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TRI-PATH ACADEMY.

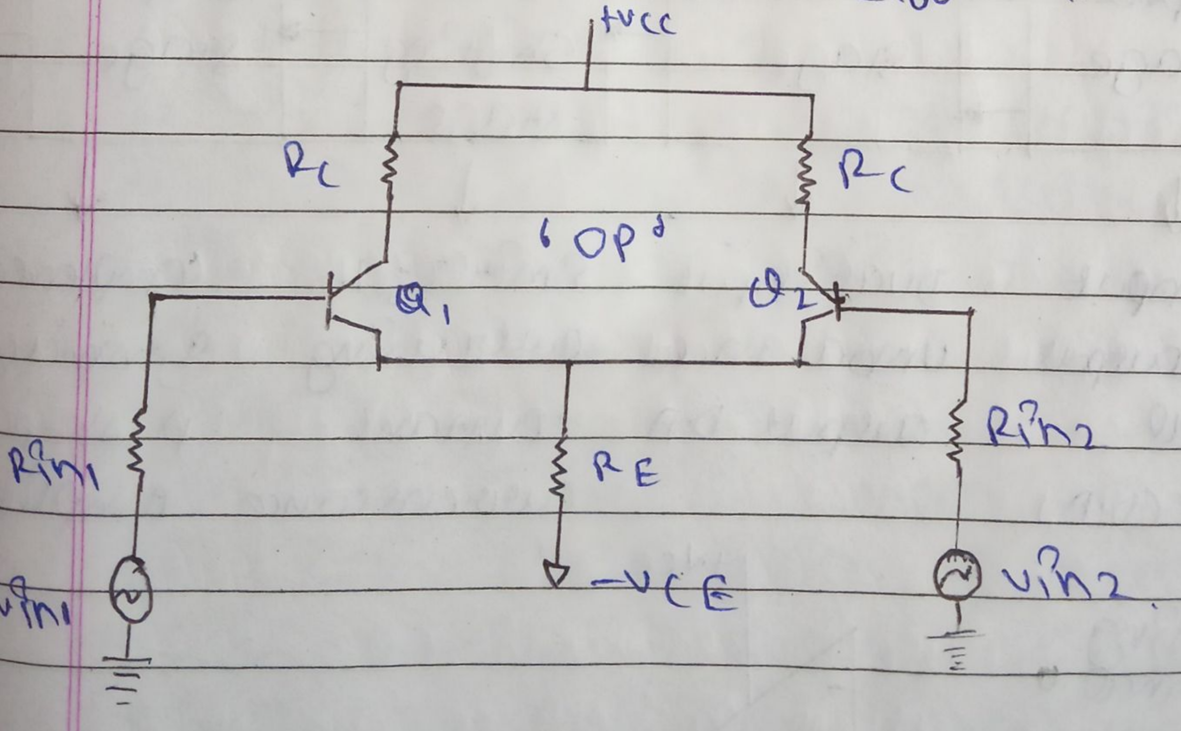
27/03/2021

Chapter = 1
Introduction to Operational Amplifier.

* Operational Amplifier :-

Operational Amplifier is a direct coupled high gain amplifier that consist of one or more differential Amplifier.

