Marks

VIGNANA BHARATHI INSTITUTE OF TECHNOLOGY
(A UGC Autonomous Institution, Approved by AICTE, Accredited by NBA & NAAC-A Grade, Affiliated to JNTUH)
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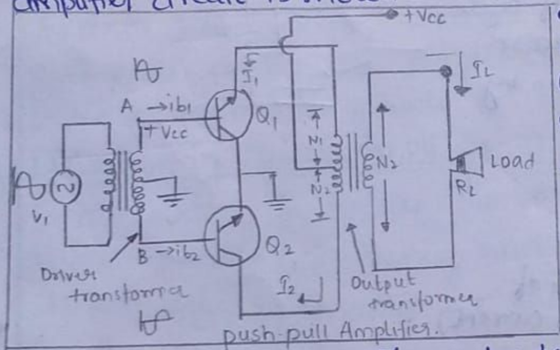
Subject : ECA | Branch : ECE-B
Submission Date : | Signature of the faculty member with date :

Assignment Sheet No : 1

1) a) With the help of neat diagram & graphical representation explain the operation of class B power amplifier (push-pull configuration). Derive the expression for efficiency & calculate the value of maximum efficiency

A. The pushpull circuit requires two transformers, one as input transformer called driver transformer and other to connect the load called output transformer. The input signal is applied to the primary of the driver transformer. Both the transformers are centre tapped transformers. The push pull class B. amplifier circuit is shown below



push-pull Amplifier.

- In the circuit, Q_1 & Q_2 are n-p-n type. The circuit can use both Q_1 and Q_2 of p-n-p type. In such a case, the only change is that the supply voltage must be -Vcc, the basic circuit remains the same. Generally the circuit using n-p-n transistors is used. Both the transistors are in common emitter configuration
- The driver transformer drives the ckt. The input signal is applied to the primary of the driver transformer. The centre tap on the secondary of the driver transformer is grounded. The centre tap on the primary of the output transformer is connected to the supply voltage +Vcc.

With respect to the centre tap, for a +ve half cycle of input signal, the point A on the secondary of the driver transformer will be positive. While the point B will be negative. Thus the voltages in the two halves of the secondary of the driver transformer will be equal but with opposite polarity. Hence the input signals applied to the base of the transistors Q_1 & Q_2 will be 180° out of phase

The transistor Q_1 conducts for the positive half cycle of the input producing positive half cycle across the load. While the transistor Q_2 conducts for the -ve half cycle of the input producing -ve cycle across the load. Thus across the load, we get a full cycle for a full input cycle. The basic push pull operation

When point A is +ve, the transistor Q_1 gets driven into an active region while, the transistor Q_2 is in cut-off region. While when point A is -ve, the pt B is +ve, hence the Q_2 gets into active & Q_1 is in cut-off region

Operation

Dc Opeeation

The dc biasing point ie Q point is adjusted on the x-axis such that $V_{CEQ} = V_{CC}$ & I_{CEQ} is zero. the coordinate points for the Q pt are (VCC,0)

Dc power I/p: Because each transistor O/p is in the form of rectifier (half-wave) the peak value of current will be taken form dc value or aveege value

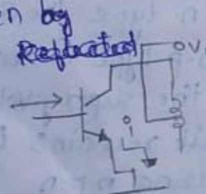
The dc value is taken as $\frac{I_m}{\pi}$ & I_P/π

$$I_{dc} = \frac{I_m}{\pi} + \frac{I_m}{\pi} \Rightarrow 2\frac{I_m}{\pi} \quad (1)$$

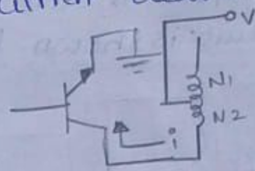
Total dc power Input

$$P_{dc} = V_{CC} \times I_{dc} = \left[\frac{2I_m}{\pi}\right] V_{CC} \quad (2)$$

Ac Operation When an AC signal is applied to the driver transformer for +ve half cycle transistor Q_1 conduct & the path of the current drawn by th Q_1 is given by



2) Similarly for -ve half cycle path of the current drawn by transistor Q_2 is given by



(3)

$$\Rightarrow R_L' = \frac{R_L}{n^2} \quad \text{where } n = \frac{N_2}{N_1}$$

then $\frac{1}{R_L'} = \frac{I_m}{V_m} \Rightarrow R_L' = \frac{V_m}{I_m}$ (4) (I_m = peak value of the collector current)

Ac Power Output

As I_m & V_m are the peak values

$$V_{rms} = \frac{V_m}{\sqrt{2}} \quad (5)$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} \quad (6)$$

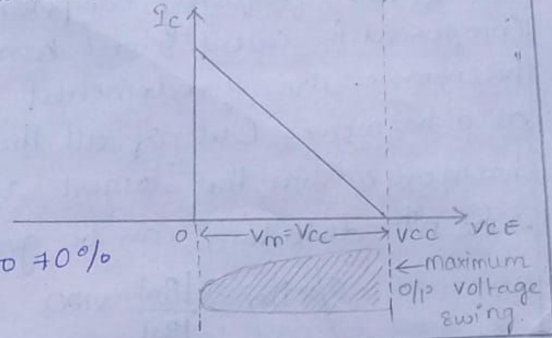
$$P_{ac} = V_{rms} I_{rms} = I_{rms}^2 R_L' = \frac{V_{rms}^2}{R_L'} \quad (7)$$

$$P_{ac} = \frac{V_m I_m}{2} = \frac{I_m^2 R_L'}{2} = \frac{V_m^2}{2R_L'} \quad (8)$$

