Amplifier is usually known to be amplebying the input signal.

In any amplifier for the given system the properties like amplification, frequency Response, input impedance and output impedance are fixed.

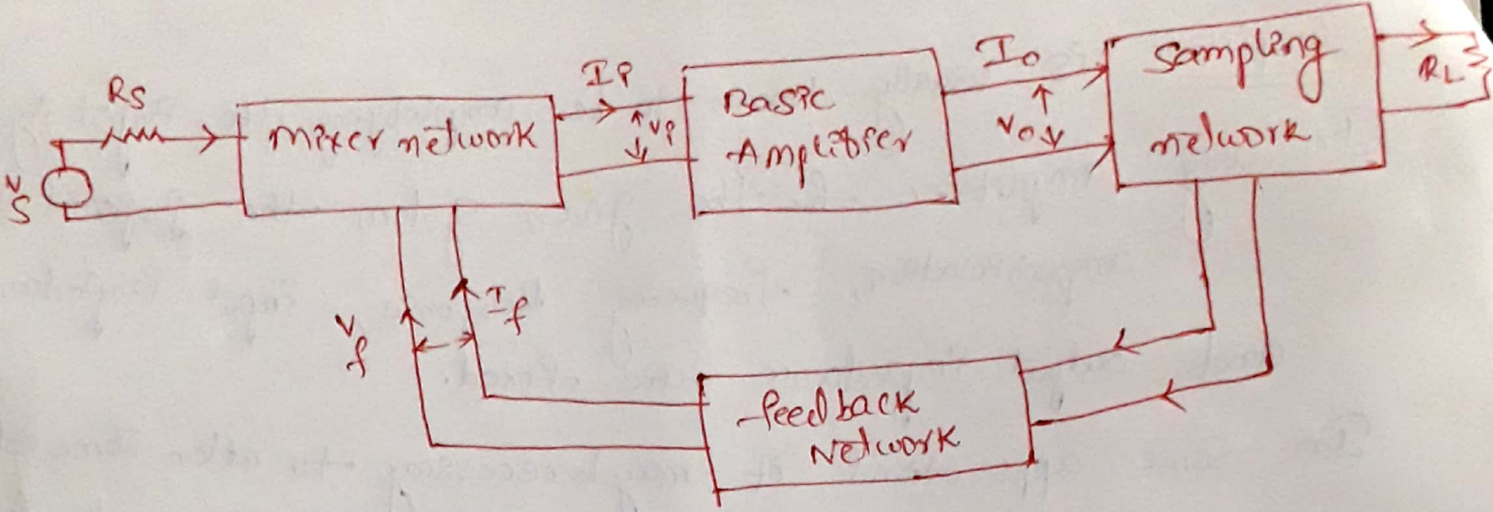
In some applications it may be necessary to alter some of properties of amplifier. Such alterations can be done by the applications of feedback Technique.

An amplifier is said to be a feedback amplifier if a part of its output is feedback or Returned to the input circuit and is combined with the input signal.

Principle of feedback in amplifiers :-

A amplifier is one in which a part of the output of the amplifier is feedback to the input.

The Block diagram shown hear is a consist of a basic amplifier with a gain of 'A'. In its output we have a sampling circuit. From this sampling circuit, we connect a feedback network, the output of the feedback network is given to the input of the amplifier through a mixture, network.



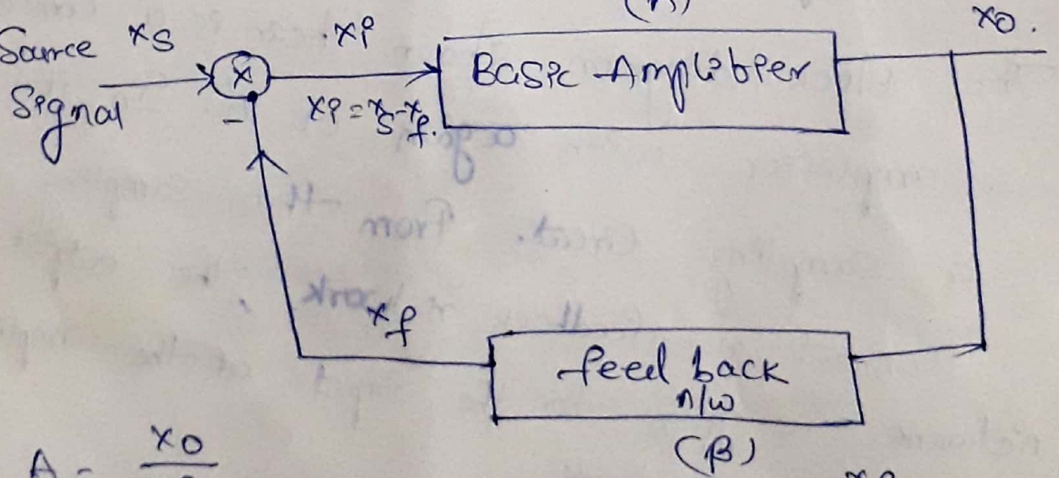

If the feedback signal causes an increase in the output of the amplifier we call it as positive feedback.

If the feedback signal produces a reduction in the output signal from the amplifier then we call the feedback as Negative feedback.

Expression for the negative feedback amplifier gain:—

Basic Block diagram:

$A = \frac{x_o}{x_i}$ $A_S = \frac{x_o}{x_s}$




$A = \frac{x_o}{x_i}$

$\beta = \frac{x_f}{x_o}$

$A = \frac{x_o}{x_s - x_f} = \frac{x_o}{x_s - \beta x_o}$

$A x_s - A\beta x_o = x_o$

$A x_s = x_o(1 + A\beta) \Rightarrow$ $\boxed{\frac{x_o}{x_s} = A_S = \frac{A}{1 + A\beta}}$

$$\boxed{\therefore \quad A_S = \frac{A}{1+A\beta}}$$

The product $A\beta$ is called the loop gain Return Ratio (or) loop Transmission feedback factor.

Sampling network:-

1. Sampling system sampled the output voltage by connecting the feedback network in shunt with the output.

2. Sampling system sampled the output current by connecting the feedback network in series with the output.

Mixing Network:-

The feedback voltage may be mixed with single voltage in two basic ways.

1. Series mixing

2. shunt mixing

feedback circuit is in series with the voltage source

feedback circuit is in shunt with the current source.

1. Voltage series feedback:- This uses output voltage sampling and series mixing at input side.

2. Current series:- This uses current sampling at output side and series mixing at input side.

3. Current shunt:- This uses current sampling at output side and shunt mixing at input side.

304

$$A_f = \frac{A}{1+A\beta}.$$

III - unit
-ve feedback amp

## (*) Basic Considerations :-

The following conditions must be met by the feedback. Circuit in order to tell the above equation is true.

1. The input signal should be transmitted to the output through the internal ~~feedback~~ amplifier 'A' and not through the feedback network.

Thus if 'A' is set to zero by reducing $h_{fe}$ (or) $g_m$ of the transistor to zero, the output must be zero. when this happen this implies that β network be unilateral. In practice this condition is fully not met because 'β' is a bilateral network.

(2). The feedback signal travels from the output to the input through the β network and not through the amplif. i.e., Reverse transmission is zero.

(3). The reverse transmission factor β of the network is independent of the load and source resistance.

(4). We find that $V_d$ (difference signal) gets multiplied by 'A' in ~~the~~ passing through the basic amplifier is further multiplied by the 'β' in passing through the feed back network and is multiplied by '-1' in the mixing n/w. In this process, the signal has traversed from the input terminals around the loop formed by the amplifier, feedback network and the mixing of the the signal gets multiplied by the $-A\beta$ factor. In the journey along the loop.

The product "$-A\beta$" is called the loop gain, return ratio (or) the loop transmission feedback factor.

The magnitude of feedback introduced into an amplifier is expressed in dB's. (decibels)

$$N = 20 \log \left( \frac{1}{1+A\beta} \right)$$

$$= 20 \log \left( \frac{A_f}{A} \right)$$

$A_f$ = with gain

$A$ = gain

Notes:-

In case of positive feedback, $(1+A\beta) < 1$ so that above equation, 'N' is a positive number.

for negative feedback 'N' is a negative number.

## General characteristics of Negative feedback Amplifier

The negative feedback Reduces the Transfer gain, However Inspite of this Reduction in Transfer gain, negative feedback is Extensively used in amplifiers since it produces various desirable characteristics.

Some of the Advantages of negative feedback:-

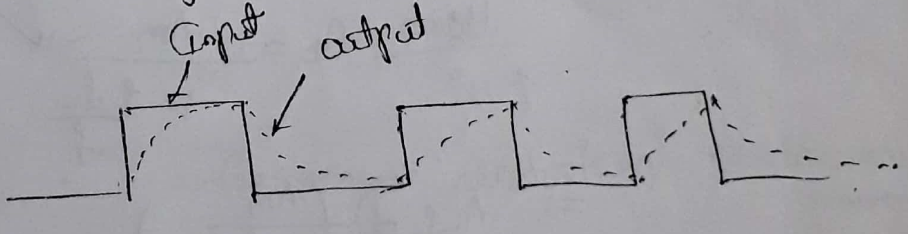
(a) **Frequency distortion:-**

In Conventional amplifiers we face the frequency distortion, this is due to unequal amplification of different frequencies present in the input signal.

In general we will not observe frequency distortion for Sinusoidal input signals.

But Non-Sinusoidal Signals ( ⎍, ⋀, ⋀⋀⋀ ) are Effected by the frequency distortion.

