

Short communication

# A multiplierless hyperchaotic system using coupled Duffing oscillators

J.S. Armand Eyebe Fouda <sup>a,1</sup>, Samrat L. Sabat <sup>b,\*</sup><sup>a</sup> Department of Physics, Faculty of Science, University of Yaoundé I, P.O. Box 812, Yaoundé, Cameroon<sup>b</sup> School of Physics, University of Hyderabad, Hyderabad 500046, India

## ARTICLE INFO

## Article history:

Received 27 November 2013

Received in revised form 1 May 2014

Accepted 3 May 2014

Available online 14 May 2014

## Keywords:

Duffing oscillator

Hyperchaos

Autonomous system

## ABSTRACT

We present a 4-dimensional electrical model for realizing a multiplierless hyperchaotic system using two Duffing oscillators with a nonlinear resistive coupling. The corresponding hyperchaotic attractor is not only numerically verified through investigating phase portraits and Lyapunov exponents spectra, but also realized experimentally by a simple electronic circuit.

© 2014 Elsevier B.V. All rights reserved.

## 1. Introduction

During the last two decades, hyperchaos has been intensively studied by the researchers in the science and engineering communities. Hyperchaos has been successfully applied in the field of secure communication, control, nonlinear circuits, etc. A system is considered to be hyperchaotic if there exists at least two positive Lyapunov exponents. Hyperchaos has the preference over ordinary low dimension chaos in practical applications like broadband signal generation, encryption and secure communication [1]. Due to its significant applications, there has been considerable interest in the design, study and circuit realization of complex hyperchaotic systems [2–8]. Designing of hyperchaotic oscillator by using lower dimension oscillator is a challenging task. Some examples of practical design have been proposed in literature [9–11] but most of them are extremely complex as they include multiplier circuits for the realization of the nonlinear element. Moreover, most of them are based on the extension of a 3-dimensional oscillator to a 4-dimensional oscillator [9,10,12]. To the best of authors knowledge there is no autonomous circuit which generates hyperchaos with a basic 2-dimensional system like the Duffing oscillator exclusively.

It has been shown that the Duffing oscillator can be used as a reference model to build complex dynamical systems [13]. Thus it is important to design and realize a hyperchaotic system using exclusively Duffing oscillators coupling.

In literature, the linear coupling of Duffing oscillator has been reported that shows complex behaviors. The transition between chaos and hyperchaos has been studied in a theoretical chain of  $N$  unidirectionally chaotically forced coupled Duffing oscillators [14]. Recently it is reported that, the linear coupling of 2-dimensional Duffing systems with no forcing term does not exhibit hyperchaos even for more than two coupling oscillators [13]. Given such importance of the Duffing system and hyperchaos, this letter presents a simple electronic circuit of an autonomous hyperchaotic oscillator constructed by

\* Corresponding author. Tel.: +91 4023134326.

E-mail addresses: [efoudajsa@yahoo.fr](mailto:efoudajsa@yahoo.fr) (J.S.A. Eyebe Fouda), [slssp@uohyd.ernet.in](mailto:slssp@uohyd.ernet.in) (S.L. Sabat).<sup>1</sup> Tel.: +237 70836099.

using two Duffing oscillators. Such a system can be useful for laboratory experiments as no forcing source is required. Our approach is based on an electrical model [15,16] where the nonlinear term was implemented using exclusively resistances and diodes. In the proposed design, first a Duffing–Duffing oscillator was designed with resistive coupling, then an electrical model was developed for such oscillator. Further stability and Lyapunov exponents spectra analysis were carried out to ensure that the circuit is hyperchaotic. At the end the phase plot of electronic circuits were analysed and confirmed that the system exhibits hyperchaotic behavior.

The rest of the paper is organized as follows: Section 2 presents the electrical model and the state space equations of the developed system, Section 3 presents the comparison between simulation and practical results while Section 4 gives some concluding remarks.

