Analysis of OFDM System Under Different Weather Condition

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***Abstract* — An extensive demonstration of OFDM system has been presented in this paper. The proposed system is tested under Rayleigh, Rician fading channels for different weather condition. It is seen from the simulation results that the OFDM system provides good reduced bit error rate, when measured. We have studied different weather condition and analyse bit error rate with respect to signal to noise ratio for fading channels. This project presents channel measurements and weather data collection experiments conducted in a different weather for an innovative OFDM technology, proposed for rural areas. Moreover, the correlation between the relative received power and weather variables are presented.**

Keyword- Orthogonal Frequency Division Multiplexing (OFDM), , Fading Channels (Rayleigh, Rician). Broadband Wireless Access (BWA).

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM), which is one of multi-carrier modulation (MCM) techniques, provides a considerable high multipath delay spread tolerance, spectral efficiency, immunity to the frequency selective fading channels and power efficiency [1]. OFDM has been chosen for high data rate communications and has been widely deployed in many wireless communication standards such as Digital Video Broadcasting (DVB) and mobile worldwide interoperability for microwave access (mobile WiMAX) based on OFDM access technology [2]. It is one of the promising BWA techniques being used today.

In OFDM, parallel narrow-band sub-carriers are used for long distance transmission. In OFDM, serial-to-parallel transmitter converts the incoming high data stream into low-data stream, and then transmits each low data stream over an infrequent orthogonal carrier. The data rate of each transmitted stream is effectively reduced by a factor of N from the original data rate. By utilizing this strategy, OFDM drastically reduces inter symbol interference (ISI) by avoiding multipath in frequency-selective channels.

Usually, there are some basic requirements of any communication system- high bandwidth, proper modulation and demodulation techniques, and channels. A major problem in wireless communication system is multipath fading in channels. Basically, the fading means the transmitted signal is collide with number of obstacles, and result multiple parts of the signal reaches to receiver. The multipath fading creates number of problems in OFDM, but the major problem is BER.

Let, $\{s_{n,k}\}$ with $E|s_{n,k}|^2=\sigma_s^2$ be the complex symbols to be transmitted at the N^{th} OFDM block. The OFDM modulated signal can be represented by equation (1).

$$s_n(t) = \sum_{k=0}^{N-1} s_{n,k} e^{j2\pi k \Delta f t} \quad 0 \leq t \leq Ts \qquad (1)$$

Here, Ts is the symbol duration, Δf is sub channel space, and N is the number of sub channels of OFDM.

At receiving end, to demodulate the OFDM signal the symbol duration should be enough such that $Ts*\Delta f=1$. It is also known as orthogonal condition. Since, it makes $e^{-j2\pi k \Delta f t}$ orthogonal to each other for different value of k. Under orthogonal condition, the transmitted symbols $\{s_{n,k}\}$ can be detected at the receiver by equation (2).

$$s_{n,k}= \frac{1}{Ts}\int_0^{Ts} s_n(t) e^{-j2\pi k \Delta f t} \qquad (2)$$

In this paper, we are analyzing bit error rate for various fading channels (Rayleigh, Rician) using simulation tool as MATLAB.

II. FADING CHANNELS

The presence of reflectors in the environment surrounding a transmitter and receiver create multiple paths that a transmitted signal can traverse. As a result, the receiver sees the superposition of multiple copies of the transmitted signal, each traversing a different path. Each signal copy will experience differences in attenuation, delay and phase shift while travelling from the source to the receiver. This can result in either constructive or destructive interference, amplifying or attenuating the signal power seen at the receiver. Strong destructive interference is frequently referred to as a deep fade and may result in temporary failure of communication due to a severe drop in the channel signal-to-noise ratio

A. Rayleigh channel

In a wireless system, the waves of multipath signals are out of phase or in phase so that signal experience to constructive interference and destructive interference which causes reduction in signal strength. Each signal may experience multipath fading and shadowing. In Rayleigh channel fading signals require investigation of the nature of the signals contributing to the interference. Rayleigh fading model is a statistical model for the effect of propagation environment on a radio signal that is used by the wireless devices [11]. Rayleigh fading channel designed for urban environment where no line of sight exists between the transmitter and receiver. As there is often movement of the transmitter or the receiver this causes change in path length and varies signal level. In the case, if an object possesses reflection or refraction in signal then it results to variation. This occurs because some of the path lengths will change and in turn this will mean their relative phases will change. On statistical basis Rayleigh fading model is being used to determine radio signal propagation. It operates best under conditions when there is no dominant signal.