**for Example:-**



And also, when we use 'pF (pico farads) capacitor at the input & output side it causes high frequency distortion, and we eliminate the pico farads.

When we use μ farad capacitor at the input and output side it causes Tilt problems.

All These problems are avoided by using feedback signal.

we make the feedback is output of phase with the input signal. So we can avoid distortions up to some extent level.

(b) Phase distortion :-

Different frequencies receive the different phase. Different frequencies does not effect the quality of a phase distortion.

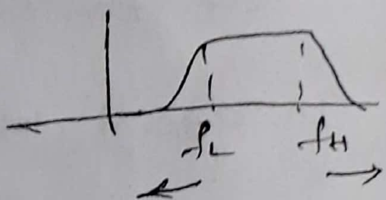
(c) Effect on Bandwidth :-

$B.W = f_L - f_H$.

B.W is increased in negative feedback amplifiers.

$f_L$ is decreased.

$f_H$ is increased.




Effect on lower cutoff frequency :-

$$A_{Lf} = \frac{A_L}{1+\beta \cdot A_L}$$

Here $A_L = \dfrac{A_m}{1 - j\dfrac{f_L}{f}}$ Here $A_m$ = Max. Amp

$$\Rightarrow A_{Lf} = \frac{\left(\dfrac{A_m}{1-j f_L/f}\right)}{1+\beta \dfrac{A_m}{\left(1-j\dfrac{f_L}{f}\right)}} = \frac{A_m}{1-j\dfrac{f_L}{f} + \beta A_m}$$

$$= \frac{A_m}{(1+\beta A_m)\left(1 - \dfrac{j f_L}{f(1+\beta A_m)}\right)}$$

$$\boxed{A_{Lf} = \frac{A_{mf}}{1 - j\dfrac{f_{Lf}}{f}}}$$

Hence above Equation proved that lower cutoff freq. is further decreased by adding the feedback. (3)

Uly

## Effect on Higher Cut Off frequency

-ve feedback Increases the higher cutoff freq.

$$\therefore \quad BW_f = f_{Hf} - f_{Lf}$$

$$\boxed{BW_f = (f_H - f_L)(1 + A_m\beta)} \quad (4)$$

## Effect on the frequency distortion:-

BW ↑ ⟶ frequency distortion ↓

$$\% \text{ tilt} = \frac{\pi f_L}{f_0} \times 100.$$

variations in '$f_L$' causes the tilt changes

$$\downarrow t_r = \frac{0.35}{f_H \uparrow}$$

∴ frequency distortion is decreased

## Effect on the Sensitivity :-

Sensitivity is defined as the

$$\boxed{S = \frac{\left(dA_f / A_f\right)}{dA / A}}$$

ability to Respond the negative feedback in the circuit.

Tells how the disturbances are influenced by n/w.

Hear $A_f = \frac{A}{1+A\beta}$.

$$\frac{\partial A_f}{\partial A} = \frac{(1+A\beta) - A \cdot \beta}{(1+A\beta)^2}$$

$$= \frac{1}{(1+A\beta)} - \frac{A\beta}{(1+A\beta)^2}$$

$$\frac{\partial A_f}{\partial A} = \frac{1+\cancel{A\beta}-\cancel{A\beta}}{(1+A\beta)^2} = \frac{1}{(1+A\beta)^2}$$

$$\Rightarrow \frac{\partial A_f}{\partial A} = \frac{A}{1+A\beta} \cdot \frac{1}{A} \cdot \frac{1}{(1+A\beta)}$$

$$\Rightarrow \frac{\partial A_f}{\partial A} = A_f \cdot \frac{1}{A} \cdot \frac{1}{(1+A\beta)}$$

$$\Rightarrow \frac{\partial A_f}{A_f} = \left(\frac{\partial A}{A}\right) \cdot \frac{1}{(1+A\beta)}$$

$$\Rightarrow \left(\frac{dA_f}{A_f}\right) = \left(\frac{dA}{A}\right) \cdot \frac{1}{(1+A\beta)}$$

$\Rightarrow$ Sensitivity $\frac{(dA_f/A_f)}{\frac{dA}{A}} = \frac{1}{1+A\beta}$.

$$\Rightarrow \left(S = \frac{1}{1+A\beta}\right)$$

De sensitivity

$$D = \frac{1}{S} = 1+A\beta.$$

## :- Effect on Harmonic distortion :- 

$D_H$ distortion w/o f.B.

$D_{Hf}$ distortion with f.B.

$\Rightarrow$

$$-A\beta \cdot D_{Hf} + D_H = D_{Hf}.$$

$\Rightarrow$

$$D_{Hf} + \beta A D_{Hf} = D_H.$$

$$D_{Hf}(1+\beta A) = D_H$$

$$\Rightarrow \boxed{D_{Hf} = \frac{D_H}{1+A\beta}}$$

Clear $D_{Hf} < D_H$.

when o/p is feed back to input, distortion also passes through feed back loop.

$$\therefore \boxed{D_{Hf} < D_H}$$

## Effect on Noise :-

$$\boxed{N_f = \frac{N}{1+A\beta}}$$ noise also Reduced

(*) It is the Ratio of change in overall feedback voltage gain to the differential change in the gain of the amplifier.

$$S = \left(\frac{dA_f}{A_f}\right) \Big/ \left(dA/A\right).$$

Problem ① ① An amplifier has a openloop gain of 200. If $f_L$ is 20Hz, $f_H$ is 20KHz. If 5% of output returned to the i/p in series opposition, Then find ① closed loop gain ② f.b. factor ③ Amount of the fb ④ $f_{Ln}$, $f_{Hn}$

Solution:-

$V_f = 5\% \ V_0$

$V_f = 0.05 \ V_0$

$\Rightarrow \beta = 0.05$ ; And given $A = 200$

$\therefore 1 + A\beta = 1 + (0.05) \times 200$

$= 1 + 10 = 11.$

(i) $A_f = \frac{A}{1 + A\beta} = \frac{200}{11}$

(ii) f.b factor $\beta = 0.05$

(iii) Amount of the feedback $= \frac{1}{1 + A\beta}$

$= \frac{1}{11}$

(or)

$= -20 \log_{10} (1 + A\beta) \ dB$

$= -20 \log_{10} (11) \ dB$

(iv) $f_{Lf} = \frac{f_L}{1 + A\beta}$ ; $f_{Hf} = f_H (1 + A\beta)$

$= (20/11) \ Hz$ $= 20K (11) \ Hz$

Problem (2) An Amplifier has gain A = 1000 ± 100, (5)

It is desired to have an amp whose gain varied by (11). not more than 0.1 % Calculate the

① C.L gain ② Amount of f.B ③ f.B factor,

Ans :-

$$A = 1000 \pm 100$$

$$= \frac{10\cancel{00}}{1\cancel{00}} = 10\%$$

$$\Rightarrow A = 1000 \pm 10\%$$

$$\Rightarrow \frac{\partial A}{A} = 10\% \quad \text{And given} \quad \frac{\partial A_f}{A_f} = 0.1\%.$$

we have

$$\frac{\partial A_f}{A_f} = \frac{\partial A}{A} \times \frac{1}{1+A\beta}.$$

$$0.1\% = 10\% \times \frac{1}{1+A\beta}.$$

$$\Rightarrow \frac{1}{1+A\beta} = \frac{0.1}{10} = 0.01$$

$$\therefore \boxed{1+A\beta = 100}$$

① C.L gain $A_f = \frac{A}{1+A\beta} = \frac{1000}{100}$

$$= \underline{10}.$$

② Amount of feedback $= \frac{1}{1+A\beta}$

(or) $-20 \log (1+A\beta)$.

③ f.B factor $1+A\beta = 100$

$$\Rightarrow \beta = \frac{100-1}{1000} = 0.099$$

Problem (3) (iii).

Intr Amp. Produced an output of 36 Volts with 7%. distortion when applied i/p is 28mV. If 1.2%. output is returned to the i/p in Series oppos. Calculate (1) O/p Voltage (2) Amount of distortion.

$$V_0 = 36\,V$$

$$V_i = 28\,mV$$

$$\therefore A = \frac{V_0}{V_i} = \frac{36}{28m} = 1285$$

$$V_{fr} = 1.2\%\ V_0 = \frac{1.2}{100} \times V_0$$

$$V_f = 0.0012\ V_0$$

$$\therefore \beta = 0.0012$$

$$\therefore 1 + A\beta = 1 + (1285) \times (0.0012)$$

$$= 16.42$$

$$\Rightarrow A_f = \frac{A}{1+A\beta} = \frac{1285}{16.42} =$$

(1) output voltage $V_0 = ?$

$$A_f = \frac{V_0}{V_i} \Rightarrow V_0 = A_f \cdot V_i$$

$$V_0 = 2.11\,V$$

(b) Amount of distortion

$$D_{HF} = \frac{D_H}{1+A\beta} = \frac{7}{16.42} = 0.4\%$$

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An amplifier with open loop voltage gain of 1000 delivers 10 W of power output at 10% second harmonic distortion when input is 10mV. If 40db negative feedback is applied and output power is to remain at 10W. Determine the required input signal $V_s$ and second harmonic distortion with feedback? (6)

Ans:

$A_V = 1000$ ; output power $= 10W$.

Input ~~power~~ Voltage $= 10mV$.

$$-40 = 20 \log \left( \frac{1}{1+A\beta} \right)$$

$\Rightarrow$ $1 + A\beta = 100$.

