The Industrial Electronics Handbook

SECOND EDITION

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Make Factory Control and Supervision More Efficient!

- Explores fundamental areas, including analog and digital circuits, electronics, electromagnetic machines, and signal processing
- Facilitates use of intelligent systems—such as neural networks, fuzzy systems, and evolutionary methods—in terms of a hierarchical structure that optimizes processes by addressing the needs of all production components

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About the Editors:

In 2008, the president of Poland awarded **Dr. Bogdan M. Wilamowski** with that country's Commander Cross of the Order of Merit for outstanding service in the proliferation of international scientific collaborations, and for achievements in the areas of microelectronics and computer science.

J. David Irwin is the past president of both the IEEE Industrial Electronics Society and the IEEE Education Society. He is currently the Earle C. Williams Eminent Scholar in Electrical and Computer Engineering at Auburn.

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Edited by
Bogdan Wilamowski and J. David Irwin
Auburn University, Alabama, USA

Series: Electrical Engineering Handbook
Series Editor: Richard C. Dorf, University of California, Davis, USA

The World's Leading Researchers Cover the Gamut—
from Simple Electric Motors to Complicated Robotics and Fabrication Processes

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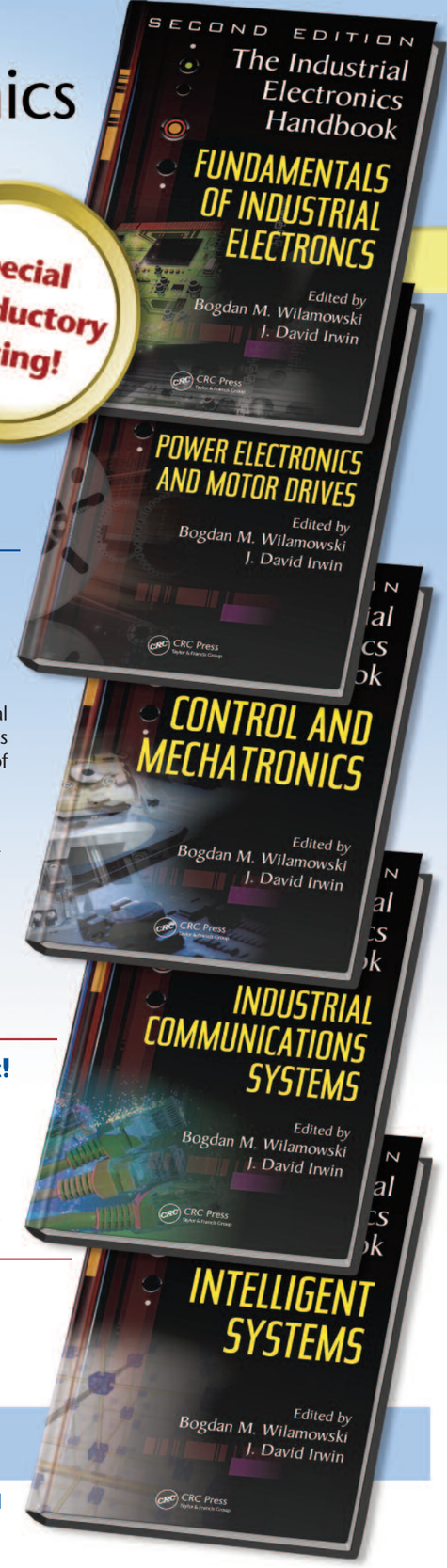
- Includes instruction in MATLAB®, Simulink®, PSPICE®, and Multisim programs, as well as sample files



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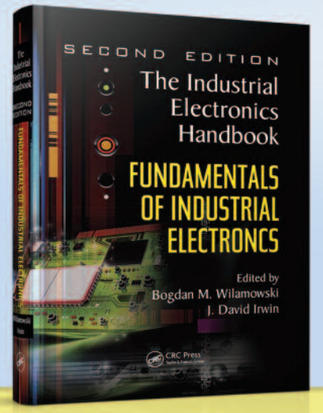

A Foundation for Learning

Fundamentals of Industrial Electronics covers the essential areas that form the basis for the field. This volume presents the basic knowledge that can be applied to the other sections of the handbook.

