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Investigation of Oscillation Frequencies of Two Coupled Chaotic Circuits

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1. Introduction

The synchronization is observed as not only natural phenomena but also in various fields. There are a lot of methods to confirm synchronization phenomena. Change of frequency when synchronization state is changed from asynchronous into synchronous has not been investigated so far. In this study, we investigate oscillation frequencies of two coupled chaotic circuits.

2. Circuit model

Figure 1 shows the circuit model. This circuit model uses two Nishio-Inaba circuits. Each circuit is connected by a resistor.

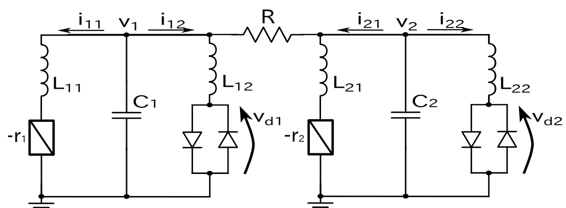

Figure 1: Circuit model.

We can derive the following normalized equations:

$$\begin{cases} \dfrac{dx_i}{d\tau} = \alpha_i x_i + z_i \\ \dfrac{dy_i}{d\tau} = \beta_i z_i - \dfrac{1}{2}|\sigma_i y_i + \beta_i| - |\sigma_i y_i - \beta_i| \\ \dfrac{dz_1}{d\tau} = \gamma_1(z_2 - z_1) - x_1 - y_1 \\ \dfrac{dz_2}{d\tau} = \gamma_2(z_1 - z_2) - x_2 - y_2 \qquad (i = 1, 2). \end{cases} \tag{1}$$

For this simulation, we set the parameters as $\alpha_1 = 0.40$, $\alpha_2 = 0.43$, $\beta_1 = \beta_2 = 3.0$ and $\gamma_1 = \gamma_2 = 470.0$, and choose the coupling strength $\sigma = \sigma_1 = \sigma_2$ as a control parameter.

3. Simulation results

We carry out computer simulations by changeing σ. First, phase difference for the coupling strength are shown in Fig. 2. The synchronization state changes from asynchronous into synchronous when we increase the coupling strength σ. Second, we measure average value of rotational frequency when the solution of chaotic attractor goes around the origin in the phase space. These frequencies are shown in Table 1. F_l is defined as the average frequency of the left circuit. F_r is defined as the average frequency of the right circuit. Finally, we investigate oscillation frequencies of two coupled chaotic circuits. Figure 3 shows comparison of the average frequencies.

As the simulation results, the frequency become closer to a value as synchronization state becomes synchronous.

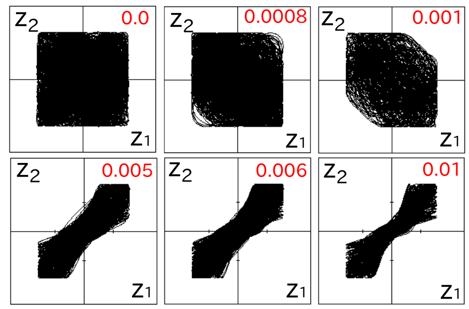

Figure 2: Phase difference.

Table 1: Average frequencies for coupling strength.

σ	F_l	F_r
0.0	6.07234496	6.08772683
0.0008	6.08972963	6.07588755
0.001	6.08995372	6.07703460
0.005	6.08447759	6.08443127
0.006	6.08444278	6.08445819
0.01	6.08458218	6.08480852

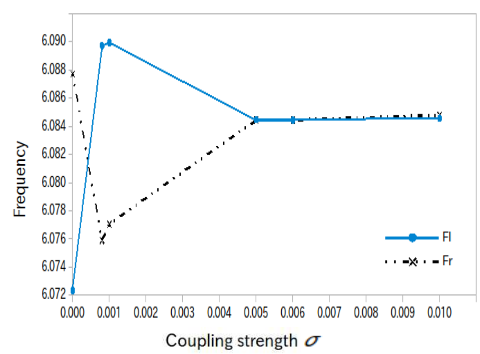

Figure 3: Comparison of average frequencies.

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.

In the future work, we intend to analyze the detailed change of the average frequencies numerically when we increase the number of circuits. Additionally, we would like to raise precision.