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SPECTRAL ANALYSIS OF THE ENVELOPE OF AN AMPLITUDE-MODULATED SIG--ETC(U)
SEP 77 A A VORONIN, A G GORDIYENKO

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SPECTRAL ANALYSIS OF THE ENVELOPE OF AN AMPLITUDE-MODULATED SIGNAL AT THE OUTPUT OF AN AMPLIFIER WITH A LOGARITHMIC AMPLITUDE CHARACTERISTIC

by

A. A. Voronin and A. G. Gordiyenko

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

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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*	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 ë 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	∝	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

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SPECTRAL ANALYSIS OF THE ENVELOPE OF AN AMPLITUDE-MODULATED SIGNAL AT THE OUTPUT OF AN AMPLIFIER WITH A LOGARITHMIC AMPLITUDE CHARACTERISTIC

A. A. Voronin and A. G. Gordiyenko

Khar'kov

When AM oscillations pass through an amplifier with a logarithmic amplitude characteristic (LAC) [ЛАХ], nonlinear distortions which depend on the modulation coefficient (m) originate in the amplifier. Amplifiers with LAC are used extensively in different communication channels, measuring and other devices. In connection with this, it is necessary to estimate the coefficient of nonlinear distortions at the output of the amplifier as a function of

m. No matter how it is obtained, the LAC of an amplifier [1] can be described by the expression

$$\dot{U}_{\text{вых}} = k_0 \dot{U}_{\text{вх}_\text{н}} \left(a \ln \frac{\dot{U}_{\text{вх}}}{\dot{U}_{\text{вх}_\text{н}}} + 1 \right), \qquad (1)$$

where $\dot{U}_{\text{вых}}$ is the output voltage of the amplifier; k_0 is the maximum gain of the amplifier (in the linear mode); $\dot{U}_{\text{вх}_\text{н}}$ is the input voltage at which the LAC of the amplifier begins; a is the coefficient which determines the dynamic range of the amplifier according to the output voltage; and $\dot{U}_{\text{вх}}$ is the voltage at the input of the amplifier.

We will assume that the input signal is modulated by one frequency. Substituting the value of $\dot{U}_{\text{вх}}$ in expression (1), we will have

$$\dot{U}_{\text{вых}} = k_0 \dot{U}_{\text{вх}_\text{н}} \left[a \ln \frac{U_{\text{вх}}}{U_{\text{вх}_\text{н}}} + a \ln (1 + m \cos x) + 1 \right], \qquad (2)$$

where $U_{\text{вх}}$ is the level of the carrier signal at the amplifier input.

Obviously, the spectrum of the envelope is determined by the expression

$$\ln (1 + m \cos x). \qquad (3)$$

In the case in question, the modulation coefficient is considered to be less than one ($m < 1$), whereupon the following inequality is satisfied:

$$0 < \ln(1 + m\cos x) \leq 2. \qquad (4)$$

In this case, expression (3) can be represented in the form of an exponential series [2] and, after transformation, we will have

$$\ln(1 + m\cos x) = A_0 + B_{t,n}\cos(2t - 1)x + A_{t,n}\cos 2tx, \qquad (5)$$

where

$$A_0 = \sum_{n=1}^{\infty} (-1)^{2n+1} \frac{m^{2n}}{2n} \cdot \frac{1}{2^{2n-1}} \binom{2n}{n};$$

$$B_{t,n} = \sum_{n=1}^{\infty} (-1)^{2n} \frac{m^{2n-1}}{2n-1} \times \frac{1}{2^{2n-2}} \binom{2n-1}{n-t};$$

$$A_{t,n} = \sum_{n=1}^{\infty} (-1)^{2n+1} \frac{m^{2n}}{2n} \times \frac{1}{2^{2n-1}} \binom{2n}{n-t}.$$

If we designate $k_0 U_{\text{вх}_\text{н}} = d$ (d is the amplifier parameter), expression (1) assumes the form

$$U_{\text{вых}} = d\left(a \ln \frac{U_{\text{вх}}}{U_{\text{вх}_\text{н}}} + aA_0 + 1\right) + adB_{t,n}\cos(2t - 1)x + adA_{t,n}\cos 2tx, \qquad (6)$$

where $d\left(a \ln \frac{U_{\text{вх}}}{U_{\text{вх}_\text{н}}} + aA_0 + 1\right)$ is the carrier level at the amplifier output during amplitude modulation; $adA_{t,n}$ is the amplitude of the even harmonics in the spectrum of the signal envelope at the amplifier output; $adB_{t,n}$ is the amplitude of the odd harmonics in the spectrum of the signal envelope at the amplifier output.

Analyzing the results obtained from the theoretical calculation, we can conclude that the carrier level at the output of amplifiers with LAC depends on the level and coefficient of modulation of the signal at the amplifier input, while the level of the envelope at the amplifier output only depends on the modulation coefficient of the input signal.

The verification agreed well with the experimental data and the results of the theoretical calculation.

Calculated by computer depending on the modulation coefficient, values A_0, $A_{I,n}$ and $B_{I,n}$ are proportional with respect to the first component and are represented by curves in the figure.

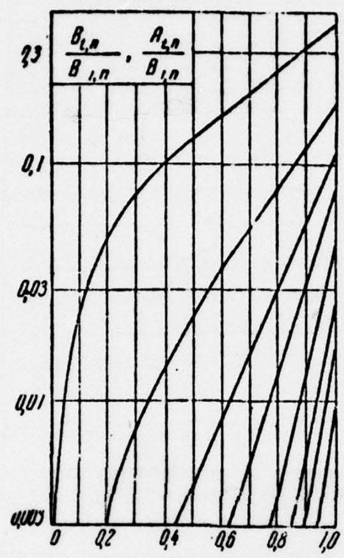
The curves obtained make it possible to find the harmonic coefficient in amplifiers with LAC at different modulation coefficients, as well as to solve the reverse problem: given the nonlinear distortion coefficient, we can find the permissible modulation coefficient. The curves are also used in analyzing measurement results.

Bibliography

1. V. M. Volkov. Logarithmic Amplifiers. Gostekhizdat UkrSSR, Kiev, 1962.

2. I. S. Gradshteyn, I. M. Ryzhik. Tables of Integrals, Sums, Series, and Derivatives. Fizmatgiz, 1963.

Figure. Normalized values of coefficients which determine the level of the spectral components ($B_{1,n}$ is the coefficient which determines the level of the first harmonic).



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