Comparative Analysis of Energy Detection and Cyclostationary Feature Detection using Simulink

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ABSTRACT: - Nearly 79 to 89 percent of the radio spectrum is not utilized at any instant of time, while on the other hand some regions of spectrum suffer from congestion simultaneously. A cognitive radio is an intelligent radio that can recognize the idle frequencies as well named as spectral holes or white spaces (which are not being used by any primary or licensed user) and allot them for the use of unlicensed secondary users. The basic functionality of a cognitive radio is aware of it environment, internal state, and location, which automatically to adjust to parameters (e.g. determine the RF environment, channel conditions, link performance) to achieve desired objective in response to the unexpected changes in the characteristics. Basic function of cognitive radio is to sense the spectrum precisely by evading any chances of hindrance or interference to primary or licensed users. By using spectrum sensing, cognitive radios can adapt themselves to the eternal wireless network. Spectrum sensing can be performed by many techniques. In our present work we have compared energy detection and cyclostationary feature detection technique for spectrum sensing with their merits and demerits on Simulink tool. Simulink is basically a data flow graphical programming language tool for modeling, simulating and analyzing a system or a model. Presently we have used Simulink for modeling different spectrum sensing (SS) models and results plotted on graph.

Keywords: - Cognitive radio (CR), software defined radio (SDR), spectrum sensing (SS), cyclostationary feature detection (CFD), energy detection (ED), primary user (PU), secondary user (SU).

1 INTRODUCTION

From 1990's radios have been developing and getting niftier and with exponential growth people need to communicate via data , voice communication, internet communication, control communication, emergency response communication.CR brings effectiveness, flexibility, ease, cost efficiency, and power to drive communication forward with wide reaching benefits [1]. Cognitive radio (CR) does work in three parts. Firstly cognitive radio is like an adaptive radio which communicates by means of monitoring their own performance, and modifies their own performance, and parameters to provide high quality of service (QOS), to increase performance level, Greater degree of adaptation. So CR is considered to be very intelligent with decision making capabilities or synthetic brain talented of making resolutions to sense, share and access the channels in the spectrum that is not being used by any primary/licensed user. This also called analyzing the spectrum. Secondly along CR dynamic spectrum access is also used in which spectrum is shared between primary user (PU) and secondary user (SU). Primary/licensed users have main hold over spectrum and they are always given priority over secondary/unlicensed users. When primary user (PU) not active or idle means they not accessing spectrum at that same time secondary/unlicensed user make permission from primary user to access the spectrum. The instant the primary user (PU) want to accesses the spectrum again, the secondary/unlicensed user has to shift to an empty portion of the spectrum. This called as spectrum sense and access in which unused spectrum detected and shared without harmful interferences to other users. Spectrum sensing (SS) can be done by are energy detection (ED), matched filter detection and cyclostationary feature detection (CFD). Thirdly CR captures the best available spectrum to meet users communication requirement called spectrum analysis and spectrum decision [2][3].CR incorporate software defined functionality in existing radio called software defined radio (SDR) to meet all above requirement. SDR technology as dynamic spectrum access system with Cognitive or smart radio functionality to reduce cost to end user to access wireless communication and enable them to communicate with whomever, whenever and whatever they needed. Here in this paper we are sensing Spectrum by energy detection (ED) and cyclostationary feature detection (CFD) and hence comparing both techniques [4][5][6].

2 ENERGY DETECTION

Energy Detection (ED) is a captivating spectrum sensing method for Cognitive Radio (CR). Energy detection is the modest and fastest method of spectrum sensing. Energy Detection (ED) has low computational complication. Whenever secondary user (SU) cannot get together any plenty information, then Energy Detection (ED) can be used due to its competence to perform without the signal erection to be sensed.

Figure 1 shows a Simulink model of Energy Detection (ED) in which input signal is passed through a band pass filter. Then this band pass filter passes the selected range of frequencies and blocks the other frequencies. Magnitude of the received input signal is squared using absolute (Abs) math function. Then window integrator is used to integrate the received signal. Integrated signal undergoes rising edge detection and for that Edge detector is used which can detect rising edge, falling edge or either edge. After that relational operator is used to compare the input signal and constant threshold signal (.1).

Output of detector is plotted by Scope.

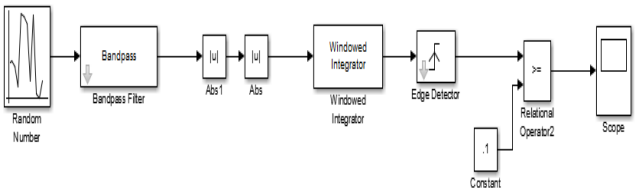

Fig. 1: Simulink model for Energy Detection

Figure 2 shows threshold comparison of 6 users using energy detection (ED) method. Energy detection blocks are sculptured as many users (6 no.) are required. There are 6 users with different signal values which are compared with threshold value. Threshold value is set at .5 and is generated using constant block. Relational Operator compares the input signal value with threshold signal value (.5) and the difference of both values shown on Scope.

