Homework 4

ECE2004 CRN:12898

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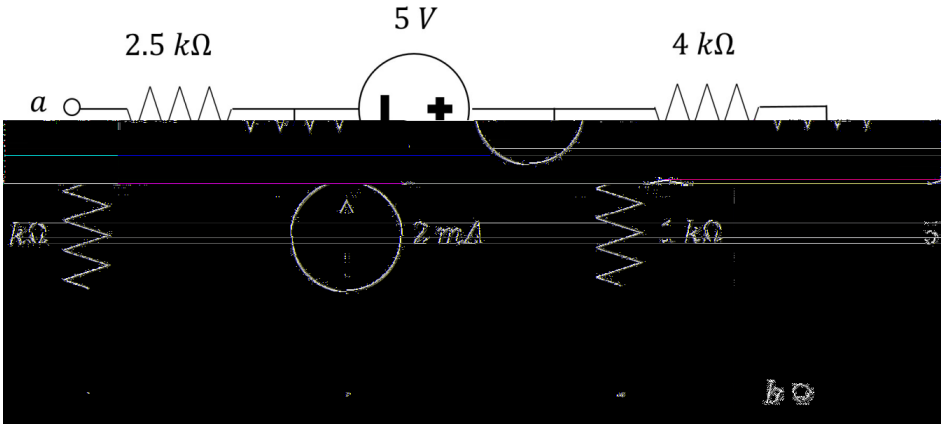
Question 1: Find the Thevenin equivalent voltage and resistance at terminals $a - b$.



Closed

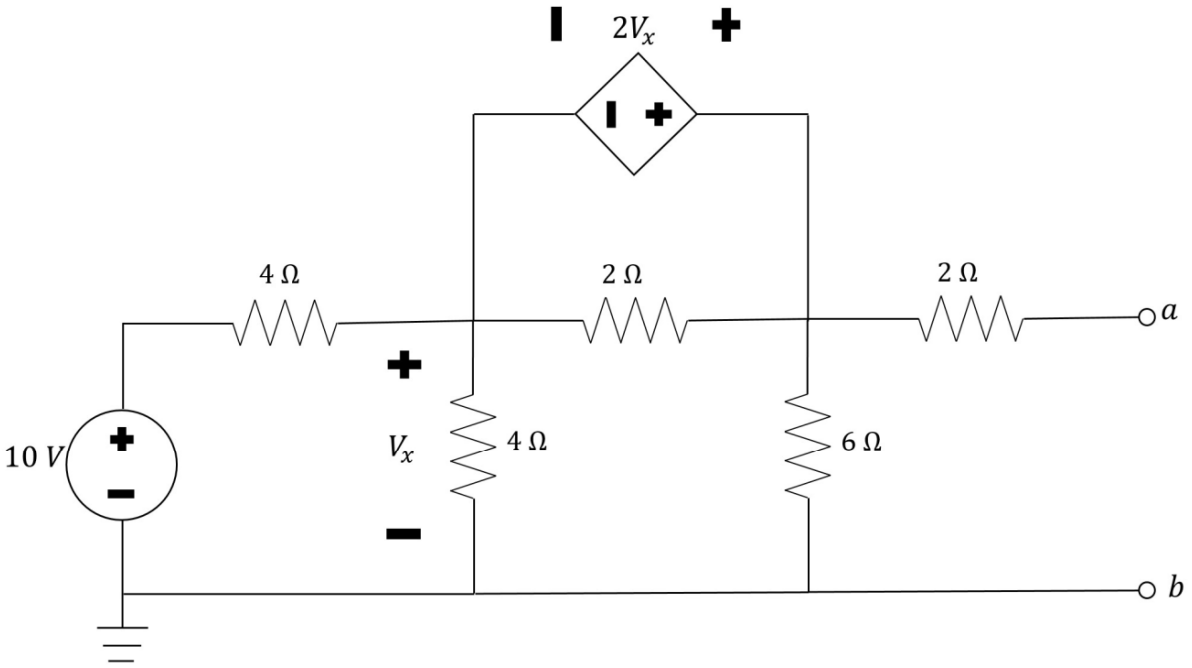
$$R_{5V} = 4k\Omega + 1k\Omega + 2.5k\Omega \parallel 5k\Omega = 6670\Omega$$
$$I_{ab5V} = \frac{5V}{2.5k\Omega} \times \frac{2.5k\Omega \parallel 5k\Omega}{6670\Omega} = 0.5mA$$
$$R_{2mA} = (4k\Omega + 1k\Omega) \parallel 5k\Omega \parallel 2.5k\Omega = 1250\Omega$$
$$V_{ab2mA} = 2mA \times 1250\Omega = 2.5V$$
$$I_{ab2mA} = \frac{2.5V}{2.5k\Omega} = 1mA$$
$$I_{ab} = 1mA - 0.5mA = 0.5mA$$

