Lecture 12

Source Transformation

Source Transformation

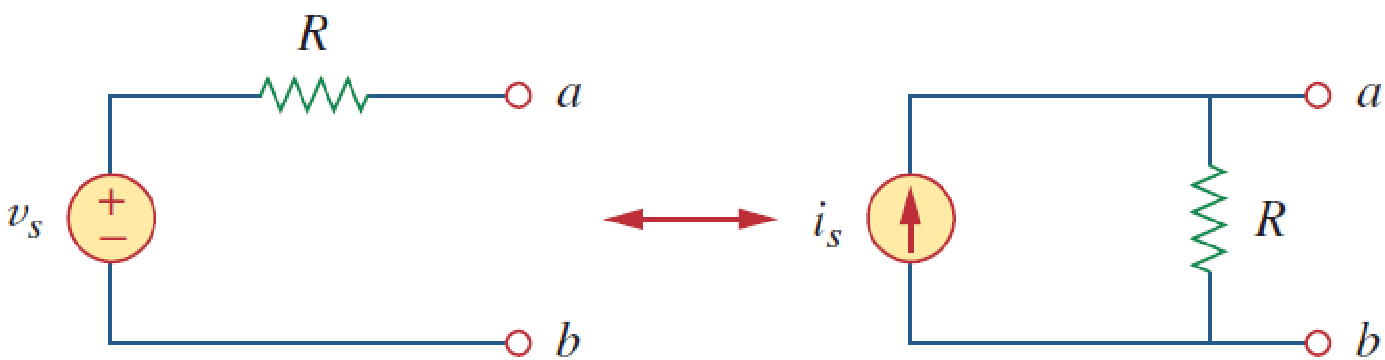
Basis for Thevenin and Norton Equivalent Circuits

Source Transformation

- We have noticed that series-parallel combination and wye-delta transformation help simplify circuits.
- Source transformation is another tool for simplifying circuits.
- Basic to these tools is the concept of equivalence.
  - an equivalent circuit is one whose *v*-*i* characteristics are identical with the original circuit.

Source Transformation

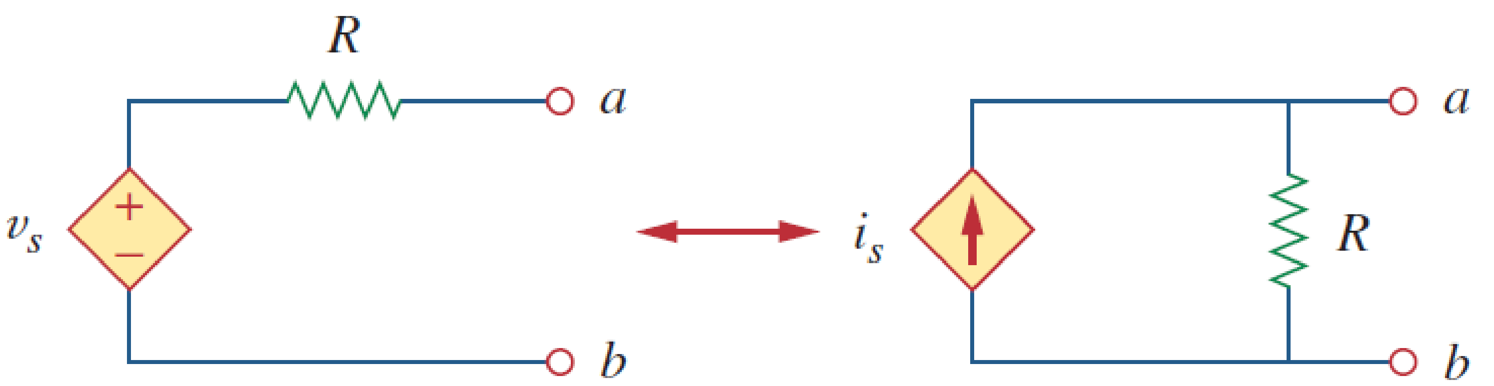
- A source transformation is the process of replacing a voltage source v_s in series with a resistor R by a current source i_s in parallel with a resistor R, or vice versa.



$$v_s = i_s R \qquad \text{or} \qquad i_s = \frac{v_s}{R}$$

Source Transformation

- Source transformation also applies to dependent sources, provided we carefully handle the dependent variable.
  - A dependent voltage source in series with a resistor can be transformed to a dependent current source in parallel with the resistor or vice versa.



