Circuits Assignment

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Questions Index

1 Question 1

Simulation Results

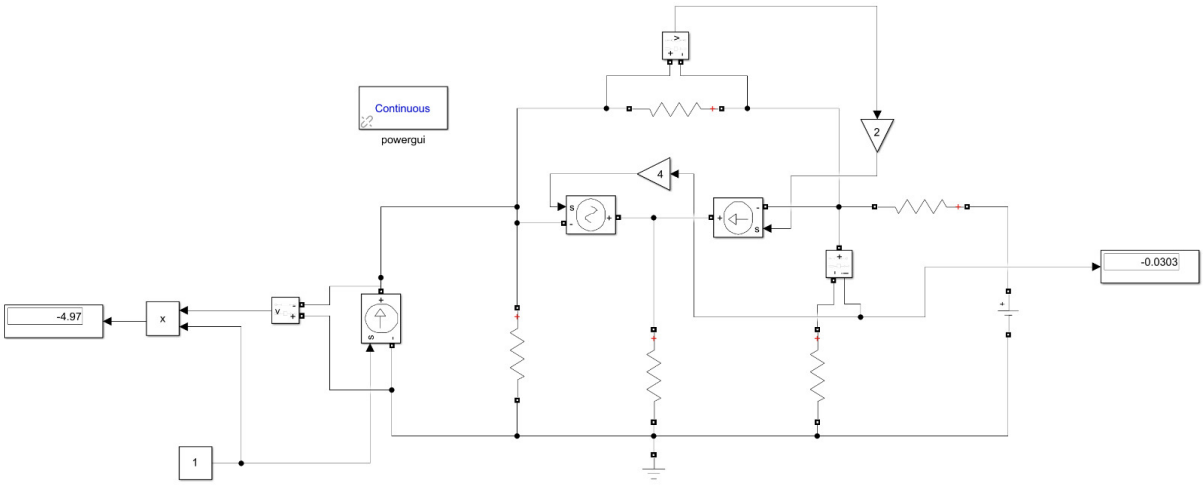

Figure 1: Simulation result for Question 1

Hand Calculations

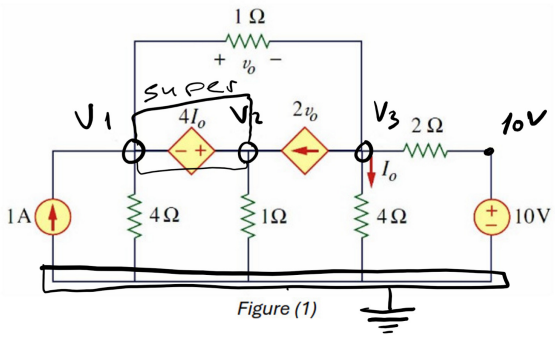

Figure 2: Hand calculation diagram for Question 1

Given relation:

$$V_2 = V_1 + 4i_0 \tag{1}$$

KCL at V_3:

$$\frac{V_3}{4} + \frac{V_3 - 10}{2} + 2V_0 + (V_3 - V_1) = 0 \tag{2}$$

Supernode equation:

$$\left(\frac{1}{4}+1+1\right)V_1 - V_3 - 2V_0 + 4i_0 = 1 \tag{3}$$

relations:

$$i_0 = \frac{V_3}{4} \tag{4}$$

$$V_1 - V_3 - V_0 = 0 \tag{5}$$

Solution:

$$\boxed{i_0 = -30\,\text{mA}}$$

Conclusion

Node-voltage analysis was successfully applied to determine the circuit variables. The analytical result agrees with the simulation. The negative current value indicates that the actual current direction is opposite to the assumed reference direction.

