OSCILLATORS → which converts DC → AC is called oscillators.

Introduction

Feedback plays an important role in almost all Electronic circuits. It is almost invariably used in the amplifier to improve its performance and to make it more ideal.

In this process of feedback, a part of o/p is sampled and fedback to the input of the amplifier.

therefore, at i/p we have two signals: Input signal, and part of the o/p which is fed back to the i/p.

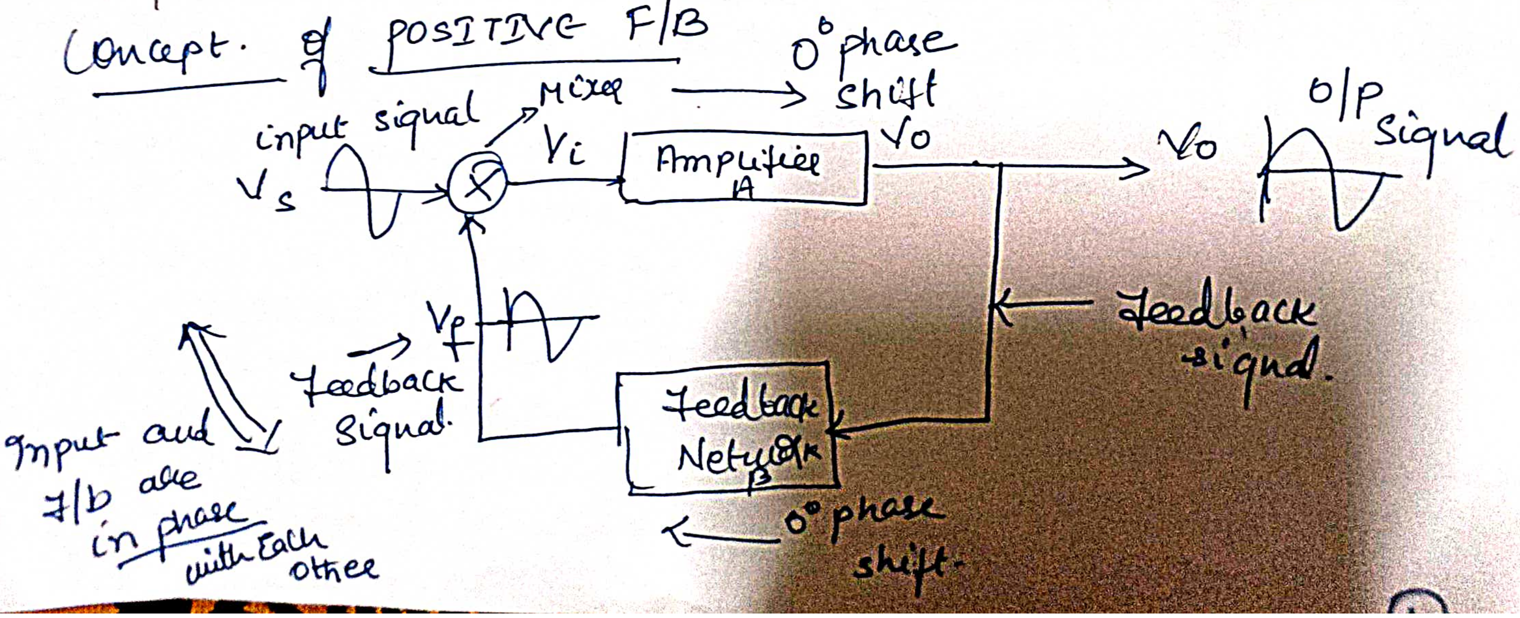
Both these signals may be in phase or out of phase.

when i/p signal and part of o/p signal are in phase, the f/b is called '+ve' f/b.

when i/p signal & part of o/p signal are out of phase, the f/b is called '-ve' f/b.

The '+ve' f/b results into oscillations and hence used in electronic circuits to generate the oscillations of desired frequency. such circuits

Concept of POSITIVE F/B



Feedback is a property which allows to feedback the part of the output, to the same circuit as its input.

