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Fundamentals of Electric Circuits

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

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

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 fiux 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

1.2 Electric Charges

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

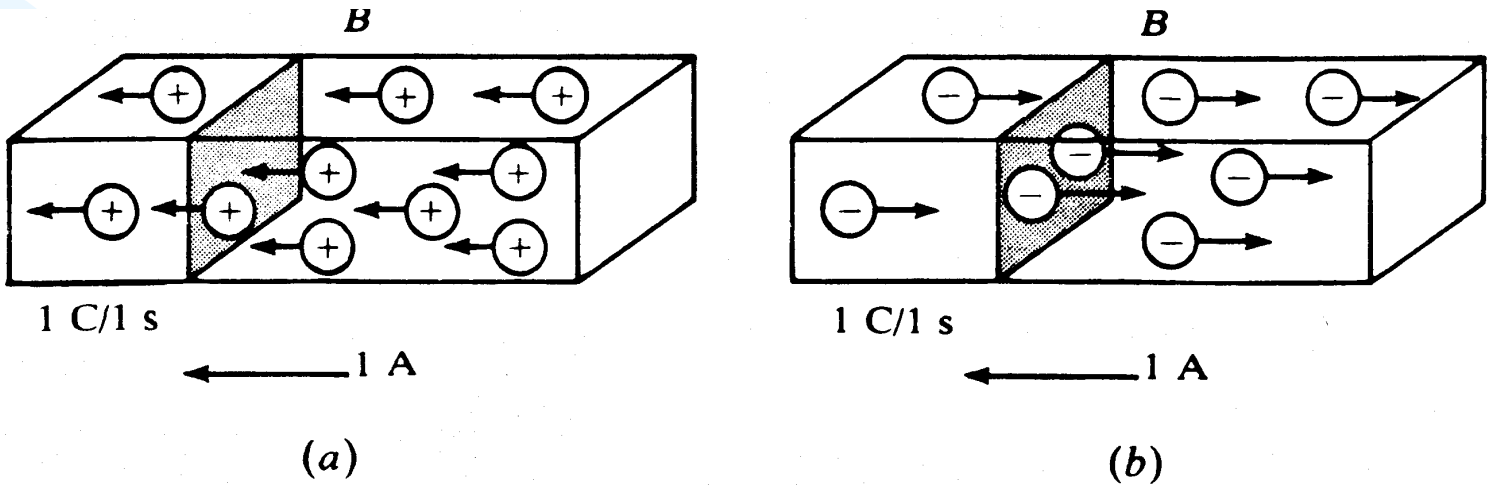
- The charge e on one electron is negative and equal in magnitude to 1.602×10^{-19} C which is called as electronic charge. The charges that occur in nature are integral multiples of the electronic charge.

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)

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

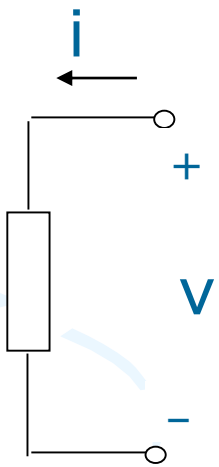
$$\frac{300\ \text{C/min}}{1.602x10^{-19}\ \text{C/electron}} = 1.87x10^{21}\ \text{electrons/ min}$$

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

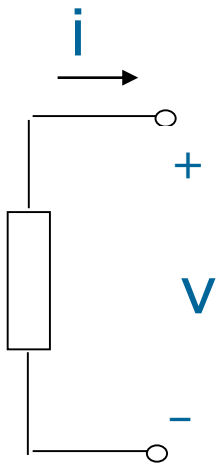
1.5 Power and Energy (1)

- Power is the time rate of expending or absorbing energy, measured in watts (W).
- Mathematical expression: $$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = vi$$



P = +vi
absorbing power

Passive sign convention



p = –vi
supplying power

1.5 Power and Energy (2)

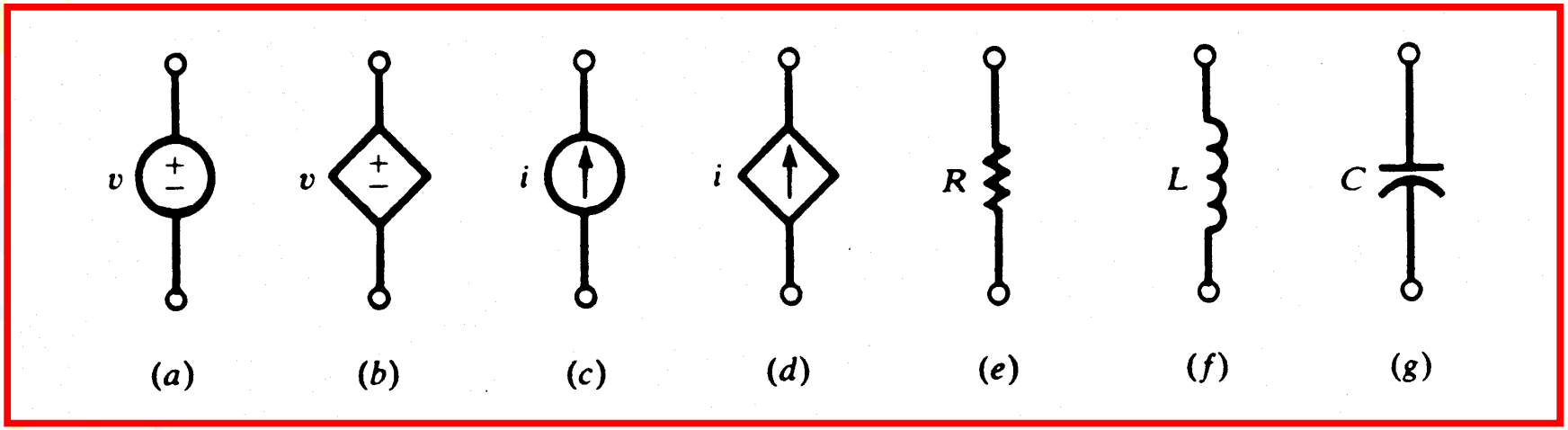
- The law of conservation of energy

$$\sum p = 0$$

- Energy is the capacity to do work, measured in joules (J).
- Mathematical expression $w = \int_{t_0}^{t} p dt = \int_{t_0}^{t} v i dt$

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.**

1.6 Circuit Elements (2)

Example 2

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

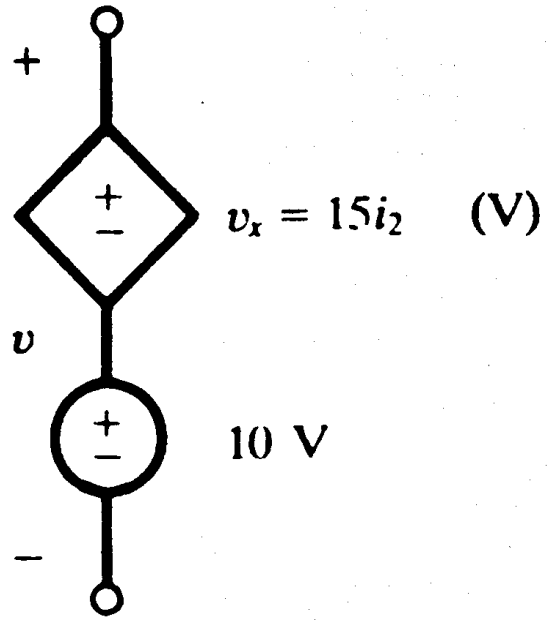


Figure 2.1.1P

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