<u>ELEC1100 – Additional Exercises – Solution Included</u>

1. <u>Short Questions</u>

- What is the resistance of a light bulb labeled “40W, 120V”?

$$R = \frac{120^2}{40} = 360\Omega$$

- A 12V voltage source is connected to two resistors, R_P and R_Q, in series, given that both R_P and R_Q are with non-zero resistance and the resistance of R_P is constant. Find the resistance of R_P if the maximum <u>possible</u> power that can be delivered to R_Q is 4W. Also write down the resistance of R_Q.

  Maximum power occurs when $R_P = R_Q$,

$$V_{R_P} = V_{R_Q} = 6V$$
$$R_P = R_Q = \frac{6^2}{4} = 9\Omega$$

- Typical human electric resistance is 10kΩ. If more than 30mA current is considered harmful to human body, explain why an AA battery (1.5V) is safe for human to touch, while a high-voltage cable (5kV) is not.

  For 1.5V, current = 1.5 / 10k = 150μA < 30mA;

  For 5kV, current = 5k / 10k = 500mA > 30mA

  Hence a 1.5V battery is safe while a 5kV cable is not.

- A light bulb is connected to a DC voltage source. In order to reduce power consumption, two suggestions are proposed: (1) Use another light bulb that uses the same DC voltage, but the resistance is doubled; (2) Use another light bulb that has the same resistance, but the DC voltage required is halved. Which one is more power-saving? Show you calculation to explain. (Hint: Let original voltage = V, original resistance = R)

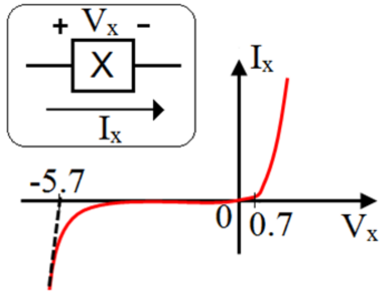
  $P_{orig} = V^2 / R$,

  (1) $P_1 = V^2 / 2R = P_{orig} / 2$

  (2) $P_2 = (V/2)^2 / R = P_{orig} / 4$

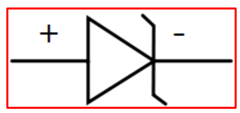
  Hence the second one is more power-saving.

- Figure below shows the I-V characteristics of an unknown component X.



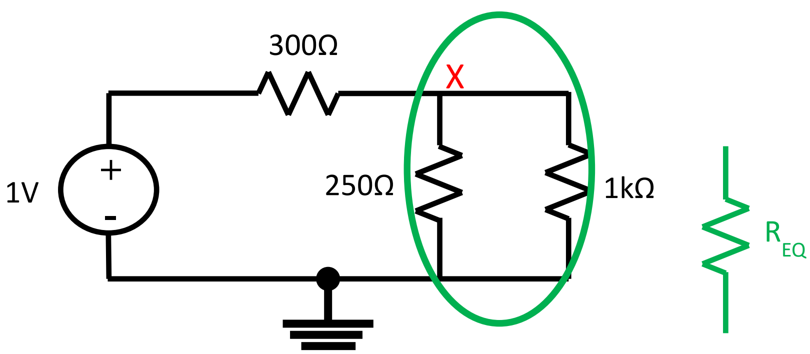
Among all the electronic components you have learned, which one has similar I-V characteristics? Draw its symbol below with indicated polarity.

Zener diode



2. Resistor & Voltage divider

For the circuit shown below, determine:
(a) the equivalent resistance R_{EQ}
(b) the value of voltage at node X.



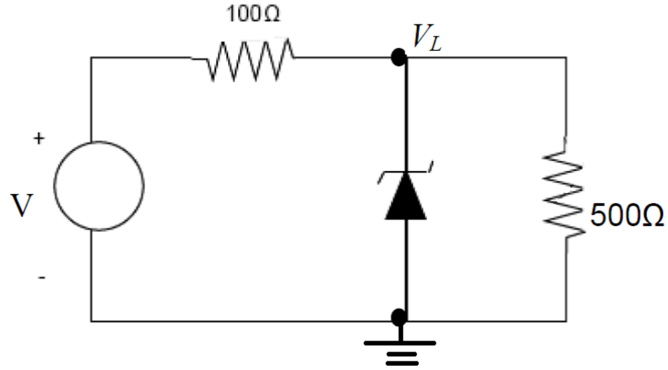
(a) $R_{EQ} = \frac{250\times 1k}{250+1k} = 200\Omega$

