International Journal of Soft Computing and Engineering (IJSCE)
ISSN: 2231-2307, Volume-5 Issue-6, January 2016

Modified SLM Combined with Interleaving and Pulse Shaping Method for PAPR Reduction using DCT and IDCT in MIMO-OFDM System

S. Sujatha, P. Raja, P. Dananjayan

Abstract— Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) is a most enthralling technology which has been recently proposed in wireless communication. It provides high data rate services and offer better system performances. It improves data throughput and delivers highest capacity as well. However, MIMO-OFDM suffers with the disadvantage of high peak-to-average power ratio (PAPR) for the large number of subcarriers which can effect the system output. Therefore, to overcome the problem of high PAPR in OFDM systems, an effective technique called Modified selective mapping (SLM) is used along with Inverse Discrete Cosine Transform (IDCT) matrix combined with interleaveing and pulse shaping to reduce the peak-to-average power ratio on both transmitter and receiver sides. By simulation results, it is seen that the proposed technique reduces PAPR.

IndexTerms—MIMO-OFDM,interleaving,pulseshaping, IDCT, PAPR

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a high speed wireless communication technology which has a demanding future in mobile communication system. It provides high data rates and high quality multimedia services to mobile users and also provides high data throughput and gives efficient wideband communication system. Due to all these advantages, OFDM plays an important role in various communication systems [1]. Multiple antennas are used to increase the competence of wireless communication systems. Space-time codes with OFDM results in wideband communication. By using multiple antennas at the transmitter and receiver, spatial diversity can be obtained as it does not increase the transmit power and signal bandwidth. Therefore, many high speed data transmission standards have been presented such as IEEE 802.16,IEEE 802.11a/g, digital video broadcasting (DVB) etc. MIMO-OFDM is an attractive and faster growing technology in wireless communication systems. It provides better performance, high data rates, reliability compare to OFDM system. However, MIMO-OFDM suffers with some of the problem which effects the communication system. PAPR is such an issue which cannot be ignored. The Peak to Average Power Ratio brought about because of expansive number of sub-bearers in normal OFDM frameworks, adequacy of the transmitted signal has a vast element reach, Promoting in-band contortion without band radiation when the signal is gone through the nonlinear locale of force enhancer. Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) is one of the most attractive standard technologies for fourth generation (4G) wireless communication. MIMO-OFDM systems use multiple antennas at both the transmitter and receiver for spatial multiplexing and spatial diversity. The transmitted signal bandwidth is so narrow that its frequency response can be assumed as being flat [2]. MIMO-OFDM is the technology which combines multiple-input, multiple-output, which multiples capacity by transmitting different signals over multiple antennas and orthogonal frequency division multiplexing. MIMO-OFDM has several advantages of high data throughput, robustness against multipath fading, high power spectral efficiency and offer better performance. However, at the same time MIMO-OFDM suffers with a problem of high PAPR. High PAPR increases the complexity of analog-to-digital and digital-to-analog converters and also, reduces the efficiency of the radio-frequency (RF) power amplifier. There are several techniques used to reduce PAPR performance in MIMO-OFDM system. The techniques are categorized into 3 types- Distortion methods, Distortion less methods and other methods. These methods includes- Clipping, Companding, Selective mapping (SLM), Partial transmit sequence (PTS), Active constellation extension (ACE), Tone reservation (TR). Clipping considers a predetermined threshold which helps in reducing PAPR to a lowest value.

Interleaving combined with SLM is also introduced to reduce the PAPR in MIMO-OFDM system. Interleaving is basically the transmission of reordered consecutive bytes of data over a large sequence to reduce the effect of burst error. In this paper, PAPR is reduced by SLM combined with interleaving and pulse shaping method in MIMO-OFDM. SLM and modified SLM belong to the probabilistic class were different signals are obtained but the signal with minimum PAPR is taken into consideration. In SLM, several signals contain same information and one OFDM signal of lowest PAPR is selected. SLM is a flexible technique but it requires high computational complexity with low bandwidth efficiency. MIMO-OFDM is the foundation for most advanced wireless local area network (WLAN) and mobile broadband network standards because it achieves the greatest spectral efficiency and, therefore, delivers the highest capacity and data throughput. [2] [9]

Revised Version Manuscript Received on January02, 2016.

S. Sujatha, Research Scholar, Department of Electrical Communication Engineering, Pondicherry Engineering College, Puducherry (Tamil Nadu). India.

P. Raja, Associate Professor, Sri Manakula Vinayagar Engineering College, (Tamil Nadu). India.

P. Dananjayan, Department of Electrical Communication Engineering, Pondicherry Engineering College, Puducherry (Tamil Nadu). India.

