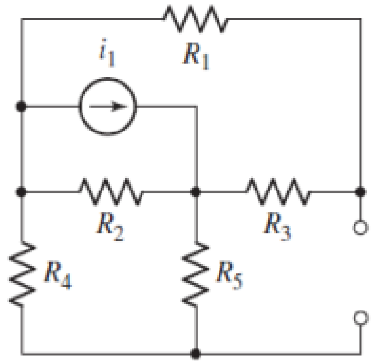
1) (a) Employ Thevenin's theorem to obtain a two-component equivalent for the network shown in Fig. shown below.

(*b*) Determine the power supplied to a 1 MΩ resistor connected to the network if i_1 = 19 μA, $R1$ = $R2$ = 1.6 MΩ, $R2$ = 3 MΩ, and $R4$ = $R5$ = 1.2 MΩ.



31. Select the top of the R_4 resistor as the reference node. v_1 is at the top of R_5, v_2 is at the "+" of v_{oc} and v_3 is at the "-" of v_{oc}. The bottom node is the negative reference of v_{oc}.

Then $$i_1 = \frac{v_1}{R_2} + \frac{v_1 - v_3}{R_5} + \frac{v_1 - v_2}{R_3} \qquad [1]$$

$$0 = \frac{v_2 - v_1}{R_3} + \frac{v_2}{R_1} \qquad [2]$$

$$0 = \frac{v_3 - v_1}{R_5} + \frac{v_3}{R_4} \qquad [3]$$ Solving,

$$v_{th} = v_{oc} = v_2 - v_3 = \boxed{\frac{R_2(R_1R_5 - R_3R_4)i_1}{R_1R_2 + R_1R_4 + R_2R_3 + R_1R_5 + R_2R_4 + R_2R_5 + R_3R_4 + R_3R_5}}$$

Next, short the open terminals and define four clockwise mesh currents i_1, i_2, i_3, and i_4. i_1 is the top mesh, i_3 is the bottom left mesh, i_4 is the bottom right mesh, and i_2 is the remaining mesh. Then

$$-R_2i_2 + (R_2 + R_4 + R_5)i_3 - R_5i_4 = 0 \qquad [1]$$

$$-R_3i_1 - R_5i_3 + (R_3 + R_5)i_4 = 0 \qquad [2]$$

$$-R_2i_3 + R_2i_2 + R_1i_1 + R_3i_1 - R_3i_4 = 0 \qquad [3]$$ and $i_2 - i_1 = i_x$ [4]

Solving, $i_{sc} = i_4 =$

$$\frac{R_2\left(R_1R_5 - R_3R_4\right)}{R_1R_2R_3 + R_1R_2R_5 + R_1R_3R_4 + R_1R_3R_5 + R_2R_3R_4 + R_1R_4R_5 + R_2R_4R_5 + R_3R_4R_5}i_1$$

Then, the ratio of v_{th} and i_{sc} yields R_{th}:

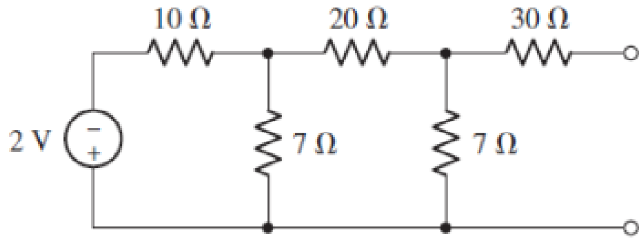
$$\boxed{\frac{R_1R_2R_3 + R_1R_2R_5 + R_1R_3R_4 + R_1R_3R_5 + R_2R_3R_4 + R_1R_4R_5 + R_2R_4R_5 + R_3R_4R_5}{R_1R_2 + R_1R_4 + R_2R_3 + R_1R_5 + R_2R_4 + R_2R_5 + R_3R_4 + R_3R_5}}$$

(b) V_{oc} = –2.2964 V; R_{th} = 1.66 MΩ. Hence $P_{1M\Omega} = \left[\frac{-2.296}{1.66\times10^6 + 10^6}\right]^2\left(10^6\right) \boxed{= 745 \text{ nW}}$

2) (a) Obtain a value for the Thévenin equivalent resistance seen looking into the open terminals of the circuit shown below by first finding V_{OC} and I_{SC}.

