Amplifier
Lecture 9

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Common Emitter Amplifier:

All types of transistor amplifier operate AC signal input which alternate a positive value and a negative value, the amplifier circuit to operate between the maximum value is required. This is achieved by using biasing. Biasing is an important in amplifier design as it establishes the correct operating point of the transistor amplifier ready to receive the signal, thereby reducing any distortion to the output signal.

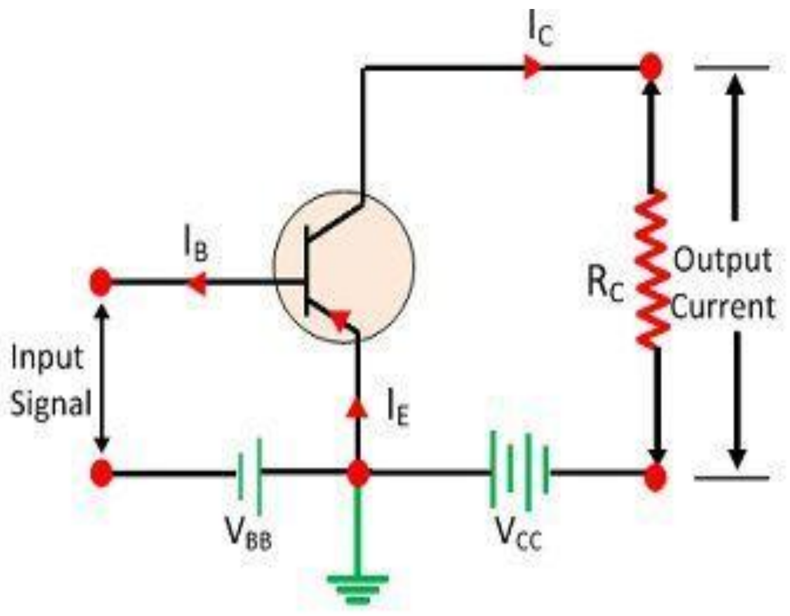

Fig 1

The single base common emitter circuit is also known as voltage divider biasing. Here the input circuit is connected between emitter and base and output is taken from the collector and emitter. Thus the emitter is common to both the input and output circuit. The amplification factor are

$$\beta = \frac{\partial I_C}{\partial I_B}$$

$$\alpha = \frac{\partial I_C}{\partial I_E}$$

Therefore

$$\beta = \frac{\alpha}{1 - \alpha}$$

Using appropriate parameter values we can replace bio-polar transistor in CE circuit with equivalent $h - parameter$ circuit (ii) and (iii). This is must be used for small input signal in accordance with linearity requirement for transistor. Since no AC voltage can appear across DC bias source, they are removed from AC equivalent circuit. From Fig (ii) using $V_O\ and\ V_i$ as rms quantities

