Grid Inertia And Frequency Control In Power Systems With

The DC/AC microgrid system is a crucial empowering technology for the integration of various types of renewable energy sources (RES) accompanied by a smart control approach to enhance the system reliability and efficiency. This book presents cutting-edge technology developments and recent investigations performed with the help of power electronics. Large-scale renewable energy integration presents challenges and issues for power grids. In particular, these issues include microgrid adaption to RES, AC machines, the new configuration of AC/DC converters, and electrification of domestic needs with optimal cost expenses from domestic standalone microgrids. Furthermore, this book elaborates cutting-edge developments in electric vehicle fast charging configuration, battery management, and control schemes with renewable energies through hardware-in-loop testing and validation for performance durability in real-time application. Overall, the book covers the diverse field of microgrids, allowing readers to adopt new technologies and prepare for future power demands with sustainable green engineering.

This book provides a thorough understanding of the basic principles, synthesis, analysis, and control of virtual inertia systems. It uses the latest technical tools to mitigate power system stability and control problems under the presence of high distributed generators (DGs) and renewable energy sources (RESs) penetration. This book uses a simple virtual inertia control structure based on the frequency response model, complemented with various control methods and algorithms to achieve an adaptive virtual inertia control respect to the frequency stability and control issues. The chapters capture the important aspects in virtual inertia synthesis and control with the objective of solving the stability and control problems regarding the changes of system inertia caused by the integration of DGs/RESs. Different topics on the synthesis and application of virtual inertia are thoroughly covered with the description and analysis of numerous conventional and modern control methods for enhancing the full spectrum of power system stability and control. Filled with illustrative examples, this book gives the necessary fundamentals and insight into practical aspects. This book stimulates further research and offers practical solutions to real-world power system stability and control problems with respect to the system inertia variation triggered by the integration of RESs/DGs. It will be of use to engineers, academic researchers, and university students interested in power systems dynamics, analysis, stability and control.

Frequency control as a major function of automatic generation control is one of the important control problems in electric power system design and operation, and is becoming more signi?cant today because of the increasing size, changing structure, emerging new uncertainties, environmental constraints and the complexity of power systems. In the last two decades, many studies have focused on damping control and vo- age stability and the related issues, but there has been much less work on the power system frequency control analysis and synthesis. While some aspects of frequency control have been illustrated along with individual chapters, many conferences and technical papers, a comprehensive and sensible practical explanation of robust f- quency control in a book form is necessary. This book provides a thorough understanding of the basic principles of power system frequency behaviour in wide range of operating conditions. It uses simple frequency response models, control structures and mathematical algorithms to adapt modern robust control theorems with frequency control issue and conceptual exp- nations. Most developed control strategies are examined by real-time simulations. Practical methods for computer analysis and design are emphasized. This book emphasizes the physical and engineering aspects of the power s- tem frequency control design problem, providing a conceptual understanding of frequency regulation, and application of robust control techniques. The main aim is to develop an appropriate intuition relative to the robust load frequency regulation problem in real-world power systems, rather than to describe sophisticated mat- matical analytical methods.

A major concern of island power systems is frequency stability. A power system is said to be frequency stable if its generators are able to supply their loads at a frequency within acceptable limits after a disturbance. Frequency instability occurs if load-generation imbalances are not corrected in appropriate manner and time. Since island power systems are more sensitive to frequency instability than large ones due to the smaller number of generators online and the lower inertia, they require a larger amount of primary reserve per generator. This book provides a worldwide overview of island power systems, describing their main features and issues. Split into two parts, the first part examines the technical operation, and in particular, frequency stability of island power systems and its technical solutions, including more efficient underfrequency load-shedding schemes. The chapters explore both conventional and advanced load-shedding schemes and consider the improvement of these schemes by making them more robust and efficient. Advanced devices are modelled and analyzed to enhance frequency stability and reduce the need for load shedding. In the second part, the economic operation of island power systems is explored in detail. For that purpose, regulations and economic operations (centralized vs. market scheme) are reviewed by the authors. The authors discuss models for renewable energy sources and for advanced devices and systems such as demand-side management, energy storage systems, and electric vehicles. This book will be critical reading to all researchers and professionals in power system planning and engineering, electrical/power delivery, RES and control engineering. It will also be of interest to researchers in signal processing and telecommunications and renewable energy, as well as power system utility providers.

