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Performance Analysis Of Ofdm System Using Dpsk Modulation Technique With Different Multipath Fading Channels

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Abstract

As we know that high data rate is necessity of the modern technology. One of the modern modulation technique called OFDM (orthogonal frequency division multiplexing) can fulfill the requirement because of its advancement and multicarrier with orthogonality. we get the better results compare to other modulation techniques. Here, In this paper we discuss the performance analysis of the OFDM system with multipath fading channel like Rayleigh and we will use the AWGN channel as a reference channel. We will use the DPSK(Differential Phase Shift Keying) modulation technique for the implementation of the OFDM system and also comparative analysis.

Index Terms: *AWGN(Additive White Gaussian Noise), BER(Bit Error Rate), Fast Fourier Transform (FFT), Inverse Fast Fourier Transform (IFFT), OFDM(Orthogonal Frequency Division Multiplexing), SNR(Signal to Noise Ratio) DPSK(Differential Phase Shift Keying)*

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1. INTRODUCTION

OFDM is a multicarrier digital modulation technique in which large number of sub carrier orthogonal to each other and all are closely spaced. Because of this it is called multicarrier modulation method. The total Band Width of the channel is divided into a number of the sub part and this all sub parts are modulated with the subcarriers which are orthogonal to each other. In first section we will discuss the basic of OFDM system with the Tx and Rx block diagram. The main application of the OFDM is in the wireless communication field. As we know that there are many types of the fading channels available in the wireless environment. One of them is the Rayleigh fading channel which is called a multipath fading channel. Due to multiple path of the analog signal a fading is occur and due to fading we got the noise in at the receiver. Here we use the Rayleigh fading channel which is also one of the multipath fading channel and due to multiple object in the environment we got the reflection in the signal and due to this the signal comes to receiver by the multiple path. In the case of no line of site we can apply the Rayleigh fading channel for the analysis. We will use the AWGN channel as a reference channel for the performance

analysis of the OFDM system. AWGN channel is the Additive White Gaussian Noise channel which is statically independent Gaussian Noise samples which can corrupt the data samples. For the AWGN we will examine the performance of the OFDM system and will compare the results of the BER and SNR for the Rayleigh Fading channel.

In first section we have seen the introduction of the overall system , In section II we see the brief introduction of the OFDM system, in section III we see the brief introduction of the AWGN and Rayleigh channel and finally in section IV we will discuss the simulation results of the system.

1.1 OFDM TRANSMITTER[1]

In practice, OFDM systems are implemented using a combination of Fast Fourier Transform (FFT) and inverse fast Fourier Transform (IFFT) blocks that are mathematically equivalent versions of the DFT and IDFT, respectively, but more efficient to implement. An OFDM system treats the source symbols (e.g., the QPSK or QAM symbols that would be present in a single carrier system) at the transmitter as though they are in the frequency-domain. These symbols are used as the inputs to an IFFT block that brings the signal into the time domain. The IFFT takes in N symbols at a time where N is the number of subcarriers in the system. Each of these N input symbols has a symbol period of T seconds. Recall that the basis functions for an IFFT are N orthogonal sinusoids. These sinusoids each have a different frequency and the lowest frequency is DC. Each input symbol acts like a complex weight for the corresponding sinusoidal basis function. Since the input symbols are complex, the value of the symbol determines both the amplitude and phase of the sinusoid for that subcarrier. The IFFT output is the summation of all N sinusoids. Thus, the IFFT block provides a simple way to modulate data onto N orthogonal subcarriers. The block of N output samples from the IFFT make up a single OFDM symbol. The length of the OFDM symbol is NT where T is the IFFT input symbol period mentioned above.