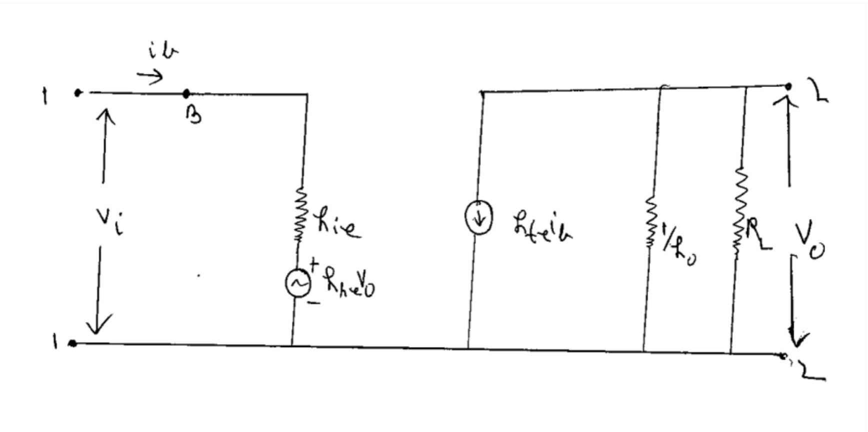

Fig 2

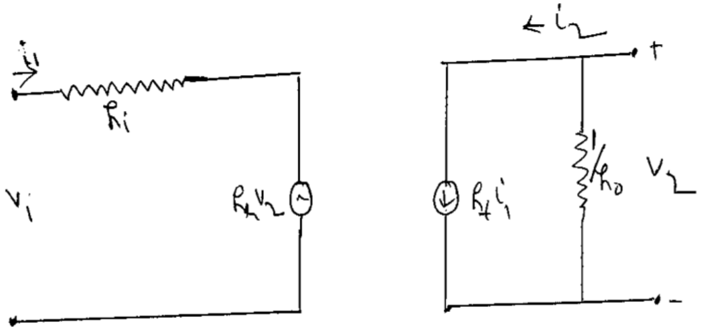

Fig 3

$$V_i = h_{ie} I_b + h_{re} V_0 \rightarrow (i)$$

$$I_c = h_{fe} I_b + h_{oe} V_0 \rightarrow (ii)$$

The frequency of operation will be considered sufficiently low that the internal transistor capacitive reactance can be ignored. Because of assigned polarity of I_c we have

$$I_c = -\frac{V_0}{R_L} \rightarrow (iii)$$

Using equation (iii) in equation (ii) we have

$$\frac{(h_{oe}R_L + 1)V_0}{h_{fe}R_L} = -I_b \rightarrow (iv)$$

Using equation (iv) in equation (ii) we find that

$$A_v = \frac{V_0}{V_i} = \frac{-1}{\left[h_{ie}(h_{oe}R_L + 1)/h_{fe}R_L\right] - h_{re}} \rightarrow (v)$$

This equation (v) gives the expression for voltage gain. For simplification we assume $h_{re} = 0$ and drop the feedback generator $(h_{re}V_0)$ from input circuit we are thereby idealising the transistor to a unilateral device.

Values of h_{oe} approximate 10^{-5} mhos while values of R_L may be 4000 to 10,000 ohms. The product of $h_{oe}R_L$ is therefore small with respect to unity and h_{oe} can be dropped from equivalent circuit. Then the circuit drawn as in fig (iv) and the equation A_v simplifies as

$$A_{ve} = \frac{V_0}{V_i} = -\frac{h_{fe}R_L}{h_{ie}} \rightarrow (vi)$$

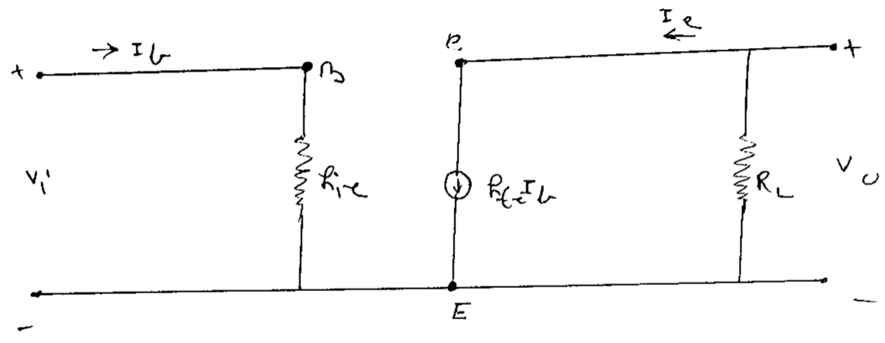

Fig 4

Which shows the major factors controlling the voltage gain. The simplifying assumptions do not have a great effect on design accuracy. The current gain is

$$A_{ie} = \frac{I_c}{I_b} = h_{fe} \rightarrow (vii)$$

Since $I_c = h_{fe} I_b$

Here Input Impedance is

$$R_{ie} = \frac{V_i}{I_b} = \frac{V_{be}}{I_b} = h_{ie} \rightarrow (viii)$$

Output resistance

$$R_{oe} = \frac{1}{h_{oe}} \approx \infty \rightarrow (ix)$$

The power gain is

$$Power\ Gain = |A_{oe}||A_{ie}| = g_m h_{fe} R_L = \frac{h_{fe}^2 R_L}{h_{ie}} \rightarrow (x)$$

Here

$$g_m = \frac{I_c}{V_{be}} = \frac{h_{fe}}{h_{ie}}\ , I_c = h_{fe}\ , h_{fe} I_b = g_m V_{be}$$

Common Base Amplifier:

For common base amplifier the input is applied to the emitter and the output is taken from the collector. The common terminal for both input and output is base. The input signal is applied between the emitter and base terminal while corresponding output signal is taken across collector and base terminal.

