实用专业英语规划教材

电力专业英语

English for Electric Power Specialty

张 华 主编

華中科技大學出版社
http://www.hustp.com

电力专业英语

English for Electric Power Specialty

主　编　张　华
副主编　邓红英　胡亦玫
编　写　熊桂芳　尹传烨　陈　伟
主　审　张晓春

华中科技大学出版社
中国·武汉

图书在版编目(CIP)数据

电力专业英语/张　华　主编.—武汉:华中科技大学出版社,2008年10月
ISBN 978-7-5609-4929-1

Ⅰ.电…　Ⅱ.张…　Ⅲ.电力工业-英语-高等学校:技术学校-教材　Ⅳ.H31

中国版本图书馆CIP数据核字(2008)第162191号

电力专业英语　　张　华　主编

策划编辑:杨　鸥
责任编辑:田　密　　封面设计:潘　群
责任校对:李　琴　　责任监印:周冶超

出版发行:华中科技大学出版社(中国·武汉)
武昌喻家山　邮编:430074　电话:(027)87557437

印　刷:湖北省通山县九宫印务有限公司

开本:787mm×1092mm　1/16　印张:10　字数:216 000
版次:2008年10月第1版　印次:2008年10月第1次印刷　定价:16.80元
ISBN 978-7-5609-4929-1/H·640

内容提要

本书涉及电力行业的多个领域，包括电力系统、发电厂、电力设备、输配电系统、继电保护、新能源发电等。

全书共8章，分别为现代电力系统的一般特性、发电厂、变压器、输配电系统及输电线路、断路器和开关设备、继电保护设计和继电器、电力系统继电保护、可再生能源。

本书可作为高等院校电力专业的教学用书，也可用作电力企业工程技术人员学习专业英语的培训教材。

前　言

本书是在编者多年教学实践的基础上，结合电力专业在校学生和广大专业技术人员实际工作的需要而编写的。

全书从电力专业的基础知识入手，内容涉及电力系统、发电厂、电力设备、继电保护以及新能源发电等，旨在帮助读者利用英语这一语言工具，阅读电力类英文技术文献和资料。书中对每章课文中的大量生词和难句都给出了详细的注释，课后配有词汇和阅读理解练习，以及相关的补充阅读材料。为适应在校学生学习的需要，本书对电力专业英语的特点、翻译时容易出错的语法问题、专业词汇的构词法、常用的数学符号和物理量的英语表达形式，以及常用专业词汇的英文缩写等都作了一些归纳，为进一步提高读者阅读的兴趣，书中还配置了大量的图片，版面设计更为新颖活泼。

在本书的编写过程中，得到许多同行的支持和热心帮助。在此，对汪祥斌副教授、陈祎娟高工、张晓春副教授、王涛老师等表示由衷的感谢。

限于编者的水平和经验，书中错误和不妥之处在所难免，敬请读者批评指正。

编　者
2008年8月

CONTENTS(目录)