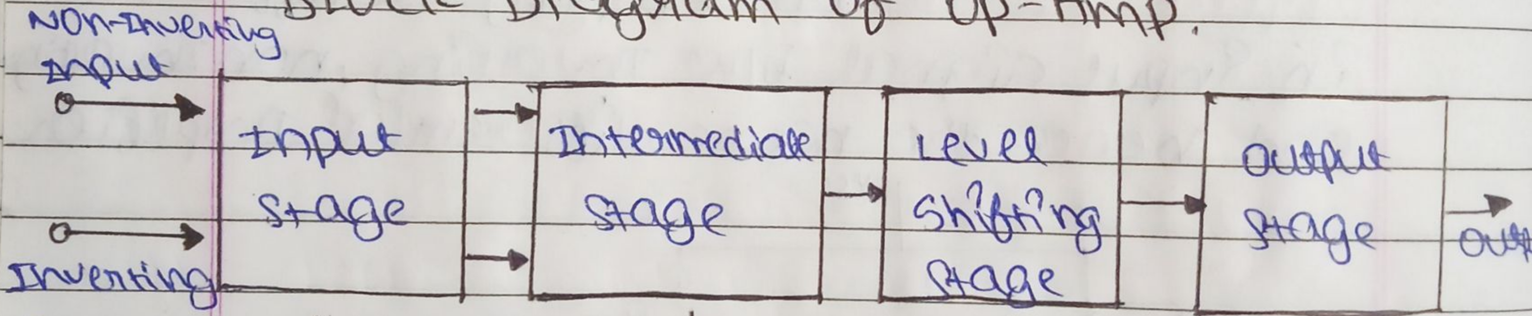
It will Amplify the difference in input signal b/w Inverting, non Inverting and hence the name differential Amplifier



* Differential amplifier :-

Operational amplifier (op amp) can be used to amplify DC as well as AC input signal and was designed for performing mathematical operation such as addition, subtraction, multiplication, integration, differentiation with addition of external feedback component.

BLOCK Diagram of Op-Amp.

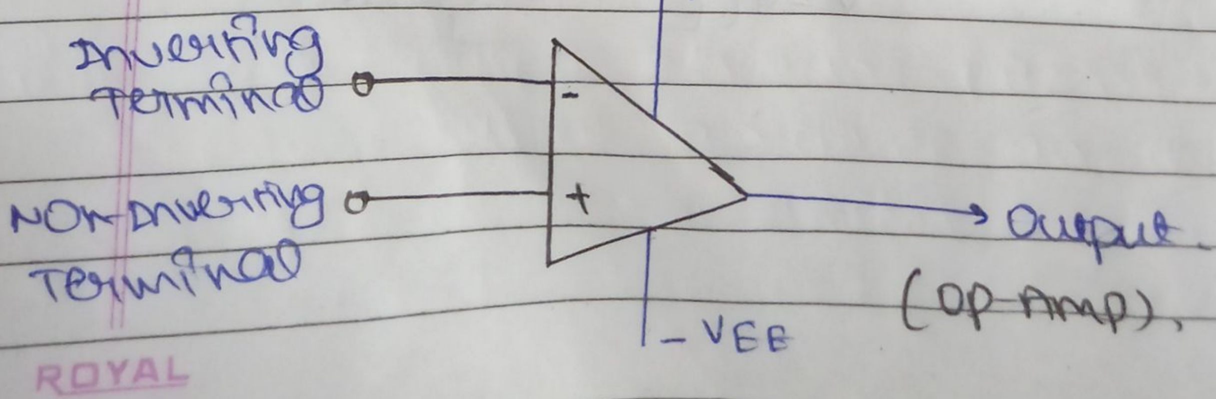


Dual input balanced-output Differential Amplifier (D.A)

Dual input unbalanced output D.A

Emitter follower using constant current source

Complementary symmetry push-pull Amplifier.



(Op-Amp).

ii) Input stage

The Input stage is dual input balanced output differential amplifier.

This stage provide most of the voltage gain of the amplifier.

iii) Intermediate stage.

The Intermediate stage is dual input unbalanced output D.A because Direct coupling is used, the DC voltage of output of Intermediate stage is above the ground potential.

