ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

Performance and Evaluation of Companding Transform for PAPR Reduction in OFDM under Nonlinear Distortions

Lakshmi. P[1], Uma Maheswari. R[2]

PG Student, Dept. of ECE, Vignan's Institute of Information Technology, Visakhapatnam, Andhra Pradesh, India[1]

Asst. Professor, Dept. of ECE, Vignan's Institute of Information Technology, Visakhapatnam, Andhra Pradesh, India[2]

ABSTRACT: In this paper we mainly focused on BER and peak-to-average power ratio (PAPR) reduction in OFDM by using Nonlinear Companding transform (NCT).Among various companding techniques NCT is an attractive solution to reduce the PAPR of OFDM signal .The proposed algorithm offers an improved BER and minimize out-of-band distortions while reducing PAPR effectively under the AWGN, Rician multipath fading and ETU channels. Theoretical analysis and computer simulations are presented.

KEYWORDS: High power amplifier (HPA), NCT, OFDM, PAPR, ETU (extended typical urban channel), Additive white Gaussian noise (AWGN).

I .INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is used in many wireless broadband communication systems because it is a simple and scalable solution to inter symbol interference caused by a multipath channel. It is used in wireless local area networks (WLAN) and wireless metropolitan area networks (WMAN) including IEEE802.11a/g and worldwide interoperability for microwave access (Wi-MAX). As a promising technique, OFDM has been widely applied in modern wireless communications due to its high spectral efficiency and low susceptibility to the multipath propagation. Very recently the use of OFDM in optical systems has attracted increasing interest. However, a major drawback of OFDM-based transmission systems is its high instantaneous peak-to-average power ratio (PAPR), which leads to undesired in-band distortion and out-of-band radiation if the linear range of the high power amplifier (HPA) is not sufficient. In an OFDM system with N subcarriers, the complex baseband representation of OFDM signal is given by [1].

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X(n) e^{\frac{j2\pi nt}{N}} \qquad 0 \le t \le T \tag{1}$$

Where $j = \sqrt{-1}$ and the vector X_k denotes the frequency-domain OFDM symbols and T is the symbol duration. To reduce the PAPR we proposed algorithm is **Non-Linear Companding transform (NCT)** technique is used .It uses strict monotonically increasing function to transform the given signal to companded signal and hence can be recovered [3]. It compresses the high level signals and expands the low level signals.

Many PAPR reduction schemes causes spectrum side-lobes generation, but the nonlinear companding transforms (NCT) can offer better PAPR reduction, less spectrum side-lobes, less BER and phase error performance than the u-law and exponential companding techniques [2].

The analytical expression regarding the achievable reduction in BER and PAPR, attenuation factor of a signal and the selection criteria of transform parameters are derived and executed through computer simulations. The proposed algorithm is compared with exponential companding technique [4] for investigating the proposed algorithm performance.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

II .LITERATURE REVIEW

This literature review attempts to provide brief overview of the Peak-to-Average power ratio reduction in OFDM by using nonlinear companding transform technique. It discusses the NCT technique, to reduce PAPR and NCT is compared with exponential companding technique. NCT uses threshold points like cut off and inflexion points to reduce Peak Power in OFDM. In order to investigate the system performance, the companded signal is passed through different noise channels like AWGN, ETU and Rician fading channels. In addition, by choosing proper transform parameters, the impact caused by companding distortion can be significantly reduced [4] .

III .PAPR IN OFDM MODEL

Generally, an OFDM signal is the sum of N independent data symbols modulated by phase shift keying (PSK) or QAM modulation. Let X (0), X (1) ,….., X (N-1) represents the data sequence to be transmitted in an OFDM symbol with N subcarriers [5]. The base band representation of OFDM is given by

$$x(t) = \frac{1}{\sqrt{JN}} \sum_{n=0}^{N-1} X(n) e^{\frac{j2\pi nt}{JN}} \qquad 0 \le t \le T \tag{2}$$

Where n=0, 1 ,…….., JN-1is time index and J is the oversampling ratio. According to the central limit theorem, when N is large, both the real and imaginary parts of x (t) become's Gaussian process. Thus it is possible that the maximum amplitude of OFDM signal may well exceed its average amplitude. Practical hardware i.e. A/D and D/A converters, a power amplifier has finite dynamic range; therefore the peak amplitude of OFDM signal must be limited [6].

$$PAPR = 10 \log_{10} \frac{\max[|\mathrm{x_n}|^2]}{\frac{1}{T}\int_0^T [|\mathrm{x_n}|^2] \; dt} \; (dB) \tag{3}$$

It is easy to see from (2) that PAPR reduction may be achieved by decreasing the numerator value and increasing the denominator or both.

