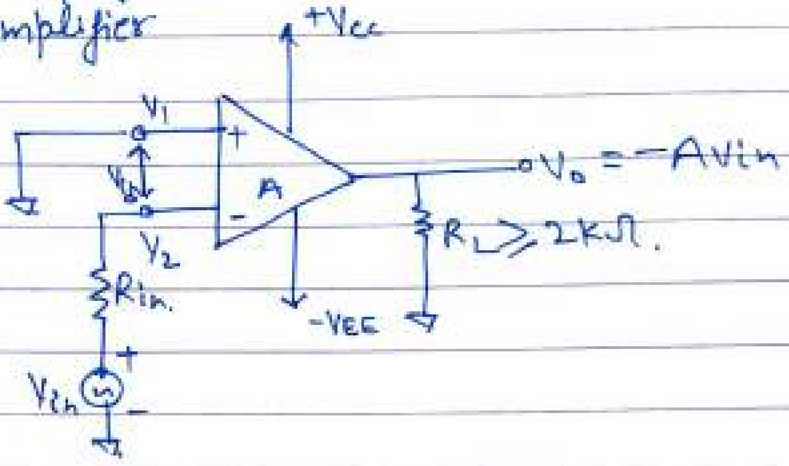
The ~~Differential~~ Amplifier:→

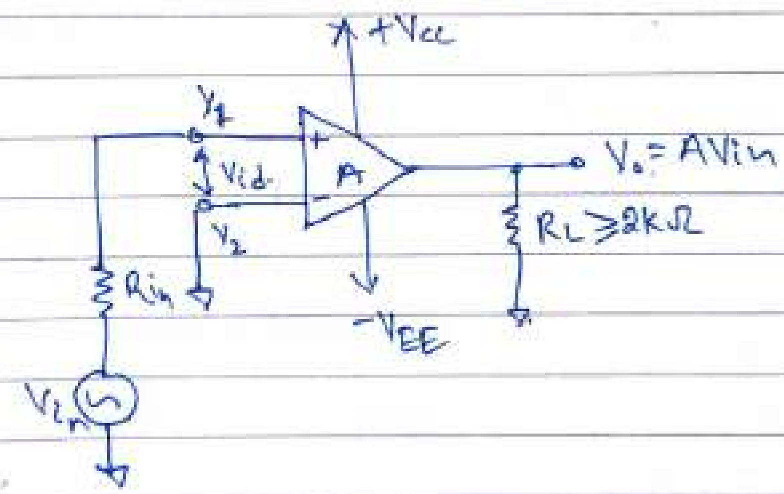
① The inverting amplifier



$V_1 = 0$

$V_o = -AV_{in}$

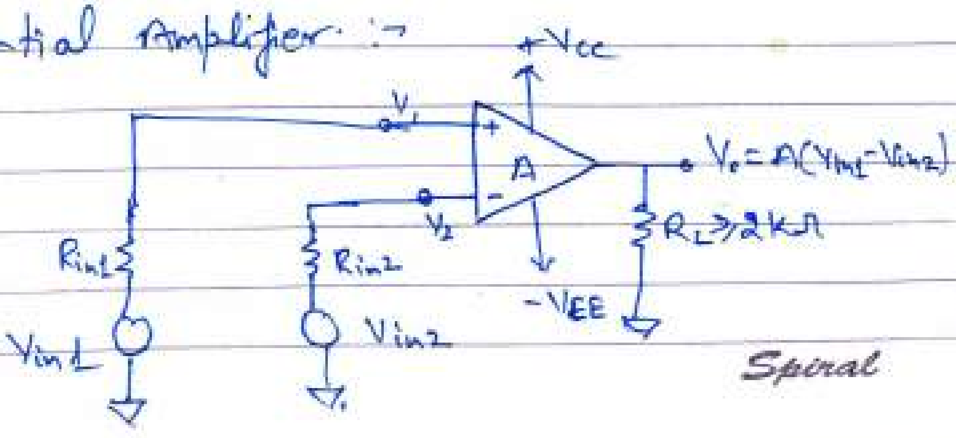
② The non-inverting Amplifier



$V_2 = 0$

$V_o = AV_{in}$

③ The Differential Amplifier :→



$$V_o = A(V_{in1} - V_{in2}).$$

All the above mentioned examples (Amplifiers) are open-loop or without feedback. amplifiers.

* Feedback *

* The open-loop gain of the op-amp is very high, only the smaller signals (of the order of microvolts or less) having very low frequency may be amplified accurately without distortion. However, signals this small are very susceptible to noise and are almost impossible to obtain.
The open-loop op-amp is generally not used in linear aplications. Nevertheless. in certain application the open-loop op-amp is purposely used as nonlinear device.

