International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

RESEARCHERID
THOMSON REUTERS

[Prajapati* *et al.*, 8(2): February, 2019]
ICTM Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

DESIGN AND IMPLEMENTATION OF MULTI HOP RELAYING IN COGNITIVE RADIO SYSTEMS WITH VARYING ENRGY HOP ALGORITHM

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DOI: 10.5281/zenodo.2557567

ABSTRACT
Cognitive Radio Systems has become one of the most prominent technologies to enable good and high data rate of networks. There is tendency of the wireless media to be very random in nature, so it is pivotal to sense the spectrum and utilize the channel state information (CSI) in order to suppress the tones of frequency that can yield low Signal to Noise Ratio (SNR). It is crucial as it aids in improving the BER performance of the system. These systems can be effectively designed as a Software Defined Radio (SDR). In this proposed paper, a multi hop cooperative relaying technique is proposed and follows a subsequent BER analysis. The model adheres to the regulations laid down by software defined radio (SDR) and is shown to exhibit low bit error performance.

KEYWORDS: Software Defined Radio (SDR), Cognitive Network, Channel State Information (CSI), Bit Error Rate (BER).

1. INTRODUCTION
Cognitive radio derives its name from the word cognizance meaning information or knowledge. When the knowledge or information about the wireless channel (radio) is available with us, then such a kind of channel is called a cognitive radio. The necessity for cognitive radio systems lies in the fact that the systems are useful for real life applications where the data is transmitted from a sending end and reaches a receiving end via a long series of hops or jumps. In the process, the signal strength fades out and the data becomes prone to errors at the receiving end. This in turn degrades the quality of service with an increasing number of errors at the receiving end. The basic functionality of cognitive radio networks is shown in the figure below.

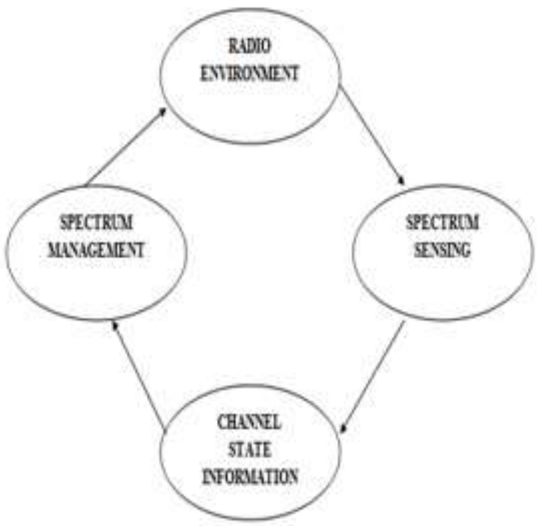

Fig.1 A typical Cognitive Radio Environment

The figure above shows the fundamental working principle of cognitive radio systems which are:
1) Spectrum sensing
2) Obtaining channel state information (CSI)
3) Spectrum management

The above three process needs to be repeated so as to obtain the latest channel state information. The decay in signal strength generally accompanies the multi-hop relaying mechanism. Hence multi-hop relaying in intertwined with cognitive methods to route data through various nodes of the network and increase the signal strength. The paper presents the basics of cognitive systems and multi-hop relaying for data transfer. The performance evaluation is made based on the probability of false alarm and probability of error or bit error rate (BER).

2. PREVIOUS WORK

There are several approaches which are commonly used for the design of cognitive systems. The most prominent approaches have been cited in the section below.

In [1], Ajay Singh et al. have proposed the design of an improved energy detector for cognitive radio systems which use a multi-hop relaying approach. The approach uses a threshold based energy detection scheme. The major advantage of this technique is the fact that the techniques used an adaptive thresholding scheme for spectrum sensing based on the level of error encountered at the receiving end of the communication system. Hence its called a adaptive energy detector scheme.

