Introduction to Low Voltage Systems, 2E, is intended for beginners. As a prerequisite to low voltage systems, students should have already taken a basic course in ac/dc electricity. Many of the systems discussed throughout this book include concepts of series and parallel circuits, as well as a functional knowledge of capacitance, inductance, and transformers.

The primary focus of Introduction to Low Voltage Systems, 2E, is the functional basics of various systems and their connecting devices. Introduction to Low Voltage Systems, 2E, was not, however, written as an installation guide, nor should it be used as one. Instead, the intent of this book is to concentrate the basic theory, standards, and Code requirement of various systems into a single reference book for the beginning student. The types of systems in Introduction to Low Voltage Systems, 2E, include audio, video (closed circuit television [CCTV system]), security, telephone, fire alarm, computer networking, and wireless.

**CODE REFERENCES**


**TARGET AUDIENCE**

This book is intended for use at the technical or community college level. It may also be used by electrical or electronics programs wishing to add a low-voltage component to their curriculum or by any low-voltage design programs already teaching low voltage systems.

**FORMAT OF THE BOOK**

All chapters begin with a list of objectives, followed by a chapter outline and a selection of key terms. Key terms are highlighted in bold throughout the chapter. The end of each chapter includes a selection of final questions to be gone over by students and the teacher after completion of assigned readings.
OUTLINE OF THE BOOK

Chapter 1 provides an introduction to the National Electrical Code® (NEC). Students are introduced to the purpose of the Code, as well as the format and structure of the book.

Chapter 2 details metal cable construction, types of conductors, insulation requirements, and the electrical properties of cable. The electrical properties of cable include cable resistance, capacitance, characteristic impedance, frequency response, cross talk, signal attenuation, and shielding.

Chapter 3 provides an introduction to grounding and bonding and Article 250 of the NEC. This chapter discusses the purpose and importance of ground, the grounding electrode system, and the differences between the grounded conductor, the equipment grounding conductor, and an ungrounded conductor. A description of a ground fault and the purpose of a ground-fault circuit interrupter are discussed and explained, as well as the purpose of bonding and the bonding conductor. Although it is true that building grounding systems are installed by electricians, knowledge of them is crucial to the safe installation of any system and must still be understood by all low-voltage electrical installers. The end of this chapter also discusses the grounding requirements of outdoor cables entering buildings, and the grounding of communications systems, as related to the 2011 NEC Articles 800, 810, and 820.

Chapter 4 discusses the physics of audio, including sound and hearing, types of waveforms, frequency response, bandwidth, harmonics, octaves, decibels, logarithms, wave propagation, the inverse square law, and the definition and use of white noise and pink noise generators.

Chapter 5 discusses audio and the various components that make up an audio system. The chapter begins with the definition of permanently installed, portable, and temporary sound systems, as well as a discussion of public address systems and intercoms. The next part of the chapter discusses the components and electrical properties of sound systems, including microphones, microphone polar patterns, phantom power, impedance levels, balanced versus unbalanced signals, ground loops, wireless microphones, and connecting hardware. The second half of Chapter 5 discusses types of loudspeakers, filters, crossovers, speaker placement, echo and reverberation, amplifiers, mixers, preamplifiers, signal processing equipment, signal levels, impedance matching transformers, 25-/70-/100-V audio systems, isolated grounds, and the wiring requirements of audio systems as referenced by NEC Article 640.

Chapter 6 details the basics of computer networking. The chapter starts with a brief history of computer networking, leading into a discussion on the basic components that make up various types of computer networks. Topics include network architecture, topology, network access, methods of communication, and collision detection. From there, Chapter 6 discusses the seven layers of the OSI model, TCP/IP protocols and their functions, network addressing, network hardware (network interface cards [NIC], hubs, routers, switches, bridges), cabling and connecting hardware, and basic troubleshooting techniques.
Chapter 7 discusses the basics of power, including both ac and dc power supplies. The chapter starts with a discussion on isolation transformers and the need for ac voltage regulation, surge protection, power line conditioners, and filters. The second half of the chapter then moves to power generators (motor or engine driven), uninterruptible power supplies (UPS), rectification, dc power supplies, battery power sources, and NEC 700, Part III, which discusses the requirements of emergency power systems.

Chapter 8 takes an in-depth look at NEC Article 725, which details the classification of remote control and signaling circuits, including Class 1, 2, and 3 circuits. The chapter also discusses the comparison and use of power-limited tray cable as well as the use of instrumentation tray cable, as referenced in NEC Article 727. Additional topics include the installation requirements of Class 1, 2, and 3 circuits; installation options with communication circuits; support of conductors; and the number of conductors to be placed in a raceway.

Chapter 9 discusses the devices and components of a fire alarm system. The chapter starts with a description of a basic fire alarm system, the concept of supervisability, a detailed description of control units, alarm initiating devices (heat and smoke detectors), and alarm indicating devices (horns and strobes). The second half of the chapter covers the wiring requirements of fire alarm systems as discussed in NEC Article 760, which defines the specifications and wiring requirements of both non-power-limited fire alarm systems and power-limited fire alarm systems. The last section of the chapter details the specifics of fire alarm wiring, specifically the differences between Class A and B systems, as well as the various wiring styles related to initiation devices and notification appliances.

