

# Analysis Of Faulted Power Systems Solution Manual

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Protective Relaying - J. Lewis Blackburn 2015-09-15

For many years, Protective Relaying: Principles and Applications has been the go-to text for gaining proficiency in the technological fundamentals of power system protection. Continuing in the bestselling tradition of the previous editions by the late J. Lewis Blackburn, the Fourth Edition retains the core concepts at the heart of power system analysis. Featuring refinements and additions to accommodate recent technological progress, the text: Explores developments in the creation of smarter, more flexible protective systems based on advances in the computational power of digital devices and the capabilities of communication systems that can be applied within the power grid Examines the regulations related to power system protection and how they impact the way protective relaying systems are designed, applied, set, and monitored Considers the evaluation of protective systems during system disturbances and describes the tools available for analysis Addresses the benefits and problems associated with applying microprocessor-based devices in protection schemes Contains an expanded discussion of intertie protection requirements at dispersed generation facilities Providing information on a mixture of old and new equipment, Protective Relaying: Principles and Applications, Fourth Edition reflects the present state of power systems currently in operation, making it a handy reference for practicing protection engineers. And yet its challenging end-of-chapter problems, coverage of the basic mathematical requirements for fault analysis, and real-world examples ensure engineering students receive a practical, effective education on protective systems. Plus, with the inclusion of a solutions manual and figure slides with qualifying course adoption, the Fourth Edition is ready-made for classroom implementation.

**Power System Transients** - Akihiro Ametani 2016-11-18

This new edition covers a wide area from transients in power systems—including the basic theory, analytical calculations, EMTP simulations, computations by numerical electromagnetic analysis methods, and field test results—to electromagnetic disturbances in the field on EMC and control engineering. Not only does it show how a transient on a single-phase line can be explained from a physical viewpoint, but it then explains how it can be solved analytically by an electric circuit theory. Approximate formulas, which can be calculated by a pocket calculator, are presented so that a transient can be analytically evaluated by a simple hand calculation. Since a real power line is three-phase, this book includes a theory that deals with a multi-phase line for practical application. In addition, methods for tackling a real transient in a power system are introduced. This new edition contains three completely revised and updated chapters, as well as two new chapters on grounding and numerical methods.

*Analysis of Faulted Power Systems* - Paul M. Anderson 1995-07-10

This classic text offers you the key to understanding short circuits, open conductors and other problems relating to electric power systems that are subject to unbalanced conditions. Using the method of symmetrical components, acknowledged expert Paul M. Anderson provides comprehensive guidance for both finding solutions for faulted power systems and maintaining protective system applications. You'll learn to solve advanced problems, while gaining a thorough background in elementary configurations. Features you'll put to immediate use: Numerous examples and problems Clear, concise notation Analytical simplifications Matrix methods applicable to digital computer technology Extensive appendices Diskette files can now be found by entering in ISBN 978-0780311459 on [booksupport.wiley.com](http://booksupport.wiley.com).

*System Engineering Analysis, Design, and Development* - Charles S. Wasson 2015-11-16

Praise for the first edition: "This excellent text will be useful to every system engineer (SE) regardless of the domain. It covers ALL relevant SE material and does so in a very clear, methodical fashion.

The breadth and depth of the author's presentation of SE principles and practices is outstanding." –Philip Allen This textbook presents a comprehensive, step-by-step guide to System Engineering analysis, design, and development via an integrated set of concepts, principles, practices, and methodologies. The methods presented in this text apply to any type of human system -- small, medium, and large organizational systems and system development projects delivering engineered systems or services across multiple business sectors such as medical, transportation, financial, educational, governmental, aerospace and defense, utilities, political, and charity, among others. Provides a common focal point for "bridging the gap" between and unifying System Users, System Acquirers, multi-discipline System Engineering, and Project, Functional, and Executive Management education, knowledge, and decision-making for developing systems, products, or services Each chapter provides definitions of key terms, guiding principles, examples, author's notes, real-world examples, and exercises, which highlight and reinforce key SE&D concepts and practices Addresses concepts employed in Model-Based Systems Engineering (MBSE), Model-Driven Design (MDD), Unified Modeling Language (UMLTM) / Systems Modeling Language (SysMLTM), and Agile/Spiral/V-Model Development such as user needs, stories, and use cases analysis; specification development; system architecture development; User-Centric System Design (UCSD); interface definition & control; system integration & test; and Verification & Validation (V&V) Highlights/introduces a new 21st Century Systems Engineering & Development (SE&D) paradigm that is easy to understand and implement. Provides practices that are critical staging points for technical decision making such as Technical Strategy Development; Life Cycle requirements; Phases, Modes, & States; SE Process; Requirements Derivation; System Architecture Development, User-Centric System Design (UCSD); Engineering Standards, Coordinate Systems, and Conventions; et al. Thoroughly illustrated, with end-of-chapter exercises and numerous case studies and examples, Systems Engineering Analysis, Design, and Development, Second Edition is a primary textbook for multi-discipline, engineering, system analysis, and project management undergraduate/graduate level students and a valuable reference for professionals.