$A\beta = 99$

$$\beta = \frac{99}{1000} = 0.099.$$

$$\Rightarrow A_{Vf} = \frac{A_V}{1 + A_V\beta} = \frac{1000}{1 + 1000 \times (0.099)}$$

$$A_{Vf} = \frac{1000}{1+99} = \frac{1000}{100} = \underline{10}$$

Hear with feedback & without feedback, Amplifier delivers a power of 10W.

$$\Rightarrow A_{Vf} = \frac{V_O}{V_S}$$

$\Rightarrow$ To maintain same output power, we should maintain the same output voltage and also Gain should should be constant.

$$\Rightarrow A_{Vf} = \frac{V_O}{V_S} = 10.$$

$$\Rightarrow V_S = V_O/10 = 10/10 = \underline{1 \text{ Volt}}$$

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Second Harmonic distortion is reduced by a fa[illegible]

$1+A\beta$.

$$\Rightarrow D_{2f} = \frac{D_2}{1+A\beta} = \frac{0.1}{1+A\beta} = \frac{0.1}{1000} = 0.0[illegible]$$

$= 0.1$

(5) An amplifier with open loop gain of $A = 2000 \pm 150$ is available. It is necessary to have the amplifier wh[illegible] voltage gain varies by not more than $\pm 0.2\%$. Calcul[illegible] $\beta$ and $A_f$?

Solution:-

$$\frac{dA_f}{A_f} = \frac{1}{1+A\beta} \cdot \frac{dA}{A}$$

$$\Rightarrow \frac{0.2}{100} = \frac{1}{1+(2000)\beta} \times \frac{150}{2000}$$

$$\Rightarrow 1+\beta A = 37.5$$

$$\beta A = 36.5$$

$$\beta = 36.5/2000 = 1.825\%$$

$$\therefore \beta = 0.01825$$

$$A_f = \frac{A}{1+A\beta} = \frac{2000}{1+(2000)\times(0.01825)}$$

$$\boxed{A_f = 53.33}$$

(6) An amplifier with open loop gain of $A_v = 1000 + 100$ is available. It is necessary to have an amplifier whose voltage gain varies by no more than $\pm 0.1\%$. Find (a) Reverse transmission factor $\beta$ of the feedback network is used

(b) Find the gain with feedback.

Ans :- (a) we know that $\frac{dA_f}{A_f} = \frac{1}{|1+\beta A|} \cdot \frac{dA}{A}$ (7)

Given $dA = 100$

$A = 1000$

$$\Rightarrow \frac{0.1}{100} = \frac{1}{(1+\beta A)} \times \frac{100}{1000}$$

$$1+\beta A = \frac{100}{0.1\times 10} = 100$$

(b) Gain with feedback = ?

$$A_f = \frac{A}{1+A\beta} = \frac{1000}{1+99}$$

$$= 10$$

(7) An amplifier without feedback gives a fundamental output of 36V with 7% second harmonic distortion when the input is 0.028V (a) If 1.2% of the output is feedback into the input negative voltage series feedback circuit. What is the output voltage? (b) If the fundamental output is maintained at a 36V but the second harmonic distortion is reduced to 1%. what is the input voltage?

Solution :- open loop gain $A = \frac{V_o}{V_i} = \frac{36}{0.028}$

$A = 1285$

$V_f = 1.2\%\ V_o = 0.012\ V_o$

$V_f = 1.2\%\ (36)$ $\Rightarrow \beta = 0.012$

$$\beta = V_f/V_o \Rightarrow \cancel{0.012} = \frac{1.2\%(36)}{\cancel{V_o}}$$

$$A_f = \frac{A}{1+A\beta}$$

$$= \frac{1285}{1 + 1285 \times 0.012}$$

$$A_f = 78.25$$

$$\Rightarrow A_f = \frac{V_o}{V_s} \Rightarrow V_o = A_f \times V_s$$

$$= 78.25 \times 0.028$$

$$\boxed{V_o = 2.19V}$$ → with feed

(b) Second Harmonic distortion

$$B_{2f} = \frac{B_2}{1+A\beta} = \frac{B_2}{D}.$$

$$1 + A\beta = \frac{B_2}{B_{2f}} = \frac{7\%}{1\%}$$

$$= 7 \Rightarrow \underline{A\beta = 6}$$

$$\Rightarrow A_f = \frac{V_o}{V_s} = \frac{A}{1+A\beta}.$$

$$= \frac{1285}{6+1} = \frac{1285}{7}$$

$$\boxed{A_f = 183.57.}$$

$$\therefore V_s = \frac{V_o}{A_f} = \frac{36}{183.57}.$$

$$\boxed{V_s = 0.196 \text{ volts}}$$

(8) The overall gain of two stage amplifier is 100 and the second stage only has 10% of output voltage applied on negative feedback. If the gain and second harmon distortion of second stages are −150 and 5% Respect without negative feedback. Find the

(a) Gain of the first stage (b) 2nd Harmonic dist of the amplifier

For the Second stage, gain with feedback is $A_2' = \frac{A_2}{1+A_2\beta}$ (8)

$$A_2' = \frac{150}{1+150 \times 0.1}$$

$$= 9.38$$

The overall gain is $A_1 \times A_2' = 100.$

$$A_1 = \frac{100}{9.38} = 10.66$$

$A_1$ = Gain of the first stage

$A_2$ = Gain of the Second stage.

## feedback Identification:-

1. Identify the input and output nodes.
2. Identify the feedback Resistor.
3. Identify If the output is taken across feedback Resistor then it is Called as Voltage Sampling otherwise it is Current Sampling.
4. If the feedback Signal is Connected input of base Transistor then it is Said to be a shunt mixing otherwise Series mixing

## Drawbacks of Conventional amplifiers:-

1. Gain is not constant due to device / Transistor Parameter variations.
2. Distortion is very high.
3. Effect of noise is greater.
4. I/P & O/P Impedances are not as desired values.

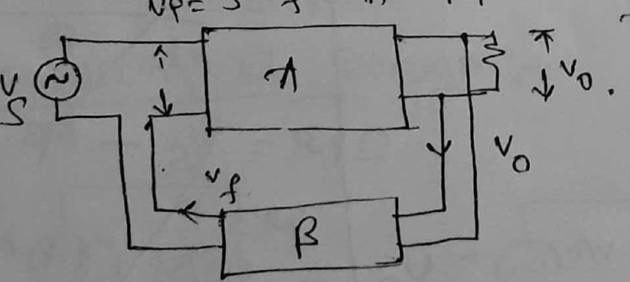
There are four ways of Connecting a feedback signal.

1. Voltage series feedback signal.
2. Voltage shunt feedback signal.
3. Current series feedback signal.
4. Current shunt " " "

## Measurements :- ( $A_{vf}$, $Z_{inf}$, $Z_{outf}$ )

① Voltage series feedback Amplifier:-

$V_P = V_S - V_f$ $A = V_O / V_P$



$A_f = \frac{V_O}{V_S}$. ①.

To find the input loop we set → $V_O = 0$.

To find the output loop we set: $I_P = 0$

$\beta = V_f / V_O$.

① Voltage follower (or) Voltage amplifier.

**Gain:-**

$$A = \frac{V_O}{V_P} = \frac{V_O}{V_S - V_f} \Rightarrow V_O = A(V_S - V_f)$$

$$V_O = A(V_S - \beta V_O)$$

$$V_O + A\beta V_O = A V_S$$

$$\Rightarrow V_O / V_S = A / 1 + A\beta.$$

## $Z_{inf}$ :-

$$Z_{inf} = \frac{V_S}{I_P} = ?$$

Hear $I_P = \frac{V_P}{Z_P} = \frac{V_S - V_f}{Z_P} = \frac{V_S - \beta V_o}{Z_P}$.

$$I_P = \frac{V_S - \beta(AV_P)}{Z_P} = \frac{V_S - \beta \cdot A \cdot I_P \cdot Z_P}{Z_P}$$

$\Rightarrow I_P Z_P = V_S - A\beta I_P Z_P$.

$I_P Z_P (1 + A\beta) = V_S$

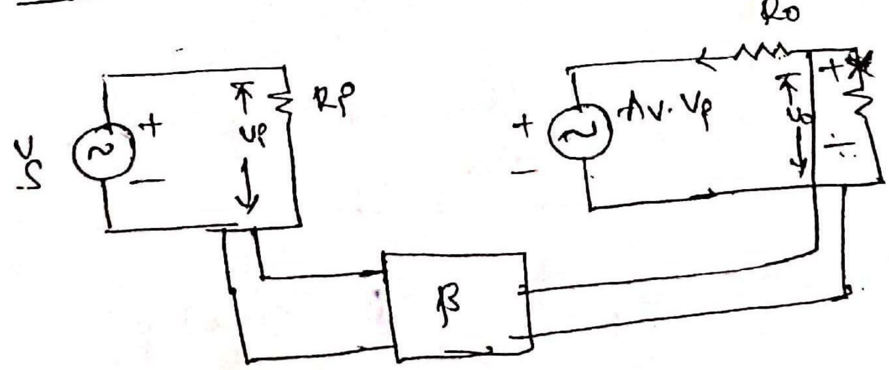
$$\Rightarrow \boxed{\frac{V_S}{I_P} = Z_{inf} = Z_P(1 + A\beta)}$$

## $Z_{outf}$ :-

To find $Z_{o/pf}$ we Equate $V_S = 0;\ I_S = 0$ Because Thevenins / Nortons Impedance looking from the output Terminals.

### Equalent ckt Diagram :-

$I_o = -I_L$




apply KVL for Loop (2) we get that.

$-V_o + I_o R_o + A_v V_P = 0$.

$V_o = I_o R_o + A_v \cdot V_P$.

