B.SC PHYSICS

SEMESTER IV

PHYCC410

UNIT 3(A): AMPLIFIERS

BY

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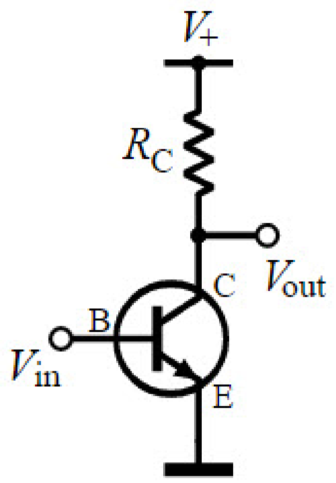
COMMON EMITTER AMPLIFIER ANALYSIS

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 original signal shape. The transistor BJT, FET 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 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.

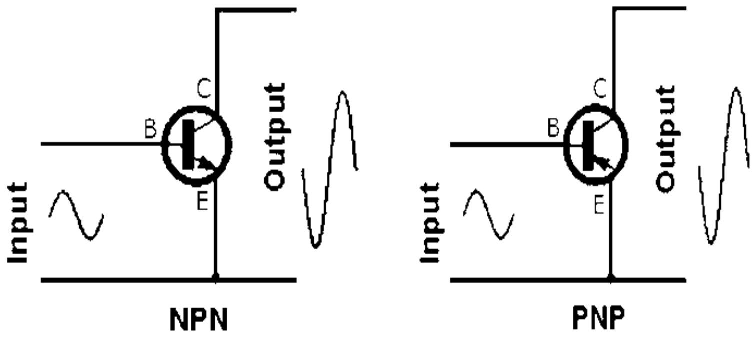
What is a Common Emitter Amplifier?

The common emitter amplifier is a three basic single stage bipolar junction transistor 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 Configuration

In Common Emitter Amplifier Configuration, the Emitter of a BJT is common to both the input and output signal as shown below. The arrangement is the same for a PNP transistor, but bias will be opposite w.r.t NPN transistor.



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 increase 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.

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 below figure (a).

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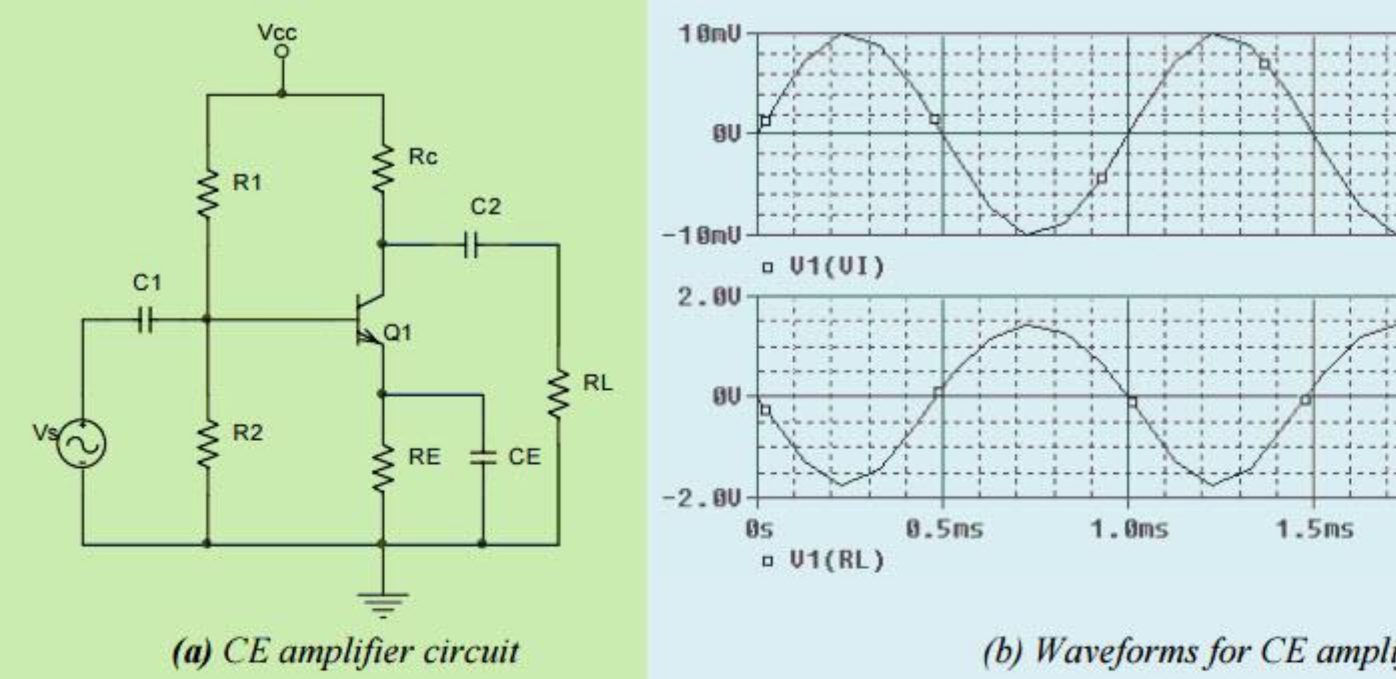


