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Performance Analysis of Signal Cancellation Method for Joint Reduction of PAPR And Side Lobe Suppression In Cooperative Network Systems

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ABSTRACT

Generally Cooperative network is a network where the nodes shares their path with each other for efficient spectrum utilization. One such system is termed as Cognitive Radio System. Non Contiguous Orthogonal Frequency Division Multiplexing based Cognitive Radio System is an emerging radio system which has the capability of specifying the necessary parameters dynamically. The network system has two main drawbacks. One is high Peak to Average Power Ratio which is caused by the high power amplifier and the other is formation of spectrum side lobe which degrades the performance of entire system. In order to reduce the two drawbacks at a time a technique is used. The key idea for proposed method is to dynamically increase a part of constellation points on the secondary user (SU) subcarrier and add minimum signal cancellation symbols on the primary user (PU) subcarrier, to generate an accurate cancellation signal for joint PAPR reduction and side lobe suppression. The simulation result provides performance improvement in the signal when compared to the original signal by reducing the PAPR and formation of side lobe. Further, the signal which is free from error is fed as input to the Long-Term Evolution system which is currently an emerging fourth generation technology. The signal which is fed is characterized based upon the requirements of the LTE system. The simulation is performed in Matlab Software. Hence the performance of the entire system gets improved by increasing the signal strength.

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INTRODUCTION

A cognitive radio is a brainy radio that can be programmed and configured dynamically. The transceiver of the system is designed to use the best wireless channels. The cognitive radio automatically detects available channels in wireless spectrum band, and based upon the detected channel changes is made in transmission or reception parameters to allow more wireless communications in a given spectrum band at one specific location. This is represented as dynamic spectrum management. Currently, cognitive radio (CR) has changes its attention from academic and industrial communities to meet the increase in needs of spectrum resources and high data rate communication. For CR systems, non-contiguous orthogonal frequency division multiplexing (NC-OFDM) is a best suite and catchier physical layer technology due to its considerable characteristic features. The features are namely high spectrum efficiency; multipath delay spread tolerance, immune to the frequency selective fading channels and high power efficiency. Non Contiguous Cognitive Radio is defined as a smart wireless system that often aware about its surrounding environment during sensing and capable of dynamically adjusting its radio spectrum parameters. Physical layer of CR should be adaptable and flexible. Non-Contiguous OFDM (NC-OFDM) is the technique, which achieves high data rate and avoids interference. Although the NC-OFDM based CR system has many advantages, it has two main drawbacks. The first main drawback is its 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 second main drawback of the NC-OFDM based CR system is its large spectrum side lobe. The large spectrum side lobe introduces distortion to the adjacent PUs, resulting in the serious

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degradation performance in the adjacent PUs.

Hence, it is highly advantageous to suppress the spectrum side lobe as much as possible in the NC-OFDM based CR system. Recently, different methods have been proposed to reduce the PAPR for the NC-OFDM based CR system in the literature, such as clipping, partial transmit sequence, active constellation extension (ACE), and tone reservation (TR). The above mentioned PAPR reduction techniques can efficiently reduce the PAPR of transmitted signals; however, they do not consider the side lobe suppression into account. Furthermore, to suppress the side lobe of the NC-OFDM based CR system, many schemes have been proposed in the literature, such as active interference cancellation (AIC), extended active interference cancellation (EAIC), constellation adjustment (CA), pulse shaping (PS), spectrum precoding (SP), and side lobe suppression with orthogonal projection (SSOP).The AIC method utilizes subcarriers as the guard band which acts as a protective band to suppress the side lobe, resulting in the decrease of the spectrum efficiency. The EAIC method uses the tones (symbol), which is spaced closer than the interval of transmitted subcarriers to generate the cancellation signals for the side lobe suppression in the NC-OFDM based CR system. However, the EAIC method (D.Qu, 2010) demolishes the orthogonality of the NC-OFDM based CR system, which will introduce dangerous interferences. Thus, the EAIC method leads to the reduction of the bit error rate (BER) performance in the NC-OFDM based CR system. For the CA method, subcarriers used in the system are multiplied by some suitable weights to generate alternative signals, and then the signal with the lower spectrum side lobe is chosen as the transmitted signal. Thus, the CA method must send the marked weights as side information to the receiver for data recovery, resulting in the reduction of data rate. Both the PS method and the SP method (W.C. Chen and C.D.Chung, 2013) can effectively suppress the side lobe of the NC-OFDM based CR system by shaping the waveform of NC-OFDM signals. However, they reduce the side lode formation it suffers from the high computational complexity. The SSOP method uses an orthogonal projection matrix for side lobe suppression, and uses several reserved subcarriers to get back the distorted signal in the receiver. Thus, the SSOP method (J. Zhang, 2012) suffers from the decrease of data rate. Furthermore, although these side lobe suppression methods can suppress the side lobe power in NC OFDM based CR system, all of these techniques do not consider the PAPR reduction into account.