Chapter 1 General Characteristics of Modern Power Systems

Chapter 2 Power Generating Stations

Chapter 3 Power Transformer

Chapter 4 Transmission System and Transmission Lines

Chapter 5 Circuit Breakers and Switches

Chapter 6 Protection Design and Relays

Chapter 7　Power System Protection

Chapter 8　Renewable Energy Sources

Chapter 1 General Characteristics of Modern Power Systems

Part 1 Evolution of Electric Power Systems

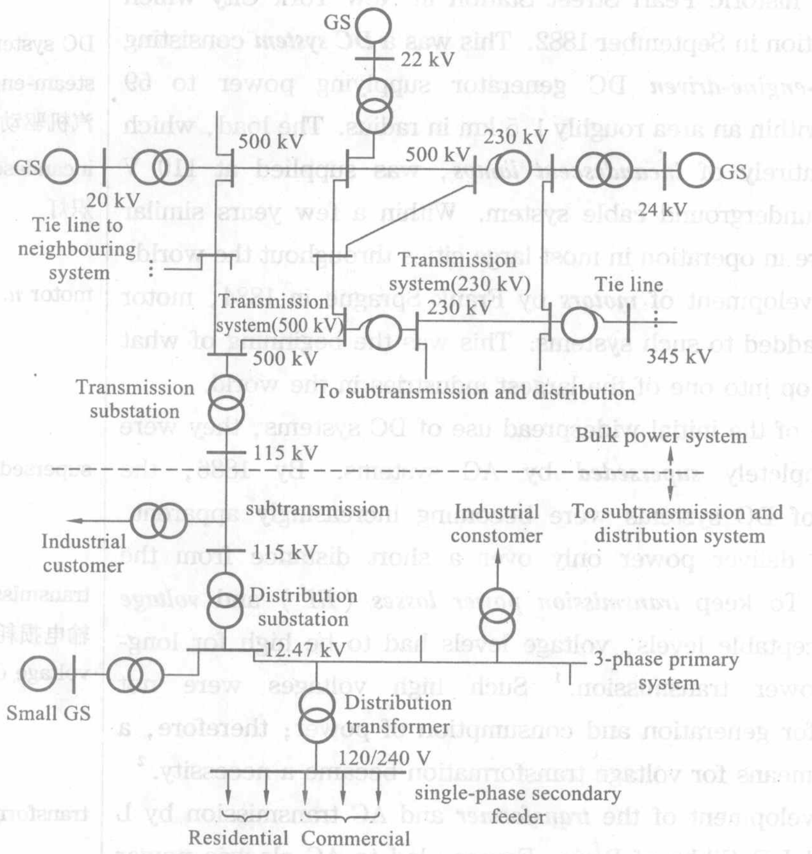

Fig. 1.1 Basic elements of a power system

Discuss the following questions with your classmates.

- What constitute the power system?
- What are the advantages of the AC systems ?
- Why HVDC transmission were significant achievements made in recent decades?
- What subsystems constitute the power system?

The purpose of this introductory chapter is to provide a general description of electric power systems beginning with a historical sketch of their evolution. The basic characteristics and structure of modern power systems are then identified. The performance requirements of a properly designed power system and the various levels of controls used to meet these requirements are also described.

The first complete electric power system (comprising a generator, cable, fuse, meter, and loads) was built by Thomas Edison—the historic Pearl Street Station in New York City which began operation in September 1882. This was a ***DC system*** consisting of a ***steam-engine-driven*** DC generator supplying power to 59 customers within an area roughly 1.5 km in radius. The load, which consisted entirely of ***incandescent lamps***, was supplied at 110 V through an underground cable system. Within a few years similar systems were in operation in most large cities throughout the world. With the development of ***motors*** by Frank Sprague in 1884, motor loads were added to such systems. This was the beginning of what would develop into one of the largest industries in the world.

DC system 直流系统
steam-engine-driven 蒸汽机驱动
incandescent lamp *n.* 白炽灯
motor *n.* 电动机

In spite of the initial widespread use of DC systems, they were almost completely ***superseded*** by AC systems. By 1886, the limitations of DC systems were becoming increasingly apparent. They could deliver power only over a short distance from the generators. To keep ***transmission power losses*** (RI^2) and ***voltage drops*** to acceptable levels, voltage levels had to be high for long-distance power transmission.[1] Such high voltages were not acceptable for generation and consumption of power; therefore, a convenient means for voltage transformation became a necessity.[2]

supersed *vt.* 取代
transmission power loss 输电损耗
voltage drop 电压降落

The development of the ***transformer*** and AC transmission by L Gaulard and J D Gibbs of Paris, France, led to AC electric power systems. George Westinghouse secured rights to these developments in the United States. In 1886, William Stanley, an associate of Westinghouse, developed and tested a commercially practical transformer and AC ***distribution system*** for 150 lamps at Great Barrington, Massachusetts. In 1889, the first AC transmission line in North America was put into operation in Oregon between Willmette Falls and Portland. It was a single-phase line transmitting

transformer *n.* 变压器
distribution system 配电系统

power at 4 000 V over a distance of 21 km.

