Dynamics of Inductor-Capacitor Networks

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Generalizations of classical electrical transmission lines, or inductor-capacitor (LC) networks, have proven useful for a number of applications in VLSI electronics, especially those related to high-frequency signal processing. A typical LC network has thousands of degrees of freedom; the differential equations that model such a network can be viewed as a spatial discretization of a PDE, or as a high-dimensional dynamical system. Here we present examples where each of these approaches has led to a better understanding of network dynamics.

The first example is that of a 2-D linear LC network. We show how the continuum limit of the network equations and a 2-D version of scalar diffraction theory can be used to design a circuit that computes Fourier transforms in the analog domain with very high throughput and low latency. The second example is that of a 1-D nonlinear LC network that supports nonlinear, periodic oscillations at the Bragg cutoff frequency. We show how Floquet theory and the method of averaging can be used to show linear stability of these oscillations.

Bio: Harish S. Bhat is an assistant professor of mathematics at Claremont McKenna College, part of the five-college consortium in Claremont, CA. From 2005-2007, he was the Chu assistant professor of applied mathematics at Columbia University. He received his A.B. in Mathematics in 2000 from Harvard University, and his Ph.D. in Control and Dynamical Systems in 2005 from the California Institute of Technology. His primary research interests are in linear/nonlinear wave propagation and applied analysis, with an eye toward applications in analog VLSI circuit design. His research in this area is partially supported by a grant from the National Science Foundation.