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Implementation Cost Analysis of the Interpolator for the Wimax Technology

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Abstract: *The design of the multirate filter (programmable) has been proposed which can be used in digital transceivers that meets 802.16d/e (wimax) standard in the wireless communication system. Wimax is a technology emerging in the wireless communication system in order to increase the broadband wireless internet access. As there is wide spread need of the digital representation of the signal for the transmission and storage which create the challenges in DSP [1]. In this paper, analysis of the implementation cost of interpolator for the wimax technology, and cost of interpolator is analyzed on the basis of number of adders and multiplier. The Filters are designed using the FDA (filters design and analysis) tool in MATLAB.*
Keywords: *Duc, Fda, Interpolator Matlab, Sdr, Wimax*

I. Introduction

The communication system is divided into the two parts which are wired and wireless. Wireless communication system plays an important role in the life of the mankind. Due to this we can transmit the information from one place to another place without the use of physical electrical medium.

With use of wireless technology, we can transmit the data from the few meters (eg. Television remote control) to thousand of the kilometer (eg. Radio communication) [2].So, due to the huge usage of the wireless communication system, devices which are used with wireless communication system should be optimized in the cost. The wireless communication system is created from the 1G which is the beginning of the mobile after that there is 2^{nd} , 3rd ,4^{th} Generation came into the picture.4G providers some advance feature like cloud computing, IP telephony, high definition mobile TV etc. 4G are further of two types one is the LTE(Long term evaluation) and the Wimax.

Wimax is the rising innovation with significant potential that is ready to revolutionize the broadband wireless internet access market [3]. It supports the high data transmission rate. To stay aware of essential development in the interest of wireless broadband system, new advances architecture are required, which can enhance the performance of system and improve network scalability while altogether reduces the equipment cost. When a signal is transmitted over a wireless communication systems it may be affected by the Intersymbol Symbol Interference (ISI) due to which the signal get distorted[4] .To avoid this distortion we use the interpolator and the decimator which are the two alteration devices.

Interpolator and Decimator are called as a sample rate converter because, Interpolator is defined as the converter which increase the sampling frequency by the factor of 2, 4 and decimator is used to decrease the received frequency by factor like 2,4. The designing of filter which plays an important role in the digital up converter. The two widely known filters are FIR (Finite impulse) response and IIR (Infinite impulse response) filter. FIR filter provides linear phase response, stable in nature, non-recursive and consumes the less power.FIR filter are developed by the Parks McClellan. On the other hand side IIR filter consumes the lot of power, non-recursive in the nature, consumes the more power and not stable in the nature. Due to these advantages FIR filter are used in the Digital up Converter [2].

II. Wimax (IEEE802.16)

WIMAX stands for the worldwide interoperability for the microwave access is technically also called the IEEE802.16.Wimax is a fourth generation technology and it is basically designed for creating the metropolitan area network (MANs). A Broadband wireless Access (BWA) technique which provides fast broadband connection by allows the user, to browse the internet on a laptop without physically connecting to the router. Wimax specifications are 802.16a, 802.16b, 802.16c and 802.16d/e. The difference between 802.16d/e is that 802.16d 2-11 GHZ is fixes wireless access system air standard and the 802.16e is fixed and mobile broadband wireless access system air standard. 802.16d/e enable high speed signal handoffs which is necessary for the communication with the users. Wimax has the frequency range of the 2-11 GHZ , range is approximately up to the 31 miles, data transfer rate 70 mbps and user are connected at a time more than 1000. Wimax system

includes a wimax tower, wimax client terminal. A single wimax tower can provides coverage to a very large area approximately equals to 8000 square kilometers.

For the wimax system the conversion ratio typically varied from 8 to10.So to achieve this conversion ratio we made digital up converter (DUC) by using the FIR filter. But if we want to achieve the higher conversion ratio then we have to use the cascaded integrator comb (CIC) filter is used in the DUC structure.

Wimax can be used with the LOS (line of sight) with a frequency of 10-66GHZ and NLOS (non line of sight) with a frequency of 2-11 GHZ. During the designing of the wimax system designer have to need the number of requirements such as processing speed, flexibility and cost also [4, 5].

III. The Digital Up Converter

Digital up converter is act as the important component in the wireless base station design. It performs the frequency translation necessary to convert the low sampling rate to the high sampling rate which becomes the input to the digital to analog converter. Digital up converter basically defined as the sample rate converter which is used in the transmitter for increase the sampling frequency of the input signal, modulate the signal and the filtering of signal. It is widely used as in a communication system for converting the sampling rate of signals. When a signal is converted from the intermediate frequency band to baseband then also DUC are used. These are mainly used in frequency shift mixer. It translates the baseband signal to high frequency rate.

