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Comparison of Bit Error Rate Performance between BPSK and 16QAM modulation scheme in cognitive radio network

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Abstract: *Radio spectrum is considered as one of the most evaluated natural resources in communication system, which all of users shares this resource and is affected directly by any change on it. Also one of the latest technologies in radio spectrum management called Cognitive radio emerged in last years of 20th century; leads to new era of exploit radio spectrum in basis of sharing resources without affecting other user whom may coexists in the same band. From this point of view this paper discusses cognitive radio main concept in band coexistence through choosing the appropriate modulation scheme, which can achieves data rate and control QoS. The discussion will be concern of two modulation schemes BPSK and 16QAM, their performance in term of bit error rate BER and the ability to achieve data rate*

Key word: *PU, SU, SDR, BPSK, 16QAM, QoS, Matlab, simulink, Cognitive radio.*

I. Introduction

Radio wave is an electromagnetic (EM) wave with all characteristic of EM wave such as interference, superposition, polarization and desperation, so if it is the media used to transmit information it should be isolated from each other by guard band avoiding all the reactions related to its nature as EM wave. Also due to this fact it was clear that the importance of issuing originations to deal with radio spectrum, assigning bands on organized basis avoiding disturbance. This led to produce a class of users with dedicated licensed bands called primary user(PU), and others unlicensed user or secondary users(SU). [1] Cognitive radio technology introduced by Mitola in 1999 as a pioneer idea managing the predicted problems resulted from scarcity in radio channel due to wide consuming of radio spectrum with its two types, the licensed and unlicensed [2]

The excepted scenario after few years, all of the radio spectrum will be occupied by users, either PU whom use licensed channel such as service provider or SU and this group includes all users without licensed channel like police and military forces. So cognitive radio technology comes as appropriate tool to solve, manage and enhance the usage of radio spectrum in its optimum situation [3].

Cognitive radio concept depends on utilization of the available unused licensed radio channel in the Contiguous channels, which may be unused for specific period of time or in a limited geographical area, to the users whom they haven't licensed channel. This simplified concept to be implemented it requires a complicated algorithm establishing an impressive sensing mechanism leads to fully awareness of the around environment with its channel modes classifying the occupied one and the others unused, to be utilized in reconfigurable manner, solving the mentioned problem. [4]

The ability of detecting and monitoring of cognitive radio system, provided by software defined radio platform (SDR), which leads to new concept called dynamic spectrum access. There are many organizations and agencies working in the field of standardization, which explains the importance and the effective role of putting standard rules to govern and manage spectrum utilization for all users. One of proposed ways to achieve these goals is cognitive radio which considered as supportive way in dynamic access method to the available radio spectrum.[5].The terminology Cognitive radio comes from the ability of cognitive radio system to collect data from vicinity environment, which lead the system dealing with adjacent systems with full awareness about all of it operational information, avoiding the interference of its signal and the exploit free spaces on the spectrum, achieving the goal of coexistence bands with PU for SUs.[6]Cognition comes through using Signal detector. There are many types of Signal detector, in our study we are using Energy detector to detect PU signals and determine the free space upon the spectrum to be used by SU. Then choices the appropriate modulation scheme to modulate SU signals and interleave it with PU signals in the same band. The chosen modulation should achieve QoS requirements such as Throughput, acceptable SIR level, acceptable SNR level and acceptable BER.[7]

Modulation is processing the data to be transmitted over radio carrier, mainly modulation compressed data in smallest size to eliminate spectrum usage, which enhances spectrum efficiency and increases bandwidth. To achieve this goal many techniques of modulation had been emerge. BPSK is common modulation scheme can transmits data rate 1 bit/Hz, so BPSK is spectral efficient modulation. [8] [9]

Although M_PSK modulation scheme is much more spectrally efficient, one of drawback represents in the difficulty to the signal to demodulate in the presence of noise. Also M-PSK can achieves constant carrier amplitude means that more efficient nonlinear power amplification can be used.[10]

The combination between amplitude and phase modulation achieves carrying more bits per symbol. This methodology used in Quadrature amplitude modulation (QAM). For example, 8QAM uses four carrier phases plus two amplitude levels to transmit 3 bits per symbol. Other popular variations are 16QAM, 64QAM, and 256QAM, which transmit 4, 6, and 8 bits per symbol respectively. While QAM is spectral efficient modulation, also it is more difficult to demodulate in the presence of noise, which is mostly random amplitude variations. Linear power amplification is also required. [11]

Cognitive radio systems based on the concept of using the free or unused spaces upon the PU spectrum; giving the fair opportunity for SU to share radio resources with PU in basis of achieving high priority to the PU. To exploit the available radio resources for SU, it needs to use sophisticated modulation schemes to achieve high data rate and control QoS. In this paper the objectives will be to compare between two types of modulation and determine the appropriate one to be used, our measurement criteria will depends on Bit Error Rate (BER) as direct parameter on QoS.