Table of Contents:

Part I: Circuits and Signals

DC and Transient Circuit Analysis. AC Circuit Analysis. Computational Methods in Node and Loop Analyses. Transistor Operation and Modeling. Application of Operational Amplifiers. Frequency Response and Bode Diagrams. Laplace Transforms.

Part II: Devices

Semiconductor Diode. Bipolar Junction Transistor. Field Effect Transistors. Noise in Semiconductor Devices. Physical Phenomena Used in Sensors. MEMS Devices. MEMS Technologies. Applications of MEMS. Transistors in Switching Circuits. Transistors in Amplifier Circuits. A Simplistic Approach to the Analysis of Transistor Amplifiers. Analog and Digital VLSI Design.

Part III: Digital Circuits

Digital Design—Combinational Logic. Digital Design—Sequential Logic. Soft-Core Processors. Computer Architecture. FPGAs and Reconfigurable Systems.

Part IV: Digital and Analog Signal Processing

Signal Processing. Analog Filter Synthesis. Active Filter Implementation. Designing Passive Filters with Lossy Elements.

Part V: Electromagnetics

Electromagnetic Fields. Propagating Electromagnetic Fields. Transmission Line Time-Domain Analysis and Signal Integrity.

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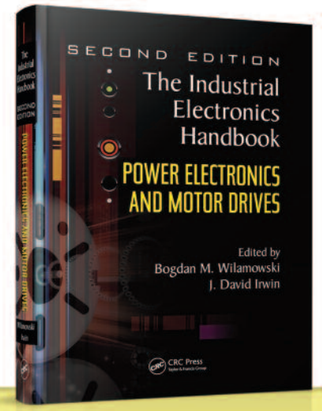

A Modern Perspective on Industrial Electronics

This volume facilitates a necessary shift in educational focus—from older low-power electronics to the newer high-power varieties used to control electromechanical systems and other industrial applications.

Table of Contents (abridged):

Part I: Semiconductor Devices

Electronic Devices for Power Switching: The Enabling Technology for Power Electronic System Development

Part II: Electrical Machines

AC Machine Windings. Multiphase AC Machines. Induction Motor. Permanent Magnet Machines. Permanent Magnet Synchronous Motors. Switched-Reluctance Machines. Thermal Effects. *...and more.*

Part III: Conversion

Three-Phase AC–DC Converters. AC-to-DC Three-Phase/Switch/Level PWM Boost Converter: Design, Modeling, and Control. DC–DC Converters. DC–AC Converters. AC/AC Converters. *...and more.*

Part IV: Motor Drives

Control of Converter-Fed Induction Motor Drives. Double-Fed Induction Machine Drives. Standalone Double-Fed Induction Generator. FOC: Field-Oriented Control. *...and more.*

Part V: Power Electronic Applications

Sustainable Lighting Technology. General Photo-Electro-Thermal Theory and Its Implications for Light-Emitting Diode Systems. *...and more.*

Part VI: Power Systems

Three-Phase Electric Power Systems. Contactless Energy Transfer. Smart Energy Distribution. Flexible AC Transmission Systems. *...and more.*

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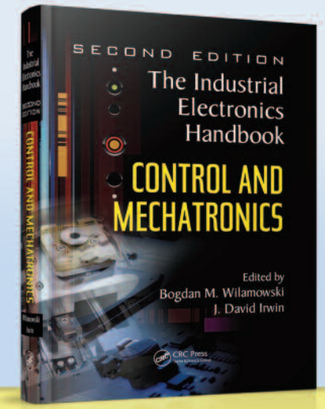

Put Practical Examples Ahead of Mathematics

This volume presents concepts of control theory in a way that makes them easily understandable and practically useful for working engineers or students working with control system applications. Focusing more on practical applications than on mathematics, this book avoids typical theorems and proofs, instead using plain language and useful examples.

