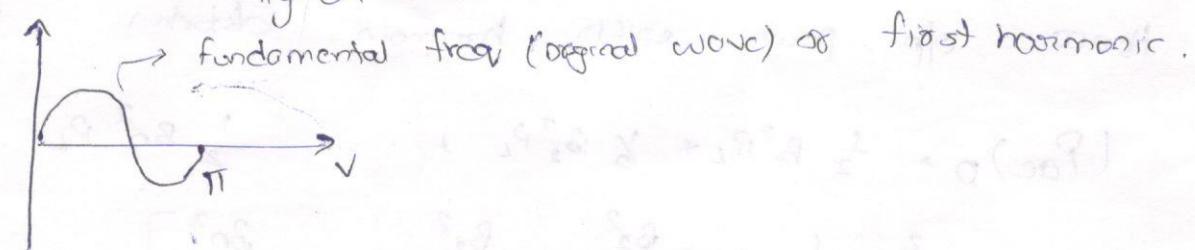


Harmonic :- It deals with waves with particular periodic waves. It is generally employed in music or acoustics, electronic power transmission, radio technology.

distortion:- This refers to disturbance in waves

As we know it is applied to repeating waves or signals, such as Sin, Cosine waves. A harmonic of such a wave is a wave with the freq that is the integral multiple of frequency of the original wave, known as fundamental frequency. * The original wave is the first harmonic, the following harmonics are higher harmonics.



How this harmonics Related to (Electrical power)

Harmonic voltages & current in an El power system are a result of non-linear ele loads. Harmonic freq in the power grid are a freq cause of power quality problems. Harmonics in power system result in increased heating in the equipment and conductors, misfiring in variable speed drives, and torque pulsation in motors. Reduction of harmonic is considered desirable.

(4)

Power o/p due to distortion

$$\begin{aligned} P_{ac} &= V \cdot I \\ &= \frac{I_m V_m}{2} \end{aligned}$$

$$P_{ac} = \frac{I_m^2 R_L}{2}$$

I_m = Peak value of the o/p current

$$I_m = \frac{I_{pp}}{2} = \frac{I_{max} - I_{min}}{2}$$

$$B_1 = \frac{I_{max} - I_{min}}{2}$$

$$I_m = B_1$$

$$P_{ac} = \frac{1}{2} B_1^2 R_L$$

Hence o/p power with harmonic distortion

$$\begin{aligned} (P_{ac})_D &> \frac{1}{2} B_1^2 R_L + \frac{1}{2} B_2^2 R_L + \dots + \frac{1}{2} B_n^2 R_L \\ &= \frac{1}{2} B_1^2 R_L \left\{ 1 + \frac{B_2^2}{B_1^2} + \frac{B_3^2}{B_1^2} + \dots + \frac{B_n^2}{B_1^2} \right\} \end{aligned}$$

$$(P_{ac})_D = P_{ac} [1 + D_2^2 + D_3^2 + \dots + D_n^2]$$

$$D^2 = D_2^2 + D_3^2 + \dots + D_n^2$$

$$(P_{ac})_D = P_{ac} [1 + D^2]$$

If the total harmonic distortion $D = 0.15$

$$\begin{aligned} (P_{ac})_D &= P_{ac} [1 + (0.15)^2] \\ &= 1.0225 P_{ac} \end{aligned}$$

So there is 2.25 % increase in the power given to the load.

(3)

B_1, B_2, B_3 and B_4 are the Amp of the fundamental, second

3rd & 4th harmonic Components.

At 3 instants

$$\text{At point 1 } \omega t = 0 \quad i_c = I_{\max}$$

$$I_{\max} = I_{CQ} + B_0 + B_1 + B_2 + B_3 + B_4 \rightarrow (6)$$

$$\text{At point 2 } \omega t = \frac{\pi}{3} \quad i_c = I_{Y_2}$$

$$i_c = I_{CQ} + B_0 + B_1 \cos \frac{\pi}{3} + B_2 \cos \frac{2\pi}{3} + B_3 \cos \frac{8\pi}{3} + B_4 \cos \frac{4\pi}{3}$$

$$I_{Y_2} = I_{CQ} + B_0 + 0.5B_1 - 0.5B_2 - B_3 - 0.5B_4 \rightarrow (7)$$

$$\text{At point 3 } \omega t = \frac{\pi}{2}, \quad i_c = I_{CQ}$$

$$i_c = I_{CQ} + B_0 + B_1 \cos \frac{\pi}{2} + B_2 \cos 2\pi + B_3 \cos 3\pi + B_4 \cos 4\pi$$

$$I_{CQ} = I_{CQ} + B_0 - B_2 + B_4 \rightarrow (8)$$

$$\text{At point 4 } \omega t = \frac{2\pi}{3} \quad i_c = I_{-Y_2}$$

$$I_{-Y_2} = I_{CQ} + B_0 - 0.5B_1 - 0.5B_2 + B_3 - 0.5B_4 \rightarrow (9)$$

$$\text{At point 4 } \omega t = \pi, \quad i_c = I_{\min}$$

$$i_c = I_{CQ} + B_0 + B_1 \cos \pi + B_2 \cos 2\pi + B_3 \cos 3\pi + B_4 \cos 4\pi$$

$$I_{\min} = I_{CQ} + B_0 - B_1 + B_2 - B_3 + B_4 \rightarrow (10)$$

Solving (5) eq we get B_0, B_1, B_2, B_3, B_4 we get.

