

LARGE SIGNAL AMPLIFIERS

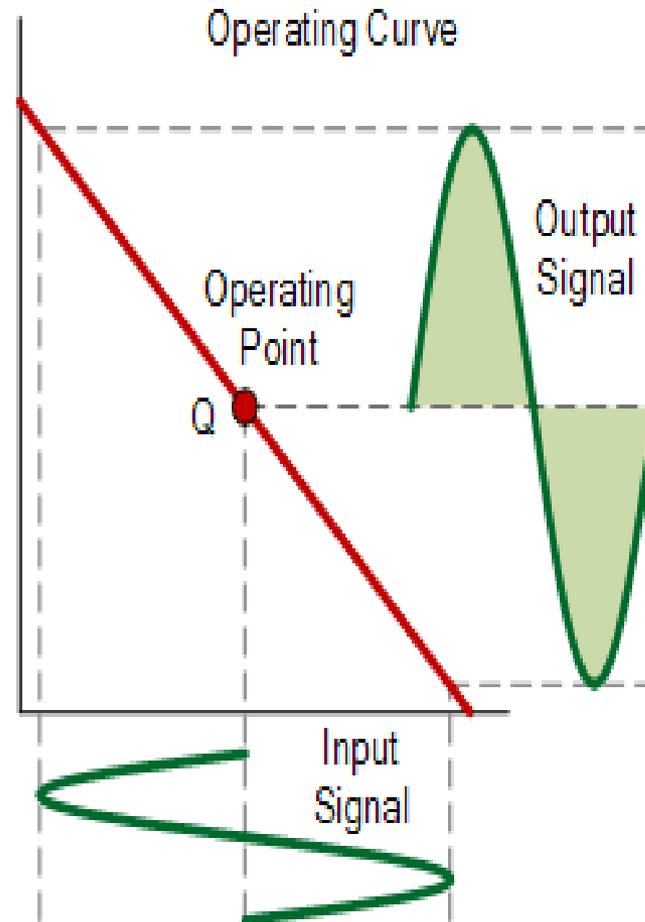
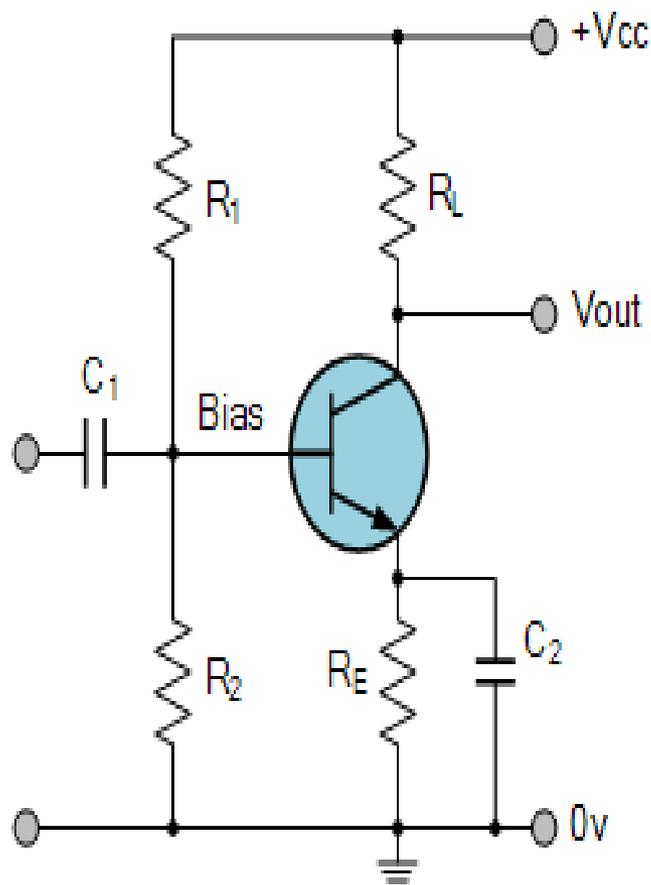
- One method used to distinguish the electrical characteristics of different types of amplifiers is by “class”, and as such amplifiers are classified according to their circuit configuration and method of operation.
- Then **Amplifier Classes** is the term used to differentiate between the different amplifier types.

- Amplifier Classes represent the amount of the output signal which varies within the amplifier circuit over one cycle of operation when excited by a sinusoidal input signal.
- The classification of amplifiers range from entirely linear operation (for use in high-fidelity signal amplification) with very low efficiency, to entirely non-linear (where a faithful signal reproduction is not so important) operation but with a much higher efficiency, while others are a compromise between the two.

