

# POWER AMPLIFIERS

- Power amplifiers amplify the power level of the signal.
- The power of the input signal is increased to a level high enough to drive loads of output devices like speakers, headphones, RF transmitters etc.

## CLASSIFICATIONS

### Based on their frequencies.

- Audio Power Amplifiers – Audio frequency range 20 Hz to 20 KHz. Also Known as Small Signal Power Amplifiers.
- Radio Power Amplifiers – Power level up to 3 Hz to 300 Hz. Also termed as Tuned Amplifiers and also known as Large Signal Power Amplifiers.

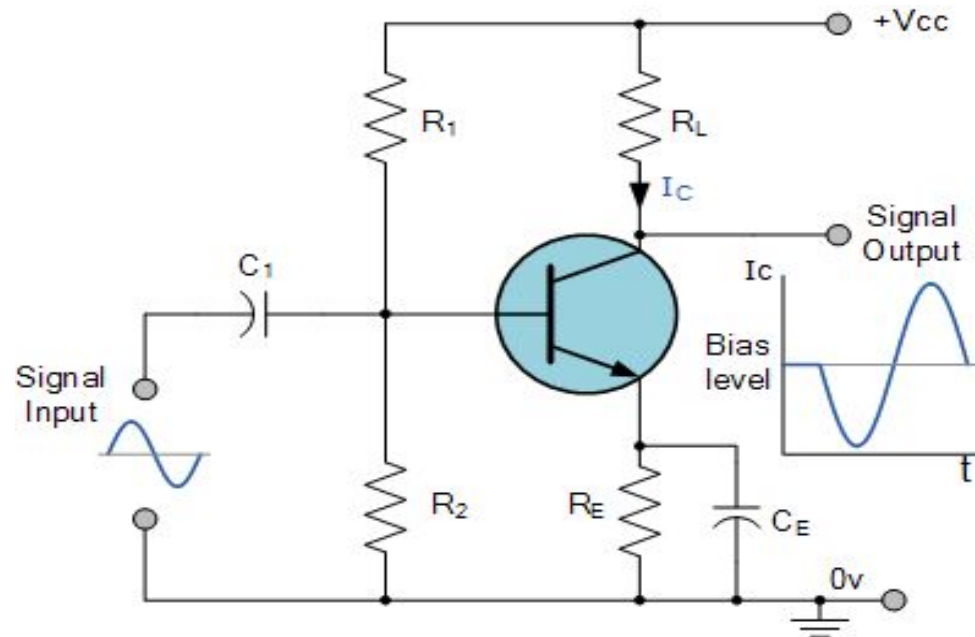
### Mode of operation

The portion of the input cycle during which collector current flows, the power amplifiers may be classified as follows

