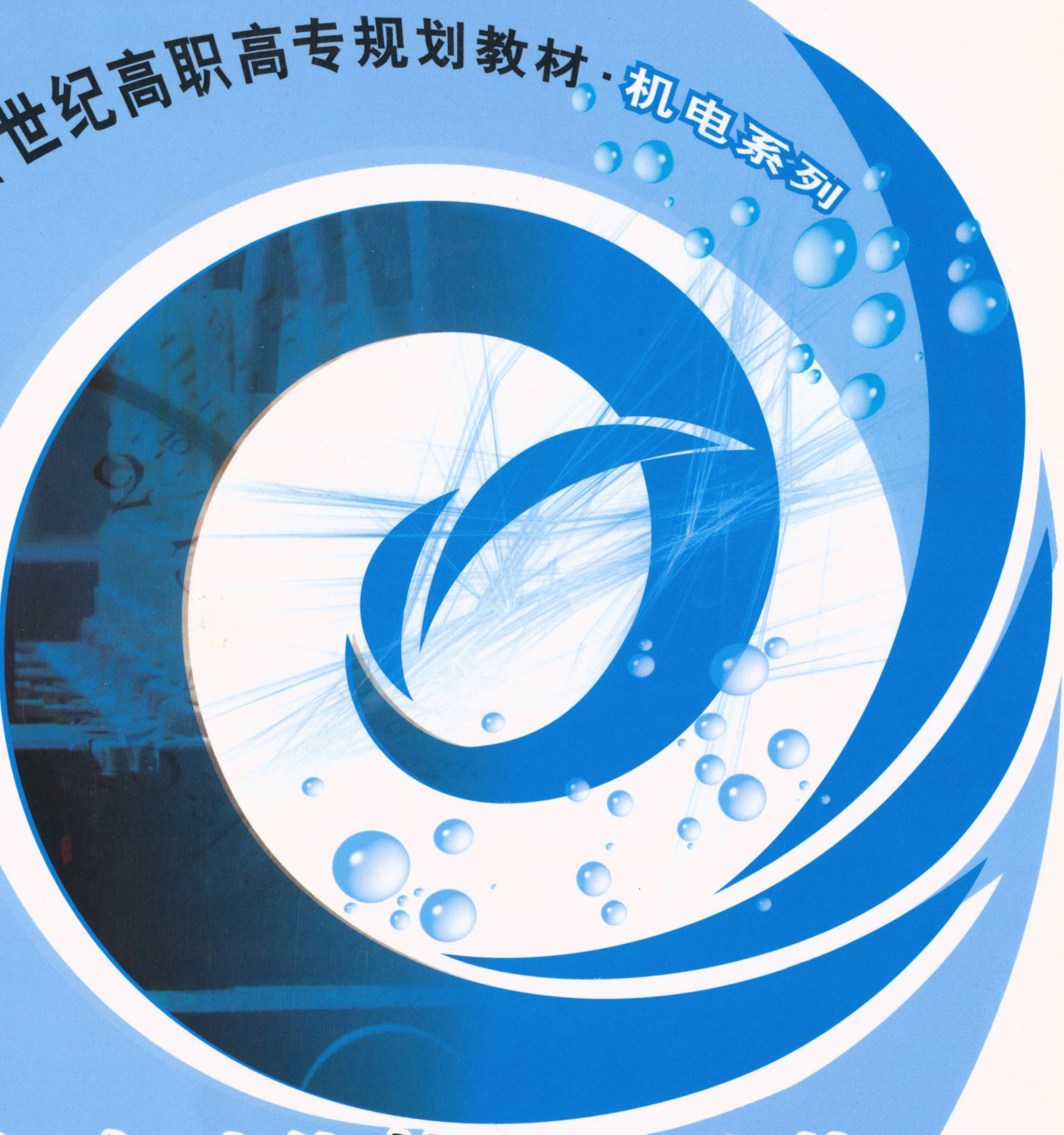
21世纪高职高专规划教材·机电系列



电气自动化技术专业英语

张　锋
张云龙　主编

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张　锋　张云龙　主　编
程秀玲　刘彦超　付志勇　副主编
石　磊　主　审

