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Sidelobe Suppression in OFDM Based Cognitive Radio Using Modified AST

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Abstract: In this paper genetic algorithm (GA) is applied on a method known as adaptive symbol transition (AST) used for suppressing the sidelobes in orthogonal frequency division multiplexing (OFDM) based cognitive radio (CR) technology. CR is an effective technique for meeting the increasing demand of frequency spectrum. It allows transmission of licensed (primary) user as well as unlicensed (secondary) user within the same spectral vicinity, depending upon the spectrum requirement by the primary user. The non-contiguous OFDM is a better signalling technique for CR as it provides high data rate and is resilient to the multipath propagation effects. Regardless of the advantages of NC-OFDM it highly suffers from out of band radiation (OOB), which results in distorted communication in adjacent wireless channel. GA is a heuristic search technique that works similar to the process of natural selection by iteratively finding the optimal solution from a set of solutions. Thus in order to reduce the OOB radiation in the NC-OFDM GA can be useful in reducing the sidelobe power levels significantly by giving the optimal solution to the value of extension added to the OFDM symbol in the AST method. In AST method the OFDM symbols are extended so as to minimize adjacent channel interference (ACI) and the value of extension to be added is obtained using optimization. The algorithm used in the AST technique is complex to implement and the time taken is also more, hence using GA is essential. Comparison of performance of the proposed GA technique along with AST and other two methods is conducted and presented in this paper.

Keywords: Non-contiguous OFDM (NC-OFDM), Cognitive Radio (CR), Out of band Radiation (OOB), Genetic Algorithm, Adaptive symbol transition (AST).

I. INTRODUCTION

In past few years, there has been tremendous growth in the domain of wireless devices, thereby increasing the need for spectrum pooling and demanding efficient spectrum utilization. OFDM has established to be the prime candidate for spectrum pooling based wireless transmission systems because itis able to achieve 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 spectrum into variety of orthogonal subcarriers makes the transmission strong to multipath channel attenuation. Moreover, it's attain able to show off the subcarriers within the neighbourhood of the first user transmissions, and therefore the spectral white areas will be filled up efficiently. There is saving of bandwidth by using Multicarrier modulation with orthogonal frequency division multiplexing. So the bandwidth for multicarrier system is less in comparison with single carrier system and hence bandwidth efficiency of multicarrier system is larger than single carrier system.

The new spectrum allocation policy proposed by FCC states that there should be secondary utilization of the unused portions of the spectrum. This secondary utilization is achieved successfully by cognitive radios. A Cognitive radio (CR) is a new technology that has attracted lots of attention recently. It 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 [1,8, 9].

But OFDM signals suffers significantly from high sidelobes which results in adjacent channel interference (ACI). In order to mitigate this effect of interference a method known as adaptive symbol transition (AST) can be employed, which efficiently suppresses the sidelobes. The AST method is similar to the windowing method used for suppressing the sidelobes, here an extension is added to each OFDM symbol so as to reduce inter-symbol interference. Here in this method the transition signal is adaptively optimized depending upon the data and detected primary user so as to reduce the interference. Simulation results show that AST can achieve a significant gain over conventional sidelobe suppression techniques. Moreover, AST does not increase the signal PAPR and keeps a low SNR loss. Although AST is one of the best methods, it is also having some of the drawbacks as the algorithm used to detect transition signal is complex to implement also time taken is more [2].

In this context we'll describe a replacement technique of optimization for the sidelobe power reduction of non-contiguous orthogonal frequency division multiplexing (OFDM) signals employing a genetic formula (GA) approach. Here we have proposed the same AST technique by using Genetic Algorithm (GA) approach. Genetic algorithm is a feature choice algorithms based on the mechanics of natural process and natural biology. In GA procedure initially, a random population is generated and therefore the fitness operate values area unit evaluated over every configuration. Any configuration that meets the improvement objective is taken into account as a best

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configuration. The configurations that don't meet the improvement objective bear replica, crossover and mutation that successively cause a replacement population of configurations. This new population can currently bear identical method as declared earlier till the most effective configurations are found [3,10].

