EEE-2103: Electronic Devices and Circuits

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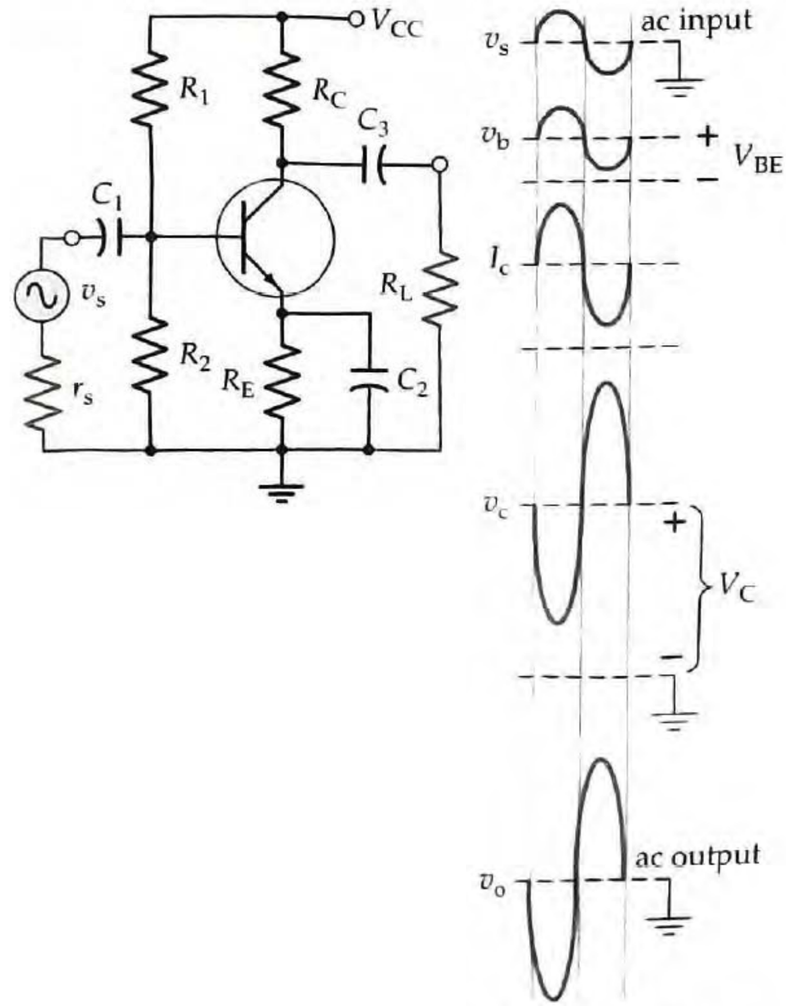
Common Emitter Circuit Analysis



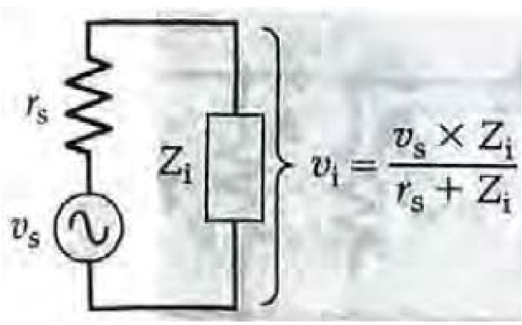
Capacitors are ac short circuits →

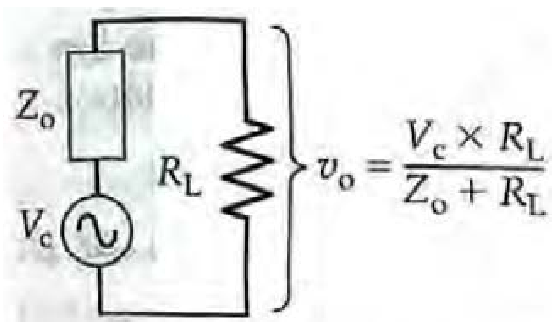
input terminals are base-emitter.

output terminals are collector-emitter.

