

● 专业英语系列教材 ●

Special  
English  
for  
Electrical  
Engineering  
and  
Automation



# 电气工程及其自动化专业英语

Special English for Electrical Engineering and Automation

► 李文娟



华中科技大学出版社  
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# 电气工程及其自动化专业英语

## Special English for Electrical Engineering and Automation

李文娟



华中科技大学出版社  
中国·武汉

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## 内 容 提 要

本书分为 14 个单元。主要包括电路、模拟电子技术、数字电子技术、电机学、自动控制、电气测量技术、电器设备、电力电子技术、电力系统等。书中内容是按每个单元用 2 学时授课的计划安排的,每个单元后都配有主要的词汇注释、要点注释和练习等内容,书后还给出了全部练习的参考答案。

本书既可作为电气工程及其自动化、工业电气自动化、自动控制、机电一体化等相关专业<sup>的</sup>专业英语教材,也可作为从事电子信息、自动化等相关专业工程技术人员的参考用书。



# 前 言

近些年,各高校普遍对教学进行了改革,重新调整了各专业的课程设置和学时分配。专业英语课程由原来的3个学期压缩至1个学期,学时也由以往的80~90学时调整到现在的28~34学时。在有限的学时中让学生阅读到本专业的主要外文文献资料,掌握基本的专业词汇,提高学生阅读和翻译英语科技文献的能力,是编者编写本书的目的。

本书所选内容涉及面广,包括电路、模拟电子技术、数字电子技术、电机学、自动控制、电气测量技术、电器设备、电力电子技术、电力系统等方面的知识。每一部分内容的选取都突出了相关技术最基础的知识,便于学生更好地学习和掌握,也有助于学生专业英语水平的进一步提高。

编者结合多年的教学授课经验,在本书选材和编排上,使每个单元的内容均可以在2个学时的教学中讲授完。这样,一次课一个主题,既清晰明了,又重点突出。本书共有14个单元,满足28~34学时授课的需要。

为了便于学习,每个单元后都给出了生词和词组,同时针对文中的难点给出了注释。每个单元还配备了练习,帮助学生巩固和加深所学知识。练习分为3类:词组或短语汉译英、根据课文回答问题、句子英译汉,并在书后给出了练习参考答案。

在表示有关“量”的符号时,按原文献给出;一些原器件的符号则按照我国国家标准加以更换,如原文献中表示电阻的符号“”都按我国标准换成“”。特此说明。

在本书的编写过程中,得到了哈尔滨理工大学许多老师和研究生的帮助,在此一并表示衷心的感谢!

由于编者的专业知识和外语水平有限,书中错误和不足之处在所难免,敬请使用本书的广大师生和读者批评指正,本人将不胜感激。

编 者  
2007年5月

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# 1 Basic Concepts of Electric Circuits

## 1.1 Introduction

Electric circuit theory and *electromagnetic* theory are the two *fundamental* theories upon which all branches of electrical engineering are built. Many branches of electrical engineering, such as power, electric machines control, electronics, communications and instrumentation, are based on electric circuit theory. Therefore, the basic electric circuit theory course is the most important course for electrical engineering students, and always an excellent starting point for beginning students in electrical engineering education. Circuit theory is also valuable to students specializing in other branches of the physical sciences because circuits are a good model for the study of energy systems in general, and because of the applied mathematics, physics, and *topology* involved. <sup>①</sup>

In electrical engineering, we are often interested in communicating or transferring energy from one point to another. To do this requires an interconnection of electrical devices. Such interconnection is referred to as an *electric circuit*, and each component of the circuit is known as an *element*.

An electric circuit is an interconnection of electrical elements.

A simple electric circuit is shown in Fig. 1.1. It consists of three basic elements: a battery, a lamp, and connecting wires. Such a simple circuit can exist by itself; it has several applications, such as a torch light, a search light, and so on.

