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GENERALIZED INDICATOR OF THE EFFECTIVENESS EVALUATION OF MILITARY RADIOCOMMUNICATION SYSTEMS

Modern military radiocommunication systems are working in the difficult conditions due to the shortage of radio frequency resources, limited computing resources and the influence of the enemy radio-electronic suppression devices. One of the ways to increase the noise immunity of military radiocommunication systems is to develop effective indicators, algorithms and methods for assessing the state of military radiocommunication systems. Nowadays, a large number of indicators for evaluating their effectiveness have been developed to evaluate military radiosystems, but their application is due to a number of limitations, that indicators with high precision are generally not used due to their high computational complexity, and those indicators having an acceptable computational complexity have low accuracy of evaluation. Therefore, in order to increase the protection of the security of military radio communication systems in the article, the authors developed a generalized indicator of the evaluation of the effectiveness of military radiocommunication systems. During the research, the authors of the article used the basic provisions of the theory of communication, mathematical statistics, management theory and the theory of tampering. The generalized indicator of the evaluation of the effectiveness of military radiocommunication systems developed in the work, allows to increase the noise immunity of military radiocommunication systems by increasing the speed of their state assessment. The carried out estimation of efficiency of the developed indicator allows to assert about its raising on 15-22% efficiency in comparison with classical indices of power and spectral efficiency of systems of military radio communication. The practical significance of the research is the possibility of using the proposed generalized indicator of the evaluation of effectiveness in developing new and modernizing existing military radiocommunication facilities (radio monitoring centers).

Keywords: noise immunity; evaluation; radiocommunication systems; radioelectronic suppression; radiocommunication facilities.

Introduction

While designing adaptive military radio systems, depending on their purpose, the task of optimizing one of the indicators of efficiency under the established restrictions to other.

The development and implementation of adaptive methods of information exchange requires the establishment of effective procedures for monitoring and forecasting the state of the radio communication system.

To solve this problem, it is necessary to involve methods of modern mathematical statistics, in particular, to check statistical hypotheses in relation to indicators (groups of indicators), that characterize the state of the radio communication system.

To evaluate radio communication systems, many indicators have developed for evaluating their effectiveness, but their application is made due to a number of limitations:

indicators with high precision are generally not used due to their high computational complexity;

indicators with acceptable computational complexity have poor accuracy.

This research is dedicated to the decision of the mentioned compromise.

Proceeding from the foregoing, ***the purpose of this article*** is to develop a generalized indicator of the evaluation of the effectiveness of military radiocommunication systems.

Presentation of the main material

In the theory of communication networks issues of assessing the effectiveness of the establishment and operation of communication networks has always been a great importance.

Undoubtedly, the improvement and development of communication networks and network technologies are conditioned not only by the growth of user necessity of communication services, but also by the growth of quality service requirements, as well as the desire to increase their efficiency. Nowadays, a variety of approaches to the selection of indicators, used to assess communication networks.

The channel bandwidth utilization rate is proposed to estimate the information efficiency of a one-channel communication system and to determine the channel utilization rate coefficient η, which is defined as the ratio of the transmission rate of V to the bandwidth of the communication channel $C : \eta = V / C$ [5]. This parameter is proposed to be used to evaluate the information efficiency of the multichannel communication system. It`s main disadvantage is that it does not give a complete description of the channels of communication with memory, since it determines only it`s high-speed characteristics.

The parameter proposed in [6] is used only to evaluate the packet switching network. It determines the total speed of sending messages to users. It is considered, that it is like the performance of the communication network P. This indicator does not reveal all the properties of the data transmission process in the communication network, but only determines the speed of data transmission by the communication system. It is not generalized, since it does not take into account the dynamic properties of the communication network, characterized by a delay in the transmission of information within it and the accuracy of data transmission.

The power factor of the communication network was introduced in [7, 8] for use in controlling the flow in the communication network and connects the bandwidth $\gamma(\lambda)$ and the average network latency $T_в$ by the ratio:

$$P = \frac{\gamma(\lambda)}{T},$$

where λ – the input speed of data packets into the network;

$\gamma = \gamma(\lambda)$ – traffic transmitted by the network;

T – avarage time delay.

The maximum traffic γ_0, that can be transmitted by the network is the bandwidth. The imbalance of communication network productivity and the average time delay T is achieved at the operating point

$$\lambda^* = \gamma_0 / 2,$$

which provides the maximum value of power P. This indicator does not fully reveal the properties of the data transmission process in the communication network, but only determines the speed of data transmission by the communication system and the average delivery time. It is not generalized, since it does not take into account the properties of the noise immunity of the communication network, characterized by the accuracy of data transmission.

