IMPROVEMENT IN SPECTRUM SENSING TECHNIQUES FOR COGNITIVE RADIO

A dissertation report

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CERTIFICATE

This is to certify that the Dissertation-II titled **"Improvement in Spectrum Sensing Technique For Cognitive Radio "** that is being submitted by " **Shruti (11507365)**" is in partial fulfilment of the requirements for the award of MASTER OF TECHNOLOGY DEGREE, is a record of bonfire work done under my guidance. The contents of this Dissertation-II report, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree of the same is certified.

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DECLARATION

I, **SHRUTI DUTTA,** student of **MASTER OF TECHNOLOGY (WIRELESSCOMMUNICATION)** under Department of ELECTRONICS ENGINEERING of Lovely Professional University, Punjab, hereby declare that all the information furnished in this dissertation II report is based on my own intensive research and is genuine.

This dissertation II, to the best of my knowledge, does not contain any part of my work which has been submitted for the award of my degree without proper citation.

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ABSTRACT

The new technologies for wireless based system are evolving significantly. The demand for electromagnetic spectrum is growing for range of services (data, image and video transmission etc.) so that the problem of bandwidth scarcity has become more noticeable. This scenario has increased the cost of spectrum too and created a conflict between various sectors. On the other hand study made by Federal Communication Commission showed that large portion of the licensed band lies idle most of the time. In order to solve the problem of spectrum under utilization, cognitive radio emerged as a technology which allows the user to use the unlicensed part of user when it is idle. Spectrum sensing techniques are used to detect the presence or absence of licensed user in cognitive radio. With the help of these sensing techniques, the unlicensed signal can transmit the data when the licensed user is not sending the data. Various sensing techniques have been devised by various researchers for the improvement in spectrum sensing.

This thesis discusses matched filter based detection double threshold technique with cyclic delay diversity for spectrum sensing in OFDM systems. Simulation results show an improvement of 0.2 times better than the conventional method of matched filter based spectrum sensing. Also, their performance for different wireless channels has been discussed. Two channels named Rician and Rayleigh are used and it has been shown using simulations that the probability of detection is 0.2 times more for Rician channel as compared to Rayleigh Channel.

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LIST OF ABBREVATIONS

BER	Bit Error Rate
CCD	Cyclic Delay Diversity
CP	Cyclic Prefix
CR	Cognitive Radio
DB	Decibels
DAC	Digital to Analogy Converter
ED	Energy Detection
FFT	Fast Fourier Transformation
FD	Feature Detection
IFFT	Inverse Fourier Transformation
ISI	Inter Symbol Interference
MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency Division Multiplexing
PSK	Phase shift keying
PCS	Personal computer software
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Key
SSCD	Spectrum Sensing With Channel Diversity

CHAPTER-1

INTRODUCTION

1.1 Introduction to Cognitive Radio

Wireless and wired techniques are very common to these days for social and industrial environment. There are various wired system used in Cognitive Radio. Cognitive radio is a system which is used for wireless communication. It designed on code outlined radio that is associate rising technology providing a platform for versatile radio systems, multi service, and multi commonplace, multiband, re-configurable and re-programmable by code for private Communication Services. It uses the methodology of sensing and learning from the scope and varies to applied science variations in actual time. Cognitive radio and physical node change its values to speak with efficiency anyplace and anytime prevent interference with authorized or unauthorized users for economical usage of the radio-frequency spectrum. Psychological feature module within the sender and receiving system should add a true manner that is achieved via a channel connect with the other channels. Receiver is enabled to convey info on the performance of the forward link to the transmitter [1]. Therefore metallic element by necessity is associate example of a feedback communication system [1]. The scheme was initial introduced by Defence Advance analysis product Agency man of science, Dr. Joseph Mitola and therefore the results of that idea is IEEE 802.22 , that could be a commonplace geared toward victimization psychological feature radio for Wireless Regional space Network victimization white areas within the TV frequency spectrum whereas reassuring that no corrupting interference is inception to the official operation, i.e., digital or analogy TV broadcasting, and low power authorized devices. IEEE P802.22.1 could be a commonplace being developed to reinforce pernicious interference [3].Cognitive radio is a divided into two parts licensed and unlicensed band which will occupies the licensed Band cognitive Radio, equipped for utilizing groups allotted to authorized clients (with the exception of unlicensed groups, for example, the U-NII band. The IEEE 802.22 working gathering is building up a standard for remote territorial range arrange which will work on unused TV stations, otherwise called television white spaces.[6][7]

Unlicensed-Bands which can only occupy unlicensed part of the signal which is cant access by the other user Combined framework is represented in the IEEE 802.15 Errand Aggregate 2 define,[8] which concentrate on the conjunction of IEEE 802.11 and Bluetooth signal. Security purpose for low consuming power band in TV broadcasting with the 700 Mc bands [3]. IEEE P802.22.2 could be a suggested observes for the start and preparation of IEEE 802.22 System. IEEE 802.22 WG could be a social unit of IEEE 802 LAN standards [3] committee that is hired to put in writing the 802.22 normal. The 2 802.22 task teams area unit composition 802.22.1 and 802.22.2 severally. Package Radio is a rising technology that has program for versatile radio systems, multiservice, multi customary, multiband, reconfigurable and reprogrammable by software for PCS. Cognitive radio extends the package radio with radio-domain model-based reasoning concerning such radio rule enhancing the pliability of non-public work through with a Radio data.

Radio Etiquettes square measure the set of RF bands, air interfaces, protocols, and abstraction and temporal patterns that intermediate the utilization of the radio-frequency spectrum. It needs through with it will connect to the radio machine control devices through radio instruction, devices, code modules, reproduction, networks, user needs, and application situations to support machine-controlled intellection concerning the requirements of the user. It empowers code system radios to conduct negotiations among peers concerning the utilization of radio-frequency spectrum across fluent of area, time, and user context and actively manipulate the protocol

Characteristics of Cognitive Radio

- Re-configurable
- Frequency agility
- Dynamic frequency selection
- Adaptive modulation technique
- Cognition

1.2 Cognitive Cycle

Basically cognitive cycle is divided into three parts

1. Spectrum Sensing
2. Spectrum Analysis

3. Spectrum Decision Making

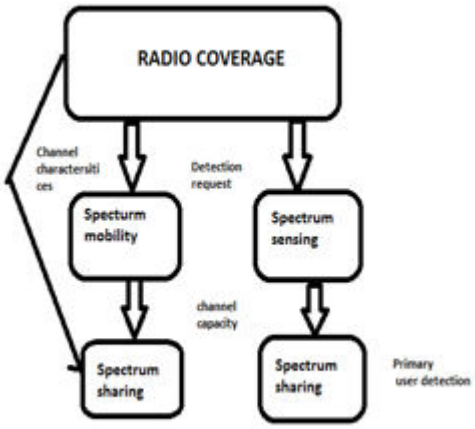


Fig 1: Cognitive cycle [2]

1. Spectrum Sensing : Spectrum sensing is that the quality to live, sense and remember of the factor associated with the cognitive receiver parameters, convenience of spectrum and power hindrance and noise, radio in operation atmosphere, users needs and applications, out there networks and node, native policies and different in operation limitation. It's done across Frequency, Time, Geographic area, Encode and part.
2. Spectrum Analysis: Spectrum Analysis relies on spectrum sensing that is analyze matters of many section within the outer and intrinsic radio surroundings and find the optimum communication rule and dynamical frequency consequently. It's additionally called channel estimation.
3. Spectrum Decision Making: Spectrum higher cognitive process involves constellation for the frequency and protocol needed for perpetually accommodate to mobile dynamical hold and improvement of output power or perhaps change of sending parameters variable image rates, totally opposite transmission cryptography schemes and characteristics by the cognitive radio devices. Metallic element ought to be ready to use various parameters for giving the decisions.

1.3 Key Points of Cognitive Radio

Cognitive radio refers some key points which is related to the sensing and used in spatial diversity in the form of frequency time and probability

- It may permit the future status for sensing because it is the basic principal of implementation of cognitive radio and provide better spectrum efficiency.
- It will used to measure the high level instruments which are helped in medical line. Like scan, ECG and other test.
- Oncesystem isn't idealistic, a sleek degradation of service is provided, as opposition the less fascinating complete and unexpected loss of service.
- Suitableness, accessibility and Reliableness of wireless services can improve from the user's position. And it will provide better quality of service.
- Cognitive radio support spectrum relief (makes it abundant easier to trade spectrum between users). Indeed, a business case might exist for changing into a spectrum broker, whereby a 3rd party manages the trade between provider and mortal and receives a commission.
- It will provide benefit to the customer provider because it is used to convert enhance to traditional services and give benefit to others.

1.4 Applications of Cognitive Radio

CR can sense its environment and, without the intervention of the user, can adapt to the user's communications needs while conforming to rules in the US. In theory, the amount of spectrum is infinite; practically, for propagation and other reasons it is finite because of the desirability of certain spectrum portions. Assigned spectrum is far from being fully utilized, and efficient spectrum use is a growing concern; CR offers a solution to this problem. A CR can intelligently detect whether any portion of the spectrum is in use, and can temporarily use it without interfering with the transmissions of other users. According to Bruce Fete, "Some of the radio's other cognitive abilities include determining its location, sensing spectrum use by neighbouring devices, changing frequency, adjusting output power or even altering transmission parameters and characteristics. All of these capabilities, and others yet to be realized, will provide wireless spectrum users with the ability to adapt to real-time spectrum conditions, offering regulators, licenses and the general public flexible, efficient and comprehensive use of the spectrum".

Examples of applications include:

- The application of CR networks to emergency and public safety communications by utilizing white space
- The potential of CR networks for executing dynamic spectrum access (DSA).
- Application of CR networks to military action such as chemical biological radiological and nuclear attack detection and investigation, command control, obtaining information of battle damage evaluations, battlefield surveillance, intelligence assistance, and targeting.

1.5 OFDM (Orthogonal Frequency Division Multiplexing)

Orthogonal Frequency Division Multiplexing (OFDM) signal can be considered as group of narrow band signals, and by increasing the number of subcarriers, the bandwidth of each subcarrier becomes narrower. By choosing the subcarrier spacing to be less than the coherence bandwidth of the channel, each subcarrier is going to be affected by a flat channel and thus no channel equalization is needed.

