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PAPR Reduction and Sidelobe Suppression Using DWT and Hadamard Transform in NC-OFDM Based Cognitive Radio Systems

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ABSTRACT: OFDM is a bandwidth efficient multicarrier modulation where the available spectrum is divided into subcarriers, with each subcarrier containing a low rate data stream.NC-OFDM is variant of OFDM which achieves high data rates and avoid interference**.** The main two drawbacks of NC-OFDM (Non Contiguous Orthogonal Frequency Division Multiplexing) based CR systems are high peak to average power ratio (PAPR) and side lobe suppression. In this paper, we compare signal cancelation (SC) method for joint PAPR reduction and sidelobe suppression in NC-OFDM based CR systems by using DWT and Hadamard Transform. Moreover, we also propose a suboptimal SC (sub-SC) method too efficiently with low computational complexity. The proposed SC method and the sub-SC method can provide both significant PAPR reduction and sidelobe suppression performances. Compared to DFT, in DWT signal is localized in frequency and time domain and bandwidth wastages are highly reduced. Also compared to DFT, Hadamard Transform reduce bandwidth storage requirement and it is faster to calculate**.**

KEYWORDS: Cognitive radio (CR), non-contiguous orthogonal frequency-division multiplexing (NC-OFDM), peak-to-average power ratio (PAPR), side lobe suppression

I. INTRODUCTION

With the development of wireless communication applications the demand of spectrum is rapidly increasing. But now-a- days this spectrum availability is a sparse resource. Communications governmental and regulationary agencies impose regulation on the spectrum usage. In order to use the spectrum effectively there comes a concept called cognitive radio systems.CR is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. There are two types of users in cognitive radio systems. Primary User: A user who has higher priority or legacy rights on the usage of a specific part of the spectrum and Secondary User: A user who has a lower priority and therefore exploits the spectrum in such a way that it does not cause interference to primary users. In CR systems, when PU is not using the licensed spectrum, a SU can intelligently access the unutilized spectrum. When SU detects that the PU is ready for the transmission using the channel, the SU releases the channel and changes over to another free channel. For CR systems, non-contiguous orthogonal frequency division multiplexing (NC-OFDM) is a best suite and physical layer technology due to its considerable characteristic features. High spectrum efficiency; multipath delay spread tolerance, immune to the frequency selective fading channels and high power efficiency are the features of CR systems.NC-OFDM is variant of OFDM which achieves high data rates and avoid interference. Although NC-OFDM CR systems has so many advantages, it has two main drawbacks, i.e. High Peak to Average Power Ratio and Spectrum sidelobe. High peak-to-average power ratio (PAPR) of the transmitted NC-OFDM signals. Since the high power amplifier (HPA) used in the NC-OFDM based CR system has limited range, the NC-OFDM signals with high PAPR will introduce nonlinear distortion, resulting in serious decrease in the bit error rate (BER) performance. The high PAPR leads to the out-of-band radiation, which produces adjacent channel interferences. The large spectrum sidelobe may introduce distortion to adjacent PUs.

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In this paper, it proposes a method called Signal Cancellation that jointly reduce PAPR and spectrum sidelobe.In SC method the outer constellation points on SU subcarriers is dynamically extended and SC signals are added to PU subcarriers to generate appropriate cancelation signal for PAPR reduction and sidelobe suppression.

II. PROBLEM DESCRIPTION

A. PAPR

Peak to Average Power Ratio is defined as the ratio of maximum power to the average instantaneous power. It is purely caused by the presence of high power amplifier. Let x (n) be the transmitted signal. Then, the mathematical representation of PAPR be

$$\mathrm{PAPR} = \frac{\max\ |x(n)|2}{E[|x(n)|2]}$$

The complementary cumulative distribution function (CCDF) is widely employed to measure the PAPR reduction performance, which is defined as the probability that the PAPR exceeds a given threshold $PAPR_0$, i.e.

$$\mathrm{CCDF} = \Pr\{\mathrm{PAPR} > \mathrm{PAPR}_0\}$$

B. SIDELOBE FORMATION

During the transmission of OFDM signal sidelobe is formed. Large formation of this sidelobe may introduce possibility of interference to the signal. Also side lobe utilizes more amount of power.

