

ANTI-JAMMING OF CHAOTIC SIGNALS

Daqin Zhou, Zhong Ren, Shi Lin, Shenchu Xu

Department of Physics, Fujian Normal University,
Fuzhou 350007, China

Abstract

It is found that the amplitude-modulation disturbance can make the chaotic output signals of Chua's circuit jump into a limit cycle. This is because the limit cycles usually encircle the chaotic orbits in the phase portraits of the Chua's circuits. The four jamproof methods adopted in our physical experiments are the limiter for clipping the sum of the chaotic signal and the disturbance signal, the adjustment of the linear resistance R which controls the slope of the load curve of the nonlinear resistance in Chua's circuit, the restarting of the Chua's circuit for retrieval of the chaotic state, the measures of the circuit shielding.

1. Introduction

In the improvement and application of the Chua's circuit,^[1,2] shown as Fig.1, we met a problem of the chaotic state jumping into a limit cycle when the amplitude-modulation disturbance happened.

The disturbance, which may cause the Chua's circuit failed, comes from the disturbed electromagnetic fields in the space or the high frequency electric impulses produced by switching other electrical appliances nearby and fed into the AC/DC transformer of the Chua's circuit through the electrical wires.

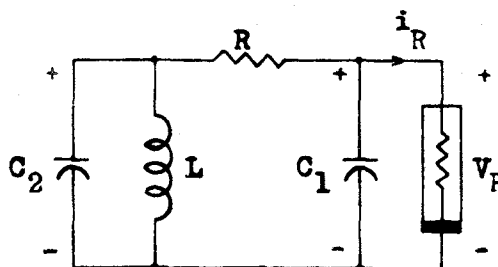


Fig.1. The Chua's circuit.

The mechanism of the transition from chaotic state to limit cycle during a disturbance impulse is as follows. For certain conditional range of the elements parameters of the Chua's circuit, the fixed point, the limit cycle, the chaotic state (the double scroll attractor) would happen separately depending on the initial condition. Usually the modulus of limit cycle signal is larger than the one of chaotic signal, i.e. the limit cycles always encircle the chaotic orbits in the phase portraits of the Chua's circuits.^[3] When the disturbance impulse comes, if the absolute value of the sum of the disturbance signal and the chaotic voltage (current) signal approaches the maxima of the limit cycle, the Chua's circuit jumps instantaneously into a limit cycle state and operates smoothly on that way.

In order to keep the Chua's circuit away from limit cycle induced by disturbance, the four jamproof methods were adopted in our

physical experiments. These methods are the clipper, the adjustment of the linear resistance, the restarting of the Chua's circuit, and the measures of the circuit shielding.

2, The clipper

According to the mechanism of the entering into limit cycle by induction of interference of the Chua's circuit, a limiter is designed. Fig.2 is the block diagram of it.

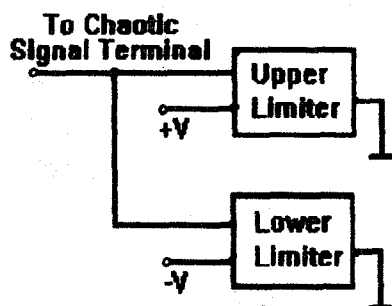


Fig.2. The block diagram of the clipper.

The working principle of the clipper is as follows. When the chaotic signal meets a disturbed impulse, the amplitude of the mixed signal increases, the clipper clips the mixed signal before it reaches the attractive range of the limit cycle so that the chaotic state be maintained.

It is demonstrated that the use of only single upper or lower limiter can efficiently clip the oscillation signal to avoid entering a limit cycle oscillation state. Because the double-scroll chaotic or limit cycle signal are both the alternating one, the clipping on one side is enough to stop the undesired oscillation. However, if the disturbance comes in such a way that one positive impulse followed by a negative one, the clipping on only one side would affect the continuity of the chaotic

signal. So, we use the upper and the lower limiters together.

In Fig.2, the "+V" and the "-V" are the upper and the lower limiting voltages of the clipper separately, they can be chosen within the positive/negative maxima of the limit cycle and can be adjusted artificially.

