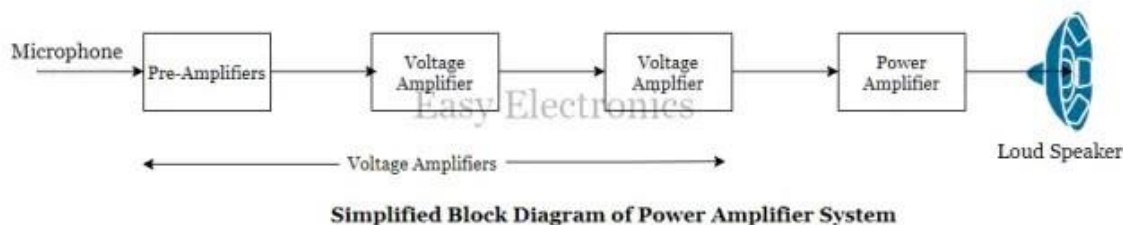


# Power Amplifier

It is called the “Large Signal Amplifier” because it is capable of supplying an adequately large amount of power to the load like a loudspeaker.



The primary aim of a power amplifier is to supply a large power therefore the voltage gain is not important.

Power amplifiers are used as the last stage in the P.A system, [radio receivers](#), TV receivers, etc.

Some of the important features of power amplifiers are as follows:

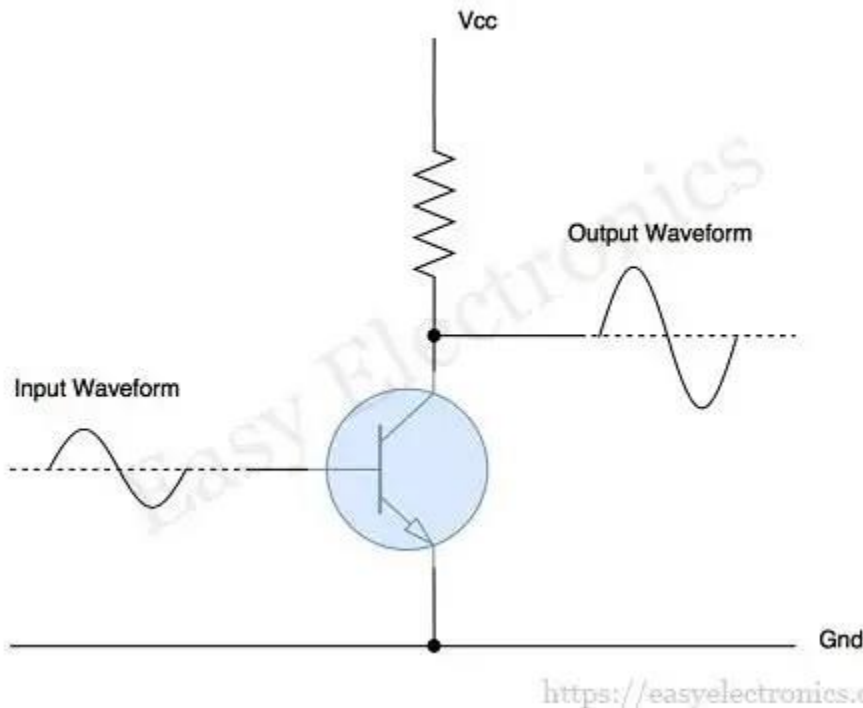
- Impedance matching with the load is necessary for the maximum transfer of power.
- They use power transistors.
- Power amplifiers are bulky due to the use of heat sinks.
- Harmonic distortion is present in the output.
- They are capable of handling a large power.

