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Set: 01

Brac University

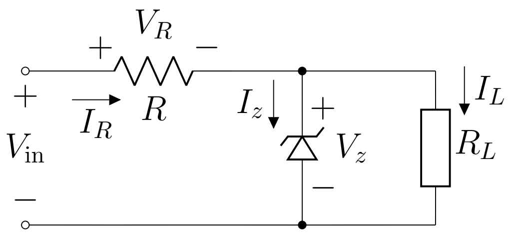
Semester: Summer 2023
Course No: CSE251
Course Title: Electronic Devices and Circuits
Section: 1 to 10

Final Exam
Full Marks: 30
Time: 1 hour 30 minutes
Date: 03 September, 2023

Answer **any 3 out of 4 questions**. All the questions carry equal marks.

Question 1 [CO3] **10**

A Zener diode voltage regulator has a regulation voltage of 5.1 V when the current through the Zener diode is 50 mA. It is characterized by the parameters, $r_z = 50\ \Omega$, $I_{\mathrm{ZK}} = 5$ mA.



(a) **Determine** the cut-in voltage, V_{Z0} of the zener diode. [1.5]

(b) Assume, the nominal value of the supply voltage, V_{in} is 15 V and $R = 200\ \Omega$. **Calculate** I_R, R_L and I_L for the worst case scenario. [1+1+1]

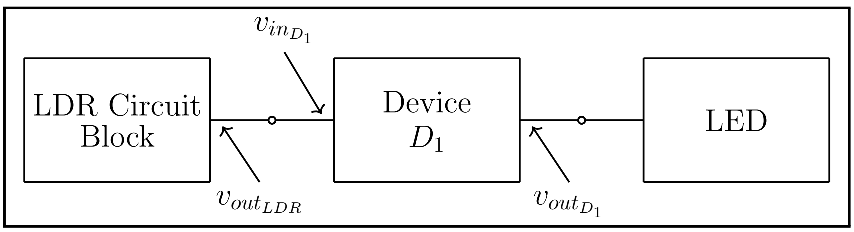
(c) Now, assume, R_L and R are both 100 Ω each. **Calculate** the minimum value of the supply voltage V_{in} at the worst case scenario. [3]

(d) The supply voltage of the regulator is now given as 15 ± 1 V. **Design** the voltage regulator circuit, i.e., **determine** the value of R, such that even in the worst-case scenario, voltage regulation is maintained and the circuit sustains a load current of 80 mA. [2.5]

Bonus: **Analyze** the effect of decreasing the load resistance, R_L and **explain** briefly. [2]

Question 2 [CO1] **10**

Rosa has a switching device, $\mathbf{D_1}$ built with 2 MOSFETs. The MOSFETs have the following parameters, $k = 1\ \mathrm{m}A/V^2$ and $V_T = 0.2$ V. The device turns ON an LED light in her dollhouse at night and turns the light OFF during the day. The supply voltage of the device is, $V_{SS} = 10$ V and the load resistance is $R_L = 10\ \mathrm{k}\Omega$. The input voltage of the device, $v_{\mathrm{in_{D1}}}$ is taken from the output voltage of an LDR Circuit Block, $v_{\mathrm{out_{LDR}}}$ as shown in the diagram below. Rosa measured the voltages and made the following table where, **HIGH** $\equiv$ 5 V and **LOW** $\equiv$ 1.5 V.



Time	$v_{\mathrm{out_{LDR}}}$	$v_{\mathrm{in_{D1}}}$	$v_{\mathrm{out_{D1}}}$
Day	*LOW*	*LOW*	*LOW*
Night	*HIGH*	*HIGH*	*HIGH*

(a) **Identify** and **explain** the logical operation of the switching device, D_1. [1+1]

(b) **Draw** the circuit diagram of the device, D_1 with proper labeling. [2]

(c) **Calculate** the on-state resistance, R_{ON} of the 1st MOSFET of the device. [2]

(d) **Draw** the Voltage Transfer Characteristic (VTC) of the device with proper labeling. [2+2]

Bonus: **Determine** the W/L **sizing** of the 1st MOSFET. [2]

Equations for MOSFET

Cut-off: $I_D = 0,$ **if** $V_{GS} < V_T$

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

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

Question 3 [CO3] **10**

Answer the following questions for ***Figure-1*** where $R_1 = 1\text{k}\Omega$, $R_2 = 2\text{k}\Omega$, $R_3 = 3\text{k}\Omega$, $R_4 = 4\text{k}\Omega$.