$$\begin{aligned} I_{\max} + I_{\min} &= I_{CQ} + B_0 + B_1 + B_2 + B_3 + B_4 \\ &= I_{CQ} + B_0 - B_1 + B_2 - B_3 + B_4 \end{aligned}$$

$$\underline{I_{\max} + I_{\min}} = 2I_{CQ} + 2B_0 + 2B_2 + 2B_4 \rightarrow (11)$$

$$2I_{Y_2} = 2I_{CQ} + 2B_0 + B_1 - B_2 - 2B_3 - B_4$$

$$\underline{2I_{-Y_2}} = 2I_{CQ} + 2B_0 - B_1 - B_2 + 2B_3 - B_4$$

$\cos 0^\circ = 1$	0
$\cos 30^\circ = \frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{2}$
$\cos 45^\circ = \frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$
$\cos 60^\circ = \frac{1}{2}$	$\frac{\sqrt{3}}{2}$
$\cos 90^\circ = 0$	$\frac{\sqrt{3}}{2}$
$\cos 120^\circ = -\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$
$\cos 135^\circ = -\frac{1}{\sqrt{2}}$	$-\frac{1}{\sqrt{2}}$
$\cos 150^\circ = -\frac{\sqrt{3}}{2}$	$-\frac{\sqrt{3}}{2}$
$\cos 180^\circ = -1$	-1
$\cos 30^\circ = 270^\circ = 0$	0

Eq. ⑪ & ⑫ → find B_0

Adding

$$I_{\max} + I_{\min} + 2I\gamma_2 + 2I-\gamma_2 = 6I_{CQ} + 6B_0 \\ = 6 [I_{CQ} + B_0] \\ = 6B_0$$

$$\therefore B_0 = \frac{1}{6} [I_{\max} + I_{\min} + 2I\gamma_2 + 2I-\gamma_2]$$

$$I_{\max} - I_{\min} = 2B_1 + 2B_3$$

$$2I\gamma_2 - 2I\gamma_2 = -2B_1 + 4B_3$$

$$I_{\max} - I_{\min} + 2I\gamma_2 - 2I\gamma_2 = 2B_1 + 2B_3 - 2B_1 + 4B_3 \\ = 6B_3$$

$$\therefore B_3 = \frac{1}{6} [I_{\max} - I_{\min} + 2I\gamma_2 - 2I\gamma_2]$$

Finally

$$B_0 = \frac{1}{6} [I_{\max} + 2I\gamma_2 + 2I-\gamma_2 + I_{\min}]$$

$$B_1 = \frac{1}{3} [I_{\max} + I\gamma_2 - I-\gamma_2 - I_{\min}]$$

$$B_2 = \frac{1}{4} [I_{\max} - 2I_{CQ} + I_{\min}]$$

$$B_3 = \frac{1}{6} [I_{\max} - 2I\gamma_2 + 2I-\gamma_2 - I_{\max}]$$

$$B_4 = \frac{1}{12} [I_{\max} - 4I\gamma_2 + 6I_{CQ} - 4I-\gamma_2 + I_{\min}]$$

Here the harmonic distortion co-efficients can be obtained by

$$D_n = \frac{|B_n|}{|B_1|}$$

$$B_2 = \frac{I_{\text{fund}} + I_{\text{min}} - 2I_{\text{Q}}}{4}$$

As the Amp of the fundamental & 2nd harmonic are
in, the 2nd harmonic distortion can be cal as

$$\% D_2 = \frac{|B_2|}{|B_1|} \times 100$$

As the method uses three points on the Collector
current waveform to obtain the amplitude of the harmonic
This is called 3-point method of determining 2nd harmonic dist.

in order harmonic distortion (five point method)

As the non-linearity present in dynamic character
increases, the order of the harmonic distortion also increases

expression for the Collector

Let the mathematical

current due to higher order harmonic be

$$i_c = k_1 i_b + k_2 i_b^2 + k_3 i_b^3 + k_4 i_b^4 \rightarrow ①$$

sob 1st signal $i_b = I_{\text{bm}} \cos \omega t$

$$i_c = k_1 I_{\text{bm}} \cos \omega t + k_2 I_{\text{bm}}^2 \cos^2 \omega t + k_3 I_{\text{bm}}^3 \cos^3 \omega t + k_4 I_{\text{bm}}^4 \cos^4 \omega t \rightarrow ②$$

sob $\cos \omega t, \cos^2 \omega t, \& \cos^4 \omega t$ & doing trigonometric oper, we get.

