Common Emitter Amplifier Circuit Working & Its Characteristics

There are **different types of transistor amplifiers** operated by using an AC signal input. This is interchanged between the positive value and negative value, hence this is the one way of presenting the common emitterto function between two peak values. This process is known as the biasing amplifier and it is an important amplifier design to establish the exact operating point of a transistor amplifier which is ready to receive the signals hence it can reduce any distortion to the output signal. In this article, we will discuss common emitter amplifier analysis.

What is an Amplifier?

The Amplifier is an electronic circuit that is used to increase the strength of a weak input signal in terms of voltage, current, or power. The process of increasing the strength of a weak signal is known as Amplification. One most important constraint during the amplification is that only the magnitude of the signal should increase and there should be no changes in the original signal shape. The transistor is a major component in an amplifier system. When a transistor is used as an amplifier, the first step is to choose an appropriate configuration, in which the device is to be used. Then, the transistor should be biased to get the desired Q-point. The signal is applied to the amplifier input and output gain is achieved.

What is a Common Emitter Amplifier?

The common emitter amplifier is a three basic single-stage and is used as a voltage amplifier. The input of this amplifier is taken from the base terminal, the output is collected from the collector terminal and the emitter terminal is common for both the terminals. The basic symbol of the common emitter amplifier is shown below.

Common Emitter Amplifier

Common Emitter Amplifier Configuration

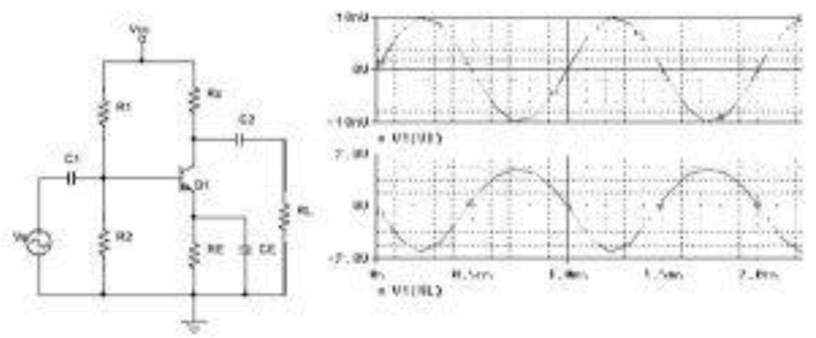
In electronic circuit design, there are three kinds of transistor configurations are used like common emitter, common base, and common collector, In that, the most frequently used one is common emitter due to its main attributes.

This kind of amplifier includes the signal which is given to the base terminal then the output is received from the collector terminal of the circuit. But, as the name suggests, the main attribute of the emitter circuit is familiar for both the input as well as output.

The configuration of a common emitter transistor is widely used in most electronic circuit designs. This configuration is evenly appropriate to both the transistors like PNP and NPN transistors but NPN transistors are most frequently used due to the widespread use of these transistors.

In Common Emitter Amplifier Configuration, the Emitter of a BJT is common to both the input and output signal as shown below.
Operation of Common Emitter Amplifier

When a signal is applied across the emitter-base junction, the forward bias across this junction increases during the upper half cycle. This leads to an increase in the flow of electrons from the emitter to a collector through the base, hence increases the collector current. The increasing collector current makes more voltage drops across the collector load resistor RC.



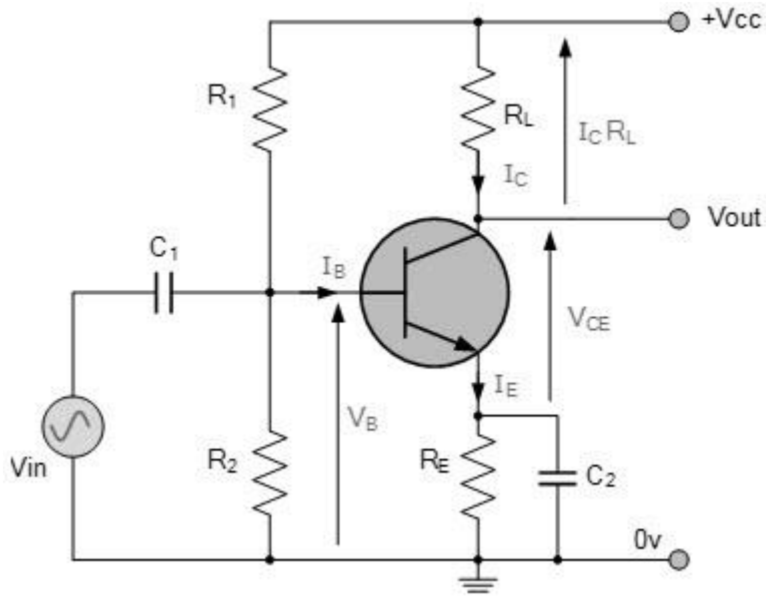
Operation of CE Amplifier

The negative half cycle decreases the forward bias voltage across the emitter-base junction. The decreasing collector-base voltage decreases the collector current in the whole collector resistor Rc. Thus, the amplified load resistor appears across the collector resistor. The common emitter amplifier circuit is shown above.

