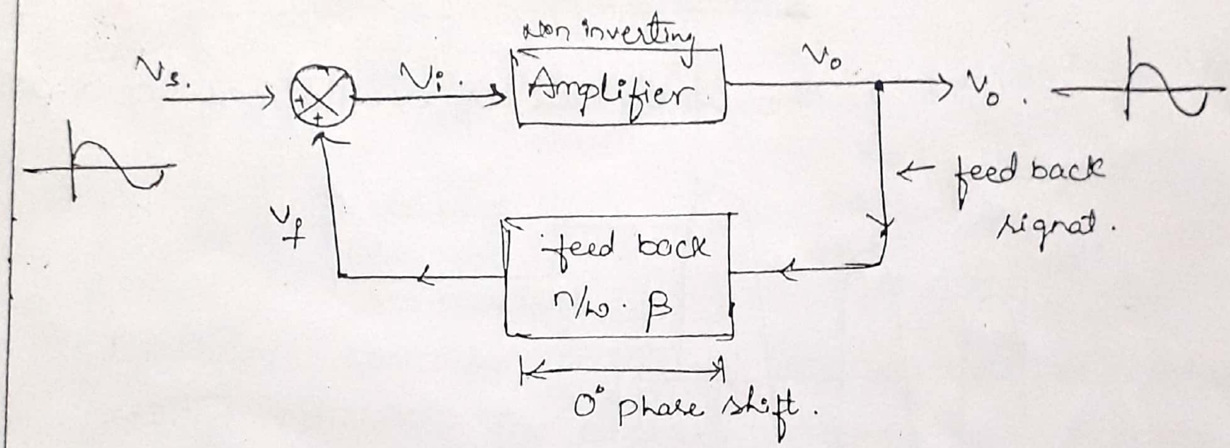
Oscillator:-

An oscillator is an electronic circuit which uses a positive feed back and generates the output which oscillates with constant frequency and constant desired amplitude.

Concept of positive feed back.



$$V_f = \beta V_o;$$

Expression for the Gain with positive feed back (A_f)

$$A_v = \frac{V_o}{V_{in}} \Rightarrow \text{for open loop gain.}$$

$$A_f = \frac{V_o}{V_s} \Rightarrow \text{for closed loop. gain.}$$

from the fig, $V_i = V_s + V_f$.

W.K.T. $V_f = \beta V_o$, $\Rightarrow V_i = V_s + \beta V_o$.

$$V_s = V_i - \beta V_o.$$

Hence $A_f = \dfrac{V_o}{V_s} = \dfrac{V_o}{V_i \mp \beta V_o}$.

2.

$$\Rightarrow A_f = \frac{V_o}{V_i\left(1-\beta \frac{V_o}{V_i}\right)}$$

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

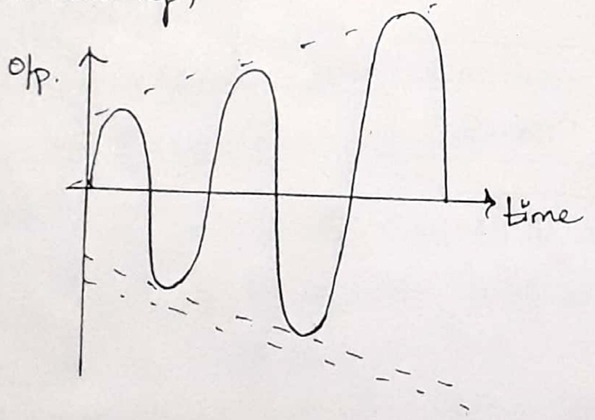
Barkhausen criterion

(i) Total phase shift around the loop should be 0° or 360°

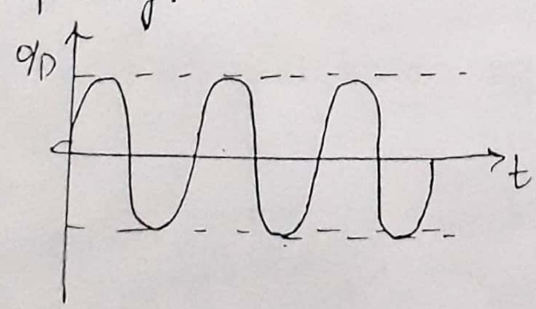
(ii) Product of open loop gain 'A' and f/b factor 'β' is equal to (or) greater than 1.

