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Abstract - In this paper a Quadrature Mirror Filter is implemented in VHDL, for wireless communication applications. The Quadrature Mirror Filter (QMF) basically is a parallel combination of a High Pass Filter (HPF) and Low Pass Filter (LPF), which performs the action of frequency subdivision by splitting the signal spectrum into two spectra. The QMF implementation is carried out on FPGA platform. The Xilinx IP Core generator will be used for instantiating the standard Xilinx parts. Xilinx ISE will be used to carry out the synthesis and bit file generation. The obtained Synthesis Report for implemented QMF will be used to analyze the occupied area and power dissipation. The study and implementation will be aimed to realize the equalizer for wireless communication system. Modelsim Xilinx Edition (MXE) will be used for simulation and functional verification. Xilinx ISE will be used for synthesis and bit file generation. The Xilinx Chip scope will be used to test the results on Spartan 3E 500K FPGA board.

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FPGA IMPLEMENTATION OF QMF FOR EQUALIZER APPLICATION OF WIRELESS COMMUNICATION CHANNEL

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Abstract - In this paper a Quadrature Mirror Filter is implemented in VHDL, for wireless communication applications. The Quadrature Mirror Filter (QMF) basically is a parallel combination of a High Pass Filter (HPF) and Low Pass Filter (LPF), which performs the action of frequency subdivision by splitting the signal spectrum into two spectra. The QMF implementation is carried out on FPGA platform. The Xilinx IP Core generator will be used for instantiating the standard Xilinx parts. Xilinx ISE will be used to carry out the synthesis and bit file generation. The obtained Synthesis Report for implemented QMF will be used to analyze the occupied area and power dissipation. The study and implementation will be aimed to realize the equalizer for wireless communication system. Modelsim Xilinx Edition (MXE) will be used for simulation and functional verification. Xilinx ISE will be used for synthesis and bit file generation. The Xilinx Chip scope will be used to test the results on Spartan 3E 500K FPGA board.

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I. INTRODUCTION

The importance of quadrature mirror filter banks in subband coding has been widely recognized and various analysis, design, and implementation issues pertaining to these filters have been intensively studied since the mid-1970. In this decade the wireless communication technologies are expected to grow multifold and spreading its usage in all communication segments. The latest processing techniques are enabling the communication system to work with longer distances, with less energy per bit. The channel equalization is an important step in all most all wireless communication receiver designs. Normal equalization techniques take long time for converging which can't be used for mobile technologies.

By virtue of the excellent coding and error propagation control capabilities of the sub band coding technique it has been used successfully in speech coding and image and video compression .A practical and efficient implementation platform for the sub band coding process is the quadrature mirror filter (QMF) bank. The QMF (quadrature mirror filter) based solution with sub band adaptive equalization can result less area solution, converges very fast, hence can meet the new generation mobile requirements. The FPGA based implementation can result in high speed processing hence the proposed architecture can work for wideband signals.

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II. ADAPTIVE EQUALIZATION

An adaptive equalizer is an equalizer that automatically adapts to time-varying properties of the communication channel.It is frequently used for eliminating mitigating the effects of multipath propagation and Doppler spreading in adaptive equalization, the filters adapt themselves to the dispersive effects of the channel. That is the coefficients of the filters are changed continuously according to the received data. The filter coefficients are changed in such a way that the distortion in the data is reduced. The adaptive equalizer shown in fig.

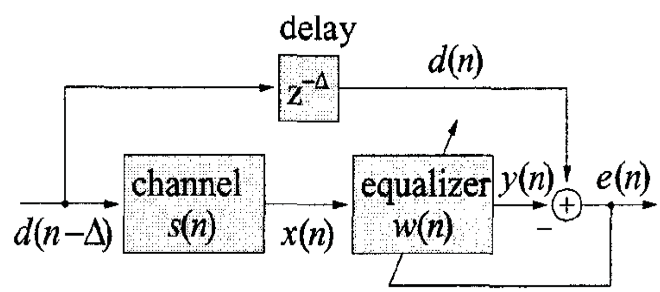

Fig.1 : Structure of Adaptive equalizer.

In this case ,the equalizer is placed after the receiving filter in the receiver. The Sequence x(n) is applied to the input of the adaptive filter.The output y(n) of the adaptive filter will be,

$$Y(n)= \sum_{i=0}^{m} \mathbf{wix(n-i)}$$

The weights wi on the taps are basically adaptive filter coefficients.A known sequence d(n-Δ)is transmitted first.This sequence is known to the receiver.The response sequencey(n) is observed.The error sequence between the two sequences is calculated

$$e(n)=d(n)-y(n) \quad n=0,1,\ldots N-1$$

if there is no distortion in the channel,then d(n)and y(n)will be exactly same producing zero error sequence.

