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Switching of Synchronization Phenomena in Coupled Chaotic Network

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1. Introduction

In this study, we investigate synchronization phenomena in coupled chaotic including a ladder and five ring structures. In our proposed network model, chaotic circuits are coupled by resistors. We set the bifurcation parameter of the circuits to generate periodic solutions or chaotic solutions. The ladder position is chaotic state and five ring positions are stable state. By the computer simulations, we confirm that synchronization state is switching in the model.

2. System Model

The chaotic circuit model is shown in Fig. 1. This circuit is called Nishio-Inaba circuit.

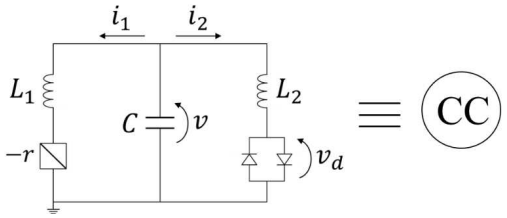

Figure 1: Chaotic circuit.

In this study, we propose network model coupled by resistors in ladder-coupled chaotic circuits including ring structure. The network model is shown in Fig. 2. Ladder position composed of CC1-CC5 generates chaotic solutions and five ring positions composed of CC6-CC20 generate periodic solutions.

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

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

where $N = 1, 2, 3, ..., 20$. 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 $\beta = 3.0$, $\delta = 470.0$ and $\gamma = 0.2$. The parameter α is changed in case of ladder and ring positions. In ladder position, α is set as 0.430, and in ring position, α is set as 0.412. In this simulation, we investigate the synchronization phenomena on our network model by using the voltage difference waveform of each circuit. When the system approaches the stable state, the waveform becomes small, and when the system approaches the unstable state, the waveform becomes large.

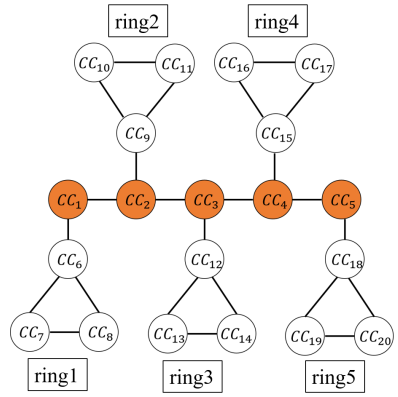

Figure 2: Network model.

As an example of simulation results, the voltage difference waveform in ring1 and ring2 is shown in Fig. 3. In our network model, the synchronization state is switched between ring. Similarly, the switching phenomena occur on other rings.

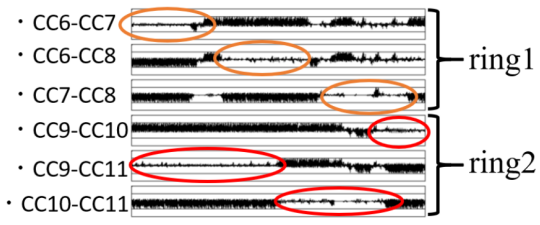

Figure 3: Voltage difference waveform of ring1 and 2.

4. Conclusion

In this study, we have proposed the network models, and we have investigated the synchronization phenomena. We have confirmed that when we couple the chaotic circuits to ladder-ring structure, the switching effect of synchronization state occur in ring structures.

In our future works, we would like to investigate the synchronization in more complex network including ladder-ring structures.