ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНІ СИСТЕМИ

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С. В. Толюпа, Ю. Я. Самохвалов, О. В. Труш
Київський національний університет імені Тараса Шевченка

АДАПТИВНЕ УПРАВЛІННЯ РАДІОРЕСУРСОМ У СКЛАДНИХ ЗАВАДОСТІЙКИХ УМОВАХ

Системи радіозв’язку спеціального призначення (СРЗ СП) функціонують на практиці в умовах випадкового впливу різних факторів, частина з яких систематизована в стандартах, а частина – заздалегідь невідома. Специфіка сучасних СРЗ СП визначає необхідність управління їх функціонуванням в умовах параметричної невизначеності, – як об’єкта управління, так і сигнальної невизначеності зовнішніх впливів. Тому виникає задача аналізу і врахування невизначеності під час функціонування такої складної ієрархічної системи, як СРЗ СП. Сутність методу полягає в адаптивній зміні режимів і параметрів СРЗ СП залежно від зміни завадової обстановки в каналі зв’язку з метою одержання максимального значення енергетичної ефективності. За запропонованим методом, на відміну від розроблених раніше, адаптація до стану сигнальної та завадової обстановки здійснюється на основі комплексного координування частотних, енергетичних, часових і інформаційних ресурсів радіоканалів з характеристиками комплексу зовнішніх умов їх реалізації зміною режимів роботи і параметрів сигналів СРЗ СП, що дає змогу підвищити ефективність функціонування військової системи радіозв’язку в умовах складної радіоелектронної обстановки.

Ключові слова: радіозв’язок, завада, сигнальна невизначеність, математична модель, енергетична ефективність, об’єкт управління, параметрична невизначеність, ретрансльована завада, частота, радіозасіб.

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S. Tolyupa, Y. Samokhvalov, A. Trush
Taras Shevchenko National University of Kyiv

ADAPTIVE RADIO RESOURCES MANAGEMENT CONSIDERING NOISEIMMUNITY CONDITIONS

Operation of radio communication systems for special purposes (FSA SP) in practice is random in terms of various factors, some of which are codified in standards, and some – previously known. Specificity of modern shipyard JV determines the need to manage their operations in terms of parametric uncertainty as facility management and signaling uncertainty of external influences. So the challenge is the analysis and consideration of uncertainty arising from the operation of such a complex hierarchical system as the FSA SP. The method is adaptive change modes and parameters Shipyard JV depending on changes in

environment-interference in the communication channel in order to obtain maximum energy efficiency. In the proposed method, in contrast to previously developed, adapting to the state of the signaling and-interference environment is based on a complex coordination of frequency, energy, time and information resources of radio channels with the characteristics of complex environmental conditions of their implementation by changing modes and parameters of signals Shipyard JV, allowing to increase the efficiency of military radio system in a complex electronic environment.

Key words: radio, obstacle, signaling uncertainty, mathematical model, energy efficiency, facility management, parametric uncertainty relayed noise ratio, frequency, radio means.

Introduction

The analysis showed that the existing radio communication system to a certain extent does not meet modern requirements of sustainability, mobility, capacity, timeliness, accuracy, secrecy, survivability, technical and can not provide enough effective application of such systems in the area of military conflict in the east of our countries.

The main factors affecting the quality of radio communication is fading signals resulting from multipath propagation of radio waves, and intentional interference created electronic suppression system (ROS) opponent. Acting on the receiving device, simulating noise or distort the received signals, impede or preclude selection of useful information, conducting radio use, reduce the range of the quality of management systems. Under the influence of radio interference and the system may stop the transfer of information, despite the full serviceability and performance.

In addition, a significant obstacle for optimal reception of signals at selective fading and active electronic suppression is a priori uncertainty characteristics of the communication channel. The main method of solving complex problems in information-interference situation was not determined and remains adaptive processing radio signals.

Thus, there is a contradiction between the possibilities of radio resources management subsystem radio communication systems, conditions of operation and requirements for an information exchange them in difficult conditions electronic environment. The solution to this problem is an important scientific and technical direction in creating a new generation of automated radio communication networks for special purposes.

Main part

Operation of radio communication systems for special purposes (FSA SP) in practice is random in terms of various factors, some of which are codified in standards, and some – previously known. Particularly worth emphasizing that the assessment of the quality of functioning shipyard joint venture must necessarily take into account both objective circumstances and likelihood factors and its characteristics should have probabilistic nature [1].

Note that the specificity of modern shipyard JV determines the need to manage their operations in terms of parametric uncertainty as facility management and signaling uncertainty of external influences. So the challenge is the analysis and consideration of uncertainty arising from the operation of such a complex hierarchical system as the FSA SP.