Complementary Cumulative Distribution Function (CCDF) curves present vital role in the OFDM signal to be transmitted. It uses to measure the effectiveness of PAPR reduction with different transforms

$$CCDF = prob(PAPR > \gamma_0) = 1 - (1 - e^{-\gamma_0})^N \tag{4}$$

IV. NCT ALGORITHM DESCRIPTION

The principle of NCT is defined as follows. The original signal x_n is companded before converted into analog waveform and amplified by the high power amplifier. Basic idea of NCT algorithm is to transform the input baseband signal $|x_n|$ into the suitable PDF defined by a multiple sub-functions, which consist of threshold points like inflexion and cutoff points of the PDF of $|y_n|$ are c(0<c<1) and A(A>0) respectively [7]. Thus, the suitable target PDF can be expressed as

$$f_{|yn|}(x) = \begin{cases} k1x\,, & 0 \le x \le cA \\ k2x + (k1 - k2)cA, & cA < x \le A \end{cases} \tag{5}$$

Where $K_1$and $K_2$are slopes of the variable parameters that determine the desirable companding form i.e PAPR, while controlling the average output power in the transform.

The Corresponding CDF of $|y_n|$ can be expressed as

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

$$F_{|yn|}(x) = \begin{cases} \frac{k1}{2}x^2 & 0 \le xcA \\ \frac{k2}{2}x^2 + (k1-k2)cAx - \frac{(k1-k2)}{2}cA^2 & cA < x \le A \\ 1 & x > A \end{cases} \tag{6}$$

And the inverse CDF function of y_n is expressed as below

$$F_{|y_n|}{}^{-1}(x) = \begin{cases} \sqrt{\frac{2x}{k1}} & x \le \frac{k_1}{2}(cA)^2 \\ \frac{1}{k_2}\left((k_2-k_1)cA + \sqrt{(k_2-k_2)\,k_1\,c^2A^2 + 2k_2}\right) & x > \frac{k_1}{2}(cA)^2 \end{cases} \tag{7}$$

Thus, the proposed companding function at the transmitter is given by below

$$h(x) = gn(x).F_{|y_n|}{}^{-1}\left(F_{|x_n|}(x)\right)\begin{cases} sgn(x)\sqrt{\frac{2}{k_1}\left(1-e^{\frac{-|x|^2}{\sigma^2}}\right)} & |x| \le \gamma_0 \\ sgn(x)\frac{1}{k_2}\left((k_2-k_1)cA + \sqrt{(k_1-k_2)k_1\,c^2A^2 + 2\,k_2\left(1-e^{\frac{-|x|^2}{\sigma^2}}\right)}\right) & |x| > \gamma_0 \end{cases} \tag{8}$$

At the receiver side, the companded signal can be recovered by the corresponding de-companding function as seen in below equation (9) .

$$h^{-1}(x) = \begin{cases} sgn(x)\sigma\sqrt{-\ln\left(1-\frac{k_1|x|^2}{2}\right)} & |x| \le cA \\ sgn(x)\sigma\sqrt{-\ln\left(\frac{k_1|x|^2}{2} + (k_2-k_1)cA|x| + 1 - \frac{c^2A^2}{2}(k_2-k_1)\right)} & |x| > cA \end{cases} \tag{9}$$

A.NCT ALGORITHM MODELING

Step 1.To obtain the OFDM symbols

Step 2.Divide the entire symbols into two disjoint sub-blocks and append zeros of 'j' oversampling Symbols between them

Step 3.To calculate CDF of these symbols

Step 4.To equate this CDF and inverse CDF for companding and de-companding of OFDM symbols.

