

Synchronization Phenomena of Three Coupled Chaotic Circuits Containing Time Delay

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1. Introduction

In this study, we investigate a ring of coupled chaotic circuits containing time delay. Especially we focus on the synchronization phenomena of our proposed circuit. By carrying out computer simulations, various types of synchronization phenomena depending on initial values can be observed. Moreover, we investigate the relationships between parameters and synchronization phenomena.

2. System model

Figure 1 shows a chaotic circuit which is containing time delay. The circuit consists of positive resistor, negative resistor and two memory elements. Chaotic phenomena can be observed in the circuit model due to time delay [1]. Figure 2 shows the three chaotic circuits coupled by the inductor. The normalized circuit equations of the system are given as follow:

(i) In case of switch connected to $-g$,

$$\begin{cases} \dot{x}_n = y_n \\ \dot{y}_n = 2\alpha y_n - x_n - \gamma(2x_n - x_{n+1} - x_{n-1}). \end{cases} \quad (1)$$

(ii) In case of switch connected to G ,

$$\begin{cases} \dot{x}_n = y_n \\ \dot{y}_n = -2\beta y_n - x_n - \gamma(2x_n - x_{n+1} - x_{n-1}) \end{cases} \quad (2)$$

$$(n = 1, 2, 3),$$

where

$$x_4 = x_1, \quad x_0 = x_3.$$

Note that α , β and γ are corresponding to negative resistor, positive resistor and coupling strength respectively.

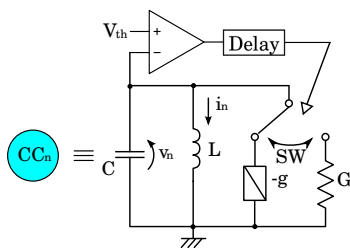


Fig. 1: Chaotic circuit.

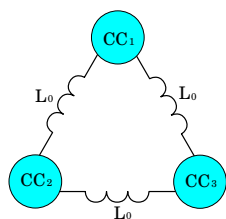


Fig. 2: Circuit model.

3. Simulation Results

Figure 3 shows simulation results. Two types of synchronization phenomena depending on initial values can be observed in the system. Figure 3 (1) and (2) show the state of 3-phase synchronization and in-phase synchronization respectively. By increasing the value of parameter β , only 3-phase synchronization is observed.

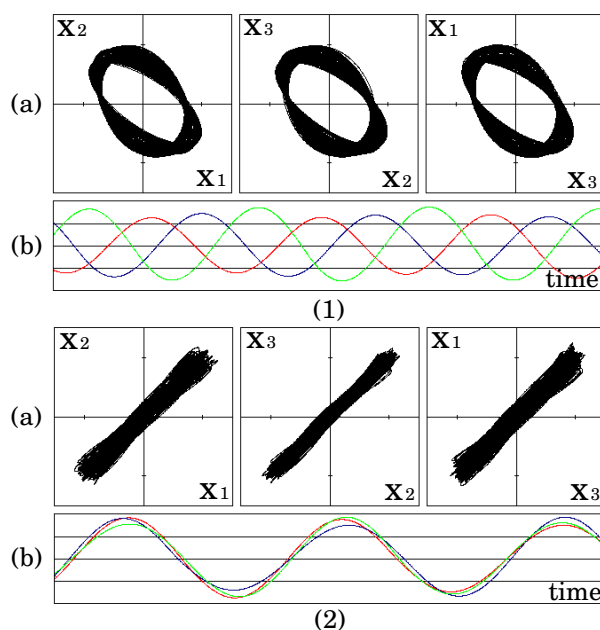


Figure 3: Simulation results. (1) 3-phase synchronization. (2) In-phase synchronization. (a) Lissajous figure. (b) Time waveform. $\alpha = 0.015$, $\beta = 0.2$ and $\gamma = 0.20$.

4. Conclusions

In this study, we investigate a ring of coupled chaotic circuits containing time delay. By carrying out computer simulations, we have observed in-phase synchronization and 3-phase synchronization phenomena depending on initial values. Moreover, the relationships between synchronization phenomena and parameters have investigated. In our future work, we will investigate in large-scale case and the basins of each synchronization.

Reference

- [1] T. Maruyama, N. Inaba, Y. Nishio and S. Mori, "Chaos in an Auto Gain Controlled Oscillator Containing Time Delay", Trans. IEICE, vol. J 72-A, pp. 1814-1820, Nov. 1989.