CE Amplifier

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

Common Emitter Amplifier Circuit Elements and their Functions

Biasing Circuit/ Voltage Divider

The resistances R1, R2 and RE used to form the voltage biasing and stabilisation circuit. 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 AC signal is applied.

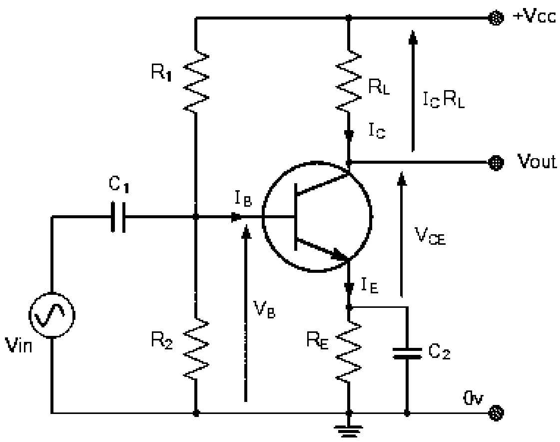
Emitter Current iE = IE + ie where,

IE = Zero signal emitter current.

Ie = AC emitter current when AC signal is applied.

iE = total emitter current.

The below circuit diagram shows the working of the common emitter amplifier circuit and it consists of voltage divider biasing, used to supply the base bias voltage as per the necessity.



In the common emitter amplifier the R_1 resistor is used for the forward bias, the R_2 resistor is used for the development of bias, the R_L resistor is used at the output it is called as the load resistance. The R_E resistor is used for the thermal stability. The C_1 capacitor is used to separate the AC signals from the DC biasing voltage and the capacitor is known as the coupling capacitor.

The alternating current 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 flowing through the collector with the help of the R_C resistance. The voltage near the resistance R_C will change because the value is very high and the values are from the 4 to 10kohm. Hence there is a huge amount of current present in the collector circuit which amplifies the weak signal, therefore common emitter transistor work as an amplifier circuit.

Voltage Gain of Common Emitter Amplifier

The current gain of 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.

$$\beta = \frac{\Delta I_C}{\Delta I_b}$$

$$A_V = \beta \frac{R_C}{R_b}$$

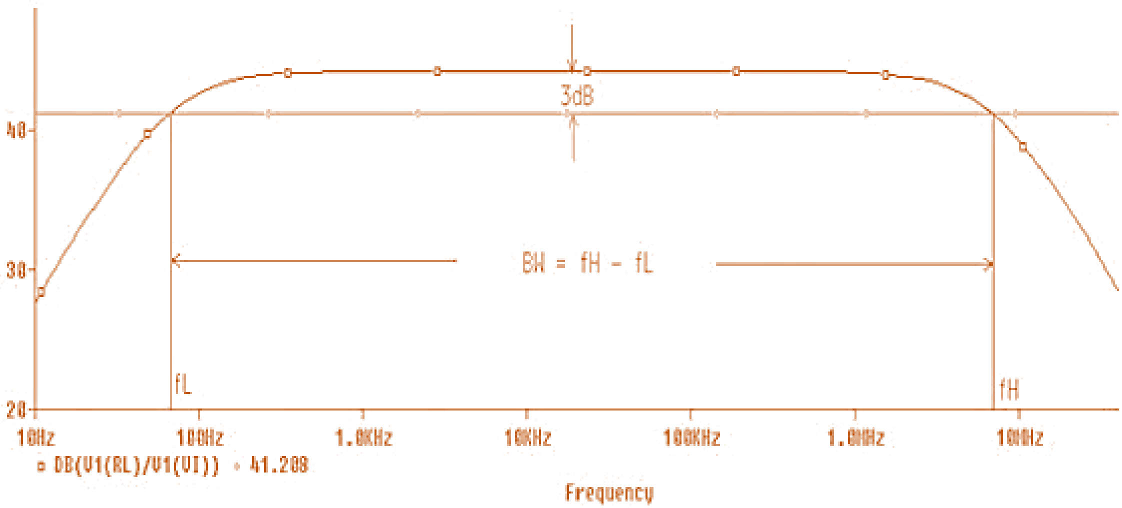
Voltage & Current Gain of Common Emitter Amplifier

Characteristics of Common Emitter Amplifier

- The voltage gain of common emitter amplifier is medium
- The power gain is high in the common emitter amplifier
- There is a phase relationship of 180 degrees in input and output
- In the common emitter amplifier, the input and output resistors are medium.