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III. Basic Principle

The basic principle for the sub band Adaptive filters is,adaptive equalization operating in the fullband, adaptive algorithms even with medium computational complexity take long time to converge.The filter lengths for fullband operation is very high which consumes high area.If the channel exhibits large spectral dynamics .which is likely in mobile applications then convergence time is even more. Adaptive filters working in sub bands the convergence time is less, hence update rate is high.The filter length is less for sub band equalizer approach. Further, the subband decomposition allows implementing QMF like high speed architectures.

(a) *Sub band adaptive equalizer*

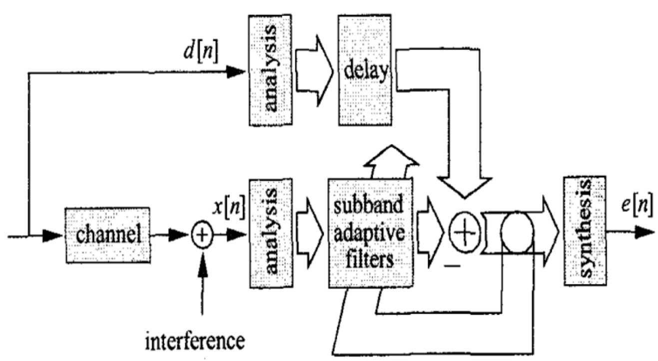


Fig.2 : Sub band adaptive equalizer.

(b) *Sub band filter section*

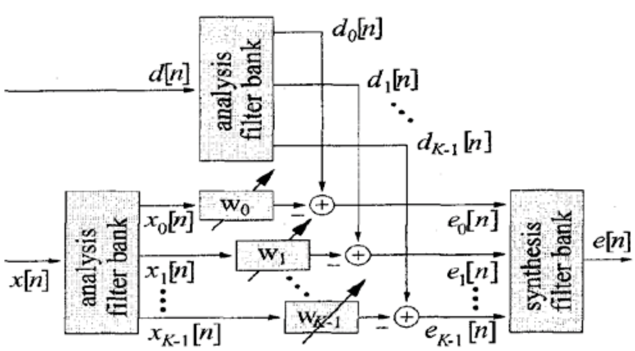


Fig .3 : Sub band filter section.

IV. Quadrature Mirror

The Quadrature Mirror Filter (QMF) basically is a parallel combination of a High Pass Filter (HPF) and Low Pass Filter (LPF), which performs the action of frequency subdivision by splitting the signal spectrum into two spectra. The general structure of a critically subsampled two-channel QMFbank is shown in Fig. 4.

It is a two channel sub band coding filter bank with complementary frequency responses. It consists of two sections.

1. Analysis section.
2. Synthesis section.

The analysis sub band filters have the transfer functions H0(z) and H1(z), and the synthesis filters are represented by G0(z) and G1(z). The input-output relation in the z-domain is given by

$$Y(z) = X(z)T_{lin}(z) + X(-z)E_{alias}(z) \quad (1)$$

With linear (distortion) transfer function

$$T_{lin}(z) = \frac{1}{2}[H0(z)G0(z) + H1(z)G1(z)] \quad (2)$$

and aliasing (distortion) transfer function

$$E_{alias}(z) = \frac{1}{2}[H0(-z)G0(z) + H1(-z)G1(z)] \quad (3)$$

Aliasing distortions are completely eliminated by the choice

$$G0(z) = H1(-z) \wedge G1(z) = -H0(-z) \quad (4)$$

If the analysis filters fulfill the requirement $H0(z) = H1(-z)$, they are referred to as quadrature-mirror filters.

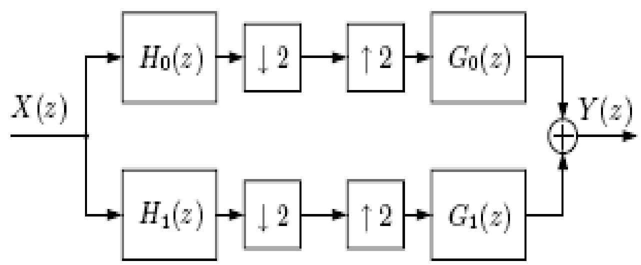


Fig.4 : General structure of a two-channel QMF bank.

