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DATA RATE ENHANCEMENT OF GSM USING OFDM TECHNIQUE

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Abstract: Error free transmission is one of the main requirements in wireless communication. Now a days in wireless communication system demands higher data rate environment and transmission. For this ADAPTIVE- OFDM is preferable to higher data rate transmission on wireless channel. In ADAPTIVE- OFDM the carriers are partitioned into the multiple subcarriers and that sub carriers are given to many users for simulation.

ADAPTIVE- OFDM supports high data rate transmission over wireless communication. There are many techniques to improve system performance and spectral efficiency of ADAPTIVE- OFDM such as adaptive modulation and adaptive user allocation. To demonstrate the strength of ADAPTIVE- OFDM in multipath channel single carrier multicarrier ADAPTIVE-OFDM and QAM are compared. In this paper each block of ADAPTIVE- OFDM is system is explained. The transmission protocol and system is also explained. This paper compares channel estimation technique with the communication system that uses QPSK and QAM and also Bit Error Rate is known as a performance index. The analysis is carried out under the MATLAB environment.

KEYWORDS: OFDM, ADAPTIVE- OFDM, Q-PSK, QAM, BER.

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INTRODUCTION

Literature Survey: According to Yang-wen Liang ; Schober, R.; Gerstacker, W.et.al in multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-ADAPTIVE- OFDM) transmit beam forming (BF) and receive combining are simple and popular methods for performance enhancement and for MIMO-ADAPTIVE- OFDM systems which uses cyclic BF filters propose a novel single-data stream, time-domain BF (TD-BF) scheme. Cyclic prefix are optimize for two different criteria by assuming perfect channel state information at the transmitter namely maximum average mutual information per sub carrier and minimum average encoded bit error rate. These both optimization problems exist if the cyclic length is equal to number of sub carriers. They present numerical methods for calculation of the optimum C-BFFs for both criteria in the practical relevant case in which cyclic length is less than number of sub carriers. [3]

Dissanayke S.D., Armstrong J et. Al. designs orthogonal frequency division multiplexing in three types asymmetrical clipped DC biased optical ADAPTIVE- OFDM (ADO-ADAPTIVE- OFDM), asymmetrical clipped optical ADAPTIVE- OFDM (ACO-ADAPTIVE- OFDM), DC biased optical ADAPTIVE- OFDM(DCO-ADAPTIVE- OFDM).ADO-ADAPTIVE- OFDM combines the remaining two types ADAPTIVE- OFDM by transferring DCO-ADAPTIVE- OFDM on even subcarriers and ACO-ADAPTIVE- OFDM on odd subcarriers. ADO – ADAPTIVE- OFDM is more power efficient than the DCO-ADAPTIVE- OFDM and ACO-ADAPTIVE- OFDM. [4]

The powerful technique for the transmission over quasi-static frequency selective fading channel with convolution coding is Bit-Loaded ADAPTIVE- OFDM. The author develops analytical method for bit error rate and frame error rate of bit loaded coded ADAPTIVE- OFDM using singular value decomposition Further the author introduce different application on this analysis Firstly they compare the several ADAPTIVE- OFDM bit loading scheme with other schemes and proposed a hybrid loading scheme. Secondly introduce three adaptive interleaving scheme 1) from a number predefined interleavers select the best interleavers 2) on the basis of pair wise error probability develops a novel adaptive bit interleaving algorithm 3) A spatial interleaving scheme for MIMO-ADAPTIVE- OFDM-SVD system with separate information sources.

To remove inter symbol interference and inter carrier interference in frequency domain ADAPTIVE- OFDM signal without cyclic prefix use probabilistic data association (PDA) equalizer. Cyclic prefix with a length longer than the channel length is used in ADAPTIVE- OFDM this cause's performance degradation due to increased required bandwidth. [6]

