"十三五"国家重点出版物出版规划项目

卓越工程能力培养与工程教育专业认证系列规划教材（电气工程及其自动化、自动化专业）

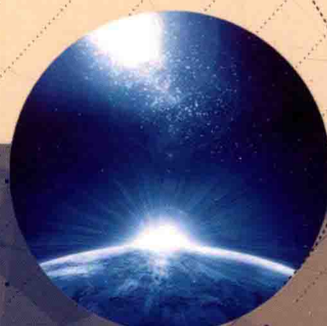
普通高等教育"十一五"国家级规划教材

# 自动化专业英语教程

## 第4版

王宏文　主编

# Specified English for Automation





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第4版


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机械工业出版社

本书是“十三五”国家重点出版物出版规划项目　卓越工程能力培养与工程教育专业认证系列规划教材、普通高等教育“十一五”国家级规划教材，是针对高等工科院校自动化专业“科技英语阅读”课程的需要、在第3版的基础上修订而成的，本书包括电气与电子工程基础、控制理论、计算机控制技术、过程控制系统、网络化与信息化控制及自动化技术的综合应用6部分，内容涉及智能控制综述、DSP、嵌入式系统、电力系统自动化、智能电网、大数据应用、知识自动化、云计算、智慧城市和智慧企业，并新增了人工智能研究的前沿热点问题综述、人工智能在机器学习领域的应用等内容，涵盖了自动化专业各个发展方向，内容新颖、全面、系统、精炼。每篇文章后都附有词汇表和注解，并配有30篇英语翻译及应用文知识，专业、学科介绍，自动化学科相关的期刊、会议、科技前沿等诸多内容，使读者在学习并掌握专业词汇和翻译技能的同时开阔眼界。本书可作为自动化专业本科生及研究生专业英语课程的教材，也可供有关工程技术人员参考。

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“十三五”国家重点出版物出版规划项目

# 卓越工程能力培养与工程教育专业认证系列规划教材

（电气工程及其自动化、自动化专业）

## 编审委员会

# 序

工程教育在我国高等教育中占有重要地位，高素质工程科技人才是支撑产业转型升级、实施国家重大发展战略的重要保障。当前，世界范围内新一轮科技革命和产业变革加速进行，以新技术、新业态、新产业、新模式为特点的新经济蓬勃发展，迫切需要培养、造就一大批多样化、创新型卓越工程科技人才。目前，我国高等工程教育规模世界第一。我国工科本科在校生约占我国本科在校生总数的1/3，近年来我国每年工科本科毕业生约占世界总数的1/3以上。如何保证和提高高等工程教育质量，如何适应国家战略需求和企业需要，一直受到教育界、工程界和社会各方面的关注。多年以来，我国一直致力于提高高等教育的质量，组织并实施了多项重大工程，包括卓越工程师教育培养计划（以下简称卓越计划）、工程教育专业认证和新工科建设等。

卓越计划的主要任务是探索建立高校与行业企业联合培养人才的新机制，创新工程教育人才培养模式，建设高水平工程教育教师队伍，扩大工程教育的对外开放。计划实施以来，各相关部门建立了协同育人机制。卓越计划要求试点专业要大力改革课程体系和教学形式，依据卓越计划培养标准，遵循工程的集成与创新特征，以强化工程实践能力、工程设计能力与工程创新能力为核心，重构课程体系和教学内容；加强跨专业、跨学科的复合型人才培养；着力推动基于问题的学习、基于项目的学习、基于案例的学习等多种研究性学习方法，加强学生创新能力训练，“真刀真枪”做毕业设计。卓越计划实施以来，培养了一批获得行业认可、具备很好的国际视野和创新能力、适应经济社会发展需要的各类型高质量人才，教育培养模式改革创新取得突破，教师队伍建设初见成效，为卓越计划的后续实施和最终目标的达成奠定了坚实基础。各高校以卓越计划为突破口，逐渐形成各具特色的人才培养模式。

2016年6月2日，我国正式成为工程教育“华盛顿协议”第18个成员国，这标志着我国工程教育真正融入世界工程教育，人才培养质量开始与其他成员国达到了实质等效，同时，也为以后我国参加国际工程师认证奠定了基础，为我国工程师走向世界创造了条件。专业认证把以学生为中心、以产出为导向和持续改进作为三大基本理念，与传统的内容驱动、重视投入的教育形成了鲜明对比，是一种教育范式的革新。通过专业认证，把先进的教育理念引入了我国工程教育，有力地推动了我国工程教育专业教学改革，逐步引导我国高等工程教育实现从课程导向向产出导向转变、从以教师为中心向以学生为中心转变、从质量监控向持续改进转变。

在实施卓越计划和开展工程教育专业认证的过程中，许多高校的电气工程及其自动化、自动化专业结合自身的办学特色，引入先进的教育理念，在专业建设、人才培养模式、教学内容、教学方法、课程建设等方面积极开展教学改革，取得了较好的效果，建

设了一大批优质课程。为了将这些优秀的教学改革经验和教学内容推广给广大高校，中国工程教育专业认证协会电子信息与电气工程类专业认证分委员会、教育部高等学校电气类专业教学指导委员会、教育部高等学校自动化类专业教学指导委员会、中国机械工业教育协会自动化学科教学委员会、中国机械工业教育协会电气工程及其自动化学科教学委员会联合组织规划了“卓越工程能力培养与工程教育专业认证系列规划教材（电气工程及其自动化、自动化专业)”。本套教材通过国家新闻出版广电总局的评审，入选了“十三五”国家重点图书。本套教材密切联系行业和市场需求，以学生工程能力培养为主线，以教育培养优秀工程师为目标，突出学生工程理念、工程思维和工程能力的培养。本套教材在广泛吸纳相关学校在“卓越工程师教育培养计划”实施和工程教育专业认证过程中的经验和成果的基础上，针对目前同类教材存在的内容滞后、与工程脱节等问题，紧密结合工程应用和行业企业需求，突出实际工程案例，强化学生工程能力的教育培养，积极进行教材内容、结构、体系和展现形式的改革。

经过全体教材编审委员会委员和编者的努力，本套教材陆续跟读者见面了。由于时间紧迫，各校相关专业教学改革推进的程度不同，本套教材还存在许多问题。希望各位老师对本套教材多提宝贵意见，以使教材内容不断完善提高。也希望通过本套教材在高校的推广使用，促进我国高等工程教育教学质量的提高，为实现高等教育的内涵式发展贡献一份力量。

**卓越工程能力培养与工程教育专业认证系列规划教材**

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# 前　言

本书第3版自2015年问世以来，得到许多学校师生的喜爱。经过4年的教学实践，对学生了解智能电网、大数据应用、知识自动化、云计算、智慧城市和智慧企业等自动化前沿研究、应用热点起到了有益的作用。在广泛采纳兄弟院校师生建议的基础上，为了响应教育部高等学校自动化类专业教学指导委员会的教改精神，及科技部于2017年发布的《新一代人工智能发展规划》，对教材内容做了进一步修订，新增加了人工智能研究的前沿热点问题综述和人工智能在机器学习领域的应用两篇文章。

编写本书的指导思想是："内容新颖、全面、系统、精炼，既重视学科基础知识又反映学科发展前沿动态"，同时新增了专业介绍、学科相关科技文献网站、自动化专业的科技前沿、学术会议等辅助内容。"见多才能识广"，希望本书对培养有开拓精神、综合素质强的科技创新型人才有所帮助。

**全书包括电气与电子工程基础、控制理论、计算机控制技术、过程控制系统、网络化与信息化控制、自动化技术的综合应用6部分共30个单元，覆盖9万余字的专业词汇量。**

本书由河北工业大学王宏文教授担任主编，河北工业大学李练兵教授、刘作军教授担任副主编。书中PART 1的UNIT 1由天津工业大学綦建教授编写；PART 1的UNIT 2、UNIT 3和PART 2的UNIT 6由天津工业大学王萍教授编写；PART 2的UNIT 1～5由河北工业大学李练兵教授编写；PART 3的UNIT 1A、UNIT 2A由李练兵教授和河北科技大学陈志军教授编写；PART 3的UNIT 1B、UNIT 2B、UNIT 4A由陈志军教授和河北科技大学薛忠辉教授编写；PART 1的UNIT 5B、UNIT 6B由河北理工大学孙进生教授编写；PART 1的UNIT 4、UNIT 5A、UNIT 6A由河北工业大学江春冬副教授编写；PART 2的UNIT 7由河北工业大学孙昊副教授编写；PART 3的UNIT 3、UNIT 5由河北工业大学岳大为副教授编写；PART 3的UNIT 4B由河北工业大学孙曙光副教授编写；PART 4由河北工业大学耿昕硕士编写；PART 5的UNIT 1、UNIT 2由河北工业大学梁涛教授编写；PART 5的UNIT 3由河北工业大学雷兆明副教授编写；PART 5的UNIT 4由河北工业大学李洁博士编写；PART 6的UNIT 1、UNIT 2、UNIT 3由河北工业大学王宏文教授编写；PART 4的UNIT 4C由河北工业大学林燕研究馆员、刘作军教授编写；PART 5的UNIT 1C、UNIT 2C由林燕研究馆员编写；PART 4的UNIT 1C、UNIT 3C由河北工业大学暴永辉硕士编写；其余章节的C部分均由刘作军教授编写。王宏文教授对全书进行总编和修改更正，河北工业大学杨鹏教授、沈阳大学李彦平教授担任主审。

在此对参加本书第1版编写工作的天津理工大学陈在平教授，以及为本书第1版的出版提供大力帮助的孙鹤旭教授、杨鹏教授表示由衷的感谢！河北工业大学2004级硕

士研究生陈悦，2005 级硕士研究生刘通学、黄伟杰、王艳霞、刘丽，2013 级硕士研究生吴红星、曹泽华、侯美杰、孟立新，2014 级硕士研究生郭章亮、雷盼云、宁乐参加了本书部分章节的计算机绘图与文字校对工作，在此一并表示感谢。

本书有完备的参考译文供任课教师使用，通信方式：18522018700@163. com，联系人：王宏文。也可登录机械工业出版社教育服务网（www. cmpedu. com）获取相关资源。

编 者

# 目　录
CONTENTS

# PART 1

# Electrical and Electronic Engineering Basics

## UNIT 1

### A Electrical Networks

An *electrical circuit or network* is composed of elements such as resistors, inductors, and capacitors connected together in some manner. If the network contains no energy sources, such as batteries or electrical generators, it is known as a *passive network*. On the other hand, if one or more energy sources are present, the resultant combination is an *active network*. In studying the behavior of an electrical network, we are interested in determining the voltages and currents that exist within the circuit. Since a network is composed of passive circuit elements, we must first define the electrical characteristics of these elements.

In the case of a resistor, the voltage-current relationship is given by Ohm's law, which states that the voltage across the resistor is equal to the current through the resistor multiplied by the value of the resistance.[1] Mathematically, this is expressed as

$$u = iR \tag{1-1A-1}$$

where $u$ = voltage, V; $i$ = current, A; $R$ = resistance, Ω.

The voltage across a pure inductor is defined by Faraday's law, which states that the voltage across the inductor is proportional to the rate of change with time of the current through the inductor. Thus we have

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

where $\mathrm{d}i/\mathrm{d}t$ = rate of change of current, A/s; $L$ = inductance, H.

The voltage developed across a capacitor is proportional to the electric charge $q$ accumulating on the plates of the capacitor. Since the accumulation of charge may be expressed as the summation, or integral, of the charge increments $\mathrm{d}q$, we have the equation

$$u = \frac{1}{C}\int \mathrm{d}q \tag{1-1A-3}$$

where the capacitance $C$ is the proportionality constant relating voltage and charge. By definition, current equals the rate of change of charge with time and is expressed as $i = \mathrm{d}q/\mathrm{d}t$. Thus an increment of charge $\mathrm{d}q$ is equal to the current multiplied by the corresponding time increment, or $\mathrm{d}q = i\,\mathrm{d}t$. Eq. (1-1A-3) may then be written as

$$u=\frac{1}{C}\int i\mathrm{d}t \qquad (1\text{-}1A\text{-}4)$$

where $C$ = capacitance, F.

A summary of Eqs. (1-1A-1), (1-1A-2) and (1-1A-4) for the three forms of passive circuit elements is given in Fig. 1-1A-1. Note that conventional current flow is used; hence the current in each element is shown in the direction of decreasing voltage.

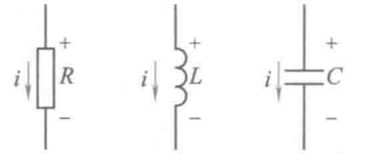


Fig. 1-1A-1 Passive circuit elements
a) Resistor b) Inductor c) Capacitor

Active electrical devices involve the conversion of energy to electrical form. For example, the electrical energy in a battery is derived from its stored chemical energy. The electrical energy of a generator is a result of the mechanical energy of the rotating armature.

Active electrical elements occur in two basic forms: *voltage sources* and *current sources*. In their ideal form, voltage sources generate a constant voltage independent of the current drawn from the source. The aforementioned battery and generator are regarded as voltage sources since their voltage is essentially constant with load. On the other hand, current sources produce a current whose magnitude is independent of the load connected to the source. Although current sources are not as familiar in practice, the concept does find wide use in representing an amplifying device, such as the transistor, by means of an equivalent electrical circuit. Symbolic representations of voltage source and current source are shown in Fig. 1-1A-2.

A common method of analyzing an electrical network is mesh or loop analysis. The fundamental law that is applied in this method is Kirchhoff's first law, which states that the algebraic sum of the voltages around a closed loop is 0, or, in any closed loop, the sum of the voltage rises must equal the sum of the voltage drops. Mesh analysis consists of assuming that currents—termed loop currents—flow in each loop of a network, algebraically summing the voltage drops around each loop, and setting each sum equal to 0.

Consider the circuit shown in Fig. 1-1A-3a, which consists of an inductor and resistor connected in series to a voltage source $e$. Assuming a loop current $i$, the voltage drops summed around the loop are

$$-e+u_R+u_L=0 \qquad (1\text{-}1A\text{-}5)$$

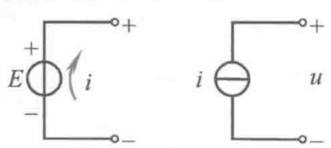


Fig. 1-1A-2 Voltage source and current source
a) Voltage source b) Current source

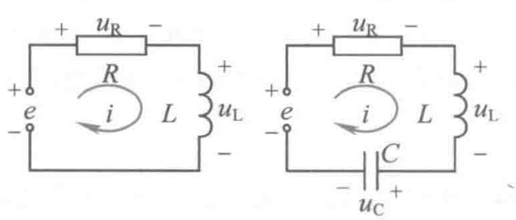


Fig. 1-1A-3 Series circuits containing $R$, $L$ and $C$

The input voltage is summed negatively since, in the direction of assumed current, it represents an increase in voltage. The drop across each passive element is positive since the current is in the direction of the developed voltage.

Using the equations for the voltage drops in a resistor and inductor, we have

$$L\frac{\mathrm{d}i}{\mathrm{d}t}+Ri=e \tag{1-1A-6}$$

Eq. (1-1A-6) is the differential equation for the current in the circuit.

It may be that the inductor voltage rather than the current is the variable of interest in the circuit.[2] As noted in Fig. 1-1A-1, $i=\frac{1}{L}\int u_L\mathrm{d}t$ . Substituting this integral for $i$ in Eq. (1-1A-6) gives

$$u_L+\frac{R}{L}\int u_L\mathrm{d}t=e \tag{1-1A-7}$$

After differentiation with respect to time, Eq. (1-1A-7) becomes

$$\frac{\mathrm{d}u_L}{\mathrm{d}t}+\frac{R}{L}u_L=\frac{\mathrm{d}e}{\mathrm{d}t} \tag{1-1A-8}$$

which is the differential equation for the inductor voltage.

Fig. 1-1A-3b shows a series circuit containing a resistor, inductor, and capacitor. Following the mesh-analysis method outlined above, the circuit equation is

$$L\frac{\mathrm{d}i}{\mathrm{d}t}+Ri+\frac{1}{C}\int i\mathrm{d}t=e \tag{1-1A-9}$$

Recalling that current $i=\mathrm{d}q/\mathrm{d}t$, a substitution of this variable may be made to eliminate the integral from the equation. The result is the second-order differential equation

$$L\frac{\mathrm{d}^2q}{\mathrm{d}t^2}+R\frac{\mathrm{d}q}{\mathrm{d}t}+\frac{q}{C}=e$$

## WORDS AND TERMS

network *n.* 网络，电路

resistor *n.* 电阻器

inductor *n.* 电感器

capacitor *n.* 电容器

passive network 无源网络

active network 有源网络

characteristic *adj.* 特性（的）；*n.* 特性曲线

Ohm *n.* 欧姆

Faraday *n.* 法拉第

electric charge 电荷

integral *n.* 积分

increment *n.* 增量

armature *n.* 电枢，衔铁，加固

aforementioned *adj.* 上述的，前面提到的

represent *v.* 代表，表示，阐明

amplify *v.* 放大

symbolic *adj.* 符号的，记号的

mesh *n.* 网孔

Kirchhoff's first law 基尔霍夫第一定律

loop current 回路电流

voltage drop 电压降

in series 串联

differential *adj.* 微分的；*n.* 微分

variable *n.* 变量

outline *n.* 轮廓；*v.* 提出……的要点

eliminate *v.* 消除，对消

## NOTES

[1] In the case of a resistor, the voltage-current relationship is given by Ohm's law, which states that the voltage across the resistor is equal to the current through the resistor multiplied by the value of the resistance.

就电阻来说，电压－电流的关系由欧姆定律决定。欧姆定律指出：电阻两端的电压等于电阻上流过的电流乘以电阻值。

in the case of：就……来说，就……而论

in case (of)：假如；万一；在……的情况下

in that case：那么，既然是那样

in this case：既然是这样

in any case：无论如何，总之

in all case：就一切情况而论

[2] It may be that the inductor voltage rather than the current is the variable of interest in the circuit.

或许在电路中，人们感兴趣的变量是电感电压而不是电感电流。

M rather than N：是 M 而不是 N

of interest：有价值的；使人感兴趣的；有意义的

# B Three-Phase Circuits

A three-phase circuit is merely a combination of three single-phase circuits. Because of this fact, current, voltage, and power relations of balanced three-phase circuits may be studied by the application of single-phae rules to the component parts of the three-phase circuit. Viewed in this light, it will be found that the analysis of three-phase circuits is little more difficult than that of single-phase circuits[1].

## Reasons for Use of Three-Phase Circuits

In a single-phase circuit, the power is of a pulsating nature. At unity power factor, the power in a single-phase circuit is zero twice each cycle[2]. When the power factor is less than unity, the power is negative during parts of each cycle. Although the power supplied to each of the three phases of a three-phase circuit is pulsating, it may be proved that the total three-phase power supplied a balanced three-phase circuit is constant. Because of this, the characteristics of three-phase apparatus, in general, are superior to those of similar single-phase apparatus.

Three-phase machinery and control equipment are smaller, lighter in weight, and more efficient than single-phase equipment of the same rated capacity. In addition to the above-mentioned advantages offered by a three-phase system, the distribution of three-phase power requires only three fourths as much line copper as does the single-phase distribution of the same amount of power.

## Generation of Three-Phase Voltages

A three-phase electric circuit is energized by three alternating emfs of the same frequency and differing in time phase by 120 electrical degrees. Three such sine-wave emfs are shown in Fig. 1-1B-1. These emfs are generated in three separate sets of armature coils in an AC generator. These three sets of coils are mounted 120 electrical degrees apart on the generator armature. The coil ends may all be brought out of the generator to form three separate single-phase circuits. However, the coils are ordinarily interconnected either internally or externally to form a three-wire or four-wire three-phase system.

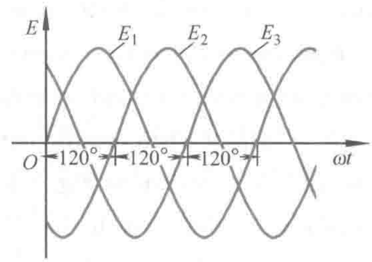


Fig. 1-1B-1 Three sine-wave emfs differing in phase by 120 electrical degrees are used for energizing a three-phase circuit

There are two ways of connecting the coils of three-phase generators, and in general, there are two ways of connecting devices of any sort to a three-phase circuit. These are the *wye-connection* and the *delta-connection*. Most generators are wye-connected, but loads may be either wye-connected or delta-Connected.

## Voltage Relations in a Wye-Connected Generator

Fig. 1-1B-2a represents the three coils or phase windings of a generator. These windings are so spaced on the armature surface that the emfs generated in them are 120° apart in time phase. Each coil ends lettered S and F (start and finish). In Fig. 1-1B-2a, all the coil ends marked S are connected to a common point N, called the neutral, and the three coil ends marked F are brought out to the line terminals A, B, and C to form a three-wire three-phase supply. This type of connection is called the wye-connection. Often the neutral connection is brought out to the terminal board, as shown by the dotted line in Fig. 1-1B-2a, to form a four-wire three-phase system.

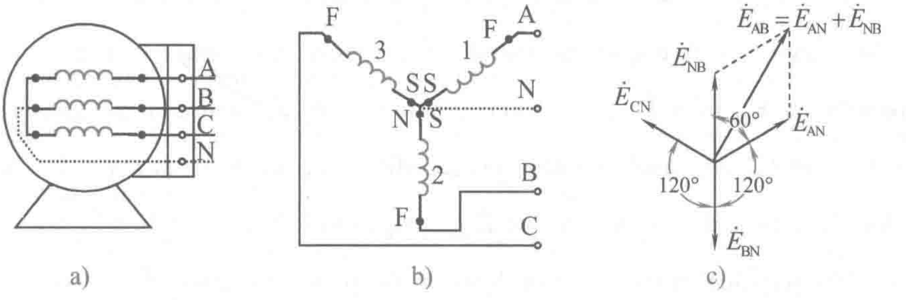


Fig. 1-1B-2 a) Connection of the phase windings in a wye-connection generator
b) Conventional diagram of a wye-connection
c) Phasor diagram showing the relation between phase and line voltages

The voltages generated in each phase of an AC generator are called the *phase voltages* (symbol $E_p$). If the neutral connection is brought out of the generator, the voltage from any one of the line terminals A, B, or C to the neutral connection N is a phase voltage. The voltage between any two of the three line terminals A, B, or C is called line-to-line voltage or, simply, a *line voltage* (symbol $E_L$).

The order in which the three voltages of a three-phase system succeed one another is called the phase sequence or the phase rotation of the voltages. This is determined by the direction of rotation of the generator but maybe reversed outside the generator by interchanging any two of the three line wires (not a line wire and a neutral wire).

It is helpful when drawing circuit diagrams of wye connection to arrange the three phases in the shape of a Y as shown in Fig. 1-1B-2b. Note that the circuit of Fig. 1-1B-2b is exactly the same as that of Fig. 1-1B-2a, with the S end of each coil connected to the neutral point and the F end brought out to the terminal in each case. After a circuit diagram has been drawn with all intersections lettered, a phasor diagram may be drawn as in Fig. 1-1B-2c. The phasor diagram shows the three phase voltages $\dot{E}_{AN}$, $\dot{E}_{BN}$, and $\dot{E}_{CN}$ which are 120° apart.

It should be noted in Fig. 1-1B-2 that each phasor is lettered with two subscripts. The two letters indicate the two points between which the voltage exists, and the order of the letters indicates the relative polarity of the voltage during its positive half-cycle. For example, the symbol $\dot{E}_{AN}$ indicates a voltage between the points A and N with the point A being positive with respect to point N during its positive half-cycle. In the phasor diagram shown, it has been assumed that the generator terminals were positive with respect to the neutral during the positive half-cycle. Since the voltage reverses every half-cycle, either polarity may be assumed if this polarity is assumed consistently for all three phases. It should be noted that if the polarity of point A with respect to N ($\dot{E}_{AN}$) is assumed for the positive half-cycle, then $\dot{E}_{NA}$ when used in the same phasor diagram should be drawn opposite to, or 180° out of phase with, $\dot{E}_{AN}$[3].

The voltage between any two line terminals of wye-connected generator is the difference between the potentials of these two terminals with respect to the neutral. For example, the line voltage $\dot{E}_{AB}$ is equal to the voltage A with respect to neutral ($\dot{E}_{AN}$) minus the voltage B with respect to neutral ($\dot{E}_{BN}$). To subtract $\dot{E}_{BN}$ from $\dot{E}_{AN}$, it is necessary to reverse $\dot{E}_{BN}$ and add this phase to $\dot{E}_{AN}$. The two phasors $\dot{E}_{AN}$ and $\dot{E}_{NB}$ are equal in length and are 60° apart, as shown in Fig. 1-1B-2c. It may be shown graphically or proved by geometry that $\dot{E}_{AB}$ is equal to 1.73, multiplied by the value of either $\dot{E}_{AN}$ or $\dot{E}_{NB}$. The graphical construction is shown in the phasor diagram. Therefore, in a balanced wye connection

$$E_L = 1.73 E_P$$

## Current Relations in a Wye-Connected Generator

The current flowing out to the line wires from the generator terminals A, B, and C (Fig. 1-1B-2) must flow from the neutral point N, out through the generator coils. Thus, the current