普通高等工科教育规划教材

电气与电子工程专业英语

主　编　赵　阳
副主编　陈雪丽

机械工业出版社
CHINA MACHINE PRESS

普通高等工科教育规划教材

电气与电子工程专业英语

主　编　赵　阳
副主编　陈雪丽
参　编　王　彤　李世锦
主　审　张功萱

机械工业出版社

本书共15章，分基础、电气工程、电子工程、信息与计算机工程以及应用与实践共五部分。书中每章后配有词汇和短语、难句注释及一定数量的习题。本书参考国外一些最新出版的教材、专著及科技资料，从实际工作的需要出发，结合了电类专业的特点，语言流畅，图文并茂，“原汁原味”，专业词汇覆盖面广；内容由浅入深，有较强可选性。

本书适合工科类本科生用作“专业英语”课程教材，也可供工程技术人员提高英语阅读能力使用。

图书在版编目(CIP)数据

电气与电子工程专业英语/赵阳主编. —北京:机械工业出版社,2005. 8
普通高等工科教育规划教材
ISBN 7-111-16710-4

Ⅰ.电...　Ⅱ.赵...　Ⅲ.①电气工程—英语—高等学校—教材②电子技术—英语—高等学校—教材　Ⅳ.H31

中国版本图书馆CIP数据核字(2005)第057169号

机械工业出版社（北京市百万庄大街22号　邮政编码 100037）
策划编辑：韩雪清　苏颖杰　责任编辑：苏颖杰
版式设计：霍永明　　　　　封面设计：姚　毅
责任印制：洪汉军
北京瑞德印刷有限公司印刷·新华书店北京发行所发行
2005年8月第1版第1次印刷
787mm×1092mm1/16·17.25印张·421千字
定价：25.00元

凡购本书，如有缺页、倒页、脱页，由本社发行部调换
本社购书热线电话（010）68326294
封面无防伪标均为盗版

前　言

编者根据多年的国外大学教学经验，参考国外最新出版的教材、专著及科技资料，在1998年出版的《电气工程专业英语》的基础上修改、整理，编写了本书。

本书从实际工作的需要出发，结合了电类专业的特点，语言流畅，图文并茂，“原汁原味”，专业词汇覆盖面广，内容由浅入深，有较强可选性。全书共15章，分基础、电气工程、电子工程、信息与计算机工程以及应用与实践五部分，有以下特点：

1. 选材广泛：本书涵盖了电类专业的专业基础及专业课程，并安排了“信息与计算机”等时代性课程。

2. 层次多样：每部分都安排了简单的和有一定难度的章节，读者可根据自己的实际情况进行选用。

3. 内容新颖：结合了电气与电子工程最新的发展技术。

4. 适用面广：由于内容的可选性，适于电类强、弱电专业的本科生及研究生。

5. 实用性强：第五部分的“应用与实践”为高年级学生的毕业设计及走向工作岗位的第一关——阅读资料奠定了雄厚的基础。

本书适合工科类本科生用作“专业英语”课程教材，也可供工程技术人员提高英语阅读能力使用。

赵阳任主编，负责全书的整理和统稿工作，并编写了第3、7～10、13、14章；陈雪丽任副主编，编写了第1章；王彤编写了第2、4、11章；李世锦编写了第5、6、12、15章。张功萱担任本书主审，提出了宝贵的修改意见，在此表示感谢。在本书编写过程中，沈雪梅、尹海平做了大量的文字输入和校对工作，在此一并表示感谢。

由于时间仓促，书中的错误在所难免，敬请广大读者批评指正。

编者于南京

Electrical and Electronic Engineering English

Contents

PART 3: ELECTRONIC ENGINEERING

PART 4: INFORMATION AND COMPUTER ENGINEERING

PART 5: APPLICATION AND PRACTICE

PART 1: FUNDAMENTAL OF ELECTRICAL AND ELECTRONIC ENGINEERING

Chapter 1 Circuit Theory Fundamentals

Variables and equations are used to characterize the various relationships in a system. If the variables are to characterize an actual physical system, they must be evaluated by measurement. Consequently, it is necessary to use instruments and give specific instructions on how they are connected. If the instrument readings can be related mathematically, then a theory can be developed to generalize and broaden the scope of applicability of the experimentally observed results①. Such is the case with electrical circuits, where theory is developed by using voltage and current measurements. In this chapter we show that a few simple measurements form the basis of fundamental relationships governing circuit elements and their interconnection.

Section 1 Kirchhoff's Laws

1. Voltage and Current

Two variables $u(t)$ and $i(t)$ characterize the various relationships in an electrical circuit. These variables are functions of time and so may change in value from one instant to the next. The $u(t)$ variable (or simply u) is called the voltage variable and the $i(t)$ variable (or simply i) is called the current variable. These variables may also be constant.

The voltmeter is the instrument that measures the $u(t)$ variable. The instrument that measures the $i(t)$ variable is called the ammeter. Since the readings obtained with these instruments and the knowledge thereby obtained from the basis of circuit theory, knowing how to use the instruments properly is necessary.

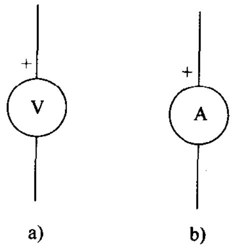


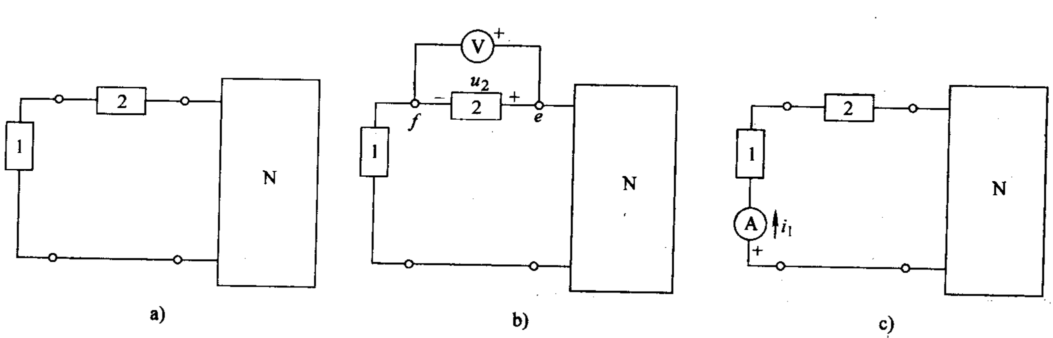
Fig. 1-1 The schematic representation of a voltmeter and an ammeter.
a) Voltmeter b) Ammeter

Fig. 1-1a gives the schematic representation of a voltmeter. It has two leads, one of which is marked with a + sign. Although not marked in the diagram, it is understood that the other lead is the negative lead. Instead of the + sign, the former lead may be colored red or connected to a red terminal on the voltmeter proper. It is important that it be distinguished from the other lead, which is the negative, or black lead or the lead tied to the black terminal of the voltmeter proper. Only one lead need be marked or identified in some manner. The letter V within the circle identifies the voltmeter.

Fig. 1-1b shows the schematic representation of an ammeter, the terminal markings of which are similar to the voltmeter. One lead is the + , or red lead, the other is the − , or black lead. This latter lead is not marked on the diagram. The letter A within the circle identifies the ammeter.

The simplest electrical elements are two-terminal devices that can be characterized by a simple voltage-current relationship. Resistors, capacitors, inductors, and sources, to be characterized shortly, are examples of such electrical elements. These elements are connected together with wires to form circuits or networks. Generally the term circuit is used to describe simple interconnections. On the other hand, a network may contain many circuits. In Fig. 1-2a an electric circuit consisting of elements 1 and 2 and network N is shown. With each two-terminal element or network we associate a voltage and a current variable. For instance, with element 2 we associate variables u_2 and i_2. With network N we have u_N and i_N and so on.

Voltage is taken as an across variable, and so voltage is measured by always connecting the voltmeter across an element or between two points in a network. In Fig. 1-2b, for instance, we measure the voltage across element 2 (between *e* and *f*) by connecting the voltmeter as shown. The reading of the voltmeter is then associated with the variable u_2, which is shown with its + and − designations next to element 2. Note that the + marking of the u_2 variable matches the + terminal of the voltmeter. If the voltmeter reading is positive, the value of the variable u_2 is positive by definition. If the voltmeter reading is negative, the value of u_2 is negative. For example, if the voltmeter reading is plus five, the voltage across element 2 is $u_2 = +5$. On the other hand, if the voltmeter reading is minus ten, $u_2 = -10$. In other words, the variable u_2 may assume positive as well as negative values depending on the sign of the voltmeter reading. It is important to know that this one-to-one correspondence between the voltmeter reading and the value assigned to the variable is based on the particular connection shown; that is, the + end of the voltmeter and the + marking of the variable refer to the same point on element 2. If these two polarity markings were not in agreement — u_2 marked + on the left and − on the right — the variable value would be taken as the negative of the voltmeter reading. Positive reading would then correspond to a negative voltage. Whether a voltage variable is marked in the + , − or − , + order in a circuit is not significant. In general, one designation or the other is chosen arbitrarily.



a) b) c)

Fig. 1-2 A simple network.

For emphasis, we repeat: voltage measurements are always taken across an element or between two points in a circuit. To speak of voltage at a point without specifying the location of the other point is meaningless②.

Voltage is measured in units of volts, abbreviated V.

Current is taken as a through variable and thus is measured by inserting the ammeter in the circuit. So in order to measure the current through element 1 in Fig. 1-2a, one of the wires tied to element 1 is cut and the ammeter introduced as shown in Fig. 1-2c. The ammeter reading is then associated with the current variable i_1 marked on the diagram. Note that i_1 has an arrow associated with it and that this arrow goes from the + terminal of the ammeter to the other terminal. When connected in this way, the variable i_1 is assigned, by definition, a positive value if the meter reading is positive. A negative reading means that the value of i_1 is taken as negative. If the arrow of i_1 is turned around without changing the ammeter connection, however, the variable value is the negative of the ammeter reading. Stated differently, when the ammeter marking and the current arrow marking match, as shown in Fig. 1-2c, the ammeter reading and variable value are one and the same. If the polarities are not lined up as shown, the reading and the variable value differ by a negative sign. Again, whether a current variable is marked with the arrow one way or the other is unimportant, for the choice, in general, is arbitrary.

In talking about current, we mean the current through an element or the current in a wire. Current is measured in units of amperes, abbreviated A.

Voltage and current variables in a circuit are designated as shown in Fig. 1-3. Always associate + and − signs with a voltage variable (clearly indicating where the signs belong) and an arrow with the current variable. The voltage u_1 is between points a and b, or u_1 is across the terminal leads of N_1. To determine u_1, a voltmeter is connected between a and b with the + lead at a. The voltage u_2 is between points c and d or across the top terminals of N_2. To measure u_2, the + lead of the voltmeter is connected to c and the other lead to d. The current i_1 represents the current through the wire marked e. To measure it, the wire must be cut at e and the ammeter inserted with the + terminal on the left side. Similarly, to measure i_2, cut the lead at f and insert the ammeter with the + lead on the right.

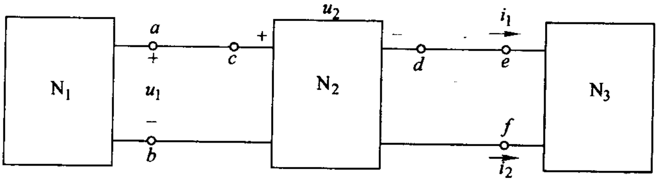


Fig. 1-3 Voltage and current variables in a circuit.

Example 1-1 In the network of Fig. 1-4a, we wish to determine the values of the u_1 and u_2 variables. To do so, voltmeter and ammeter readings are taken as shown in Fig. 1-4b. What is the value of u_1? What is the value of i_2? (Here the standard symbols for the voltmeter and ammeter are

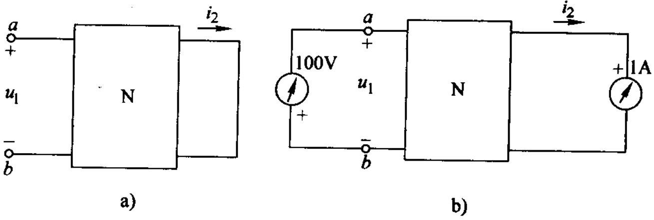


Fig. 1-4 Example 1-1.

not used in order to show the numerical values of meter deflections.)

Solution The voltmeter shows an upscale deflection of 100. (If the voltmeter had a digital readout, it would have indicated + 100.) The polarity marking of the variable u_1 is in opposition to the voltmeter marking. So

$$u_1 = -100\text{V} \qquad (\text{Ans.})$$

The current i_2 goes through the + terminal of the ammeter. Thus the ammeter reading represents the value of the i_2 variable — that is,

$$i_2 = 1\text{A} \qquad (\text{Ans.})$$

2. Kirchhoff' s Current Law

In a circuit, a node is a junction involving the connection of two or more wires. If we explore with an ammeter the current distributions at the nodes of an actual network, we can soon discover that there is a law governing this distribution. Consider, for instance, the node shown by a dot in Fig. 1-5a. Three wires, and hence three currents, are associated with this node. Suppose that we direct all three current variables into the node and label them i_1, i_2, and i_3. See Fig. 1-5a. To measure these currents, we connect three ammeters as shown in Fig. 1-5b. Note that the negative terminals of all three ammeters face the node; therefore the variable values are the same as the ammeter readings. In obtaining the ammeter readings, we find that

$$i_1 + i_2 + i_3 = 0 \qquad (1\text{-}1\text{a})$$

In other words, the sum of the three ammeter readings is zero, or the sum of the current variables directed into the node is zero. This means, of course, that all values are not of the same sign. For instance, if i_1 and i_2 are positive, then i_3 must be negative so as to satisfy Eq. (1-1a).

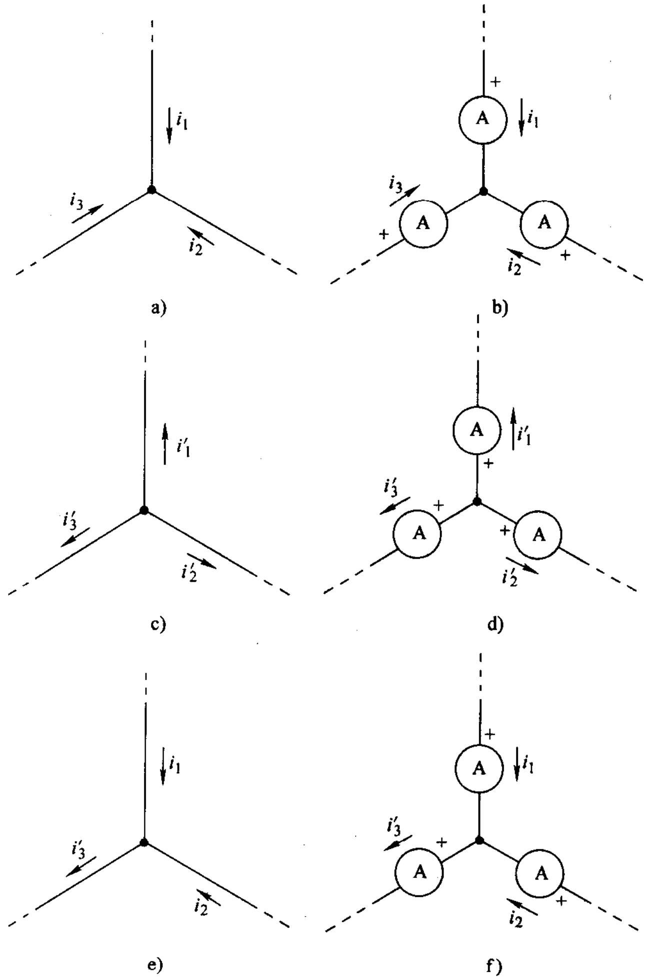


Fig. 1-5 Fundamental property of current at a node.

Next, suppose that instead of directing all current variables into the node, we direct them all away from the node, as shown in Fig. 1-5c. Correspondingly, we connect the ammeters as shown in

Fig. 1-5d in order to obtain the values of i'_1, i'_2, and i'_3. Note that the positive terminals of all three ammeters face the node. Again, the ammeter readings show that

$$i'_1 + i'_2 + i'_3 = 0 \qquad (1\text{-}1b)$$

Thus we can state that the sum of the current variables directed away from the node is zero. Indeed, if we had recognized that

$$i_1 = -i'_1,\ i_2 = -i'_2,\ i_3 = -i'_3$$

We could have obtained Eq. (1-1b) directly from Eq. (1-1a) as follows.

$$i_1 + i_2 + i_3 = (-i'_1) + (-i'_2) + (-i'_3) = -(i'_1 + i'_2 + i'_3) = 0$$

Finally, suppose that we direct two of the current variables into and one away from the node as shown in Fig. 1-5e. When the ammeter readings, taken as shown in Fig. 1-5f, are ordered, we find that

$$i_1 + i_2 = i'_3 \quad \text{or} \quad i_1 + i_2 - i'_3 = 0 \qquad (1\text{-}1c)$$

So we can state that the sum of the two currents coming into the node is equal to the current going out of the node, or the sum of currents taken in one sense minus those taken in the opposite sense is zero. Again, Eq. (1-1c) could have been obtained directly from Eq. (1-1a) by recognizing that is $i_3 = -i'_3$. We could have written

$$i_1 + i_2 + i_3 = i_1 + i_2 + (-i'_3) = 0 \quad \text{or} \quad i_1 + i_2 = i'_3$$

Alternatively, we could have started with Eq. (1-1b) and obtained Eq. (1-1c) as shown below by using $i'_1 = -i_1$ and $i'_2 = -i_2$.

$$i'_1 + i'_2 + i'_3 = (-i_1) + (-i_2) + i'_3 = 0 \quad \text{or} \quad i_1 + i_2 = i'_3$$

It was the German physicist Kirchhoff who first observed this fundamental property of currents at a node, and the law governing the currents at every node of a circuit is known as Kirchhoff's Current Law. It can be stated in three ways, depending on how the current variables are designated at a node. Consider the general case of n wires coming together to form the node p in Fig. 1-6.

(1) If all the n currents are directed toward the node p as shwon in Fig. 1-6a, then Kirchhoff's Current Law can be stated as:

Sum of all currents entering a node = 0

Stated mathematically,

$$\sum_{j=1}^{n} i_j = 0 \qquad (1\text{-}2a)$$

(2) If all the n currents are directed away from the node p as shown in Fig. 1-6b, Kirchhoff's Current Law can be stated as:

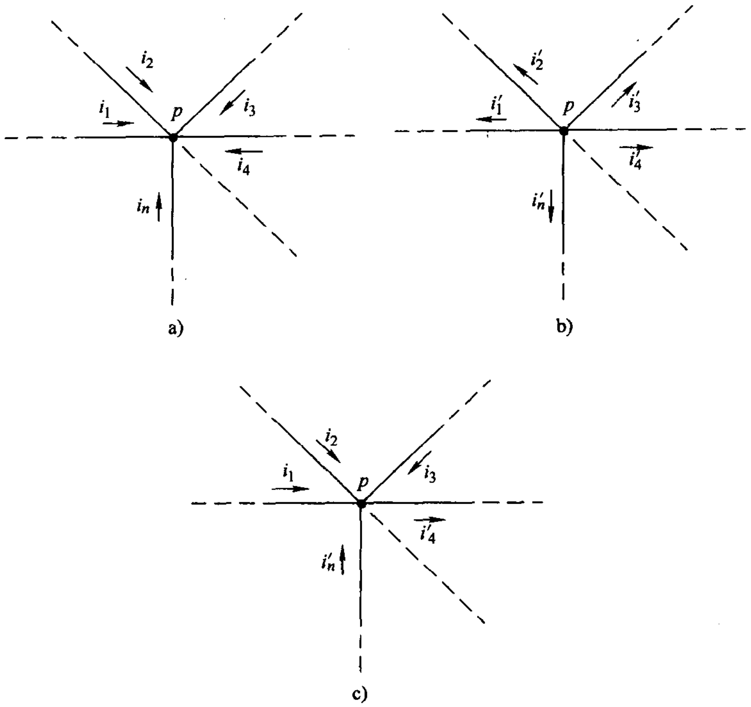
Sum of all currents leaving a node = 0

$$\sum_{j=1}^{n} i'_j = 0 \qquad (1\text{-}2b)$$

(3) If some of the currents are directed toward and the rest away from the node p as shown in Fig. 1-6c, Kirchhoff's Current Law can be stated as:

Sum of currents entering the node = Sum of currents leaving the node

$$\sum_{j=1}^{k} i_j = \sum_{j=k+1}^{n} i'_j \qquad (1\text{-}2c)$$



a) b) c)

Fig. 1-6 Kirchhoff's Current Law at the node p.

In Eq. (1-2c) k currents are directed toward and $n-k$ currents are directed away from the node. Alternatively, Eq. (1-2c) can be written

$$\sum_{j=1}^{k} i_j - \sum_{j=k+1}^{n} i'_j = 0$$

that is, the sum of currents taken in one sense minus the sum taken in the other sense is zero.

Since $i_j = -i'_j$, the three forms of Kirchhoff's Current Law given by Eq. (1-2) are equivalent statements. It should be emphasized that Kirchhoff's Current Law holds at every node of the circuit and is valid at every instant of time. As time changes, the currents entering and leaving a node may change in value, but the sum of currents coming in is always equal to the sum of currents going out.

3. Kirchhoff's Voltage Law

In a circuit, a loop is a closed path containing circuit elements. Exploring the voltages around a loop with a voltmeter soon shows that there is a law governing them. Consider, for instance, the loop shown with a clockwise arrow in Fig. 1-7a. Three elements, and hence three voltages, are associated with this loop. Suppose that we label these voltages u_1, u_2, u_3 and orient their polarities all in the same sense: + to − in a clockwise direction. See Fig. 1-7a. To measure these voltages, we connect three voltmeters as shown in Fig. 1-7b. Note that the polarity markings of the voltmeters match the + and − designations of the variables, and thus the variable values are the same as the voltmeter readings. When we obtain the voltmeter readings, we find that

