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Enhancing and implementing a digital filter using CIC and FIR filters

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ABSTRACT

This research designed and implemented a CIC-FIR filter structure for receivers. When it's necessary that limits communications in specific cutoff frequency ranges, Band pass filters are a crucial component of common electronics used in digital signal processing It is possible to make It Passing filtration with the use of FIR. However, because of its challenges in satisfying time closure of the design and the growing complexity of hardware, the CIC-FIR filter structure has been proposed for handling the limitations of FIR filter-based BPF design. To demonstrate the CIC-FIR structure is superior for designing BPF, many comparisons were conducted applying it for varying orders and sampling frequencies. By lowering the filter's sampling rate, this structure will make the system's needs achievable. In addition to making timing closure simple, this approach indirectly lowers power usage.

KEYWORDS
Decimator, MATLAB, Interpolator, FIR-CIC filters, filters for FIR, or CIC filters.

1. INTRODUCTION

A filter is a tool used in signal processing. It eliminates an undesirable aspect or element of the signal. The digital filters make use of discrete time samples. To get the intended result, the discrete sample is processed. According to the Fourier Analysis Theory, dividing a pair of signals in the frequency plane is the same as linearly combining among two consecutive signals in the duration dimension. Digital processing has effects on the filter's impulse response and the frequency-domain multiply of the audio spectra. As is well known, the perfect band-pass filter lowers every frequency out of its passband and has a fully flat passband. All digital components are present in digital filtering, which receives digital input along with Digital output: Processing is a method that uses to a sampling frequency (Fs) as to convert analogue signals to digital outputs. The rate of the Nyquist signal represents it eliminates a frequency component that is greater than the sample frequency Fs/2 [1]. Using MATLAB, however, this principle is given to develop the BPF for the specified frequencies that cut off for high-pass and low-pass technologies.

II. FIR FILTER

The Finite impulse response (FIR) filter's structure that can be used to implement almost any sort of frequency response digitally. A series of delays, multipliers and adders is used to get FIR filter output.

Fig. 1 The basic filter blocks

The block diagram in Figure 2 represents a FIR filter at order N. The delay occurs by the use on the previous values. Where N is the FIR filter's order, that varies from 0 to N-2, and the coefficient h[N] values are utilized for adding up. A suitable coefficient is fitted to the delayed samples. The output of this summation is at time "N." The process called Dot Product is where a FIR filter operates. This is accomplished by multiplying the Tap coefficients, which are a collection of constants, and then adding up the components in the resultant collection. The procedure takes a new sample as input and removes the old data.

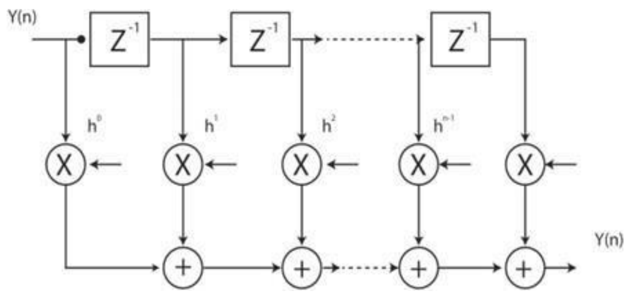

Figure 2: FIR filter block diagram

The procedure is performed. Digital filtering techniques include screens with a (FIR). The initial response of the filter approaches negligible. The term "Finite" filter is frequently used to describe this. An infinite outcome filter is not the same as this restricted amount filter [2]. An infinite response impulse (IIR) filter is unsteady; because it includes an inbuilt feedback loop and reacts indefinitely. Because FIR filters contain a multiplier, their coefficients for filtering are complicated for order N.

II. CIC Filter

CIC filters are an equilibrium type of digital difference and digitally integrate. CIC filters provide both decimation and digital lowpass filtering capabilities. The CIC [3]. Filters need no compound circuits, which makes them the most advantageous way to implement hardware. Using the CIC filter, the structural difficulty of the FIR detector may be recovered. Figure 3 illustrates the first-order schematic diagram with CIC. The use of hardware is important as delayed features are implemented in the divider step. For differentiator circuits and M delay elements are essential. Delay components are implemented via bits. Hardware design is important as the distinguished step uses delayed components. There must be M delayed components. with networks that use differentiators. Delayed components are controlled using circuits. Since some registers contain time components, the higher oversampling factor doubled both the number of delayed components and total amount of bytes utilized to hold input. Hogen Auer's CIC decimate filter, represented in Fig. 3, displays N cascaded electronic integrates running at an increased input sample rates, Fs, and N passed on distinguishing factors at a reduced input sampling rate, Fs/R, where R is the decimation factor, a positive integer. H(Z), an N-stage sinc operation, is a transferring functional [4].

