

Matlab Based Decimeter Design Analysis Wimax Application

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Abstract: A Digital down Converter (DDC), which is basically used to convert an intermediate frequency (IF) signal to its baseband form, forms an integral part of wireless receivers. The major functional blocks of a DDC constitute a mixer, Numerically Controlled Oscillator (NCO) and an FIR filter chain. In this paper, We can comparison of two window and see the costs of all Window filters

Keywords: Matlab, Filter, Interpolated, Decimeter, WIMAX

I. Introduction

Two Type of Communication wired and wireless. The invention of wireless communication has been a boon to mankind. With The Help Of Wireless Communication Information can transmitted from one place to another, without the use of a External electrical medium. It Is advances technology, information can be transmitted from one place to another (Ex: Television remote control) to thousands of kilometers (Ex: Radio communication). This would indeed come at the cost of on-chip area, speed and power where a lot of research is being carried out to optimize the same . From the past few years wireless telecom technology has achieved wide popularity across the globe mainly due to high usage of cellular phones . SDR is a wireless interface tech. that provides compatibility between different communication standards so that they can be utilized into a single transceiver. Software defined radio (SDR) is an emerging research topic where the reconfiguration of transceiver architectures is reached by means of software based projects methodologies for all electronic product lower circuit complexity is always an imported design target since it reduces cost[1]

1.1 wimax

WiMAX (Worldwide Interoperability for Microwave Access) WiMAX refers to interoperable implementations of the IEEE 802.16 family of wireless-networks standards ratified by the WiMAX Forum. (Similarly, Wi-Fi refers to interoperable implementations of the IEEE 802.11 Wireless LAN standards certified by the Wi-Fi Alliance.) WiMAX Forum certification permits vendors to sell fixed or mobile products as WiMAX certified, thus ensuring a level of interoperability with other certified products, as long as they fit the same profile. The structure of DDC depends upon conversion ratio required for WIMAX systems the conversion ratio is typically 8 to 10. for this kind of low conversion factor DUC is typically constructed using FIR filters only are normally used. IEEE 802.16d can be applied in NLOS transmission with frequency between 2-11 GHz and in LOS with frequency between 10-66 GHz. Designer of WIMAX system need to meet a number of critical requirements such as processing speed, flexibility and time to market and it is these tight requirements that ultimately drive the selection of hardware platform[2].

1.2 FIR Filter

Finite impulse response (FIR) filter is a filter whose impulse response (or response to any finite length input) is of finite duration, because it settles to zero in finite time. FIR filter is always stable, realizable & provides a linear phase response under specific condition. These characteristics make FIR Filter attractive to many filter designers. It requires no feedback, the present input does not depends on previous output. The numeric error that occur when implementing fir filter in computing arithmetic occur separately with each calculation. It does not remember its past numeric error, since they have no feedback elements, so any bounded input results in bounded output. FIR filter is a stable filter as there is nil feedback and every poles are located at origin and thus they are within the unit circle. The another important aspect of FIR filter is its linear phase response where the phase response is a linear function of frequency.

To design a filter simply means to select the coefficients such that the system has specific characteristics. The required characteristics are stated in filter specifications. Most of the time filter specifications refer to the frequency response of the filter. This paper presents the windowing technique for designing of FIR Filter. A window is a finite array consisting of coefficients selected to satisfy the desirable requirements. When designing digital FIR filters using window functions it is necessary to specify:

- A window function to be used and
- The filter order according to the required specifications (selectivity and stopband attenuation).

The different window functions(Rectangular,Hamming, Hanning, Bartlett, Blackman, Kaiser) can be compared each other and the best filter specification can be obtained .fir filter 's performance can be analyzed using multirate filter, enables one to convert a digital signal of a specified sampling rate into another signal with the desired sampling rate without significantly destroying the signal components of interest.They are suited to multi-rate applications. By multi-rate, we mean either "decimation"(reducing the sampling rate), "interpolation" (increasing the sampling rate), or both.Whether decimating or interpolating, the use of FIR Filters allows some of thecalculations to be omitted, thus providing an important computational efficiency. The principle objective this paper is to determine the coefficients of the FIR Filters that met desired specifications. The determinations of coefficients involve channel equalization, system identification using LMS algorithm. This paper is to investigate the performance of an FIR filter equalizer for data transmission over a channel that causes intersymbol interference.[3]