The block diagram of two channel QMF is as shown in above Fig.. Here in this figure at the transmission end, the input signal x(n) is splitted into two subband signals using Analysis filters having equal bandwidth using the lowpass and highpass analysis filter HoCz) and HI Cz) respectively. Then these subband signals are decimated by factor of two. At the receiver end the decimated signal is first interpolated by factor of two and then passed through corresponding synthesis filters FoCz) and F I Cz) respectively. The outputs of the synthesis filters are combined to obtain the reconstructed signal y(n). This y(n) may not be perfect replica of x(n), due to; aliasing error or amplitude error or phase error. The elimination of aliasing effect or amplitude distortion or phase error can be achieved thereby resulting a perfect reconstruction of input signal at the output of QMF if the following conditions are satisfied by analysis filters HkCz) and synthesis filters FkCz)

1. The length L, of the window, wCn), is an integer multiple of the number of sub-bands.
2. The synthesis filters fkCn), is related to the analysis filters by a time-reversal.
3. FIR lowpass and highpass has linear phase.
4. The filter components satisfy the pairwise power complementary requirement .i.e the magnitude response of the filters satisfy the following .

Condition:-

Amplitude distortion can be elliminated completely, if above mentioned condition is satisfied. The normalized frequency response of this filter is as shown in Fig. Here the normalization is done with the total Bandwidth of our interest. From this it is clear that with two sub-bands as mentioned above the flat response can be obtained for the frequency band of interest i.e. almost flat response can be obtained for the entire frequency range of interest. In particular, perfect reconstruction is guaranteed for a filter bank with analysis filters, hkCn), and synthesis filters,

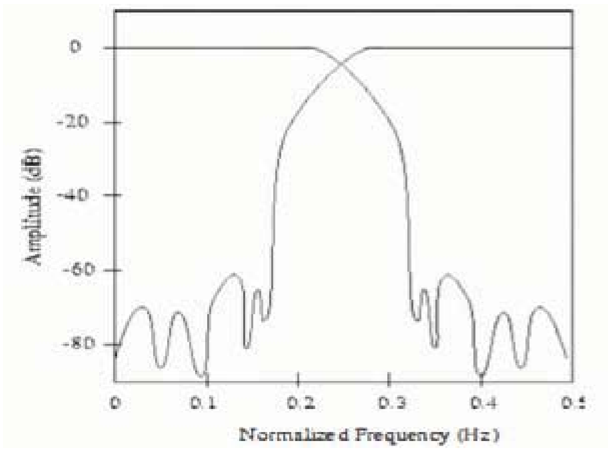


Fig.5 : Normalized Frequency Response of QMF Filter.

V. Applications

QMF finds wide applications in many signal processing tasks such as trans-multiplexing, equalizing wireless communication channels, sub-band coding of speech and image signals, sub-band acoustic echo cancellation.

