时代教育·国外高校优秀教材精选

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(英文版·原书第4版)

电子技术实验

Electronics for Electricians

(美) 斯蒂芬 L.赫尔曼 (Stephen L.Herman) 著

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引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出了许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关。同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，举办原版教材的教师培训，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

机械工业出版社

序

Electronics for Electricians，4e 是一本面向电子技术实验的教科书，它的结构体系独特，知识内容涵盖面广，叙述简明扼要，实践性很强，便于自学。本书具有以下特点：

1. 本书正文分两大部分，第一部分为知识介绍，共 48 个单元，前 43 个单元采用电子元器件与其应用电路相结合的方法编排内容，后 5 个单元为 5 个独立的设计题目；第二部分为实验训练。

2. 在前 43 个单元中，以外特性为主介绍电子元器件，并从应用的角度出发，结合了应用实例。每个单元的开头都有明确的教学要求，从中体现出该单元的主要内容，单元的结尾又有习题与之呼应。语言叙述简练，虽然篇幅不长，但与实践相关的部分描述较为详细，甚至可直接按其进行操作，有利于读者自学和进行实验。

3. 书中介绍的电子元器件十分广泛，包括二极管、三极管、场效应管、单结晶体管、晶闸管、电子开关、集成运放和各种门电路；而每种元件又包含了多种类型，如二极管中就包括了普通二极管、稳压二极管、发光二极管、光敏二极管、隧道二极管、变容二极管、肖特基二极管等几乎所有目前常见的二极管。书中的应用举例电路简单易懂，而且具有独立功能，因而不但能够使读者开阔眼界，了解各种元器件的特点，还能学会它们的基本应用。

4. 虽然书中具体的实验设计题目仅有 5 个，却包含了书中所涉及到的大多数元器件及其基本应用。由于有前面的知识作基础，读者可以较轻松地从基本应用过渡到小型电子系统的设计和实现，十分有利于提高其综合应用能力。

5. 书中的实验训练部分(Laboratory Exercise)独具特色，它将第一部分中出现的 46 个单元的主要电路全部放入了实验室，在测试方法、测试仪器的接法、测试步骤等方面，按实验的先后顺序，采用由简到繁、循序渐进的方法，提示读者完成实验，有利于提高读者的实践能力。

对比于目前国内的电子技术实验课程，本书内容较偏重整流技术及与之相关的元器件和电路，而相对缺少模拟、数字电子电路中的基本部分，如信号的运算及处理电路、可编程逻辑器件等。此外，书中还缺少 EDA 技术及其应用方面的内容。

尽管如此，本书仍不失为一本优秀的实验教材，在国内如此编写的实验教材很少，无论对教师还是学生都有广泛的借鉴和参考价值。

清华大学

华成英

2004 年 4 月

PREFACE

Electronics for Electricians, 4th edition, is intended for students in the electrical field. The text assumes that the student has knowledge of basic electricity, including Ohm's Law, series, parallel, and combination circuits. *Electronics for Electricians* is a hands-on approach to the subject of electronics; components are presented in a straightforward manner as opposed to mathematical concepts. Components are explained from a standpoint of how they operate and how they can be used in a circuit. *Electronics for Electricians* is written with the knowledge that students learn electronics better by doing than by computing.

By popular demand, the laboratory experiments have been placed at the end of the book. They use common devices that are readily available from a number of sources, and they all have been student tested. Like the theoretical units, the laboratory experiments are designed to help the student to learn by doing.

The fourth edition of *Electronics for Electricians* has added coverage on the following:

- Diodes
- Semiconductor materials
- Conventional and electron current flow theory
- MOVs
- Variable frequency drives
- Light-emitting-diodes

Electronics for Electricians, 4th edition, is the update of a text well-known for teaching electrical students electronics from a practical, hands-on approach.

ABOUT THE AUTHOR

Stephen L. Herman has been both a teacher of industrial electricity and an industrial electrician for many years. His formal training was obtained at Stephen F. Austin University in Nacogdoches, Texas, and

Catawba Valley Technical College in Hickory, North Carolina. Mr. Herman has worked as a maintenance electrician for Superior Cable Corp. and as a class "A" electrician for National Liberty Pipe and Tube Co. During these years of industrial experience he has gained both a practical and theoretical knowledge of electronics circuits as they apply to industrial applications. He was employed as the instructor in electrical maintenance at Randolph Technical College in Asheboro, North Carolina, for nine years. As of the date of this text, Mr. Herman is employed as an instructor in Electrical Technology at Lee College in Baytown, Texas.