(b) $Voltage\ at\ X = 1V \times \frac{200}{300+200} = 0.4V$

3. Zener Diode & Voltage regulator

Figure below shows a simple voltage regulator design. Assume that the breakdown voltage of the Zener diode is 6.8V. Find out the current flowing through the Zener diode for the following cases:

(a) V = 5V
(b) V = 8V
(c) V = 12V



(a) Since V<6.8V, $i_z = 0A$

(b) Assume the Zener diode is off,

$V_L = 8 \times \frac{500}{100+500} = 6.67V < 6.8V$,

diode is off, $i_z = 0A$

(c) Assume the Zener diode is off,

$$V_L = 12 \times \frac{500}{100+500} = 10V > 6.8V$$

The Zener diode should be ON in breakdown mode.

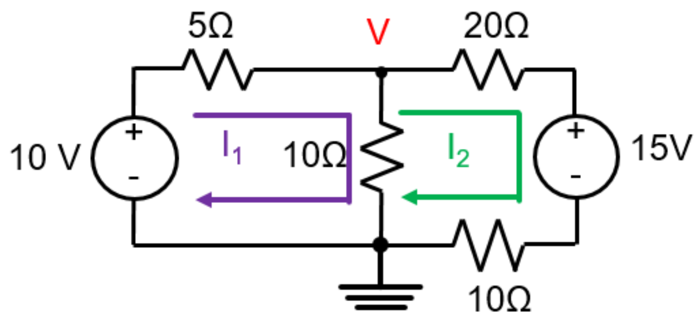
Using KCL,

$$\frac{12-6.8}{100} = i_z + \frac{6.8}{500}$$

$$i_z = 38.4mA$$

4. KCL & KVL

Find the current values of I_1 & I_2, and the voltage value of V in the given circuit below.



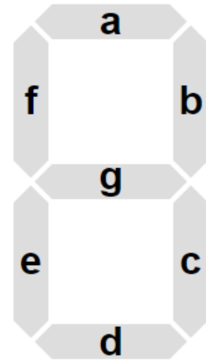
$$5I_1 + 10(I_1 - I_2) - 10 = 0$$

$$10(I_2 - I_1) + 20I_2 + 15 + 10I_2 = 0$$

$$\begin{cases} I_1 = 1/2 \\ I_2 = -1/4 \end{cases}$$

$$V = 10(I_1 - I_2) = 10\left(\frac{1}{2} + \frac{1}{4}\right) = 7.5V$$

5. Logic Design



A seven-segment display is an electronic device for displaying decimal numbers. The 7 segments are labelled as ***a*** to ***g***. A 4-bit binary input $Q_3Q_2Q_1Q_0$ (Q_3 is MSB and Q_0 is LSB) is used to light up segment ***e*** for the numbers 0, 2, 6, 8.

(a) Complete the truth table for the output ***e***.

Q_3	Q_2	Q_1	Q_0	***e***
0	0	0	0	**1**
0	0	0	1	**0**
0	0	1	0	**1**
0	0	1	1	**0**
0	1	0	0	**0**
0	1	0	1	**0**
0	1	1	0	**1**
0	1	1	1	**0**
1	0	0	0	**1**
1	0	0	1	**0**
1	0	1	0	**0**
1	0	1	1	**0**
1	1	0	0	**0**
1	1	0	1	**0**
1	1	1	0	**0**
1	1	1	1	**0**

(b) Use K-map to find out the ***<u>simplest</u>*** output expression in terms of the input bits $Q_3Q_2Q_1Q_0$.

		Q_3Q_2			
		00	**01**	**11**	**10**
Q_1Q_0	**00**	**1**	**0**	**0**	**1**
	01	**0**	**0**	**0**	**0**
	11	**0**	**0**	**0**	**0**
	10	**1**	**1**	**0**	**0**

$$e = \overline{Q_3} \cdot Q_1 \cdot \overline{Q_0} + \overline{Q_2} \cdot \overline{Q_1} \cdot \overline{Q_0}$$

6. <u>Pulse Generation and PWM</u>

A shop wants to install an advertisement lightbox with neon lights. Figure 6 shows a proposal of the input voltage pulse to the lights. The total value of the variable resistor is ($R_A + R_B$) = 4kΩ with R_A (across pins 8 & 7) and R_B (across pins 7 & 6).

