BIT ERROR RATE SIMULATION FOR MARITIME COMMUNICATION

Prof. Poonam Y. Bhosale[1], Prof. Sneha S. Lad [2]

[1] Assistant Professor, Department Of Electronics And Telecommunication Engineering, Sanjeevan Engineering and Technology Institute, Panhala, Maharashtra, India

[2] Assistant Professor, Department Of Electronics And Telecommunication Engineering, Sanjeevan Engineering and Technology Institute, Panhala, Maharashtra, India

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Abstract - *In this paper, we study Bit Error Rate (BER) for Marine Communication using MATLAB. Marine communication includes a system that transmits digital data from one location to other location. Bit Error Rate is the rate at which errors are occurred in the transmitter. For study of simulation digital data MATLAB is an ideal tool because easy commands and data visualization capability but require some basic knowledge. In this paper we are analyzed Bit Error Rate for different marine environments. We describe bit error rate level according to sea states under Rician fading channel model. Bit error rate patterns are designed using MATLAB.*

Key Words: *Bit Error Rate, MATLAB, Maritime Communication.*

1. INTRODUCTION

Bit Error Rate (BER) is the rate at which errors occur in a transmission system i.e. it is a ratio of number of bit errors by total number of transmitted bits. An error can be occurred in the digital data due to noise,distortion, interference or bit synchronization errors. In maritime communication errors are get generated into the transmitted data because of different environmental conditions, these conditions are called as sea states and we use the sea state data from Pierson-Moskowitz sea spectrum [1].

2. PROBLEM DOMAIN

Conventional maritime wireless communication is based on voice communication, which is using radio devices of MF, HF, VHF and satellite system. The radio types for sailing vessels defined by IMO and ITU on which radio devices are loaded. As the conventional maritime communication has low cost, but cannot support the e-navigation service due to lack of bandwidth. To overcome this problem, we use IEEE 802.16 [2], [3] over marine environment. The 802.16 standards targets at the fixed wireless access also designed to support mobile

applications. This standard includes base station (BS), relay station (RS) and mobile station (MS) [4].

3. AFFECT ON BIT ERROR RATE

The BER is affected by the factors like channel noise, distortion, bit synchronization problems, interference, attenuation, wireless multipath fading, etc. and it can be improved by the selection of strong signal strength, by choosing a slow and robust modulation scheme. The transmission BER is the ratio of number of incorrect bits before error correction to total number of transmitted bits. In this paper error in the transmitted bits is randomly generated in accordance to the sea state condition, collected data from Pierson-Moskowitz sea spectrum.

4. SYSTEM DESCRIPTION

Marine wireless communication is mainly affected by the factors like path loss path shadowing and multipath fading [5]. Large propagation distance between transmitter and receiver station caused path loss. Large obstacles between transmitter and receiver station is the cause of path shadowing. The multiple receptions of the original signal due to the sea surface reflections are cause of multipath fading.

An error gets generated into the digitally transmitted data from the transmitter due to reasons discussed in above paragraph. Another one parameter which plays an important role in transmission of data is the sea state parameters. Ocean waves change their nature depending upon sea state value as the sea states get changed according to the speed of wind. The ocean wave movement generally considered as sine pattern; however by experiments the wave shape is described as a Trochoid, whose properties are known to be similar to that of sea states. Since we do not have real data, we use the sea states from Pierson-Moskowitz sea spectrum [1].

Table -1: Sea State Parameters [1]

Sea State	Wind Speed (knots)	Average Wave Period (sec)	Significant Wave Height (m)	Average Wave length (m)
4	18	5	1.83	24.1
5	21	5.5	2.4	32
6	27	7.5	4.3	56.1
7	37	10	7.62	100.13
8	49	13	13.72	180.1

5. SIMULATION TOOL (MATLAB)

MATLAB (matrix laboratory) is a fourth generation programming language developed by Math Works, widely used in all areas of applied mathematics. MATLAB has powerful graphic tool to produce pictures in both 2D and 3D. MATLAB is also used to solve algebraic and differential equations and numerical integration. One of the frequently used tasks in the area of digital communication is bit error rate simulation and testing of modems. In MATLAB we represent continuous time signals with a sequence of numbers or samples, which are generally stored in the form of vector or an array. When this signal in the form of array gets transmitted due to the sea states discussed in above section error get introduced in the transmitted data. At the receiver we analyze an amount of generated error by testing bit error rate and try to reduce it.

