LOGARITHMS

As a first step in clarifying the relationship between the variables of a logarithmic function, consider the following mathematical equations:

$$\boxed{a = b^x, \qquad x = \log_b a} \tag{11.1}$$

The variables a, b, and x are the same in each equation. If a is determined by taking the base b to the x power, the same x will result if the log of a is taken to the base b. For instance, if $b = 10$ and $x = 2$,

$$a = b^x = (10)^2 = 100$$

but

$$x = \log_b a = \log_{10} 100 = 2$$

Logarithms taken to the base 10 are referred to as *common logarithms*, while logarithms taken to the base e are referred to as *natural logarithms*. In summary:

$$\boxed{\text{Common logarithm:} \quad x = \log_{10} a} \tag{11.2}$$

$$\boxed{\text{Natural logarithm:} \quad y = \log_e a} \tag{11.3}$$

The two are related by

$$\boxed{\log_e a = 2.3 \log_{10} a} \tag{11.4}$$

DECIBELS

The term *bel* was derived from the surname of Alexander Graham Bell. For standardization, the bel (B) was defined by the following equation to relate power levels P_1 and P_2:

$$\boxed{G = \log_{10} \frac{P_2}{P_1}} \quad \text{bel} \tag{11.9}$$

so the decibel (dB) was defined such that 10 decibels = 1 bel.

$$\boxed{G_{dB} = 10 \log_{10} \frac{P_2}{P_1}} \quad \text{dB} \tag{11.10}$$

$$G_{dB} = 10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{V_2^2/R_i}{V_1^2/R_i} = 10 \log_{10}\left(\frac{V_2}{V_1}\right)^2$$

$$\boxed{G_{dB} = 20 \log_{10} \frac{V_2}{V_1}} \quad \text{dB}$$

GENERAL FREQUENCY CONSIDERATIONS / LOW-FREQUENCY RESPONSE — BJT AMPLIFIER

/ HIGH-FREQUENCY RESPONSE — BJT AMPLIFIER / Impact of Rs and RL on low frequency response

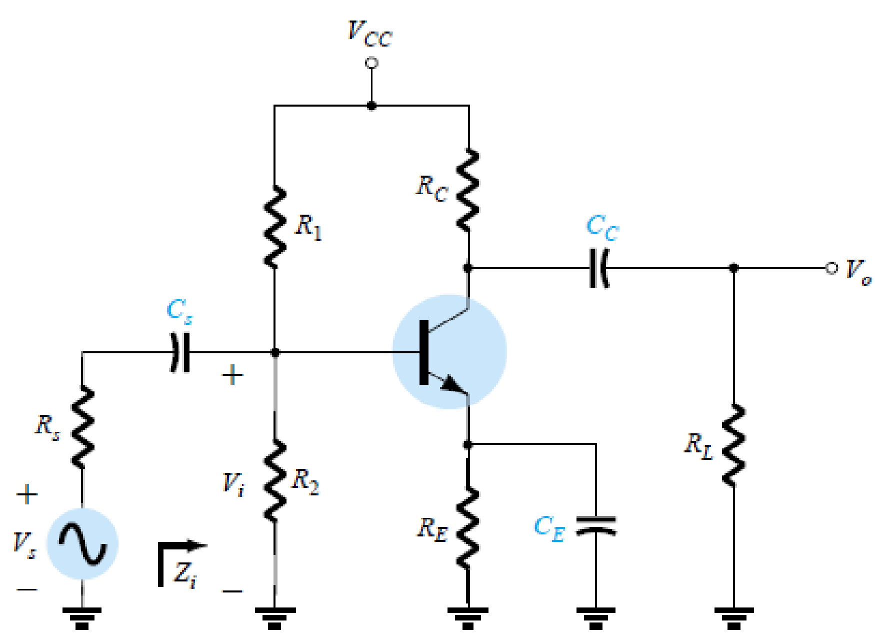


Figure 11.16 Loaded BJT amplifier with capacitors that affect the low-frequency response.

The response of a single stage or multistage amplifier depends on the frequency of the applied signal. At low frequency the coupling and bypass capacitors effect the low frequency response

At high freq, the internal capacitance of BJT & stray wiring capacitors effect the high frequency response.

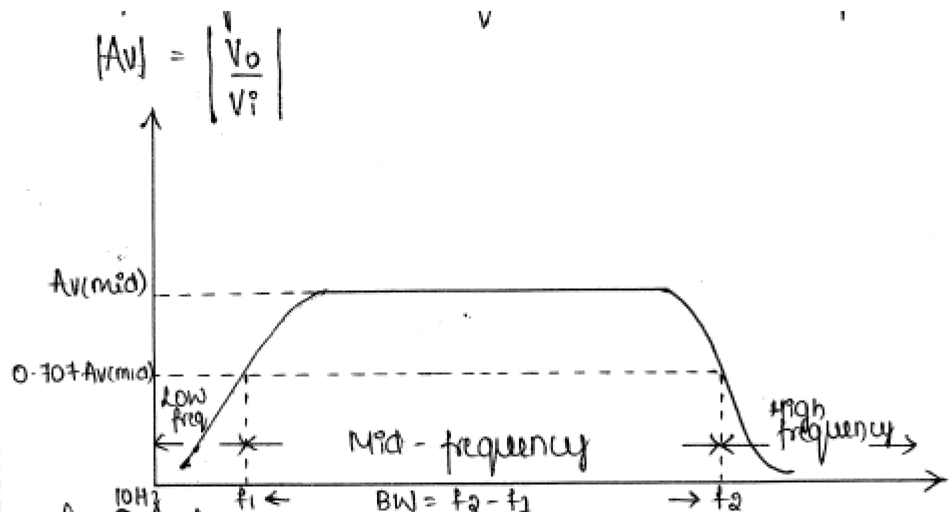


fig ①: freq response of R-C coupled amplifier.

The frequency response of an amplifier is the plot of the magnitude of voltage gain as a function of frequency.

* The frequency range is divided into three regions:

i) Low frequency region.

ii) Mid frequency region.

iii) High frequency region.

* At low frequencies, the drop in the gain is due to the coupling capacitors (C_C & C_S) and bypass capacitor (C_E).

* At high frequencies the drop in the gain is due to the internal device capacitances & the stray wiring capacitance.

* In the mid frequency range the gain is almost independent of the frequency. This is due to the fact that at mid frequencies the coupling & bypass capacitors act as short circuits & the device stray wiring capacitances acts as open ckt.
Thus voltage gain is constant in the mid-band frequency range and is denoted by $(A_V)_{mid}$.

* The frequencies f_1 & f_2 at which the gain is $0.707 A_{V(mid)}$ are called cut-off frequencies or corner frequencies or break frequencies.
* f_1 is called the lower cut-off frequency and f_2 is the upper cut-off frequency.
* The bandwidth of the amplifier is given by:

$$\boxed{BW = f_2 - f_1}$$

Low frequency analysis :-

* In low frequency region, the amplifier gain increases with frequency. Hence it can be modelled as a high-pass RC ckt as shown in fig ①

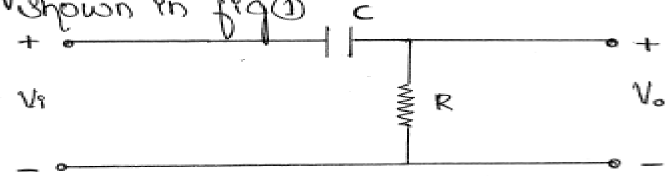


fig ①: Amplifier modelled as high pass RC ckt

* The capacitor 'C' represents the combined effect of coupling & bypass capacitance & the resistance 'R' represents the effect of resistive elements of the amplifier N/w.

* The capacitive reactance is given by:

$$\boxed{X_C = \frac{1}{2\pi f c}}$$

when $\boxed{f = 0\,Hz, \; X_C = \infty\,\Omega}$.

At low frequencies the capacitor acts as a open ckt as shown in fig ②.

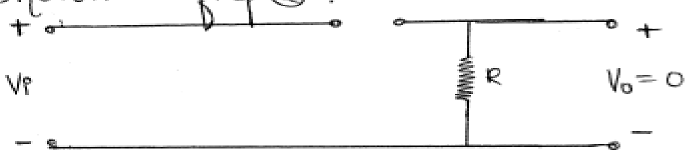


fig ②: capacitor acts as open ckt at f = 0

Now o/p $\boxed{V_o = 0}$

* At high frequencies, $\boxed{X_C \approx 0\,\Omega}$

i.e, at high freq's the capacitor acts as a short ckt as shown in fig ③.

