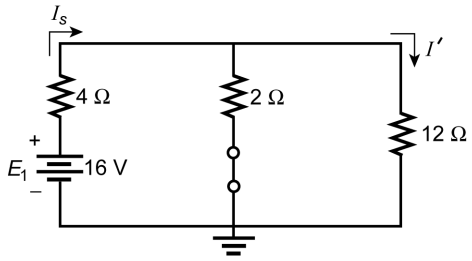
Chapter 9

1. a. E_1:

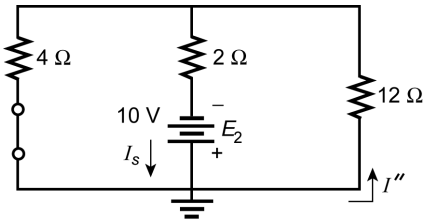


R_T (from source) = 4 Ω + 2 Ω || 12 Ω
= 4 Ω + 1.71 Ω
= 5.71 Ω

$$I_s = \frac{E_1}{R_T} = \frac{16\text{ V}}{5.71\text{ V}} = 2.8\text{ A}$$

$$I'_{12\Omega} = \frac{2\ \Omega(2.8\text{ A})}{2\ \Omega + 12\ \Omega} = 0.4\text{ A}$$

E_2:



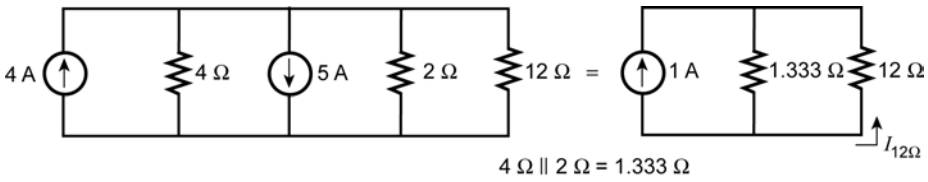
R_T (from source) = 2 Ω + 4 Ω || 12 Ω
= 2 Ω + 3 Ω
= 5 Ω

$$I_S = \frac{E_2}{R_T} = \frac{10\text{ V}}{5\ \Omega} = 2\text{ A}$$

$$I''_{12\Omega} = \frac{4\ \Omega(2\text{ A})}{4\ \Omega + 12\ \Omega} = 0.5\text{ A}$$

$I_{12\Omega}\uparrow = 0.5\text{ A} - 0.4\text{ A} = \mathbf{0.1\ A}$

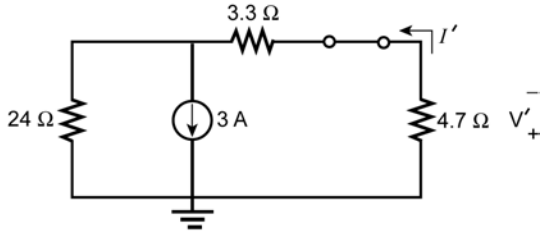
b.



$$I_{12\Omega} = \frac{1.333\ \Omega(1\text{ A})}{1.333\ \Omega + 12\ \Omega} = \mathbf{0.1\ A}$$

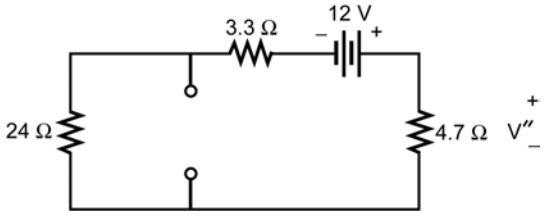
c. the same

2. a.