$$i_c = B_0 + B_1 \cos \omega t + \frac{B_2 I_{\text{bm}}}{2} \cos 2\omega t \rightarrow ③$$

$$i_c = B_0 + B_1 \cos \omega t + B_2 \cos 2\omega t + B_3 \cos 3\omega t + B_4 \cos 4\omega t \rightarrow ④$$

The total current at Collector including dc bias can be written as

$$i_c = i_{\text{CQ}} + B_0 + B_1 \cos \omega t + B_2 \cos 2\omega t + B_3 \cos 3\omega t + B_4 \cos 4\omega t \rightarrow ⑤$$

where $\underline{i_{\text{CQ}} + B_0}$ is the dc component

(2)

It can be seen that due to presence of harmonics, the dc current increases practically the presence of harmonic can be detected by connecting milliammeter in the collector circuit. The readings can be observed without an a.c input signal and with ac input signal. If the two readings are almost same there are no harmonic present. But if milliammeter shows an increase in current, when an input is applied, then the harmonics can be concluded to present in the o/p signal.

Now to find the value of total collector current at the various instant 1, 2 & 3

At point 1, $\omega t = 0$, sub in 5

$$\therefore i_c = I_{CQ} + B_0 + B_1 + B_2 = I_{max} \rightarrow 6$$

At point 2 $\omega t = \frac{\pi}{2}$

$$\therefore i_c = I_{CQ} + B_0 - B_2 = I_{CQ} \rightarrow 7$$

At point 3 $\omega t = \pi$

$$\therefore i_c = I_{CQ} + B_0 - B_1 + B_2 = I_{min} \rightarrow 8$$

But at

$$\omega t = 0, i_c = I_{max}$$

$$\omega t = \frac{\pi}{2}, i_c = I_{CQ}$$

$$\omega t = \pi, i_c = I_{min}$$

Hence the eq

from eq (3)

$$B_0 = B_2$$

Now

$$I_{max} - I_{min} = I_{CQ} + B_0 + B_1 + B_2 - I_{CQ} - B_0 + B_1 - B_2$$

$$I_{max} - I_{min} = 2B_1$$

$$B_1 = \frac{I_{max} - I_{min}}{2}$$

$$I_{max} + I_{min} = I_{CQ} + B_0 + B_1 + B_2 + I_{CQ} + B_0 - B_1 + B_2$$

$$= 2I_{CQ} + 2B_0 + 2B_2$$

$$I_{max} + I_{min} = 2I_{CQ} + 4B_2$$

$$B_2 = \frac{I_{max} + I_{min} - 2I_{CQ}}{4}$$

As the Amp of the fundamental & 2nd harmonic are known, the 2nd harmonic distortion can be cal as

$$\% D_2 = \frac{|B_2|}{|B_1|} \times 100$$

As the method uses three point on the collector

current waveform to obtain the amplitude of the harmonics. This is called 3-point method of determining 2nd harmonic dist.

Higher order harmonic distortion (five point method)

As the non-linearity present in dynamic character increase, the order of the harmonic distortion also increases

Let the mathematical expression for the collector

current due to higher order harmonic be

$$i_c = k_1 i_b + k_2 i_b^2 + k_3 i_b^3 + k_4 i_b^4 \rightarrow ①$$

sub 1st signal $i_b = I_{bm} \cos \omega t$

$$i_c = k_1 I_{bm} \cos \omega t + k_2 I_{bm}^2 \cos^2 \omega t + k_3 I_{bm}^3 \cos^3 \omega t + k_4 I_{bm}^4 \cos^4 \omega t \rightarrow ②$$

Sub $\cos \omega t, \cos^2 \omega t, \& \cos^4 \omega t$ & doing trigonometric oper, we get

$$i_c = B_0 + B_1 \cos \omega t + \frac{B_2 I_{bm}}{2} \frac{1 + \cos 2\omega t}{2} \rightarrow ③$$

$$i_c = B_0 + B_1 \cos \omega t + B_2 \cos 2\omega t + B_3 \cos 3\omega t + B_4 \cos 4\omega t \rightarrow ④$$

The total current at collector including dc bias can be written

$$i_c = i_{CQ} + B_0 + B_1 \cos \omega t + B_2 \cos 2\omega t + B_3 \cos 3\omega t + B_4 \cos 4\omega t \rightarrow ⑤$$

where $\underline{i_{CQ} + B_0}$ is the dc component

(3)

B_1, B_2, B_3 and B_4 are the Amp of the fundamental, second

3rd & 4th harmonic Components.