This book outlines the challenges that increasing amounts of renewable and distributed energy represent when integrated into established electricity grid infrastructures, offering a range of potential solutions that will support engineers, grid operators, system planners, utilities, and policymakers alike in their efforts to realize the vision of moving toward greener, more secure energy portfolios. Covering all major renewable sources, from wind and solar, to waste energy and hydropower, the authors highlight case studies of successful integration scenarios to demonstrate pathways toward overcoming the complexities created by variable and distributed generation.

Over the last century, energy storage systems (ESSs) have continued to evolve and adapt to changing energy requirements and technological advances. Energy Storage in Power Systems describes the essential principles needed to understand the role of ESSs in modern electrical power systems, highlighting their application for the grid integration of renewable-based generation. Key features: Defines the basis of electrical power systems, characterized by a high and increasing penetration of renewable-based generation. Describes the fundamentals, main characteristics and components of energy storage technologies, with an emphasis on electrical energy storage types. Contains real examples depicting the application of energy storage systems in the power system. Features case studies with and without solutions on modelling, simulation and optimization techniques. Although primarily targeted at researchers and senior graduate students, Energy Storage in Power Systems is also highly useful to scientists and engineers wanting to gain an introduction to the field of energy storage and more specifically its application to modern power systems.

RENEWABLE INTEGRATED POWER SYSTEM STABILITY AND CONTROL Discover new challenges and hot topics in the field of penetrated power grids in this brand-new interdisciplinary resource Renewable Integrated Power System Stability and Control delivers a comprehensive exploration of penetrated grid dynamic analysis and new trends in power system modeling and dynamic equivalencing. The book summarizes long-term academic research outcomes and contributions and exploits the authors' extensive practical experiences in power system dynamics and stability to offer readers an insightful analysis of modern power grid infrastructure. In addition to the basic principles of penetrated power system modeling, model reduction, and model derivation, the book discusses inertia challenge requirements and control levels, as well as recent advances in visualization of virtual synchronous generators and their associated effects on system performance. The physical constraints and engineering considerations of advanced control schemes are deliberated at length. Renewable Integrated Power System Stability and Control also considers robust and adaptive control strategies using real-time simulations and experimental studies. Readers will benefit from the inclusion of: A thorough introduction to power systems, including time horizon studies, structure, power generation options, energy storage systems, and microgrids An exploration of renewable integrated power grid modeling, including basic principles, host grid modeling, and grid-connected MG equivalent models A study of virtual inertia, including grid stability enhancement, simulations, and experimental results A discussion of renewable integrated power grid stability and control, including small signal stability assessment and the frequency point of view Perfect for engineers and operators in power grids, as well as academics studying the technology, Renewable Integrated Power System Stability and Control will also earn a place in the libraries of students in Electrical Engineering programs at the undergraduate and postgraduate levels who wish to improve their understanding of power system operation and control.

This book discusses relevant microgrid technologies in the context of integrating renewable energy and also addresses challenging issues. The authors summarize long term academic and research outcomes and contributions. In addition, this book is influenced by the authors' practical experiences on microgrids (MGs), electric network monitoring, and control and power electronic systems. A thorough discussion of the basic principles of the MG modeling and operating issues is provided. The MG structure, types, operating modes, modelling, dynamics, and control levels are covered. Recent advances in DC microgrids, virtual synchronousgenerators, MG planning and energy management are examined. The physical constraints and engineering aspects of the MGs are covered, and developed robust and intelligent control strategies are discussed using real time simulations and experimental studies.

