Unit - IV Large Signal Amplifiers (Power Amplifiers).

→ Class A : power Amplifier
* Series fed & conversion, Efficiency
• Transformer coupled & conversion Efficiency.

→ Class B Power Amplifier
• Push pull & conversion efficiency
• complimentary symmetry & conversion Efficiency.

→ Principle of operation of class AB.

→ Class C Amplifiers.

Introduction of large signal Amplifiers

1. Power amplifier is an amplifier which can be capable of providing large amount of power to the load such as loud speaker or servo motor
2. Power amplifier is most commonly known as audio amplifier or also known as large signal amplifier
3. Power amplifier is an amplifier which converts DC input power into AC output power whose action is controlled by AC input signal
4. Some of the applications are public address system, radio recievers, driving servo motor, industrial control system, tape players, TV - recievers etc.

→ A voltage amplifier provides amplification to increase the voltage of the input signal. Power amplifiers are primarily provides sufficient power to the output load to drive other power devices

→ The power amplifiers must have low output impedence. Hence CC and CE amplifiers are used in power amplifier circuits

→ The main objective of power amplifier is
- To handle large power
- High frequency
- Less losses
- Less distortions.

Small signal Amplifier	Large signal Amplifier
→ small input signal	→ Large input signal
→ Linear region (Active)	→ Linear and non-linear regions
→ Mathematical method (h-parameter analysis)	→ Graphical method analysis. (Load line analysis)
→ Normal transistors are sufficient. Ex: BC107, BC108, etc	→ Power transistors are required Ex: 2N3055, 2N6078, BD136 etc.
→ The heat sinks are not required. Size is small.	→ Heat sinks are essential Due to large size transistors and transformers, the overall size is large and bulky.
→ Distortions is not present. The power handling capacity is small	→ Distortions is present. The power handling capacity is large.

→ the ratio of output ac power to input dc power is called conversion efficiency (η).

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Classification of power amplifiers:

Based on frequency range: Audio frequency Power Amplifier
Radio " " "

Based on conduction angle and selection of Q-point

- class - A Power Amplifier
- Class - B Power Amplifier
- class - AB Power Amplifier
- Class - C Power Amplifier

} efficiency.

Class - D → etc → switched power amplifier.
, etc.

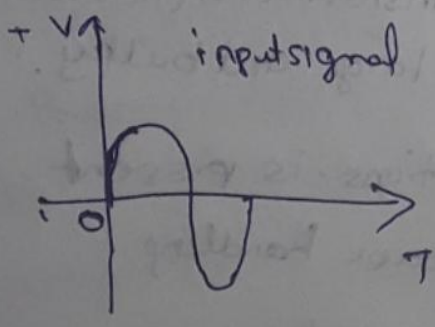
Class - A Power Amplifier:

Q-point

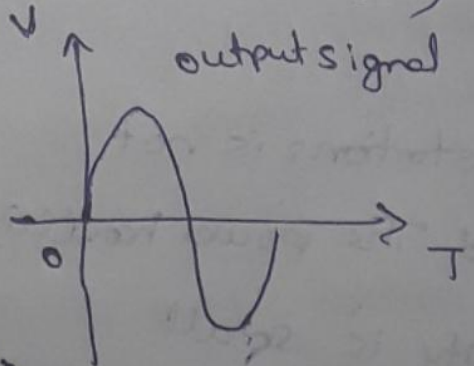
It is one in which the operating point and amplitude of the input signal are selected in a such away that the output current flows for the complete cycle of the input signal.

conduction angle: 360°.

selection of Q - point: Middle of the DC load line.



(360°)

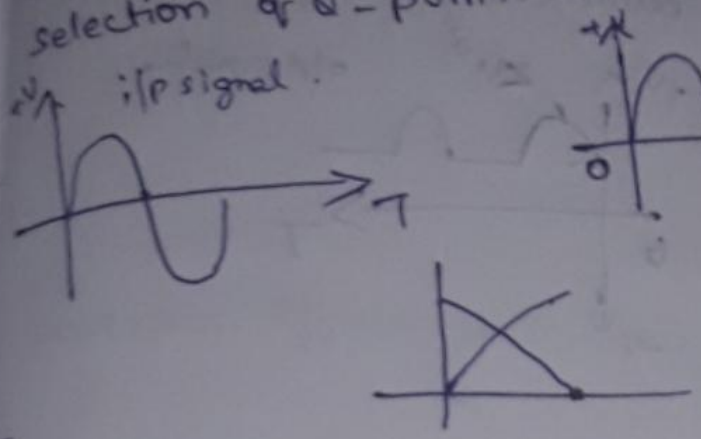


Class-B Power Amplifier:

It is the one in which the operating point and amplitude of the i/p signal are selected in such a way that the o/p current flows for the half cycle of the i/p signal

conduction angle: 180°

selection of Q-point: on x-axis.



