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Performance of AWGN and fading channels on wireless communication systems using several techniques

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ABSTRACT

In UWB (ultra-wide band), the receiver is receiving data with high data rate, so that necessary for reducing errors and delimit from BER value to give the best performance of the system with less noise. Therefore, necessary to choose the better channel with better BER performance when building the transceiver in order to produce less noise and high performance. The simulation results show a better performance of AWGN channel than fading channel. When using AWGN channel, the system will be shows a better performance, low bit error rate (BER) and low SNR. In this paper, Analyses the performance of BER based on various wireless communication techniques and some of the digital modulation schemes to compare between AWGN and fading channels. Fading channel divide into Rayleigh and Rician channels.

Keywords – AWGN channel, Fading channel, Rayleigh fading, Rician fading, BFSK, MQAM, DS-CDMA, SFH-CDMA.

1. INTRODUCTION.

UWB signals of a bandwidth-hungry have some advantages such as determine well-scale discovery of geographic locations, many immunities; it has a resistance to narrow the scope of overlap and finally has the transport capacity is low. Synchronize with the development of experienced digital communication systems; it is imperative to ensure efficient transportation services for real-time applications and give users services that are more efficient and have more power. However, to achieved promise using the best technology that known digital encoding techniques, which has many properties including efficient performance, error rate, cost, bandwidth efficiency, energy efficiency, etc. In recent years, the wireless network and mobile communication methods are most widely used in the industry. The wireless communication systems will be obverse the request for increment link reliability, high mobility, higher carrier frequency and data rates in the next generation. The digital communication system performance is regarding the wireless propagation channel characteristics. Therefore, it is necessary to define the performance of the wireless channel [1]. Therefore, to system design and strategic planning through study comparative between different modulation methods, it's necessary making the full analysis of indoor and outdoor propagation channel [2]. In this paper, digital communication system performance has been tested for both modulation schemes that are namely BFSK and MQAM. The data transmission performance is taken up through testing their BER. BER at the receiver is a function of SNR. Several models have been examined to compute SNR in wireless communication use a channel gain and path loss gain in these models. In addition, it has been used a three main frequently from channels such as AWGN, Rayleigh and Rician patterns. This paper has been layout as follows. In section (2) study channel model that qualified the different type of channels AWGN and fading channels (Rayleigh and Rician). While in sections (3 & 4), the study of performance for both channels to known the better performance for each channel. In section (5) qualified simulation Result has been shown. Finally, in section (6) conclusions were qualified.

2. Channel Models.

In this section, it has described the working principle for different channels such as AWGN and FADING channels which is divided in to Rayleigh and Rician as following:

2.1 AWGN Channel.

This is a channel known as an Additive White Gaussian Noise (AWGN), this channel, namely additive due to adding the amount of noise to send signals cannot multiply, Gaussian because noise in this channel will be amount randomly in normal. Therefore, cannot determine the amount of noise. Otherwise, when the rejecting amount of definite noise will get the receiver without any noise, white because of power for every frequency equal [3]. Therefore, at each frequency, the noise level and frequency domain are fixed. In the A channel, the supposition of Gaussian noise is permitted in current causes. The noise is defined through front -end. This noise has energy spectral intensity. The AWGN channel is the perfect pattern for communication satellite. It is not the ideal model for obtained links because of overlap, multitude, covering relief, etc. An AWGN channel can be used for imitation noise and its capacity can express in equation (1)

$$C = \frac{1}{2}\log\left(1+\frac{P}{N}\right) \quad (1)$$

where P $represents\ the\ maximum\ channel\ power.$

2.2

2.3 Fading Channel.

Fading assumed as the attenuation produced by spread media or considered as the perversion in wireless communications. It either is already with reason shadowing from difficulty simulating the wave spread or with reason multipath spread [4]. Also, the Fading already modify with radio frequencies, time, and geographical position. In this paper, two kinds of fading will be studying as following:

a. Rayleigh fading.
b. Rician fading.

a. Rayleigh fading channel.

