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Breakdown of Synchronization in Coupled Chaotic Circuits with Time-Varying Couplings

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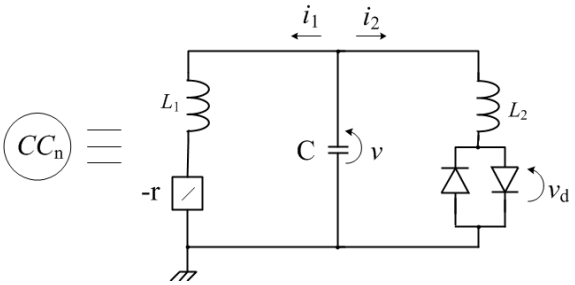
1. Introduction

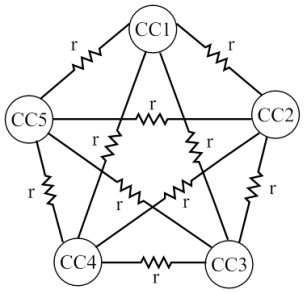
Synchronization phenomena are one of the nonlinear phenomena, and we consider that they can be expressed by using coupled oscillators. In this paper, we focus on breakdown of synchronization phenomena observed from chaotic circuits network with time-varying couplings.

2. Circuit model

Figure 1(a) shows a circuit model used in this study. The circuit consists of a negative resistance, a nonlinear resistance consisting of two diodes, capacitor and two inductors. This circuit is called Nishio-Inaba chaotic circuit. The circuit model of fully-coupled chaotic circuits is shown in Figure 1(b) . In this system, the coupling between the circuits is cut off one by one at random every 25τ in the computer simulation.



(a) Nishio-Inaba chaotic circuit.



(b) System model (n=5).

Figure 1: Circuit model.

The normalized circuit equations of fully-coupled system are given as:

$$\dot{x} = \alpha x_i + z_i \quad (1)$$

$$\dot{y} = z - f(y) \quad (2)$$

$$\dot{z} = -x_i - \beta y_i - \gamma_{ij} \sum_{i=1}^{n} (z_i - z_j) \quad (3)$$

$$(i, j = 1, 2, \cdots n)$$

where f(y) is described as follows:

$$f(y) = \frac{\delta}{2}(|y + \frac{1}{\delta}| - |y - \frac{1}{\delta}|). \quad (4)$$

The variables and parameters are shown as follows;

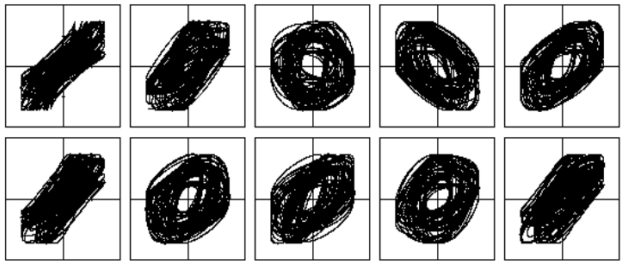
$$i_1 = \sqrt{\frac{C}{L_1}} Vx; \quad i_2 = \frac{\sqrt{L_1 C}}{L_2} Vy; \quad v = Vz;$$

$$\alpha = r\sqrt{\frac{C}{L_1}}; \quad \beta = \frac{L_1}{L_2} \quad \delta = r_d \frac{\sqrt{L_1 C}}{L_2};. \quad t = \sqrt{L_1 C}\tau.$$

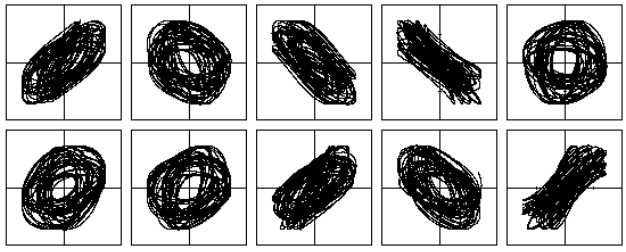
3. Simulation Result

Figure 2 (a) and (b) show the simulation results of the phase difference. For the simulation, we set the parameters as α=0.41, β=3.0, γ=470, andδ=0.05.

We confirm the changing of synchronization state by increasing the number of cut-off couplings. Namely, the ratio of asynchronous increases with the simulation time.



(a) τ=2575.



(b) τ=4800.

Figure 2: Simulation results of phase difference.

4. Conclusions

In this study, we focused on breakdown of synchronization phenomena of the chaotic circuit network with time-varying couplings. By using the computer simulations, we have observed the interesting synchronization phenomena.

In the future works, we would like to investigate the mechanism of observed synchronization phenomena in detail.