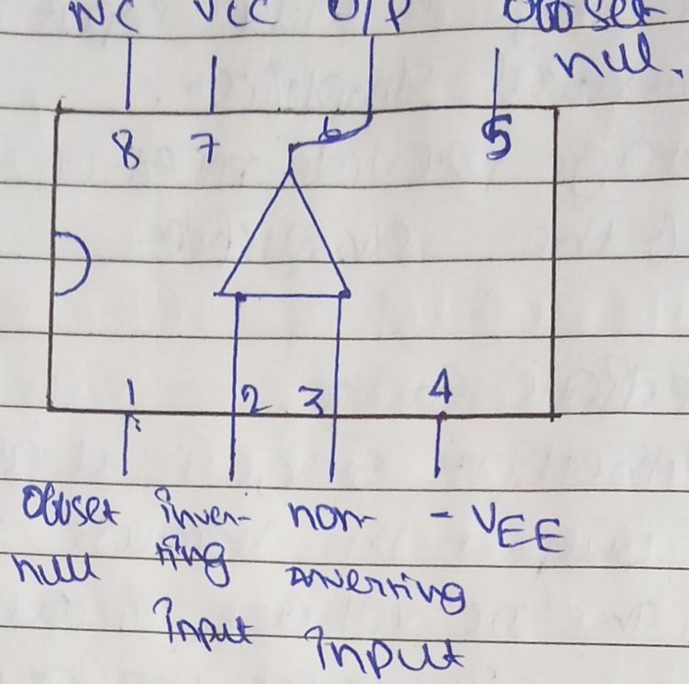
iii) Level shifting stage.

It is used after the intermediate stage to shift the DC level to output voltage with respect to ground.

v) Output stage

The Final stage is complementary symmetry push-pull Amplifier. It increases the output voltage & raising the current supplying capacity of operation Amplifier (op-Amp).

* PIN Diagram Of 741 IC.



Characteristics Of Ideal Op-Amp.

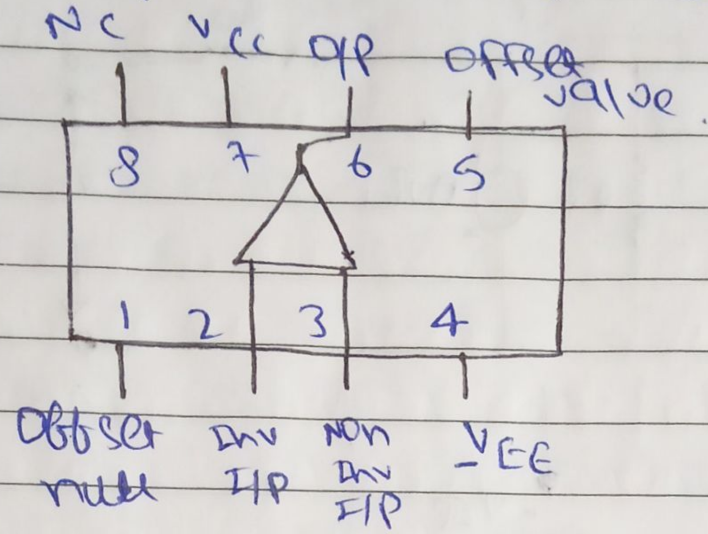
i) Infinite voltage gain:

ii) Infinite input resistance (R_i):
So that any signal source can drive it and there is no loading of proceeding stage.

iii) Zero output resistance (R_o):
So that output can drive an infinite number of other devices.

iv)) zero output voltage:

when input resistance is zero (offset value).



v)) Infinite bandwidth:

so that any signal form 0 to ∞ Hz can be amplified without any attenuation.

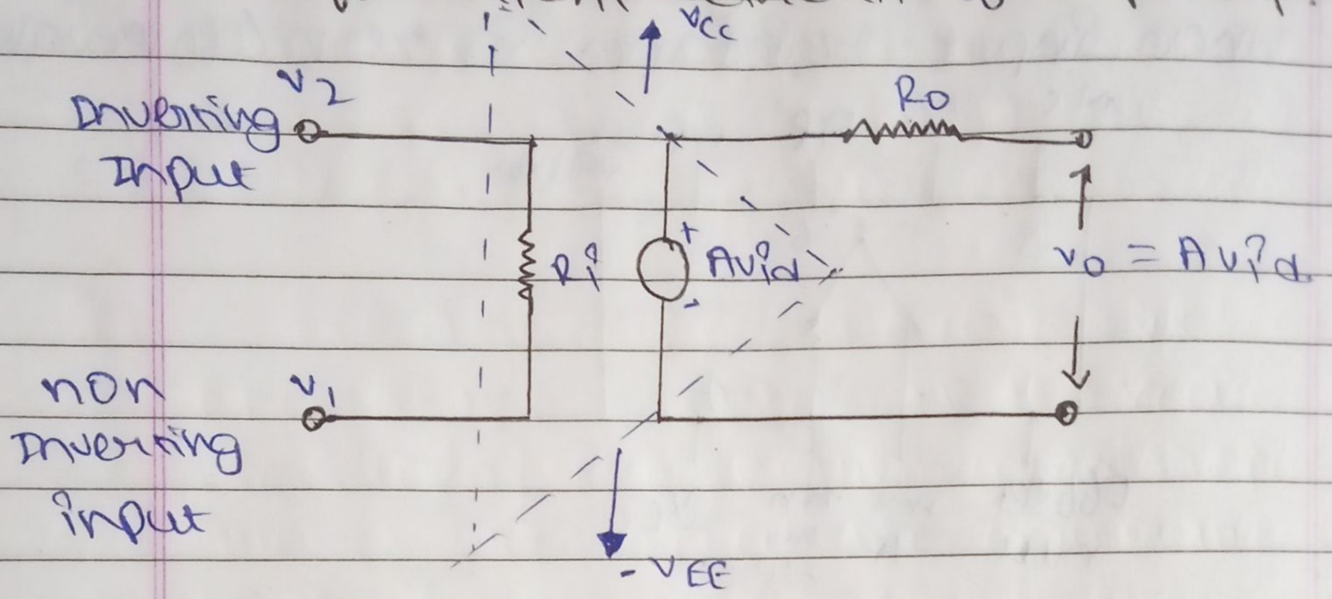
vi)) Infinite common volt rejection ratio:

so that output common volt noise is small.

vii)) Infinite slew rate:-

so that output voltage changes occur with the change in input voltage.

* Equivalent circuit of Op-Amp.



The output voltage is

$$\boxed{V_o = A v_{id} = A(v_1 - v_2)}$$

where,

A = large signal voltage gain.

v_{id} = Difference input voltage.

