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Simple Inductor-Free Chaotic Generator: Design, Research and Computer Modelling

Volodymyr Rusyn[1], Christos H. Skiadas[2]

[1] Department of Radio Engineering and Information Security, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine
(E-mail: rusyn_v@ukr.net)
[2] ManLab, Techchnical University of Crete, Chania, Crete, Greece
(E-mail: skiadas@cmsim.net)

Abstract. Circuit realization of the generator that demonstrate chaotic behavior is presented. This circuit contains three operational amplifiers, three capacitors, one diode, eight resistors, and one voltage source. The system's behavior was investigated through numerical simulations, by using well-known tools of nonlinear theory, such as phase portrait, chaotic attractor and time distributions of two chaotic system-variables. This proposed circuit of chaotic generator can be used as a main part of modern systems transmitting and receiving information for masking and decryption of an information carrier.
Keywords: Chaos, Inductor-free, MultiSim.

1 Introduction

In the area of engineering, chaos has been found to be very useful and has great potential in many technological disciplines, such as in information and computer sciences, power systems protection, flow dynamics, liquid mixing, biomedical systems analysis etc.
Chaos is the most interdisciplinary thematic areas; it includes very interesting, complex, nonlinear phenomena, that have been intensively studied and regard many different areas ranging from sciences, mathematics and engineering to social systems [1-11].
Chaotic signals can be generated by electronic circuits [12-23]; memristors [24, 25], simple and more complex; analog, digital or mixed signal. These signals depend on the system's initial conditions and this dependence is very sensitive; thus, they demonstrate the feature of being unpredictable. At the same time chaotic signals are wide-band signals, i.e. the have a broad spectrum. Although they seem to be random, they are fully deterministic, highly sensitive to the system parameters, as well.
It is apparent that there is great interest in the implementation of chaotic systems by nonlinear circuits. These are beneficial to applications related to secure communication transmission or to real chaotic system modeling, to mention a

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few. Simulation of these circuits is an interesting approach that easily and quickly provides with the properties of chaotic circuits. In the section that follows, a new chaotic generator is proposed, and its experimental behavior is demonstrated, by means of simulation.

2 A New Simple Inductor-Free Chaotic Generator

Figure 1 shows the proposed hereby, simulated scheme of a new simple chaotic generator. The proposed topology implements a non-autonomous, nonlinear circuit that includes an amplifier, incorporating both a negative and a positive feedback, antagonizing one another; thus, locally destabilizing the circuit's convergence to a stable state, giving rise to chaotic behavior.

The exact circuit of this new chaotic generator was realized around three operational amplifiers, namely TL082. The elements used and their values were: one diode 1N4148, resistors R1 = 400 Ω, R2 = 10 kΩ, R3 = 20 kΩ, R4 = 10 kΩ, R5 = R6 = R7 = 1 kΩ, R8 = 10 kΩ, and capacitors C1 = 100 nF, C2 = C3 = 10 nF. The circuit was powered by a symmetrical power source of ± 15 V, while the needed external bias voltage V1 was 20 V.

Simulations of the circuit behavior were carried out by using NI's MultiSim platform. In the figures that follow, the resulting behavior is illustrated. In Figure 2 the generated phase portrait based on the circuit's chaotic signals is presented on the platform's virtual oscilloscope. The *x*-axis corresponds to the non-inverting input voltage signal of the op-amp DA2, which will be called the *x-signal*; while the *y*-axis corresponds to the voltage of capacitor C1 (U_{C1}), which will be called the *y-signal*. It is noted that the channels' settings were for channel A, 500 mV/div and channel B, U_2 = 1 V/div. The chaotic nature of the produced attractor, as this comes out of the its complex structure, is evident.