If X_1 and X_2 are two Gaussian random variables each distributed according to N $(0,\sigma^2)$, then

$$X = \sqrt{X_1^{\,2} + X_2^{\,2}} \qquad (3)$$

a Rayleigh random variable. We can say that the Rayleigh random variable is the square root of an exponential random variable. Thus, the PDF of a Rayleigh random variable is

$$p(x) = \begin{cases} \frac{x}{\sigma^2} e^{\frac{-x^2}{2\sigma^2}} & x > 0 \\ 0 & otherwise \end{cases} \qquad (4)$$

and its mean and variance are

$$E[X] = \sigma\sqrt{\frac{\pi}{2}} \qquad (5)$$

$$VAR[X] = (2-\frac{\pi}{2})\sigma^2 \qquad (6)$$

B. Rician channel

There is a direct line of sight between the transmitter and receiver in this channel. In rural environments where the multipath includes a few reflected paths combined with a strong line of sight path, then it follows the Rician distribution. In microcellular propagation Rician model is more appropriate. In Rician model, the signal is the phasor sum of two or more dominant signals, e.g. line of sight and ground reflection. These signals mostly treated as deterministic signals. The combination of dominant signals also experiences shadow attenuation.

If X_1 and X_2 are two Gaussian random variables each distributed according to N (m_1, σ^2) and N (m_2, σ^2) i.e., the variances are equal and the means may be different , then

$$X = \sqrt{X_1^{\,2} + X_2^{\,2}} \qquad (7)$$

Thus, the PDF of Rician random variable is,

$$p(x) = \begin{cases} \frac{x}{\sigma^2} I_0(\frac{sx}{\sigma^2}) e^{\frac{-x^2+s^2}{2\sigma^2}} & x > 0 \\ 0 & otherwise \end{cases} \qquad (8)$$

Where, s = $\sqrt{m_1^{\,2} + m_2^{\,2}}$ and I_0(x) is the Bessel function of the order 0. It is readily seen that for s = 0, the Rician random variable reduces to a Rayleigh random variable. The Rice factor K as

$$K = \frac{s^2}{2\sigma^2} \qquad (9)$$

III. SIMULATION ENVIRONMENT AND PERFORMANCE METRICS

A. *System Model*

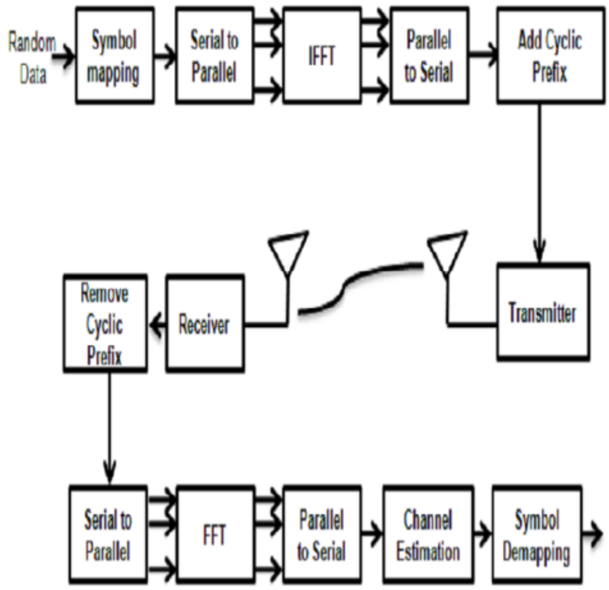

Figure1..Schematic block diagram of OFDM System

B. Model description

IFFT function is to transform a spectrum into a time domain signal, it convert complex data point of length that is power of 2, into the time domain signal. It is not necessary that number of subcarrier and IFFT bin size should be equal and inverse operation is performed by FFT. Cyclic Prefix is used to avoid inter symbol interference (ISI) which is one of the major drawback in multicarrier transmission. In preamble of data we use guard period to avoid the inter symbol interference.