The efficient transmission of a signal requires a method that reduces the PAPR and also suppresses the sidelobe. Signal Cancellation is a method that reduces the PAPR and suppress the sidelobe.

III. SYSTEM MODEL

A. SIGNAL CANCELLATION METHOD

Here, we propose a Signal Cancellation (SC) method that jointly reduce PAPR and suppress the sidelobe. In SC method, part of the outer constellation points is dynamically extended on SU subcarriers, whereas several SC symbols are added on PU subcarriers.

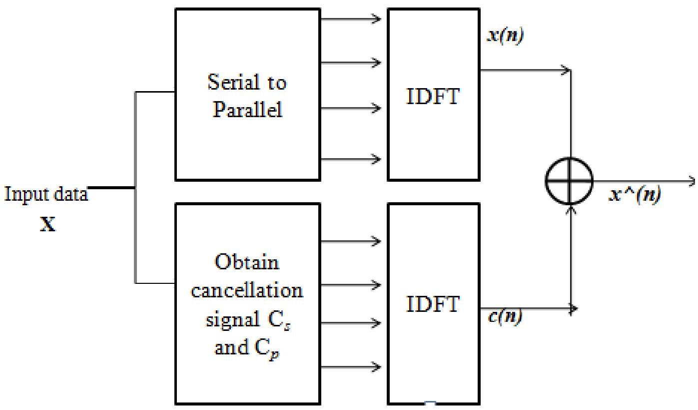

Fig.1 Block diagram of SC method

Fig. 2 shows the constellation extension regions when the quadrature amplitude modulation (QAM) is employed for the SC method. For the SU subcarriers, the constellation points are classified as inner points, boundary points, and corner points. Inner points cannot be extended, boundary points can be extended only outward in one direction along the

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arrowed lines, and corner points can be extended to the shaded regions. The minimum Euclidean distance of the modified constellation points can be maintained the same as that of the original constellation points; thus, the BER performance of the SC method can be maintained.

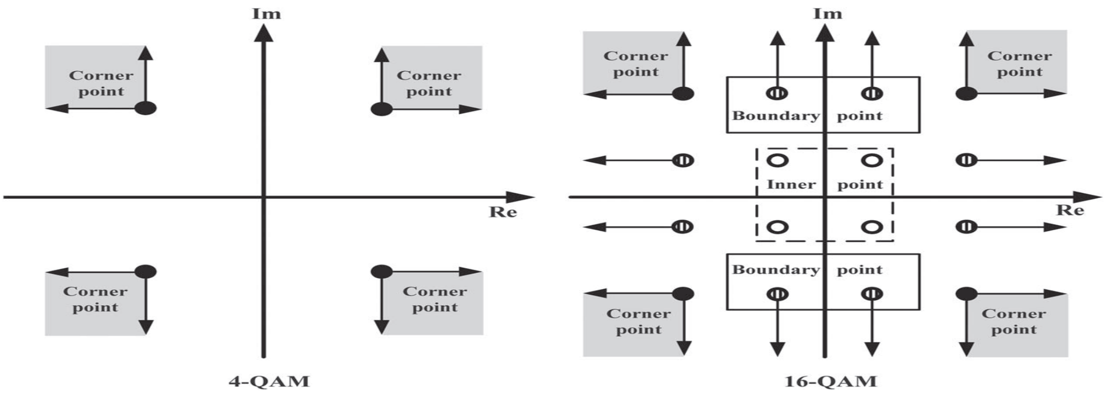

Fig. 2 Constellation region on SU subcarriers with 4-QAM and 16-QAM, respectively.