II. System Analysis

The study adopted simulation method; simulation had been implemented by Matlab simulink, using SNR and BER to determine the internal status of the system. Simulation block diagram consist of PU block, SU block, Energy detector, cognitive radio system, error rate calculator and BER monitor.

PU is user with licensed band; this band is assigned especially for transmission PU signal. The mentioned band may be set idle for a while, so other user (SU) may use it in PU absence period.

PU has high priority than other SU, because PU classify as the owner of the band, since he has a license. PU blocks in simulation depicted in Fig (1):

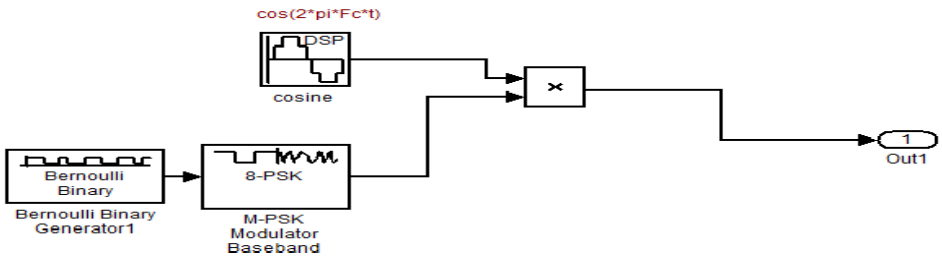

FIG (1): Primary User Block in Simulink

SUs are the non commercial cooperation in the society such as police, army and emergency forces. The SU used to exploit radio spectrum in their communication to provide special services like security and helping people.

SU is same like PU as technology, the difference only PU has license. Cognitive radio gives the opportunity to send SU signal on PU band, through studying vicinity environment; determine PU spectrum characteristics and provides appropriate frequency for SU. Energy detector one of the significant techniques used in Cognitive radio as guidance of SU to detect white hole in PU spectrum. Energy detector designed to detect radio wave depending on its energy. Fig (2) below shown Energy detector blocks as implemented in simulation. [12][13]

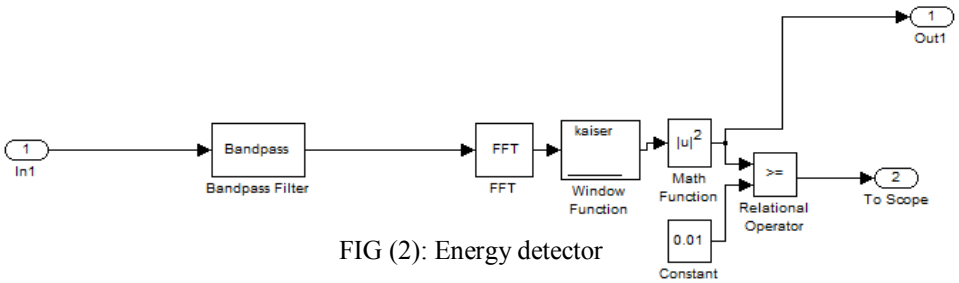

FIG (2): Energy detector

Since the adjacent environment had been detected; cognitive radio system deals with detected Spectrum to provide SU spectrum and avoiding any impact of coexistence same band.

After the SU signal transmitted, BER calculated using BER calculation unit in the simulation to examine QoS status in term of bit error rate BER; which consider as one of significant parameters in the evaluation of modulation techniques efficiency.

III. Mathematical Model:

Estimated Bit error rate can be calculated as:

$$\text{BER} = \frac{\text{Number of error bits}}{\text{Number of total bits}}$$

IV. Computer Model

The implemented simulation model structure consists of the phases as depicted in Fig (3) below:

i. Energy detector unit: the function of Energy detector unit is to provide status of adjacent environment to the Cognitive system.

ii. Energy detector unit used the mechanism of energy detection as one of the used method on cognitive radio to detect PU signal and determine the white hole over PU spectrum.

iii. If the PU signal detected; it will be available for cognitive radio system to starts analysis for adjacent environment, to choice covenant frequency to SU with in PU Spectrum white spaces; or other more complex methodologies. The known used methods to coexistence SU with PU are interweave method, underlay and overlay, where overlay is considered as the most complicated between them. If the PU signal is not detected. Energy detector unit will keep searching to determine PU Signal Scheme.

iv. The implementation of cognitive radio system based on the knowledge of PU signal Scheme, white space on spectrum and idle period of the spectrum.
In case of spectrum availability, SU can exploit PU spectrum, otherwise cognitive radio system set idle.

v. After Cognitive system successes in modulates SU signal and send it over radio spectrum, finally BER could be calculated, measuring QoS.

