Analog Electronic Circuits
(UEC301)

By

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THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
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Subject: Analog Electronic Circuits (UEC301)

Faculty names: Dr. Mayank Kumar Rai (Associate Professor & Course Coordinator)

Topic of today's Lecture : Small Signal Model and Operation of BJT-III

Key points

- ✓ **Hybrid Parameters (h parameters)**
- ✓ **Determination of h parameters**
- ✓ **h parameter equivalent linear circuit**
- ✓ **h parameters and equivalent hybrid model of BJT**
- ✓ **Determination of the h parameters in BJT**
- ✓ **Low frequency analysis of a transistor amplifier circuit using h parameters**

Contents of this lecture are based on the following books:

- *Jacob Milman & and C.C.Halkias, **"Integrated Electronics Analog and Digital Circuit and Systems"** Second Edition.*
- *Adel S. Sedra & K. C. Smith, **"MicroElectronic Circuits Theory and Application"** Fifth Edition.*
- *Robert L. Boylestad & L. Nashelsky, **"Electronic Devices and Circuit Theory"** Eleventh Edition.*

Hybrid Parameters (h parameters)

Figure 1:Two port network.

$$v_1 = h_{11} i_1 + h_{12} v_2 \qquad \text{.........(1)}$$

$$i_2 = h_{21} i_1 + h_{22} v_2 \qquad \text{..........(2)}$$

Determination of h parameters

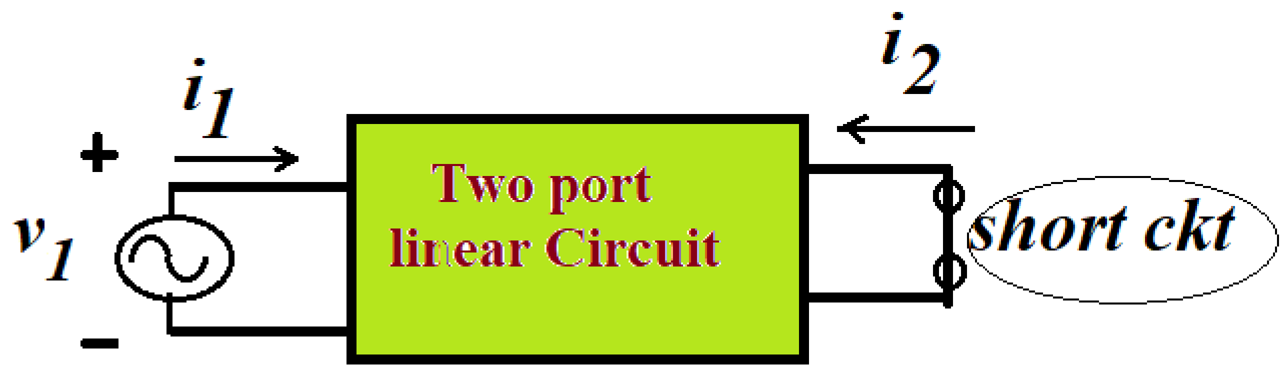


Figure 2:Two port network with output shorted .

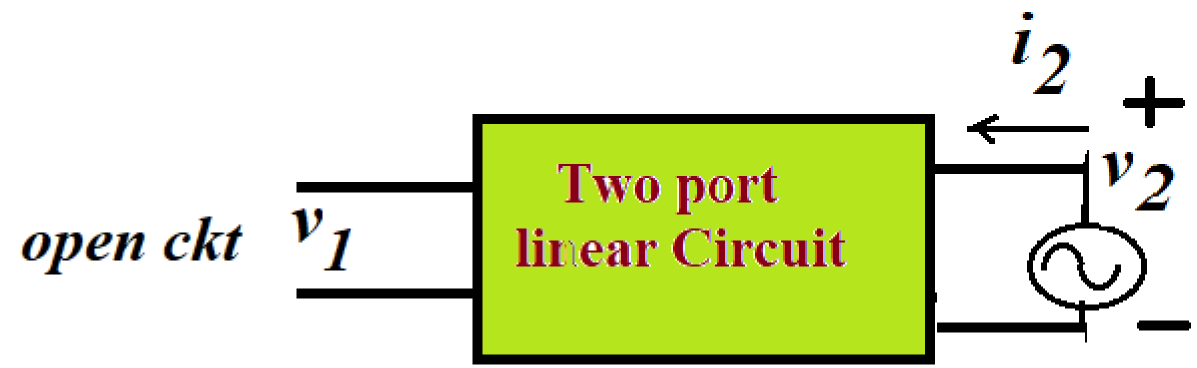


Figure 3:Two port network with open input.

