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THE USE OF A LOGARITHMIC AMPLIFIER IN DESIGNING AN ALTERNATE-PERIOD COMPENSATOR FOR PASSIVE JAMMING

by

L. D. Vilesov, E. D. Lapchik,
et al.

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EDITED TRANSLATION

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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

*<u>ye</u> initially, after vowels, and after ъ, ь; <u>e</u> 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	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	Υ	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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THE USE OF A LOGARITHMIC AMPLIFIER IN DESIGNING AN ALTERNATE-PERIOD COMPENSATOR FOR PASSIVE JAMMING

L. D. Vilesov, E. D. Lapchik, A. P. Lukoshkin, Yu. Ye. Monakhov, and A. A. Chude

ABSTRACT We examine the question of using a logarithmic receiver in designing alternate-period compensation of passive jamming. We give an estimate of the detection efficiency. END ABSTRACT

1. OPERATING PRINCIPLE

The use of alternate-period subtraction at the output of a linear receiver makes it possible to detect weak signals from moving targets against a background of passive jamming. As a rule, a requirement for assuring a given dynamic range is imposed on such a system. One way of satisfying this requirement is to replace the linear receiver with a logarithmic one.

Figure 1 shows the block diagram of a system for compensating for passive jamming with external coherence. We know that the basic disadvantage of a system with external coherence is the loss of signal in the absence of a background of interference reflections. However, if passive jamming is of an extended nature and is uniform, the use of a logarithmic receiver makes it possible to eliminate this disadvantage. For this purpose, at the input of the log receiver is linear stage 1 whose gain is switched at the repetition rate. Switching of 1 leads only to a change of the constant component of the interference at the output of log receiver 2, and has no effect on dispersion at the output, since dispersion at the ouput of logarithmic transformation is constant. The low-frequency change of the constant component is suppressed by upper-frequency filter 3. Compensator 4 subtracts two voltages: the undelayed (at the output of 3) and that delayed by a period (at the output of 5). With total alternate-period (or cross-period) correlation of interferene it is suppressed. If there is no noise, the signal of the previous period is not equal to that of the next period, since unit 1 changes the receiver gain during the period. Therefore, at the output of 4 in this case as well there is separation of the signal.

2. BASIC STATISTICAL CHARACTERISTICS AT THE COMPENSATOR OUTPUT

The signal of reflection from local objects is represented in the form of narrow-band random processes. Then, with action of a signal against a background of interference, considering the internal receiver noise, the input voltage

$$\xi(t)=\xi_{\text{ш}}(t)+\xi_{\text{п}}(t)+\xi_{\text{с}}(t), \qquad (1)$$

where $\xi_{\text{ш}}(t)$ is the voltage of internal receiver noise: $\xi_{\text{п}}(t)$ is the voltage of passive jamming; $\xi_{\text{с}}(t)$ is the signal voltage. $\xi_{\text{ш}}(t)$, $\xi_{\text{п}}(t)$ and $\xi_{\text{с}}(t)$ are distributed by the normal law with zero mean, while their envelopes - $R_{\text{ш}}(t)$, $R_{\text{п}}(t)$ and $R_{\text{с}}(t)$ - are distributed by the Rayleigh law. It is necessary to find the probability density at the output of the compensator that makes the transformation:

$$x=a\ln bR(t_1)-a\ln bR(t_2), \qquad (2)$$

where t_1 and t_2 - two moments of time separated by the repetition period;

a and b - constants of the logarithmic receiver.

The probability density at the output of (2) is

$$W(x)=\frac{2(1-\rho^2)}{a}\,\frac{\exp\left[\frac{2}{a}\left(x-a\ln\frac{\sigma_1}{\sigma_2}\right)\right]\left[1+\exp\left(\frac{2}{a}\left(x-a\ln\frac{\sigma_1}{\sigma_2}\right)\right)\right]}{\left\{\left[\exp\left[\frac{2}{a}\left(x-a\ln\frac{\sigma_1}{\sigma_2}\right)\right]+1\right]^2-4\rho^2\exp\left[\frac{2}{a}\left(x-a\ln\frac{\sigma_1}{\sigma_2}\right)\right]\right\}}, \tag{3}$$

where P - envelope of the correlation coefficient $\xi(t_1)$ and $\xi(t_2)$;

σ^2_1 and σ^2_2 - dispersions $\xi(t_1)$ and $\xi(t_2)$.

The envelope of the correlation coefficient $\xi(t_1)$ and $\xi(t_2)$ with a signal on the background of interference, considering internal receiver noise for optimum speeds:

$$P=\frac{\left|P_n\frac{\sigma_{n1}}{\sigma_{m1}}\cdot\frac{\sigma_{n2}}{\sigma_{m2}}-P_s\frac{\sigma_{s1}}{\sigma_{m1}}\cdot\frac{\sigma_{s2}}{\sigma_{m2}}\right|}{\left\{\left[1+\left(\frac{\sigma_{n1}}{\sigma_{m1}}\right)^2+\left(\frac{\sigma_{s1}}{\sigma_{m1}}\right)^2\right]\cdot\left[1+\left(\frac{\sigma_{n2}}{\sigma_{m2}}\right)^2+\left(\frac{\sigma_{s2}}{\sigma_{m2}}\right)^2\right]\right\}^{1/2}}, \tag{4}$$

where P_n - envelope of correlation coefficient $\xi_n(t)$;

P_s - envelope of correlation coefficient $\xi_s(t)$.