Features solving problems in real time leads to the fact that the lack of computing power (mismatch computing resources complexity of the problem) is equivalent, in a sense, the lack of information about the problem.

It should be noted that FSA SP and its elements can be controlled either on the basis of a priori information in the form of a program for the entire period of the system, or through procedures and recurrent adaptive assessment to eliminate a priori parametric uncertainties using the principles of feedback control. In this case, adaptation is not limited to a single act, and continues during the observation Shipyard JV.

The presence in the adaptation of uncertainty not accurately assess the impact of control actions on the objective function. Difficulty Shipyard JV and uncertainty of information about it growing, and requirements for accuracy of the resulting solution increased, so the problem of representation of uncertainty is one of the key, but at the same time and for the least studied objects Shipyard JV.

Important is the right choice for the appropriate level of management models Shipyard JV and the amount of transmitted data for calculations. Complications mathematical model that takes into account a large number of measured parameters, reduces errors introduced model. However, large-scale models is a very significant component of the error, inaccuracy introduced applicable analytical and numerical methods. The time large-scale solution could also be acceptable in its solving in real time. Complications mathematical model requires an increase in the amount of data transferred from the lower level, and also increases the corresponding component error. So you need to find a reasonable compromise between these factors depending on the government [2].

The use of more sophisticated mathematical methods greatly increases the validity and effectiveness of operational decisions taken by management shipyard JV. It is known that in complex systems the ratio between the components of error for sustainable modes are: malfunctioning due to initial data – 82–84 %, due to malfunctioning model – 14–15 %

A large share of output data error occurs error in the calculation of the objective function, which leads to significant areas of uncertainty in choosing the best mode of the system.

To reduce them using various methods of filtering and smoothing background information, and averaging the weighing data. Also used methods of restoring missing data interpolation and extrapolating, robust algorithms. The property provides robustness class treatments insensitive to small changes in the initial (primary) assumptions.

To optimize complex distributed Shipyard JV commonly used methods of multilevel governance, which are based on the idea of decomposition and coordination. As a result of the decomposition of complex Shipyard JV divided into small sub group with the relationship to the global optimization problem evolved into a group of local optimization problems, that some decisions will be made on limited information, without the use of total data [3].

Go to the hierarchical management structure narrows the set of feasible strategies, but also reduces the level of uncertainty that makes it possible to obtain better solutions.

Based on the above it can be noted that the specific operation of modern shipyard JV identifies the need for adaptive management of the operation in terms of parametric uncertainty as facility management and signaling uncertainty of external influences. This fact determines the relevance of research in the field of adaptive management of the joint venture shipyard capable of the detection of unknown type interference manage radio resources so as to prevent a decrease in the quality of communication.

It should be noted that the shipyard joint venture one of the most adverse noise is relayed obstacle (obstacle in reply) [3–4]. Range of radio-electronic suppression (REP) depends on many factors, including the power transmitting radio communications devices (ZRZ) and RAP means, characteristics of antenna systems, the sensitivity of receiving equipment, the conditions of propagation of electromagnetic waves, radiation types and methods of signal processing length of a wave, how to protect against interference. In addition, the range of ROS affect the intensity of interference from local objects, earth (water) surface and extraterrestrial sources, the nature of radiation and scattering of electromagnetic waves purposes ZRZ observed. Take into account all these factors are extremely difficult. In this regard ZRZ range suppression and required power tools REP evaluated mathematically averaged for the specified parameters and process modeling.

We estimate time opportunities enemy by setting relay interference to suppress the FSA SP.

Station interference, which incorporates electronic intelligence equipment to solve problems by suppressing Shipyard JV should provide:

- detection of radio signals around the working frequency range for as short time;
- measuring the frequency and direction of arrival of the intercepted signal with the required accuracy;
- adjust the transmitter frequency noise on the signal attenuation;
- radiation noise in a given spatial sector.

Expiry relay noise should coincide with the termination of radiation signals from radio product.

The time required to perform these functions (response time relay station interference) Δt_{cnp} must be small enough to relayed obstacle managed to influence the receiver of radio to the point where the transmitter Shipyard JV to another frequency.

The result of the impact of noise on the receiver relay ZRZ generally can be estimated value of the average probability of error on Sat bits of information that is:

$$P_б = r P_1\left(\frac{E_c}{G_0 + G_з}\right) + (1 - r) P_2\left(\frac{E_c}{G_{0з}}\right) \quad (1)$$

where $P1$ – average probability of error per bit when exposed to noise relay; $P2$ – the average probability of bit errors on the absence of relay noise at the input of the demodulator, r – coefficient characterizing the frequency of the element affected obstacle (coefficient overlapping) $0 \le r \le 1$.

