21 世纪高等院校电气工程与自动化规划教材
21 century institutions of higher learning materials of Electrical Engineering and Automation Planning

English in Electrical Engineering and Automation

电气工程与自动化专业英语

李军 王斌 编著

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Ⅰ. ①电… Ⅱ. ①李… ②王… Ⅲ. ①电气工程－英语－高等学校－教材②自动化技术－英语－高等学校－教材 Ⅳ. ①H31

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内 容 提 要

本书针对高等工科院校电气工程和自动化专业“科技英语”阅读的需要而编写，内容包括电气与电子工程基础、电机控制、自动控制基础及先进控制 4 个部分共 15 章，涵盖和反映了电气工程和自动化专业的发展动态，内容系统全面，选材新颖精炼。每章由基础知识（Text A）和进阶阅读（Text B）两部分组成，文中的专业词汇和长句难句以脚注和注释的形式进行了编排，以便于对照学习，每篇文章附有相应的词汇和段落翻译习题，每章章末还配有科技英语常见语法知识、专业文献篇章结构及相应的概念和定义的规范和准确描述、理论和方法的逻辑关系、事实和实验的客观分析、专业演讲文稿的写作等内容，共 15 篇。这样，学生在阅读和撰写实际的专业文献时，能更好地理解与把握科技论文的内容和表达规范。

本书可作为电气工程类和信息工程类相关专业本科生和研究生专业英语课程的教材，也可供相关的工程技术人员参考、学习、培训使用。

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PREFACE

前 言

随着我国工业化水平的不断提高和技术的不断发展，我国迫切需要专业技术精、英语能力强的电气工程和自动化技术人才，以满足研发具有自主知识产权的高精尖产品和改造落后产业的需要。对相应的专业英语课程提出了更高的要求：要以国际化的视野学习和理解专业知识、获取新的专业科技信息，了解和掌握专业发展动态和方向，参与国际科技交流和合作。以这些目的来看，专业英语是一门集英语、专业和科技信息学为一体的交叉课程，是英语学习的高级阶段。

本书内容以电气与电子技术、电机控制、自动控制系统三大模块的基础内容为核心，通过对近年来国际经典教材和文献刊物进行精选，力图涵盖电气工程及自动化专业的基础知识并反映专业发展的前沿动态；同时每章最后配有科技英语常见语法知识、专业文献篇章结构及相应的概念和定义的规范和准确描述、理论和方法的逻辑关系、事实和实验的客观分析、专业演讲文稿的写作等内容，以期满足专业英语课程提出的高要求，具体体现在以下方面：

第一，书中核心内容突出、前沿知识广泛。本书既强调电气工程与自动化专业的电气电子技术、电机控制、自动控制系统的基础知识，又涉及自适应控制、预测控制、神经网络控制、模糊控制、人工智能控制和机器人等前沿技术领域。

第二，对近年来国际经典英文教材和文献刊物进行取材时，在体现专业英语语言学习纯正性和规范性的同时，特别注意专业知识的系统性、完整性和一致性，以保证书中内容的深广度和先进性。本书既是一本专业英语课程的教科书，又是一本专业知识的参考书，适用于高等学校电气工程与自动化专业的本科生和研究生的教学。

第三，书中选取较为新颖的专业英语语法、专业论文篇章结构和专业演讲文稿撰写等英语知识，以加强对学生专业英语阅读理解能力的培养，提高参与国际科技交流和合作的能力。我们希望这在丰富本书内容的同时，有助于培养学生的综合能力。

第四，本书提供了大量的专业术语翻译，对长句和难点进行了注释，以方便学生自学和对照阅读。

第五，考虑到本书是作为电气工程类和信息工程类相关专业本科生和研究生专业英语课程两个层次的教材，作者对第四篇先进控制系统的练习提高了要求，增加了针对课文内容撰写论文摘要、按计算方法的格式书写算法、按控制工程的要求描述实验流程、按研讨会演讲的要求归纳课文内容等内容，以更加适应研究生英语教学需要。

本书提供了丰富的电气工程和信息工程类专业英语内容，把英语和专业知识进

行了系统的融合。希望学生能从英语的角度了解用另一种语言观察和认知世界的方法和习惯，熟悉起源于西方的科学技术在规范表达和准确描述、理论方法和逻辑关系、实验事实和客观分析等方面的知识，从而加快接触和学习世界先进科学技术成果的进程，提高参与国际交流和合作的能力，获得综合素质的全面发展。

