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Third-order RLCM-four-elements-based chaotic circuit and its coexisting bubbles

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Abstract

This paper presents a new third-order RLCM-four-elements-based chaotic circuit, in which the memristor element is equivalently implemented by a diode-bridge cascaded with an inductor. Mathematical model is established and its equilibrium stability is analyzed. The dynamical properties of the memristive chaotic circuit are disposed by MATLAB numerical simulations and confirmed by breadboard experimental measurements. In particular, the antimonotonicity phenomena of coexisting periodic and chaotic bubbles are observed under some specified control system parameters and the evolutions of coexisting bubbles are exhibited with the variations of two control system parameters. The presented memristive chaotic circuit is very simple and only third-order but can emerge complex dynamics with chaos, period, coexisting bifurcation modes, and coexisting bubbles.

Keywords Memristor; third-order chaotic circuit; RLCM; coexisting bubbles

1. Introduction

Recently, various physical implementations of memristors powerfully promote the developments and improvements of basic circuit fundamentals and engineering applications [1–4]. To better investigate memristor-based chaotic oscillating circuits in hardware breadboard experiments, some types of memristor emulators equivalently implemented by commercially available components have been reported in recent years [5–13], which can be mainly divided into two groups: memristor equivalent realization circuits constructed by operational amplifiers and analog multipliers [5–9], as well as memristive diode bridge cascaded with single inductor, parallel resistor and capacitor (RC) filter, parallel inductor and capacitor (LC) oscillator, or hybrid resistor, inductor, and capacitor (RLC) filter [10–13]. Based on these memristor emulators, numerous memristive chaotic oscillating circuits are consecutively proposed [5–9, 11, 12, 14–22], in which, however, most memristive oscillating circuits are at least fourth-order autonomous [5–8, 12, 14, 16, 17] or third-order non-autonomous [19–21], only few memristive oscillating circuits are third-order autonomous [9, 11, 18, 19] or second-order non-autonomous [22].

To enrich the family of the third-order autonomous memristive chaotic oscillating circuits [9, 11, 18, 19], this paper presents a new third-order RLCM-four-elements-based autonomous memristive chaotic circuit. The new memristive chaotic circuit is achieved by an active oscillator and a memristor in parallel, in which the active oscillator is combined by three elements of a negative resistor, an inductor and a capacitor, and the memristor is emulated by a memristive diode bridge cascaded with an inductor. The memristive diode bridge-based emulator was firstly reported by Corinto and Ascoli in 2012 [13]. To simplify the memristor emulator circuit topology and mathematical modeling, a simplest memristive