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Change of Behavior with Higher Dimensions in Four Dimensional Hyperchaotic Systems

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1. Introduction

Chaos are phenomena that are observed in our daily lives. For example, weather forecast, traffic system and so on. Further most of these phenomena in our daily lives are caused by the high-dimensional chaos that several elements are combined. Previously, the complex systems including several elements such as high-dimensional chaos are actively studied [1]. The previous study's circuit model is shown in Fig. 1. This circuit generates the hyperchaos which is a kind of high-dimensional chaos.

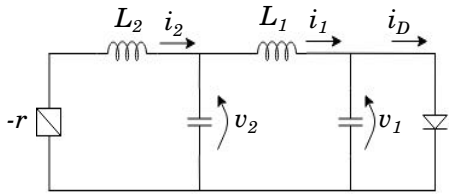


Figure 1: Previous study's circuit.

In this study, we investigate the change of chaotic attractor by changing the number of inductors and capacitors in the circuit.

2. System Model

The chaotic circuit model is shown in Fig. 2. This is the circuit in which one inductor and one capacitor are added to Fig. 1

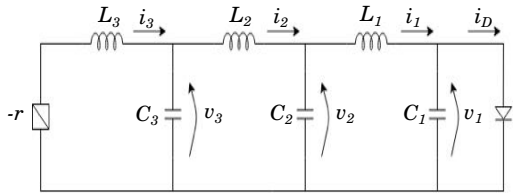


Figure 2: Proposed chaotic circuit.

The normalized circuit equations are described as follows:

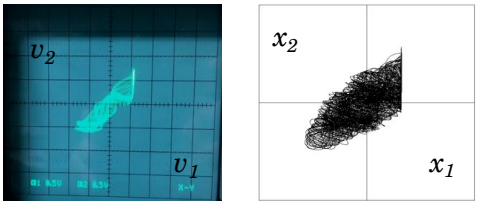
$$\begin{cases} \dfrac{dx_1}{d\tau} = x_4 - f(x_1) \\ \dfrac{dx_2}{d\tau} = \gamma_{C1}(x_5 - x_4) \\ \dfrac{dx_3}{d\tau} = \gamma_{C2}(x_6 - x_5) \\ \dfrac{dx_4}{d\tau} = x_2 - x_1 \\ \dfrac{dx_5}{d\tau} = \gamma_{L1}(x_3 - x_2) \\ \dfrac{dx_6}{d\tau} = -\gamma_{L2}x_3 + \alpha x_6. \end{cases} \tag{1}$$

where the parameter $f(x)$ is the equation for the diode and described as follows:

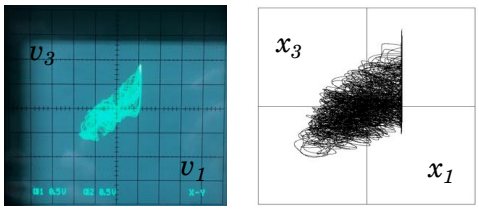
$$f(x) = \frac{1}{2}\varepsilon^{-1}\left(|x-1| + x - 1\right). \tag{2}$$

3. Results

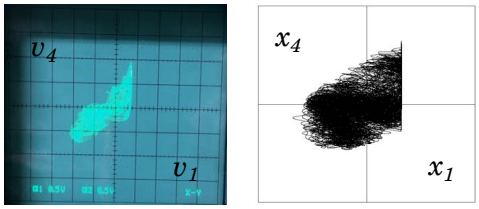
In this study, we compared the results of three circuits. Figure 3(a), 3(b) and 3(c) show the results of the circuit experiment and the simulation. Figure 3(a) shows attractor which obtained from the circuit of Fig. 1. Figure 3(b) shows attractor which obtained from the circuit of Fig. 2. Figure 3(c) shows attractor which obtained from the circuit in which one inductor and one capacitor are added to Fig. 2. We confirmed that the attractors in Fig. 3(b) and 3(c) are larger than the attractors in Fig. 3(a). Further we also confirmed that the shape of attractors has changed.



(a) Attractors obtained from the circuit of Fig. 1.



(b) Attractors obtained from the circuit of Fig. 2.



(c) Attractor obtained from the circuit in which one inductor and one capacitor are added to Fig. 2.

Figure 3: Attractor by circuit experiment and simulation.

4. Conclusion

In this study, we have investigated the change of chaotic attractor by changing the number of inductors and capacitors in the circuit. In this result, we have confirmed that the shape and size of the attractor changed by adding inductors and capacitors. That is to say, the change in dimension affects chaos.

Reference

[1] Y. Nishio, S. Mori and T. Saito "Extremely simple hyperchaos generators including one diode", *Proc. IEEE international Symposium on Circuits and Systems*, vol. 6, pp. 2797-2800, May 1992.