Зв'язок

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METHOD OF FORMING RATIONAL VALUES PARAMETERS OF THE SIGNAL IN CONDITIONS OF DISTRIBUTION OF MULTIPATH RADIO WAVES

In the work offered method of forming rational values parameters of the signal in conditions of distribution of multipath radio waves. Specified method based on adaptive management parameters of the signal when dynamic changes of signal and noise conditions.

Keywords: *unmanned aviation complex, signal-code construction, speed of information transfer, bit error probability, radio-electronic suppression.*

Introduction. Experience of recent local conflicts, military training and fighting in eastern Ukraine unmanned aircraft systems increasingly using for solving tasks, communications and causing fire strikes on enemy positions [1]. As base technology of information transmission for unmanned aircraft systems using method of orthogonal frequency division multiplexing with OFDM (Orthogonal Frequency Division Multiplexing) [2, 7]. Main feature of OFDM signals invariance of phenomenon of multipath channel. However, these systems has drawbacks, the main ones are:

- high pic-factor;
- nonlinear distortion devices of radio communications;
- mistakes of synchronization;
- harmful effects of intentional interference.

Also characteristic of communication channels for unmanned aviation systems need permanent increasing range of management systems and data, increase data rates when working in unstable propagation. Conducted in uniforms [2, 7] analysis shows that using of OFDM technology does not fully satisfy all above requirements for control channels and communication with unmanned aircraft systems. One improving efficiency of radio communication systems is application of spatial processing signals in radio systems, including technology Multiple-Input Multiple-Output - MIMO [3,4]. In MIMO technology combined spatial-temporal methods of reception antennas using adaptive methods and space-time coding and space-time separation of signals.

Key feature is the ability to convert MIMO multipath propagation effects that significantly affects quality of wireless communication, advantage for user. Just MIMO makes it possible to improve operational performance without increasing required radio communication system bandwidth. Analysis different methods of improving efficiency wireless communication systems [2, 3, 4, 7] reveals number of contradictions. Growth channel bandwidth increases bandwidth of radio communication, but at the same time leads to increased noise power in channel. Increase transmitter power is ineffective and unacceptable in terms of ensuring the secrecy of radio communication.

Strategic direction in solving problem of improving effectiveness of information transfer is transition from system of rigid structure for adaptive systems [5, 6]. In adaptive algorithms systems for transmission and reception signals may vary depending on the agreed changes in external conditions. Algorithms should allow adaptation to work in conditions of minimal prior information to achieve optimum system parameters.

Searching alternatives of secure and speed control system and communications for unmanned aircraft systems showed that combined using OFDM and MIMO technologies for controlling and communication with unmanned aviation complexes are promising and appropriate.

Purpose is developing methods of forming rational parameters signal under conditions of multipath propagation. Methods of selecting rational parameters MIMO-OFDM-signal consists of following stages.

1. Data input. Introduced parameters and transmitter channel, value permissible value of probability of false signals and the minimum necessary information transfer rate.

2. Determination number of antennas in MIMO system. At that stage choosing depending on the channel number of transmitting and receiving antennas for unmanned aviation sector, taking into account required signal/noise ratio and required rate. So, if you set permissible speed MIMO-systems, fluctuations in average signals v_Σ, then threshold value $\lambda^{(Q^2)}_{threshold}$ for choosing necessary number of most powerful own channels, can search from equation:

$$P\left(\lambda^{(Q^2)}_{threshold}, Q_0^2\right) = 1 - v_\Sigma / v_{max}\,.$$

So $\lambda_{\text{threshold}}^{(Q^2)}$ depends from average relation signal/noise Q_0^2, from this speed of data transfer $v_\Sigma = \left(\lambda_{\text{threshold}}^{(Q^2)} = \lambda_{\text{threshold}}^{(Q^2)}\left(Q_0^2, v_\Sigma\right)\right)$ and increase with increasing relation signal/noise Q_0^2.

3. Distribution of power between own channels.

With water filling method, carried out distribution of power between own channels. This procedure repeated at intervals of length group of characters that are divided flow signals.