The occurrences of high peaks in the transmitted OFDM signal causes the degradation of the system performance due to various non-linear effects like spectral spreading and inter-modulation distortion [2]. Normally, OFDM signals have the problem of high peak-to-average power ratio (PAPR) when the signals of all sub-carriers are added constructively and so the peak power can be number of sub-carriers times the average power. The power consumption of a power amplifier depends largely on the peak power than the average power. Thus, handling occasional large peaks leads to low power efficiency. Therefore the PAPR problem is dealt with techniques including clipping, commanding, selective mapping (SLM) and non-linear commanding transforms and DCT. Clipping reduces the signal power but degrades bit error rate (BER) performance and causes non-linear phenomena such as spectral spreading. Spectral spreading causes degradation of spectral efficiency [1]. The absence of the PAPR reduction techniques will cause the increase in the transmit power, increase in BER at the receiver and data rate loss [8]. Therefore, an effective technique SLM has been used in this paper which helps to reduce PAPR to a minimum value. SLM is a distortionless type method and an attractive technique used to improve the PAPR reduction performance. In SLM, the data input information is divided into many smaller disjoint subsequences. The input data is carried out and IFFT is performed. Each subsequence is then multiplied with rotating phase factors. The output combined with rotating phase factors are then added to obtain OFDM symbol for transmission [9]. Each and every subsequence determines the PAPR reduction. PAPR is computed for each resulting sequence and the signal sequence with minimum PAPR is considered and transmitted. The partitioning types for PAPR reduction can be categorised as- interleaving partition, adjacent partition and pseudo-random partition. However, SLM in modified form is the better option compared to an ordinary SLM because in an ordinary SLM, all the phase factor combination are considered which results in the increasing complexity with the several number of subsequences. Hence, modified SLM is being considered to complete the PAPR reduction and to reduce the system complexity as well. Therefore modified SLM is a successful technique and has real and imaginary parts which are separatly multiplied with phase factors.

II. PAPR OF OFDM SIGNALS

The PAPR of OFDM is defined as the ratio between the maximum instantaneous power to the average power, given by:

$$PAPR = \frac{\max\left|x(t)\right|^2}{E\left[\left|x(t)\right|\right]^2} \qquad (1)$$

.
where x(t) denotes an OFDM signals after IFFT, and E[.] denotes expectation. The complex baseband OFDM signal for N subcarriers can be represented as,

$$s(t) = \frac{1}{\sqrt{N}} \sum_{k=1}^{N-1} Y_k e^{j\pi k \Delta f t} \qquad (2)$$

where Y_k is the data symbol carried by the k^{th} subcarrier.

According to the central limit theorem, both real and imaginary part of s(t) is Gaussian distributed, for large values of N. The Cumulative Distributed Function (CDF) of the signal is

$$F(z) = 1 - \exp(-z) \qquad (3)$$

If there are N subcarriers in an OFDM system and all the sampling values are completely independent, the CDF of the system is given by the equation:

$$P(PAPR \le z) = (f(z))^N = (1 - e^{-z})^N \qquad (4)$$

So in case of no over-sampling, the Complementary Cumulative Distribution Function (CCDF), which is usually used as an important parameter to describe the PAPR of an OFDM system is given by,

$$P(PAPR > z) = (f(z))^N = (1 - e^{-z})^N \qquad (5)$$

SLM is one of the probabilistic techniques adopted to reduce the PAPR of the OFDM signal. Hence it can achieve PAPR reduction without distorting the signal and will not cause any loss of data. The main disadvantage of SLM is that the complexity is high. Now there are many extension schemes for reducing the complexity of SLM [13-16].

III. SELECTIVE LEVEL MAPPING

The SLM technique was first described by Bauml et al.[8]. In the SLM, from a number of copies that represent the same information, one with lowest PAPR is chosen for transmission

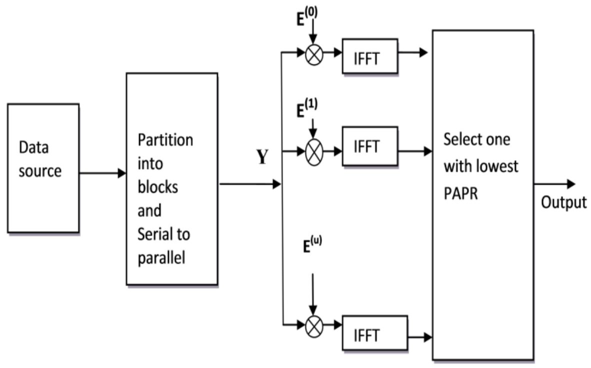


Fig.1 Selective Mapping

Figure 1 shows the block diagram of the SLM technique. Y is the OFDM data block, C_n is the phase vector and Y_n is the modified data vector in the frequency domain. So, the time domain signal, is given by,

$$Y_u(t) = \frac{1}{\sqrt{N}} Y_k e_u k e^{j2\pi k \Delta f t} \qquad (6)$$

where u = 1,2,……U and N is length of Y, also the number of subcarriers.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Among the modified data blocks, the one with the lowest PAPR is selected for transmission. The amount of PAPR reduction for SLM depends on the number of phase sequence U and the design of the phase sequence.

