EEE 51 Assignment 6

2nd Semester SY 2017-2018
Due: 5pm Tuesday, Mar. 13, 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 Differential CS Amplifier.** Given the following:

$V_{DD} = 5V$, I_R=50uA , $k_{1,2,7,8} = 2k_6 = 100\frac{uA}{V^2}$, $k_{3,4} = 2k_5 = 75\frac{uA}{V^2}$ $\lambda = 0.02V^{-1}$, and $V_{TH_{n|p}} = 1V$:

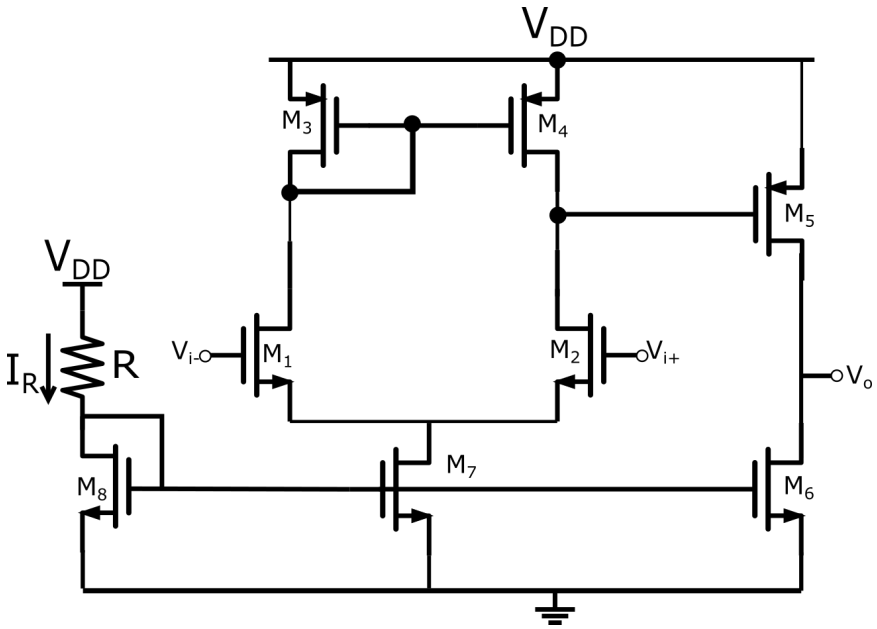

Figure 1: Differential-CS amplifier

(a) Complete the table and ignore channel length modulation effect and assuming all transistors in saturation. [7 pts]

Parameter	M1	M2	M3	M4	M5	M6	M7	M8
ID								
|Vgs|								
gm								
ro								

Figure 2: Parameter table

(b) Solve for the gain of the 1st and 2nd stage as well as the overall gain of the amplifier. [3 pts]

2. **BJT Cascode Amplifier with Cascode Load**. A Cascode amplifier is designed as shown in Figure 3. Bias voltages have been provided to it, and the input is fed through a DC block in order to maintain proper biasing. All transistors are confirmed to be biased properly to forward active. The load is a Cascode current mirror designed to provide an output resistance similar to the amplifier's.

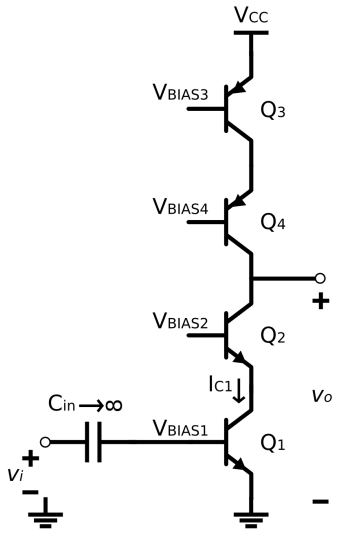

Figure 3: Cascode Amplifier

(a) Draw the small-signal equivalent circuit. Determine the total output resistance R_o, transconductance G_m and gain A_v of the whole amplifier as a function of the small-signal parameters (g_{m1}, r_{o1}, $r_{\pi 1}$, g_{m2}, etc.). [6 pts]

(b) Convert the small-signal parameters such that G_m, R_o and A_v are then a function of the quiescent collector current of Q_1, I_{C1}. For both NPN and PNP transistors, $V_A = 200\,\text{V}$, $\beta = 200$, and let $V_T = 26\,\text{mV}$. [3 pts]

(c) Given that the gain and output characteristics of the amplifier have been shown in relationship to the bias current, as a design problem how would you determine what to set the bias current as, based on what possible and reasonable parameters or specifications? [1 pt]

3. **Multistage Amplifier**. For the given figure below, you are given the following assumptions: $\beta \gg 1$ and $|V_{BE}| = 0.7V$. The input and output DC quiescent voltages are set to 0.

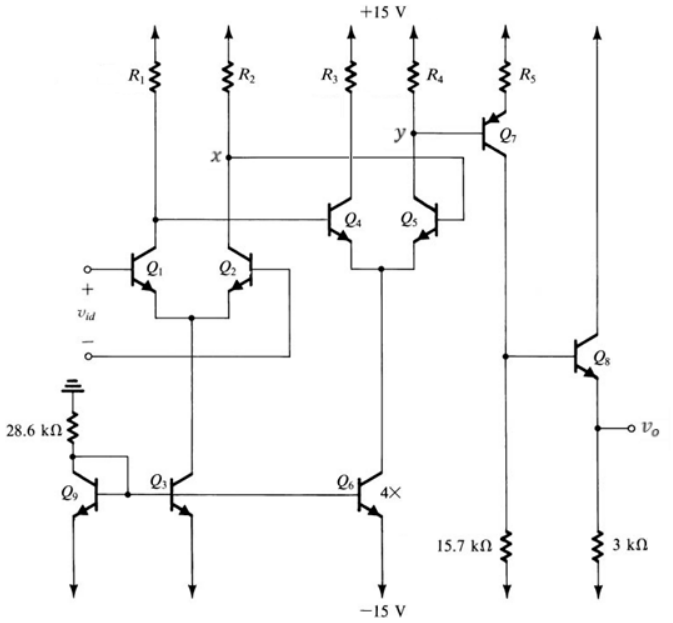

Figure 4: Multistage Amplifier

(a) Determine all the DC collector currents of each transistor. [2 pts]

(b) Given V_x= 6 V and V_y= 7.5 V, what are the values of resistors R_1 to R_5? [2 pts]

(c) Assuming ideal current sources, find the circuit gain A_v with loading in-between stages. Write your *complete* solution. [6 pts]

TOTAL: 30 points.