17-55

Coexistence in van der Pol Oscillators Coupled by Fifth-Power Nonlinear Resistor

Yoko Uwate and Yoshifumi Nishio
(Tokushima University)

1. Introduction

Coexistence of attractors in coupled oscillatory systems is important for applying them to novel parallel information processing systems. Generally, in two oscillators coupled by a resistor, only one synchronization state becomes stable even if plural states exist. In this study, two van der Pol oscillators coupled by a fifth-power nonlinear resistor are investigated. By computer calculations and circuit experiments, interesting synchronization phenomena can be confirmed to be generated in this system. Fist, we observe the coexistence of in-phase and anti-phase synchronizations.

2. Circuit Model

Figure 1 shows the circuit model. In this circuit, two identical van der Pol oscillators are coupled by a fifth-power nonlinear resistor.

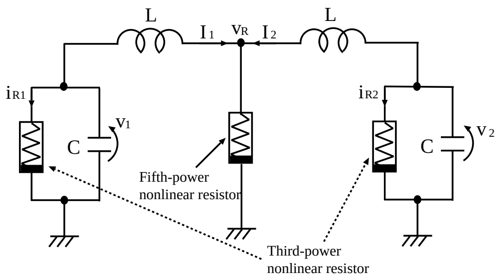


Figure 1: Circuit model.

The normalized circuit equations are given as following equation:

$$\begin{cases} \dfrac{dx_k}{d\tau} = -y_k + \varepsilon(x_k - \beta\zeta x_k^3) \\ \dfrac{dz_k}{d\tau} = x_k - \alpha\{(y_1+y_2) - \beta(y_1+y_2)^3 + (y_1+y_2)^5\} \\ \qquad\qquad\qquad\qquad\qquad\qquad (k=1,2) \end{cases} \tag{1}$$

where ε is the strength nonlinearity, α is the coupling factor.

3. Synchronization Phenomena

In our proposed system, the coexistence can be observed. This is very novel phenomena in two coupled oscillators. The simulation result of the coexistence of in-phase and anti-phase synchronization is shown in Fig. 2. Next, we investigate the phase difference when the two parameters β and ζ are changed. This simulated results are shown in Fig. 3. In this figure, the black color means the in-phase state and the yellow color means the anti-phase state. We can observe the anti-phase state everywhere in these parameter area. Namely, the in-phase state area corresponds to the coexistence area.

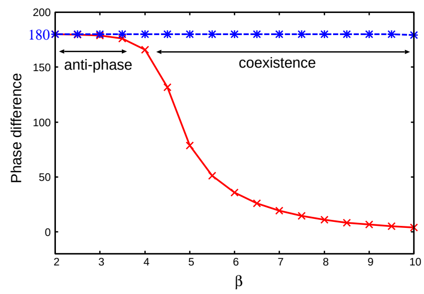
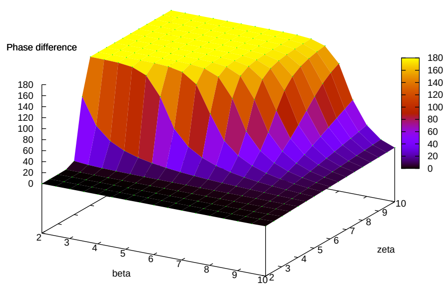
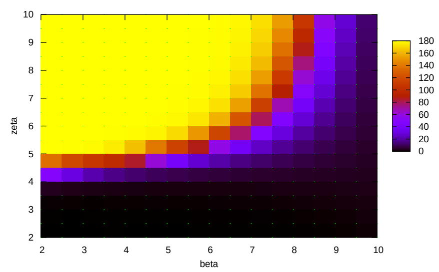


Figure 2: Phase difference for $\varepsilon = 0.4$, $\alpha = 0.002$ and $\zeta = 5.0$.



(a) 3d plot.



(b) 2d plot.

Figure 3: Phase difference for $\varepsilon = 0.4$ and $\alpha = 0.002$ (β vs ζ).

4. Conclusions

We confirmed the coexistence of in-phase and anti-phase synchronization in two van der Pol oscillators coupled by a fifth-power nonlinear resistor. Furthermore, the influence of the coupling strength and nonlinearity of the van der Pol oscillator was investigated.

References

[1] Y. Uwate and Y. Nishio, "Switching phase states of chaotic circuits coupled by time-varying resistor," *Proc. of ISCAS'07*, pp.209-212, May. 2007.