OPAMP

Lecture 14

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OPAMP as Scale Changer:

As shown in $Fig\ 1$, non-inverting terminal is grounded and virtual short circuit exist at input terminal. Here $R_1 = R_f$. The output voltage V_0 is equal to $(-V_1)$ i.e. slightly sign of the input voltage changed. Hence such a circuit is known as a phase inverting amplifier and is called sign or scale changer.

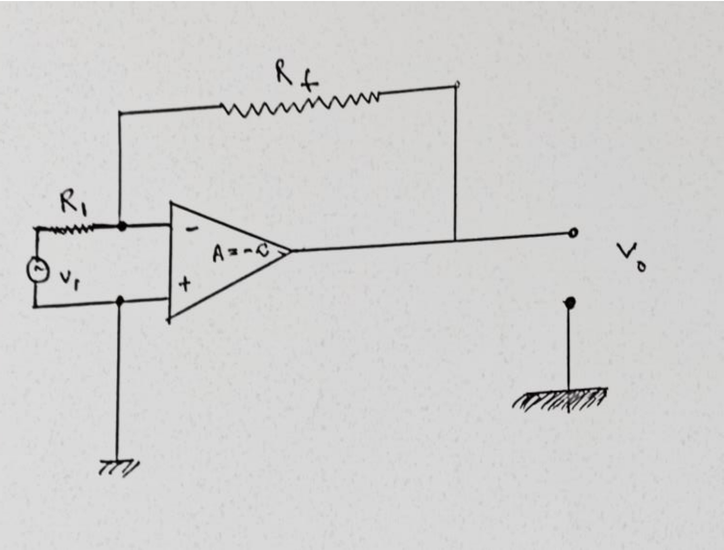

Fig 1

In case inverting amplifier, let $\frac{R_1}{R_f} = K$, where K is real constant, then output voltage

$$V_o = -KV_1 \rightarrow (i)$$

Thus output voltage scale is obtained by multiplying input voltage scale $-k$, called Scale Factor. Then inverting amplifier can be served as a scale changer. A low voltage can be accurately measured by amplifying a voltage by a scale chnger and dividing the amplified voltage by scale factor.

Adder or Summing Amplifier:

As shown in Fig 2 as G is virtual ground i.e. at ground potential, the input impedance is infinite, the current $i_1, i_2, \ldots\ldots i_n$ be equal to i_0 i.e.

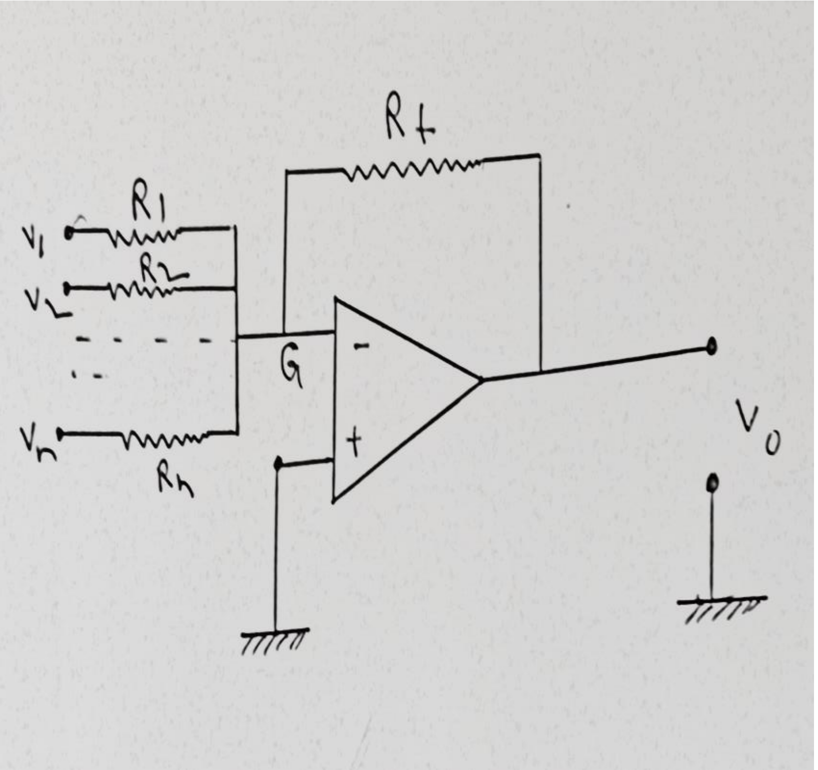

Fig 2

$$i_1 + i_2 + \cdots + i_n = i_0$$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \cdots + \frac{V_n}{R_n} = -\frac{V_0}{R_f}$$

$$V_0 = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \cdots + \frac{R_f}{R_n}V_n\right)$$

If

$$R_1 = R_2 = \cdots = R_n = R$$

Then

$$V_0 = -\frac{R_f}{R}(V_1 + V_2 + \cdots + V_n)$$

If

$$R_f = R$$

Then

$$V_0 = -(V_1 + V_2 + \cdots + V_n) \rightarrow (ii)$$

This shows that output V_0 is numerically equal to algebraic summation of input voltage $V_1, V_2, \ldots V_n$.