When a f/b is said to be positive whenever the part of the o/p that is fed back to the amplifier as its input, is in phase with the original i/p signal applied to the amplifier. Consider a non-inverting amplifier with the vltg gain A.

Assume that a sinusoidal input signal (voltage) V_s is applied to the circuit.

As amplifier is non-inverting, the o/p vltg V_o is in phase with the i/p signl V_s.

the part of the o/p is fed back to the i/p with the help of ~~the~~ a f/b N/w.

How much part of the o/p is to be fed back, gets decided by the f/b N/w gain β.

No phase change is introduced by the f/b N/w. Hence the f/b voltage V_f is in phase with the i/p signal V_s.

EXPRESSION FOR GAIN WITH FEEDBACK:

The amplifier is A i.e, it amplifies its i/p $V_i \rightarrow$ A times to produce O/P V_o.

$$\therefore \boxed{A = \frac{V_o}{V_i}}$$

This is called OPEN LOOP GAIN of the amplifier.

→ The i/p is supply voltage V_s &

→ Net o/p is V_o.

→ The ratio of o/p [V_o] to i/p [V_s] considering effect of f/b is called closed loop gain of the circuit or gain with f/b denoted as A_f

$$\boxed{A_f = V_o/V_s}$$

∴ The f/b is positive and voltage V_f is added to V_o to generate o/p of amplifier V_i.

∴ from fig we can write

$$\boxed{V_i = V_s + V_f} \quad \text{——— (1)}$$

→ The f/b voltage V_f depends on the f/b element gain β. so we can write. ——— (2)

$$\boxed{V_f = \beta V_o}$$

∴ Substituting (2) in (1).

$$V_i = V_s + \beta V_o$$

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

substituting in expression for A_f

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

$\div$ both numerator & denominator by V_i

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

$$\frac{\cancel{V_i}}{\cancel{V_i}} - \frac{\beta V_o}{V_i}$$

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

$$\therefore \boxed{A_f = \frac{A}{1-\beta A}} \Rightarrow \text{as } A = \frac{V_o}{V_i}$$

NOTE: The gain with F/b increases as the amount of positive F/b increases.

$\Rightarrow$ Thus without an INPUT, the OUTPUT will continue to oscillate whose frequency depends upon the F/b N/w or the amplifier or both. Such a circuit is called as an oscillator

$\rightarrow$ An oscillator is an amplifier, which uses a positive F/b and without any external i/p signal generates an o/p waveform, at a desired frequency

[An oscillator does not require any i/p signal].

[An oscillator is a circuit which basically acts as a generator] generating the o/p signal which oscillates with const amplitude and const desired frequency.

NOTE: → As $A\beta = 1$ then $A_f = \infty$.

→ The +ve' f/b increases the instability as gain tends to ∞ hence NEGATIVE F/b is preferred over +ve' f/b.

[An Oscillator is a POSITIVE F/b Amplifier].

