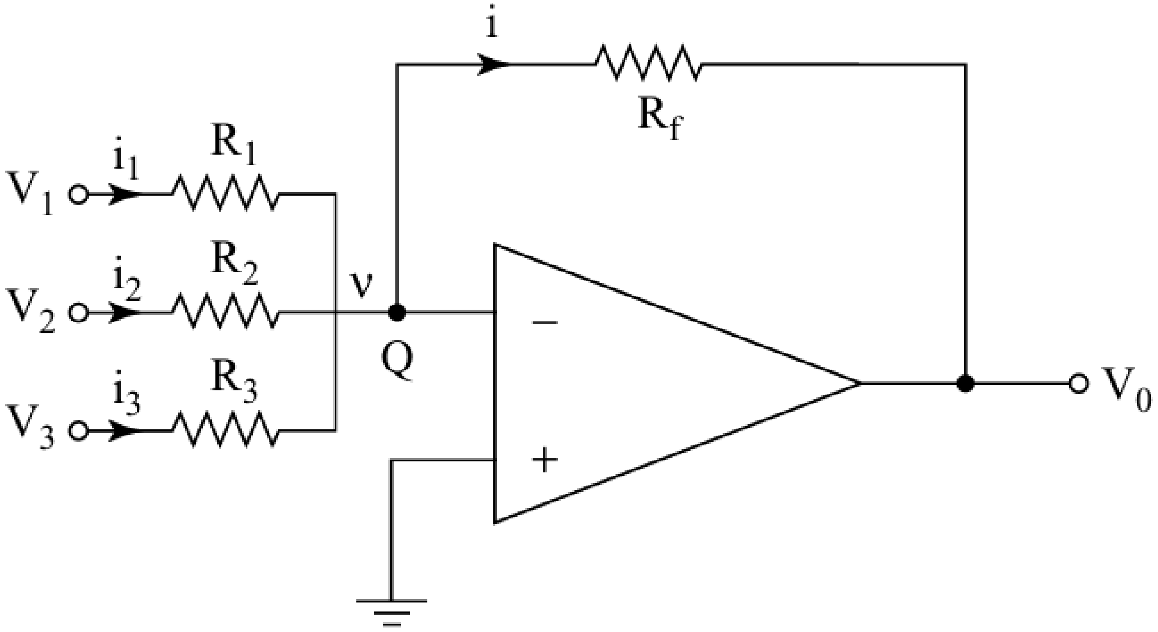
Applications of Operational Amplifiers

By : Dr. Atul R. Phadke
Associate Professor in Electrical Engineering
COEP Technological University Pune (Maharashtra)

OP-AMP AS SUMMING AMPLIFIER:



Assuming point Q at potential v, and assuming no current flowing through the amplifier (infinite input impedance) –

$$i_1 + i_2 + i_3 = i$$

$$\therefore \frac{V_1 - v}{R_1} + \frac{V_2 - v}{R_2} + \frac{V_3 - v}{R_3} = \frac{v - V_o}{R_f}$$

$$V_o = Av \quad or \quad v = \frac{V_o}{A}$$

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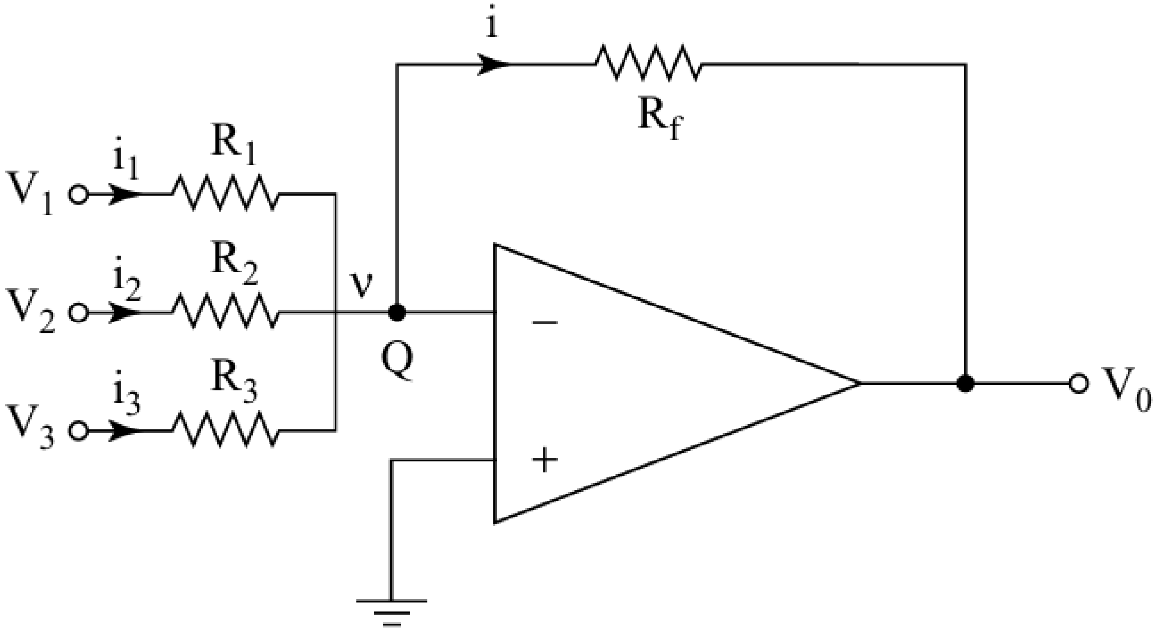

