International Conference on Smart Electronic Systems - 2016
KLE Society's Dr M S Sheshgiri College of Engineering & Technology, Belagavi

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 3, 2016, pp. 17-21

PAPR Reduction by Symbol Preference

Bahubali K. Shiragapur [1], Uday V. Wali[2], Sandeep Bidwai[3]
Department of E&C, K.L.E. Society's Dr. M.S. Sheshgiri College of Engineering & Technology, Belgavi, Karnataka, India.
Email:{bahu2001@rediffmail.com[1], udaywali@gmail.com[2],profssb@Gmail.com[3]}

Abstract— **Lower Peak to Average Power Ratio (PAPR) is critical to the performance of an OFDM system. This paper discusses a new proposal for PAPR reduction based on symbol preferences. The basic idea of the proposed method is to estimate the power required for a symbol and choose a set of symbols that consume less power. The effect of various coding techniques on power consumption and choice of symbol set is discussed. This can result in asymmetric allocation of symbol set that is hard to decode. However, newer ANN based classification methods can alleviate the decoding problem. We have presented simulation results based on a 64-set of symbols.**

Index Terms—***Orthogonal Frequency Division multiplexing, Peak-to-Average-Power, Selective Mapping, Additive White Gaussian Noise.***

I. Introduction

OFDM is a multi-carrier system superior to a single carrier system because of its high spectral efficiency, robustness to channel fading, immunity to impulse interference, good spectral density, and reduced non-linear distortion over nonlinear channels [1-5]. Now-a-days OFDM modulation technique used in many new broadband Digital Audio Video Broadcast (DAVB) systems. In recent years OFDM has emerged as the key technology for high data rate transmission applications (up to 100 Mbps on down link and 30 Mbps on the uplink) [5]. However, OFDM system suffers from High Peak-to-Average ratio (PAPR) which is an undesirable. This puts a limitation over the transmission of OFDM signal. Among all techniques that have been proposed to reduce the PAPR based on signal scrambling techniques, the Selected Mapping technique is one of the best good techniques. SLM is a probabilistic technique. The basic idea is to convert a data block into several data blocks which are independent of each other. Select the data blocks having lower PAPR Among these blocks for the transmission of OFDM signals [8-12].

The proposed method goes one step further trying to identify specific combinations of I-Q combinations that yield low PAPR. Selection among these symbols can significantly reduce overall PAPR. We also show that the reduction is independent of encoding methods used to reduce peak power.

This paper is organized as a description of OFDM systems, OFDM implementation, Coding techniques and result & discussion followed by a conclusion.

II. OFDM system:

In multi-carrier signal system, sub-carrier frequencies are integral multiple of base band signal frequency. These set of sub-carriers are mutually orthogonal to each other over a period of a base band signal. In OFDM digital modulation system, individual carriers are usually modulated by QPSK or QAM. In practice QPSK-OFDM, 16-QAM and 64-QAM OFDM systems are used to transmit OFDM temporal signal. The 64-QAM OFDM system is widely used for terrestrial DAVB. Figure 1 refers to a 16-QAM constellation; each symbol is characterized by four bits of binary combinations.

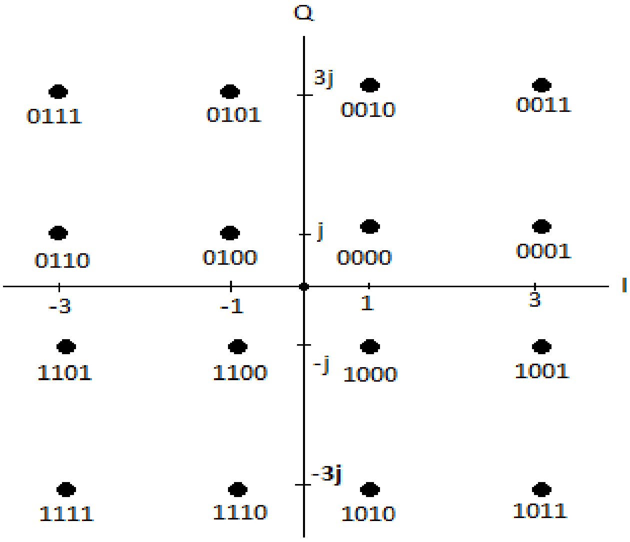

Figure-1: OFDM constellation, using 16-QAM

The serial input data stream is converted into *N* parallel sub-streams with a selected modulation scheme (signal mapper) resulting in *N* sub-channels containing information in complex number form [4]. The figure 2 shows a block diagram of basic OFDM modulation using 16-QAM [10].