本课程的教学课时数为32，各章的参考教学课时见以下的课时分配表。

篇	章	课程内容	课时分配
第1篇 Electrics and Electronics	第1章	Analog Signal Processing	2
	第2章	Circuit Analysis	2
	第3章	Signals and Systems	2
	第4章	Operational Amplifiers and Sampling Theorem	2
第2篇 Electric Motors and Drives	第5章	DC Motor Steady-State and Transient Analysis	2
	第6章	DC Motor Drives	2
	第7章	Operating Characteristics and Equivalent Circuit of Induction Motors	2
	第8章	Stepping Motor Characteristics and Drives	2
第3篇 Fundamental of Control Systems	第9章	Control Systems Basics	2
	第10章	Classical Control System Design	2
	第11章	Modern Control System Design	2
	第12章	MIMO Systems	2
第4篇 Advanced Control Systems	第13章	Adaptive Control and Predictive Control	2
	第14章	Fuzzy Control and ANN Control Systems	2
	第15章	AI Control for Robots	4
课时总计			32

本书由重庆大学自动化学院李军副教授和王斌副教授编著，其中李军编写了第9～15章，王斌编写了第1～8章。本书在编写中引用的文献资料均已在参考文献中列出，在此向原作者表示衷心的感谢。

由于编者水平有限，书中难免存在错误和不妥之处，希望广大读者批评指正。

编 者

2015年3月

CONTENTS

目 录

Part 1 Electrics and Electronics

CONTENTS

Part 2 Electric Motors and Drives

Part 3 Fundamental of Control Systems

CONTENTS

Part 4 Advanced Control Systems

Part 1

Electrics and Electronics

This part concentrates on the following themes: analog signal processing, circuit analysis, signals and systems, and operational amplifiers. This part describes how electrical signals represent information and circuit interconnection laws.

Chapter 1 Analog Signal Processing

This chapter introduces the fundamental circuit elements, equivalent circuits and circuit interconnection laws. It is important to understand how physical elements operate in the real-world and how a circuit connects generic elements to transform the input signal into output signal.

Text A Circuit Elements and Interconnection Laws

1.1 Generic Circuit Elements

Knowing that information can be represented by signals, what we need to understand is how signals are physically realized. Over the years, electric signals have been found to be the easiest to use. Voltages and currents comprise the electric instantiations of signals. Thus, we need to delve into the world of electricity and electromagnetism. The systems used to manipulate electric signals directly are called circuits, and they refine the information representation or extract information from the voltage or current. In many cases, they make nice examples of linear systems.

A generic circuit element places a constraint between the classic variables of a circuit: voltage and current. Voltage is electric potential and represents the "push" that drives electric charge from one place to another. What causes charge to move is a physical separation between the positive and negative charge. A battery generates, through electrochemical means, excess positive charge at one terminal and negative charge at the other, creating an electric field. Voltage is defined across a circuit element, with the positive sign denoting a positive voltage drop across the element. When a conductor connects the positive and negative potentials, current flows, with positive current indicating that positive charge flows from the positive terminal to the negative.① Electrons comprise current flow in many cases. Because electrons have

① When a conductor connects the positive and negative potentials, current flows, with positive current indicating that positive charge flows from the positive terminal to the negative.

译文：当一个导体连接正负极，电流产生，正电流表示正电荷从正极流向负极。

a negative charge, they move in the opposite direction of positive current flow: Negative charge flowing to the right is equivalent to positive charge moving to the left.

It is important to understand the physics of current flow in conductors to appreciate the innovation of new electronic devices. Electric charge can arise from many sources, the simplest being the electron. When we say that "electrons flow through a conductor," what we mean is that the conductor's constituent atoms freely give up electrons from their outer shells. "Flow" thus means that electrons hop from atom to atom driven along by the applied electric potential. A missing electron, however, is a virtual positive charge. Electrical engineers call these holes, and in some materials, particularly certain semiconductors, current flow is actually caused by them. Current flow also occurs in nerve cells found in our brain. Here, neurons "communicate" using propagating voltage pulses that rely on the flow of positive ions (potassium and sodium primarily, and to some degree calcium) across the neuron's outer wall. Thus, current can come from many sources, and circuit theory can be used to understand how current flows in reaction to electric fields.

Current flows through circuit elements, as depicted in Figure 1.1, and through conductors, which we indicate by lines in circuit diagrams. For every circuit element we define a voltage and a current. The element has a v-i relation defined by the element's physical properties. In defining the *v-i* relation, we have the convention that positive current flows from positive to negative voltage drop. Voltage has units of volts, and both the unit and the quantity are named after Volta. Current has units of amperes, and is named after the French physicist Ampère.

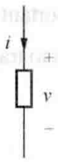

Figure 1.1 The generic circuit element.