$$V_o = Av \quad or \quad v = \frac{V_o}{A}$$

$$As \quad A\ tends\ to \quad , \qquad v\ tends\ to\ zero\ (virtual\ ground)$$

$$\therefore \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = \frac{-V_o}{R_f}$$

$$\therefore V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$$

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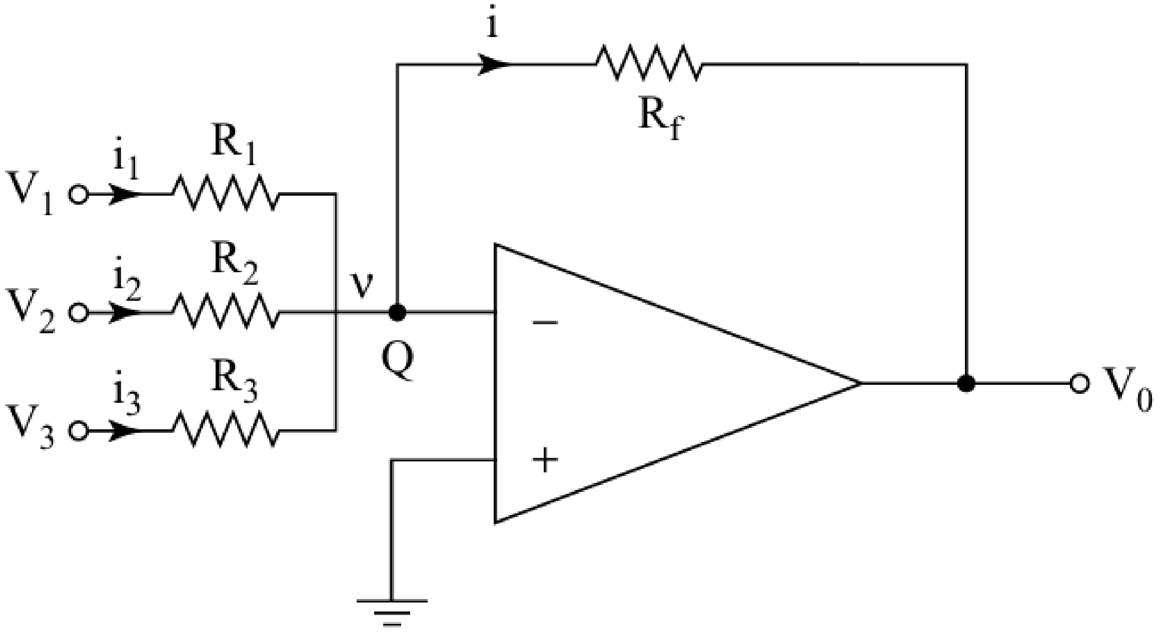


