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Digital Generation of Wideband Chaotic Signal with the Comb-Shaped Spectrum for Communication Systems Based on Spectral Manipulation

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Abstract—An algorithm for the digital generation of broadband chaotic signal with comb-shaped spectrum has been developed on the basis of nonlinear discrete system with delay. The data transmission method using the spectral manipulation technique with digital generation and processing was experimentally implemented. The results obtained can be utilized in the systems of transmitted data security from unauthorized access.

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The application of noise-like signals in modern broadband telecommunications systems makes it possible to ensure a high noise immunity and stable operation under conditions of multipath propagation at the simultaneous operation of numerous subscribers operating in the common frequency range and also ensures the electromagnetic compatibility with narrow-band radio systems [1].

The development of the dynamic chaos theory for nonlinear systems [2] stipulated the appearance of a new class of noise-like signals: broadband chaotic signals [3] that can be successfully applied in noise telecommunication and radar systems [4–8].

Chaotization of self-oscillating systems with delay [9, 10] represents one of the methods for generating such signals. A particular place among these methods is occupied by ring self-oscillating systems operating in the dynamic chaos mode [11, 12], providing a wide variety of chaotic modes and making it possible to obtain signals with specified properties.

At present, owing to the development of digital methods of signal forming and processing, it became possible to create chaotic signal sources on the basis of commercial digital devices of different integration density for telecommunication, radar and navigation systems [13–17].

Devices implementing the digital generation of signals possess relevant advantages over the devices for analog formation of signals. Characteristics of digital devices do not alter with changes of environmental conditions, because they are implemented on the basis of digital elements providing stable operation under conditions of changing temperature, humidity, etc. Since the duration of information storage by digital elements is virtually unlimited, the performance of a series of operations becomes possible that in principle cannot be implemented on the basis of analog elements, for example, the operations associated with the need of a large time of storage of signal samples. Modern digital devices are produced in the form of large-scale and very large-scale integration circuits, in particular, in the form of microprocessors or FPGA (field-programmable gate array) making it possible to significantly enhance their reliability and reduce their production costs.

At the state-of-the-art electronic circuitry, two different techniques of digital generation of signals are used. The first one is the method of direct digital synthesis (DDS). This method implies that signal samples with specified parameters formed by using a predeveloped algorithm are written into a binary file, which is loaded into the memory of digital device. Next, signal samples are extracted from memory cells at the specific clock frequency and transformed into an analog signal using a high-speed digital-to-analog converter [18]. A disadvantage of such method becomes apparent, where it is necessary to form a continuous

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