CHAPTER 2. Circuit Elements

is a straight line, its slope can be used to calculate the value of resistance:

\[ R = \frac{\Delta v}{\Delta i} = \frac{25 - 0}{0.25 - 0} = \frac{25}{0.25} = 100 \Omega \]

A circuit model having the same \( v - i \) characteristic is a 0.25 A current source in parallel with a 100Ω resistor, as shown below:

![Circuit Diagram](image)

[b] Draw the circuit model from part (a) and attach a 25Ω resistor:

![Circuit Diagram](image)

Note that by writing a KVL equation around the right loop we see that the voltage drop across both resistors is \( v_t \). Write a KCL equation at the top center node, summing the currents leaving the node. Use Ohm's law to specify the currents through the resistors in terms of the voltage drop across the resistors and the value of the resistors.

\[-0.25 + \frac{v_t}{100} + \frac{v_t}{25} = 0, \quad so \quad 5v_t = 25, \quad thus \quad v_t = 5 \text{ V} \]

\[ p_{25} = \frac{v_t^2}{25} = 1 \text{ W}. \]

AP 2.9 First note that we know the current through all elements in the circuit except the 6 kΩ resistor (the current in the three elements to the left of the 6 kΩ resistor is \( i_1 \); the current in the three elements to the right of the 6 kΩ resistor is \( 30i_1 \)). To find the current in the 6 kΩ resistor, write a KCL equation at the top node:

\[ i_1 + 30i_1 = i_{6k} = 31i_1 \]

We can then use Ohm's law to find the voltages across each resistor in terms
of \( i_1 \). The results are shown in the figure below:

\[
\begin{align*}
\text{[a]} & \quad \text{To find } i_1, \text{ write a KVL equation around the left-hand loop, summing voltages in a clockwise direction starting below the 5V source:} \\
& \quad -5 \, V + 54,000i_1 - 1 \, V + 186,000i_1 = 0 \\
& \quad \text{Solving for } i_1 \\
& \quad 54,000i_1 + 186,000i_1 = 6 \, V \quad \text{so} \quad 240,000i_1 = 6 \, V \\
& \quad \text{Thus,} \\
& \quad i_1 = \frac{6}{240,000} = 25 \, \mu\text{A} \\
\text{[b]} & \quad \text{Now that we have the value of } i_1, \text{ we can calculate the voltage for each component except the dependent source. Then we can write a KVL equation for the right-hand loop to find the voltage } v \text{ of the dependent source. Sum the voltages in the clockwise direction, starting to the left of the dependent source:} \\
& \quad +v - 54,000i_1 + 8 \, V - 186,000i_1 = 0 \\
& \quad \text{Thus,} \\
& \quad v = 240,000i_1 - 8 \, V = 240,000(25 \times 10^{-6}) - 8 \, V = 6 \, V - 8 \, V = -2 \, V \\
& \quad \text{We now know the values of voltage and current for every circuit element.}
\end{align*}
\]
Let’s construct a power table:

<table>
<thead>
<tr>
<th>Element</th>
<th>Current ($\mu$A)</th>
<th>Voltage (V)</th>
<th>Power Equation</th>
<th>Power ($\mu$W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 V</td>
<td>25</td>
<td>5</td>
<td>$p = -vi$</td>
<td>-125</td>
</tr>
<tr>
<td>54 kΩ</td>
<td>25</td>
<td>1.35</td>
<td>$p = Ri^2$</td>
<td>33.75</td>
</tr>
<tr>
<td>1 V</td>
<td>25</td>
<td>1</td>
<td>$p = -vi$</td>
<td>-25</td>
</tr>
<tr>
<td>6 kΩ</td>
<td>775</td>
<td>4.65</td>
<td>$p = Ri^2$</td>
<td>3603.75</td>
</tr>
<tr>
<td>Dep. source</td>
<td>750</td>
<td>-2</td>
<td>$p = -vi$</td>
<td>1500</td>
</tr>
<tr>
<td>1.8 kΩ</td>
<td>750</td>
<td>1.35</td>
<td>$p = Ri^2$</td>
<td>1012.5</td>
</tr>
<tr>
<td>8 V</td>
<td>750</td>
<td>8</td>
<td>$p = -vi$</td>
<td>-6000</td>
</tr>
</tbody>
</table>

[c] The total power generated in the circuit is the sum of the negative power values in the power table:

$$-125 \, \mu W + -25 \, \mu W + -6000 \, \mu W = -6150 \, \mu W$$

Thus, the total power generated in the circuit is 6150 $\mu$W.

[d] The total power absorbed in the circuit is the sum of the positive power values in the power table:

$$33.75 \, \mu W + 3603.75 \, \mu W + 1500 \, \mu W + 1012.5 \, \mu W = 6150 \, \mu W$$

Thus, the total power absorbed in the circuit is 6150 $\mu$W.

AP 2.10 Given that $i_\phi = 2$ A, we know the current in the dependent source is $2i_\phi = 4$ A. We can write a KCL equation at the left node to find the current in the 10 $\Omega$ resistor. Summing the currents leaving the node,

$$-5 \, A + 2 \, A + 4 \, A + i_{10\Omega} = 0 \quad \text{so} \quad i_{10\Omega} = 5 \, A - 2 \, A - 4 \, A = -1 \, A$$

Thus, the current in the 10 $\Omega$ resistor is 1 A, flowing right to left, as seen in the circuit below.

![Circuit Diagram](image-url)
[a] To find \(v_s\), write a KVL equation, summing the voltages counter-clockwise around the lower right loop. Start below the voltage source.

\[-v_s + (1 \text{ A})(10 \Omega) + (2 \text{ A})(30 \Omega) = 0 \quad \text{so} \quad v_s = 10 \text{ V} + 60 \text{ V} = 70 \text{ V}\]

[b] The current in the voltage source can be found by writing a KCL equation at the right-hand node. Sum the currents leaving the node

\[-4 \text{ A} + 1 \text{ A} + i_v = 0 \quad \text{so} \quad i_v = 4 \text{ A} - 1 \text{ A} = 3 \text{ A}\]

The current in the voltage source is 3 A, flowing top to bottom. The power associated with this source is

\[p = vi = (70 \text{ V})(3 \text{ A}) = 210 \text{ W}\]

Thus, 210 W are absorbed by the voltage source.

[c] The voltage drop across the independent current source can be found by writing a KVL equation around the left loop in a clockwise direction:

\[-v_{5A} + (2 \text{ A})(30 \Omega) = 0 \quad \text{so} \quad v_{5A} = 60 \text{ V}\]

The power associated with this source is

\[p = -v_{5A}i = -(60 \text{ V})(5 \text{ A}) = -300 \text{ W}\]

This source thus delivers 300 W of power to the circuit.

[d] The voltage across the controlled current source can be found by writing a KVL equation around the upper right loop in a clockwise direction:

\[+v_{4A} + (10 \Omega)(1 \text{ A}) = 0 \quad \text{so} \quad v_{4A} = -10 \text{ V}\]

The power associated with this source is

\[p = v_{4A}i = (-10 \text{ V})(4 \text{ A}) = -40 \text{ W}\]

This source thus delivers 40 W of power to the circuit.

[e] The total power dissipated by the resistors is given by

\[(i_{30\Omega})^2(30 \Omega) + (i_{10\Omega})^2(10 \Omega) = (2)^2(30 \Omega) + (1)^2(10 \Omega) = 120 + 10 = 130 \text{ W}\]