Chapter 10 details the theory and use of fiber-optic cable. The chapter starts with an introduction to fiber-optic theory and the basic concepts of light and light transfer. The discussion continues to fiber-optic cable construction, types of cables, single mode versus multimode, glass versus plastic, NEC Article 770, and types of fiber-optic connecting hardware splices, and fiber color codes.

Chapter 11 discusses the basics of telephone systems. The chapter starts with a brief history of the telegraph and the telephone in America and leads to a technical description of the local loop and the various components that make up a modern telephone system. Topics include the functional parts of the telephone, dual-tone multifrequency (DTMF), dialing ringers, ringer equivalence numbers (RENS), exchanges and area codes, cordless telephone systems, cabling, connecting hardware, NEC Article 800 requirements, and a discussion of commercial systems, including the main distribution frame (MDF), the intermediate distribution frame (IDF), and the differences between a private branch exchange (PBX) and an electronic key system (EKS). Also included is a description and illustration of loop start versus ground start systems, as well as the terminations and color codes of 25-, 50-, 150-, and 300-pair telephone cables.

Chapter 12 details the basic components and wiring of security and access-control systems. The first half of the chapter deals with the theory of various security system sensors (passive and active infrared, ultrasonic, microwave/radar, motion detectors, acoustic and shock-type glassbreak sensors, photoelectric beams, and
video motion detection), and the connection of devices to the control panel. The second half of the chapter discusses access-control systems, including card readers, the various types of card entry, request to exit (RTE), maglocks, electric strikes, reporting systems, keypads, and biometrics. Within each type of system, a detailed description of device wiring and the differences between open-loop and closed-loop connections are also discussed. The chapter ends with a discussion on integrated open source systems that operate over a computer network.

Chapter 13 discusses the fundamentals of wireless communication. Topics include the theory of basic wireless communication, carrier frequencies, modulation techniques, antennas, transmitters, receivers, and repeaters. The chapter comprehensively explores wireless with a discussion on cellular phone communication, satellite communication, wireless computer networks, and the requirements of NEC Article 810 for radio and television communication.

Chapter 14 details the components that make up a closed circuit television (CCTV) system. The chapter begins with an introduction on the purpose of a CCTV system and leads into a discussion on the various types of CCTV cameras. Other topics include camera sensitivity, foot-candles versus lux, camera resolution, analog versus digital, lens formats, types of lenses, focal length, depth of field, field of view, f-stops, the shutter speed, transmission link, power-over-Ethernet (POE) standards, digital transmission, viewing monitors, video formats, recording systems, and the requirements of NEC Article 820.

SUPPLEMENTS

Lab Manual

A Lab Manual with at least one lab for each chapter is available. Objectives, required material, pre-questions and post-questions are provided. Some labs are analytical, and some require hands-on activity. ISBN: 9781111639549

Instructor Companion Site

An Instruction Companion Website containing supplementary material is available. This site contains Answers to Review Questions, testbanks, an image gallery of text figures, and chapter presentations done in PowerPoint. Contact Delmar Cengage Learning or your local sales representative to obtain an instructor account.

Accessing an Instructor Companion Website site from SSO Front Door

1. Go to: http://login.cengage.com and log in, using the Instructor e-mail address and password.
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ABOUT THE AUTHORS

Amy DiPaola is currently the owner and lead instructor of The Minnesota Electrical Training Center. She provides continuing education for the electrical and electronics industry, primarily for individuals needing to renew their state electrical licenses. Prior to opening her own business, Amy was an instructor for nearly 10 years with a technical college in Minneapolis, Minnesota. Amy gained her low-voltage experience as a project manager and design technician for the Federal Bureau of Investigation (FBI), assigned to the Intrusion Detection Program. Her work with the FBI included the building and fabrication of circuits, as well as the installation of security, access-control, and CCTV systems.

Samuel DiPaola is currently the training director for the Minnesota Statewide Limited Energy JATC, providing apprenticeship training for low-voltage electrical installers affiliated with the International Brotherhood of Electrical Workers (IBEW). Prior to becoming training director, Sam was the Director of Electronics at a technical college in Minneapolis, Minnesota. His industry experience includes seven years as a design technician for Emerson Process Management, previously known as Rosemount Engineering. His primary job responsibilities involved the building of automated test systems, as well as the development of test software used in the manufacturing of SMART temperature transmitters.

Prior to working in manufacturing, Sam gained his low-voltage experience with Muzac Inc., where he worked as an electronics technician of audio and video systems. His work also included the occasional design and installation of recording studios and theater systems.

Both Sam and Amy hold a valid Power-Limited License with the state of Minnesota and have been approved to teach low-voltage continuing education classes through the Electrical Licensing and Inspection unit of Minnesota.

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