- The crystal material (Rochele salt) which is mostly used in microphones associated with tape recorder, head set, loud speaks.

- Quartz is inexpensive and easily available in nature.

- When the crystal is not vibrating it is equivalent to a capacitance due to the mechanical mounting of crystal.

- When it is vibrating there are internal frictional losses which are denoted by R while mass of crystal which is the indication of inertia force (inductor).

J.S.
22/07/11

26.07.11

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

where

$Q = \frac{WL}{R}$, $Q \Rightarrow 20{,}000$ or 10^6

↓

quality factor

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$ where ϕ is unity

200 to 300 KHz

WKT

$$X_L = X_C \; ; \; f_s = \frac{1}{2\pi\sqrt{LC}}$$

~~When~~

$$C_{eq} = \frac{C_m \cdot C}{C_M + C} \; ; \; f_p = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

When the reactances of series resonance by equals the reactance of mounting capacitance C_M.

* Crystal stability

The freq. of crystal tends to change slightly with the time due to temperature, aging etc.

★ Temperature stability

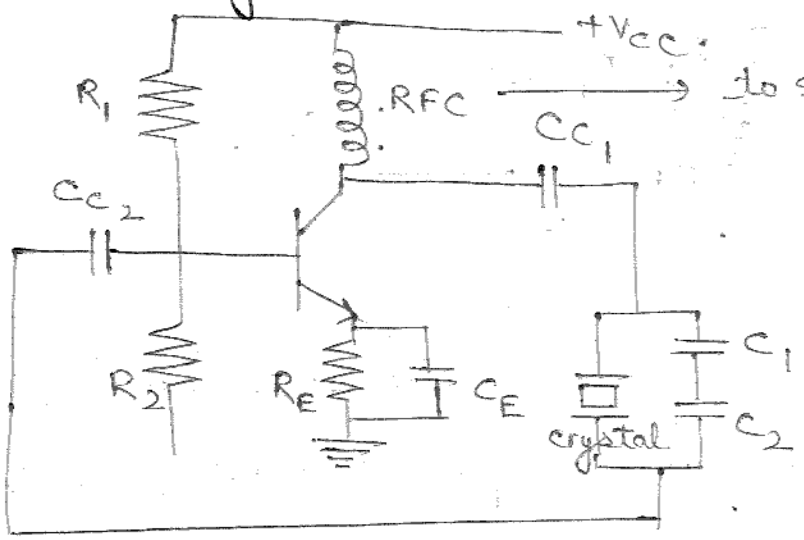
The change in freq. Hz / MHz / °c change in temp.

★ Long term stability

This is ~~basci~~ ~~basci~~ basically due to aging of the crystal material, the aging rate is 2×10^{-8} / yr.

For quartz = negligibly small

→ Pierce crystal oscillator

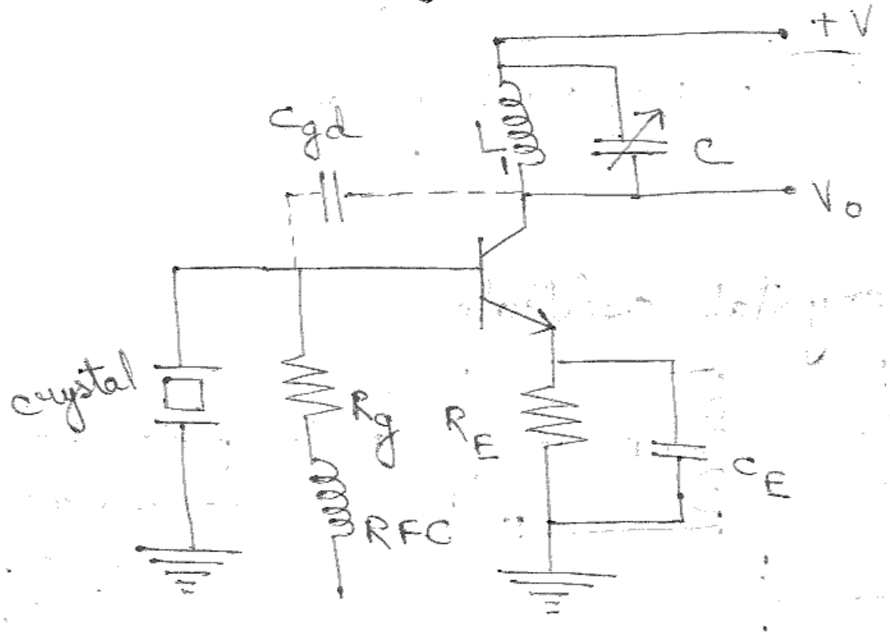


to seprate the dc and ac freq.

Colpit oscillator can be modified by using the crystal to ~~before~~ behave as an inductor for a frequency slightlly higher than the series resonance freq. fs.

The R_1, R_2 and R_E provides dc bias while the capacitor C_E is in bypass capacitance. The resulting ckt freq is set by the series resonant freq of oscillator.

→ Millers crystal oscillator

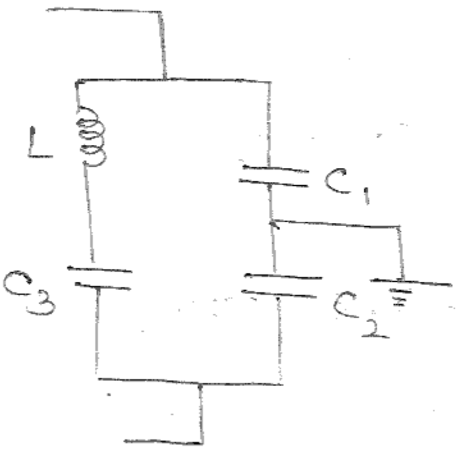


- ~~This is similar~~ to The similar modification in colpit oscillator make the pierce osc. ckt. Like that the modific on Hartley osc. will give miller crystal osc.

- One inductor is replaced by the crystal which act as an inductor for the frequencies slightly greater than the series resonance freq. The tuned ckt of L_1 and C is off tuned to behave as an inductor. The crystal behave as another inductor L_2 b/w base and ground.

2.7.7.11

* Clapp oscillator



To achieve the freq. stability colpit osci. is slightly modified in practice called clapp oscillator. One more capacitor C_3 is introduced in series with inductance. The value of C_3 is much smaller than C_1 and C_2.

