Design of Lowpass Narrowband FIR Filters Using IFIR and Modified RRS Filter

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ABSTRACT
This paper presents a new efficient method for the design of lowpass narrowband (LP) finite impulse response (FIR) filters using a modified interpolated finite impulse response (IFIR) filter and an improved recursive running sum (RRS) filter. Since the number of parameters of the RRS filter is increased the adjustment of the frequency characteristic of the interpolator filter using fewer stages of the RRS filter is possible.

INTRODUCTION
The main disadvantage of FIR filters is that they involve a higher degree of computational complexity comparing to IIR filters with equivalent magnitude response. Many design methods have been proposed to reduce the complexity of FIR filters in the past few years for example (J. W. Adams and A.N.Willson, 1984), (Y.Lian and Y.C.Lim, 1998), (M.E.Nordberg, 1996), (A.Bartolo, B.D.Clymer, 1996) etc. One of the most difficult problems in digital filtering is the design of narrowband filters, (Mitra 2001). The difficulty lies in the fact that such filters require high-order designs in order to meet the desired specification. In turn, high order filters require a large amount of computation so are difficult to implement.

We consider the design of lowpass narrowband FIR filters with cutoff frequencies considerably lower than the sampling rate. One efficient technique for the design of FIR filters is called the interpolation FIR (IFIR) technique (A.Bartolo, B.D.Clymer, 1996) etc. One of the most difficult problems in digital filtering is the design of narrowband filters, (Mitra 2001). The difficulty lies in the fact that such filters require high-order designs in order to meet the desired specification. In turn, high order filters require a large amount of computation so are difficult to implement.

2. MODIFICATION OF RRS FILTER

The parameters of an RRS filter are M and K. If the specification is not satisfied for a given M we must increase K to the next integer value. To avoid doing this, we modify the structure of the RRS filter by introducing additional parameters.

Using M=2N according to the equations (2) and (4) we can write the system function of the modified RRS filter

$$H_m(z) = \left(\sum_{i=0}^{2N-1} z^{-i}\right)^K \left(\sum_{k=0}^{N-1} z^{-2k}\right)^2 = H(z)X_1(z)$$

Example 1:
We consider N=4, k1=0 and k2=0. From (5), we have

$$H_m(z) = \left(\sum_{i=0}^{4} z^{-i}\right)^K \left(\sum_{k=0}^{2} z^{-2k}\right)^2 = H(z)X_1(z).$$

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3. PROPOSED STRUCTURE

We propose the modified RRS filter as the interpolator in the IFIR structure. The resulting structure is shown in Figure 2. Adjusting all three parameters of the modified RRS filter we can satisfy the given specification using the lower order interpolator filter.

The method is illustrated in the next example.

Example 2:

We design the filter having these specifications: Passband and the stopband frequencies are \( w_p = .01 \) and \( w_s = .05 \), respectively. Passband ripple is \( R_p = 0.1 \) dB and the stopband attenuation is \( A_s = 60 \) dB.

The direct design using the Parks McClellan algorithm results in a filter of the order 172. If we use the IFIR structure with the RRS filter and the interpolation factor \( M = 8 \) we obtain the order of the model filter of only \( N_G = 22 \).

In order to improve the stopband characteristic we use the modified RRS filter with \( k_1 = 3 \), \( k_2 = 1 \) and \( M = 8 \). The corresponding magnitude response is shown in Figure 3. Observe that the stopband specification is satisfied using \( K = 4 \) in the RRS filter, but this filter is more complex than the modified RRS filter with \( k_1 = 3 \) and \( k_2 = 1 \).

REFERENCES


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