2 Question 2

Simulation Results

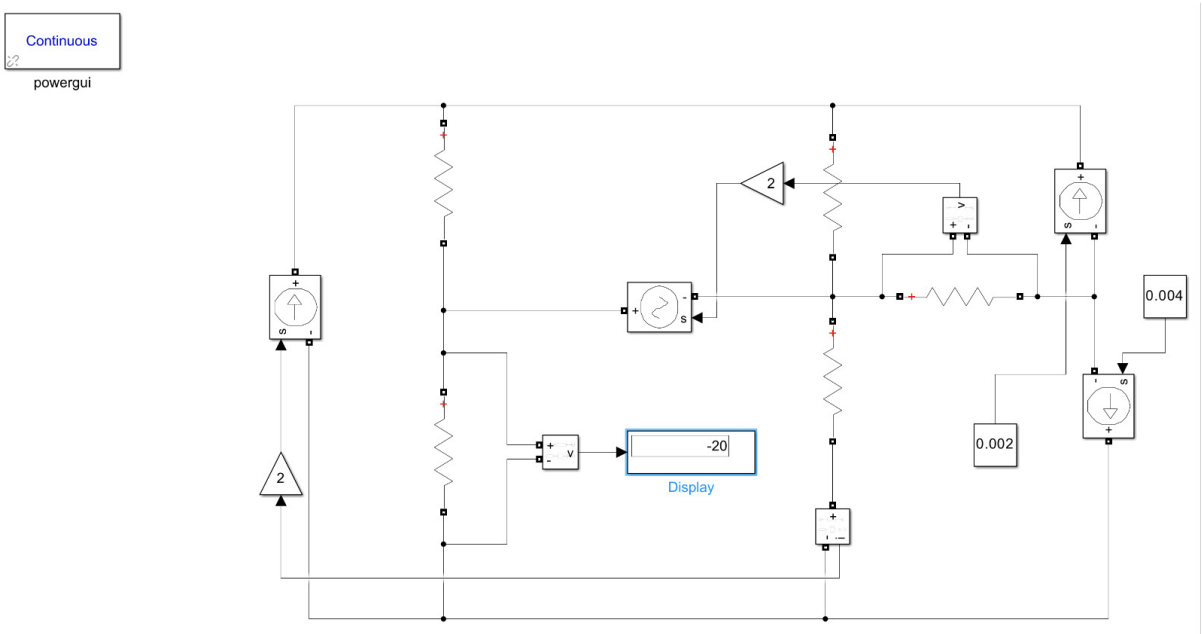

Figure 3: Simulation result for Question 2

Hand Calculations

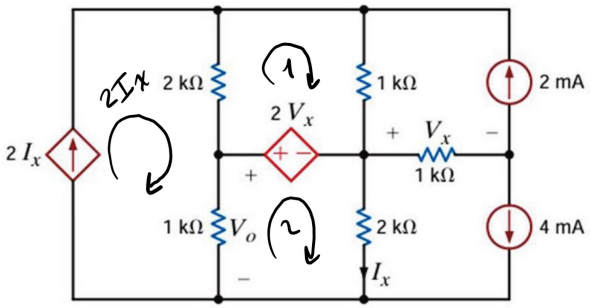

Figure 4: Hand calculation diagram for Question 5

Mesh 1 equation:

$$3i_1 - 4i_\mathcal{X} + 2 = 2V_\mathcal{X} \tag{1}$$

Mesh 2 equation:

$$3i_2 - 2i_\mathcal{X} - 8 = -2V_\mathcal{X} \tag{2}$$

relations:

$$i_{\mathcal{X}} = i_2 - 4 \tag{3}$$

Solution:

$$\boxed{V_0 = -20\,\mathrm{V}}$$

Conclusion

Mesh-current analysis was used to form the equations of the circuit. The analytical voltage value matches the simulation result.