II. Digital Down Converter

A digital down converter (DDC) gives the link between the analog RF front end and the digital baseband of a receiver. The data is demodulated from the high frequency carrier and subsequently the sampling frequency of the data stream is reduced. The data stream is then compatible with the baseband modem.The algorithm consists of 3 stages shown in Figure 1:

1. Mixer – A numerically controlled oscillator (NCO) generates two orthogonal sinusoids at the carrier frequency and these are mixed with the input stream from the analog-digital-converter (ADC).
2. Decimation – The sampling frequency of the intermediate frequency (IF) samples is reduced. Filtering is needed to guard against aliasing in the decimation process.
3. Channel Filter – Applies pulse shaping to attenuate any out of band energy in the baseband data.

Figure 1. Digital Down Converter Block DiagramThe **headings** and **subheadings**, starting with "1.

For this DDC reference design, the sampling rate parameters are given by:

IF: 91.392 MSPS

Baseband: 11.424 MSPS[1]

2.1 Design of NCO

The Numerically Controlled Oscillator has been implemented using the widely used, Look-up Table (LUT) approach. The NCO produces a cosine signal having IF frequency. The mixer, upon mixing this signal with the received input signal, produces the baseband frequency signal, which is then fed to the filter chain.[5] NCO Compiler generates numerically controlled oscillators customized for Altera devices. This particular design utilizes the oscillators quadrature carrier generators in the I-Q Mixer stage to modulate the I-Q channels onto orthogonal carriers.[6]

In DDC digital radio receivers often have fast ADC converters delivering large amounts of data; but in many cases, the signal of interest represents a small proportion of that bandwidth. A DDC permits the rest of that data to be discarded, allowing more intensive processing to be performed on the signal of interest. As an example, consider a radio signal lying in the range 39-40MHz. The signal bandwidth is 1MHz. However, it is often digitised with a sampling rate over 100MHZ, representing in the region of 200Mbyte/second.The DDC permits us to select the 39-40MHz band, and to transfer its frequency down to baseband. Once this is over, the sampling rate can be decreased – with a 1MHz bandwidth, a sampling rate of 2.5MHz would be ok - giving a data rate of only 5Mbyte/second. This is shown in Figure 1.

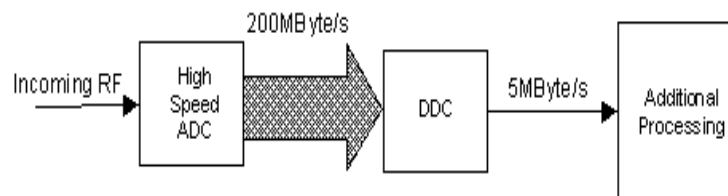


Figure 1- An Overview of the DDC Function

III. Matlab Based Design And Simulation

The magnitude response of decimator has been derived from MATLAB. It should fulfill spectral mask regulations otherwise it can lead to interference with other spectrums. The filters are designed using MATLAB filter design toolbox. Filter design and analysis tool is a powerful source for designing and analyzing filters immediately. FDA tool equipped you to design digital FIR or IIR filters by setting filters specifications by

importing filters from your MATLAB workspace. FDA tool also gives you tools for analyzing filters such as magnitude, phase response and step response . The transmit spectral mask for WIMAX is defined in IEEE802.16-200 standard. Equipment manufacturers of WIMAX are require to ensure that their system compatiable with spectral mask regulations to prevent interference with other telecommunication devices in order to have interference free communication possible. This lead to need that filter and power amplifier must be designed such that no spectral bandwidth beyond allowed channel bandwidth. Decimator can be designed using filter design tool in MATLAB and we have three stages in total for both of these. First we have single rate filter giving the pulse shaping and secondly interpolation by factor of 2 and then interpolation by factor of 4 with different low pass filters and window methods. In this we can see the comparison of window method which decreased the cost of filters and give better band limiting. The 2 decimator filter required very sharp transition so number of taps required will be large as compared to other two stages. The first filter is used to attenuate the spectral energy outside the spectral mask, this filter required the sharpest roll off and hence the maximum numbers of taps. The second filter is associated with rate change of 4 this filter attenuates the spectral images of baseband data in applies band limiting in DDC [7].

