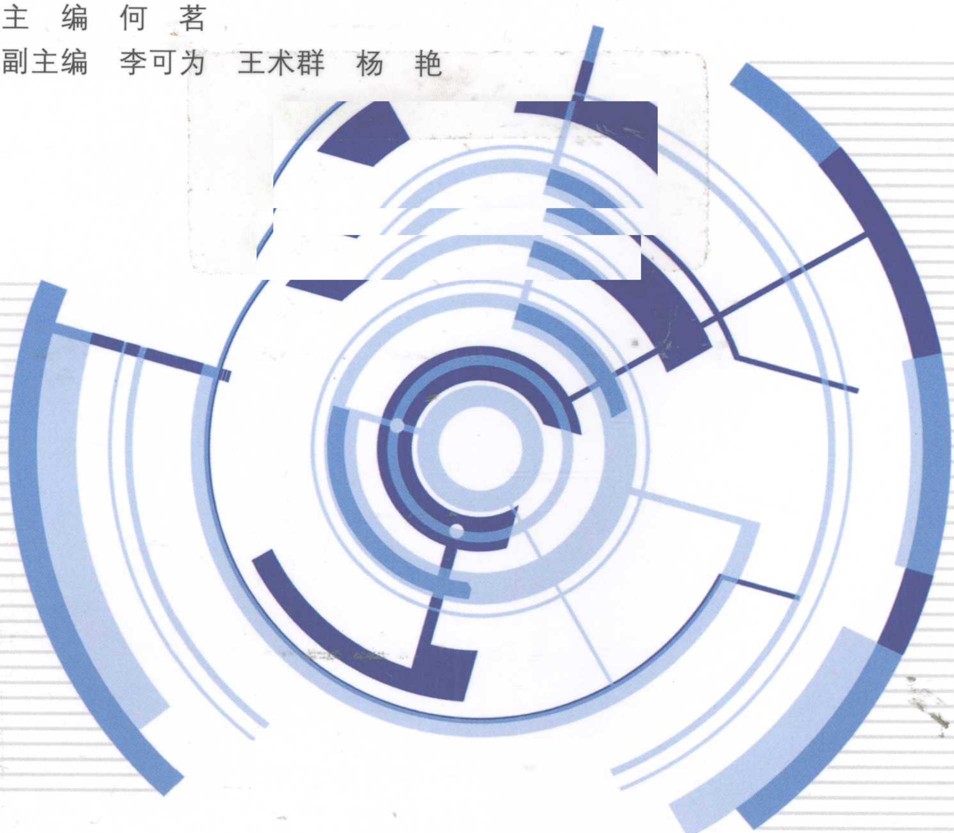
面向“十二五”高等学校精品规划教材
高等教育课程改革项目研究成果

电子技术专业英语

Specialized English for Electronic Technology

主　编　何　茗
副主编　李可为　王术群　杨　艳



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内 容 提 要

本书由基础篇和应用篇两大部分组成，内容涉及基本的应用电子技术、微电子技术和自动控制技术。应用电子技术包括电路分析、数字电路、模拟电路等；微电子技术由半导体材料、半导体物理、芯片制造工艺、芯片封装、集成电路、版图等组成；自动控制技术包括控制系统的介绍、自动控制技术的应用等。

本书可作为本科院校的应用电子技术、微电子技术、自动控制技术等专业的教材，也可供相关专业技术人员和行业英语爱好者学习与参考。

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前言

为了顺应电子信息应用技术的高速发展和普及，专业英语是在校学生必须学习的专业课程。学习专业英语的目的是强化巩固基础英语并进行实践应用，从而掌握科技英语技能，熟练阅读国外相关文献，了解国内外本专业发展前沿的最新动态，并具有一定的科技写作能力。同时，专业英语教学对于学生提高思想素质和科学文化素质，掌握职业技能，形成综合职业能力，以及今后的学习和发展具有重要作用。因此，通过专业英语的学习能更加适应现代高科技发展的需要。

