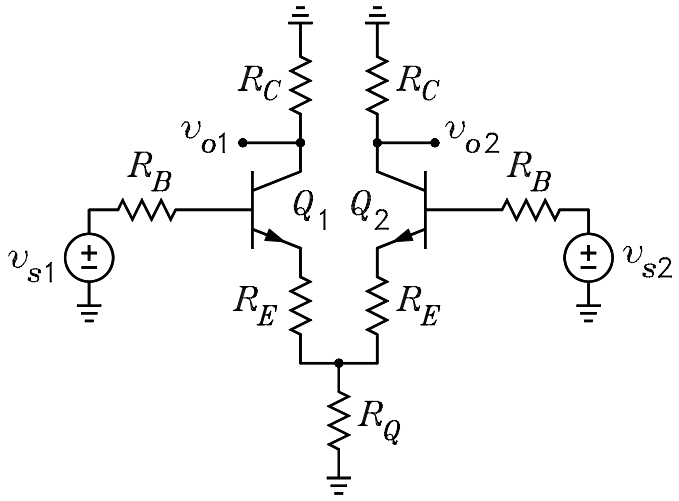
ECE 3050 Analog Electronics Quiz 6

September 30, 2009

Professor Leach Name_____

Instructions. Print your name in the space above. Place a box around your answers. Points will be subtracted if you do not express each numerical answer as a decimal number and if you do not put a box around answers. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials _____

1. The figure shows the ac signal circuit for a differential amplifier. For each BJT, it is given that $\alpha = 0.99$, $\beta = 99$, $r_x = 0$, $g_m = 49.5\,\text{mS}$, $r_\pi = 2\,\text{k}\Omega$, $r_e = 20\,\Omega$, $r_0 = \infty$, $R_B = 1\,\text{k}\Omega$, $R_E = 70\,\Omega$, $R_Q = 50\,\text{k}\Omega$, and $R_C = 12\,\text{k}\Omega$.
   (a) Replace v_{s1} and v_{s2} with differential inputs. Solve for the differential gain $A_{v(d)} = v_{o1}/v_{id}$.
   (b) Replace v_{s1} and v_{s2} with common-mode inputs. Solve for the common-mode gain $A_{v(cm)} = v_{o1}/v_{icm}$.
   (c) What is the common-mode rejection ratio?



Solutions on next page.

$\alpha := 0.99$ $\beta := 99$ $g_m := 49.5 \cdot 10^{-3}$ $r_\pi := 2000$ $r_e := 20$ $R_B := 1000$

$R_E := 70$ $R_Q := 50000$ $R_C := 12000$ $r'_e := \frac{R_B}{1+\beta} + r_e$ $r'_e = 30$

You were expected to use the small-signal models to arrive at the following answers:

(a) $v_{i1} = \frac{v_{id}}{2}$ $v_{i2} = \frac{-v_{id}}{2}$ $v_{o1} = -i'_{c1} \cdot R_C = -\alpha \cdot i'_{e1} \cdot R_C = -\alpha \cdot \frac{\frac{v_{id}}{2}}{r'_e + R_E} \cdot R_C$

$A_{vd} = \frac{v_{o1}}{v_{id}}$ $A_{vd} := \frac{\frac{-\alpha}{2} \cdot R_C}{r'_e + R_E}$ $A_{vd} = -59.4$

(b) $v_{i1} = v_{icm}$ $v_{i2} = v_{icm}$ $v_{o1} = -i'_{c1} \cdot R_C = -\alpha \cdot i'_{e1} \cdot R_C = -\alpha \cdot \frac{v_{icm}}{r'_e + R_E + 2 \cdot R_Q} \cdot R_C$

$A_{vcm} = \frac{v_{o1}}{v_{icm}}$ $A_{vcm} := \frac{-\alpha \cdot R_C}{r'_e + R_E + 2 \cdot R_Q}$ $A_{vcm} = -0.119$

(c) $CMRR := \left| \frac{A_{vd}}{A_{vcm}} \right|$ $CMRR = 500.5$

$CMRR_{dB} := 20 \cdot \log(CMRR)$ $CMRR_{dB} = 53.988$