Hands out on Fedback in amplifier

A- Basic principles and types of feedback

⇨ Feedback is the process by which a fraction or part of output energy of an amplifier is injected back to combine with its input as shown in the diagram:

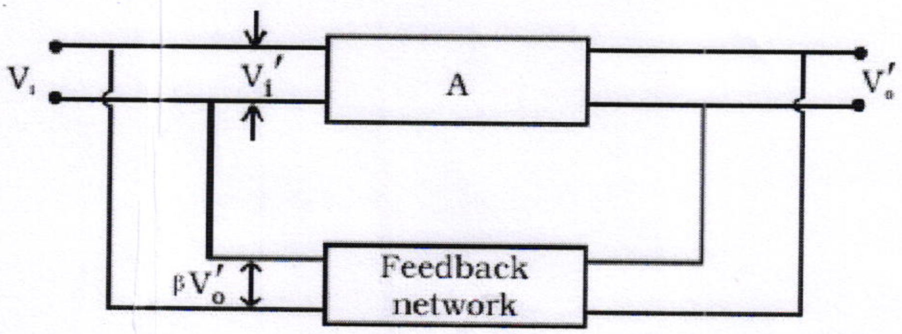


Fig Feedback amplifier

⇨ The output injected back may aid or oppose the input signal & on this basis feedback can be of two types:

1.**Positive or regenerative feedback**
2.**Negative or degenerative feedback**

1- **Positive or regenerative feedback :** When the fraction of output injected back is in phase with the input signal & aids with it, it is called **positive or regenerative** feedback.

Adv: Overall gain of amplifier is increased.
Disadvantage: 1- Increased Noise & distortion in output.
2- Results in poor stability
Application: In Oscillator circuits .

2.**Negative or degenerative feedback :** In case the fraction of output injected back is in opposition or 180^0 out of phase with input signal, it is known as negative or degenerative feedback.

Adv:1- Decreased Noise & distortion in output.
2- Improved stability
Disadvantage: 1- Overall gain of amplifier is decreased.
Application: widely used in amplifier circuits .

⇨ Types Of Feedback on the basis of Electrical Quantity:
On this Basis the feedback can be classified as below:
1- Voltage Feedback
2- Current feedback
⇨ Both voltage or current can be fed back to input either in series or in shunt.
⇨ Where series feedback connections generally increase input impedance, the shunt feedback connections tend to decrease input impedance.
⇨On other hand voltage feedback decreases output impedance whereas current feedback decreases output impedance.

B- Derivation of expression for gain of an amplifier employing feedback:

⇨ Let V_1 be input to amplifier & V_O be output of the amplifier Without feedback. In This Condition Voltage Gain A_v Of this amplifier will be given as

$$A_v = V_O / V_1$$

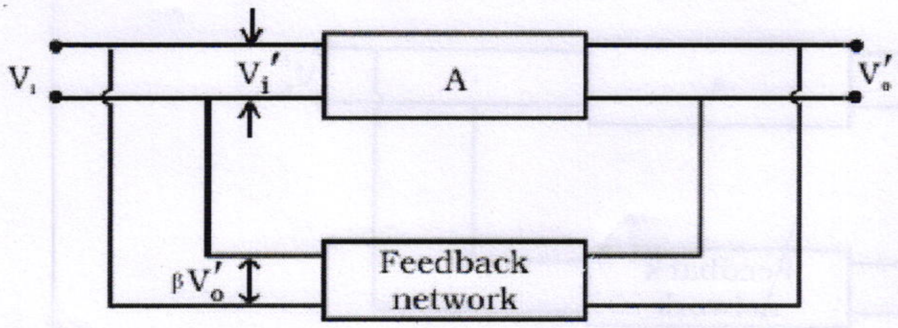


Fig Feedback amplifier

Calculation of gain with feedback

⇨ When a feedback network is employed than the new input to the amplifier is

$$V_1' = V_1 \pm \beta V_O$$

($V_1' = V_1 + \beta V_O$ for Positive Feedback & $V_1' = V_1 - \beta V_O$ For negative feedback)

Where β is factor of feedback circuit, the value of which depends on the type of feedback network used.

⇨ Value of $\beta<1$ when the feedback network consists of passive components only & $\beta>1$ if there are active components in the feedback network .