Depending on the position of the Q-point or operating point on the load line, the Power amplifiers are classified into the following four categories:

1. Class-A amplifiers
2. Class-B amplifiers
3. Class-C amplifiers
4. Class-AB amplifiers

## Class-A Power Amplifier

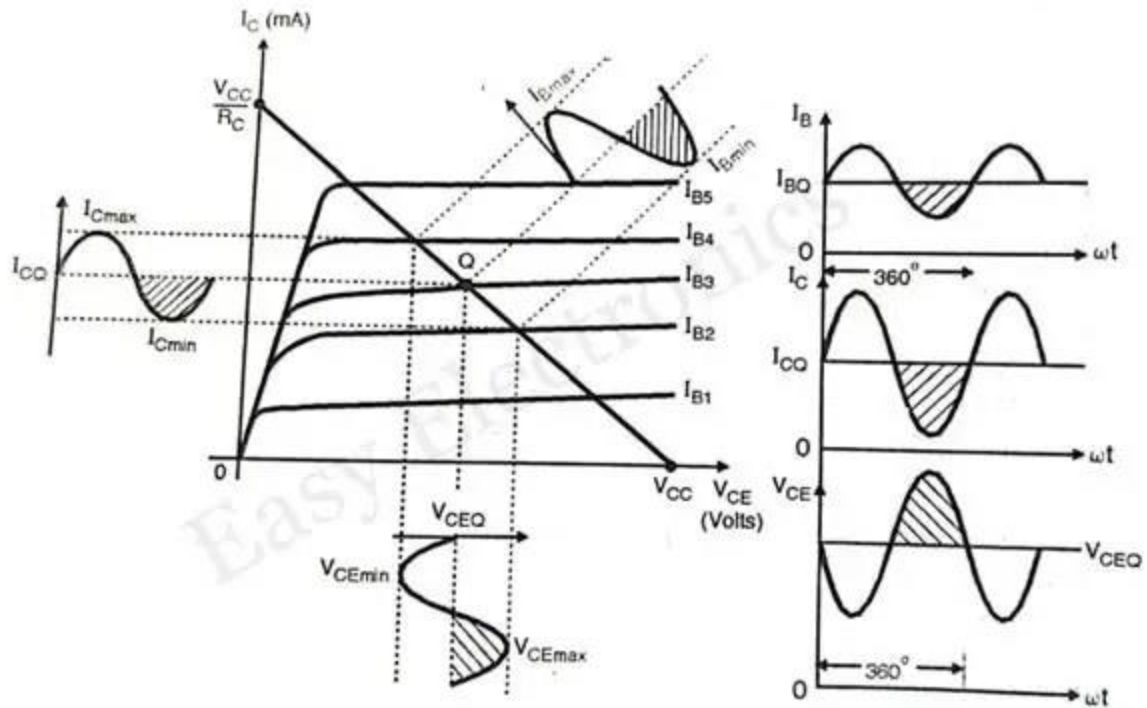
- An amplifier is referred to as a class A amplifier if the transistor used for amplification conducts for the full cycle duration of the input ac signal.



- The Q-point is adjusted exactly at the center of the load line as shown in the figure below.
- Due to this, the output signal is obtained for the full cycle of the ac input. i.e.  $360^\circ$ .
- The power transistor is biased such that the operating point (Q-point) is approximately at the center of the load line.
- Now, when we apply the ac signal to the base of the power transistor, the base current changes sinusoidally above and below the quiescent base current  $I_{BQ}$ .
- In response to the changes in  $I_B$ , the collector current changes sinusoidally above and below its quiescent current value  $I_{CQ}$ . The collector current and base currents are in phase with each other.
- Due to changes in  $I_C$ , the voltage  $V_{CE}$  will also fluctuate sinusoidally.

**Note:**  $V_{CE}$  and  $I_C$  are  $180^\circ$  out of phase.

## Operation of Class-A Power Amplifier



- The transistor remains in the “**active region**” for all the values of the input signal and never enters into the saturation or cutoff regions. So **class-A power amplifiers are linear amplifiers**.
- The transistor conducts the complete cycle of ac input i.e. for  $360^\circ$ . Thus the angle of collector current flow is  $360^\circ$  or a full cycle.
- As shown above figure, the input signal is amplified faithfully, without introducing any distortions. Thus harmonic contents in the output will be low.
- As the transistor continuously operates in its active region, the voltage  $V_{CE}$  across it and current  $I_c$  through it, both are simultaneously high.
- Therefore a large power will be dissipated in the transistor in the form of heat.
- Therefore the efficiency of class A power amplifiers is low. In fact, it is the lowest of all the power amplifiers.
- Typically the **efficiency (n)** of a class A power amplifier lies between **25% to 50%**.

