Large Signal or Power Amplification

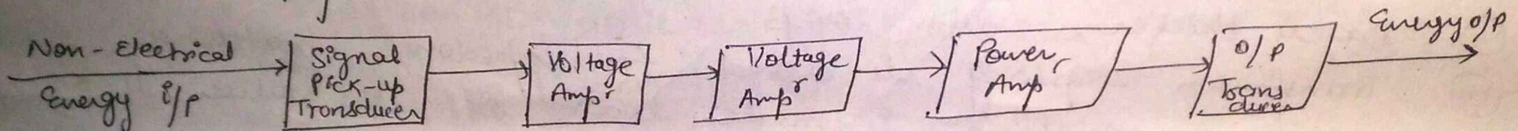
The function of voltage amplifiers are to provide a large enough voltage signal to the large-signal amplifier stages to operate such output devices.

A large - signal ampʳ ~~stages to~~ must operate ~~such~~ efficiently and be capable of handling large amount of power.

factor of greatest concern to the large signal power amplifiers are the power efficiency of the ckt, the maximum amount of signal power the ckt is capable of handling and impedance matching to the o/p device.

Power amplifiers is meant to raise the power level of the i/p signal.

To get large power at o/p, it is necessary that the i/p - signal voltage is large. Thats why, a voltage amplifier always precedes the power amplifier.



That why power ampʳ are called large - Signal Ampʳ.

Power ampʳ does not amplify power, but it draws power from dc supply connected to the o/p ckt and converts it into useful ac signal power. Thus power ampʳ may be defined as a device that converts dc power into ac power and whose action is controlled by the i/p signal.

Difference b/w power transistor & conventional transistor.

1. base is made thicker to handle large currents.
2. Area of collector region is made considerably large in order to dissipate the heat developed.
3. Heat sinks are used
4. Emitter & base layers are heavily doped.
5. Base layer & lead contact area is increased like ring so that area is increased. By doing so ohmic resistance b/w E & B reduced

due to low resistance small power is required at i/p.

Difference b/w Voltage & Power Amplier :-

(1) Voltage Amp^r :- Voltage Gain $A_v = \beta R_C/R_{in}$

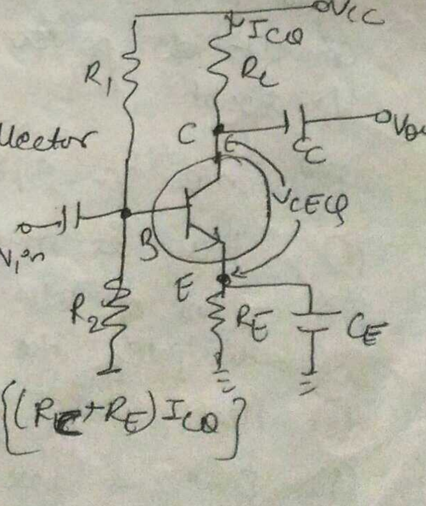
To achieve high voltage amplification :-

(i) Base should be thin with high β.
(ii) input resistance R_{in} is quite low comparison to R_C
(iii) To permit high collector load, A_v shoule be high so Voltage Amp^r always operated at low collector current.
(iv) R-C coupling is preferred.

(2) Power Amp^r :- is required to deliver a large amount of power and such it has to handle large current. so amplification needs :-

(i) Large sized power transistors are used in order to dissipate the heat produced
(ii) Base is thicker with low β.
(iii) Transformer coupling is used for impedance matching.
(iv) collector resistance is made low. If its value is high power losses in the R_C will increased; and voltage drop across it will increase and therefore operating voltage will be reduced.

* A high power dissipation voltage amplifier can not replaced ~~by~~ or w as power amp^r.



because $V_{CEQ} = V_{CC} - (R_C + R_E) I_{CQ}$

DC power Supplied to the amp^r from collector

$= V_{CC} I_{CQ}$

DC power i/p to transistor $= V_{CEQ} I_{CQ}$

wastage of power $= V_{CC} I_{CQ} - V_{CEQ} I_{CQ}$

$= I_{CQ}(V_{CC} - V_{CEQ}) = I_{CQ}\{(R_C + R_E) I_{CQ}\}$

$= I_{CQ}^2 (R_E + R_C)$

Power wastage can be reduced by shorting R_C & R_E; but R_E can't be eliminated because it is a part of biasing n/w & R_C can't be short ckt if R_C is short circuited R_L will be short-circuited and there will be no transfer of power to the R_L.