The indicator of the cybernetic power of the communication network is proposed for assessing it`s information capabilities [8] and obtained by multiplying the number of N messages contained in the communication system in the process of storage and transmission within the system to the performance of the communications network G, averaged for a given interval of time^

$$T : KW = N^* G | T .$$

If the parameter is considered as a guaranteed message transmission time, N determines the maximum number of messages, that may be in the communication network. The KW indicator allows you to evaluate the limitations of the communication network with the transfer of user traffic, reflecting it`s storage properties in the process of transmission, routing and performance.

The KW cybernetic power parameter will be used to evaluate the information efficiency of the communication systems by comparing its performance with the limitations of message transmission. However, an indirect assessment of the main indicator of the data transmission process - the average delivery time and does not take into account the properties of the noise immunity of the radio communication system, which is characterized by the accuracy of data transmission.

Taking into account the analysis carried out, it is suggested to use the indicator of the estimation of the efficiency of the communication network a generalized indicator, which is the volume of the radio communication system W, which is determined in the metric space F by partial performance performance indicators, such as performance P, velocity V, and accuracy of information transmission T.

The accuracy of T is numerically equal to the number of messages taken per unit time without taking into account missed messages, lost packets in the network, and also packets not delivered, that is

$$T = \Pi - \Delta\Pi ,$$

where $\Delta\Pi$ is the total number of messages that are not delivered accurately and measured by messages/second.

The class of performance indicators is highlighted on the basis of the classification of network indicators [10], according to which the main classes of communication network indicators are defined, such as:

class A - network quality performance indicators,

class B - class of performance stability indicators;

class E - class of indicators efficiency.

In separate classes, indicators are determined, that determine the values of quality indicators functioning of the communication network - class C; performance indicators, that determine the stability of performance indicators - Class D:

Performance indicators, that affect performance - Class F.

In this case, the class A includes performance P, speed V and accuracy of information transfer T, which is in accordance with the provisions of recommendation МСЭ I.350.

These performance indicators are interrelated, and the value of one or two of them is not enough to evaluate the network.

The space of the quality performance indicators F is metric: for some system of its subsets, a mapping is introduced

$$W : H_{ci} \rightarrow R$$

such that, where W_i is the non-negative accountable additive function, that determines the volume in $(\text{messages/sec})^3$ and represents the measure in the network of network performance indicators.

Each pair

$$H_{ci}, H_{cj} \in \Phi$$

is associated with a real number

$$\rho\left(H_{ci}, H_{cj}\right),$$

representing the distance between elements of space satisfying the conditions of the measure theory.

The probability of timely delivery Q is an integral indicator of the quality of functioning and characterizes the performance of the communication system (average flow intensity served λ_{served} for a given average intensity of the input stream $\lambda_{incoming}$), when providing user requirements over time and accuracy of transmission.

The performance indicators are components of the vector F in space R^3 . The process of functioning

$$\Phi = \left(\Pi, T_{availability}^{-1}, T \right)$$

of the communication system and any of the elements can take place only within the limits of their loading abilities

$$H_c = \Pi_{\max}, V_{\max}, T_{\max},$$

thus

$$\Phi \subset H_c .$$

The space F is metric: for some system of its subsets, a mapping is introduced

$$W : H_{ci} \to R,$$

such that

$$W_i = \Pi_i V_i T_i \; -$$

a measure, that represents the volume of the network.

The load capacity exists for any element of the communication network, its sites and the network as whole. It can be calculated analytically, obtained experimentally by measuring or collecting and processing statistical data.

Indicators with one sense, entering into the network and coming out of the network messages streams are the intensity of the flow, the intensity of aging and authenticity.

Construction of the metric space allows us to calculate the efficiency of the communication system and on its basis conduct an objective comparative analysis of communication networks and their elements.We will evaluate the effectiveness of the developed generalized indicator. This indicator was compared with the energy efficiency of military radiocommunication systems and the frequency effectiveness of military radio communication systems (Fig. 1).

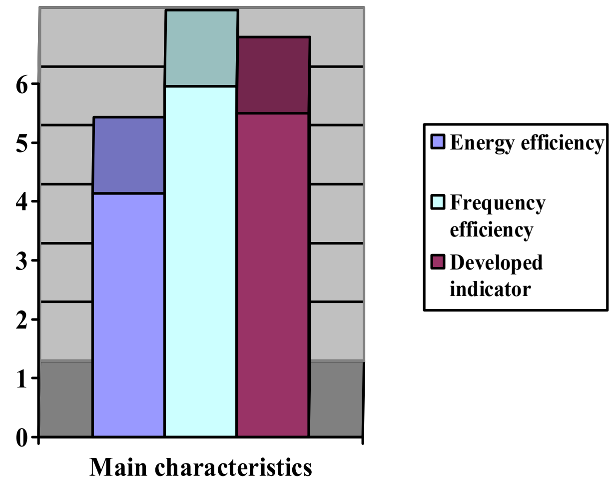

Fig. 1. Comparative analysis of the effectiveness of the proposed indicator with known indicators

Comparative analysis suggests, that the proposed generalized indicator of the effectiveness of military radio communication systems can get a winning of 15-22% depending on the signal-interference situation.