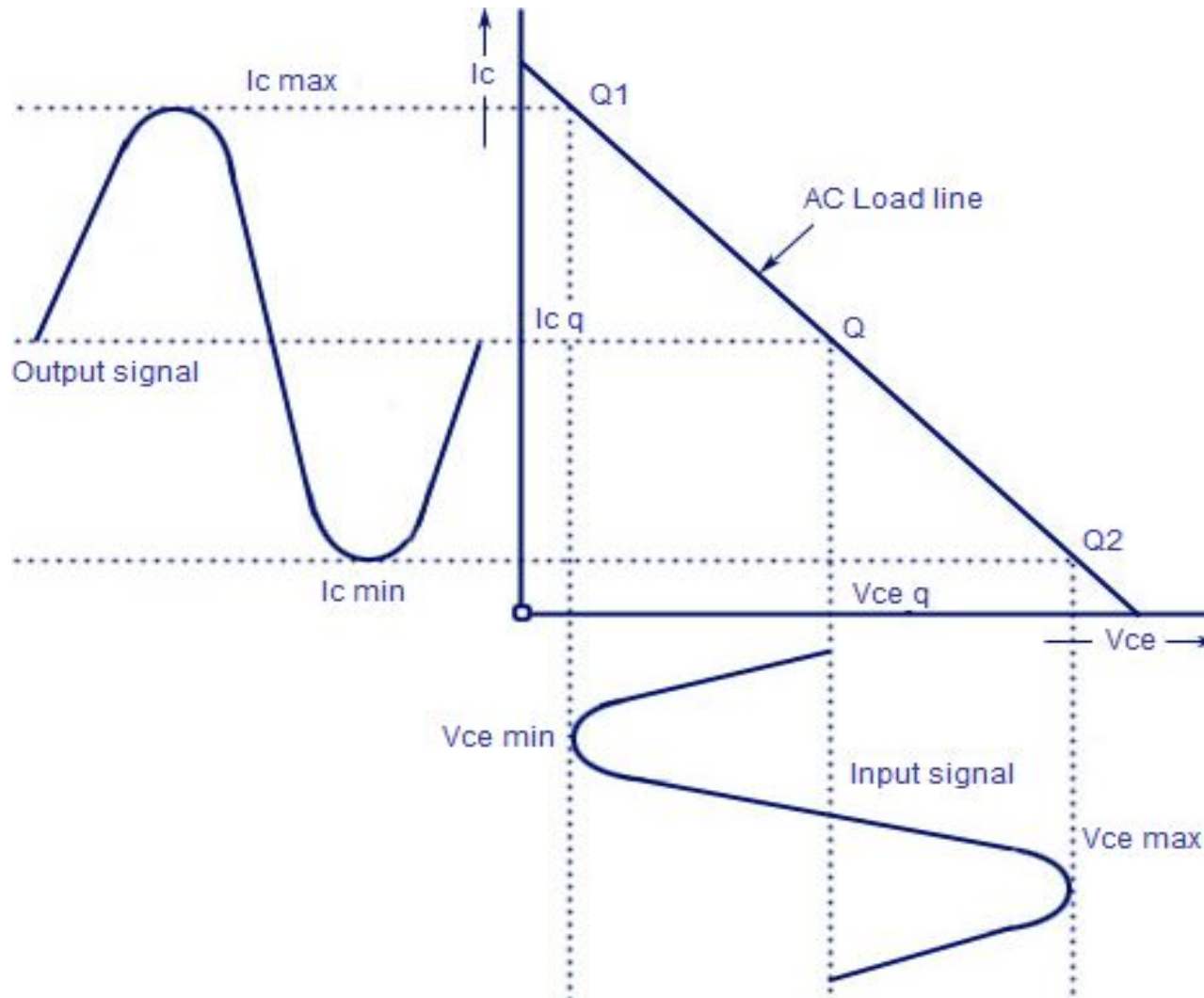
- **Class A Power amplifier** - When the collector current flows at all times during full cycle of the input signal.
- **Class B Power amplifier** - When the collector current flows at only during half cycle of the input signal.
- **Class C Power amplifier** - When the collector current flows for less than half cycle of the input signal.

# CLASS - A AMPLIFIER

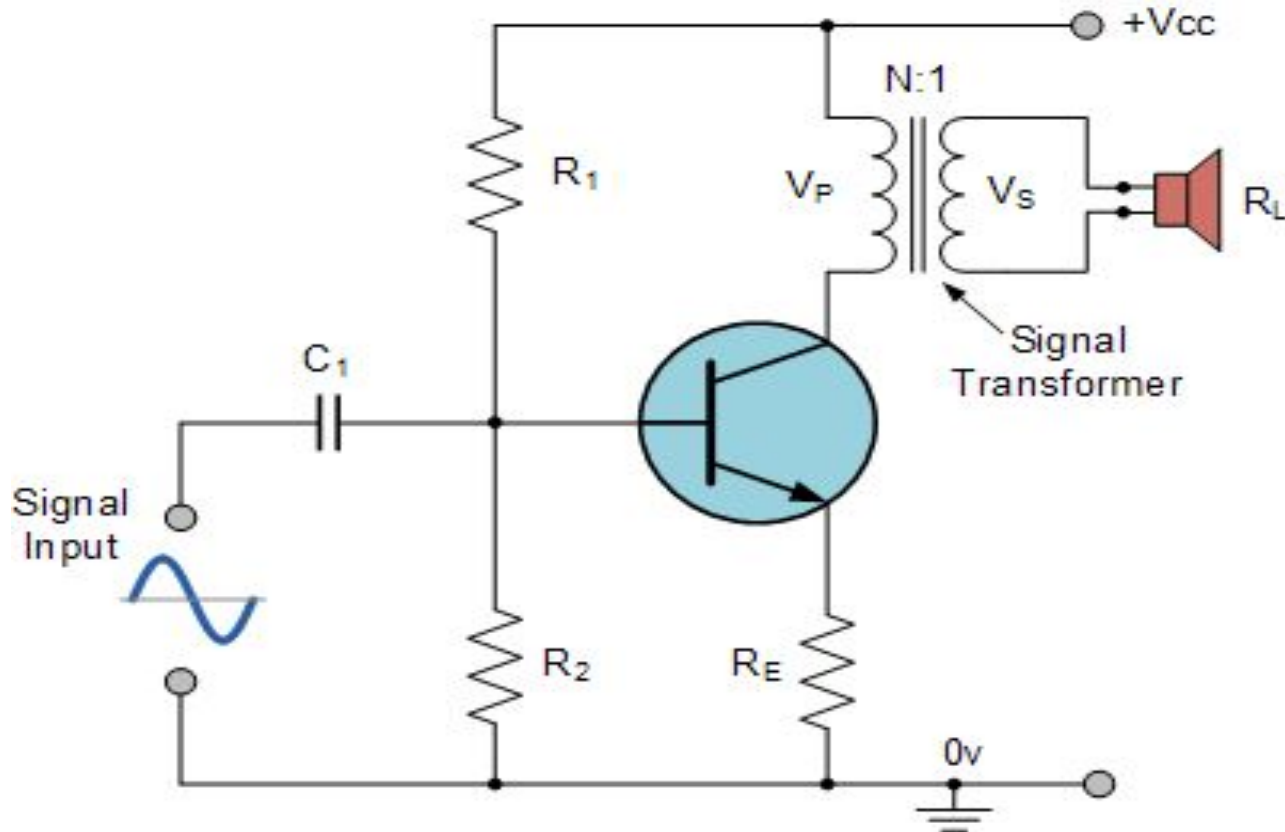
- . Commonly used type of power amplifier configuration is the **Class A Amplifier**.
- It uses a single switching transistor in the standard common emitter circuit configuration.
- The transistor is always biased “ON” so that it conducts during one complete cycle of the input signal waveform producing minimum distortion and maximum amplitude of the output signal.