(i) Putting v_2=0 in Eqs.(1) and (2)

$v_1=h_{11}i_1+h_{12}\,x0$ $\quad h_{11}$(Input impedance)$=\dfrac{v_1}{i_1}$ for v_2=0 i.e., output shorted

$i_2=h_{21}i_1+h_{22}\,x0$ $\quad h_{21}$(Current gain)$=\dfrac{i_2}{i_1}$ for v_2=0 i.e., output shorted

(ii) Putting i_1=0 in Eqs.(1) and (2)

$v_1=h11\,x0+h_{12}v_2$ $\quad h_{12}$(voltage feedback ratio)$=\dfrac{v_1}{v_2}$ for i_1=0 i.e., input open

$i_2=h_{21}\,x0+h_{22}v_2$ $\quad h_{22}$(output admittance)$=\dfrac{i_2}{v_2}$ for i_1=0 i.e., input open

h parameter equivalent linear circuit

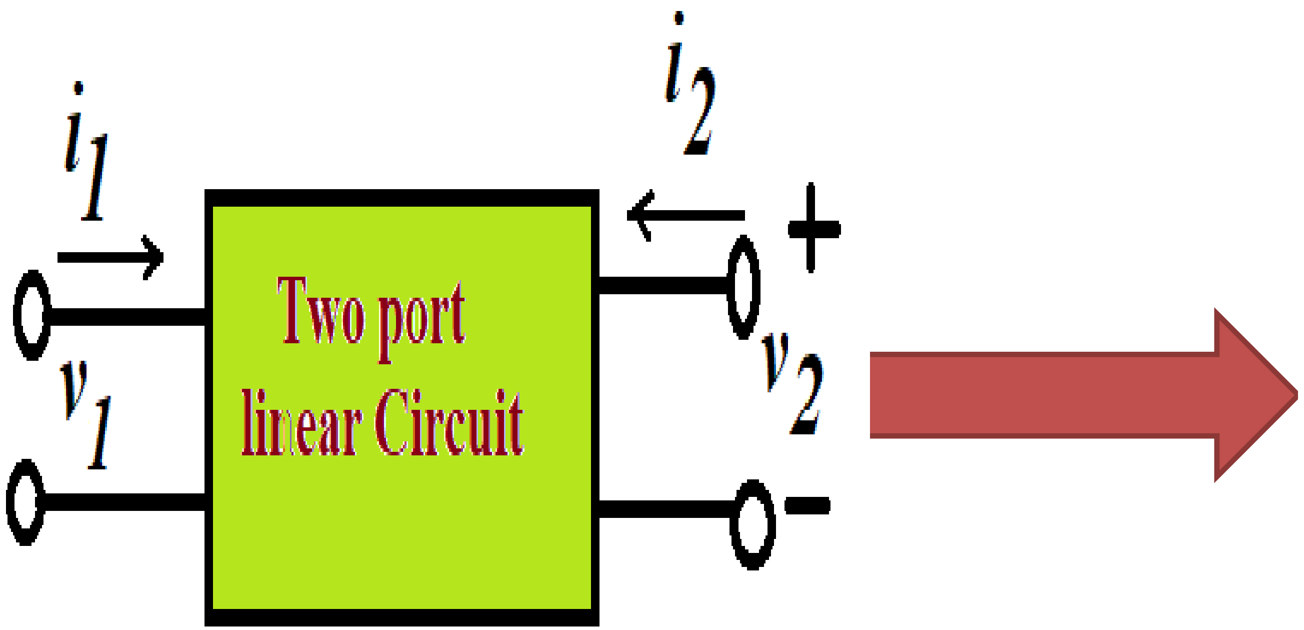


Figure 4:Two port network circuit.