* If an output signal fed back to the input either directly or via another network. ~~It~~ is called the feedback. or closed-loop. If the signal fed back is of opposite polarity or out of phase by 180° (or odd. integer multiples of 180°) with resp. to the input signal the feedback is called negative feedback. An amplifier with negative feedback has a self-correction ability against any change in output voltage caused by change in environ-mental condition. On the other hand if the signal is of the same polarity or in phase with input signal, the feedback is called positive feedback. Positive feedback is necessary in oscillator circuits.

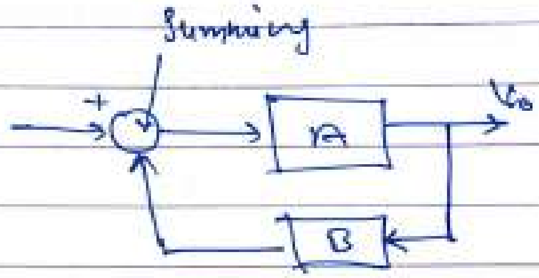
$$A_f = \frac{1}{B}$$

Also

$$A_f = \frac{A(R_1+R_f)}{R_1+R_f+AR_1}$$

$$\Rightarrow A_f = \frac{A\left(\frac{R_1+R_f}{R_1+R_f}\right)}{\frac{R_1+R_f}{R_1+R_f} + \frac{AR_1}{R_1+R_f}}$$

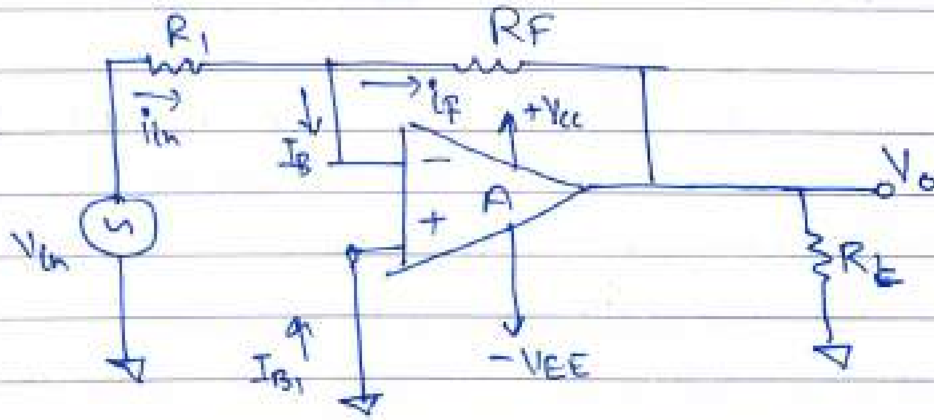
$$\boxed{A_f = \frac{A}{1+AB}}$$



AB = loop gain

—x — x — x — x —

— x — Inverting amplifier with feedback — x —



$$i_{in} = i_f + I_B$$

$$i_{in} \simeq i_f$$

Since R_i is very large, the input bias current I_B is negligibly small. Eg

$R_i = 2M\Omega$ & $I_B = 0.5\mu f$ for 741C.

$$\Rightarrow \quad \frac{V_{in} - V_2}{R_1} = \frac{V_2 - V_0}{R_F} \quad — ①$$

Also $$A = \frac{V_0}{V_1 - V_2} \quad — ②$$

Since $V_1 = 0V$.

$$A = -\frac{V_0}{V_2} \Rightarrow V_2 = -\frac{V_0}{A} \quad — ③$$

Substituting this value of V_2 in above eq. ③ in ①

$$\frac{V_{in} + V_0/A}{R_1} = \frac{-(V_0/A) - V_0}{R_F}$$

$$A_F = \frac{V_0}{V_{in}} = -\frac{AR_F}{R_1 + R_F + AR_1} \text{ (exact)} \quad — ④$$

$AR_F >> R_1 + R_F$

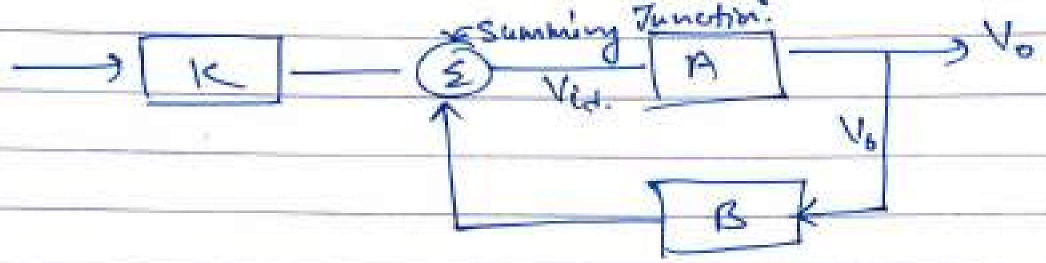
$$\Rightarrow \boxed{A_F = \frac{V_0}{V_{in}} = -\frac{R_F}{R_1}} \text{ (ideal)} \quad — ⑤$$