Eg :- $C_1 = C_2 = 0.001\mu f$; $L = 15\mu H$; $C_3 = 50 pf$

$$C_{eq} = 4.545 \times 10^{-11}$$

$$f = \frac{1}{2\pi\sqrt{LC_3}} \quad , \quad C_1 = C_2 \gg C_3 \quad \text{--- (3)}$$

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

$$= 6.09\,\text{MHz}$$

If

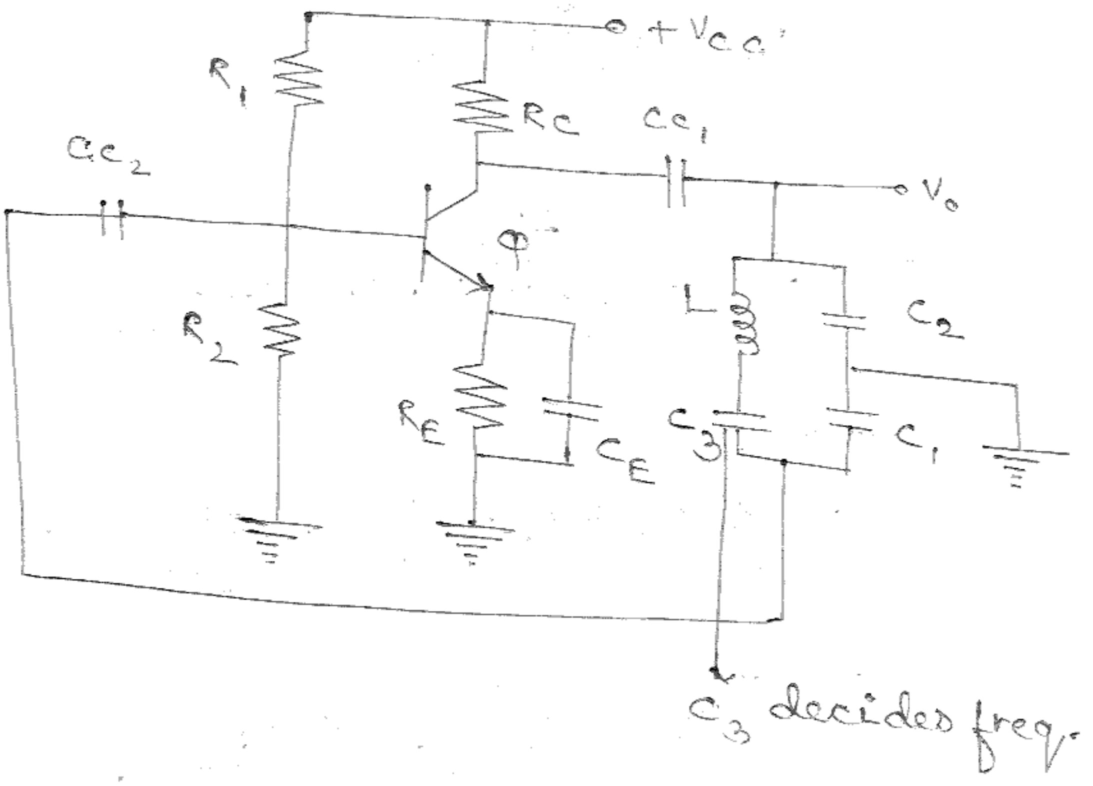
$$f = \frac{1}{2\pi\sqrt{LC_3}}$$

$$= 5.82\,\text{MHz}$$

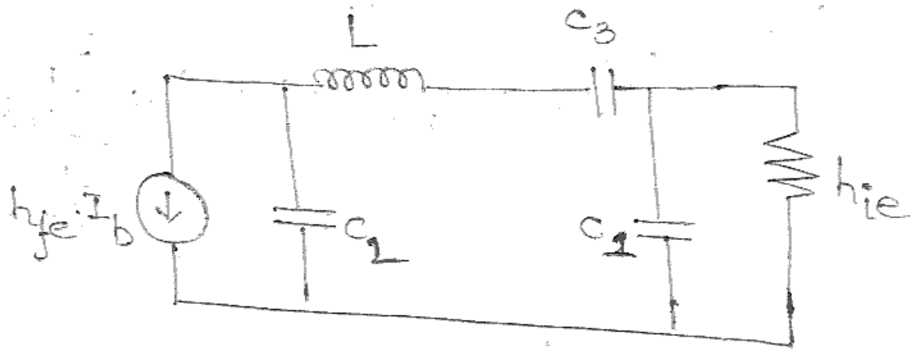
$$C_{eq} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \quad \text{--- (1)}$$

$$f = \frac{1}{2\pi\sqrt{LC_{eq}}} \quad \text{--- (2)}$$

- Transistorised circuit for clapp oscillator



- Derivation of freq. of oscillation



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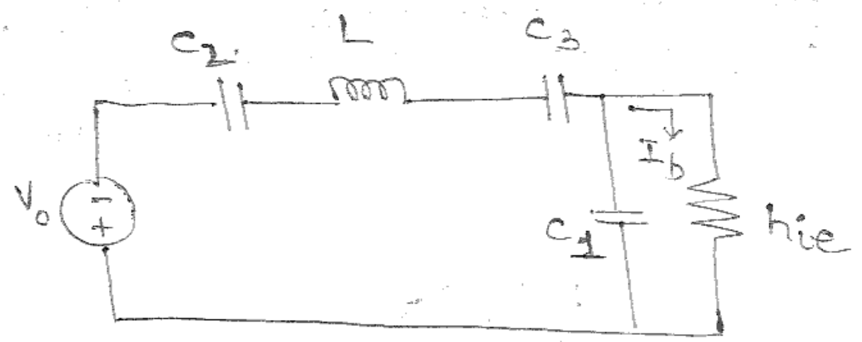


$$V_o = h_{fe} I_b X_{c_2} \quad \text{— (4)}$$

$$V_o = h_f I_b \frac{1}{j\omega C_2}$$

$$I = \frac{-V_o}{(X_{c_2} + X_{c_3} + X_L) + (X_{c_1} \,||\, h_{ie})} \quad \text{— (5)}$$

where;

$$X_{c_2} + X_{c_3} + X_L = \frac{1}{j\omega C_2} + \frac{1}{j\omega C_3} + j\omega L$$

$$X_{c_1} \,||\, h_{ie} = \frac{\frac{1}{j\omega C_1} \, h_{ie}}{\frac{1}{j\omega C_1} + h_{ie}}$$

$$\therefore I = \frac{-h_f I_b \frac{1}{j\omega C_2}}{\left(\frac{1}{j\omega C_2} + \frac{1}{j\omega C_3} + j\omega L\right) + \dfrac{\frac{1}{j\omega C_1} \cdot h_{ie}}{\frac{1}{j\omega C_1} + h_{ie}}} \quad \text{— (6)}$$

$$I = \frac{-h_f I_b / j\omega C_2}{\dfrac{j\omega C_3 + j\omega C_2 + j^3 \omega^3 L C_2 C_3}{j^2 \omega^2 C_2 C_3} + \dfrac{h_{ie} / \cancel{j\omega C_1}}{\frac{1 + j\omega C_1 h_{ie}}{\cancel{j\omega C_1}}}}$$

$$I = \frac{h_f I_b / j\omega C_2}{\;}$$

$$I = \frac{-h_{fe} I_b / sC_2}{sC_3 + sC_2 + s^3 L C_2 C_3 + \dfrac{h_{ie}}{1 + sC_1 h_{ie}}} \quad \text{— (7)}$$

Here

$s = j\omega$

Multi num and deno by sC_2

$$I = \frac{-h_{fe} I_b}{\left(1 + \dfrac{C_3}{C_2} + s^2 L C_3\right) + \dfrac{h_{ie} C_2}{1 + C_1 h_{ie}}}$$

$$I = \frac{-h_{fe} I_b C_3 (1 + sC_1 h_{ie})}{s^3 L C_1 C_2 h_{ie} + s^2 L C_2 C_3 + s h_{ie}(C_2C_3 + C_1C_2 + C_1C_3) + C_2 + C_3}$$

