

Lesson 1: Introduction to Circuit Analysis

SI system of units

TABLE 1.1 The six basic SI units.

| Quantity | Basic unit | Symbol |
|---------------------------|------------|--------|
| Length | meter | m |
| Mass | kilogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Thermodynamic temperature | kelvin | K |
| Luminous intensity | candela | cd |

Engineering notation

It is common practice in engineering to avoid using exponential notation if a suitable engineering prefix exists.

For example:

$$15 \times 10^{-5} \text{ sec}$$

$$150 \mu\text{s}$$

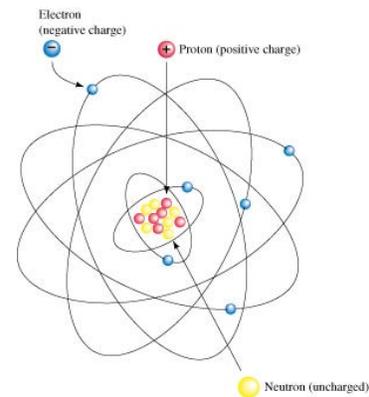
$$0.15 \text{ ms}$$

Charge

The most basic quantity in an electrical circuit is electric charge.

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

1. The smallest unit of charge is an electron which $e =$ _____ C.
2. The coulomb is a large amount of charge. In 1 C of charge there are _____ electrons.
3. The law of _____ states that charge can neither be created or destroyed, only transferred.



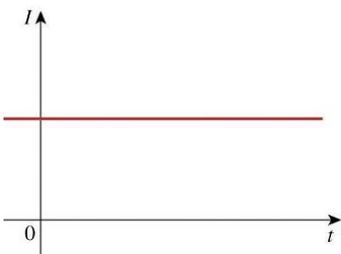
Current

Electric current is the time rate of change of charge, measured in _____ (_____).

Mathematically, current (i) is defined $i =$

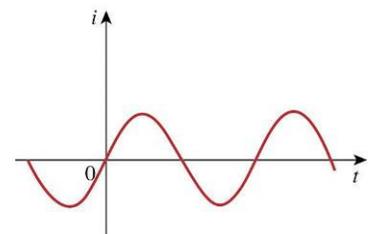
The measure of current, an _____ is define as a rate of flow: 1 ampere =

The charge transferred between time t_0 and t is given by $Q =$



_____ current (dc) is a current that remains constant with time and is represented by _____.

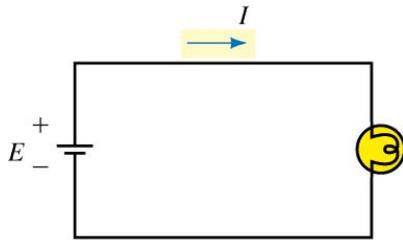
_____ current (ac) is a current that varies sinusoidally with time and is represented by _____.



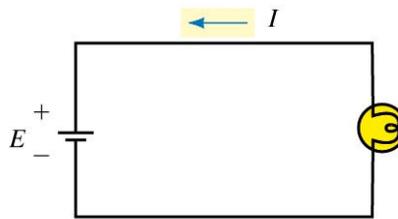
Current direction

Initially it was believed that current was the flow of positive charges. This is called _____ current direction.

The actual flow of charge is by _____ (negative charge) called electron flow direction. We will use conventional current.



(a) Conventional current direction



(b) Electron flow direction

Why does current flow?

Current is the movement of charge, but how do we get charges to move?

The movement of charge is the result of an _____ (EMF).

Moving an electron in a conductor requires _____ or _____ transfer.

Voltage

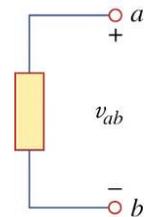
The _____ v_{ab} between two points a and b in a circuit is the work (energy) needed to move a unit charge from a to b

$$v_{ab} =$$

where w is energy in joules (J) and q is charge in coulombs (C). 1 volt =

It can be said that:

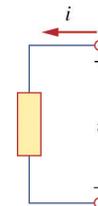
- Point a is at a potential v_{ab} volts higher than point b .
- The potential at point a with respect to point b is v_{ab} .
- Also, $v_{ab} =$ _____



An important semantic distinction

Current is always _____ an element.

