* LC Oscillator's :-

- These are also known as tuned oscillators or tank ckt oscillators. They are used to produce an o/p with frequencies ranging from 1MHz to 500MHz.
- A BJT or an FET is used as an amplifier with tuned circuit oscillator's.
- With an amplifier and an LC tank circuit, we can feedback a signal with proper amplitude and phase to obtain sustained oscillations.

Application's of LC oscillators: Most of the oscillators used in radio transmitters and receivers are of LC oscillators type

- Depending upon the way the f/b is used in the circuit, the LC oscillators are of the following 5 types:-

1] Tuned-collector (Armstrong oscillator):
It uses inductive f/b from the collector of a transistor to the base. The LC tank ckt is in the collector ckt.

2] Tuned base oscillator:- It also uses inductive feedback. But the LC tank is in the base ckt.

3] Hartley oscillator: It uses inductive feedback.

4] Colpitt's oscillator: It uses capacitive feedback.

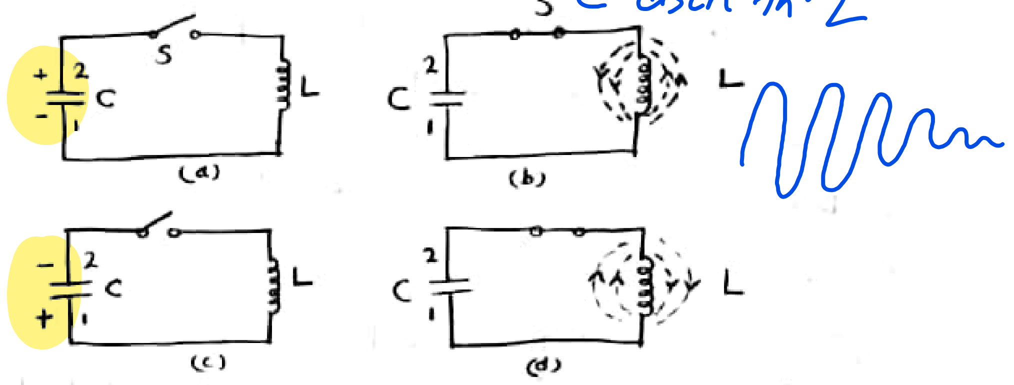
5] Clapp's oscillator: It also uses capacitive feedback.

* How LC Tank circuit produces oscillations?

- LC tank ckt produces electrical oscillation of any desired frequency. It consists of 2 reactive element L and C.

S C disch thr L

- Inductor (L) stores energy in its magnetic field, whenever current flow's through it.
- Capacitor (C) stores energy in its electric field, whenever a voltage is applied across its plate.



ckt : LC Tank ckt as an Oscillatory circuit

- Suppose C is charged from a dc source. As switch 's' is open, it cannot discharge through L. (fig a). When 's' is closed, C discharges through L.
- This discharging current (from plate 2 to 1) fig (b), sets up magnetic field around the coil. Because of inductive effect, the current grows up slowly towards the max value. This situation occurs, when C is fully discharged (ie electrical energy across C is completely converted into magnetic energy around the coil)
- Once C is discharged completely, magnetic field around L begins to collapse and produces a counter emf.
- According to Lenz's law, counter emf keeps electron's (charges) moving in same direction. This again charges the C but in opposite direction (fig c).
- When C is charged completely in opposite direction, Magnetic-field around L is also collapsed completely.
- After this, when 's' is closed, C starts discharging in opposite direction (fig d), so that charges now move from plate 2 to 1. ie Electric field starts collapsing whereas magnetic field starts building up again, but in reverse direction.
- Above sequence of charging and discharging of a C results in energy being alternatively stored in the E-field of C and magnetic field of L.
- This interchange of energy between C and L continues and results in the production of electrical oscillations.
- In a practical tank ckt, oscillation's are damped becoz of losses in L & C. As a result, amplitude of oscillation's reduces gradually and reaches 0.

Radio frequency oscillator :- / LC oscillator's

LC tank circuit, Hartley, Colpitts and clap oscillator

- In LC oscillators, the feedback network consists of inductors (L) and capacitors (C) instead of R and C in case of RC oscillators.