## 2. The coupled Duffing–Duffing hyperchaotic system

### 2.1. Proposed hyperchaotic circuit

The proposed Duffing–Duffing oscillator uses the basic electrical model given in [16]. Using the same model as feedback element, with some coupling resistances, the electronic circuit of the hyperchaotic system is shown in Fig. 1. The Resistance

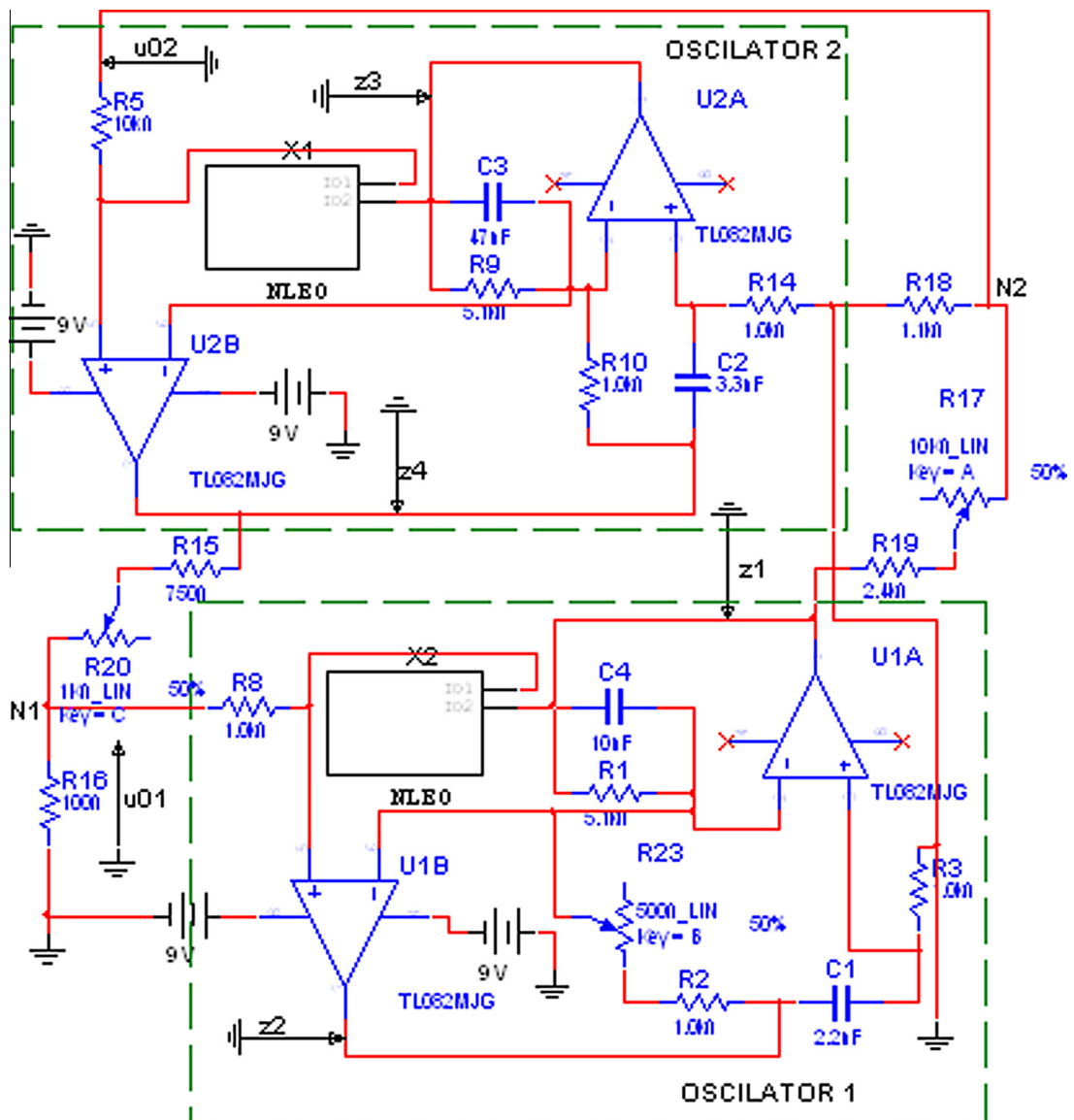


Fig. 1. Electrical model of the autonomous hyperchaotic Duffing oscillator.

Download English Version:

<https://daneshyari.com/en/article/758155>

Download Persian Version:

<https://daneshyari.com/article/758155>

[Daneshyari.com](https://daneshyari.com)