From the voltage waveforms for the CE circuit shown in Fig. (b), It is seen that there is a 180-degree phase shift between the input and output waveforms.

Working of Common Emitter Amplifier

The below circuit diagram shows the working of the common emitter amplifier circuit and biasing, used to supply the base bias voltage as per the necessity. The voltage divider biasing has a potential divider with two resistors are connected in a way that the midpoint is used for supplying base bias voltage.



Common Emitter Amplifier Circuit

There are different components in the common emitter amplifier which are R1 resistor is used for the forward bias, the R2 resistor is used for the development of bias, the RL resistor is used at the output it is called the load resistance. The RE resistor is used for thermal stability. The C1 capacitor is used to separate the AC signals from the DC biasing voltage and the capacitor is known as coupling capacitor.

The figure shows that the bias vs gain common emitter amplifier transistor characteristics if the R2 resistor increases then there is an increase in the forward bias and R1 & bias are inversely proportional to each other. The voltage is applied to the base of the transistor of the common emitter amplifier circuit then there is a flow of small base current. Hence there is a large amount of current flow through the collector with the help of the RC resistance. The voltage near the resistance RC will change because the value is very high and the values are from 4 to 10kohm. Hence there is a huge amount of current present in the collector circuit which amplified from the weak signal, therefore common emitter transistors work as an amplifier circuit.

Voltage Gain of Common Emitter Amplifier

The current gain of the common emitter amplifier is defined as the ratio of change in collector current to the change in base current. The voltage gain is defined as the product of the current gain and the ratio of the output resistance of the collector to the input resistance of the base circuits. The following equations show the mathematical expression of the voltage gain and the current gain.

$\beta = \Delta Ic / \Delta Ib$

$Av = \beta \, Rc/Rb$

Circuit Elements and their Functions

The common emitter amplifier circuit elements and their functions are discussed below.

Biasing Circuit/ Voltage Divider

The resistances R1, R2, and RE used to form voltage divider. The biasing circuit needs to establish a proper operating Q-point otherwise, a part of the negative half cycle of the signal may be cut-off in the output.

Input Capacitor (C1)

The capacitor C1 is used to couple the signal to the base terminal of the BJT. If it is not there, the signal source resistance, Rs will come across R2, and hence, it will change the bias. C1 allows only the AC signal to flow but isolates the signal source from R2

Emitter Bypass Capacitor (CE)

An Emitter bypass capacitor CE is used parallel with RE to provide a low reactance path to the amplified AC signal. If it is not used, then the amplified AC signal following through RE will cause a voltage drop across it, thereby dropping the output voltage.

Coupling Capacitor (C2)

The coupling capacitor C2 couples one stage of amplification to the next stage. This technique used to isolate the DC bias settings of the two coupled circuits.

CE Amplifier Circuit Currents

Base current iB = IB +ib where,

IB = DC base current when no signal is applied.

ib = AC base when AC signal is applied and iB = total base current.

Collector current iC = IC+ic where,

iC = total collector current.

IC = zero signal collector current.

ic = AC collector current when the AC signal is applied.

Emitter Current iE = IE + ie where,

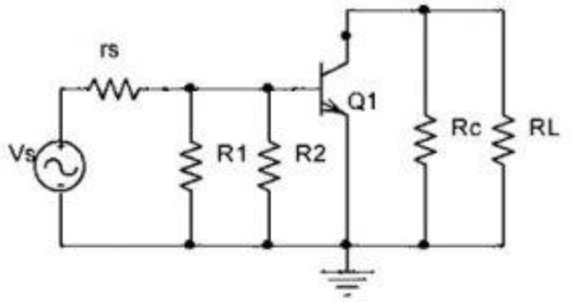
IE = Zero signal emitter current.

Ie = AC emitter current when AC signal is applied.

iE = total emitter current.

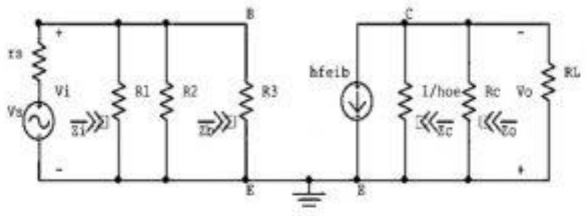
Common Emitter Amplifier analysis

The first step in AC analysis of Common Emitter amplifier circuit is to draw the AC equivalent circuit by reducing all DC sources to zero and shorting all the capacitors. The below figure shows the AC equivalent circuit.



