Rajasthan Institute of Technology and Management , Jaipur

Mid-Term -II solution

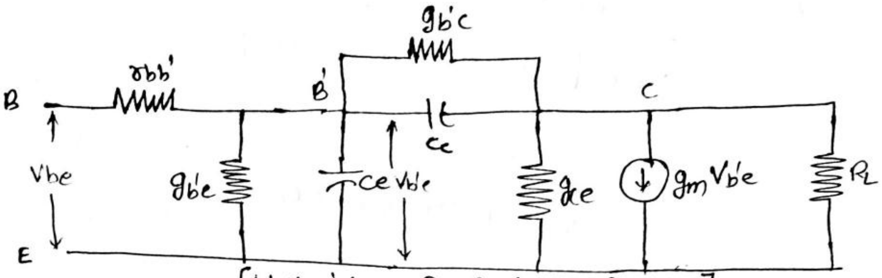
Subject - Analog Electronics

Semester-4th

Faculty- Green Maraiya

Set-A

CE short circuit current gain

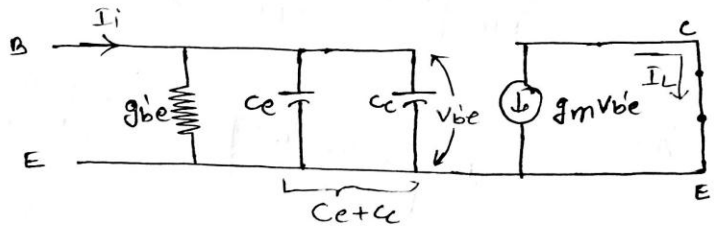


[Hybrid-π Equivalent circuit]

For short circuit current gain and hence it will be assumed $R_L = 0$ output S.C as result.

① g_{ce} is shorted and becomes zero.

② since $r_{b'c} >> r_{b'e}$ (therefore $g_{b'c} << g_{b'e}$ hence $g_{b'c}$ is neglected in comparison with $g_{b'e}$



$$I_L = -g_m V_{b'e} \quad \text{——— (1)}$$

KCL at input side.

$$I_i = \frac{V_{b'e}}{1/g_{b'e}} + \frac{V_{b'e}}{\frac{1}{j\omega(C_e+C_c)}}$$

$$I_i = V_{b'e}\left[g_{b'e} + j\omega(C_c+C_e)\right] \quad \text{——— (2)}$$

Current gain under short circuit

$$A_I = \frac{I_L}{I_i}$$

$$A_I = \frac{-g_m V_{b'e}}{V_{b'e}\left[g_{b'e} + j\omega(C_e + C_c)\right]}$$

$$A_I = \frac{-g_m}{g_{b'e} + j\omega(C_e + C_c)} \quad \text{— (3)}$$

$$\therefore \quad g_{b'e} = \frac{g_m}{h_{fe}}$$

$$A_I = \frac{-g_m}{g_{b'e}\left[1 + \frac{j\omega(C_e + C_c)}{g_{b'e}}\right]}$$

$$A_I = \frac{-g_m}{\frac{g_m}{h_{fe}}\left[1 + \frac{j\omega(C_e + C_c)}{g_{b'e}}\right]}$$

$$A_I = \frac{-h_{fe}}{1 + \left[\frac{j\omega(C_e + C_c)}{g_{b'e}}\right]} = \frac{-h_{fe}}{1 + \left[j 2\pi f (C_e + C_c) / g_{b'e}\right]}$$

$$\boxed{A_I = \frac{-h_{fe}}{1 + j\left(\frac{f}{f_\beta}\right)}} \quad \text{— (4)}$$

$$f_\beta = \frac{g_{b'e}}{2\pi(C_e + C_c)} = \frac{g_m}{h_{fe}\, 2\pi(C_e + C_c)} \quad \text{— (5)}$$

$$\boxed{|A_I| = \frac{h_{fe}}{\sqrt{1 + \left(\frac{f}{f_\beta}\right)^2}}}$$

At $f = f_\beta$

$$A_I = \frac{h_{fe}}{\sqrt{2}}$$

β- Cut-off frequency :

f_β is defined as the frequency at which CE S.C current gain falls $\frac{1}{\sqrt{2}}$ (or 0.707 or fall by 3dB) of its low frequency current gain value i.e h_{fe} the value of f_β is

$$f_\beta = \frac{g_{b'e}}{2\pi(C_e + C_c)}$$

unity gain frequency (f_T)

Frequency f_T is defined as the frequency at which CE S.C current gain becomes unity.

At $f = f_T$

$$A_I = 1 = \frac{h_{fe}}{\sqrt{1 + \left(\frac{f_T}{f_\beta}\right)^2}}$$

$\frac{f_T}{f_\beta} >>> 1$

$$1 = \frac{h_{fe}}{\sqrt{\left(\frac{f_T}{f_\beta}\right)^2}}$$

$$\frac{f_T}{f_\beta} = h_{fe}$$

$$f_T = h_{fe} \cdot f_\beta$$

f_T represent the CE S.C current gain-bandwidth product.

$$f_T = h_{fe} \cdot f_\beta$$

$$f_\beta = \frac{f_T}{h_{fe}}$$

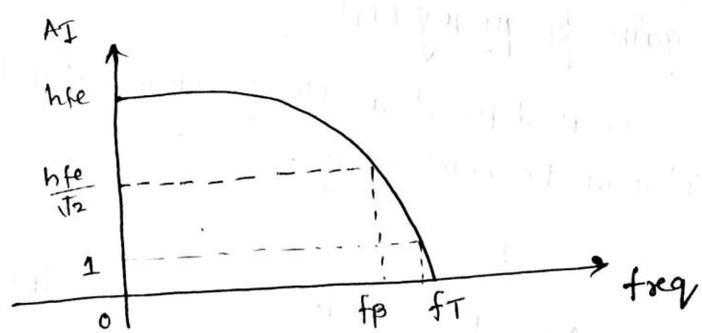
from eq-(5)

$$\frac{f_T}{h_{fe}} = \frac{g_m}{h_{fe}\, 2\pi (C_e + C_c)}$$

$$f_T = \frac{g_m}{2\pi (C_e + C_c)} \qquad C_e >>> C_c$$

$$\boxed{f_T = \frac{g_m}{2\pi C_e}}$$

current Gain versus frequency curve



Ques-1

Solution

i) $g_m = \frac{I_C}{V_T} = \frac{1mA}{26mA}$

$= 38.46 \, mA/V$

ii) $r_{b'e} = \frac{h_{fe}}{g_m} = \frac{200}{38.46 \times 10^{-3}}$

$= 5.20 k\Omega$

iii) $(C_e + C_c) = \frac{g_m}{2\pi f_T} = \frac{g_m}{\omega_T}$

$= \frac{38.46 \times 10^{-3}}{500 \times 10^{6}}$

$C_e + C_c = 76.92 \, PF$

$C_{b'e} = C_e = 76.92 PF - 3PF = 73.92 \, PF$

(iv) $f_T = h_{fe} \cdot f_\beta$

$2\pi f_T = h_{fe} \, 2\pi f_\beta.$

$\omega_T = h_{fe} \, \omega_\beta$

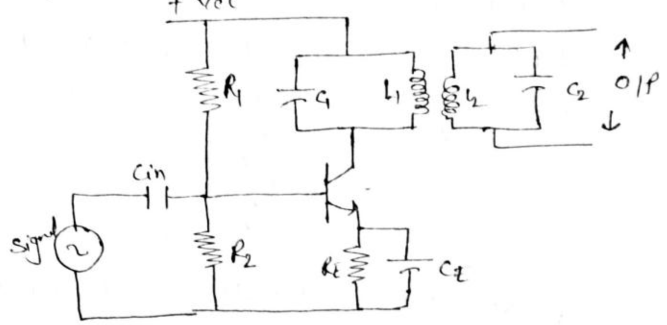
$\omega_\beta = \frac{\omega_T}{h_{fe}} = \frac{500 \times 10^{6}}{200}$