Voltages and currents also carry power. Again using the convention shown in Figure 1.1 for circuit elements, the instantaneous power at each moment of time consumed by the element is given by the product of the voltage and current.

$$p(t)=v(t)i(t) \tag{1.1}$$

A positive value for power indicates that at times the circuit element is consuming power; a negative value means it is producing power.[①] With voltage expressed in volts and current in amperes, power defined this way has units of watts. Just as in all areas of physics and chemistry, power is the rate at which energy is consumed or produced. Consequently, energy is the integral of power.

$$E(t)=\int_{-\infty}^{t} p(\alpha)\mathrm{d}\alpha \tag{1.2}$$

Again, positive energy corresponds to consumed energy and negative energy corresponds to energy production. Note that a circuit element having a power profile that is both positive and negative over some intervals could consume or produce energy according to the sign of the integral of power. The units of energy are joules since a watt equals joules/second.

1.2 Ideal Circuit Elements

The elementary circuit elements——the resistor, capacitor, and inductor——impose linear relationship

① A positive value for power indicates that at times the circuit element is consuming power; a negative value means it is producing power.
译文：功率值符号为正，表示电路元件在当前时刻下消耗功率；符号为负表示产生功率。

between voltage and current.

The resistor is far and away the simplest circuit element. In a resistor, the voltage is proportional to the current, with the constant proportionality R, known as the resistance.

$$v(t) = Ri(t) \tag{1.3}$$

Resistance has units of ohms, denoted by Ω, named after the German electrical scientist Georg Ohm. Sometimes, the v-i relation for the resistor is written as $i = Gv$, with G, the conductance, equal to 1/R. Conductance has units of Siemens (S), and is named for the German electronics industrialist Werner von Siemens.

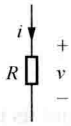

Figure 1.2 Resistor.

When resistance is positive, as it is in most cases, a resistor consumes power. A resistor's instantaneous power consumption can be written one of two ways.

$$p(t)=Ri^2(t)=\frac{1}{R}v^2(t) \tag{1.4}$$

As the resistance approaches infinity, we have what is known as an open circuit: No current flows but a non-zero voltage can appear across the open circuit.① As the resistance becomes zero, the voltage goes to zero for a non-zero current flow. This situation corresponds to a short circuit. A superconductor physically realizes a short circuit.

The capacitor stores charge and the relationship between the charge stored and the resultant voltage is $q = Cv$. The constant of proportionality, the capacitance, has units of farads (F), and is named for the English experimental physicist Michael Faraday. As current is the rate of change of charge, the v-i relation can be expressed in differential or integral form.

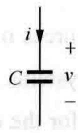

Figure 1.3 Capacitor.

$$i(t) = C\frac{\mathrm{d}v(t)}{\mathrm{d}t} \quad \text{or} \quad v(t) = \frac{1}{C}\int_{-\infty}^{t} i(\alpha)\mathrm{d}\alpha \tag{1.5}$$

If the voltage across a capacitor is constant, then the current flowing into it equals zero. In this situation, the capacitor is equivalent to an open circuit. The power consumed/produced by a voltage applied to a capacitor depends on the product of the voltage and its derivative.

$$p(t)=Cv(t)\frac{\mathrm{d}v(t)}{\mathrm{d}t} \tag{1.6}$$

This result means that a capacitor's total energy expenditure up to time t is concisely given by

$$E(t)=\frac{1}{2}Cv^2(t) \tag{1.7}$$

This expression presumes the fundamental assumption of circuit theory: All voltages and currents in any circuit are zero in the far distant past ($t=-\infty$).

The inductor stores magnetic flux, with larger valued inductors capable of storing more flux.②

① As the resistance approaches infinity, we have what is known as an open circuit: No current flows but a non-zero voltage can appear across the open circuit.

译文：当电阻无穷大，就得到所谓的开路：无电流流通，但可能存在非零电压。

② The inductor stores magnetic flux, with larger valued inductors capable of storing more flux.

译文：电感储存磁通量，电感值越大，能够储存的磁通越多。

Inductance has units of henries (H), and is named for the American physicist Joseph Henry. The differential and integral forms of the inductor's v-i relation are

$$v(t) = L\frac{\mathrm{d}i(t)}{\mathrm{d}t} \quad or \quad i(t) = \frac{1}{L}\int_{-\infty}^{t} v(\alpha)\mathrm{d}\alpha \tag{1.8}$$

The power consumed/produced by an inductor depends on the product of the inductor current and its derivative

$$p(t) = Li(t)\frac{\mathrm{d}i(t)}{\mathrm{d}t} \tag{1.9}$$

and its total energy expenditure up to time t is given by

$$E(t) = \frac{1}{2}Li^2(t) \tag{1.10}$$

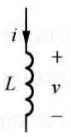

Figure 1.4 Inductor.