3 Question 3

Simulation Results

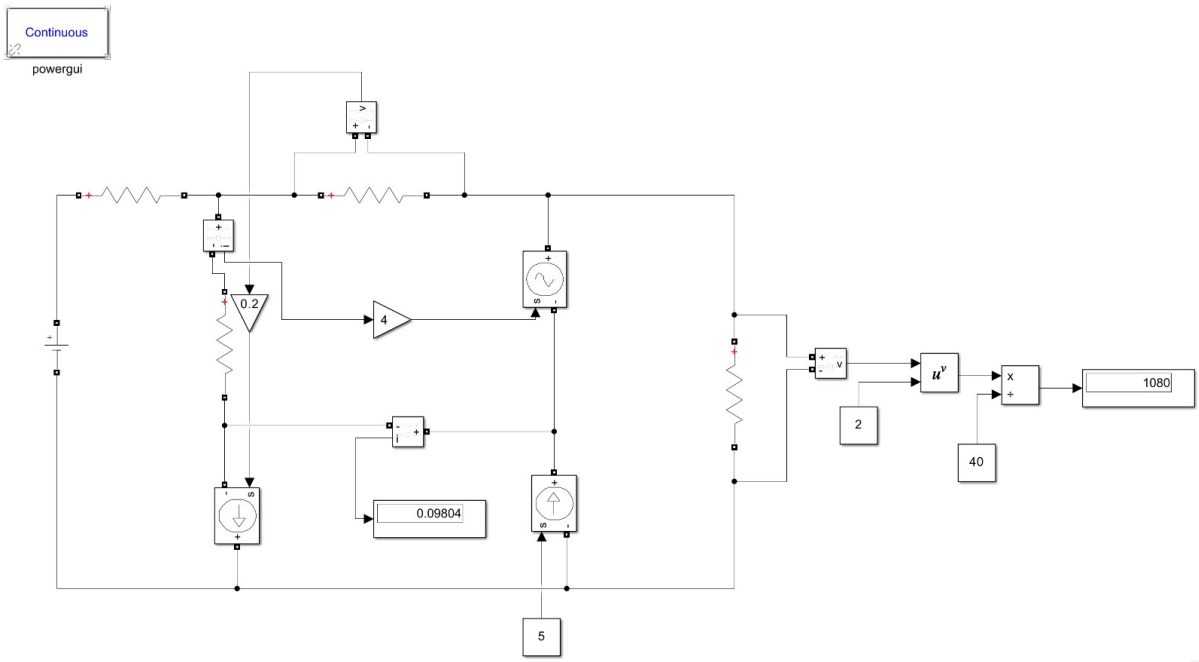

Figure 5: Simulation result for Question 3

Hand Calculations

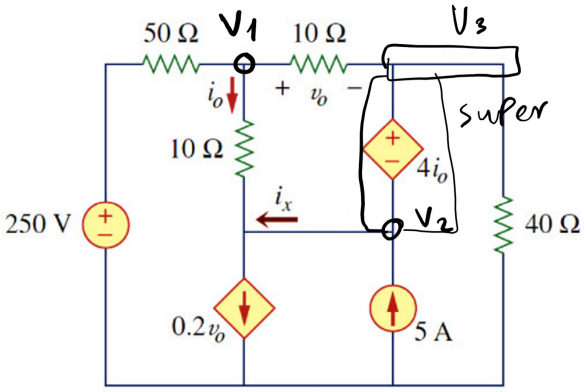

Figure 6: Hand calculation diagram for Question 3

KCL at V_1:

$$\frac{V_1 - V_2}{10} + \frac{V_1 - 250}{50} + \frac{V_1 - V_2 - 4i_0}{10} = 0 \tag{1}$$

Supernode equation:

$$\frac{V_0}{5} - 5 + \frac{V_2 - V_1}{10} + \frac{V_2 + 4i_0 - V_1}{10} + \frac{V_2 + 4i_0}{40} = 0 \tag{2}$$

relations:

$$i_0 = \frac{V_1 - V_2}{10} \tag{3}$$

$$V_0 = V_1 - V_2 - 4i_0 \tag{4}$$

Solution:

$$V_3 = 207.84\,\mathrm{V}$$

Power dissipated in the $40\,\Omega$ resistor:

$$\boxed{P = \frac{V^2}{R} = \frac{207.84^2}{40} = 1080\,\mathrm{W}}$$

Conclusion

Node-voltage analysis with supernodes was applied to solve the circuit. The calculated voltage and power values closely match the simulation results, with minor differences due to rounding.

