IMPORTANT: Besides your **calculator** and the sheets you use for calculations you are only allowed to have an A4 sized **"copy sheet"** during this exam. Notes, problems and alike are not permitted. **Please submit your "copy sheet" along with your solutions.** You may get your "copy sheet" back after your solutions have been graded.

EHB222E INTRODUCTION TO ELECTRONICS (12137)

Final Exam 8 January 2017 12-14

Bora DÖKEN, Bülent YAĞCI, İbrahim ÇATALKAYA, İnci ÇİLESİZ

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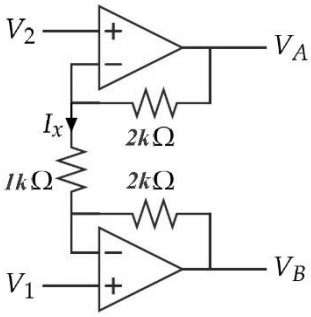
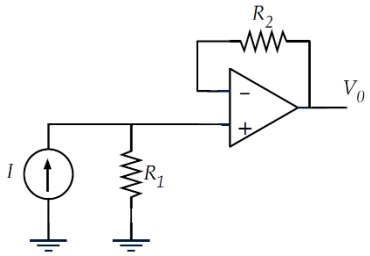
1. Consider the op-amp circuit shown on the right. Determine the current I_x and output voltage V_A when V_1 =1V and V_2 =2V. (12.5 points)
2. Consider the op-amp circuit shown below left. Calculate the output voltage. (R_1= R_2=2kΩ, I=1mA) (12.5 points)

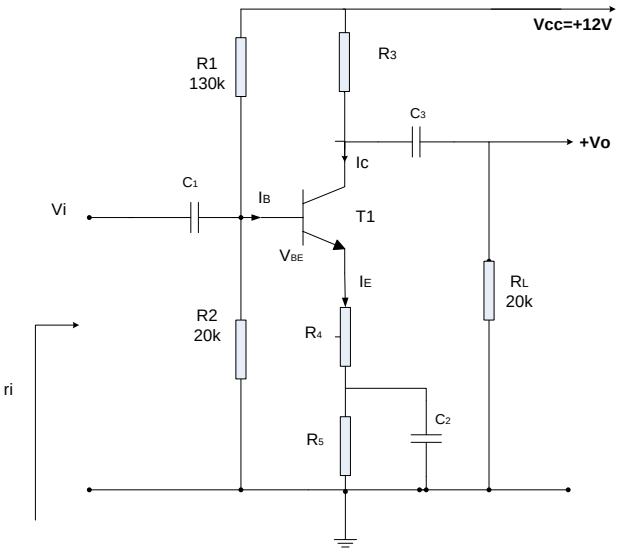


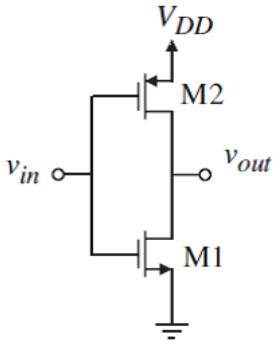


3. For the transistors shown below β=h_{fe} = h_{FE} = 200, V_{BE} =0.6V, and V_T = 25mV. All capacitors are ideal.

a) Find R_3, R_4 and R_5 for I_C = 1mA, V_{CE}= 4V and r_i=10kΩ (12.5 points)

b)Calculate v_o/v_i. (12.5 points).





4. Find the gain and output resistance of the CMOS amplifier shown above left. You need to draw the small signal circuit (not neglecting V_A) to analyze this circuit. (20 points)
5. When a transistor amplifier is operating, the current in any branch is ……

a) Sum of a.c. and d.c. b) a.c. only c) d.c. only d) difference of a.c. and d.c. e) none of the above

6. The purpose of capacitors in a transistor amplifier is to ……
7. In the d.c. equivalent circuit of a transistor amplifier, the capacitors are considered ……..
8. Operating point of a transistor amplifier represents ……..
   a) Values of I_C and V_{CE} when signal is applied
   b) The magnitude of signal
   c) Zero signal values of I_C and V_{CE}
   d) Gain of the amplifier
   e) None of the above
9. In a p-channel MOSFET, the charge carriers are ……..
10. In the breakdown region, a Zener diode behaves like a …… source.
11. What is a semiconductor? How does a semiconductor differ from a conductor? Explain within two sentences.
12. What are some of the similarities and differences between MOSFET and BJT transistors. Provide at least 2 of each.

