SMALL SIGNAL CE AMPLIFIERS

CE amplifiers are very popular to amplify the small signal ac. After a transistor has been biased with a Q point near the middle of a dc load line, ac source can be coupled to the base. This produces fluctuations in the base current and hence in the collector current of the same shape and frequency. The output will be enlarged sine wave of same frequency.

The amplifier is called linear if it does not change the wave shape of the signal. As long as the input signal is small, the transistor will use only a small part of the load line and the operation will be linear.

On the other hand, if the input signal is too large. The fluctuations along the load line will drive the transistor into either saturation or cut off. This clips the peaks of the input and the amplifier is no longer linear.

The CE amplifier configuration is shown in fig. 1.

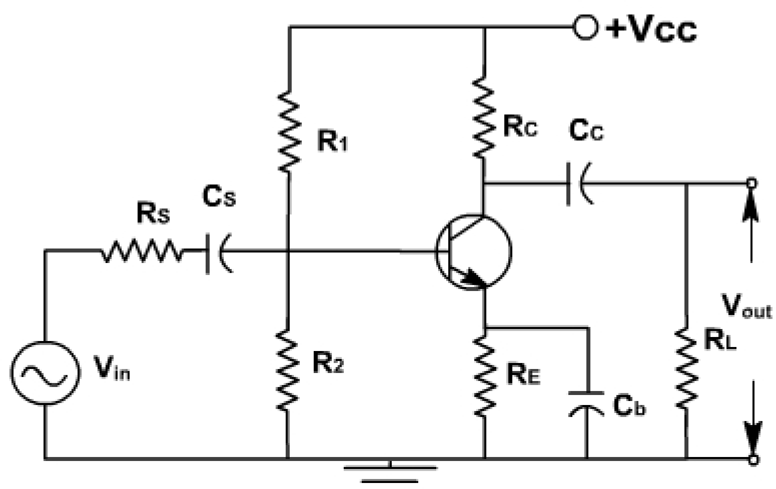

Fig. 1

The coupling capacitor (C_C) passes an ac signal from one point to another. At the same time it does not allow the dc to pass through it. Hence it is also called blocking capacitor.

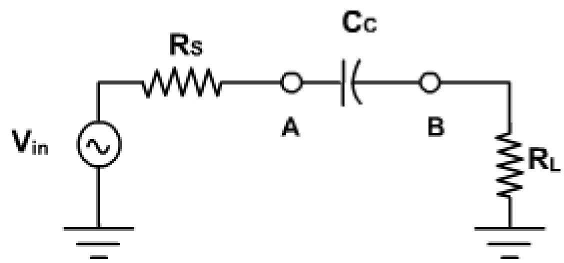

Fig. 2

For example in fig. 2, the ac voltage at point A is transmitted to point B. For this series reactance X_C should be very small compared to series resistance R_S. The circuit to the left of A may be a source and a series resistor or may be the Thevenin equivalent of a complex circuit. Similarly R_L may be the load resistance or equivalent resistance of a complex network. The current in the loop is given by

$$i = \frac{v_{in}}{\sqrt{(R_S + R_L)^2 + X_C^2}}$$

$$= \frac{v_{in}}{\sqrt{R^2 + X^2}}$$

As frequency increases, $X_C \left(= \frac{1}{2\pi fc} \right)$ decreases, and current increases until it reaches to its maximum value v_{in} / R. Therefore the capacitor couples the signal properly from A to B when $X_C \ll R$. The size of the coupling capacitor depends upon the lowest frequency to be coupled. Normally, for lowest frequency X_C £ 0.1R is taken as design rule.

The coupling capacitor acts like a switch, which is open to dc and shorted for ac.

The bypass capacitor C_b is similar to a coupling capacitor, except that it couples an ungrounded point to a grounded point. The C_b capacitor looks like a short to an ac signal and therefore emitter is said ac grounded. A bypass capacitor does not disturb the dc voltage at emitter because it looks open to dc current. As a design rule X_{Cb} £ $0.1R_E$ at lowest frequency.

Analysis of CE amplifier:

In a transistor amplifier, the dc source sets up quiescent current and voltages. The ac source then produces fluctuations in these current and voltages. The simplest way to analyze this circuit is to split the analysis in two parts: dc analysis and ac analysis. One can use superposition theorem for analysis .