The author applies the modulation scheme of asymmetrically and symmetrically clipping optical (ASCO)-ADAPTIVE- OFDM into optical wireless communications (OWC). The symmetrically clipping optical (SCO)-ADAPTIVE- OFDM symbols and the asymmetrically clipping optical (ACO)-ADAPTIVE- OFDM symbols are mapped into even columns and odd columns respectively. The average data rate of ASCO-ADAPTIVE- OFDM is higher than that of ACO-ADAPTIVE- OFDM due to an ASCO-ADAPTIVE- OFDM signal. The spectral efficiency of two dimensional ASCO – ADAPTIVE- OFDM is greater than the two dimensional ACO- ADAPTIVE- OFDM. Under the environment of additive white Gaussian noise (AWGN) the symbol error rate (SER) performance of 2 dimensional ASCO-ADAPTIVE- OFDM is simulated and it exhibits better SER performance than the 2 dimensional ACO-ADAPTIVE- OFDM.[8]

The conventional ADAPTIVE- OFDM cannot be directly applied in optical systems because of only the intensity of a signal is used to carry information. To overcome this problem several modified ADAPTIVE- OFDM systems have been studied such as Unipolar ADAPTIVE- OFDM, asymmetrical clipped optical ADAPTIVE- OFDM, DC biased optical ADAPTIVE- OFDM and flip ADAPTIVE- OFDM. During the transmission of real signal in optical environment there is Hermitian symmetric constraint with discrete Fourier transform. For removing this Hermitian constrain author propose a novel ADAPTIVE- OFDM system namely position modulating ADAPTIVE- OFDM which utilize DFT but removes the constraint. [9]

Introduction: The ADAPTIVE- OFDM is a special case of multicarrier modulation in which serial stream of data is divided in parallel and modulated by orthogonal sub-carriers with partial overlapping frequency bands. As compare to the single carrier modulation with a narrow bandwidth the ADAPTIVE- OFDM symbols have relatively long time duration that results in less complex equalizer which helps to perform the channel equalization in frequency domain. Due to the features of ADAPTIVE- OFDM like transmission rate, bandwidth efficiency, less complex equalizer ADAPTIVE- OFDM adopted as a major data transmission technique wireless communication standards. ADAPTIVE- OFDM is developed to meet demands for higher data rate in communication.

In ADAPTIVE- OFDM data is transmitted by carriers and at the lower rate. It is takes place on the basis of spreading. The Information is expressed in the form of bit in digital communications. Symbol is referred to as a collection, of bits [1]. Data in ADAPTIVE- OFDM are generated by using symbols in spectral space and by taking Inverse Fourier transform convert the spectra to time domain. Because of Inverse Fast Fourier Transform (IFFT) is more cost effective to implement, it is usually used [2].ADAPTIVE- OFDM is able to provide high data rate, allowable

Bit Error Rate and maximum delay. ADAPTIVE- OFDM is used to split the total transmission bandwidth into number of orthogonal subcarriers for the transmission the symbol.

In Contrast to FDM, the Spectral overlapping among subcarrier allow in ADAPTIVE- OFDM. In ADAPTIVE- OFDM equalization is simpler than a single carrier frequency and in differential encoding implement equalization may be avoided. In ADAPTIVE- OFDM some processing is done on the source data such as coding for correcting data. By using IFFT in ADAPTIVE- OFDM symbols are modulated on orthogonal sub carriers. By using FFT demodulation is to be done. In ADAPTIVE- OFDM cyclic prefix is used to find the start of each frame.

Advantages of ADAPTIVE- OFDM

As Compare to FDM, ADAPTIVE- OFDM permits higher data rate.