(*b*) Connect a 1 A test source to the open terminals of the original circuit after shorting the voltage source, and use this to obtain R_{TH}.

(*c*) Connect a 1 V test source to the open terminals of the original circuit after again zeroing the 2 V source, and use this now to obtain R_{TH}.



35. (a) We select the bottom node as the reference node. The top left node is then –2 V by inspection; the next node is named v_1, the next v_2, and the far right node is v_{oc}.

$$0 = \frac{v_1 + 2}{10} + \frac{v_1}{7} + \frac{v_1 - v_2}{20} \qquad [1]$$

$$0 = \frac{v_2 - v_1}{20} + \frac{v_2}{7} \qquad [2]$$

Solving,

$$v_2 = v_{oc} = -185.3 \text{ mV}$$

Next, we short the output terminals and compute the short circuit current. Naming the three clockwise mesh currents i_1, i_2 and i_{sc}, respectively, beginning at the left,

$$2 + 17i_1 - 7i_2 = 0 \qquad [1]$$

$$-7i_1 + 34i_2 - 7i_{sc} = 0 \qquad [2]$$

$$-7i_2 + 37i_{sc} = 0 \qquad [3]$$

Solving, isc = -5.2295 mA.

Hence

$$R_{TH} = \frac{v_{oc}}{i_{sc}} = \boxed{35.43\ \Omega}$$

(b) Connecting a 1 A source to the dead network, we can simplify by inspection, but performing nodal analysis anyway:

$$0 = \frac{v_1}{10} + \frac{v_1}{7} + \frac{v_1 - v_2}{20} \qquad [1]$$

$$0 = \frac{v_2 - v_1}{20} + \frac{v_2}{7} + \frac{v_2 - v_{test}}{30} \qquad [2]$$

$$1 = \frac{v_{test} - v_2}{30} \qquad [3]$$

Solving, v_{test} = 35.43 V hence R_{TH} = 35.43/1 = $\boxed{35.43\ \Omega}$

(c) Connecting a 1 A source, we can write three mesh equations after defining clockwise mesh currents:

$$0 = 17i_1 - 7i_2 \qquad [1]$$

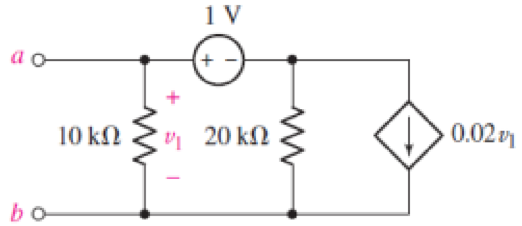
$$0 = -7i_1 + 34i_2 - 7i_3 \qquad [2]$$

$$-1 = -7i_2 + 37i_3 \qquad [3]$$

Solving,

i_3 = –28.23 mA. Thus, R_{TH} = 1/(–i_3) = $\boxed{35.42\ \Omega}$

3.) With regard to the circuit of Fig. 5.82, determine the power dissipated by
(*a*) a 1 kΩ resistor connected between *a* and *b*;
(*b*) a 4.7 kΩ resistor connected between *a* and *b*;
(*c*) a 10.54 kΩ resistor connected between *a* and *b*.



41. We define nodal voltage v_1 at the top left node, and nodal voltage v_2 at the top right node. The bottom node is our reference node. By nodal analysis,

$$-0.02v_1 = \frac{v_1}{10\times10^3} + \frac{v_2}{20\times10^3} \quad [1]$$

and $v_2 - v_1 = 1$ [2]

Solving,

$$v_1 = -2.481 \text{ mV} = v_{oc} = v_{TH}$$

Next, short the 1 V independent source and connect a 1 A source across the open terminals. Define v_{test} across the source with the "+" reference at the arrow head of the source.