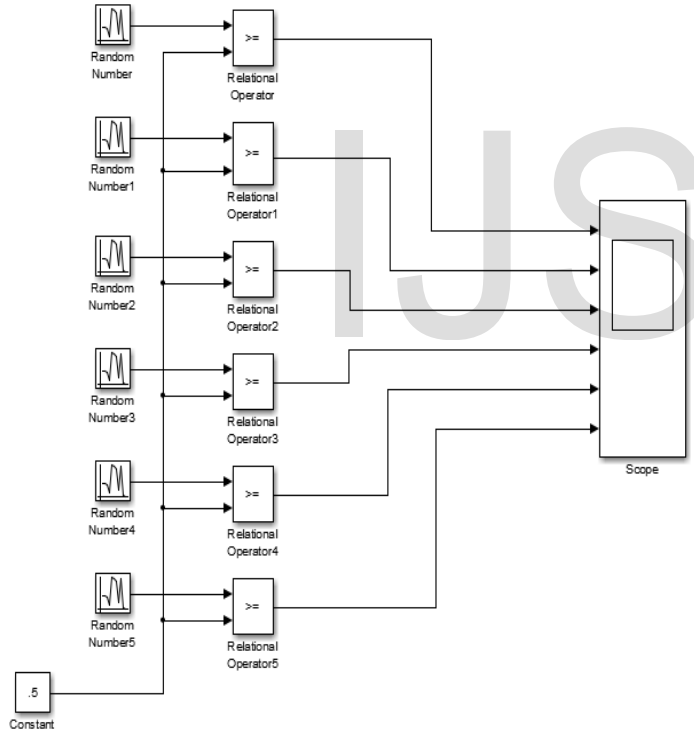

Fig. 2: Simulink model for Energy Detection with 6 users (comparison of threshold)

3 CYLOSTATIONARY FEATURE DETECTION

The most challenging task in the conniving and execution of cognitive radio (CR) is spectrum sensing (SS). By using spectrum sensing, cognitive radios (CR) can familiarize themselves to the unending wireless spectrum environment. Cyclostationary sensing is an effective method for signal detection. A modified radio signal is considered as a cyclostationary process and the statistical properties of cyclostationary process differ periodically over time. The autocorrelation function is the cyclic processes with a periodicity T. Cyclostationary feature detection (CFD) deals with cyclostationary statistical characteristics of the signal. It accomplishes periodicity in received primary signal to identify the presence of primary user (PU). Cyclostationary feature detection (CDF) method obtains greater noise protection than any other spectrum sensing (SS) method because it has periodic statistics and spectral correlation that cannot be found in any interference signal or stationary noise [7] [8].

Figure 3 shows cyclostationary feature detection (CFD) model. Applied input signal is a discrete sine wave. Additive White Gaussian Noise (AWGN) is added to the input signal. Peak notch filter is used to reject very few range of frequencies and it is opposite of band pass filter. ADC quantizer is used to quantize the input signal; its effect is to quantize a smooth signal into a stair step function. Encoder block converts the quntizer's output in the form of integers. Conversion of the signal from time domain to frequency domain is done using FFT (Fast Fourier Transform) block. Kaiser window is used as window function. Data type conversion block converts any signal in the form of user specified signal. In the last section constant block generates threshold value which is compared by relational operator with the input signal. The output is taken on scope.

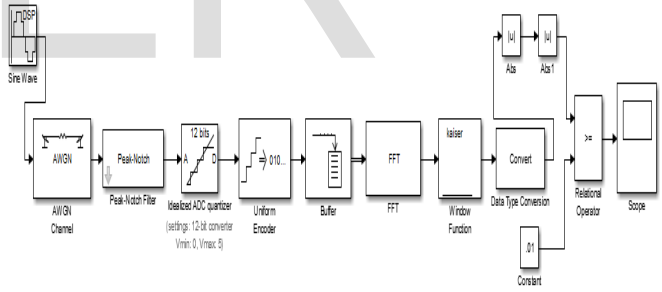

Fig. 3: Simulink model Cyclostationary Feature Detection

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4 RESULTS

Figure 4 shows the output result of Energy Detection method. Threshold is set to .1 and if user will cross the threshold value than user is present otherwise user will be idle and at that instant secondary user can occupy space. In figure 4 threshold value (.1 in this case) is indicated using green line.

