

## PATTERN DYNAMICS OF STOCHASTIC SYNCHRONIZATION PHENOMENA ON COUPLED MULTI-STATE CHAOTIC OSCILLATORS

MASAHIRO WADA<sup>1</sup>, MASAHIRO TANAKA<sup>1</sup> AND YOSHIFUMI NISHIO<sup>2</sup>

<sup>1</sup>Department of Intelligence and Informatics  
Konan University

8-9-1 Okamoto, Higashinada, Kobe 658-8501, Japan  
{wada-m; m.tanaka}@konan-u.ac.jp

<sup>2</sup>Department of Electrical and Electronic Engineering  
Tokushima University

2-1 Minami-Josanjima, Tokushima 770-8506, Japan  
nishio@ee.tokushima-u.ac.jp

Received February 2009; revised September 2009

**ABSTRACT.** *Nonlinear oscillators including chaotic systems are very important devices and faithful models for several dynamics. Furthermore, chaotic behavior is one of the essential components in the real world to solve a mechanism of a nonlinear dynamics in several networks. In this paper, we propose Multi-State Chaotic Circuit that includes three different states, namely, a chaotic oscillation and two limit cycles. Synchronization phenomena and complex behavior on a simple network system of the MSCCs coupled by some inductors are investigated. Stochastic behavior of several interesting chaotic phenomena of phase synchronization have been observed in the coupled network systems.*

**Keywords:** Chaos, Oscillator, Synchronization, Coupled network, Multi-state mode, Stochastic behavior

**1. Introduction.** An oscillator is an important device and one of the essential component in the real world. Nonlinear dynamics on coupled oscillators is considerably interesting for a wide variety of systems in several scientific fields and some engineering applications, especially in stochastic models. One dimensional chaotic systems are also reported in detail [1]. This is a popular mathematical model for numerical simulation. Although many types of coupled circuit systems have been widely studied in order to clarify inherent features, and many researchers have already proposed and investigated mechanism of them. The dynamics of multimode oscillations or phase synchronization on several coupled systems causes still considerable interest from the viewpoint of both natural scientific fields and several applications. They have been confirmed in several systems; e.g., coupled van der Pol oscillators [2], laser systems [3] and so on. Phase synchronization and pattern dynamics are also interesting for several engineering applications.

On the other hand, many types of chaotic systems and circuits have already been proposed and investigated in detail. As interesting phenomena, there are famous chaotic attractors such a double-scroll family [4],  $n$ -double scroll [5–7] and scroll grid attractors [8]. Several synchronization phenomena in two chaotic circuits coupled by an inductor have been investigated on the real circuit experiments and in some numerical calculations [9]. If the active elements included in the systems have complexity constructed by some compound nonlinear elements, it can be easily considered that they yield several interesting features of stochastic models.