5.3.Class C Power Amplifier

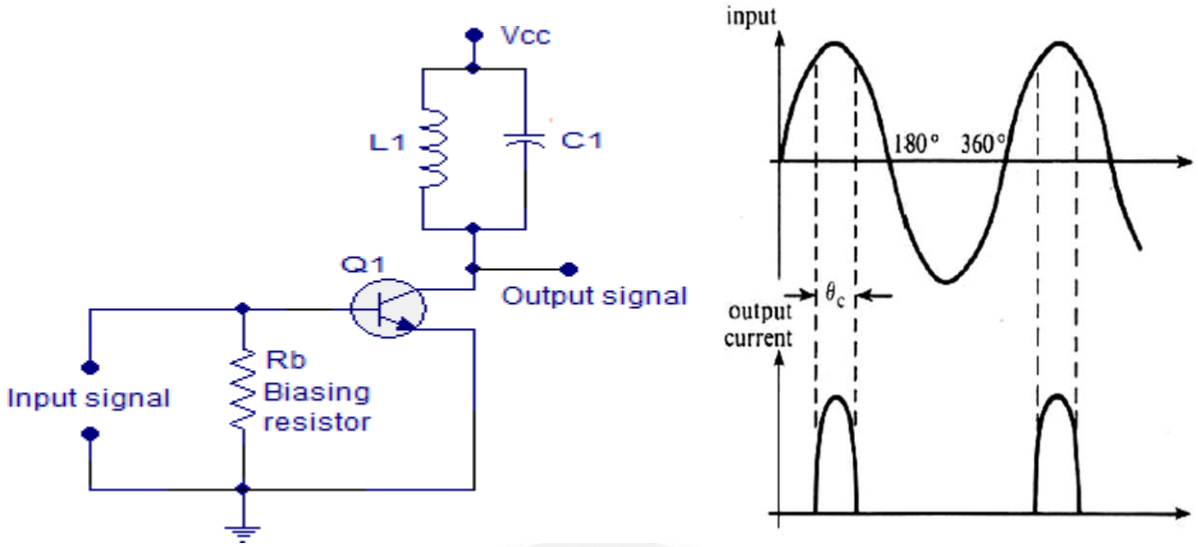


Fig 5.3.1 Class C amplifier

(Source: Electronic Circuit Analysis- K.LalKishore, Page-205)

- When the collector current flows for less than half cycle of the input signal, the power amplifier is known as **class C power amplifier**.
- The efficiency of class C amplifier is high while linearity is poor. The conduction angle for class C is less than 180º.
- It is generally around 90º, which means the transistor remains idle for more than half of the input signal. So, the output current will be delivered for less time compared to the application of input signal.
- The following figure shows the operating point and output of a class C amplifier.

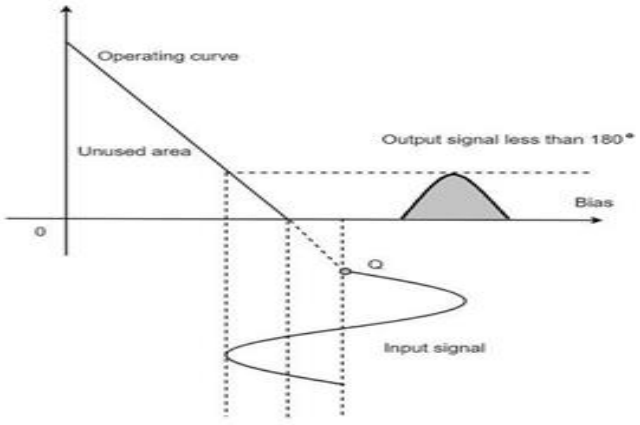


Fig 5.3.2 Class C amplifier wave forms

(Source: Electronic Circuit Analysis- K.LalKishore, Page-210)

- This kind of biasing gives a much improved efficiency of around 80% to the amplifier, but introduces heavy distortion in the output signal.
- Using the class C amplifier, the pulses produced at its output can be converted to complete sine wave of a particular frequency by using LC circuits in its collector circuit.
- The types of amplifiers that we have discussed so far cannot work effectively at radio frequencies, even though they are good at audio frequencies.
- Also, the gain of these amplifiers is such that it will not vary according to the frequency of the signal, over a wide range.
- This allows the amplification of the signal equally well over a range of frequencies and does not permit the selection of particular desired frequency while rejecting the other frequencies.
- When the input signal is applied the tuned circuit starts resonating at the frequency of the input signal. Transistor produces a series of current pulses based on the input.
- By selecting Proper L1, C1 resonance can be achieved. This resonance frequency is extracted by the tuned load at the output. Harmonics can be eliminated by adding filters to the circuit shown in figure .
- The biasing resistance pulls the q point below Cut off region. Hence the transistor conducts only after the input amplitude is greater than the base emitter voltage.