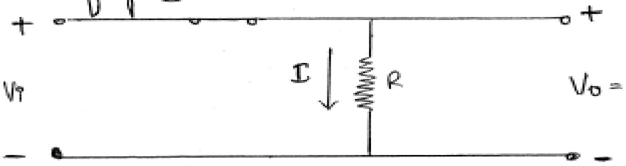


fig ③: capacitor acts as short ckt at high freq's

* from the ckt, $\boxed{V_o \approx V_i}$

* using voltage divider rule in the fig ①, we have

$V_o = IR$

where

$I = \dfrac{V_i}{R - jX_C}$

$$\boxed{V_o = \frac{V_i}{R - jX_C} \cdot R} \quad — ①$$

The magnitude of Vo is

$$V_o = \frac{V_i R}{\sqrt{R^2 + X_C^2}}$$

when $\boxed{X_C = R}$

$$V_o = \frac{V_i R}{\sqrt{R^2 + R^2}} = \frac{V_i R}{\sqrt{2R^2}} = \frac{V_i R}{\sqrt{2}\, R}$$

$$\boxed{V_o = \frac{V_i}{\sqrt{2}}} \longrightarrow ②$$

& $|A_v| = \dfrac{V_o}{V_i} \longrightarrow ③$.

Sub eq ② in eq ③

$$|A_v| = \frac{V_i/\sqrt{2}}{V_i} = \frac{1}{\sqrt{2}}$$

$$\boxed{|A_v| = 0.707} \Big|\, X_C = R$$

(Or)

$$\boxed{|A_v|_{dB} = -3dB.}$$

* The frequency for which $X_C = R$, the O/p will be 70.7% of the I/p.

The frequency at which $X_C = R$ is determined by

$$X_C = R$$

$$\frac{1}{2\pi f C} = R$$

$$\boxed{f = \frac{1}{2\pi RC}} \longrightarrow (4)$$

The input section of the circuit can represented as shown below

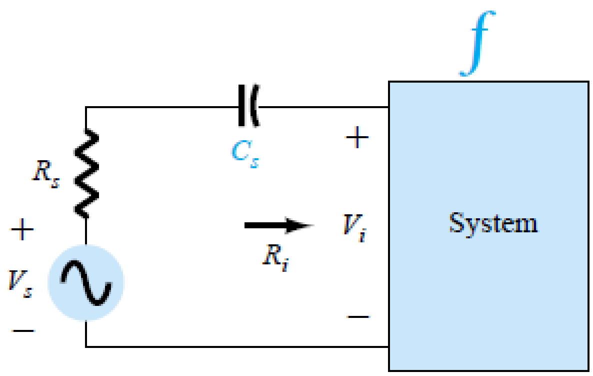


Figure 11.17 Determining the effect of C_s on the low frequency response.

For low frequencies, at the input section, $f=f_{Ls}$, $R=R_s+R_i$, and $C=C_s$

Hence equation 4 can be written as,

$$\boxed{f_{L_s} = \frac{1}{2\pi\,(R_s + R_i)C_s}}$$

Similarly, For low frequencies at the output section, $f=f_{Ls}$, $R=R_s+R_i$, and $C=C_s$

Hence equation 4 can be written as,

$$\boxed{f_{L_C} = \frac{1}{2\pi\,(R_o + R_L)C_C}}$$

Where $R_o = R_C \| r_o$

In the high frequency region , parasitic capacitances (*Cbe*, *Cbc*, *Cce*) and wiring capacitances (*CWi*, *CWo*) decreases the gain as shown below.

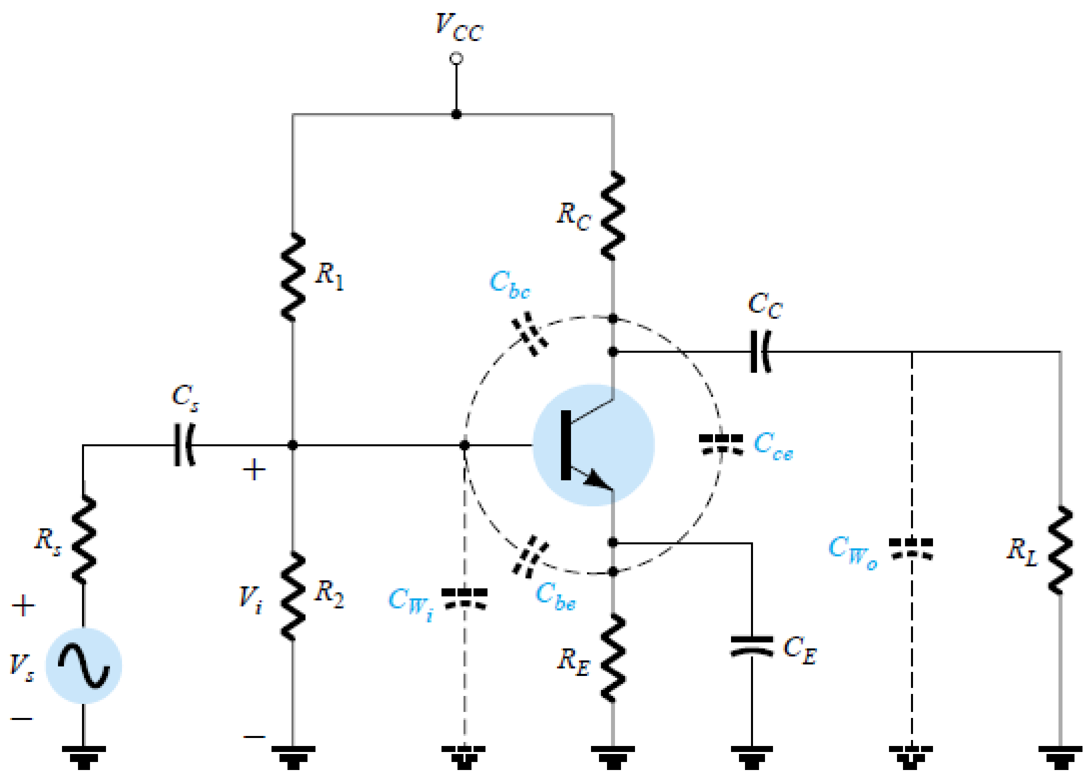


Figure Network with the capacitors that affect the high-frequency response.

Determining the Thévenin equivalent circuit for the input and output networks of the above

Fig we get

$$f_{H_o} = \frac{1}{2\pi R_{Th_o} C_o}$$

$$R_{Th_o} = R_C \| R_L \| r_o$$

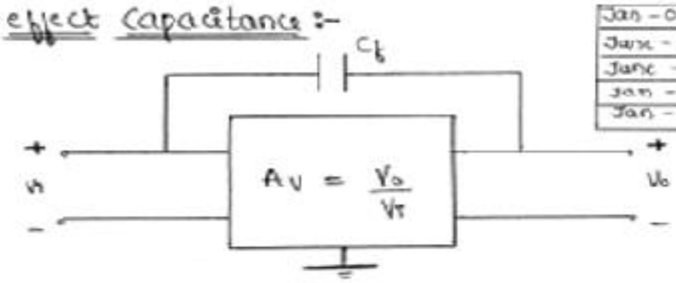
$$C_o = C_{W_o} + C_{ce} + C_{M_o}$$

Where

C_{M_o} = the output Miller capacitance

Miller effect Capacitance :-

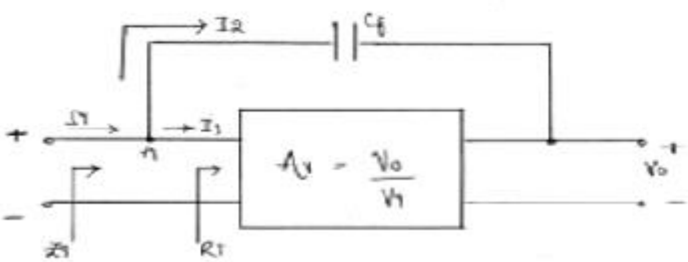
Jan - 09 , 10m
June - 10 , 10m
June - 09 , 2m
Jan - 10 , 10m
Jan - 05 , 6m



fig①: Amplifier with capacitance between I/p & o/p Nodes

using Miller's theorem we can find the loading effect of C_f on the I/p & o/p ch/s of the amplifier.