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CONTENTS

UNIT 1
The Oscilloscope

For many years the industrial electrician's measuring tools have been the volt-ohm-milliammeter (VOM), and the clamp-on ammeter. These old standbys are still good tools and are the best way to troubleshoot many of the circuits the industrial electrician encounters. However, many of the electronic control systems in today's industry produce voltage pulses that are meaningless to a VOM. In many instances, it is necessary not only to know the amount of voltage present at a particular point in a circuit, but also the length or duration of the pulse and its frequency. Some pulses may be less than one volt and last for only a millasecond. A VOM does not measure many of these things. Therefore, the oscilloscope must be used to learn what is actually happening in a circuit.

OBJECTIVES

After studying this unit the student should be able to:

- Discuss the operation of an oscilloscope
- Discuss various oscilloscope controls
- Connect an oscilloscope into a circuit
- Interpret wave forms produced on the display of the oscilloscope

OSCILLOSCOPE BASICS

This unit is designed to teach some of the fundamentals of using an oscilloscope. It is not intended to make you an expert in its use. The first point to understand about the oscilloscope is that it is a voltmeter; it measures voltage. It does not measure current, resistance, or watts. The oscilloscope not only measures a voltage during a particular period of time, it creates a two-dimensional image, or picture, on its screen.

Some Important Parts of the Oscilloscope

The oscilloscope is divided into two main sections. One section is the voltage section and the other is the time base. The display of the oscilloscope is divided by vertical and horizontal lines, figure 1-1. Voltage is measured on the vertical or Y axis of the display and time is measured on the horizontal or X axis of the display.

When using the VOM, a range switch permits the selection of a different range of voltages which will deflect the meter full scale, 600 volts, 300 volts, or 60 volts, for instance. Changing voltage ranges permits much more accurate measurements of voltage. Trying to measure 24 volts on the 600 volt range will not move the meter enough to make any kind of accurate measurement. By changing to a range of 60 volts full scale, however, 24 volts can be read very accurately.

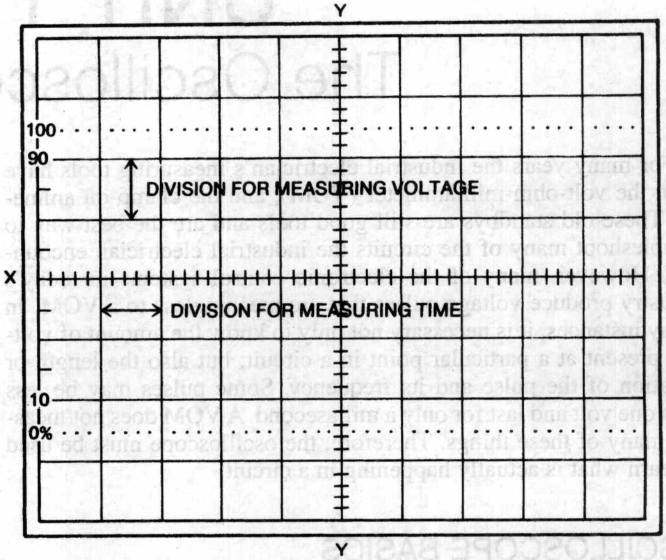

Figure 1-1 Display of oscilloscope. *Copyright © Tektronix, Inc. Reproduced by permission.*

The oscilloscope also has a voltage range switch, figure 1-2. The voltage range switch on an oscilloscope selects volts per division instead of volts full scale. For instance, the voltage range switch shown in figure 1-2 is set for 10 millivolts (mv) at the 1X position. This means that each of the lines in the vertical direction (the Y axis) of the display, figure 1-1, has a value of 10 millivolts per division. Assume the oscilloscope has been adjusted to 0 volt on the centerline of the display. The probe is then removed from ground and connected to the circuit to be tested. If the trace rises above the centerline, the voltage is positive with respect to ground. If the trace drops below the centerline, the voltage is negative with respect to ground. If the oscilloscope probe is connected to a positive voltage of 30 millivolts, the trace rises to the position marked (A) in figure 1-3.