In civilized passage vehicles, building and other objects, the signal come at the recipient R_X, the sender T_X on different paths. When there are different signal paths among the receiver and transmitter, A Rayleigh constrains the total signal at the recipient and can change the probability intensity Function of Rayleigh fading channel [5] and can be expressed in equation (2)

$$P_R(r) = \frac{r}{\sigma^2}\exp\left(-\frac{r^2}{2\sigma^2}\right) pour\ r \geq 0 \quad (2)$$

where $\sigma^2 = the\ difference\ of\ random\ variable$ and $r = the\ envelope\ amplitude\ of\ RX\ signal$

b. Rician fading channel.

The recipient signal is a mixing of multipath fading and a line of line seeing among a recipient and sender. The LOS (line of sight) path is the portents signal path that leaves immediately from the sender to recipient. The action of Rayleigh fading on the sender signal will be more than in the Rician fading [6].

The probability intensity Function of Rician fading channel can be express in equation (3).

$$P_{R(r)} = \frac{r}{\sigma^2} e^{\frac{-(r^2+s^2)}{\sigma^2}} I_0\left(\frac{rs}{\sigma^2}\right) for\ r \geq 0, s \geq 0 \quad (3)$$

3. Comparative between modulation channel based on digital communication.

In this section, the comparative of BER performance between the fading and AWGN channels based on different types of modulation. As well as known, the fading channel performance of any digital modulation can be express as below [7].

$$P_b = \int_0^{\infty} pb, AWGN(\gamma)\ P_{df}(\gamma)d\gamma \quad (4)$$

where $P_b = bit\ error\ probability$

$P_b, AWGN(\gamma) = probability\ of\ error\ in\ awgn\ channel$

$\gamma = signal - to - noise\ ratio$

$$\gamma = h^2\ \frac{Eb}{No} \quad (5)$$

$h = random\ variable$

$\frac{Eb}{No}$ $is\ the\ ratio\ of\ bit\ energy\ to\ noise\ power\ density\ in\ a\ non-fading\ awgn\ channel$

$h^2 erpresent\ the\ instant\ power\ of\ the\ fading\ channel$

$P_{df}(\gamma) = probability\ density\ of\ \gamma\ of\ fading\ chyannel$

3.1 Binary frequency shifts keying (BFSK) modulator.

BFSK is the type of modulation that used in some application, which needs to non-coherent format and this is useful to prevent of phase reference. As shown in Fig. (1)

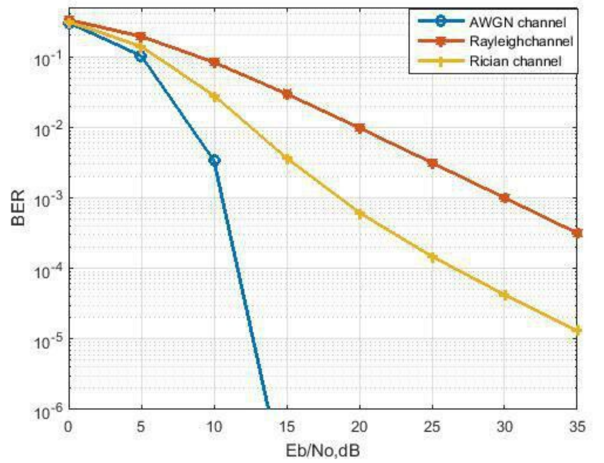

Figure .1. Compare Between AWGN and FADING Channels Based on Channels Performance Using BFSK.

Probability for Rician fading channel in equation (6)

$$P_{b,BFSK(Ric)} = \frac{1+kr}{2+2kr+\bar{\gamma}} \exp\left(\frac{kr\bar{\gamma}}{2+2kr+\bar{\gamma}}\right) \quad (6)$$

where

Kr is the ratio of power between LOS path and NLOS path in channel known Rician fading channel. Probability for AWGN channel in equation (6) as bellow where $k = \infty$

$$P_{b,AWGN} = \frac{1}{2}\exp\left(\frac{-Eb}{2No}\right) \quad (7)$$

Probability for Rayleigh channel in equation (7) at $k = 0$

$$P_{b,BFSK(Ray)} = \frac{1}{2+\bar{\gamma}} \quad (8)$$

3.2 Binary phase shift keying (BPSK) modulator.

In AWGN channel, BER performance for M-PSK can be expressed bellow as in [1].