Open

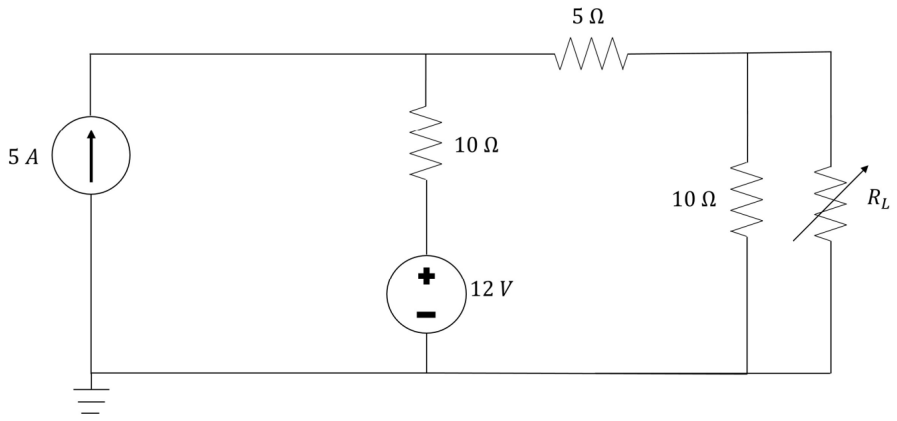
$$V_{ab5V} = V_{5k\Omega 5V}$$
$$V_{5k\Omega 5V} = 5V\frac{5k\Omega}{5k\Omega + 4k\Omega + 1k\Omega} = 2.5V$$
$$V_{ab2mA} = V_{5k\Omega 2mA}$$
$$V_{5k\Omega 2mA} = 2mA\frac{1}{\frac{1}{5k\Omega} + \frac{1}{4k\Omega + 1k\Omega}} = 5V$$
$$V_{ab} = 5V - 2.5V = 2.5V$$

$$V_{Th} = 2.5V$$
$$R_{Th} = \frac{V_{ab}}{I_{ab}} = \frac{2.5V}{0.5mA} = 5k\Omega$$

Question 2: Find the Norton equivalent current and resistance at terminals $a - b$.



Question 3: What is the maximum power that can be delivered to R_L?



Open

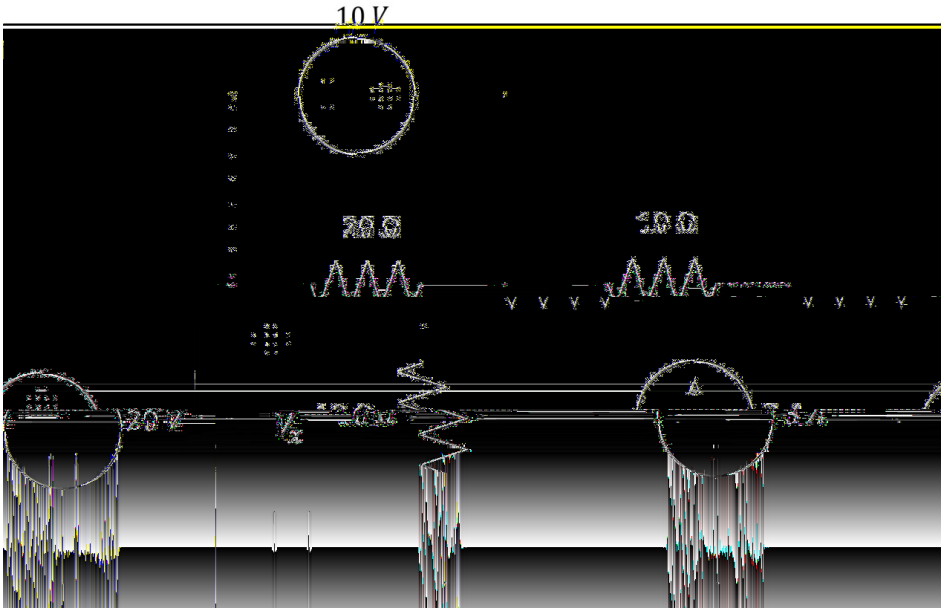
$$R_{12V} = 10\Omega + 5\Omega + 10\Omega = 25\Omega$$
$$V_{R_L 12V} = V_{10\Omega 12V}$$
$$V_{10\Omega 12V} = 12V\frac{10\Omega}{25\Omega} = 4.8V$$
$$R_{5A} = 10\Omega \parallel (5\Omega + 10\Omega) = 6\Omega$$
$$V_{R_L 5A} = V_{10\Omega 5A}$$
$$V_{10\Omega 5A} = 5A \times 6\Omega\frac{10\Omega}{5\Omega + 10\Omega} = 20V$$
$$V_{R_L} = 20V + 4.8V = 24.8V$$

Closed

$$R_{12V} = 10\Omega + 5\Omega = 15\Omega$$
$$I_{R_L 12V} = \frac{12V}{15\Omega} = 0.8A$$
$$R_{5A} = 10\Omega \parallel 5\Omega = \frac{10}{3}\Omega$$
$$I_{R_L 5A} = 5A\frac{10\Omega}{15\Omega} = \frac{10}{3}A$$
$$I_{R_L} = 0.8A + \frac{10}{3}A = \frac{62}{15}A \approx 4.13A$$

$$V_{Th} = 24.8V$$
$$R_{Th} = \frac{V_{ab}}{I_{ab}} = \frac{24.8V}{\frac{62}{15}A} = 6\Omega$$

Question 4:



A) Use superposition to find V_x.

$$R_{20V} = 10\Omega + 10\Omega = 20\Omega$$
$$V_x = 20V\frac{10\Omega}{20\Omega} = 10V$$
$$V_{10\Omega} = 20V - 10V = 10V$$
$$V_{20\Omega} = 0V$$

$$R_{10V} = \frac{1}{\frac{1}{20\Omega} + \frac{1}{10\Omega+10\Omega}} = 10\Omega$$
$$V_{20\Omega} = 10V$$
$$V_x = 10V\frac{10\Omega}{20\Omega} = 5V$$
$$V_{10\Omega} = 10V - 5V = 5V$$

$$R_{3A} = \frac{1}{\frac{1}{10\Omega} + \frac{1}{10\Omega}} = 5\Omega$$
$$V_{20\Omega} = 0V$$
$$V_x = 10\Omega \times 3A \times \frac{1}{2} = 15V$$
$$V_{10\Omega} = 15V$$

$$V_x = 10V - 5V + 15V = 20V$$

B) Analyse the full circuit with mesh current or nodal analysis to find V_x.