Fundamentals of

Electric Circuits

TEXT BOOK

Fundamentals of Electric Circuits

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Other Goals

- Discuss with your classmates
- Learn how to express your thoughts
- Learn how to study on internet
- Evaluate yourself and compare with yourself

Feature

- 1. Latest technology
- 2. Multisim
- 3. myDAQ
- 4. theory and practice

PART 1 DC CIRCUITS
CHAPTER 1 BASIC CONCEPTS

- An electric circuit is an interconnection of electrical elements.
- Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).
- Electric current is the time rate of change of charge, measured in amperes (A).

Mathematically, the relationship between current i, charge q, and time t is

$$i \triangleq \frac{dq}{dt} \tag{1.1}$$

where current is measured in amperes (A), and

1 ampere = 1 coulomb/second

The charge transferred between time t_0 and t is obtained by integrating both sides of Eq. (1.1). We obtain

$$Q \triangleq \int_{t_0}^{t} i\, dt \tag{1.2}$$

DC & AC

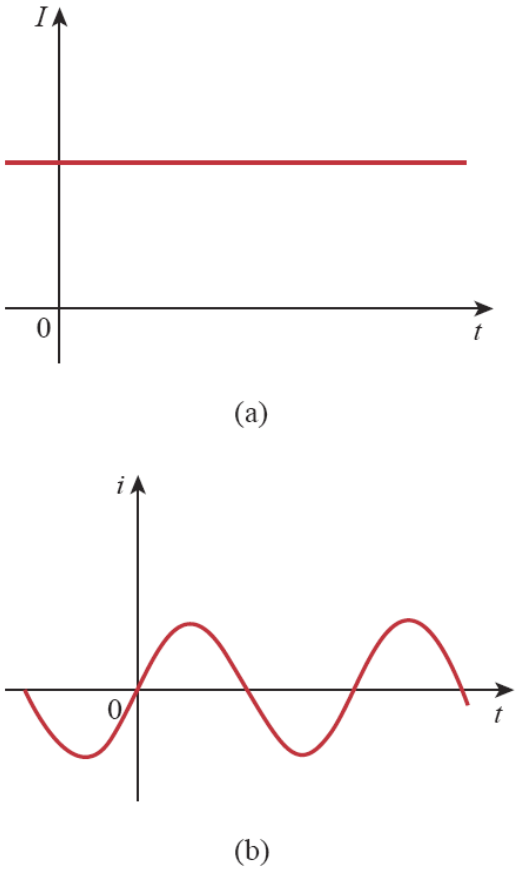


Figure 1.4
Two common types of current: (a) direct current (dc), (b) alternating current (ac).

A direct current (dc) is a current that remains constant with time.

An alternating current (ac) is a current that varies sinusoidally with time.

