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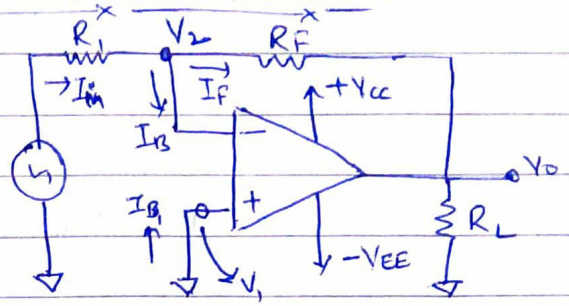
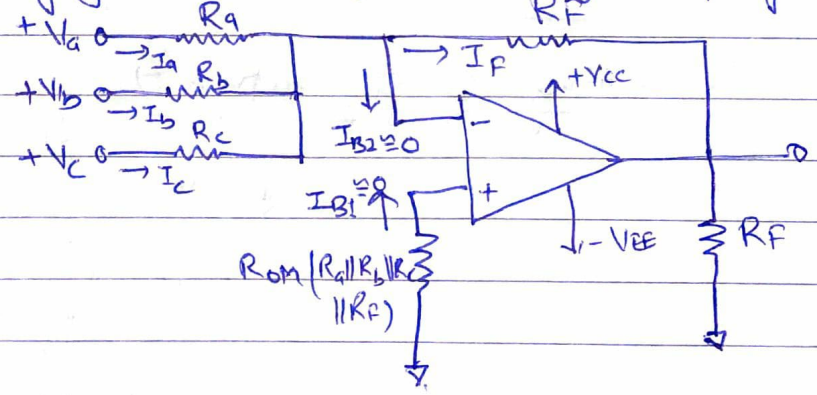
Inverting Input Terminal at virtual Ground :-



In figure the non-inverting terminal is grounded and the signal is applied to the inverting terminal via resistor R_i. However, as the difference input voltage is ideally zero; that is, the voltage at the inverting terminal (V_2) is approximately equal to that at the noninverting terminal (V_1). In other words, the inverting terminal voltage V_2 is approximately at ground potential. Therefore the inverting terminal is said to be virtual ground.

$$V_1 = V_2 = 0\,V$$

Inverting Configuration :- (Summing Amplifier)



$$I_a + I_b + I_c = I_B + I_F$$

Since R_i and A of the op-amp are ideally infinity

$I_B = 0\,A$ and $V_1 = V_2 \simeq 0\,V$

$$\frac{V_a}{R_a} + \frac{V_b}{R_b} + \frac{V_c}{R_c} = -\frac{V_o}{R_F}$$

Spiral

$$V_o = -\left(\frac{R_F}{R_a}V_a + \frac{R_F}{R_b}V_b + \frac{R_F}{R_c}V_c\right) \quad -(1)$$

(a) Summing amplifier

When $R_a = R_b = R_c = R$.

$$V_o = -\frac{R_F}{R}(V_a + V_b + V_c) \quad -(2)$$

Where $= -\frac{R_F}{R}$ is gain of the circuit.

$R_a = R_b = R_c = R_F$

$$\boxed{V_o = -(V_a + V_b + V_c)}$$

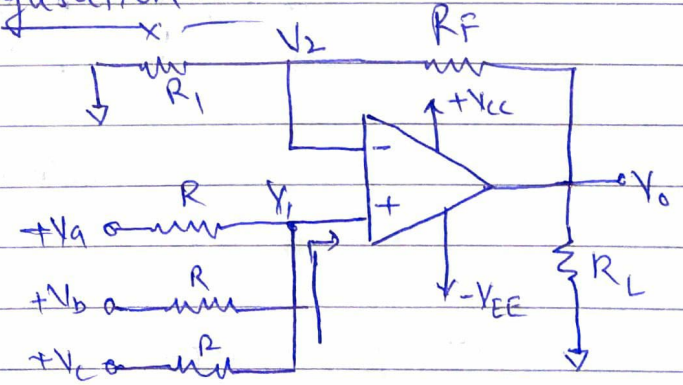
(b) Average circuit

When $\frac{R_F}{R} = \frac{1}{n}$

eq (2) $n = 3$

$$V_o = -\frac{(V_a + V_b + V_c)}{3}$$

Non inverting Configuration :-



At non-inverting terminal

$$V_1 = \frac{R/2}{R+R/2}V_a + \frac{R/2}{R+R/2}V_b + \frac{R/2}{R+R/2}V_c$$

($R/2$ is $\|^{el}$ Combination Resistance)

$$V_1 = \frac{R}{2}\frac{V_a}{3} + \frac{V_b}{3} + \frac{V_c}{3} = \frac{1}{3}(V_a + V_b + V_c).$$

The output voltage V is

$$V_o = \left(1 + \frac{R_F}{R_1}\right) V_1$$

$$= \left(1 + \frac{R_F}{R_1}\right)\left(\frac{V_a + V_b + V_c}{3}\right) \quad \text{— (1)}$$

(a) Averaging amplifier

if gain is 1, the output voltage will be equal to the average of all input voltage.

