EEE 51 Assignment 4

2nd Semester SY 2017-2018
Due: 5pm Tuesday, Feb. 27, 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 color coded according to your lecture section. The color scheme is as follows:

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

1. **MOSFET-BJT Amplifier Design.** Figure 1 shows an amplifier configuration that uses current mirrors to generate the DC voltages needed by M_1 and Q_2 with only one DC voltage supply. The output DC voltage requirement is 2.5 V at room temperature, while using a single 5 V supply voltage and M_1 having a quiescent DC drain current of 1 mA. Assume that the given capacitor and inductor elements are ideal and have infinitely large values.

   Given $\beta = 300$, $|I_S|$=$1fA$, and $|V_A|$=$100V$ for the PNP transistors and $k = 2\frac{mA}{V^2}$, $\lambda = 0.1V^{-1}$, and $V_{TH} = 1V$ for the NMOS transistors:

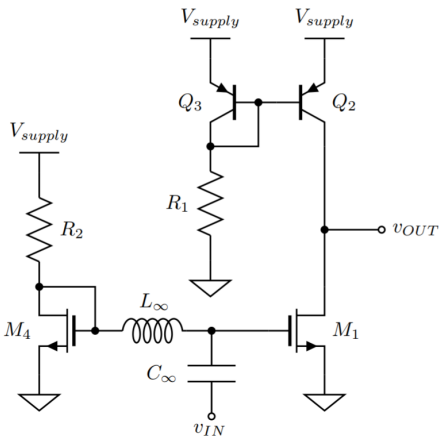

Figure 1: MOSFET-BJT Amplifier

   (a) Determine the required R_1 and R_2. [4 pts]
   (b) Determine the small signal gain, $A_V = \frac{v_{out}}{v_{in}}$, of the amplifier. [3 pts]

2. **BJT Current Mirror with Emitter Resistors**. A current mirror was constructed as shown in Figure 2 with a resistor R_A used to generate a bias current. Q_1 and Q_2 are used to mirror that current and generate I_{OUT}. The current mirror has already been biased such that both transistors are in forward active over some range of output voltage, and so $r_{\pi 1}$, $r_{\pi 2}$, r_{o1}, r_{o2}, g_{m1}, g_{m2} are known to be some set of values, as well as R_A, R_B and R_C.

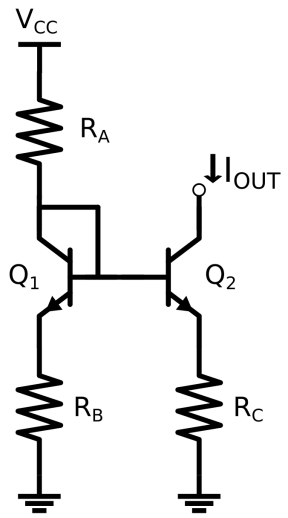

Figure 2: BJT Current Mirror

(a) Draw the small-signal equivalent circuit. Label all parameters, voltages, currents necessary. Label terminal names, and if possible, label the nodes mapping to the pins of the transistors. [3 pts]

(b) Determine the output resistance R_o in terms of the small-signal parameters and resistor values. Do not omit terms based on common assumptions. If possible, show a detailed step by step solution and simplify or expand terms for clarity. [4 pts]

3. **MOSFET Cascode Current Mirror**. Given the cascode current mirror below, determine the following:

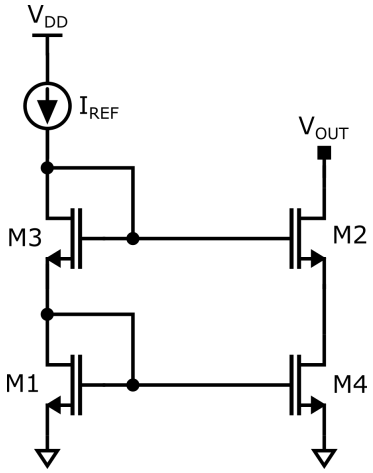

Figure 3: MOSFET Cascode Current Mirror

(a) Draw the *simplified* small-signal equivalent circuit. State all assumptions and properly label all parameters, voltages, and terminal names. [3 pts]

(b) Determine the circuit's output resistance R_o in terms of the transistor g_m and r_o. [3 pts]

TOTAL: 20 points.