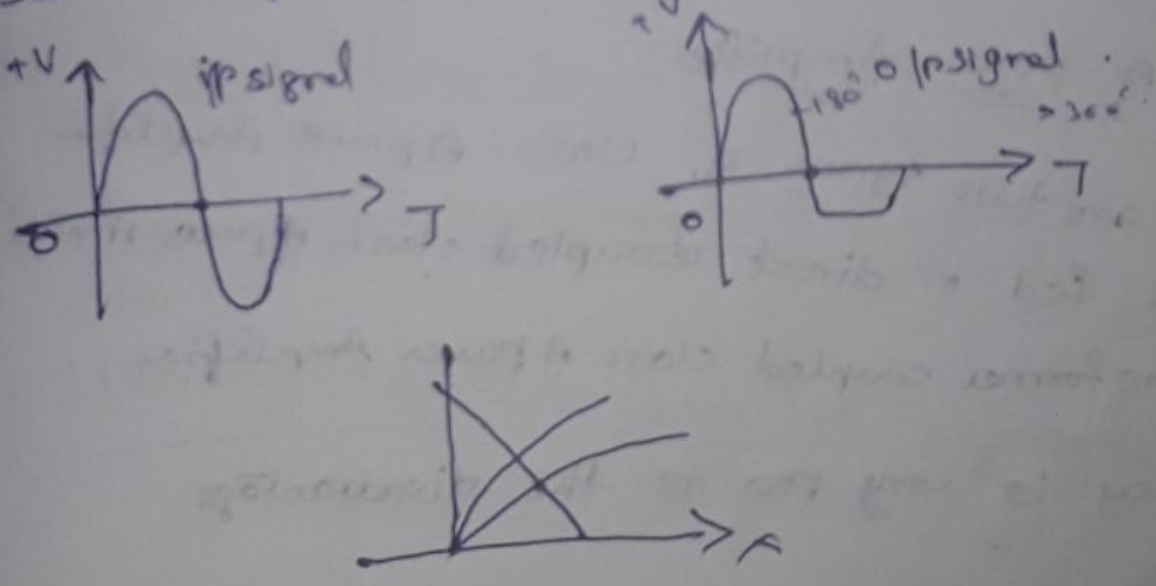
1. Push pull
2. complementary symmetry.

Class-AB Power Amplifier:

It is one in which the operating point and amplitude of the i/p signal are selected in such a way that, the o/p current flows for the more than half cycle and less than full cycle.

conduction angle in b/w $180^\circ < \theta < 360^\circ$.

Selection of Q-point: above the x-axis.

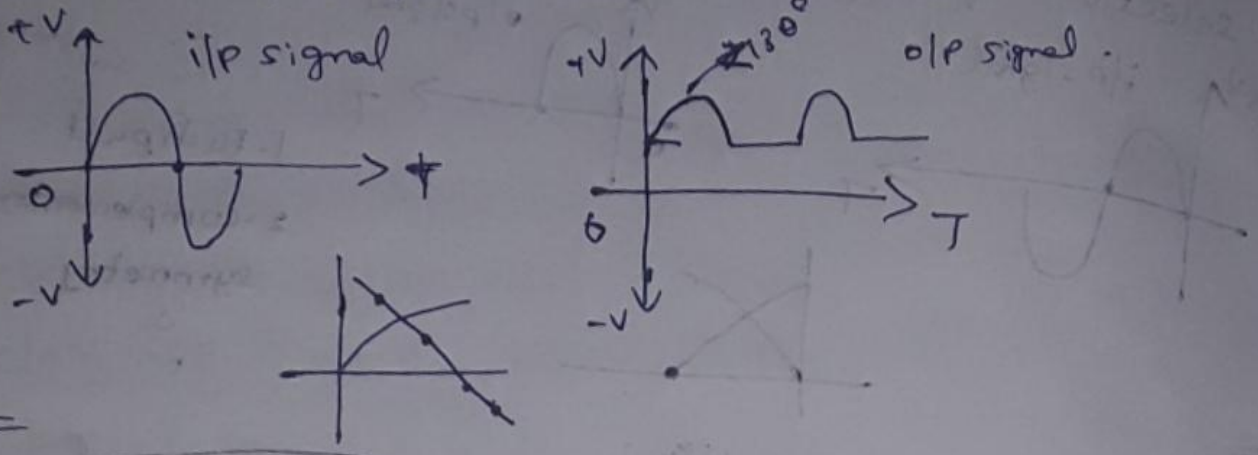


Class - C Power Amplifier:

It is one in which the operating point and amplitude of the input signal are selected in such away that the o/p current flows for the less than half cycle of the i/p signal.

conduction angle: $\theta < 180^\circ$

selection of Q-point: below the x-axis



	A	B	AB	C
conduction angle	360°	180°	$180^\circ < \theta < 360^\circ$	$< 180^\circ$
Q-point	Middle of active region	on x-axis	Above the x-axis	Below the x-axis

DC load line [Not imp for information]

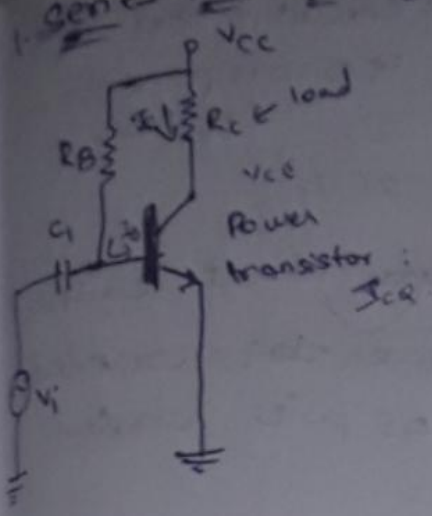
Class A power Amplifier:

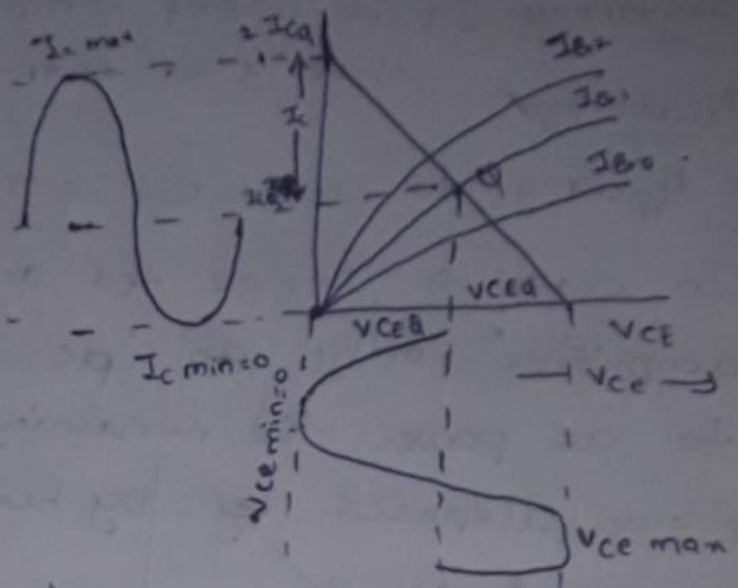
There are two types of class-A power Amplifiers

1. series fed or direct coupled class-A power Amplifier
2. Transformer coupled class A power Amplifier.

→ Efficiency is very poor is the disadvantage

1. Series fed or Direct coupled class-A power amplifier.





** Load line diagram.

* Conversion efficiency $\eta = \frac{\text{o/p } P_{ac}}{\text{i/p } P_{dc}}$

1. $P_{dc} = V_{dc} \times I_{dc} = V_{CC} I_{CQ}$

2. $P_{ac} = V_{rms} \times I_{rms} = \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}$ ... [∵ w.r.t.]

$$\left[\because V_m = \frac{V_{pp}}{2} = \frac{V_{max} - V_{min}}{2}, \quad I_m = \frac{I_{pp}}{2} = \frac{I_{max} - I_{min}}{2}\right] = \frac{V_m I_m}{2}.$$

$$P_{ac} = \frac{V_m I_m}{2} = \left(\frac{V_{max} - V_{min}}{2}\right) \cdot \frac{I_{max} - I_{min}}{2} \cdot \frac{1}{2}.$$

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

$$\eta = \frac{P_{ac}}{P_{dc}} = \frac{(V_{max} - V_{min})(I_{max} - I_{min})}{8} \times \frac{1}{V_{CC} I_{CQ}}$$

$$\eta = \frac{(V_{CC} - 0)(2I_{CQ} - 0)}{8 V_{CC} I_{CQ}} = \frac{2 V_{CC} I_{CQ}}{8 V_{CC} I_{CQ}} = \frac{1}{4} = 0.25$$

$V_{max} = V_{CC}$
$V_{min} = 0$
$I_{max} = 2I_{CQ}$
$I_{min} = 0$

$\% \eta = 25\%$.

$\% \eta_{\text{Practical ckt}} = 15\%$ to 10%.

Efficiency is very poor.

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Advantage: It is a very simple circuit & load is directly to output, less components are required.

Disadvantage:

1. Efficiency is less: It is only 25%.

In class-A series fed or Direct coupled amplifier only 25% dc power is converted to ac power the remaining 75% is wasted i.e Power dispated by heat.

Power Dissipation:-

The amount of power that much be disipated by the transistor is the difference btw the DC power input P_{dc} and the AC power delievered to the load P_{ac}.

Power Dissipation $P_d = P_{dc} = P_{ac}$.

$P_{dc} = \eta$ + losses.

$= 25\% + 75\%$.

$P_{dc} = P_{ac} + P_D$.

$P_D = P_{dc} - P_{ac}$.

