

Fundamentals Of Electrical Drives Gk Dubey

Fundamentals Of Electrical Drives Gk Dubey Introduction to Fundamentals of Electrical Drives GK Dubey Fundamentals of Electrical Drives GK Dubey is an essential subject for students and professionals involved in electrical engineering, especially those focusing on power systems, motor control, and automation. GK Dubey's comprehensive approach provides a solid foundation for understanding the principles, components, and control techniques used in electrical drives. This article aims to explore the core concepts, classifications, components, control methods, and applications of electrical drives based on the insights from GK Dubey, offering a detailed guide for learners and practitioners alike.

What Are Electrical Drives? Definition and Overview

An electrical drive is a system that controls the performance of an electric motor by adjusting its speed, torque, or position according to specific requirements. It comprises primarily of a motor (the driven machine), a power converter, and a control system. The main objective of an electrical drive is to convert electrical energy into mechanical energy efficiently and accurately.

Types of Electrical Drives

Electrical drives are broadly classified based on the nature of the load, control requirements, and power source. The primary categories include:

- DC Drives:** Utilize DC motors controlled by rectifiers and choppers.
- AC Drives:** Use AC motors such as induction or synchronous motors, controlled through inverters and controllers.

Fundamental Concepts from GK Dubey

Basic Components of Electrical Drives GK Dubey

GK Dubey emphasizes understanding the fundamental components that make up an electrical drive system:

- Motor:** The prime mover converting electrical energy into mechanical energy.
- Power Modulator:** Converts and controls the power flow, including rectifiers, inverters, or choppers.
- Controller:** The control system that governs the operation of power converters based on feedback signals.
- Load:** The mechanical system or machinery driven by the motor.

4. Control Strategies in Electrical Drives GK Dubey

GK Dubey explores various control strategies crucial for optimal drive operation:

- Scalar Control:** Control based on

magnitude and frequency, suitable for simple applications. Vector Control (Field-Oriented Control): Provides independent control of torque and flux, suitable for high-performance applications. Direct Torque Control (DTC): Offers rapid dynamic response by directly controlling torque and flux. Classification of Electrical Drives Based on Nature of Control Electromechanical Drives: Controlled by variable frequency and voltage. Solid-State Drives: Use power electronic converters for precise control. Based on Power Source DC Drives: Powered by DC supply, easier to control but less efficient. AC Drives: Powered by AC supply, more efficient and widely used. Based on Type of Motor DC Motor Drives Induction Motor Drives Synchronous Motor Drives Principles of Operation DC Motor Drives DC drives operate by controlling the armature voltage and field excitation. The main methods include: Adjusting the armature voltage for speed control. 1. Varying the field flux for torque control. 2. GK Dubey details how choppers and controlled rectifiers are used for efficient DC drive control. 3. AC Motor Drives AC drives use inverters to supply variable frequency and amplitude to the motor. Key points include: Speed control is achieved by varying the frequency of the supplied voltage. Torque control depends on the magnitude of the stator current. Control Techniques in Electrical Drives (GK Dubey) Scalar Control Simple control method suitable for applications where high dynamic performance is not required. It involves controlling voltage and frequency independently. Vector Control (or Field-Oriented Control) Provides decoupled control of torque and flux, enabling precise control of motor performance. It requires coordinate transformation and feedback mechanisms. Direct Torque Control (DTC) Offers rapid response with direct control of torque and flux without complex coordinate transformations. Widely used in high-performance drives. Power Electronic Converters in Electrical Drives Rectifiers Convert AC to DC power. Types include uncontrolled, half-controlled, and fully controlled rectifiers. Inverters Convert DC back into AC with variable frequency and amplitude. Types include Voltage Source Inverter (VSI) and Current Source Inverter (CSI). Choppers Control DC voltage by switching on and off rapidly. Used mainly in DC drives for speed regulation. Applications of Electrical Drives 4 Industrial Applications Machine tools Elevators and hoists Cranes and lifts Conveyor systems Transportation Electric vehicles Electric trains