II. SYSTEM MODEL

We have considered a CR system which uses OFDM as its signalling scheme. The radio channel characteristics are known to the cognitive radio, as well as it is equipped with the environment surrounding it. The CR scans the complete channel and identifies the occupied and vacant bands. Thereafter it allows the secondary user to use the unoccupied band for transmission by the secondary user. This way the CR radio gives efficient spectrum utilization while keeping the interference minimum to the primary user [4]. The working of cognitive radio depends on the cognitive cycle which carries out the three fundamental tasks as shown in figure 1. The CR technology will enable the users to (1) determine which portions of the spectrum is available and detect the presence of licensed users (spectrum sensing), (2) select the best available channel (spectrum management), (3) co-ordinate access to this channel with other users (spectrum sharing), and (4) vacate the channel when a licensed user is detected (spectrum mobility). Once a cognitive radio selects the best available channel, then the challenge is to make the network adaptive to the available spectrum. Hence, new functionalities are required in a network to support this adaptively.

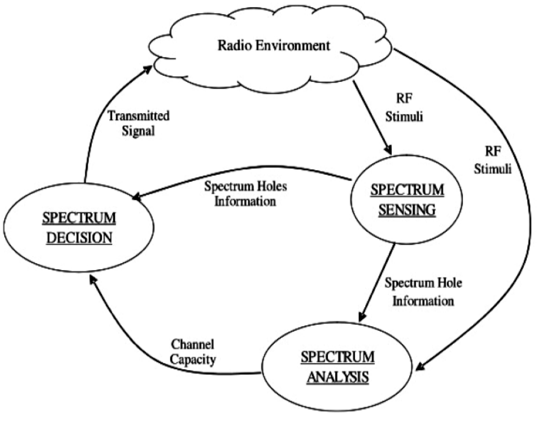

Fig1. Schematic representation of Cognitive Cycle

The system model is shown in the figure 2. First the data is encoded and then modulated using different techniques like PSK, QPSK, or QAM. The signal is then fed to an N-point inverse fast Fourier transform (IFFT) unit.

We define $F_{N_1,N_2} = \{F_{n_1,n_2}\}$ as the N_1 point Fourier point matrix of a vector of length N_2, where

$$F_{n_1,n_2} = \exp\left(\frac{-j2\pi n_1 n_2}{N_1}\right). \qquad (1)$$

The time domain signal at the output of IFFT is

$$X^{(m)} = \frac{1}{N} F^{*}_{N.N} X^{(m)} \qquad (2)$$

Where (m) is the symbol index, N is the IFFT size, $(.)^{*}$ Is the complex conjugate operator, $\frac{1}{N}F^{*}$ is the inverse Fourier transform matrix, and $X^{(m)} = [X_1^{(m)}, X_2^{(m)} \ldots\ldots X_N^{(m)}]^T$ is the modulated data vector.

The signal is then added with a Cyclic Prefix consisting of G samples and the extended symbols $y^{(m)}$ are fed to the new adaptive optimal block. In the mean-time the information regarding the primary and secondary user operating in the same band is sent to the subcarrier mapper and modified adaptive optimal block by the cognitive engine. This information is then used to suppress the interference to the primary user by disabling the subcarriers operating in the LU bands due to OFDM sidelobes as explained in the following sections [2].