$$\therefore V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$$

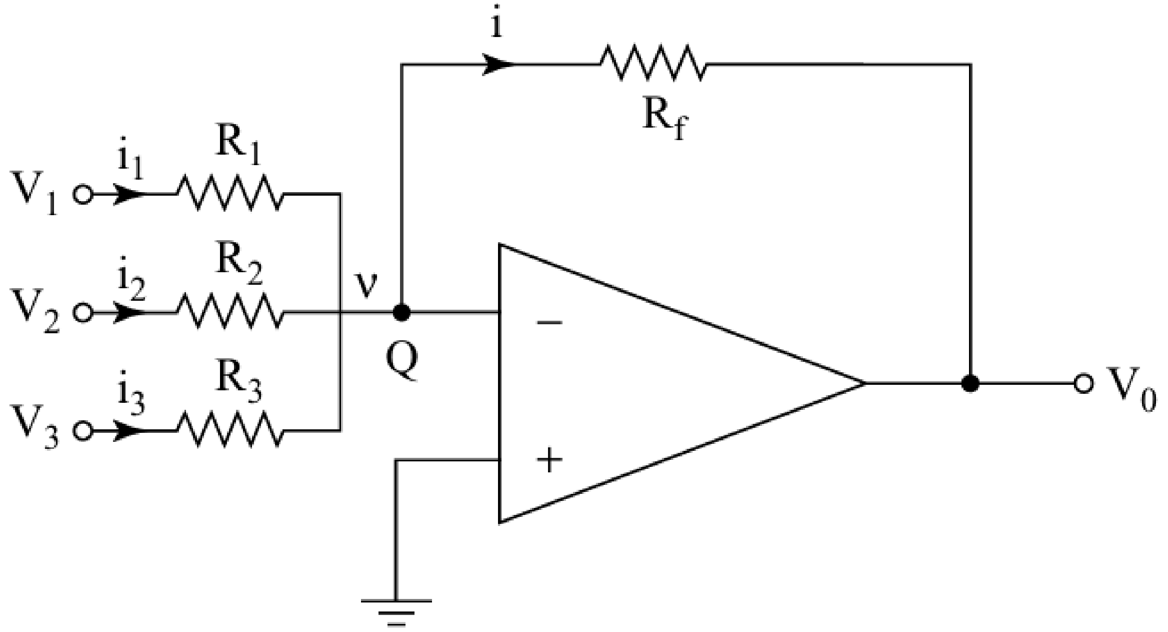
By choosing a suitable ratio of $\frac{R_f}{R}$, the output voltage can be made equal to the sum of the desired ratio of the input voltages.

If $R_1 = R_2 = R_3 = R$, $\quad V_o = -\frac{R_f}{R}[V_1 + V_2 + V_3]$

If $R_f = R$, $\quad V_o = -[V_1 + V_2 + V_3]$

EXAMPLE:

Determine the output voltage V_o for the configuration shown in figure,



If $R_1 = R_2 = R_3 = R_f = 1\ k\Omega$

$V_1 = +2\ V, V_2 = +1\ V\ and\ V_3 = +4\ V$

Ans: The circuit is inverting adder (summing) circuit

$$\therefore V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right] = -[V_1 + V_2 + V_3]$$

$$\therefore V_o = -[2 + 1 + 4] = -7\ V$$

OP-AMP AS A SUBTRACTOR:

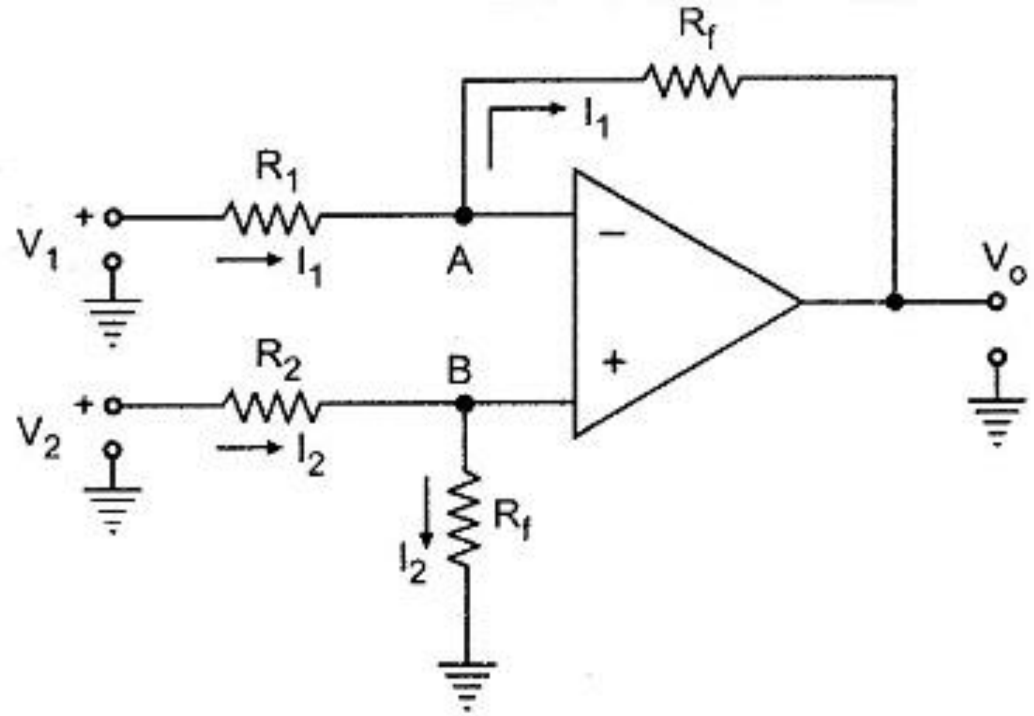


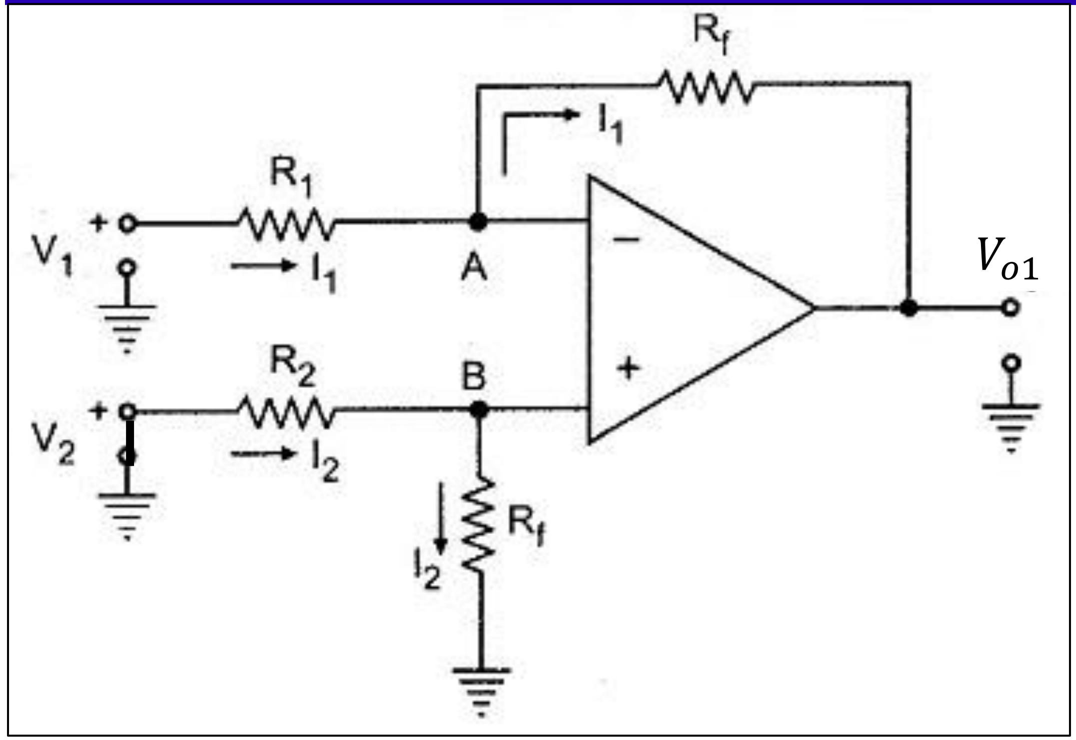
Figure shows a differential amplifier, or a difference amplifier, or simply a subtractor.

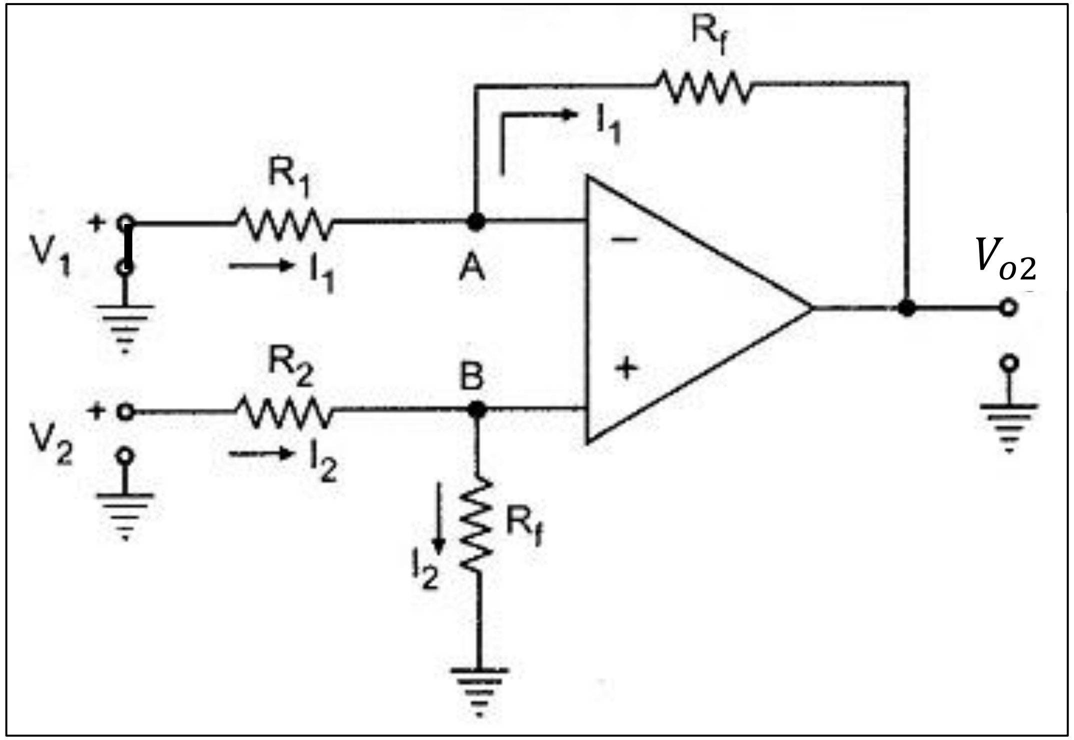
Here, the difference between two voltages, i.e., V_2 and V_1 can be amplified using this circuit.

