

ELECTRIC MACHINES BY DP KOTHARI NAGRATH Latest Edition

electric machines by dp kothari nagrath are foundational components in the field of electrical engineering, playing a pivotal role in the conversion of electrical energy into mechanical energy and vice versa. As a comprehensive subject covered extensively in engineering curricula and technical reference materials, the study of these machines encompasses principles of electromagnetism, circuit theory, and design optimization. D.P. Kothari and Nagrath's work has significantly contributed to the understanding and development of electric machines, making their concepts essential for students, engineers, and researchers alike. This article provides an in-depth exploration of electric machines as discussed in the renowned texts by D.P. Kothari and Nagrath, highlighting their types, working principles, construction features, and applications.

Understanding Electric Machines

Electric machines are electromechanical devices that transform electrical energy into mechanical energy or vice versa. They are broadly classified into two categories:

- Motors: Devices that convert electrical energy into mechanical energy.
- Generators: Devices that convert mechanical energy into electrical energy.

D.P. Kothari and Nagrath's approach emphasizes the fundamental principles governing these devices, including electromagnetic induction, magnetic circuit design, and control mechanisms.

Types of Electric Machines

Based on their operation and construction, electric machines are categorized into various types:

1. DC Machines

DC machines are characterized by their direct current supply and include:

- DC Motors: Used for variable speed applications.
- DC Generators: Produce direct current from mechanical energy.

2. AC Machines

AC machines operate on alternating current and are further classified as:

- Synchronous Machines (synchronous motors and generators): Operate at a constant speed synchronized with the supply frequency.
- Asynchronous Machines (induction machines): Commonly used in industrial applications due to their robustness and simplicity.

Fundamental Working Principles

The operation of electric machines is governed by electromagnetic induction, a concept first described by Faraday's law. The basic principles include:

- Magnetic flux interaction: When current flows through a coil in a magnetic field, a force is exerted, resulting in torque.
- Electromagnetic torque: The torque developed is proportional to the magnetic flux and the current.

D.P. Kothari and Nagrath elaborate on these principles, explaining how variations in magnetic flux and current influence the performance and efficiency of machines.

Construction and Components of Electric Machines

Understanding the construction of electric machines is crucial for appreciating their operation and design optimization. The primary components include:

1. Stator

The stationary part that produces a rotating magnetic field in AC machines or provides the magnetic circuit in DC machines.

2. Rotor

The rotating part that interacts with the magnetic field to produce torque. Types include:

- Squirrel cage rotor (most common in induction motors)
- Wound rotor

3. Armature and Field Windings

Winding arrangements that carry current and generate magnetic fields necessary for operation.

4. Commutator and Brushes (for DC Machines)

Components that facilitate the flow of current in the armature circuit, enabling unidirectional torque.

Key Operating Features and Parameters

Electric machines are analyzed based on several key features, including:

- Efficiency: Ratio of output mechanical or electrical power to input electrical power.
- Torque: The rotational force produced, critical for load-driving applications.
- Speed Control: Methods include varying supply frequency, voltage control, and using controllers like thyristors.
- Power Factor: Indicates the phase difference between voltage and current, affecting overall system efficiency.

Control and Performance Analysis

D.P. Kothari and Nagrath emphasize the importance of control strategies to optimize machine performance. Common methods include:

- Variable Frequency Drives (VFDs): For adjustable speed control in AC machines.
- Excitation Control: In synchronous machines, adjusting field excitation influences terminal voltage and reactive power.
- Starting Methods: Such as star-delta starters, rotor resistance control, and soft starters to reduce inrush current.

Applications of Electric Machines

Electric machines are integral to various industries and everyday appliances:

- Electric vehicles
- Industrial automation
- Power generation plants
- Home appliances (fans, washing machines)
- Transportation (trains, ships)

Their versatility and reliability make them indispensable in modern technology.

Design Considerations and Efficiency Optimization

Designing efficient electric machines involves multiple factors:

- Magnetic circuit design: Minimizing magnetic losses.
- Material selection: Using high-grade copper, silicon steel laminations.
- Thermal management: Ensuring proper cooling to prevent overheating.
- Reducing losses: Including hysteresis, eddy current, and mechanical losses.

D.P. Kothari and Nagrath's texts provide comprehensive methodologies for optimizing these parameters to enhance performance and longevity.