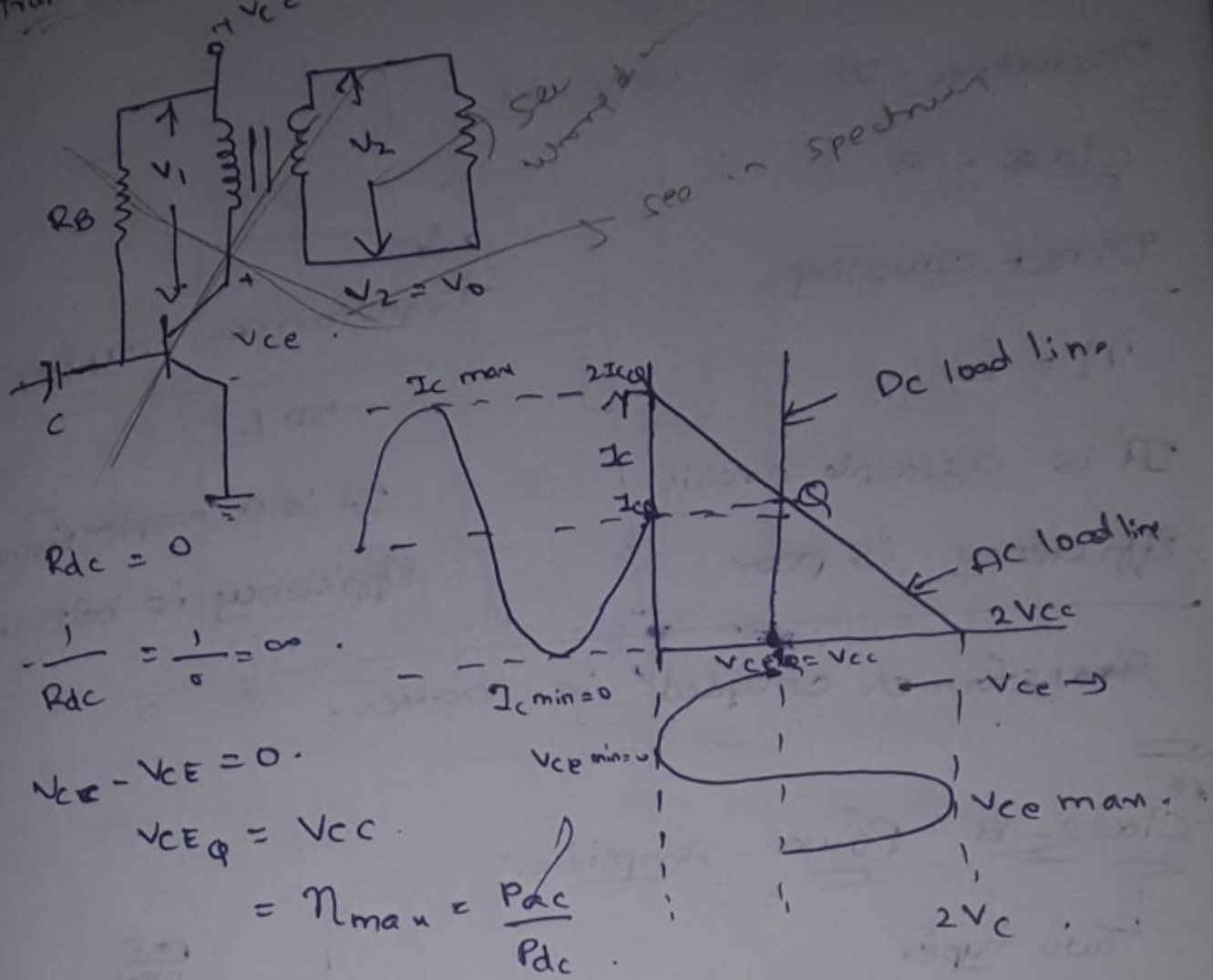
$P_{assume} = P_{DC} = V_{CC} I_{CQ}$.

$P_{dc} = V_{CC} I_{CQ}$.

⇒. Lack of impendence matching so efficiency is less.

To over come this problem we use Transformer coupled.

Transformer coupled class-A power amplifier



$R_{dc} = 0$

$\frac{1}{R_{dc}} = \frac{1}{0} = \infty$

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

$V_{CE_Q} = V_{cc}$

$\eta_{max} = \frac{P_{ac}}{P_{dc}}$

$$P_{ac} = \left[\frac{V_{max} - V_{min}}{2}\right]\left[\frac{I_{max} - I_{min}}{2}\right]$$

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

$$P_{ac} = \frac{(2V_{cc} - 0)(2I_{cq} - 0)}{8}$$

$V_{max} = 2V_{cc}$

$V_{min} = 0$

$I_{max} = 2I_{cq}$

$I_{min} = 0$

$P_{dc} = V_{cc} I_{cq}$

1. $\eta_{max} = \frac{P_{ac}}{P_{dc}} \times 100$

$$= \frac{2V_{cc}\, 2I_{cq}}{8} \times \frac{1}{V_{cc} I_{cq}} \times 100$$

$\eta_{max} = \frac{4}{8} = \frac{1}{2} \times 100 = 50\%$.

$P_D = P_{DC} - P_{ac}$.

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

Disadvantage. It is very cost.

Class - A

Direct coupling	Transformer coupling
$\eta = 25\%$.	50%.
It is a simple circuit	It is a complex circuit.
Efficiency is poor	Efficiency is better.

Transformer coupled is better.

Class - B Power - Amplifier:

PNP / NPN.

Two types.

1. Push pull - PNP / NPN
2. Complementary symmetry

Depending upon the type of two transistors whether PNP or NPN class B power amplifiers are classified two types.

