Dissipation Curve :- since we know that by definition of power amplifier —

D.C power input = a.c power output + Dissipated power

i.e $(P_{in})_{dc} = (P_o)_{a.c} + P_d$

When no signal is applied, then it is the worst case because total power dissipated

$\therefore P_d = (P_{in})_{dc} = V_{cc} I_{c_Q}$

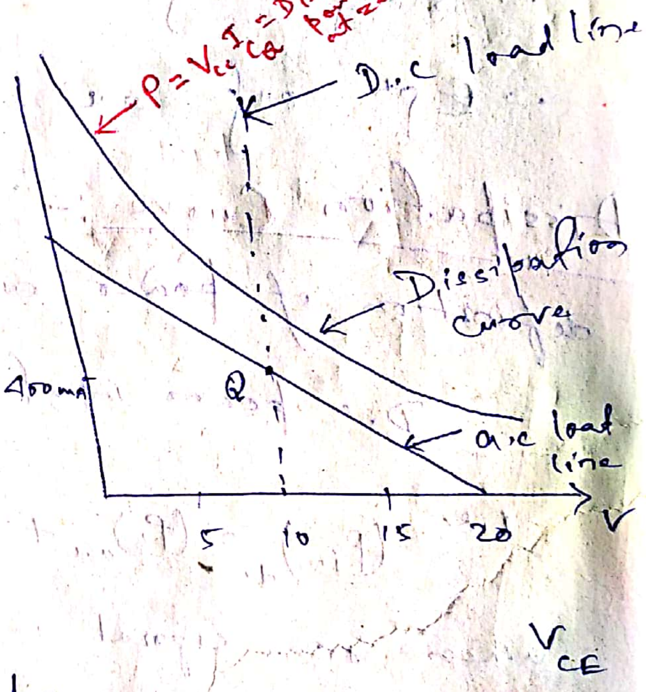
We plote $P_d = V_{cc} I_{c_Q}$ i.e I_{c_Q} versus V_{cc} in such a way that P_d remains constant by taking arbitrary value of V_{cc} and I_{c_Q} so that their product be constant.

When no signal is applied, then transistor is required to dissipate or throw max^m power. The signal-cond^n is also called power rating cond^n.

Let, at zero signal cond^n, max^m power thrown by transistor is 4W, then

$$P_d = V_{ce} I_{C_Q} = 4 \text{ watt}$$

Now, we choose V_{ce} & I_{C_Q} so that $V_{ce} I_{C_Q}$ must be constant then we plot it.

