Incorporation Of Dummy Sequence Insertion Algorithm For Papr Reduction On Ieee 802.11a Wlan/Ofdm Standard

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Abstract

Orthogonal Frequency Division Multiplexing (OFDM) is the best choice to achieve high data rate transmission in wireless environment. OFDM system shows many favorable property such as high spectral efficiency, robustness to channel fading and immunity to impulse interference. The main disadvantage of OFDM is the high time-domain peak-to-average power ratio (PAPR) that limits transmitter power efficiency. Otherwise, OFDM signal may be distorted by the nonlinear behavior of the high power amplifier (HPA) at the transmitter. The transmitter can reduce PAPR by distorting the data carriers or by adding power to the free carriers. This paper analyzes the capability of Dummy Sequence Insertion (DSI) algorithm to reduce PAPR in wireless local-area network (WLAN)/OFDM system. The incorporation of DSI on this system is performed by measuring the PAPR at the output of the IFFT (Inverse Fast Fourier Transform) after adding a 6-bit sequence at the dummy sub-channels inputs and make a decision to transmit the data if the PAPR for this data sequence under a specified threshold. Unlike most of the data distortion algorithms used for PAPR reduction methods, the low complexity DSI method did not need any kind of side information. Simulation results are presented for a network model designed by WLAN 802.11a standard using MATLAB as a mathematical simulation software tool. The network model has been simulated in Additive White Gaussian Noise (AWGN) channel environment to investigate the behavior of PAPR and Bit-Error Rate (BER) performance. The simulation results show that the data distortion technique based on DSI reduces PAPR down to 4 dB compared to conventional OFDM system, and down to 2 dB compared with clipping technique for the same BER performance.

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الخلاصــة

يعتبر نظام التضمين بتقسيم التردد المتعامد من الطرق النموذجية للإرسال في الشبكات اللاسلكية ذات معدلات إرسال البيانات العالية. تتميز طريقة التضمين آنفة الذكر بمواصفات عديدة أهمها الإشغال الكفوء للطيف الترددي و الصمود بوجه ظاهرة الخفوت بالإضافة إلى الحيلولة دون تداخل الإشارات المرسلة. من أهم المشاكل التي تعيق عمل النظام المذكور هي القيمة العالية للقمة نسبة إلى المعدل لقدرة الإشارة المراد إرسالها الأمر الذي يقلل من كفاءة عملية تكبير الإشارة قبل الإرسال من قبل المضخم العالي للقدرة. قد تحدث عملية تشويه في الإشارة خلال عملية الإرسال وذلك نتيجة للطبيعة اللاخطية للمضخم خلال مرحلة التكبير وبسبب القيمة العالية لنسبة القمة-إلى-المعدل لقدرة تلك الإشارة. يمكن تقليل نسبة القمة إلى المعدل من خلال التلاعب بتوزيع القدرة في الإشارة إما بالتشويه المدروس أو بإضافة بيانات زائفة لها. يهدف هذا البحث إلى دراسة إمكانية تقليل نسبة القمة-إلى-المعدل من خلال إضافة سلاسل بيانات زائفة إلى سلاسل بيانات المعلومات المراد إرسالها لنظام للشبكات اللاسلكية المحلية المبني على أساس التضمين بتقسيم التردد المتعامد. تتلخص طريقة إدراج البيانات الزائفة بإضافة سلسلة بيانات زائفة مكونة من ستة رموز إلى سلاسل البيانات قبل المرحلة الخاصة بتحويل فورير. تغير الرموز الستة لسلسلة البيانات الزائفة لحين تحقيق شرط العتبة لنسبة القمة-إلى-المعدل. تتميز هذه الطريقة بالبساطة وبعدم الحاجة إلى إرسال بيانات إضافية. أجريت المحاكاة على النظام القياسي IEEE 802.11a للشبكات اللاسلكية المحلية القائمة على التضمين بتقسيم التردد المتعامد وتم اعتماد قناة ذات ضوضاء كاوسية مضافة لدراسة تخفيض نسبة القمة-إلى-المعدل بالإضافة إلى معدل الخطأ في الرموز. أظهرت نتائج المحاكاة أن طريقة إدراج الرموز الزائفة قللت نسبة القمة-إلى-المعدل بما يقارب ٤ ديسيبل مقارنة مع نظام التضمين بتقسيم التردد المتعامد الاعتيادي والى ٢ ديسيبل مقارنة مع طريقة التقليم لنفس معدل الخطأ في الرموز.

1. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has emerged as the standard in a number of high data rate technologies. Such standards include digital television broadcasting (such as European DAB and DVB-T [l]), and wireless local area networks (e.g., IEEE 802.11a operating at 5 GHz [2] and ETSI BRAN'S HYPERLAN 2 standards [3]). By serial-to-parallel converting N bits and transmitting them simultaneously over N orthogonal carriers, OFDM achieves high data rates while avoiding multipath in frequency selective channels.

However, OFDM and its method of orthogonal carrier transmission are not without drawback. High peaks in power (up to N times the average) result from unstable envelopes, a consequence of using N independently modulated carriers. This, in turn, leads to inefficient operation of the transmit power amplifier. A number of solutions to OFDM's peak-to-average power ratio (PAPR) problem have been proposed in the literature (i.e., block coding [4], and selective mapping (SLM) [5], partial transmit sequences (PTS) [6]). Several coding schemes that use a special forward error correcting code set that excludes OFDM signals with a large PAPR, thus they significantly reduce the rate of transmission for large values of N. Selective mapping (SLM) and partial transmit sequence (PTS) are based on scrambling each OFDM signal with different scrambling sequences to obtain lower PAPRs, and the sequence with the lowest PAPR is transmitted, both of which need to transmit side information (SI) to the receiver to recover the original sequence.

Clipping [8] is a simple effective technique for PAPR reduction by clipping the peak amplitude of amplification. Since clipping is a nonlinear process, it may cause significant in-band distortion and out-of-band radiation. Recently [9], Dummy sequence insertion (DSI) technique is proposed which is more spectrally efficient than the block coding method and is very simple than PTS and SLM methods. In the DSI method, dummy sequence is added into the input data for the PAPR reduction before the IFFT stage. That sequence does not work as the side information unlike the PTS and SLM methods. Because there is no degradation from the side information error, DSI has better BER performance than the PTS and SLM.

In this paper, the DSI method is applied to IEEE 802.11a WLAN/OFDM Standard. A certain prescribed PAPR threshold level (PAPRo) is applied after the IFFT stage. If the PAPR is lower than PAPRo then the data sequence is transmitted. If the PAPR is greater than PAPRo then a 6-bit sequence is added to the input data sequence at the dummy sub-carriers to lower the PAPR. The sequences $(000000)_2$ to $(111111)_2$ are tested successively as a dummy sequences to reach the specified threshold.

2. OFDM SYSTEM

OFDM is a multi-carrier modulation system employing FDM of orthogonal sub-carriers, each modulating a low bit rate digital stream. In this system, N overlapping orthogonal sub-carriers, each carrying a baud rate of 1/T and spaced l/T apart is used. Orthogonality of sub-carriers requires that each sub-carrier have exactly integer number of cycles in the interval T. The IFFT ensures orthogonality among sub carriers and is decoded exactly with a FFT on the receiver side. The block diagram of OFDM system is shown in Fig.(1).The input binary data stream modulated into certain