Microgrid Protection and Control is the result of numerous research works and publications by R&D engineers and scientists of the Microgrid and Energy Internet Research Centre. Through the authors long-routed experience in the microgrid and energy internet industry, this book looks at the sophisticated protection and control issues connected to the special nature of microgrid. The book explains the different ways of classifying types of microgrids and common misconceptions, looking at industrial and research trends along with the different technical issues and challenges faced with deploying microgrid in various settings. Forecasting short-term demand and renewable generation for optimal operation is covered with techniques for accurate enhancement supported with practical application examples. With chapters on dynamic, transient and tertiary control and experimental and simulation tests this reference is useful for all those working in the research, engineering and application of microgrids and power distribution systems. Contains practical examples to support the research and experimental results on microgrid protection and control Includes detailed theories and referential algorithms Provides innovative solutions to technical issues in protection and control of microgrids

The main scope of this study is to emphasize exergy efficiency in all fields of industry. The chapters collected in the book are contributed by invited researchers with a long-standing experience in different research areas. I hope that the material presented here is understandable to a wide audience, not only energy engineers but also scientists from various disciplines. The book contains seven chapters in three sections: (1) "General Information about Exergy," (2) "Exergy Applications," and (3) "Thermoeconomic Analysis." This book provides detailed and up-to-date evaluations in different areas written by academics with experience in their fields. It is anticipated that this book will make a scientific contribution to exergy workers, researchers, academics, PhD students, and other scientists in both the present and the future.

Energy storage systems have been recognized as the key elements in modern power systems, where they are able to provide primary and secondary frequency controls, voltage regulation, power quality improvement, stability enhancement, reserve service, peak shaving, and so on. Particularly, deployment of energy storage systems in a distributed manner will contribute greatly in the development of smart grids and providing promising solutions for the above issues. The main challenges will be the adoption of new techniques and strategies for the optimal planning, control, monitoring and management of modern power systems with the wide installation of distributed energy storage systems. Thus, the aim of this book is to illustrate the potential of energy storage systems in different applications of modern power systems, with a view toward illuminating recent advances and research trends in storage technologies. This exciting new volume covers the recent advancements and applications of different energy storage technologies that are useful to engineers, scientists, and students in the discipline of electrical engineering. Suitable for the engineers at power companies and energy storage consultants working on energy storage field, this book offers a cross-disciplinary look across electrical, mechanical, chemical and renewable engineering aspects of energy storage. Whether for the veteran engineer or the student, this is a must-have for any library.

Undoubtedly, the energy sector is moving towards a more renewable and sustainable path. This means renewable energy will increase their penetration into the electric power grid. Wind Energy, in particular Offshore Wind Energy, is becoming the leader of the renewable energy in terms of future possibilities, and their technology is evolving to a more controllable devices. Double Fed Induction Generator Wind Turbines (DFIG), also known in the industry as Type 3 Wind Turbines, and Fully Rated Converter-based Wind Turbines, Type 4, use power electronics to decouple the generator from the grid. Type 3 does this partially and Type 4 decouples completely the generator from the system. This allows