Advantages:

- Less Physical size.
- Used in RF applications.
- High Efficiency (higher than 95%)
- Low power loss in power transistors

Disadvantage:

- Creates lot of RF Interference.
- Selection of ideal Inductors is problem.
- Not suitable in Audio applications.

Applications:

- Tuned amplifiers**,** RF amplifiers, oscillators, Booster amplifiers, and High Frequency repeaters.

Class AB Power Amplifier

- As the name implies, 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 ofboth 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. This is achieved only by using class AB configuration, as shown in the following circuit diagram.

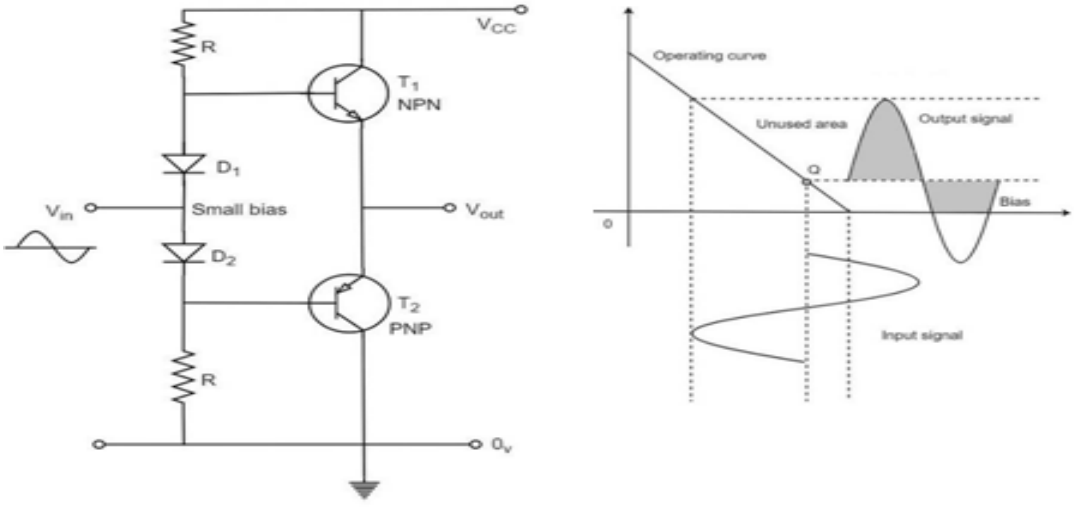


Fig 5.3.3 Class AB amplifier circuit and waveforms

(Source: Electronic Circuit Analysis- K.LalKishore, Page-212)

- Therefore, in class AB amplifier design, 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 conduction angle of class AB amplifier is somewhere between 180^o to 360^o depending upon the operating point selected. This is understood with the help of above figure.
- The small bias voltage given using diodes D_1 and D_2, as shown in the above figure, helps the operating point to be above the cutoff point. Hence the output waveform of class AB results as seen in the above figure. The crossover distortion created by class B is overcome by this class AB, as well the inefficiencies of class A and B don't affect the circuit.
- So, the class AB is a good compromise between class A and class B in terms of efficiency and linearity having the efficiency reaching about 50% to 60%. The class A, B and AB amplifiers are called as **linear amplifiers** because the output signal amplitude and phase are linearly related to the input signal amplitude and phase.

Distortions in amplifiers:

- If the output of an amplifier is not a complete sine wave, then it is distortion. It can be analysed by using Fourier analysis.in this method any distorted periodic waveform can be broken down into different frequencycomponents. These components are harmonics of the fundamentalfrequency.Harmonics are integer multiples of a fundamentalfrequency (F). For example, 1st harmonic is 1 x F kHz.

TYPES OF DISTORTION

Amplitude or Non Linear distortion:

- Due to the non-linearity of transistor (nonlinear dynamic characteristics of transistor) the output is different from the input.

This kind of distortion is known as amplitude distortion or harmonic or non-linear distortion.

Harmonic distortion %D = (A_n/A_1)*100

Frequency Distortion:

- When different frequency components of the input signal are amplified differently frequency amplification takes place.This is mainly due to the internal capacitance effect of the transistors.

Delay or Phase shift distortion:

- If the phase shift introduced by amplifier is not proportional to the frequency then phase distortion takes place.

THERMAL STABILITY:

- Average power of a transistor depends on the collector base junction. It is around 150 to 200º. If the temperature exceeds this limit then transistor get physically damaged.Performance of transistor depends on the ability of transistor to dissipate the heat generated in base collector junction. This can be achieved by

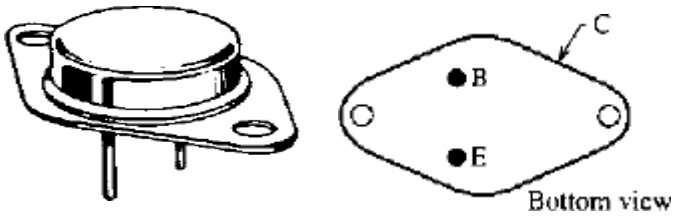
✓ Operating the transistor in safe region (proper biasing).