$$I' = \frac{24\ \Omega(3\text{ A})}{24\ \Omega + 8\ \Omega} = 2.25\text{ A}$$

$V' = I'R = (2.25)(4.7\ \Omega) = 10.575\text{ V}$



$$V'' = \frac{4.7\ \Omega(12\text{ V})}{4.7\ \Omega + 3.3\ \Omega + 24\ \Omega} = 1.763\text{ V}$$

$$V_{+}^{-} = 10.575\text{ V} - 1.763\text{ V} = \mathbf{8.81\ V}$$

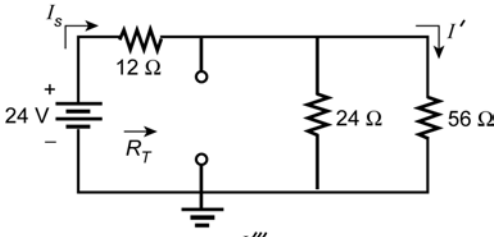
b. $P = \dfrac{V'^2}{R} = \dfrac{(10.575\text{ V})^2}{4.7\ \Omega} = \mathbf{23.79\ W}$

c. $P = \dfrac{V''^2}{R} = \dfrac{(1.763\text{ V})^2}{4.7\ \Omega} = \mathbf{0.661\ W}$

d. $P = \dfrac{V^2}{R} = \dfrac{(8.81\text{ V})^2}{4.7\ \Omega} = \mathbf{16.51\ W}$

e. $23.79\text{ W} + 0.661\text{ W} \neq 16.51\text{ W}$
$24.45\text{ W} \neq 16.51\text{ W}$

3. *E*:

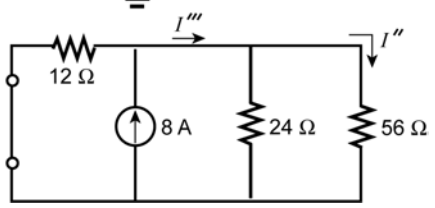


$R_T = 12\ \Omega + 24\ \Omega \parallel 56\ \Omega = 28.8\ \Omega$

$I_s = \dfrac{E}{R_T} = \dfrac{24\text{ V}}{28.8\ \Omega} = 0.833\text{ A}$

$I'_{56\Omega} = \dfrac{24\ \Omega(0.833\text{ A})}{24\ \Omega + 56\ \Omega} = 0.25\text{ A}$

I:



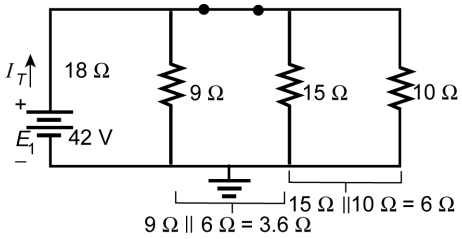
$24\ \Omega \parallel 56\ \Omega = 16.8\ \Omega$

$I''' = \dfrac{12\ \Omega(8\text{ A})}{12\ \Omega + 16.8\ \Omega} = 3.33\text{ A}$

$I''_{56\Omega} = \dfrac{24\ \Omega(3.33\text{ A})}{24\ \Omega + 56\ \Omega} = 1\text{ A}$

$I_{56\Omega} = I' + I'' = 0.25\text{ A} + 1\text{ A} = \mathbf{1.25\ A}\downarrow$

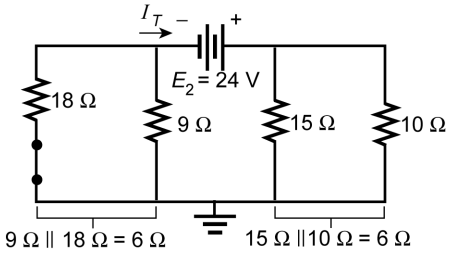
4. E_1:



$I_T = \dfrac{42\text{ V}}{18\ \Omega + 3.6\ \Omega} = 1.944\text{ A}$

$I_1 = \dfrac{9\ \Omega(I_T)}{9\ \Omega + 6\ \Omega} = \dfrac{9\ \Omega(1.944\text{ A})}{15\ \Omega}$
$= 1.17\text{ A}$

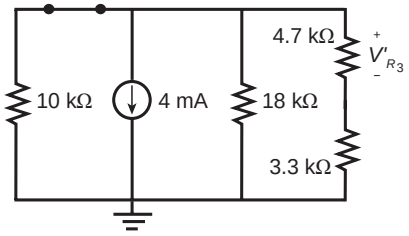
E_2:

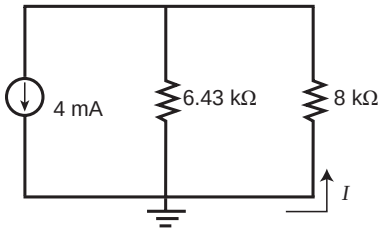


$I_T = \dfrac{E_2}{R_T} = \dfrac{24\text{ V}}{12\ \Omega} = 2\text{ A}$

$I_{24V} = I_T + I_1 = 2\text{ A} + 1.17\text{ A} = \mathbf{3.17\ A\ (dir.\ of\ } \boldsymbol{I}_1\mathbf{)}$

5. *I*:



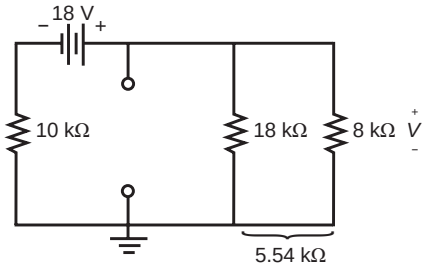


$$I = \frac{6.43\ \text{k}\Omega(4\ \text{mA})}{6.43\ \text{k}\Omega + 8\ \text{k}\Omega} = 1.78\ \text{mA}$$

$$V'_{R_3} = -IR_3 = -(1.78\ \text{mA})(4.7\ \text{k}\Omega)$$

$$V'_{R_3} = -8.37\ \text{V}$$

E:



$$V = \frac{5.54\ \text{k}\Omega(18\ \text{V})}{5.54\ \text{k}\Omega + 10\ \text{k}\Omega} = 6.42\ \text{V}$$

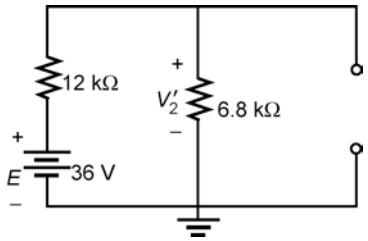
$$V''_{R_3} = \frac{4.7\ \text{k}\Omega(6.42\ \text{V})}{4.7\ \text{k}\Omega + 3.3\ \text{k}\Omega} = 3.77\ \text{V}$$

$$V_{R_3} = V'_{R_3} + V''_{R_3}$$

$$= -8.37\ \text{V} + 3.77\ \text{V}$$

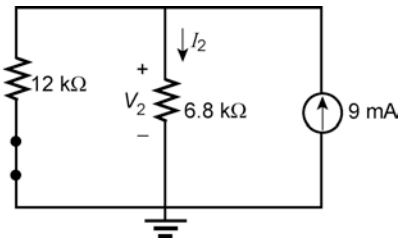
$$= \mathbf{-4.6\ V}$$

6. *E*:



$$V'_2 = \frac{6.8\ \text{k}\Omega(36\ \text{V})}{6.8\ \text{k}\Omega + 12\ \text{k}\Omega} = 13.02\ \text{V}$$

I:

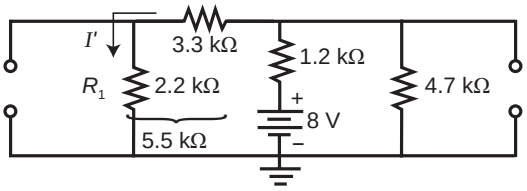


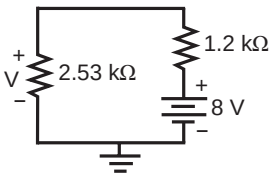
$$I_2 = \frac{12\ \text{k}\Omega(9\ \text{mA})}{12\ \text{k}\Omega + 6.8\ \text{k}\Omega} = 5.75\ \text{mA}$$

$$V''_2 = I_2 R_2 = (5.75\ \text{mA})(6.8\ \text{k}\Omega) = 39.10\ \text{V}$$

$$V_2 = V'_2 + V''_2 = 13.02\ \text{V} + 39.10\ \text{V} = \mathbf{52.12\ V}$$

7. *E*:



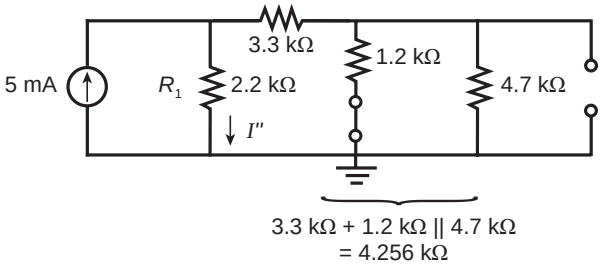


$5.5\ \text{k}\Omega \parallel 4.7\ \text{k}\Omega = 2.53\ \text{k}\Omega$

$$V = \frac{2.53\ \text{k}\Omega(8\ \text{V})}{2.53\ \text{k}\Omega + 1.2\ \text{k}\Omega} = 5.43\ \text{V}$$

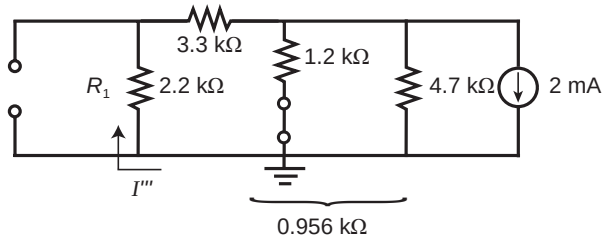
$$I' = \frac{V}{R_1 + R_2} = \frac{5.43\ \text{V}}{5.5\ \text{k}\Omega} = 0.987\ \text{mA}$$

I (5 mA):



$$I'' = \frac{4.256\ \text{k}\Omega(5\ \text{mA})}{4.256\ \text{k}\Omega + 2.2\ \text{k}\Omega} = 3.296\ \text{mA}$$

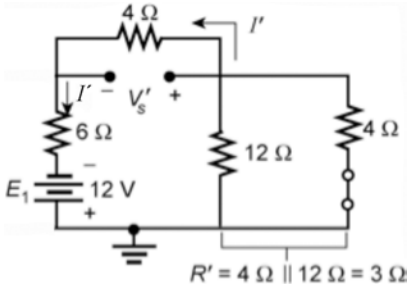
I (2 mA):



$$I''' = \frac{0.956\ \text{k}\Omega(2\ \text{mA})}{0.956\ \text{k}\Omega + 5.5\ \text{k}\Omega} = 0.296\ \text{mA}$$

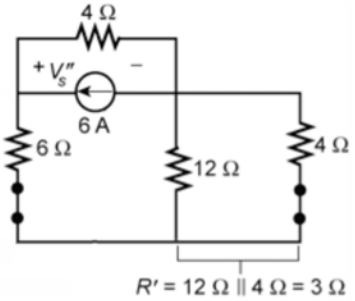
$$I_{R_1} = I' + I'' - I'''$$
$$= 0.987\ \text{mA} + 3.296\ \text{mA} - 0.296\ \text{mA}$$
$$= \mathbf{3.99\ mA\downarrow}$$

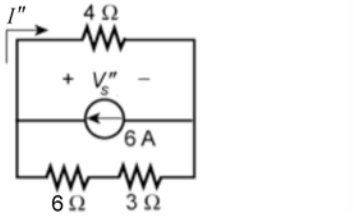
8. E_1:



$$I' = \frac{12\ \text{V}}{12\ \Omega \parallel 4\ \Omega + 4\ \Omega + 6\ \Omega}$$
$$= \frac{12\ \text{V}}{3\ \Omega + 10\ \Omega} = \frac{12\ \text{V}}{13\ \Omega}$$
$$= 923.1\ \text{mA}$$
$$V_s^1 = IR = (923.1\ \text{mA})(4\ \Omega) = 2.492\ \text{V}$$

I:

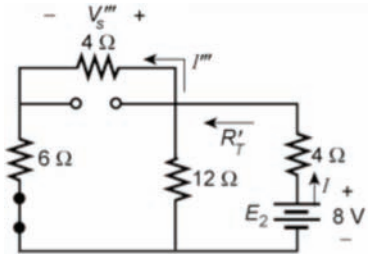




$$I'' = \frac{9\ \Omega(6\ \text{A})}{9\ \Omega + 4\ \Omega} = 4.154\ \text{A}$$

$$V_s'' = I''4\Omega = (4.154\ \text{A})(4\ \Omega) = 16.62\ \text{V}$$

E_2:



$R'_T = 12\ \Omega \parallel (4\ \Omega + 6\ \Omega) = 12\ \Omega \parallel 10\ \Omega = 5.455\ \Omega$

$$I = \frac{E_2}{R_T} = \frac{8\ \text{V}}{4\ \Omega + 5.455\ \Omega} = 0.846\ \text{A}$$

$$I''' = \frac{12\ \Omega(I)}{12\ \Omega + 10\ \Omega} = \frac{12\ \Omega(0.846\ \text{A})}{22\ \Omega} = 0.462\ \text{A}$$

$V_3''' = I'''(4\ \Omega) = 0.462\ \text{A}(4\ \Omega) = 1.848\ \text{V}$

V_s (polarity of V_s'') = $V_s'' - V_s' - V_s'''$

= 16.62 V − 2.492 V − 1.848 V = **12.28 V**

9. a. $R_{Th} = R_3 + R_1 \parallel R_2 = 4\ \Omega + 6\ \Omega \parallel 3\ \Omega = 4\ \Omega + 2\ \Omega =$ **6 Ω**

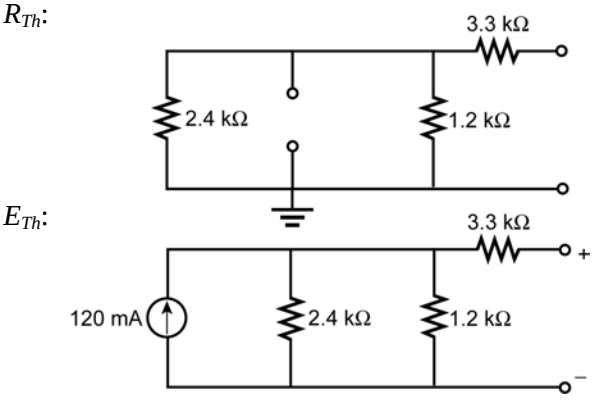
$$E_{Th} = \frac{R_2 E}{R_1 + R_2} = \frac{3\ \Omega(18\ \text{V})}{3\ \Omega + 6\ \Omega} = \textbf{6 V}$$

b. $$I_1 = \frac{E_{Th}}{R_{Th} + R} = \frac{6\ \text{V}}{6\ \Omega + 2\ \Omega} = \textbf{0.75 A}$$

$$I_2 = \frac{6\ \text{V}}{6\ \Omega + 30\ \Omega} = \textbf{166.67 mA}$$

$$I_3 = \frac{6\ \text{V}}{6\ \Omega + 100\ \Omega} = \textbf{56.60 mA}$$

10. a. R_{Th}:



$\leftarrow R_{Th} = 3.3\ \text{k}\Omega + 1.2\ \text{k}\Omega \parallel 2.4\ \text{k}\Omega$

$= 3.3\ \text{k}\Omega + 0.8\ \text{k}\Omega$

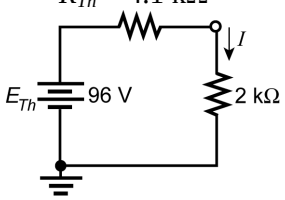
$= \mathbf{4.1\ k\Omega}$

E_{Th}:

$E_{Th} = (120\ \text{mA})(2.4\ \text{k}\Omega \parallel 1.2\ \text{k}\Omega)$

$= \mathbf{96\ V}$

b. $R_{Th} = 4.1\ \text{k}\Omega$



$$I = \frac{96\ \text{V}}{6.1\ \text{k}\Omega} = 15.74\ \text{mA}$$

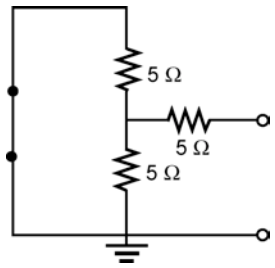
$P = I^2R = (15.74\ \text{mA})^2\ 2\ \text{k}\Omega = \mathbf{0.495\ W}$

