EECE 210

Quiz 2 – Nov 20, 2010

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1. The current components in a resistor R, as found from superposition, are -8 A and +4 A. Determine the power dissipated in the resistor if R = 2 Ω.

Solution: The magnitude of the current through R is 4 A. The power dissipated in R is 16R.

Version 1: R = 2 Ω, P = 16R = 32 W

Version 2: R = 3 Ω, P = 16R = 48 W

Version 3: R = 4 Ω, P = 16R = 64 W

Version 4: R = 5 Ω, P = 16R = 80 W

Version 5: R = 6 Ω, P = 16R = 96 W.

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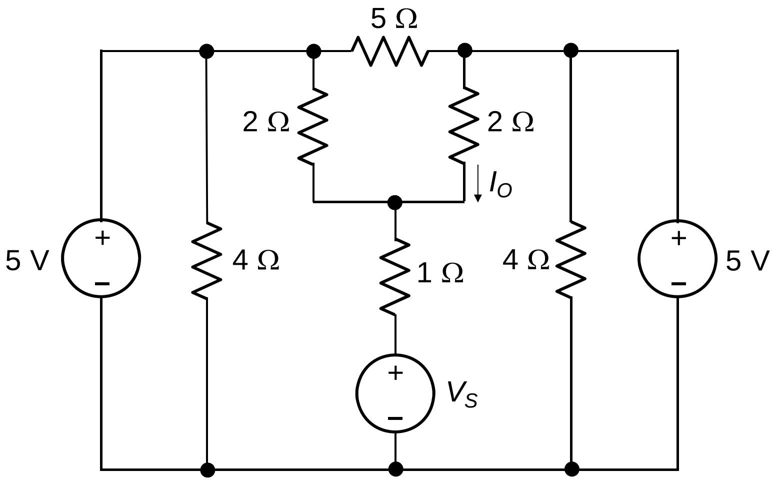
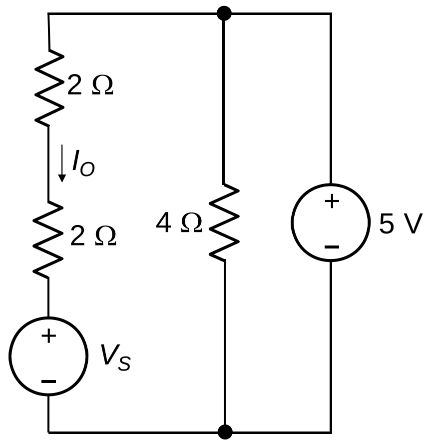
2. Determine I_O if V_S = 1 V.



Solution: The two terminals of the 5 Ω resistor are at the same voltage. Hence, this resistor carries no current and can be removed. The 1 Ω in series with V_S can be split into two parallel branches, each of 2 Ω in series with V_S. The circuit can then be split into two halves as shown. It follows that $I_O = \frac{5 - V_S}{4}$ A.



Version 1: V_S = 1 V, $I_O = \frac{5-1}{4} = 1$ A

Version 2: V_S = 2 V, $I_O = \frac{5-2}{4} = 0.75$ A

Version 3: V_S = 3 V, $I_O = \frac{5-3}{4} = 0.5$ A

Version 4: V_S = 4 V, $I_O = \frac{5-4}{4} = 0.25$ A

Version 5: V_S = 5 V, $I_O = \frac{5-5}{4} = 0$ A.

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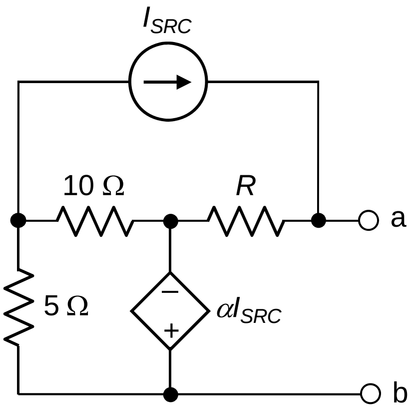
3. Determine R so Norton's current between terminals a and b is zero, given that I_{SRC} = 5 A and α = 1 V/A.



