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Emitter-coupled pair chaotic generator circuit

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Abstract

An emitter-coupled pair chaotic generator is proposed with a control parameter that can be tuned for distinct chaotic behaviors. The proposed circuit is a compact, high-speed implementation of the chaotic map based on the hyperbolic tangent function. It is demonstrated that the circuit and map parameters are analytically related. As an application, we design a random number generator that passes all NIST statistical tests by applying a post-processing to the balanced bit sequence generated by a quantization of the circuit output.

Index Terms

Chaotic map, current-mode circuit, electronic circuit, random number generator, NIST statistical tests.

I. Introduction

An emitter-coupled pair (ECP) is a versatile electronic circuit found in a broad range of analogue and digital devices, including operational amplifiers, Gilbert cells, high-speed emitter-coupled logic. In this work, we show how an ECP can be used for chaos generation.

Chaos is a dynamical property of some nonlinear deterministic systems, characterized by random-like outputs and strong sensitivity to initial conditions. These properties motivate the use of chaotic signals in a variety of applications, *e.g.*, cryptography [1], multiuser digital communication [2], watermarking [3], annealing noise source [4], optical communication [5]. A one-dimensional discrete-time chaotic series $\{x_k\}_{k=0}^{\infty}$ can be generated by the iterative process

$$x_{k+1} = f(x_k) \tag{1}$$

starting from an initial condition x_0, where $f(x)$ is a chaotic map. The analogue circuits commonly used to generate discrete-time chaotic signals are based on two main approaches. The first one determines a circuit with a transfer characteristic that approximates the analytic description of the map, as for example, the logistic map [6] and the zig-zag map [7]. The other approach analyses chaotic circuits implemented using specific technologies that not necessarily admit an analytic description of the map, that is, an expression for $f(x)$ is unknown (see for example [8]). In this work, we apply the hyperbolic tangent function description of the transfer characteristic of the ECP to present a circuit implementation for the chaotic map proposed in [9], called the tanh map. The chaotic

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