C. Simulation Parameter

BER performance calculated on the basis of different parameter.

Number of Subcarriers	64
FFT Length	64
Number of symbol	10^3
Channel	Rayleigh, Rician
Modulation technique	BPSK

Table I. OFDM specification

IV. RESULT AND ANALYSIS

In this section, MATLAB 8.1 investigates bit error performance under Rayleigh, Ricianl fading channel for different weather condition. The use of fading channel is to improve the performance of system, as the demand of data rate is increasing, system become more sensitive to errors. The work of modulation technique is to transfer the stream of bits over the channel.

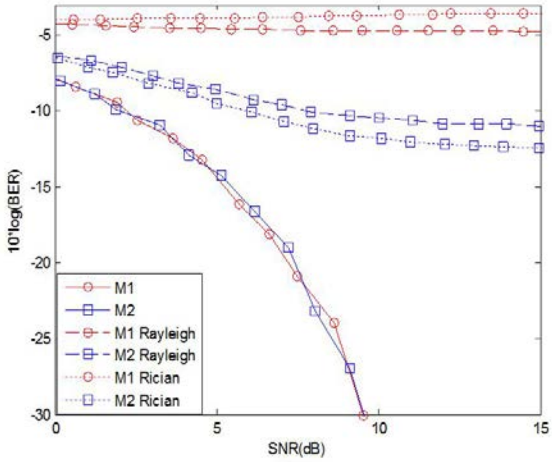

Figure.2. Simulation of fading channels

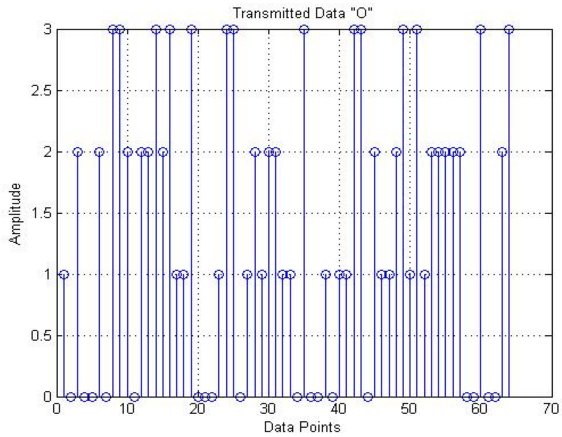

Figure.3. Simulation at different data points

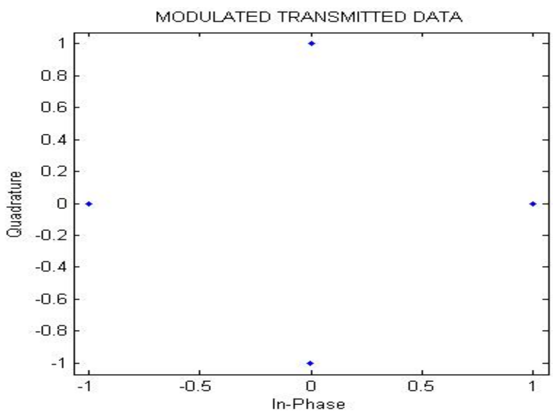

Figure.4. Simulation at different phase

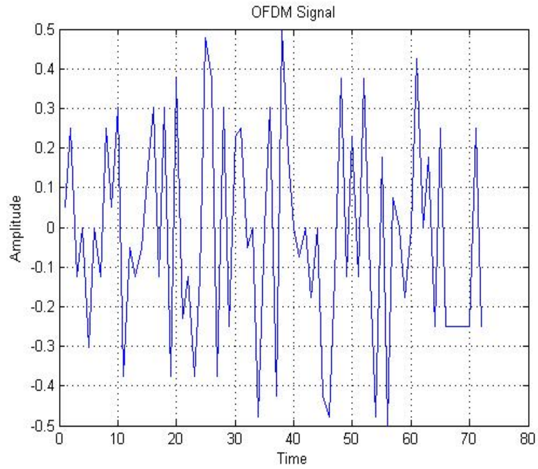

Figure.5. Simulation of OFDM signal

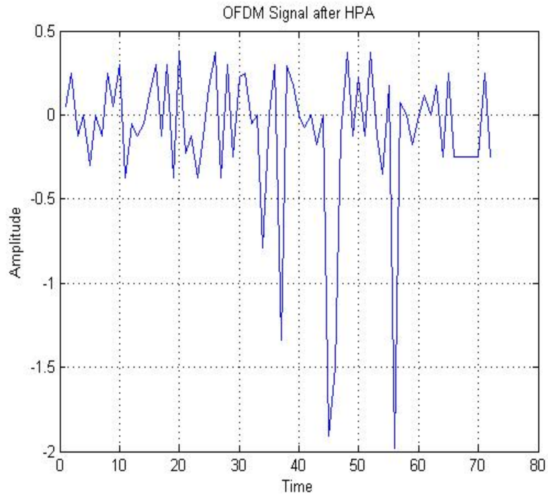