⇨ Let us consider calculation og gain for a negative feedback amplifier. For such an amplifier, new input value will be

$$V_1' = V_1 - \beta V_O$$

⇨ Now Gain of this amplifier will be $A_v = V_O / V_1' = V_O / V_1 - \beta V_O$

or alternatively $A_v \times (V_1 - \beta V_O) = V_O$

or $A_v \times V_1 - A_v \times \beta V_O = V_O$

or $A_v \times V_1 = (V_O + A_v \times \beta V_O) = V_O\ (1 + \beta A_v)$

or $A_v / (1 + \beta A_v) = V_O / V_1 = A_v'$

Where A_v' is the gain of amplifier with negative feedback

Similarly gain for an amplifier with positive feedback can be calculated & that comes out to be

$$A_v' = A_v / (1 - \beta A_v)$$

⇨ The expression for gain with feedback shows that the gain is affected after using feedback circuit.

C- Effect of Negative feedback on gain stability, distortion and bandwidth of an amplifier

1- Increased Gain stability :

⇨ Gain of an amplifier may change due to change either in power supply or in parameters of active device used. Change in gain adversely affects overall performance of an amplifier & therefore needs stability.

⇨ Using negative feedback makes gain stable & thus results in better performance of the amplifier .

⇨ As we know, gain of an amplifier with negative feedback is given as

$$A_v' = A_v / (1 + \beta A_v)$$

⇨ If by any means we are able to make $\beta A_v >> 1$, then quantity 1 in expression $(1+ \beta A_v)$ can be neglected & in that condition

$$1+ \beta A_v = \beta A_v$$

⇨ In this condition above expression (i) will be read as

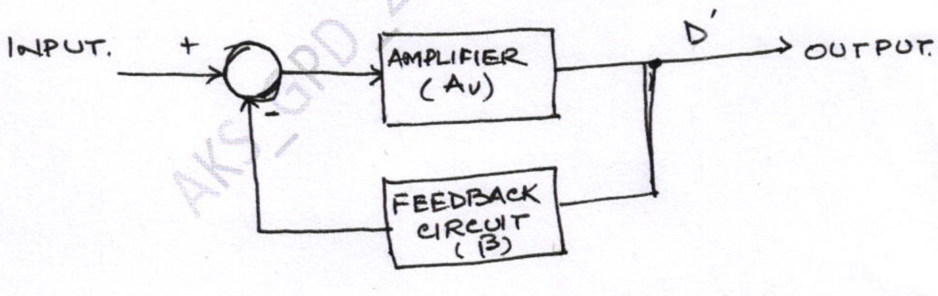
$$A_v' = A_v / \beta A_v = A_v' = 1/ \beta$$

⇨ Thus we see that that by just making $\beta A_v >> 1$, the overall gain of negative feedback amplifier becomes independent of internal gain & depends inversely on feedback factor β .

⇨ This Shows that using negative feedback increases gain stability & thus overall performance of amplifier is improved.

2- Reduction in Distortion & noise:

⇨ When negative feedback is employed in an amplifier, the harmonic distortion is reduced, this can be understood by the following block diagram:



⇨ Let us assume that the amplifier with gain A_v produces distortion D. When feedback is applied the gain becomes A_v' & the distortion D'.

⇨ The distortion changes as a part of distortion D' is fed to input through the feedback network & this amounts to be βD' as shown in above diagram.

⇨ This distortion βD' is amplified by gain A_v of the amplifier & due to negative feedback D' is expressed as

$$D' = D - \beta A_v D'$$

$$\text{or } D' = D/1+ \beta A_v$$

⇨ Thus we see that in an amplifier with feedback, distortion is reduced by a factor of $(1+ \beta A_v)$

⇨ Similarly it can be shown that in an amplifier with negative feedback, noise level in output is reduced in the same magnitude.

3- **Effect of Negative feedback on Frequency response & Bandwidth:**

⇨ As we know, overall gain of an amplifier with negative feedback decreases & is given by the following expression:

$A_v' = A_v / (1 + \beta A_v)$ Where A_v is gain of amplifier

⇨ With change in gain by a factor of $(1 + \beta A_v)$, the upper & lower cut off frequency are also affected by this factor.

⇨ In fact the lower cut off frequency is decreased & upper cut off frequency is increased by a factor of $(1 + \beta A_v)$, when negative feedback is employed in an amplifier circuit.