Efficiency $\% \eta = \frac{P_{ac}}{P_{dc}} \times 100 = \frac{\left(\frac{V_m I_m}{2}\right)}{\frac{2}{\pi} V_{CC} I_m} \times 100$ $\boxed{\% \eta = \frac{\pi}{4} \frac{V_m}{V_{CC}} \times 100}$ (9)

Maximum Efficiency

from eq ①, it is clear that as the peak value of the collector voltage V_m increases, the efficiency increases. The maximum value of V_m possible is equal to V_{CC} as shown



$V_m = V_{CC}$ for maximum η

$$\% \eta_{max} = \frac{\pi}{4} \times \frac{V_{CC}}{V_{CC}} \times 100$$

$$= 78.5\%$$

for practical circuits it is up 65 to 70%

b) Discuss about the distortion present in power amplifiers. Derive the expression for the total amount of distortion present in the amplifiers. Explain how even harmonic distortion can be reduced in a class B push-pull configured amplifier. Explain the origin of crossover distortion. Describe various methods to minimize the distortion

A) **Distortion in Power Amplifier** The input signal applied to the amplifiers is alternating in nature. The basic features of any alternating signal are amplitude, frequency and phase. The amplifier output should be reproduced faithfully i.e there should not be the change or distortion in the amplitude, frequency and phase of the signal. Hence the possible distortions in any amplifier are amplitude distortion, phase distortions and frequency distortion. But the phase distortions are not detectable by human ears as human ears are insensitive to the phase changes while the change in gain of the amplifier with respect to the frequency is called frequency distortions.

Harmonic distortion:

The Harmonic distortion means the presence of the frequency components in the output wave form, which are not present in the input signal. The component same as the input signal is called fundamental frequency component. The additional frequency components present in the output signal are having frequency components. The additional frequency components are called harmonic components or harmonic components. These components are called harmonic components or harmonics components.

For example, if the fundamental frequency of f Hz, then the output signals contains fundamental frequency component of f Hz & additional frequency components at 2f Hz, 3f Hz, 4f Hz & so on. The 2f component is called second harmonic, the 3f component is called third harmonic. The fundamental frequency components is not considered as a harmonic. Out of all the harmonic components, the second harmonic has the largest amplitude

→ The n^{th} distortion can be given as

$$\% D_n = \frac{|B_n|}{|B_1|} \times 100$$

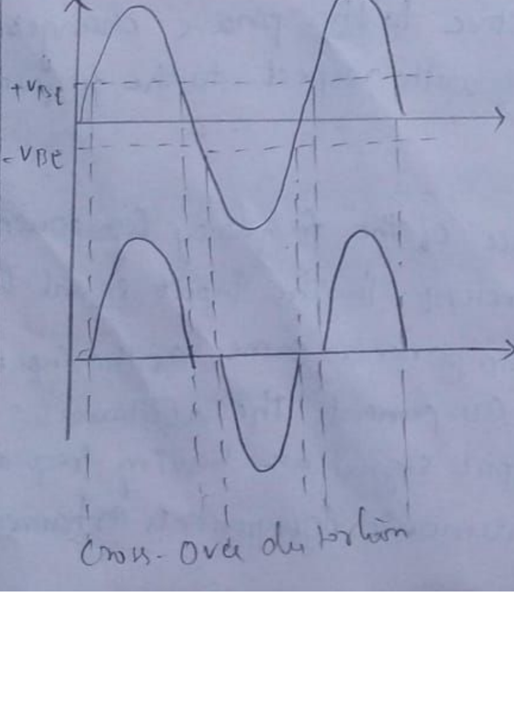
for second harmonic ⇒ $D_2 = \frac{B_2}{B_1} \times 100\%$

for 3rd harmonic ⇒ $D_3 = \frac{B_3}{B_1} \times 100\%$

for total harmonic distortion can be as $\% D = \sqrt{D_2^2 + D_3^2 + \cdots} \times 100\%$

Cross Over distortion :-

For a transistor to be in active region, the base emitter junction must be forward biased, this is done till the voltage applied becomes greater than cut in voltage (V_{BE}), when the transition occurs from one transistor to the other transistor, if a second transistor is not going into conduction stage until it reaches cut in voltage the output waveform produces ovalue, this is called as cross-over distortion



Cross-Over distortion

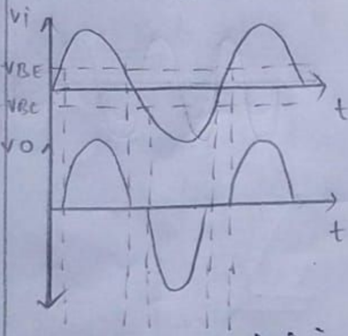
Elimination of cross-over distortion

→ To eliminate the cross-over distortion some modification are necessary in the basic circuits of class B amplifiers. The basic reason for the cross over distortion is the cut-in voltage of the transistor junction. To overcome their cut-in voltage, a small forward biased is applied to the transistors

Origin of cross over distortion:-

For a transistor to be in active region the base emitter junction must be forward biased. The junction cannot be made forward biased till the voltage applied becomes greater than cut-in voltage (V_{BE}) of the junction, which is generally 0.7V for silicon & 0.2 V for germanium transistors. Hence as long as the magnitude of the input signal is less than the cut-in voltage of the base emitter junction, the collector current remain zero & transistor remains in cut-off region.

Hence there is a period between the crossing of the half cycle of the input signal, for which none of the transistors is active and the output is zero. Hence the nature of the output signal gets distorted and no longer remains same as that of input. Such a distorted output wave form due to the cut in voltage is the cross over distortion. Such a distortion in the o/p signal is called as cross-over distortion.



Methods to minimize the distortion

To minimize the distortion in power Amplifiers.