To find the Miller's I/p capacitance 'C_{Mi}' :-



fig②: circuit to find Miller I/p capacitance

Applying KCL at node A, we get

$$\boxed{I_i = I_1 + I_2} \longrightarrow ①$$

from fig ②,

$$I_i = \frac{V_i}{Z_i} \quad , \quad I_1 = \frac{V_i}{R_i}$$

$$\& \quad I_2 = \frac{V_i - V_o}{X_{C_f}}$$

w.k.t $A_V = \frac{V_o}{V_i}$

$$\boxed{V_o = A_V V_i}$$

$$I_2 = \frac{V_i - A_V V_i}{X_{C_f}}$$

$$\boxed{I_2 = \frac{V_i\left[1 - A_V\right]}{X_{C_f}}}$$

Substituting I_1, I_2 & I_i in Eq ①, we get

$$\frac{V_i}{Z_i} = \frac{V_i}{R_i} + \frac{V_i\left[1 - A_V\right]}{X_{C_f}}$$

$$\frac{V_i}{Z_i} = V_i\left[\frac{1}{R_i} + \frac{1 - A_V}{X_{C_f}}\right]$$

$$\frac{1}{Z_i} = \frac{1}{R_i} + \frac{1 - A_V}{X_{C_f}}$$

$$\frac{1}{Z_i} = \frac{1}{R_i} + \frac{1}{\left[\frac{X_{C_f}}{1 - A_V}\right]}$$

$$\frac{1}{Z_i} = \frac{1}{R_i} + \frac{1}{X_{CMi}}$$

where $\boxed{X_{CMi} = \frac{X_{C_f}}{1 - A_V}} \longrightarrow ②$

& $\boxed{X_{C_f} = \frac{1}{2\pi f C_f}} \longrightarrow ③$

Sub Eq ③ in Eq ②, we get

$$X_{CMi} = \frac{1}{2\pi f\left[1 - A_V\right] C_f}$$

where $C_{Mi} = \left[1 - A_V\right] C_f$

C_{Mi} is called the Miller I/p capacitance

To find the Miller o/p capacitance 'C_{Mo}' :-

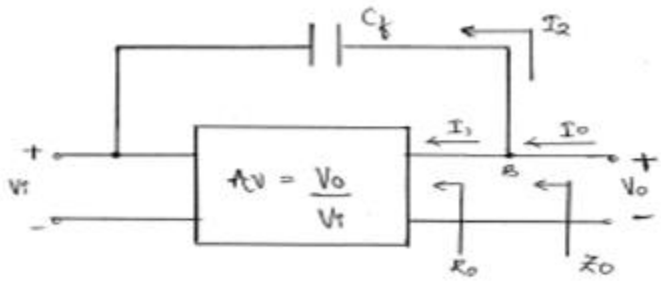


fig ③ : ckt to find miller o/p capacitance

Applying KCL at node B

$$\boxed{I_o = I_1 + I_2} \longrightarrow ①$$

from fig ③,

$$I_o = \frac{V_o}{Z_o} \quad , \quad I_1 = \frac{V_o}{R_o}$$

$$\& \quad \boxed{I_2 = \frac{V_o - V_i}{X_{Cf}}} \longrightarrow ②$$

W.K.T $\quad A_V = \frac{V_o}{V_i}$

$$\boxed{V_i = \frac{V_o}{A_V}} \longrightarrow ③$$

Sub eq ③ in eq ②, we get

$$I_2 = \frac{V_o - \left[\frac{V_o}{A_V}\right]}{X_{Cf}} = \frac{V_o\left[1 - \frac{1}{A_V}\right]}{X_{Cf}}$$

Substituting for I_1, I_2 & I_o in eq ①, we get.

$$\frac{V_o}{Z_o} = \frac{V_o}{R_o} + \frac{V_o\left[1 - 1/A_V\right]}{X_{Cf}}$$

usually R_o is large & hence the term $\frac{V_o}{R_o}$ can be neglected

Now,

$$\frac{V_o}{Z_o} = \frac{V_o\left[1 - 1/A_V\right]}{X_{Cf}}$$

$$\frac{1}{Z_o} = \frac{1 - 1/A_V}{X_{Cf}}.$$

$$Z_o = \frac{X_{cf}}{\left[1 - \frac{1}{A_V}\right]}$$

W.K.T

$$X_{cf} = \frac{1}{2\pi f C_f}$$

$$Z_o = \frac{1}{2\pi f \left[1 - \frac{1}{A_V}\right] C_f}$$

$$Z_o = \frac{1}{2\pi f C_{MO}}$$

where $\boxed{C_{MO} = \left[1 - \frac{1}{A_V}\right] C_f} \longrightarrow (4)$

C_{MO} is called the Miller o/p capacitance

* usually $A_V >> 1$, thus eq (4) reduces to

$C_{MO} \approx C_f$.

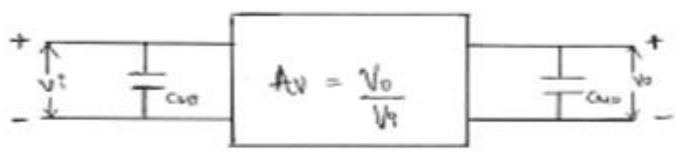
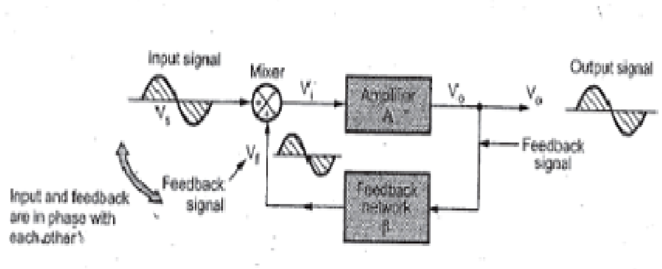
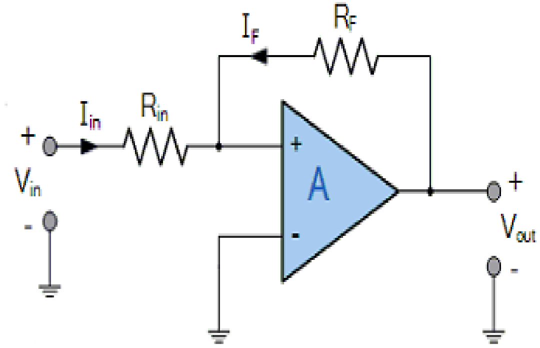


fig (4): Amplifier with Cf replaced with Miller capacitance

✣ Concept of Positive feedback :-



Concept of positive feedback



Positive feedback control of the op-amp is achieved by applying a small part of the output voltage signal at Vout back to the non-inverting (+) input terminal via the feedback resistor, R_F.

If the input voltage Vin is positive, the op-amp amplifies this positive signal and the output becomes more positive. Some of this output voltage is returned back to the input by the feedback network.

Thus the input voltage becomes more positive, causing an even larger output voltage and so on. Eventually the output becomes saturated at its positive supply rail.

→ A feedback is said to be +ve whenever the part of the o/p that is fed back to the amplifier as its i/p is in phase with the original i/p signal applied to the amplifier.

→ The amplifier gain AV, is :-

$$\boxed{A_V = \frac{V_o}{V_i}}$$ This is called open loop gain of the amplifier.

→ The closed loop gain of the amplifier is denoted by A_f,

$$\boxed{A_f = \frac{V_o}{V_s}} \quad \text{--- (1)}$$

→ The feedback is +ve & voltage V_f is added to V_s to generate i/p of amplifier V_i.

$$\boxed{V_i = V_s + V_f} \quad \text{--- (2)}$$

→ The feedback element gain β is,

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

$$\boxed{V_f = \beta V_o} \quad \text{--- (3)}$$

Substituting eq^n (3) in eq^n (2)

$$V_i = V_s + \beta V_o$$

$$\boxed{V_s = V_i - \beta V_o} \quad \text{--- (4)}$$

Substituting eq^n (4) in eq^n (1)

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

Dividing both numerator & denominator by V_i,

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

W.k.t

$$A_v = \frac{V_o}{V_i}$$

$$\therefore \boxed{A_f = \frac{A_v}{1 - A_v\beta}}$$

Requirements of oscillations

Barkhausen criteria

Conditions which are required to be satisfied to operate the circuit as an oscillator is called as "Barkhausen criterion" for sustained oscillations.

The Barkhausen criteria should be satisfied by an amplifier with positive feedback to ensure the sustained oscillations.

The Barkhausen criterion states that:

• The loop gain is equal to unity in absolute magnitude, that is, | β A | = 1 and

• The total phase shift around the loop is zero or 360^0

Consider the ckt shown below

For an oscillation circuit, there is no input signal "Vs", hence the feedback signal Vf itself should be sufficient to maintain the oscillations.

The product β A is called as the "loop gain".

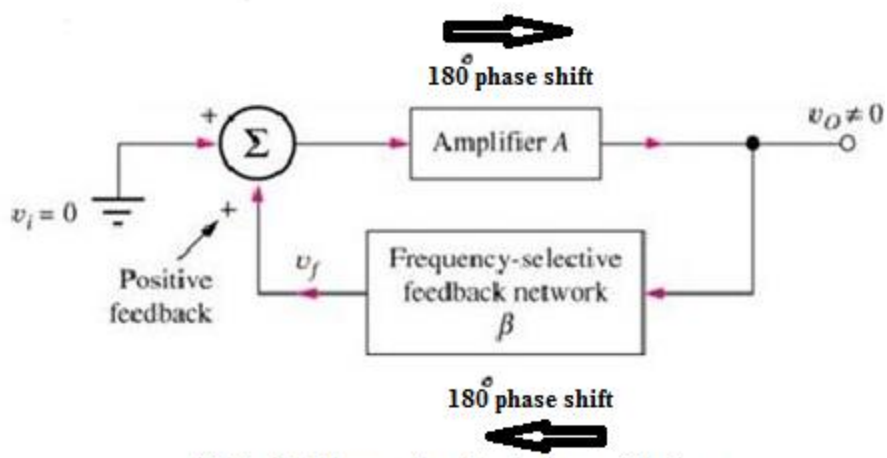


Fig1: Barkhausen's criteria for oscillations

From the circuit we have $V_o=AV_i$ ......(1)

And $V_f=\beta V_o$ ......(2)

Substituting (1) in (2) we get

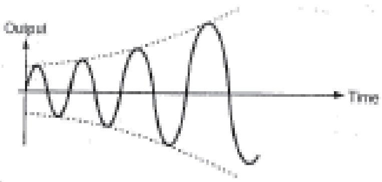
$V_f=A\beta V_i$ .....(3)

When $|A\beta| = 1$, V_f acts as V_i and is in phase with V_i.

