International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

Spectrum Sensing based on Energy Detection for Cognitive Radio using FPGA

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***Abstract*— Spectrum sensing in cognitive radio (CR) is essential method that identifies the presence of primary user signal in a channel. Cognitive technology solves the difficulty by access the unlicensed users from licensed bands. In this paper, energy detection technique algorithm is used for modulated signal to identify the presence of deterministic primary user (PU) signal in the channel whereas signal is present or absent. There are considered two types of modulated signals which are BPSK and QPSK under noise (AWGN). Also simulation performance characteristics of receiver operating curves for modulated signal are done on MATLAB with detection probability versus false alarm probability using the Monte Carlo method. The hardware implementation created on FPGA board for the switching the absent signal to required secondary user (SU).**

***Keywords*— Additive white Gaussian noise, Cognitive Radio, Energy detection, FPGA, Spectrum Sensing**.

I. INTRODUCTION

Cognitive radio is the most important next door wireless communication technology which can be accomplish to use the spectrum and also it is clever reconfigurable radio which craftily users a certified spectrum [1]. The main work of cognitive radio is dependable, well behaved and usual recognition of vacant licensed spectrum [2]. Cognitive radios (CRs) have been feasible answer to progress to use of spectrum by spectrum sharing method. Their technology ability permits CRs to energetically permission to vacant part of the spectrum resources operation [3]. In the writing of spectrum sensing, recognize the vacant spectrum band separately by enabling spectrum sensing without any interference of primary signal for secondary user. Also energy detection required less detection period when it can be maximize the signal to noise ratio [4]. In spectrum sensing, considered energy detector which apply on the spectrum band for calculate the energy and differentiate it with fixed or dynamic threshold value. Therefore the spectrum band is absent when energy level is less than threshold and while threshold is less than energy level then spectrum band is present. This technique is very effortless and easy than the Cyclostationary feature detection and matched filter detection. The performance of this energy detector mostly helpless for differentiate the energy from primary transmission while noise level is changing [5]. In this work, analyze the energy detection technique. It is very preserve method which can detect the spectrum without any information about primary users (PU) signal. It detects the occurrence of a signal from the spectrum by comparing the received signal energy over the noise floor. The simulation performance of receiver operating curve (ROC) with respect to Pd Vs Pfa and SNR for modulated signal is implement on MATLAB using Monte Carlo method also this MATLAB code interface serially through FPGA hardware for observe the switching the absent signal to secondary user.

The remaining part of this paper is as follow: section 2 is discussion of spectrum sensing techniques. In section 3, system design model is discussed. In section 4, mentioned simulation setup and discussion of results. Finally presents conclusion in section 5.

II. SPECTRUM SENSING TECHNIQUES

A. Matched Filter Detection

Thinking about the matched filter detection is a descent detecting technique when cognitive radio has information of primary user (PU). It is right for the reason that it maximizes the signal to noise ratio (SNR) through the received signal. The output of matched filter and fixed threshold will decides the presence of primary user when matched filter signal is correlates with time shifting version and hence, in this the working of matched filter is pitifully when data is not correct [6].

B. Cyclostationary Features Detection

In spectrum sensing, modulated signals differentiate from the additive noise by using the implementation of cyclostationary feature detection when mean and auto correlation values of signals are in cyclic function then signal is cyclostationary. This technique can compares the noise from primary user at less SNR using basic knowledge of signal which is not a part of noise [7].

C. Energy Detection

In spectrum sensing energy detection technique is very important because it is less computational and less execution complexities. In this detection, the receiver is totally independent on the prior knowledge of primary user's. The energy detection technique is easily apply on the primary signal with noise and on the basis of energy of observed signal it can be detect the primary signal which is present or absent[7][8].

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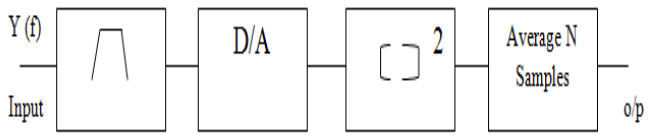

Fig 1.Energy Detection in Time Domain

Here, Y (f) is the input signal transmitted to band pass filter further by using DAC converts the digital signal to analog signal. To measure received signal energy the band pass filter output is squared over the average N samples. Finally the output is compared by threshold to make a decision whether a licensed signal is present or not [9].

III. SYSTEM MODEL DESIGN

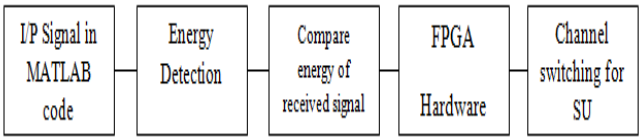

Fig 2. System Model Design

The system mainly consists by single primary user and single secondary user. In this, for detecting the primary user's transmission the energy detector is apply on the secondary user. Hence, observing the primary user's traffic which is gradually varying for example remaining part of primary user's signal which in transmission state are(occupied/ inactive) for sufficient time to be seen in similar status through whole detection method.