R_C can be replaced by inductor because dc power loss in the choke is almost zero.

Termed used in Power Ampr :-

① Collector efficiency :- The effectiveness of a power amplifier is measured by its capability of converting dc power from supply battery into ac ~~output~~ power at the o/p. This is known as collector efficiency = ~~(ac output signal to the zero~~ ~~signal power)~~

$$= \frac{\text{ac output signal}}{\text{zero signal power}}$$

② Power Dissipation capacity :- Can be increased by making a suitable provision for rapid conduction of heat away from the junction, this can be achieved by heat sink.

Power dissipation capacity is defined as its ability to dissipate the heat developed in it.

③ Distortion :- transistor operation becomes non-linear, the problem of distortion arises.

Classification of power Amplifiers :-
- Audio power Ampr (small signal power Ampr) raise the power levels of signal A.F. (20Hz - 20KHz)
- Radio power Ampr (Large signal power Ampr) raise the power level of signals that have RF range

According to mode :- This classification is based on the amount of transistor bias and amplitude of the i/p signal.

① Class A power Ampr :- In this o/p current flows for the entire cycle of i/p.

* Transistor should operate only for linear region of its load line.
* Such ampr amplify small amplitude i/p signal.
* ampr has high fidelity of the output.

* Efficiency with resistive load is 25%
* collector efficiency " " " " 50%
* signal is free from distortion.

Class B :- output current flows only during +ve half cycle of i/p

* zero signal, the $I_C = 0$ and no biasing system is required in class-B.
* operating point is selected at collector cut-off voltage
* High distortion occur.
* comparison to class A avg current is less & power dissipation is less
* Efficiency 78.5%

Class AB :- Biased at a dc level above the zero base current level of class B power amplifiers and above one-half the supply voltage level of class A.

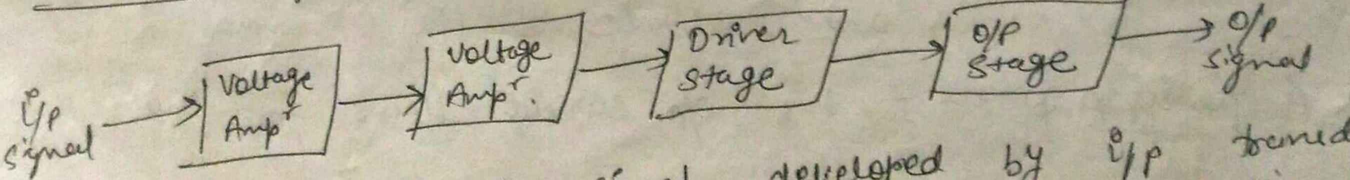
* output signal swing occurs b/w 180° and 360°

Class C :- Biased for operation for less than 180° of i/p signal and operate only with tuned or resonant ckt.

Class D :- * operate with digital or pulse type signals
* Advantage of class D power ampr is that it is on only for short interval and the overall efficiency is high.

Based on deriving output:
- Single-ended
- Double ended or push-pull
- Complementry symmetry push-pull

Power Amplifier :-



(A) Voltage Amplification :- Signal developed by i/p transducer is very small and need amplification so for raising level of weak signal, it is amplified in two or more stages.

Driver stage :- power amplification occurs. concentrated effort is made to provide maximum power gain and so transformer-coupled class A power ampr is used. driver transformer is usually a step-down transformer and facilitates impedance matching.

