Simple Chaotic Oscillator Using Four RC Circuits

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1. Introduction

Recently, study of chaos research has been done in various fields. The features of chaos are sensitivity on initial values and its complexity, and draw attentions because of wide possible applications. In the field of electrical and electronic engineering, there are many studies using a simple chaotic oscillator. Even if each circuit is a simple, various interesting phenomena occur by combining them. Hence, it is very important to propose simple chaos oscillators and to investigate them. In our previous study, we have proposed a simple chaotic oscillator using two RC circuits [1].

In this study, we extend the circuit in the previous research to the circuit with more RC circuits in order to increase the application capability of the chaotic oscillators. Circuit experiments with four RC circuits confirm the generation of chaos.

2. Circuit model

Figure 1(a) shows the circuit model. In the circuit, four RC circuits are coupled via simple comparators. The rectangular voltage 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.

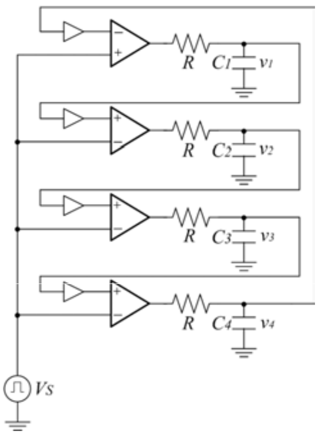


Figure 1: Circuit model.

We assume that the input signal is the rectangular voltage with the amplitude of V_S and the period of T_S. The circuit equations are derived as follows:

$$RC\frac{dv_1}{dt} = \begin{cases} -v_1 - E & (v_4 > V_S) \\ -v_1 + E & (v_4 < V_S) \end{cases} \tag{1}$$

$$RC\frac{dv_k}{dt} = \begin{cases} -v_k + E & (v_{k-1} > V_S) \\ -v_k - E & (v_{k-1} < V_S) \end{cases} \tag{2}$$

$$(k = 2, 3, 4)$$

By using the following variables and the parameters,

$$v_n = Ex_n,\ t = RC\tau,\ V_S = E\alpha,\ T_S = RC\beta \tag{3}$$

$$(n = 1, 2, 3, 4)$$

we obtain the normalized circuit equations. Because the circuit equation is linear in each region, the exact solutions can be derived as follows:

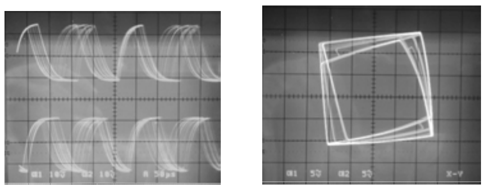
$$x_1 = \begin{cases} (x_{10} - 1)e^{-\tau} - 1 & (x_4 > \alpha) \\ (x_{10} - 1)e^{-\tau} + 1 & (x_4 < \alpha) \end{cases} \tag{4}$$

$$x_k = \begin{cases} (x_{k0} - 1)e^{-\tau} + 1 & (x_{k-1} > \alpha) \\ (x_{k0} - 1)e^{-\tau} - 1 & (x_{k-1} < \alpha) \end{cases} \tag{5}$$

$$(k = 2, 3, 4)$$

3. Circuit experimental results

We carry out circuit experiment for the simple chaotic oscillator using four RC circuits. Figures 2(a) and 2(b) show the results. Figure 2(a) is an example of time waveforms of v_1 and v_3. Figure 2(b) shows the attractor on $v_1 - v_3$ plane. We can see that the oscillation is chaotic and that the attractor looks like a rectangular shape.



(a) (b)

Figure 2: Circuit experimental results. (a) Time waveform. (b) Attractor.

4. Conclusions

In this study, we have proposed a simple chaotic oscillator using four RC circuits. We implemented the proposed circuit and carried out circuit experiments. We observed chaotic attractor from the circuit.

In the future works, we will carry out computer simulations and theoretical analysis for the proposed circuit. Also, we will investigate what kind of chaos appears as increasing the number of RC circuits.

References

[1] S. Masuda, Y. Uchitani and Y. Nishio, "Simple Chaotic Oscillator Using Two RC Circuits," Proc. of NCSP'09, pp. 89-92, 2009.