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Sidelobe Suppression in Ofdm based Cognitive Radio- Review

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Abstract-*Cognitive radio (CR) technology has attracted lots of attention recently. It is an intelligent wireless communication system that is aware of its surrounding environment. Orthogonal Frequency Division Multiplexing (OFDM) is proved to be the best signaling technique for CR systems, as it is able to achieve high data rate communication by utilizing variety of orthogonal frequency bands that are modulated. The performance of OFDM is severely affected due to the out of band radiation (OOB) occurring because of sidelobes of modulated subcarriers. Thus the result of a system employing CR with OFDM suffers from interference between the primary and secondary user. In this paper study of various sidelobe suppression methods is done and presented. Different problems of sidelobe generation are studied, along with their effects on a CR system.*

Keywords- *OFDM, CR, Sidelobe suppression, Modulation, Spectrum, Licensed user, Secondary user.*

I. INTRODUCTION

In past few years, there has been tremendous growth in the domain of wireless devices, thereby increasing the need for spectrum availability and demanding its efficient utilization. But the current static frequency allocation is unable to meet the increasing demand of frequency spectrum by the various wireless devices and users.In order to meet this ever increasing demand, Cognitive Radio (CR) technology has proved to be efficient. The CR system prevents overcrowding of a particular spectrum as well as uder-utilization of another spectrum. In CR systems there are two types of users namely licensed user (LU) also called as primary user (PU) and unlicensed user called as secondary user (SU). The cognitive radio system has the ability to shape the spectrum such that minimum interference to the LU is achieved. In CR systems, whenever the LU is not using the spectrum then it can be allotted to the SU, and hence efficient utilization of available frequency spectrum is achieved. Systems employing CR is proved to be an optimal solution to the problem of inefficient spectrum utilization. Orthogonal frequency division (OFDM) is a better option for CR systems as it reduces the inter symbol interference (ISI) as well as increases the transmission efficiency

A COGNITIVE RADIO

Cognitive radio is a new technology that has attracted lots of attention recently and is a completely unique wireless communication approach with the flexibility to sense the external atmosphere, learn from its history, and build intelligent selections in adjusting its transmission parameters supported the present atmosphere.
“Cognitive radio is an intelligent wireless communication system that is aware of its surrounding environment (i.e., outside world), and uses the methodology of understanding-by-building to find out from the environment and adapt its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameter
(1) Extremely reliable s (e.g., carrier frequency, transmit power and modulation strategy) in real time, with two important objectives in mind: communications whenever and where needed;
(2) Economical utilization of the spectrum” [1].

The three fundamental tasks of the CR system are called as cognitive cycle, which is shown in Figure 1.

1.1.1 Spectrum Estimation or Sensing

Spectrum sensing is a technique in CR networks to identifythe unused spectrum bands in order to provide the information regarding availability of spectrum, required for other functions.

1.1.2Channel State Estimation

In a CR system the function of channel state estimation is to select the most appropriate band according to the quality of service (QoS) requirement.The decision of selecting the accurate spectrum is performed by taking into consideration the end-to-end route which consists of multiple hops. The attainable spectrum bands in a CR network can differ from one hop to the other.

1.1.3 Spectrum Sharing

It is based on the radio spectrum scenario and the channel state information, the system dynamically adapts parameters such as power, spectrum, and data rate and modulation scheme. It enables CR users to perform channel selection and power allocation according to their QoS.

1.1.4 Spectrum mobility

CR users are mobile visitors to the spectrum. If the spectrum currently in use by a CR user is required for PU, the communication of the CR secondary user needs to be continued in another idle portion of the spectrum.

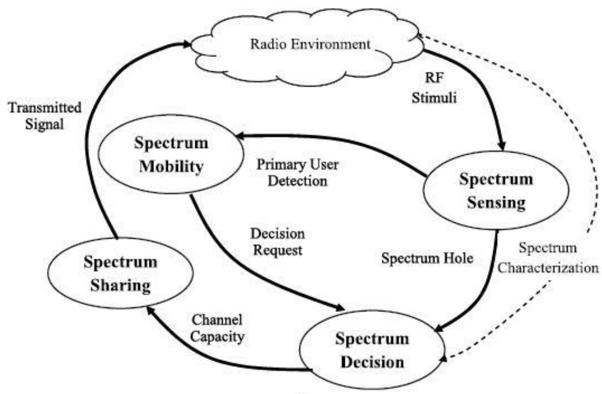

Figure 1. Cognitive cycle.