IV. DCT TRANSFORM

The Discrete Cosine Transform is a Fourier-like transform, which was first proposed by Ahmed et al. [17-23]. The idea to use the DCT transform is to reduce the autocorrelation of the input sequence to reduce the peak-to-average power problem and it requires no side information to be transmitted to the receiver. In the section, we briefly review DCT transform. The 1D discrete cosine transform (1D DCT) A[k] of a sequence a[n] of length N is defined as:

$$A\left[k\right] = a\left[k\right]\sum_{n=0}^{N-1} a[n]\cos\pi\left[\frac{\pi(2n+1)k}{2N}\right] \quad (7)$$

For k = 0,1 . . . N- 1 , the inverse DCT is defined as,

$$a\left[n\right] = \sum_{n=0}^{N-1} a[k]A\left[k\right]\cos\pi\left[\frac{\pi(2n+1)k}{2N}\right] \quad (8)$$

k= 0, 1… N-1 where a[k] is defined as:

$$a[k] = \begin{cases}\sqrt{1/N} & for \quad k=0\\ \sqrt{2/N} & for \; k=1,2,\ldots\ldots\ldots\ldots N-1\end{cases} \quad (9)$$

The basis sequences of the 1D DCT are real, discrete-time sinusoids defined by:

$$C_N\left[n,k\right] = \cos\frac{\pi(2n+1)k}{2N} \quad (10)$$

The DCT basis consists of the following N real sequences.

$$C_N\left[n,0\right], C_N\left[n,1\right], \ldots\ldots\ldots\ldots C_n\left[n,N-1\right] \quad (11)$$

The equation (9) is expressed in matrix

$$A = C_N a \quad (12)$$

where A and a are both the vector with Nx1 and C_N is a DCT transform matrix with N x N.

The row (or column) of the DCT matrix C_N are orthogonal matrix vectors. Then we can use this property of the DCT matrix and reduce the peak power of OFDM signals. DCT can reduce the autocorrelation between the each component of OFDM signal and this can be applied to reduce the PAPR.

V. DCT WITH MODIFIED SELECTIVE MAPPING

DCT along with Selective Mapping is an efficient PAPR reduction technique. Despite the fact that the PAPR is reduced by modifying the OFDM signal without any distortion, the complexity of SLM is high. For every OFDM frame, SLM technique requires 'n' IFFT operations and this operation makes the system complicated. So as to prevail over system complexity, modified SLM is proposed. The modified SLM reduces IFFT operations and also the PAPR. This technique comprises of an IFFT block at the transmitter end and the decision of selecting data with lowest PAPR is accomplished using a decision algorithm before IFFT. Generally, the OFDM system is employed considering orthogonal basis of complex exponential function set. But, OFDM can also be implemented using a single set of co-sinusoidal function as an orthogonal basis. This co-sinusoidal function is integrated along with a discrete cosine transform (DCT). Therefore, this scheme is termed as DCT-OFDM and the output signal can be given as [2], The sequence of process is given below.

i. At the transmitter end, the source data is forwarded to the linear block encoder

ii. To the outcome of encoder DCT is applied and the transformed data is processed by modified SLM unit

iii. The modified algorithm illustrated in algorithm-1 is invoked

iv. The information with low PAPR is selected and output is generated

$$s(x) = \sqrt{\frac{2}{n}}\sum_{i=0}^{n-1} ds_i D_i \cos\left(\frac{i\pi x}{T_s}\right) \quad (13)$$

In the above equation, ds_0, ds_1, $\cdots$ ds_{n-1} represent the independent data symbols that are attained as of a modulation constellation. D_i takes the value as,

$$D_i = \begin{cases}\frac{1}{2}, & i=0\\ 1, & i=1,2\ldots n-1\end{cases} \quad (14)$$

The Modified SLM with Inverse Discrete Cosine Transform (IDCT) is picturized in Figure 2.

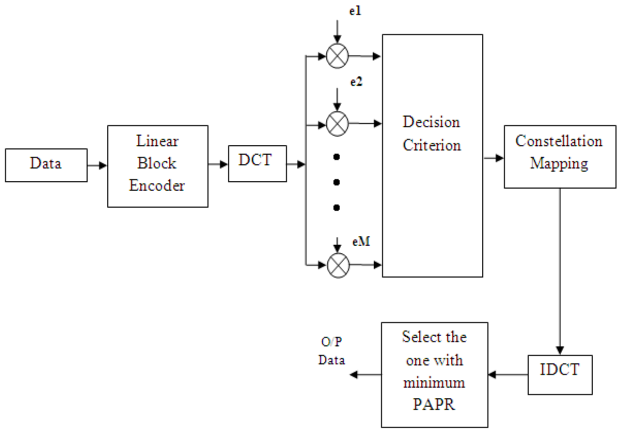


Figure-2 Modified SLM with Inverse Discrete Cosine Transform (IDCT)

VI. INTERLEAVING IN OFDM

In interleaving, a set of fixed permutations is used to break the highly correlated frames of OFDM to reduce PAPR [15]. In this technique, the transmitter uses K-1 interleaver which produce

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

K-1 permuted frames of the input data. The minimum PAPR frame among all the K frames is selected for transmission. The identity of the corresponding interleaver is also sent to the receiver as additional information. If all the K, PAPR computations are done simultaneously and lowest PAPR sequence is selected in one step, the processing delay at the transmitter is significantly reduced. Therefore, it can also be used with high speed data transmissions. he long correlation patterns explained in above concept can be broken down and reduces PAPR further. An arrangement of settled changes i.e. Interleaving is utilized to separate these examples and serves to lessen the PAPR. in this, a methodology of P-1 interleaves are utilized for transmitter and produces P-1 permuted edges of the information. For transmission, the least PAPR frames are selected having K frames and even transmitted at the receiver end. On the off chance that every one of the counts are done at the same time, the lower PAPR succession is chosen instantly and the deferral at the transmitter is altogether decreased.