- Amplifier classes are mainly lumped into two basic groups.
- The first are the classically controlled conduction angle amplifiers forming the more common amplifier classes of A, B, AB and C, which are defined by the length of their conduction state over some portion of the output waveform, such that the output stage transistor operation lies somewhere between being “fully-ON” and “fully-OFF”.

- The second set of amplifiers are the newer so-called “switching” amplifier classes of D, E, F, G, S, T etc, which use digital circuits and pulse width modulation (PWM) to constantly switch the signal between “fully-ON” and “fully-OFF” driving the output hard into the transistors saturation and cut-off regions.

Class A Amplifier



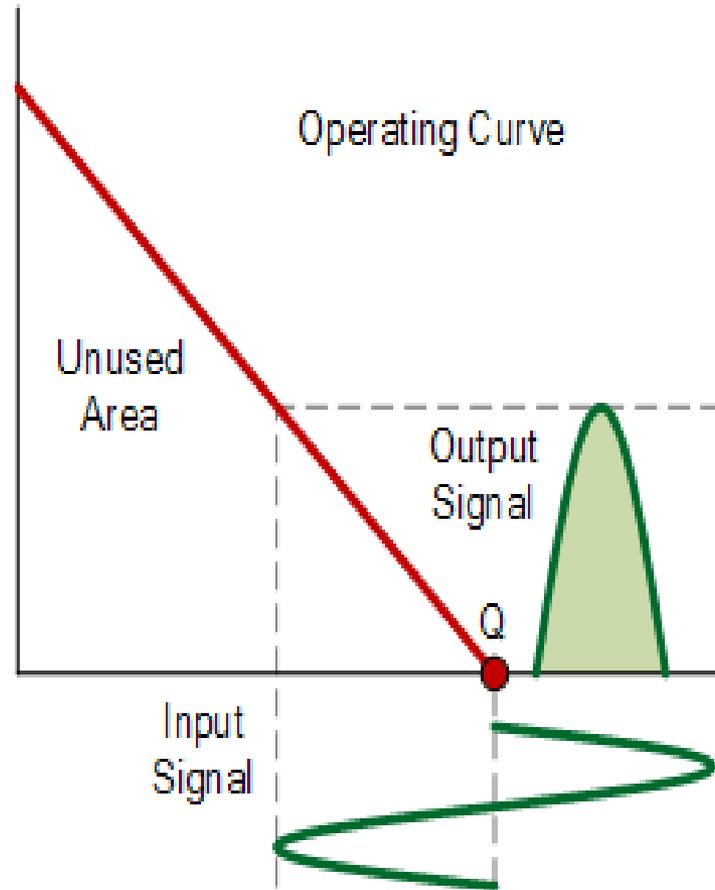
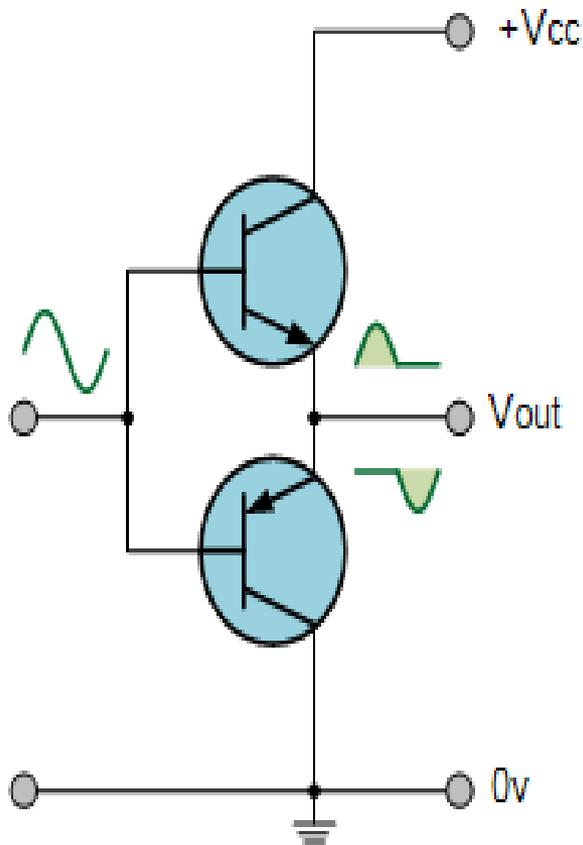
- To achieve high linearity and gain, the output stage of a class A amplifier is biased “ON” (conducting) all the time. Then for an amplifier to be classified as “Class A” the zero signal idle current in the output stage must be equal to or greater than the maximum load current (usually a loudspeaker) required to produce the largest output signal.

