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AEC

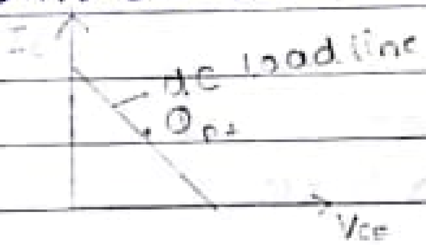
UNIT-3

Chapter

LARGE SIGNAL AMPLIFIERS.

Classification of Power Amplifiers:

i Class A amplifier: {Based on the location of Q point on DC load line}.

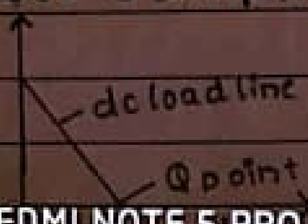


Q point is located at the centre of dc load line so that it is in the middle of Active region. And collector current I_c due to signal flows for entire cycle of i/p. Hence Conduction L'e ; $\phi_c = 360°$

Conversion efficiency η_c

$$25\% \leq \eta_c \leq 50\%.$$

ii Class B amplifier:



Q-point is located in the cut off region so that the Collector current I_c flows only for half-cycle of i/p. Hence conduction

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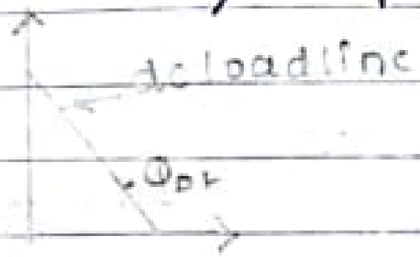
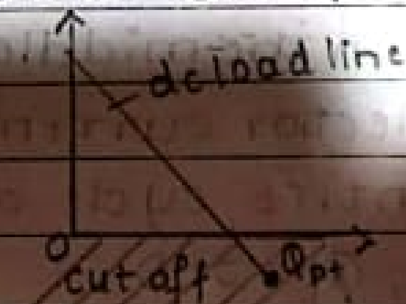
L'c is 180° & $\phi_C = 180°$.
$\eta_c = 78.5\%$.

3 Class AB amplifier.
Q point is located nearer to Cutoff and Collector current flows for more than half cycle of i/p but less than Full cycle of i/p signal.



$180° < \phi_c < 360°$
$50\% < \% \eta_c < 78.5\%$.

4 Class C amplifier:



Q point is located deep into cut off region. Hence Collector current flows for less than half cycle of i/p signal.
$\phi_c < 180°$
$98.5\% > \% \eta_c > 78.5\%$.

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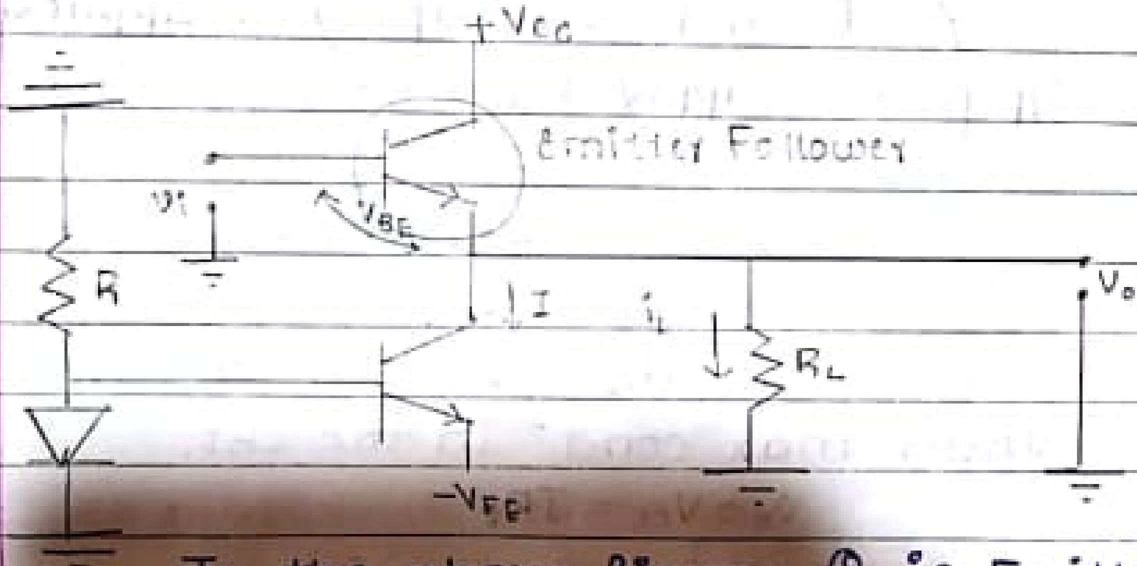
Class A Power amplifier.

There are 2 types of class A Power amplifiers.

a Class A amplifier using Emitter follower.
b Transformer coupled Power amplifiers.

1 Emitter follower.



In the above figure Q_1 is Emitter follower and Q_2 is used as Current Mirror inorder to get constant current I. It should be noted that whenever i/p voltage changes, Emitter current I_E changes and that change will appear across R_L as o/p voltage.

