Unit-2 (EDC)

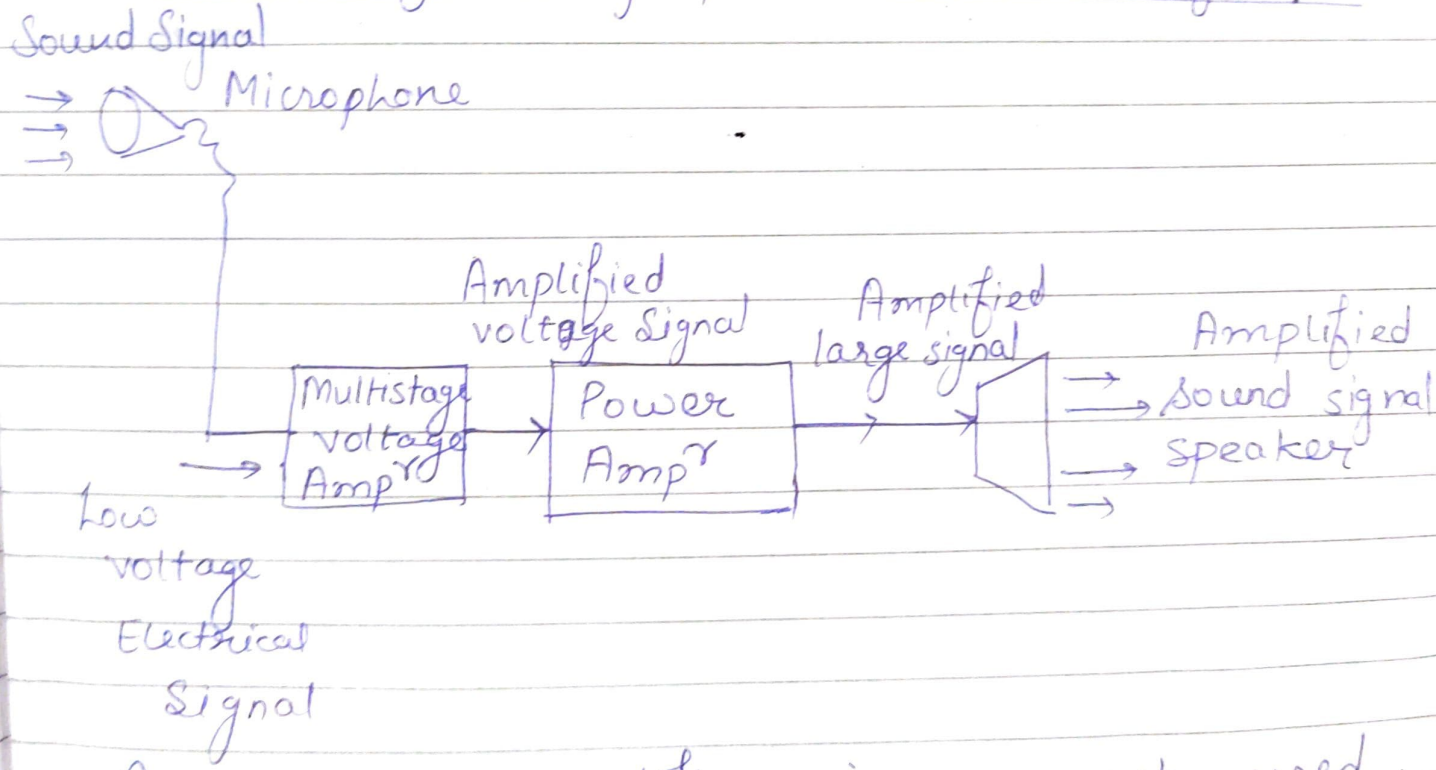
Large Signal Amplifier

Power Amplifier

Power amplifier may be defined as a device that converts dc power into ac power and whose action is controlled by the input signal.

A transistor amplifier which raises the power level of the signal in audio frequency range is known as transistor audio power amplifier.

Block diagram of public adress system



A voltage amplifier is commonly used at the first stage of amplification. On the other hand, power amp^r is used in the last stage of amplification.

