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MATLAB/Simulink-based modelling and performance assessment of wind–diesel energy storage system

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Abstract

In this article, a comprehensive model is developed to study the performance of a hybrid wind–diesel energy storage system. Energy storage system exchanges both real and reactive power with the wind–diesel system to improve both frequency and voltage. For obtaining pre-disturbance steady-state scenario of the system, a modified load flow algorithm is proposed which calculates induction machine slip and other initial conditions, in addition to the results obtained with conventional load flow. A compact model is developed by integrating network model, energy storage system and machine equations along with the associated control systems. For frequency estimation concept, centre of inertia is utilised. Energy storage system is modelled as a controllable current source. Complete modelling is carried out in MATLAB/Simulink environment. Simulations are carried out for load disturbance as well as wind perturbations to demonstrate the efficacy of the proposed scheme.

Keywords

Frequency and voltage control, wind–diesel system, energy storage system, controllable current source, centre of inertia, modified load flow, wind perturbation, load disturbance, MATLAB/Simulink

Introduction

Isolated power systems have experienced a fast development in the areas where grid connectivity is not feasible. These systems are installed at places with abundant renewable energy sources, like wind, and are often integrated with the existing diesel unit to increase the system reliability (Das et al., 1999; Kusakana and Herman, 2014). A good application of such standalone system is that generated power can be supplied to near load centres which eliminates the requirement of long transmission lines (Kim et al., 2013). The control of power quality in such systems is however a challenging task; any disturbance like variation in generation and loading condition can cause havoc on the system performance (frequency and voltage) because of low system inertia (Rehman et al., 2012). An important requirement of standalone system is to maintain constant frequency and voltage. Frequency and voltage variation depends on the difference between demand and supply of real and reactive power, respectively (Das et al., 1999; Kaseem and Abdelaziz, 2014). Frequency control of an isolated wind–diesel system using energy storage under load disturbance has been reported, but voltage control has not been touched, also effect of wind disturbances has not been considered (Kouba Nour et al., 2016). In the study of Jeffries et al. (1996), dynamic response of a wind–diesel system has been reported but without any energy storage system (ESS).

The mismatch in active power can be taken care by fast-acting energy storage devices and their power conditioning system. Different energy storage devices are available in the market like pumped storage hydroelectric systems, battery ESS, redox flow batteries, superconducting magnetic energy storage (SMES) systems, super capacitors and flywheel ESS

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