Long term Evolution System (LTE) is an upgraded version in the recent networks. It is commonly used in mobile phones for its admirable speed of transmission of data. The challenging task undergone in the network is its increase in the capacity of data transmission and its transmission speed. The main use of this system is purely for the transmission of the signal in fourth generation networks. For efficient transmission the improvement in signal strength is necessary. The LTE system generally provides good scalability in bandwidth and uses low power. The LTE system achieves flexible usage of frequency bands during the transmission process. The system is inter-operable between two modes i.e., TDD and FDD. The LTE system maintains high level of security which is an enhancing feature. The system generally uses OFDM signal as input so that efficient transmission is possible. Hence the signal which is free from the two drawbacks such as PAPR and Side lobe is fed as input to the system so that the signal strength of the system gets improved.

Problem description:

In cooperative network system the two main problems is its peak to average power ratio and formation of side lobe. The first problem leads to degradation in the data rate and efficiency which is caused because of the presence of the High Power Amplifier while the latter causes interference to the primary users. The side lobe is the formed along with the main lobe which is purely because of the presence of noises.

Peak to Average Power Ratio: PAPR is defined as the ratio of maximum power to the average instantaneous power. It is purely caused by the presence of high power amplifier. The peak signal causes the distortion in the transmitted signal which in turn paves a path for cross talk. Let x(n) be the transmitted signal. Then, the mathematical representation of PAPR be,

$$PAPR = \frac{max0 \leq n \leq JN-1 |x(n) * x(n)}{E[|x(n)\, x*(n)|]} \quad (1)$$

The PAPR can be reduced by different techniques. The clipping, filtering are the processes which reduces the PAPR but there is no significant changes in Side lobe suppression. In AIC method only the constellation points are extended. By this process only the peak signals are considerably neglected, the formation of side lobe remains unchanged.

Side lobe Formation:

During the transmission of the OFDM signal the side lobe is formed. Larger the formation of the side lobe causes larger the possibility of interference in the signal. The side lobe utilizes more amount of power which is the major problem. In order to solve the problem several methods are proposed. The EAIC method degrades the side lobe formation but increases the PAPR. The SP and PS method uses waveform to reduce the side lobe. But the conclusion is that these approaches separately reduces side lobe alone, there is no improvement in the reduction of PAPR.

The efficient transmission of signal requires a

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method which reduces both the PAPR and suppresses the side lobe simultaneously. The signal cancellation method provides a solution for the reduction of PAPR and suppresses the side lobe.

System model:

The system architecture is described in fig.1 which explains the flow process of the entire project. It has two stages. Primary stage is the signal cancellation process for joint reduction of PAPR and Side lobe suppression. Secondary stage is the performance analysis of the LTE system. The final output is the signal which is free from both the drawbacks and it gives the high signal strength.

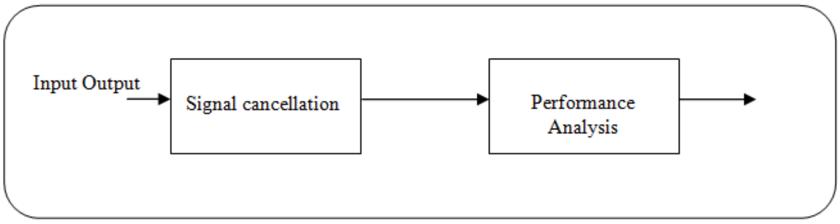

Fig. 1: System Architecture Representation.