In [2], the authors have discussed the various spectrum sensing techniques which are energy detection, cyclo-stationarity detection, wavelet detection and matched filter detection. The importance and applicability of each of the above mentioned techniques has been cited with illustrations pertaining to the bit error rate (BER) performance of each of the techniques.

In [3], the authors have presented the sensing techniques for TV white spaces and its importance. It has been shown that transmission quality can be improved with sensing the spectrum. The sensing of the transmission spectrum can lead to lesser bit errors (TV white spaces in this context). A comparative analysis of the TV transmission with and without spectrum sensing has also been presented.

In [4] the proposed work presents a two stage process for spectrum sensing. The initial stage senses the spectrum without pilot bits while the second stage senses the channel with pilot bits. It has been shown that the BER falls steeper in case the pilot bits are added to the system. However, addition of pilot bits result in the complexity enhancement of the system.

In [5] the authors have proposed a cooperative sensing technique for cognitive radio systems. The major challenge in this case is to design a cooperative and intelligent algorithm that can adjust weights according to the channel conditions. Moreover, multiple input and multiple output systems need to be designed in this case. The reason for the above is the fact that each pair of transmitter and receiver sense the channel in a different way. The parallel paths of the different data steams received by the receiving end of the system try to estimate the state of the radio.

In [6], the author have proposed a technique that is based on the maximum-minimum approach of eigen values of the channel state response (CSI). In this case, a robust framework has been developed and the eigen values of the CSI matrix is updated as per the inputs received by the receiving end of the channel state matrix. The eigen value approach has the benefit of gathering data that is inherent to the radio and not superfluous to it.

3. MATERIALS AND METHODS

The present work utilizes the channel state information (CSI) for multi-hop relaying in the cognitive network. This is necessary for low bit errors as the amount of boosting the signal needs critically depends on the amount of fading the signal undergoes. The channel sensing technique used in this approach is the energy detection

approach in which the fading is estimated by sensing the received signal energy or power and then comparing it with the transmitted signal's power or energy. Mathematically,
Let the time domain transmitted data be in the form:

$$E_{tx}(t) = E_0 e^{-j(\omega t+\varphi)} \quad \text{(i)}$$

And let the time domain received data be in the form:

$$E_{rx}(t) = E_0 e^{-j(\omega t+\varphi)} \quad \text{(ii)}$$

Here,
$E_{tx}(t)$ is the time domain energy signal with a varying envelope of the transmitted data.
$E_{rx}(t)$ is the time domain energy signal with a varying envelope of the received data.

E_0 is the amplitude of the signal
ω is the angular frequency
φ is the phase constant
t is the time index
Comparing $E_{tx}(t)$ and $E_{rx}(t)$, the state of the channel can be estimated. However it should be noted that it can be a function of frequency of the data transmission (f) i.e.

$$H = f(frequency) \quad \text{(iii)}$$

Here,
H represents the channel matrix or channel state information.
The probability of false alarms depends on the threshold for noise. It makes sense to consider the fact that as the noise threshold increases, the chances for false alarm also decreases. Mathematically,

$$P(F.A.) = f(N_{Th}) \quad \text{(iv)}$$

Here,
F.A. represents False alarm
P represents probability
f represents a function of
N_{Th} represents the noise threshold
Further, the system designed is illustrated by the algorithm given below:
Step.1: Let the binary data to be transmitted be given by X(t)
Step.2: Estimate the CSI by comparing $E_{tx}(t)$ and $E_{rx}(t)$
Step.3: Decide the noise threshold (N_{Th})
Step.4: Obtain the probability of false alarm with respect to variance in noise threshold (N_{Th})
Step.5: Design a multi-hop relaying technique based on **H.**
Partition energy of each hop into two:

$$E_{boost} = \frac{E}{2} \quad \text{(v)}$$

$$E_{tx} = \frac{E}{2} \quad \text{(vi)}$$

Step.6: Decide E based on the CSI **(H)**
Step.7: Add noise to the channel (N). Let the signal after noise addition be given by:

$$E\_chan_{out} = E_{rx}(t) + n_{chan}(t) \quad \text{(vii)}$$

Here,
E_chan_{out} is the energy of the channel at the output of the channel
$n_{chan}(t)$ is the time domain random noise added in the channel
$E_{rx}(t)$ is the received signal at the end of the channel without noise.
It can be seen that the system designed above satisfies the mathematical model of the real time multi-hop network using channel state information. This is also termed as the **Variable Energy Hop approach.**
Step.8: Compute the (Bit Error Rate) BER of the system as:

$$BER = \frac{N_e}{N_{TOT}} \quad \text{(vii)}$$

Here,
N_e is the number of bits containing errors
N_{TOT} is the total number of bits transmitted.

ISSN: 2277-9655
Impact Factor: 5.164
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4. RESULTS AND DISCUSSION

The results are obtained using the simulation platform of MATLAB (Matrix Laboratory). The simulation environment emulates a practical multi-hop relaying network. The results obtained are the binary transmission of data followed by the reception of the data at the receiving end with noise addition. The next step is the plot of the probability of false alarm under two cases:

1) Theoretical
2) Practical

Subsequently the BER performance of the system is obtained for simple multi-hop relaying with and without noise effects. Further, a fading model if designed to encompass the fading effects generally affecting the signal transmitted through the channel. The comparative BER analysis renders clear insight into the effects that the fading, noise and finally fading plus noise has on the system BER. The earlier and steeper fall of the BER curve is envisaged to ensure better quality of service. The graphs that follow have been presented in the sequence of events discussed above.

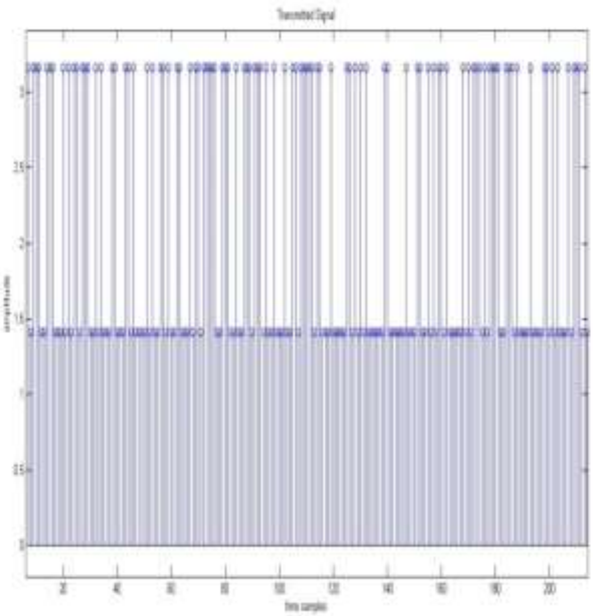

Fig.2 Binary Transmitted Data

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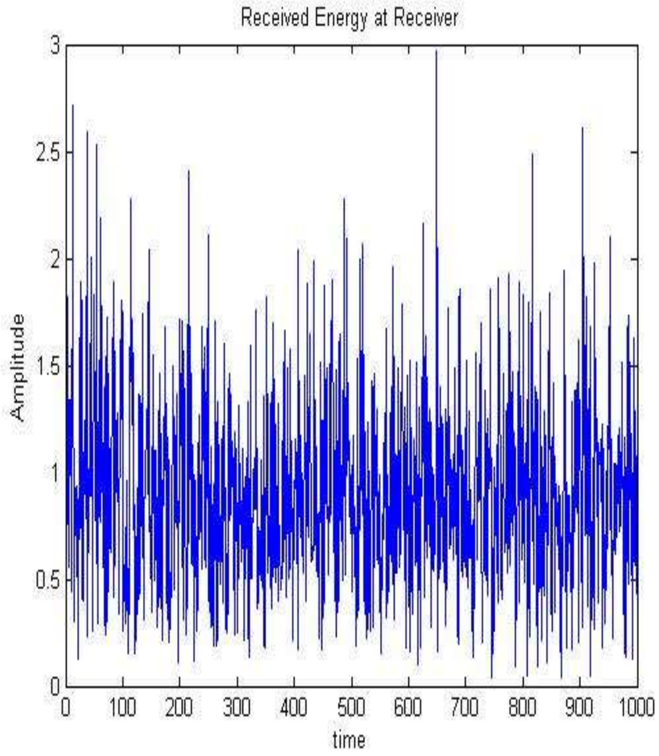