variable wind speed operation and higher controllability for grid support. They improve the grid support provided by Fixed Wind Speed Turbines, except for the Fast Primary Frequency Response which is related directly with the inertia stored in the system. These types of wind turbines are not able to provide natural inertia response due to their decoupling from the grid. If we increase the penetration of this kind of wind turbines without giving a solution to the Fast Primary Frequency Response we will be lowering the Frequency Response and enable disturbances in the grid. This project proves how the Frequency control improves Frequency Response of the system in front of a sudden frequency drop even when the Percentage of Wind Energy Penetration is at the 30% level. We also prove how Control values of inertia constant, Droop and operational wind speeds affects the Frequency Response, being a fundamental step to take into account the operational point of the turbine depending on the working wind speed and the tune of the Frequency control values depending on the turbine characteristics.
During the last two decades, increase in electricity demand and environmental concern resulted in fast growth of power production from renewable sources. Wind power is one of the most efficient alternatives. Due to rapid development of wind turbine technology and increasing size of wind farms, wind power plays a significant part in the power production in some countries. However, fundamental differences exist between conventional thermal, hydro, and nuclear generation and wind power, such as different generation systems and the difficulty in controlling the primary movement of a wind turbine, due to the wind and its random fluctuations. These differences are reflected in the specific interaction of wind turbines with the power system. This book addresses a wide variety of issues regarding the integration of wind farms in power systems. The book contains 14 chapters divided into three parts. The first part outlines aspects related to the impact of the wind power generation on the electric system. In the second part, alternatives to mitigate problems of the wind farm integration are presented. Finally, the third part covers issues of modeling and simulation of wind power system.
Gain an in-depth understanding of converter-interfaced energy storage systems with this unique text, covering modelling, dynamic behaviour, control, and stability analysis. Providing comprehensive coverage, it demonstrates the technical and economic aspects of energy storage systems, and provides a thorough overview of energy storage technologies. Several different modelling techniques are presented, including power system models, voltage-sourced converter models, and energy storage system models. Using a novel stochastic control approach developed by the authors, you will learn about the impact of energy storage on the dynamic interaction of microgrids with distribution and transmission systems. Compare the numerous real-world simulation data and numerical examples provided with your own models and control strategies. Accompanied online by a wealth of numerical examples and supporting data, this is the ideal text for graduate students, researchers, and industry professionals working in power system dynamics, renewable energy integration, and smart grid development.
The various efforts of promoting the use of renewables has resulted in a steady growth of electricity coming from renewable energy sources which is expected to continue even further into the future. From a physics point of view, many of these renewable energy sources behave quiet differently from the synchronous generators installed in conventional power plants. Synchronous generators have mechanical inertia and are therefore capable of storing kinetic energy in their rotating mass. Moreover, since the terminals of these generators are directly linked with the network, this energy is inherently exchanged with the system during disturbances which makes the network less prone to frequency fluctuations in case of an imbalance between generation and load. Renewable generation units (mainly photovoltaic solar and wind power) on the other hand, are equipped with a power electronic converter which decouples the generator from the grid and as such provide no inertia to the system. As it is projected that many of the conventional power plants will be gradually displaced by these renewable energy sources, the total inertia perceived by the system will thus decrease. As discussed in this study, it expected that inertia related issues will mainly arise in terms of frequency control as low system inertia results in high rate of change of frequency (ROCOF) values and substantial frequency deviations which can lead to instability of the system including load shedding or even a blackout. There are however many possible solutions available to cope with these issues, which are all described in more detail in the report, ranging from a simple redispatch to a modified control approach for converters. Within Europe, many efforts have already been made by ENTSO-E to deal with the inertia issues in a coordinated and harmonized way though their operational guidelines, network codes and system studies. However, as most of the guidelines and network codes related to system inertia are non-exhaustive, there is still a wide variety in the way each TSO implement them. TSOs in large interconnected synchronous areas, such as the Continental European system, currently only adapt the allowed ROCOF relay settings or include a ROCOF withstand capability (for new units) in their grid code. Island systems on the other hand, such as Ireland and GB, are already a step ahead as they expect to encounter high levels of converter penetration. Currently they mostly try to limit the ROCOF by limiting the largest credible loss or keeping the inertia above a certain minimum value. However, to reach even higher penetration levels, new system services will need to be procured. A prognosis of the future system inertia in 2030 within the synchronous area of Continental Europe is made based on the generation capacities of the EUCO30 scenario. Although it expected that there will be a substantial increase in converter connected penetration by 2030, the analysis shows that there remains enough inertia in the system to cope with imbalance which are much higher than the current reference incident. Nevertheless, in accordance with the operation guidelines of ENTSO-E, it is recommended that a tool to monitor and forecast the inertia at operational level is gradually put into place within the Continental European System. Furthermore, to be future proof, it is also necessary to already draft procedures to cope with a possible lack of inertia. In this respect, it is important to take into account the operational experience gained by TSOs in smaller systems such as the one of Ireland.
Renewable Energy (RE) sources differ from conventional sources in that, generally they cannot be scheduled, they are much smaller than conventional power stations and are often connected to the electricity distribution system rather than the transmission system. The integration of such time variable ‘distributed’ or ‘embedded’ sources into electricity networks requires special consideration. This new book addresses these special issues and covers the following: The characteristics of conventional and RE generators with particular reference to the variable nature of RE from wind, solar, small hydro and marine sources over time scales