With the development of ***polyphase*** systems by Nikola Tesla, the AC system became even more attractive. By 1888, Tesla held several ***patents*** on AC motors, generators, transformers, and transmission systems. Westinghouse bought the patents to these early inventions, and they formed the basis of the present-day AC systems. In the 1890s, there was considerable ***controversy*** over whether the electric utility industry should be standardized on DC or AC. There were passionate arguments between Edison, who ***advocated*** DC, and Westinghouse, who favoured AC[3]. By the turn of the century, the AC system had won out over the DC system for the following reasons:

(1) Voltage levels can be easily transformed in AC systems, thus providing the ***flexibility*** for use of different voltages for generation, transmission, and consumption.

(2) AC generators are much simpler than DC generators.

(3) AC motors are much simpler and cheaper than DC motors.

The first three-phase line in North America went into operation in 1893—a 2 300 V, 12 km line in southern California. Around this time, AC was chosen at Niagara Falls because DC was not ***practical*** for transmitting power to Buffalo, about 30 km away. This decision ended the AC versus DC controversy and established victory for the AC system.

In the early period of AC power transmission, ***frequency*** was not standardized. Many different frequencies were in use: 25, 50, 60, 125 and 133 Hz. This posed a problem for ***interconnection***. Eventually 60 Hz was adopted as standard in North America, although many other countries used 50 Hz.

The increasing need for transmitting larger amounts of power over longer distances created an incentive to use progressively higher voltage levels. The early AC systems used 12, 44 and 60 kV (***RMS*** line-to-line). This rose to 165 kV in 1922, 220 kV in 1923, 287 kV in 1935, 330 kV in 1953, and 500 kV in 1965. Hydro Quebec energized its first 735 kV in 1966, and 765 kV was introduced in the United States in 1969.

To avoid the ***proliferation*** of an unlimited number of voltages,

polyphase *n.*	多相
patent *n.*	专利权
controversy *n.*	争议
advocate *vt.*	提倡
flexibility *n.*	灵活
practical *adj.*	实用的
frequency *n.*	频率
interconnection *n.*	互联
RMS	均方根(值)
proliferation *n.*	扩散

the industry has standardized voltage levels. The standards are 115, 138, 161 and 230 kV for the high voltage (HV) class, and 345, 500 and 765 kV for the ***extra-high voltage*** (EHV) class.

extra-high voltage 超高压

With the development of ***mercury arc valves*** in the early 1950s, high voltage DC (***HVDC***) transmission systems became economical in special situations. The HVDC transmission is attractive for transmission of large blocks of power over long distances. The cross-over point beyond which DC transmission may become a competitive alternative to AC transmission is around 500 km for overhead lines and 50 km for underground or submarine cables. HVDC transmission also provides an ***asynchronous*** link between systems where AC interconnection would be impractical because of system stability considerations or because nominal frequencies of the systems are different.[4] The first modern commercial application of HVDC transmission occurred in 1954 when the Swedish mainland and the island of Gotland were interconnected by a 96 km submarine cable.

mercury arc value 汞弧阀

HVDC 高压直流输电

asynchronous *adj.* 非同步的

With the advent of ***thyristor*** valve converters, HVDC transmission became even more attractive. The first application of an HVDC system using thyristor valves was at Eel River in 1972—a ***back-to-back*** scheme providing an asynchronous tie between the power systems of Quebec and New Brunswick. With the cost and size of conversion equipment decreasing and its reliability increasing, there has been a steady increase in the use of HVDC transmission.

thyristor *n.* 晶闸管

back-to-back 背靠背

Interconnection of neighbouring ***utilities*** usually leads to improved system security and economy of operation. Improved security results from the mutual emergency assistance that the utilities can provide. Improved economy results from the need for less generating ***reserve*** capacity on each system. In addition, the interconnection permits the utilities to make economy transfers and thus take advantage of the most economical sources of power. These benefits have been recognized from the beginning and interconnections continue to grow. Almost all the utilities in the United States and Canada are now part of one interconnected system. The result is a very large system of enormous complexity. The design of such a system and its secure operation are indeed challenging problems.

