Direct Methods For Stability Analysis Of Electric Power Systems Theoretical Foundation Bcu Methodologies And Applications

This authoritative treatment covers theory, optimal estimation and a range of practical applications. The first book on the subject, and written by leading researchers, this clear and rigorous work presents a comprehensive theory for both the stability boundary and the stability regions of a range of nonlinear dynamical systems including continuous, discrete, complex, two-time-scale and non-hyperbolic systems, illustrated with numerical examples. The authors also propose new concepts of quasi-stability region and of relevant stability regions and their complete characterisations. Optimal schemes for estimating stability regions of general nonlinear dynamical systems are also covered, and finally the authors describe and explain how the theory is applied in applications including direct methods for power system transient stability analysis, nonlinear optimisation for finding a set of high-quality optimal solutions, stabilisation of nonlinear systems, ecosystem dynamics, and immunisation problems.

Filling a gap in the literature, this volume offers the first comprehensive analysis of all the major types of system models. Throughout the text, there are many examples and applications to important classes of systems in areas such as power and energy, feedback control, artificial neural networks, digital signal processing and control, manufacturing, computer networks, and socio-economics. Replete with exercises and requiring basic knowledge of linear algebra, analysis, and differential equations, the work may be used as a textbook for graduate courses in stability theory of dynamical systems. The book may also serve as a self-study reference for graduate students, researchers, and practitioners in a huge variety of fields.

The market liberalization is expected to affect drastically the operation of power systems, which under economical pressure and increasing amount of transactions are being operated much closer to their limits than previously. These changes put the system operators faced with rather different and much more problematic scenarios than in the past. They have now to calculate available transfer capabilities and manage congestion problems in a near on line environment, while operating the transmission system under extremely stressed conditions. This requires highly reliable and efficient software aids, which today are non-existent, or not yet in use. One of the most problematic issues, very much needed but not yet en countered today, is on-line dynamic security assessment and control, enabling the power system to withstand unexpected contingencies without experienc ing voltage or transient instabilities. This monograph is devoted to a unified approach to transient stability assessment and control, called SIngle Machine Equivalent (S1ME).

Power System Stability and Control contains the hands-on information you need to understand, model, analyze, and solve problems using the latest technical tools. You'll learn about the structure of modern power systems, the different levels of control, and the nature of stability problems you face in your day-to-day work.

Provides practical solutions to the challenge of modeling and analyzing rock masses Consolidates a wealth of previously published technical papers on the subject and introduces previously unseen material This authoritative title is a key reference for any Geo-engineer. Rock masses differ considerably from man-made materials, and their properties can vary with location, direction and time. As a result there is a critical need to capture these variations via modeling and analysis. Zhu and Zhao provide an expert introduction to the techniques and analytical methods needed for studying underground excavations in fractured rock masses. The book brings together previously published

and new material to provide a comprehensive and up-to-date reference. Provides practical solutions to the challenge of modeling and analyzing rock masses Consolidates a wealth of previously published technical papers on the subject and introduces previously unseen material

This book presents theoretical explorations of several fundamental problems in the dynamics and control of flexible beam systems. By integrating fresh concepts and results to form a systematic approach to control, it establishes a basic theoretical framework. It includes typical control design examples verified using MATLAB simulation, which in turn illustrate the successful practical applications of active vibration control theory for flexible beam systems. The book is primarily intended for researchers and engineers in the control system and mechanical engineering community, offering them a unique resource.

This research monograph is in some sense a sequel to the author's earlier one (Power System Stability, North Holland, New York 1981) which devoted cons- erable attention to Lyapunov stability theory, construction of Lyapunov fu- tions and vector Lyapunov functions as applied to power systems. This field of research has rapidly grown since 1981 and the more general concept of energy funct ion has found wide spread application in power systems. There have been advances in five distinct areas (i) Developing energy functions for structure preserving models which can incorporate non-linear load models (ii) Energy fu- tions to include detailed model of the generating unit i. e. , the synchronous machine and the excitation system (iii) Reduced order energy functions for large scale power systems, the simplest being the single machine infinite bus system (iv) Characterization of the stability boundary of the post-fault stable eQui- brium point (v) Applications for large power networks as a tool for dynamic security assessment. It was therefore felt appropriate to capture the essential features of these advances and put them in a somewhat cohesive framework. The chapters in the book rough ly fo llow this sequence. It is interesting to note how different research groups come to the same conclusion via different reas- ings.