Fig.3 Fluctuating Envelope of signal at receiving end

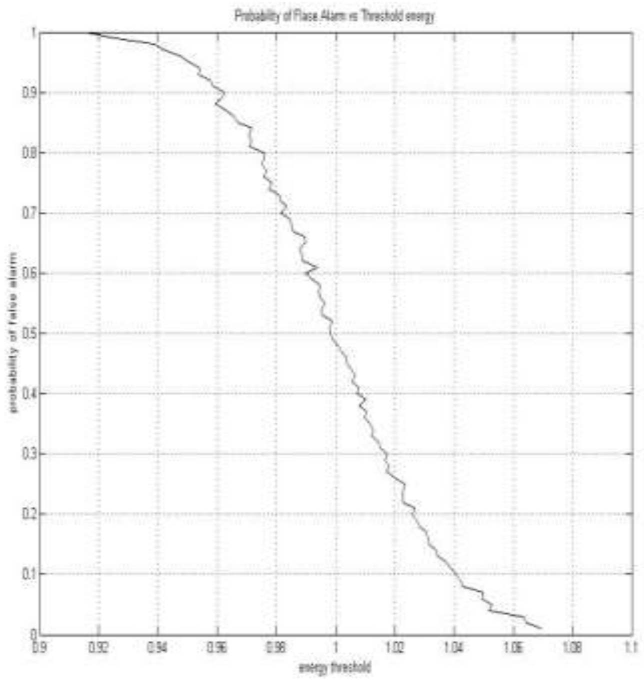

Fig.4 Probability of F.A. w.r.t Practical Energy Threshold

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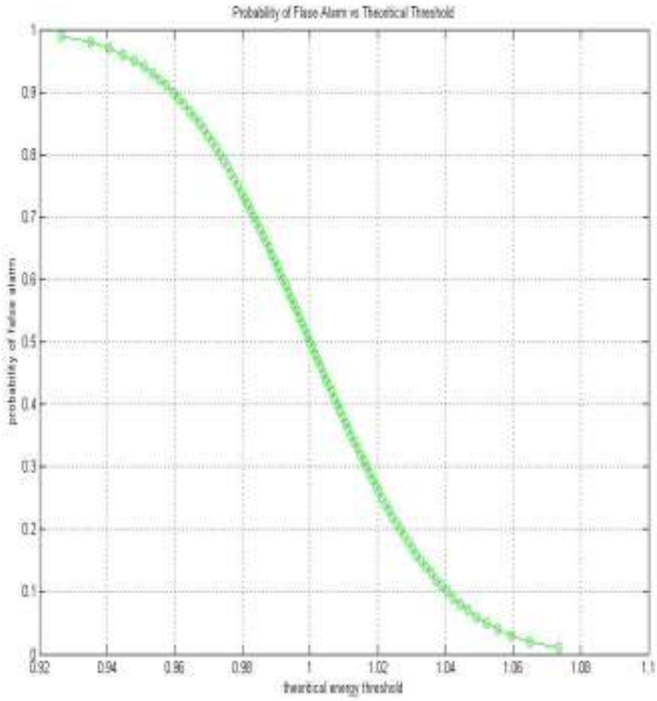