$$\therefore \underline{\underline{A\beta \geq 1}} \quad (|A\beta| = 1$$

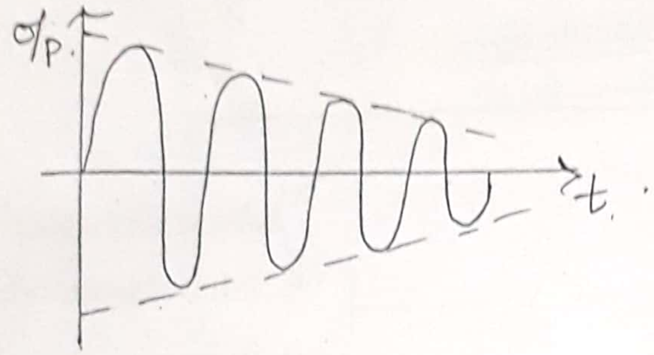
a) if $|A\beta| > 1$; the amplitude of oscillations goes on increasing,



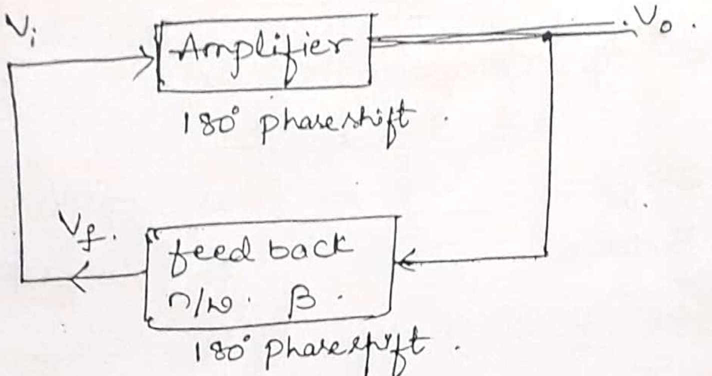
b) if $|A\beta| = 1$, oscillation are with constant amplitude & frequency.



c) If $|A\beta| < 1$, decaying oscillations,



Block diagram of an Oscillator



$V_o = AV_i$

$V_f = \beta V_o$

$V_f = A\beta V_i$ $|A\beta| = 1$

* Oscillator basically consists of an amplifier and phase shifting network. The amplifier receives the o/p of phase shifting n/w.
* Amplifier amplifies it and phase shifts it through 180° and applies it to the i/p of phase shifting network.
* Phase shifting n/w shifts the amplifier o/p through 180° and attenuates it before applying it back to the amplifier i/p.
* Due to total phase shift of 360°, the f/b becomes +ve f/b, which gives rise to oscillations.

Classifications of Oscillators

1) Classification based on the nature of o/p waveform

Oscillators

Sinusoidal.
* RC Phase shift.
* Wein Bridge
* Hartley

Non-sinusoidal.
* Multivibrator
* UJT relaxation osc.

2) Based on type of components used

* RC
  a) Phase shift.
  b) Wein Bridge.
  c) UJT
* LC.
  a) Hartley
  b) Colpitts
  c) Clap.

