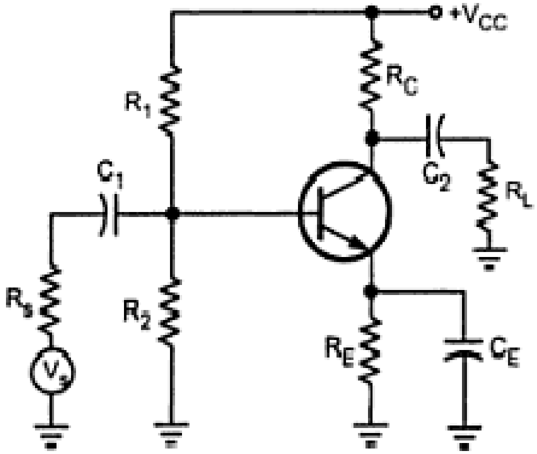
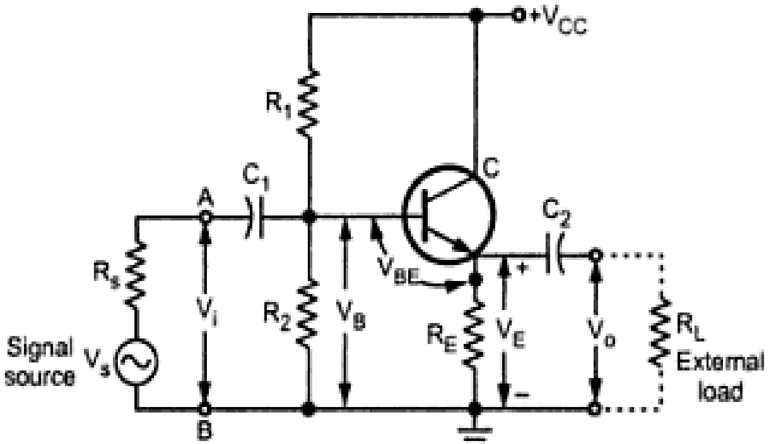
UNIT-4

Transistor Amplifiers

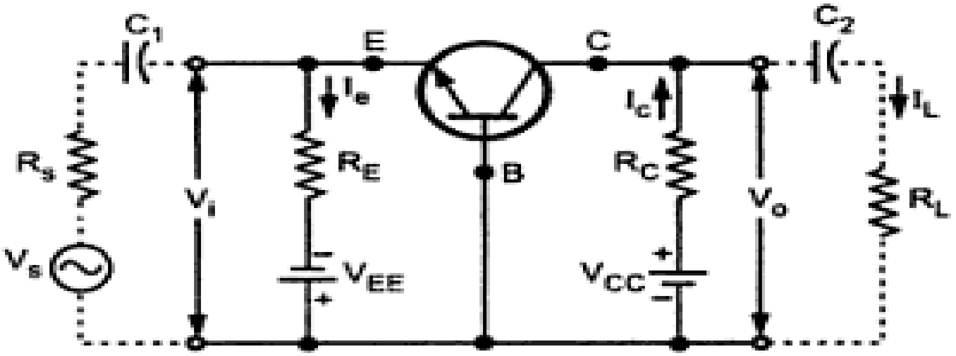
CE, CC, & CB Amplifiers



Practical common emitter amplifier circuit



Common collector circuit



Common base circuit

H-Parameters Representation Of An Amplifier

$$V_i = h_{11} I_i + h_{12} V_o$$

$$I_o = h_{21} I_i + h_{22} V_o$$

Definitions of h-parameter

The parameters in the above equation are defined as follows :

$h_{11} = \left.\frac{V_i}{I_i}\right|_{V_o=0}$ = Input resistance with output short-circuited, in ohms.

$h_{12} = \left.\frac{V_i}{V_o}\right|_{I_i=0}$ = Fraction of output voltage at input with input open circuited.

This parameter is ratio of similar quantities, hence unitless

$h_{21} = \left.\frac{I_o}{I_i}\right|_{V_o=0}$ = Forward current transfer ratio or current gain with output short circuited.

This parameter is a ratio of similar quantities, hence unitless.

