1-1

Chaotic Attractors Observed in RC Phase Shift Oscillator and Pulse Generator

Yoshinori DOIKE Yoko UWATE Yoshifumi NISHIO
(Tokushima University)

1. Introduction

In this study, we propose new chaotic circuit. The proposed model is composed of RC phase shift oscillators using operational amplifier and pulse generators. We carry out computer calculation and circuit experiment in order to verify the validity of the proposed model.

2. Circuit model

Figure 1 shows the circuit model in this study. The proposed model is composed of RC phase shift oscillator with an operational amplifier and a pulse generator.

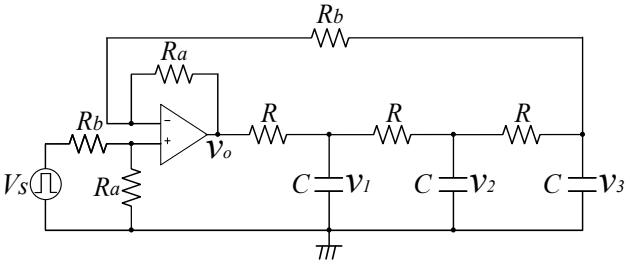
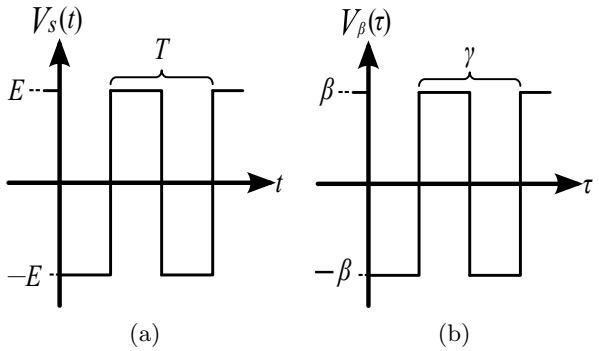


Figure 1: Circuit model.

The following equation of the approximated input-output characteristic of the deffer amplifier is described as follows:

$$v_o = \frac{1}{2}\left\{|\alpha(V_S - v_3) + E| - |\alpha(V_S - v_3) + E|\right\}. \quad (1)$$

Figure 2(a) shows the input voltage waveform $V_S(t)$. V is the amplitude of the pulse voltage and T is the period of the waveform. Figure 2(b) shows the normalized voltage waveform $V_\beta(\tau)$. V_β corresponds to V_S, γ corresponds to T and τ corresponds to t.



(a) (b)

Figure 2: Input voltage waveforms.

The circuit equations are described as follows:

$$\begin{aligned} RC\frac{dv_1}{dt} &= -2v_1 + v_2 + v_o \\ RC\frac{dv_2}{dt} &= v_1 - 2v_2 + v_3 \\ RC\frac{dv_3}{dt} &= v_2 - v_3. \end{aligned} \quad (2)$$

By using the following variables and the parameters,

$$v_1 = Ex,\ , v_2 = Ey,\ v_3 = Ez,$$
$$t = RC\tau,\ \alpha = \frac{R_a}{R_b},\ V_S = E\beta,\ T = RC\gamma,$$

the normalized circuit equation is described as follows:

$$\begin{aligned} \frac{dx}{dt} &= -2x + y + f(z) \\ \frac{dy}{dt} &= x - 2y + z \\ \frac{dz}{dt} &= y - z. \end{aligned} \quad (3)$$

where $f(z)$ is a piecewise-linear function corresponding to (1) and is described as

$$f(z) = \frac{1}{2}\left\{|\alpha(\beta - z) + 1| - |\alpha(\beta - z) + 1|\right\}. \quad (4)$$

3. Results

We show the chaotic attractors which are obtained by computer calculation and circuit experiment as shown Fig. 3.

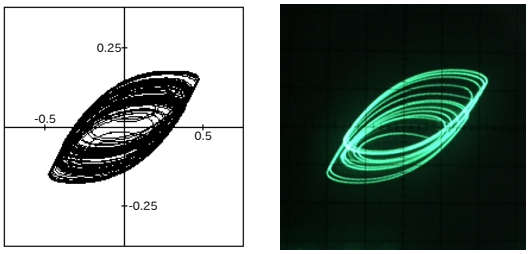


Figure 3: The chaotic attractors of x vs y. (a) Computer calculation ($\alpha = 50, \beta = 0.03$, and $\gamma = 8.0$). (b) Circuit Experiment ($R = 10[k\Omega], R_a = 750[k\Omega], R_b = 15[k\Omega], C = 103[nF], V_S = 0.3[V]$ and $f = 140[Hz]$).

5. Conclusions

In this study, we have investigated new chaotic circuit composed of RC phase shift oscillator with an operational amplifier and a pulse generator. We have carried out computer calculation and circuit experiment. From computer simulations and circuit experiments, we have verified the validity of the proposed model.