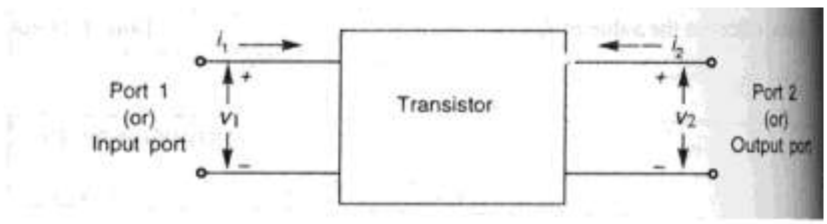
H – Parameter model :-

→ The equivalent circuit of a transistor can be dram using simple approximation by retaining its essential features.

→ These equivalent circuits will aid in analyzing transistor circuits easily and rapidly.

Two port devices & Network Parameters:-

→ A transistor can be treated as a two part network. The terminal behaviour of any two part network can be specified by the terminal voltages V_1 & V_2 at parts 1 & 2 respectively and current i_1 and i_2, entering parts 1 & 2, respectively, as shown in figure.



Two port network

→ Of these four variables V_1, V_2, i_1 and i_2, two can be selected as independent variables and the remaining two can be expressed in terms of these independent variables. This leads to various two part parameters out of which the following three are more important.

1. Z – Parameters (or) Impedance parameters
2. Y – Parameters (or) Admittance parameters
3. H – Parameters (or) Hybrid parameters.

Hybrid parameters (or) h – parameters:-

→ If the input current i_1 and output Voltage V_2 are takes as independent variables, the input voltage V_1 and output current i_2 can be written as

$$V_1 = h_{11} i_1 + h_{12} V_2$$
$$i_2 = h_{21} i_1 + h_{22} V_2$$

The four hybrid parameters h_{11}, h_{12}, h_{21} and h_{22} are defined as follows.

$$h_{11} = [V_1 / i_1] \text{ with } V_2 = 0$$

= Input Impedance with output part short circuited.

$h_{22} = [i_2 / V_2]$ with $i_1 = 0$

= Output admittance with input part open circuited.

$h_{12} = [V_1 / V_2]$ with $i_1 = 0$

= reverse voltage transfer ratio with input part open circuited.

$h_{21} = [i_2 / i_1]$ with $V_2 = 0$

= Forward current gain with output part short circuited.

The dimensions of h – parameters are as follows:

h_{11} - Ω
h_{22} – mhos
h12, h21 – dimension less.

→ as the dimensions are not alike, (ie) they are hybrid in nature, and these parameters are called as hybrid parameters.

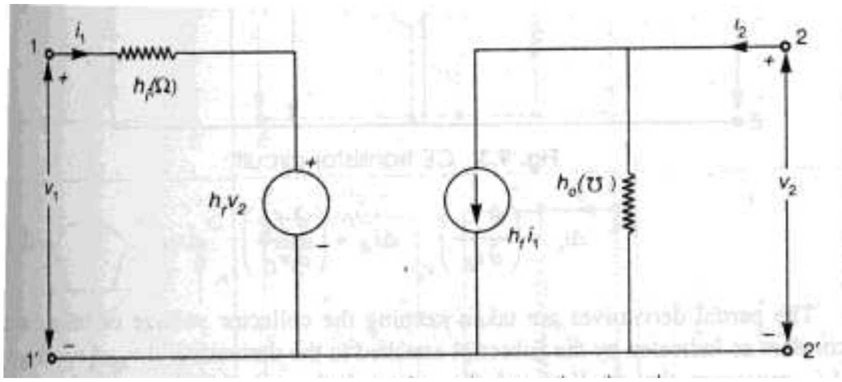
I = 11 = input ; 0 = 22 = output ;
F = 21 = forward transfer ; r = 12 = Reverse transfer.

Notations used in transistor circuits:-

$h_{ie} = h_{11e}$ = Short circuit input impedance
$h_{0e} = h_{22e}$ = Open circuit output admittance
$h_{re} = h_{12e}$ = Open circuit reverse voltage transfer ratio
$h_{fe} = h_{21e}$ = Short circuit forward current Gain.