BARKHAUSEN CRITERION –

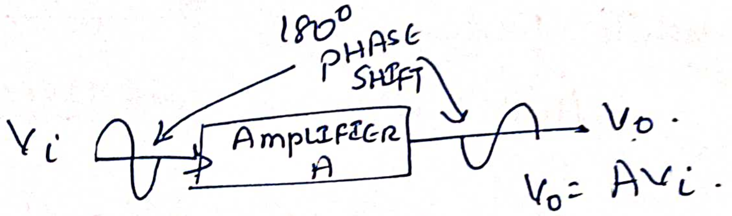
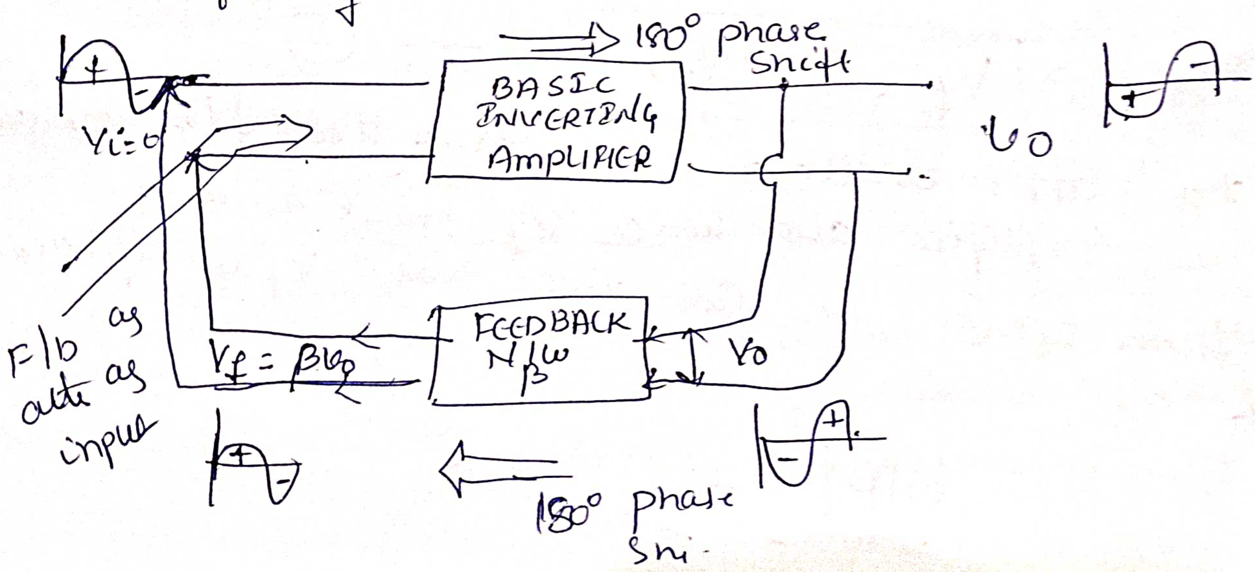


FIG: INVERTING AMPLIFIER

– Consider a basic Inverting amplifier with an open loop gain A.

→ The F/b N/w attenuation factor β is less than UNITY

→ As basic amplifier is Inverting, it produces a phase shift of 180° b/w i/p & o/p as shown in fig



⇒ Now the i/p V_i applied to the amplifier an (i/p) it is be derived from o/p V_o using F/b Network.

⇒ But F/b must be POSITIVE.
i.e, the voltage produced (derived) from o/p using F/b network must be in phase with V_i.

→ Thus the feedback n/w must introduce a phase shift of 180° while feeding back the v/tg from o/p to i/p. This ensures POSITIVE F/b

→ Consider a voltage V_i is applied at the i/p of the amplifier. we get

$$\boxed{V_o = AV_i} \quad \text{—— (1)}$$

→ The F/b factor β decides the f/b to be given to i/p

$$\boxed{V_f = \beta V_o} \quad \text{—— (2)}$$

→ Now substituting Eqn (1) in eqn (2) we get

$$\boxed{V_f = \beta [AV_i]} \quad \text{—— (3)}$$

∴ For the oscillator, we want that f/b should drive the amplifier and hence V_f must act as V_i

∴ From eqn (3) we can write that, V_f is sufficient to act as V_i

$$\therefore |A\beta| = 1 \quad \text{—— (4)}$$

→ And the phase of V_f is same as V_i. i.e., feedback network should introduce 180° phase shift in addition to 180° phase shift introduced by inverting amplifier. This ensures positive f/b. So total phase shift around a loop is 360°

$$\Big[\underbrace{180}_{\text{From I/O side Inverting amplifier}} + \underbrace{180^\circ}_{\text{From F/b N/w}}\Big] = \underline{360^\circ}.$$

→ In this condition, V_f drives the circuit and without external o/p circuit works as an oscillator.