It has multipath delay spread tolerance

Disadvantages of ADAPTIVE- OFDM

ADAPTIVE- OFDM is more complex than single carrier modulation

It requires more linear power amplifier

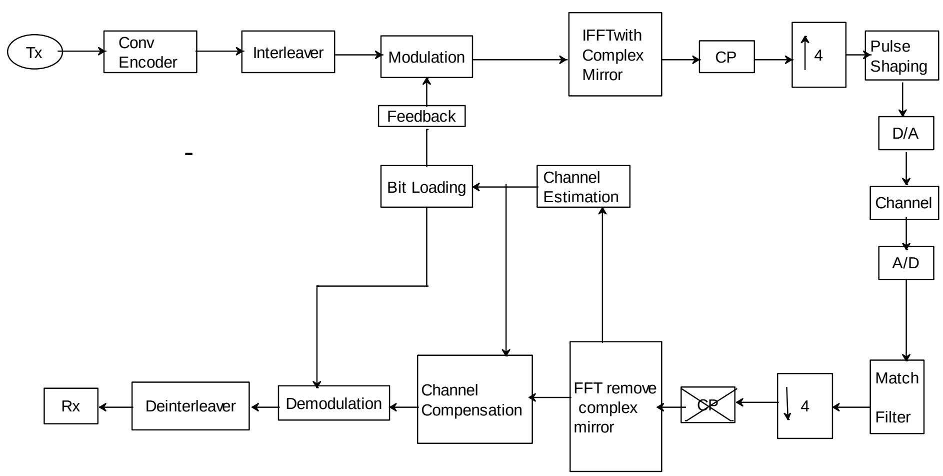


Figure 1: OFDM system [12]

The ADAPTIVE- OFDM System Model is shown in figure 1. It consists of transmitter, receiver, and channel. The Number of carriers in ADAPTIVE- OFDM system is limited by the IFFT which describes the complexity of system. If the system is more complex then the higher size IFFT used by this higher data transmission rate achieved. The Choice of encoder modulator varies the data rate and Bit Error Rate.

For ***ADAPTIVE- OFDM*** if the system bandwidth is B, Number of sub-carriers is given by

$$N_c = \frac{B}{1/1T_S} = 2\boldsymbol{BT_S}$$

ADAPTIVE- OFDM has the potential to at least double the number of sub-carriers i.e. double the total transmission rate over the system bandwidth

Cyclic prefix

Cyclic Prefix is inserted between the two successive ADAPTIVE- OFDM to avoid ISI (Inter Symbol Interference). Cyclic Prefix eliminates inter symbol interference and inter carrier interference. It suffers from intra carrier interference. It causes reduction in data rate as a result of increased ADAPTIVE- OFDM symbol time. Cyclic Prefix is nothing but the tail symbol of massage frame. The length of cyclic prefix is one forth of IFFT. In Cyclic Prefix each ADAPTIVE-OFDM symbol is preceded by a periodic extension of the signal itself. The Cyclic Prefix (CP) length, Tcp, should cover the maximum length of the time dispersion. Increasing Tcp without decreasing Δ*f* implies increased overhead in power and bandwidth. The Length of Cyclic Prefix is must to be known short length of cyclic prefix gives inter symbol interference on the other hand increasing length cyclic prefix increase the power loss. Thus choosing length of CP is tradeoff between power loss and time dispersion. The disadvantages of cyclic prefix are that it does not carry new data which lowers the transmitted energy per information.

Assume f_i, f_j are two ADAPTIVE- OFDM sub-carriers and ϕ_{ij} is the phase shift associated with the cyclic prefix and multi-path channel

$$\int_0^{T_S} sin(2\pi f_i t)\sin(2\pi f_j t + \varphi_{ij})\,dt$$

$$= \int_0^{T_S} sin(2\pi f_i t)[\ sin(2\pi f_i t)\cos(\varphi_{ij}) + \cos(2\pi f_j t)\sin(\varphi_{ij})]dt$$

$$= \cos(\varphi_{ij}) \int_0^{T_S} sin(2\pi f_i t) sin(2\pi f_j t)\, dt + \sin(\varphi_{ij}) \int_0^{T_S} sin(2\pi f_i t) \cos(2\pi f_j t)\, dt$$

$$\int_0^{T_S} sin(2\pi f_i t) \sin(2\pi f_j t + \varphi_{ij})\, dt = 0$$

*Cyclic Prefix eliminates **Inter-carrier Interference (ICI)***

Assume an ADAPTIVE- OFDM sub-carrier f_i, and ϕ_{ii} is the phase shift associated with the cyclic prefix and multi-path channel

$$\int_0^{T_S} \sin(2\pi f_i t) \sin(2\pi f_i t + \varphi_{ii})\, dt = \int_0^{T_s} \sin(2\pi f_i t) [\sin(2\pi f_i t) \cos(\varphi_{ii}) + \cos(2\pi f_i t) \sin(\varphi_{ii})] dt$$

