Signal Processing Seminar

Title: Time-domain Impedance

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Date: Wednesday, January 28, 2009
Time: 4:00 - 5:00 pm
Where: 4269 Beckman Institute

Abstract:

Impedance is the cornerstone of engineering, and has remained a frequency domain construct. Impedance has well documented frequency domain properties that make it special, such as *positive realness* (PR), and causality. These properties are typically described in the complex frequency domain ($s = \sigma + \jmath\omega$), where they sometimes have difficult properties. For example: (1) a loss-less PR function has poles and zeros that alternate on the $\jmath\omega$ axis (Foster's reactance theorem); (2) causality is a result of the *Cauchy integral theorem*, which requires that any causal function be analytic in the right-half s plane (RHP $\equiv \sigma > 0$); (3) the admittance function $y(t) \equiv z^{-1}(t)$, the inverse impedance, must be causal; (4) both the impedance poles and zeros must be in the s RHP. The question addressed here is: "What is the time-domain meaning of PR, and what is the best time-domain representation of an impedance?" Namely what are the time-domain properties that assure that both $z(t)$ and its inverse $y(t)$ (i.e. $y(t) \star z(t) = \delta(t)$) are causal and stable? A solution to this void is proposed, based on the well known properties of the uniform transmission line. The proposed solution defines power since the product of the input and the output of an impedance is the instantaneous power, i.e. $P \equiv i(t) \cdot v(t) = i(t) \cdot z(t) \star i(t)$. This time domain definition of impedance seems to resolve several important previously unidentified issues. Examples are given which suggest that time-domain impedance may still not be well understood. Our results connect DSP with ASP, as they define power in terms of wave-forms. Across and through variables (voltage and current) are related to a simple time domain kernel operator which physically is the reflectance.