4. In figure 1 below, the biasing components have been omitted. The transistors are identical with $\beta_o = 200$. $I_{C1} = 1$ mA and $I_{C2} = 5$ mA. $R_{C1} = 5$ kΩ, $R_{C2} = 1$ kΩ,
$R_{E2} = 150$ Ω, $R_S = 1$ kΩ.

Calculate g_{m1}, g_{m2}, r_{be1} and r_{be2}.

Calculate R_i, R_o, $A_v = v_o/v_i$ and $A_{vs} = v_o/v_s$.

(Ans $R_i = 5$ kΩ, $R_o = 1$ kΩ, $A_v = +1111$, $A_{vs} = +926$).

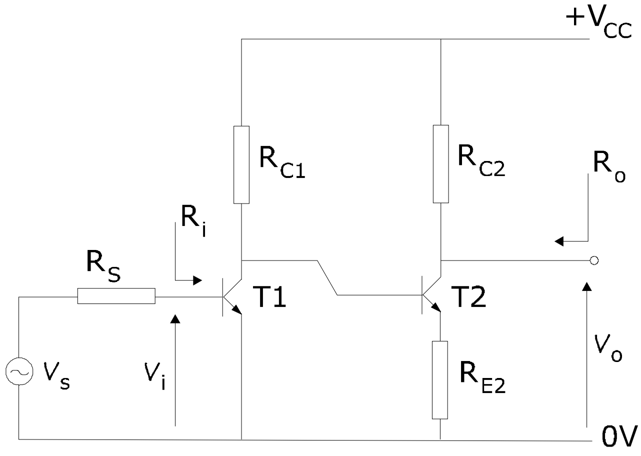

Figure 1

Solution

$$g_{m1} = 40 I_{C1} = 40 mA/V$$

$$g_{m2} = 40 I_{C2} = 200 mA/V$$

$$r_{be1} = \frac{\beta_0}{g_{m1}} = 5k\Omega,\ r_{be2} = \frac{\beta_0}{g_{m2}} = 1k\Omega$$

CE (I stage), CE-ED (II stage)

$$R_{i1} = R_i(for\ \ CE) = r_{be1} = 5k\Omega$$

$$R_o = R_o(for\ \ CE - ED) = R_{C2} = 1k\Omega$$

$$A_V = \frac{v_{o2}}{v_{i1}} = \frac{v_{o2}}{v_{i2}}\frac{v_{o1}}{v_{i1}} = A_{V2} \times A_{V1}$$

$$A_{V2} = -\frac{g_{m2}R_{C2}}{1 + g_{m2}R_{E2}} = -\frac{200m \times 1k}{1 + 200m \times 150}$$

A_{V2} = - 6.45

$$R_{i2} = r_{be2} + (1 + \beta_0)R_{E2} = 1k + 201 \times 150$$ **= 31.15 k**

$$A_{V1} = -g_{m1}(R_{C1} \parallel R_{i2}) = -40m \times 4.31k$$

A_{V1} = 172.4

A_V ~ 1,111

$$A_{vs} = \frac{v_{o2}}{v_s} = \frac{v_{o2}}{v_{i1}}\frac{v_{i1}}{v_s} = A_V \cdot \frac{r_{be1}}{r_{be1} + R_S} = 926.5$$

5. In figure 2 the biasing components have been omitted. The transistors are identical with $\beta_o = 99$ and $r_{be} = 2\ k\Omega$, $R_C = 3\ k\Omega$, $R_E = 50\ \Omega$ and $R_S = 600\ \Omega$.
Calculate the trans-resistance gain V_o/i_s.
(Ans - $34.2 \times 10^3\ \Omega$).

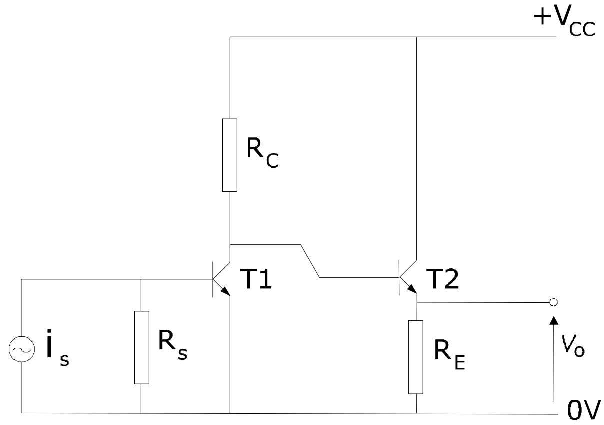

Figure 2

Solution
CE (I stage), CC (II stage)

$$g_{m2} = \frac{99}{2k} = 50mA/V$$

$$R_M = \frac{v_o}{i_s} = \frac{v_o}{v_{i2}}\frac{v_{i2}}{v_{i1}}\frac{v_{i1}}{i_s} \quad \textbf{or} \quad R_M = \frac{v_o}{i_s} = \frac{v_o}{v_{i2}}\frac{v_{o1}}{v_{i1}}\frac{v_{i1}}{i_s} = A_{V2} \times A_{V1} \times \frac{v_{i1}}{i_s}$$

and $i_S = \dfrac{v_{i1}}{R_S \parallel r_{be1}}$ **so** $\dfrac{v_{i1}}{i_s} = \dfrac{R_S \times r_{be1}}{R_S + r_{be1}}$

so $R_M = A_{V2} \times A_{V1} \times \dfrac{R_S \times r_{be1}}{R_S + r_{be1}}$

$$A_{V2} = \frac{g_{m2}R_E}{1+g_{m2}R_E} = \frac{50m \times 50}{1+50m \times 50}$$

A_{V2} = 0.71

$$A_{V1} = -g_{m1}(R_C \parallel R_{i2}) = 50m \times \frac{R_C \times R_{i2}}{R_C + R_{i2}}$$

$$R_{i2} = r_{be2} + (1+\beta_0)R_E = 2k + 100 \times 50 = 7k\Omega$$

So $A_{V1} = -g_{m1}(R_C \parallel R_{i2}) = 50m \times \dfrac{3k \times 7k}{3k+7} = 50m \times 2.1k$

A_{V1} = -105

$$\frac{R_S \times r_{be1}}{R_S + r_{be1}} = \frac{600 \times 2k}{600+2k} = \frac{1.2k}{2.6k} = 460\ \Omega$$

$$R_M = 0.71 \times -105 \times 460 \approx -34k\Omega.$$