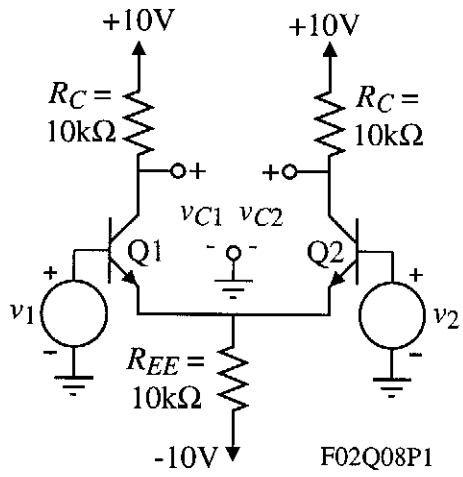
QUIZ NO. 8 - SOLUTION

(Average score = 7.7/10 for only those students taking the quiz)

Assume that Q1 and Q2 and the resistors R_C of the differential amplifier shown are matched. If $\beta_F = 100$, $V_t = 25\text{mV}$, $V_{BE} = 0.7\text{V}$ and $V_A = \infty$, find (a.) the numerical value of I_{C1} and I_{C2} if $v_1 = v_2 = 0$. (b.) *Assume* that $I_{C1} = I_{C2} = 0.5\text{mA}$ and find the numerical value of v_{C1}/v_{id} where $v_{id} = v_1 - v_2$. (c.) Continuing to assume that $I_{C1} = I_{C2} = 0.5\text{mA}$, find the numerical value of v_{C1}/v_{ic} where $v_{ic} = v_1 = v_2$.



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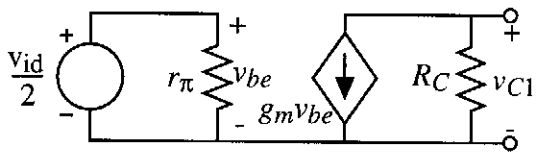
Solution

(a.) $I_{C1} = I_{C2} = \dfrac{\alpha(V_{EE}-V_{BE})}{2R_{EE}} = \dfrac{10\text{-}0.7}{2\cdot 10}\text{ mA} =$ <u>0.465mA</u>

(b.) If $I_{C1} = I_{C2} = 0.5\text{mA}$, then $g_m = \dfrac{I_{C1}}{V_t} = \dfrac{0.5}{25}\text{ S} = 20\text{mS}$ and $r_\pi = \dfrac{\beta_F}{g_m} = 5\text{k}\Omega$

Small-signal model:



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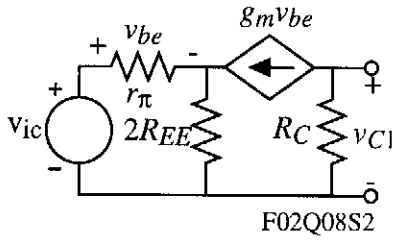
$$v_{C1}/v_{id} = \frac{-g_m R_C}{2} = \frac{-20\cdot 10}{2} = \underline{-100\text{V/V}}$$

(c.) The small-signal model for this part is shown.



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$$\frac{v_{C1}}{v_{id}} = \left(\frac{v_{C1}}{v_{be}}\right)\left(\frac{v_{be}}{v_{ic}}\right) = -g_m R_C\left(\frac{v_{be}}{v_{ic}}\right)$$

$$v_{be} = v_{ic} - 2R_{EE}\left(\frac{1}{r_\pi} + g_m\right)v_{be} = v_{ic} - \frac{2R_{EE}}{r_\pi}(1+\beta_F)v_{be}$$

$$\therefore \quad \frac{v_{be}}{v_{ic}} = \frac{1}{1 + \dfrac{2R_{EE}}{r_\pi}(1+\beta_F)}$$

$$\frac{v_{C1}}{v_{id}} = \left(\frac{v_{C1}}{v_{be}}\right)\left(\frac{v_{be}}{v_{ic}}\right) = \frac{-g_m R_C}{1 + \dfrac{2R_{EE}}{r_\pi}(1+\beta_F)} = \frac{-200}{1+404} = \underline{-0.494\text{V/V}}$$