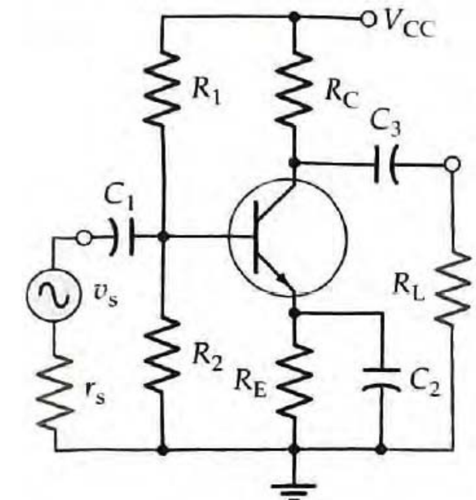
180° phase shift between input and output waveforms.

Input impedance and output impedance →



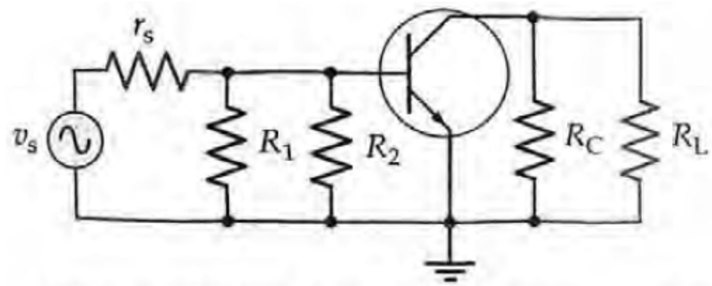


Common Emitter Circuit Analysis



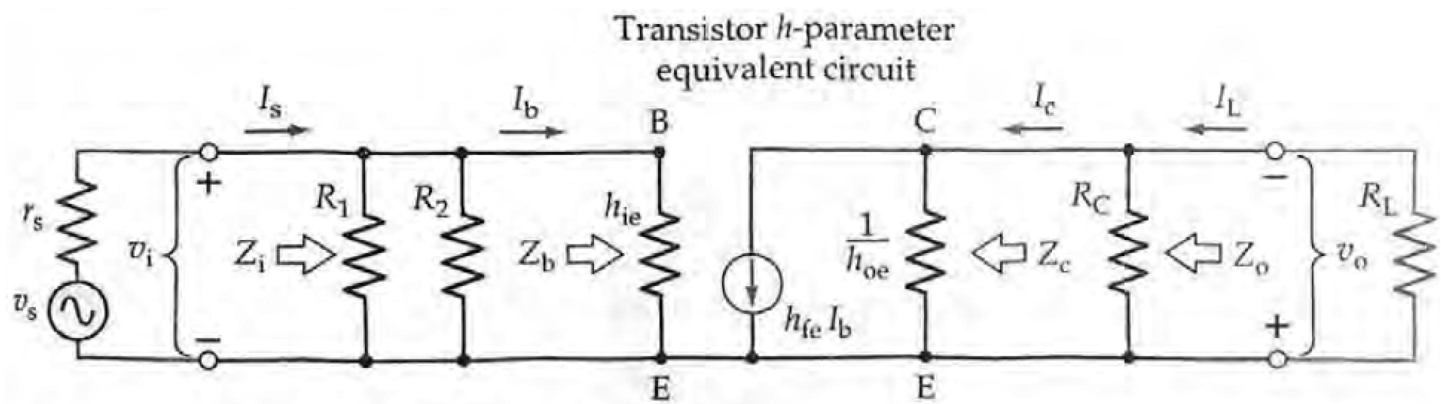
ac equivalent circuit →

power supply and capacitors = short circuit.



h-parameter circuit →

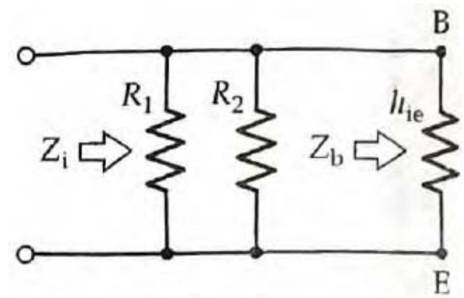
replace transistor with its *h*-parameter model



