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Chaos Phenomena in DC-DC Converter and Chaos Control

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Abstract

Chaos is a kind of quasi-stochastic behaviors of determinate nonlinear system. Chaos in three typical topology power electronic converters with a close loop controller is studied in this paper. Recently, how to apply chaos has become the researching focus, chaos control is the basic problem of the application of chaos. To deal with this problem, some existing methods are reviewed and their features are analyzed, and then, this paper places emphasis on chaos control. Diversity chaotic systems are, diversity control methods are.

Keywords: Chaos, Nonlinear system, Chaos control, Power electronic converter;

1. Introduction

Power electronic technology is widely used in the industrial, commercial, household and outer space, this subject is related to the conversion of power solved urgently in the production practice. In power electronic subject, it is noticed that how to design the circuits to meet the needs of actual production. So, people usually find a particular circuit or system has already been put into a wide range of applications before it is analyzed thoroughly [1]. At present people are still widely and deeply studying the characteristics and model of converters. Nonlinear is a general phenomenon in the power electronics; however, it has not been fully pay attention in previous analysis and design process. In the 1990s, the nonlinear power electronics and chaos phenomena have begun to notice. Chaotic motion occurs frequently in the DC-DC converters, for the performance of the harsh electromagnetic noise, the control system of the intermittent unstable and critical operation of the collapse, and so on. Chaos movement studies have

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identified in the DC-DC converters, most of them because of bifurcation and chaos caused in the system [2]. Therefore, further study on power electronics, the chaos phenomenon, of power electronic circuit design, the analysis of the power electronics system is of great theoretical and practical significance.

2. Chaos phenomena in three types of closed loop DC-DC converters

Closed loop BUCK converter is shown in figure 1. BUCK is a step-down converter, and through the load current feedback control switches action points. In a circuit have a controllable switch (GTR or MOSFET) and a controlled by diode to realize switch (when controllable switch turn-on, diode shut off, inductive current and load the current up. When controllable switch off when the current inertia through the diode and the load on the attenuation. Chosen appropriately inductance parameters and switch frequency can be won a succession of current and stable output voltage. The switch conduction and off through the feedback control, the control signal by load current error and triangle wave is integral to control. Wave amplitude of the triangle is greater than the integrator output error, control switch opening, when wave amplitude of the triangle is less than the integral error switch[3-4].

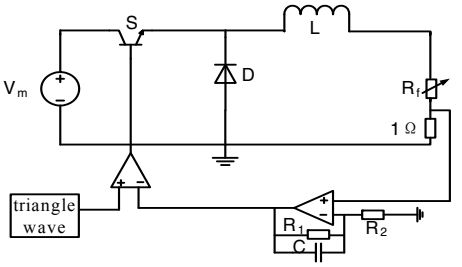

Fig. 1. Closed loop BUCK converter

When the frequency of triangle wave is 2KHz, input voltage is 20V, inductance is 16mH,load resistor is 10Ω. The circuit appears Chaos phenomenon.

Current feedback type BOOST converter is shown in figure 2. BOOST circuit that consisted of inductance and capacitance, resistance and diode is the second order circuit. When circuit in the current work continuously state, two switch work orders are: (1) Switch is on, Diode is off. (2) Switch is off, Diode is on; two switch state variations. Hypothesis switch of the opening of the time is $nT \le t \le (n+d)T$, the time of switch off is $(n+d)T \le t \le (n+1)T$. Among them, providing n integer, T for switch cycle, switches cycle is decided by clock frequency of the signal. d stands for duty ratio[5].

When inductance is 12mH, capacitance is $12\mu F$, resistor is 20Ω, T is $1/10000$ s, input voltage is 10V and Iref is 4A. The circuit appears Chaos phenomenon.

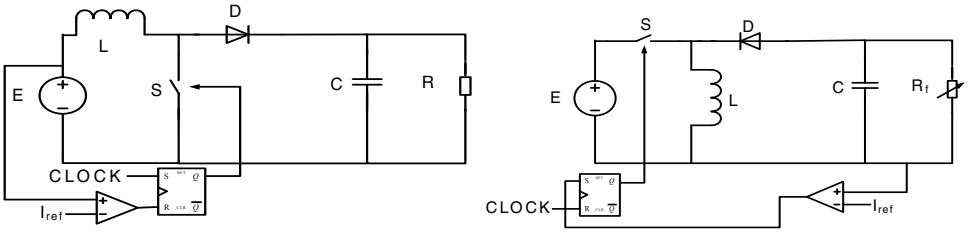

Fig.2. Current feedback type BOOST converter

Fig.3. Current feedback type BUCK-BOOST converter

Current feedback type BUCK-BOOST converter is shown in figure 3. This circuit is by inductance and capacitance, resistance and diode constitute of the second order circuit. When the switch S opening, diode D shut off, through the inductance of the current increasing, when switch S shut off, diode conduction, inductive current by inertia continue to flow through the load, inductive current attenuation. Control of empty, the S than can control output voltage. This circuit switch S accounted for empty by current and inductance than a given value deviation to control[6-7].

3. Chaos control method that is existing

3.1. Based on the bifurcation analysis and parameter adjusting

The most simple chaotic control method is by changing the system parameters, also is change the design of the system to fulfill. This method is simple, intuitive, and the system parameters can request but on a large scale changes, and the physical system usually parameters is fixed or can only in the small scope change, so it is hard to meet the requirements. So some people think that this method and its call control chaotic than that avoid chaos.

3.2. OGY method

OGY method has the following characteristics: the method through the chaotic time series or use single variable delay coordinates embedded technology can get M and the chaos, so for effective control, don't need to be accused of system dynamic model. Any can control the parameters can be as plus disturbance. In no noise and error, can use any small parameter perturbation, realize control; In a noise and error, the control signal amplitude must be large enough to effectively control. The occasional noise may make the original control stable orbit become unstable. In the stability to the period orbits transient chaos there before, transient chaos time length and the initial conditions.

3.3. Entrainment and Migration method

The method is: the characteristics of the open loop control; Don't need to understand the system parameters, but needs to be control system exists several attractors or attract domain (if control target is fixed point, all of the system there are attractive regions); Must understand the dynamic characteristics of the system, and has a priori knowledge of the domain of into; Autonomous system of any special solutions can be used as the goal, control must be included in the field, can enter into the control at a slower speed.

3.4. Linear Feedback Control

The characteristics of this method is that the system of any solutions can be as control target, including fixed point, not stable period orbits, etc.; The structure of the controller is very simple; Don't need precise know the parameters of the system; Small parameter changes to the system and disturbance has certain robustness; The method to calculate the analytical solution of the target control or approximate analytic, this solution is not easy to get or larger amount of calculation; The control can be applied in any time, this is the method of OGY method with a crucial difference.

3.5. Filter control

Using the method of realization filter chaotic control, in fact, a kind of frequency domain method, this kind of method has the following characteristics: the method is a kind of linear feedback control; In any time can exert control; Control fast: control method is easier to implement; The choice of parameters calculation is more complex[8].

4. Conclusion

The research on chaos phenomena of power converters is just an initial stage; there are many problems to deal with. However, there is no denying that with the further study on chaos phenomena of power converters, scholars will understand deeply the nature of power converters, the characteristic of power converters will be boosted. Above all, all of researches on chaos phenomena of power converters benefits industry.

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