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DETERMINATION OF CHARACTERISTICS OF RELIABILITY OF RADIO CONNECTION TAKING INTO ACCOUNT THE DISTURBING EFFECTS OF INTERFERENCES AND TECHNICAL CONDITION OF THE RADIO EQUIPIMENT

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Let us take into consideration the general case when the operation of n transmitting devices (the sources of interferences) of the system is possible during the overlapping time intervals. The distribution functions of duration of work in emission mode $F_i^{'}(\tau)$ and pauses $F_i^{0}(\tau)$ are known for each transmitter.

The rigorous solution for the function of availability of the radio connection channel in this case can be received, in principle, but it appears to be very cumbersome.

For a larger number of devices in the system n, even though the solution is rigorous, it appears to be impossible to obtain a compact expression for $G_n(t)$. The possible simplifications are based on the following. As it has been shown [3], the time for the function $G_n(t)$ to reach the value $G_n(\infty)$ is in direct proportion to the mean value of intervals between the interference pulses. Therefore, it can be assumed that the increase of the number of the noise sources can only lead to decrease of the time t_1.

In this connection, the reliability of the radio communication channel can be characterized by the value of the availability ratio.

$$K_{\Gamma\Pi} = \sum_{j=k_1} \Phi_j$$
(1)

where Φ_j are the final interval-transition probabilities of the Semi Markov process *q(t).*

As it can be seen, the value of Φ_j is the portion of time of remaining in the state *j* of the Semi Markov process *q(t)* in an established state. In other words, Φ_j is defined as a probability of finding the process *q(t)* in the *j*- state. Therefore, the sum Φ_j over the set of operable states equals to the time while *q(t)* remains within the subset, which, of course, corresponds to the definition of the notion of the availability ratio [4].

The final probabilities Φ_j can be expressed by the final probabilities $\Phi_j^{si}\,(s = 0.1)$ of the fluxes $\xi_i(t)$, which describe the switch-over processes of the transmitting means of the system. Actually, to each of the *j* state of the *q(t)* process corresponds the known set of the states of fluxes $\xi_i(t)(i = \overline{1,n})$. Since it can assume only two values, the state the *q(t)* process can be expressed in the binary code as S_i. The event of the *q(t)* process being in a j-state can occur only in such a case when there is a presence of the correlative set of states of the fluxes $\xi_i(t)$ [2]

Thus, $\Phi_j = \Phi_1^{s_1} \cdot \Phi_2^{s_2} ....\Phi_n^{s_n}$

Where the sequence $S_i, S_2.....S_n$ is the code of the *j*- state of the *q(t)* process.

In their turn, Φ_i^{si} can be expressed through the mean unconditional times of fluxes $\xi_i(t)$ remaining in the states

$$\langle T_i \rangle^{si} = \int_{\infty}^{\infty} \left[1 - F_i^s(t)\right] dt$$
(3).

Since the initial $\xi_i(t)$ processes are alternating, the final probabilities of the nested Markov chains are independent of the states of the fluxes. Therefore,

$$\Phi_i^{si} = \frac{\langle T_i^{si} \rangle}{\langle T_i^1 \rangle + \langle T_i^0 \rangle}$$
(4)

by substituting (2), (4), (1) and after simple transformations we receive

$$\text{K}_{\Gamma\Pi} = \frac{\sum_{j \Xi k} \langle T_1^{s1} \rangle \langle T_2^{s2} \rangle ... \langle T_\eta^{s\eta} \rangle}{\sum_{j=k} \langle T_1^{s1} \rangle \langle T_2^{s2} \rangle ... \langle T_n^{sn} \rangle}$$

(5)

where K-2^n is the set of states of *q(t)*

K_1 is the subset of operable states;

j, just like in (2) determines the code of the sequence $S_i, S_2.....S_n$.

It is worthy of mentioning that the similar result has been received on the basis of other assumptions. It confirms the truthfulness of the expressions (1) and (2).

In order to take into account the parameter spread of the means of the system let's consider a more complex task. Here we shall assume that the frequency and energy parameters of the affecting interferences and the energy parameters of the receiving and transmitting devices of the communication channel have the stochastic values. In this case, the required quality of functioning of the communication channel in each state of the *q(t)* process can be achieved with the probability $P_{k\Phi i}$ I.e. each i-state of $q\ (t)$ can be attributed to the subset of operable states with the probability $P_{k\Phi i}$ or to the inoperable states with the probability $1 - P_{k\Phi_i}$. In other words, the set k cannot be divided into two subsets k_1 and k_o, then (1) loses the determination.

It is possible, however to offer another method of calculation of the availability ratio.

$$K_{\Gamma\Pi} = \sum_{J=1}^{K} p_{K\Phi_I}\Phi j$$

(6)

which is, essentially, another form of expression (1).