ranging from seconds to months The power balance and frequency stability in a network with increasing inputs from variable sources and the technical and economic implications of increased penetration from such sources with special reference to demand side management The conversion of energy into electricity from RE sources and the type and characteristics of generators used The requirement to condition the power from RE sources and the type and mode of operation of the power electronic converters used to interface such generators to the grid The flow of power over networks supplied from conventional plus RE sources with particular reference to voltage control and protection The economics and trading of 'green' electricity in national and international deregulated markets The expected developments in RE technology and the future shape of power systems where the penetration from RE sources is large and where substantial operational and control benefits will be derived from extensive use of power electronic interfaces and controllers The text is designed to be intelligible to readers who have little previous knowledge of electrical engineering. The more analytical electrical aspects are relegated to an Appendix for readers who wish to gain a more in depth understanding. The book's flexible structure makes its accessible to the general engineer or scientists but also caters for readers with a non-scientific background. Economists, planners and environmental specialists will find parts of the book informative.

This handbook serves as a guide to deploying battery energy storage technologies, specifically for distributed energy resources and flexibility resources. Battery energy storage technology is the most promising, rapidly developed technology as it provides higher efficiency and ease of control. With energy transition through decarbonization and decentralization, energy storage plays a significant role to enhance grid efficiency by alleviating volatility from demand and supply. Energy storage also contributes to the grid integration of renewable energy and promotion of microgrid.

Discover new challenges and hot topics in the field of penetrated power grids in this brand-new interdisciplinary resource Renewable Integrated Power System Stability and Control delivers a comprehensive exploration of penetrated grid dynamic analysis and new trends in power system modeling and dynamic equivalencing. The book summarizes long-term academic research outcomes and contributions and exploits the authors' extensive practical experiences in power system dynamics and stability to offer readers an insightful analysis of modern power grid infrastructure. In addition to the basic principles of penetrated power system modeling, model reduction, and model derivation, the book discusses inertia challenge requirements and control levels, as well as recent advances in visualization of virtual synchronous generators and their associated effects on system performance. The physical constraints and engineering considerations of advanced control schemes are deliberated at length. Renewable Integrated Power System Stability and Control also considers robust and adaptive control strategies using real-time simulations and experimental studies. Readers will benefit from the inclusion of: A thorough introduction to power systems, including time horizon studies, structure, power generation options, energy storage systems, and microgrids An exploration of renewable integrated power grid modeling, including basic principles, host grid modeling, and grid-connected MG equivalent models A study of virtual inertia, including grid stability enhancement, simulations, and experimental results A discussion of renewable integrated power grid stability and control, including small signal stability assessment and the frequency point of view Perfect for engineers and operators in power grids, as well as academics studying the technology, Renewable Integrated Power System Stability and Control will also earn a place in the libraries of students in Electrical Engineering programs at the undergraduate and postgraduate levels who wish to improve their understanding of power system operation and control.

This open access book presents papers displayed in the 2nd International Conference on Energy and Sustainable Futures (ICESF 2020), co-organised by the University of Hertfordshire and the University Alliance DTA for Energy. The research included in this book covers a wide range of topics in the areas of energy and sustainability including: • ICT and control of energy; • conventional energy sources; • energy governance; • materials in energy research; • renewable energy; and • energy storage. The book offers a holistic view of topics related to energy and sustainability, making it of interest to experts in the field, from industry and academia.