Hear $V_P = -V_f$

Because $V_S = V_P + V_f$

when $V_S = 0 \Rightarrow V_P = -V_f$

$\Rightarrow V_o = I_o R_o - A_v V_f$

$V_o = I_o R_o - A_v \cdot \beta V_o$

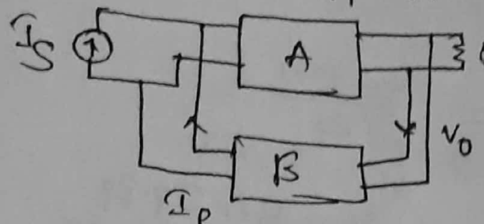
$\Rightarrow V_o(1 + A_v \cdot \beta) = I_o R_o \Rightarrow \boxed{Z_{of} = \frac{R_o}{1 + A_v \beta}}$

Voltage shunt feedback Amplifiers:- we so

$I_i = I_s - I_f \quad A = V_o / I_i$

I/P:- loop → $V$, $I$

O/P loop → $I_s$




$$\boxed{A_f = \frac{V_o}{I_s}}$$ → Trans Resistance gain

$$\beta = \frac{I_f}{V_o}$$

1. It is also called Trans Resistance Amplifier.

Gain:-

$$A = \frac{V_o}{I_i}$$

$$A = \frac{V_o}{I_s - I_f} = \frac{V_o}{I_s - \beta V_o} \Rightarrow V_o = A(I_s - \beta V_o)$$

$$V_o(1 + A\beta) = A I_s$$

Tells Take Trans Resistance gain is $\boxed{R_{mf} = \frac{A}{1 + A\beta}}$

$$\boxed{A_f = \frac{V_o}{I_s} = \frac{A}{1 + A\beta}}$$

Hear $A = R_m$

Input Impedance:-

$$Z_{inf} = \frac{V_s}{I_s} = \frac{V_i}{I_s}$$

Hear $I_s = \frac{V_i}{Z_{if}} \Rightarrow Z_{if} = \frac{V_i}{I_i + I_f}$

$$Z_{if} = \frac{V_i}{I_i + \beta V_o} = \frac{V_i}{I_i + \beta(A \cdot I_i)}$$

$$Z_{if} = \frac{V_i}{I_i(1 + A\beta)} = \frac{Z_{in}}{(1 + A\beta)}$$

$$\left(\therefore Z_{if} = \frac{Z_{in}}{1 + A\beta}\right)$$

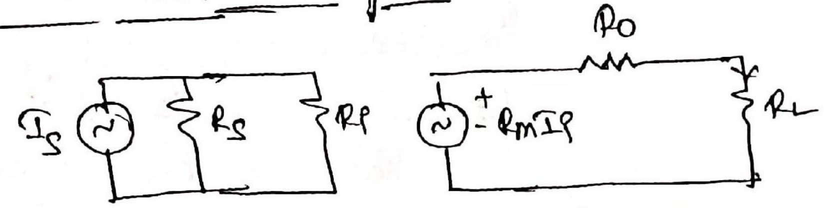
$Z_{of}$ :-

Equate, $I_S = 0$.

$\therefore I_S = I_i + I_f$

$\Rightarrow I_i = -I_f$.

Equalient Ckt Diagram :-




$$-V_o + I_o R_o + R_m I_i = 0.$$

$$V_o = I_o R_o + R_m I_i.$$

$$V_o = I_o R_o - R_m I_f$$

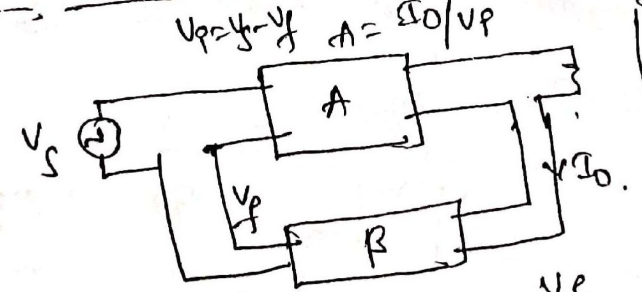
$$\Rightarrow V_o = I_o R_o - R_m(\beta V_o)$$

$$V_o(1 + R_m \beta) = I_o R_o.$$

$$\boxed{Z_{of} = \frac{V_o}{I_o} = \frac{R_o}{1 + R_m \beta}}$$

Current Series feedback Amplifier :-

To find
Input loop
$I_o = 0$
Output loop.
$I_i = 0$




$$\boxed{A_f = \frac{I_o}{V_s}}$$

$$\beta = \frac{V_f}{I_o}$$

1. It is a Trans Conductance Amplifier.

**Gain :-**

$$A = \frac{I_o}{V_i}$$

$$A = \frac{I_o}{V_s - V_f} \Rightarrow I_o = A(V_s - \beta I_o)$$

$$I_o(1 + A\beta) = A \cdot V_s$$

$$\boxed{G_{mf} = \frac{I_o}{V_s} = \frac{A}{1 + A\beta}}$$

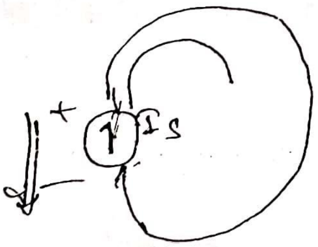
Here $A = G_m$.

**Zinf :-**

$$Z_{inf} = \frac{V_s}{I_s}$$

$$= \frac{V_s}{I_s} = \frac{V_s}{I_i}$$

Here $I_i = \frac{V_{in}}{Z_{in}} = \frac{V_s - V_f}{Z_{in}} = \frac{V_s - \beta I_o}{Z_{in}}$.




$$I_i = \frac{V_s - \beta(A V_i)}{Z_{in}}$$

$$\Rightarrow I_i Z_{in} = V_s - \beta A \cdot V_i$$

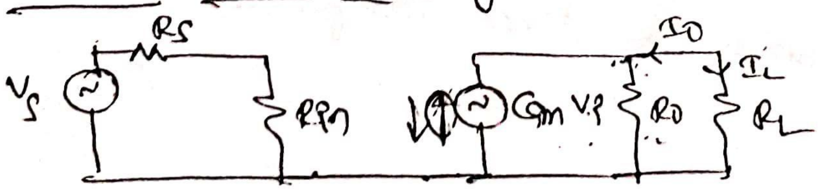
$$I_s Z_{in} = V_s - A\beta(I_s Z_{in})$$

$$\Rightarrow I_s Z_{in}(1 + A\beta) = V_s$$

$$\Rightarrow \boxed{V_s / I_s = Z_{in}(1 + A\beta)}$$

**Zoutf :-**

Equivalent Circuit Diagram :-




$$-I_o + \frac{V_o}{R_o} + G_m V_i = 0.$$

$$I_o = \frac{V_o}{Z_o} + G_m V_i$$

$$I_o = \frac{V_o}{Z_o} + G_m(-V_f)$$

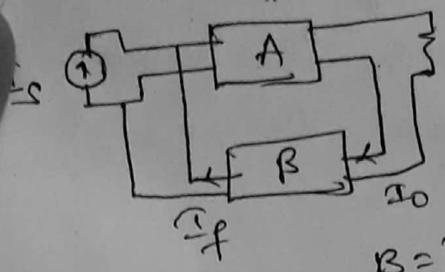
$$I_o = \frac{V_o}{Z_o} - G_m \beta I_o.$$

$$\Rightarrow I_o(1 + G_m\beta) = \frac{V_o}{Z_o}$$

$$\Rightarrow \boxed{Z_{outf} = \frac{Z_o(1 + G_m\beta)}{\cancel{1 + G_m}}}$$

## Current – shunt – feedback Amplifiers:

$A = I_o / I_i$.



$\left(A_f = \frac{I_o}{I_s}\right)$

To find the output of w.r.f.

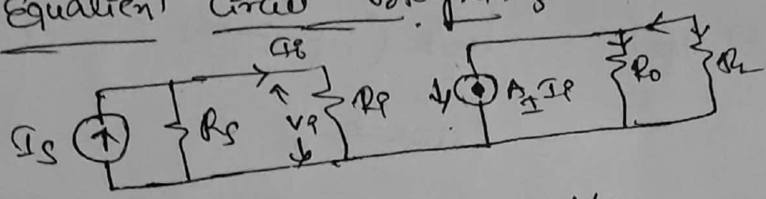
we set $I_s = 0$

at the o/p side we set $I_o \infty$

$\beta = \frac{I_f}{I_o}$

1. It is a Current Amplifier.

## Equalient Circuit Diagram:



**$Z_{if}$:**

$$Z_{if} = \frac{V_I}{I_S} = \frac{V_I}{I_i + I_f}$$

$$= \frac{V_I}{I_i + \beta \cdot I_o} = \frac{V_I}{I_i + \beta \cdot (A I_i)}$$

$$Z_{if} = \frac{(V_i / I_i)}{1 + A\beta} = \frac{Z_i}{1 + A\beta}.$$

**$Z_{of}$:**

$$Z_{of} = \frac{V_o}{I_o}.$$

$$I_o = \frac{V_o}{Z_o} + A_I I_i.$$

$$= \frac{V_o}{Z_o} + A_I(-I_f).$$

$$= \frac{V_o}{Z_o} - A_i \cdot I_f = \frac{V_o}{Z_o} - A_i(\beta \cdot I_o).$$

$$I_o = \frac{V_o}{Z_o} + (-A_i\beta \cdot I_o)$$

$$I_o(1 + A_i\beta) = \frac{V_o}{Z_o} \Rightarrow \frac{V_o}{Z_o \cdot I_o} = (1 + A_i\beta)$$

$$\boxed{\therefore Z_{of} = Z_o(1 + A_i\beta)}$$

Problems ①

Determine the voltage gain & Input Impedance output impedance with feedback for voltage-series feedback having $A = -100$, $R_i = 10k\Omega$, $R_o = 20k\Omega$, for feedback of ⓐ $\beta = -0.1$, ⓑ $\beta = -0.5$.