Common Emitter Circuit Analysis

Input impedance at base terminal →

$Z_b \approx h_{ie} \approx 1.5\ \text{k}\Omega$

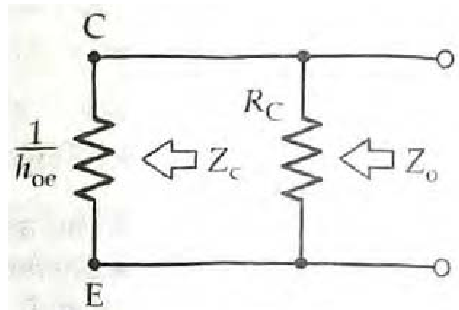


Circuit input impedance →

$Z_i = R_1||R_2||h_{ie}$

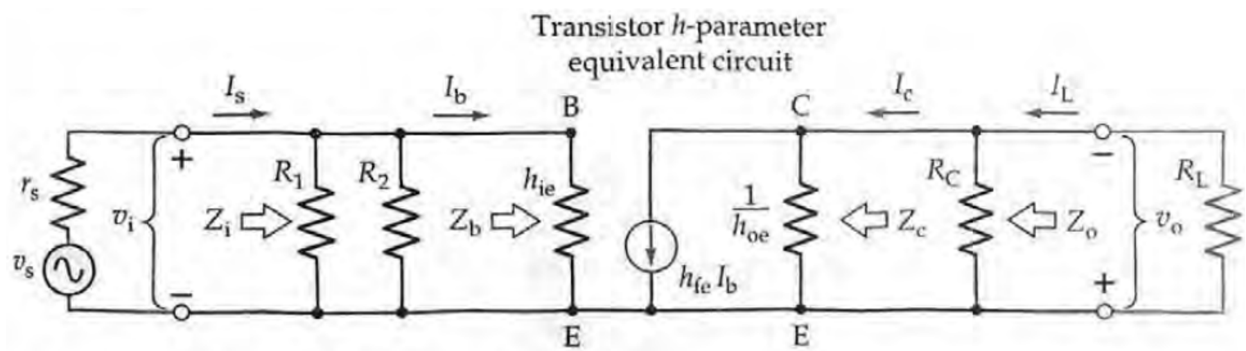
Output impedance at collector terminal →