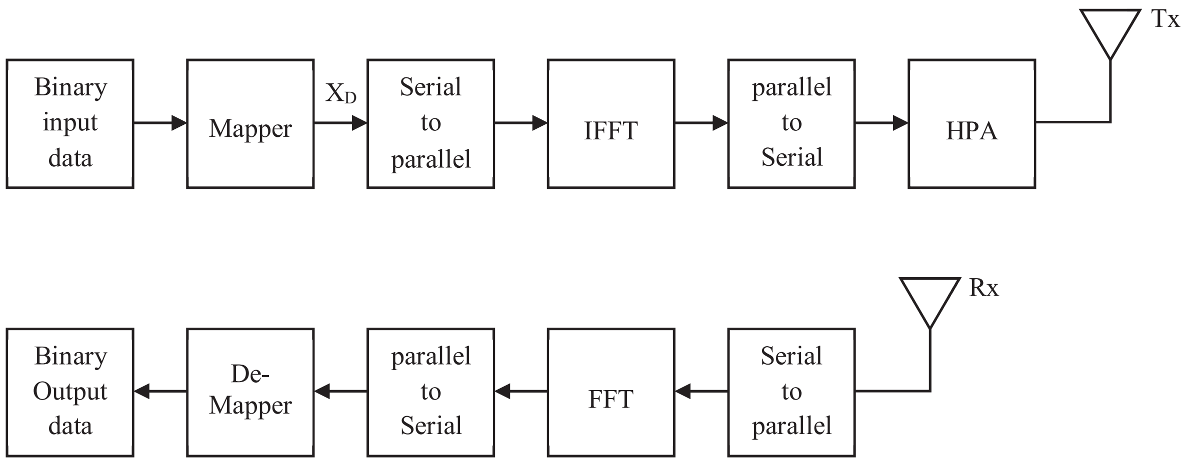


Fig.(1): The block diagram of OFDM transmitter and receiver

modulation stream and converted into several parallel low bit rate data streams. IFFT is implemented on this data stream. This is again converted into serial form and then transmitted via high power amplifier (HPA) transmitter. In the receiver side, reverse operation is done to recover the data.

Let us denote the modulated data block of length N as a vector $X_D=[X_0, X_1,\ldots, X_{N-1}]$ where N is equal to the number of sub-carriers. $X=(X_D)^T$. The duration of the mapped data symbol X_m in X is T. Each data symbol in X modulates one of a set of sub-carriers, {fm, m=0, 1, 2, ... , N-l }. The N sub-carriers are chosen to be orthogonal that is, fm=mΔf, where Δf=l/NT and NT is the duration of an OFDM data block. The complex envelope of the transmitted OFDM is given by:

$$x(m)=\frac{1}{\sqrt{N}}\sum_{m=0}^{N-1} Xm \exp(j2\pi fmt) \qquad (1)$$

The PAPR of the transmitted signal in (1) is defined as:

$$PAPR=\frac{Max\{\ |x(t)|^2\}}{E\{\ |x(t)|^2\}} \qquad (2)$$

where the numerator is the maximum power of the time domain signal and the denominator is its expectation.

3. DSI TECHNIQUE

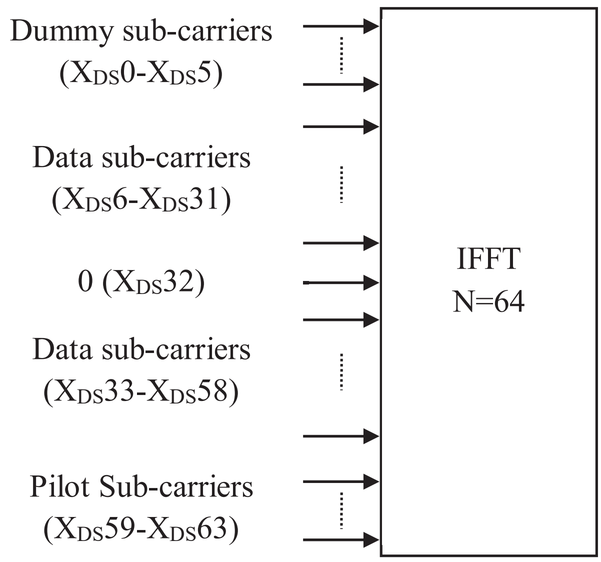


Fig.(2): Arrangement of sub-carriers at the input of IFFT for
IEEE 802.11a WLAN/OFDM Standard