Let us derive power conversion efficiency for this amplifier.

$$\eta = \frac{P_o}{P_i} \times 100 = \frac{P_{o\,acload}}{P_{I\,dc}} \times 100 .$$

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where P_{oac} across the load is nothing but the voltage v_o has to be taken in terms of rms. Hence

$$V_{o\,ac\,load} = \left(\frac{v_o}{\sqrt{2}}\right)\frac{2}{R_L}$$

$$= \frac{v_o^2}{2R_L} \quad \text{— (a)}$$

As Dual Power supply is applied to ckt, i/p power supply $P_{idc} = 2V_{cc} \cdot I$ — (b)

$$\therefore \%\,\eta_c = \frac{v_o^2}{2R_L \times 2V_{cc}\,I} \times 100$$

$$= \frac{v_o}{R_L} \cdot \frac{V_o}{V_{cc} \cdot I} \times \frac{1}{4} \times 100 \quad \text{—(c)}$$

Under max cond^n in the ckt,

$$v_o = V_{cc} = IR_L$$

$$\therefore \%\,\eta_c = \frac{1}{4}(100) = 25\%$$

1. For a class A amplifier (emitter follower Pow Amp), $V_{cc} = 10V$, $I = 100mA$, $R_L = 100\Omega$, $V_o = 8V_{peak}$. Find a) Power delievered to Load
b) Average power drawn from supply.
c) Power conversion efficiency.

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Sol:

a $P_{o\,ac} = \dfrac{V_o^2}{2R_L} = \dfrac{8}{2(100)} = 0.32\,W$.

b $P_{i\,dc} = 2V_{cc} \times I$.

$= 2(10)(100 \times 10^{-3})$

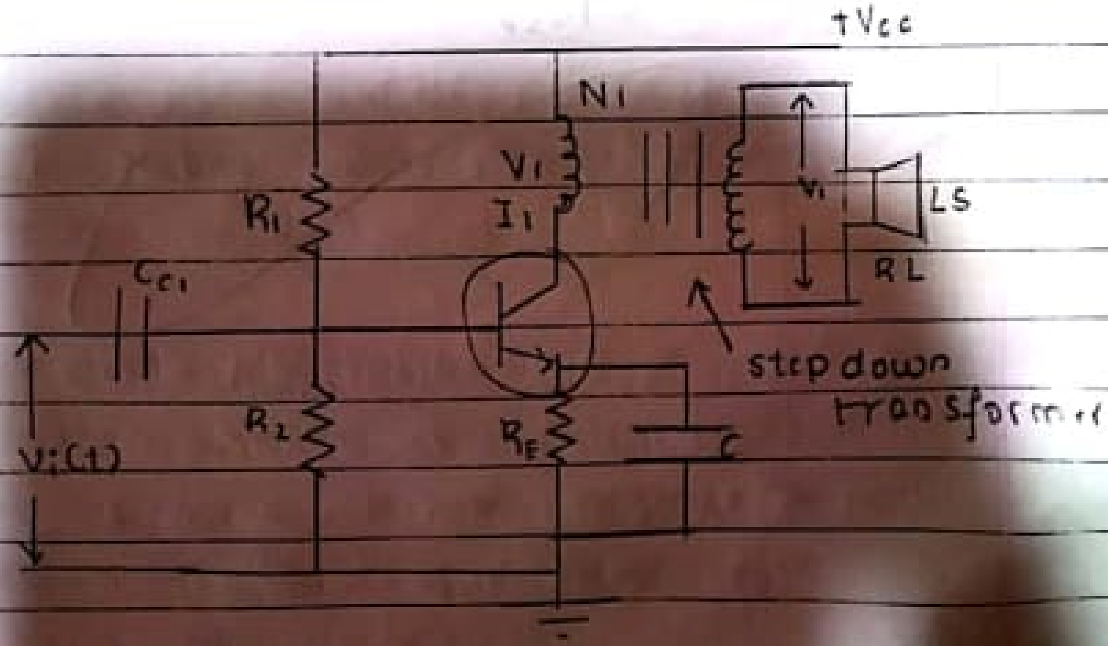
$= 2\,W$.

c $\%\,\eta_c = \dfrac{P_{o\,ac}}{P_{i\,dc}} \times 100$

$= \dfrac{0.32}{2} \times 100$

$= 16\%$.

2 Transformer Coupled Power Amplifier.



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Ckt diagram.

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Analysis.

WKT,

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \quad -(1) \quad \& \quad \frac{I_1}{I_2} = \frac{N_2}{N_1} \quad -(2).$$

(1) ÷ (2),

$$\frac{V_1 I_2}{V_2 I_1} = \frac{N_1}{N_2} \times \frac{N_1}{N_2} = \left(\frac{N_1}{N_2}\right)^2 \quad -(3).$$

$$\frac{V_1}{I_1} = \frac{V_2}{I_2}\left(\frac{N_1}{N_2}\right)^2 \quad -(4).$$

where $\frac{V_1}{I_1}$ → effective Load Resistence at collector denoted by R_L'