$R = 100\ \text{k}\Omega$:

$$I = \frac{96\ \text{V}}{104.1\ \text{k}\Omega} = 0.922\ \text{mA}$$

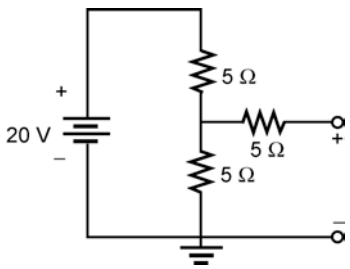
$P = I^2R = (0.922\ \text{mA})^2\ 100\ \ \text{k}\Omega = \mathbf{85\ mW}$

11. a. R_{Th}:



$\leftarrow R_{Th} = 5\ \Omega + 5\ \Omega \parallel 5\ \Omega = \mathbf{7.5\ \Omega}$

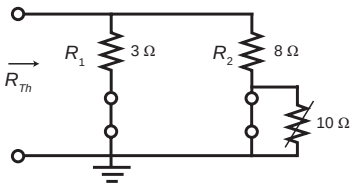
E_{Th}:



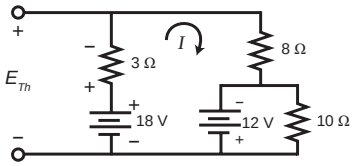
$$E_{Th} = \frac{20\ \text{V}}{2} = \mathbf{10\ V}$$

b. $R = 2\ \Omega$: $P = \left(\dfrac{E_{Th}}{R_{Th} + R}\right)^2 R = \left(\dfrac{10\ \text{V}}{7.5\ \Omega + 2\ \Omega}\right)^2 2\ \Omega = \mathbf{2.22\ W}$

$R = 100\ \Omega$: $P = \left(\dfrac{10\ \text{V}}{7.5\ \Omega + 100\ \Omega}\right)^2 100\ \Omega = \mathbf{0.87\ W}$

12. 

$R_{Th} = 3 \parallel 8\ \Omega = \mathbf{2.18\ \Omega}$

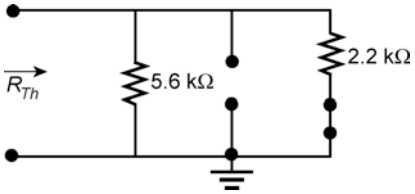


$$I = \frac{18\text{ V} + 12\text{ V}}{3\ \Omega + 8\ \Omega} = \frac{30\text{ V}}{11\ \Omega} = 2.73\text{ A}$$

$V_{3\Omega} = IR_1 = (2.73\text{ A})(3\ \Omega) = 8.19\text{ V}$

$E_{Th} = E_1 - V_{R_1} = 18\text{ V} - 8.19\text{ V} = \mathbf{9.81\ V}$

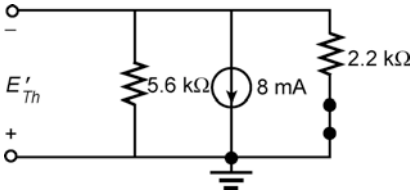
13. R_{Th}:



$R_{Th} = 5.6\ \text{k}\Omega \parallel 2.2\ \text{k}\Omega = \mathbf{1.58\ k\Omega}$

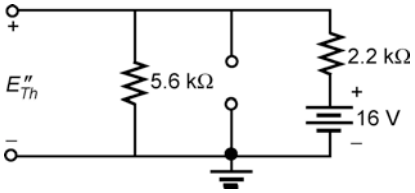
E_{Th}: Superposition:

I:



$$E'_{Th} = IR_T$$
$$= 8\text{ mA}(5.6\ \text{k}\Omega \parallel 2.2\ \text{k}\Omega)$$
$$= 8\text{ mA}(1.579\ \text{k}\Omega)$$
$$= 12.64\text{ V}$$

