

Delayed Feedback and GHz-Scale Chaos on the Driven Diode-Terminated Transmission Line

Steven M. Anlage⁽¹⁾, Vassili Demergis⁽¹⁾, Alexander Glasser⁽²⁾, Marshal Miller⁽²⁾,
Thomas M. Antonsen Jr.^(1,2), and Edward Ott^(1,2)

(1) Physics Department, University of Maryland, College Park, MD 20742 USA

(2) IREAP, University of Maryland, College Park, MD 20742 USA

Controlled GHz-scale chaos is a new frontier for both science and technology. Methods of generating and understanding such high frequency chaos are just beginning to be studied. The approach taken here is an extension of the driven lumped element RLD circuit chaos and focuses on the importance of time scales and the nonlinear capacitance of the diode. With the increasing speeds of computer chips, there is an increasing demand to understand the dynamics of high frequency signals on computer bus lines. It has been shown that chaotic instabilities could arise at GHz frequencies from the electrostatic discharge protection circuits commonly found surrounding most computer components. Through an understanding of the general system, it may be possible to avoid such instabilities. In addition, systems that can create chaos at GHz frequencies may enable high bandwidth communication technologies using synchronized chaotic oscillations.

A simple model of a distributed, non-linear circuit that produces chaos at GHz frequencies is introduced and tested experimentally. The model circuit is a driven diode-terminated transmission line with the transmission line impedance mismatched to that of the source. Experiments were performed with sinusoidal driving frequencies of 10 MHz to 1.2 GHz, driving powers of -30 to +50 dBm, and transmission line delay times from 3 to 20 ns. Diode reverse recovery times ranged from 4 to 100 ns. As a result of many experiments, it was found that chaotic behavior was strongly dependent on the unbiased, small signal reactance of the system as seen by the driving source, and influenced by an applied DC voltage-bias across the diode. In the experiments that showed period-doubling and / or chaos, the reverse recovery times of the diodes were on the order of both the driving period and the delay time of the circuits. Comparisons between theory and experiment are in general agreement. Chaos produced with a driving frequency of 1.105 GHz has been observed experimentally (below, right).

This work is supported by DoD MURI AFOSR Grant F496200110374, DURIP Grants FA95500410295 and FA95500510240. We would also like to thank M. Harrison and J. Gaudet for their valuable discussions and feedback.