Power amplifiers are classified as:-

(i) Audio power amplifier:- These are used to amplify power level of audio frequency signals (20 Hz to 20 KHz)

(ii) Radio power amplifiers :- These are used to amplify power level of radio frequency signals.

Difference b/w voltage amp^r and power amp^r

Voltage Amplifier	Power Amplifier
(i) It is used to raise the voltage level of signal.	It is used to raise the power level of signal.
(ii) The transistor with high value of β is used. So, it has thin base.	The transistor with low value of β is used. So, it has thick base.
(iii) High collector load resistance is used in circuit. (4-10 KΩ)	Low collector load resistance is used (4-20Ω)
(iv) The collector current in circuit is low. (1 mA)	The collector current is high (100 mA)
(v) The i/p voltage is low.	The i/p voltage is high

(vi) Its o/p impedance is high.	(vi) Its o/p impedance is low.
(vii) R-C coupling is used.	(vii) Transformer coupling is used.

Important terms in power amplifier

(i) Distortion
(ii) Power dissipation capacity
(iii) Collector efficiency

Distortion

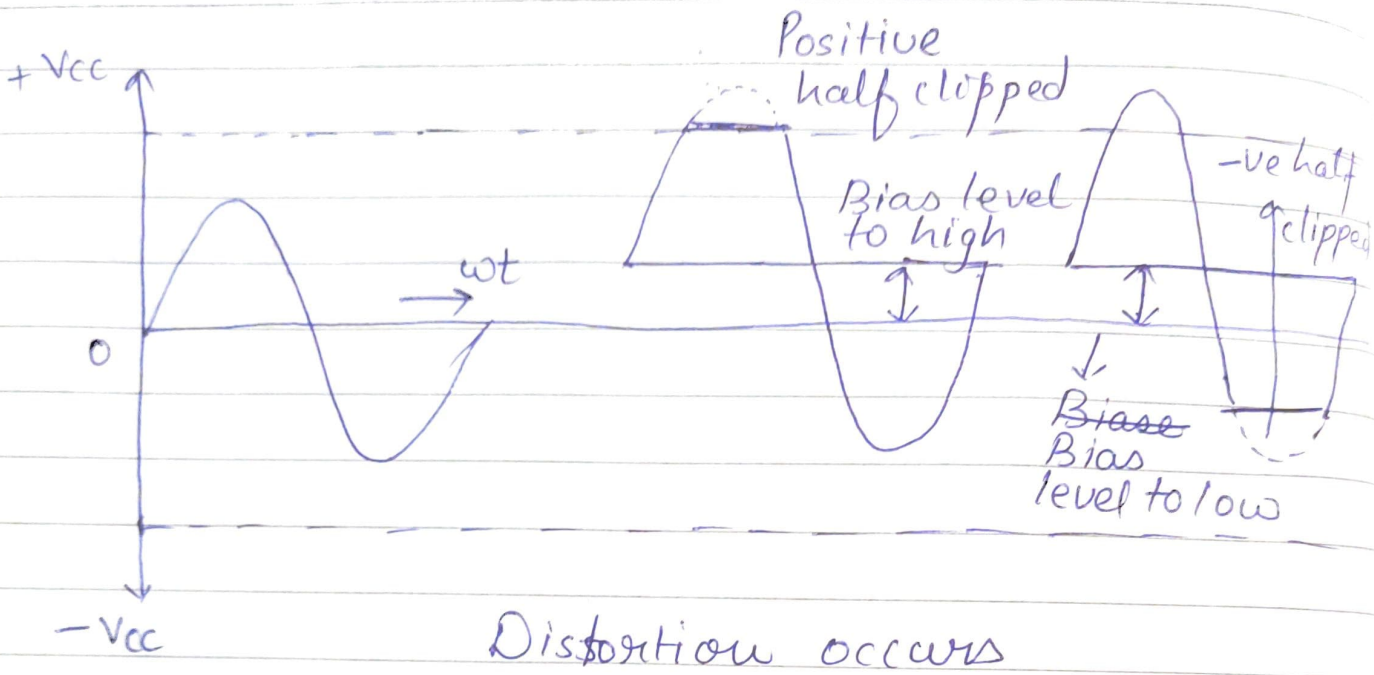
When the o/p of ~~am~~ an amplifier is not similar to i/p signal, distortion occurs. It is due to the non-linear characterstics of transistor.