To avoid ISI, symbols duration is extended by adding a guard band to the beginning of each symbol in what is known as Cyclic Prefix (CP).If we define the delay spread (or multipath spread) of the channel as the delay between the first and last received paths over the channel, the CP should be longer than that delay. However, to avoid fast fading effect, OFDM symbol time is chosen to be shorter than the coherence time of the channel. In the frequency domain, mobility results in a frequency spread of the signal which depends on the operating frequency and the relative speed between the transmitter and receiver, also known as Doppler spread. Doppler spread of OFDM signals results in Inter-Carrier interference (ICI) which can be reduced by increasing the subcarrier spacing

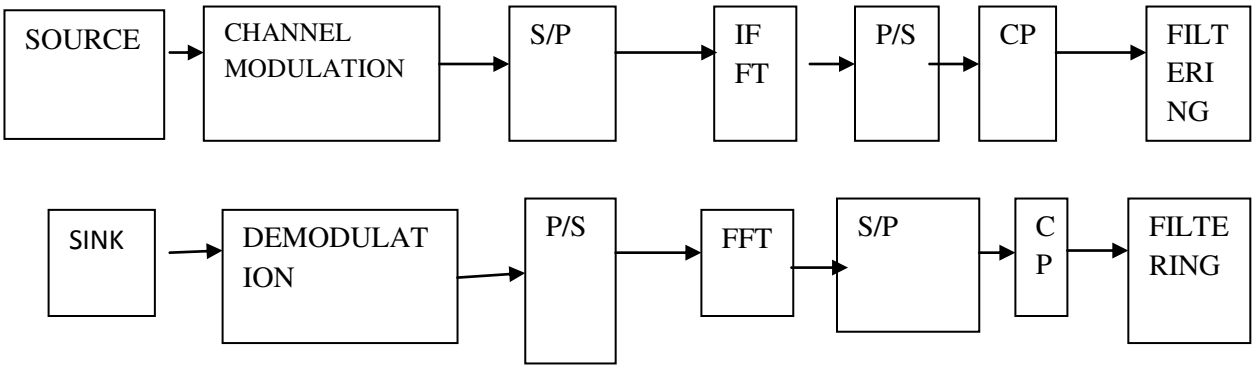


Fig 2: Block Diagram of OFDM

It is a unique kind of modulation strategy utilized as a part of remote correspondence framework .It is a technique for encoding digital information on numerous transporter frequencies .It is utilized for wide band advanced information correspondence whether remote or copper wires utilized as a part of utilization, for example

- Digital Television and sound Broadcasting
- DSL web access
- Wireless system
- Power line networking
- 4 G portable Communication

OFDM is an innovation used to pack a lot of information with only little measure of bandwidth. OFDM was the rule of frequency division multiplexing to permit various messages to be sent over a signal radio direct in a controlled way .This is finished by changing over the information into parallel stream transmitted by QAM subcarriers. OFDM transmits the information utilizing vast number of restricted data transmission subcarriers that are frequently divided in frequency .The frequency dispersing and the time synchronization of the subcarriers are picked in such way that the subcarrier overlap each other in frequency area. Be that as it may, they don't interference to each since they are put orthogonal to each other.

The data is balanced onto a subcarrier by changing amplitude of the subcarrier .so that either PSK or QAM is regularly utilized as subcarrier. There are many sorts of PSK and QAM, for example, QPSK, 8QAM 16QAM, 64QAM, etc. A regular OFDM framework is appeared above the

approaching serial information is changed over from serial to parallel and assembled into "n" bits. Each OFDM image has a particular time interval. Henceforth, the OFDM motion in Ts =N/2-1 the time area s(t) can be communicated as a summation of every data image C(I,k) being carried in the kth subcarrier inside the it OFDM image. Contingent upon the balance utilized for the subcarriers, this superposition of subcarriers framing s(t) can bring about complex qualities[7].

OFDM image have 256 sub carriers. There are 3 sorts of sub carriers are utilized here. They are information, preparing, pilot and dc sub carrier. 200 of the aggregate 256 sub carriers are utilized for information and pilot sub bearers, eight of which are pilots for all time dispersed all through the OFDM range. The staying 192 dynamic transporters take up the information sub carriers. Presently we need to change over our information into OFDM calculated symbol. Thus we need to take the information as row organization then include pilot signal and preparing signal with our information then utilize a vertical concatenate to make an OFDM signal comprises of information, pilot signal and preparing grouping and guard band [8]. The significant parts of OFDM symbol are here we have created the Training and pilot sub carrier utilizing block with constant value here we have utilized complex capacity to produce complex preparing and pilot signal. We have utilized complex capacity in view of after adjustment our information change into complex frame. The primary reason for preparing to produce guard band The principle reason to utilize guard band to reduce the effect inter symbol interference. The transmission parameters that can be changed based on the spectrum awareness include bandwidth, FFT size, filters, windows, modulation, transmit power, and active subcarriers used for transmission.

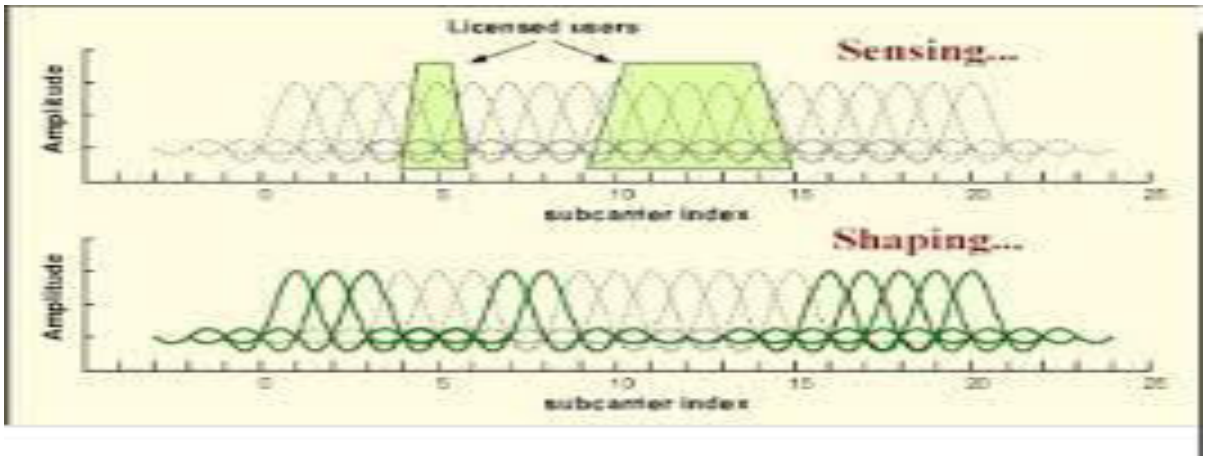


Fig 3: Waveforms of OFDM [3]

The parameters that can be adapted depending on the characteristics of the environment in order to optimize the transmission include cyclic prefix size, coding rate/type, modulation type, interleaving method, pilot patterns, preambles and duplexing method. While employing CR, Secondary Users (SUs) should not interfere with other licensed users using the spectrum; so to guarantee an interference-free communication between rental users, the spectrum sensing information between multiple cognitive radio devices needs to be shared to decrease or even eliminate the probability of interference with licensed users. The processing time too plays an important role as spectrum sensing is done frequently, so the overhead of sharing such information will increase, thus reducing the spectrum efficiency of the whole system and increasing the system complexity but in OFDM systems, conversion from time domain to frequency domain is achieved inherently by using Discrete Fourier Transform (DFT). Hence, all the points in the time–frequency grid can be scanned without any extra hardware and computation because of the hardware reuse of Fast Fourier Transform (FFT) [2].

Advantages of OFDM

- Makes effective utilization of the range by overlapping.
- Eliminates ISI and ICI with the utilization of a cyclic prefix [7].
- It is conceivable to utilize most extreme probability decoding with as less as complexity Is less sensible to test timing counterbalances than single transporter frameworks are.
- Provides great security against co-channel interference and hasty noise.
- Channel evening out gets to be distinctly less complex than by utilizing versatile adjustment methods with single transporter frameworks.
- By partitioning the channel into narrowband sub channels, OFDM is more resistant to frequency selective fading than single bearer frameworks.
- Using sufficient channels coding and interleaving one can recover symbol lost because of the frequency selectivity of the OFDM channel.
- OFDM is computationally productive by utilizing FFT procedures to execute the balance and demodulation capacities.

Limitations of OFDM

- It is more delicate to transporter recurrence balance and float than single bearer frameworks are because of spillage of the DFT.
- Nonlinear enhancement wrecks the orthogonally of the OFDM signal and it is exceptionally sensitive to ICI (Inter Channel Interference) [8].

1.6 Diversity

It is basically used to improve the reliability of message signal by using different channels and carriers. Diversity basically used in radio communication and combines two or more fading channels and attenuation for providing the best result, multiple type of signal is transmitted like time, frequency and polarization.

Types of Diversity Techniques

- **Time diversity**: In this technique no of similar signals are transmitted through with different time instant where time is vary with different signal is called time diversity and which is basically used to decode the burst error correction
- **Frequency diversity**: Many of signals are transmitted with different frequency with large fading and frequency channels which are affected with the frequency selective channels which are basically used OFDM and spread spectrum technique
- **Space diversity:** The signal transmits through various channels. In wired transmission signal is transmit through different wires whereas in wireless medium84 it will be achieved by antenna diversity exploitation multiple transmitter antennas and/or multiple receiving antennas.Within the latter case, a diversity combining technique is applied before additional signal process takes place. If the antennas are way apart, for instance at totally different cellular base station sites or wireless local area network access points, this is often referred to as macro diversity or web site diversity. If the antennas are at a distance within the order of 1 wavelength, this is often referred to as micro diversity. In phase antenna array, it is used for phase array.

- **Polarization diversity:** Many signals are transmitted through various channels with different polarization factor and receive the signal at receiver. It is used in spatial diversity.
- **Cyclic delay diversity:** Cyclic delay diversity is OFDM based technology which is introduced in 2001.Cyclic means shifting the signal in which the signal is added with the original signal to remove the prefix in signal. Cyclic prefix mainly used in OFDM to add the redundant bits and get the original signal back. In telecommunications, the term cyclic prefix refers to the prefixing of a logo with a repetition of the tip. While the serial is essentially organized to discard the alternate prefix samples, the rare prefix serves 2 functions. As a guard interruption, it eliminates the lay to rest image delay from the immediate image.

