UNIT - III

SINUSOIDAL OSCILLATORS

Introduction:-

Oscillator is defined as a circuit which generates an a.c output signal without requiring any external input signal.

The osillator converts d.c energy into a.c energy at a desired frequency.

An oscillator is an amplifier, which uses a positive feedback without any external input signal. generates an output waveform at a desired frequency.

Concept of positive feedback:-

→ The process of combining a part of output energy back to the input is known as feedback.

→ An oscillator uses a positive feedback.

→ In positive feedback the part of the output that is fed back to the amplifier as its input, is in phase with the original input signal applied to the amplifier. (0° or 360°).

→ positive feedback increases the gain of the circuit.

→ Consider a non-inverting amplifier with the voltage gain 'A' as shown in fig.

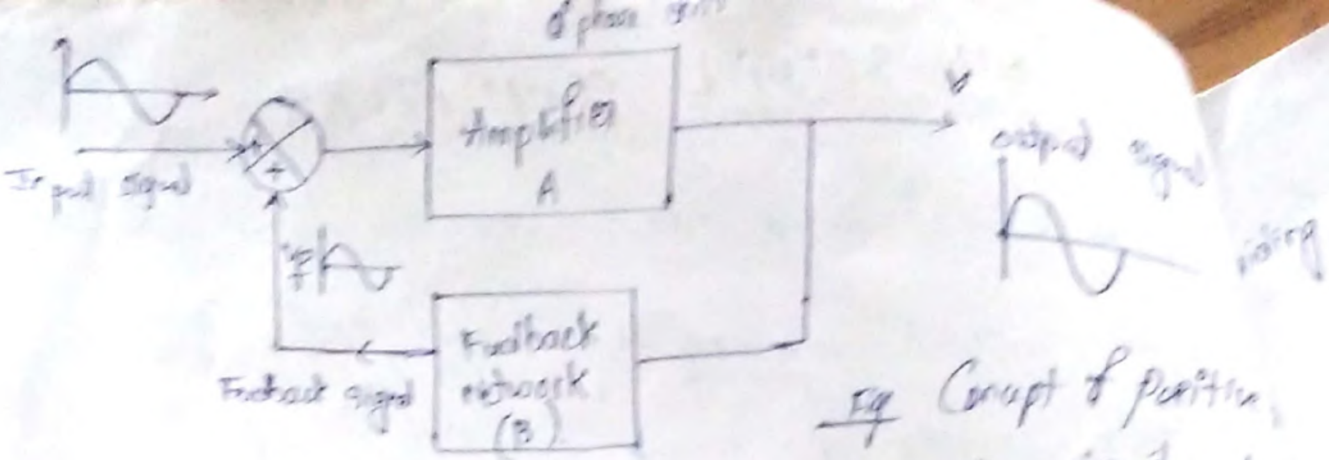

Fig Concept of positive

A sinusoidal input signal V_s is applied to the circuit. As amplifier is non-inverting, the output voltage V_o is in phase with the input signal V_s. No phase is introduced by the feedback network. Hence the feedback voltage V_f is in phase with the input signal V_s.

As the phase of the feedback signal is same as that of the input signal, the feedback is called positive feedback.

The amplifier gain is 'A' i.e it amplifies its input V_i, A times to produce o/p V_o $\quad A = \frac{V_o}{V_i}$

A is openloop gain of the amplifier

The closed loop gain $A_f = \frac{V_o}{V_s}$

From the ~~input of ampli~~ above circuit $\quad V_i = V_s + V_f \longrightarrow$ (1

~~The feedback is positive and voltage V_f is.~~

$$V_f = \beta V_o \longrightarrow (2)$$

Substitute eq (2) in eq (1). $\quad V_i = V_s + \beta V_o$

$$V_s = V_i - \beta V_o \longrightarrow (3)$$

Substitute eq (3) in 'A_f' $\quad A_f = \frac{V_o}{V_s} = \frac{V_o}{V_i - \beta V_o}$

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$$A_f = \frac{V_o}{V_i - \beta V_o}$$

Dividing both numerator and denominator by V_i.

$$A_f = \frac{(V_o/V_i)}{1 - \beta(V_o/V_i)}$$

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

Barkhausen Criteria :-

1. The total phase shift around the loop should be zero degrees or 360°.
2. The magnitude of product of the open loop gain of the amplifier (A) and the feedback factor β is unity i.e $|A\beta| = 1$

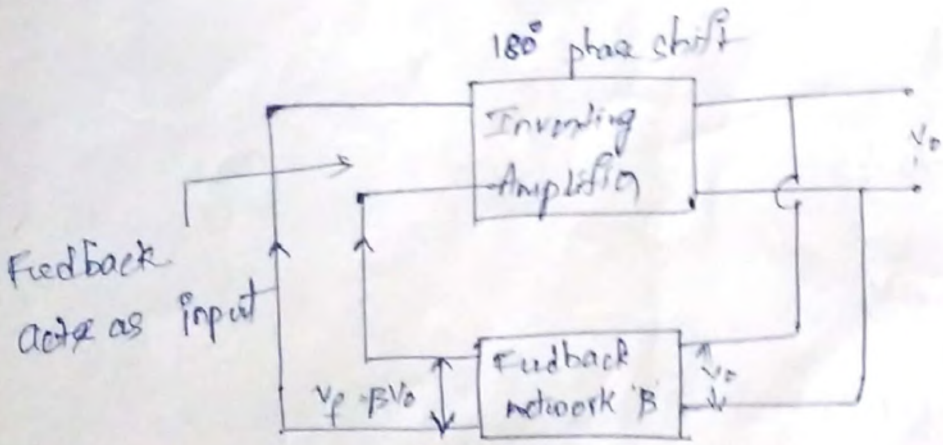

Fig : Basic block diagram of Oscillator circuit.

→ The feedback n/w i/p is 'V_o' then the feedback n/w produces 180° phase shift.

→ This feedback signal is given to the input of the inverting amplifier. then again 180° phase shift is provided by the inverting amplifier

So total phase shift around a loop is 0° or 360°

→ let the input voltage of the feedback network is V_0 and output voltage of the inverting amplifier is V_0, and it is given by.

$$A = \frac{V_0}{V_i}$$

$$V_0 = AV_i$$

→ Feedback network provides 180° phase shift and it is given by

$$\beta = \frac{-V_f}{V_0} \Rightarrow V_f = -\beta V_0$$

where $-ve$ sign indicates the 180° phase shift provided by the feedback network.

→ For the oscillator V_f must acts as a i/p voltage of inverting amplifier.

$$V_i = V_f$$

$$V_f = -\beta V_0$$

$$V_i = -\beta V_0$$

$$\cancel{V_i} = -\beta A \cancel{V_i}$$

$$-A\beta = 1$$

$$|A\beta| = 1$$ The magnitude of product of A & β is 1

The above condition is called barkhausen criteria:

The phase of V_f must be same as V_i i.e feedback n/w should introduce 180° phase shift in addition to 180° phase shift

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producing by inverting amplifier. So total phase shift around a loop is 360°.

→ The above two conditions are required to satisfies the circuit works as an oscillator producing sustained oscillations of constant freq. and amplitude.

Let us see the effect of magnitude of the product of gain and feedback factor on the nature of the oscillations

① $|A\beta| > 1$

The total phase shift around a loop 0° or 360° and $|A\beta| > 1$. Then the oscillations are growing type. The amplitude of oscillations goes on increasing as shown in fig.