and trams Home and Office Equipment HVAC systems Elevators Robotics and automation systems Advantages and Disadvantages of Electrical Drives Advantages High efficiency and precise control Flexibility in speed and torque regulation Enhanced automation and process control Reduced mechanical wear and tear Disadvantages High initial cost of power electronic components Complex control systems requiring expertise Electromagnetic interference (EMI) issues Maintenance of power electronic devices Recent Trends and Developments in Electrical Drives (GK Dubey) Advanced Control Algorithms Artificial intelligence and machine learning for adaptive control Fuzzy logic and neural networks for improved performance 5 Energy Efficiency and Sustainability Use of regenerative drives to recover energy Integration with renewable energy sources Smart Drives and IoT Integration Remote monitoring and diagnostics Automation and data analytics for predictive maintenance Conclusion The fundamentals of electrical drives GK Dubey provide a comprehensive understanding of how modern electrical systems are designed, controlled, and optimized for various applications. From basic components and control strategies to advanced control algorithms and applications, the subject covers a broad spectrum of knowledge essential for engineers and technologists. As technology advances, electrical drives continue to evolve with innovations in power electronics, control methods, and integration with digital systems, making them vital in the pursuit of energy-efficient and intelligent automation solutions.

QuestionAnswer What are the main components of an electrical drive system as described in GK Dubey's 'Fundamentals of Electrical Drives'? The main components include the electric motor, power converter, control system, and load. These work together to control the speed, torque, and position of the motor as per the application's requirements.

How does a DC motor differ from an AC motor in the context of electrical drives? DC motors are typically used for precise control of speed and torque and are easier to control, while AC motors are more robust, require less maintenance, and are suitable for high-power applications.

GK Dubey discusses their operation, control methods, and suitability in detail. What are the key types of controllers used in electrical drives according to GK Dubey? Key controllers include ON/OFF controllers, proportional controllers, PID controllers, and advanced digital controllers like

microprocessor-based and DSP controllers, which enable precise control of motor performance. What is the significance of the power electronic converters in electrical drives? Power electronic converters such as rectifiers, inverters, and choppers are essential for converting electrical power to suitable forms and frequencies, enabling efficient speed and torque control of the motor. 6 Explain the concept of regenerative braking in electrical drives as per GK Dubey. Regenerative braking involves converting the kinetic energy of the motor and load back into electrical energy during deceleration, which is then fed back into the power supply, improving overall efficiency. What are the advantages of vector control (field-oriented control) in AC drives? Vector control provides precise control of torque and flux in AC motors, allowing for dynamic response similar to DC motors, and improves the efficiency and performance of AC drives. How does the concept of torque-speed characteristics influence the selection of an electrical drive? The torque-speed characteristics determine how the motor responds under load conditions. Selecting a drive depends on matching these characteristics to the application's requirements, such as constant torque or variable torque needs. What are the common challenges faced in the operation of electrical drives discussed by GK Dubey? Challenges include harmonics, thermal management, power quality issues, control stability, and efficiency concerns, which require careful design and control strategies to mitigate. Why is understanding the fundamentals of electrical drives important for engineers? Understanding these fundamentals enables engineers to design, control, and troubleshoot drive systems effectively, leading to improved performance, energy efficiency, and reliability of industrial and commercial applications. Fundamentals of Electrical Drives GK Dubey: An Expert Insight Electrical drives form the backbone of modern automation and manufacturing industries, providing the essential interface between electrical energy and mechanical motion. Among the authoritative texts on this subject, "Fundamentals of Electrical Drives" by G.K. Dubey stands out as a comprehensive source that blends theoretical foundations with practical applications. This article offers an in-depth exploration of the core concepts presented in Dubey's work, aiming to serve as an expert guide for students, engineers, and industry professionals seeking to deepen their