Interleaving is the information reordering which is to be transmitted in a manner that progressive bytes of information are scattered over a bigger arrangement of data to diminish the upshot of burst lapses. The utilization of interleaving, all things considered, builds the capacity of blunder assurance codes for amended burst lapses.

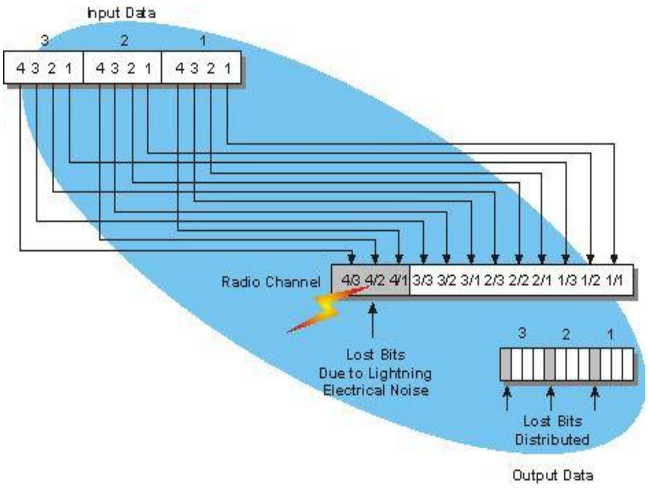


Fig 3 Interleaving Operation

MIMO-OFDM interleaving operation is very feasible for spectrum monitoring. The frequency location of every subcarriers of one subblock can be controlled by catching one subcarrier with framework parameters. For interleaved MIMO – OFDM, the N subcarriers gets parceled into V groups. At that point k^{th} subcarrier of every gathering is relegated to k^{th} user.

$$x^{(k)}(n) = \sum_{m=0}^{V-1} X_m^{(k)} e^{j\left(\frac{2\pi}{N}\right)(mQ+k)n} \qquad (15)$$

where k=0,1,…….Q-1 is the file of users and N is the aggregate number of subcarriers.

An interleaved MIMO-OFDM framework with N subcarriers is scaled from OFDM framework.

Importance of Interleaving

• Users screens radio movement on lone subblock via detecting stand out or two subbearers of subblock rather than all the subcarriers over entire recurrence band.

• Interleaving is likewise utilized to battle the impact of clamor bursts and blurring in error revision framework.

• A data frame, the crests in related OFDM signal is compacted by utilizing interleaving.

VII. PULSE SHAPING

Pulse shaping is the method indicating changing of transmitted pulses. The main purpose of pulse shaping technique is to provide better suitable transmitted signal for the communication of data. Inter symbol interference is caused due to transmission of high modulated signal. When signal bandwidth is increased by the channel bandwidth, it starts introducing distortion into the signals. The pulse shaping filters are used at the transmitter where it determines the signal's spectrum. A group of time waveforms that reduces the PAPR of OFDM signals was proposed in [16, 17]. However, the reduction obtained was not considerable. Consider a time waveform with constant energy equals to energy signal (Es=1) and uncorrelated symbols within each OFDM block, the maximum PAPR is obtained as follows:

$$PAPR \le PAPR_{\max} = \frac{1}{N}\max\left[\sum_{n=0}^{N-1}\left|P_m(t)\right|\right]^2, 0 \le t \le T \qquad (16)$$

where $P_m(t)$ is a pulse shape used at each subcarrier. With large number of subcarriers, the maximum of the PAPR occurs with very low probability.

The cross-correlation function of the OFDM signal is obtained as,

$$R_s(t_1,t_2) = \sum_{n=0}^{N-1}\sum_{m=0}^{N-1} SS^*_{m,k}\, p_n(t_1)\, p^*_m(t_2)\, e^{i\omega_c(nt_1 - mt_2)}$$

(17)

where ω_c is the carrier frequency of the system and the cross-correlation coefficient is zero for all samples separated by multiples of T.

A possible solution to reduce the PAPR of the OFDM signals is then to create some correlation between the different OFDM samples of the same block. The new set of pulse shape indicates that each subcarrier pulse of the OFDM scheme has a different shape and all these pulse shapes are derived from the same pulse. This will also reduce the PAPR of the OFDM transmitted signal since the peak amplitude of the different pulse shapes will never occur at the same time instant unless time waveform is a rectangular pulse.

The impulse response of a raised cosine filter is

$$r(t) = \text{sinc}(\pi \frac{t}{T}) \left[\cos(\frac{\pi\alpha t}{T}) / 1 - \frac{4\alpha^2 t^2}{T^2} \right] \qquad (18)$$

where the parameter α is the roll-off factor which ranges between 0 and 1. Lower values of α introduce more pulse shaping and more suppression of out-of-band signal components. Pulse shapes are very flexible and can control the correlation between the OFDM block samples without destroying the orthogonality property between the subcarriers of the OFDM modulated signal.

