专业英语系列教材

English
for
Automation
Science
and
Technology

自动化专业英语

English for Automation Science and Technology

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副主编 周克良 廖高高

华中科技大学出版社
http://www.hustp.com

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图书在版编目(CIP)数据

自动化专业英语/任金霞　何小阳　主编.—武汉:华中科技大学出版社,2008年11月
ISBN 978-7-5609-5004-4

Ⅰ.自…　Ⅱ.①任…　②何…　Ⅲ.自动化-英语-高等学校-教材　Ⅳ.H31

中国版本图书馆CIP数据核字(2008)第180016号

自动化专业英语　　任金霞　何小阳　主编

策划编辑:杨　鸥
责任编辑:汪　漾　　封面设计:潘　群
责任校对:张　琳　　责任监印:周治超

出版发行:华中科技大学出版社(中国·武汉)
武昌喻家山　邮编:430074　电话:(027)87557437

印　刷:湖北恒泰印务有限公司

开本:787mm×1092mm　1/16　印张:10.25　字数:260 000
版次:2008年11月第1版　印次:2008年11月第1次印刷　定价:18.00元
ISBN 978-7-5609-5004-4/H·643

内容提要

全书由电路电子及电气技术、控制理论、计算机控制系统、自动化技术前沿等4个部分组成，共30个单元。每个单元包括课文、生词短语、注释和练习。本书精选了电力电子技术、电机、自动控制理论、计算机控制、过程控制、智能机器人、现场总线、无线传感网络、神经网络与模糊控制以及网络控制等方面的科技文献，并在每个部分后面介绍了专业英语的特点、科技文献的阅读和翻译、科技文摘的写作方法等科技英语学习中的实用基础知识。

本书选材广泛、内容丰富、实用性强，既可作为自动化、电子信息工程、电气工程、机电一体化等相关专业本科生、研究生使用的专业英语教材，也可作为具有一定英语基础的电子、电气工程、自动化和机电等相关专业人员的参考书。

前　言

自动化是目前国际国内发展最为迅速、技术更新最为活跃的工程领域之一。面对日趋激烈的国际化竞争，自动化专业的学生应具备专业英语阅读、翻译和写作的能力。编著本书的主要目的是扩充学生的专业词汇量，提高学生阅读和翻译科技英语资料的能力，扩展和深化学生对本学科关键技术的认识，培养具有国际竞争力的技术人才。

全书由电路电子及电气技术、控制理论、计算机控制系统、自动化技术前沿等4个部分组成，共30个单元，基本覆盖了自动化专业课程的所有内容，并有所拓宽和延伸。每个部分后面还精选了科技英语的相关阅读材料，介绍了专业英语的特点、科技文献的阅读、科技文献的翻译、科技英语文摘写作方法等科技英语学习中的实用基础知识。而每个单元除课文之外，还配有生词短语、注释和练习。课文侧重展示本领域的关键技术，扩展和深化学生对本学科的认识；注释旨在解决课文中英语语言难点和专业知识难点；练习主要围绕课文内容，加深学生对课文的理解，同时进行翻译实践的训练。

本书选材广泛、内容丰富，根据专业学习的不同阶段，按基础知识、专业基础知识、专业知识和专业拓宽知识来划分学习内容，具有良好的学习系统性。文章选材着重于自动化领域的基础理论、设计方法和工程应用，具有鲜明的实用性。课文的选择力求反映当今先进的专业发展水平，使学生既能从中提高科技英语的水平及应用技能，又能扩大视野，了解国内外专业领域的发展动态。本书不仅适合学生在校作为教材使用，而且可以作为具有一定英语基础的电子、电气工程、自动化和机电等相关专业人员的参考书。

本书由江西理工大学的任金霞、广西大学的何小阳担任主编，江西理工大学的周克良、廖高高任副主编。其中Unit 6、Unit 14、Unit 23 、Unit 25、Unit 26 、Unit 29及专业英语知识介绍由何小阳编写，Unit 1、Unit 2、Unit 3、Unit 4 、Unit 5、Unit 8、Unit 15、Unit 16由周克良和廖高高编写，其余部分均由任金霞编写。全书由任金霞与何小阳共同审订。在编写过程中，研究生杨赛参与了部分文字录入与部分插图的绘制，此外还得到了许多同事及华中科技大学出版社编辑们的关心和帮助，在此向他们表示诚挚的谢意。