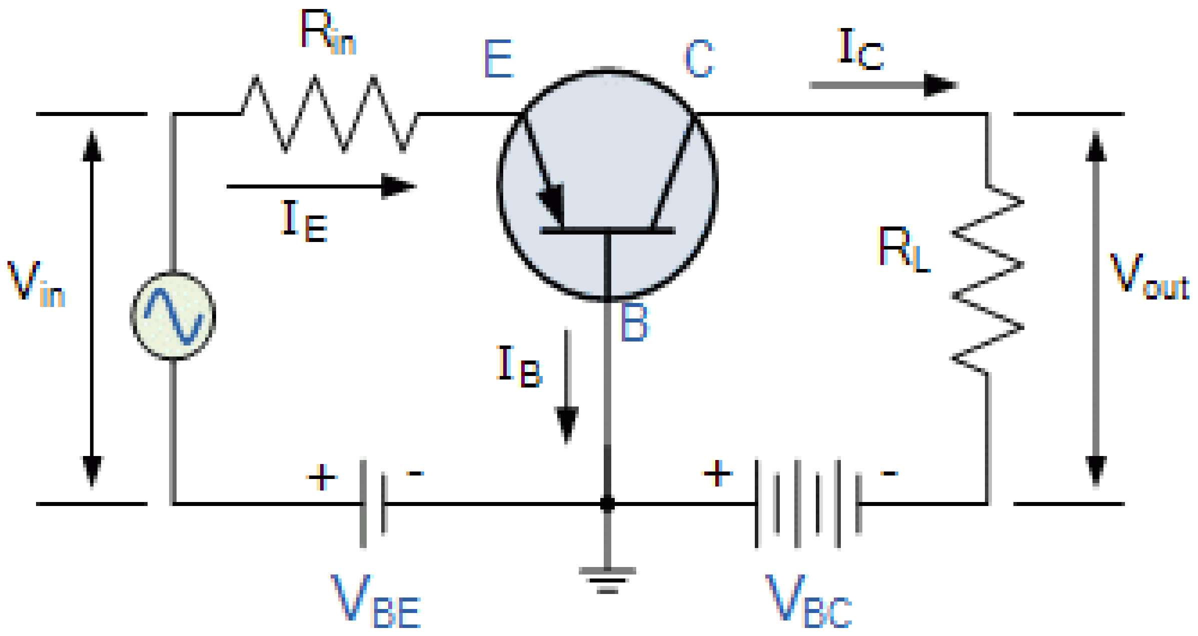

Fig 5

In this case transistor is replaced with h-parameter circuit using CB parameter as shown in $Fig\ 5$ in we revert CE parameters since they are most readily obtained. The input signal is applied between emitter and base and the input current I_e instead of I_b in CE circuit. We can say that

$$h_{ib}I_e = h_{ie}I_b$$

And knowing that

$$I_b = \frac{I_e}{(1 + h_{fe})}$$

We find that

$$h_{ib} = \frac{h_{ie}}{1 + h_{fe}} \rightarrow (xi)$$

Thus we can replace h_{ib} with its equivalent value expressed in CE parameter and the circuit is changed to that as shown in $Fig\ 7$.