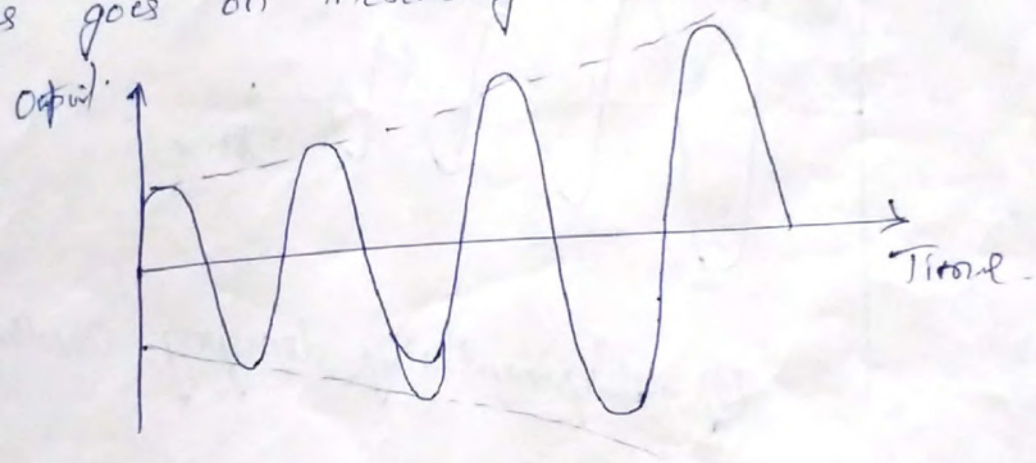

Fig: Growing type oscillations

② $|A\beta| = 1$:- when total phase shift around a loop is 0° or 360° ensuring positive feedback and $|A\beta| = 1$ then the oscillations are with constant frequency and amplitude called sustained Oscillations as shown in figure.

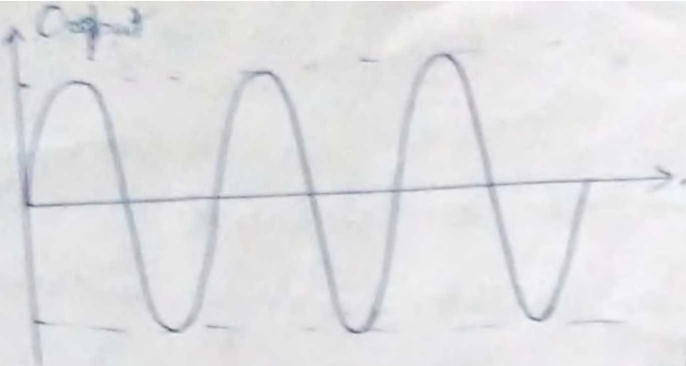

Fig: Sustained Oscillations

③ $|A\beta| < 1$

When total phase shift around a loop is $0°$ or $360°$ but $|A\beta| < 1$ then the oscillations are of decaying type i.e., the amplitude decreases exponentially as shown in fig.

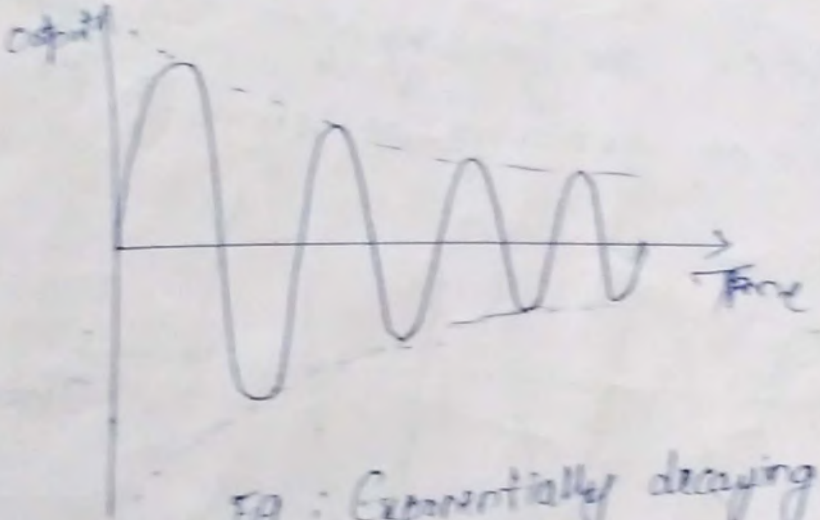

Fig: Exponentially decaying oscillations.

Classification of Oscillators:-

Based on the output waveform:-

Under this oscillators are classified as Sinusoidal & Non-Sinusoidal oscillators.

1. Sinusoidal: The sinusoidal oscillators generate purely sinusoidal wave at the o/p
2. Non-Sinusoidal: The non-sinusoidal oscillators generate an o/p waveform as Triangular.

on the Circuit Components -

The oscillators are ~~classified~~ using the components Resistance (R) and capacitor (c), are called RC oscillators. while the oscillators using the components inductance (L) and capacitor (C), are called LC oscillators. In some oscillators, crystal is used which are called crystal oscillator.

Based on the Range of operating frequency:-

The oscillators which generates signals in the audio frequency range are known as Audio Frequency oscillators.

The oscillators which generates signals in the Radio Frequency range are known as Radio Frequency oscillators.

The classification of such oscillators as shown.

Oscillator	Frequency range.
Audio Frequency (A.F) Oscillators	Few Hz - 20 KHz
Radio Frequency (R.F) Oscillators	20KHz - 30MHz
Very High Frequency (V.H.F) Oscillators	30MHz - 300MHz
Ultra High Frequency (U.H.F) Oscillators	300MHz - 3GHz
Microwave Oscillators	3GHz - Several GHz.

The RC oscillators are used for low frequency range. while the LC oscillators are used for high frequency range.

Based on: wether Feedback is used or not:-

The oscillators in which the feedback ~~used~~ is used, which satisfies the required conditions are Feedback type oscillators. The oscillators in which the feedback is not used to generate the oscillations are nonfeedback Oscillat

The nonfeedback oscillators are negative resistance region of characteristics of the device used. Eg: UJT Relaxation Os

Oscillators

- Sinusoidal
  - Low frequency
    $f \leq 20KHz$
    RC phase shift
    Wien bridge
  - High Frequency
    $f > 20KHz$
    LC oscillators
    ~~Hartley~~
    Colpitts
    Clapp
    Crystal
- Non-Sinusoidal
  - UJT Relaxation Oscillator
  - Multivibrators
    - Mono stable
    - Astable
    - Bistable
  - Time Base generators

RC phase shift Oscillator:-

RC phase shift oscillator consists of an amplifier and a feedback network consisting of resistors and capacitors arranged in a ladder fashion. Hence such an oscillator is also called ladder type RC phase shift oscillator

~~RC phase shift~~

Oscill

Feedback Network:-

The Feedback network consisting of resistors and capacitors. In oscillators feedback network must introduce a phase of ~~of~~ 180° to obtain total phase shift around a loop as 360°. Thus if one RC network produces phase shift of $\phi = 60°$ then to produce phase shift of ~~80~~ such three RC networks must be connected in cascade.

→ Hence in RC phase shift oscillator, the feedback network consists of Three RC sections each producing a phase shift of 60°, Thus Total phase shift due to feedback is 180° (3×60°).