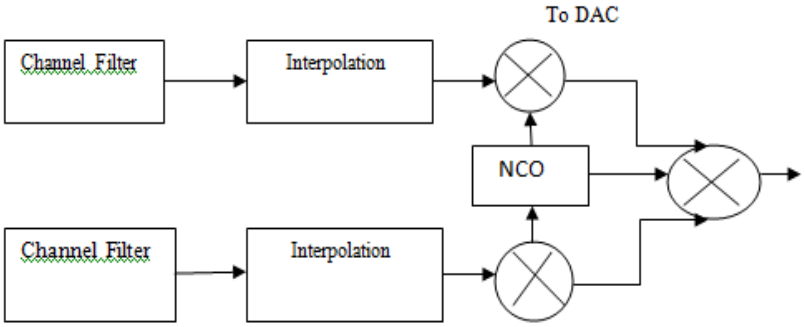

Figure1. Block Diagram of DUC

Digital up converter consist mainly the two parts which are interpolator and single rate FIR filter. As the single rate FIR filter is provided by the pulse shaping. Interpolator conversion ratio is the 8 for wimax which is further divided into the two stages as L=2 and L=4 making the total is equal to 8.The baseband signal has sampling rate of 11.424 Msps and signal has to up sample by 91.392 Msps. We can also use three stages when L=2 taken three times. Simply a single stage DUC can be made of L=8 value if we use CIC filter. By the use of CIC filter the number of stages will be decreased but hardware complexity also increased. So if the hardware complexity is to be reduced then we have to use the number of stages is 3.First is the FIR single rate filter which provides the pulse shaping which takes care that spectral mask should not be violated. After that the second stage is the FIR filter with the interpolation factor of 2.Then third stage which gives the FIR filter with the interpolation factor of 4 which makes the total conversion factor is equal to 8 which is our requirement.

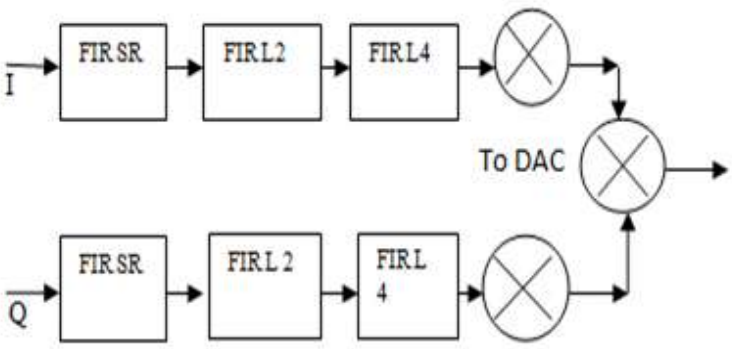

Figure2. Block Diagram of DUC with three stages

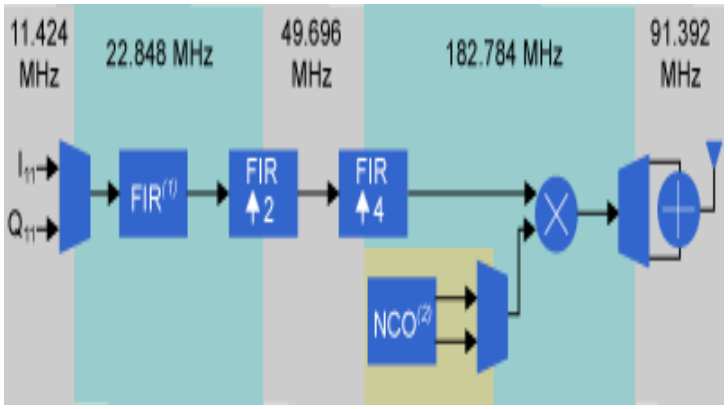

Figure3. Time division multiplexing DUC

If the interpolating factor is too large then it is divided into three or more number of stages and use of the CIC filter with the n1, n2, n3 and which should be satisfy the overall factor. NCO is the numerically controlled oscillator which is mainly used with the digital to analog converter at the output to create the direct digital synthesizers. The NCO produces a cosine signal having IF frequency.NCO is the numerically controlled oscillator which is mainly used with the digital to analog converter at the output to create the direct digital synthesizers. The NCO produces a cosine signal having IF frequency.

IV. Interpolator

Interpolator is up sampling the given signal by a factor of L where L is defined as positive integer which gives an output sequence which is L times larger than than given input sequence.Up sampling is implemented by inserting the L-1equidistant zero valued samples between the two consecutive samples in between the original signal of the x[n].

