

* LC Oscillators :-

15

- 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 oscillators.
- With an amplifier and an LC tank circuit, we can feedback a signal with proper amplitude and phase to obtain sustained oscillations.

Applications of LC oscillators: Most of the oscillators used in radio transmitters and receivers are of LC oscillators type.

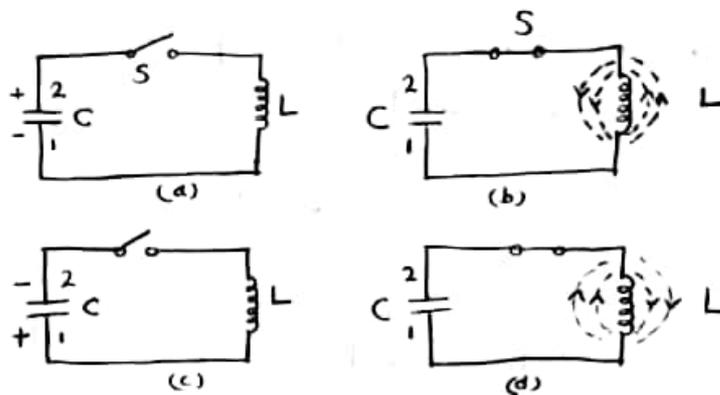
- Depending upon the way the flb is used in the circuit, the LC oscillators are of the following 5 types:-
 - 1] Tuned-collector (Armstrong oscillator):
It uses inductive flb from the collector of a transistor to the base. The LC tank ckt is in the collector ckt.
 - 2] Tuned base oscillator:- It also 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? | 16

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

• Inductor (L) stores energy in its magnetic field, whenever current flows 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 (figc).

• 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 (figd), 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 e 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 oscillators

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 used, we need small values of L & C which are small in size & less expensive.