全书由电子信息的基础篇和应用篇两部分组成，其中基础篇 10 个单元，应用篇 6 个单元；合计 16 个单元。每个单元的内容以电子技术、微电子技术和自动控制技术等方面现代科技新技术、新发展为主。对课文中出现的一些语言现象、难点、难句均作了较详细的注释。每篇课文后配有生词表、专业术语和相应的练习，在一定程度上减轻了学习的难度。而且每篇课文的内容是独立的，便于学习时根据需要选读。

本书遵照语言学习规律、认知规律编写，内容循序渐进，拓宽了知识面。本书可作为本科院校的应用电子技术、微电子技术、自动控制技术等专业的教材，也可供从事该专业领域的技术人员和行业英语爱好者学习使用。在教学中，教师也可根据学时、具体情况酌定取舍。

何茗编写了 Part I 中的 Unit 5 ~8，Part II 中的 Unit 1 ~2，Unit 5 ~6；王[illegible]群编写了 Part I 中的 Unit 2 ~4，Part II 中的 Unit 3；杨艳编写了 Part I 中的 Unit 10，Part II 中的 Unit 4；吕晶晶编写了 Part I 中的 Unit 9；吴非编写了 Part I 中的 Unit 1；张婷编写了附录部分。李可为对全书进行了总审校。

本书在编写时，参考了大量的国外文献资料及一些专业网站，在此向这些文献资料的作者深表谢意。由于作者水平有限，书中难免存在不足之处，敬请读者批评指正。

编 者

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Chapter 1

Electric Circuit

Unit 1

Basis of Electric Circuits

1.1 Electric circuits

The elements that comprise the circuit model are called ideal circuit components. An ideal circuit component is a mathematical model of an actual electrical component, like a battery or a light bulb. It is important for the ideal circuit component used in a circuit model to represent the behavior of the actual electrical component to an acceptable degree of accuracy. The tools of circuit analysis, the focus of this unit, are then applied to the circuit. Circuit analysis is based on mathematical techniques and is used to predict the behavior of the circuit model and its ideal circuit components. A comparison between the desired behavior, from the design specifications, and the predicted behavior, from circuit analysis, may lead to refinements in the circuit model and its ideal circuit elements. Once the desired and predicted behaviors are in agreement, a physical prototype can be constructed.

The physical prototype is an actual electrical system, constructed from actual electrical components. Measurement techniques are used to determine the actual, quantitative behavior of the physical system. This actual behavior is compared with the desired behavior from the design specifications and the predicted behavior from circuit analysis. The comparisons may result in refinements to the physical prototype, the circuit model, or both. Eventually, this iterative process, in which models, components, and systems are continually refined, may produce a design that accurately matches the design specifications and thus meets the need.

From this description, it is clear that circuit analysis plays a very important role in the design process. Because circuit analysis is applied to circuit models, practicing engineers try to use mature ciruit models so that the resulting designs will meet the design specifications in the first iteration. In this unit, we use models that have been tested for between 20 and 100 years; you can assume that they are mature. The ability to model actual electrical systems with ideal circuit elements makes circuit theory extremely useful to engineers.

Saying that the interconnection of ideal circuit elements can be used to quantitatively predict the behavior of a system implies that we can describe the interconnection with mathematical equations. For the mathematical equations to be useful, we must write them in terms of measurable quantities. In the case of circuits, these quantities are voltage and current. The study of circuit analysis involves understanding the behavior of each ideal circuit element in terms of its voltage and current and understanding the constraints imposed on the voltage and current as a result of interconnecting the ideal elements.

Circuit analysis is based on the variables of voltage and current. Voltage is the energy per unit charge created by charge separation and has the SI unit of volt $v = \mathrm{d}w/\mathrm{d}q$. Current is the rate of charge flow and has the SI unit of ampere ($i = \mathrm{d}q/\mathrm{d}t$). The ideal basic circuit element is a two-terminal component that cannot be subdivided; it can be described mathematically in terms of its terminal voltage and current. The passive sign convention uses a positive sign in the expression that relates the voltage and current at the terminals of an element when the reference direction for the current through the element is the direction of the reference voltage drop across the element.

