Electric Circuits
Lecture 2 Resistive Circuits

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Lecture Outline

- Review
- Chapter 3 in the textbook
  - Kirchoff’s laws (KCL, KVL)
  - Voltage and current dividers
  - Series and parallel simplification
  - Circuit analysis examples

Review

1) current $i = \frac{dq}{dt}$ (A)

2) voltage, $v = \frac{dw}{dq}$ (V)

3) Power, $p = v \cdot i$ (W)

Energy, $w = \int p \, dt$ (J)

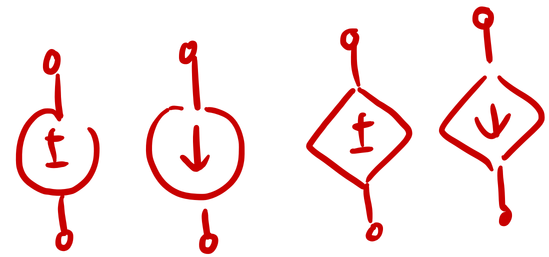
4) Linearity: superposition, homogeneity,

5) Active vs. passive (R, L, C)

6) Resistors, $R = \rho \cdot \frac{L}{A}$ (Ω)

7) Independent Sources

Dependent



Example 1 –
Terminal Variables and Power into a Resistor

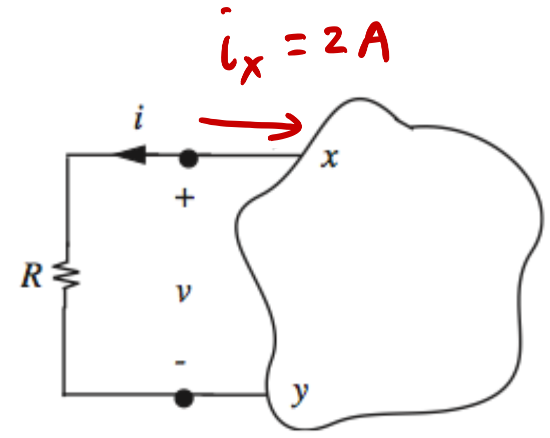
- A resistor (10 Ohms) is connected to an arbitrary circuit at points x and y. Assume the current flowing into the network at node x is 2 A. Find i, v, p.

$i = -2A$

$v = i \cdot R = (-2) \cdot 10 = -20V$

$p = v \cdot i = (-20) \cdot (-2) = 40W \quad > 0$

passive



Example 2 – Power Supplied by a Battery

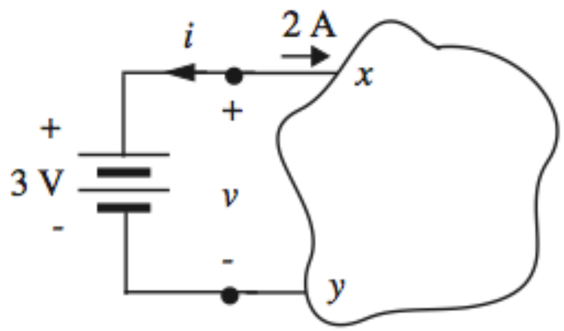
- The same example but replaced with a 3-V battery.

