Lect # 3

Note Title 10/26/2008

Next:

- Kirchhoff's Current Law
- Kirchhoff's Voltage Law
- Examples

Objectives:

- Be able to state Ohm's Law, Kirchhoff's Current Law, Kirchhoff's Voltage Law, and be able to use those Laws to analyze sample circuits
- Know how to calculate power for each element in a sample circuit and be able to determine (check) whether or not power balances for the whole circuit.

Kirchhoff's Law

- Kirchhoff's Current Law (KCL)

  The algebraic sum of all the currents at any node in a circuit equals zero.

- Kirchhoff's Voltage Law (KVL)

  The algebraic sum of all the voltages around any closed path in a circuit equals zero.

Gustav Kirchhoff - 1848

- To use KCL - algebraic sign corresponding to a reference direction must be assigned to every current at a node

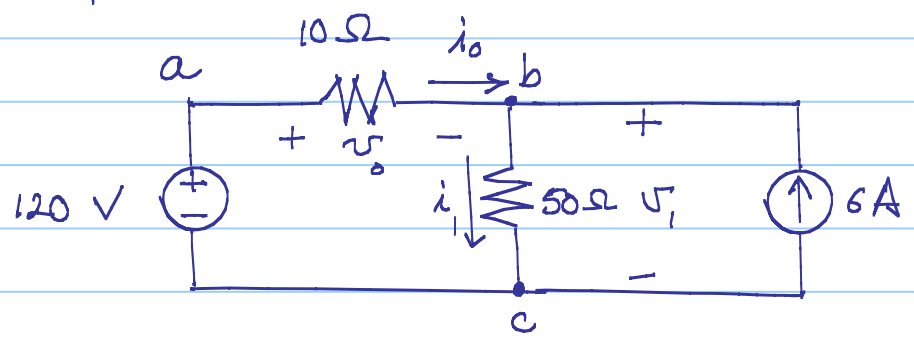
  + sign (− sign) to current leaving a node requires
  − sign (+ sign) to current entering a node

- To use KVL - algebraic sign corresponding to a reference direction must be assign to each voltage in a loop.

  As we trace a closed path a voltage will appear either as a raise or a drop in the tracing direction.

  + sign (− sign) to a voltage rise requires − sign (+ sign) to a voltage drop.

Example:



$i_o = ?$

At node b (assigning + to outgoing currents)

1) $+i_1 - i_o - 6 = 0$ KCL

Clockwise around the first loop
(assign + to voltage drops)

$$-120 + v_o + v_1 = 0 \qquad \text{KVL}$$

2) $$-120 + 10 i_o + 50 i_1 = 0 \qquad \text{Ohm's Law}$$

$$\begin{array}{lrcl} 10 \times 1) & 10 i_1 - 10 i_o & = & 60 \\ 2) & 50 i_1 + 10 i_o & = & 120 \\ \hline + & 60 i_1 & = & 180 \end{array}$$

$$i_1 = 3 \text{ Amp}$$

From 1) $$i_o = -3 \text{ Amp}$$

$$v_o = 10 i_o = -30 \text{ Volts}$$
$$v_1 = 50 i_1 = 150 \text{ Volts}$$

Check: Total power generated
= total power dissipated ?

power dissipated in the resistors:

$$P_{50\Omega} = i_1^2\, 50 = 3^2 \cdot 50 = 450 \text{ Watts}$$

$$P_{10\Omega} = i_3^2\, 10 = (-3)^2 \cdot 10 = 90 \text{ Watts}$$

power delivered to the voltage source

$$P_{120V} = -120\, i_3 = -120\,(-3) = 360 \text{ Watts}$$

power delivered to the current source

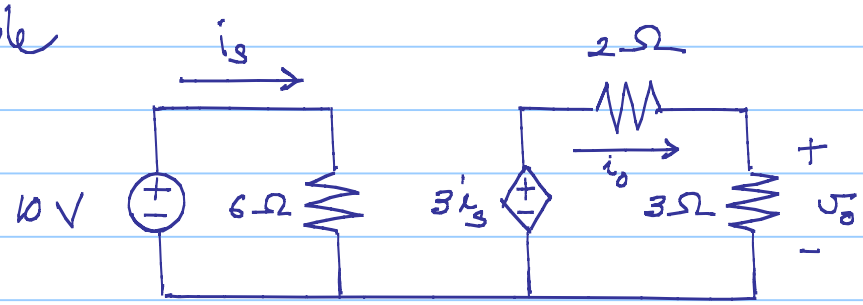
$$P_{6A} = -v_1 \cdot 6 = -150 \cdot 6 = -900 \text{ Watts}$$

In summary:

The 6A current source is delivering 900 Watts
120 V voltage source is absorbing 360 Watts

total power absorbed is $360 + 450 + 90 = 900$ Watts

Example



Left Loop

1) $i_s 6 = 10$ (Ohm's Law)

Right Loop

2) $-3i_s + 2i_o + 3i_o = 0$

1) $\Rightarrow$ $i_s = \frac{5}{3}$ Amp

2) $\Rightarrow$ $i_o = 1$ Amp

$v_o = i_o 3 = 3$ Volts.

power delivered to independent voltage source

$$P_{10V} = -v\, i_s = -10\ \frac{5}{3} = -\frac{50}{3} \text{ Watts}$$

power delivered to dependent voltage source

$$P_3 = -(3 i_s)\, i_o = -(5)\, 1 = -5 \text{ Watts}$$

power delivered to the resistors

$$P_{6\Omega} = i_s^2\, 6 = \left(\frac{5}{3}\right)^2 6 = \frac{50}{3} \text{ Watts.}$$

$$P_{2\Omega} = i_o^2\, 2 = 1^2\, 2 = 2 \text{ Watts.}$$

$$P_{3\Omega} = i_o^2\, 3 = 1^2\, 3 = 3 \text{ Watts}$$

Total power delivered by the sources $= \frac{50}{3} + 5$ Watts

" " absorbed by (dissipated) by the resistors $= \frac{50}{3} + 5$ Watts