ECE 3050 Analog Electronics Quiz 4
June 16, 2010

Professor Leach Name____________________________________

Instructions. Print your name in the space above. **Honor Code:** *I have neither given nor received help on this quiz.* Initials ______________

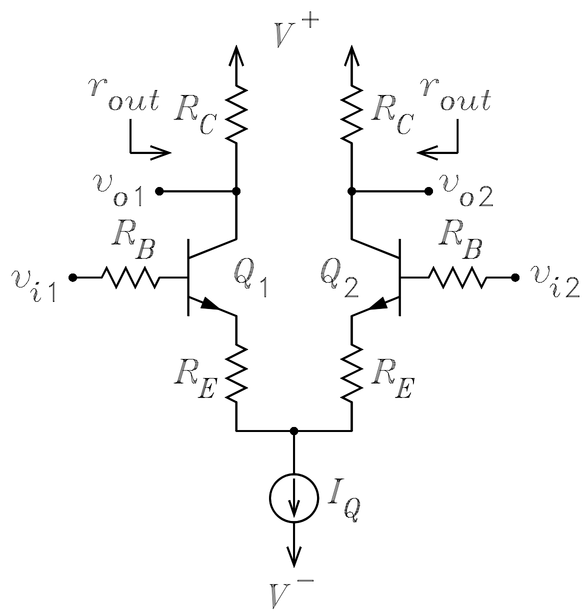
Formulas: $g_m = I_C/V_T$, $r_\pi = V_T/I_B$, $r_e = V_T/I_E$, $r_0 = (V_A + V_{CE})/I_C$, $G_m = (R_{tb}/\beta + 1/g_m + R_{te}/\alpha)^{-1}$,

$$r_{ib} = r_\pi + (1+\beta) R_{te} \qquad r_{ie} = \frac{R_{tb} + r_x}{1+\beta} + r_e \qquad r_{ic} = r_0 \left(1 + \frac{\beta R_{te}}{R_{tb} + r_\pi + R_{te}}\right) + (R_{tb} + r_\pi) \| R_{te}$$

The figure shows a BJT diff amp. Given: $I_Q = 2\,\text{mA}$, $V_T = 25\,\text{mV}$, $\beta = 99$, $\alpha = 0.99$, $V_A = \infty$ ($r_0 = \infty$). $R_B = 1.2\,\text{k}\Omega$, $R_E = 163\,\Omega$, and $R_C = 18\,\text{k}\Omega$.

(a) Solve for the numerical expressions for the small-signal output voltages v_{o1} and v_{o2} as functions of the input voltages v_{i1} and v_{i2}.

(b) What would be the expressions if the tail supply has a small-signal resistance $R_Q = 20\,\text{k}\Omega$? Assume I_E does not change.



Solutions on page 2.

$I_Q := 0.002 \quad V_T := 0.025 \quad \beta := 99 \quad \alpha := 0.99 \quad R_B := 1200 \quad R_E := 163 \quad R_C := 18000$

$I_E := 0.001 \quad r_e := \frac{V_T}{I_E} \quad r_e = 25 \quad r_\pi := \frac{(1+\beta)\ V_T}{I_E} \quad r_\pi = 2.5 \cdot 10^3$

$g_m := \frac{I_C}{V_T} \quad g_m = 0.04 \quad g_m^{-1} = 24.848 \quad r_{ie} := \frac{R_B}{1+\beta} + r_e \quad r_{ie} = 37$

$R_{te} := 2 \cdot R_E + r_{ie} \quad R_{te} = 363 \quad A_{va} := \frac{-\alpha \cdot R_C}{2 \cdot (r_{ie} + R_E)} \quad A_{va} = -44.55$

$v_{o1} = A_{va}(v_{i1} - v_{i2}) \quad v_{o2} = -v_{01}$

$R_Q := 20000 \quad A_{vb} := \frac{-\alpha \cdot R_C}{r_{ie} + R_E + R_p(R_Q, R_E + r_{ie})} \quad k := \frac{R_Q}{R_Q + R_E + r_{ie}}$

$A_{vb} = -44.772 \quad k = 0.99 \quad k \cdot A_{vb} = -44.328$

$v_{o1} = A_{vb}(v_{i1} - k \cdot v_{i2}) \quad v_{o2} = A_{vb}(v_{i2} - k \cdot v_{o1})$