Alexander-Sadiku

Fundamentals of Electric Circuits

Chapter 1

Basic Concepts

Basic Concepts - Chapter 1

1.1 System of Units (1)

Six basic 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

3

1.1 System of Units (2)

The derived units commonly used in electric circuit theory

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

Factor	Prefix	Symbol
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Decimal multiples and submultiples of SI units

4

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 1.602×10^{-19} C which is called as electronic charge. The charges that occur in nature are integral multiples of the electronic charge.

5

1.3 Current (1)

Electric current $i = dq/dt$. The unit of ampere can be derived as 1 A = 1C/s.

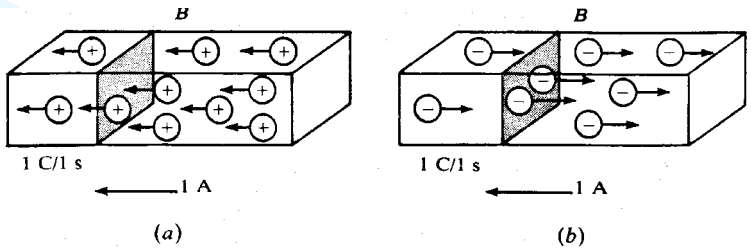
A direct current (dc) is a current that remains constant with time.

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

6

1.3 Current (2)

The direction of current flow



Positive ions

Negative ions

7

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?

8

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

$$\frac{300\ \text{C/min}}{1.602x10^{-19}\ \text{C/electron}} = 1.87x10^{21}\ \text{electrons/min}$$

9

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, $v_{ab} = dw/dq$ (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.

10

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

11

1.5 Power and Energy (2)

The law of conservation of energy

$$\sum p = 0$$

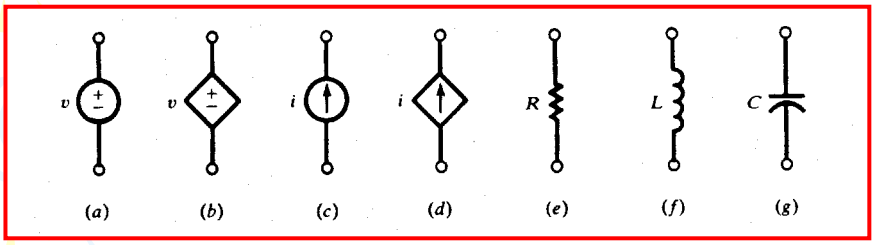
Energy is the capacity to do work, measured in joules (J).

Mathematical expression $w = \int_0^t pdt = \int_0^t vidt$

12

1.6 Circuit Elements (1)

Active Elements | **Passive Elements**



Independent sources

Dependant sources

A dependent source is an active element in which the source quantity is controlled by another voltage or current.

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

13

1.6 Circuit Elements (2)

Example 2

Obtain the voltage *v* in the branch shown in Figure 2.1.1P for i_2 = 1A.

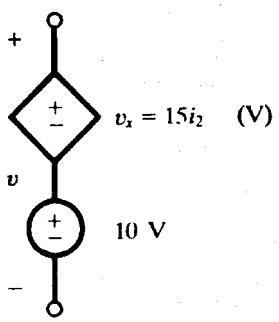


Figure 2.1.1P

14

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 Ω.

Therefore, $v = 10 + v_x = 10 + 15(1) = 25$ V

15