Phase Change of Three Coupled Chaotic Circuits to Input Signals

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Abstract— **In this study, the synchronization state of a three-phase coupled chaotic circuit with an external sinusoidal input signal is investigated by circuit experiments. As a result, it is confirmed that the synchronization state changes when the amplitude of the sinusoidal input signal is varied.**

Keywords; Synchronization; Chaotic circuit;

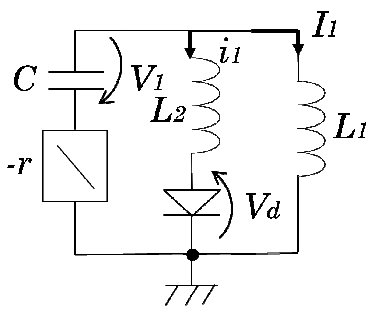
I. INTRODUCTION

Synchronization phenomena can be found in various aspects of daily life. A typical example is the oscillation of a metronome. Research on engineering applications of chaos has also attracted the attention of many researchers. Encoding and compounding of communications, synchronization phenomena in neurons of the human brain, etc. is observed and are expected to be applied to computers in the brain. Furthermore, the observation and analysis of phenomena using electric circuits is one of the most useful tools because it can be applied to actual physical systems. Therefore, it is very important to study synchronous phenomena in chaotic circuits for future engineering applications. In a previous study, synchronization phenomena were investigated when input signals are added to two chaotic circuits coupled by resistors [1]-[4].

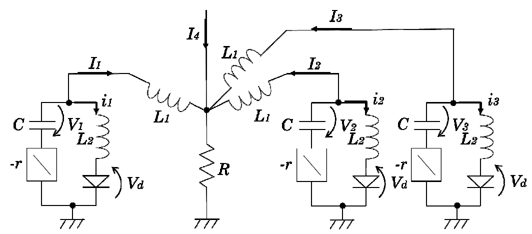
In this study, a coupled three-phase chaos circuit is created by coupling three chaos circuits, and synchronization phenomena are investigated when an external sinusoidal signal is added to the circuit system. Specifically, a sinusoidal signal with the amplitude and frequency of the current of a chaotic circuit is used as the standard input signal. The synchronization phenomenon is investigated when the amplitude of this sinusoidal input signal is varied. Current waveforms are obtained from circuit experiments.

II. SYSTEM MODEL

The chaotic circuit used in this study is shown in Fig.1(a). The circuit in Fig.1(a) is a 3-D autonomous circuit that generates the chaos shown in Fig.2 and proposed by Inaba and Mori [5]. This circuit consists of a negative resistor, two inductors, a capacitor, and a diode. In the circuit shown in Fig.1(b), the three Inaba circuits are coupled by a single coupling resistor R. The input signal is added to the coupling resistor as a current I_4. In this study, we investigate the synchronization phenomenon when the amplitude of the sinusoidal input signal is varied using the circuit experiment. The amplitude of the sinusoidal input signal I_4 is A_m.



(a) Chaotic circuit.



(b) Coupled three chaotic circuits with input signal.

Figure 1. System Model.

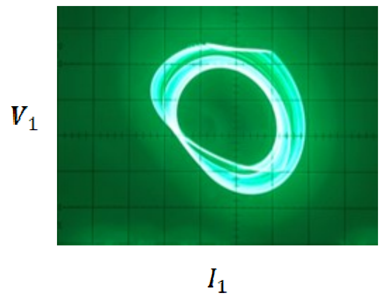


Figure 2. An example of chaotic attractors.

III. RESULTS

Figures 3, 4, and 5 show the results using circuit experiments. A sinusoidal signal with the amplitude and frequency of the current of the chaotic circuit is used as the standard value. The amplitude of the current in that sinusoidal signal is set to 2.5 [mA]. The amplitude is varied by a factor of 0, 1, and 2 to investigate how the phase changes.

A. In the case of no input signal

Figure 3 shows the result of no input signal. It is found the three chaos circuits are almost synchronized in three phases.