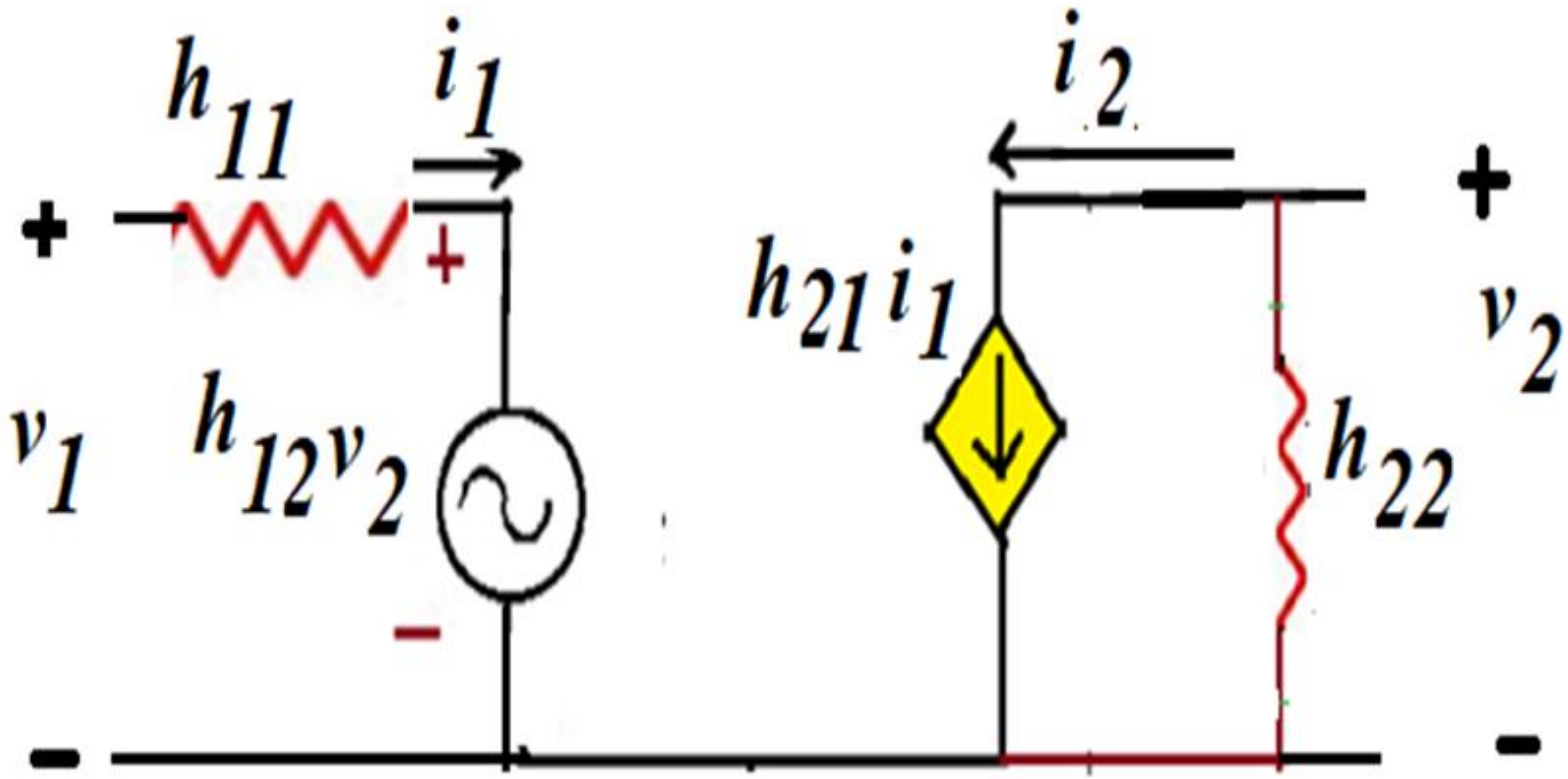


Figure 5:Two port equivalent linear circuit.

