ID:	Sec:	Name:

Set: 01

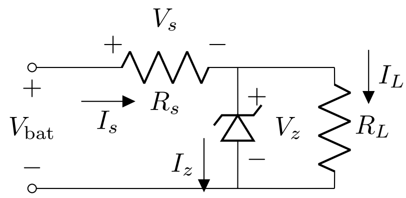
Brac University

Semester: Fall 2022
Course No: CSE251
Course Title: Electronic Devices and Circuits
Section: 1 to 14

Final Exam
Full Marks: 30
Time: 1 hour 40 minutes
Date: January 2, 2023

Answer **any 3 questions**. All the questions carry equal marks.

Question 1 [CO1, CO2] **10**



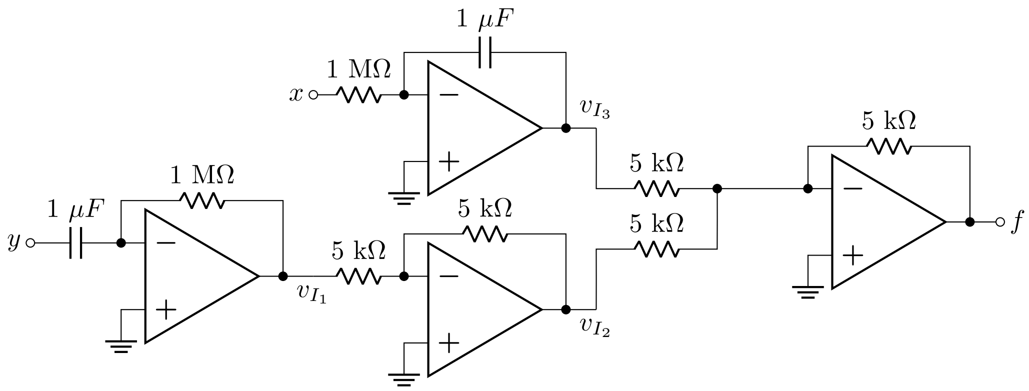
The circuit above is a voltage regulator used to power a load R_L from a battery V_{bat}. For this circuit, $R_s = 0.2$ kΩ, $R_L = 2$ kΩ, $V_{z_0} = 4$ V, $r_z = 0$ Ω, and $I_{zk} = 0.5$ mA.

(a) **Identify** the zener current I_z in the worst-case scenario. In this worst-case scenario, **calculate** the zener voltage V_z, load current I_L and input current I_s. [5]

(b) **Design** the circuit, *i.e.*, find the minimum value of the input voltage V_{bat} such that, voltage regulation is maintained even in the worst-case scenario. [3]

(c) **Determine** whether the circuit will maintain regulation if V_{bat} is increased. If yes, **argue** if it should be increased or not. [2]

Question 2 [CO3, CO4] **10**



(a) **Analyze** the circuit above to find an expression of f in terms of inputs x and y. Also, **determine** the intermediate outputs v_{I_1}, v_{I_2}, and v_{I_3} as denoted in the circuit. [4]

(b) Draw the circuit of an inverting amplifier and **design** it in such a way that the voltage gain, $k = -4$. (*i.e.*, find the values of R_1 and R_2). [3]

(c) **Show** the input and output waveforms of the inverting amplifier of part (b) assuming a sinusoidal input of 0.5 V amplitude. **Calculate** the amplitude of the output. [2]

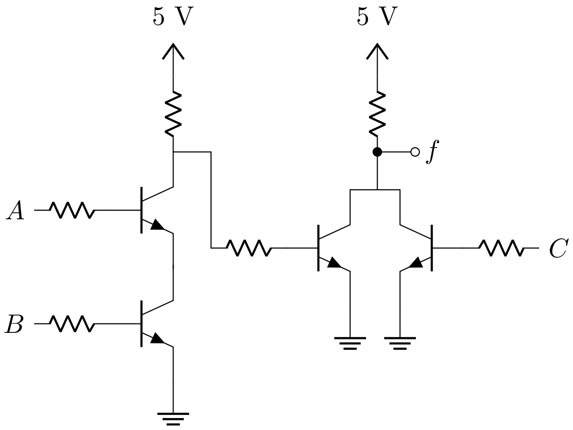
(d) Consider the inverting amplifier of part (b) again. Assume the input voltage can provide a maximum current of 0.5 μA. **Determine** the design changes required, if any, for the circuit to work. [1]

