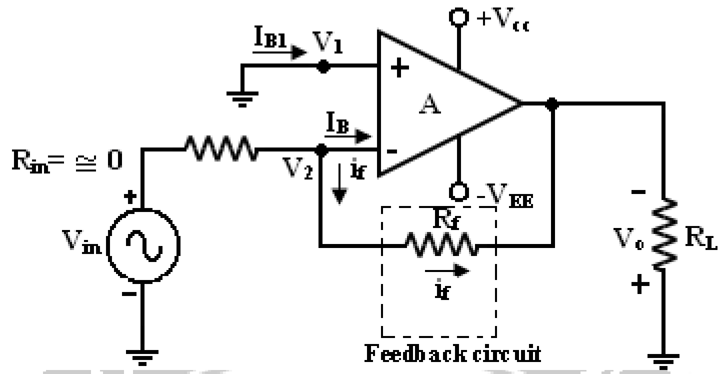
Voltage Shunt Feedback Amplifier:[Inverting Amplifier]



The input voltage drives the inverting terminal, and amplified as well as inverted output signal also applied to the inverting input via feedback resistor R_F .

Note:

Non-inverting terminal is grounded and feedback circuit has R_F and extra resistor R_1 is connected in series with the input signal source Vin.

We derive the formula for

1. Voltage gain
2. Input and output resistance
3. Bandwidth
4. Total output offset voltage.

1. Closed – loop voltage gain A_F :

A_F of volt shunt feedback amplifier can be obtained by writhing KCL eqn at the input node V_2 .

$i_{in} = i_F + I_B$ ------ (12.a)

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

i_{in} t i_F

(i.e) $\frac{Vin - V_2}{R_i} = \frac{V_2 - V_0}{R_F}$ ------ (12.b)

Consider, from eqn,

$V_1 - V_2 = - V_0 /A$

Since $V_1 = 0V$

$V_2 = -V_0 /A$

Sub this value of V_2 in eqn (12.b) and rearranging,

$\frac{Vin + V_0 /A}{R_i} = \frac{-(V/A) - V_0}{R_F}$

$A_F = \frac{V_0}{Vin} = - \frac{AR_F}{R_1 + R_F + AR_1}$ (exact) --------- (13)

The –ve sign indicates that the input and output signals are out of phase 180^0 . (or opposite polarities).

Because of this phase inversion the diagram is known as Inverting amplifier with feedback. Since the internal gain A of the op-amp is very large (α) , $AR_1 >> R_1 + R_F$, (i.e) eqn (13)

$A_F = V_0 / V_{in} = -R_F / R_1$ (Ideal)

To express eqn (13) in terms of eqn(6). To begin with, we divide both numerator and denominator of eqn (13) by $(R_1 + R_F)$

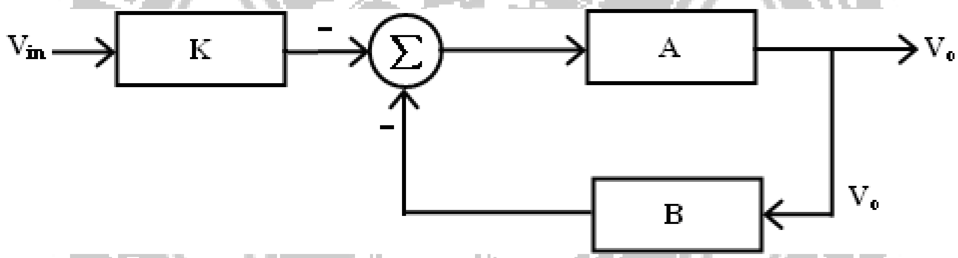
$A_F = AR_F / R_1 + R_F$

$$\frac{\quad}{1 + AR_1 (R_1 + R_F)} \quad \text{---(15)}$$

$A_F = - AR/ 1+AB)$

Where $K = R_F / (R_1 + R_F)$

$B = R_1 / (R_1 + R_F)$ Gain of feedback.



The comparison of eqn (15) with feedback (6) indicates that in addition to the phase inversion (-sign), the closed loop gain of the inverting amplifier in K times the closed loop gain of the Non-inverting amplifier where K< 1. To derive a ideal closed loop gain, we can use Eqn 15 as follows,

If AB >> 1, then (1+AB) = AB and $A_F = K/B = -R_F / R_1$ ---- (16)

2. Input Resistance with feedback:

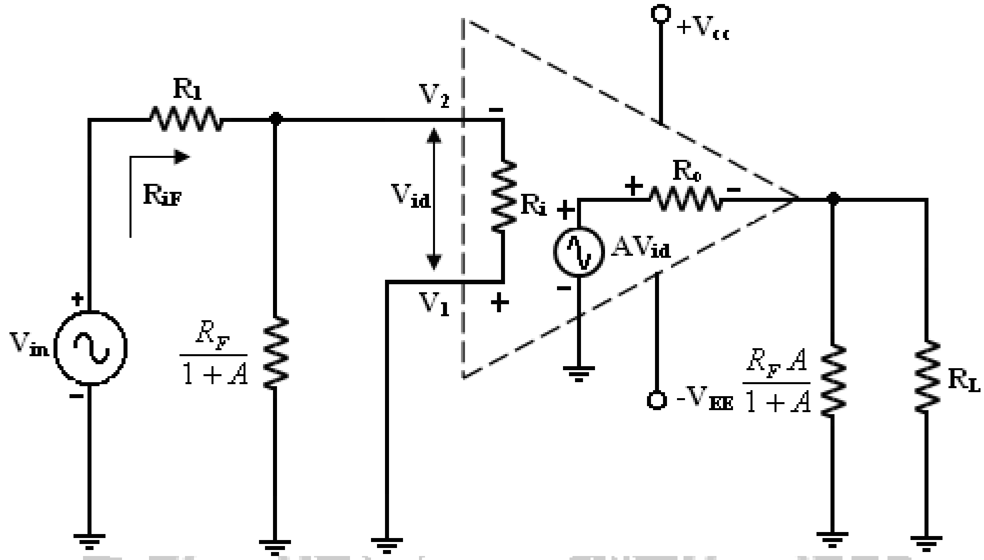
Easiest method of finding the input resistance is to millerize the feedback resistor R_F . (i.e) Split R_F in to its 2 Miller components as shown in fig.