$Z_c \approx 1/h_{oe} \approx 50\ \text{k}\Omega$



Circuit output impedance →

$Z_o \approx R_c||(1/h_{oe})$



Common Emitter Circuit Analysis

Voltage gain →

$$A_v = v_o/v_i$$

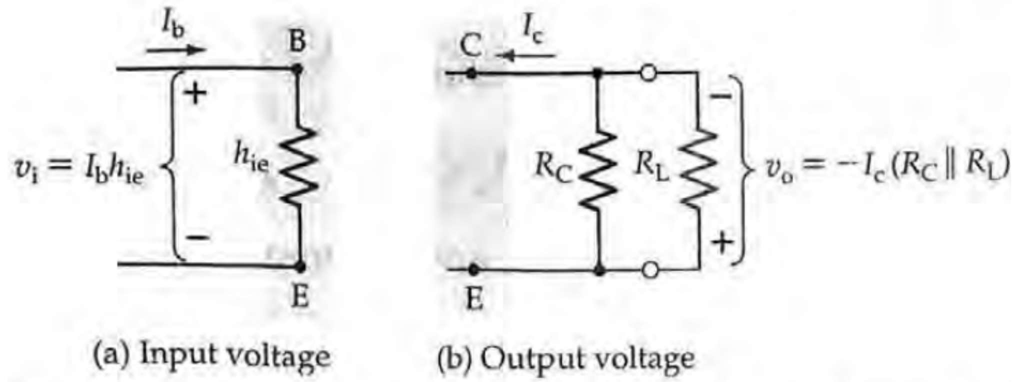
$v_i = I_b h_{ie}$

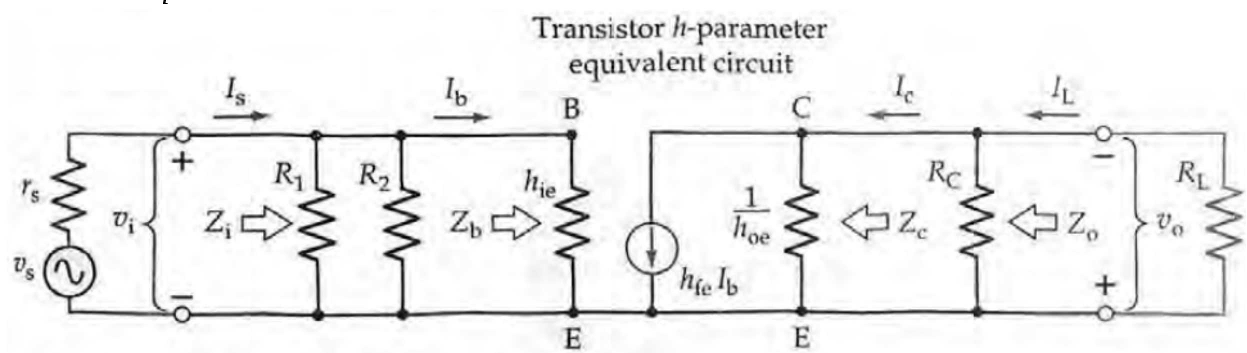
$v_o = -I_c(R_c||R_L)$

$$A_v = \frac{-I_c(R_C \| R_L)}{I_b h_{ie}} = \frac{-h_{fe}(R_C \| R_L)}{h_{ie}}$$

$$A_v \approx \frac{-(R_C \| R_L)}{h_{ib}}$$

Minus sign = v_o is 180^0 out of phase with v_i





Common Emitter Circuit Analysis

Current gain →
Device current gain (not circuit gain) =

$h_{fe} = I_c/I_b$

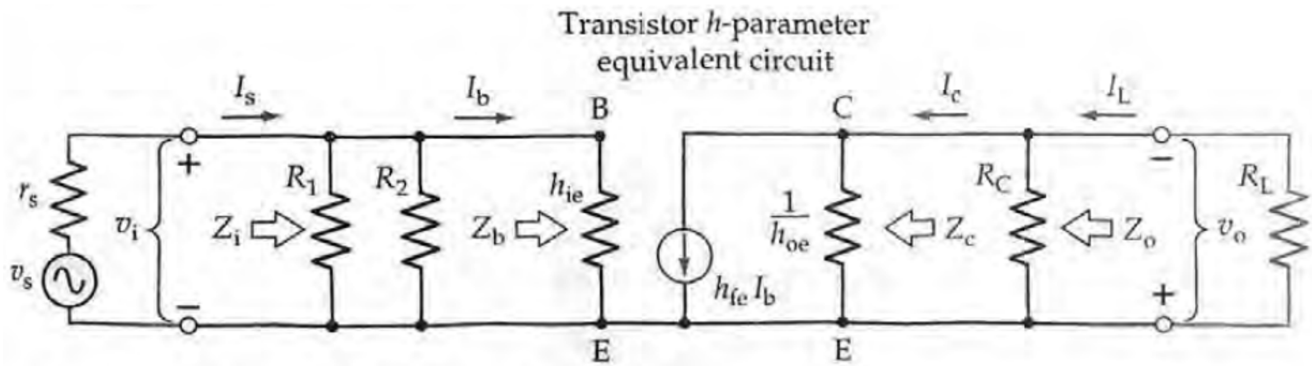
Signal current I_s → h_{ie} and $R_B = R_1||R_2$
Output current I_c → R_C and R_L

