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Synchronization Penomena of Coupled Chaotic Circuits with Different Degree Distribution

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1. Introduction

In this study, we investigate synchronization phenomena of chaotic circuits of several network topological structures by changing the coupling strength. We use chaotic circuits which are coupled by resistors. We use several network topological structures with different degree distributions.

2. System Model

The chaotic circuit model which called Nishio-Inaba circuit is shown in Fig. 1. Furthermore, the network model which we used in this study is shown in Fig. 2.

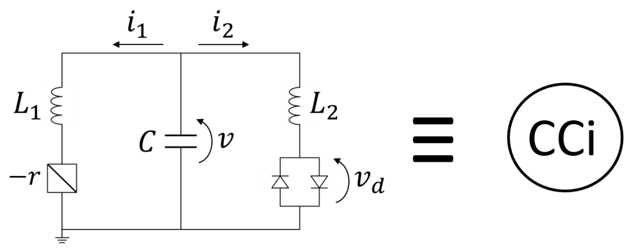

Figure 1: Circuit model.

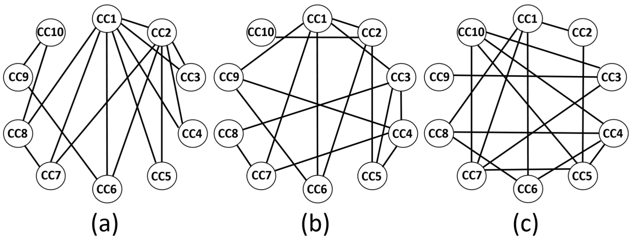

Figure 2: Network model.

Figure 2 shows ten circuits network which are connected by resistors. The normalized circuit equations of this circuit equations are given by the following equations.

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

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

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

3. Simulation results

Figure 3 (a), (b) and (c) show the degree distribution which used network in this study. The model (a) imitates the degree distribution of the power law. The model (b) imitates the degree distribution of a random network. The model (c) is the degree distribution of soaring. We fixed that the number of edges of any degree distribution is 16.

Synchronization rate of degree distribution (a), (b) and (c) is shown in Table 1. Path length of this result is nearly the same value at 1.8. Synchronization rate is almost the same in coupling strength $\delta = 0.05$. However, in the case of coupling strength $\delta = 0.1$, synchronization rate of degree distribution (a) is lower than others.

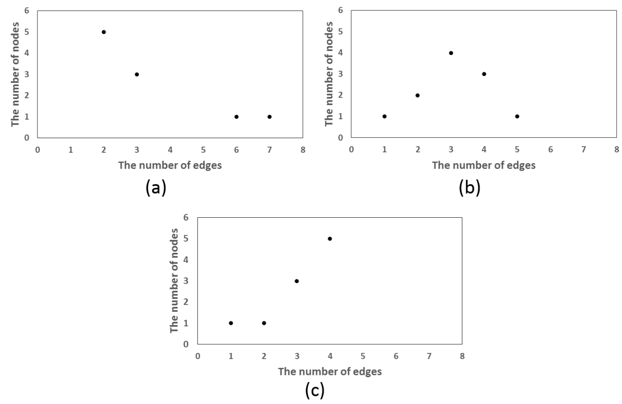

Figure 3: Degree distribution.

Table 1: Shynchronization rate with degree distribution (a), (b) and (c).

	(a)	(b)	(c)
$\delta = 0.05$	32.63%	32.94%	33.13%
$\delta = 0.1$	37.50%	40.63%	40.63%

3. Conclusion

In this study, we investigated synchronization rate of several network topology structures. The network topology structures is following degree distribution of three types.

In this result, we have confirmed synchronization rate of each degree distribution is almost the same with weak coupling strength. On the other hand, we have confirmed that synchronization rate of the models which imitate a random network and soaring are better than that of power law as coupling strength increase. In other words, we have observed that synchronization rate of the model which imitate the degree distribution of the power law is worse than others.

As our future works, we develop the network model that we add a weight to the coupling by changing the coupling strength for each circuit.