VIII. PROPOSED SOLUTION

Figure 3. Transmitter of modified SLM with interleaving and pulse shaping in OFDM system

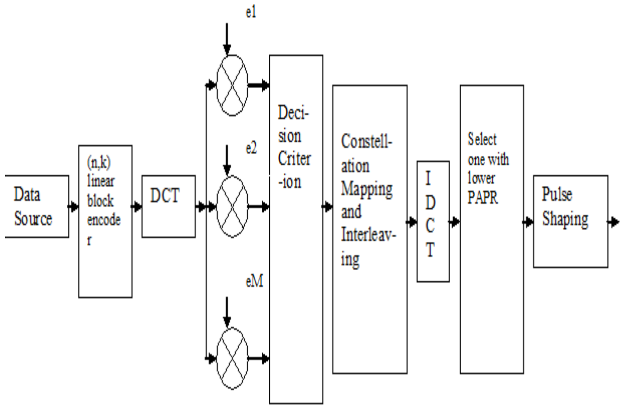


Figure 4 demonstrates the data structure of OFDM block for a MIMO-OFDM/A downlink. It includes one base station (BS) with C_t antennas. From each antenna, an OFDM block with K subcarriers is transmitted.

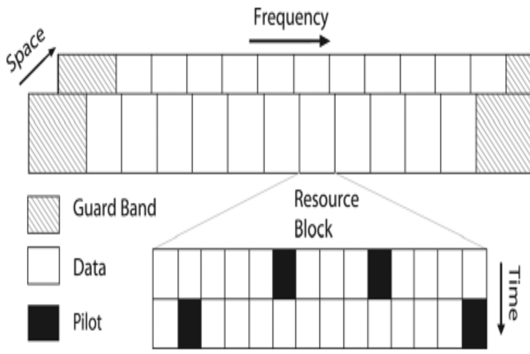


Figure 4. OFDM block for a MIMO-OFDM/A downlink

K subcarriers contains K_n subcarriers enclosed with two guard bands with Energy level = 0. K_n are clustered into X resource blocks (Re_B) with $K_{rb} = K_n/X$ subcarriers. The multiple user's data is placed in Re_B and mapped into the space-time domain using an Inverse Discrete Cosine Transform (IDCT) and space-time block coding (STBC) technique. Also, Re_B includes several pilot subcarriers which permits channel estimation at the receivers.

IX. SIMULATION RESULTS

The simulation is done by using the software MATLAB 7.12. The simulation parameters are given in the Table-1.

Table-1 Simulation Parameters

Simulation Parameters	Type/Values
Number of OFDM Blocks	1000
Number of subcarriers(K)	64,128,256,512,1024 & 2048
Number of sub blocks(N)	4
Over sampling factor (L)	4
Sub block partitioning	Interleaving
Scheme	
Modulation scheme	QPSK
Roll-off factor (R)	0.6
Codeword length (n)	7
Message length(k)	4

Fig. 4 shows the comparison of the PAPR reduction performance for modified SLM with interleaving and pulse shaping using IDCT and IFFT for 64 subcarriers. In the modified based SLM IDCT the PAPR is reduced at 2.73dB whereas in SLM IFFT the PAPR is reduced at only 3.19dB.

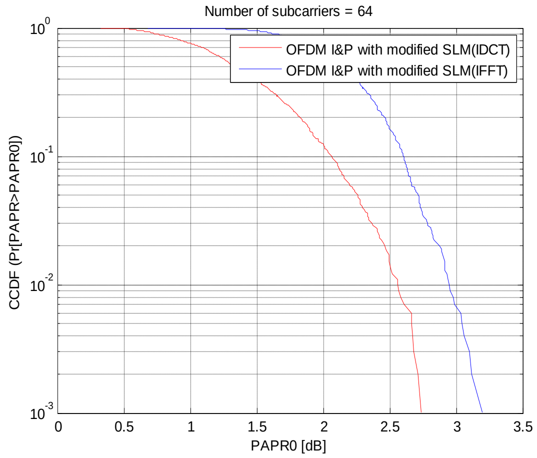


Figure 4 Comparison for PAPR of IDCT based Modified SLM - (DCT used before IFFT, IDCT in SLM) for number of subcarriers as 64.

Fig. 5 shows the PAPR reduction performance for the system with 128 subcarriers. With increase in subcarriers, the PAPR increases. In the modified based SLM IDCT the PAPR is reduced at 2.85dB whereas in SLM IFFT the PAPR is reduced at only 3.27dB.

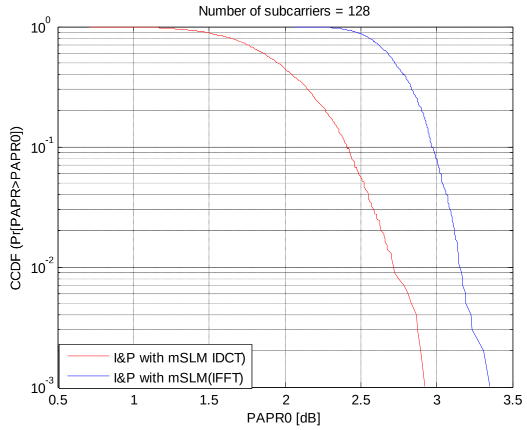


Figure 5 comparison for PAPR of IDCT based Modified SLM - (DCT used before IFFT, IDCT in SLM) for number of subcarriers as 128.