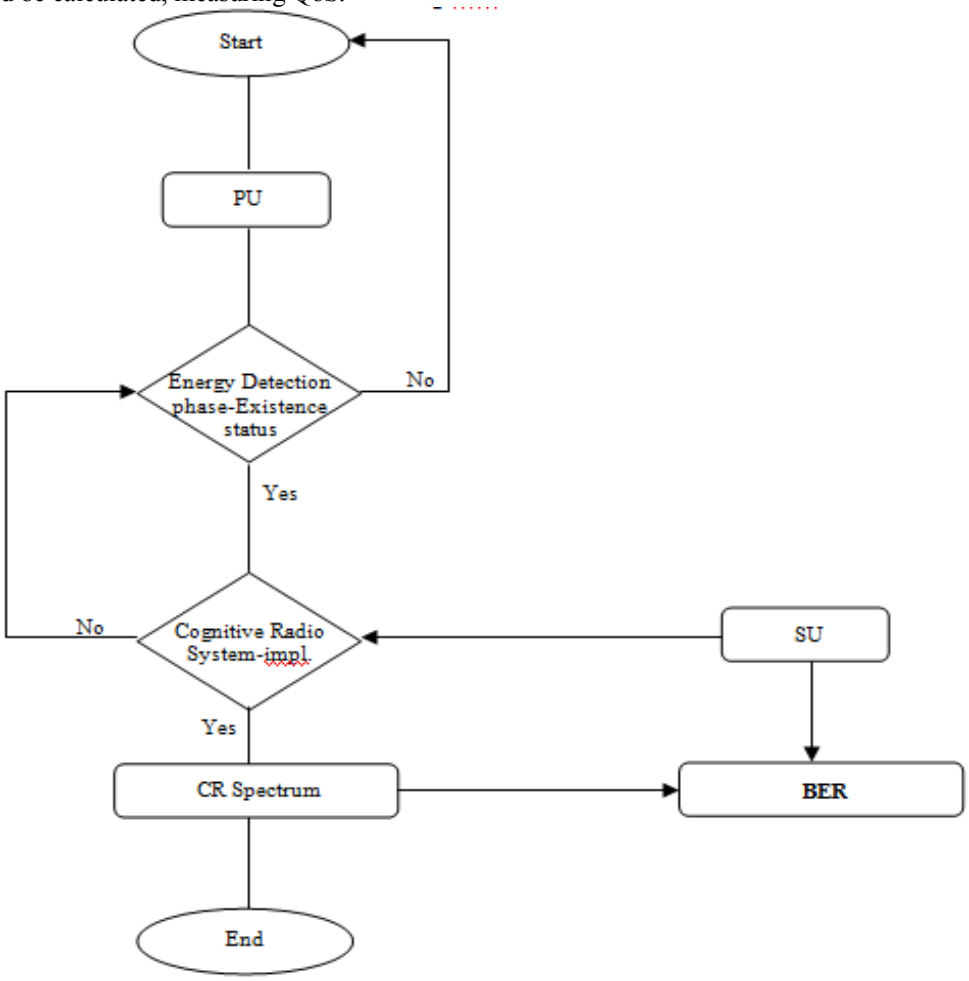

FIG (3): Cognitive radio simulation steps

V. Simulation parameter

Parameter	Value
SNR Range	0-12 dB
Modulation Technique	BPSK & 16QAM
Channel	AWGN

VI. Result& Discussion

After execution of simulation, the result were obtain in graphical form for bit error rate versus SNR in both modulation scheme BPSK and 16QAM as depicted in Figures(4,5,6)

