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Chaos Synchronization by Chaotic Signal with Suppressed Frequency Components

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1. Introduction

Recently, the momentum to apply chaos to engineering system is risen and various fundamental studies are performed. A study of chaos synchronization is one of them. In various fields such as communication and cryptography, chaos application systems that use chaos synchronization and have good advantages that conventional systems do not have are studied actively[1].

In this study, we consider transferring chaotic signal observed from a driving side to a response side when the signal is suppressed by the channel with frequency dependency. We investigate the synchronization phenomenon between both sides.

2. Circuit Model

Figure 1 shows a circuit model. In the circuit, the chaotic signal of Shinriki-Mori chaotic circuit of a driving side is suppressed by the lowpass filter and sent to a response side.

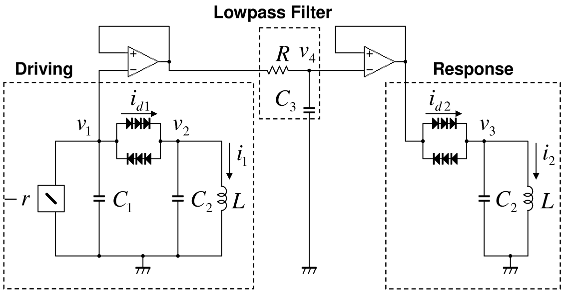

Figure 1: Circuit model.

By changing the variables and the parameters,

$$\begin{aligned} & t=\sqrt{LC_2}\tau, \quad \text{“}\cdot\text{”}=\frac{d}{d\tau}, \\ & i_1=V\sqrt{\frac{C_2}{L}}z_1, \quad i_2=V\sqrt{\frac{C_2}{L}}z_2, \\ & v_1=Vx_1, \quad v_2=Vy_1, \quad v_3=Vy_2, \quad v_4=Vx_2, \\ & \alpha=\frac{C_2}{C_1}, \quad \beta=\frac{1}{r}\sqrt{\frac{L}{C_2}}, \quad \gamma=\frac{1}{RC_3}\sqrt{LC_2}, \\ & \delta=G_d\sqrt{\frac{L}{C_2}}, \end{aligned} \tag{1}$$

the circuit equations of the driving side are normalized as follows;

$$\begin{cases} \dot{x_1}=\alpha(\beta x_1-f(x_1-y_1)) \\ \dot{y_1}=f(x_1-y_1)-z_1 \\ \dot{z_1}=y_1 \end{cases} \tag{2}$$

The circuit equations of the response side are normalized as follows;

$$\begin{cases} \dot{x_2}=\gamma(x_1-x_2) \\ \dot{y_2}=f(x_2-y_2)-z_2 \\ \dot{z_2}=y_2 \end{cases} \tag{3}$$

where the $i-v$ characteristics of the nonlinear resistor consisting of diodes are normalized as follows;

$$f(x_k-y_k)=\begin{cases} \delta(x_k-y_k+1) & (x_k-y_k<-1) \\ 0 & (|\,x_k-y_k\,|\le 1) \\ \delta(x_k-y_k-1) & (x_k-y_k>1) \end{cases} \tag{4}$$

where k =1, 2. In the following computer calculations, we set parameters as follows; α=0.5, β=0.6, δ=100.0.

3. Computer Calculated Results

Figure 2 shows computer calculated results. Figure 2(1) shows attractors of driving side and Fig. 2(2) shows phase differences. For example, we can see that chaotic signal of driving side is synchronized with chaotic signal after passing the lowpass filter from Fig. 2(2-c). Moreover, we can confirm that the driving and the response sides are gradually synchronized as the parameter γ becomes large.

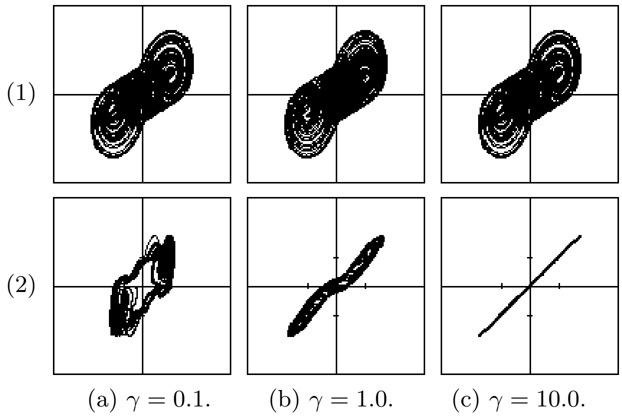

Figure 2: Computer calculated result.
(1) x_1 vs. z_1. (2) x_1 vs. x_2.

4. Conclusions

In this study, we investigated what kind of influence was given to chaos synchronization by chaotic signal with suppressed frequency components.

In the future, we investigate chaos synchronization observed from a circuit model with more sophisticated filters.

Reference

[1] Junji KAWATA, Yoshifumi NISHIO and Akio USHIDA, “On the Influence of Transmission Line on Communication System Using Chaos Synchronization,” Proceedings of IEEE International Symposium on Circuits and Systems (ISCAS’97), vol. 2, pp. 897-900, Jun. 1997.