Basic Concept

1) | E | B | C | active

↓ I_E F.B [Forward Bias]   ↓ I_C R.B [Reverse Bias]

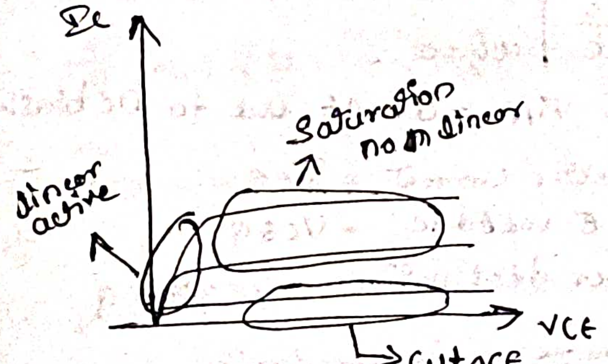
2) | E | B | C | Saturation

FB   FB

3) | E | B | C | Cut off

RB   RB

O/P characteristics

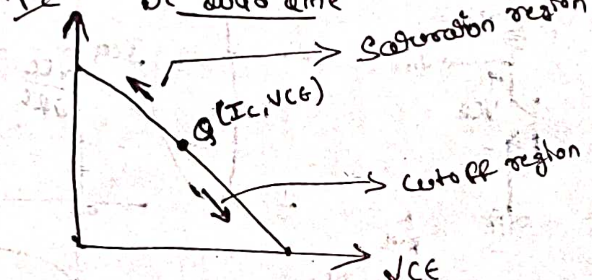


Types of power amplifier :-

operating point

$Q = f(I_C, V_{CE})$

DC load line



V. I Amplifier → active or linear (Q)

Power amplifier → linear & non linear (Q)

[Silicon - 0.7V
Germanium - 0.2V]

→ NPN

if V I/P > 0.7V
then BE Junction - F.B

if V I/P < 0.7V
then BE Junction - R.B

Rever PNP V I/P < -0.7V then F.B
V I/P > +0.7V then R.B

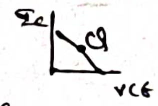
O/P = No signal it called Dead Zone

Classification

1

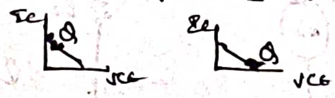
1. Class A Amplifier

linear → Q → middle of DC load line



2. Class B amplifier

non-linear → Q → Top or Q → Bottom



3. Class AB amplifier

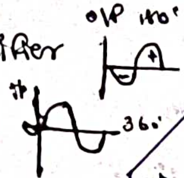
Slightly above cutoff
Slightly below saturation
(non-linear)

4. Class C amplifier

Q → deep cutoff
deep saturation
non-linear

* Non-linear mean's distortion

Characteristics of Class A amplifier



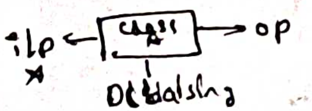
1) o/p current flow entire cycle (0° to 360°) (active point)
2) Does not have non-linear distortions
3) Nature of i/p signal not changed at o/p.
4) Q point lies in the middle of load line (Active region)
5) low conversion efficiency = 25%. [10W i/p − 2.5 o/p] ($P_{DC} \to P_{AC}$)
6) power dissipation high when i/p is not amplified.
7) provide undistorted o/p (because of linear region)
8) Conduction angle (360°)

Advantage

1. Distortion ✗
2. thermal Run away ✗ [self dissipation]

Disadvantage

1) % η low
2) power drain



Class A power amplifiers

1) A class A power amplifier is one in which the o/p current flows for the entire cycle of the AC i/p supply

* Hence the complete signal present at the i/p is amplified at the o/p
* In fig. shows the operating point of a class amplifier is present in the linear region.
* It is so selected that the current flows for the entire ac i/p cycle.
* The wave form fig shows the selection of operating point.
* The o/p characteristics with operating point Q is shown in the fig.
* Here $(I_C)_Q$ & $(V_{CE})_Q$ represent no signal collector current & voltage b/w collector & emitter respectively
* when the signal is applied, the 'Q' point shifts to Q_1 & Q_2
* The o/p current increases to $(I_C)_{max}$ & decreases to $(I_C)_{min}$. Similarly the collector-emitter voltage increases to $(V_{CE})_{max}$ & decreases to $(V_{CE})_{min}$.

