Hydraulic Turbine Control Design A New Approach In Modeling Of Hydraulic Turbines Based On Velocity Diagram For Control Applications

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European Control Conference 1995 Elsevier
Power System Frequency Control: Modeling and Advances evaluates the control schemata, secondary controllers, stability improvement methods, optimization considerations, microgrids, multi-microgrids, and real-time validation required to model and analyze the dynamic behavior of frequency in power systems. Chapters review a range of advanced modeling and analytical considerations for single to multi-area networks using traditional and hybrid sources, including renewable sources, FACT devices and storage. The work also considers broad aspects of upstream and downstream control mechanisms which enable novel solutions in the area of automatic generation control in power system networks. Highly recommended for power system engineers, researchers and practitioners with interests in load frequency control, automatic generation control, linearized models of isolated microgrid, and multi-microgrid, and hybrid LFC scheme, this book is an ideal resource on the topics discussed. Explains the function and purpose of power network frequency loops, including primary control, secondary control and emergency control loops Models LFC schemes from single-area to multi-area interconnected power systems Demonstrates five fundamental controller designs alongside their main error principles Evaluates dynamic response analysis with transient performance stated for modern indices Discusses performance studies such as state-space modeling, random loading, sensitivity and stability analyses
Control Design and Validation for the Hydraulic DOT500 Wind Turbine Springer Nature
Uses real world case studies to present the key technologies of design and application of the synchronous generator excitation system This book systematically introduces the important technologies of design and application of the synchronous generator excitation system, including the three-phase bridge rectifier circuit, diode rectifier for separate excitation, brushless excitation system and the static self-stimulation excitation system. It fuses discussions on specific topics and basic theories, providing a detailed description of the theories essential for synchronous generators in the analysis of excitation systems. Design and Application of Modern Synchronous Generator Excitation Systems provides a cutting-edge examination of excitation system, addressing conventional hydro-turbines, pumped storage units, steam turbines, and nuclear power units. It looks at the features and performance of the excitation system of the 700MW hydro-turbine deployed at the Three Gorges Hydropower Plant spanning the Yangtze River in China, as well as the working principle and start-up procedure of the static frequency converter (SFC) of pumped storage units. It also expounds on the composition of the excitation transformer, power rectifier, de-excitation equipment, and automatic excitation regulator—in addition to the

performance features of the excitation system of conventional 600/1000MW turbines and the excitation system of the 1000MW nuclear power unit. Presents cutting-edge technologies of the excitation system from a unique engineering perspective Offers broad appeal to power system engineers who require a better understanding of excitation systems Addresses hydro-turbines, pumped storage units, steam turbines, and nuclear power units Provides an interdisciplinary examination of a range of applications Written by a senior expert in the area of excitation systems Written by an author with over 50 years' experience, Design and Application of Modern Synchronous Generator Excitation Systems is an excellent text that offers an interdisciplinary exposition for professionals, researchers, and academics alike.

Cavitation Instabilities and Rotordynamic Effects in Turbopumps and Hydroturbines Elsevier

Hydraulic Turbine Control DesignControl Algorithm Design for Use with Hydraulic Turbine-driven GeneratorsControl Design and Validation for the Hydraulic DOT500 Wind TurbinePrinciples of Hydraulic Systems Design, Second EditionWind Energy SystemsCRC Press

Training Manual on Steam Turbines & Auxiliaries (Non Reheat Type) Springer

Hydroelectric power stations are a major source of electricity around the world; understanding their dynamics is crucial to achieving good performance. The electrical power generated is normally controlled by individual feedback loops on each unit. The reference input to the power loop is the grid frequency deviation from its set point, thus structuring an external frequency control loop. The book discusses practical and well-documented cases of modelling and controlling hydropower stations, focused on a pumped storage scheme based in Dinorwig, North Wales. These accounts are valuable to specialist control engineers who are working in this industry. In addition, the theoretical treatment of modern and classic controllers will be useful for graduate and final year undergraduate engineering students. This book reviews SISO and MIMO models, which cover the linear and nonlinear characteristics of pumped storage hydroelectric power stations. The most important dynamic features are discussed. The verification of these models by hardware in the loop simulation is described. To show how the performance of a pumped storage hydroelectric power station can be improved, classical and modern controllers are applied to simulated models of Dinorwig power plant, that include PID, Fuzzy approximation, Feed-Forward and Model Based Predictive Control with linear and hybrid prediction models.

