Synchronization Phenomena in Coupled Two Rings of Chaotic Circuits

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I. Introduction

Synchronization phenomena have been found in various fields of natural world [1]. In this study, we investigate synchronization phenomena of coupled two rings of chaotic circuits. In addition, we observe the synchronization phenomena by changing the coupling strength.

II. System Model

The chaotic circuit is shown in Fig. 1 and the system model is shown in Fig. 2. In this study, we couple three chaotic circuits on the ring structure and we propose a system model that the two rings are coupled via a resistor. One ring chaotic circuit generates chaotic attractors and the other ring generates three-periodic attractors. Then, we focus on synchronization phenomena of the chaotic circuits.

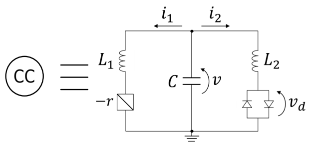

Fig. 1. Chaotic circuit.

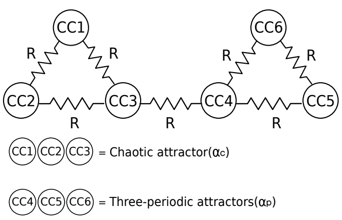

Fig. 2. System model.

The normalized circuit equations of the system are given as follows:

$$
\begin{cases}
\dfrac{dx_i}{d\tau} = \alpha x_i + z_i, \\
\dfrac{dy_i}{d\tau} = z_i - \dfrac{1}{2}\left(\left|y_i + \dfrac{1}{\delta}\right| - \left|y_i - \dfrac{1}{\delta}\right|\right), \\
\dfrac{dz_i}{d\tau} = -x_i - \beta y_i - \displaystyle\sum_{i,j=1}^{6} \gamma_{ij}(z_i - z_j) \\
\qquad (i, j = 1, 2, \cdots, 6),
\end{cases}
\tag{1}
$$

where γ is the coupling strength.

We define α_c to generate the chaotic attractor, and α_p is defined to generate the three-periodic attractors.

III. Simulation Result

We set the parameters of the system as $\alpha_c = 0.460$, $\alpha_p = 0.412$, $\beta = 3.0$ and $\delta = 470.0$. Figure 3 shows attractor of each chaotic circuit and Fig. 4 shows the difference of voltage waveform when we set the $\gamma = 0.001$. CC5 and CC6 are synchronized. Figure 5 shows attractor of each chaotic circuit and Fig. 6 shows the difference of voltage waveform when we set the $\gamma = 0.23$. Synchronous and asynchronous states change with the simulation time. Here, we make a comparison the circuits between CC1 - CC2 and CC5 - CC6. We can say that the circuits of CC1 and CC2 are more synchronized than the circuits of CC5 and CC6.

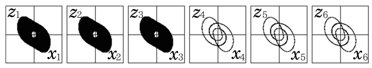

Fig. 3. Attractor ($\gamma = 0.001$).

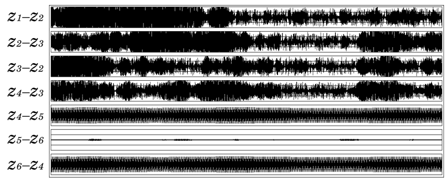

Fig. 4. Different waveform ($\gamma = 0.001$)

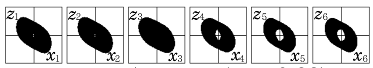

Fig. 5. Attractor ($\gamma = 0.23$).

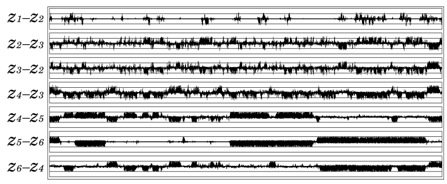

Fig. 6. Different waveform ($\gamma = 0.23$)

IV. Conclusion

We have investigated synchronization phenomena by increasing the coupling strength. As a result, we confirmed that synchronous and asynchronous states of chaotic solutions changed with the simulation time when the coupling strength γ is set to 0.23.

References

[1] C. M. Gray, "Synchronous Oscillators in Neural Systems: Mechanisms and Functions," J. Computational Neuroscience, vol. 1, pp. 11-38, Feb. 1994.