Chapter 1
Wind Turbine Emulator Based on DC Motor

Chaymaâ Boutahiri
Laboratory of Computer Science, Applied Math and Electrical Engineering (IMAGE), EST, Moulay Ismail University, Morocco

Ayoub Nouaiti
Laboratory of Computer Science, Applied Math and Electrical Engineering (IMAGE), EST, Moulay Ismail University, Morocco

Aziz Bouazi
Laboratory of Computer Science, Applied Math and Electrical Engineering (IMAGE), EST, Moulay Ismail University, Morocco

Abdallah Marhraoui Hsaini
Laboratory of Computer Science, Applied Math and Electrical Engineering (IMAGE), EST, Moulay Ismail University, Morocco

ABSTRACT

Wind energy emerges as a promising solution for electricity generation, circumventing greenhouse gas emissions. However, the complexities of establishing wind energy conversion systems in a laboratory setting have spurred researchers to contemplate the utilization of wind turbine emulators. These latter afford the capability to accurately replicate the behavior of an actual wind turbine. In this chapter, an intricate description of the selected wind turbine emulator is provided, consisting of a DC motor regulated by a DC-DC buck converter. This converter is controlled by the PWM pulses generated by the wind turbine model. Proficient control of the DC motor allows electric sinusoidal voltage and current to be produced by the asynchronous generator in accordance with the adopted wind profile. Subsequently, the emulator undergoes rigorous implementation and thorough analysis within the MATLAB/Simulink environment to validate the efficiency of its system.

DOI: 10.4018/979-8-3693-0497-6.ch001

I. INTRODUCTION

In recent times, global energy consumption has witnessed a substantial surge. This has spurred researchers to seek solutions that can offset this increase while also taking into consideration the impacts of climate change (Kirikkaleli, 2021; Pérez-Lombard, 2008; Sadorsky, 2009; Garcia, 2016).

Wind energy stands out as one of the solutions capable of generating power without emitting greenhouse gases. It serves the purpose of converting kinetic energy into mechanical energy, and subsequently into electrical energy. Nevertheless, the intricacies involved in installing wind energy conversion systems within laboratory settings have prompted researchers to contemplate the utilization of a wind turbine emulator (Wen, 2021; Aljarhizi Y. a., 2023; Garg, 2018; Dekali, 2021).

Several pivotal reasons have contributed to the adoption of this emulator. Firstly, it enables the testing of their functionality without being constrained by various wind conditions. Additionally, it ensures maximum energy efficiency and heightened reliability. Furthermore, it plays a role in diminishing costs and development timelines by circumventing costly and time-intensive field testing phases. The emulator also proves instrumental in assessing the resilience of wind turbines under extreme weather conditions. It establishes a secure framework that fosters the development and fine-tuning of cutting-edge control algorithms. These algorithms empower wind turbines to dynamically adapt to fluctuations in wind patterns, thus optimizing their electricity production output. Moreover, it streamlines the process of simulating interactions between wind turbines and the electrical grid (Taveiros, 2013; Moussa, 2019; Aljarhizi Y. a., 2020).

In summation, the modeling of a wind turbine emulator assumes a pivotal role in propelling the advancement of wind energy. It not only facilitates performance optimization and heightened reliability but also promotes a seamless integration into the global electrical network. These strides make a substantial contribution towards the transition to a more sustainable energy future firmly rooted in renewable sources.

The wind turbine emulator allows for the replication of the wind turbine's behavior, through precise modeling of each of its components, including the blades, the generator, the electrical converter, and the control systems, among others. It can generate various operational scenarios dependent on a simulated weather conditions. Furthermore, it incorporates control strategies identical to those employed in real wind turbines to respond consistently to wind variations. The emulator also enables the calculation of electrical power generated based on the simulated wind speed.

The choice of motor type for the wind turbine emulator presents a range of emulator options. Generally, three categories of motors are commonly used: direct current motors, induction motors, and synchronous motors (Moussa, 2019).

Direct current motors remain the preferred choice for wind turbines due to their control via the armature current, allowing for a direct correlation with the machine's generated torque. This enables precise control of speed and torque, which is crucial in a wind context. Moreover, they can replicate variations in wind speed and optimize energy production. Furthermore, their control is well established, thus facilitating their implementation. DC motors are widely adopted due to their simplicity of control and outstanding performance (Martínez-Márquez, 2019; Benaaouinate, 2019).

On the other hand, induction emulators are known for their robustness and ability to adapt to variable loads. They operate on the principle of electromagnetic induction, making them well-suited for the changing conditions encountered in wind applications. While their control may be more complex, they offer excellent control flexibility and high reliability (Mousarezaee, 2020).

Related Content