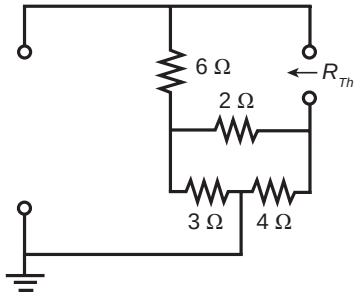
E:



$$E''_{Th} = \frac{5.6\ \text{k}\Omega(16\text{ V})}{5.6\ \text{k}\Omega + 2.2\ \text{k}\Omega}$$
$$= 11.49\text{ V}$$

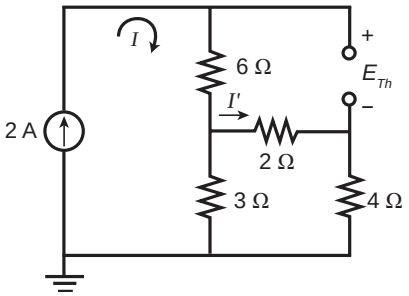
$E_{Th} = 11.49\text{ V} - 12.64\text{ V} = \mathbf{-1.15\ V}$

14. R_{Th}:



$R_{Th} = 6\ \Omega + 2\ \Omega \parallel 7\ \Omega = 6\ \Omega + 1.56\ \Omega = \mathbf{7.56\ \Omega}$

E_{Th}:

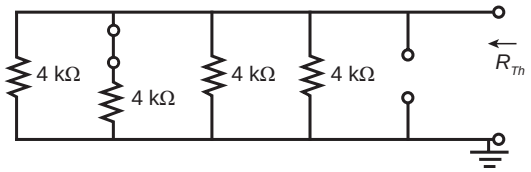


$I = 2\text{ A}$

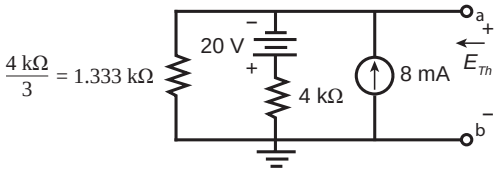
$$I' = \frac{3\ \Omega(2\text{ A})}{3\ \Omega + 6\ \Omega} = 0.667\text{ A}$$

$V_{2\Omega} = I'R = (0.667\text{ A})(2\ \Omega) = 1.333\text{ V}$
$E_{Th} = I6\ \Omega + V_{2\Omega} = (2\text{ A})(6\ \Omega) + 1.333\text{ V}$
$= 12\text{ V} + 1.333\text{ V} = \mathbf{13.33\ V}$

15. a. R_{Th}:

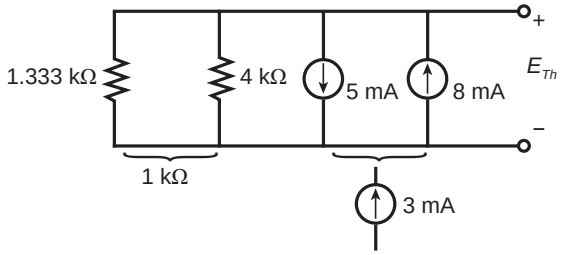


$$R_{Th} = \frac{4\text{ k}\Omega}{4} = \mathbf{1\ k\Omega}$$



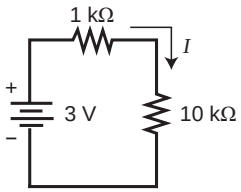
Source conversion:

$$I = \frac{20\text{ V}}{4\text{ k}\Omega} = 5\text{ mA},\ R_p = 4\text{ k}\Omega$$



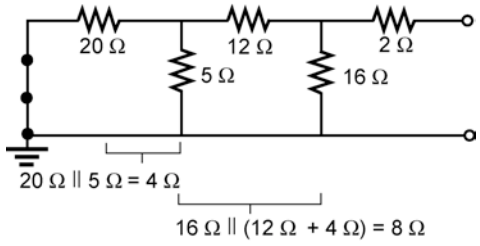
$E_{Th} = I_T R_T = (3\text{ mA})(1\text{ k}\Omega) = \mathbf{3\ V}$

b.