3, The adjustment of the linear resistance

Our investigation deals with what will happen when the linear resistance R , which controls the slope of the load curve of the nonlinear resistance in Chua's circuit, is adjusted under the conditions of keeping the C_1 , C_2 , L and other circuit parameters constant. The emphases are concentrated on the following three experimental facts:

(1) The limit cycle encircles the chaotic orbits in the phase portraits of the Chua's circuit.

(2) When the R is adjusted increasingly, the limit cycle and the chaotic orbits change expansively; when the R is adjusted decreasingly, the limit cycle and the chaotic orbits shrink obviously.

(3) There are a value R_1 , and a value R_2 . At $R=R_1$, the chaotic signal jumps into a limit cycle as the R is decreasingly adjusted; for $R=R_2$, the limit cycle evolves into a chaos as the R is increasingly adjusted. It is obtained from our experiments that $R_2 > R_1$. Therefore, the choice of $R > R_2$ can make the Chua's circuit have a better jamproof ability to maintain a chaotic state, if the spectrum of the chaotic signals is still suitable for use.

4, The restarting of the Chua's circuit

Another anti-jamming measure of chaotic signals is the design and making of the "restarting circuit", illustrated in Fig.3.

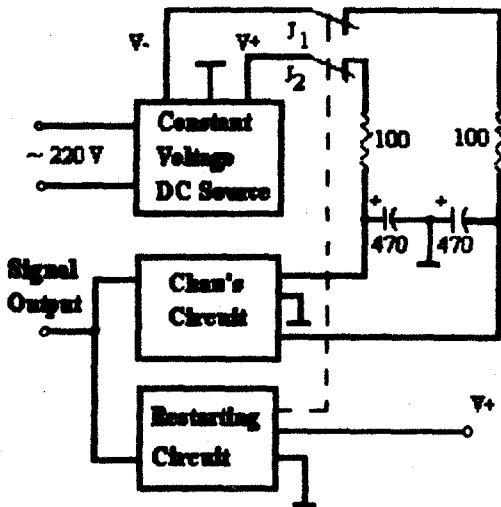


Fig.3. The schematic diagram of the restarting circuit.

Based on the fact that the amplitude of the limit cycle signal is always greater than the one of the chaotic signal, the restarting circuit can recognize the limit cycle instantaneously and switch off the DC sources $V+$ and $V-$ of the Chua's circuit immediately by disconnecting the J_1 and J_2 . After a short pause, the J_1 and J_2 are reconnected, the DC source is switched on again, the source voltage increases gradually owing to the role of a buffer circuit. The buffer composed of the two 100 ohms resistances and the two 470 uF capacitors makes the Chua's circuit restart from the zero value fixed point, then the Chua's circuit retrieves its double-scroll chaotic state automatically and reliably. Therefore, the restarting circuit plays the role of a limit cycle eliminator by pause function.

Usually the clipper and the restarting circuit can be used for different cases. The clipper is suitable for the case for which a distinct blank

exists between the limit cycles and the chaotic orbits in the phase portraits of the Chua's circuit. The restarting circuit can be used when the clipper fails for the voltage or current magnitude demands.

5, The measures of the circuit shielding

In order to eliminate the effect of disturbance, the bulk shielding, the sensitive devices (especially, the inductor L) shielded and the shielding wires are also needed. The constant voltage DC sources can absorb the disturbance coming from the electrical wires in some extent

But, the equivalent frequency of the fundamental wave of the disturbance impulse is approximate to the average frequency of the positive (or negative) component of the chaotic signal, this can be observed and measured in an oscilloscope roughly, therefore it is hard to use an ordinary filter to eliminate the disturbance signal selectively.

References

- [1] L.O.Chua, M.Komuro, and T.Matsumoto, "The double scroll family", IEEE Trans. Circuits Syst., vol.CAS-33, pp. 1072-1118, Nov.1986.
- [2] T.Matsumoto, "A chaotic attractor from Chua's circuit", IEEE Trans. Circuits Syst., vol.CAS-31, pp. 1055-1058, Dec.1984.
- [3] T.Matsumoto, "Chaos in Electronic Circuits", Proceedings of the IEEE, vol.75, No.8, 1036, Aug. 1987.