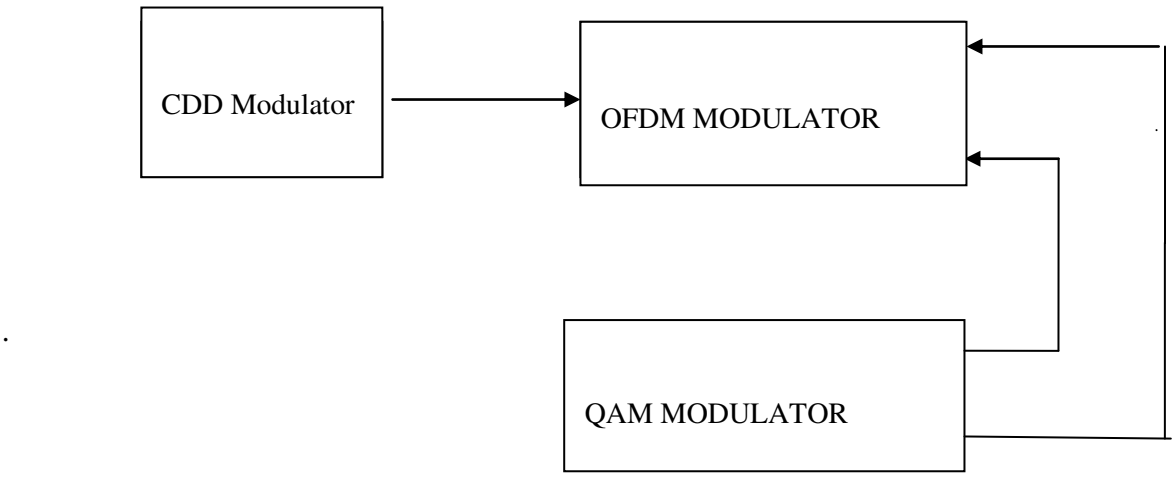


Fig 4: CDD model

As a repetition of the tip of the image, it permits the linear convolution of a frequency-selective multipath channel doomed modelled as circular convolution, that successively manage be reworked to the frequency domain by a disparate Fourier rework. This concern permits for straightforward frequency-domain process, one as channel estimation and effort. so as for the cyclic prefix to be keen (i.e. to act in situ of its aforesaid objectives), the length of the broken al prefix should be a minimum of approach to the intensity of the multipath channel though the assembly of discontinuous prefix has been historically associated by all of OFDM systems, the

cyclic prefix is directly additionally second user in single fighter aircraft systems to boost the lustiness to multipath propagation [12]

Principle of cyclic delay diversity

Cyclic prefix is frequently used as a vicinity of conjunction with modulation detains order to retain sinusoids' properties in multipath channels. It's plenteously realised that curved signs square measure Manfred Eigen functions of straight and time-invariant frameworks. During this means, if the channel is believed to be direct and time-invariant, previous a sinusoid of expansive length potential associate degree Manfred Eigen works. In any case, in prepare, this cannot be accomplished, as frank signs square measure forever time-constrained. Thus, to repeat the wide conduct, prefixing the conclude of the image to the late makes the straight convolution of the channel gain as still it were diagonal convolution, and hereby, recover this plot within the image of the image at the heels of the cyclic prefix[10]

1.7 Spectrum Sensing

Spectrum sensing is that the quality to live, sense and remember of the factor associated with the cognitive receiver parameters, convenience of spectrum and power hindrance and noise, radio in operation atmosphere, users needs and applications, out there networks and node, native policies and different in operation limitation. It's done across Frequency, Time, Geographic area, Encode and part.

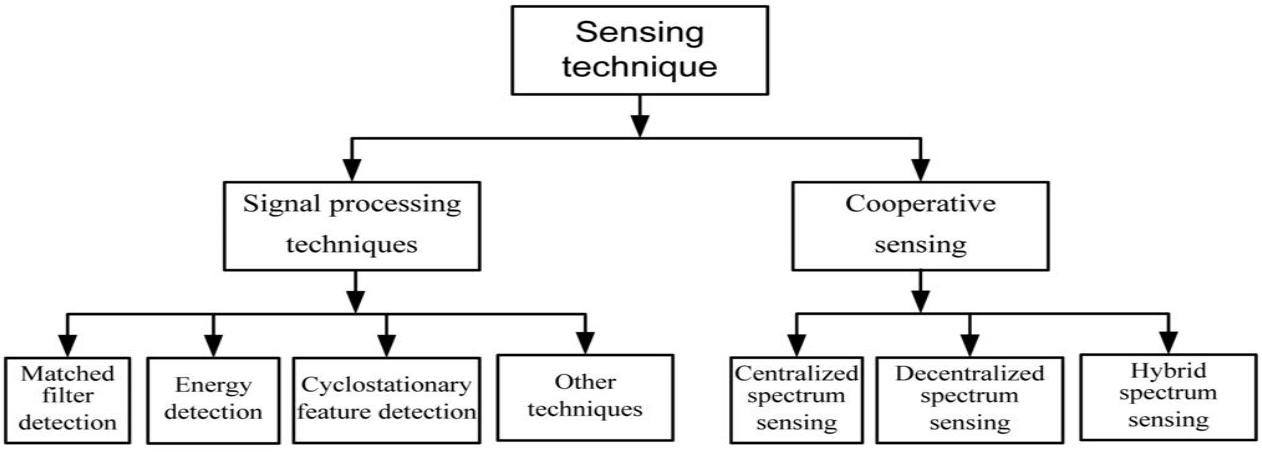


Fig 5: spectrum sensing model

Types of Spectrum Sensing Techniques

Signal processing techniques

- **Energy Detection**

  It is a non coherent detection method that detects the primary signal based on the sensed energy [1]. Due to its simplicity and no requirement on a prior knowledge of primary user signal, energy detection (ED) is the most popular sensing technique in cooperative sensing [15]-[17], signal is passed through band pass filter of the bandwidth and is integrated over time interval. The output from the integrator block is then compared to a predefined threshold. This comparison is used to discover the existence of absence of the primary user. The threshold value can set to be fixed or variable based on the channel conditions. The ED is said to be the Blind signal detector because it ignores the structure of the signal. It estimates the presence of the signal by comparing the energy received with a known threshold derived from the statistics of the noise. Analytically, signal detection can be reduced to a simple identification problem, formalized as a hypothesis test.

- **Matched Filter Detection**

  To improve the SNR, a matched filter is regularly utilized at the recipient front end. Matched filter coefficients are essentially given by the complex conjugated turned around signal tests as far as discrete signals. Two sorts of coherent or non-coherent collectors are utilized in signal examination either as intricate signal or interferences. In the event that the Amplitude and period of the got signal are known coherent receivers are utilized outcomes in a suitable match between the matched filter coefficients and the signals. If there should be an occurrence of a noncoherent receiver, the received signal is displayed as an imitation of the original signal with an arbitrary phase error. With a noncoherent recipient the recognition after the matched filter is for the most part in light of the power or greatness of the signal since we require both real and imaginary parts to characterize the signal totally [15].

- **Cyclostationary Feature Detection**

  It exploits the periodicity in the received primary signal to identify the presence of primary users (PU). The periodicity is commonly embedded in sinusoidal carriers, pulse trains,

spreading code, hopping sequences or cyclic prefixes of the primary signals. Due to the periodicity, these cyclostationary signals exhibit the features of periodic statistics and spectral correlation, which is not found in stationary noise and interference [19].Thus, cyclostationary feature detection is robust to noise uncertainties and performs better than energy detection in low SNR regions. Although it requires a priori knowledge of the signal characteristics, cyclostationary feature detection is capable of distinguishing the CR transmissions from various types of PU signals. This eliminates the synchronization requirement of energy detection in cooperative sensing. Moreover, CR users may not be required to keep silent during cooperative sensing and thus improving the overall CR throughput. This method has its own shortcomings owing to its high computational complexity and long sensing time. Due to these issues, this detection method is less common than energy detection in cooperative sensing.

Cooperative Sensing Technique

- **Decentralized Uncoordinated Technique** The cognitive users in the network don't have any kind of cooperation which means that each CR user will independently detect the channel, and if a CR user detects the primary user it would vacate the channel without informing the other users. Uncoordinated techniques are fallible in comparison with coordinated techniques. Therefore, CR users that experience bad channel realizations detect the channel incorrectly thereby causing interference at the primary receiver
- **Centralized Coordinated Techniques**: In such networks, an infrastructure deployment is assumed for the CR users. One CR that detects the presence of a primary transmitter or receiver, informs a CR controller which can be a wired immobile device or another CR user. The CR controller notifies all the CR users in its range by means of a broadcast control message. Centralized schemes can be further classified according to their level of cooperation as: Partially cooperative where network nodes cooperate only in sensing the channel. CR users independently detect the channel and inform the CR controller which then notifies all the CR users; and totally cooperative Schemes where nodes cooperate in relaying each other are information in addition to cooperatively sensing the channel [27].
- **Decentralized Coordinated Techniques:** This type of coordination implies building up a network of cognitive radios without having the need of a controller. Various algorithms

have been proposed for the decentralized techniques among which are the gossiping algorithms or clustering schemes, where cognitive users gather to clusters, auto coordinating themselves [23]. The cooperative spectrum sensing raises the need for a control channel, which can be implemented as a dedicated frequency channel or as an underlay UWB channel

CHAPTER-2

REVIEW OF LITERATURE

S.Haykin et al.[1] described that cognitive radio is used to improve the natural resources like EM wave spectrum. it is a radio defined software which is used to improve the natural resources and intelligent networks for wireless communication and which uses the methodology and characteristic to improve the results in this we are using different algorithm for sensing analysis .it will provide two main function high and efficient communication and efficient networks for transmitting and receiving the data. There are three main three retrospectives which are 1) Radio-spectrum analysis. 2) Channel-state diversity and constructive modelling. 3) Transmit-power management and dynamic spectrum management. This work additionally discusses the emerging behaviour of cognitive radio. It will provide the better result and get the software defined in natural resources and intelligent networks how to implement in the natural resources.

Yucek, Tevfi et al.[2] discussed multimedia media framework applications require fundamental transfer speed, various frameworks will be given by third-era administrations. Indeed, even with generous interest in 3G framework, the range allocated to 3G is limited. Cognitive radio offers a system for the adaptable pooling of range utilizing another classification of conventions known as formal radio manners. This approach may extend the transmission capacity available for standard uses and develop the spatial scope of 3G in an exceedingly novel means. Intellectual radio might be an unequivocal augmentation of programming bundle radio that utilizes display based thinking with respect to clients, mixed media framework substance, and interchanges setting. This paper describes the potential commitments of intellectual radio to range pooling and depictions relate starting structure for formal radio-decorum conventions.