(a) Why a MOSFET can be used as a switch? **Explain** briefly. [2]

(b) **Analyze** the circuit in *Figure-1* to **determine** the values of I_C, I_B, I_E, v_C of T_1. [3]

(c) **Analyze** the circuit in *Figure-1* to **determine** the value of I_{DS_2}, v_O of T_2. [5]

Bonus: **Design** a circuit with the boolean inputs A, B, C, D using ideal MOSFETs (S-model) to implement the logic function, $f = \overline{A.C} + B.D$ [2]

Question 4 [CO1, CO3] **10**

(a) **Draw** the I-V characteristic of a BJT. **Indicate** the operating regions with proper labeling. [2]

(b) A linear amplifier follows the equation, $V_{out} = -5V_{in}$ where the valid input range is -10V to +10V. **Illustrate** the Voltage Transfer Characteristic (VTC) of the amplifier with proper labels. [2]

(c) For the BJT CE Amplifier of ***Figure-2***, $v_{IN} = 2 + 0.2\sin(100\pi t)$ and $v_O = 4 - 2\sin(100\pi t)$. **Design** the Amplifier circuit, i.e., **calculate** the value of V_S, R_L and R_I. [2+2+2]

Bonus: **Identify** the lowest value of the input voltage for which amplification occurs. **Explain** your reasoning. [2]

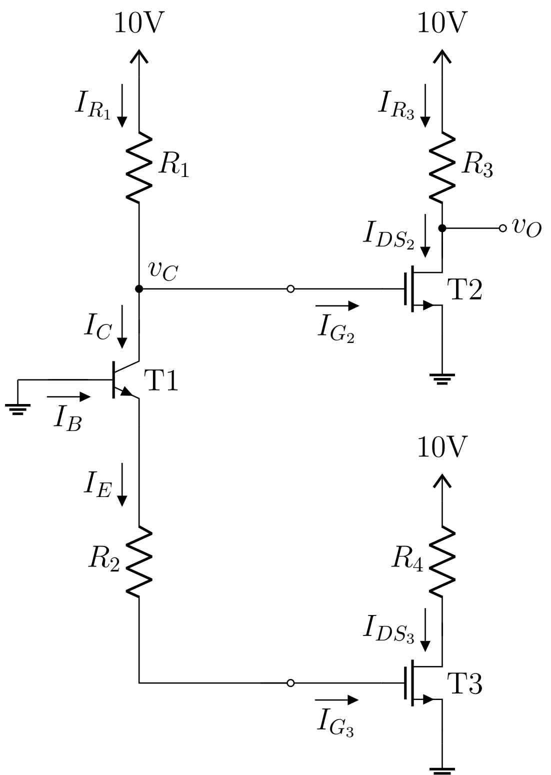


Figure-1

for BJT
$\beta = 100$
$\alpha = 0.99$
$v_{BE(Active)} = 0.7V$
$v_{BE(Saturation)} = 0.8V$
$v_{CE(Saturation)} = 0.2V$

for MOSFET
$V_T = 1V$
$k = 5mA/V^2$

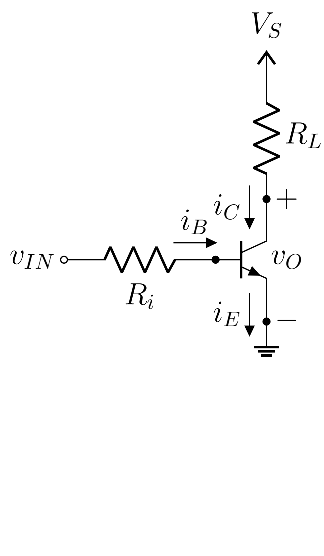


Figure-2