$h_{22} = \left.\frac{I_o}{V_o}\right|_{I_i=0}$ = Output admittance with input open-circuited, in mhos.

a) With output short circuited :

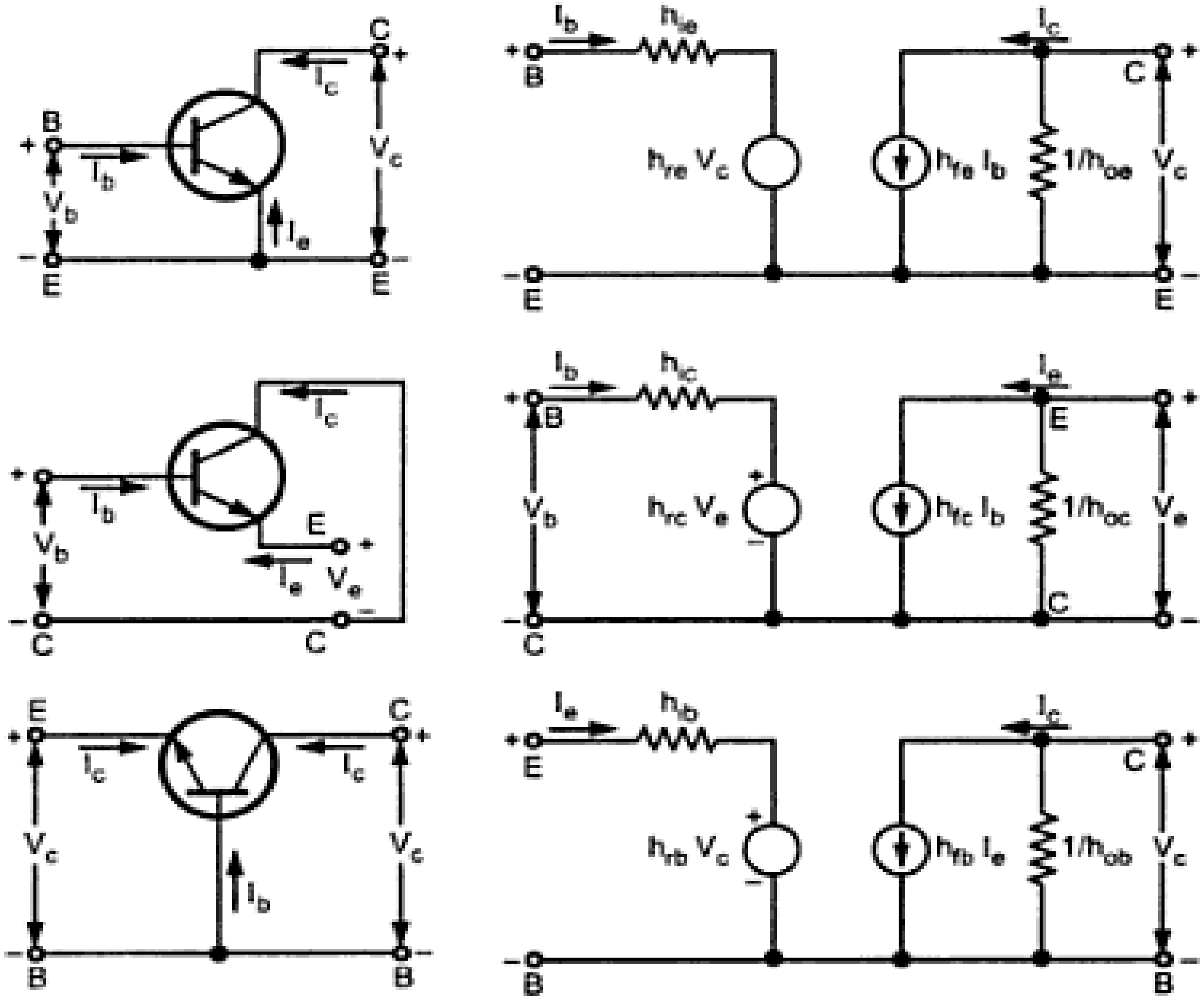
$h_{11} = h_i$: Input resistance

$h_{21} = h_f$: Short circuit current gain

b) With input open circuited :

