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M. Sc. Błażej Jakubowski
Department of Electrical Machines, Drives and Measurements
Faculty of Electrical Engineering
Wroclaw University of Technology

Abstract of the doctoral dissertation "Analysis of the converter control systems of autonomous induction generator"

The doctoral dissertation consists of ten chapters and a list of references.

The first chapter contains an introduction, a critical review of the literature related to the topic of the dissertation subject and goals and a scope of the work as well.

The second chapter presents a mathematical model of a three-phase induction machine with a linear and non-linear magnetic circuit. This model has been used in analytical computations, simulation studies and in an experimental setup. In this chapter, the steady state analysis of the autonomous induction generator has been presented. Static characteristics for different parameters of the system (an excitation capacitance C, an angular rotor speed ω_e, etc.) have been determined. The steady-state analysis of the system with the autonomous induction generator, which has been carried out as a part of this work, has allowed to determine necessary conditions for the generator excitation.

A method for determining conditions of the excitation process for the stand-alone induction generator in transient states (at the initial time of the excitation process) has been developed. Experimental results during the excitation process, no load and load operation of the stand-alone induction generator have been presented. Moreover, results for different values of the parameters of the system have been presented.

Methods to control the stator voltage amplitude of the generator that are based on controlling the reactive power, which is delivered from a three-phase excitation capacitor banks, have been analyzed.

The third chapter presents the topology of the converter control systems for autonomous induction generator using a three-phase excitation capacitor bank and systems without this capacitors bank as well. The operation principle of the converter control systems for the induction generator without using of the three-phase capacitor banks has been presented. A mathematical model of the AC/DC converter with a dynamic DC-voltage source in the DC-link has been described. The control of an amplitude of the generator stator voltage by adjusting the inductive reactive power, which is delivered from the AC/DC inverter that is connected directly to the generator stator, has been discussed.

The fourth chapter presents an optimization criterion used for a synthesis of the control systems. The optimization criterion allows to tune the controller with an assumed maximum overshoot of the step response of the control system. This analysis consists in determining the optimum point on the complex plane, where the poles of the closed loop should be located.

Chapter fifth, sixth and seventh is devoted to the analysis and synthesis of converter systems whereby the stator voltage amplitude of the autonomous induction generator without the use of a three-phase excitation capacitor bank is controlled. The Analysis and synthesis of the control systems of the DC-link voltage has been performed. In these chapters, the analytical results confirmed by the simulation and experimental studies have been presented. The analytical, simulation and experimental studies involved the no-load states of the autonomous induction generator during the changes of the commanded amplitude of the stator voltage and the commanded value of the DC-link voltage have been considered. Moreover,

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the load conditions of the induction generator have been examined. For this reason, the three-phase load has been directly connected to the stator of the generator and the load in the DC-link voltage has been applied as well. Additionally, the studies during changes of the angular rotor speed of the induction generator has been carried out.

The fifth chapter presents a scalar method for control of the autonomous induction generator. Also the analysis and synthesis of the control system of the DC-link voltage has been presented. The control of DC-link voltage by changing of a value of the induction generator slip has been achieved. In case of considered method, the amplitude of the stator voltage has been directly commanded (open-loop control of the generator stator voltage amplitude).

In the sixth chapter, a method of the rotor field oriented control of the induction generator (vector method) with appropriate decoupling bloks has been presented. The method for estimating the angle of the rotor linkage flux vector (direct and indirect method) has been investigated. In the DC-link voltage control structure, the inner stator current control loop has been analyzed and synthesized. In the system realizing the control of a stator voltage amplitude, the inner stator current control loop has been analyzed and synthesized. The analysis and synthesis of the structures used for the stator current vector components decoupling has been carried out. The method, which allows to limit the components of the decoupling voltage vector, has been described. The presented method ensures the correct process of the self-excitation of the autonomous induction generator. An analysis of an influence of induction generator parameters changes on the dynamic properties (overshoot, regulation time) of the designed control systems has been performed.

In the seventh chapter, method of a stator field oriented control of the induction generator has been presented. For the DC link control circuit an inner control system of the appropriate stator vector current component was applied. For the regulation of the stator amplitude voltage the inner control system of stator flux linkage module vector was analyzed and synthesized. The analysis and synthesis of the structure used for the stator current vector component decoupling has been carried out. An analysis of an influence of the induction generator parameters changes on the dynamic properties (overshoot, regulation time) of the designed control systems has been studied.

The eighth chapter concerns the analysis and synthesis of the converter control methods for system with autonomous induction generator using the three-phase excitation capacitor bank. This chapter presents the analysis and synthesis of the control systems whereby the stator voltage amplitude and DC link voltage is controlled. In this chapter, the following control methods have been considered: rotor field oriented control, generator active and reactive power control. Eighth chapter presents the results of analytical calculations and the results of the simulation studies.

In the ninth chapter, laboratory setup used for studies of autonomous systems with the induction generators have been described and presented. In this chapter, the parameters and the rated data of the machines and devices used in the laboratory setup have been specified.

The tenth chapter contains a summary of the work and conclusions.

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