This book gathers high-quality research papers presented at the First International Conference, ICSC 2019, organised by THDC Institute of Hydropower Engineering and Technology, Tehri, India, from 20 to 21 April 2019. The book is divided into two major sections – Intelligent Computing and Smart Communication. Some of the areas covered are Parallel and Distributed Systems, Web Services, Databases and Data Mining Applications, Feature Selection and Feature Extraction, High-Performance Data Mining Algorithms, Knowledge Discovery, Communication Protocols and Architectures, High-speed Communication, High-Voltage Insulation Technologies, Fault Detection and Protection, Power System Analysis, Embedded Systems, Architectures, Electronics in Renewable Energy, CAD for VLSI, Green Electronics, Signal and Image Processing, Pattern Recognition and Analysis, Multi-Resolution Analysis and Wavelets, 3D and Stereo Imaging, and Neural Networks.

OSES2019 drives a confluence of leading industrial, policy, and academic professionals to challenge convention Offshore Energy Generation and Storage Technology, Environmental Integration, Policy, and Expanding Global Markets will be a tackled at this event Cleaner and smarter energy systems mean sustainable economic growth Offshore Energy and Storage capitalizes on the tremendous resource opportunities associated with coastal regions Over half the world lives near the coast Its energy should too

The current power system should be renovated to fulfill social and industrial requests and economic advances. Hence, providing economic, green, and sustainable energy are key goals of advanced societies. In order to meet these goals, recent features of smart grid technologies need to have the potential to improve reliability, ?exibility, ef?ciency, and resiliency. This book aims to address the mentioned challenges by introducing advanced approaches, business models, and novel techniques for the management and control of future smart grids.

ENERGY STORAGE for MODERN POWER SYSTEM OPERATIONS Written and edited by a team of well-known and respected experts in the field, this new volume on energy storage presents the state-of-the-art developments and challenges for modern power systems for engineers, researchers, academicians, industry professionals, consultants, and designers. Energy storage systems have been recognized as the key elements in modern power systems, where they are able to provide primary and secondary frequency controls, voltage regulation, power quality improvement, stability enhancement, reserve service, peak shaving, and so on. Particularly, deployment of energy storage systems in a distributed manner will contribute greatly in the development of smart grids and providing promising solutions for the above issues. The main challenges will be the adoption of new techniques and strategies for the optimal planning, control, monitoring and management of modern power systems with the wide installation of distributed energy storage systems. Thus, the aim of this book is to illustrate the potential of energy storage systems in different applications of modern power systems, with a view toward illuminating recent advances and research trends in storage technologies. This exciting new volume covers the recent advancements and applications of different energy storage technologies that are useful to engineers, scientists, and students in the discipline of electrical engineering. Suitable for the engineers at power companies and energy storage consultants working in the energy storage field, this book offers a cross-disciplinary look across electrical, mechanical, chemical and renewable engineering aspects of energy storage. Whether for the veteran engineer or the student, this is a must-have for any library. AUDIENCE Electrical engineers and other designers, engineers, and scientists working in energy storage

