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POLYPHASE STRUCTURE FOR IIR FILTERS WITH PURE IMAGINARY POLES

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IIR half-band digital filters are widely used in multirate systems. Such filters have are pure imaginary poles. This simplifies the implementation essentially. The polyphase structure based on parallel connection of two allpass networks is especially economic for the half-band filter pairs with power complementary characteristics [1]. However, when there is not necessary in the filter pairs, the cascade structure may be more preferable as it requires considerably smaller coefficient wordlength [2]. Unfortunately, almost whole filter arithmetic in case of decimation or interpolation on factor 2 corresponds to the high sampling frequency. Below an alternative polyphase structure free from this lack is proposed. It may be easily obtained from the cascade structure.

The cascade filter transfer function with pure imaginary poles can be submitted as

$$H(z)=\prod_{i=1}^{K}\frac{B_{0i}+B_{1i}z^{-1}+B_{2i}z^{-2}}{1+A_i z^{-2}}=A(z^2)\prod_{i=1}^{K}(B_{0i}+B_{1i}z^{-1}+B_{2i}z^{-2}). \quad (1)$$

We shall rewrite the right part of (1) as

$$H(z)=A(z^2)\sum_{i=0}^{2K}h_i z^{-i}=A(z^2)[P_0(z^2)+z^{-1}P_1(z^2)] \quad (2)$$

where $P_0(z^2)$ and $P_1(z^2)$ are polyphase components.

The right part of (2) describes the proposed polyphase structure of the IIR filter. We shall notice that the filter based on this or cascade structure, generally, cannot be named as the half-band filter when its coefficients are quantized [2].

Fig.1 shows decimation and interpolation systems with factor 2 based on the proposed structure. Here whole arithmetic corresponds to the low sampling frequency f_s as in the half-band filter based on allpass networks.

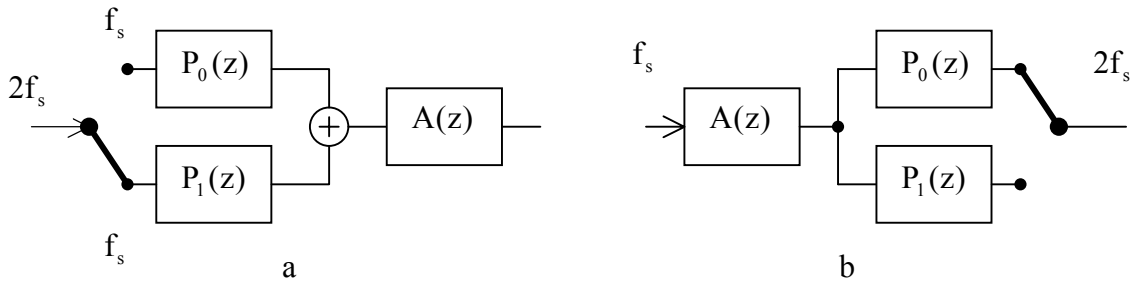

Fig.1. Decimation (a) and interpolation (b) systems.

The filter configurations on Fig.1a and Fig.1b are not identical. Therefore noise properties of the interpolation and decimation filters are not identical also. The roundoff noise of the proposed structure does not depend from pole-zero pairing and depends from allpole section ordering in A (z). How strongly will differ the proposed and cascade structure in relation to the coefficient wordlength and roundoff noise depends on the filter specifications.

References

1. Vaidyanathan P.P. Multirate digital filters, filter banks, polyphase networks, and application: A tutorial. //Proc. IEEE. 1990. V. 78. No. 3. – P. 56-93.
2. Mingazin A.T. Minimal coefficient wordlength of two half-band IIR filter structures.//6th Int. Conf. 'DSPA'. 2004. V.1. –P.46-47.