h parameters and equivalent hybrid model of BJT

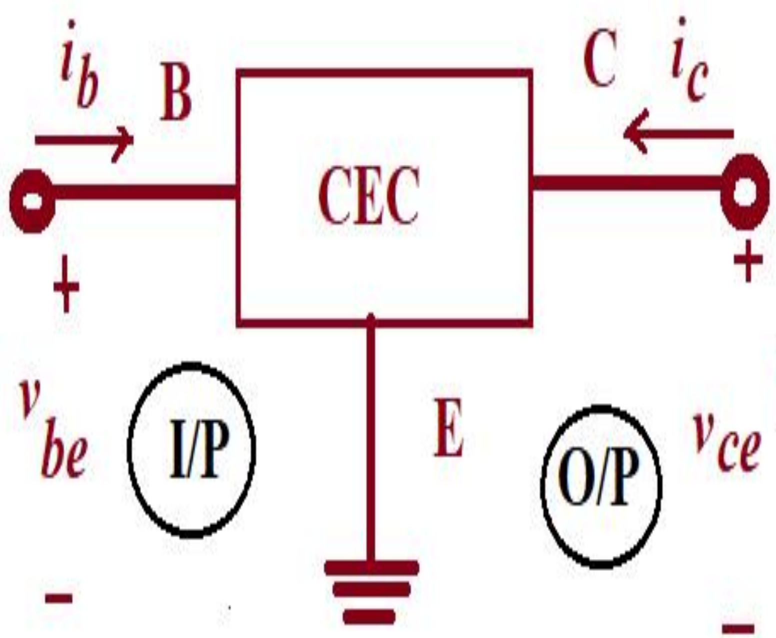


Figure 6:Two port network of CEC.

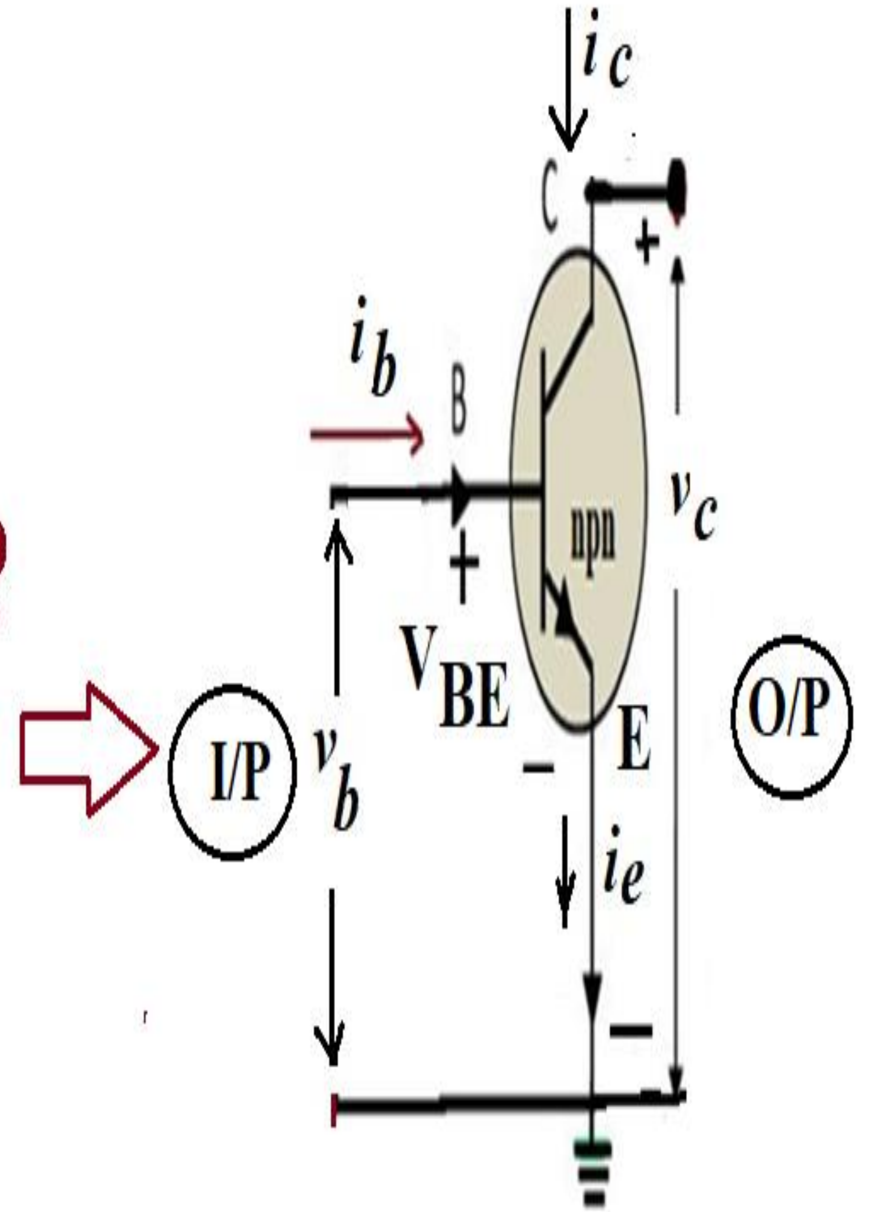


Figure 7: npn transistor connected in Common emitter.

