Design and Optimization of Programmable Band Pass Filter for Wireless Applications

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Abstract-This paper presents the design and optimization of minimum order programmable bandpass filter for wireless applications. The designed filter covers a wide range of 10 MHz – 40 MHz which covers multiple wireless standards from TETRA, IS-95, GSM to TACS.The responses of the designed filter for various bandwidths are discussed and compared at varying bandwidths.A test bed is then developed to optimize the designed filter.

Keywords-*Attenuation,digital filters,equiripple bandpass filter,sampling frequency,transition frequency*

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I. INTRODUCTION

Digital filters are an essential elements of transceivers especially with the coming in of software defined radios and cognitive radios where the digital circuitry of the radio needs to configure the filters on the fly. Wei-Kang et al have designed an optimal pulse-shaping filter design for multilevel QAM/QPR digital radio systems resulting into minimum adjacent channel interference and AWGN channel BER [1].Parent et al have designed a low power and high speed 10 GHz sampling rate digital FIR filters with powers-of-two coefficients and the designed filter has applications in wireless communication in digital radio transmitter[2].Clarkson et al have worked on programmable digital FIR filter design for spread-spectrum receivers with reduced inherent latency [3]. Parikh et al have Optimized design of cascaded digital filters in wideband wireless transmitters using genetic algorithms. The proposed technique was demonstrated for digital WiMAX and WCDMA transmitters, for which near-optimal solutions appeared to have been achieved in a relatively short time compared to the traditional manual design techniques[4].Clarkson et al have reviewed digital filter design for frequency-hopping receivers. Even high-order filters may be designed using this technique [5].Presently most of the work done has been either in the area of simulation using matlab or development of algorithms using Xilinx and other FPGA workstations. There is a need to bridge the gap between these two design methodologies.

II. METHODOLOGY

MATLAB is used to design digital filters for noise cancellation for wireless applications. In this paper an equiripple programmable band select filter is proposed which covers an entire range of 10Mhz-40Mhz and it can be increased beyond this range also.Modelsim is used and iterations are performed to optimize the designed real time digital filter.

III. DESIGN CALCULATIONS

An equiripple filter is the one whose amplitude response oscillates uniformly between the tolerance bounds of each band.It has the smallest maximum deviation from the ideal filter when compared to all other linear-phase FIR filters of the same order.An equiripple filter has following equation:

$$\text{Max } \varepsilon(j2\pi f) = f\epsilon[-0.5, 0.5] \left| Q\{j2\pi f\} [H_d ((j2\pi f)-H\{e^{j2\pi f}\}] \right| \quad (1)$$

$H\{e^{j2\pi f}\}$is the best approximation frequency response
$H_d ((j2\pi f)$ is the ideal frequency response
$Q\{j2\pi f\}$ is the weighting function
$\varepsilon(j2\pi f)$ is the Equiripple factor

IV. RESULTS

An equiripple programmable band pass filter is designed in MATLAB whose results are discussed here.The Input and filtered output for 10 MHz and 40 MHz bandwidth digital filter are shown in Fig. 1-2.The magnitude and phase responses are further shown in Fig. 3-4.The pole zero plots are shown in Fig. 5-6.The responses in between this range can be obtained in similar ways. A test bed is created for optimization of real time digital filter. After this iterations are performed to optimize the real time digital filter for noise cancellation.The results are shown in Fig. 7-8.

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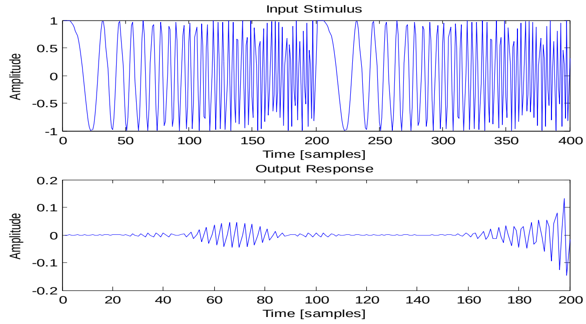

Fig. 1

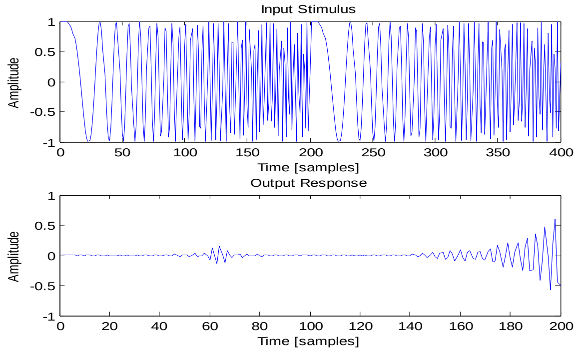

Fig. 2

Figure 1-2 Input and output response of proposed filter (10MHz and 40MHz)