4 Question 4

Simulation Results

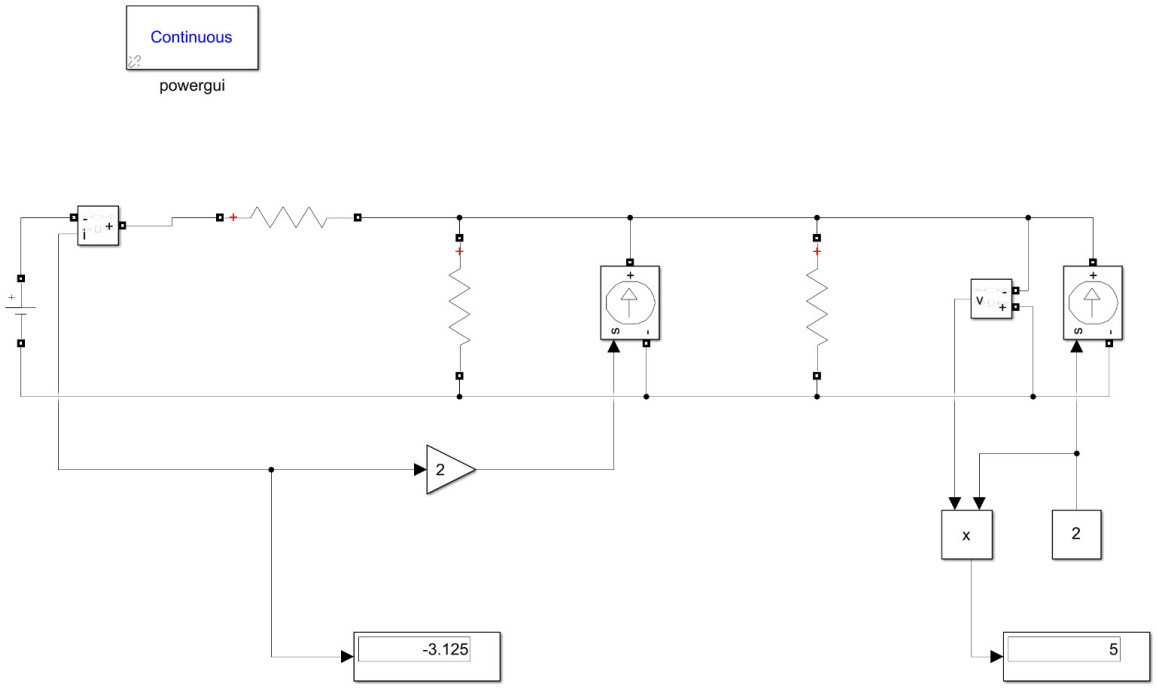

Figure 7: Simulation result for Question 4

Hand Calculations

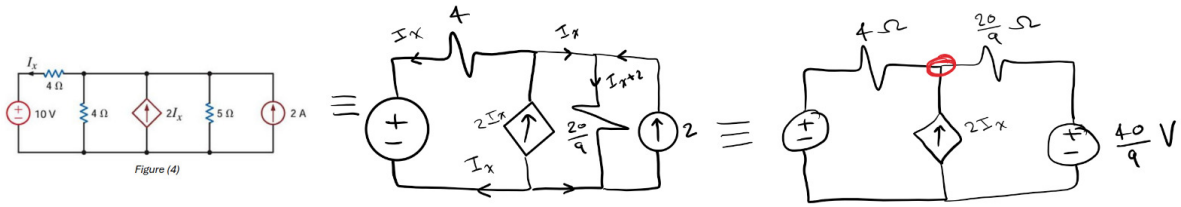

Figure 8: Hand calculation diagram for Question 4

Equivalent resistance of parallel resistors:

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{4 \times 5}{4 + 5} = \frac{20}{9}\,\Omega \tag{1}$$

Source transformation:

$$V_{source} = I \times R_{eq} = 2 \times \frac{20}{9} = \frac{40}{9}\,\mathrm{V} \tag{2}$$

KVL equation:

$$10 - \frac{40}{9} = -4I_{\mathcal{X}} + \frac{20}{9}I_{\mathcal{X}} \tag{3}$$

Solution:

$$\boxed{I_{\mathcal{X}} = -3.125\,\mathrm{A}}$$

Power supplied by the 2A source:

$$\boxed{P = 5\,\mathrm{W}}$$

Conclusion

Source transformation and KVL were used to simplify the circuit. The analytical current and power values confirm the simulation results.