1) Choose the correct Amplifier class.
2) Linearization Techniques
3) Negative feedback
4) Component selection
5) proper biasing
6) Harmonic filtering
7) Optimized Grounding & layout

(2) A class B push-pull amplifier supplies power to a resistive load of 12Ω. The o/p transformer has a turns ratio of 3:1 and efficiency of 78.5%. obtain a) Maximum power output b) Maximum power dissipation in each transistor c) Maximum base & collector current for each transistor. Assume $h_{fe} = 25$ & $V_{CC} = 20V$.

$R_L = 12\Omega$

turns Ratio $= \frac{n_1}{n_2}$

Sol: Given $R_L = 12\Omega$

~~turns~~ Ratio $= \frac{N_1}{N_2} = 3:1$

Efficiency $\eta = 78.5\%$

$h_{fe} = 25$

$V_{CC} = 20V$

(i) $P_{out} = \frac{V_m^2}{2R_L'}$ ($V_m = V_{cc}$) at Maximum

$= \frac{V_{cc}^2}{2R_L'}$

whee $R_L' = n^2 R_L$

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

$= (3)^2 R_L$

$= (3)^2 \times 12$

$\boxed{R_L' = 108\Omega}$

$= \frac{(20)^2}{2\times(108)}$

$\boxed{P_{out} = 1.85W}$

(ii) Max power dissipation

$P_d(max) = \frac{4}{\pi^2} P_o(ac)$

$= \frac{4}{(\pi)^2}(1.85)$

$P_d(max) = 0.75W$

$P_d(max)$ per transistor $= \frac{0.75}{2} \Rightarrow 0.375W$

(iii) Collector Current $I_c = \frac{P_{out}}{V_{cc}}$

$= \frac{1.85}{20} = 0.0925A$

Base Current $= I_b = \frac{I_c}{h_{fe}}$

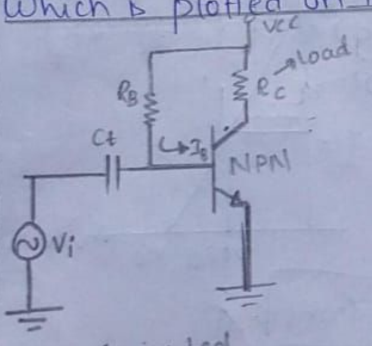
$= \frac{0.0925}{25}$

$\boxed{I_b = 0.0037\ A}$

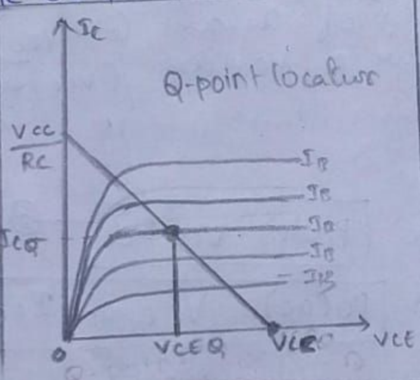
(8) With the help of neat diagram & graphical representation explain the Operation of class-A power amplifier. Derive the expression for efficiency and calculate the value of maximum efficiency

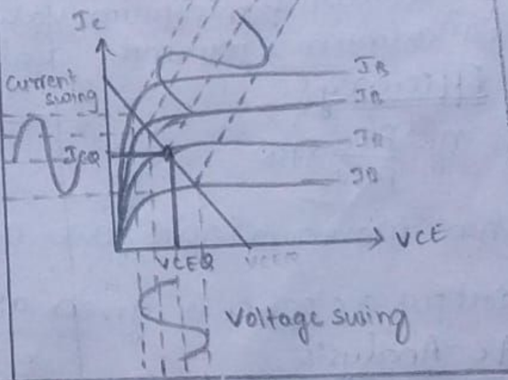
A) **Series Fed class-A power amplifier:-**

→ For any amplifier Operating point (Q-pt) is fixed by selecting the proper DC Biasing to the transistor used. This Q-point is shown on the load drive characteristics of the transistor which is plotted on the Output characteristics Of the transistor



Series fed Class-A Amplifier





→ For a class A amplifier Q-point is at the centre of the load line.

→ If the Q-point & the input signal are selected such that the output signal is obtained for a full input cycle (360°). For class A amplifiers the Q-point is at the Centre of the loadline.

→ In series fed class-A Amplifier load resistance/resistor is directly connected to the output of the transistor

connected to the output of the transistor direct coupled class-A amplifier.

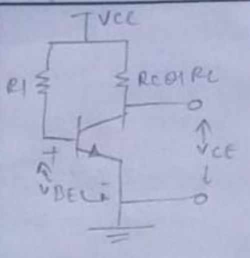
→ Therefore, this is also called as direct coupled class-A amplifier.

→ In series fed class A amplifier the transistor is always in Active region

→ when an input AC signal is applied, the output will vary from its DC biasing Operating voltage & current

DC-Analysis For DC Analysis open circuit AC sources and Capacitors

→ The Q-point coordinates for the circuit V_{CEQ}, I_{CQ}



→ Apply KVL for the loop base & emitter $V_{CC} - I_B R_B - V_{BE} = 0$ — (1)

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} \quad (2)$$

$$I_C = \beta I_B \quad (3)$$

Apply KVL for the loop C & E loop $V_{CC} - I_C R_C - V_{CE} = 0$ — (4)

$$V_{CE} = V_{CC} - I_C R_C \quad (5)$$

→ To plot the dc load line we have to consider two worst case conditions for the given circuit

