

Decimation Filter Design for Multistandard Wireless Communication

Pooja R. Bande, S. D. Bansod

Abstract— In this work, we propose a decimator filter able to deal with GSM, WCDMA, WLAN 802.11(a/b/g) and WiMAX. By taking into account the operating frequency, bandwidth and intermodulation effects, an appropriate input sampling frequency is selected. Meanwhile, with the parameters of blocking and interference profile, Passband limits and Passband ripple, for all this radio communication standard, we are designing decimation filter design tool in Matlab using “GUIDE” environment for visual analysis. so, user can select required wireless standard among this standard and obtain corresponding multistage decimation filter design and analysis. Through the analysis of the frequency responses we can see how the filter selects signal channels for multimode communication. The decimation filter design toolbox helps the user or design engineer to perform a quick design and analysis of decimation filter for multiple standards without doing extensive calculation.

Keywords—Decimation filter, MATLAB toolbox, Multistandard Receiver, Sigma-delta A/D converter

I. INTRODUCTION

Software defined radio (sdr) is a Multi-standard radio terminal capable of operating according to variety of different mobile communication standards. Software Defined Radio (SDR) system is a radio communication system which can Tune to any frequency band and receive any modulation across a large frequency spectrum by means of a programmable hardware which is controlled by software.

An ideal software radio does not have any analog stages for signal processing, except antenna, power amplifier and microphone or loudspeaker. In this case, the analog signals in the receiver are converted to digital virtually right next to the antenna. These signals can then be handled by the necessary processor. A goal in software defined radio is to push the digitalization point as close as possible to the antenna. Several papers are available in literature that deals with the design issues of decimation filters for wireless Communication Receivers.

A fifth order comb decimation filter with programmable decimation ratios and sampling rates for GSM (Global System for Mobile communications) and DECT (Digital Enhanced Cordless Telecommunication) standards are presented in [1].

Manuscript received May 15, 2013. (Fill the Details)

Ms. Pooja R. Bande, Electronics & Tele-Communication, Department, G. H. R.C.E. & M. Amravati University, Amravati, India

Prof. Suprit D. Bansod, Electronics & Tele-Communication, Department, G. H. R. C. E. & M. Amravati University, Amravati, India

Multiplier –free cascaded Integrator Comb Filter that can handle large sampling rate conversion are presented in [2]. sampling Rate conversion for software defined radio is presented in [3]. A decimation filter structure based on cascaded integrator comb (CIC) filters and polynomial interpolation filters to perform fraction sample rate conversion is presented in [4]. Low complexity decimation filter architecture is presented in [5] by using infinite impulse response (IIR) filters implemented by all-pass sum that avoids multiplications. A low-power high linearity variable gain amplifier (VGA) embedded in a multi-standard receiver that meets the standard requirements is reported in [6].

In this paper, a decimation filter design toolbox is developed in MATLAB GUIDE (Graphical User Interface Development Environment) addressing the design issues Presented in the above papers. In This paper, Decimation Filter is designed for six wireless standards including GSM, WCDMA, WLANa, WLANb, WLANg and WiMAX etc using GUIDE (Graphical user interface development environment)in Matlab for visual analysis. Decimation is done in two or three stages to reduce the hardware Complexity and power dissipation. Each stage is implemented with optimized filters so that the overall cascaded filter response meets the specification for a particular standard. Section II describes Receiver architecture. Section III presents a multistage decimation filter structure. Section IV includes the GUI (graphical user interface) and its features. Section V provides the decimation filter implementation results for multiple standards. Section VI concludes the paper.

