ID:	Name:

Brac University

Semester: Spring 2024
Course Code: CSE251
Electronic Devices and Circuits
Section: 01-23

Set
01

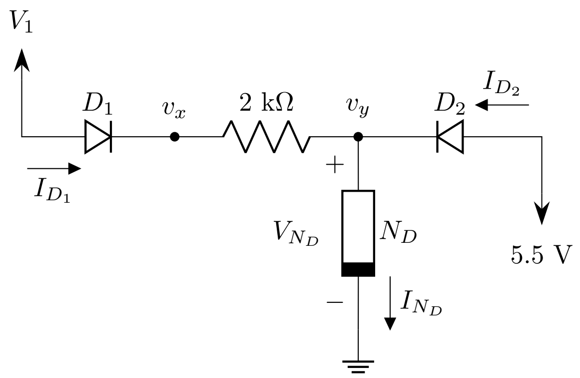
Assessment: *Midterm Exam*
Duration: 1 hour 30 minutes
Date: 08 March, 2024
Full Marks: 30

Instructions: Answer **any 3 out of 4** questions.

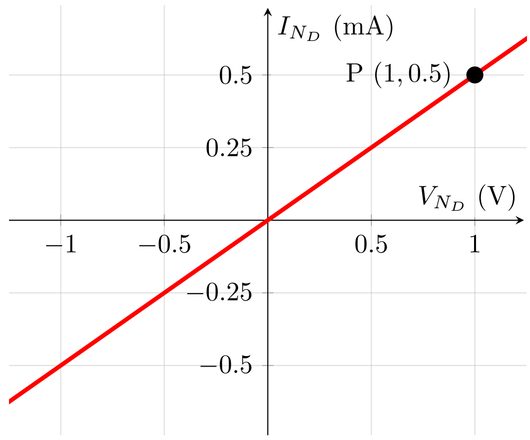
■ Question 1 of 4 *[CO1, CO2, CO3] [10 marks]*

The adjacent truth table represents a logic circuit implemented with ideal diodes and a 5 V supply voltage. '**A**' and '**B**' are the boolean input variables of the circuit and 'f' is the boolean output variable of the circuit. V_A and V_B are the input voltages corresponding to '**A**' and '**B**'. The voltage level corresponding to the output variable 'f' is denoted by V_f.

A	**B**	f
0	0	0
0	1	0
1	0	0
1	1	1



(a) Circuit-1



(b) I-V Characteristics of the device $\mathbf{N_D}$

(a) [**1 mark**] **Deduce** the logical function f and **draw** the mentioned logic circuit.

(b) [**1 mark**] **Calculate** the value of 'V_f' when $V_A = 4$ V and $V_B = 5$ V.

(c) [**2 marks**] **Identify** the equivalent circuit model for the I-V characteristics of the unknown device, N_D in Fig. (b). **Calculate** the model parameters.

(d) [**6 marks**] **Assume**, D_2 is 'ON' and $V_1 = V_f$. **Redraw** Circuit-1 by replacing N_D with the equivalent circuit model found in part-(c). Now, **analyze** Circuit-1 to **determine** the values of I_{D_1}, I_{D_2}, v_x, and v_y. You must **validate** your assumptions. Here, the forward voltage drop of both of the diodes is, $V_{D0} = 0.5$ V.

■ Question 2 of 4 *[CO1, CO2, CO3] [10 marks]*

The input voltage of a half-wave rectifier is a **Sine** wave with amplitude $V_M = 10$ V and 40 Hz frequency. The output load resistance is $R = 50\,\text{k}\Omega$. A silicon diode is used in this circuit whose forward voltage drop is $V_{D_0} = 0.6\,\text{V}$.

(a) [**4 marks**] Briefly **explain** the purpose of a rectifier. **Draw** the input and output waveforms of the mentioned rectifier with proper labeling. **Draw** the Voltage Transfer Characteristic (VTC) curve of the rectifier.

(b) [**1 mark**] **Calculate** the DC value of the output voltage, V_{DC}.

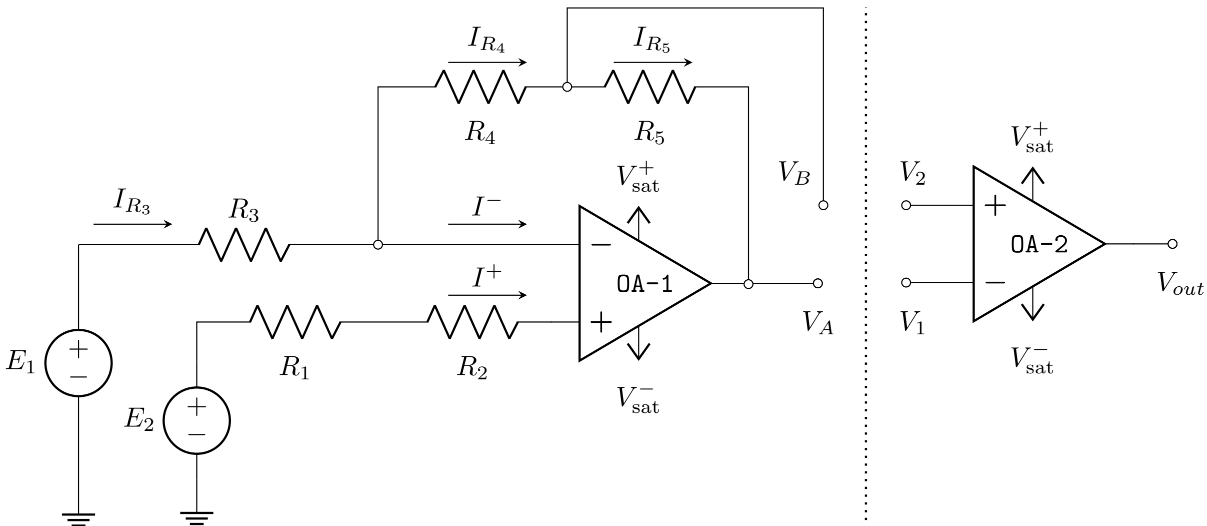
(c) [**3 marks**] After connecting a capacitor parallel to the load, V_{DC} changes to $V_{\text{DC(Cap)}}$ and the new output voltage can be expressed as $V_{\text{out}} = V_{\text{DC(Cap)}} \pm 0.5$ V. **Calculate** the peak-to-peak ripple voltage $V_{r(p-p)}$, and **determine** the ripple frequency, f_{r}. Now, **calculate** the value of the capacitor, C.