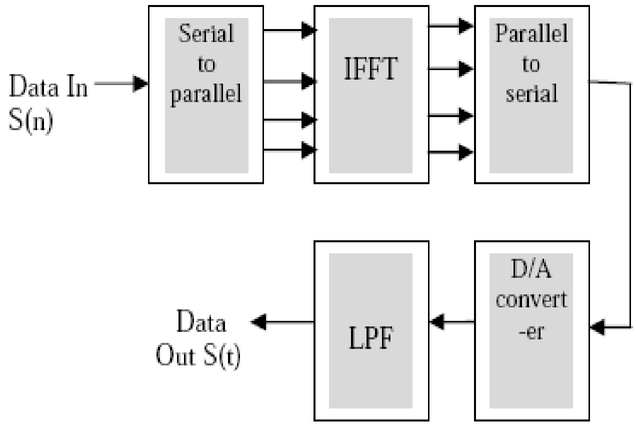

Fig-1: Block Diagram of OFDM Transmitter[2]

After some additional processing, the time-domain signal that results from the IFFT is transmitted across the channel.

1.2. OFDM Rx[1]

At the receiver, an FFT block is used to process the received signal and bring it into the frequency domain. Ideally, the FFT output will be the original symbols that were sent to the IFFT at the transmitter. When plotted in the complex plane, the FFT output samples will form a constellation, such as 16-QAM.

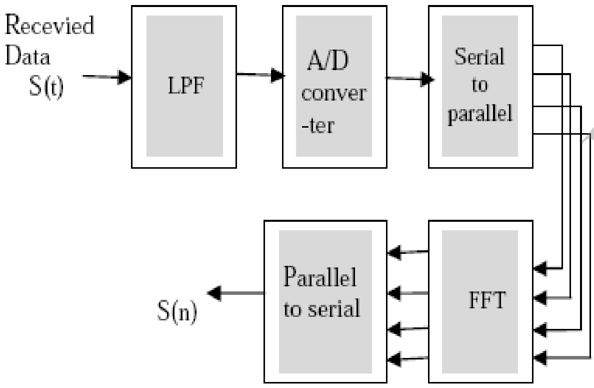

Fig-2: Block Diagram of OFDM Receiver[2]

However, there is no notion of a constellation for the time-domain signal. When plotted on the complex plane, the time-domain signal forms a scatter plot with no regular shape. Thus, any receiver processing that uses the concept of a constellation (such as symbol slicing) must occur in the frequency- domain.

2. FADING CHANNELS[3]

Wireless communication utilizes modulation of electromagnetic (radio) waves with a carrier frequency varying from a few hundred megahertz to several gigahertz depending on the system. Therefore, the behavior of the wireless channel is a function of the radio propagation effects of the environment. In such an environment the following may happen.

1. Multiple delayed receptions of the transmitted signals due to the reflections of buildings, hills, cars and other obstacles, etc.
2. Sometimes even a line-of-sight path is not possible.
3. Each path has a different attenuation, time delay, phase shift.
4. Due to the relative phase shifts, the signals from different paths add constructively sometimes or cancel each other resulting in a weak signal other times.

A. INTRODUCTION OF RAYLIEGH AND AWGN CHANNEL

The received signal is modelled as bandwidth at which frequency selectivity becomes relevant.

$$r(t)=\alpha(t)s(t)+\eta(t)\,; \qquad (1)$$

Where,

$$\alpha(t)=x(t)+jy(t)=a(t)e^{j\varphi(t)}\,; \qquad (2)$$

is a zero-mean complex Gaussian. Denoting x and y as samples taken from x(t) and y(t) where $x \sim \aleph\left(o,\sigma^2\right)$ and $y \sim \aleph\left(o,\sigma^2\right)$. Then α is described by a zero mean complex Gaussian random variable

$$f_{x,y}(x,y)=\frac{1}{2\pi\sigma^2}\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right); \qquad (3)$$

Fading envelop (amplitude), $a=\sqrt{x^2+y^2}$, Fading phase, $\phi=\arctan\left(\frac{y}{x}\right)$.Let $x=a\cos\phi$ and $y=a\sin\phi$.

