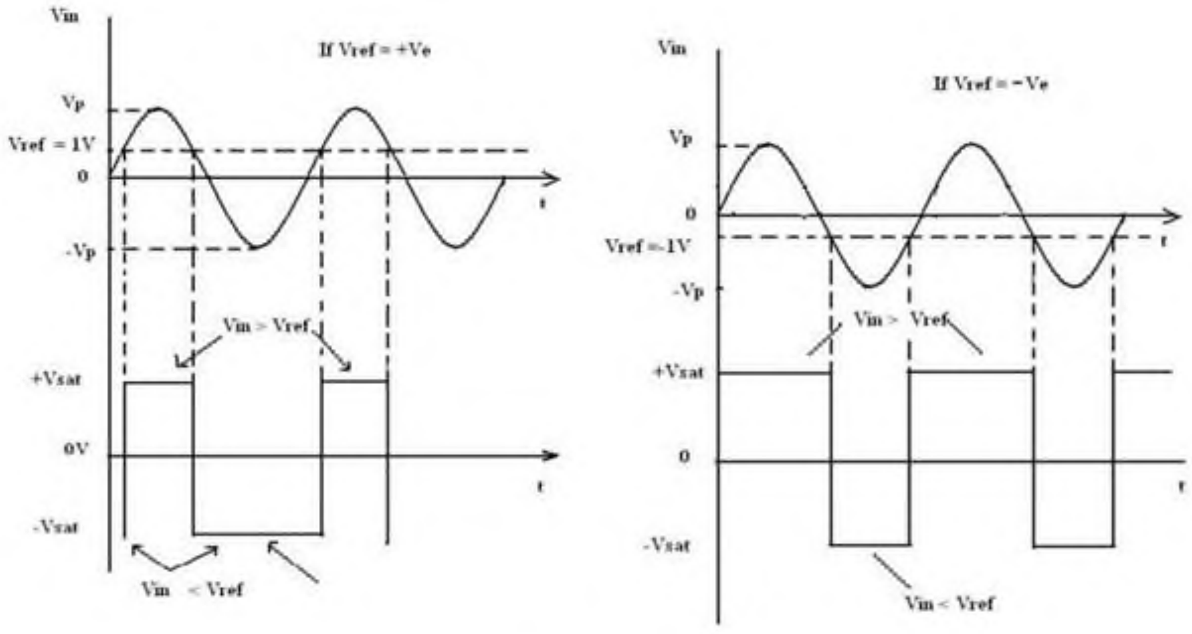
When Vin is greater than V_{ref}, the (+) input becomes positive, the V_0 goes to $+V_{sat}$.

$$[V_{in} > V_{ref} \Rightarrow V_0\ (+V_{sat})].$$

Thus the V_0 changes from one saturation level to another.

The diodes D_1 and D_2 protect the op-amp from damage due to the excessive input voltage V_{in}. Because of these diodes, the difference input voltage Vid of the op-amp diodes are called clamp diodes.

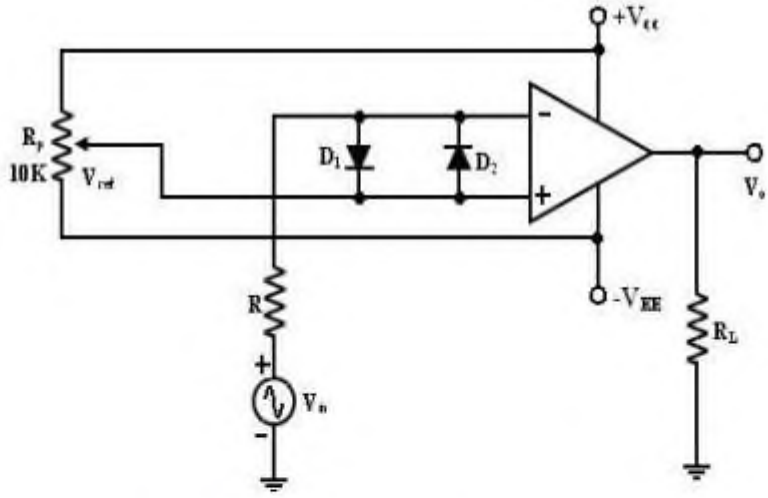
The resistance R in series with V_{in} is used to limit the current through D_1 and D_2. To reduce offset problems, a resistance R_{comp} = R is connected between the (-ve) input and V_{ref}.