北京交通大学出版社
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内 容 简 介

本书是针对高职高专电气自动化技术专业的特点和要求及教育部《关于加强高职高专教材建设的若干意见》编写而成的。

全书分为六章，共计29个单元。第一章电工电子技术基础，主要介绍电路元器件、电路网络分析、二极管、三极管、运算放大器、逻辑电路等；第二章电机和电机控制，主要介绍变压器、直流电动机、交流异步电动机、常见电器及电动机控制电路等；第三章工业计算机控制技术，主要介绍 PLC、单片机、现场总线等；第四章自动检测系统，主要介绍传感器的原理、组成，温度传感器、压力传感器、流量传感器及液位传感器等；第五章自动控制系统，主要介绍自动控制系统简介、传递函数、波德图、过程控制、系统仿真等；第六章主要介绍电力系统相关知识。本书所有课文均精心选自国外相关网站和教材，具有专业性和实用性强、难度适宜等特点，有助于培养学生阅读电类英文资料的能力。

本书可作为高职高专电气自动化技术等相关专业的教材，也可供中等职业学校相关专业使用及专业英语爱好者学习参考。

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前　　言

本书是根据目前高职高专教育的特点并结合当前行业的发展和人才的需求编写而成的。

随着经济发展逐步全球化，外资企业和合资企业不断进入中国，这些企业起点高，技术新，有大量的设备需要用到电气自动化控制方面的知识；与此同时，很多大中型企业为了提高产品质量和数量以加大竞争力，进行技术改造，也大量引进先进设备，电气设备，PLC 控制技术、现场总线技术、变频技术、计算机集散控制技术（DCS）、微电子技术等，新知识在各行各业中特别是在工业中用得越来越多，这就要求专业技术人员不仅要懂专业，同时还需要掌握一定的专业英语词汇。

专业英语的教学目的是指导学生阅读与自己专业相关的英文书刊和文选，使学生能以英语为工具，获取与专业相关的信息。本书共分为六章：第一章电工电子技术基础，主要介绍电路元器件、电路网络分析、二极管、三极管、运算放大器、逻辑电路等；第二章电机和电机控制，主要介绍变压器、直流电动机、交流异步电动机、常见电器及电动机控制电路等；第三章工业计算机控制技术，主要介绍 PLC、单片机、现场总线等；第四章自动检测系统，主要介绍传感器的原理、组成，温度传感器、压力传感器、流量传感器及液位传感器等；第五章自动控制系统，主要介绍自动控制系统简介、传递函数、波德图、过程控制、系统仿真等；第六章主要介绍电力系统相关知识。本书所有课文均精心选自国外相关网站和教材，尽量保持原著本色，具有专业性和实用性强、难度适宜等特点，有助于培养学生阅读机电类英文资料的能力。

本书由张锋、张云龙担任主编，程秀玲、刘彦超、付志勇担任副主编，在编写过程中，为保证本书针对专业的准确性和前瞻性，我们还特别聘请美籍专家 Peter Craig 对全书进行了详细的审核，并提出了许多宝贵的建议，在此，向他表示由衷的谢意。全书由张锋统稿。

本书由石磊副教授担任主审，他对本书进行了认真的审阅并提出了许多宝贵意见，在此表示最衷心的感谢！

由于本书涉及学科较广，加之编者水平有限，书中不妥之处在所难免，恳请各位读者提出宝贵意见。

编　者

2011 年 1 月于包头

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Chapter

1 Electric and Electronic Technology Fundamentals

Unit 1 Electrical Elements and Components

Introduction

Electrical elements are conceptual abstractions used in the analysis of electrical networks. Any electrical network can be analyzed as multiple, interconnected electrical elements in a schematic diagram or circuit diagram, each of which affects the voltage in the network or current through the network.[1] These ideal electrical elements represent real, physical electrical or electronic components but they do not exist physically and they are assumed to have ideal properties according to a lumped element model. While components are objects with less than ideal properties, a degree of uncertainty in their values and some degree of nonlinearity, each of which may require a combination of multiple electrical elements in order to approximate its function.

Circuit analysis using electric elements is useful for understanding many practical electrical networks using components. By analyzing the way a network is affected by its individual elements, it is possible to estimate how a real network will behave.

The elements

The four fundamental circuit variables are current, I; voltage, V; charge, Q; and magnetic flux, Φ. Only 5 elements, produced by manipulating these four variables, are required to represent any component or network in a linear system[2].