Conclusion from this explosion

In the course of the research, a generalized indicator of the effectiveness of military radiocommunication systems was developed.

An assessment of effectiveness of the developed indicator with the known indicators, during which it was established, that this indicator allows obtaining a generalized assessment of the state of the military radiocommunication system, which is a logical generalization of the energy and frequency effectiveness of the evaluation of military radiocommunication systems.

The gain from the application of the proposed indicator is estimated at 15-22%, depending on the signal-interference situation.

Directions of further research will be directed at the development of methods for increasing the noise immunity of military radiocommunication systems.

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Узагальнений показник оцінки ефективності систем військового радіозв'язку

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Сучасні системи військового радіозв'язку функціонують в складних умовах, що обумовлено дефіцитом радіочастотного ресурсу, обмеженими обчислювальними ресурсами та впливом засобів радіоелектронного подавлення супротивника. Одним зі шляхів підвищення завадозахищеності військових систем радіозв'язку є розробка ефективних показників, алгоритмів, методів та методик оцінювання стану систем військового радіозв'язку. На даний час для оцінки систем військового радіозв'язку розроблено безліч показників оцінки їх ефективності, проте їх застосування обумовлено рядом обмежень, яка полягає в тому, що показники, що мають високу точність як правило не використовуються в зв'язку з високою їх обчислювальною складністю, а ті показники, що мають прийнятну обчислювальну складність мають низьку точність оцінювання. Тому з метою підвищення завадозахищеності систем військового радіозв'язку в зазначеній статті авторами проведено розробку узагальненого показника оцінки ефективності систем військового радіозв'язку. Під час проведення дослідження авторами статті були використані основні положення теорії зв'язку, математичної статистики, теорії управління та теорії завадозахищеності. Розроблений в роботі узагальнений показник оцінки ефективності систем військового радіозв'язку дозволяє підвищити завадозахищеність систем військового радіозв'язку за рахунок збільшення швидкості оцінювання їх стану. Проведена оцінка ефективності розробленого показника дозволяє стверджувати про його підвищену на 15-22 % ефективність у порівнянні з класичними показниками енергетичної та спектральної ефективності систем військового радіозв'язку. Практична значимість проведеного дослідження полягає у можливості використання запропонованого узагальненого показника оцінки ефективності під час розробки нових та модернізації існуючих засобів військового радіозв'язку (центрах радіомоніторингу).

Ключові слова: завадозахищеність; оцінка; система радіозв'язку; радіоелектронне подавлення; засоби радіозв'язку.

Обобщенный показатель оценки эффективности систем военного радиосвязи

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Современные системы военной радиосвязи функционируют в сложных условиях, что обусловлено дефицитом радиочастотного ресурса, ограниченными вычислительными ресурсами и воздействием средств радиоэлектронного подавления противника. Одним из путей повышения помехозащищенности военных систем радиосвязи является разработка эффективных показателей, алгоритмов, методов и методик оценки состояния систем военной радиосвязи. В настоящее время для оценки систем военной радиосвязи разработано множество показателей оценки эффективности, однако их применение обусловлено рядом ограничений, заключающиеся в том, что показатели, которые имеют высокую точность обычно не используются в связи с высокой их вычислительной сложностью, а те показатели, имеющие приемлемую вычислительную сложность, имеют низкую точность оценки. Поэтому с целью повышения помехозащищённости систем военной радиосвязи в указанной статье авторами проведена разработка обобщенного показателя оценки эффективности систем военной радиосвязи. Во время проведения исследования авторами были использованы основные положения теории связи, математической статистики, теории управления и теории помехозащищённости. Разработанный в работе обобщенный показатель оценки эффективности систем военной радиосвязи позволяет повысить помехозащищенность систем военной радиосвязи за счет увеличения скорости оценки их состояния. Проведенная оценка эффективности разработанного показателя позволяет утверждать о его повышенной на 15-22% эффективности по сравнению с традиционными показателями энергетической и спектральной эффективности систем военной радиосвязи. Практическая значимость проведенного исследования заключается в возможности использования предложенного обобщенного показателя оценки эффективности при разработке новых и модернизации существующих средств военной радиосвязи (центрах радиомониторинга).

Ключевые слова: помехозащищенность; оценка; система радиосвязи; радиоэлектронное подавление; средства радиосвязи.