— (8)

$$I_b = I \times \frac{X_{C_1}}{X_{C_1} + h_{ie}}$$

Here,

$$\frac{X_{C_1}}{X_{C_1} + h_{ie}} = \frac{1/j\omega C_1}{\dfrac{1}{j\omega C_1} + h_{ie}} \Rightarrow \frac{\dfrac{1}{sC_1}}{\dfrac{1}{C_1 s} + h_{ie}}$$

$$I_b = I \times \frac{1/sC_1}{\frac{1}{sC_1} + h_{ie}}$$

$$I_b = \frac{I}{1 + sC_1 h_{ie}} \quad \text{—— (9)}$$

sub I in I_b

$$\cancel{I_b} = \frac{-h_{fe}\cancel{I_b}C_3}{s^3LC_1C_2C_3h_{ie} + s^2LC_2C_3 + sh_{ie}[C_2C_3 + C_1C_2 + C_1C_3] + C_2 + C_3}$$

$$1 = \frac{-h_{fe}C_3}{s^3LC_1C_2C_3h_{ie} + s^2LC_2C_3 + sh_{ie}[C_2C_3 + C_1C_2 + C_1C_3] + C_2 + C_3}$$

Subtitute $s = j\omega$; $s^2 = j^2\omega^2$; $s^3 = -j\omega^3$ in above eq
$= -\omega^2$

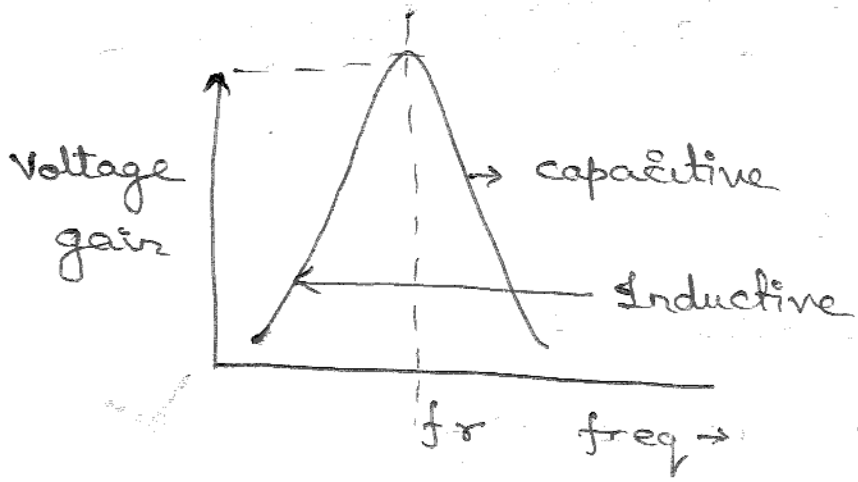
$$1 = \frac{-h_{fe}C_3}{C_2 + C_3 - \omega^2LC_2C_3 + j\omega h_{ie}\{C_1C_2 + C_2C_3 + C_1C_3 - \omega^2LC_1C_2C_3\}}$$

9.8.11 **Unit - 03. Tuned Amplifier**

- To amplify the selective range of frequencies the resistive load, R_c is ~~neglected~~ replaced by a tuned circuit.

- The tuned ckt is capable of amplifying a signal over a narrow band of freq. centered at f_R. The amplifier with such tuned ckt is known as tuned amplifier.

- ~~At resonance~~



$\cos\phi = 1$

$$f_c = \frac{1}{2\pi\sqrt{LC}} \quad ; \quad Z_r = \frac{L}{CR}$$

- At resonance inductive and capacitive effects of tuned ckt is cancle to each other.

- As a result ckt is like resistive and $\cos\phi = 1$, voltage and current are in phase.

10.08.11

★ Q - factor

Defined as the ratio of maximum energy stored per cycle to energy dissipated by cycle.

It can also be represented as the ratio of reactance to resistance.

$$Q = 2\pi \left[\frac{\text{max Energy stored / cycle}}{\text{Energy diss / per cycle}} \right]$$

★ Coil Losses

- Copper loss $\propto 1/f$
- Eddy current loss $\propto f$
- Hysteresis loss $\propto f$

→ The tuned ckt consist of coil practically not pure inductive. It consist of few losses they are represented in the form of leakage resistance in series with inductor. Total loss will be

Total loss = copper loss + Eddy current loss + hysteresis loss.

→ The result of eddy current is a loss due to heating within the inductor (copper or core).

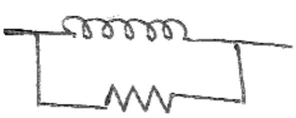
* Unloaded and loaded Q of tank circuit

→ The Q is the ratio of reactance to resistance and therefore, it is unitless.

→ It is the measure of how pure or real an inductor.

Series ckt

Parallel ckt

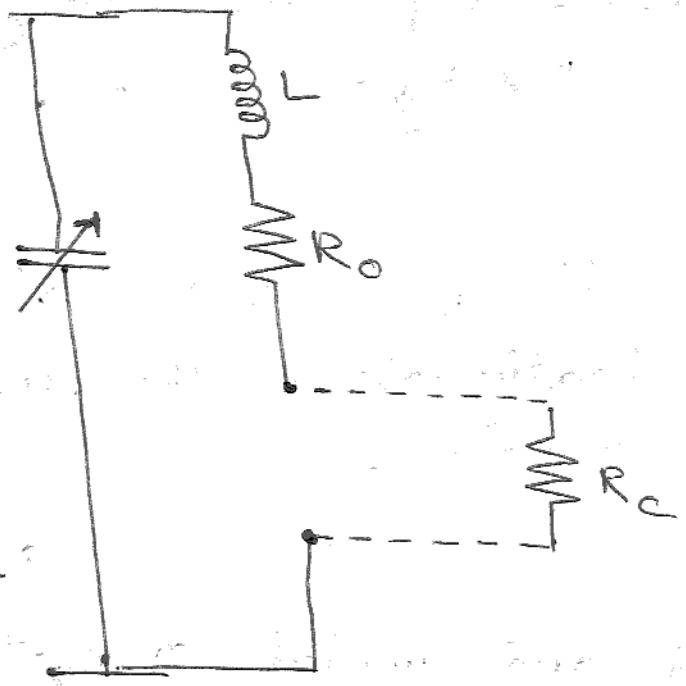


$$\text{quality factor } Q = \frac{1}{D} = \frac{\omega L_S}{R_S} = \frac{R_P}{\omega L_P}$$

$\frac{\omega L_S}{R_S}$ = inductive impedance

$\frac{R_P}{\omega L_P}$ = inductive admittance

L, C → represents tank circuit



$\frac{R_p}{\omega L_p}$ or $\frac{\omega L_s}{R_s}$

The internal ckt losses of inductor are represented ~~Rg~~ by R_o and R_c represents its couple load.