1.2 OFDM

OFDM has established to be the prime candidate for spectrum pooling based mostly wireless transmission systems because it is able to do high rate communications, by together utilizing variety of orthogonally spaced frequency bands that are modulated by several slower information streams, and this division of the out there spectrum into variety of orthogonal subcarriers makes the transmission strong to multipath channel attenuation. Moreover, it's attainable to show off the subcarriers within the neighborhood of the first user transmissions, and therefore the spectral white areas will be filled up efficiently [2].
In a classical parallel data transmission system that uses frequency division multiplexing (FDM), the carriers are spaced apart in frequency such that the signal carried by each carrier can be demodulated. This is done by using guard bands to avoid the spectral overlap of the channels, and hence, there is a huge waste of the spectrum, resulting in improper use of the spectrum. This condition is shown in Figure1.4. However, due to orthogonality overlapping of the subcarriers is possible without leaving spectral guard bands, and still be able to remove theinterference caused by adjacent subcarrier.

Combination of Multicarrier modulation with orthogonal frequency division multiplexing results in efficient use of spectrum and thus saving of bandwidth. So the required bandwidth for multicarrier system is much less than the bandwidth required for single carrier system. Thus it can be said that multicarrier system is much more efficient than single carrier system.Figure 2 shows the conventional frequency division multiplexing and OFDM technique. We can see that there is saving of bandwidth in OFDM over conventional OFDM.

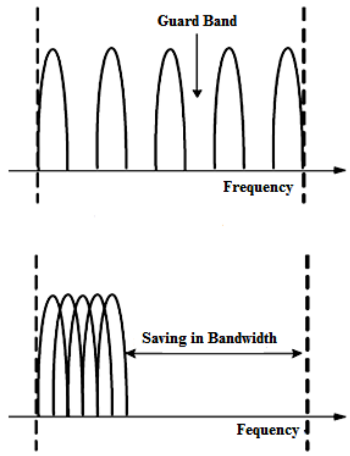

Figure 2 Conventional FDM vs OFDM

1.1 SIDELOBES IN OFDM

The radiation pattern of any antenna consists of number of lobes at various angles and in different directions. When the strength of the signal falls to zero, then it is called as a null. In case of a directional antenna the radiation is in one direction only and the lobe in that direction is called as main lobe, whereas the lobes in other direction are called as sidelobes. Sidelobes are nothing but unwanted radiations in undesired direction. The back lobe is the lobe which is in opposite direction to that of the main lobe. Sidelobes waste energy and cause interference to other signals.
OFDM experiences high out of band (OOB) radiation [3]. Thus for a CR system using OFDM as signaling technique the sidelobes are very harmful as they cause interference between secondary and primary users. For efficient working of a CR system the interference should be as less as possible, then only we can achieve proper working among the various users of the CR systems. Hence various measures are taken for sidelobe suppression of an OFM based CR system.

2. TECHNIQUES FOR SIDELOBE SUPPRESSION IN OFDM BASED CR

2.1 Active interference cancellation

This technique is widely used for minimizing the interference in the CR system which employs Ultra Wide Band (UWB) OFDM technique. This UWB system is based on Multi band OFDM [4].In here the interference is treated in the equivalent baseband signal. In order to reduce the interference, two special tones called as active interference cancellation tones are introduced at the edge of interference band, whose values are determined without any disturbance to the information tones because of orthogonality.

2.2 Subcarrierweighing

In subcarrier weighing method weight of the subcarrier is particularly used. Here optimization algorithm allowing various optimization constraints is used to suppress the sidelobes of the transmission signal depending upon the values of subcarrier weight. The subcarrier weight is multiplied by respective used subcarrier in this method. The subcarrier weighting method reduces the sidelobes by more than 10dB, but there is a loss in BER performance of the system.

2.3 Orthogonal Projection

In this method an orthogonal projection matrix is used for sidelobe suppression. The signals which are distorted due to the interference as a result of sidelobes, are recovered at the receiver by adopting very few, reserved subcarrier using orthogonal projection matrix. In here the orthogonal projection matrix results in zero emission at desired frequency and suppresses emission at the neighboring frequencies. In orthogonal projection method, the pre-distortion matrix introduces inter symbol interference (ISI), which is efficiently eliminated using reserved subcarriers [5].

2.4 Transform Domain

In this method transform domain approach time frequency analysis is done using various tools such as wavelet, short-time Fourier transform (STFT), winger, chirplet etc. Time frequency analysis (TFA) is a very powerful approach for classification and separation of signals. They are described jointly in frequency and time characteristics as a time domain window is formed using STFT. Further the STFT is extended by employing different types of window function in dvariable frequency bands. In chirplet the time frequency characteristics are analyzed in such a way that the chirplets (time frequency atoms) appears as the rotated version ofSTFT or wavelets in the frequency time plane. The constantlychanging frequency content signals are separated using TRF's although there is overlapping power spectrum [6].
In transform domain approach the signal is initially converted to transform domain, thereafter some of the components are erased, and finally inverse transform is applied to obtain the required signal.