OFDM modulation and demodulation is performed for all sub-carriers by IFFT at the transmitter and FFT at the receiver side. As shown in figure-2 bit stream is an input data for IFFT, consider a 16-QAM OFDM modulation scheme as shown in figure 2. In 16-QAM four bits (e.g., 0110) are allocated to symbol (I) and carrier (k) [10].

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 3, 2016, pp. 17-21

The complex data *S(I,k)* is input to the IFFT can be expressed as;

$$S(I,k)= D(I,k)+ j\, E\, (I,k) \quad (1)$$

$$=-3+j \quad (2)$$

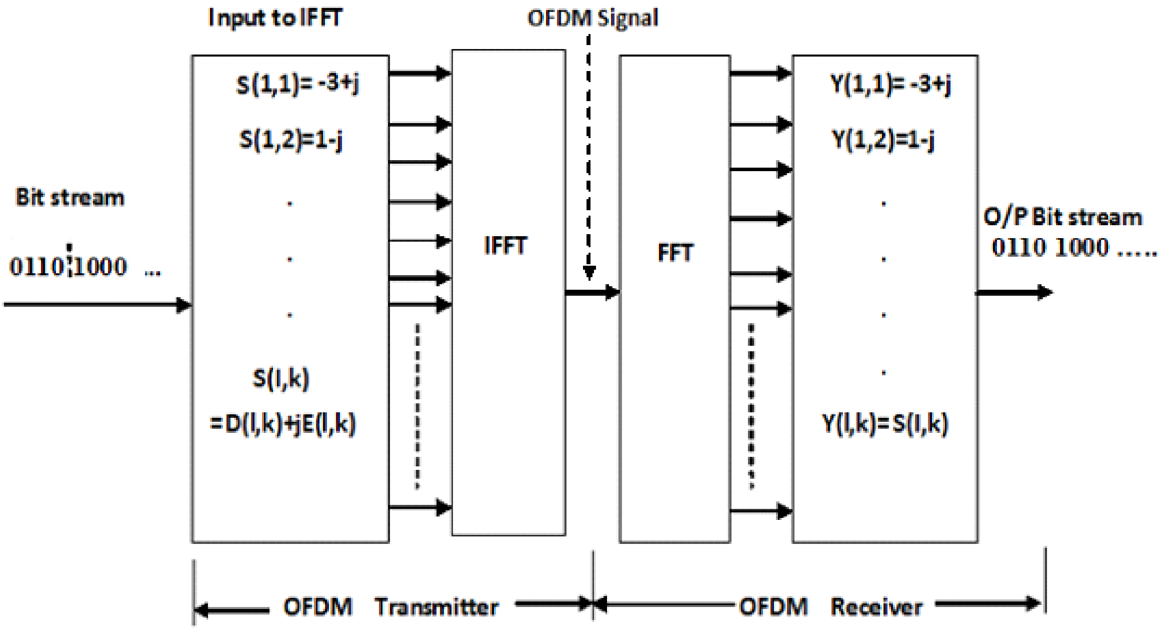

Figure-2: OFDM system using 16-QAM modulation

The data conversion will be done for all sub-carriers of the 16-QAM OFDM system. The data *S (I, k)* are input to IFFT and finally OFDM signal obtained. Similarly, on receiver side inverse operations are done with the transmitted signal to obtain a bit stream.

It is important to note that at the transmitter side, certain symbols have the same phase and amplitude, adding each other results into high peaks at the output of IFFT. This resultant high peak quantity in OFDM temporal signal is expressed as Peak-to-Average-Power Ratio (PAPR). Our research aims to reduce this quantity to improve the performance of OFDM system.

III. Symbol Sampling

During the simulation of these techniques we observed that certain sets of symbols consume more power compared to other sets of symbols. This consumption of power is not related to the amplitude of the encoded symbol, but the symbol distribution over code set. We have extensively studied such power distribution over symbol sets for various coding techniques. The main objective of this study is to identify symbols that are likely to be power intensive and avoid such symbols by using an alternate symbol assignment. The results suggest asymmetric allocation of symbol maps over the traditional symmetric symbol map. The technique and results of this observation are discussed.