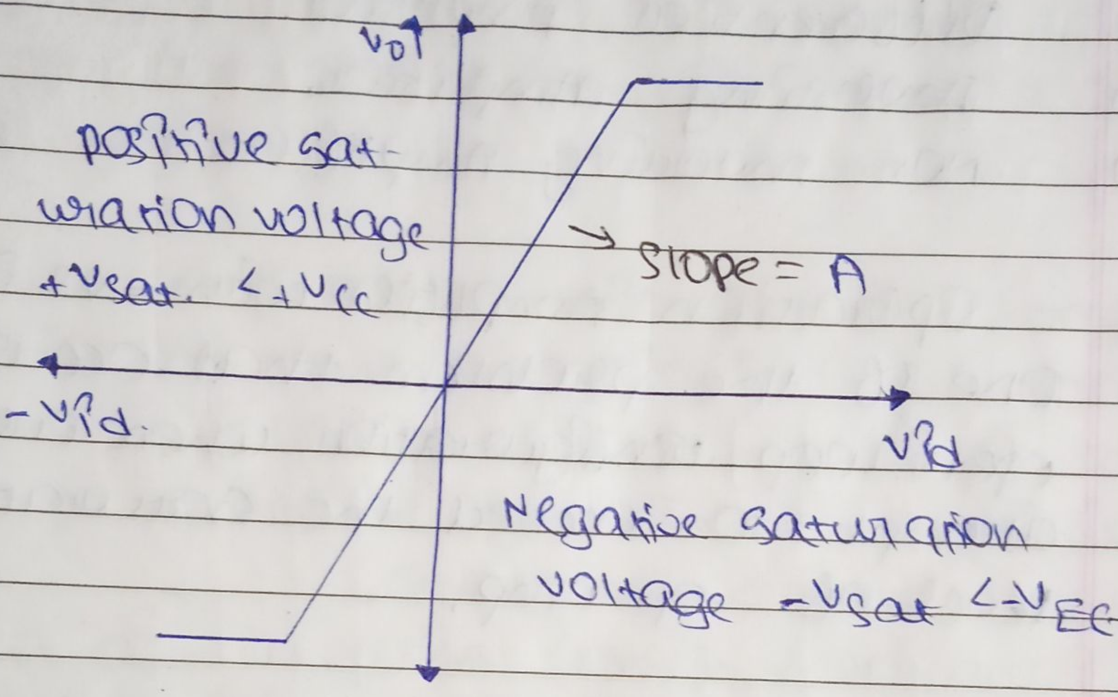
v_1 = voltage at non Inverting input

v_2 = voltage at Inverting input

NOTE :

$A v_{id}$ is equivalent thevinin voltage source & R_o is Thevenin equivalent resistance (180° out of phase in phase).

* Ideal voltage transfer curve.



$$\boxed{V_0 = A\,V_{id} = A(V_1 - V_2).}$$

The output voltage cannot exceed the +ve & -ve saturation voltage. These saturation voltage are specified by an o/p voltage swing rating of an op-amp for the given value of supply voltage.

This means that output voltage is directly proportional to input difference voltage until it reaches the saturation voltage then after output voltage remain constant.

* Open loop op-Amp configuration.
i) Differential Amplifier.
ii) Inverting Amplifier.
iii) Non-Inverting Amplifier.

* Operation Amplifier with -ve feedback
One of the problem that occur in open loop configuration when output attempt to exceed the saturation level of op-Amp.

☆ Drawback.
i) In case of open loop configuration, the open loop (OL) gain is very high, only the smaller signal is less or low frequency can be amplified accurately without any distortion.

ii) Open loop voltage gain of op-amp is not constant voltage gain even varies with change in temperature & power supply.

ROYAL

iii) Bandwidth of open loop-amplifier is negligible small. For this reason, the open loop of op-amp is practically impossible.

iv) Open loop op-amp is used as non linear device because the gain of open loop op-amp is large which makes the op-amp unstable for linear application. Therefore we use closed loop op-amp in which feedback is introduced in the circuit. so that gain of op-amp can be controlled.

Negative feedback in op-amp.

i) Stabilize the gain.
ii) Increases the bandwidth.
iii) changes the input & output resistance.

Advantage of op-amp.

i) Reduced distortion.
ii) Reduced offset output voltage.
iii) Reduced the effect of temperature
iv) Reduced the effect of supply voltage variation

