POWER AMPLIFIERS

The function of a power amplifier is to raise the power level of input signal. It is required to deliver a large amount of power and has to handle large current.Power amplifiers amplify the power level of the signal.

Applications are related to radio frequencies that employ Radio Power amplifiers.

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.

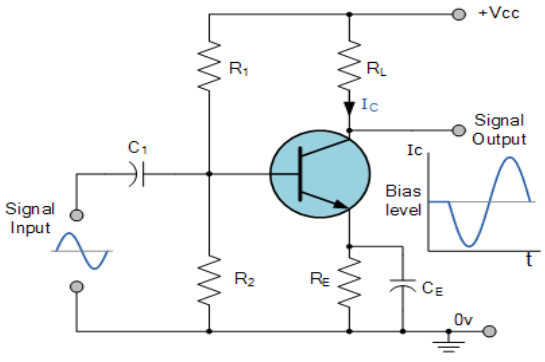
Mode of operation

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.



Advantages –

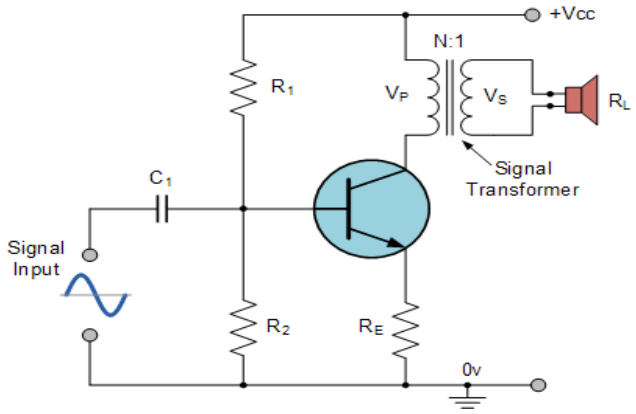
- The current flows for complete input cycle

- It can amplify small signals
- The output is same as input
- No distortion is present

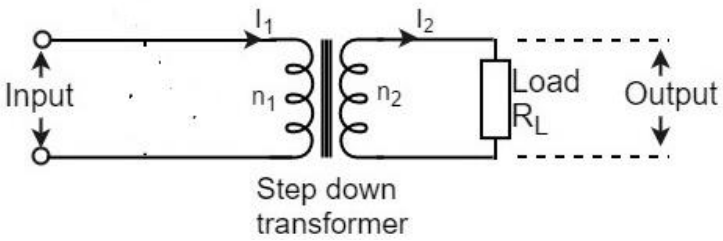
Disadvantages −

- Low power output
- Low collector efficiency

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, *Ic* 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 2*Vcc* giving a maximum collector current of twice *Ic* when the Collector voltage

is at its minimum. The efficiency of this type of Class A amplifier configuration can be calculated as follows.

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 (Pac) 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 (Pdc) 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 40%..

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° 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%.

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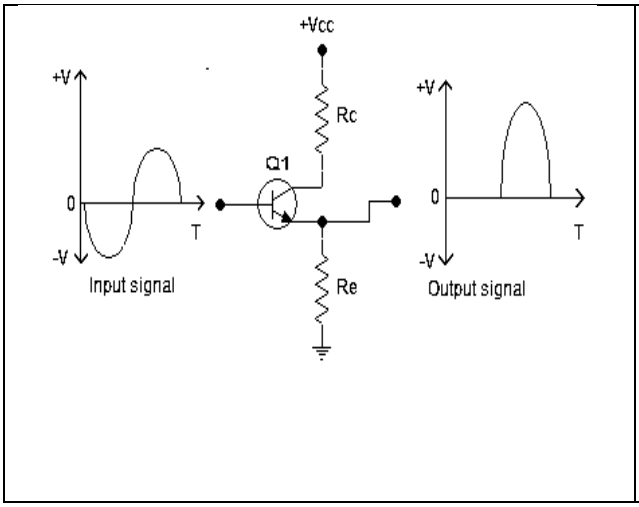
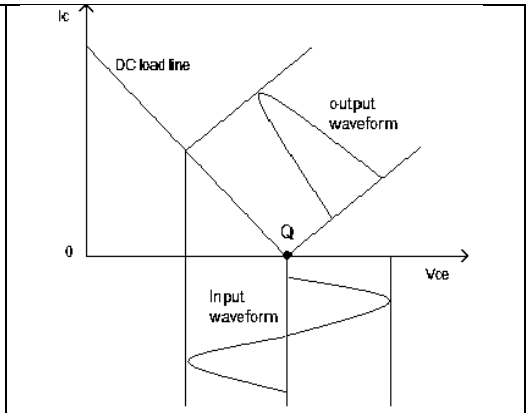




