ISSN: 2278-0181
ICIATE - 2017 Conference Proceedings

# Analysis of Energy Detector for Spectrum Sensing in Multiuser Environment

Kavita Bani
Research Scholar
MPSTME, Mumbai

Vaishali Kulkarni
Associate Professor
MPSTME, Mumbai

***Abstract*— Cognitive Radio (CR) is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. Spectrum Sensing can detect unused spectrum and sharing it, without harmful interference to other users; an important requirement of the cognitive-radio network is to sense empty spectrum. Detecting primary users is the most efficient way to detect empty spectrum. Here Energy detector(ED) is used for spectrum sensing for its low complexity. Energy detector is implemented for single, double and multi user environment with the help of Matlab /Simulink. Spectrum and Scope output show the results of the all users with specific threshold level.**

***Keywords*— Cognitive Radio (CR), Spectrum Sensing (SS), Energy detector (ED), Primary User (PU), Secondary User (SU).***

## I. INTRODUCTION

Software Defined Radio (SDR) technology is invented in 1990, where the radio platform gets an additional feature as software for controlling and implementing various parameters like coding, modulation type and frequency bands can be changed at any time by adding software. On demand SDR enables radios to switch functions and operations by having re configurability. But SDR is not capable to reconfigure by itself only. This need leads to cognitive radio (CR) invention.

In Mitola's dissertation [1], he has invented new term cognitive radio which become adjusted to new conditions and cleverly changed its transceiver parameters when it needed. Today however CR has become an all-round in wide variety of technologies that enable radios to successfully bring various levels of self-configuration, wireless access, and dynamic spectrum access for a future device centric interference.

Spectrum utilization is the one of the primary motto of the CR. By using Cognitive radio with MIMO radio, gives flexibility in terms of carrier frequency, transmit power, channel bandwidth and multiplexing gain [2]. Spectrum opportunities in opportunistic Secondary Spectrum Allocation (SSA) can be done in spectrum holes or white spaces, where a portion of the band is left completely idle by the primary users like radar systems or TV channel.

The U.S. Federal Communications Commission (FCC) uses a narrower definition for this concept: "A Cognitive Radio (CR) is a radio that can change its transmitter parameters based on interaction with the environment in which it operates. The majority of cognitive radios will probably be SDR (Software Defined Radio) but neither having software nor being field programmable is requirements of a cognitive radio" [3].

CR is investigated by regulation committee to enable the technology for opportunistic access which is lead to access TV white spaces. Amount of large parts of TV bands are available by geographically because of nowadays analog communication is switched over digitalization. United Kingdom (UK) and United State of America (USA) have adapted the CR model and decided 802.22 standards for utilization of these TV white spaces. So in future worldwide, CR is expecting to become main area in advanced technology [3].

Unlicensed spectrum like 2.4GHz and 5G Hz are known as ISM bands who are using for wireless computer networking area. Home appliance, microwave oven, energy falls in 2.4GHz band but it is not suitable to allocate the licensed spectrum for this kind of application as its using for a particular purpose. Similarly, Wi-Fi (802.11) and Bluetooth are coexisting and working based on determining frequency time slots to use and keep trying until they find the vacant channel in their specific band [4].

In order to avoid interference, the spectrum holes need to be sensed, primary user detection is the most efficient way for the spectrum sensing. Spectrum sensing (SS) techniques are divided into three categories,

1) Transmitter detection
2) Cooperative detection
3) Interference based detection

In spectrum sensing (SS), transmitter detection is further classified in three types,

1) Energy detection
2) Matched filter detection
3) Cyclostationary feature detection.

## II. LITERATURE SURVEY

Mansi Subhedar, [5] by increasing demand in no of wireless applications, spectrum which is available to the radio, has to utilize in very effective manner. CR is the technology which can overcome to this problem. Spectrum sensing is the most important task for CR networks for utilization of spectrum. Many advanced techniques, including distributed spectrum sensing, interference the method used in identifying the interference and/or spectrum sensing should be reliable and

prompt so that the primary user will not suffer from CR system to utilize their licensed spectrum.
Kulbir Singh,[6] Energy Detection and Cyclostationary feature detection technique of Spectrum sensing techniques are implemented on Simulink model. In energy detection method presented in this paper, has noise very much present shown by result which are overcome by the Cyclostationary feature detection (CFD) method. In Cyclostationary detection detectors in this paper employ the inherent periodicity of the modified signals. Although CFD method increases the complication of the system but still user is present under heavy noisy environment which proves that noise effect is very small.