- As a class A amplifier operates in the linear portion of its characteristic curves, the single output device conducts through a full 360 degrees of the output waveform. Then the class A amplifier is equivalent to a current source.

Class B Amplifier

- **Class B amplifiers** were invented as a solution to the efficiency and heating problems associated with the previous class A amplifier.
- The basic class B amplifier uses two complimentary transistors either bipolar or FET for each half of the waveform with its output stage configured in a “push-pull” type arrangement, so that each transistor device amplifies only half of the output waveform.

Class B Amplifier

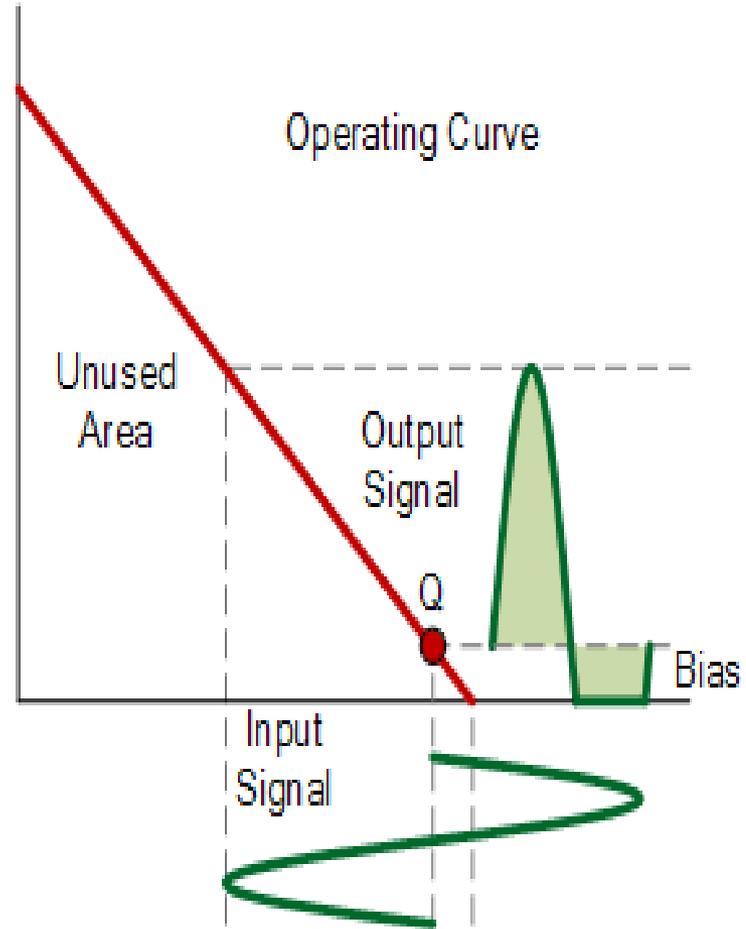
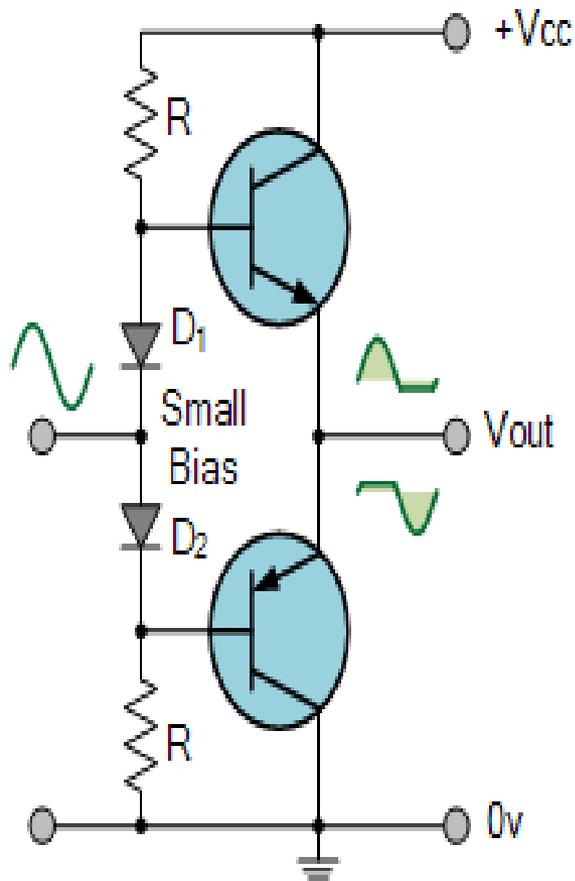


- When the input signal goes positive, the positive biased transistor conducts while the negative transistor is switched “OFF”.
- Likewise, when the input signal goes negative, the positive transistor switches “OFF” while the negative biased transistor turns “ON” and conducts the negative portion of the signal.
- Thus the transistor conducts only half of the time, either on positive or negative half cycle of the input signal.
- Then we can see that each transistor device of the class B amplifier only conducts through one half or 180 degrees of the output waveform in strict time alternation, but as the output stage has devices for both halves of the signal waveform the two halves are combined together to produce the full linear output waveform.

