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Propagation of Chaos Solution and Periodic Solution in Ladder Coupled Chaotic Circuits

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1. Introduction

In this study, we investigate the state of propagation of chaotic solution and periodic solution. We propose the network model that ten chaotic circuits are coupled on the ladder structure. We use chaotic circuits which are coupled by resistors.

2. System Model

The chaotic circuit model is shown in Fig. 1. This is called Nishio-Inaba circuit. In this study, we couple ten chaotic circuits on the ladder structure. Five chaotic circuits generate three-periodic attractors and the other chaotic circuit generates chaotic attractors. Then we investigate propagation by increasing the coupling strength.

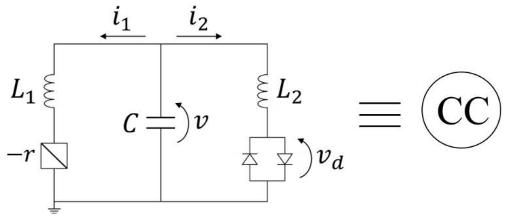

Figure 1: Chaotic circuit

Figure 2 shows the network of ten chaotic circuits which is connected by resistors.

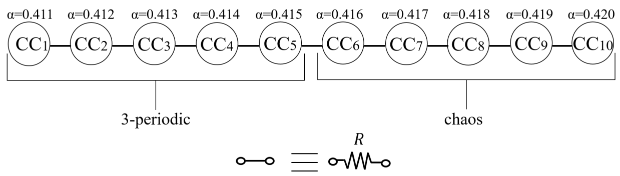

Figure 2: Network model.

The normalized circuit equations of this circuit equations are given by the following equations.

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

where $N = 1, 2, 3, ..., 10$. The parameter γ corresponds the coupling strength between the circuits. $f(y)$ is described as follows :

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

3. Simulation results

We set the parameters of the system as $\beta = 3.0$ and $\delta = 470.0$. The parameters α are set from 0.411 to 0.420 with step size 0.001. Figures 3, 4, and 5 show attractor of each chaotic circuit. When we set the coupling strength as $\gamma = 0.001$, these attractors do not propagate. In the case of $\gamma = 0.01$, chaotic attractors become three-periodic attractors. Furthermore, we set the coupling strength as $\gamma = 0.011$, chaotic attractors are propagated to all circuits.

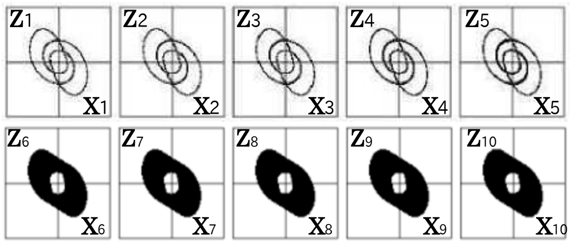

Figure 3: $\gamma = 0.001$

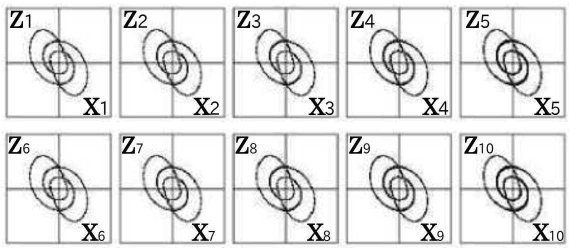

Figure 4: $\gamma = 0.01$

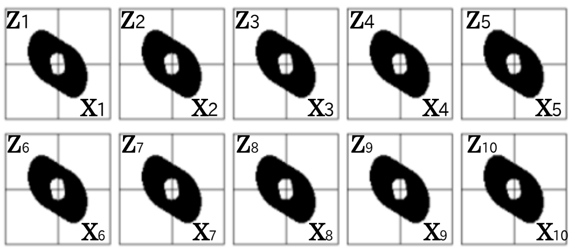

Figure 5: $\gamma = 0.011$

4. Conclusion

In this study, we have investigated propagation when we have used the chaotic circuits on the ladder structutre. In this result, we have confirmed that when we raise coupled strength up to $\gamma = 0.01$, chaotic solution becomes periodic solution. Also, chaotic solution is propagated on this network when we raise it up to $\gamma = 0.011$.