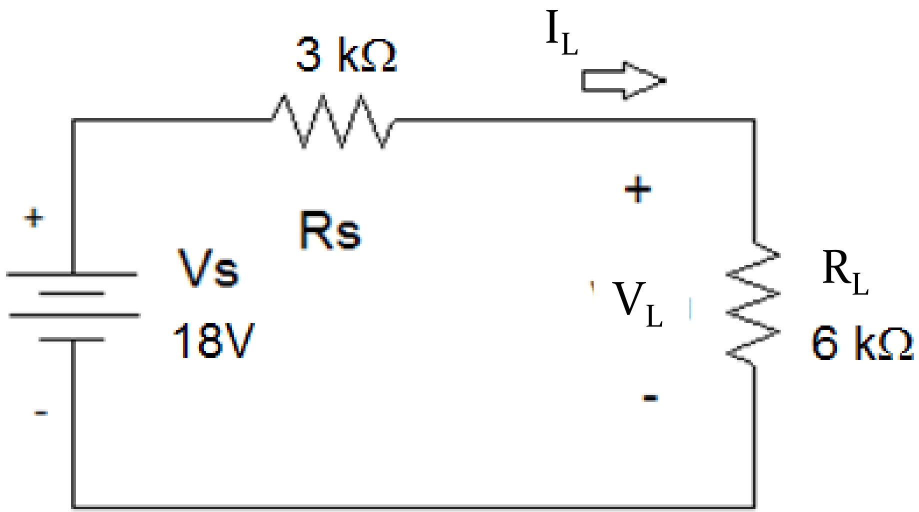
$$v_s = i_s R \qquad \text{or} \qquad i_s = \frac{v_s}{R}$$

Equivalence

- An equivalent circuit is one in which the *i*-*v* characteristics are identical to that of the original circuit.
  - The magnitude and sign of the voltage and current at a particular measurement point are the same in the two circuits.

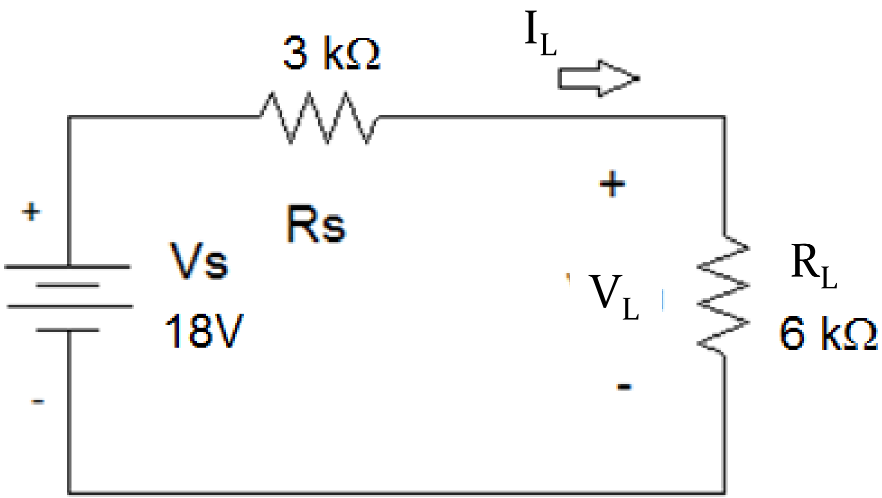
Example 1…

- Find an equivalent current source to replace Vs and Rs in the circuit below.