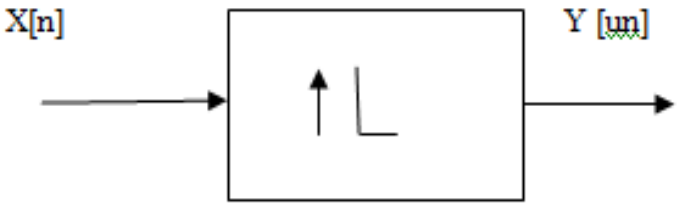

Figure4. Basic Interpolator

If the L=2 and L-1=1 means that zero valued samples will be insert in between the original signals. The zero valued samples inserted by the up sampler are interpolated using some type of filtering process in order that the new higher rate sequence has no unnecessary spectral component. This process called interpolation [6].

$$x_u[n] = \begin{cases} X[n/L], & n=0, +-L, +-2L \ldots \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

The Interpolation filter is mainly used to raise the sampling frequency to oversampling rate and to suppress the spectral replica centered at f_s, $2f_s$ …….. (Oversampling rate -1) f_s. Due to high sampling rate, the pass band and transition band are extremely narrow compared to nyquist bandwidth of the output signal. A multirate structure is generally preferred to reduce the computation complexity [7]. By using the different sampling rate software defined ratio flexibility are improved which helps in different type of application of Digital Signal Processing and it reduces the expensive anti aliasing filter [8].

V. Matlab Based Design And Simulation

The magnitude and the phase response of the interpolator have been derived from MATLAB. The filters are designed using the MATLAB filter design toolbox. Filter design and analysis is a powerful tool for designing and analyzing filter quickly.FDA tool provides the way by which we can design the FIR and IIR filter by setting the filter specification. By the help of these FDA tool we can analyzed the filter in magnitude response, phase response and pole zero plots. The interpolator and Decimator are both can be designed by using the filter design tool in MATLAB and we have three stages in total for both these. In three stages, Single rate is first which required very sharp transition so number taps required large as compared to other stages. Single rate filter are used for providing pulse shaping .After that two interpolator are used of a factor 2, 4. The first filter requires the maximum number of taps because it requires sharpest roll off for attenuating the spectral energy outside the spectral mask. Other two interpolator further attenuates the spectral images and the band limiting associated with a rate change of stage 2 and 4. From the magnitude and phase response it is observed that when L= 2, 4 the ripples starts in magnitude responses from 6 and 25 MHZ respectively. In overall cascaded response of the magnitude, ripples start from the 5 MHZ.

The magnitude response should satisfy the spectral mask otherwise it creates the interference. The spectral mask which is transmitted for the wimax is defined for the Wimax (IEEE802.16).The equipments which are designed for the wimax must satisfy the spectral mask regulation to avoid the Intersymbol interference with other telecommunication device so that we get interference free signal.FIR filter are mainly used to perform the filtering operation in DUC system. This can be done separately or by combining the responses of a filter implemented by a single filter. The main function is implemented by FIR filters are image rejection for the interpolator, anti-aliasing for the decimation spectral shaping for the transmitted data and channel selection for the received data [9].