∴ BARKHAUSEN CRITERION states that

1. The total phase shift around a loop, as the signal proceeds from input through amplifier, feedback network back to o/p again, completing a loop, is precisely 0° or 360°

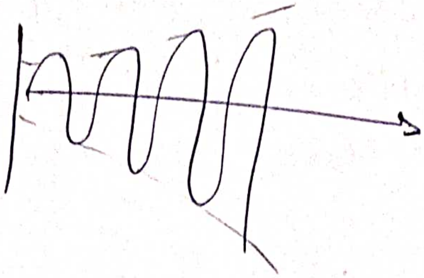
2. The magnitude of the product of the open loop gain of the amplifier (A) and the magnitude of the feedback factor β is unity i.e

$$|A\beta| = 1.$$

⇒ Satisfying these conditions, the circuit works as an oscillator producing sustained oscillations of constant frequency and amplitude

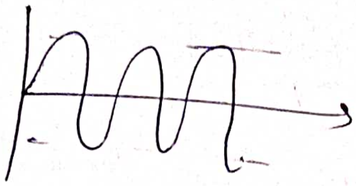
~~Reroduct~~ 3 condition

1. when $|A\beta| > 1$. → oscillations are is called growing type.



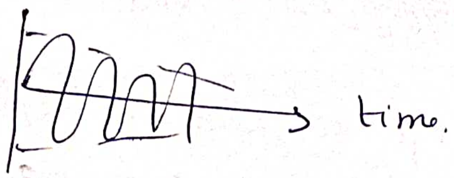
→ amplitude goes on increasing

2. $|A\beta| = 1$



→ sustained oscillations

3. $|A\beta| < 1$.



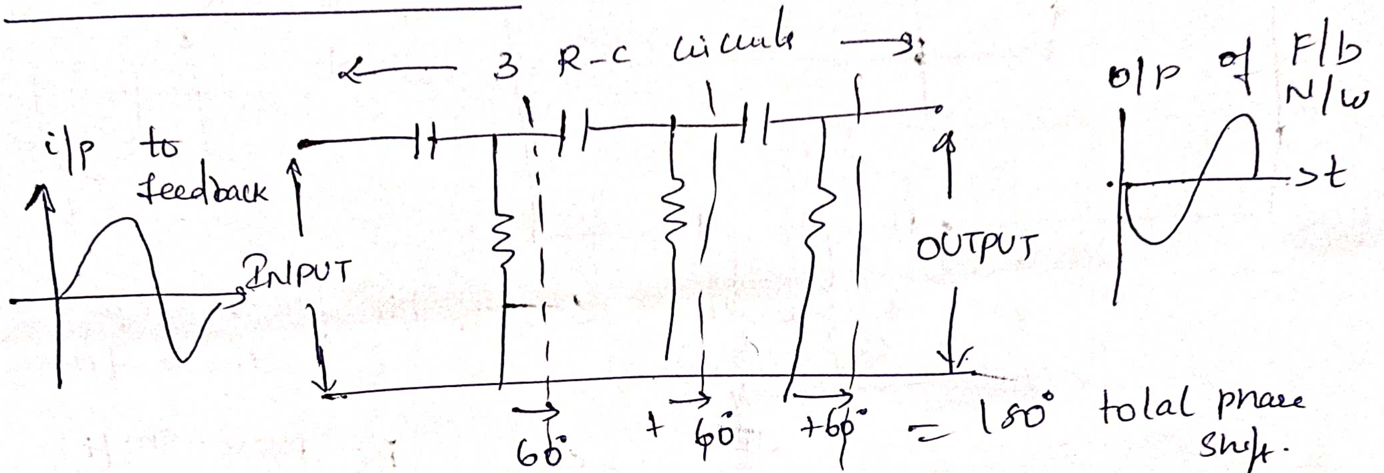
decaying oscillation

RC - PHASE SHIFT OSCILLATOR

RC phase shift oscillator basically consists of an amplifier and a f/b network. Consisting of Resistors and Capacitors arranged in Ladder fashion. Hence such an oscillator is also called ladder type RC phase shift oscillator.

The capacitor C & Resistor R are in series.

RC FEEDBACK N/W



→ RC N/w is used in f/b path.

→ In oscillator, f/b N/w must introduce a phase shift of 180° to obtain total phase shift around a loop as 360°.

→ Thus if one RC N/w produces phase shift (ϕ) = 60° then to produce phase shift of 180° such 3 RC n/w must be connected in cascade.

