SIGNAL GENERATORS

8

→ Conditions for Oscillations :-

→ Oscillators are defined as an electronic ckt which essentially produces a signal output waveform even without input signal excitation.

→ Applications

(1) used to generate sinusoidal signals which are used in radio and TV broad Cable.

(2) to generate clock in Computation and other synchronous digital system.

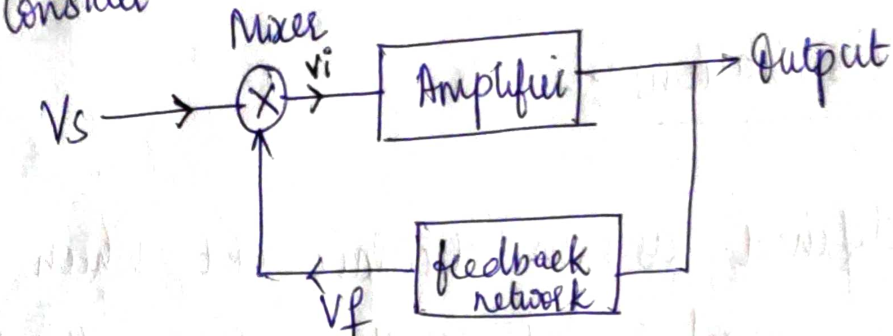
→ Oscillator operation :

→ In the process of feedback, a part of the output is sampled and fed back to input of the amplifier.

→ When both input signal and part of the output fed back to input are in phase then it is known as positive feedback

→ When both input signal and part of the output feedback to input are out of phase then it is known as negative feedback.

Consider



→ The amplifier gain of open loop ckt is,

$$A = \frac{V_o}{V_s} \quad \text{——} (1)$$

→ The ratio of output V_o to input V_s considering the effect of feedback is called closed loop gain.

$$\therefore A_f = \frac{V_o}{V_s} \quad \text{——} (2)$$

ie V_f is added to V_s to produce input to amplifier.

$$\therefore V_i = V_s + V_f \quad \text{——} (3)$$

→ V_f depends of feedback factor β.

$$\therefore V_f = \beta V_o \quad \text{——} (4) \equiv \beta \cdot A V_i$$

$$\therefore V_i = V_s + \beta V_o \qquad A_f = \frac{V_o}{V_s + \beta V_o} =$$

$$V_s = V_i - \beta V_o$$

Substituting for A_f, we get

$$A_f = \frac{V_o}{V_s + \beta V_o} \Rightarrow \frac{A \cdot V_s}{V_s + \beta V_o}$$

$$A_f = \frac{A \cdot (V_s/V_s)}{1 + \beta(V_o/V_s)} \quad \left\{ \text{∵ Dividing Numerator and denominator by } V_s \right.$$

$$\boxed{A_f = \frac{A}{1 + A\beta}} \quad \text{——} ★★ \text{ for the feedback.}$$

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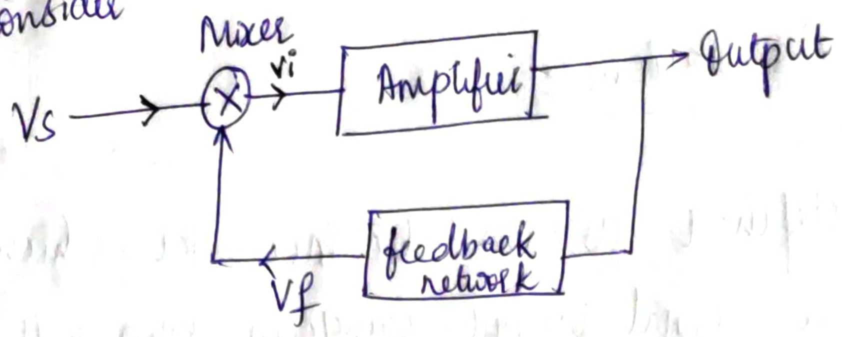

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CONDITIONS FOR OSCILLATION ☆★