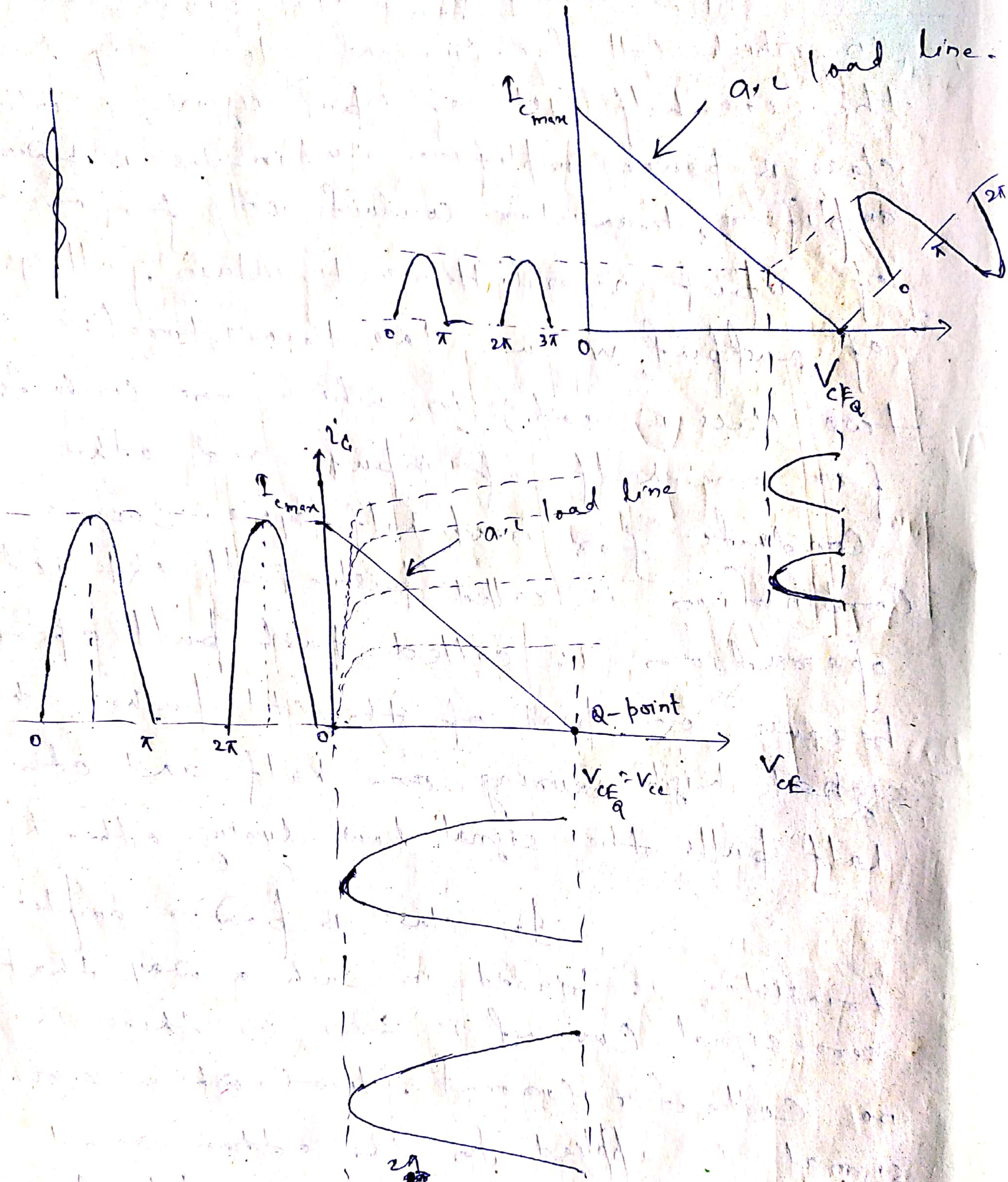


The figure shows the dissipation curve. The Q-point must be below the dissipation curve.

If value of Q is selected above the dissipation curve transistor will be damaged.

Class B Power Amplifier :- The power amplifier in which collector current flows only for the one-half cycle of input signal, is called class B power amplifier. i.e in class B power amplifier, transistor conducts only for one-half of input signal. Hence, to obtain full-cycle of output, we use two transistors (or two class B amp.) in which one conducts for one-half of input and other conducts for next half-cycle. Such a combination is called push-pull ckt and operation is called push-pull operation because one part of the ckt pushes the signal high during one half and other half pulls the signal low during other half.

In class B power amplifier, transistor is biased in such a way that zero-signal current is zero i.e, there is no collector current flows when zero-signal is applied. In ~~the~~ other word there is no need of biasing ckt. And, for this operating point is set at collector cutt-off voltage point. as shown in figure.



$$I_{av.} = I_{dc} = \frac{1}{2\pi}\int_0^{\pi} I_{c_{max}} \sin\theta \, d\theta = \frac{I_{c_{max}}}{\pi}$$

$$\therefore \ (P_{in})_{dc} = V_{cc} I_{dc} = \frac{V_{cc} I_{c_{max}}}{\pi}$$

since output-wave is just like the output of half-wave rectifier, RMS value of output voltage $= \frac{V_m}{\sqrt{2}} = \frac{V_{CEQ}}{\sqrt{2}}$

$$V_{rms} = \frac{V_{cc}}{\sqrt{2}}$$

$$\therefore (P_0)_{ac} = V_{rms} I_{rms} = \frac{V_{cc}}{\sqrt{2}} \cdot \frac{I_{cmax}}{\sqrt{2}} = \frac{V_{cc} I_{cmax}}{4}$$

[for one-half cycle]