The Electric Power Engineering Handbook, Third Edition updates coverage of recent developments and rapid technological growth in crucial aspects of power systems, including protection, dynamics and stability, operation, and control. With contributions from worldwide field leaders—edited by L.L. Grigsby, one of the world’s most respected, accomplished authorities in power engineering—this reference includes chapters on: Nonconventional Power Generation Conventional Power Generation Transmission Systems Distribution Systems Electric Power Utilization Power Quality Power System Analysis and Simulation Power System Transients Power System Planning (Reliability) Power Electronics Power System Protection Power System Dynamics and Stability Power System Operation and Control Content includes a simplified overview of advances in international standards, practices, and technologies, such as small-signal stability and power system oscillations, power system stability controls, and dynamic modeling of power systems. Each book in this popular series supplies a high level of detail and, more importantly, a tutorial style of writing and use of photographs and graphics to help the reader understand the material. This resource will help readers achieve safe, economical, high-quality power delivery in a dynamic and demanding environment. Volumes in the set: K12642 Electric Power Generation, Transmission, and Distribution, Third Edition (ISBN: 9781439856284) K12648 Power Systems, Third Edition (ISBN: 9781439856338) K13917 Power System Stability and Control, Third Edition (9781439883204) K12650 Electric Power Substations Engineering, Third Edition (9781439856383) K12643 Electric Power Transformer Engineering, Third Edition (9781439856291)

The subject of sparse matrices has its root in such diverse fields as management science, power systems analysis, surveying, circuit theory, and structural analysis. Efficient use of sparsity is a key to solving large problems in many fields. This second edition is a complete rewrite of the first edition published 30 years ago. Much has changed since that time. Problems have grown greatly in size and complexity; nearly all

examples in the first edition were of order less than 5,000 in the first edition, and are often more than a million in the second edition. Computer architectures are now much more complex, requiring new ways of adapting algorithms to parallel environments with memory hierarchies. Because the area is such an important one to all of computational science and engineering, a huge amount of research has been done in the last 30 years, some of it by the authors themselves. This new research is integrated into the text with a clear explanation of the underlying mathematics and algorithms. New research that is described includes new techniques for scaling and error control, new orderings, new combinatorial techniques for partitioning both symmetric and unsymmetric problems, and a detailed description of the multifrontal approach to solving systems that was pioneered by the research of the authors and colleagues. This includes a discussion of techniques for exploiting parallel architectures and new work for indefinite and unsymmetric systems.

The twin challenge of meeting global energy demands in the face of growing economies and populations and restricting greenhouse gas emissions is one of the most daunting ones that humanity has ever faced. Smart electrical generation and distribution infrastructure will play a crucial role in meeting these challenges. We would need to develop capabilities to handle large volumes of data generated by the power system components like PMUs, DFRs and other data acquisition devices as well as by the capacity to process these data at high resolution via multi-scale and multi-period simulations, cascading and security analysis, interaction between hybrid systems (electric, transport, gas, oil, coal, etc.) and so on, to get meaningful information in real time to ensure a secure, reliable and stable power system grid. Advanced research on development and implementation of market-ready leading-edge high-speed enabling technologies and algorithms for solving real-time, dynamic, resource-critical problems will be required for dynamic security analysis targeted towards successful implementation of Smart Grid initiatives. This books aims to bring together some of the latest research developments as well as thoughts on the future research directions of the high performance computing applications in electric power systems planning, operations, security, markets, and grid integration of alternate sources of energy, etc.

