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MODELLING OF DYNAMICAL CHAOS OF COLPITTS OSCILLATOR WITH 4.5 DEGREES OF FREEDOM

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The use of deterministic chaos in radioengineering and telecommunication systems requires the creation of sources of chaotic oscillation modes of which can be controlled by changing the settings. The use of bipolar transistor has allowed increasing the upper limits of frequencies of signals from 10 kHz —10MHz to 1000 MHz. The proposed generator of chaotic oscillations can be used in telecommunication systems of communication in a narrow strip of frequencies, which is set by the parameters of the L-shaped filters.

Key words: Chaos, simulation, Colpitts oscillator.

Information security in modern conditions is considerably complicated, due to the complexity of encryption technology because of the need to protect not only the state and military but also industrial and commercial secrets. [1].

Determinate chaos is one of the new elements which are used in modern telecommunication systems to mask the information carrier in a certain chaotic law [2]. The nonlinearity of processes in the generator of chaos generating sensitivity to initial conditions and detune of parameters, consequently his condition is unpredictable at large intervals [3].

Research of chaotic Colpitts oscillator is caused by some technological aspects which are important from the standpoint of increasing of the upper limit of chaotic frequency signals, the expansion of bandwidth of chaotic signals, of simplicity and controllability of accepted schemes etc [4]. The presence of an infinite number of unstable periodic orbits in the dynamic system influenced the creation of a mathematical theory of complex dynamics of chaos [5]. Mathematical model allows defining limits of application and options of generators of chaos.

Mathematical modelling of chaotic generator

The task of creating chaos generators includes developing the structure of the generator, mathematical models and studying of the bifurcation effect. Mathematical model of Colpitts oscillator (capacitive three-point) quite completely described in [5]. This paper investigates the possibility of generating a stream of chaotic radiopulses by the action of external periodic signal to a dynamic system. In the circuit is used one nonlinear element which serves as the transistor VT-2N2222A. Schematic diagram of Colpitts oscillator with 4.5 degrees of freedom is shown in Fig.1.

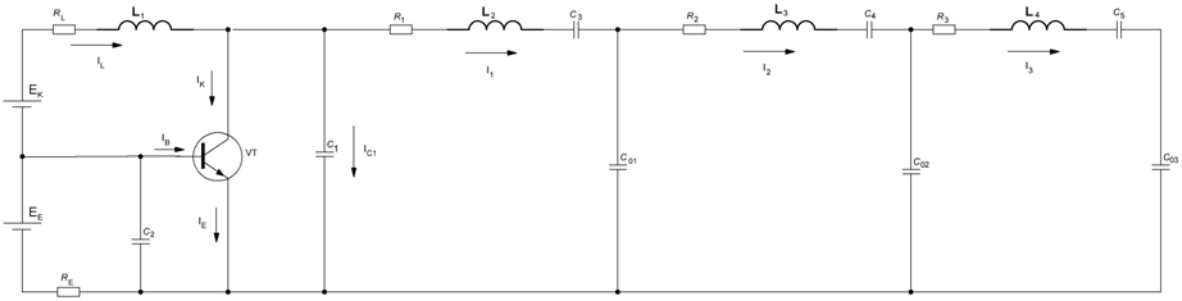

Fig.1. Schematic diagram of nonautonomous Colpitts oscillator

The generalized mathematical model is described by a system of differential equations (1):