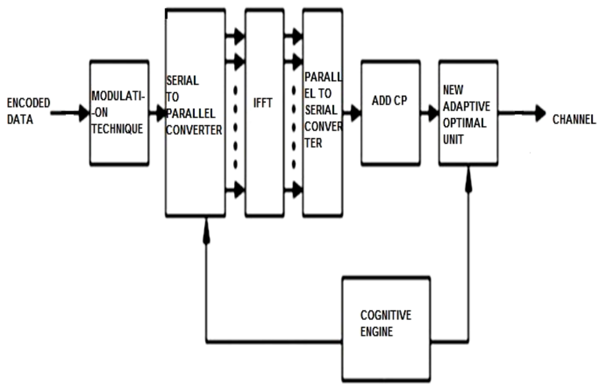

Fig. 2 System model of the proposed methodology

III.PROPOSED MODIFIED AST METHOD

In this paper the sidelobe suppression of OFDM-based CR is achieved by using modified AST. In the AST method an extension is added to each OFDM symbol, but the algorithm is quite complex hence we are implementing this algorithm using genetic formula in our modified method. The genetic algorithm flow graph is shown in figure 3. There are different stages in the flow graph like initial population, evaluation of fitness function. A GA is a random search technique that searches for the most effective feature from a groundwork area provided to it. This search is supported by an objective function, otherwise known as a fitness function that is employed for locating the most effective match at intervals the search area. This operation is evaluated at every individual within the population over many generations till a configuration is found that meets the specified objective. The search area is quite a population of configurations. These configurations area unit that are binary coded options known as chromosomes or strings algorithms are feature choice algorithms supported the mechanics of natural process [5, 6, 7]. Here we have to reduce the interference power thus our fitness function is as follows. Assuming the transmit signal, s(t) on each subcarrier of the OFDM-transceiver system is a rectangular non-return-to-zero (NRZ) signal, the power spectral density of s(t) is represented in the form:

$$\phi_{ss}(f) = A^2 T \left(\frac{\sin\pi f T}{\pi f T}\right)^2$$

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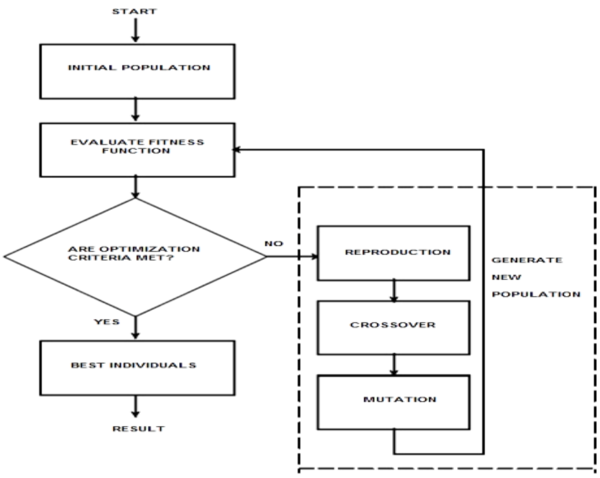

Fig. 3 Genetic Algorithm flow graph

Where A denotes the signal amplitude and T is the symbol duration which consists of the sum of symbol duration, TS and guard interval, TG. The assumption that the transmit signal s(t) on each subcarrier is a rectangular NRZ signal is valid since it matches the wireless LAN standards. Now assuming that, the legacy system is located in the vicinity of the rental system, the mean relative interference,$P_{\text{Interference}}$ (n), to a legacy system subband is defined as

$$P_{\text{Interference}}\ (n) = \frac{1}{P_{\text{Total}}}\int_{n}^{n+1} \phi_{ss}(f)df$$

where P_{Total} is the total transmit power emitted on one subcarrier and n represents the distance between the considered subcarrier and the legacy system in multiplesof Δf.

IV. SIMULATIONS AND RESULTS

The performance of the proposed method is investigated using computer simulations. Here the modulation scheme used is Pulse amplitude modulation (PAM). The total no. of subcarriers is 256. N is the size of IFFT which is taken to be 1024. The compensation length is 12. Guard band length is 2 and cyclic prefix length is 4. Here we have taken a primary user band starting from 64 to 128 of the data.

