Homework 4

P4.1.7 (a) Determine V_{SRC} in Figure P4.1.7 by deriving TEC between terminals ‘bc’. (b) Determine I_{SRC}, V_X, and V_Y.

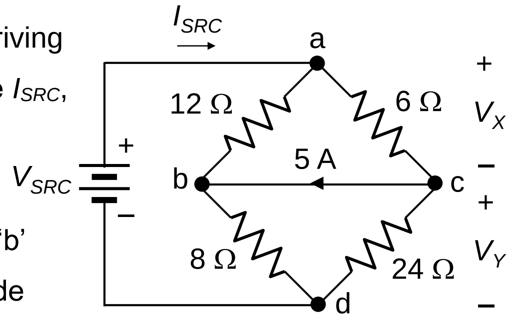


Figure P4.1.7

Solution: (a) $V_{Th} = V_{cd} - V_{bd}$, where node ‘c’ is taken as positive with respect to node ‘b’ since current flows from node ‘c’ to node ‘b’. From voltage division, $V_{cd} = V_{SRC}(24/30)$, and $V_{bd} = V_{SRC}(8/20)$. Hence,

$$V_{Th} = V_{SRC}\left(\frac{4}{5} - \frac{2}{5}\right) = \frac{2}{5}V_{SRC} =$$

$0.4V_{SRC}$. With V_{SRC} replaced by a short circuit, the resistance seen between terminals ‘bc’ is 8||12 + 6||24 = 4.8 + 4.8 =

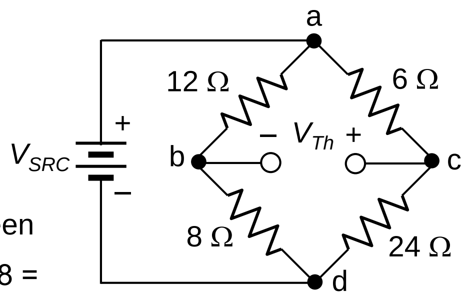


Figure P4.1.7-1

9.6 Ω. TEC becomes as shown, where I_X is the short circuit current given by:

$$\frac{0.4V_{SRC}}{9.6} = 5$$. It follows that V_{SRC} = 120 V.

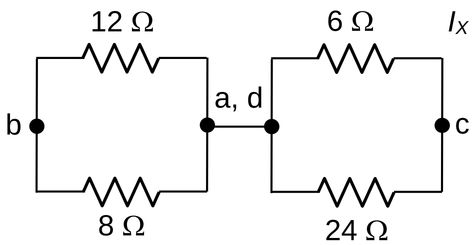


Figure P4.1.7-2

(b) The resistance between nodes ‘a’ and ‘b’ and ‘c’ connected together in the given circuit is 12||6 = 4 Ω, and the resistance between nodes ‘b’ and ‘c’ connected together and node ‘d’ is 8||24 = 6 Ω. The circuit can be redrawn as a voltage divider, as shown. It follows that I_{SRC} = 120/(4 + 6) = 12 A; V_X = 120(4/10) = 48 V, and V_Y = 120(6/10) = 72 V. As a check, the current in the 6 Ω resistor is 48/6 = 8 A, and the current in the 24 Ω resistor is 72/24 = 3 A, the difference being 5 A.

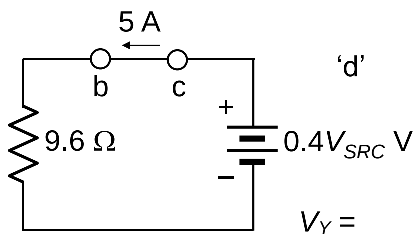


Figure P4.1.7-3

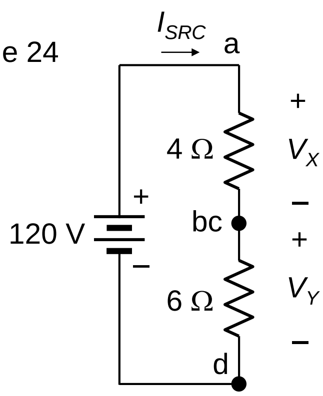


Figure P4.1.7-4

P4.1.11 Derive TEC looking into terminals ‘ab’ in Figure P4.1.11.

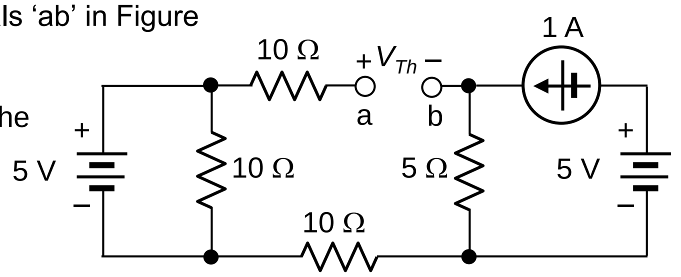


Figure P4.1.11

Solution: **Initialize.** All given values and the required V_{Th} are entered. The nodes are labeled.

Simplify. The circuit is in a Simple enough form.