The arrangement of sub-carriers at the input of IFFT for IEEE 802.11a WLAN/OFDM Standard are shown if Fig.(2). The first six sub-carriers ($X_{DS}0$-$X_{DS}5$) is assigned for dummy inputs. For the ordinary operation mode, all dummy sub-carriers fed by zeros. Our proposed technique is to modulate the dummy sub-carriers by a 6-symboles dummy sequence so that the last one is one of 2^6=64 sequences for BPSK (the default mapping scheme in the above standard). The insertion of dummy sequence among the data block is to arrange the inputs at the frequency side of the IFFT stage in order to reduce the PAPR of the time domain output OFDM signal. The flow chart of the suggested algorithm for DSI is shown in Fig.(3). Here X ;the mapped binary-data block (BPSK mapping); are firstly modulates the data sub-carriers with all dummy sub-carriers set to zero. The output of the IFFT (X_{DS}) checked for satisfying a threshold PAPR (PAPRo) condition, i. e., if the PAPR of the output below PAPRo then the sequence accepted for transmission. Otherwise a dummy sequence generated and padded to the data block and the previous check is repeated. The last step repeated each time PAPR fail to stay within PAPRo threshold or the maximum iterations number (k) is exceeded (>kmax) where kmax identified by the length of dummy sequence (here the length is 6 and kmax $=2^6$=64). If kmax is reached without making $PAPR<PAPR_o$ then X_{DS} with the least PAPR through calculation is transmitted. It is important to remark that the main task for dummy sequence inserted is to reduce the PAPR of the transmitted sequence through manipulating the power at the

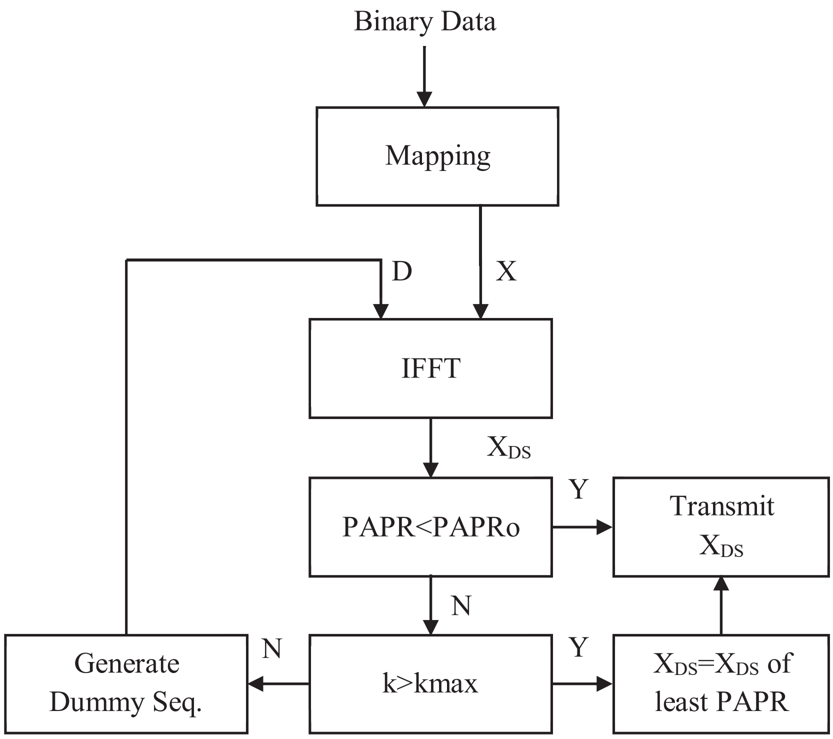


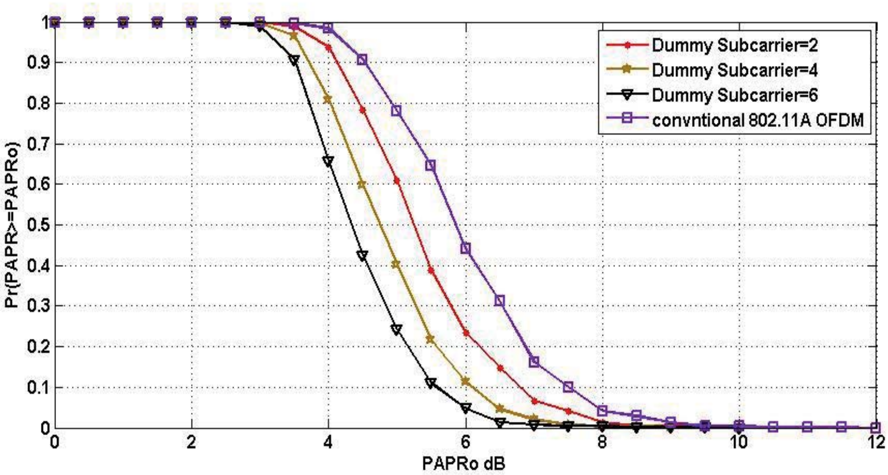
Fig.(3): The flow chart of the suggested algorithm for DSI

frequency side of the IFFT and according to that it is not required to inform the receiver about the dummy sequence value, in other words the dummy sequence is not considered a side information so that the system complexity is reduced compared to PTS and SLM. The relatively high BER due to the non-linear operation incorporated in clipping technique is avoided in DSI method because the transmitted sequence need not to satisfy the threshold ($PAPR_o$) before the transmission.