Table of Contents (abridged):

Part I: Control System Analysis

Nonlinear Dynamics. Basic Feedback Concept. Stability Analysis. Frequency-Domain Analysis of Relay Feedback Systems. Linear Matrix Inequalities in Automatic Control. *...and more.*

Part II: Control System Design

Internal Model Control. Dynamic Matrix Control. PID Control. Nyquist Criterion. Root Locus Method. Variable Structure Control Techniques. Digital Control. Phase-Lock-Loop-Based Control. *...and more.*

Part III: Estimation, Observation, and Identification

Adaptive Estimation. Observers in Dynamic Engineering Systems. Disturbance Observation–Cancellation Technique. *...and more.*

Part IV: Modeling and Control

Modeling for System Control. Intelligent Mechatronics and Robotics. State-Space Approach to Simulating Dynamic Systems in SPICE. Iterative Learning Control for Torque Ripple Minimization of Switched Reluctance Motor Drive. *...and more.*

Part V: Mechatronics and Robotics

Introduction to Mechatronic Systems. Actuators in Robotics and Automation Systems. Robot Qualities. Robot Vision. Robot Path Planning. Mobile Robots.

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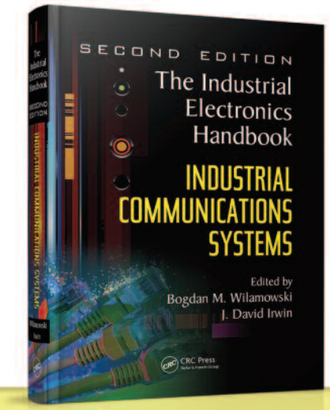

Tools to Optimize System Connection and Performance

Modern communication operations in factories use many different—and increasingly sophisticated—systems to send and receive information. Packed with information, this volume spans the full gamut of concepts that engineers require to maintain a well-designed, reliable communications system that can ensure successful execution of any production process.

Table of Contents (abridged):

Part I: Technical Principles

ISO/OSI Model. Media. Media Access Methods. Routing in Wireless Networks. Profiles and Interoperability. Industrial Wireless Sensor Networks. Ad Hoc Networks. Radio Frequency Identification. *...and more.*

Part II: Application-Specific Areas

Embedded Networks in Civilian Aircraft Avionics Systems. Process Automation. Building and Home Automation. Industrial Multimedia. Industrial Wireless Communications Security (IWCS)/C42. *...and more.*

Part III: Technologies

Controller Area Network. Profibus. INTERBUSa. WorldFip. Foundation Fieldbus. Modbus. Industrial Ethernet. EtherCAT. *...and more.*

Part IV: Internet Programming

User Datagram Protocol—UDP. Transmission Control Protocol—TCP. Development of Interactive Web Pages. Interactive Web Site Design Using Python Script. Running Software over Internet. *...and more.*

Part V: Outlook

Trends and Challenges for Industrial Communication Systems. Processing Data in Complex Communication Systems.

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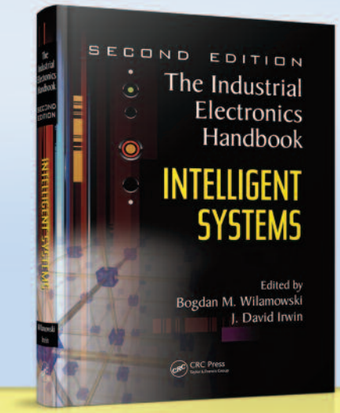

Explore New Developments in Computational Intelligence

Artificial neural networks, fuzzy systems, and other intelligent applications are used to derive difficult measurements essential to successful modeling and system operation. This volume illustrates how such tools help engineers model nonlinear system behavior, determine and evaluate system parameters, and ensure overall system control.

Table of Contents (abridged):

Part I: Introductions

Introduction to Intelligent Systems. From Backpropagation to Neurocontrol. Neural Network–Based Control. Fuzzy Logic–Based Control Section.

Part II: Neural Networks

Understanding Neural Networks. Neural Network Architectures. Radial-Basis-Function Networks. GMDH Neural Networks. Optimization of Neural Network Architectures. *...and more.*

Part III: Fuzzy Systems

Fuzzy Logic Controllers. Neuro-Fuzzy System. Introduction to Type-2 Fuzzy Logic Controllers. Fuzzy Pattern Recognition. Fuzzy Modeling of Animal Behavior and Biomimcry.

Part IV: Optimizations

Multiobjective Optimization Methods. Fundamentals of Evolutionary Multiobjective Optimization. Ant Colony Optimization. *...and more.*

Part V: Applications

Evolutionary Computation. Data Mining. Autonomous Mental Development. Synthetic Biometrics for Testing Biometric Systems and User Training.

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