# CHARACTERISTIC CURVES- CLASS A POWER AMPLIFIER

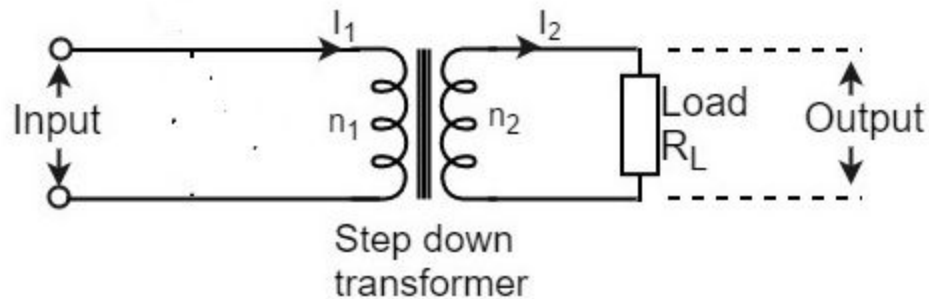


# TRANSFORMER COUPLED CLASS – A AMPLIFIER



**TRANSFORMER COUPLED CLASS - A AMPLIFIER**

- $R_1$  and  $R_2$  -potential divider. Resistor  $R_e$  provides stabilization,  $R_e$  to prevent A.C. voltage.
- The high impedance primary of the transformer is connected to the high impedance collector circuit. The low impedance secondary is connected to the load (generally loud speaker). Transformer used in the collector circuit is for impedance matching.
- $R_L$  is the load connected in the secondary of a transformer.
- Number of turns in the primary are  $n_1$  and the secondary are  $n_2$ .
- $V_1$  and  $V_2$  - primary and secondary voltages.  $I_1$  and  $I_2$  be the primary and secondary currents respectively.



- As the Collector current,  $I_c$  is reduced to below the quiescent Q-point set up by the base bias voltage, due to variations in the base current, the magnetic flux in the transformer core collapses causing an induced EMF in the transformer primary windings.
- This causes an instantaneous collector voltage to rise to a value of twice the supply voltage  $2V_{cc}$  giving a maximum collector current of twice  $I_c$  when the Collector voltage is at its minimum.
- The efficiency of this type of Class A amplifier configuration can be calculated as follow

$$\eta_{(\max)} = \frac{P_{ac}}{P_{dc}} \times 100\%$$

- R.M.S. Collector voltage is given as

$$V_{CE} = \frac{V_{C(\max)} - V_{C(\min)}}{2\sqrt{2}} = \frac{2V_{CC} - 0}{2\sqrt{2}}$$

- R.M.S. Collector current is given as

$$I_{CE} = \frac{I_{C(\max)} - I_{C(\min)}}{2\sqrt{2}} = \frac{2I_C - 0}{2\sqrt{2}}$$

- The r.m.s. Power delivered to the load ( $P_{ac}$ ) is therefore given as

$$P_{ac} = V_{CE} \times I_{CE} = \frac{2V_{CC}}{2\sqrt{2}} \times \frac{2I_C}{2\sqrt{2}} = \frac{2V_{CC} 2I_C}{8}$$

- The average power drawn from the supply ( $P_{dc}$ ) is given by

$$P_{dc} = V_{CC} \times I_C$$

- Efficiency of a Transformer-coupled Class A amplifier is given as

$$\eta_{(max)} = \frac{P_{ac}}{P_{dc}} = \frac{2V_{CC} 2I_C}{8V_{CC} I_C} \times 100\%$$

- An output transformer improves the efficiency of the amplifier by matching the impedance of the load with that of the amplifiers output impedance.
- By using an output or signal transformer with a suitable turns ratio, class-A amplifier efficiencies reaching 50%.