$h_{12} = h_r$: Reverse voltage transfer ratio

$h_{22} = h_o$: Output admittance



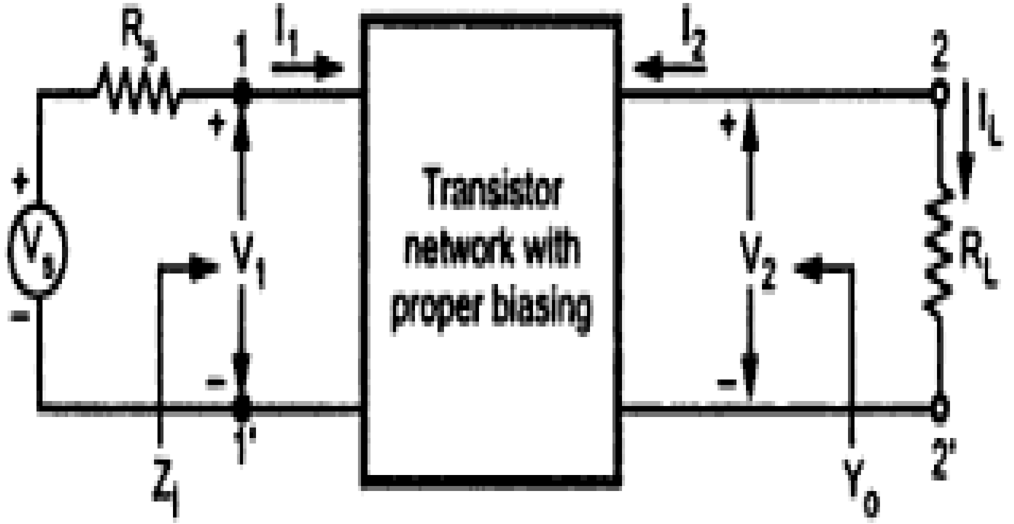
CE
$V_b = h_{ie} I_b + h_{re} V_c$
$I_c = h_{fe} I_b + h_{oe} V_c$

CC
$V_b = h_{ic} I_b + h_{rc} V_e$
$I_e = h_{fc} I_b + h_{oc} V_e$

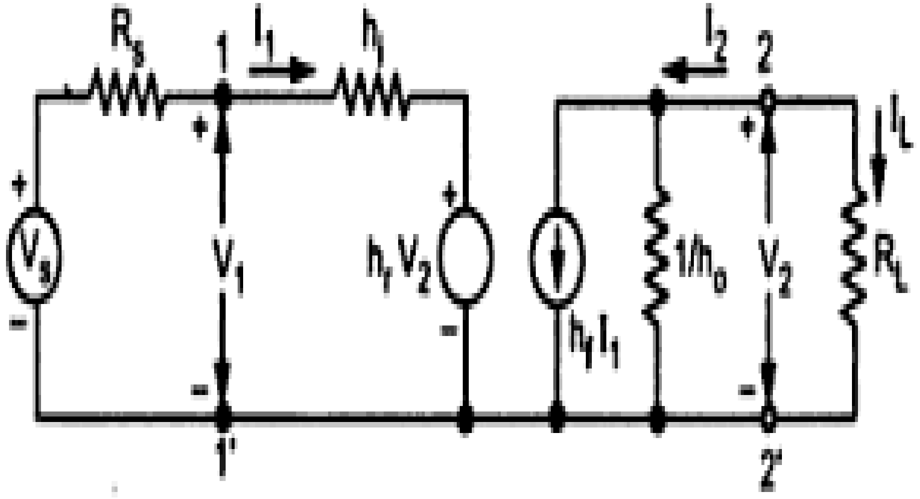
CB
$V_e = h_{ib} I_e + h_{rb} V_c$
$I_c = h_{fb} I_e + h_{ob} V_c$