⇨ This causes an increase in bandwidth (BW) because BW is difference of upper & lower cut off frequencies.

⇨ Thus, it is concluded that with negative feedback in amplifier, the bandwidth increases & the frequency response is improved.

4- **Effect of Negative feedback on Input Impedance :**

⇨It is found that input impedance of an amplifier after employing negative feedback is given as :

$Z_i' = Z_i (1+ \beta A_v)$ Where Z_i' = Input Impedance after negative feedback

Z_i = Input Impedance without feedback

β = Feedback factor of feedback network

A_v = Gain of amplifier without feedback.

⇨ The above expression clearly shows that input impedance is increased by factor of $(1+ \beta A_v)$ after negative feedback is applied.

4- **Effect of Negative feedback on output Impedance :**

⇨It is found that output impedance of an amplifier after employing negative feedback is given as :

$Z_o' = Z_o / (1+ \beta A_v)$ Where Z_o' = Output Impedance after negative feedback

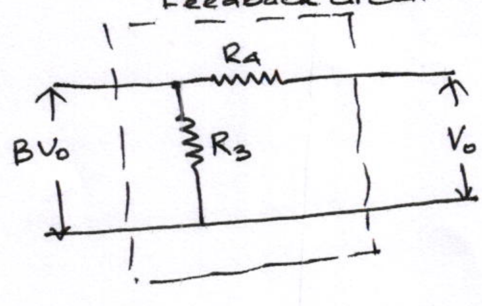
Z_o = output Impedance without feedback

β = Feedback factor of feedback network

A_v = Gain of amplifier without feedback.

⇨ The above expression clearly shows that output impedance is decreased by factor of $1/ (1+ \beta A_v)$ after negative feedback is applied.

D-CONCEPT OF FEEDBACK CIRCUIT

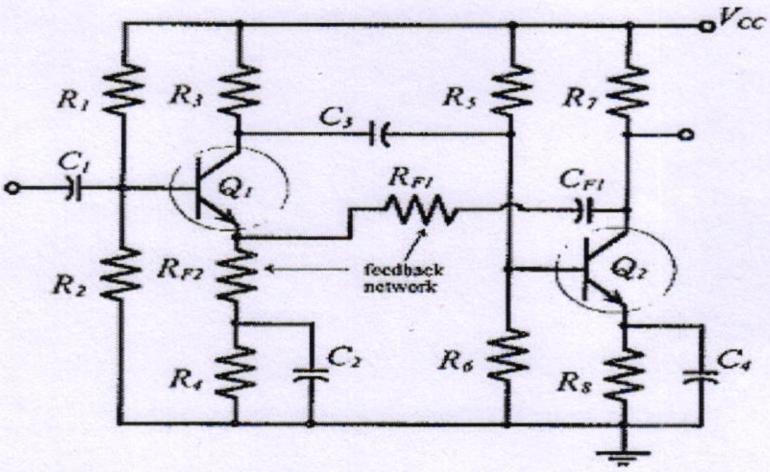


⇨ A feedback circuit is essentially a voltage divider circuit whose primary function is to feed a fraction of output voltage back to input of the amplifier circuit.

⇨ The block of feedback circuit contains two resistors R_3 & R_4 as shown in the adjacent circuit diagram .

E- RC coupled amplifier with emitter bypass capacitor :

⇨ Also Known as two stage Common emitter amplifier with series negative feedback where a two stage R C coupled amplifier is facilitated with suitable arrangement to provide negative feedback as shown in the diagram:



⇨ The additional components R_1, R_2 & C_1 incorporated in usual two stage RC Coupled amplifier constitute the feedback network.

⇨ The Output voltage is divided across the resistors R_1, R_2 to produce feedback voltage that is in series with signal at base of transistor Q_2.