II. RECEIVER ARCHITECTURE

The need for global roaming and high-speed wireless data transfer are increasing the telecommunications companies’ interest for a multi-standard hand set. The increasing demand for wireless communication other than voice, such as mobile TV, internet connection,

The simplest multi-standard terminal is realized by means of several transceivers, one for each standard, operating separately. However the high cost, high power consumption and large area do not meet the demands for modern integrated techniques. To overcome these problems appropriately, selection of the receiver architecture is quite important. A two-stage down-conversion superheterodyne receiver is shown in figure 2-1. It is also called dual-IF type which is mostly used in today’s RF receivers. In this system, the signal is translated to a low frequency band by two stages of down-conversion mixing. The RF front-end filter serves to remove out of band

energy and perform rejection of image-band signals. The noise or image-rejection filter (IRF), which follows the low noise amplifier (LNA), further attenuates the undesired signals present at the image frequencies. The two IF Band pass filters, typically combined receiver architecture that uses less comp-

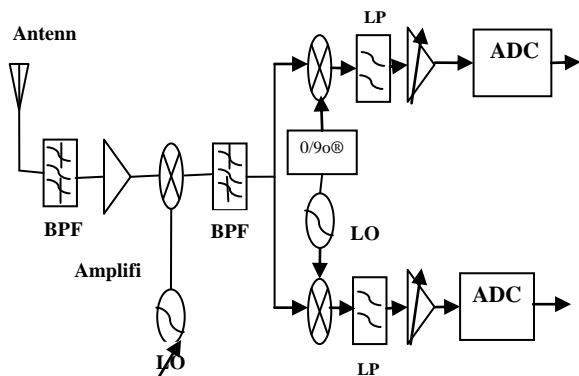


Figure 2-1: Superheterodyne receiver with second IF is zero

ADC

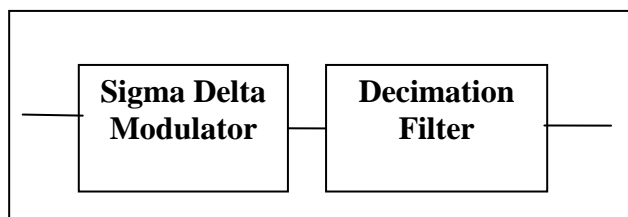


Figure 2-2: Sigma Delta Analog to Digital Converter

Onent receive signal path is homodyne receivers, or direct conversion receivers. In this receiver, no IF stage exists in the Whole receive path. Although the direct down conversion receiver has higher levels of integration than the superheterodyne system due to the reduction of discrete components, it suffers from the problems of LO leakage and DC offset. Because the local oscillator (LO) is at the same frequency as the RF carrier, the LO may leakage to either the mixer or to the signal input port of the low noise amplifier (LNA) due to improper isolation. The unintentionally transmitted LO signal may reflect off of nearby objects and ‘re-received’, then self-mixing with the local oscillator generating a dc offset at the output of the mixer. OSR can be selected as 128 for low data rate application, such as GSM receiver, due to a much smaller signal bandwidth. IF receivers down convert the RF signal to an intermediate frequency by the local oscillator. There are two types of IF receivers, Low-IF receivers where the IF could be either one or two times the information bandwidth and Wideband IF receivers in which the IF can be selected arbitrarily depending on the system requirements and communication demands. IF-receivers combine the advantages of both superheterodyne and homodyne receivers.

III. MULTISTAGE DECIMATION FILTER

The sampling rate is downconverted from the over sampled rate of sigma-delta modulator to a data rate that can be conveniently processed by existing DSP processors. This minimizes the power consumption of DSP processors for demodulation and equalization. The purpose of decimation filter is to remove all the out-of-band signals and noise, and to reduce the sampling rate from oversampled frequency of the sigma-delta modulator to Nyquist rate of the channel.

A. Filter structure and design

1) Cascaded integrated comb (CIC) filter

Hogenaur devised a flexible, multiplier free cascaded integrated comb (CIC) filter that can handle large sampling rate changes suitable for hardware implementation. The basic structure of hogenaur CIC filter is shown in figure 3.1.

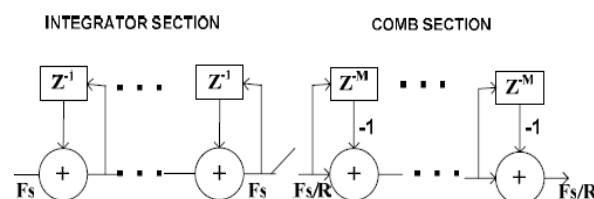


Fig.3.1 CIC Filter

This consists of integrator and comb filter as two basic building blocks. So it is an infinite impulse response (IIR) filter followed by a finite impulse response (FIR) filter.

