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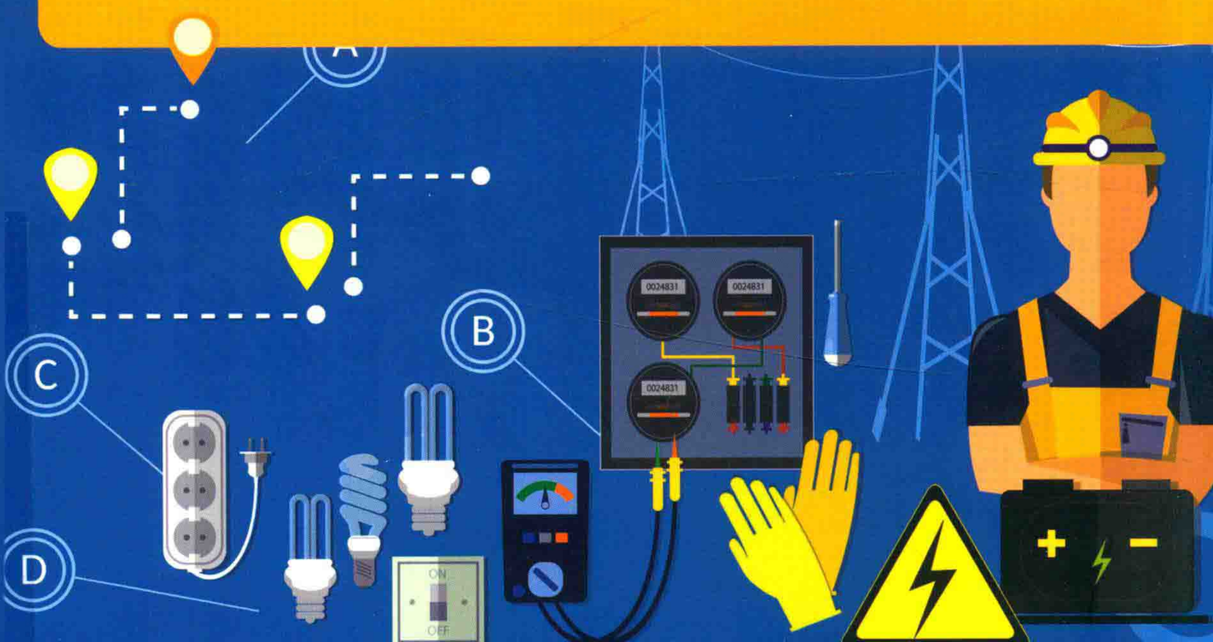
Professional English for Electrical Engineering & Automation

电气工程与自动化专业英语

主　编：郑雪钦
副主编：苏鹭梅　高海燕



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前　　言

通过专业英语的学习，可以培养学生对英文专业资料、文献和信息的阅读能力、专业写作能力，扩充学生的专业词汇量，帮助学生掌握科技英语和专业英语的特点。

本书供普通高等院校电气类和自动化本科专业使用，共六章。分别为第一章“电子电路”，第二章“电机学”，第三章“电力电子”，第四章“电气工程”，第五章“自动化”，第六章“智能电网信息技术”。每章结合专业英语特点，增设课堂实践，如文献检索、视听口译、器件说明书阅读、科研报告的幻灯片制作及其演说、论文摘要的撰写等练习，力求理论与实践的深度融合。

本书第一章和第三章由苏鹭梅编写，第二章和第四章由郑雪钦编写，第五章和第六章由高海燕编写。全书由郑雪钦和苏鹭梅统稿。本书大部分插图绘制、文稿录入、资料收集等工作由研究生陈晓雄、吴景丽和陈明泉完成，在此表示衷心的感谢。

本书的出版得到厦门理工学院教材建设基金项目资助，在此表示衷心的感谢。

在本书完稿之际，对书末所附参考文献的作者也致以衷心的感谢。

笔者虽然长期工作在专业英语的教学第一线，但毕竟水平有限，加之编写时间仓促，书中难免有些疏漏及错误，请读者批评指正。

编　者

于厦门理工学院电气工程与自动化学院

2018年5月

目　　录

CONTENTS

Chapter 1

ELECTRIC CIRCUIT

Unit 1 Basic Circuit Elements

1.1 Electrical Resistance (Ohm's Law)

Resistance is the capacity of materials to impede the flow of current, or more specifically, the flow of electric charge. The circuit element used to model this behavior is the resistor. Fig. 1-1 shows the circuit symbol for the resistor, with R denoting the resistance value of the resistor.