The generation of cancellation signal is the main task to reduce the PAPR and suppress the side lobe. The cancellation signal stops the formation of the interferences in the system which is used to improve the overall efficiency of the system. The cancellation signal is generated in the primary user part where as the constellation points in the secondary user are extended so that both the problems come to a solution. The primary users are considered as the licensed user where as the secondary users are unlicensed user. Due to this property of the CR system, the secondary user constellation points are extended. The side lobe is the formation which is attached along with the main lobe. This side lobe creates a larger interference to the primary user. So the suppression of side lobe along with the reduction of PAPR is the challenging task. The idea of creating cancellation signal by making changes in the primary and secondary user part is more essential to solve the two problems simultaneously. For continuous reduction of PAPR and side lobe suppression an iterative procedure which currently suppresses the side lobe along with the PAPR reduction. Each iteration solves both the problems together. So this paper provides an efficient way for reducing the drawback of the CR system.

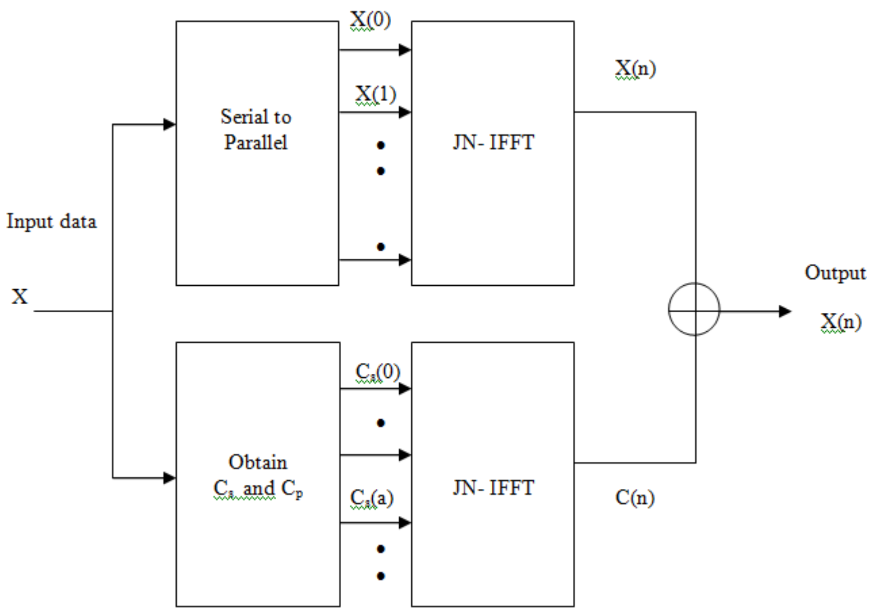

Fig. 2: Block Diagram of Signal Cancellation method.

The fig.2 depicts the formation of the cancellation signal along with the constellation extension of the secondary user. The QAM modulation which is an efficient one is used in the system. The QAM modulation is the best suitable modulation for cognitive radio systems. Here it utilizes both the amplitude and phase variations. The transformation used is IFFT. The fast Fourier transformation is used in order to improve the spectral efficiency. In addition to that IFFT is also used to raise the frequency which is used in the baseband to transmittable high frequency. Thus this reduces the interference between the carriers of nearer frequencies. The constellation points of primary and secondary user is extended based upon their requirement. The constellation points are Cs and Cp. The former is the constellation point of the secondary user which is dynamically extended during the generation of the cancellation signal and the latter is the constellation point of the primary user. This approach is an enhanced one which gives a solution for the reduction of PAPR as well as suppression of side lobe altogether in an iterative manner. Considering both the problem in an iterative procedure gives an idea for low power consumption. So economically it is more powerful approach. Each iteration gives solution for both problems. The constellation symbols are adjusted along with the addition of cancellation symbols to the primary user. The loop is terminated only when the appropriate constraint is not met. So the usage of power is low when compared to the other reduction techniques.

