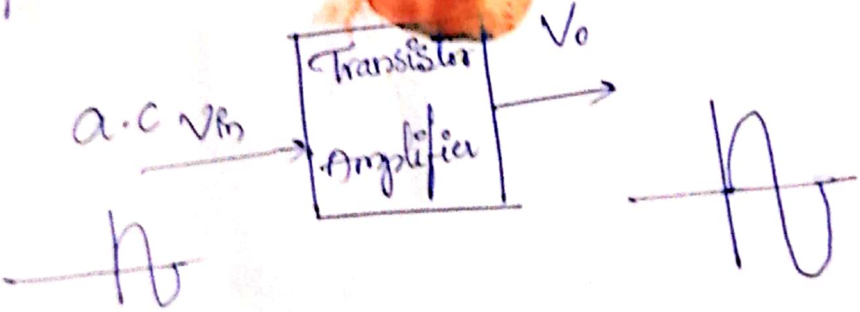
UNIT-I

SINGLE STAGE & MULTI STAGE AMPLIFIERS

Single Stage Amplifiers :

Amplifiers :- A circuit that increases the amplitude of the given input signal is called an amplifier.

→ A small a.c. signal is fed to the amplifier and is obtained as a larger a.c signal of the same frequency at the output.



Exs: 1) In radio, television and other communication circuits.

2) In discrete circuits, BJT and FET are used as amplifying elements.

Depending on the nature and level of amplification and impedance matching requirements, different types of amplifiers can be considered.

Classification of Amplifiers :-

Classification of amplifiers can be done in many ways based on various methods.

1) Based on active device used

   (a) BJT Amplifier (b) FET Amplifier

2) Based on common Terminal used (Based on configuration)

BJT	FET
(a) Common Base Amplifier	Common Gate Amplifier
(b) Common Emitter Amplifier	Common Source Amplifier
(c) Common Collector Amplifier	Common Drain Amplifier

3) Based on the no. of Amplification Stages

   (a) One stage - Single Stage Amplifiers (Voltage Amplifiers)

   (b) More than one stage - Multi Stage Amplifiers

4) Based on input Signal strength

ⓐ Small Signal Amplifiers (Voltage Amplifiers)

ⓑ Large Signal Amplifiers (power Amplifiers)

5) Based on Load Line Analysis

ⓐ Linear Amplifiers

ⓑ Non-Linear Amplifiers

6) Based on the Coupling methods

ⓐ RC coupled amplifier

ⓑ Transformer Coupled amplifier

ⓒ Direct coupled amplifier

7) Based on the operating point (Q point) (I_C, V_{CE})

ⓐ Class A Amplifier

ⓑ Class B Amplifier

ⓒ Class AB Amplifier

ⓓ Class C Amplifier

8. Based on the Band Width
   a. Narrow band amplifiers
   b. Wide band amplifiers

9. Based on Operating frequency range
   a. Low frequency - AF amplifiers (Audio frequency)
   b. Mid frequency - IF amplifiers (Intermediate)
   c. High frequency - RF amplifiers (Radio)

10. Based on feed back
   a. Voltage Series feedback amplifier
   b. Voltage Shunt feed back amplifier
   c. Current Series feed back amplifier
   d. Current Shunt feed back amplifier

11. Depending upon the type of load impedance
   a. Untuned amplifiers
   b. Tuned amplifiers

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Hybrid Parameters:

Hybrid parameters are commonly known as h-parameters. These are generally used to determine amplifier characteristic parameters. such as current gain (A_I), Voltage gain (A_V), Input resistance (R_i) & Output resistance (R_o).

Amplifier characteristic parameters may be determined by current gain β and values of the other circuit components.

This approach has the following advantages:

(i) values of the circuit components are easily available

(ii) the procedure followed is quite simple and easily understandable

(iii) The results obtained are not very accurate is the drawback.

It is because of the fact, that base and collector circuits of a transistor are not completely independant of each other.