A.1 Constellation Mapper:

The constellation Mapper maps the incoming bits into symbols, these symbols are having different frequency and phases. These symbols are loaded onto different sub-carrier. For experimentation 16-QAM is used. The incoming bits are mapped into complex and real value for gray coded bits are mapped based on below table- I.

Table-I Gray coded bit combinations for complex and real values

Gray coded bit combination of the LSB		Complex value	Gray coded bit combination of MSB		Real value
D3	D2	-	D1	D0	-
0	0	-3j	0	0	-3
0	1	-j	0	1	-1
1	0	3j	1	0	3
1	1	J	1	1	1

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 3, 2016, pp. 17-21

The data bits are grouped into 4-bits each, represented in Gray-code for better understanding. The below figure 3 shows the constellation diagram for 16-QAM in gray coded format, D0D1 bits used to represent In-phase (I) component and D2D3 are used to represent Quadrature (Q) component.

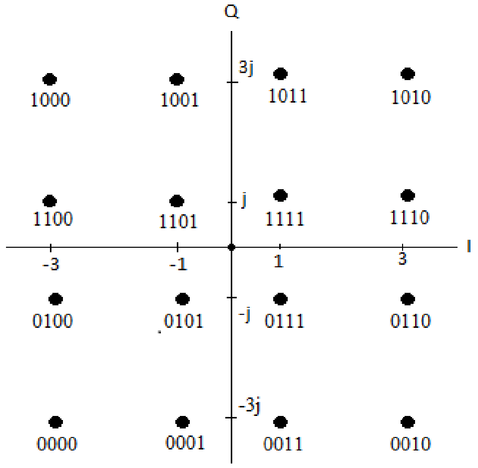

Figure 3: 16-QAM Graded coded corresponding complex value

B Linear coding techniques Symbol power:

We have calculated the symbol power using the following equation;

$$PAPR = \frac{max_n\{x[n]^2\}}{E_n[x[n]^2]} \;; \qquad (3)$$

Where x[n] represents a discrete time domain symbol and E_n is its statistical expectation. Squaring of these parameters allows us to express the ratio as power term. PAPR has been always a positive number and generally measured in dB. In our simulation x[n] is the real and imaginary data of the OFDM modulator system. We have plotted the results using 2D and 3D plots for different PAPR reduction techniques associated contour map, details are discussed further.

B.1 Hamming Encoder

Hamming code (7, 4) is used with single error correction capability, lower Hamming distance symbols are selected for transmission.

B.2 Low density parity check code

In an experiment (6, 12) LDPC code is used. The LDPC coded bits are further processed by symbol mapper. The basic idea is to introduce LDPC code before symbol mapper is to, add redundancy and spread the signals in time domain to reduce PAPR.

B.3 *Convolutional Encoder*

For experimentation code rate 1/2 with constraint length of ([5, 4]) is used to encode the input data. To verify the efficiency of Linear block codes 64-symbols are considered for analysis PAPR.

B.4 *Hybrid technique*

It is a combination of probabilistic and commanding technique, we have reported elsewhere [11, 14] significant reduction of PAPR by hybrid technique as compared to other conventional techniques.

IV. Result and Discussion:

Figure 4 shows a 2D contouring plot for the simple OFDM modulator. It is observed that, for real data value (0) and imaginary data value (1.5) occupies highest power (Region R2), (0, -1.5) minimal power (R4), (-0.5, -1.5) moderate power (R3) and (-0.5, -0.5) represents the average power (R1).

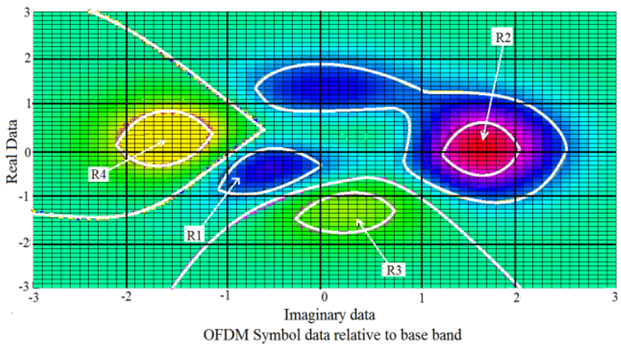

Figure 4: 2D contour plot of OFDM Symbol power

Figure-5 represents data symbols' power requirement and distribution analysis done by contour plot using MATLAB tool. As it is shown in figure 5 peak P1 represents a certain set of symbols requires high power (red color region represents a higher power symbols region). The peak P2 represents moderate peak requires average power (blue color region shows an average power symbols region) and peak P3 represents minimum power (green region shows Minimum power symbols region).

