



Introduction

Systems naturally described by a set of boolean states may display sensitive dependence to small perturbations. Here we used very simple electronic devices, composed of commercially available, high-speed logic gates to generate chaotic behavior with continuous time Boolean states.

Digital Chaotic Circuits

Schematics for digital chaotic circuit

XOR NO₁ XOR XOR τ_3 **U**5



 τ 1 to τ 5 stand for different delay times

XOR gate		
input1	input2	output
0	0	0
0	1	1
1	0	1
1	1	0

True table Of XOR



We recorded the temporal evolution of the voltage at a point in the circuit.



Temporal evolution of the circuit shows chaotic behavior with clearly defined discrete states of voltages.

Ultra-Wide Band Digital Chaotic Circuits - Part I: Introduction and Implementation

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Appl. Math. 44, 111 (1984). 2 - "Ultra-Wide-Band Digital Chaotic Circuits - Part II: Characterization and Details", H. L. D. de S. Cavalcante, et al., Dynamics Days 2009 P62. 3.- "Ultra Wide Band Antenna Design for Transmission of a Digital Chaotic Signal", S. D. Cohen, et al., Dynamics Days 2009 P9.

Simulation

To model the observed behavior, we start with Boolean delay equations based on the form introduced by Ghil et.al [1]: Boolean delay equations are evolution equations for vector Boolean variables $\mathbf{x}(t)$:

$$x_i(t) = f_i(x_1(t - \tau_{i1}), \dots, x_n(t - \tau_{in}))$$

where f_i is logic functions and τ_i are constant delay times. Simulations show that this model generates only periodic or quasiperiodic solutions. To predict chaotic behaviors similar to that observed in the experiment, we need to address short pulse rejection and degradation effect where the delay time τ_{in} through logic gates depends on its pulsewidth instead of being constant.





5 Conclusion

Digital chaotic circuit with delayed feed back can generate a nonrepeating pattern, which shows sensitivity to initial conditions. Those circuits can be used as a building block in secure spread-spectrum communication systems or as an ultra-wide-band sensor [2,3].



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