Fig. 6 portrays the PAPR reduction performance of Modified SLM with interleaving and pulse shaping using IDCT and IFFT with 256 subcarriers. It is found that at CCDF of 10^{-3}, the PAPR is reduced to 2.89dB in SLM IDCT and to 3.52dB in SLM IFFT, with 256 subcarriers.

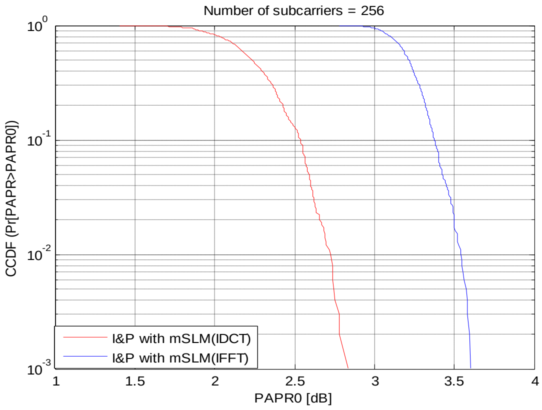


Figure 6 Comparison for PAPR performance of DCT based Modified SLM - (DCT used before IFFT, IDCT in SLM) for number of subcarriers as 256.

The PAPR performance of modified SLM combined with interleaving and pulse shaping with IDCT and IFFT is compared in Fig. 7 for 512 subcarriers. It is found that for CCDF of 10^{-3}, the PAPR is about 3.07dB for modified SLM combined with interleaving and pulse shaping with IDCT and 4.07dB for modified SLM combined with interleaving and pulse shaping with IFFT.

Figure 7 Comparison for PAPR of DCT based Modified SLM - (DCT used before IFFT, IDCT in SLM) for number of subcarriers as 512. Figure 8 shows the comparison performance of modified SLM combined with interleaving and pulse shaping using IDCT and IFFT, for 1024 subcarriers. In the modified based SLM IDCT the PAPR is about 3.20dB whereas in SLM IFFT the PAPR is reduced at only 4.84dB.

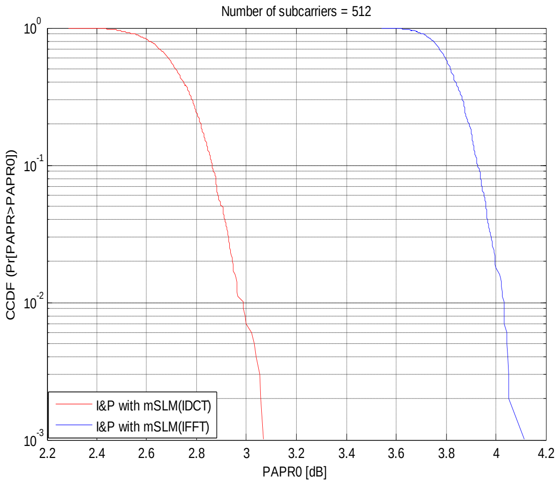


Figure 8 Comparison for PAPR of DCT based Modified SLM - (DCT used before IFFT, IDCT in SLM) wth number of subcarriers as 1024.

In fig. 9, we show the comparison graph with number of subcarriers as 2048 for modified SLM with interleaver and pulse shaping for IDCT and IFFT. In the modified based SLM IDCT the PAPR is reduced at 3.43dB whereas in SLM IFFT the PAPR is reduced at only 5.05dB.

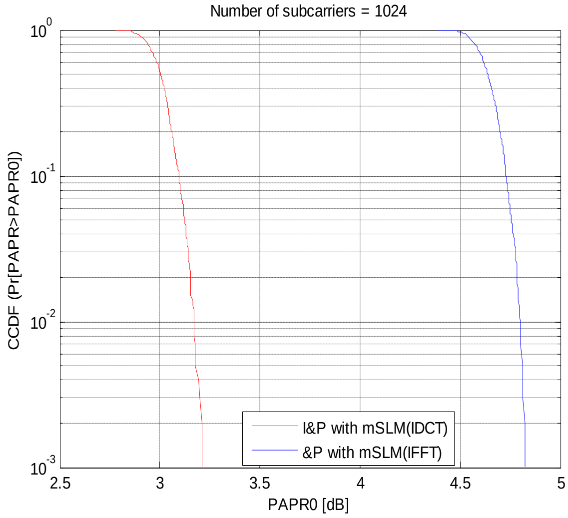
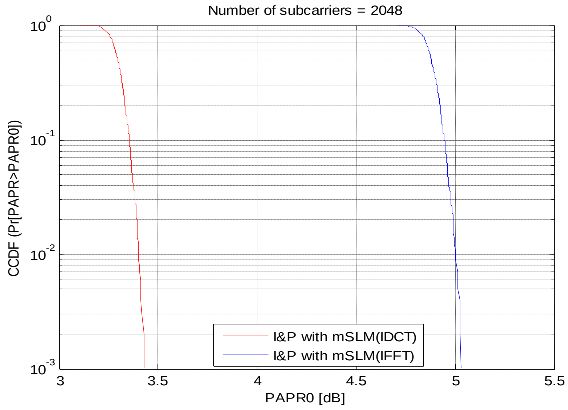


Figure 9 Comparison for PAPR of DCT based Modified SLM - (DCT used before IFFT, IDCT in SLM) with number of subcarriers as 2048.



