THE ANALYSIS AND SYNTHESIS OF DISCONTINUOUS COMMUNICATION WITH DIVERSITY OF RECEPTION FOR INCREASE IN EFFECTIVE TRANSFER OF DIDCRETE INFORMATION IN SYSTEMS OF THE EARTH-SPACE INTERFEROMETRY

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Abstract. Problems of increase of efficiency data transmission on the wireless channel fading with is considered when using algorithm of discontinuous communication with the diversity reception. Optimum value of a threshold and radio line efficiency by criterion of minimization probability of error is shown.

Keywords: discontinuous communication, diversity reception, integration, Nakagami fading, radio line efficiency, optimum value, probably of error, noise immunity.

1. Problem definition.

Various ways processing of fading signals in these channels are known. The greatest effect is usually reached when using adaptive algorithms in transmitting devices. Use of such algorithms expediently in case $2T << \tau$, where T – time of propagation for a signal on the communication line, τ - interval of correlation envelope of signal. Using technology with time duplex, TDD (Time Divide Duplex), it is enough to provide $T << \tau$. Among known modes we will pay attention on following three: use of the automatic adjustment of power of the transmitter (AAPT); adjustment of speed information transfer depending on level of signals on entrances of receivers; application of discontinuous signaling on the similar method applied in systems of meteoric communication. By transfer of digital data on considerable distances via tropospheric and ionospheric channels the signal is subject to a various fading. This results from the fact that in a reception point the signal represents the sum of several components $r_i \cdot e^{\Theta_i}$ (i = 1, 2, 3, …, n), passable various ways, their amplitudes r_i and a phase Θ_i randomly change in time [1]. Components are formed owing to signal splitting at its passing through dispersive environments with various electrophysical properties. Amplitude of signal’s envelope (R) in a point of reception fades randomly with a probability density under Nakagami's law.

Fading under Nakagami's law subject, for example, signals at the long-distance tropospheric communication, passed under a small corner to the horizon. Tropospheric communication lines were intensively investigated in the late sixties, the beginning of the 70th years of the last century [2, 3]. Then, at the beginning of the 90th years, in process development of personal mobile communication, interest to them has weakened.

Further, in process development of communication systems, there was a need to carry out communication with the satellite transceiver not only during its flight over terrestrial station, but at small corners to the horizon. In these conditions usually there is a signal fading under Nakagami's law.

At integration of discontinuous communication with the diversity reception the advantage compare of diversity reception without discontinuous communication will be less, than advantage of discontinuous communication compare of continuous single reception. This advantage decreases when increase number of branches of diversity because in this case fading decreases and interval correlation of fading decreases. However use of discontinuous communication at limited number of branches of the diversity, usually put into practice, has to lead to noticeable increase noise immunity. Besides, application of discontinuous communication at the diversity reception increases the efficiency of the radio line representing the relation of time of data transmission in discontinuous communication by the general time of a communication session (η_M) that also has to raise a reception noise immunity.

Features of integration of discontinuous communication with the diversity reception and application methods of discontinuous communication for increase of noise immunity of transfer of discrete messages in channels with Rayleigh, generally Rayleigh (Rice), lognormal fading and a fading under Nakagami's law, in the TDD mode, are considered in works [4-8]. Dependences of probability of error from the average ratio signal/noise (SNR) at integrate of discontinuous communication with the diversity reception, as a rule at value of level of a threshold (γ_t) equal to average value SNR (γ_0) are investigated in these works

Work purpose: decrease probability of error data in channels a fading under Nakagami's law, application of integration of discontinuous communication with the diversity reception, with optimum sum of branches of a diversity, depending on threshold level at the fixed: power of the transmitter and average value of SNR.

2. Decrease probability of error reception of data, at a integration of discontinuous communication with the diversity reception, in channels with a fading under Nakagami's law in a mode with time duplex (TDD).

As level of a threshold we will define its rated value (k), as the relation actually threshold level (γ_t) to γ_0 (1)

$$k = \frac{\gamma_t}{\gamma_0}. \tag{1}$$

The probability of error of incoherent reception of signals DBPSK (**D**ifferential **B**inary **S**hift **K**ey), at a integration of discontinuous communication with the diversity reception, at optimum sum of branches of a diversity, will be defined from a formula (2) [7]

$$P(k) = \frac{1}{2}\left[\frac{1}{1+\alpha\frac{\gamma_0}{m}\eta_M(k)}\right]^{mM} \frac{\Gamma\left[mM, km+\alpha\gamma_0 k\eta_M(k)\right]}{\Gamma(mM, kM)}, \tag{2}$$

Where α=1 for phase modulation and ½ for frequency modulation, *m* – the parameter of a fading characterizing depth of a fading of Nakagami, *M* – number of branches of a diversity, $\eta_M(\kappa)$ - the efficiency of the radio line showing a ratio of time of data transmission by the general time of a communication session [4-8], and defined by a formula [7]

$$\eta_M = \frac{\Gamma(mM, kM)}{\Gamma(mM)}. \tag{3}$$

Dependences of efficiency of the radio line on number of branches of diversity *M* at various k and m equal 0,7 are presented in fig. 1.