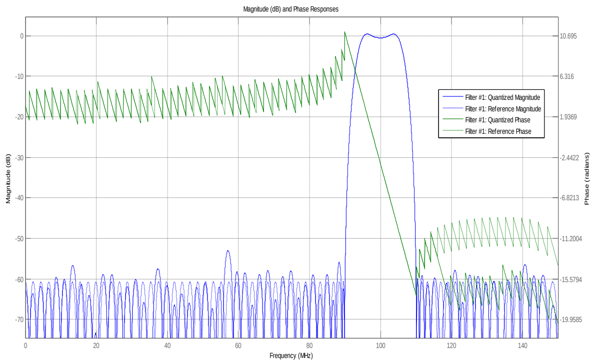

Fig. 3

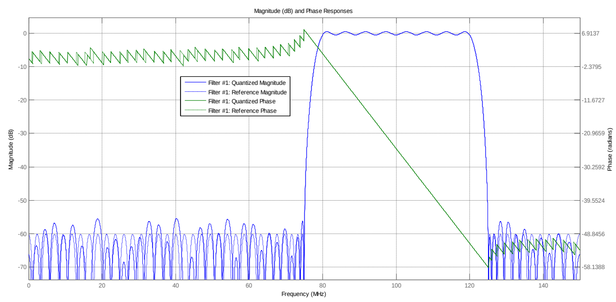

Fig. 4

Figure 3-4 Magnitude and phase response of proposed filter (10 MHz and 40 MHz)

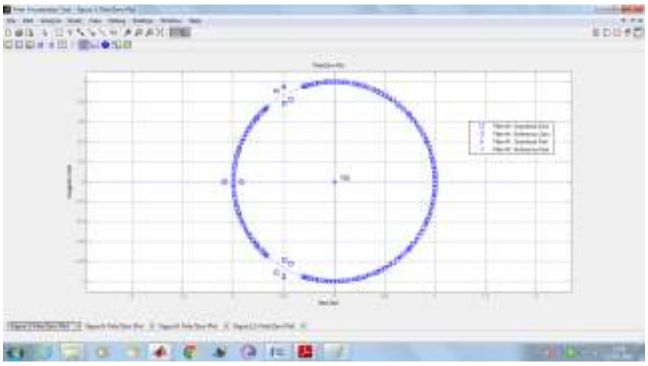

Fig. 5

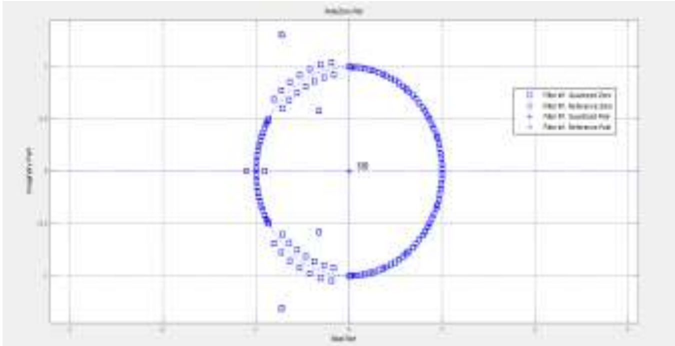

Fig. 6

Figure 5-6 Pole Zero plot of proposed filter (10 MHz and 40 MHz)

Fig. 7

Fig. 8

Figure 7-8 Modelsim results of proposed filter (10 MHz and 40 MHz)

TABLE I
PERFORMANCE COMPARISON OF PROPOSED FILTER AT VARYING BANDWIDTHS

Parameter name	For 10 MHz Bandwidth	For 20 MHz Bandwidth	For 30 MHz Bandwidth	For 40 MHz Bandwidth
Passband Frequency	95MHz-105MHz	90MHz-110MHz	85MHz-115MHz	80MHz-120MHz
Lower Stopband edge Frequency	90 MHz	85MHz	80 MHz	75 MHz
Upper Stopband edge Frequency	110 MHz	115MHz	120 MHz	125 MHz
Filter length	136	132	130	127
Group Delay(in samples)	67.5	66.5	64.5	63
Run Time(in ms)	0.0055	0.0054	0.00538	0.00535

The performance of designed filter is compared at varying bandwidths in Table I which shows that for 500 iterations the run time for designed filter for varying bandwidths is reduced from 0.0055ms,0.0054ms,0.00538ms to 0.00535ms showing how fast the filter is showing the outputs.It greatly simplifies the time constraint problem. The filter coefficients are reduced from 136,132,130 to 127 for varying ranges and hence the complexity of design is greatly reduced. As it can be seen that responses from MATLAB and multisim are almost similar in performances, so the designed test benches are successfully implemented.

V. CONCLUSION

From the simulation results, it is clear that filter has minimum ripple and so the desired signal contains less distortion and the result is upright using this method.The designed filter is stable, linear and has constant group delay.Also. The filter performance is better compared to previous researches as it provides much improved and stable response and less time consumption in its designing. The versatility of the designed filter lies in bandwidth programmability over a wide frequency domain and hence wide range of prototype filter banks can be designed.

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