At 5 instants

At point 1 $\omega t = 0$ $i_c = I_{\max}$

$$I_{\max} = I_{CQ} + B_0 + B_1 + B_2 + B_3 + B_4 \rightarrow (6)$$

At point 2 $\omega t = \frac{\pi}{3}$ $i_c = \frac{1}{2}I_{\max}$

$$i_c = I_{CQ} + B_0 + B_1 \cos \frac{\pi}{3} + B_2 \cos \frac{2\pi}{3} + B_3 \cos \frac{3\pi}{3} + B_4 \cos \frac{4\pi}{3}$$

$$\frac{1}{2}I_{\max} = I_{CQ} + B_0 + 0.5B_1 - 0.5B_2 - B_3 - 0.5B_4 \rightarrow (7)$$

At point 3 $\omega t = \frac{\pi}{2}$, $i_c = i_{CQ}$

$$i_c = I_{CQ} + B_0 + B_1 \cos \frac{\pi}{2} + B_2 \cos \frac{2\pi}{2} + B_3 \cos \frac{3\pi}{2} + B_4 \cos \frac{4\pi}{2}$$

$$I_{CQ} = I_{CQ} + B_0 - B_2 + B_4 \rightarrow (8)$$

At point 4 $\omega t = \frac{2\pi}{3}$ $i_c = \frac{1}{2}I_{\max}$

$$\frac{1}{2}I_{\max} = I_{CQ} + B_0 - 0.5B_1 - 0.5B_2 + B_3 - 0.5B_4 \rightarrow (9)$$

At point 4 $\omega t = \pi$, $i_c = I_{\min}$

$$i_c = I_{CQ} + B_0 + B_1 \cos \pi + B_2 \cos 2\pi + B_3 \cos 3\pi + B_4 \cos 4\pi$$

$$I_{\min} = I_{CQ} + B_0 - B_1 + B_2 - B_3 + B_4 \rightarrow (10)$$

Solving (5) eq we get B_0, B_1, B_2, B_3, B_4 we get.

$$I_{\max} + I_{\min} = I_{CQ} + B_0 + B_1 + B_2 + B_3 + B_4$$

$$= I_{CQ} + B_0 - B_1 + B_2 - B_3 + B_4$$

$$I_{\max} + I_{\min} = 2I_{CQ} + 2B_0 + 2B_2 + 2B_4 \rightarrow (11)$$

$$2\frac{1}{2}I_{\max} = 2I_{CQ} + 2B_0 + B_1 - B_2 - 2B_3 - B_4$$

$$2\frac{1}{2}I_{\min} = 2I_{CQ} + 2B_0 - B_1 - B_2 + 2B_3 - B_4$$

$$2\frac{1}{2}I_{\max} + 2\frac{1}{2}I_{\min} = 4I_{CQ} + 4B_0 - 2B_2 - 2B_4 \rightarrow (12)$$

$\cos 0^\circ = 1$	0
$\cos 30^\circ = \frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{2}$
$\cos 45^\circ = \frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$
$\cos 60^\circ = \frac{1}{2}$	$\frac{\sqrt{3}}{2}$
$\cos 90^\circ = 0$	$\frac{1}{2}$
$\cos 120^\circ = -\frac{1}{2}$	$\frac{-\sqrt{3}}{2}$
$\cos 135^\circ = -\frac{1}{\sqrt{2}}$	$\frac{-1}{\sqrt{2}}$
$\cos 150^\circ = -\frac{\sqrt{3}}{2}$	$\frac{-\sqrt{3}}{2}$
$\cos 180^\circ = -1$	-1
$\cos 30^\circ = 2\frac{1}{2}0 = 0$	$\frac{\pi}{2}$

Adding Eqs (11) & (12) to find B_0

$$I_{\max} + I_{\min} + 2I_{\gamma_2} + 2I_{-\gamma_2} = 6I_{CQ} + 6B_0$$

$$= 6 [I_{CQ} + B_0]$$

$$= 6 B_0$$

$$\therefore B_0 = \frac{1}{6} [I_{\max} + I_{\min} + 2I_{\gamma_2} + 2I_{-\gamma_2}]$$

$$I_{\max} - I_{\min} = 2B_1 + 2B_3$$

$$2I_{-\gamma_2} - 2I_{\gamma_2} = -2B_1 + 4B_3$$

$$I_{\max} - I_{\min} + 2I_{-\gamma_2} - 2I_{\gamma_2} = 2B_1 + 2B_3 - 2B_1 + 4B_3$$

$$= 6B_3$$

$$\therefore B_3 = \frac{1}{6} [I_{\max} - I_{\min} + 2I_{-\gamma_2} - 2I_{\gamma_2}]$$

