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Synchronization of Chaos Circuits Coupled by LC Circuit

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1. Introduction

Many nonlinear dynamical systems in various fields have been confirmed to exhibit chaotic oscillation.

Synchronization of chaos observed in coupled chaotic systems attract many researchers' attentions, because such a phenomenon includes many unsolved interesting behavior and at the same time possesses possible future engineering applications.

There have been many researches on chaos synchronizations. We also have investigated chaotic circuits coupled by a resistor, an inductor, and a transmission line.

In this study, we investigate two simple chaotic circuits coupled by LC circuit.

2. Circuit Model

The chaotic circuit used in this study was proposed by Inaba [1]. We investigate two Inaba circuits combined like Fig. 1 by LC circuit.

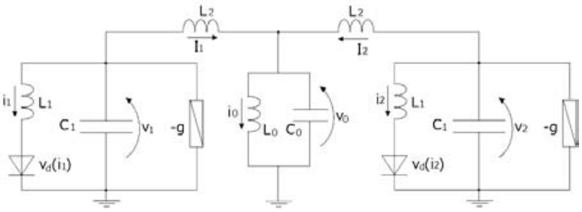

Figure 1: Two Inaba circuits coupled by LC circuit.

We can derive the normalized state equations of the Inaba circuit coupled by LC circuit as follows.

$$\begin{cases} \dfrac{dx_n}{d\tau} = z_n - \dfrac{\alpha}{2}\left(x_n + \dfrac{1}{\alpha} - \left|x_n - \dfrac{1}{\alpha}\right|\right) \\ \dfrac{dy_n}{d\tau} = z_n - \delta\omega_2 \\ \dfrac{dz_n}{d\tau} = -x_n - \beta y_n + \gamma z_n \\ \dfrac{d\omega_1}{d\tau} = \delta\omega_2 \\ \dfrac{d\omega_2}{d\tau} = \beta(y_1 + y_2) - \varepsilon\omega_1 \end{cases} \quad (1)$$

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

where variables and parameters are defined by the following equations.

$$i_n = \sqrt{\frac{C_1}{L_1}}Vx_n\ , I_n = \frac{\sqrt{L_1C_1}}{L_2}Vy_n\ , v_n = Vz_n$$

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

$$i_0 = \frac{\sqrt{L_1C_1}}{L_0}V\omega_1\ , v_0 = \frac{C_1}{C_0}V\omega_2$$

$$\alpha = r\sqrt{\frac{C_1}{L_1}}\ , \beta = \frac{L_1}{L_2}\ , \gamma = g\sqrt{\frac{L_1}{C_1}}\ , \delta = \frac{C_1}{C_0}\ , \varepsilon = \frac{L_1}{L_0}$$

In the circuit equations, the parameters α, β, and γ are bifurcation parameters of each Inaba circuit, and the parameters δ and ε express the coupling capacitor and inductor, respectively.

3. Simulation results

We fixed the parameters α= 4.0, β= 0.1, and γ= 0.27, and investigate the influence of the coupling parameters δ and ε on synchronization. Figure 2 shows two examples of computer simulation results. In the figures, the attractors of the left Inaba circuit, the attractor of the right Inaba circuit, and the synchronization state between the two Inaba circuits from the left. The parameter δ seems to control the synchronization ability. Namely, for smaller δ the two circuits do not synchronize. For relatively large δ the circuits start to synchronize as shown in Fig. 2. However, for large δ, the synchronization breaks down and the attractors diverge. Moreover, the parameter ε seems to control the synchronization states. Namely, for smaller ε the two circuits tend to synchronize at in-phase as shown in Fig. 2(a), while for larger ε they tend to synchronize at anti-phase as shown in Fig. 2(b).

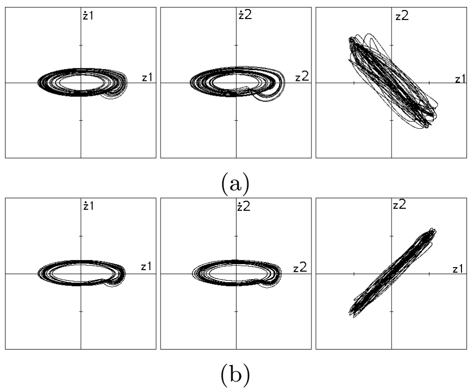

Figure 2: Synchronization of chaos. α=4.0, β=0.1, γ=0.27, δ=0.7. (a) In-phase synchronization for ε=0.5. (b) Anti-phase synchronization for ε=1.0.

4. Conclusions

In this study, we investigated the synchronization of two Inaba circuit coupled by LC circuit. By carrying out computer calculations and circuit experiments, we observed two different types of chaos synchronization and investigated the effect of the coupling parameters.

References

[1] N. Inaba and S. Mori, "Chaotic Phenomena in a Circuit with a Diode due to the Change of the OScillation Frequency," Trans of IEICE, vol. E71, no. 9, pp. 842-849, Sep. 1988.