Class AB Amplifier

- As its name suggests, the **Class AB Amplifier** is a combination of the “Class A” and the “Class B” type amplifiers we have looked at above.
- The AB classification of amplifier is currently one of the most common used types of audio power amplifier design.
- The class AB amplifier is a variation of a class B amplifier as described above, except that both devices are allowed to conduct at the same time around the waveforms crossover point eliminating the crossover distortion problems of the previous class B amplifier.

Class AB Amplifier



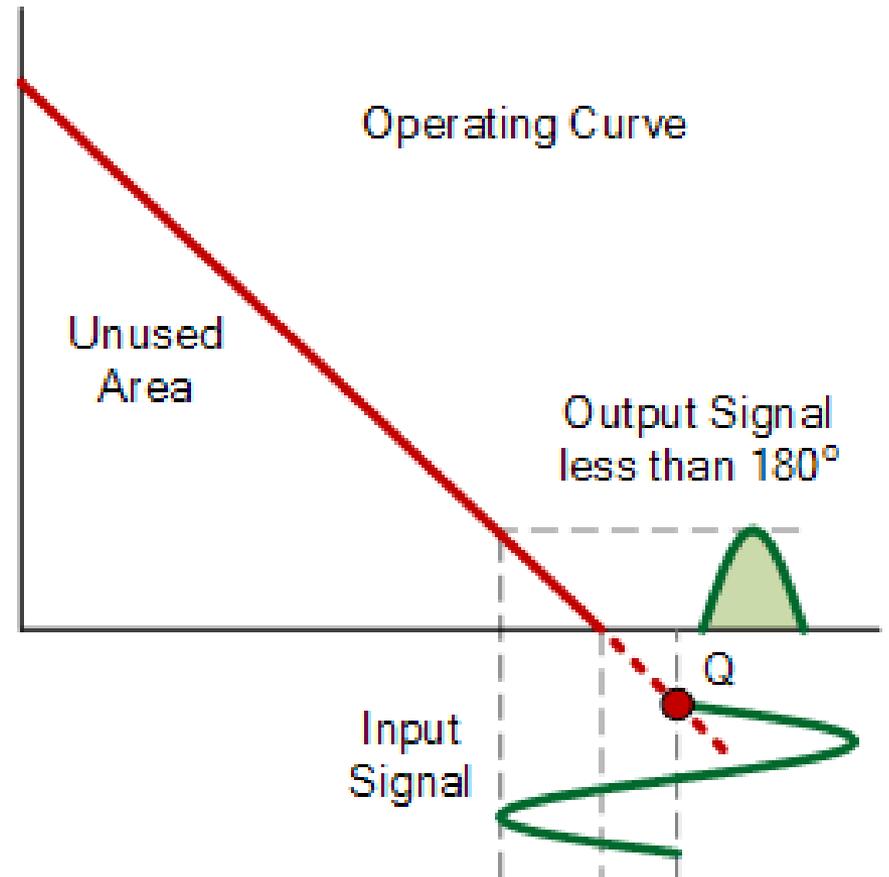
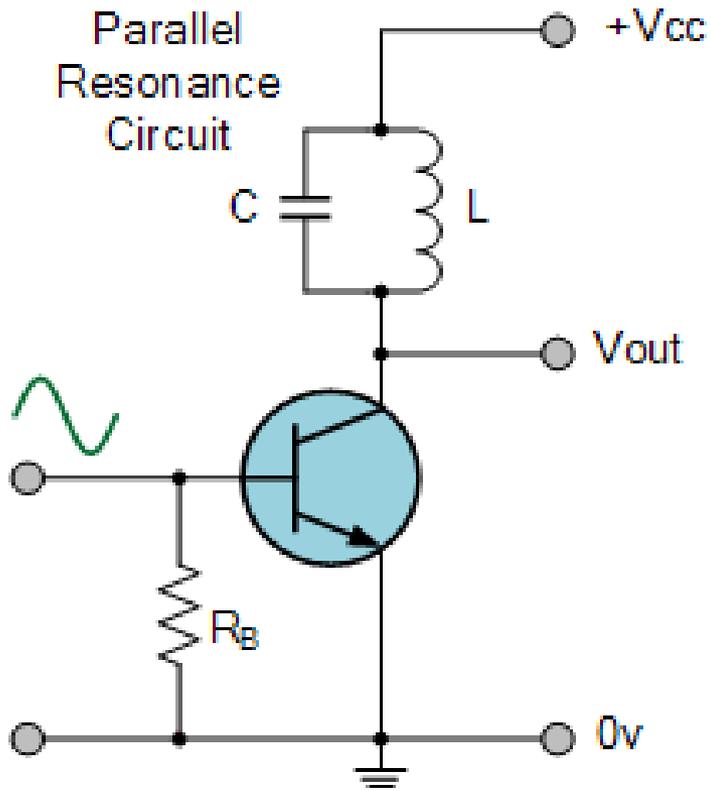
- The advantage of this small bias voltage, provided by series diodes or resistors, is that the crossover distortion created by the class B amplifier characteristics is overcome, without the inefficiencies of the class A amplifier design.