Two sources:

- Current source, measured in amperes — produces a current in a wire. An ideal current source is a mathematical model, which real devices can only approach in performance. The current through an ideal current source is independent of the voltage across it.
- Voltage source, measured in volts — produces a potential difference across two points. An

ideal voltage source only exists in mathematical models of circuits. Similarly, the voltage across an ideal voltage source is independent of the current through it.

Three passive elements:

- Resistance R, measured in ohms — produces a voltage proportional to the current flowing through the element. Voltage and current are related according to the relation $u = R \cdot i$.

- Capacitance C, measured in farads — produces a current proportional to the rate of change of voltage across the element. Relates Charge and voltage are related according to the relation $q = C \cdot u$, $i = \mathrm{d}q/\mathrm{d}t = C \cdot (\mathrm{d}u/\mathrm{d}t)$.

- Inductance L, measured in henries — produces a voltage proportional to the rate of change of current through the element. Flux and current are related according to the relation $\phi = L \cdot i$, $u = \mathrm{d}\phi/\mathrm{d}t = L \cdot (\mathrm{d}i/\mathrm{d}t)$.

The Components

A battery provides electromotive force (emf), or voltage, in a circuit. It contains layers of chemicals that cause electrons to move in a certain direction, from its negative pole to its positive pole[3]. It is marked with a rating of how much voltage there is across the two poles, and a (–) for the negative pole and a (+) for the positive pole. Batteries may also be marked with an ampere hour (Ah) rating, indicating total charge capacity.

An ideal battery can thus be represented as a voltage source. In practice, a battery also has an internal resistance that is represented as a resistance in series with the voltage source.

If a wire is used to connect the two poles of a battery, electrons flow through the wire from the negative end to the positive end. (The wire will also get hot because it isn't a perfect conductor, and the battery will quickly exhaust all its power.) Thus a wire can be represented as a low-value resistor.

Current sources are often absent from basic electric circuits, and are more likely to be found in electronic circuits containing semiconductors[4]. For example, on a first degree of approximation, a bipolar (junction) transistor may be represented by a variable current source that is controlled by the input voltage.

A resistor is a component whose function is to regulate the current in the circuit. One common kind is a little cylinder of graphite with metal wires coming out of either end. These are painted with colored stripes that indicate the resistance, in ohms, and the tolerance, in percent. This system is called the resistor color code.

Another kind of resistor is a filament, which is a coil of metal wire that can withstand high temperature but has a finite resistance[5]. When a current is passed through a filament, it heats up because of this resistance. Filaments are commonly used in light bulbs and heaters. They are marked with the voltage that should be applied to them, and the power, in watts, that they will then give off as light and heat. Due to the effect of heating, a filament's resistance is higher when it is hot than when it is cold.

An electric charge can be stored and then quickly released by a component called a capacitor. A common type of capacitor consists of two pieces of metal foil (or plates) with an insulator (the dielectric) such as waxed paper between them.

If an electric charge is placed on the plates of a capacitor, it will stay there because it can't cross the insulator to the other plate. If a wire is then connected between the two plates, the charge will flow through the wire to balance the charges on the opposite plates — the capacitor is then said to be discharged.

Some capacitors look like a cylinder or blob with two wires coming out one end, and are marked to indicate their capacitance (the charge that they store per volt) in microfarads (μF), nanofarads (nF) or picofarads (pF).

Inductance in a circuit is provided by components called inductors, which are almost always built from coils of wire. Large values of inductance are obtained by forming the coil around a magnetic core, such as a lump of iron or ferrite. Inductance is also present in the windings of electric motors and generators, and to a lesser extent in any piece of wire.

Elements vs. components

There is a distinction between real, physical electrical or electronic components and the ideal electrical elements by which they are represented.

- Electrical elements do not exist physically, and are assumed to have ideal properties according to a lumped element model[6].
- Conversely, components do exist, have less than ideal properties, their values always have a degree of uncertainty, they always include some degree of nonlinearity and typically require a combination of multiple electrical elements to approximate their functions.

