Transistor Amplifiers

Objectives

Describe the purpose of an amplifier.

Describe classes of amplifier operation.

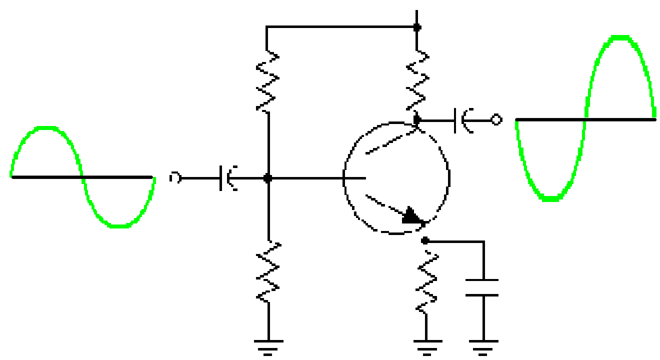
Describe common emitter amplifiers.

Describe common collector amplifiers.

Describe common base amplifiers.

The purpose of an amplifier is to increase signal strength.

Signal is a general term used to describe current, voltage, or power in a circuit.



A radio is a good example of how amplifiers are used.

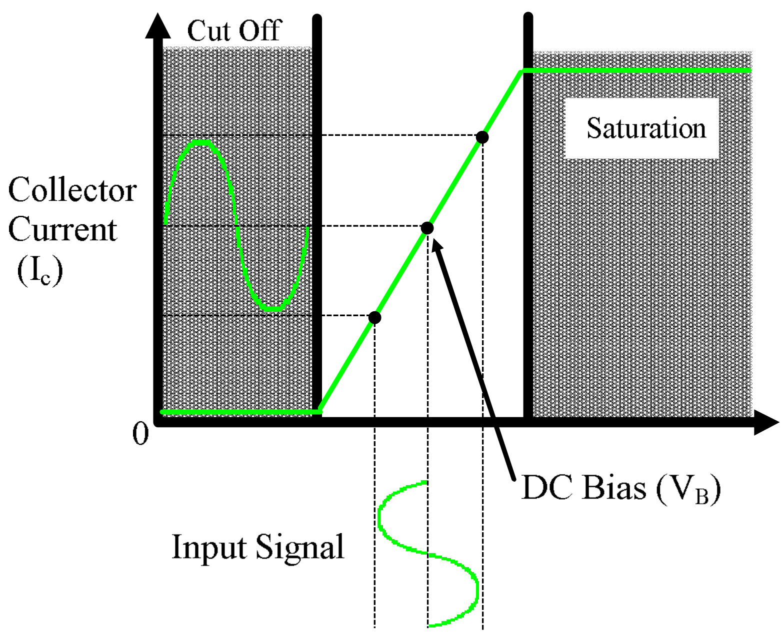
The signal received by the antenna is small (around 2 μV). This small voltage cannot drive the speaker.

Amplifiers in the radio increase the voltage to about 2 volts. That is an increase of 1,000,000 times.

Transistor amplification of an input signal occurs because a small change in base bais causes a large change in collector current.

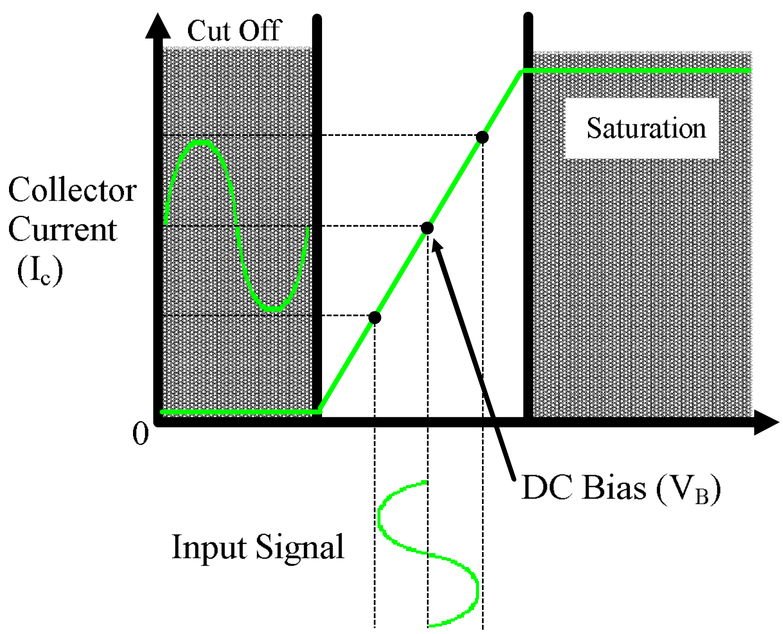
Once a transistor is DC biased, an AC input signal is applied that adds to or subtracts from the bias level.

The changing base bias changes the collector current. A small change in base bias causes a large change in collector current. This is amplification.



The point where a transistor is DC biased determines the class of operation.

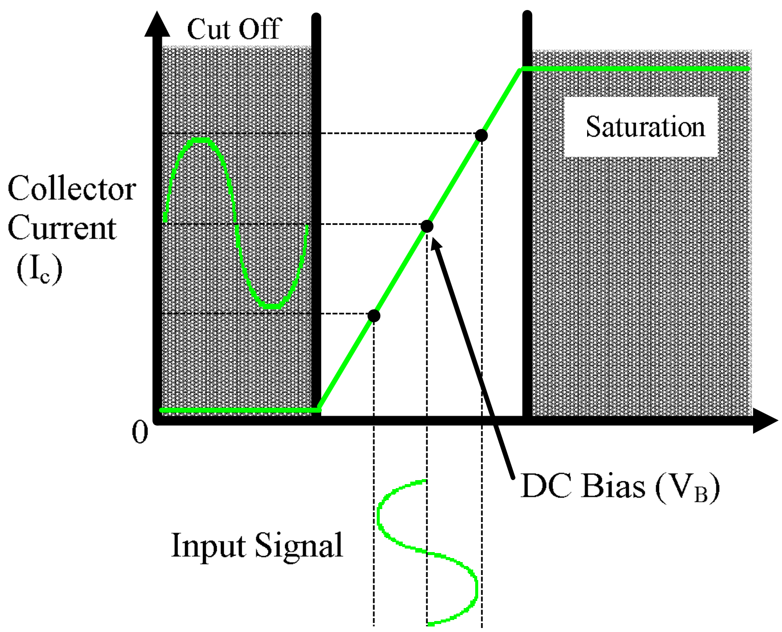
We will discuss four different classes of operation: Class A, class B, Class AB, and Class C

