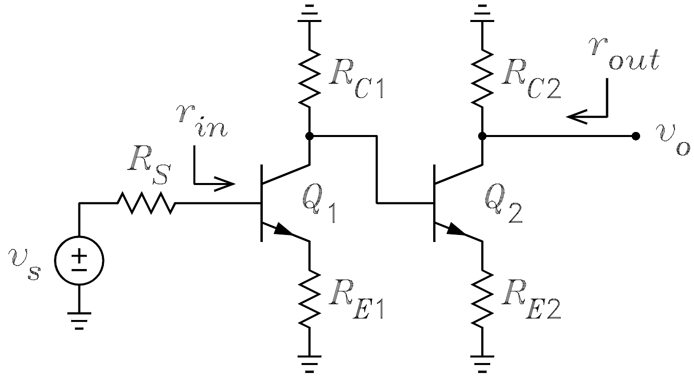
ECE3050 Homework Set 8

1. The figure shows the ac signal circuit of a cascade common-emitter amplifier. For each BJT, it is given that $I_E = 1.5\,\text{mA}$, $\alpha = 0.99$, $\beta = 99$, $r_x = 20\,\Omega$, $r_0 = \infty$, and $V_T = 0.025\,\text{V}$. The circuit element values are $R_S = 1\,\text{k}\Omega$, $R_{E1} = R_{E2} = 47\,\Omega$, $R_{C1} = R_{C2} = 10\,\text{k}\Omega$.



(a) Looking out of the base of Q_2, use the Norton collector circuit of Q_1 to show that

$$v_{tb2} = -i_{c1}R_{c1} = -134.03v_s \qquad R_{tb2} = R_{C1} = 10\,\text{k}\Omega$$

(b) Use the Norton collector circuit for Q_2 to show that

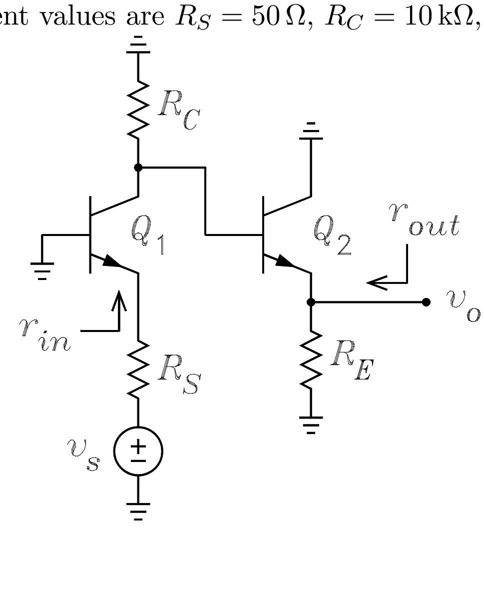
$$v_o = 8097v_s \qquad r_{out} = R_{C2} = 10\,\text{k}\Omega$$

(c) Show that

$$r_{in} = r_{ib1} = 6.387\,\text{k}\Omega$$

(d) If a resistor $R_L = 1\,\text{k}\Omega$ is connected from output to ground, show that the new gain is reduced by a factor $R_L/\left(r_{out} + R_L\right)$ to the value $v_o/v_s = 736.1$ and that the dB decrease in gain is 20.83 dB.

2. The ac signal circuit of a common-base amplifier driving a common-collector amplifier is shown. For each BJT, it is given that $I_E = 1.5\,\text{mA}$, $\alpha = 0.99$, $\beta = 99$, $r_x = 20\,\Omega$, $r_0 = \infty$, and $V_T = 0.025\,\text{V}$. The circuit element values are $R_S = 50\,\Omega$, $R_C = 10\,\text{k}\Omega$, $R_E = 1\,\text{k}\Omega$. **??**