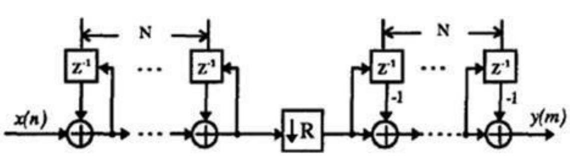

Figure 3: Block Diagram of CIC Filter by using decimation factor

$$H(z) = \left(\frac{1 - z^{-R}}{1 - z^{-1}} \right)^{N}$$

Several characteristics make a such of decimation filter extremely effective:

(1) There is no multiplying circuits needed.
(2) The filter's parameters don't need to be stored.
(3) The amount of intermediate storage is decreased through integration at a high sampled rate.
(4) The CIC filter is filtered at an extremely low sampling rate.
(5) Either complex local timings or a tiny external control is needed.
(6) By slight modifications to filter time and the addition of a scalability component, this decimation filter design is used for several variations in rate component R is values.

IV. CIC-FIR STRUCTURE

The suggested setup works by introducing the result of the CIC low-pass filter through the FIR high pass filter, resulting in a filter known as bandpass. As comparison to the FIR configuration alone, the CIC FIR configuration offers many equivalent benefits such as:

(1) The sample rate is decreased with the aid of CIC decimation filters. By integrating frequency multiplication, this function improves the system's overall efficiency

(2). As the sample speed decreases, the FIR filter's order decreases as well. Consequently, the FIR filter's efficiency and use of resources decrease

(3). Depending on the filter's sequence, FIR filters can allow for good transition band (sharp) response

(4). The setting up of CIC filters is straightforward.

In many instances, it makes perfect sense to combine CIC and FIR filters to generate BPF. Due to these features, the CIC-FIR structure appears to be more cost-effective when As contrasting to obtaining a band pass filter using simply the FIR structure [5]. For determining the CIC-FIR order, the block schematic is shown in Fig. 4. The primary feature of the CIC layout is that the overall reducing the sample rates, Fs, which is to Fs/R, whereby R is the decimated variable, or the rate reduction factor. Continuously running at frequency of sampling Fs is the primary unit. The sampling rate the Fs is constantly employed by the initial filter to function. The block's input is going to be utilized after the CIC filter and FIR are applied. The speed of Fs/R samples [6]. The FIR filter blocks are going to force them to run at the same speed. If the FIR filter that is used is the initial block, this won't occur. Therefore, the CIC filter in the initial block is an additional cost-effective filter configuration than the BPF design approach with CIC FIR. Therefore, the layout takes advantage of the CIC-FIR structure.

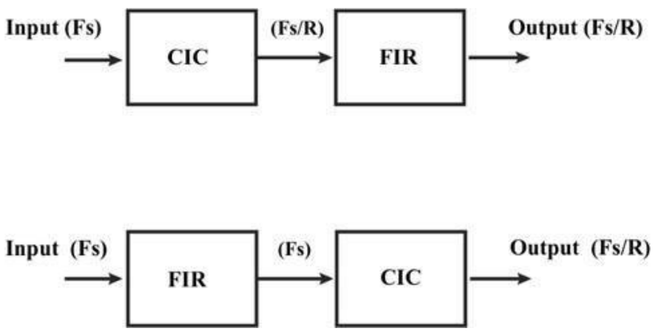

Figure 4: Blocks schematic showing the CIC-FIR architecture

V. CIC-FIR STRUCTURE

The rate of sampling is decreased with the aid of Cascaded integrator–comb decimation filter. Through implementing period, a technique called multiple this function enhances the system's overall effectiveness. As the data acquisition speed decreases, the FIR filter's ordering decreases as well. Consequently, the FIR filter's input density and complexity decrease. Depending on the filter's sequence, FIR filters allow for good transition band (sharp) responsiveness [7]. The establishment of CIC filters is straightforward. In many situations, it is a very smart idea to combine CIC as well as the FIR filters that are cascaded to make Band Pass Filter (BPF).

VI. AN ANALYSIS OF THE SUGGESTION Or REVEALED STRUCTURES

The FIR structural characteristics and the CIC FIR structural characteristics are contrasted here. The FIR configuration is intended for sampling, with a high pass cutoff at 8.28MHz and a low pass cutoff at 11MHz. filter order of 40 and a frequency of 100 MHz with filter order 10, the CIC-FIR structure can be modified to have the identical low pass and high pass thresholds. Thus, a four-fold reduction in the sample rate is possible. Tables 1 and 2 display design. characteristics of the CIC-FIR and FIR filters, correspondingly [8]. Adders and multiplies components make up the combined circuits that make up FIR and CIC filters.