$\boxed{\omega_\beta = 2.5 M \, rad/sec}$

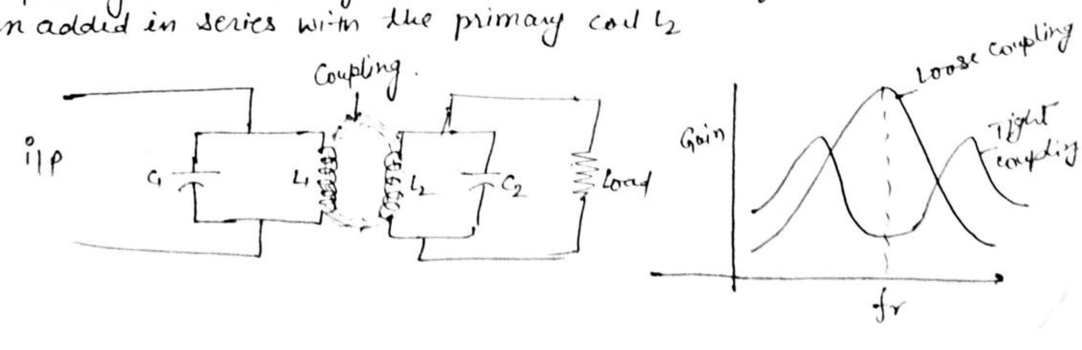
Ques-2

Double-tuned Amplifier

It consist of a transistor amplifier containing two tuned circuit one (L_1C_1) in the collector and the other (L_2C_2) in the output. The high frequency signal to be amplified is applied to the input terminals of the amplifier. The resonant frequency of tuned circuit (L_1C_1) is made equal to the signal frequency. Under such condition the tuned circuit offers very high impedance to the signal frequency, consequently large output appears across the tuned circuit L_1C_1. The output from this tuned circuit is transferred to the second tuned circuit L_2C_2 through mutual inductance. Double tuned circuit are extensively used for coupling the various circuit of radio and television recievers.



Frequency response:- The frequency response of a doble tuned circuit depends upon the degree of coupling i.e upon the amount of mutual inductance b/w the two tuned circuit when coil L_2 is coupled to L_1 a portion of load resistance is coupled into the primary tank ckt L_1C_1 and affect the primary ckt in exactly the same manner as though a resistor had been added in series with the primary coil L_2



when the coils are spread apart, all the primary coil L_1 flux will not link the secondry coil L_2 The coil are said to have loose coupling. Under such condition the resistance reflected from the load (ie secondry circuit) is small. The resonance curve will be sharp and the circuit Q is high. when primary and secondry coils are very close together, they are said to have tight coupling under such conditions, the reflected resistance will be large and the circuit Q is lower.

Bandwidth of double tuned Circuit

BW increase with degree of coupling, determining factor in a double tuned circuit is not Q but the coupling for given frequency; the lighter the coupling, the greater is BW.

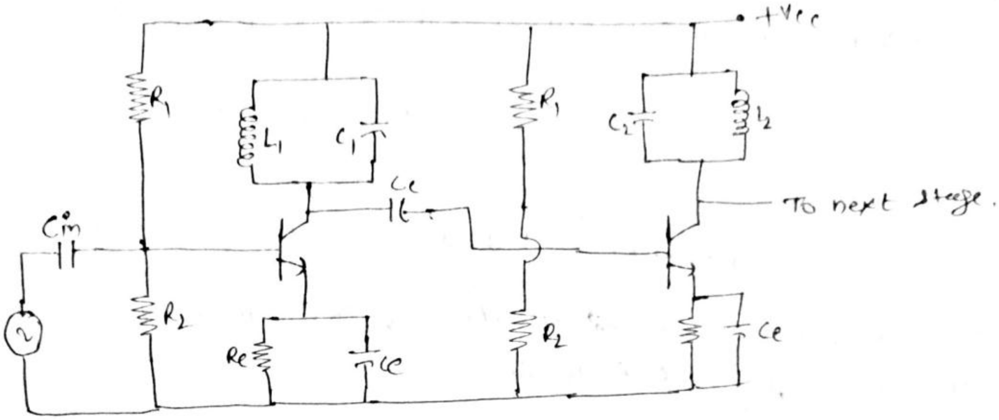
$$BW = k f_r$$

K = coefficient of coupling.

Advantages of double tuned Amplifier.

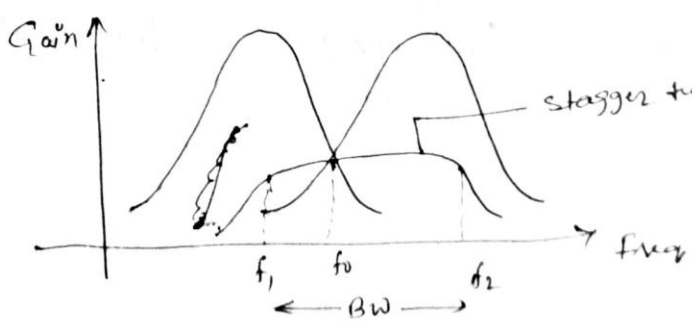
1) BW is increased
2) Senstivity (i.e ability to recieve weak signal) is increased
3) selectivity (i.e " to discriminate against signal is adjacent band s) is increased.

Stagger tuned Amplifier



If two or more tuned circuits are cascaded and tuned to the same frequency ; thus the overall bandwidth decreases It is known as synchronous tuning.

If the tuned are cascaded and they are tuned to different frequencies it is possible to obtain increased bandwidth with more desirable bandpass charq (i e flat pass band with steep sides This technique is called stagger tunning.



Amplifier has a greater BW and flatter or pass band. If more number of stages are used flatter will be the passband and steeper will be the gain fall-of outside the passband.