For average speeds:

$$P=\frac{P_n\frac{\sigma_{n1}}{\sigma_{m1}}\cdot\frac{\sigma_{n2}}{\sigma_{m2}}+P_s\frac{\sigma_{s1}}{\sigma_{m1}}\cdot\frac{\sigma_{s2}}{\sigma_{m2}}}{\left\{\left[1+\left(\frac{\sigma_{n1}}{\sigma_{m1}}\right)^2+\left(\frac{\sigma_{s1}}{\sigma_{m1}}\right)^2\right]\left[1+\left(\frac{\sigma_{n2}}{\sigma_{m2}}\right)^2\left(\frac{\sigma_{s2}}{\sigma_{m2}}\right)^2\right]\right\}^{1/2}}. \tag{5}$$

When approximating W(x) by the normal law, the formulas for F and D are simplified, and the detection equation has the form

$$D=2-\Phi\left\{\frac{\sigma_0\Phi^{-1}[1-0,5F]+\beta}{\sigma}\right\}-\Phi\left\{\frac{\sigma_0\Phi^{-1}[1-0,5F]-\beta}{\sigma}\right\}, \qquad (6)$$

where σ^2_0 - dispersion of x with no signal;

σ^2 - dispersion of x with signal;

β - increment of constant component at output of compensator, causing signal suppression:

$$\sigma_0^2=\frac{2}{\pi}a^2(1-P_0^2), \qquad (7)$$

$$\sigma^2=\frac{2}{\pi}a^2(1-P^2), \qquad (8)$$

$$\beta=0,5\sigma\left[\ln\frac{\sigma^2_{m1}+\sigma^2_{a1}+\sigma^2_{s1}}{\sigma^2_{m2}+\sigma^2_{a2}+\sigma^2_{s2}}-\ln\frac{\sigma^2_{a1}+\sigma^2_{s1}}{\sigma^2_{a2}+\sigma^2_{s2}}\right]. \qquad (9)$$

THE RESULTS OF THEORETICAL AND EXPERIMENTAL STUDIES

The detection efficiency was estimated for a noise-like pulsed signal reflected from a moving target against a background of passive jamming, with consideration of internal receiver noise. The interperiod processing of the pulse train at the output of the compensator was done using a digital accumulator. Two adjacent pulses were considered to be uncorrelated, which is valid if we retune the frequency of the transmitter every two repetition periods.

The radiation pattern was approixmated by a rectangle. Calculations were performed for the following qualitative relationships:

signal/internal receiver noise ratio $\left(\frac{\sigma_{с}}{\sigma_{ш}}\right)^2 = 15$ dB;

signal correlation coefficient $P_{s} = 0.99$;

passive jamming correlation coefficient $P_{п} = 0.99$ and 0.97;

number of pulses in the sequence $n = 32$.

Figure 2 shows the theoretical characteristics of detection at the output of the discrete accumulator for optimum target speeds, where the phase of the signal changes by $(2n + 1)\pi$ with $n = (0, 1, 2, \ldots)$. The probability of a false alarm is 10^{-2}. From the graphs we see that a signal can be detected with a probability $D = 0.73$ when

$F=10^{-2}$ and $\left(\frac{\sigma_{\alpha}}{\sigma_{s}}\right)^{2}$ = 15 dB. Experimental studies gave good confirmation of the theoretical results.

When designing the examined compensator it should be remembered that inaccuracy of the logarithmic characteristic of the amplifier should not exceed $10^{0}/_{0}$, while the signal delay time in the delay line should be matched with the period of the radiated signals.

CONCLUSIONS

1. The use of logarithmic amplifiers makes it possible to protect the passive jamming compensator from overloading. In this case its efficiency is insignificantly reduced. Detection is realized from the ratio $\left(\frac{\sigma_{s}}{\sigma_{n}}\right)^{2}$ = -15dB when $F = 10^{-2}$.

2. The use of alternate-period keying of the gain in conjunction with a logarithmic amplifier makes it possible to eliminate signal dropout in systems with external coherence in the absence of reflections from local objects.

Fig. 1. Block diagram of the compensation system.

Fig. 2. Theoretical characteristics of detection.

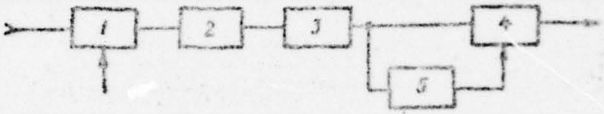

Fig. 1.

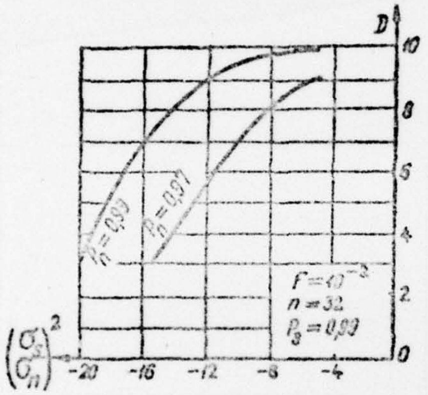

Fig. 2.

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