Power is energy per unit of time and is equal to the product of the terminal voltage and current; it has the SI unit of watt. The algebraic sign of power is interpreted as follows:

If $p > 0$, power is being delivered to the circuit or circuit component.
If $p < 0$, power is being extracted from the circuit or circuit component.

The circuit elements introduced in this chapter are voltage sources, current sources, and resistors. An ideal voltage source maintains a prescribed voltage regardless of the current in the device. An ideal current source maintains a prescribed current regardless of the voltage across the device. Voltage and current sources are either independent, that is, not influenced by any other current or voltage in the circuit; or dependent, that is, determined by some other current or voltage in the circuit. A resistor constrains its voltage and current to be proportional to each other.

The value of the proportional constant relating voltage and current in a resistor is called its resistance and is measured in ohms.

Ohm's Law establishes the proportionality of voltage and current in a resistor. Specifically,

$$V = IR \tag{1-1}$$

if the current flow in the resistor is in the direction of the voltage drop across it, or

$$V = -IR \tag{1-2}$$

if the current flow in the resistor is in the direction of the voltage rise across it.

By combining the equation for power, $p = vi$, with Ohm's Law, we can determine the power absorbed by a resistor:

$$P = I^2 R = \frac{U^2}{R} \tag{1-3}$$

Circuits are described by nodes and closed paths. A node is a point where two or more circuit elements join. When just two elements connect to form a node, they are said to be in series. A closed path is a loop traced through connecting elements, starting and ending at the same node and encountering intermediate node only once each.

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 for the voltages across and the current in every element. However, for more complex interconnection we need to use two more important algebraic relationships, known as Kirchhoff's Law, to solve for all the voltage and current.

The Kirchhoff's Current Law is:

The algebraic sum of all the currents at any node in a circuit equals zero.

The Kirchhoff's Voltage Law is:

The algebraic sum of all the voltages across any closed path in a circuit equals zero.

1.2 Technology of circuit analysis

So far, we have analyzed relatively simple resistive circuits by applying Kirchhoff's laws in combination with Ohm's Law. We can use this approach for all circuits, but as they become structurally more complicated and involve more and more elements, this direct method soon becomes cumbersome. In this lesson we introduce two powerful techniques of circuit analysis that aid in the analysis of complex circuit structures: the node-voltage method and the mesh-current method. These techniques give us two systematic methods of describing circuits with the minimum number of simultaneous equations.

The final topic in this lesson considers the conditions necessary to ensure that the power delivered to a resistive load by a source is maximized. Therein equivalent circuits are used in establishing the maximum power transfer conditions.

1.2.1 Introduction to the node-voltage method

We introduce the node-voltage method by using the essential nodes of the circuit. The first step is to make a neat layout of the circuit so that no branches cross over and to make clearly the essential nodes on circuit diagram. If the circuit has N essential nodes, therefore, we need $(N-1)$ node-voltage equations to describe the circuit. The next step is to select one of the N essential nodes as a reference node. Although theoretically the choice is arbitrary, practically the choice for the reference node often is obvious. For example, the node with the most branches is usually a good choice. The optimum choice of the reference node will become apparent after you have gained some experience using this method. After selecting the reference node, we define the node voltage on the node voltages on the circuit diagram. A node voltage is defined as the voltage rise from the reference node to a nonreference node.

When a voltage source is the only elements between two essential nodes, the node-voltage method is simplified. As an example, look at the circuit in Figure 1.1.1. There are four essential nodes in this circuit, which means that three simultaneous equations are needed. From these four essential nodes, a reference node has been chosen and three other nodes have been labeled.

But the 36 V source constraints the voltage between node 1 and node 2 to 36V. This means that the current that flows from node 1 to node 2 will be added to the equations. We are now ready to generate the node-voltage equations.

