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A comparison study on the SNR values by using digital modulation schemes with multiple fading channels

Ambily Govindan[1], Jithin Jose Kallada[2]

1 PG student, dept. Electronics and communication engineering ,Nehru college of engineering and research centre ,Thrissur,India ,ambilyec7@yahoo.co.in

2 Assistant professor , dept. Electronics and communication engineering ,Nehru college of engineering and research centre, Thrissur,India jithinjosekallada@gmail.com

ABSTRACT

Signal to noise ratio is used as an indicator for evaluating the quality of communication. Due to this feature it is very important to estimate the SNR value for the modern wireless communication. In this paper a comparison study on the SNR value for different modulation schemes through fading channels is proposed. The proposed estimator is moment based one and performance evaluated on different channel conditions. For the performances analysis an expression for the moments of the received signals be developed .Modulation schemes like bipolar phase shift keying (BPSK), Quadrature amplitude modulation (QAM) and quadrature phase shift keying (QPSK) are performed for the SNR estimator. This estimator works on Additive White Gaussian Noise AWGN, Nakagami and Rayleigh fading channels. The existing model SNR estimation methods were degraded for higher level modulation scheme. As an extension we propose a moment based SNR estimator for different modulation scheme using AWGN, Rayleigh and Nakagami. Results provide that proposed estimator works better in low SNR conditions which are applicable to different communication scenarios.

Key Words: Digital modulations, fading channel, OFDM, SNR

1. INTRODUCTION

SNR at the receiver side is important due to its significance for several techniques used in modern wireless communication systems. SNR estimation techniques can be classified into Data-Aided (DA), Decision-Directed (DD), and Non Data-Aided (NDA) estimators. DA estimators like the ones represented in [8] use the transmitted pilot symbols to get their estimates. DD estimators can be considered as a special case of the DA estimators when the pilot symbols are replaced with the output of the decoder [8]. NDA estimators do not require knowledge of the transmitted signal allowing in service and inter-systems SNR estimation. A blind and data aided SNR estimator using the moments of the received signal is proposed in this paper. This envelope-based estimator works for different modulation schemes. Interestingly, the proposed estimator operation and performance is independent of the digital modulation of the received signal in the case of non data aided signal. But for data aided the performance will be poor at low SNR values. Moreover, the expression results in lower implementation complexity.

The performance of the proposed estimator is evaluated under different conditions of the channel. Fading channels like AWGN, Rayleigh and Nakagami are user for evaluating the performances of the SNR estimator. This shows how much the fading channel affected the transmitted signal in the data aided transmission.

In [1]deals with the problem of non data aided (NDA) signal to noise ratio (SNR) estimation of Orthogonal Frequency Division Multiplexing (OFDM) signals transmitted through unknown multipath fading channel. Most of existing OFDM SNR estimators are based on the knowledge of pilot sequences which is not applicable in some contexts such as cognitive radio for instance. It shows that it is possible to take advantage of the periodic redundancy induced by the cyclic prefix to get an accurate NDA SNR estimator. Considering multicarrier transmissions [5] present a maximum likelihood estimator of the subcarrier signal-to-noise ratio (SNR) based on the expectation maximization (EM) algorithm. This estimator is applicable to any linearly-modulated signal. It is a non-data-aided (NDA) method since no a priori knowledge

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is assumed about the transmitted data. The Nakagami-m distribution [4] is a good fit to empirical fading data obtained from radio communication channels. The proposed algorithm uses absolute second and fourth moments of the envelope of the received signal over a block of data. . The SNR estimators are executed by the computer simulation of baseband binary phase-shift keying (PSK) signals in real additive white Gaussian noise (AWGN) [7]. The performance of existing non-data-aided (NDA) SNR estimation methods are substantially degraded for high level modulation scheme such as M-ary amplitude and phase shift keying (APSK) or quadrature amplitude modulation (QAM)[2].

2. SYSTEM MODEL

The high data rates in wireless communication can be achieved by increased or more efficient use of, bandwidth and transmitting power. The key technique used for spectral optimization is orthogonal frequency division multiplexing (OFDM). The European Telecommunication Standards Institute (ETSI) and IEEE have proposed OFDM for high speed wireless LAN. ETSI's proposed HIPERLAN/2 standard describes the physical (PHY) layer based on OFDM technology. It employs OFDM operating in the 5GHz and offers raw data rates up to 54 Mbits/s. This model shows transmitter side coding and different modulation methods with ½ and ¾ code rates with a corresponding ideal receiver chain and different multiple fading channels like AWGN, Rayleigh and Nakagami.