D.C power loss in load $= I_{dc}^2 R_c$

$$= \left(\frac{I_{cmax}}{\pi}\right)^2 R_c$$

$\therefore$ D.c power loss in collector region

$$P_c = P_{tr} - (P_0)_{ac}$$

$$= (P_{in})_{d.c} - P_{R_c} - (P_0)_{a.c}$$

$$\therefore \eta_{overall} = \frac{(P_o)_{a.c}}{(P_{in})_{d.c}} = \frac{\cancel{V_{cc}} \cancel{I_{cmax}}/4}{\cancel{V_{cc}} \frac{\cancel{I_{cmax}}}{\pi}} = \frac{\pi}{4}$$

$$= 0.785 = 78.5\%$$

Advantages :- i) It is possible to obtain greater power output in comparison to class-A power amplif-

ii) Efficiency is higher than class-A

iii) Negligible power loss at no-signal condition

iv) Class-B push-pull configured amplifier cancel the even harmonics.

Dis-advantages :- i) Harmonic distortion is higher.

ii) Self-bias can not be used

iii) Supply voltage must have good regulation.

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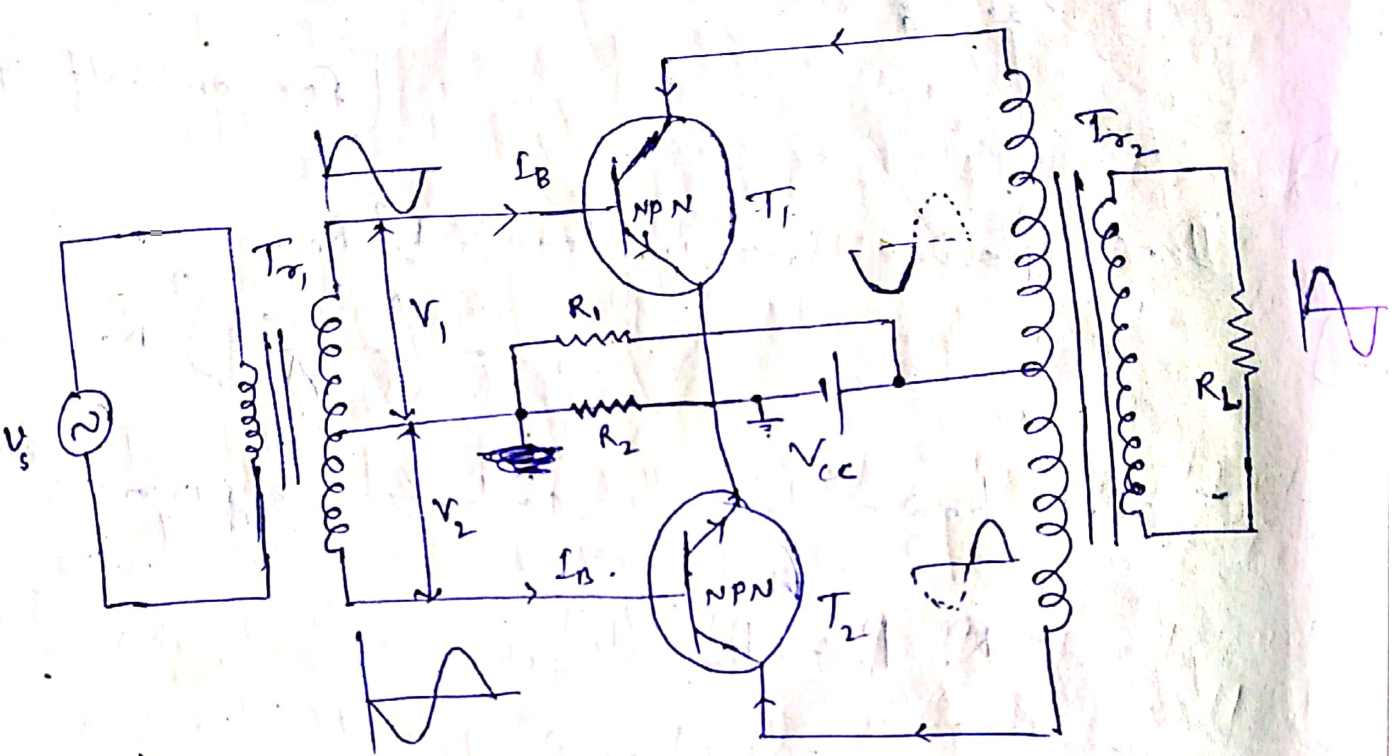
Class B Push-Pull power amplifier :-

The ckt arrangement of class B push-pull power amplifier is shown below :-



The ckt consist of two centre tapped tranformer Tr_1 and Tr_2 called input and output centre tapped transformer. The two transistors T_1 & T_2, whose emitter is connected together, are biased in such a way that zero-signal collector current be zero. ~~For this the base of both~~ The base of both transi T_1 and T_2 are connected to the secondary of input transformer Tr_1.

