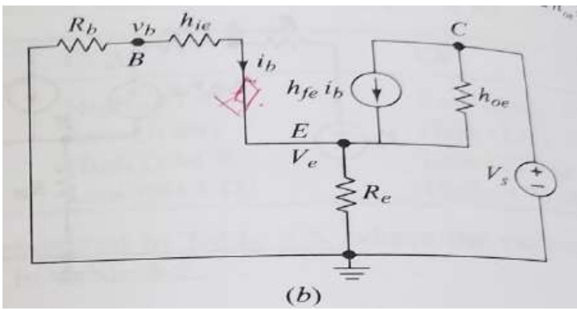
Thapar University, Patiala

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Course Code: UEC 301; Course Name: Analog Electronics

B. Tech, ECE (III-Sem), "Tutorial Sheet No. - 5"

Q1. For the circuit of fig. (1), (a) find the expression for V_b and V_e in terms of V_s and other circuit parameters. (b) If $R_b = 50\ k\Omega, and\ R_e = 1\ k\Omega$, determine $\frac{V_b}{V_s}$ and $\frac{V_e}{V_s}$. Use h-parameter model of CE equivalent circuit. Given $h_{ie} = 1k\Omega,\ h_{re} = 0, h_{fe} = 100, and\ h_{oe} = \frac{1}{50}\ k\Omega$.



Solution (*a*) Using the equivalent circuit of Fig. 8.6*a*, and noting that $h_{re} = 0$, the given circuit can be re-drawn as shown in Fig. 8.24*b*. Writing KCL at the emitter node yields,.

$$\frac{V_e}{R_e} + \frac{V_e}{R_b + h_{ie}} + \frac{h_{fe}V_e}{R_b + h_{ie}} + (V_e - V_s)\,h_{oe} = 0$$

where we have used $i_b = -\dfrac{V_e}{R_b + h_{ie}}$. Solving for V_e, we get

$$V_e = \frac{h_{oe}}{\left(\dfrac{1}{R_e} + \dfrac{(1+h_{fe})}{R_b + h_{ie}} + h_{oe}\right)} \cdot V_s$$

Noting that $V_b = \dfrac{R_b}{R_b + h_{ie}} V_e$, yields

$$V_b = \frac{R_b h_{oe}}{(R_b + h_{ie})\left(\dfrac{1}{R_e} + \dfrac{(1+h_{fe})}{R_b + h_{ie}} + h_{oe}\right)} \cdot V_s$$

(b) Substituting values in the above two equations yields,

$$\frac{v_e}{v_s} = \frac{1}{150}$$

and

$$\frac{v_b}{v_s} = \frac{1}{153}$$

These numbers show that a signal applied to the collector terminal appears significantly attenuated at the base and emitter terminals. This is, of course, the reason that one never uses the collector of a transistor as an input terminal.

Note also that because the small-signal equivalent circuit of a transistor is linear, the reciprocity theorem is applicable to it, so that (v_b/v_s) in Fig. 8.24*b* is simply the reciprocal of the gain of the circuit in which the input is applied at the base, and the output taken at the collector. And since the gain from the base to the collector is high, it is expected that the *gain* from the collector to the base will be low (being the reciprocal of the previous gain).

Q2. The transistor of Fig.2 is connected as a CE amplifier. Find the various gains and input and output impedances using h-parameters. Given that $R_L = 10K, R_s = 1\ K, h_{ie} = 1.K, h_{re} = 2.5\ \times 10^{-4}, h_{fe} = 50, h_{oe} = 25\ \mu A/V$

$$A_I = -\frac{h_{fe}}{1 + h_{oc}R_L} = -\frac{50}{1 + 25 \times 10^{-6} \times 10^4} = -40.0$$

$$R_i = h_{ie} + h_{re}A_IR_L = 1{,}100 - 2.5 \times 10^{-4} \times 40.0 \times 10^4 = 1{,}000\ \Omega = 1\ \text{K}$$

$$A_V = \frac{A_I R_L}{R_i} = -\frac{40 \times 10}{1} = -400$$

$$A_{Vs} = \frac{A_V R_i}{R_i + R_s} = -\frac{400 \times 1}{1 + 1} = -200$$

$$A_{Is} = \frac{A_I R_s}{R_i + R_s} = -\frac{40.0 \times 1}{1 + 1} = -20.0$$

Note that $A_{Vs} = A_{Is}R_L/R_s$.

$$Y_o = h_{oc} - \frac{h_{fe}h_{re}}{h_{ie} + R_s} = 25 \times 10^{-6} - \frac{50 \times 2.5 \times 10^{-4}}{2{,}100} = 19.0 \times 10^{-6}\ \mho = 19.0\ \mu\text{A/V}$$

$$Z_o = \frac{1}{Y_o} = \frac{10^6}{19.0}\ \Omega = 52.6\ \text{K}$$

Q3. The circuit shown in Fig.3 is a _____amplifier. If $R_S = 50\,ohm, R_L = 2\,K\ and\ R_B = 50\,K,$ then

(i) What is the configuration of amplifier (CE or CB or CC)

(ii) Determine $A_V = v_o/v_s$ of the amplifier.