### Advantages of class A power amplifier

1. Simple construction.
2. Distortionless output voltage.

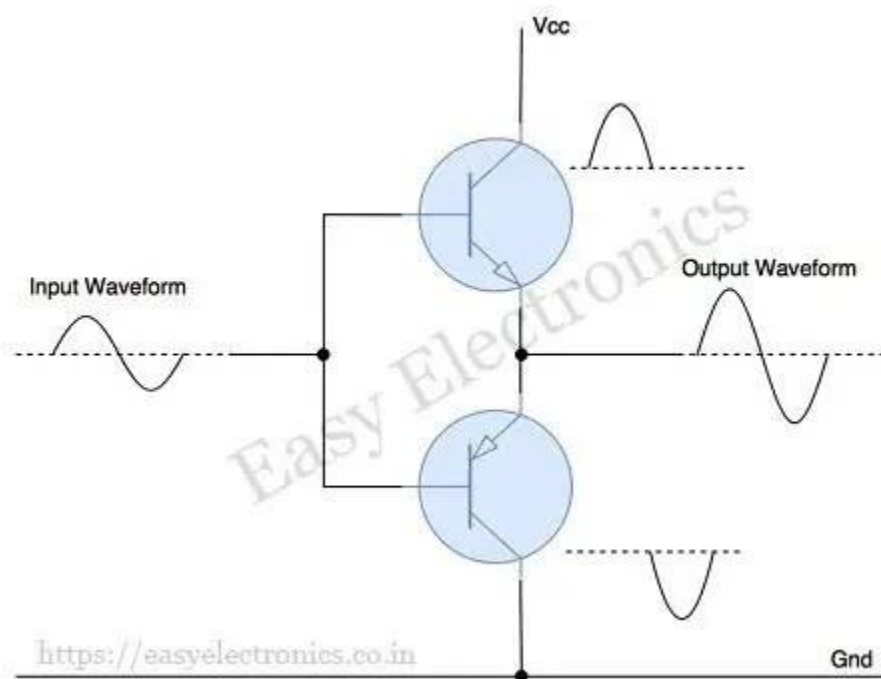
## Disadvantages of class A power amplifier

1. Very low efficiency (25% or 50%)
2. Large power dissipation in the power transistors.

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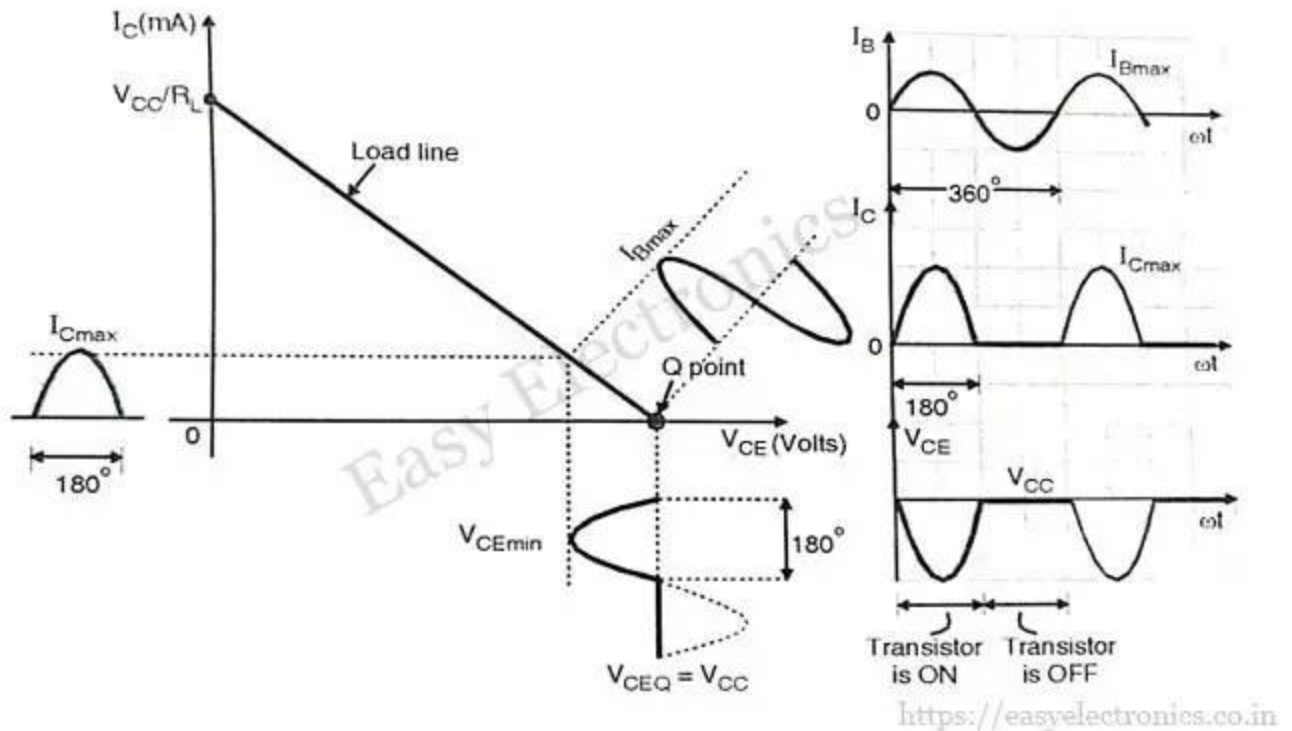
## Class-B Power Amplifier

