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Error Rate Performance of Binary Modulation through Wireless Body Area Networks

Sukhraj Kaur[1], Rachita[2] and Dr. Jyoteesh Malhotra[3]

[1,2,3]*ECE Department, GNDU RC- Jalandhar*

[1]*sukhrajkaur91@gmail.com,* [2]*rachitasharma9 @gmail.com,* [3]*Jyoteesh@gmail.com*

Abstract

In this paper, the performance of one of the very crucial simulation parameter i.e. the carrier frequency have been evaluated for its different values by taking Binary Phase Shift Keying modulation in the WBAN channel model. The power profile for WBAN channel have been generated by using Rayleigh and Weibull distributions. The evaluation is done by calculating the value of Bit error rate for the given values of Signal to noise ratio at different carrier frequencies for BPSK. The graphs have also been plotted between bit error rate and signal to noise ratio.

Keywords: *Wireless Body Area Networks, Bit Error rate, BPSK modulation*

1. Introduction

Wireless Body Area Network (WBAN) has great potential to revolutionize the future of healthcare technology. There are strong demands on introducing body area network (BAN) technology from various parties such as medical and healthcare societies as well as information and communications technology (ICT) industries. There are numerous reasons to adopt WBAN technology as its one of the important feature is it covers the smallest area of human body through the small energy-efficient nodes which forms the sensor networks. The information regarding the patient's health is gathered by sensors placed in or on the body and the collected information is immediately sent to the doctors, physicians to review it.

This gives patients greater mobility and increased comfort by freeing them from the need to be connected to hospital equipments that would otherwise be required to monitor their conditions.

The second important feature of WBAN is its low power consumption as it protect the body tissues while communicating. It may use either conventional source of energy or it is also compatible with body energy scavenge operation. WBAN uses ISM frequency band which is approved band of Regulatory and medical authorities for in or around human body.

To design and develop a competent and reliable system suitable for WBAN, a knowledge of a radio propagation channel as well as a simple and generic channel model are inevitably required.

In this paper, Binary Phase Shift Keying modulation is used as a signaling technique in the channel for various rake receivers i.e. All Rake , Selective rake and Partial rake receivers.

The organization of paper is done as follows:

In the following sections, brief description of the WBAN channel model and about BPSK modulation has been given. In section 3, we have discussed the Simulation methodology. Results and discussions are given in section 4 followed by conclusion in section 5.

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2. WBAN Channel Model

The body area channel is very different from other wireless channels because it contains the Human body interaction. Transmitter and Receiver are the integral part of the body area channel. The static path loss and impulse response models for the wearable and implantable wireless body area network include miniature antennas. According to IEEE 802.15.6 document (Channel Model for Body Area Network), three types of nodes can be there:

1) Implant node: A node that is placed inside the human body. This could be immediately below the skin to further deeper inside the body tissue
2) Body Surface node: A node that is placed on the surface of the human skin or at most 2 centimetres away
3) External node (Gateway Node): A node that is not in contact with human skin (between a few centimetres and up to 5 meters away from the body).
   In this paper, we have worked on Body surface node which corresponds to CM3 channel. [1]The information can be transmitted successfully through a channel with the help of the suitable modulation.

WBAN receiver can take advantage of diversity by using Rake receiver [3] to improve the performance of the system. The basic type of the Rake receiver consists of multiple correlators (fingers) where each of the fingers can detect/extract the signal from the multipath components of the channel. The A-Rake structure used here indicates the receiver with unlimited resources (fingers or correlators) .The S-Rake selects the best 16/32 taps (a subset of the available resolved multipath components) and P-Rake selects the first 16/32 taps (which are not necessarily the best) then combines the selected subset. In this paper, BPSK are implemented with rake receivers i.e. all-rake, Partial rake and Selective rake.

While the bit streams we wish to transmit are inherently discrete time, all physical media are continuous time in nature; hence we need to represent the bit stream as a continuous time signal for transmission, a process called modulation. There are various possible modulation options that depend on the application, design specifications and constraints, range, transmission and reception power, quality of service requirements, regulatory requirements, hardware complexity, data rate, reliability of channel, and capacity. Therefore, it is crucial to choose the right modulation for the right purpose. Some of the well-studied modulation or mapping options are BPSK, QPSK, PAM, OOK, PPM, PIM, and PSM.