6. SIMULATION STEPS

In this section, we present and analyze bit error rate for different marine environments. Bit error rate analysis can be done by the use of a transmitter; a receiver and a channel. We generate a long random bit sequence as input to the transmitter. The transmitter modulates these bits into some form of digital signaling, which can be send through a simulated channel. Bit error rate is generally plotted on a two dimensional graph. The two quantities are normalized signal-to-noise ratio (SNR) expressed as energy per bit E_b divided by one sided power spectral density of the noise N_0 (E_b/N_0) measured in decibels (dB). The abscissa is the bit error rate, a dimensionless quantity, usually expressed in powers of ten. We plot series of points in bit error rate versus SNR. These points requires us to run a simulation at a specific value of SNR, this can be obtained after following the steps mentioned below.

6.1 Transmitter

The first step in simulation is to run transmitter to which Pseudo random generated bit of sequence in input to create a digitally modulated signal. Once we have created signal x (n), we need to make some measurements of it.

6.2 SNR Calculation

The signal to noise ratio (SNR) or E_b/N_0 is usually expressed in decibels, but we must convert it to an ordinary ratio before we can make further use of SNR. If we set SNR to x dB, then E_b/N_0 will be:

$$E_b/N_0 = 10^{(x/10)} \qquad (1)$$

6.3 Calculation of E_b

Energy per bit E_b is the total energy of the signal, divided by the number of bits contained in the signal. We can also express energy per bit as the average signal power multiplied by the duration of one bit.

$$E_b = \frac{1}{N \cdot f_{bit}} \sum_{n=1}^{N} x^2(n) \qquad (2)$$

Where, N=total number of samples in the signal
f_{bit}= bit rate in bits per second
The signal x (n) has unit Volts and E_b has unit Joules.

6.4 Calculation of N_0

With the known values of SNR and energy per bit, the value of N_0 will be calculated, which is nothing but one sided power spectral density of the noise. The value of N_0 can be calculated just by dividing E_b by the value of SNR, which we have converted from dB to the ratio (a unit less quantity). The unit of power spectral density is Watts per Hertz.

6.5 Calculation of σ_n

The one sided power spectral density of the noise N_0 tells us how much noise power is present in a 1 Hertz bandwidth of the signal. To find the variance or average power of the noise, we must know the noise bandwidth. For a real signal x (n), sampled at frequency f_s Hz, the noise bandwidth will be half the sampling rate. Therefore, we find the average power of the noise by multiplying the power spectral density of the noise by the noise bandwidth.

$$\sigma_n = (N_0 f_s)/2 \qquad (3)$$

Where, σ_n = Noise variance in Watt

N_0 = One sided power spectral density of the noise in Watt/Hz.

6.6 Generation of Noise

MATLAB has communication toolbox, in which additive white Gaussian noise (AWGN) is generated by using a standard built-in function. As the noise has zero mean, its power and variance are identical. In this algorithm we have to generate a noise vector that is the same length as our input signal vector x (n), this noise vector should have variance 1 W.

6.7 Add Noise

The generated noisy signal vector will act as an input to the receiver, and receiver demodulated this signal. The receiver will produce a sequence of demodulated bits, which we must compare to the transmitted bits, in order to determine how many demodulated bits are in error.

6.8 Determination of Offset

Due to filtering and other delay including operations typical of most receivers, there will be an offset between the received bits and the transmitted bits. Before we can compare the two bit sequences to check for errors, we must first determine this offset. One way to do this by correlating the two sequences, then searching for the correlation peak. Consider our transmitted bits are stored in vector t (x), and received bits are stored in vector r (x). The received vector should contain more bits than transmitted vector, since the receiver will produce outputs while the filters are filling and flushing. If the length of the transmitted bit vector is l[t (x)], and the length of received vector is l[r (x)] the range of possible offset is between zero and l[tr(x)]-l[t (x)]-1. We can create a partial cross-correlation, from bit vectors t (x) and r (x).