The relation between the inputs and output can be determined using Superposition principle.

Let V_{o1} be the output, with input V_1 acting alone and $V_2 = 0$ to be zero and V_{o2} be the output, with input V_2 acting alone and $V_1 = 0$.

OP-AMP AS A SUBTRACTOR:





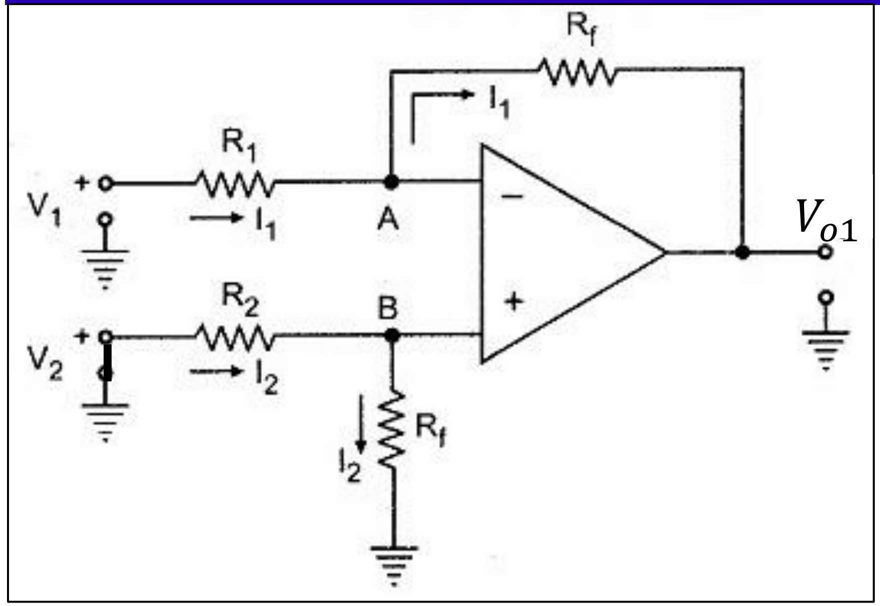
With $V_2 = 0$, the circuit acts as an inverting amplifier. Hence, we can write –

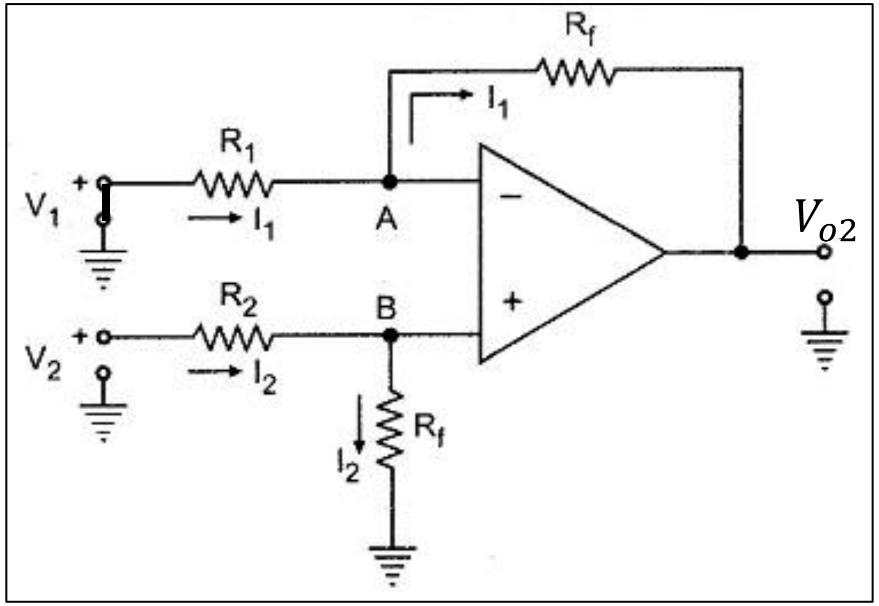
$$V_{o1} = -\frac{R_f}{R_1} V_1 \qquad \cdots (1)$$