Distortion may occur because :—

(i) Incorrect biasing levels may not allow amplification of complete signal. A part of signal may not get amplified due to improper bidsing.

(ii) The i/p signal may be too large causing the amplifying transistor to be ~~d~~ limited by supply voltage.

(iii) Amplification may not be linear over complete range of i/p frequencies.



Distortion occurs

Types of distortion

(i) Harmonic distortion
(ii) Phase distortion
(iii) Frequency distortion.

Harmonic distortion :- Transistor characteristics are not linear which leads to harmonic distortion.
The o/p contains frequencies which are multiples of original frequency.

Wave shape of o/p signal is expressed as :-

$$i_o = I_0 + I_1 \sin \omega t + I_2 \sin 2\omega t + \dots$$

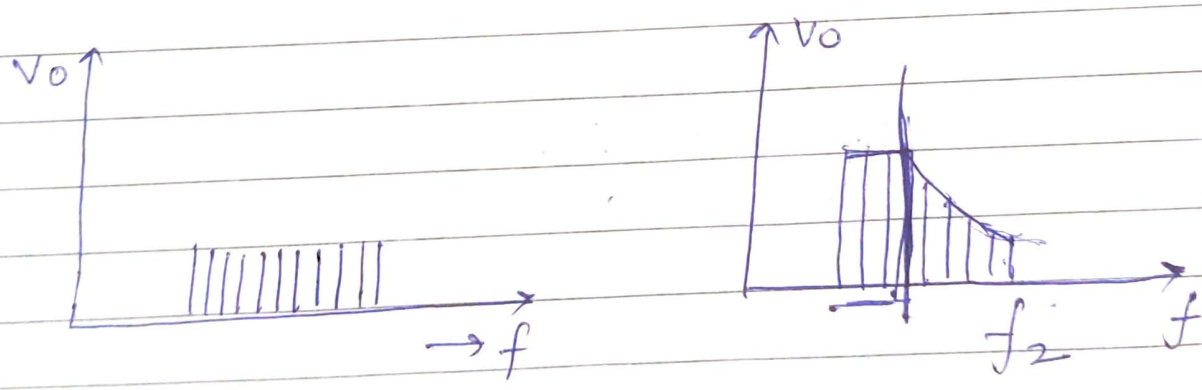
I_0 = dc component of o/p signal.
I_1 = peak value of 1st harmonic
I_2 = peak value of 2nd harmonic
and so on.

(b) Phase distortion :-

Every amplifier contains some reactive components which cause some time delay for some frequencies.

(c) Frequency distortion :-

Frequency distortion occurs in amplifier if the freq. components of signal are not equally amplified.



Power dissipation Capacity

The ability of transistor to dissipate the heat developed in it.

Power dissipation capacity will decide the max. power that can be handled by the amplifier.

Collector Efficiency

The ~~ration~~ ratio of A.C o/p to zero signal power is known as collector efficiency. (η)

$$(\eta)_{collector} = \frac{\text{avg. AC power o/p}}{\text{avg. DC power i/p}} = \frac{P_{ac}}{P_{dc}}$$

$$\boxed{\eta = \frac{V_{ce} \cdot I_c}{V_{cc} \cdot I_c}}$$

$\frac{\text{o/p}}{\text{I/p}}$

Classification of Power Amplifier

1. Class A Amplifier
2. Class B Amplifier
3. Class C Amplifier
4. Class AB Amplifier

Class A Amplifier

Operating point is fixed such that o/p current flows during complete cycle of input signal.

→ Amplify the low amplitude signal.