In this circuit, the input resistance with feedback Rif is then

$$Rif = R_1 + \frac{R_F}{1+A} \parallel (R_i) \text{ -------- (18)}$$

Since Ri and A are very large.

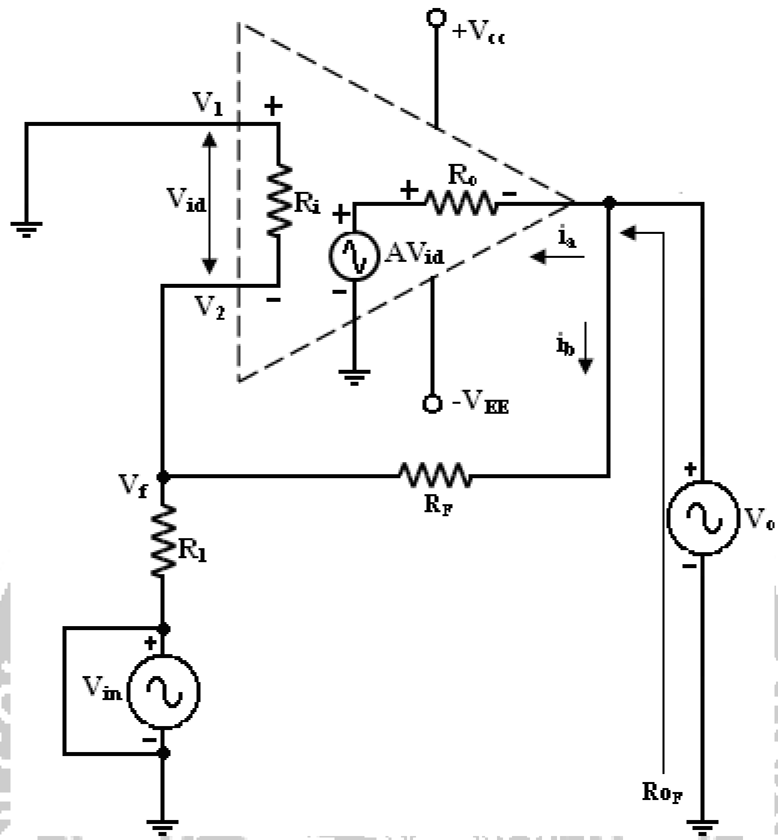
$R_1 + R_F$----- || (R_1) t 0Ω



1+A

3. Output Resistance with feedback:

The output resistance with feedback R_{OF} is the resistance measured at the output terminal of the feedback amplifier. Thevenin's circuit is exactly for the same as that of Non-inverting amplifier because the output resistance R_{OF} of the inverting amplifier must be identical to that of non – inverting amplifier.



R_0 = Output Resistance of the op-amp

A = Open loop volt gain of the op-amp

B = Gain of the feedback circuit.

4. Bandwidth with Feedback:

The gain Bandwidth product of a single break frequency op-amp is always constant.

Gain of the amplifier with feedback < gain without feedback

The bandwidth of amplifier with feedback f_F must be larger than that without feedback.

$f_F = f_0 (1+AB)$ ---------- (21.a)

f_0 = Break frequency of the op-amp

$$\text{= unity gain Bandwidth} = \frac{\text{unity gain Bandwidth}}{\text{Open- loop voltage gain}} = \frac{UGB}{A}$$

Sub this value of f_0 in eqn (21.a)

f_F = UGB------- (1+AB)A
f_F = UGB (K) -----(21.b)A_F
Where $K = R_F /(R_1 + R_F)$; $A_F = AK/1+AB$

Eqn 10.b and 21.b => same for the bandwidth.

Same closed loop gain the closed loop bandwidth for the inverting amplifier is

< that of Non –inverting amplifier by a factor of K(<1)

5. Total output offset voltage with feedback:

When the temp & power supply are fixed, the output offset voltage is a function ofthe gain of an op-amp.

Gain of the feedback < gain without feedback.

The output offset volt with feedback < without feedback.

Total Output offset Voltage with f/b =Total output offset volt without f/b- 1+AB

Vout = ±Vsat--------- ----(22)1+AB

±Vsat = Saturation Voltage

A = open-loop volt gain of the op-amp

B = Gain of the f/b circuit

$B= R_1 /(R_1 + R_F)$

In addition, because of the –ve f/b,

1. Effect of noise
2. Variations in supply voltages
3. Changes in temperature on the output voltage of inverting amplifier are reduced.