*Power Plants and Power Systems Control 2003* - Kwang Y Lee 2004-04

Provides the latest research on Power Plants, Power Systems Control Contains contributions written by experts in the field Part of the IFAC Proceedings Series which provides a comprehensive overview of the major topics in control engineering.

*Computer Modelling of Electrical Power Systems* - Jos Arrillaga 1983

Describes the use of power system component models and efficient computational techniques in the development of a new generation of programs representing the steady and dynamic states of electrical power systems. Presents main computational and transmission system developments. Derives steady state models of a.c. and d.c. power systems plant components, describes a general purpose phase a.c. load flow program emphasizing Newton Fast Decoupled Algorithm, and more. Considers all aspects of the power system in the dynamic state.

Power System Protection - Electricity Council 1986

*Power System Analysis and Design* - J. Duncan Glover 2011-01-03

The new edition of POWER SYSTEM ANALYSIS AND DESIGN provides students with an introduction to the basic concepts of power systems along with tools to aid them in applying these skills to real world situations. Physical concepts are highlighted while also giving necessary attention to mathematical techniques. Both theory and modeling are developed from simple beginnings so that they can be readily extended to new and complex situations. The authors incorporate new tools and material to aid students with design issues and reflect recent trends in

the field. Important Notice: Media content referenced within the product description or the product text may not be available in the ebook version.

**Transient Analysis of Power Systems** - Juan A. Martinez-Velasco 2015-01-27

The simulation of electromagnetic transients is a mature field that plays an important role in the design of modern power systems. Since the first steps in this field to date, a significant effort has been dedicated to the development of new techniques and more powerful software tools.

Sophisticated models, complex solution techniques and powerful simulation tools have been developed to perform studies that are of supreme importance in the design of modern power systems. The first developments of transients tools were mostly aimed at calculating over-voltages. Presently, these tools are applied to a myriad of studies (e.g. FACTS and Custom Power applications, protective relay performance, simulation of smart grids) for which detailed models and fast solution methods can be of paramount importance. This book provides a basic understanding of the main aspects to be considered when performing electromagnetic transients studies, detailing the main applications of present electromagnetic transients (EMT) tools, and discusses new developments for enhanced simulation capability. Key features: Provides up-to-date information on solution techniques and software capabilities for simulation of electromagnetic transients. Covers key aspects that can expand the capabilities of a transient software tool (e.g. interfacing techniques) or speed up transients simulation (e.g. dynamic model averaging). Applies EMT-type tools to a wide spectrum of studies that range from fast electromagnetic transients to slow electromechanical transients, including power electronic applications, distributed energy resources and protection systems. Illustrates the application of EMT tools to the analysis and simulation of smart grids.

**Handbook of Power Systems Engineering with Power Electronics Applications** - Yoshihide Hase 2012-11-20

Formerly known as Handbook of Power System Engineering, this second edition provides rigorous revisions to the original treatment of systems analysis together with a substantial new four-chapter section on power electronics applications. Encompassing a whole range of equipment, phenomena, and analytical approaches, this handbook offers a complete overview of power systems and their power electronics applications, and presents a thorough examination of the fundamental principles, combining theories and technologies that are usually treated in separate specialised fields, in a single unified hierarchy. Key features of this new edition: Updates throughout the entire book with new material covering applications to current topics such as brushless generators, speed adjustable pumped storage hydro generation, wind generation, small-hydro generation, solar generation, DC-transmission, SVC, SVG (STATCOM), FACTS, active-filters, UPS and advanced railway traffic applications Theories of electrical phenomena ranging from DC and power frequency to lightning-/switching-surges, and insulation coordination now with reference to IEC Standards 2010 New chapters presenting advanced theories and technologies of power electronics circuits and their control theories in combination with various characteristics of power systems as well as induction-generator/motor driving systems Practical engineering technologies of generating plants, transmission lines, sub-stations, load systems and their combined network that includes schemes of high voltage primary circuits, power system control and protection A comprehensive reference for those wishing to gain knowledge in every aspect of power system engineering, this book is suited to practising engineers in power electricity-related industries and graduate level power engineering students.