With $V_1 = 0$, the circuit acts as a noninverting amplifier. Hence, we can write –

$$V_{o2} = \left(1 + \frac{R_f}{R_1}\right) V_B \qquad \cdots (2)$$

OP-AMP AS A SUBTRACTOR:





$$I_2 = \frac{V_2}{(R_2 + R_f)} \qquad \cdots (3)$$

$$\therefore V_B = I_2 \times R_f = \frac{V_2}{(R_2 + R_f)} R_f \qquad \cdots (4)$$

Substituting V_B in equation (2)

$$V_{o2} = \left[1 + \frac{R_f}{R_1}\right]\left[\frac{R_f}{R_2 + R_f}\right] V_2 \qquad \cdots (5)$$

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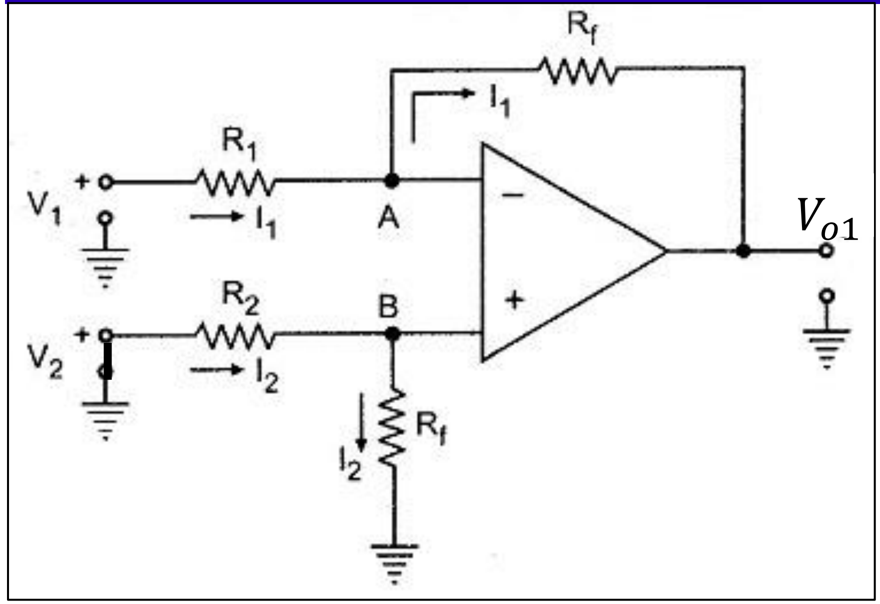
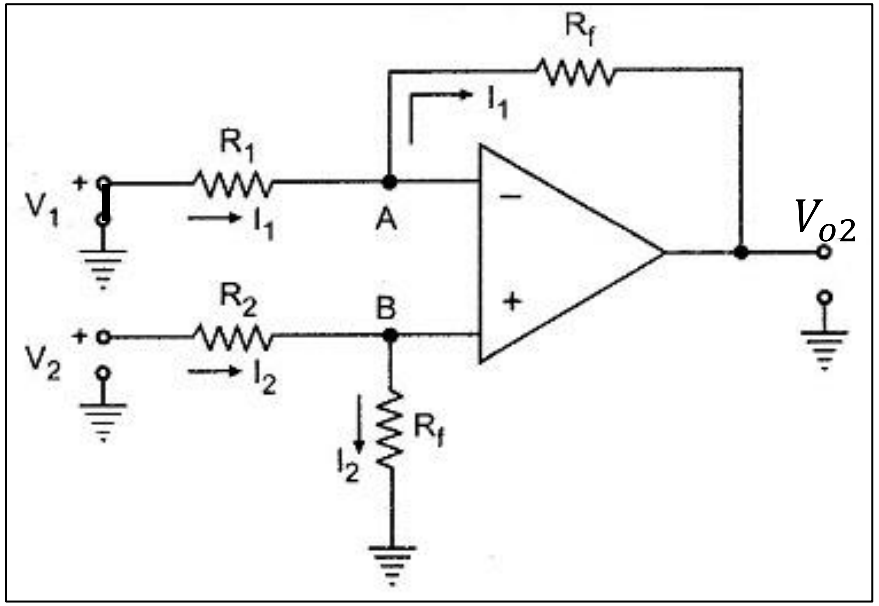