Case 1 : $|A_v \beta| > 1$:-

→ When that total phase shift around a loop is $0°$ or $360°$ & $|A_v\beta| > 1$, then the o/p oscillates but the oscillations are of growing type.

→ The amplitude of oscillations goes on increasing as shown in the figure.

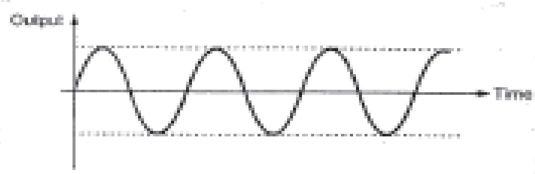


Growing type oscillations

Case 2 : $|A_v \beta| = 1$:-

→ As stated by Barkhausen Criterion, when the total phase around a loop is $0°$ & $360°$ - ensuring +ve feedback & $|A_v\beta| = 1$, then the oscill-ations are with constant fre-quency & amplitude are called sustained oscillations.

$|A\beta| = 1$

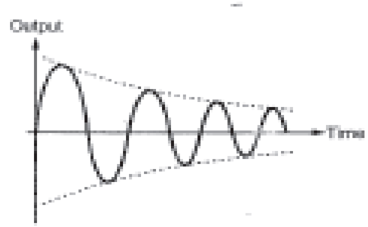


Sustained oscillations

Case 3 : $|A_v \beta| < 1$:-

→ When total phase shift around a loop is $0°$ or $360°$ but $|A_v\beta| < 1$, then the oscillations are of decaying type. ie. such osci-llation's amplitude decreases exponentially & the oscillation finally cease (dies out). Thus circuit works as an amplifier without oscillation.

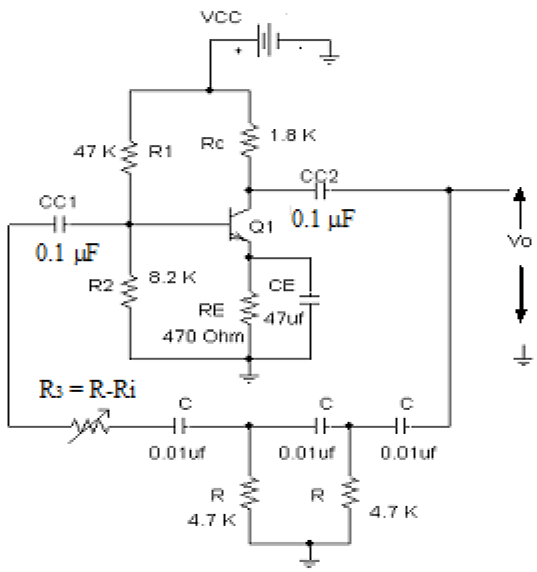
$|A\beta| < 1$

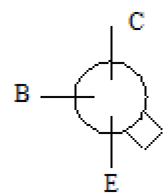


Exponentially decaying oscillations

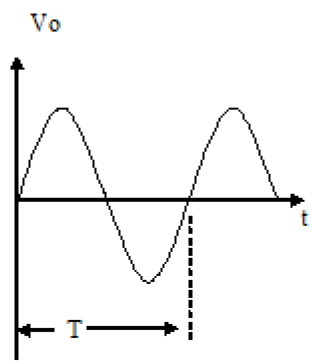
RC Phase Shift Oscillator

Circuit Diagram :





SL100
or
CL100



The Barkhausen criteria states that in a positive feedback amplifier to obtain sustained oscillations, the overall loop gain must be unity (1) and the overall phase shift must be 0° or 360°.

When the power supply is switched on, due to random motion of electrons in passive components like resistor, capacitor a noise voltage of different frequencies will be developed at the collector terminal of transistor, out of these the designed frequency signal is fed back to the amplifier by the feed back network and the process repeats to give suitable oscillation at output terminal

→ RC-phase shift oscillator basically consists of an CE amplifier & a feedback network consisting of resistors & capacitors.

→ The resistors R_1, R_2 & R_E provides necessary bias to the circuit. The capacitors C_{C1} & C_{C2} are coupling capacitors.

→ The feedback network consists of three RC sections each producing 60° phase shift to get a total phase shift of 180°.

→ The CE amplifier produces a phase-shift of 180°.

→ Thus the total phase shift around a loop is 360°. This satisfies the required condition for +ve feedback.

→ When feedback is adjusted such that $|A\beta| = 1$, the circuit works as an oscillator.

→ The frequency of an oscillator is given by

$$\boxed{f = \frac{1}{2\pi RC\sqrt{6+4K}}} \quad \text{where, } K = \frac{R_C}{R}$$

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

→ The current gain h_{fe} of the transistor must satisfy the condition

$$\boxed{h_{fe} > 4K + 23 + \frac{29}{K}}$$

Advantages :-

1> The circuit is simple to design.
2> This circuit can produce o/p over audio frequency range.
3> This circuit produces sinusoidal o/p waveform.
4> It is a fixed frequency oscillator.

Disadvantages :-

{By changing the values of R & C, the frequency of the oscillator can be changed}

→ The values of R & C of all three sections must be changed simultaneously to satisfy the oscillating conditions. But this is practically impossible. Hence the phase shift oscillator is considered as a fixed frequency oscillator for all practical purposes.

→ Frequency stability is poor.

Design :

Given, $\mathbf{V_{CE} = 5\ V, I_C = 2\ mA}$ and (Assume $\beta = 100$)

$V_{CC} = 2V_{CE} = 2 \times 5 = \mathbf{10\ V}$

Let $V_{RE} = 10\%\ V_{CC} = 1\ V$

$R_E = V_{RE} / (I_C + I_B)$

$I_B = I_C / \beta = 2mA / 100 = 20\ \mu A$

$R_E = 1 / (2m + 20\mu) = 495\Omega$

Choose $\mathbf{R_E = 470\ \Omega}$

$f_o = 1 / T$ Hz

Apply KVL to collector loop

$V_{CC} - I_C R_C - V_{CE} - V_E = 0$

$R_C = (V_{CC} - V_{CE} - V_E) / I_C = (10 - 5 - 1) / 2\ m$

$R_C = 2\ K\Omega$ Choose $\mathbf{R_C = 1.8\ K\Omega}$

Let $I_{R1} = 10\ I_B = 10 \times 20\ \mu A = 200\ \mu A$

$V_{R2} = V_{BE} + V_E = 0.6 + 1 = 1.6\ V$ (Since transistor is silicon make $V_{BE} = 0.6\ V$)