本书的内容大部分选自国外原版教材及著名公司网站提供的技术性应用文章，也有部分引用了国内其他自动化专业英语的教科书，在此谨向摘用文章的全体作者和出版社表示感谢和敬意。

由于编者的水平有限，书中的疏漏或谬误之处在所难免，敬请广大读者批评指正。

编　者

2008年9月

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Contents

PART Ⅰ CIRCUIT, ELECTRONIC AND ELECTRICAL TECHNOLOGY

Unit 1 Circuit Variables and Circuit Elements

Voltage and Current

The concepts of voltage and current are useful from an engineering point of view because they can be expressed quantitatively.① The electric charge is the basis for describing all electrical phenomena. The charge is bipolar, meaning that electrical effects are described in terms of positive and negative charges. In circuit theory, the separation of charge creates an electric force (voltage), and the motion of the charge creates an electric fluid (current). Whenever positive and negative charges are separated, energy is expended.② Voltage is the energy per unit charge created by the separation. We express this ratio in a differential form as

$$v=\frac{\mathrm{d}w}{\mathrm{d}q} \tag{1.1}$$

where v = the voltage in volts,

w = the energy in joules,

q = the charge in coulombs.

The electrical effects caused by charges in motion depend on the rate of the charge flow. The flow of charge flow is known as the electric current, which is expressed as

$$i=\frac{\mathrm{d}q}{\mathrm{d}t} \tag{1.2}$$

where i = the current in amperes,

q = the charge in coulombs,

t = the times in seconds.

Equation (1. 1) and (1. 2) are definitions for magnitude of voltage and current, respectively. Though current is made up of discrete, moving electrons, we do not need to consider them individually because of the enormous numbers of them. Rather, we can think of electrons and corresponding charge as one smoothly flowing entity. Thus, i is treated as a continuous variable.

The bipolar nature of electric charge requires that we assign polarity references to these variables. The assignments of the reference polarity for voltage and the reference for current are entirely arbitrary. However, once you have assigned the reference, you must write all subsequent equations to agree with the chosen references. The most widely used sign convention applied to these references is called the passive sign convention,③ which can be stated as follows:

Whenever the reference direction for the current in an element is in the direction of the reference voltage drop across the element, use a positive sign in any expression that relates the voltages to the current. Otherwise, use a negative sign.

The Ideal Basic Circuit Element

An ideal basic circuit element has three attributes: (1) it has only two terminals, which are points of connection to other circuit components; (2) it is described mathematically in terms of voltage and current; (3) it cannot be subdivided into other elements. We use the word ideal to imply that a basic circuit element does not exist as a realizable physical component. We use the word basic to imply that the circuit element cannot be further reduced or subdivided into other elements. Thus the basic circuit elements form the building blocks for constructing circuit models, but they themselves cannot be modeled with any type of element. There are five ideal basic circuit elements: voltage sources, current sources, resistors, inductors, and capacitors. An active element is one that models a device capable of generating electric energy. Passive elements model physical devices that cannot generate electric energy. Resistors, inductors and capacitors are examples of passive circuit elements.

Voltage and Current Sources

An ideal voltage source is a circuit element that maintains a prescribed voltage across its terminals regardless of the current flowing in those terminals. Similarly, an ideal current source is a circuit element that maintains a prescribed current across its terminals regardless the voltage across those terminals. These circuit elements do not exist as practical devices—they are idealized models of actual voltage and current sources.

Ideal voltage and current source can be further described as either independent sources or dependent sources. An independent source establishes a voltage or current in a circuit without relying on voltages and currents elsewhere in the circuit. The value of the voltage or current supplied is specified by the value of the independent sources alone. In contrast, a dependent source establishes a voltage or current whose value depends on the value of voltage or current elsewhere in the circuit. You cannot specify the value of a dependent source unless you know the value of the voltage or current on which it depends on.

The circuit symbols for the ideal independent sources are shown in Figure 1. 1. Note a circle is used to represent an independent source.

