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THE FUNCTION OF AVAILABILITY OF THE MEANS OF RADIO CONNECTION UNDER INTERFERENCE EFFECTS DURING THE NON-OVERLAPPING TIME INTERVALS

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Let us examine the case where the radio receiver of a communication channel is affected by the noise generated by a certain known number of electronic devices. The ratios between the time intervals of operation / pause of each of the noise generating devices are such that the probability of the simultaneous operation of two or greater number of the noise generators is negligibly small. The latter makes it possible to assume that the activity of the devices occurs during the non-overlapping time intervals and that effects of the noise can be represented by the summary pulse noise flux $n\ (t)$. [1].

Let us assume that the frequency-energy parameters of the interferences are stochastic due to the above-considered reasons. Due to the effects from the flux $n\ (t)$, the quality of functioning of the connection channel is being changed; let us call such gradations in quality states. Of all possible states of the radio channel let's separate the two, one of which is capable of operation (let's call it "2") and the other state is the denial, non operable (let's call it "1"), the quality of functiong of both thus can be either higher or lower of the acceptable level. Whenever the noise pulse appears, the operable channel state shifts to inoperable state with the probability $\boldsymbol{p}$, which depends on the frequency-energy parameters of both the noise and receiver, i.e. determined by the probability of appearance of the required operational quality $p= 1-p_{кф}$.

Since denials due to the impact of the noise are self-eliminating, the probability of the back shift in quality at the end of the interference equals to 1. In other words, the matrix of one-step probabilities of the shift process describing the change of quality of functioning of the radio channel under the effects of the interferences can be expressed as:

$$\{\pi_y\} = \begin{vmatrix} 0 & 1 \\ 1 & 1-p \end{vmatrix}$$

As it is known [3], the duration of mutually effecting interferences in the radio channels of the aviation communication can be described by the Erlang distribution, while the intervals between them can be described by the exponential distribution. Therefore, the process *n(t)* is an alternating self-recovery process, while the *q(t)* is the Semi Markov process. As it was mentioned above, to set the *q(t)* process, apart from $\{\pi_y\}$, it is essential to set the matrix *{Fy(t)}* that describes the conditional time intervals of remaining in the states. In addition, for the given example it is possible to make simplifications [61].

It can be assumed that the duration of interference is much less than the duration of the intervals between interferences. In this case, the flux of the events of appearance of interferences follows the Poisson distribution, while the process can be reduced to its particular case, the alternating recovery process with the matrix $\{\pi_y\}$ of simple form

$$\{\pi_y\} = \begin{vmatrix} 0 & 1 \\ 1 & 0 \end{vmatrix} \quad (1)$$

It is obvious that to receive *{Fy(t)}* it will be suffice to determine $F_{12}(t)$ and $F_{21}(t)$.

In order to reduce *q(t)* to the alternating process of recovery let's assume that the receiver is effected by the flux *n'(t,)* which is received from *n(t)* by a random discharge. The probability of exclusion of a pulse from the flux *n(t)* equals to *1 –p*. Since the flux of events of appearance of pulses in *n(t)* follows the Poisson distribution pattern, the similar flux in *n(t)* should also have the Poisson distribution with the intensity *p* times less the initial value.

Thus, the matrix of the process $\{\pi_y\}$ will have the form (1), while the distribution functions can be expressed as:

$$f_{12}(t) = \frac{dF_{12}(t)}{dt} = \frac{\lambda^{\eta} t^{\eta-1}}{r(n)} e^{-2i}$$

$$f_{21}(t) = \frac{dF_{12}(t)}{dt} = \rho\eta e^{-\rho\eta t}$$

(2)

Let us determine the interval- transient probabilities of the process $p\eta << \frac{\lambda}{n}\Phi_{ij}(t)$

By *resolving* the system (2.1.) using the Laplace transforms. Let's designate the one-sided Laplace transform of the function *F(x) as*

$$F^{\psi}(S) = \int_0^{\infty} e^{-sx} F(x)dx$$

After making the Laplace transform, we receive:

$$\Phi_{ij}^{\psi}(s) = \delta_{ij}\psi_i^{\psi} + \sum_{k=1}^{2} \pi_{ik} f_{ik\psi}(s)\Phi_{kj}^{\psi}(s)$$

(3)

The functions, which are present in (3) F*ik(s) and $\psi_i^{\psi}(S)$, taking into account (1) can be expressed as

$$f_{12}^{\varphi}(s)=\frac{\lambda^{\eta}}{(s+\lambda)^{\eta}};\ \psi_l^{\varphi}(s)=\left[1-f_{12}^{\varphi}(s)\right]\Big/\ s$$

$$f_{12}^{\varphi}(s)=\frac{\rho^{\lambda}}{s+\rho\eta};\ \psi_l^{\varphi}(s)=\left[1-f_{12}^{\varphi}(s)\right]\Big/\ s$$

(4)

Omitting the intermediary transformations, we receive the following result for the system (3)

$$\Phi_{11}(s)=[(s+p\eta)(s+\lambda)^{n}-\lambda^{n}(s+p\eta)]/\varphi(s)$$

$$\Phi_{12}(S)=S\lambda^{n}/\varphi(s)$$

$$\Phi_{21}(S)=[p\eta(s+\lambda)^{n}-\lambda^{n}p\gamma]/\varphi(s)$$

$$\Phi_{22}(s)=s(s+x)^{n}/\varphi(s)$$

$$\Phi_{22}(s)=s[(s+p\eta)(s+x)^{n}+\lambda^{n}p\eta]$$

(5)

The inverse transformations of $\Phi_{ii}(t)$ can be found by implementing [2, 3].