Solution: If a and b are short-circuited and no current flows in the short circuit, I_{SRC} flows through R. Applying KVL, $RI_{SRC} = \alpha I_{SRC}$, which gives $R = \alpha$ Ω.

Version 1: α = 1, R = 1 Ω

Version 2: α = 2, R = 2 Ω

Version 3: α = 3, R = 3 Ω

Version 4: α = 4, R = 4 Ω

Version 5: α = 5, R = 5 Ω.

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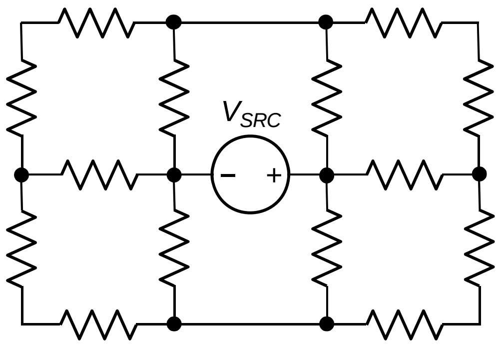
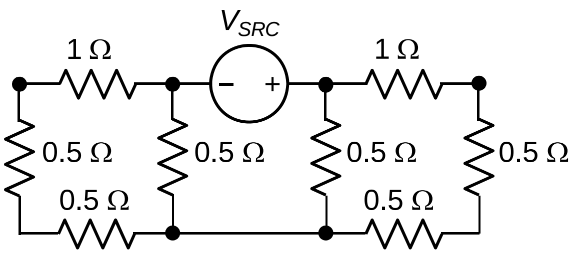
4. Determine the power delivered by the source, assuming all resistances are 1 Ω and V_{SRC} = 1 V.



Solution: From symmetry, each top node along the same vertical line is at the same voltage as the corresponding bottom node. Joining these nodes together simplifies the circuit to that shown. The resistance on each side of the source is 0.5||2 Ω = 0.4 Ω. Hence, $I_{SRC} = V_{SRC}/0.8$ A and the power delivered by the source is $\frac{V_{SRC}^2}{0.8}$ W.



Version 1: V_{SRC} = 1 V, $P = \frac{1}{0.8} = 1.25$ W

Version 2: V_{SRC} = 1.2 V, $P = \frac{(1.2)^2}{0.8} = 1.8$ W

Version 3: V_{SRC} = 1.4 V, $P = \frac{(1.4)^2}{0.8} = 2.45$ W

Version 4: V_{SRC} = 1.6 V, $P = \frac{(1.6)^2}{0.8} = 3.2$ W

Version 5: V_{SRC} = 1.8 V, $P = \frac{(1.8)^2}{0.8} = 4.05$ W

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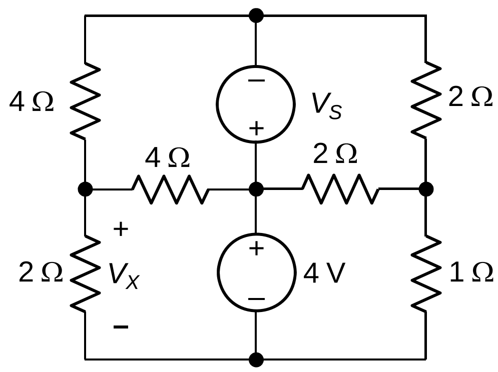
5. Determine V_X assuming V_S = 1 V.



Solution: With the 4 V source applied alone, and V_S set to zero, $V_{X1} = \frac{2}{2+4\,||\,4} \times 4 = 2$ V. With V_S applied and the 4 V source set to zero, $V_{X2} = -\frac{2\,||\,4}{4+2\,||\,4} \times V_S = -\frac{4/3}{4+4/3} \times V_S = -\frac{V_S}{4}$; V_X $= 2 - \frac{V_S}{4}$ V.