$$= \cos(\varphi_{ii}) \int_0^{T_s} sin^2(2\pi f_i t) \mathrm{dt} + \sin(\varphi_{ii}) \int_0^{T_S} \sin(2\pi f_i t) \cos(2\pi f_i t)\, dt$$

$$\int_0^{T_S} \sin(2\pi f_i t) \sin(2\pi f_i t + \varphi_{ii})\, dt = \cos(\varphi_{ii}) \int_0^{T_S} sin^2(2\pi f_i t) \mathrm{dt} + 0 = \cos(\varphi_{\mathrm{ii}})$$

With Cyclic Prefix remains the component $\cos(\varphi_{ii})$ *as a source of **Intra-Carrier Interference***

Channel Estimation

Channel Estimation in ADAPTIVE- OFDM is mainly divided into two categories namely blind and non-blind categories. In which blind channel estimation used to statistical behavior of received signal and requires large amount of data on the other hand in non blind channel estimation some portion of transmitted signal are available to the receiver which is to be used for channel estimation.

The Channel block gives channel estimation $H(n)$. the receiver signal can be given as

$$Y(n) = X(n)H(n) + E(n) \qquad For\ \ n = 1,2, \dots \dots \dots \dots ., N$$

Where $E(n)$ zero mean noise dependent on time and frequency

$\widehat{H}$ (n)=$\frac{\alpha(L,n)}{\beta(L,n)}$ $\qquad n = 1 \dots 127$

Where

$$\alpha(L, n) = \lambda X_P(L, n)Y_P(L, n) + (1 - \lambda)\alpha(L - 1, n)$$

$$\beta(n, L) = \lambda X_P(L, n)X_P(L, n) + (1 - \lambda)\beta(L - 1, n)$$

And where

$X_P(L, n)$ - Transmitted pilot, $Y_P(L, n)$ - Received pilot, λ- Forgetting factor, L – Index of current pilot frame, n- Sub channel index

∴ $X(L, n)$ is transmitted symbol of $l^{th} pilot$ of $n^{th} subchannel$

The estimated transmitted signal can be given as

$\hat{X}$ =$\frac{Y(n)}{\widehat{H}\ (n)}$

The power spectrum of white Gaussian noise is added in channel

∴ $E_e(n) = Y_0(n) - \widehat{H}\ (n)X_0(n)$ $\qquad$ Here $X_0(n) = 0$

So the Variance of N sample of noise is given as

σ_N^2 = $\frac{1}{N}\sum_{n=0}^{N-1} Y_0(n)^2$

IFFT

Inverse FFT is the key component of the ADAPTIVE- OFDM System at transmitter and FFT at receiver. For linear mapping between N complex data symbol and N complex ADAPTIVE- OFDM symbols inverse FFT and FFT used which results into robustness against fading multiple channel.

Let X(1),X(2),……………..,X(N) is the data set to be transmitted

Where, N- Total number of sub carriers

Then after IFFT discrete time representation of signal is

$x(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(K).e^{j2\pi k\frac{n}{N}}$ n=0……….N-1

By performing FFT on received signal data is recovered at receiver side

$Y(k) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x(n)e^{-j2\pi k\frac{n}{N}}$ k=0…………………….N-1

Signal Generation

In ADAPTIVE- OFDM inverse FFT is used to transfer data in time domain and that data transform back to frequency domain using FFT at receiver.

Suppose

$U(-N/_2), U(-N/_{2+1}), \dots \dots \dots \dots \dots \dots . U(N/_{2-1})$ is the data set which is to be transmitted

Where N is total no of subcarriers

Then the discrete time representation of signal after IFFT is

$$U(N) = \frac{1}{\sqrt{N}} \sum_{k=N/_2}^{N/_{2-1}} U(k)e^{j2\pi\frac{k}{N}n}$$

Where $n \in [-N/_2, N/_2)$.

By performing FFT on received signal data is recovered at receiver side is

$U(N) = \frac{1}{\sqrt{N}} \sum_{u=-N/_2}^{N/_{2-1}} u(n)e^{j2\pi\frac{n}{N}k}$ Where $k \in [-N/_2, N/_2)$.