(i) when the transistor is in saturation region ie $V_{CE} = 0$

then eq (5) becomes $V_{CC} - I_C R_C = 0$

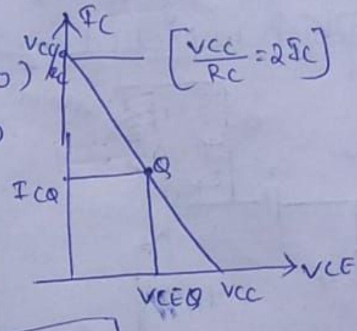
$$\boxed{I_{CQ} = \frac{V_{CC}}{R_C}} \quad (6)$$

(ii) when the transistor is in cut-off state ie $I_C = 0$

then eq (5) becomes $\boxed{V_{CEQ} = V_{CC}}$ — (7)

→ Maximum & minimum values of I_C are $(V_{CC}/R_C, 0)$

→ maximum & minimum values of V_{CE} are $(V_{CC}, 0)$



$$\left[\frac{V_{CC}}{R_C} = 2I_C\right]$$

Efficiency

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

then maximum input power DC $\boxed{P_i(dc) = V_{CQ} I_Q}$ — (8)

output ac power is given as $\boxed{P_o(ac) = V_{CEQ}(rms)\, I_{CQ}(rms)}$ — 9

Ac-Analysis

→ $\boxed{P_o(ac) = I_{CQ}^2(rms) R_C}$ (10) (or) $\boxed{P_{ac} = \frac{V_{CE}^2(rms)}{R_C}}$ (11)

Generally $V_{rms} = \frac{V_m}{\sqrt{2}}$ & $I_{rms} = \frac{I_m}{\sqrt{2}}$

→ similarly in term of peak signal ⇒ $V_{rms} = \frac{V_P}{\sqrt{2}}$ & $I_{rms} = \frac{I_P}{\sqrt{2}}$

→ In terms of peak to peak signal → $V_{rms} = \frac{V_{PP}}{2\sqrt{2}}$ & $I_{rms} = \frac{I_{PP}}{2\sqrt{2}}$

Rewriting eq (9) with peak to peak values

$$P_o(ac) = \frac{V_{CE}(pp)}{2\sqrt{2}} \times \frac{I_C(p-p)}{2\sqrt{2}} \Rightarrow P_o(ac) = \frac{V_{CE}(pp)\, I_C(pp)}{(2\sqrt{2})(2\sqrt{2})}$$

$$P_o(ac) = \frac{V_{CE}(pp)\, I_C(pp)}{8}$$

In similar manner, rewriting (10) & (11) by substituting peak to peak voltage & current values

(11) → $P_{o(ac)} = \frac{I_c^2(p\text{-}p)}{(2\sqrt{2})^2} R_C \Rightarrow \frac{I_c^2(pp)}{8} R_C$

(12) → $P_{o(ac)} = \frac{V_{ce}^2(p\text{-}p)}{(2\sqrt{2})^2} R_C \Rightarrow \frac{V_{ce}^2(p\text{-}p)}{8} R_C$

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

$$\eta = \frac{V_{CEQ}(p\text{-}p) \cdot I_{CQ}(p\text{-}p)}{8 V_{CEQ} I_{CQ}} \Rightarrow \frac{(V_{CE\,max} - V_{CE\,min})(I_{c\,max} - I_{c\,min})}{8 V_{cc} I_c}$$

Maximum efficiency:

$\left.\begin{array}{l} V_{max} = V_{cc} \ \& \ V_{min} = 0 \\ I_{max} = 2I_{CQ} \ \& \ I_{min} = 0 \end{array}\right\}$ for maximum swing

$$\%\eta = \frac{(\cancel{V_{cc}}-0)(2\cancel{I_{CQ}}-0)}{8\cancel{V_{cc}} \times \cancel{I_{CQ}}} \times 100$$

$\%\eta = \frac{1}{4} \times 100$

$\boxed{\%\eta = 25\%}$ → maximum efficiency

4) a) A single ended class A amplifier has a transformer coupled load of 8 Ω. If the transformer turns ratio is 10, Find the maximum power o/p delivered to the load. Take the zero signal collector current of 500mA

Sol Given $R_L = 8\Omega$.

Turns Ratio: $\left(\frac{N_1}{N_2}\right) = 10:1$

$I_c = 500mA = I_m$

where $R_L' = n^2 R_L$
$= (10)^2 \, 8$
$= 800\Omega$

Then maximum power output delivered is

$P_{ac} = \frac{V_m^2}{2R_L'}$ (where $V_m = I_m R_L'$
$= (500)(800\Omega)$
$V_m = 0.4V$

$= \frac{(0.4)^2}{(2)(800 \times 10^{-3})}$

$\boxed{P_{ac} = 0.1W}$

b) A transistor in a transformer Coupled (Class-A) power amplifier has to deliver a maximum of 5 watts to a load of 4Ω load. The quiescent point is adjusted for symmetrical swing, and the collector supply voltage $V_{CC}=20$ volts, Assume $V_{min}=0$ volts

(i) what is the transformer turns ratio.