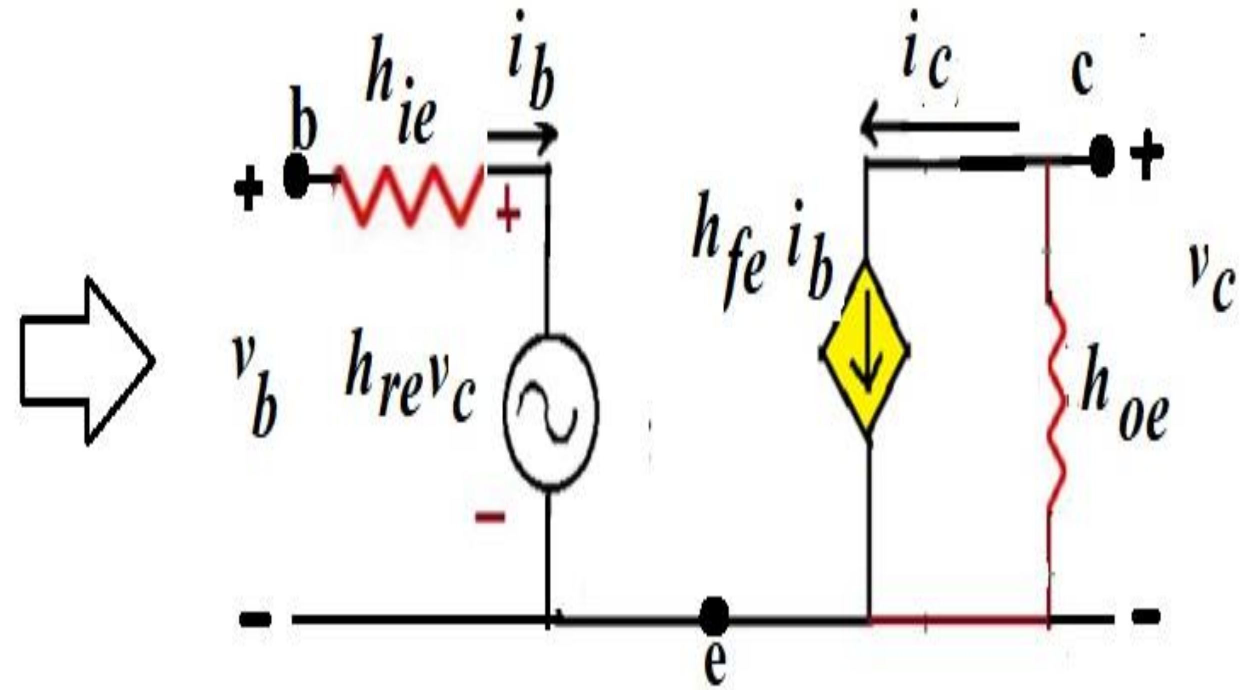


Figure 8:Equivalent hybrid model of BJT

Determination of the h parameters in BJT

$v_1 = h_{11} i_1 + h_{12} v_2$ ....(1)

$i_2 = h_{21} i_1 + h_{22} v_2$ ....(2)

$v_{be} = h_{ie}\, i_1 + h_{re}\, v_{ce}$ ....(3)

$i_c = h_{fe}\, i_1 + h_{oe}\, v_{ce}$ ....(4)

$$h_{ie}\,(\text{Input impedance}) = \frac{v_{be}}{i_b} \quad \text{for } v_{ce}=0$$

$$h_{fe}\,(\text{Current gain}) = \frac{i_c}{i_b} \quad \text{for } v_{ce}=0$$

$$h_{re}\,(\text{voltage feedback ratio}) = \frac{v_{be}}{v_{ce}} \quad \text{for } i_b=0$$

$$h_{oe}\,(\text{output admittance}) = \frac{i_c}{v_{ce}} \quad \text{for } i_b=0$$