(b) Summing amplifier.

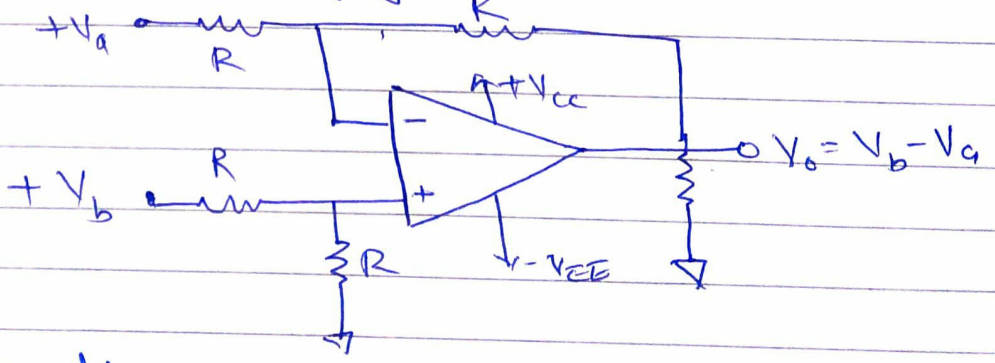
$$\Rightarrow \left(1 + \frac{R_f}{R_1}\right) = 3.$$

this is from eq (1)

$$V_o = V_a + V_b + V_c.$$

Differential Configuration.

(a) Subtractor.



The output voltage of the diff. amp. with a gain 1 is.

$$V_o = -\frac{R}{R}(V_a - V_b)$$

That is $V_a = V_b - V_a$

Reference: - Op-amp and linear integrated circuits:- Ramakant A. Gayakwad

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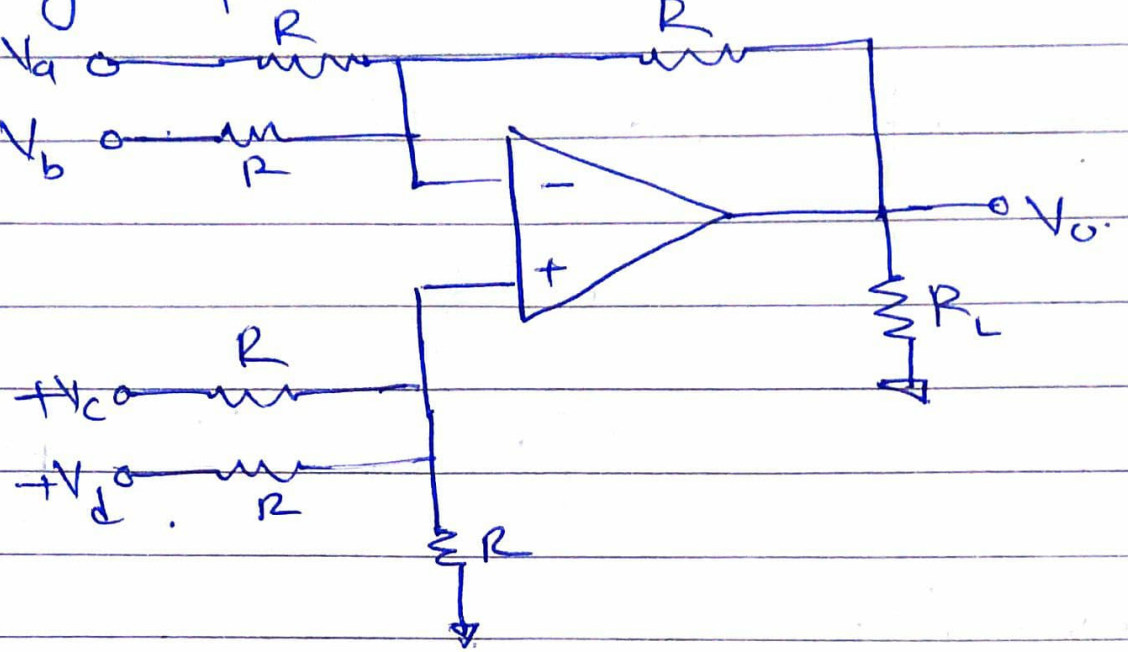
(2) Summing amplifier.



$$V_o = -V_a - V_b + V_c + V_d$$

The output voltage eq for this circuit can be obtained by using the superposition theorem.