Finally

$$B_0 = \frac{1}{6} [I_{\max} + 2I_{\gamma_2} + 2I_{-\gamma_2} + I_{\min}]$$

$$B_1 = \frac{1}{3} [I_{\max} + I_{\gamma_2} - I_{-\gamma_2} - I_{\min}]$$

$$B_2 = \frac{1}{4} [I_{\max} - 2I_{CQ} + I_{\min}]$$

$$B_3 = \frac{1}{6} [I_{\max} - 2I_{\gamma_2} + 2I_{-\gamma_2} - I_{\max}]$$

$$B_4 = \frac{1}{12} [I_{\max} - 4I_{\gamma_2} + 6I_{CQ} - 4I_{-\gamma_2} + I_{\min}]$$

Now the harmonic distortion co-efficient can be obtained by

$$D_n = \frac{|B_n|}{|B_1|}$$

(4)

Power o/p due to distortion

$$P_{ac} = V \cdot I$$

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

$$P_{ac} = \frac{I_m^2 R_L}{2}$$

$$V = i R$$

$$V_m = i_m R_L$$

I_m = Peak value of the o/p current

$$= \frac{\sum I_p}{2} = \frac{I_{max} - I_{min}}{2}$$

$$B_1 = \frac{I_{max} - I_{min}}{2}$$

$$I_m = B_1$$

$$\boxed{P_{ac} = \frac{1}{2} B_1^2 R_L}$$

Hence o/p power with harmonic distortion

$$(P_{ac})_D = \frac{1}{2} B_1^2 R_L + \frac{1}{2} B_2^2 R_L + \dots + \frac{1}{2} B_n^2 R_L$$

$$= \frac{1}{2} B_1^2 R_L \left\{ 1 + \frac{B_2^2}{B_1^2} + \frac{B_3^2}{B_1^2} + \dots + \frac{B_n^2}{B_1^2} \right\}$$

$$(P_{ac})_D = P_{ac} [1 + D_2^2 + D_3^2 + \dots + D_n^2]$$

$$D^2 = D_2^2 + D_3^2 + \dots + D_n^2$$

$$(P_{ac})_D = P_{ac} [1 + D^2]$$

If the total harmonic distortion $D = 0.15$

$$(P_{ac})_D = P_{ac} [1 + (0.15)^2]$$

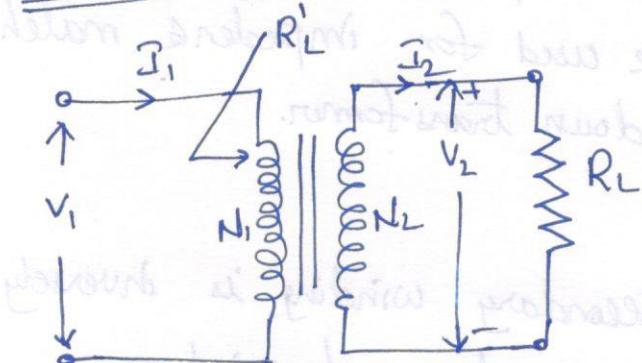
$$= 1.0225 P_{ac}$$

So there is 2.25 % increase in the power given to the load.

Transformer Coupled class A Amplifier:-

- * For maximum power transfer to the load, the impedance matching is necessary.
- * For loads like loudspeaker, having two impedance values, impedance matching is difficult using directly coupled amplifiers circuit.
- * This is because loudspeaker resistance is in the range of 3 to 4 ohms to 16 ohms while the output impedance of series fed directly coupled class A amplifier is very much high.
- * This problem can be eliminated by using transformer to deliver power to the load. The transformer is called an output transformer and amplifier is called transformed coupled class A amplifier.

Properties of transformer:



- * Consider a transformer as shown in the fig. which is connected to a load resistance R_L .
- * While analysing transformer, it is assumed that the transformer is ideal and there are no losses in transformer. Similarly the winding resistances are assumed to be zero.

N_1 = Number of turns on primary

N_2 = Number of turns on secondary

V_1 = Voltage applied to primary

V_2 = Voltage on secondary

I_2 = Primary Current.

1) Turns ratio:-

The ratio of no. of turns on secondary to the no. of turns on primary is called turns ratio and is denoted by n .

$$n = \frac{N_2}{N_1}$$

* Sometimes it is specified as $\frac{N_2}{N_1} : 1$ (or $\frac{N_1}{N_2} : 1$)

2) Voltage transformation:-

The transformer transforms the voltage applied on one side proportional to turns ratio. The transformer can be step up or step down transformer.

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = n$$

In amplifier analysis, load impedance is going to be small. And the transformer is to be used for impedance matching. Hence it has to be a step down transformer.

3) Current transformation:-

The current in the secondary winding is inversely proportional to the number of turns of windings.

$$\frac{I_2}{I_1} = \frac{N_1}{N_2} = \frac{1}{n}$$

4) Impedance transformation!

As current and voltage get transformed from primary to secondary, an impedance seen from either side also changes. The impedance of the load on secondary is R_L .

$$R_L = \frac{V_2}{I_2} \text{ and } R_L = \frac{V_1}{I_1}$$

$$V_1 = \frac{N_1}{N_2} V_2$$

and

$$\frac{I_1}{I_2} = \frac{N_2}{N_1}$$

$$I_1 = \frac{N_2}{N_1} I_2$$

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

$$R'_L = \frac{R_L}{n^2}$$

The R'_L is reflected impedance.