Then

$$V_0 = -\frac{R_f}{R}(V_1 + V_2 + \cdots + V_n) \rightarrow (iii)$$

So the circuit is known as Summing Amplifier or Adder. If algebraic sum of input voltage is small, the output voltage V_0 is measured with $R_f > R$

Differential Amplifier or Subtractor:

Let as shown in $Fig\ 3$ difference between $V_2\ and\ V_1$ is to be amplified. The voltage gain of OPAMP be infinite and point A and B will have same potential say V_x, then we can write

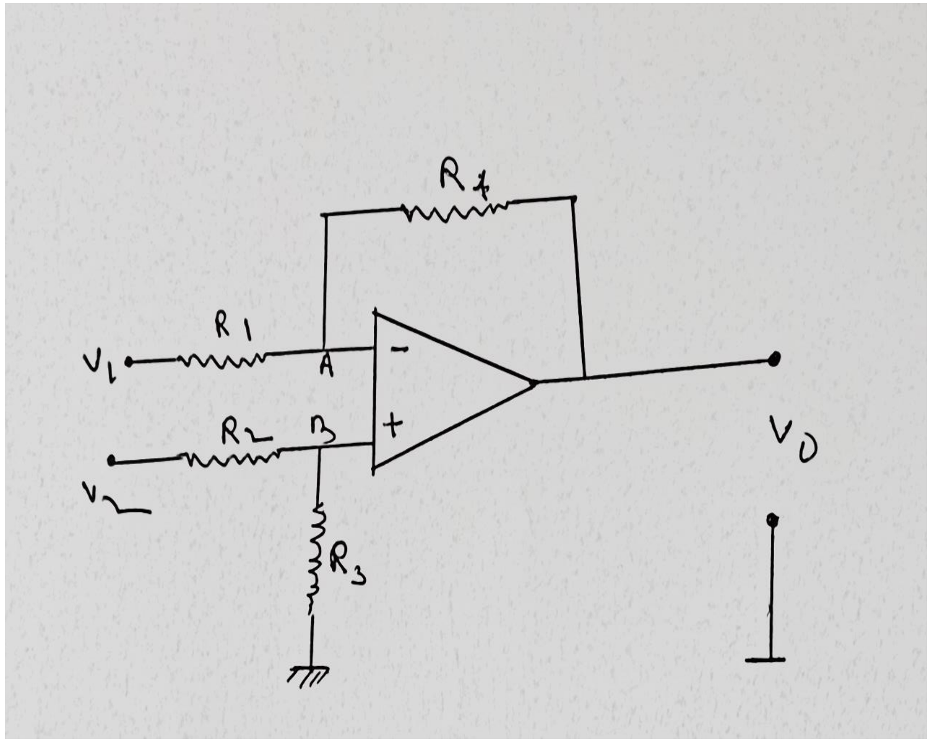

Fig 3

$$\frac{V_1 - V_x}{R_1} = \frac{V_x - V_0}{R_2}$$

$$\frac{V_2 - V_x}{R_1} = \frac{V_x}{R_2}$$

Where we have assumed that the input impedance of OPAMP is infinite. Subtracting the two equations we get

$$V_0 = \frac{R_2}{R_1}(V_2 - V_1)$$

Where V_0 is amplified version of difference $(V_2 - V_1)$. The voltage gain of amplifier system being $\frac{R_2}{R_1}$. If $R_1 = R_2$, the circuit serve as subtractor, the output voltage gain the difference of $(V_2 - V_1)$.

Differentiator:

This circuit as shown in $Fig\ 4$ gives the output voltage V_0 , which is proportional to the derivative of input voltage V_1 with respect to time. The infinite voltage gain of OPAMP makes G , a virtual ground . The change of capacitor C is

$$q = CV_1$$

$$V_1 = \frac{q}{C}$$

Where i is current flows through capacitor C . Since input impedance of OPAMP is infinite the current i flows through resistance R. Therefore