Using superposition principle,

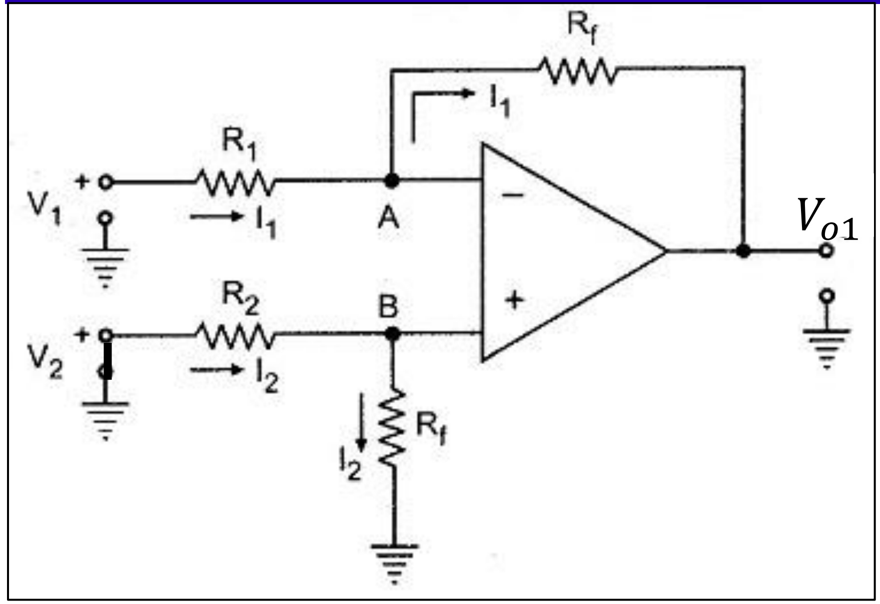
$$V_o = V_{o1} + V_{o2} \qquad \cdots (6)$$

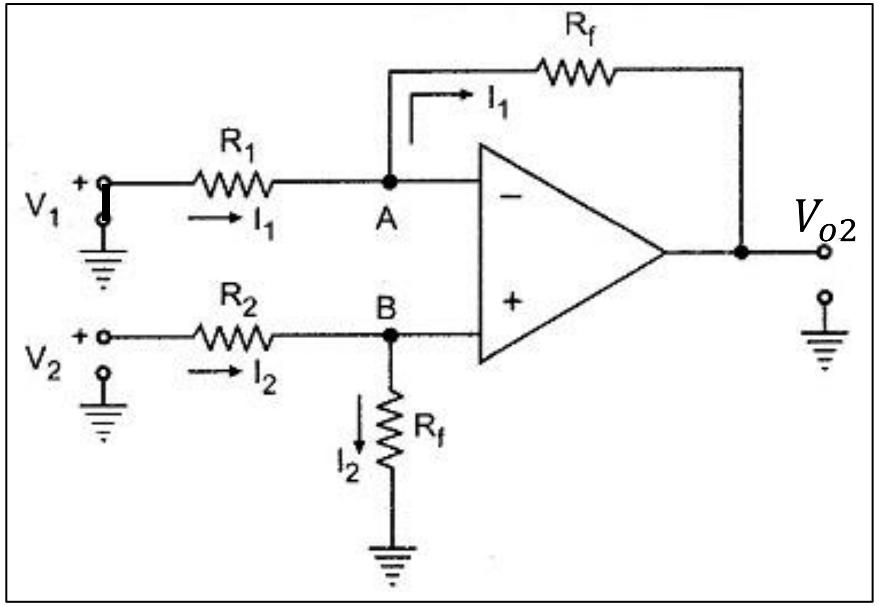
$$V_o = -\frac{R_f}{R_1}V_1 + \left[1 + \frac{R_f}{R_1}\right]\left[\frac{R_f}{R_2 + R_f}\right]V_2 \qquad \cdots (7)$$

Now if the resistances are selected as $R_1 = R_2$,

$$V_o = -\frac{R_f}{R_1}V_1 + \left[1 + \frac{R_f}{R_1}\right]\left[\frac{R_f}{R_1 + R_f}\right]V_2 = -\frac{R_f}{R_1}V_1 + \frac{R_f}{R_1}V_2 \qquad \cdots (8)$$

OP-AMP AS A SUBTRACTOR:





$$V_o = -\frac{R_f}{R_1}V_1 + \left[1 + \frac{R_f}{R_1}\right]\left[\frac{R_f}{R_1 + R_f}\right]V_2 = -\frac{R_f}{R_1}V_1 + \frac{R_f}{R_1}V_2 \qquad \cdots (8)$$

$$\therefore V_o = +\frac{R_f}{R_1}(V_2 - V_1) \qquad \cdots (9)$$

Thus, the output voltage is proportional to the difference between the two input voltages.