QPSK

4-array PSK signal is nothing but the Quadrature Phase Shit Keying. The phase of carrier in QPSK takes $0, \frac{\pi}{2}, \pi, 3\pi/_2$ space shift. The QPSK transmitted signal defined by

$$S_1(t) = \sqrt{2E/_T} \cos[(2i-1)\,\pi/_4]\, cosw_ct - \sqrt{2E/_T} \sin[(2i-1)\,\pi/_4]\, sinw_ct$$

$= \sqrt{E}cos\cos[(2i-1)\,{}^{\pi}/_{4}]\,cosw_ct\; - \sqrt{{}^{2}/_{T}}\sin[(2i-1)\,{}^{\pi}/_{4}]\sqrt{{}^{2}/_{T}}\,sinw_ct$

$= S_{i1}\emptyset_1(t) + S_{i2}\emptyset_2(t)$ Where i=1, 2, 3, 4

Modulated Wave of QPSK can be expressed as

$$S(t) = \sqrt{{}^{2E}/_{T}}\; d_{even}(t)sinw_ct - \left\{d_{odd}(t)\sqrt{{}^{2E}/_{T}}\right\}\, cosw_ct + \left\{d_{even}(t)\sqrt{{}^{2E}/_{T}}\right\} sinw_ct$$

The Bandwidth of efficiency of QPSK is double of PSK thus we transmitted 2 bits per signal.

$$P_e = {}^{1}/_{2}\, erfc(\sqrt{{}^{E_b}/_{N_0}})$$

Where P_e is the average probability of bit error of QPSK signal

QAM

The modulation scheme in which modulation is carried out by modulating the amplitude of two carrier wave is quadrature amplitude modulation (QAM).The carrier wave is out of phase by 90°. The first stage in the modulation block needs to be a serial to parallel conversion to change the bit stream into log_2M streams where M Is number of symbols.

Spectrum Sensing:

Spectrum Sensing is an essential component of the CR technology. Spectrum sensing involves, finding spectrum holes and after that when an identified spectrum hole is being used by the secondary users, to rapidly detect the onset of primary transmission. This needs to be done such that the guaranteed interference levels to the primary are maintained and there is efficient use of spectrum by the secondary. This involves detecting primary user signals possibly weak, reliably, rapidly and randomly.

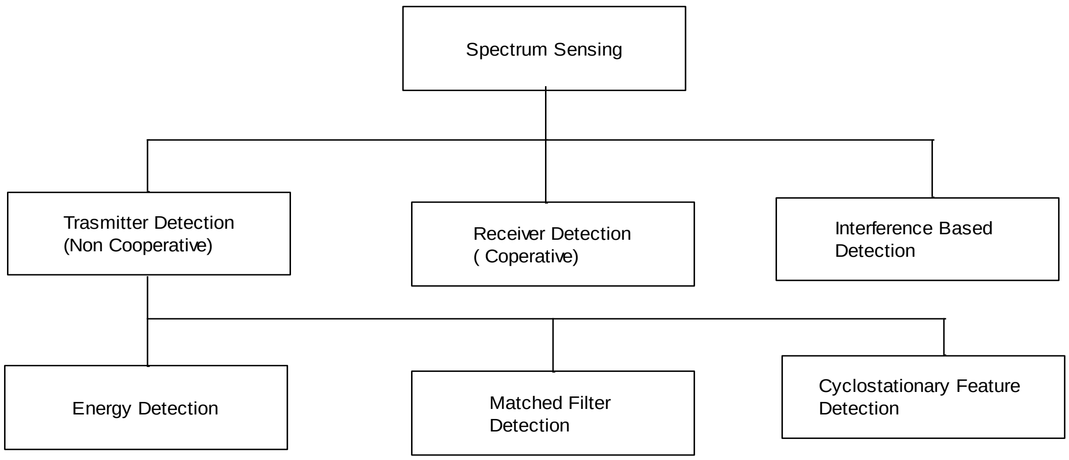


Figure 2 .Spectrum Detection Techniques [10]

Energy Detection:

It is method that detection of the primary signal basis on the sensed energy [11]., energy detection (ED) is the most popular sensing technique in cooperative sensing because of its simplicity and no requirement on a priori knowledge of primary user signal.