- So the class AB amplifier is a good compromise between class A and class B in terms of efficiency and linearity, with conversion efficiencies reaching about 50% to 60%.

Class C Amplifier

- The **Class C Amplifier** design has the greatest efficiency but the poorest linearity of the classes of amplifiers mentioned here.
- The previous classes, A, B and AB are considered linear amplifiers, as the output signals amplitude and phase are linearly related to the input signals amplitude and phase.
- However, the class C amplifier is heavily biased so that the output current is zero for more than one half of an input sinusoidal signal cycle with the transistor idling at its cut-off point.

Class C Amplifier



- Due to its heavy audio distortion, class C amplifiers are commonly used in high frequency sine wave oscillators and certain types of radio frequency amplifiers, where the pulses of current produced at the amplifiers output can be converted to complete sine waves of a particular frequency by the use of LC resonant circuits in its collector circuit.

Class D Power Amplifier

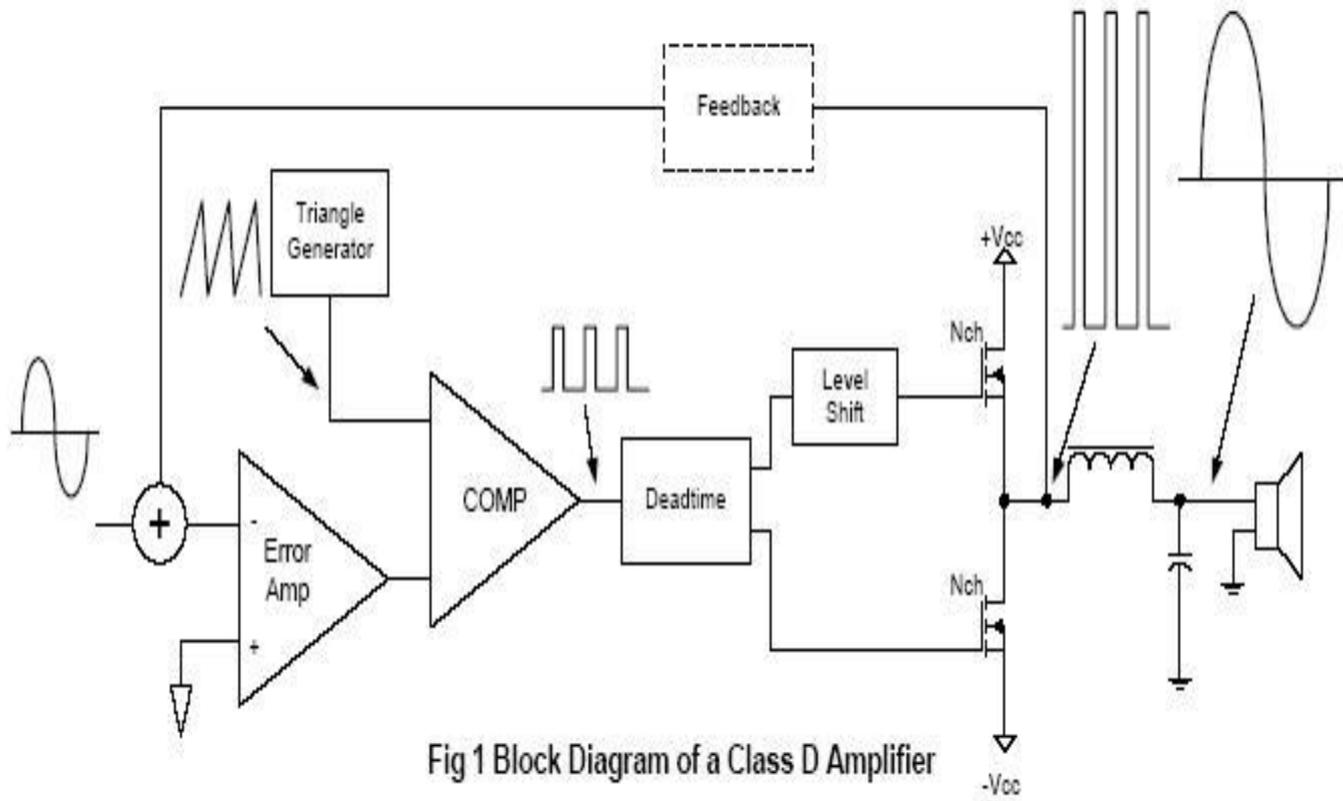
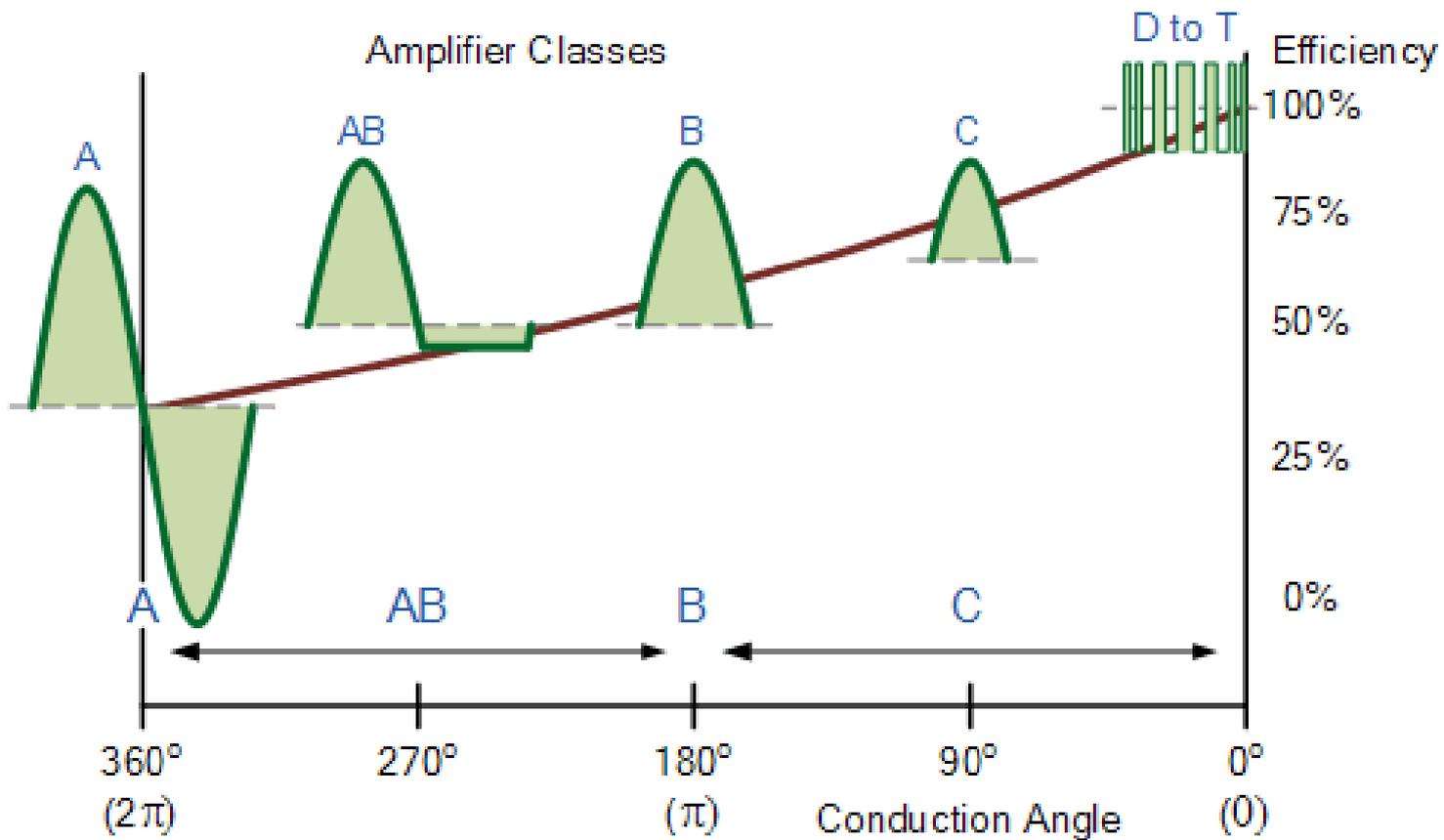


Fig 1 Block Diagram of a Class D Amplifier

- A Class D audio amplifier is basically a non-linear switching amplifier or PWM amplifier.
- Class-D amplifiers theoretically can reach 100% efficiency, as there is no period during a cycle where the voltage and current waveforms overlap as current is drawn only through the transistor that is on.