2) Half band filter

Half band filters are a special class of symmetric FIR filters used in second stage of multistage decimators.

Half band filters are characterized by equal pass band and Stop band ripples ($\delta_p = \delta_s$).

3) FIR filter

The third type of filter used in multistage decimeter is FIR filter. The CIC filter response exhibits a droop in the pass band which progressively attenuates the signals. The pass band droop and stop band attenuation increases as the number of section of CIC filter increases. The FIR filter used in the last stage performs decimation and CIC droop compensation.

IV. PASSBAND AND RIPPLE

Passband and Passband ripple are another two elements to consider when we are designing filters. In this work, we see 80% of the bandwidth as the Passband. For GSM and WLAN, we can find the values of Passband ripples in practice; however we remark them to remind that they are our assumptions in WCDMA and WiMAX.

Table 4.1: Passband and ripple

Standard	GSM	WCDMA	WLANa	WLANb	WLANg	WiMAX
Passband (MHZ)	0.08	2	8	10	10	8
Passband Ripple (dB)	0.1	0.5*	0.5	0.5	0.5	0.5*

V. GUI FOR MULTI-STANDARD DECIMATION FILTER DESIGN TOOLBOX

The proposed ‘Multistandard decimation filter design toolbox’ is designed using signal processing toolbox and filter design toolbox from MATLAB using GUIDE environment. The can select a required wireless communication standard and obtain the corresponding multistage decimation filter implementation using this toolbox. The toolbox will help the user or design engineer to perform a quick design and analysis of a decimation filter for multiple standards without doing extensive calculation of the underlying methods.

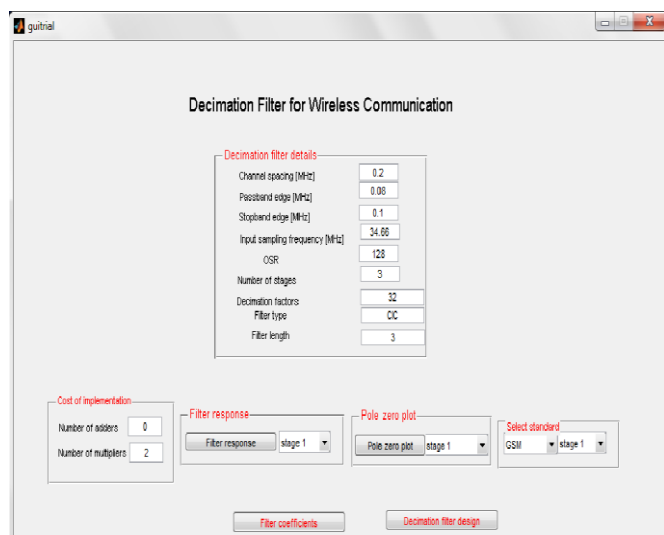


Figure 5-1: Decimation Filter Design Toolbox

A. Multi-stage Decimation Filter Design

The toolbox is designed for six popular wireless communication standards, namely GSM, WCDMA, WLANa, WLANb, WLANg and WiMAX. Initially, the desired standard is selected from the pop-up menu as in Fig. 5.2 and the filter design is obtained by pressing the push button named Multistandard Decimation Filter Design. The filter details such as the required channel spacing for a selected standard, Passband edge, stop band edge, input sampling frequency, OSR, number of stages and type of filter used in each stage, decimation factors for each stage, and filter complexity are displayed on the GUI as in Fig. 5.3