Pawan Yadav, [7] has implemented Simulink based spectrum sensing. The energy detection is done with the four users. The Primary user signal is present is decided based on the threshold value. Energy detection has been adopted as an alternative spectrum sensing method for CRs as practically ED is easy to implement and ED doesn't require any prior information about the signal which is further going to detect.

F. F. Digham, [8] ED is implemented for unknown signal over the environment of multipath channels. Here, sampling theory-based approach is used for the performance ED for an unknown transmit signal under the AWGN channel and fading channels. Receiver diversity schemes like square-law combining and square-law selection are added to improve the performance of ED.

## III. SPECTRUM SENSING USING ENERGY DETECTION

Energy detection technique is most common way of detection because of its low computational and implementation complexities. In energy detection approach, the receivers do not need any knowledge on the Primary users' signals as in matched filters and other approaches. This is given by eq $^{n}$ ( 1)

The aim of the spectrum sensing is to decide between two hypotheses which are

$x(t) = w(t)$ , H0 (Primary User absent)

$x(t) = h\,n(t) + w(t)$ , H1 (Primary User present) ….(1)

Where x(t) is the signal received by the CR user, n(t) is the transmitted signal of the primary user, w(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. Energy Detection is the common way of spectrum sensing for its low computational and implementation complexities. It is a non-coherent detection method which is used to detect the licensed user signal [9] and is based on the use of the FFT (Fast Fourier transform), which transforms a signal from a time domain to a frequency domain representation, determines the power in each frequency of the signal resulting in which is known as the PSD (Power Spectral Density).

In this technique, the output of the energy detector compares with a threshold depending on the noise floor and signal is detected.

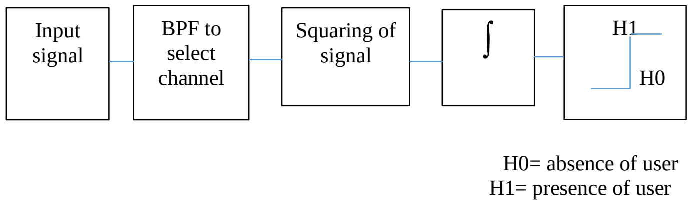


Figure 1 energy detector block diagram

Figure 1 shows block diagram of energy detector [10]. Here signal is applied to band pass (BP) filter to select channel and is followed by a squaring device to measure the received energy and is integrated over time interval. Lastly the output of the integrator compares with a threshold to determine whether primary user is present or not. The threshold value can set to be fixed or variable based on the channel conditions.

## IV. IMPLEMENTATION OF ENERGY DETECTION

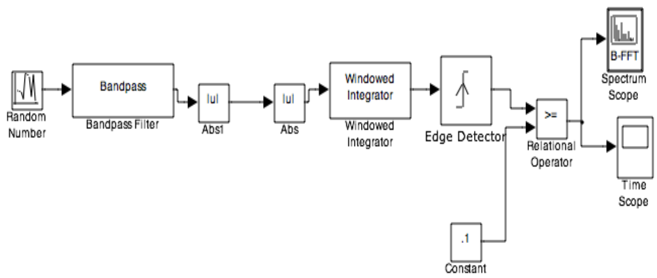


Figure 2.Energy detector Simulink model for single user

Figure 2 shows Simulink model of Energy detector. Input signal is generated through random number which is further passed into band pass filter (BPF) to choose a specific band of frequencies and block the other frequencies. After the BPF, 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. Than to generate output signal, relational operator is used to compare the input signal and constant threshold signal (.1). Output of energy detector is plotted on time scope as well as on FFT spectrum.

Similarly figure 3&4 show the energy detector simulink model
with double users and multi (five ) users respectively.

