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Dynamic performance improvement of isolated power system using intelligently controlled SMES

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Abstract

Isolated power system comprising of wind, diesel and energy storage presents an effective economical approach for supplying power. Advanced and intelligent control techniques are required to improve the power dispatch between storage devices and wind-diesel system especially during disturbances. This paper focuses on development of one step ahead adaptively controlled superconducting magnetic energy storage (SMES) for smoothing the power fluctuations of a standalone wind-diesel power system. Two sets of gate turn off (GTO) converters are utilized for obtaining a four quadrant operation of SMES system. System is represented by a third order autoregressive discrete time model. For estimating the system parameters online, recursive least square algorithm is used. System is considered as a two input two output system, where real and reactive powers demanded by SMES are the control signals issued by the controller. To restrict the energy trade within limits, constraints are imposed on the SMES current. Discrete time model of SMES is used for converting SMES current constraints into the energy level predictions and a separate model is then used for imposing the constraints. Scheme is tested for two disturbances and in both the cases, SMES current constraints are never violated while reducing the frequency and voltage deviations significantly.

1 | INTRODUCTION

Due to the limited availability of fossil fuels, environmental concerns and rapid increase in energy demand, more attention is focused on harnessing the power from non conventional energy sources like wind power [1–3]. Wind energy conversion system is one of the most mature renewable energy technology and can be operated both in isolated or grid connected mode. In standalone mode of operation, if integrated with the diesel generator set for supplying power to a remote location reduces the operation cost of the diesel engine [4].

However, due to low inertia any disturbance in wind speed will pose a significant threat to power quality, especially in case of high wind penetration power system. To mitigate the power quality issues, energy storage systems are often used in synchronicity with the wind-diesel system to maintain an instant balance between generation and demand [5]. Integration of energy storage system enhances the robustness of the system, making it more resistant to disturbances [3, 6, 7]. Energy storage devices with fast response time, high ramp rates and high cyclic efficiency are well suited for mitigating the power fluctuations that are generated due to stochastic nature of wind power. In this context, energy storage devices like battery energy storage system, super capacitor energy storage (SCES) and superconducting magnetic energy storage (SMES) are the favourable option [2]. Super capacitors have lower energy density and cell voltage, on the other hand batteries have short service life in terms of number of charge and discharge cycles. The service period of battery is also influenced by the depth of discharge, where as in case of SMES service life period is independent of depth of discharge and thus has large number of cycles of charge and discharge [8]. Power exchange between SMES and power system is very fast as compared to BESS, as energy conversion is not required [1]. Since the 1970's SMES has been used in power system for transient and dynamic stability, enhanced power quality and automatic generation control [9–11].

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