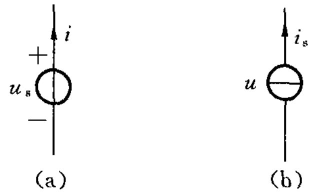

Figure 1. 1 The circuit symbols

(a) an ideal independent voltage source;
(b) an ideal independent current source

The circuit symbols for the ideal dependent sources are shown in Figure 1. 2. A diamond is used to represent an dependent source. Both the dependent current source and the dependent voltage source may be controlled by either a voltage or a current elsewhere in the circuit, so there are a total of four variations, as indicated by the symbols in Figure 1. 2. Dependent sources are sometimes called controlled sources.

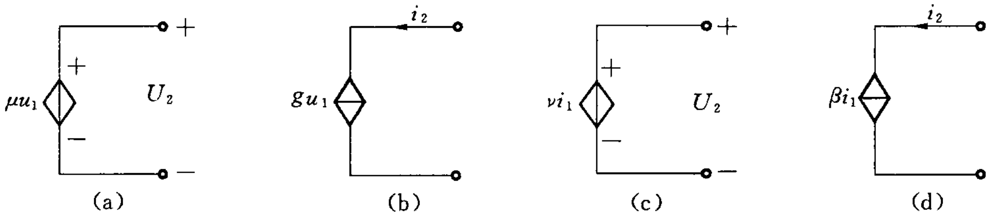

Figure 1.2 The circuit symbol for ideal dependent voltage sources
(a) VCVS; (b) VCCS; (c) CCVS; (d) CCCS

Electrical Resistance (Ohm's Law)

Resistance is the capacity of materials to impede the flow of current or, more specifically, the flow of the electric charge. The circuit element used to model this behavior is the resistor. Figure 1.3 shows the circuit symbol for the resistor. In SI units, resistance is measured in ohms, The Greek letter omega (Ω) is the standard symbol for an ohm.

Figure 1.3 The circuit symbol for a resistor

Most materials exhibit measurable resistance to current. The amount of the resistance depends on the material. Metals such as copper or aluminum have small values of resistance, making them good choices for wiring used to conduct electric current. In fact, when represented in a circuit diagram, copper or aluminum isn't usually modeled as a resistor; the resistance of the wire is so small compared to the resistance of other elements in the circuit that we can neglect the wiring resistance to simplify the diagram. ④

Ohm law is the algebraic relationship between voltage and current for a resistor, which states that the voltage across the resistor is equal to the current through the resistor multiplied by the value of the resistance. Mathematically, this is expressed as

$$u = iR \tag{1.3}$$

where

u = the voltage in volts,

i = the current in amperes,

R = the resistance in ohms.

Equation (1.3) expresses the voltage as a function of the current. However, expressing the current as a function of the voltage is also convenient. Thus,

$$i = \frac{u}{R} \tag{1.4}$$

The Inductor

An inductor (Figure 1.4) is an electrical component that opposes any change in electrical current. It is composed of a coil of wire wound around a supporting core whose material may be magnetic or nonmagnetic. The behavior of inductors is based on phenomena associated with magnetic fields. The source of the magnetic field is varying with time. A time-varying magnetic field induces a voltage in any conductor linked by the field. The

Figure 1.4 The graphic symbol for an inductor

circuit parameter of inductance relates the induced voltage to the current.

Inductance is the circuit parameter used to describe an inductor. Inductance is symbolized by the letter L, measured in henrys (H), and is represented graphically as a coiled wire—a reminder that inductance is a consequence of a conductor linking a magnetic field. ⑤ The voltage across a pure inductor is defined by Faraday's law, which states the voltage across the inductor is proportional to the rate of change with time of the current through the inductor. Thus we have

$$u = L\frac{\mathrm{d}i}{\mathrm{d}t} \tag{1.5}$$

where u is measured in volts, L in henrys, i in amperes, and t in seconds.

The Capacitor

A capacitor (Figure 1. 5) is an electrical component that consists of two conductors separated by an insulator or dielectric material. The capacitor is the only device other than a battery that can store electrical charge. The behavior of capacitor is based in phenomena associate with electric fields. The source of the electric field is separation of charge, voltage. If the voltage is varying with time, the electric field is varying with time. The circuit parameter of capacitance relates the displacement current to the voltage, where the displacement current is equal to the conduction current at the terminals of the capacitor. ⑤

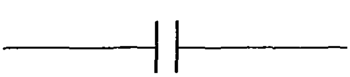

Figure 1. 5 The graphic symbol for a capacitor

The circuit parameter of capacitance is represented by the letter C, measured in farads (F), and is symbolized graphically by two short parallel conductive plates. Because the farad is an extremely large quantity of capacitance, practical capacitor values usually lie in the picofarad (pF) to microfarad (μF) range.