Further divide both numerator and denominator of eq. ④ by $R_1 + R_F$

$$A_F = -\frac{AR_F / R_1 + R_F}{1 + \frac{AR_1}{R_1 + R_F}}$$

$$\boxed{A_f = -\frac{AK}{1+AB}}$$

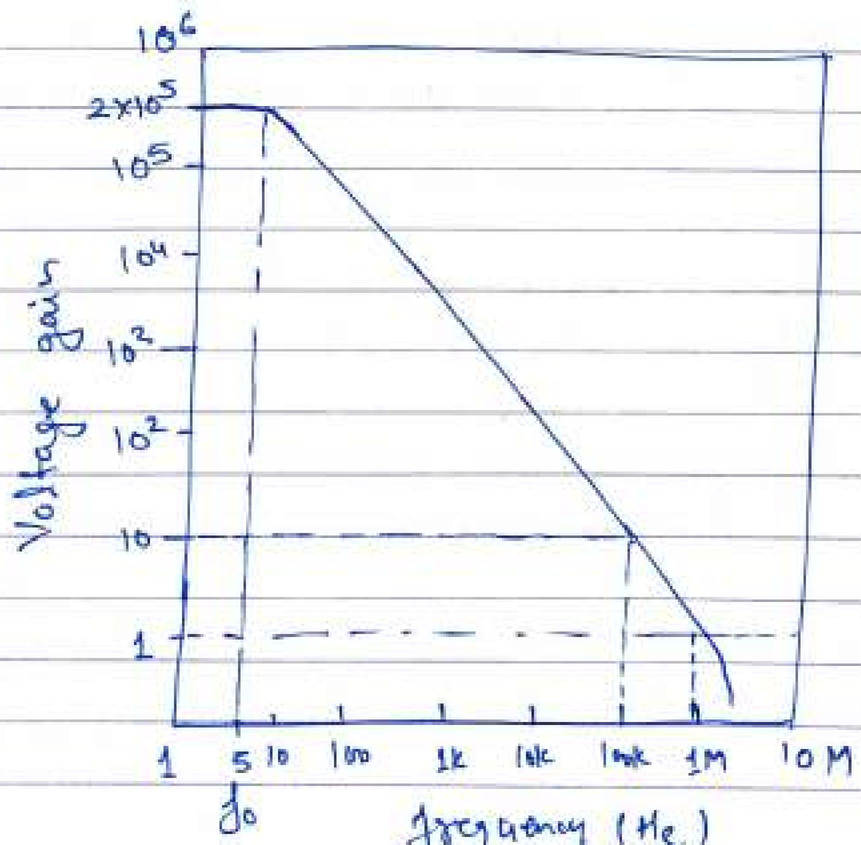
$$K = \frac{R_F}{R_1+R_F}$$ → Voltage attenuation factor.



$$B = \frac{R_1}{R_1+R_F}$$

Band width with feedbac.

The bandwidth of an amplifier is defined as the band (rang) of frequencies for which the gain remains constant.



Open-loop gain versus frequency curve of the 741C

Spiral

(*) The open-loop gain of 741C op-amp from the curve. is 2,00,000 and the bandwidth is approximately 5 Hz. and gain-bandwith product is (2,00,000 × 5 Hz) = 1 MHz On the other extreme the bandwidth is approximately 1 MHz when the gain is 1. This the gain-bandwidth product is constant. This holds true only for op-amp like the 741 that have just one break frequency below unity gain-bandwidth. For the 741, 5 Hz is the break frequency; the frequency at which the gain A is 3 dB down from its value at 0 Hz denoted by "f_o". on the other hand, the frequency at which the gain equals 1 is known as the unity gain-bandwidth (UGB)

$$UGB = (A)(f_o) \quad \text{— (1)}$$

where A = open-loop voltage gain.

f_o = break frequency of an op-amp.

or alternatively, only for a single break frequency op-amp.

$$UGB = (A_F)(f_F) \quad \text{— (2)}$$

Where A_F = Closed loop voltage gain

f_F = bandwidth with feedback.

$$(A)(f_o) = (A_F)(f_F)$$

$$f_F = \frac{A f_o}{A_F} \quad \text{— (3)}$$

However, for the non-inverting amplifier with feedback.

Spiral

$$A_F = \frac{A}{1+AB} \quad — (4)$$

Substituting the value of A_F (4) in (3).

$$f_F = \frac{(A)(f_o)}{A/(AB+1)}$$

$$f_F = f_o(1+AB) \quad — (5)$$

(This for non-inverting amp with feedback)
This result shows that ~~it~~ desired voltage gain A_F is 10; then the closed-loop bandwidth f_F will be approximately 100kHz. This can also be determined from the graph (fig).

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