Tuned Collector Oscillator
(OR Resonant - circuit oscillator)

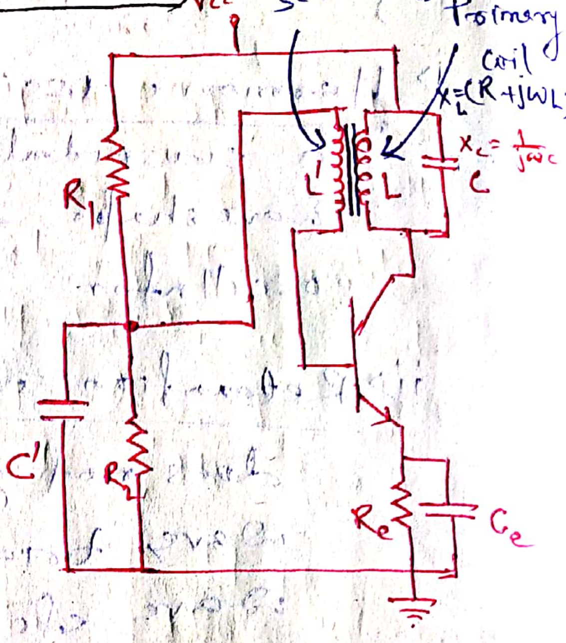

Fig-1.

The adjacent fig-1 represents collector tuned oscillator. Here, the primary winding of transformer which is connected in parallel with a capacitor C as shown in fig-1 constitute a tank ckt. As it is clear that the tank ckt is connected at collector as a load, the oscillator is named as collector tuned oscillator. Resistor R_1, R_2 forms the biasing arrangement and C_e is known as bypass capacitor that blocks the d.c. and bypass a.c component. C' is also known as bypass capacitor. Here, primary coil of transformer induces a.c voltage in phase opposition by mutual induction into secondary coil. This a.c voltage is supplied bet^n ~~base~~ and emitter terminal of transistor because the capacitor C' provides bypass path or makes a.c ground. Thus, here secondary winding acts as feedback ckt that fed a.c voltage into base-emitter terminal.

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Here, oscillation to be sustained, there must be loop-phase shift or phase shift around the loop should be 0° or 2π (or integral multiple of 2π). Since here the used transistor is in CE configuration that provides 180° phase shift ~~of~~ in output signal in comparision to input signal at collector due to transistor action and again the primary of transformer induces voltage in secondary winding with 180° phase shift, thus, the total phase shift around the loop or phase difference betn input and output becomes 360° which is the need for oscillation to be sustained.

Working of circuit: As the power supply is switched on, the collector current increasing due to transistor action and causes to charge the capacitor. When capacitor gets fully charge, it starts discharging through the primary winding of transform of inductance L. Thus this charging and discharging process of tank ckt sets up an electrical oscillation. These electrical oscillation induces some a.c voltage in opposite phase at the secondary terminal due to mutual induction of transformer action. This induced voltage into secondary provides feedback ~~and~~ across base-emitter terminal and causes to vary the base current. Due to transistor action, this feedback part, which is the secondary a.c voltage, is now amplified and appears at collector terminal again with 180° phase shift. Thus, total phase shift now is 360° which the need for oscillat's to be sustained! A part of this amplified energy appeared at collector is used to overcome (or compensate) the loss of tank ckt and rest is radiated in the form of electromagnetic wave.

Further more these electrical oscillation is coupled to the next stage in the electronic ckt. The output of tank ckt is usually taken by using inductive coupling as shown in fig. 2.

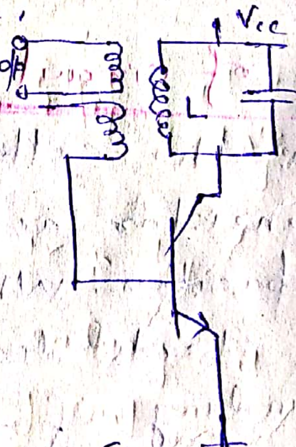

Fig-2

Mathematical Analysis.

Frequency of oscillation

Frequency to be sustain, $|A\beta| = 1$, (Barkhausan criteria)

since Voltage gain of CE amplifier, without feedback,

$$A = -\frac{h_{fe} Z_L}{h_{ie} + \Delta h Z_L}, \quad \Delta h = h_{ie} h_{oe} - h_{fe} h_{re},$$

(from h-parameter analysis, see lecture notes)

$$\therefore |A| = \frac{h_{fe} Z_L}{h_{ie} + \Delta h Z_L}$$

We can draw equivalent ckt using h-parameter, as shown in fig-3.