- An amplifier is referred to as a class B amplifier if the output signal is obtained only for one half-cycle period of the input ac signal.



- The transistor conducts only in a one-half cycle of the input and the collector current, therefore, flows for only  $180^\circ$ , as shown in the below figure.
- For this, the Q point is adjusted to be a cut-off. i.e. on the X-axis as shown in the below figure. Thus in the absence of an ac input signal, the transistor remains in the off state.
- The coordinates of the Q-point are  $(V_{cc}, 0)$ .

## Operation of Class-B power amplifier



- As we apply a sinusoidal input signal to the base of the transistor, the B-E junction of the transistor is forward-biased only during the positive half cycle of the input and the base current starts flowing.
- The transistor remains in the active region, only for the positive half cycle of the input signal. In the negative half cycle, the transistor remains in the off state. Thus collector current flows for only 180° (half cycle) of the input signal.
- As seen from the above figure, only one-half cycle is obtained at the output. Therefore the output voltage waveform is distorted because it is no more a sine wave.
- The distortion can be eliminated by using two transistors in alternate half cycles of the input signal to produce the complete cycle of the signal at the output. Each transistor conducts only 180°. This is called the push-pull class B power amplifier.
- As the transistor remains off for the complete negative half cycle, the power dissipation in the transistor is reduced as compared to that in the class A power amplifier.
- Therefore the efficiency of class B amplifiers is higher than that of class A power amplifiers.
- The maximum efficiency of the class-B configuration can be 78.5% which is much higher than that of the class-A power amplifier.

## Crossover Distortion

- The waveform distortion near the zero-crossing points is observed in class B power amplifiers.
- This happens because the transistors are biased at cut-off.
- The [crossover distortion](#) can be eliminated by using the class-AB type power amplifier.

## Advantages of class B power amplifier

1. Higher efficiency (78.5%)
2. Zero power dissipation under quiescent conditions.
3. Impedance matching with load is possible.
4. The second harmonic component gets automatically canceled.

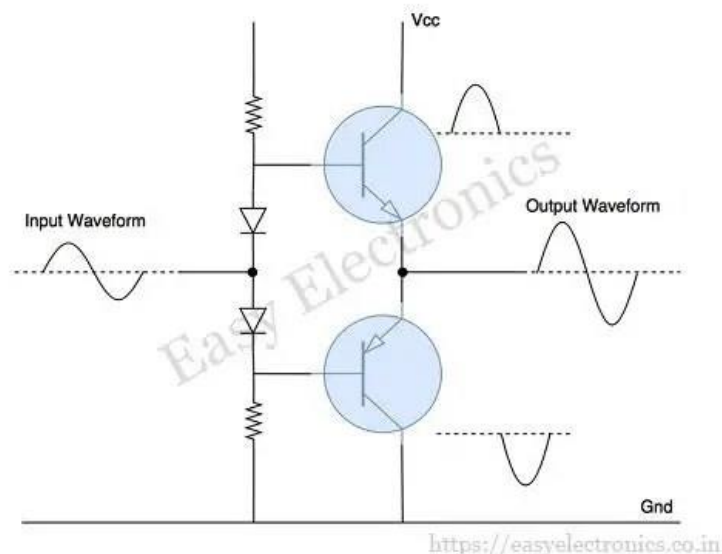
## Disadvantages of class B power amplifier

