Non-Conventional Carrier Waveforms in a four user OFDMA Communication System

T.Venkata SubbaReddy[1], B.Madhava Reddy[1], B.Sai Venkatesh[1]
[1]Department of Electronics and Communication Engg.
School of EEE, SASTRA University
Thanjavur, Tamilnadu, India,
subbareddy.984@gmail.com

R. Ganapathy[2], R.K. Karn[2]
[2]Senior Assistant Professor,
Department of Electronics and Communication Engg,.
School of SEEE, SASTRA University
Thanjavur,Tamilnadu,India,
rganapathy@ece.sastra.edu

Abstract— **Conventional communication systems use either sinusoids (pass band) or square waves (baseband) as carriers. However tradeoffs have to be made with regards to bandwidth, fidelity, power consumption and system complexity. This paper explores using Non-conventional waveforms including Gaussian like pulses as carrier waveforms using a 4-user OFDMA system as the benchmark. SPICE simulations are done at the deep submicron VLSI level (120 nm) using MicroWind. The performance of the various carrier waveforms are assessed by using standard metrics such as Bit Error Rate, Signal to Noise ratio and eye-diagram. The results presented in this work give valuable insights into Non-conventional carrier waveforms and their impact on SNR and BER leading to more robust.**

Keywords— Gaussian like pulses, Non-conventional carriers. OFDMA, deep submicron VLSI, MicroWind.

I.INTRODUCTION

In a day -today scenario the need of High speed communications is very vital. One such technology is Orthogonal Frequency Division Multiple Access (OFDMA). OFDMA [1] is an extension of OFDM that can provide a single frequency network with higher spectral efficiency. Here several users can transmit simultaneously at less data rate. There are several advantages of using OFDMA technology compared to OFDM [1]. The main advantage is Multi-user diversity. The Technologies that use OFDMA are Wi-Max, LTE-A. Wi-Max [2] standard allows data transmissions in the range 10-66 GHz. It plays a crucial role in 4G, making it possible to transfer very high bit rates and promising speeds in the order of 1Gbit/s [6].

Transmission in this range is effected by noise as a result signal is distorted. One way of getting the signal without transmission loss is applying error control coding. This technique reduces the amount of data to be transmitted as a result capacity is reduced. In order to optimize the trade-off we need new techniques that employs special methods.

This paper uses alternate carriers to solve twin problems of noise and capacity. Here spectral properties of sine and square are investigated. New carriers are proposed based on hyperbolic functions sech whose spectral width lies between both sine and square. Thus low error rates and high capacity can be achieved without using error control coding techniques. The carriers are generated in submicron VLSI 120nm [4], [5] and Implementation of 4 user OFDMA system in mat lab.

II.METHODOLOGY

Firstly spectral properties of sine and square carriers are reviewed. As shown in the Fig. sine wave spectrum with and without noise are plotted. With noise new unwanted components are created, which interfere with other user carriers. Similarly square wave spectrum with and without noise are plotted. It is observed that huge bandwidth is required and the channel thus formed creates Low pass filter effect, attenuating high frequencies. The spectrums of various waves are as shown in Fig.1,2,3,4,5,6.