I. ⓐ $A_{vf} = \frac{A_v}{1+A\beta} = \frac{-100}{1+(-100)\times(-0.1)} = -9.09$.

ⓑ $Z_{inf} = Z_{in}(1+A\beta) = 10k(1+(-100)\times(-0.1))$

$= 110k\Omega$.

ⓒ $Z_{outf} = \frac{Z_o}{(1+A\beta)} = \frac{20k}{(1+(-100)\times(-0.1))} = \frac{20k}{(1+10)}$

$= \frac{20k}{11} =$

II. ⓐ $A_{vf} = \frac{A_v}{1+A\beta} = \frac{-100}{1+(-100)\times(-0.5)} = \frac{-100}{1+50} = \frac{-500}{51}$

ⓑ $Z_{inf} = Z_{in}(1+A\beta) = 10k(1+(-100)\times(-0.5))$

$= 10k(1+50) = 510k$.

ⓒ $Z_{outf} = \frac{Z_o}{(1+A\beta)} = \frac{20k}{(1+(-100)\times(-0.5))} = \frac{20k}{(1+50)}$

$= \frac{20k}{51} =$.

Problems ⑤.

An Amplifier has an openloop gain of 100, an input impedance of $1k\Omega$ and an output impedance of $100\Omega$. A feed back network with a feedback factor of 0.99 is connected to the amplifier in a voltage series feedback mode. The New input impedance and output impedance ~~of~~ are Respectively?

(13)

Given $A = 100$, $Z_{in} = 1K\Omega$

$Z_{out} = 100\Omega$.

$\beta = 0.99$

Voltage - series feedback mode.

(i) $Z_{inf} = Z_{in}(1+A\beta)$

$= (1K\Omega)(1+100\times0.99)$

$= (1K)(1+99) = 100k$

$Z_{inf} = 100K\Omega$

(ii) $Z_{outf} = Z_{out}/(1+A\beta)$

$= \frac{100}{(1+100\times0.99)} = \frac{100}{100}$

$= 1\Omega$,

(3) Calculate the gain of a negative - feedback Amplifier having $A = -2000$, $\beta = -1/10$.

(4) Calculate the gain, input, output impedances of a voltage-series feedback Amplifier having the Gain $A = -300$, $R_i = 1.5K\Omega$, $R_o = 50K\Omega$, $\beta = -1/15$.

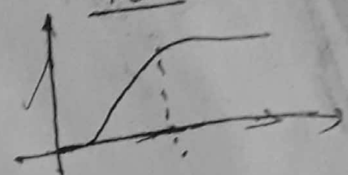
(1) feedback signal sampled
(2) o/p signal
(3) To find input loop we set
(4) To find output loop. we set.
(5). signal same form.
(6) $\beta$, $A_f$, $D$, $A_f$, $R_{if}$, $R_{of}$, $R_{oft}$

Resonance's ⟷ $\downarrow X_L = 2\pi fL \downarrow$

$\uparrow X_L = 2\pi fL$

$0.001\,uf \rightarrow 0$

$X_L = 0$



## Effect of negative feedback on Amplifier performance

| Property | | Voltage-series | V/shunt | Cu-series | Cu-shunt |
|---|---|---|---|---|---|
| ① $X_f$ | → | Voltage | Current | Voltage → | Current |
| ② $X_o$ | → | voltage | Voltage | Current → | Current |
| ③ $\beta$ | → | $V_f/V_o$ | $\frac{I_f}{V_o}$ | $\frac{V_f}{I_o}$ → | $\frac{I_f}{I_o}$ |
| ④ A | → | $V_o/V_i$ | $\frac{V_o}{I_i}$ | $\frac{I_o}{V_i}$ → | $\frac{I_o}{I_i}$ |
| ⑤ D | → | $1+A\beta$ | $1+R_m\beta$ | $1+G_m\beta$ → | $1+A_I\beta$ |
| ⑥ $A_f$ | → | $\frac{A_v}{1+A_v\beta}$ | $\frac{V_o}{I_s}$ | $\frac{I_o}{V_s}$ → | $\frac{I_o}{I_s}$ |
| ⑦ $R_{if}$ | → | Increased | Decreased | Increased → | decreased |
| ⑧ $R_{of}$ | → | decreased | Decreased | Increased → | Increased |
| ⑨ To find input loop we set | → | $V_o=0$ ✓ $I_o=0$ | $V_o=0$ ✓ $I_o=0$ | $V_o=0$ $I_o=0$ ✓ → | $V_o=0$ $I_o=0$ ✓ |
| ~~⑩ To find output loop we set~~ | | ~~$V_s=0$ $I_i=0$~~ | ~~$V_s=0$ $I_s=0$~~ | ~~$V_s=0$ $I_s=0$~~ → | ~~$V_s=0$ $I_s=0$~~ |
| ⑩ To find output loop we set | | $I_i=0$ ✓ | $V_s=0$ ✓ | $I_i=0$ | $V_s=0$ |

Parallel $V_o=0$

Series current $I_o=0$

4 copies   Unit - III   III - unit   +ve feedback

## Oscillators:-

Oscillator is a Source of A.C Voltage (or) A.C Current. we get A.C output from the oscillator circuit. In alternator (A.C generators) the Thermal Energy is converted into Electrical Energy at 50Hz.

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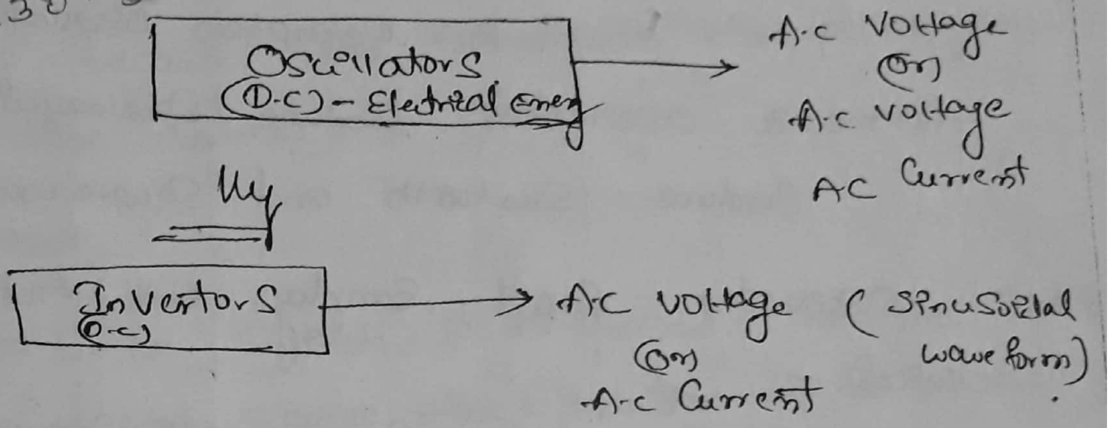
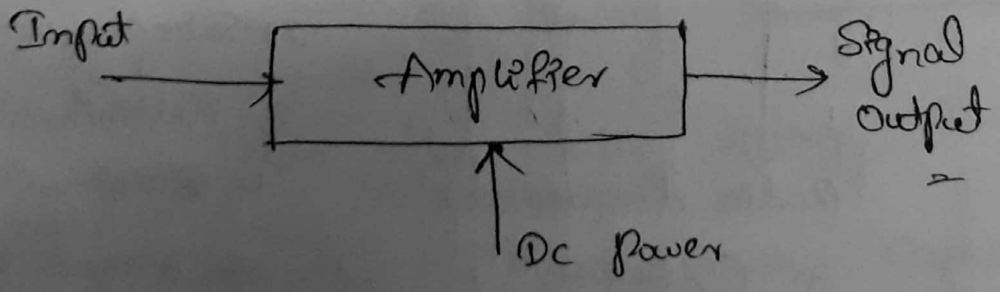


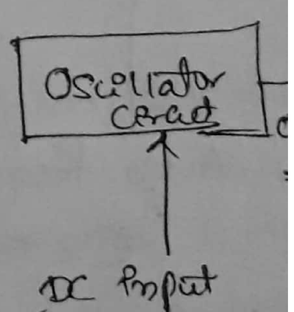

In the oscillator circuits that we are describing now, Electric Energy is in the form DC is converted into Electrical Energy in the form of A.C.

In the Invertors Electrical Energy DC is converted into A.C But there only output power is criteria and not the Actual shape of the wave form.

### Amplifier Circuit:-




### Oscillator Circuit



Oscillator is a circuit which generates ~~the~~ AC output without giving any A.C input is called the oscillator.

There are two types of oscillator circuits:

1. Harmonic oscillators.
2. Relaxation oscillators.

Harmonic oscillators produce sinewaves. Relaxation oscillat produce sawtooth and square waveforms etc..,

Oscillator circuit employ both Active and passive devices.

Active device components converts the D.C into A.C and passive components determine the frequency of oscillations.