utility *n.*（公用事业）电力公司

reserve *n.* 备用

Part 2 Structure of the Power System

Electric power systems vary in size and structural components. However, they all have the same basic characteristics:

(1) Be comprised of three-phase AC systems operating essentially at constant voltage. Generation and transmission ***facilities*** use three-phase equipment. Industrial loads are invariably three-phase; single-phase residential and commercial loads are distributed equally among the phases so as to effectively form a balanced three-phase system.

facility *n.* 设施

(2) Use synchronous machines for generation of electricity. ***Prime movers*** convert the primary sources of energy (***fossil***, ***nuclear***, and ***hydraulic***) to mechanical energy that is, in turn, converted to electrical energy by synchronous generators.

prime mover 原动机
fossil 化石
nuclear *n.* 原子能
hydraulic 水利的

(3) Transmit power over significant distances to consumers spread over a wide area. This requires a transmission system comprising subsystems operating at different voltage levels.

Fig. 1. 1 illustrates the basic elements of a modern power system. Electric power is produced at generating stations (GS) and transmitted to consumers through a complex network of ***individual*** components, including transmission lines, transformers, and switching devices.

individual *adj.* 单独的

It is common practice to ***classify*** the transmission network into the following subsystems.

classify *vt.* 分类

(1) Transmission system.

(2) Subtransmission system.

(3) Distribution system.

The transmission system interconnects all major generating stations and main load centres in the system. It forms the ***backbone*** of the integrated power system and operates at the highest voltage levels (typically, 230 kV and above). The generator voltages are usually in the range of 11 to 35 kV. These are stepped up to the transmission voltage level, and power is transmitted to transmission substations where the voltages are stepped down to the subtransmission level (typically, 69 to 138 kV).[5] The generation and

backbone *n.* 中枢，支柱

transmission subsystems are often referred to as the bulk power system.

The subtransmission system transmits power in smaller quantities from the transmission ***substations*** to the distribution substations. Large industrial customers are commonly supplied directly from the subtransmission system. In some systems, there is no clear ***demarcation*** between subtransmission and transmission circuits. As the system expands and higher voltage levels become necessary for transmission, the older transmission lines are often ***relegated*** to subtransmission function.

substation *n.* 变电站
demarcation *n.* 划分
relegate *v.* 归入

The distribution system represents the final stage in the transfer of power to the individual customers. The primary distribution voltage is typically between 4. 0 kV and 34. 5 kV. Small industrial customers are supplied by primary feeders at this voltage level. The secondary distribution ***feeders*** supply residential and commercial customers at 120/240 V.

feeder *n.* 馈线

Small generating plants located near the load are often connected to the subtransmission or distribution system directly.

Interconnections to neighbouring power systems are usually formed at the transmission system level.

The overall system thus consists of multiple generating sources and several layers of transmission networks. This provides a high degree of structural ***redundancy*** that enables the system to withstand unusual ***contingencies*** without service disruption to the consumers.

redundancy *n.* 冗余
contingency *n.* 偶然事件(故障)

Part 3 Power System Control

The function of an electric power system is to convert energy from one of the naturally available forms to the electrical form and to transport it to the points of consumption. Energy is seldom consumed in the electrical form but is rather converted to other forms such as heat, light, and mechanical energy.[6] The advantage of the electrical form of energy is that it can be transported and controlled with relative ease and with a high degree of ***efficiency*** and reliability. A properly designed and operated power system should, therefore, meet the following fundamental requirements.

efficiency *n.* 效率

1. The system must be able to meet the continually changing load demand for ***active and reactive power***. Unlike other types of energy, electricity cannot be conveniently stored in sufficient quantities. Therefore, adequate "***spinning***" reserve of active and reactive power should be maintained and appropriately controlled at all times.

