TECHNOLOGICAL EDUCATION INSTITUTE OF
CENTRAL MACEDONIA
SCHOOL OF TECHNOLOGICAL APPLICATIONS
DEPARTMENT OF MECHANICAL ENGINEERING

Graduate Studies Program:

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"Renewable Energy Systems: Design, Development and Optimization"

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Subject:

Recent developments in power transmission and electric generator technology: Improving the performance of a typical wind turbine.

Introduction & Motivation:

This Thesis will investigate the reliability issues associated with one of the most critical parts of a wind turbine, the gearbox. The transmission or gearbox converts the low rotor blades rotational speed to high generator-required rotational speed. This vital part of a wind turbine is very expensive to manufacture and to replace it in case of failure. In order to extend the life-span of a gearbox, regular maintenance is needed, which adds to the overall cost. This complex piece of engineering is very heavy, something that puts extra stress to the tower. Usually wind turbines with gearboxes need stronger and deeper foundation. In addition gearbox reduces the efficiency of a wind turbine due to inertia; it is vulnerable to wind gusts and the most likely part of a wind turbine to fail.

One way to improve the efficiency of a wind turbine and make it more fault-tolerant is to avoid using gearboxes and use direct-drive systems instead. At gearless or direct-drive wind turbines, the rotor is the only moving part that transfers the energy from the blades to the electric generator via a low speed shaft. Those wind turbines eliminate gearboxes by replacing them with variable speed electric generators and solid-state electronic converters. The downside is that a wind turbine with direct-drive generators, which operates at lower rotational speeds, can cost up to 30% more than other turbines.

In this Thesis we investigate several issues arising from the use of transmissions or gearboxes. The analysis addresses Mechanical as well as Electrical issues. At the first part, static structure analysis as well as nodal analysis will be presented. At the second part, an electrical analysis will be given, pointing out ways to convert the low frequency and low voltage AC signal to grid-required AC signal. Finally, ways to improve even further the electrical part of the wind turbine will be suggested with the use of advance power electronics.

Implementation & Means:

This M.Sc. Thesis will be completed in two phases. During the first phase, an investigation will be carried out on the transmission system, as well as on other proposed gearbox topologies. The second phase will present the result from the simulation work on two areas (mechanical and electrical). Initially, on the mechanical area of interest, using ANSYS an investigation will be done to the static structure of the wind turbine with and without the gearbox and a nodal analysis will follow. Next the area that will be investigated, through simulation, is the electrical area of a wind turbine. OrCAD/PSpice will be used to simulate the electrical side of the wind turbine with and without the gearbox. In addition, because for the gearless turbines solid-state electronic converters are needed, some power converter topologies will be evaluated and the results will be presented. Finally, with the help of Labview, both mechanical and electrical areas will be combined and electro-mechanical model will be presented. The whole wind turbine system will be simulated and the benefits of using a gearless wind turbine will be discussed.

References:

[1] P. Jamieson, *"Innovation in wind turbine design"*, 1st ed. ed. Chichester, West Sussex; Hoboken, N.J.: Wiley, 2011.

[2] L. Sethuraman, V. Venugopal, A. Zavvos and M. Mueller, *"Structural integrity of a direct-drive generator for a floating wind turbine"*, Renewable Energy 63, pp. 597-616, 2014.

[3] B. Wu, *"Power conversion and control of wind energy systems"*, Oxford: Wiley-Blackwell, 2011.

[4] W. Haiyun, W. Weiqing and B. Liang, *"Power quality analysis and system simulation on permanent magnet direct-drive wind turbine"*, in International Conference on Electrical Machines and Systems (ICEMS 2008) 2008, pp. 866-869.