TWO EXAMPLES OF MULTIPLIERLESS PERFECT RECONSTRUCTION LATTICE FILTER BANK DESIGN

Mingazin A.

This paper is devoted to solving of the task of multiplierless two-channel perfect reconstruction lattice filter banks [1-4]. A modified algorithm combining a variation of initial parameters (VIP) and a variation of coefficients (VC) are used. Two examples show that the refuse of a simplified selection of a spectral factor code (C) leads to substantial improvement of results.

Example 1. Filter bank requirements: the nominal edges are \( f_{sn} = 0.18 \), \( f_{zn} = 0.32 \), and the sampling frequency equal 1, the order of each filter is \( 2N-1 = 27 \), the mantissa of binary coefficients is \( M \leq 10 \), the number of non-zero bits in the coefficients is \( m \leq 2 \). The task 1: the minimum stopband attenuation is \( a_0 \rightarrow \max \). The task 2: the total number of adders in the multiplierless filter is \( \Sigma \rightarrow \min \), \( a_0 \geq 45 \ dB \).

A value \( a_0 = 45.45 \ dB \) (more precisely \( 45.37 \ dB \) [4]) at \( M = 10 \) and \( m = 2 \) (\( \Sigma = 56 \)) is reached in [1]. Improved solutions for simplified selected \( C = 33 \) are obtained in [4] by VIP+VC algorithm. In [1] an initial filter with continuous coefficients corresponds to \( C = 0 \) and the designed multiplierless filter corresponds to \( C = 32 \). Therefore it is interesting to find solutions by VIP+VC modified algorithm for \( C = 32 \). The values \( a_0 = 48.59 \ dB \), \( \Sigma = 54 \), \( M = 8 \) and \( a_0 = 45.49 \ dB \), \( \Sigma = 50 \), \( M = 8 \) are obtained for this value \( C \). Both solutions improve the result [1].

Designing by VIP+VC modified algorithm for \( C = 0,1, \ldots, 127 \) and \( C = 16383-0,1, \ldots, 127 = 0,1, \ldots, 127 \) leads to many solutions exceeding results [1,4]. Two best of them are \( C = 102 \), \( a_0 = 53.35 \ dB \), \( \Sigma = 54 \), \( M = 9 \) and \( C = 25 \), \( a_0 = 45.39 \ dB \), \( \Sigma = 46 \), \( M = 4 \). For the second solution the found coefficients \( \alpha_0, \alpha_1, \ldots, \alpha_3 \) (on fig. 1b in [1,2]) are \( 1 - 2^{-4}, 2^{-3}, 2, -1 - 2^{-1}, 2 - 2^{-3}, -2^{-4}, -2^{-1} + 2^{-4}, -1 - 2^{-4}, -2^{-2} - 2^{-3}, -2^{2} + 2^{-1}, 2^{-4}, 2 + 2^{-2}, -2^{-4}, 2 + 2^{-3} \). Interestingly, that this second solution is possible to reach by using the only VIP algorithm.

Example 2. The requirements: the nominal edges are some, \( \tilde{a}_0 \geq 45.45 \ dB \), \( 2N-1 = 21 \), \( M = 9 \), \( m \leq 3 \) and \( \Sigma \rightarrow \min \) [2]. A solution with \( \Sigma = 56 \) and \( \tilde{a}_0 = 45.78 \ dB \) (more precisely \( 45.19 \ dB \) [3]) is achieved in [2]. VIP algorithm [3] leads to \( \Sigma = 56 \) and \( \tilde{a}_0 = 45.01 \ dB \). Here we use VIP+VC modified algorithm for a set of \( C \). For solutions [2,3] all zero appropriated to a passband are inside the unit circle. In this case for the given filter order the code \( C = 0 \) or \( C = 1984-k64, k = 0,1, \ldots, 31 \). We shall be limited \( C = 0 \) and \( C = 1984 \). In the first case solution with \( \Sigma = 56, \tilde{a}_0 = 45.16 \ dB \) and in the second case solution with \( \Sigma = 56, \tilde{a}_0 = 45.66 \ dB \) are obtained. It is interesting that the coefficients \( \alpha_0, \alpha_1, \ldots, \alpha_{10} \) for \( C = 1984 \) distinguish from that were founded in [2] by the only coefficient. We have \( \alpha_0 = -2^{2} + 2^{-6} \) and in [2] \( \alpha_0 = -2^{2} + 2^{-5} \). Besides our value \( \alpha_0 \) is included into a range of exhaustive search [2]. Apparently the misprint is accepted in [2].

Designing for \( C = 1,2, \ldots, 32 \) lead to very big number of solutions with \( \tilde{a}_0 \geq 45.45 \ dB \) and \( \Sigma \leq 56 \), two best of them are \( C = 2, \tilde{a}_0 = 46.19 \ dB \), \( \Sigma = 48 \) and \( C = 12, \tilde{a}_0 = 45.64 \ dB \), \( \Sigma = 46 \). For the second solution \( \alpha_0, \ldots, \alpha_{10} \) are \( 2^{-3}, 2^{-1} - 2^{-9}, -2^{3} + 2 + 2^{-3}, -1 + 2^{-2} + 2^{-5}, 2^{-4}, -2^{2} - 2^{-5} - 2^{-7}, -2^{-1} + 2^{-6}, 2^{2} - 2^{-1}, 1 + 2^{-3} + 2^{-6}, -2^{1}, -2^{2} - 2^{-3} \). In comparison to the solution at \( C = 1984 \) the number of adders is reduced from 56 to 46.

References