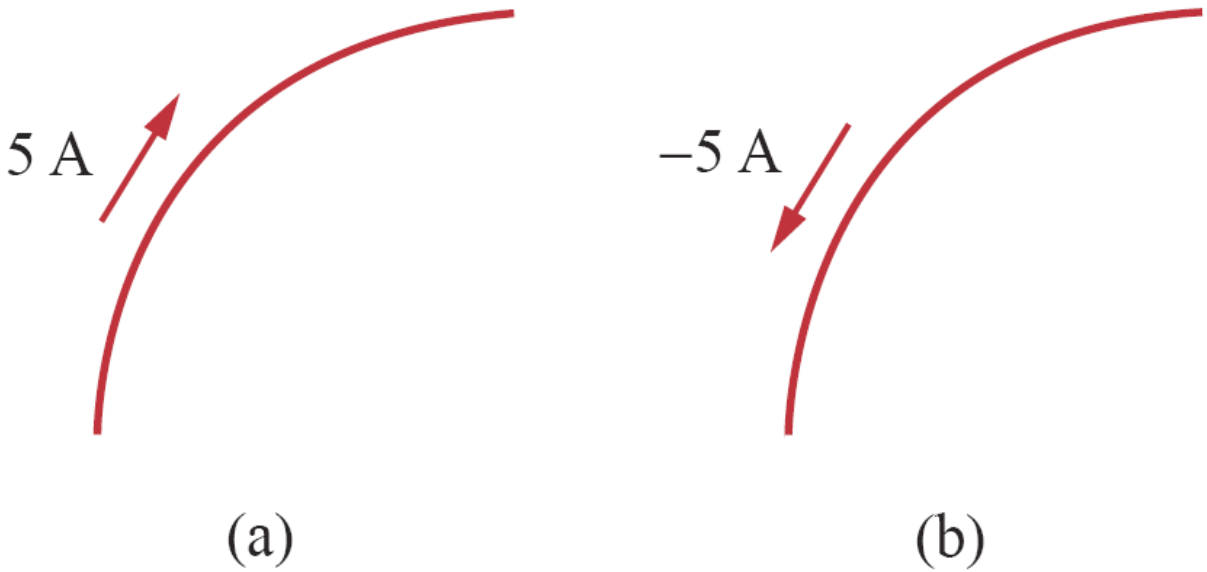


Figure 1.5
Conventional current flow: (a) positive current flow, (b) negative current flow.

The total charge entering a terminal is given by $q = 5t \sin 4\pi t$ mC. Calculate the current at $t = 0.5$ s.

Solution:

$$i = \frac{dq}{dt} = \frac{d}{dt}(5t \sin 4\pi t) \text{ mC/s} = (5 \sin 4\pi t + 20\pi t \cos 4\pi t) \text{ mA}$$

At $t = 0.5$,

$$i = 5 \sin 2\pi + 10\pi \cos 2\pi = 0 + 10\pi = 31.42 \text{ mA}$$

VOLTAGE

- *voltage or potential difference. The voltage between two points a and b in an electric circuit is the energy (or work) needed to move* a unit charge from *a to b; mathematically,*

$$v_{ab} \triangleq \frac{dw}{dq}$$

where *w is energy in joules (J) and q is charge in coulombs (C). The* voltage or simply *v is measured in volts (V).*

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

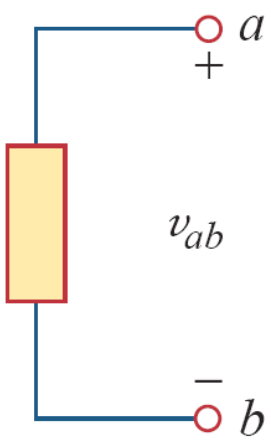
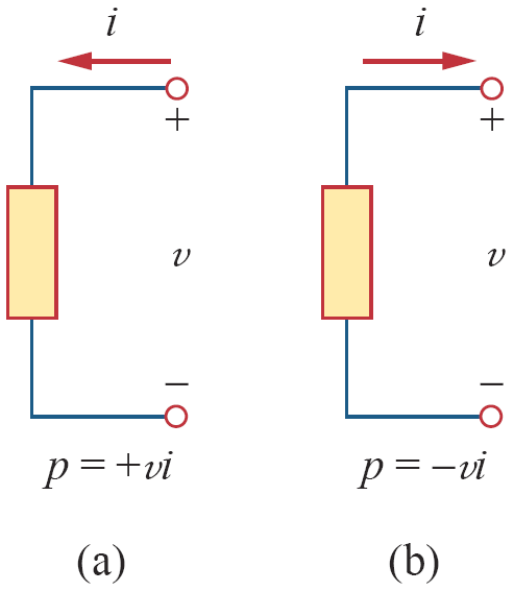


Figure 1.6
Polarity of voltage v_{ab}.

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



$$p \triangleq \frac{dw}{dt}$$

$$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = vi$$

Figure 1.8
Reference polarities for power using the passive sign convention: (a) absorbing power, (b) supplying power.

- *Passive sign convention is satisfied when the current enters through the positive terminal of an element and p=+ vi.*
- *If the current enters through the negative terminal, p=-vi.*

In fact, the *law of conservation of energy* must be obeyed in any electric circuit. For this reason, the algebraic sum of power in a circuit, at any instant of time, must be zero:

$$\sum p = 0 \tag{1.8}$$

This again confirms the fact that the total power supplied to the circuit must balance the total power absorbed.