Problem

The load of 4Ω is connected to the secondary of a transformer having primary turns of 200 and secondary turns of 20. Calculate the reflected load impedance on primary.

Solution Given that

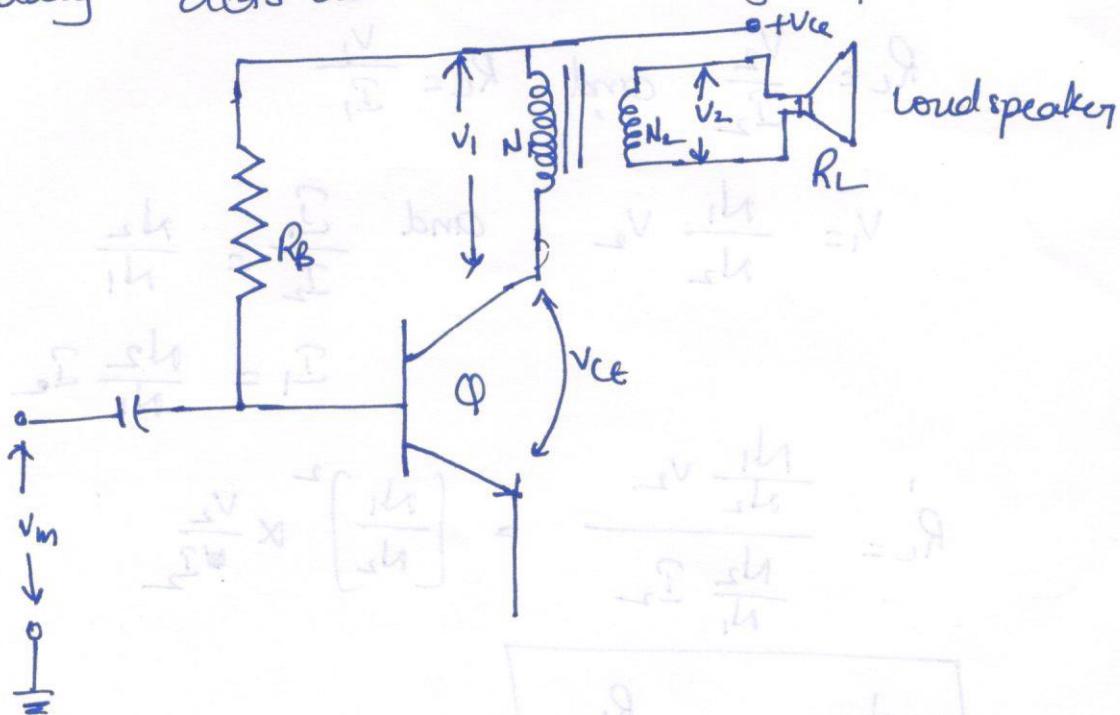
$$R_L = 4\Omega \quad N_1 = 200 \quad N_2 = 20$$

$$n = \frac{N_2}{N_1} = \frac{20}{200} = 0.1$$

$$R'_L = \frac{R_L}{n^2} = \frac{4}{(0.1)^2} = 400\Omega$$

Circuit diagram of transformer Coupled Amplifier

The basic circuit of a transformer coupled amplifier is shown in below fig. The loudspeaker connected to the secondary acts as a load having impedance of R_L .



The transformer used is a step down transformer with turns ratio as $n = \frac{N_2}{N_1}$.

DC operation

- (*) It is assumed that winding resistances are 0Ω.
- (*) Hence for dc purposes the resistance is 0Ω.
- (*) There is no voltage drop across the primary winding of the transformer.
- (*) The slope of the d-c load line is reciprocal of the d-c resistance in collector circuit, which is zero in this case.
- (*) Hence slope of d-c load line is ideally infinite. The d-c load line is practically straight line.

Apply KVL at collector side

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

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

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

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

* The intersection of d-c load line and the base current set by the circuit is the Quiescent operating point. The d-c load line as shown in fig (1).