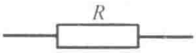

Fig. 1-1 The circuit symbol for a resistor having a resistance R

Conceptually, we can understand resistance if we think about the moving electrons that make up electric current interacting with and being resisted by the atomic structure of the material through which they are moving. In the course of these interactions, some amount of electric energy is converted to thermal energy and dissipated in the form of heat. This effect may be undesirable. However, many useful electrical devices take advantage of resistance heating, including stoves, toasters, irons, and space heaters.

1.2 The Capacitor

1.2.1 Ideal Capacitor Model

Previously, we termed independent and dependent sources active elements, and the linear resistor a passive element, although our definitions of active and passive are still slightly fuzzy and need to be brought into sharper focus. We now define an active element as an element that is capable of furnishing an average power greater than zero to some external device, where the average is taken over an infinite time interval. Ideal sources are active elements, and the operational amplifier is also an active device. A passive element however, is defined as an element that cannot supply an average power that is greater than zero over an infinite time interval. The resistor falls into this category; the energy it receives is usually transformed into heat, and it never supplies energy.

We now introduce a new passive circuit element, the capacitor. We define capacitance C by the voltage-current relationship as in Eq. (1-1), where v and i satisfy the conventions for a passive element, as shown in Fig. 1-2.

$$i=C\frac{\mathrm{d}v}{\mathrm{d}t} \tag{1-1}$$

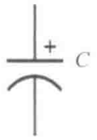

Fig. 1-2 Electrical symbol and current-voltage conventions for a capacitor

We should bear in mind that v and i are functions of time. If needed, we can emphasize this fact by writing $v(t)$ and $i(t)$ instead. From Eq. (1-1), we may determine the unit of capacitance as an ampere-second per volt, or coulomb per volt. We will now define the farad (F) as one coulomb per volt, and use this as the unit of capacitance.

The ideal capacitor defined by Eq. (1-1) is only a mathematical model of a real device. A capacitor consists of two conducting surfaces on which charge may be stored, separated by a thin insulating layer that has a very large resistance. If we assume that this resistance is sufficiently large that may be considered infinite, then equal and opposite charges placed on the capacitor "plates" can never recombine, at least by any path within the element. The construction of the physical device is suggested by the circuit symbol shown in Fig. 1-2.

1.2.2 Important Characteristics of an Ideal Capacitor

(1) There is no current through a capacitor if the voltage across it is not changing with time. A capacitor is therefore an open circuit to DC.

(2) A finite amount of energy can be stored in a capacitor even if the current through the capacitor is zero, such as when the voltage across it is constant.

(3) It is impossible to change the voltage across a capacitor by a finite amount in zero time, as this requires an infinite current through the capacitor. (A capacitor resists an abrupt change in the voltage across it in a manner analogous to the way a spring resists an abrupt

change in its displacement.)

(4) A capacitor never dissipates energy, but only stores it. Although this is true for the mathematical model, it is not true for a physical capacitor due to finite resistances associated with the dielectric as well as the packaging.

1.3 The Inductor

In the early 1800s the Danish scientist Oersted showed that a current-carrying conductor produced a magnetic field (compass needles were affected in the presence of a wire when current was flowing). Shortly thereafter, Ampere made some careful measurements which demonstrated that this magnetic field was linearly related to the current which produced it. The next step occurred some 20 years later when the English experimentalist Michael Faraday and the American inventor Joseph Henry discovered almost simultaneously that a changing magnetic field could induce a voltage neighboring circuit. They showed that this voltage was proportional time rate of change of the current producing the magnetic field. The constant of proportionality is what we now call the inductance, symbolized by L and therefore:

$$v = L\frac{\mathrm{d}i}{\mathrm{d}t} \tag{1-2}$$

We must realize that v and i are both functions of time. When we wish to emphasize this, we may do so by using the symbols $v(t)$ and $i(t)$.

The circuit symbol for the inductor is shown in Fig. 1-3, and it should be noted that the passive sign convention is used, just as it was with the resistor and the capacitor. The unit in which inductance is measured is the henry (H), and the defining equation shows that the henry is just a shorter expression for a volt-second per ampere.

