



Wind Turbine Emulation Using an Inverter-Controlled Induction Motor



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Wind Turbine, Emulation System, Renewable Energy Systems.

Abstract

The focus of this work is on the wind turbine emulation, using an induction motor (IM) driven by a variable speed drive and real time control software, to supply a mechanical power to the generator' shaft. From a given wind profile, using the turbine characteristics and the rotational speed of the generator, the theoretical mechanical power is calculated and regulated at the output of the induction motor. The drive train was designed for small scale power systems, and it is based on a variable speed wind energy system, using a permanent magnet synchronous generator, decoupled from the grid by a power rectifier bridge and a photovoltaic (PV) inverter. The inverter approach aims to provide cost effective solutions and technological independence, aiming at exploring a large amount of feasible sites. In order to corroborate the proposed design, the experimental platform has been tested with two different PV inverters.

1. Introduction

The development of energy conversion systems from renewable energy sources has increased significantly due to a degradation of the environment and to curtail adverse effects of fossil fuel based power generation. Additionally, the integration of distributed generation into low voltage grids or microgrids is an emerging solution for sustainable systems. Therefore, small-scale wind energy systems are very attractive due to their complementary nature with other renewable energy sources, mainly photovoltaic (PV) systems. The research of small-scale wind energy systems, especially those using innovative AC-DC-AC conversion systems, different generators' topologies, maximum power extraction algorithms, requires a test bench able to emulate the wind turbine, with independence of physical wind resources and wind turbines. Therefore, to reproduce the behavior of the wind turbine under certain wind profile in a laboratory environment the wind turbine emulators are used.

2. Wind energy conversion system

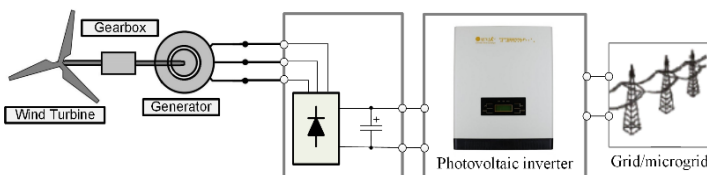


Fig. 1. Topology of the wind energy conversion system

3. Implementation of the wind turbine emulator

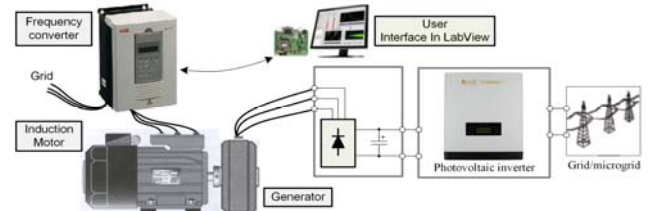


Fig. 3. Laboratorial structure of the overall wind energy system.

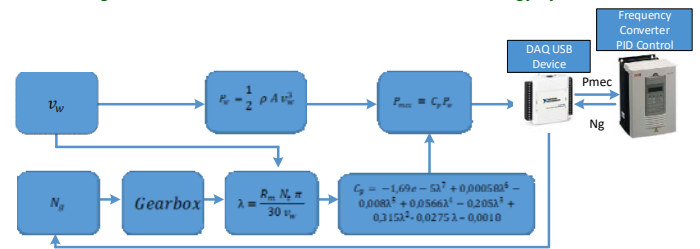


Fig. 4. Block diagram implemented in LabVIEW.

4. Experimental results

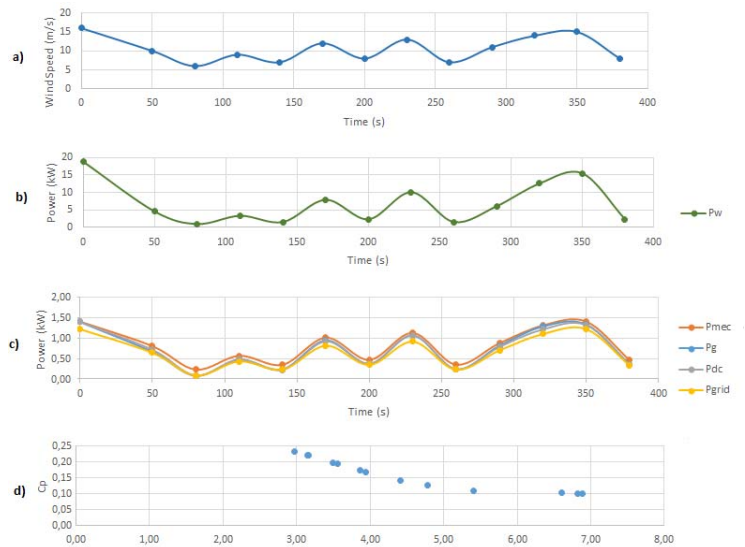


Fig. 4. Wind turbine emulation using Omniksol: (a) Wind Profile (b) Wind power (c) Mechanical power, output generator power, DC bus power and power delivered to the grid (d) Power Coefficient vs Tip Speed Ratio

5. Conclusion

A laboratorial set up for emulation of wind turbines was proposed, based on an IM as prime mover with real-time control software, to provide a controlled mechanical power to the generator' shaft. The control algorithm uses two closed loops of control: speed and power control. The first one allows the determination of the power coefficient as a function of the turbine load, through the actual tip speed ratio and the corresponding power coefficient, and the second one allows the definition of the reference mechanical power of the tur-bine, for a given wind speed.

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