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ALGORITHM FOR SEPARATION OF MUTUALLY NON-ORTHOGONAL SIGNALS WITH BINARY PHASE SHIFT KEY IN PERSPECTIVE 5G MOBILE COMMUNICATION SYSTEMS

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АЛГОРИТМ РОЗДІЛЕННЯ ВЗАЄМНО НЕОРТОГОНАЛЬНИХ СИГНАЛІВ З ДВІЙКОВОЮ ФАЗОВОЮ МАНІПУЛЯЦІЄЮ У ПЕРСПЕКТИВНИХ СИСТЕМАХ МОБІЛЬНОГО ЗВ'ЯЗКУ 5G

У статті наводиться опис запропонованого оптимального, за критерієм мінімуму ймовірності помилки в оцінці дискретних параметрів, алгоритму розділення двох взаємно неортогональних BPSK-сигналів, що передаються у одній частотно-часовій області.

In today's rapidly growing demand conditions for wireless services, Power-Domain Non-Orthogonal Multiple Access (PD-NOMA) technology is becoming a key element in fifth-generation (5G) communication systems. Its implementation is drive, enable the connection of a large number of devices (including various types of sensors) and improve the quality of user service.

Traditional orthogonal multiple access methods, currently actively used in fourth generation (4G) communication systems, use methods of frequency and time allocation of resources among users, which limits the number of simultaneous connections and therefore reduces the spectral efficiency of such systems. The use of PD-NOMA systems will allow to increase the efficiency of using limited spectral resources by allocating power among users in the same time and frequency domains.

Since in PD-NOMA systems users transmit signals using one frequency-time resource, differing only in power levels [1], there is a need to eliminate the mutual influence of similar (interfering) signals. In order to eliminate such interfering signals PD-NOMA systems used of the method of successive error elimination (SIC) [2]. It should be noted that the efficiency of SIC may decrease due to the accumulation of demodulation errors, especially in conditions of real interference. Also, insufficient difference in the power levels of user signals transmitted in the same frequency-time domain may lead to a further increase in the probability of errors. The above emphasizes the importance of assessing the potential interference immunity of such systems, which will allow identifying possible vulnerabilities of modern wireless networks.

Let us consider the case when the PD-NOMA system uses mutually non-orthogonal signals with binary phase shift keying (BPSK).

From the theory of optimal nonlinear filtering it is known that the problem of a compatible, interconnected estimation of the initial phase of the carrier vibration and the discrete information parameter of the BPSK signal has already been solved [3]. In this case, to increase the signal-to-noise ratio during the removal of manipulation from the BPSK signal at the input of the phase-locked loop, used a “soft” estimation of the discrete parameters of signals. In this way, the reference (carrier) signal obtained used for quasi-coherent processing signals.

In the statistical theory of digital signal separation, there is a known algorithm for separation-demodulation of two mutually non-orthogonal digital BPSK-signals, which is optimal according to the criterion of minimum probability of error in estimating discrete information parameters of each signal [4]. This algorithm was obtained in the formulation of the classical theory of potential noise immunity, where all non-information parameters of signals that are mutually non-orthogonal over the length of the information packet are considered to be exactly known. It should be noted that the second result is generalized to the case when it is possible to process one of the signals (more powerful) quasi-coherently, and the other (less powerful) – incoherently.

The paper proposes to combine this the results and use them to separate mutually non-orthogonal BPSK-signals. According to the results of the research, it was found that when demodulating a more powerful signal, it is unnecessary to estimate the initial phase and amplitude of the carrier vibration of the less powerful signal. In addition, in order to receive the same probability of error for both signals, the difference between their instantaneous powers should be $\geq$ 6 dB, which will allow, when estimating the non-information parameters of the more powerful signal, to neglect the presence in the observation of the less powerful signal. In this case, the difference in the initial phases of the mutually non-orthogonal carrier BPSK-signals over the length of the information clock interval must remain slowly-variable.

In Fig. 1 presented one possible implementation option for such a quasi-coherent-incoherent demodulator of non-orthogonal BPSK-signals, which can be used in building 5G systems with using PD-NOMA technology.