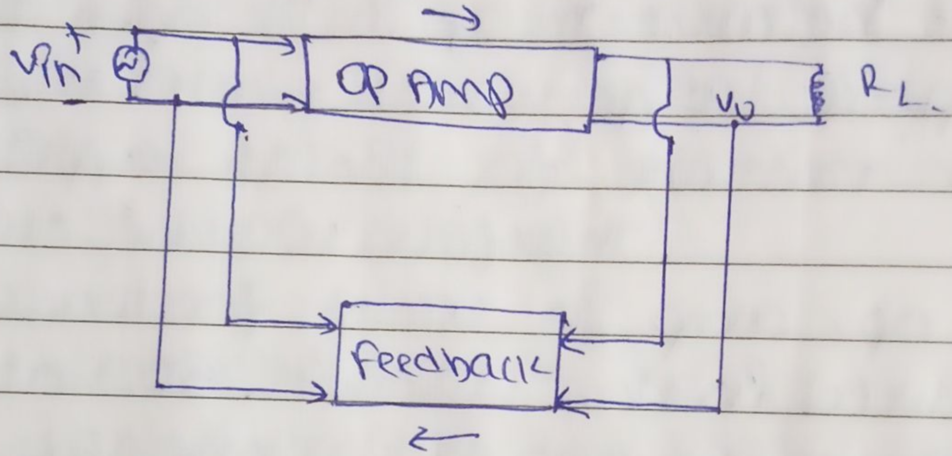
* closed loop op-Amp configuration

It can be represented by two blocks

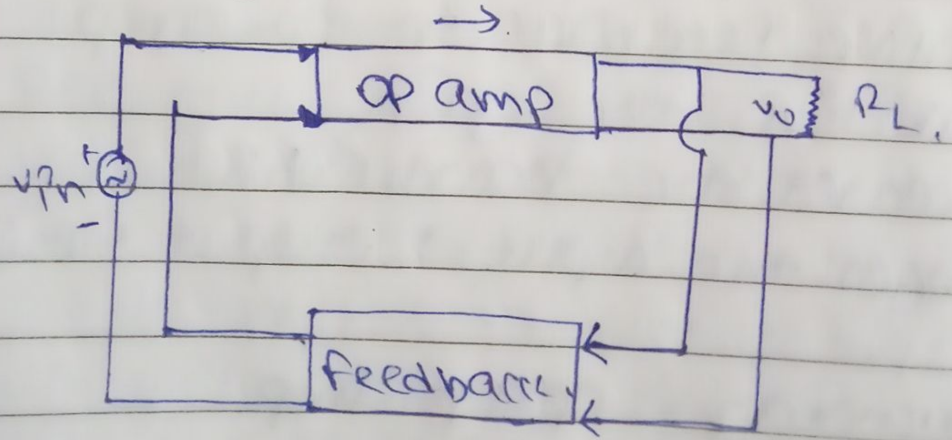
i) Inverting Amplifier (voltage shunt feed

ii) Non-Inverting Amplifier (voltage series Feedback

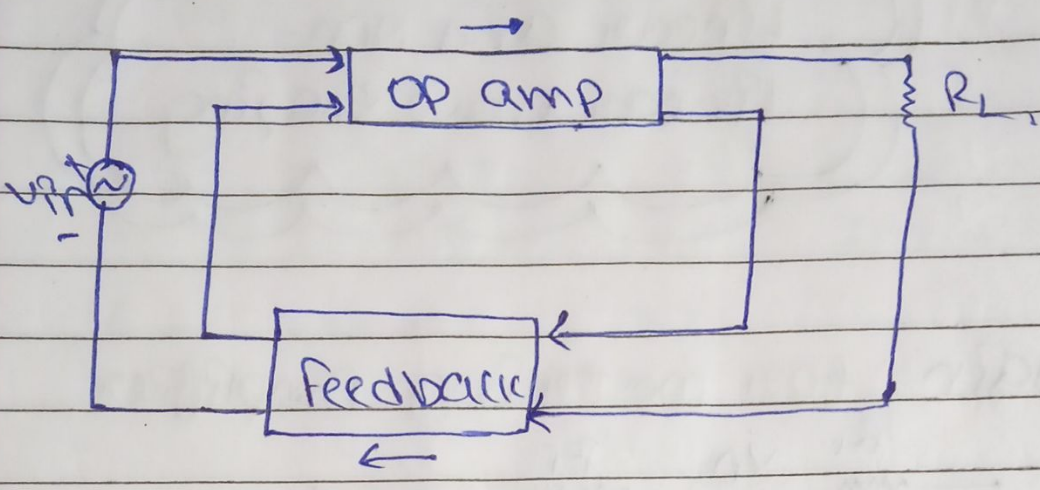
i) voltage shunt feedback.