Using transformation formula between random variable pairs (x,y) and (a,ϕ).

$$f_{a,\phi}(a,\phi)=\left|J(a,\phi)\right|\times f_{x,y}(x,y)\Big|_{x=a\cos\phi}\Big|_{y=a\sin\phi}\,; \qquad (4)$$

Where, $J(.)$: Jacobean of the transformation.

$$J(a,\phi)=\begin{pmatrix}\frac{\delta x}{\delta a} & \frac{\delta x}{\delta\phi}\\ \frac{\delta y}{\delta a} & \frac{\delta y}{\delta\phi}\end{pmatrix}=\begin{pmatrix}\cos\phi & -a\cos\phi\\ \sin\phi & a\cos\phi\end{pmatrix}=a; \qquad (5)$$

From the above Rayleigh distribution maybe given as

$$f_a(a) = \int_0^{2\pi} f_{a,\phi}(a,\phi)d\phi = \frac{a}{\sigma^2}\exp\left(-\frac{a^2}{2\sigma^2}\right) \quad (6)$$

This is known as Rayleigh fading and is typically encountered in land mobile channels in urban areas where are many obstacles which make line-of-sight paths rare. For a Rayleigh distributed random variable, the average power is

$$\Omega = E\left[a^2\right] = 2\sigma^2 \quad (7)$$

$$f_a(a) = \frac{2a}{\Omega}\exp\left(-\frac{a^2}{\Omega}\right) \quad (8)$$

For normalized average power, $\Omega = 1$

$$f_a(a) = \frac{2a}{\Omega}\exp\left(-a^2\right) \quad (9)$$

Multipath channel modeling represented by Rayleigh fading represents the condition in an environment full of high-rise structures and other similar obstructions. The Rayleigh multipath fading in channels has been simulated using the Clarke-Gans model assuming mobility of a receiver handset. The fading thus created is similar to a Rayleigh distribution.

Additive white Gaussian noise[4][7] (**AWGN**) is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple and tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered.

Wideband Gaussian noise comes from many natural sources, such as the thermal vibrations of atoms in conductors (referred to as thermal noise or Johnson-Nyquist noise), shot noise, black body radiation from the earth and other warm objects, and from celestial sources such as the Sun.

The AWGN channel is represented by a series of outputs Y_i at discrete time event index i. Y_i is the sum of the input X_i and noise, Z_i, where Z_i is independent and identically-distributed and drawn from a zero-mean normal distribution with variance n (the noise). The Z_i are further assumed to not be correlated with the X_i.

3. DPSK

DPSK(Differential Phase Shift Keying)[6], one of the digital modulation technique which is not require any type of estimation of carrier signal. To understand this lets take one example, suppose we need to demodulate the encoded signal by multiplying $r(t)$ by $\cos 2\pi f_c t$ and $\sin 2\pi f_c t$ and integrating the two products over the interval T. At the k^{th} signaling interval, the demodulator output is

$$r_k = \left[\sqrt{\varepsilon_s}\cos(\theta_k - \phi) + n_{k1} + \sqrt{\varepsilon_s}\sin(\theta_k - \phi) + n_{k2}\right] \quad (10)$$

Or equivalently,

$$r_k = \sqrt{\varepsilon_s}e^{j(\theta_k - \phi)} + n_k \quad (11)$$

Where, θ_k is the phase angle of the transmitted signal at the k^{th} signaling interval, ϕ is the carrier phase, and $n_k = n_{k1} + jn_{k2}$ is the noise vector. Similarly, the received signal vector at the output of the demodulator in the preceding signaling interval is,

$$r_{k-1} = \sqrt{\varepsilon_s}e^{j(\theta_{k-1} - \phi)} + n_{k-1} \quad (12)$$

The decision variable for the phase detector is the phase difference between these two complex numbers. Equivalently, we can project r_k onto r_{k-1} and use the phase resulting complex number; that is

$$r_k r_{k-1}^* = \varepsilon_s e^{j(\theta_k - \theta_{k-1})} + \sqrt{\varepsilon_s}e^{j(\theta_{k-1} - \phi)}n_{k-1}^* + \sqrt{\varepsilon_s}e^{-j(\theta_k - \phi)}n_k + n_k n_{k-1}^* \quad (13)$$

Which, in the absence of noise, yields the phase difference $\theta_k - \theta_{k-1}$. Thus, the mean value of $r_k r_{k-1}^*$ is independent of the carrier phase differentially encoded PSK signaling that is demodulated and detected as described above is called Differential Phase Shift Keying.

