IMPROVING THE RELIABILITY OF SYSTEM FOR SECURE INFORMATION TRASMISSION

Vo Duy Phuc; Mai Van Ha
Faculty of Information Technology, University of Science and Technology, The University of Danang, Danang City, Vietnam

By using masking noise-like signals, modern **Secure Information Transmission Systems** (SITS) use auto-oscillating systems in order to generate deterministic chaos. Dynamic chaos has properties which absolutely comply with the secure communication system. These properties include a high speed data transmission of stable broadband signals to multipath fading and the possibility to confidential communication in real time. In this chaotic process, it can be obtained by using fairly simple dynamical systems which utilize reproducible numerical calculations. [1, 2].

The application of chaos in communication systems pose a variety of serious problems related to their reliability. The most common version of SITS consists of modulating information signal which controls parameters of noise transmitting generator. The useful signal modulates one of the parameters of the transmitting generator. Between the transmitting and receiving generators, there exists a mode of complete chaotic synchronization. After the subtraction of the signals from the sending and receiving devices, the information signal is detected.

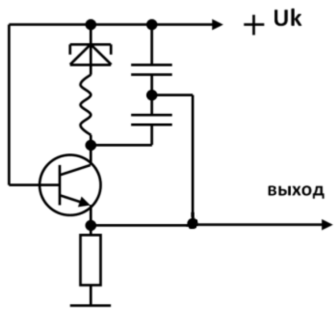


Fig. 1. Example of a chaos generator on the tunnel diode

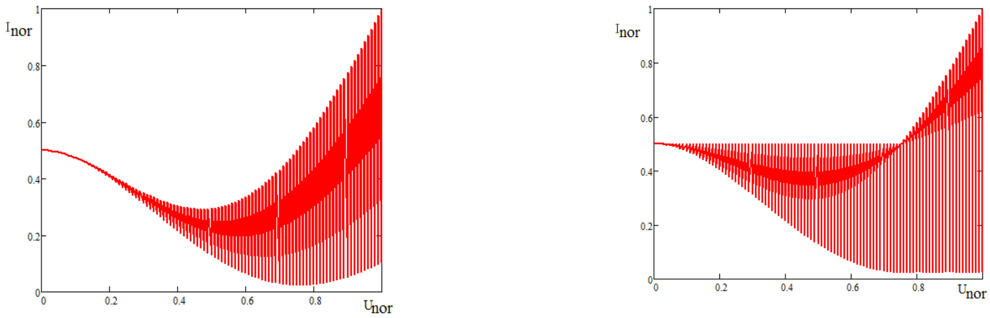
The reliability of SITS is provided by improving the accuracy and temperature stability of elements in order to observe the identification of the parameters from the transmitter and receiver generators. In this system, for stable synchronization, generators of chaotic oscillations on the basis of tunnel diodes are used. Chaos mode in generator in fig.1 is associated with the presence of area with negative differential resistance (NDR) in the current – voltage characteristics (CVC) of semiconductor components. There are two operational modes of the generator: change of the working point of the diode or the amount of positive feedback.

The disadvantage of chaos generators using tunnel diodes is showed in the characteristics of chaotic signal (without controlling the shape of the CVC of the nonlinear element). To make significant changes in the characteristics of the chaotic signal, thereby it has to increase the degree of the secret information, possibly by changing the temperature of the nonlinear element such as surrounding it with heat control devices. With increasing the temperature, the shape of the CVC of the diode is also changed, that is linked to the increase in the tunnel and drift current.

Consider the normalized approximating function of CVC tunnel diode N-like forms

$$I_{nor} = (1{,}5\cdot\alpha^2 + 2{,}9)\cdot\sin^3(\beta\cdot U_{nor}) - 3\cdot\sin^2(\beta\cdot U_{nor}) + 0{,}5, \tag{1}$$

That is selected and scaled by using the given parameters α and β. Parameters α and β are permitted to cover all possible relations between the width of the NDR (δU_{nor}) and the slope of the region with positive nonlinearity K_{nor} (Fig. 2), caused by temperature changes. Parameter α is a coefficient of evenly stretching (contraction) of the CVC normalized curve along the axis. In the case of changing two parameters α and β (Fig. 2 b), the amendment is not only in the values δU_{nor} and K_{nor}, but also in the ratio $\delta U_{\text{nor}}/K_{\text{nor}}$. Parameter β characterizes the degree of difference between the slope of both nonlinear positive and negative regions.



a) b)

Fig. 2. Normalized approximating function N-like forms CVC tunnel diode:
a) $\alpha = 0..1$, $\beta = 1$; b) $\alpha = 0..1$, $\beta = 0..1$

