ECE 3050 Analog Electronics Quiz 4

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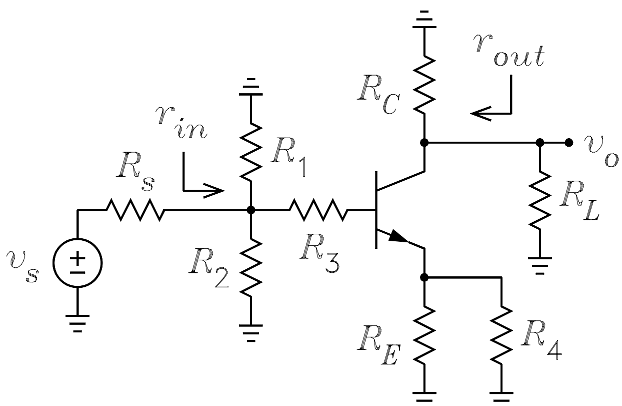
Instructions. Print your name in the spaces above. Place a box around any answer. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials __________

The figure shows the signal circuit of a common-emitter amplifier. It is given that $R_s = 300\,\Omega$, $R_1 = 20\,\text{k}\Omega$, $R_2 = 10\,\text{k}\Omega$, $R_3 = 200\,\Omega$, $R_C = 24\,\text{k}\Omega$, $R_E = 2\,\text{k}\Omega$, $R_4 = 75\,\Omega$, and $R_L = 12\,\text{k}\Omega$. The BJT has the parameters and bias values $\beta = 99$, $\alpha = 0.99$, $r_x = 100\,\Omega$, $I_C = 1.5\,\text{mA}$, $V_{CE} = 10\,\text{V}$, $V_A = \infty$, and $V_T = 0.025\,\text{V}$.

$$r_\pi = \frac{V_T}{I_B} \qquad r_e = \frac{V_T}{I_E} \qquad g_m = \frac{I_C}{V_T} \qquad r'_\pi = r_x + r_\pi + (1+\beta)\,R_{te}$$

$$r_0 = \frac{V_A + V_{CE}}{I_C} \qquad r'_e = \frac{R_{tb} + r_x}{1+\beta} + r_e \qquad r_{ic} = \frac{r_0 + r'_e \| R_{te}}{1 - \alpha \dfrac{R_{te}}{r'_e + R_{te}}}$$

(a) Solve for v_{tb}/v_s, R_{tb}, and R_{te}. For the values given, why is r_0 an open circuit?
(b) Solve for the voltage gain $A_v = v_o/v_s$.
(c) Solve for the output resistance r_{out}.
(d) Solve for the input resistance r_{in}.



Next page for solutions.

$R_s := 300$ $R_1 := 20000$ $R_2 := 10000$ $R_3 := 200$ $R_C := 24000$ $R_E := 2000$

$R_4 := 75$ $R_L := 12000$ $\beta := 99$ $\alpha := 0.99$ $r_x := 100$ $I_C := 0.0015$

$V_T := 0.025$ $I_B := \frac{I_C}{\beta}$ $I_E := \frac{I_C}{\alpha}$ $g_m := \frac{I_C}{V_T}$ $r_\pi := \frac{V_T}{I_B}$ $r_e := \frac{V_T}{I_E}$ $v_s := 1$

Part (a)

$v_{tb} := v_s \cdot \frac{R_{p2}(R_1, R_2)}{R_s + R_{p2}(R_1, R_2)}$ $v_{tb} = 0.957$ $R_{tb} := R_{p3}(R_s, R_1, R_2) + R_3$ $R_{tb} = 4.871 \cdot 10^2$

$R_{te} := R_{p2}(R_E, R_4)$ $R_{te} = 72.289$

Part (b) using the simplified π model

$r'_\pi := r_x + r_\pi + (1+\beta) \cdot R_{te}$ $r'_\pi = 8.979 \cdot 10^3$

$i_b := \frac{v_{tb}}{R_{tb} + r'_\pi}$ $i_b = 1.011 \cdot 10^{-4}$ $i'_c := \beta \cdot i_b$ $i'_c = 1.001 \cdot 10^{-2}$

$v_o := -i'_c \cdot R_{p2}(R_C, R_L)$ $v_o = -80.065$ This is the voltage gain

Part (b) using the simplified T model

$r'_e := \frac{R_{tb} + r_x}{1+\beta} + r_e$ $r'_e = 22.371$

$i'_e := \frac{v_{tb}}{r'_e + R_{te}}$ $i'_e = 1.011 \cdot 10^{-2}$ $i'_c := \alpha \cdot i'_e$ $i'_c = 1.001 \cdot 10^{-2}$

$v_o := -i'_c \cdot R_{p2}(R_C, R_L)$ $v_o = -80.065$ This is the voltage gain

Part (c)

$r_{out} := R_C$ $r_{out} = 2.4 \cdot 10^4$

Part (d)

$r_{ib} := r'_\pi$ $r_{in} := R_{p3}(R_1, R_2, R_3 + r_{ib})$ $r_{in} = 3.862 \cdot 10^3$