Assignment 1
CSE251

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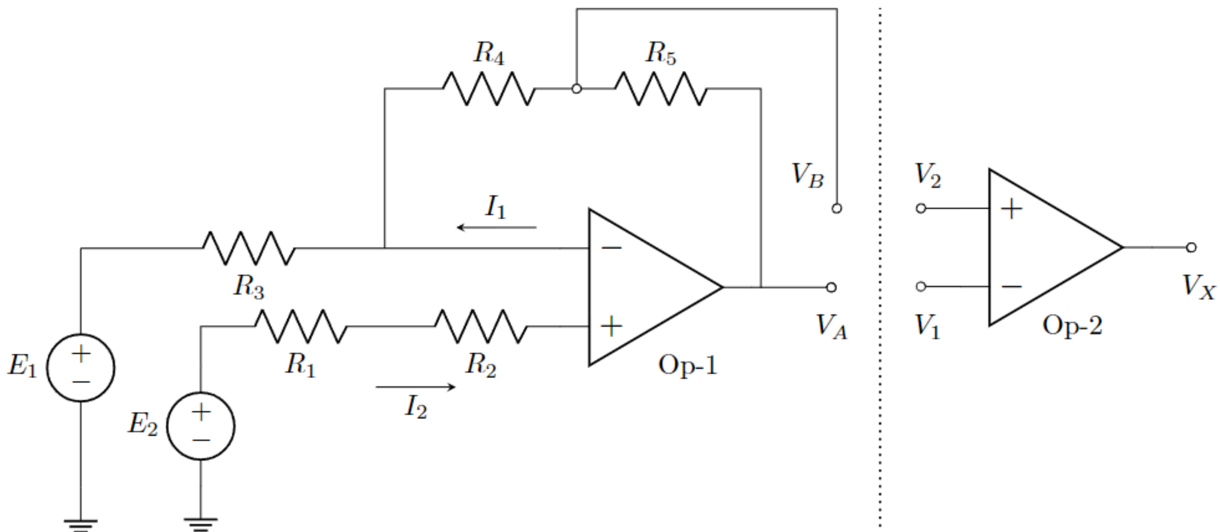
BRAC UNIVERSITY

Department of Computer Science and Engineering

Assignment 01, Section: 06, Summer 2024

CSE 251: Electronic Devices and Circuits

1.



The 'ideal' operational amplifiers (Op-Amp) have been connected to saturation voltages $V_{sat}^{+} = +8V$ and $V_{sat}^{-} = -8V$. The resistor values are given as,

$R_1 = R_2 = 1k\Omega$, and $4R_4 = 10R_5 = 20k\Omega$

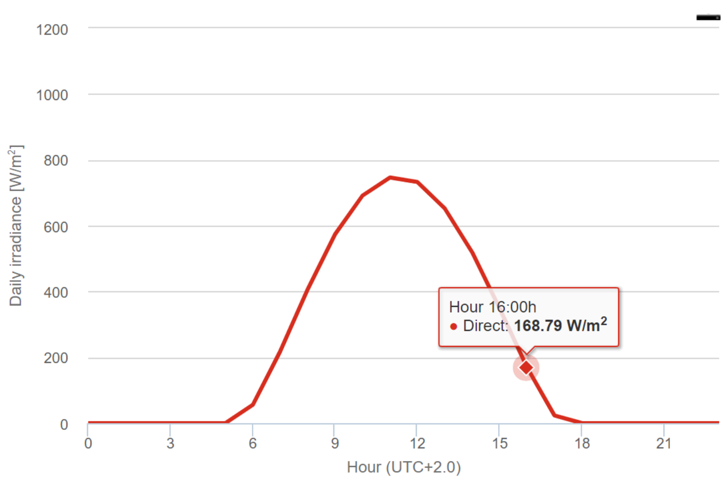
(a) What are the current values of I_1 and I_2? [1]

(b) If $E_1 = 5V$, $E_2 = 0V$, and $R_3 = 10k\Omega$, determine V_A and V_B. [2+2]

(c) For the setup of question (b), find the value of V_X when we take V_1=V_A and V_2=V_B. [2]

(d) For $E_1 = 0V$ and $E_2 = 2.2V$ we measure V_A=5.13V. Calculate what value of R_3 will make this possible. [3]

2.