Circuit current gain →

$$A_i = \frac{h_{fe}R_C R_B}{(R_C+R_L)(R_C+h_{ie})}$$

Power gain →

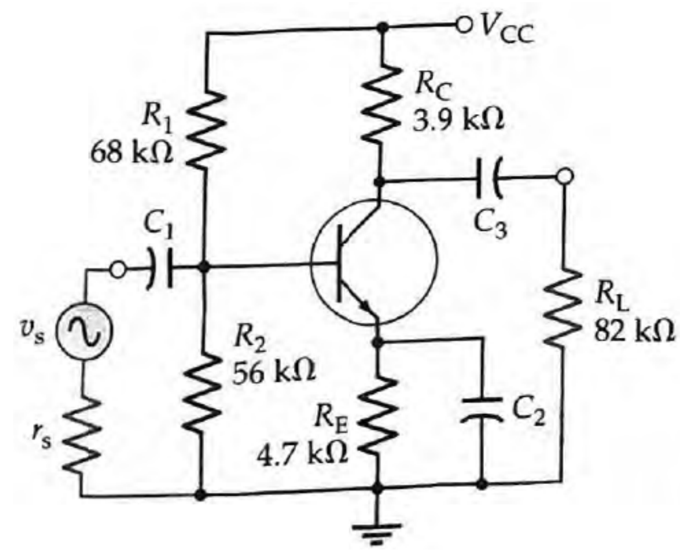
$A_p = A_v \times A_i$



Common Emitter Circuit Analysis

Problem-32:

The transistor in the CE circuit in Fig. 32 has the following parameters: h_{ie} = 2.1 kΩ, h_{fe} = 75, and h_{oe} = 1 μS. Calculate the circuit input impedance, output impedance, and voltage gain.



Input impedance →

$Z_i = R_1||R_2||h_{ie}$ = 68||56||2.1 kΩ = 1.97 kΩ

Output impedance →

$Z_o \approx R_c||(1/h_{oe}) = 3.9\times10^3||[1/(1\times10^{-6})] \approx 3.9$ kΩ

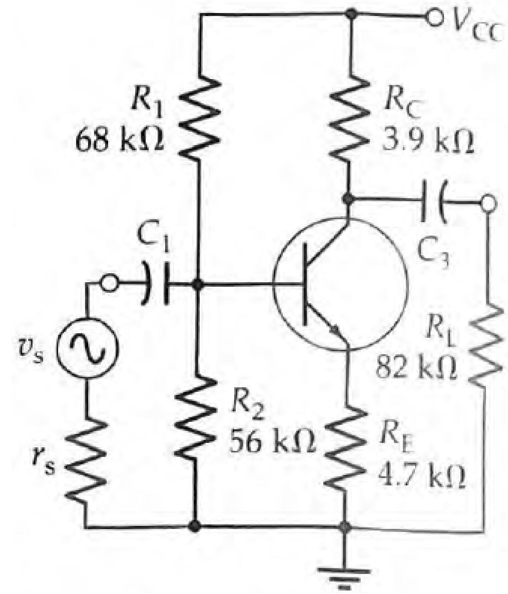
Voltage gain →

$$A_v = \frac{-h_{fe}(R_C \| R_L)}{h_{ie}} = \frac{-75\times(3.9\times10^3 \| 82\times10^3)}{2.1\times10^3} = -133$$

Common Emitter Circuit Analysis

Problem-33:

The transistor in the CE circuit in Fig. 33 has the following parameters: h_{ie} = 2.1 kΩ, h_{fe} = 75, and h_{oe} = 1 μS. Calculate the circuit input impedance, output impedance, and voltage gain.



