Design High Pass FIR Filter With Signed Power Of Two Using MATLAB

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Abstract

The design of digital filter, using signed power of two is implemented. The filter is designed without multipliers. The design is based on the remez exchange algorithm for the design of high pass filters. Linear phase FIR filter with coefficients consisting of minimum number of power of two is formulated. The aim of this thesis is first to reduce the region that contains the optimal solution in order to decrease the computation time and ,then FIR filter are designed using mixed integer linear programming.

Keyword: remez exchange algorithm, Linear phase FIR filter, mixed integer linear programming, Signed power of two.

1 INTRODUCTION

Recently numerous algorithms have been proposed for designing multiplier less finite impulse response (FIR) filters. In multiplier less digital filter multiplication are replaced with a sequence of shift and adds. Therefore only adders are required for the coefficient implementation. This leads to significant reduction in the computational complexity and power consumption. Filters with such specifications can be designed by appropriate modification of the McClellan-Park algorithm. By suitable choice of the weighting function of the equirriple error.The purpose of this paper is to advance a new technique for the design of linear phase FIR filters with equirriple stop band and with a prescribed degree of flatness in the pass band. the proposed technique is based on McClellan-Park algorithm for FIR filter design and optimization is involved here. In Section II the method is introduced along with numerical examples. For the design of narrow pass band filters, a number of improved method are described in Section III, and IV based on high pass filters. In Section V we discuss certain implementation considerations.

II SATEMENT OF THE PROBLEM

The Parks-McClellan algorithm, published by James McClellan and Thomas Parks in 1972, is an iterative algorithm for finding the optimal Chebyshev finite impulse responses (FIR) filter.. The Parks-McClellan algorithm is utilized to design and implement efficient and optimal FIR filters.

The defining characteristic of FIR filter optimal in the Chebyshev sense is that they minimize the maximum frequency-response error-magnitude over the frequency axis. In other terms, an optimal Chebyshev FIR filter is optimal in the minimax sense: The filter coefficients are chosen to minimize the worst-case error (maximum weighted error-magnitude ripple) over all frequencies. This also means it is optimal in the **L-- infinity** sense because, as noted above, the **L—infinity** norm of a weighted frequency-response error

$$E(\omega) = W(\omega)\,H(\omega) - D(\omega)|$$

Is the maximum magnitude over all frequencies:

$$\| E \|_\infty = \max_{-\pi \le \omega < \pi} |E(\omega)|$$

Thus, we can say that an optimal Chebyshev filter minimizes the **L—infinity** norm of the (possibly weighted) frequency-response error. The **L—infinity** norm is also called the uniform norm. While the optimal Chebyshev FIR filter is unique, in principle, there is no guarantee that any particular numerical algorithm can find it.

The optimal Chebyshev FIR filter can often be found effectively using the Remez multiple exchange algorithm (typically called the Parks-McClellan algorithm when applied to FIR filter design) . The Parks-McClellan/Remez algorithm also appears to be the most efficient known method for designing optimal Chebyshev FIR filters (as compared with, say linear programming methods using matlab's . This algorithm is available in Matlab's Signal Processing Toolboxes firpm() (formerly called remez())There is also a version of the Remez exchange algorithm for complex FIR filters.

The Remez multiple exchange algorithm has its limitations. Optimal Chebyshev FIR filters are normally designed to be linear phase so that the desired frequency response **D(ω)** can be taken to be real (*i.e.*, first a zero-phase FIR filter is designed). The design of linear-phase FIR filters in the frequency domain can therefore be characterized as *real* polynomial approximationon .

In optimal Chebyshev filter designs the error exhibits an equiripple characteristic--that is, if the desired response is **D(ω)** and the ripple magnitude is ϵ, then the frequency response of the optimal FIR filter (in the unweighted case, *i.e.*, **W(ω)** for all ω)

will oscillate between **D(ω)+€** and **D(ω)-€** as ω increases. The powerful alternation theorem characterizes optimal Chebyshev solutions in terms of the alternating error peaks. Essentially, if one finds sufficiently many for the given FIR filter order, then you have found the unique optimal Chebyshev solution Another remarkable result is that the Remez multiple exchange converges monotonically to the unique optimal Chebyshev solution (in the absence of numerical round-off errors).