Power System Small Signal Stability Analysis and Control, Second Edition analyzes severe outages due to the sustained growth of small signal oscillations in modern interconnected power systems. This fully revised edition addresses the continued expansion of power systems and the rapid upgrade to smart grid technologies that call for the implementation of robust and optimal controls. With a new chapter on MATLAB programs, this book describes how the application of power system damping controllers such as Power System Stabilizers and Flexible Alternating Current Transmission System controllers—namely Static Var Compensator and Thyristor Controlled Series Compensator—can guard against system disruptions. Detailed mathematical derivations, illustrated case studies, the application of soft computation techniques, designs of robust controllers, and end-of-chapter exercises make it a useful resource to researchers, practicing engineers, and post-graduates in electrical engineering. Considers power system small signal stability and provides various techniques to mitigate it Offers a new and straightforward method of finding the optimal location of PSS in a multi-machine power system Includes MATLAB programs and simulations for practical applications

Probably the first book to describe computational methods for numerically computing steady state and Hopf bifurcations. Requiring only a basic knowledge of calculus, and using detailed examples, problems, and figures, this is an ideal textbook for graduate students.

In this book, we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems. A number of computing techniques are considered, such as methods of operator approximation with any given accuracy; operator interpolation techniques including a non-Lagrange interpolation; methods of system representation subject to constraints associated with concepts of causality,

memory and stationarity; methods of system representation with an accuracy that is the best within a given class of models; methods of covariance matrix estimation; methods for low-rank matrix approximations; hybrid methods based on a combination of iterative procedures and best operator approximation; and methods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory. As a result, the book represents a blend of new methods in general computational analysis, and specific, but also generic, techniques for study of systems theory ant its particular branches, such as optimal filtering and information compression. Best operator approximation, Non-Lagrange interpolation, Generic Karhunen-Loeve transform Generalised low-rank matrix approximation Optimal data compression Optimal nonlinear filtering

Direct methods are an alternative for power system transient stability analysis to avoid the enormous computational efforts of conventional time-domain method. The development of direct methods in last three decades makes it an effective potential approach to both on-line security assessment and off-line analysis tools. Among the direct methods, the Boundary of stability region based Controlling Unstable equilibrium point (BCU) method is the most successful, having a sound theoretical basis and practical application in power systems. It finds the controlling UEP of the original system via a reduced-state system. This thesis investigates the development of direct methods and the related theoretical foundation. Several widely used direct methods are presented and compared. The theoretical foundation and computational issues of BCU methods are discussed. Incorporation of more realistic power system models can be incorporated in BCU methods is introduced. Based on BCU method, some small system cases are tested for a given fault.

Nonlinearities exist in all process control systems. The use of linear control techniques is valid only in a narrow region of operation. Nonlinear control is central to future industrial development. In this book, multivariable nonlinear control techniques based on differential geometry are considered in a pragmatic manner. The book provides a simplified and systematic approach to geometric nonlinear control theory. A case study of an industrial evaporator is used as an example throughout the entire book. Various other examples are also used throughout the text to illustrate the theory. The book successfully demonstrates the superiority and simplicity of the class of controllers studied through simulations and actual plant implementations. The simulations were done using the symbolic computation package MAPLE. Discussions are given on the application of symbolic computation in process engineering. This book is aimed at industrial practitioners and postgraduates in engineering, and will be particularly valuable to practicing engineers who find the theory books on control somewhat heavy going. The insights provided in the book will encourage more industrial implementations of nonlinear controllers, and thereby help to bridge the widening gap between control theory and industrial practice.

This monograph is a collective work. The names appear ing on the front cover are those of the people who worked on every chapter. But the contributions of others were also very important: C. Risito for Chapters I, II and IV, K. Peiffer for III, IV, VI, IX R. J. Ballieu for I and IX, Dang Chau Phien for VI and IX, J. L. Corne for VII and VIII. The idea of writing this book originated in a seminar held at the University of Louvain during the academic year 1971-72. Two years later, a first draft was completed. However, it was unsatisfactory mainly because it was ex ce~sively abstract and lacked examples. It was then decided to write it again, taking advantage of -some remarks of the students to whom it had been partly addressed. The actual text is this second version. The subject matter is stability theory in the general setting of ordinary differential equations using what is known as Liapunov's direct or second method. We concentrate our efforts on this method, not because we underrate those which appear more powerful in some circumstances, but because it is important enough, along with its modern developments, to justify the writing of an up-to-date monograph. Also excellent books exist concerning the other methods, as for example R.