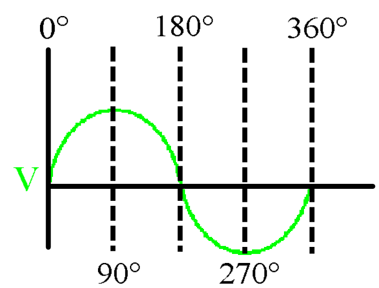


Class A amplifiers are biased so the input signal occurs within the limits of cutoff and saturation.

Collector current (I_c) flows for the complete 360 ° cycle of the input signal. The bias point is normally mid-way between cutoff and saturation.

Class A amplifiers are commonly used in audio amplifiers.





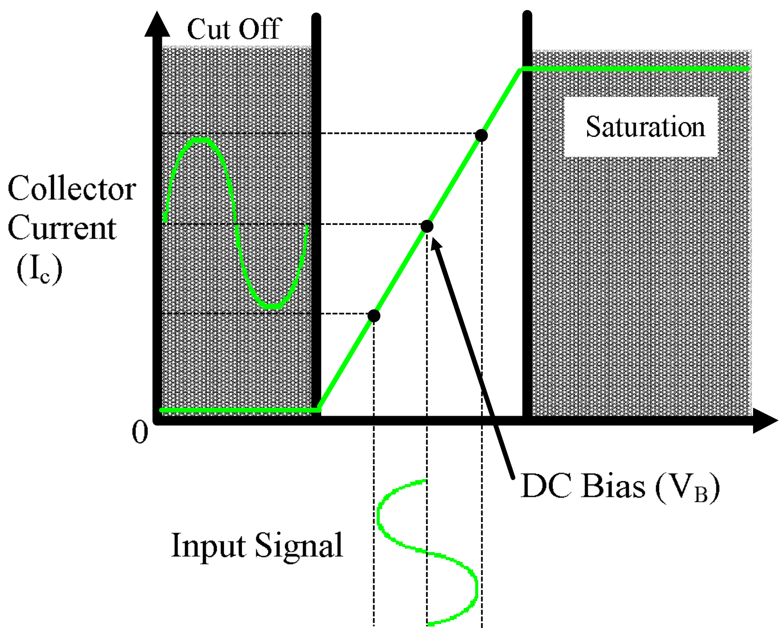
Advantages of a class A amplifier are great fidelity and low distortion.

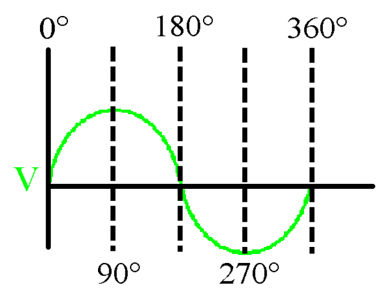
Fidelity is how accurate a signal is reproduced with the exception of amplitude.

Distortion is the opposite of fidelity.

A disadvantage of a class A amplifier is poor efficiency.

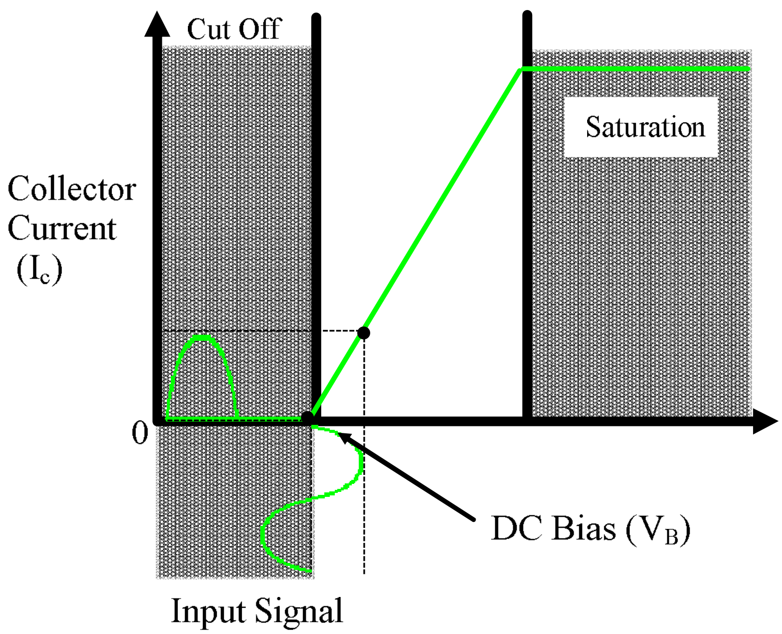
Efficiency is how much power is consumed for a given input signal.

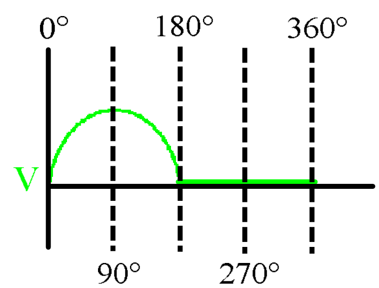




Class B amplifiers are biased so collector current is zero for half (one alternation) of the input signal.