Akyildiz Ian et al.[3] has proved that remote systems territory unit described by a set range task strategy. Be that as it may, a larger than average bit of the designated range is utilized occasionally and land varieties inside the use of distributed range ranges from V-day to eighty fifth with a high change in time. The limited reachable range and subsequently the unskillfulness inside the range use require a fresh out of the box new correspondence worldview to exploit the overall remote range astutely. This new systems administration worldview is said as People to come Systems

additionally as Powerful Range Get to and mental component radio systems. The term xg system is utilized all through the paper. The novel functionalities and current investigation difficulties of the xg systems region unit clarified personally. a great deal of particularly, a short rundown of the mental component radio innovation is given and along these lines the xg detail is presented. Also, the xg arrange capacities like range administration, range quality and range sharing region unit clarified personally. The impact of those capacities on the execution of the higher layer conventions like steering and transport range unit examined and open examination issues in these territories are made open. At last, the cross-layer style challenges in XG systems zone unit talk about talk about cr.

S.Marzairnovkeeet et al.[4] showed that cognitive radio is being deliberation research because the sanctionative technology for alternate access to the supposed TV White areas , giant parts of spectrum within the UHF/VHF bands that become out there on a geographic basis once digital reverse. Each within the North American nation, and a lot of recently, within the Britain the regulators have given dependant endorsement to the current new mode of access. This paper reviews the progressive in technology, regulation and standardization of cognitive access to TVWS. It examines the spectrum chance and industrial use cases related to this kind of alternative access.

Won-yeol Lee et al.[5] discussed that cognitive radio systems can offer high transmission capacity to versatile clients by means of heterogeneous remote designs and dynamic range get to procedures. In any case, metallic component systems force challenges attributable to the flimsy way of the offered range, still on the grounds that the different QOS needs of shifted applications. Range administration capacities will address these difficulties for the finish of this new system worldview. to supply a higher comprehension of metallic component arranges, this content presents late improvements and open examination issues in range administration in metallic component systems. a considerable measure of particularly, the dialog is focused on the occasion of metallic component arranges that need no adjustment of existing systems. Initial, a short rundown of intellectual radio and furthermore the metallic component detail is given. At that point four primary difficulties of range administration square measure talked about: range detecting, range call, range sharing, and range mobile.

MIin.LIet al.[6] proposed that Chinese Beidou satellite route framework group of stars by and by comprises of eight Beidou satellites and may give preparatory administration of route and situating inside the Asia-Pacific Locale. upheld the self-created code Position And Route data Analysis(PANDA) and Beidou Trial interest Stations (Wagers), that territory unit designed by city College, the investigation of Beidou exact circle assurance, static exact reason situating (PPP), and high exactness relative situating, and differential situating square measure designated exhaustively. Comes about demonstrate that the spiral exactness of the Beidou satellite circle assurance is best than ten centimetres. The RMS of static operation will achieve numerous centimeters to even millimetres for standard relative situating. The exactness of kinematic pseudo-run differential situating and RTK mode situating square measure 2–4 m and 5–10 cm severally, that square measure close to the degree of GPS exact situating. Examination amid this paper confirms that, with support of ground reference station organize, Beidou satellite route framework will give exact situating from numerous decimetres to meters inside the wide space and centimetre the territorial space. These promising outcomes would be helpful for the usage and utilizations of Beidou satellite route system.

S .Haykins et.al.[7] studied the usable satellite spectrum is changing into scarce because of ceaselessly increasing demand for broadcast, multimedia system and interactive services. During this context, psychological feature satellite communications has received vital attention late within the analysis community. Exploring economical spectrum sharing techniques for enhancing spectral potency in satellite communication has become a crucial analysis challenge. During this paper, we tend to study the most aspects of satellite cognitive communications and gift potential sensible situations for hybrid/dual cognitive satellite systems. Moreover, appropriate cognitive techniques for the thought-about eventualities are known. A lot of specifically, Spectrum Sensing (SS), interference modeling, and beam forming techniques are mentioned for hybrid psychological feature situation and SS, interference alignment, and psychological feature beam hopping techniques are mentioned for twin satellite systems. This paper concludes by providing attention-grabbing open analysis problems during this domain.

Ian F. et al.[8] explained the cognitive radio systems can give high data transfer capacity to portable clients by means of heterogeneous remote structures and dynamic range get to methods. Be that as it may, nuclear number 24 systems force challenges attributable to the temperamental

way of the out there spectrum, as well on the grounds that the various QOS necessities of arranged applications. Range administration capacities will address these difficulties for the conviction of this new system worldview. to create a higher comprehension of nuclear number 24 organizes, this content presents late improvements and open investigation issues in range administration in nuclear number 24 systems. A great deal of particularly, the discourse is focused on the occasion of nuclear number 24 arranges that need no adjustment of existing systems. Initial, a short rundown of mental element radio and furthermore the nuclear number 24 detail is given. At that point four primary difficulties of range administration are examined: range detecting, range call, range sharing, and spectrum**.**

Zeljko Tabakovic et al.[9] gave an A fundamental problem facing the future wireless systems is where to find suitable spectrum bands to meet the demand of future services. While essentially all of the radio spectrum is allocated to different services, applications and users, observation provide evidence that usage of the spectrum is actually quite low. In order to overcome this problem and improve spectrum utilization, cognitive radio concept has been proposed. This paper provides an overview of cognitive radio for opportunistic spectrum access and related research topics. Cognitive radio objective is to use scarce and limited natural resources efficiently without causing excessive interference to the primary licensed users. Consequently, cognitive radio has to sense and understand its spectrum environment, identify temporarily vacant spectrum, transmit adaptively and learn from its behaviour. A number of promising concepts for cognitive radio were briefly presented and discussed in this paper in the area of passive and active spectrum awareness, spectrum management and transmit power control.

Mansi Subhedar et al.[10] explaining The growing demand of wireless applications has put a lot of constraints on the usage of available radio spectrum which is limited and precious resource. However, a fixed spectrum assignment has lead to under utilisation of spectrum as a great portion of licensed spectrum is not effectively utilised. Cognitive radio is a promising technology which provides a novel way to improve utilisation efficiency of available electromagnetic spectrum. Spectrum sensing helps to detect the spectrum holes (underutilised bands of the spectrum) providing high spectral resolution capability. In this paper, survey of spectrum sensing techniques is presented. The challenges and issues involved in implementation of spectrum sensing techniques are discussed in detail.

Ahmed Heshma Mehana et al.[11] proposed that we are comprising the two diversity techniques that is cyclic delay diversity and alamouti signalling to achieve the better performance of multi antenna signal carrier block transmission. In this paper we analysis that the value of diversity is not only depends upon on antenna configuration and the channel memory and simulation results prove the high data rate will reproduce in cyclic delay diversity of SISO as compared to other techniques which gives the twice value of the diversity. In this, we achieve the low threshold value under two diversity techniques.

Ti Ahen XU et al.[12] discussed that comparing the two algorithm of spectrum sensing to detect the probability of false alarm under threshold detection we are using feature detection and energy detection of a signal to achieve the better performance under low SNR value .In this paper We are using two algorithm spectrum sensing with channel state diversity SSCD and feature detection algorithm under fast time varying channels which will gives the probability of false alarm. We simulate that from this paper that SSCD algorithm will give better performance then FDFW algorithm and it will capture the feature branch having different observation window. The future work of this paper we derive the detail derivation for the relationship between the probability of false alarm and window separation and detection threshold.

Fang Yang et al.[13] gave that the how narrow band interference is caused by the licensed and unlicensed services that effect the performance of MIMO systems . To improve this problem a new concept is introduced where 2d antenna is used in spatial networks each receiver antenna is used to measure the device. From this paper, we learn about 2D SCS method for MIMO is used to recover the narrow band interference in the system.

CHAPTER-3

RATIONALE AND SCOPE OF COGNITIVE RADIO

3.1 Benefits of the Earlier Paper Published

- A "Cognitive Radio" senses the spectral environment over a wide range of frequency bands and exploits the temporally unoccupied bands for opportunistic wireless transmissions. Since a cognitive radio operates as a secondary user which does not have primary rights to any pre assigned frequency bands, it is necessary for it to dynamically detect the presence of primary users.
- Spectrum sensing is the basic and essential mechanisms of Cognitive Radio (CR) to find the unused spectrum. Spectrum sensing (spectrum detection technique)is the main task in cognitive cycle and the main challenge to the CRs. Energy detection (also denoted as non coherent detection), is the signal detection mechanism using an energy detector (also known as radiometer) to specify the presence or absence of signal in the band.
- Various techniques have been developed traditionally to detect the energy in the cognitive radio but are not able to perform efficiently because the techniques faces the variations in the value of the detected value of the energy
- Other backlog was that none of filtration was performed over the signals in order o remove the noise from the signals. The traditional method is based on the single threshold value which is again a lacking point. Hence there is a need to develop such a technique which can overcome the problems of the existing techniques.
- In the main earlier research author main focus on to improve the detection probability using different channels and algorithms..

- Implemented a new concept of probability of false alarm and threshold coefficient using SSCD Algorithm.

3.2 Scope of The Study

Cognitive radio provides dynamic access of radio spectrum, demand and overcrowding of radio frequency spectrum are the result of enhancement in wireless communication services .This gives rise on cost of spectrum and created a conflict between the public, private and military sectors over frequency rights. Cognitive radio provides an opportunity to secondary users to use the spectrum that is free from particular time. Cognitive Radio provides the opportunity to change its setting according to the neighbour environment in order to improve the performance of spectrum sensing. According to its operational area cognitive radio has scope of the study as followed:

- It can be used in multi band, multi service, multi standard and a multi channel system.
- It can also be used in spectrum management, artificial intelligent and dynamic channel with the help of software defined radio.

CHAPTER 4

OBJECTIVE OF THE STUDY

The objectives of the proposed work are as follows:

1. To study and simulate the spectrum sensing techniques in cognitive radio
2. To study and analyze the performance of spectrum sensing technique using pd versus threshold detection
3. To study the impact of various channels on spectrum sensing techniques.
4. To implement and design the double threshold concept for spectrum sensing.
5. To implement the matched filter at the receiver end to removing the noise from the signals.
6. To implementation of SSCD algorithm in calculating the probability of false alarm for different threshold detection values.
7. To analyze the system performance with different encoding techniques with SSCD algorithm in Cognitive radio
8. To compare the proposed curves with conventional methods.

CHAPTER-5

RESEARCH METHODOLOGY

5.1 System model: In system model where the properties of spectrum sensing and compatibility of cyclic prefix are shifted. We adopt two techniques where two antennas are used OFDM system with CDD the transmitter architecture for primary user can be depicted. At one antenna OFDM symbols are sent as normal while at the other antenna data symbols are shifted and other antenna can based cyclic delay.