$$R_L' = \left(\frac{N_1}{N_2}\right)^2 R_L \quad -(5)$$

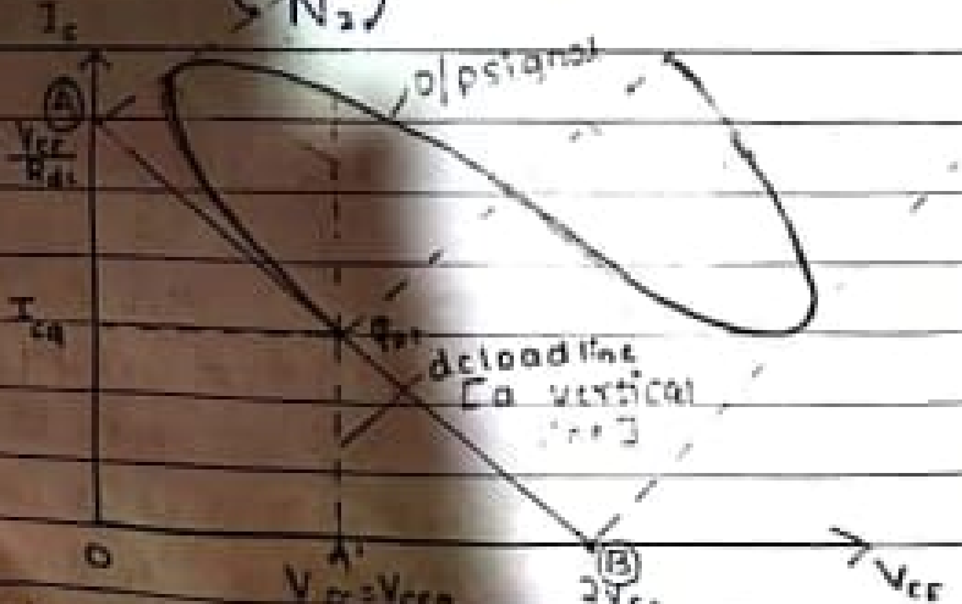

Fig 2b

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For AC load line, considering the collector part of ckt, along with emitter part with V_{CE} voltage across Collector and Emitter terminals and considering R_{ac} as effective ac resistence of primary winding whose dc resistence is assumed to be 0. As seen from diagram, emitter terminal is directly grounded for AC signal.

Hence we can write the following eq:

$$V_{CC} = I_C R_{ac} + V_{CE} \quad -(1)$$

$V_{CE} = 0$

$$\left. I_{Csat} = \frac{V_{CC}}{R_{ac}} \quad - \text{pt } A \right\} \text{ac load line}$$

Note: When $I_C = 0$, inductor opposes change.
{back emf is produced in the dir^n opp to cause i.e. V_{CC}}

When $I_C = 0$, because of inductor this current won't become 0. Instead back emf is produced inorder to oppose this change by which it has been produced.

$\therefore$ $E_b = -V_{CC} = I_C R_{ac}$.

$\therefore$ (1) can be written as, $V_{CE} = -V_{CC} + V_{CE}$

$V_{CE} = 2V_{CC}$ } ac load line

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As dc resistence of primary winding is assumed to be 0, in eq^n 1, $R_{ac} = 0$. Hence

$$\left.\begin{array}{l} V_{CE} = V_{CC} \quad \text{- pt } (A') \\ \text{where } V_{CE} = 0,\ I_C = \dfrac{V_{CC}}{R_{ac}} \quad \text{but } R_{ac} = 0 \\ \therefore I_C = \infty. \quad \text{- pt } (B') \end{array}\right\} \text{dc load line}$$

Hence dc load line is vertical load line $V_{CEq} = V_{CC}$ as shown in fig 2 b.

The intersection of ac & dc load line is operating or Q pt. & o/p signal varies about this Q pt as shown in fig 2 b.

Power conversion efficiency.

$$P_{i_{dc}} = V_{CC} I_C \quad -(a).$$

$$P_{o_{ac}} = \left(\frac{V_o}{\sqrt{2}}\right)^2 \times \frac{1}{R_L} = \frac{V_o^2}{2R_L} = \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}$$

$$= \frac{V_m I_m}{2} \quad -(b)$$

$$\%\eta_c = \frac{P_{o_{ac}}}{P_{i_{dc}}} \times 100 = \frac{V_m I_m}{V_{CC} I_C} \times \frac{1}{2} \times 100. \quad -(c)$$

for max $\%\eta_c$, $V_m = V_{CC}$ & $I_m = I_C$.

$$\therefore \%\eta_{c_{max}} = 50\%.$$

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1. Transformer coupled class A power amplifier has a current of 200mA from a collector supply of 10 V when no signal is applied to it. Determine max i/p power, max collector efficiency if load connected across transformer secondary is 2Ω & turns ratio is 5:1.

Sol^n: $I_{dc} = 200\,mA$.

$R_L = 2\Omega$.

$V_{dc} = V_{cc} = 10V$.

$P_{idc} = I_{dc} \times V_{dc} = 200 \times 10^{-3} \times 10$.

$= 2W$.

$P_{oac} = \left(\frac{I_m}{\sqrt{2}}\right)^2 R_L'$ $\quad (I_m = I_c = 200mA)$

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

$= 5^2(2) = 50\Omega$.

$P_{oac} = \left(\frac{200 \times 10^{-3}}{\sqrt{2}}\right)^2 50 = 1W$.

$\%\eta = \frac{P_{oac}}{P_{idc}} \times 100 = \frac{1}{2}(100)$

$= 50\%$.

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Class B transformer coupled amplifier or Push-pull transformer.