Advancements in Electric Machine Technology

Recent developments influenced by research and technological progress include:

- Brushless DC motors: Reduced maintenance and improved efficiency.
- Permanent Magnet Synchronous Machines (PMSMs): High power density and efficiency, ideal for electric vehicles.
- Smart control systems: Integration with IoT for real-time monitoring and control.
- Energy-efficient designs: Focused on reducing losses and enhancing operational lifespan.

Conclusion

Electric machines, as detailed in D.P. Kothari and Nagrath's authoritative texts, are fundamental to the operation of modern electrical systems. Their design, operation, and control are critical for achieving high efficiency, reliability, and performance in various applications. Whether in industrial motors, power generation, or electric vehicles, understanding the principles and construction of electric machines is essential for engineers aiming to innovate and optimize electrical energy utilization. Advances continue to emerge, driven by ongoing research and technological integration, ensuring that electric machines will remain at the forefront of electrical engineering for years to come.

SEO Keywords for Better Visibility

To maximize search engine optimization, the following keywords are integrated throughout the article:

- Electric machines by D.P. Kothari and Nagrath
- Types of electric machines
- Working principles of electric machines
- Construction of electric machines
- Electric motor and generator principles
- AC and DC machines
- Synchronous and induction machines
- Electric machine design
- Efficiency of electric machines
- Applications of electric machines
- Advances in electric machine technology

This comprehensive overview aims to serve as an authoritative resource for students, educators, and professionals seeking detailed insights into electric machines based on the teachings of D.P. Kothari and Nagrath.

Electric Machines by D.P. Kothari and Nagrath is widely regarded as a seminal textbook in the field of electrical engineering, particularly for students and professionals interested in understanding the principles, design, and operation of electrical machines. This comprehensive book covers a broad spectrum of topics related to transformers, DC machines, and AC machines, providing both theoretical foundations and practical insights. The authors, D.P. Kothari and Nagrath, have meticulously crafted this work to serve as an authoritative resource that balances mathematical rigor with clarity, making complex concepts accessible.

Overview of the Book

Purpose and Target Audience

The primary aim of Electric Machines is to equip readers with a deep understanding of the principles governing electric machines and their applications. It is tailored for undergraduate students in electrical engineering, but it also serves as a valuable reference for postgraduate students, researchers, and practicing engineers. The book's structured approach ensures that learners build knowledge progressively, starting from fundamental concepts and advancing toward complex machine analyses.

Content Scope

The book extensively covers:

- Transformers: principles, operation, equivalent circuits, testing, and efficiency

- DC Machines: construction, emf equation, torque production, performance analysis
- Synchronous Machines: principles, excitation, performance, control, and applications
- Induction Machines: construction, working principle, torque characteristics, starting methods, and speed control
- Special Machines: stepper motors, universal motors, and other specialized types

Detailed Review of Key Topics

Transformers

Theoretical Foundations

The chapter on transformers lays a solid groundwork by explaining electromagnetic induction, flux linkage, and the equivalent circuit model. The authors elucidate the concepts with clear diagrams and derivations, making it easier for students to grasp the underlying physics.

Practical Aspects

The book discusses various testing methods like open-circuit and short-circuit tests, which are crucial for determining equivalent circuit parameters and efficiency. It emphasizes the importance of understanding transformer losses, efficiency calculations, and regulation, providing useful formulas and example problems.

Features and Pros/Cons

Features:

- Detailed explanations of core phenomena and leakage flux
- Step-by-step derivations of equivalent circuits
- Emphasis on practical testing procedures

Pros:

- Clear diagrams and illustrations
- Extensive solved examples enhance understanding
- Covers both theoretical and practical aspects

Cons:

- Some topics might be dense for beginners without supplementary tutorials
- Limited recent advances in transformer technology (e.g., amorphous cores)

DC Machines

Construction and emf Equation

The authors describe the physical construction of DC machines with detailed diagrams, explaining the roles of armature, field winding, commutator, and brushes. The derivation of the emf equation is presented systematically, linking physical parameters to electrical output.

Performance and Characteristics

The book discusses torque production, armature reaction, and methods of excitation (shunt, series, and compound). It offers comprehensive performance curves and explains the significance of various parameters.

