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Chaos Propagation in Coupled Chaotic Circuits

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1. Introduction

In this study, we investigate chaos propagation in coupled chaotic circuits when one circuit is set to generate chaotic attractor and the other circuits are set to generate three-periodic attractors. Moreover, we observe how to propagate chaos by increasing the coupling strength.

2. System model

The chaotic circuit is shown in Fig. 1. This circuit consists of a negative resistor, two inductors, a capacitor and dual-directional diodes. We propose a system model in Fig. 2. In this system, 6th circuit generates chaotic attractor and the other circuits generate three-periodic attractors. In order to investigate the chaos propagation, we use two parameters of coupling strength. Each circuit is coupled by the resistor.

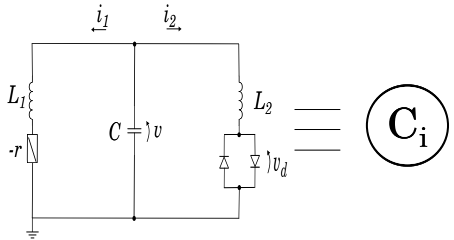

Figure 1: Chaotic circuit.

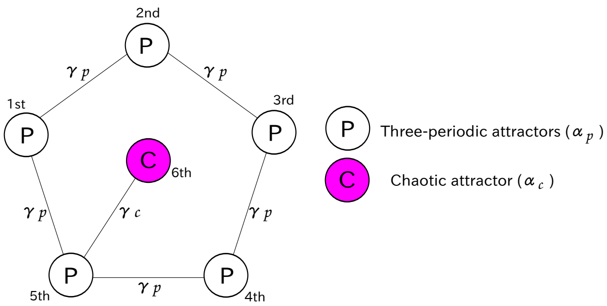

Figure 2: System model.

The normalized circuit equations of the system are given as follows:

$$
\begin{cases}
\dfrac{dx_i}{d\tau} = \alpha x_i + z_i \\
\dfrac{dy_i}{d\tau} = z_i - f(y_i) \\
\dfrac{dz_i}{d\tau} = -x_i - \beta y_i - \displaystyle\sum_{i,j=1}^{N} \gamma_{ij}(z_i - z_j) \\
\qquad\qquad (i, j = 1, 2, \cdots, N).
\end{cases}
\tag{1}
$$

In Eq. (1), N is the number of coupled chaotic circuits and γ is the coupling strength. $f(y_i)$ is described as follows:

$$
f(y_i) = \frac{1}{2}\left(\left|y_i + \frac{1}{\delta}\right| - \left|y_i - \frac{1}{\delta}\right|\right). \tag{2}
$$

The coupling strength which connected with 6th is γ_c, and the others are γ_p. We define α_c to generate the chaotic attractor, and α_p is defined to generate the three-periodic attractors.

3. Simulation results

In this study, we set the parameters of the system as $\alpha_c = 0.460$, $\alpha_p = 0.412$, $\beta = 3.0$ and $\delta = 470.0$. Figure 3 shows the initial state when all circuits are not connected. Figure 4 shows the observed attractors by increasing γ_p when we fix the coupling strength as $\gamma_c = 0.0007$. The 5th circuit is only propagated the chaotic attractor of 6th chaotic circuit (see. Fig. 4(a)). The chaotic attractor of 5th circuit propagates to both side of the neighbor circuits (see. Fig. 4(b)). The states of all circuits become the chaotic attractors (see. Fig. (c)). As a result, three-periodic attractors are affected from chaotic attractor by increasing γ_p.

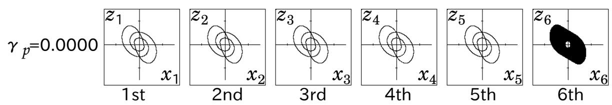

Figure 3: Chaos propagation ($\gamma_c = 0.0000$).

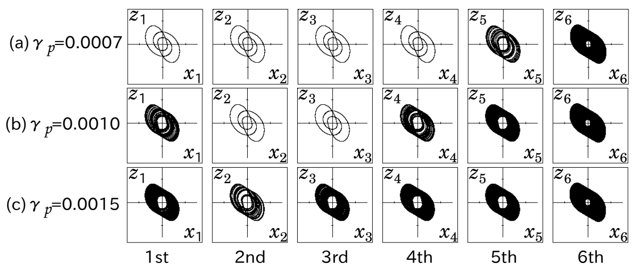

Figure 4: Chaos propagation ($\gamma_c = 0.0007$).

4. Conclusions

In this study, we have investigated chaos propagation in coupled chaotic circuits as our proposed system. By the computer simulations, We have observed that the chaotic attractor is propagated to the other circuits. The three-periodic attractors are affected from the chaotic attractors when the coupling strength increase.

As our future works, we develop the network model into cubic and more complex. Considering the other network of chaotic circuits is important subjects for us.