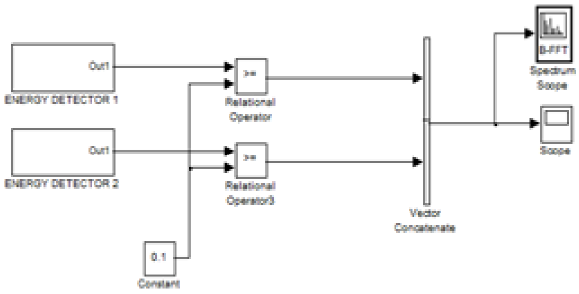


Figure 3. Energy detector Simulink model for double users

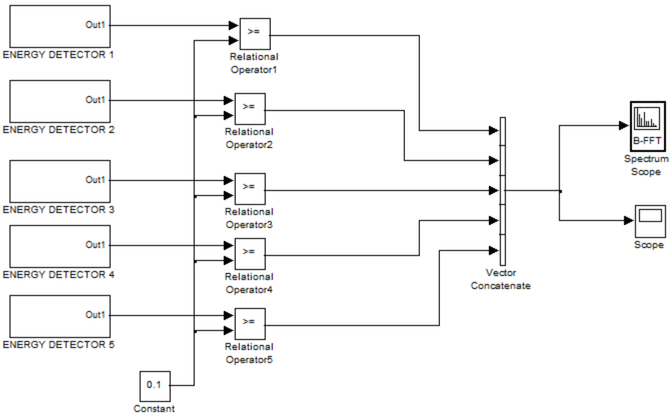


Figure 4. Energy detector Simulink model for multi (five) users

## V. RESULTS

Figure 5 shows scope output of Energy detector for single user. The result of edge detector shows for a threshold of 0.1 for a single primary user (PU). It can be seen that wherever the energy is detected more than the threshold, the primary user is present.

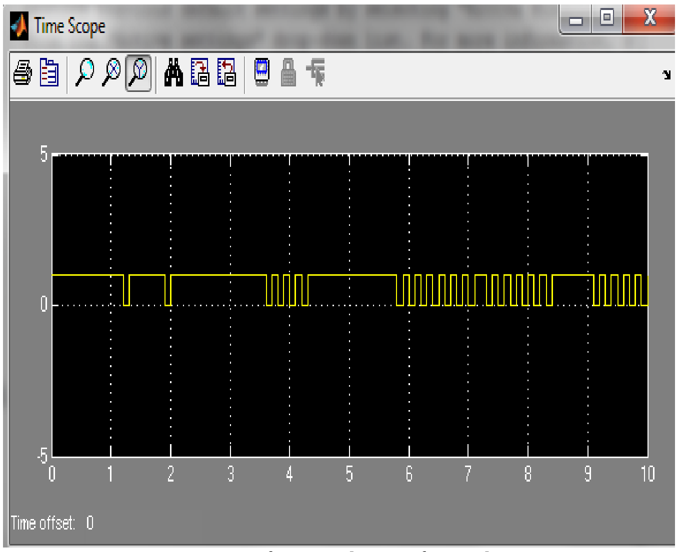


Figure 5. Scope output of Energy detector for single primary user

Figure 6 shows the FFT Spectrum output of Energy detector for single primary user with peak at -5dB and frequency is 10Hz, rest all peaks are noise.

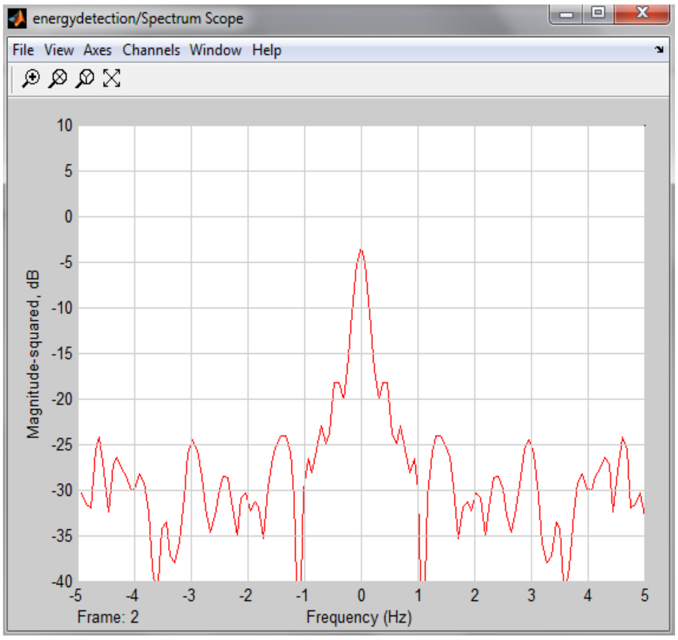


Figure 6 FFT Spectrum output of Energy detector for single primary user

Figure 7 shows the scope output of Energy detector for double primary users. Two random users have been simulated by varying seed of random numbers. It can be seen through the scope that there are some spectrum holes at time interval 4 to 4.5 and interval 6 to 6.5 where the both primary users are absent.