1. Crossover distortion is present in the output waveform.
2. Efficiency is not so high.

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## Class-AB Power Amplifier

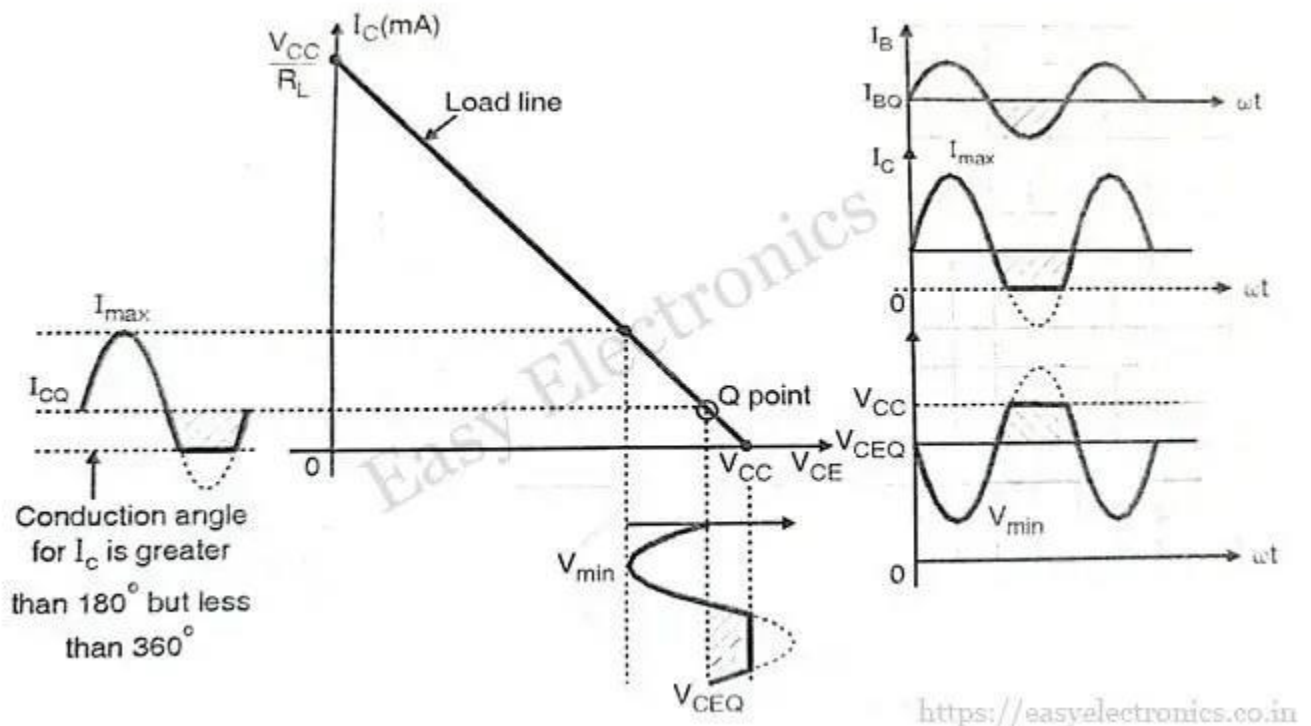
An amplifier is referred to as a class AB amplifier if the output signal is obtained for more than  $180^\circ$  but less than  $360^\circ$  of the ac input signal.



That means the power transistor connected in a class AB power amplifier will conduct for more than  $180^\circ$  but less than  $360^\circ$  of the ac input.

For this, the Q-point is positioned slightly above the cutoff. Thus in absence of an ac input signal, the transistor is “Just conducting”.