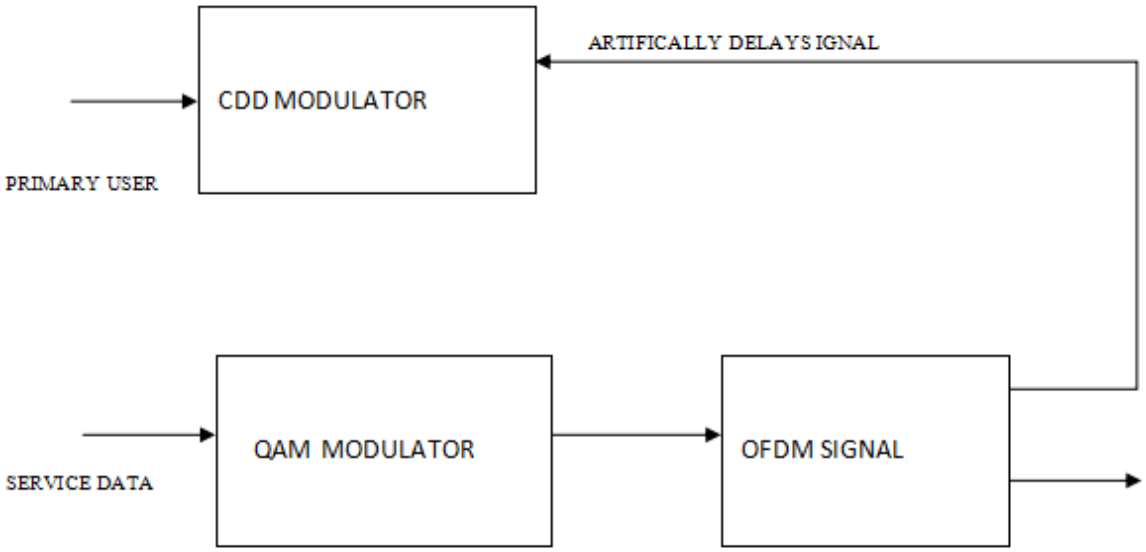
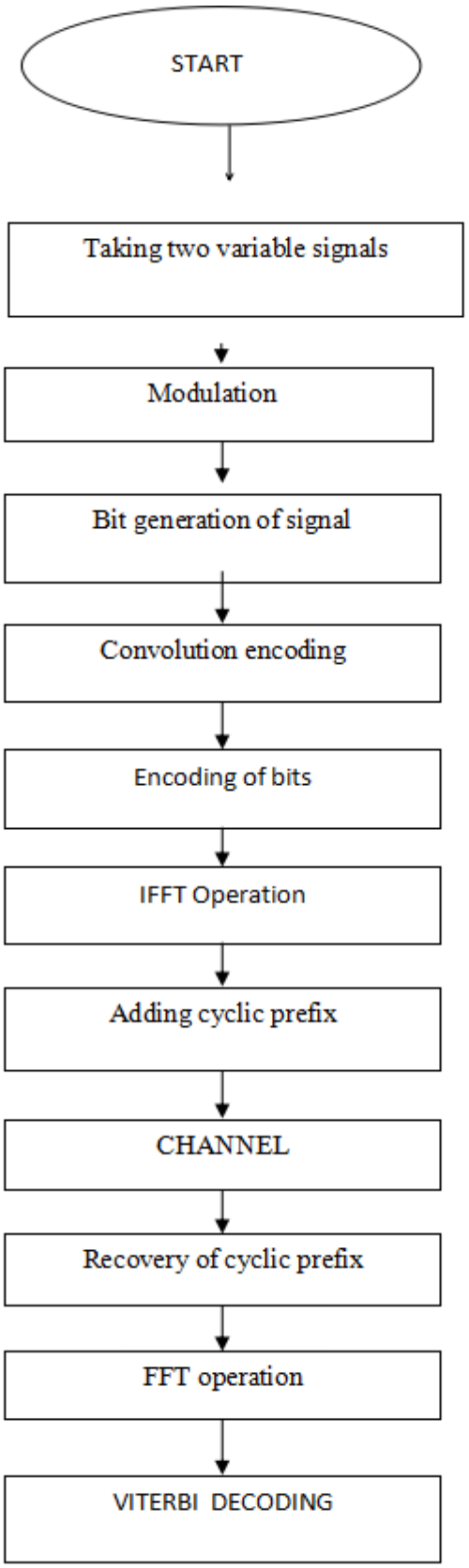


Fig 6: System model

The simulation shows that at the transmission end we are using two OFDM signals. . We adopt two techniques where two antennas are used OFDM system with CDD the transmitter architecture for primary user can be depicted. At one antenna OFDM symbols are sent as normal while at the other antenna data symbols are shifted and other antenna can based cyclic delay. First we analyze that how to do fast time varying channels determine the performance of FDFW sensing technique can be used to detect the false alarm with the help of SCF and CAF correlation


START
Taking two variable signals
Modulation
Bit generation of signal
Convolution encoding
Encoding of bits
IFFT Operation
Adding cyclic prefix
CHANNEL
Recovery of cyclic prefix
FFT operation
VITERBI DECODING

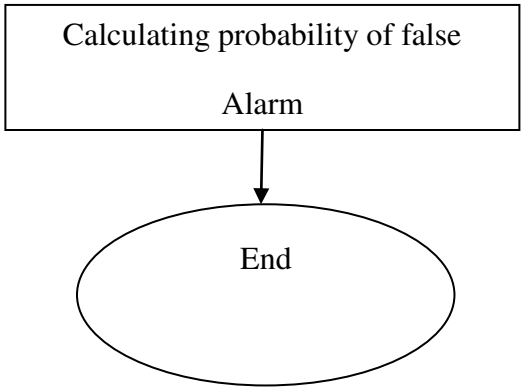


Fig 7: Flow Chart

5.2 Steps involved in Flow chart

- From the above algorithm the two signals are inserted into the system where as the first signal is OFDM signal and another signal is used to shift the values.
- Signal is modulated using QPSK modulation and then encode the signal using convolution encoding for calculate the probability of false alarm.
- Now IFFT operation is done and signal is move to the CCD concept where new bits are added to get the original data.
- Rayleigh channel is used for providing the fading effect FFT is done and signal is Viterbi decoding to get the original signal back.
- After decoding process calculate the bit error rate versus SNR to detect the probability false alarm and missed detection.
- Calculate the noise effect using different channels.

CHAPTER 6

RESULTS AND DISCUSSION

6.1 Implementation of Double Threshold Filtration

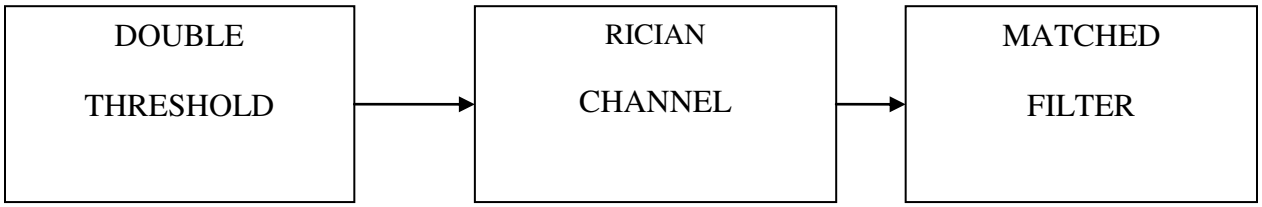


Fig8: Proposed model

In this implementations in previous results if signal is not recover by the single threshold then double threshold will use to recover that signal and perform the same task. Then, the signal is applied to the Rician fading effect. Signal is received after adding noise is calculated and compared with single threshold value the effect of noise is less as compared to previous result. This process repeated for 1000 realization with change in SNR. The performance of probability of detection and SNR is analyzing using filter process. After adding the matched filter the presence of noise is less which will remove the after noise and the result is better than the previous channel. The results of Rician channel is better than the Rayleigh channel because there is no presence of line of sight and used for detection and probability of detection is improved using Rician which we can see using graphical representation in coming section.

Table 1: Simulation Parameters

PARAMETERS	VALUES
Carrier frequency	2.5 GHZ
FFT size	512
CP length	n/4
Coding rate	½
Modulation	QPSK
Channel	Rician and Rayeigh
Encoding	Convolution encoding

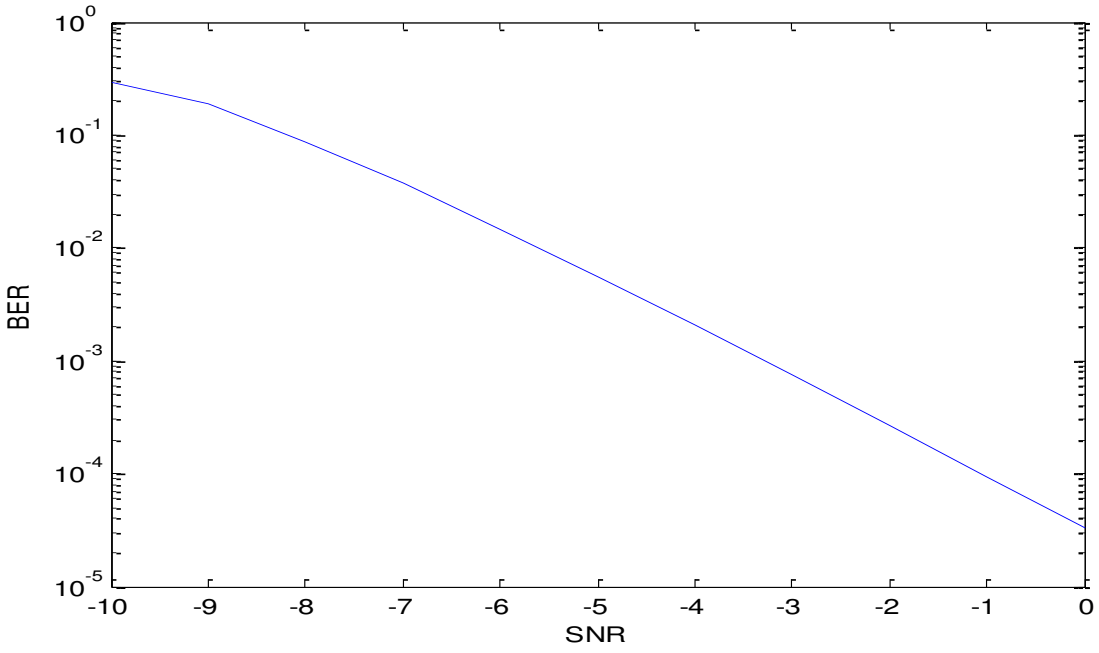


Fig 9: Graph for system model

In figure 8, the performance plot of SNR versus BER for different values of probability false alarm is shown. It can be concluded from this plot the performance of the SNR will increases then BER will decreases. This graph is plotted for different values of SNR and it is clearly shown that increasing the SNR will improve the value of BER. When taking the value of SNR -10 the BER having 0.5 from and when SNR value is -1 the BER having $10^{-4.}$ From this value we clearly Concluded that increasing the value of SNR will decreases in BER.