understanding of electrical drives. --- Introduction to Electrical Drives Electrical drives are systems used to control the motion of electrical machines, primarily motors, to achieve desired speed, torque, and position. They encompass a combination of a motor, power converters, controllers, and feedback devices, working together to enable precise control of mechanical output. Key Components of Electrical Drives: - Motor: Converts electrical energy into mechanical energy. - Power Converter: Modulates voltage, current, and frequency supplied to the motor. - Controller: Regulates the power converter based on feedback to attain desired performance. - Feedback Devices: Sensors like encoders or tachometers that provide real-time data on speed, position, or torque. Dubey emphasizes that the fundamental goal of an electrical drive is to ensure efficient, reliable, and precise control of motor operation in various industrial applications. --- Fundamentals Of Electrical Drives Gk Dubey 7 Types of Electrical Drives Electrical drives can be broadly classified based on the nature of their control and the type of motor used. 1. Classified by Power Source and Control: - DC Drives: Utilize DC motors; controlled via variable resistance or armature and field circuits. Known for high starting torque and precise control but require maintenance due to brushes and commutators. - AC Drives: Use AC motors; controlled through power electronic converters like inverters. They are more rugged and require less maintenance. 2. Classified by Type of Motor: - DC Motors: Including series, shunt, and compound motors. - Induction (Asynchronous) Motors: Widely used due to ruggedness and simplicity. - Synchronous Motors: Offer precise speed control, used in applications requiring constant speed. Dubey discusses that the choice of drive type depends on application requirements, such as speed range, control precision, starting torque, and maintenance considerations. --- Fundamental Principles of Electrical Drives At the core, electrical drives operate based on the principles of electrical machine theory, power electronics, and control systems. Dubey meticulously explains these fundamentals: 1. Electromechanical Energy Conversion The essence of an electrical drive is converting electrical energy into mechanical energy with high efficiency. This involves understanding the motor's torque-speed characteristics, which are influenced by its construction and control methods. 2. Torque-Speed Characteristics Each motor type

exhibits unique torque-speed curves, which dictate its suitability for various applications:

– DC Motors: Exhibit high starting torque with a nearly constant torque region followed by a drop at high speeds. – Induction Motors: Exhibit a slip- dependent torque characteristic, with maximum torque at a specific slip. – Synchronous Motors: Provide constant speed operation, with torque depending on the excitation and control. Dubey emphasizes that understanding these characteristics is crucial for selecting and designing appropriate drive systems.

3. Power Electronics in Drives The evolution of electrical drives is closely linked to advances in power electronic Fundamentals Of Electrical Drives Gk Dubey 8 converters, enabling precise control of motor supply parameters:

– Rectifiers: Convert AC to DC for DC drives. – Inverters: Convert DC back to AC with variable frequency and voltage for AC drives. Key inverter types discussed include:

– Voltage Source Inverters (VSI): – Current Source Inverters (CSI): – Pulse Width Modulation (PWM) techniques:

Enhance control fidelity and reduce harmonic distortion. Dubey highlights that power electronic devices like thyristors, IGBTs, and MOSFETs are fundamental to modern drive systems.

--- Control Strategies in Electrical Drives Effective control strategies are vital for achieving desired performance metrics such as speed accuracy, torque regulation, and dynamic response.

1. Scalar Control Also known as V/f control, scalar control adjusts the magnitude of voltage and frequency, maintaining a constant ratio to control motor speed in an open-loop manner. It is simple but offers limited dynamic performance and is less suitable for precise applications.

2. Vector Control (Field-Oriented Control) Dubey emphasizes that vector control represents a significant advancement, enabling independent control of torque and flux components, akin to DC motor control. It involves:

– Coordinate transformation (e.g., Clarke and Park transforms) – Sinusoidal control of stator currents – Real-time feedback for precise speed and torque regulation This method allows for rapid dynamic response and high-precision control, making it ideal for industrial automation.

3. Direct Torque Control (DTC) Another sophisticated technique, DTC directly manages torque and flux without complex coordinate transformations, providing fast dynamic response and simplified control algorithms.

--- Applications of Electrical Drives Dubey's comprehensive treatment covers a wide range of practical applications,