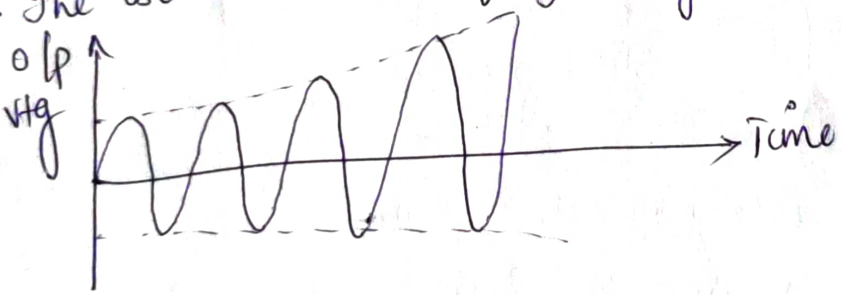
The Conditions required to make the circuits to work as oscillator are called **Barkhausen Criterion for Oscillations**.

→ "It states that, "The total phase shift around the loop, as the signal proceeds from input through amplifier, feedback network back to input again, completing a loop is precisely 0° or 360°".

→ ie $\boxed{|A\beta| = 1}$.

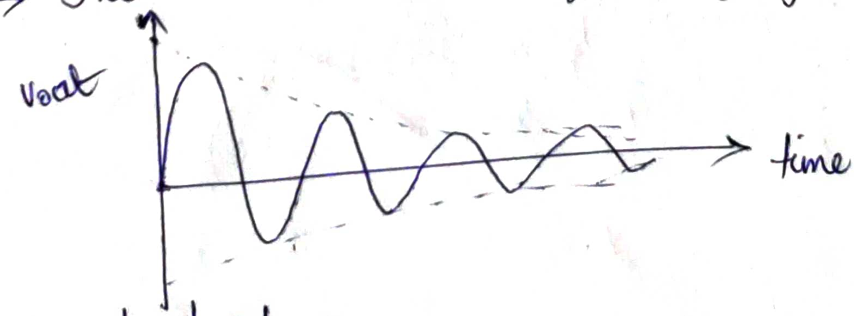
When (i) $|A\beta| > 1$

→ The oscillation are of growing type



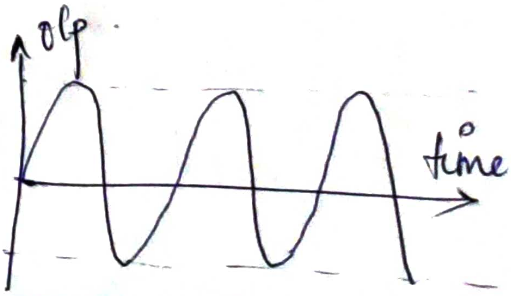
When (ii) $|A\beta| < 1$

→ The oscillations are of decaying type



When (iii) $|A\beta| = 1$

→ The oscillations are of Sustained type.



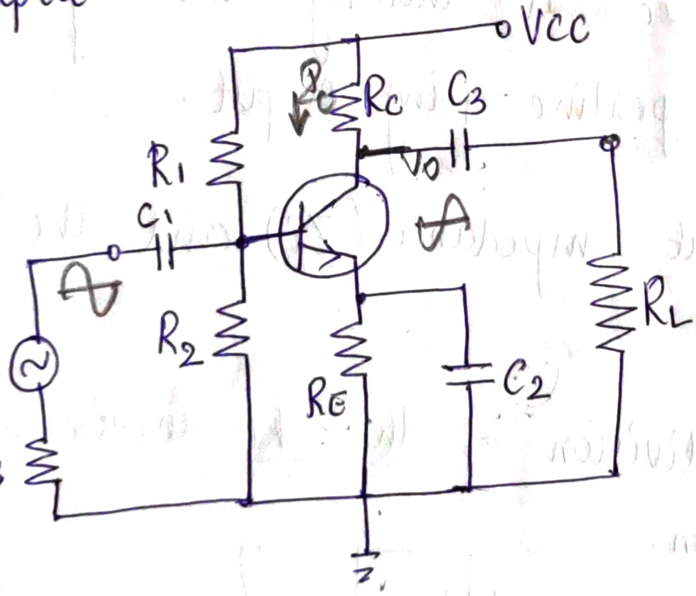
COMMON EMITTER CIRCUIT ANALYSIS [TRANSISTOR AS AMPLIFIER] OR [CE AC ANALYSIS]