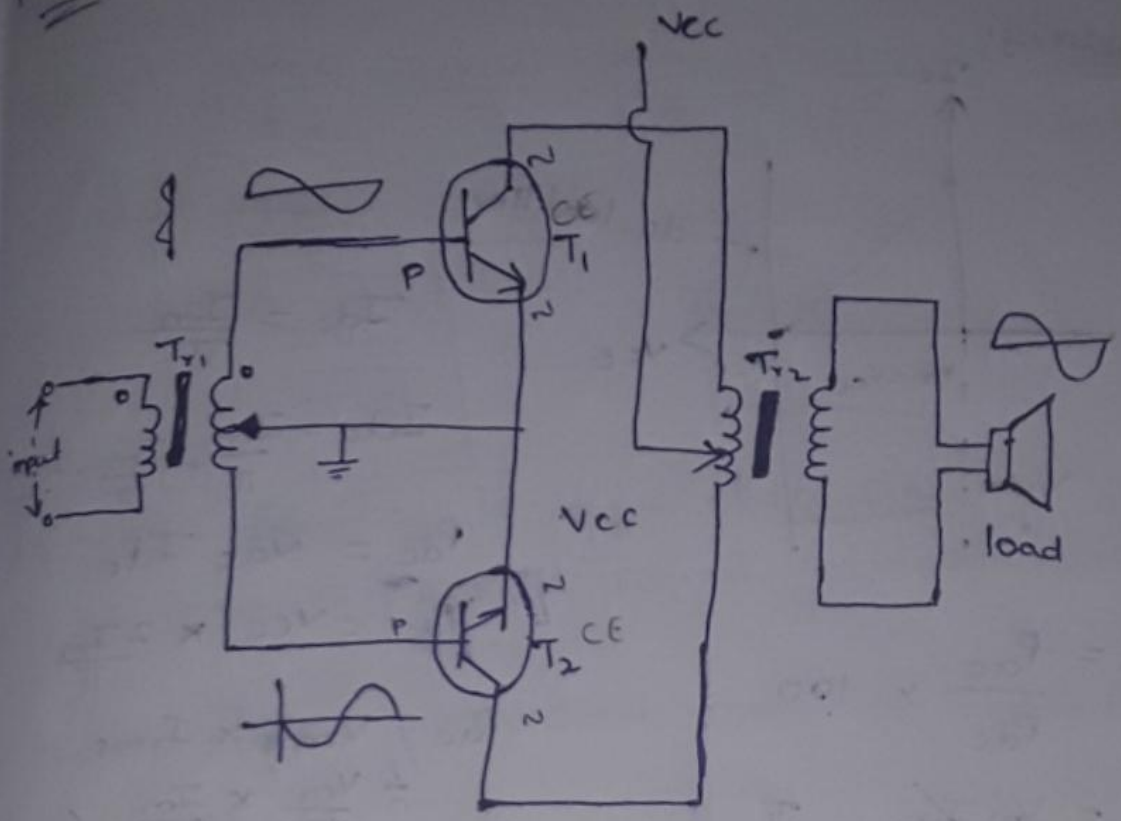
1, Push pull class B Power Amplifier:

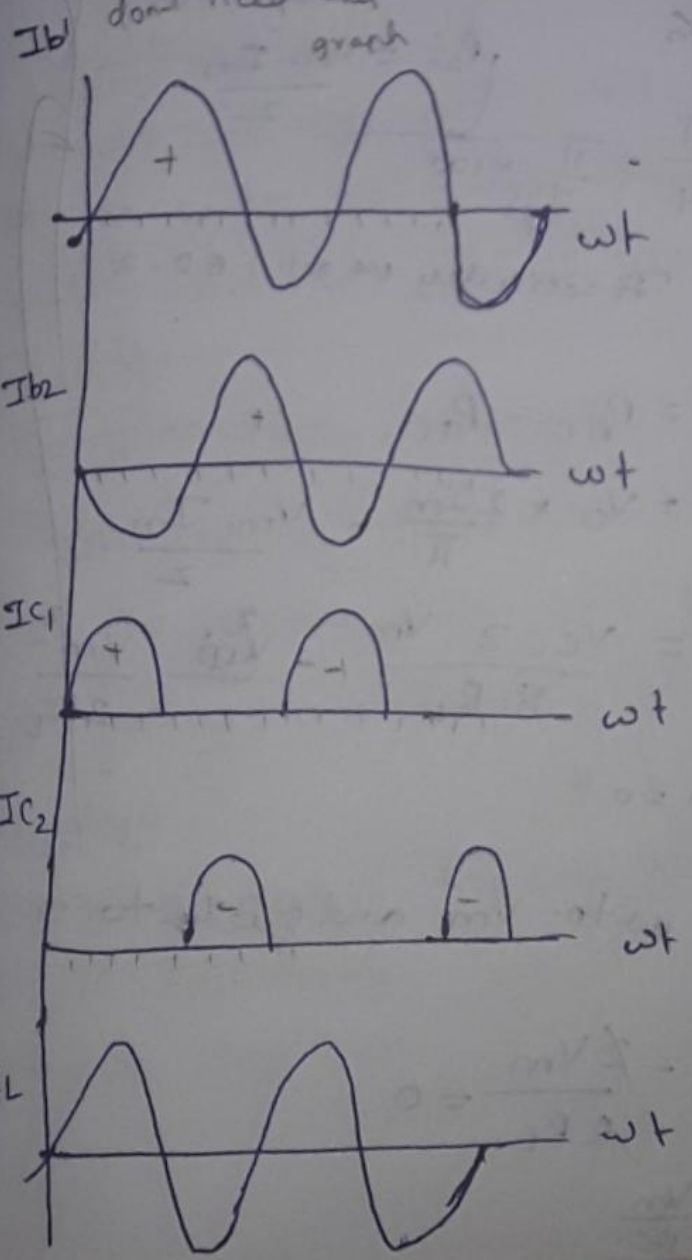
when the both the transistors are of same type i.e either NPN or PNP then the circuit

2, Complementary Symmetry class - B Power Amplifier

when the two transistors are complementary type i.e one is NPN and other is ~~PNP~~ PNP.

