Effect of Bi-Directional Coupling Strength for Synchronization Phenomena of Chaotic Circuits

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1. Introduction

Synchronization phenomena have been discovered in nature and in other fields. Among them, synchronization phenomena in networks are an area of great interest from a scientific point of view. In addition, networks show a variety of properties depending on their different coupling strength. And it is hoped that understanding the properties of those coupling strength allow the investigation of even more detailed structures of natural and social networks. In this study, we investigate synchronization rate of two coupled chaotic circuits when coupling strength is changed in both directions as a fundamental study for analyzing the network. As the result, an interesting phenomena was observed in the change of synchronization rate.

2. System Model

Figure 1 show the circuit model. This is a Nishio-Inaba chaotic circuit.

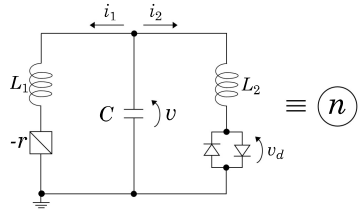

Figure 1: Nishio-Inaba circuit.

The normalized circuit equations are given as follows:

$$\begin{cases} \dot{x_i} = \alpha x_i + z_i \\ \dot{y_i} = z_i - f(y_i) \\ \dot{z_i} = -x_i - \beta y_i - \sum_{i,j=0}^{1} \gamma_{ij}(z_i - z_j). \end{cases} \tag{1}$$

Figure 2 shows the proposed system model. This is a model connecting two nodes. γ_a is defined as the coupling strength from node 0 to node 1, and γ_b is defined as the coupling strength from node 1 to node 0.

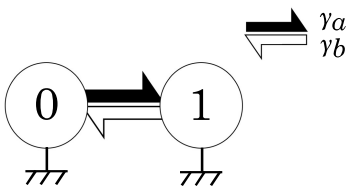

Figure 2: Proposed system model.

In this study, by using numerical simulation, two nodes are connected by a resistor to create system model in Fig. 2. It is set 6 patterns with an initial value difference of 0.01. Synchronization rate is investigated when γ_a remains unchanged to 0.20 and γ_b is changed regularly from 0 to 0.20. For the simulations, the system parameters are set to $\alpha = 0.414$, $\beta = 3.0$ and $\delta = 470$.

3. Simulation Results

Figure 3 shows the average of synchronization rate investigated at 6 patterns with an initial value.

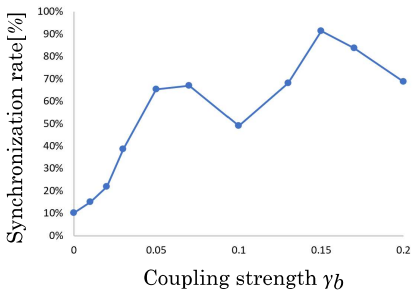

Figure 3: Average of synchronization rate.

6 patterns with an initial value resulted in similar changes in synchronization rate shows that the initial value does not have much effect on synchronization rate. Figure 3 shows that as the coupling strength increases, the synchronization rate also increases. However, when the coupling strength is maximum, the synchronization rate is not maximum.

4. Conclusion

In this study, we investigated synchronization phenomena in two chaotic circuits when the coupling strength is changed in the bi-directional. It is found that the synchronization rate changed in a similar pattern regardless of the initial value. It is also found that the synchronization rate is not proportional to the coupling strength and when the coupling strength is maximum, the synchronization rate is not maximum. In the future work, we would like to dynamically change the network for switching. In addition, I would like to increase the number of nodes closer to a social network.

Reference

[1] K. Nakabai, K. Nakashima, Y. Uwate and Y. Nishio, "Investigation of Coupled Chaotic Circuits with Ladder and Ring Structures", *Proceedings of RISP International Workshop on Nonlinear Circuits, Communications an Signal Processing (NCSP'19)*, pp.550-553, Mar. 2019.