Low frequency analysis of a transistor amplifier circuit using h parameters

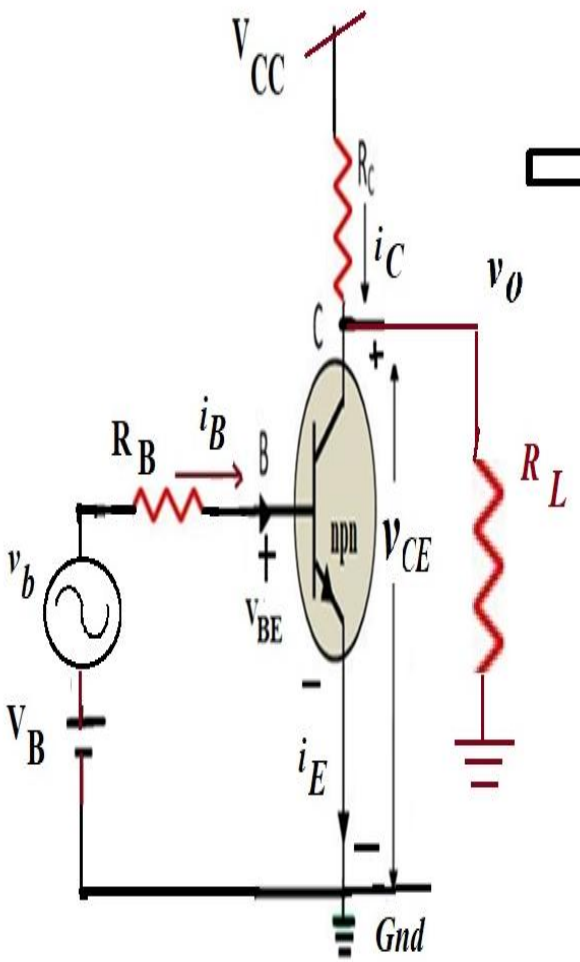


Figure 9:Single stage transistor amplifier.

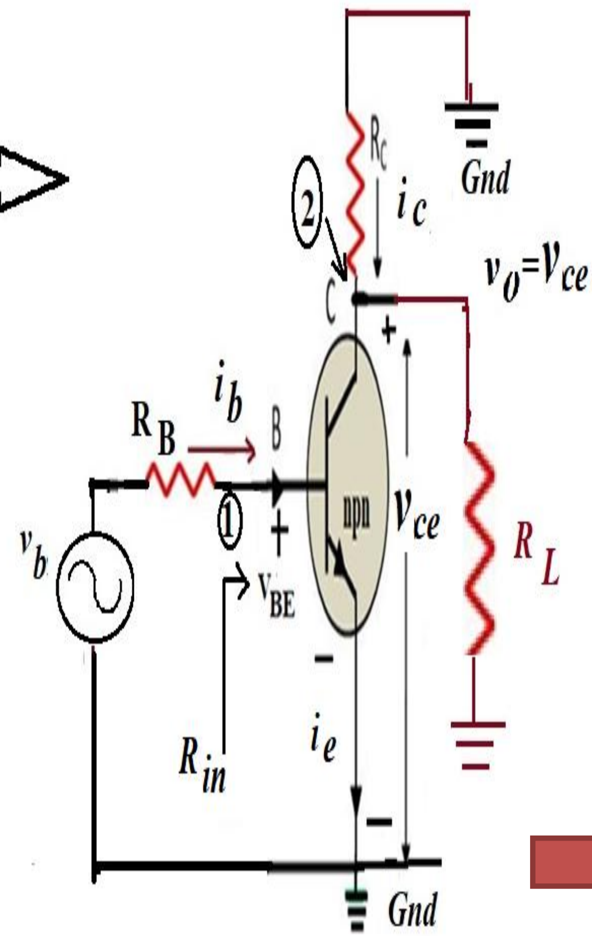


Figure 10:Equivalent ac signal based circuit.