expressions $I_{BQ} = \frac{(V_{CC} - 0.7)}{R_B}$, $I_{CQ} = \beta I_{BQ}$

$V_{EQ} = V_{CC} - I_{CQ}R_L$

Q point at (V_{CEQ}, I_{CQ}) P_{dc} (i/p) $= V_{CC}I_{CQ}$

$P_{ac} = \frac{((V_{max} - V_{min}) - (I_{max} - I_{min}))}{8}$

Power dissipation.
$P_d = P_{dc} - P_{ac}$.
o/p − i/p

eff % $= \frac{i/p (P_{ac})}{o/p\ P(dc)} \times 100$

Advantages of Class-A amplifier:-

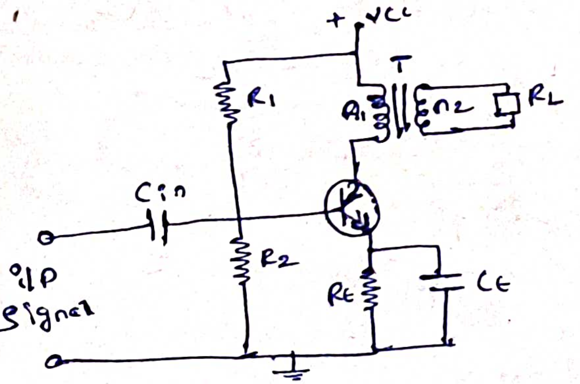
- → The current flows for complete i/p cycle
- → It can amplify small signals
- → The o/p is same as i/p
- → No distortion is present.

disadvantages

- → low power o/p
- → Low collector efficiency

Transformer Coupled Class A amplifier

* The construction of ~~class A pow~~ transformer coupled class A amplifier this is similar to the normal amplifier ckt. but connected with a transformer in the collector load.
* Here R_1 & R_2 provide potential divider arrangement.



* The RE resistor provides stabilization.
* Ce is the bypass capacitor & Re to prevent ac voltage

* The transformer is used here step-down transformer
* The transformer used in the collector ckt is for impedance matching.
* R_L is connected to the secondary of the transformer

operation :-

* If the peak value of the collector current due to signal is equal to zero. signal collector current
* then the max. ac power o/p is obtained. So in order to achieve the complete amplification
* the operating point should lie at the center of the load line.
* The operating point obviously varies the signal is applied.
* The collector voltage varies in opposite to the collector current.
* The variation of collector voltage appears across the primary of the transformer.
* The effi. is nearly 50%

$$\text{primary } R_L = \left[N_1/N_2\right]^2 R_L \qquad V_{cc(rms)} = \frac{V_{cc(P)}}{2\sqrt{2}}$$

$$P_{i/p} = V_{cc} \times I_c \qquad \text{Power dissipation } P_d = P_{dc} = V_{cc} I_{cq}$$

$$P_{o/p} = \frac{V_{cc} \times I_c}{2} \qquad \%\eta = \frac{P_{o/p}}{P_{i/p}} \times 100$$

$$I_{c(rms)} = \frac{I_{c(P)}}{\sqrt{2}}$$

Slope of dc load line ideally ∞.