From Eq. (1.6), the energy absorbed or supplied by an element from time t_0 to time t is

$$w = \int_{t_0}^{t} p\,dt = \int_{t_0}^{t} vi\,dt \tag{1.9}$$

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

The electric power utility companies measure energy in watt-hours (Wh), where

$$1 \text{ Wh} = 3{,}600 \text{ J}$$

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

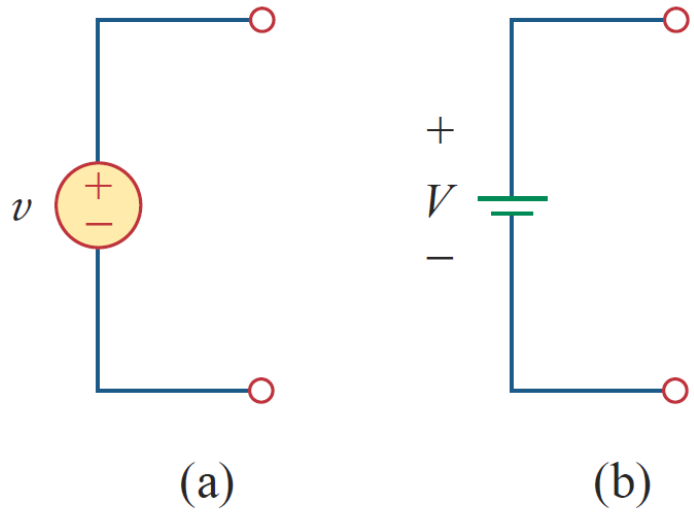


Figure 1.11
Symbols for independent voltage sources: (a) used for constant or time-varying voltage, (b) used for constant voltage (dc).

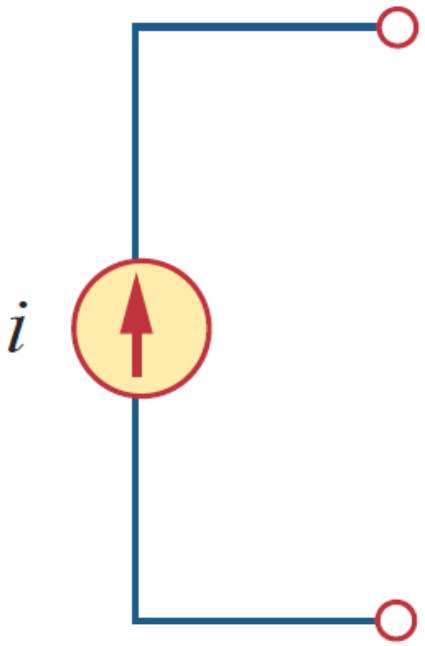


Figure 1.12
Symbol for independent current source.

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

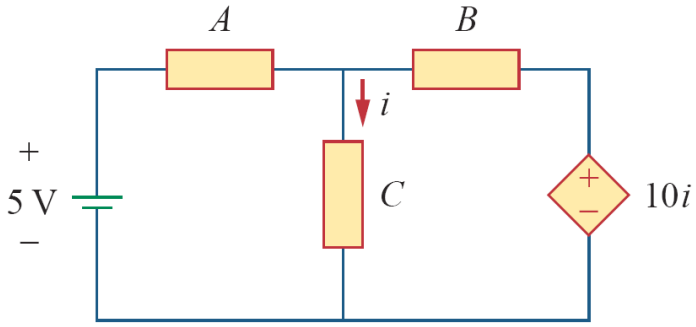


Figure 1.14
The source on the right-hand side is a current-controlled voltage source.

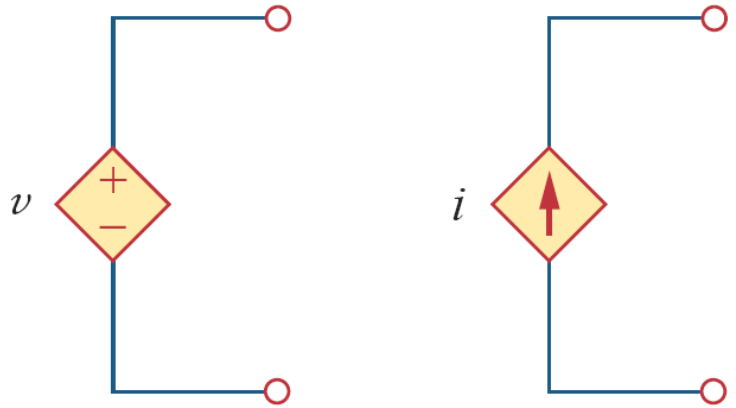


Figure 1.13
Symbols for: (a) dependent voltage source, (b) dependent current source.