Transistor configurations and their hybrid models

Small Signal Analysis Of A Junction Transistor



Basic transistor amplifier

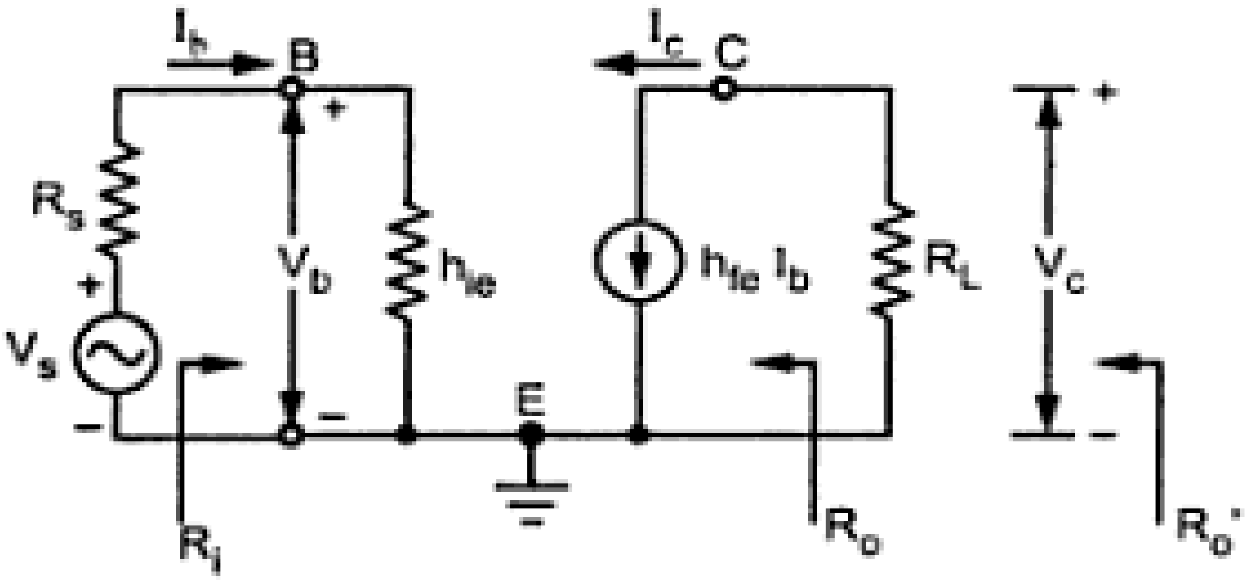


Transistor amplifier in its h-parameter model

small-signal analysis of a transistor amplifier

$A_i = -\dfrac{h_f}{1 + h_o R_L}$
$A_{is} = \dfrac{A_i R_s}{Z_i + R_s}$
$Z_i = h_i + h_r A_i R_L = h_i - \dfrac{h_f h_r}{h_o + Y_L}$
$A_v = \dfrac{A_i R_L}{Z_i}$
$A_{vs} = \dfrac{A_v R_i}{Z_i + R_s} = \dfrac{A_i R_L}{Z_i + R_s} = \dfrac{A_{is} R_L}{R_s}$
$Y_o = h_o - \dfrac{h_f h_r}{h_i + R_s} = \dfrac{1}{Z_o}$
$A_P = A_V A_i = A_i^2 \dfrac{R_L}{Z_i}$