Fig 5-2: POP-UP Menu

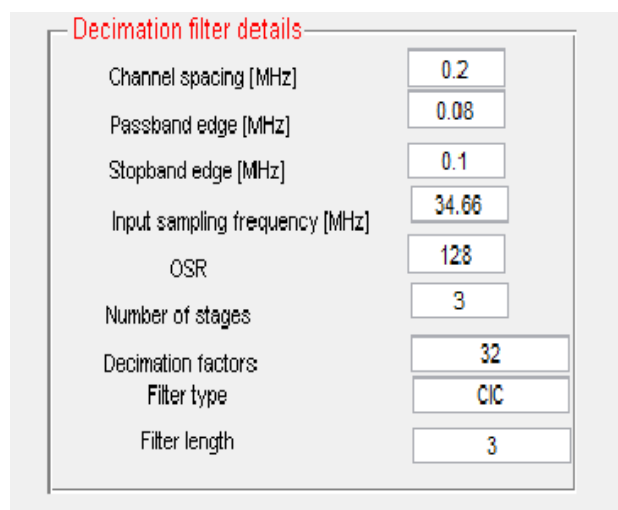


Fig 5-3: Decimation Filter Specification

B. Cost of implementation

The cost of implementation of multistage decimator is in terms of total number of adders and multipliers required for all stages.

C. Filter Co-efficient

The filter coefficients can be visualized by pressing the push button named Filter coefficient. Then a message box will pop up and it displays the filter coefficients for each stage. For GSM (current display), the message box displays the number of sections of the CIC filter as ‘3 integrators and 3 combs’, 11 halfband filter coefficients and 101 droop compensation FIR filter coefficients.

D. filter response

The push button named Filter response is used to display the magnitude response. The desired response such as the magnitude response for individual filter stages, cascaded responses after each stage or the multistage overall response can be selected from the pop-up menu as in Fig. 5.1. The cascaded filter response and the overall response of the multistage decimator are displayed using filter visualization tool (FVTool) in MATLAB as in Fig. 13. The magnitude response of individual filter is displayed on the graphical window, called axes, embedded on the front panel of the GUI

E. pole-zero plots

To get the pole-zero plot of individual filter, each stage can be selected from a pop-up menu as in Fig. 5.1. The push button named Pole-Zero Plot is used to display the corresponding plot on the front panel graphical window of the GUI. The multiplicity number of each pole and zero are indicated in the plot. The filter is stable when the poles lie inside the unit circle in z-plane. FIR filters are stable by design since the transfer functions do not have denominator polynomials, and thus no feedback to cause instability. CIC filters are stable even with the presence of integrators, as the poles on unit circle due to the denominator of transfer function are cancelled by equal number of zeros at the same position produced by the numerator.