Bellman [1953] and W. A. Coppel [1965].

Voltage Stability is a challenging problem in Power Systems Engineering. This book presents a description of voltage instability and collapse phenomena. It intends to propose a uniform and coherent theoretical framework for analysis. It describes practical methods that can be used for voltage security assessment and offers a variety of examples.

The articles in this volume cover power system model reduction, transient and voltage stability, nonlinear control, robust stability, computation and optimization and have been written by some of the leading researchers in these areas. This book should be of interest to power and control engineers, and applied mathematicians.

This work seeks to provide a solid foundation to the principles and practices of dynamics and stability assessment of large-scale power systems, focusing on the use of interconnected systems - and aiming to meet the requirements of today's competitive and deregulated environments. It contains easy-to-follow examples of fundamental concepts and algorithmic procedures.

An in-depth treatment of the transient stability problem, its physical description and formulation. Discusses methods for transient stability analysis, sensitivity assessment and control. Considers conventional and non-conventional techniques including direct and artificial intelligence, system theory, load modeling, evaluation of machine parameters, saturation effects and pattern recognition approaches. Features practical examples and simulation results.

The structure, layout, and components of the electric power grid are changing rapidly leading to new components, models, and power system static and dynamic behaviors that existing power system analysis tools cannot accommodate. Since electricity is an integral part of our daily lives, it is important that power system analysis and control tools keep up with the changes in the power grid. An existing methodology/tool with the potential to help the power industry keep up with the changing needs for dynamic stability and control of the power system, due to its strong theoretical basis, is the boundary of the stability region based controlling unstable equilibrium point (BCU) method. This thesis develops tools for the online transient stability analysis and control of modern power systems using the BCU method. Towards this goal we first propose a method for improving the robustness of unstable equilibrium point computations using a combination of quotient gradient transformation and the pseudo-transient continuation method. We also extend the application of the BCU method to the assessment of the transient stability of power systems with nonlinear excitation system models. The thesis also studies the dynamics of transmission line switching events under changing loading conditions and proposes and implements a novel BCU-based method for the direct transient stability assessment of transmission switching events. A method based on a three-stage strategy is also proposed for the fast determination of transmission line switching candidates that can be used to enhance the transient stability of multiple contingencies for look-ahead loading conditions of a power system. Finally, a three-stage, fast scenario-based tool for the online transient stability

assessments of power systems with load or generation uncertainties under look-ahead load conditions is proposed and implemented.

A number of methods currently exist for the analysis and design of slopes. This book provides a critical review of these and offers several more appropriate approaches for overcoming numerical convergence and the location of critical failure surfaces in two-dimensional and three-dimensional cases. New concepts in three-dimensional stability analysis, finite element analysis and the extension of slope stability problems to lateral earth pressure problems are also addressed. It gives helpful practical advice and design resources in the form of recommendations for good analysis and design practice, design charts and tables for the engineer. Limitations are detailed of both limit equilibrium and the finite element method in the assessment of the stability of a slope, and guidance is provided for assessing the fundamental assumptions and limitations of stability analysis methods and computer modelling. The book provides ample examples to illustrate how this range of problems should be dealt with. The final chapter touches on design and its implementation on site. The emphasis is on the transfer of the design to its physical implementation on site in a holistic way, taking full account of the latest developments in construction technology. Engineering and construction problems tend to be pigeonholed into different classes of problem such as slope stability, bearing capacity and earth pressure behind retaining structures. This is quite unnecessary. This book offers a unified approach, which is conceptually, practically and philosophically more satisfying.

This book details the state of the art in the development and application of the transient energy function (TEF) method as a tool for power system transient stability assessment. It provides both the analytical foundations of the TEF method and the practical issues involved in the application of the method to analyze power systems. Of primary interest to electric utility engineers who need to understand and apply the technique, as well as engineers in research organizations involved in research and development projects on power system dynamics, and utility engineers interested in the use of the TEF method as a tool for dynamic security assessment.

