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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

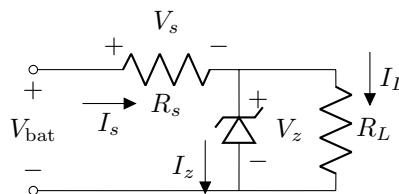
Time: 1 hour 40 minutes

Date: January 2, 2023

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

Question 1 [CO1, CO2]

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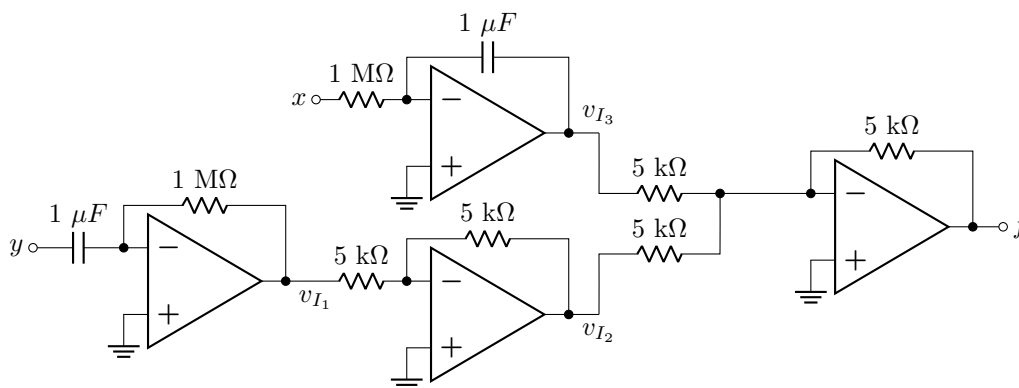


The circuit above is a voltage regulator used to power a load R_L from a battery V_{bat} . For this circuit, $R_s = 0.2 \text{ k}\Omega$, $R_L = 2 \text{ k}\Omega$, $V_{z0} = 4 \text{ V}$, $r_z = 0 \Omega$, and $I_{zk} = 0.5 \text{ mA}$.

- 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]
- 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]
- 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]

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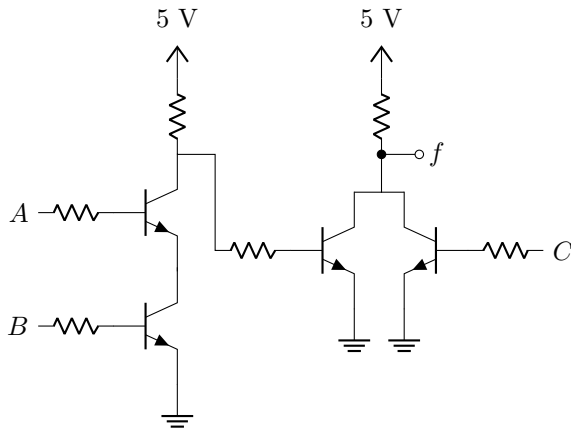
- Analyze** the circuit above to find an expression of f in terms of inputs x and y . Also, **determine** the intermediate outputs v_{I1} , v_{I2} , and v_{I3} as denoted in the circuit. [4]
- Draw the circuit of an inverting amplifier and **design** it in such a way that the voltage gain, $k = -4$. (*i.e.*, find the values of R_1 and R_2). [3]
- 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]
- 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

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

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

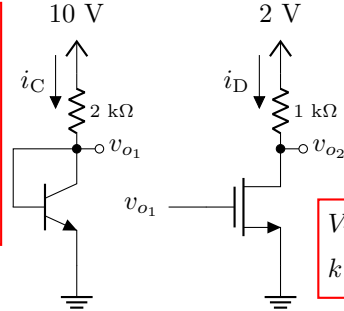
$$I_D = \frac{1}{2} k (V_{GS} - V_T)^2, \text{ if } V_{GS} \geq V_T \text{ and } V_{DS} \geq (V_{GS} - V_T)$$



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

$$\begin{aligned} \beta &= 100 \\ \alpha &= 0.99 \\ v_{BE(Act)} &= 0.7 \text{ V} \\ v_{BE(Sat)} &= 0.8 \text{ V} \\ v_{CE(Sat)} &= 0.2 \text{ V} \end{aligned}$$

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



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

$$\begin{aligned} V_T &= 0.2 \text{ V} \\ k &= 4 \text{ mA/V}^2 \end{aligned}$$

Question 3 [CO1, CO4]

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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.

- Deduce** the logic function for f in terms of the boolean inputs x and y . [2]
- 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, CO4]

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- Analyze** the Ckt - 2 to find i_C and v_{O1} using the Method of Assumed State. **Validate** your assumptions. [5]
- Analyze** the Ckt - 3 to find i_D and v_{O2} using the Method of Assumed State. Here, the input of the MOSFET is the output of Ckt - 2 from part (a), *i.e.*, v_{O1} . You must **validate** your assumptions. [5]

Question 5 [CO1, CO4]

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

- Determine** the valid input range for which the BJT of the amplifier will remain in the active mode. [3]
- Calculate** the small signal gain k of the amplifier. [1]
- Calculate** the DC operating point (V_X , V_Y) of the amplifier. [2]
- Determine** the operating bias point (V_X , V_Y) to get the maximum input swing. [2]
- Discuss** two main differences between BJT and MOSFET. [2]