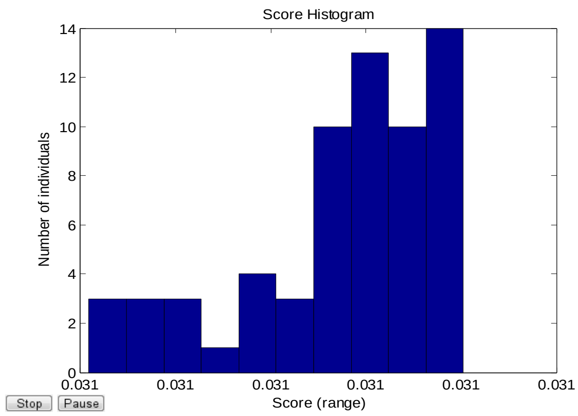

Fig. 4 Genetic algorithm plot

For genetic algorithm the initial population is 64, maximum generation is 100 and time limit is 10ns. Figure 4 shown below is the genetic algorithm plot using score histogram plot. This plot provides us the optimised value using different individual of population.

Figure 5 shows the spectrum of our optimal adaptive method with frequency on x-axis and normalised frequency on y axis. The graph shows that the interference is reduced approximately by 20 db for our method. As we can see that for the primary user band the interference power for normal method is -50db, whereas the modified method has interference power of -70db.

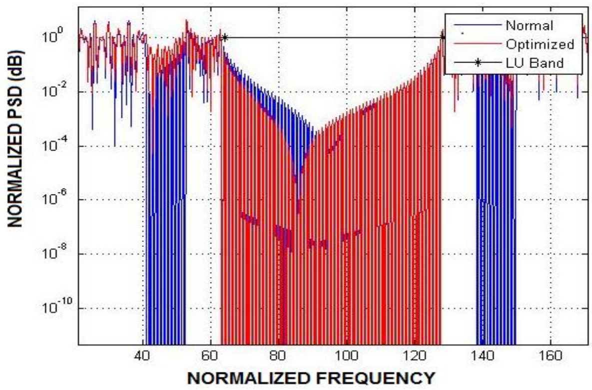

Fig. 5 Spectrum of normal and optimised method

Figure6 shows the SNR versus BER plot for primary user and secondary user. Our main aim is to reduce the interference caused to the primary user because of the OFDM sidelobes. It can be clearly seen in the SNR vs. BER plot that for a particular value of SNR the bit error rate of the primary user is less as compared to that of the secondary user; hence we can say that the interference to the primary user is reduced.

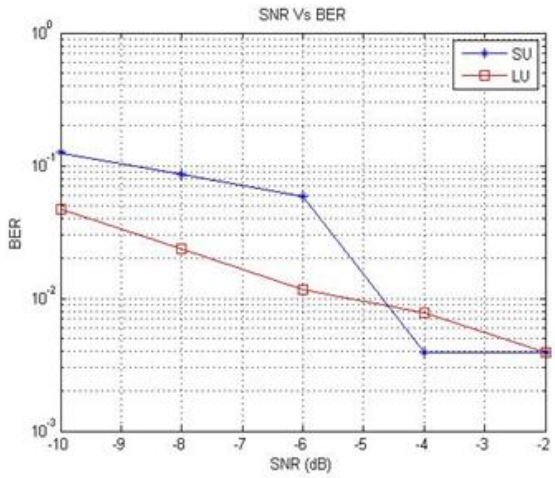

Fig. 6 SNR Vs BER Plot for Secondary and Primary user

IV. CONCLUSION AND FUTURE WORK

In this paper, an attempt has been made for suppressing the interference power resulting from the rental system to the legacy system to acceptable levels. Consequently, the coexistence of the legacy and the rental systems is made more feasible. A novel algorithm has been proposed in this

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paper which introduces a new adaptive optimal method to improve performance of CR. The new system is optimized to reduce error in performance.

This new adaptive method is having a constant signal peak-to-average-power radio (PAPR) and keeps a low SNR loss. The BER vs. SNR graph shown in result depicts the high performance of the proposed system. The result shows that the interference reduces further to less than −70dB.

Every time when we run the genetic algorithm we found new optimum value, which gives us different suppression gains each time. As the GA is a heuristic method of finding optimal value hence to get same output each time we need to set an initial value. This can be done in future to get optimal as well as exact value. Also it would be interesting to the proposed algorithms implemented on a cognitive/software-defined radio hardware platform.

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