The second edition of the highly acclaimed Wind Power in Power Systems has been thoroughly revised and expanded to reflect the latest challenges associated with increasing wind power penetration levels. Since its first release, practical experiences with high wind power penetration levels have significantly increased. This book presents an overview of the lessons learned in integrating wind power into power systems and provides an outlook of the relevant issues and solutions to allow even higher wind power penetration levels. This includes the development of standard wind turbine simulation models. This extensive update has 23 brand new chapters in cutting-edge areas including offshore wind farms and storage options, performance validation and certification for grid codes, and the provision of reactive power and voltage control from wind power plants. Key features: Offers an international perspective on integrating a high penetration of wind power into the power system, from basic network interconnection to industry deregulation; Outlines the methodology and results of European and North American large-scale grid integration studies; Extensive practical experience from wind power and power system experts and transmission systems operators in Germany, Denmark, Spain, UK, Ireland, USA, China and New Zealand; Presents various wind turbine designs from the electrical perspective and models for their simulation, and discusses industry standards and world-wide grid codes, along with power quality issues; Considers concepts to increase penetration of wind power in power systems, from wind turbine, power plant and power system redesign to smart grid and storage solutions. Carefully edited for a highly coherent structure, this work remains an essential reference for power system engineers, transmission and distribution network operator and planner, wind turbine designers, wind project developers and wind energy consultants dealing with the integration of wind power into the distribution or transmission network. Up-to-date and comprehensive, it is also useful for graduate students, researchers, regulation authorities, and policy makers who work in the area of wind power and need to understand the relevant power system integration issues.

This updated edition of the industry standard reference on power system frequency control provides practical, systematic and flexible algorithms for regulating load frequency, offering new solutions to the technical challenges introduced by the escalating role of distributed generation and renewable energy sources in smart electric grids. The author emphasizes the physical constraints and practical engineering issues related to frequency in a deregulated environment, while fostering a conceptual understanding of frequency regulation and robust control techniques. The resulting control strategies bridge the gap between advantageous robust controls and traditional power system design, and are supplemented by real-time simulations. The impacts of low inertia and damping effect on system frequency in the presence of increased distributed and renewable penetration are given particular consideration, as the bulk synchronous machines of conventional frequency control are rendered ineffective in emerging grid environments where distributed/variable units with little or no rotating mass become dominant. Frequency stability and control issues relevant to the exciting new field of microgrids are also undertaken in this new edition. As frequency control becomes increasingly significant in the design of ever-more complex power systems, this expert guide ensures engineers are prepared to deploy smart grids with optimal functionality.

The increased penetration of renewable energy resources particularly those connected via inverters to the electric grid like wind and solar, has resulted in the displacement of traditional synchronous generators. This has subsequently led to a decline in the available rotational inertia from these synchronous generators that provides immediate frequency response in the event of a disturbance to the grid. The result is a larger increase in the frequency deviation, rate of change of frequency, and a slower settling time, all of which can lead to frequency instability and an eventual collapse of the grid. This network condition has been termed low-inertia power systems. The aim of this dissertation is to design control and optimization algorithms that will enable these inverter-based resources participate effectively and optimally in providing frequency control response in a low-inertia power systems by controlling their inverter interfaces. The first part of this dissertation focuses on optimizing the performance of the popular virtual synchronous machine control structure for inverter-based resources, by developing an algorithm to optimally design the inertia and damping gain coefficient of its frequency control loop. This enables these inverter-based resources to participate efficiently in the inertia response portion of primary frequency control, by producing active power proportional to frequency measurements, in response to a power imbalance or disturbance to the grid, just like a synchronous generator. The second part of this dissertation focuses on designing a novel inverter-based resource control strategy termed inverter power control, which is based on model predictive control, to directly determine the optimal active-power set-point for the inverter-based resources in the event of a power imbalance or disturbance in the system. This proposed control framework alleviates a fundamental drawback of the virtual synchronous machine approach that constrains the inverter-based resources to behave like synchronous machines when responding to a frequency event thereby limiting the potentials of these fast acting and flexible inverter-based resources.

Modern Aspects of Power System Frequency Stability and Control describes recently-developed tools, analyses, developments and new approaches in power system frequency, stability and control, filling a gap that, until the last few years, has been unavailable to power system engineers. Deals with specific practical issues relating to power system frequency, control and stability Focuses on low-inertia and smart grid systems Describes the fundamental processes by which the frequency response requirements of power systems in daily operation are calculated, together with a description of the actual means of calculation of these requirements