Step 5 .To evaluates the performance of the proposed algorithm under different channel environment**.**

V. RESULT AND DISCUSSION

PAPR OF THE COMPANDED SIGNAL

PAPR is pictured in fig.1. This algorithm offers a tolerable flexibility in the PAPR reduction by adopting the values of K2 and c .Accordingly, the ultimate PAPR of the companded signal can be in effect, imprisoned in the separation [4.8db, 7.8db].

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

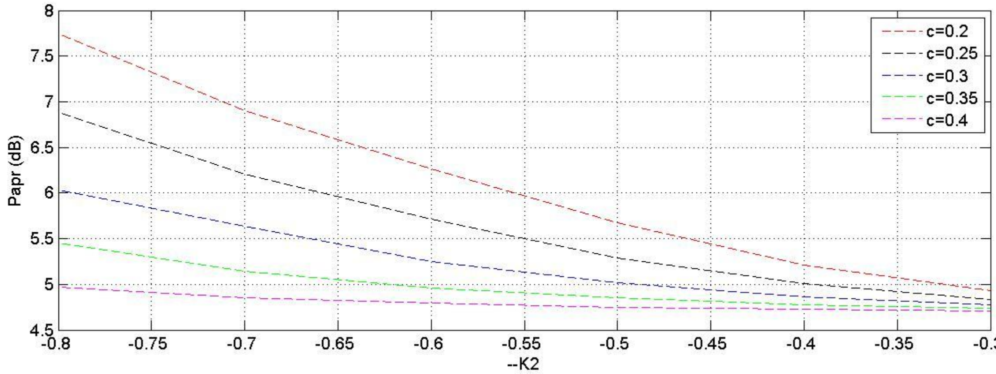

Fig 1.The ultimate PAPR of companded signal

TRANSFORM GAIN OF THE COMPANDED SIGNAL

Gain is depicted in fig 2.The achievable transform gain G in the PAPR is from 6 to 7.7 dB

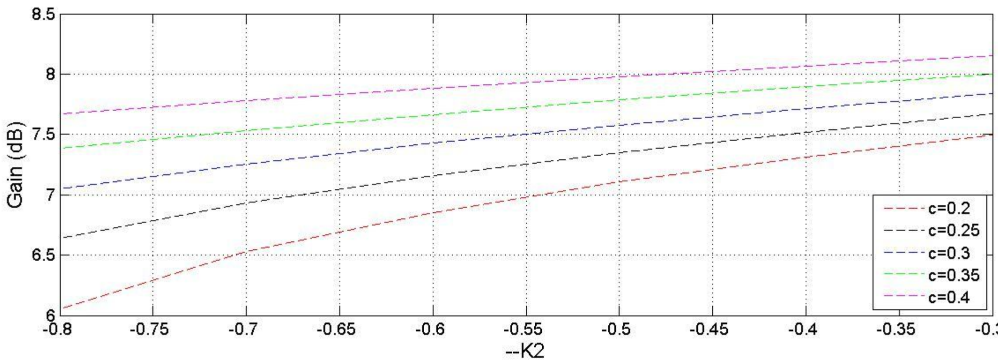

Fig.2.Transform gain of proposed algorithm

ATTENUTION FACTOR OF PROPOSED ALGORITHM

The theoretical results of attenuation is depicted in fig .3, from that we can see that attenuation gradually tends to 1 as k2 and c decrease.