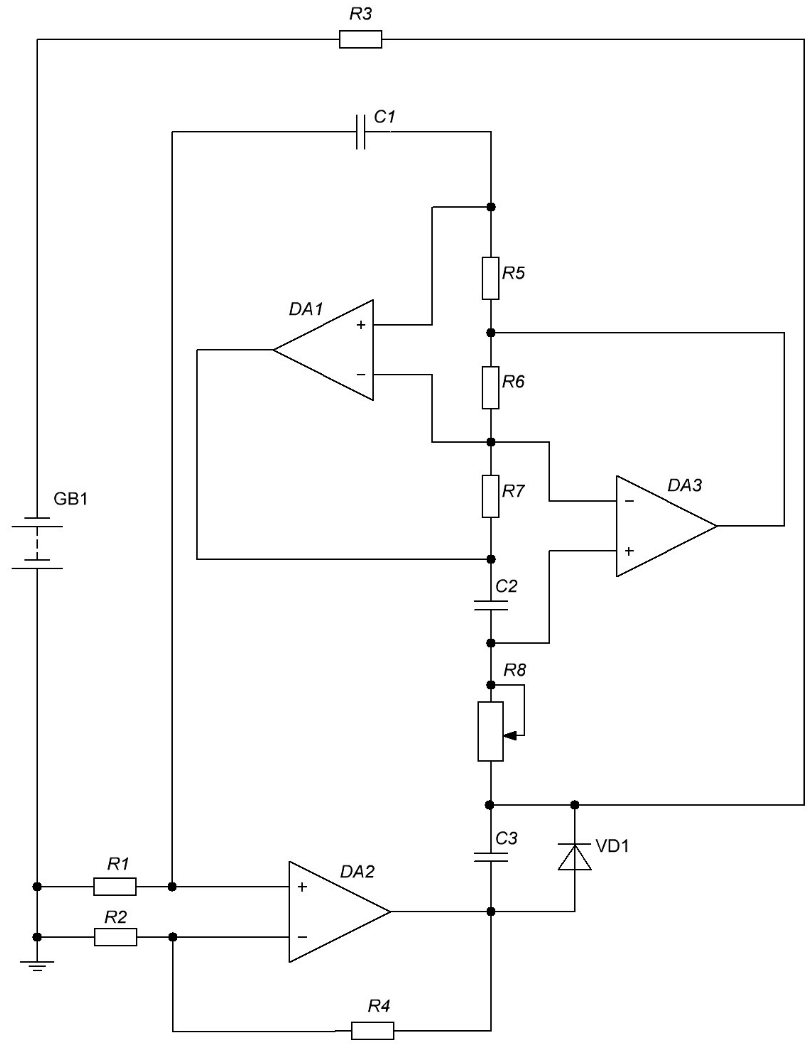

Fig. 1. Circuit topology of a new simple chaotic generator

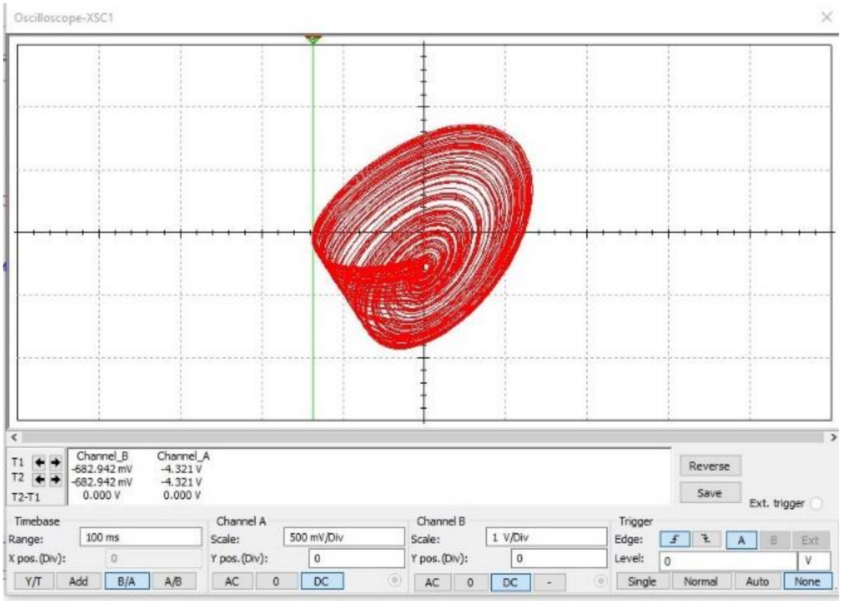

Fig. 2. The simulated chaotic attractor of the new simple chaotic oscillator. Its complex structure clearly supports the circuit's chaotic behavior

In Figure 3 the timeseries of both *x*- and *y-signals* appear. Their non-periodic nature is evident. shows time dependences of the coordinates X (top) and Y (bottom) respectively (the channels' settings were for channel A, 1V/div and for channel B, 2V/div.