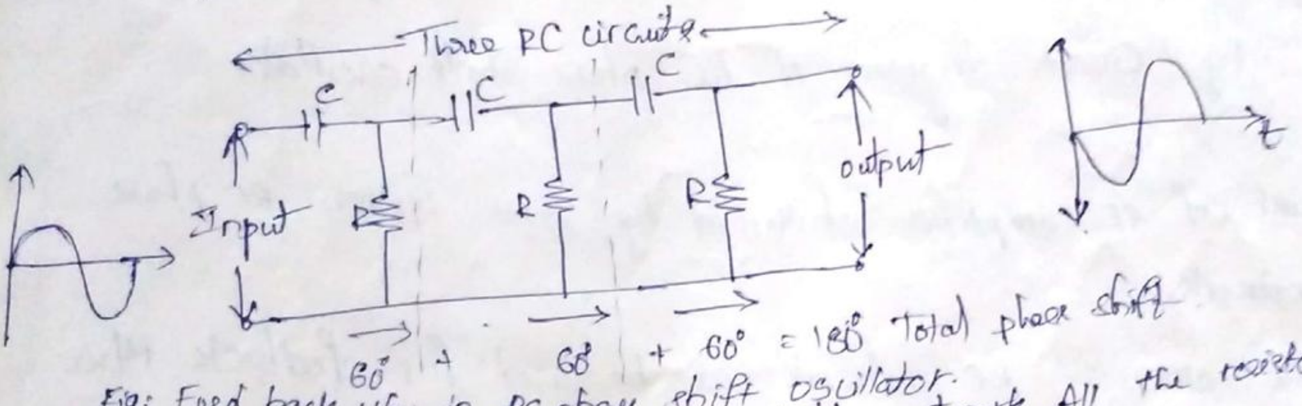

Fig: Feed back N/w in RC phase shift oscillator.

The network is also called the ladder network. All the resistance values and all the capacitance values are same, So that for a particular frequency, each section of R and C produces a phase shift of 60°.

RC phase Shift Oscillator:-

RC phase shift oscillator consists of an amplifier and a feedback network consisting of resistors and capacitors arranged in a ladder fashion. Hence such an oscillator is also called ladder type RC phase shift oscillator.

→ RC oscillator generates the oscillations in low frequencies.

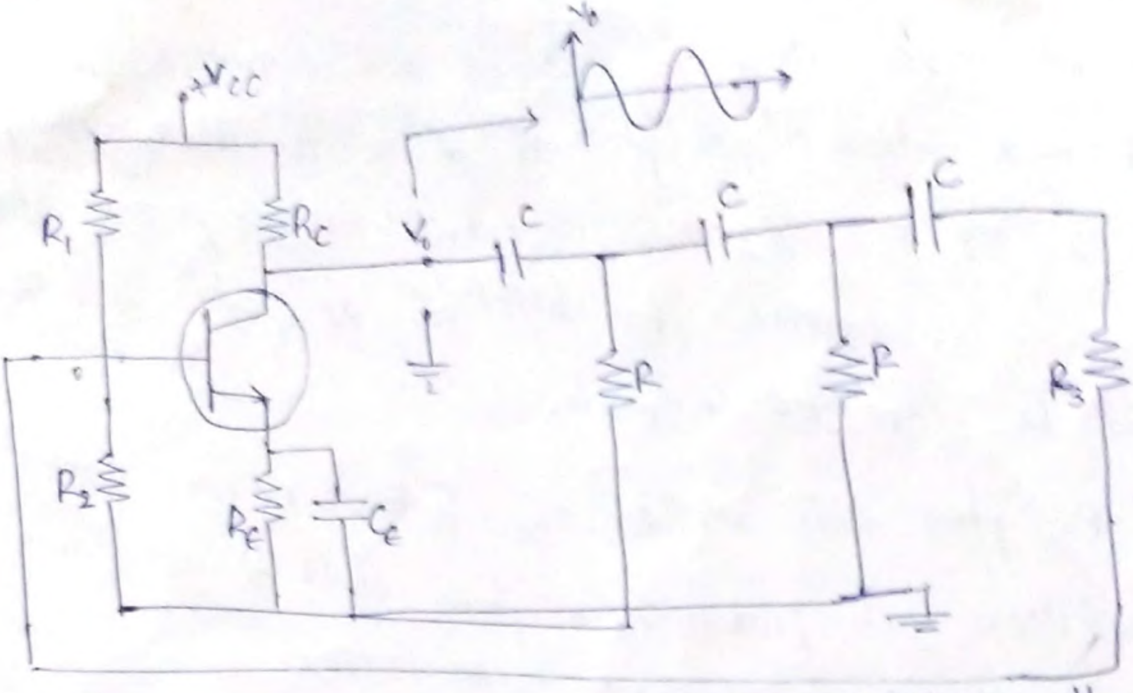

Fig: Circuit diagram of RC phase shift oscillator.

-> It consist of CE amplifier followed by three section. RC phase shift network.

-> In this ckt the RC network can be used for feedback N/w.

-> In oscillator amplifier produces 180° phaseshift and feedback must be introduce phaseshift of 180° to obtain total phaseshift around a loop is 360°.

-> Each RC N/w produces a phase shift of 60°.

-> Here three RC networks produce the phase shift of 180° (60+60+60)

-> This feedback N/w is also called Ladder network.

-> In this each n/w has same values of resistance and Capacitance.

-> At particular frequency each section of RC produces a phase shift of 60°.

-> The output of amplifier is given as i/p to the feedback n/w. Then the o/p of feedback n/w is given as an input to the amplifier

To make 3 RC sections are identical, R_3 is so selected such that the resultant of the two resistance is R.

i.e $h_{ie} + R_3 = R$.

where h_{ie} is the input impedance of the amplifier stage

→ The phase shift ϕ produced by the RC section is.

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

$$\phi = \tan^{-1}\left(\frac{1}{\omega C R}\right) \qquad X_c = \omega C$$

$$\omega = 2\pi f$$

$$\phi = \tan^{-1}\left(\frac{1}{2\pi f C R}\right)$$

Let us assume that $R = 1k\Omega$, $C = 0.1\mu F$ & $f = 1kHz$.

$$\phi = \tan^{-1}\left(\frac{1}{2\pi \times 1 \times 10^3 \times 1 \times 10^3 \times 0.1 \times 10^{-6}}\right)$$

$$\phi = 57 \cong 60^\circ$$

→ Each section produces a phase shift of 60, So the total phaseshift of three RC N/w is 180°

→ The CE amplifier produces ~~180~~ phase shift of 180°. then the the RC n/w produces a phase shift of 180° ~~then~~:

→ So the ~~total~~ phase shift around the ckt is 360°. By this It satisfies Barkhausen criterion So RC phase shift oscillator produces sustained Oscillations.

→ The frequency generated by the RC phase shift Oscillator is

$$f = \frac{1}{2\pi RC\sqrt{6+4k}}$$

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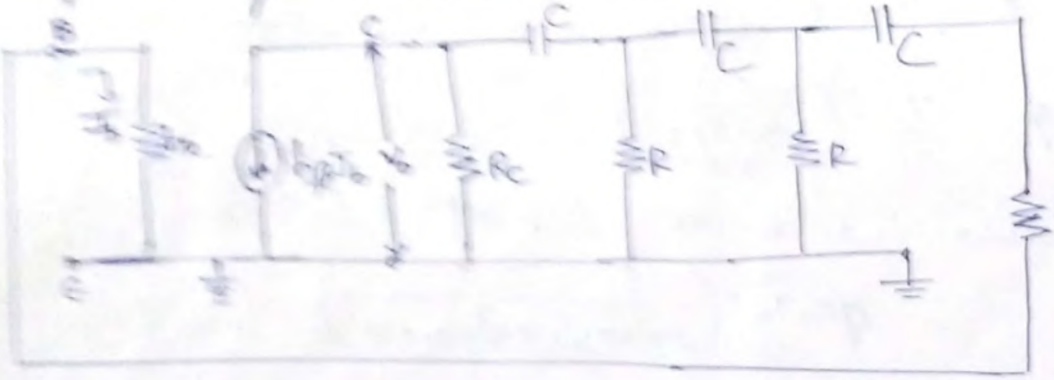
h_{ie} = Input impedance of the amplifier stage.