<u>classification:-</u>

- Oscillators
  - Sinusoidal oscillators (Harmonic oscillators)
    - Audio frequencies (< 20KHz)
      1. RC phase shift oscillators (FET, BJT) fixed A.F oscillations.
      2. using op-amp (wein Bridge)
    - Radio frequencies (> 20KHz)
      - LC oscillators (variable freq)
        1. Hartley
        2. Colpitts oscillators
      - Crystal oscillators (fixed freq) Eg:- Crystal oscilla
  - Non Sinusoidal oscillato (Relaxation oscillators)
    Eg:-
    1. Square wave oscil
    2. Sweep voltage gen
    3. Multivibrators.
    4. Blocking oscillat
    5. Triangular wave oscillators

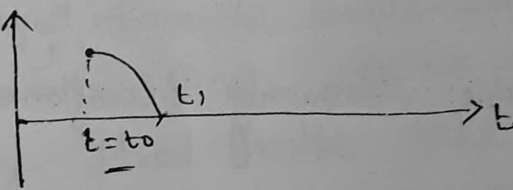
4. Both Capacitor 'C', Inductor 'L' are Lossless, ideal devices. So quality factor is infinity.

5. Energy is introduced into the circuit by charging the capacitor to 'V' volts. If switch is open, 'C' cannot discharges because there is a "no" path for discharging the current to flow.

(W/W) Circuit operation:-

① Suppose at t = to switch 'S' is closed. Then the current flows. Voltage across the "L" inductor will be 'V'. At t = t the voltage across the 'C' is 'V' volts.

② when the switch is closed, current flows. So the charge across the capacitor 'C' decreases.




③ The Energy stored in the Capacitor decreases, the Energy stored in the Inductor 'L' increases, because Current is flowing through the 'L'.

"Thus the total Energy in the Circuit remains the same"

④ when the 'V' across the capacitor 'C' becomes 0, the Current through the inductor is maximum. when the Energy in 'C' is 0, Energy in 'L' is a maximum

"And Current in the inductor starts the charging capacitor in the Reverse direction"

Performance measures of oscillator Circuits:—

① stability :—

This is determined by the passive Components. R,C and L determine the frequency of oscillations. If 'R' changes with T, 'f' changes So stability is affected. capacitors should be of high quality with low leakage. So silver and mica Ceramic capacitors are widely used.

② Amplitude Stability :—

To get large output voltage, amplification is to be done.

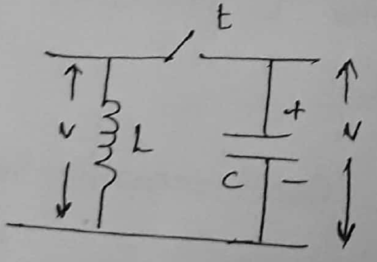
③ output power :—

Class A, class B, class C operations can be done. But class 'C' gives the Largest output power but harmonics are more.

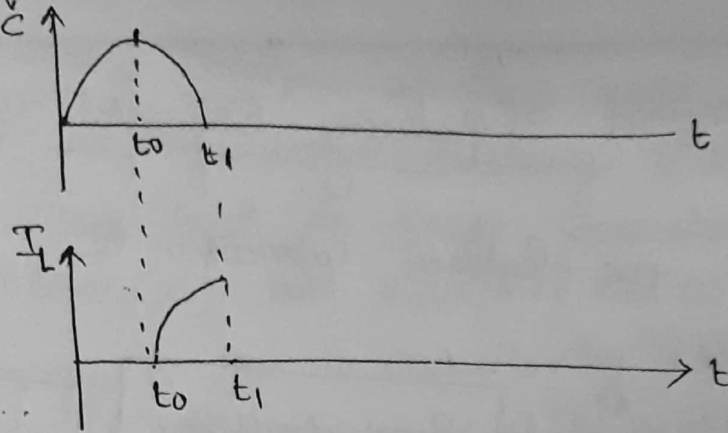
④ Harmonics :—

Un desirable frequency Components are called harmonics.

:- Principle of operation :—




1. In the Circuit L, C are Reactive Elements. They store the Energy.
2. The Capacitor stores Energy in the form of Electric field when ever there is a voltage across the its plates.
3. The Inductor stores Energy in its magnetic field whenever Current flow



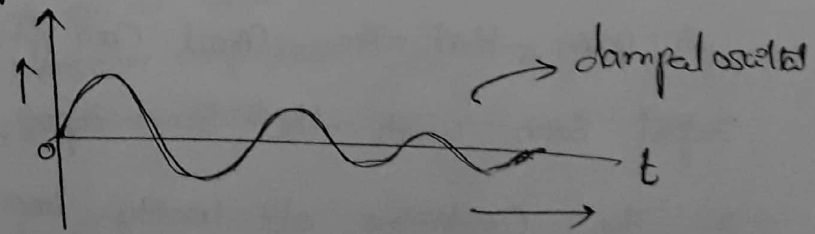

So at $t=t_1$ Current in 'L' is maximum and for $t>t_1$ the Current starts changing 'c' in the opposite direction. So v across the 'c' becomes the negative as shown in figure.

" Thus we are getting Sinusoidal variations without giving any one input".

Note:-

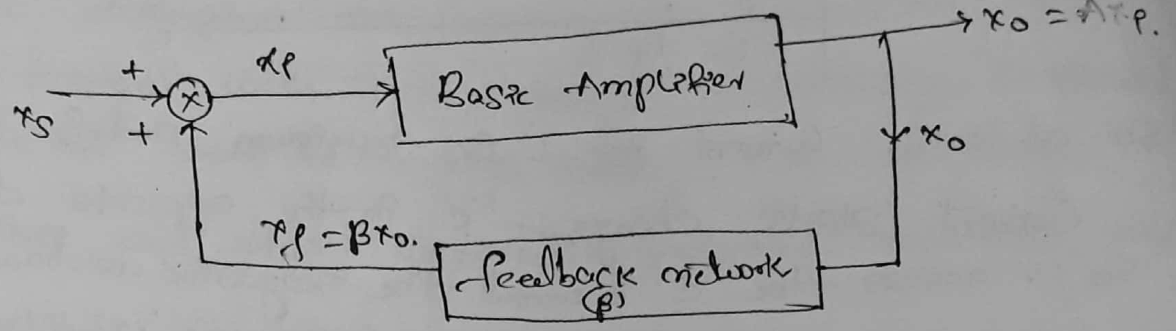
1. "Sinusoidal function is the only function that satisfies the conditions governing the Exchange of the Energy in the Circuit."

2. But these the circuit is not a practical circuit. Because we have to take output from the circuit; Energy has to be Extracted, from the circuit. As we draw the Energy from circuit, the Energy stored in the C&L decreases. So output also decreases or the Voltage across the C&L decreases So output also decreases (or) ~~decreases~~ the voltage across the C&L decreases so we get damped oscillations.



## Another method of producing Sinusoidal oscillation is

They used +ve feedback connection is:




$x_f = \beta x_o$

open loop gain is $A = \frac{x_o}{x_i}$

$A = \frac{x_o}{x_s + x_f} \Rightarrow A = \frac{x_o}{x_s + \beta x_o}$

$\Rightarrow A x_s + A\beta x_o = x_o$

$\therefore A_f = \frac{x_o}{x_s} = \frac{A}{1 - A\beta}$

Overall gain of the amplifier: $A_f = \frac{A}{1 - A\beta}$

$$\boxed{\therefore A_f = \frac{A}{1 - A\beta}}$$

If $\beta A = 1$ then the $A_f \rightarrow \infty$.

is gain that the circuit can produce of a finite amount of output even with the zero input.

→ The condition of unity loop gain is called Barkhausen's Cond.

magnitude of loop gain is $|A\beta| = 1$.

phase of loop gain is $0^\circ$ (or) $360^\circ$ (or) integral multiple of $2n\pi$

Hear $n \rightarrow$ integer where $n = 0, 1, 2 \ldots$

Oscillatory Circuit:- A Circuit which produces Electrical oscillations of any desired frequency is known as oscillatory (or) Tank Circuit. (A Simple oscillatory circuit consists of a capacitor (C) and inductance coil (L) in parallel.

If some Energy is give to capacitor by charging it, then this Energy will be alteranately stored in the Electric field of the capacitor 'C' and magnetic field in the inductor coil (L).

This interchange of Energy between the inductor and capacitor is repeated over and over again, resulting in the production of oscillations. The frequency of oscillations will depend upon the values of L & C.)

① An oscillatory circuit itself produces damped oscillations, oscillations whose magnitude decreases gradually. It is because of during each cycle, a small part of Energy is used to overcome the resistive and Radiation losses in the coil and dielectric losses in the capacitor.

② In practice, we need continuous undamped oscillations, for successful operation of Electronics Equipment. In order to make the oscillations ~~are more~~ in the Tank Circuit undamped, it is necessary to supply correct amount of Energy to the Tank Circuit at the proper time to meet the losses.

③ The essential Components of oscillator are
① A Tank (or) LC Circuit
② A Transistor amplifier.
③ A feedback Circuit.

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## LC oscillators:-

In an LC oscillator, the oscillations of desired frequency are produced in an oscillatory (LC) circuit. The transistor and feedback circuit are properly connected to the LC circuit to sustain undamped oscillations.

The following are the most commonly used LC oscillators.

1. Tuned collector oscillator
2. Hartley oscillator
3. Colpitts oscillator.

The major difference b/w these oscillators lies in the method by which the energy is supplied to the tank circuit, to meet the losses.

## RC oscillator:-

In an RC oscillator, we use a RC network instead of LC circuit. There are two basic types of RC ~~[illegible]~~ sinusoidal oscillators.

1. RC phase shift oscillator
2. Wien bridge oscillator.

(i) An RC phase shift oscillator essentially consists of a RC phase-shift network and a transistor amplifier. For a given set of RC values, there is only one frequency at which the RC n/w produces a phase shift of 180°. A further phase shift of 180° introduced in the circuit due to transistor ~~parameters~~ properties.