4.1 Nyquist Filter

The Nyquist frequency, named after electronic engineer Harry Nyquist, is half of the sampling rate of processing system. It is also known as the folding frequency of a sampling system, e.g. folding is depicted in where f_s is the sampling rate and $0.5 f_s$ is the corresponding Nyquist frequency. The black dot plotted at $0.6 f_s$ represents the amplitude and frequency of a sinusoidal function whose frequency is 60% of the sample-rate (f_s). The other three dots indicate the frequencies and amplitudes of three other sinusoids that would give the same set of samples as the actual sinusoid that was sampled. The symmetry about $0.5 f_s$ is known as folding.

The Nyquist frequency should not be confused with the Nyquist rate, which is the minimum sampling rate that satisfies the Nyquist sampling criterion for a given signal or family of signals. The Nyquist rate is double the maximum component frequency of the function being sampled. For example, the Nyquist rate for the sinusoid at $0.6 f_s$ is $1.2 f_s$, which implies that at the f_s rate, it is being undersampled. Thus, Nyquist rate is a property of a continuous-time signal, whereas Nyquist frequency is a property of a discrete-time system. When the function domain is time, sample rates are usually described in samples/second, and the unit of Nyquist frequency is cycles/second (hertz). When the function domain is distance, as in an image sampling system, the sample rate might be dots per inch and the corresponding Nyquist frequency would be in cycles/inch.

4.2kaiser Window

The **Kaiser window**, also known as the **Kaiser-Bessel window**, was developed by James Kaiser at Bell Laboratories. It is a one-parameter family of window functions used for digital signal processing, and is defined by the formula :

$$w[n] = \begin{cases} \frac{I_0\left(\pi\alpha\sqrt{1-\left(\frac{2n}{N-1}-1\right)^2}\right)}{I_0(\pi\alpha)}, & 0 \leq n \leq N - 1 \\ 0 & \text{otherwise,} \end{cases} \quad \text{-----(1)}$$

where:

- N is the length of the sequence.
- I_0 is the zeroth order Modified Bessel function of the first kind.
- α is an arbitrary, non-negative real number that finds the shape of the window. In the frequency domain, it finds the trade-off between main-lobe width and side lobe level, which is a central decision in window design.

When N is an odd number, the peak value of the window is $w[(N-1)/2]=1$, and when N is even, the peak values are $w[N/2-1] = w[N/2] < 1$.

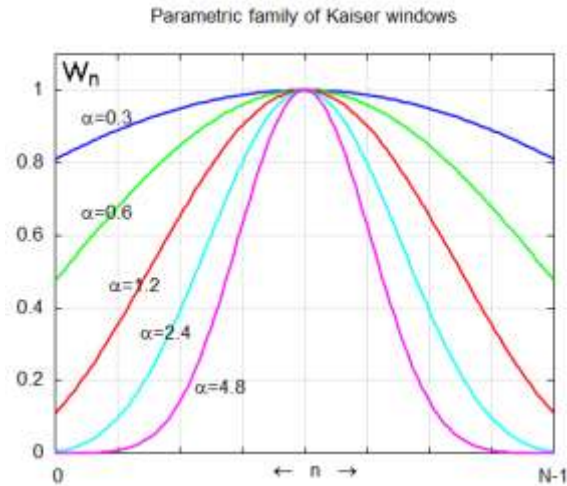


Fig 2 Kaiser window

4.3 Blackman–Harris window

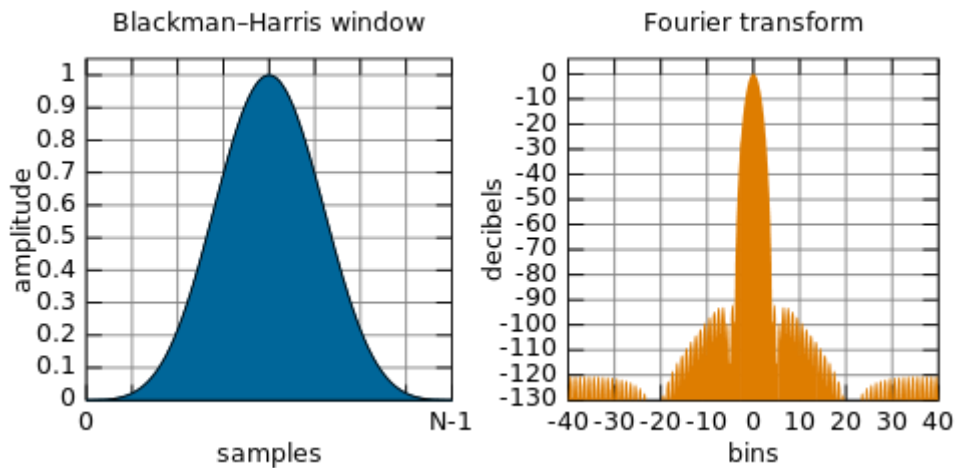


Fig 3 Blackman–Harris window; $B = 2.0044$

A generalization of the Hamming family, produced by adding more shifted sinc functions, meant to minimize side-lobe levels:

$$w(n) = a_0 - a_1 \cos\left(\frac{2\pi n}{N-1}\right) + a_2 \cos\left(\frac{4\pi n}{N-1}\right) - a_3 \cos\left(\frac{6\pi n}{N-1}\right)$$

$$a_0 = 0.35875; \quad a_1 = 0.48829; \quad a_2 = 0.14128; \quad a_3 = 0.01168 \quad \text{-----(2)}$$

IV. Filter Response And charcterics

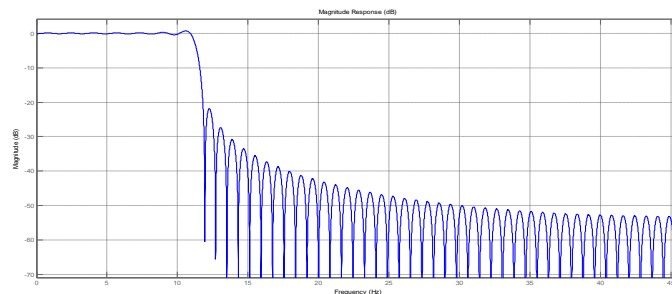


Fig 4 Magnitude response of Nquist filter decimator 2 kaiser window

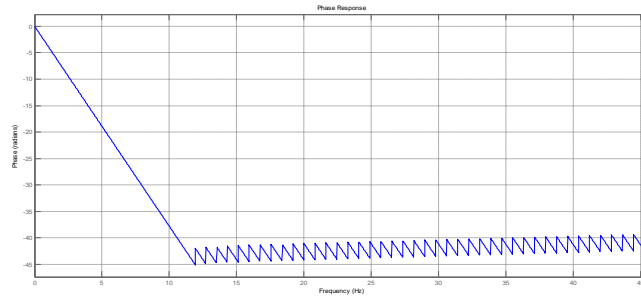


Fig 5 Phase response of Nquist filter decimator 2 kaiser window

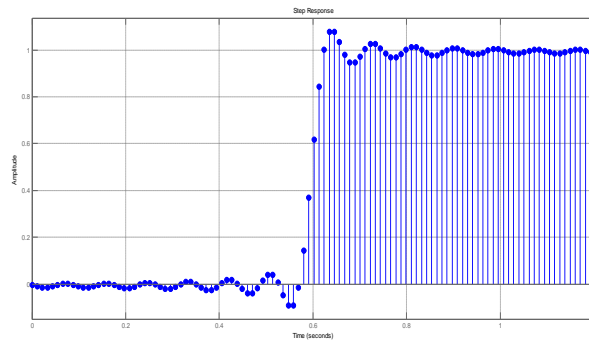


Fig 6 Step response of Nquist filter decimator 2 kaiser window

In this filter, decimator 2 is used at sampling frequency of 91.392 MHz by using Kaiser window. In this filter there is direct form FIR. The length of filter is 111 and it's in stable form . The figure shown is linear phase if yes(type1) . Now we came to the cost of filter which we analyzed in a way that the multipliers which are being used to design the filter is 85. Adder we used are 84 in this filter. States we used are 110 in this filter Multiplier and addition per input sample is 85 and 84 respectively.