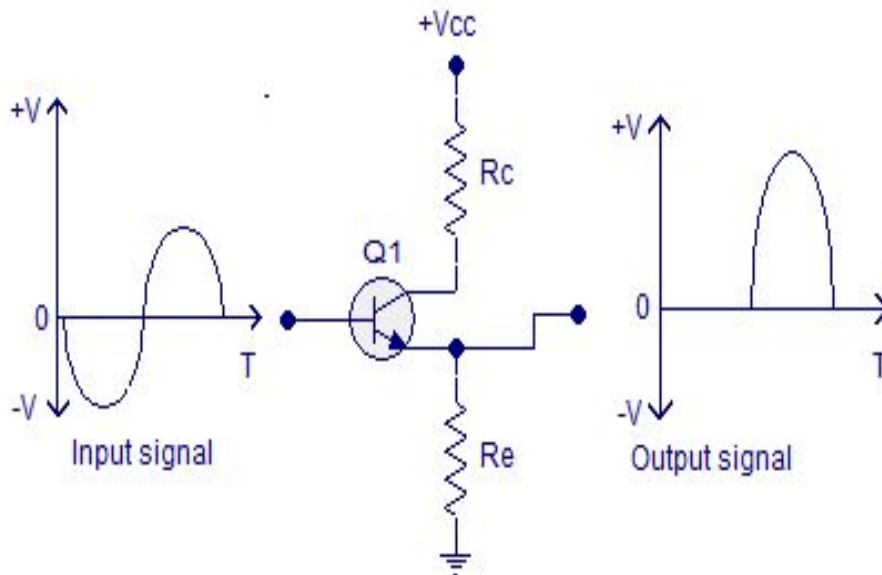
### **Advantages**

- Provides good DC isolation as there is no physical connection between amplifier output and load

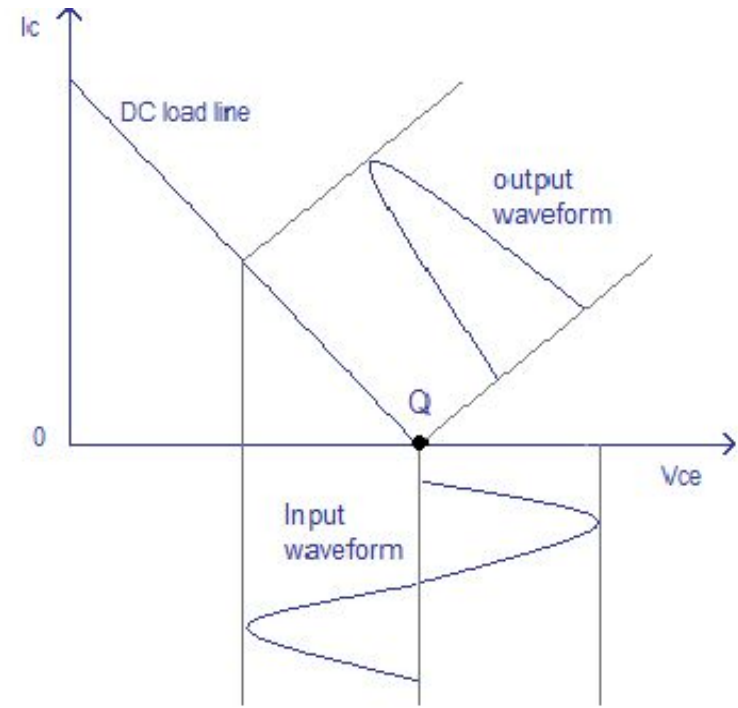
**Disadvantage** - Additional cost and size of the audio transformer required.

# CLASS B POWER AMPLIFIER

- It is a type of power amplifier where the active device (transistor) conducts only for one half cycle of the input signal. The conduction angle is  $180^\circ$  for a Class B amplifier.
- The active device is switched off for half the input cycle, the active device dissipates less power and hence the efficiency is improved.
- Theoretical maximum efficiency of Class B power amplifier is 78.5%.