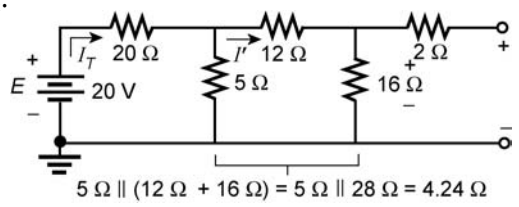
$$I_{10k\Omega} = \frac{3\text{ V}}{1\text{ k}\Omega + 10\text{ k}\Omega} = \frac{3\text{ V}}{11\text{ k}\Omega} = \mathbf{0.273\ mA}$$

16. a. R_{Th}:



$\leftarrow R_{Th} = 2\ \Omega + 8\ \Omega = \mathbf{10\ \Omega}$

E_{Th}:



$E_{Th} = V_{16\Omega}$

$$I_T = \frac{20\text{ V}}{20\ \Omega + 4.24\ \Omega} = 825.08\text{ mA}$$

$$I' = \frac{5\ \Omega(I_T)}{5\ \Omega + 28\ \Omega} = \frac{5\ \Omega(825.08\text{ mA})}{33\ \Omega} = 125.01\text{ mA}$$

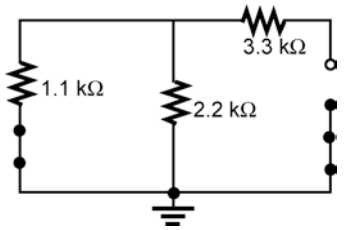
$$E_{Th} = V_{16\Omega} = (I')(16\ \Omega) = (125.01\text{ mA})(16\ \Omega) = \mathbf{2\ V}$$

b. 20 Ω: $I = \dfrac{E_{Th}}{R_{Th} + R} = \dfrac{2\text{ V}}{10\ \Omega + 20\ \Omega} = \dfrac{2\text{ V}}{30\ \Omega} = \mathbf{66.67\ mA}$

50 Ω: $I = \dfrac{2\text{ V}}{10\ \Omega + 50\ \Omega} = \dfrac{2\text{ V}}{60\ \Omega} = \mathbf{33.33\ mA}$

100 Ω: $I = \dfrac{2\text{ V}}{10\ \Omega + 100\ \Omega} = \dfrac{2\text{ V}}{110\ \Omega} = \mathbf{18.18\ mA}$

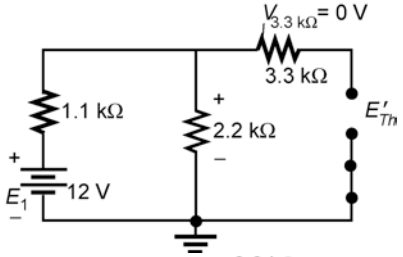
17. a. R_{Th}:



$\leftarrow R_{Th}$ = 3. 3 kΩ + 2.2 kΩ || 1.1 kΩ
= 3.3 kΩ + 0.73 kΩ
= **4.03 kΩ**

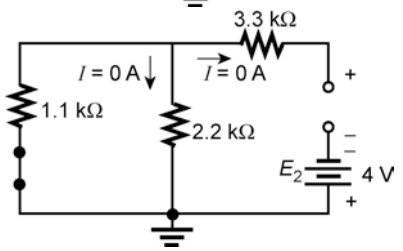
E_{Th}: Superposition:

E_1:



$E'_{Th} = V_{2.2\text{k}\Omega} = \dfrac{2.2\ \text{k}\Omega(12\text{ V})}{2.2\ \text{k}\Omega + 1.1\ \text{k}\Omega}$

$= 8\text{ V}$



$E_{Th}'' = E_2 = 4\text{ V}$

$E_{Th} = E'_{Th} + E''_{Th} = 8\text{ V} + 4\text{ V} = \mathbf{12\ V}$

b.