**Power System Relaying** - Stanley H. Horowitz 2014-01-28

With emphasis on power system protection from the network operator perspective, this classic textbook explains the fundamentals of relaying and power system phenomena including stability, protection and reliability. The fourth edition brings coverage up-to-date with important advancements in protective relaying due to significant changes in the conventional electric power system that will integrate renewable forms of energy and, in some countries, adoption of the Smart Grid initiative. New features of the Fourth Edition include: an entirely new chapter on protection considerations for renewable energy sources, looking at grid interconnection techniques, codes, protection considerations and practices. new concepts in power system protection such as Wide Area Measurement Systems (WAMS) and system integrity protection (SIPS) - how to use WAMS for protection, and SIPS and control with WAMS. phasor measurement units (PMU), transmission line current differential, high voltage dead tank circuit breakers, and relays for multi-terminal lines. revisions to the Bus Protection Guide IEEE C37.234 (2009) and to

the sections on additional protective requirements and restoration. Used by universities and industry courses throughout the world, Power System Relaying is an essential text for graduate students in electric power engineering and a reference for practising relay and protection engineers who want to be kept up to date with the latest advances in the industry.

**Power System Dynamics and Stability** - Peter W. Sauer 2006

**Scientific and Technical Books in Print** - 1972

**Principles of Power Engineering Analysis** - Robert C. Degeneff 2017-03-31

"Preface In the late 1800s as electrical engineering programs were taking shape, they were structured to emphasize power generation, transmission, and its utilization. However, by the middle of the 20th century in recognition of the vast advances in controls, electronics, and computers these programs were being drastically restructured as they moved away from the traditional core. This transition was so swift and complete that within a decade few electrical engineering programs offered more than a class or two in electric power. Utilities and manufactures of heavy electrical equipment, still in need of competent practitioners, found it difficult to find engineers with the desired skills in heavy three-phase electrical power. Recognizing this situation Dr. Eric T.B. Gross, with the financial support of American Electric Power, formed the Department of Electric Power Engineering at Rensselaer Polytechnic Institute (RPI). The primary purpose of this department was to educate power engineers to fill this void. A unique characteristic of this department from its onset was its focus on the masters degree rather than the bachelors or doctorate. Additionally, the student was encouraged to complete the program in a calendar year. For the following four decades this program was one of the very few that offered graduate work in electric power engineering. In recognition of its successfully achieving its goal, students were consistently attracted to it from around the world. To facilitate graduation in a year, the program required the completion of 10 three credit hour classes without a dissertation. It was felt, I think with substantial justification, that a thesis at the masters degree level was of less value to an engineer than several well taught classes"--Provided by publisher.

**Protection of Electricity Distribution Networks** - Juan M. Gers 1998

It is essential to provide suitable protection schemes for distribution networks in order to ensure that faults are quickly remedied. This reference guide uses detailed examples and exercises taken from actual case studies to explain the co-ordination and inception of protection schemes.

**Energy Research Abstracts** - 1994-10

**Core List of Books and Journals in Science and Technology** -

Russell H. Powell 1987

Provides an annotated list of publications dealing with agriculture, astronomy, biology, chemistry, computer science, engineering, geology, mathematics, and physics

**Modern Power Systems Analysis** - Xi-Fan Wang 2010-06-07

The capability of effectively analyzing complex systems is fundamental to the operation, management and planning of power systems. This book offers broad coverage of essential power system concepts and features a complete and in-depth account of all the latest developments, including Power Flow Analysis in Market Environment; Power Flow Calculation of AC/DC Interconnected Systems and Power Flow Control and Calculation for Systems Having FACTS Devices and recent results in system stability. **Power System Analysis** - N. V. Ramana 2011

Power System Analysis is a comprehensive text designed for an undergraduate course in electrical engineering. Written in a simple and easy-to-understand manner, the book introduces the reader to power system network matrices and power system steady-state stability analysis. The book contains in-depth coverage of symmetrical fault analysis and unbalanced fault analysis; exclusive chapters on power flow studies; a comprehensive chapter on transient stability; precise explanation supported by suitable examples and is replete with objective questions and review questions.