$$R_o = \frac{\omega_o L}{Q_u}$$

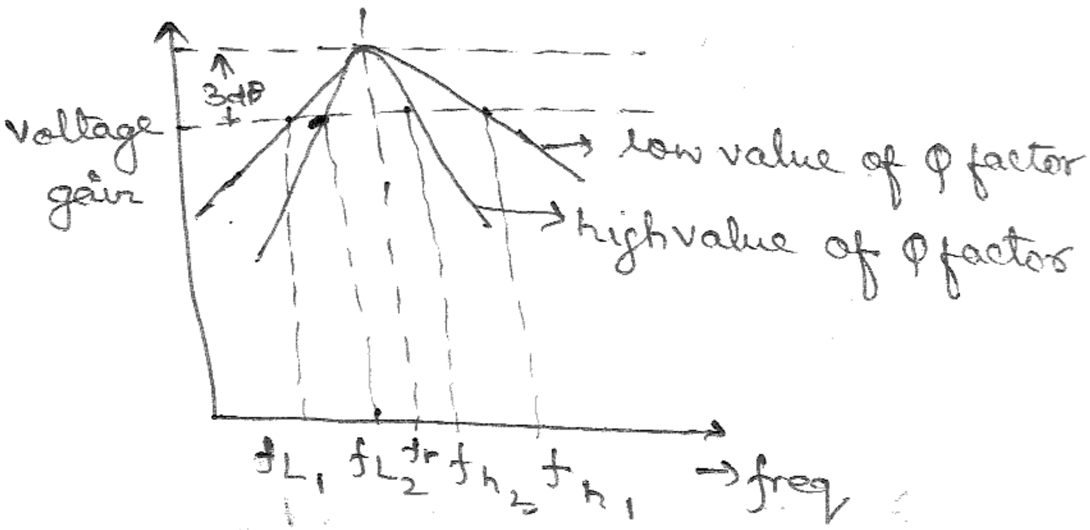
$$R_c = \frac{\omega_o L}{Q_L}$$

where,

Q_u = unloaded Q factor

Q_L = Loaded Q factor

Ckt efficiency $\eta = \frac{I^2 R_c}{I^2 (R_c + R_o)} = \frac{Q_u}{Q_u + Q_L} \times 100$

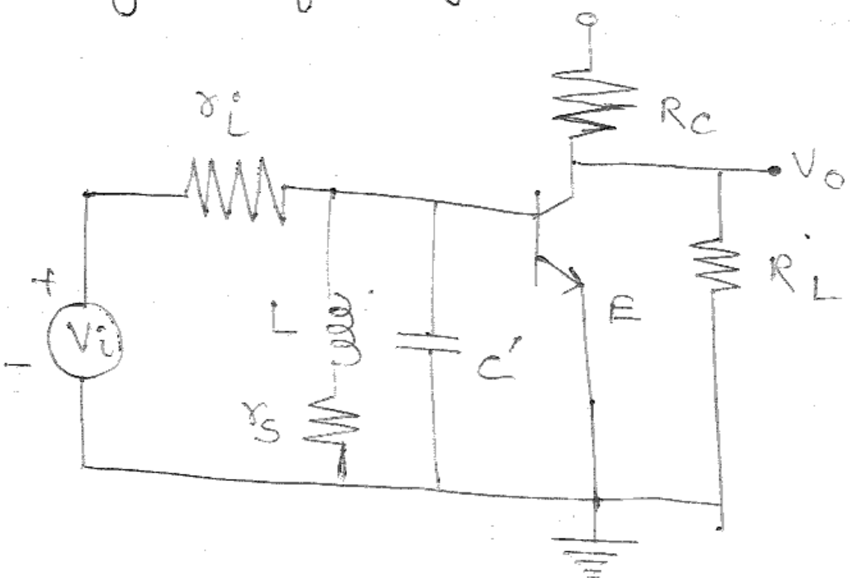


→ In Tuned amplifier Q is kept ~~to~~ as high as possible to get better selectivity.

→ Such tuned amplifier is used in communication and broadcast receiver.

12.08.11

→ Analysis of single tuned amplifier



Assumption

i) $R_L << R_C$

ii) $r_{b'b} = 0$

$\Rightarrow$

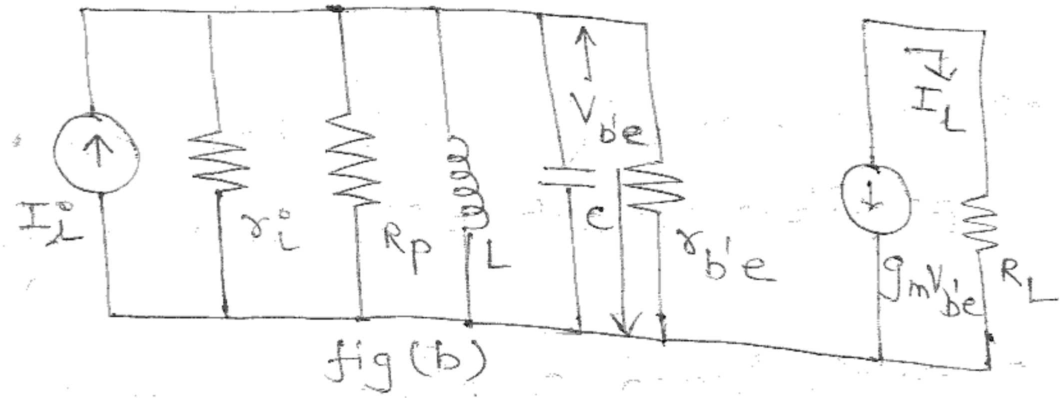


fig (b)

$$C_{eq} = C' + C_{b'e} + (1 + g_m V_{b'e}) C_{b'c}$$

where,

C' = external capacitance used to tuned the ckt.

$C_{b'c}(1 + g_m V_{b'e})$ = millers capacitance

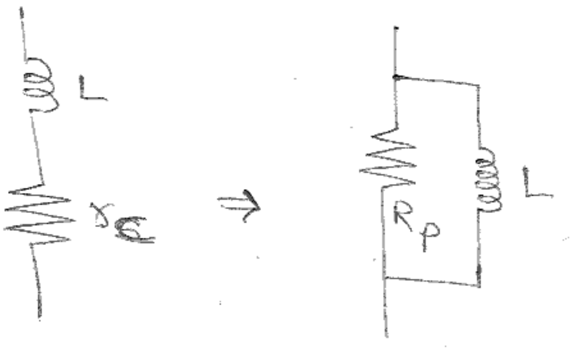
r_s = represents losses in coil

- Assuming coil loss is low over the freq band of interesst i.e. coil Q is high.

$$Q_c = \frac{\omega L}{r_c} >> 1 \qquad \text{—— (1)}$$

The conditions for equivalence are

most easily estabilished by equating the admittances.