The only book on the market that provides current, necessary, and comprehensive technical knowledge of extruded cables and high-voltage direct-current transmission This is the first book to fully address the technical aspects of high-voltage direct-current (HVDC) link projects with extruded cables. It covers design and engineering techniques for cable lines, insulation materials, and accessories, as well as cable performance and life span and reliability issues. Beginning with a discussion on the fundamentals of HVDC cable transmission theory, Extruded Cables for High-Voltage Direct-Current Transmission: Advances in Research and Development covers: Both the cable and the accessories (joints and terminations), each of which affects cable line performance The basic designs of HVDC cables—including a comparison of mass insulated non-draining cables with extruded HVDC cables The theoretical elements on which the design of HVDC cables is based—highlighting the differences between HVAC and HVDC cables Space charge-related problems that have a critical impact on extruded insulation for HVDC application Recent advances in extruded compounds for HVDC cables such as additives and nano-fillers The improved design of extruded HVDC cable systems—with emphasis on design aspects relevant to accessories Cable line reliability problems and the impact on cable system design Including more than 200 illustrations,Extruded Cables for High-Voltage Direct-Current Transmission fills a gap in the field, providing power cable engineers with complete, up-to-date guidance on HVDC cable lines with extruded insulation.

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.

The total inertia stored in all rotating masses (synchronous generators, induction motors, etc.) connected to a power system grid is an essential force that keeps the system stable after disturbances. Power systems have been experiencing reduced inertia during the past few decades [1]. This trend will continue as the level of renewable generation (e.g., wind and solar) increases. Wind power plants (WPPs) and other renewable power plants with power electronic interfaces are capable of delivering frequency response (both droop and/or inertial response) by a control action; thus, the reduction in available online inertia can be compensated by designing the plant control to include frequency response. The source of energy to be delivered as inertial response is determined by the type of generation (wind, photovoltaic, concentrating solar power, etc.) and the control strategy chosen. The importance of providing ancillary services to ensure frequency control within a power system is evidenced from many recent publications with different perspectives (manufacturer, system operator, regulator, etc.) [2]-[6]. This paper is intended to provide operators with a method for the real-time assessment of the available inertia of a WPP. This is critical to managing power system stability and the reserve margin. In many states, modern WPPs are required to provide ancillary services (e.g., frequency regulation via governor response and inertial response) to the grid. This paper describes the method of estimating the available inertia and the profile of the forecasted response from a WPP.

Control of Power Electronic Converters and Systems, Volume 3, explores emerging topics in the control of power electronics and converters, including the theory behind control, and the practical operation, modeling, and control of basic power system models. This book introduces the most important controller design methods, including both analog and digital procedures. This reference explains the dynamic characterization of terminal behavior for converters, as well as preserving the stability and power quality of modern power systems. Useful for engineers in emerging applications of power electronic converters and those combining control design methods into different applications in power electronics technology. Addressing controller interactions - in light of increasing renewable energy integration and related challenges with stability and power quality - is becoming more frequent in power converters and passive components. Discusses different applications and their control in integrated renewable energy systems Introduces the most important controller design methods, both in analog and digital Describes different important applications to be used in future industrial products Explains the dynamic characterization of terminal behavior for converters

The utilization of AC or DC microgrids across the world has increased dramatically over the years and has led to development opportunities as well as technical challenges when they are connected to the main grids or used as stand-alone systems. This book overviews the development of AC/DC microgrids; explains the microgrid concepts, design and control considerations, discusses operational and technical issues, as well as interconnection and integration of these systems. This book is served as a reference for a general audience of researchers, academics, PhD students and practitioners in the field of power engineering.

This book presents innovative techniques and approaches to maintaining dynamic security of modern power systems that have a high penetration of renewable energy sources (RESs). The authors propose a number of frequency control strategies and schemes to address and evade stability problems in system frequency and voltage that can lead to power interruption and power failure/blackout. The book includes case studies aimed at validating the effectiveness of the techniques and strategies presented, and will be a valuable resource for researchers working in electrical power engineering, power system stability, dynamics and control, and microgrids.