$Z_b = h_{ie} + R_E(1+h_{fe}) = 2.1×10^3 + 4.7×10^3(1+75)$
$= 359$ kΩ

Input impedance →

$Z_i = R_1||R_2||Z_b = 68||56||359$ kΩ $= 28.3$ kΩ

Output impedance →

$Z_o \approx R_c = 3.9$ kΩ

Voltage gain →

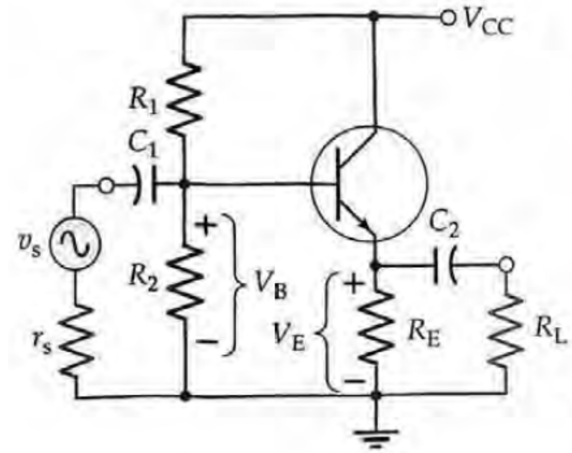
$$A_v = \frac{-h_{fe}(R_C \| R_L)}{h_{ie}+R_E(1+h_{fe})} = \frac{-75\times(3.9\times10^3 \| 82\times10^3)}{2.1\times10^3+4.7\times10^3(1+75)} = -0.78$$

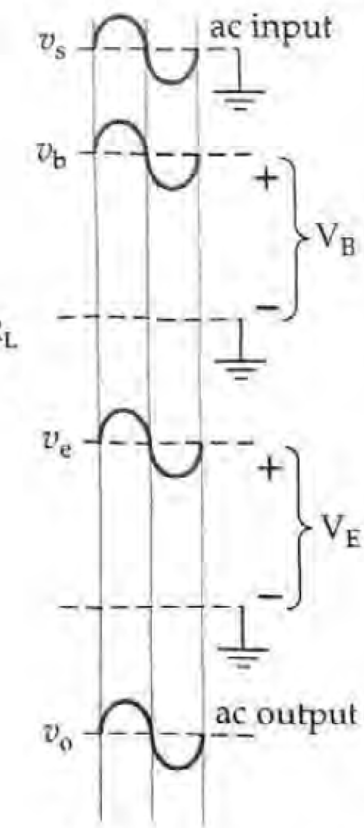
Common Collector Circuit Analysis

$V_E = V_B - V_{BE}$

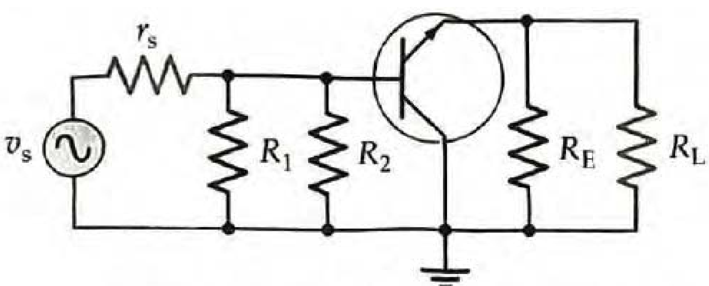
ac signal is applied via C_1 to base
change in V_E is coupled via C_2 to load

Emitter follower →
    input voltage = output voltage
    no gain + no phase shift.