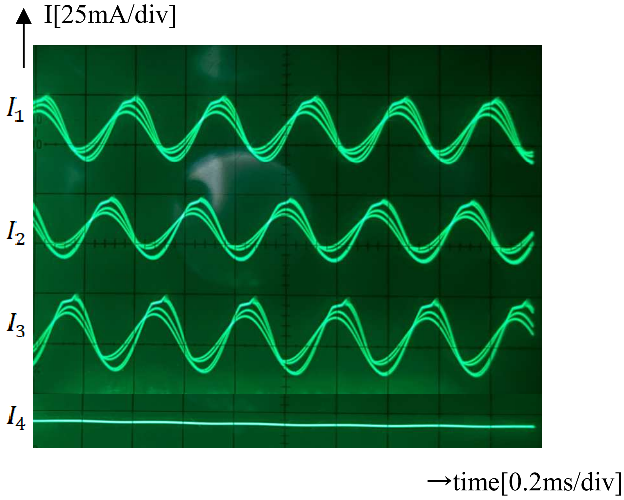


Figure 3. In the case of no input signal current characteristics. L_1=100mH, L_2=10mH, C=33nF and R=110Ω.

B. In the case of the standard input signal

Figure 4 shows the result of the standard input signal. It is found that the three chaotic circuits and the sinusoidal signal are synchronized in almost four phases under the influence of the input signal.

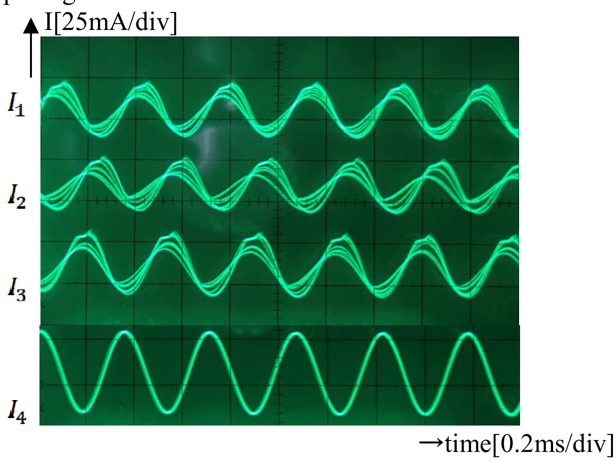


Figure 4. In the case of the standard input signal current characteristics. L_1=100mH, L_2=10mH, C=33nF and R=110Ω.

C. In the case of about doubled amplitude of the standard input signal

Figure 5 shows the result of doubled amplitudes. It is found that under the influence of the input signal, the two chaotic circuits are nearly synchronized, while one chaotic circuit and the sinusoidal signal are nearly antiphase synchronized.

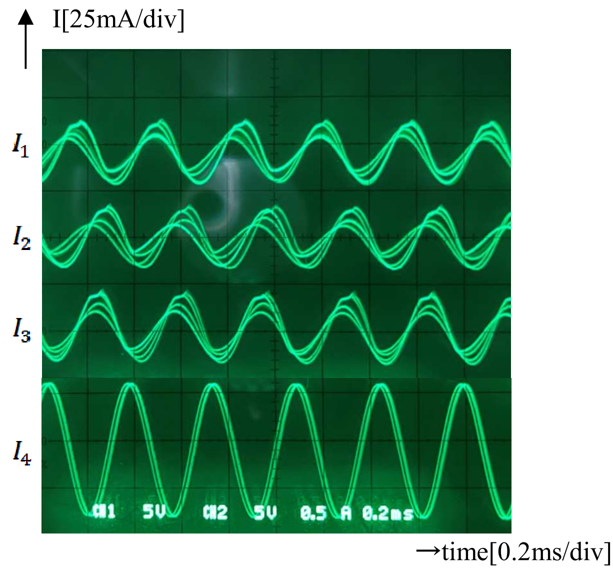


Figure 5. In the case of about doubled amplitude of the standard input signal current characteristics. L_1=100mH, L_2=10mH, C=33nF and R=110Ω.

IV. CONCLUSIONS

In this study, we investigated the synchronization state of a coupled three-phase chaotic circuit with input signals using circuit experiments. The synchronization state changes with the value of the amplitude of the input signal, a sinusoidal signal. It is found a new synchronization phenomenon, especially when the amplitude is doubled. As a future work, we would like to investigate the case when the value of angular frequency is varied and when the input signal is a square wave signal.

V. REFERENCES

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