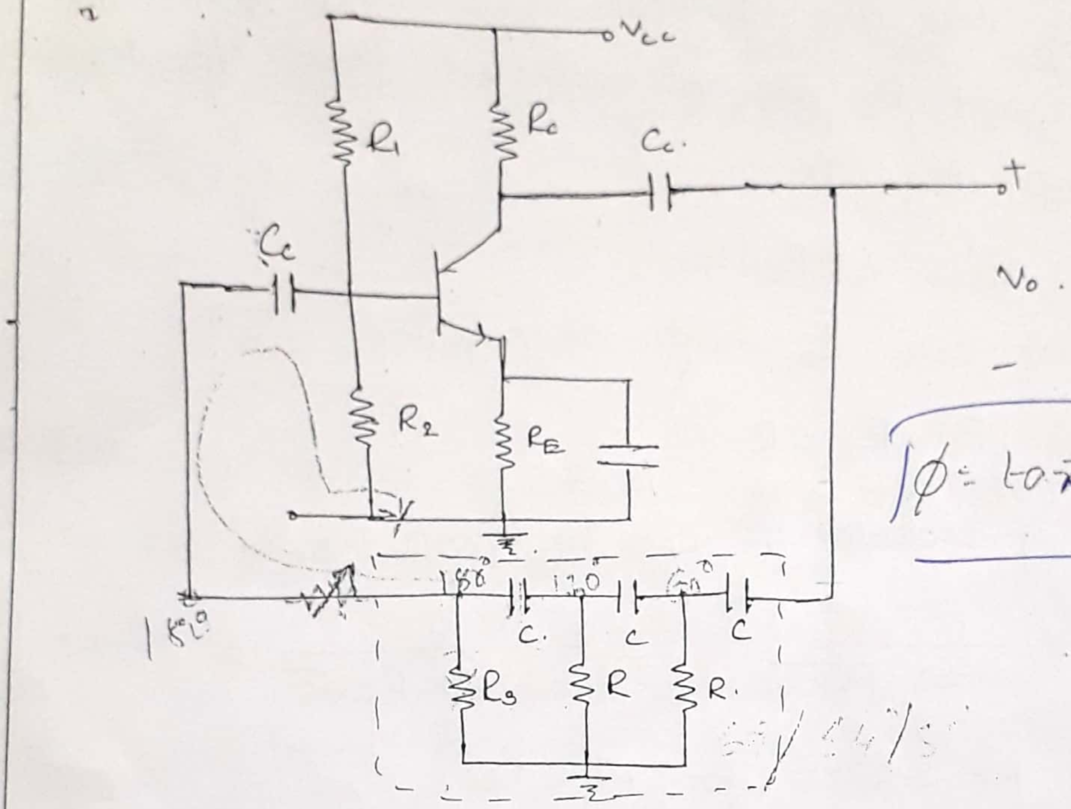
3) Based on range of frequency.
* High frequency osc.
* Low frequency osc.

RC Phase shift oscillator

The feed back n/w in RC phase shift oscillator consists of resistors and capacitors arranged in ladder fashion. Hence it is called as RC phase shift oscillator.

Tuned Oscillator Ckts

The oscillators which use the elements L & C to produce the oscillations are called LC oscillator or tuned oscillators. The ckt using elements L & C is called tank ckt. or oscillatory ckt, which is an important part of LC oscillators.



$$\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$$

→ A phase shifting n/w is a f/b n/w, so o/p of amplifier is given as an i/p to feedback n/w. While o/p of an f/b network is given as an i/p to amplifier. Thus amplifier supplies its own i/p through the f/b n/w.

* Neglecting R_1 and R_2, as these are sufficiently large we can write,

h_{ie} = i/p impedance of amplifier stage.

* Now R_3 and h_{ie} are in series and value of R_3 is so selected such that resultant of two resistance is 'R' which is required value of resistance in the last section of RC phase shifting n/w.

$$\therefore \quad h_{ie} + R_3 = R$$

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* This ensures that all the three sections of phase shifting n/w are identical.
* If R_1 and R_2 are not neglected then i/p impedance of amp stage is

$$R_i' = R_1 \| R_2 \| h_{ie}.$$

in such case R_3 must be selected

$$R_i' + R_3 = R$$

* Freq of oscillator 'F' can be given as

$$F = \frac{1}{2\pi RC\sqrt{4K+6}} \quad \text{or} \quad F = \frac{1}{2\pi RC\sqrt{6}}.$$

where $K = 2.6925$ for min. h_{fe}.

$$K = \frac{R_c}{R}.$$

$$h_{fe}\ min = 44.54$$

* Advantages of RC phase shift osc.
  a) Ckt is simple to design
  b) Can produce o/p over audio freq range.
  c) Produces sinusoidal o/p wf.
  d) It is a fixed freq osc.

Disadvantages

* By changing the values of R & C freq of the osc can be changed. but values for R & C for all three sections must be change
* freq stability is poor.

1) RC phase shift osc, phase shift n/w uses resistance each of $4.7 K\Omega$ and $C = 0.47 \mu F$. Find the freq of osc.

Soln:
$$f = \frac{1}{2\pi\sqrt{6}\,RC}$$

$$f = 29.413\ Hz$$

2) Estimate values of R & C for o/p freq of 1KHz, in RC phase shift osc.

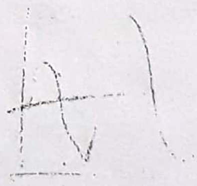
$F = 1KHz$
$$f = \frac{1}{2\pi\sqrt{6}\,RC}$$

Choose $C = 0.1 \mu F$.