Analysis: The gain of tuned-single amplifier is given by

$$\frac{A_v}{(A_v \text{ at resonance})} = \frac{1}{1+j2Q\delta} = \frac{1}{1+jx} \qquad x = 2Q\delta$$

Since one stage is tuned ato the freq below f_0 and other above f_0 the corresponding selectivity is

$$\left(\frac{A_v}{A_v \text{ at resonance}}\right) = \frac{1}{1+j(x-1)} \quad -1$$

$$\frac{A_v}{(A_v \text{ at resonance})} = \frac{1}{1+j(x+1)} \quad -(2)$$

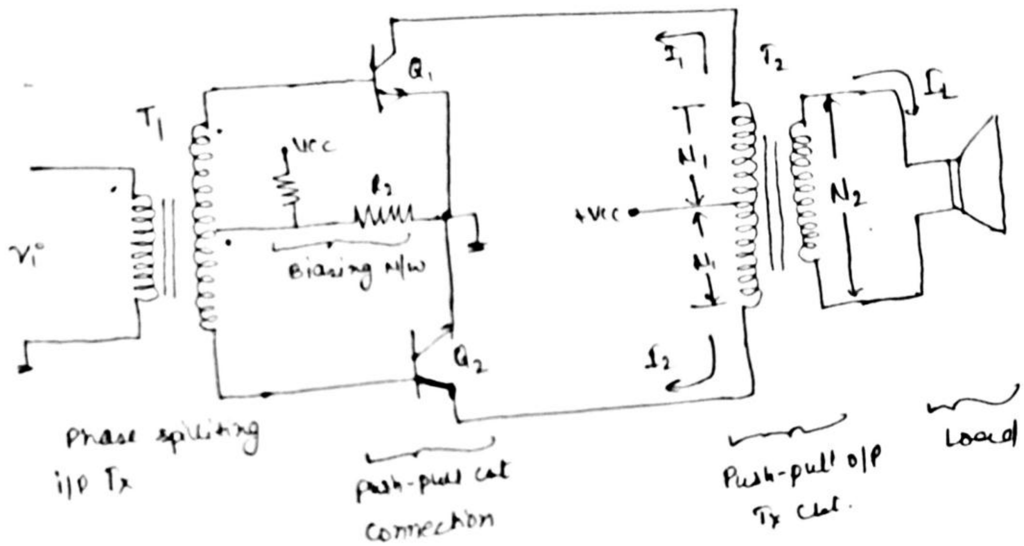
$$1 \times 2 = \frac{1}{1+j(x-1)} \times \frac{1}{1+j(x+1)} = \frac{1}{2-x^2+2jx}$$

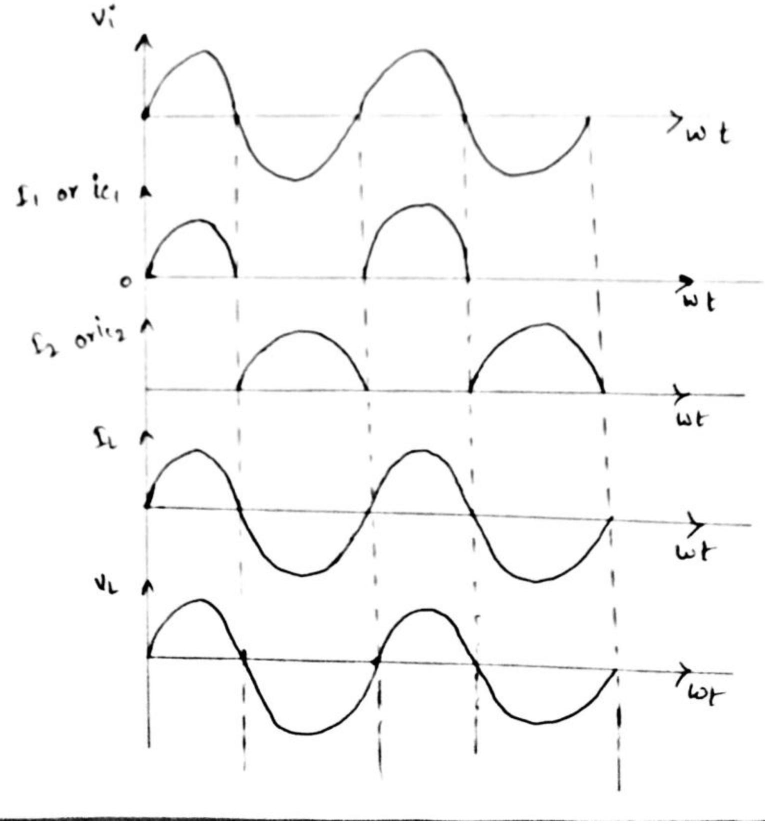
$$|gain| = \frac{1}{\sqrt{(2-x^2)^2+(2x)^2}} = \frac{1}{\sqrt{4+x^4}}$$

$$|gain| = \frac{1}{\sqrt{4+(2Q\delta)^4}} = \frac{1}{2}\frac{1}{\sqrt{1+4Q^4\delta^4}}$$

Ques-3

Draw the circuit diagram and explain the operation with relevant waveforms of class-B push-pull amplifier. Also show that the maximum conversion efficiency of class-B push-pull amplifier is 78.5%.





The dc biasing point i.e Q point is adjusted on the x-axis such that $V_{CEQ} = V_{CC}$ and $I_{CQ} = 0$

→ Hence co-ordinates of the Q point are $(V_{CC}, 0)$

Dc ~~output~~ power i/p

→ Each transistor o/p is in the form of half rectified sinusoid with a peak value of I_m or $I_{C(P)}$

→ Thus the average current in each transistor is $\frac{I_m}{\pi}$

→ Since, there are two transistor, the dc current drawn from the supply V_{CC}, by both the transistor is

$$I_{dc} = 2 \times (\text{Average current in each transistor})$$

$$\boxed{I_{dc} = \frac{2 \times I_m}{\pi}}$$

∴ The Dc i/p power

$$P_{i(dc)} = V_{CC} \cdot I_{dc}$$

$$= V_{CC} \cdot \left(\frac{2 I_m}{\pi}\right)$$

$$\boxed{P_{i(dc)} = \frac{2}{\pi} \times V_{CC} \cdot I_m}$$

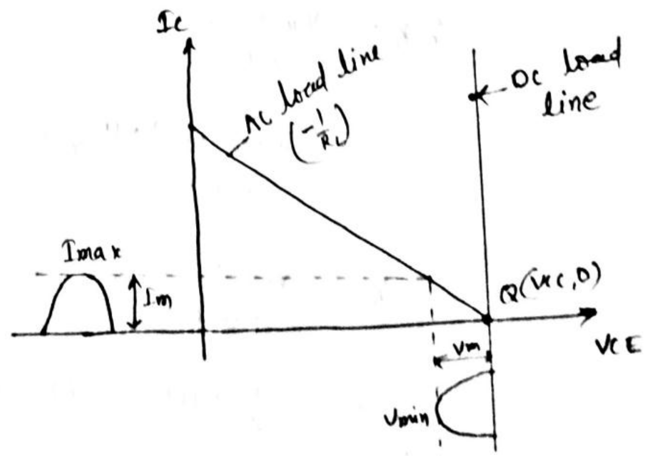
Ac operation

The Ac power is

$$P_{ac} = V_{rms} \cdot I_{rms}$$

$$= \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}$$

$$\boxed{P_{ac} = \frac{V_m \cdot I_m}{2}}$$



$$P_{ac} = \frac{V_m}{2} \cdot \frac{V_m}{R_L'} \qquad \text{or} \qquad P_{ac} = I_m \cdot R_L' \cdot \frac{I_m}{2}$$

$$\boxed{P_{ac} = \frac{V_m^2}{2R_L'}} \qquad \boxed{P_{ac} = \frac{I_m^2 \cdot R_L'}{2}}$$

efficiency :-

$$\%\eta = \frac{P_{ac}}{P_{dc}} \times 100$$

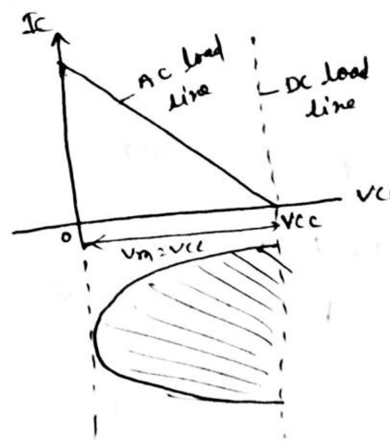
$$= \frac{\frac{V_m \cdot I_m}{2}}{V_{CC} \cdot \frac{2I_m}{\pi}} \times 100$$