Power System Modeling, Computation, and Control Academic Press

Flow in the draft tube of a hydraulic turbine operating under off-design conditions is very complex. The instability of the swirling flow may lead to the formation of a helical precessing vortex called the "vortex rope". The vortex rope causes efficiency reduction, severe pressure fluctuation, and even structural vibration. The primary objectives of the present study are to model and analyze the vortex rope formation using high fidelity numerical simulations. In particular, this work aims to understand the fundamental physical processes governing the formation of the vortex rope, and to investigate the capability of turbulence models to simulate this complex flow. Furthermore, mitigation of the vortex rope formation is addressed. Specifically, a vortex rope control technique, which includes injection of water from the runner crown tip to the inlet of the draft tube, is numerically studied. A systematic approach is considered in this study starting from the simplest and advancing towards the most complicated test case. First, steady simulations are carried out for axisymmetric and three-dimensional grids in a simplified axisymmetric geometry. It is shown that steady simulations with Reynolds-averaged Navier-Stokes (RANS) models cannot resolve the vortex rope, and give identical symmetric results for both the axisymmetric and three-dimensional flow geometries. These RANS simulations underpredict the axial velocity by at least 14%, and turbulent kinetic energy (TKE) by at least 40%, near the center of the draft tube even quite close to the design condition. Moving farther from the design point, models fail in giving the correct levels of the axial velocity in the draft tube. This is attributed to the underprediction of TKE production and diffusion near the center of the draft tube where the vortex rope forms. Hence, a new RANS model taking into account the extra production and diffusion of TKE due to vortex rope formation is developed, which can successfully predict the mean flow velocity with as much as 37% improvements in comparison with the realizable k-[epsilon] model. Then, unsteady simulations are performed, where it is concluded that Unsteady RANS (URANS) models cannot capture the self-induced unsteadiness of the vortex rope, but instead give steady solutions. The hybrid URANS/large eddy simulation (LES) models are proposed to be used in unsteady simulations of the vortex rope. Specifically, a new hybrid URANS/LES model in the framework of partially-averaged Navier-Stokes (PANS) modeling is developed. This new model is one of the main contributions of the present study. The newly developed PANS model is used in unsteady numerical simulations of two turbulent swirling flows containing vortex rope formation and breakdown, namely swirling flow through an abrupt expansion and the flow in the FLINDT draft tube, a model-scale draft tube of a Francis turbine. The present PANS model accurately predicts time-averaged and root-mean-square (rms) velocities in the case of the abrupt expansion, while it is shown to be superior to the delayed detached eddy simulation (DDES) and shear stress transport (SST) k-[omega] models. Predictions of the reattachment length using the present model shows 14% and 23% improvements compared to the DDES and the SST k-[omega] models, respectively. For the case of the FLINDT draft tube, four test cases covering a wide range of operating conditions from 70% to 110% of the flow rate at the best efficiency point (BEP) are considered, and numerical results of PANS simulations are compared with those from RANS/URANS simulations and experimental data. It is shown that RANS and PANS both can predict the flow behavior close to the BEP operating condition. However, RANS results deviate considerably from the experimental data as the operating condition moves away from the BEP. The pressure recovery factor predicted by the RANS model shows more than 13% and 58% overprediction when the flow rate decreases to 91% and 70% of the flow rate at BEP respectively. Predictions can be improved dramatically using the present unsteady PANS simulations. Specifically, the pressure recovery factor is predicted by less than 4% and 6% deviation for these two operating conditions. Furthermore, transient features of the flow that cannot be resolved using RANS/URANS simulations, e.g., vortex rope formation and precession, is well captured using PANS simulations. The frequency of the vortex rope precession, which causes severe fluctuations and vibrations, is well predicted by only about 2.7% deviation from the experimental data. Finally, the physical mechanism behind the formation of the vortex rope is analyzed, and it is confirmed that the development of the vortex rope is associated with formation of a stagnant region at the center of the draft tube. Based on this observation, a vortex rope elimination method consisting of water jet injection to the draft tube is introduced and numerically assessed. It is shown that a small fraction of water (a few percent of the total flow rate) centrally injected to the inlet of the draft tube can eliminate the stagnant region and mitigate the formation of the vortex rope. This results in improvement of the draft tube performance and reduction of hydraulic losses. Specifically in the case of the simplified FLINDT draft tube, the loss coefficient can be reduced by as much as 50% and 14% when the turbine operates with 91% and 70% of the BEP flow rate, respectively. In addition, reduction (by about 1/3 in the case with 70% of BEP flow rate) of strong pressure fluctuations leads to more reliable operation of the turbine.