Thus, for the function of availability $G_n(t)$ we have:

$$G_n(t)=\rho_l^0\Phi_{12}(t)+p_2^0\Phi_{22}(t)$$

(6)

If the processes $\xi_i(t)$ are stationary then the probabilities of the initial states P_i^0 of the process $q(t)$ should be equal to the values of the final interval transition probabilities:

$$p_1^0=np\eta\Big/(\lambda+np\eta);\quad p_2^0=\lambda\Big/(\lambda+np\eta)$$

(7)

Calculation of the functions of availability from the expression (5), taking into account the inverse Laplace transforms of the function (5) gives the following result:

$$n=1\ \ G_n(z)=G_n(\infty)=\frac{b}{b+1}$$

$$n=2\ \ G_n(z)=\frac{b}{b+2}\left[1+\frac{2}{\sqrt{2b-1}}e^{-(b+\frac{1}{2})^2}\cdot\sin\frac{z\sqrt{1b-1}}{2}\right]$$

$$n=3\ \ G_n(z)=\frac{b}{b-3}\left[1+\frac{(a-b)^3-3b^2}{a[(x-a)^2+y^2]}e^{-az}+2e^{-k^2}\sqrt{\frac{C^2+D^2}{E^2+F^2}}\sin(yz+arctg\frac{CE-DF}{DE-CF})\right]$$

Where

$$Z = p\eta t\ ;\ b = \frac{\lambda}{p\eta}\ ;\ a = \frac{3b-1}{3} - A - B\ ;\ x = \frac{A+B}{2} + \frac{3b+1}{3}\ ;\ y = \frac{A-B}{2}\sqrt{3}$$

$$A = \sqrt[3]{(9b - 27b^2 - 2)/54 + a\sqrt{(27b^2 - 14b + 3)/108}}$$
$$B = \sqrt{(9b - 27b^2 - 2)/54 + a\sqrt{(27b^2 - 14b + 3)/108}}$$
$$C = (x - 3b)x^2 + 3y^2(b - x) + b^2(3x - b - 3)$$
$$D = y^3 - 3y(x - b);$$
$$E = 2y^2(a - 2x)$$
$$F = 2y(ax - x^2 + y^2)$$

As it can be seen, the growth of n, all else being equal results in growth of the time Z_1, which is the first reaching of the value $G_n(\infty)$ by the function $G_n(t)$. Therefore, the pessimistic evaluation of the time can be achieved when $n=2$.
It is easy to show that Z_1 can be received from the equation

$$Z_1 \cdot \frac{\sqrt{4b-1}}{2} = \pi$$

Then

$$t_1 = \frac{Z_1}{p\eta} = \frac{2\pi}{\sqrt{p\eta(4\lambda - p\eta)}}$$

While for $t > t_1$ we can assume $G_n(t) \approx K_m$.
The availability ratio K_m for any Erling orders can be calculated by using the formula

$$K_{rn} = \frac{b}{b+n}. \quad (8)$$

The given analysis allows to make the following conclusions. In a complex electromagnetic situation, the value K_m can appear to be less than 1. In this case the function of availability of the communication channel, which takes into account both the irreversible denials of the transmitting-receiving devices AND the due–to–interferences denials, can be determined, essentially, by $G_n(t)$ since $G_1(\infty)$ during operational processes is maintained at the level close to 1.
For the time intervals $t > t_1$ the availability ratio, which value can be calculated easily enough from the formula (8), can serve as the reliability characteristic of the channel.
The received expressions allow to make more profound and reliable estimations of the reliability of the radio communication channels in the civil aviation, along with taking into

account the effects of the mutual interferences as the external factor under the real daily operational conditions.

References

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2. The Probability Theory by Ventzel E.S. Mir Publishers, Moscow, 2001.
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V.Hodakovskis, T. Hodakovska. Radiosakaru iekārtu gatavības funkcija nepārtraukto laika intervālu traucējumu apstākļos

Aprakstītā radiouztvērēja funkcionēšana dažādos darbības traucējumu apstākļos, pieņemot, ka radiostacijas traucējumi rodas nejauši. Norādīts, ka uztvērēja izejošais parametrs – jutīgums parādās kā pusmarkova process ar statistiskiem ieslēgšanās un izslēgšanās raksturojumiem radiostacijas traucējumu apstākļos.

V. Khodakovsky, T. Khodakovska. The function of availability of the means of radio connection under interference effects during the non-overlapping time intervals

The model of functioning of a radio receiver in conditions of influence of various handicaps is described. It is supposed, that hindering radio stations are switched on and switched off randomly. It is shown, that the target parameter of the receiver - sensitivity can be submitted by semi-markov process with statistical characteristics dependent on statistical characteristics of switching of hindering radio stations.

В. Ходаковский, Т. Ходаковская. Функция готовности средств радиосвязи при условии помех в течении неперекрывающихся временных интервалов

Описывается модель функционирования радиоприемника в условиях воздействия различных помех в предположении, что мешающие радиостанции включаются случайным образом. Показано, что выходной параметр приемника – чувствительность может быть представлен полумарковским процессом со статистическими характеристиками заисящими от статистических характеристик включения-выключения мешающих радиостанций.