III PROBLEM ANAYSIS

Design and plot the equirriple linear phase FIR high pass filter with order 36.using signed power of two terms. Normalized frequency of pass band and stop band are 0.15, 0.25.

TABLE 1
Cofficients of H(z) in Example
Filter length =36

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h(0) = 0.0088 = h(36)
h(1) = 0.0069 = h(35)
h(2) = 0.0044 = h(34)
h(3) = 0.0004 = h(33)
h(4) = -0.0074 = h(32)
h(5) = -0.0131 = h(31)
h(6) =-0.0162 = h(30)
h(7) = -0.0111 = h(29)
h(8) = -0.0003 = h(28)
h(9) = 0.0166 = h(27)
h(10) = 0.0307 = h(26)
h(11) = 0.0375 = h(25)
h(12) = 0.0275 = h(24)
h(13) = 0.0002 = h(23)
h(14) =- 0.044 = h(22)
h(15) = -0.0979 = h(21)
h(16) = -0.1498 = h(20)
h(17) = - 0.1861= h(19)
h(18) = 0.7998

IV IMPLEMENTATION

FIR digital filter designed over the signed power of two (SPT) discrete spaces were first proposed by Lim and Constantinides. This section briefly describes the SPT number characteristics and exiting optimization techniques for the design of digital filter subject to SPT coefficient.

Signed Power of Two

In mathematics, a power of two is any of the integer powers of the number two.because two is the base of the binary system, power of two are important to computer science.

Signed Digit Representation

The radix-2 signed digit format is a 3-valued representation of a radix-2 number and employs three digit values 0,1 and -1.A simple algorithm representation which convert radix-2 binary number to equivalent SD representation is as follow.

$$C_{-i} = a_{-i-1} - a_{-i}\,,\ i = b,$$
b-1, …………………..1,

After that decimal number is represent the binary number using this formula

$$G(q) = \sum_{i=1}^{b} a_{-i}\, 2^{-1}$$

TABLE II
Implemented Result
Cofficients of H(z) in Example
Filter length =36

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h(0) = 0 = h(36)

h(1) = 0 = h(35)

h(2) = 0 = h(34)

h(3) = 0 = h(33)

h(4) = 0 = h(32)

h(5) = 0 = h(31)

h(6) = 0 = h(30)

h(7) = 0 = h(29)

h(8) = 0 = h(28)

h(9) = 0 = h(27)

h(10) = 0 = h(26)

h(11) = 2^{-5} = h(25)

h(12) = 0 = h(24)

h(13) = 0 = h(23)

h(14) = -2^{-5} = h(22)

h(15) = $-2^{-4}-2^{-5}$ = h(21)

h(16) = -2^{-3} = h(20)

h(17) = $-2^{-3}-2^{-5}$ = h(19)

h(18) = $-2^{-3}-2^{-4}$

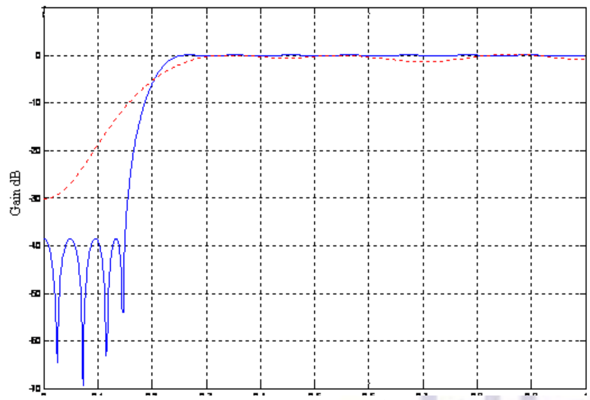

Fig. 1 magnitude response and coefficient for N = 36 , high pass filter

V CONCLUSION

In this paper the methods of integer linear programming are particularly useful for designing FIR filters with the power of two coefficients. the aim of optimization is only the minimization of the number of PT terms. Extensive research has shown that the complexity of an FIR filter can be reduced by implementation its coefficient as sum of PT terms and faster hardware implementation of the multiplication operation.

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