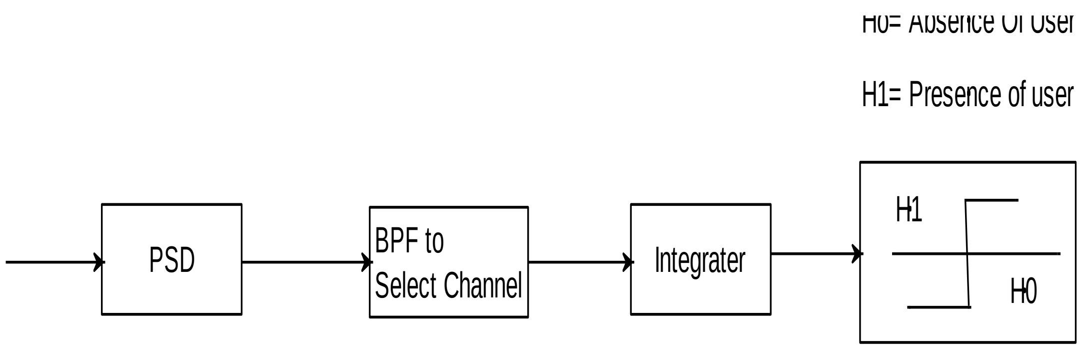


Figure 3: Energy detector block diagram [11]

The block diagram for the energy detection technique is shown in the Figure 3. In this energy detection method, through band pass filter of the bandwidth W signal is passed and that signal integrated over time interval. With the predefined threshold the output from the integrator block is then compared. By using this comparison we discover the existence of absence of the primary user. On the basis of the channel conditions the threshold value can set to be variable or fixed.

ED ignores the structure of the signal that's why it is said to be the Blind signal detector. By comparing the energy received with a known threshold derived from the statistics of the noise

ED estimates the presence of signal. Analytically, signal detection can be reduced to a simple identification problem, formalized as a hypothesis test,

$y(k) = (k) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. H_0$

$y(k) = h * \ s(k) + n(k) \ldots\ldots\ldots.. H_1$, Where y (k) is the sample to be analyzed at each instant k and n (k) is the noise of variance σ^2.

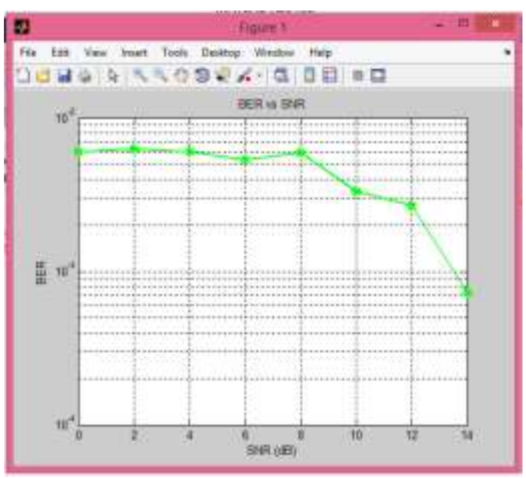
Let y (k) be a sequence of received samples k ∈ {1, 2….N} at the signal detector, then a decision rule can be stated as,

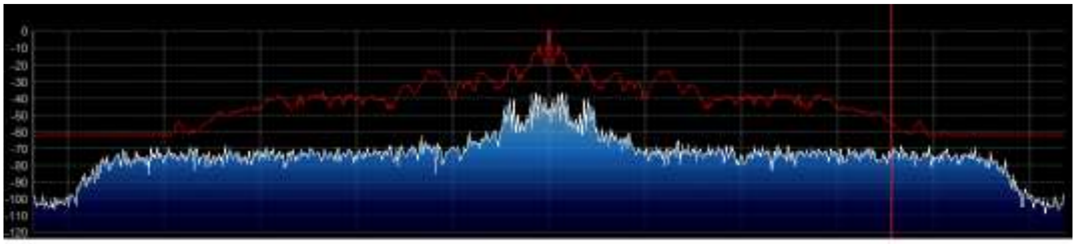
$H_0 \ldots\ldots\ldots.. if\ \varepsilon < \ v$

