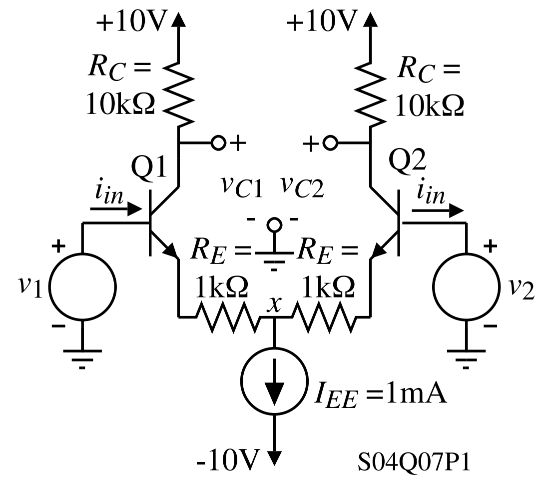
QUIZ NO. 7 - SOLUTION

(Average score = 6.0/10 of those taking the quiz)

Assume that Q1 and Q2 and the resistors R_C and R_E of the differential amplifier shown are matched. If $\beta_F = 100$, $V_t = 25\text{mV}$,and $V_A = \infty$, find (a.) Find the numerical value of v_{C1}/v_{id} where $v_{id} = v_1 - v_2$. (Hint: assume node x is at ac ground.) (b.) Find the numerical value of the differential input resistance defined as,

$$R_{id} = v_{id}/i_{in}$$

when $v_1 = 0.5v_{id}$ and $v_2 = -0.5v_{id}$ (c.) Find the numerical value of v_{C1}/v_{cm} where $v_{cm} = v_1 = v_2$.



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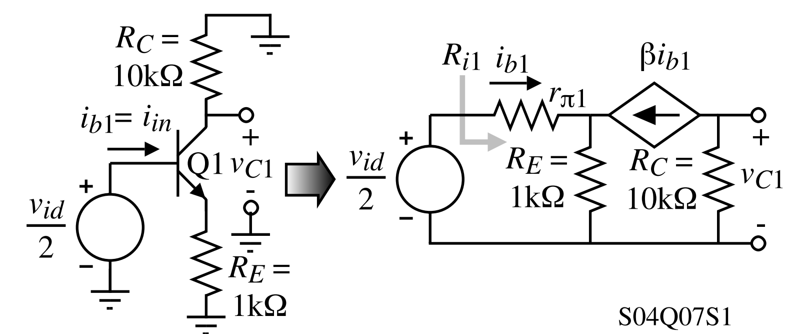
Solution

a.) Simplifying the circuit for differential mode analysis gives the model shown.

$$g_m = \frac{I_{C1}}{V_t} = \frac{0.5\text{mA}}{25\text{mV}} = 20\text{mS}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{20\text{mS}} = 5\text{k}\Omega$$



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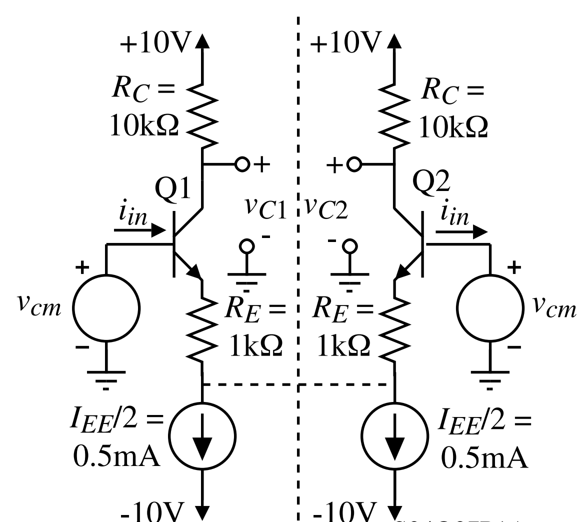
$$R_{i1} = r_{\pi1} + (1+\beta)R_E = 5\text{k}\Omega + (101)1\text{k}\Omega = 106\text{k}\Omega$$

$$\frac{v_{C1}}{v_{id}} = \frac{1}{2}\frac{v_{C1}}{v_{id}/2} = \frac{1}{2}\left(\frac{v_{C1}}{i_{b1}}\right)\left(\frac{i_{b1}}{v_{id}/2}\right) = \frac{1}{2}\left(\frac{v_{C1}}{i_{b1}}\right)\left(\frac{1}{R_{i1}}\right) = \frac{-\beta R_C}{2R_{i1}} = \frac{-100\cdot 10\text{k}\Omega}{2\cdot 106\text{k}\Omega} = \underline{\underline{-4.717\text{ V/V}}}$$

b.) $R_{id} = \dfrac{v_{id}}{i_{in}} = 2\dfrac{v_{id}}{2i_{b1}} = 2\dfrac{v_{id}/2}{i_{b1}} = 2R_{id} = 2(106\text{k}\Omega) = \underline{\underline{212\text{k}\Omega}}$

c.) The common mode gain is zero because the resistance of the I_{EE} current source (R_{EE}) is infinite. This is illustrated in the circuit shown for the common mode analysis.



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