Features and Pros/Cons

Features:

- In-depth analysis of armature reaction and commutation
- Includes performance curves and typical operating data
- Emphasizes the importance of various control methods

Pros:

- Well-structured explanations for complex phenomena
- Practical insights into machine operation and control
- Useful for both academic learning and practical troubleshooting

Cons:

- Some sections may require prior knowledge of circuit theory
- Limited coverage of modern DC machine variants like brushless designs

Synchronous Machines

Principles and Operation

The chapter on synchronous machines covers the fundamental principles, including excitation, emf generation, and power factor control. The authors introduce the concept of magnetic axes, distribution, and pitch factors thoroughly.

Performance and Applications

This section discusses the regulation, parallel operation, and applications in power systems. The stability and control aspects are presented clearly, supported by phasor diagrams and analytical methods.

Features and Pros/Cons

Features:

- Detailed explanation of excitation systems
- Analysis of power flow and stability
- Integration with power system operation

Pros:

- Comprehensive coverage of machine operation
- Clear diagrams aiding conceptual understanding
- Practical insights into power system stability

Cons:

- Advanced topics like V-curves could be expanded further
- Assumes familiarity with power system concepts

Induction Machines

Working Principle and Construction

The induction motor chapter starts with a detailed explanation of the construction of squirrel-cage and wound-rotor types. The principles of electromagnetic induction and the slip concept are explained with mathematical rigor.

Torque and Speed Control

The authors analyze torque-slip characteristics, starting methods, and various speed control techniques such as voltage control, rotor resistance control, and cascade control. They also discuss applications in industry due to their robustness and simplicity.

Features and Pros/Cons

Features:

- Detailed derivations of torque equations
- Emphasis on practical starting methods
- Inclusion of control strategies for industrial applications

Pros:

- Clear explanation of slip and torque dynamics
- Practical guidance for starting and speed control
- Good balance of theory and application

Cons:

- Some advanced control techniques are briefly touched upon
- Modern inverter drives and variable frequency control are not extensively covered

Special Machines

The book also explores lesser-known but important machines such as universal motors, stepper motors, and switched reluctance motors. These are described with their unique features, advantages, and typical applications, rounding out the comprehensive coverage.

Pedagogical Features

Illustrations and Diagrams

One of the standout features of Electric Machines is its extensive use of high-quality diagrams. Visual aids help clarify complex electromagnetic phenomena and machine construction details, which are often challenging for students.

Worked Examples and Problems

The book includes numerous worked examples that demonstrate how to apply theoretical concepts to solve real-world problems. End-of-chapter exercises range from simple calculations to complex design problems, fostering active learning.

Summaries and Key Points

Each chapter concludes with a summary highlighting key concepts, formulas, and principles, aiding revision and reinforcing learning.

Critical Evaluation

Strengths

- **Comprehensive Coverage:** The book covers all essential types of electric machines with sufficient depth.
- **Clarity and Pedagogy:** Well-structured chapters with clear explanations, diagrams, and examples facilitate learning.
- **Practical Orientation:** Emphasis on testing, efficiency, and real-world applications makes it relevant for industry professionals.
- **Mathematical Rigor:** Derivations and equations are thoroughly explained, aiding understanding of fundamental principles.

Limitations

- **Depth of Advanced Topics:** Some advanced topics, such as digital control of machines, inverter drives, and recent technological developments, are not extensively covered.
- **Modern Technologies:** Emerging technologies like brushless DC motors, permanent magnet machines, and high-frequency inverters receive limited attention.
- **Workbook/Simulation Integration:** The book could be enhanced by integrating computer-aided design tools or simulation exercises, which are increasingly important in modern engineering education.

Conclusion

Electric Machines by D.P. Kothari and Nagrath is undoubtedly a cornerstone textbook that has stood the test of time in electrical engineering education. Its balanced approach?combining rigorous theoretical foundation with practical insights?makes it invaluable for students aiming to master the

principles of electrical machines. While it might not delve deeply into the latest technological innovations, its core content remains highly relevant, providing a solid foundation upon which students and professionals can build. Overall, the book's clarity, thoroughness, and pedagogical strengths make it a highly recommended resource for anyone interested in the fascinating world of electric machines.