$R2 = V_{R1} / (I_{R1} - I_B) = 1.6 / (200\ \mu A - 20\ \mu A)$

$R2 = 8.8\ K\Omega$ Choose $\mathbf{R2 = 8.2\ K\Omega}$

$R1 = (V_{CC} - V_{R2}) / I_{R1} = (10 - 1.6) / 200\ \mu A$

$R1 = 42\ K\Omega$ Choose $\mathbf{R1 = 47\ K\Omega}$

$X_{CE} << R_E$

$X_{CE} = R_E / 10$

$1 / (2 \pi f C_E) = 470 / 10$ Let $f = 100$ Hz

$C_E = 33\ \mu F$ Choose $\mathbf{C_E = 47\ \mu F}$

Choose $\mathbf{C_{C1} = C_{C2} = 0.1\ \mu F}$

Tank Circuit : Assume fo = 1 kHz

$f_o = 1/[(2 \times \pi \times R \times C (6+4k)^{0.5}]$

where $k = R_c / R$, and $R_i = R_1 \parallel R_2 \parallel h_{ie}$

$4k+23+29/k = h_{fe}$

Assume $h_{fe} = \beta = 100$

Therefore $4k+23+29/k = 100$

$4k^2+23k+29 = 100$

$4k^2 - 77k + 29 = 0$

$k = 18.865$ or 0.385

if $k = 18.865$, $R_c / R = 18.865$

R is very small. Therefore proper oscillations are not obtained

Choosing k = 0.385

R_c = 1.8 k Ω

R = 4.675 k Ω

Choose R = 4.7 k Ω

$C = 1/[2 \times \pi \times f_o \times R\,(6+4 \times 0.385)^{0.5}]$

C = 0.012 μF

Choose C = 0.01 μF

R_i = 8.2K ‖ 47K ‖ 1.1K

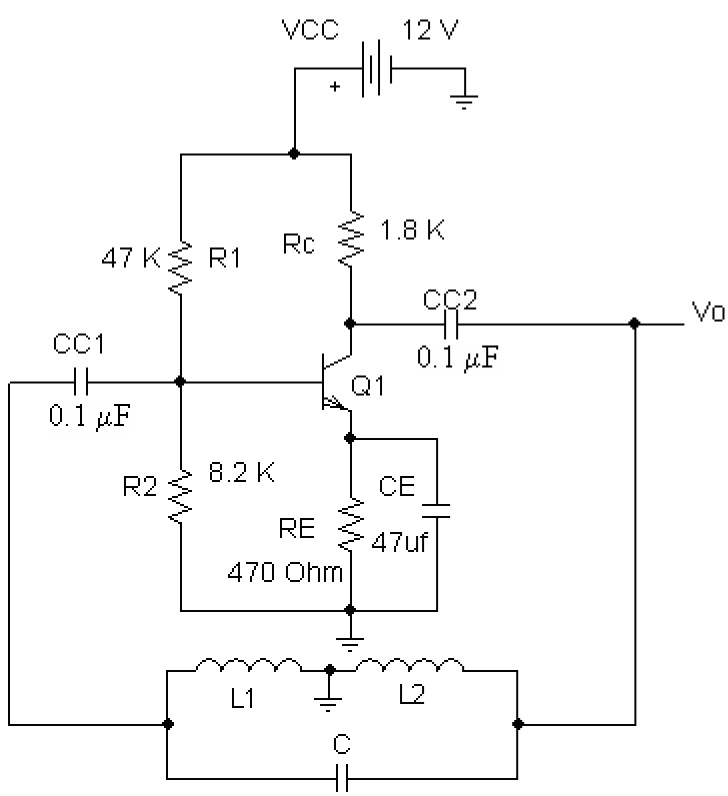
R_i = 0.9 k Ω

$R_3 = R - R_i$

R_3 = 3.8 k Ω

Tuned Oscillators (Hartley and Colpitt's)

Hartley Oscillator



→ It is a LC oscillator which uses two inductors & one capacitor in its tank circuit.

→ Two inductors L_1 & L_2 are connected in series across a capacitor C to complete the tank circuit.

→ The resistance R_1, R_2, R_C & R_E provides necessary bias to the circuit.

→ The capacitors C_{C1} & C_{C2} are coupling capacitors.

→ The feedback network consists of tank circuit made up of two inductors L_1, L_2 and capacitor C.

→ The CE amplifier provides a phase shift of $180°$.

→ When V_{CC} is switched ON, capacitor 'C' gets charged & tank circuit provides $180°$ phase shift.

→ When feedback is adjusted such that $|A\beta| = 1$, the circuit works as an oscillator.

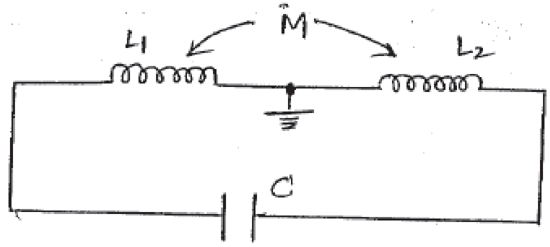
→ The frequency of oscillations is given by

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

There are 2 inductors L_1 & L_2 in series, hence equivalent inductance of the tank circuit is

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

frequency of oscillation of HARTLEY oscillator.



Feedback circuit.

In feedback circuit, sum of all the 3 reactances must be equal to zero.

i.e. $jX_{L1} + jX_{L2} + \frac{1}{jX_c} = 0$

$$jX_{L1} + jX_{L2} - jX_c = 0$$

$$\cancel{j}[X_{L1} + X_{L2}] = \cancel{j}X_c$$

$$\omega_{L1} + \omega_{L2} = \frac{1}{\omega c}$$

$$\omega(L_1 + L_2) = \frac{1}{\omega c}$$

$$\omega^2 = \frac{1}{(L_1+L_2)C}$$

$$\omega^2 = \frac{1}{L_{eq}C}$$ where $L_{eq} = (L_1+L_2)$

$$\omega = \frac{1}{\sqrt{L_{eq}C}}$$

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

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

Design :

Given, **V_{CE} = 5 V and I_C = 2 mA** Assume $\beta = 100$

$V_{CC} = 2V_{CE} = 2 X 5 =$ **10 V**

Let V_{RE} = 10% V_{CC} = 1 V

$R_E = V_{RE} / (I_C + I_B)$

$I_B = I_C / \beta = 2mA / 100 = 20\ \mu A$

$R_E = 1 / (2m + 20\mu) = 495\Omega$, Choose **$R_E$ = 470 Ω**

Apply KVL to collector loop

$V_{CC} - I_C R_C - V_{CE} - V_E = 0$

$R_C = (V_{CC} - V_{CE} - V_E) / I_C = (10 - 5 - 1) / 2\ m$

$R_C = 2\ K\Omega$ Choose **R_C = 1.8 KΩ**

Let $I_{R1} = 10\ I_B = 10 X 20\ \mu A = 200\ \mu A$

$V_{R2} = V_{BE} + V_E = 0.6 + 1 = 1.6\ V$ (Since transistor is silicon make V_{BE} = 0.6 V)

$R2 = V_{R1} / (I_{R1} - I_B) = 1.6 / (200\ \mu A - 20\ \mu A) = 8.8\ K\Omega$ Choose **R2 = 8.2 KΩ**

$R1 = (V_{CC} - V_{R2}) / I_{R1} = (10 - 1.6) / 200\ \mu A = 42\ K\Omega$ Choose **R1 = 47 KΩ**

$X_{CE} << R_E$, $X_{CE} = R_E / 10$

$1 / (2\ \pi\ f C_E) = 470 / 10$ Let f = 100 Hz

$C_E = 33\ \mu F$ Choose **C_E = 47 µF**

Choose **$C_{C1} = C_{C2}$ = 0.1 µF**

Hartley oscillator: Design of tank circuit: Assume fo = 100 kHz

Formula $f_o = 1 / 2\pi \sqrt{(L_T . C)}$

Where $L_T = L_1 + L_2$

Barkhausen's criterion is $A\beta = 1$

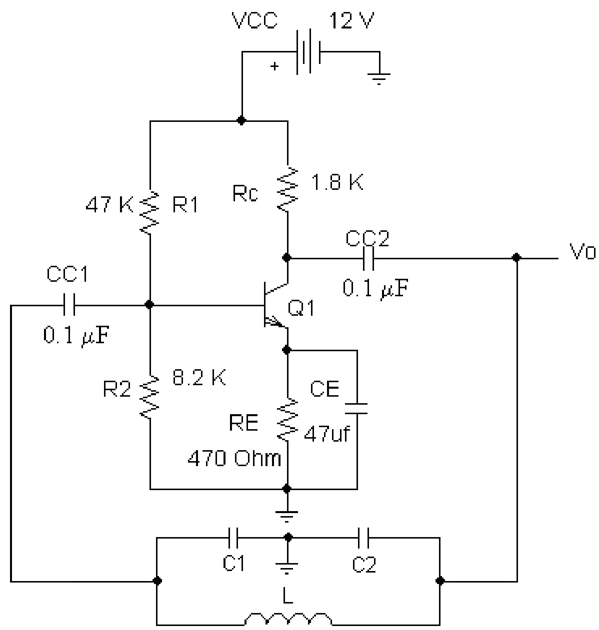
Therefore $\beta = 1/A = L_1 / L_2$

For this circuit, A = 2.4 because gain of the amplifier is 2.4

$L_2 = 2.4 . L_1$

Assume $L_1 = 100\ \mu H$, therefore $L_2 = 240\ \mu H$, then C = 7.45 nF

Colpitt's Oscillator



→ The tank circuit of Colpitt's oscillator uses 2 capacitors & one inductor.

→ The two capacitors C_1 & C_2 are connected in series across the inductor L.

→ The resistance R_1, R_2 R_C & R_E provides necessary bias to the circuit.

→ The capacitors C_{c1} & C_{c2} are Coupling Capacitors.

→ The capacitance divider C_1 & C_2 in tank circuit provides necessary feedback for oscillations.

→ The CE amplifier provides a phase shift of 180°.

→ When the supply is switched ON, the oscillatory current is setup in the tank circuit. It produces ac voltages across C_1 & C_2. Tank circuit provides 180° phase shift.

→ The frequency of oscillations is given by

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

where, $C_{eq} = \dfrac{C_1 C_2}{C_1 + C_2}$

frequency of oscillation of COLPITTS oscillator.

sol^n: The frequency of oscillation can be easily obtained. In feedback circuit, shown in fig, sum of all the three reactances must be equal to zero.