→ ∴ from 3 RC section Each producing a phase shift of 60°

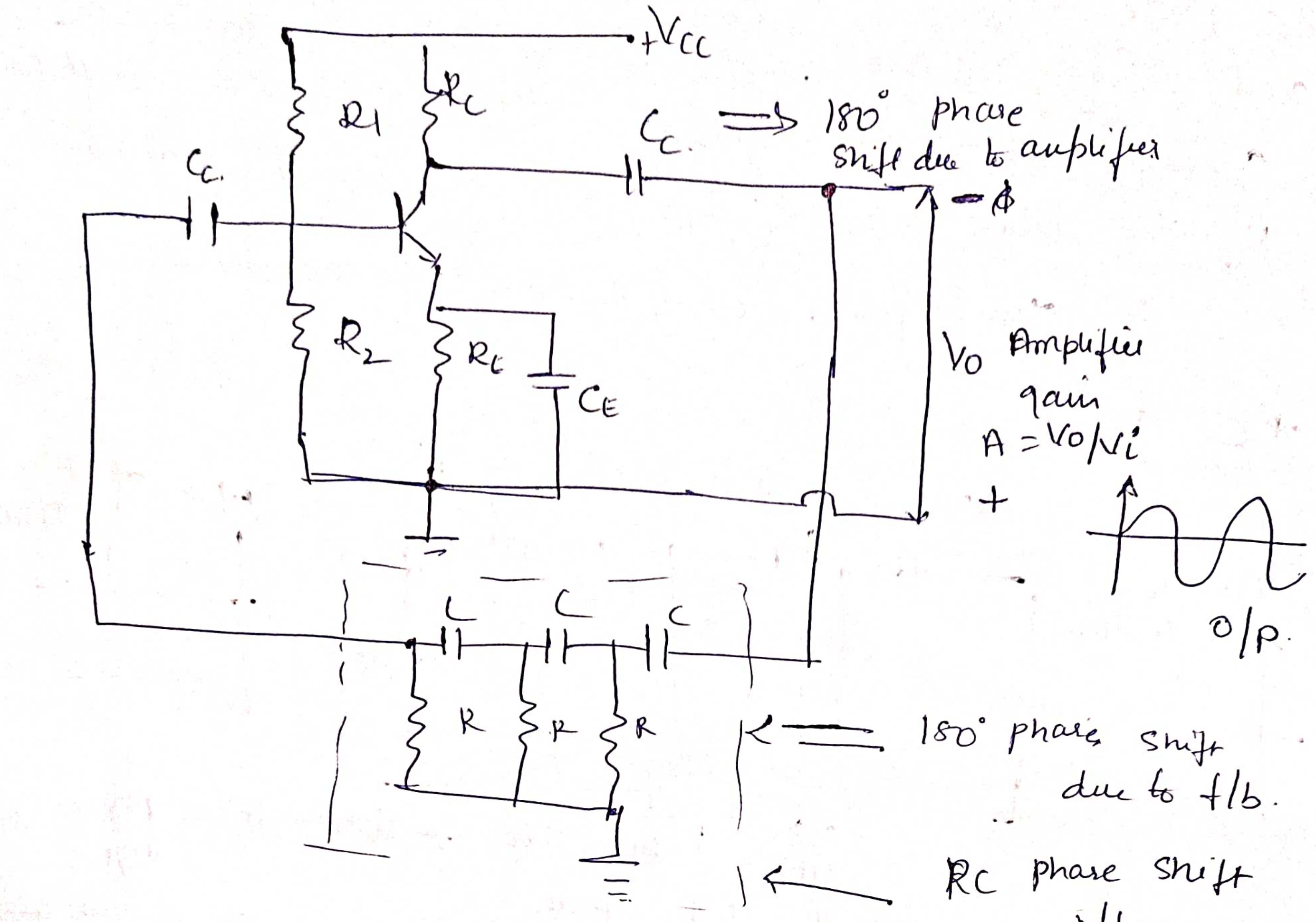
∴ 60 × 3 = 180°

→ The N/w is also Called the LADDER N/W.