Class B Amplifier

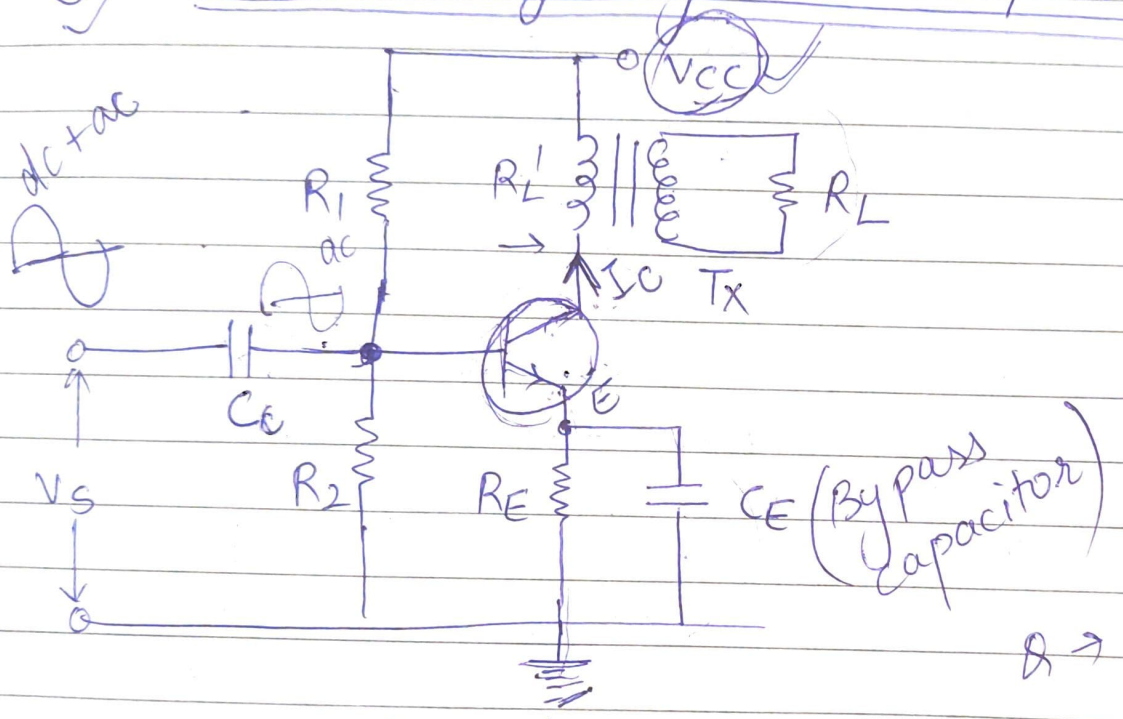
The collector current flows only for half the cycle of signal, remaining

half cycle is in cut off region.

Class C Amplifier

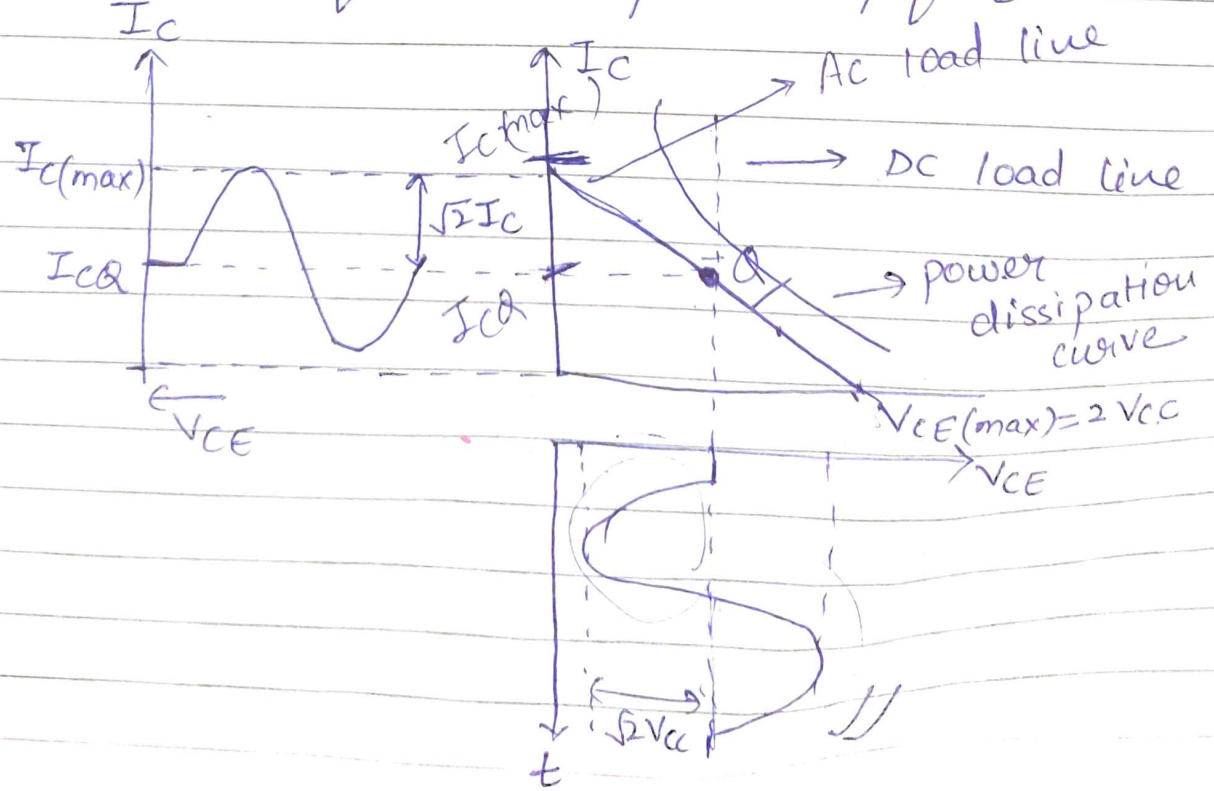
Collector current flows for less than half cycle of i/p signal.