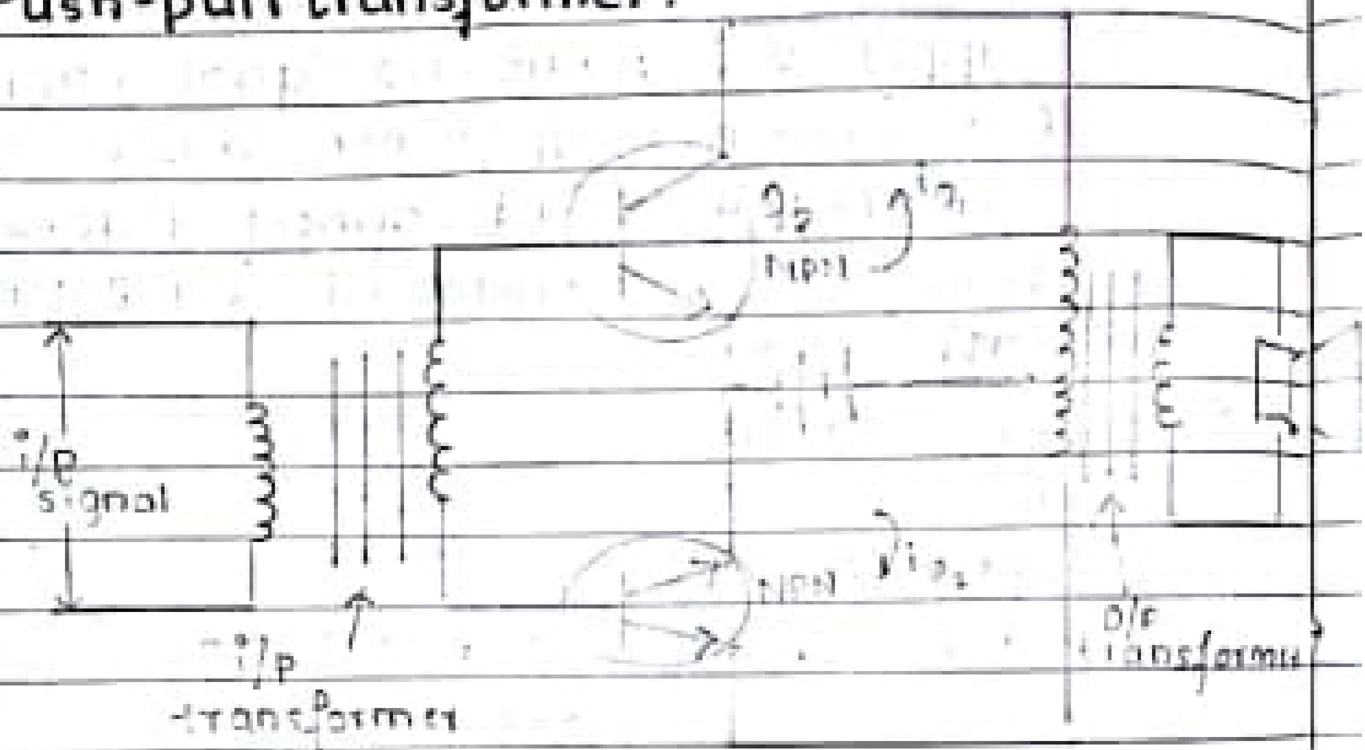

Fig 2a

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o/p AC power denoted as $P_{oac} = V_{rms} \cdot I_{rms}$

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

$$= \frac{V_m I_m}{2} \quad \text{—(1)}$$

i/p DC power supplied

$$P_{idc} = I_{dc} \cdot V_{dc}.$$

But as o/p current is like full wave rectified o/p. avg current i_{dc} is given by $2I_m/\pi$

Hence, $P_{idc} = \frac{2I_m}{\pi} \cdot V_{cc}$

$$\% \eta_c = \frac{P_{oac}}{P_{idc}} \times 100$$

$$= \frac{1}{\frac{I_m V_m}{2} \times \frac{\pi}{2 I_m V_0}}$$

$$= \frac{\pi}{4} \times \frac{V_m}{V_{cc}} \times 100.$$

To get max conversion efficiency $V_m = V_{cc}$.

$$\therefore \eta_{max} = \frac{\pi}{4}(100)$$

$$= 78.5\%$$

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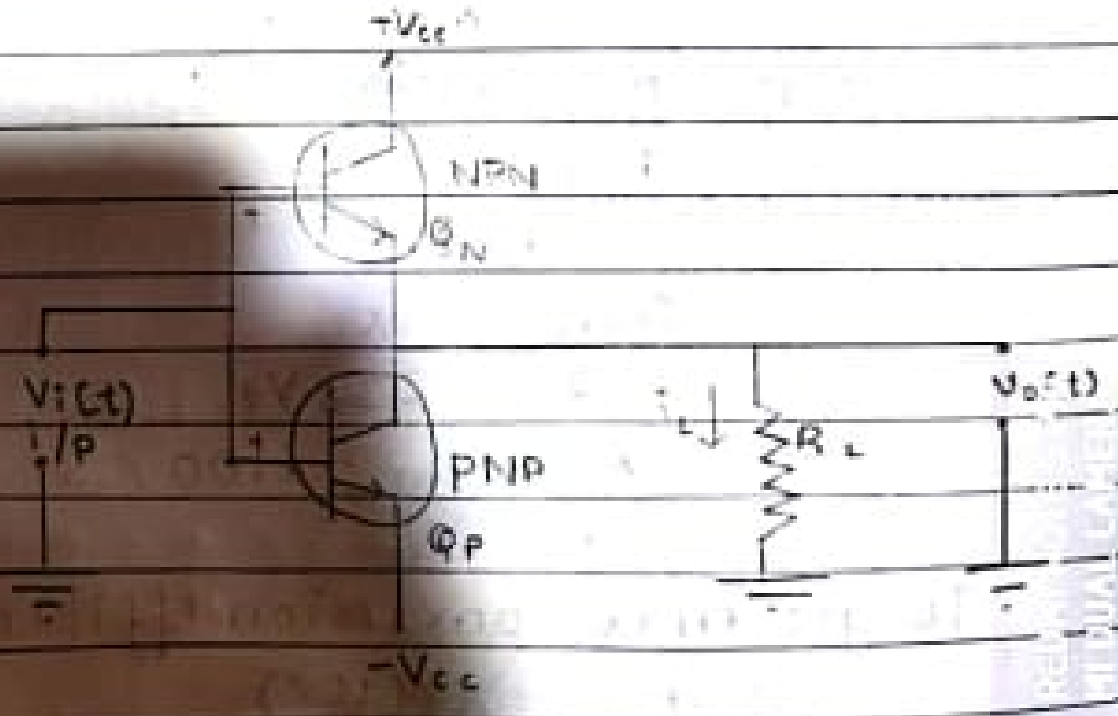
1 In class B power amplifier, $V_{cc} = 50V$ & o/p voltage $= 45 V_{peak}$. Determine conversion efficiency of this amplifier.