CE Amplifier Frequency Response

The voltage gain of a CE amplifier varies with signal frequency. It is because reactance's 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. Below figure shows the frequency response of a typical CE amplifier.



Frequency Response of Common Emitter Amplifier

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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).

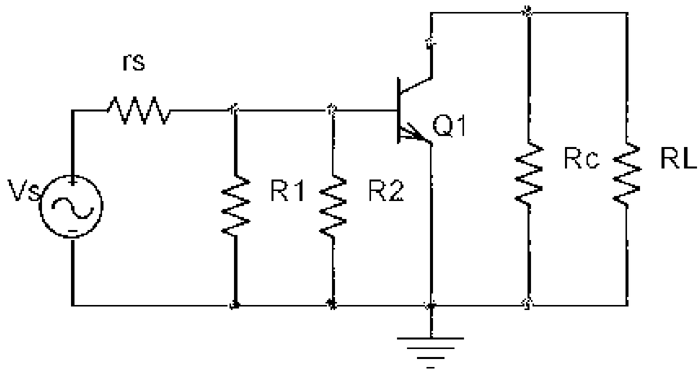
At low frequencies (< FL) The reactance of coupling capacitor C_2 is relatively high and hence very small part of the signal will pass from amplifier stage to the load.
Moreover, C_E cannot shunt the R_E effectively because of its large reactance at low frequencies. These two factors cause a drops off of voltage gain at low frequencies.

At high frequencies (> FH) The reactance of coupling capacitor C_2 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 high frequency.

At mid frequencies (FL to FH) The voltage gain of the amplifier is constant. The effect of the coupling capacitor C_2 in this frequency range is such as to maintain a constant voltage gain. Thus, as the frequency increases in this range, the reactance of C_C decreases, which tend 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.

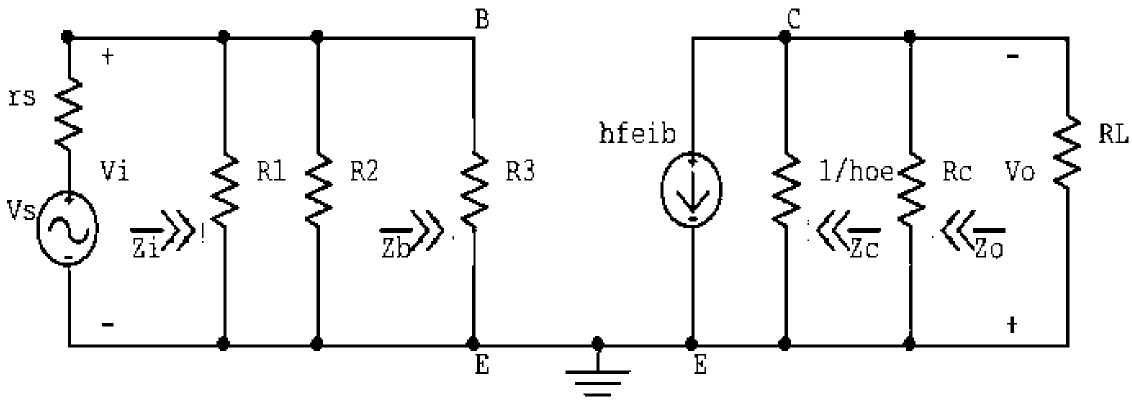
Common Emitter Amplifier analysis

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



AC Equivalent Circuit for CE Amplifier

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

Applications of Common Emitter Amplifier

- The common emitter amplifiers are used in the low-frequency voltage amplifiers.
- These amplifiers are used typically in the RF circuits.
- The common emitter circuit is popular because it’s well-suited for voltage
- amplification, especially at low frequencies.
- Common-emitter amplifiers are also used in radio frequency transceiver circuits.
- In general, the amplifiers are used in the Low noise amplifiers.

Advantages of Common Emitter Amplifier

- The common emitter amplifier has a low input impedance and it is an inverting amplifier
- The output impedance of this amplifier is high
- This amplifier has highest power gain when combined with medium voltage and current gain
- The current gain of the common emitter amplifier is high

Disadvantages of Common Emitter Amplifier

- In the high frequencies, the common emitter amplifier does not respond
- The voltage gain of this amplifier is unstable
- The output resistance is very high in these amplifiers
- In these amplifiers, there is a high thermal instability
- High output resistance