Modeling and Experimental Verification of the Power Transfer Characteristics of Piezoelectric Transformers Subjected to Combined Thermal and Electrical Loading

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Abstract

For a piezoelectric transformer the input electrical energy is transferred to the output through mechanical excitation by using both direct and converse coupling characteristics evinced by piezoelectric materials. Since the basic theory of piezoelectric transformers was published in 1956 there have been numerous design approaches to implementing such devices. Recent developments have included new high power materials, low loss electrodes, advances in the driving circuitry, new excitation techniques as well as novel manufacturing methods have all expanded the operating range of transformers. However, despite the extensive research and progress in the field of piezoelectric transformers, current devices do not simultaneously meet high efficiency, power and reliability standards of today's elevated power requirements. In order to develop piezoelectric transformers exhibiting both high conversion efficiency and high power throughput in wide voltage and current range, we have developed a realistic piezoelectric transformer model and an experimental setup for verification. The model is distinctively capable of coupling thermal and electrical loads to a piezoelectric transformer, an inherently coupled electro-mechanical system, by using the COMSOL Multiphysics software. The experimental setup can successfully monitor the device during operation. In the case of this study we are analyzing the devices at high power and high frequency, which increases the device temperature. Additionally, the model is capable of analyzing environmental parameters such as dynamic electrical loading, thermal and structural mechanical effects from system packaging and variations of input conditions. In this presentation we will present the experimental verification of a realistic piezoelectric transformer system model. This study will detail electrical output and thermal characteristics of the piezoelectric transformer model for a range of different loading and ambient conditions. The results of this study will be crucial in development of effective design and testing tools for further integration of piezoelectric devices in commercial electronic systems.

Reference

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