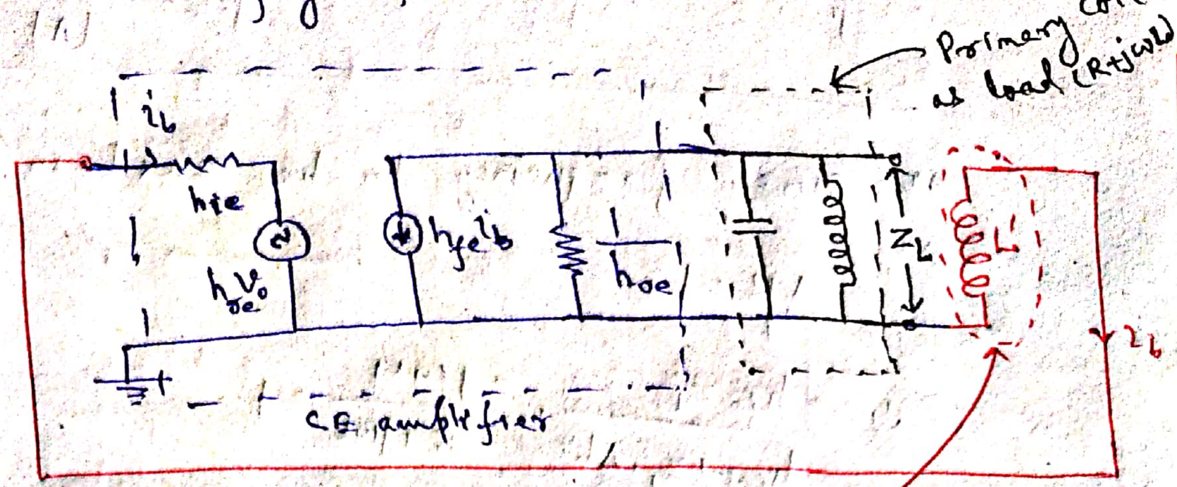

fig-3

From fig-3,

$$\frac{1}{Z_L} = \frac{1}{X_L} + \frac{1}{X_C} \quad \text{or,} \quad \frac{1}{Z_L} = \frac{1}{R+j\omega L} + \frac{1}{1/j\omega C}$$

$$\text{or,} \quad \frac{1}{Z_L} = j\omega C + \frac{1}{R+j\omega L}$$

$$\text{or,} \quad \boxed{Z_L = \frac{R+j\omega L}{1-\omega^2 LC + j\omega RC}}$$

Now feedback fraction, β is given by —

$$\beta = \frac{\text{Voltage induced in secondary coil}}{\text{Voltage across primary coil}}$$

$$\text{or} \quad \beta = \frac{(-j\omega M)\, I_L}{(R+j\omega L)\, I_L}$$; $X_M = j\omega M$ = Mutual inductive impedance

M = Mutual inductance

–ve sign indicates 180° phase by transformer.

Since frequency to be sustain —

$$A\beta = 1$$

$\therefore$ $$\frac{-h_{fe} Z_L}{h_{ie} + Z_L \cdot \Delta h} \cdot \frac{-j\omega M}{R + j\omega L} = 1$$

or $$\frac{+h_{fe} Z_L}{h_{ie} + Z_L \Delta h} = \frac{R + j\omega L}{j\omega M}$$ or, $$\frac{h_{ie} + \Delta h \cdot Z_L}{h_{fe} Z_L} = \frac{j\omega M}{R + j\omega L}$$

or $$\frac{h_{ie} + \Delta h Z_L}{Z_L} = \frac{j\omega M h_{fe}}{R + j\omega L}$$

or $$\frac{h_{ie}}{Z_L} + \Delta h = \frac{j\omega M h_{fe}}{R + j\omega L}$$

or $$h_{ie}\left[\frac{1 - \omega^2 LC + j\omega RC}{R + j\omega L}\right] + \Delta h = \frac{j\omega M h_{fe}}{R + j\omega L}$$

or $$h_{ie}(1 - \omega^2 LC + j\omega RC) + \Delta h(R + j\omega L) = j\omega M h_{fe}$$

or $$h_{ie} - h_{ie}\omega^2 LC + j h_{ie}\omega RC + \Delta h R + j \Delta h \omega L - j\omega M h_{fe} = 0$$

or $$(h_{ie} - h_{ie}\omega^2 LC + \Delta h R) + j(h_{ie}\omega RC + \Delta h \omega L - \omega M h_{fe}) = 0$$

Equating real part and imaginary part to zero we get —

$$h_{ie} - h_{ie}\omega^2 LC + \Delta h R = 0$$ or $$\omega^2 LC h_{ie} = h_{ie} + \Delta h R$$

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or, $\omega^2 LC = \frac{h_{re}}{h_{re}} + \frac{\Delta h R}{h_{re}}$

or $\omega^2 = \frac{1}{LC}\left(1 + \frac{\Delta h R}{h_{ie}}\right)$

or $\omega = \frac{1}{\sqrt{LC}} \sqrt{1 + \frac{\Delta h R}{h_{ie}}}$

$$\therefore \boxed{f = \frac{1}{2\pi\sqrt{LC}}\left(\sqrt{1 + \frac{\Delta h R}{h_{ie}}}\right)}$$

Since resistance of coil 'R' is very small and Δh is also small and h_{ie} is very large, hence $\frac{\Delta R}{h_{ie}}$ can be neglected

$\therefore$ Frequency of oscillation is given by—

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

Now, equating imaginary part to zero, we we get the condition for sustained oscillation,

i.e, $h_{ie}\omega RC + \Delta h \omega L - \omega M h_{fe} = 0$

$\Rightarrow \boxed{M = \frac{RCh_{ie} + \Delta h L}{h_{fe}}}$ = Mutual inductance

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