

Article

Parametric Sensitivity Analysis of Rotor Angle Stability Indicators [†]Ashish Shrestha ^{*} and Francisco Gonzalez-Longatt ^{*}

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[†] This paper is an extended version of a paper that will be presented at the 8th International Conference on Power and Energy Systems Engineering at Fukuoka Institute of Technology, Fukuoka, Japan, 10–12 September 2021.

Abstract: With the increasing penetration rate of Power Electronic Converter (PEC) based technologies, the electrical power systems are facing the problem of transient stability since the PEC based technologies do not contribute to the system inertia, and the proportion of synchronous generators (i.e., the source of inertia) is in decreasing rate. In addition, PEC based technologies' components have poor inherent damping. It is very important to analyze the system characteristics of a power system to minimize the potential instabilities during the contingencies. This paper presents the parametric sensitivity analysis of the rotor angle stability indicators for the 39-bus New England power system. The indicators of rotor angle stability analysis such as critical fault clearing time (CCT), Eigenvalue points, damping ratio, frequency deviation, voltage deviation, and generator's speed deviation are identified and analyzed for three case scenarios; each scenario has six sub-cases with different inertia constants. The results show that the CCTs for each component will be reduced if the inertia reduces at any section of a multi-machine power system. Although the applied three scenarios with six sub-cases are identified to be stable in this analysis, the decreasing inertia constant has significant impact on the power system dynamics.

Keywords: power system dynamics; power system stability; low inertial power system



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1. Introduction

Power systems have become more complex than in the past, caused by the integration of numerous Distributed Generation Resources (DGRs) and the rapidly growing power electronic converter (PEC) based technologies. The modern power system faces complex transformation in all levels, such as generation, transmission, distribution, and utilization [1]. With this rapid transformation, the modern power system faces significant changes in the power system dynamics; one of the main reasons behind this is reduction of system inertia because of these PEC-based technologies [2]. In the conventional power system, most of the power generators were of the synchronous type; they are characterized as the source of rotational inertia in a power system, whereas in a modern power system, the proportion of synchronous generators is at a decreasing rate [3]. Moreover, the PEC-based technologies adopted in the generation (e.g., kinetic energy less solar PV and doubly-fed induction generator based wind turbines), transmission line (e.g., HVDC), distribution system (e.g., controllers), and utilization level (e.g., controller based equipment) do not contribute to the system inertia, which results in a drop of system inertia in the modern power system, resulting in drastic changes in the system dynamics [4]. Not only these but the transient stability of the DGR integrated power system is also highly sensitive to the proportion of the penetration level, fault location and its severity [5]. Titiens et al. presented a detailed study on the relevance of inertia in the operation and control of a power system, which shows that the decreasing system inertia results in the high Rate of Change of Frequency (RoCoF) values and frequency deviation, which may increase the system instability [6]. The DGRs are integrated into the distribution lines at a low voltage

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Table of Contents Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21

1. Understanding the eBook Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - The Rise of Digital Reading Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Advantages of eBooks Over Traditional Books
2. Identifying Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - User-Friendly Interface
4. Exploring eBook Recommendations from Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Personalized Recommendations
 - Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 User Reviews and Ratings
 - Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 and Bestseller Lists
5. Accessing Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 Free and Paid eBooks
 - Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 Public Domain eBooks
 - Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 eBook Subscription Services
 - Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 Budget-Friendly Options
6. Navigating Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 eBook Formats
 - ePub, PDF, MOBI, and More
 - Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 Compatibility with Devices
 - Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21 Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21

- Highlighting and Note-Taking Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
- Interactive Elements Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
- 8. Staying Engaged with Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
- 9. Balancing eBooks and Physical Books Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Setting Reading Goals Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Fact-Checking eBook Content of Sensitivity Stability And Parametric Analysis Mathematical Programming Study 21
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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29 000 en 1990 les communes voisines connaissent une progression sensiblement analogue