- These LC components determine the frequency of oscillations of the LC oscillator.

- With an amplifier and an LC tank circuit, sustained oscillations are produced as per Barkhausen's criterion.

- These oscillators can operate at high frequencies typ from 200KHz to few GHz. They are not suited for low operating frequencies becoz the values of L and C will be large at Low frequencies.

- large value of L & C are bulkier and expensive as well.

- But as the operating frequency is ↑sed, we need small values of L (μH or mH) & C which are small in size & less expensive. μF, nF, pF

Derivation (Not in syllabus): Just for reference

General form of LC oscillators:-

- Many oscillator ckts (LC) fall into the general form as shown below:-

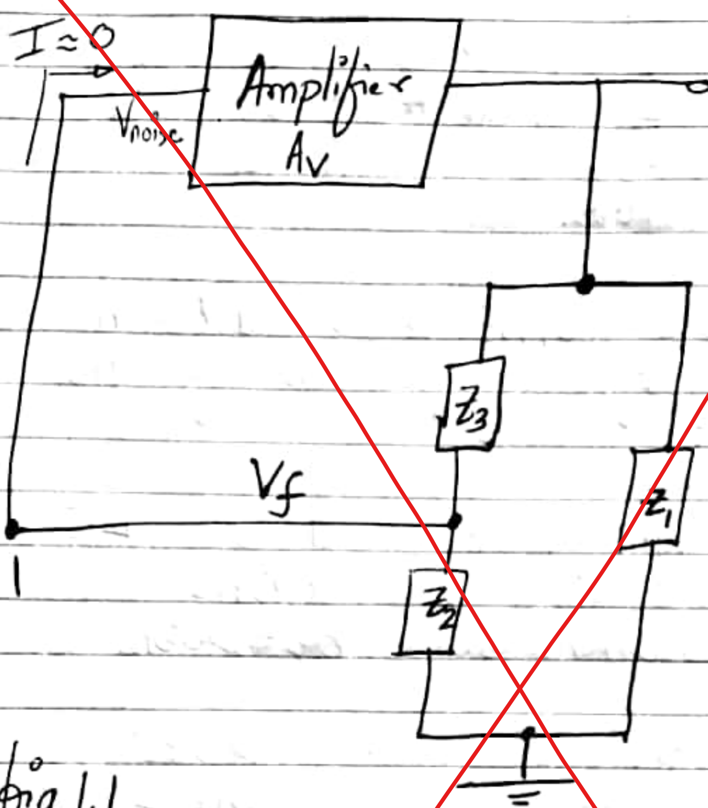


fig 1.1

- The active device can be a bjt or an FET.