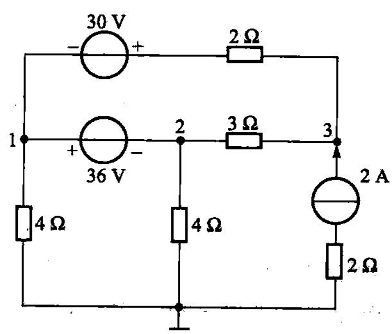

Figure 1.1.1 An example of node-voltage method

$$\left(\frac{1}{2}+\frac{1}{4}\right)U_1-\frac{1}{2}U_3=I-\frac{30}{2}$$

$$\left(\frac{1}{3}+\frac{1}{4}\right)U_2-\frac{1}{3}U_3=-I \qquad (1-4)$$

$$\left(\frac{1}{2}+\frac{1}{3}\right)U_3-\frac{1}{2}U_1\ \frac{1}{3}U_2=2+\frac{30}{2}$$

$$U_1 - U_2 = 36$$

In general, when a voltage source is the only elements between two essential nodes, the node-voltage method requires some additional manipulations.

1.2.2 Introduction to the mesh-current method

As stated in this lesson, the mesh-current method of circuit analysis enables us to describe a circuit. A mesh current is the current that exists only in the perimeter of a mesh. On a circuit diagram it appears as either a closed solid line or an almost-closed solid line that follows the perimeter of the appropriate mesh. An arrowhead on the solid line indicates the reference direction for the mesh current. Note that by definition, mesh currents automatically satisfy Kirchhoff's current law. That is, at any nodes in the circuit, a given mesh current both enters and leaves the node.

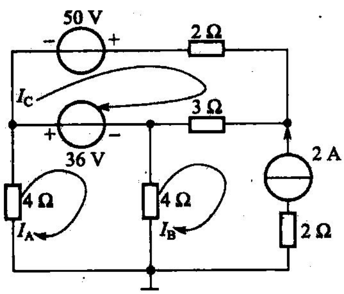

Figure 1.1.2 An example of mesh-current method

When a branch includes a current source, the mesh-current method requires some additional manipulations. The circuit shown in Figure 1. 1. 2 depicts the nature of the problem.

We are now ready to generate the mesh-current equations.

$$(4+4)I_A - 4I_B = -36$$
$$I_B = -2 \qquad (1-5)$$
$$(3+4)I_C - 3I_B = 50+36$$

In general, when you use the mesh-current method to solve circuits that have a branch including a current source, the number of the equations is reduced.

New Words

circuit analysis *n.* 电路分析
mathematical *adj.* 数学的
node *n.* 节点
the node-voltage method *n.* 节点电压法
constraint *vt.* 限制,约束
branch *n.* 支路
prototype *n.* 模型,原型
algebraic *adj.* 代数的,关于代数学的
behavior *n.* 行为,举止,性能
the mesh-current method *n.* 网孔电流法
essential *adj.* 基本的,必不可少的
perimeter *n.* 周边,周围,周长

Notes

1. The elements that comprise the circuit model are called ideal circuit components. 组成电路模型的部分被称为理想电路元件。

2. An ideal circuit component is a mathematical model of an actual electrical component, like a battery or a light bulb. 理想电路元件是实际电路元件的数学模型，比如电池或者灯泡。

3. In simple circuit structures, Ohm's Law is sufficient for solving for the voltages across and the current in every element. 在简单电路中，欧姆定律足够解决任意元件两端电压和流经的电流。

4. So far, we have analyzed relatively simple resistive circuits by applying Kirchhoff's laws in combination with Ohm's Law. 到目前为止，我们应用基尔霍夫和欧姆定律来分析相对简单的电阻性电路。

5. In this lesson we introduce two powerful techniques of circuit analysis that aid in the analysis of complex circuit structures: the node-voltage method and the mesh-current method. 本课中，我们介绍两种有效分析复杂电路的方法：节点电压法和网孔电流法。

6. In general, when you use the mesh-current method to solve circuits that have a branch including a current source, the number of the equations is reduced. 一般来说，使用网孔电流法分析某支路含有电流源的电路可以减少方程。

Exercises

1. What is Kirchhoff's current law?
2. What is Kirchhoff's voltage law?
3. What is the node-voltage method?
4. What is the mesh-current method?