The above figure shows the variation of daily average solar irradiance (in units of W/m^2) throughout the day in Egypt. In the legend, we can see that at 16:00h, the direct solar irradiance is about $168.79\ W/m^2$.

A photodetector module that produces a voltage V_S across its terminal as per the following relation, is used to convert solar irradiance **G** (in units of **kW/m^2**) to usable voltage.

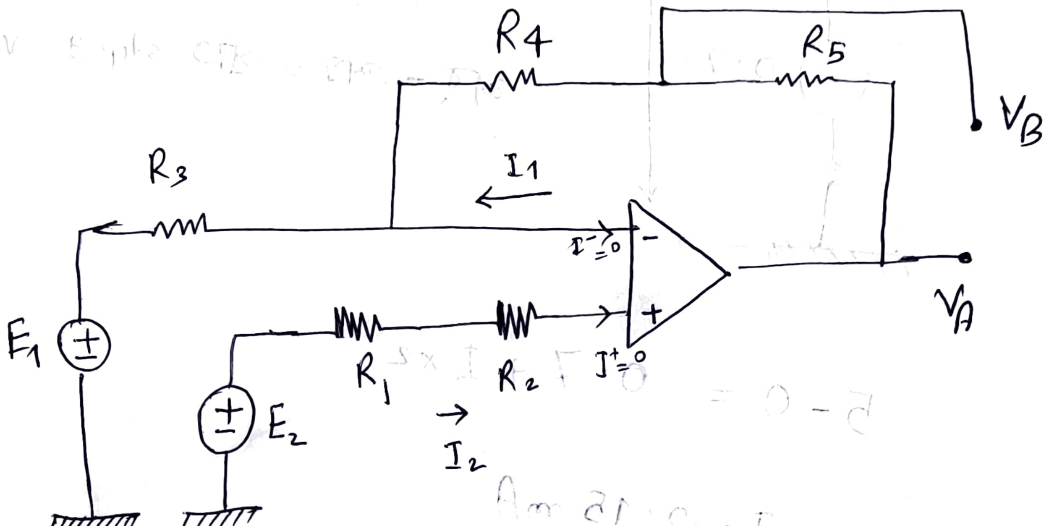
$$V_S(G) = 5G^2 + 8G$$

You are asked to **design** a circuit using an Op-Amp that will be connected to *a street-lamp (or an LED)* and that will **turn the lamp (LED) ON after 17:00h**. The lamp (LED) turns **<u>ON</u>** at **5 V**, and remains **<u>OFF</u>** at **0 V**.

a. Determine whether the Op-Amp comparator circuit needed will be in inverting, or non-inverting configuration. [2]
b. Determine the **threshold (reference) voltage** with which the input voltage is compared. [3]
c. Draw the completed Op-Amp comparator circuit. Clearly indicate input, output, terminals, saturation and reference voltages. [5]

①

(1)