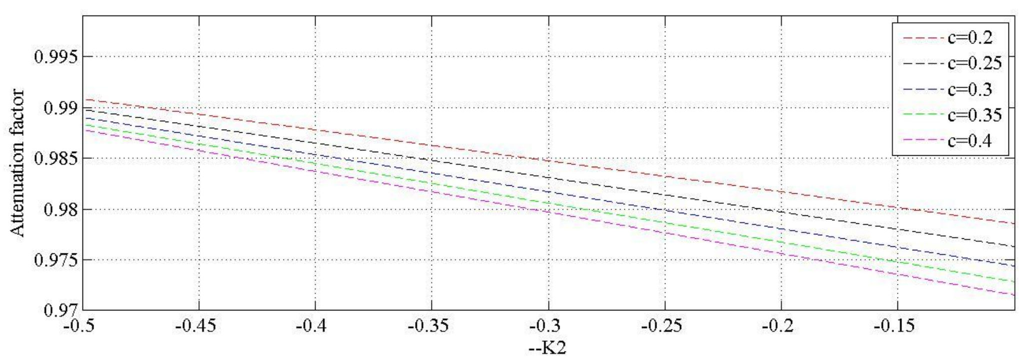

Fig.3.Theoritical results of attenuation factor of the proposed algorithm

COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION

Fig.4**,** depicts the CCDF of the PAPR with different transforms. The new algorithm was roughly 0.3dB and 0.1Db inferior to exponential but surpasses the origin signal by 0.1 to 0.8 dB.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

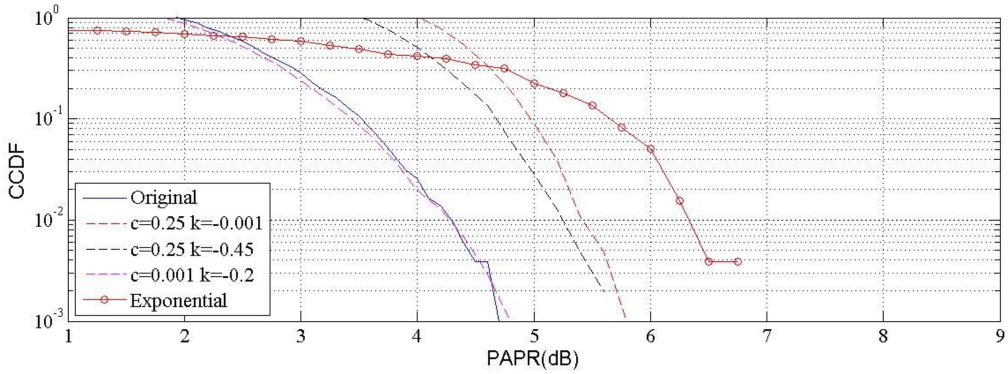

Fig.4 PAPR reduction performance of different transform for OFDM system with N=1024 symbols

BER PERFORMANCE UNDER DIFFERENT MULTIPATH FADING CHANNELS

In order to investigate the performance degradation and spectral regrowth, we also consider passing the companded signal through **AWGN** channel, **Rician** multipath fading channel and **ETU** (extended typical urban channel).In fig 5 and 6 present BER versus E_b/N_o curves with different transform under an AWGN channel and Rician fading channel using QPSK and 16QAM, respectively .These two fig's shows that the NCT methods effectively reduces the PAPR, BER performance at the receiver side. It can be seen that the required E_b/N_o of the proposed algorithm are better than the referred methods for a given BER.