4. SIMULATION RESULTS

A. FOR THE AWGN CHANNEL

Here, The result of the BER Vs SNR for the OFDM system and analyze the result for number of message symbols that we are transmitted.

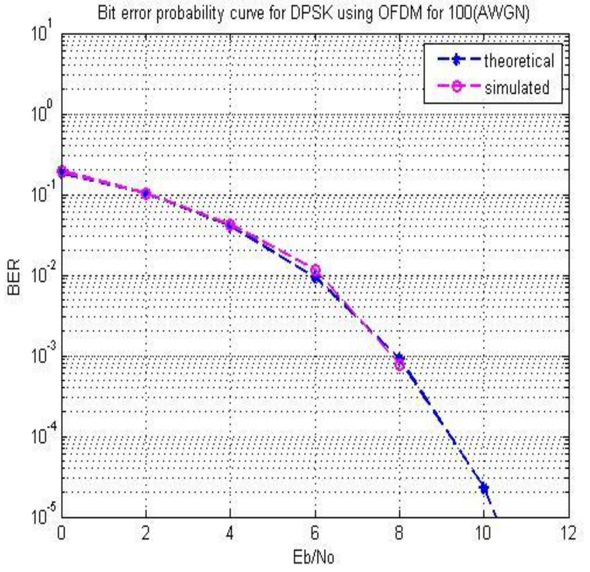

Fig-3: BER Vs SNR for 100 message symbol (AWGN)

When increasing the number of the message symbol we will get the reduced bit error rate for the same channel which is shown in figure 4 and figure 5.

Table-1: Comparison of BER for DPSK using OFDM for 100 Message Symbols (AWGN)

Eb/No(dB)	BER(Theoretical)	BER(Simulated)
0	0.1944	0.1944
2	0.1021	0.1021
4	0.0423	0.0423
6	0.0093	0.0117
8	0.0007	0.0007

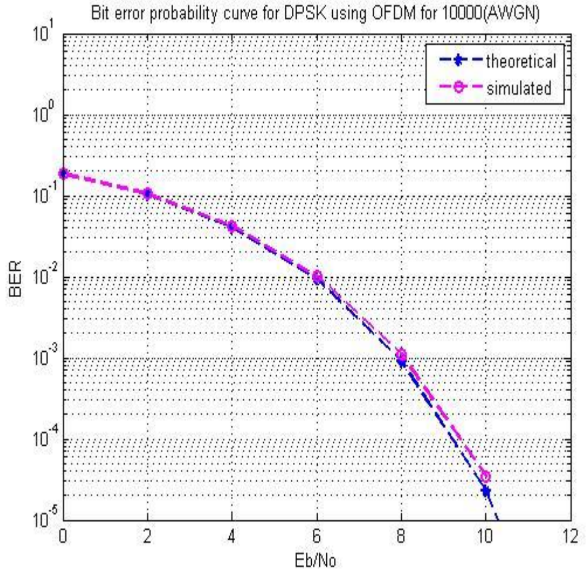

Fig-4: BER Vs SNR for 10000 message symbols. (AWGN)

Table-2: Comparison of BER for DPSK using OFDM for 10000 Message Symbols (AWGN)

Eb/No(dB)	BER(Theoretical)	BER(Simulated)
0	0.1944	0.1944
2	0.1021	0.1021
4	0.0423	0.0423
6	0.0093	0.0101
8	0.0007	0.0011

The comparison of 100 message symbol and 10000 message symbol can be observed from the table no.1 and 2. , The simulated result in 10000 message symbol is much improve compare to 100 message symbol for the AWGN channel.

