Reliable Logic Circuit Elements that Exploit Nonlinearity in the Presence of a Noise Floor

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Abstract

The response of noisy nonlinear systems to deterministic input signals can be enhanced by cooperative phenomena. When a two square wave is used as input to the two state, the response of the system can produce the logical output of the probability controlled by the noise intensity (NOR = OR). When a noise is added (for fixed threshold or nonlinearity), the probability of reflecting the output of NOR = or operation increases to a unit and then decreases.

1. Introduction

Over the last few years, it has become increasingly obvious that understanding how noise and nonlinearity cooperate, in a dynamical system, to produce novel effects is critical in understanding how complex systems behave and evolve [1].

Stochastic resonance provides one such example wherein the cooperative behavior between noise and dynamics produces interesting, often counterintuitive, physical phenomena. SR has received much attention over the past few decades and consists of the enhancement of weak input signals through a delicate interplay between the signal, noise, and nonlinearity [2].

2. Content

As computing equipment and platform size shrink and speed increase, we are faced with more and more basic noise characteristics which cannot be suppressed or eliminated. Therefore, the understanding of the cooperative behavior between the base and the nonlinearity of the equipment noise will play a more and more important role in the design and development of the future computing concepts and equipment [3].

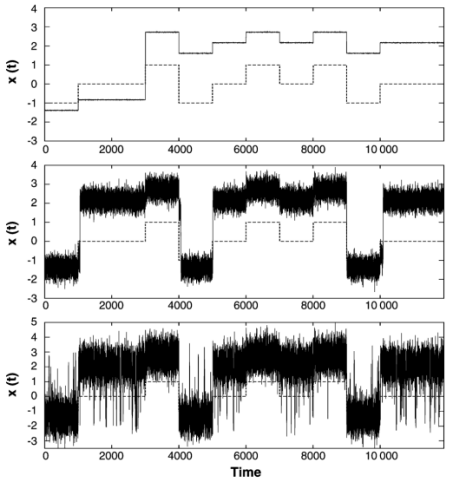

Figure 1. Each panel has 2 curves. Solid curves represent the solution x(t) from numerical simulations for additive noise intensities D equal to (top to bottom) 0.01, 0.5, and 1. The input I is the sum of randomly switched square pulse trains (see text), and is the same (dashed line) in each panel. For an optimal noise intensity (center panel) a reliable OR=NOR gate is obtained.

Input Set (I1, I2)	OR	AND	NOR	NAND
(0,0)	0	0	1	1
(0,1)/(1,0)	1	0	0	1
(1,1)	1	1	0	0

Table 1. NOR (or the NAND) gates logic operations

The article shows how to use the interaction between noise base and nonlinearity to design the key logic gates. In particular, the direct and flexible implementation of the basic logic gates NOR and NAND in an optimal noise band has been demonstrated, and any general computing device can be built. In addition, we demonstrate the use of nonlinearity as a logical response controller to switch logic functions [4].

References

[1] M. R. Choudhury and K. Mohanram. Reliability analysis of logic circuits. *Microelectronics Reliability*, 16(1):29–33, 1977. 1

[2] S. P. Dokouzgiannis and J. M. Kontoleon. A cubical logic circuit modelling for reliability studies. *Microelectronics Reliability*, 27(5):823–831, 1987. 1

[3] K. Murali, I. Rajamohamed, S. Sinha, W. L. Ditto, and A. R. Bulsara. Realization of reliable and flexible logic gates using noisy nonlinear circuits. *Applied Physics Letters*, 95(19):104101, 2009. 1

[4] K. Murali, S. Sinha, W. L. Ditto, and A. R. Bulsara. Reliable logic circuit elements that exploit nonlinearity in the presence of a noise floor. *Physical Review Letters*, 102(10):104101, 2009. 1