The resistance R_3 and h_{ie} are in series and then

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

Derivation for the frequency of oscillations:-

Replacing the transistor by its approximate h-parameter model, we get the equivalent oscillator circuit as shown in fig.



$h_{ie} + R_3 = R$

Assume $k = \frac{R_c}{R}$

Replace the current source $h_{fe}I_b$ by its equivalent voltage source

The modified equivalent circuit is shown in fig.

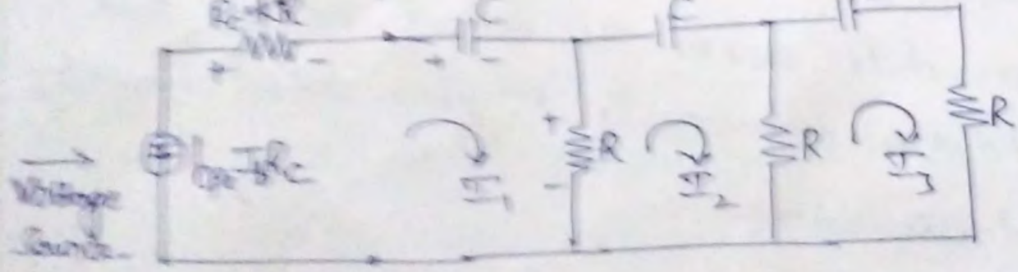


Fig: Modified equivalent circuit.

Apply KVL for the various loops in the modified equivalent circuit we get.

loop1,

$$-I_1 R_c - \frac{1}{j\omega C} I_1 - I_1 R + I_2 R - h_{fe} I_b R_c = 0.$$

$$-h_{fe} I_b R_c = I_1 R_c + \frac{1}{j\omega C} I_1 + R(I_1 - I_2)$$

$$= I_1 \left(R_c + R + \frac{1}{j\omega C}\right) - I_2 R$$

Replacing 'R_c' by 'KR' and '$j\omega$' by 's' we get,

$$I_1 \left[(K+1)R + \frac{1}{sC}\right] - I_2 R = -h_{fe} I_b R_c \longrightarrow (2)$$

For loop 2.

$\cancel{\frac{1}{j\omega C} I_2 \; I_2}$

$$R(I_2 - I_1) + \frac{1}{j\omega C} I_2 + R(I_2 - I_3) = 0.$$

$$-I_1 R + \left(2R + \frac{1}{j\omega C}\right) I_2 - I_3 R = 0$$

$$-I_1 R + \left(2R + \frac{1}{sC}\right) I_2 - I_3 R = 0 \longrightarrow (3).$$

For loop 3,

$$R(I_3 - I_2) + \left(\frac{1}{j\omega C}\right) I_3 + I_3 R = 0$$

$$-R I_2 + \left(2R + \frac{1}{j\omega C}\right) I_3 = 0$$

$$-R I_2 + \left(2R + \frac{1}{sC}\right) I_3 = 0 \longrightarrow (4).$$

Using Cramer's Rule to solve for I_3,

$$D = \begin{vmatrix} (K+1)R + \frac{1}{sC} & -R & 0 \\ -R & \left(2R + \frac{1}{sC}\right) & -R \\ 0 & -R & \left(2R + \frac{1}{sC}\right) \end{vmatrix}$$

$$= \left[(k+1)P + \frac{1}{sc}\right]\left[\left(2P+\frac{1}{sc}\right)^2 - R^2\right] + R\left[(-R)\left(2P+\frac{1}{sc}\right) - 0\right]$$

$$= \left[(k+1)R + \frac{1}{sc}\right]\left[\left(2R+\frac{1}{sc}\right)^2\right] - R^2\left[(k+1)R+\frac{1}{sc}\right] - R^2\left(2R+\frac{1}{sc}\right)$$

$$= \left(\frac{scR(k+1)+1}{sc}\right)\left(\frac{(2RCs+1)^2}{(sc)^2}\right) - R^2\left[\frac{(k+1)sRC+1}{sc}\right] - R^2\left[\frac{2sRC+1}{sC}\right]$$

$$= \frac{\left(sRC(k+1)+1\right)\left((2sRC+1)^2\right)}{(sc)^3} - R^2\left(\frac{(k+1)sRC+1}{sC}\right) - R^2\left(\frac{2sRC+1}{sC}\right)$$

First term can be written as,

$$\frac{\left[sKRC + sRC+1\right]\left[4s^2R^2C^2+4sRC+1\right)}{(sc)^3} =$$

$$= \frac{4s^3KR^3C^3 + 4s^2KR^2C^2 + sKRC + 4s^3R^3C^3 + 4s^2R^2C^2 + sRC + 4s^2R^2C^2 + 4sRC + 1}{s^3C^3}$$

$$= \frac{4s^3KR^3C^3 + 4s^3R^3C^3 + 4s^2KR^2C^2 + 8s^2R^2C^2 + sKRC + 5sRC + 1}{s^3C^3}$$

$$= \frac{s^3R^3C^3(4K+4) + s^2R^2C^2(4K+8) + sRC(K+5)+1}{s^3C^3}$$

Second and the third term can be combined to get,

$$= \frac{-R^2\left((k+1)sRC+1\right)}{sC} - R^2\left(\frac{2sRC+1}{sC}\right)$$

$$= \frac{-(k+1)sR^3C - R^2 - 2sR^3C - R^2}{sC} = \frac{-(2R^2+3sR^3C+KsR^3C)}{sC}$$

Combining the two terms and taking LCM as s^3C^3 we get,

$$D = \frac{s^3R^3C^3(4K+4) + s^2R^2C^2(4K+8) + sRC(K+5)+1}{s^3C^3} - \frac{(2R^2+3sR^3C+KsR^3C)}{sC}$$

$$= \frac{s^3R^3C^3(4K+4) + s^2R^2C^2(4K+8) + sRC(K+5)+1 - (2R^2+3sR^3C+KsR^3C)(s^2C^2)}{s^3C^3}$$

$$= \frac{s^3R^3C^3(4K+4) + s^2R^2C^2(4K+8) + sRC(K+5)+1 - (2R^2s^2C^2 + 3s^3R^3C^3 + Ks^3R^3C^3)}{s^3C^3}$$

$$= \frac{s^3R^3C^3(3K+1) + s^2R^2C^2(4K+6) + sRC(K+5)+1}{s^3C^3} \longrightarrow (5)$$

Now.

$$D_3 = \begin{vmatrix} (K+1)R+\frac{1}{sC} & -R & -h_{fe}I_bKR \\ -R & 2R+\frac{1}{sC} & 0 \\ 0 & -R & 0 \end{vmatrix}$$

$$= \cancel{+R}\left(-h_{fe}I_bKR\left[(-R)(GR) - 0\right]\right.$$

$$= -h_{fe}I_bKR^3$$

$$\therefore I_3 = \frac{D_3}{D}$$

$$\therefore I_3 = \frac{(-h_{fe}I_bKR^3)(s^3C^3)}{s^3R^3C^3(3K+1)+s^2R^2C^2(4K+6)+sRC(K+5)+1} \longrightarrow (7)$$

I_3 = output current of the feedback circuit

I_b = Input current of the amplifier.