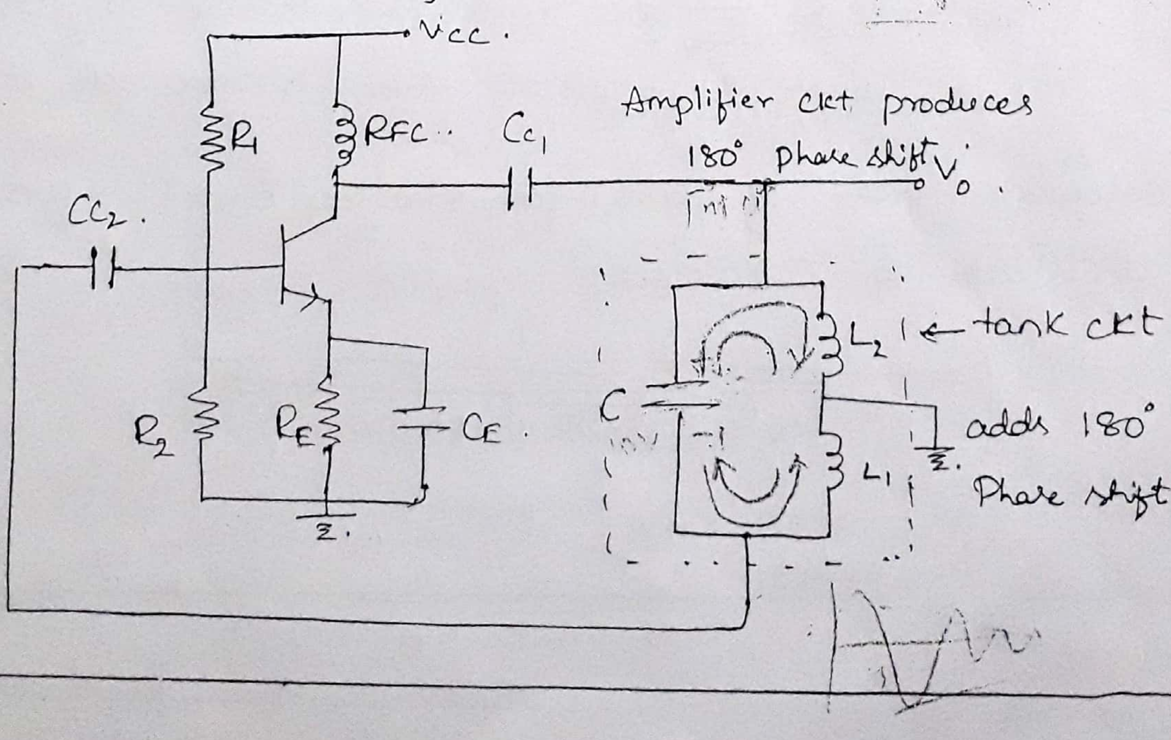
$$1\times 10^{3} = \frac{1}{2\pi\sqrt{6}\, R \times 0.1\times 10^{-6}}$$

$$R = 649.74\,\Omega$$

Choose $R = 680\,\Omega$.



Transistorised Hartley oscillator



* Hartley oscillator uses two inductive reactances and one capacitive reactance in feed back network.
* Amplifier stage uses an active device as a transistor in CE configuration.
* Resistors R_1 & R_2 are biasing resistors. RFC is radio freq choke. It's reactance value is very high freq. hence it can be treated as open ckt.
* R_E is biasing ckt resistance and C_E is bypass Capacitor.
* C_{C1} & C_{C2} are coupling capacitors,
* CE amplifier provides 180° phase shift. As emitter is gnd and base & collector voltages are out of phase by 180°.
The LC tank ckt provides 180° phase shift necessary to satisfy oscillation condition.
* Freq of osc is given by

$$f = \frac{1}{2\pi\sqrt{L_{eq} C}}$$

where $L_{eq} = L_1 + L_2$.

17 Calculate freq of Osc for Hartley osc $L_1 = 0.5 mH$ $L_2 = 1 mH$ & $C = 0.2 \mu F$.

$$\Rightarrow f = \frac{1}{2\pi\sqrt{L_{eq} C}} = \frac{1}{2\pi\sqrt{(1+0.5)m \times 0.2\mu}}$$

$$f = 9.19 \text{ KHz}$$

In transistorized Hartley oscillator, L_1 and L_2 are 2mH and 20 μH resp, with $f = 950$ KHz to 2050 KHz. Calculate the range over which the capacitor is to be varied.