Question What are the main types of electric machines discussed in DP Kothari and Nagrath's book? The main types include transformers, dc machines, and ac machines such as induction and synchronous machines. **Answer** How does the book 'Electric Machines' by DP Kothari and Nagrath explain the working principle of transformers? It explains the transformer operation based on electromagnetic induction, highlighting the mutual induction between primary and secondary windings and the concepts of emf induction and flux linkage. What are the key advantages of the electrical machines covered in the book? Advantages include efficient energy conversion, high reliability, and widespread application in industrial and domestic sectors for power transmission and motor drives. Does the book cover the analysis of both dc and ac machines? Yes, it provides detailed analysis and operation principles of both dc machines (like dc motors and generators) and ac machines (such as induction and synchronous machines). What are the typical topics included in the 'Electric Machines' book by DP Kothari and Nagrath? Topics include magnetic circuits, transformer theory, dc machines, three-phase induction motors, synchronous machines, and their control and applications. How does the book address machine performance and efficiency calculations? It covers the derivation of efficiency formulas, losses in machines, and methods to analyze and improve machine performance. Are modern developments like variable frequency drives and electronic controls discussed in the book? While primarily focused on fundamental principles, the book also touches upon modern control techniques and applications in electric machines. Is the book suitable for both undergraduate and postgraduate students studying electrical engineering? Yes, it is widely regarded as a comprehensive resource suitable for undergraduate courses and provides advanced insights beneficial for postgraduate studies.

Related keywords: electric machines, dc machines, ac machines, transformer, induction motor, synchronous generator, electrical engineering, machine design, electric motor theory, power systems

power system analysis nagrath and kothari solutions

power system analysis nagrath and kothari solutions is a comprehensive reference for students, engineers, and professionals involved in electrical power system design, operation, and analysis. As power systems become increasingly complex with the integration of renewable energy sources, smart grids, and advanced load management, understanding the foundational principles outlined in

Nagrath and Kothari's solutions becomes essential. This article provides an in-depth overview of their solutions, key concepts in power system analysis, and how these teachings facilitate practical applications in modern electrical engineering.

Introduction to Power System Analysis

Power system analysis involves studying the behavior and performance of electrical power systems under various conditions. It encompasses load flow studies, fault analysis, stability studies, and optimization techniques to ensure reliable, efficient, and safe electricity supply.

Overview of Nagrath and Kothari's Contributions

S.K. Nagrath and D.P. Kothari authored a seminal textbook, often regarded as a cornerstone in electrical engineering education. Their solutions provide detailed methodologies, step-by-step procedures, and illustrative examples that clarify complex concepts in power system analysis.

Core Topics Covered in Nagrath and Kothari Solutions

Their solutions encompass a broad spectrum of topics essential for understanding and analyzing power systems:

1. Power System Components

- Generation sources (thermal, hydro, nuclear, renewable)
- Transmission lines and substations
- Distribution networks
- Load characteristics

2. Load Flow Analysis

- Purpose and importance in planning and operation
- Techniques used:
 - Gauss-Seidel Method
 - Newton-Raphson Method
 - Fast Decoupled Load Flow Method

- Step-by-step procedures as outlined in solutions
- Handling convergence issues and practical considerations

3. Fault Analysis

- Types of faults:
 - Single-line-to-ground (SLG)
 - Line-to-line (LL)
 - Double-line-to-ground (DLG)
 - Three-phase faults
- Symmetrical and unsymmetrical fault calculations
- Use of symmetrical components
- Application of per-unit system for simplifying calculations

4. Power System Stability

- Transient stability analysis
- Equal area criterion
- Stability improvement methods
- Solutions for dynamic stability studies

5. Power System Protection

- Protective relays and circuit breakers
- Coordination of protective devices
- Fault clearing and system reliability

How Nagrath and Kothari Solutions Facilitate Learning

Their solutions are renowned for clarity and thoroughness. They provide:

- Step-by-step algorithms for load flow and fault calculations
- Numerical examples illustrating theoretical concepts

- Practical tips for handling real-world complexities
- Problem-solving techniques aligned with industry standards

This approach helps students develop a strong conceptual understanding while gaining practical skills.