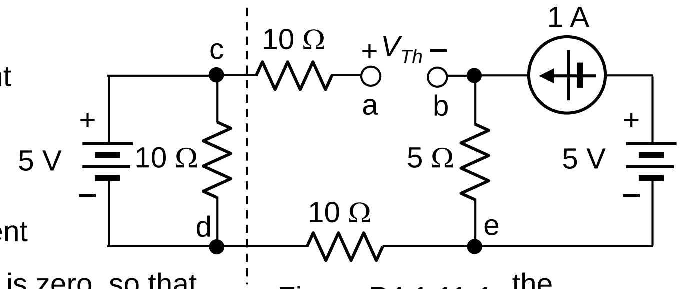
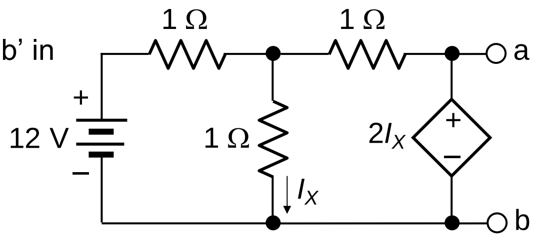


Figure P4.1.11-1

Deduce. The 1 A source current flows through the 5 Ω resistor, producing a voltage drop of 5 V. The current through the upper 10 Ω resistor is zero, so that the current through the lower 10 Ω resistor is zero, and the voltage across this resistor is zero. From KVL starting at node ‘b and going CW:-5 + 0 + 5 – V_{Th} = 0, which gives V_{Th} = 0.

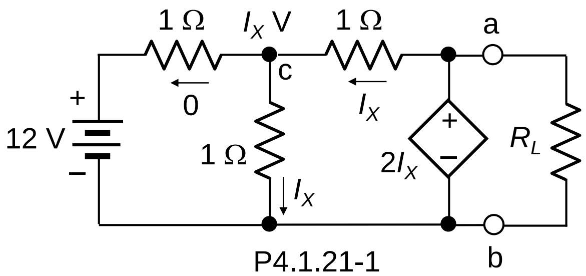
To determine R_{Th}, the sources are set to zero. The 10 Ω resistor on the left is short-circuited, leaving the remaining resistors in series. It follows that R_{Th} = 25 Ω.

P4.1.21 Connect a resistor R_L between terminals ‘ab’ in Figure P4.1.21 and show that the voltage V_{ab} is independent of R_L. Deduce that TEC looking into terminals ‘ab’ is an ideal voltage source. Verify this deduction by determining V_{Th} and R_{Th} looking into terminals ‘ab’.



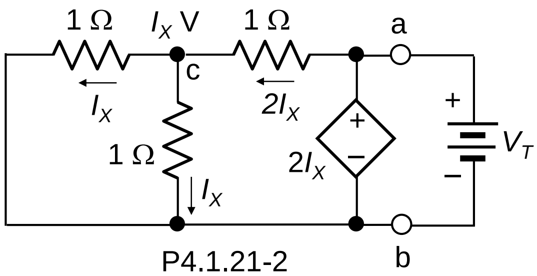
P4.1.21

Solution: $V_{cb} = I_X$ V, $V_{ac} = I_X$ V, $I_{ac} = I_X$ A, and current through 12 V source is zero, it follows that $V_{cb} = I_X$ V = 12 V, V_{ab} = $2I_X$ V = 24 V, independently of R_L, Hence, V_{Th} = 24 V, R_{Th} = 0.



P4.1.21-1

On opencircuit V_{cb} = 12 V = I_X so that $V_{Th} = V_{ab}$ = 24 V. If at test source is applied, I_{cb} through the 1 Ω resistor on the LHS Is I_X; $I_{ac} = 2I_X$ and V_{ab} across the resistors Is $3I_X$, which equals the source voltage $2I_X$. It follows that I_X = 0 so that the trst source



P4.1.21-2

sees a short circuit.

P4.1.28 Derive TEC looking into terminals ‘ab’ in Figure P4.1.28.

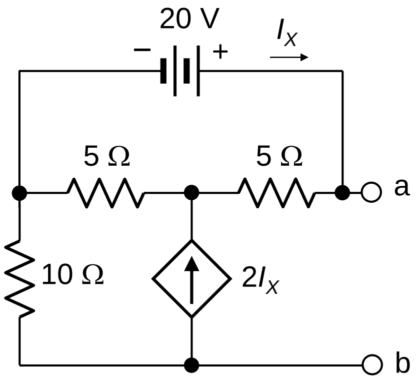


Figure P4.1.28

Solution: **Initialize.** All given values and the required V_{Th} are entered. The nodes are labeled.

Simplify. The circuit is in a Simple enough form.

Deduce. On open circuit, the currents are as shown. $I_{ac} = I_X$; $I_{cd} = 3I_X$; $I_{db} = 2I_X$; from KVL around the upper mesh, $20 = 20I_X$, so that $I_X = 1$ A. It follows that $V_{Th} = V_{ab} = 2\times10 + 20 = 40$ V.

