十二五

普通高等教育“十二五”规划教材

高等学校专业英语教材

测控技术与仪器专业英语

殷 红 彭珍瑞 主编

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内 容 简 介

本书是普通高等教育“十二五”规划教材，针对测控技术与仪器专业知识体系的经典内容和最新发展，精选国外经典英语原著、国外著名大学最近版本的教材以及 IEEE 和 ACM 等机构的 TOP 期刊与杂志的英文文献，涵盖了测量、电子、控制、机械、网络、计算机等几乎测控技术与仪器专业的全部课程领域。依据典型测控系统结构工作流程脉络组织内容，使专业英语与测控技术与仪器专业知识体系深度有机结合，成为本书的创新点。

全书共 6 个部分、12 个单元，包括综述、信息获取、信息处理、信息传输、信息控制和新技术，分别介绍了测控技术背景、数据采集、测试系统特性、传感技术、信号描述、误差理论、信号处理、通信网络、自动控制、微机原理、软件技术、精密机械，以及虚拟仪器和人工智能等先进测控技术。每个单元包括正文、注释、难句解析和专业知识解释，并配有相关拓展知识的阅读材料。同时，每个部分后面分节介绍了专业英语阅读、翻译和写作技巧。

本书可作为测控技术与仪器、电气工程及其自动化、自动化等相关专业的教材，也可供相关领域的教师、科研人员参考。同时，本书选材广泛，专业内容难度适中，其他专业的大专生、本科生、研究生及其他从业人员如果希望了解测控技术、自动化技术的概貌和新技术，可以选择阅读本书的部分内容。

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前　言

随着现代测控技术的发展，“测控技术与仪器”专业已发展成为集传感技术、计算机技术、电子技术、现代光学、精密机械等多种高新技术于一体的学科。其专业内容新颖丰富，知识更新频率快。因此，与之相应的测控技术与仪器专业的内容也需跟随该学科的发展而同步更新。为了更快、更准确地了解本专业的发展动向，更好地进行对外科学技术交流，大力吸收国外先进测控技术和科学发展的先进经验，良好的测控技术与仪器专业英语文献阅读和写作能力已成为工程技术人员必备的能力。本书即为满足广大测控技术工程师和测控技术与仪器专业学生提高专业英语翻译和论文写作的水平而编写的。

该教材从测控技术与仪器专业的经典内容和最新发展的角度出发，选编了测量、电子、控制、机械、网络、计算机等方面的英文文献。几乎覆盖测控技术与仪器专业所涉及的全部课程领域。其中，很多是近年来的新成果、新技术，更有利于开阔读者视野。

书中阅读材料均选自国外经典英语原著、国外著名大学最近版本的教材以及 IEEE 和 ACM 等机构的 TOP 期刊与杂志，权威性和实用性很强。书中精选经典专业英文文章，以便学生掌握专业知识的同时体会专业英文的写作手法。在阅读材料之后，书中还系统地介绍专业英语的基本概念、特点、翻译技巧和方法，以及常用科学符号和公式的英语表达、专业英语论文的组织写作等实用内容。本书内容组织新颖合理，根据典型测控系统数据传输的流程脉络将知识进行分块叙述，更好地结合测控技术与仪器专业的知识结构特点，以强化学生对专业英语的掌握。全面深入而实用地将英语学习与测控技术与仪器专业知识体系有机结合，是本书的突出特色。

全书共 6 个部分、12 个单元。第 1 部分综述，包括 1 个单元，综合介绍了测控技术的背景，测试、控制和仪器的基本知识。第 2 部分信息获取，包括 2 个单元。数据采集单元介绍了数据采集的方式、测试系统的静动态特性、测试系统的组成和功能。传感技术单元介绍了智能传感器、遥感和无线传感网络技术。第 3 部分信息处理，包括 3 个单元。误差原理单元介绍了误差处理方法、测量不确定度、仪器的标定。信号描述单元介绍了信号分类和描述方式、采样技术、调制解调技术。信号处理单元介绍了信号处理的内容和方式、运算放大器和滤波器的工作原理。第 4 部分信息传输，包括 1 个单元，讲述了现场总线、集散控制系统和工业以太网等工业测控网络技术。第 5 部分信息控制，包括 3 个单元。自动控制单元阐述了自动控制原理，拉氏变换和传递函数，系统补偿和 PID 校正器。微机控制单元介绍了单片机、PLC、面向对象技术。精密机械单元讲述了机械设计特性，机械设计材料和机械负载。第 6 部分新技术，包括 2 个单元，测量新技术单元介绍了虚拟仪器、监控与数据采集 SCADA 和无损检测技术。控制新技术单元介绍了人工智能、神经网络、工业机器人。对每个单元，课文后都有注释，包括生词、术语表达、难句解析和专业知识解释。同时，每个单