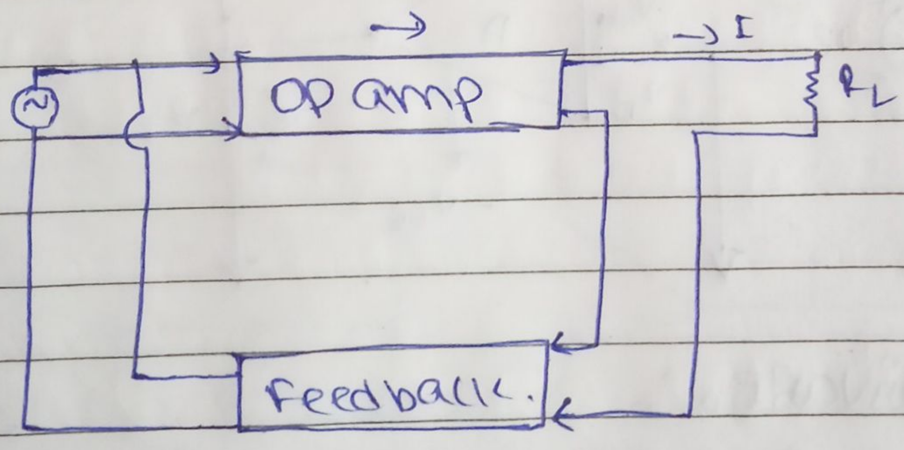
ii) voltage series feedback.



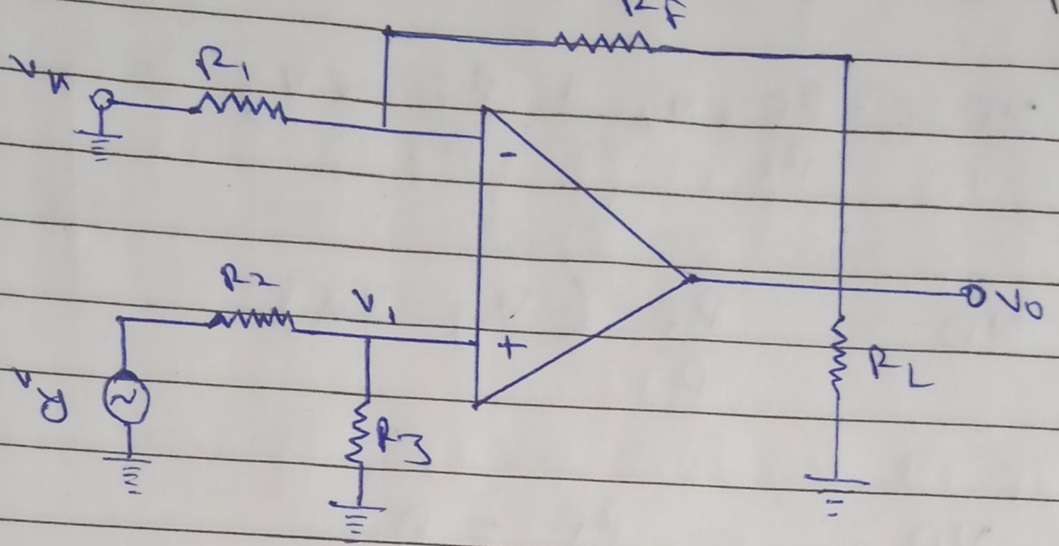
iii) current series feedback.



iv) current shunt feedback.



* Differential amplifier of one op-amp.



When we apply input at vx.

$$V_{ox} = -\frac{R_F}{R_1} \times V_x \quad \text{---} \; ①$$

When we apply input at vy

$$V_{oy} = \left(1+\frac{R_F}{R_1}\right) \times V_y \times \frac{R_3}{R_2+R_3} \quad \text{---} \; ②$$

Adding eq ① & ②

$$V_O = V_{ox} + V_{oy}$$

$$V_O = -\frac{R_F}{R_1} \times V_x + \left(1+\frac{R_F}{R_1}\right) \times \left(\frac{R_3}{R_2+R_3}\right) V_y$$