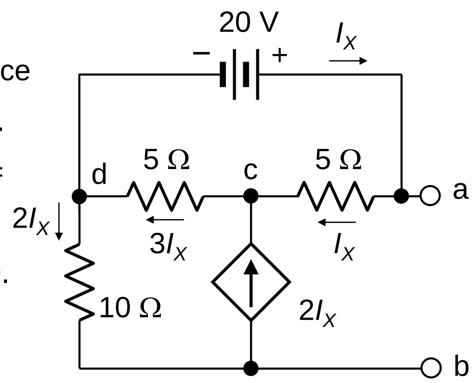


Figure P4.1.28-1

When a test source is applied, with the 20 V source set to zero, $I_{ac} = I_T + I_X$; $I_{cd} = I_T + 3I_X$; $I_{db} = I_T + 2I_X$;. from KVL in the upper mesh, $5(I_T + I_X + I_T + 3I_X) = 0$, which gives, $I_T = -2I_X$. It follows that $V_T = 10(I_T + 2I_X) = 0$, so that $R_{Th} = 0$.

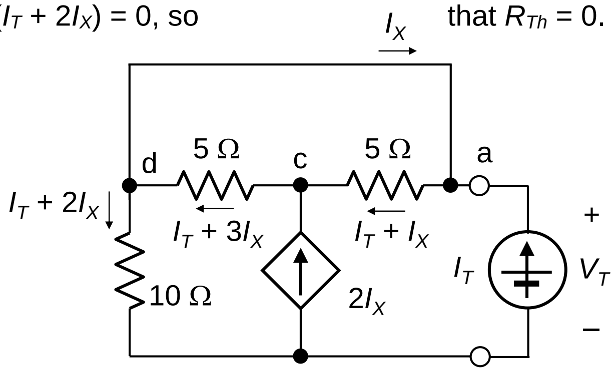


Figure P4.1.28-2

P4.1.30 Determine V_O in Figure P4.1.30 using TEC.

Solution: Initialize. All given values and the required V_{Th} are entered. The nodes are labeled.

Simplify. The circuit is in a Simple enough form.

Deduce. When the 4 Ω resistor is removed, $I_X = 0$, and the dependent source becomes an open circuit. It follows that $V_{Th} = 10$ V. When the resistor is replaced by a short circuit, the circuit becomes as shown, where $I_x = I_{SC}$ and the dependent source becomes $5I_{SC}$. $I_{ac} = 2.5$ A. It follows from KCL that: $I_{SC} = 5I_{SC} + 2.5$, which gives $I_{SC} = -2.5/4 = -5/8$ A, and $R_{Th} = V_{Th}/I_{SC} = -80/5 = -16$ Ω. Hence,

$$V_O = \frac{4}{4-16} \times 10 = -\frac{10}{3}\text{ V.}$$

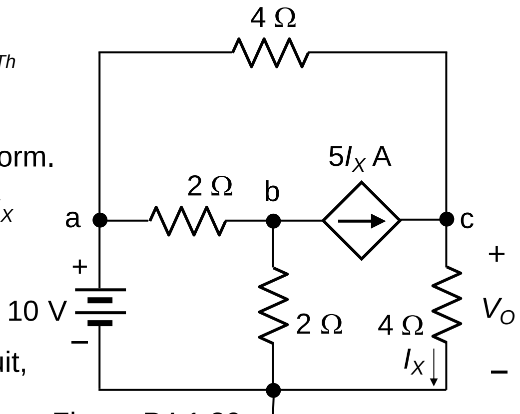


Figure P4.1.30

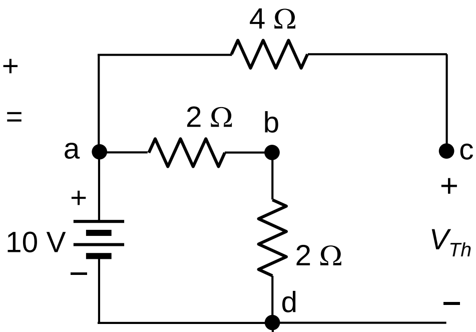


Figure P4.1.30-1

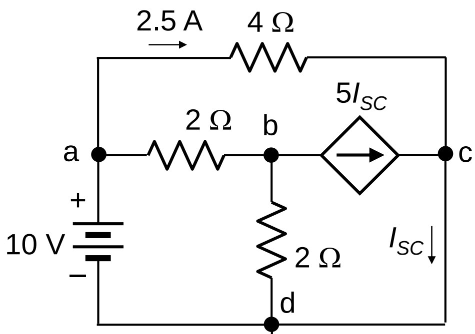


Figure P4.1.30-2

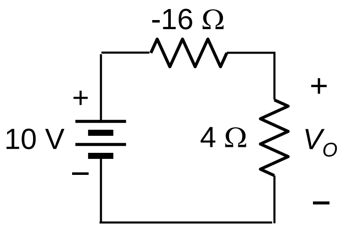


Figure P4.1.30-3