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***QUESTION 1. Connect up online the circuit below using Multisim from National Instruments:***

***Place voltmeters at each node of the circuit and ammeters at each branch.***

***Run the simulation***.

**(i) Verify by calculation that each of the voltage and current values shown are**

**correct. Use the Voltage Divider rule to verify the voltage at Node 2.**

**[10 Marks]**

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|  | **Using the Voltage Divider rule to verify the voltage at Node 2 (V =7.0588)** |

**(ii) Verify by calculation Kirchhoff’s Current Law for the circuit. Compare with the**

**results given by the simulator.**

**[10 Marks]**

* Kirchhoff’s Current Law states that the total current entering a node must equal the total current leaving the node and vice versa.
* The algebraic sum of electrical currents at any node in an electrical circuit is equal to zero at every instant in time.
* Comparisons with the simulator are shown on the left.

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| Node 1  The current entering the node is **4.9412mA**.  V = IR  This is true for when the current enters the node, and when it leaves the node.  Hence, Kirchhoff’s Current Law works in Node 1. | A close up of text on a white surface  Description automatically generated |
| Node 2  The current entering node 2 is **4.9412mA**.  Hence, Kirchhoff’s current law works in Node 2. | A close up of a map  Description automatically generated |
| Node 3  This is the exact same as node 2, except the total current leaving node 2 should be equal to the total current entering node 3.    Hence, Kirchhoff’s current law works for Node 3. | A close up of a map  Description automatically generated |

**(iii) Verify by calculation Kirchhoff’s Voltage Law for the circuit. Compare with the**

**results given by the simulator.**

**[10 Marks]**

* *Kirchhoff’s Voltage Law* *states that the algebraic sum of branch voltages around any loop in an electrical circuit is equal to zero at every instant in time.*
* The voltage of the source minus the sum of the branch voltages should equal zero.

In our case 12V minus the voltage drops across R1, R2 and R3 should equal zero**.**

* Let’s call E = 12V

V1 = branch voltage for R1

V2 = branch voltages for R2 and R3

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*Hence, KVL (Kirchhoff’s Voltage Law) is true; it works for this circuit.*

**(iv) Replace the battery with a 12V (peak) ac source, run the simulation, observe**

**Grapher and explain your results**

**[10 Marks]**

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* On simulation of the circuit, the sinusoidal graph looks like this:

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Explain your results:

* **For PR1: V(1)** – The 12V (peak) AC source, it only peaks at 11.982 V instead of 12 V. This shows a potential percentage error in the simulator multi-sim.

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* **The same happens for PR2: V(2) -** it only peaks at 7.0482 V instead of 7.0588 V. A percentage error could be the cause of this.

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* Kirchoff’s Current Law is proved – **The current entering node 2 (PR3) is equal to the total current leaving node 2 (PR5 + PR6)**; similar to destructive interference.

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**PR3(peak) = 4.337 mA PR6(peak) = 1.4096 mA PR5(peak) = 3.5241 mA**



**Hence, PR3 = PR6 + PR5**



* **PR8: V(0)** – remains constant at 0 V. This is because the circuit is grounded, the ground acts as a 0 V reference point, and the voltage drop across R2 and R3 is 7.0588 V; this supplements our previous findings.

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***QUESTION 2. Connect up the circuit below. You can assume the resistance of the lamp is about 10 Ohms.***

***You should support your answers with calculations.***

**(i) Run the simulation. What do you observe?**

**[10 Marks]**

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* **T**he 12 V bulb X1 is glowing brightly once the simulation is taking place. This is because current flows from the 40 V DC source through the resistor R1 and into the bulb. This current flows through the circuit and approximately 0.4A of current flows through the bulb to make it glow brightly as shown in the diagram above.
* The power of 1.975 Watts provides enough power for the bulb to light brightly.

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**(ii) Replace R1 with a 1K resistor. What do you observe and why?**

**[10 Marks]**

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* What I observe: The 12V bulb X1 is very lightly glowing, but the bulb is not glowing brightly. The simulator multi-sim displays the bulb glowing to a very small degree.
* Why does this happen: When I changed the resistance from 80Ω to 1kΩ(1000Ω), the resistance increased drastically.

From the equation V= IR

V in this case is constant, at 40 V from the DC source.

* Henceforth, if R increases, the value of I must decrease to preserve equilibrium.

Therefore, the current decreases with increasing resistance; this makes sense because the more resistance you apply to a current, the less current can flow through a circuit.

* Since less current was flowing through the circuit, the 12 V bulb X1 only glowed to a very small degree – it was almost not glowing. Also, the power of 0.0157 Watts is small compared to our previous power value of 1.975W in part (i).

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**(iii) With R1 at 80 Ohms, place a 1K resistor in parallel with the lamp. What do you**

**observe and why?**

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* What I observed: The 12 V bulb X1 glows brightly with the **80Ω**, as if the **1kΩ** resistor in parallel didn’t exist.
* Why this phenomenon occurs: Current will always prefer to flow through the path of least resistance. At node 2, the current can either flow through the bulb (with the same resistance) or go through the **1000Ω (1kΩ)** resistor R2 which takes more effort.
* The current flows through the path of least resistance, hence the majority of the current simply flows through the lightbulb, rather than the **1kΩ** resistor.
* Since a 1kΩ resistor is added in parallel, only a small fraction of the total current flows through it since the resistance of the bulb is significantly less the resistance of R2.
* Since the resistance of R2 is much greater than the resistance of the bulb, the majority of the current flows through the bulb. Therefore, the bulb glows brightly.

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**(iv) Replace the parallel 1K resistor with a 10 Ohm resistor keeping R1 at 80 Ohms.**

**What do you observe and why?**

**[10 Marks]**

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* The 12V bulb X1 glows in a dim manner, this is because the lamp’s current is only **0.235 A** and the voltage is only **2.35 V** (shown below).
* The low current means less current is flowing through the bulb, and henceforth it’s only glowing to a small extent.
* The bulb’s **0.235A** compared with the previous **0.44A** from part (iii) is nearly half the current; that is why the bulb was glowing brightly in part (iii) but only slightly glowing now.

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