Fig. 1-3 Electrical symbol and current-voltage conventions for an inductor

1.4 Voltage and Current Sources

Before discussing ideal voltage and current sources, we need to consider the general nature of electrical sources. An electrical source is a device that is capable of converting nonelectric energy to electric energy and vice versa. A discharging battery converts chemical energy to electric energy, whereas a battery being charged converts electric energy to chemical energy. A dynamo is a machine that converts mechanical energy to electric energy and vice versa. If operating in the mechanical-to-electric mode, it is called a generator. If transforming from electric to mechanical energy, it is referred to as a motor. The important thing to remember about these sources is that they can either deliver or absorb electric power, generally maintaining either voltage or current. This behavior is of particular interest for circuit analysis and led to the creation of the ideal voltage source and the ideal current source as basic circuit elements. The challenge is to model practical sources in terms of the ideal basic circuit elements.

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 through its terminals regardless of the voltage across those terminals. These circuit elements do not exist as practical devices — they are idealized models of actual voltage and current sources.

Using an ideal model for current and voltage sources places an important restriction on how we may describe them mathematically. Because an ideal voltage source provides a steady voltage, even if the current in the element changes, it is impossible to specify the current in an ideal voltage source as a function of its voltage. Likewise, if the only information you have about an ideal current source is the value of current supplied, it is impossible to determine the voltage across that current source. We have sacrificed our ability to relate voltage and current in a practical source for the simplicity of using ideal sources in circuit analysis.

Specialized English Words

circuit element 电路元件
electric charge 电荷
electron 电子
capacitor 电容器
operational amplifier 运算放大器
dielectric 电介质
conductor 导体
wire 导线
generator 发电机
resistance 电阻
resistor 电阻器
electric energy 电能
active/passive element 有源 / 无源元件
insulating layer 绝缘层
inductor 电感器
magnetic field 磁场
inductance 电感
motor 马达；电动机

Unit 2 Basic Circuit Laws

2.1 Introduction

We are now ready to meet another idealized element, the linear resistor. The resistor is the simplest passive element, and we begin our discussion by considering the work of an obscure German physicist, Georg Simon Ohm, who published a pamphlet in 1827 that described the results of one of the first efforts to measure currents and voltages, and to describe and relate them mathematically. One result was a statement of the fundamental relationship we now call Ohm's law, even though it has since been shown that this result was discovered 46 years earlier in England by Hey Cavendish, a brilliant semi-recluse.

Ohm's law states that the voltage across conducting materials is directly proportional to the current flowing through the material as defined in Eq. (1-3), where the constant of proportionality R is called the resistance. The unit of resistance is the ohm, which is 1 V/A and customarily abbreviated by a capital omega, Ω.

$$v = Ri \tag{1-3}$$

2.2 Kirchhoff's Current Law

We are now ready to consider the first of the two laws named for Gustav Robert Kirchhoff (two h's and two f's), a German university professor who was born about the time Ohm was doing his experimental work. This axiomatic law is called Kirchhoff's current law (abbreviated KCL), and it simply states that

The algebraic sum of the currents entering any node is zero.

This law represents a mathematical statement of the fact that charge cannot accumulate at a node. A node is not a circuit element, and it certainly cannot store, destroy, or generate charge. Hence, the currents must sum to zero. A hydraulic analogy is sometimes useful here: for example, consider three water pipes joined in the shape of a Y. We define three "currents" flowing into each of the three pipes. If we insist that water is always flowing, then obviously we cannot have three positive water currents, or the pipes would burst. This is a result of our defining currents independent of the direction that water is actually flowing. Therefore, the value of either one or two of the currents as defined must be negative. Consider the node shown in Fig. 1-4. The algebraic sum of the four currents entering the node must be zero, as defined by Eq. (1-4).

$$i_A + i_B + (-i_C) + (-i_D) = 0 \tag{1-4}$$

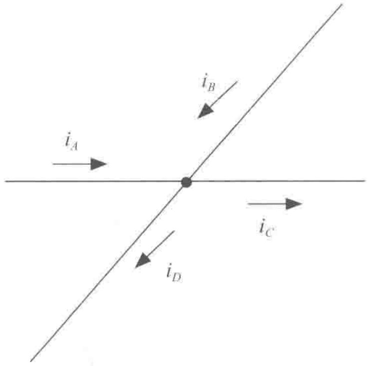

Fig. 1-4 Example node to illustrate the application of Kirchhoff's current law

However, the law could be equally well applied to the algebraic sum of the currents leaving the node, as defined by Eq. (1-5).