Transformer coupled class A amplifier

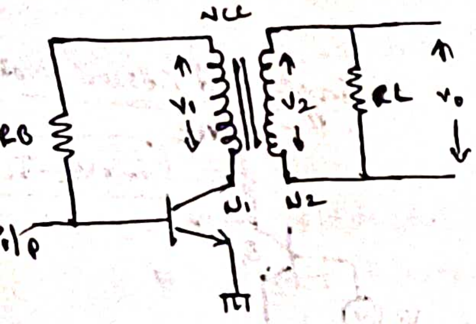
why this → η% ↑

Note :- Dc power disipation ↓

efficiency = ↑

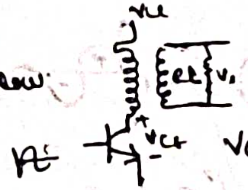
10W ⟶ 5W
i/p o/p

ckt



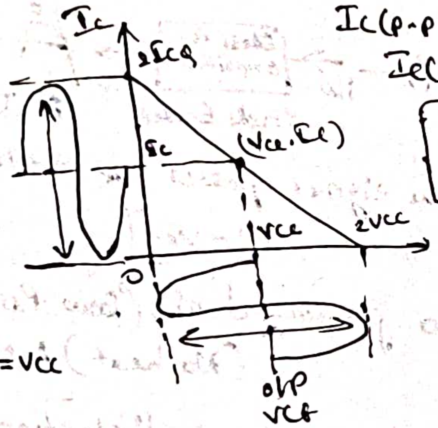
How η increase

R_C → I_C flows
loss
don't flow
In T/F → $I_C \times R_L$



At $V_{CE} = V_{CC}$

Load line



$I_C(p\text{-}p) = 2I_C - 0$

$I_C(p) = I_C \quad \left[\frac{2I_C}{2}\right]$

$$I_C(rms) = \frac{I_C(p)}{\sqrt{2}}$$

$V_{CE}(p\text{-}p) = 2V_{CC}$

$V_{CC}(p) = V_{CC} \left[\frac{2V_{CC}}{2}\right]$

$$V_{CC}(rms) = \frac{V_{CC}(p)}{\sqrt{2}}$$

Basic of T/F

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$, $\frac{I_1}{I_2} = \frac{N_2}{N_1}$

$\frac{V_2}{I_2} = R_L$. $\frac{V_1}{I_1} = R_{ep} = \frac{V_2 \times \frac{N_1}{N_2}}{I_2 \times \frac{N_2}{N_1}}$

$= \frac{V_2}{I_2} \times \left(\frac{N_1}{N_2}\right)^2$

$$R_L(\text{primary}) = R_L\left(\frac{N_1}{N_2}\right)^2$$

∴ $P_{o/p} = V_{rms} \times I_{rms}$

$$P_{o/p} = \frac{V_{CC} \times I_C}{2}$$

$P_{i/p} = V_{CC} \times I_C$

$$P_{i/p} = V_{CC} \times I_C$$

$\%\eta = \frac{P_{o/p}(AC)}{P_{i/p}(DC)} \times 100$

$= \frac{V_{CC} \times I_C}{2(V_{CC} \times I_C)}$

$= \frac{1}{2} \times 100$

$$\%\eta = 50\%$$

in t/f coupled class-A load are almost speakers.

problems on class-A.

1) A T/F coupled class-A amplifier supplies 3watt power to speaker if supply voltage is 30V & I_{CQ} is 200mA. then find η% of this amplifier

$P_{oc} = 3w$

$\eta\% = \frac{P_{o/p}(ac)}{P_{i/p}(dc)}$

speaker - load
$P_{o/p} = 3W$

$P_{in} = V_{CC} \times I_C$

$= 30 \times 200$

$= 6000\ mW$

$$P_{in} = 6watt$$

$\eta\% = \frac{P_{o/p}}{P_{i/p}} = \frac{3}{6} = 0.5$

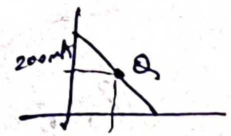
$$\eta = 50\%$$

2) If series fed direct coupled class-A amplifier supplies 0.8w power to speaker if supply voltage is 30V & I_{CQ} is 200mA - then find the η% of this amplifier.

$P_{o/p} = 0.8W$

$V_{CC} = 30V$

$I_{CQ} = 200mA$



advantages T/F class A amplifier

* No loss of signal power in the base or Collector resistor
* Excellent impedance matching is achived.
* Gain is high.
* DC isolation is provided.

disadvantages

* Low frequency signals are less amplified Comparatively
* Hum Noise is introduced by transformer
* Transformer are bulky & Costly
* Poor frequency response

$P_{in} = V_{cc} \times I_{cq}$

$= 30 \times 200$

$= 6000 mA\ Watt/10^3$

$P_{in} = 6W$

$P_{o/p} = 0.8W$

[Note:- in T/F Coupled amplifier o/p is high because effi. is 50% high in Series fed that is 25% low]