If the probe is connected to a negative 30 millivolts, the trace falls to the position marked (B) in figure 1-3. Notice that the oscilloscope can display a negative voltage as easily as it can display a positive voltage. If the range is changed to 20 volts per division, (A) in figure 1-3 will display a value of 60 volts positive.

The next part of the oscilloscope to become familiar with is the time base, figure 1-4. The time base is calibrated in seconds per divi-

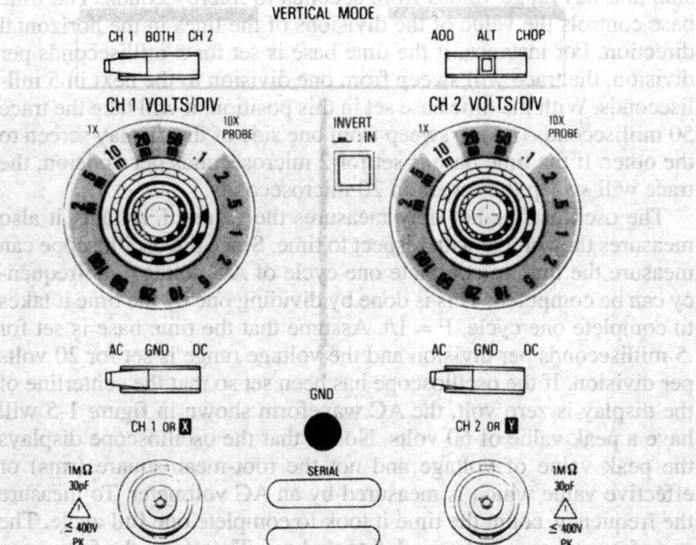

Figure 1-2 Voltage range control. *Copyright © Tektronix, Inc. Reproduced by permission.*

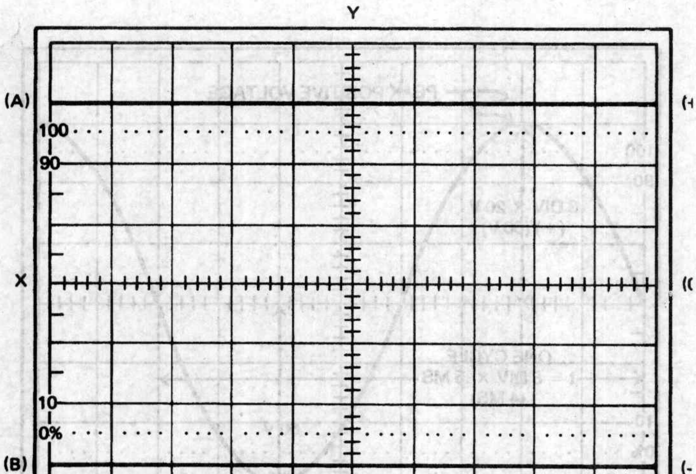

Figure 1-3 Display showing positive and negative dc voltages. *Copyright © Tektronix, Inc. Reproduced by permission.*

Figure 1-4 Time base. *Copyright © Tektronix, Inc. Reproduced by permission.*

sion and has range values from seconds to microseconds. The time base controls the value of the divisions of the lines in the horizontal direction. For instance, if the time base is set for 5 milliseconds per division, the trace will sweep from one division to the next in 5 milliseconds. With the time base set in this position, it will take the trace 50 milliseconds (ms) to sweep from one side of the display screen to the other. If the time base is set for 2 microseconds per division, the trace will sweep the screen in 20 microseconds.

The oscilloscope not only measures the value of voltage, it also measures the voltage with respect to time. Since the oscilloscope can measure the time to complete one cycle of AC voltage, its frequency can be computed. This is done by dividing one by the time it takes to complete one cycle, F = 1/t. Assume that the time base is set for .5 milliseconds per division and the voltage range is set for 20 volts per division. If the oscilloscope has been set so that the centerline of the display is zero volt, the AC waveform shown in figure 1-5 will have a peak value of 60 volts. Notice that the oscilloscope displays the peak value of voltage and not the root-mean-square (rms) or effective value which is measured by an AC voltmeter. To measure the frequency, count the time it took to complete one full cycle. The waveforms shown in figure 1-5 took 4 ms. Therefore, the frequency is 1/.004 s = 250 (hertz) Hz.