(a) Looking out of the base of Q_2 use the Norton collector circuit of Q_1 to show that

$$v_{tb2} = 148.06 v_s \qquad R_{tb2} = 10\,\mathrm{k}\Omega$$

(b) Use the simplified T model for Q_2 to show that

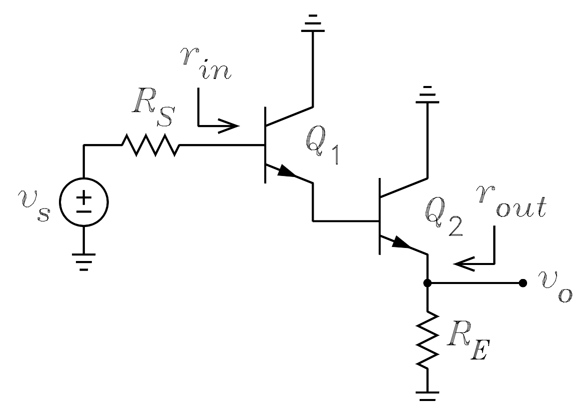
$$v_o = 132.56 v_s \qquad r_{out} = r_{ie2} \| R_E = 104.638\,\Omega$$

(c) Use the simplified T model for Q_1 to show that

$$r_{in} = r_{ie1} = 16.867\,\Omega$$

(d) If a resistor $R_L = 1\,\mathrm{k}\Omega$ is connected from output to ground, show that the new gain is reduced by the factor $R_L / (r_{out} + R_L)$ to the value $v_o/v_s = 120.01$ and the dB decrease in gain is 0.864 dB. Note that the gain does not change nearly as much as it did in problem 1. Explain.

3. The figure shows a cascade common-collector amplifier, also called a Darlington connection. For each BJT, it is given that $\alpha = 0.99$, $\beta = 99$, $r_x = 20\ \Omega$, $r_0 = \infty$, and $V_T = 0.025\,\mathrm{V}$. The emitter current in Q_2 is $I_{E2} = 10\,\mathrm{mA}$. The circuit element values are $R_S = 10\,\mathrm{k}\Omega$ and $R_E = 100\,\Omega$.



(a) Looking out of the base of Q_2, use the simplified T model for Q_1 to show that

$$v_{tb2} = v_s \qquad R_{tb2} = r_{ie1} = 350.2\,\Omega$$

(b) Use the simplified T model for Q_2 to show that

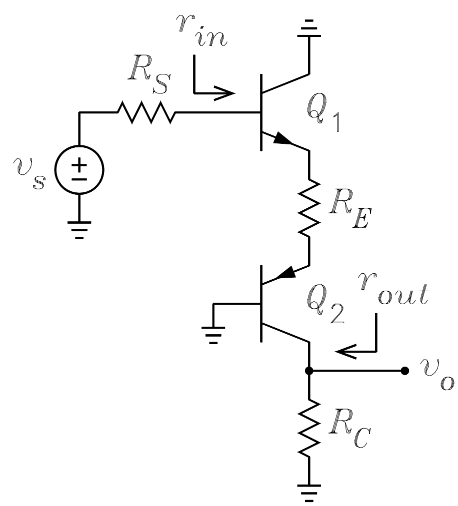
$$v_o = 0.942 v_s \qquad r_{out} = r_{ie2} \| R_E = 5.84\,\Omega$$

(c) Show that

$$r_{in} = r_{ib1} = 1.052\,\mathrm{M}\Omega$$

(d) If Q_1 and Q_2 are removed and R_E is connected to the right node of R_S, show that $v_o/v_s = 9.901 \times 10^{-3}$, a decrease of 39.56 dB.

4. The figure shows a common-collector stage driving a common-base stage. For each BJT, it is given that $I_E = 1.5\,\mathrm{mA}$, $\alpha = 0.99$, $\beta = 99$, $r_x = 20\,\Omega$, $r_0 = \infty$, and $V_T = 0.025\,\mathrm{V}$. The circuit element values are $R_S = 1\,\mathrm{k}\Omega$, $R_E = 100\,\Omega$, $R_C = 10\,\mathrm{k}\Omega$.



(a) Use the simplified T model for Q_1 to show that

$$v_{te2} = v_s \qquad R_{te2} = R_E + r_{ie1} = 126.87\,\Omega$$

(b) Use the Norton collector circuit of Q_2 to show that

$$v_o = 68.88 v_s \qquad r_{out} = R_C = 10\,\mathrm{k}\Omega$$

(c) Show that

$$r_{in} = r_{ib1} = 13.37\,\mathrm{k}\Omega$$