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Investigation of Oscillation Frequencies of Coupled Chaotic Circuits

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1. Introduction

Synchronous discrimination of the chaotic circuit uses the phase difference generally. Not only the phase difference but also period and oscillation frequency exist in the coupled chaotic circuits. We pay attention to oscillation frequency in the coupled chaotic circuits. We consider that entire circuits synchronize when oscillation frequency included in a certain circuit converges on a certain value. In this study, we compare synchronous discrimination by using phase difference and oscillation frequency.

As simulation result, we confirm that synchronous state of chaotic circuits has no relationship with the oscillation frequency, although oscillation frequency converges on a steady value conclusively. Next, we compare timing of synchronization of among the coupled chaotic circuits. We investigate whether there is relationship in the timing of synchronization as we determine synchronous state of circuit by using oscillation frequency or phase difference.

2. Circuit model

We use chaotic circuits called Nishio-Inaba circuit [1]. We consider a ladder network using chaotic circuits as shown in Fig. 1.

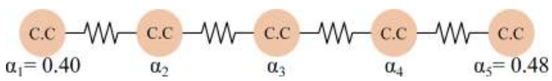

Figure 1: Setting condition of parameter α_n (n = 5, α_2=α_3=α_4=the variable).

Normalized equation of coupled chaotic circuits is described as follow,

$$\begin{cases} \dot{x_n} = \alpha x_n + z_n. \\ \dot{y_n} = z_n - f(y_n). \\ \dot{z_n} = -x_n - \beta y_n + \sigma(z_(n+1) - z_n), \\ \qquad\qquad (n = 1) \\ \dot{z_n} = -x_n - \beta y_n + \sigma(z_(n-1) - z_n), \\ \qquad\qquad (n = the\ maximum\ value) \\ \dot{z_n} = -x_n - \beta y_n + \sigma(z_(n+1) + z_(n-1) - 2z_n), \\ \qquad\qquad (otherwise) \end{cases} \tag{1}$$

For this simulation, the parameters are set as follows, $\beta_n = 3.0$ and $\gamma_n = 470.0$. Own oscillation frequency and phase difference of the chaotic circuits depend on the parameter α. Each circuit is assigned α to investigate transition of oscillation frequency when the chaotic circuits are synchronized. Parameter α is fixed value $0.40 \leq \alpha \leq 0.48$. In addition, the parameter α_1 and α_n located in both ends of coupled chaotic circuit are fixed $\alpha_1 = 0.40$ and $\alpha_n = 0.48$ to make it easier to compare transition of oscillation frequency.

3. Simulation results

Figure 2 shows transition of oscillation frequency when the coupling strength is changed.

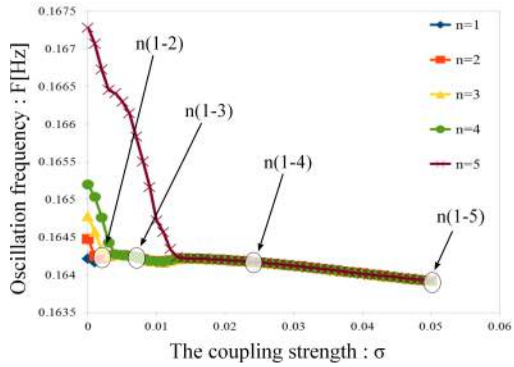

Figure 2: Transition of oscillation frequency when the value of α are set equability($\alpha_2 = 0.41$, $\alpha_3 = 0.435$, $\alpha_4 = 0.46$).

We set parameters $\alpha_2 = 0.41$, $\alpha_3 = 0.435$, $\alpha_4 = 0.46$. From Fig. 2, $n(a - b)$ is indicated circuit state between circuit number a and b. In addition, we surround the coupling strength with circle when the phase difference is below 30 degrees. Each circuit does not synchronize when oscillation frequency converges on a steady value. And, oscillation frequencies are obtained a stable value before entire circuit becomes synchronization.

Next, we pay attention to timing of synchronization of among the coupled chaotic circuits. Timing of synchronization are investigated using oscillation frequency and the phase difference. As a result, timing of synchronization between oscillation frequency and phase difference has no relationship.

4. Conclusions

In this study, we investigated oscillation frequencies of two coupled chaotic circuits. We confirmed that frequency became closer to a value when synchronization state was changed from asynchronous into synchronous, and there is no similarity in each timing. From these, we confirm that synchronous state of chaotic circuits has no relationship with the oscillation frequency.

References

[1] Y. Nishio, N. Inaba, S. Mori and T. Saito, “Rigorous analyses of windows in a symmetric circuit,” IEEE Trans. Circuits Syst., Vol. 37, No. 4, pp. 473-487, 1990.