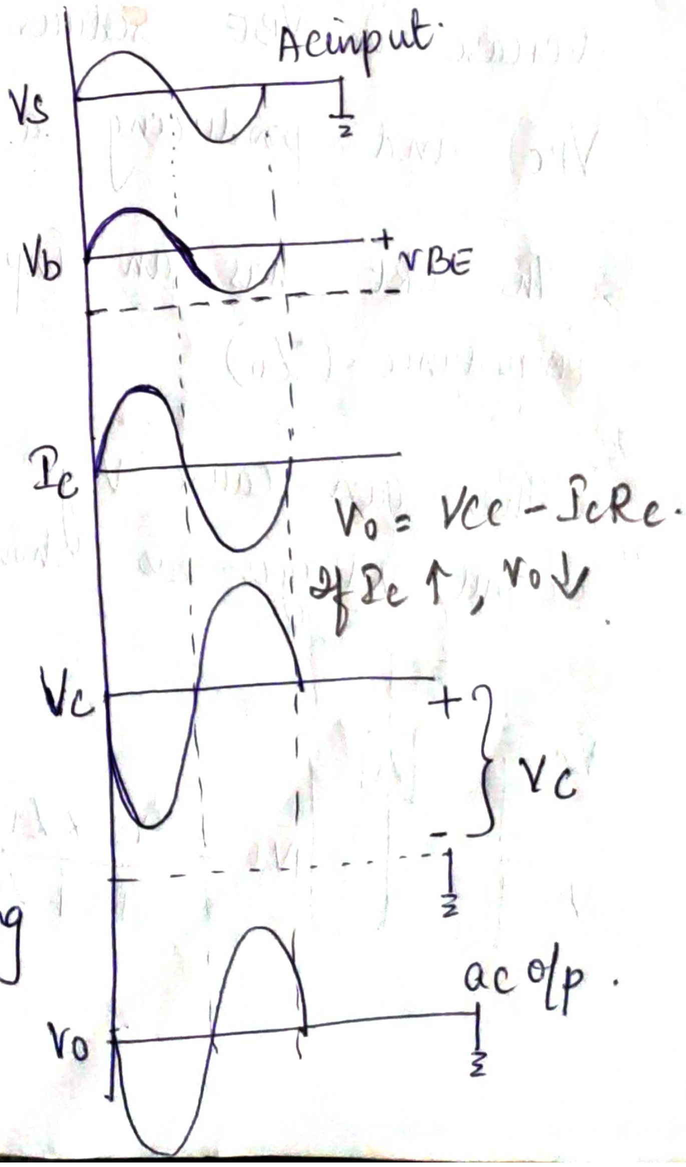
→ Common Emitter circuit

→ Consider the transistor amplifier ckt as shown below:-

→ When the capacitors are regarded as ac short circuits, it is seen that the circuit input terminals are the transistor base and emitter, and the output terminals are the collector and emitter.

→ So, the emitter terminal is common to both input and output and the circuit is called as common emitter confn





→ It is seen that there is 180° phase shift between the input and output waveforms.

→ This can be understood by considering the effect of positive going input signal.

→ When V_s increases in a positive direction, it incr...
the transistor base emitter voltage (V_{BE}).

→ The increase in raises the level of I_c thereby increasing the voltage drop accross R_c and thus reducing the level of the collector voltage (V_c).

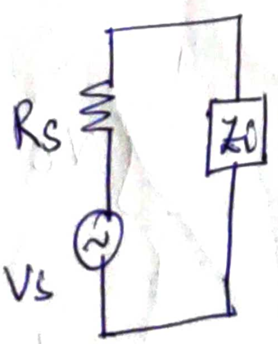
→ The changing level of V_c is capacitor coupled to the circuit o/p to produce the ac o/p voltage (V_o).

→ As V_s increases in +ve direction, V_o goes in a −ve direction.

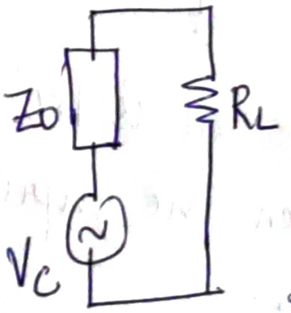
→ III^ly when V_s changes in −ve direction, the resultant decrease in V_{BE} reduces I_c level, there by reducing V_{Rc} and producing a positive going output.