The resultant vector is a partial cross-correlation of the transmitted and received bits, over the possible range. We need to find the location of the maximum value of cross-correlation, since this will tell us the offset between the bit vectors. We need to subtract one from the index of correlation peak in MATLAB numbers array elements.

6.9 Generation of Error Vector

After calculation of an offset between transmitted and received bit vectors, we are ready to calculate error bits. For bit values of zero and one, a simple difference will reveal bit errors. Wherever there is a bit error, the difference between the bits will be ±1, and wherever there is not a bit error, the difference will be zero.

6.10 Count Bit Errors

The error vector contains non-zero elements in the locations where there were bit errors. We need to tally the number of non-zero elements, since this is the total number of bit errors in this simulation.

6.11 Calculation of Bit Error Rate

For different values of SNR we run the bit error rate simulation, we transmit and receive a fixed number of bits. We determine how many bits are there with an error, then compute bit error rate as the number of bit errors divided by the total number of bits in the transmitted signal.

7. SIMULATION RESULTS

In this section, we present the simulation results, with underlying assumptions for the proposed techniques to improve system performance. Performance is evaluated in terms of bit error rate with respect to E_b/N_0. Different range of errors will be occurred due to sea surface reflections, fading, time delay, Doppler shift, sea state and rocking motion of ships. For our simulation, we use the sea state data from Pierson-Moskowitz sea spectrum. Figure 1 show our simulation model.

We simulated performance of single transmit, single receive system without power loss, time delay and Doppler shift under sea state conditions at Rician fading channel. Figure 1 shows simulation result.
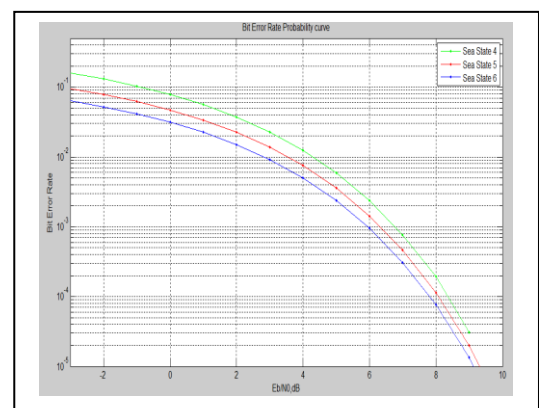

Fig -1: Performance of single transmits and single receives system under sea state 4, 5, 6 conditions

The slope of BER graph indicates the degree of diversity achieved, this is characterized by the performance improvement in BER. The figure above also shows the performance of the system for different sea state conditions. It is apparent from results that sea state 4, 5 and 6 are appropriate for communication and

performance can be improved further by reducing the errors at the receiver end.

8. CONCLUSION

In this paper, we analyze the maritime wireless communication under different sea state conditions by evaluating BER. Conventional maritime communication systems are based on MF, HF, VHF radios, which cannot support the e-Navigation service due to lack of bandwidth [6]. A bit error rate test provides a very useful indication of the performance of the system that can be directly related to its operational performance. BER testing is a powerful methodology for end to end testing of digital transmission systems. We simulated the bit error rate performance by adding a controlled amount of noise different for different sea state conditions to the transmitted signal. This signal with noise then given as input to the receiver. Then receiver demodulates the signal, producing a recovered bits sequence. Finally, the received bits are compared with transmitted bits, and match up the errors through bit error rate versus E_b/N_0. From the results obtained, it is concluded that as the sea states increased from 4 to 6 errors are increased but performance can be improved by reducing noise in the system.

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BIOGRAPHIES

Prof. Poonam Y. BhosaleWorking as Assistant Professor in Sanjeevan Engineering and Technology Institute, Panhala, Maharashtra (India). Has Received a B.E. (Electronics) degree Shivaji University, Kolhapur, India in 2009. She received the M.Tech. degree from Walchand College of Engineering, Sangli, India in 2011. Her area of specialization is Electromagnetic Fields, Microwave Engineering and communication network.

Prof. Sneha S. LadWorking as Assistant Professor in Sanjeevan Engineering and Technology Institute, Panhala, Maharashtra (India). Has Received a B.E. (Electronics) degree Shivaji University, Kolhapur, India in 2011. She received the M.E. degree from Shivaji University, Kolhapur, India in 2014. Her area of specialization is Network Analysis, communication network and Image Processing.