ECEN101C

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0.1 Introduction to electric circuits

0.1.1 Volt classification

Electric volt can be classified into three categories: low, Medium and high.

Low voltage	Medium voltage	High voltage
:1000V	1kV:50kV	50kV:500kv

0.1.2 Electric circuit components

For an electric circuit to be one some elements need to be present.

1. Power supplies A power supply is needed to create a potential difference to provide the circuit with a current.

2. A load "loads" are energies converted in the circuit by elements that consume the power generated.

3. Wires Wires are used to connect all the elements of the circuit together (Most commonly made of copper or aluminum).

4. Switches Switches are used to "open" or "close" the circuit.

0.1.3 Basic circuit quantities

1. The electric charge (Coloumb)

2. The electric current (Ampere)
   The current is the rate of change of the quantity of charge.

$$I = \frac{dq}{dt}$$

$$\therefore q = \int i(t).dt$$

   Example:

$$q = 12e^{-12t} \rightarrow I = (-12)12e^{-12t}$$

3. The potential difference (Volt $\rightarrow$ J/C "Joule per Coloumb")
   The potential difference is the energy affecting the charge moving it a certain distance.

$$V = \frac{dw}{dq}$$

4. The electric energy (Joule)

5. The electric power (Watt $\rightarrow$ J/s "Joule per second") The power is the energy consumed/delivered in a certain period of time.

$$P = \frac{dW}{dt} = I \times V = I^2 \times R = \frac{V^2}{R}$$

0.1.4 Circuit types

1. DC circuits
   Direct current circuits are circuits with constant voltage and current.

2. AC circuits
   Alternating current circuits are circuits with alternating voltage and current.

0.1.5 Basic circuit elements

- Passive elements
  Elements that absorb the power generated by the active elements.
  Some of the common passive elements seen in circuits:

Element	Unit	Found in
Resistors	Ohm (Ω)	AC and DC
Electrical coils	Henry (L)	AC only
Capacitors	Farad (C)	AC only

- Active elements
  Elements that generate power for the circuit.

  – Current sources

    1. Independant Current sources
       Independant sources provide constant current intensity.
    2. Dependant current sources
       Dependant sources have variable current intensities and are either:
       * Voltage controlled (V_x)
       * Current controlled (I_y)

0.2 Basic circuit laws

0.2.1 Ohm's law

$$V = I \times R$$

Power types and the conventional sign rule

- Power absorbed

  Power is absorbed when the current's direction is into the positive terminal

- Power supplied

  Power is supplied when the current's direction is into the negative terminal

For any balanced (ideal) circuit, the sum of the power consumed equals the sum of power absorbed.

$$\Sigma P_{abs} = \Sigma P_{con}$$

Note: The conventional sign rule is only applied when both the current and the voltage are positive and allows the switching of either the direction of a current of the terminals of a voltage source in case the magnitude is a negative value.

Example

0.2.2 Kirchhoff's laws

Kirchhoff's voltage law

In any loop in a circuit, the sum of voltages across the loop equals zero

$$\sum V_{loop} = 0$$

Series connection

Circuit elements are in series only if the same current intensity passes through them as the voltage is divided between the elements (not equally).
Therefore the equivalent resistance of a number of resistors in series is:

$$R_{eq} = \sum_{n=1}^{r} R_n$$

Voltage division

As the voltage is divided between the elements in series in non-uniform quantities, the voltage of each element can be found as the voltage is directly proportional with the value of the resistance of each element. Therefore:

$$V_a = V_t \times \frac{R_a}{R_{eq}}$$

Kirchhoff's current law

* Junctions: points of connection that connect only two circuit elements.
* Nodes: points of connection that connect more than two circuit elements.

At any node, the sum of currents with a direction into the node equals to the sum of currents with a direction outside the node.

$$\sum I_{in} = \sum I_{out}$$

Parallel connection

Circuit elements are in parallel only if they share the same starting and ending node as the current is divided between each element while the voltage remains the same.
Therefore the equivalent resistance of a number of resistors in series is:

$$\frac{1}{R_{eq}} = \sum_{n=1}^{r} \frac{1}{R_n}$$

Current division

As the current is devided between the elements in parallel non-uniform quantities, the current through each element can be found as the current intensity is inversly proportional with the value of the resistance of each element. Therefore:

$$I_a = I_t \times \frac{R_b}{R_a + R_b}$$

Conductance

Conductance (G) is the receprocal quantity to the electrical resistance and is measured in siemens (S)

$$G = \frac{I}{V} = \frac{1}{R}$$

0.3 Techincal methods for solving electrical circuits

0.3.1 Nodal analysis

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0.4 Technical theorems

0.4.1 Superposition

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0.4.4 Norton's theory

0.5 Energy storing elements

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0.6.1 Diode operations

0.6.2 Diode analysis