Input and Output Waveforms of non-inverting comparator

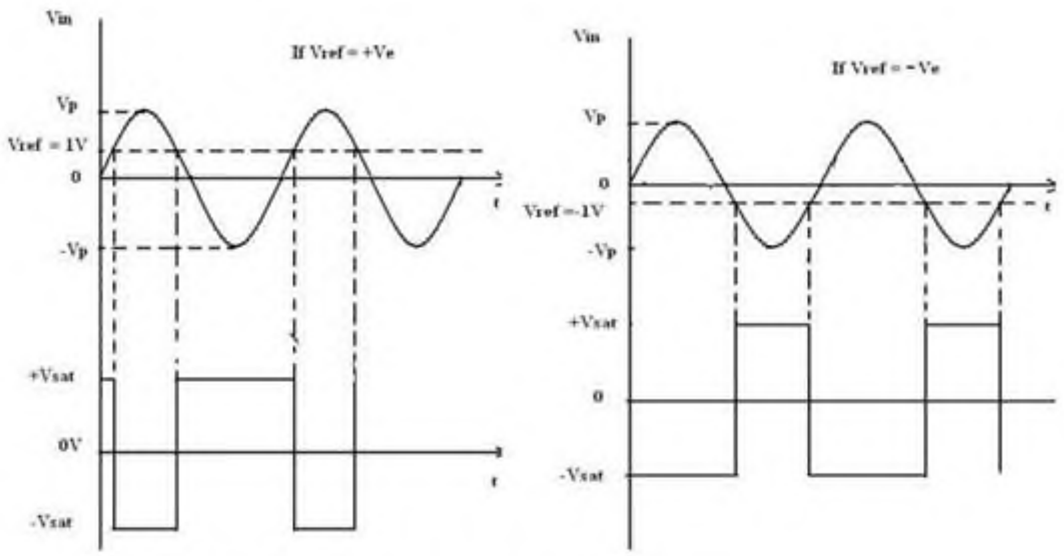
Inverting Comparator:

This fig shows an inverting comparator in which the reference voltage V_{ref} is applied to the (+) input terminal and V_{in} is applied to the (-) input terminal.



Inverting comparator circuit

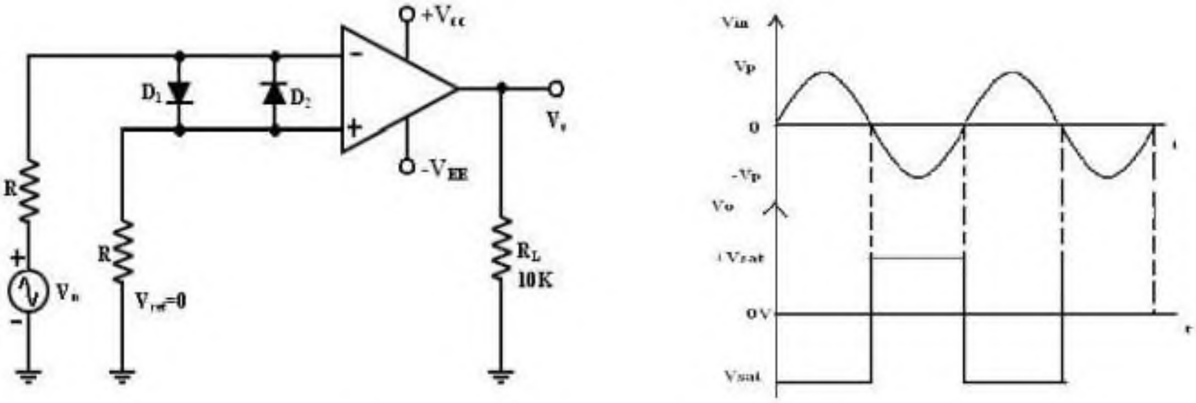
In this circuit V_{ref} is obtained by using a 10K potentiometer that forms a voltage divider with DC supply volt $+V_{cc}$ and -1 and the wiper connected to the input. As the wiper is moved towards $+V_{cc}$, V_{ref} becomes more positive. Thus a Vref of a desired amplitude and polarity can be got by simply adjusting the 10k potentiometer.



Input and Output Waveforms of non-inverting comparator

Applications:

Zero Crossing Detector: [Sine wave to Square wave converter]



Zero crossing detector circuit and input-output waveforms

One of the applications of comparator is the zero crossing detector or —sine wave to Square wave Converter. The basic comparator can be used as a zero crossing detector by setting Vref is set to Zero.This Fig shows when in what direction an input signal V_{in} crosses zero volts. (i.e.) the o/p V_0 is driven into negative saturation when the input the signal V_{in} passes through zero in positive direction. Similarly, when Vin passes through Zero in negative direction the output V_0 switches and saturates positively.

Drawbacks of Zero- crossing detector:

In some applications, the input Vin may be a slowly changing waveform, (i.e) a low frequency signal. It will take Vin more time to cross 0V, therefore V_0 may not switch quickly from one saturation voltage to the other.

Because of the noise at the op-amp‘s input terminals the output V0 may fluctuate between 2 saturations voltages +Vsat and –Vsat. Both of these problems can be cured with the use of regenerative or positive feedback that cause the output V0 to change faster and eliminate any false output transitions due to noise signals at the input Inverting comparator with positive feedback This is known as Schmitt Trigger.