…Example 1…

- Find I_L and V_L.



$$V_L = \frac{R_L}{R_L + R_S} V_S$$

$$V_L = \frac{6k\Omega}{6k\Omega + 3k\Omega} 18V = 12V$$

$$I_L = V_L / R_L$$

$$I_L = 12V / 6k\Omega = 2mA$$

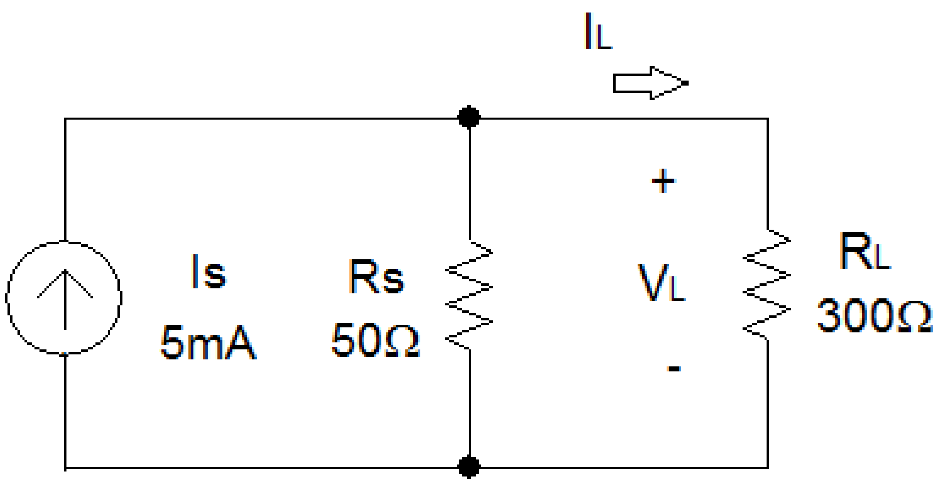
$$P_{Vs} = P_L + P_{Rs}$$

$$P_{Vs} = 12V(2mA) + (18V - 12V)(2mA)$$

$$P_{Vs} = 36mW$$

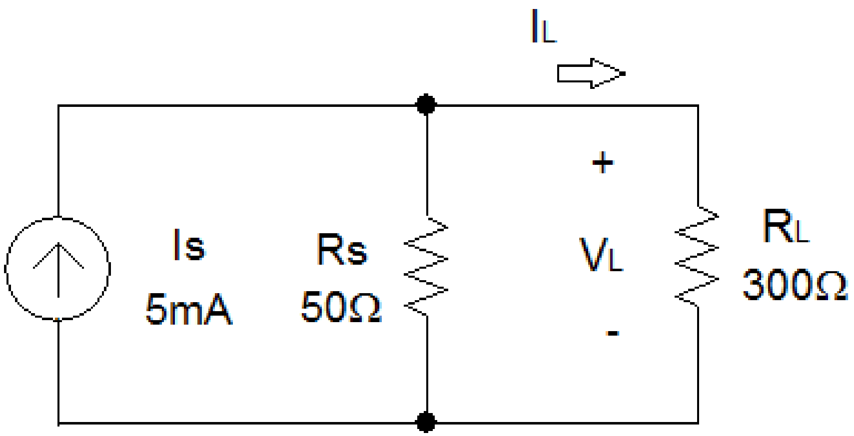
Example 2…

- Find an equivalent voltage source to replace Is and Rs in the circuit below.



…Example 2…

- Find I_L and V_L.