The developed scheme of a quasi-coherent-incoherent demodulator of two mutually non-orthogonal BPSK-signals differs from the known one in that first, quasi-coherent reception of the first more powerful signal occurs (r_1^*), then the first received signal is compensated from the mixture at the correlator output , and only after that incoherent (quadrature) reception occurs of the second less powerful signal (r_2^*). The presence of a reactive element (RE) in the scheme allows for an estimate of the initial phase of the more powerful signal. The decision on acceptance of the second less powerful signal is based on the addition of the in-phase and quadrature components of the signal.

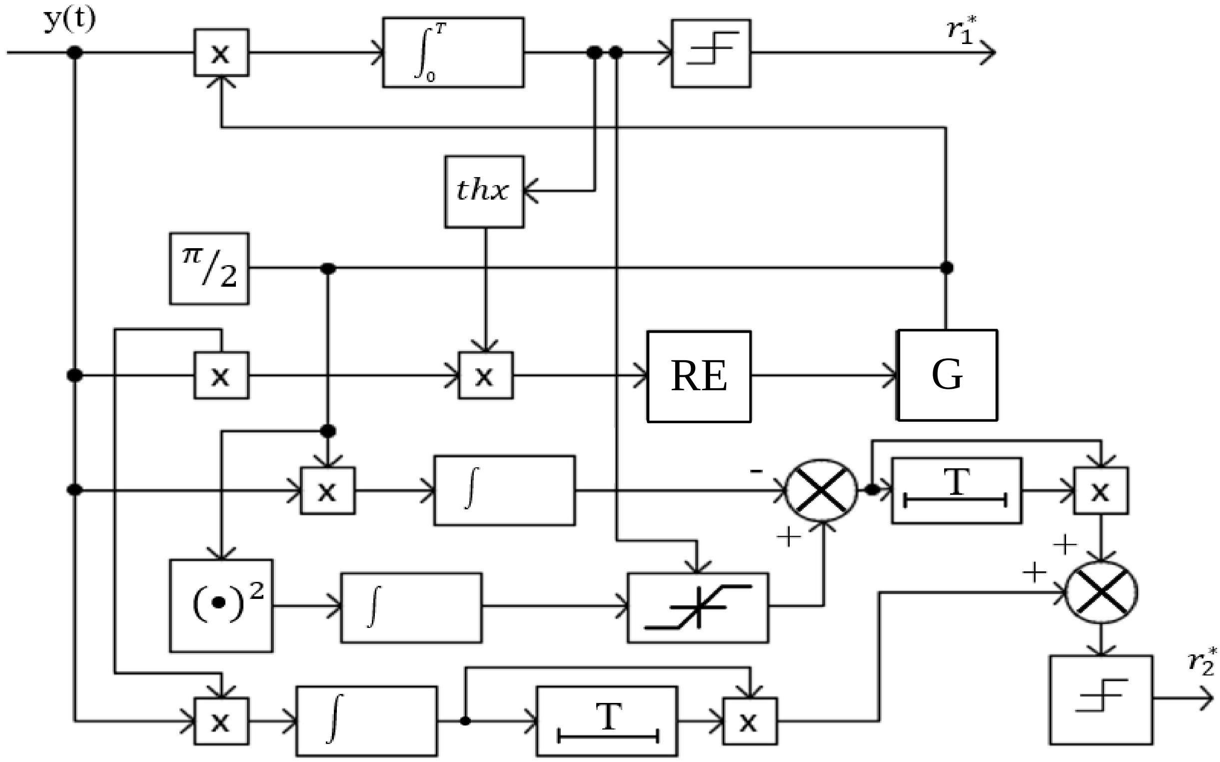

Fig. 1. Block diagram of a quasi-coherent-incoherent demodulator of mutually non-orthogonal BPSK-signals.

Conclusion. The paper proposes an algorithm for the separation-demodulation of two mutually non-orthogonal BPSK-signals, in which, when processing two similar interfering signals, it is necessary to estimate the non-information parameters (amplitude of the initial phase) of only the more powerful signal, which is processed quasi-coherently.

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