VI. RESULT

A. WLANa, WLANb, WLANg, WiMAX

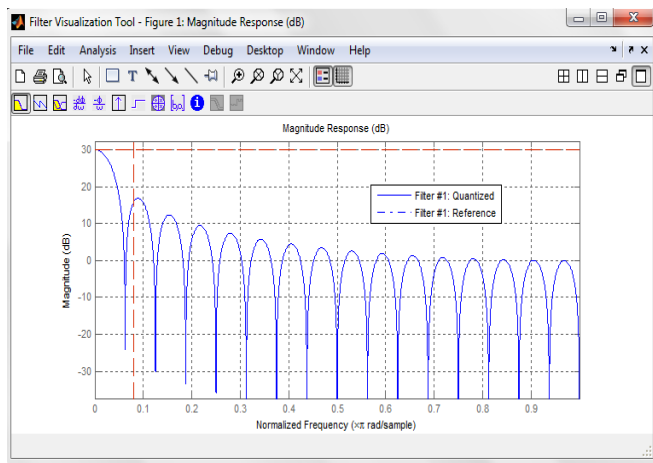


Fig.6-1: Magnitude response of CIC filter for GSM

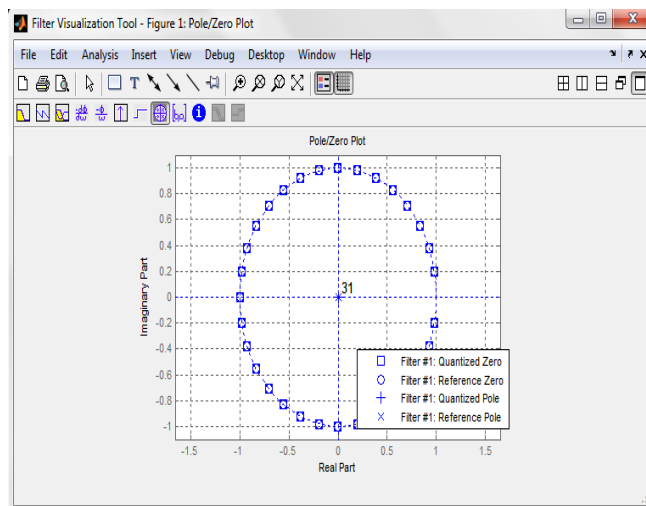


Figure 6-2: Pole-zero plot of CIC filter

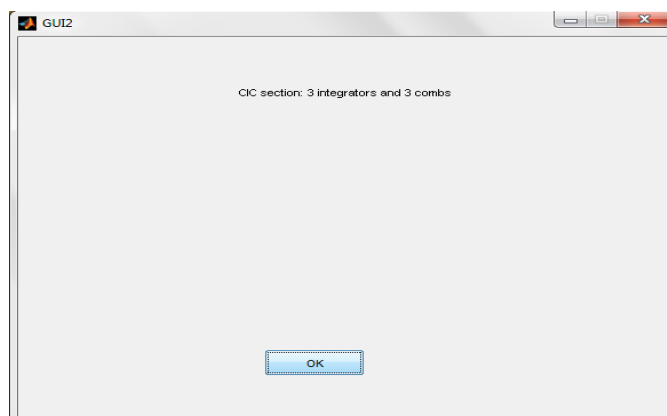


Figure 6-3: Filter coefficient of CIC filter

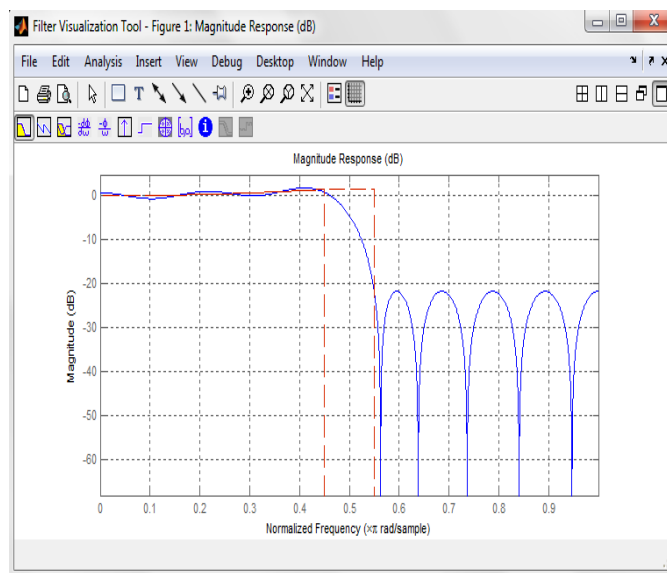


Figure 6-4. Filter response of CIC compensation FIR filter

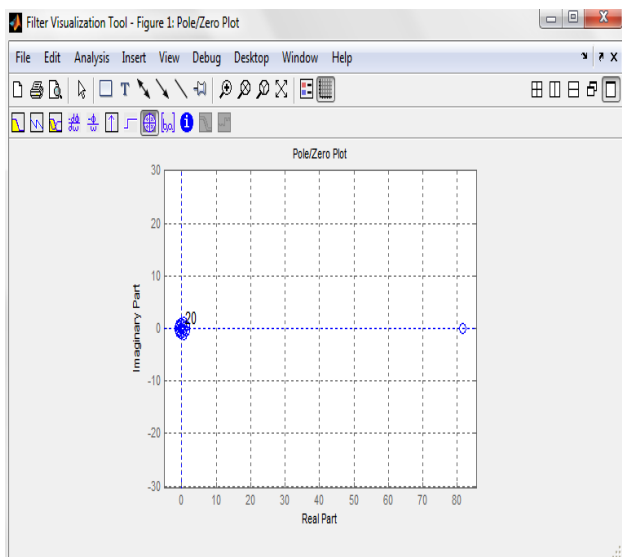


Figure 6-5 Pole zero plot of CIC compensation FIR filter

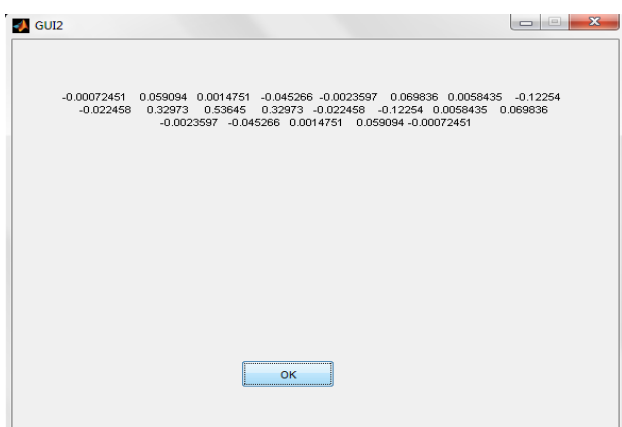


Fig 6-6: Filter coefficient of CIC compensation FIR filter

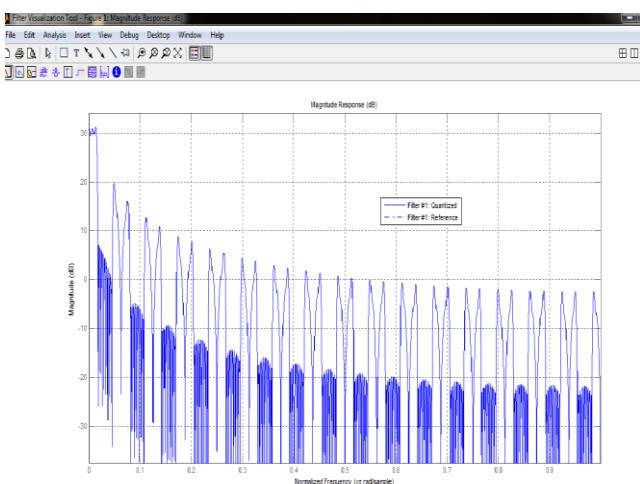


Fig 6-7: Cascaded response of Decimation Filter

VII. FUTURE WORK

We see from filter design results, compensation FIR filter that cost lots of area and power us are going to explore the possibility to replace those IIR filters which inherently have simple architectures due to the feedback. Especially for those having relaxing requirements on the linearity, IIR filter

becomes more economical. In addition, the presented work has been validated in system level. It is very interesting to implement in the future. Furthermore, the control and switching circuits are going to be done as well.

REFERENCES