$$I_L = \frac{50\Omega}{300\Omega + 50\Omega} I_S$$

$$I_L = 0.714mA$$

$$V_L = I_L R_L$$

$$V_L = 0.714mA(300\Omega) = 0.214V$$

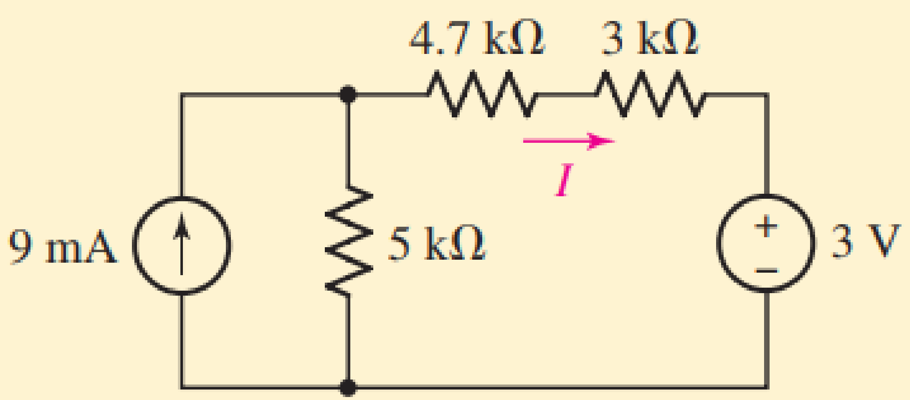
$$P_{Vs} = P_L + P_{Rs}$$

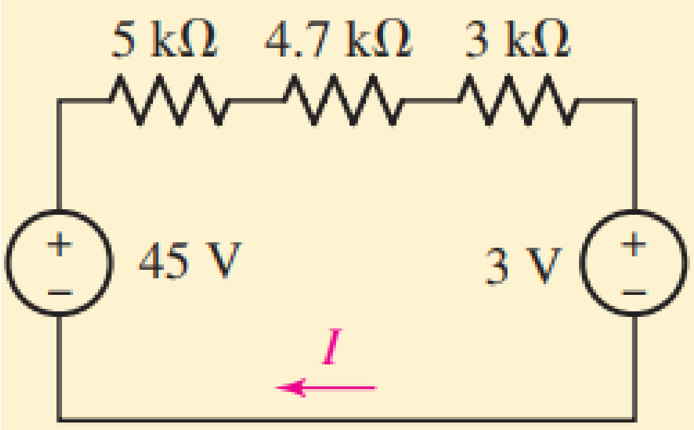
$$P_{Vs} = 0.214V(0.714mA) + 0.214V(5mA - 0.714mA)$$

$$P_{Vs} = 1.07mW$$

Example 3

Compute the current through the 4.7 kΩ resistor in Fig. 5.17*a* after transforming the 9 mA source into an equivalent voltage source.