If the work of radio communication (ZRZ) on one frequency Δt_p, less than the total response time $\Delta t_{спр}$ and time delay $\Delta t_з$ interference caused by placement (topology) on the ground transmitter and receiver Shipyard JV and relay station interference and finite speed of propagation, the relayed obstacle is inefficient.

In the advanced relay stations interference UHF band, using the latest technological advances and high-speed microprocessor technology in the equipment REP minimum response time $\Delta t_{спрmin}$ may be equal to 100 microseconds or less [5]. In these circumstances, an important parameter of radio (in terms zavadozahyschenosti) is the actual time on the same frequency t_p

The coefficient overlapping signal relay obstacle depends not only on $\Delta t_{спр}$, response time, but the relative position (topology) PRD transmitter and receiver PRM Shipyard JV and relay stations obstacles on the ground that determines the delay interference $\Delta t_з$.

If the work of radio on the same frequency Δt_p, is less than the total response time $\Delta t_{спр}$ nd time delay $\Delta t_з$, Δt_p.

$$\Delta t_р \le \Delta t_{спр} + \Delta t_з; \quad \Delta t_з = \frac{1}{C_р}(r_1 + r_2 - r_{12}), \quad (2)$$

where r_1 – the distance from the relay station to the transmitter noise Shipyard JV, r_2 – the distance from the relay station to the receiver noise FSA SP, r_{12} – distance transmitter and receiver Shipyard JV, Wed – speed of propagation.

The closer the receiver is to SRH SP relay station noise, the less time it allowed Δt_p work without the influence of noise.

Effective relay impact noise when it sufficient power to the receiver Shipyard JV achieved the performance ratio.

By using this expression, we can estimate the time relay station capabilities noise suppression at Shipyard JV with varying durations of one frequency.

The method is adaptive change modes and parameters Shipyard JV depending on changes in environment-interference in the communication channel in order to obtain maximum energy efficiency.

$$(1 - r)\Delta t_р \ge \frac{r_1 + r_2 - r_{12}}{C_р} + \Delta t_{спр}. \quad (3)$$

Formulation of the problem

Given: modes of radio communication

$$\Phi = \{f_i\}, \ i = \overline{1, n}, \quad (4)$$

where $f_1 ... f_2$ – modes (OFDM, FHSS mode, noise signals with direct expansion range);

transmitter settings and channel

$$y = \{y_i\}, \ i = \overline{1, m}, \quad (5)$$

where $y_1 ... y_2$, $y_1 ... y_m$ power signal, operating frequency, pulse signal bandwidth communication channel, view manipulation, adjustment type code, signal processing method, type intentional interference, the signal noise ratio.

Required: to maximize the value of the coefficient of signal b_E while ensuring a given value of probability of false acceptance $P_{пом} \le P_{пом\ доп}$.

The system of equations for solving the optimization problem has the form

$$\begin{cases} b_E = F_1(C_i, v_{\text{i}}, f_0, \Delta F, P_{\text{c}}, M, n, R, d, N_{\text{A}}) \to \max; \\ P_{\text{пом}} = F_2(C_i, M, R, P_{\text{c}}, n, R, d) \le P_{\text{пом доп}}, \end{cases} \quad (6)$$

where C_i – mode and means of radio communication; n – length code combination; PC – signal; M – dimension band signals; R – rate correcting code ($R = k/n$); k – number of information bits in the code combinations of length n; d – the value of the code range, N_A – the number of active subcarriers (mode OFDM); f_0 – operating frequency; ΔF – width of the signal.

Adaptive methods allow estimation based on the results of real channel interference due to provide nearly optimal modes of the system by automatically perestroika algorithm changes redundancy messages and signals coding structure of devices and other similar measures.

The method is based on the representation of SRH joint venture in the form of a controlled system that works on the principle of rejection. Generalized model of adaptive Shipyard JV shown in Fig. 1. The system is based on the measurement of external influences (noise characteristics deliberate and selective fading) **z**, causing deviations of the system from the set. Control Law is:

$$u_1 = \Psi(x_i) \cdot \text{b}, \quad (7)$$

where i – step number adaptation; $\Psi = \|y_{vm}\|$ $(n = 1, 2, \ldots, N_1; m = 1, 2, \ldots, M_1)$ – matrix of size $N_1 \times M_1$ linearly independent functions that characterize the shipyard joint venture; x_i – vector variable settings FSA SP (parameters and operating modes); b – coefficients vector control unit.