In Figure 10, the comparison graph with all the subcarriers is shown for the modified SLM based PAPR reduction in OFDM with interleaver and pulse shaping

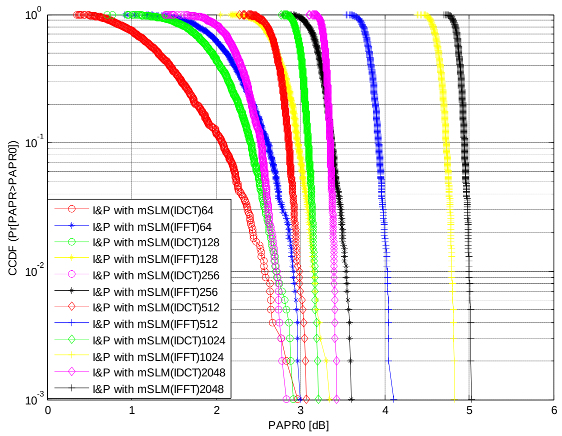


Figure 10 Comparisons for PAPR of DCT based Modified SLM - (DCT used before IFFT, IDCT in SLM) for number of subcarriers as 64, 128, 256, 512, 1024 and 2048.

In Fig. 11, the graph is drawn between the bit error rate and signal to noise ratio which represents the performance of the system. When the signal to noise ratio increases the bit error rate decreases so in our system the error rate is reduced at 10^-5 at 18dB.

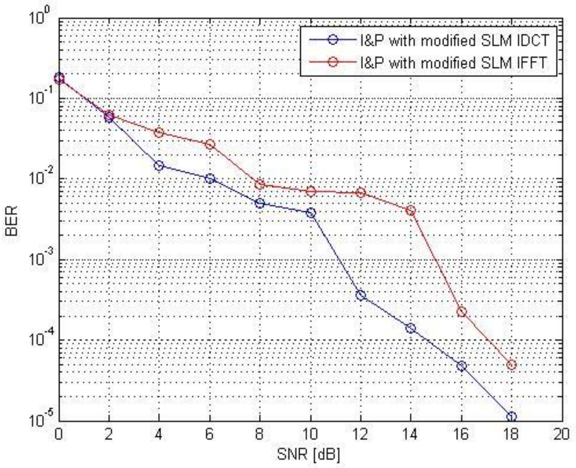


Figure 11 BER performance of OFDM system with interleaver and pulse shaping

The comparison table is given in Table-2 for the various numbers of subcarriers.

Table-2 Comparison of Various Methods of PAPR Reduction

Methodology	N=64	N=128	N=256	N=512	N=1024	N=2048
DCT-MODIFIED SLM WITH IFFT	3.19	3.27	3.52	4.07	4.84	5.05
DCT-MODIFIED SLM WITH IDCT	2.73	2.85	2.89	3.07	3.2	3.43

X. CONCLUSION

In this paper, we have performed PAPR reduction analysis using IDCT in MIMO-OFDM networks. In this technique, modified Selective Level Mapping (SLM) with Inverse Discrete Cosine Transform (IDCT) matrix is used to reduce the peak to average power ratio with constant modulus algorithm. Then Interleaving and pulse shaping are applied on both transmitter and receiver sides. By simulation results, we have shown that the proposed modified SLM with interleaver and pulse shaping IDCT technique reduces PAPR for subcarriers 64 to 2048.