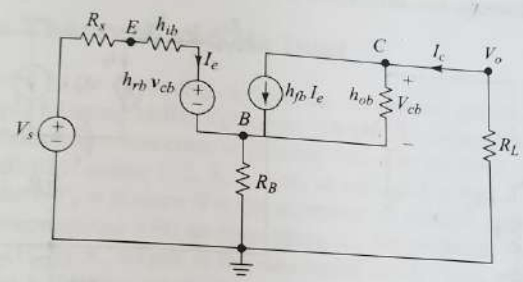


Fig. 8.23(b) *Small-signal circuit of Fig. 8.23(a).*

Solution Following the rules described in this section, we replace the transistor with its equivalent circuit, of Fig. 8.15, and re-draw the circuit, as shown in Fig. 8.23(*b*). Writing KVLs for the input and output loops yields

$$-V_s + (R_s + h_{ib})\,I_e + h_{rb}V_{cb} + R_B\,(I_e + I_c) = 0$$

and

$$R_L I_C + (1/h_{ob})\,(I_c - h_{fb}\,I_e) + R_B\,(I_e + I_c) = 0.$$

Also,

$$V_{cb} = (1/h_{ob})\,(I_c - h_{fb}\,I_e)$$

Re-writing the two KVL equations,

$$\left(R_s + h_{ib} - \frac{h_{fb}\,h_{rb}}{h_{ob}} + R_B\right)I_e + \left(\frac{h_{rb}}{h_{ob}} + R_B\right)I_c = V_s$$

and

$$\left(-\frac{h_{fb}}{h_{ob}} + R_B\right)I_e + \left(R_L + \frac{1}{h_{ob}} + R_B\right)I_c = 0$$

or,

$$(0.05 + 0.0216 + 0.98 \times 2.9 \times 10^{-4} \times 2040 + 50)\,I_e + (2.9 \times 10^{-4} \times 2040 + 50)\,I_c = V_s$$

and

$$(0.98 \times 2040 + 50)\,I_e + (2 + 2040 + 50)\,I_c = 0$$

or,

$$50.65I_e + 50.59I_c = V_s$$

and

$$2049.2I_e + 2092I_c = 0$$

Solving, we get,

$$I_e = 0.91\,V_s \quad \text{and} \quad I_c = -\,0.89\,V_s$$

Now

$$\boxed{V_o = -\,R_L\,I_c} = -\,2\,(-0.89\,V_s)$$

so that

$$A_V = v_o/v_s = 1.78$$

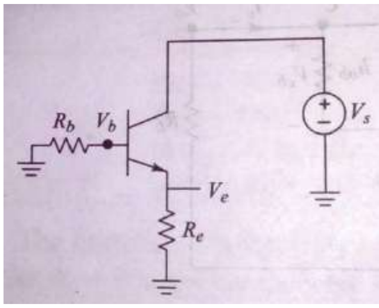


Fig.1

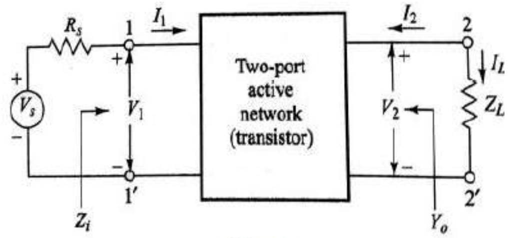


Fig.2

Fig.2

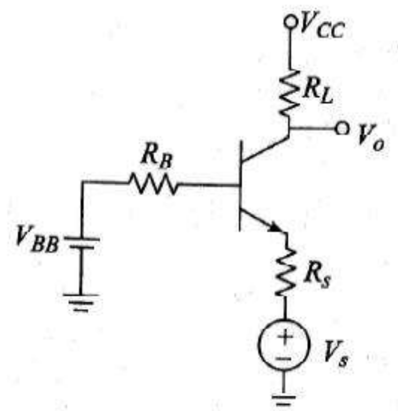


Fig.3