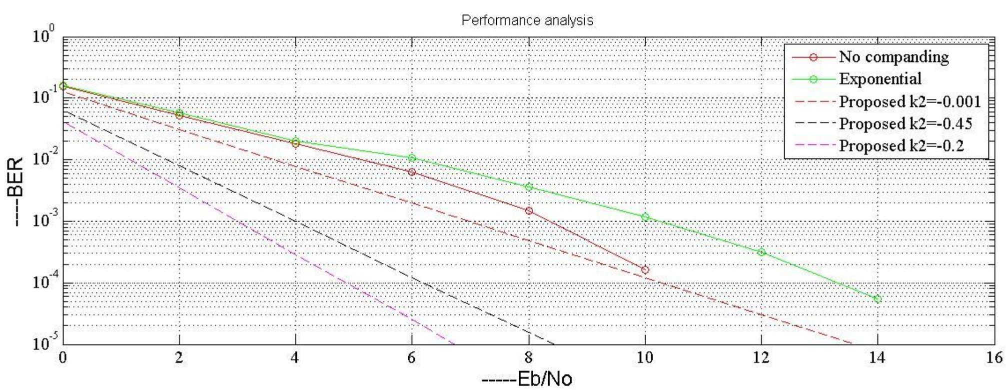

Fig.5 BER performance of different transform under an AWGN channel

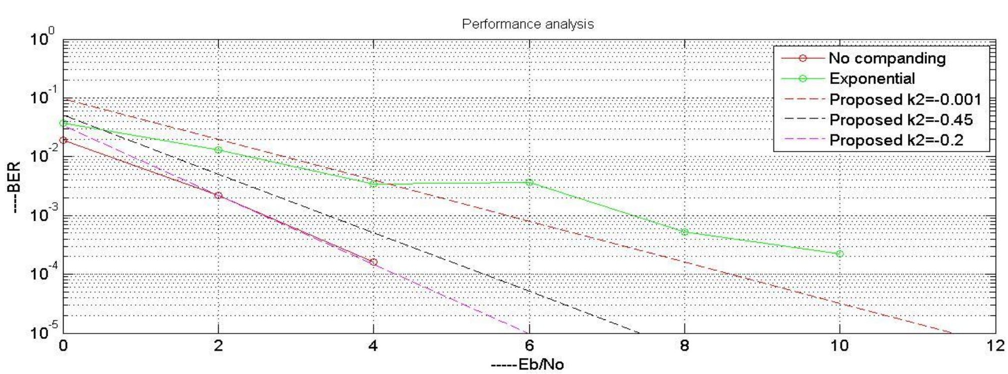

Fig.6 BER performance of different transform under Rician multipath fading channel

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

BER UNDER ETU CHANNEL

ETU channel is moreover used in mobile environment for communicating in high density areas like Japan, Tokyo and Europe countries. In ETU channel path gain is very much high and BER is less when compared to remaining noisy channels.

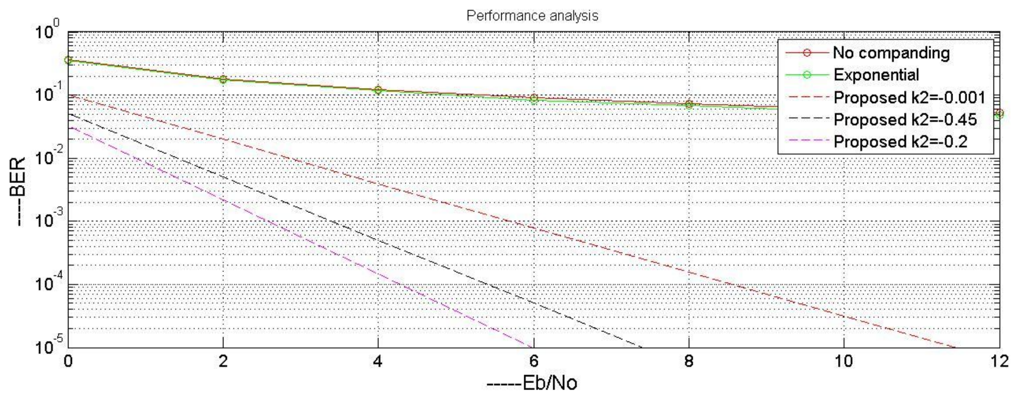

Fig.7.BER performance of different transform under the ETU channel

SPECTRAL CHARACTERISTICS

The spectral regrowth comparision is shown in fig.8,we can find that the new algorithm with c=0.25,k2=-0.45 can produce about 2db to 4db lower out-of-band interference than other referred methods at normalized frequency 0.4.