$\eta = \frac{P_{o/p}(ac)}{P_{in}(DC)} = \frac{0.8}{6} \times 100$

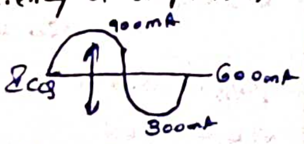
$= 0.13 \times 100$

$\eta = 13\%$

Q. Single Stage Class A Amplifier has

$V_{cc} = 20V$ $V_{CEQ} = 10V$ $I_{cq} = 600mA$ $R_L = 16\Omega$	AC o/p current varries by 300mA And i) power Supplied by DC Source to amplifier. ii) efficiency of amplifier.

Soln



$I_{P-P} = 900 - 300$

$= 600mA$

$I_{Peak} = 300mA$

$\eta\% = \frac{P_{o/p}(ac)}{P_{i/p}(DC)}$

$P_{o/p} = V_{CE}(rms) \times I_c(rms)$

$I_c(rms) = \frac{300}{\sqrt{2}} mA$

$P_{o/p} = I_c^2 rms \times R_L$

$P_{o/p} = \left(\frac{300}{\sqrt{2}}\right)^2 \times 10^{-6} \times 16$

$= \frac{90000}{2} \times 10^{-6} \times 16$

$P_{o/p} = 0.72 watt$

$P_{in} = V_{cc} \times I_{cq}$

$= 20 \times 600$

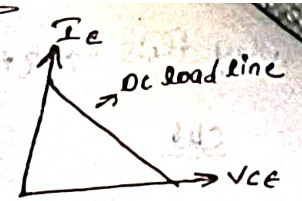
$= 12000 mA$

$P_{i/p} = 12W$

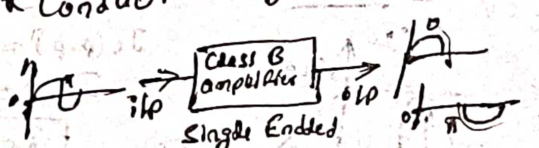
$\%\eta = \frac{0.72}{12} \times 100$

$\eta = 6\%$

Class - B power amplifier



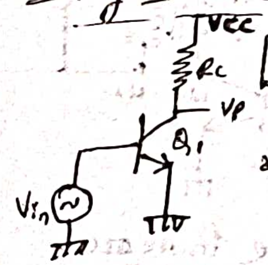
* Q point is in cut-off region (I_c, V_{CE})
* No Biasing is used. [i/p Power need]
* η is very high (78.5%)
* Conduction angle is 180°



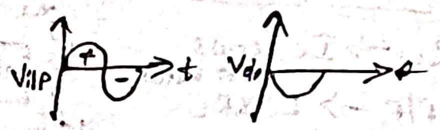
[The signal passes o/p in +ve or -ve].

* No power drain (Low Pdiss) (No heat) loss
* it has lot of distortion
* Information at o/p = 50%
* In o/p only one single is come that's for only 50% signal is come

Single fed Class B amplifier



$V_o = V_{cc} - I_c R_c$



Case I

Positive halfcycle

$Q_1 \rightarrow$ J_E FB, J_C RB — active region

negative cycle

$Q_1 \rightarrow$ J_E RB, J_C FB — cutoff region

$\downarrow V_o = V_{cc} - I_c \uparrow R_c$

...ntages of Class B

-> Impedance with load is posible
-> Second harmonic get automatically Cancelled
-> ~~Zero power dissipation~~
-> High eff-%. Compared with Class A amplifier.

disadvatages

-> Crossover distrotion is present in the o/p wave form
-> the transistor biased at cut off region the wave form is distorted near zero crossings