OFDM splits a high data rate stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. Because the symbol duration increases for the lower rate parallel subcarriers which use OFDM as a multi carrier modulation technology. The OFDM symbol is constructed in frequency domain can be converted in to time domain by using IFFT technology. At the receiver side the reverse operation (FFT) is occurred. It is a radix 2 operation. The cyclic prefix as a guard interval eliminates inter symbol interferences from the previous symbol [7]. It is used in OFDM to combat the multipath by making channel estimation easy. OFDM uses a modulation bank consists of BPSK, QPSK and QAM for different data rates .Demodulation will be provided for the multipath faded signals in the OFDM system.

Nakagami distribution gained wide spread application in the modelling of physical fading channels .It is a generalized distribution which can model different fading environments with greater flexibility and accuracy. It can be used to model small scale fading. Nakagami distribution is a probability distribution related to the gamma distribution [1]. The two parameters are shape parameter m and controlling parameter α. It can be used to model attenuation of wireless signals travelling multipath. The phase of the signal following the distribution as

$$f(x;m,\propto) = \frac{2}{\Gamma(m)}\left(\frac{m^m}{\alpha^m}\right)x^{2m-1}\exp\left(\frac{-\frac{m}{\alpha}x^2}{\alpha^m}\right)$$

Rayleigh fading provides statistical model for the effect of a propagation environment on a high frequency signal, such as that used by wireless devices. Rayleigh fading models assume that the magnitude of a signal that has passed through transmission medium will vary randomly according to a Rayleigh distribution.. The phase of the signal following the distribution as

$$f(x;\sigma) = \frac{x}{\sigma^2}e^{-x^2/(2\sigma^2)}, \qquad x \geq 0$$

Noise which gives white characteristics called white noise; it is caused by random movement by using Gaussian distribution, which has zero mean value. This noise could be destroyed the signal in additive manner so this noise called Additive White Gaussian Noise (AWGN). The phase of the signal following the distribution as

$$f(n) = e\left(\frac{\Pi^2}{2\sigma^2}\right)/\sqrt{2\Pi\sigma^2}$$

$$\sigma^2 = \frac{No}{2Tb}$$

Thus the SNR value of received signal is obtained by using a moment based estimator .SNR value will be varied according channel fading and data rates. Figure 1 shows the functional block diagram of the system model. Moment based SNR estimator works on Gaussian distributed signal, where the signal having real and imaginary components.

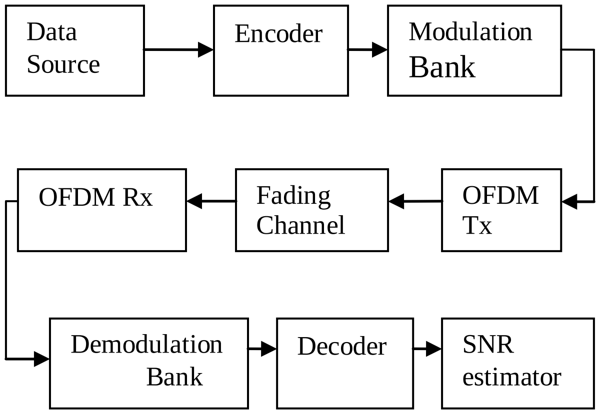

Figure 1:Functional block diagram of system model

3. PROPOSED MODEL

3.1. Data source

The Bernoulli Binary Generator block generates random binary numbers using a Bernoulli distribution. The output signals can be a frame based matrix, a sample-based row or column vector, or a sample-based one dimensional array. These attributes are controlled by the Frame based outputs, Samples per frame, and Interpret vector parameters as 1-D parameters.

3.2. Encoder

The convolution Encoder block encodes a sequence of binary input vectors to produce a sequence of binary output vectors. This block can process multiple symbols at a time. This block can accept inputs that vary in length during simulation. To define the convolution encoder, use the Trellis structure parameter. If the encoder takes k input bit streams (that is, it can receive 2^K possible input symbols), the block input vector length is L*k for some positive integer L. Similarly, if the encoder produces n output bit streams (that is, it can produce 2n possible output symbols), the block output vector length is L*n. This block accepts a column vector input signal with any positive integer for L. For variable-size inputs, the L can vary during simulation. The operation of the block is governed by the Operation mode parameter.

3.3. Modulation Bank

Digital modulation is used to transfer a digital bit stream over an analog band pass channel. OFDM scheme used as a digital multi carrier modulation methods. Each subcarrier is modulated with a conventional modulation scheme such as QPSK at different symbol rates and also maintaining total data rates similar to conventional single carrier modulation schemes in the same bandwidth by using cyclic prefix.