$$BER_{M-PSK} = \frac{2}{\max(\log_2 M,2)} \sum_{K=1}^{\max\left(\frac{M}{4},1\right)} Q\left(\sqrt{\frac{2E_b \log_2 M}{No}} \sin\frac{(2k-1)\pi}{M}\right) \quad (9)$$

when M=2,

$$BER_{BPSK,AWGN} = \frac{1}{2}\ erfc\left(\sqrt{\frac{Eb}{No}}\right) \quad (10)$$

BER for Rayleigh fading channels can be expressed in (11).

$$BER_{BPSK,Rayleigh} = \frac{1}{2}\left(1 - \sqrt{\frac{\bar{\gamma}}{1+\bar{\gamma}}}\right) \quad (11)$$

$\bar{\gamma} = \frac{Eb}{No}\ E[h^2]$,when $E = [h^2] = 1$

$$BER_{BPSK,Rayleigh} = \frac{1}{2}\left(1 - \sqrt{\frac{\frac{Eb}{No}}{1+\frac{Eb}{No}}}\right) \quad (12)$$

The probability of BER in Rician fading channel can be expressed in (13).

$$P_{b,Rician} = Q1(a,b) - \frac{1}{2}\left[1 + \sqrt{\frac{d}{1+d}}\right]\exp\left(-\frac{a^2+b^2}{2}\right) I_0(ab) \quad (13)$$

where

$$a = \left[\sqrt{\frac{K_r^2[1+2d-2\sqrt{d(d+1)}}{2(d+1)}}\right] \text{ and } b = \left[\sqrt{\frac{K^2{}_r[1+2d+2\sqrt{d(d+1)}}{2(d+1)}}\right]$$

$$Q1(a,b) = \exp\left(\frac{-a^2+b^2}{2}\right)\sum_{l=0}^{\infty} I_{0(ab)} \quad ,b \geq a > 0$$

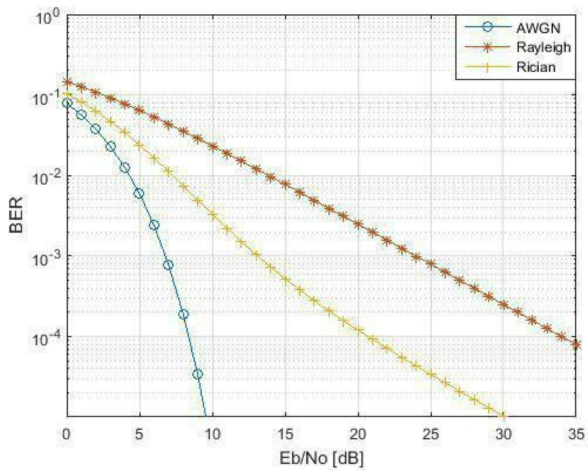

Figure .2. comparison between AWGN and FADING channels based on channels performance using BPSK.

3.3 Quadrature amplitude modulation (MQAM) when M = 4,8,16.

For compute channel's performance of both AWGN channel and FADING channel (Rayleigh fading and Rician fading), dependent on equations (14) and (15).

$$BER_{16QAM,AWGN} \approx \frac{4}{Log_2M}\left(1-\frac{1}{\sqrt{M}}\right)\sum_{i=1}^{\frac{\sqrt{M}}{2}} Q\left(\sqrt{\frac{3Log_2MEb}{(M-1)No}}\right) \quad (14)$$

$$BER_{MQAM,AWGN} \approx \frac{2}{log_2M}\left(1-\frac{1}{\sqrt{M}}\right)\sum_{i=1}^{\frac{\sqrt{M}}{2}}\left(1-\sqrt{\frac{1.5(2i-1)^2\overline{\gamma}}{M-1+1.5(2i-1)^2\overline{\gamma}\ \log_2 M}}\right. \quad (15)$$