元后面都附有两篇相关的补充阅读材料。针对不同学习能力的广大读者，可以有详有略，有的放矢地学习。

本书可作为测控技术与仪器、电气工程及其自动化、自动化等相关专业的教材，也可供相关领域的教师、科研人员参考。同时，本书选材广泛，专业内容难度适中，其他专业的大专生、本科生、研究生及其他从业人员如果希望了解测控技术、自动化技术的概貌和新技术，可以选择阅读本书的部分内容。

本书由殷红、彭珍瑞担任主编，杨立清、黄福珍、胡聪、杨丽颖担任副主编。其中，第 2 单元、第 3 单元、第 4 单元、第 5 单元、第 6 单元、第 7 单元、第 12 单元、常用符号和表达式、专业英语翻译技巧（一）、专业英语翻译技巧（二）、附录 A、附录 B、附录 C 由殷红编写，第 1 单元、第 11 单元、专业英语的特点由彭珍瑞编写，第 8 单元由胡聪编写，第 9 单元由杨丽颖和董小平编写，第 10 单元由杨立清编写，专业英语论文写作基础由黄福珍编写，常用英文文体写作由卫晓娟和陈寿宏编写。全书统稿、定稿由殷红和彭珍瑞完成。祁文哲、董海棠、王黎和邱英在本书的编写和校稿过程中做了大量的工作，在此一并表示感谢。

本书参考了国内外许多作者的论著、先进技术和应用成果，在此谨致谢意。本书的出版得到了电子工业出版社的大力支持和帮助，在此深表感谢。特别感谢电子工业出版社凌毅编辑，她对本书的编写提出了建设性的指导意见。在本书的编写过程中得到任胜利等专家的大力支持，在此深表谢意。

由于编者水平有限，书中难免会有不妥和错误之处，恳请读者批评指正，我们的邮箱是：yinhong0728@163.com。

作 者

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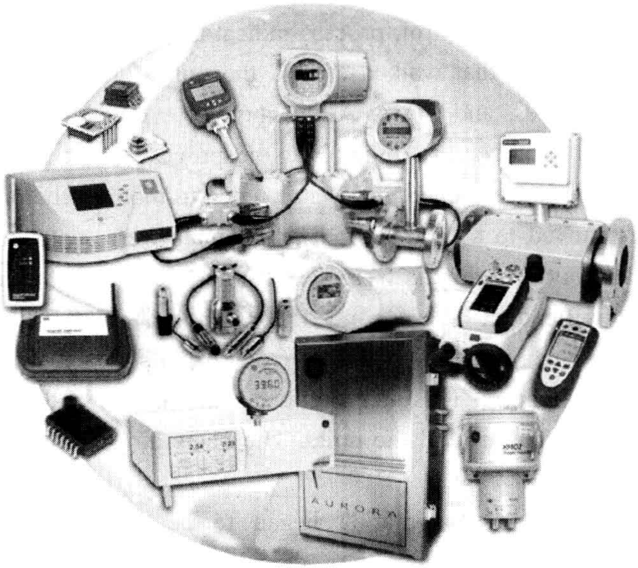
目 录

Part 1

Overview

Unit 1 Measurement, Control and Instrumentation



Instrumentation is defined as the art and science of measurement and control. Instrumentation engineers are responsible for controlling a whole system like a power plant.

An instrument is a device that measures and/or regulates process variables such as flow, temperature, level, or pressure. Instruments include many varied contrivances that can be as simple as valves and transmitters, and as complex as analyzers. Instruments often comprise control systems of varied processes such as refineries, factories, and vehicles. The control of processes is one of the main branches of applied instrumentation. Instrumentation can also refer to handheld devices that measure some desired variable. Diverse handheld instrumentation is common in laboratories, but can be found in the household as well. For example, a smoke detector is a common instrument found in most western homes.

Output instrumentation includes devices such as solenoids,valves,regulators,circuit breakers, and relays. These devices control a desired output variable, and provide either remote or automated control capabilities. These are often referred to as final control elements when controlled remotely or by a control system.

Transmitters are devices that produce an output signal, often in the form of a 4～20mA electrical current signal, although many other options using voltage, frequency, pressure, or ethernet are possible. This signal can be used for informational purposes, or it can be sent to a PLC, DCS, SCADA system, LabView or other type of computerized controller, where it can be interpreted into readable values and used to control other devices and processes in the system.

Control Instrumentation plays a significant role in both gathering information from the field and changing the field parameters, and as such are a key part of control loops.