Soln

$$f = \frac{1}{2\pi\sqrt{L_{eq} \cdot C}}$$

$$L_{eq} = L_1 + L_2 = 2\times10^{-3} + 20\times10^{-6} = 0.00202.$$

$$f = f_{max} = 2050 \text{ KHz}.$$

$$2050\times10^{3} = \frac{1}{2\pi\sqrt{C\times0.00202}}$$

$$\underline{\underline{C = 2.98 PF}}$$

$$f_{min} = 950 \text{ KHz}.$$

$$950\times10^{3} = \frac{1}{2\pi\sqrt{C\times0.00202}}$$

$$\underline{\underline{C = 13.89 PF}}$$

3> Given $L_1 = 20 μH$, $L_2 = 2mH$ and C is variable, f to be varied from 1MHz to 2.5MHz.

Soln:

$$L_{eq} = L_1 + L_2 = 2.002\times10^{-3} H.$$

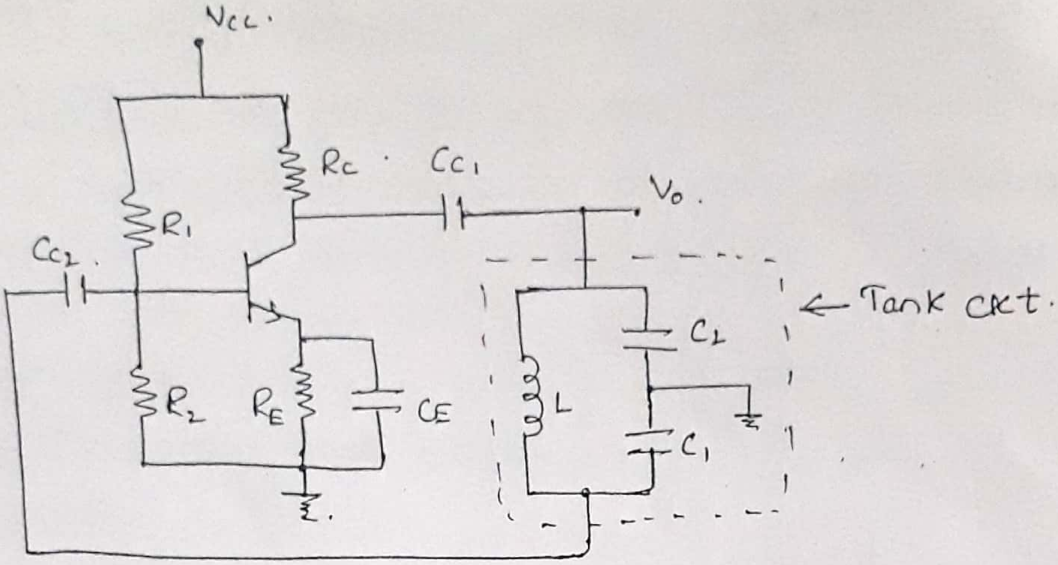
$$f_{max} = 2.5 MHz.$$

$$2.5\times10^{6} = \frac{1}{2\pi\sqrt{C\times2.002\times10^{-3}}}$$

$$\underline{C = 2.02 PF}$$

$$f_{min} = 1\times10^{6} = \frac{1}{2\pi\sqrt{C\times2.002\times10^{-3}}} \Rightarrow \underline{C = 12.65 pF}$$

Colpitts Oscillator



* Amplifier uses a active device as transistor in CE configuration.
* Amplifier provides 180° phase shift and LC tank ckt provides 180° phase shift.
* Frequency of Osc $f = \frac{1}{2\pi\sqrt{L\,C_{eq}}}$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}.$$

1) In Colpitts osc $C_1 = C_2 = C$ & $L = 100\,\mu H$, $f = 500\,kHz$ determine C.

Soln:-

$$f = \frac{1}{2\pi\sqrt{L\,C_{eq}}}$$

$$500\times10^{3} = \frac{1}{2\pi\sqrt{100\times10^{-6}\times C_{eq}}}$$

$$C_{eq} = 1.0132\times10^{-9}\,F.$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{\cancel{2}C^{\cancel{2}}}{\cancel{2}\cancel{C}} \Rightarrow \quad 2.0264\times10^{-9} = C$$

6 11

27. In colpitts osc f is 500KHz find L assume $C = 1000PF$

Sol:-

$C_1 = C_2 = C = 1000PF$.