**Fault Location on Transmission and Distribution Lines** - Swagata Das 2021-11-22

This book provides readers with up-to-date coverage of fault location algorithms in transmission and distribution networks. The algorithms will help readers track down the exact location of a fault in the shortest possible time. Furthermore, voltage and current waveforms recorded by

digital relays, digital fault recorders, and other intelligent electronic devices contain a wealth of information. Knowledge gained from analysing the fault data can help system operators understand what happened, why it happened and how it can be prevented from happening again. The book will help readers convert such raw data into useful information and improve power system performance and reliability.

**Scientific and Technical Books and Serials in Print** - 1989

**Power System Analysis** - Charles A. Gross 1979

Provides a basic comprehensive treatment of the major electrical engineering problems associated with the design and operation of electric power systems. The major components of the power system are modeled in terms of their sequence (symmetrical component) equivalent circuits. Reviews power flow, fault analysis, economic dispatch, and transient stability in power systems.

**Handbook of Power System Engineering** - Yoshihide Hase 2007-06-13

Maintaining the reliable and efficient generation, transmission and distribution of electrical power is of the utmost importance in a world where electricity is the inevitable means of energy acquisition, transportation, and utilization, and the principle mode of communicating media. Our modern society is entirely dependent on electricity, so problems involving the continuous delivery of power can lead to the disruption and breakdown of vital economic and social infrastructures. This book brings together comprehensive technical information on power system engineering, covering the fundamental theory of power systems and their components, and the related analytical approaches. Key features: Presents detailed theoretical explanations of simple power systems as an accessible basis for understanding the larger, more complex power systems. Examines widely the theory, practices and implementation of several power sub-systems such as generating plants, over-head transmission lines and power cable lines, sub-stations, including over-voltage protection, insulation coordination as well as power systems control and protection. Discusses steady-state and transient phenomena from basic power-frequency range to lightning- and switching-surge ranges, including system faults, wave-form distortion and lower-order harmonic resonance. Explains the dynamics of generators and power systems through essential mathematical equations, with many numerical examples. Analyses the historical progression of power system engineering, in particular the descriptive methods of electrical circuits for power systems. Written by an author with a wealth of experience in the field, both in industry and academia, the Handbook of Power System Engineering provides a single reference work for practicing engineers, researchers and those working in industry that want to gain knowledge of all aspects of power systems. It is also valuable for advanced students taking courses or modules in power system engineering.

Catalog of Copyright Entries. Third Series - Library of Congress. Copyright Office 1972

*Electric Power Systems Manual* - Geradino A. Pete 1992

Essential engineering information and data for utilities, large manufacturing facilities, and independent power producers and co-generators. Table of Contents: Voltage and Current Relationships; Power; Circuit Elements; Complex Frequency; Transmission Lines; Load Flow; Power Circle Diagrams; Symmetrical Components; Symmetrical Versus Asymmetrical Current; The Fourier Transform; Transformers. 150 illustrations.

**Solutions Manual for Power System Analysis** - Charles A. Gross 1979

**Computer-Aided Power System Analysis** - Ramasamy Natarajan 2002-04-03

This title evaluates the performance, safety, efficiency, reliability and economics of a power delivery system. It emphasizes the use and interpretation of computational data to assess system operating limits, load level increases, equipment failure and mitigating procedures through computer-aided analysis to maximize cost-effectiveness.

Engineering Education - 1981

**Power System Protection** - Electricity Training Association 1995-06-30

A set of four volumes compiled by leading authorities in the electricity supply industry and manufacturing companies to provide a comprehensive treatment of power system protection.

