高等学校电工电子类系列教材

Michael Collier（英） 郑娟娟

Electrical Measurement Theory and Practice

中国石油大学出版社
China University of Petroleum Press

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高等学校电工电子类系列教材

出版说明

电工电子技术作为当前信息技术的基础，在国民经济和社会发展中起着越来越直接和越来越重要的作用。在高校中，由于广阔的技术应用和良好的就业前景，使电工电子类专业成为近年来发展势头最强劲的专业之一。在学生人数激增、学科应用拓展、学科发展加速的现实背景下，要使高校的专业教学跟上发展的步伐，适应社会的需求，则必须进行课程体系和课程内容的改革。这是摆在我们电工电子类专业从教者面前的一项重要而紧迫的任务。

正是在这种共同认识的驱动下，我们20多所高校——一些平时在教学改革方面颇多交流、在学科建设方面颇多借鉴的院校，走到了一起。我们这些院校各有所长，在一起切磋、比较、学习，搭建了一个很好的学习和交流的平台，共同推动了教育教学改革，促进了各自的发展。经验告诉我们，教改的核心是课程体系和课程内容的改革，但课程体系和课程内容改革的成果呈现在学生面前的最主要资源便是构架完备系统的教材。因此，课程改革与教材建设同步，编写出一套适合当前教学改革要求、结构体系完备、体现教学改革思路的好教材，成了我们共同的追求。

教材指导教学，教材体现教改。根据我们现实的教学需求和进一步的发展规划，我们把这套教材的建设构架为三个方面，也可以说是三个模块：

第一个方面是电工电子的基础理论与技术教材，主要针对工科类学生的通识课或者基础课，包括信号与系统、电路分析、电子线路、模拟电子技术、数字电子技术、单片机原理及应用、微机原理及应用、电气控制及PLC技术、计算机控制技术、电机与电气控制技术、传感器与检测技术、电机与拖动等，涵盖电气工程及其自动化、自动化、电子信息工程、通信工程、计算机科学与技术、电子科学与技术等专业的基础知识。为确保教材的权威性、科学性，各书主编及主要撰写者，均由具有多年教学经验的教授和专家担任。教材的覆盖面广、知识面宽，以高校的精品课建设为基础，着重基本概念和基本物理过程的论述，注重教学内容的内拓和精选，突出先进性、针对性和实用性。

第二个方面是实验与实训类教材。实验教学是培养学生基本工程素质、提高工程实践能力的重要手段，是高校工科教育教学改革的核心课题。为此，我们这些高校都极其重视实验教学改革与教材建设，不断更新实训教育理念，注重学生创新能力和动手能力的综合发展。国家级实验教学示范中心是高等学校实验教学研究和改革的基地，引领全国高等学校实验教学改革的方向。我们的整套实训教材以山东科技大学和青岛大学“国家级电工电子实验教学示范

中心”为依托，将任务驱动与项目引领相结合，融基础实验与综合技能训练、系统设计与综合应用、工程训练和创新能力培养为一体，体系完整、内容丰富、工程实践性强，以期达到加强学生的系统综合设计能力和训练学生工程思维的目的。这一类教材主要包括电路实训教程、模拟电子技术实验教程、数字电路逻辑设计与实训教程、电子工艺与实训教程、PLC 应用实训教程、电子工程实训教程、电气工程实训教程等。相信这部分教材对加强、规范和引导相关高校的实验教学会有一定的借鉴作用。

第三个方面则是我们独具特色的电工电子类专业的双语教学教材。我们本着自编和引进并重的原则，打造适合我国高等教育发展的电工电子类双语教材体系。我们拥有具有东西方不同教学体系下丰富教学经验的外国专家和教授，他们以纯正的英语语言直接面向我们的大学生编写教材，这在国内恐属首创。比如这套教材中的双语教材之一《Introductory Microcontroller Theory and Applications》就是由英籍专家 Michael Collier 主编完成的英文版双语教材。该教材已在试用中得到了教师和学生的很高评价。在编写原创双语教材的同时，为了提供更丰富的双语教材资源，弥补原创双语教材在数量上的不足，各校将在共同讨论的基础上，引进相对适应性广泛的原版教材。另外，电工电子类双语教学网站也在同步建设中，为师生提供双语教学资源，打造师生互动平台。

诸事万物，见仁见智。对一套好教材的追求是我们的愿望。但当我们倾力追求教材对于我们学校现实的适用性时，我们真的惧怕它们或许已离另一些学校更远。站在不同的起点或角度进行教材构架时，这种差异有时会影响人们对教材的评判。这就时刻提醒我们参与教材编写的院校，在追求教材对于自身的适用性的同时，需要努力与其他院校做更多的沟通和了解，以使自身更好地融入全国教改的主流，同时使这套教材具有更好的普适性，有更广泛的代表意义和借鉴作用。