The collector of both transistor are connected to the primary of output transformer. V_{cc} is used to bias the collector as shown in figure.

<u>Circuit operation:-</u> When input signal is applied to the primary ~~input~~ of input transformer, transformer develops two signals which are identical but opposite in phase. The transistor T_1 and T_2 are driven by these two signals. As from the figure when V_1 is going +ve then V_2 is going to negative and in this case the transistor T_1 goes to forward biase and T_2 goes to reverse biase. With result of this, T_1 conducts but T_2 does not conduct. Thus, the collector current increase from zero and it produces half-cycle of sine-wave. Again, When V_1 is going to -ve then V_2 is going to +ve and in this case T_1 is biased off and T_2 is biased on and again collector current increase from zero ~~to~~ but in opposite dirn and it also produce the half-cycle of sinesoidal wave.

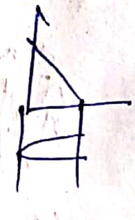
The effect of the two-half cycles in seperate halves of the primary of output transformer produces magnetic flux in the core, which flows first in one dirⁿ and then in opposite dirⁿ of first. This flux links with secondary of ~~output~~ output transformer and generate a complete sine-wave output which is passed on to the load.

As from the ckt, it is clear that, one part of the ckt pushes signal to high and other part pulls the signal to low, hence, the operation is called push-pull operation.

Now,

the current in each transistor is the average of half-sine loop

i.e. $I_{d.c} = \frac{I_{cmax}}{\pi}$; [For half-cycle]



$\therefore (P_{in})_{d.c} = 2(V_{cc}\ I_{d.c}) = \frac{2V_{cc}\ I_{cmax}}{\pi}$; [For both cycles]

$\therefore$ RMS value of output current $= \frac{I_{cmax}}{\sqrt{2}}$.

" " " voltage $= \frac{V_{CEmax}}{\sqrt{2}}$.

$= \frac{V_{cc}}{\sqrt{2}}$

$\therefore (P_o)_{ac} = V_{rms} I_{rms} = \frac{V_{cc} I_{cmax}}{2}$.

$$\therefore \eta = \frac{(P_o)_{ac}}{(P_{in})_{dc}} = \frac{V_{cc} I_{cmax}/2}{\frac{2 V_{cc} I_{cmax}}{\pi}} = \pi/4$$

$\eta = 78.5\%$. It is called optimum condition.