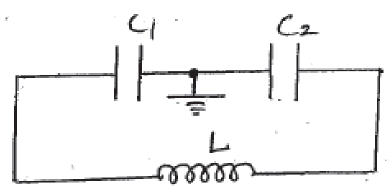


fig:- Feedback circuit

$$\text{ie.} \quad \frac{1}{jX_{C_1}} + \frac{1}{jX_{C_2}} + jX_L = 0$$

$$-jX_{C_1} - jX_{C_2} + jX_L = 0$$

$$jX_L = jX_{C_1} + jX_{C_2}$$

$$\cancel{j}X_L = \cancel{j}[X_{C_1} + X_{C_2}]$$

$$\omega L = \frac{1}{\omega C_1} + \frac{1}{\omega C_2}$$

$$\omega L = \frac{1}{\omega}\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$

$$\omega^2 = \frac{1}{L}\left[\frac{C_1 + C_2}{C_1 C_2}\right]$$

$$(2\pi f)^2 = \frac{1}{L\left[\frac{C_1 C_2}{C_1 + C_2}\right]}$$

$$(2\pi f)^2 = \frac{1}{L \cdot C_{eq}} \quad \text{--- where} \quad C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$2\pi f = \frac{1}{\sqrt{L \cdot C_{eq}}}$$

$$\boxed{f = \frac{1}{2\pi\sqrt{L \cdot C_{eq}}}}$$

Design :

Given, **V_{CE} = 5 V and I_C = 2 mA** Assume $\beta = 100$

$V_{CC} = 2V_{CE} = 2 \times 5 =$ **10 V**

Let $V_{RE} = 10\% \, V_{CC} = 1$ V

$R_E = V_{RE} / (I_C + I_B)$

$I_B = I_C / \beta = 2\text{mA} / 100 = 20\ \mu\text{A}$

$R_E = 1 / (2\text{m} + 20\mu) = 495\Omega$, Choose **$R_E$ = 470 Ω**

Apply KVL to collector loop

$V_{CC} - I_C R_C - V_{CE} - V_E = 0$

$R_C = (V_{CC} - V_{CE} - V_E) / I_C = (10 - 5 - 1) / 2\,m$

$R_C = 2\ K\Omega$ Choose **$R_C = 1.8\ K\Omega$**

Let $I_{R1} = 10\ I_B = 10 \times 20\ \mu A = 200\ \mu A$

$V_{R2} = V_{BE} + V_E = 0.6 + 1 = 1.6\ V$ (Since transistor is silicon make $V_{BE} = 0.6\ V$)

$R2 = V_{R1} / (I_{R1} - I_B) = 1.6 / (200\ \mu A - 20\ \mu A) = 8.8\ K\Omega$ Choose **$R2 = 8.2\ K\Omega$**

$R1 = (V_{CC} - V_{R2}) / I_{R1} = (10 - 1.6) / 200\ \mu A = 42\ K\Omega$ Choose **$R1 = 47\ K\Omega$**

$X_{CE} << R_E,\quad X_{CE} = R_E / 10$

$1 / (2 \pi f C_E) = 470 / 10$ Let $f = 100$ Hz

$C_E = 33\ \mu F$ Choose **$C_E = 47\ \mu F$**

Choose **$C_{C1} = C_{C2} = 0.1\ \mu F$**

Colpitt's oscillator: Design of tank circuit: Assume fo = 100 kHz

Formula $f_o = 1 / 2\pi \sqrt{(C_T . L)}$

Where $C_T = C_1 . C_2 / (C_1 + C_2)$

Barkhausen's criterion is $A.\beta = 1$

Therefore $\beta = 1/A = C_2/ C_1$

For this circuit, A = 2.4 because gain of the amplifier is 2.4

$C_1 = 2.4 . C_2$

Assume $C_2 = 0.01\ \mu F$, therefore $C_1 = 0.024\ \mu F$, then $L = 358.8\ \mu H$

the amplifier by the feed back network and the process repeats to give suitable oscillation at output terminal

WEIN BRIDGE Oscillator

→ Generally in an oscillator, amplifier stage introduces 180° phase shift & feedback network introduces additional 180° phase shift, to obtain a phase shift of 360° around a loop. This is the required condition for any oscillator.

→ But Wien Bridge oscillator uses a non-inverting amplifier & hence does not provide any phase shift during amplifier stage.

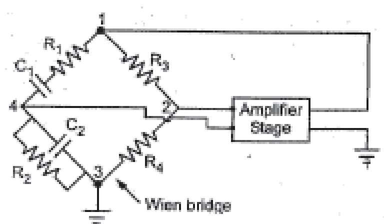
→ Thus no phase shift is necessary through feedback. ie. Total phase-shift around a loop is 0°.

❖ WEIN BRIDGE OSCILLATOR :-

→ Fig shows Wein bridge oscillator

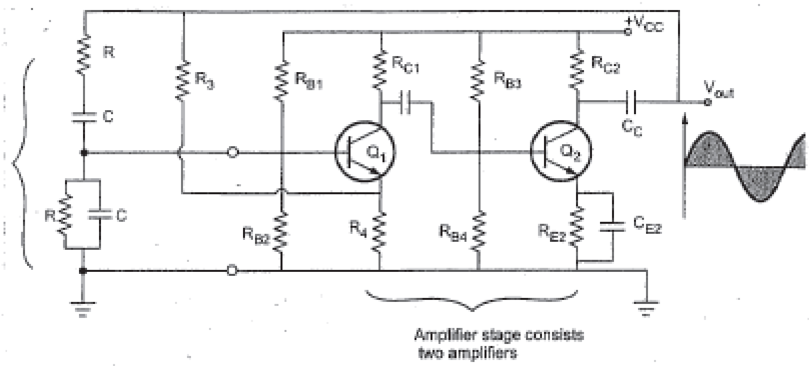
→ The o/p of the amplifier is applied between the Terminals 1 & 3, which is the i/p to the feedback network.

→ While the amplifier i/p is supplied from the diagonal Terminals 3 & 4 which is the o/p from the feedback network.



Basic circuit of Wien bridge oscillator

→ This is because the components of these two arms decide the frequency of the oscillator.



Transistorised Wien bridge oscillator

→ The Wien bridge oscillator consists of two stage common emitter transistor amplifier.

→ Each stage contributes 180° phase shift hence the total phase shift due to the amplifier stage becomes 360° or 0° which is necessary as per the oscillator conditions.

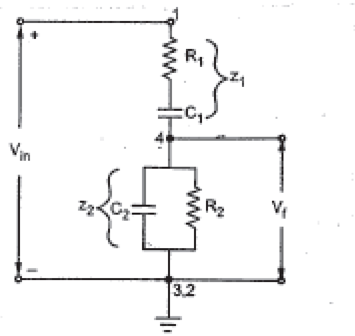
→ The bridge consists of R_1 & C_1 in series, R_2 & C_2 in parallel, R_3 & R_4.

→ The feedback is applied from the collector of Q_2 through the coupling capacitor, to the bridge circuit.

→ The resistance R_4 serves the dual purpose of emitter-resistance of the transistor Q_1 & also the element of the Wien bridge.

→ The two stage amplifier provides a gain much more than 3 & it is necessary to reduce it.

* The two arms of the bridge namely R_1, C_1 in series & R_2, C_2 in parallel are called frequency sensitive arms.



Feedback network of Wien bridge oscillator

* To reduce the gain, the negative feedback is used without bypassing the resistance R_4.
* The -ve feedback can accomplish the gain stability & can control the o/p magnitude.
* The -ve feedback also reduces the distortion & therefore o/p obtained is a pure sinusoidal in nature.
* The amplitude stability can be improved using non-linear resistor for R_4.
* Thus the loop gain depends on the amplitude of the oscillations.
* Increase in the amplitude of the oscillations, increases the current through non-linear resistance, a greater amount of -ve feedback is applied. This reduces the loop gain. Hence signal amplitude gets reduced & controlled.
* The expression for the frequency of oscillation is obtained from the balancing condition of the bridge.

→ The balancing condition is given by

$$\boxed{\frac{R_3}{R_4} = \frac{R_1}{R_2} + \frac{C_2}{C_1}} \quad \text{—(1)}$$

if $R_1 = R_2 = R$ & $C_1 = C_2 = C$

$$\frac{R_3}{R_4} = \frac{\cancel{R}^{1}}{\cancel{R}_{1}} + \frac{\cancel{C}^{1}}{\cancel{C}_{1}}$$

$$\frac{R_3}{R_4} = 1 + 1 \quad \Rightarrow \boxed{\frac{R_3}{R_4} = 2} \quad \text{—(2)}$$

→ In the bridge R_1, R_2, C_1 & C_2 are known as frequency selecting circuit.

The frequency of oscillation is given by

$$\boxed{f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}} \quad \text{—(3)}$$

if $R_1 = R_2 = R$ & $C_1 = C_2 = C$

$$\boxed{f = \frac{1}{2\pi RC}} \quad \text{—(4)}$$

→ In order to obtain sustained oscillations the gain of the amplifier should be atleast equal to 3.

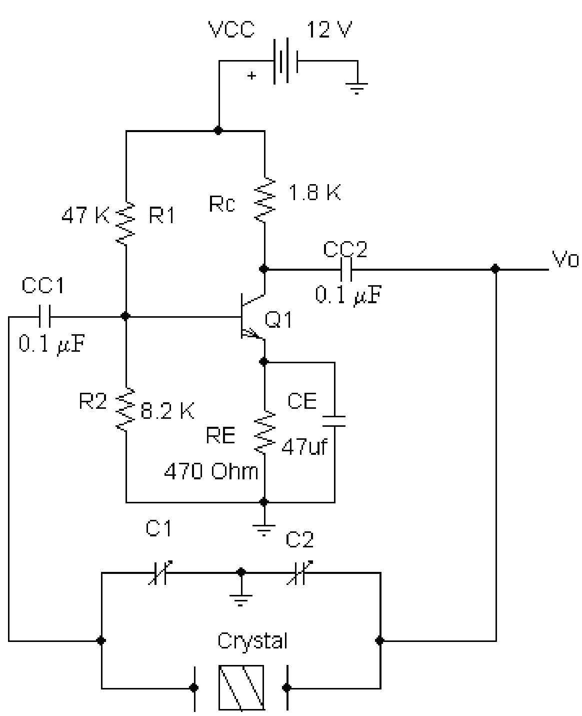
$$\therefore\ 1 + \frac{R_3}{R_4} \geq 3$$

$$\boxed{\frac{R_3}{R_4} \geq 2} \quad \text{—(5)}$$

Comparison of RC phase shift and WEIN bridge oscillator.