4. SIMULATION, RESULTS, AND DISCUSSION

Matlab simulation is used to evaluate the PAPR and BER performance of DSI technique implemented OFDM system. N=64 sub-carriers are considered.

Fig.(4) depicts PAPR statistical distribution (represented by the Complementary Cumulative Distribution Function (CCDF)) for conventional and proposed IEEE 802.11a WLAN/OFDM system with multiple length of dummy sequence (D=2, 4, and 6). The proposed system offers a good PAPR reduction performance compare to the conventional system because the contribution of dummy sequence in input signal-power manipulation after the IFFT. It is clear that the ability of the proposed technique in reduce the PAPR is forward proportional with the number of dummy sub-carriers inserted. The last behavior comes as a result of increasing the probability of input sequences that gives minimum PAPR. From Fig.(5-a), a wide variation in the instantaneous normalized power for the conventional system is clearly shown, which leads to high PAPR. The ability of the proposed method to reduce the variation in the instantaneous normalized power can be observed obviously in Fig.(5-b). Fig.(6) shows the overcoming of DIS method on clipping method to reduce PAPR. The threshold parameter in the clipping method picked out to insure a similar BER performance to that of the proposed technique with D=6. The BER degradation of the clipping method will be as shown Fig.(7) if the last system is calibrated to obtain CCDF specifying the performance of PAPR approximately identical to that of the proposed system. Fig.(8) shows the average number of iterations required to reach a predefined PAPRo with D as parameter. This logical result is expected

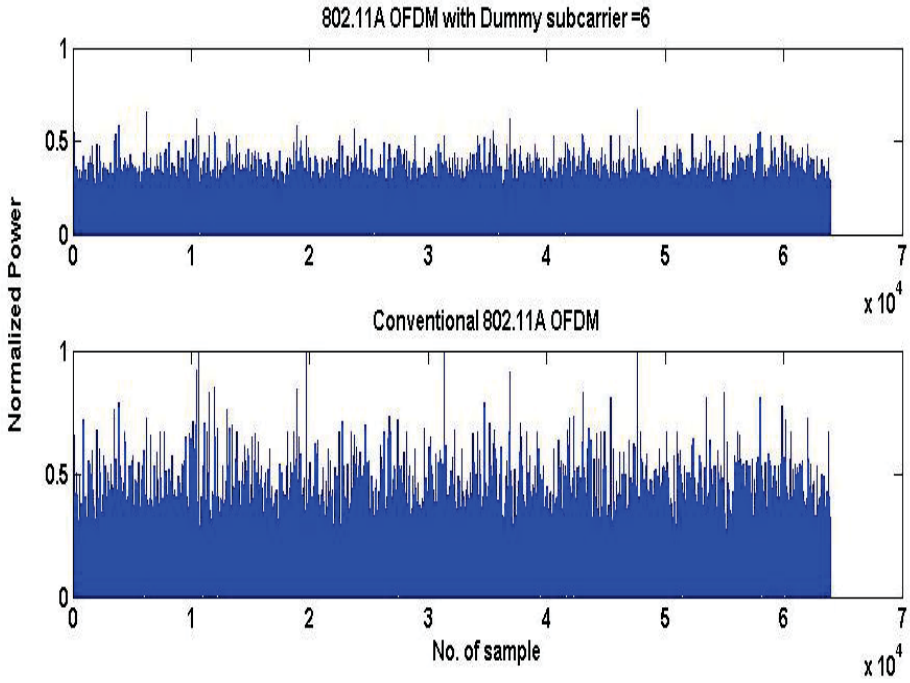


Fig(4). CCDF for conventional 802.11a and proposed system for various dummy sequence length (D).