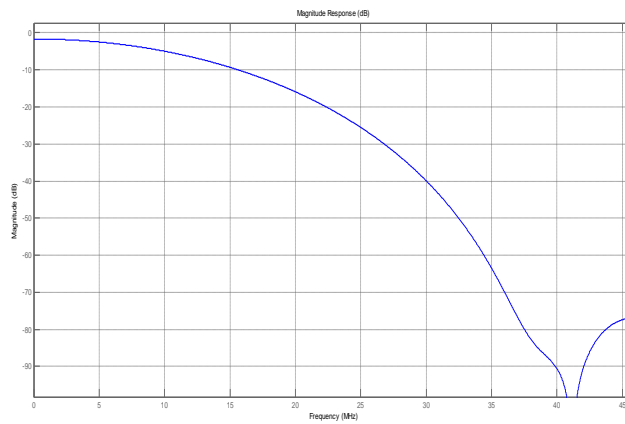


Fig 7 Magnitude response of Nquist filter decimator 2 blackman window

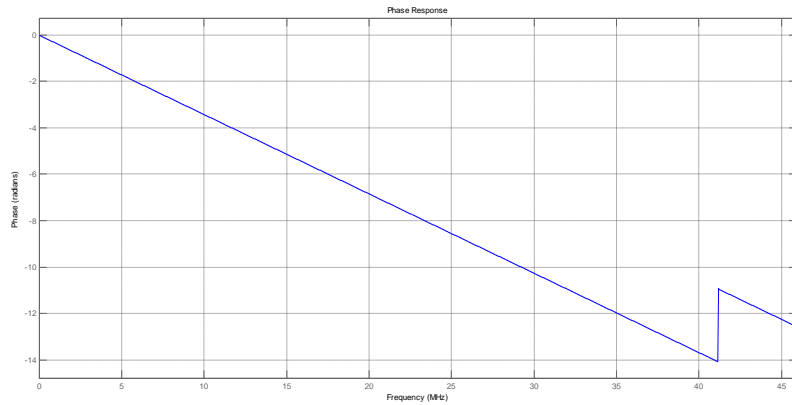


Fig 8 Phase response of Nquist filter decimator 2 blackman window

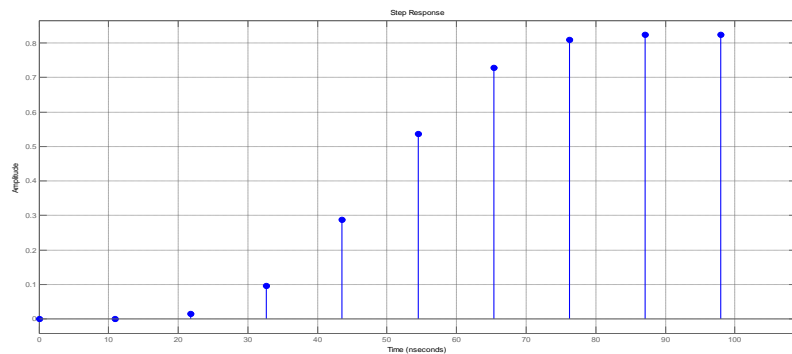


Fig 9 Step response of Nquist filter decimator 2 blackman window

In this filter, decimator 2 is used at sampling frequency of 91.392 MHz by using blackman window. In this filter there is direct form FIR. The length of filter is 11 and it's in stable form . The figure shown is linear phase if yes(type1) . Now we came to the cost of filter which we analyzed in a way that the multipliers which are being used to design the filter is 9. Adder we used are 8 in this filter. States we used are 110 in this filter Multiplier and addition per input sample is 9 and 8 respectively.