illustrating how the principles are implemented across industries: – Industrial Automation: Robotics, conveyor belts, machine tools—demand precise position and speed control. – Electric Vehicles: Require high-performance drives for acceleration, regenerative braking, and energy efficiency. – HVAC Systems: Variable speed drives improve energy efficiency in fans and pumps. – Wind and Solar Power: Drives regulate generators to optimize power extraction. The versatility of electrical drives, as detailed by Dubey, underscores their Fundamentals Of Electrical Drives Gk Dubey 9 centrality in modern electrical and mechanical engineering. --- Control of Speed and Torque Dubey delves into the methodologies for controlling speed and torque, emphasizing the importance of feedback and sensor integration. 1. Speed Control Methods include: – Open-loop control (less precise) – Closed-loop control with feedback (preferred for accuracy) – Techniques such as PID control, fuzzy logic, and adaptive control for enhanced performance 2. Torque Control Achieved through current regulation in the motor windings, often employing controllers that regulate armature or stator currents to meet torque demands. --- Efficiency and Energy Conservation A recurring theme in Dubey's work is optimizing the efficiency of electrical drives: – Proper selection of motor types based on load characteristics. – Use of energy-efficient power electronic converters. – Implementing regenerative braking to recover energy. – Minimizing harmonic distortions through advanced PWM schemes. Efficiency considerations are vital not only for operational cost reduction but also for environmental sustainability. --- Emerging Trends and Future Directions Dubey's "Fundamentals of Electrical Drives" also discusses the future landscape, highlighting trends such as: – Integration with Renewable Energy Sources: Drives for wind turbines and solar inverters. – Smart Drives and IoT: Incorporating sensors and communication protocols for predictive maintenance and remote monitoring. – Advanced Control Algorithms: Machine learning and AI to optimize drive performance. – Wireless Power Transfer: Emerging methods for contactless energy transmission. These developments point toward increasingly intelligent, efficient, and versatile electrical drive systems. --- Conclusion: Why Dubey's Work is a Must-Read G.K. Dubey's "Fundamentals of Electrical Drives" remains a seminal reference that bridges foundational concepts with

cutting-edge technology. Its systematic approach to topics—from basic principles, motor types, power electronics, to control strategies—makes it an invaluable resource for anyone serious about mastering electrical Fundamentals Of Electrical Drives Gk Dubey 10 drives. This detailed examination underscores that understanding the fundamentals of electrical drives is essential for designing, operating, and optimizing motor-driven systems across diverse industries. Dubey's insights provide a solid foundation, guiding engineers and students alike toward innovative and efficient solutions in the dynamic field of electrical drives. --- In summary, the key takeaways from Dubey's "Fundamentals of Electrical Drives" include: – A clear understanding of different motor types and their characteristics. – The vital role of power electronics in drive control. – The importance of advanced control strategies like vector control and DTC. – Practical insights into applications and energy-saving techniques. – A glimpse into future technological trends shaping the industry. Whether you are a newcomer seeking foundational knowledge or an experienced engineer aiming to stay updated, Dubey's work offers authoritative guidance that remains relevant in the fast-evolving domain of electrical drives. electrical drives, d.c. motors, a.c. drives, power electronics, control systems, motor control, energy efficiency, adjustable speed drives, power converters, electrical engineering

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encouraged by the response to the first edition and to keep pace with recent developments fundamentals of electrical drives second edition incorporates greater details on semi conductor controlled drives includes coverage of permanent magnet ac motor drives and switched reluctance motor drives and highlights new trends in drive technology contents were chosen to satisfy the changing needs of the industry and provide the appropriate coverage of modern and conventional drives with the large number of examples problems and solutions provided fundamentals of electrical drives second edition will continue to be a useful reference for practicing engineers and for those preparing for engineering service examinations

this book provides a comprehensive introduction to the fundamental concepts of electric drives and is eminently suited as a textbook for b e b tech amie and diploma courses in electrical engineering it can also be used most effectively by all those preparing for gate and upsc competitive examinations as well as by practising engineers the topics which range from principles and techniques to industrial applications include characteristic features of drives methods of braking and speed control electromagnetic and solid state control of motors motor ratings transients in drive systems and operation of stepper

motors

a study of power semiconductor controlled drives that contain dc induction and synchronous motors discusses the dynamics of motor and load systems open and closed loop drives and thyristor power transistor and gto converters also reviews arc drives brushless and commutatorless dc drives and rectifier controlled dc drives annotation copyrighted by book news inc portland or

this comprehensive text examines existing and emerging electrical drive technologies the authors clearly define the most basic electrical drive concepts and go on to explain the most important details while maintaining a solid connection to the theory and design of the associated electrical machines also including links to a number of industrial applications the authors take their investigation of electrical drives beyond theory to examine a number of practical aspects of electrical drive control and application key features provides a comprehensive summary of all aspects of controlled speed electrical drive technology including control and operation handling of electrical drives is solidly linked to the theory and design of the associated electrical machines added insight into problems and functions are illustrated with clearly understandable figures offers an understanding of the main phenomena associated with electrical machine drives considers the problem of bearing currents and voltage stresses of an electrical drive includes up to date theory and design guidelines taking into account the most recent advances this book s rigorous coverage of theoretical principles and techniques makes for an excellent introduction to controlled speed electrical drive technologies for electrical engineering msc or phd students studying electrical drives it also serves as an excellent reference for practicing electrical engineers looking to carry out design analyses and development of controlled speed electrical drives