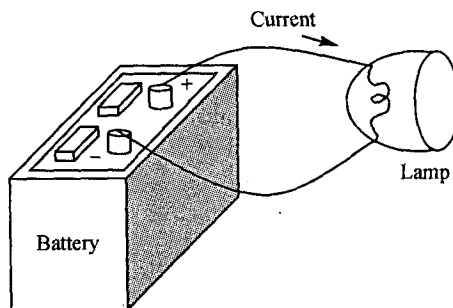


Fig. 1.1 A simple electric circuit

Electric circuits are used in numerous electrical systems to accomplish different tasks. The objective is not the study of various uses and applications of circuits. Rather our major concern is the analysis of the circuits. By the analysis of a circuit, we mean a study of the behavior of the circuit: How does it respond to a given input? How do the interconnected elements and devices in the circuit interact?

We commence our study by defining some basic concepts. These concepts include charge, current, voltage, circuit elements, power and energy.

## 1.2 Charge and Current

The concept of electric charge is the underlying principle for explaining all electrical phenomena. Also, the most basic quantity in an electric circuit is the *electric charge*. We all experience the effect of electric charge when we try to remove our wool sweater and have it stick to our body or walk across a carpet and receive a shock.

Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).<sup>②</sup>

We now consider the flow of electric charges. A unique feature of electric charge or *electricity* is the fact that it is mobile; that is, it can be transferred from one place to another, where it can be converted to another form of energy.

When a conducting wire is connected to a battery (a source of electromotive force), the charges are *compelled* to move; positive charges move in one direction while negative charges move in the opposite direction. This motion of charges creates electric current. It is conventional to take the current flow as the movement of positive charges, that is, opposite to the flow of negative charges, as Fig. 1.2 illustrates.

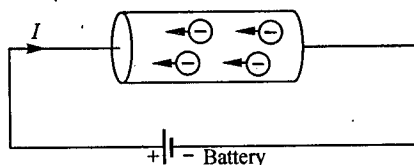


Fig. 1.2 Electric current due to flow of electronic charge in a conductor

Electric current is the time rate of change of charge. Mathematically, the relationship between current  $i$ , charge  $q$ , and time  $t$  is

$$i = \frac{dq}{dt} \quad (1.1)$$

where current is measured in amperes (A), and

$$1 \text{ ampere} = 1 \text{ coulomb/second}$$

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

$$q = \int_{t_0}^t i dt \quad (1.2)$$

The way we define current as  $i$  in Eq. (1.1) suggests that current need not be a constant-valued function.

If the current does not change with time, but remains constant, we call it a *direct current* (DC), that is, a direct current is a current that remains constant with time. By convention the symbol  $I$  is used to represent such a constant current.

A time-varying current is represented by the symbol  $i$ . A common form of time-varying current is the sinusoidal current or *alternating current* (AC), that is, an alternating current is a current that varies sinusoidally with time. Such current is used in the household, to run the air conditioner, refrigerator, washing machine and other electric appliances.

Once we define current as the movement of charge, we expect current to have an associated direction of flow. As mentioned earlier, the direction of current flow is conventionally taken as the direction of positive charge movement.

### 1.3 Voltage

To move the electron in a conductor in a particular direction requires some work or energy transfer. This work is performed by an external electromotive force (emf), typically represented by the battery in Fig. 1.1. This emf is also known as *voltage* or *potential difference*. The voltage  $u_{AB}$  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,

$$u_{AB} = \frac{dw}{dq} \quad (1.3)$$

where  $w$  is energy in joules (J) and  $q$  is charge in coulombs (C). The voltage  $u_{AB}$  or simply  $u$  is measured in volts (V). From Eq. (1.3), it is evident that