Technical Words and Expressions

conceptual *adj*.	概念上的	abstraction *n*.	抽象
lumped element model	集总参数元件模型	are objects with	倾向于
nonlinearity *n*.	非线性特性	charge *n*.	电量
magnetic flux	磁通量	ideal current source	理想电流源
potential difference	电势差	ideal voltage source	理想电压源
passive element	无源元件	ohm *n*.	欧姆（电阻单位）
resistance *n*.	电阻	capacitance *n*.	容量，电容
farad *n*.	法拉（电容单位）	inductance *n*.	电感
henries *n*.	亨利（电感单位）	electromotive force	电动势
negative pole	负极	positive pole	正极
exhaust *vt*.	用尽，耗尽	cylinder *n*.	圆柱体
graphite *n*.	石墨	colored stripe	色环
tolerance *n*.	额定容量	filament *n*.	金属丝
withstand *v*.	抵挡，经受住	capacitor *n*.	电容器

nanofarad *n.* 纳法（拉） picofarad *n.* 皮法（拉）
inductor *n.* 感应器 lump *n.* 块（尤指小块）
ferrite *n.* 铁氧体

Notes

[1] Any electrical network can be analyzed as multiple, interconnected electrical elements in a schematic diagram or circuit diagram, each of which affects the voltage in the network or current through the network.

译文：任何电网络都可以分解为原理图或电路图中多个相互连接的元件来研究，并且每一个元件都会影响到电网络中的电压和电流。

[2] Only 5 elements, produced by manipulating these four variables, are required to represent any component or network in a linear system.

译文：在线性系统中仅用五个理想元件就可以表示任何电器件或任何电网络，而这五个理想元件来源于这四个变量的相互结合。

[3] It contains layers of chemicals that cause electrons to move in a certain direction, from its negative pole to its positive pole.

译文：电池由若干层化学物质组成，这些化学物质令电子从负级到正级做定向运动。

[4] Current sources are often absent from basic electric circuits, and are more likely to be found in electronic circuits containing semiconductors.

译文：电流源在基本电路中是找不到的，多数出现在含有半导体器件的电子电路当中。

[5] Another kind of resistor is a filament, which is a coil of metal wire that can withstand high temperature but has a finite resistance.

译文：另一种电阻是绕线电阻，这种电阻由耐高温小阻值的金属丝线圈构成。

[6] Electrical elements do not exist physically, and are assumed to have ideal properties according to a lumped element model.

译文：理想元件在自然界是不存在的，它是一种被假定为具有理想特性的集总参数模型。

Exercises

I. Translate the following Chinese into English.

1. （理想）元件
2. （实际）元件
3. 电流
4. 电压
5. 电量
6. 磁通量
7. 电流源
8. 电压源
9. 电阻
10. 电容
11. 电感
12. 欧姆
13. 法拉
14. 韦伯
15. 集总参数元件
16. 电动势

II. Complete the following sentences.

1. The concept of __________ is used in the analysis of __________.
2. Each electrical element affects the __________in the network or __________ through the network in particular way.
3. Resistance R, measured in __________ produces a voltage __________the current flowing through it.
4. On a first degree of approximation, a bipolar transistor may be represented by a ______ that is controlled by the __________.
5. A network is a connection of __________ or __________ components, and may not necessarily be a __________.

Unit 2 Network Analysis

Introduction

A network, in the context of electronics, is a collection of interconnected components. Network analysis is the process of finding the voltages across, and the currents through, every component in the network[1]. There are a number of different techniques for achieving this. However, for the most part, they assume that the components of the network are all linear. The methods described in this article are only applicable to linear network analysis except where explicitly stated.

Definitions

Component: A device with two or more terminals into which, or out of which, charge may flow[2].

Node: A point at which terminals of more than two components are joined. A conductor with a substantially zero resistance is considered to be a node for the purpose of analysis.

Branch: The component(s) joining two nodes.

Mesh: A group of branches within a network joined so as to form a complete loop.

Port: Two terminals where the current into one is identical to the current out of the other.

Equivalent circuits

A useful procedure in network analysis is to simplify the network by reducing the number of components[3]. This can be done by replacing the actual components with other notional components that have the same effect. A particular technique might directly reduce the number of components, for instance by combining impedances in series. On the other hand, it might merely change the form into one in which the components can be reduced in a later operation. For instance, one might transform a voltage generator into a current generator using Norton's theorem in order to be able to later combine the internal resistance of the generator with a parallel impedance load.