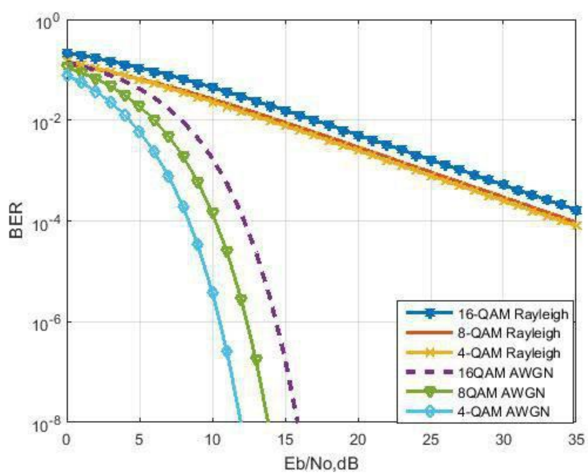

Figure. 3. Comparison between AWGN and FADING channels based on channels performance using MQAM.

4. Comparative between modulation channel based on communication Techniques of Wireless communication.

The most used techniques of wireless communication are known as following:

4.1 SFH – CDMA (slow frequency hopping – code division multiple access)

Over a carrier frequency, all data bit is split that in FH-CDMA. The types of FH-CDMA are slow frequency hopping (SFH) and fast frequency hopping (FFH). The slow frequency hopping needs bandwidth less than fast frequency hopping [8]. Each hope or slot has one or more information symbols in a slow frequency hopping system.

The probability of SFH-CDMA is given by equation (16).

$$P = \frac{1}{q}\left(1 + \frac{1}{N_b}\right) \quad (16)$$

where $N_b = number\ of\ bits\ per\ hop,$

$q = stands\ for\ the\ number\ of\ hops.$

The hit probability given by equation (17)

$$P_h = 1 - (1-p)^{k-1} \quad (17)$$

where $k = total\ number\ of\ active\ users$ and $for\ large\ q,$

$$P_h(k) = 1 - \left(1-\frac{1}{q}\right)^{k-1} \approx \frac{k-1}{q} \quad (18)$$

The Probability of BER for SFH-CDMA use MFSK modulation express in equation (19).

$$P_{SFH}(K) = \sum_{k=1}^{K}\binom{K-1}{k} p_h^k (1-p_h)^{K-1} \quad (19)$$

$where\ K = users\ number$

the probability of BER in FADING and AWGN channels for SFH-CDMA when hitting reference user by all users are active, can express in equation (20)

$$P_{MFSK}(K) = \begin{cases} \sum_{i=1}^{M-1}\frac{(-1)^{i+1}}{i+1}\binom{M-1}{i}\exp\left(-\frac{i\frac{Eb}{No}}{i+1}\right) & AWGN \\ \sum_{i=1}^{M-1}\frac{(-1)^{i+1}}{1+i+i\frac{Eb}{No}}\binom{M-1}{i} & Rayleigh\ fading \end{cases} \quad (20)$$

where P_h is the probability that has many user interfering are transmitting on channel such as reference user has equal frequency – hope.

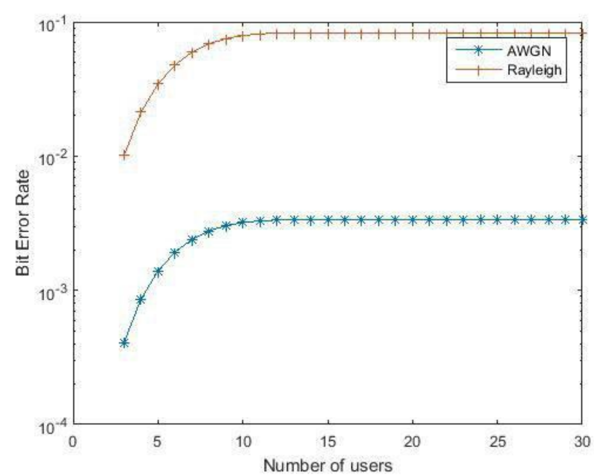

Figure.4. comparison between FADING and AWGN channels based on channels performance using SFH-CDMA.