→ All the resistance values and all the capacitance values are same, so that for a particular frequency, each section of R & C produces a phase shift of 60°

(5)

RC PHASE SHIFT OSCILLATOR USING TRANSISTOR



$$\therefore \quad f = \frac{1}{2\pi\sqrt{6}\,RC}$$

⟹ RC phase shift oscillator (CE) single stage, amplifier produces 180° + F/b N/w 180° total 360°. This satisfies the required condition of +ve f/b. & circuit works as an oscillator

LC OSCILLATORS

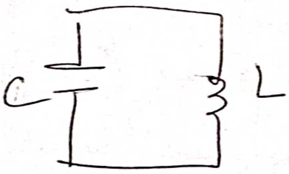
→ The oscillators which uses the Elements L and C to produce oscillations are called LC oscillators.

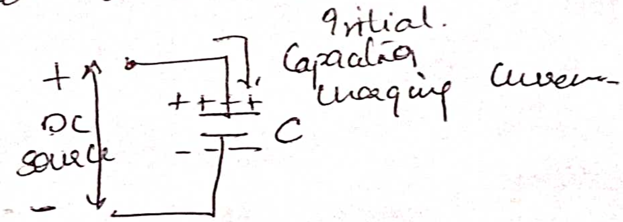
→ The circuit using Elements L and C is called tank circuit (or) oscillator circuit.

→ These oscillators are used for high frequency range from 200KHz up to few GHz.

Operation of LC Tank circuit

→ The LC tank circuit consists of Elements L and C connected in parallel as shown in fig

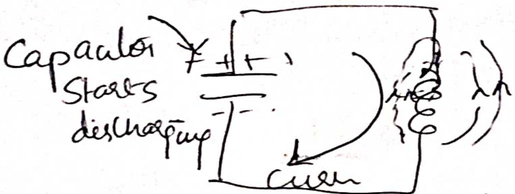


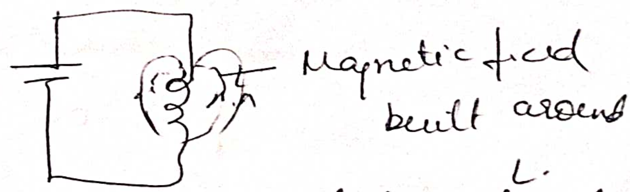


→ Let capacitor is initially charged from a D.C source with the polarities as shown in fig

→ when the capacitor is fully gets charged, the Energy stored in the capacitor is called ELECTROSTATIC ENERGY.

→ when such charged capacitor is connected across inductor in a tank circuit, the capacitor starts discharging through L





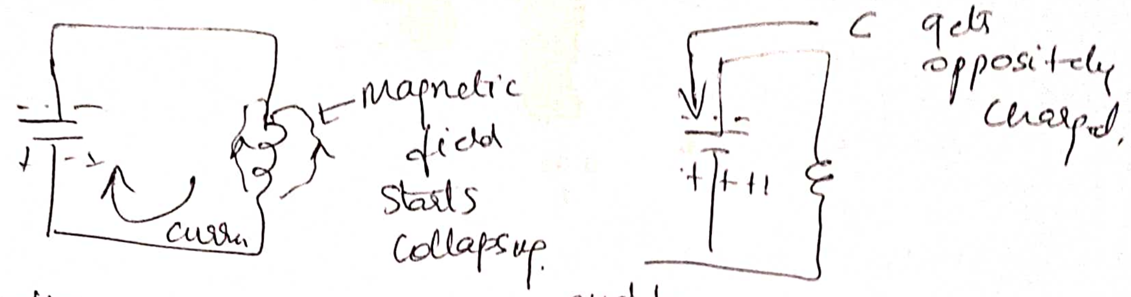
→ The arrow indicates direction of flow of conventional current.

→ Due to such current flow, the magnetic field gets sets up around the 'L'.

→ Thus inductor 'L' starts storing the energy

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

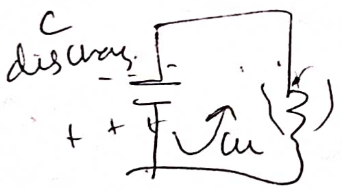
→ At this instant all Electrostatic Energy gets stored as magnetic energy in 'L'

→ C 

→ Now the magnetic field around L starts collapsup.