$i = -2\text{ A}$

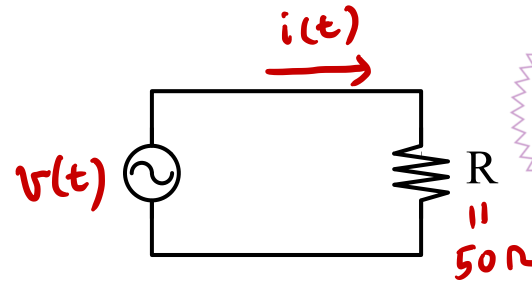
$v = 3\text{ V}$

$p = 3 \cdot (-2) = -6\text{ W}$

Active



Example 3 – AC (alternating current) Power

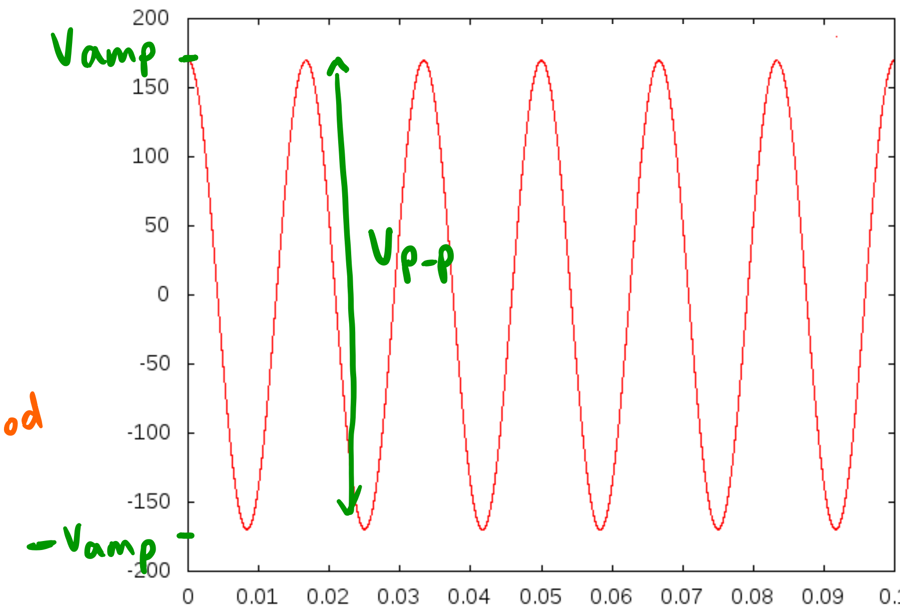


- 110-V 60-Hz AC voltage

$V_{rms} = 110$ V

$V_{amp} = \sqrt{2} \cdot 110$ V

$V_{p-p} = 2 \cdot \sqrt{2} \cdot 110$ V
(peak-to-peak)



$v(t) = \sqrt{2} \cdot 110 \cdot \sin(2\pi \cdot 60 t)$ V

Frequency = 60 Hz

Period = 1/60 s

* What is the period of p(t)?

$i(t) = \frac{v(t)}{50} = \frac{\sqrt{2} \cdot 110}{50} \sin(2\pi \cdot 60 t)$ A, $p(t) = v(t) \cdot i(t) = \frac{110^2}{50}\left[1 - \cos(2\pi \cdot 120 t)\right]$ W,

- What would be the power dissipated by the resistor if the voltage was a constant value of 110 V?

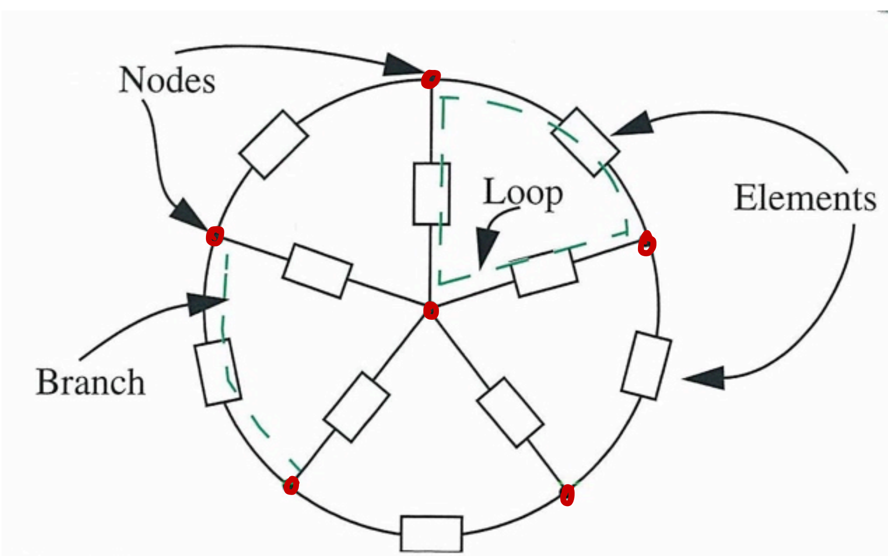
$P = 110 \cdot \frac{110}{50} = \frac{110^2}{50}$ W

Chapter 3 Resistive Circuits

Terminology

Component

- Element is accessed through its terminals.
- Node: the junction point where the terminals of two or more elements are connected.
- Branch: the connection between nodes.
- Loop: a closed path through a circuit along its branches.