Voltage is always _____ an element or between two points.



Power

Power is defined as the rate of _____ or the rate of energy transfer, measured in _____.

$$p =$$

where p is power in watts (W).

We need to express this in terms of voltage and current.

current $i =$ _____ power $p =$ _____

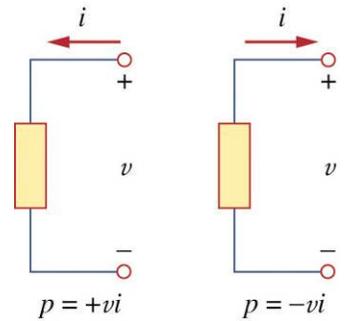
voltage $v =$ _____

The power p is a time-varying quantity and is called _____ power.

Power flow

Power flow is indicated by the sign.

- If power has a + sign, power is being _____ to or _____ by an element.
- If power has a - sign, power is being _____ by the element.



Passive sign convention

Current flow and voltage polarity determine the sign of the power.

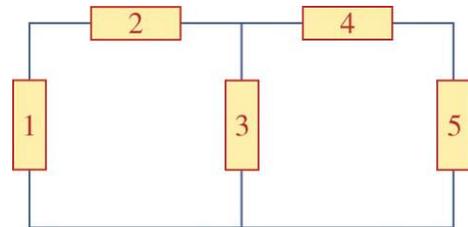
The passive sign convention is satisfied when current _____ through the _____ polarity of the voltage and $p = +vi$ (power is being _____).

If current enters the negative terminal, $p = -vi$.

Conservation of energy

The law of conservation of energy must be obeyed in any electric circuit, thus

$$\sum p = 0$$



Energy

The energy (w) measured in joules (J) absorbed or supplied by an element from t_0 to t is

$w =$

Circuit elements

There are two types of elements in circuits:

_____ elements are capable of generating energy (batteries, generators, amplifiers).

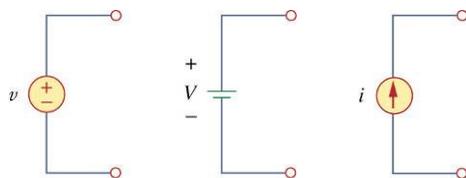
_____ elements are not capable of generating energy (resistors, capacitors, inductors).

Sources

The most important active elements are voltage and current sources.

There are two kinds of sources

An _____ source is an active element that provides a specified voltage or current that is completely independent of other circuit elements.

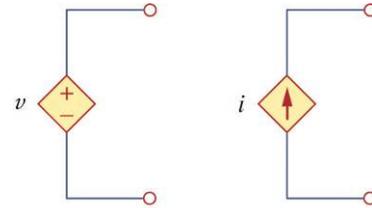


Sources

An ideal _____ source is an active element in which the source quantity is controlled by another voltage or current.

There are four possible dependent sources:

- Voltage-controlled voltage source (VCVS)
- Current-controlled voltage source (CCVS)
- Voltage-controlled current source (VCCS)
- Current-controlled current source (CCCS)



Dependent sources are useful for modeling elements such as transistors, operational amplifiers, and integrated circuits.

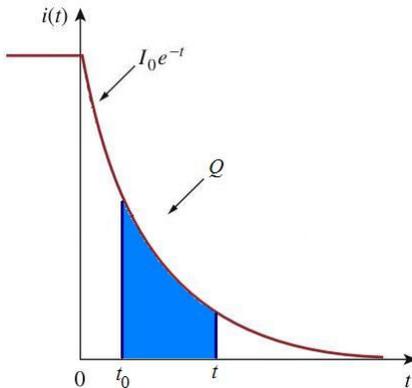
Circuit analysis

An electric circuit is an interconnection of electrical elements.

Circuit analysis is the process of determining the _____ across or _____ through elements of the circuit.

Example Problem 1

Determine the total charge leaving the circuit element between $t = 1$ s and $t = 2$ s if the current through the device is given $i(t) = 10e^{-5t}$ A



Example Problem 2

Calculate the power supplied or absorbed by each element in the circuit below.