// Class-A Sig Single ended power Amplifier



Q →

Transformer-coupled Amplifier



R_C has been replaced by primary winding of a transformer. The Tx provides a low resistance path to d.c thus reducing d.c power loss in R_C. It also matches the load impedance with the o/p impedance of amp^r.

Since both windings of transformer are electrically isolated from each other, D.C cannot flow to the load. However AC is supplied to the load by transformation action of transformer.

Working:- In order to get max. a.c power o/p, the peak value of the collector current due to signal should be equal to zero signal collector current. Thus Q should be located at the centre of load line. The o/p voltage and curren waveform are shown in figure.

When AC i/p signal is applied, operating paint Q moves up and down from its quiescent position. The o/p current will also increase or decrease. Similarly collector voltage V_{CE} will increase or decrease from its no-signal (V_{CC}) value.

$$V_{CE(peak)} = \frac{V_{max} - V_{min}}{2}$$

AC voltage is induced in the secondary winding which in turn develops ac power in load.

Hence, total avg. dc power drawn by the circuit from collector battery V_{cc} is

Dc i/p power = dc power in transistor

$$P_{in(dc)} = P_{tr(dc)} = V_{cc} \times I_c$$

under max. capacity of class A amp^r, voltage changes from $V_{CE(max)}$ to zero and $I_{c(max)}$ to zero.

$$V_{rms} = \frac{V_{CE(peak)}}{\sqrt{2}} = \frac{V_{CE(max)} - V_{CE(min)}}{2\sqrt{2}}$$

$$I_{rms} = \frac{I_{c(peak)}}{\sqrt{2}} = \frac{I_{c(max)} - I_{c(min)}}{2\sqrt{2}}$$

The average power can be calculated as

$$P_{o(ac)} = V_{rms} \times I_{rms}$$

$P = V \times I$

Power efficiency

Under zero-signal condition, there is no ac o/p power, all the power given to transistor is wasted as heat.

Collector efficiency (η)

$$\eta\,(\text{collector}) = \frac{P_{o(ac)}}{P_{in(dc)}} = \frac{\text{avg. ac o/p power}}{\text{avg. dc I/P power}}$$

we know that

$$P_{o(ac)} = V_{rms} \times I_{rms}$$

$$= \frac{[V_{CE(max)} - V_{CE(min)}][I_{C(max)} - I_{C(min)}]}{(\sqrt{2} \times 2\sqrt{2})}$$

