

## Studentship Project

**Piezoelectric transformers for power electronics applications**

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Piezoelectric transformers (PTs) utilise electromechanical coupling to transfer electrical energy between the primary and secondary regions of a poled piezoelectric ceramic. Due to their ceramic construction and high power density, PTs allow smaller, lighter, more compact transformer designs to be realised than conventional magnetic technology. PTs also produce very little EMI, offer excellent reliability, and are cost effective when mass produced. However, since high efficiency coupling is only obtained when operating close to mechanical resonance, and the frequency of resonance is load and temperature dependant, considerable control effort is required to maintain high efficiency operation in a PT-based converter.

High voltage step-up PTs have already been extensively commercialised in applications such as cold cathode fluorescent lamp backlighting for LCDs. However, step-down PTs have yet to be widely adopted, mainly due to the more complex nature of the PTs themselves and the control schemes required to maintain high efficiency operation with load and line regulation. Recently there have been some significant advances in step-down PT technology, such as the Transoner<sup>®</sup> radial mode PT, and one of the main aims of this project is to develop equivalent circuit models that allow radial mode PTs to be analytically designed for specific switch mode power supply applications.

Experimentally, PTs are usually modelled with the lumped equivalent circuit shown in Figure 1. By using the equations of piezoelectricity to develop relationships between the dominant vibration mode and the input voltage and current and output voltage and current, approximate expressions can be developed that relate each of the electrical elements in the equivalent circuit to the physical characteristics of the PT (i.e. the material parameters, device dimensions, and electrode layout).

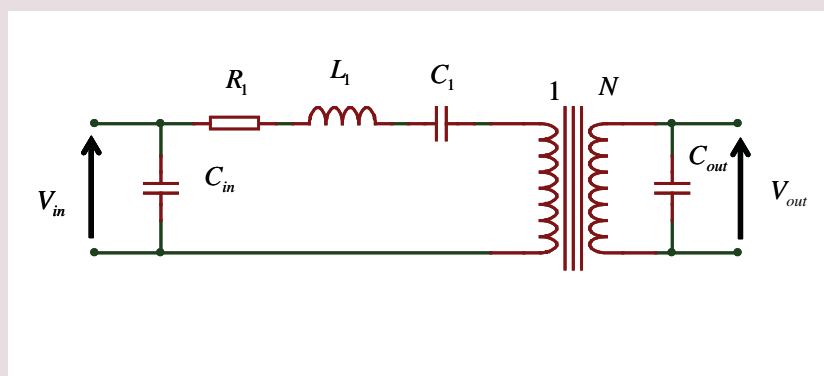


Figure 1: Equivalent circuit for a PT operating near resonance

To date, a review of the current state-of-the-art in piezoelectric transformer technology has been published at the European Power Electronics Conference 2007, and a lumped equivalent circuit model for the radial mode piezoelectric transformer has been published at the Applied Power Electronics Conference 2009. This model is currently being expanded to include a feedback layer which can be used to monitor the tank current for control purposes, and to include the effect of having different electrode radius in the primary and secondary sections.