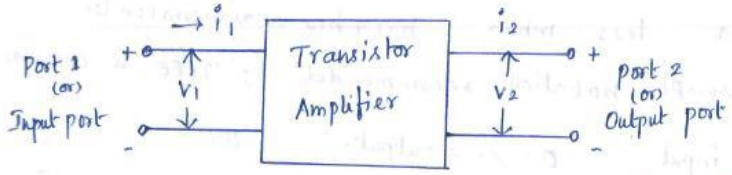
Topic 2.1 : Two port devices and Network parameters (Z,Y,H parameters)

Method of drawing Small-Signal Equivalent Circuit

* A transistor can be treated as a two port Network.
* The terminal behaviour of any 2 port network can be specified by the terminal voltage V_1 & V_2 at port 1 & port 2 respectively & current's i_1 & i_2 entering port 1 & 2 respectively as shown in Fig:



* From 4 variables V_1, V_2 & i_1, i_2 2 can be selected as independent variables & remaining 2 can be expressed interms of the independent variables.
* The transistor can be analyzed using various 2 port parameters which of the following are more important.

1. Z - parameter (or) Impedance parameter
2. Y - parameter (or) Admittance parameter
3. H - parameter (or) Hybrid parameter.

H-parameter (or) Hybrid parameters:

* 2 Mark

* If the input current i_1 & the output voltage V_2 are taken as independent variables, the input voltage V_1 & output current i_2 can be expressed as

$$V_1 = h_{11} i_1 + h_{12} V_2 \quad \text{—①}$$

$$i_2 = h_{21} i_1 + h_{22} V_2 \quad \text{—①}$$

* The 4 h-parameters $h_{11}, h_{12}, h_{21}, h_{22}$ are defined as

$h_{11} = \left[\frac{V_1}{i_1}\right]$ with $V_2 = 0$ in eqn ① → input impedance with output port short circuited.

$h_{22} = \left[\frac{i_2}{v_2}\right]$ with $i_1 = 0$ in eqn ② ⇒ output admittance with input port short circuited.

$h_{12} = \left[\frac{v_1}{v_2}\right]$ with $i_1 = 0$ in eqn ① ⇒ Reverse voltage transfer gain with input port open circuited.

$h_{21} = \left[\frac{i_2}{i_1}\right]$ with $v_2 = 0$ in eqn ② ⇒ Forward current gain with output port short circuited.

* The dimensions of h-parameters are

$h_{11} = \Omega$ $h_{22} = mhos$ h_{21} & h_{12} = dimensionless

* Alternate subscript notation recommended by IEEE is commonly used

i = 11 = input ; o = 22 = output — ③

f = 21 = forward Transfer r = reverse Transfer — ④

* According to eqn ③ & ④ for common Emitter Amplifier

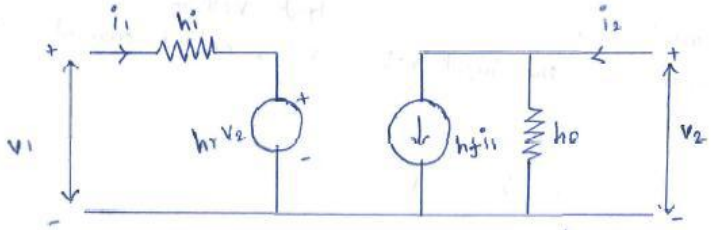
$h_{11} = h_{ie}$; $h_{22} = h_{oe}$ — ⑤

$h_{12} = h_{re}$; $h_{21} = h_{fe}$ — ⑥

① ⇒ $V_1 = h_i i_1 + h_r V_2$ — ⑦

② ⇒ $i_2 = h_f i_1 + h_o V_2$ — ⑧

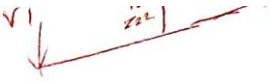
* For this equation we want to draw equivalent circuit & it verify using KVL to input, KCL to output node.



H-parameter for all the 3 configurations

parameters	CE	CB	CC
Input resistance (h_{11})	h_{ie}	h_{ib}	h_{ic}
Reverse voltage gain	h_{re}	h_{rb}	h_{rc}
Forward Transfer current gain	h_{fe}	h_{fb}	h_{fc}
Output admittance	h_{oe}	h_{ob}	h_{oc}

① Z parameters or Impedance parameters



i_1, i_2 - independent variables

V_1, V_2 - are given as

$$V_1 = Z_{11} i_1 + Z_{12} i_2$$

$$V_2 = Z_{21} i_1 + Z_{22} i_2$$

Four impedance parameters, Z_{11}, Z_{22}, Z_{12} and Z_{21} are defined as

$$Z_{11} = \left[\frac{V_1}{i_1}\right] \text{ with } i_2 = 0$$

= input impedance with output port open circuited

$$Z_{22} = \left[\frac{V_2}{i_2}\right] \text{ with } i_1 = 0$$

= output impedance with input port open circuited

$$Z_{12} = \left[\frac{V_1}{i_2}\right] \text{ with } i_1 = 0$$

= reverse transfer impedance with port 1 open circuited

$$Z_{21} = \left[\frac{V_2}{i_1}\right] \text{ with } i_2 = 0$$

= Forward transfer impedance with port 2 open circuited

② Y parameters or Admittance Parameters

V_1, V_2 – independent variables

i_1, i_2 are given by

$$i_1 = y_{11} V_1 + y_{12} V_2$$

$$i_2 = y_{21} V_1 + y_{22} V_2$$

$y_{11}, y_{12}, y_{21}, y_{22}$ → short circuit admittance parameters or simply admittance parameters

$y_{11} = \left[\frac{i_1}{v_1}\right]$ with $v_2 = 0$

= input admittance with port 2 short circuited

$y_{22} = \left[\frac{i_2}{v_2}\right]$ with $v_1 = 0$

= output admittance with port 1 short circuited

$y_{12} = \left[\frac{i_1}{v_2}\right]$ with $v_1 = 0$

= reverse transfer admittance with port 1 short circuited

$y_{21} = \left[\frac{i_2}{v_1}\right]$ with $v_2 = 0$

= Forward transfer admittance with port 2 short circuited