Version 1: V_S = 1 V, $V_X = 2 - \frac{1}{4} = 1.75$ V

Version 2: V_S = 2 V, $V_X = 2 - \frac{2}{4} = 1.5$ V

Version 3: V_S = 3 V, $V_X = 2 - \frac{3}{4} = 1.25$ V

Version 4: V_S = 4 V, $V_X = 2 - \frac{4}{4} = 1$ V

Version 5: V_S = 5 V, $V_X = 2 - \frac{5}{4} = 0.75$ V.

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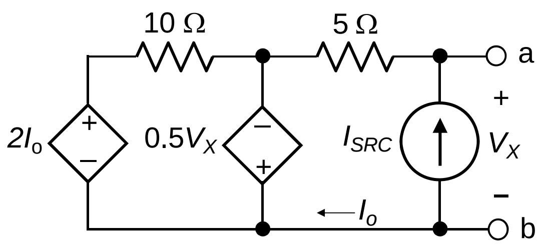
6. Determine Norton's current at terminals a and b, assuming I_{SRC} = 0.5 A.



Solution: When terminals ab are short circuited, V_X = 0 and the dependent voltage source $0.5V_X$ is zero, so that $I_N = I_{SRC}$.

Version 1: I_{SRC} = 0.5 A, I_N = 0.5 A

Version 2: I_{SRC} = 1 A, I_N =1 A

Version 3: I_{SRC} = 1.5 A, I_N = 1.5 A

Version 4: I_{SRC} = 2 A, I_N = 2 A

Version 5: I_{SRC} = 2.5 A, I_N = 2.5 A.

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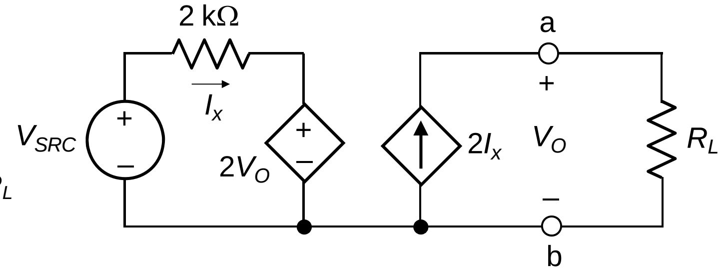
7. Determine Thevenin's voltage between terminals a and b, with R_L removed, assuming V_{SRC} = 5 V.



Solution: When terminals ab are open circuited, $I_X = 0$. To make $I_X = 0$, $2V_O = V_{SRC}$, so that $V_{Th} = V_{SRC}/2$ V.

Version 1: $V_{SRC} = 5$ V, $V_{Th} = V_{SRC}/2 = 2.5$ V

Version 2: $V_{SRC} = 10$ V, $V_{Th} = V_{SRC}/2 = 5$ V

Version 3: $V_{SRC} = 15$ V, $V_{Th} = V_{SRC}/2 = 7.5$ V

Version 4: $V_{SRC} = 20$ V, $V_{Th} = V_{SRC}/2 = 10$ V

Version 5: $V_{SRC} = 25$ V, $V_{Th} = V_{SRC}/2 = 12.5$ V.

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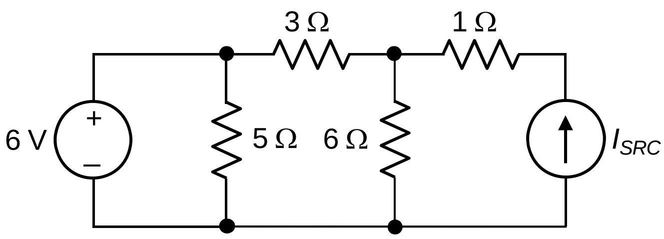
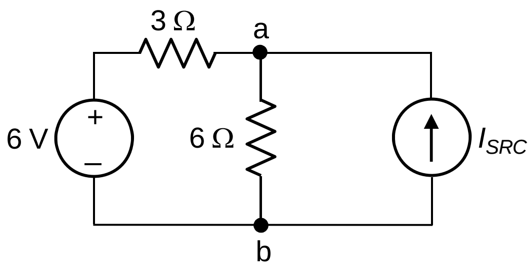
8. Determine the power delivered by I_{SRC} assuming $I_{SRC} = 0.5$ A.



