**Entropy and Entropy Production Rate in Dielectric and Magnetic Metrology and Relaxation**

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In this paper I make the case that many electromagnetic metrology areas can be formulated using the concepts of information entropy and also entropy production. Information entropy can be used to study stochastic systems and yields probability density functions consistent with a given set of constraints. The information entropy concept has been used successfully in electromagnetic compatibility (EMC) studies on reverberation chambers and other electromagnetic areas such as inverse scattering. Entropy production, on the other hand, is a measure of power dissipated per unit temperature and can be applied to studies of dielectric and magnetic relaxation and also in metrology areas related to power in rf systems. I also present an algorithm for Boltzmann's constant determination using an equation I recently derived in terms of entropy production. Many high-frequency electromagnetic measurements are based on the relationships between dissipation and fluctuations. These areas include noise, material measurements, power, Boltzmann constant determination, reverberation chambers and other area of EMC. In nanotechnology an understanding of fluctuations of thermal and electromagnetic energy and the effects of nonequilibrium are particularly important. The approach used here is based on a derivation of an entropy evolution equation using an exact reversible Liouville-based statistical-mechanical theory. In this paper I develop an exact equation for entropy rate in terms of time correlations of the microscopic entropy production. This equation is an exact fluctuation-dissipation relation. I then define the entropy and its production in electromagnetic driving, both in the time and frequency domains, and apply this equation to dielectric and magnetic material measurements, cavity resonance, noise, and power. I apply this equation to study entropy fluctuation dissipation equations for dielectric and magnetic susceptibilities, impedance and resonant systems, and Johnson-Nyquist noise. We relate entropy production to cavity resonance and relaxation loss peaks and derive a relation for the positivity of the permittivity loss factor. I overview fluctuation-dissipation relations, both traditional and those based on entropy production, and indicate how they can be used in electromagnetic metrology areas of research.