A resistive circuit is a circuit containing only resistors, ideal current sources, and ideal voltage sources. If the sources are constant (DC) sources, the result is a DC circuit. The analysis of a circuit refers to the process of solving for the voltages and currents present in the circuit. The solution principles outlined here also apply to phasor analysis of AC circuits.

Two circuits are said to be equivalent with respect to a pair of terminals if the voltage across the terminals and current through the terminals for one network have the same relationship as the voltage and current at the terminals of the other network[4] (Fig.1.1).

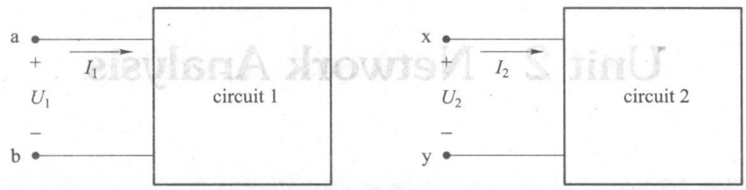


Fig.1.1 Circuit equivalence

If $U_2 = U_1$ implies $I_2 = I_1$ for all (real) values of U_1, then with respect to terminals ab and xy, circuit 1 and circuit 2 are equivalent.

The above is a sufficient definition for a one-port network. For more than one port, then it must be defined that the currents and voltages between all pairs of corresponding ports must bear the same relationship.[5] For instance, star and delta networks are effective three port networks and hence require three simultaneous equations to fully specify their equivalence.

Impedances in series and in parallel

Any two terminal network of impedances can eventually be reduced to a single impedance by successive applications of impedances in series or impedances in parallel.

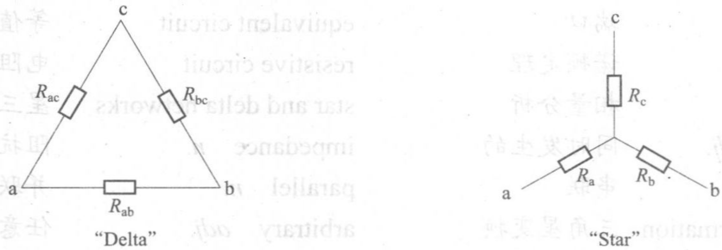
Impedances in series: $Z_{eq} = Z_1 + Z_2 + \cdots + Z_3$

Impedances in parallel: $\frac{1}{Z_{eq}} = \frac{1}{Z_1} + \frac{1}{Z_2} + \cdots + \frac{1}{Z_n}$

The above simplified for only two impedances in parallel: $Z_{eq} = \frac{Z_1 Z_2}{Z_1 + Z_2}$

Delta-wye transformation

A network of impedances with more than two terminals cannot be reduced to a single impedance equivalent circuit. An n-terminal network can, at best, be reduced to n impedances. For a three terminal network, the three impedances can be expressed as a three node delta (Δ) network or a four node star (Y) network. These two networks are equivalent and the transformations between them are given below. A general network with an arbitrary number of terminals cannot be reduced to the minimum number of impedances using only series and parallel combinations. In general, Y-Δ and Δ-Y transformations must also be used. It can be shown that this is sufficient to find the minimal network for any arbitrary network with successive applications of series, parallel, Y-Δ and Δ-Y; no more complex transformations are required (Fig.1.2).



$$R_{ac} = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b}$$

$$R_{ab} = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$$

$$R_{bc} = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

$$R_a = \frac{R_{ac} R_{ab}}{R_{ac} + R_{ab} + R_{bc}}$$

$$R_b = \frac{R_{ab} R_{bc}}{R_{ac} + R_{ab} + R_{bc}}$$

$$R_c = \frac{R_{bc} R_{ac}}{R_{ac} + R_{ab} + R_{bc}}$$

Fig.1.2 Star-to-delta transformation and Delta-to-star transformation

For equivalence, the impedances between any pair of terminals must be the same for both networks, resulting in a set of three simultaneous equations. The equations below are expressed as resistances but apply equally to the general case with impedances.

Source transformation

A generator with an internal impedance (i.e. non-ideal generator) can be represented as either an ideal voltage generator or an ideal current generator plus the impedance. These two forms are equivalent and the transformations are given below. If the two networks are equivalent with respect to terminals ab, then U and I must be identical for both networks. Thus,

Norton's theorem states that any two-terminal network can be reduced to an ideal current generator and a parallel impedance[6].