$$\begin{cases} C_1 \dfrac{dU_{C1}}{dt} = I_L - I_K - I_1 \\ C_2 \dfrac{dU_{C2}}{dt} = \dfrac{E_E - U_{C2}}{R_E} - I_L - I_B \\ L_1 \dfrac{dI_L}{dt} = E_K - I_L R_L - U_{C1} + U_{C2} \\ L_2 \dfrac{d^2 I_1}{dt^2} + R_1 \dfrac{dI_1}{dt} + (\dfrac{1}{C_1} + \dfrac{1}{C_3} + \dfrac{1}{C_{01}}) I_1 = \dfrac{I_L - I_K}{C_1} + \dfrac{I_2}{C_{01}} \\ L_3 \dfrac{d^2 I_2}{dt^2} + R_2 \dfrac{dI_2}{dt} + (\dfrac{1}{C_{01}} + \dfrac{1}{C_4} + \dfrac{1}{C_{02}}) I_2 = \dfrac{I_1}{C_{01}} + \dfrac{I_3}{C_{02}} \\ L_4 \dfrac{d^2 I_3}{dt^2} + R_3 \dfrac{dI_3}{dt} + (\dfrac{1}{C_{02}} + \dfrac{1}{C_5} + \dfrac{1}{C_{03}}) I_3 = \dfrac{I_2}{C_{02}} \end{cases} \quad (1)$$

The modelling system (1) was conducted in the Wolfram Mathematica 8 software sector for the following values of the parameters of the electrical circuit:
$U_K = 30V$; $U_E = 30V$; $R_L = 500\Omega$; $L_1 = 10\mu H$; $C_2 = 70pF$; $R_E = 2400\Omega$; $C_1 = 150pF$; $R_1 = 20\Omega$; $L_2 = 1\mu H$; $C_{01} = 150pF$; $R_2 = 20\Omega$; $L_3 = 1\mu H$; $C_4 = 150pF$; $C_{02} = 150pF$; $R_3 = 20\Omega$; $L_4 = 1\mu H$; $C_5 = 150pF$; $C_{03} = 150pF$.
Chaotic operation mode is reflected by timing diagram of voltage on C_1 and current of inductor L in Fig. 2.

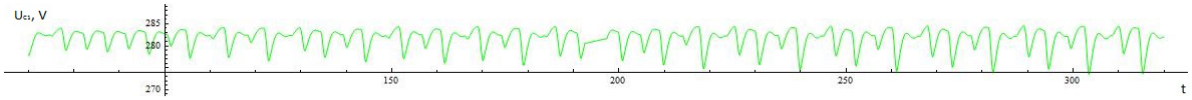

Fig. 2. Timing diagrams of voltage on C_1 and current of inductor L

The chaotic attractor and bifurcation diagram of the generator of chaotic signals are shown in Fig. 3 and 4.

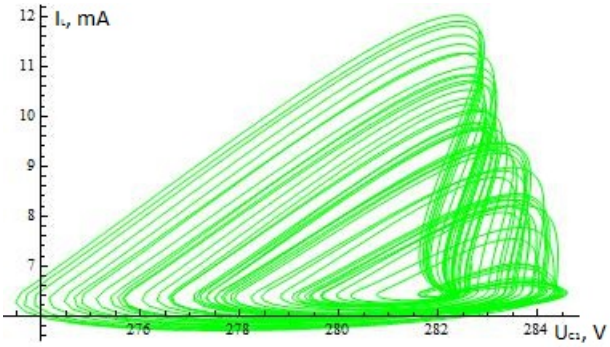

Fig.3. The chaotic attractor of the chaotic oscillator

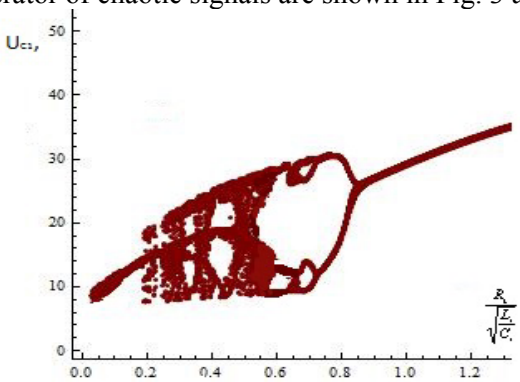

Fig. 4. The bifurcation diagram of chaotic oscillator

In this paper were analyzed chaotic modes of nonautonomous Colpitts oscillator with 4.5 degrees of freedom. From bifurcation diagrams follows that chaotic modes arise by changing of control parameters within the limits $0.2 \div 0.4; 0.47 \div 0.59$, that is corresponding to the change of capacity C_1 in the range of 130÷170 pF, and inductance of 1÷15μH.

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