I_c = $h_{fe} I_b$ = Input current of the feedback circuit

$\therefore$ $\beta = \dfrac{\text{Output of feedback circuit}}{\text{Input to feedback circuit}} = \dfrac{I_3}{h_{fe} I_b}$

and $A = \dfrac{\text{Output of amplifier circuit}}{\text{Input to amplifier circuit}} = \dfrac{I_c}{I_b} = h_{fe}$

$$\therefore A\beta = \frac{I_3}{h_{fe} I_b} \times h_{fe} = \frac{I_3}{I_b} \longrightarrow (8)$$

Using eq (8) we get,

$$A\beta = \frac{-KR^3 h_{fe} s^3 C^3}{s^3C^3R^3(3K+1) + s^2C^2R^2(4K+6) + sRC(5K+5)+1} \longrightarrow (9)$$

Substituting $s = j\omega$, $s^2 = j^2\omega^2 = -\omega^2$, $s^3 = j^3\omega^3 = -j\omega^3$ in eq (9). we get,

$$A\beta = \frac{+j\omega^3 KR^3C^3 h_{fe}}{-j\omega^3C^3R^3(3K+1) - \omega^2C^2R^2(4K+6) + j\omega RC(5+K)+1}$$

Seperating the real and imaginary parts in the denominator we get,

$$A\beta = \frac{+j\omega^3 KR^3C^3 h_{fe}}{\cancel{j\omega^3C^3R^3(3K+1)}\ (1 - 4K\omega^2C^2R^2 - 6\omega^2C^2R^2] - j\omega(3K\omega^2R^3C^3 + \omega^2R^3C^3 - 5RC - KRC]}$$

Dividing numerator and denominator by $j\omega^3R^3C^3$

$$A\beta = \frac{Kh_{fe}}{\left(\dfrac{1 - 4K\omega^2C^2R^2 - 6\omega^2C^2R^2}{-j\omega^3R^3C^3}\right) - \left(\dfrac{j\omega(3K\omega^2R^3C^3 + \omega^2R^3C^3 - 5RC - KRC)}{-j\omega^3R^3C^3}\right)}$$

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Replacing $\frac{1}{j} = j$,

$$= \frac{Kh_{fe}}{j\left\{\frac{1}{\omega^3R^3C^3} - \frac{4K}{\omega RC} - \frac{6}{\omega RC}\right\} + \left\{3K+1 - \frac{5}{\omega^2R^2C^2} - \frac{K}{\omega^2R^2C^2}\right\}}$$

Replacing $\frac{1}{\omega RC} = \alpha$ for simplicity.

$$\therefore A\beta = \frac{Kh_{fe}}{\left[(3K+1) - 5\alpha^2 - K\alpha^2\right] + j\left(\alpha^3 - 4K\alpha - 6\alpha\right)} \longrightarrow (10)$$

As per the barkhausen criterion, $\angle A\beta = 0°$, Now the angle of numerator term Kh_{fe} of the eq (10) is $0°$ to have an angle of the $A\beta$ term as 0. The imaginary part of the denominator term must be '0'.

$$\therefore \quad \alpha^3 - 4K\alpha - 6\alpha = 0.$$

$$\alpha(\alpha^2 - 4K - 6) = 0.$$

$$\alpha^2 = 4K+6.$$ neglecting zero value.

$$\alpha = \sqrt{4K+6}.$$

$$\frac{1}{\omega RC} = \sqrt{4K+6}.$$

$$\omega = \frac{1}{RC\sqrt{4K+6}}$$

$$\boxed{f = \frac{1}{2\pi RC\sqrt{4K+6}}}$$

This is the freq. at which $\angle A\beta = 0°$. At the same

Substituting $\alpha = \sqrt{4K+6}$ in the eq (10) we get,

$$A\beta = \frac{Kh_{fe}}{3K+1-(4K+6)(5+K)} = \frac{Kh_{fe}}{3K+1-20K-30-4K^2-6K}$$

$$= \frac{Kh_{fe}}{-4K^2-23K-29}$$

Now $|A\beta| = 1$

$$\therefore \left|\frac{Kh_{fe}}{-4K^2-23K-29}\right| = 1$$

$$Kh_{fe} = 4K^2+23K+29$$

$$h_{fe} = 4K+23+\frac{29}{K}$$

This must be the value of 'h_{fe}' for the oscillations.

Advantages:-

1. The circuit is simple to design
2. less cost.
3. Complexity is less
4. It is used to generate low freq. signals.
5. It satisfies the Barkhausen criteria.

Disadvantages:-

1. By changing the values of R & C the freq. of oscillations can be changed.
2. It is unable to generate high freq. signals.

Wien Bridge Oscillator:-

→ It is used to generate frequencies from low to moderate in the range of 5Hz ~~to about~~ - 1MHz.

→ The circuit diagram of a wien bridge ~~amplifier~~ oscillator is shown in fig.

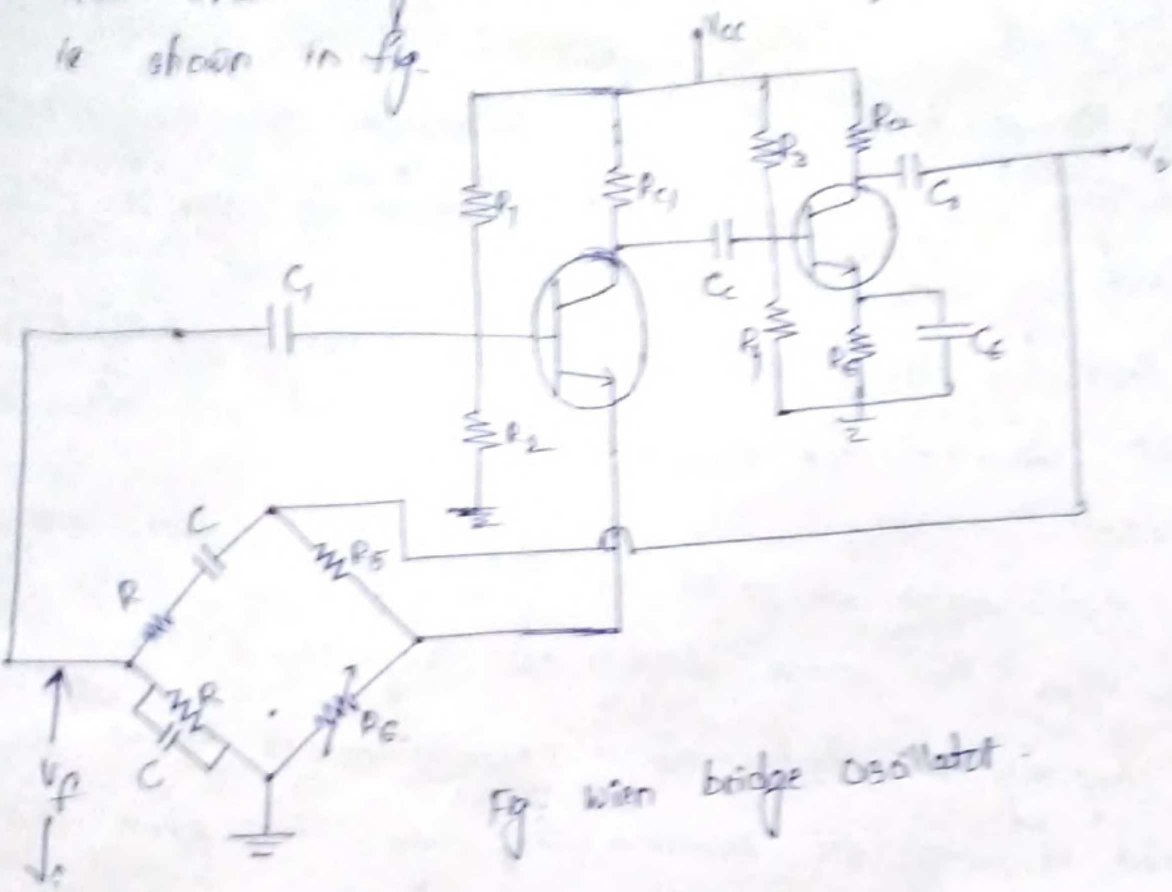
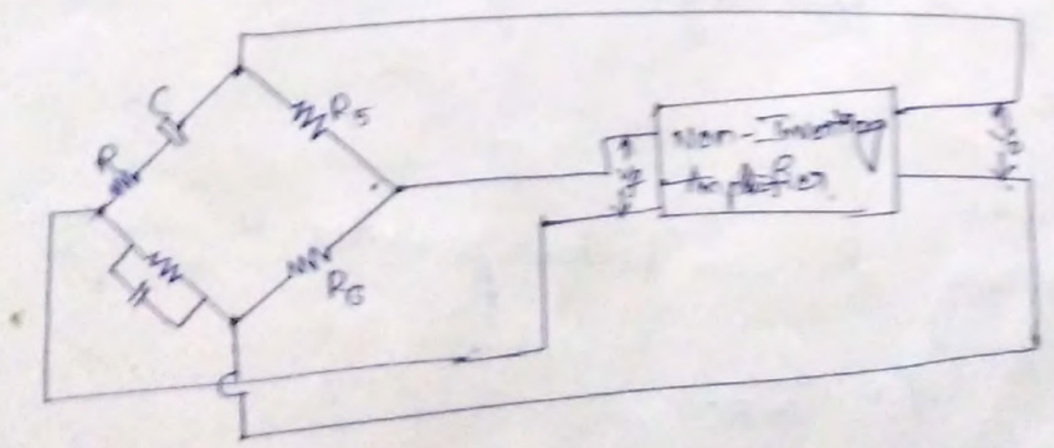