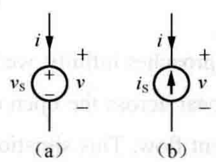

Figure 1.5 (a) The voltage source (b) the current source.

Sources of voltage and current are also circuit elements, but they are not linear in the strict sense of linear systems. For example, the voltage source's v-i relation is $v = v_s$ regardless of what the current might be. As for the current source, $i = -i_s$ regardless of the voltage. Another name for a constant-valued voltage source is battery, which can be purchased in any supermarket. Current sources, on the other hand, are much harder to acquire; we'll learn the reason for this later.

1.3 Ideal and Real-World Circuit Elements

Source and linear circuit elements are ideal circuit elements. One central notion of circuit theory is combining the ideal elements to describe how physical elements operate in the real world. For example, the 1kΩ resistor you can hold in your hand is not exactly an ideal 1 kΩ resistor. First of all, physical devices are manufactured to close to lerances (the tighter the tolerance, the more money you pay), but they never possess exactly their advertised values. The fourth band on resistors specifies their tolerance; 10% is common. More pertinent to the current discussion is another deviation from the ideal: If a sinusoidal voltage is placed acrossa physical resistor, the current will not be exactly proportional to it as frequency becomes high, say above 1 MHz. At very high frequencies, the way the resistor is constructed introduces inductance and capacitance effects.① Thus, a smart engineer must be aware of the frequency ranges over which his ideal models match reality well.

On the other hand, physical circuit elements can be readily found that well approximate the ideal, but they will always deviate from the ideal in some way. For example, a flashlight battery, like a C-cell, roughly

① At very high frequencies, the way the resistor is constructed introduces inductance and capacitance effects.
译文：在特高频率下，电阻的内部构造引入了电感和电容效应。

corresponds to a 1.5 V voltage source. However, it ceases to be modeled by a voltage source capable of supplying any current (That's what ideal ones can do!) when the resistance of the light bulb is too small.

1.4 Electric Circuits and Interconnection Laws

A circuit connects circuit elements together in a specific configuration designed to transform the source signal (originating from a voltage or current source) into another signal, the output that corresponds to the current or voltage defined for a particular circuit element. A simple resistive circuit is shown in Figure 1.6.This circuit is the electrical embodiment of a system with its input provided by a source system producing $v_{in}(t)$.

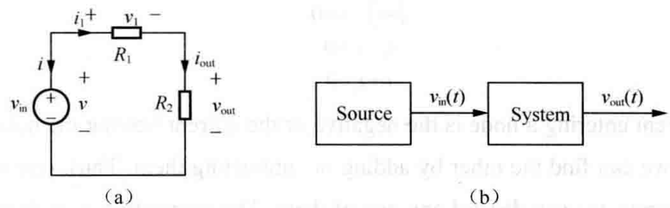

Figure 1.6 (a) the circuit that performs a signal processing function (b) the block diagram that corresponds to the circuit.

To understand what this circuit accomplishes, we want to determine the voltage across the resistor labeled by its value R_2. Recasting this problem mathematically, we need to solve some set of equations so that we relate the output voltage v_{out} to the source voltage. It would be simple, a little too simple at this point, if we could instantly write down the equation that relates these two voltages. Until we have more knowledge about how circuits work, we must write a set of equations that allow us to find all the voltagesand currents that can be defined for every circuit element.① Because we have a three-element circuit, we have a total of six voltages and currents that must be either specified or determined. You can define the directions for positive current flow and positive voltage drop any way you like. Once the values for the voltages and currents are calculated, they may be positive or negative according to your definition. When two people define variables according to their individual preferences, the signs of their variables may not agree, but current flow and voltage drop values for each element will agree. Do recall in defining your voltage and current variables that the *v*-*i* relations for the elements presume that positive current flow is in the same direction as positive voltage drop. Once you define voltages and currents, we need six non-redundant equations to solve for the six unknown voltages and currents. By specifying the source, we have one; this amounts to providing the source's *v*-*i* relation. The *v*-*i* relations for the resistors give us two more. We are only halfway there; where do we get the other three equations we need?

What we need to solve for every circuit problem are mathematical statements that express how the circuit elements are interconnected. In other words, we need the laws that govern the electrical connection of circuit elements. First of all, the places where circuit elements attach to each other are called nodes. Two nodes are explicitly indicated in Figure 1.6; a third is at the bottom where the voltage source and resistor R_2

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① Until we have more knowledge about how circuits work, we must write a set of equations that allow us to find all the voltages and currents that can be defined for every circuit element.

译文：在我们获得关于电路工作的更多知识之前，必须写出可以求解每个电路元件电压和电流的方程组。