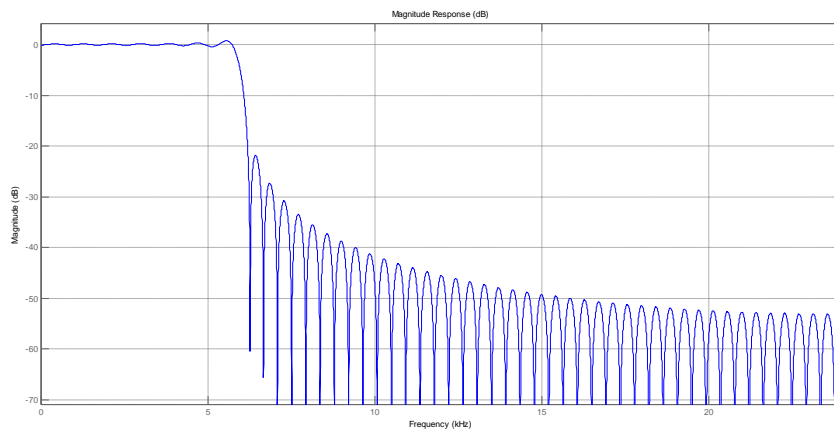


Fig 10 Magnitude response of Nquist filter decimator 4 kaiser window

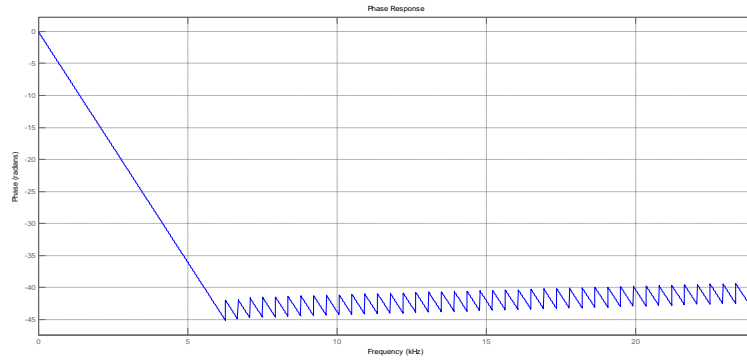


Fig 12 Phase response of Nquist filter decimator 4 kaiser window

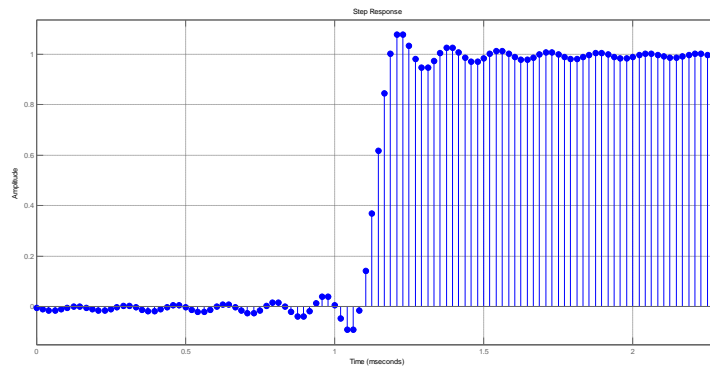


Fig 13 Step response of Nquist filter decimator 4 kaiser window

In this filter, decimator 4 is used at sampling frequency of 91.392 MHz by using kaiser window. In this filter there is direct form FIR. The length of filter is 111 and it's in stable form . The figure shown is linear phase if yes(type1) . Now we came to the cost of filter which we analyzed in a way that the multipliers which are being used to design the filter is 85. Adder we used are 84 in this filter. States we used are 110 in this filter Multiplier and addition per input sample is 21.26 and 21 respectively.