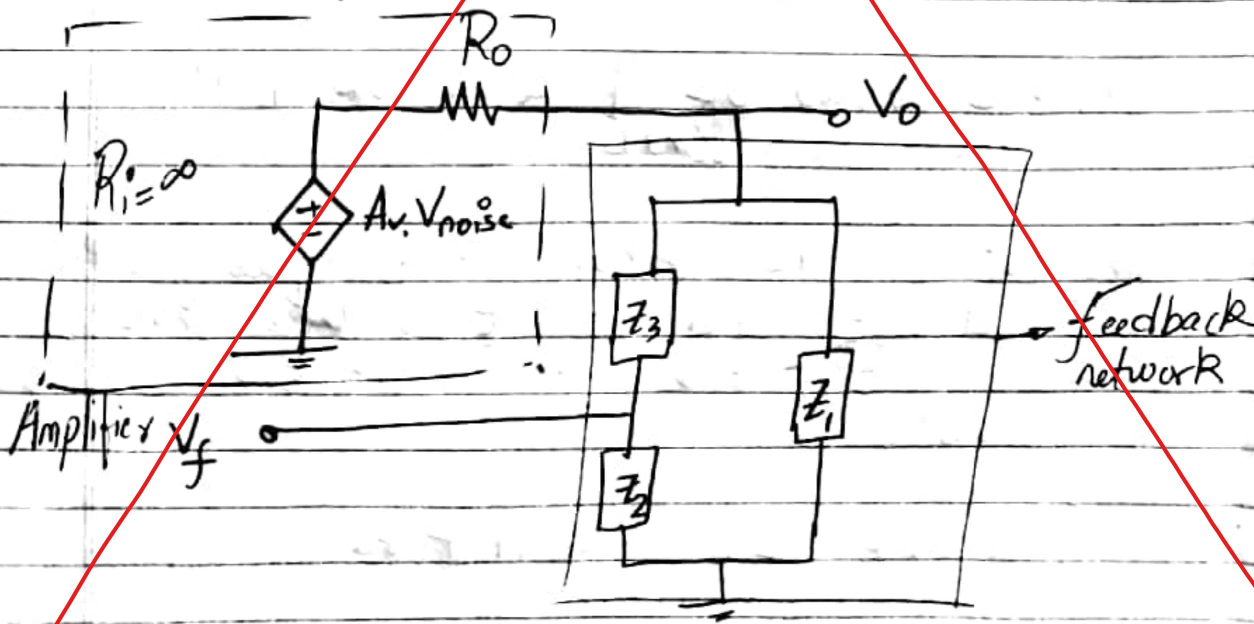


fig 1.2 Equivalent circuit using an BJT

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Derivation (Not in syllabus): Just for reference

- The active device in fig 1.2 is assumed to have v.high input resistance.

- The amplifier has a voltage gain of Av and it feeds in a feedback n/w which consists of impedances Z_1, Z_2 and Z_3

- The amplifier introduces a phase-shift of 180° and the feedback network will provide an additional phase shift of 180° to make the total phase shift of 0° and satisfies the Barkhausen's conditions:-

#- Derivation for gain A and feedback factor β (LC oscillator):-

- In the LC oscillators we connect L or C in place of the impedances Z_1, Z_2 and Z_3.

- As the input impedance of the amplifier is assumed to be v.high, current I flowing into the i/p terminal 1 is zero as shown in fig 1.1.

- Since, I=0 the impedances Z_2 and Z_3 will come in series across Z_1.

∴, the equivalent load impedance Z_L is given by,

$$Z_L = Z_1 \parallel (Z_2+Z_3) \quad \text{— (1)}$$

Derivation (Not in syllabus): Just for reference

- We replace the combination of Z_1, Z_2 and Z_3 in fig 1.2 by Z_L & re-draw the figure.

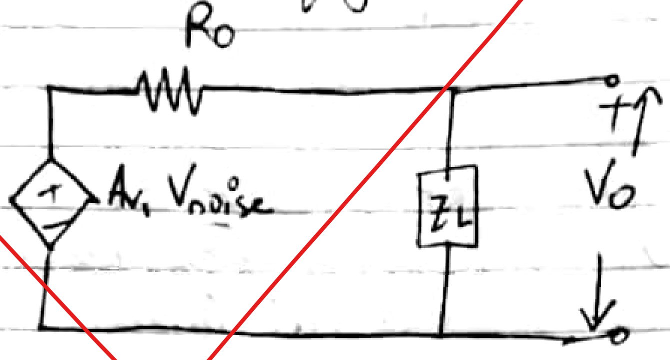

fig 1.3a)

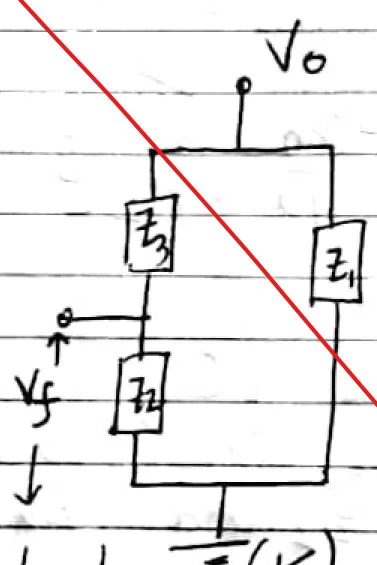

fig 1.3b) feedback Network

Feedback factor (K) is,

From fig 1.3b), $K = \dfrac{V_f}{V_o}$

$$K = \frac{\frac{Z_2}{Z_3+Z_2} \times V_o}{V_o} \quad \text{(by VDR)}$$

$$K = \frac{Z_2}{Z_2+Z_3} \quad \text{— (2)}$$

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Derivation (Not in syllabus): Just for reference

