CIC BASED DECIMATION FILTER FOR AMPLITUDE SHARPENING

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Abstract - Cascaded Integrator Comb (CIC) filters can perform filtering without multiplying operations and this quality makes practicing engineers and researchers find it highly useful especially for high sample rate signals. The simplest multiplier less decimation filter is the cascaded-integrator-comb (CIC) filter. However, CIC filters introduce a pass band droop, which is intolerable in many applications. The droop can be reduced by connecting a linear-phase finite-impulse-response filter called compensator in cascade with CIC filter. Since CIC filters are multiplier less, CIC compensators with multiplier less structures are preferable. In the thesis, two methods for the design of multiplier less CIC compensators have been proposed. Both methods are based on minimization of the maximum pass band deviation. However, the first method provides an efficient compensation by using coefficients expressed as sums of powers of two (SPT), whereas the second method brings simple compensator's structures by representing each coefficient assigned power of two. In both approaches, the optimum coefficients are found by using global optimization. In processing of wideband signals, CIC filter is often incapable of meeting the requirement for high folding-band attenuations. To improve CIC filter folding band response, various structures have been developed. An efficient structure arises from polynomial sharpening of the folding-band response. This structure implements a so-called sharpened CIC (SCIC) filter.

Key Words: CIC, SPT, COMB, DECIMATION,FILTER

1.INTRODUCTION

CIC filters are multiplier less structures, consisting of only adders and delay elements which is a great advantage when aiming at low power consumption. The magnitude characteristic of CIC filter has a pass band droop in the desired pass band that is dependent upon the decimation factor D and the cascade size K. The authors, G. J. Dolecek and S. K. Mitra, proposed an idea for improving the pass band using compensating filters. Narrowband compensation technique improves the pass band characteristics. The sharpening technique originally introduced by Kaiser and Hamming. It consists of a comb section and a sharpening comb section with the later section operating at a lower rate than the high input rate for the realization of comb-decimation filter with a sharpened magnitude response. In this thesis, we give a comparison between CIC filter, sharpened CIC filter and modified sharpened CIC filter. Also we give a comparison between cascaded cosine CIC filter, modified cascaded cosine CIC filter and compensated modified cosine CIC filter.

2.PROPOSED THREE STAGE COMB DECIMATION FILTER

The design of CIC filter depends three parameters; they are decimation factor 'M', number of stages 'K' and delay in comb section. The structure proposed in this paper is shown in Figure 4.1 which consists of three stages. By applying sharpening technique in the second stage and third stage will improve the pass band droop compared to existing CIC filter structures.

Filter sharpening is the technique to improve the pass band droop and stop band attenuation using multiple realization of a low order basic filter having the form.

$$H_{nm}(f) = H^{n+1}{}_p(f) \sum_{k=0}^{m} \frac{(n+k)!}{n!k!} [1-H_p(f)]^K$$

Where, Hp(f) is a low order basic filter, n and m are nonnegative integers represent the number of non-zero derivatives of Hnm(f) at points Hnm(f) = 0 and Hnm(f) = 1 respectively. The Kaiser-Hamming sharpening technique applied to linear phase FIR filters with group delay of D samples has the transfer function of H11(z), for n=1; m=1 can be written as

$$H_{11}(z) = H_p{}^2(z) \; [3z^{-D} - 2H_p(z)]$$

The term [$3z^{-D}$ – 2 H_p (z)] is responsible for pass band droop reduction and Hp (z)is responsible for stop band rejection. The magnitude response of the sharpened filter [13] is

$$|H_{sh}(e^{j\omega})| = \left| 3\left[\frac{1}{M}\frac{\sin(\omega M/2)}{\sin(\omega/2)}\right]^{2K} - 2\left[\frac{1}{M}\frac{\sin(\omega M/2)}{\sin(\omega/2)}\right]^{3K} \right|$$

The generalized transfer function of CIC filter can be written a

$$H(z) = H_1(z)\, H_2(z^{M_1})\, H_3(z^{M_1 M_2})$$

WHERE

$$H_1(z) = \frac{1}{M_1}\left(\frac{1-z^{-M_1}}{1-z^{-1}}\right)$$

$$H_2(z^{M_1}) = \frac{1}{M_2}\left(\frac{1-z^{-M_1 M_2}}{1-z^{-M_1}}\right)$$

$$H_3(z^{M_1 M_2}) = \frac{1}{M_3}\left(\frac{1-z^{-M}}{1-z^{-M_1 M_2}}\right)$$

The decimation factor M is subdivided in to M1 , M2 and M3 . The magnitude response is

$$|H_1(e^{j\omega})| = \left|\frac{1}{M_1}\frac{\sin(\omega M_1/2)}{\sin(\omega/2)}\right|$$

$$|H_2(e^{j\omega M_1})| = \left|\frac{1}{M_2}\frac{\sin(\omega M_1 M_2/2)}{\sin(\omega M_1/2)}\right|$$

$$|H_3(e^{j\omega M_1 M_2})| = \left|\frac{1}{M_3}\frac{\sin(\omega M/2)}{\sin(\omega M_1 M_2/2)}\right|$$

Transfer function of proposed CIC filter structure is given by

$$H_{PS}(z) = [H_1(z)]^L \{3[H_2(z^{M_1})]^{2K} - 2[H_2(z^{M_1})]^{3K}\} \{3[H_3(z^{M_1 M_2})]^{2K} - 2[H_3(z^{M_1 M_2})]^{3K}\}$$

Where, is the number of stages in corresponding filter.

