Eploiting Non-Attractive Chaotic Invariant Set for Circuit Control.

Exploiting Non-Attractive Chaotic Invariant Set for Circuit Control

Luiz Felipe Ramos Turci
Instituto Tecnológico de Aeronáutica – ITA - Dpto. de Sistemas e Controle
São José dos Campos – SP - Brasil
felipeturci@yahoo.com.br

Elbert. E. N. Macau
Laboratório Associado de Computação e Matemática Aplicada – LAC
Instituto Nacional de Pesquisas Espaciais – INPE
São José dos Campos – SP - Brasil
elbert@lac.ita.br

Takashi Yoneyama
Instituto Tecnológico de Aeronáutica – ITA - Dpto. de Sistemas e Controle
São José dos Campos – SP - Brasil
takashi@ita.br

Extended Abstract

Power electronics engineers frequently encounter phenomena as sub-harmonic oscillations, jumps, quasi-periodic operations, bifurcations and chaos, despite not knowing what causes them, (di Bernardo and Tse, 1999). Most power supply engineers would have experienced bifurcation phenomena and chaos in switching regulators when some parameters (e.g., input voltage and feedback gain) are varied, but usually do not examine the phenomena in detail. The usual reaction of the engineers is to
avoid these phenomena by adjusting component values and parameters, often through some trial-and-error procedure.

However, knowing many previously unused nonlinear operating regimes as chaos may be profitably exploited for useful engineering applications, provided that such operations are thoroughly understood.

Many of the studies about chaos control are focused on the dynamic presented in systems attractors [1,2,4,7,8]. It is important to recognize, however, that there are other types of invariant sets in the dynamical systems that are not attracting, and that these non-attracting invariant sets also play a fundamental role in the understanding and prediction of dynamics.

These non-attracting invariant sets are called chaotic saddles, which are responsible for different system behaviors as chaotic transients (Rempel and Chian, 2003), basin boundary, chaotic scattering and interior crisis-induced intermittency [5,9,10].

As in the chaotic attractors, in chaotic saddles there are also an infinity number of unstable fixed points (periodic orbits) that once reached, the system will stay in that orbit. But, differently from chaotic attractors, chaotic saddles are non-attractive invariant sets and it's not possible for the system to reach a chaotic saddle fixed point naturally.

A simple diode circuit consisted of a sinusoidal input voltage signal; an inductor, a resistor, and a diode providing the nonlinearity for the system can exhibits a wide range of nonlinear phenomena as saddle-node bifurcations, period doubling route to chaos, interior crisis and inclusively it can presents chaotic saddles.

We show in this work, how this simple circuit can have a rich dynamic, with the presence of chaotic saddles; and we explore the chaotic saddle influence on system dynamic to control the system.

Keywords: Attractors, Chaotic Saddle, Chaos, Diode Circuit, Control.

References

[1] Baker, G. L., “Control of the Chaotic Driven Pendulum”, Am. J. of Physics, v. 63 (9), 832, 1995.

[2] Boccaletti, S.; Grebogi, C.; Lai, Y.-C.; Mancini, H.; Maza, D., “The Control of Chaos: Theory and Applications”, Physics Reports, 329, p. 103, 2000.

[3] di Bernardo, M.; Tse, C. K., “Chaos in Power Electronics: An Overview”.

[4] Ditto, W. L.; Spano, M. L.; Lindner, J. F., “Techniques for the Control of Chaos”, Physica D, vol. 86, p. 198, 1995.

[5] Ott, E., “Chaos in Dynamical Systems”, Cambridge Univ. Press, Cambridge, 1993.

[6] Rempel, E.L.; Chian, A.C.-L., “High- Dimensional Chaotic Saddles in the Kuramoto- Sivashinky Equation”, Physics Letters A., 319, p. 104, 2003.

[7] Sadler, R., “Control of Chaos”.

[8] Shimazaki, H., “Topics in Chaos Control Theory”.

[9] Szabó, K. G.; Lai, Y.-C.; Tel, T.; Grebogi, C., Physica D, Ver. E 61, p. 5019, 2000.

[10] Ziemniak, E. M.; Jung, C.; Tél, T., Physica D, vol. 36, p. 137, 1989.

This work is supported by FAPESP.