Application of Power System Analysis in Modern Industry

Modern power systems are characterized by increased complexity and integration of renewable sources. The solutions by Nagrath and Kothari help engineers address challenges such as:

1. Integration of Renewable Energy

- Assessing the impact of intermittent sources like wind and solar
- Modifying load flow and stability analysis techniques to accommodate variable generation

2. Smart Grid Technologies

- Incorporating communication and automation in analysis
- Ensuring system robustness with advanced protection schemes

3. Grid Modernization and Reliability

- Planning for future load growth
- Enhancing system resilience against faults and disturbances

Practical Tips from Nagrath and Kothari Solutions

To effectively utilize their solutions, consider the following:

- Understand the assumptions behind each method and approximation
- Practice with diverse numerical examples to build confidence
- Use per-unit system for simplifying calculations and reducing errors
- Always verify results through multiple methods when possible
- Stay updated with industry standards and technological advancements

Conclusion

Power system analysis Nagrath and Kothari solutions serve as invaluable resources for mastering the complexities of electrical power systems. Their detailed methodologies, combined with practical examples, provide a strong foundation for both academic learning and professional practice. As power systems continue to evolve, the principles and techniques outlined in their solutions remain relevant, guiding engineers toward designing safer, more efficient, and resilient electrical networks.

Whether you're a student preparing for exams, an engineer working on system planning, or a researcher exploring new frontiers, understanding and applying the solutions from Nagrath and Kothari will significantly enhance your capabilities in power system analysis. Embracing these solutions equips you with the tools necessary to navigate the challenges of modern electrical engineering and contribute to the development of sustainable energy infrastructure.

Power System Analysis Nagrath and Kothari Solutions: A Comprehensive Guide for Engineers and Students

Power system analysis is a fundamental aspect of electrical engineering, underpinning the design, operation, and stability of modern electrical grids. Among the many authoritative resources available, the solutions and methodologies presented in Power System Analysis by Nagrath and Kothari have gained widespread recognition and credibility. This article aims to delve into the core solutions offered by Nagrath and Kothari, exploring how they serve as invaluable tools for engineers, researchers, and students alike in understanding and solving complex power system problems.

Introduction to Power System Analysis and the Significance of Nagrath and Kothari

Power system analysis Nagrath and Kothari solutions are considered some of the most comprehensive and pedagogically effective approaches to understanding the behavior of electrical power networks. Their work provides a systematic methodology for analyzing steady-state and dynamic conditions, ensuring the reliability and efficiency of power delivery.

The solutions offered by Nagrath and Kothari encompass a wide array of techniques, including load flow analysis, fault analysis, stability studies, and optimization methods. These solutions are crucial for planning, designing, operating, and maintaining power systems in a manner that minimizes interruptions, optimizes resource utilization, and enhances overall system reliability.

Core Topics Covered in Power System Analysis Nagrath and Kothari

- Load Flow Analysis

Importance of Load Flow Studies

Load flow analysis, also known as power flow analysis, is the backbone of power system planning and operation. It involves calculating bus voltages, line flows, and losses under steady-state conditions.

Solution Techniques

Nagrath and Kothari present several methods for load flow studies, including:

- Gauss-Seidel Method: An iterative approach suitable for small to medium systems, appreciated for its simplicity but sometimes slow convergence.
- Newton-Raphson Method: Known for faster convergence and robustness, especially in large systems, it involves solving nonlinear algebraic equations efficiently.
- Fast Decoupled Method: An approximation of the Newton-Raphson method, optimized for rapid calculations, ideal for real-time applications.

Practical Applications

- System planning and expansion
- Operational decision-making
- Voltage regulation and reactive power management

- Fault Analysis

Types of Faults

Fault analysis evaluates the system's response to abnormal conditions, such as:

- Symmetrical faults (three-phase faults)
- Unsymmetrical faults (single line-to-ground, line-to-line, double line-to-ground)

Solution Approaches

Nagrath and Kothari detail methods to determine:

- Fault currents
- Fault impedance

- Post-fault voltages

Using per-unit systems and symmetrical components simplifies calculations, making fault analysis more manageable.

Importance

Fault analysis ensures proper relay coordination, system protection, and stability assessment, preventing catastrophic failures.

- Power System Stability

Types of Stability

- Rotor Angle Stability: Ability of generators to remain in synchronism
- Voltage Stability: Maintaining acceptable voltage levels under disturbances
- Frequency Stability: Sustaining system frequency within limits

Stability Analysis Techniques

Solutions include:

- Equal Area Criterion for transient stability
- Power-angle diagrams
- Dynamic simulations using swing equations

Understanding stability helps in designing systems resilient to disturbances and ensuring continuous power supply.