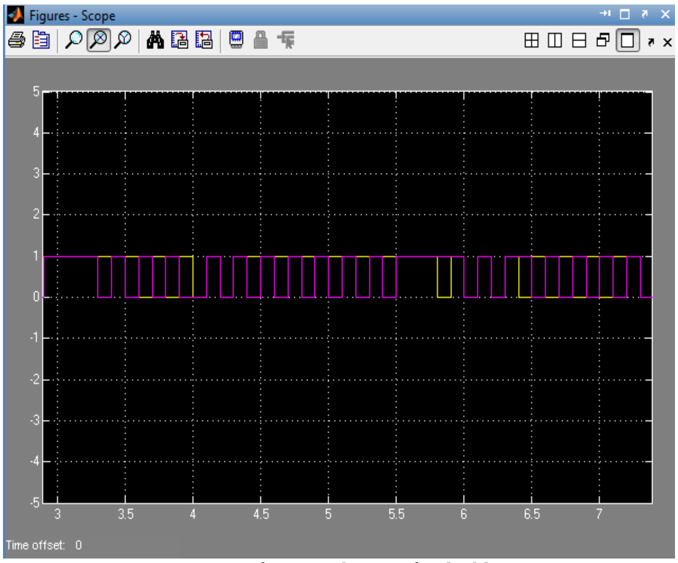


Figure 7. Scope output of Energy detector for double primary users

Figure 8 shows the FFT Spectrum output of Energy detector for double primary users with blue and magenta colors, peaks at -5dB and frequency is 10Hz, rest all peaks are noise.

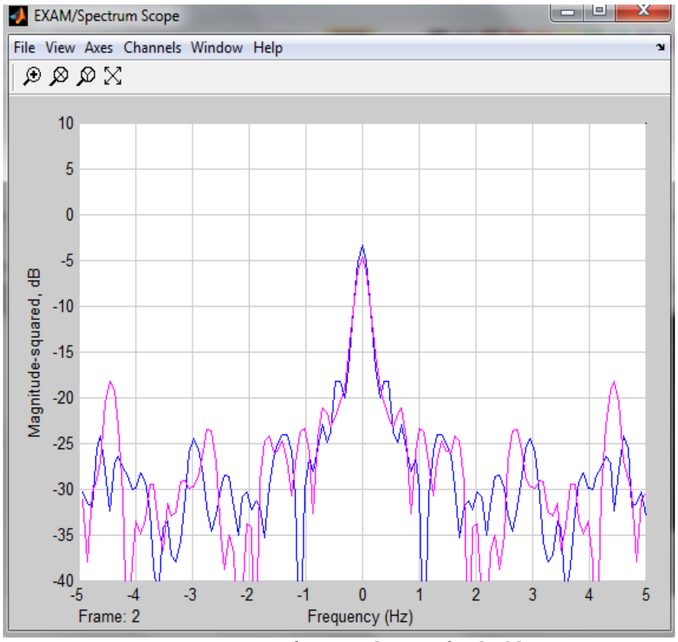


Figure 8 FFT Spectrum output of Energy detector for double primary users

Figure 9 shows the scope output of Energy detector for multi (five) primary users. Five random users have been simulated by varying seed of random numbers. It can be seen through the scope that there are some spectrum holes at time interval between 9.1 to 9.2, where the all five primary users are absent.

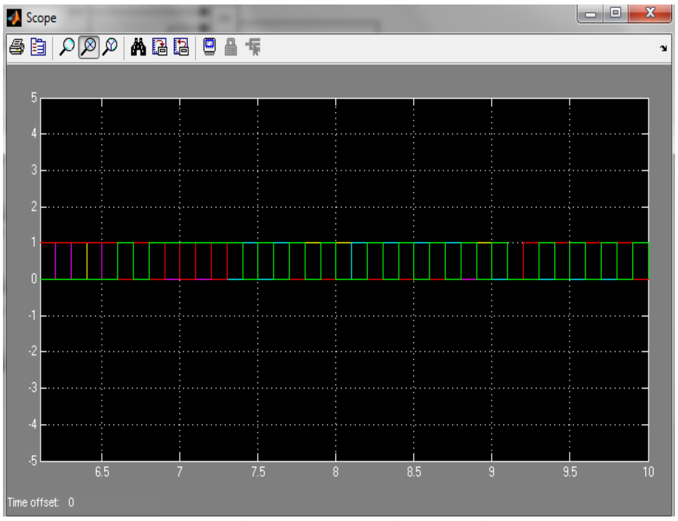


Figure 9.Scope output of Energy detector for multi (five) primary users

Figure 10 shows the FFT Spectrum output of Energy detector for multi (five) primary users with different five colors, all PU's peaks at -5dB and frequency is 10Hz, rest all peaks are noise.