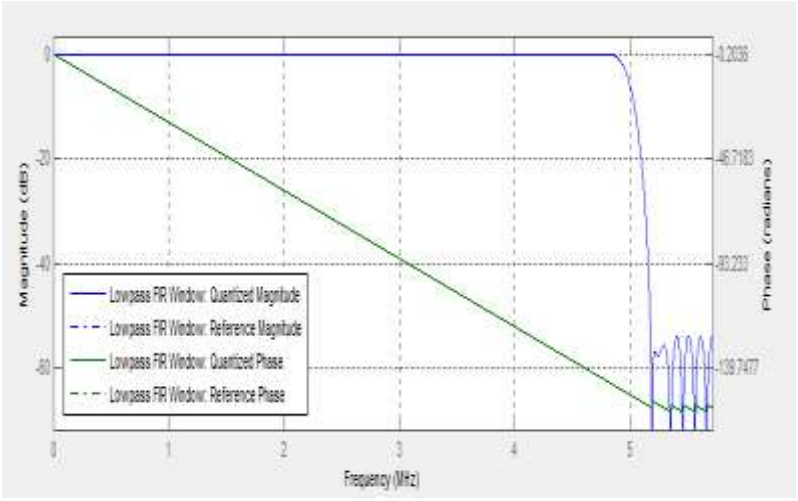

Figure5. Magnitude and Phase Response of a Single Rate Filter

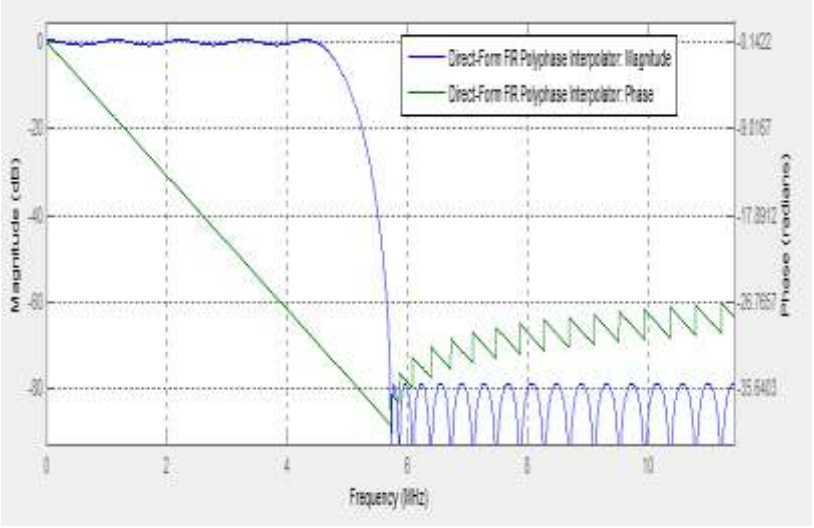

Figure6. Second Stage Responses

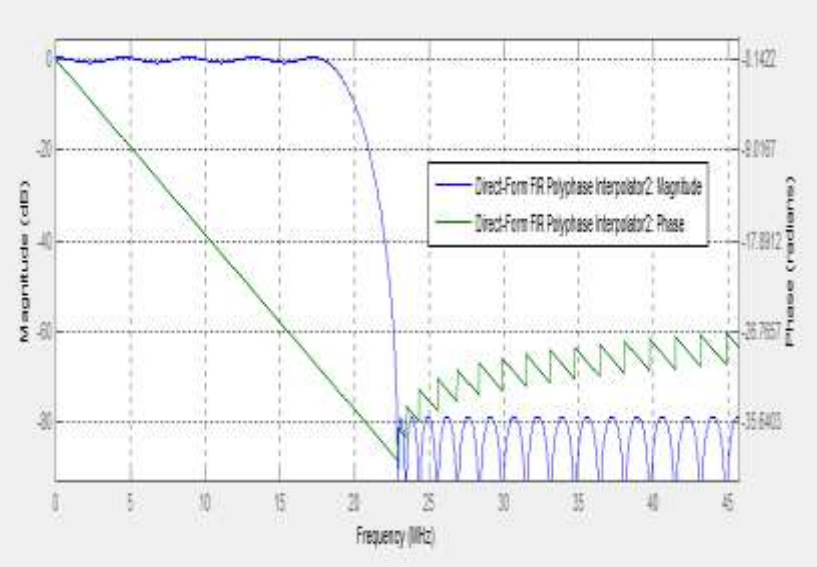

Figure6. Third Stage Response

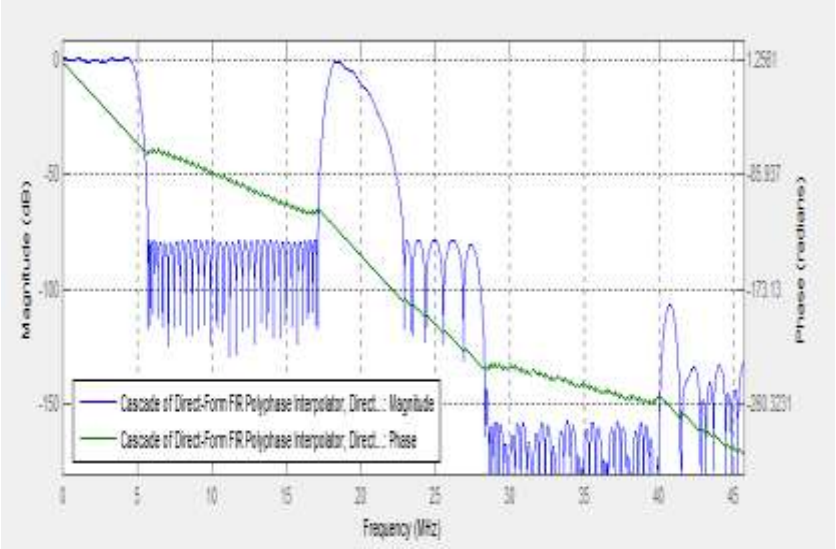

Figure7. Over all Cascaded Magnitude and Phase Response

Interpolator	No. of multiplier	Adders	No. of states	Multiplier per I/P sample	Adder per I/P sample
FIR	111	110	110	111	110
L=2	51	49	25	51	49
L=4	51	47	12	51	47
cascaded	213	206	147	1041	1023

Table1.Implementation cost analysis for different interpolator factor

VI. Conclusion

In this paper we analyzed the interpolator cost which is the part of DUC for wimax technology. The filters are designed using the MATLAB filter design toolbox. All the figures above represents the different types of responses for single rate filter, for the interpolator factor L=2, for interpolator factor L =4 and overall cascaded response. When the interpolator factor (L) =2 is increased to the L=4, numbers of adders are decreased and the numbers of the multipliers are remains same. In the overall cascaded the numbers of adders and multipliers are increased and they are the sum of the adders and multipliers used for the 2, 4 factor.

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