Amplifier Classes and Efficiency

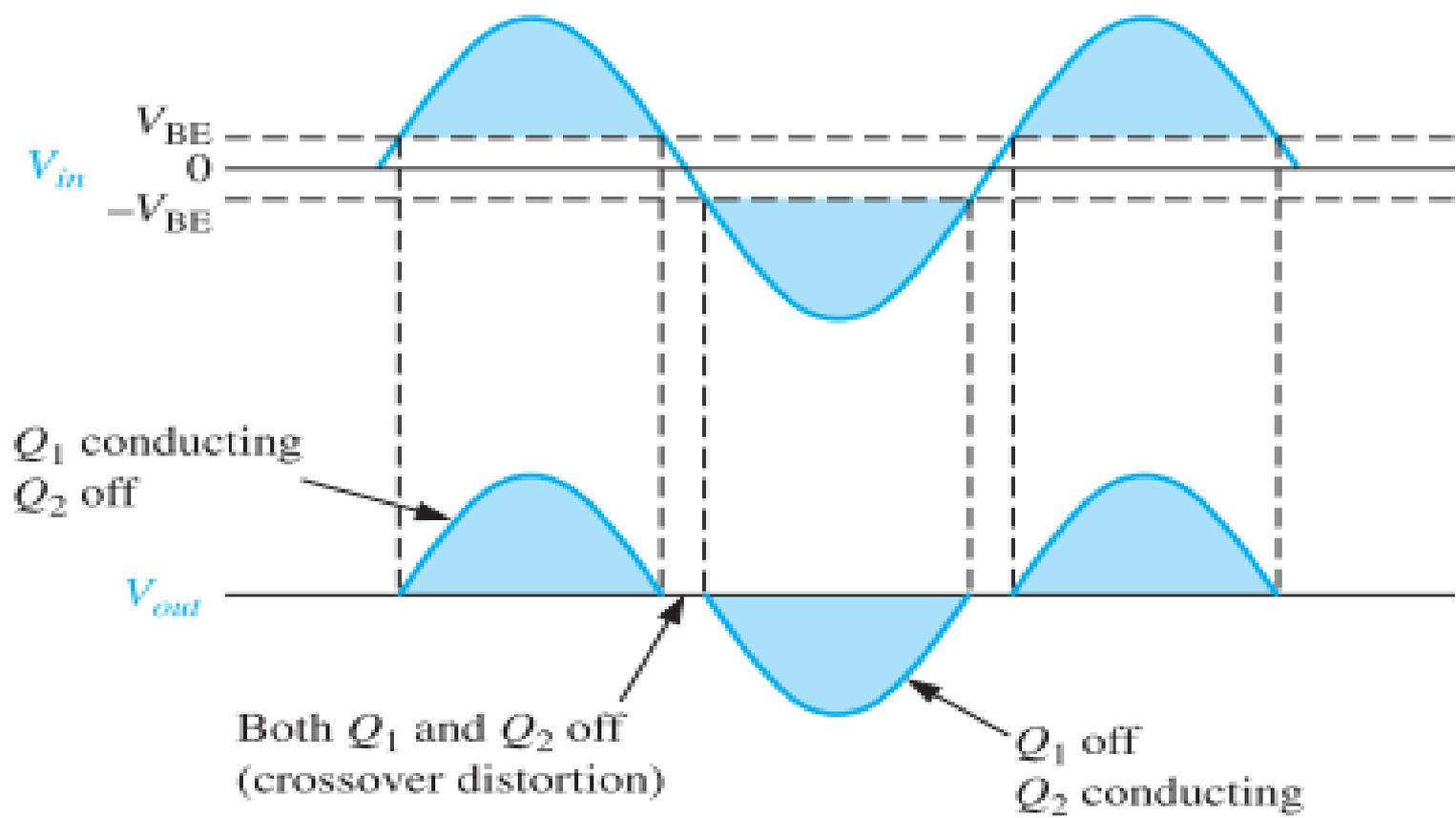


Amplifier Class by Conduction Angle

Amplifier Class	Description	Conduction Angle
Class-A	Full cycle 360° of Conduction	$\theta = 2\pi$
Class-B	Half cycle 180° of Conduction	$\theta = \pi$
Class-AB	Slightly more than 180° of conduction	$\pi < \theta < 2\pi$
Class-C	Slightly less than 180° of conduction	$\theta < \pi$
Class-D to T	ON-OFF non-linear switching	$\theta = 0$

Crossover Distortion

- When the dc base voltage is zero, both transistors are off and the input signal voltage must exceed V_{BE} before a transistor conducts.
- Because of this, there is a time interval between the positive and negative alternations of the input when neither transistor is conducting, as shown in Figure.
- The resulting distortion in the output waveform is called **crossover distortion**.