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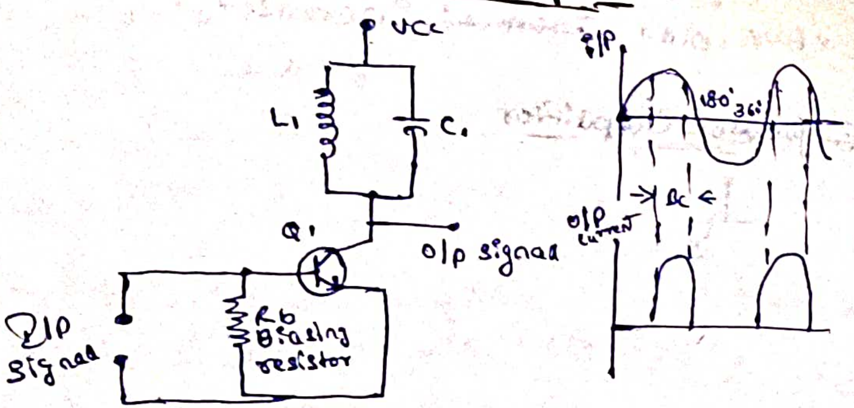
* ~~when the signal is~~ the balsing of the transistor in class B operation is in such a way that. at zero signal Condition.
* there will be no collector current.
* The operating point is to be at cut-off voltage
* So when the signal is applied only the positive half cycle is amplified at the o/p.
* But during Negative half cycle of the i/p, the ckt is reverse biased & the collector current will be absent.
* ~~Hence only the positive half~~ when the applied signal increase, the power dissipation will be more.

* But when compared to class A power amplifier. the o/p effi. will ~~...~~ increased.

~~Class C power Amplifier~~

Class C power amplifiers –



* The fig shows the class c power amplifier
* When the collector current flows for less than half cycle of the i/p signal, the power amplifier is known as class c power amplifier.
* The effi. class c amplifier is high while linearity is poor.
* The conduction angle is less than 180°. It is generally 90°
* using class c amplifier, the pulses produced at it's o/p can be converted to complete sine wave of a particular frequency by using LC ckt. in it's collector ckt.
* the gain of these amplifiers is not vary according to the frequency of the signal.
* over a wide rang.

* when i/p signal is applied, the tuned ckt resonating at the frequency is extracted by the tuned load at the o/p.
* Harmonic can be eliminated by adding filters.
* The biasing resistance pulls the 'q' point below cut-off region. So the effi. is around 80%.

Advantages

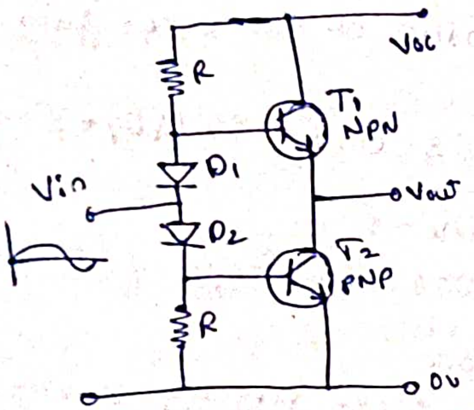
* Less physical size
* Used in RF application
* High efficiency (higher than 95%)
* Low power loss in power transistor

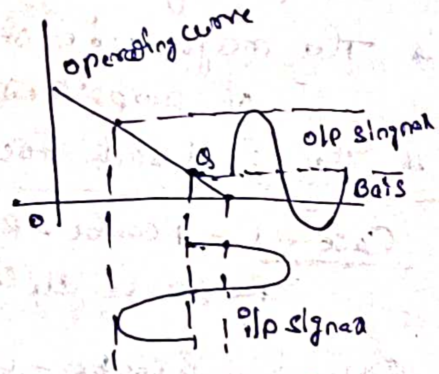
Disadvantages

* creates lot of RF interference
* Selection of ideal inductors is problem
* Not suitable in audio applications.