Approximate H-Model For CE Amplifier



Approximate CE model

Current Gain $A_i \approx -h_{fe}$

Input Impedance $R_i \approx h_{ie}$

Voltage Gain : $A_v = \frac{A_i R_L}{R_i} = \frac{A_i R_L}{h_{ie}}$

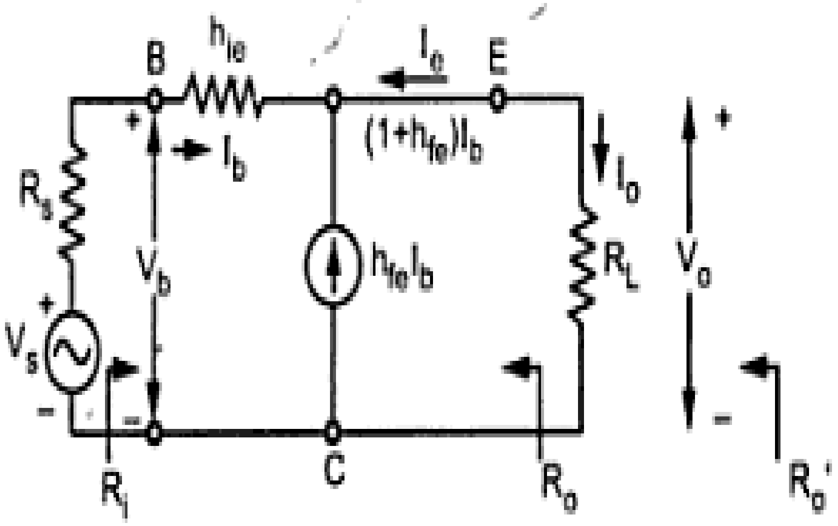
Output Impedance

$$Y_o = 0$$

$$R_o = \frac{1}{Y_o} = \infty$$

$$R'_o = R_o \parallel R_L = \infty \parallel R_L = R_L$$

Approximate H-Model For CC Amplifier



Simplified CC model

Current gain $A_i = \frac{I_o}{I_b} = \frac{-I_e}{I_b} = 1 + h_{fe}$

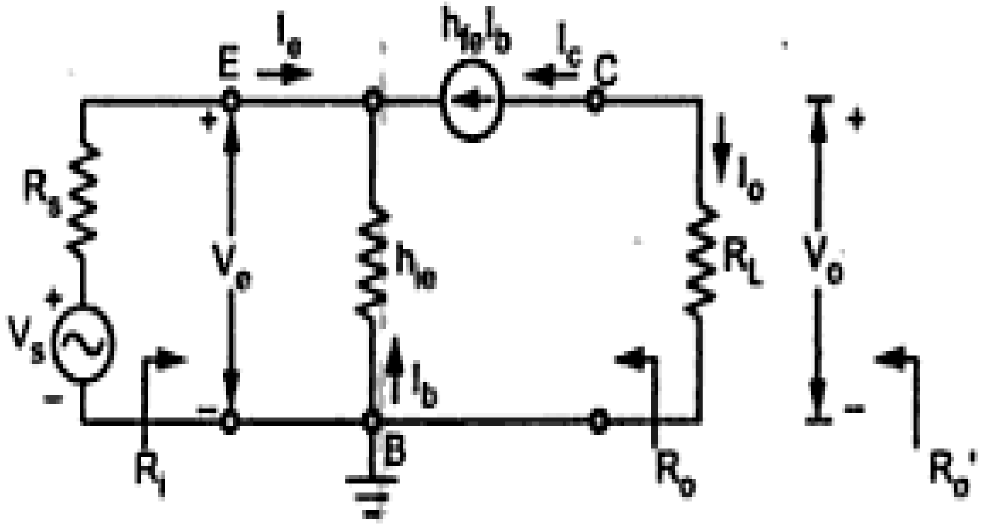
Input resistance : $R_i = \frac{V_b}{I_b} = h_{ie} + (1 + h_{fe})\, R_L$