For experiment analysis 64 sets of data symbols are considered among several set of symbols. From figure 6 to figure 9represents data symbols power requirement of OFDM systems with Convolutional LDPC, Hamming code and Hybrid technique similarly result analysis carried out using MATLAB tool. It is also observed that certain set of symbols are near to origin for Convolutional OFDM and LDPC OFDM as compared to simple OFDM. This shows that near to origin symbols requires lesser power as compared to far away from the origin, signifies a reduction in peak power by linear coding techniques. Finally, it is concluded that, selection

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 3, 2016, pp. 17-21

symbol preference plays an important role in the reduction of PAPR.

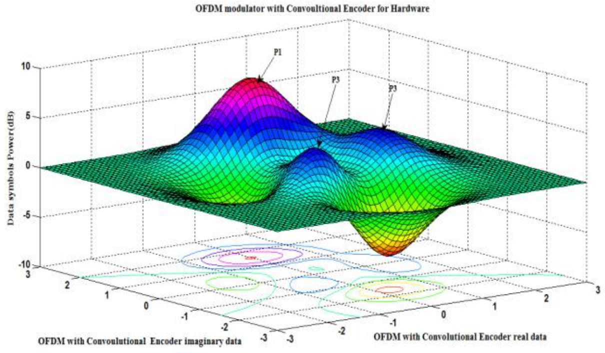

Figure 5: Simple OFDM Modulator data symbol's power (dB)

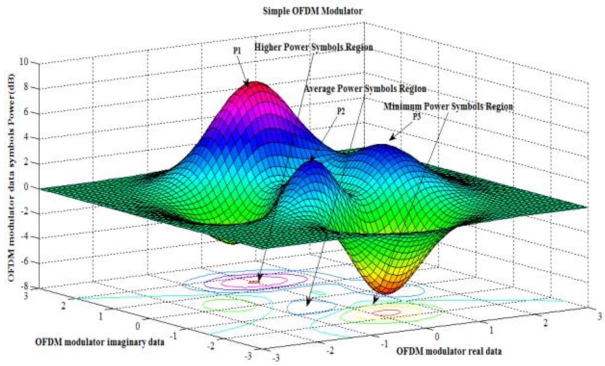

Figure 6: Convolutional OFDM Modulator data symbol's power (dB)

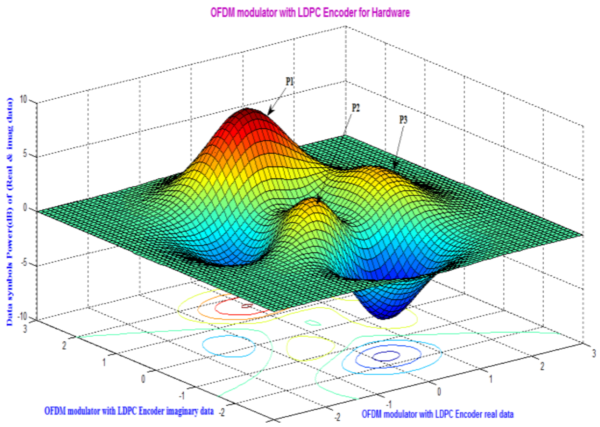

Figure 7: OFDM Modulator with LDPC data symbol's power (dB)

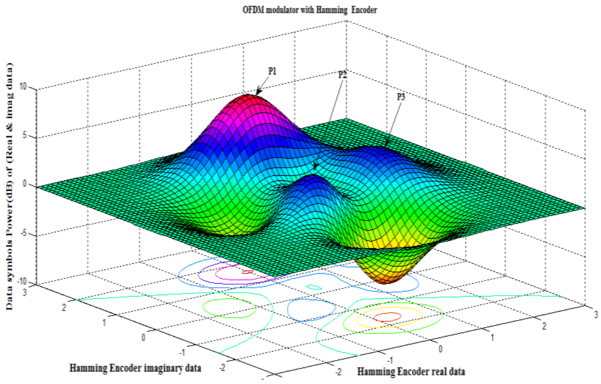

Figure 8: OFDM Modulator with Hamming code data symbol's power (dB)