$$Y_1 = \frac{1}{r_c + j\omega L} \Rightarrow \frac{r_c - j\omega L}{r_c^2 + \omega^2 L^2} \approx \frac{r_c}{r_c^2 + \omega^2 L^2} - \frac{j\omega L}{r_c^2 + \omega^2 L^2}$$

$$Y_1 = \frac{r_c}{\omega^2 L^2} + \frac{1}{j\omega L} \quad \because \omega L \gg r_c \text{ from } (1)$$

$$Y_2 = \frac{1}{R_p} + \frac{1}{j\omega L}$$

Equating Y_1 and Y_2

$$Y_1 = Y_2$$

$$\frac{r_c}{\omega^2 L^2} + \cancel{\frac{1}{j\omega L}} = \frac{1}{R_p} + \cancel{\frac{1}{j\omega L}}$$

$$r_c = \frac{\omega^2 L^2}{R_p}$$

where $\omega L = Q_c R_c$

$$\cancel{R_p = r_c \omega^2 L^2}$$

$$R_p = \frac{\omega^2 L^2}{r_c} = \frac{(Q_c R_c)^2}{r_c} \Rightarrow R_p = Q_c^2 r_c$$

$$R_p = \omega L Q_c$$

from fig (b)

$$R = r_i \| R_p \| r_{b'e} \quad \text{--- (3)}$$

the current gain of amp is

$$A_i = \frac{-g_m R}{1 + j\left(\omega RC - \frac{R}{\omega L}\right)}$$

$$A_i = \frac{-g_m R}{1 + j\omega_0 RC\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)} \quad \text{--- (4)}$$

where

$$\omega_0^2 = \frac{1}{LC}$$

$$Q_i = \frac{R}{\omega_0 L} = \omega_0 RC \quad \text{--- (5)}$$

then

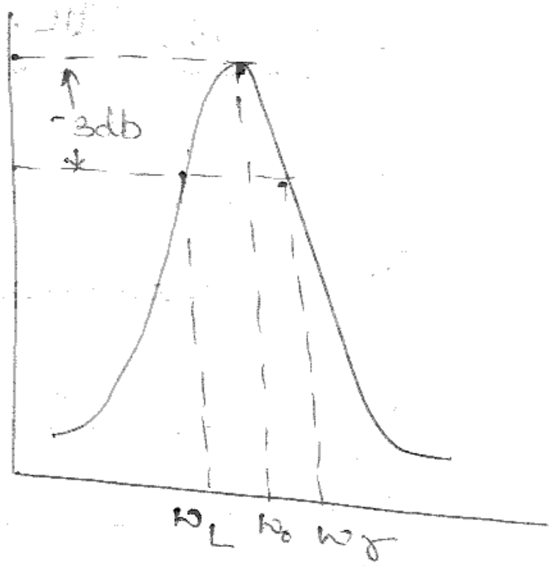
$$A_i = \frac{-g_m R}{1 + jQ_i\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)} \quad \text{--- (6)}$$

at $\omega = \omega_0$ the gain is maximum

$$A_{i(max)} = -g_m \cdot R \quad \text{--- (7)}$$

at 3dB

$$|A_i| = \frac{g_m R}{\sqrt{2}}$$



$\therefore$ at 3dB

$$1 + jQ_c\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) = \sqrt{2}$$

then

$$1 + Q_i^2\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)^2 = 2 \quad \text{—— (8)}$$

$$BW = f_H - f_L = \frac{\omega_0}{2\pi Q_1} = \frac{1}{2\pi RC} \quad \text{—— (9)}$$

$$\boxed{BW = \frac{1}{2\pi RC}}$$

Unit - 04. MULTIVIBRATOR CIRCUITS

→ Consider a transmission n/w consist of linear elements.

→ If a sinusoidal signal is applied to the ckt or such n/w in steady state the output signal is also sinusoidal signal or shape.

→ The effect of ckt of the i/p produces the output is characterised by two parameter

a) Ratio of the amplitude of output to i/p.

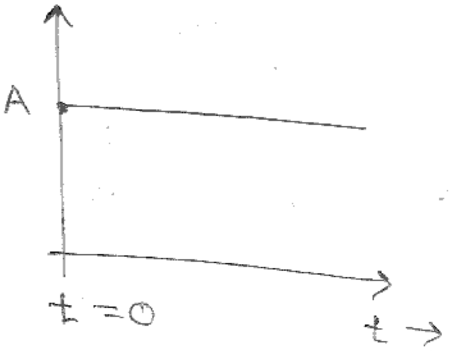
b) Phase angle b/w o/p to i/p.

→ The process by which the shape of non sinusoidal signal is changed by passing the signal through the network consist of linear elements called linear wave shaping. The non-sinusoidal signal in practice are

a) Step b) Pulse c) Square wave

d) Ramp.

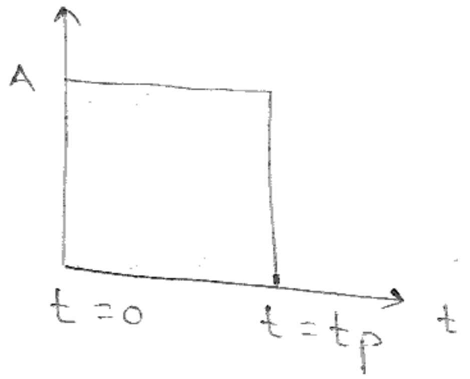
• step signal



$V_i(t) = 0 \qquad t < 0 \quad \text{— (1a)}$

$V_i(t) = A \qquad t \geq 0 \quad \text{— (1b)}$

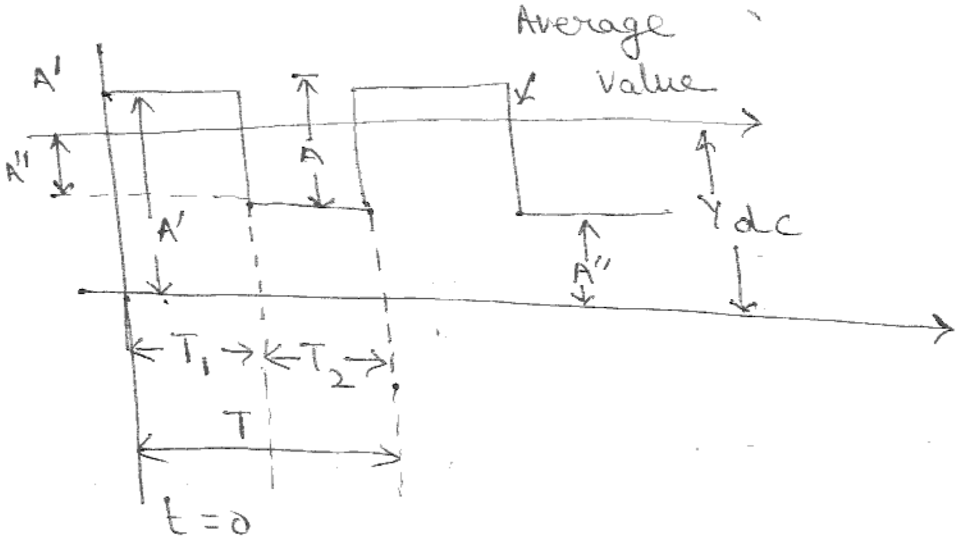
• Pulse wave



$V_i(t) = 0 \qquad \text{for } t < 0 \quad \text{— (2a)}$

$V_i(t) = A \qquad \text{for } 0 \leq t \leq t_p \quad \text{— (2b)}$

- Square wave



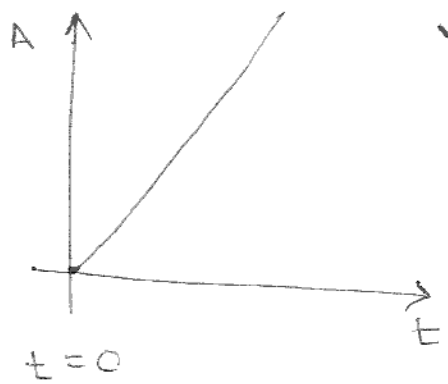
Square wave form has a const A' maintai for a time period for t_1 and A'' maintain for a time period T_2.