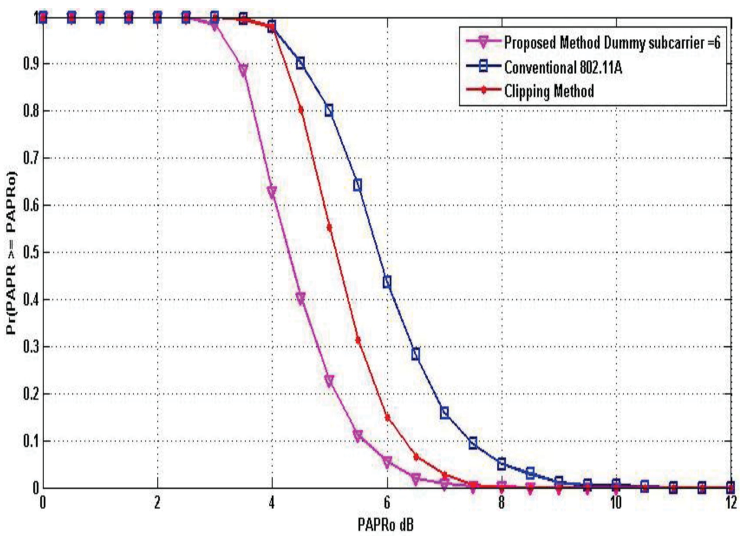
because the increasing of PAPRo reduces the convergent time that required to generate a suitable dummy sequence for keeping PAPR within the required threshold. The convergent time increases with D as a result of increasing the number of dummy sequence constellation and hence the time required to scan them in order to realize the closest agreement to PAPRo.

5. CONCLUSION

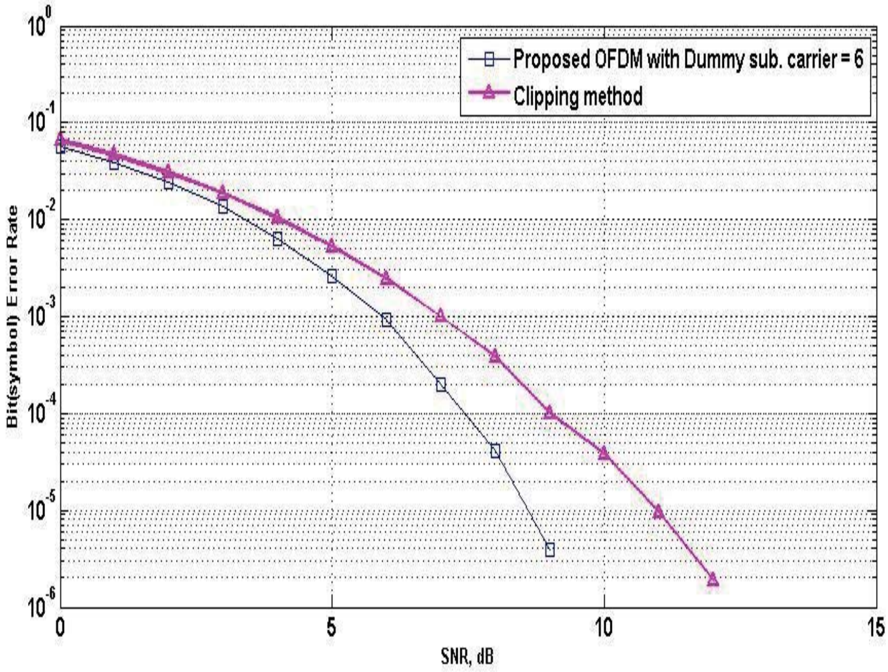
A proposed dummy sequence insertion (DSI) method is proposed for the reduction of PAPR for IEEE 802.11a WLAN/OFDM standard. This technique based on the insertion of dummy sequence with length D symbols simultaneously with X input data sequences in order to modify the power on the time domain side (the output of the IFFT) and limits PAPR to fixed threshold (PAPRo). Simulation results performed for the above system for the performances of PAPR and BER. A comparison among conventional, clipping method, and proposed DSI technique is performed. The simulation shows that PAPR performance for the proposed system is improved compared to conventional system and this improvement is forward proportional the D. However, increasing D will increase the number of iteration required to lock PAPR as close as possible to PAPRo. For the same PAPR performance, DSI method insure to be better than the clipping technique in reducing BER.