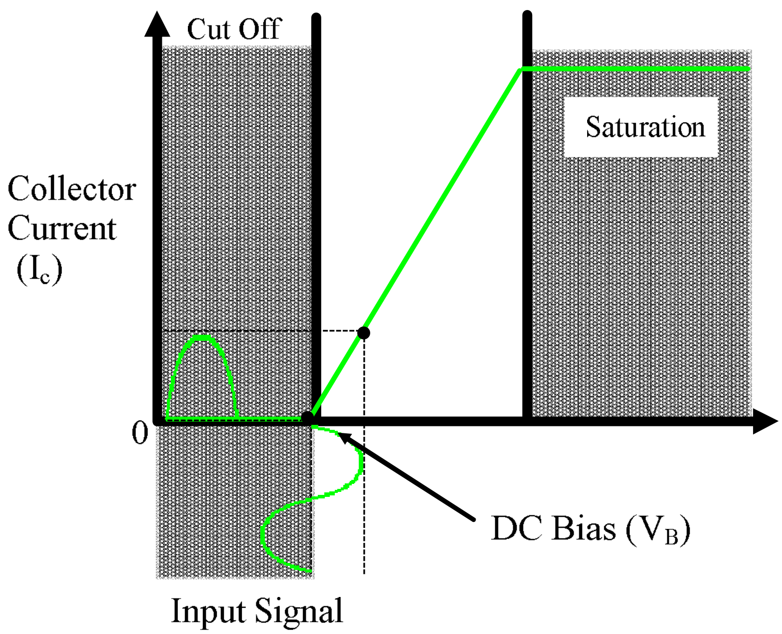
The DC bias point is at cutoff. Collector current (I_c) only flows half (180°) of the input signal.

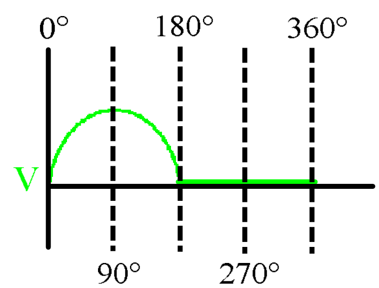




Class B amplifiers are commonly used in push-pull amplifiers.

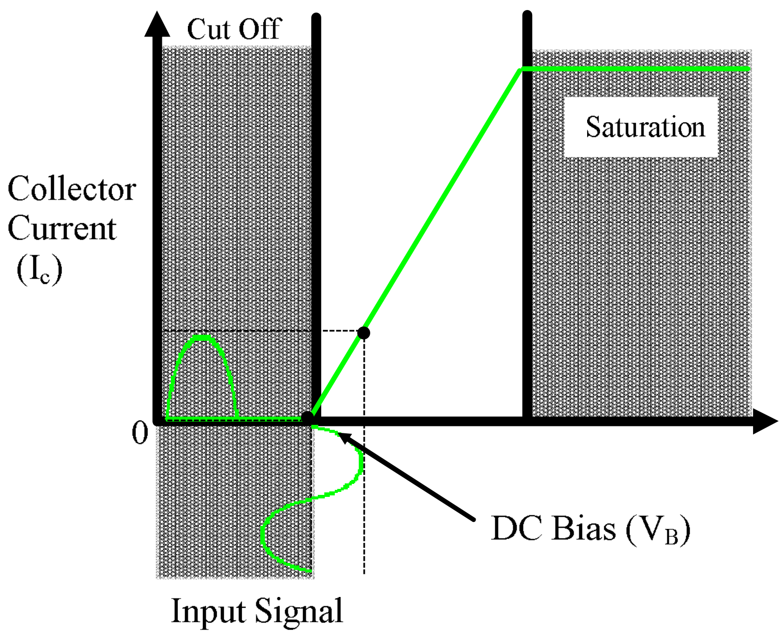
Push-pull amplifiers are two amplifiers with their outputs tied together. One amplifier conducts for 180 ° while the other is off. Then they switch. This overcomes the poor fidelity but maintains good efficiency.

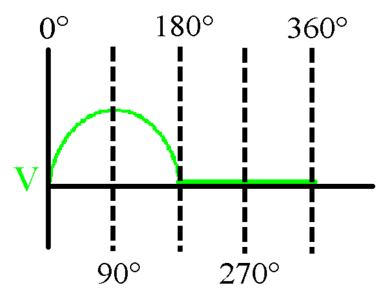




An advantage of class B operation is increased efficiency since the transistor is only conducting during half of the input signal.

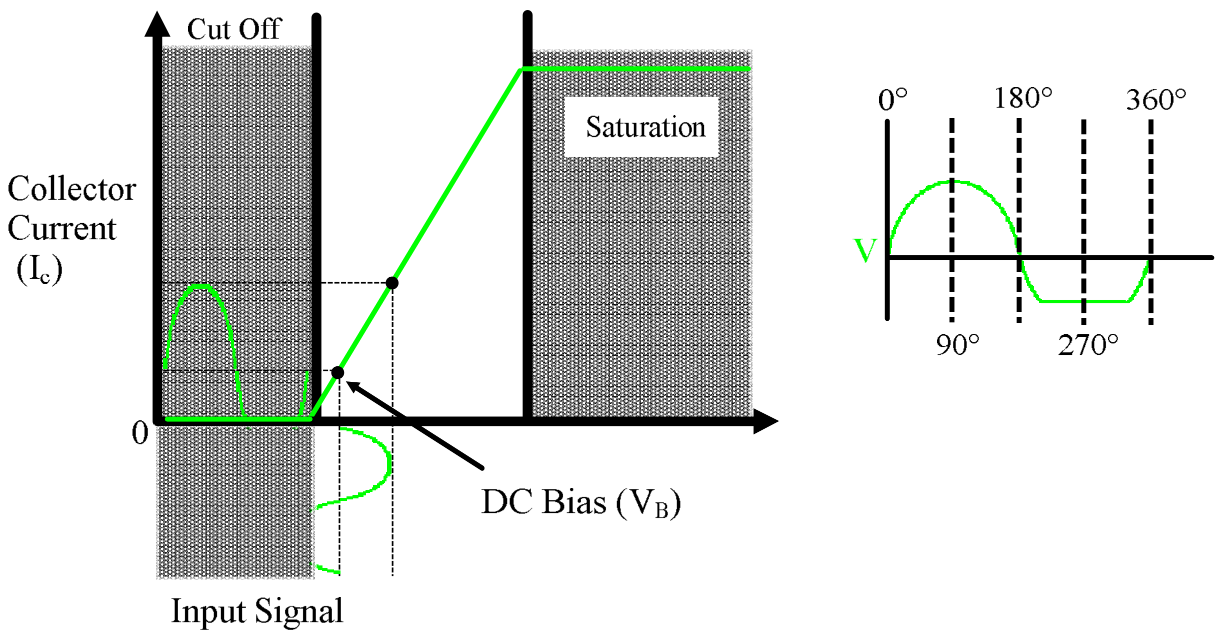
A disadvantage is that it has poor fidelity. Only half the signal is replicated from the input signal.