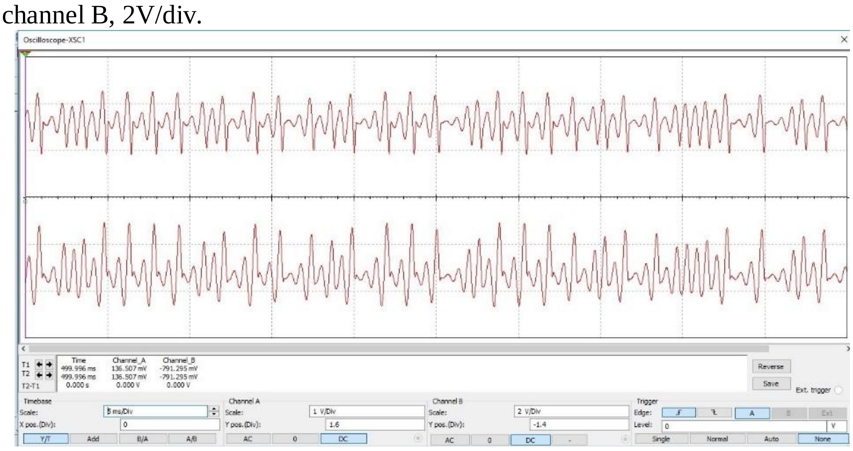

Fig. 3. The *x-signal* (upper) and the *y-signal* (lower) timeseries. Their non-periodic nature is evident

Finally, in Figure 4 and Figure 5 the power spectrum for each of the two registered signals appears. Apparently, the power spectra of the produced signals are broadband, typical of chaotic signals. They span to a frequency range that goes beyond 5 kHz. The peak of the frequency spectrum was measured to be at 1.7 kHz, and it corresponds to a prevailing frequency of the implementing oscillating loop.

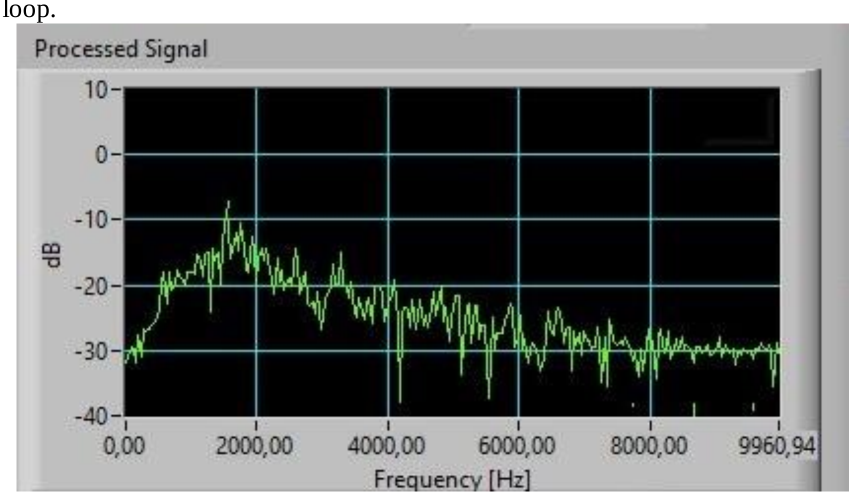

Fig. 4. The spectral distribution of the *x-signal*, typical of chaotic signals

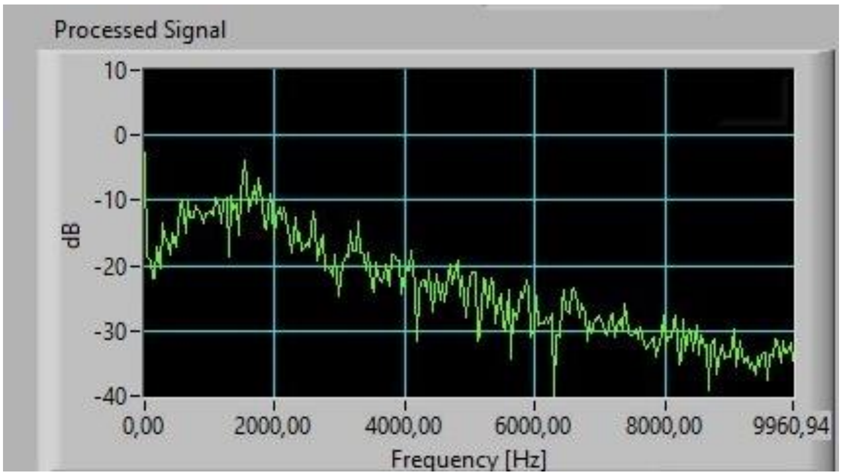

Fig. 5. The spectral distribution of the *y-signal*, typical of chaotic signals

Conclusions

In the preceding lines a new, non-autonomous, chaotic circuit, is presented. Experimental verification of its chaotic behavior, by utilizing NI's MultiSim simulation platform, is apposed. This behavior is confirmed both by the demonstrated attractor and the power spectra of the generated signals. Since this circuit can generate chaotic oscillations, it can be used as part of modern telecommunication systems for masking and decrypt information.

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