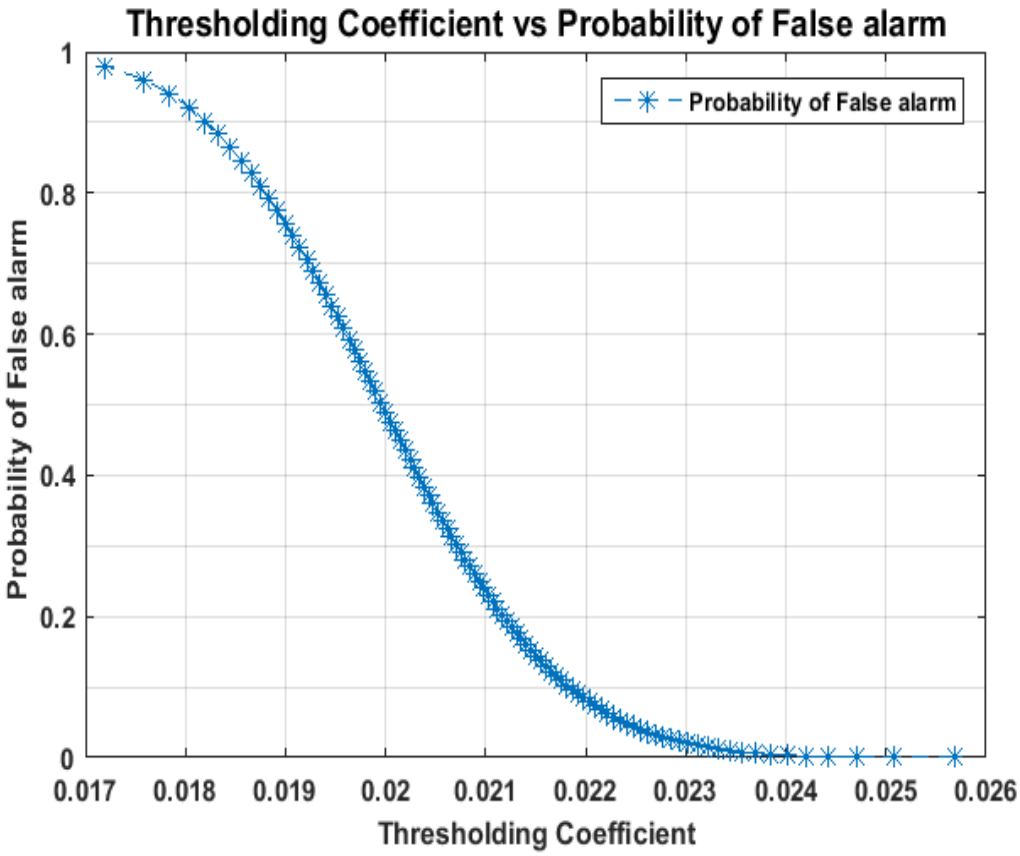


Fig 10: P_d versus threshold coefficient for probability detection

In figure 9, the performance plot of Threshold coefficient versus probability of false alarm (P_d). For different values of probability false alarm is shown. It can be concluded from this plot the performance of the threshold coefficient will increases as well as the probability of false alarm will decreases. This graph is plotted for different values of threshold coefficient and $P_{d.}$ It is clearly shown that probability of false alarm will decreases.

Table 2: Numerical values to calculation the probability of false alarm

Threshold coefficient	Probability of false alarm
0.022	0.1
0.023	0.01
0.024	0
0.018	0.9
0.019	0.73

From table 2 shows that 0.022 increases in Threshold coefficient decreases the probability of false alarm 0.1.It is clearly shows from the different values that the increasing the value of threshold coefficient will decreasing the $P_{d.}$

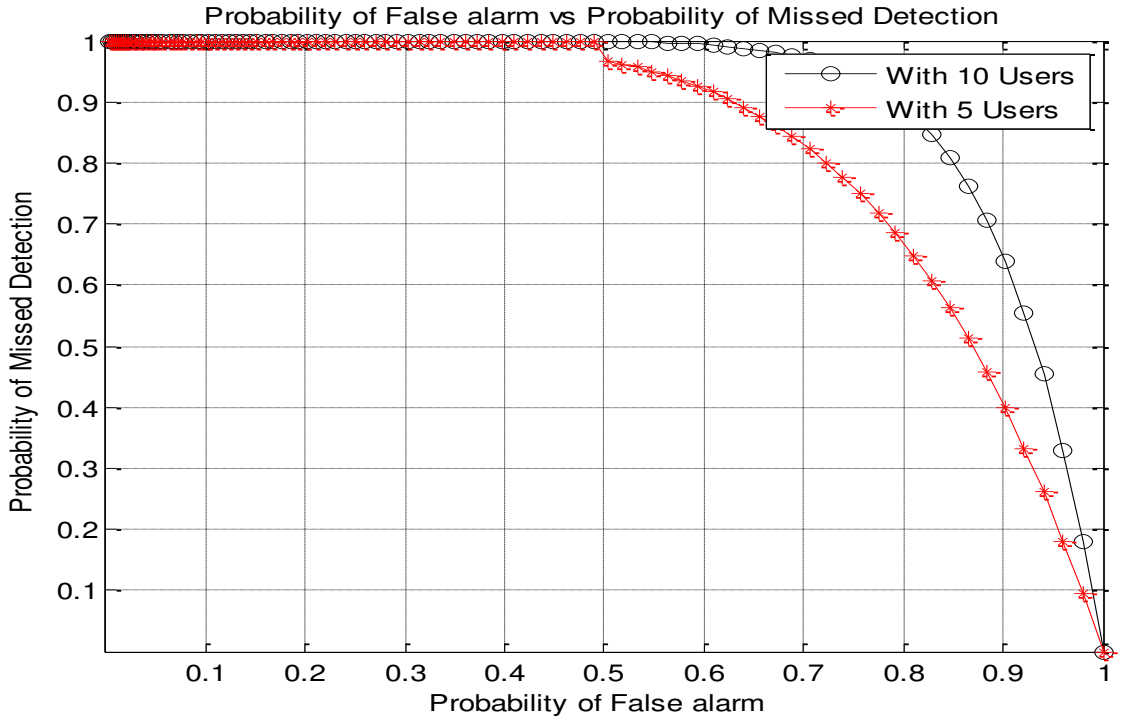


Fig 11: P_d versus missed detection for detection of users

In figure 10, the performance plot of probability of false alarm (P_d) versus missed detection. And different values of probability false alarm are shown. It can be concluded from this plot the performance of the Probability of false alarm will increases as well as the probability of false missed detection will decreases. This graph is plotted for different values in which 10 users probability of missed detection is less as compare to Users 5.

Table 3: Missed detection and probability of false alarm

No of users	**Probability of false alarm**	**Probability of missed detection**
5 users	0.9	0.4
10 users	0.9	0.6
5 users	1	0.9
10 users	1	0.95

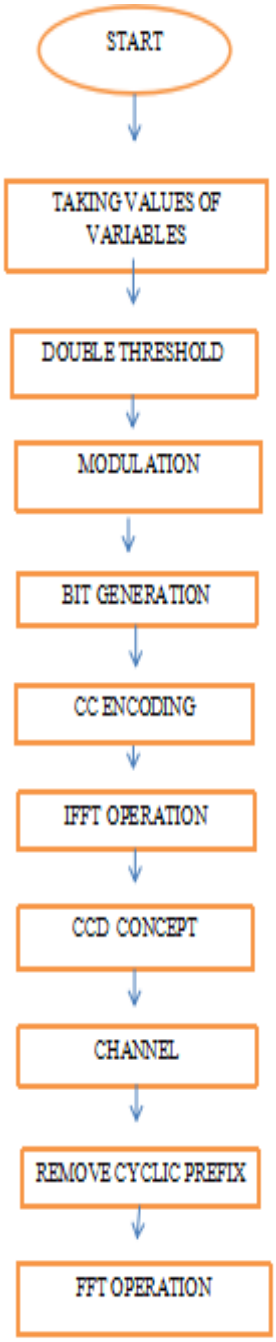
From this table it can be concluded that probability of missed detection users 10 will more as compare to user 5.

6.2 Proposed Methodology:

After having a review to the previous work it is detected that the problem of variations in the value of the energy, single threshold value and existence of noise in the signals were faced. Hence in order to solve these issues the proposed work aims to implement the double threshold value in

order to overcome the issues of the single threshold value, and match filters to remove the noise from the signals.

- In this flow chart take the two values and generate the empty matrix for noise, energy as well as threshold.
- Now Double threshold concept is applied to the signal to become a energy signal.


START
TAKING VALUES OF VARIABLES
DOUBLE THRESHOLD
MODULATION
BIT GENERATION
CC ENCODING
IFFT OPERATION
CCD CONCEPT
CHANNEL
REMOVE CYCLIC PREFIX
FFT OPERATION

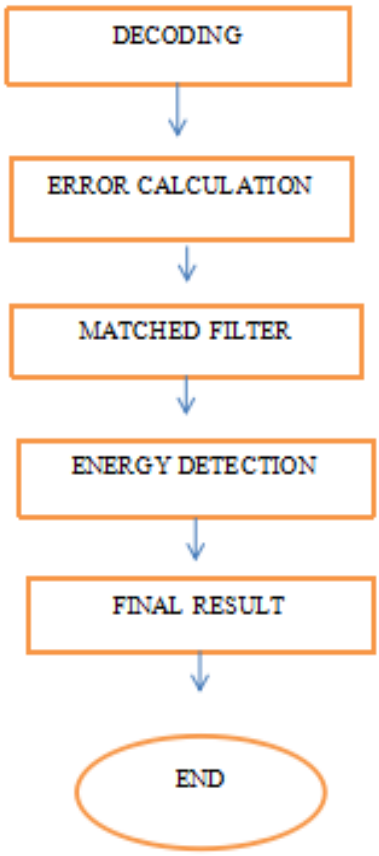


Fig 12: Proposed Methodology

- QPSK modulation is done and creates the new two information signal where one signal is OFDM and other one is variable signal which is used to shift the values.
- Convolution encoding is done for better result and CCD is added to add the new bits and remove the prefix from the signal.
- Rician channel and AWGN channels is used to provide the noise matrix and remove the noise from the signal.
- Decode the coming signal and remove the cyclic prefix from the signal and calculate the error and compare with the previous result.
- Matched filter is used to remove the present noise in the signal and create the loop for taking final result.