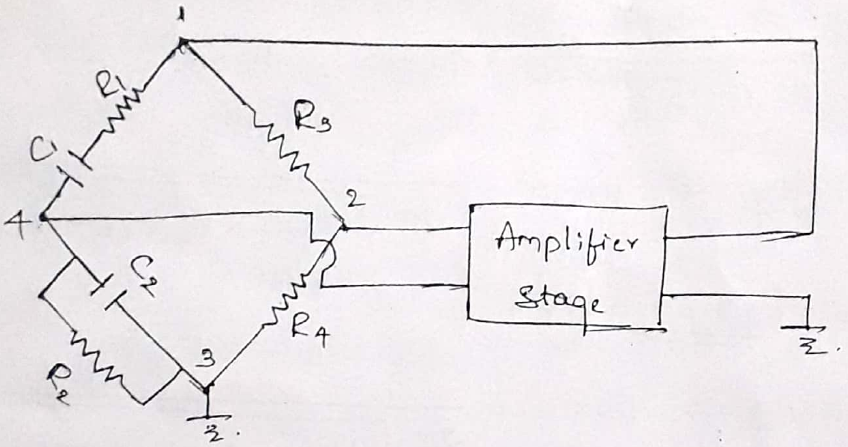
$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = 500\ PF.$$

$$f = \frac{1}{2\pi\sqrt{L C_{eq}}} \Rightarrow 500 \times 10^3 = \frac{1}{2\pi\sqrt{L \times 500 \times 10^{-12}}}$$

$L = 202.64\mu H$

$L \times 500 \times 10^{-12} = 1.01 \times 10^{-16}$

Wein Bridge Oscillator:



Amplifier i/p 2&4

o/p 1&3

* Wein bridge oscillator uses a non-inverting amplifier and hence does not provide any phase shift during amplifier stage.
* As total phase shift required is 0° in Wein bridge type no phase shift is necessary through feed back. Thus total phase shift around the loop is 0°.
* The o/p of amplifier is applied b/w 1 & 3 terminals which is the i/p to the feedback n/w.
* Amplifier i/p is supplied from the terminals 2 & 4 which is o/p from feedback n/w.

* The two arms of the bridge R_1, C_1 is series & $R_2 C_2$ in parallel are called freq. sensitive arms. This is because these two arms decide the freq of oscillator.
* Freq of oscillations is given by,

$$f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}} \quad \text{or} \quad f = \frac{1}{2\pi RC}.$$

1) The freq sensitive arms of the wein bridge osc uses $C_1 = C_2 = 0.001\mu F$ and $R_1 = 10k\Omega$ while R_2 is kept variables. The freq is to be varied from 10 KHz to 50KHz by varying R_2. Find the min & max values of R_2

Soln:

$$f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

for $f = 10KHz \Rightarrow 10\times10^3 = \frac{1}{2\pi\sqrt{10\times10^3 \times R_2 \times (0.001\times10^{-6})^2}}$

$$R_2 = 25.33 K\Omega$$

for $f = 50KHz \Rightarrow 50\times10^3 = \frac{1}{2\pi\sqrt{10\times10^3\times R_2 \times (0.001\times10^{-6})^2}}$

$$R_2 = 1.013 K\Omega$$

So min value of R_2 is $1.013 K\Omega$ while max value of R_2 is $25.33 K\Omega$.

Advantages of Wein Bridge Osce.

* It gives constant o/p
* The circuit works quite easily
* Overall gain is high becoz of two Transistors.
* The freq of oscillations can be easily changed by using potentiometer.

Disadvantages.

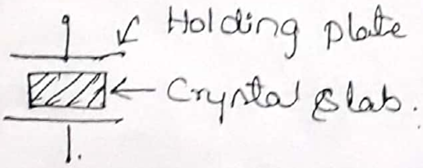
* Ckt requires two transistors & large number of components
* It cannot generate very high frequencies.

Crystal Oscillator

Crystal exhibits the piezo-electric effect, It means under the influence of mechanical pressure the voltage gets generated across the opposite faces of crystal.