DC power input

The d-c power input is provided by supply voltage with no signal input. the dc current drawn is the collector bias current I_{CQ}

$$P_{DC} = V_{CC} I_{CQ}$$

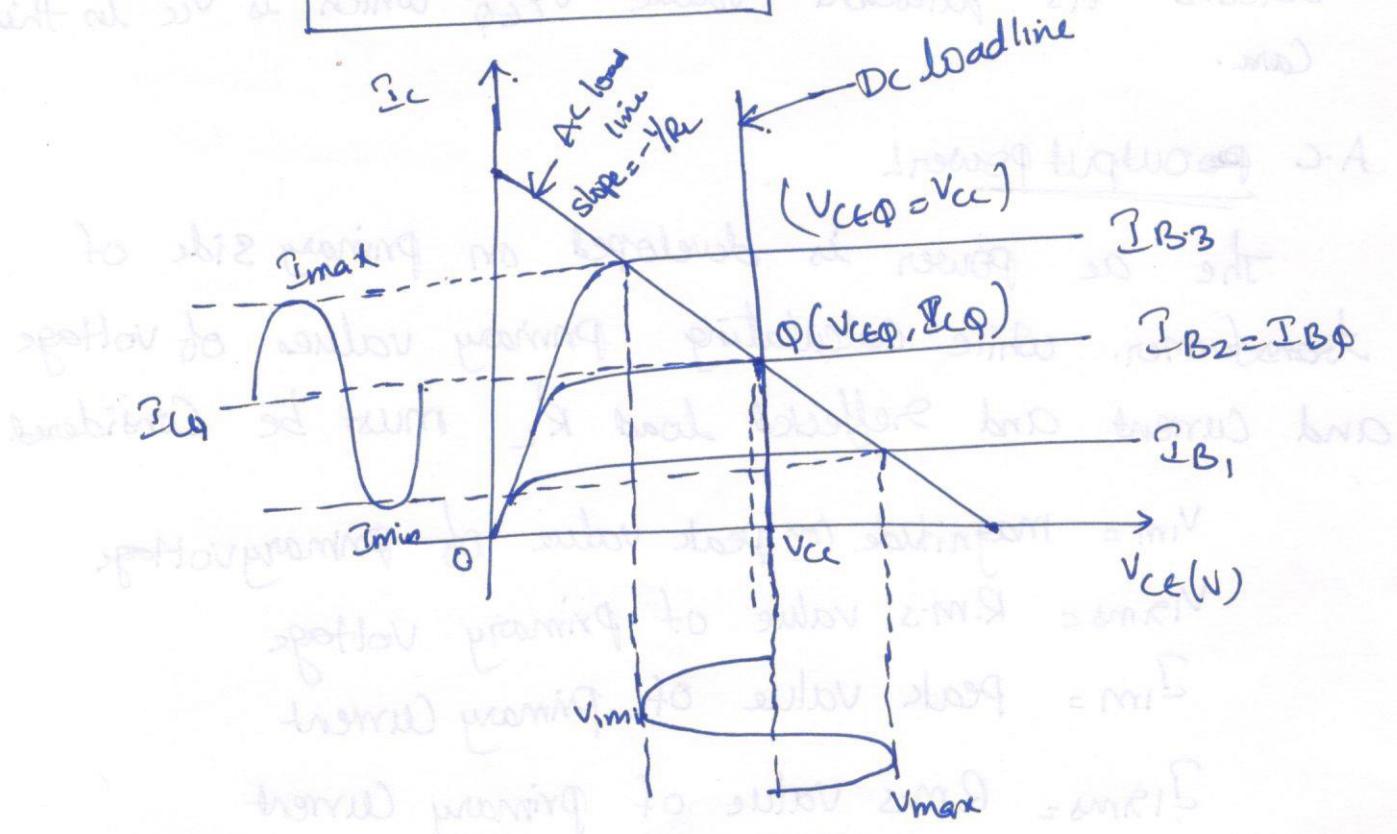


Fig (1).

A-C Operation!

- * For a-c analysis, it is necessary to draw an ac load line on the output characteristics.
- * For ac purposes, the load on secondary is the load impedance R_L , and the reflected load on primary is R'_L .
- * The load line drawn with a slope of $\left[-\frac{1}{R'_L}\right]$ and passing through the operating point is called a-c load line. shown in fig(1).
- * The output Current i.e. collector current varies around its quiescent value I_{CQ} , when a-c input signal applied to the amplifier.
- * The corresponding output voltage also varies sinusoidally around its quiescent value V_{CEQ} which is V_C in this case.

A-C Output Power

The ac power is developed on primary side of transformer. While calculating primary values of voltage and current and reflected load R'_L must be considered.

V_{1m} = magnitude (or peak value of primary voltage)

V_{1rms} = R.m.s value of primary Voltage

I_{1m} = peak value of primary current

I_{1rms} = R.m.s value of primary current

a.c power developed on Primary

$$P_{ac} = V_{1\text{rms}} I_{1\text{rms}}$$

$$P_{ac} = I_{1\text{rms}}^2 R_L' \quad \left[\because V = IR \right]$$

$$= \frac{V_{1\text{rms}}^2}{R_L'}$$

$$\boxed{P_{ac} = \frac{V_{1m} I_{1m}}{2} = \frac{I_{1m}^2 R_L'}{2} = \frac{V_{1m}^2}{2 R_L'}}$$

a.c power developed on Secondary

$$P_{ac} = V_{2\text{rms}} I_{2\text{rms}} = I_{2\text{rms}}^2 R_L = \frac{V_{2m}^2}{2 R_L}$$

$$\boxed{P_{ac} = \frac{V_{2m} I_{2m}}{2} = \frac{I_{2m}^2 R_L}{2} = \frac{V_{2m}^2}{2 R_L}}$$

- ① power delivered on primary is same as power delivered to the load on secondary assuming ideal transformer.
- ② for practical circuit, the transformer can not be ideal. Hence power delivered to load is slightly less than primary.