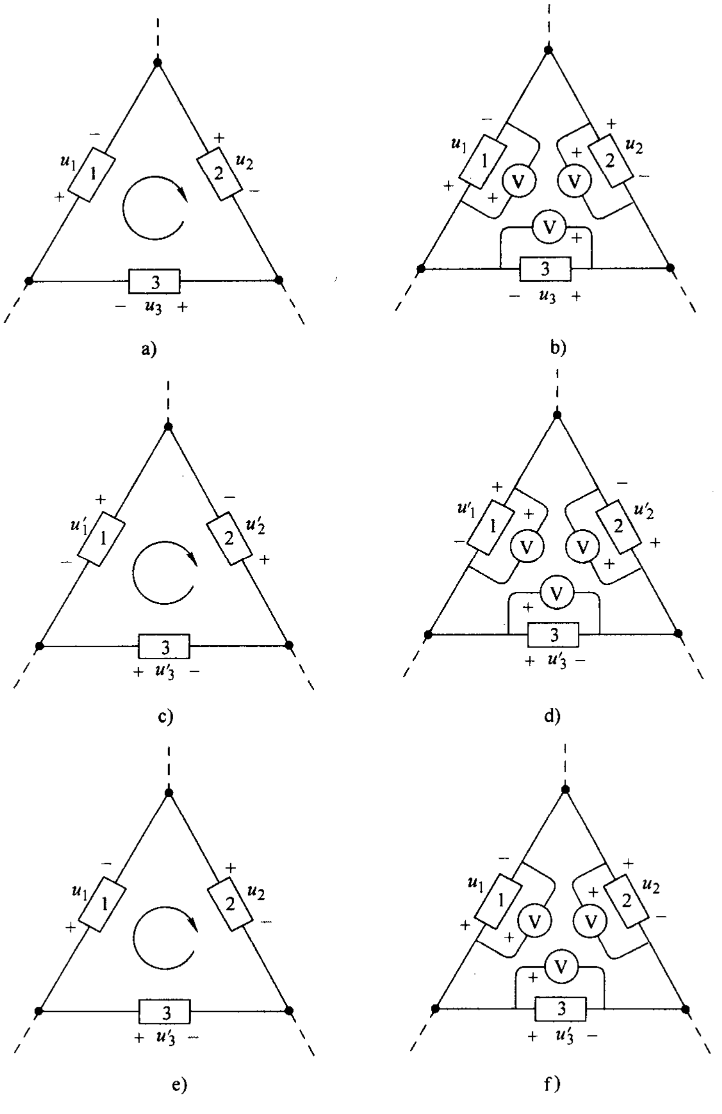


Fig. 1-7 Fundamental property of voltages around a loop.

$$u_1 + u_2 + u_3 = 0 \qquad (1\text{-}3a)$$

Thus the sum of the voltages taken in the + to − sense around the loop adds up to zero. In other words, all values are not of the same sign — one is of opposite sign.

In Fig. 1-7c all voltages are marked in the − to + sense in going clockwise around the loop. The voltmeters are connected as shown in Fig. 1-7d to measure voltages u'_1, u'_2, and u'_3. Noting that the voltmeter readings are the same as the variable values, we find that

$$u'_1 + u'_2 + u'_3 = 0 \qquad (1\text{-}3b)$$

Thus the sum of voltages taken in the − to + sense around the loop adds up to zero. Having Eq. (1-3a), we could have obtained Eq. (1-3b) by recognizing that

$$u'_1 = -u_1,\ u'_2 = -u_2,\ u'_3 = -u_3$$

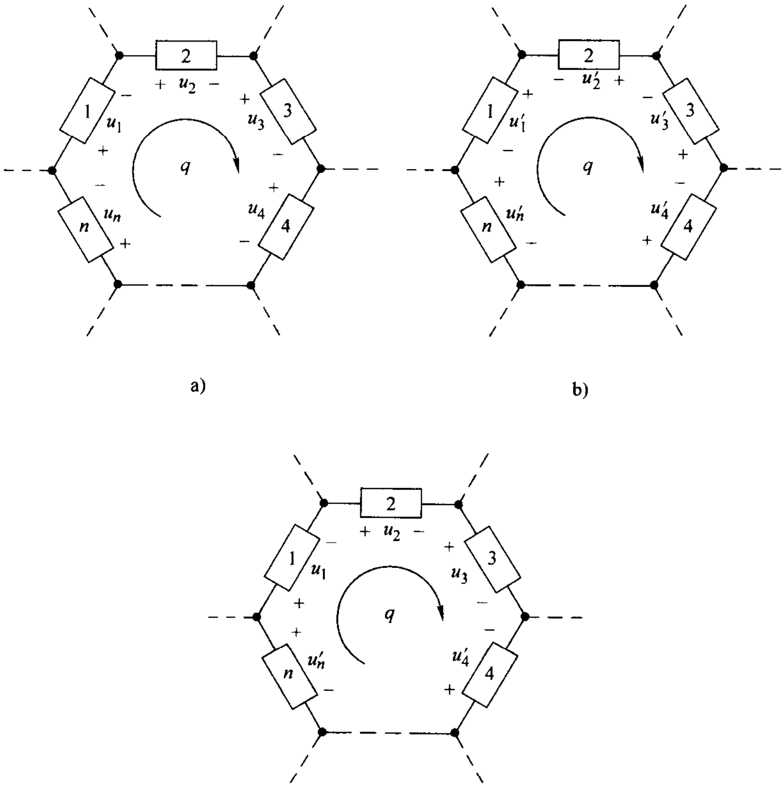
In Fig. 1-7e u_1 and u_2 are designated in the + to − sense, whereas u'_3 is designated in the − to + sense in going clockwise around the loop. As shown in Fig. 1-7f, the voltmeters are connected so that they measure the variable values (not their negatives). The result is