$$= \frac{V_m}{2} \times \frac{1}{\frac{2V_{CC}}{\pi}} \times 100$$

$$\boxed{\%\eta = \frac{V_m \cdot \pi}{4V_{CC}} \times 100}$$

Maximum efficiency :-

$V_m = V_{CC}$ - For max efficiency



$$\%\eta = \frac{V_m \cdot \pi}{4V_{CC}} \times 100$$

$$= \frac{(V_{max} - V_{min}) \times \pi}{4V_{CC}} \times 100$$

$$\%\eta = \frac{V_{CC} \cdot \pi}{4V_{CC}} \times 100$$

$$\%\eta = \frac{\pi}{4} \times 100 = 78.5\%$$

Ques-3

Solve $V_{cc} = 10V$ $R_L = 16\Omega$ overall η = collector $\eta = 0.5$

$P_{tr} = 100mW$

(i) output power a.c

$$\text{Collector efficiency} = \frac{(P_o)_{ac}}{P_{tr}}$$

$$0.5 = \frac{(P_o)_{ac}}{100mW}$$

$$(P_o)_{ac} = 0.5 \times 0.1 = 0.05 \text{ watts.}$$

(ii) output power ac is given by

$$(P_o)_{ac} = \frac{1}{2} V_{cc} \cdot I_{CQ}$$

$$0.05 = \frac{1}{2} \times 10 \times I_{CQ}$$

$$0.05 = 5 \times I_{CQ}$$

$$I_{CQ} = \frac{0.05}{5} = 0.01A$$

(iii) Transformer turns ratio

$$R_L' = N^2 R_L$$

$$R_L' = \frac{V_{cc}}{I_{CQ}} = \frac{10}{0.01} = 1000\Omega$$

$$1000 = N^2 \times R_L$$

$$N = \sqrt{\frac{1000}{16}}$$

$$\boxed{N = 8}$$

Ques-4(a)

The comparison b/w voltage and power Amplifiers.

Parameter	Voltage Amplr.	Power Amplr
β	high (>100)	Low (5 to 20)
R_C	high (4-10 kΩ)	low (5 to 20 Ω)
coupling	usually R-C coupling	Transformer coupling
Input voltage	low (a few mV)	high (2-4V)
collector current	low (≃ 1mA)	high >(100mA)
Power o/p	low	High
output impedance	High (≃ 12 kΩ)	low (200 Ω)

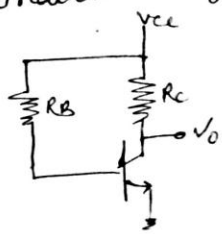
Classification of power Amplifier

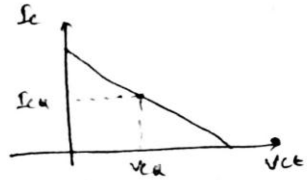
- Class-A power Amplifier
- → Class-B
- → Class-AB
- → Class-C
- → Class-D

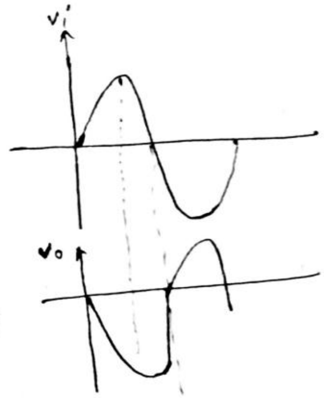
Class-A power power Amplifier

→ Collector current flows for entire 360° of I/P signal.

Conduction angle = 2π







→ Q point is located at Centre of dc load line

Advantage :- Minimum distortion

→ Extellent thermal stability i.e, no thermal runaway problem.

Disadvantage :- Small power conversion efficiency

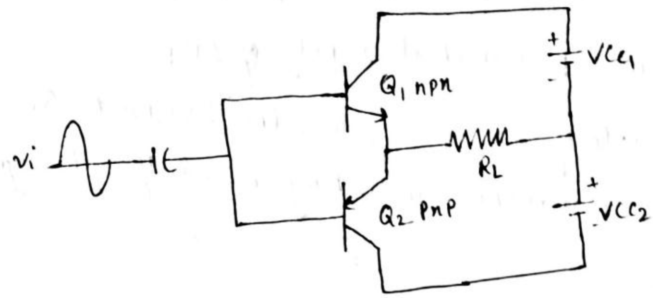
Application :- Designing of audio freq amplifier.

→ In class-A operation, power dissipated by Tx is equal to max signal power O/P.

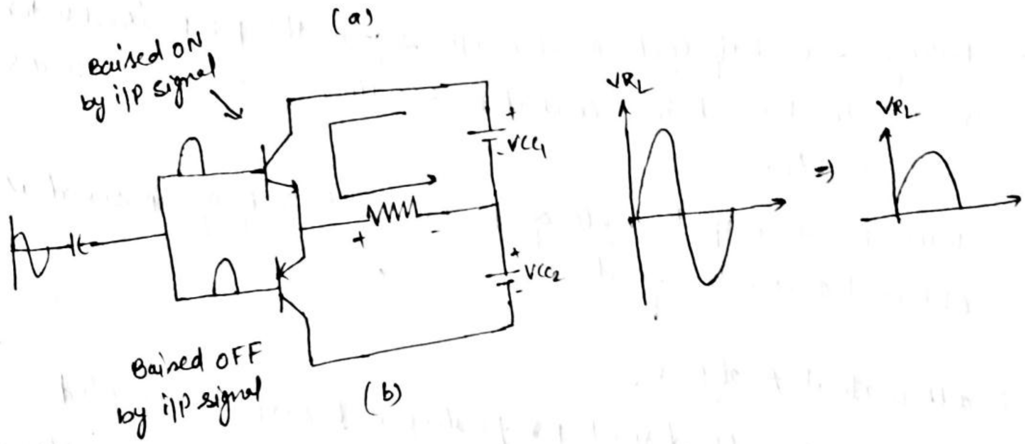
For Class-A, $P_D = P_{o\,max}$ i.e max power O/P.