active and reactive power 有功和无功功率

spin *v.* 旋转

2. The system should supply energy at minimum cost and with minimum ecological impact.

3. The "quality" of power supply must meet certain minimum standards with regard to the following factors:

(1) ***constancy*** of frequency;

(2) constancy of voltage;

(3) level of reliability.

constancy *n.* 始终如一

Several levels of controls involving a complex array of devices are used to meet the above requirements. These are depicted in Fig. 1.2 which identifies the various subsystems of a power system and

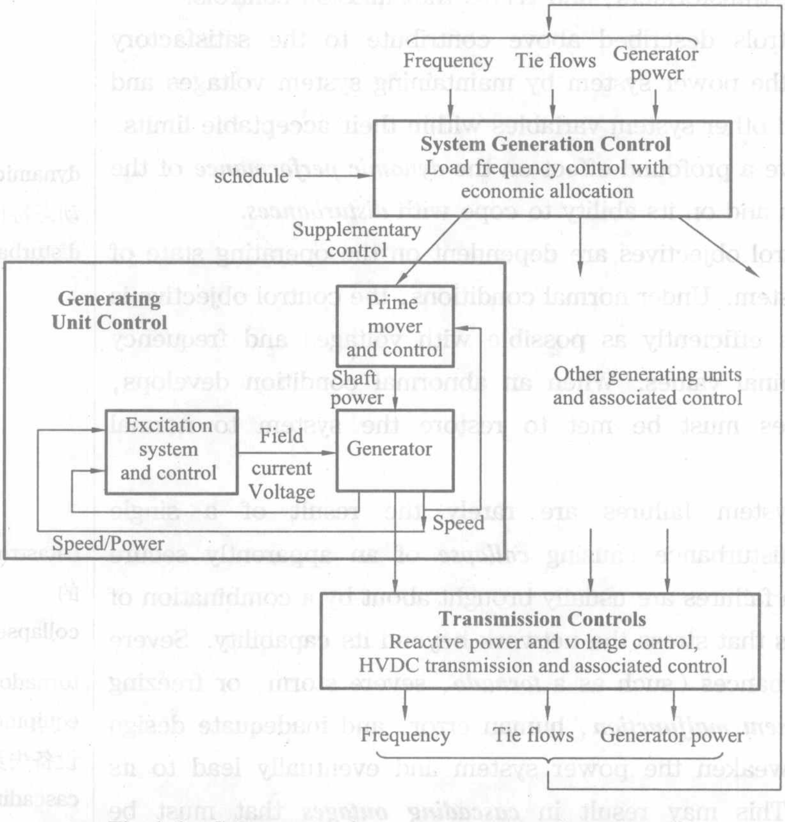

Fig. 1.2 Subsystems of a power system and associated

the associated controls. In this overall structure, there are controllers operating directly on individual system elements. In a generating unit these consist of prime mover controls and ***excitation*** controls. The prime mover controls are concerned with speed regulation and control of energy supply system variables such as ***boiler*** pressures, temperatures, and flows. The function of the excitation control is to regulate generator voltage and reactive power output. The desired MW outputs of the individual generating units are determined by the system-generation control.

The primary purpose of the system-generation control is to balance the total system generation against system load and losses so that the desired frequency and power interchange with neighbouring systems (***tie flows***) is maintained.[7]

The transmission controls include power and voltage control devices, such as static var compensators, synchronous condensers, switched capacitors and reactors, tap-changing transformers, phase-shifting transformers, and HVDC transmission controls.[8]

The controls described above contribute to the satisfactory operation of the power system by maintaining system voltages and frequency and other system variables within their acceptable limits. They also have a profound effect on the ***dynamic performance*** of the power system and on its ability to cope with ***disturbances***.

The control objectives are dependent on the operating state of the power system. Under normal conditions, the control objective is to operate as efficiently as possible with voltages and frequency close to nominal values. When an abnormal condition develops, new objectives must be met to restore the system to normal operation.