General form of LC oscillators:-

- Many oscillator ckt's (LC) fall into the general form as shown below:-

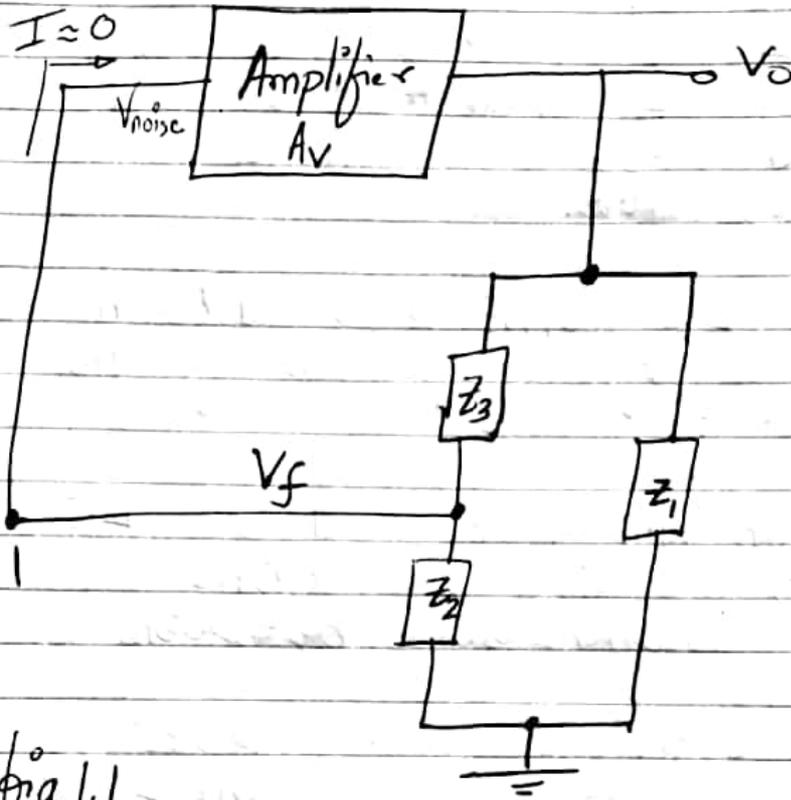


fig 1.1

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

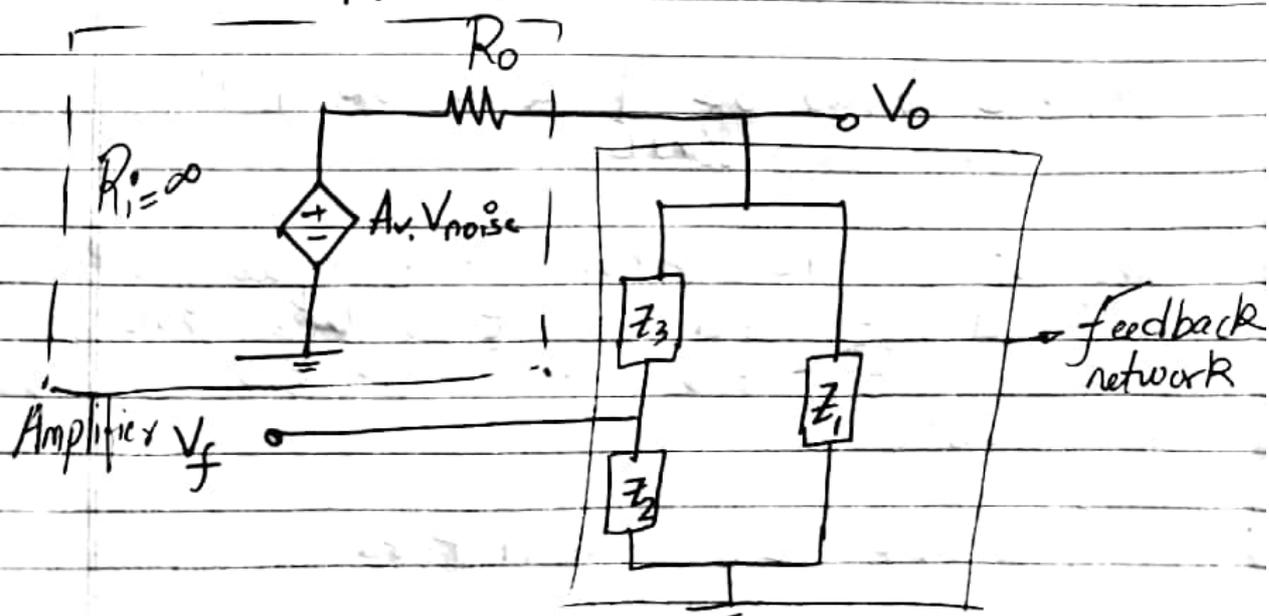


fig 1.2 Equivalent circuit using an BJT

Derivation (Not in syllabus): Just for reference

- The active device in fig 1.2 is assumed to have ∞ high input resistance.
- The amplifier has a voltage gain of A_v 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 ∞ high, current I flowing into the i/p terminal 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 .

\therefore the equivalent load impedance Z_L is given by,

$$Z_L = Z_1 \parallel (Z_2 + Z_3) \quad - (1)$$

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.

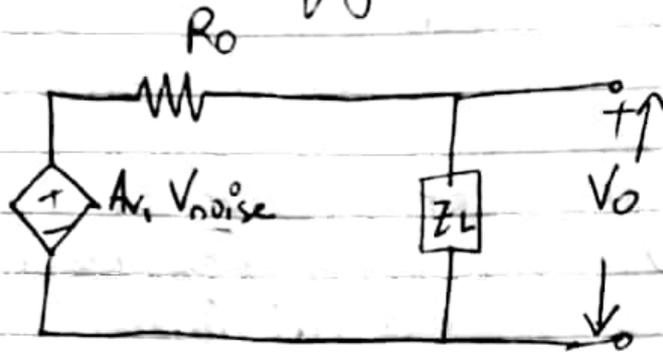


fig 1.3a)

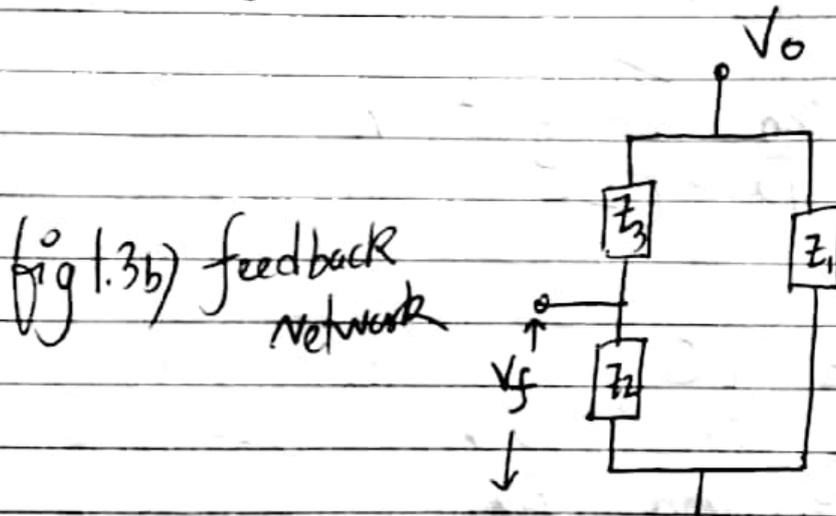


fig 1.3b) feedback network

Feedback factor $= (K)$ is,

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

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

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

From fig 1.3 a,

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

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 criterion,

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

ie $A.K = \frac{Z_L A_v}{Z_L + R_o} \times \frac{Z_2}{Z_2 + Z_3}$

$$A.K = \frac{Z_1 (Z_2 + Z_3) A_v \times Z_2}{(Z_1 + Z_2 + Z_3)}$$

$$\frac{(Z_1 (Z_2 + Z_3) + R_o) (Z_2 + Z_3)}{Z_1 + Z_2 + Z_3}$$

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

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

Then,

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

where, $X = \omega L$ for inductor

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

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

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

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

÷ by -1

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

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

$$\text{i.e. } R_o (X_1 + X_2 + X_3) = 0$$

$$\text{i.e. } X_1 + X_2 + X_3 = 0 \quad \text{--- (6a)}$$

Hence, eqⁿ (6) gets modified as,

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

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

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

$$\boxed{AK = -\frac{A_v X_2}{X_2}} \quad \text{--- (7)}$$

- According to Barkhausen's criterion, AK should be +ve & greater than or equal to 1.

- To achieve this, in eqⁿ (7), both X_1 and X_2 should have the same sign.

- That means X_1 and X_2 should be same type of reactances either inductive or capacitive.

- From eqⁿ (6a), $X_3 = -(X_1 + X_2)$

- Hence, X_3 must be an opposite type of reactance to X_1 and X_2 .

- 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 flb n/w		
	X_1	X_2	X_3
Hartley oscillator	L	L	C
Colpitt's oscillator	C	C	L