(d) [**1 mark**] **Calculate** the DC value of the output voltage after connecting the capacitor, $V_{\text{DC(Cap)}}$.

(e) [**1 mark**] **Compare** $V_{\text{DC(Cap)}}$ with V_{DC} determined in part-(b) and briefly **explain** their difference.

■ Question 3 of 4 *[CO1, CO2, CO3] [10 marks + 2 marks (bonus)]*

The 'ideal' operational amplifiers (Op-Amp) below have been connected to saturation voltages $V^+_{\text{sat}} = +\,8\,\text{V}$and $V^-_{\text{sat}} = -\,8\,\text{V}$. The resistor values are given as: $R_1 = R_2 = 1$ kΩ, and $4R_4 = 10R_5 = 20$ kΩ.



(a) [**1 mark**] **State** the current values of I^- and I^+.

(b) [**4 marks**] If $E_1 = 5\,\text{V}$, $E_2 = 0\,\text{V}$, and $R_3 = 10\,\text{k}\Omega$, **determine** V_A and V_B.

(c) [**2 marks**] **Find** the value of V_{out} if $V_1 = V_A$ and $V_2 = V_B$.

(d) [**3 marks**] For $E_1 = 0\,\text{V}$ and $E_2 = 2.2\,\text{V}$, we measure V_A to be $5.13\,\text{V}$. Showing necessary calculations, **select** what value of R_3 will make this possible.

(e) [**2 marks (bonus)**] After obtaining R_3 in question (d), find the value of V_B.

■ Question 4 of 4 *[CO1, CO2, CO3] [10 marks]*

Answer questions **(a-d)** based on **Figure 1** and question **(e)** based on the data shown in **Figure 2**.

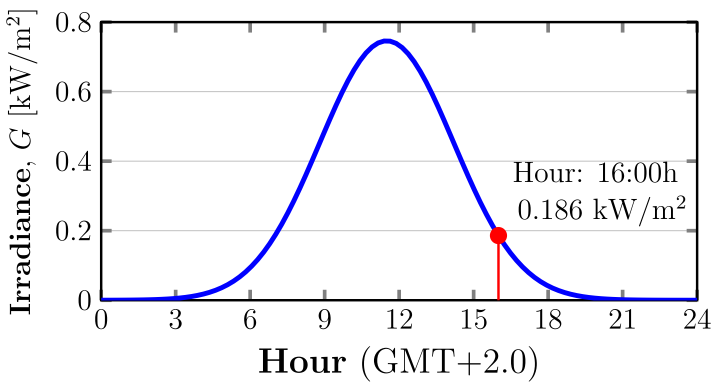


Figure 1: **For questions (a-d)**

$$V_O = X_1 V_1 - X_2 \int V_2 dt$$

Where, $X_1 = 1+$ last digit of student ID
$X_2 = 1+$ 2nd last digit of student ID

Figure 2: **For question (e) only.**

Figure 1 shows the variation of direct solar irradiance, **G** (in units of $\mathbf{kW/m^2}$) throughout the day in Egypt. The irradiance is $\mathbf{0.186\ kW/m^2}$ at **16:00 hours**. A photodetector generates a voltage of $\mathbf{V_S}$ by converting solar irradiance **G** (in units of $\mathbf{kW/m^2}$) according to the following equation:

$$V_S(G) = 6G^2 + 7G \tag{1}$$

You have to design an automatic system with an Op-Amp comparator circuit. This system will take $\mathbf{V_S}$ as an input from a photodetector and control a street lamp, ensuring it meets the following **conditions**:

- The lamp switches **ON** after **16:00 hours**.
- The lamp switches **ON** when system output is **5 V**.
- The lamp switches **OFF** when system output is **0 V**.

Based on the above scenario, answer the following questions:

(a) [**1 mark**] **Calculate** the photodetector voltage $\mathbf{V_S}$ at **16:00 hours**. **Determine** how $\mathbf{V_S}$ changes before and after **16:00 hours**.

(b) [**1 mark**] **Show** how the changes in irradiance **G** and subsequently $\mathbf{V_S}$ - with respect to the value obtained in part (a) - should affect the street lamp operation (ON / OFF states).

[**Hint:** Observe the graph in Fig. 1 and Equation (1)]

(c) [**2 marks**] **Determine** whether the Op-Amp comparator circuit of the system should be in an **inverting** or **non-inverting** configuration. **Justify** your choice by explaining briefly how this configuration meets the conditions mentioned above.

(d) [**3 marks**] **Draw** the completed Op-Amp comparator circuit clearly marking the input and output terminals and the positive and negative saturation voltages Also clearly indicate the **reference voltage** against which the input of the comparator is compared.

(e) [**3 marks**] **Design** a circuit with Op-Amps that implements the function shown in **Figure 2**. Clearly indicate the input, output, and circuit parameters.