ⓐ We know that,

$I^+ = 0$

$\Rightarrow I_2 = I^+ = 0$

$\Rightarrow I_2 = 0$

$I^- = 0$

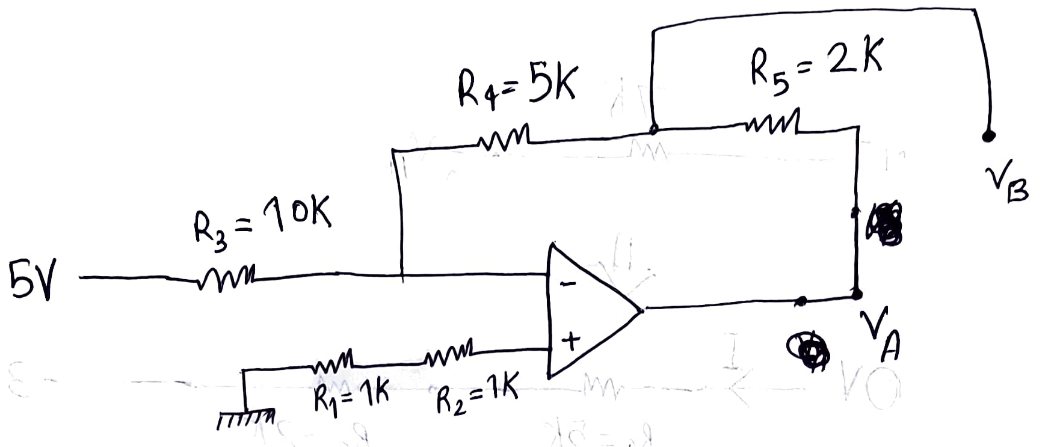
$\Rightarrow -I_1 = I^- = 0$

$\Rightarrow I_1 = 0$

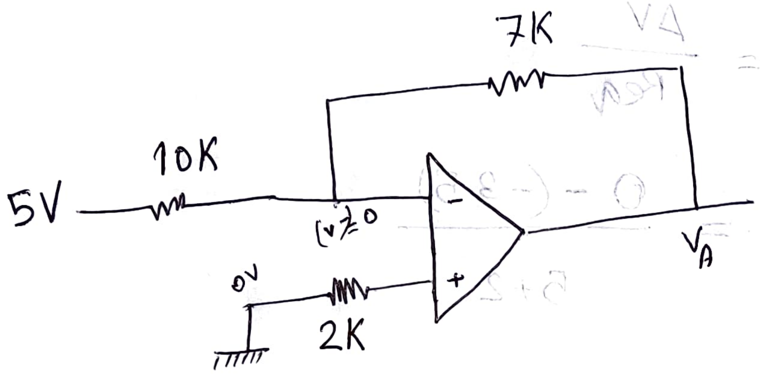
$\therefore I_1 = I_2 = 0$

(Ans)

(b)



⇓



We know from the figure,
$\Rightarrow I^+ = I^- = 0$
$\Rightarrow V^+ = V^- = 0$

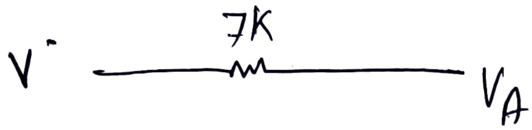
$$V_A = -\frac{R_f}{R_3}(V_{in})$$

$$= -\frac{7}{10}(5)$$

$$= -\frac{7}{2}$$

$$= -3.5$$

(iii)



$\Downarrow$

$\therefore V_{total} = 0 - (-3.5)$

$= +3.5V$

$V_5 = \frac{5}{5+2} \times V_{total}$

$= \frac{5}{7} \times 3.5$

$= 2.5$

$\therefore \Delta V = V_S$

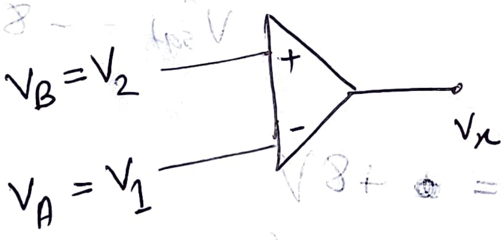
$\Rightarrow 0 - V_B = 2.5$

$\Rightarrow V_B = -2.5V$

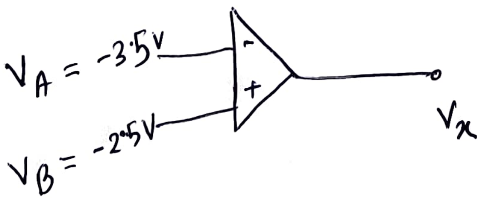
$\therefore V_A = -3.5V$

$V_B = -2.5V$ (Ans)

c.