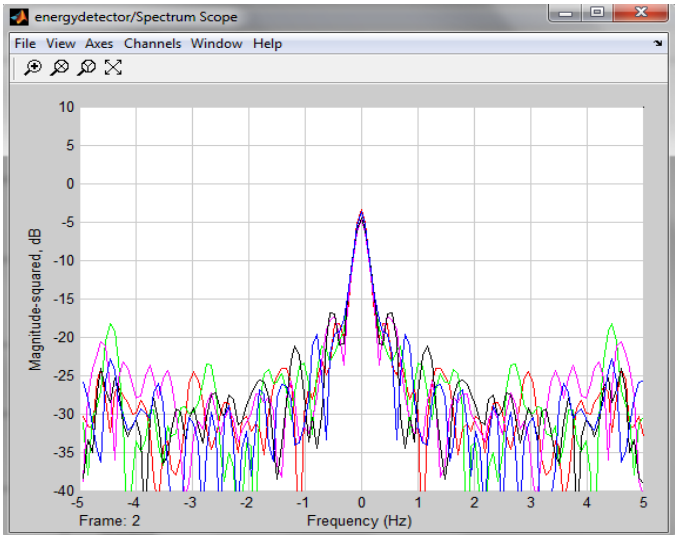


Figure 10 FFT Spectrum output of Energy detector for multi (five) primary users

## VI. CONCLUSION

Energy detector has been implemented in Matlab / Simulink. It has been implemented for single, double and multi (five) primary users. The results are shown with scope and FFT spectrum for all kind of primary users (PUs). There are spectrum holes which can be allocated to secondary users (SUs) for that time interval by adaptively using an appropriate allocation scheme.

The prior information is needed to implement this technique, is a disadvantage of the energy detector. A more robust technique for spectrum sensing will be implemented for future scope.

## REFERENCES

[1] J. Mitola III, "Cognitive radio: An integrated agent architecture for software defined radio." PhD thesis, Royal Institute of Technology (KTH), Stockholm, Sweden, May 2000

[2] S. Haykin, "Cognitive radio: Brain-empowered wireless communications," IEEE Journal on Selected Areas in Communications, vol. 23, pp. 201–220, Feb. 2005.

[3] A. M. Wyglinski, M. Nekovee, Y. T. Hou, "Cognitive Radio Communications and Networks: Principles and Practice" Elsevier, December 2010.

[4] M. McHenry, D. McCloskey, and G. Lane-Roberts, "Spectrum occupancy measurements, location 4 of 6: Republican national convention, New York City, NY, Aug. 30, 2004–Sept.3, 2004, revision 2," tech. report, Shared Spectrum Company, Aug. 2005.

[5] Mansi Subhedar and Gajanan Birajdar "Spectrum Sensing Techniques in Cognitive Radio Networks: a survey", International Journal of Next-Generation Networks (IJNGN) Vol.3, No.2, June 2011

[6] Kulbir Singh, Rita Mahajan, "Comparative Analysis of Energy Detection and Cyclostationary Feature Detection using Simulink", International Journal of Scientific & Engineering Research, Volume 5, Issue 5, May-2014 ISSN 2229-5518

[7] Pawan Yadav, Rita Mahajan, "Energy Detection for Spectrum Sensing In Cognitive Radio Using Simulink" , International Journal of Advanced Research in Electrical,Electronics and Instrumentation Engineering Vol. 3, Issue 5, MAY 2014

[8] F. F. Digham, M.-S. Alouini, and M. Simon, "On the energy detection of unknown signals over fading channels," in Proceedings of the IEEE International Conference on Communications, May 2003

[9] B. Fette, Cognitive Radio Technology. Boston, MA, USA: Elsevier, 2006.

[10] Prashant Mohan Trivedi, S.T.Aarthy, Suraj Kumar Sharm,a "Comparison of Different Local Spectrum Sensing Techniques in Cognitive Radios", 2014 IJEDR | Volume 2 Issue 1 | ISSN: 2321-9939.