	RC Phase Shift Oscillator	Wien Bridge Oscillator
1.	It is a phase shift oscillator used for low frequency range.	It is also a phase shift oscillator used for low frequency range.
2.	The feedback network is RC network with three RC sections.	The feedback network is lead-lag network which is called Wien bridge circuit.
3.	The feedback network introduces 180° phase shift.	The feedback network does not introduce any phase shift.
4.	Amplifier circuit introduces 180° phase shift.	Amplifier circuit does not introduce any phase shift.
5.	The frequency of oscillations is, $f = \frac{1}{2\pi RC\sqrt{6}}$	The frequency of oscillations is, $f = \frac{1}{2\pi RC}$
6.	The amplifier gain condition is, $\lvert A \rvert \geq 29$	The amplifier gain condition is, $\lvert A \rvert \geq 3$
7.	The frequency variation is difficult.	Mounting the two capacitors on common shaft and varying their values, frequency can be varied.

Crystal Oscillator



A **crystal oscillator** is an electronic circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wristwatches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits designed around them were called "crystal oscillators".

→ The resistance R_1, R_2 R_C & R_E provides necessary bias to the circuit.

→ The capacitors C_{c1} & C_{c2} are Coupling Capacitors.

→ The crystal behaves as an inductor for a frequency slightly higher than the series resonance frequency f_s.

→ The two capacitors C_1, C_2 required in the tank ckt along with an crystal.

→ The resulting circuit frequency is set by the series resonant frequency of the crystal.

→ Change in supply voltages, Temperature, transistor-parameters have no effect on the circuit operation-condition & hence good frequency stability is obtained.

→ The CE amplifier provides a phase shift of 180°.

∴ The Total phase-shift is 0° or 360°.

→ When feedback is adjusted such that $|A\beta| = 1$, the circuit works as an oscillator.

→ Series resonance frequency

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

→ Parallel resonance frequency:

The equivalent capacitance is

$$\boxed{C_{eq} = \frac{C_M C}{C_M + C}}$$

C_M → mounting capacitance

$$\boxed{f_p = \frac{1}{2\pi\sqrt{L C_{eq}}}}$$

ADVANTAGES :-

1> The frequency stability of the crystal is very high.
2> The temperature stability of a crystal is very good. ie the frequency drift due to temperature change is negligibly small.
3> Quartz crystals are readily available in nature.
4> Crystal replaces inductor in the tank circuit. As a result, crystal oscillator circuits are less bulky, inexpensive & lighter in weight.

DISADVANTAGES :-

1> Crystals are very delicate & hence require careful handling.
2> The thickness of the crystal is inversly proportional to the frequency. Hence higher frequency crystals are thinner in size & are mechanically weak.

Design :

Given, $\mathbf{V_{CE} = 5\ V}$ and $\mathbf{I_C = 2\ mA}$ Assume $\beta = 100$

$V_{CC} = 2V_{CE} = 2 \times 5 = \mathbf{10\ V}$

Let $V_{RE} = 10\%\ V_{CC} = 1\ V$

$R_E = V_{RE} / (I_C + I_B)$

$I_B = I_C / \beta = 2mA / 100 = 20\ \mu A$

$R_E = 1 / (2m + 20\mu) = 495\Omega$, Choose $\mathbf{R_E = 470\ \Omega}$

Apply KVL to collector loop

$V_{CC} - I_C R_C - V_{CE} - V_E = 0$

$R_C = (V_{CC} - V_{CE} - V_E) / I_C = (10 - 5 - 1) / 2\ m$

$R_C = 2\ K\Omega$ Choose $\mathbf{R_C = 1.8\ K\Omega}$

Let $I_{R1} = 10\ I_B = 10 \times 20\ \mu A = 200\ \mu A$

$V_{R2} = V_{BE} + V_E = 0.6 + 1 = 1.6\ V$ (Since transistor is silicon make $V_{BE} = 0.6\ V$)

$R2 = V_{R1} / (I_{R1} – I_B) = 1.6 / (200\ \mu A - 20\ \mu A) = 8.8\ K\Omega$ Choose $\mathbf{R2 = 8.2\ K\Omega}$

$R1 = (V_{CC} – V_{R2}) / I_{R1} = (10 – 1.6) / 200\ \mu A = 42\ K\Omega$ Choose $\mathbf{R1 = 47\ K\Omega}$

$X_{CE} << R_E$, $X_{CE} = R_E / 10$

$1 / (2 \pi f C_E) = 470 / 10$

Let f = 1MHz; $C_E = 33\ \mu F$ Choose $\mathbf{C_E = 47\ \mu F}$

Choose $\mathbf{C_{C1} = C_{C2} = 0.1\ \mu F; C1=C2=0.001 \mu F}$

❖ FREQUENCY STABILITY OF OSCILLATOR :-

❖ **What is frewuency stability in oscillators? What factors affect the frequency stability. Explain how crystal oscillator provides good stability.** **June-09,6M**

The factors which affect the frequency stability of an oscillator are as follows :-

1> Due to change in temperature, the values of inductors, capacitors in tank circuit changes, due to which frequency does not remain stable.

2> Due to change in temperature, the parameters of the active devices used like BJT, FET get affected which inturn affect the frequency.

3> The variation in the power supply is another factor affecting the frequency.

4> The changes in the load connected, affect the effective resistance of the tank circuit.

5> The capacitive effect in transistor & stray capacitances, affect the capacitance of the tank circuit & hence the frequency.

1> In a RC-phase shift oscillator, phase shift n/w uses resistance each of $R = 4.7\,K\Omega$ & capacitance each of $C = 0.47\,\mu F$. Find frequency of oscillation.

Sol^n → Given: $R = 4.7\,K\Omega$, $C = 0.47\,\mu F$.

$$f = \frac{1}{2\pi RC\sqrt{6}} = \frac{1}{2\pi \times 4.7K \times 0.47\mu \times \sqrt{6}}$$

$$\boxed{f = 29.41\ Hz}$$

2> Estimate the value of R & C for feedback n/w of RC phase shift oscillator for a frequency of 1 KHz.

Sol^n: w.k.t $f = \frac{1}{2\pi RC\sqrt{6}}$

$$RC = \frac{1}{2\pi f\sqrt{6}} = 6.497 \times 10^{-5}$$

let $C = 0.1\,\mu F$

then $R = \frac{6.497 \times 10^{-5}}{0.1\,\mu F}$

$$\boxed{R = 649.74\ \Omega}$$

4> An RC-phase shift oscillator uses a transistor with $h_{fe} = 100$. If $R_c = 10\,k\Omega$ & $R = 2\,k\Omega$, will this ckt oscillate?

Sol^n: Condition for sustained oscillations is

$$h_f > 4k + 23 + 29/k.$$

w.k.t. $K = \frac{R_C}{R} = \frac{10k}{2k} = 5.$

$$h_{fe} > (4)(5) + 23 + 29/5$$

$$\boxed{h_{fe} > 48.8}$$

since the h_{fe} of the transistor is 100 which is greater than 48.8, the circuit oscillates.

---

5) Find the value of R_C for an RC-phase shift oscillator for a frequency of oscillation of 1000 Hz. A transistor with $h_{fe} = 200$ & $R = 2.7\,k\Omega$. will this circuit oscillates ?

Soln: The condition to get sustained oscillation is

$$h_{fe} > 4K + 23 + \frac{29}{K}$$

$$200 > 4K + 23 + \frac{29}{K}$$

Choose $K = 1$,

$$200 > 4(1) + 23 + 29/1$$

$$\boxed{200 > 56}$$

Since h_{fe} of the transistor is 200 which is greater than 56, the circuit oscillates.

→ w.k.t $K = \frac{R_C}{R}$

$$\therefore R_C = K R$$

$$= (1)(2.7\,k\Omega)$$

$$\therefore \boxed{R_C = 2.7\,k\Omega}$$

❖ **Calculate operating frequency of a BJT Phase-shift oscillator for $R=6K\Omega$, $C=1500pF$, $R_C=18k\Omega$. Determine minimum current gain of transistor required for sustained oscillations.** **Jan-09,6M**

Given : $R = 6K\Omega$, $R_c = 18K\Omega$, $C = 1500pF$, $f = ?$ & $h_{fe} = ?$

Sol :-

* $K = \dfrac{R_c}{R} = \dfrac{18K\Omega}{6K\Omega} = 3$

* $f = \dfrac{1}{2\pi RC\sqrt{6+4K}} = \dfrac{1}{2\pi \times 6K\Omega \times 1500\,pF \cdot \sqrt{6+(4\times 3)}}$

$\boxed{f = 4.168\,KHz} \longleftarrow \boxed{4M}$

* Condition for Sustained oscillation is given by:

$h_{fe} > 4K + 23 + \dfrac{29}{K}$

$h_{fe} > (4\times 3) + 23 + \dfrac{29}{3}$

$\boxed{h_{fe} > 44.66} \longleftarrow \boxed{2M}$

1) The following circuit parameter values are given for the hartley oscillator.

