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EFFICIENCY OF MULTISTAGE COMMUNICATION SIGNAL SEARCH WITH CONSIDERATION OF RECEIVER COMPLEXITY

by

Yu. S. Agafonov



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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	Sheh, sheh
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 yë or ë.
 The use of diacritical marks is preferred, but such marks
 may be omitted when expediency dictates.

GREEK ALPHABET

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

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All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

EFFICIENCY OF MULTISTAGE COMMUNICATION SIGNAL SEARCH WITH
CONSIDERATION OF RECEIVER COMPLEXITY

Yu. S. Agafonov

The elimination of initial frequency and time ambiguity in communication systems with pseudorandom discrete phase-manipulated signals requires large amounts of time. The signal search time can be reduced by using multistage procedures and multichannelling. Then the number of stages and channels providing the minimum mean signal search time at a fixed complexity and given quality of detection are determined. The plane of ambiguity is broken down into rectangular cells. The sides of the rectangle are equal to the frequency and time search intervals. The search intervals are selected to obtain the minimum search time, with the reduction in the level of the signal

ambiguity function being 0.5 in this case [1]. Signal search consists of determining the position of a cell on the parameter plane.

We will use the multistage procedure with single-threshold sampling of cells characterized by the gradual improvement of detection quality from stage to stage [2, 3].

After sequential testing of cells in the first stage, the number of cells selected in each successive stage is random and we will assume that its distribution adheres to the binomial law [2, 3].

The quality of detection for the independent solutions found in the stages of an L-stage procedure is characterized by the probabilities of correct detection and false alarms [1-3]:

$$D = \prod_{i=1}^L D_i \quad (1)$$

$$F = \prod_{i=1}^L F_i \quad (2)$$

where D_i, F_i are the probabilities of correct detection and false alarm, respectively, in the i -th step.

The total mean search time in the absence of a signal [1]

$$T = \frac{fN}{0.6} \left(T_1^2 + F_1 T_2^2 + \dots + \prod_{i=1}^{L-1} F_i T_L^2 \right), \quad (3)$$

where f is frequency ambiguity, Hz; N is time ambiguity, expressed in the number of elementary pulses of the pseudorandom signal; and T_i is the signal accumulation time in a cell in the i -th stage.

The total minimum of nonlinear function (3) with boundary conditions (1) and (2) is found by dynamic programming [3, 4]. The procedure is optimized on a Minsk-22 computer for the detection of a signal whose amplitude fluctuates according to Rayleigh's law in normal stationary noise and whose phase is evenly distributed in the interval $[0-2\pi]$, when [5]

$$F_i = m_i D_i^{1+\rho T_i}, \quad (4)$$

where m_i is the number of channels in the i -th stage; ρ is the signal/noise ratio in the signal band.

We will point out that signal search is terminated at the time of arrival in the first stage. The number of channels in the first stage of search is

$$m_1 = m_t + m_f, \quad (5)$$

where m_t and m_f are the number of time of arrival and frequency channels, respectively.

The number of channels in each successive stage is equal to m_f .

We found the value of the gain in search time Q for the multistage procedure with several channels compared to the single-stage procedure with one channel at a detection quality of $D = 0.9$, $F = 10^{-10}$. The curves in Fig. 1 show the gain in search time for the two- (---), three- (—) and four- (-.-.-.-) step procedures, depending on m_1 with parameter m_f (the numbers on the curve).

The solutions used for selecting the best version of the search system should be based on the selection of the so-called "preferable" versions, i.e., those for which all the remaining solutions result in excessive expenditures or an insufficient reduction in search time. A number of versions of constructing the search system were compared by this method. We will use the following complexity model:

$$c = 1 + k_t m_t + k_f m_f + k_{st} L m_f, \quad (6)$$

where k_t, k_f are coefficients which consider the complication of

the receiver from the addition of each time and frequency search channel, respectively; k_{st} is a coefficient which considers the complication of the receiver due to the introduction of more than one stage.

As an example of the calculation of the efficiency of a search system which provides a 100-fold search time gain, the coefficients in formula (6) can be rather arbitrarily selected as follows:

$$k_t = 0,25; \quad k_f = 0,25; \quad k_{st} = 0,15.$$

The curves in Fig. 1 show that a given gain in search time can be obtained with a different number of channels in each procedure. The dependence of the search time gain (for the two- (---), three- (—) and four- (-.-.-) step) procedure on complexity is plotted in Fig. 2 for each version of the solution to the problem. The numbers on the curves show the number of frequency and time of arrival channels, respectively. For this example ($D = 0,9$, $F = 10^{-10}$) the structure of the search system should be: the three-step search procedure should be used; four channels each should be used for time and frequency search.

We can use the curves (Fig. 1) to find the optimum structure of the search system in each case for other complexity models.

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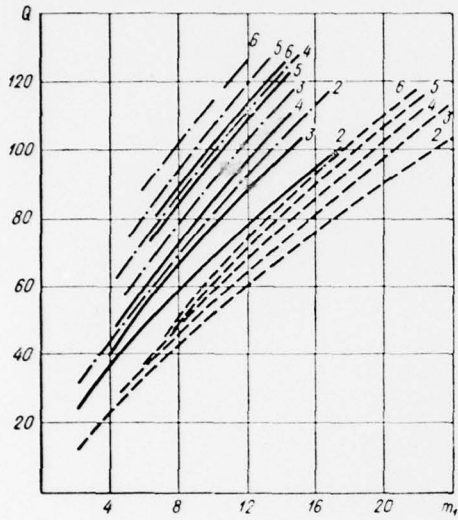


Fig. 1.

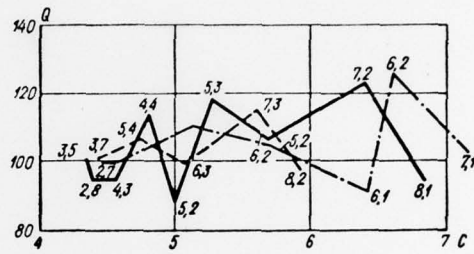


Fig. 2.

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