Synchronization Phenomena by Coupled Chaotic Circuits in Three Types of Network

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I. Introduction

Complex networks attract attention from various fields. Complex networks of chaotic circuits have been studied [1]. In this study, we investigate synchronization phenomena in complex networks of coupled chaotic circuits with different degree distribution. In addition, we research difference of synchronization phenomena of each network.

II. System model

The chaotic circuit model is shown in Fig. 1. This circuit consists of a negative resister, a capacitor, two inductors and dual-directional diodes.

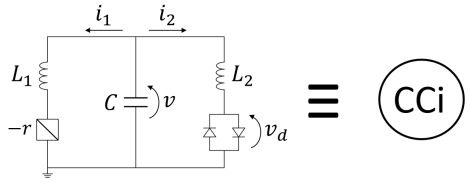

Fig. 1. Circuit model.

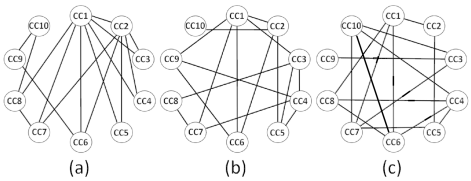

Fig. 2. Network model.

Figure 2 shows networks of coupled ten chaotic circuits which are connected by resistors. The number of nodes is fixed at 10 and the number of edges is fixed at 16. Furthermore, network model (a) is based on scale free network. Network model (b) is based on random network. Network model (c) is different from the others. The normalized circuit equations of each network are given as follows:

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

The parameter δ corresponds the coupling strength between the circuits. The parameter α is chaos degree and the parameter N is the number of circuits.

III. Simulation results

Definition of synchronization in this study is determined by a voltage difference. We define synchronization as the following equation (2).

$$|Z_j - Z_i| < 0.15 \qquad (i,j = 1,2,\cdots,10) \tag{2}$$

Synchronization rates of network model (a), (b) and (c) are shown in Fig. 3. The parameter α of each network model is fixed as 0.460 and the path length of each network model is nearly the same value at 1.8.

In this result, we confirmed synchronization rate of network model (a) is the lowest. In the coupling strength δ=0.02 to δ=0.4, synchronization rate of each network model is almost the same value. However, synchronization rate of network model (a) is the lowest in the coupling strength δ=0.05 to δ=0.1.

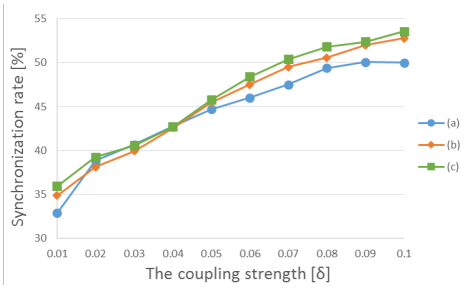

Fig. 3.Synchronization rate with different degree distribution.

IV. Conclusions

In this study, we have investigated synchronization phenomena of coupled chaotic circuits with different degree distribution by changing the coupling strength.

In this result, synchronization rate of network model based on random network is higher than that of scale free network. We considered that node with many connections is influenced variously by other nodes. Therefore, network based on scale free network is low synchronization rate.

References

[1] K.Ago, Y.Uwate, Y.Nishio, "Investigation of Synchronization in Coupled Chaotic Circuit Network with Local Bridge", IEEE Workshop on Nonlinear Circuit Networks, December 12-13, 2014.