The graphic symbol for a capacitor is a reminder that capacitance occurs whenever electrical conductors are separated by a dielectric, or insulating, material. This condition implies that electric charge is not transported through the capacitor. Although applying a voltage to the terminals of the capacitor cannot move a charge through the dielectric; it can displace a charge within the dielectric. As the voltage varies with time, the displacement of charge also varies with time, causing is known as displacement current.

At the terminals, the displacement current is indistinguishable from a condition current. The current is proportional to the rate at which the voltage across the capacitor varies with time, or, mathematically,

$$i = C\frac{\mathrm{d}u}{\mathrm{d}t} \tag{1.6}$$

Where i is measured in amperes, C in farads, u in volts, and t in seconds.

Energy can be stored in both magnetic and electric fields. Hence you should not be too surprised to learn that inductors and capacitors are capable of storing energy. For examples, energy can be stored in an inductor and then released to fire spark plug. Energy can be stored in capacitors and then released to fire a flashbulb. In ideal inductors and capacitors, only as much energy can be extracted as has been stored. Because inductors and capacitors cannot generate energy, they are classified as passive elements.

Key Words and Terms

1.	quantitatively	*adv.*	数量上	2.	phenomena	*n.*	现象
3.	expend	*vt.*	花费，消耗，用光	4.	differential	*adj.*	微分的
5.	magnitude	*n.*	大小，数量，量级，幅度	6.	discrete	*adj.*	不连续的，离散的
7.	continuous variable		连续变量	8.	references	*n.*	参考，索引，参照
9.	assignment	*n.*	分配，委派，任务	10.	arbitrary	*adj.*	任意的
11.	convention	*n.*	协定，习俗，惯例	12.	attribute	*n.*	属性，标志，定语
13.	component	*n.*	元件，组件	14.	resistor	*n.*	电阻(元件)
15.	inductor	*n.*	电感(元件)	16.	capacitor	*n.*	电容(元件)
17.	prescribed	*adj.*	规定的，指定的	18.	algebraic	*adj.*	代数的，代数学的
19.	magnetic	*adj.*	磁的，有磁性的，有吸引力的	20.	field	*n.*	场
21.	dielectric	*adj.*	不导电的，绝缘的				

Notes

① The concepts of voltage and current are useful from an engineering point of view because they can be expressed quantitatively.

根据工程学的观点，电压和电流的概念非常有用，因为它们可以用数量表示。

② Whenever positive and negative charges are separated, energy is expended.

无论何时，正电荷和负电荷分开时都需要消耗能量(电场要做功)。

③ The most widely used sign convention applied to these references is called the passive sign convention.

这种最常用的参考方向的符号约定称为无源符号约定。

④ In fact, when represented in a circuit diagram, copper or aluminum isn't usually modeled as a resistor; the resistance of the wire is so small compared to the resistance of other elements in the circuit that we can neglect the wiring resistance to simplify the diagram.

实际上，铜或铝导线在电路图中通常不被模型化为电阻，因为导线电阻相对于电路中其他元件的阻值而言太小，因此我们会忽略导线的阻值来简化电路图。

⑤ Inductance is symbolized by the letter L, measured in henrys (H), and is represented graphically as a coiled wire—a reminder that inductance is a consequence of a conductor linking a magnetic field.

电感用字母 L 表示，单位为亨利(H)，图形符号用线圈表示，这表明电感是一个导线连接磁场的结果。

a reminder 补充说明 *a coiled wire*，其后跟一由 *that* 引导的同位语从句。*reminder* 由名词转换为动词，译为“表明”。

⑥ The circuit parameter of capacitance relates the displacement current to the voltage, where the displacement current is equal to the conduction current at the terminals of the capacitor.