Class AB power amplifier

* Class AB is a combination of class A & class B type of amplifier.
* as class A has the low eff.
* as class B has the lot distortion
* by utilizing the advantages of both the class in class AB amplifier





* But the cross over distortion is occurs when both the transistor are off at the same instant during the transition period.
* so we use class AB configuration.
* The conduction angle of class AB amplifier is lies b/w 180° to 360° depending upon the operating point.
* The small voltages is given using D_1 & D_2. it helps the operating point to be in above cut off point.
* Hence the o/p wave form is shown in fig.
* b/w class A & class B in terms of eff. having 50 to 60%.
* ∴ class A & B & AB amplifier are called as linear amplifiers.
* because the o/p signal amplitude & phase are linearly related to the i/p signal amplitude & phase

Types of Distortion

1. amplitude or Non linear distortion (Harmonic) distortion

Due to the non-linearity of transistor, the o/p is different from the i/p. is known as ——

$$HD\% = \frac{A_0}{A_1} \times 100$$

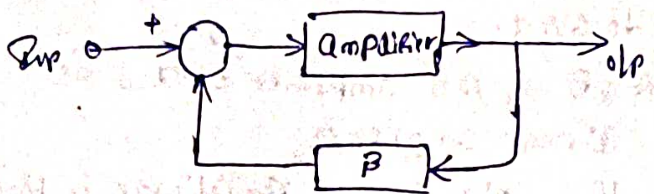
2. frequency distortions–

when different frequency components of the i/p signal are amplified differently frequency amplification takes place. This is may due to the internal capacitance effect of the transistor

3. Delay or phase shift distortions–

If the phase shift introduced by amplifier is not proportional to the frequency then phase distortion takes place the modified equalent ckt

The basic structure of a sinusoidal oscilator



* an osicillator is a ckt which basically acts as generator.
* the o/p signal which oscillates with constant amplitude & constant desired frequency
* the propertity of f.B which allows to f.B the part of the o/p. to the same ckt i/p.
* as the phase of the feedback to the i/p with the help of a f.B networ. signal is same as that of the i/p applied. the f.B is called +ve f.B.
* The closed loop gain by +ve f.B.

$$A_f = \frac{A}{1 - A\beta}$$

* for -ve f.B $A_f = \frac{A}{1 + A\beta}$

advantages:-

* higher i/p impedance
* stable voltage gain
* improved frequency responce
* linear operation
* lower o/p impedance reduce noise

Barkhausen criteria

$A\beta = 1$ $A_f = \infty$ for oscillation $A\beta \geq 1$

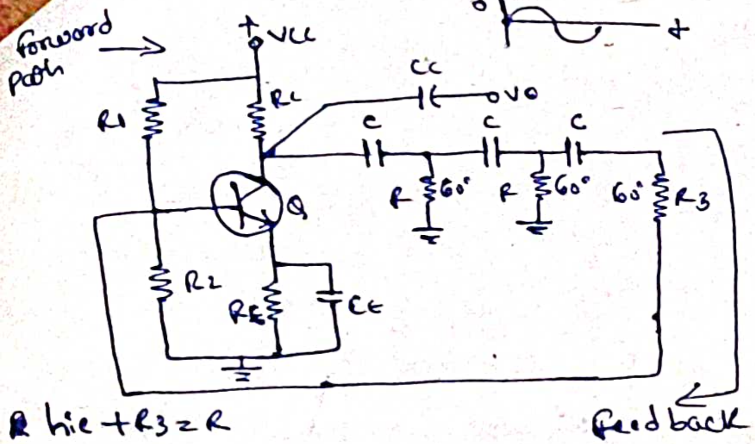
* It state that. the total phase shift around a loop as the signal proceeds from i/p through the amplifier
* f.B network back to the i/p gain.
* Completing a loop, is precisely 0° or 360°
* The magnitude of the product of the open gain of amplifier
* the feed back factor β is unity. i.e $|A\beta| = 1$

Case - 1 - β can be - RC Network
Rc phase shift oscilator - low frequency oscilation