→ ~~A~~Now the 'C' start charging the Capacitor 'C' with opposite polarity

→. After some time, 'C' gets fully charged 'C' with opposite polarities, Now the entire magnetic energy gets converted back to electrostatic energy in 'C'



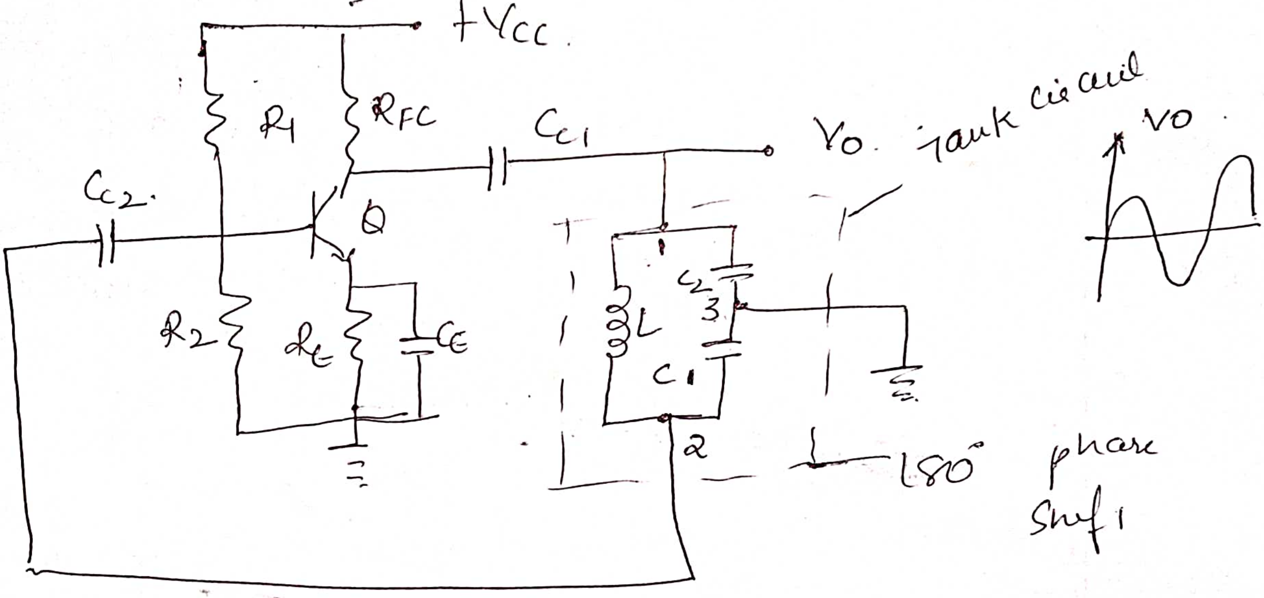
Now capacitor again starts discharging through inductor 'L'. But the direction of current is now opposite to compare to the earlier.

→ ~~When~~ Every time when energy is transferred from C to L & L to C, the losses occur due to which amplitude of oscillating current keeps on decreasing ~~Effecting~~ of current.

COLPITT'S OSCILLATOR

→ Tank circuit of Colpitt's oscillator uses 2 capacitors & 1 inductor. The 2 capacitors C_1 & C_2 which are connected in series across the inductor L to complete the tank circuit.

180° phase shift



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

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

$$\therefore f = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

$A\beta = 1$, Since $A\beta = 1$, the circuit works as an oscillator.

→ When the supply Vcc is switched on, the oscillatory current is set up in the tank circuit.