**Single ended Class B amplifier**

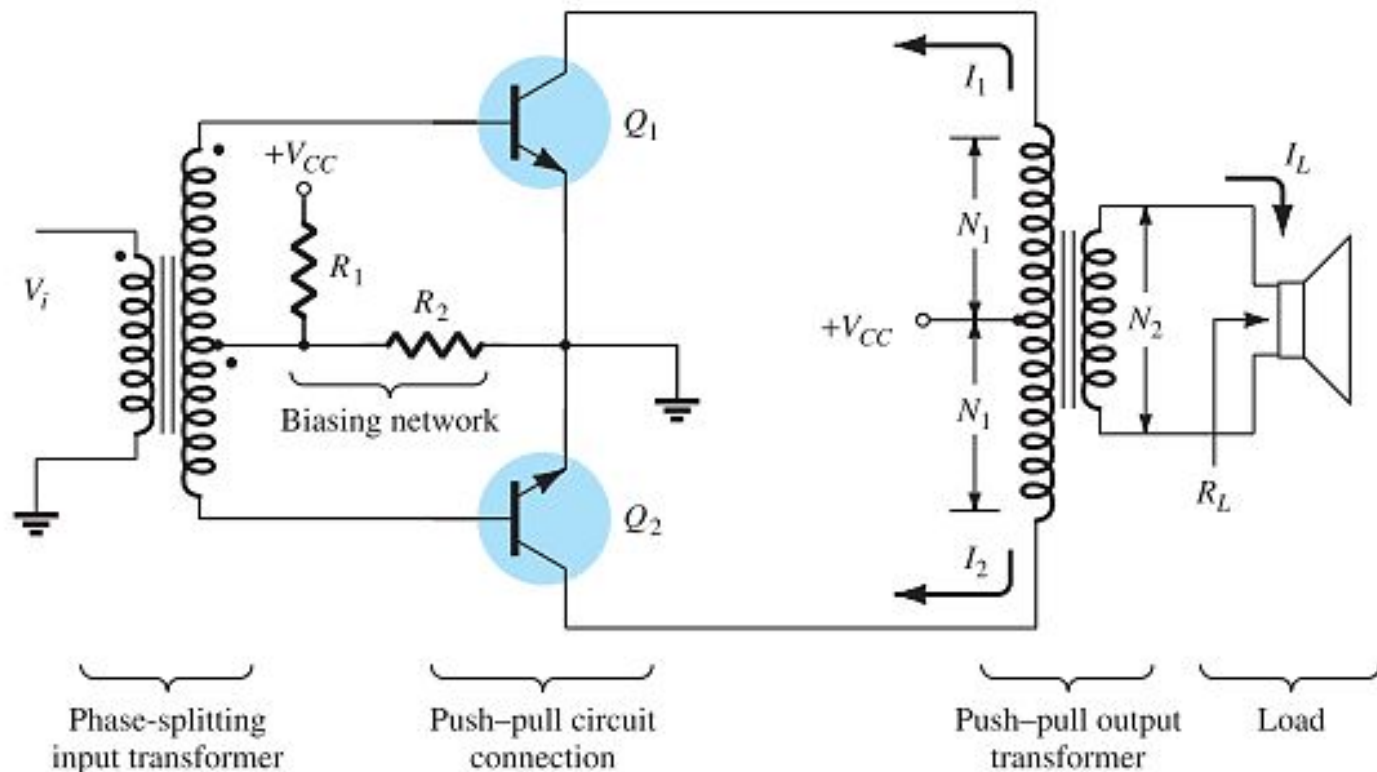


**Class B – Output characteristics**



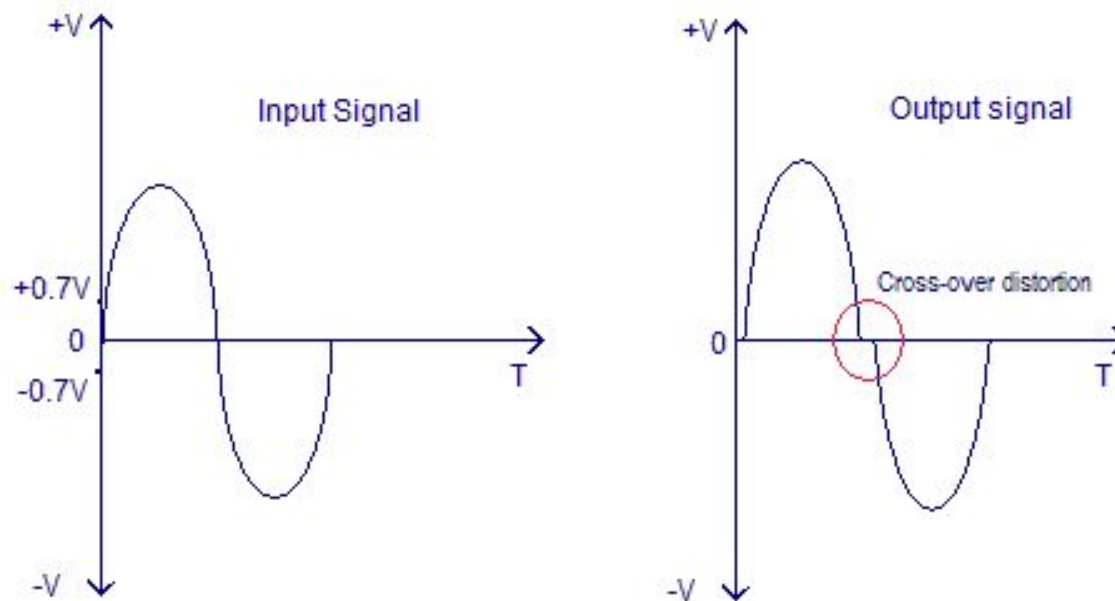
# CLASS B PUSH-PULL AMPLIFIER

- In practical Class B amplifier a pair of active devices (transistors) arranged in push-pull mode where one transistor conducts one half cycle and the other transistor conducts the other half cycle.
- The output from both transistors are then combined together to get a scaled replica of the input.