Case - 2 - β can be - LC Network
· Colpitts & Hartly - radio. frequency 100KHz

Cas - 3 - β can be - cristal. - Mega Hz

Rc phase shift oscillator



$h_{ie} + R_3 = R$

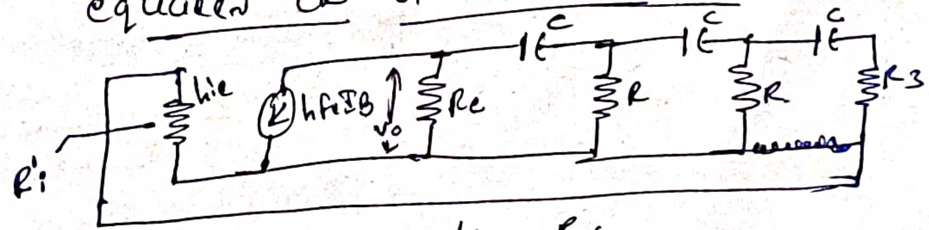
* Rc phase shift oscillator basically consists of an amplifier & a feed back network
* it consisting of resistor & capacitors arranged in ladder fashion.
* Rc Network is used feed back path in osc
* the network must introduce a 180° phase shift
* to obtain total 360° phase shift around loop
* in each Rc Network produce 60° of phase shift. & the phase shift due to feedback is 180°
* a transistor is used as an active device element of the amplifier
* Rc phase shift osc which uses a common emitter single stage amplifier
* & the Network consist 3 indentical Rc sections

* The o/p of F.B network gets loaded due to low impedance of a transistor.
* amplifier stage can be used to avoid the problem of low i/p impedance
* But if only single stage can be used, then the voltage shunt feed back. (R_3) is used to connected in series with the amplifier i/p resistance
* while o/p of the F.B Network is given as an i/p to the amplifier.
* Thus amplifier supplies it's own i/p through the feedback Network
* Neg $h_{ie} + R_3 = R$
* ∴ thus all the 3 sections of the phase shifting Network are identical

$R_i' = R_1 \| R_2 \| h_{ie}$

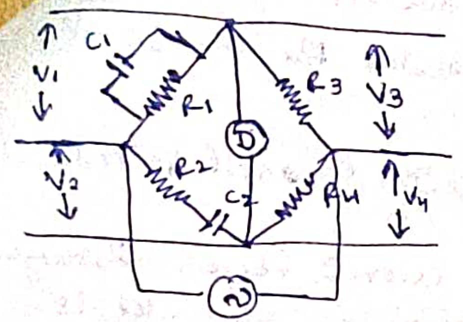
$R_i' + R_3 = R$

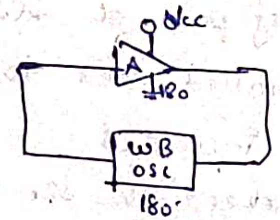
equalent ckt of the oscilator



asume = $k = \frac{R_c}{R}$

...ge Oscillator





* The wien Bridge osc is so called because the ckt is based on frequency-selective form of the wheatstone bridge ckt
* With no i/p signal the wien bridge osc. produces o/p oscillations
* The wien bridge oscillator can produce a large range of frequencies
* The voltage gain of the amplifier must be at least 3
* The Network can be used with a Non Converting amplifier
* The i/p resistance of the amplifier must be high compared to (R) so that the (RC) network is not overloaded & alter the required condition
* The o/p resistance of the amplifier must be low so that the effect of external loading is minimised.

* With amplitude stabilisation in the form of feedback diodes, oscillations form the oscillator can go on indefinitely (8)

$-jX_c = \frac{-j}{\omega C} = \frac{1}{j\omega C}$

Balance bridge

$Z_1 Z_4 = Z_2 Z_3$

$Z_1 = \frac{R_1}{1+j\omega C_1 R_1}$

$Z_2 = R_2 - \frac{1}{j\omega C_2}$

$Z_3 = R_3$ $Z_4 = R_4$

for balance bridge

$Z_1 Z_4 = Z_2 Z_3$

$\left(\frac{R_1}{1+j\omega C_1 R_1}\right)(R_4) = \left(R_2 - \frac{1}{j\omega C_2}\right)(R_3)$

$\frac{R_4}{R_3} = \frac{1}{j\omega C_2 R_1} + \frac{C_1}{C_2} + \frac{R_2}{R_1} + j\omega C_1 R_2$

real, imaginary

equating the real terms

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

equating the imaginary parts

$\frac{1}{j\omega C_2 R_1} + j\omega C_1 R_2 = 0$

$-\omega C_2 R_1 + \omega C_1 R_2 = 0$

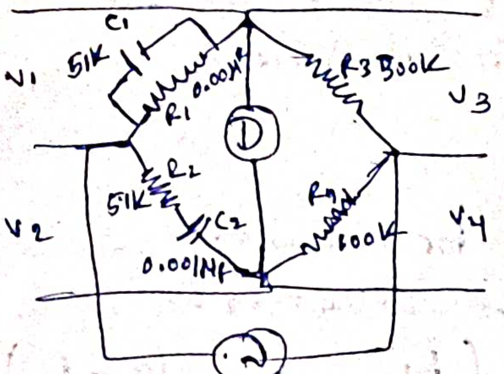
$\omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$