CANCELLATION OF EVEN HARMONICS IN PUSH-PULL POWER AMPLIFIER

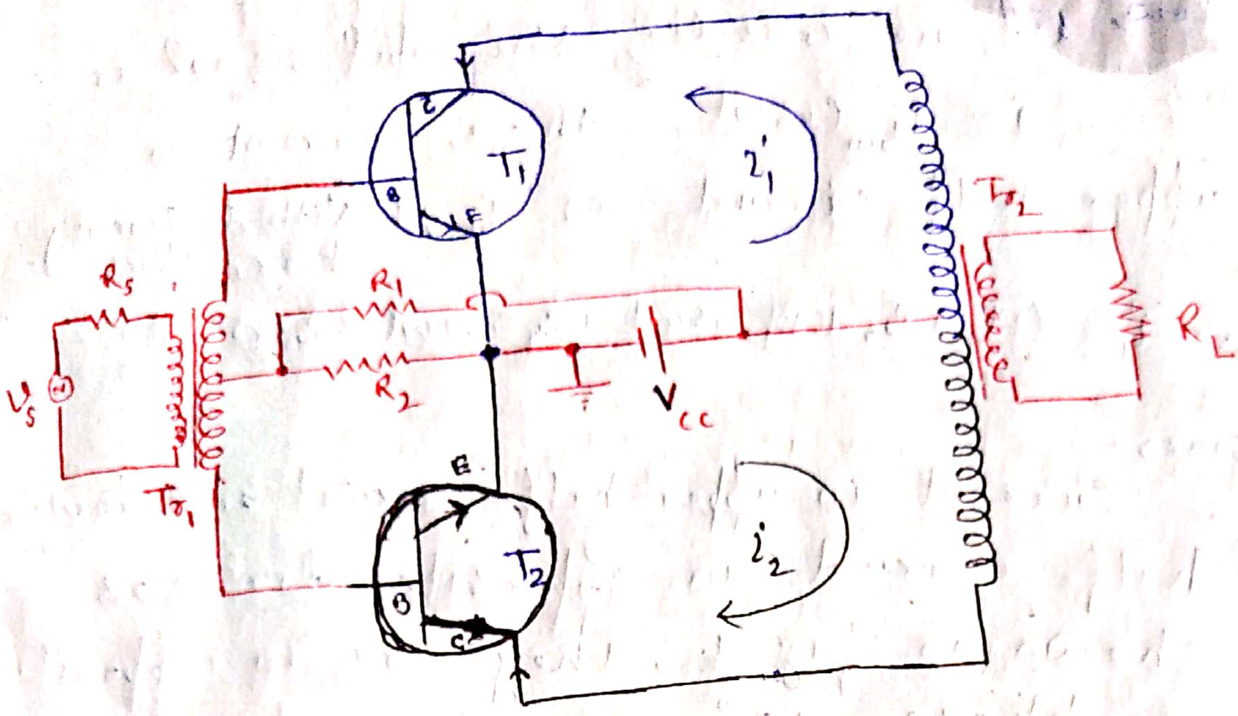


Fig - 1.
Two - transistor Push - Pull arrangement

Above fig - 1 arrangement is called Push-Pull amplifier. Here, circuit consists of two cener-tapped transformer - Tr_1 and Tr_2. Clearly, when circuit excitation is introduced through Tr_1, transistor T_1 gets +ve half-cycle of input signal at the base which make it forward bias (Base - emitter junction) and T_1 conducts. But, at the same time, T_2 gets -ve half-cycle of input signal and becomes reverse biased and does not conduct. That, is for one-half cycle, one transistor pushes the collect current ~~to~~ from zero to high and other transistor pulls to low. Thus, the configuration is called Push-Pull arrangement.

Now, let, us consider, the input signal is

$i = I_{bm} \cos \omega t$, then, current in upper half-circuit is i_1; (With different harmonics)

$$\therefore i_1 = (I_c + B_0 + B_1 \cos \omega t + B_2 \cos 2\omega t + B_3 \cos 3\omega t + \cdots$$

Since

Current in upper half-circuit and lower half-circuit in opposite dirn as shown in fig-1, they are in opposition of phase $180^\circ = \pi$.

$$\therefore i_2 = I_c + B_0 + B_1 \cos(\pi + \omega t) + B_2 \cos(2\pi + 2\omega t) + B_3 \cos(3\pi + 3\omega t) + B_4 \cos(4\pi + 4\omega t) + \cdots$$

$$\text{or } i_2 = I_c + B_0 - B_1 \cos \omega t + B_2 \cos 2\omega t - B_3 \cos 3\omega t + B_4 \cos 4\omega t + \cdots$$

$\therefore$ Total output current, $i = i_1 - i_2$

$$\text{or } i = (I_c + B_0 + B_1 \cos \omega t + B_2 \cos 2\omega t + B_3 \cos 3\omega t + B_4 \cos 4\omega t + \cdots - (I_c + B_0 - B_1 \cos \omega t + B_2 \cos 2\omega t - B_3 \cos 3\omega t + B_4 \cos 4\omega t + \cdots$$

$$\text{or } \boxed{i = 2(B_1 \cos \omega t + B_3 \cos 3\omega t + \cdots)} \quad \text{—— (i)}$$

Above eqn (i) shows that output current contains no-even harmonics. Thus Push-Pull arrangement cancel the even-harmonic component

Advantages of Push-Pull system

i> Because of no-presence of even harmonics, the push-pull amplifier gives more output per active device for a given amount of distortion.

ii> In Push-Pull amplifier, d.c components of collector current as ($I_c + B_0$), oppose each other magnetically in transformer core. This eliminates any tendency toward core saturation

iii> If ripples appeared in power-supply, the these ripples are also balanced out in this arrangement.