Characterization of Transducers and Resonators under High Drive Levels

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Abstract - In many applications, piezoelectric transducers are driven at AC voltage levels well beyond the level for which the material was nominally characterized. In this paper we describe an experimental setup that allows for the determination of the main transducer or resonator properties under large AC drive. A sinusoidal voltage from a waveform generator is amplified and applied across the transducer/resonator in series with a known high power resistor. The amplitude of applied voltage and the amplitude and the relative phase of the current through the resistor are monitored on a digital scope. The frequency of the applied signal is swept through resonance and the voltage/current signals are recorded. After corrections for the series resistance and parasitic elements the technique allows for the determination of the complex impedance spectra of the sample as a function of frequency. In addition, access to the current signal allows for the direct investigation of non-linear effects through the application of Fourier transform techniques on the current signal. The strain determined from the analysis of the impedance data was compared to the strain measured directly with a Fotonics sensor during the frequency sweep and the data were found to be in good agreement. Our results indicate that care is required when interpreting impedance data at high drive level due to the frequency dependence of the dissipated power. Although the transducer/resonator at a single frequency and after many cycles may reach thermal equilibrium, the spectra as a whole cannot be considered an isothermal measurement due to the temperature change with frequency. Methods to correct for this effect will be discussed. Results determined from TE resonators of both soft and hard PZT and a variety of ultrasonic horn transducers will be presented.