Class B – Output characteristics

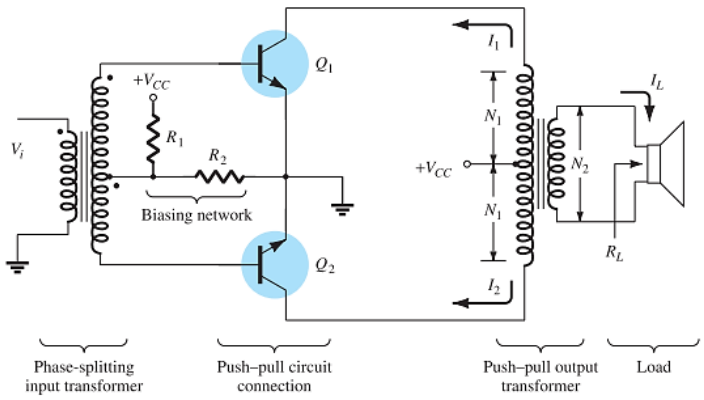
Advantages

- 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 B PUSH-PULL AMPLIFIER



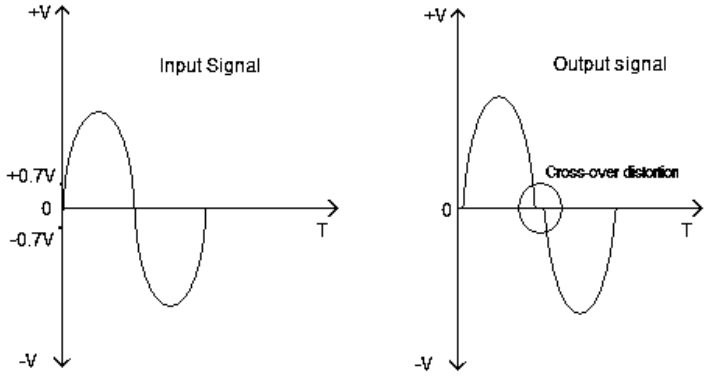
Operation

The circuit of class B push-pull amplifier shown in the above figure clears that both the transformers are center-tapped. When no signal is applied at the input, the transistors

Q_1 and Q_2 are in cut off condition and hence no collector currents flow. As no current is drawn from V_{CC}, no power is wasted.

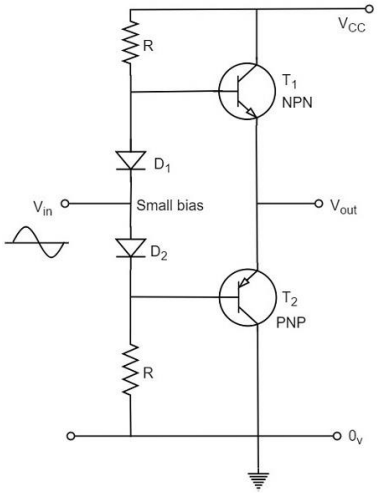
When input signal is given, it is applied to the input transformer which splits the signal into two signals that are 180^o out of phase with each other. These two signals are given to the two identical transistors Q_1 and Q_2. For the positive half cycle, the base of the transistor Q_1 becomes positive and collector current flows. At the same time, the transistor Q_2 has negative half cycle, which throws the transistor Q_2 into cutoff condition and hence no collector current flows.

CROSS OVER DISTORTION



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. Each of the push-pull transistors is conducting for slightly more than the half cycle of conduction in class B, but much less than the full cycle of conduction of class A. The small bias voltage given using diodes D_1 and D_2, helps the operating point to be above the cut off point.



Advantages of Class AB power amplifier.

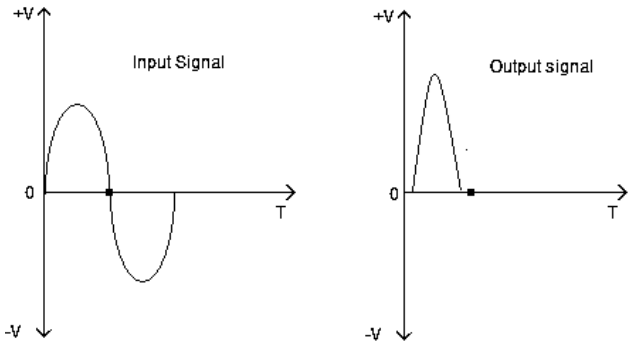
- No cross over distortion.
- No need for the bulky coupling transformers.
- No hum in the output.

Disadvantages of Class AB power amplifier.

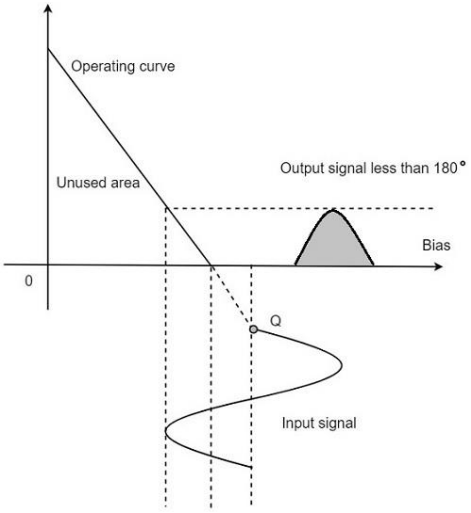
- Efficiency is slightly less when compared to Class B configuration.
- There will be some DC components in the output as the load is directly coupled.
- Capacitive coupling can eliminate DC components but it is not practical in case of heavy loads.

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° and its typical value is 80° to 120°. The reduced conduction angle improves the efficiency to a great extend but causes a lot of distortion.
- Theoretical maximum efficiency of a Class C amplifier is around 90%.



Input and output waveforms - Class C power amplifier



Output Characteristics of 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.