$L_1 = 750\ \mu H$, $L_2 = 750\ \mu H$, $M = 150\ \mu H$.

$L_{RFC} = 0.5\ mH$, $C = 150\ pF$, $C_L = 10\ \mu F$, $h_{fe} = 50$

a) Calculate the frequency of oscillations.

b) Check to make sure that the condition for oscillation is satisfied.

Sol^n : a) $f = \dfrac{1}{2\pi\sqrt{L_{eq} C}}$

$$L_{eq} = L_1 + L_2 + 2M$$

$$= 750\ \mu H + 750\ \mu H + 2 \times 150\ \mu H$$

$$L_{eq} = \underline{\underline{1800}}\ \mu H$$

$$\therefore \boxed{f = 306.25\ KHz}$$

b) Condition for sustained oscillation taking mutual inductance into account is

$$h_{fe} \geq \frac{L_1 + M}{L_2 + M}$$

given, $h_{fe} = 50$

$$h_{fe} \geq \frac{750\ \mu H + 150\ \mu H}{750\ \mu H + 150\ \mu H} = 1$$

$$\boxed{h_{fe} = 1}$$

$\therefore$ The condition for oscillation is satisfied.

2> In a transistor hartley oscillator, $L_1 = 10\mu H$, $L_2 = 10\mu H$. Find the value of C required for an oscillating frequency of 150 KHz.

Soln :

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

$$f^2 = \frac{1}{4\pi^2(\sqrt{L_{eq}C})^2}$$

$$f^2 = \frac{1}{4\pi^2 \cdot L_{eq}C}$$

$$\boxed{L_{eq} = \frac{1}{4\pi^2 f^2 C}}$$

$$C = \frac{1}{4\pi^2 f^2 \cdot L_{eq}}$$

w.k.t

$$L_{eq} = L_1 + L_2 + 2M$$

Since 'M' is not given we can take $M = 0$

$$L_{eq} = 10\mu H + 10\mu M + 0$$

$$\boxed{L_{eq} = 20\mu H}$$

$$C = \frac{1}{4\pi^2 f^2 \cdot L_{eq}} = \frac{1}{4\pi^2(150\times10^3)^2 \times (20\mu H)}$$

$$\boxed{C = 56.28\,nF}$$

3> In a transistor hartley oscillator $C = 0.01\mu F$ & $h_{fe} = 50$. Find the values of L_1 & L_2 required for a frequency of oscillation of 150 kHz.

Soln : w.k.t $L_{eq} = \frac{1}{4\pi^2 f^2 C} = 112.5\,\mu H.$

Neglecting mutual inductance

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

$$\therefore \boxed{L_1 + L_2 = 112.5\ \mu H} \quad \text{--- (1)}$$

Condition for oscillation

$$h_{fe} \geq \frac{L_1}{L_2}$$

$$50 \geq \frac{L_1}{L_2}$$

$$\frac{L_1}{L_2} \leq 50 \quad \Rightarrow \quad \boxed{L_1 \leq 50 L_2}$$

select $L_1 = 10L_2$

let $\boxed{\frac{L_1}{L_2} = 10}$

$$\frac{L_1}{L_2} = 10$$

$$L_1 = 10L_2 \quad \text{--- (2)}$$

substituting eqⁿ (2), in eqⁿ (1)

$$L_1 + L_2 = 112.5\ \mu H$$

$$10L_2 + L_2 = 112.5\ \mu H$$

$$11L_2 = 112.5\ \mu H$$

$$L_2 = \frac{112.5\ \mu H}{11}$$

$$\boxed{L_2 = 10.23\ \mu H} \quad \text{--- (3)}$$

Sub eq (3) ie value of L_2 in eqⁿ (1)

$$L_1 + L_2 = 112.5\ \mu H$$

$$L_1 + 10.23\ \mu H = 112.5\ \mu H$$

$$L_1 = 112.5\ \mu H - 10.23\ \mu H$$

$$\boxed{L_1 = 102.3\ \mu H}$$

1) The following data are available for the Colpitts oscillator
$C_1 = 1nF$, $C_2 = 99nF$, $L = 1.5mH$, $L_{RFC} = 0.5mH$, $C_c = 10\mu F$, $h_{fe} = 110$

a) Calculate the frequency of oscillation.

b) Check to make sure that the condition for oscillation is satisfied.

Soln: a)

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

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{(1nF)(99nF)}{1nF + 99nF} = 0.99nF$$

$$f = \frac{1}{2\pi\sqrt{(1.5mH)(0.99nF)}} = 130.6\ KHz.$$

b) Condition for sustained oscillation is

$$h_{fe} \geq \frac{C_2}{C_1}$$

$$\frac{C_2}{C_1} = \frac{99nF}{1nF} = 99$$

Given $h_{fe} = 110$

$$\therefore 110 \geq 99$$

Thus the condition for oscillation is satisfied.

3) In a colpitts oscillator, $C_1 = C_2 = C$ & $L = 100\,\mu H$. The frequency of oscillation is 500 kHz. Determine value of C.

Soln : $L = 100\,\mu H$, $C_1 = C_2 = C$ & $f = 500\,kHz$.

$$f = \frac{1}{2\pi\sqrt{L.C_{eq}}}$$

$$f^2 = \frac{1}{4\pi^2.L.C_{eq}}$$

$$C_{eq} = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4\pi^2 (500\,kHz)^2 (100\,\mu H)}$$

$$\boxed{C_{eq} = 1.0132 \times 10^{-9} F}$$

but $C_{eq} = \dfrac{C_1 C_2}{C_1 + C_2}$

and $C_1 = C_2 = C$

$$\therefore C_{eq} = \frac{(C)(C)}{C+C} = \frac{C^{\cancel{2}}}{2\cancel{C}}$$

$$\boxed{C_{eq} = \frac{C}{2}} \Rightarrow \boxed{C = 2C_{eq}}$$

$$1.0132 \times 10^{-9} F = \frac{C}{2}$$

$$\boxed{C = 2.026\ nF}$$

4> Design the value of an inductor to be used in Colpitt's oscillator to generate a frequency of 10MHz. The circuit is used a value of $C_1 = 100\,pF$ & $C_2 = 50\,pF$

Sol^n^ : $C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = 33.33 \times 10^{-12}\,F$

$$f = \frac{1}{2\pi\sqrt{L \cdot C_{eq}}}$$

$$L = \frac{1}{4\pi^2 f^2 \cdot C_{eq}}$$

$$\therefore \boxed{L = 7.6\,\mu H}$$

1) The following component values are given for the Wien bridge oscillator of the circuit.

$R_1 = R_2 = 33\,k\Omega$, $C_1 = C_2 = 0.001\,\mu F$, $R_3 = 47\,k\Omega$, $R_4 = 15\,k\Omega$

a) Will this circuit oscillate ?

b) Calculate the resonant frequency ?

c) Suggest the RC elements to increase the frequency by two fold.

Sol^n: a) $\dfrac{R_3}{R_4} = \dfrac{47\,k\Omega}{15\,k\Omega} = 3.13$

condition for circuit oscillation

$$\frac{R_3}{R_4} > 2$$

The circuit oscillates since $\dfrac{R_3}{R_4} > 2$.

b) $R_1 = R_2 = R = 33\,k\Omega$, $C_1 = C_2 = C = 0.001\,\mu F$

$$f = \frac{1}{2\pi RC}$$

$$f = \frac{1}{2\pi (33\,k\Omega)(0.001\,\mu F)} = 4.82\ kHz.$$

c) When f is increased i.e. $2 \times f_{old}$, find the values of R & C

$$f_{new} \longrightarrow 2 \times f_{old} = 2 \times 4.82\ kHz.$$

$$f_{new} = 9.64\ kHz.$$

w.k.t $f_{new} = \frac{1}{2\pi RC}$

$$RC = \frac{1}{2\pi f_{new}}$$

Assume or Choose $C = 0.001\ \mu F$

Now, $R = \frac{1}{2\pi C \cdot f_{new}} = \frac{1}{2\pi(9.64\ KHz)(0.001\ \mu F)} = \underline{\underline{16.5\ k\Omega}}$

- **Calculate the frequency of a wein bridge oscillator circuit when R=12K ohm and C=2400pf.** **June-08,4M**

Given :- $R = 12k\Omega$, $C = 2400pF$, $f = ?$

$$f = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 12k\Omega \times 2400\ pF} = \underline{5.526\ KHz}$$