Sol^n: $\% \eta_c = \frac{\pi}{4} \times \frac{V_m}{V_{cc}} \times 100$.

$= \frac{\pi}{4} \times \frac{45}{50} \times 100$.

$= 70.68\%$.

Transformless Class B Power Amplifier. [Complementary Amplifier].



Dual Power Supply

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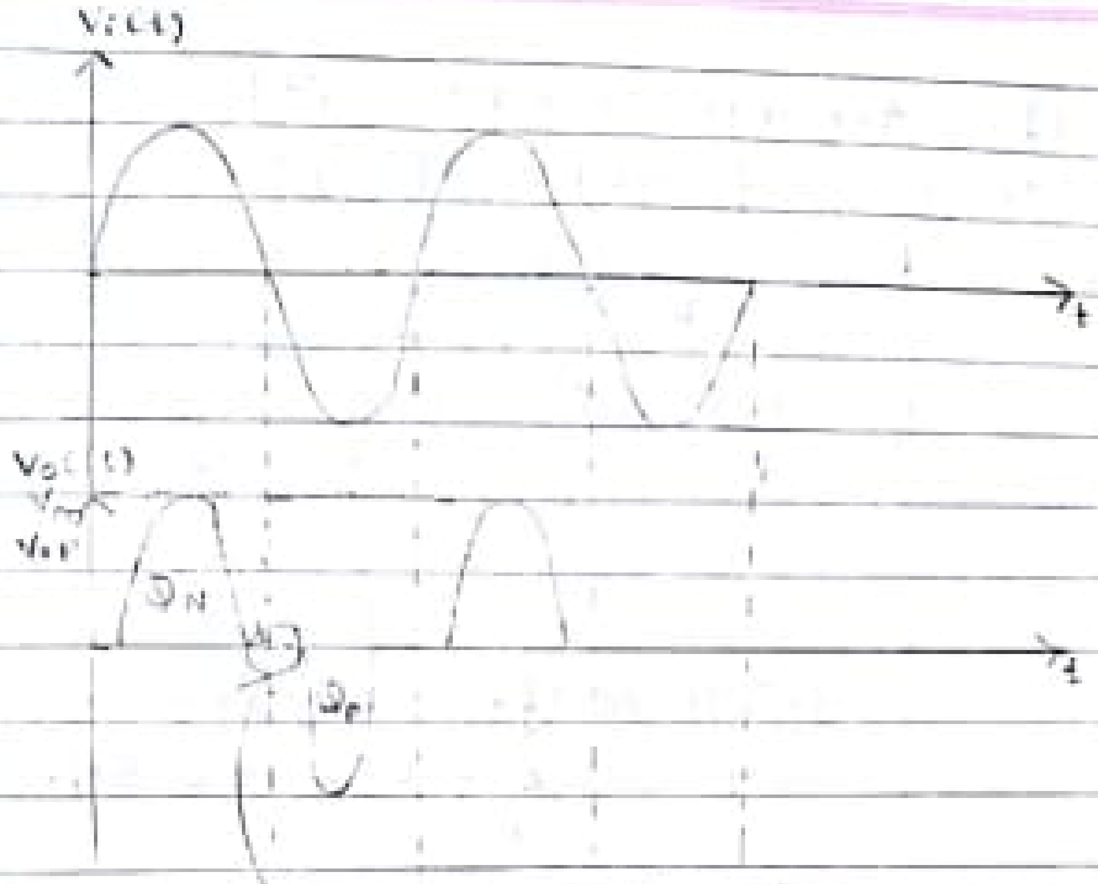

cross-over distortion.