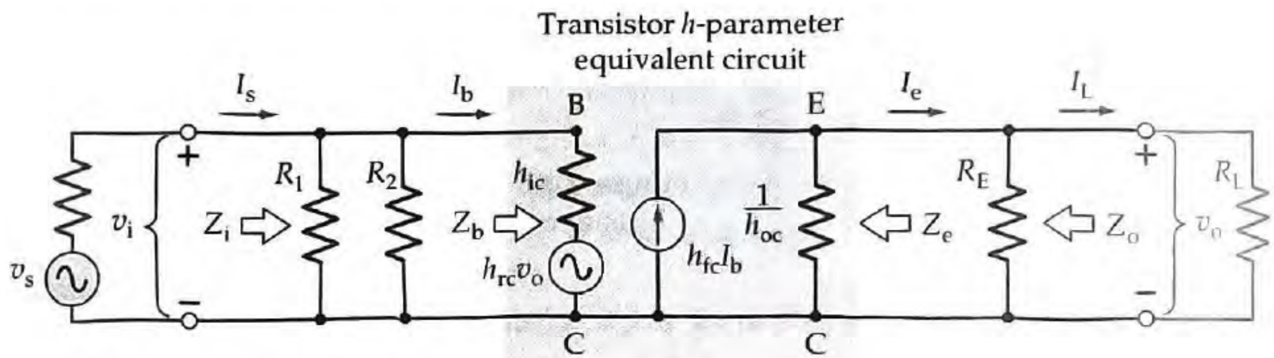


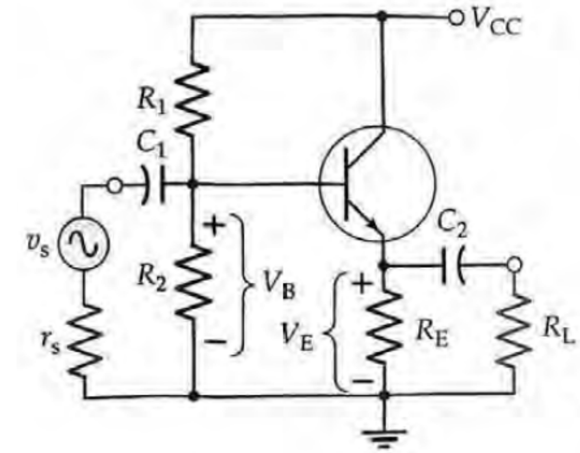
<u>*h*-parameter equivalent circuit:</u>
ac equivalent circuit →
    Power supply and capacitors are replaced with short circuits.

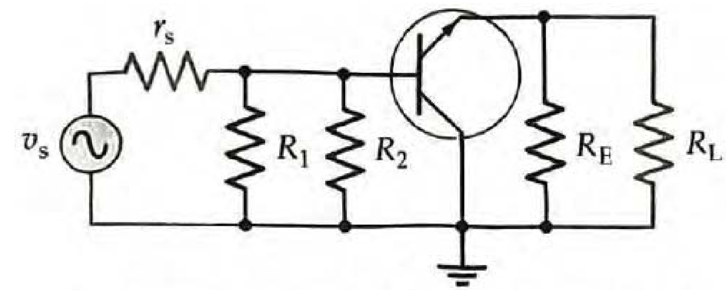


Common Collector Circuit Analysis

<u>h-parameter equivalent circuit:</u>
Substitute transistor h-parameter model.







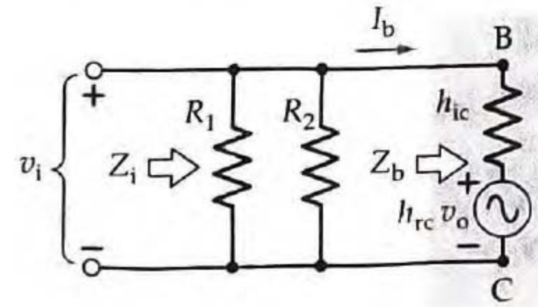
$h_{rc} = 1$
v_o is fed back to input

Common Collector Circuit Analysis

Input impedance:

$Z_i = R_1||R_2||Z_b$

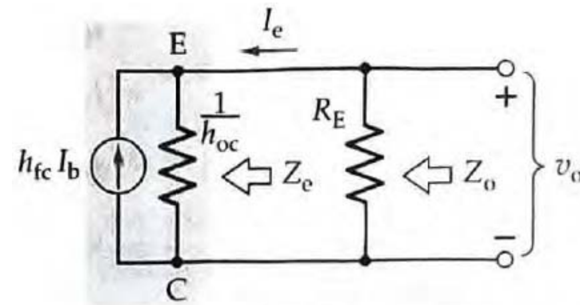
$Z_b = h_{ic} + h_{fc}(R_E||R_L)$



Output impedance:

$Z_o = Z_e||R_E$

$Z_e = \frac{h_{ic}+(R_1 \| R_2 \| r_s)}{h_{fc}}$



Voltage gain:

$v_i = I_b[h_{ic} + h_{fc}(R_E||R_L)]$

$v_o = I_e(R_E||R_L)$

$A_v = \frac{v_o}{v_i} = \frac{I_e(R_E \| R_L)}{I_b[h_{ic}+h_{fc}(R_E \| R_L)]} = \frac{(R_E \| R_L)}{h_{ib}+(R_E \| R_L)}$

$A_v \approx 1$