✓ By effectively removing the heat to the surrounding air quickly.

✓ To remove the heat we use Heat sinks. The concept of Heat Sink is to keep the junction of the power device (transistor) to below a maximum operating temperature.

Heat sinks:

- All power devices come in complete package where there is a metal contact which connects the external heat sink to the metal surface of the device.(Usually to the collector terminal)



- Fig5.3.4 :Heat Sink(a) Top view (b) Bottom view

(Source: Electronic Circuit Analysis- K.LalKishore, Page-216)

- In Fig5.3.4 B – Base , E – Emitter & C – Collector terminal. From the above figure 14(b) we can notice that the Collector is connected to the metal top (chasis or heat sink) which has more area than Base & Emitter. So the heat generated at the output junction(collector junction) is dissipated fast. If more number of devices are connected to the same sink the INSULATORS are needed to shield individually. Usually Nylon material is used to ensure.

CLASS D AMPLIFIERS:

- Class D type is designed to work with pulse or digital input signals. The Input V_{in} is compared with saw tooth wave (known as chopping wave) and accordingly a pulse waveform is generated which is fed to the amplifier.

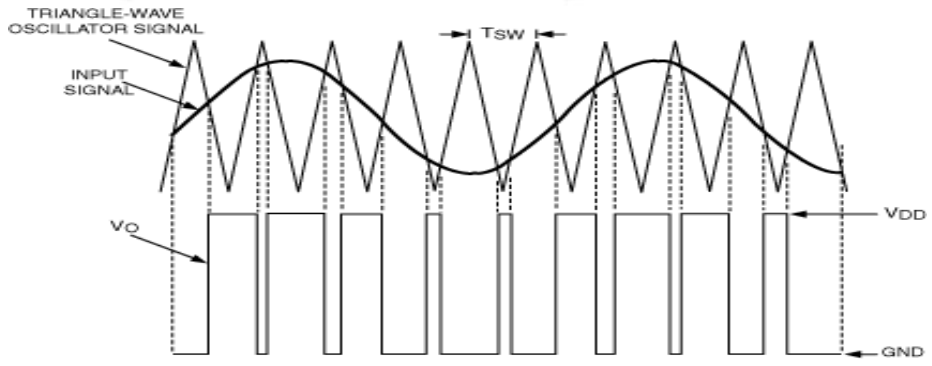


Fig 5.3.4: Class D operation

(Source: Electronic Circuit Analysis- K.LalKishore, Page-218)

- The circuit diagram of class D amplifier is shown in Figure .Input is applied to the non-inverting terminal of the comparator and the saw tooth wave is applied to the inverting terminal.

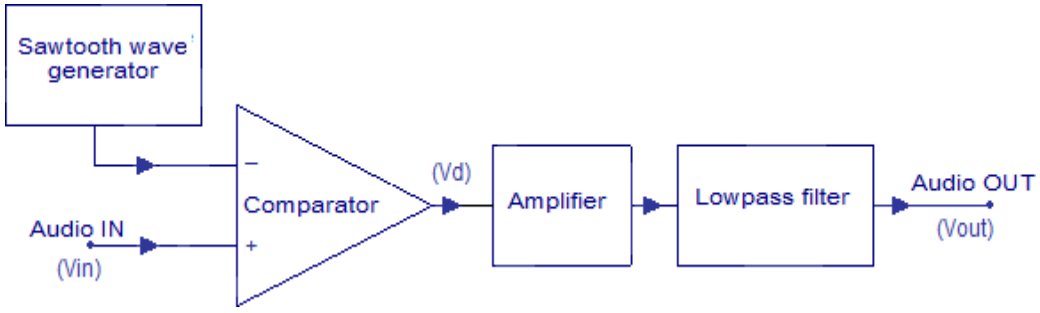


Fig 5.3.5: Class D amplifier

(Source: Electronic Circuit Analysis- K.LalKishore, Page-217)

- Based on this the comparator produces an output pulse width modulated waveform and this PWM wave is amplified by the amplifier as shown in figure . Transistor in the amplifier circuit just acts as a switch and hence the power loss is very less. Low pass filter converts the pulse wave back into sinusoidal signal.At the output thus we have sinusoidal signal.

Efficiency:

- Transistor operates in saturation region when turned on .So V_{ce} is small. This is the reason for class D amplifiers have very high efficiency (Around90%).

Advantages:

- High efficiency
- Possible to amplify the digital signals and analog signals as well.