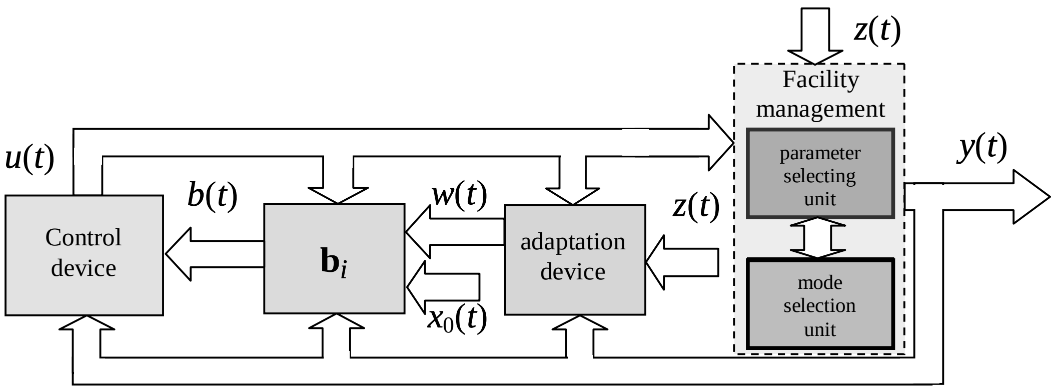

Fig. 1. Generalized model of adaptive FSA SP

Optimality criterion is the maximum value of the coefficient of signal strength

$$b_E = M\{\mathbf{x}_{0i} - \mathbf{x}_i\}, \quad (8)$$

where $\mathbf{x}_{0i}$ – the initial impact applied to the system.

The optimal parameter vector control unit $b = b^*$ is using an algorithm

$$\mathbf{b}_{i+1} = \mathbf{b}_i - a_{1i+1} \nabla F_1\left(\mathbf{x}_{0i} - \Phi(\mathbf{x}_i, \Psi(\mathbf{x}_i)\mathbf{b}_i \mathbf{w}_i\right), \quad (9)$$

where a_{1i} – the value of pitch change system parameters; $\Phi(\mathbf{x})$ – matrix of known functions, depending on the parameters SRZ SP.

Find the optimal parameters working functions $b_E(\mathbf{w}_i)$ carried out by the possible directions

$$b_{Ei+1} = b_{Ei} - a_{i+1} c_i, \quad (10)$$

where a_i – value step change device settings adjustment; c_i – the direction of search, which depends on the type and parameters of external influences (intentional interference and selective fading) z, where the condition $b_E(\mathbf{w}_{i+1}) > b_E(\mathbf{w}_i)$.

The size of the step α_i is defined such that.

$$b_E(\mathbf{w}_{i+1} - a_i c_i) = \max_a b_E. \quad (11)$$

Adaptation Shipyard JV under the impact of intentional interference and selective fading according to the proposed method is implemented as follows. In most cases, it is possible to identify several possible scenarios-interference environment. This scenario in line can be put different strategies SRH N SP (parameters and operating modes), which should be chosen based on the parameters of efficiency Shipyard JV under the influence of different types of intentional interference. This approach is the basis for the development of algorithm functioning shipyard JV with structural adjustment and can be extended to a greater number of degrees of adaptation.

Initial data in communications is driving the current values of vectors: a controlled quantity x (x_1 – capacity factor signal; x_2 – the probability of false acceptance); regulatory impact u (u_1 – type of modulation; u_2 – length code combination; u_3 – correction capability of the code; u_4 – speed code; u_5 – signal; u_6 – the number of active subcarriers (when OFDM); u_6 – operating frequency of the transmitter); intentional interference z (z_1 – kind of deliberate interference; z_2 – of bandwidth Shipyard JV occupied obstacle; z_3 – level signal in multipath fading channel; z_4 – the signal / noise ratio). Keeping communication using the chosen mode of signal-code construction is carried out until the probability of erroneous reception will not increase more than a specified level ($P_{\text{пом}} > P_{\text{пом доп}}$.).

Conclusion

Thus it can be argued that the operation of adaptive FSA SP checks the current value of the probability of erroneous reception and determined the type and parameters of intentional interference, which operates in the communication channel. If the result of changes in the environment-interference $P_{\text{пом}}$ current value is greater than the permissible value $P_{\text{пом}}$ extra, the decision to change the settings or mode of radio communication by changing the type of intentional interference, which operates in the communication channel.

In the proposed method, in contrast to previously developed, adapting to the state of the signaling and-interference environment is based on a complex coordination of frequency, energy, time and information resources of radio channels with the characteristics of complex environmental conditions of their implementation by changing modes and parameters of signals Shipyard JV, allowing to increase the efficiency of military radio system in a complex electronic environment.

In most cases, it is possible to identify several possible scenarios-interference environment. This scenario in line can be put N different modes (parameters) of radio communication, which should be chosen based on the parameters of efficiency Shipyard JV under the influence of different types of intentional interference.

This approach could be the basis for developing adaptive algorithm functioning shipyard JV. Without loss of generality, this approach can be extended to a larger number of degrees of adaptation.

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