Solution: To determine V_{ab}, the 5 Ω and 1 Ω resistances are redundant. Transforming the voltage source to a current source, it follows that $V_{ab} = 2(2 + I_{SRC})$ From the original circuit, the voltage rise across the current source is $V_{ab} + 1\times I_{SRC} = 3I_{SRC} + 4$, and the power delivered is $P = I_{SRC}(3I_{SRC} + 4)$.



Version 1: $I_{SRC} = 0.5$ A, $P = 0.5(1.5 + 4) = 2.75$ W

Version 2: $I_{SRC} = 1$ A, $P = 1(3 + 4) = 7$ W

Version 3: $I_{SRC} = 1.5$ A, $P = 1.5(4.5 + 4) = 12.75$ W

Version 4: $I_{SRC} = 2$ A, $P = 2(6 + 4) = 20$ W

Version 5: $I_{SRC} = 2.5$ A, $P = 2.5(7.5 + 4) = 28.75$ W.

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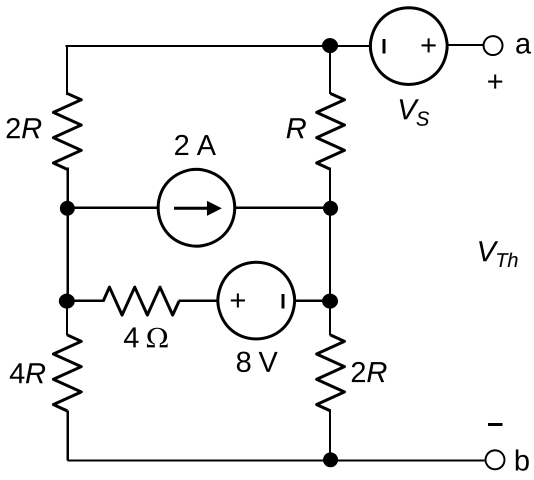
9. Determine V_{Th} assuming $V_S = 1$ V and $R = 2$ Ω.



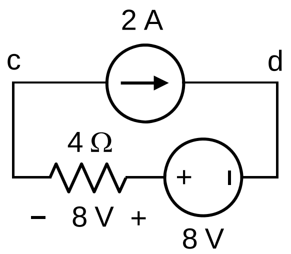
Solution: Let V_X be the voltage drop V_{dc}.

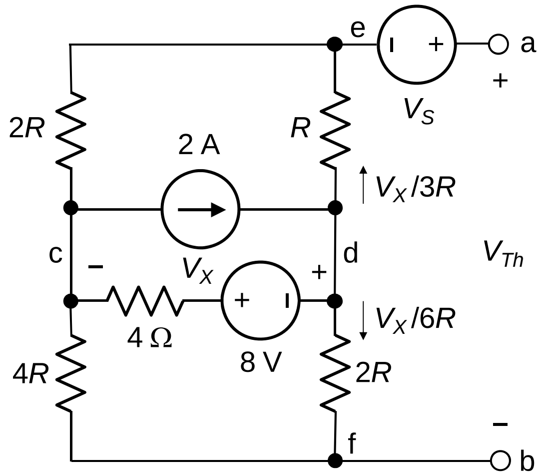
Applying KCL to node d:

$\frac{V_X}{3R} + \frac{V_X}{6R} + \frac{V_X + 8}{4} = 2$; this gives $V_X = 0$,

so that $V_{ef} = 0$ and $V_{Th} = V_S$.

Alternatively, if the subcircuit between nodes c and d is removed, V_{dc} in this circuit is zero, and V_{dc} in the bridge is zero, which makes $V_{ef} = 0$ and $V_{Th} = V_S$.