Voltage gain (A_v) $A_v = \frac{(1+h_{fe})R_L}{h_{ie} + (1+h_{fe})R_L} \cong 1$

Output resistance R_o $R_o = \frac{V_o}{I_e} = \frac{R_s + h_{ie}}{1 + h_{fe}}$

$R'_o = R_o \,||\, R_L = \infty \,||\, R_L = R_L$

Approximate H-Model For CB Amplifier



Simplified CB model

Current gain $A_i = \frac{h_{fe}}{1+h_{fe}}$

Input resistance (R_i) $R_i = \frac{h_{ie}}{1+h_{fe}}$

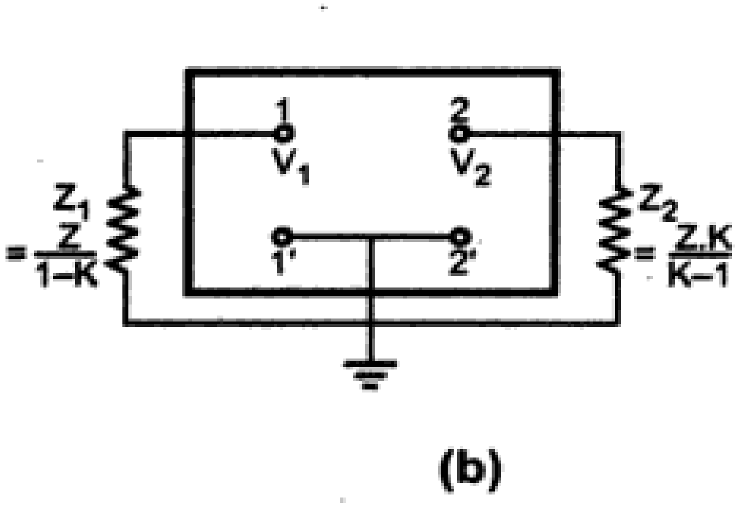
Voltage gain (A_v) $A_v = \frac{\frac{h_{fe}}{1+h_{fe}} \times R_L}{\frac{h_{ie}}{1+h_{fe}}} = \frac{h_{fe}R_L}{h_{ie}}$

Output resistance (R_o) $R_o = \left.\frac{V_o}{I_c}\right|_{V_s=0}$

$R'_o = R_o \parallel R_L = \infty \parallel R_L = R_L$

Miller's Theorem

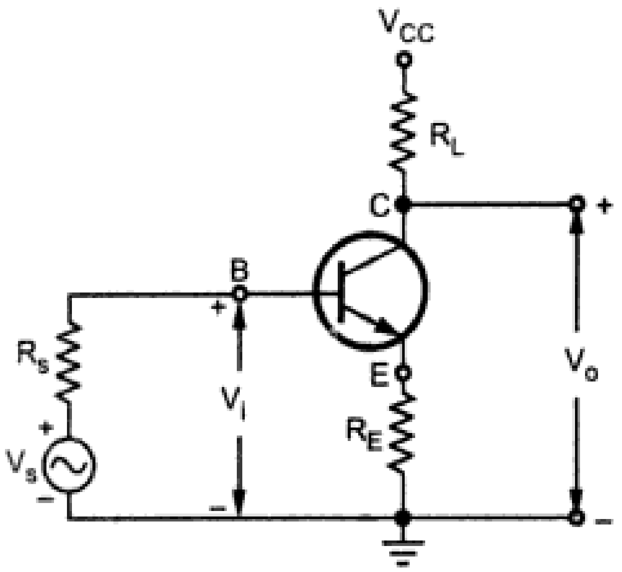
Millers theorem is used to simplify the analysis of a circuit whenever there is a feedback connection in the circuit