## Operation of Class-AB Power Amplifier



- In order to obtain the output signal for more than  $180^\circ$  and less than  $360^\circ$  of the ac input signal, the Q point is positioned slightly above the X-axis but below the mid-point of the load line.
- The transistor conducts for the complete positive half cycle and a part of the negative half cycle of the input signal.
- The output signal is distorted. However, this distortion can be eliminated by using two transistors which can conduct in the alternate half cycles of the input. The class AB operation is helpful in eliminating cross-over distortion.
- The Q point is neither in the middle of the load line like the class A operation nor on the X-axis like class B. It is in between the two. Therefore the name class AB operation. The transistor conducts for more than  $180^\circ$  (class B) but less than  $360^\circ$  (class A), therefore the power dissipation in the transistor is



less than that in class A operation and more than that in the class B operation.

- Hence the efficiency of the class AB power amplifier is higher than class A but less than the class B power amplifier.

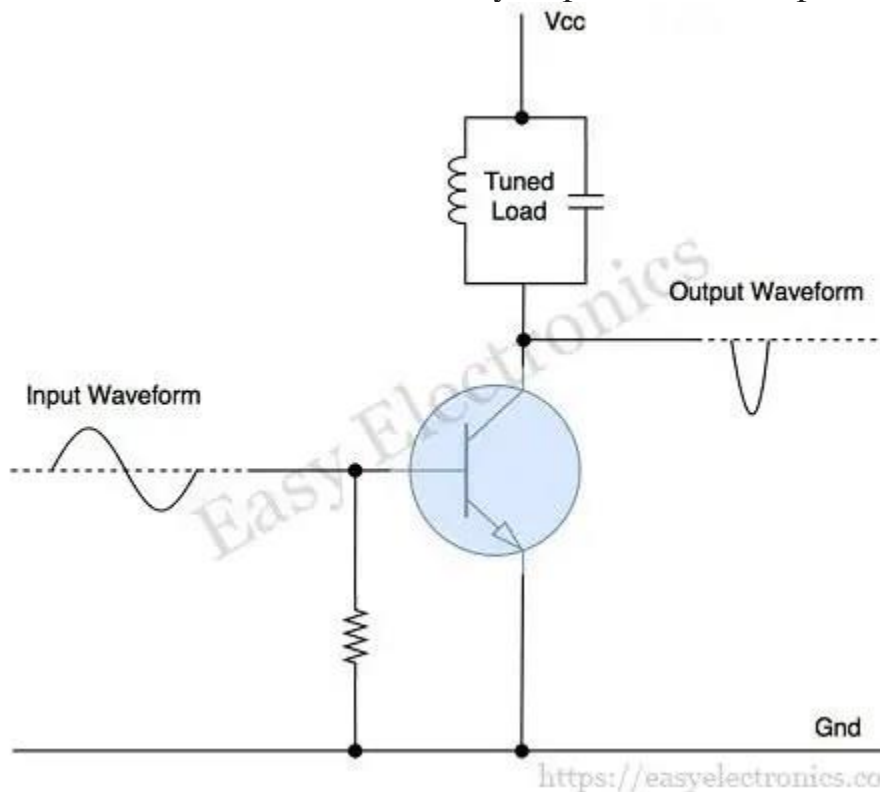
### Advantage of class AB power amplifier

1. The biggest advantage of class AB amplifiers is the elimination of crossover distortion.
2. Hence this configuration is preferred in all audio systems, radio, TV receivers, etc.

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## Class C Power Amplifier

- An amplifier is referred to as a class C power amplifier if its output is obtained for less than a half-cycle period of the input ac signal.