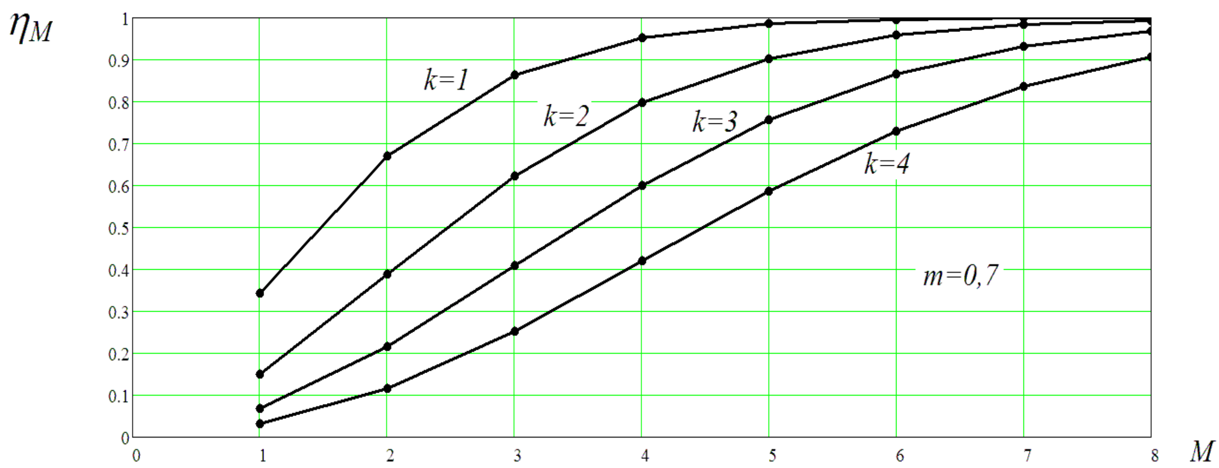

Fig. 1. Dependences of efficiency of the radio line on number of branches of diversity M at a fading under Nakagami's law, at various k and m values equal 0,7.

For ensuring transfer of all data file for a communication session it is necessary to increase transfer speed in inverse proportion to radio line efficiency (η_M), reducing thus duration of information bits, and, respectively expanding a strip (range) of a signal. From the schedule in fig. 1 follows that at increase in number of branches of diversity the efficiency of the radio line increases, aspiring to 1.

Dependences of probability of a error from value k (on a formula 2) at the fixed: power of the transmitter, average value of SNR on a receiver entrance (γ_0), *m* equal 0,7 and *M* equal 8 when energy of bit of a signal decreases at reduction of efficiency of the radio line, are presented in fig. 2.