Expanding the function (1) in Taylor series (limited fifth member) and substituting $|U_{\text{nor}}| = |U_{0\text{nor}} + U_{m\text{nor}}\cdot\cos(\omega t)| \le 1$, we can get expressions for given levels of the second and third harmonics:

$$\text{I}_{2\text{nor}} = -1{,}5\cdot U_{m\text{nor}}^2\cdot\beta^2 + 1{,}5\cdot U_{0\text{nor}}\cdot U_{m\text{nor}}^2\cdot\beta^3\cdot\left(1{,}5\cdot\alpha^2 + 2{,}9\right) + \beta^4\times$$

$$\times\left(3\cdot U^2_{0\text{OTH}}\cdot U_{m\text{nor}}^2 + 0{,}5\cdot\frac{U_{m\text{nor}}^4}{8}\right) - \beta^5\cdot\frac{\left(1{,}5\cdot\alpha^2 + 2{,}9\right)}{2}\cdot\left(5\cdot U_{0\text{nor}}^3\cdot U_{m\text{nor}}^2 + 2{,}5\cdot U_{0\text{nor}}\cdot U_{m\text{nor}}^4\right),$$

$$\text{I}_{3\text{nor}} = 0{,}25\cdot U_{m\text{nor}}^3\cdot\beta^3\cdot\left(1{,}5\cdot\alpha^2 + 2{,}9\right) + \beta^4\cdot U_{0\text{nor}}\cdot U_{m\text{nor}}^3 -$$

$$-\beta^5\cdot\frac{\left(1{,}5\cdot\alpha^2 + 2{,}9\right)}{2}\cdot\left(2{,}5\cdot U_{0\text{nor}}^2\cdot U_{m\text{nor}}^3 + \frac{5}{16}\cdot U_{m\text{nor}}^5\right). \tag{2}$$

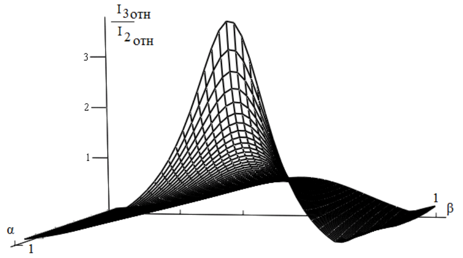


Fig. 3. The dependence of the ratio I_3/I_2 to parameters α and β

Taking the constants $U_{m\text{nor}} = 1$ and $U_{0\text{nor}} = 0{,}5$ in expressions (2), can build the dependence of the ratio of the levels of the third and second harmonics of the signal response parameters α and β (Fig. 3).

From Fig. 3, for certain values of α и β, characterizing the ratio between the width of the region of negative nonlinearity and steepness of the positive nonlinearity, it could be observed the prevalence of the level of the third harmonic above the level of the second ($I_3/I_2 \geq 1$). Hence, we can prove that the CVC curve of tunnel diode has regions, which border with negative and positive nonlinearities, and these regions are the cause of inversion in the ratio of levels of harmonics of the converted signal.

Conclusions

The most common version of SITS consists of modulating information signal which controls parameters of noise transmitting generator. The reliability of such system requires high accuracy and temperature stability of elements to protect the identity parameters of the transmitter and receiver generators. For these systems from the convenience of synchronization, we should use the generators of chaotic oscillations on the basis of tunnel diodes. To make significant changes in the characteristics of the chaotic signal, thereby it has to increase the degree of the secret information, possibly by changing the temperature of the nonlinear element such as surrounding it with heat control devices. Therefore, the degrees in the information path of non-linear products and their ratio depend on the parameters of the shape characteristics of the semiconductor device, the position of working point and the amplitude of the modulating signal.

References

1. Cuomo K. M. Synchronization of Lorenz-based chaotic circuits with application to communications / K. M. Cuomo, A. V. Oppenheim, S. H. Strogatz // IEEE Trans. Circ. Syst. 1993. II. 40. 10. − PP. 626-633.

2. Dedieu H. Chaos shift keying: Modulation and demodulation of a chaotic carrier using self-synchronizing Chua's circuits / H. Dedieu, M. Kennedy, M. Hasler // IEEE Trans. Circuits and Systems. Oct. 1993. V. CAS-40. № 10. − PP. 634.

Аннотация

Предложено способ повышение надежности систем скрытой передачи информации с использованием синхронизированных генераторов хаоса на базе туннельных диодов. Рассмотрены особенности изменения параметров хаотического сигнала для повышения степени скрытности информации.

Ключевые слова: скрытая передача информации, детерминированный хаос, туннельный диод.

Анотація

Запропоновано спосіб підвищення надійності систем прихованої передачі інформації з використанням синхронізованих генераторів хаосу на базі тунельних діодів. Розглянуто особливості зміни параметрів хаотичного сигналу для підвищення ступеня скритності інформації.

Ключові слова: прихована передача інформації, детермінований хаос, тунельний діод.

Abstract

The proposed method aims to improve the reliability of the system of secure information transmission using synchronized chaos generators on the basis of tunnel diodes. The features of changes of the parameters of the chaotic signal should be considered in order to increase the degree of the secretiveness of information.

Keywords: secure communication, deterministic chaos, tunnel diode.