1. Comb-Based Decimator for SDR Applications” Gordana Jovanovic Dolecek Institute INAOE, Department of Electronics, Puebla, Mexico.
2. CIC Filter Introduction” Matthew Donadio, IEEE Int. conf. 2000.
3. Sample Rate Conversion Technology in Software Defined Radio”, T. Wang and Cheng Li, IEEE Int. conf. May 2006.
4. Multistandard Digital Channel Selection Using Decimation Filtering for ADC Modulator” Chiheb REBAI, Salma BOURBIA, Nejmeddine JOUIDA IEEE Int. conf 2008.
5. Richard schreier and William Martin Snelgrove “Decimation for Band pass sigmadeltaanalogtodigitalconversion”IEEE2002.

AUTHORS PROFILE

Ms.Pooja R.Bande received her Bachelor’s Degree in Electronics and Communication Engineering from M.I.E.T College Gondia, R.T.M Nagpur University, Nagpur, India in 2009 and Pursuing Masters Degree in Electronics & Telecommunication from G.H.R.C.E&M , Amravati University, Amravati, India in 2013. She was a Lecturer in P.I.E.T College of Engineering, Nagpur University in 2010-11.

Prof. S. D. Bansod is a Lecturer in G.H.R.C.E & M, Amravati. He received his Bachelor’s degree in Electronics and Telecommunication from P.R.M.I.T & R, Badnera-Amravati in 2009. He received his Post Graduate Degree in Electronics from S.G.G.S.I.E & T, Nanded, S.R.T.M. Nanded University in 2012. He has presented a research paper in ICVGIP2012, titled ‘Detection and Removal of Ground Shadows