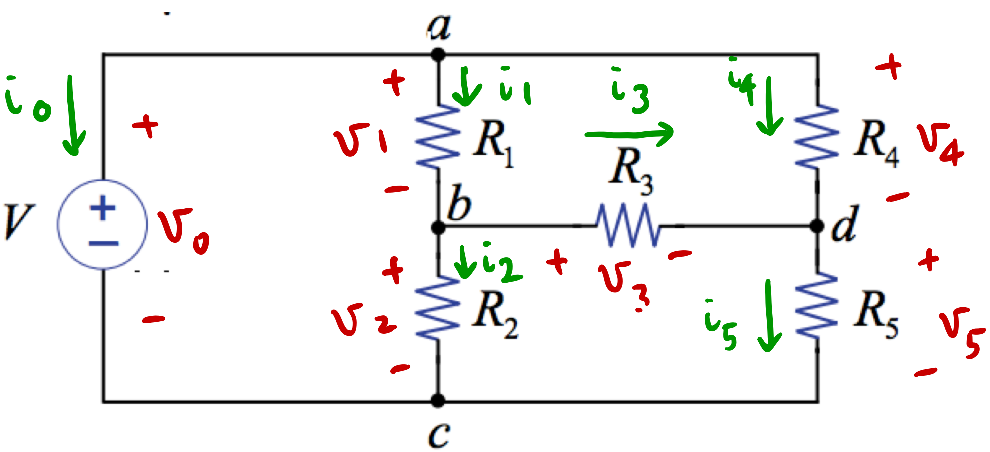
Kirchhoff’s Law

- Kirchhoff’s Law: from conservation of charge and conversation of energy.
  - Kirchhoff’s current law (KCL): the algebraic sum of the current into a node at any instant is zero.
  - Kirchhoff’s voltage law (KVL): the algebraic sum of the voltage around any loop in a circuit is zero at all time.

Basic KVL/KCL Method of Circuit Analysis

- Analyzing a circuit means to find out all the element v's and i's.

  ∘ 6 elements, 12 unknowns (v, i)

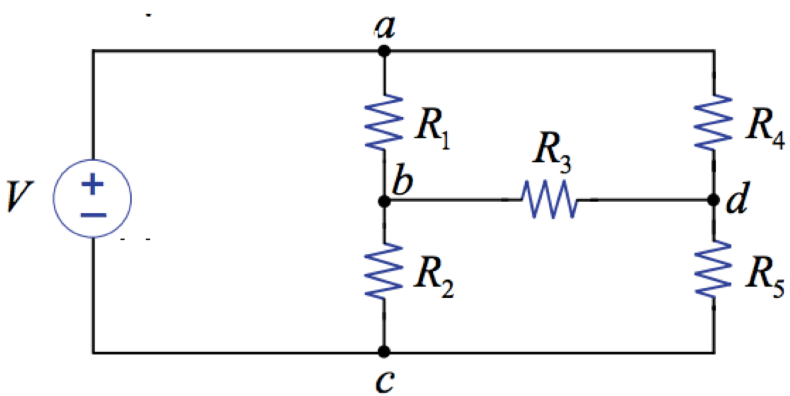


1. Label all elements' v's and i's.
2. Write element v-i relationship.
3. Write KCL for all nodes.
4. Write KVL for all loops.

- Basically lay out all equations…

Basic KVL/KCL Method of Circuit Analysis

- Goal: find out all element v's and i's (12 unknowns).
- Step 2: Write v-i relation for all elements.



$v_0 = V$

$v_1 = i_1 \cdot R_1$

$v_2 = i_2 \cdot R_2$

$v_3 = i_3 \cdot R_3$

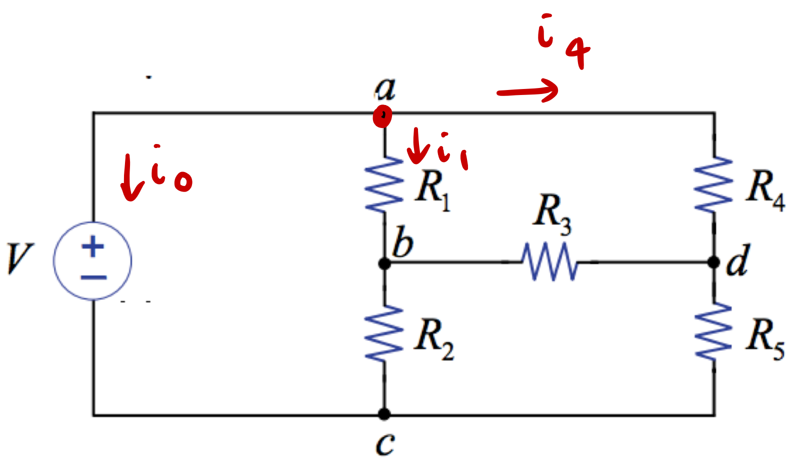
$v_4 = i_4 \cdot R_4$

$v_5 = i_5 \cdot R_5$

6 independent equations

Basic KVL/KCL Method of Circuit Analysis

- Goal: find out all element v's and i's (12 unknowns).
- Step 3: Apply KCL at the nodes.



