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ABSTRACT

Doctoral dissertation

„Analysis of power electronics converter systems of wind turbine with permanent magnet synchronous generator"

The doctoral dissertation consists of nine chapters, list of references and two attachments. The first chapter presents an introduction of the development of the wind energy conversion systems. In the further part, the state of the art related to the topic of the dissertation has been discussed. At the end of the chapter the objectives of the dissertation and thesis have been formulated. The scope of the dissertation has been given.

In the second chapter the review of the wind energy conversion system has been presented. The division of wind turbine technology and wind energy generators used in wind system have been introduced. The wind turbine systems with squirrel cage induction generators SCIG, wound rotor induction generators WRIG, double fed induction generators DFIG, synchronous generators SG and permanent magnets synchronous generators PMSG have been described and discussed. In the further part, the detailed analysis of power electronics converter system with PMSG generators have been presented. The wind turbine systems with DC/DC converters, conventional and multilevel AC/DC/AC converters and AC/AC converters have been described. At the end of the chapter the wind turbine systems with AC/DC/AC converters and multiphase PMSG generators have been discussed.

The third chapter presents and describes the mathematical models of elements of the wind turbine system, including: wind turbine, drive transmission system, synchronous generator with permanent magnet PMSG and power electronics converter systems.

The fourth chapter presents the division of the Maximum Power Point Tracking algorithms for wind turbine control systems. The algorithms based on using of mechanical data and parameters of wind turbine have been described. The incremental MPPT algorithms have been also presented.

The fifth chapter presents the analysis of the control methods and algorithms of wind energy conversion systems. The selected control methods of the machine side converter MSC, DC/DC converter and grid side converter GSC are discussed. In the control methods of the MSC the MPPT algorithms have been included. In the control of MSC the Rotor Field Oriented Control (RFOC)

methods and Direct Torque Control (DTC) methods have been applied. In the control of GSC the Voltage Oriented Control (VOC) methods and Direct Power Control (DPC) methods have been used.

The simulation results of selected control methods and algorithms have been presented in the chapter six. The assumptions adopted in the formulation of simulation models have been described. The possibilities of the operation of wind energy conversion system with PMSG generator cooperating with grid systems and with stand alone systems have been verified by simulation studies.

The seventh chapter presents the description of the designed experimental test bench. In this chapter the chosen experimental studies of wind energy system with AC/DC/AC converters and PMSG generator have been shown. The structure of the control of the wind turbine emulator has been developed. The chosen experimental studies for different operation states of wind energy conversion system have been carried out.

The eighth chapter presents the analysis of the operation of wind energy conversion system under AC grid faults caused by the voltage sags. The classification of voltage sags has been presented and discussed. The basic requirements for wind energy conversion system during the occurrence of grid voltage sags have been described. The simulations and experimental results concerning of the state of voltage sags have been presented. The influence of the grid voltage sags on the operation of wind energy conversion control system has been carried out. The proposed control system modified by the author of the dissertation, which ensures the proper operation of wind turbine system during the balanced and unbalanced voltage sag has been presented.

The ninth chapter presents the final summary and the description of the of the author original achievements.

In the appendix A presents the data and parameters used in the simulation and experimental tests. The detailed description of considered main circuits of the laboratory model and the simulation model have been also presented.

In the appendix B the coordinate transformations used in the theoretical consideration have been presented.

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