Fig.5 Probability of F.A. w.r.t. Theoretical Energy Threshold

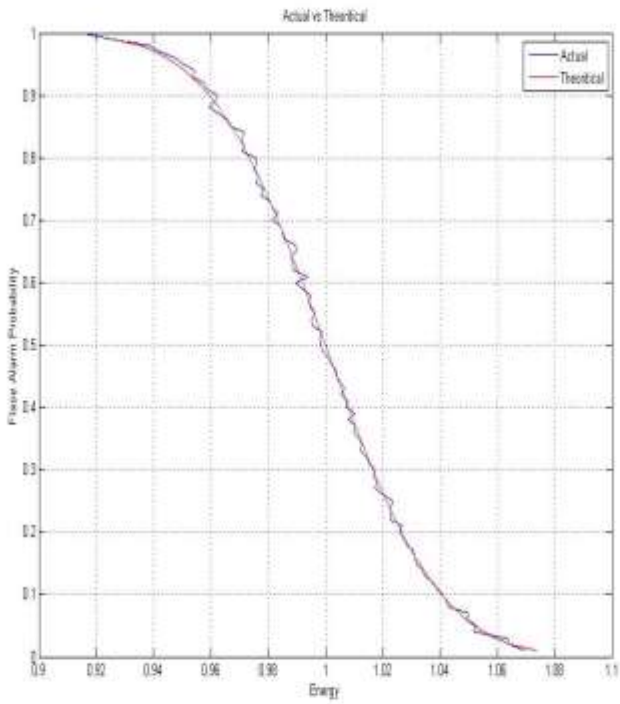

Fig.6 Comparative F.A. analysis for theoretical and actual conditions

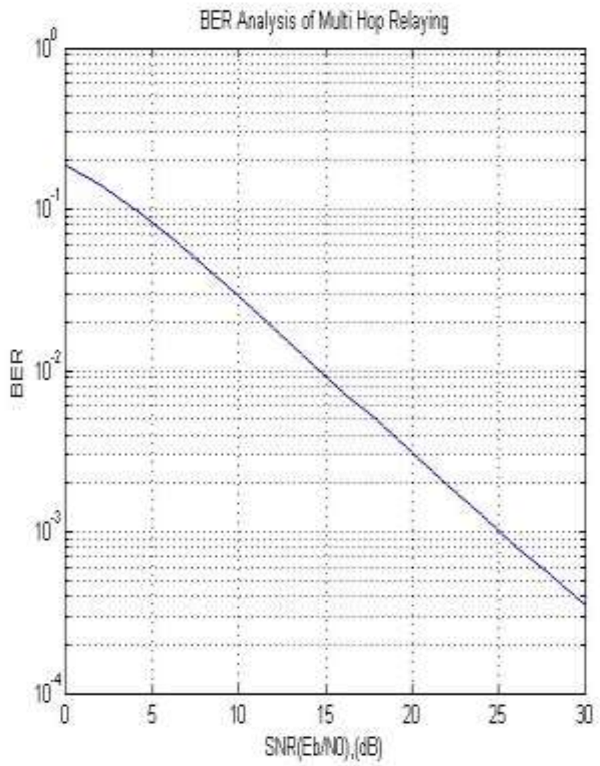