Figure 5 shows the output of cyclostationary feature detection (CFD). The threshold is set at .1. Cyclostationary feature detection (CFD) method has very less effect of noise so we can see that pulse fall down for very less time otherwise most of time remains high. It proves that user will be present under very heavy noise.

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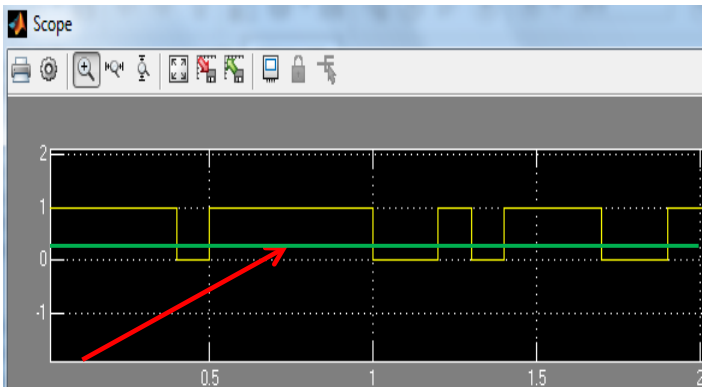
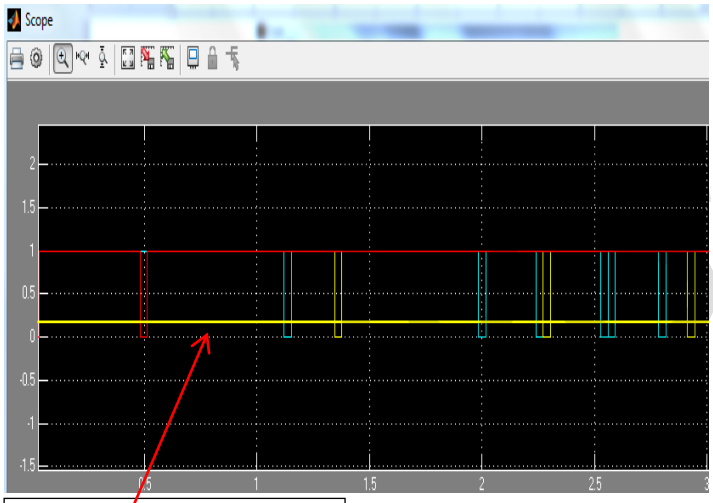


User crossing threshold set at 0.1 (shown by green line).Hence user is

Fig. 4: Simulink output for Energy Detection



Threshold set at (.1) shown by yellow line

Fig. 5: Simulink output for Cyclostationary Feature Detection

In figure 6 we can see that threshold value is set at (.5). Total number of users is 6. The user who will cross the threshold value is assumed to be present and who will not cross threshold value is assumed to be idle. As shown in graph that 1st, 3rd and 5th user cross the threshold value so they are assumed to be present. 2nd, 4th and 6th user does not cross the threshold value so they are assumed to be idle means there spectrum is free to access. So , secondary user (SU) can use that spectrum.

Figure 7 shows the difference between energy detection (ED) method and cyclostationary feature detection (CFD) method. Upper portion of the graph shows energy detection (ED) and lower portion shows cyclostationary feature detection (CFD). In energy detection (ED) method there is heavy effect of noise,

