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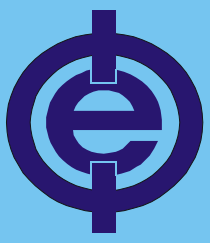
DESIGNING AND MODELLING OF THE POWER ULTRASONIC TRANSDUCERS



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Dr. Milan Đ. Radmanović, Dr. Dragan D. Mančić

DESIGN AND MODELING OF THE POWER ULTRASONIC TRANSDUCERS

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PREFACE

Field of power ultrasonic technique, which represents an important field of industrial electronics, in recent two decades experienced very swift and dynamic development. An intensive development concerns as design and construction of new ultrasonic devices, as well as broadening of application fields of power ultrasound in many industrial branches and processes (mechanical, electric, and chemical industry). Aside with appearing of new applications of ultrasound, new, more perfect sandwich transducers are designed and developed, and numerous scientific papers appeared, in which are treated different aspects of power ultrasonic technique, especially different electromechanical models by which is obtained design and optimization of ultrasonic transducers.

In this monograph firstly is performed systematization of different existing procedures and methods for modeling of power ultrasonic transducers. Besides that, new procedures of modeling, design, and optimization of power ultrasonic transducers are presented, based on previously realized original models of piezoceramic and metal rings. Thus is completed design of a sandwich transducer as a unique system, consisted of piezoceramic rings, emitting and reflecting metal ending, as well as of central bolt. Basic idea of the authors was to help with realized models to the designers of new ultrasonic systems, due to the fact that currently there is no literature from this field in Serbian.

Original results, presented in this monograph, are product of several-year-research in the field of power ultrasound in the Laboratory for energetic electronics and control of electroenergetic transducers in the Faculty of Electronics in Niš, wherefrom originated over 50 scientific papers from this field. Concrete results, presented here, are part of one master thesis and one doctoral dissertation, realized in the frame of research in this field.

On this occasion authors express their gratitude to the reviewers, Prof Vanča Litovski, Ph.D. and Prof Stojan Ristić, Ph.D. on their useful suggestions and notes.

Niš, January 2004 *Authors*

CONTENTS

Prof. Milan Đ. Radmanović, Ph.D. was born on the 15th of October 1948, in Poljane, Republic of Croatia. Graduated in 1972 on Faculty of Electronics in Niš, where he also acquired the title of master of electrical engineering in 1977, and the title of doctor of technical sciences in 1988. Currently on position of Professor Associate in the Department of Electronics of the Faculty of Electronics in Niš. At undergraduate and postgraduate studies teaches the subjects of Energetic electronics, Electroenergetic transducers, and Control of electroenergetic transducers. Supervised and took part in realization of 14 projects financed by Ministry for Science and Technology of Republic of Serbia. Author or coauthor over one hundred papers, reported or printed in journals and paper collections, and coauthor of one university textbook. Scope of his scientific interest is energetic electronics, and modeling and design of power ultrasonic transducers and generators.

Dragan D. Mančić, Ph.D. was born on the 9th of April 1967 in Visočka Ržana near Pirot. Graduated on Faculty of Electronics in Niš in 1991, and became master of science on the same faculty in 1995. In 2002 acquired the doctor's degree, also on Faculty of Electronics in Niš. Dragan Mančić, Ph.D. is a reader on the Faculty of Electronics for section of electronics, where he teaches in courses for Electronics, Automation, and Industrial energetics in subjects Energetic electronics and Control of electroenergetic transducers. Coauthor of one university textbook. He published over sixty scientific and expert papers in international and national journals and collections of papers from international and national conferences. He deals with energetic electronics, and modeling and design of power ultrasonic transducers and generators.

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When designing ultrasonic transducers for high power applications, it is necessary to apply a static prestress in the ceramic stack in order to avoid large strains that may provoke fractures in the ceramics. The simulation of this prestress can be performed with COMSOL MultiphysicsÂ® as a two-step simulation consisting of a stationary study followed by an eigenfrequency or a frequency domain study to determine the behavior of the system.Â In order to quantify the uncertainty of the theoretical model, the modal behavior of three different rectangular plates has been analyzed by both methods, obtaining a correction factor that allows a more accurate initial approach and that depends on the relation between the thickness of the plate and the distance between nodal lines. The proper electrical model for an ultrasonic transducer is a capacitance in parallel with an LCR series resonant circuit. The fixed capacitance corresponds simply to the electrical capacitance of the transducer, neglecting mechanical oscillation effects. The LCR circuit corresponds to the resonant behaviour of the transducer.Â To get around this problem, you need to use a matching network to adapt the electrical properties of the transducer to something that the inverter is happy driving. Matching networks come in many different forms, but the most common are LC and LLCC. Do a Google search on them and you should find some useful results. Suppliers (23/01/13). Some interesting suppliers of ultrasonic transducers and related equipment Ultrasonic devices modeling is often based on the finite element method (FEM). Several physical phenomena are involved in these devices: electromechanical transduction, transducer vibration, coupling with propagation medium, and acoustic or elastodynamic radiation. Generally, these models are based on linear constitutive relationships such as theory of elasticity, constitutive law of piezoelectricity, and theory of linear acoustics.Â A cascade structure of half-wavelength transducer is proposed for improving power capacity of the transducer, and a dual-excited full-wavelength piezoelectric ultrasonic transducer consisting of two half-wavelength transducers is especially studied.