电路的电容参数将位移电流与电压联系起来，这里的位移电流等于电容两端的传导电流。*relate A to/with B* 意思是将（两事物）联系起来。

Exercises

1. After reading the text, please state the sign convention that is most widely used.
2. According to the passage, give the definition of the passive element and state some passive elements.
3. What is the relationship between voltage and current?
4. After reading the text, discuss the characteristics of the inductor.
5. After reading the text, discuss the characteristics of the capacitor.

Unit 2 Techniques of Circuit Analysis

Kirchhoff's Law

A circuit is said to be solved when the voltage across and the current in every element have been determined. Ohm's law is an important equation for deriving such solutions. In simple circuit structures, Ohm's law is sufficient for solving the voltages across and the currents in every element. However, for more complex interconnections we need to use two more important algebraic relationships, known as Kirchhoff's laws, after Gustav Kirchhoff, who first stated them in a paper published in 1848. The two laws that state the constraints in mathematical form are known as Kirchhoff's current law and Kirchhoff's voltage law.

It is necessary to identify nodes in order to use Kirchhoff's current law. A node is a point where two or more circuit element meet. And Kirchhoff's current law can be stated as: the algebraic sum of all the current at any node in a circuit equals zero.

In Figure 2. 1, the nodes are labeled a, b, c, d. To use Kirchhoff's current law, an algebraic sign corresponding to a reference direction must be assigned to every current at the nodes. Assigning a positive sign to a current leaving a node requires assigning a negative sign to a current entering a node. Conversely, giving a negative sign to a current leaving a node requires giving a positive sign to a current entering a node. ① Applying Kirchhoff's current law to the four nodes in Figure 2. 1, using the convention that currents leaving a node are considered positive, yields four equations.

Node a $I_s - I_3 = 0$

Node b $I_3 + I_2 = 0$

Node c $-I_2 - I_1 = 0$

Node d $I_1 - I_s = 0$

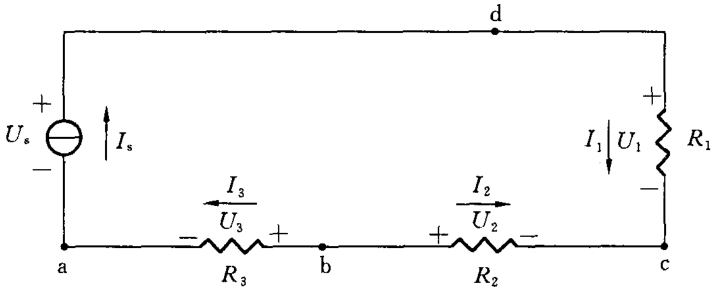

Figure 2. 1 Circuit diagram

Before we can state Kirchhoff's voltage law, we must define a closed path or loop. Starting at an arbitrarily selected node, we trace a closed path in a circuit through selected basic circuit elements and return to the original node without passing through any intermediate node more than once. ② The circuit shown in the Figure 2. 1 has only one closed path or loop. For example, choosing Node a as start point and tracing the circuit clockwise. We form the closed path by moving through Nodes d, c, b, and back to Node a. We can now state Kirchhoff's voltage law: the algebraic sum of all the voltages around any closed path in a circuit equals zero.

We now apply Kirchhoff's voltage law to the circuit shown in Figure 2. 1. We select to trace the closed path clockwise, assigning a positive sign to voltage drops. Starting at Node d leads to the expression:

$$U_3 - U_2 + U_1 - U_s = 0$$

Mesh-Current Method

In the mesh current method, you will work with loop currents instead of branch currents. A branch current is the actual current through a branch. An ammeter placed in a given branch will measure the branch current. Loop currents are different because they are mathematical quantities that are used to make circuit analysis somewhat easier than with the branch current method. The term mesh comes from the fact that a multiple-loop circuit, when drawn, can be imagined to resemble a wire mesh. ③ The method of mesh analysis is given in the following steps.

Step1. Although direction of an assigned loop current is arbitrary, we will assign a current in the clockwise direction around each nonredundant closed loop, for consistency. This may not be the actual current direction, but it does not matter. The number of loop-current assignments must be sufficient to include current through all components in the circuit.

Step2. Indicate the voltage drop polarities in each loop based on the assigned current directions.

Step3. Apply Kirchhoff's voltage law around each closed loop. When more than one loop current passes through a component, include its voltage drop. This results in one equation for each loop.