教材是教学之本。我们希望这套教材：不仅能符合专业培养要求，而且能顺应专业培养方向；不仅能符合教育教学规律，而且能符合学生的接受能力和知识水平；不仅能蕴含和体现丰富的教学经验和思想，而且能为学生呈现良好的学习方法，能指导学生学会自主学习，能调动学生的创造力和学习热情……我们将为此继续努力！

编委会

2008 年 8 月

Preface

Today's world is an exciting place in which new discoveries and inventions are constantly being made. As we look at all these developments, we see that many of them are dependent on electrical signals or power. Even mechanical machines, like car engines, are making increasing use of electronic circuits in their control systems, and of course the worldwide explosion of communication is the result of huge advances in electronic theory and practice.

Behind all this activity, there is a need to be able to test and measure the quantities that we are using. Whether it is farming, rocketry, navigation or telephony, the requirement of knowing the values of quantities is the same. Thus electrical instrumentation is of paramount importance in current technology.

In this context, the subject of Electrical Measurements is a vital ingredient of the curriculum in Chinese universities, and is incorporated into a wide spectrum of subject majors in the science and technology disciplines. The emphasis by the Chinese government on bilingual engineering education is very relevant to the present time, and this textbook has been produced as a resource for such a programme here in Shandong University of Science and Technology. The subject is taught to third-year undergraduates in most departments of the College of Information and Electrical Engineering. As part of the bilingual experiment, the course is taught in three modes to different classes of student. One group uses entirely Chinese as the medium of instruction, while another receives their oral lectures and uses textbooks in English. A third group is lectured in Chinese while using an English textbook. These disparate combinations have all produced positive results, and led to some interesting research findings.

We, the authors, have taught this subject for a number of years, and are convinced of its relevance to engineering education today. Since English is widely used on the international front for this discipline, we hope to equip our students with the skills to interact with overseas engineers, businessmen and decision-makers. English is now the preferred medium for international conferences and for many technical and popular journals. The increasing number of links between Chinese universities and those overseas demands an ability to communicate technically in English.

We offer this publication in the hope that it will benefit other universities wishing to teach this subject in English. Since we are aiming initially at Chinese students, there is a

vocabulary list of new technical terms at the end of each chapter. To assist the growing population of foreign students now studying in China, we have included the pinyin rendering of words. The book has been written using British English.

Since feedback is an important topic in the book, we would like to encourage readers to communicate with us, in order to improve the text and content of future revisions. We wish to acknowledge the work of those who have assisted with this production: colleagues, the publishing house, and our College of Information and Electrical Engineering.

We dedicate this book, with affection and respect, to our spouses Pamela Collier and Gao Bo who have encouraged us in this undertaking.

Michael Collier
collier1942@yahoo.co.uk

Zheng Juanjuan
jade_zjj@hotmail.com

Shandong University of Science and Technology, Huangdao, July 2009

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Appendix A The ASCII Character Set

Appendix B Pinouts of Some Useful Integrated Circuits

Appendix C English-Chinese Vocabulary List

Chapter 1
Fundamentals of Measurement Systems

1.1 Why do we need electrical measurements?

Although we may not be aware of it, life in the 21st century involves an enormous number of measurements of a wide range of quantities. The production of a weather report is the result of hundreds of pieces of data from sensors scattered across a wide area of the globe, which information is then transmitted to central locations for processing and display. The control of a manufacturing plant also entails scores of measurements along production lines and within processing machines. Modern cars use sensors in the engine, brakes, lubrication system and passenger compartment to provide safe and comfortable travel. In fact, electrical measurements are found almost everywhere in the modern world.

In this book we will look at the various aspects of measurements from the simple devices which collect data to advanced electronic systems which operate automatically. Not only will we look at the theory of these things, but we will also consider the practical aspects of making measurements. We will cover the spectrum from analogue sensors which work by changing their resistance to computer-based measurement using the concept of virtual instrumentation.

Measurement theory is related to precision, which is important for evaluating the results of data received from a system. Different situations require different levels of precision. For example, if you are talking about the weather, you may say "It's quite hot today", and that is probably adequate for casual conversation. However, if you want to know the temperature inside a nuclear reactor, then "It's quite hot" is obviously far too vague! Instead, you expect something like "It's 1 156 ℃". The use of numerical information is generally required in all types of engineering situations. Lord Kelvin, shown in Figure 1.1, was a famous scientist in the 19th century. He said the following:

"When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of science."

Figure 1.1 Lord Kelvin

In general terms, we can divide the concept of electrical measurements into two areas depending on whether the quantity measured is an actual electrical unit or a general physical variable. The following sections describe these two areas.