According to [2], all FIR filters have one multiplying as well as adder at its initial stage; therefore, in the Nth stage, it has N multipliers and N adders. The structural challenges associated with the FIR filter construction comes from the multiplication component. By using the identical CIC-FIR order, this level of detail can be eliminated.

With lowering the filtering's structure, the threshold frequency Band Pass Filter can be intended to resemble which of a FIR filter. According to Table 3, as the filter's value rises so does the minimum address space components needed; in a result, the filter's structure gets larger and takes longer for it to work. The result might be overcome by employing the CIC-FIR order, that eliminates the need for a multiplication component within the CIC filter. Use of energy could reduce as the number of continuous cycles drops. be minimized [9]. The identical approach can be used with a Field Programmable where the CIC-FIR design makes it easier to meet time the end than the FIR architecture. Figures 5 and 6 display an example bandpass frequencies graph for the FIR filter and FIR-CIC filter method, respectively. This indicates that the CIC-FIR design produces a sharper change band response with the FIR structure separately. The wavelength of the planned structureis2.72MHz. It will also be made with a wavelength of 0.39MHz. They are basically narrowed bandpass filters. The specifications for the design can be found in Tables 4 and 5. Two of these distinct design parameters allow us to see Both the filter's order as well as sample rate are decreased [10]. The two CIC-FIR and FIR filter frequency plots for a channel width of 0.39MHz are shown in Figures 7 and 8.

Table 1: Shows the FIR filter's design specifications.

DESIGN PARAMETERS	VALUES
Rate for sampling	100 MHz
Order	50
Cut-off of high pass filter	9MHz
Cut- off for low pass filter	10MHz

Table 2: Shows the FIR filter's design specifications.

DESIGN PARAMETERS	VALUES
Rate for sampling	100 MHz
Order	5
Rate for CIC sample	50MHz
R (factor of determination)	2
Differential delay, and M	3
N (the quantity of sections)	4
Cut-off of high pass filter	9MHz
Cut- off for low pass filter	10MHz
Bandwidth	3.57MHz

Table 3: Shows the FIR filter's design specifications.

FILTER TYPE	ORDER	SAMPLING RATE
FIR	50	100MHZ
FIR-CIC	10	100MHZ

Table 4: Shows the FIR filter's design specifications.

DESIGN PARAMETERS	VALUES
Rate for sampling	100 MHz
Order	100
High pass cutoff	0.9MHz
Low pass cutoff	1.22MHz

Table 5: CIC-FIR filter design parameters.

DESIGN PARAMETERS	VALUES
Rate for sampling	100 MHz
Order	10
Rate for CIC sample	10MHz
R (factor of determination)	2
Differential delay, and M	4
N (the quantity of sections)	2
Cut-off of high pass filter	0.80MHz
Cut- off for low pass filter	1.20MHz
Bandwidth	0.40MHz

Table 6: FIR and CIC-FIR compare by ordering & number of samples

FILTER TYPE	ORDER	SAMPLING RATE
FIR	100	100MHZ
FIR-CIC	20	100MHZ

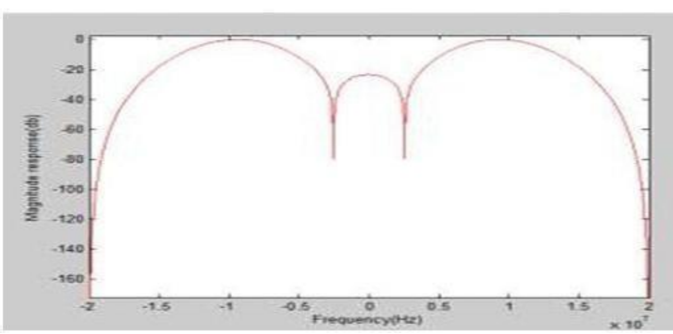

Illustration 5: Bandwidth for the BPF for CIC-FIR structure = 2.57MHz

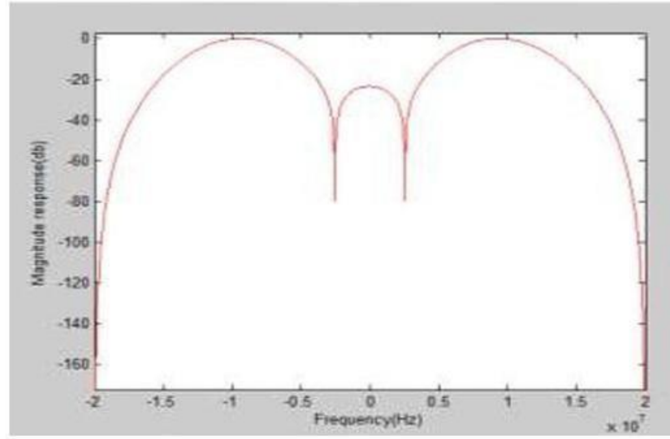

Illustration.6 BPF in order in the FIR structure (Bandwidth =2.57MHz)