$$\therefore T_{total} = T = T_1 + T_2$$

$$V_i(t) = A' \quad , \quad 0 < t \leq T_1 \quad - (3a)$$

$$V_i(t) = A'' \quad , \quad T_1 < t \leq T_2 \quad - (3b).$$

- Ramp wave



$V_i(t) = 0 \quad , \quad t < 0$

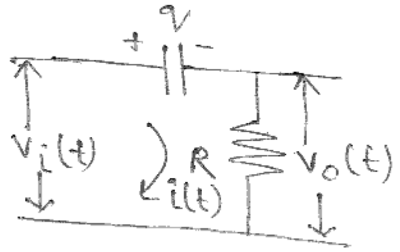
$V_i(t) = \alpha t \quad , \quad t > 0$

The wave form which is zero for $t<0$ a linearly increase at $t>0$ is called a ramp waveform or sweep wave form.

The RC ckt can be divided into two catagories

- High pass RC
- Low pass RC

High Pass RC



(3a) capacitive reactance $X_c = \dfrac{1}{2\pi f c}$ — (1)

(3b) $X_c \propto \dfrac{1}{f}$, here $f\uparrow$ $X_c\downarrow$

~~The~~ At very high freq the capacitor act as a short ckt and all the input appears at the output.

- At 0 freq the reactance becomes infinite and hence offers open ckt.

- Capacitor totally locks, not allowing it to reach the output.

- The magnitude of ratio of o/p to i/p is the transfer function or ~~appli~~ amplification or gain.

$$|A| = \frac{1}{\sqrt{1+\left(\frac{f_1}{f}\right)^2}}$$ where $f_1 = \frac{1}{2\pi RC}$

f = I/P freq

gain = 0.707

→ Three types

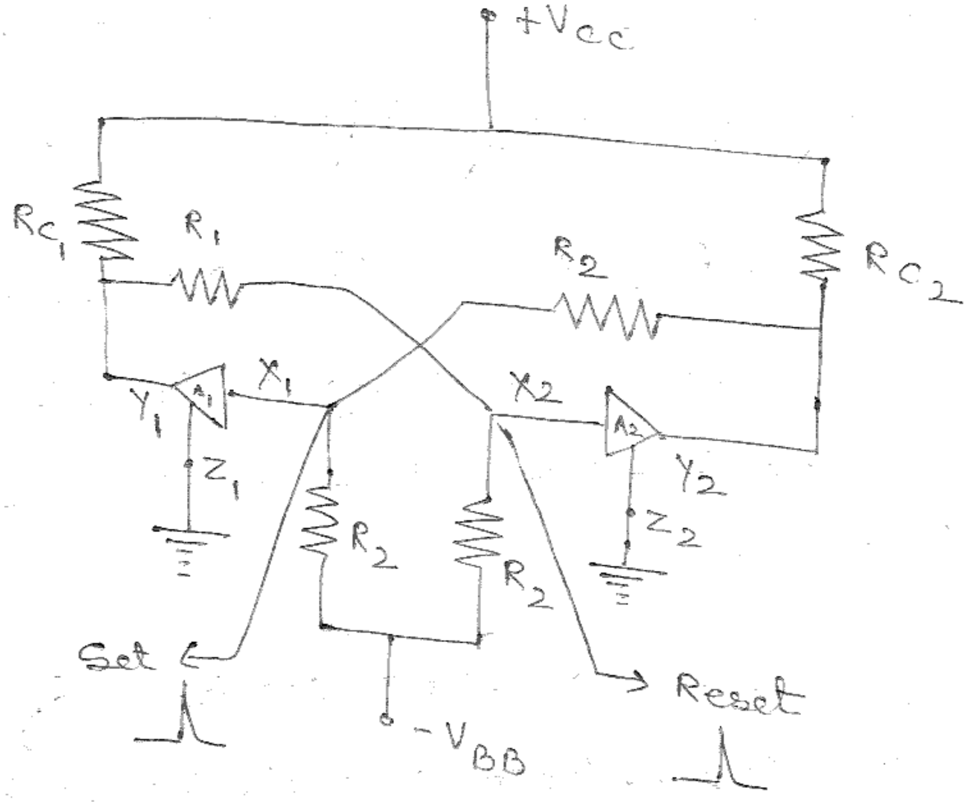
1) Bi-stable multivibrator

II) Monostable "

III) Astable "

The multivibrator is a ckt consist of active components used to generate non-sinusoidal signal such as square wave, triangular wave, pulse wave and ramp wave.

i) Bi- stable Multivibrator



- It has two stable state.
- It requires an external pulse to change one stable state to another.

$$V_W = V_{c_1} - V_{c2}$$

ECCles Jordan ckt

(or)

trigger ckt (or) Scale of 2 toggle flip flop

(or) binary

$\underbrace{\qquad\qquad\qquad}_{\text{other name of}}$

- This ckt is used for many digital application. Such as counting and storing of binary information.

- A_1 and A_2 are active divices which are transistor having 3 terminals - X, Y and Z like base, emitter and collector.

- I_1 and I_2 quiscent current of the two stages. Both current must be same and both the devices are operated in cut off region or saturation region. But practically it has no signification.