Power conversion efficiency:

Let V_m be the peak value of o/p signal

then $P_{o\,ac} = \left(\frac{V_m}{\sqrt{2}}\right)^2 \times \frac{1}{R_L}$

$$= \frac{V_m^2}{2R_L} \quad -(1).$$

As there is a Dual Power Supply, $P_{i\,dc}$ will be equal to $2(I_{dc} \times V_{cc})$.

$$P_{i\,dc} = 2V_{cc} \cdot I_{dc}$$

$$= 2I_{dc}V_{cc} \quad -(2)$$

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I_{dc} - Average current written as $V_m/\pi R_L$ as the avg of only half-cycle is taken.

$$\therefore P_{idc} = \frac{2V_m}{\pi R_L} \times V_{cc} \quad -(3).$$

$$\therefore \% \eta_c = \frac{P_{odc}}{P_{idc}} \times 100 = \frac{V_m R}{2 R_L} \times \frac{\pi R_L}{2V_m \times V_{cc}}$$

$$= \frac{\pi}{4} \frac{V_m}{V_{cc}} \times 100 \quad -(4).$$

To get max efficiency $V_m = V_{cc}$.

$$\% \eta_{max} = \frac{\pi}{4}(100) = 78.5\%.$$

Determine dc power supplied to the ckt of transformer loss class B power amplifier. Output power delievered to the load & power conversion efficiency when o/p peak voltage is 2.6 V & $V_{cc} = 3V$, $R_L = 1K\Omega$.

$$\% \eta_c = \frac{\pi}{4} \times \frac{2.6}{3} \times 100 = \frac{P_{odc}}{P_{idc}}$$

$$P_{idc} = \frac{2V_m}{\pi R_L} \times V_{cc} = 4.96 mW.$$

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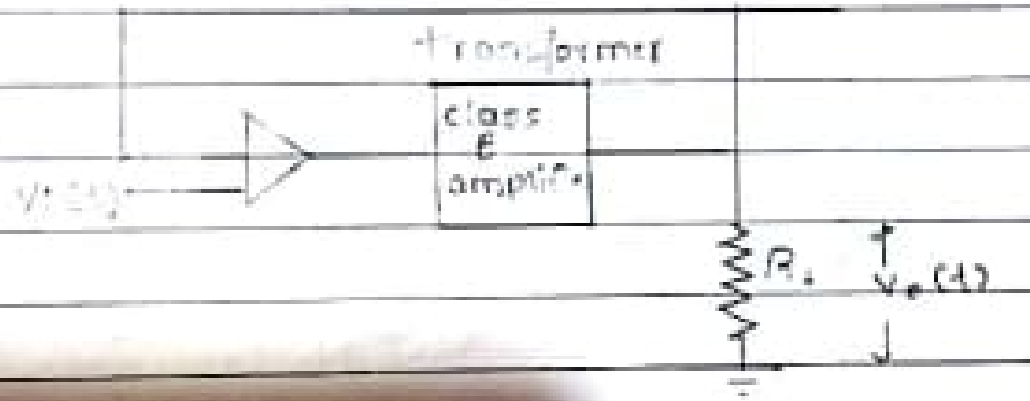
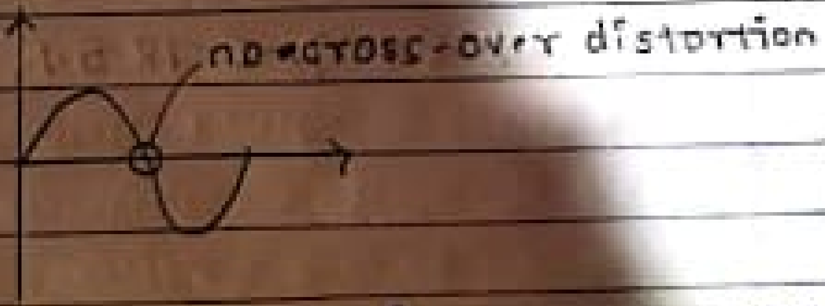
$P_{oac} = \frac{V_m}{2R_L} = 3.38\,mW$.

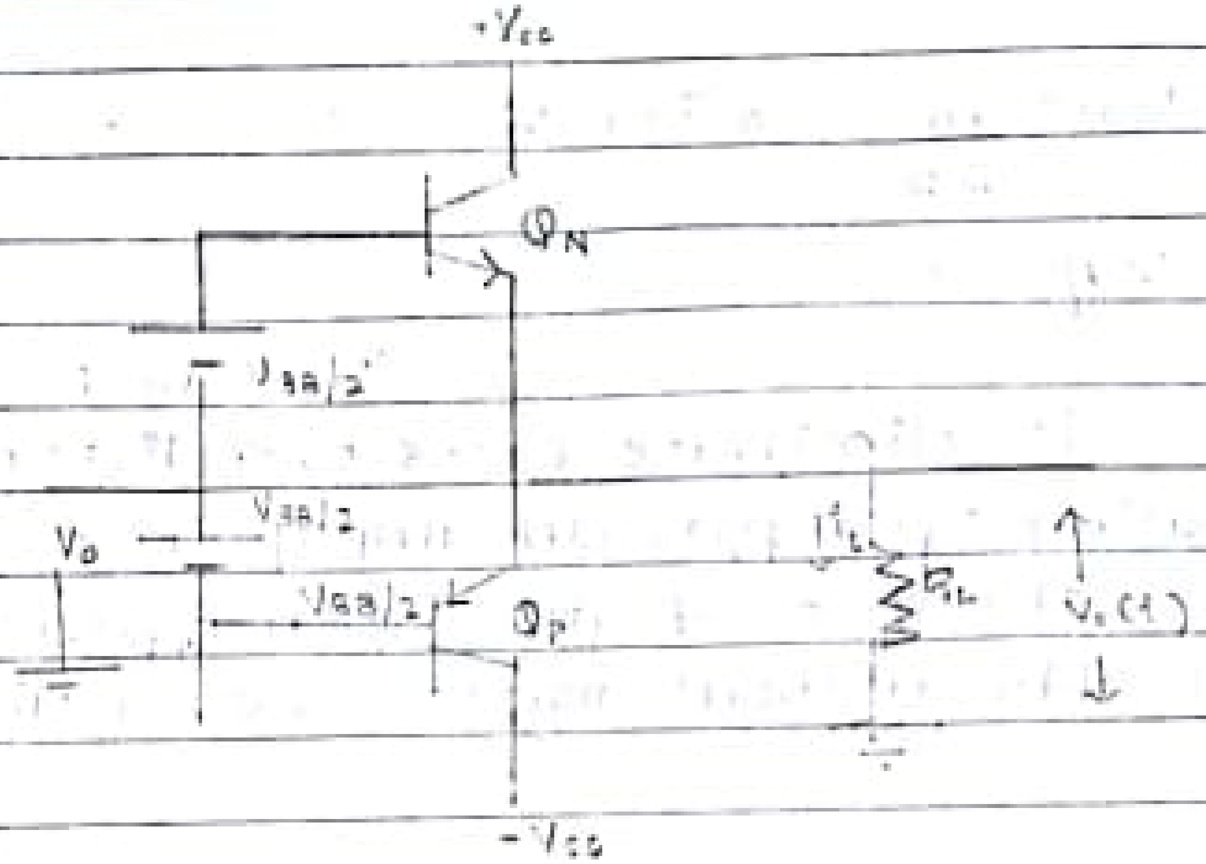
$\%\eta_c = 68\%$.