Actually, if it is known for sure that the required operational quality is not achieved in the i-state of the $q\ (t)$ process, then the???- item of the (6) is not taken into account, while in (1) it pertains to the subset of inoperable states and thus is excluded from calculations. Thus, with the random parameters of the signal and noises the availability ratio of the radio channel can be calculated from (6).

Let's examine the specific example, the case of two interferences effecting the radio receiving device. The duration of the distribution functions τ_1^1 and τ_1^0 are given as follows

$$\frac{dF_1^1(t)}{dt} = \frac{\lambda_i^{ni}}{\Gamma(ni)} t^{\eta_i - 1} e^{\lambda 1}$$

$$\frac{dF_1^0(t)}{dt} = \eta i e^{-\eta_i 1}$$

(7)

The combined impact of the two interferences results in appearance of the inter-modulation reception channel, while the effects from each of them can be revealed via the out-of-band reception channels. Let us designate the states of the radio-receiving device: i is the absence of interference, 2,3 is the single-interference impact, while 4 is the combined impact.

For the probabilities of provision of the required qualities of operation for each state it can be written:

$$P_{k\Phi 1} = \Phi(\frac{m_{cbx} - m_0}{\delta_0 \sqrt{1+r^2}});$$

$$P_{k\Phi 2} = \Phi(\frac{m_{cbx} - m_0 - k_1 m_{nbx} q_{dop}}{\delta_0 \sqrt{1+r^2}});$$

$$P_{k\Phi 3} = \Phi(\frac{m_{cbx} - m_0 - k_2 m_{nbx} q_{dop}}{\delta_0 \sqrt{1+r^2}});$$

$$P_{k\Phi 4} = \Phi(\frac{m_{cbx} - m_0 - k_4 m_{nbx} q_{dop}}{\delta_0 \sqrt{1+r^2}})$$

where k_1, k_2, k_4 are the transfer constants of the radio receiver via the inter-modulation and the out-of-band reception channels on the frequencies of the first and the second interference accordingly.

$m_{n1} = m_{n2} = m_{nbx}$ are the expectation values of the powers of the affecting interferences at the input of the radio receiver.

Substituting (7), (3), (4) and (2) for the probabilities of the states of the process of changes of quality of operation of the communication channel, we can put it as follows:

$$\Phi_1 = \frac{b_1 b_2}{(b_1+1)(b_2+1)}; \ \Phi_2 = \frac{b_1}{(b_1+1)(b_2+1)}$$

As it can be seen at the known mean power values of the interferences it is possible to demand the quite certain requirements to the level of the signal at the entrance of the receiver that at the given tolerances in the parameters of the means of communication can provide the required value of the index of reliability of the radio connection or at the given values of power of the signal and receiver sensitivity to demand the certain tolerances for the parameters of the receiving and transmitting devices.

It must be noted that the given methods for determining the parameters of the receiving and transmitting devices of the radio communication channel differs from the examined earlier since it takes into account the changes of the interference conditions over time. In addition, it ensures the required quality of functioning of the radio channel, averaging it over the long-enough period of time.

It is obvious that, generally, the optimal values of parameters of the transceiver means of the communication channel are different for every set of the operating transmitting devices in the system. Ensuring the required indexes of operational quality and reliability of the communication channel under conditions of changing interference environment requires the adaptive tuning of the parameters of the receiving and transmitting means.

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Vladimirs Hodakovskis, Tamāra Hodakovska. Radiosakaru raksturojumu noteikšana sakarā ar mijiedarbības efektu un tehnisko radioiekārtu stāvokļa mijiedarbību
Sakarā ar radio uztvērēja darbību sarežģītos elektromagnētiskos apstākļos uztvērēja jutīguma izmaiņas pēc iepriekš aprakstītās shēmas noved pie radiokanāla gatavības koeficienta izmaiņām. Pēc šiem datiem atrod koeficienta sadalīšanas funkciju ar zināmo radio traucējumu statistiku.

Vladimir Khodakovsky, Tamara Khodakovska. Determination of characteristics of reliability of radio connection taking into account the disturbing effect of unterferences and technical condition of the radio equipment
Change of sensitivity of the receiver of model described before is resulted to a factor of readiness of a radio channel. The function of distribution of factor of readiness at known statistics of a radio noise is resulted.

Владимир Ходаковский, Тамара Ходаковская. Определение характеристик надежности радиосвязи с учетом мешающего эффекта взаимодействия и технического состояния радиооборудования
С учетом работы радиоприемника в сложной электромагнитной обстановке изменение чувствительности приемника по описанной ранее модели приводиться к изменению коэффициента готовности радиканала. По этим данным находиться функция распределения коэффициента готовности при известной статистике радиопомех.