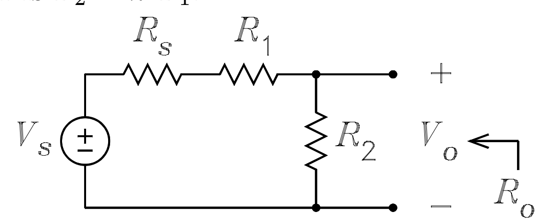
ECE 6416 Quiz 2

November 9, 2005

Professor Leach Name______________________________

Instructions. Print your name in the space above and at the top of all other pages in your quiz. Place a box around each answer. Express each numerical answer as a decimal number. Staple your formula sheet to the back of the quiz. Do not place the staple over any of your work or over a problem number. Numerical values are $4kT_0 = 1.6 \times 10^{-20}$ J and $q = 1.6 \times 10^{-19}$ C. **Honor Code:** *I have neither given nor received help on this quiz.* Initials ____________

1. (a) The figure shows a source (V_s and R_s) connected to an attenuator (R_1 and R_2). It is desired to have $V_o = kV_s$ and $R_o = R_s$. What are the equations for R_1 and R_2 as functions of R_s and k?
   (b) When the source is connected to an amplifier having the noise parameters v_n^2, i_n^2, and γ, the noise factor is F_1. With the attenuator between the source and the amplifier, show that the noise factor is $F_2 = k^2 F_1$.



$$\frac{R_2}{R_s + R_1 + R_2} = k \qquad R_2 \| (R_s + R_1) = R_s \Longrightarrow k(R_s + R_1) = R_s \Longrightarrow R_1 = \frac{1-k}{k} R_s$$

$$R_2 = k\left(R_s + \frac{1-k}{k} R_s + R_2\right) \Longrightarrow R_2 = (1-k) R_s$$

$$V_{o(oc)} = kV_s + V_{ni} = k\left(V_s + \frac{V_{ni}}{k}\right) \Longrightarrow v_{ni}'^2 = k^2 v_{ni}^2 \Longrightarrow F_2 = k^2 F_1$$

2. (a) The figure shows the T model of a BJT common-emitter amplifier with the collector and emitter connected to signal ground. Assuming that the flicker noise can be neglected, redraw the figure with all noise sources added.
   (b) Solve for the Thévenin equivalent circuit seen looking out of the base.
   Treating r_x as an external resistor, we can write

$$V_{tb} = V_s + V_{ts} + V_{tx} + I_{shb}(R_s + r_x) \qquad R_{tb} = R_s + r_x$$

   (c) Use the equivalent circuit found in part (b) to solve for I_e' as a function of all appropriate sources.

$$I_e' = \frac{V_{tb}}{R_{tb} + r_e} + \alpha I_e' \frac{R_{tb}}{R_{tb} + r_e} \Longrightarrow I_e' = \frac{V_{tb}}{(1-\alpha) R_{tb} + r_e}$$

(d) Making use of the equation for I'_e, solve for $I_{c(sc)}$.

$$I_{c(sc)} = \alpha I'_e + I_{shc} = \alpha \frac{V_s + V_{ts} + V_{tx} + I_{shb}\left(R_s + r_x\right)}{\left(1-\alpha\right) R_{tb} + r_e} + I_{shc}$$

(e) From the equation for $I_{c(sc)}$, solve for the equation for V_{ni} in series with V_s. You do not have to solve for the mean-square value of V_{ni}.

$$I_{c(sc)} = \frac{\alpha}{\left(1-\alpha\right) R_{tb} + r_e}\left[V_s + V_{ts} + V_{tx} + I_{shb}\left(R_s + r_x\right) + I_{shc}\frac{\left(1-\alpha\right) R_{tb} + r_e}{\alpha}\right]$$

$$\Longrightarrow \quad V_{ni} = V_{ts} + V_{tx} + I_{shb}\left(R_s + r_x\right) + I_{shc}\frac{\left(1-\alpha\right) R_{tb} + r_e}{\alpha}$$