$\Downarrow$



$$\therefore V_x = A(V^+ - V^-)$$

$$= A(V_B - V_A)$$

$$= A(-2.5 - (-3.5))$$

$$= A(-2.5 + 3.5)$$

$$= 1 \times A$$

$$= 1 \times \infty$$

$$= \infty$$

This op-Amp is an ideal op-Amp

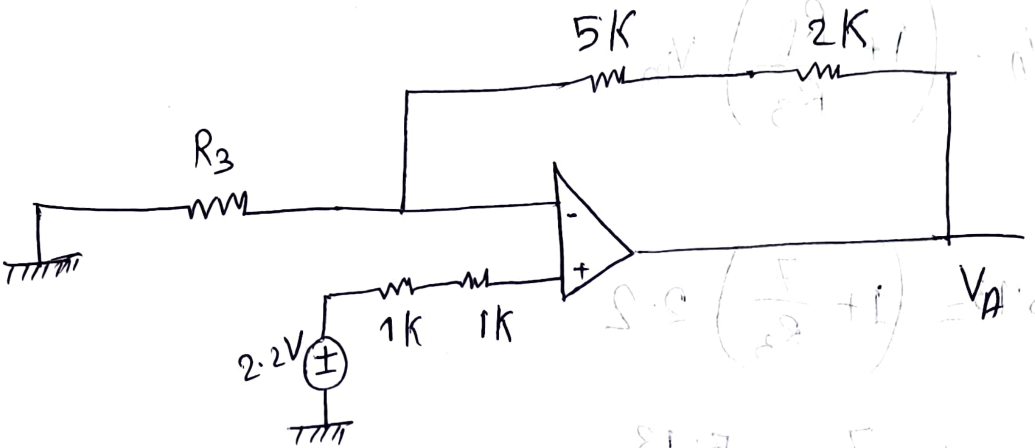
$V^+_{sat} = +8V$

$V^-_{sat} = -8V$

$\therefore$ For V^+ saturation $= +8V$

(Ans)

(d)



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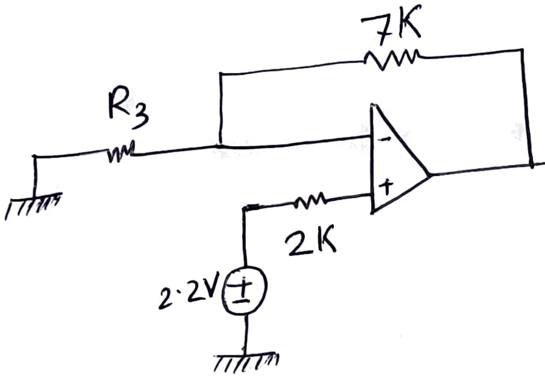


$V_A = 5.13V$

$I^+ = I^- = 0$

therefore, there will be no voltage drop due to 2K resistance

$V^+ = 2.2V$

$V^- = 2.2V$

(vii)

$$V_A = \left(1 + \frac{R_f}{R_3}\right) V_{in}$$

$$\Rightarrow 5.13 = \left(1 + \frac{7}{R_3}\right) 2.2$$

$$\Rightarrow 1 + \frac{7}{R_3} = \frac{5.13}{2.2}$$

$$\Rightarrow 1 + \frac{7}{R_3} = 2.3318$$

$$\Rightarrow \frac{7}{R_3} = 1.3318$$

$$\Rightarrow R_3 = 5.25\,K$$

The possible value of R_3 is $5.25\,K$

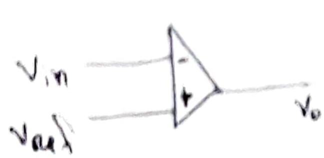
2.

ⓐ From the graph, we clearly see that after 16·00 hour on 17·00 hours the value of G is decreasing and V_{in} is dependent on G. So, the value of V_{in} will also be reduced. and from 18·00 hour the value is near to zero.

The Led will turned on at 17.00 hours. Before that the V_{in} is greater and after 17.00 hours the ~~value~~ V_{in} is smaller. So, here is the condition that when $V_{in} < V_{ref}$, we are getting V_{+sat} and

if $V_{in} > V_{ref} \Rightarrow V_{-(sat)}$

which is also the condition of a inverting comparator



(Ans)

(b) At 16:00h $G = 168.79\ W/m^2$

$= 0.16879\ kW/m^2$

At 18:00h $G = 0$

$\therefore$ At 17:00h $G = \cancel{168} \dfrac{0.16879 + 0}{2}$

$= 0.084395$

$\therefore V_s(0.084395) = 5 \times (0.084395)^2 + 8 \times 0.084395$

$\Rightarrow V_{ref(17h)} = 0.71\ V$

At the ~~t~~ time of 17.00h, ~~the~~ v will be 0.71 V.
This will be the voltage with which the input voltage ~~is~~ will be compared.

(x)

(c) $V_{ref} = 0.71V$

$V_{+sat} = 5V$

$V_{sat}^{-} = 0V$