$$Z_1 = \frac{Z}{1-K}$$

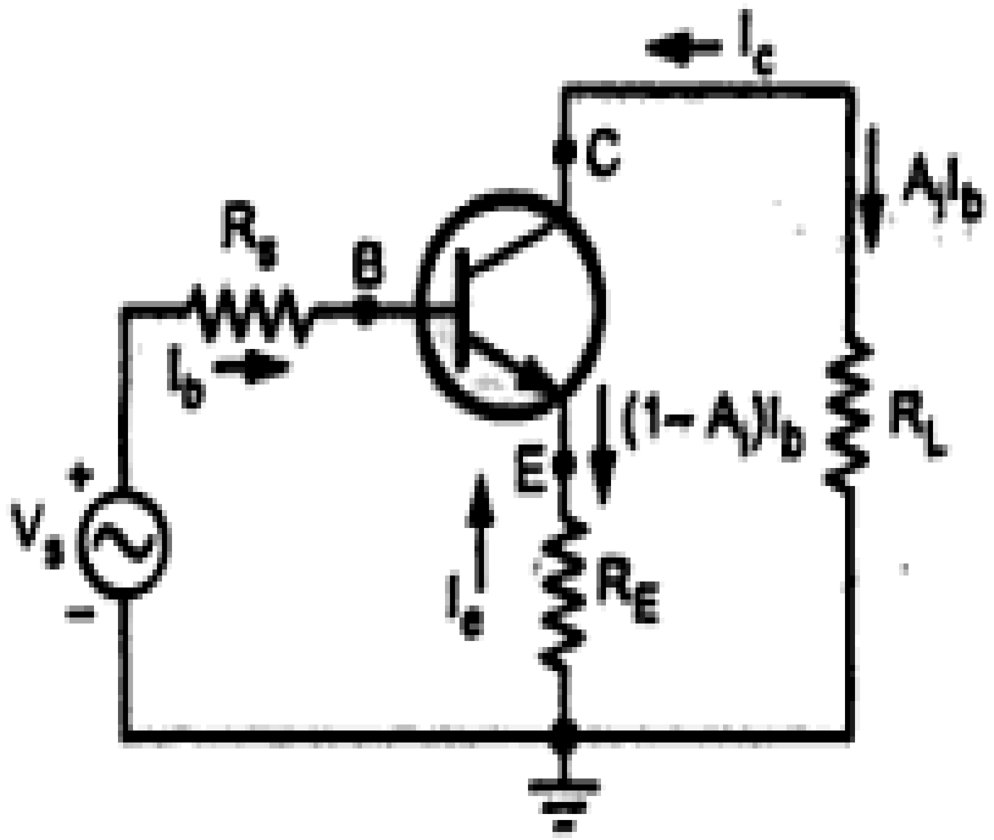
$$Z_2 = \frac{Z \cdot K}{K-1}$$

Analysis Of CE Amplifier With Unbypassed RE

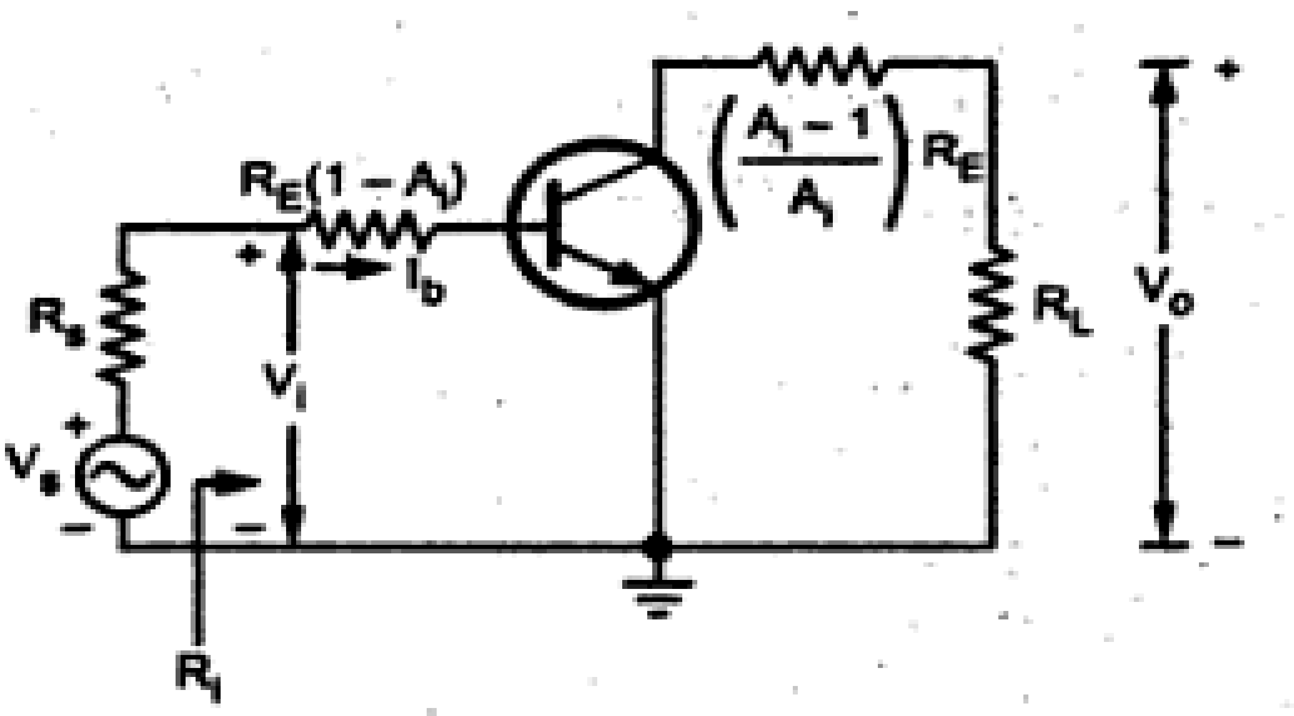


- R_E is added to stabilize the gain of the amplifier
- R_E acts as a feedback resistor
- The overall gain will reduce with unbypassed R_E

