SMALL SIGNAL LOW FREQUENCY TRANSISTOR MODELS

All the transistor amplifiers are two port networks having two voltages and two currents. The positive directions of voltages and currents are shown in fig. 1.

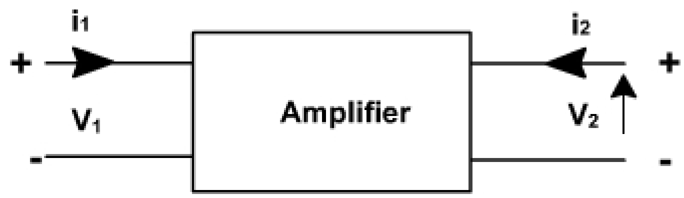

Fig. 1

Out of four quantities two are independent and two are dependent. If the input current i_1 and output voltage v_2 are taken independent then other two quantities i_2 and v_1 can be expressed in terms of i_1 and V_2.

$$v_1 = f_1 (i_1, v_2)$$
$$i_2 = f_2 (i_1, v_2)$$

The equations can be written as

$$v_1 = h_{11} i_1 + h_{12} v_2$$
$$i_2 = h_{21} i_1 + h_{22} v_2$$

where h_{11}, h_{12}, h_{21} and h_{22} are called h-parameters.

$$h_{11} = \left.\frac{v_1}{i_1}\right|_{v_2 = 0}$$

$= h_i =$ input impedance with output short circuit to ac.

$$h_{12} = \left.\frac{v_1}{v_2}\right|_{i_2 = 0}$$

$=h_r$ = fraction of output voltage at input with input open circuited or reverse voltage gain with input open circuited to ac (dimensions).

$$h_{21} = \left.\frac{i_2}{i_1}\right|_{v_2=0}$$

$= h_f$ = negative of current gain with output short circuited to ac.

The current entering the load is negative of I_2. This is also known as forward short circuit current gain.

$$h_{22} = \left.\frac{i_2}{i_1}\right|_{i_2=0}$$

$= h_o$ = output admittance with input open circuited to ac.

If these parameters are specified for a particular configuration, then suffixes e,b or c are also included, e.g. h_{fe} ,h_{ib} are h parameters of common emitter and common collector amplifiers

Using two equations the generalized model of the amplifier can be drawn as shown in fig. 2.

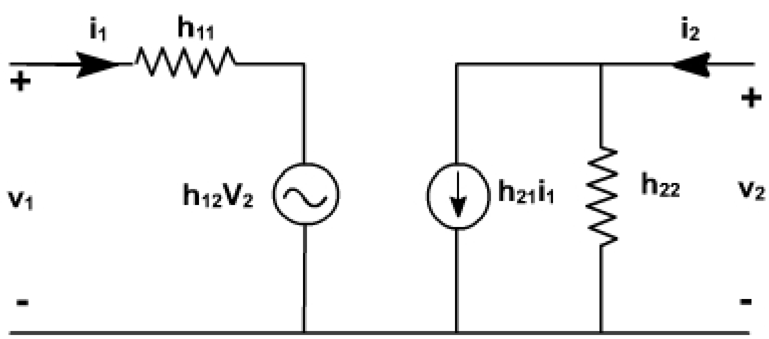

Fig. 2

The hybrid model for a transistor amplifier can be derived as follow:

Let us consider CE configuration as show in fig. 3. The variables, iB, iC ,vC, and vB represent total instantaneous currents and voltages iB and vC can be taken as independent variables and vB, IC as dependent variables.

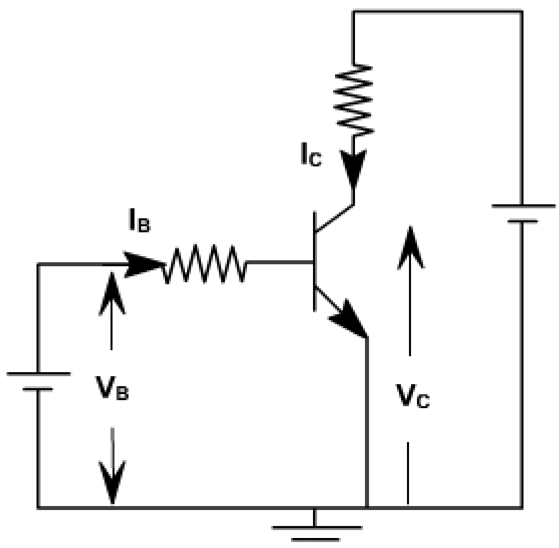

Fig. 3

vB = f1 (iB ,vC)

IC = f2 (iB , vC).

Using Taylor 's series expression, and neglecting higher order terms we obtain.

$$\Delta v_B = \left.\frac{\partial f_1}{\partial i_B}\right|_{v_C} \Delta i_B + \left.\frac{\partial f_1}{\partial v_C}\right|_{i_B} \Delta v_C$$

$$\Delta i_C = \left.\frac{\partial f_2}{\partial i_B}\right|_{v_C} \Delta i_B + \left.\frac{\partial f_2}{\partial v_C}\right|_{i_B} \Delta v_C$$

The partial derivatives are taken keeping the collector voltage or base current constant. The Δ vB, Δ vC, Δ iB, Δ iC represent the small signal (incremental) base and collector current and voltage and can be represented as vb ,ib ,vC ,iC.

$$\therefore v_b = h_{ie}\, i_B + h_{re}\, v_C$$
$$i_C = h_{fe}\, i_B + h_{oe}\, v_b$$

where

$$h_{ie} = \left.\frac{\partial f_1}{\partial i_B}\right|_{v_C} = \left.\frac{\partial v_B}{\partial i_B}\right|_{v_C} ; \qquad h_{re} = \left.\frac{\partial f_1}{\partial v_C}\right|_{i_B} = \left.\frac{\partial v_B}{\partial v_C}\right|_{i_B}$$
$$h_{fe} = \left.\frac{\partial f_2}{\partial i_B}\right|_{v_C} = \left.\frac{\partial i_C}{\partial i_B}\right|_{v_C} ; \qquad h_{oe} = \left.\frac{\partial f_2}{\partial v_C}\right|_{i_B} = \left.\frac{\partial v_B}{\partial v_C}\right|_{i_B}$$

The model for CE configuration is shown in fig. 4.

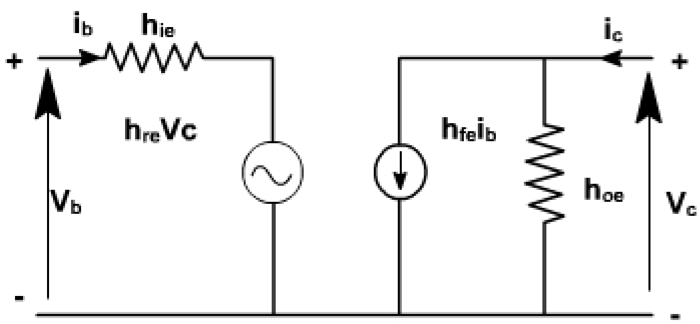

Fig. 4