

## Article

Parametric Sensitivity Analysis of Rotor Angle Stability Indicators <sup>†</sup>Ashish Shrestha <sup>\*</sup> and Francisco Gonzalez-Longatt <sup>\*</sup>

Department of Electrical Engineering, Information Technology and Cybernetics, University of South-Eastern Norway, N-3918 Porsgrunn, Norway

<sup>\*</sup> Correspondence: [sthashish2010@gmail.com](mailto:sthashish2010@gmail.com) (A.S.); [fglongatt@fglongatt.org](mailto:fglongatt@fglongatt.org) (F.G.-L.)

<sup>†</sup> 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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