History

In the early years of process control, process indicators and control elements such as valves were monitored by an operator that walked around the unit adjusting the valves to obtain the desired temperatures, pressures, and flows. As technology evolved pneumatic controllers were invented and mounted in the field that monitored the process and controlled the valves. This reduced the amount of time process operators were needed to monitor the process. Later years the actual controllers were moved to a central room and signals were sent into the control room to monitor the process and outputs signals were sent to the final control element such as a valve to adjust the process as needed. These controllers and indicators were mounted on a wall called a control board. The operators stood in front of this board walking back and forth monitoring the process indicators. This again reduced the number and amount of time process operators were needed to walk around the units. The basic air signal used during these years was 3～15 psig.

In the 1970s electronic instrumentation began to be manufactured by the instrument companies. Each instrument company came out with their own standard signal for their instrumentation, 10～50mA, 0.25～1.25V, 0～10V, 1～5V, and 4～20mA, causing only confusion until the 4～20mA was universally used as a standard electronic instrument signal for transmitters and valves. The transformation of instrumentation from mechanical pneumatic transmitters, controllers, and valves to electronic instruments reduced maintenance costs as electronic instruments were more dependable than mechanical instruments. This also increased efficiency and production due to their increase in accuracy.

The next evolution of instrumentation came with the production of Distributed Control Systems (DCS). The pneumatic and electronic control rooms allowed control from a centralized room, DCS systems allowed control from more than one room or control stations. These stations could be next to each other or miles away. Now a process operator could sit in front of a screen and monitor thousands of points throughout a large unit or complex.

Measurement

Instrumentation is usually used for measurement. *Measurement* is the process or the result of determining the magnitudes of many parameters (physical values). These parameters include:

(1) Chemical composition;

(2) Chemical properties;

(3) Properties of light;

(4) Vibration;

(5) Weight;

(6) Voltage;

(7) Inductance;

(8) Capacitance;

(9) Resistivity;

(10) Viscosity;

(11) Other mechanical properties of materials;

(12) Properties of ionising radiation;

(13) Frequency;

(14) Current;

(15) Pressure, either differential or static;

(16) Flow;

(17) Temperature;

(18) Levels of liquids etc.;

(19) Density.

With the exception of a few seemingly fundamental quantum constants, units of measurement are essentially arbitrary; in other words, people make them up and then agree to use them. Nothing inherent in nature dictates that an inch has to be a certain length, or that a mile is a better measure of distance than a kilometre. Over the course of human history, however, first for convenience and then for necessity, standards of measurement evolved so that communities would have certain common benchmarks. Laws regulating measurement were originally developed to prevent fraud in commerce.

Measurement methods are often scrutinized for their validity, applicability, and accuracy. It is very important that the scope of the measurement method be clearly defined, and any aspect included in the scope is shown to be accurate and repeatable through validation.

Measurement method validations often encompass the following considerations:

(1) Accuracy and precision: Demonstration of accuracy may require the creation of a reference value if none is yet available.

(2) Repeatability and Reproducibility, sometimes in the form of a Gauge R&R.

(3) Range, or a continuum scale over which the measurement method would be considered accurate. Example: 10N to 100N force test.

(4) Measurement resolution, be it spatial, temporal, or otherwise.

(5) Curve fitting, typically for linearity, which justifies interpolation between calibrated reference points.

(6) Robustness, or the insensitivity to potentially subtle variables in the test environment or setup which may be difficult to control.

(7) Usefulness to predict end-use characteristics and performance.

(8) Measurement uncertainty.

(9) Interlaboratory or round robin tests.

(10) other types of measurement systems analysis.

Control

In addition to measuring field parameters, instrumentation is also responsible for providing the ability to modify some field parameters.

Modern day *control engineering* (also called control systems engineering) is a relatively new field of study that gained a significant attention during 20th century with the advancement in technology. It can be broadly defined as practical application of control theory. Control engineering has an essential role in a wide range of control systems, from simple household washing machines to high-performance F-16 fighter aircraft. It seeks to understand physical systems, using mathematical modeling, in terms of inputs, outputs and various components with different behaviors; use control systems design tools to develop controllers for those systems; and implement controllers in physical systems employing available technology. A system can be mechanical, electrical, fluid, chemical, financial and even biological, and the mathematical modeling, analysis and controller design uses control theory in one or many of the time, frequency and complex-*s* domains, depending on the nature of the design problem.

