Chapter 1
Basic Concepts

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Basic Concepts - Chapter 1

1.1 Systems of Units
1.2 Electric Charge
1.3 Current
1.4 Voltage
1.5 Power and Energy
1.6 Circuit Elements
1.1 System of Units (1)

Six basic units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Basic unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>meter</td>
<td>m</td>
</tr>
<tr>
<td>Mass</td>
<td>kilogram</td>
<td>Kg</td>
</tr>
<tr>
<td>Time</td>
<td>second</td>
<td>s</td>
</tr>
<tr>
<td>Electric current</td>
<td>ampere</td>
<td>A</td>
</tr>
<tr>
<td>Thermodynamic temperature</td>
<td>kelvin</td>
<td>K</td>
</tr>
<tr>
<td>Luminous intensity</td>
<td>candela</td>
<td>cd</td>
</tr>
</tbody>
</table>
### 1.1 System of Units (2)

The derived units commonly used in electric circuit theory

#### Derived Units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric charge</td>
<td>coulomb</td>
<td>C</td>
</tr>
<tr>
<td>electric potential</td>
<td>volt</td>
<td>V</td>
</tr>
<tr>
<td>resistance</td>
<td>ohm</td>
<td>Ω</td>
</tr>
<tr>
<td>conductance</td>
<td>siemens</td>
<td>S</td>
</tr>
<tr>
<td>inductance</td>
<td>henry</td>
<td>H</td>
</tr>
<tr>
<td>capacitance</td>
<td>farad</td>
<td>F</td>
</tr>
<tr>
<td>frequency</td>
<td>hertz</td>
<td>Hz</td>
</tr>
<tr>
<td>force</td>
<td>newton</td>
<td>N</td>
</tr>
<tr>
<td>energy, work</td>
<td>joule</td>
<td>J</td>
</tr>
<tr>
<td>power</td>
<td>watt</td>
<td>W</td>
</tr>
<tr>
<td>magnetic flux</td>
<td>weber</td>
<td>Wb</td>
</tr>
<tr>
<td>magnetic flux density</td>
<td>tesla</td>
<td>T</td>
</tr>
</tbody>
</table>

#### Decimal Multiples and Submultiples of SI Units

<table>
<thead>
<tr>
<th>Factor</th>
<th>Prefix</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^9$</td>
<td>giga</td>
<td>G</td>
</tr>
<tr>
<td>$10^6$</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>$10^3$</td>
<td>kilo</td>
<td>k</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>centi</td>
<td>c</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>micro</td>
<td>μ</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>nano</td>
<td>n</td>
</tr>
<tr>
<td>$10^{-12}$</td>
<td>pico</td>
<td>p</td>
</tr>
</tbody>
</table>

Decimal multiples and submultiples of SI units
Metric mishap caused loss of NASA orbiter

September 30, 1999

CNN NASA lost a 125 million Mars orbiter because a Lockheed Martin engineering team used English units of measurement while the agency's team used the more conventional metric system for a key spacecraft operation, according to a review finding released Thursday.

The units mismatch prevented navigation information from transferring between the Mars Climate Orbiter spacecraft team in at Lockheed Martin in Denver and the flight team at NASA's Jet Propulsion Laboratory in Pasadena, California.

Lockheed Martin helped build, develop and operate the spacecraft for NASA. Its engineers provided navigation commands for Climate Orbiters thrusters in English units although NASA has been using the metric system predominantly since at least 1990.

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1.2 Electric Charges

- **Charge** is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).

- The charge $e$ on one electron is negative and equal in magnitude to $1.602 \times 10^{-19}$ C which is called as electronic charge. The charges that occur in nature are integral multiples of the electronic charge.
1.3 Current (1)

- Electric current $i = dq/dt$. The unit of ampere can be derived as $1 \text{ A} = 1 \text{C/s}$.
- A **direct current (dc)** is a current that remains constant with time.
- An **alternating current (ac)** is a current that varies sinusoidally with time. (reverse direction)
1.3 Current (2)

- The direction of current flow

Positive ions

Negative ions
1.3 Current (3)

Example 1

A conductor has a constant current of 5 A.

How many electrons pass a fixed point on the conductor in one minute?
1.3 Current (4)

Solution

Total no. of charges pass in 1 min is given by
5 A = (5 C/s)(60 s/min) = 300 C/min

Total no. of electronics pass in 1 min is given

\[ \frac{300 \text{ C/min}}{1.602 \times 10^{-19} \text{ C/electron}} = 1.87 \times 10^{21} \text{ electrons/min} \]
1.4 Voltage (1)

- Voltage (or potential difference) is the **energy** required to move a **unit charge** through an element, measured in volts (V).

- Mathematically,  
  \[ v_{ab} = \frac{dw}{dq} \text{ (volt)} \]
  - \( w \) is energy in joules (J) and \( q \) is charge in coulomb (C).

- **Electric voltage**, \( v_{ab} \), is always **across the circuit element or between two points in a circuit**.
  - \( v_{ab} > 0 \) means the potential of \( a \) is higher than potential of \( b \).
  - \( v_{ab} < 0 \) means the potential of \( a \) is lower than potential of \( b \).
1.5 Power and Energy (1)

- Power is the time rate of expending or absorbing energy, measured in watts (W).

- Mathematical expression:
  \[ p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = vi \]

Passive sign convention:

\[ P = +vi \]  
absorbing power

\[ p = -vi \]  
supplying power
1.5 Power and Energy (2)

- The law of conservation of energy

\[ \sum p = 0 \]

- Energy is the capacity to do work, measured in joules (J).

- Mathematical expression
  \[ w = \int_{t_0}^{t} pdt = \int_{t_0}^{t} v idt \]
1.6 Circuit Elements (1)

**Active Elements**

- Independent sources
- Dependant sources

**Passive Elements**

- They have four different types: VCVS, CCVS, VCCS, CCCS. Keep in mind the signs of dependent sources.

- A dependent source is an active element in which the source quantity is controlled by another voltage or current.
1.6 Circuit Elements (2)

**Example 2**

Obtain the voltage $v$ in the branch shown in Figure 2.1.1P for $i_2 = 1\text{A}$.

\[ v_x = 15i_2 \quad (\text{V}) \]

Figure 2.1.1P
1.6 Circuit Elements (3)

Solution

Voltage \( v \) is the sum of the current-independent 10-V source and the current-dependent voltage source \( v_x \).

Note that the factor 15 multiplying the control current carries the units \( \Omega \).

Therefore, \( v = 10 + v_x = 10 + 15(1) = 25 \text{ V} \)
End of Chapter 1