$$i = -\frac{V_0}{R}$$

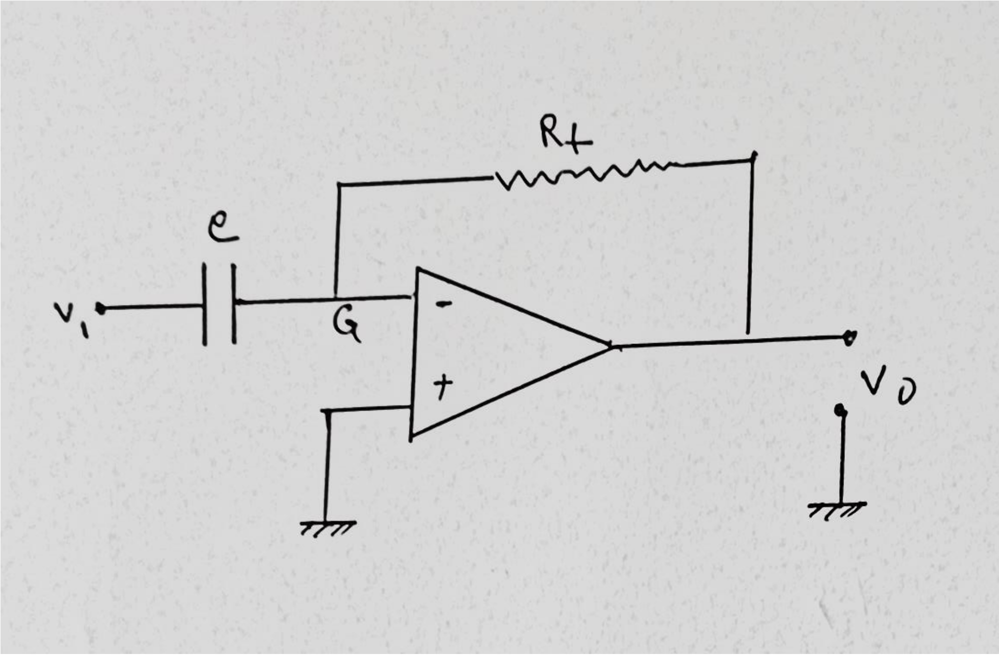

Fig 4

Therefore

$$V_0 = -CR\frac{dV_1}{dt}$$

Obviously output voltage of V_0 is proportional to the time derivative of input voltage V_1 , the proportionality constant is $(-CR)$.

Integrator:

As shown in Fig 5 , the point G is again at virtually grounded and the gain is infinite. The current flowing through resistance R is

$$i = \frac{V_1}{R}$$

The input impedance of OPAMP being infinite the current i flows through a feedback capacitance C to produce output voltage V_0.

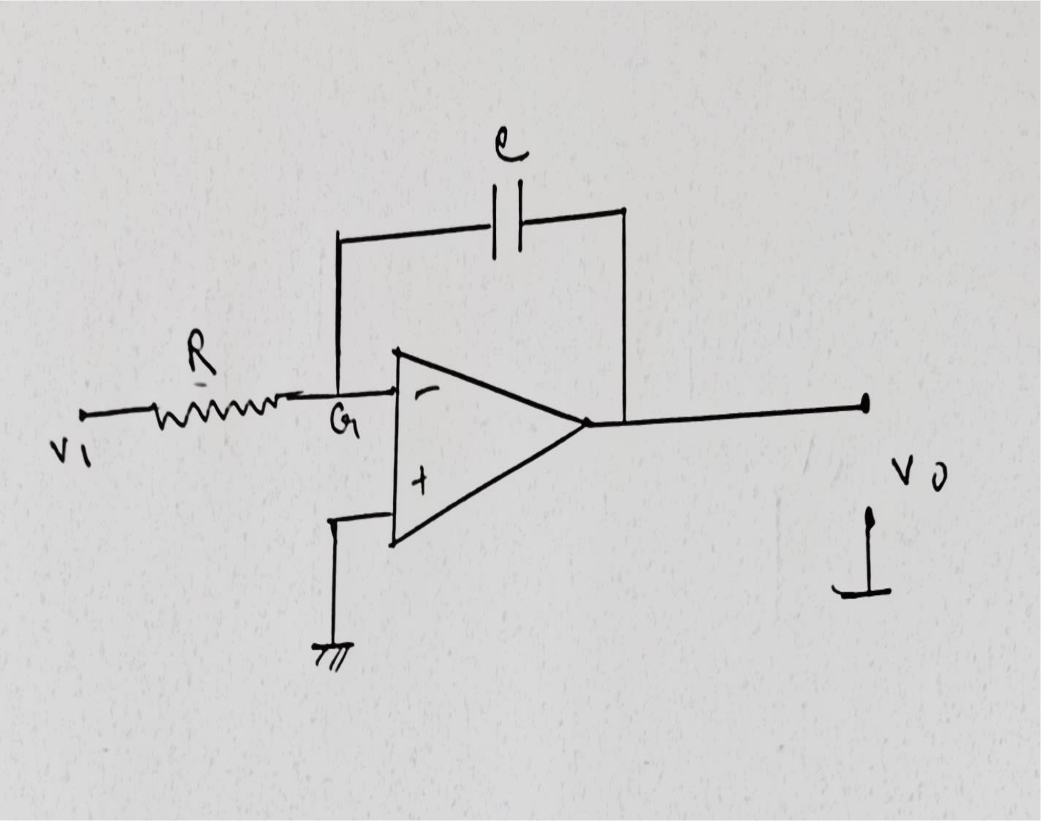

Fig 5

Therefore

$$V_0 = -\frac{1}{C}\int_0^t i dt$$

$$V_0 = -\frac{1}{CR}\int_0^t V_1 dt$$

The output voltage V_0 is thus proportional to time integral of input voltage V_1, the constant of proportionality is $\left(-\frac{1}{CR}\right)$.