Major system failures are rarely the result of a single ***catastrophic*** disturbance causing ***collapse*** of an apparently secure system. Such failures are usually brought about by a combination of circumstances that stress the network beyond its capability. Severe natural disturbances (such as a ***tornado***, severe storm, or freezing rain), ***equipment malfunction***, human error, and inadequate design combine to weaken the power system and eventually lead to its breakdown.[9] This may result in ***cascading outages*** that must be

excitation *n.* 励磁

boiler *n.* 锅炉

tie flow 联络线潮流

dynamic performance 动态特性

disturbance *n.* 扰动

catastrophic *adj.* 灾难的

collapse *n.* 崩溃

tornado *n.* 飓风

equipment malfunction 设备失灵

cascading outage 连锁故障

contained within a small part of the system if a major blackout is to be prevented.

Operating states of a power system and control strategies

For purposes of analyzing power system security and designing appropriate control systems, it is helpful to conceptually classify the system-operating conditions into five states: normal, alert, emergency, in extremis and restorative. Fig. 1.3 depicts these operating states and the ways in which transition can take place from one state to another.[10]

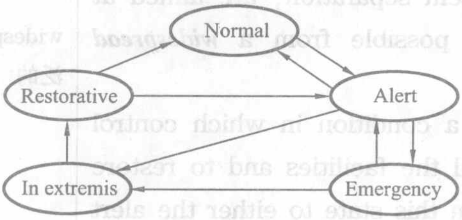

Fig. 1.3 Power system operating states

In the normal state, all system variables are within the normal range and no equipment is being ***overloaded***. The system operates in a secure manner and is able to withstand a contingency without violating any of the constraints.

overload *vt.* 超负荷

The system enters the alert state if the security level falls below a certain limit of adequacy, or if the possibility of a disturbance increases because of adverse weather conditions such as the approach of severe storms. In this state, all system variables are still within the acceptable range and all constraints are satisfied. However, the system has been weakened to a level where a contingency may cause an overloading of equipment that places the system in an emergency state. If the disturbance is very severe, the in extremis (or extreme emergency) state may result directly from the alert state.

Preventive action, such as generation shifting (***security dispatch***) or increased reserve, can be taken to restore the system to the normal state. If the restorative steps do not succeed, the system remains in the alert state.

security dispatch 安全调度

The system enters the emergency state if a sufficiently severe disturbance occurs when the system is in the alert state. In this state, voltages at many buses are low and/or equipment loadings exceed short-term emergency ratings. The system is still intact and may be restored to the alert state by the initiating of emergency control actions: fault clearing, excitation control, fast-valving, generation tripping, generation run-back, HVDC modulation and load curtailment.[11]

If the above measures are not applied or are ineffective, the system is in extremis; the result is cascading outages and possibly a shut-down of a major portion of the system. Control actions, such as load shedding and controlled system separation, are aimed at saving as much of the system as possible from a ***widespread*** blackout.

The restorative state represents a condition in which control action is being taken to reconnect all the facilities and to restore system load. The system transits from this state to either the alert state or the normal state, depending on the system conditions.

Characterization of the system conditions into the five states as described above provides a framework in which control strategies can be developed and operator actions identified to deal effectively with each state.[12]

For a system that has been disturbed and that has entered a ***degraded*** operating state, power system controls assist the operator in returning the system to a normal state. If the disturbance is small, power system controls by themselves may be able to achieve this task. However, if the disturbance is large, it is possible that operator actions such as ***generation rescheduling*** or element switching may be required for a return to the normal state.

The philosophy that has evolved to cope with the diverse requirements of system control comprises a ***hierarchial structure*** as shown in Fig. 1.4. In this structure, there are controllers operating directly on individual system elements such as excitation systems, prime movers, boilers, ***transformer tap changers*** and DC converters. There is usually some form of overall plant controller that ***coordinates*** the controls of closely linked elements. The plant controllers are in turn supervised by system controllers at the operating centres. The system-controller actions are coordinated by

widespread *adj*.	分布广泛的
degraded *adj*.	被降级的
generation reschedul	发电再调度
hierarchial structure	分层结构
transformer tap changer	变压器分接头
coordinate *v*.	协调