→ The ckt has an input impedance (Z_i) and the o/p impedance (Z_o)

→ These can cause vtg division of the ckt input and output voltages as shown.

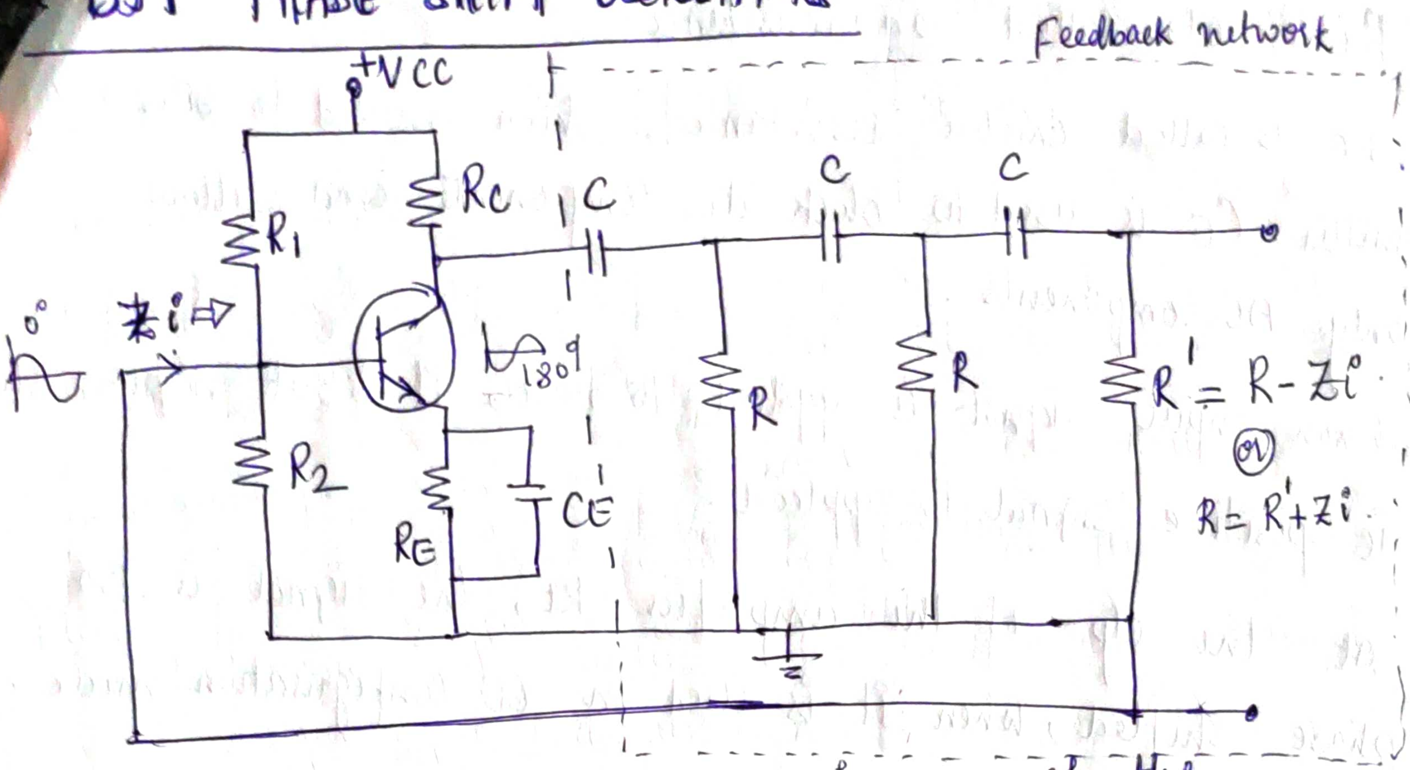


$$V_i = \frac{V_s \times Z_i}{R_s + Z_i}$$



$$V_o = \frac{V_c \times R_L}{Z_o + R_L}$$

BJT PHASE SHIFT OSCILLATORS



→ An RC (phase shift) oscillator is one of the sinusoidal oscillators and produce a sine wave o/p by using linear electronic components.

→ RC oscillators are more suitable for low frequency applications.