Thévenin's theorem states that any two-terminal network can be reduced to an ideal voltage generator plus a series impedance (Fig.1.3).

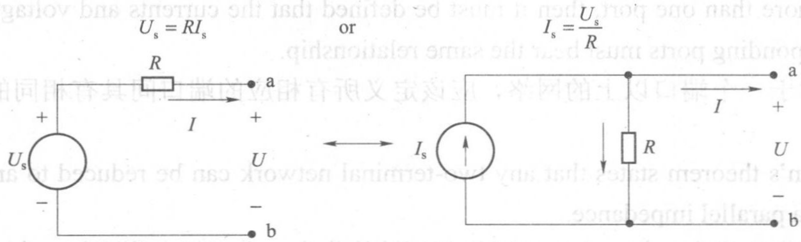


Fig.1.3 Source transformation

Technical Words and Expressions

linear network	线性网络	component *n.*	元件，组件
terminal *n.*	终端	explicitly *adv.*	明白地，明确地
node *n.*	节点，结点	mesh *n.*	网孔
port *n.*	端口	equivalent circuit	等值电路
Norton's theorem	诺顿定理	resistive circuit	电阻性电路
phasor analysis	相量分析	star and delta networks	星三角网络
simultaneous *adj.*	同时发生的	impedance *n.*	阻抗
series *n.*	串联	parallel *n.*	并联
delta-wye transformation	三角星变换	arbitrary *adj.*	任意的
successive *adj.*	连续的	equivalence *n.*	同等，等价
source transformation	电源变换	identical *adj.*	同一的，同样的
Thévenin's theorem	戴维南定理		

Notes

[1] Network analysis is the process of finding the voltages across, and the currents through, every component in the network.

译文：网络分析是一个寻求网络元件上电压及流过网络元件电流的过程。

[2] Component: A device with two or more terminals into which, or out of which, charge may flow.

译文：元件是一种两端或多端设备，电荷可从这些端口流入或流出。

[3] A useful procedure in network analysis is to simplify the network by reducing the number of components.

译文：通过减少元件数量来简化电路是一种网络分析的有用方法。

[4] Two circuits are said to be equivalent with respect to a pair of terminals if the voltage across the terminals and current through the terminals for one network have the same relationship as the voltage and current at the terminals of the other network.

译文：如果一个网络的端电压和流过端点间的电流之间的关系与另一个网络端点间的电压和电流关系相同，这两个端点间的电路等效。

[5] For more than one port, then it must be defined that the currents and voltages between all pairs of corresponding ports must bear the same relationship.

译文：对于一个端口以上的网络，应该定义所有相应的端口间具有相同的电流、电压关系。

[6] Norton's theorem states that any two-terminal network can be reduced to an ideal current generator and a parallel impedance.

译文：诺顿定理为：任一个二端网络都可被简化为一个理想电流源与一个电阻的并联。

Exercises

I. Translate the following Chinese into English.

1. 节点　　2. 支路
3. 网孔　　4. 端口
5. 等效电路　　6. 三角形变换
7. 串联　　8. 并联
9. 诺顿定理　　10. 戴维南定理

II. Complete the following sentences.

1. Network analysis is the process of finding the __________ across, and __________ though, every __________ in the network.
2. A useful procedure in network analysis is to __________ the network by reducing the __________ of components.
3. A resistive circuit is a circuit containing only __________, ideal __________, and ideal __________.
4. Star and delta networks are effective __________ networks and hence require __________ simultaneous equations to fully specify their __________.
5. A generator with an __________ (i.e. non-idea generator) can be represented as either __________ or __________ plus the impedance.

Unit 3 Transistor

Introduction

A transistor is a semiconductor device used to amplify and switch electronic signals. It is made of a solid piece of semiconductor material, with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be much more than the controlling (input) power, the transistor provides amplification of a signal[1]. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits[2].

The transistor is the fundamental building block of modern electronic devices, and is ubiquitous in modern electronic systems. Following its release in the early 1950s the transistor revolutionized the field of electronics, and paved the way for smaller and cheaper radios, calculators, and computers, amongst other things.