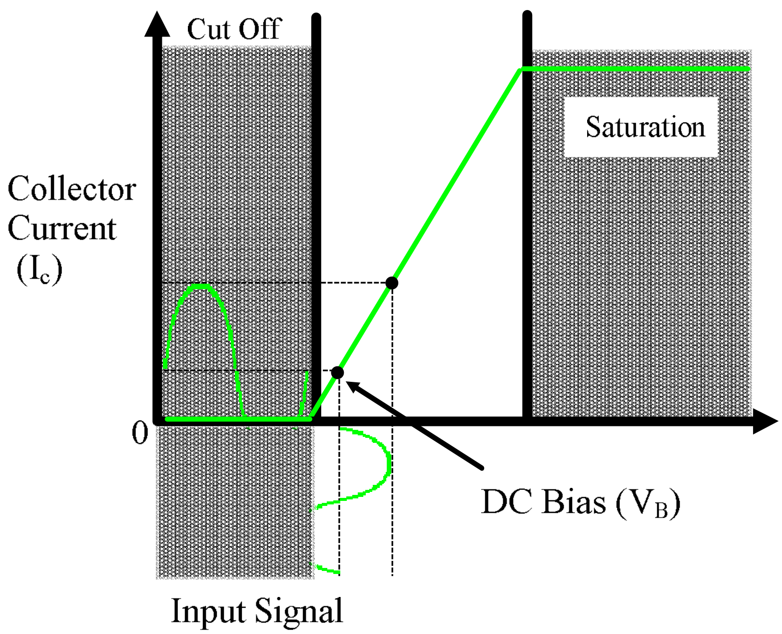
Class AB amplifiers are biased so the collector current (I_c) is zero for a portion of one alternation.

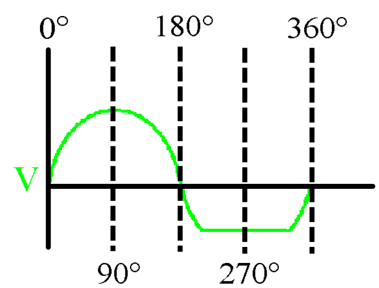
The bias point is above cutoff so collector current flows for more than 180 °, but less than 360°.



Class AB amplifiers are commonly used in place of class B push-pull amplifiers to overcome crossover distortion.

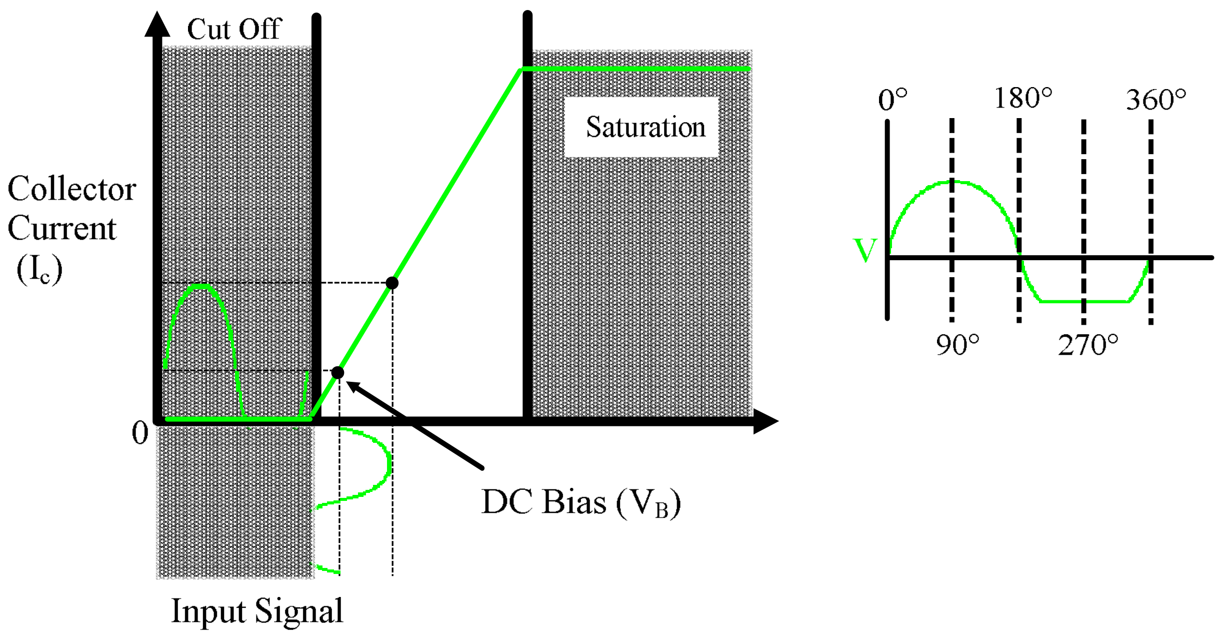
Crossover distortion occurs when one class B amplifier in a push-pull amplifier is turning off before the other class B amplifier turns on.