→ The basic principle of the RC phase shift oscillator is that before feeding back a portion of the o/p of the amp to the input, the amplifier o/p passes through a phase shift network.

→ The necessary condition for producing the oscillation is the total phase shift around the loop must be 360 degrees.

→ Hence in addition to the 180° phase shift by the amp, this RC phase network gives 180° phase shift. hence the total phase shift is 360° which is also called Zero degrees.

→ Rc is also called load resistance.

→ R_E is called emitter resistance, which is used to bias the emitter. C_E is used to block dc components and allow only AC components.

→ When input signal is applied to base, it is at 0° phase shift. ie positive signal is applied.

→ At the o/p of the amplifier ckt, the signal is 180° phase shifted, when it is used in CE configuration mode.

→ In the ckt, 3 RC network ckts are used because each RC network produces a phase shift of 60°.

→ Therefore at the end of the 3rd RC network, 360° phase shift is achieved

$$f = \frac{1}{2\pi RC\sqrt{2N}} = \frac{1}{2\pi RC\sqrt{6}} \quad \text{if } R_c/R \ll 1.$$

or

$$f = \frac{1}{2\pi RC\cdot\sqrt{6 + 4R_c/R}}$$

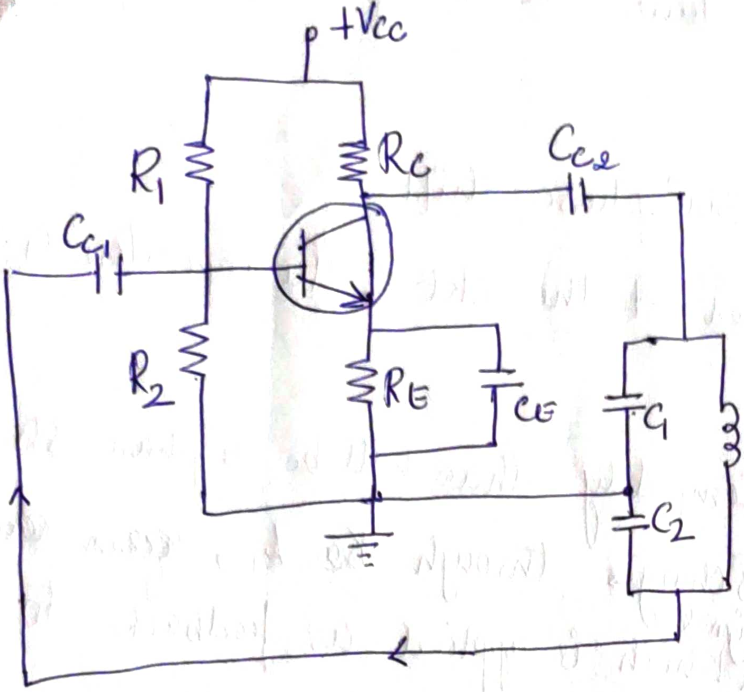
& $$h_{fe(min)} = 23 + \frac{29R}{R_c} + \frac{4R_c}{R}$$

ie when $R = R_c$, a min h_{fe} of 56 is required to sustain ckt oscillation.

BJT COLPITTS OSCILLATORS :

Advantages :-

(i) The Colpitts oscillator produces a more purer sinewave due to low impedance paths of the capacitors at high frequencies. (1 to 60MHz)



→ In the ckt we have coupling capacitors, which blocks the dc components and allow ac ~~component~~ signal to flow into the circuit ie to provide ac signal to the ckt.

→ R_1 and R_2 resistors act as voltage divider and also helps in self biasing of the circuit.

→ R_E and R_C are emitter resistance and collector resistance which helps in self biasing of emitter and collector junctions

→ The capacitor C_E is used to block dc and provide ac →

→ In practical ckt, R_C is replaced by Radio frequency choke (RFC) coil. This allows dc collector current to pass.

→ Basically the Colpitts oscillator constitute of 2 circuits

(i) The common emitter configuration amplifier

(ii) LC tank circuit.

$$\boxed{f_r = \frac{1}{2\pi\sqrt{C_T L}} \quad \text{where} \quad C_T = \frac{C_1 C_2}{C_1 + C_2}}$$

→ The CE amplifier ckts gives the sinusoidal o/p which is 180° phase shift and the tank circuit also gives 180° phase shifted signal.