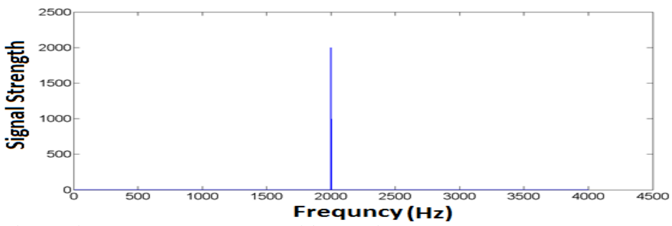

Fig 1. Sine wave FFT spectrum without noise

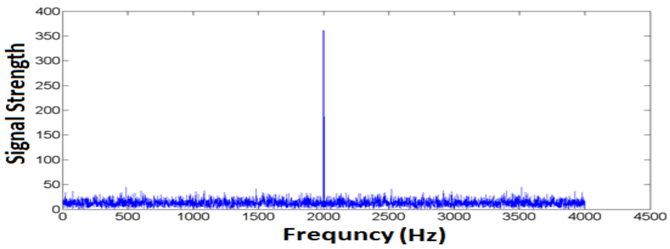

Fig 2. Sine wave FFT spectrum with noise

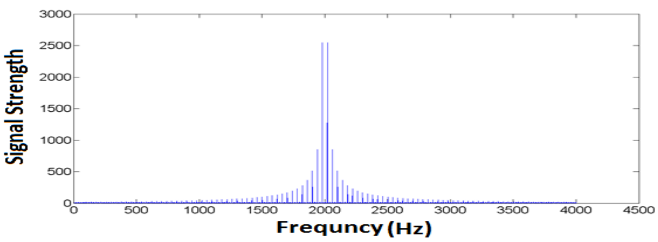

Fig 3. Square wave FFT spectrum without noise

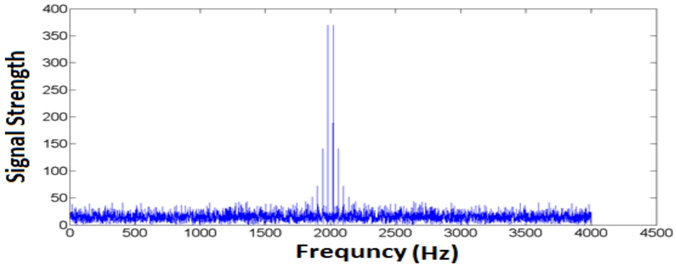

Fig 4. Square wave FFT spectrum with noise

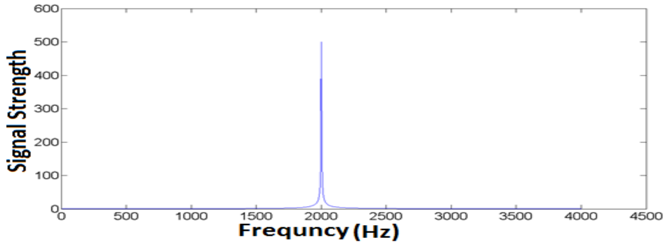

Fig 5. Sech pulse FFT spectrum without noise

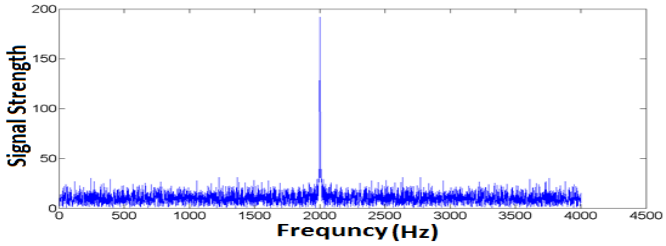

Fig 6.Sech pulse FFT spectrum with noise

In order to compensate this effect we must require a carrier with spectral width in between sine and square. One such example is sech hyperbolic functions. To generate sech pulse [3] based carriers, nonlinearity is required. This can be obtained from semiconductor devices such as MOSFETs. Non linearity of gate and source is effectively used to generate the pulse based carriers. Simulations are done using Microwind.

A. Generation of Pulse in Microwind

The simplest way of generation is to couple a sine oscillator to a CMOS inverter gate terminal. The Fig.7,8,9 show the circuit diagram and the Microwind layout and 3D View that is implemented in deep submicron VLSI 120nm. The generated sech pulse is shown in Fig. 10.

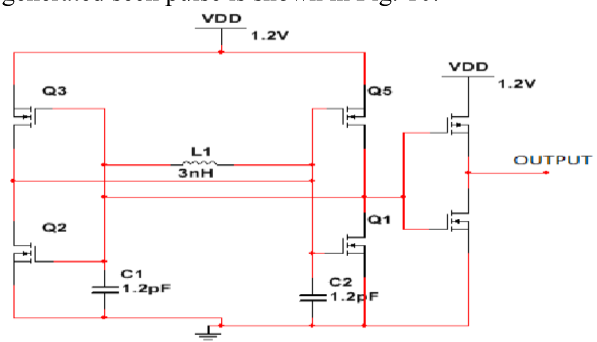

Fig 7. Ciruit Diagram to generate pulse.

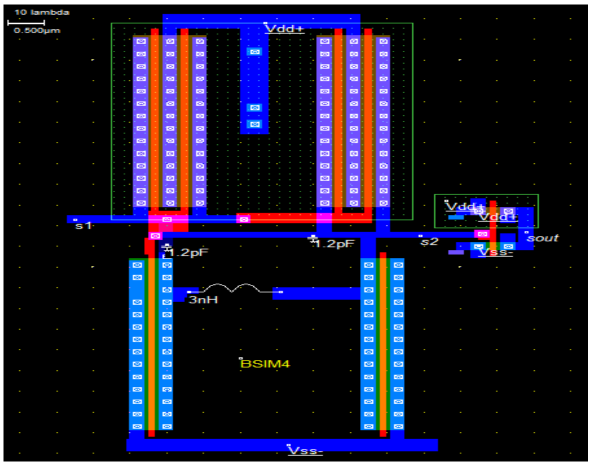

Fig 8. Layout design to generate pulse in Microwind.