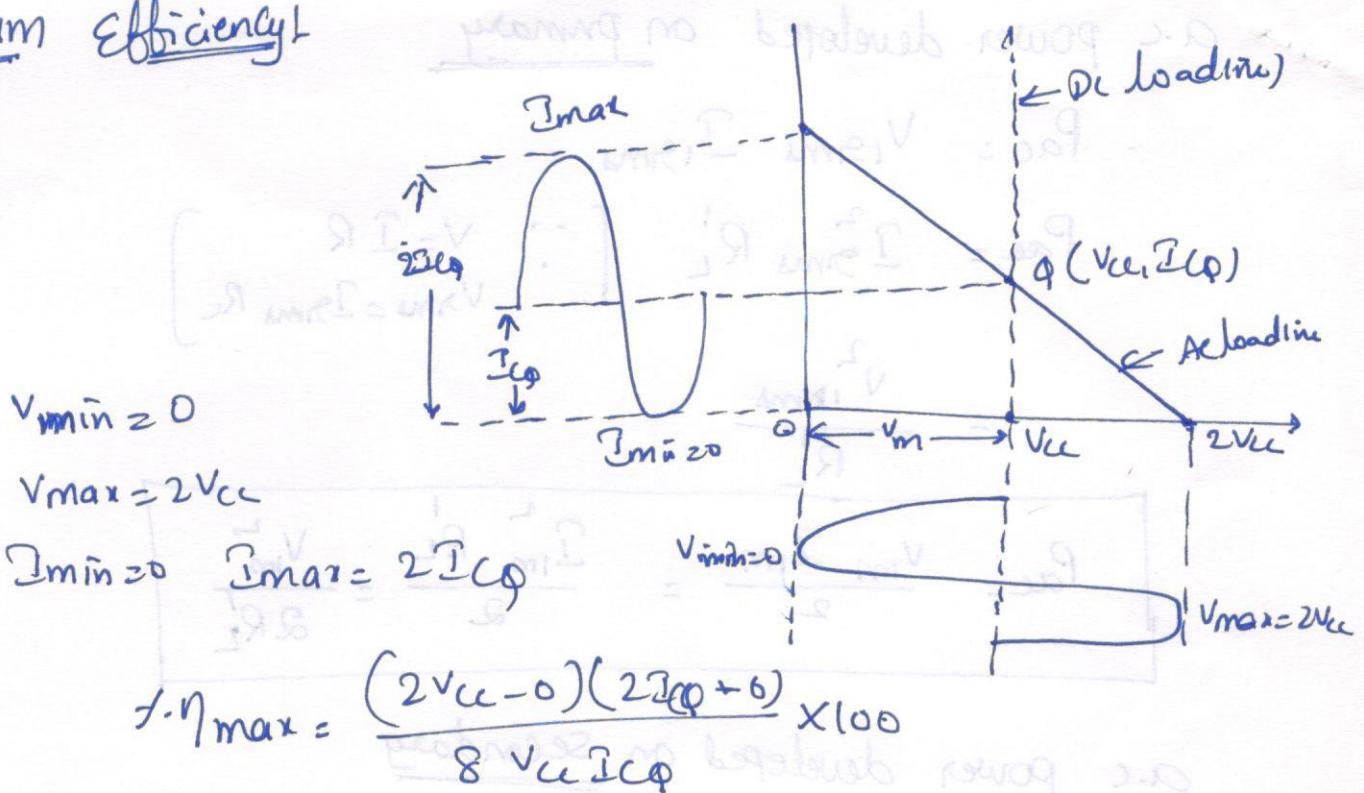
In class A amplifier

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

Efficiency!

$$\eta = \frac{P_{ac}}{P_{dc}} \times 100 = \frac{(V_{max} - V_{min})(I_{max} - I_{min})}{8 I_{CQ} V_{CC}} \times 100$$

maximum Efficiency



$$= \frac{4V_{ce}I_{CQ}}{8V_{ce}I_{CQ}} \times 100$$

$$= 50\%$$

Power dissipation

Power dissipation is the difference between a-c power output and the d-c power input

$$P_d = P_{dc} - P_{ac}$$

Advantages

- 1) The efficiency of operation is higher than directly coupled amplifier.
- 2) The impedance matching required for maximum power transfer is possible

Disadvantages

- 1) Due to transformer, the circuit becomes bulkier, heavier and costlier compared to directly coupled circuit.
- 2) Frequency limit is poor.