→ So totally there will be 360° phase shift.

→ As soon as Vcc is applied to the ckt, the capacitors C_1 and C_2 starts charging.

→ When C_1 and C_2 charges completely there will be a phase shift of 180° and when C_2 discharges through ~~Re~~ L_1, ~~again there~~ ~~will~~ ~~the~~ 180° phase shift signal, which is applied as feedback to the ckt.

→ When capacitor charges completely, the inductor(L) will be discharged and when capacitor discharges, the inductor L_1 charges completely.

→ This process keeps repeating and the oscillations are produced

→ ie sinusoidal wave.

Working of tank ckt: When Vcc is applied, the capacitors C_1 and C_2 start charging & after the capacitors gets fully charged, the capacitor starts discharging through the inductor L_1 in the ckt causing damped oscillations in the tank ckt.

→ Thus AC vtg is produced across C_1 and C_2 by the oscillatory ckt in the tank ckt.

→ While these capacitors gets fully discharged, the electrostatic energy stored in the capacitors gets transfered in the form of magnetic flux to the inductor and inductor gets charged. ||ly when L_1 starts discharging the C1 and C2 start charging again and process repeats.

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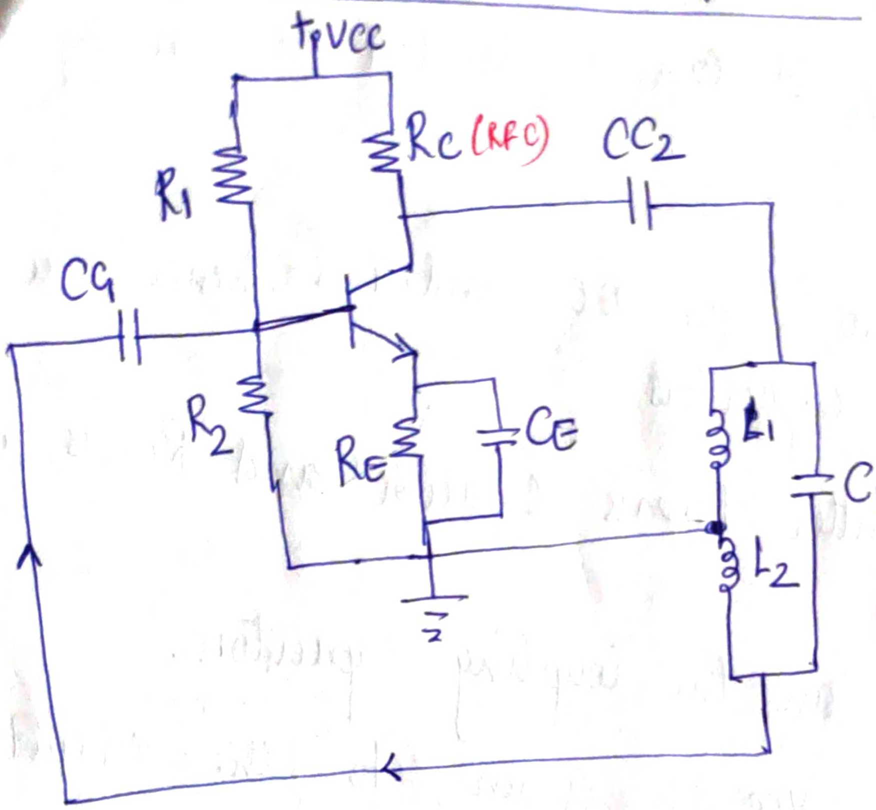
HARTLEY OSCILLATORS USING BJT :-



$$f_r = \frac{1}{2\pi\sqrt{L_T C}}$$ where, $L_T = L_1 + L_2$

→ Hartley oscillator is inductively coupled, variable frequency oscillators where the oscillations may be a series or shunt fed.

→ Hartley oscillators is the advantage of having one tuning capacitor and one centre tapped inductor.

→ This processor simplifies the construction of a Hartley oscillator circuit.

⇒ **Working :-**

→ An NPN transistor connected in a common emitter configuration works as the active device in amplifier stage.

→ R1 and R2 are biasing resistors and RFC is the radio frequency choke, which provides the isolation between AC and DC operation.