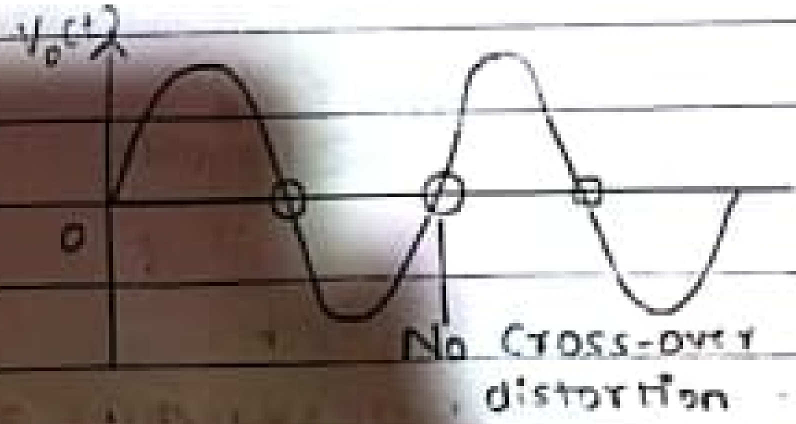
To eliminate cross over distortion using opamp as an amplifier as shown in the below figure, then o/p across R_L will be without any cross over distortion.





Other way of reducing cross-over distortion is by applying biasing for both transistors as shown below. But this ckt is no longer a class B power amplifier. It is class AB amplifier.