$\omega = 2\pi f$

Frequency of osc

$\therefore f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$

Calculation the frequency of osc 0.001MF

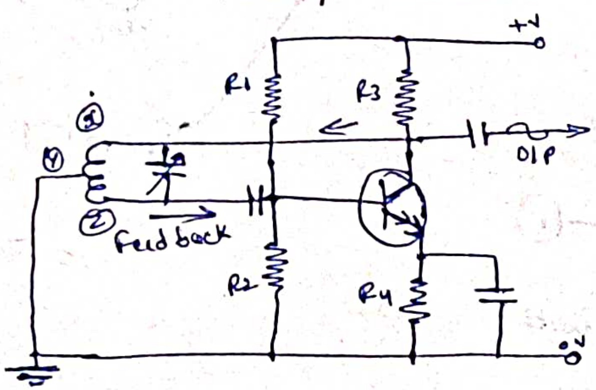


$= 3.1207 \times 10^3$

$\therefore f = 3120.7\,Hz$

$$f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}} = \frac{1}{2\pi\sqrt{0.001 \times 51 \times 51 \times 0.001}}$$

Hartley oscillator:-

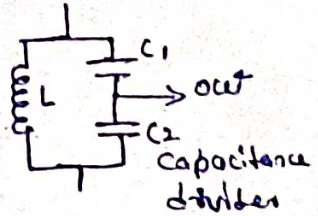


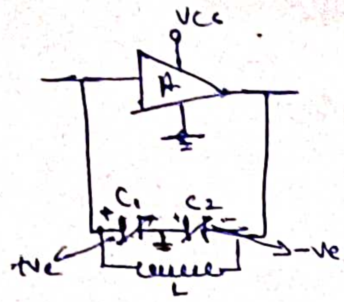
* The fig shows the Hartley osc.
* when the ckt is oscillating the v (x) collector, relative to y (emitter) is 180°.
* out of phase with voltage z point relative to y
* Feed back loop provides the collector phase relationship of +ve feedback to maintained oscillation
* The amount of F.B depends upon the tapping point of the inductor
* If it is moved near to collector the amount of feedback increased.
* but o/p taken b/w the collector & earth is reduced & vice versa
* In the ckt the DC collector current flows through part of the coil & for this reason the ckt is said to "series - fed.

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

where $L_T = L_1 + L_2 + 2M$

Colpitts oscillators





* The colpitts oscillator design uses two Centre-tapped Capacitors in Series with a parallel inductor to form its resonance tank Ckt ~~provide~~ producing Sinusoidal oscillation.
* In many way the colpitts is opposite of the Hartley oscillator.
* The basic Configuration of the colpitts osc. resembles that of the Hartley osc. but the difference this time is that. the Center tapping of tank sub-ckt is made at the junction of a "capacitive voltage drive"
* The amount of the feedback is determine the C1 & C2 these two Capacitors. are generally "ganged" they provides Constant amount of F.B

$\therefore$ $f_r = \frac{1}{2\pi\sqrt{LC_T}}$

C_T = Capacitance total

$\therefore \frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$ or $C_T = \frac{C_1 \times C_2}{C_1 + C_2}$

ex:-

$C_1 = 24nF$

$C_2 = 240nF$

$L = 10mH = 0.01H$

$f_r = ?$

$C_T = ?$

$f_r = \frac{1}{2\pi\sqrt{LC_T}}$

$C_T = \frac{24nF \times 240nF}{24nF + 240nF} = 21.82nF$

$f_r = \frac{1}{2\pi\sqrt{0.01 \times 21.82 \times 10^{-9}}} = 10.8KHz$