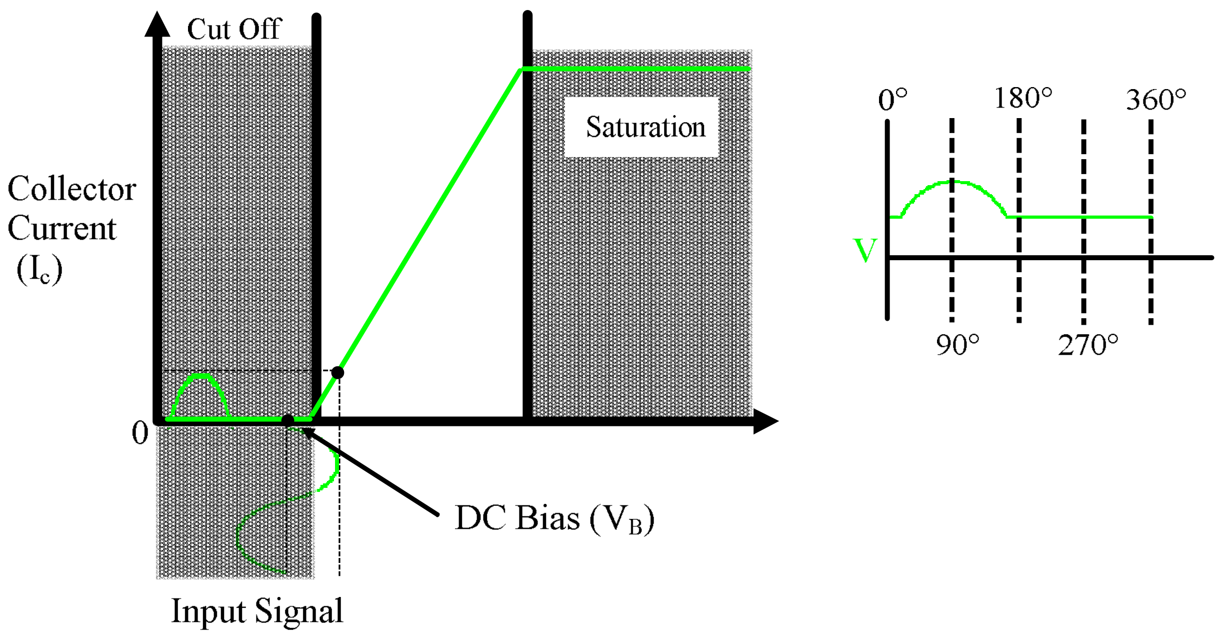
An advantage of class AB operation is that it is more efficient than class A and has better fidelity than class B.

A disadvantage is that it has less fidelity than class A and less efficiency than class B.



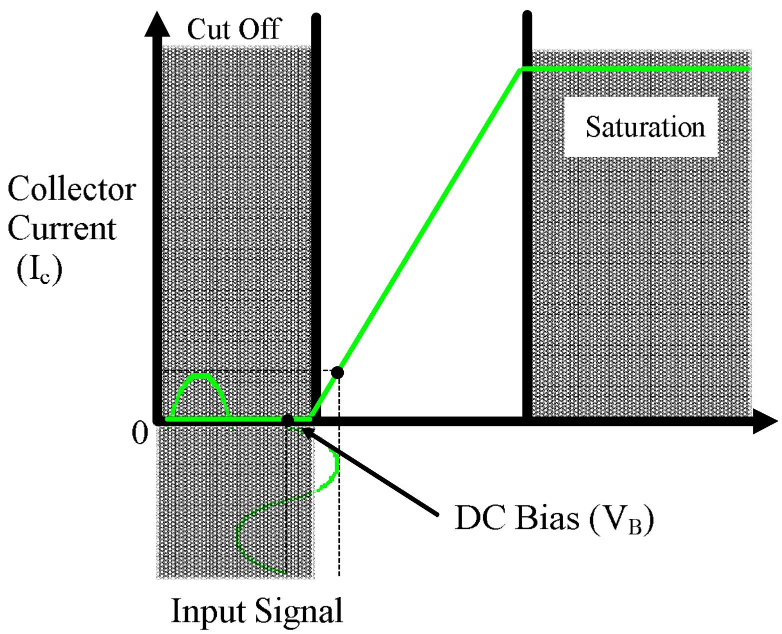
Class C amplifiers are biased so that collector current is zero for most of the input cycle.

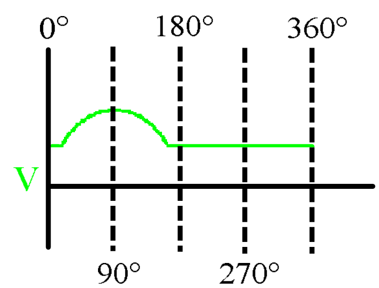
The bias point is below cutoff so collector current (I_c) flows for less than 180 °.



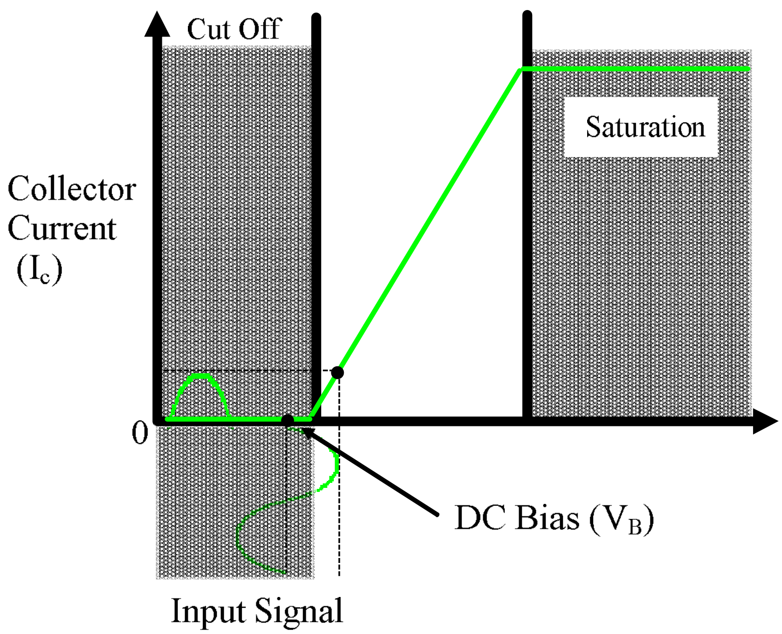
An advantage of class C operation is that it the highest efficient. Collector current (I_c) flows for less than 180 ° of the input signal.