$H_1 \ldots\ldots\ldots.. if\ \varepsilon\ > v$

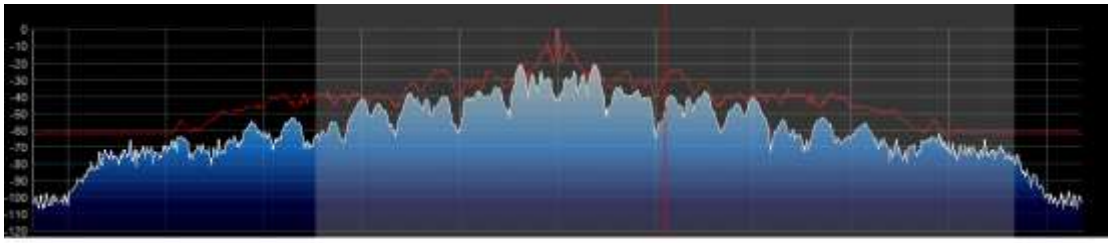
Disadvantages of ED method is i) to achieve a given probability of detection sensing time taken may be high. ii) Detection performance is subject to the uncertainty of noise power. iii) To distinguish primary signals from the CR user signals ED cannot be used. iv)To detect spread spectrum signals ED cannot be used [12].

Simulation Result:

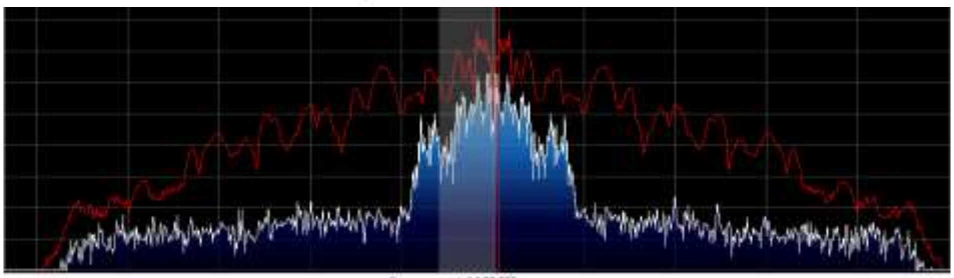




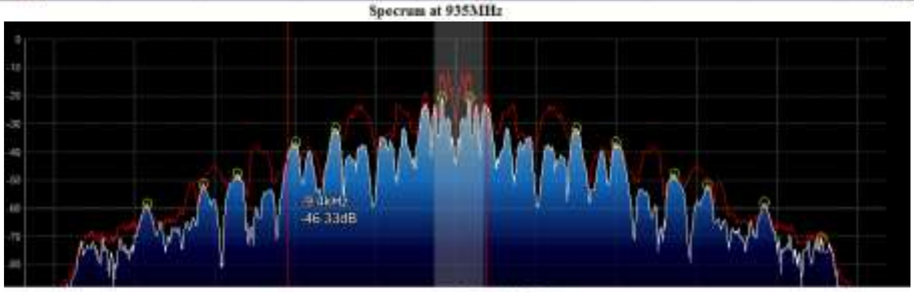
Spectrum at 930 MHz



Spectrum at 940 MHz



Specrum at 935MHz



Example Plot

Conclusion: In this paper we have explain how transmission placed on ADAPTIVE- OFDM. The major advantage of ADAPTIVE- OFDM is that it can handle multipath transmission. The purpose of this paper is to select algorithm by which the spectral efficiency of ADAPTIVE- OFDM increases. By using wavelet transform ADAPTIVE- OFDM system gives better spectrum efficiency. Addition of cyclic prefix to remove ISI and ICI is the main disadvantage of conventional FFT based ADAPTIVE- OFDM system. The BER is reduced when signal to noise ratio increased and when signal to noise ratio is low then it does not have any impact on the BER.

With using QAM in FFT based ADAPTIVE- OFDM system has better BER performance than the other systems. The Various channel estimation techniques is also discuss in this paper.

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