(ii) what is the peak collector current

A) Given $P_{max} = 5$ watts

$R_L = 4\Omega$

$V_{CC} = 20$ volts

then V_{pp} or V_m :

$$\because \quad P = \frac{V_m^2}{2R_L}$$

$$V_m = \sqrt{2 \cdot P \cdot R_L}$$

$$= \sqrt{2 \times 5 \times (4)}$$

$$\boxed{V_m = 6.32V}$$

(i) $V_m = \dfrac{V_{CC}}{2N}$

$$N = \frac{20}{2V_m}$$

$$N = \frac{20}{2 \times 6.32}$$

$$\boxed{N = 1.58 \text{ (turns ratio)}}$$

(ii) Peak collector current I_m or I_C

$$V_m = I_{C\,peak} \cdot R_L$$

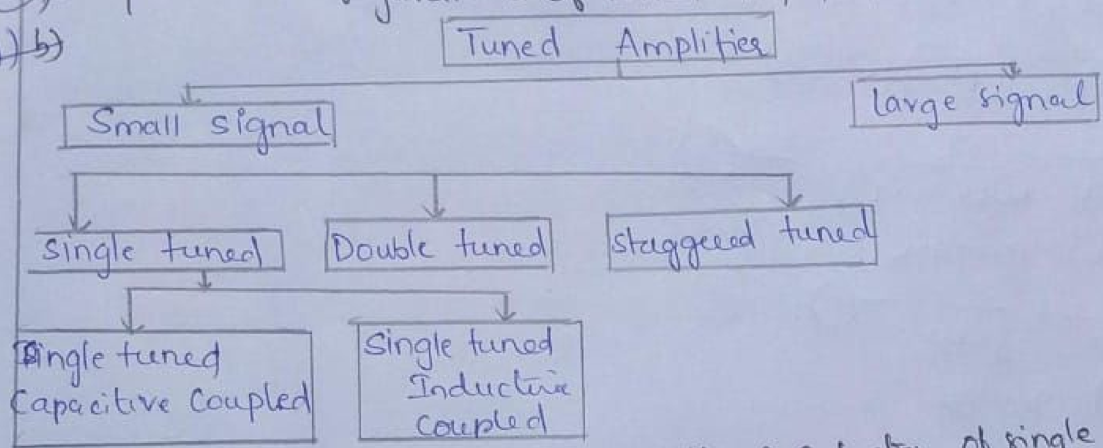
$$6.32 = I_{C\,peak}(4)$$

$$I_{C\,peak} = \frac{6.32}{4}$$

$$\boxed{I_{C(peak)} = 1.58 \text{ Amps}}$$

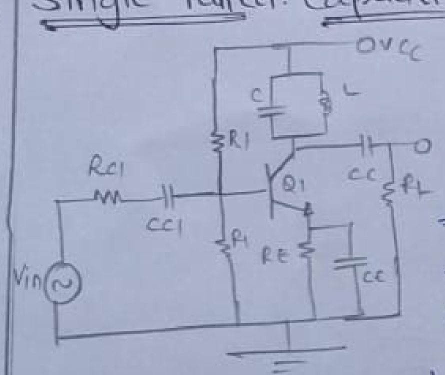
5 a) List possible Configurations of tuned Amplifiers.

A) b)



b) Derive the expression for BandWidth & Q-factor of single tuned, capacitive Coupled amplifier. List the assumption made for the derivation

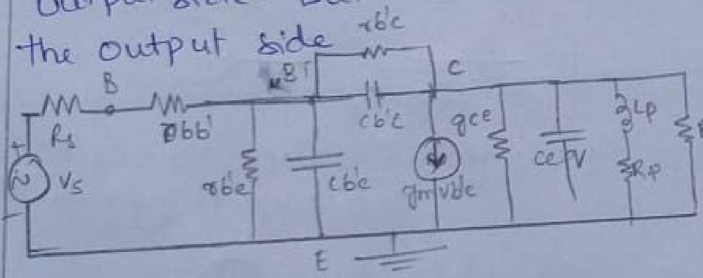
A) Single-tuned. Capacitive Coupled Amplifier



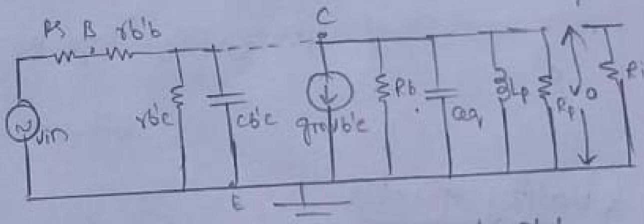
L&C tuned circuit is not connected b/w collector & ground by the transistor will be short circuited at some frequency other than resonant frequency

=) Modified equivalent ckt using Miller's theorem

=) According to Miller's theorem, the feedback Capacitance C_c is $C_c(1-A)$ on the i/p side and $C_c(A-1/A)$ on the output side. But where as Resistance is $r_{b'c}/(1-A)$ on i/p side $r_{b'c}/(A-1/A)$ on the output side



Hybrid-π Model



Simplified equivalent ckt

Series Admittance

$$Y_s = \frac{1}{R+j\omega L} \quad \text{—} (1)$$

Rationalize the eq (1)

$$Y_s = \frac{1}{R+j\omega L} \times \frac{R-j\omega L}{R-j\omega L}$$

$$= \frac{R-j\omega L}{(R+j\omega L)(R-j\omega L)} \Rightarrow \frac{R-j\omega L}{(R)^2-(j\omega L)^2} \Rightarrow \frac{R-j\omega L}{R^2+(\omega L)^2} \Rightarrow \frac{R-j\omega L}{R^2+\omega^2 L^2}$$

$$= \frac{R}{R^2+\omega^2 L^2} - \frac{j\omega L}{R^2+\omega^2 L^2}$$

Now Multiply & divide with ω in Complex form only

$$= \frac{R}{R^2+\omega^2L^2} - \left(\frac{j\omega L}{R^2+\omega^2L^2} \times \frac{\omega}{\omega}\right)$$

$$= \frac{R}{R^2+\omega^2L^2} - \frac{j\omega^2 L}{j\omega(R^2+\omega^2L^2)} \quad \text{—} (2)$$