The Hybrid Model for Two-port Network:-

$$V_1 = h_{11}\, i_1 + h_{12}\, V_2$$
$$I_2 = h_1\, i_1 + h_{22}\, V_2$$
$$\downarrow$$
$$V_1 = h_1\, i_1 + h_r\, V_2$$
$$I_2 = h_f\, i_1 + h_0\, V_2$$

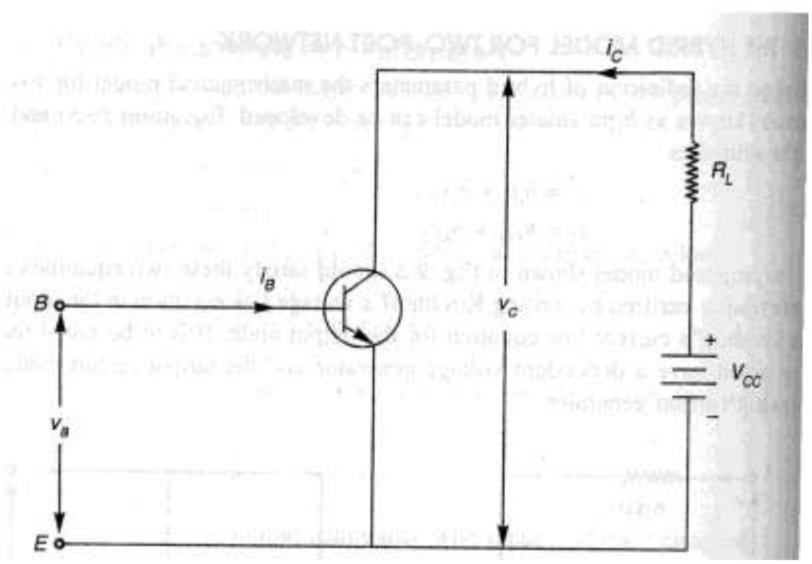


The Hybrid Model for Two-port Network

<u>Transistor Hybrid model</u>:-

Use of h – parameters to describe a transistor have the following advantages.

1. h – parameters are real numbers up to radio frequencies .
2. They are easy to measure
3. They can be determined from the transistor static characteristics curves.
4. They are convenient to use in circuit analysis and design.
5. Easily convert able from one configuration to other.
6. Readily supplied by manufactories.



<u>CE Transistor Circuit</u>

To Derive the Hybrid model for transistor consider the CE circuit shown in figure.The variables are i_B, i_c, $v_{B(=v_{BE})}$ and $v_{c(=v_{CE})}$. i_B and v_c are considered as independent variables.

Then , $v_B = f_1(i_B, v_c)$ ----------------------(1)

$i_C = f_2(i_B, v_c)$ ----------------------(2)

Making a Taylor's series expansion around the quiescent point I_B, V_C and neglecting higher order terms, the following two equations are obtained.

$$\Delta v_B = \left(\partial f_1/\partial i_B\right)_{Vc} . \Delta i_B + \left(\partial f_1/\partial v_c\right)_{IB} . \Delta v_C \text{ ---------------(3)}$$

$$\Delta i_C = \left(\partial f_2/\partial i_B\right)_{Vc} . \Delta i_B + \left(\partial f_2/\partial v_c\right)_{IB} . \Delta v_C \text{ ----------------(4)}$$

The partial derivatives are taken keeping the collector voltage or base current constant as indicated by the subscript attached to the derivative.

Δv_B , Δv_C , Δi_C , Δi_B represent the small signal(increment) base and collector voltages and currents,they are represented by symbols v_b , v_c , i_b and i_c respectively.

Eqs (3) and (4) may be written as

$$V_b = h_{ie}\, i_b + h_{re}\, V_c$$
$$i_c = h_{fe}\, i_b + h_{oe}\, V_c$$

Where $h_{ie} = \left(\partial f_1/\partial i_B\right)_{Vc} = \left(\partial v_B/\partial i_B\right)_{Vc} = \left(\Delta v_B /\Delta i_B\right)_{Vc} = \left(v_b / i_b\right)_{Vc}$

$$h_{re} = \left(\partial f_1/\partial v_c\right)_{IB} = \left(\partial v_B/\partial v_c\right)_{IB} = \left(\Delta v_B /\Delta v_c\right)_{IB} = \left(v_b /v_c\right)_{IB}$$

$$h_{fe} = \left(\partial f_2/\partial i_B\right)_{Vc} = \left(\partial i_c /\partial i_B\right)_{Vc} = \left(\Delta i_c /\Delta i_B\right)_{Vc} = \left(i_c / i_b\right)_{Vc}$$

$$h_{oe} = \left(\partial f_2/\partial v_c\right)_{IB} = \left(\partial i_c /\partial v_c\right)_{IB} = \left(\Delta i_c /\Delta v_c\right)_{IB} = \left(i_c /v_c\right)_{IB}$$

The above equations define the h-parameters of the transistor in CE configuration.The same theory can be extended to transistors in other configurations.

Hybrid Model and Equations for the transistor in three different configurations are are given below.