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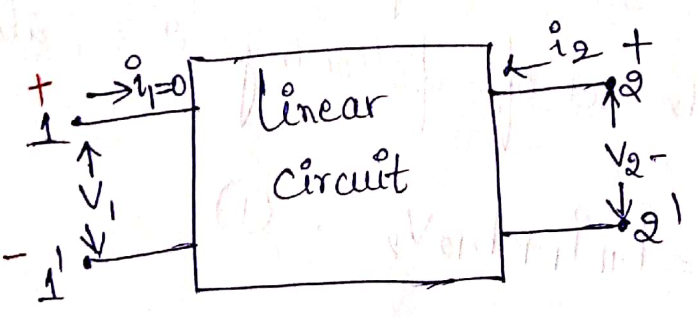
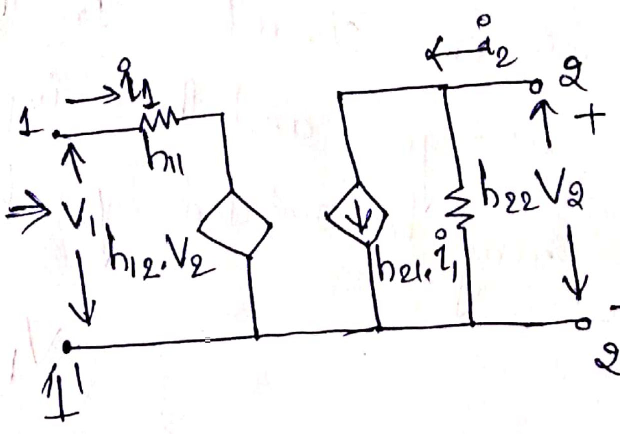
These drawbacks are removed by the usage of hybrid parameters.

The h-parameters give a very accurate results in transistor amplifier circuit analysis.

h-parameter of a Linear circuith

The figure shows the model of a linear circuital device. A circuit is represented by a box and has four terminals ie; two terminals 1, 1' for input and 2 terminals 2, 2' for the output.





The behaviour of the circuit is specified by two voltages and two currents namely V_1, V_2 & I_1, I_2.

The polarity of voltages and direction of currents may be carefully noted. The polarity of voltages is such that upper terminal is positive and lower terminal is negative. Both the input and output currents assumed to flow into the box. It is standard convention of representing the voltages and currents. And donot correspond with the actual polarity of voltages and direction of currents.

The linear circuit may be replaced by an equivalent circuit as shown in figure 'b'. The equivalent circuit is called hybrid model of a linear circuit. In this ckt, input and output voltages and the input and output currents (variables) may be related by the set of following '2' equations:

$$V_1 = h_{11} i_1 + h_{12} V_2 \quad - (1)$$

$$i_2 = h_{21} i_1 + h_{22} V_2 \quad - (2)$$

where h_{11}, h_{12}, h_{21} & h_{22} are called hybrid parameters. Eq. (1) & (2) are obtained by applying KVL to the input and output circuits of the hybrid model. These parameters completely describe the behaviour of the circuit and are constant for a given ckt. They are expressed in different units, h_{11} in ohms, h_{12} & h_{21} are dimension less & h_{22} in mhos (or Siemens.

Since these parameters have mixed units, therefore these are called hybrid (mixed) or h-parameters.

Determination & Meaning of h-parameters

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Determination of h_{11} and ~~h22~~ h_{21} &

h_{11} & h_{21} are determined by short circuiting the output terminals 2-2'. Therefore, $V_2 = 0$, we know that

$$V_1 = h_{11} i_1 + h_{12} V_2 \quad \text{since } V_2 = 0$$

$$V_1 = h_{11} \cdot i_1$$

$$\boxed{h_{11} = \frac{V_1}{i_1}}$$

Since, h_{11} is the ratio of voltage to current, it has the units of ohms. Therefore, 'h_{11}' is called input resistance with output short circuited.

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

$$V_2 = 0$$

$$i_2 = h_{21} \cdot i_1$$

$$\Rightarrow \boxed{h_{21} = \frac{i_2}{i_1}}$$

the parameter h_{21} is called forward current gain with output short circuited. the ratio of i_2 to i_1 has no units.

