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ORDER REDUCTION OF A LOW-FREQUENCY PROTOTYPE FILTER BY ITS MAGNITUDE RESPONSE SYMMETRIZATION IN THE TASK OF FILTER BANK DESIGN FOR WIDEBAND MONITORING

D.I. KAPLUN, D.M. KLIONSKIY, A.S. VOZNESENSKIY, V.V. GULVANSKIY

Saint-Petersburg Electrotechnical University "LETI"
Russian Federation, 197376, Professora Popova str., 5
mitya_kapl@front.ru, klio2003@list.ru, a-voznesensky@yandex.ru, slava-a-a@mail.ru

The present paper discusses order reduction of a low-frequency prototype filter on the basis of its magnitude response symmetrization. The effectiveness of this approach for a particular prototype filter is demonstrated. The filter, whose characteristics are analyzed in the manuscript, is part of a multi-channel filter bank intended for monitoring the frequency range from 0 to 1 MHz.

Key words: prototype filter, filter order, order reduction, magnitude response symmetrization, filter bank, wideband monitoring.

Introduction. In works [1,2] it was mentioned that impulse responses (IR) of filters, whose magnitude responses are symmetric with respect to $f_s/4$ (here f_s is sampling rate), have nearly half zero-valued coefficients. If a magnitude response of some filter is double-symmetric, the IR of such a filter may contain nearly 3/4 (75%) zero-valued coefficients. Due to this shrinkage of impulse response non-zero samples it becomes possible to decrease hardware costs for filter implementation and also improve filter performance.

At the same time, symmetry condition is rather strong and is very rarely encountered in wideband monitoring [3]. This is caused by the fact that as a rule filter passband is much more narrow than $f_s/4$. However in practice we often need to extend the boundaries of using symmetric properties, which will definitely increase effectiveness of such filters in multichannel systems.

Symmetric filters. Consider a low-frequency filter (LF-filter) and let us introduce the following notations: f_{pass1}, f_{pass2} are left-side and right-side boundary frequencies of a passband; f_{stop1}, f_{stop2} are left-side and right-side boundary frequencies of a stopband; d_1 and d_2 are magnitude response unevenness in the passband and stopband, respectively. In the following we will consider only LF-filters used as filter protypes since they often occur in wideband monitoring tasks.

If $f_s/4$ is located in a transitional band, symmetrization is achieved by reinforcing requirements to the magnitude response. This implies shifting boundary frequencies of a LF-prototype in a transitional band. If $f_s/4$ is located in the stopband, there is a possibility of representing a LF-filter in the form of cascaded bandstop filter (BS-filter) and LF-filter or BS-filter and high-frequency filter. Such an approach makes it possible to significantly reduce the order of the original prototype filter.

Experimental results. In the present paper we will deal with the case when $f_s/4$ is in the stopband and therefore to fulfil symmetrization it is necessary to employ cascaded LF-filter and BS-filter (Fig.1).

The original prototype filter was aimed at creating a multi-channel filter bank [3-5] for wideband monitoring. The parameters of the prototype filter are as follows: order – 15200; one-side bandwidth – 1473 Hz, rectangularity shape factor – 1.24.

The filter bank itself has 320 channels with two-sided channel bandwidth – 3125 Hz. Such a bank monitors the frequency range from 0 to 1 MHz.

Using computer simulation in MATLAB we have obtained the most important characteristics of cascaded BS-filter and LF-filter (Table 1).

Table 1. Characteristics of cascaded LF-filter and BS-filter

	f_s, MHz	f_{pass1}, kHz	f_{stop1}, kHz	f_{stop2}, kHz	f_{pass2}, kHz	d_1	d_2	n
BS-filter	1	1.5	1.7	498.3	498.5	0.05	10^{-6}	11162
LF-filter	1	1.7	498.3	-	-	0.05	10^{-6}	5

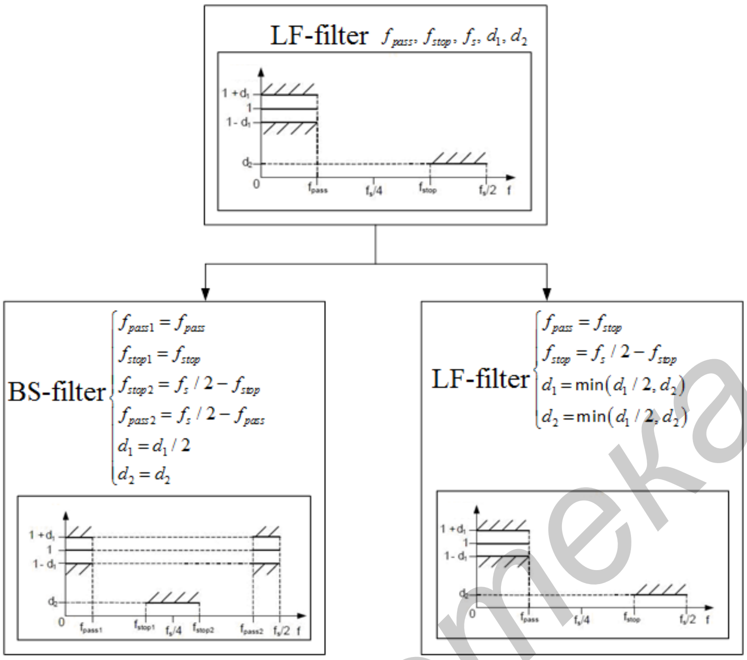

Fig.1. Diagram illustrating the symmetrization method

The combination of two filters represented in the table contains 11167 multipliers, which makes 73.5% of the total number of those in the original filter.

Conclusion. Thus, cascaded structure of two filters allows us to reduce the order of a LF prototype filter by 26.5%.

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