ELECP01

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Notes Repository

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1 Basic Concepts

Current is the rate of change of charge over time.

$$i = \frac{\mathrm{d}q}{\mathrm{d}t}$$

$$Q = \int_{t_0}^{t_1} i \, \mathrm{d}t$$

Voltage is the difference of electric potential between two points.

$$v = \frac{\mathrm{d}w}{\mathrm{d}q}$$

$$p = \frac{\mathrm{d}w}{\mathrm{d}t}$$

$$p = \frac{\mathrm{d}w}{\mathrm{d}t} = \frac{\mathrm{d}w}{\mathrm{d}q} \frac{\mathrm{d}q}{\mathrm{d}t} = vi$$

$$w = \int_{t_0}^{t_1} p \, \mathrm{d}t = \int_{t_0}^{t_1} vi \, \mathrm{d}t$$

2 Basic Laws

Resistance

$$R = \rho \frac{\updownarrow}{A}$$

ρ is known as the resistivity of the material.

$$v \propto i$$
$$v = iR$$
$$R = \frac{v}{i}$$
$$1\Omega = 1\frac{V}{A}$$

A short circuit is a circuit element with resistance approaching zero. An open circuit is a circuit element with resistance approaching infinity.

Conductance

$$G = \frac{1}{R} = \frac{i}{v}$$

A branch represents a single element such as a voltage source or a resistor. A node is the point of connection between two or more branches.

A loop is any closed path in a circuit.

Two or more elements are in series if they exclusively share a single node and consequently carry the same current.

Two or more elements are in parallel if they are connected to the same two nodes and consequently have the same voltage across them.

Kirchhoff's current law states that the algebraic sum of currents entering a node is zero.

$$\sum_{n=1}^{N} i_n = 0$$

Kirchhoff's voltage law states that the algebraic sum of all voltages around a closed path is zero.

$$\sum_{n=1}^{N} v_n = 0$$

The equivalent resistance of any number of resistors connected in series is the sum of individual resistances.

The equivalent conductance of resistors connected in parallel is the sum of their individual conductances.

Wye-Delta transformations

Delta to Wye conversion

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$
$$R_2 = \frac{R_a R_c}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

Wye to Delta conversion

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_1 R_3}{R_1}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_1 R_3}{R_2}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_1 R_3}{R_3}$$

3 Methods of Analysis

Nodal Analysis

1. Selected a node as the reference node. Assign voltages $v_1, \dots v_{n-1}$ to the remaining $n-1$ nodes. The voltages are referenced with respect to the reference node.
2. Apply KCL to each of the $n-1$ non-reference nodes. Use Ohm's law to express the branch currents in terms of node voltages
3. Solve the resulting simultaneous equations to obtain the unknown node voltages.

Current flows from a higher potential to a lower potential in a resistor.

$$i = \frac{v_h - v_l}{R}$$

4 Circuit Theorems

A linear circuit is one whose output is linearly related to its input.

The superposition principle states that the voltage or current across an element in a linear circuit is the algebraic sum of the voltages or currents through that element due to each independent source acting alone.

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 and vice versa.

$$v_s = i_s R$$
$$i_s = \frac{v_s}{R}$$

Thevenin's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source v_{th} in series with a resistor R_{th}, where v_{th} is the open-circuit voltage at the terminals and R_{th} is the input or equivalent resistance at the terminals when the independent sources are turned off.

Norton's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a current source I_N in parallel with a resistor R_N, where I_N is the short-circuit current through the terminals and R_N is the input or equivalent resistance at the terminals when the independent sources are turned off.

$$p = i^2 R_L = \left(\frac{v_{th}}{R_{th} + R_L} \right)^2 R_L$$
$$p_{\max} = \frac{v_{th}^2}{4 R_{th}}$$

5 Operational Amplifiers