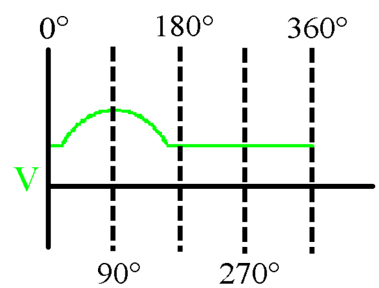
A disadvantage is that it has the least fidelity and the most distortion.





Class C amplifiers are normally used in RF turned amplifier applications. Fidelity is not an issue in these applications.

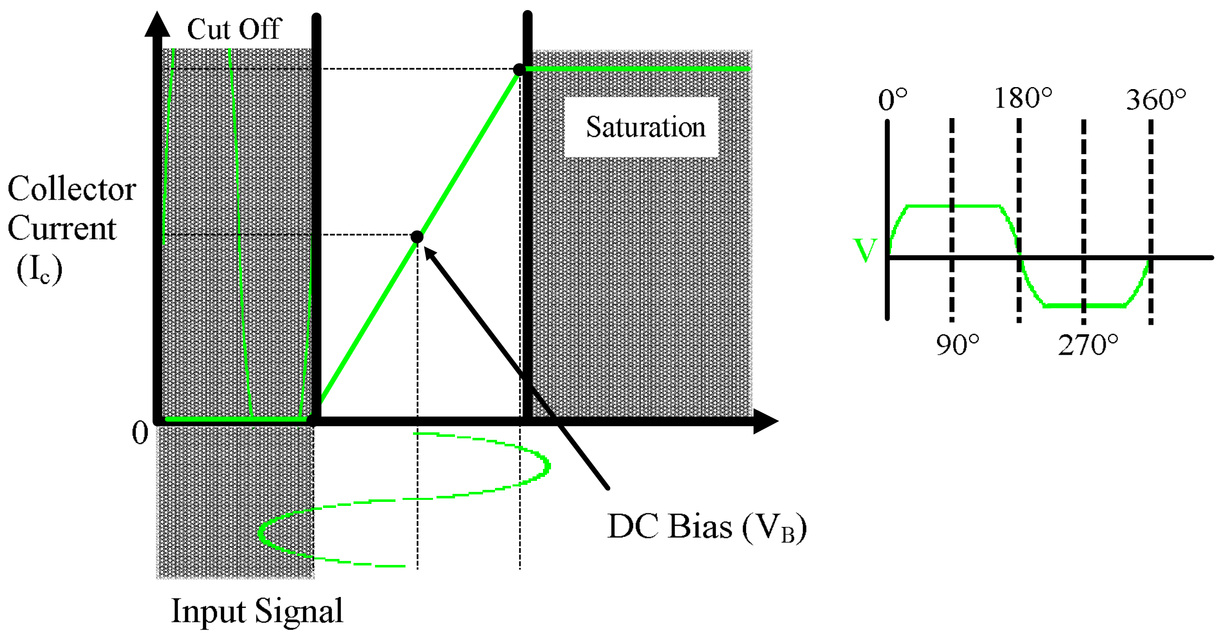




The transistor goes into saturation and cutoff if the amplitude of the input signal is too high. This is called overdriving the amplifier.

Any class of amplifier can be overdriven.

Overdriving an amplifier distorts the output signal.

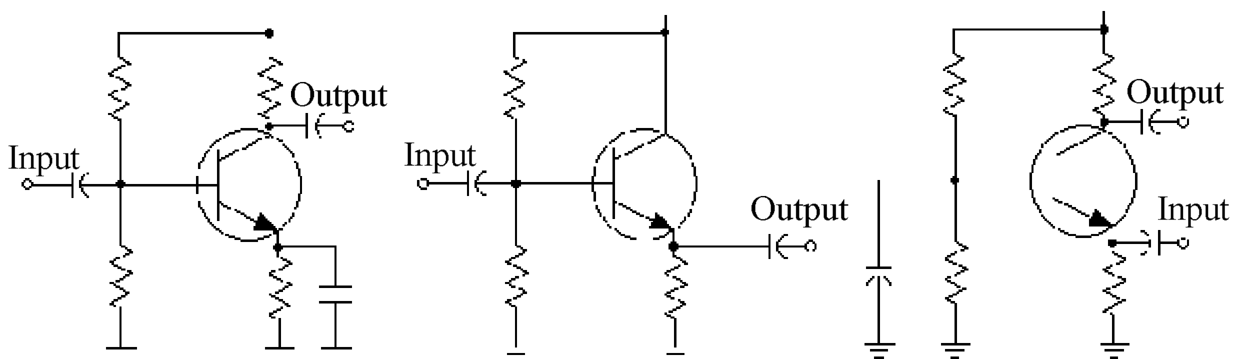


Three basic circuit configurations for transitor amplifiers are:

Common Emitter, Common Collector, and Common Base

The common terminal is the lead on the transistor that is neither the input or output.

Each configuration has particular characteristics that make it ideal for specific applications.



Common Emitter Common Collector Common Base

The common emitter configuration is the most popular amplifier in use.