Complementary Symmetry Class-B Amplifier

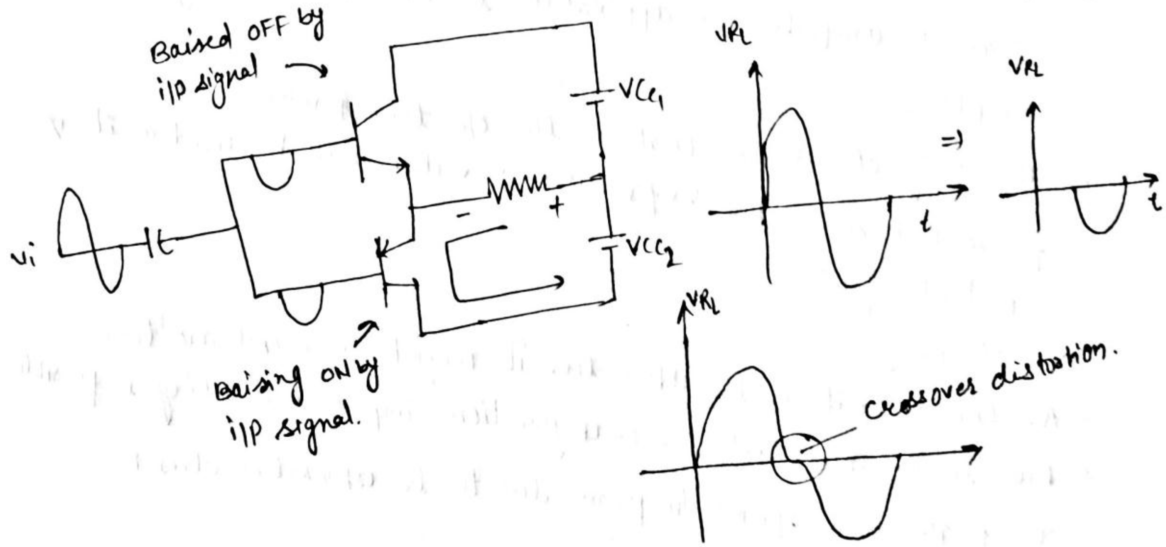
(Common collector-Emitter follower)



(a)



(b)



→ In Complementary symmetry Class-B amplifier, one is n-p-n and the other is p-n-p transistor.

→ The transistor Q_1 is n-p-n while Q_2 is p-n-p type

→ The Circuit is driven from a dual supply of ± Vcc

→ During +ve half cycle of the i/p signal, the transistor Q_1 will be biased into conduction, resulting in a half cycle signal across the load

→ During -ve half Cycle of the i/p signal the p-n-p transistor Q_2 will be baised into conduction resulting in -ve half Cycle across the load R_L.

→ Thus For a complete cycle of i/p a Complete cycle of o/p signal is obtained across the Load.

Mathematical Analysis:

→ All the result derived for push-pull transformer coupled Class-B amplifier are applicable to the complementary class-B amplifier.

→ The only change is that as the o/p transformer is not present hence in the Expression, R_L value must be used as it is instead of R_L'

Advantages :-

→ As the circuit is transformerless. its weight, size & cost are less

→ Due to Common Collector configuration, impedance matching is possible.

→ The frequency response improves due to transformerless class-B amplifier ckt.

Rajasthan Institute of Technology and Management,Jaipur

Mid-Term-II Solution

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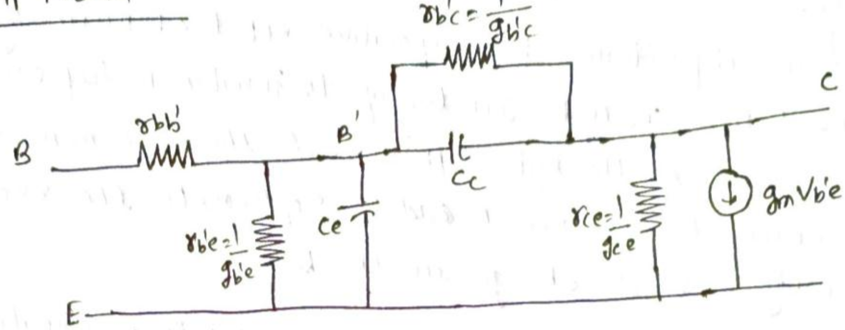
Set-B

Question-1

Hybrid-π Model



$r_{bb'}$ = Ohmic base spreading resistance

r_{ce} = Early effect

$r_{b'e}$ = Forward junction resistance

$r_{b'c}$ = show early effect for J_c Junction (high)

g_m = Transconductance $\boxed{g_m = \frac{|I_c|}{V_T}}$

$r_{bb'}$ - Base region of transistor is very thin compared to emitter & collector region & its resistance lies b/w 40 to 400Ω. The ohmic resistance of E and C is usually of order of 10 Ω and can be neglected in comparision to that of base region.

$r_{b'e}$ — Incremental resistance of E-B diode which is FB in active region.

$r_{b'c}$ - It acconts for feedback from O/P to I/P due to base width modulation or early effect the value of $r_{b'c}$ is usually very high (several MΩ) and will be neglected in analysis.

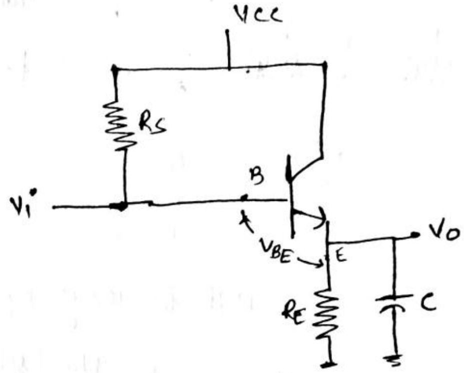
rce :- o/p resitance and it is also due to Early effect

<u>The hybrid Capacitance</u>

Forward baised PN Junction exhibits a capacitive effect called diffusion Capacitance. This Capacitive effect of normally forward baised base-emitter Junction of transistor is represented by cb'c or ce in the hybrid-π model the diffusion capacitance ce connected between B and E represents the Excess minority Carrier storage in the base.

The reverse biased PN Junction exhibits a capacitive effect called trantion capacitance. The capacitive effect of normally reverse baised collector base junction of the transistor represented by Cb'c or cc in the hybrid-π model.

High frequency Response of Emitter follower



$V_{BE} = 0.7$ for Si

$= 0.3$ for Ge

KCL

$V_{BE} + V_o - V_i = 0$

$V_{BE} - V_i = -V_o$

$\boxed{V_o = V_i - V_{BE}}$

if $V_i = 40$

$V_o = 40 - 0.7$

$V_o = 39.3V$ For Si

$V_o = 40 - 0.3$

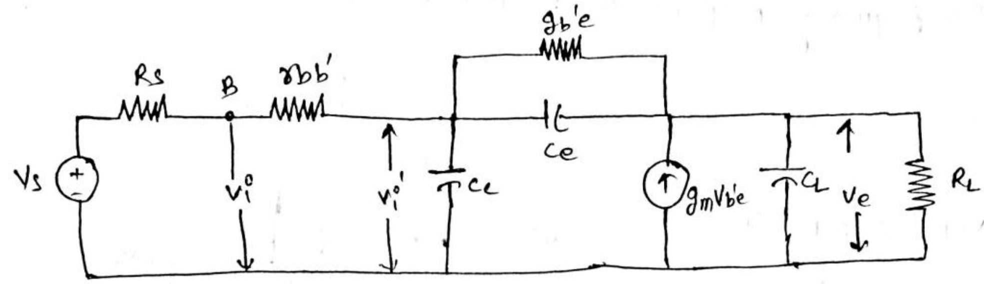
$= 39.7V$ For Ge

So, $V_o \cong V_i$

gain $= \frac{V_o}{V_i} = A_V$

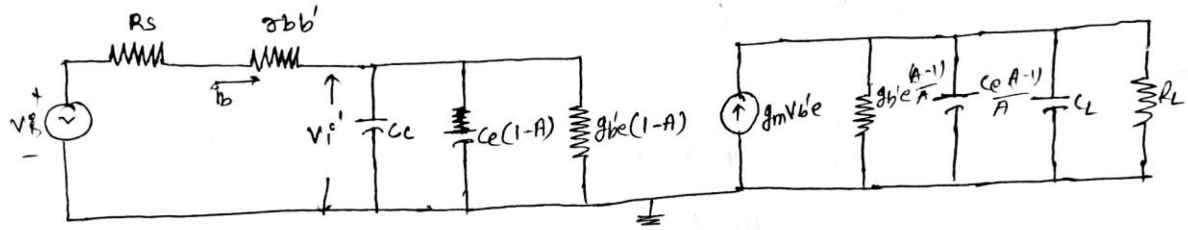
$\boxed{A_V \simeq 1}$

The circuit of Emitter follower at high frequency is described using fig a Capacitive C_L is included across the resister R_E because the emitter follower due to its low o/p impedance is often used to drive capacitive load, C_L respresents the shunt Capacitance of capacitive load.