Push pull class-B Power Amplier:



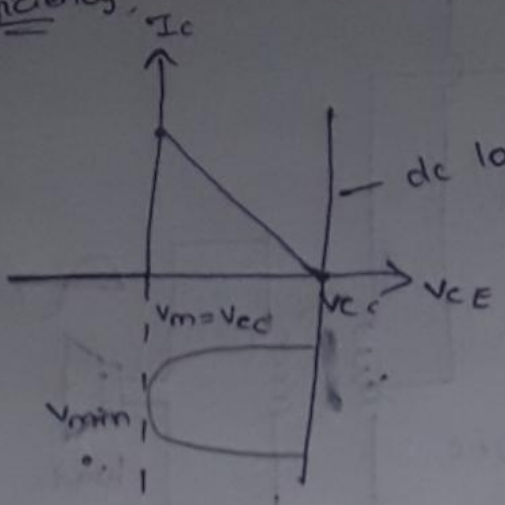


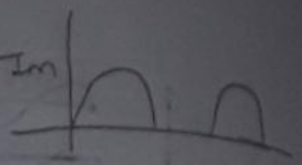
$$I_L = I_{C_1} - I_{C_2}$$

$V_c = V_{cc}\left[1 - \frac{I}{R_E}\right]$

Load line analysis:

Efficiency:





$$I_{dc} = \frac{I_m}{\pi}$$

$$I_{dc} = \frac{I_m}{\pi} + \frac{I_m}{\pi} = \frac{2I_m}{\pi}$$

$$P_{dc} = V_{dc}\, I_{dc}$$

$$P_{dc} = V_{cc} \times \frac{2I_m}{\pi}$$

$$\eta = \frac{P_{ac}}{P_{dc}} \times 100$$

$$P_{ac} = V_{rms} \times I_{rms}$$

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

$$P_{ac} = \frac{V_m \cdot I_m}{2}$$

$$= \frac{V_m I_m}{2} \times \frac{\pi}{2 V_{cc} I_m}$$

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

$\eta = 78.5\%$

Practically we get 60-70%.

Power dissapation: $P_D = P_{DC} - P_{ac}$

$$= V_{cc} \times \frac{2I_m}{\pi} + \frac{V_m \cdot I_m}{2}$$

$$= \frac{V_{cc}\, 2 \cdot V_m}{\pi R_L} - \frac{V_m^2}{2R_L} \quad \text{---} (1)$$

$I = \frac{V_m}{R_L}$

$V = IR$

$V_m = I_m R_L$ also can use

(if $i/p = 0$, $V_m = 0$ & $P_D = 0$).

Differentiate w.r.to. V_m and equate to 0

$$\frac{dP_D}{dV_m} = \frac{2}{\pi} \frac{V_{cc}}{R_L} - \frac{2V_m}{2R_L} = 0$$

$$= \frac{2V_{cc}}{\pi R_L} = \frac{V_m}{R_L}$$

$\therefore V_m = \frac{2V_{cc}}{\pi}$ → condition for

$P_D(max) = \frac{2V_{cc}}{\pi R_L} \cdot \frac{2V_{cc}}{\pi} - \left(\frac{2V_{cc}}{\pi}\right)^2 \times \frac{1}{2R_L}$ [∵ substitute in Eqn ①]

$= \frac{4V_{cc}^2}{\pi^2 R_L} - \frac{4V_{cc}^2}{2\pi R_L} = \frac{2V_{cc}^2}{\pi^2 R_L}$

$$P_D(max) = \frac{2V_{cc}^2}{\pi^2 R_L}$$

Advantages: Efficiency is higher than Class-A.

* If there is no input signal power dissapiation is 0

* For transformer impedance matching is possible for we get efficiency.

Disadvantages:

Fabrication is very difficult.

→ It is centre transformer trapped is used. It is bulky and cost. It is complex time is taken

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2. Complementary symmetry:

Efficiency is 78.5 % mean.

It is same like pull push. but we are using CC transitions not using transformers.

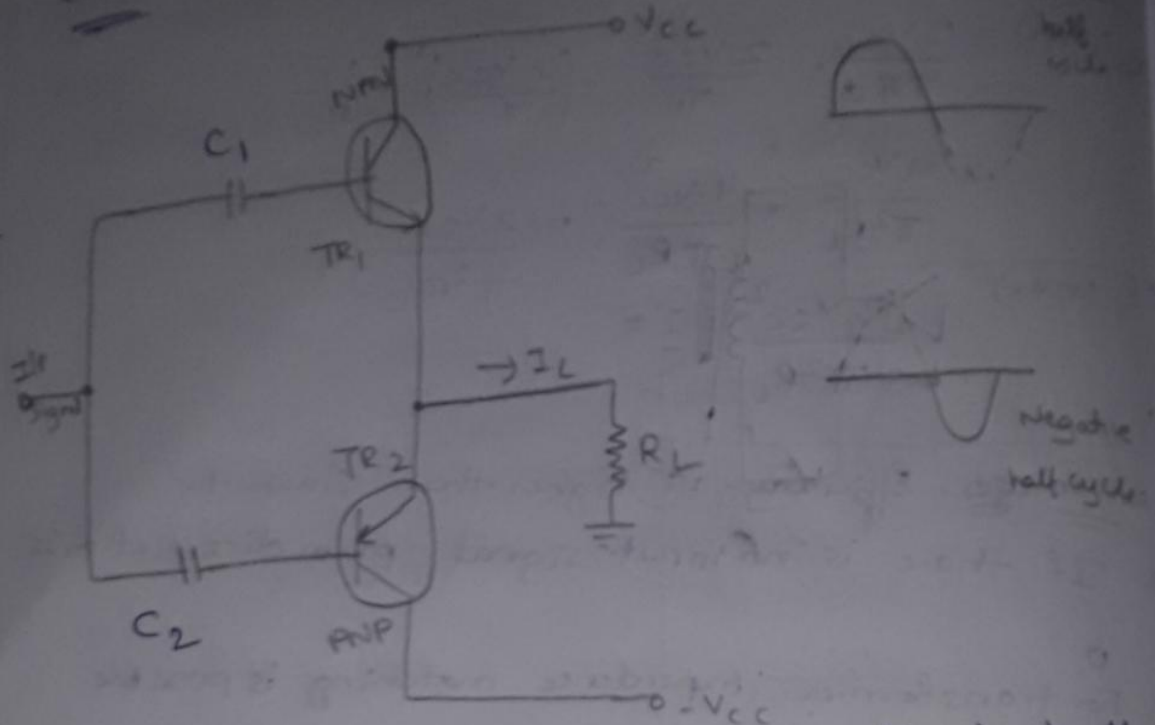
Advantages.