$$(-i_A) + (-i_B) + i_C + i_D = 0 \tag{1-5}$$

We might also wish to equate the sum of the currents having reference arrows directed into the node to the sum of those directed out of the node, which simply states that the sum of the currents going in must equal the sum of the currents going out, as defined by Eq. (1-6).

$$i_A + i_B = i_C + i_D \tag{1-6}$$

2.3 Kirchhoff's Voltage Law

Current is related to the charge flowing through a circuit element, whereas voltage is a measure of potential energy difference across the element. There is a single unique value for any voltage in circuit theory. Thus, the energy required to move a unit charge from point *A* to point *B* in a circuit must have a value independent of the path chosen to get from *A* to *B* (there is often more than one such path). We may assert this fact through Kirchhoff's voltage law (abbreviated KVL):

The algebraic sum of the voltages around any closed path is zero.

In Fig. 1-5, if we carry a charge of 1 C from *A* to *B* through element the reference polarity signs for v_1 show that we do v_1 joules of work. Now if, instead, we choose to proceed from *A* to *B* via node *C*, then we expend $(v_2 - v_3)$ joules of energy. The work done, however, is independent of the path in a circuit, and so any route must lead to the same value for the voltage. In other words,

$$v_1 = v_2 - v_3 \tag{1-7}$$

It follows that if we trace out a closed path, the algebraic sum of the voltages across the individual elements around it must be zero. Thus, we may write

$$v_1 + v_2 + v_3 + \cdots + v_N = 0 \tag{1-8}$$

or, more compactly,

$$\sum_{n=1}^{N} v_n = 0 \tag{1-9}$$

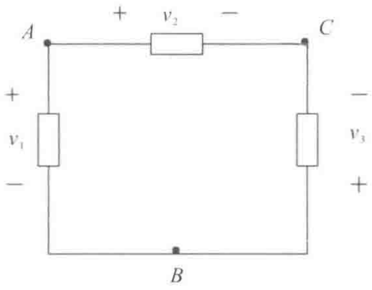

Fig. 1-5 Illustration for the potential difference between points *A* and *B* is independent of the path selected

Specialized English Words

passive element	无源元件	conducting material	导电材料，导电物质
resistance	电阻	Kirchhoff's Current Law (KCL)	基尔霍夫电流定律
charge	电荷	hydraulic	液压的，水力的
polarity	极性	Kirchhoff's Voltage Law (KVL)	基尔霍夫电压定律
joule	焦耳		

Unit 3 Basic Circuit Analysis Methods

3.1 Introduction

Armed with the trio of Ohm's and Kirchhoff's laws, analyzing a simple linear circuit to obtain useful information such as the current, voltage, or power associated with a particular element is perhaps starting to seem a straightforward enough venture. Still, for the moment at least, every circuit seems unique, requiring (to some degree) a measure of creativity in approaching the analysis. In this Unit, we learn two basic circuit analysis techniques—**nodal analysis** and **mesh analysis**—both of which allow us to investigate many different circuits with a consistent, methodical approach. The result is a streamlined analysis, a more uniform level of complexity in our equations, fewer errors and, perhaps most importantly, a reduced occurrence of "I don't know how to even start!"

3.2 Nodal Analysis

We begin our study of general methods for methodical circuit analysis by considering a powerful method based on KCL, namely nodal analysis. In other lessons we considered the analysis of a simple circuit containing only two nodes. We found that the major step of the analysis was obtaining a single equation in terms of a single unknown quantity—the voltage between the pair of nodes.

We will now let the number of nodes increase and correspondingly provide one additional unknown quantity and one additional equation for each added node. Thus, a three-node circuit should have two unknown voltages and two equations; a 10-node circuit will have nine unknown voltages and nine equations; an N-node circuit will need (N-l) voltages and (N-l) equations. Each equation is a simple KCL equation.

The mesh is a property of a planar circuit. We define a mesh as a loop that does not contain any other loop within it. Once a circuit has been drawn neatly in planar form, it often has the appearance of a multipaned window and the boundary of each pane in the window may be considered to be a mesh.

If a network is planar, mesh analysis can be used to accomplish the analysis. This technique involves the concept of a mesh current, which is introduced by considering the analysis of the two-mesh circuit.