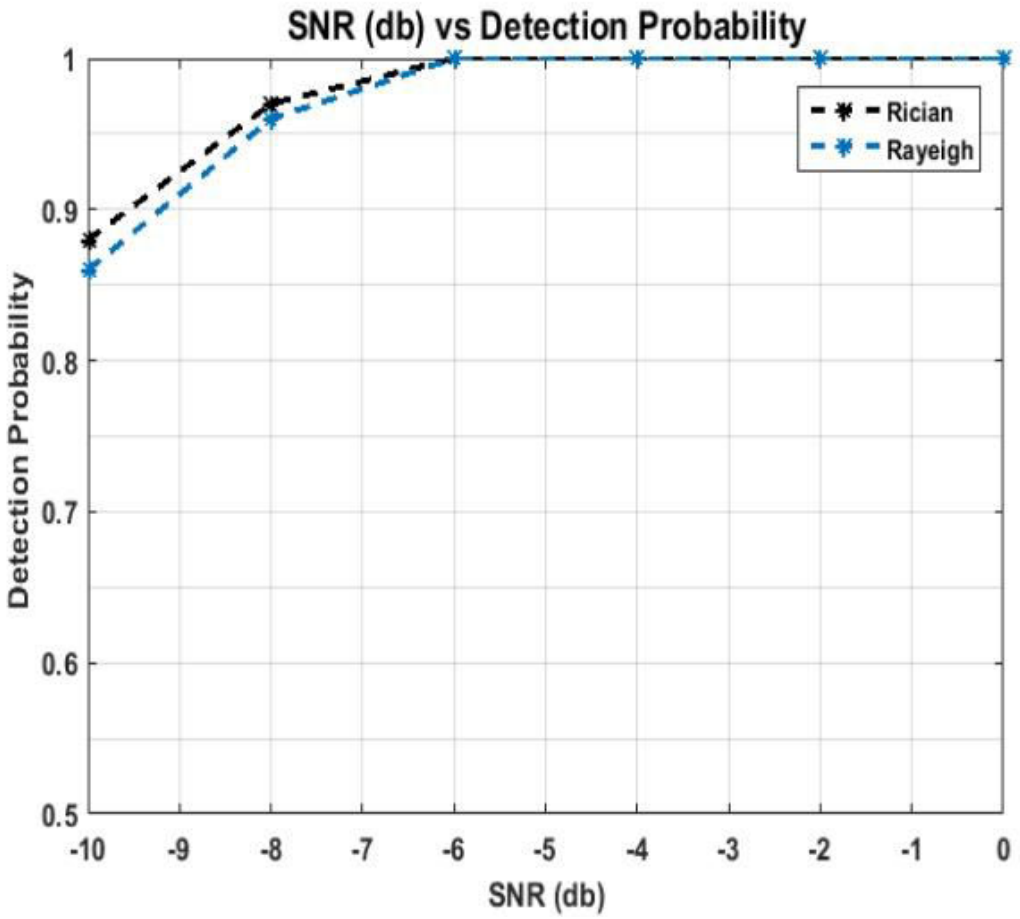


Fig 13: Detection probability versus SNR

In this graph, the performance of SNR versus probability of detection (P_d) for different values of probability of false alarm is shown for detection .It can be concluded from this graph the increases in the SNR will increases the detection probability. In this graph it is clearly shown that performance of Rician channel is better than Rayleigh channel.

Table 4: improvement table for detection probability

SNR (DB)	**Detection probability (Rician)**	**Detection Probability (Rayleigh)**	**Improvement**
-9	0.90	0.92	0.20
-8	0.95	0.96	0.10
-7	0.96	1.98	0.20

Table No.4 shows different values of the detection probability for Rayleigh and Rician channel. The detection probability is low in Rician channel and provides the better result 0.10.

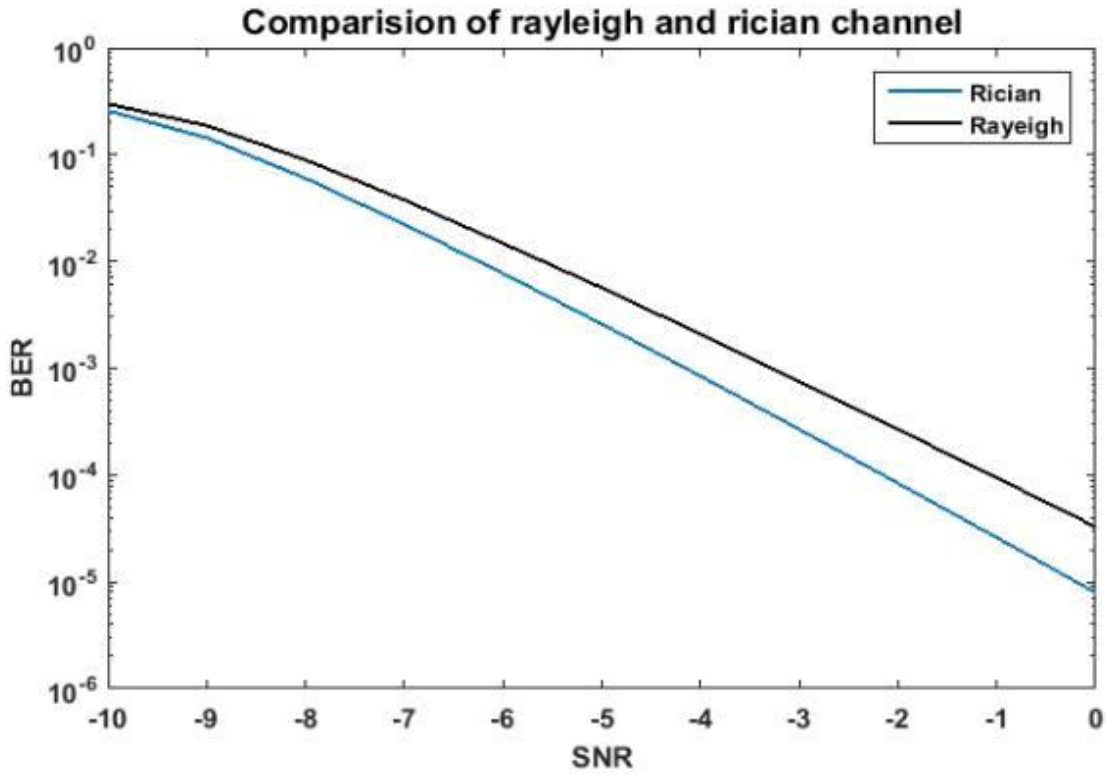


Figure 14: Comparisons of BER versus SNR of channels

From this graph it will show the comparison between the bit error rate and SNR for two different channels Rician and Rayleigh channel the value of bit error rate will be decreases with the increase in SNR value. From this graph we analyze that the performance of Rician channel is better because there is no line and sight is present in the Rician channel .From this graph we analyze that by increasing the value of SNR then there is gradual change in BER by taking the different values.

6.2 Proposed Work Graphs For Probability Of False Alarm (P_d).

In figure 13, the performance plot of SNR versus BER for different values of probability false alarm is shown. It can be concluded from this plot the performance of the SNR will increases then

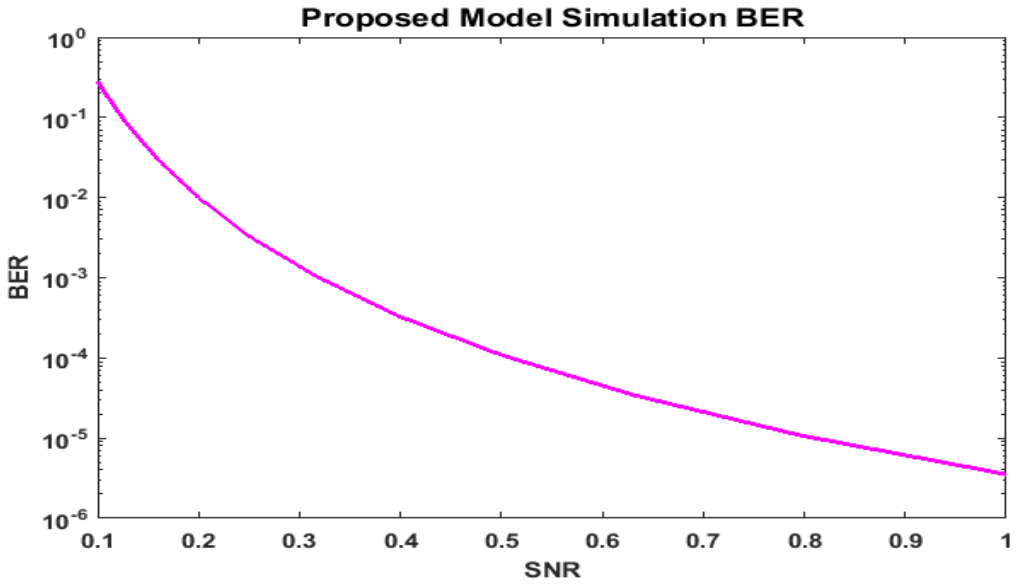


Fig 15: Proposed simulation of BER versus SNR

BER will decreases. This graph is plotted for different values of SNR and it is clearly shown that increasing the SNR will improve the value of BER. When taking the value of SNR 10^4 the BER Having 0.5 from and when SNR value is -1 the BER having 10^{-4} .From this value we clearly concluded that increasing the value of SNR will decreases in BER. This graph is purposed model and shows the better result from previous result.

