Results Analysis of Experimental Studies of Correcting Filters

Rauf Nabiyev
Cybernetics Institute of ANAS, Baku, Azerbaijan
rauf_nabiyev@rambler.ru

***Abstract*— In this paper the study of metrological efficiency of standard correcting filters is conducted. Factors of a finite difference filter having different orders are estimated by means of digital simulation on computer.**

***Keywords*— correcting; filters; noise; supersampling**

I. Introduction

We shall conduct the study of metrological efficiency of standard correcting filters (CF) concerning typical noise suppression in different frequency bands of the sampled sequence spectrum and at the measuring signal transfer with minimum distortion in frequency band $-\omega_0<\omega<\omega_0$. Such study allows, on the one hand to define metrological efficiency of limiting pulsed (digital) filters, and on the other hand to estimate rational parameters of these filters, both on the individual and joint application in corresponding subtracts of information-measuring systems (IMS) of quantitative account of oil and oil products (OOP).

II. Problem Statement

The energy characteristics of minimax CF G(Z), synthesized by us in [1] are easy to be estimated and analyzed, considering filter parameters (r, g_m, m=0...r-1) and estimating root-mean-square values of systematic and centered stationary noise components, being present at the input and at the output. However, in practice of normalization of IMS errors they usually use the estimations of the systematic component in the manner of mathematical expectation of error and the random component in the manner of its dispersion.

III. Problem Decision

Coming from noted above, it is reasonable to estimate the energy characteristics of considered CF on the following efficiency factors:

1) a suppression ratio of the systematic component of input noise

$$\overline{K}_g = \frac{M[\varepsilon_B(\nu T_0)]}{M[\varepsilon_g(\nu T_0)]}; \qquad (1)$$

2) a suppression ratio of the dispersion of input noise

$$K_g^0 = \frac{\sigma_B^2}{\sigma_g^2} \qquad (2)$$

Making use of linear nature of the operator M[ ] and considering characteristics of error components of the OOP mass measurement, we shall write

$$\begin{aligned} M[\varepsilon_B(\nu T_0)] &= M[\overline{\varepsilon}_B(\nu T_0)] + M[\varepsilon_B^0(\nu T_0)] \equiv M[\overline{\varepsilon}_B(\nu T_0)] \\ M[\varepsilon_g(\nu T_0)] &= M[\overline{\varepsilon}_g(\nu T_0)] + M[\varepsilon_g^0(\nu T_0)] \equiv M[\overline{\varepsilon}_g(\nu T_0)] \end{aligned} \qquad (3)$$

According to these expressions we shall present (1) in the form of

$$\overline{K}_g = \frac{M[\overline{\varepsilon}_B(\nu T_0)]}{M[\overline{\varepsilon}_g(\nu T_0)]}; \qquad (4)$$

On base of the dependences between corresponding components of input and output noise of the considered CF, factors (2) and (4) in points set of the observation interval are expressed by means of filter parameters as follows:

$$\overline{K}_g \approx \left[\sum_{\nu=0}^{N-1} \varepsilon(\nu T_0)\right] \left\{\sum_{\nu=0}^{N-1}\sum_{m=0}^{M-1} g_m \overline{\varepsilon}_B[(M+\nu-1-m)T_0]\right\}^{-1}$$

$$\overline{K}_g^0 \approx \eta \left[\sum_{m=0}^{M-1} g_m^2 - 2\sum_{K=1}^{M-1}\sum_{m=0}^{M-1-K} g_m g_{m+k}\left(1-\frac{\sin\frac{\pi k}{\eta}}{\frac{\pi k}{\eta}}\right)\right]^{-1}$$

In particular, when G(Z) represents a finite difference filter, the factor $\overline{K}_g$ is defined on the following expression

$$\overline{K}_{\Delta,r} \approx \left[\sum_{\nu=0}^{N-1} \overline{\varepsilon}(\nu T_0)\right] \left\{\sum_{\nu=0}^{N-1}\sum_{m=0}^{M-1} (-1)^m C_r^m \overline{\varepsilon}_B[(M+\nu-1-m)T_0]\right\}^{-1}$$

Factors of a finite difference filter having different orders are estimated by means of digital simulation on computer. The machine experiment results for r=1, 4 and N=500 are provided in tables I, II, III.