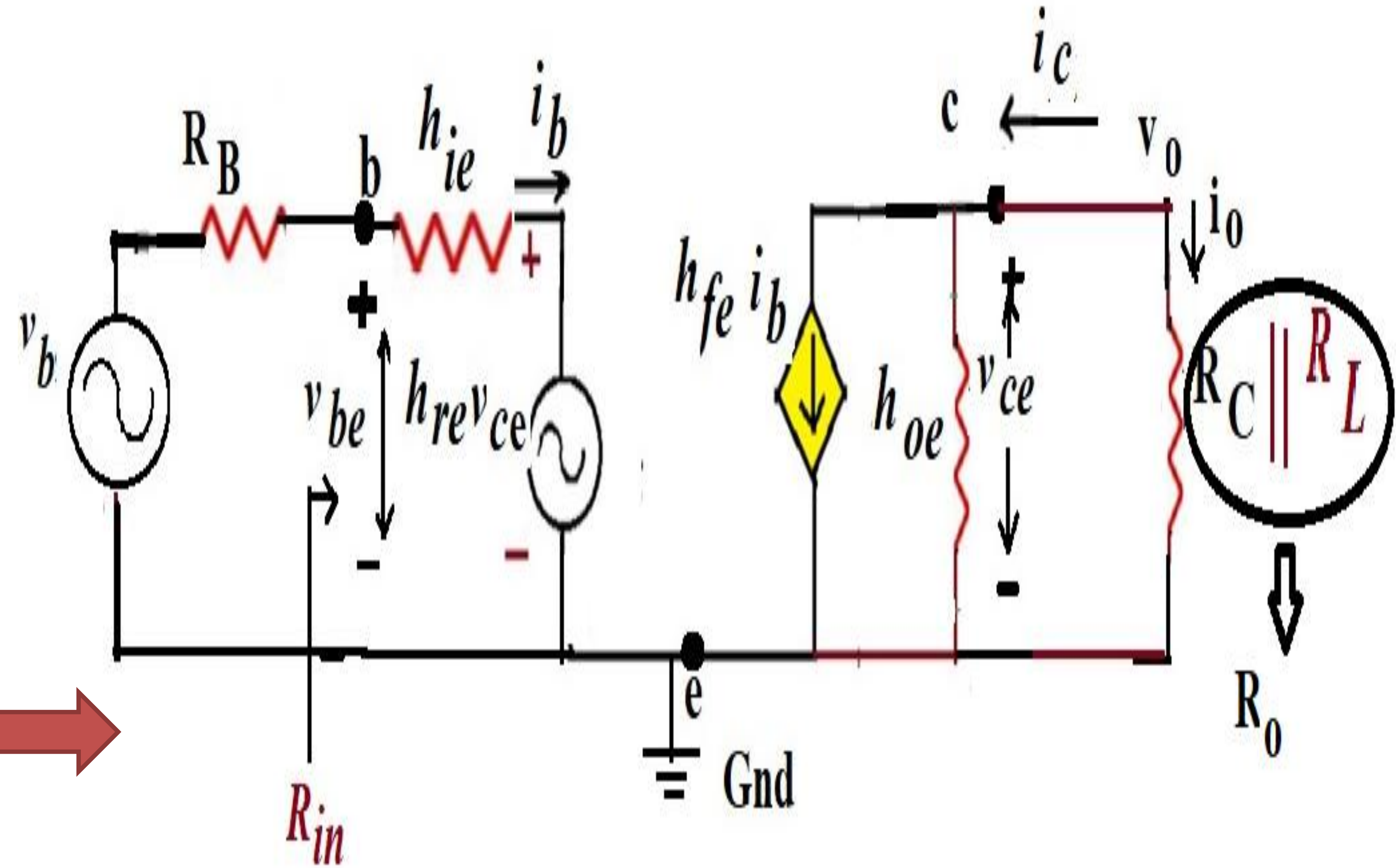
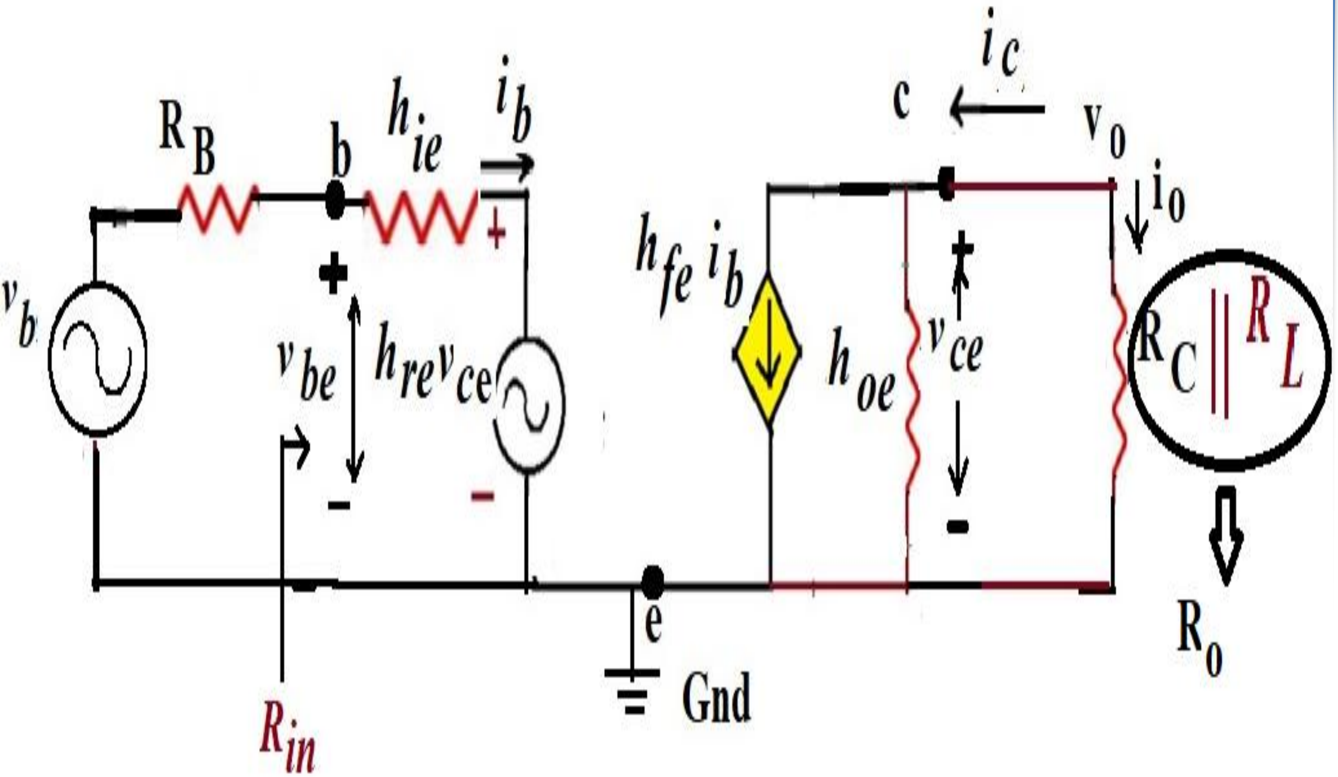