Power Plants and Power Systems Control 2003 Springer Science & Business Media

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.

Blade-Pitch Control for Wind Turbine Load Reductions Prameela Technical Solutions

This book presents a set of soft computing approaches and their application in data analytics, classification model, and control. The basics of fuzzy logic implementation for advanced hybrid fuzzy driven optimization methods has been covered in the book. The various soft computing techniques, including Fuzzy Logic, Rough Sets, Neutrosophic Sets, Type-2 Fuzzy logic, Neural Networks, Generative Adversarial Networks, and Evolutionary Computation have been discussed and they are used on variety of applications including data analytics, classification model, and control. The book is divided into two thematic parts. The first thematic section covers the various soft computing approaches for text classification and data analysis, while the second section focuses on the fuzzy driven optimization methods for the control systems. The chapters has been written and edited by active researchers, which cover hypotheses and practical considerations; provide insights into the design of hybrid algorithms for applications in data analytics, classification model, and engineering control.

Wind Energy Systems Springer Science & Business Media

Highly Recommended for : Power Plant Professionals seeking high growth in career Interview preparations for power plant jobs A comprehensive training manual on Steam Turbines & auxiliaries (Non Reheat Type) covering all aspects for thermal power plants. Its a 300 page Spiral bound manual must for every power plant professional. The manual contains text, images/drawings & illustrations. So far the books written on thermal plants describe mostly the reheat type units. These books are intended for technical personnel working in utility plants but, again, most of them deal predominantly with the theoretical aspects of turbines and their auxiliaries and lack in practical side of the subject. The aim is to give following benefits to the reader: To provide an in-depth knowledge of plant and equipment to the plant professionals associated with industrial boilers and turbines. It is to be noted that most of the industrial thermal units (like captive power plants attached to main technological units) are of non-reheat type. To cover the practical aspects of thermal power stations missing in most of the books available in the market. The book describes in details the constructional features of the plant and equipment, their operation and maintenance and overhauling procedures, performance monitoring as well as troubleshooting. To cover the theoretical aspects of a thermal unit necessary to be known to the professionals for thorough understanding of the systems involved. This knowledge would assist them: In selecting the plant and equipment suitable to their requirement In operating and maintaining the plant with best efficiency, availability and reliability The book is a must for those working professionals who aspire for a fast growth of their professional career. It will also be of immense help to the personnel preparing for boiler proficiency examinations. It contains following topics: Chapter – 1 Thermodynamics of a Steam Turbine Chapter – 2 Steam Turbine Fundamentals Chapter – 3 Constructional features of steam turbines Chapter – 4 The lubricating oil system Chapter – 5 Steam turbine governing system Chapter – 6 Steam turbine protection system Chapter – 7 Turbovisory system Chapter – 8 Turbine gland sealing system Chapter – 9 Turbine system and cycles Chapter – 10 Condensers, deaerators and closed feedwater heater Chapter – 11 Main and auxiliary cooling water systems and cooling towers Chapter – 12 Turbine Plant Pumps Chapter – 13 Condensate and feed water treatment Chapter – 14 Turbine Plant Operation Chapter – 15 Turbine Plant Maintenance Chapter – 16 Turbine performance and optimization

Advances in Clean Energy and Sustainability CRC Press

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

Modelling and Controlling Hydropower Plants Springer

This book provides users, pump manufactures, engineers, researchers and students with extensive information about pump’s behavior in reverse operation. It reports on cutting-edge methods for selecting the proper PAT and improving PAT’s efficiency, discusses PAT’s reliability, economic issues and environmental impact as well. The book describes in detail electromechanical equipment of PAT systems, their installation and operation, and gives important practical insight into the use of PAT in water transmission and distribution systems, as part of thermal power plants and cooling systems, in oil distribution systems and other systems as well. It reports on different types on PAT control modes as well as on numerical methods useful for PAT analysis and implementation. All in all, the book represents a comprehensive practice-oriented reference-guide to design engineers, as well as PAT general users and manufactures. It also provides researchers with extensive technical information on the use of PAT thus fostering new