AC Equivalent Circuit for CE Amplifier

The next step in the AC analysis is to draw an h-parameter circuit by replacing the transistor in the AC equivalent circuit with its h-parameter model. The below figure shows the h-parameter equivalent circuit for the CE circuit.



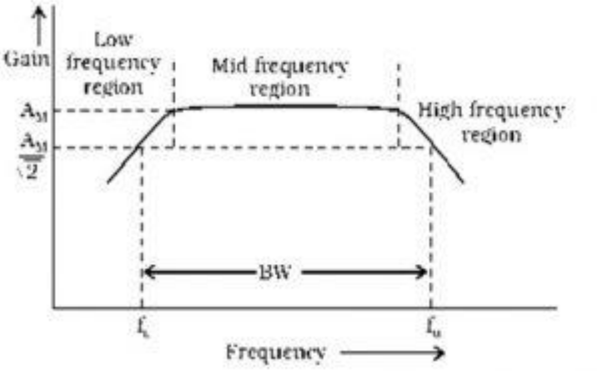
h-Parameter Equivalent Circuit for Common Emitter Amplifier

The typical CE circuit performance is summarised below:

- Device input impedance, Zb = hie
- Circuit input impedance, Zi = R1 || R2 || Zb
- Device output impedance, Zc= 1/hoe
- Circuit output impedance, Zo = RC || ZC ≈ RC
- Circuit voltage gain, Av = -hfe/hie*(Rc|| RL)
- Circuit current gain, AI = hfe. RC. Rb/ (Rc+RL) (Rc+hie)
- Circuit power gain, Ap = Av * Ai

CE Amplifier Frequency Response

The voltage gain of a CE amplifier varies with signal frequency. It is because the reactance of the capacitors in the circuit changes with signal frequency and hence affects the output voltage. The curve drawn between voltage gain and the signal frequency of an amplifier is known as frequency response. The below figure shows the frequency response of a typical CE amplifier.



Frequency Response

From the above graph, we observe that the voltage gain drops off at low (< FL) and high (> FH) frequencies, whereas it is constant over the mid-frequency range (FL to FH).

At Low Frequencies (< FL) The reactance of coupling capacitor C2 is relatively high and hence very small part of the signal will pass from the amplifier stage to the load. Moreover, CE cannot shunt the RE effectively because of its large reactance at low frequencies. These two factors cause a drops off of voltage gain at low frequencies.

At High Frequencies (> FH) The reactance of coupling capacitor C2 is very small and it behaves as a short circuit. This increases the loading effect of the amplifier stage and serves to reduce the voltage gain.
Moreover, at high frequencies, the capacitive reactance of base-emitters junction is low which increases the base current. This frequency reduces the current amplification factor β. Due to these two reasons, the voltage gain drops off at a high frequency.

At Mid Frequencies (FL to FH) The voltage gain of the amplifier is constant. The effect of the coupling capacitor C2 in this frequency range is such as to maintain a constant voltage gain. Thus, as the frequency increases in this range, the reactance of CC decreases, which tends to increase the gain.
However, at the same time, lower reactance means higher almost cancel each other, resulting in a uniform fair at mid-frequency.

We can observe the frequency response of any amplifier circuit is the difference in its performance through changes within the input signal's frequency because it shows the frequency bands where the output remains fairly stable. The circuit bandwidth can be defined as the frequency range either small or big among fH & fL.

So from this, we can decide the voltage gain for any sinusoidal input in a given range of frequency. The frequency response of a logarithmic presentation is the Bode diagram. Most of the audio amplifiers have a flat frequency response that ranges from 20 Hz – 20 kHz. For an audio amplifier, the frequency range is known as Bandwidth.

Frequency points like fL & fH are related to the lower corner & the upper corner of the amplifier which are the gain falls of the circuits at high as well as low frequencies.

These frequency points are also known as decibel points. So the BW can be defined as

$$\mathbf{BW = fH - fL}$$

The dB (decibel) is 1/10th of a B (bel), is a familiar non-linear unit to measure gain & is defined like 20log10(A). Here 'A' is the decimal gain which is plotted over the y-axis.

The maximum output can be obtained through the zero decibels which communicate toward a magnitude function of unity otherwise it occurs once Vout = Vin when there is no reduction at this frequency level, so

$$\mathbf{VOUT/VIN = 1, so\ 20log(1) = 0dB}$$

We can notice from the above graph, the output at the two cut-off frequency points will decrease from 0dB to -3dB & continues to drop at a fixed rate. This reduction within gain is known commonly as the roll-off section of the frequency response curve. In all basic filter and amplifier circuits, this roll-off rate can be defined as 20dB/decade, which is equal to a 6dB/octave rate. So, the order of the circuit is multiplied with these values.

These -3dB cut-off frequency points will describe the frequency where the o/p gain can be decreased to 70 % of its utmost value. After that, we can properly say that the frequency point is also the frequency at which the gain of the system has reduced to 0.7 of its utmost value.