Figure.6. Simulation of OFDM signal after HPA

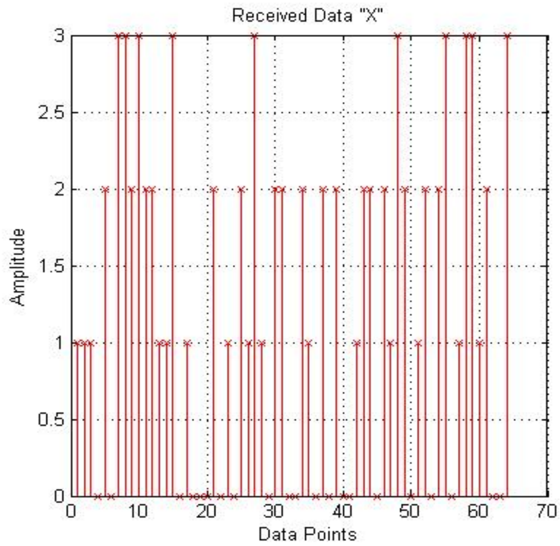

Figure.7. Simulation at Receiver

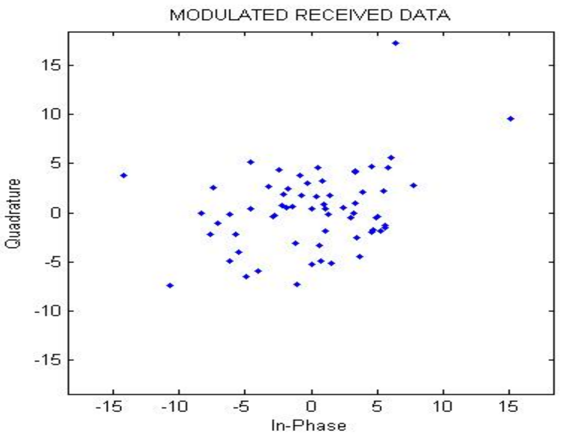

Figure.8. Simulation of modulated received data

VI. CONCLUSION

According to the relative received signal, OFDM uplink channels experience temporal fading. Moreover, the correlation between the relative received power and weather variables are presented. Results show that all weather variables exhibit a negative average correlation with received power. Wind speed records the highest average negative correlation coefficient of -0.35. Local maxima of negative correlation, ranging from 0.49 to 0.78, between the weather variables and relative received signals were registered between 5- 6 a.m. The highest measured correlation (-0.78) of this time of the day was exhibited by wind speed. These results show greater time variation which experienced by OFDM channels deployed in different weather.

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