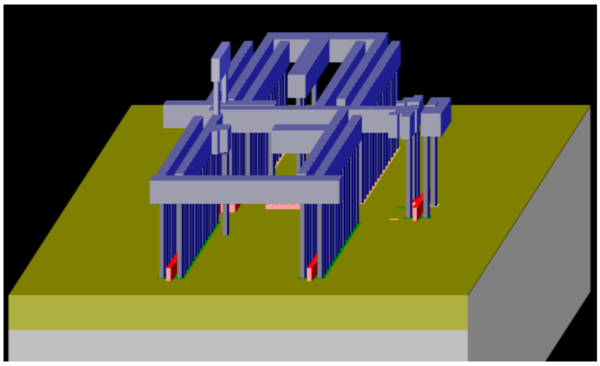

Fig 9. 3D view of the design to generate pulse.

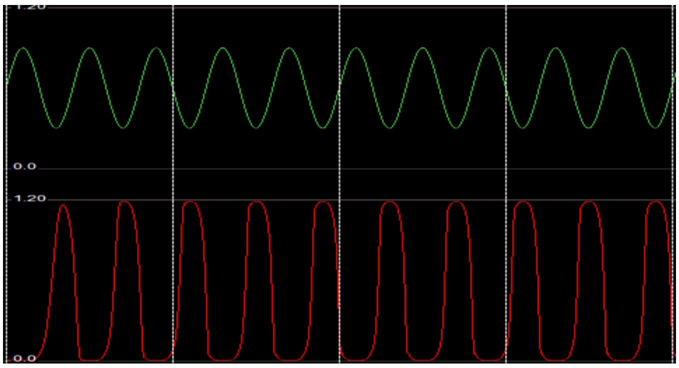

Fig 10. Oscillator output sine wave and pulse generated.

B. Four User OFDMA System

The block diagram shown in Fig.11 is a 4 user OFDMA system.

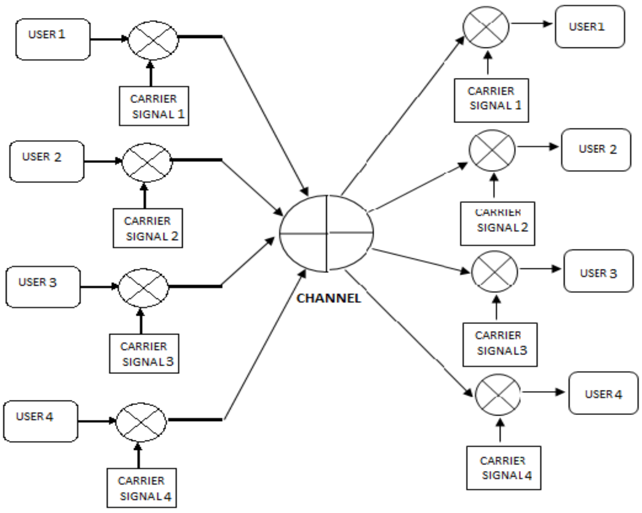

Fig 11. Block diagram of OFDMA system.

Four carrier pulses each for one user are generated in Microwind. To maintain orthogonality, carriers can be chosen in integral multiples of fundamental value 5GHz i.e. (5, 10, 15, 20). Each user signal can be modulated with each pulse and finally all the four modulated signals are added. The resultant signal can be communicated through a channel and at the receiver end the OFDMA signal can be demodulated with four pulses individually. Performance of the system can be characterized by Bit error rates (BER) and eye diagrams at different SNR values for the AWGN channel.

III. Results and Discussions

The OFDMA System block diagram is implemented in the Matlab. For message signals random bit streams are chosen and Amplitude Shift Keying (ASK) modulation is performed with four different carrier signals. The Four individually modulated waveforms are shown in Fig.12,13,14,15 and they are added to combine them.

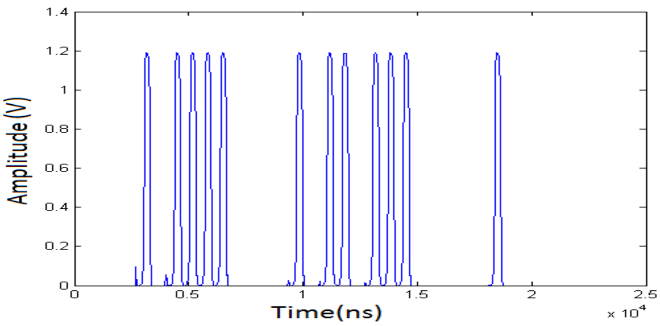

Fig 12. User1 modulated waveform.

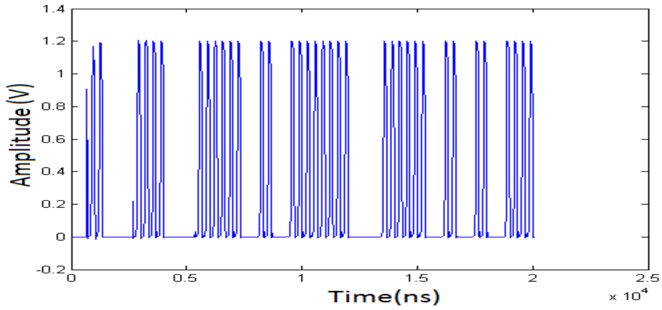

Fig 13. User2 modulated waveform.

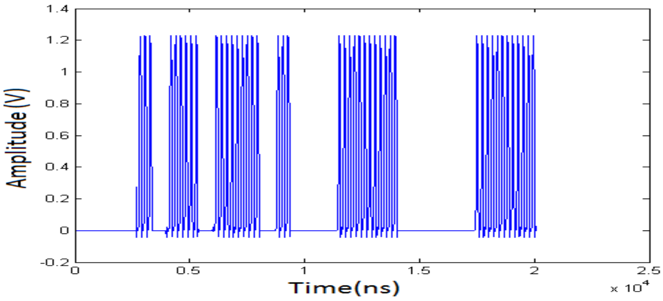

Fig 14. User3 modulated waveform.

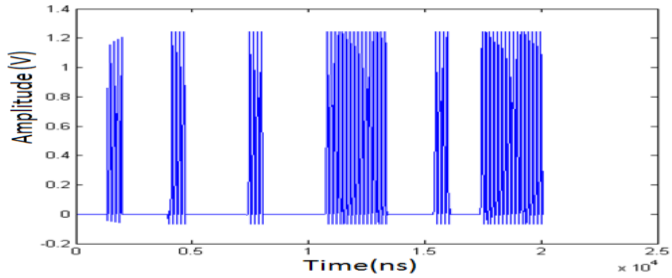

Fig 15. User4 modulated waveform.

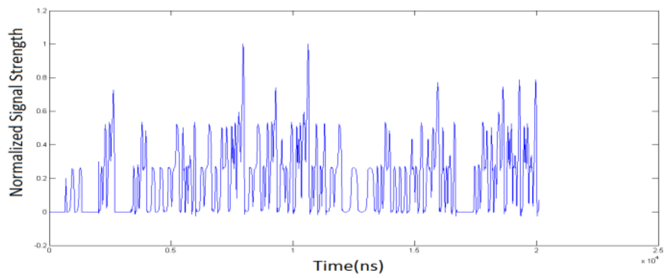

Fig 16. Combined waveform of all four users.

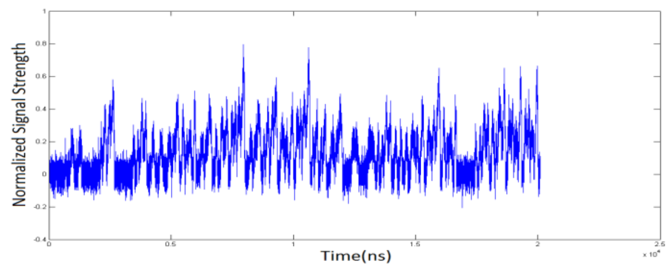

Fig 17. Combined waveform of all users along with channel noise and fading.

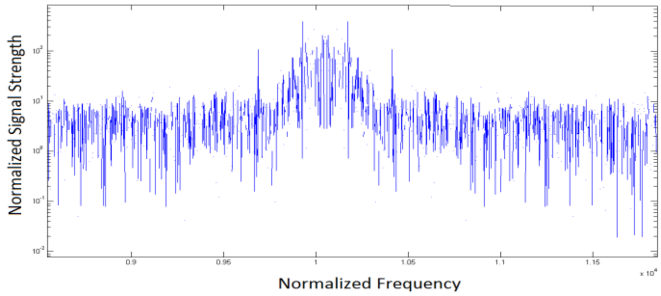

Fig 18. Normalized Spectrum of combined waveform.

The resulted waveform along with it's spectrum are shown in Fig. 16 and Fig. 18 respectively. It is sent through the AWGN Channel with multipath fading and noise. The combined waveform along with channel effects is shown in Fig. 17.For receiver conventional envelope detection and thresholding is used. The bit error rates are calculated for four demodulated signals.

The system is tested with sine, square and pulse signals and performance assessment is done by comparing pulse carrier with sine and squares using BER for various SNR's for four users. Eye diagrams of four users are given as follows in Fig.19,20,21.

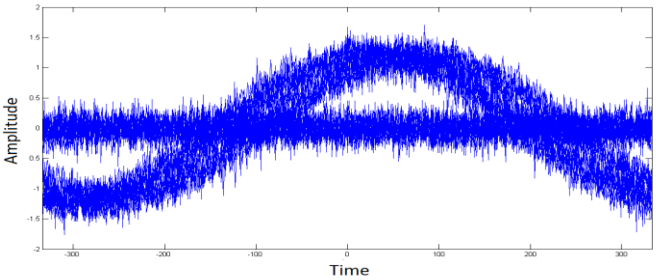

Fig 19. Eye diagram of sine wave.

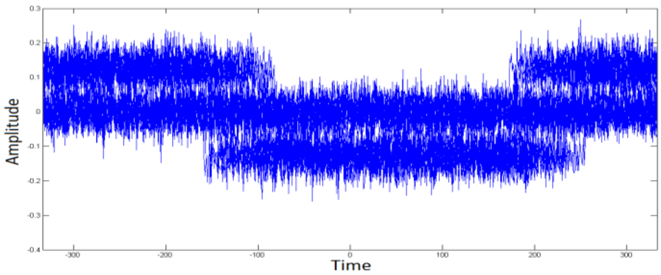

Fig 20. Eye diagram of square wave.

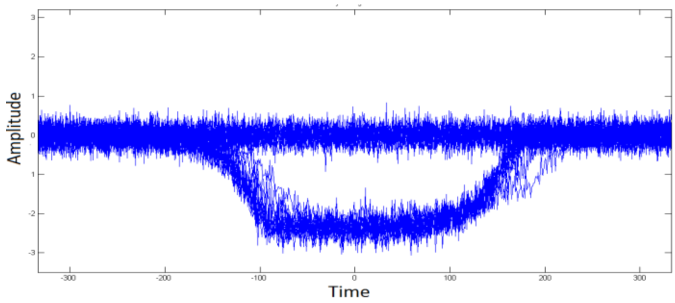

Fig 21. Eye diagram of pulse.

As can be seen, pulse yields lower BER [6] and clear eye diagram leading to distortion free communications

TABLE

Signal	Noise(dB)	BER1	BER2	BER3	BER4
Pulse	0	0.1667	0.2	0.0333	0.1333
	-5	0.2	0.2333	0.1333	0.1333
Sine	0	0.56	0.5333	0.5	0.4667
	-5	0.6337	0.6	0.577	0.4667
Square	0	0.633	0.5667	0.5333	0.4667
	-5	0.6667	0.6	0.5	0.533

Acknowledgement:
The work of Ganapathy.R was supported in part by DST-SERC, Government of India and in part by the Research and Modernization Fund of SASTRA University. Sai Venkatesh.B acknowledges SASTRA University for providing University Fellowship.

REFERENCES

[1] Henrik Schulze, Christian Lueders, "*Theory and Applications of OFDM and CDMA: Wideband Wireless Communications Hardcover*", Wiley-Blackwell, USA, 2005.

[2] K.Sarfaraz, S.A.Ghorashi, M.Ghavami and A.H.Aghvami, *"Performance of Wi-Max receiver in presence of DS-UWB system*", Electronics Letters, Vol.41, 1388-1390, 2005.

[3] K.Porsezian, R.Ganapathy, A.Hasegawa and V.N.Serkin, "*Nonautonomous Soliton Dispersion Management*", IEEE Journal of Quantum Electronics, Vol.45,1577-1583, 2009.

[4] J.P.Uyemura, "*Chip Design for Submicron VLSI: CMOS Layout and Simulation*", Thomson/Nelson, USA, 2006.

[5] Douglas A. Pucknell and Kamran Eshraghian, "*Basic VLSI Design*", Prentice Hall, 2005.

[6] B.Sai Venkatesh , R.Ganapathy and K.Porsezian " *Design of Terahertz Radio over Fiber - Beyond 4G*", Workshop on Recent Advances in Photonics,IEEE Conference Publications,1-2 ,2013.