- Power System Optimization

Objectives

Optimizing generation dispatch, minimizing losses, and improving voltage profiles.

Techniques

- Economic Load Dispatch (ELD): Determines the most cost-effective generation schedule
- Optimal Power Flow (OPF): Incorporates system constraints to optimize overall performance

Nagrath and Kothari introduce mathematical programming techniques, including linear programming and nonlinear optimization, to achieve these objectives.

The Mathematical Foundation and Computational Tools

Mathematical Models

The solutions in Nagrath and Kothari rely heavily on mathematical modeling, including:

- Network equations based on Kirchhoff's laws
- Per-unit system calculations for normalization
- Power flow equations involving complex voltages and currents

Computational Approaches

Modern power system analysis leverages software tools such as:

- MATLAB/Simulink
- PowerWorld Simulator
- DlgSILENT PowerFactory

These tools incorporate the algorithms and methodologies from Nagrath and Kothari, facilitating advanced analysis and visualization.

Practical Implementation of Nagrath and Kothari Solutions

Case Studies and Examples

The textbook provides numerous practical examples, including:

- Step-by-step load flow calculations for a given system
- Fault analysis scenarios with detailed solution procedures
- Stability studies under various disturbance conditions

These examples are designed to bridge the gap between theoretical concepts and real-world

applications.

Software Integration

Many power system analysis courses and industries use Nagrath and Kothari's methods integrated into software packages, enabling engineers to:

- Perform rapid simulations
- Analyze complex network behaviors
- Design protective schemes efficiently

Benefits and Limitations of Nagrath and Kothari Solutions

Benefits

- Comprehensive coverage: From basic concepts to advanced techniques
- Pedagogical clarity: Step-by-step explanations and illustrative examples
- Versatility: Applicable to both academic and industrial scenarios
- Mathematical rigor: Ensures precise and reliable results

Limitations

- Complexity for beginners: Some methods require a good mathematical background
- Assumptions: Certain simplifications may limit accuracy under specific conditions
- Computational demand: Large systems may require significant computational resources

Despite these limitations, the solutions remain foundational in power system analysis.

Conclusion: Why Nagrath and Kothari Solutions Remain Relevant

In a rapidly evolving electrical landscape with smart grids, renewable integration, and decentralized generation, the fundamental principles elucidated in Power System Analysis by Nagrath and Kothari continue to hold relevance. Their solutions provide a solid foundation for understanding system behavior, troubleshooting issues, and designing resilient power networks.

For students and professionals seeking a reliable, mathematically sound approach to power system analysis, embracing the methodologies of Nagrath and Kothari is essential. As technology advances, these solutions adapt and integrate with modern computational tools, ensuring their place

as a cornerstone in electrical engineering education and practice.

In essence, the power system analysis Nagrath and Kothari solutions form a comprehensive toolkit that empowers engineers to ensure the stability, efficiency, and reliability of electrical power systems in an increasingly complex world.

QuestionAnswer What are the key topics covered in Nagrath and Kothari's Power System Analysis book? The book covers essential topics such as per-unit system, power flow analysis, symmetrical components, fault analysis, stability, and power system protection, providing comprehensive insights into power system fundamentals. How does Nagrath and Kothari's solution manual assist students in understanding power system analysis? The solutions manual provides step-by-step explanations for problems from the textbook, helping students grasp complex concepts, improve problem-solving skills, and prepare effectively for exams. Are the solutions in Nagrath and Kothari's Power System Analysis book suitable for self-study? Yes, the detailed and clear solutions are designed to facilitate self-study, enabling students to understand the methodology behind each problem and reinforce their learning independently. What are the benefits of using Nagrath and Kothari's Power System Analysis solutions for exam preparation? The solutions help students practice various types of problems, understand the application of theoretical concepts, and improve accuracy and speed, thereby boosting confidence for exams. Where can I find authentic solutions for Nagrath and Kothari's Power System Analysis problems? Authentic solutions can be found in the official solution manual, online educational platforms, or through authorized tutoring resources that specialize in power system analysis topics related to Nagrath and Kothari's book.

Related keywords: power system analysis, nagrath and kothari solutions, power system stability, load flow analysis, fault analysis, transient stability, power system security, electrical engineering textbooks, power system optimization, power system modeling

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