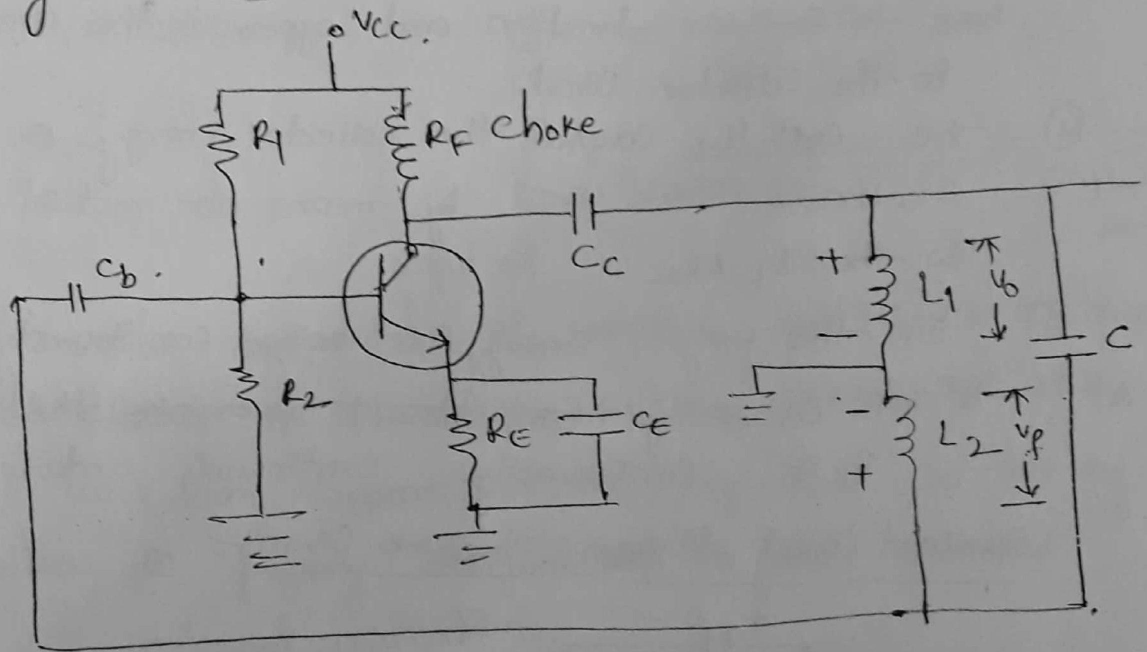
As a result, phase shift around the entire loop is 360° and undamped oscillations are produced.

(ii) In wien bridge oscillator, the phase shift of 180° is determined by wien bridge instead of RC network.

## Difference b/w the Alternator and oscillator:-

Although an alternator produces sinusoidal oscillations of 50Hz, it is fundamentally different from an oscillator. First, an alternator is a mechanical ~~energy~~ device having rotating parts whereas an oscillator is a non-rotating device. Second, an alternator converts mechanical energy into a.c energy whereas an oscillator converts d.c energy into a.c energy. Third, an alternator cannot produce high frequency oscillations whereas an oscillator can produce oscillations ranging from a few Hz to several MHz.

## Hartley oscillator:-




## Circuit Details

① $L_1, L_2, C$ forms a Tank circuit. frequency of oscillations are to be determined with the help of all these 3 parameters.

② $L_2$ is acts like a feed back Inductor and output is Taken across the Inductor $L_1$

③ $R_1, R_2$ Provides necessary biasing, $R_E, C_E$ are Provides the necessary gain.

(4) $L_1$ & $L_2$ are Connected with the opposite polarity. (2)

## Circuit Operation :-

(1) When the Circuit is Switch on $V_{cc}$, i.e. d.c power Supply is applied to Amplifier Circuit, Collector Current starts raising and charges the Capacitor C.

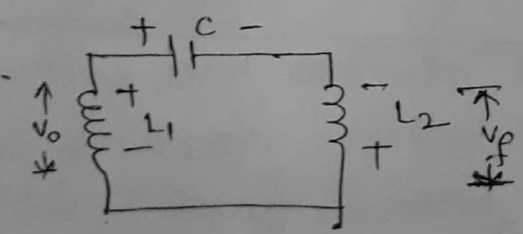
(2) When the Capacitor is fully Charged, it discharges through the Coils $L_1$ & $L_2$.

(3). The oscillations across the $L_2$ are applied to the base to Emitter Junction and appear in the amplified form in the Collector Circuit.

(4) The Coil $L_1$ couples the collector energy (or) Circuit Energy into Tank Circuit by means of mutual inductance b/w the $L_1$ & $L_2$

(5) In this way, Energy is being continuously supplied to Tank Circuit ~~by means of~~ to overcome the losses occur in it. Consequently, continuous undamped o/p is obtained.

Equivalent Circuit diagram of Tank Circuit:-




note:- $L_2$ produces a wave form of 180° phase shift of whenever the voltage developed across the inductor $L_1$.

(1) Feed back fraction $m_v$.

The amount of feedback voltage in Hartley oscillator is depends upon the feedback fraction "$m_v$" of the Circuit,

For this Circuit

feedback fraction $\boxed{m_v = \frac{V_f}{V_{out}} = \frac{X_{L_2}}{X_{L_1}} = \frac{L_2}{L_1}}$

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④ Condition for sustained oscillations are $\boxed{h_{fe} = \frac{L_1}{L_2}}$

③ Condition for oscillations is

$$x_1 + x_2 + x_3 = 0.$$

$$j\omega L_1 + j\omega L_2 + \frac{1}{j\omega C} = 0.$$

$$j\omega L_1 + j\omega L_2 = \frac{-1}{j\omega C}$$

$$\cancel{j}\omega L_1 + \cancel{j}\omega L_2 = \frac{\cancel{j}}{\omega C}$$

$$\omega^2 (L_1 + L_2) = \frac{1}{C}$$

$$\omega^2 = \frac{1}{C(L_1+L_2)}$$

$$f = \frac{1}{2\pi\sqrt{(L_1+L_2)C}} = \frac{1}{2\pi\sqrt{L_T C}}$$

$$\therefore f = \frac{1}{2\pi\sqrt{L_T C}}$$

Hear $L_T = L_1 + L_2$.

⑤ Transistor produces output of 180° waveform and $C_1, C_2$ combination provides further 180° phase shift wave form. Total 360° of the wave form appears at the input side. In this way feedback is properly designed to produce continuous undamped oscillations.

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## Phase shift oscillator:-

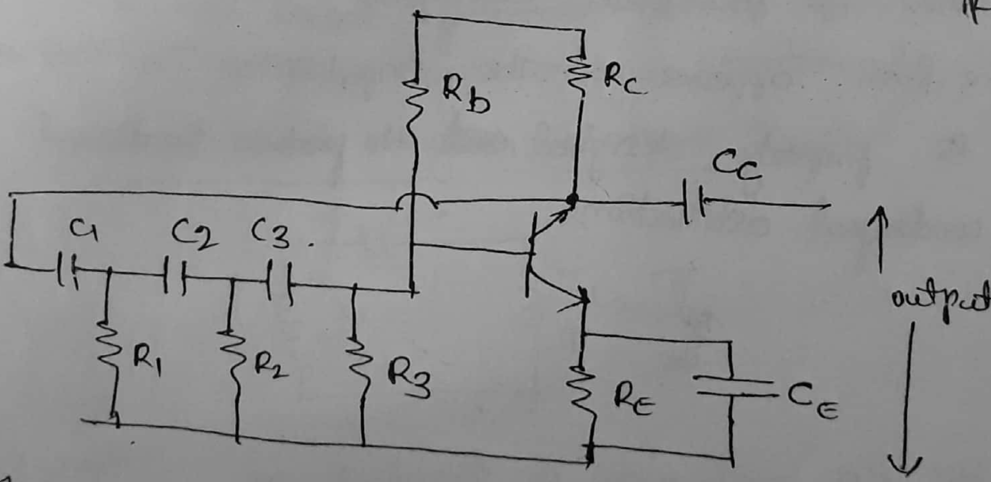
The oscillator circuits employing L-C elements have two general drawbacks. firstly, they suffer from frequency instability and poor wave form. secondly, they cannot be used for very low frequencies, because they become too much bulky and expensive.

(Good frequency stability and waveform can be obtained from oscillators employing resistive and capacitive elements. Such amplifiers are called RC phase shift oscillators and have additional advantage that they ~~have~~ can be used for very low frequencies.)