5 Question 5

Simulation Results

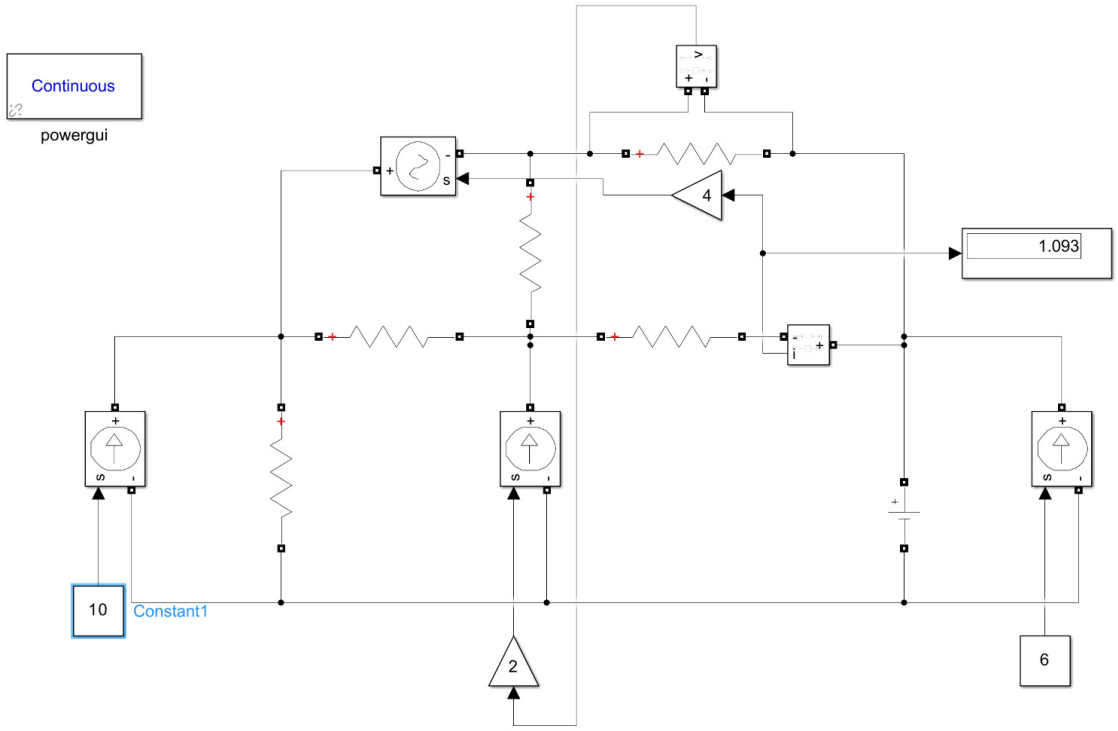

Figure 9: Simulation result for Question 5

Hand Calculations

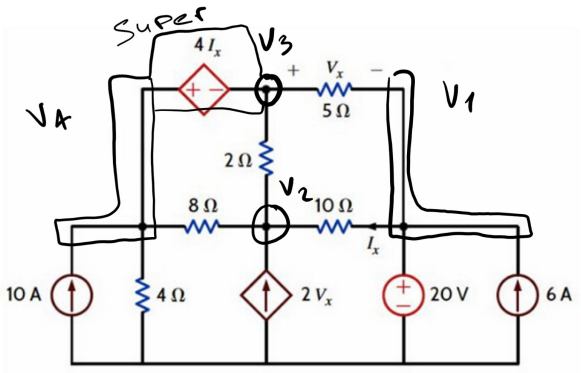

Figure 10: Hand calculation diagram for Question 5

KCL equation for V_2:

$$\frac{V_2 - 20}{10} - 2V_x + \frac{V_2 - V_3}{2} + \frac{V_2 - V_3 - 4i_x}{8} = 0 \tag{1}$$

Supernode equation:

$$\frac{V_3 - V_2}{2} + \frac{V_3 - 20}{5} + \frac{V_3 + 4i_{\mathcal{X}}}{4} + \frac{V_3 + 4i_{\mathcal{X}} - V_2}{8} - 10 = 0 \tag{2}$$

relations:

$$i_{\mathcal{X}} = \frac{20 - V_2}{10} \tag{3}$$

$$V_{\mathcal{X}} = V_3 - 20 \tag{4}$$

Solution:

$$\boxed{i_{\mathcal{X}} = 1.09\,\mathrm{A}}$$

Conclusion

The node-voltage method with dependent sources was successfully applied. The simulation confirms the analytical behavior of the circuit.