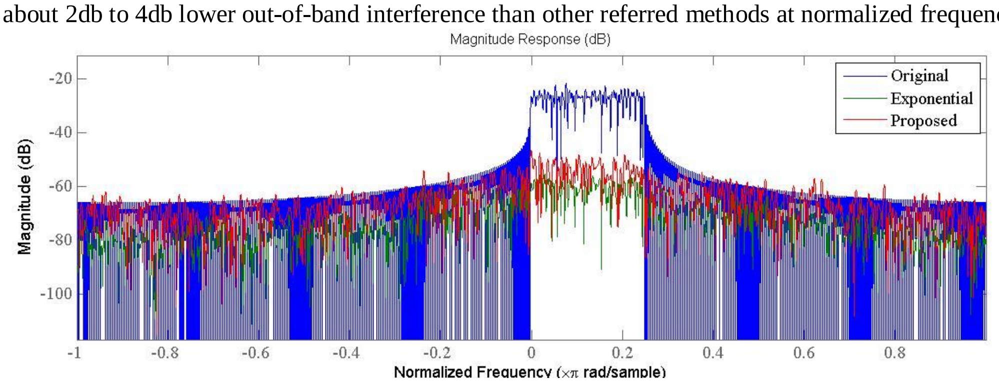

Fig 8.Simulated PSD of different transforms for the OFDM system with N= 1024

.

VI .CONCLUSION

Due to its simplicity and effectiveness, NCT is an attractive solution to reduce the PAPR of OFDM signal .This algorithm can offer the transform gain in PAPR of 6 to 7.7db compared to the original signal .Both theoretical analysis and computer simulations show that the algorithm offers improved performance in terms of BER, in-band and out-of-band distortions while reducing PAPR effectively.

VII .FUTURE SCOPE

In future, there are following possible topics to continue this paper work.
1. This paper can be extended for different types of modulation technique (64QAM, BPSK), it can be used higher modulation order and high number of sub carrier to be utilized in other wireless standards.
2. BER expressions for other fading channels like Nagakami-m channels can be evaluated and confirmed.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

REFERENCES

[1] T. Hwang, C. Yang, G. Wu, S. Li, and G. Y. Lee, "OFDM and its wireless application: A survey," *IEEE Trans. Veh. Technol.*, vol. 58, no. 4, pp. 1673–1694, May 2009.

[2] T. Jiang and Y. Wu, "An overview: Peak-to-average power ratio reduction techniques for OFDM signals," *IEEE Trans. Broadcast.*, vol. 54, no. 2, pp. 257–268, Jun. 2008.

[3] X. B. Wang, T. T. Tjhung , and C. S. Ng, "Reduction of peak-to-average power ratio of OFDM system using a companding technique," *IEEE Trans. Broadcast.*, vol. 45, no. 3, pp. 303–307, Sep. 1999.

[4] T. Jiang, Y. Yang, and Y. Song, "Exponential companding transform for PAPR reduction in OFDM systems," *IEEE Trans. Broadcast.*, vol. 51, no. 2, pp. 244–248, June 2005.

[5] Y. Jiang, "New companding transform for PAPR reduction in OFDM," *IEEE Commun. Lett.*, vol. 14, no. 4, pp. 282–284, Apr. 2010.

[6] D. Dardari, V. Tralli, and A. Vaccari, "A theoretical characterization ofnonlinear distortion effects in OFDMsystems," *IEEE Trans. Commun.*,vol. 48, no. 10, pp. 1755–1764, Oct. 2000.

[7] P. Banelli, "Theoretical analysis and performance of OFDM signals in nonlinear fading channels," *IEEE Trans.Wireless Commun.*, vol. 2, no.2, pp. 284–293, Mar. 2003.

[8] *Digital Video Broadcasting: Framing Structure, Channel Coding, and Modulation for Digital Terrestrial Television*, ETSI EN 300 744 v1.4.1,2001..

BIOGRAPHY

Lakshmi Pindi obtained her B.Tech. Degree from Avanthi Institute of Information Technology, affiliated to JNTU Kakinada, Andhra Pradesh, India in the year 2012. Now she is pursuing M.Tech from Vignan's Institute of Information and Technology, Visakhapatnam, affiliated to JNTU Kakinada, India. She is interested in the field of Wireless communication, image processing and signal processing.

Uma Maheswari obtained her B.Tech. Degree from Avanthi Institute of Information Technology, affiliated to JNTU Kakinada, Andhra Pradesh, India. She is obtained her M.Tech specialization in VLSI design .currently she is working as a Assistant professor in Vignan's Institute of Information and Technology, Visakhapatnam, Andhra Pradesh. She is interested in the field of VLSI design, Wireless communication.

10.15662/ijareeie.2014.0311062