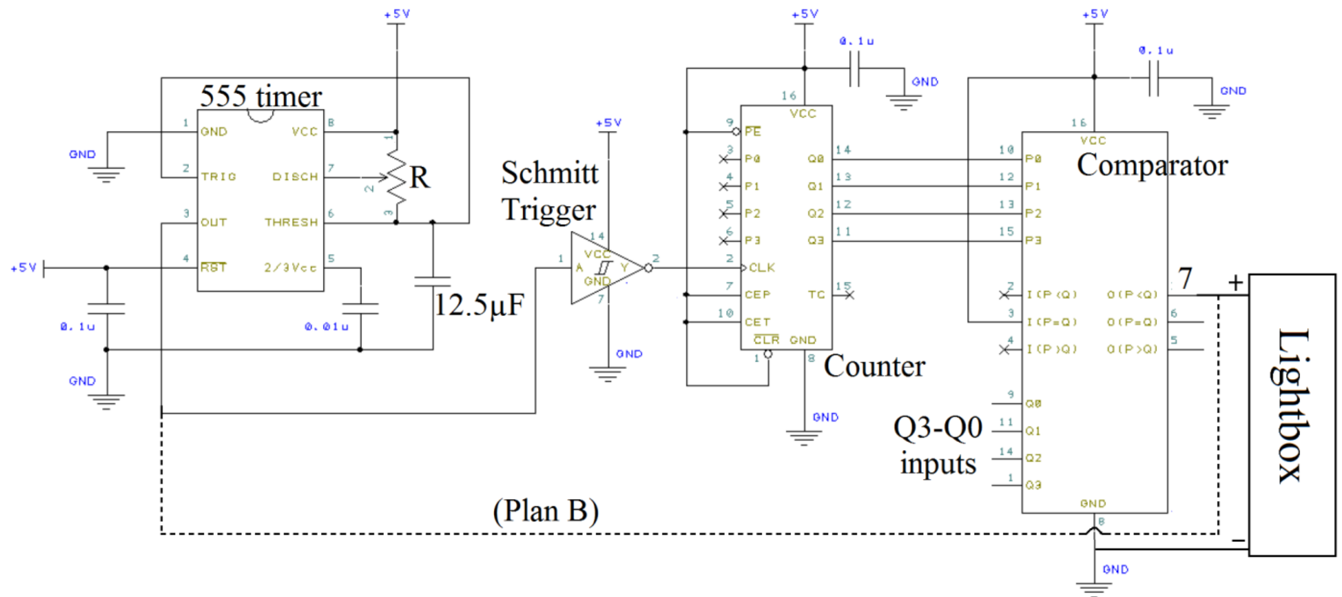


Figure 6

The lights should flash at a frequency of $\frac{10}{7}$ Hz

a) Determine the comparator inputs Q3-Q0 when the duty cycle at pin 7 (P<Q) is $\frac{5}{8}$.

b) Using the timer equations, determine the values of R_A and R_B.

c) Due to some technical reason, the comparator IC is not available. The shop decides to provide the input voltage pulse directly from the timer (Plan B, dotted line in the figure). For this scheme change, three variable resistors are available: R = 4kΩ; R = 50kΩ; R = 100kΩ. Which one should you choose in order to keep the same frequency?

a) Since duty cycle = $\frac{5}{8}$, Q = $\frac{5}{8} \times 16 = 10$; Q3-Q0 = 1 0 1 0

b) Frequency of comparator $= \frac{10}{7}$; Frequency of timer $= \frac{10}{7} \times 16 = \frac{160}{7}$

Timer Period $T = \frac{1}{Freq} = \frac{7}{160} = 0.7(R_A + 2R_B) \times 12.5 \times 10^{-6}$ → $R_A + 2R_B$ = 5kΩ

with given information: $R_A + R_B$ = 4kΩ → R_A = 3kΩ, R_B = 1kΩ

c) Frequency = 10 / 7; Period T = 7/10 = 0.7($R_A + 2R_B$)(12.5μ); → $R_A + 2R_B$=80kΩ;

Analysis: R = $R_A + R_B$ = 4kΩ → R_A = -72kΩ (x, negative resistance), R_B = 76kΩ

R = $R_A + R_B$ = 50kΩ → R_A = 20kΩ, R_B = 30kΩ (√)

R = $R_A + R_B$ = 100kΩ → R_A = 120kΩ, R_B = -20kΩ (x, negative resistance)

Conclusion: Choose R = 50kΩ with R_A = 20kΩ, R_B = 30kΩ