discussions and ideas to improve current methods and cope with future challenges.
Proceedings of the 11th International Conference on Modelling, Identification and Control (ICMIC2019) European Control Association
Gravity Energy Storage provides a comprehensive analysis of a novel energy storage system that is based on the working principle of well-established, pumped hydro energy storage, but that also recognizes the differences and benefits of the new gravity system. This book provides coverage of the development, feasibility, design, performance, operation, and economics associated with the implementation of such storage technology. In addition, a number of modeling approaches are proposed as a solution to various difficulties, such as proper sizing, application, value and optimal design of the system. The book includes both technical and economic aspects to guide the realization of this storage system in the right direction. Finally, political considerations and barriers are addressed to complement this work. Discusses the feasibility of gravity energy storage technology Analyzes the storage system by modelling various system components Uniquely discusses the characteristics of this technology, giving consideration to its use as an attractive solution to the integration of large-scale, intermittent renewable energy
Design, Control and Monitoring of Tidal Stream Turbine Systems Jones & Bartlett Publishers
Maximizing reader insights into the latest technical developments and trends involving wind turbine control and monitoring, fault diagnosis, and wind power systems, 'Wind Turbine Control and Monitoring' presents an accessible and straightforward introduction to wind turbines, but also includes an in-depth analysis incorporating illustrations, tables and examples on how to use wind turbine modeling and simulation software. Featuring analysis from leading experts and researchers in the field, the book provides new understanding, methodologies and algorithms of control and monitoring, computer tools for modeling and simulation, and advances the current state-of-the-art on wind turbine monitoring and fault diagnosis; power converter systems; and cooperative & fault-tolerant control systems for maximizing the wind power generation and reducing the maintenance cost. This book is primarily intended for researchers in the field of wind turbines, control, mechatronics and energy; postgraduates in the field of mechanical and electrical engineering; and graduate and senior undergraduate students in engineering wishing to expand their knowledge of wind energy systems. The book will also interest practicing engineers dealing with wind technology who will benefit from the comprehensive coverage of the theoretic control topics, the simplicity of the models and the use of commonly available control algorithms and monitoring techniques.
Hydraulic Turbine Control DesignControl Algorithm Design for Use with Hydraulic Turbine-driven GeneratorsControl Design and Validation for the Hydraulic DOT500 Wind TurbinePrinciples of Hydraulic Systems Design, Second EditionWind Energy Systems
These proceedings present selected research papers from CISC'16, held in Xiamen, China. The topics include Multi-agent system, Evolutionary Computation, Artificial Intelligence, Complex systems, Computation intelligence and soft computing, Intelligent control, Advanced control technology, Robotics and applications, Intelligent information processing, Iterative learning control, Machine Learning, and etc. Engineers and researchers from academia, industry, and government can get an insight view of the solutions combining ideas from multiple disciplines in the field of intelligent systems.
Wind Turbine Control Systems CRC Press
Small and Micro Hydropower Plants is a guidebook for the reliable and sustainable solutions for design of small scale hydroelectric systems. It presents the most recent knowledge of all aspects of small hydropower engineering, thus forming a comprehensive collection of modern and innovative technology and practices. Different types of weir and water intakes are discussed, as well as hydrology aspects like discharge estimation and measurement. The book explores the latest advances in turbine, gear boxes, belt drives, generators, and remote control, critically assessing and comparing these technologies' viability for commercial application. It offers an analysis of operation tools, remote supervision and maintenance. Finally, the book also considers social aspects, like community negotiation, as well as environmental aspects, like ecological flow, fish bypassing, and climate change impacts. Engineering researchers, advanced graduate students and practitioners working in small and micro hydropower have in this book an ideal reference for designing and improving these systems through reliable and sustainable solutions. Prior knowledge of hydropower systems design is assumed. Presents the latest advances small and micro hydropower, including the most recent available technology, engineering concepts, control systems, impact assessment methodologies, economics and policy aspects Examines step by step real-life design and global implementation cases Discusses factors for sustainability of hydropower plants, such as the impact of Climate Change and community mediation
Hydraulic Turbine Control Design World Scientific
This book thoroughly covers the fundamentals of the QFT robust control, as well as practical control solutions, for unstable, time-delay, non-minimum phase or distributed parameter systems, plants with large model uncertainty, high-performance specifications, nonlinear components, multi-input multi-output characteristics or asymmetric topologies. The reader will discover practical applications through a collection of fifty successful, real world case studies and projects, in which the author has been involved during the last twenty-five years, including commercial wind turbines, wastewater treatment plants, power systems, satellites with flexible appendages, spacecraft, large radio telescopes, and industrial manufacturing systems. Furthermore, the book presents problems and projects with the popular QFT Control Toolbox (QFTCT) for MATLAB, which was developed by the author.
