Chaotic Transmission Line Oscillators for Generating CW, Ultra-Wideband Waveforms

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Chaotic dynamics is an unconventional source of ultra-wideband waveforms for application in radar and remote sensing systems. The broadband and non-repeating nature of chaos provides an ideal combination of high range resolution and zero range ambiguity. Chaotic waveforms can be generated by very simple nonlinear systems, suggesting a cost-effective solution for low-power, high-capability sensors. Furthermore, multiple oscillators can synchronize, allowing the coherent combination of several chaotic "noise" sources in an array. In this talk we describe a class of chaotic transmission-line oscillators that appears particularly well suited for low-cost radar applications.

These novel devices consist of a linear transmission line terminated with a negative resistance on one end and a diode on the other. Loosely speaking, chaos arises when voltage waves are "stretched" upon reflection from the negative resistance and then "folded" by the nonlinearity of the diode. Despite their incredibly simple construction, these oscillators can generate continuous-wave, ultra-wideband waveforms from VHF up to microwave bands. By adjusting the bandwidth of the active element in the negative resistor, the dimensionality of the chaotic attractor can be controlled. At one extreme, a relatively narrow bandwidth amplifier yielding a single active mode results in low-dimensional dynamics characterized by a simply folded band chaotic attractor, which is ideally suited for synchronization and control. At the other extreme, a wider bandwidth provides a large number of active modes, and the oscillator produces noise-like high-dimensional chaos, which may also be synchronized. Experimental results are shown for oscillators constructed using coaxial cable and micro-strip transmission lines and continuing efforts to achieve even faster oscillators (>1GHz) by this design are described.