AC & DC Equivalent Circuits:

For dc equivalent circuit, reduce all ac voltage sources to zero and open all ac current sources and open all capacitors. With this reduced circuit shown in fig. 3 dc current and voltages can be calculated.

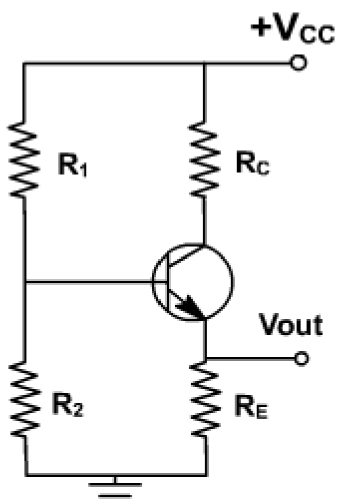

Fig. 3

For ac equivalent circuits reduce dc voltage sources to zero and open current sources and short all capacitors. This circuit is used to calculate ac currents and voltage as shown in fig. 4.

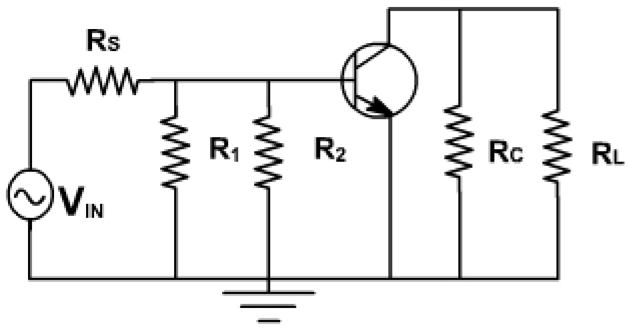

Fig. 4

The total current in any branch is the sum of dc and ac currents through that branch. The total voltage across any branch is the sum of the dc voltage and ac voltage across that branch.

Phase Inversion:

Because of the fluctuation is base current; collector current and collector voltage also swings above and below the quiescent voltage. The ac output voltage is inverted with respect to the ac input voltage, meaning it is 180^o out of phase with input.

During the positive half cycle base current increase, causing the collector current to increase. This produces a large voltage drop across the collector resistor; therefore, the voltage output decreases and negative half cycle of output voltage is obtained. Conversely, on the negative half cycle of input voltage less collector current flows and the voltage drop across the collector resistor decreases, and hence collector voltage increases we get the positive half cycle of output voltage as shown in fig. 5.

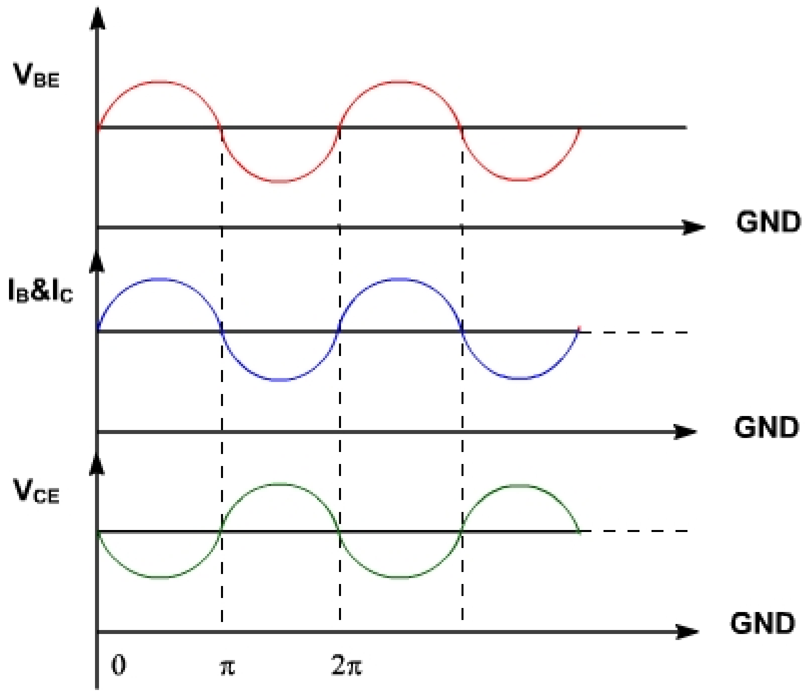

Fig. 5