Then, the SC method formulates the problem of the joint PAPR reduction and sidelobe suppression as a quadratic ally constrained quadratic program (QCQP) and the optimal cancelation signal can be obtained by convex optimization. We also propose a suboptimal SC (sub-SC) method to efficiently solve the QCQP optimization problem with low complexity.

B. SUB SIGNAL CANCELLATION METHOD

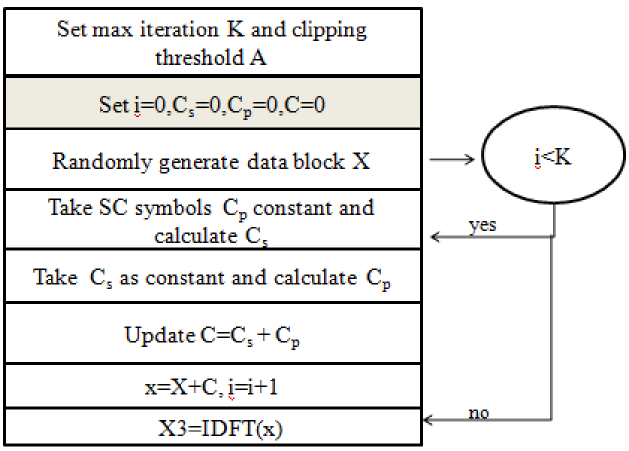

Fig. 3 Algorithm of Sub SC method

For the sub-SC method, the constellation adjustment symbol **C**s on SU subcarriers is only employed to generate the peak-cancelling signal for PAPR reduction, and it does not consider the sidelobe suppression. Also the SC symbol **C**p on PU subcarriers is only utilized for the sidelobe suppression, and it does not take PAPR reduction into account.

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Fig.4 shows algorithm of sub –SC method. From the figure, the C_S can be obtained by projection on to convex set algorithms as shown in fig 4.

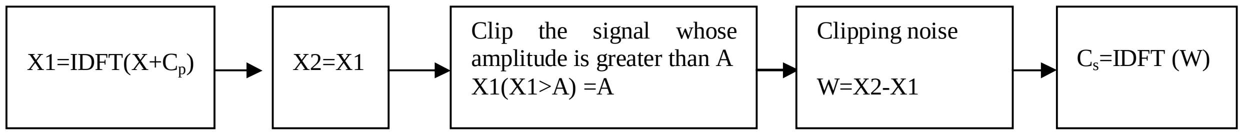

Fig .4. Calculation of C_s

Then for calculating C_P, the constellation adjustment symbol Cs is seen as a constant, and the SC symbol Cp on PU subcarriers is utilized as a variable to suppress the sidelobe in NC-OFDM-based CR systems.

$$Cp=T\hat{C}_P \qquad (1)$$

Denote $\hat{Cp}$ as an $L \times 1$ vector, which squeezes out zero from the $N \times 1$ vector Cp and only leaves the weights on the position R^c. Moreover, **T** is a matrix that transfers $\hat{Cp}$ to Cp.

$$\hat{C}_P = -(B^H B)^{-1} B^H P_d (X+C_S) \qquad (2)$$

Where $B=P_d T$, and B^H denotes the complex conjugate transpose matrix of B.

Substituting 1 and 2, we have

$$C_p = -T\,(B^H B)^{-1} B^H P_d (X+C_s)$$

$$= Q(X+C_S) \qquad (3)$$

Where $Q=-T\,(B^H B)^{-1} B^H P_d$

Thus we obtain the total added symbol C as

$$C=C_P+C_S \qquad (4)$$

IV. DISCRETE WAVELET TRANSFORMS

The time windowed exponentials are replaced by wavelet carriers at different scales and position on time axis.In numerical analysis and functional analysis, a Discrete Wavelet Transform (DWT) is any wavelet transform for which wavelets are discretely sampled. As with the other wavelet transform, a key advantage is has over the Fourier transform is temporal resolution, i.e. it captures both frequency and location information

V. WALSH HADAMARD TRANSFORMS

The Walsh Hadamard Transform (WHT) is a non-sinusoidal, orthogonal linear transform. WHT decomposes a signal into set of basic functions. These functions are Walsh functions, which are square waves with values of +1 or -1. The proposed Hadamard Transform scheme may reduce the occurrence of the high peaks comparing the original OFDM system. The idea to use the WHT 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.