References

[1] James W. Nilsson, Susan A. Riedel. Introductory Circuits for Electrical and Computer Engineering[M]. New Jersey: Prentice Hall, 2007.

Unit 2

Analog Circuits

Analog circuits operate with currents and voltages that vary continuously with time and have no abrupt transitions between levels. Generally speaking, analog circuits are contrasted with digital circuits that function as though currents or voltages existed only at one of a set of discrete levels, all transitions between levels being ignored. Since most physical quantities, e. g. , velocity and temperature, vary continuously, as does audio, an analog circuit provides the best means of representing them. However, digital circuits are often preferred because of the ease with which their outputs can be manipulated by computers, and because digital signals are more robust and less subject to transmission errors. There are special analog-to-digital and digital-to-analog circuits to convert from one type of signal to the other.

The circuits in this unit make use of IC, or integrated circuit, components. Such components are actually networks of interconnected components manufactured on a single wafer of semiconducting material. Integrated circuits providing a multitude of pre-engineered functions are available at a very low cost, benefiting students, hobbyists and professional circuit designers alike. Most integrated circuits provide the same functionality as "discrete" semiconductor circuits at higher levels of reliability and at a fraction of the cost. Usually, discrete-component circuit construction is favored only when power dissipation levels are too high for integrated circuits to handle.

Perhaps the most versatile and important analog integrated circuit for the student to master is the operational amplifier, or op-amp. Essentially nothing more than a differential amplifier with very high voltage gain, op-amps are the workhorse of the analog design world. By cleverly applying feedback from the output of an op-amp to one or more of its inputs, a wide variety of behaviors may be obtained from this single device. Many different models of op-amps are available at a low cost, but circuits described in this unit will incorporate only commonly available op-amp models.

2.1 Basic analog circuits

Resistance:

Resistance can be defined as the characteristic of a medium that opposes flow of current through itself. As illustrated in Figure 1.2.1, the unit of resistance is ohms which is represented by the Greek letter Ω (Omega). The power value associated with resistance is quantified as the amount of power that the resistor can dissipate as heat without overheating itself.

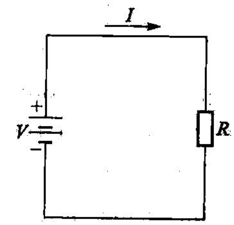

Figure 1.2.1 Simple representation of Ohm's Law

The current I through the resistor R is defined as:

$$I = V/R$$

$$V = IR \text{ or } R = V/I$$

For a 1 Mega ohm resistance, the current resulting from the application of 10V would be 10 micro-amperes.

Ohm's Law is the fundamental equation that describes the above relationship between voltage potential, the current flowing in the circuit, and the resistance of the circuit. The power dissipated in a load resistance R is defined as the product of the current and the voltage. Other relationships for power can be easily derived from this by applying Ohm's Law and substituting.

Note: Digital multimeters (DMMs) are the most common measurement devices found in automated test systems. DMMs are usually simple to use and are often low-cost instruments. Generally, DMMs have built-in conditioning that provides:

a) high resolution (commonly measured in digits);

b) multiple measurements (volts, current, resistance, etc.);

c) isolation and high voltage capabilities.

Capacitors:

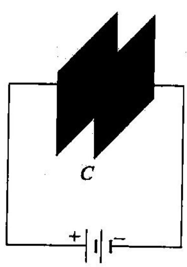

Figure 1.2.2 Capacitance circuit

Capacitors store energy in the form of electrical charge. The amount of charge that the capacitor can hold depends on the area of the two plates in Figure 1.2.2 and the distance between them. Large plates with a small distance between them have a higher capacity to hold charge. The electric field between the plates of a capacitor resists changes in applied voltage. Capacitors decrease their resistance with frequency.

