Dr. Norbert Cheung's Lecture Series

Level 2z Topic no: 02

Basic Electricity Concepts

Contents

Reference:
xxx – Schaum's Outline Series

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1. International Systems of Units

The International System of Units (SI) is the international measurement language. SI has nine base units, which are shown in Table 1-1 along with the unit symbols. Units of all other physical quantities are derived from these.

Table 1-1

Physical Quantity	Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
current	ampere	A
temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd
plane angle	radian	rad
solid angle	steradian	sr

The SI prefixes have symbols as shown in Table 1-2, which also shows the corresponding powers of 10. For most circuit analyses, only mega, kilo, milli, micro, nano, and pico are important.

Table 1-2

Multiplier	Prefix	Symbol	Multiplier	Prefix	Symbol
10^{18}	exa	E	10^{-1}	deci	d
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	μ
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10^{1}	deka	da	10^{-18}	atto	a

2. Electric Charge, Current and Voltage

Scientists have discovered two kinds of electric charge: positive and negative. Positive charge is carried by sub-atomic particles called protons, and negative charge by sub-atomic particles called electrons.

The electric charge of an electron is -1.602 x 10^{-19} C and that of a proton is +1.602 x 10^{-19} C. The combined charge of 6.241 x 10^{18} electrons equals -1 C (coulumb).

Electric current results from the movement of electric charge. The SI unit of current is the ampere with unit symbol *A* (ampere). The quantity symbol is *I* for a constant current and *i* for a time-varying current.

$$I(\text{amperes}) = \frac{Q(\text{coulombs})}{t(\text{seconds})}$$

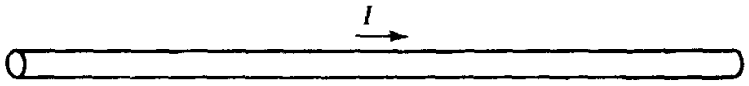


Fig. 1-1

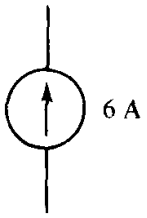


Fig. 1-2

If a steady flow of 1 C of charge passes a given point in a conductor in 1 s, the resulting current is 1 A.

The concept of electric voltage involves work, which in turn involves force and distance.

W(joules) = F(newtons) x s (meters)

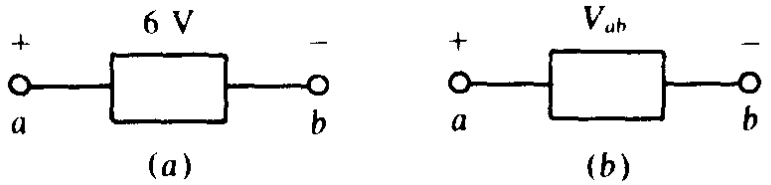
where W, F, and s are the quantity symbols for work, force, and distance, respectively. Energy is the capacity to do work

The voltage difference (also called the potential difference) between two points is the work in joules required to move *1 C* of charge from one point to the other. The SI unit of voltage is the volt with unit symbol *V*. The quantity symbol is *V* or *v*, although *E* and *e* are also popular.

$$V(\text{volts}) = \frac{W(\text{joules})}{Q(\text{coulombs})}$$

The voltage quantity symbol F sometimes has subscripts to designate the two points to which the voltage corresponds.

$$V_{ab} = W_{ab}/Q.$$



A constant voltage is called a dc voltage. And a voltage that varies sinusoidally with time is called an ac voltage.

3. Independent and Dependent Source, Power and Energy

Independent Source

A voltage source, such as a battery or generator, provides a voltage that, ideally, does not depend on the current flow through the source. Figure l-4a shows the circuit symbol for a battery. This source provides a dc voltage of 12 V.

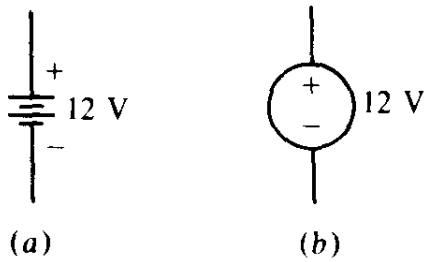
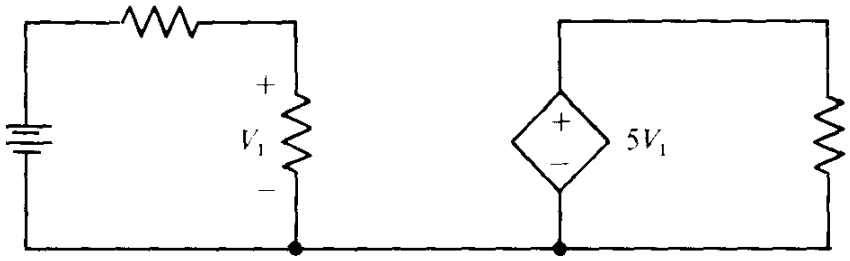


Fig. 1-4

Dependent Source

The voltage sources shown above are independent sources. An independent source provides a current / voltage, independently of any other voltage or current. In contrast, a dependent source (also called a controlled source) provides a voltage or current that depends on a voltage or current elsewhere in a circuit. There are four types of dependent sources: e.g. a voltage-controlled voltage source as shown below:



Power

Power is the rate at which something either absorbs or produces energy.

$$P(\text{watts}) = \frac{W(\text{joules})}{t(\text{seconds})}$$

The power absorbed by an electric component is the product of voltage and current if the current reference arrow is into the positively referenced terminal, as shown in Fig. 1-6:

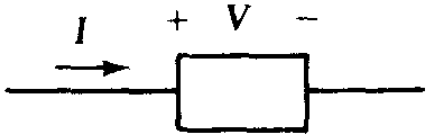


Fig. 1-6

P(watts) = V(volts) x I(amperes)

If the calculated P is positive with either formula, the component actually absorbs power (load). But if P is negative, the component produces power -- it is a source of electric energy.

Electric motors and other systems have an efficiency (rj) of operation defined by:

$$\text{Efficiency} = \frac{\text{power output}}{\text{power input}} \times 100\% \qquad \text{or} \qquad \eta = \frac{P_{out}}{P_{in}} \times 100\%$$

Fig. 1-7

The overall efficiency of a cascaded system as shown in Fig. 1-7 is the product of the individual efficiencies:

$$\frac{P_{out}}{P_{in}} = \eta_1 \eta_2 \eta_3 \cdots \eta_n$$

Energy

Electric energy used or produced is the product of the electric power input or output and the time over which this input or output occurs:

W(joules) = P(watts) x t(seconds)

Electric energy is what customers purchase from electric utility companies. These companies do not use the joule as an energy unit but instead use the much larger and more convenient kilo-watt-hour (kWh) even though it is not an SI unit.

$$W(\text{kilowatthours}) = P(\text{kilowatts}) \times t(\text{hours})$$

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Glossary – English/Chinese Translation

English	Chinese
international systems of units	国际单位制
electric charge	电荷
electric current	电流
electric voltage	电压
independent source	独立源
dependent source	依赖源
power	权力
energy	能源
sub-atomic	亚原子
protons	质子
electrons	电子
coulomb	库仑
ampere	安培
joules	焦耳
volts	伏
work force and distance	劳动力和距离
potential difference	位差
dc voltage	直流电压
ac voltage	交流电压
battery	电池
controlled source	受控源
voltage controlled voltage source	电压控制电压源
watts	瓦
negative and positive	消极和积极
electric energy	电能
kilo watt hour	千瓦时
efficiency	效率
cascaded system	级联系统

Your Notes: