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Analysis of OFDM System by Using Pulse Shaping Filters for DSP Applications

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ABSTRACT: *- In recent days there is a need of wireless communication systems with greater standards. Orthogonal frequency-division multiplexing (OFDM) meritoriously mitigates inter symbol interference (ISI) present in thewireless communication channels. As this undesired ICI degrades the performance of the communication system. In this paper, we put our effort to investigate the working scenario of OFDM system can perform when a signal is transmitted over an Additive white Gaussian noise (AWGN) channel using BPSK, QPSK, and 8QAM modulation schemes. In this paper, we studied and analyzed the various pulse shaping filters along with FIR and evaluated the performance of these pulse shaping filters The performance of OFDM system with uncoded and Coded pulse shaping filters are also evaluated and results reveal that the coded SQRC OFDM improve the overall performance of the system in terms of BER.*

Index Terms*–AWGN, SQRC, ICI, Pulse shaping filters*

I. INTRODUCTION

In recent days wireless communications is an evolving field and its immense increase in the mobile phone sector, Wi-Fi leads to exponential progress of the Internet as well as increased ultimatum for new methods of obtaining high capacity wireless networks. Next generation wireless communication systems or Fourth Generation (4G) [1], systems aim to support cooperative multimedia service and also on other end wireless Internet access at an ambitious data rate of 100Mbps or additional. Here higher data rates can easily achieved over wide range of channels is considerably restricted by major constraint inter-symbol interference (ISI), which is a result of multiple copies of the transmitted signal created by the reflection of objects.

These techniques is termed as multipath fading and to overcome ISI methods like multicarrier modulation schemes such as Orthogonal Frequency Division Multiplexing (OFDM) [2], are among the possible solutions that have been suggested. The OFDM job is to convert a selective frequency channel into a group of frequency-flat sub-channels with partially overlapping spectra. This is achieved by splitting the input high-rate data stream into a number of sub-streams that are communicated in parallel via orthogonal subcarriers. OFDM can be easily generated using an Inverse Fast Fourier Transform (IFFT) and reconstructed using a Fast Fourier Transform (FFT) [3]. By employing OFDM channel equalization can effortlessly be achieved in the frequency domain over a bank of one-tap multipliers where it raises the robustness contrary to multipath distortions. Also, it provides larger flexibility by allowing independent selection of the modulation parameters resembling the constellation size and coding scheme, through each subcarrier. In order to support multiple users we do require OFDM along with two way communication systems by employing multiuser system that can furnishes flexible and some sort of effective communication system.

In OFDMwe canuse any coherent or differential, phase or amplitude modulation scheme.Each modulation scheme provides a tradeoff between Spectral Efficiency and the Bit Error Rate (BER). The spectral efficiency can be maximized by choosing the highest modulation scheme that will give an acceptable Bit Error Rate (BER). The classic OFDM employing baseband Quadrature Amplitude Modulation (QAM) and rectangular pulse shape, denoted asOFDM/QAM, is most commonly used in today'sapplications, which refers to OFDM. In an idealchannel where no frequency offset is induced, InterCarrier Interference (ICI) can be fully removed byorthogonality between sub-carriers. Inter SymbolInterference (ISI), which is caused by multipathpropagation, can also be eliminated by adding guard interval which is longer than the maximumtime dispersion which leads to a loss of spectral efficiency immediately raises the level of power consumption. Also OFDM system with offset

QAM for each sub-carrier, denoted as OFDM/OQAM [4], [5] provides better spectral efficiency and meanwhile it reduces combined ISI/ICI.

II. RELATED WORK

The Orthogonal Frequency Division Multiplexing (OFDM) is an encouraging wideband communication method for attaining excessive data rate in wired and Wi-Fi environments. There are numerous advantages related to OFDM techniques. Considered one of them is its high spectral efficiency because of the minimum spectral spacing between the subcarriers, attributed to their orthogonality [10]. Also adaptive modulation schemes can be used on individual subcarriers, in step with the transmission conditions on each subcarrier. Additionally this multicarrier transmission procedure can be applied in the digital domain by means of using computationally effective IFFT.

Despite its multidimensional advantages of OFDM systems undergo nevertheless from a quantity of drawbacks. The excessive peak-to-average power Ratio (PAPR) is the most severe one [11] [12]. As this was caused due to positive interference between many sub-carriers, which may arise at few time instants inside the symbol duration. One of the vital apparent difficulties concerning excessive PAPR is to be maintained at power amplifiers stage at transmitter RF side to furnish linear dynamic range. Minimizing the PAPR permits a larger usual power to be transmitted to for a constant peak power, making improvements to the overall signal to noise ratio (SNR) at the receiver, which is more essential to reduce the average PAPR.Generally to serve wide range of communications several techniques were suggested in the works to challenge this foremost issue [13]-[15]. Moreover important task is of reduction in PAPR is accomplished by employing these strategies is relative and is obtained at the cost of both a different complexity to the OFDM transmitter and receiver. Different feasible replacement resolution is to try to take benefit of other parameters of the OFDM sign. Employing the subcarrier waveforms of the OFDM signal seems as an attractive answer for lowering PAPR of OFDM signals.

Yet another accurate frequency and time synchronization are fundamental for OFDM approach. The sensitivity towards provider frequency offset factors attenuation and rotation of subcarriers. For that reason orthogonality among the many carriers is misplaced and thus it yields in constraint so called inter-carrier interference (ICI). The undesired ICI degrades the efficiency of the system. Quite a lot of researchers have proposed numerous ICI mitigation techniques to resolve this crisis [17][18].

The pulse shaping method employed in OFDM system utilized in this study work for reduction of PAPR is also employed for reduction of inter-carrier-interference power through the reduction of side lobes in each carrier. Efficient Pulse shaping technique using new pulse shapes for improving the performance of OFDM system is the major focus of this research work.

III. PROPOSED APPROACH

As shown in fig.1 (a) and 1(b) show the structure of a typicalOFDMcommunication system with several pulse shaping filters are employed. Here high speed data stream is divided into group of lower speed data streams and thus modulates into orthogonal carriers by employing Inverse Fast Fourier(IFFT) [6] and also pulse shaping filters. The Quadrature amplitude modulation QAM constellation diagrams are used for mapping the transform.

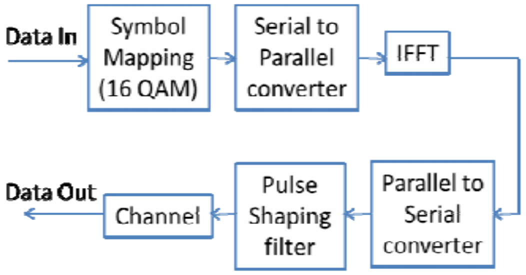

Fig.1 (a) Transmitter of a pulse shaped OFDM System

Here by using pulse-shaping filter in OFDM can be formulated as:

$$s(t) = e^{j2\pi f_c t} \sum_{k=0}^{N-1} D_k\, p(t) e^{j2\pi f_k t} \ldots\ldots\ldots\ldots..(1)$$

Where j=$\sqrt{-1}$, Number of subcarrier is N, Carrier frequencyof OFDM system isf_c, Subcarrier frequency of k$_{th}$subcarrieris, $f_k$and here k = 0, 1… N – 1, and pt is time limited pulseshaping filter. Transmitted symbol is D_k which is presumedtohave zero mean and normalized average symbol energy. Alsowe consider that all data symbols are uncorrelated [7, 8].i.e

$$E[D_k D_m^*] = \begin{cases} 1, k = m \\ 0\,, k \neq m \end{cases} \ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Where m=0,1 ,…………, N-1

Where D_m^* is the complex conjugate of D_k .To ensure theorthogonality of subcarrier, it is very imperative to satisfied the below equation for OFDM system [9, 10]. The subcarrier frequency is

$$f_k = \frac{k}{T_s} \dots\dots\dots\dots\dots\dots\dots (3)$$

Where k=0, 1,…………, N-1

$$f_k - f_m = \frac{k-m}{T_s} \dots\dots\dots\dots\dots .(4)$$

Where k=m= 0, 1………. N-1

In order to maintainat least subcarrier frequency spacing should have $\frac{1}{T_s}$for retainingorthogonally between subcarriers, thus at the receiver the obtained received signal can be denoted as

$$r(t) = s(t) \otimes h(t) + w(t) \dots\dots\dots\dots .(5)$$

In above calculation convolution is represented by$\otimes$, h (t)isthechannel impulse response along with additive white Gaussiannoise is exemplified by w (t) which where themethod with zero meanand variance NO / 2 per dimension.

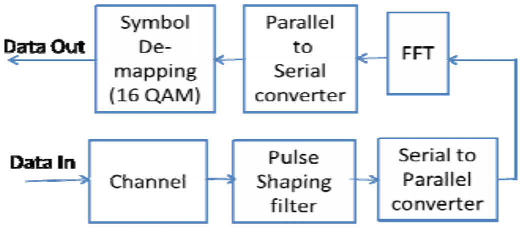

Fig.1 (b) Receiver of a pulse shaped OFDM System

Each carrier in the OFDM spectrum is exemplified by main lobe with a number of side lobes having lower amplitudes. The peak power is mainly lies in the main lobe whereas Inter Symbol Interference (ISI) is present in the side lobes only. Henceforth our objective is to increase the main lobe width and at the same time to decrease the amplitude of side lobes [7] by employing pulse shaping filters.

Pulse shaping technique is used to transmit data within a limited bandwidth which further reduces the Inter Symbol Interference (ISI) [9]. In our paper we used some commonly used pulse shaping filters such as Raised cosine and Square Root Raised Cosine Filter. ICI power for various shaping pulses is

Raised cosine Pulse

$$P_{RC}(f) = sinc(ft)\frac{\cos(\pi\alpha ft)}{1-(2\alpha ft)^2} \dots\dots\dots\dots\dots\dots (6)$$

Where is the roll off factor $0 \le \alpha \le 1$ and f, t are called frequency and time respectively.

Square Root Raised cosine Pulse

$$p_{srrc}(f) = sinc(ft)\left(\frac{4a}{\pi\sqrt{f}}\cos(1+a)\frac{\pi f}{t}\right) + \frac{(\frac{t}{4af}\sin(1-a)\frac{\pi a}{t}}{(1-(\frac{4af}{t})^2)} \dots\dots\dots .(7)$$

In this project we are simulated our work in Mat lab 2013a by utilizing 3well known modulation schemes namely BPSK, QPSK and 8-QAM.

- In the first phase we applied to all the 3 techniques like BPSK, QPSK and 8 QAM with Rectangular pulse shaping (RPS).
- In the second phase we simulated the system using the Square Root Raised Cosine (SQRC) filter as pulse shaping filter and matched filter with the assistance of BPSK modulation and we observed that overall loss didn't cross the 0.5dB. Subsequently we also applied the same with QPSK and 8-QAM to study the comparative results.

- Finally in the last phase we evaluated the coded and uncoded performance of all the 3 techniques i.e, BPSK, QPSK and 8QAM with SQRC pulse shaping. Also we do analyze the transmitted signal spectrum in every occasion.

IV. EXPERIMENTAL RESULTS

In this paper we tookSQRC and simulated initially to the BPSK modulation technique. In this work our main motto is to design SQRC filter by taking FIR filter design into account, since it coefficients number decide the overall performance of the system.We done several iterations in simulation to get few no. of coefficients to have loss in the system that does not exceed 0.5dB at the10^-5 BER.We observer from the Fig.2 the plot of SQRC the count of the coefficients to be 25.

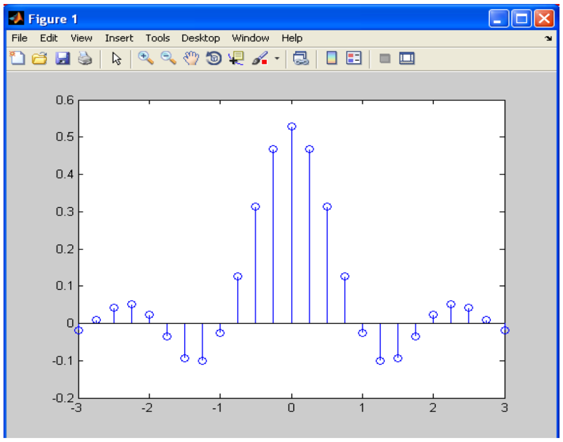

Fig.2coefficientsof Square root raised cosine filter

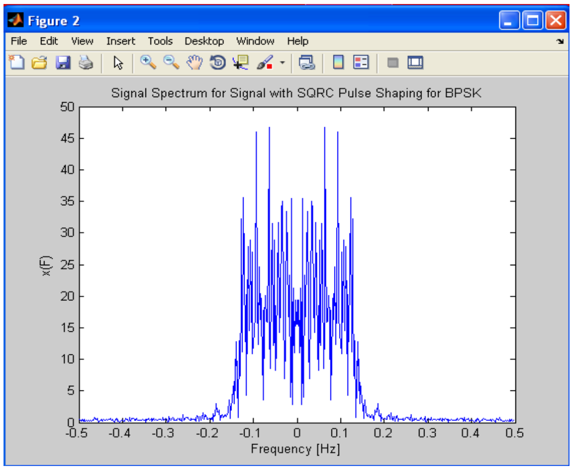

Fig.3Spectrumof Square root raised cosine filter with BPSK

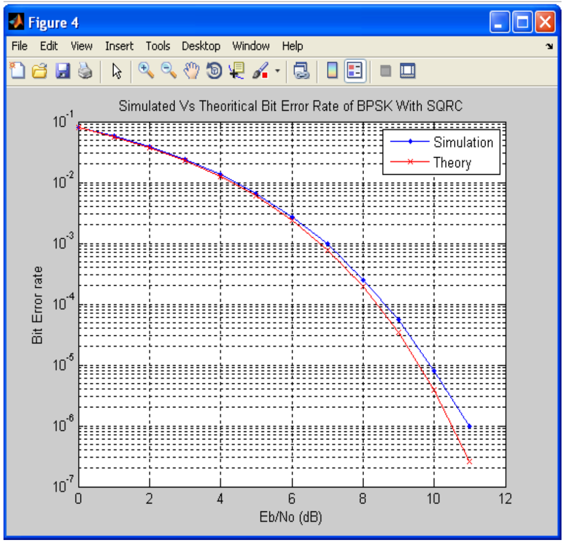

Fig.4 BPSK with SQRC

From Fig.4 we observe that the performance curve of BPSK system after applying the FIR filter to the system. It can be seen that the loss at BER of 10^-5 is less than 0.5dB.

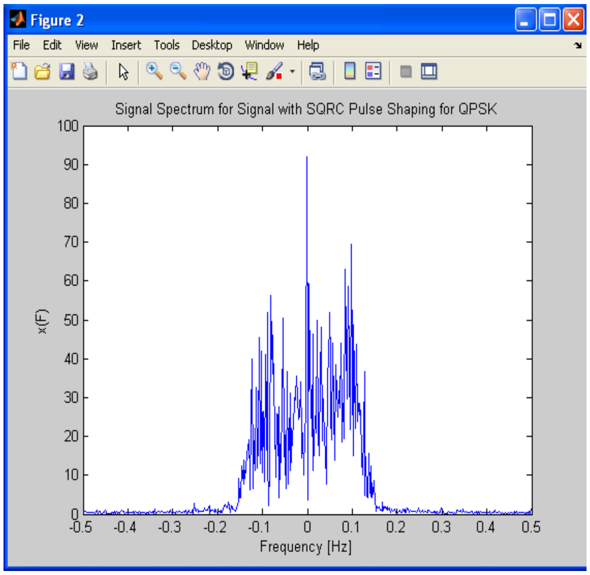

Fig .5 Spectrum of Square root raised cosine filter with QPSK

Here the same filter attained for BPSK simulation is deployed to estimate the performance of QPSK. We observe that in QPSK system, the loss at BER is same as BPSK to be 10^-5. Fig.6 shows the overall performance of QPSK scheme after relating on the SQRC filter with no improvement.

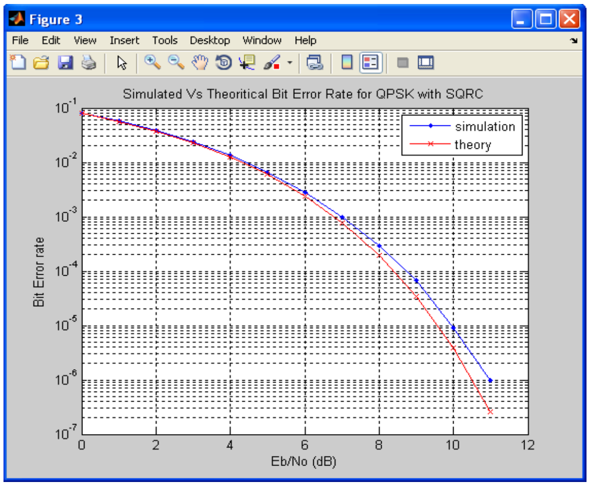

Fig.6: QPSK with SQRC

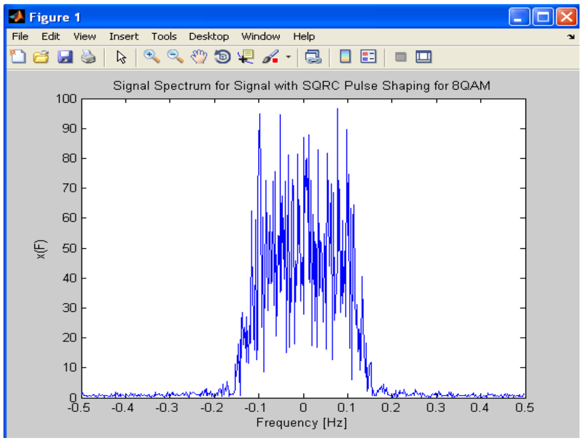

Fig .7 Spectrumof Square root raised cosine filter with 8QAM

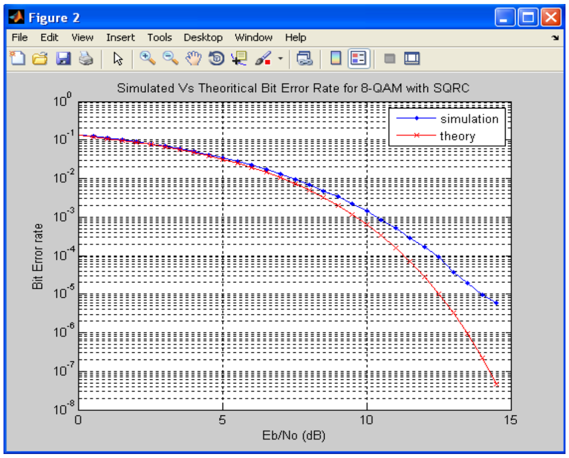

Fig .88QAM with SQRC

However, from above discussion the performance of BPSK and QPSK was similar after applying the SQRC filter. Nonetheless when the same filter was applied to the 8 QAM scheme it was observed from the Fig.8it seems to be loss at BER of 10^-5 exceeded to 1.5dB.

From Fig.9 coded performance of BPSK is seems to be better than the uncoded performance. It is found that coding gain can be 0.2dB at $10^{-5}$and it can be further increases as the no. of coefficients increases of FIR filter. We also observed that difference in the curves of both theoretical and simulation which is due to the usage of formulae to evaluate the performance is the value of approximation.

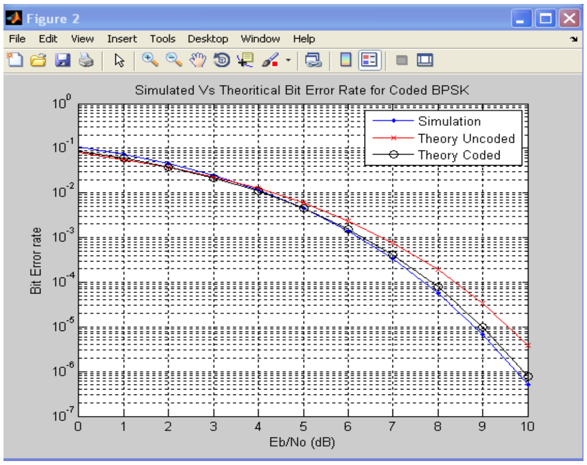

Fig.9 Coded BPSK with SQRC

V. CONCLUSION

In this paper, simulation results have been offered to determine that pulse shaped OFDM suggestively enhances better performance of communication system as related to simple OFDM. It can be concluded that usage of pulse shaping filter possess spectrum with higher main lobe width and smaller amplitude of side lobes, also pulse shaping filter maintains less ICI and better bandwidth efficiency. We have assessed the performance of these pulse shaping filters with OFDM in terms of BER with varying SNR values for BPSK,QPSK and 8-QAM also we observed that the coded performance of BPSK is seems to be better than the uncoded performance.

REFERENCES

[1] T.S.Rappaport, Wireless Communications:Principles and Practice. Upper SaddleRiver, NJ: Prentice-Hall, 2002.

[2] Louis Litwin and, MichaelPugel, “Principles of OFDM”, RF Signalprocessing, January 2001.

[3] B. Hirosaki, “An orthogonally multiplexedQAM system using the discrete Fouriertransform,” IEEE Trans. OnCommunications, vol. 29, no. 7, pp. 982–989, July 1981.

[4] H.Bolcskei, “Orthogonal FrequencyDivision Multiplexing Based on OffsetQAM”, Advances in Gabor Analysis,Birkhauser, 2003.

[5] P. Siohan, C. Siclet and N. Lacaille,“Analysis and design of OFDM/OQAMsystems based on filter bank theory”,

IEEETransactions on Signal Processing, vol.50, no. 5, pp. 1170–1183, May 2002.

[6]. M.Palaivelan, S. Anand and S. P. Venkatesan, “PAPRand ICI Reduction in OFDM Systems using ModifiedRaised Cosine Power Pulse Shape”, European Journalof Scientific Research, ISSN: 1450-216, Vol.72, No.4,pp. 618-627, 2012.

[7]. SrabaniMohapatra and Susmita Das, “PerformanceEnhancement of OFDM System with ICI ReductionTechnique”, In Proceedings of the World Congress onEngineering, Vol. 1, July 2009.

[8]. Nadieh M. Moghaddam and Mohammad Mohebbi, “ICIReduction Methods in OFDM Systems", RecentAdvance in Wireless Communication and Networks,Prof. Jia-Chin Lin (Ed.), ISBN: 978-953-307-274-6,August 23, 2011.

[9]. P. Tan, N.C. Beaulieu, “Reduced ICI in OFDM systemsusing the better than raised-cosine pulse”, IEEECommun. Lett.volume 8 issue 3, pp. 135–137, 2004.

[10] S .Weinstein and P. Ebert, “Data Transmission by Frequency DivisionMultiplexing Using the Discrete Fourier Transform,” IEEE Transaction onCommunication, Vol.19, and Issue: 5, pp. 628–634, Oct.1971

[11] S. H. Han and J. H. Lee, "An Overview of Peak-to-Average Power Ratio ReductionTechniques for Multicarrier Transmission," IEEE Wireless Communications, Vol.12, no. 2, pp. 56-65, 2005.

[12] Josef Urban and Roman Marsalek, “OFDM PAPR Reduction by Combination ofInterleaving with Clipping and Filtering,” IEEE Communication Letter, pp. 249–252, June 2007.

[13] S.H Muller and J.B Huber, “OFDM with Reduced Peak-to-Average power Ratio byOptimum Combination of Partial Transmit Sequences,” IEEE Electronics Letters onCommunication& Signal Processing, Vol. 33, Issue. 5, pp. 368-369, 27 Feb. 1997.

[14] Bauml, R.W.; Fischer, R.F.H.; Huber, J.B, “Reducing the Peak-to-Average PowerRatio of Multicarrier Modulation by Selected Mapping,” IEEE Electronics Letters,Vol.32, pp. 2056-2057, 24 Oct. 1996.

[15] R.F.H. Fischer, “Widely-Linear Selected Mapping for Peak-to- Average PowerRatio Reduction in OFDM,” IEEE Electronics Letters, pp. 766–767, July 2007.

[16] L. J. Cimini Jr. and N. R. Sollenberger, "Peak-to-Average Power Ratio Reduction ofan OFDM Signal using Partial Transmit Sequences," IEEE Communications Letters,Vol. 4, no. 3, pp. 86-88, 2000.

[17] H. M. Mourad, “Reducing ICI in OFDM Systems using a Proposed Pulse Shape,”Wireless Person.Communication, Vol. 40, pp. 41–48, 2006.

[18] V. Kumbasar and O. Kucur, “ICI Reduction in OFDM Systems by usingImprovedSinc Power Pulse,” Digital Signal Processing, Vol.17, Issue 6, pp.997-1006, Nov. 2007.