this contributed volume is written by key specialists working in multidisciplinary fields in electrical engineering linking control theory power electronics artificial neural networks embedded controllers and signal processing the authors of each chapter report the state of the art of the various topics addressed and present results of their own research

laboratory experiments and successful applications the presented solutions concentrate on three main areas of interest motion control in complex electromechanical systems including sensorless control fault diagnosis and fault tolerant control of electric drives new control algorithms for power electronics converters the chapters and the complete book possess strong monograph attributes important practical and theoretical problems are deeply and accurately presented on the background of an exhaustive state of the art review many results are completely new and were never published before well known control methods like field oriented control foc or direct torque control dtc are referred as a starting point for modifications or are used for comparison among numerous control theories used to solve particular problems are nonlinear control robust control adaptive control lyapunov techniques observer design model predictive control neural control sliding mode control signal filtration and processing fault diagnosis and fault tolerant control

power electronics handbook fifth edition delivers an expert guide to power electronics and their applications the book examines the foundations of power electronics power semiconductor devices and power converters before reviewing a constellation of modern applications comprehensively updated throughout this new edition features new sections addressing current practices for renewable energy storage transmission integration and operation as well as smart grid security intelligent energy artificial intelligence and machine learning applications applied to power electronics and autonomous and electric vehicles this handbook is aimed at practitioners and researchers undertaking projects requiring specialist design analysis installation commissioning and maintenance services provides a fully comprehensive work addressing each aspect of power electronics in painstaking depth delivers a methodical technical presentation in over 1500 pages includes 50 contributions prepared by leading experts offers practical support and guidance with detailed examples and applications for lab and field experimentation includes new technical sections on smart grid security and intelligent energy artificial intelligence and machine learning applications applied to power electronics and autonomous and electric vehicles features new chapter level templates and a narrative

progression to facilitate understanding

electrical drives convert in a controlled manner electrical energy into mechanical energy electrical drives comprise an electrical machine i e an electro mechanical energy converter a power electronic converter i e an electrical to electrical converter and a controller communication unit today electrical drives are used as propulsion systems in high speed trains elevators escalators electric ships electric forklift trucks and electric vehicles advanced control algorithms mostly digitally implemented allow torque control over a high bandwidth hence precise motion control can be achieved examples are drives in robots pick and place machines factory automation hardware etc most drives can operate in motoring and generating mode wind turbines use electrical drives to convert wind energy into electrical energy more and more variable speed drives are used to save energy for example in air conditioning units compressors blowers pumps and home appliances key to ensure stable operation of a drive in the aforementioned applications are torque control algorithms in advanced electrical drives a unique approach is followed to derive model based torque controllers for all types of lorentz force machines i e dc synchronous and induction machines the rotating transformer model forms the basis for this generalized modeling approach that ultimately leads to the development of universal field oriented control algorithms in case of switched reluctance machines torque observers are proposed to implement direct torque algorithms from a didactic viewpoint tutorials are included at the end of each chapter the reader is encouraged to execute these tutorials to familiarize him or herself with all aspects of drive technology hence advanced electrical drives encourages learning by doing furthermore the experienced drive specialist may find the simulation tools useful to design high performance controllers for all sorts of electrical drives

the aim of revision is mainly to acquaint the students with the recent trends in the development of electric motors used as prime movers in electric drive systems the chapter on introduction to solid state controlled drives has been expanded to include sections on increasingly used brushless dc motors and switched reluctance motors a

separate chapter on the more commonly used position control drive motors namely stepper motors has been also incorporated the drives used in the fast growing petroleum industry have been included in the chapter on industrial applications