Importance

The transistor is the key active component in practically all modern electronics, and is considered by many to be one of the greatest inventions of the twentieth century. Its importance in today's society rests on its ability to be mass produced using a highly automated process (semiconductor device fabrication) that achieves astonishingly low per-transistor costs[3].

Although several companies each produce over a billion individually packaged (known as discrete) transistors every year, the vast majority of transistors now produced are in integrated circuits (often shortened to IC, microchips or simply chips), along with diodes, resistors, capacitors and other electronic components, to produce complete electronic circuits. A logic gate consists of up to about twenty transistors whereas an advanced microprocessor, as of 2009, can use as many as 2.3 billion transistors (MOSFETs). "About 60 million transistors were built this year[2002]... for[each] man, woman, and child on Earth."

The transistor's low cost, flexibility, and reliability have made it a ubiquitous device. Transistorized mechatronic circuits have replaced electromechanical devices in controlling appliances and machinery. It is often easier and cheaper to use a standard microcontroller and write a computer program to carry out a control function than to design an equivalent mechanical control function.

Transistor as a switch

Transistors are commonly used as electronic switches, for both high power applications including switched-mode power supplies and low power applications such as logic gates[4].

In a grounded-emitter transistor circuit, such as the light-switch circuit shown, as the base voltage rises the base and collector current rise exponentially, and the collector voltage drops because of the collector load resistor. The relevant equations:

$U_{RC} = I_{CE} \times R_C$, the voltage across the load (the lamp with resistance R_C)

$U_{RC} + U_{CE} = U_{CC}$, the supply voltage shown as 6V

If U_{CE} could fall to 0 (perfect closed switch) then I_C could go no higher than U_{CC} / R_C, even with higher base voltage and current. The transistor is then said to be saturated. Hence, values of input voltage can be chosen such that the output is either completely off, or completely on. The transistor is acting as a switch, and this type of operation is common in digital circuits where only "on" and "off" values are relevant (Fig.1.4).

Transistor as an amplifier

The common-emitter amplifier is designed so that a small change in voltage (U_{in}) changes the small current through the base of the transistor and the transistor's current amplification combined with the properties of the circuit mean that small swings in U_{in} produce large changes in U_{out}[5] (Fig.1.5).

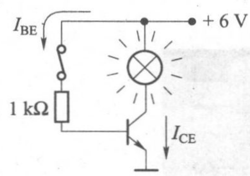


Fig.1.4 BJT used as an electronic switch

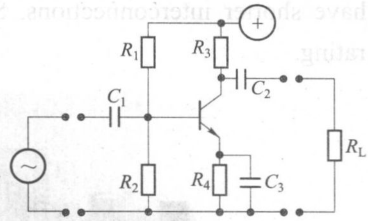


Fig.1.5 The common emitter amplifier circuit

Various configurations of single transistor amplifier are possible, with some providing current gain, some voltage gain, and some both.

From mobile phones to televisions, vast numbers of products include amplifiers for sound reproduction, radio transmission, and signal processing[6]. The first discrete transistor audio amplifiers barely supplied a few hundred milliwatts, but power and audio fidelity gradually increased as better transistors became available and amplifier architecture evolved.

Modern transistor audio amplifiers of up to a few hundred watts are common and relatively inexpensive.

Types

Transistors are categorized by

- Semiconductor material: germanium, silicon, gallium arsenide, silicon carbide, etc.;
- Structure: BJT, JFET, IGFET (MOSFET), IGBT, "other types";
- Polarity: NPN, PNP (BJTs); N-channel, P-channel (FETs);
- Maximum power rating: low, medium, high;
- Maximum operating frequency: low, medium, high, radio frequency (RF), microwave (The maximum effective frequency of a transistor is denoted by the term f_T, an abbreviation for "frequency of transition". The frequency of transition is the frequency at which the transistor yields unity gain);
- Application: switch, general purpose, audio, high voltage, super-beta, matched pair;
- Physical packaging: through hole metal, through hole plastic, surface mount, ball grid array, power modules;
- Amplification factor hfe (transistor beta). Thus, a particular transistor may be described as silicon, surface mount, BJT, NPN, low power, high frequency switch.

Packaging

Transistors come in many different packages (semiconductor packages) (see Fig.1.6). The two main categories are through-hole (or leaded), and surface-mount, also known as surface mount