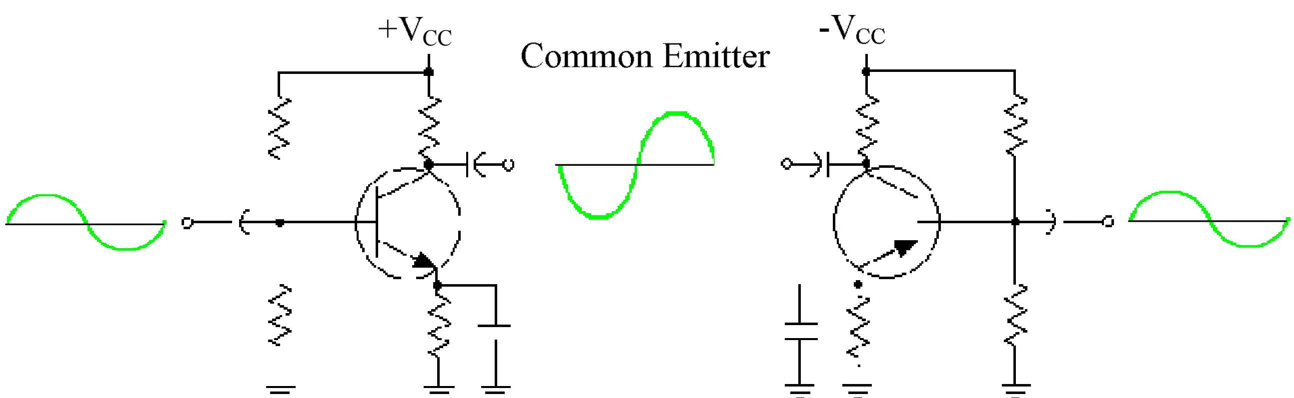
It provides good overall voltage, current, and great power amplification.

The input is on the base; the output is on the collector, and the emitter is common.

Note that the output is 180° out of phase with the input signal. It is the only amplifier configuration that has phase reversal.

The input impedance is medium (500 Ω to 1500Ω) because the input is applied to the forward biased base-to-emitter PN junction.

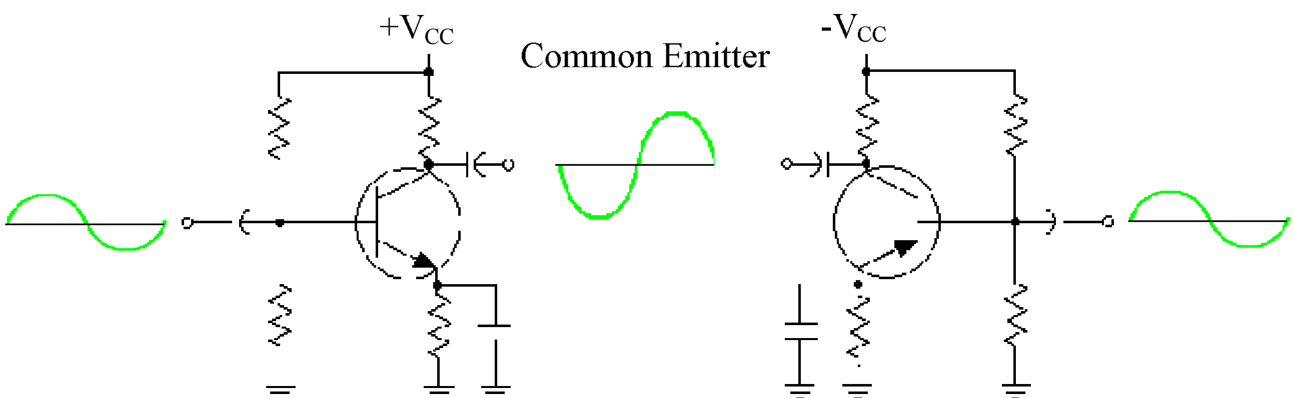
The output impedance is medium (30k Ω to 50kΩ) because the output is taken from the reversed biased base-to-collector PN junction.



The common emitter configuration has:

Input/ Output phase - 180°	Power gain - high
Input impedance - medium	Voltage gain - medium
Output impedance - medium	Current gain - medium

Gain is the ratio of Output /Input



The common collector configuration is used for impedance matching..

High impedance inputs are matched with low impedance loads.

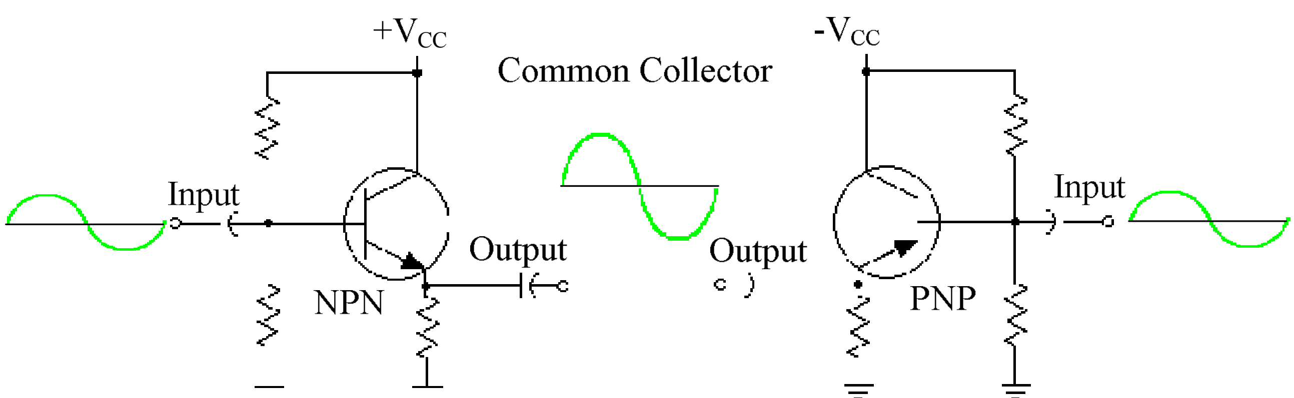
The input is on the base; the output is on the emitter, and the collector is common.