VI. Results

a) Simulation Results

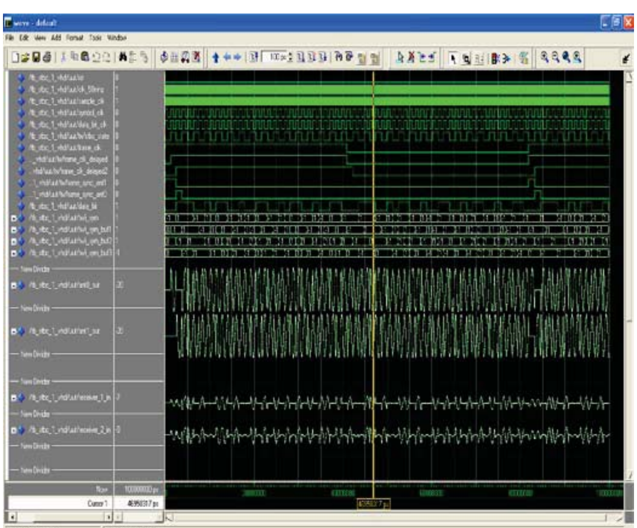


Fig .6 : Analysis bank

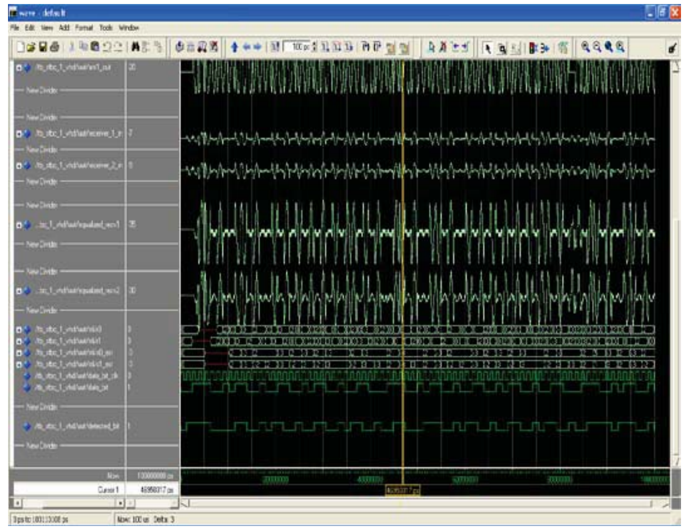
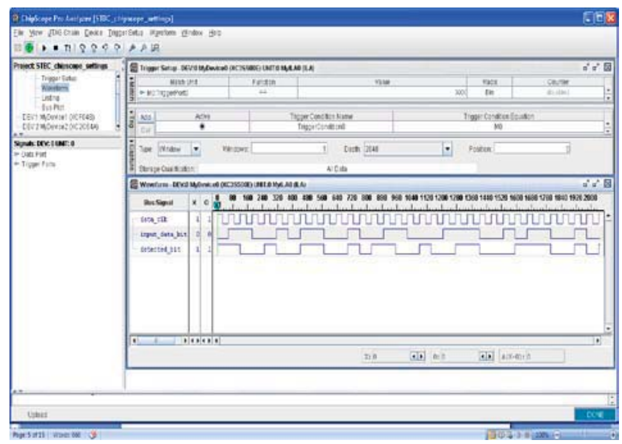
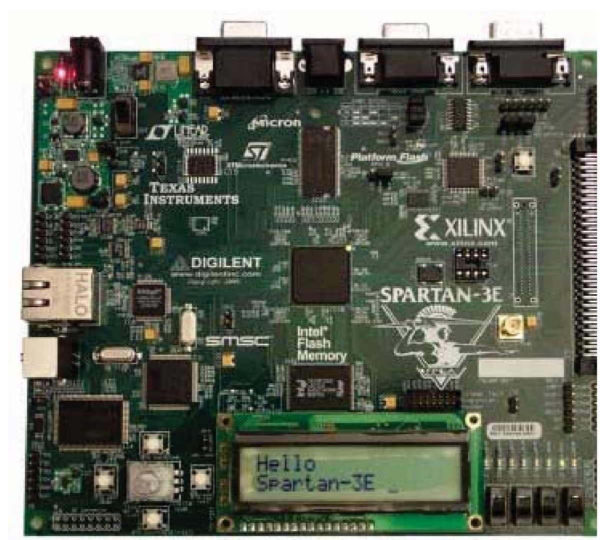


Fig.7 : Synthesis bank

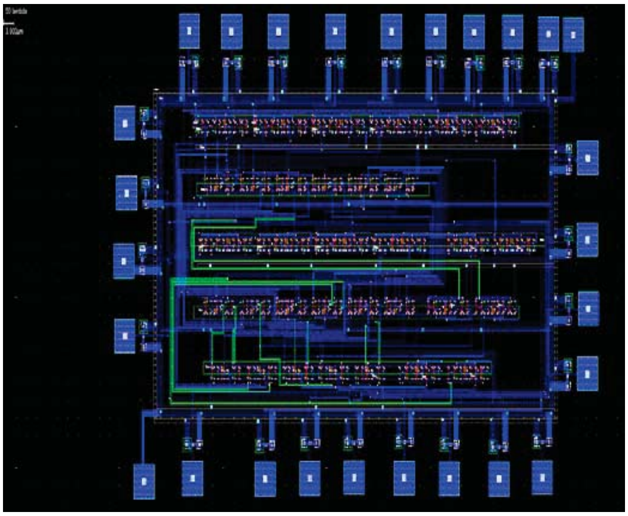
b) Chip scope Result



c) Spartan_3e



d) Floor Planning



VII. Conclusions

Here the QMF implementation for equalizer application of wireless communication channel is done and Modelsim Xilinx Edition (MXE) will be used for simulation and functional verification. Xilinx ISE will be used for synthesis and bit file generation. The Xilinx Chip scope will be used to test the results on Spartan 3E 500K FPGA board.

References Références Referencias

1. Ram Kumar Soni, Alok Jain, and Rajiv Saxena, 'New efficient Iterative Optimization Algorithm to Design the Two Channel QMF Bank', International Journal of Applied Science, Engineering and Technology 3; 3www.waset.org Summer 2007.
2. John G. Proakis and Dimitris G. Manolakis,'Digital Signal Processing Principles, Algorithms, and Applications', 2nd edition, Pearson publication.
3. ITU-T Recommendation G.726, "40, 32, 24, 16 kbitJs differential pulse code modulation (dpcm)".
4. ITU-T Recommend edition G.728, "Coding of speech at 16 kbitJs usinglow-delay code excited linear prediction".
5. QMF Implementation using Xilinx SysGen (XSG) *Chakalabbi Jairaj M., Dr.Mrs.Shaila Subbaraman IEEE 2010.*
6. Design of Iir qmf Banks With Near-Perfect Reconstruction And Low Complexity *Heinrich W. L ¨ollmann and Peter Vary IEEE 2008.*