Admittance in parallel

$$Y_p = \frac{1}{R_p} + \frac{1}{j\omega L_p} \quad \text{—} (3)$$

from (2) & (3) $Y_s = Y_p$

$$= \frac{1}{R_p} + \frac{1}{j\omega L_p}$$

eq (2) can be written as

$$Y_s = \frac{1}{\frac{R^2+\omega^2L^2}{R}} + \frac{1}{\frac{j\omega(R^2+\omega^2L^2)}{\omega^2 L}}$$

$$\therefore R_p = \frac{R^2+\omega^2L^2}{R} \quad (4), \quad L_p = \frac{R^2+\omega^2L^2}{\omega^2 L} \quad (5)$$

At resonant frequency ($\omega L >> R$) then $R_p = \frac{\omega^2 L^2}{R}$

At resonant frequency ($\omega >> R$) then $L_p = L$

for resonant frequency to become $f_r = \frac{1}{2\pi\sqrt{L_p C_{eq}}}$ — (6)

where $C_{eq} = C_o + C$ where C = capacitance of tuned ckt

C_o = output capacitance

Quality factor

$Q = \frac{X_L}{R}$ which is also equal to $Q = \frac{\omega_r L_p}{R_p}$ — (7)

where ω_r = angular frequency at resonance

L_p & R_p are inductance & Resistance of tank ckt

=> Quality factor can be written in 2-ways

1) Loaded Quality factor (Q_L): when the ckt is connect to any external load in an amplifier

$$Q_L = \frac{\text{max energy stored}}{\text{dissipated energy in tank ckt} + \text{dissipated energy due to external load}}$$

$$\boxed{Q_L = \frac{\omega_r L}{R_C}} \quad \text{—} (8)$$

<u>Unloaded Quality factor</u> (Q_U):- When the tank ckt of any amplifier is not connected to any load.

$$Q_u = \frac{\text{max energy stored per cycle}}{\text{energy dissipated per cycle in tank ckt}}$$

$$\boxed{Q_u = \frac{\omega_r L}{R_0}} \quad \text{——— (9)}$$

Bandwidth

$$\Delta f = \frac{1}{2\pi R_t C_{eq}}$$

$$= \frac{\omega_r}{2\pi Q_{eff}}$$

Quality factor

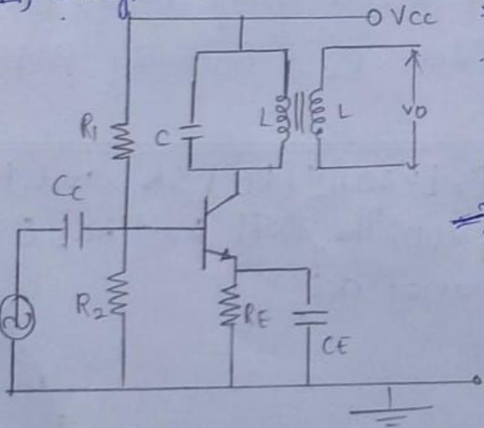
$$Q = \frac{f_0}{BW}$$

$f_0 \Rightarrow$ resonant frequency

6) a) Using the circuit diagram and equivalent circuit of inductively coupled single stage tuned amplifier. Derive expression bandwidth which interrelated to the circuit components values and quality factor of the tuned circuit and resonant frequency.

A) **Inductive Coupled Single Tuned Amplifiers**:-

In Single tuned amplifiers, LC circuit is used for frequency tuning.



$\Rightarrow$ If the Output is taken across an inductor, then the tuned ckt is called inductively coupled tuned circuit. It is otherwise called as transformer coupled tuned ckt.

$\Rightarrow$ The circuit typically consists of a tuned ckt connected in parallel with the load resistor R_L. The tuned ckt is coupled to the input and output circuits via mutual inductance M. The input signal is applied across the tuned circuits, and the Output is taken across the load resistor R_L.

$\Rightarrow$ The resonant frequency ω_0 of the tuned ckt is given by

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$\Rightarrow$ The Quality factor Q of the tuned circuit is defined as the ratio of the energy stored in the circuit to the energy dissipated per radian at resonance. It is given by

$$Q = \frac{\omega_0 L}{R_{eq}}$$

where R_{eq} is the equivalent Resistance of tuned ckt

For the Bandwidth BW is related to the quality factor Q & the resonant frequency ω_0.

$$BW = \frac{\omega_0}{Q}$$

-) For parallel resonant ckt, the equivalent Resistance R_{eq} seen by the inductor is equal to the resistance parallel with inductor.

In this its R_L

thus, the Quality factor Q is expressed as

$$Q = \frac{\omega_0 L}{R_L}$$

Substituting in Bandwidth formula we get

$$BW = \frac{\omega_0}{\frac{\omega_0 L}{R_L}}$$

$$\boxed{BW = \frac{R_L}{L}}$$

∴ so the BW of the inductively coupled single-stage tuned Amplifier is directly proportional to the load Resistance R_L & inversely proportional to the inductance L.

b) In a tuned Amplifier Ckt $C = 500pF$, $L = 20\mu H$, $R_L = 1.5K$ and the transistor has $h_{fe} = 50$ & i/p resistance of 200. The coil used has Q-factor 30. Calculate (i) resonant frequency of the tuned ckt

