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Synchronization of Chua's Circuits with Transmission Lines

Yuki Nakaaji Yoshifumi Nishio
Tokushima University

1 Introduction

Recently, several researchers have investigated synchronization of chaotic circuits. Chua's circuit is one of the simplest autonomous chaotic circuits. Chua's circuit consists of a resistor, a capacitor, a nonlinear resistor and an LC resonator.

We have already confirmed that the two Chua's circuit with transmission lines could be synchronized by the effect of the cross talk [1].

In this study, we investigate the synchronization of the two Chua's circuits linked by the cross talk in detail, especially, paying our attentions to the breakdown of chaos synchronization.

2 Circuit Model

We model the transmission lines placed in parallel by the circuit shown in Fig. 1. In this model, the effect of the crosstalk is given by the connections via coupling mutual inductors.

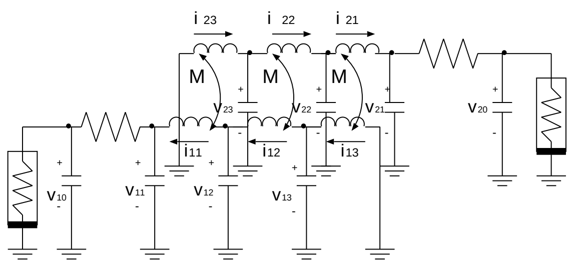


Figure 1: Circuit Model.

We can obtain the normalized circuit equations of Fig. 1 as follows:

$$
\begin{aligned}
\dot{x_{k0}} &= x_{k1} - x_{10} - f(x_{k0}) \\
\dot{x_{k1}} &= \alpha(y_{k1} - x_{k1} + x_{k0}) \\
\dot{x_{k2}} &= \alpha(y_{k2} - y_{k1}) \\
\dot{x_{k3}} &= \alpha(y_{k3} - y_{k2}) \\
\dot{y_{k1}} &= \gamma(x_{k2} - x_{k1}) - \beta(-y_{(k+1)3}) \\
\dot{y_{k2}} &= \gamma(x_{k3} - x_{k2}) - \beta(y_{(k+1)3} - y_{(k+1)2}) \\
\dot{y_{k3}} &= \gamma(-x_{k3}) - \beta(y_{(k+1)2} - y_{(k+1)1})
\end{aligned}
\qquad (1)
$$

where $y_{31} = y_{11}$ and (k=1, 2).

$$
\begin{aligned}
f(x_{k0}) &= c x_{k0} + \frac{1}{2}(a-b)(|x_{k0}+1| - |x_{k0}-1|) \\
&\quad + \frac{1}{2}(b-c)(|x_{k0}+d| - |x_{k0}-d|), \qquad (2)
\end{aligned}
$$

$$
t = R_1\tau, \quad \text{“}\cdot\text{”} = \frac{d}{d\tau}, \quad v_{kj} = B_{p1}x_{kj}, \quad i_{kl} = \frac{B_{p1}}{R_1}y_{kl},
$$

$$
\alpha = \frac{C_{10}}{C}, \beta = \frac{R_1^2 C_{10} M}{(L_{2l}-M)(L_{1l}-M)-M^2},
$$

$$
\gamma_k = \frac{R_1^2 C_{10}(L_{k+1}-M)}{(L_2-M)(L_1-M)-M^2},
$$

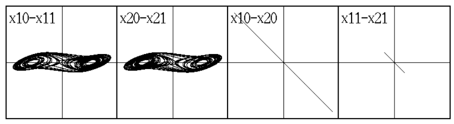
where $L_3 = L_1$, (k=1, 2), (l=1, 2, 3) and (j=1, 2, 3, 4).

3 Simulation Result

In the following simulations, we fix the parameters as follows:

$$
a = -1.2, \quad b = -0.75, \quad c = 10, \quad d = 8,
$$

$$
\alpha = 5.4, \quad \gamma = 0.3. \qquad (3)
$$



M = 3 and β = 1.37.

Figure 2: Simulation results of cross talk via mutual inductor M.

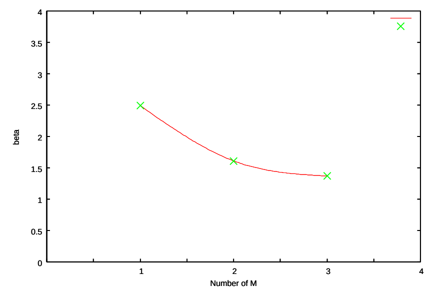


Figure 3: Coupling parameter at which the synchronization breaks down.

Figure 3 shows computer simulation results. The vertical axis shows coupling parameter at which the synchronization breaks down. And the horizontal axis shows the number of mutual inductor M.

We confirmed that the the number of mutual inductor M and coupling parameter at which the synchronization breaks down are in the relation of inverse proportion.

4 Conclutions

In this study, we have considered the two Chua's circuits with lossless transmission lines placed in parallel. We have modeled the effect of the cross talk by mutual inductors. By computer simulations, we have investigated various interesting phenomena related with chaos synchronization.

References

[1]Y. Nakaaji and Y. Nishio, "Synchronization of Chaotic Circuits with Transmission Line " *Proc. of NCSP'06*, pp.353-356. 2006.