node a: $-i_0 - i_1 - i_4 = 0$

node b: $i_1 - i_2 - i_3 = 0$

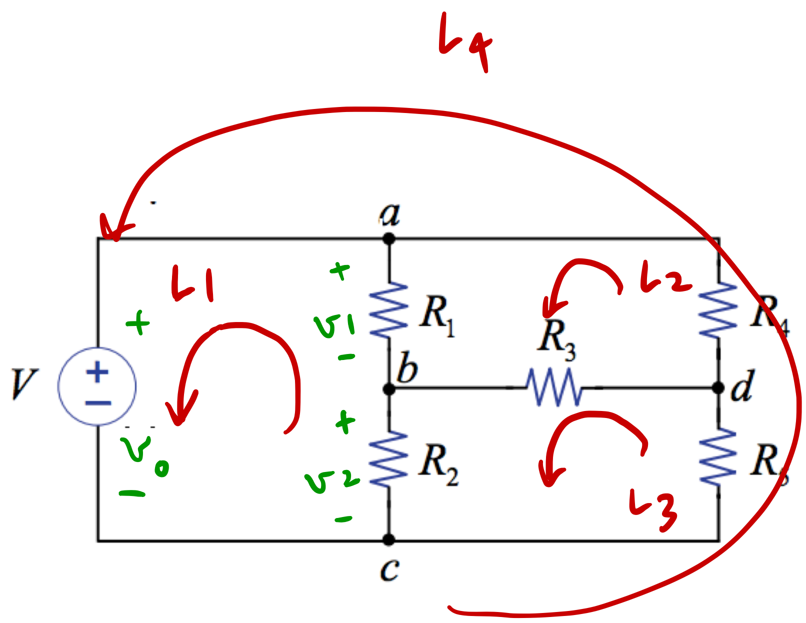
node c: $i_0 + i_2 + i_5 = 0$

node d: $i_3 + i_4 - i_5 = 0$

3 independent equations

Basic KVL/KCL Method of Circuit Analysis

- Goal: find out all element v's and i's (12 unknowns).
- Step 4: Apply KVL for the loops



L_1: $v_1 + v_2 - v_0 = 0$

L_2: $v_4 - v_3 - v_1 = 0$

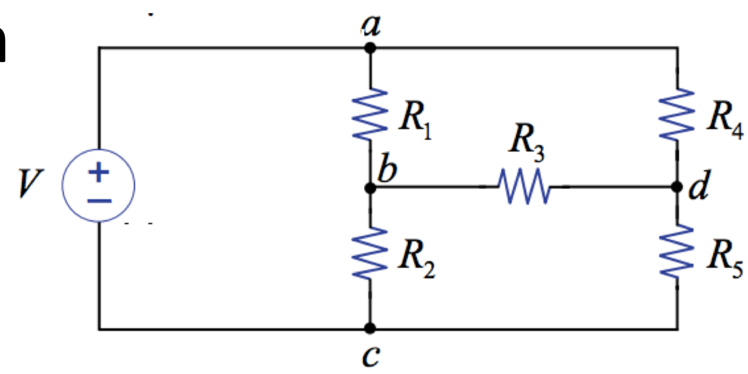
L_3: $v_5 - v_2 + v_3 = 0$

L_4: $v_4 + v_5 - v_0 = 0$

3 independent equations

Basic KVL/KCL Method of Circuit Analysis

- 12 equations for 12 unknown
  - 1. Element *v*-*i* relationships



$$v_0 = V_0 \qquad v_3 = i_3 \cdot R_3$$
$$v_1 = i_1 \cdot R_1 \qquad v_4 = i_4 \cdot R_4$$
$$v_2 = i_2 \cdot R_2 \qquad v_5 = i_5 \cdot R_5$$

  - 2. KCL at the nodes

$$a: \quad i_0 + i_1 + i_4 = 0$$
$$b: \quad i_2 + i_3 - i_1 = 0$$
$$c: \quad i_5 - i_3 - i_4 = 0$$
$$(d: \quad -i_0 - i_2 - i_5 = 0)$$

3. KVL for the loops

$$L1: \quad -v_0 + v_1 + v_2 = 0$$
$$L2: \quad v_1 + v_3 - v_4 = 0$$
$$L3: \quad v_3 + v_5 - v_2 = 0$$
$$(L4: \quad -v_0 + v_4 + v_5 = 0)$$