→ At high frequencies the reactance value of this ch[illegible] is very high, hence it can be treated as an open circuit

→ The reactance is zero for DC condition hence causes no problem for DC capacitors

→ The CE is the emitter bypass capacitor and RE is also be a biasing resistor.

→ The CC1 and CC2 are the coupling capacitors.

→ When DC supply VCC is given to the circuit, the collector current Ic starts raising and begins with the charging of the capacitor C.

→ Once capacitor C is fully charged, it starts discharging through L1 and L2 and again starts charging.

→ This back and forth voltage waveform is a sinewave which is small and leads with its negative alterations, ~~which~~ it will eventually decrease unless amplified.

→ Now, the transistor comes to the picture. The sinewave generated by the tank circuit is coupled to the base of the transistor through capacitor Cc1

→ Since the transistor is configured as common emitter, it takes the input from the tank ckt and inverts it to a standard sinewave with a leading positive alterations

Thus the transistor provides amplification along with inversion to amplify and correct the signal generated by the tank circuit.

→ The mutual inductance between L_1 and L_2 provides the feedback of energy from CE ckt to the BE (Base emitter ckt)

→ **Advantages** :-

1) Instead of 2 separate coils L_1 and L_2, a single coil of bare wire can be used and the coil grounded at any desired point along it.

2) By using a variable capacitor or by making core movable, frequency of oscillations can be varied.

3) Very few components are needed, including either 2 fixed inductors or a tapped coil.

4) The amplitude of the output remains constant over the working frequency range.

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Hartley oscillator circuit having 2 individual inductors of 0.5mH are designed to resonate in parallel with a variable capacitor that can be adjusted b/w 100pF & 500pF. Determine the upper & lower frequencies of oscillator & also hartley oscillators bandwidth.

$L_T = L_1 + L_2$

A -

$$f_H = \frac{1}{2\pi\sqrt{L_T C}} = \frac{1}{2\pi\sqrt{1\times10^{-3}\times100\times10^{-12}}}$$

$$= 503.25\ kHz.$$

$$f_L = \frac{1}{2\pi\sqrt{L_T C}} = \frac{1}{2\pi\sqrt{1\times10^{-3}\times500\times10^{-12}}}$$

$$\Rightarrow 225.05\ kHz.$$

Bandwidth $= f_H - f_L$

$278.176\ kHz$

2.) A colpitts oscillator circuit having 2 capacitors of 24nF & 240nF respectively are connected in parallel with inductor of 10mH. Determine the frequency of oscillators of the circuit. The feedback fraction & draw the circuit.

A -

$$f_r = \frac{1}{2\pi\sqrt{C_T L}}$$

$$C_T = \frac{C_1 C_2}{C_1 + C_2} = \frac{24\times240}{264} = 21.81\times10^{-9}\ F$$

$$L = 10\times10^{-3}\ H$$

$$f_r = \frac{1}{2\pi\sqrt{\frac{24\times240}{264}\times10^{-2}}}$$

$$= 10.8\ KH$$

The frequency of oscillators for the colpitts oscillations for colpitts oscillator is 10.8KH with feed back fraction of

$$F_f = \frac{C_1}{C_2} \times 100$$

$$= \frac{24}{240} \times 100$$

$$= 10\%$$

3) A 3-stage RC phase shift oscillator is required to produce an oscillation frequency of 6.5KH if 1nF capacitors are used in the feed back circuit. Calculate the value of frequency determining resistors & the value of feedback resistor required to sustain oscillations.

A - $$f_r = \frac{1}{2\pi RC\sqrt{2N}}$$

where $f_r \rightarrow$ output frequency

$R \rightarrow$ Resistance in ohms

$C \rightarrow$ Capacitance in farads

$N \rightarrow$ no. of RC stages

$$6.5 \times 10^3 = \frac{1}{2\pi \times R \times 1 \times 10^{-9}\sqrt{2 \times 3}}$$

$$\boxed{R = 10K\Omega}$$

The operational amplifier gain must be equal to 29 in order to get sustained oscillations i.e

$$A_v = \frac{R_F}{R}$$

$$29 = \frac{R_F}{10K\Omega}$$

$$\boxed{R_F = 290k\Omega}$$