$$1 \text{ volt} = 1 \text{ joule/coulomb} = 1 \text{ newton meter/coulomb}$$

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

Fig. 1.3 shows the voltage across an element (represented by a rectangular block) connected to points  $A$  and  $B$ . The plus (+) and minus (−) signs are used to define the reference direction or voltage polarity. The  $u_{AB}$  can be interpreted in two ways: (1) point  $A$  is at a potential of  $u_{AB}$  volts higher than point  $B$ , or (2) the potential at  $A$  with respect to point  $B$  is  $u_{AB}$ . It follows logically that in general

$$u_{AB} = -u_{BA} \quad (1.4)$$

Current and voltage are the two basic variables in electric circuits. The common term *signal* is used for an electric quantity such as a current or a voltage when it is used for conveying information.<sup>③</sup> Like the electric current, a constant voltage is called a *DC voltage* and is represented by  $U$ , whereas a sinusoidally time-varying voltage is called an *AC voltage* and is represented by  $u$ . A DC voltage is commonly produced by a battery; an AC voltage is produced by an electric generator.

### 1.4 Power and Energy

Although current and voltage are the two basic variables in an electric circuit, they are not sufficient by themselves. For practical purposes, we need to know how much *power* an electric device can handle. We all know from experience that a 100-watt bulb gives more light than a 60-watt bulb. We also know that when we pay our bills to the electric utility companies, we are paying for the electric *energy* consumed over a certain period of time. Thus power and energy calculations are important in circuit analysis.

To relate power and energy to voltage and current, we recall from physics that: Power is the time rate of expending or absorbing energy, measured in watts (W). We write this

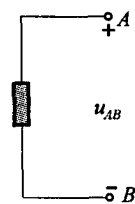


Fig. 1.3 Polarity of voltage  $u_{AB}$

relationship as

$$p = \frac{dw}{dt} \quad (1.5)$$

where  $p$  is power in watts (W),  $w$  is energy in joules (J), and  $t$  is time in seconds (s). From Eq. (1.1), Eq. (1.3), and Eq. (1.5), it follows that

$$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = ui \quad (1.6)$$

or

$$p = ui \quad (1.7)$$

The power  $p$  in Eq. (1.7) is a time-varying quantity and is called the *instantaneous power*. Thus, the power absorbed or supplied by an element is the product of the voltage across the element and the current through it. If the power has a + sign, it is being delivered to or absorbed by the element. If, on the other hand, the power has a - sign, it is being supplied by the element. But how do we know when the power has a negative or a positive sign?

Current direction and voltage polarity play major roles in determining the sign of power. It is therefore important that we pay attention to the relationship between current  $i$  and voltage  $u$  in Fig. 1.4(a). The voltage polarity and current direction must conform with those shown in Fig. 1.4(a) in order for the power to have a positive sign. This is known as the *passive sign convention*. By the passive sign convention, current enters through the positive polarity of the voltage. In this case,  $p = +ui$  or  $ui > 0$  implies that the element is absorbing power. However, if  $p = -ui$  or  $ui < 0$ , as in Fig. 1.4(b), the element is releasing or supplying power.

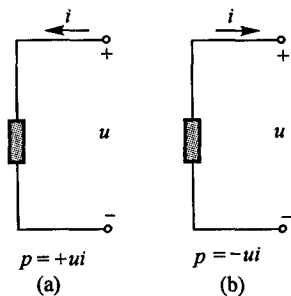


Fig. 1.4 Reference polarities for power using the passive sign convention

(a) absorbing power; (b) supplying power

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:

$$\sum p = 0 \quad (1.8)$$

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

$$w = \int_{t_0}^t p dt = \int_{t_0}^t u i dt \quad (1.9)$$

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

The electric power utility companies measure energy in watt-hours (W · h), where

$$1 \text{ W} \cdot \text{h} = 3\,600 \text{ J}$$

## 1.5 Summary

1. An electric circuit consists of electrical elements connected together.
2. Current is the rate of charge flow.

$$i = \frac{dq}{dt}$$

3. Voltage is the energy required to move 1C of charge through an element.

$$u = \frac{dw}{dq}$$

4. Power is the energy supplied or absorbed per unit time. It is also the product of voltage and current.

$$p = \frac{dw}{dt} = ui$$

5. According to the passive sign convention, power assumes a positive sign when the current enters the positive polarity of the voltage across an element.