Then

$$1 - 0.02v_1 = \frac{v_1}{10\times10^3} + \frac{v_1}{20\times10^3} \quad [1]$$

$$v_1 = v_{test} = 49.63 \text{ V}$$

Hence,

$$R_{TH} = v_{test}/1 = 49.63\ \Omega$$

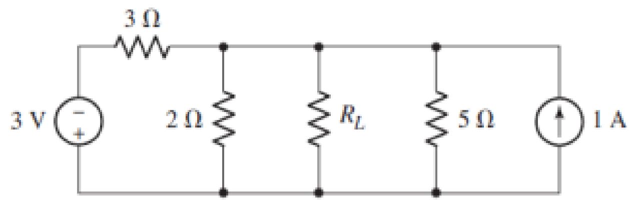
$P_{R_L} = \left(\frac{-2.481\times10^{-3}}{R_L + 49.63}\right)^2 R_L$. Plugging in resistor values,

(a) $\boxed{5.587 \text{ nW}}$

(b) $\boxed{1.282 \text{ nW}}$

(c) $\boxed{578.5 \text{ pW}}$

4) For the circuit of Fig. 5.90, what value of R_L will ensure it absorbs the maximum possible amount of power?

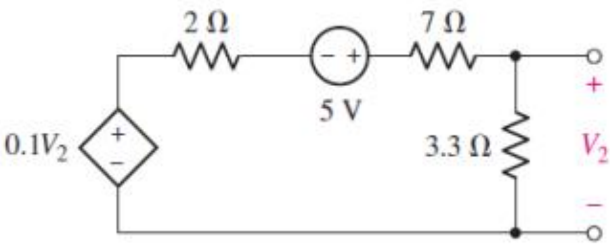


50. We need only R_{TH}. Setting all sources to zero, removing R_L, and looking into the terminals,

$$R_{TH} = 5 \parallel 2 \parallel 3 = 967.7 \text{ m}\Omega$$

$\boxed{\text{Setting } R_L = R_{TH} = 967.7 \text{ m}\Omega \text{ achieves maximum power delivery.}}$

5.) Referring to the circuit of Fig. 5.92,
(*a*) determine the power absorbed by the 3.3 Ω resistor;
(*b*) replace the 3.3 Ω resistor with another resistor such that it absorbs maximum power from the rest of the circuit.



(a) Define clockwise mesh current i. Then

$-0.1v_2 + 2i - 5 + 7i + 3.3i = 0$ where $v_2 = 3.3i$

Hence,

$$-0.1(3.3i) + 12.3i = 5$$

Solving,

$$i = 417.7 \text{ mA} \text{ and so } v_2 = 1.378 \text{ V} = v_{TH}$$

Consequently, $P = (v_2)^2/3.3 = \boxed{575.4 \text{ mW}}$

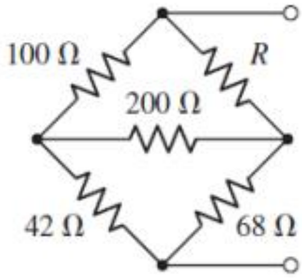
(b) Find R_{TH} by connecting a 1 A source across the open terminals.

$1 = \dfrac{v_2 - 0.1v_2}{9}$. Solving, $v_2 = 10$ V.

Thus, $R_{TH} = v_2/1 = 10\ \Omega$

Hence, replace the 3.3 Ω resistor in the original circuit with 10 Ω.

6. For the network of Fig. 5.98, select a value of *R* such that the network has an equivalent resistance of 70.6 Ω.



$R_A = 42\ \Omega$; $R_B = 200\ \Omega$; $R_C = 68\ \Omega$.
Then $R_1 = 27.10\ \Omega$, $R_2 = 43.87\ \Omega$, and $R_3 = 9.213\ \Omega$

The new network is then $(100 + 27.1) \parallel (R + 43.87) + 9.213 = 70.6\ \Omega$

Solving, $\boxed{R = 74.86\ \Omega}$