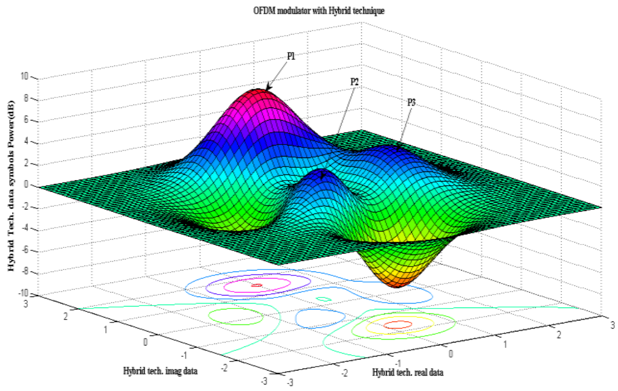

Figure 9: OFDM Modulator with Hybrid technique data symbol's power (dB)

V. CONCLUSION

In this paper, we have presented power associated with an OFDM symbol, without considering integral multiple frequencies of base band. By slightly modifying the symbol allocation it is possible to choose a symbol set that has low power. Non integral allocation of symbol frequency will pose problems in decoding the incoming signal but can be decoded using ANN techniques, which are still under development.

VI. REFERENCES

[1] Prasad, R. V. , "OFDM Wireless Mutlimedia Communications" Uitgave: Artech House Publishers, 2000.

[2] Molisch, A. F., "Wireless Communications", John Wiley & Sons Ltd, 2011.

[3] Rappaaport, T. S., "Wireless communications, Principles and Practices",2nd edition, N.J.; Printice hall, 2002.

[4] Shu Lin, Daniel J and Costello, "Error control coding fundamentals and applications", Pearson 2nd edition.

[5] J. Tellado "Peak to Average Power Reduction for multi-carrier Modulation", Stanford University,Ph.D dissertation, 2000.

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 3, 2016, pp. 17-21

[6] O. Daoud and O. Alani, "Reducing the P APR by utilization of the LDPC code", lET Communication, Vol. 3, no. 4, pp., 520-529, 2009.

[7] O. Daoud and Alani O. "PAPR Reduction by Linear Coding Techniques for MIMO- OFDM Systems Performance Improvement: Simulation and Hardware Implementation", European Journal of Scientific Research ISSN 1450-216X Vol.36 No.3. pp 376-393, 2009.

[8] Bauml R.W, Fischer, R.F.H and Huber, J.B, "Reducing the Peak-to-Average Power Ratio of Multicarrier Modulation by Selected Mapping", Elect. Lett., pp. 2056–57, vol. 32, no. 22, Oct. 1996.

[9] Sajjad Ali, Zhe Chen, and Fuliang Yin, "Peak-to-Average Power Ratio Reduction Using N-tuple Selective Mapping Method for MC-CDMA", ETRI Journal, Volume 37, Number 2, pp.-339-347, April 2015.

[10] Yang Jie, Chen Lei, Liu Quan and Chen De "A Modified Selected Mapping Technique to Reduce the Peak-to-Average Power Ratio of OFDM Signal", Consumer Electronics, IEEE Communication Transcation, pp-846-851, August 2007.

[11] Bahubali K. Shiragapur1 and Uday Wali "Peak-to-Average Power ratio reduction using coding and hybrid techniques for OFDM system", ICTACT Journal on Communication Technology, March 2016, volume: 07, issue: 01, issn: 2229-6948 (online).

[12] Bahubali K Shiragapur, Dr Uday Wali and Mr. Sandeep Bidwai, "Novel Technique to reduce PAPR in OFDM systems Using Threshold SLM", AKGEC Ghaziabadh, UP, pp. 516-520, IEEE Catlog-Number: CFP1339F-CDR, ISBN-978-1-4673- 4528-6, ISSN- 978-1-4673-4529-/12/$31.00c, 2013.

[13] Bahubali K Shiragapur, Dr Uday Wali and Mr. Sandeep Bidwai, "Novel technique to reduce PAPR in OFDM systems by clipping and filtering", ICACCI, Mysore, pp.- 1593 –1597, Print ISBN: 978-1-4799-2432-5, 2013.

[14] Bahubali K Shiragapur, Dr Uday Wali "Hybrid techniques for PAPR reduction of OFDM signal", Transtellar, International Journal of Computer Networking, Wireless and Mobile Communications" ISSN (P):2250-1568; ISSN (E):2278- 9448; Impact Factor (JCC): 5.6349, 2016.