+Vcc
QN
VBB/2
VBB/2
Vo
VBB/2
QP
iL
RL
vo(t)
-Vcc


vo(t)
0
No Cross-over
distortion

$50\% < \%\eta_c < 78.5\%$

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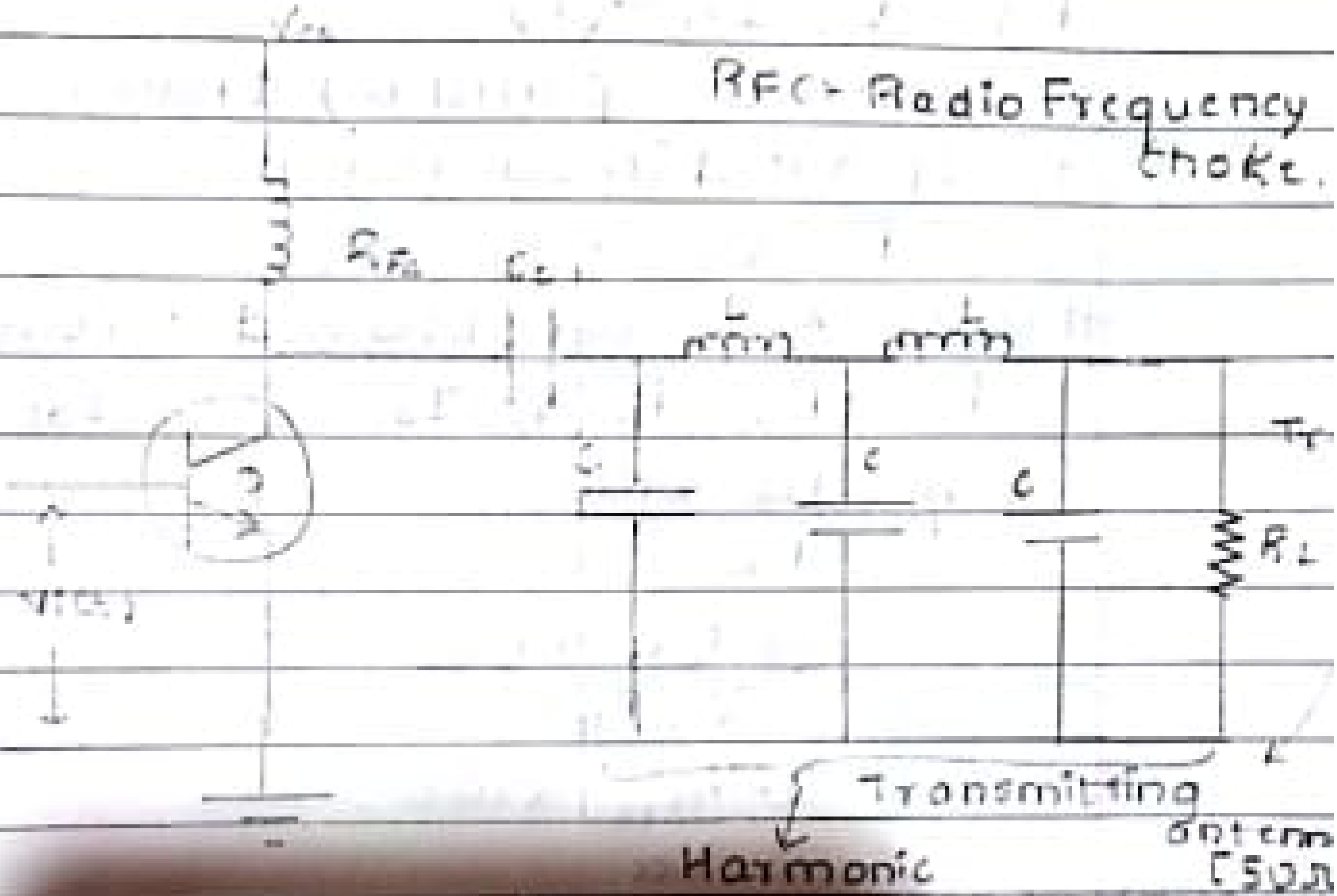
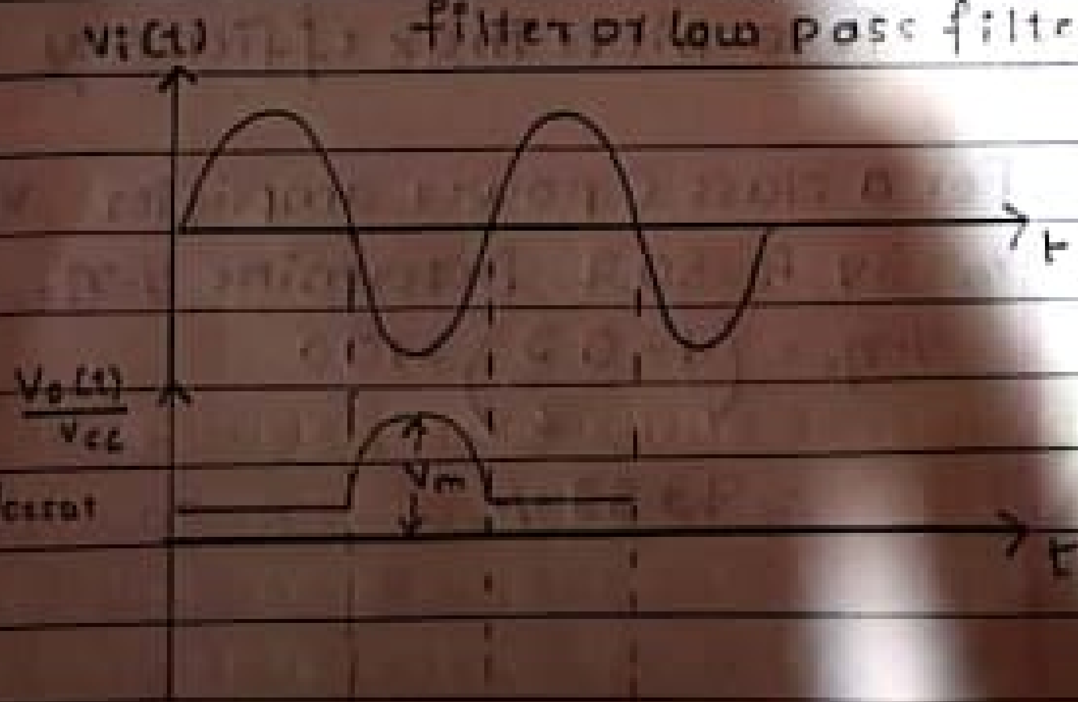
Class C Power amplifier [Class C o/p stage].

RFC - Radio Frequency Choke.





Power conversion efficiency.

Input dc power supplied to ckt

$P_{idc} = V_{cc} I_{dc}$ —(1)

Power dissipated by transistor, when it is operated in sat region.

$P_T = V_{CEsat} \times I_{dc}$ —(2).

then o/p AC power obtained across the load

$P_{oac} = P_{idc} - P_T = V_{cc} I_{dc} - V_{CEsat} I_{dc}$ —(3).

$\% \eta_c = \frac{P_{oac}}{P_{idc}} \times 100$.

$= \frac{I_{dc} (V_{cc} - V_{CEsat})}{V_{cc} I_{dc}}$.

$= 1 - \frac{V_{CEsat}}{V_{cc}} \times 100$.

To achieve max efficiency $V_{CEsat} << V_{cc}$

1 For a class C power amplifier, $V_{CEsat} = 0.2V$, $V_{cc} = 3V$, $R_L = 50\Omega$. Determine $\% \eta_c$.

Sol^n: $\% \eta_c = \left(1 - \frac{0.2}{3}\right) \times 100$

$= 93.33 \%$.

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