Learn how to implement BCU methods for fast direct stabilityassessments of electric power systems Electric power providers around the world rely on stabilityanalysis programs to help ensure uninterrupted service to theircustomers. These programs are typically based on step-by-stepnumerical integrations of power system stability models to simulatesystem dynamic behaviors. Unfortunately, this offline practice isinadequate to deal with current operating environments. For years,direct methods have held the promise of providing real-timestability assessments; however, these methods have presentedseveral challenges and limitations. This book addresses these challenges and limitations with theBCU methods developed by author Hsiao-Dong Chiang. To date, BCUmethods have been adopted by twelve

major utility companies in Asiaand North America. In addition, BCU methods are the only directmethods adopted by the Electric Power Research Institute in itslatest version of DIRECT 4.0. Everything you need to take full advantage of BCU methods isprovided, including: Theoretical foundations of direct methods Theoretical foundations of energy functions BCU methods and their theoretical foundations Group-based BCU method and its applications Numerical studies on industrial models and data Armed with a solid foundation in the underlying theory of directmethods, energy functions, and BCU methods, you'll discover how toefficiently solve complex practical problems in stability analysis.Most chapters begin with an introduction and end with concludingremarks, making it easy for you to implement these tested andproven methods that will help you avoid costly and dangerous poweroutages.

A thorough and exhaustive presentation of theoretical analysis and practical techniques for the small-signal analysis and control of large modern electric power systems as well as an assessment of their stability and damping performance.

An authoritative treatment by leading researchers covering theory and optimal estimation, along with practical applications.

Provides students with an understanding of the modeling and practice in power system stability analysis and control design, as well as the computational tools used by commercial vendors Bringing together wind, FACTS, HVDC, and several other modern elements, this book gives readers everything they need to know about power systems. It makes learning complex power system concepts, models, and dynamics simpler and more efficient while providing modern viewpoints of power system analysis. Power System Modeling, Computation, and Control provides students with a new and detailed analysis of voltage stability; a simple example illustrating the BCU method of transient stability analysis; and one of only a few derivations of the transient synchronous machine model. It offers a discussion on reactive power consumption of induction motors during start-up to illustrate the low-voltage phenomenon observed in urban load centers. Damping controller designs using power system stabilizer, HVDC systems, static var compensator, and thyristor-controlled series compensation are also examined. In addition, there are chapters covering flexible AC transmission Systems (FACTS)—including both thyristor and voltage-sourced converter technology—and wind turbine generation and modeling. Simplifies the learning of complex power system concepts, models, and dynamics Provides chapters on power flow solution, voltage stability, simulation methods, transient stability, small signal stability, synchronous machine models (steady-state and dynamic models), excitation systems, and power system stabilizer design Includes advanced analysis of voltage stability, voltage recovery during motor starts, FACTS and their operation, damping control design using various control equipment, wind turbine models, and control Contains numerous examples, tables, figures of block diagrams, MATLAB plots, and problems involving real systems Written by experienced educators whose previous books

and papers are used extensively by the international scientific community Power System Modeling, Computation, and Control is an ideal textbook for graduate students of the subject, as well as for power system engineers and control design professionals.

Knowing the safety factor for limit states such as plastic collapse, low cycle fatigue or ratcheting is always a major design consideration for civil and mechanical engineering structures that are subjected to loads. Direct methods of limit or shakedown analysis that proceed to directly find the limit states offer a better alternative than exact time-stepping calculations as, on one hand, an exact loading history is scarcely known, and on the other they are much less time-consuming. This book presents the state of the art on various topics concerning these methods, such as theoretical advances in limit and shakedown analysis, the development of relevant algorithms and computational procedures, sophisticated modeling of inelastic material behavior like hardening, non-associated flow rules, material damage and fatigue, contact and friction, homogenization and composites.

The control of power systems and power plants is a subject of worldwide interest which continues to sustain a high level of research, development and application. Papers pertaining to areas directly related to power systems and representing the state-of-the-art methods are included in this volume. The topics covered include security analysis, dynamic state estimation, voltage control, power plant control, stability analysis, data communication, expert systems and training simulators for power plants. This interchange between those involved in the research and those involved in the practical applications of new ideas and developments provide a comprehensive reference source for all involved in the power industry.