# 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 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 Noliac ring-type PT. This annular thickness-mode device can achieve power densities of around $50W/cm^3$ and output powers of around 50W. The aim of this project is to model the electrical behaviour of these devices and design resonant power converters that will allow off-the-shelf PT-based power supplies to be realised for consumer electronic equipment.

In order to design PT-based resonant converters, the transfer response of the PT must be known. An electrical equivalent circuit provides a way of predicting the transfer response of the PT when driving various values of load, and thus allows the behaviour of the device within a resonant converter to be calculated. To date, the main focus of the project has been on PT equivalent circuit modelling and determining the equivalent circuit component values. The accepted equivalent circuit for modelling a PT operating at a single resonant mode is shown in Figure 1.

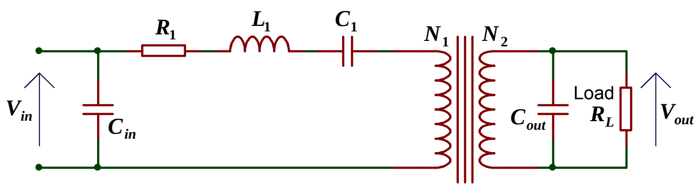


**Figure 1: Equivalent circuit for a PT operating at resonance**

Although the equivalent circuit of Figure 1 suggests that a PT behaves linearly at resonance, in general this is not true. In particular, the value of the loss resistance $R_1$ is dependant upon the input voltage and the power dissipation within the device. This means that some of the existing methods for obtaining the PT equivalent circuit parameters, such as the resonator analysis function on some impedance analyzers, are not valid because they result in $R_1$ being characterised at unrealistically low excitation levels.

A network-analyser-based method of device characterisation has been developed and will hopefully become the subject of a forthcoming research paper. Another publication which reviews the current state-of-the-art piezoelectric transformer technology is currently under review. The project is now moving towards the selection of appropriate resonant converter topologies and producing design tools for specifying the discrete components required to produce a given specification of power supply from a given set of PT parameters.