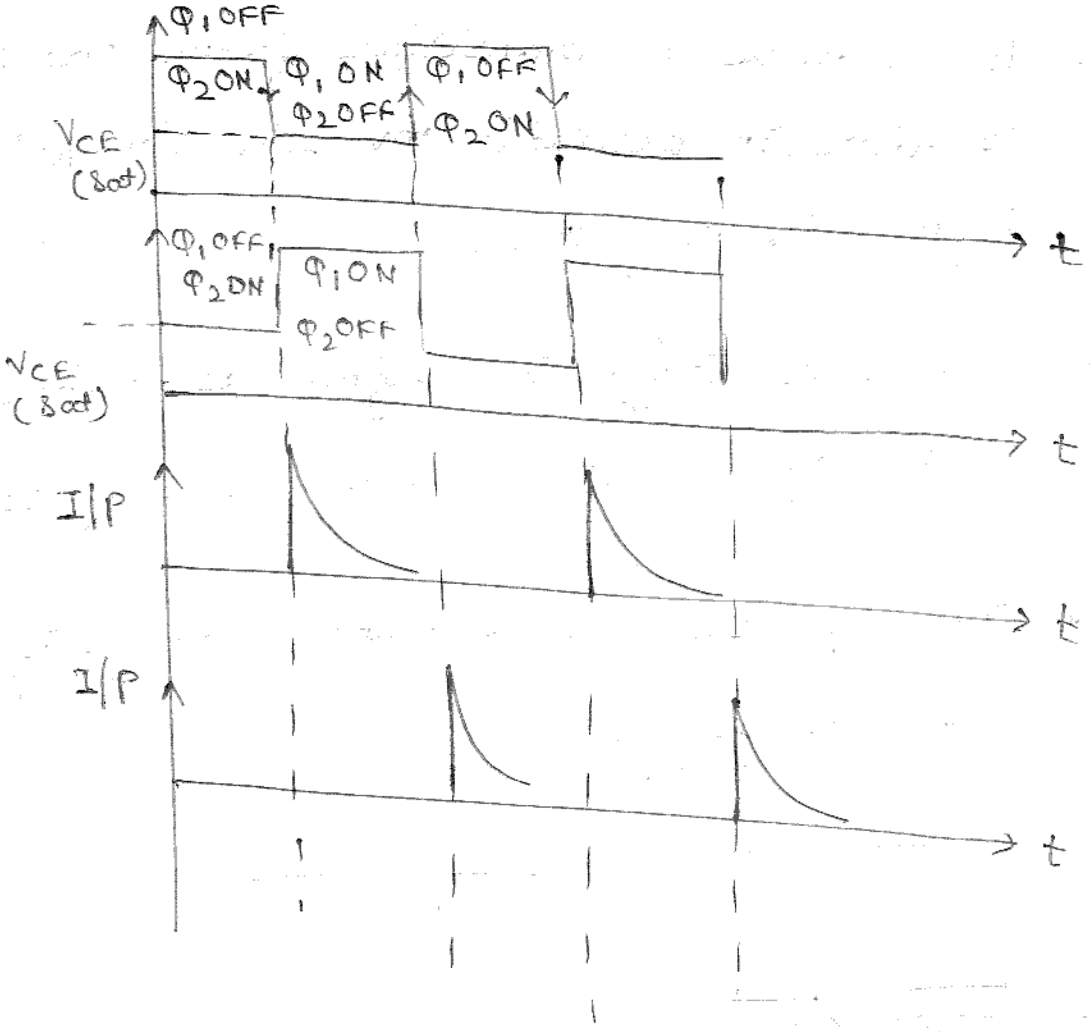
- Current I_1 and I_2 can be obtaind using Krichoff law.

- There are two type of bi-stable MV.

→ Fixed biased bi-stable mv.

→ Self biased bi-stable ".

output waveform



i) ϕ_1 off (cut off) and ϕ_2 on (sat)

ii) ϕ_2 off (") and ϕ_1 on (")

- The change in collector voltages result in due to the transition from one state to other state is called o/p voltage swing i.e

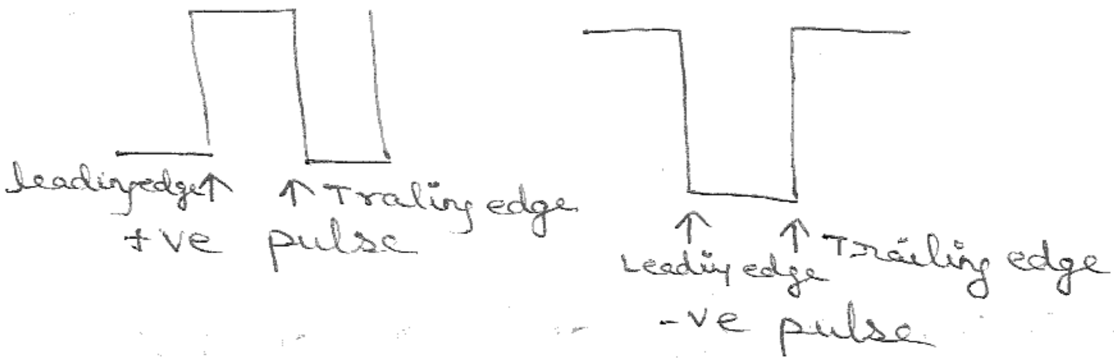
$$V_w = V_{c_1} - V_{c_2}$$

★ Triggering of bistable multivibrator

- To achieve a transition from one state to other in bistable mv the triggering signal is required.

- Such a triggering signal is either a pulse of short duration or step voltage

- The pulse can be either +ve going or -ve going.



→ Types of triggering

1) Un-symmetrical

2) Symmetrical

Un-symmetrical

- In this two trigger i/p are given one

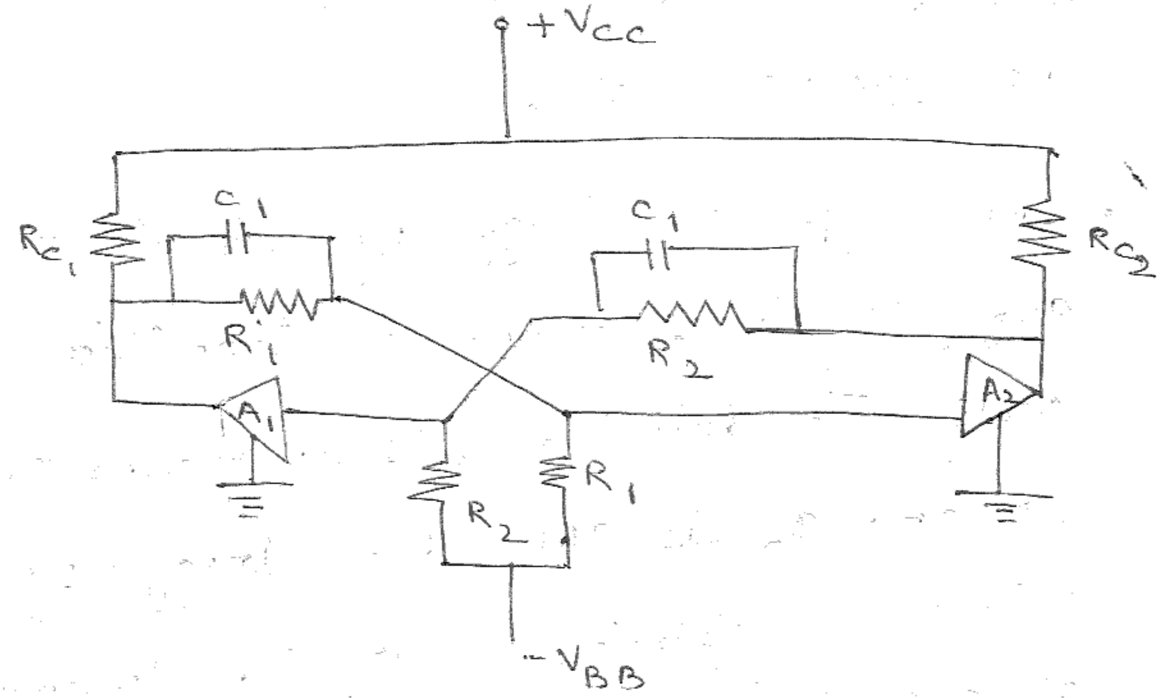
to set the ckt in particular stable state. And other to reset the ckt to the opposite state.