Frequency is more. ∴ Frequency response increase.

→ It is transformer less.

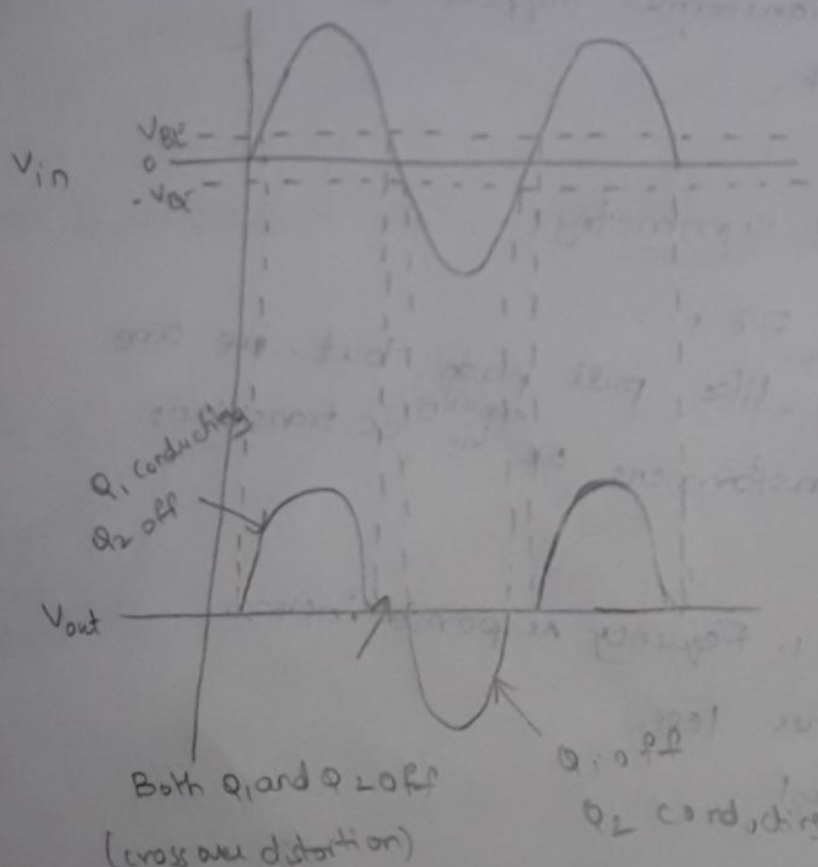
→ It is less cost.

circuit diagram:



Cross over disortion is disadvantage in both cases

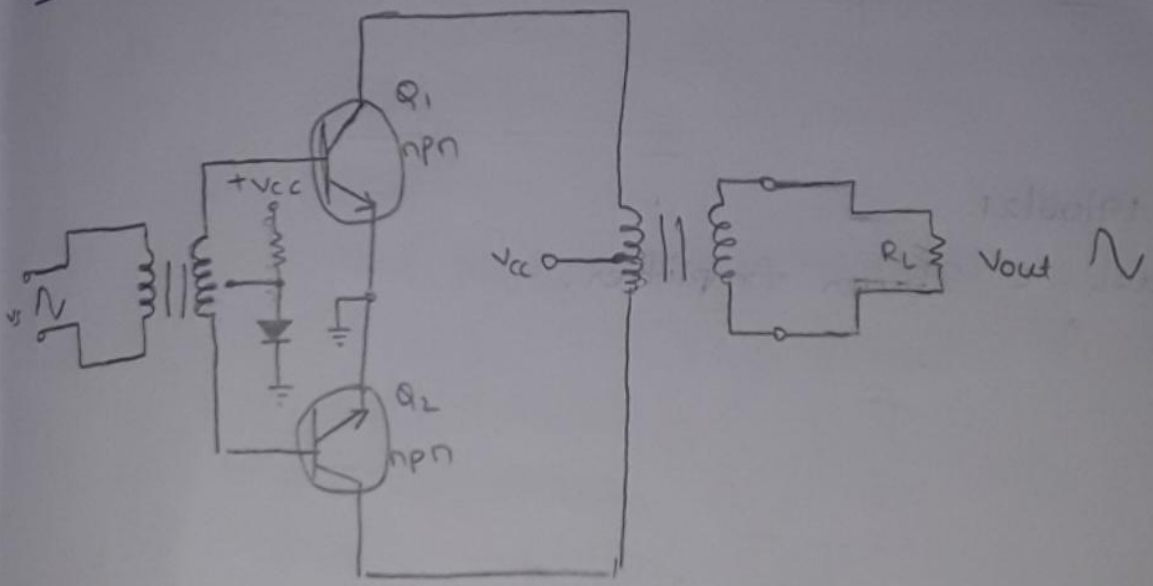
Cross over distortion.