REFERENCES

1. K. Muralibabu and Dr. M .Sundhararajan, "DCT Based PAPR and ICI Reduction Using Companding Technique in MIMO-OFDM System", International Journal of Advanced Research in Computer Science and Software Engineering 3(8), August – 2013.
2. Mehboob Ul Amin, Randhir Singh and Javaid.A.Skeikh, "A New Method for PAPR Reduction in MIMOOFDM Using Combination of OSTBC Encoder and DCT Matrix", International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-2, Issue-2, May 2013.
3. Karima El Mouhib and Ahmed Oquour, "PAPR Reduction Using BPSO/PTS and STBC in MIMO OFDM System", Journal of Computer Science 7.4 (2011).
4. Emmanuel MANASSEH, Shuichi OHNOy and Yong JIN, "Minimization of PAPR in MIMO-OFDM Systems by Tone Reservation Techniques and Pilot Tones", APSIPA ASC 2011.
5. Narmatha.T and Sathish Kumar.K, "An Enhanced Algorithm for Papr Reduction in MIMO OFDM/A", IJARCST 2014.
6. P.Mukunthan and P.Dananjayan, "A Modified PTS Combined with Interleaving and Pulse Shaping Method Based on PAPR Reduction for STBC MIMO-OFDM System", WSEAS Transactions on Communications 12.3 (2013).
7. Seyran Khademi and Alle-Jan van der Veen, "Constant Modulus Algorithm for Peak-to-Average Power Ratio (PAPR) Reduction in MIMO OFDM/A", IEEE Signal Processing Letters, Vol. 20, No. 5, May 2013.
8. Gamal Mabrouk Abdel–Hamid, Sahar Abdel- Rahman and Hala Gaber Farrag, "Performance Improvement of MIMO-OFDM Wireless Systems using PAPR Reduction Techniques", International Journal of Computer Applications (0975 – 8887) Volume 53– No.18, September 2012.
9. ÖĞR.GÖR. MURAT TÖREN, "PAPR Reduction with Wavelet Transform and Different PAPR Reduction Tecniques in MIMO-OFDM Systems", Journal of Engineering and Architecture, Vol. 1 No. 2, December 2013.
10. Chin-Liang Wang, Shun-Sheng Wang and Hsiao-Ling Chang, "A Low-Complexity SLM Based PAPR Reduction Scheme for SFBC MIMO-OFDM Systems", Wireless Communications and Networking Conference (WCNC), 2011 IEEE.
11. Seyran Khademi, Alle-Jan Van der Veen and Thomas Svantesson, "Precoding Technique for Peak-To-Average-Power-Ratio (Papr) Reduction in Mimo Ofdm/A Systems", Acoustics, Speech and Signal Processing (ICASSP), 2012 IEEE International Conference on IEEE 2012.
12. Christoph Stude and Erik G. Larsson, "PAR-Aware Large-Scale Multi-User MIMO-OFDM Downlink", IEEE Journal on Selected Areas in Communications, Vol. 31, No. 2, February 2013.
13. G. O. Young, "Synthetic structure of industrial plastics (Book style with paper title and editor)," in Plastics, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.
14. W.-K. Chen, Linear Networks and Systems (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.
15. H. Poor, An Introduction to Signal Detection and Estimation. New York: Springer-Verlag, 1985, ch. 4.
16. B. Smith, "An approach to graphs of linear forms (Unpublished work style)," unpublished.
17. E. H. Miller, "A note on reflector arrays (Periodical style—Accepted for publication)," IEEE Trans. Antennas Propagat., to be published.
18. J. Wang, "Fundamentals of erbium-doped fiber amplifiers arrays (Periodical style—Submitted for publication)," IEEE J. Quantum Electron., submitted for publication.
19. C. J. Kaufman, Rocky Mountain Research Lab., Boulder, CO, private communication, May 1995.
20. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interfaces(Translation Journals style)," IEEE Transl. J. Magn.Jpn., vol. 2, Aug. 1987, pp. 740–741 [Dig. 9th Annu. Conf. Magnetics Japan, 1982, p. 301].
21. M. Young, The Techincal Writers Handbook. Mill Valley, CA: University Science, 1989.
22. (Basic Book/Monograph Online Sources) J. K. Author. (year, month, day). Title (edition) [Type of medium]. Volume(issue). Available: http://www.(URL)
23. J. Jones. (1991, May 10). Networks (2nd ed.) [Online]. Available: http://www.atm.com
24. (Journal Online Sources style) K. Author. (year, month). Title. Journal [Type of medium]. Volume(issue), paging if given. Available: http://www.(URL)
25. R. J. Vidmar. (1992, August). On the use of atmospheric plasmas as electromagnetic reflectors. IEEE Trans. Plasma Sci. [Online]. 21 (3). pp. 876—880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

AUTHOR PROFILE

S. Sujatha. Received the B.E. Degree in Telecommunication Engineering from MVJ College of Engineering, Bangalore, India, in 2001, the M.Tech. Degree in VLSI and embedded system design from the BMS College of Engineering Bangalore, India, in 2010, and Pursing Ph.D. degree in Electronics and Communication Engineering from , Pondicherry Engineering College, Puducherry, India. She is working as an Associate Professor in the Department of Telecommunication CMR institute of Technology since 2007 till date.

Her research interests include Wireless Communication, Optical Communication, Optical Communication Network, Microcontroller, and MSP430. She is presented and published several papers in National and International Journal.

P. Raja received B.E degree in Electronics and Communication Engineering from Madras University, Chennai in 1999, M.Tech degree in Microelectronics and VLSI Design from IIT Madras, Chennai in 2008 and Doctor of Philosophy from Pondicherry University in 2015 . He is serving as Associate Professor in Department of Electronics and Communication Engineering, Sri Manakula Vinayagar Engineering College, Madagadipet, Puducherry. His research interests include VLSI Design and wireless sensor networks.

P. Dananjayan received Bachelor of Science from University of Madras in 1979, Bachelor of Technology in 1982 and Master of Engineering in 1984 from the Madras Institute of Technology, Chennai and Ph.D. degree from Anna University, Chennai in 1998. He is working as Professor in the Department of Electronics and Communication Engineering, Pondicherry Engineering College, Pondicherry, India. He has been as visiting professor to AIT, Bangkok. He has to his credit more than 90 publications in National and International Journals. He has presented more than 160 papers in National and International Conferences. He has guided 12 Ph.D candidates and is currently guiding 7 Ph.D students. His research interests include spread spectrum techniques, wireless communication, wireless adhoc and sensor networks.