

# EEE 51 Assignment 1

2nd Semester SY 2017-2018

Due: 5pm Tuesday, Jan. 30, 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.

1. **BJT DC Biasing 1.** Consider the circuit shown below. Provided that  $V_{CC} = 5V$ ,  $V_{IN} = 3V$ ,  $R_{B1} = 200k\Omega$ ,  $R_{C1} = 2k\Omega$ ,  $R_{C2} = 200\Omega$ ,  $\beta_{Q1} = 100$ ,  $\beta_{Q2} = 50$ ,  $V_{BE1,on} = V_{BE2,on} = 0.7V$  and  $V_{CE1,sat} = V_{CE2,sat} = 0.2V$  determine the following:

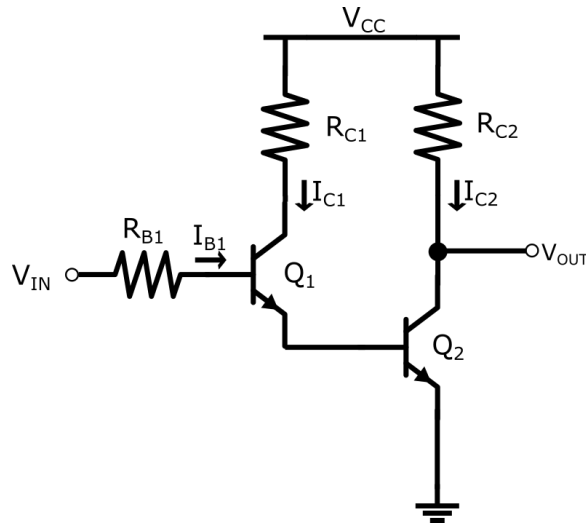


Figure 1: BJT Darlington Pair

- (a)  $I_{B1}$ ,  $I_{C1}$  and  $V_{CE1}$ . State all necessary assumptions. [3 pts]
- (b)  $I_{C2}$  and  $V_{OUT}$ . State all necessary assumptions. [2 pts]
- (c) Suppose we want to achieve a  $V_{OUT}$  of at least  $1V$  by changing  $R_{B1}$ . Determine the minimum value of  $R_{B1}$  needed to get the desired  $V_{OUT}$ . Again, state all necessary assumptions. [2 pts]
2. **BJT DC Biasing 2.** To understand her EEE 51 class better, Mina plans to implement the circuit in Figure 2.  $V_{CC} = 12V$ ,  $R_1 = 1k\Omega$ ,  $R_2 = 500\Omega$ ,  $R_3 = 129k\Omega$ , and  $R_4 = 1k\Omega$ . For transistor  $Q_1$ ,  $V_A \rightarrow \infty$  and  $\beta = 150$ . For both  $Q_1$  and  $Q_2$ ,  $|V_{BE,on}| = 0.7V$  and  $|V_{CE,sat}| = 0.2V$ . In this circuit, the current through resistor  $R_1$  should be  $5mA$ , and the voltage across  $R_4$  should be  $10V$ . Round your answers up to four decimal places.
- (a) What is the value of  $V_{IN}$ ? [2 pts]
- (b) Since all components but  $Q_2$  are available at the lab, Mina asks her friends for help to build the circuit. Momo, Jennie, and Irene each offer her a box that contains a BC556A, BC556B, and BC557C respectively. (Datasheet: [https://www.mouser.com/ds/2/302/nxp\\_bc556\\_557-1188849.pdf](https://www.mouser.com/ds/2/302/nxp_bc556_557-1188849.pdf)) To make the circuit operate with the given requirements, which of her friends should Mina choose and why? You can assume that  $V_A \rightarrow \infty$  for  $Q_2$ . (Hint:  $h_{FE}$  is the same as  $\beta$ .) [2 pts]
- (c) Mina disconnects  $R_3$  from  $Q_1$  and decides to test only the left side of the circuit. She replaces  $R_1$  with a  $2k\Omega$  resistor and  $R_2$  with a  $1.25k\Omega$  resistor, and she biases  $Q_1$  with a voltage of  $4V$ . What is the voltage that Mina expects to measure across  $R_2$ ? [2 pts]

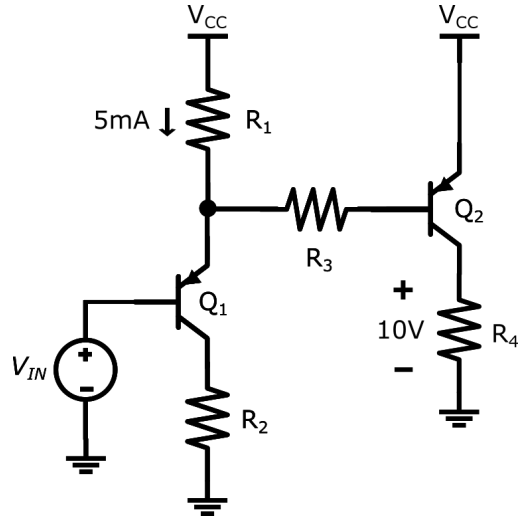


Figure 2: Mina's Circuit

3. **MOSFET DC Biasing.** In the circuit shown in Figure 3, the current across the load resistance  $R_L$  is 1 mA. Given that  $R_L = 4k\Omega$ ,  $R_3 = 1600\Omega$ , and  $V_{DD} = 12V$ . For both transistors,  $|V_{TH}| = 3V$ ,  $k = 1000\mu A/V^2$  and  $\lambda = 0$ . Assume that there is no body effect.

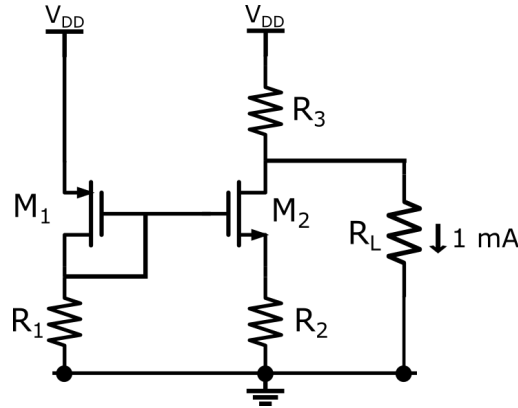


Figure 3: MOSFET Circuit

- What is the drain current of transistor M2? [2 pts]
- What is the maximum resistance of resistor R2 such that M2 remains in the saturation region? State all necessary assumptions. [3 pts]
- What must be the resistance of R1 in order to supply the correct voltage to the gate of M2? Use the values from your calculations in (b). [2 pts]

TOTAL: 20 points.