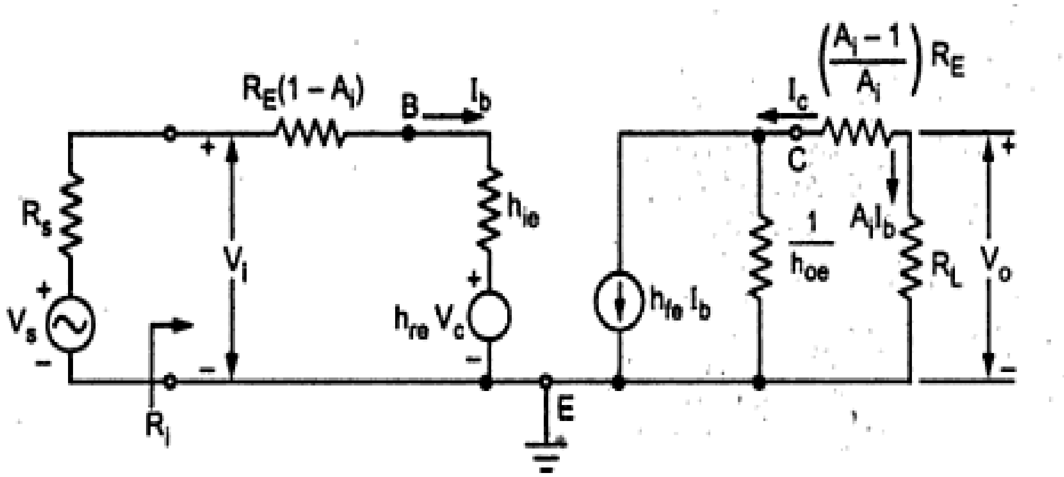
AC Equivalent Circuit For CE Amplifier with Unbypassed R_E



AC Equivalent Circuit For CE Amplifier with RE Splitted using dual of Miller's Theorem

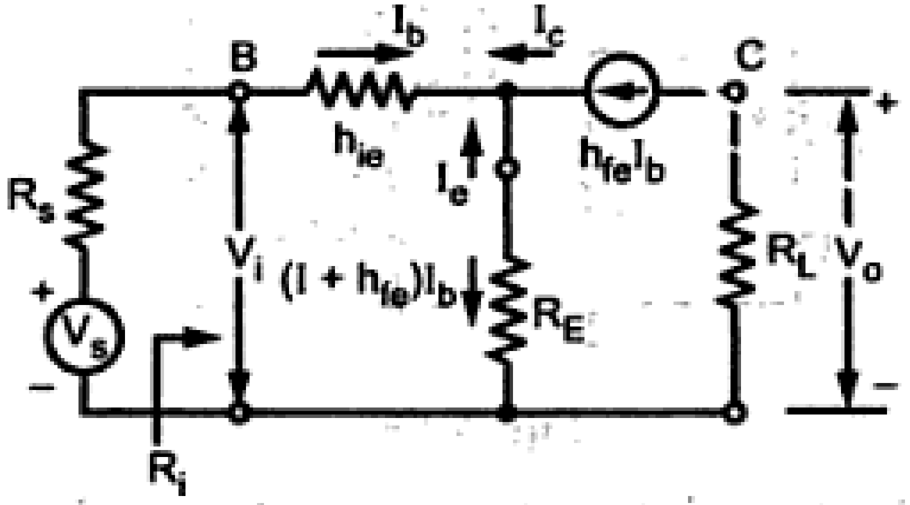


h-Parameter Equivalent Circuit (Exact Analysis)



$$A_i = \frac{-h_{fe}}{1+h_{oe}R_L'} = \frac{-h_{fe}}{1+h_{oe}\left(R_L + \frac{A_i - 1}{A_i}R_E\right)}$$

h-Parameter Equivalent Circuit (Approximate Analysis)



Approximate model for CE amplifier with R_E