Step4. Using substitution or determinants solve the resulting equation for the loop currents.

As shown in Figure 2. 2, first, the loop currents I_1 and I_2 are assigned in the clockwise direction. A loop current could be assigned around the outer perimeter of the circuit, but this would be redundant since I_1 and I_2 already pass through all of the components. Second, the polarities of the voltage drops across R_1, R_2 and R_3 are shown based on the loop-current directions. Notice that I_1 and I_2 are in opposite directions through R_2 because R_2 is common to both loops. Therefore, two voltage polarities are indicated. In reality, the R_2 current cannot be

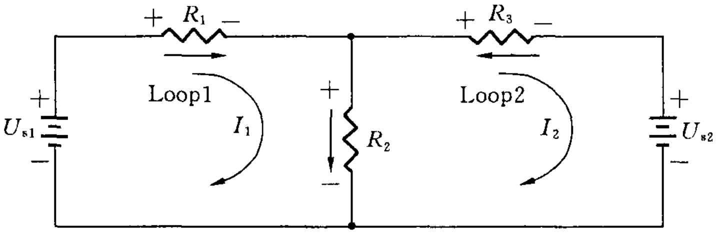

Figure 2. 2 Example of circuit diagram for mesh analysis method

separated into two parts, but remember that the loop currents are basically mathematical quantities used for analysis purposes. The polarities of the voltage sources are fixed and are not affected by the current assignments. Third, Kirchhoff's voltage law applied to the two loops results in the following two equations:

$$\text{for Loop 1} \qquad R_1 I_1 + R_2(I_1 - I_2) = U_{s1}$$

$$\text{for Loop 2} \qquad R_3 I_2 + R_2(I_2 - I_1) = -U_{s2}$$

Notice that I_1 is positive in Loop 1 and I_2 is positive in Loop 2. Fourth, the like terms in the equations are combined and rearranged into a form for convenient solution so that they have the same position in each equation, that is, the I_1 term is first and the I_2 term is second. The equations are rearranged into the following form. Once the loop currents are evaluated, all of the branch currents can be determined.

$$\text{for Loop 1} \qquad (R_1 + R_2)I_1 - R_2 I_2 = U_{s1}$$

$$\text{for Loop 2} \qquad -R_2 + (R_2 + R_3)I_2 = -U_{s2}$$

Node Voltage Method

Another method of analysis of multiple-loop circuits is called the node voltage method. It is based on finding the voltages at each node in the circuit using Kirchhoff's current law. A node is the junction of two or more components. The general steps for the node voltage method of circuit analysis are as follows.

Step1. Determine the number of nodes.

Step2. Select one node as a reference. All voltages will be relative to the reference node. Assign voltage designations to each node where the voltage is unknown.

Step3. Assign currents at each node where the voltage is unknown, except at the reference node. The directions are arbitrary.

Step4. Apply Kirchhoff's current law to each node where currents are assigned.

Step5. Express the current equations in terms of voltage, and solve the equations for the unknown node voltages using Ohm's law.

We will use Figure 2.3 to illustrate the general approach to node voltage analysis. First, establish the nodes. In this case, there are four nodes, as indicated in the figure. Second, let's use Node b as the reference. Think of it as the circuit's reference ground. Node voltages c and d are already known to be the source voltages. The voltage at Node a is the only unknown; it is designated as U_a. Third, arbitrarily assign the branch currents at Node a as indicated in the figure. Fourth, the Kirchhoff current equation at Node a is

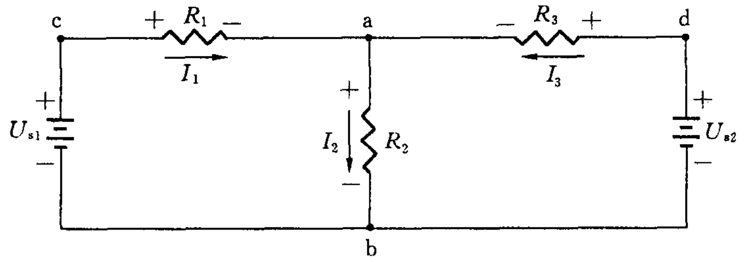

Figure 2.3 Example of circuit diagram for node voltage method