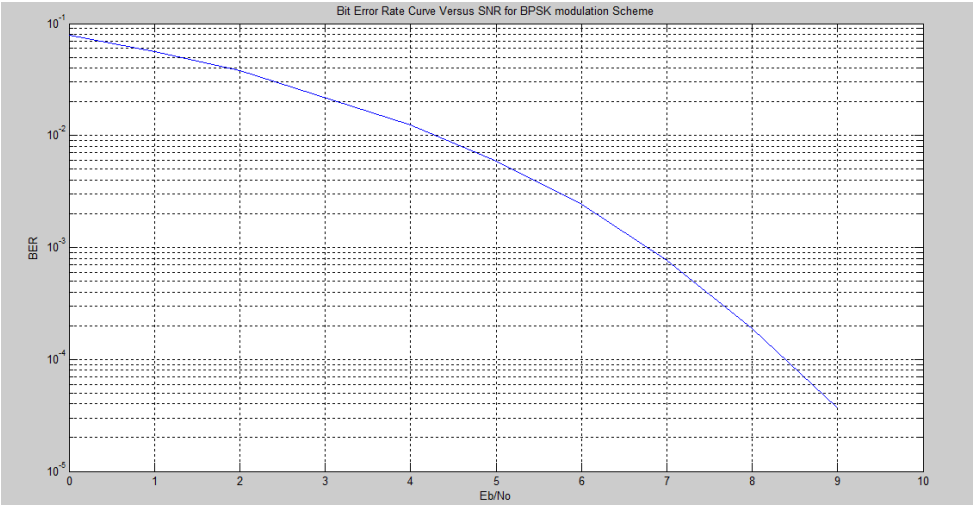

FIG (4) BER versus SNR in BPSK Modulation

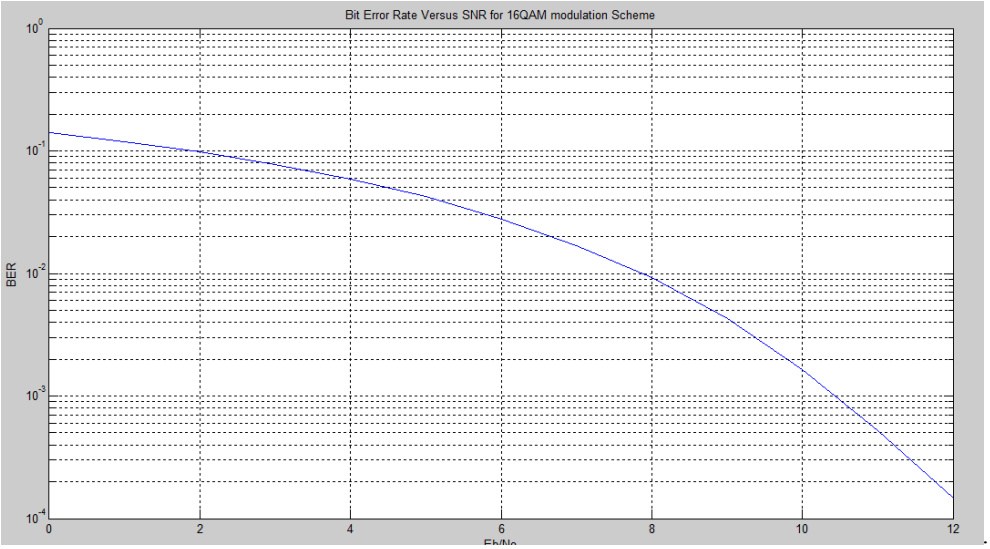

FIG (5) BER versus SNR in 16QAM Modulation

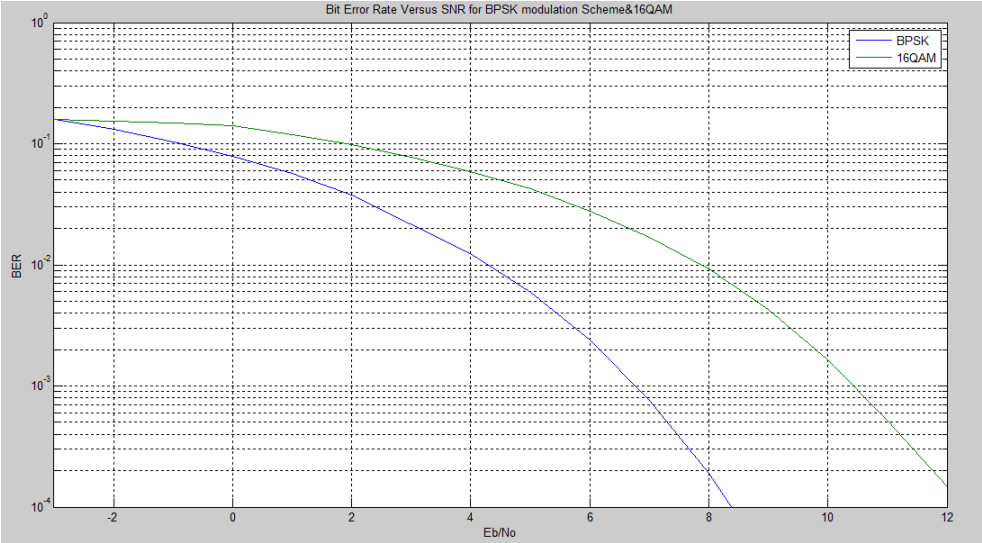

FIG (6) Comparison between BPSK and 16QAM

For modulation BPSK the result as shown in Fig (4), where bit error rate decrease when SNR increase
Also for modulation 16QAM the graph shown in Fig (5), explain that bit error rate performance decreases when SNR increase For 16QAM.
Fig (6) shown the comparison between BPSK and16QAM, from graph BPSK modulation gain less BER than 16QAM.

VII. Concussion

In cognitive radio network bit error rate perfoemance in BPSK modulation scheme is better than 16QAM .Cognitive radio system could be treated as normal wireless system in modulation scheme effects,with advantage in sharing spectrum radio for more than one user.

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