(ii) Impedance of the tuned ckt

(iii) Voltage gain of the stage

A) (i) ~~$f_0 = \frac{1}{2\pi\sqrt{L C_{eq}}}$~~ $f_0 = \frac{1}{2\pi\sqrt{LC}}$

$$= \frac{1}{2\pi\sqrt{(500\times10^{-12})(20\times10^{-6})}}$$

$$f_0 = \frac{1}{2\pi\sqrt{10000\times10^{-12}\times10^{-6}}}$$

$$= \frac{1}{2\pi\sqrt{10^{-14}}}$$

$$f_0 = \frac{1}{2\pi(10^{-7})}$$

$$= \frac{1}{6.28(10^{-7})}$$

$$\boxed{f_0 = 1.592\ MHz}.$$

(ii) Impedance of the tuned ckt

$$Z = \sqrt{R_L^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

where $\omega = 2\pi f_0$

$$\omega = 2 \times 3.14 \times 1.592 \times 10^{-6}$$

$$\omega = 9.99 \times 10^{6}\ rad/s.$$

$$Z = \sqrt{R_L^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$= \sqrt{(1.5\times10^{3})^2 + \left(9.99\times10^{6} \times 20\times10^{-6} - \frac{1}{9.99\times10^{6}\times500\times10^{-12}}\right)^2}$$

$$= \sqrt{(1.5\times10^{3})^2 + (199.8 - 200.2)^2}$$

$$= \sqrt{(1.5\times10^{3})^2 + (-0.4)^2}$$

$$= \sqrt{2250000 + (0.16)}$$

$$= \sqrt{2250000.16}$$

$$\boxed{Z = 1500.00\Omega}$$

iii) Voltage gain (A_v)

$$A_v = -h_{fe} \times \frac{Z}{R_L + R_{in}}$$

$$= -50 \times \frac{1500.0}{1500 + 200}$$

$$A_v = -44.117$$

∴ The Voltage gain of the stage is approximately

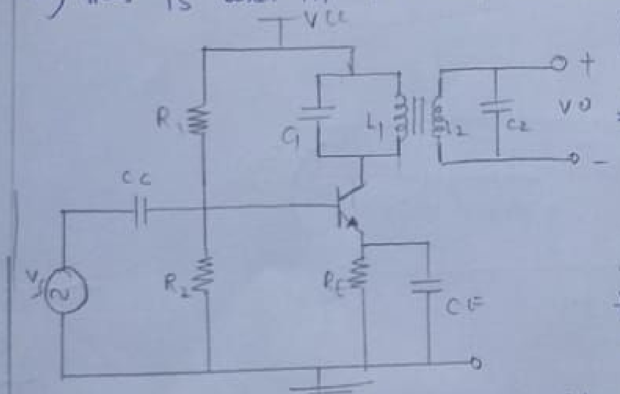
$$\boxed{A_v = -44.12}$$

7) a) Draw the circuit of double tuned transformer coupled amplifier and the working of it in detail and discuss the nature of the amplifier for different values of $kQ=1$, $kQ>1$, and $kQ<1$

A) To Overcome the drawback of single tuned amplifier, double tuned amplifiers are used. In this method, two tuned circuits are inductively coupled to eachother. L_1C_1 is used as collector load and L_2C_2 is used as output circuit. R_1, R_2, R_E provide dc current and voltage for the transistor

=) This circuit provide high impedance to the input signal and a large output appears across the tuned circuit L_1C_1. This output is inductively coupled to L_2C_2 tuned circuit

=) this is used in radio & television receiver.



Operation:

=) The signal which has to amplify is a high-frequency signal and it is given to the i/p of the amplifier. The primary tuning circuit like L1C1 can be tuned towards the i/p signal frequency

=> In this state, the tuned circuit gives high reactance towards the signal frequency. As a result, huge o/p becomes visible at the o/p of the primary tuned circuit then it is coupled with the secondary tuned circuit like L_2C_2 using mutual inductance. These circuits are widely used to connect different circuit of TV and radio receivers

Nature of the amplifier

at

$kQ=1$ =) when $k=\frac{1}{Q}$, $f_1=f_2=f_r$. This condition is known critical coupling.

$kQ<1$ =) when $k<\frac{1}{Q}$, the peak gain is less than maximum gain and the coupling is poor

$kQ>1$ => when $k>1/Q$, the circuit is Overcoupled and response shows the double peak. Such double peak response is useful when more bandwidth is required.

b) Why Cascaded amplifiers are prefered for tuned amplifiers derive the BW effect formula for single tuned cascaded amplifier (Synchronous)

A) **Effect of Cascading Single tuned Amplifier on Bandwidth:**

In order to obtain a high overall gain, several identical stages of tuned amplifiers can be used in cascade. The overall gain is the product of the voltage gains of the individual stages. let us see the effect of cascading of stages on bandwidth.

Consider n stages of single tuned direct coupled amplifiers connected in cascade. We know that the relative gain of a single tuned amplifier with respect to the gain at resonant frequency fr is

$$\left|\frac{A_v}{A_v(\text{at resonance})}\right| = \frac{1}{\sqrt{1+(2\delta Q_{eff})^2}} \quad \text{--- (1)}$$

∴ the relative gain of n stage cascaded amplifier becomes

$$\left|\frac{A_v}{A_v(\text{at resonance})}\right|^n = \left[\frac{1}{\sqrt{1+(2\delta Q_{eff})^2}}\right]^n = \frac{1}{[1+(2\delta Q_{eff})^2]^{n/2}} \quad \text{--- (2)}$$

The 3 dB frequency for the n stage cascaded amplifier can be found by equating

$$\left|\frac{A_v}{A_v(\text{at resonance})}\right|^n = \frac{1}{\sqrt{2}}$$

$$\left|\frac{A_v}{A_v(\text{at resonance})}\right|^n = \frac{1}{(2)^{1/2}} \quad \text{--- (3)}$$

eq (2) & (3) $[1+(2\delta Q_{eff})^2]^{n/\cancel{2}} = (2)^{1/\cancel{2}}$

$$[1+(2\delta Q_{eff})^2]^n = 2$$

$$(1+2\delta Q_{eff})^2 = 2^{1/n}$$

$$(2\delta Q_{eff})^2 = 2^{1/n} - 1$$

$$\boxed{2\delta Q_{eff} = \sqrt{2^{1/n} - 1}} \quad \text{--- (4)}$$

$\delta \Rightarrow$ fractional variation

$$\delta = \frac{\omega - \omega_r}{\omega_r} = \frac{f - f_r}{f_r} \quad \text{--- (5)}$$