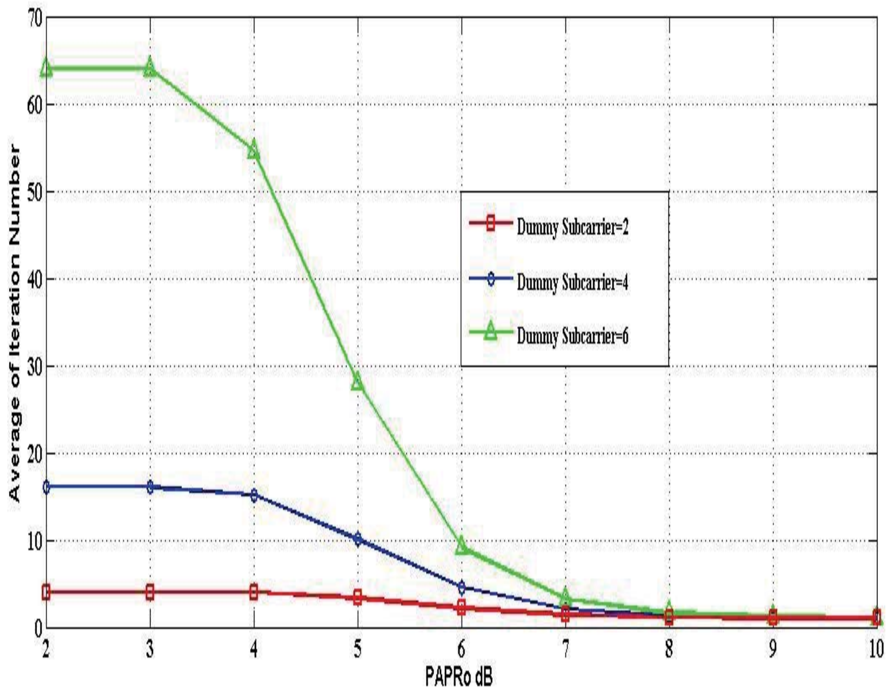
Fig(5). Normalize Power for conventional 802.11a and Proposed Technique.



Fig(6). Comparison PAPR for dummy subcarriers with D=6 & clipping method.



Fig(7). BER performance for proposed & clipping methods.



Fig(8). Average of iterations no. for proposed technique for different values of D.

REFERENCES

[1] T. de Couasnon, "OFDM for digital TV broadcasting," Signal Processing, vol. 39, pp. 1-32, 1994.

[2] IEEE 802.1 1, "Draft supplement to standard for telecommunications and information exchange between systems – LAN/MSN specific requirements - Part II: wireless MAC and PHY specifications: High speed physical layer in the 5 GHz band," P802.11a/D6.0, May 1999.

[3] TR 101 031, "Broadband radio access networks (BRAN); high performance radio local area network (HIPERLAN) Type 2; requirements and architectures for wireless broadband access," January 1999.

[4] T. A. Wilkinson and A. E. Jones, "Minimization of the peak to mean envelope power ratio in multicarrier transmission schemes by block coding," in Proc. VTC'95, July 1995, pp. 825-831.

[5] E. Lawrey and C. J. Kikkert, "Peak to average power ratio reduction of OFDM signals using peak reduction carriers," Signal Processing and Its Applications, 1999, ISSPA '99, Proceedings of the Fifth International Symposium on, Vol. 2, Aug. 1999, pp. 737-740.

[6] S. H. Muller and J. B. Huber, "OFDM with reduced peak-to-average power ratio by optimum combination of partial transmit sequences," elec. Letts., Vol. 33, No. 5, Feb 1997, pp. 368-369.

[8] X. Li and L. J. Cimini, Jr., "Effects of clipping and filtering on the performance of OFDM," in Proc. VTC'97, May 1997, pp. 1634-1638.

[9] Heung-Gyoon Ryu, Jae-Eun Lee and Jin-Soo Park, " Dummy Sequence Insertion (DSI) for PAPR Reduction in the OFDM Communication System," IEEE Transactions on Consumer Electronics, Vol. 50, No. 1, FEBRUARY 2004.