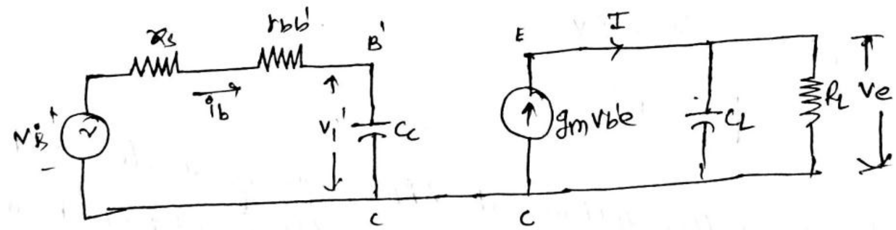
High frequency equivalent circuit.

Apply Miller's theorem to the hybrid π-Model.



we know that, the freq of an emitter follower is very close to unit

∴ $(A \cong 1)$



$$V_e = I \times Z$$

$$V_e = I \times \left(\frac{R_L \times \frac{1}{j\omega C_L}}{R_L + \frac{1}{j\omega C_L}} \right)$$

$$V_e = g_m V_{b'e} \times \frac{R_L}{(1 + j\omega C_L R_L)}$$

$$V_e = \frac{g_m \cdot R_L}{1 + j\omega C_L R_L} \cdot V_{b'e}$$

$$V_e = \frac{g_m \cdot R_L}{1 + jwC_L R_L}(V_i' - V_e)$$

$$V_e = \frac{g_m \cdot R_L \cdot V_i'}{1 + jwC_L R_L} - \frac{g_m \cdot R_L V_e}{1 + jwC_L R_L}$$

$$V_e\left(1 + \frac{g_m R_L}{1 + jwC_L R_L}\right) = \frac{g_m R_L \cdot V_i'}{1 + jwC_L R_L}$$

$$V_e\left(\frac{1 + jwC_L R_L + g_m R_L}{1 + jwC_L R_L}\right) = \frac{g_m \cdot R_L \cdot V_i'}{1 + jwC_L R_L}$$

$$\frac{V_e}{V_i'} = \frac{g_m R_L}{1 + g_m R_L + jwC_L R_L}$$

$$\frac{V_o}{V_i} = \frac{V_e}{V_i'} = \frac{g_m R_L}{(1 + g_m R_L)\left[1 + \left(\frac{jwC_L R_L}{1 + g_m R_L}\right)\right]}$$

$$\frac{V_o}{V_i} = \frac{\frac{g_m R_L}{1 + g_m R_L}}{1 + \frac{jwC_L R_L}{1 + g_m R_L}}$$

$$\frac{V_o}{V_i} = \frac{g_m R_L}{1 + g_m R_L} \times \frac{1}{1 + j\left(\frac{f}{f_H}\right)}$$

$$\boxed{A_v = \frac{A_o}{1 + j\left(\frac{f}{f_H}\right)}}$$

$$A_o = \frac{g_m R_L}{1 + g_m R_L} \simeq 1 \text{ (Gain)}$$

$$f_H = \frac{1 + g_m R_L}{2\pi C_L R_L}$$

Now, since the input impedance between terminal B and C is very large in comparison $(r_{bb'} + R_S)$ so overall voltage gain

$$A_{vs} = \frac{V_e}{V_i} = \frac{A_o}{1 + j\left(\frac{f}{f_H}\right)}$$

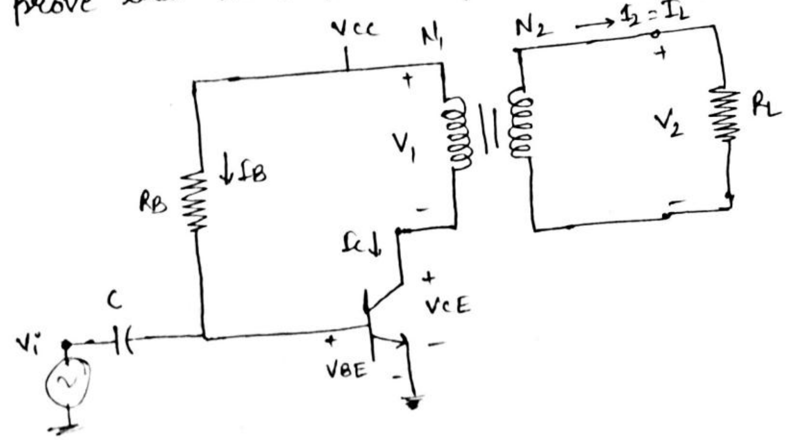
$f_H \rightarrow$ High cut-off freq

Ques-2

- Transformer coupled class-A power Amplifier.

or

- prove that the maximum power efficiency is 50%.



Dc operation

→ It is assumed that the winding resistances are zero ohms

→ There is no dc voltage drop across primary of transformers

w.r.t the slop of dc load line is reciprocal of the dc. resistance in the collector ckt ($\frac{1}{R(dc)} = \frac{1}{0} = \infty$)

Applying KVL to the collector ckt.

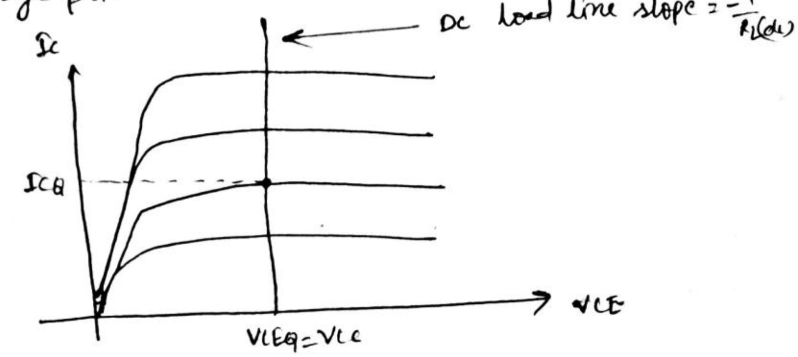
$$V_{CC} - V_{CE} = 0$$

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

$$\boxed{V_{CEQ} = V_{CC}}$$

This is the dc bias voltage V_{CEQ} for the transistor.