Fig. wien bridge oscillator.



→ It consist of two stage RC coupled amplifier. Each amplifier provides 180° phase shift so that the overall shift is 360°.

→ The output of the second stage RC coupled amplifier feedback ~~circuit~~ to the first stage through the bridge network.

→ The bridge network consists of a feedback circuit called a lead-lag network.

→ The lead-lag network consists of two reactive arms that contain two RC networks. one of which is in shunt and other is in series.

→ These two arms are called as frequency sensitive arms because these two arms decides the frequency of the oscillator.

→ The frequency at which o/p is maximum is known as resonant frequency. At resonance frequency the phase shift is

→ At high freq. the lead-lag n/w acts as a lead network and the phase angle is positive

→ At low freq. the phase angle is negative and its acts as a lag network.

~~→ The resistor~~

→ The frequency of wien bridge oscillator is given by

$$f = \frac{1}{2\pi RC}$$

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Advantages:-

1. This gives good frequency stability.
2. By replacing R_6 with a thermistor, amplitude stability of oscillator output voltage can be increased.
3. Overall gain is high because of two transistors.
4. Frequency of oscillations can be changed.
5. It provides good sine wave output.

Disadvantages:-

1. It requires two transistors and large number of components.
2. It cannot generate very high frequencies.
3. Difficult to design.
4. Cost is high.

→ At very low frequencies, the series capacitor looks open to the i/p signal and there is no output. The phase angle is positive, and the circuit acts like a lead network.

→ At very high frequencies, the shunt capacitor looks shorted, and there is no output. At very high frequencies, the phase angle is negative, and the circuit acts like a lag network.

→ In between very low and very high frequencies, the output voltage reaches a maximum value. The freq. at which the output is maximized is called the resonant frequency.

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LC oscillators:-

The oscillators which use the elements L and C to produce oscillations are called LC oscillators.

The circuit using elements L and C is called tank circuit or Oscillatory circuit. or tuned circuit.

These oscillators are used for high frequency range from 20kHz upto few MHz.

→ Due to high frequency range, these oscillators are used for sources of RF (Radio frequency) energy.

Operation of LC Tank Circuit:-

The LC tank circuit consists of elements L and C connected in parallel as shown in the fig.

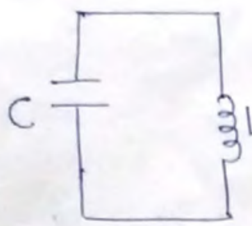


Fig: LC tank circuit

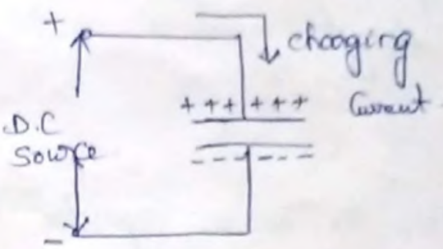


Fig: Initial charging.

→ let capacitor is initially charged from a d.c source with the polarities as shown in fig.

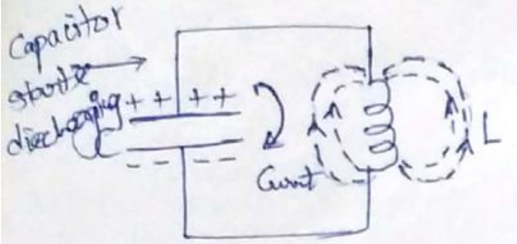
→ when the capacitor gets charged, the energy gets stored in a capacitor called electrostatic energy.

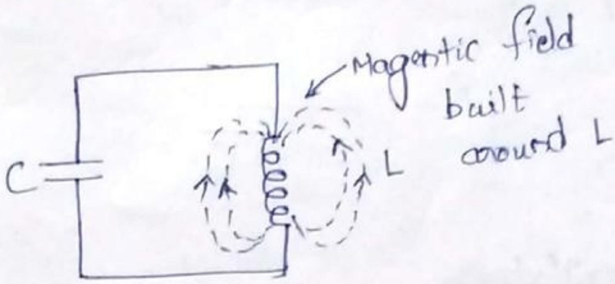
→ Then such a charged capacitor is connected across inductor 'L' in a tank circuit, the capacitor starts discharging through 'L' as shown in fig.

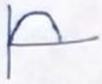
The arrow indicates the direction of flow of current. Due to such current flow, the magnetic field gets set up around the inductor 'L'. Thus inductor starts storing the energy.

→ when capacitor is fully discharged, the maximum current flows through the circuit.

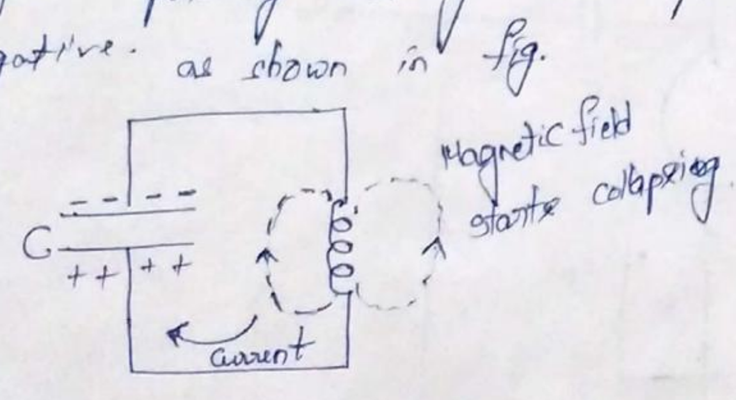
→ At this instant all the electrostatic energy get stored as a magnetic energy in the inductor L.