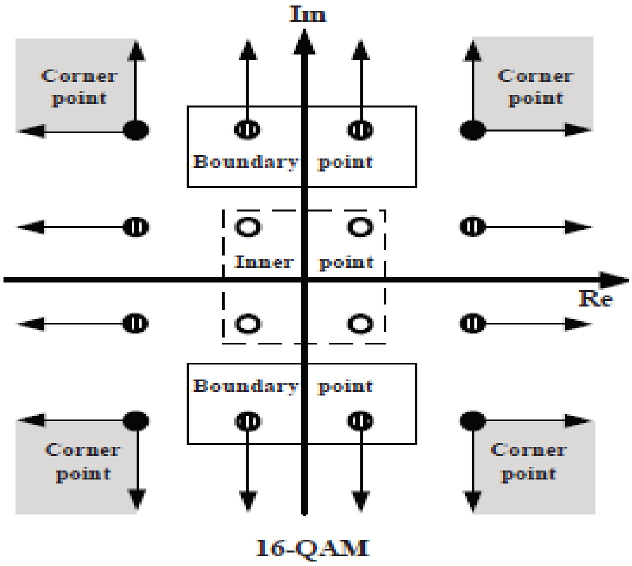

Fig. 3: Representation of constellation region for 16- QAM.

Fig.3 shows the constellation extension of secondary user sub carriers when QAM modulation is employed. The constellation points are classified into inner points, corner points and boundary points. It is clear that the boundary points and the corner points are alone extended. The inner points remain as such. The boundary points are extended only in outward direction where as corner points are extended in both the directions along the shaded portion. Along with the constellation extension the mean square error rate and bit error rate is calculated. The PAPR is reduced and the side lobe is suppressed so that the signal transmitted is free from distortion.

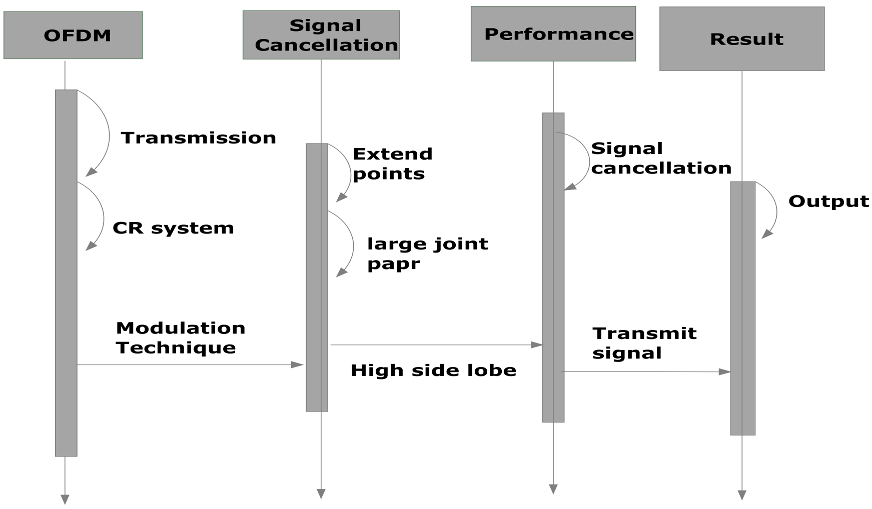

Fig. 4: Sequence diagram description of the entire system.

Table 1: Representation of various parameters.

Parameter	Cognitive radio system	Long term Evolution system
Saturation level	5Db	5Db
Modulation used	QAM	QAM
Number of Sub carriers	256	128
Transformation	FFT	FFT
Bandwidth (Hz)	20	20

Results analysis and discussion:

In NC-OFDM based cognitive radio system, FFT is used with maximum spectral efficiency. The performance of these methods was simulated on MATLAB, and it successfully reduces the PAPR and suppresses the side lobe. Finally it is proved that the proposed system is implementable with less computational complexity and with reduction in bit error rate which provides increase in the data rate. The signal is fed to the LTE system and the signal strength is analyzed. The Parameters of the LTE system gets varied in accordance to the cognitive radio system. Various parameters which are used for the joint reduction of PAPR and side lobe suppressions in cognitive radio system along with the LTE system are tabulated below.