For max. ac power o/p

$$V_{CE(max)} = 2V_{CC}$$

$$V_{CE(min)} = 0$$

Similarly, $I_{C(max)} = 2I_{CQ}$

$$I_{C(min)} = 0$$

$$P_{o(ac)} = \frac{2V_{CC} \times 2I_{CQ}}{8} = \frac{1}{2} V_{CC} \cdot I_{CQ}$$

$$P_{in(dc)} = V_{CC} \times I_{CQ}$$

$$\eta\,(\text{collector})\,(\%) = \frac{\frac{1}{2} V_{CC} \times I_{CQ}}{V_{CC} \times I_{CQ}} \times 100$$

$$\boxed{\eta_{collector} = 50\%}$$

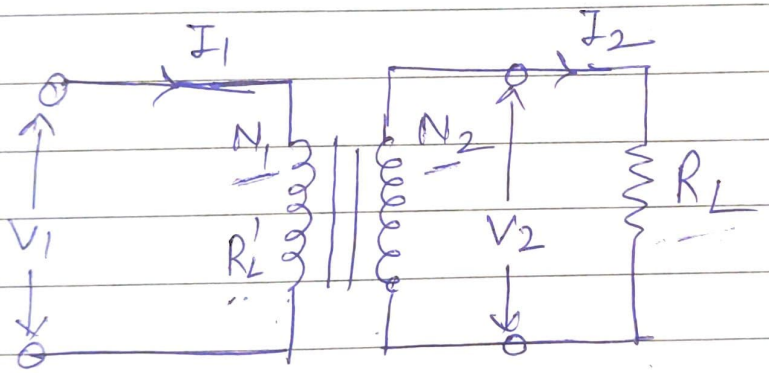
Importance of Impedance matching in power Amplifier using transformer

To obtain the max. efficiency, it is desired that max. power should be transferred from source

Impedance matching is done to acheive this objective of max. power transfer. Generally a step down transformer is used for this purpose.

$$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

$N_1 > N_2$



$$R = \frac{V}{I}$$

A resistance R_L is connected across the secondary which turns ratio $\frac{N_1}{N_2}$

R_L' is seen into primary side.

$$\text{Ratio of } \frac{R_L'}{R_L} = \frac{V_1/I_1}{V_2/I_2} = \left(\frac{V_1}{V_2}\right) \times \left(\frac{I_2}{I_1}\right)$$

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

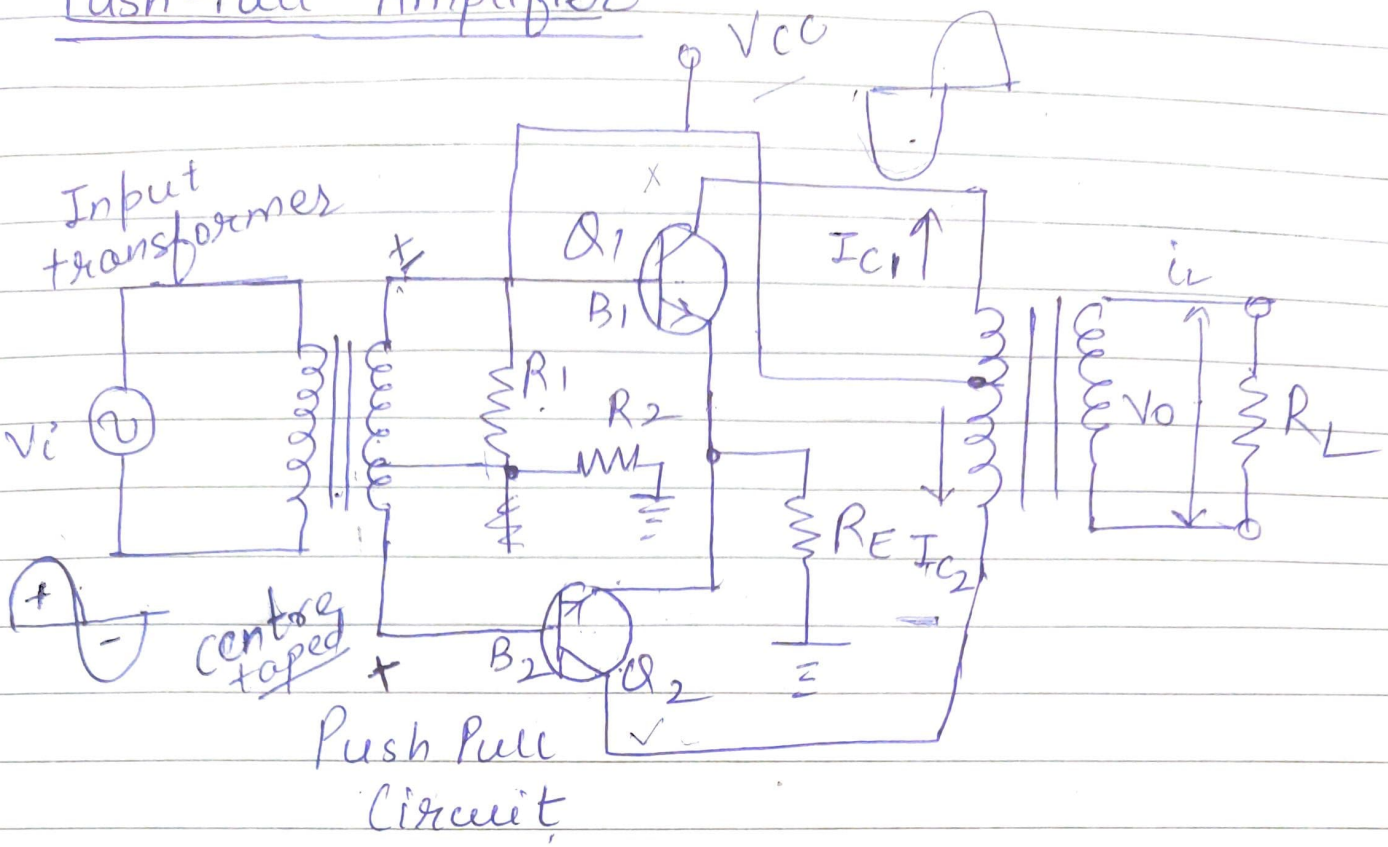
$$\boxed{R_L' = \left(\frac{N_1}{N_2}\right)^2 \times R_L}$$