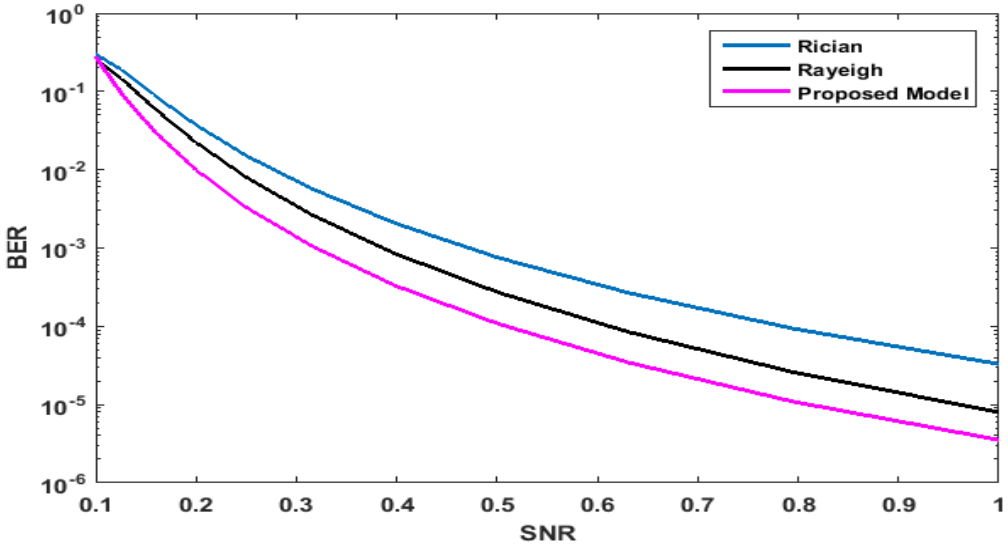


Fig 16: Proposed model BER versus SNR

In figure 14, the performance plot of SNR versus BER for different values of probability false alarm is shown. It can be concluded from this plot the performance of the SNR will increases then BER will decreases. This graph is plotted for different values of SNR and it is clearly shown that increasing the SNR will improve the value of BER. When taking the value of SNR 10^4 the BER Having 0.5 from and when SNR value is -1 the BER having 10^{-4} .From this value we clearly concluded that increasing the value of SNR will decreases in BER. This graph is purposed model and shows the better result from previous result.

Table for SNR versus BER for proposed model

SNR(DB)	RICIAN (BER)	RAYLEIGH(BER)	PROPOSED (BER)
-0.9	$10^{-5.5}$	10^{-4}	10^{-5}
-1	$10^{-5.9}$	$10^{-5.5}$	10^{-6}

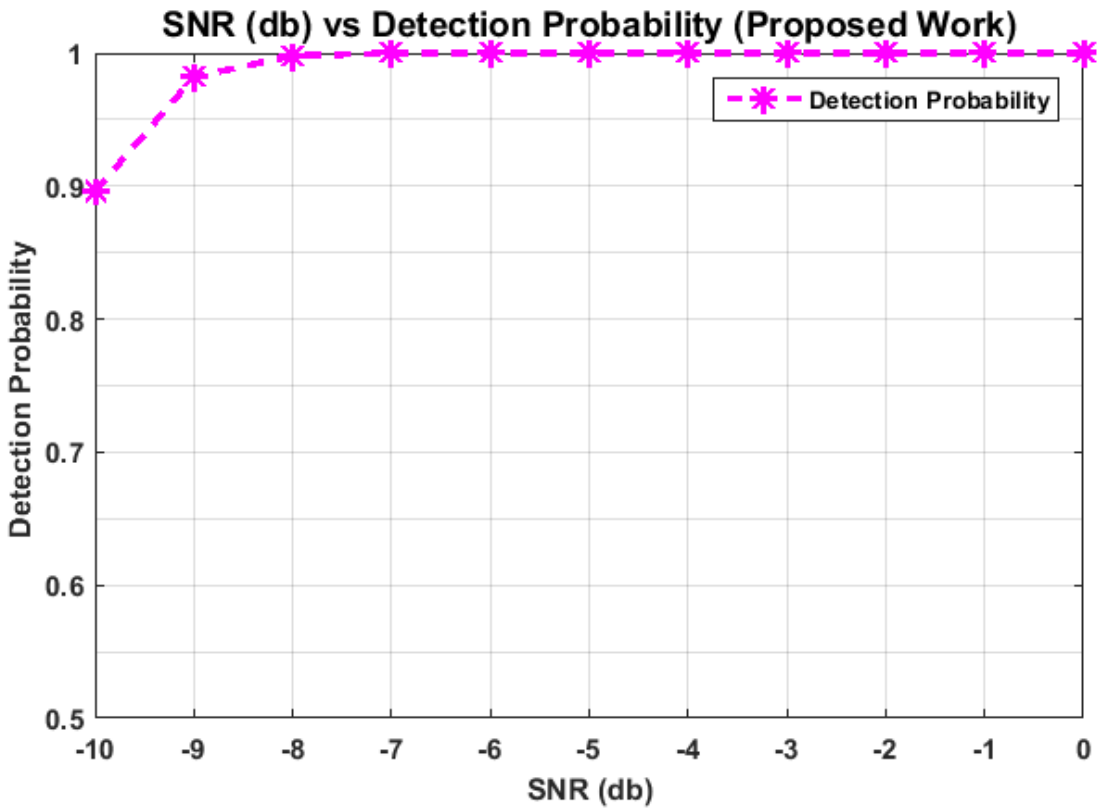


Figure 17: SNR versus Detection Probability

In this graph the performance of SNR versus probability of detection (P_d) for different values of probability of false alarm is shown for detection .It can be concluded from this graph the increases in the SNR will increases the detection probability.

Table 5.Table for Detection Probability

Detection probability	SNR(DB)
0.9	-10
0.9	-9
1	-8
1	-7

It will show detection probability and SNR value with the increase in SNR values it will increase and the detection probability.

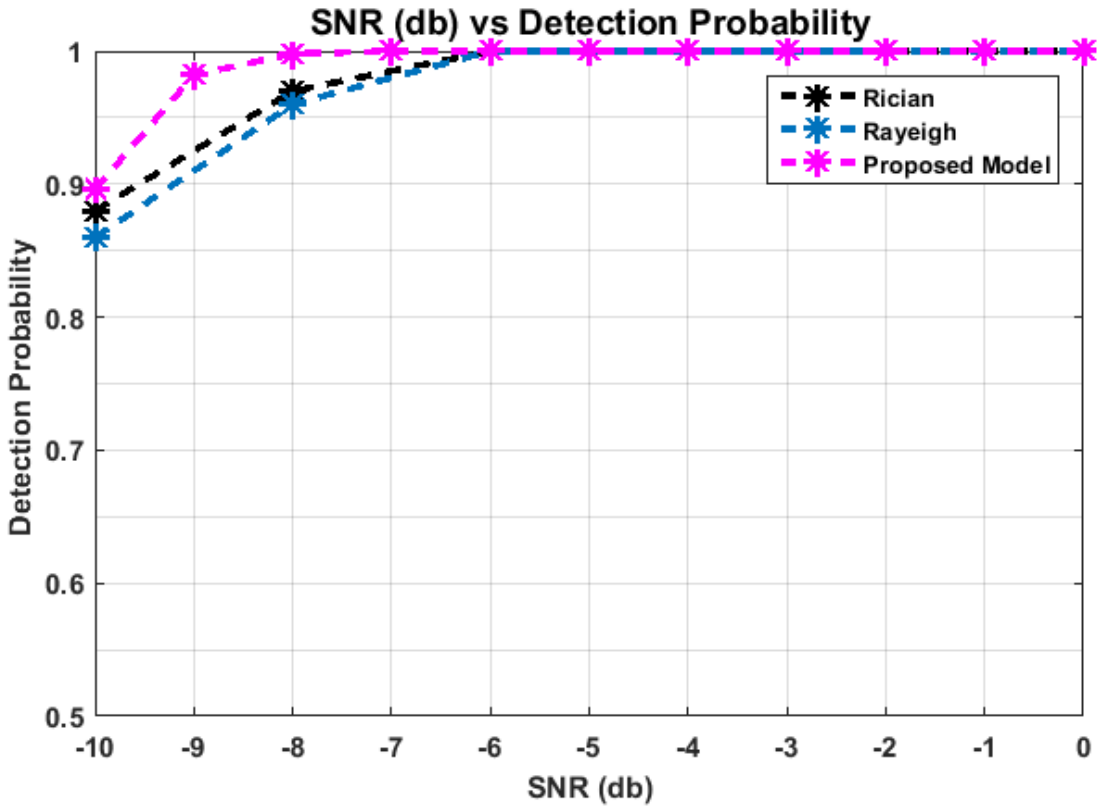


Fig 18: Proposed detection probability versus SNR

From this graph the performance SNR versus detection probability for various channels. It can be concluded from this graph SNR will increase so detection probability will increases. From this plot it is clearly shown that Rician channel and proposed probability will provide better result with the help of double threshold filtration method.

Table 6: improvement in detection probability

SNR(dB)	RAYLEIGH (P_d)	RICIAN(P_d)	PROPOSED (P_d)
-10	0.85	0.87	0.90
-9	0.9	0.92	0.97
-8	0.95	0.97	0.99
-7	0.97	0.98	1

From above table it will show the various values for detection probability versus SNR. Detection probability is increased using double threshold filtration method.

CHAPTER 7

CONCULSION AND FUTURE WORK

6.1 Conclusion

This thesis focuses on matched filter based spectrum sensing technique. Two operations have been used to improve the performance of spectrum sensing techniques. The performance of spectrum sensing techniques has been evaluated using double threshold and single threshold. The curves are plotted for different probability of detection P_d versus SNR and Missed detection P_m versus SNR. The matched filter method is used for spectrum sensing well in various fading channels and under low SNR conditions. The proposed matched filter operation helps to improve the performance of probability of detection. An improvement of up to 0.3 times for Rayleigh channel has been achieved as the operation has been changed for single to double threshold.

With the help of increasing SNR, the performance of spectrum sensing has been improved. With increase in 10 db SNR, the probability of detection increases up to 0.9 to 1 for Rayleigh channel whereas in the case of Rician channel, the probability of detection is improved 0.1 times. Also, it has also been observed that increase in probability of false alarm, improves the probability of detection of a particular spectrum sensing method. It has been observed that using single threshold the noise effect is more as compared to double threshold. In noise, Double threshold performs 0.5 % better than single threshold.

6.2 Future Scope

- To overcome the effect of noise we can further implement the proposed technique in cooperative detection where multiple cognitive devices sense the channel and decision is taken from fusion detection.
- Further, the result can be improved by using double threshold with filters to get the better decision.

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[1] Dutta, Shruti, and Komal Arora. "Review On Cognitive Radio."*international Journal of Engineering Technology, Management and Applied Sciences* , Volume 5 Issue 4, pp. 2349-4476,April 2017

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