Equations for MOSFET

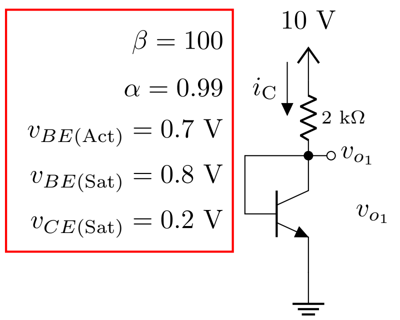
$$I_D = 0, \text{ if } V_{GS} < V_T$$

$$I_D = k\left[(V_{GS} - V_T)\,V_{DS} - \frac{1}{2}V_{DS}^2\right], \text{ if } V_{GS} \geq V_T \text{ and } V_{DS} < (V_{GS} - V_T)$$

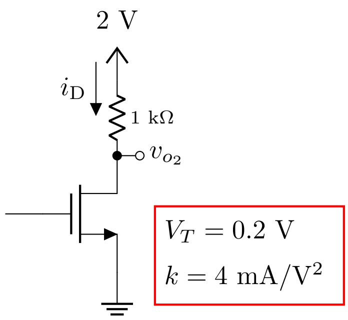
$$I_D = \frac{1}{2}k\,(V_{GS} - V_T)^2, \text{ if } V_{GS} \geq V_T \text{ and } V_{DS} \geq (V_{GS} - V_T)$$



(a) Ckt - 1
for Question 3 (**Part B**)



(b) Ckt - 2
for Question 4 (**Part a**)



(c) Ckt - 3
for Question 4 (**Part b**)

Question 3 [CO6] **10**

Part A: In digital systems, binary data may be subjected to noise that can alter a 0 to a 1 or a 1 to a 0. A simple way to check if any error has occurred is to use an **even parity checker**. If there are two input bits x and y, the output of the even parity checker (denoted as f) will be **HIGH** if there are even number of 1s, *i.e.*, if both x and y are 0 or if both of them are 1.

(a) **Deduce** the logic function for f in terms of the boolean inputs x and y. [2]

(b) **Design** a circuit using MOSFET logic gates to implement this function. [4]

Part B: **Analyze** the Ckt - 1 to find an expression of f in terms of boolean inputs A, B, C. [3]

Part C: **Compare** the BJT logic gates with MOSFET logic gates to argue which ones are better. [1]

Question 4 [CO1, CO5] **10**

(a) **Analyze** the Ckt - 2 to find i_C and v_{O_1} using the Method of Assumed State. **Validate** your assumptions. [5]

(b) **Analyze** the Ckt - 3 to find i_D and v_{O_2} using the Method of Assumed State. Here, the input of the MOSFET is the output of Ckt - 2 from part (a), *i.e.*, v_{O_1}. You must **validate** your assumptions. [5]

Question 5 [CO6] **10**

Consider a BJT Common Emitter amplifier with $\beta = 150, R_I = 100$ kΩ$, R_L = 5$ kΩ and $V_S = 12$ V. The input has a DC bias of 1 V with a small sinusoidal signal of 0.2 V amplitude, *i.e.*, $v_{IN} = 1 + 0.2\sin(\omega t)$

(a) **Determine** the valid input range for which the BJT of the amplifier will remain in the active mode. [3]

(b) **Calculate** the small signal gain k of the amplifier. [1]

(c) **Calculate** the DC operating point $(V_X,\ V_Y)$ of the amplifier. [2]

(d) **Determine** the operating bias point $(V_X,\ V_Y)$ to get the maximum input swing. [2]

(e) **Discuss** two main differences between BJT and MOSFET. [2]