Chaotic Oscillator Using Two RC Circuits

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***Abstract*— In this study, a simple chaotic circuit using two coupled RC circuits are proposed. We have confirmed that the circuit generates chaotic oscillation by both computer calculations and circuit experiments.**

I. Introduction

There have been many simple circuits exhibiting chaotic oscillations. In particular, simple oscillators excited by periodic signals can be a good circuit model to study the mechanism of chaos generation, because some of them can be analyzed in a rigorous way. In [1], Tang et al. investigated a simple multivibrator with periodic pulse and explained the generation of chaos using one-dimensional map. Torikai et al. proposed a chaotic pulse generator realized by an oscillator and a periodic signal and also controlled the generated chaos [2].

In this study, we propose a simple chaotic oscillator using two RC circuits. In the circuit model, the two RC circuits are coupled via comparators whose input is controlled by external periodic signal. Computer simulations and circuit experiments confirm the generation of chaos.

II. Circuit model

Figure 1 shows the circuit model. In the circuit, two RC circuits are coupled via simple comparators of operational amplifiers. The rectangular voltage wave is inputted to the other input terminals of the comparators and the comparators produce the output voltage $\pm E$ which is their power supply voltage according to the input signals. Figure 2 shows the

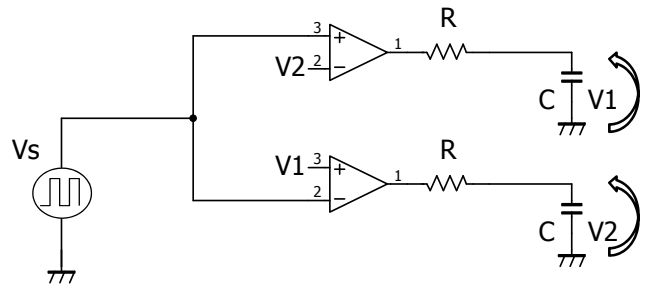


Fig. 1. Circuit model.

rectangular voltage wave inputted to the comparators. The circuit equations are described as follows.

$$\begin{aligned} RC\frac{dV_1}{dt} &= -V_1 \pm E \\ RC\frac{dV_2}{dt} &= -V_2 \pm E \end{aligned} \tag{1}$$

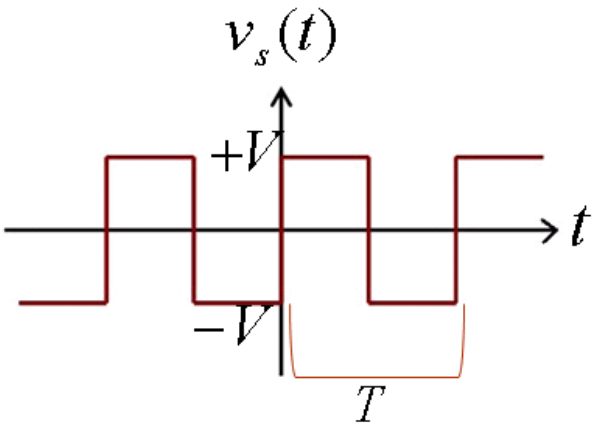


Fig. 2. Rectangular voltage wave.

By using the following variables and the parameters,

$$v_1 = E\,x_1, \quad v_2 = E\,x_2, \quad t = RC\,\tau, \tag{2}$$

the normalized circuit equations are given as follows.

$$\begin{aligned} \frac{dx_1}{dt} &= -x_1 \pm 1 \\ \frac{dx_2}{dt} &= -x_2 \pm 1 \end{aligned} \tag{3}$$

Because the circuit equation is linear in each region, the exact solution can be derived as follows.

$$\begin{aligned} x_1 &= k_1 e^{-\tau} \pm 1, \\ x_2 &= k_2 e^{-\tau} \pm 1, \end{aligned} \tag{4}$$

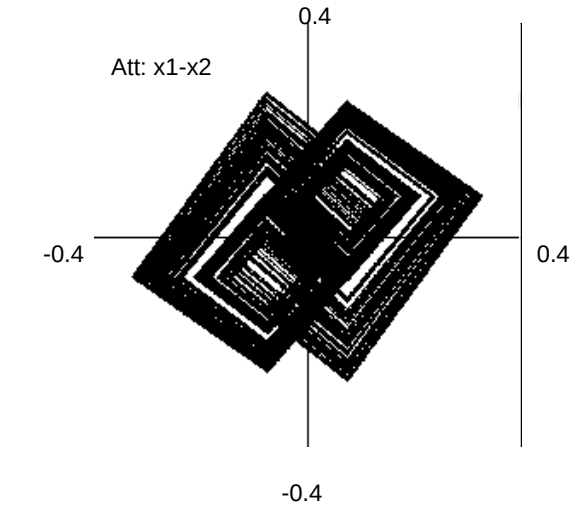
where k_1 and k_2 are the arbitrary constants and $\pm$ are decided according to the outputs of the comparators.