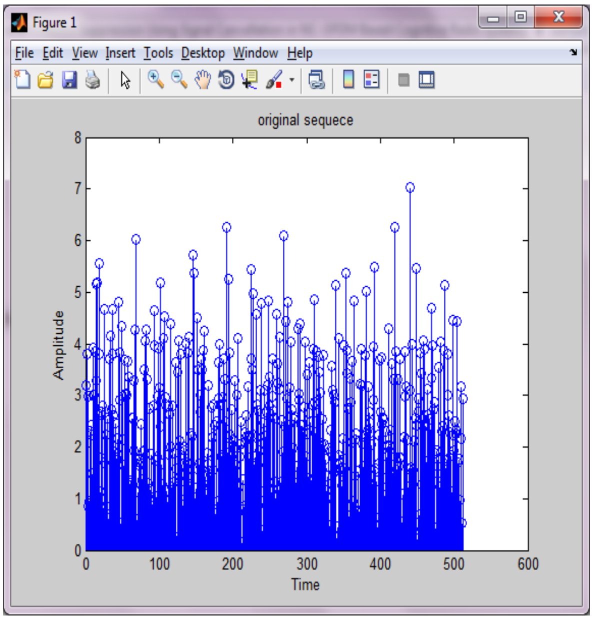

Fig. 5: Original transmitted OFDM sequence

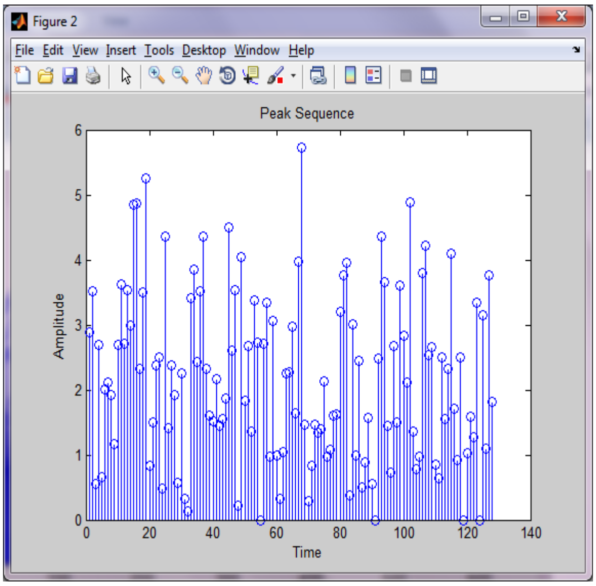

Fig. 6: Representation of PAPR Sequence.

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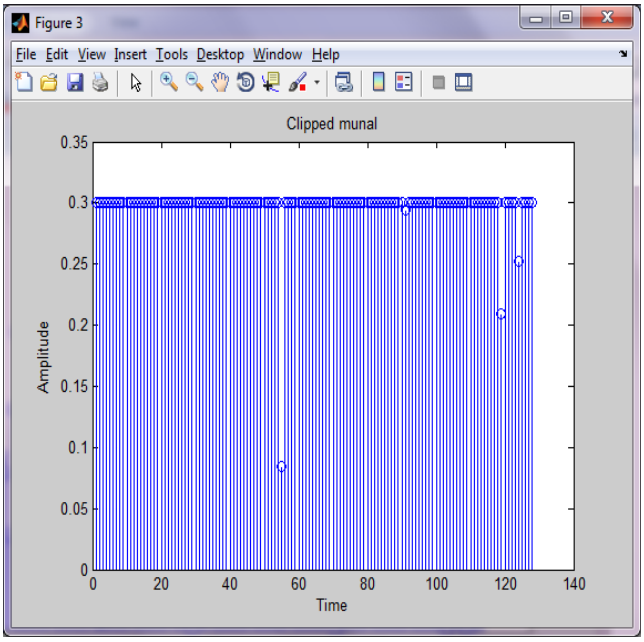

