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NON-INTEGER ORDER IN FINITE WORDLENGTH COEFFICIENT DESIGN OF DIGITAL FILTERS BASED ON ALLPASS NETWORKS

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A design problem of finite wordlength coefficient digital filters based on parallel connection of two allpass networks [1,2] is considered. For its solution a modified algorithm of a variation of initial parameters (VIP) is proposed. The essence of modification for VIP algorithm [2] consists in the use of one more varied parameter in equations for calculation of elliptic filter coefficients, namely the filter order which can by varied continuously accepting non-integer values N_0. At the same time a filter order N itself remains the constant and integer. This approach may result to globally optimal solutions, as well as a systematic algorithm [1], as it will be shown by design examples.

The transfer function of low-pass filter based on allpass networks can be expressed as

$$H(z) = \frac{1}{2}\left[\frac{\alpha_0 + z^{-1}}{1+\alpha_0 z^{-1}} \prod_{i=2,4,...}^{K} A_i(z) + \prod_{i=1,3,...}^{K} A_i(z)\right], \qquad (1)$$

where $A_i(z) = \dfrac{\beta_i + \alpha_i(1+\beta_i)z^{-1} + z^{-2}}{1+\alpha_i(1+\beta_i)z^{-1} + \beta_i z^{-2}}$, $K \le (N-1)/2$, $\beta_i < \beta_{i+1}$, N is the odd filter order.

Below three design examples of filters with the transfer function (1) are considered. VIP algorithm does not give feasible solutions for these examples, but modified VIP algorithm enable to get such solutions. Varied initial parameters of elliptic filters are the passband ripple Δa, edge frequencies f_1, f_2 and parameter N_0. We shall accept the following denotations: $\tilde{a}_0$ is a minimum stopband attenuation, f_{1n}, f_{2n} are nominal edge frequencies, M is a fractional part coefficient wordlength and Σ_m is the total number of adders replacing of multipliers on coefficients. The symbol ~ means adequacy to the quantized coefficients α_i, β_i.

<u>Example 1.</u> The half-band specifications are $\tilde{a}_0 \ge 98$ dB, f_{2n}=0.3125, N=15 and M=8. The modified VIP algorithm results to the feasible solution at initial parameters Δa=2.1e-12 dB (or 1.37e-10 dB), f_1=0.193386, f_2= 0.306614, N_0=13.5. In order to obtain α_i, β_i which are identical to found in [1] (see http://www.cs.tut.fi/~ylikaaki/CASILWD/results.m) it is necessary to calculate the “elliptic” low-pass filter at these initial parameters, to put all α_i=0 (as in half-band filters) and to round off all β_i at M=8. The appropriate attenuation $\tilde{a}_0$=98.41 dB.

<u>Example 2.</u> The low-pass filter specifications are $\Delta\tilde{a} \le$ 0.2 dB, $\tilde{a}_0 \ge 65$ dB, f_{1n}=0.2125, f_{2n}=0.2875, N=7, M=6 and Σ_m=8. The proposed algorithm results to the solution at Δa=0.005615 dB, f_1=0.207633, f_2=0.282827 and N_0=6.94. The appropriate coefficients are identical to that obtained in [1].

<u>Example 3.</u> The half-band specifications are $\tilde{a}_0 \ge 46$ dB, f_{2n}=0.27, N=9 and $M=7$. The proposed algorithm for the half-band design results to f_2=0.2703, N_0=8.9. The coefficients are β_1=0.125, β_2=0.4140625, β_3=0.6953125, β_4= 0.90625. The attenuation $\tilde{a}_0$=46.08 dB.

References

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