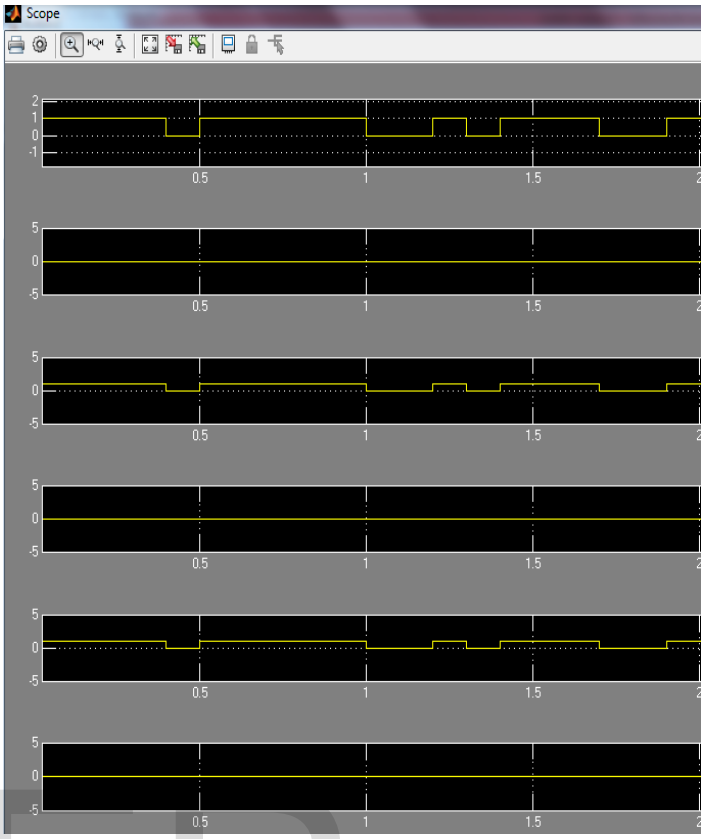


Fig. 6: Simulink output for Energy Detection with 6 users Comparison

this degrades the quality of signal. Due to noise pulse falls for long time, cause the interference to the users. On the other hand in cyclostationary feature detection (CFD) noise effect is very less. Pulse fall down for very short time which shows that cyclostationary feature detection (CFD) method have very small effect of noise. So the quality of signal remains better in cyclostationary feature detection (CFD) method and cause less interference to the users [9][10].

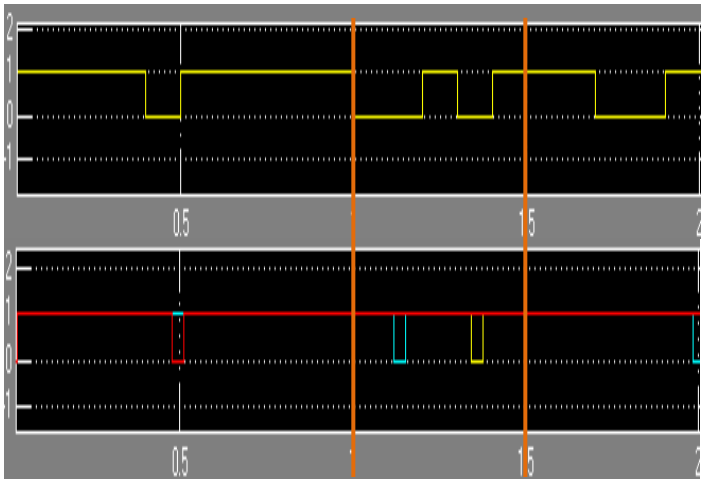


Fig. 7: Comparison of energy detection method and cyclostationary

detection method.

5 CONCLUSION

Our paper has executed Simulink based spectrum sensing methods. The energy detection (ED) method for spectrum sensing (SS) is carried out for six users. The appearance or nonappearance of the licensed user is selected based on the threshold value which is manually adjusted. In energy detection method presence of noise is very much so it shows degraded results which are overcome by the cyclostationary feature detection (CFD) method. In cyclostationary detection detectors employ the inherent periodicity of the modified signals. Although this method increases the complication of the system but still user is present under heavy noisy environment which proves that noise effect is very small. Hence cyclostationary feature detection (CFD) method is better as compared to energy detection (ED) method

REFERENCES

[1] Doyle, Linda E., "Essentials of Cognitive Radio" First edition, Cambridge University Press, 2009.

[2] Mitola J. and G.Q.Maguire, "Cognitive Radio: Making software radios more personal", IEEE Personal Communications, vol: 6, Pp: 13-18, 1999.

[3] D. Bielefeld, et al., "Energy Efficient Ultra Wideband Signaling for Cooperative Sensing in Cognitive Radio," in Proc. IEEE Vehicular Technology Conference Spring, Budapest, pp. 1-5, 2011.

[4] M. Subhedar and G. Birajdar, "Spectrum Sensing Techniques in Cognitive Radio Networks: A Survey," International Journal of Next-Generation Networks, vol. 3, no.2, 2011.

[5] Avila.J, et al., "Simulink Based Spectrum Sensing", International Journal of Engineering and Technology (IJET), ISSN: 0975-4024, Vol: 5, No: 2, Pp: 872-877, Apr-May 2013.

[6] Aparna P. S. and M. Jayasheela, "Cyclostationary Feature Detection in Cognitive Radio for Ultra-Wideband Communication Using Cooperative Spectrum Sensing", International Journal of Future Computer and Communication, Vol. 2, No. 6, December 2013.

[7] Artem Tkachenko, "Test bed Design for Cognitive Radio Spectrum Sensing Experiments".

[8] Castro, Marcos E., "cyclostationary detection for ofdm in cognitive radio systems" (2011).Electrical Engineering Theses and Dissertations. Paper 21.

[9] The MathWorks Simulink Website. URL: http://www.mathworks.com/products/simulink/

[10] The MathWorks MATLAB Website. URL: http://www.mathworks.com/products/matlab/

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