In phase shift oscillators, a phase shift of 180° is obtained with a phase shift circuit instead of inductive and reactive capacitive coupling. A further phase shift of 180° is introduced due to transistor properties.

$$RC = \frac{R \times dt}{dv}$$

$$= dt \text{ sec}$$




The phase shift n/w consists of a three sections $R_1C_1$, $R_2C_2$, $R_3C_3$. At some particular frequency $f_0$, the phase shift in each RC section is 60°. So that the total phase shift produced by the RC n/w is 180°. The frequency of oscillations is given by $f_0 = \frac{1}{2\pi\sqrt{6}\,RC}$.

where $R_1 = R_2 = R_3 = R$ & $C_1 = C_2 = C_3 = C$

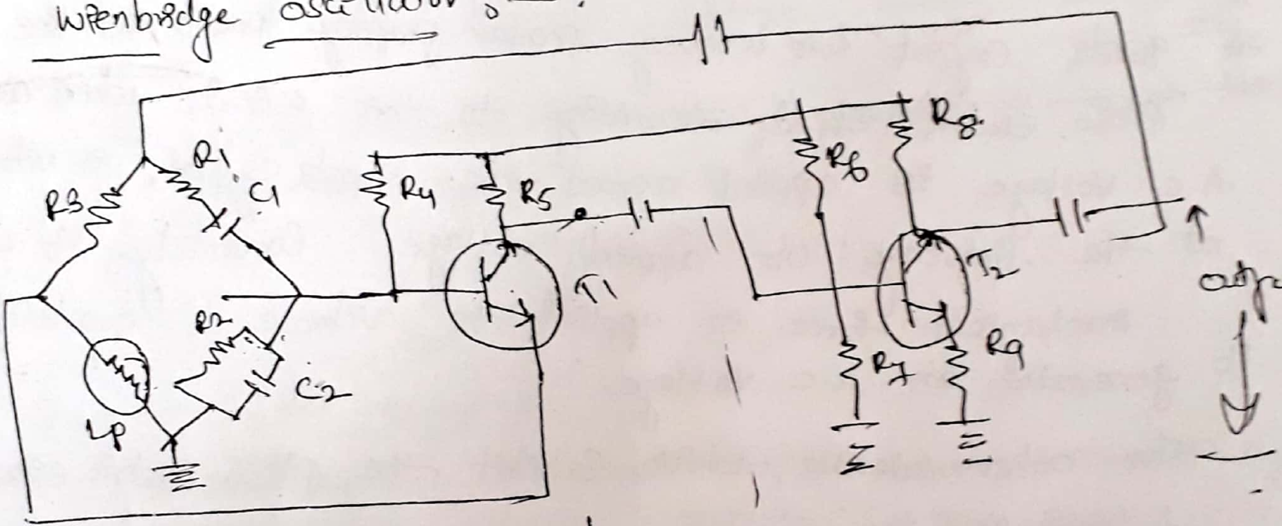
① For Transistor in phase shift oscillator we employed voltage shunt feedback.

② FET phase shift oscillator employed voltage series feedback.

③. Input impedance of BJT is very low compare with FET so we employed voltage shunt feedback.

④ If we want to design, voltage series feedback RC-phase shift oscillator, we connect a resistor in shunt with with the feedback network.

Wienbridge oscillator :—




$$f = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

T↑ R↑ $I_B$↓ $I_C$↓ $V_C$↓ $\alpha T_2$↑ $V_0$

T↓ R↓ ↑ → —— original

~~T↑ R↑ $I_B$↓~~ T↑ R↑ ↓ → ↑ —— amplitude

③ T↓ R↓ $I_B$↑ $I_C$↑ $V_C$↑ $\alpha T_2$↓ Cause like -ve feed ↓ desired level

→ constant gain

① Gain is constant

② Circuit works very easily

③ overall gain is also high.

④ Two transistors & large no of comp

## Crystal oscillators :- quartz crystal

①. The crystal oscillator use a piezo electric crystal as a Tank circuit. The crystal usually, made of quartz, or when material and provides a high degree of quality, frequency stability and accuracy.

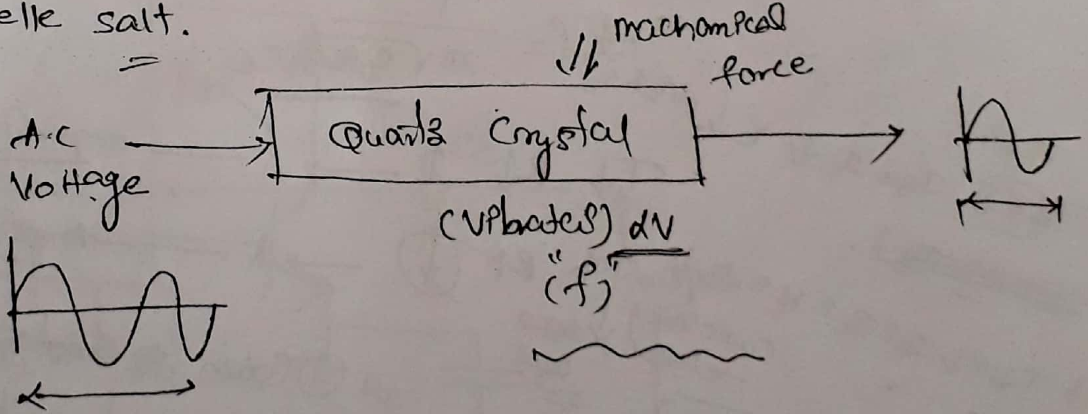
Therefore crystal oscillators are useful in those applications, where the frequency stability is very essential.

The crystal oscillators are widely used in communication Tx, digital watches and clocks.

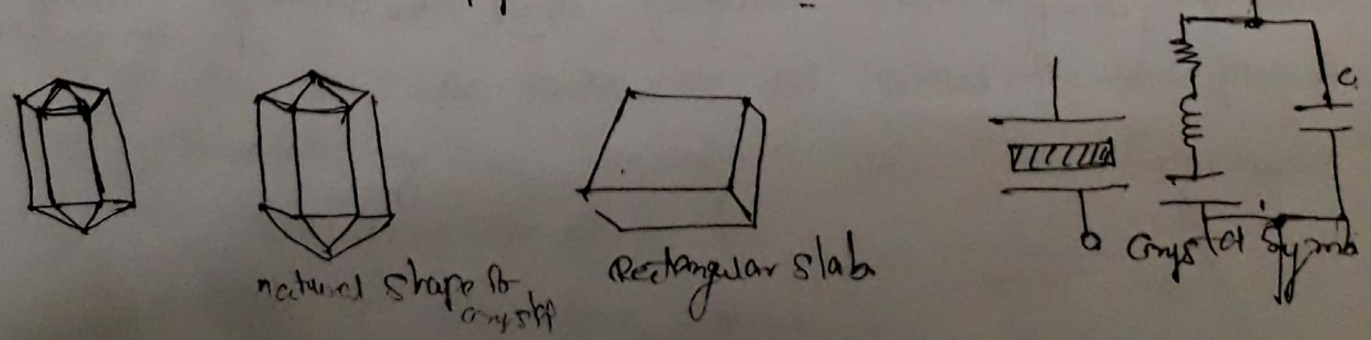
A quartz crystal has a very peculiar property known as the piezo electric effect. According to this effect, when an A.C voltage is applied across the quartz crystal, it vibrates at the frequency of applied voltage. Conversely, if a machanical force is applied to vibrate a quartz crystal it generates an a.c voltage.

The other materials, which exhibit the piezo electric effect is Rochelle salt.

①




The natural shape of a quartz crystal is a hexagonal prism with pyramids at the ends of prism.



when it is vibrating, there are internal frictional losses which are denoted by a Resistance R. while the mass of the crystal, which is indication of its line of motion represented by an inductance L.

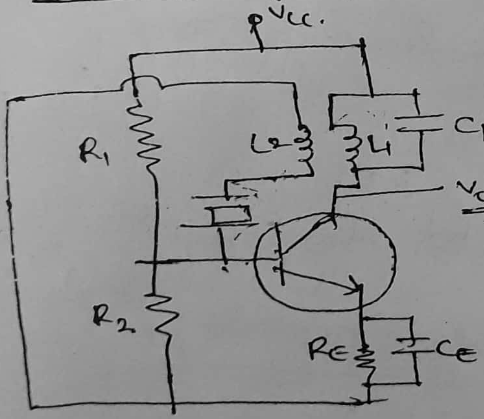
In vibrating condition, it is having some stiffness, which is representing ed by a capacitance 'c'. The mounting capacitance is a shunt capacitance.

RLC forms a reasonating circut. The Expression for the reasonating frequency "fr" is:

$$f_r = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{Q^2}{1+Q^2}} \longrightarrow Q = \frac{WL}{R}$$

→ The crystal frequency is inversely proportional to the thickness of the crystal. $t \propto 1/f$.

Circut of crystal oscillators :-




shows the circut of a Transistor crystal oscillator. A Tank circut $L_1C_1$ is placed in the collector and crystal is connected in the Base circut. Feedback is obtained by coil $L_2$ inductively coupled to coil $L_1$. The crystal is connected in series with feedback wind. The natural frequency of LC circut is made nearly equal to the natural frequency of crystal.

Circut operation :-

when the power is turned on, capacitor $C_1$ changed. when this capacitor discharged, it setus up oscillations. The voltage across the $L_1$ is fed to coil $L_2$ due to mutual inductance the positive feedback ~~produce the~~ causes the oscillator to produce oscillations. The frequency of oscillations in the circut is controlled by the crystal. It is because of the crystal is connected

in the base circuit and hence its influence on the frequency of the circuit is much more than the LC circuit. Consequently it vibrates at the natural frequency of the crystal.
As the frequency of crystal is independent of temperature & therefore, the circuit generates at a constant frequency.

Advantages
① High order quality & frequency stability
② "Q" is very high. →

Dis Advantages:
① low power circuits.
②

Advantages of phase shift oscillator And Disadvantages:-

Advantages:-
1. It does not require transformers and inductors.
2. Frequency stability
3. It can produce the good low frequency signals.

Dis advantages:-
1. low output power.
2. It is very difficult to start frequency for oscillator

Advantages and Disadvantages of wein Bridge oscillators:-

Advantages:
①. It Easily to generate the oscillations.
②. Constant output, gain is more.
③ frequency can also Easily change by means of capacitor, R

Dis advantages
① The circuit designing is complex thing.

35, 98, 100, 103, 108, 109, 110, 111, 118, very Stable.
②. Frequency Range is