Heat sinks in amplifiers

In power amplifiers, the power dissipated at collector junction of transistor is large, so that we use heat sinks to dissipate heat.

Heat sink is a mechanical device which is connected to the metallic case of semi-conductor device in order to provide a path for the flow of heat developed. The heat flows through heat sink and is radiated in surrouding air.

Push-Pull Amplifier



The circuit uses two similar transistors biased to operate in class B operation. Power efficiency of amplifier is an important factor in this type of circuit.

The ckt uses two similar Transistor T_1 and T_2. emitter terminal of both transistors are connected together and grounded through R_E. A transformer is provided on the input to connect signal source to input section of two transistor. Another transformer is connected to supply o/p power to load. Both transformers have a centre taped secondary winding.

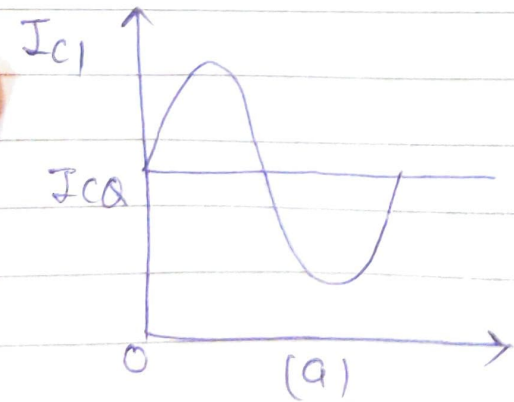
Working :- When i/p signal v_i is applied to primary winding of i/p transformer, it induces two equal and opposite voltages at secondary winding.

Thus voltage applied to base B_2 is opposite to the base B_1.

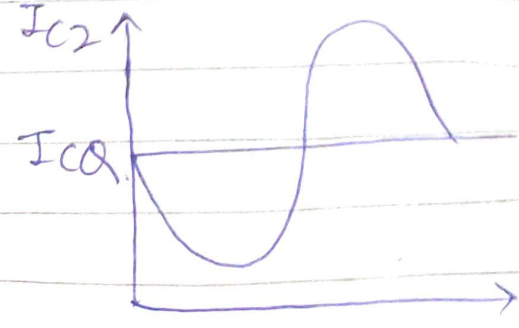
→ In +ve half cycle, T_1 moves into active region while T_2 moves in cut-off region.
Current I_{B1} and hence I_{C1} flows through transistor 1 which I_{C2} is zero.

→ In negative half cycle, T_2 moves in active region which T_1 moves in cut-off region.