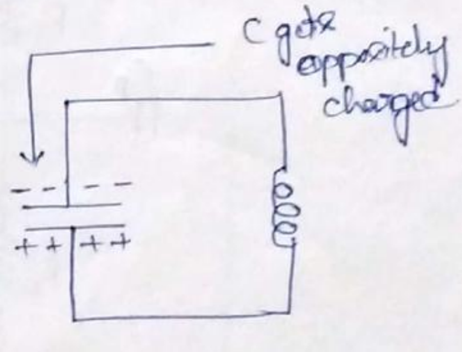




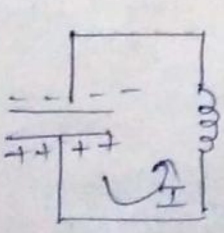


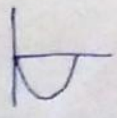
→ Now the magnetic field around 'L' starts collapsing. As per Lenz's law, this starts the charging the capacitor with opposite polarity making lower plate positive and upper plate negative. as shown in fig.





→ Then capacitor again starts discharging through inductor 'L' but the direction of current through the inductor in the 'L' but the direction of current through the inductor in the ckt is shown in fig.





→ Again electrostatic energy converted ~~to~~ converted to mag[netic]
when the capacitor is fully discharged and again magnet[ic field]
collapses and again the capacitor gets charging in opposit[e direction]

→ Thus the capacitor charges with alternate polarities and
discharges, ~~is~~ alternating current in the tank circuit
producing.

→ The freq. of oscillations produced in the circuit is given
by

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

Heartly Oscillator:-

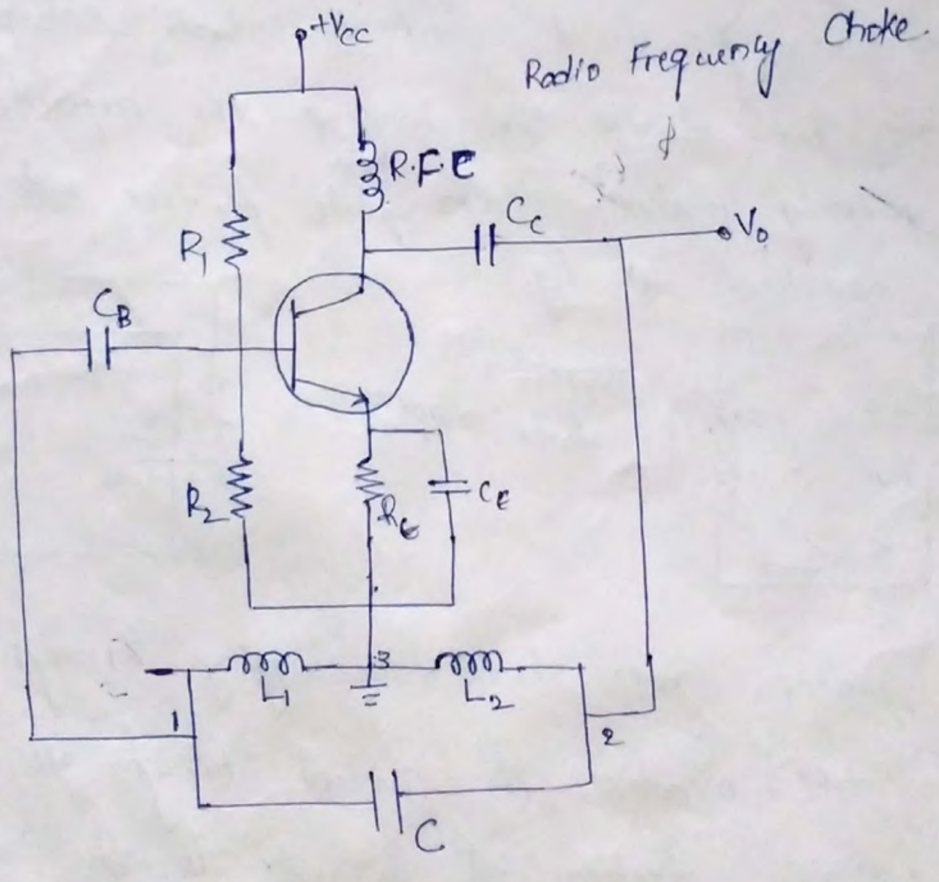


Fig: Hartley Oscillator.

Above fig shows the ckt diagram of a Hartley oscillator.

It is a radio frequency oscillator.

It consists of tank circuit with two coils L_1 and L_2, and one capacitor C.

The capacitor C_C is used as coupling capacitor. It permits only AC current to pass to the tank circuit.

The capacitor C_B is known as blocking capacitor. It avoids dc grounding the transistor base.

The Radio Frequency choke (R.F.C) is to allow dc current and to block ac currents.

Since the terminal '3' is grounded, the voltage across L_2 is 180° out of phase with the voltage across L_1. The CE amplifier provides a phase shift of 180°. Hence the total phase shift is 360°.

The feedback factor $\beta = \frac{V_f}{V_0}$.

For oscillations $|A\beta| = 1$ The imaginary part is 0 to have an angle of 0

The general form of equation is

$$(1+h_{fe})Z_1Z_2 + h_{ie}(Z_1+Z_2+Z_3) + Z_1Z_3 = 0.$$

$$Z_1 = j\omega L_1 \; ; \; Z_2 = j\omega L_2 \; ; \; Z_3 = \frac{1}{j\omega C}$$

$$\Rightarrow (1+h_{fe})(j\omega L_1)(j\omega L_2) + h_{ie}\left(j\omega L_1 + j\omega L_2 + \frac{1}{j\omega C}\right) + (j\omega L_1)\left(\frac{1}{j\omega C}\right) = 0$$

$$(1+h_{fe})(-\omega^2 L_1L_2) + \frac{L_1}{C} + j h_{ie}\left(\omega L_1 + \omega L_2 - \frac{1}{\omega C}\right) = 0$$

Equating imaginary parts to '0'.

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

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

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

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

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

$$\boxed{f=\frac{1}{2\pi\sqrt{L_{eq}C}}} \quad (\because L_{eq}=L_1+L_2)$$

By equating real part to zero $\boxed{h_{fe}=\frac{L_1}{L_2}}$

Advantages:-

1. The freq. varies by changing the value of capacitor 'C' in the tank circuit.
2. It is used to generate the high frequency signals.
3. The output amplitude remains constant when tuned over the frequency range.
4. The feedback ratio of L_1 and L_2 remains constant.

Disadvantages:-

1. It is unable to generate the low frequency signals.
2. It is difficult to design because a tuned ckt used in the Oscillator circuit.
3. It is not suitable where pure sine wave is required.

It is used in Radio Receivers.
2. It is used in high frequency applications.