# CROSS OVER DISTORTION

- The regions of the input signal where the amplitude is less than  $0.7V$  will be missing in the output signal and it is called cross over distortion.



## **ADVANTAGES OF CLASS B AMPLIFIER**

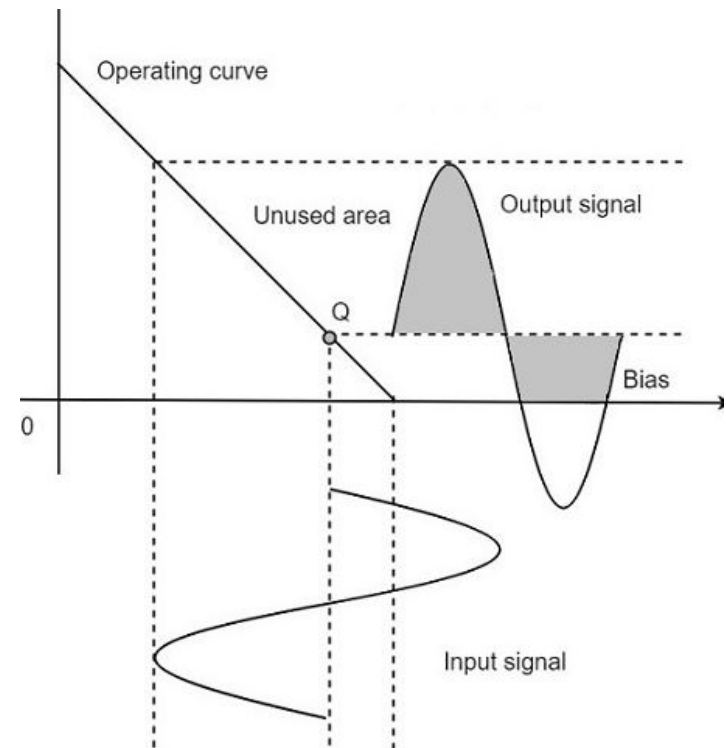
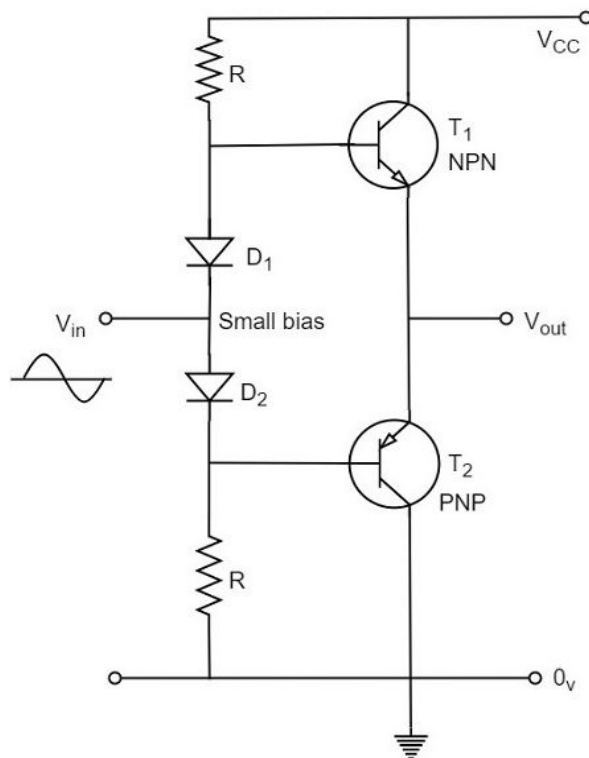
- High efficiency when compared to the Class A configurations.
- Push-pull mechanism avoids even harmonics.
- No DC components in the output (in ideal case).