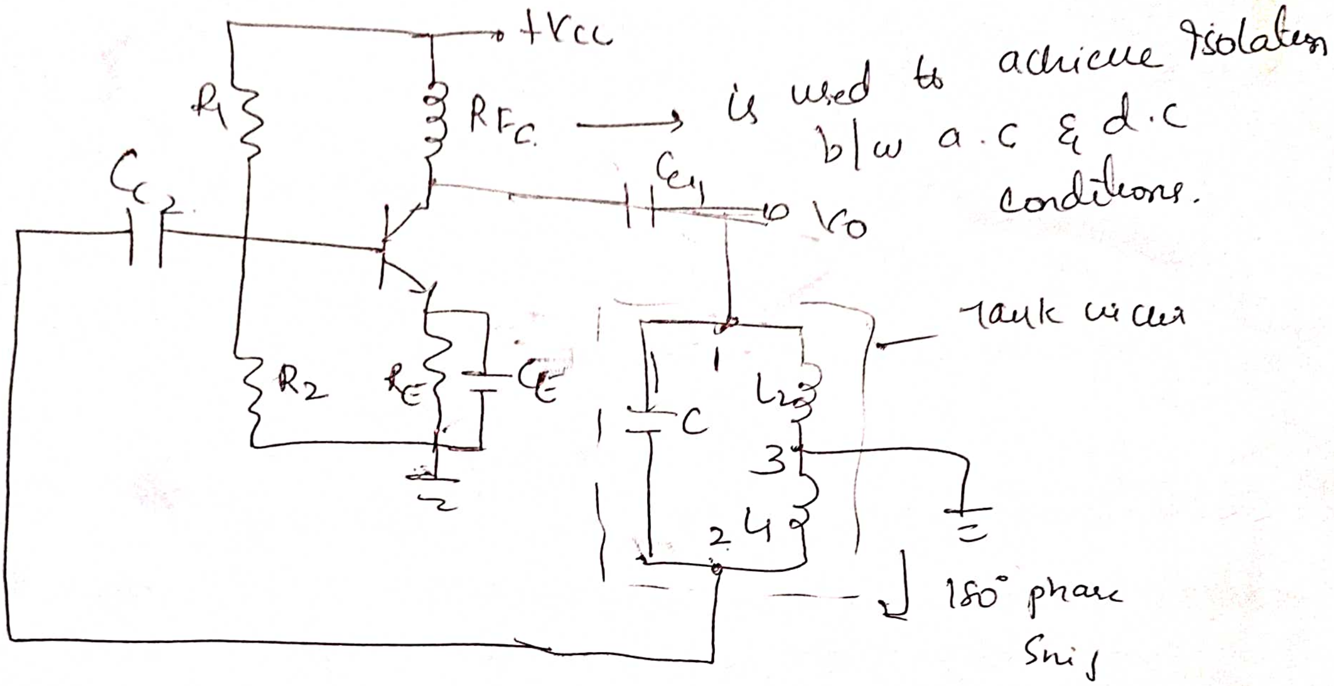
→ It produces a.c vltg across C_1 & C_2.

→ The terminal 3 is grnd hence it is at '0' potential.

HARTLEY

→ This is another LC oscillator which uses 2 inductors and 1 capacitor in its tank circuit.

→ The 2 inductors L_1 & L_2 which are connected in series across the capacitor C to complete the tank circuit. → 180° phase shift



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

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

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

Calculate the frequency of oscillations of a Hartley oscillator having $L_1 = 0.5\,mH$, $L_2 = 1\,mH$ & $C = 0.2\,\mu F$

6·b
6·a

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

$$L_{eq} = L_1 + L_2 = 0.5\,H = 1.5\,mH$$

$$f = \frac{1}{2\pi\sqrt{1.5\times10^{-3}\times0.2\times10^{-6}}} = 9.19\,kHz$$

(2c) In a Hartley oscillator $L_1: 20\,\mu H$, $L_2 = 2\,mH$ & C is variable. Find the range of C if frequency is to be varied from 1 MHz to 2.5 MHz. Neglect mutual inductance

nal,

$$L_{eq} = L_1 + L_2 = 20\times10^{-6} + 2\times10^{-3} = 2.002\times10^{-3}\,H$$

$$f = f_{max} = 2.5\,MHz$$

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

$C =$ $\qquad C = 2.024\,pF$

d

Ayn

For $f = f_{min} = 1\,MHz$

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

$$C = 12.625\,pF$$

d