4.2 Direct sequence – code division multiple access (DS–CDMA)

In the CDMA systems, the wide band of message signal is doubled by signals have high chip rate and have much high bandwidth signals. The signal is spread and called spreading signal with high chip rate. Each user is using the same both of sending simultaneously and carrier frequency that in CDMA. The user could not be known because of pseudo noise or spreading signal will be casual. Assume that used the power control to action the near-far issue that in the CDMA.

P_b (bit error rate) in AWGN channel for DS-CDMA can express in equation (21).

$$P_{b,CDMA(AWGN)} = \varphi\left(\frac{1}{\sqrt{\frac{K-1}{3N}+\frac{No}{2Eb}}}\right) \quad (21)$$

where

$K-1$ *is the undesired users transmitted signals*

$\frac{No}{2Eb}$ = *additive noise*

BER in the Rayleigh fading can be express in equation (22).

$$P_{b,CDMA(Ray)} = \frac{1}{2}\left(1-\frac{1}{\sqrt{1+\frac{No}{2Eb}+\frac{K-1}{3N}}}\right) \quad (22)$$

where

σ^2 *is the variance of Rayleigh fading random variable*

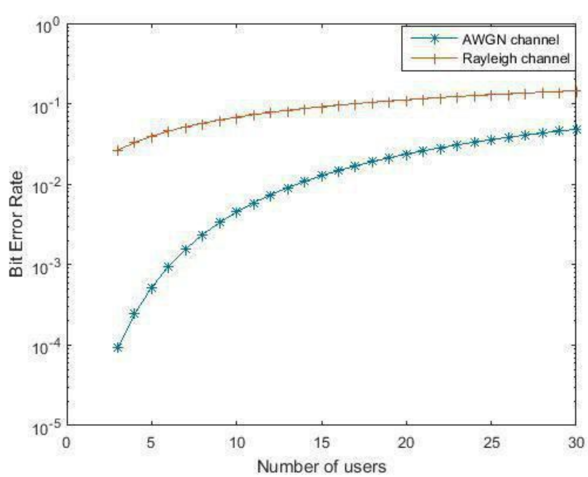

Figure.5. Comparison between FADING channel and AWGN channel based on channels performance using DS-CDMA.

5. Discussion of results.

In this section, the execution of channels performance for both channels AWGN and FADING with the tool used is the MATLAB environment. It was learning of kinds for digital modulation performance in AWGN and FADING channels from these modulation BFSK and MQAM (M=4,8,16). In the Fig. (1), compare between FADING and AWGN channels based on channel performance using BFSK, while Fig. (2), compare between FADING and AWGN channels based on channel performance using BPSK and there is gain value of AWGN channel equal to 8.35 dB and Rician fading channel 20.5 dB and Rayleigh channel 34 dB . While Fig (3) differentiates between FADING and AWGN channel based on channels performance using MQAM (M = 4,8,16). Also, in Figs. (1, 2, & 3) observe the amount of P_b (probability of error in AWGN channel) minimizes exponentially while P_b (probability of mistakes in FADING channel) reduces linearity and the BER decreases for AWGN channel and increases for fading channel (Rayleigh and Rician) that is to say the Rayleigh fading channel has performed less from AWGN and Rician channels. In the wireless communication, figs. (4, & 5) P_b for both channels AWGN and FADING increase and wherever a number of users increment the BER value in SHF-CDMA fixed while in DS-CDMA is changed.

6. CONCLUSION.

In the communication systems, data rate tasks are the increment to warranty implementation favor, goodness that lets the real-time removal of the video. In this paper, the execution of digital communication used kinds of modulation BFSK and MQAM and implementation of wireless communication used DS-CDMA and SFH-CDMA for implementations in both channels are AWGN and FADING (Rayleigh and Rician). Observe from obtaining results; the AWGN channel will be better realization than Rayleigh fading channel because the BER value lower than the BER value of fading use Rayleigh channel while using Rician fading as shown in Fig. (1).Rician fading better realization than AWGN and Rayleigh channels because BER value of Rician channel less than Rayleigh fading and upmost than AWGN channel .

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