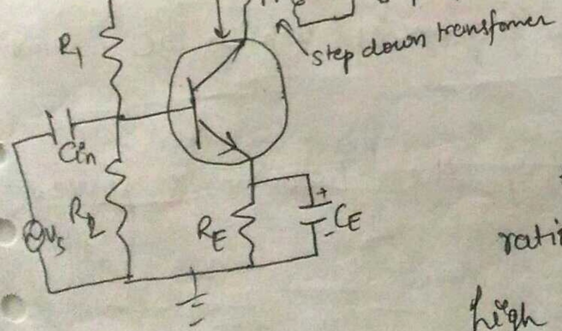
Output stage :- consists of a power ampr and is meant for transferring maximum power to the o/p.

in order to transfer maximum power at high efficiency, push-pull arrangement is employed in class B operation in this two transistors are used in class B operation and are fed from the centre-tapped secondary of the transformer whose primary forms the collector load for the driver stage.

Class A power Amplifier :- current flow for the full cycle 360° of i/p.

With zero signal applied at the i/p of class A power amplifier, ac power developed across the load reduces to zero and therefore, all the power fed to the transistor is wasted in the form of heat. Thus a transistor dissipates maximum power under zero signal condition.

Transformer Coupled class A Power Amplifier - The collector resistive load and cause large wastage of dc power in it.

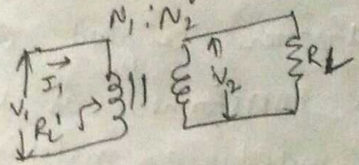


Transformer for coupling the load to the amplifier is usually employed.

A step-down transformer of suitable turn ratio $\left(\alpha = \frac{N_1}{N_2}\right)$ is provided to couple the high impedance collector circuit to low impedance load.

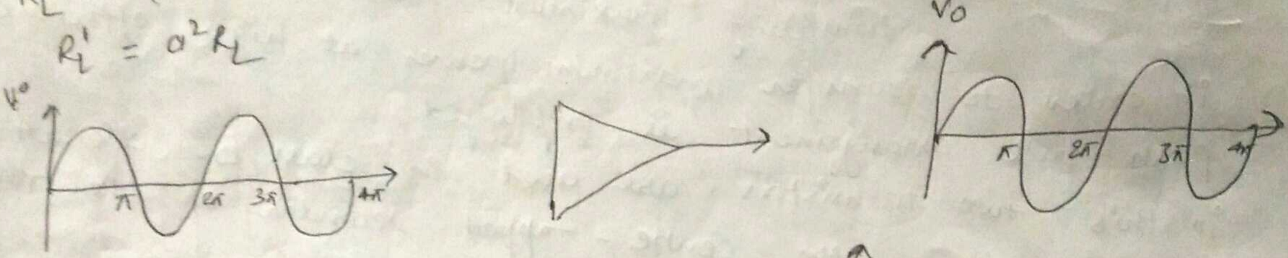
Impedance Matching :- maximum power transfered by amplifier to the load only if the amplifier output impedance equals the load impedance R_L.

$$\frac{R_L'}{R_L} = \frac{V_1/I_1}{V_2/I_2} = \frac{V_1}{V_2}\,\frac{I_2}{I_1} = \frac{N_1}{N_2} \times \frac{N_1}{N_2}$$



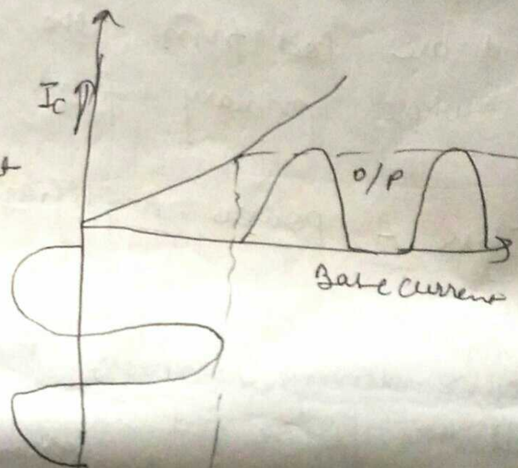
$$\frac{R_L'}{R_L} = \left(\frac{N_1}{N_2}\right)^2 = a^2$$

$$R_L' = a^2 R_L$$



Class B :- The transistor is so biased that zero-signal collector current is zero.

The operating point is set at cut-off. It remains f.B. for only half cycle of the i/p. conduction angle is 180°



Harmonic distortion :- Caused due to non-linearity of the active device employed for amplification.

- Harmonic distortion increases as we go from Class A operation to Class C operation.