electrical drives play an important role as electromechanical energy converters in transportation material handling and most production processes the ease of controlling electrical drives is an important aspect for meeting the increasing demands by the user with respect to flexibility and precision caused by technological progress in industry as well as the need for energy conservation at the same time the control of electrical drives has provided strong incentives to control engineering in general leading to the development of new control structures and their introduction to other areas of control this is due to the stringent operating conditions and widely varying specifications a drive may alternately require control of torque acceleration speed or position and the fact that most electric drives have in contrast to chemical or thermal processes well defined structures and consistent dynamic characteristics during the last years the field of controlled electrical drives has undergone rapid expansion due mainly to the advances of semiconductors in the form of power electronics as well as analogue and digital signal electronics eventually culminating in microelectronics and microprocessors the introduction of electronically switched solid state power converters has renewed the search for adjustable speed ac motor drives not subject to the limitations of the mechanical commutator of dc drives which dominated the field for a century

the book is primarily intended for b e b tech students of electrical engineering electrical and electronics engineering having courses in electric drives power semiconductor drives it will also be highly useful for m e m tech students of these disciplines specializing in power electronics industrial drives electric drives the text is divided into eight chapters the first two chapters cover the control of dc motors by using various kinds of converters the third chapter focuses on dual converters and various braking techniques chopper control fed dc motors are discussed in the fourth chapter the next three chapters are devoted to control methods for induction motors the eighth chapter deals with the control

of synchronous motor drives fed from vsi converters and cycloconverters

digital control of electrical drives offers insight into electric drives and their usage in motion control environment it provides links among electrical machine and control theory practical hardware aspects programming issues and application specific problems the book prepares the reader to understand the key elements of motion control systems analyze and design discrete time speed and position controllers set adjustable feedback parameters and evaluate closed loop performances basic engineering principles are used to derive the controller structure in an intuitive manner so that designs are easy to comprehend modify and extend digital control of electrical drives helps the reader acquire practical skills in designing discrete time speed and position controllers each chapter is followed by a set of matlab and simulink tools which help readers master the phases of design tuning simulation and evaluation of discrete time controllers and foresee the effects of control solution on the overall motion control system readers will also understand the present performance limits of digital motion controllers

this book aims to offer a thorough study and reference textbook on electrical machines and drives the basic idea is to start from the pure electromagnetic principles to derive the equivalent circuits and steady state equations of the most common electrical machines in the first parts although the book mainly concentrates on rotating field machines the first two chapters are devoted to transformers and dc commutator machines the chapter on transformers is included as an introduction to induction and synchronous machines their electromagnetics and equivalent circuits chapters three and four offer an in depth study of induction and synchronous machines respectively starting from their electromagnetics steady state equations and equivalent circuits are derived from which their basic properties can be deduced the second part discusses the main power electronic supplies for electrical drives for example rectifiers choppers cycloconverters and inverters much attention is paid to pwm techniques for inverters and the resulting harmonic content in the output waveform in the third part electrical drives are discussed combining the traditional rotating field and dc commutator electrical machines treated in the first part and

the power electronics of part two field orientation of induction and synchronous machines are discussed in detail as well as direct torque control in addition also switched reluctance machines and stepping motors are discussed in the last chapters finally part 4 is devoted to the dynamics of traditional electrical machines also for the dynamics of induction and synchronous machine drives the electromagnetics are used as the starting point to derive the dynamic models throughout part 4 much attention is paid to the derivation of analytical models but of course the basic dynamic properties and probable causes of instability of induction and synchronous machine drives are discussed in detail as well with the derived models for stability in the small as starting point in addition to the study of the stability in the small a chapter is devoted to large scale dynamics as well e g sudden short circuit of synchronous machines the textbook is used as the course text for the bachelor s and master s programme in electrical and mechanical engineering at the faculty of engineering and architecture of ghent university parts 1 and 2 are taught in the basic course fundamentals of electric drives in the third bachelor part 3 is used for the course controlled electrical drives in the first master while part 4 is used in the specialised master on electrical energy

this problem oriented book provides solutions to the common problems in two major areas of electrical engineering discipline such as electric machines and electric drives with power electronics linking them under a single cover it serves as a supplement to textbooks on the subject the book includes as many as 163 well graded solved problems covering topics such as transformer dc machine ac machines induction motor and synchronous types special motors power electronics and electric drives the problems have been solved in a clear and step by step manner each chapter discusses various formulas and other details such as circuit diagrams and relevant waveforms used to solve the problems the book contains 161 supplementary problems with answers for practice their complete solutions are also provided at the end of the book the students can hone their skills and enhance their understanding of the subject matter by solving these supplementary problems the book is designed for the undergraduate students of electrical engineering it will also be useful for those preparing for amie and competitive

examinations

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