Version 1: V_S = 1 V, V_{Th} = 1 V

Version 2: V_S = 1.5 V, V_{Th} = 1.5 V

Version 3: V_S = 2 V, V_{Th} = 2 V

Version 4: V_S = 2.5 V, V_{Th} = 2.5 V

Version 5: V_S = 3 V, V_{Th} = 3 V.

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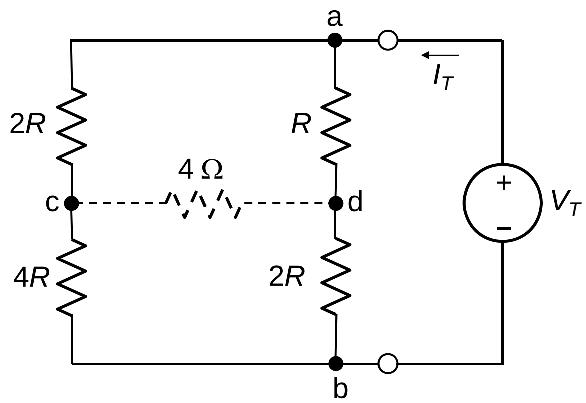
10. Determine R_{Th} in the preceding problem.



Solution: If a test source is applied with all independent sources set to zero, the circuit reduces to that shown, where the current in the 4 Ω resistor is zero. It follows that R_{Th} = $3R||6R = 2R$.

Version 1: R = 1 Ω, R_{Th} = 2 Ω

Version 2: R = 1.5 Ω, R_{Th} = 3 Ω

Version 3: R = 2 Ω, R_{Th} = 4 Ω

Version 4: R = 2.5 Ω, R_{Th} = 5 Ω

Version 5: R = 3 Ω, R_{Th} = 6 Ω.

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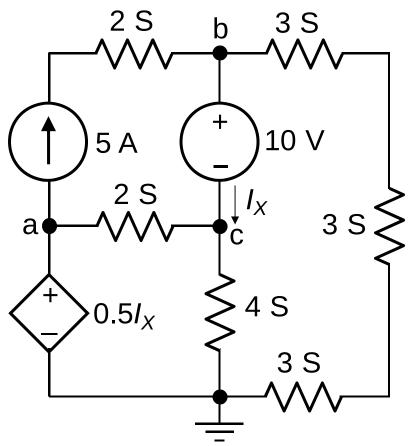
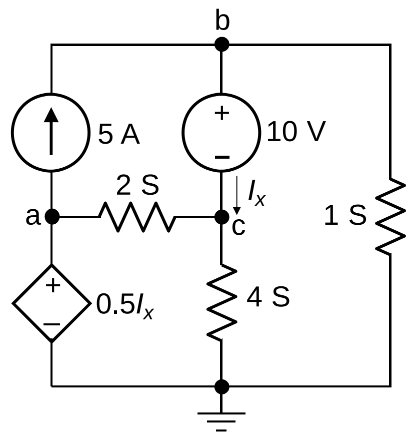
11. For the circuit shown, write the circuit equations in terms of the node voltages V_a, V_b, and V_c. **<u>You are not required to solve these equations</u>**.



Solution: The circuit is redrawn as shown with the redundant 2 S resistor removed and the three 3S resistors combined into a 1 S resistor.



For node a: $V_a = 0.5I_X$, where, for node b, $I_X = 5 - 1\times V_b$. Substituting and rearranging, $\boxed{2V_a + V_b = 5}$. For node c: $-2V_a + 6V_c = I_X = 5 - V_b$; or $\boxed{-2V_a + V_b + 6V_c = 5}$. The third equation is: $\boxed{V_b - V_c = 10}$.