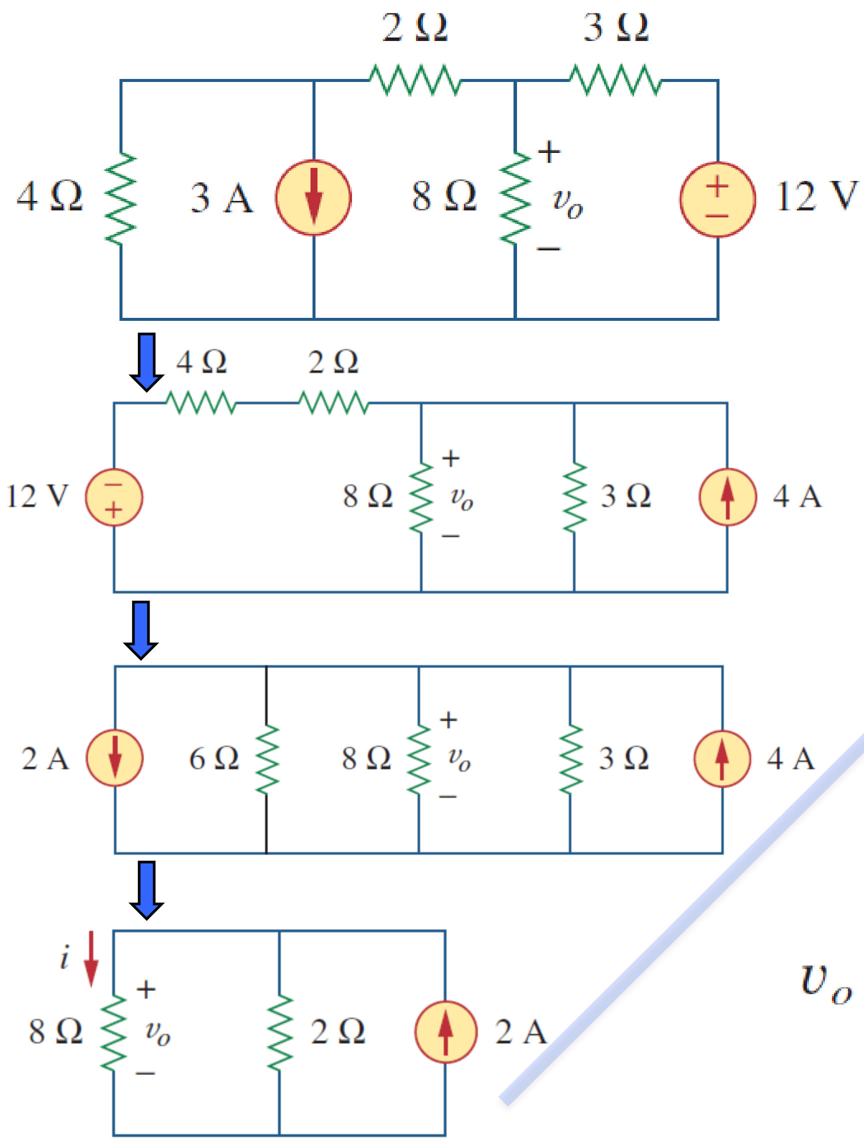




$$-45 + 5000I + 4700I + 3000I + 3 = 0$$

which is easily solved to yield $I = 3.307$ mA.

Example 4



- Use source transformation to find v_0 in the circuit.
  - Use current division

$$i = \frac{2}{2+8}(2) = 0.4 \text{ A}$$

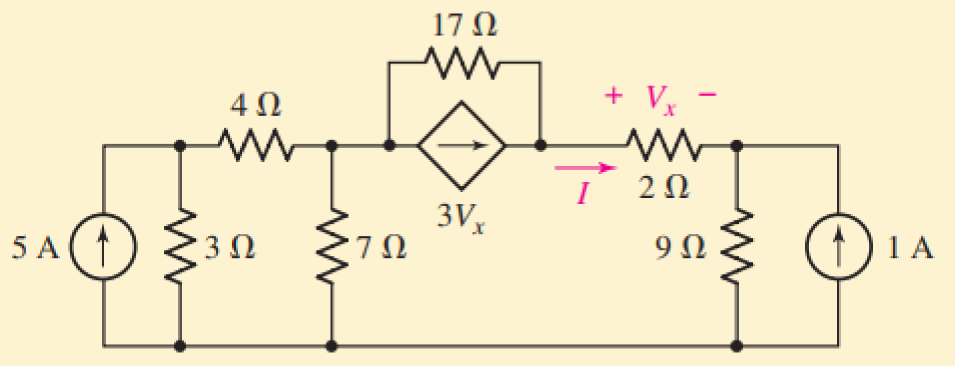
$$v_o = 8i = 8(0.4) = 3.2 \text{ V}$$

  - or

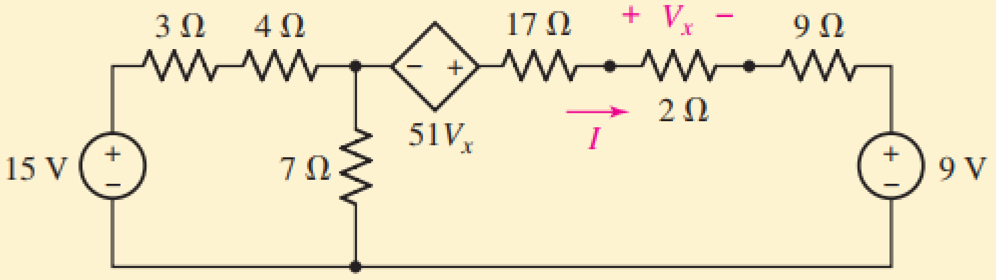
$$v_o = (8 \parallel 2)(2 \text{ A}) = \frac{8 \times 2}{10}(2) = 3.2 \text{ V}$$