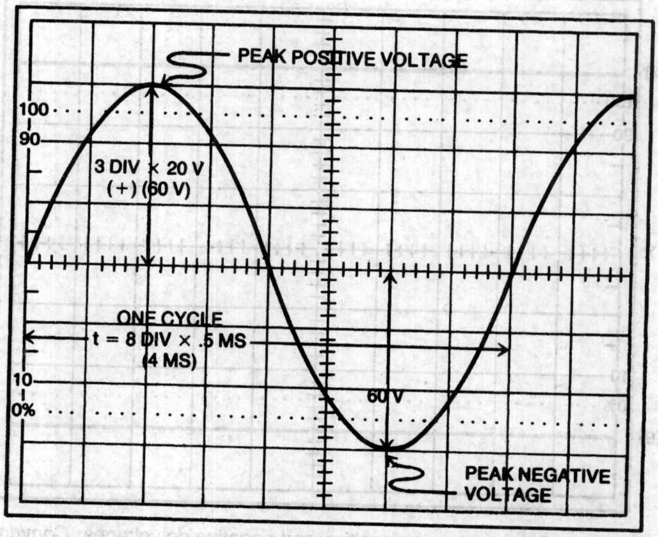

Figure 1-5 Display showing ac sine wave. *Copyright © Tektronix, Inc. Reproduced by permission.*

Most oscilloscopes use a probe which acts as an attenuator. An **attenuator** is a device that divides or makes smaller the input signal. An attenuated probe is used to permit higher voltage readings than are normally possible. Most attenuated probes are 10:1. This means that if the voltage range switch is set for 5 volts per division, the display is read as 50 volts per division. If the voltage range switch is set on 2 volts per division, each division on the display has a value of 20 volts per division.

Probe attenuators are made in various styles by manufacturers. Some probes have the attenuator located in the head while others have it located a the scope input. Regardless of the type of attenuator used, it may have to be compensated or adjusted. In fact, probe compensation should be checked frequently. The manufacturers also use different methods for compensating (adjusting) their probes, so follow the procedures given in the operator's manual for the oscilloscope being used.

Some Common Controls

Become familiar with the more common controls found on an oscilloscope, figure 1-6.

- **Power:** The power switch is used to turn the oscilloscope on or off (1).

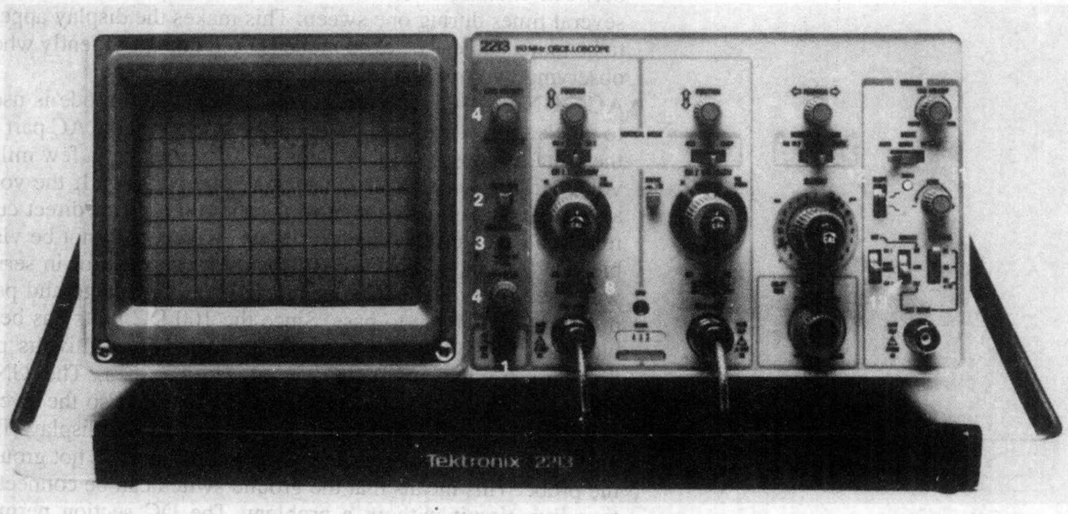

Figure 1-6 Front of Tektronix Model 2213 oscilloscope. *Copyright © Tektronix, Inc. Reproduced by permission.*