1-4

Simple Chaotic Oscillator Composed RC Circuits and Square Wave Generator

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1. Introduction

In this study, we investigate a chaotic oscillator composed RC circuits and square wave generator. By computer simulations, we show the attractor, waveform and bifurcation diagram of proposed circuit.

2. Circuit model

Figure 1 shows the circuit model in this study. Two RC circuits are coupled via comparators of operational amplifiers. The square wave is inputted to the other input terminals of the comparators. The comparators produce the output voltage $\pm E$ which is their power supply voltage, according to the input signals.

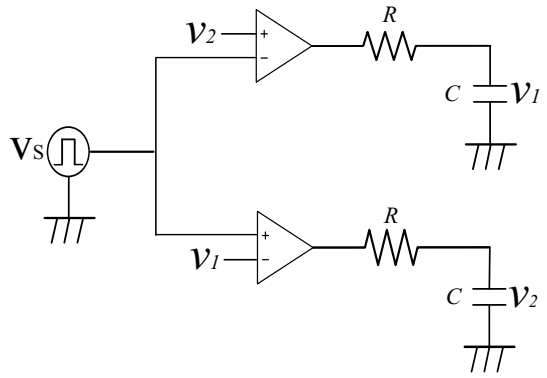


Figure 1: Circuit model.

The exact solutions of normalized circuit equations are described as follows:

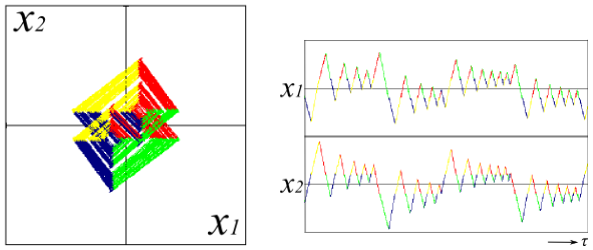
$$x_1 = \begin{cases} (x_{10}-1)e^{-\tau}+1 & (x_2 > \alpha) \\ (x_{10}+1)e^{-\tau}-1 & (x_2 < \alpha) \end{cases}$$

$$x_2 = \begin{cases} (x_{20}-1)e^{-\tau}+1 & (x_1 > \alpha) \\ (x_{20}+1)e^{-\tau}-1 & (x_1 < \alpha) \end{cases} \quad (1)$$

where α is the parameter corresponding to V_s and β is the parameter corresponding to T. x_{10} and x_{20} are initial values.

3. Simulation results

We show the chaotic attractor and waveform which are obtained by computer calculation as shown Fig. 2. The parameter of α is 0.06 and β is 4.0. The step size of τ is 0.01. In order to modify an error, we use a method of bisection.



(a)　(b)

Figure 2: Simulation results. (a)Attractor. $x_1 - x_2$. (b)Waveform. $x_1 - x_2$.

We observe that the state equations are changed as shown Fig. 2. Red, blue, green and yellow colors denote the case of x_1 and x_2 are lager than V_α, x_1 and x_2 are smaller than V_α, x_1 is larger than V_α and x_2 is smaller than V_α and x_1 is smaller than V_α and x_2 is larger than V_α respectively. From these results, there is the periodicity of changing state equation on the proposed circuit.

Figure 3 shows the one parameter bifurcation diagram when α is changed from 0 to 0.1. The vertical axis shows x_1 and the horizontal axis shows α. Parameter step is 0.01, plotted time is 2000[τ] and β is 4.0. When the plus or minus sign is changed, the value of x_1 is plotted on bifurcation diagram.

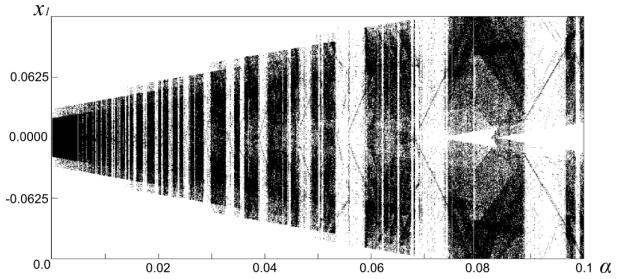


Figure 3: Bifurcation diagram.

Bifurcation phenomena of periodic orbits and chaos are observed from Fig. 3.

5. Conclusions

In this study, we have investigated a simple chaotic oscillator composed two RC circuits and square wave generators. We have confirmed that there is the periodicity of changing state equation on the proposed circuit. And, bifurcation phenomena of periodic orbits and chaos are observed.