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SIMULATION OF ENERGY DETECTION TECHNIQUE WITH OFDM FOR SPECTRUM SENSING IN COGNITIVE RADIO USING SIMULINK

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ABSTRACT: With the emerging technologies in the field of spectrum utilization, there is a need of efficient technology which solves the problem of scarcity of spectrum utilization. Today, a large number of users are increasing with the rapid pace and the only solution for efficient utilization of spectrum is cognitive radios. Cognitive radio solves spectral limitation problems occupying the frequency band in an opportunistic manner. Cognitive radio involves different spectrum sensing methods. We have detected a spectrum hole by detecting the presence of the primary user in its allocated frequency spectrum. It is done by energy detection technique. The advantage of this technique is its simplicity to implement. A complete OFDM transmitter and receiver chain is designed for primary and each secondary user. The energy of the detected symbols is then compared to detect the presence of the primary user so that a spectrum hole can be identified. The proposed work is simulated on Matlab (R2010b) using Simulink modeling to detect the spectrum hole using energy detection method for cognitive radio. The performance of the system is evaluated and analyzed for one primary user and two secondary users.
Keywords: Cognitive Radio, Spectrum Sensing, Energy Detection, Primary user, Secondary user, OFDM.

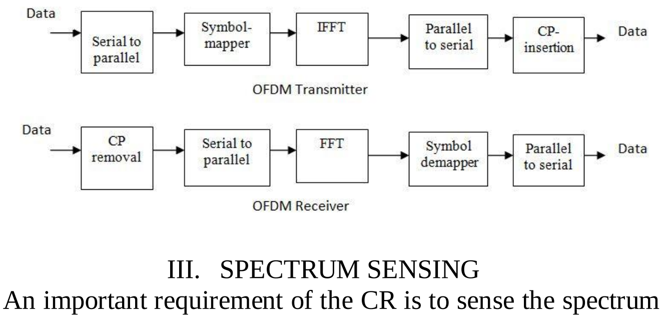
I. INTRODUCTION

Static spectrum allocation strategies do not efficiently utilize licensed spectrum which is indicated in a report published by FCC. In order to efficiently utilize unused frequency spectrum of a licensed band, generally referred to as a ‘spectrum hole’, the concept of cognitive radio can be employed by which efficient spectrum utilization can be achieved by optimistic spectrum sensing technique Cognitive Radio (CR) is mostly a research topic today, and the wireless market has not seen a mass commercial deployment/ exploitation of the CR technology yet [1]. A user in cognitive environment should be aware of radio environment in order to predict available resources and requirements of the application and could adapt to performance parameters according to available resources and user request. Other cognitive user (Secondary users) can make use of the spectrum which is already allocated without affecting the priority of the primary user in utilizing the spectrum. This in turn, helps in maximizing the efficiency of the spectrum which was licensed to only single user. Software defines radio (SDR) and Application specific integrated chips (ASIC) help in dealing with hardware challenges of cognitive radio [2-4]. The important functions of a CR include:1) Spectrum Sensing 2) Spectrum Management 3) Spectrum Mobility4) Spectrum Sharing [5]. The spectrum sensing techniques [6] can be classified as transmitter detection, cooperative detection, and interference-based detection. If the secondary user cannot gather sufficient information about the PU signal, the optimal detector is an energy detector, also called as a radiometer, which is used in this work. In this paper we have simulated the energy detection feature using Simulink tool of MATLAB for an OFDM system. The energy of the detected symbols is then compared to detect the presence of the primary user so that a spectrum hole can be identified.

II. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

Multi carrier modulation, (MCM), is used in mobile wireless applications to mitigate the impact of fading channel impairments on BER. It offers more resistance to interference caused by impulse noise and enhanced immunity to inter-symbol interference, as compared to single-carrier systems. MCM splits data to be transmitted into several parallel components and sends each of these components over separate carrier. If the sub-carriers, on which these components are sent, are orthogonal to each other the MCM is called orthogonal frequency division multiplexing (OFDM).

Figure 2.8 shows the block diagram of an OFDM transmitter and receiver. Efficient implementation of OFDM is achieved with the help of inverse fast Fourier transform (IFFT) and FFT blocks. Inter-carrier and inter-symbol interferences are removed by insertion of guard time interval called as cyclic prefix. Error correction coding is used to restore bits that are lost over weak sub-carriers. Finally, OFDM symbols are transmitted after radio frequency modulation.



