FACULTATEA DE ELECTROTEHNICA SI ELECTROENERGETICA

Universitatea Politehnica Timişoara

HABILITATION THESIS

Contributions to the Optimal Structures of the Electromechanical Systems and the Electric Power Quality

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1. ABSTRACT

1.1. Abstract

The habilitation thesis presents the most important professional and scientific results obtained by the author during 2001-2014. This period follows the public presentation of his doctoral thesis, which took place in 2000.

Three main research areas have been addressed: *The optimal design of AC motors*, *The optimal control of electrical drives with AC motors* and *Single-phase power factor correction converters*.

The activity in the domain of *Optimal design of AC motors* has been oriented towards: (i) the study of the skin effect in the high rectangular bars of the rotors of the three-phase inverter fed induction motors; (ii) the study of the use of ferrite permanent magnets in designing synchronous machines as an alternative to the version with rare earth magnets; (iii) education.

The study of the skin effect in the rotor bars of the three phase induction machines fed by PWM inverters is a continuation of the doctoral activity. The obtained results at the end of the research offers the possibility to calculate the equivalent global factors that change the resistance, respectively the reactance, which characterize the high rectangular rotor bars of the induction motors, under the conditions of the non-sinusoidal regime determined by the inverter supplying. The author has published 14 articles as follows: 4 articles in journals indexed BDI, 3 articles issued in volumes of ISI conferences, 3 articles issued in volumes of BDI indexed conferences, 1 article at an international conference without indexation and 4 articles in national conferences. In recognition of the results obtained, the author was invited to write a chapter entitled *The Behavior in Stationary Regime of an Induction Motor Powered by Static Frequency Converters* of the book entitled *Induction motor. Modeling and control ,* published in 2012, at InTech Europe Publishing House under the coordination of Professor Rui Estevez Araujo.

In the domain of designing synchronous machines using ferrite magnets as an economical alternative to the solution of using rare earth magnets, during the research 8 new variants of rotors were conceived, designed, modeled and simulated. Of these, seven variants are with variable reluctance having the rotor flux barriers filled with ferrite magnets and a rotor topology is with flux concentration, also designed to be made with ceramic magnets. All the solutions studied aim a much cheaper alternative to the synchronous motors with rare earth permanent magnets. The research team addressed this direction in 2010, within an international project with Diehl Company from Germany, the author being the manager. The paper section regarding this topic presents the results obtained for three variants of rotor, considered by the author as being representative: a row of flow barriers 1V, with two rows of flux barriers 2V and with flux concentration which have been already executed as a prototype in two variants. The prototypes were made at Electromotor Timişoara, under the author's direct guidance, while the stand tests, whose results are presented in the paper, were performed in Germany. One study was published in the volume of IECON Conference of 2013, from Vienna, under the aegis of IEEE Industrial Electronics Society, an ISI indexed paper. The paper received the Certificate of appreciation for the best work of the section. Three other works are being under review. The author has published three books and one specialty article, in collaboration, on educational topics. It should be highlighted that the author is the project holder from the discipline Electrical motors, taught to the students from Power Engineering.

In the domain of the optimal control of electrical drives with AC motors, the research can be grouped into two categories: (i) electric drives with vector control for induction motors implemented in naval mechanisms, (ii) development of new algorithms for optimal control of AC motors.

In the first domain, the author was part of a joint team consisting of researchers from the Politehnica University of Timişoara, Faculty of Electrical and Power Engineering and from "Mircea cel Bătrân" Naval Academy of Constanţa, Faculty of Marine Military, who collaborated in partnership, approaching the problem of implementing the direct vector control in the torque and flux of the induction machine, for the electric drive systems for naval mechanisms. The theoretical and experimental study was conducted under a national grant in which the author participated as Politehnica University of Timişoara responsible representative. The results were published in 14 articles: 2 in an ISI indexed volume, 1 in a BDI indexed volume, 3 in international conferences and 8 at national conferences. The author collaborated to the publication of three books.

The second domain presents the author's results obtained after his participation in a research developed during 2004-2013 by a joint team consisting of specialists from the German company Diehl and the teachers from Politehnica University of Timişoara. In the theoretical and experimental study the team has developed new algorithms for controlling AC motors. For the present study, three algorithms have been selected to be presented as they have significantly improved the existing control strategies while maintaining the same level of their complexity. 12 articles have been published: 1 article in an ISI indexed journal, 1 in BDI indexed journals, 8 in volumes of ISI indexed conferences and 2 in volumes of BDI conferences. In the educational area, the author taught two subjects, both newly introduced.

The domain of Power factor correction converters was addressed relatively recently, in 2013. The undertaken research has resulted in two international projects in which the author participated as a manager. The first project focused on the segment of single-phase power converters with a power up to 4 [kW] and the second project of the three-phase converters powered up to 10 [kW]. So far, three articles have been written, both under review.

The thesis is structured in five sections.

The first section presents the achievements and results in the author's career.

The second section is devoted to the optimal design of AC motors. The first part of this section presents a selection of results obtained by the author in the study of skin effect that manifests in the high rectangular rotor bars of the induction motor fed by a voltage inverter. This study aims to develop a theory of asynchronous motor, under non-sinusoidal power regime, leading to the optimization of the methodology of the constructive / technologic design, under favorable economic conditions. The second part of this section is devoted to promote a new concept of an economically advantageous design of the synchronous motors. For this purpose, the paper proposes three new topologies of rotors for the synchronous machine. All the solutions studied aim a much cheaper alternative to the synchronous motors with rare earth permanent magnets.

The third section is devoted to the Optimal control of electrical drives with AC motors. The first part of this section presents the results obtained from the implementation of vector control directly in torque and flux for the electric drive systems of marine mechanisms. The second section presents the results of the practical implementation of the algorithms for controlling the AC motors fitting the reversible driving systems, characterized by a wide range of speeds.

The fourth section presents a summary of the research results obtained in the field of single-phase power factor correction converters. The study analyzed the following power factor correction converters: the boost converter, the interleaved boost converter, the bridgeless converter and the bridgeless interleaved converter.

The last section of the habilitation thesis presents perspectives of future development. It presents new possible research directions in the domains mentioned above.