Colpitt's Oscillator:-

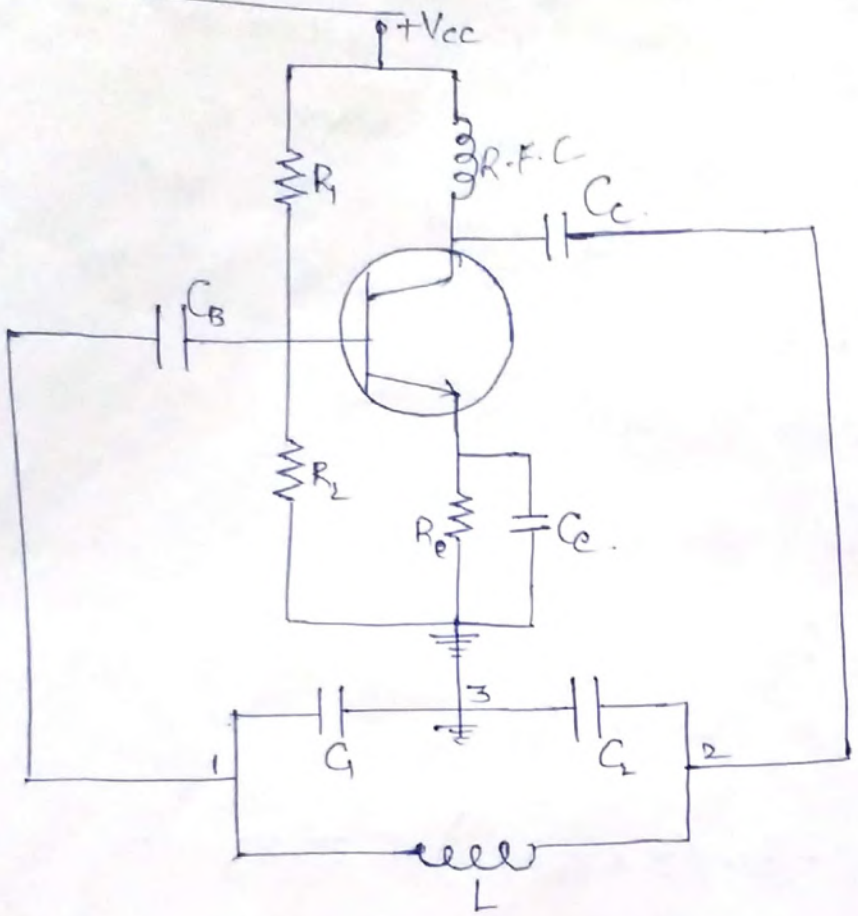


Fig: Colpitts Oscillator.

→ Above fig shows the circuit diagram of colpitts oscillator.
→ It consists of a tank circuit with two capacitors C_1 and C_2 and one inductor L.
→ The capacitor C_c is used as coupling capacitor. It allows only ac current to pass to the tank circuit.
→ The capacitor C_B is known as blocking capacitor. It avoids dc grounding the transistor base.
→ RFC connected b/w power supply V_{cc} and collector of the transistor.

→ The main function of RFC ...

to block ac currents.

→ when the supply voltage V_{cc} is switched on. oscillat... current is set up in the tank circuit. This current pr... ac voltage across C_1 and C_2. ~~Since~~.

→ Since the terminal '3' is ground, the voltage across 'C_2' is 180° out of phase with the voltage across C_1.

→ Then the phase difference b/w '1' and '2' is 180°. Hence

→ The CE amplifier provides a phase shift of 180°. Hence the ~~total~~ phase shift is 360°.

The feedback factor $\beta = \frac{V_f}{V_0}$.

For Oscillations $|A\beta| = 1$

The general form of eq. is.

$$(1+h_{fe})Z_1Z_2 + h_{ie}(Z_1+Z_2+Z_3) + Z_1Z_3 = 0.$$

we know

$$Z_1 = \frac{1}{j\omega C_1} ; \; Z_2 = \frac{1}{j\omega C_2} \quad \text{and} \quad Z_3 = j\omega L.$$

$$(1+h_{fe})\left(\frac{1}{j\omega C_1}\right)\left(\frac{1}{j\omega C_2}\right) + h_{ie}\left(\frac{1}{j\omega C_1} + \frac{1}{j\omega C_2} + j\omega L\right) + \left(\frac{j\omega L}{j\omega C_1}\right) = 0$$

$$(1+h_{fe})\left(\frac{-1}{\omega^2 C_1 C_2}\right) + j h_{ie}\left(\frac{-1}{\omega C_1} + \frac{-1}{\omega C_2} + \omega L\right) + \left(\frac{L}{C_1}\right) =$$

$$-(1+h_{fe})\left(\frac{1}{\omega^2 C_1 C_2}\right) - j\, h_{ie}\left(\frac{1}{\omega C_1} + \frac{1}{\omega C_2} - \omega L\right) + \frac{L}{C_1} = 0$$

To obtain $\angle A\beta = 0$.

Equating imaginary part to '0' we get,

$$\left(\frac{C_1+C_2}{\omega C_1 C_2} \mp \omega L\right) = 0.$$

$$\frac{C_1+C_2-\omega^2 C_1 C_2 L}{\omega C_1 C_2} = 0.$$

$$C_1+C_2-\omega^2 C_1 C_2 L = 0$$

$$C_1+C_2-\omega^2 C_1 C_2 L = 0$$

$$C_1+C_2 = \omega^2 C_1 C_2 L.$$

$$\omega^2 = \frac{C_1+C_2}{C_1 C_2 L}.$$

$$\omega^2 = \frac{1}{\left(\frac{C_1 C_2}{C_1+C_2}\right)L} = \frac{1}{\left(\frac{1}{C_1}+\frac{1}{C_2}\right)L}$$

$$\omega^2 = \frac{1}{C_{eq} L}. \qquad \frac{1}{C_{eq}} = \frac{1}{C_1}+\frac{1}{C_2}$$

$$(2\pi f)^2 = \frac{1}{C_{eq} L}$$

$$2\pi f = \frac{1}{\sqrt{L C_{eq}}}.$$ This is the freq of oscillation.

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

Equating real part to zero. $\boxed{h_{fe} = \frac{C_2}{C_1}}$

The above eq. gives the condition for sustained oscillations in Colpitts oscillator.

Advantages:-

The colpitts oscillator is better than the hartely because in hartely oscillator uses inductance which are bulky and economically.

-> Alignment is difficult.

Disadvantage:-

1. Less freq. stability. The freq. varies in case of any change in any one value of capacitor.

Applications:

-> It is used to generate high frequency signals so the circuit is mostly used in high freq. circuits.

-> It is used in Radio and mobile applications.

The clapp Oscillators:-

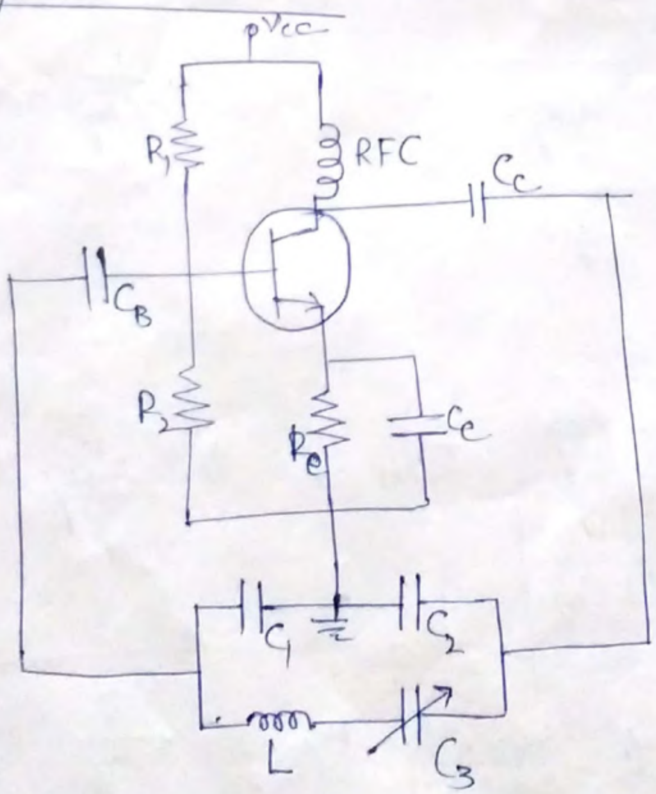


Fig: The clapp oscillator.