The circuit acts as a Subtractor using Op-Amp or difference amplifier.

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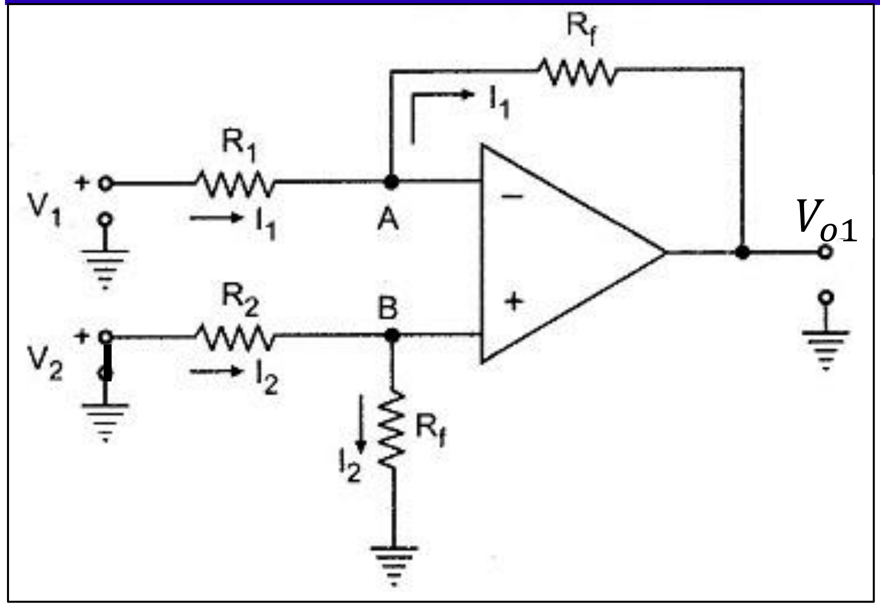

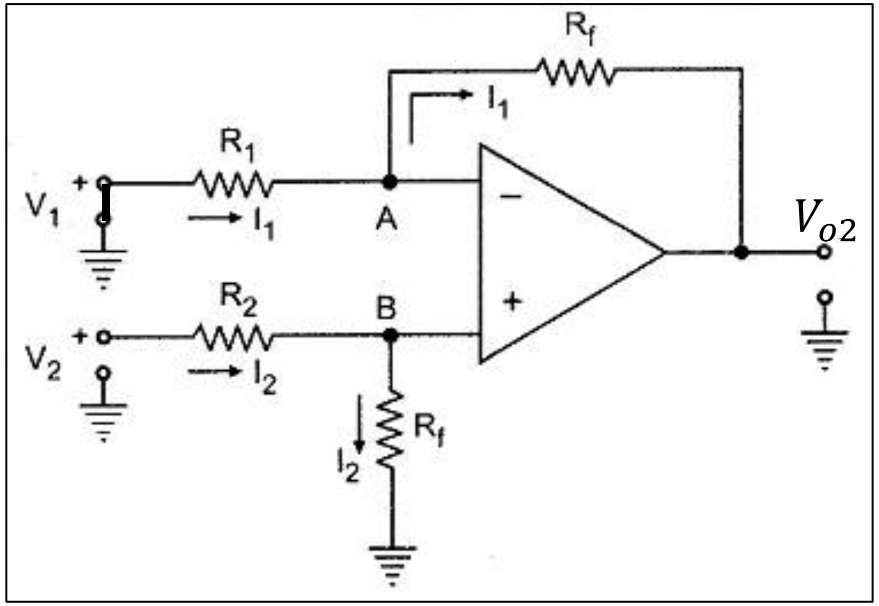

$$\therefore V_o = +\frac{R_f}{R_1}(V_2 - V_1) \qquad \cdots (9)$$

$$If \;\; R_1 = R_2 = R_f$$

$$V_o = (V_2 - V_1) \qquad \cdots (10)$$

By selecting proper values of R_1, R_2, and R_f, we can obtain the subtraction of two inputs with appropriate strengths like –

$$V_o = aV_2 - bV_1 \cdots (11)$$

OTHER APPLICATIONS OF OP-AMP:

There are many applications of op-amps in the field of electronics.

Some of them are mentioned below:

1) Current to voltage converter where the output voltage is proportional to the input current.
2) Digital to analog converter.
3) Analog computer which is constructed by using op-amp integrators and adders to solve differential equations.
4) Waveform generators or function generators.
5) Oscillators: The oscillators are used to generate repetitive alternating current and voltage waveforms of fixed amplitude and frequency.
6) Filters: Filters pass a specified band of frequencies and block signals of frequencies outside this band.

Thank You