- This type of triggering signal is effective in inducing a transition in only one direction. This means Q_1 is ON and Q_2 is OFF then triggering signal is applied to Q_1 i/p to change it OFF due to which Q_2 becomes ON.

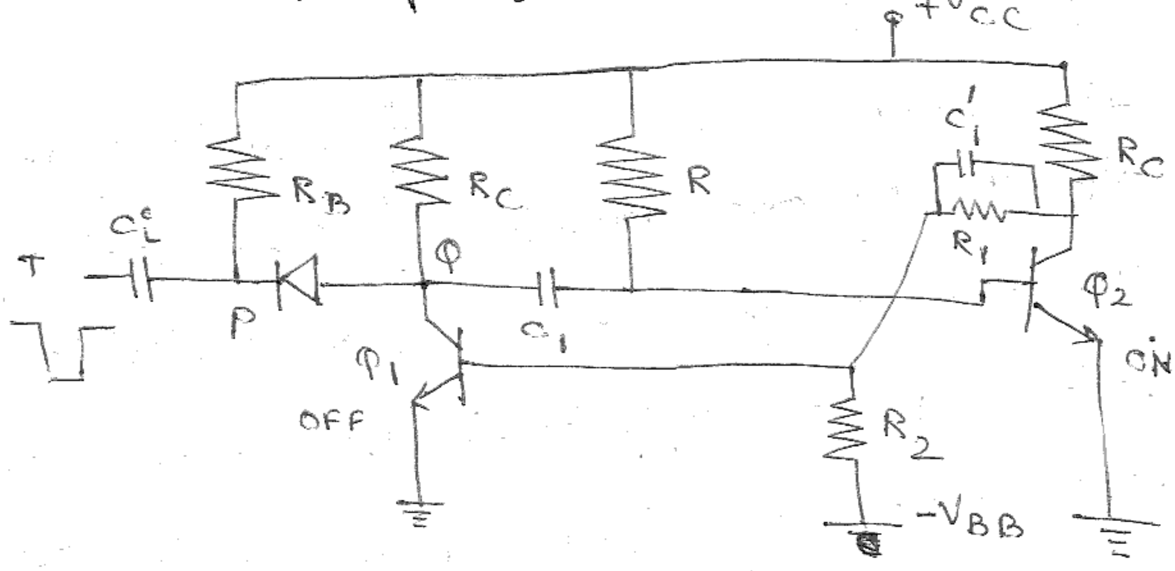
Symmetrical

- The symmetrical triggering uses only one i/p to any one transistor. The state of the ckt is changed each time suitable trigger pulses applied. Thus each successive triggering signal induce a transition and symmetrical triggering is used in binary counting ckts and some other applications.

★ Bistable Multivibrator



★ Triggering of mono-stable m.v.

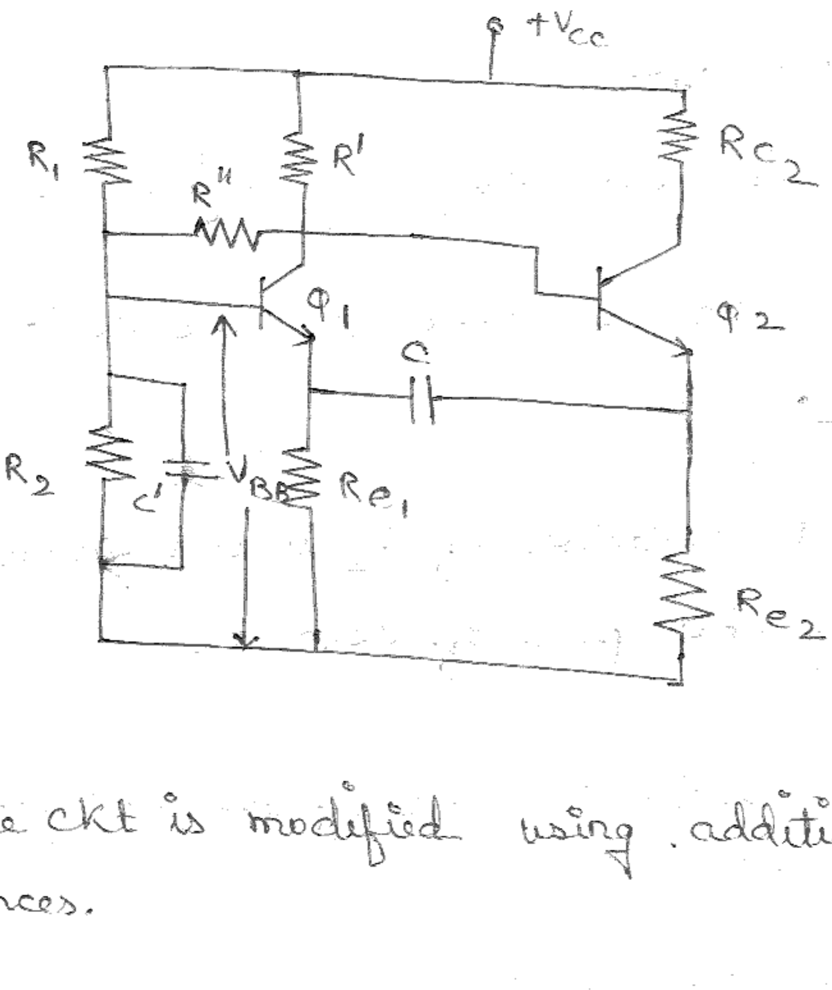


- The collector monostable is triggered with the pulses of such polarity that the non conducting transistor is brought out of cut off.

- Hence in practice the pulses are selected of that polarity which turns the ON transistor to OFF.

- The circuit is very effective when trigger input is continuously form such as sine wave instead of short trigger.

★ Practical Emitter Coupled Astable M.V.



- The ckt is modified using additional resistances.

- The voltage V_{BB} is obtained using potential devider R_1 and R_2 So neglecting base current of Q_1

$$V_{BB} = \left(\frac{V_{CC}}{R_1 + R_2} \times R_2 \right) \quad 1$$

- The capacitor C' is bypass capacitor and used to keep V_{BB} as constant hence C' will not appear any where.

$$R_{C_1} = \frac{R' R''}{R' + R''}$$

$$V_{CC_1} = \frac{V_{CC} R''}{R' + R''} + \frac{V_{BB} R'}{R' + R''}$$

→ Advantage

- No external triggering signal is required.
- The o/p is taken at the collector of Q_2.
- But collector of Q_2 is not connected to any other part of circuit.
- Distortion in the o/p due to transient is absent.
- The i/p terminal is based on the Q_1.
- The ~~sig~~ single capacitor C controls the freq.

→ ~~Disto~~ Disadvantage

- No. of components are more.
- R_{e_1} and R_{e_2} can not differ much.
- Costly.

* Complementary m.v.