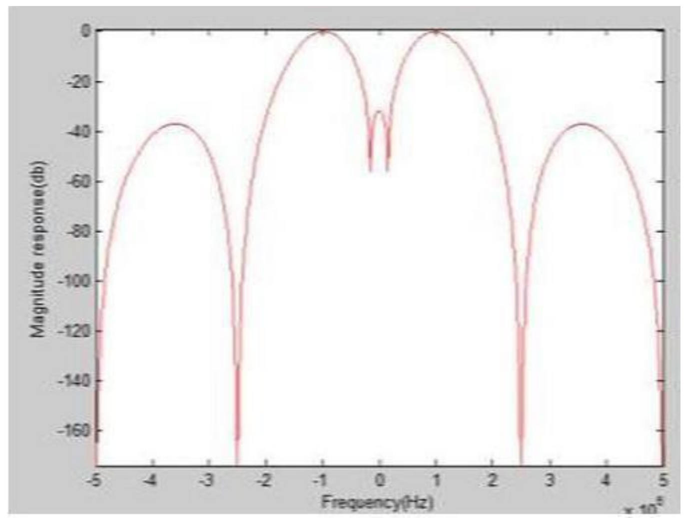

Illustration.7 BPF for the design and construction of CIC-FIR

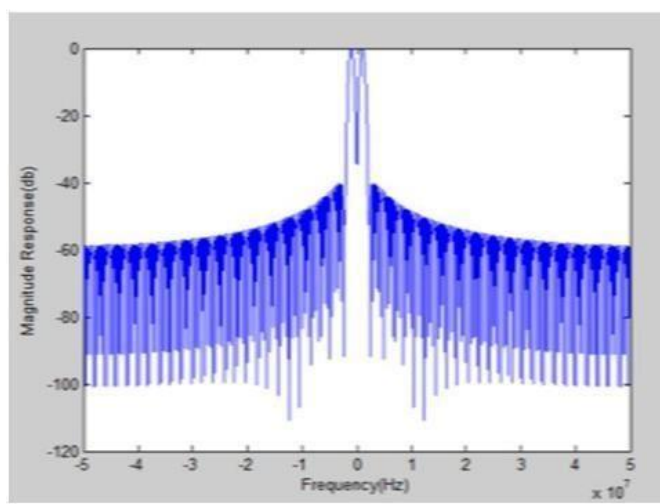

Illustration.8 BPF for the FIR design (BW=0.40MHz)

VIII. FURTURE SCOPE

Many opportunities for more study as advancement are made possible by the suggested CIC-FIR filter arrangement. To improve the droop qualities of the CIC filter and expand its relevance to situations with more stringent bandwidth specifications, future study can concentrate on optimizing the compensation element filter design. The CIC-FIR layout can also be enhanced with progressive filtering methods to increase its adaptability in changing signal settings. This layout may also be used in battery-powered, inexpensive computer systems and Internet of Things equipment, wherein cost and hardware efficiency are crucial. A greater comprehension of the trade-offs regarding locale, acceleration, of fuel may be possible with more research into VLSI integration and ASIC design. Furthermore, the CIC-FIR concept can be expanded to multidate circuit processing applications where effective filtering at different sampling rates is crucial, including software-defined radios and biological signal analysis.

VII. CONCLUSION

This study presents while assessing the effectiveness of a band pass filter (BPF) design using a CIC-FIR filter in signal processing applications. Compared to traditional FIR-based BPFs, the recommended arrangement has a major value because it simplifies the component design, making frequency a conclusion quicker while using less resources generally on Programmable systems. The CIC FIR topology successfully reduces area and energy use by reducing the volume of intricate mixed components, such as integrators and adders. It is also an inexpensive option for limited bandwidth purposes since it permits filtering frequency decrease while sacrificing important performance specifications. Although an established drawback, the intrinsic lower of CIC filters is mitigated in situations with strict roll-off criteria by employing adequate compensating filtered. Additionally, the suggested architecture makes it possible to lower the frequency at which samples are collected, which would increase the system's power efficiency even more.

CIC-FIR technology is a viable substitute for low-power, area-efficient BPF implementations in contemporary electronic systems since it exhibits comparable results overall with fewer requirements.

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