## **DISADVANTAGES OF CLASS B AMPLIFIER.**

- The major disadvantage is the cross-over distortion. Coupling transformers increases the cost and size.
- It is difficult to find ideal transformers.
- Transformer coupling causes hum in the output and also affects the low frequency response.
- Transformer coupling is not practical in case of huge loads.

# CLASS AB POWER AMPLIFIER

- class AB is a combination of class A and class B type of amplifiers. As class A has the problem of low efficiency and class B has distortion problem, this class AB is emerged to eliminate these two problems, by utilizing the advantages of both the classes.
- The cross over distortion is the problem that occurs when both the transistors are OFF at the same instant, during the transition period. In order to eliminate this, the condition has to be chosen for more than one half cycle. Hence, the other transistor gets into conduction, before the operating transistor switches to cut off state.



### **Advantages of Class AB power amplifier.**

No cross over distortion.

No need for the bulky coupling transformers.

No hum in the output.

### **Disadvantages of Class AB power amplifier.**

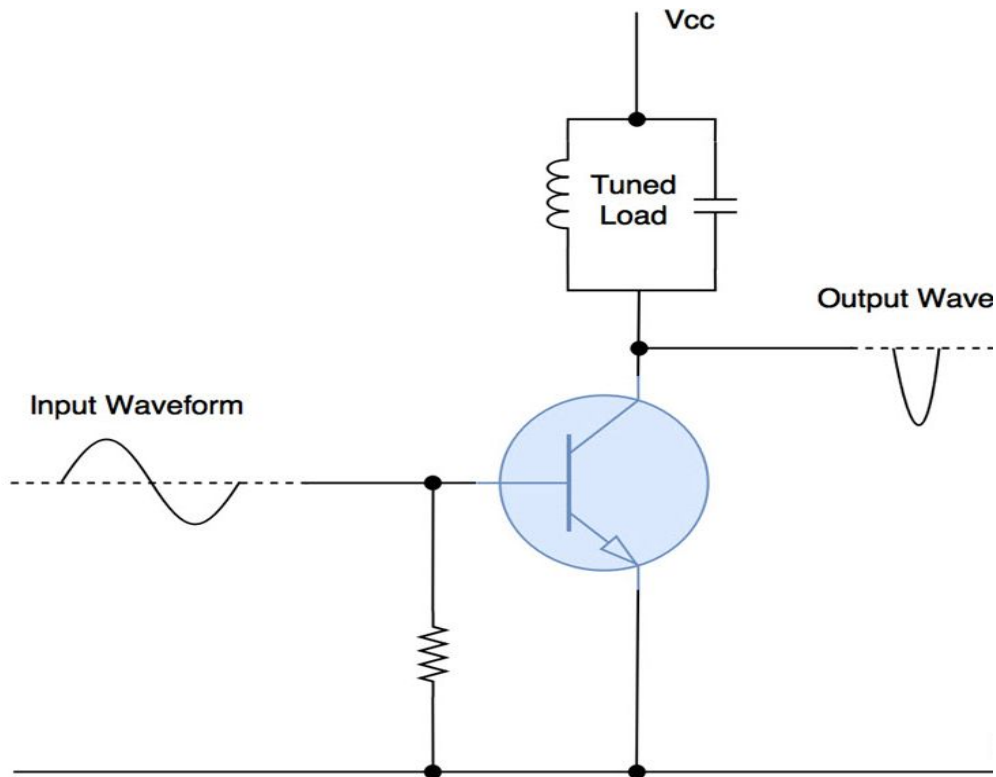
Efficiency is slightly less when compared to Class B configuration.

There will be some DC components in the output as the load is directly coupled.