2.1. Binary Phase Shift Keying Modulation

BPSK is one of the most popular modulation techniques due to its smooth power spectrum and low BER[3]. One of the factor influencing the choice of modulation is the noise level.

Phase-shift keying (**PSK**) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal. BPSK (also sometimes called PRK, phase reversal keying, or 2PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision.

2.2. Bit Error Rate

The bit error rate is the ratio of number of bit errors to the total transferred bits during a time interval for which the performance is measured. It is also called bit error ratio (BER).The probability of bit error rate is an approximate estimation of bit error rate and for BPSK, it is calculated as

$$P_b = Q\left(\sqrt{\frac{E_b}{N_o}}\right) \quad (1)$$

Or

$$P_b = \frac{1}{2} erf_c\left(\sqrt{\frac{E_b}{N_o}}\right) \quad (2)$$

3. Simulation Methodology

It is necessary to design channel model using some standard measurements and in this channel model all measurements, i.e. sample rate, spreading bandwidth etc, are taken from NICTA channel measurements. Since the performance analysis of the WBAN receiver is based on statistical model of the channel [1].

3.1. Algorithm

With the help of above digital modulation techniques various graphs are plotted between Signal to Noise Ratio (SNR) and Bit Error Rate (BER).by using the following steps.
Step1: Generate power profile ([signal,time_samp,mean_path_loss] = generate_power_profile_wmban(), of WBAN channel ( ).
Step2: Calculate absolute value of signal.
Step3: Calculate received SNR of each sample of power profile with the help of transmitted SNR and mean_path_loss.
Step4: Calculate received signal to noise ratio for various rake taps (all-rake, partial rake, selective rake).
Step5: (a) Calculate BER for BPSK receiver (all-rake, partial rake, selective rake).
Step6: BER vs SNR curves are plotted for BPSK at different carrier frequencies.

Table 1. NICTA Specification for WBAN Parameter

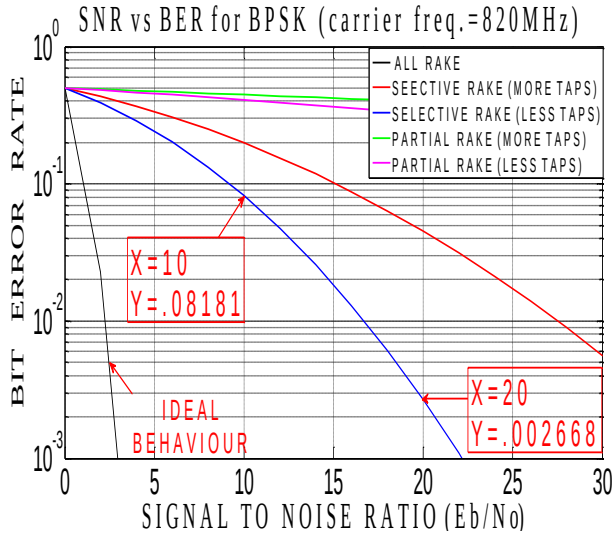
Parameter	**NICTA specification**	**Allowed range**
Carrier Frequency(f_c)	820MHz	420-2500MHz
Sample rate	1KHz	0.75-15KHz
Velocity	1.5-5.5km/h	1.5-20km/h

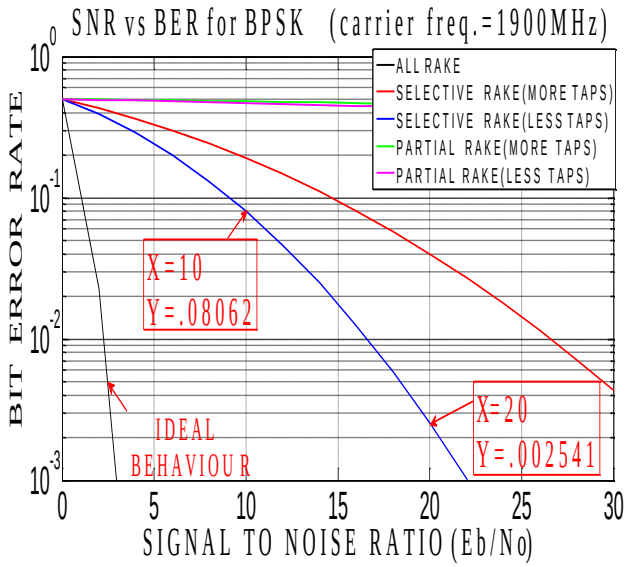
3.2. Simulation Parameter-Carrier Frequency