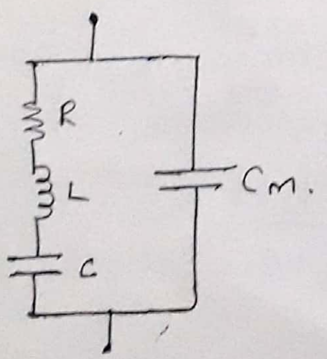
* If the mechanical force is applied in such a way to force the crystal to vibrate, a.c. voltage gets generated across it.
* If the crystal is subjected to a.c voltage, it vibrates causing mechanical distortion. So under the influence of mechanical vibrations crystal generates an electrical signal of constant freq.

Constructional details



* The natural shape of a quartz crystal is hexagonal prism but for its practical use it is cut to the rectangular slab. This slab is then mounted between two metal plates. (i.e. holding plates)

* A.C. Equivalent ckt of a crystal



* When crystal is not vibrating, it is equal to capacitance due to mechanical mounting of a crystal.

* When it is vibrating there are internal frictional losses which a.c. equivalent ckt of are denoted by Resistance R. while mass of crystal represented by inductance L. In vibrating condition it is having some stiffness which is represented by capacitor C. The Cm is mounting capacitance.

* RLC forms a resonating ckt. The resonating freq. fr is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}} \cdot \sqrt{\frac{Q^2}{1+Q^2}}$$

where Q is quality factor of crystal

$$Q = \frac{\omega L}{R}.$$

Q is typically very high i.e. 20,000 hence

$$\boxed{f_r = \frac{1}{2\pi\sqrt{LC}}}$$

Series and Parallel Resonance.

* One resonant condition occurs when the reactances of series RLC leg are same. i.e. $X_L = X_C$. This is nothing but a series resonance.

* The series resonance freq is given by

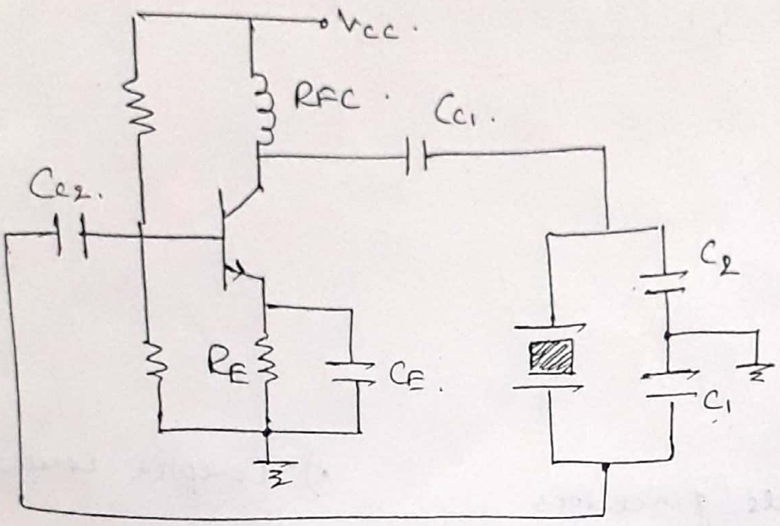
$$f_s = \frac{1}{2\pi\sqrt{LC}}.$$

* The other resonant condition occurs when reactance of series resonant leg equals the reactance of mounting capacitance Cm. This is parallel resonance or anti resonance condition. $C_{eq} = \frac{C_m C}{C_m + C}$

∴ hence parallel resonating freq is given by

$$f_p = \frac{1}{2\pi\sqrt{L C_{eq}}}$$

Pierce Crystal Oscillator



* The crystal behaves as an inductor for a freq stability higher than series resonance freq f_s.
* The working of pierce crystal osc is same as Colpitts osc.
* The resistors R_1, R_2 & R_E provide d.c. bias while CE is emitter bypass capacitor. RFC is radio freq Choke provides isolation b/w a.c. & d.c. operation. C_{c1} & C_{c2} are coupling capacitors.
* Change in supply voltage, temp and transistor Parameters have no effect on ckt operating conditions hence good freq. stability is obtained.
* The resulting ckt is set by series resonant freq of crystal.

Advantages of positive feedback.

* It increases the output voltage in turn ~~of~~ voltage gain.
* Input and o/p are in phase.

Disadvantages of Positive feedback.

* Frequency stability is less.
* Distortion increases.
* Less stable for noise.

Applications.

*) Clock signals/generators
*) Audio & frequency generators
*) Calculators
*) Complex computers

Feedback Ckt → Frequency selective Ckt
Resonant Ckt.

When the input and part of the output signal which is fed back are out of phase then the feedback is negative.
If they are in phase then the feedback is positive