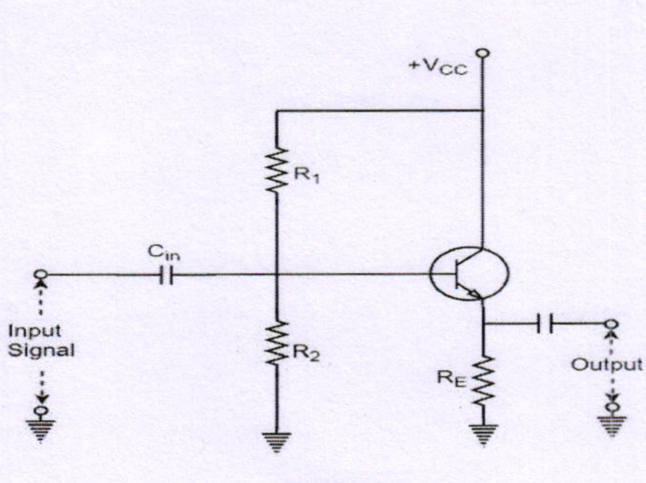
⇨ The capacitor C_1 behaves as open circuit to DC & as short circuit to AC & thus used as dc blocking capacitor to prevent the DC voltage at collector of transistor Q_2 from affecting bias condition of transistor Q_1.

F -Emitter follower amplifier and its application

⇨ Also known as common collector amplifier circuit, it is a very useful negative current feedback circuit ideal for impedance matching.

⇨ The most important characteristic of this circuit is it's high input impedance & low output impedance.

⇨ Typical circuit of an emitter follower is shown below:



⇨ When input is applied, resulting current i_E flows through R_E & produces output voltage V_o across R_E means $V_o = i_E R_E$. This voltage V_o opposes the signal voltage & thus provides negative feedback.

⇨Moreover the voltage V_o fed back to input is proportional to emitter current, that's why the circuit is called a negative current feedback circuit.

⇨Since in this configuration, output voltage which is in fact emitter voltage, follows the input voltage, hence this circuit is known as emitter follower.

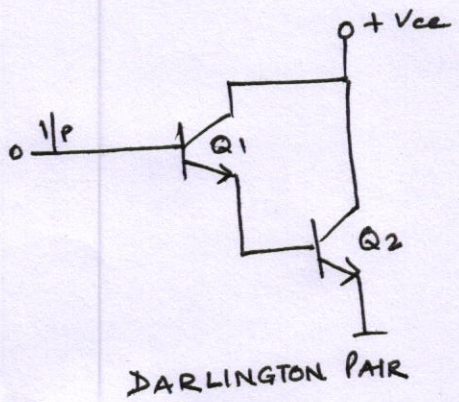
⇨ Gain of this amplifier is less than 1

⇨ Input impedance of this amplifier is given as $\beta R_E + R_i$

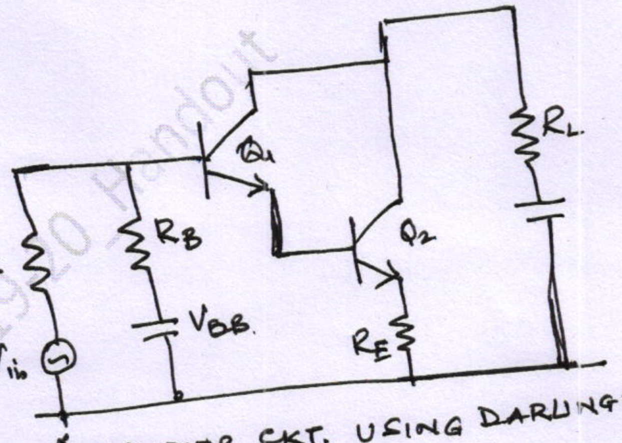
⇨ Output impedance is very Low & is given by $R_o / 1+\beta$

G- Darlington Amplifier

⇨ Here an interconnection of two bipolar junction transistors as a single unit is used .Normally one BJT is low power while the other one has high power. this unit is commercially known as Darlington pair after it's inventor. Darlington pair & amplifier circuit using such pair is shown below:



DARLINGTON PAIR



AMPLIFIER CKT. USING DARLINGTON PAIR.

⇨The Emitter of one transistor is connected to the Base of the other to produce a more sensitive transistor with a much larger current gain being useful in applications where current amplification or switching is required.

⇨ Main feature of this amplifier circuit is that the two BJT work as a single transistor with it's current amplification ratio as the product of current amplification ratios of the individual BJT. In other words ,if β_1 & β_2 are current amplification ratio of the two BJT then overall amplification factor β of Darlington pair is given as $\beta = \beta_1 \times \beta_2$

⇨ Such amplifiers are used where high gain is required at a low frequency like Power regulators, Audio **amplifier** output stages.