A carrier signal is a transmitted electromagnetic pulse or wave at a steady base frequency of alternation on which information can be imposed by increasing signal strength, varying the base frequency, varying the wave phase, or other means. This variation is called modulation. A carrier frequency is frequency of carrier signal. In order to evaluate the performance of WBAN channel for BPSK modulation, we have performed simulations for three values of carrier frequency in the range 420-2500 Mhz.

4. Result and Discussions

Bit Error Rate (BER) is the number of bits of error occur within one second in the transmitted signal. Extensive simulations have been carried out in this work to observe the variations of the BER performance for BPSK modulation [3] at different carrier frequencies within the constraints specified by NICTA. In these graphs ,y-axis represents bit error rate and x-axis represents signal to noise ratio(SNR).BER vs SNR has been plotted for BPSK modulation scheme for different carrier frequencies as follow:





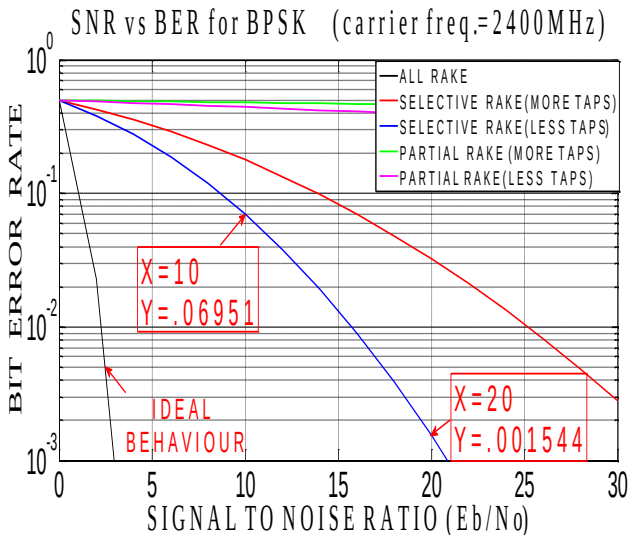


Figure 1. BER vs SNR in WBAN Channel for BPSK with the Variation in Carrier Frequency

Table 2. Effect on BER of Variation in Carrier Frequency Around the Body in BPSK

CAR. FREQUENCY(MHz)	S/N RATIO(X)	BIT ERROR RATE(Y)
820	10	.08181
1900	10	.08062
2400	10	.06951
820	20	.002668
1900	20	.002541
2400	20	.001544

In the above graphs, we have calculated the value of Bit error rate for the given value of SNR *i.e.*, Signal to Noise ratio for BPSK modulation at different values of carrier frequency. It is clear from the tabular values that the minimum value of bit error rate is coming at carrier frequency 2400 Mhz. for the two values of SNR(*i.e.*, 10 and 20). Even, it is clear that the performance of rake receivers improves as number of taps increased.

5. Conclusion

For the implementation of WBAN, the use of modulation technique and the frequency for transmission are very critical. The section 4 presented some results which will give an idea to researchers and system developers about the BPSK modulation at different carrier frequencies and which is the best. So in this work, the error rate performance of BPSK modulation at different carrier frequencies for WBAN channel is observed .The performance is observed by carrying out extensive simulations .So we concluded in this work that at carrier frequency=2400 Mhz by using BPSK modulation in the WBAN channel, we get the minimum Bit Error rate. Hence, 2400 Mhz is the suitable carrier frequency for WBAN by using the BPSK modulation. Thus the result

obtained in this paper will help network designer to systematically design the WBAN products in future.

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