$R_2 = R_1$, & $R_3 = R_f$

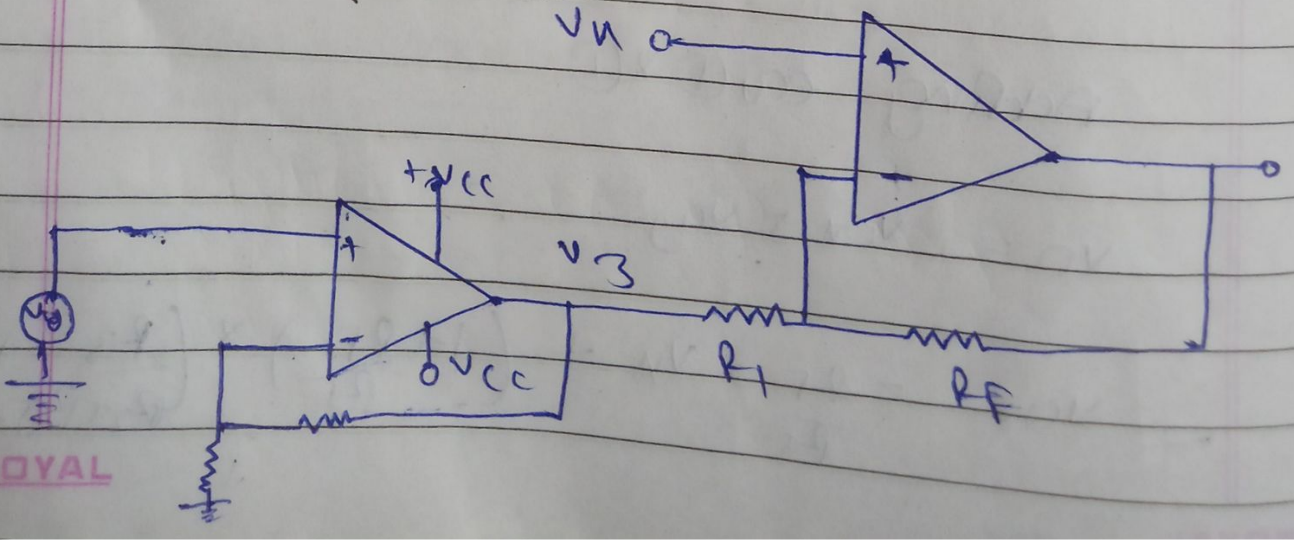
$$V_O = -\frac{R_F}{R_1} \times V_x + \frac{R_F}{R_1} \times V_y .$$

$$V_O = \frac{R_f}{R_1} (V_y - V_x)$$

$$\frac{V_O}{V_y - V_x} = \frac{R_F}{R_1} = A.$$

$$\boxed{V_O = \frac{R_f}{R_1} (V_y - V_x).}$$

* Differential amplifier with two op-amp.



Output of first op-amp.

(v_z) $v_z = \left(1+\frac{R_3}{R_2}\right) v_y$ --- (1)

Output of second op-amp.

$v_o = v_{ox} + v_{oz}$

$v_{ox} = \left(1+\frac{R_f}{R_1}\right) v_x$ --- (2)

$v_{oz} = -\frac{R_f}{R_1} \times v_z$

from eq (1)

$v_{oz} = -\frac{R_f}{R_1} \times \left(1+\frac{R_3}{R_2}\right) v_y$

Substitute $R_1 = R_3$ & $R_2 = R_f$

$v_{oz} = -\frac{R_f}{R_1} \times \left(1+\frac{R_1}{R_f}\right) v_y$

$v_{oz} = -\left(1+\frac{R_f}{R_1}\right) v_y$ --- (3).

Now,

$v_o = v_{ox} + v_{oz}$.

$$v_0 = \left(1+\frac{R_f}{R_1}\right) v_x - \left(1+\frac{R_f}{R_1}\right) v_y$$

$$\boxed{v_0 = \left(1+\frac{R_f}{R_1}\right) (v_x - v_y)}$$

Input Resistance for v_y

$$R_{if_y} = R_i (1+A\beta)$$

$$\beta = \frac{R_2}{R_2+R_3}$$

$$R_{if_x} = R_i (1+A\beta)$$

$$\beta = \frac{R_1}{R_1+R_f}$$