Example 5

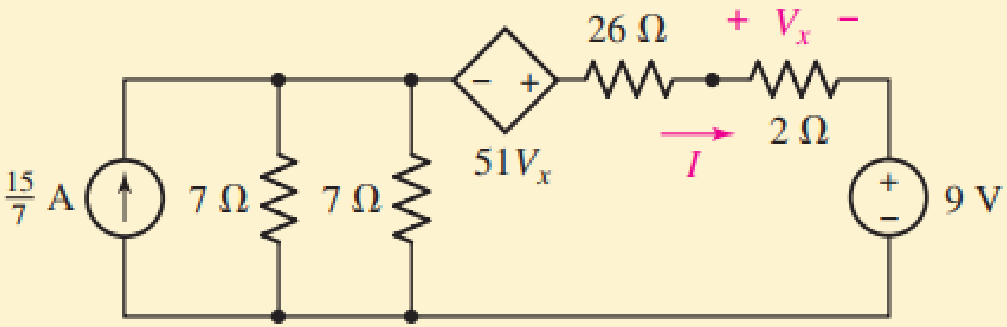
Calculate the current through the 2 Ω resistor in Fig. 5.19*a* by making use of source transformations to first simplify the circuit.



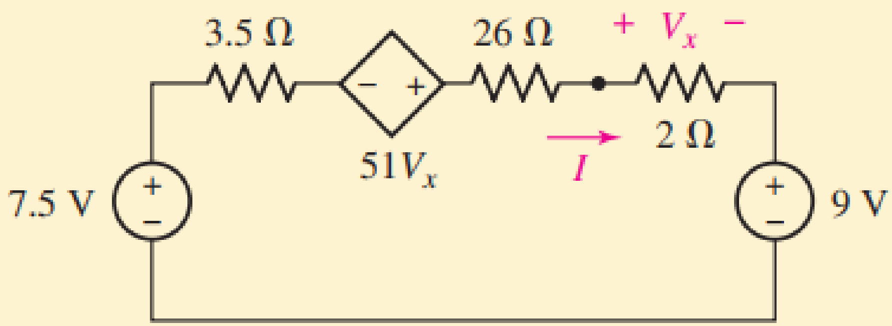
(*a*)



(*b*)



(c)



(d)

The current I can now be found using KVL:

$$-7.5 + 3.5I - 51V_x + 28I + 9 = 0$$

where

$$V_x = 2I$$

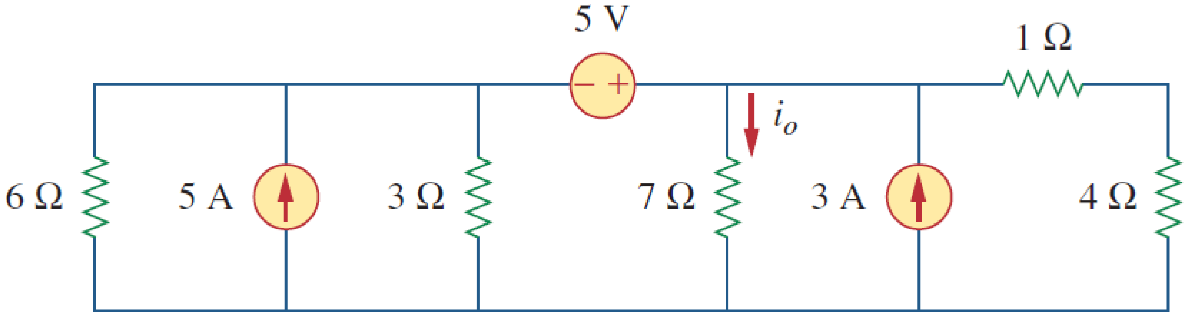
Thus,

$$I = 21.28 \text{ mA}$$

Example 6

- Use source transformation to find i_0 in the circuit.

Answer: 1.78 A.



Thank You