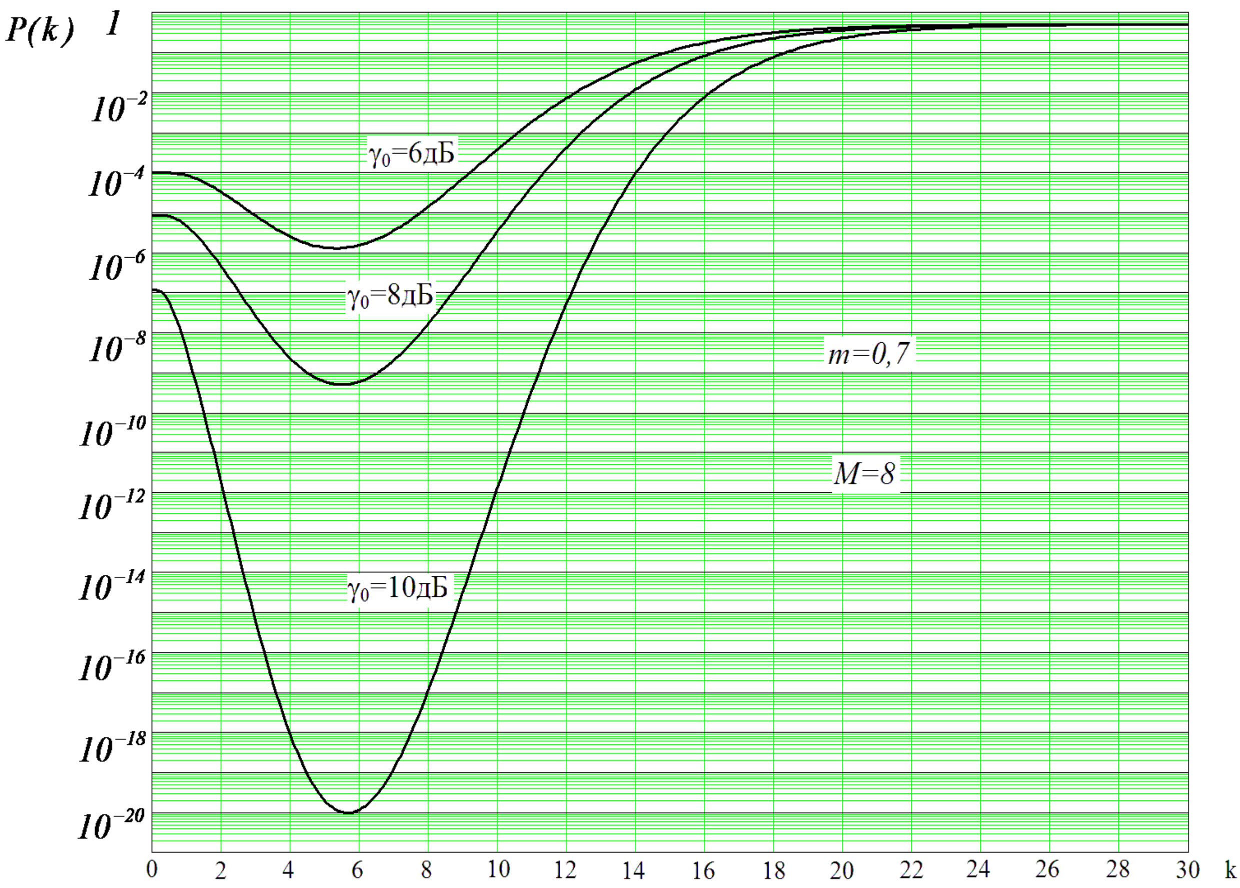

Fig. 2. Dependence of probability of error of the incoherent diversity reception of signals DBPSK at discontinuous communication with optimum sum of diversity's branches from k at various average values of SNR (γ_0), m equal 0,7 and number of branches of a diversity the M equal 8 in the channel with a fading under Nakagami's law.

3. Application of synthesis of discontinuous communication with diversity reception in systems of a earth-space interferometry (Millimetron project).

Within creation of system of a earth-space interferometry with the high-precision permission, functioning in the millimetric, submillimetric and infrared range of radio waves it is supposed that one of shoulders of the interferometer will carry out reception of signals in the poorly indignant point Lagrange (L2) located at distance of about 1,75 million km from Earth. For transfer of accepted information from the onboard equipment to Earth the high-informative radio engineering complex (HIRC) which after reception and preliminary data processing will transfer them from a space segment to Earth by means signals of phase modulation will be created.

Thus, on the one hand, radio signals will pass through a layer of the troposphere, from 8 to 18 km thick depending on latitude, on the other hand, the distance from Earth to a point of Lagrange pass a radio signal during about 6 c, that considerably exceeds an interval of correlation of envelope signal. Condition under which it $T << \tau$ isn't carried out. Therefore correlation of levels signals at out of the transmitter and a receiver’s entrance, in the TDD mode, realized at small (to hundred km) distances, in this case isn't possible.

For elimination of the specified shortcoming it is necessary to transfer data with the increased speed, without discontinuous communication, in inverse proportion η_M, previously having written down them in buffer memory. In this case the signal will be accepted not only during the periods when instant value of SNR (γ) exceeds threshold level (γ_t), but also during the periods of a deep fading, significantly reducing a noise immunity, increasing thus probability of a error which will be defined according to (4)

$$P(k) = \frac{1}{2}\left[\frac{1}{1+\alpha\frac{\gamma_0}{m}\eta_M(k)}\right]^{mM} . \qquad (4)$$

Dependences of probability of error from value k (on a formula 4) (a curve 1) at the fixed power of the transmitter, average value of SNR on a receiver entrance (γ_0), m equal 0,7 and M equal 8 in comparison with probability of a error on a formula 2 (a curve 2) are presented on fig. 3.