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VI. RESULT

Fig.5. shows the performance of PAPR with SC and Sub SC method. The black line in the graph represents PAPR reduction by using SC method and blue line in the graph represents PAPR reduction by using Sub SC method with low computational complexity. Fig.6. shows the power spectrum density of NC-OFDM signals.Fig.7. Shows PAPR reduction when DWT is employed .Fig. 8. Shows PAPR reduction when Hadamard Transform is employed.

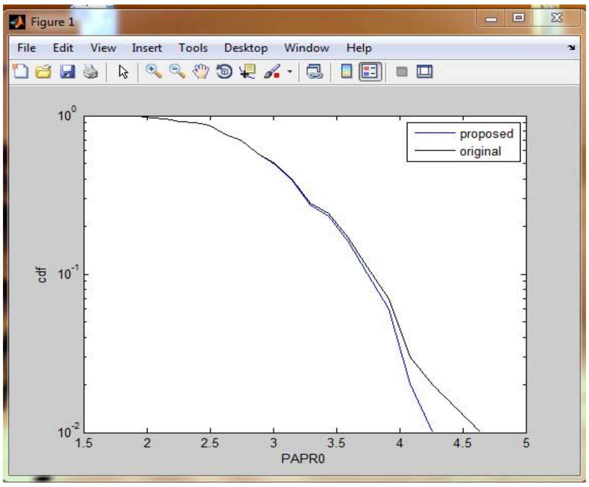

Fig.5. PAPR reduction with SC and Sub SC method

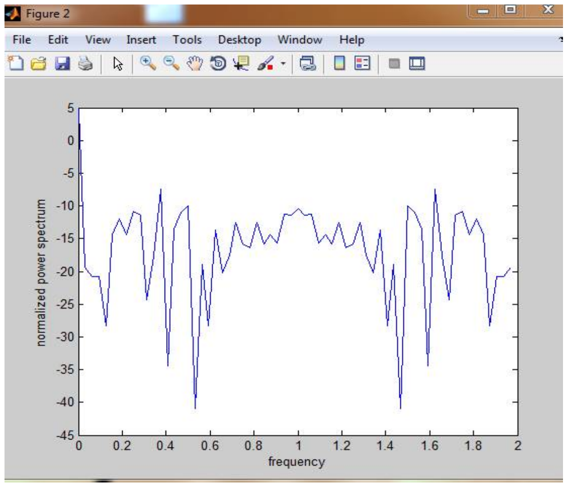

Fig.6. Power Spectrum Density

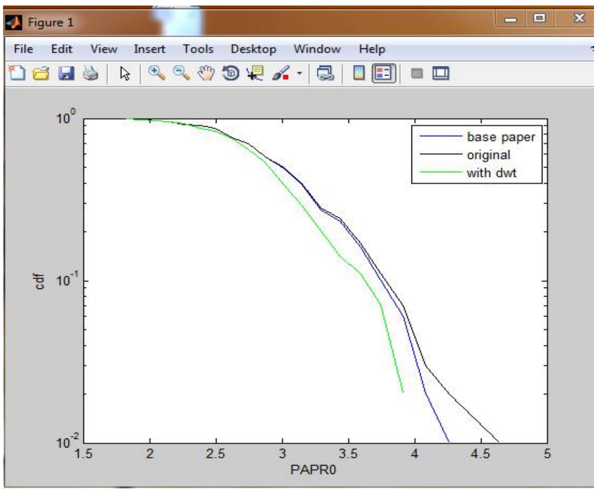

Fig.7. PAPR reduction using DWT

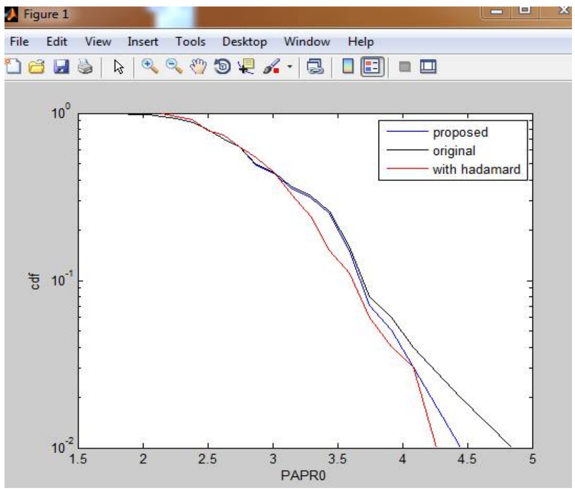

Fig.8. PAPR reduction using Hadamard Transform

VII. CONCLUSION

In the proposed method, by replacing DFT with DWT, the key advantage is that it captures both frequency and location information. By replacing DFT with Walsh Hadamard Transform (WHT) is less complex compared to other PAPR reduction techniques. By Signal Cancellation method we can jointly reduce both PAPR and also suppress sidelobe.

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Moreover we also proposed a Sub SC method to efficiently reduce PAPR and suppress the sidelobe with low computational complexity.

REFERENCES

[1] S. Haykin, "Cognitive radio: Brain-empowered wireless communications,"*IEEE J. Sel. Areas Commun.*, vol. 23, no. 2, pp. 201–220, Feb. 2005.