In class-B push pull and complementry symmetry power amp none of the transitor will get into ~~off~~ on position during $-V_{BE}$ to V_{BE} so distortion is introduced at output such a distortion in the o/p signal are called cross-over distortion.

It can be eliminated by providing biasing resistances to class-B power amplifier which is known as class-AB power amplifier.

class-AB power amplifier:

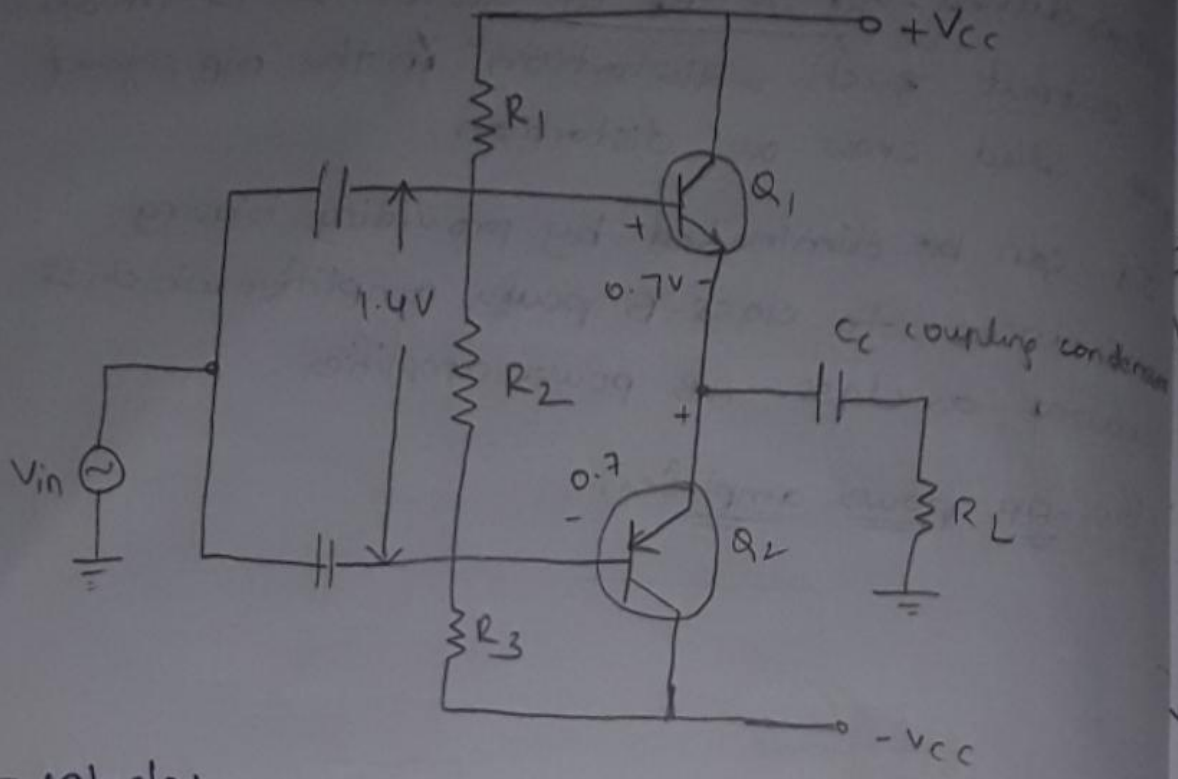


Push pull class-AB Power Amplifier.

To overcome cross over distortion we use this class AB power amplifier.

Vcc to +ve = FB.

complementary Symmetry class - AB power Amplifier



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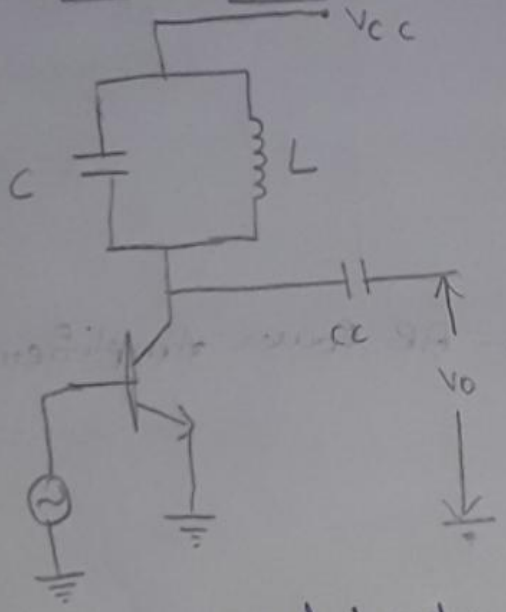
Class - C Power Amplifier:



Class - C Tuned bard.

It gives narrow bard response. Most Efficiency is very high.