III. SPECTRUM SENSING

An important requirement of the CR is to sense the spectrum holes. It is designed to be aware of and sensitive to the changes its surrounding. The spectrum sensing function enables the cognitive radio to adapt to its environment by detecting the primary users that are receiving data within the communication range of a CR user [6, 7]. In reality, however, it is difficult for a cognitive radio to have a direct measurement of a channel between a primary transmitter detection based on local observations of CR users [5]. In [1] the spectrum has been classified into three types by estimating the incoming RF stimuli, thus, black spaces, grey spaces and white spaces. Black spaces are occupied by high power local interferer some of the time and unlicensed users should avoid those spaces at that time. Grey spaces are partially occupied by low power interferers but they are still candidates for secondary use. White spaces are free RF interferers except for ambient noise made up of natural and artificial forms of noise e.g. thermal noise, transient reflection and impulsive noise. White spaces are obvious candidates for secondary use [1]. The goal of the spectrum sensing is to decide between the two hypotheses, namely

$$x\ (t) = n(t)\ ,H_0$$

$$x\ (t) = h\ s\ (t) + n(t)\ ,H_1$$

Where X(t) is the signal received by the CR user, s(t) is the transmitted signal of the primary user , n(t) is the AWGN band, h is the amplitude gain of the channel. H0 is a null hypothesis, which states that there is no licensed user signal. Generally, the spectrum sensing techniques can be classified as transmitter detection, cooperative detection, and interference-based detection.

Energy Detection If the secondary user cannot gather sufficient information about the PU signal, the optimal detector is an energy detector, also called as a radiometer. It is common method for detection of unknown signals. The block diagram of the energy detector is shown in Figure 2 below.

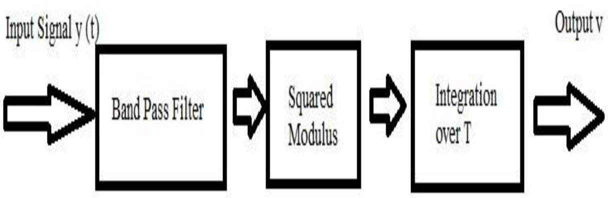


Fig. 2 Energy Detection in Cognitive Radio

First, the input signal y(t) is filtered with a band pass filter (BPF) in order to limit the noise and to select the bandwidth of interest. The noise in the output of the filter has a band-limited, flat spectral density. Next, in the figure there is the energy detector consisting of a squaring device and a finite time integrator. The output signal V from the integrator is

$$V=1/T\int_{t-T}^{T}|y(r)|^2 dr$$

Finally, this output signal V is compared to the threshold η in order to decide whether a signal is present or not. The threshold is set according to statistical properties of the output V when only noise is present. The probability of detection Pd and false alarm Pf are given as follows:

$$\boldsymbol{p_d} = \{\boldsymbol{y}>V\backslash H_1\}$$

$$\boldsymbol{p_f} = \{\boldsymbol{y}>V\backslash Ho\}$$

From the above functions, while a low Pd would result in missing the presence of the primary user with high probability which in turn increases the interference to the primary user, a high Pf would result in low spectrum utilization since false alarm increase the number of missed opportunities. Since it is easy to implement, the recent work on detection of the primary user has generally adopted the energy detector. However, the performance of energy detector is susceptible to uncertainty in noise power. In order to solve this problem, a pilot tone from the primary transmitter is used to help improve the accuracy of the energy detector. The energy detector is prone to the false detection triggered by the unintended signals [7].

IV. SIMULATION MODEL & RESULTS

Simulink model of energy detection using orthogonal frequency division multiplexing technique is presented in this section.

OFDM Transceiver Block:

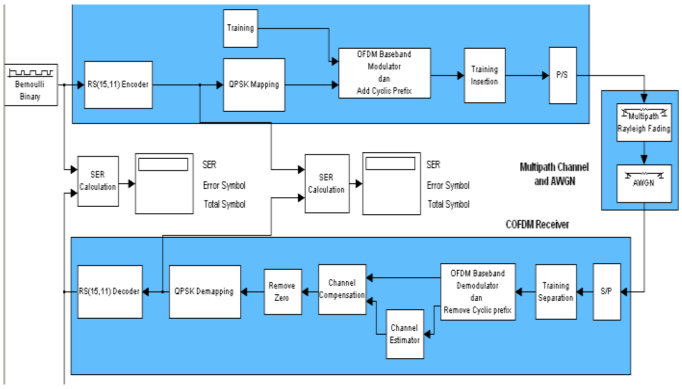


Fig. 3 OFDM Transceiver Block

Spectrum Sensing Block:

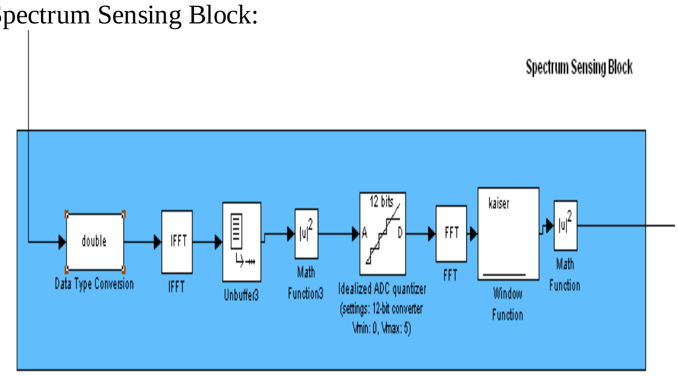


Fig. 4 Spectrum Sensing Block

Threshold Comparison Block:

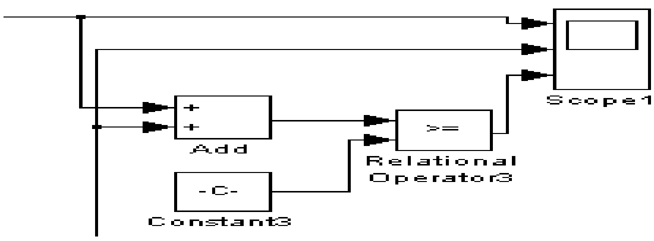


Fig.5 Threshold Comparison Block

Complete Simulink model is formed by combining fogures 3, 4 & 5. Both the primary user and secondary users have their individual spectrum sensing and energy detection blocks. The energy detection from primary user and secondary user are then compared using the threshold comparison block as shown in the figure 6.

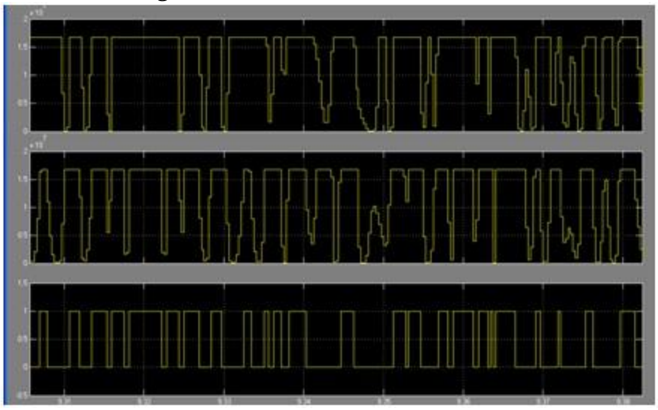


Figure 6 shows the primary signal in the topmost graph while the middle graph represents the secondary user. An absence of pulse is detected whenever the received energy of the signal goes below the threshold limit set in the lowermost graph.

Figure 6 shows the primary signal in the topmost graph while the middle graph represents the secondary user. An absence of pulse is detected whenever the received energy of the signal goes below the threshold limit, as set in the lowermost graph. The region during absence of pulse can be considered as white spot & signals of secondary users can be inserted in those bands. Another result has been shown in form of graph between bit error rate and E_b / N_o for the system under consideration for two times as simulation 0 and simulation 1.

V. CONCLUSION

This paper presented the simulation of Energy detection technique with OFDM for spectrum sensing is done using MATLAB SIMULINK Model. With the help of this model spectrum holes in the spectrum of primary user can be observed and secondary users are given opportunity accordingly. Performance and BER computation can also be done with the help of BER & Eb / N0 curve.

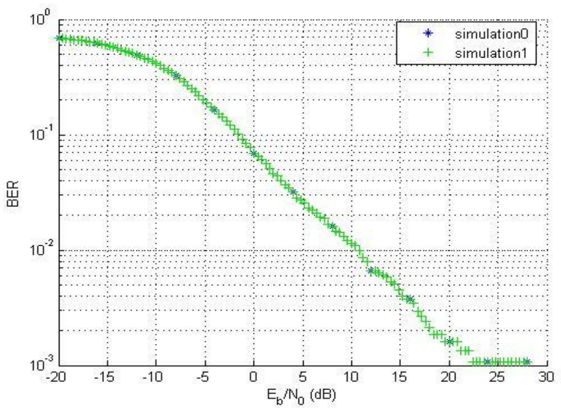


Fig. 7 BER vs Eb/No graph for Eb/No varying from -20dB to 28 db

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