[2] A. Ghassemi, L. Lampe, A. Attar, and T. A. Gulliver, "Joint sidelobe and peak power reduction in OFDM-based cognitive radio," in *Proc. IEEE 72nd Veh. Technol. Conf. Fall*, Sep. 2010, pp. 1–5.

[3] D. Li, X. Dai, and H. Zhang, "Sidelobe suppression in NC-OFDM systems using constellation adjustment," *IEEE Commun. Lett.*, vol. 13, no. 5,pp. 327–329, May 2009

[4] L. J. Cimini and N. R. Sollenberger, "Peak-to-average power ratio reduction of an OFDM signal using partial transmit sequences," IEEE Commun. Lett., vol. 4, no. 3, pp. 86–88, March. 2000.

[5] H. Yamaguchi, "Active interference cancellation technique for MBOFDM cognitive radio," in *Proc. 34th IEEE Eur. Microw. Conf.*, Oct. 2004, vol. 2, pp. 1105–1108.

[6] S. Brandes, I. Cosovic, and M. Schnell, "Sidelobe suppression in OFDM systems by insertion of cancellation carriers," in *Proc. IEEE Veh. Technol. Conf.*, Sep. 2005, vol. 1, pp. 152–156.

[7] Van Nee, R. , and Wild, A., "Reducing the Peak to Average Power Ratio of OFDM," in *IEEE Vehicular Technology Conference*, May 1998, Vol.3.

[8] T. jiang and y. wu,"an over view peak to average power ratio reduction techniques for ofdm signals, IEEE transactions on broad casting, vol.54, no.2, June 2008, pp.257-268.

[9] C. V. Bouwel, et. al, *Wavelet Packet Based Multicarrier Modulation*, IEEE Communications and Vehicular Technology, SCVT 200, pp. 131-138, 2000.

[10] Haixia Zhang, et. al, Research of DFT-OFDM and DWT-OFDM on Different Transmission Scenarios. Proceeding of the second international conference on Information Technology for Application (ICITA 2004).