4. Select number of subcarriers.

In OFDM group signal modem at interval transmission single character can be presented as [7]. At this stage, the number of selected subcarrier signal with OFDM, at which the predetermined signal / noise ratio. Evaluation of transmission characteristics of the communication channel. At this stage, using pilot-bearing condition estimated multipath channel and determines its transmission rate. In general, the assessment of the channel can be performed both direct and indirect methods. Also at this stage using method proposed in [6] assessed the state of multipath channel.

5. Convert channel with intersymbol distortion channel with set of Gaussian channels without memory. In real frequency-limited channels except additive noise occurs intersymbol interference (ISI), which is caused by memory channels. Reaction sequence channel input signals cause mutual overlay signal at output. As result of above conversion Gaussian channels with intersymbol interference in independent set of parallel Gaussian channels without memory input and output of each channel associated expression

$$Z_i = K_i X_i + B_i\ ,\ i = \overline{0, L-1}\,.$$

6. Characterization previous distortion signals. Consider the approach to coding channels with ISI, based on a synthesis of signal-code designs that take into account the "deformation" space signals in the transmission channel for real [3]. To optimize parameters of OFDM signal group introduced prior to transmission signal distortion $X_i = \xi_i / |K_i|$ and correction on input $\xi_i = b_i Z_i$, where $b_i = e^{-j\arg K_i}$.

7. Determination of the average power of the output signal Gaussian channel without memory (GCWM). If the output channel has significant unevenness of amplitude-frequency characteristics in the band Nyquist is channels can be quite different. GCWM differences must be considered when building signals signal-code constructions (SCC).

Typically, in parallel with previous GCWM using different alphabets distortion signals with quadrature amplitude modulation (QAM), but at the same Euclidean minimum distance d, which is independent of number and GCWM. Need to consider possibility of constructing variant explained based on effective signal and signal-code constructions [7].

8. Organize subchannels in descending order of relation signal/noise ratio at receiver input. At this stage of evaluation of transmission characteristics of the channel assignment performed each subchannel sequence numbers in descending order of relation signal/noise (worse subchannels have larger numbers):

$$Q_1^2 \ge Q_2^2 \ge \ldots \ge Q_N^2\,.$$

9. Iterative procedure disconnection subchannels doing by discarding inferior half of subchannels (subchannels screening poorer half, the redistribution of power on subchannel, adding better half in subchannels). Then the transmitter power is evenly distributed between other not unplugged (active) subchannels. Because through the redistribution of power by disabled subchannels signal / noise ratio in the active subchannels increases, it can be assumed that it is advisable not to turn off all subchannels for which $Q_i^2 \le Q_{\text{per}}^2$, but only part of them.

10. Choosing rational signal-code constructions. At this stage of finite number of correcting codes and modulation types, determined by initial data, depending on the current signal / noise ratio for each subchannel determined by SCC, which allows to get maximum transmission rate while ensuring given probability of bit errors. Main stages of selecting optimal signal-code constructions are:

Based on parameters of radio and channel $\Psi = \{\psi_i\}$ and value of permissible value probability of bit error band of radio signals select the dimension N (design with one-dimensional, two-dimensional and multidimensional signals) and band structure signals. Detailed calculations of the probability of bit error for *M* positional signals with phase shift keying (PSK) and QAM are presented in [7]. Selects type correction code. In view of all SCC noise immunity codes can be divided into two major classes: on basis of block codes and based on continuous codes. In addition, a separate class consists SCC-based cascading of codes used both block and continuous codes.

Selects manipulation code. In agreeing codec binary code and noise-immune multiposition modem signals necessary to use manipulation code in which greater consideration in Hemet between code combinations to meet greater distance between Euclid signals that correspond to them. Control unit selection signal parameters should only choose from set of possible SCC optimal for channel status.