Fig.7 BER Analysis of Conventional Multi-Hop relaying

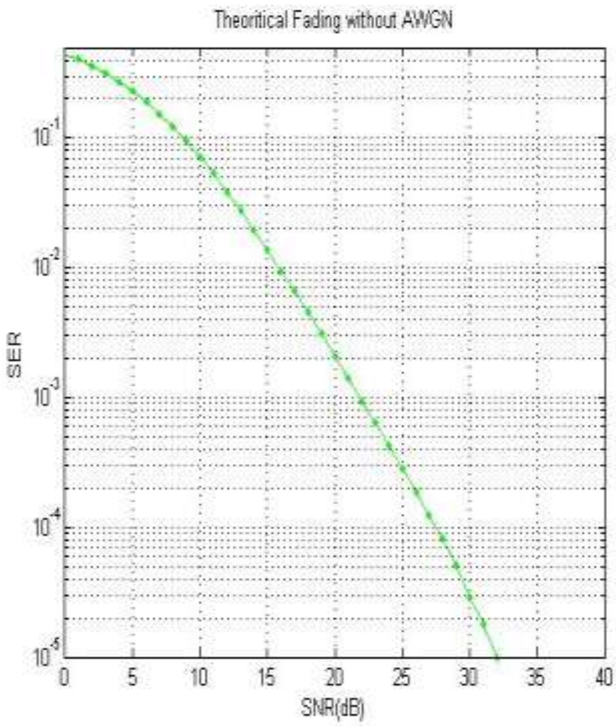

Fig.8 BER Analysis without fading

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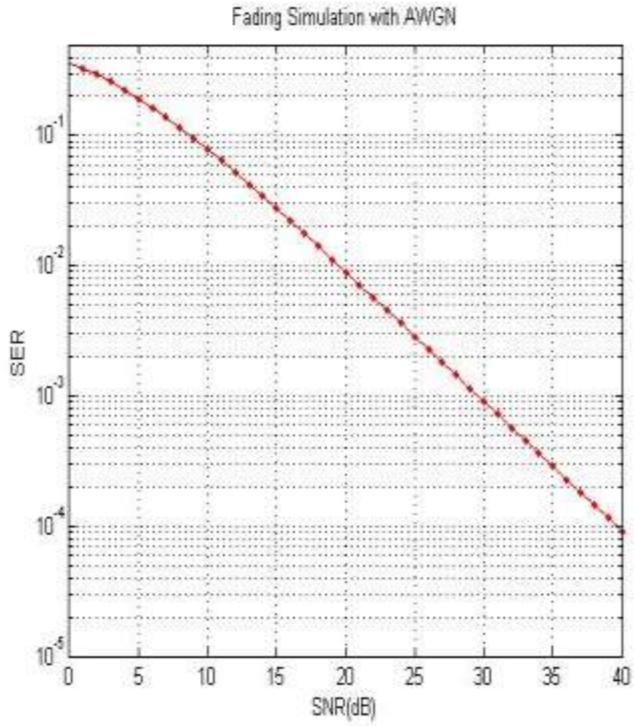