*Power System Protection* - Paul M. Anderson 2022-02-15

A newly updated guide to the protection of power systems in the 21st century Power System Protection, 2nd Edition combines brand new

information about the technological and business developments in the field of power system protection that have occurred since the last edition was published in 1998. The new edition includes updates on the effects of short circuits on: Power quality Multiple setting groups Quadrilateral distance relay characteristics Loadability It also includes comprehensive information about the impacts of business changes, including deregulation, disaggregation of power systems, dependability, and security issues. Power System Protection provides the analytical basis for design, application, and setting of power system protection equipment for today's engineer. Updates from protection engineers with distinct specializations contribute to a comprehensive work covering all aspects of the field. New regulations and new components included in modern power protection systems are discussed at length. Computer-based protection is covered in-depth, as is the impact of renewable energy systems connected to distribution and transmission systems.

*Computer Analysis of Power Systems* - Jos Arrillaga 1990

Describes the main computer modelling techniques that constitute the basic framework of modern power system analysis. Basic knowledge of power system theory, matrix analysis and numerical techniques is presumed, although appendices and references are included to provide the relevant background.

**Optimal Coordination of Power Protective Devices with Illustrative Examples** - Ali R. Al-Roomi 2021-11-30

Optimal Coordination of Power Protective Devices with Illustrative Examples Provides practical guidance on the coordination issue of power protective relays and fuses Protecting electrical power systems requires devices that isolate the components that are under fault while keeping the rest of the system stable. Optimal Coordination of Power Protective Devices with Illustrative Examples provides a thorough introduction to the optimal coordination of power systems protection using fuses and protective relays. Integrating fundamental theory and real-world practice, the text begins with an overview of power system protection and optimization, followed by a systematic description of the essential steps in designing optimal coordinators using only directional overcurrent relays. Subsequent chapters present mathematical formulations for solving many standard test systems, and cover a variety of popular hybrid optimization schemes and their mechanisms. The author also discusses a selection of advanced topics and extended applications including adaptive optimal coordination, optimal coordination with multiple time-current curves, and optimally coordinating multiple types of protective devices. Optimal Coordination of Power Protective Devices: Covers fuses and overcurrent, directional overcurrent, and distance relays Explains the relation between fault current and operating time of protective relays Discusses performance and design criteria such as sensitivity, speed, and simplicity Includes an up-to-date literature review and a detailed overview of the fundamentals of power system protection Features numerous illustrative examples, practical case studies, and programs coded in MATLAB® programming language Optimal Coordination of Power Protective Devices with Illustrative Examples is the perfect textbook for instructors in electric power system protection courses, and a must-have reference for protection engineers in power electric companies, and for researchers and industry professionals specializing in power system protection.

Power System Stability and Control, Second Edition - Prabha S. Kundur 2022-06-03

The classic guide to power system stability and control—updated for the latest advances This thoroughly revised engineering guide contains the hands-on information needed to understand, model, analyze, and solve problems using the latest technical tools. You will explore the structure of modern power systems, the different levels of control, and the nature of stability problems. Power System Stability and Control, Second Edition contains complete explanations of equipment characteristics and modeling techniques along with real-world examples. This edition features coverage of adaptive control and other emerging applications, including cyber security of power systems. Coverage includes: General characteristics of modern power systems The power grid stability problem Synchronous machine theory and modelling Synchronous machine parameters Synchronous machine representation in stability studies AC transmission Power system loads Excitation systems Prime movers and energy supply systems High-voltage DC transmission Control of active and reactive power Small-signal, transient, and voltage stability Sub-synchronous oscillations Mid- and long-term stability Methods of improving stability

**Proceedings of the IEEE International Conference on Industrial Technology** - 1994

**Power Systems Analysis** - P.S.R. Murty 2017-06-09

Power Systems Analysis, Second Edition, describes the operation of the interconnected power system under steady state conditions and under dynamic operating conditions during disturbances. Written at a foundational level, including numerous worked examples of concepts discussed in the text, it provides an understanding of how to keep power flowing through an interconnected grid. The second edition adds more information on power system stability, excitation system, and small disturbance analysis, as well as discussions related to grid integration of renewable power sources. The book is designed to be used as reference, review, or self-study for practitioners and consultants, or for students from related engineering disciplines that need to learn more about power systems. Includes comprehensive coverage of the analysis of power systems, useful as a one-stop resource Features a large number of worked examples and objective questions (with answers) to help apply the material discussed in the book Offers foundational content that provides background and review for the understanding and analysis of more specialized areas of electric power engineering