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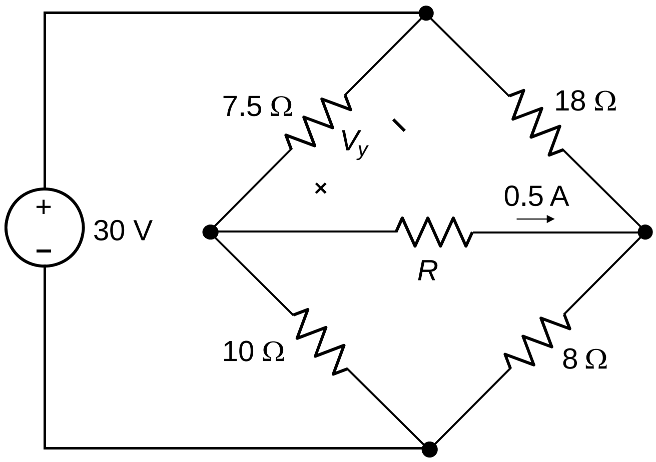
12. Use the substitution theorem and superposition to determine V_y, where R is unknown.



Solution: In accordance with the substitution theorem, R can be replaced by a 0.5 A current source. With this current source set to zero, V_{y1} = $-\frac{7.5}{17.5}\times 30 = -\frac{225}{17.5}$ V. With the 30 V source set to zero and the 0.5 A current source applied, V_{y2} = $-\frac{10}{17.5}\times 0.5 \times 7.5 = -\frac{37.5}{17.5}$ V. It follows that $V_y = V_{y1} + V_{y2}$ = $-\frac{225+37.5}{17.5} = -\frac{262.5}{17.5} = -15$ V.

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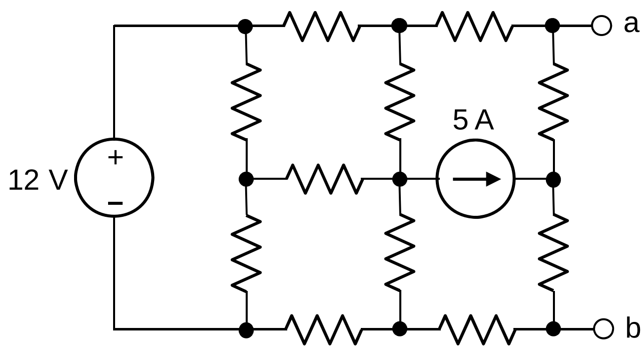
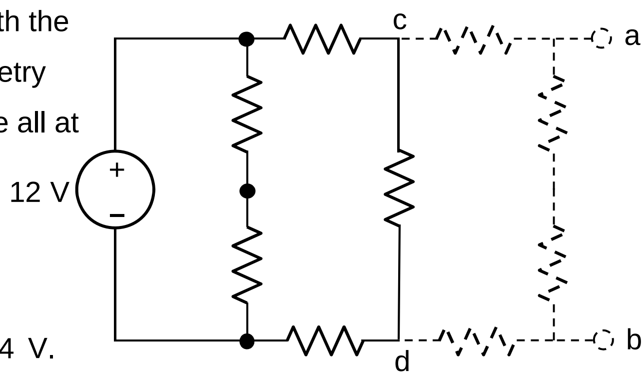
13. Determine Thevenin's equivalent circuit between terminals ab, assuming all resistances are 5 Ω.



Solution: With the 5 A source applied alone, it follows from symmetry that V_{Th1} = 0. With the 12 V source applied alone, it follows from symmetry (as in Example 4.5.1a) that the middle nodes are all at the same voltage. The circuit reduces to that shown, where the effective resistance between nodes c and d is 10||20 = 20/3 Ω, so that V_{cd} = $\frac{20/3}{20/3+10}\times 12 = 4.8$ V, and V_{Th} = $\frac{10}{20}\times 4.8 = 2.4$ V. Alternatively, V_{Th} can be found by scaling.



To determine R_{Th}, with the two sources set to zero, it follows again from Example 4.5.1a that the middle nodes are at the same voltage so that the horizontal resistor in the middle carries no current and can be removed. With the 12 V source replaced by a short circuit, the circuit reduces to that shown. It follows that the effective resistance between nodes c and d is 5 Ω, and R_{Th} = 15||10 = 6 Ω.