Fig. 7: Representation of clipped signal

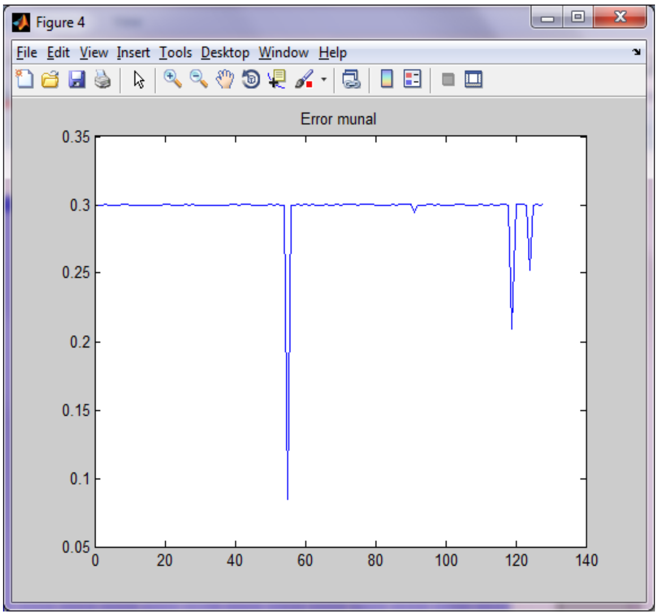

Fig. 8: Error Signal Representations.

Simulation results:

In CR systems, NC- OFDM acts as an attractive physical layer technology to transmit the signal. In order to send the signal error free, it is necessary to use Signal Cancellation method. The error free signal is allowed to pass through the LTE system where the signal characteristics gets altered is also explained in the simulation part. Simulation part of the signal transmission is employed in MATLAB software which is shown below.

Fig. 5 shows the original signal which is being transmitted in the channel. This plot specifies the transmitted signal which uses 128 samples. It shows the formation of all the symbols along with the high peak signals. It is the overall representation of the transmitted sequence. Fig.6 shows the high peak signal which causes interference to the OFDM signal which is to be transmitted. It briefly shows the high peak signal which causes the major interference in the transmitted signal. It majorly causes the degradation of the data rate which in turn reduces the entire spectral efficiency.

Fig.7 specifies the process of clipping the high peak signal over certain amplitude in order to reduce the BER and signal degradation of the transmitted signal. Clipping is a process which reduces the high peak formation so as to obtain a signal which is free from PAPR problem. By using this method it is capable to reduce the major problem of high PAPR which is caused by HPA. It also avoids the out of band radiation and adjacent channel interferences. Fig.8 shows the representation of the error signal which is estimated in the MATLAB by using MMSE estimation. After estimation of the MMSE, it is easy to plot the error signal for the taken 128 samples of input. For each sample the error is calculated and based upon the error the graph is plotted.

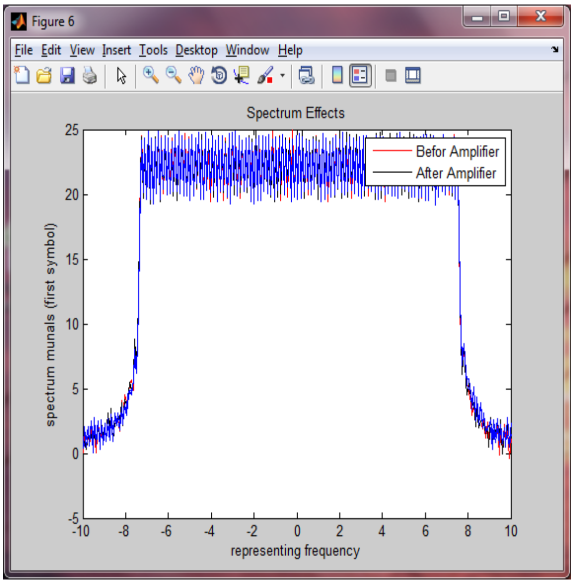

Fig. 9: Representation of Spectrum.

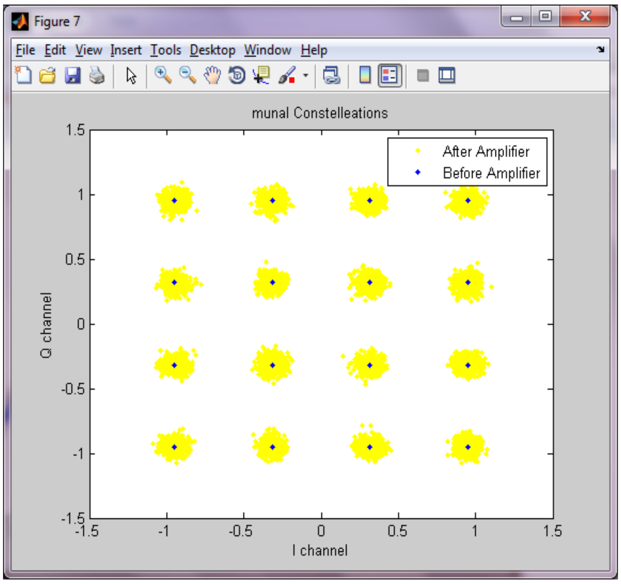

Fig. 10: Signal Constellation of QAM signal.