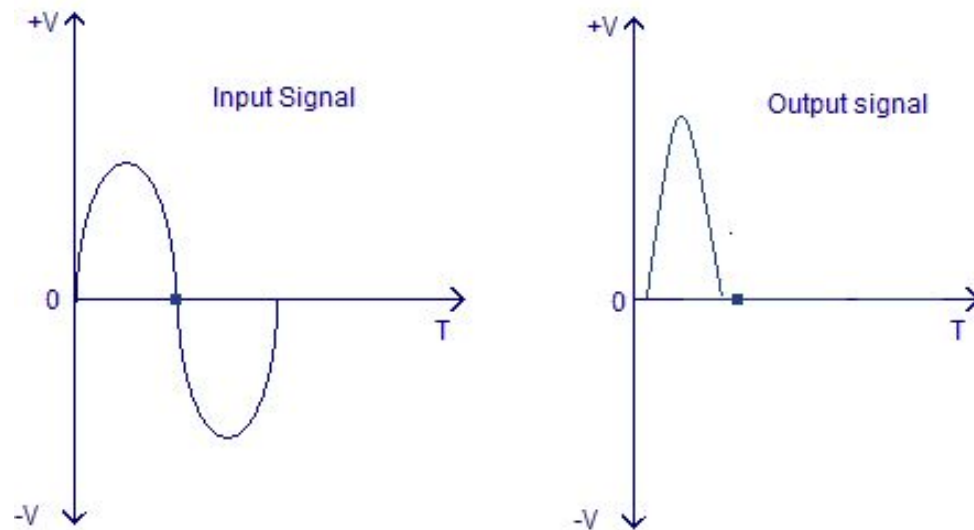
Capacitive coupling can eliminate DC components but it is not practical in case of heavy loads.

# CLASS C POWER AMPLIFIER

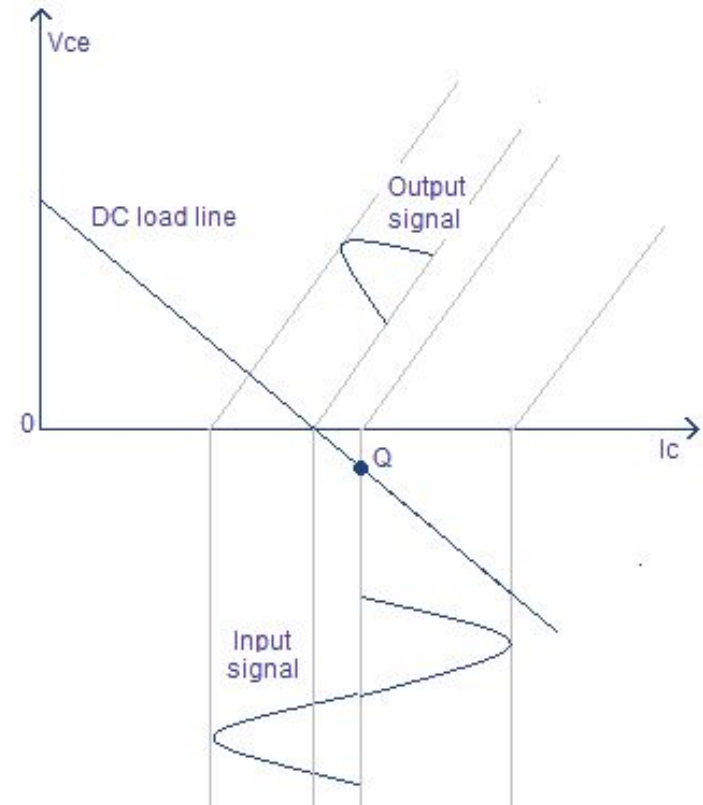
- Class C power amplifier is a type of amplifier where the active element (transistor) conduct for less than one half cycle of the input signal.
- Less than one half cycle means the conduction angle is less than  $180^\circ$  and its typical value is  $80^\circ$  to  $120^\circ$ . The reduced conduction angle improves the efficiency to a great extent but causes a lot of distortion.
- Theoretical maximum efficiency of a Class C amplifier is around 90%.



# CLASS C POWER AMPLIFIER



**Input and output waveforms - Class C power amplifier**



**Output Characteristics of Class C Power Amplifier**

# **CLASS C POWER AMPLIFIER.**

## **Advantages**

- High efficiency.
- Excellent in RF applications.
- Lowest physical size for a given power output.

## **Disadvantages**

- Lowest linearity.
- Not suitable in audio applications.
- Creates a lot of RF interference.
- It is difficult to obtain ideal inductors and coupling transformers.
- Reduced dynamic range.

## **Applications**

- RF oscillators.
- RF amplifier.
- FM transmitters.
- Booster amplifiers.
- High frequency repeaters.
- Tuned amplifiers etc.