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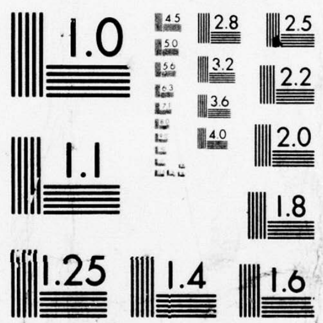

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OPTIMUM DIVISION OF THE OBSERVATION INTERVAL DURING THE DETECTION OF SIGNALS IN A RADIO LINE WITH ACTIVE RESPONSE

by

V. M. Katikov

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	⍺	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Τ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ κ	ϰ	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

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OPTIMUM DIVISION OF THE OBSERVATION INTERVAL DURING THE DETECTION OF SIGNALS IN A RADIO LINE WITH ACTIVE RESPONSE

V. M. Katikov

The detection procedure in a radar device with active response, in the general case, has two stages. In the first stage (during interval T_1) inquiry signals are detected in the receiver of the transponder and in the second stage (interval T_2) the reply signals are detected. The quality of detection (probability of errors) in the first and second stages under the influence of interference is determined by values T_1 and T_2 and therefore in the case of a limited total observation interval ($T = T_1 + T_2$) the problem arises of its subdivision into two parts.

Let us examine a discrete model for sampling data which is applicable for the cases of greatest practical interest. In interval T_1 let the detector of the transponder receive n_1 random values of a mixture of the inquiry signal and interference. At the end of interval T_1 the reply signal is characterized by the probability of a correct response p_{n_1}. The on-board detector carries out joint processing of n_2 random values received in interval T_2 of the response signal. The total number of random values $n = n_1 + n_2$ is limited by the given observation interval $T = T_1 + T_2$. The quality of detection is characterized by a target function $F(n_2, p_{n_1})$.

We shall look for the point $(n_2^*, p_{n_1}^*)$, which yields the maximum of the target function in the set of points (n_2, p_{n_1}), which satisfy the assigned condition of communication, i.e., we shall look for the joint solution (if it exists) of the system of equations:

(1)
$$\begin{cases} F(n_2^*, p_{n_1}^*) = \max\limits_{n_2, p_{n_1}} F(n_2, p_{n_1}) \\ p_{n_1}^* = p(n_1^*) = p(n - n_2^* + 1) \end{cases}$$

For this, let us represent the first difference of the target function in the form:

(2)
$$\Delta F(n_2, p_{n_1}) \equiv F(n_2, p_{n_1}) - F(n_2 - 1, p_{n_1+1}) = \Delta F_{p_{n_1}}(n_2) - \Delta F_{n_2 - 1}(p_{n_1+1}),$$

where

$$\Delta F_{p_{n_1}}(n_2)=F(n_2,p_{n_1})-F(n_2-1,p_{n_1});\ \Delta F_{n_2-1}(p_{n_1+1})=F(n_2-1,p_{n_1+1})-F(n_2-1,p_{n_1}).$$

Then the extremal point $(n_2^*, p_{n_1}^*)$, determined by (1) must satisfy the following system of inequalities:

(3a)
(3b)

$$\begin{cases}\Delta F_{p_{n_1}}(n_2)\geqslant\Delta F_{n_2-1}(p_{n_1+1})\\ \Delta F_{p_{n_1-1}}(n_2+1)\leqslant\Delta F_{n_2}(p_{n_1})\end{cases}.$$

Considering the convexity and continuity of the target function with respect to argument p_n in the range of the maximum it is possible to write sufficient conditions of the maximum following from (3):

(4a)
(4b)

$$\begin{cases}\Delta F_{p_{n_1}}(n_2)\geqslant F'_{n_2-1}(p_{n_1})[p_{n_1+1}-p_{n_1}]\\ \Delta F_{p_{n_1-1}}(n_2+1)\leqslant F'_{n_2}(p_{n_1})[p_{n_1}-p_{n_1-1}]\end{cases};$$

During binary processing of the reply signals for the target function one can use the cumulative function of binomial distribution which determines the probability of correct detection:

(5)

$$F(n,p)=\sum_{k=m}^{n}\binom{n}{k}p^{k}(1-p)^{n-k}.$$

Using the known properties of this function [1]

(6)
$$F'_n(p)=\frac{\partial}{\partial p}F(n,p)=m\binom{n}{m}p^{m-1}(1-p)^{n-m}$$

(7)
$$\Delta F_p(n)=F(n,p)-F(n-1,p)=\binom{n-1}{m-1}p^m(1-p)^{n-m},$$

for the examined case we finally obtain:

(8a)

(8b)
$$\begin{cases} p_{n_1+1}-p_{n_1}\leq \dfrac{p_{n_1}(1-p_{n_1})}{n_2-m} \\ p_{n_1}-p_{n_1-1}\geq \dfrac{p_{n_1}(1-p_{n_1})}{n_2-m+1}\left(\dfrac{p_{n_1-1}}{p_{n_1}}\right)^m\left(\dfrac{1-p_{n_1-1}}{1-p_{n_1}}\right)^{n_2-m} \end{cases}.$$

The obtained expressions (8) make it possible to find the optimum subdivision of the selection of a given volume (m) between the on-board detector (n_2^*) and the active transponder (n_1^*) with the assigned function of the quality of the response $p_{n_1}=p(n_1)$.

In the range defined by the inequality (8a) the target function necessarily increases with an increase of n_2 and in the range of inequality (8b), necessarily decreases. The extremal point ($n_1^*, p_{n_1}^*$) is located in the area of intersection of inequalities (8a) and (8b) or in the area of indeterminacy (incompatibility of the inequalities).

It should be remembered that the obtained expressions are valid in the area of convexity of the target function with respect to the argument p_n. The boundary of this area can easily be found according to the well-known rule of determination of the inflection point which for function (5) leads to the following inequality giving the area of convexity:

$$p_n > \frac{m-1}{n_2-1}. \quad (9)$$

More specific definition of expression (8) is possible in the case of the assigned analytical dependence $p_n = p(n_1)$.

LITERATURE

1. Tables of the Cumulative Binomial Probability Distribution, Cambridge, Mass., 1955.

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