Fig.9 represents the spectrum formation during two process (i.e.) one is calculated before the amplification process and the other is calculated after the amplification which is plotted for first symbol duration. In Fig.9 the red points the spectrum effect before amplification and the blue color represents the spectrum after amplification process. Fig.10 exhibits the signal constellation of QAM signal. It infers the constellation points before and after amplification process. In fig.10 the yellow color represents the constellation after amplification process whereas the blue color represents the constellation before amplification process. For LTE system the constellation is done for 16 QAM.

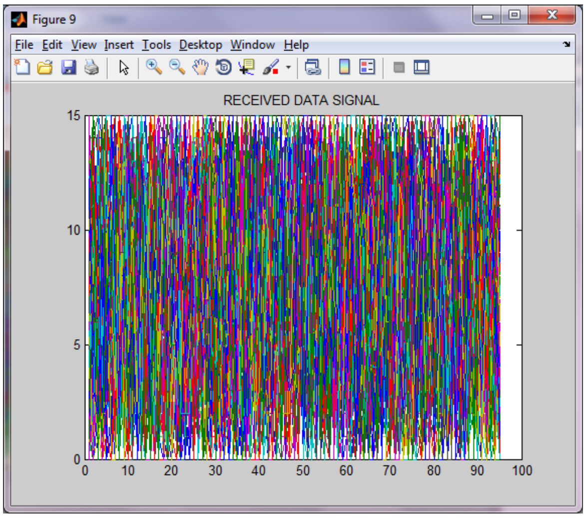

Fig.11: Representation of the Received signal in LTE

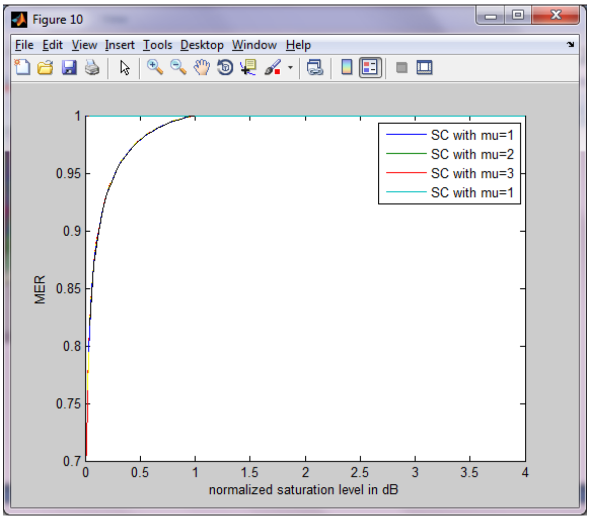

Fig. 12: Estimation of Mean Error Rate.

Fig.11 represents the received signal of the LTE system which has improvement in the signal strength whereas the Fig.12 represents the mean error rate for different symbols.here the maximum saturation level is 5Db.

Conclusion:

In this paper, we proposed a sub optimal signal cancellation method for joint PAPR reduction and side lobe suppression in NC-OFDM based CR systems. The proposed method dynamically extends the constellation points on the SU carriers and adds minimum signal-cancellation symbols on the PU carriers to jointly reduce the PAPR and suppress the side lobe of NC-OFDM signals. This method uses iterative procedure to reduce the PAPR and suppress the side lobe with low computational complexity. Simulation results show that sub optimal SC method can provide significant PAPR reduction and side lobe suppression performances. Further, the OFDM signal which is free from both PAPR and Side lobe is applied to long term evolution systems so that the performance and efficiency of the system gets increased. The performance of the entire network system gets improved by this method. The signal strength is increased so that the efficiency of the system is also enhanced.

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