Hybrid (h) Parameters

By

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Hybrid or h parameter

- Widely used in modeling electronic components and circuits particularly the transistor. It is call hybrid because both the open and short circuit parameters are used.
- Here the difference with the Z and Y parameter is that we use voltage at one port and the current at the other port

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

Forming the equations

$$V_1 = h_{11}I_1 + h_{12}V_2$$

$$I_2 = h_{21}1I_1 + h_{22}V_2$$

h Parameters

- Forming the equations

  $V_1 = h_{11}I_1 + h_{12}V_2$

  $I_2 = h_{21}I_1 + h_{22}V_2$

- Assuming short circuit at output port so V2=0

  $V_1 = h_{11}I_1$ or $h_{11} = V_1 / I_1$.

  $I_2 = h_{21}1I_1$ or $h_{21} = I_2 / I_1$

h_{11} is called as input impedance measured in Ohms while $h_{21}1$ is forward current gain which is unitless quantity

- Now assuming the input to be open circuited so I1=0, rewriting the equations we get

  $V_1 = h_{12}V_2$ or $h_{12} = V_1 / V_2$

  $I_2 = h_{22}V_2$ $h_{22} = I_2 / V_2$

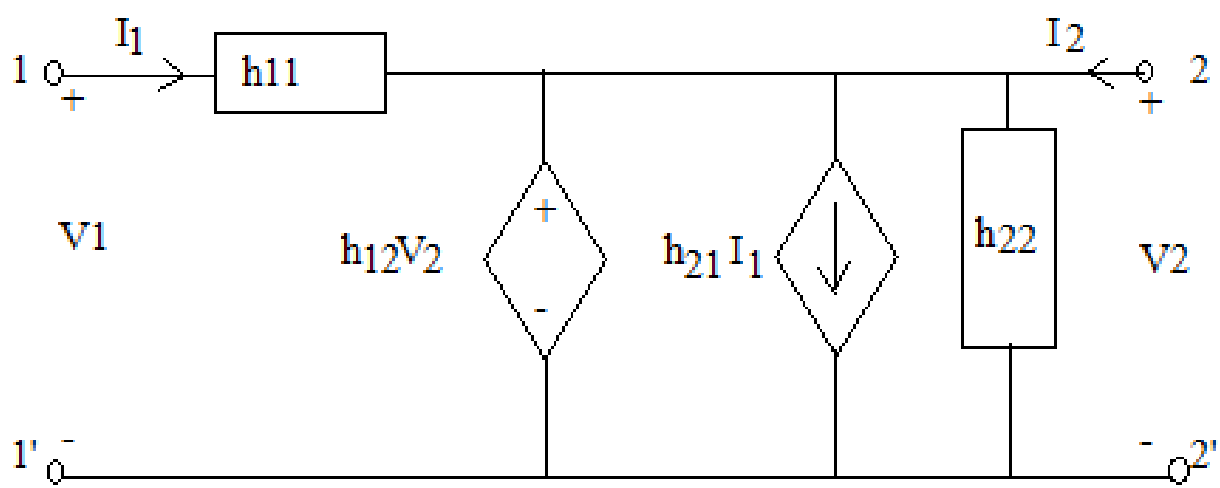
- h_{12} is called as reverse voltage gain and h_{22} is called output admittance of the circuit.
- The equivalent circuit of the h parameter is shown below:

Equivalent Circuit

From the equations

$V_1 = h_{11}I_1 + h_{12}V_2$

$I_2 = h_{21}I_1 + h_{22}V_2$



Ex. A common emitter transistor amplifier hardware circuit can be represented by a four terminal network. The signal source strength being 1mV, a resistive load of 10kOhm is applied at the output of the network. The following data is given:

Short circuit input impedance hi= 2kOhm

Short circuit forward current ratio hf = 50

Open circuit output admittance ho = $25x10^{-6}$.

Open circuit reverse voltage gain hr = $3x10^{-4}$.

Express these values in terms of h-parameters, Determine:

i. h-parameter equivalent circuit

ii. Voltage drop across the load

iii. Load current

iv. Voltage gain

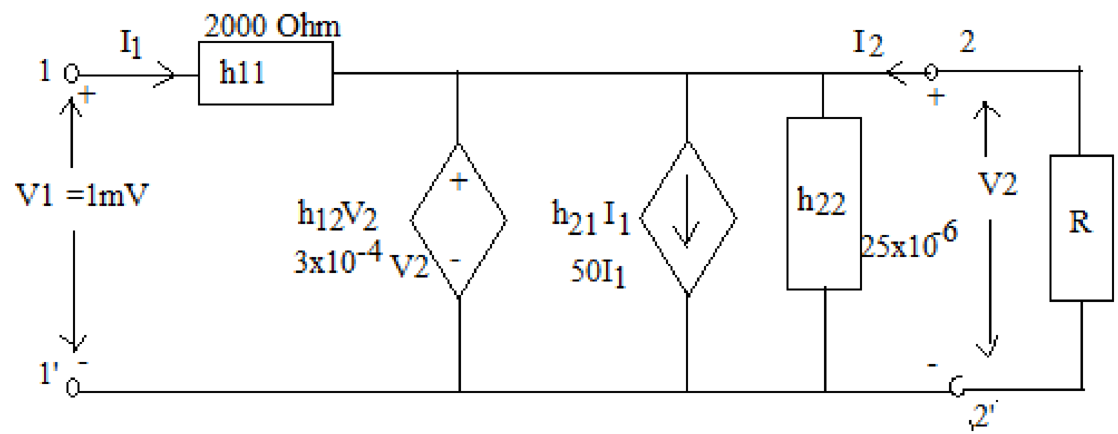
v. Current Gain

ANS

h11 = hi = 2kOhm h12 = hr = $3x10^{-4}$. h21 =hf 50 h22=ho = $25x10^{-6}$

H parameter equations being : $V_1 = h_{11}I_1 + h_{12}V_2$ $I_2 = h_{21}I_1 + h_{22}V_2$

- (i) Equivalent circuit



ii. KVL at input port $V_1 = h_{11}I_1 + h_{12}V_2$

$1mV = 2000I1 + 3x10^{-4}.V2$

$V2 = (1x10^{-3} - 2000I1)/ 3x10^{-4}$....................(i)

and $I_2 = h_{21}I_1 + h_{22}V_2 = 50I1 + 3x10^{-4}V2$

$-V_2/R = 50I1 + 25x10^{-6}V_2$; $-V_2/10x10^3 = 50I1 + 25x10^{-6}V_2$

-I1

$-I1 = (25x10^{-6} + 1/10x10^3)\ V_2$.

$I1=(125x10^{-6})/50$

Substituting this value of I1in eqn (i) we get:

$V_2 = (1x10^{-3} – 2000x\ 125x10^{-6}/50)/ 3x10^{-4} = -0.213V$

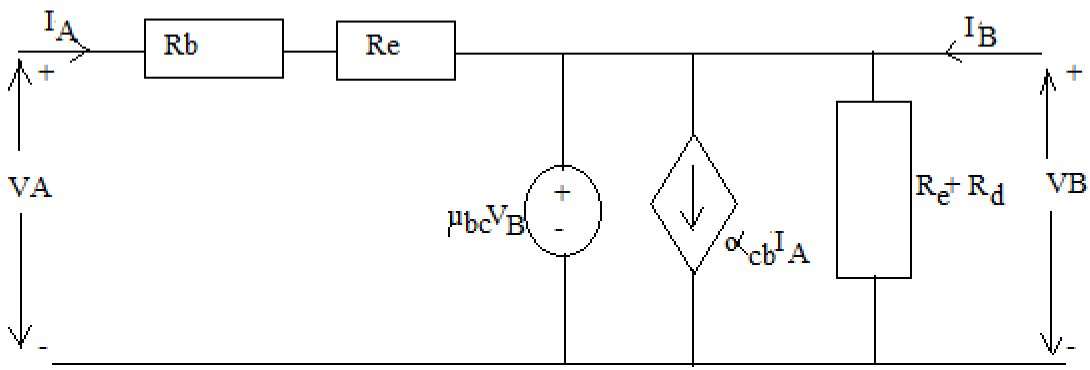
(iii) Load Current

$I = V_2/R = -0.213/ 10x10^{-3}. = -21.3uA$ (-ve means opposite direction)

(iv) Voltage Gain of the circuit $V_2/V_1 = -0.213/0.001 = -213$

(v) Current Gain = I_2/I_1.

Q. Find the h parameter for the CE transistor equivalent circuit shown below



ANS:

Apply KVL at the input: VA = (Rb + Re)IA + ubcVB

Apply KCL at the output port we get

IB = αcbIA + VB/(Re+Rd)

Rearranging in matrix form

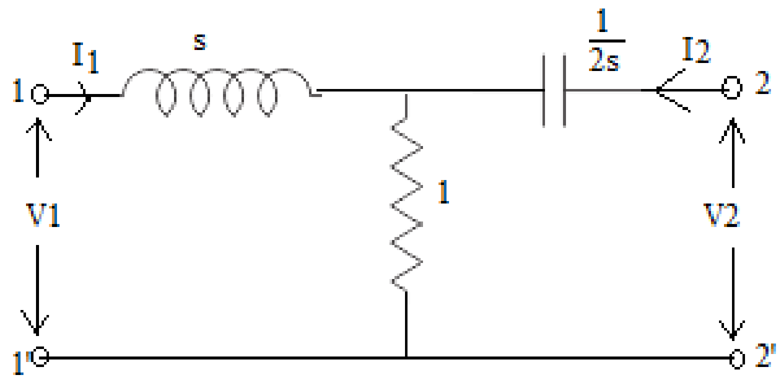
$$\begin{bmatrix} V_A \\ I_B \end{bmatrix} = \begin{bmatrix} (R_b + R_e) & u_{bc} \\ \alpha_{cb} & \dfrac{1}{R_e + R_d} \end{bmatrix} \begin{bmatrix} I_A \\ V_B \end{bmatrix}$$

Therefore:

h11 = (Rb + Re); h12 = ubc

h21 = αcb h22 = 1/(Re+Rd)

HW-1 : For the circuit given below, find the h parameters



HW-2: Determine the h parameters for a transistor in middle frequency range is represented as shown in figure below.