The structure of this spectrum sensing problem is designed using the algorithm of binary hypothesis testing as follows [10].

H0: y[n] =w[n]……PU absent
H1: y[n] =s[n] +w[n]……..PU present
n = 1, 2, 3 ….N.

Where s[n] is sample of primary signal, w[n] denotes sample of noise signal and y[n] is samples of output of received signal over N is the length of observations in detection process. In this work the system of energy detection for spectrum sensing will be shown in figure 2 in this process, energy level is measured over the interest of band and compare with the hypothesis and check statements which are true for deciding whether the band is accessible or not for secondary user. So, we have to selected BPSK and QPSK modulating signal from MATLAB simulation and it is given to FPGA (Spartan 3) board using serial communication and when signal is present or absent, FPGA board will be switch the channel accordingly to free signal from the channel, and using Monte Carlo simulation detector is characterized the performance of Pd verses Pfa with respect to SNR [7].

IV. RESULT AND DISCUSSION

The primary user signal waveform on which energy detection technique algorithm is applies for spectrum sensing. Transmitter can have different transmitting parameter like sampling frequency, sampling period, and SNR. The system parameters are setup and convert the signal in modulation form which is BPSK or QPSK. Further add noise to receiver signal and compare energy of signal with energy of received signal. In this simulation we take the decision that if energy of signal is greater than energy of received signal then signal is absent else signal is present. After we interface the FPGA board and transmit the data to serially, when signal is absent FPGA board switch the absent signal to required secondary user. This section also shows the simulation results of Monte Carlo method which is used under non fading channel AWGN in MATLAB version R2014a simulation tool. The ROC curves of energy detector allowing for permanent value for detection threshold of BPSK and QPSK signals. Considered signal to noise ratios are -4dB, -8dB, -12dB, -16dB & -20dB with probability of false alarm varies from 0.1 to 1. The graph is demonstrates execution metrics of false alarm probability is expanded when detection probability is increases with increasing in noise ratio of signal.

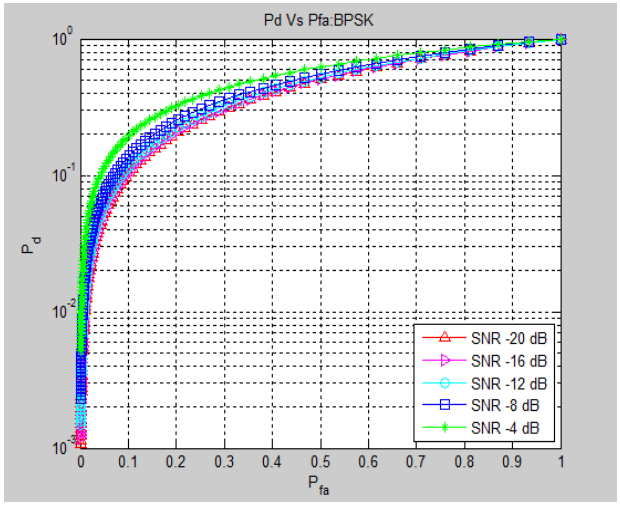

Fig 3. ROC curve of energy detector for BPSK signal

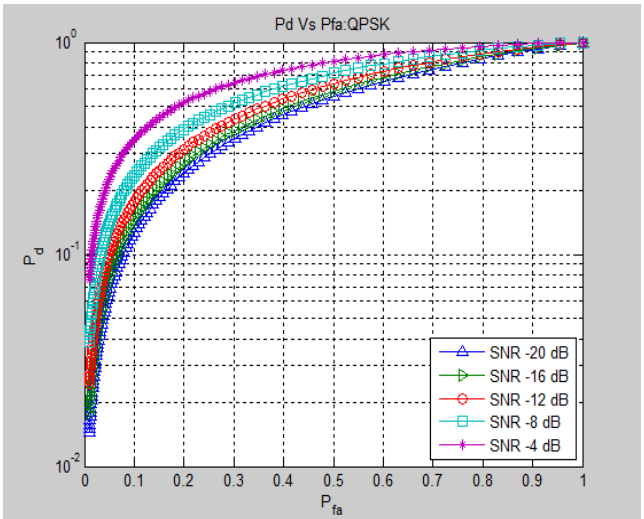

Fig 4. ROC curve of energy detector for QPSK signal

So, we get the result of energy detection of spectrum sensing for cognitive radio and finally we have switched the absent signal to required secondary user with the help of FPGA.

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V. CONCLUSION

In this paper, we have talked about energy detection of spectrum sensing for cognitive radio network using BPSK and QPSK modulated signals in the presence of sampling period, sampling frequency with noise ratio. We detect vacant signal and provide to the secondary user using switching by FPGA. And also we have discussed ROC curves of Pd Vs Pfa. The probability of detection and false alarm probability are varies based on SNR using Monte Carlo simulations in MATLAB R2014a. This can be shows that detection probability decreases with decreasing false alarm probability with respect to increase in SNR and vice versa. For this we are execute the energy detector and switching the absent signal on hardware as a FPGA platform.

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