GOOD LUCK

Problem 1: Ix = 1 mA, VA = 4V

Problem 2: V+= 2V Therefore Vo= 2 V because there is no current flow.

Problem 3:

$V_{BB} = \frac{R_2 \cdot V_{cc}}{R_1+R_2} = 1.6V \qquad R_{BB} = R_1 // R_2 = 17.3k$

$I_c = h_{FE} \cdot \frac{V_{BB} - V_{BE}}{R_{BB} + (h_{FE}+1) R_E} \Rightarrow R_E = 0,91\ k$

$R_E = R_4 + R_5$

$r_i = R_1 // R_2 // r_i' \qquad r_i' = 23.7\ k$

$r_i' = h_{fe}(re + R_e) \qquad R_e = R_4 \qquad \frac{V_T}{I_c} = re = 25\ \Omega$

$R_e = R_4 = 93.5\ \Omega \qquad R_5 + R_4 = 910\ \Omega$

$R_5 = 816.5\ \Omega$

$V_{cc} = I_c \cdot R_3 + V_{CE} + R_E \cdot I_E \Rightarrow R_c = 7.1k = R_3$

$R_c' = R_3 // R_L = 5.2k$

$\frac{v_o}{v_i} = -\frac{R_c'}{re + R_e} = -\frac{5.2k}{25+93.5} = -44$

Problem 4: http://www.yildiz.edu.tr/~nicoskun/Chap05(7_5_06).pdf

Small-Signal Performance of the Push-Pull Amplifier

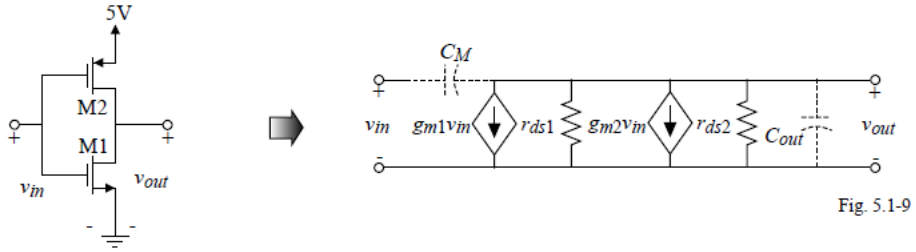


Fig. 5.1-9

Small-signal analysis gives the following results:

$$\frac{v_{out}}{v_{in}} = \frac{-(g_{m1}+g_{m2})}{g_{ds1}+g_{ds2}} = -\sqrt{(2/I_D)}\left[\frac{\sqrt{K'_N(W_1/L_1)}+\sqrt{K'_P(W_2/L_2)}}{\lambda_1+\lambda_2}\right]$$

$$R_{out} = \frac{1}{g_{ds1}+g_{ds2}}$$

5. When a transistor amplifier is operating, the current in any branch is ……
a) Sum of a.c. and d.c. b) a.c. only c) d.c. only d) difference of a.c. and d.c. e) none of the above
6. The purpose of capacitors in a transistor amplifier is to couple or bypass a.c. component
7. In the d.c. equivalent circuit of a transistor amplifier, the capacitors are considered open
8. Operating point of a transistor amplifier represents …….
   a) Values of I_C and V_{CE} when signal is applied
   b) The magnitude of signal
   c) Zero signal values of I_C and V_{CE}
   d) Gain of the amplifier
   e) None of the above
9. In a p-channel MOSFET, the charge carriers are holes
10. In the breakdown region, a Zener diode behaves like a constant voltage source.
11. What is a semiconductor? How does a semiconductor differ from a conductor? Explain within two sentences.
12. What are some of the similarities and differences between MOSFET and BJT transistors. Provide at least 2 of each.