$$u_1 + u_2 = u'_3 \quad \text{or} \quad (u_1 + u_2) - u'_3 = 0 \tag{1-3c}$$

which indicates that, around the loop, the sum of voltages taken in the + to − sense equals the voltage taken in the − to + sense, or the sum of voltages in one sense minus those in the other sense is zero. By recognizing that $u'_3 = -u_3$, we see that Eq. (1-3c) reduces to Eq. (1-3a). Alternatively, by using $u_1 = -u'_1$ and $u_2 = -u'_2$, Eq. (1-3c) can be made the same as Eq. (1-3b).

Again, Kirchhoff observed this fundamental property of voltages around a loop. The law governing the voltages around every loop in a circuit, known as Kirchhoff's Voltage Law, can be stated in three different ways, depending on how the voltage variables are designated around a loop. Consider the general case of n elements that form the loop q shown in Fig. 1-8.

(1) If all voltages are designated in the + to − sense around the loop as shown in Fig. 1-8a, then Kirchhoff's Voltage Law can be stated as



a) b) c)

Fig. 1-8 Kirchhoff's Voltage Law around the loop q.

$$\sum_{j=1}^{n} u_j = 0 \tag{1-4a}$$

(2) If all voltages are designated in the – to + sense around the loop as shown in Fig. 1-8b, Kirchhoff's Voltage law can be stated as

$$\sum_{j=1}^{n} u'_j = 0 \tag{1-4b}$$

(3) If some of the voltages are designated + to – and the rest – to + around the loop as shown in Fig. 1-8c, Kirchhoff's Voltage Law can be stated as

$$\sum_{j=1}^{k} u_j = \sum_{j=k+1}^{n} u'_j \quad \text{or} \quad \sum_{j=1}^{k} u_j - \sum_{j=k+1}^{n} u'_j = 0 \tag{1-4c}$$

In Eq. (1-4c) k voltages are designated in the + to – and $n-k$ voltages in the – to + sense.

Since $u_j = -u'_j$, the three forms of Kirchhoff's Voltage Law given by Eq. (1-4) are equivalent statements. The law is also valid if the loop is taken in the counterclockwise sense. It should be emphasized that Kirchhoff's Voltage Law holds around every loop of the circuit and is valid at every instant of time. The voltages around the loop may change their values with time, but their sum is always governed by Eq. (1-4).

Implicit in the statement of Kirchhoff's Voltage Law is the understanding that voltages appear across the elements that are drawn as boxes in Fig. 1-7 and 1-8 and that zero voltage is associated with the wires connecting the elements. In other words, in a circuit diagram the voltages are concentrated at the elements and not at the connecting wires. When the voltages across the connecting wires cannot be neglected, however, the wires themselves can be regarded as elements across which voltages are present.

Often an alternative form of Kirchhoff's Voltage Law is used: the sum of voltages between any two nodes in a circuit is the same regardless of the path taken to go from one node to the other. (If such were not the case, voltages would not sum to zero around the loops that are formed by the paths.) Consider, for instance, part of a circuit shown in Fig. 1-9a. Loop k has four elements, and hence four voltages, associated with it. Two of these voltages, u_1 and u_2, appear in the – to + sense; the other two, u_3 and u_4, appear in the + to – sense as we go around loop k in the clockwise sense. Consequently, by Kirchhoff's Voltage Law, Eq. (1-4c), we have

Sum of voltages in one sense = Sum of voltages in the other sense

$$u_1 + u_2 = u_3 + u_4$$

Had we gone clockwise around loop l instead of loop k, we would have obtained

$$u_3 + u_4 = u_5$$

On the other hand, if we had gone clockwise around the loop composed of elements 1, 2, and 5 (which is not designated with an arrow in the diagram), Kirchhoff's Voltage Law would have given us

$$u_1 + u_2 = u_5$$

So we see that