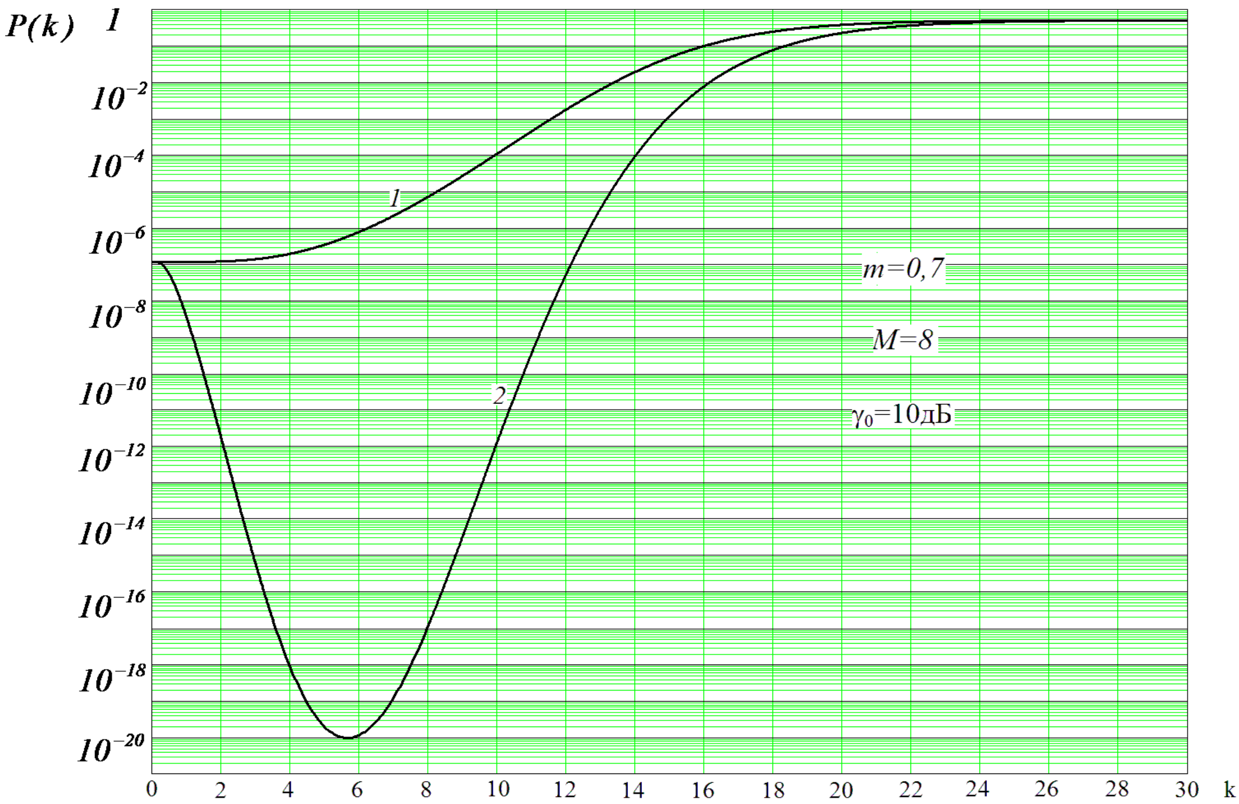

Fig. 3. Probabilities of error at the diversity reception of a signal DBPSK with optimum sum of branches of a diversity without interruption (a curve 1) and at synthesis of discontinuous communication with the diversity reception with optimum sum of branches of a diversity (a curve 2).

Analyzing the accepted data (for example, with use of CRC-codes) it is possible to define those sites time of reception data at which there was a considerable number of errors, and, thereby to define those time points at which weakening (fading) of a signal was considerable. Using the return channel it is possible to transfer necessary commands for repeated transfer of low-quality data. The increased speed of transfer (in inverse proportion η_M) allows realizing it without information loss.

Choosing values k at the accounting of efficiency of the radio line (η_M) and the probability of a error (according to fig. 1 and fig. 2, 3) can carry out data transmission with low probability of a error at insignificant expansion of a strip signal.

Application technology of orthogonal frequency multiplexing [6, 7, 9] (OFDM - **O**rthogonal **F**requency **D**ivision **M**ultiplexing) along with increase of spectral efficiency, give opportunity is adaptive to operate a frequency resource, allows to fight against an intersymbolical interference effectively.

Conclusion

1. For the channel with a signal fading under Nakagami's law synthesis of discontinuous communication with the diversity reception, with optimum sum branches of diversity, obtained analytical expression of probability of error depending on threshold level at the fixed: power of the transmitter and average value of SNR. Its optimum value is shown.
2. Possibility implementation of realization of noise immunity and spectrally effective data transmission in a earth-space interferometry (within the Millimetron project) is shown by a integration of discontinuous communication with the diversity reception, at optimum sum branches of diversity.

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