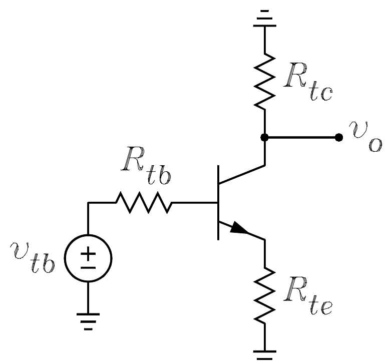
ECE 3040 Microelectronic Circuits Quiz 8
July 7, 2004

Professor Leach Name____________________________________

Instructions. Print your name in the space above. The quiz is closed-book and closed-notes. The quiz consists of one problem. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials ______________

1. The figure shows the ac signal circuit of a common-emitter amplifier. It is given that $I_E = 2\,\text{mA}$, $\beta = 99$, $r_0 = \infty$, and $V_T = 0.025\,\text{V}$, $g_m = I_C/V_T$, $r_\pi = V_T/I_B$, $r_e = V_T/I_E$, and $r'_e = R_{tb}/(1+\beta) + r_e$.
(a) Let $R_{te} = 0$ and $R_{tb} = 3.3\,\text{k}\Omega$. Replace the transistor with the π model and use $i'_c = g_m v_{be}$. Write the appropriate equations and solve for the value of R_{tc} such that $v_o/v_{tb} = -200$.
(b) Let $R_{te} = 0$ and $R_{tc} = 3.3\,\text{k}\Omega$. Replace the transistor with the T model and use $i'_c = \alpha i'_e$. Write the appropriate equations and solve for the value of R_{tb} such that $v_o/v_{tb} = -50$.
(c) Let $R_{tb} = 1\,\text{k}\Omega$, $R_{te} = 50\,\Omega$, and $R_{tc} = 10\,\text{k}\Omega$. Use the simplified T model to solve for v_o/v_{tb}.



Solutions: (see the class notes for the small-signal circuits) $g_m = I_C/V_T = \alpha I_E/V_T = 0.079\,\text{S}$, $r_\pi = V_T/I_B = (1+\beta)V_T/I_E = 1.25\,\text{k}\Omega$, $\alpha = \beta/(1+\beta) = 0.99$, $r_e = V_T/I_E = 12.5\,\Omega$, $r'_e = R_{tb}/(1+\beta) + r_e = 22.5\,\Omega$

(a)

$$v_o = -i'_c R_{tc} = -[g_m(v_{be})]R_{tc} = -\left[g_m\left(v_{tb}\frac{r_\pi}{R_{tb}+r_\pi}\right)\right]R_{tc}$$

$$\implies R_{tc} = \frac{R_{tb}+r_\pi}{g_m r_\pi}\left(-\frac{v_o}{v_{tb}}\right) = \frac{3300+1250}{0.079 * 1250}(200) = 9.192\,\text{k}\Omega$$

(b)

$$v_o = -i'_c R_{tc} = -[\alpha(i'_e)]R_{tc} \qquad v_{tb} = i_b R_{tb} + i'_e r_e = \frac{i'_e}{1+\beta}R_{tb} + i'_e r_e = i'_e\left(\frac{R_{tb}}{1+\beta}+r_e\right)$$

$$\implies i'_e = \frac{v_{tb}}{\dfrac{R_{tb}}{1+\beta}+r_e} \implies v_o = -\left[\alpha\left(\frac{v_{tb}}{\dfrac{R_{tb}}{1+\beta}+r_e}\right)\right]R_{tc}$$

$$\implies R_{tb} = (1+\beta)\left[\alpha R_{tc}\left(\frac{v_o}{v_{tb}}\right)^{-1} - r_e\right] = (1+99)\left[0.99\times 3300\left(\frac{1}{50}\right)^{-1} - 12.5\right] = 5.284\,\text{k}\Omega$$

(c)

$$v_o = -i'_c R_{tc} = -[\alpha(i'_e)]R_{tc} = -\left[\alpha\left(\frac{v_{tb}}{\dfrac{R_{tb}}{1+\beta}+R_{te}+r_e}\right)\right]R_{tc}$$

$$\implies \frac{v_o}{v_{tb}} - \frac{\alpha R_{tc}}{\dfrac{R_{tb}}{1+\beta}+R_{te}+r_e} = -\frac{0.99\times 10000}{\dfrac{1000}{1+99}+50+12.5} = -136.5$$