→ I_{C1} and I_{C2} are opposite in phase



(a)



(b)

When the current in one transistor is pushed up, the current in the other transistor is pulled down. Hence named push-pull amplifier.

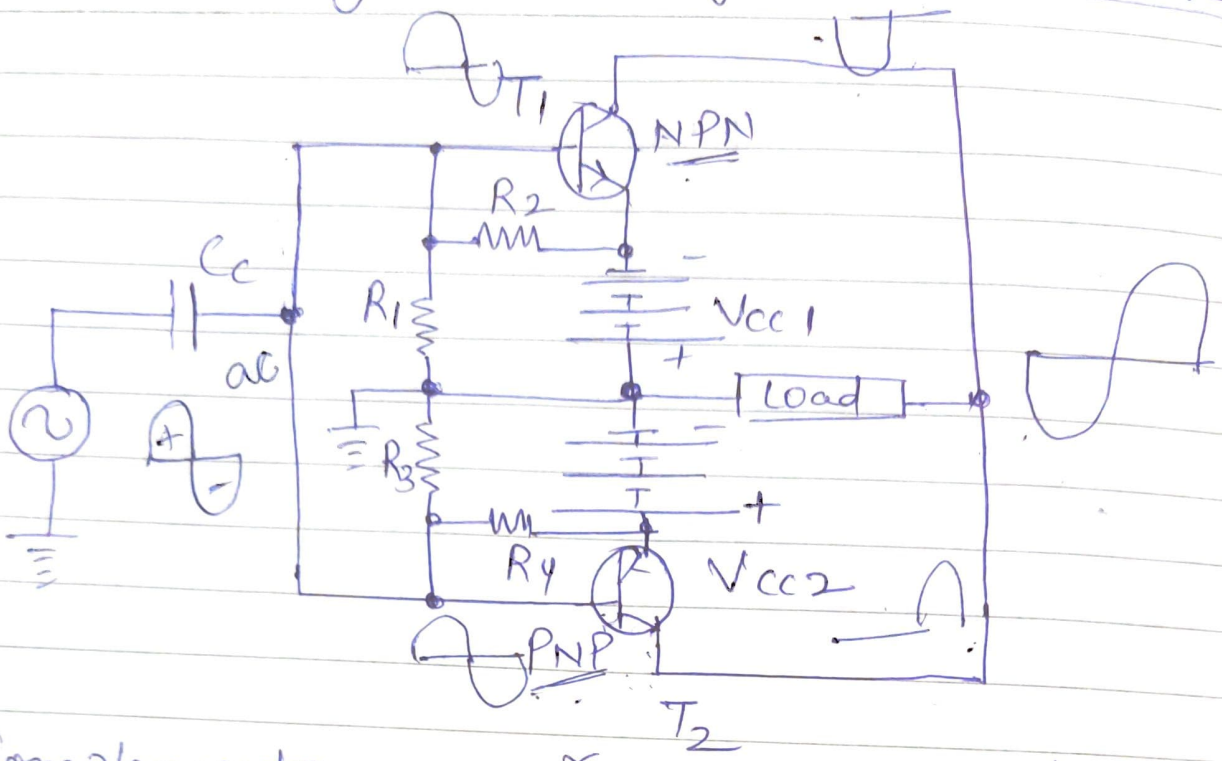
Advantages :-

1. Cost of transformer core and size is less.
2. Even order harmonics are not present in the o/p of push pull amp^r. This reduces distortion.
3. It has high efficiency.

Disadvantages :-

1. It requires two centre taped transformer Circuit becomes heavy and bulky.
2. It requires a matched pair of similar transistors. Many times characterstics of transistors are different. This can cause distortion in o/p.

Complementary symmetry push pull Amplifier



Complementary amp^{r} uses two batteries V_{cc1} and V_{cc2}. Two transistors have similar characteristics but these are opposite in nature. One is PNP type and other is NPN.

→ When ac signal is applied at both transistors, NPN transistor is fwd biased which PNP gets reverse biased. Hence NPN conducts during +ve half of cycle.

→ Reverse condition occurs in PNP transistor, it conducts during -ve half cycle.

→ Since the ckt does not use any transformer The ckt is light in weight.