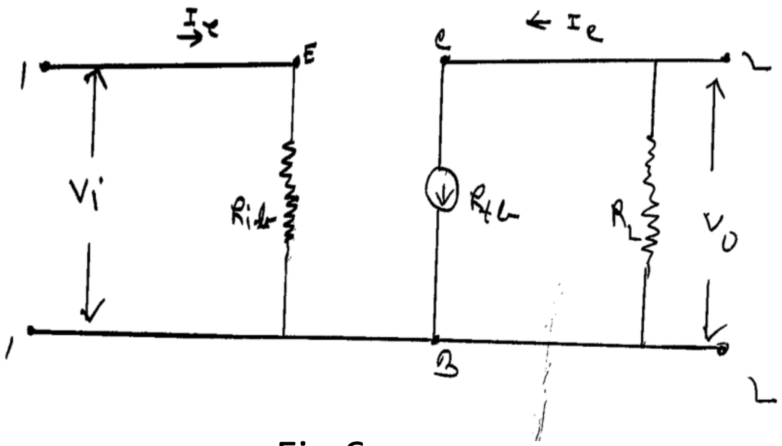

Fig 6

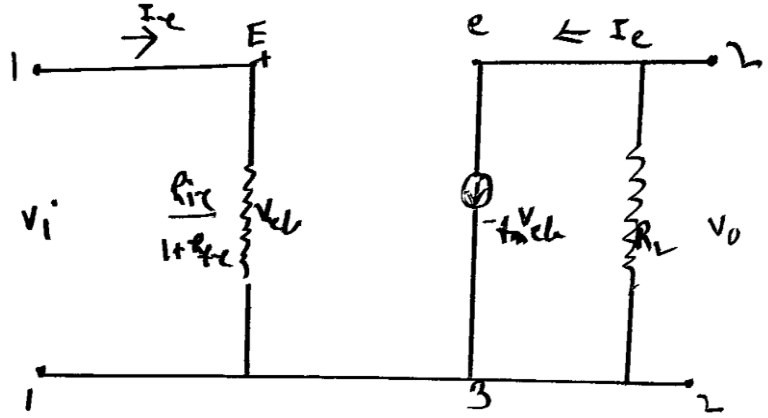

Fig 7

By definition we know that

$$I_c = -\frac{h_{fe}}{1 + h_{fe}} I_e$$

Again

$$\frac{h_{fe}}{1 + h_{fe}} = \alpha$$

We can write

$$V_{eb} = \frac{h_{ie}}{1 + h_{fe}} I_e$$

By taking the ratio of these quantities we find that

$$g_m = \frac{I_c}{V_{eb}} = \frac{-[h_{fe}/(1 + h_{fe}]I_e}{[h_{ie}/(1 + h_{fe})]I_e} = -\frac{h_{fe}}{h_{ie}}$$

$$g_m = -\frac{h_{fe}}{h_{ie}} \rightarrow (xii)$$

The transconductance for CB circuit has same magnitude as far the CE circuit. The negative sign arise because we are using V_{eb} for the input voltage rather than V_{bc} . From circuit $I_c = -g_m V_{eb}$ and output voltage is

$$V_0 = -I_c R_L = g_m R_L V_{eb} \rightarrow (xiii)$$

Since $V_{eb} = V_i$ the voltage gain for CB circuit is

$$A_{vb} = \frac{V_0}{V_i} = g_m R_L \rightarrow (xiv)$$

In CB circuit there is no phase shift in voltage gain. From the above relation we find that the current gain as

$$A_{ib} = \frac{I_e}{I_b} = -\frac{g_m h_{ie}}{1 + h_{fe}} \approx -1 \rightarrow (xv)$$

There is a phase shift of 180^0 in current gain. The input reactance at (1,1) port can be approximate as

$$R_{ib} = \frac{h_{ie}}{1 + h_{fe}} \approx \frac{h_{ie}}{h_{fe}} = \frac{1}{g_m} \rightarrow (xvi)$$

This is low resistance. To find the output resistance at (2,2) port we make $V_i = 0$ which reduce the dependent g_m source to open circuit. The actual resistance across the port is

$$\frac{1}{h_{ob}} = \frac{(1 + h_{fe})}{h_{oe}}$$

And this is usually $1\ M\Omega$ will be neglected as large.

The power gain is

$$Power\ Gain = |A_{vb}||A_{ib}| = g_m R_L \rightarrow (xvii)$$

The current gain is near but less than unity and voltage gain is equal to that of CE amplifier without phase shift. The major advantage of this circuit is its impedance transforming property by which a low impedance source can be power matched to a high resistance load.