Abstract

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DESIGN and IMPLEMENTATION OF LOW SPEED, SMALL SCALE, DIRECT DRIVEN PMSG FOR RENEWABLE ENERGY

Renewable energies in general and wind energy in particular are becoming more and more vital in the energy generation industry. While normal focus is on the mega and giga watt scale of units, the small scale - for individual isolated - users are less of interest for large production firms, but are recently gaining their interest. Nevertheless for wind turbines, most of the designers and manufacturers are targeting high wind sites, hence the design target and methodology is focusing on this concept, which excluded vast available amount of areas and energies from extraction for moderate low wind speeds. This thesis is dedicated to design an electrical generator that converts available sources of renewable energy into electrical power, such as wind hy ower. The thesis as well is concerned with generators for the small scale users as in homes, small farms, cell phone towers, remote inhabitants army units, and most importantly generators that are directly connected to the prime mover with no means of gears, operating at speed less than five hundred revolution per minute and power rating in the fractional and few kilowatt range. A linear lumped element based model of a permanent magnet synchronous generator (PMSG) is presented this model is used for both the purpose of analysis and design. A proposed design procedures asserted with equations, tables, design limits and practical recommendations, also a flowchart is developed to be later used as a code Matlab M-file for PMSG design with specific requirements. Different case studies are conducted. The results from the linear design and finite element method (FEM) software (Maxwell) are compared to each other. Another case study is conducted and compared to a recently published work for validation hence introducing the proposed procedures to be used as a good design tool for low speed generator. One of the conducted case studies is experimentally implemented, rated at one kilowatt and three hundred revolutions per minute the generator is later tested at different loads and various speeds and operating conditions. The experimental hardware test results demonstrate that the implemented generator prototype performs satisfactorily with good agreement compared to the corresponding results obtained from the FEM simulation.