- Hence the dc load line is a vertical straight line passing through a voltage point on the x-axis which is $V_{CEQ} = V_{CC}$



Similarly, the ac power delivered to the load on secondry can be calculated using secondry quantities.

let V_{2m} = peak value of secondry or load voltage
I_{2m} = peak value of secondry or load current

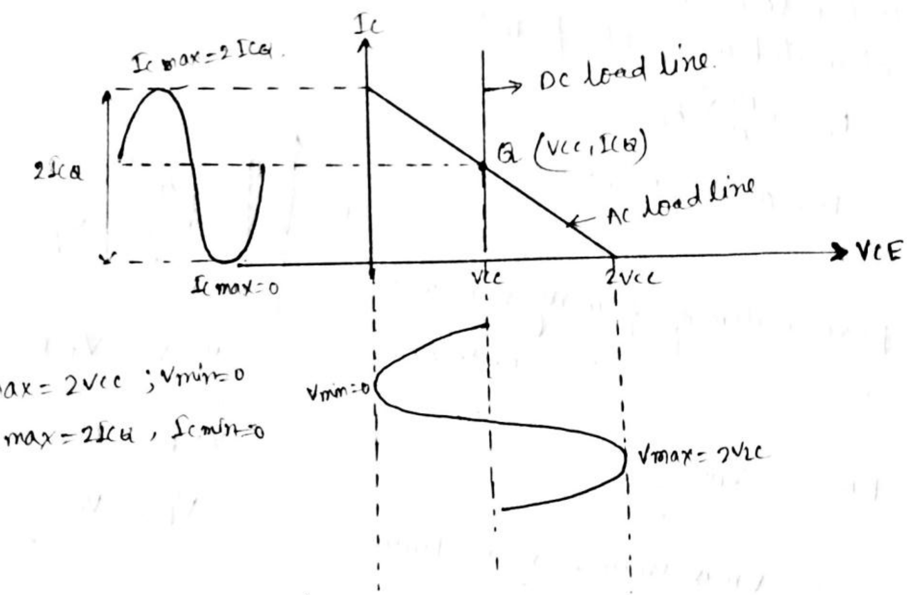
$$P_{ac} = \frac{V_{2m} \cdot I_{2m}}{2}$$

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

Efficiency:-

$$\eta = \frac{P_{ac}}{P_{dc}} \times 100$$

$$\boxed{\eta = \frac{(V_{max} - V_{min}) \cdot (I_{max} - I_{min})}{8 V_{CC} \cdot I_{CQ}} \times 100}$$



$V_{max} = 2V_{CC}$; $V_{min} = 0$
$I_{Cmax} = 2I_{CQ}$, $I_{Cmin} = 0$

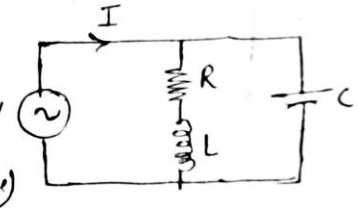
$$\eta = \frac{(2V_{CC} - 0)(2I_{CQ} - 0)}{8 V_{CC} \cdot I_{CQ}} = \frac{1}{4} = 50\%$$

$$\boxed{\eta = 50\%}$$

Ques-3

<u>parallel resonance</u> (practical tank (ckt))

- Circuit current is in phase with valtage applied.
- → phase angle ϕ b/w current and valtage is zero.
- → The Circuit is resistive in nature
- → power factor $(\cos\phi) = 1$



<u>Resonant frequency</u>

$X_L = 2\pi f L$ (Inductive reactance)

$X_C = \frac{1}{2\pi f C}$ (Capacitive reactance)

$Z_1 = R + JX_L$

$Y_1 = \frac{1}{R + JX_L}$ (admittance)

$= \frac{1}{R+JX_L} \times \frac{R-JX_L}{R-JX_L} = \frac{R-JX_L}{R^2+X_L^2}$

$Y_1 = \frac{R}{R^2+X_L^2} - \frac{JX_L}{R^2+X_L^2}$ ——— (1)

$Z_2 = -JX_C$

$Y_2 = \frac{1}{-JX_C} = \frac{J}{X_C}$ ——— (2)

<u>Total admittance</u>

$Y_T = Y_1 + Y_2$

$$= \frac{R}{R^2+X_L^2} - \frac{jX_L}{R^2+X_L^2} + \frac{j}{X_C}$$

$$Y_T = \frac{R}{R^2+X_L^2} + j\left(\frac{1}{X_C} - \frac{X_L}{R^2+X_L^2}\right)$$

At resonance

imaginary part of Y_T is zero.

$$\frac{1}{X_C} - \frac{X_L}{R^2+X_L^2} = 0$$

$$\frac{X_L}{R^2+X_L^2} = \frac{1}{X_C} \Rightarrow X_L X_C = R^2+X_L^2$$

$$2\pi f_r L \cdot \frac{1}{2\pi f_r C} = R^2 + (2\pi f_r L)^2$$

$$\frac{L}{C} = R^2 + 4\pi^2 f_r^2 L^2$$

$$\frac{L}{C} - R^2 = (4\pi^2 L^2) \cdot f_r^2$$

$$f_r = \frac{1}{2\pi L}\sqrt{\frac{L}{C} - R^2}$$

$$f_r = \frac{1}{2\pi}\sqrt{\frac{L}{CXL^2} - R^2}$$

$$\boxed{f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}$$

Dynamic resistance

At resonance

$Z_1 = R + j\omega L$ $\quad Z_2 = \frac{1}{j\omega C} = -\frac{j}{\omega C}$

$(R+j\omega L) \cdot \frac{j}{\omega C}$

$R + j\omega L - \frac{j}{\omega C}$

$$Y_T = \frac{R}{R^2+X_L^2}$$

impedance $= R_D = \frac{1}{Y_T} = \frac{R^2+X_L^2}{R}$

$$Z_r = \frac{Z_L^2}{R}$$

$$Z_r = \frac{L/C}{R}$$

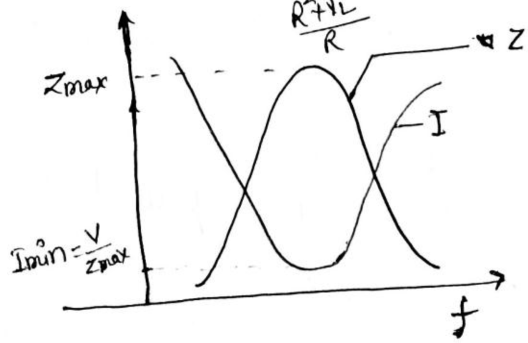
$$\boxed{Z_r = \frac{L}{CR}}$$ Dynamic resistance

At parallel resonance

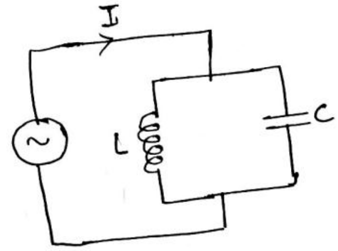
→ Admittance decrease. i.e impedance ↑es.

→ Current decrease.

→ This Ckt is rejector circuit.