From fig 1.3a,

$$V_o = \frac{Z_L}{Z_L + R_o} A_v . V_{noise}$$

ie $$\frac{V_o}{V_{noise}} = \frac{Z_L A_v}{Z_L + R_o}$$

$$A = \frac{Z_L A_v}{Z_L + R_o} \quad -(3)$$

→ According to Barkhausen's criterio,

$$\boxed{A.K = 1 + j0} \quad -(4)$$

ie $$AK = \frac{Z_L A_v}{Z_L + R_o} \times \frac{Z_2}{Z_2 + Z_3}$$

$$AK = \frac{\frac{Z_1(Z_2+Z_3) A_v}{(Z_1+Z_2+Z_3)} \times Z_2}{\left(\frac{Z_1(Z_2+Z_3)}{Z_1+Z_2+Z_3} + R_o\right)(Z_2+Z_3)}$$

$$AK = \frac{Z_1 A_v Z_2}{Z_1(Z_2+Z_3) + R_o(Z_1+Z_2+Z_3)} \quad -(5)$$

→ Let us assume that the impedances Z_1, Z_2 and Z_3 are purely reactive (either inductive or capacitive)

Derivation (Not in syllabus): Just for reference

Then,

$$Z_1 = jX_1 , \quad Z_2 = jX_2 , \quad Z_3 = jX_3$$

where, $X = \omega L$ for inductor

$X = -\frac{1}{\omega C}$ for capacitor

Substituting the above values of Z_1, Z_2 and Z_3 in to eqn (5), we get.

$$AK = \frac{A_v (jX_1)(jX_2)}{R_o(jX_1 + jX_2 + jX_3) + jX_1(jX_2 + jX_3)}$$

$$AK = \frac{-A_v X_1 X_2}{j R_o(X_1 + X_2 + X_3) - X_1(X_2 + X_3)}$$

$\div$ by -1

$$AK = \frac{A_v X_1 X_2}{X_1(X_2 + X_3) - j R_o(X_1 + X_2 + X_3)} \quad -(6)$$

$\therefore$ For loop gain (AK) to be real (zero phase shift) the imaginary part must be zero.

ie $R_o(X_1 + X_2 + X_3) = 0$

ie $X_1 + X_2 + X_3 = 0 \quad -(6a)$

Hence, eq^n 6 gets modified as,

$$A K = \frac{A_v X_1 X_2}{X_1 (X_2 + X_3)}$$

Now, from (6a), $X_1 = -(X_2 + X_3)$ — (6c)

$$A K = \frac{-A_v \cancel{(X_2+X_3)} X_2}{X_1 \cancel{(X_2+X_3)}}$$

$$\boxed{A K = -\frac{A_v X_2}{X_1}} \quad \text{— (7)}$$

- According to barkhausen's criterion, AK should be +ve & greater than or equal to 1.
- To achieve this, in eq^n 7, both X_1 and X_2 should ~~be~~ have the same sign.
- That means X_1 and X_2 should be same type of reactances either inductive or capacitive.
- From eq^n (6.a), $X_3 = -(X_1 + X_2)$
- Hence, X_3 must be an opposite type of reactance to X_1 and X_2.

Derivation (Not in syllabus): Just for reference

~~- That means X_3 should be inductive if X_1 and X_2 are capacitive and it should be capacitive if they are inductive.~~

~~- Thus X_1 and X_2 should be of same type and X_3 should be of opposite type of X_1 and X_2.~~

~~- Depending on the components used in place of X_1, X_2 and X_3 we obtain two types of LC oscillators namely Hartley and Colpitt's oscillators.~~

Name	Components used in f/b n/w		
	X_1	X_2	X_3
Hartley osc*illator	L	L	C
Colpitt's osc*illator	C	C	L