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Investigation of Chaos-Generating Circuit Composed of RL Circuits

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1. Introduction

Recently, chaos phenomena attract many researchers' attentions. In the field of electrical and electronic engineering, various applications using chaos have been proposed. To implement these systems, we have to understand chaos phenomena in detail. In this study, simple chaotic circuits using two coupled RL circuits are proposed. We observe the generation of interesting chaotic phenomenon.

2. Circuit model

Figure 1 shows the circuit model. In this circuit, two RL 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(a) shows the rectangular voltage waveform $V_S(t)$. $E\alpha$ is the amplitude of the rectangular voltage and T is the period of the waveform. E is the output voltage of the comparators, namely the DC supply voltage of the operational amplifiers.

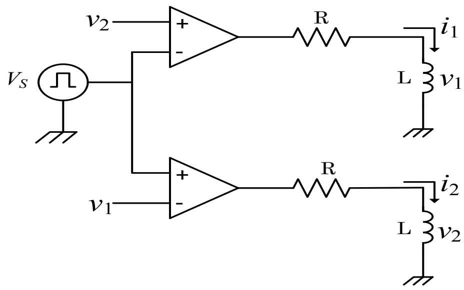
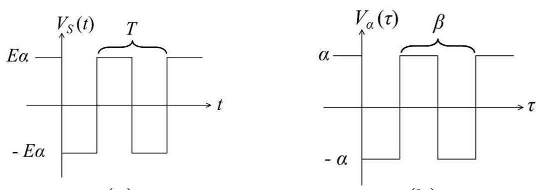


Figure 1: Circuit model.



(a) (b)

Figure 2: Rectangular voltage waveform.

By using the following variables and the parameters,

$$v_n = Ex_n,\ t = RC\tau,\ T = \frac{R}{L}\beta,\ (n = 1, 2)$$

the normalized circuit equations are given as follows.

$$x_1 = \begin{cases} (x_{10} - \dfrac{R_L + R}{R})e^{-\tau} + \dfrac{R_L}{R} & (x_2 > V_\alpha) \\ (x_{10} + \dfrac{R_L + R}{R})e^{-\tau} - \dfrac{R_L}{R} & (x_2 < V_\alpha) \end{cases}$$
$$x_2 = \begin{cases} (x_{20} + \dfrac{R_L + R}{R})e^{-\tau} - \dfrac{R_L}{R} & (x_1 > V_\alpha) \\ (x_{20} - \dfrac{R_L + R}{R})e^{-\tau} + \dfrac{R_L}{R} & (x_1 < V_\alpha). \end{cases} \quad (1)$$

where V_α corresponds to V_S and is shown in Fig. 2(b), x_{10}, x_{20} are initial values and R_L is internal resistance of L.

3. Computer calculated results

Figures 3 and 4 show computer calculated results for $V_\alpha = 0.0005$, $\beta = 22$ $R_L = 17$ and $R = 1000$. We observe chaos phenomenon.

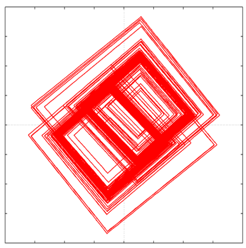


Figure 3: Attractor $x1 - x2$.

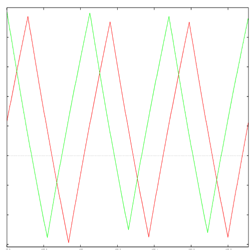


Figure 4: Waveform.

4. Circuit experimental results

Figures 5 and 6 show circuit experiment results for $R_1 = 1.003[k\Omega], R_2 = 1.005[k\Omega]$, $R_{L1} = 14.61[k\Omega], R_{L2} = 14.93[k\Omega]$ and $f = 110[kHz], V_S = 6[V]$. We observe chaos phenomenon.

Figure 5: Attractor $v1 - v2$.

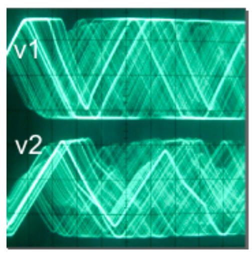


Figure 6: Waveform.

5. Conclusions

In this study, we have proposed a simple chaotic oscillator including two RL circuits. We have confirmed that the circuit generated chaotic oscillation by both computer calculations and circuit experiments.