Fig.9 BER Analysis considering Fading

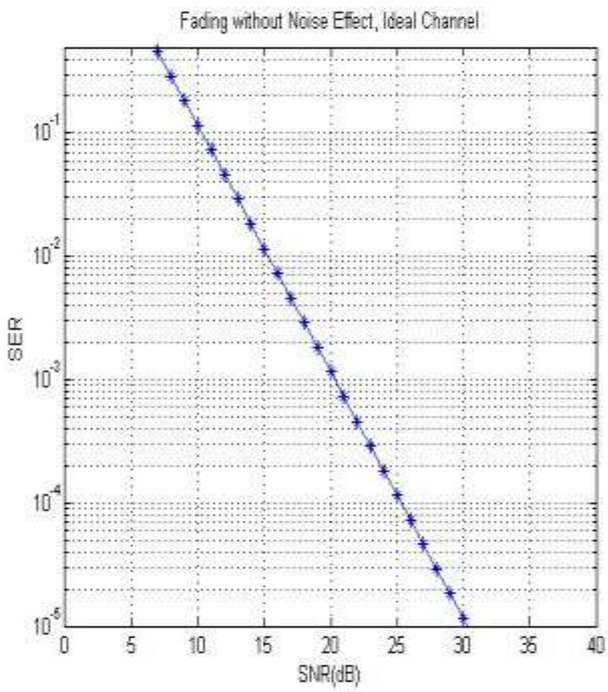

Fig.10 Fading under Zero Noise (Ideal) condition

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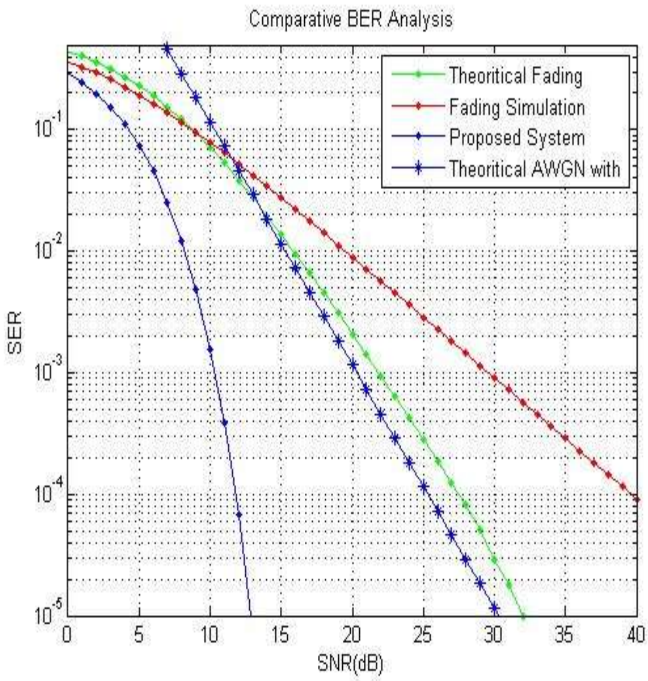

Fig.11 Comparative BER Analysis

Table.1. Comparison tabulation of BER for designed system

	SNR needed in Previous Work	SNR needed in Proposed Work
BER=10^{-1}	8dB	3dB
	12dB	8dB
	30dB	11dB

5. CONCLUSION

Here an algorithm is put forth that implements multi hop relaying in cognitive radio systems defined by software defined radio (SDR). The simulations have been applied for different and various conditions. It is clearly observed that better BER performance is achieved by the proposed system compared to previously existing methods [1]. The steep reduction in the BER of the system can be inferred as thee increased reliability of the system. The necessity for low SNR is indicative of a steep or early descent in the BER of the proposed system.

REFERENCES

[1] Ajay Singh, Manav R. Bhatnagar and Ranjan K. Mallik, “Performance of an Improved Energy Detector in Multi-Hop Cognitive Radio Networks”, IEEE 2016
[2] N. Yadav and S. Rathi, Spectrum sensing techniques: Research, challenge and limitations 1," 2011.
[3] V. Goncalves and S. Pollin, The value of sensing for TV white spaces," in New Frontiers in Dynamic Spectrum Access Networks (DySPAN), 2011 IEEE Symposium on. IEEE, 2011.
[4] S. Maleki, A. Pandharipande, and G. Leus, Two-stage spectrum sensing for cognitive radios," in Acoustics Speech and Signal Processing (ICASSP), 2010 IEEE International Conference on. IEEE, 2010.
[5] M. Yang, J. An, X. Bu, and L. Sun, \An improved eigenvalue-based algo-rithm for cooperative spectrum sensing," in Wireless Communications Net-working and Mobile Computing (WiCOM), 2010 6th International Confer-ence on. IEEE, 2010.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

[6] H. Liu and W. Chen, A robust detection algorithm based on maximum-minimum eigenvalue for cognitive radio," in Wireless Communications, Net-working and Mobile Computing (WiCOM), 2012 8th International Confer-ence on. IEEE, 2012.
[7] A. Satheesh, S. Aswini, S. Lekshmi, S. Sagar, and H. Kumar, \Spectrum sensing techniques a comparison between energy detector and cyclostationarity detector," in 2013 International Conference on Control Communication and Computing (ICCC).
[8] M. Li and L. Li, Performance analysis and optimization of cooperative spectrum sensing based on soft combination," in Wireless Communications, Networking and Mobile Computing (WiCOM), 2011 7th International Conference on. IEEE, 2011.
[9] T. Cui, F. Gao, and A. Nallanathan, Optimization of cooperative spectrum sensing in cognitive radio," Vehicular Technology, IEEE Transactions 2011.
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