## New Words and Expressions

electromagnetic *a.* 电磁的  
 topology *n.* 拓扑, 拓扑学  
 underlying *a.* 基本的  
 conventionally *ad.* 按照惯例  
 with respect to 关于, 至于  
 deliver *v.* 送, 传; 释放  
 conform with 符合, 依照  
 instant *n.* 时刻

fundamental *a.* 基本的  
 commence *v.* 着手, 开始  
 shock *n.* 电击, 打击  
 coulomb *n.* 库仑 (电荷的单位,  $1\text{C} = 1\text{A} \cdot \text{s}$ )  
 instantaneous *a.* 瞬间的, 即时的  
 expend *v.* 消耗, 花费  
 algebraic *a.* 代数的, 关于代数学的  
 confirm *v.* 确认, 确定

## Notes

- ① Circuit theory is also valuable to students specializing in other branches of the physical sciences because circuits are a good model for the study of energy systems in general, and because of the applied mathematics, physics, and topology involved.  
 电路理论对于专门研究自然科学其他分支的学生来说也十分有价值, 因为电路一般可以很好地作为能量系统研究的模型, 并且电路理论涉及应用数学、物理学和拓扑学的相关知识。
- ② Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).  
 电荷是组成物质的原子微粒所具有的电气属性, 其单位为库伦。

- ③ The common term *signal* is used for an electric quantity such as a current or a voltage when it is used for conveying information.

当像电流或电压这样的电量用于传递信息时,常称这个电量为信号。

## Exercises

### I. Translate the following phrases into English

- |         |         |            |
|---------|---------|------------|
| 1. 电路   | 2. 电气工程 | 3. 电机      |
| 4. 自然科学 | 5. 电气设备 | 6. 电气元件    |
| 7. 正电荷  | 8. 负电荷  | 9. 直流      |
| 10. 交流  | 11. 电压  | 12. 导体     |
| 13. 功   | 14. 电动势 | 15. 电势差    |
| 16. 功率  | 17. 极性  | 18. 能量守恒定律 |

### II. Answer the following questions according to the text

1. What is the most basic quantity in an electric circuit?
2. What is the feature of electric charge or electricity?
3. How is electric current created?
4. What is a DC?
5. What is an AC?
6. How does power transmit if the power has a + sign?

### III. Translate the following sentences into Chinese

1. An electric circuit is an interconnection of electrical elements.
2. Electric current is the time rate of change of charge.
3. Voltage (or potential difference) is the energy required to move a unit charge through an element, measured in volts (V).
4. Power is the time rate of expending or absorbing energy, measured in watts (W).
5. The power absorbed or supplied by an element is the product of the voltage across the element and the current through it.
6. Energy is the capacity to do work, measured in joules (J).
7. The total power supplied to the circuit must balance the total power absorbed.

## 2 Basic Laws of Electric Circuits

### 2.1 Introduction

Unit one introduced basic concepts such as current, voltage, and power in an electric circuit. To actually determine the values of these variables in a given circuit requires understanding some fundamental laws that govern electric circuits. These laws, known as Ohm's Law and Kirchhoff's Laws, form the foundation upon which electric circuit analysis is built. <sup>①</sup>