Wind Turbine Control Systems Springer
This book presents selected papers from the 8th International Conference on Advances in Energy Research (ICAER 2022), providing coverage encompassing advanced conventional energy technology, renewable and non-conventional energy technology, electric mobility, energy storage, energy, environment and society, industry innovations in energy, sector-coupled energy system, and energy education. The contents of this book are of use to researchers from not only scientific background, but also economics and anthropology. It encourages researchers to conduct research on the ways to assess and analyse the acceptance of the novel energy forms among the mass population from a financial and social perspective.
Pumps as Turbines CRC Press
Based on the system thought and GERAM, a methodology and ICMMS (Intelligent Control-Maintenance-technical Management Systems) reference model for hydropower plants are proposed. Because the structures of the hydropower generating process are unchanging, the methodology employs the process-oriented approaches to model the hydropower plants, and the models constructed through this methodology are stable and reusable. The proposed Reference Model grasps the similarities and unchangeabilities of the hydropower plants, therefore the redistributing of the function modules inside the system can be done in a natural and easy way, while the synergies among the components of the system are guaranteed. To implement the ICMMS in hydropower plants, HSAS (Hybrid Smart Automation System) is proposed in which integrates the conventional controllers and fieldbus based components under fully distributed system architecture. In the maintenance domain, the concept of Condition Monitoring is clearly defined, and related technologies for hydropower plants are summarized and analyzed. The condition monitoring system is integrated into the ICMMS under the Reference Model proposed above.In the technical management domain, the performance evaluation methods and implement system is a lacuna item to the HGUs (Hydroelectric Generating Units), however it is indispensable for ICMMS. Some important concepts, indexes, criterions and methodologies for the performance evaluation on HGUs are proposed. An economic performances evaluation system for HGUs is proposed, with which the efficiency state, the level of operation management, and the maintenance state of an HGU can be measured through qualitative indexes. A real test case illustrated effectiveness of the method. Based on this method, a new maintenance strategy, EBM (Economic performance Based Maintenance) is proposed and illustrated through a case study. As a contribution to the control domain, a new method, DAA (Disturbance Attenuation Approach), is proposed to design hydraulic turbine governors. Finally, some philosophical thoughtlets of the author for the system integration are presented.
Wind Turbine Control and Monitoring Springer Nature
This book emphasizes the application of Linear Parameter Varying (LPV) gain scheduling techniques to the control of wind energy conversion systems. This reformulation of the classical problem of gain scheduling allows straightforward design procedure and simple controller implementation. From an overview of basic wind energy conversion, to analysis of common control strategies, to design details for LPV gain-scheduled controllers for both fixed- and variable-pitch, this is a thorough and informative monograph.
Advanced Synchronization Control and Bifurcation of Chaotic Fractional-Order Systems Springer Nature
The book provides a detailed approach to the physics, fluid dynamics, modeling, experimentation and numerical simulation of cavitation phenomena, with special emphasis on cavitation-induced instabilities and their implications on the design and operation of high performance turbopumps and hydraulic turbines. The first part covers the fundamentals (nucleation, dynamics, thermodynamic effects, erosion) and forms of cavitation (attached cavitation, cloud cavitation, supercavitation, vortex cavitation) relevant to hydraulic turbomachinery, illustrates modern experimental techniques for the characterization, visualization and analysis of cavitating flows, and introduces the main aspects of the hydrodynamic design and performance of axial inducers, centrifugal turbopumps and hydo-turbines. The second part focuses on the theoretical modeling, experimental analysis, and practical control of cavitation-induced fluid-dynamic and rotordynamic instabilities of hydraulic turbomachinery, with special emphasis on cavitating turbopumps (cavitation surge, rotating cavitation, higher order cavitation surge, rotordynamic whirl forces). Finally, the third part of the book illustrates the alternative approaches for the simulation of cavitating flows, with emphasis on both modeling and numerical aspects. Examples of applications to the simulation of unsteady cavitation in internal flows through hydraulic machinery are illustrated in detail.
Hydraulic Machinery and Cavitation Elsevier
This thesis investigates the use of blade-pitch control and real-time wind measurements to reduce the structural loads on the rotors and blades of wind turbines. The first part of the thesis studies the main similarities between the various classes of current blade-pitch control strategies, which have to date remained overlooked by mainstream literature. It also investigates the feasibility of an estimator design that extracts the turbine tower motion signal from the blade load measurements. In turn, the second part of the thesis proposes a novel model predictive control layer in the control architecture that enables an existing controller to incorporate the upcoming wind information and constraint-handling features. This thesis provides essential clarifications of and systematic design guidelines for these topics, which can benefit the design of wind turbines and, it is hoped, inspire the development of more innovative mechanical load-reduction solutions in the field of wind energy.