The common collector amplifier has high current gain.

Note that the output is in phase with the input.

The input impedance is high (2k Ω to 500kΩ) because the input is applied to the reversed biased base-to-collector PN junction.

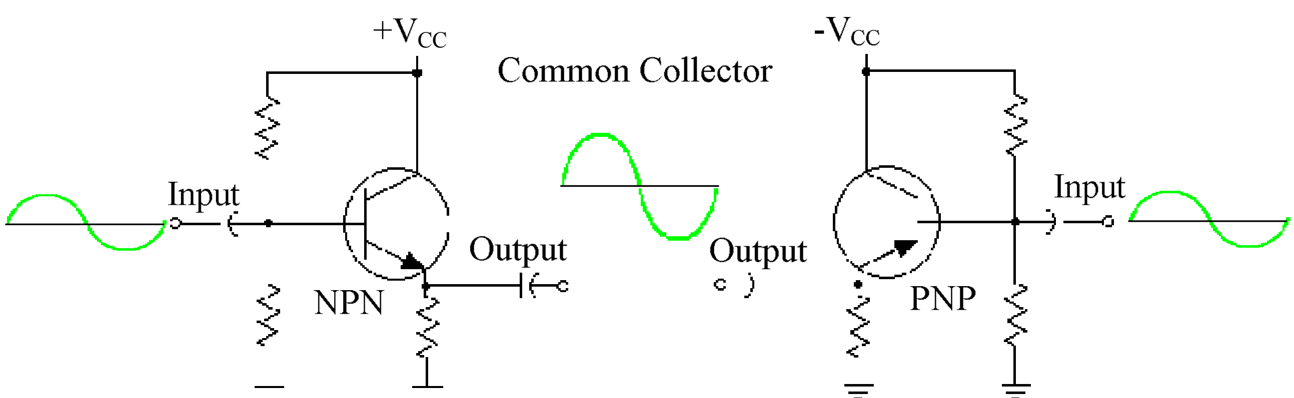
The output impedance is low (50 Ω to 1500Ω) because the output is taken from the forward biased base-to-emitter PN junction.



The common collector configuration has:

Input/ Output phase - 0°	Power gain - medium
Input impedance - high	Voltage gain - low
Output impedance - low	Current gain - high

Gain is the ratio of Output /Input



The common base configuration is also used for impedance matching..

Low impedance inputs are matched with high impedance loads.

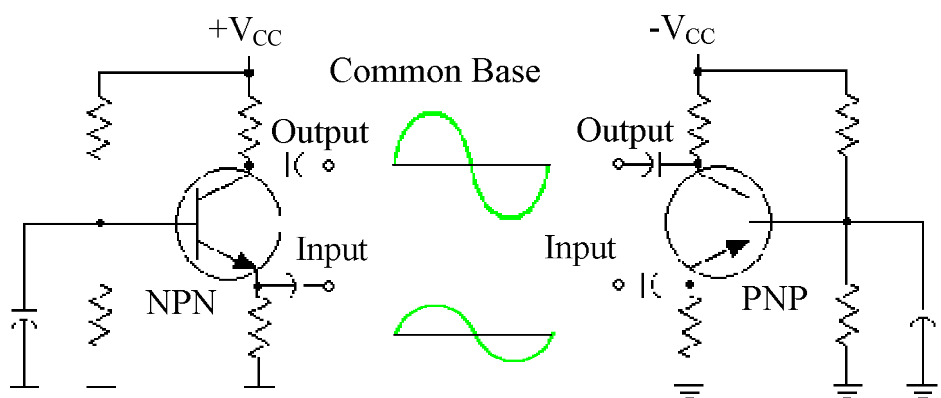
The input is on the emitter; the output is on the collector, and the base is common.

The common base amplifier has high voltage gain.

Note that the output is in phase with the input.

The input impedance is low (30 Ω to 160Ω) because the input is applied to the forward biased base-to-emitter PN junction.

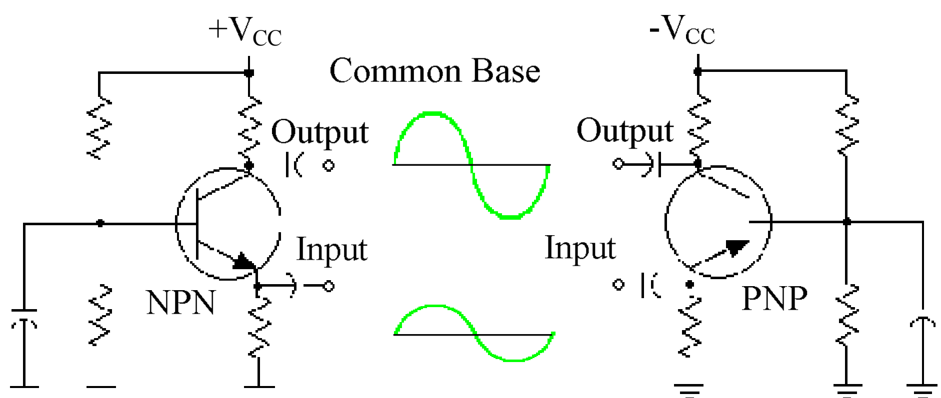
The output impedance is high (250k Ω to 550kΩ) because the output is taken from the reversed biased base-to-collector PN junction.



The common base configuration has:

Input/ Output phase - 0°	Power gain - low
Input impedance - low	Voltage gain - high
Output impedance - high	Current gain - low

Gain is the ratio of Output /Input



In summary, this is a comparison of the different transistor amplifier configurations.

Properties	Common Emitter	Common Collector	Common Base
Input/ Output phase	180°	0°	0°
Input impedance	Medium	High	Low
Output impedance	Medium	Low	High
Power gain	High	Medium	Low
Voltage gain	Medium	Low	High
Current gain	Medium	High	Low

The common emitter is the best overall amplifier configuration.

The common collector and base are best impedance matching.