III. Computer calculated results

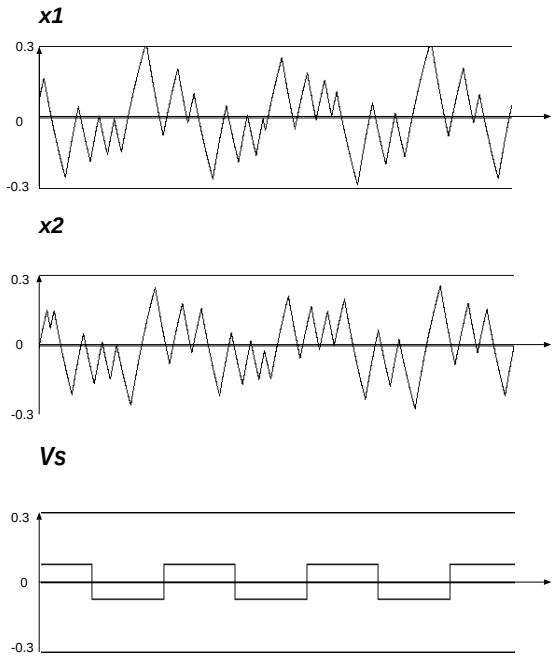
Figures 3(a) and (b) show computer calculated results for $V/E = 0.075$ and $T/RC = 3.0$. We can confirm that the circuit exhibits chaos.

IV. Circuit experimental results

Figures 4(a) and (b) show circuit experimental results for C = 47μF and R = 1.2Ω. These results agree well to the computer calculated results.



(a)

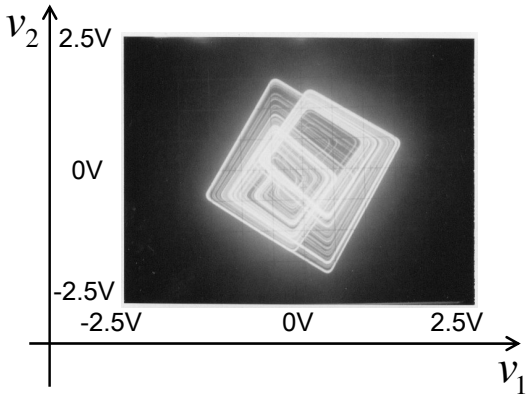


(b)

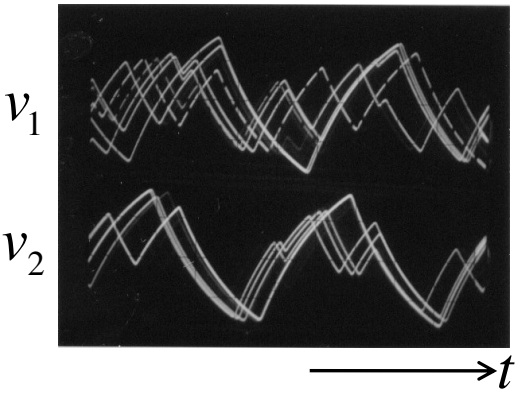
Fig. 3. Computer simulation results. (a) Attractor x_1–x_2. (b) Time waveform.

V. Conclusions

In this study, we have proposed a simple chaotic oscillator using two RC circuits. Computer simulations and circuit experiments confirmed the generation of chaos.



(a)



(b)

Fig. 4. Computer simulation results. (a) Attractor x_1–x_2. (b) Time waveform.

Acknowledgments

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References

[1] Y.S. Tang, A.I. Mees and L.O. Chua, "Synchronization and Chaos," *IEEE Trans. Circuits Syst.*, vol. 30, no. 9, pp. 620-626, Sep. 1983.

[2] H. Torikai, T. Saito and W. Schwarz, "A Chaotic Pulse Generator and Sawtooth Control for Information Processing," *IEEE ISCAS 1997*, pp. 729-732, Jun. 1997.