It follows from the got results that $\overline{K}_{\Delta,r}$ is a few orders under both distribution laws of random numbers. However as can be seen from the table 3, $K^{0}_{\Delta,r}$ greatly depends on sampling step T_0.

TABLE I. DEPENDENCY $\overline{K_{\Delta,r}}$ ON R DURING FILTERING OF UNIFORMLY DISTRIBUTED RANDOM NUMBERS INDEXES

R	$\overline{K_{\Delta,r}}$
1	369,7
2	1090,6
3	317,4
4	126,5

TABLE II. DEPENDENCY $\overline{K_{\Delta,r}}$ ON R DURING FILTERING OF NORMALLY DISTRIBUTED RANDOM NUMBERS WITH NORMALIZED CORRELATION FUNCTION OF THE TYPE E

αT_0 / r	$\overline{K_{\Delta,r}}$		
	0,01	0,1	1,0
1	467,4	52,4	27,6
2	1213,0	93,5	34,2
3	380,2	67,4	16,1
4	611,8	82,9	8,3

TABLE III. DEPENDENCY $K^{0}_{\Delta,r}$ ON R DURING FILTERING OF NORMALLY DISTRIBUTED RANDOM NUMBERS WITH NORMALIZED CORRELATION FUNCTION OF THE TYPE E-α/τ/

αT_0 / r	$K^{0}_{\Delta,r}$		
	0,01	0,1	1,0
1	6,92	3,67	0,74
2	3,41	1,71	0,29
3	1,15	0,56	0,15
4	0,32	0,16	0,08

A finite difference filter is enough sensitive to supersampling effect and so even under small values of η it is provided an enough high degree of the dispersion suppression of input noise, moreover growth of τ favorably influences upon efficiency of the considered filter. In case of absence of supersampling (η=1) the suppression ratio is always less than one and falls as far as an order growing of τ, since $K^{0}_{\Delta,r} \approx (C^{r}_{2r})^{-1}$ at the same time.

The favorably influence of r value upon efficiency of a finite difference filter under η>1 is explained by high spectral sensitivity of this filter to frequency of filtered sequence.

For spectral sensitivity estimation a finite difference filter is defined in the form of

$$K_{\Delta,r}(\omega) = \left[2\sin\frac{\omega T_0}{2}\right]^{r} \approx (\omega T_0)^{r}$$

It follows from here that under $\omega < \pi/(3T_0)$ a finite difference filter works in the mode of noise displacement.

So, a finite difference filter answers the presented to G(Z) requirements in that case if ω<π/(3T0) is provided. For that it is enough to realize supersampling with depth η>3, as it is confirmed by results from table 4.

TABLE IV. DEPENDENCY $K^{0}_{\Delta,r}$ ON THE SUPERSAMPLING PARAMETER η

r / η	$K^{0}_{\Delta,r}$				
	1	2	3	4	5
3	0,500	0,167	0,050	0,014	0,00
4	8,696	14,286	19,608	25,641	30,3
5	39,063	169,492	625,0	$2{,}04\cdot10^{3}$	$6{,}25\cdot10^{3}$
7	105,820	909,091	$6{,}2\cdot10^{3}$	$40{,}0\cdot10^{3}$	$227{,}0\cdot10^{3}$
9	228,833	$3{,}03\cdot10^{3}$	$35{,}7\cdot10^{3}$	$400{,}0\cdot10^{3}$	$588\cdot10^{3}$
10	315,457	$5{,}26\cdot10^{3}$	$76{,}9\cdot10^{3}$	$1315{,}8\cdot10^{3}$	$6667\cdot10^{3}$

IV. CONCLUSION

When carrying out of these conditions further effectiveness increase of a finite difference filter is provided by choice of the required order of r. If some restrictions are superimposed on the last, for example from considerations of realization simplicity of a finite difference filter by means of hardware or software, then required efficiency should be provided at the expense of increasing of η.

REFERENCES

[1] Rauf Nabiyev. Principles of building of intellectual IMS for oil and oil products quantitative account. PCI 2010. The third International Conference "Problems of Cybernetics and Informatics". September 6-8, 2010. Baku, Azerbaijan. Volume I, pp 343-346.