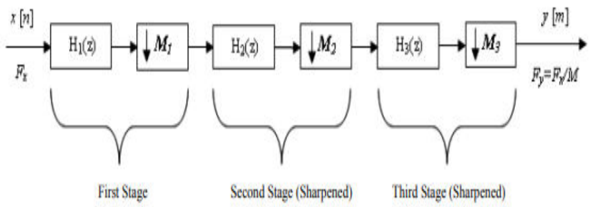

Figure 1: Proposed CIC filter structure

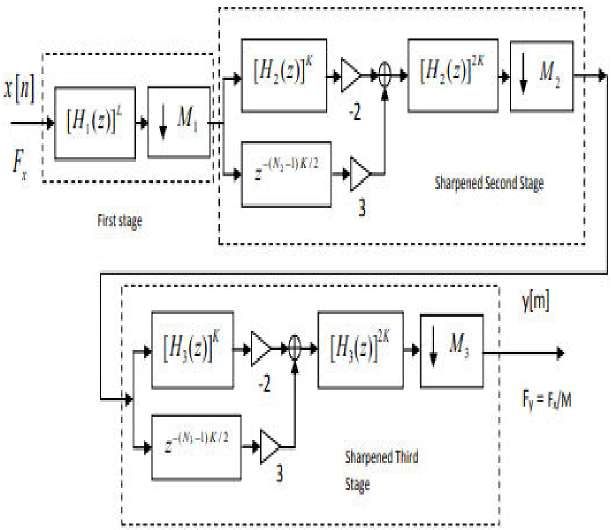

Figure 2: Implementation of proposed CIC filter structure

3.RESULTS AND DISCUSSION

Simulation results obtained by using the proposed CIC decimation filter with sharpening technique in the second stage and third stage. In order to compare the results with the classical comb filter we found the equivalent number of the stages of the classical comb filter of the length. In the first stage we have a comb filter of length M1with L stages. In the second and third stages we have the sharpened comb filter of length M2 and M3 with K stages.

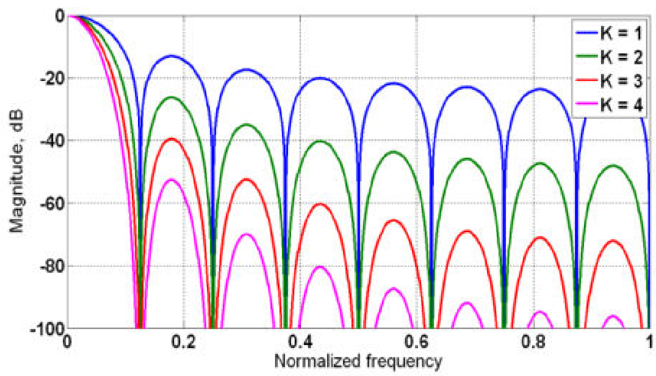

Figure 3: Response of CIC filter with different K values

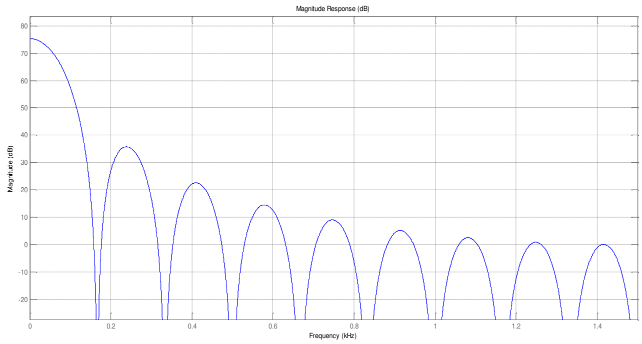

Figure 4: Magnitude Response of Proposed method

4. CONCLUSIONS

A new method is presented for improving the CIC filter characteristics. This opted solution has examined the effect of sampling rate on the CIC filter gain response by finding the optimal sampling rate value which improves efficiently the CIC filter characteristics. The evaluated results of the proposed CIC filter confirmed the enhancements in both stop band attenuation and ripple as well as the pass band droop. Besides, the comparison carried out between our method and some other existing CIC filters showed the effect of the sampling rate parameter on both stop band and pass band performances. This improvement makes our CIC filter suitable for many signal processing applications, especially in wireless domain including WCDMA and WiMAX with different parameter combinations.

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