1. Control theory

There are two major divisions in control theory, namely, classical and modern, which have direct implications over the control engineering applications. The scope of classical control theory is limited to single-input and single-output (SISO) system design. The system analysis is carried out in time domain using differential equations, in complex-*s* domain with Laplace transform or in frequency domain by transforming from the complex-*s* domain. All systems are assumed to be second order and single variable, and higher-order system responses and multivariable effects are ignored. A controller designed using classical theory usually requires on-site tuning due to design approximations. Yet, due to easier physical implementation of classical controller designs as compared to systems designed using modern control theory, these controllers are preferred in most industrial applications. The most common controllers designed using classical control theory are PID controllers.

In contrast, modern control theory is carried out in the state space, and can deal with multi-input and multi-output (MIMO) systems. This overcomes the limitations of classical control theory in more sophisticated design problems, such as fighter aircraft control. In modern design, a system is represented as a set of first order differential equations defined using state variables. Nonlinear, multivariable, adaptive and robust control theories come under this division. Being fairly new, modern control theory has many areas yet to be explored. Scholars like Rudolf E. Kalman and Aleksandr Lyapunov are well-known among the people who have shaped modern control theory.

2. Control systems

Control engineering is the engineering discipline that focuses on the modeling of a diverse range of dynamic systems (e.g. mechanical systems) and the design of controllers that will cause these systems to behave in the desired manner. Although such controllers need not be electrical many are and hence control engineering is often viewed as a subfield of electrical engineering. However, the falling price of microprocessors is making the actual implementation of a control system essentially trivial. As a result, focus is shifting back to the mechanical engineering discipline, as intimate knowledge of the physical system being controlled is often desired.

Electrical circuits, digital signal processors and microcontrollers can all be used to implement control systems. Control engineering has a wide range of applications from the flight and propulsion systems of commercial airliners to the cruise control present in many modern automobiles.

In most of the cases, control engineers utilize feedback when designing control systems. This is often accomplished using a PID controller system. For example, in an automobile with cruise control the vehicle's speed is continuously monitored and fed back to the system, which adjusts the motor's torque accordingly. Where there is regular feedback, control theory can be used to determine how the system responds to such feedback. In practically all such systems stability is important and control theory can help ensure stability is achieved.

Although feedback is an important aspect of control engineering, control engineers may also work on the control of systems without feedback. This is known as open loop control. A classic example of open loop control is a washing machine that runs through a pre-determined cycle without the use of sensors.

3. Recent advancement

Originally, control engineering was all about continuous systems. Development of computer control tools posed a requirement of discrete control system engineering because the communications between the computer-based digital controller and the physical system are governed by a computer clock. The equivalent to Laplace transform in the discrete domain is the *z*-transform. Today many of the control systems are computer controlled and they consist of both digital and analog components.

Therefore, at the design stage either digital components are mapped into the continuous domain and the design is carried out in the continuous domain, or analog components are mapped in to discrete domain and design is carried out there. The first of these two methods is more commonly encountered in practice because many industrial systems have many continuous systems components, including mechanical, fluid, biological and analog electrical components, with a few digital controllers.

Similarly, the design technique has progressed from paper-and-ruler based manual design to computer-aided design, and now to computer-automated design (CAutoD), which has been made possible by evolutionary computation. CAutoD can be applied not just to tuning a predefined control scheme, but also to controller structure optimisation, system identification and invention of novel control systems, based purely upon a performance requirement, independent of any specific control scheme.

Instrumentation engineering

Instrumentation engineering is the engineering specialization focused on the principle and operation of measuring instruments that are used in design and configuration of automated systems in electrical, pneumatic domains etc. They typically work for industries with automated processes, such as chemical or manufacturing plants, with the goal of improving system productivity, reliability, safety, optimization, and stability. To control the parameters in a process or in a particular system, devices such as microprocessors, microcontrollers or PLCs are used, but their ultimate aim is to control the parameters of a system.

Instrumentation technologists

Instrumentation technologists, technicians and mechanics specialize in troubleshooting and repairing and maintenance of instruments and instrumentation systems. This trade is so intertwined with electricians, pipefitters, power engineers, and engineering companies, that one can find him/herself in extremely diverse working situations.