As we did in the single-loop circuit, we will begin by defining a current through one of the branches. Let us call the current flowing to the right through the 6 Ω resistor i_1. We will apply KVL around each of the meshes, and the two resulting equations are sufficient to determine two unknown currents. We next define a second current i_2 flowing to the right of the 4 Ω resistor. We might also choose to call the current flowing downward through the central branch i_3, but it is evident from KCL that i_3 may be expressed in terms of the two previously assumed currents as ($i_1 - i_2$).

Following the method of solution for the single loop circuit, we now apply KVL to the left-hand mesh and obtain

$$-42+6i_1+3(i_1-i_2)=0$$

or

$$9i_1-3i_2=42 \tag{1-10}$$

Applying KVL to the right-hand mesh, we obtain

$$-3(i_1 - i_2) + 4i_2 - 10 = 0$$

or

$$-3i_1 + 7i_2 = 10 \qquad (1\text{-}11)$$

Eq. (1-10) and (1-11) are independent equations; one cannot be derived from the other. With two equations and two unknowns, the solution is easily obtained:

$$i_1 = 6A \qquad i_2 = 4A$$

and

$$(i_1 - i_2) = 2A \qquad (1\text{-}12)$$

3.3 Summary of Basic Nodal Analysis Procedure

(1) **Count the number of nodes** (N).

(2) **Designate a reference node.** The number of terms in your nodal equations can be minimized by selecting the node with the greatest number of branches connected to it.

(3) **Label the nodal voltages** (there are $N-1$ of them).

(4) **Write a KCL equation for each of the non-reference nodes.** Sum the currents flowing into a node from sources on one side of the equation. On the other side, sum the currents flowing out of the node through resistors. Pay close attention to "–" signs.

(5) **Express any additional unknowns such as currents or voltages other than nodal voltages in terms of appropriate nodal voltages.** This situation can occur if voltage sources or dependent sources appear in our circuit.

(6) **Organize the equations**. Group terms according to nodal voltages.

(7) **Solve the system of equations for the nodal voltages** (there will be $N-1$ of them).

3.4 Summary of Basic Mesh Analysis Procedure

(1) **Determine if the circuit is a planar circuit**. If not, perform nodal analysis instead.

(2) **Count the number of meshes (**M**)**. Redraw the circuit if necessary.

(3) **Label each of the M mesh currents**. Generally, defining all mesh currents to flow clockwise results in a simpler analysis.

(4) **Write a KVL equation around each mesh**. Begin with a convenient node and proceed in the direction of the mesh current. Pay close attention to "–" signs. If a current source lies on the periphery of a mesh, no KVL equation is needed and the mesh current is determined by inspection.

(5) **Express any additional unknowns such as voltages or currents other than mesh**

currents in terms of appropriate mesh currents. This situation can occur if current sources or dependent sources appear in our circuit.

(6) **Organize the equations.** Group terms according to mesh currents.

(7) **Solve the system of equations for the mesh currents** (there will be *M* of them).

Specialized English Words

linear circuit	线性电路	nodal analysis	节点分析法
mesh analysis	网孔分析法	node	节点
branch	分支	resistor	电阻器
loop	回路		

Unit 4　Operational Amplifier

4.1 Ideal and Practical Models

The concept of the operational amplifier (usually referred to as an op-amp) originated at the beginning of the Second World War with the use of vacuum tubes in DC amplifier designs developed by the George A. Philbrick Co. (Some of the early history of operational amplifiers is found in Williams, 1991). The op-amp was the basic building block for early electronic servomechanisms, for synthesizers, and in particular for analog computers used to solve differential equations. With the advent of the first monolithic integrated circuit (IC) op-amp in 1965 (the μA709, designed by the late Bob Widlar, then with Fairchild Semiconductor), the availability of op-amps was no longer a factor, while within a few years the cost of these devices (which had been as high as $200 each) rapidly plummeted to close to that of individual discrete transistors.

Although the digital computer has now largely supplanted the analog computer in mathematically intensive applications, the use of inexpensive operational amplifiers in instrumentation applications, in pulse shaping, in filtering, and in signal processing applications in general has continued to grow. There are currently many commercial manufacturers whose main products are high quality op amps. This competitiveness has ensured a marketplace featuring a wide range of relatively inexpensive devices suitable for use by electronic engineers, physicists, chemists, biologists, and almost any discipline that requires obtaining quantitative