2.5 Filter-Based Approach

In this method filters are used for suppressing the sidelobes, which uses a FIR filter. Here least square technique is used to design each FIR filter. These filters prevents the attenuation of out of band radiation (OOB) as well as of the deactivated subcarriers in case of non-contiguous OFDM (NC-OFDM). We can achieve a suppression of upto 30 dbm using this filter approach [7].

2.6Adaptive symbol transition (AST)

The AST technique is quite similar to the windowing method of sidelobe suppression of OFDM. In order to reduce the interference caused to the licensed user (LU), the windowing method uses a filter which is predefined, however the AST method depende upon detection of LU and thereafter optimizing the transition signals adaptively. In here the OFDM symbols are extended in time to smooth the transition between two consecutive symbols. The value extension that is added to the OFDM symbols is obtained by optimization, which reduces the adjacent channel interference (ACI), such that the extension power is acceptable [8].

3. COMPARISON OF VARIOUS SIDELOBE SUPPRESSION METHODS

Different methods for sidelobe suppression in OFDM based cognitive radio has been compared in this paper. The first method proposed for sidelobe suppression is the Active interference cancellation method. In this method although the suppression gain achieved is high but it's hardware complexity is more as compared to other methods. This method also results in a high PAPR value. Both methods reduce the system throughput. Other proposed algorithm for sidelobe suppression is cancellationof carriers (CC) method. The CC technique significantly suppressesthe OFDM sidelobes, but it increases the peak-to-average-power ratio (PAPR) of the system as well as the performance of this method depends significantly on the cyclic prefix (CP) size. The second method discussed is the subcarrier weighing method. It reduces the OFDM sidelobes efficiently but the bit error rate (BER), of the system is increased and the sidelobe reduction is not as significant as the CC method. Another method discussed here is filter method. In this method the symbol duration is prolonged and is easy as compared to other methods but hardware complexity is more. The orthogonal projection method is also one of the good method but it is quite complex as compared to other methods for sidelobe suppression.The last method proposed in this paper is Adaptive symbol transition (AST)[9]. This method is similar to windowing technique but instead of using a predefined filter as in windowing, here the signal is adaptively optimized. The OFDM symbols are extended in time to reduce the effect of symbol transition. The transmission rate reduction is high and the interference reduction is insignificant compared to the CC method.

4. USING HISTORY FOR PREDICTION

We havediscussed various method for sidelobe suppression in ofdm based cr. Out of all the methods the ast method is proved to be the best method for suppressing the sidelobes. This method is quite similar to the windowing method. By using this algorithm, it is possible to achieve a high value of side lobe suppression using this algorithm. Moreover the PAPR value remains sameand reduction of transmission rate is also less as compared to other similar methods. Here an extension is added to each OFDM symbol and the value of extension to be addedis calculated by optimization. This methods gives the suppression gain of about 50dbm.

But this method is quite complex and the algorithm used is difficult to implement hence we have proposed a new method known as modified AST. We have applied genetic algorithm on the AST method, where the value to be added as an extension to each OFDM symbol is calculated using genetic algorithm.

Figure 3 shows the AST method figure 4 shows the modified AST where the AST unit is replaced by modified optimized unit.

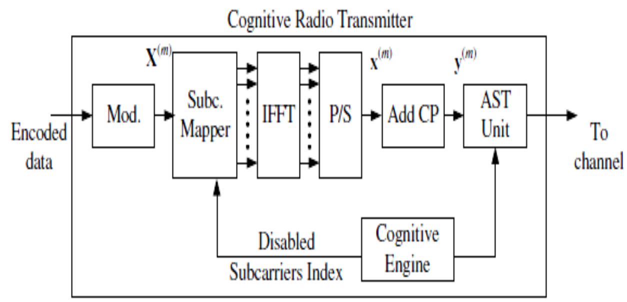

Figure 3 AST method

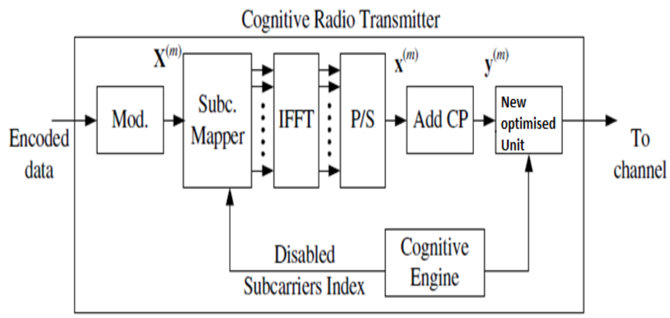

Figure 4 Modified AST

5. CONCLUSION AND FUTURE SCOPE

In this literature we will introduce a novel adaptive optimal technique to enhance performance of CR. Here we need to design a system for Power and error both in order to reduce the suppression. The new system is expected to keep a low SNR loss and PAPR value. The new method is expected to reduce the interference further to less than −50 dB.

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