Determination of h_{12} and h_{22} :-

These are determined by open circuit the terminals 1-1'.

$\therefore i_1 = 0$

we know that,

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

$$V_1 = h_{12} V_2 \quad =0$$

$$\Rightarrow \boxed{h_{12} = \frac{V_1}{V_2}}$$

$\therefore$ h_{12} is ratio of voltages, it has no units.

$\therefore$ h_{12} is called reverse voltage gain when input open circuited.

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

$$i_1 = 0$$

$$i_2 = h_{22} V_2$$

$$\boxed{h_{22} = \frac{i_2}{V_2}}$$

Since h_{22} is ratio of current to voltage, it has units of mhos or Siemens.

$\therefore h_{22}$ is called output conductance with input ~~short~~ open circuited.

Another Representation of h-parameters :

S.NO	h-parameter	meaning	Condition
1.	h_{11}	Input Resistance	Output shorted
2.	h_{12}	Reverse voltage gain	Input open
3.	h_{21}	Forward current gain	Output shorted
4.	h_{22}	Output conductance	Input open.

Sometimes, it is more convenient to find h parameters $h_{11}, h_{12}, h_{21}, h_{22}$ as h_i, h_r, h_f, h_o.

In other words: $h_i = h_{11}$

$h_r = h_{12}$

$h_f = h_{21}$

$h_o = h_{22}$

This type of representation is the standard IEEE notation.

h-parameter representation for Transistors:

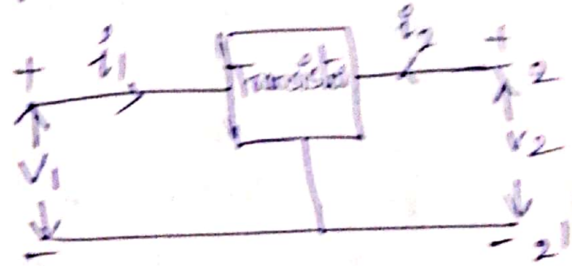
The h-parameters of a transistor depending upon type of the configuration used ie; common emitter, common base and common collector configuration. Because of this, each of 4 h-parameters carries a second subscript letter 'e' for CE & 'b' for CB & 'c' for CC.

the following table shows a notation for commonly used h-parameters;

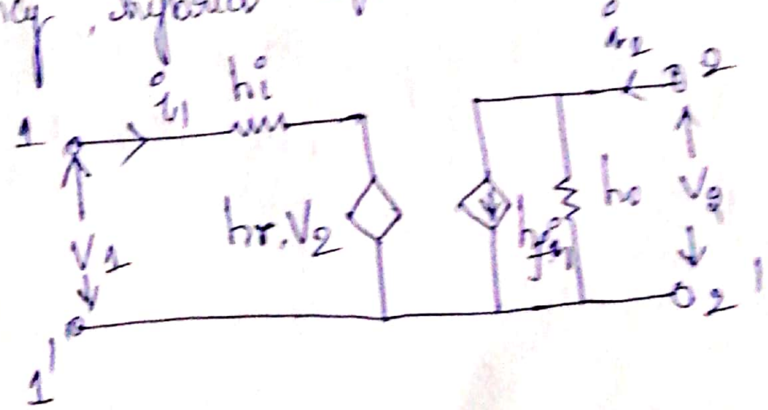
S.NO	h-parameter	CE	CB	CC
1.	$h_i = h_{11}$	h_{ie}	h_{ib}	h_{ic}
2.	$h_r = h_{12}$	h_{re}	h_{rb}	h_{rc}
3.	$h_f = 21$	h_{fe}	h_{fb}	h_{fc}
4.	$h_o = h_{22}$	h_{oe}	h_{ob}	h_{oc}

Hybrid Equivalent Circuit of a Transistor

following figure shows the general transistor circuit



the following shows the small signal low frequency hybrid equivalent circuit:



Hybrid equations of a transistor:

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$$V_1 = h_i i_1 + h_r V_2$$
$$i_2 = h_f \cdot i_1 + h_o \cdot V_2$$

Hybrid equivalent circuit of CE Transistor:

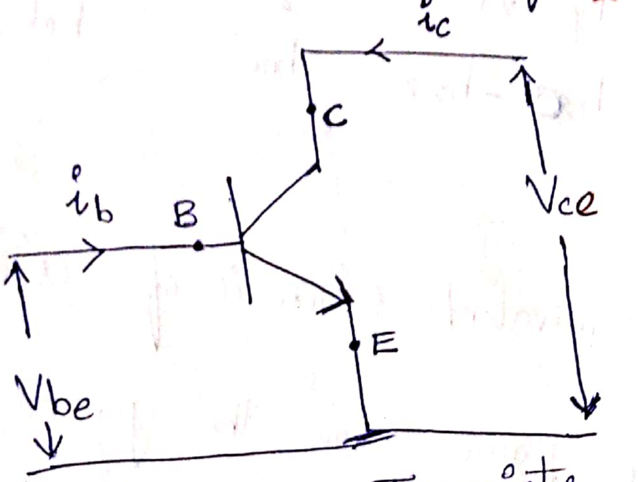
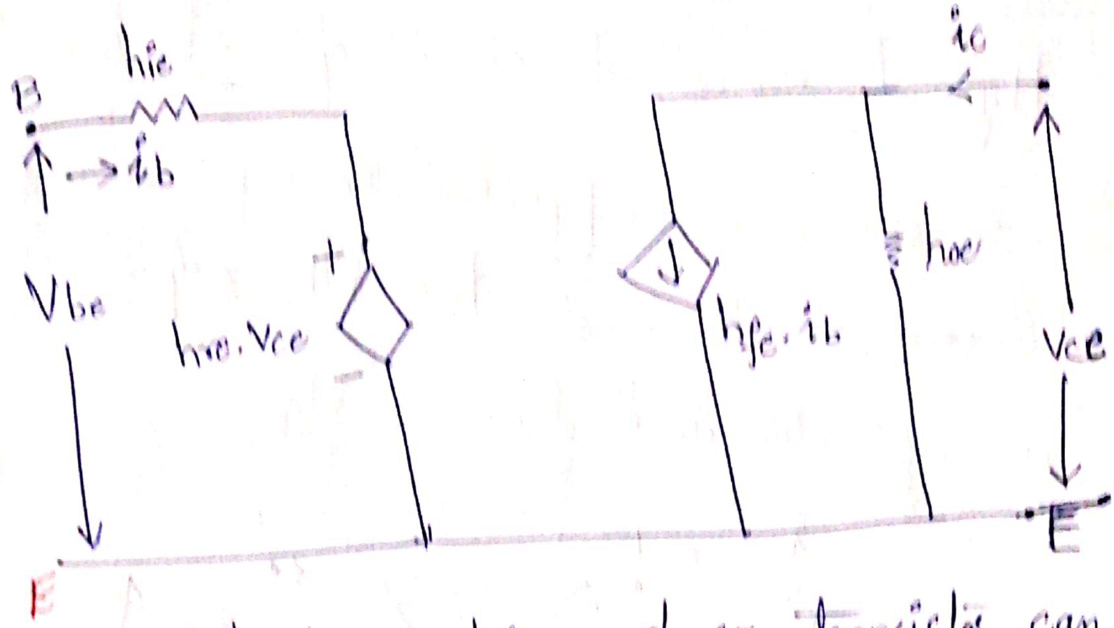


fig CE Transistor

In the CE transistor, the input is applied between base and emitter and output is taken across collector and emitter.