* The output waveform contains components of frequencies which are harmonics of the i/p signal freq.

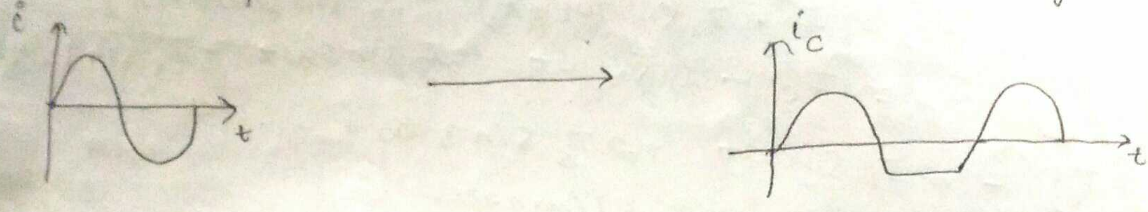
* spectrum analyzer permits the measurement of the harmonics present in the signal.

Total distortion $D = \sqrt{D_2^2 + D_3^2 + D_4^2 + \ldots}$

$D_2 = \frac{I_2}{I_1}$, $D_3 = \frac{I_3}{I_1}$ $D_4 = \frac{I_4}{I_1}$

10% Distortion represents a power increase of only 1% of fundamental

Class AB – operate for ~~less than~~ greater than 180° of the i/p signal cycle



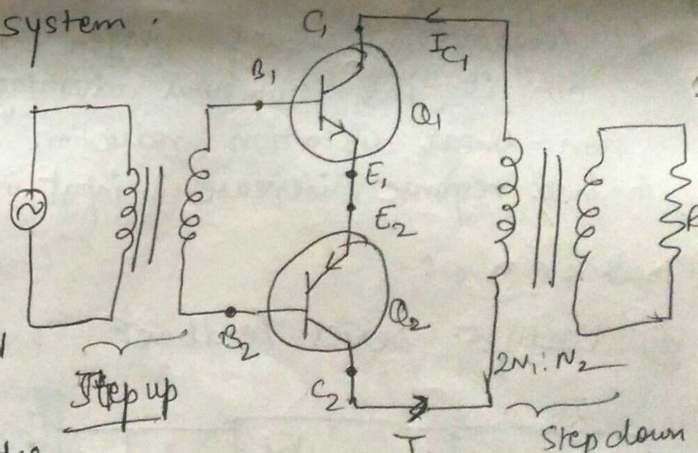
Class C :- operates for less than 180°

Class D :- efficiency 90%. Efficiency of class D amplifiers open the posibility for powerful, small, light ampr. with good sound quality.

Push-Pull Amplifiers :- Distortion is introduced because of non-lineari[ty] of dynamic transfer characteristics.

Such a distortion may be greatly reduced by using Push-Pull operation.

* The push-pull amplifier is a power ampr and is frequently used in the output stages.
* Audio power ampr used in transistor receivers, tape-recorder, recorder players, public address system.
* i/p signal is converted before amplification into two separate signals, which are identical except 180° phase difference.
* The output transformer is connected in the collector circuits of the transistors in such a way that the collector currents of the two transistors combine to provide an overall signal having the same waveform i/p signal.



Push-pull circuit

* Q_1 drive with +ve cycle $I_C \uparrow$ collector potential $\downarrow$
* Q_2 drives a reverse action $I_C \downarrow$, , , $\uparrow$

as I_{C_1} increases (pulls) the I_{C_2} decrease (pushes) collector current $I_{C_1} = I_C + I_1 \sin\omega t + I_2 \sin 2\omega t + I_3 \sin 3\omega t$

$I_{C_2} = I_C + I_1 \sin(\omega t + \pi) + I_2 \sin(2\omega t + 2\pi) \cdots$

$I_{C_2} = I_C - I_1 \sin\omega t + I_2 \sin 2\omega t - I_3 \sin 3\omega t$

$I_{C_1} - I_{C_2} = 2 I_1 \sin\omega t + 2 I_3 \sin 3\omega t + \cdots \infty$

all even harmonics are eliminated.

* This transistor can not removes hum.