Figure 11:Small signal hybrid model equivalent circuit.



The Current Gain

$$A_o = \frac{i_o}{i_b} = -\frac{i_c}{i_b} \quad \text{....................(5)}$$

k.c.l. to collector side

$$i_c = h_{fe}\, i_b + h_{oe}\, v_{ce} \quad \text{..............................(6)}$$

Substituting $v_{ce} = i_o R_o = -\,i_c R_o$ *in Eq.(6), we obtain*

$$A_o = \frac{i_o}{i_b} = -\frac{i_c}{i_b} = -\frac{h_{fe}}{1+h_{oe}R_o} \quad \text{.......(7)}$$

The Input Resistance

$$R_{in} = \frac{v_{be}}{i_b} \quad \text{........................(8)}$$

k.v.l. to base side, we have

$$v_{be} = h_{ie}\, i_b + h_{re}\, v_{ce} \quad \text{........................(9)}$$

$$R_{in} = \frac{h_{ie}\, i_b + h_{re}\, v_{ce}}{i_b} = h_{ie} + h_{re}\frac{v_{ce}}{i_b} \quad \text{..........(10)}$$

Substituting $v_{ce} = i_o R_o = -\,i_c R_o = A_o i_b R_o$ *in Eq.(10), we obtain*

$$R_{in} = h_{ie} + h_{re}\frac{A_o i_b R_o}{i_b} = h_{ie} - \frac{h_{re}h_{fe}}{(1/Ro)+h_{oe}} \quad \text{.....(11)}$$

The Voltage gain

$$A_v = \frac{v_{ce}}{v_{be}} = \frac{A_o i_b R_o}{R_{in} i_b} = \frac{A_o R_o}{R_{in}} \quad \text{...............(12)}$$

Thank You