The hybrid equivalent circuit of CE transistor is drawn as:



The hybrid equations of CE transistor can be written as

$$V_{be} = h_{ie}\, i_b + h_{re} \cdot V_{ce}$$
$$i_c = h_{fe} \cdot i_b + h_{oe} \cdot V_{ce}$$

$$h_{ie} = \left.\frac{V_{be}}{i_b}\right| V_{ce} = \text{const.}$$

$$h_{re} = \left.\frac{V_{be}}{V_{ce}}\right| i_b = \text{const.}$$

$$h_{fe} = \left.\frac{i_c}{i_b}\right| V_{ce} = \text{const.}$$

$$h_{oe} = \left.\frac{i_c}{V_{ce}}\right| i_b = \text{const.}$$

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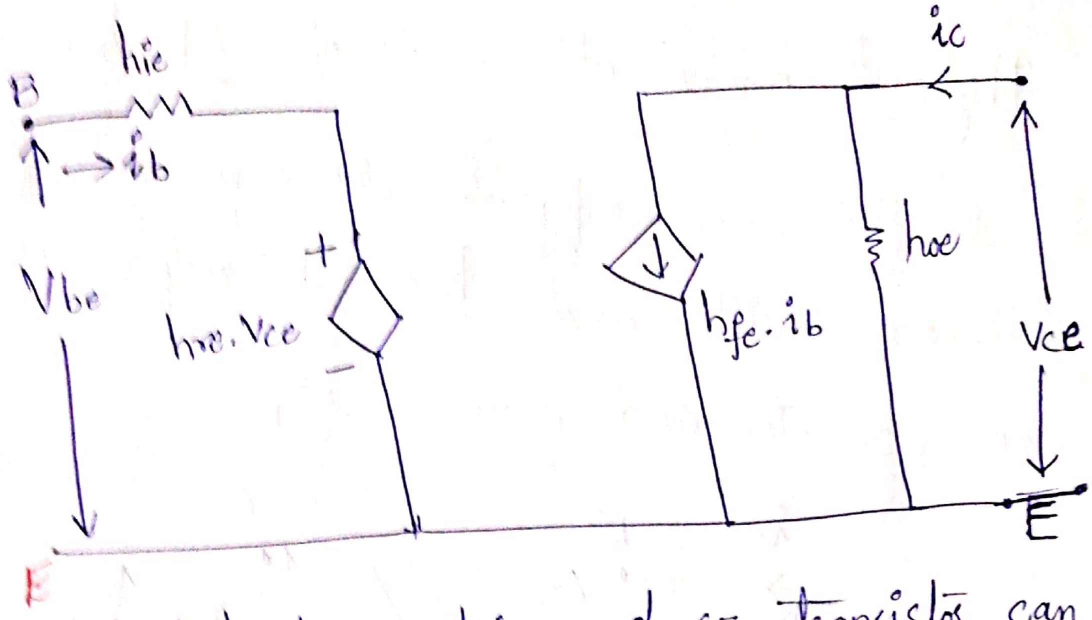


The hybrid equations of CE transistor can be written as

$$V_{be} = h_{ie}\, i_b + h_{re} . V_{ce}$$

$$i_c = h_{fe} . i_b + h_{oe} . V_{ce}$$

$$h_{ie} = \left.\frac{V_{be}}{i_b}\right| V_{ce} = \text{const.}$$

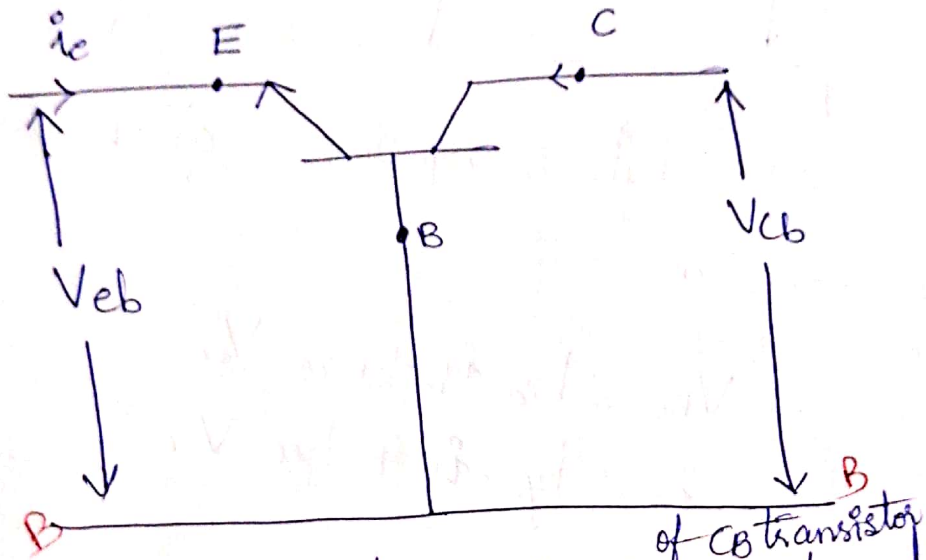
$$h_{re} = \left.\frac{V_{be}}{V_{ce}}\right| i_b = \text{Const.}$$

