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Modelling and Performance Evaluation of MPPT-based PMSG Wind Energy Conversion System with Different Interfaces in Matlab/Simulink Environment

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Abstract

Power from blowing wind is converted mainly to electricity in the Wind based Energy Conversion System (WBECS). In such applications, a dedicated wind turbine along with other necessary arrangements such as a gear, controller, brake system etc. converts the kinetic energy of the blowing wind into an electrical counterpart. Earlier, asynchronous generators were used in such applications. However, with the advent of solid-state devices now-a-days AC generators, particularly permanent magnet synchronous generators (PMSG), are mostly used in such applications. In small scale applications, the output of WBECS is converted to DC through a rectifier mechanism. However, due to variation in the wind profile, the output is not a steady one, which is not suitable for DC applications. In this regard, power electronic based converters lay a vital role. Such an application may find its usefulness particularly in coastal regions where wind has a good potential from an electricity generation point of view particularly to charge up electric vehicles (EV). In the present study, a small-scale application of a WBECS system incorporated with PMSG is modelled in MATLAB/Simulink environment with a DC load. The o utput of the system is regulated with buck and boost converters and a comparison of their performance was done. Duty ratio of the converters was controlled by the maximum power point tracking algorithm (MPPTA). In the present study, the Hill Climbing method was adopted.

Keywords: sustainability; permanent magnet synchronous generator; wind energy based energy conversion system; maximum power point tracking; hill climbing algorithm

1. Introduction

Energy is the main key feature in present civilization. Continuous progress in the field of science and technology leads to harnessing of energy in different forms. Among all other forms, electricity is the most versatile and compact form and it can be easily converted to a desired form by suitable means. However, the main problem with energy conversion is unavoidable heat loss. Energy resources may be either non-renewable or renewable. Non-renewable resources are of depleting nature and cause pollution as they are mainly fossil fuel-based resources. On the other hand, renewable resources are eco-friendly but have very low energy density. Moreover, techniques for harnessing energy from renewable resources are not very popular and they are costly.

It is well known that fossil fuel-based resources will not sustain forever [1]. On the contrary, per capita energy consumption has to be maintained at the highest possible value indicating proper growth of a country in terms of economic development [2-4]. Hence, a compromise in terms of an optimized mix between renewable and non-renewable resources is inevitable and can be implemented by adopting the concept of different energy efficient techniques such as energy conservation, sustainable development, cogeneration, energy management etc. [5-7]. Wind has good potential from an electricity generation point of view throughout the globe [8-9]. The random nature of wind causes an instability [10], frequency fluctuation problem [11] and voltage flicker in the WBECS system [12]. In small scale applications WBECS systems are incorporated with a power electronic interface to smooth out the output to a desirable limit.

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