3.4. OFDM transmitter

PN Sequence Generator block generates a sequence of pseudorandom binary numbers using a linear-feedback shift register (LFSR). If the input consists of integers between 0 and M-1, where M is the M-ary number parameter, then the output consists of integers between 0 and M-1. If M is even, then the output is odd. If M is odd, then the output is even. This block is only designed to work when the input value is within the set {0, 1, 2..(M-1)}, where M is the M-ary number parameter. If the input value is outside of this set of integers the output may not be valid. Append or prepend a constant value to the input along the specified dimensions known as zero padding. The IFFT block computes the inverse fast Fourier transform (IFFT) of each row of a sample based 1by P input vector. Add cyclic prefix as a guard interval, it eliminates the ISI from the previous symbol .It is used in OFDM to combat multipath by making channel estimation easy.

3.5. Fading channel

OFDM technology using a channel for SNR estimation. In this paper mainly three types of multipath fading channels are compared for its SNR estimation they are AWGN, Rayleigh and Nakagami. The noise is added to the OFDM transmitted signal .Gaussian distributed signals following the Rayleigh and Nakagami distribution. All channels depend on the m shaping parameter .In the case of AWGN it will be infinity. For a Rayleigh channel it will be one. And for Nakagami distribution it will be greater than one.

3.6. OFDM receiver

At the receiver side remove the added prefix in the transmitter section. FFT is used to convert time domain in to frequency domain. The received signal converts bipolar sequence to unipolar for the SNR estimation. Then remove the zero padding because there is no effect in the padding value at the receiver section. Then select rows from a group of rows for estimation purpose.

3.7. Demodulation Bank

Demodulation will be the reverse process of modulation. Demodulation of QPSK, BPSK and QAM are done for different rate id. The channels coefficients are demodulated in this stage.

3.8. Decoder

The Viterbi decoder block decodes input symbols to produce binary output symbols. This block can process several symbols at a time for faster performance. This block can output sequences that vary in length during simulation. If the convolution code uses an alphabet of 2n possible symbols, this block's input vector length is L*n for some positive integer L. Similarly, if the decoded data uses an alphabet of 2k possible output symbols, this block's output vector length is L*k.

3.9. SNR estimator

Algorithm for SNR estimator

1. Initiate the number of received OFDM symbols x
2. For loop iteration initialise i=0
3. Initialize second moment of received signal M2 as zero
4. Initialize fourth moment of received signal M4 as zero
5. Starting the loop with a condition i less than x
6. Find the square of the absolute value of the received signal ,then assign Result into variable A
7. Take square of A , then assign to variable B
8. M2=M2+ A
9. M4=M4+B
10. Increment the loop iteration number
11. End of the loop
12. Estimation parameter will be the ratio of M4 and M2,assign the result to variable z
13. SNR will be inverse of the estimation parameter

4. SIMULATION RESULTS

The simulation results show the variation of SNR in terms of BER by using different modulation scheme through various multipath fading channels. The modulation schemes are BPSK and QPSK with ½ and ¾ code rates, 16 QAM with ½ and ¾ code rates and 64 QAM with ¾ code rate. Moment based SNR estimator is independent of the different modulation scheme but depends on the fading channel.

The figure 2 shows the BER vs SNR using ½ BPSK and ½ QPSK and ½ QAM 16modulation with AWGN channel. From the figure QAM having high BER compared to QPSK and BPSK.As the signal constellation points (M) increased the BER also get increased. Here for the simulation purpose taking the SNR value from 0 to 10. From the analysis it is clear that the value of the BER on 1/2QPSK and 1/2 BPSK modulation with 200 OFDM symbols are affected by the increasing value of the SNR. Graph BPSK modulation over AWGN channel is under QPSK and QAM modulation, it indicates that the BPSK modulation BER on AWGN channel has better performance than the BER on QPSK and QAM modulation with rate id ½.

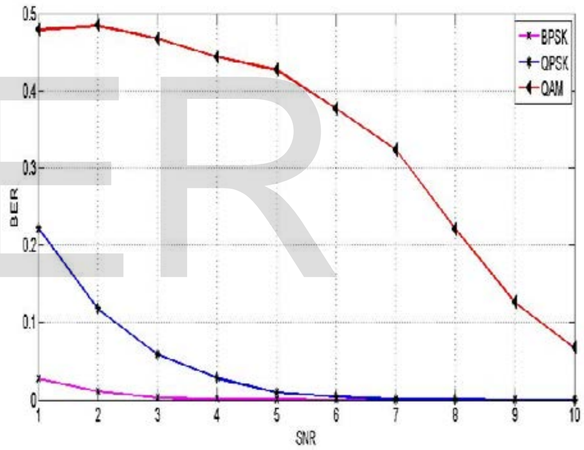

Figure 2: BER vs SNR in QPSK,BPSK,QAM over AWGN channel

The figure 3 shows the BER vs SNR using ½ BPSK and ½ QPSK and ½ QAM 16modulation with Rayleigh channel. From the figure QAM having high BER compared to QPSK and BPSK modulation. As the signal constellation points (M) increased the BER also get increased. Here for the simulation purpose taking the SNR value from 0 to 10. From the analysis it is clear that the value of the BER on 1/2QPSK and 1/2 BPSK modulation with 200 OFDM symbols are decreased gradually by the increasing value of the SNR. Graph BPSK modulation over Rayleigh channel is under QAM modulation. Figure2 indicates that the BPSK modulation BER on Rayleigh channel has better performance than the

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BER on QPSK and QAM modulation with rate id ½.