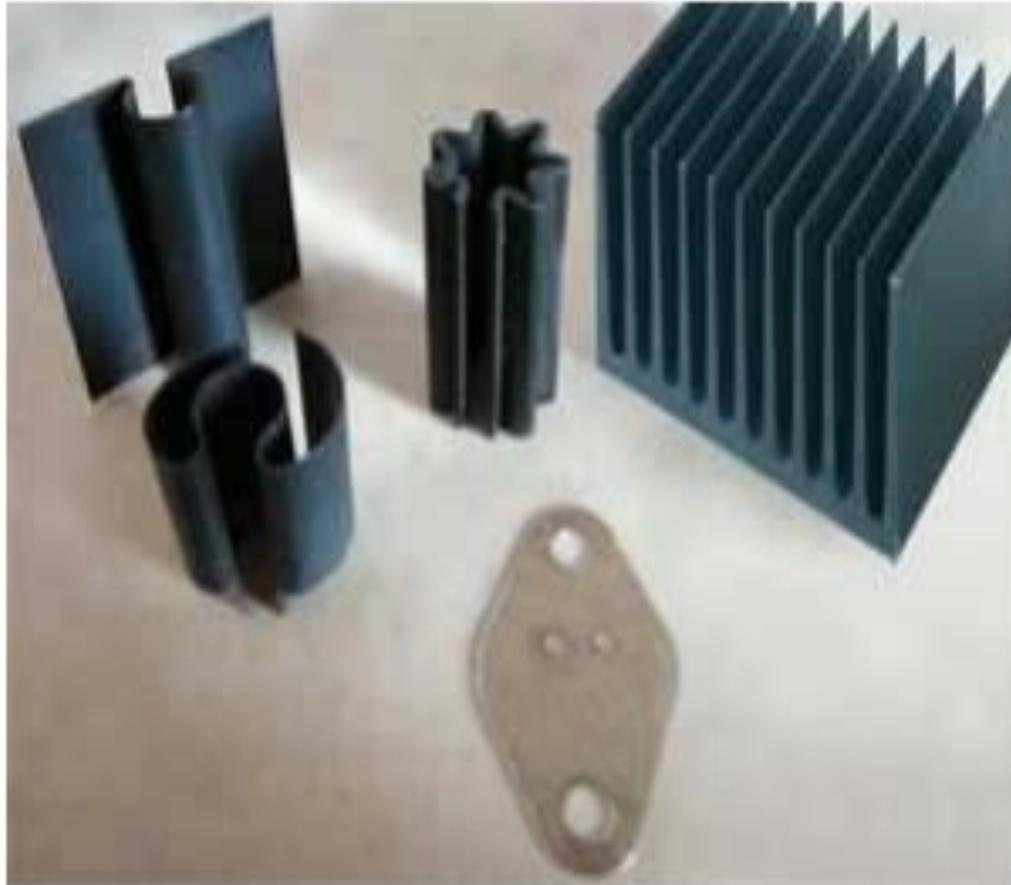
Thermal stability of Power amplifiers

- Each heat-sink has a parameter called its Thermal Resistance (R_{th}) measured in $^{\circ}\text{C}/\text{Watt}$ and the lower the value of R_{th} the faster heat is dissipated.
- Other factors affecting heat dissipation include the power (in Watts) being dissipated by the transistor, the efficiency of heat transfer between the internal transistor junction and the transistor case, and the case to the heat-sink.
- The difference between the temperature of the heatsink and the air temperature surrounding the heat-sink (the ambient temperature) must also be taken into account.
- The main criterion is that the heat-sink should be efficient enough, too efficient is not a problem.

Heat Sinks

- A heat-sink is designed to remove heat from a transistor and dissipate it into the surrounding air as efficiently as possible.
- Heat-sinks take many different forms, such as finned aluminium or copper sheets or blocks, often painted or anodised matt black to help dissipate heat more quickly..

Heat Sinks



- Good physical contact between the transistor and heat-sink is essential, and a heat transmitting grease (heat-sink compound) is smeared on the contact area before clamping the transistor to the heat-sink.
- Where it is necessary to maintain electrical insulation between transistor and heat-sink a mica layer is used between the heat-sink and transistor.
- Mica has excellent insulation and very good heat conducting properties.