EEE 51 Assignment 9

2nd Semester SY 2017-2018
Due: 5pm Tuesday, May 8, 2018 (Rm. 220)

Instructions: Write legibly. Show all solutions and state all assumptions. Write your full name, student number, and section at the upper-right corner of each page. Start each problem on a new sheet of paper. Box or encircle your final answer.

Answer sheets should be colored according to your lecture section. The color scheme is as follows:

THQ – yellow
THR – blue
THU – white
THX – green
WFX – pink

1. **What is Feedback?** Chaeyoung is an engineer who is building a communication system. She wants to reduce the effect of noise from unwanted nearby signals by using a negative feedback circuit, which is shown in Figure 1. Assume that the op amp is ideal, and $\beta \to \infty$ for the transistor.

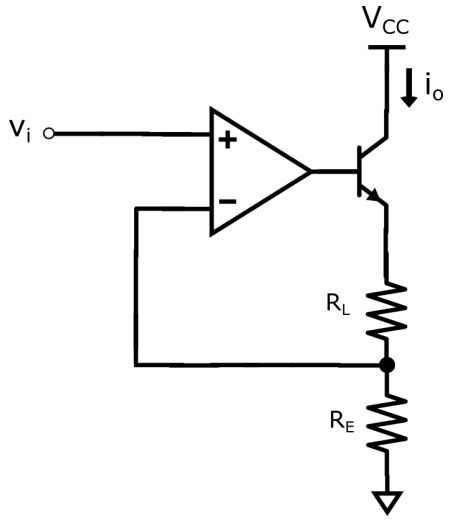

Figure 1: Tzuyu's negative feedback circuit

   (a) What is the quantity being sampled (i.e. what is the output quantity): voltage or current? [0.5 pt]

   (b) What is the quantity being mixed with the input: voltage or current? [0.5 pt]

   (c) From your answers in (a) and (b), what type of feedback topology is being used? [1 pt]

   (d) Recall that the forward gain, A, is the ratio of the output signal (s_o) to the error signal (s_e). Express A in terms of R_L and R_E. [2 pts]

   (e) On the other hand, the feedback factor F is the ratio of the signal being fed back to the input (s_{fb}) to the output signal (s_o). Express T in terms of R_L and R_E. [2 pts]

   (f) Given your answers in (d) and (e), what is the closed loop gain, A_{CL}? [2 pts]

2. **Frequency response of a common emitter amplifier with feedback.** A common emitter amplifier is shown in Figure 2. Given that $V_{CC} = 12\,\text{V}$, $V_{IN} = 5\,\text{V}$, $V_A = 100\,\text{V}$, $I_S = 1\,\text{fA}$, $R_S = 10\,\text{k}\Omega$, $R_C = 500\,\Omega$, $R_f = 1\,\text{k}\Omega$, and $\beta = 50$, answer the following questions.

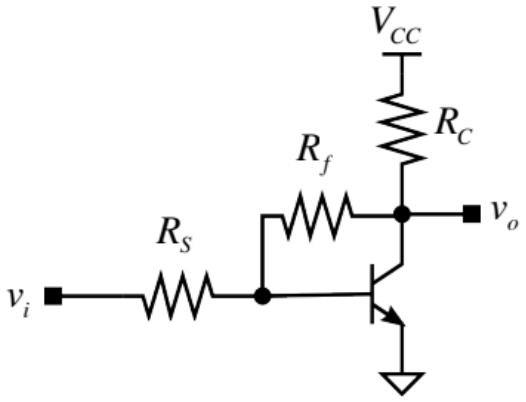

Figure 2: Common Emitter Amplifier with Capacitive Load

(a) Draw the equivalent small-signal circuit for both open-loop and closed-loop circuits. (Ignore parasitic capacitances.)[4 pts]

(b) What is the small-signal open-loop gain of the amplifier? [3 pts]

(c) What is the small-signal closed-loop gain of the amplifier? [3 pts]

3. **Analysis of a feedback amplifier.** Consider the feedback amplifier shown in Fig. 3. Provided that all transistors have $\beta \to \infty$, $V_{be,on} = 0.7V$, $V_A \to \infty$, an input DC voltage of 1V and an output DC voltage of 1.5V,

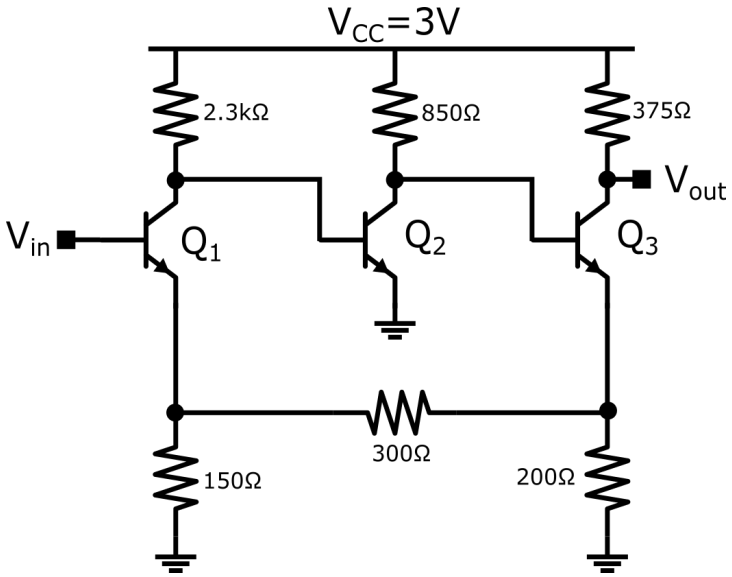

Figure 3: Basic feedback amplifier

(a) Determine the collector currents and transconductances of Q_1, Q_2 and Q_3. [1 pt]

(b) What type of feedback topology is used in this circuit? Draw the feedback network. [2 pts]

(c) Find the feedback factor, F, the input and output resistances of the feedback network. [3 pts]

(d) Draw the small signal model of the amplifier. [2 pts]

(e) Determine the open-loop gain of the amplifier. [2 pts]

(f) What is the loop gain of the feedback network? [1 pt]

(g) What is the closed-loop gain of the amplifier? [1 pt]

TOTAL: 30 points.