$$h_{fe} = \left.\frac{i_c}{i_b}\right| V_{ce} = \text{const.}$$

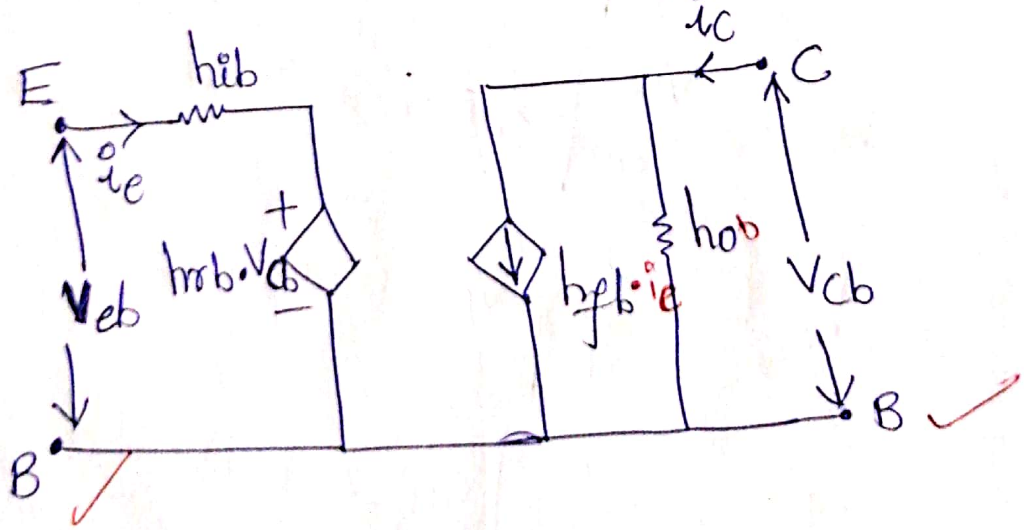
$$h_{oe} = \left.\frac{i_c}{V_{ce}}\right| i_b = \text{Const.}$$

Hybrid equivalent circuit of CB transistor :

In the CB configuration, the input is applied between emitter and base, the output is taken as collector and base.



The hybrid equivalent circuit of CB transistor can be drawn as :



The hybrid equations for Cb transistor can be written as:

$$V_{eb} = h_{ib} . i_e + h_{rb} . V_{cb}$$
$$i_c = h_{fb} . i_e + h_{ob} . V_{cb}$$

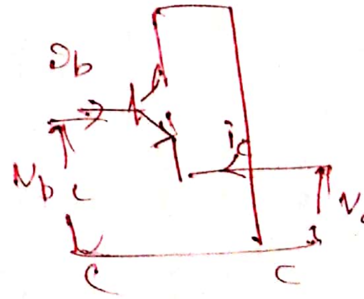
V_{eb} $$h_{ib} = \left. \frac{V_{eb}}{i_e} \right| V_{cb} = \text{const.}$$