Reading capacitor values:

The unit of capacitance, as shown in Figure 1.2.2, is Farad which is represented by the letter F. The formula to calculate capacitance is:

$$C = Q/V$$

where

C = capacitance in Farads

Q = accumulated charge in Coulombs

V = voltage difference between the plates

Inductance:

Inductance is defined as the amount of voltage dropped across the inductor for a given rate of change of current flowing through it. Inductors increase their resistance with frequency. The unit of inductance is Henry which is represented by the letter H.

Impedance:

Impedance Z is generally defined as the total opposition a device or circuit offers to the flow of an alternating current (AC) at a given frequency. Its value is equal to the ratio between the voltage and the current over an element of a circuit. Therefore, the unit of impedance is Ohm Ω.

Impedance is represented as a complex quantity which is graphically shown on a vector plane. An impedance vector consists of a real part (resistance, R) and an imaginary part (reactance, X). Impedance can be expressed using the rectangular coordinate form $R + jX$ or in the polar form as a magnitude and phase angle Z.

Admittance:

Admittance Y is the reciprocal of impedance. It is also a complex quantity: the real part is called conductance (C) and the imaginary part is called susceptance (B).

The unit of admittance is Siemens (S)

$$Y = G + jB$$

where Y is admittance; G represents conductance and B susceptance.

Operational amplifier (op-amp):

The Figure 1.2.3 below is a basic op-amp model that consists of the following three basic stages of an op-amp:

1) Differential amplifier: an amplifier whose output is proportional to the difference between the input signals.

2) Gain/frequency response: A filter changes the amplitude or phase characteristics of a signal with respect to frequency. The frequency domain behavior of a filter is mathematically described in terms of a transfer function or a network function. The transfer function $H(s)$ is described as a ratio between output and input signals.

$$H(s) = V_{out}(s) / V_{in}(s)$$

where $V_{out}(s)$ and $V_{in}(s)$ are the output and input voltage signals and s is the complex frequency

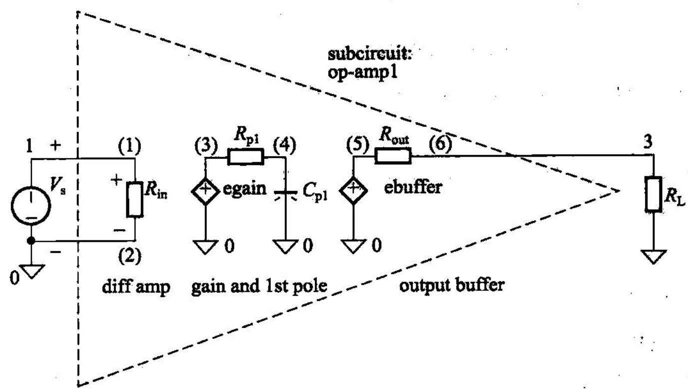

Figure 1.2.3 Basic operational amplifier (op-amp) model

variable.

The magnitude of transfer function is called amplitude response or frequency response especially in radio applications.

3) Output buffer.

2.2 Analog chip

An analog chip is a set of miniature electronic analog circuits formed on a single piece of semiconductor material.

The circuits in analog chips operate with voltage and current varying in a continuous fashion; in contrast, digital chips only use and create voltages or currents at discrete levels, with no intermediate values. Analog chips often have passive elements (inductor/capacitors/resistors) built into them, whereas most digital chips typically do not.

Many modern analog chips contain digital logic elements also — either to replace some analog functions, or to allow the chip to communicate with a microprocessor. For this reason and since logic is commonly implemented using CMOS technology, these chips use BiCMOS processes by companies such as Freescale (Freescale Analog products), Texas Instruments, STMicroelectronics and others.

The death of pure analog chips has been proclaimed regularly, however, the field continues to grow and prosper. Some examples of long-lived and well-known analog chips are the 741 op-amp which was the original internally compensated op-amp, and the 555 timer. The popular 555 timer was invented by Hans Camenzind in the 1970s.