Substitute (5) in (4)

$$2\left[\frac{f-f_r}{f_r}\right]Q_{eff} = \pm\sqrt{2^{1/n}-1}$$

$$2(f-f_r)\,Q_{eff} = \pm f_r\sqrt{2^{1/n}-1}$$

$$\boxed{f-f_r = \pm\frac{f_r}{2Q_{eff}}\sqrt{2^{1/n}-1}} \quad — (6)$$

Now consider f_1 & f_2 are lower & upper cut-off 3dB frequency

$$f_2 - f_r = +\frac{f_r}{2Q_{eff}}\sqrt{2^{1/n}-1} \quad — (7)$$

$$f_r - f_1 = +\frac{f_r}{2Q_{eff}}\sqrt{2^{1/n}-1} \quad — (8)$$

$f_r \Rightarrow$ resonant frequency
$f_2 \Rightarrow$ upper cut off frequency
$f_1 \Rightarrow$ lower cut off frequency

Adding (7) & (8)

$$f_2-\cancel{f_r}+\cancel{f_r}-f_1 \Rightarrow (f_2-f_1)_n = \frac{\cancel{2}f_r}{\cancel{2}Q_{eff}}\sqrt{2^{1/n}-1}$$

$$\boxed{(BW)_n = BW_1\sqrt{2^{1/n}-1}} \quad —$$

$BW_1 \rightarrow$ Bandwidth of single ~~stage~~ stage
$BW_n \rightarrow$ Bandwidth of n stages

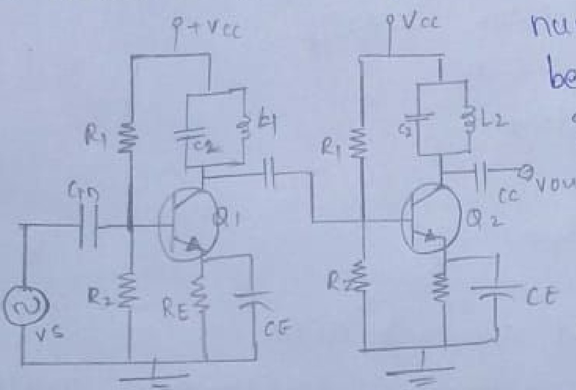
8) What is stagger tuning amplifier explain the circuit Operation? Mention the need for stagger-tuned amplifiers with applications, advantages & disadvantages.

A) **Stagger tuned amplifier:** In Order to increase bandwidth, double tuned amplifiers are preferred, but their aligment is difficult. A much better overall response can be had by stagger tuning. If two or more tuned circuit are cascaded and tuned to the same frequency, it is called the synchchronous tuning. The overall bandwidth is reduced. On the other hand, if the tuned circuits are cascaded and they are tuned to different frequency, it is possible to have increased with more desirable characteristics (ie.) flat passband with steeper sides). This technique

Operation A two stage tuned voltage amplifier. In stagger tuned circuits two single tuned cascaded amplifier having a certain bandwidth are taken and the resonant frequencies of the two tuned circuts are so adjusted that they are separated by an amount equal to the bandwidth of each stage • Stagger tuned amplifier are usually designed so that the overall response exhibits maximum flatness around the center frequency f_0

(19)

It Needs a number of tuned circuits Operating in union. If more



number of stages are employed flatter will be the passband and steeper will be the gain fall of outside the passband. Because of stagger tuning there is a loss of voltage gain. The Overall frequency response of a stagger tuned amplifier is obtained by adding individual response together. Since the resonant frequencies of different tuned circuits are displaced or staggered, they are referred as Stagger tuned circuits

Need for stagger-tuned circuits:

Wider Bandwidth: By using multiple tuned circuits with slightly different resonant frequencies, stagger tuned amplifiers can acheive a broader bandwidth compared to single-tuned amplifiers. This wider bandwidth allows the amplifier to amplify a range of frequencies without significant loss of signal strength

Improved selectivity: stagger tuning can also improve the selectivity of the amplifier, allowing it to amplify specific frequency ranges while attenuating others. This is particularly useful in communication systems where signals from different channels need to be seperated.

Reduced signal distortion: stagger tuning can help reduce signal distortion by minimizing the interaction between adjacent stages in the amplifier. This can lead to cleaner amplification of the input signal

Enhanced stability: Stagger-tuned amplifiers can be more stable over temperature & Component Variations compared to single-tuned amplifiers providing more consistent performance Over a range of operating Conditions

Applications of stagger tuned amplifier

1) These type of tuned amplifiers are employed in wideband applications for the amplifications of video

2) IF amplifiers in the superheterodyne receiver

3) TV receiver & satellite transponder

4) Used in Wireless local are networks (WLANs)

5) Used in RF amplifier for radio applications like radio receivers
6) Used for Y-amplifiers for Oscilloscope Working
7) Used in Various Industrial applications
8) Used in radio UHF relay system

Advantages

The stagger tuned amplifier advantages are
1) The tuning of this amplifier is very easy
2) It has better flat wideband characteristics.
3) The bandwidth is increased $\sqrt{2}$ times when compared to single tuned amplifier.
4) The Overall gain is increased due to the cascading of two single tuned amplifier
5) Enhanced Stability of the circuit

Disadvantages:

The Stagger tuned amplifier disadvantages are
1) The alignment of stagger-tuned amplifiers are difficult. Hence, two single tuned amplifier are cascaded.
2) The selectivity is reduced and the tuning of tank ckt is critical.