Words & Terms

instrumentation [ˌinstrumen'teiʃən] n. 测量仪器，仪表
measurement [meʒəmənt] n. 量度，测量，衡量，（量得的）尺寸
power plant 发电站；发电厂，电动装置，发电机
contrivance [kən'traivəns] n. 发明，发明才能，想出的办法，发明物
analyzer ['ænəlaizə] n. 分析器
variable ['vɛəriəbl] n. 变量，变数
handheld devices 手持式设备
smoke detector 烟雾探测器
solenoid ['səulinɔid] n. 线圈，螺线管
regulator ['regjuleitə] n. 调节器
circuit breakers 断路器，电路分流器
relay ['ri:lei] n. 中继转发（设备）
transmitter [trænz'mitə] n. 变送器，发射机
control loops 控制回路
process control 过程控制
pneumatic [nju: 'mætik] adj. 充气的，由压缩空气操作（推动）的，风动的

mount [maunt] vt. 安装，配有……
psig abbr. pounds per square inch(gauge) 磅/平方英寸
manufacture [ˌmænjuˈfæktʃə] vt. 制造
dependable [diˈpendəbəl] adj. 可信赖的，可靠的
Distributed Control Systems (DCS) 分布式控制系统，集散控制系统
complex [ˈkɔmpleks] n. 综合体，集合体
composition [ˌkɔmpəˈziʃən] n. 成分，混合物，合成物
property [ˈprɔpəti] n. 性质，属性
vibration [vaiˈbreiʃən] n. 振动，摆动，摇摆
voltage [ˈvəultidʒ] n. 电压，伏特数
inductance [inˈdʌktəns] n. 感应系数，自感应
capacitance [kəˈpæsitəns] n. 电容，电容量
resistivity [ˌri:zisˈtiviti] n. 电阻系数
viscosity [viˈskɔsiti:] n. 黏性，黏稠
ionising radiation 电离辐射
frequency [ˈfri:kwənsi] n. 频率，（声波或无线电波的）振动频率
current [ˈkʌrənt] n. 电流
flow [fləu] n. 流量
density [ˈdensiti] n. 密度
quantum [ˈkwɔntəm] n. 量子，定量，总量
inherent [inˈhiərənt] adj. 固有的；内在的
convenience [kənˈvi:njəns] n. 方便，便利
benchmark [ˈbentʃˌma:k] n. 基准
fraud [frɔ:d] n. 欺诈，欺骗行为；骗子
scrutinize [ˈskru:tnˌaiz] vt. 仔细检查，详审
validation [væliˈdeiʃən] n. 批准；确认
encompass [enˈkʌmpəs] vt. 围绕；包围
gauge [geidʒ] n. 规范，计，量规 vt. 计量，度量
range [reindʒ] n. 量程，范围，射程，距离
scale [skeil] n. 刻度，比例（尺），程度，范围，等级，级别
resolution [ˌrezəˈlu:ʃən] n. 分辨力，分辨率
spatial [ˈspeiʃəl] adj. 空间的，立体空间的，三维空间的
temporal [ˈtempərəl, ˈtemprəl] adj. 时间的
curve fitting 曲线拟合
interpolate [inˈtə:pəˌleit] v. 插值，内插，插补
end-use 最终用途

measurement uncertainty 测量不确定度
insensitivity 不灵敏，不灵敏度
interlaboratory [ˌintəˈlæbərətəri] adj. 多个实验室(进行)的
round robin 轮转，循环，比对
complex [ˈkɔmpleks] n. 复数
differential equations 微分方程
second order 二阶
higher-order system 高阶系统
the state space 状态空间
adaptive [əˈdæptiv] adj. 自适应
robust [rəuˈbʌst] adj. 鲁棒，健壮的 n. 鲁棒性
dynamic [daiˈnæmik] adj.动力的
microprocessor [ˈmaikrəuˌprɔsesə] n. 微处理机
trivial [ˈtriviəl] adj. 琐碎的，没有价值的，没有意义的
propulsion [prəˈpʌlʃən] n. 推进
cruise [kru:z] n. 巡航
feedback [ˈfi:dbæk] n. 反馈，反馈信息
torque [tɔ:k] n. 扭转力，转（力）矩
discrete [disˈkri:t] adj. 离散的
map [mæp] vt. 映射
structure optimization 结构优化
specialization [ˌspeʃəlaiˈzeiʃən] n. 特别化；专门化
configuration [kənˌfigjuˈreiʃən] n. 构造，形状，外貌，轮廓
troubleshooting n. 发现并修理故障，解决纷争
intertwine [ˌintəˈtwain] vi. & vi. 缠结在一起

Notes

The control of processes 意为“过程控制”。

Output instrumentation includes devices such as solenoids, valves, regulators, circuit breakers, and relays. These devices control a desired output variable, and provide either remote or automated control capabilities. These are often referred to as final control elements when controlled remotely or by a control system. 句中 desired output variable 意为“期望输出变量”，are referred to as 意为“被称为”。全句译为：输出仪器包括线圈、阀、调节器、断路器和中继器等元件。这些元件控制期望输出变量，使之实现远程控制或自动控制功能。在远程控制或自动控制系统中，称这些元件为终端控制元件。

Control Instrumentation plays a significant role in both gathering information from the field