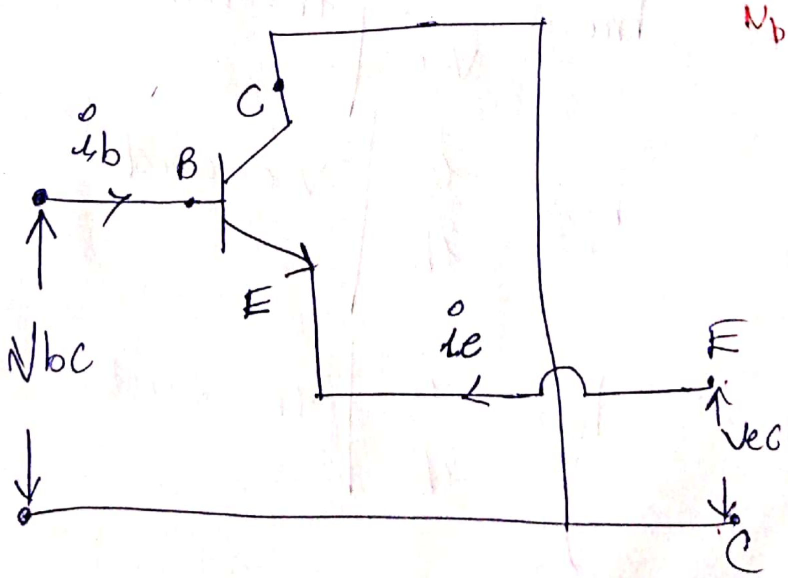
$$h_{rb} = \left. \frac{V_{eb}}{V_{cb}} \right| i_e = \text{const.}$$

$$h_{fb} = \left. \frac{i_c}{i_e} \right| V_{cb} = \text{const.}$$

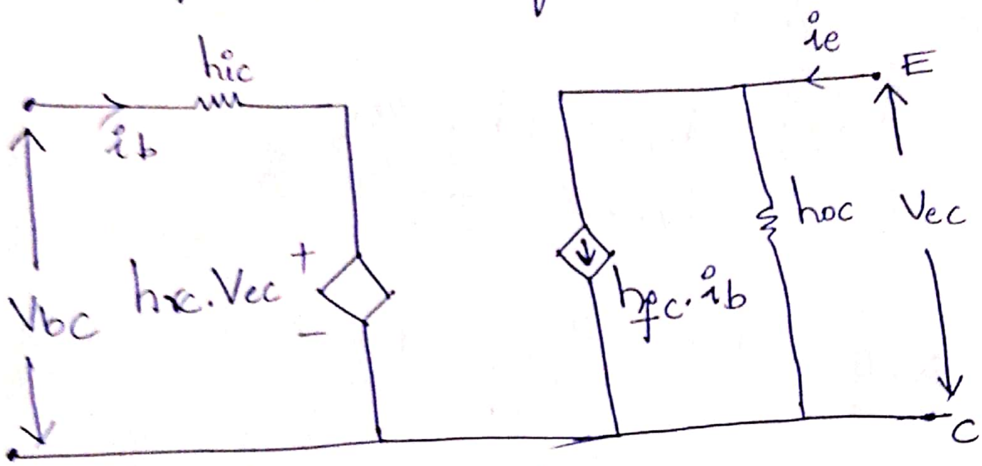
$$h_{ob} = \left. \frac{i_c}{V_{cb}} \right| i_e = \text{const.}$$

Hybrid equivalent circuit of common collector ~~(CE)~~ (CC) transistor:





Hybrid equivalent circuit of CC transistor :



The hybrid equations for CC transistor can be written as :

$$V_{bc} = h_{ic}.i_b + h_{rc}.V_{ec}$$
$$i_e = h_{fc}.i_b + h_{oc}.V_{ec}$$

$$h_{ic} = \left.\frac{V_{bc}}{i_b}\right| V_{ec} = \text{const.}$$

$$h_{rc} = \left.\frac{V_{bc}}{V_{ec}}\right| i_b = \text{Const.}$$

$$h_{fc} = \left.\frac{i_e}{i_b}\right| V_{ec} = \text{const.}$$

$$h_{oc} = \left.\frac{i_e}{i_b}\right| i_b = \text{Const.}$$