### 2.2 Ohm's Law

Materials in general have a characteristic behavior of resisting the flow of electric charge. This physical property, or ability to resist current, is known as *resistance* and is represented by the symbol  $R$ . The resistance of any material with a uniform cross-sectional area  $A$  depends on  $A$  and its length  $l$ , as shown in Fig. 2.1 (a). We can represent resistance (as measured in the laboratory), in mathematical form,

$$R = \rho \frac{l}{A} \quad (2.1)$$

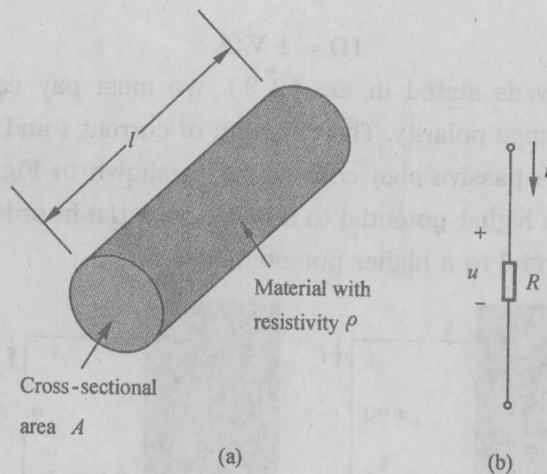


Fig. 2.1 Diagrams of:

(a) Resistor; (b) Circuit symbol for resistance

where  $\rho$  is known as the *resistivity* of the material in ohm-meters. Good conductors, such as copper and aluminum, have low resistivities, while insulators, such as mica and paper, have high resistivities. The resistivity of semiconductors, such as carbon and silicon, is between those of conductors and insulators.

The circuit element used to model the current-resisting behavior of a material is the



*resistor*. For the purpose of constructing circuit, resistors are usually made from metallic alloys and carbon compounds. The circuit symbol for the resistor is shown in Fig. 2.1(b), where  $R$  stands for the resistance of the resistor. The resistor is the simplest passive element.

Georg Simon Ohm (1787—1854), a German physicist, is credited with formulating the current-voltage relationship for a resistor. ② This relationship is known as *Ohm's Law*.

Ohm's Law states that the voltage  $u$  across a resistor is directly proportional to the current  $i$  flowing through the resistor.

That is,

$$u \propto i \quad (2.2)$$

Ohm defined the constant of proportionality for a resistor to be the resistance,  $R$ . (The resistance is a material property which can change if the internal or external conditions of the element are altered, e. g., if there are changes in the temperature.) Thus, Eq. (2.2) becomes

$$u = iR \quad (2.3)$$

which is the mathematical form of Ohm's Law.  $R$  in Eq. (2.3) is measured in the unit of ohms, designated  $\Omega$ . Thus, the resistance  $R$  of an element denotes its ability to resist the flow of electric current; it is measured in ohms ( $\Omega$ ).

We may deduce from Eq. (2.3) that

$$R = \frac{u}{i} \quad (2.4)$$

so that

$$1\Omega = 1\text{ V/A}$$

To apply Ohm's Law as stated in Eq. (2.3), we must pay careful attention to the current direction and voltage polarity. The direction of current  $i$  and the polarity of voltage  $u$  must conform with the passive sign convention, as shown in Fig. 2.2(b). This implies that current flows from a higher potential to a lower potential in order for  $u = iR$ . If current flows from a lower potential to a higher potential,  $u = -iR$ .

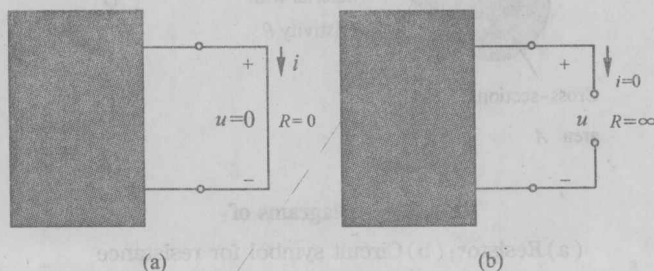


Fig. 2.2 An element with:

(a) Short circuit ( $R=0$ ); (b) Open circuit ( $R=\infty$ )

The reciprocal of resistance  $R$  is named as conductance  $G$ .

Since the value of  $R$  can range from zero to infinity, it is important that we consider the two extreme possible values of  $R$ . An element with  $R=0$  is called a *short circuit*, as