**Fault-Tolerant Systems** - Israel Koren 2010-07-19

Fault-Tolerant Systems is the first book on fault tolerance design with a systems approach to both hardware and software. No other text on the market takes this approach, nor offers the comprehensive and up-to-date treatment that Koren and Krishna provide. This book incorporates case studies that highlight six different computer systems with fault-tolerance techniques implemented in their design. A complete ancillary package is available to lecturers, including online solutions manual for instructors and PowerPoint slides. Students, designers, and architects of high performance processors will value this comprehensive overview of the field. The first book on fault tolerance design with a systems approach Comprehensive coverage of both hardware and software fault tolerance, as well as information and time redundancy Incorporated case studies highlight six different computer systems with fault-tolerance techniques implemented in their design Available to lecturers is a complete ancillary package including online solutions manual for instructors and PowerPoint slides

**Power System Analysis** - Hadi Saadat 2009-04-01

This is an introduction to power system analysis and design. The text contains fundamental concepts and modern topics with applications to real-world problems, and integrates MATLAB and SIMULINK throughout.

**A fault detection method for FADS system based on interval-valued neutrosophic sets, belief rule base, and D-S evidence reasoning** - Qianlei Jia

Fault detection, with the characteristics of strong uncertainty and randomness, has always been one of the research hotspots in the field of aerospace. Considering that devices will inevitably encounter various unknown interference in the process of use, which greatly limits the performance of many traditional fault detection methods. Therefore, the main aim of this paper is to address this problem from the perspective of uncertainty and randomness of measurement signal. In information engineering, interval-valued neutrosophic sets (IVNSs), belief rule base (BRB), and Dempster-Shafer (D-S) evidence reasoning are always characterized by the strong ability in revealing uncertainty, but each has

its drawbacks. As a result, the three theories are firstly combined in this paper to form a powerful fault detection algorithm. Besides, a series of innovations are proposed to improve the method, including a new score function based on p-norm for IVNSs and a new approach of calculating the similarity between IVNSs, which are both proved by authoritative prerequisites. To illustrate the effectiveness of the proposed method, flush air data sensing (FADS), a technologically advanced airborne sensor, is adopted in this paper. The aerodynamic model of FADS is analyzed in detail using knowledge of aerodynamics under subsonic and supersonic conditions, meanwhile, the high-precision model is established based on the aerodynamic database obtained from CFD software.

**Computer Safety, Reliability, and Security** - Barbara Gallina 2018-09-03

This book constitutes the refereed proceedings of the 37th International Conference on Computer Safety, Reliability, and Security, SAFECOMP 2018, held in Västerås, Sweden, in September 2018. The 19 revised full papers and 1 short paper presented together with three abstracts of keynotes were carefully reviewed and selected from 63 submissions. The papers are organized in topical sections on Automotive Safety Standards and Cross-domain Reuse Potential; Autonomous Driving and Safety Analysis; Verification; Multi-concern Assurance; Fault Tolerance; and Safety and Security Risk.

**Electric Power Systems** - Alexandra von Meier 2006-06-30

A clear explanation of the technology for producing and delivering electricity Electric Power Systems explains and illustrates how the electric grid works in a clear, straightforward style that makes highly technical material accessible. It begins with a thorough discussion of the underlying physical concepts of electricity, circuits, and complex power that serves as a foundation for more advanced material. Readers are then introduced to the main components of electric power systems, including generators, motors and other appliances, and transmission and distribution equipment such as power lines, transformers, and circuit breakers. The author explains how a whole power system is managed and coordinated, analyzed mathematically, and kept stable and reliable. Recognizing the economic and environmental implications of electric energy production and public concern over disruptions of service, this book exposes the challenges of producing and delivering electricity to help inform public policy decisions. Its discussions of complex concepts such as reactive power balance, load flow, and stability analysis, for example, offer deep insight into the complexity of electric grid operation and demonstrate how and why physics constrains economics and politics. Although this survival guide includes mathematical equations and formulas, it discusses their meaning in plain English and does not assume any prior familiarity with particular notations or technical jargon. Additional features include: \* A glossary of symbols, units, abbreviations, and acronyms \* Illustrations that help readers visualize processes and better understand complex concepts \* Detailed analysis of a case study, including a Web reference to the case, enabling readers to test the consequences of manipulating various parameters With its clear discussion of how electric grids work, Electric Power Systems is appropriate for a broad readership of professionals, undergraduate and graduate students, government agency managers, environmental advocates, and consumers.