B. *FOR RAYLIEGH CHANNEL*

The results for the Rayleigh channel that is in a fading environment. As the number of symbols are increased bit error rate is reduced which shown figure 5 and figure 6.

But compare to AWGN channel, in Rayleigh channel bit error rate is more for same SNR because it is in a fading environment.

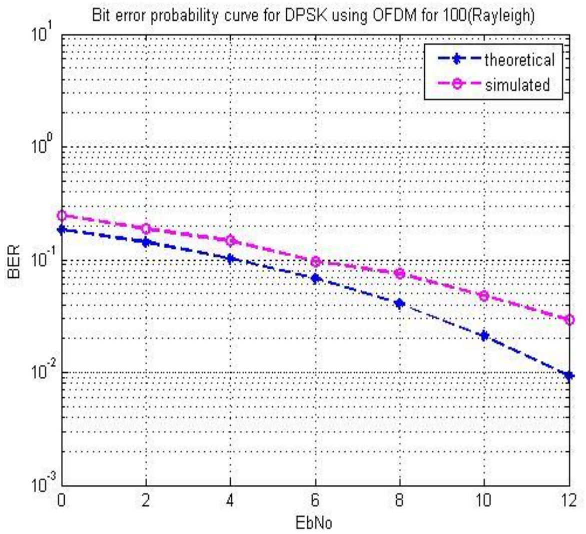

Fig-5: BER Vs SNR for 100 message symbol (Rayleigh)

Table-3: Comparison of BER for DPSK using OFDM for 100 Message Symbols (Rayleigh)

Eb/No(dB)	BER(Theoretical)	BER(Simulated)
0	0.1839	0.2490
2	0.1420	0.1868
4	0.1025	0.1473
6	0.0679	0.0963
8	0.0405	0.0750

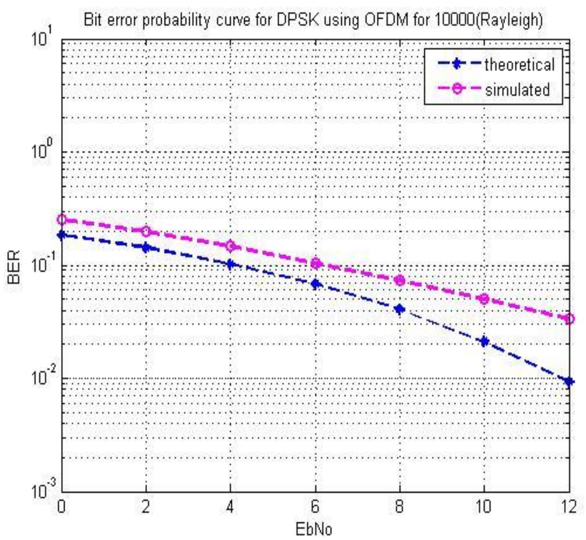

Fig-6: BER Vs SNR for 10000 message symbol (Rayleigh)

Table-4: Comparison of BER for DPSK using OFDM for 10000 Message Symbols (Rayleigh)

Eb/No(dB)	BER(Theoretical)	BER(Simulated)
0	0.1839	0.2530
2	0.1420	0.1962
4	0.1025	0.1461
6	0.0679	0.1039
8	0.0405	0.0729

The comparison of 100 message symbol and 10000 message symbol can be observed from the table no.3 and 4. The simulated result in 10000 message symbol is much improve compare to 100 message symbol for the Rayleigh fading channel.

CONCLUSION

From the above work with the various fading channel for the OFDM system, for the Rayleigh fading channel bit error rate is more for same SNR compare to AWGN channel. Because in Rayleigh channel fading is more compare to any other channel. Also conclude that as the number of message symbols are increased, the bit error rate is reduced. Here, DPSK digital modulation technique for the OFDM system is used. The same method can be apply on BPSK, QPSK digital modulation techniques.

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BIOGRAPHIES

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