The figure 4 shows the BER vs SNR uses ½ BPSK and ½ QPSK and ½ QAM 16modulation with Nakagami fading channel. From the figure QAM having high BER compared to QPSK and BPSK.. Graph BPSK modulation over Nakagami channel is under QPSK and QAM modulation, it indicates that the BPSK modulation BER on AWGN channel has better performance than the BER on QPSK and QAM modulation with rate id ½. The figure 4 shows the BER vs SNR using ½ BPSK and ½ QPSK and ½ QAM16 modulation with Nakagami fading channel. From the figure QAM having high BER compared to QPSK and BPSK modulation.

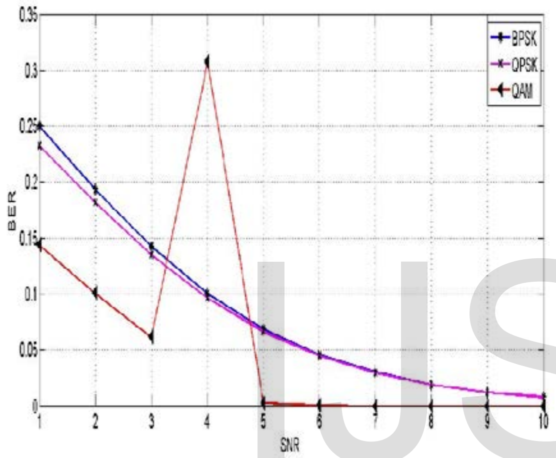

Figure 3:BER vs SNR in QPSK,BPSK,QAM over Rayleigh channel

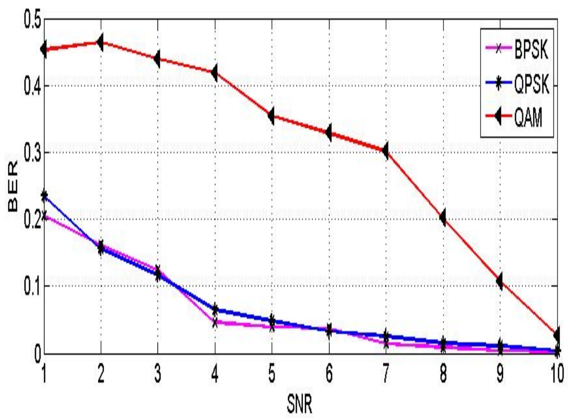

Figure 4: BER vs SNR in QPSK,BPSK,QAM over Nakagami channel

Figure 5 shows the variation of the SNR estimator performance with the Normalized Root Mean Squared-Error with different modulation schemes. The performance analysis is taken over AWGN channel with different rate id. From the figure it is cleared that NRMSE is higher for QPSK with rate id ¾ .Here QAM64 with ¾ rate id is used .Based on these performance decided the application in the communication field. This also decides the quality of the communication link .The effect of multipath fading channel provides variations in the estimated value.

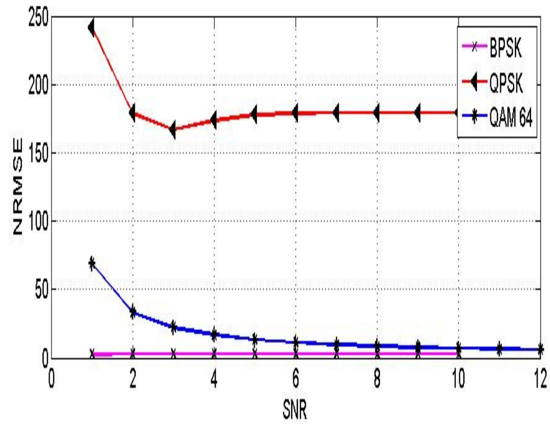

Figure 5: NRMSE vs SNR for BPSK,QPSK,QAM64

5. DISCUSSION

This paper discuss about a comparison on SNR in terms of BER. This comparison is done under different modulation scheme in OFDM system with different rate id such as ½ and ¾ .The comparison study indicates that BER is higher for QAM. Moment based SNR estimator is used for studying the performance under different multipath fading channels. This performance evaluation results can be used in applications like cognitive radio. The cognitive radio can be operated in the low SNR values. NDA and DA estimator having a slight significant difference in OFDM system.SNR estimator on the OFDM system improving the performance with various rate ids.

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