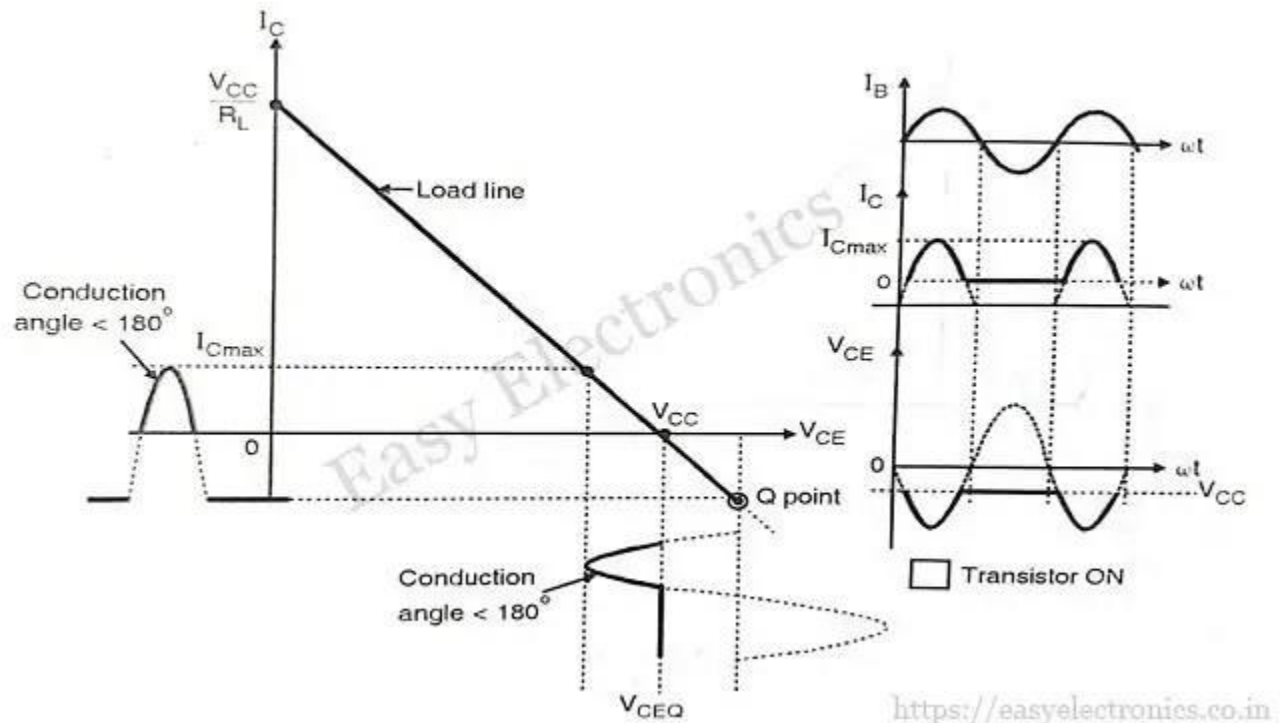


- Thus the power transistor in a class C configuration will conduct for a duration that is less than the period of a half cycle of the ac input signal.



- For this, the operating point is adjusted to be below the X-axis as shown in Figure below. Thus the transistor is biased below the cut-off.

## Operation of Class C Power Amplifier



- Due to the biasing below the cut-off, the transistor can remain in the active region for less than a half-cycle period. Thus collector current flows for less than  $180^\circ$ . In other words, the conduction angle is less than  $180^\circ$ .
- Due to the reduced conduction angle, the output signal is heavily distorted. The percent distortion is higher than that for a class B power amplifier. Therefore class C power amplifiers are not used as A.F. power amplifiers.
- The efficiency of class C amplifiers is very high. In fact, it is the highest of all the power amplifiers.
- **Typically the efficiency is above 95%.**

### Advantage of class C power amplifier

1. Very high efficiency (higher than 95%).
2. Low power loss in the power transistors.

## The disadvantage of class C power amplifier

1. The output waveform can be distorted.

## Applications of class C power amplifier

- Class C amplifiers generally use a tuned circuit as a load. Such amplifiers are called class – C tuned amplifiers.
- These amplifiers are used as the collector modulator to produce the amplitude-modulated signal.

## comparison of power amplifiers

Sr. No	Parameter	Class A	Class B	Class C	Class AB
1.	Conduction angle of collector current	360° or full-cycle	180° or half cycle	Less than 180°	Between 180° and 360°
2.	Position of Q-point on the load line	At the center	On the X-axis	Below the X-axis	Above the X-axis but below the midpoint
3.	Distortion in output voltage	No distortion	More than class-A (Crossover)	More than A, B, and AB	Low
4.	Efficiency	Lowest 25% to 50%	Higher (78.5%)	Very High(95%)	Between 50 and 78.5%
5.	Power dissipation in transistors	Very high	Low	Very low	Moderate