11. Calculation maximum rate in each subchannel. Maximum speed of each GCWM at fixed is defined as follows:

$$\nu\left(q_j, P_{q_j} / P_{\text{nonse}}\right) = \nu\left(q_j, d_E^2 \varphi^{(2^{q_j})} / P_{\text{nonse}}\right).$$

12. Determination of maximum rate signal group. Total rate of GCWM given expression

$$\nu = \nu_0 \cdot \frac{1}{N} \cdot \sum_{j=1}^{Q} s_j \cdot \left(q_j, d_E^2 \varphi^{(2^{q_j})} / P_{\text{nonse}}\right),$$

where $s_j - m_j - m_{j-1}$, $m_0 = 0$ — number of GCWM with same alphabet QAM. Optimization options considered by the speed with limited average signal power at the input channel comes down to choosing the optimal partitioning of parallel GCWM at the same rate, the optimal choice of alphabets and minimum FSK them. Accordingly, the maximum speed that can be achieved GCWM with previous distortions and arbitrary alphabets FSK in each of the parallel GCWM provided that the minimum distance in all alphabets constant and equal to d, given expression in the constraints described above, the permissible average power input signal GCWM, but $s_j = m_j - m_{j-1}, m_0 = 0,\ 0 < m_1 < m_2 < ... < m_Q \le M_1$ – breakdown many GCWM on groups with v_j parallel channels, each of which uses the same alphabet FSK with average power $P_{q_J} = d_E^2 x(2^{q_j})$.

13. Transfer next character. As result of determined parameters of next OFDM-symbol, number of active subchannels N_A and their numbers, M and R for each subchannel, information about value of which is transferred as part of service information for counter station.

Conclusion

1. In article offered method of forming rational parameters signal in terms of multipath radio propagation. Novelty of developed method is to adapt parameters of hybrid MIMO-OFDM-systems to improve the efficiency.

2. Novelty of technique lies in fact that optimal parameters signal-code constructions are determined in the case of transmitting information over communication channel. Also carried adaptive formation matrix subchannel by adaptive to signal-interference environment selection structure antenna system of unmanned aircraft systems, turning off generators matrices, thereby narrowing or expanding frequency range of signal OFDM (respectively decreasing or increasing number of subchannel) need to increase energy and frequency effectiveness of radio conditions of active electronic countermeasures.

Optimal parameters MIMO-OFDM-signal for particular channel state determined from finite allowable number of options that can simplify practical implementation of adaptive equipment modem radio communication systems.

Based on evaluation of efficiency techniques choice of rational parameters signal for unmanned aircraft systems to maximize energy efficiency, which amounted to about 2-3 dB depending on the depth of fading multipath channel, it can be argued that based on borders Shannon frequency efficiency using the proposed method and relevant SCC should rise in value of about 2-4 dB.

Direction of future research is development of information technology data for multipath channels of unmanned aviation systems.

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МЕТОДИКА ФОРМУВАННЯ РАЦІОНАЛЬНИХ ЗНАЧЕНЬ ПАРАМЕТРІВ СИГНАЛУ В УМОВАХ БАГАТОПРОМЕНЕВОГО ПОШИРЕННЯ РАДІОХВИЛЬ

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В роботі запропонована методика формування раціональних значень параметрів сигналу в умовах багатопроменевого поширення радіохвиль. Зазначена методика базується на адаптивному управлінні параметрами сигналу при динамічній зміні сигнально-завадової обстановки.

Ключові слова: *безпілотний авіаційний комплекс, сигнально-кодова конструкція, швидкість передачі інформації, ймовірність бітової помилки, радіоелектронне подавлення.*

МЕТОДИКА ФОРМИРОВАНИЯ РАЦИОНАЛЬНЫХ ЗНАЧЕНИЙ ПАРАМЕТРОВ СИГНАЛА В УСЛОВИЯХ МНОГОЛУЧЕВОГО РАСПРОСТРАНЕНИЯ РАДИОВОЛН

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В работе предложена методика формирования рациональных значений параметров сигнала в условиях многолучевого распространения радиоволн. Указанная методика основана на адаптивном управлении параметрами сигнала при динамическом изменении сигнально-помеховой обстановки.

Ключевые слова: *беспилотный авиационный комплекс, сигнально-кодовая конструкция, скорость передачи информации, вероятность битовых ошибок, радиоэлектронноее подавление.*