Ideal tank Ckt



$Y_T = Y_L + Y_C$

$Z_L = jX_L \quad ; \quad Z_C = -jX_C$

$Y_L = \frac{1}{jX_L} \qquad Y_L = \frac{j}{X_C}$

$Y_T = j\left[\frac{1}{X_C} - \frac{1}{X_L}\right]$

At resonance

$\frac{1}{X_C} - \frac{1}{X_L} = 0$

$\frac{1}{X_C} = \frac{1}{X_L} \Rightarrow$ ~~$2\pi f_r L = 2\pi f_r C$~~

$X_L = X_C$

$2\pi f_r L = \frac{1}{2\pi f_r C} \qquad f_r^2 = \frac{1}{(2\pi)^2 LC}$

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

Ques-4

Solution i) $g_m = \frac{I_c}{V_T} = \frac{1mA}{26mA}$

$= 38.46 \, mA/V$

ii) $r_{b'e} = \frac{h_{fe}}{g_m} = \frac{200}{38.46 \times 10^{-3}}$

$= 5.20 \, k\Omega$

iii) $(C_e + C_c) = \frac{g_m}{2\pi f_T} = \frac{g_m}{\omega_T}$

$= \frac{38.46 \times 10^{-3}}{500 \times 10^{6}}$

$C_e + C_c = 76.92 \, PF$

$C_{b'e} = C_e = 76.92 \, PF - 3 \, PF = 73.92 \, PF$

(iv) $f_T = h_{fe} \cdot f_\beta$

$2\pi f_T = h_{fe} \, 2\pi f_\beta$.

$\omega_T = h_{fe} \, \omega_\beta$

$\omega_\beta = \frac{\omega_T}{h_{fe}} = \frac{500 \times 10^{6}}{200}$

$\boxed{\omega_\beta = 2.5 \, M \, rad/sec}$

Unit-5

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Power Amplifier

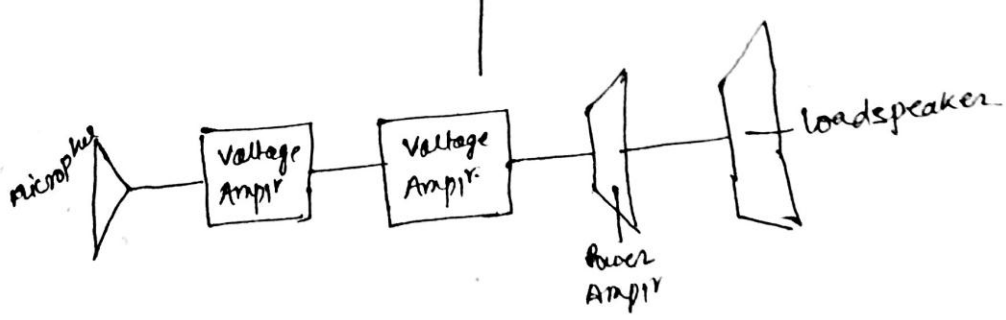
→ It is last stage of multistage Amplifier

→ power Amplifier is defined as ability of amplifier to convert available o/p dc power into ac signal power with the amplification of i/p signal.

→ Transistor used in power Amplifier are called power transistor

→ power Amplifier are designed mostly by BJT & they are generally in CE mode.

Small signal Amplifier	large Signal Amplifier
→ i/p signal amplitude are very small (μV or mV)	i/p signal amplitude are very high (>1V)
→ operate only in linear region	→ operate only both in linear and Non-linear region of i/p charq. curve.
→ Important specification AI, Av, Ri Ro, φ	→ Important specification are: → power conversion efficiency η → DC power available at o/p
→ Analysis amp will be done using graphical as well as mathematical.	→ by only graphical analysis.



The comparison b/w Valtage and power Amplifier

Parameter	Valtage Ampl^r.	Power Ampl^r.
β	high (>100)	Low (5 to 20)
Rc	high (4-10 kΩ)	low (5 to 20 Ω)
Coupling	usually R-C coupling	Transformer Coupling
Input Valtage	low (a few mV)	high (2-4V)
collector current	low (≃ 1mA)	high >(100mA)
Power o/p	low	High
output Impedance	High (≃12 kΩ)	low (200 Ω)

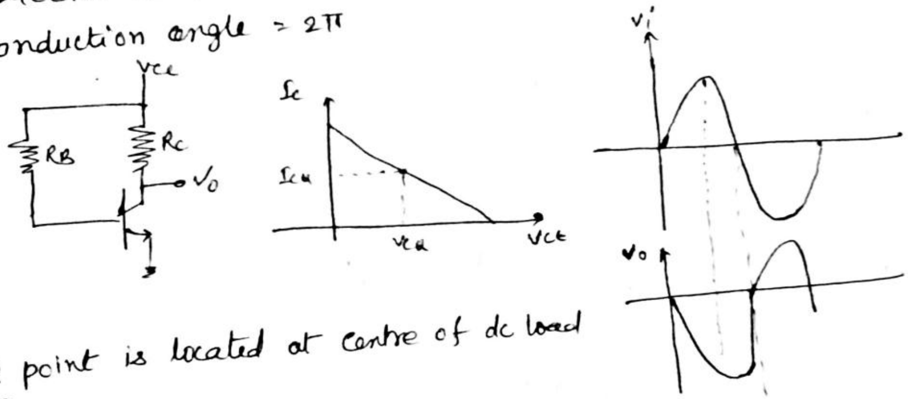
Classification of power Amplifier

- Class-A power Amplifier
- → Class-B
- → Class-AB
- → Class-C
- → Class-D

Class-A power power Amplifier

→ Collector current flows for entire 360° of I/P signal.

Conduction angle = 2π



→ Q point is located at centre of dc load line

Advantage :- Minimum distortion

→ Extellent thermal stability i.e, no thermal runaway problem.

Disadvantage :- Small power conversion efficiency

Application :- Designing of audio freq amplifier.

→ In class-A operation, power dissipated by Tx is equal to max signal power O/P.

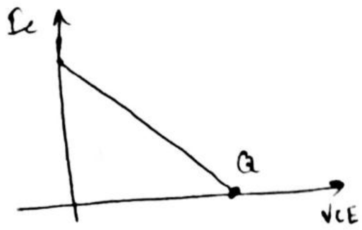
For class-A, $P_D = P_{o\,max}$ i.e max power O/P.

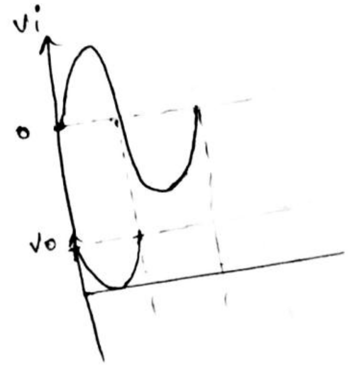
Class-B operation :-

→ collector current flows exactly for 180° of i/p signal.

→ Q point is located at cut-off.

→ It is double ended amplifier i.e two transistor in one stage.





Advantage :- Higher efficiency (78.5%)

Power drain is eliminated

Disadvantage :- Higher distortion

→ Thermal stability is less

→ Introduce crossover distortion.

Power dissipated by single Tx in ckt.

$P_D = 0.2 P_{omax}$

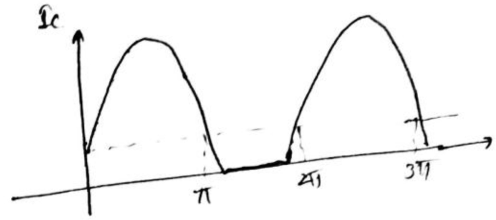
Power dissipated by circuit i.e 2Tx

$P_D = 0.4 P_{max}$.

For e.g:- To design a class-B amplifiers with 20W o/p signal power, Tx must dissipate 4W of Pow.

Class-AB power Amplifier :-

- conduction angle $180° < \phi < 360°$
→ Q point is located in active region but close to cut-off region
→ Distortion & Noise interference is more as compared to class-A & less than compared to class-B.



Class-C power Amplifier

→ conduction Angle $< 180°$