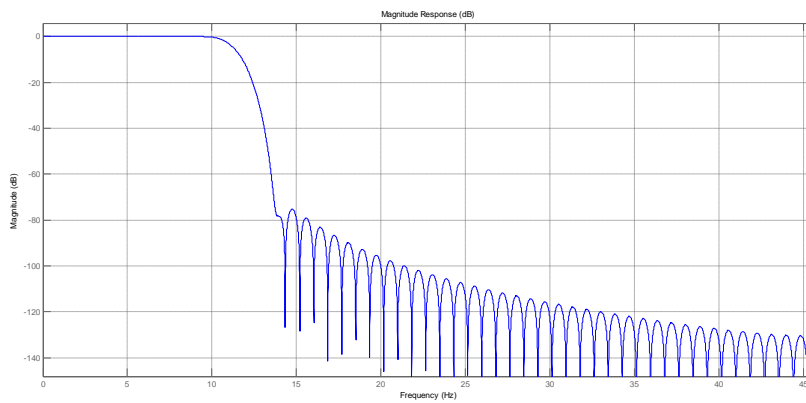


Fig 14 Magnitude response of Nquist filter decimator 4 blackman window

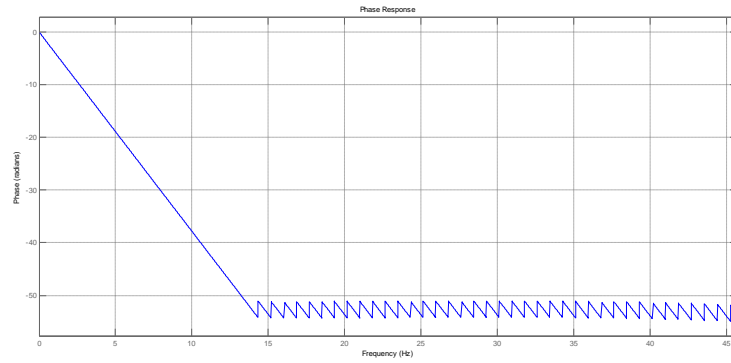


Fig 15 Phase response of Nquist filter decimator 4 blackman window

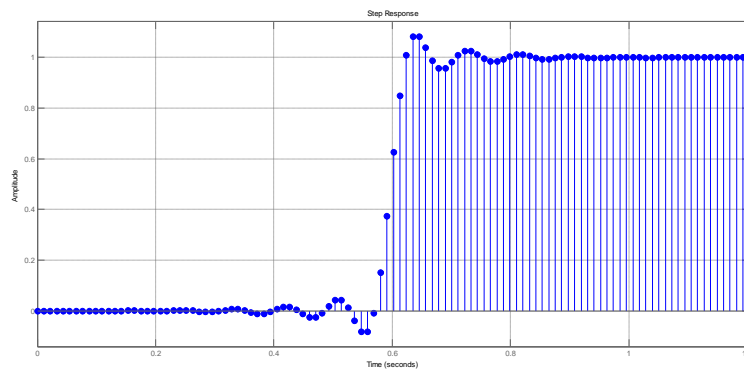


Fig 16 Step response of Nquist filter decimator 4 blackman window of frequency

In this filter, decimator 4 is used at sampling frequency of 91.392 MHz by using blackman window. In this filter there is direct form FIR. The length of filter is 111 and it's in stable form. The figureshown is linear phase if yes(type1). Now we came to the cost of filter which we analyzed in a way that the multipliers which are being used to design the filter is 85. Adder we used are 84 in this filter. States we used are 110 in this filter Multiplier and addition per input sample is 85 and 21 respectively

5.1. Performance Comparison

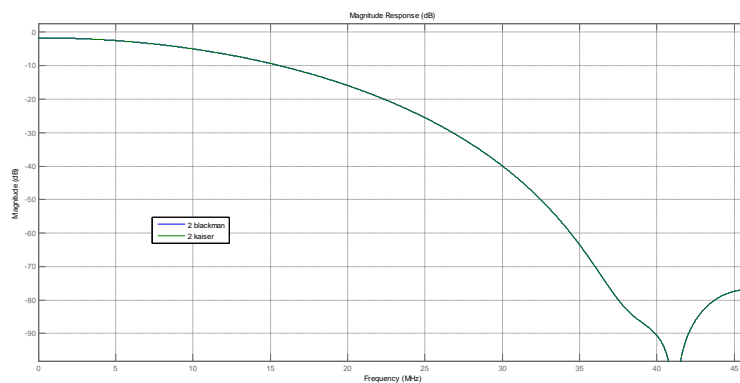


Fig 17 Comparison of Kaiser and blackman decimator 2

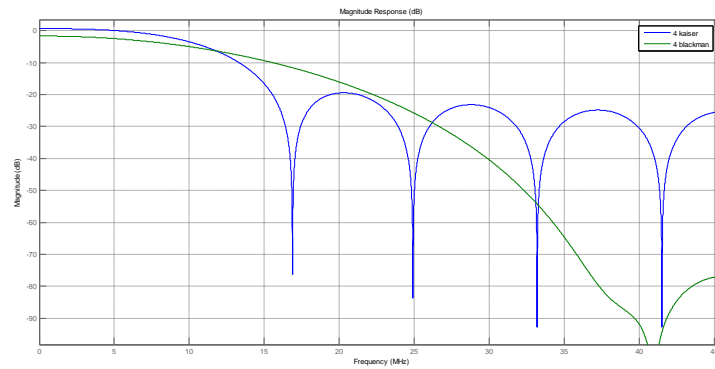


Fig 18 Comparison of 4 decimator of Kaiser and blackman window

The cost of both the filters along with resource consumption are compared and its results have are shown in Table1. Hence, the requirement of multipliers and adders are less in case of Blackman FIR Filter, for same decimator 2 and 4 with $F_s = 91.31$. Both the filters have linear phase and stability.

Description	Kaiser window 2 and 4 decimator		Blackman window 2 and 4 decimator	
multipliers	85	85	9	85
Adder	84	84	8	84
NO. States	110	108	10	110
Multiplier per input sample	85	21.26	9	85
Addition per input sample	84	21	8	84

V. Conclusion

In this paper, an analysis and comparison of 2 fractional rate converter use FIR filter and fractional rate converter use Nyquist FIR filters with decimator 2 and 4 has been presented with sampling frequency 99.31 MHz and magnitude response, phase response and impulse response have been observed. The number of adders and multipliers, Filter length are also on a comparison, hence finding the better one for optimizing area and speed simultaneously. The whole design can be implemented by using sampling frequency as 99.31 MHz. From the developed design it is clear that the kaiser window is more cost effective solution of ddc wimax communication systems.

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