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Fundamental field: Engineering Sciences
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HABILITATION THESIS

- ABSTRACT -

**Contributions to the design, optimization, and testing of
electromagnetic devices implemented in planar electromagnetic
technology**

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The Habilitation Thesis entitled “Contributions to the design, optimization, and testing of electromagnetic devices implemented in planar electromagnetic technology” represents a synthesis of the authors research activities from the PhD Thesis defense in 2012 till present in the Field of Electrical Engineering.

The Habilitation Thesis is comprised of three parts developed along five chapters. The first part represents a short introduction containing information about the professional evolution and the research themes and directions of the author, followed by the second part where the main scientific, professional and academic accomplishments in three main directions are highlighted. In the end, the third part presents future plans considering the academic career.

The defense of the PhD Thesis entitled “Contributions to the improvement of filters implemented in planar electromagnetic technology” in September 2012, represented the starting point of a scientific career dedicated to the in-depth study and expansion of research in the field of planar electromagnetic structures and beyond. Thus, in the first part of the Habilitation Thesis the author’s academic path and the courses taught are detailed, showing how they have been harmoniously integrated with her research activity, whose results have contributed to the improvement of the educational process. The research topics and directions addressed are also presented, including the design, modeling, optimization, and use of spiral planar structures in various electrical and electronic devices, the design, optimization, practical implementation, and experimental testing of antennas, as well as software and embedded applications supporting experimental research. The results of the researches were highlighted through scientific articles and books publication and research contracts in which the author has been and is currently involved.

Iso within this first part, the fulfillment of the minimum requirements is highlighted. It is specified that the author has published approximately 131 papers in ISI-indexed journals, ISI conference proceedings, BDI-indexed journals, BDI conference proceedings, as well as non-indexed journals and proceedings. International recognition is evidenced by a significant number of citations, approximately 150 in WoS- and BDI-indexed journals and conference volumes. The author is also the co-author of six specialized books, three of which as first author. It is further noted that she serves as a reviewer for journals such as Computers, Sensors, Energies, Aerospace, Machines, Electronics, IoT, Future Internet, Applied Sciences, Entropy, Micromachines, Drones, Photonics, Inventions, and the Journal of Marine Science and Engineering.

Part II of the habilitation thesis presents the scientific, professional, and academic achievements of the author, structured into three main research directions. The first chapter, entitled *Design, modeling, optimization, and use of planar spiral structures in various electrical and electronic devices*, presents the author’s research on planar technology structures. Thus, the studies on EMI filters are highlighted, for which the analyses initiated in the doctoral thesis have been further developed in order to improve their performance.

Due to their similarity with these structures, the author has also addressed planar transformers in her studies, analyzing them in terms of losses, parasitic capacitances between the primary and secondary windings, as well as the influence of the ferrite core used. Another type of spiral structures investigated concerns those used in induction heating, where numerical modeling was performed and an experimental test bench was developed; moreover, an induction plate was also modeled. Last but not least, studies on wireless power transfer systems are presented, which were the subject of a research project and also form the basis for investigations on RFID systems. In addition to the parametric analysis of different configurations of coils for wireless power transfer and their optimization using numerical

modeling tools, these structures were practically implemented, experimentally tested, and the results were validated, with potential applications in devices such as pacemakers

The next chapter, entitled *Design, optimization, practical implementation, and experimental testing of antennas*, focuses on the numerical analysis of antennas, as well as their practical realization and experimental testing. Several types of antennas analyzed by the author are presented, including wire and slot antennas, patch antennas, as well as various derived configurations such as array antennas, MIMO systems, and antennas intended for RFID applications. The influence of various geometric parameters such as dimensions, corner chamfering or rounding, dielectric thickness, or the inclusion of slots on the antennas' operating behavior is investigated. The use of new dielectric materials and different feeding methods is also analyzed in terms of relevant performance parameters. Different optimization methods for the studied structures are presented for the targeted frequency bands, with new structures being developed and investigated, offering improved performance compared to existing solutions.

In the case of MIMO antennas, in order to determine the specific parameters and obtain satisfactory results, different decoupling techniques are analyzed. The studied structures are numerically modeled, relevant parameters are compared, and the optimal solution is identified, which is then to be practically implemented and experimentally tested. For each of these processes leading to the practical realization of the structures presented in the studies, a step-by-step production workflow has been developed.

Given that the influence of antennas on the human body is currently a highly important topic, this aspect is also analyzed for the developed structures, and the results are evaluated in accordance with the standards in force.

RFID structures have been one of the areas of interest, following an extensive process in which antennas covering all relevant frequency ranges were investigated, modeled, practically implemented, and tested, starting from low frequencies and reaching up to 2.4 GHz. Within this process, not only was the existing laboratory equipment and the software available at the Technical University of Cluj-Napoca used, but new measurement setups were also developed to support the evaluation and optimization of the structures.

The fourth chapter, also part of the second section of the Habilitation Thesis, is entitled *Software and embedded applications supporting experimental research*. This chapter presents user-friendly software applications developed for the design of patch and Yagi-Uda antennas, based on established formulas, created both for further research and for teaching purposes, using various programming environments. An application is also presented that facilitates the design of spiral planar inductors used in RFID structures and supports the interpretation of results, as well as a predictive model for the gain of the developed antennas. In the case of MIMO antennas, a software application was developed for interpreting results obtained through numerical modeling tools (S-parameters), as well as for the representation and analysis of relevant parameters aimed at improving the efficiency of complex structures. Last but not least, a complex MySQL database was proposed, containing the antennas developed and analyzed over time, in order to enable easier management and to allow fast and efficient identification of suitable solutions for each application based on precise queries.

The test benches developed within the studies are also presented in this chapter. Thus, a setup designed for controlling the distance and rotation angle of antennas, operated via a mobile application, is described, as well as an application for temperature control within a small enclosure.

Part III comprises Chapter 5, *Plans for Career Development and Evolution*, which outlines future research directions and the plans for the development of the author's

academic and scientific career, based on the achievements to date, but also aimed at extending into other related fields.

The Habilitation Thesis concludes with references, as well as a list of figures and tables that document the author's results in the field throughout her career, and a list of publications including six books, three of which with the author as first author, and 131 scientific articles.