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An Efficient Design for SNR Estimator for Digitally Modulated Signals on Multiple Fading Channels

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Abstract: Signal to noise ratio is used as an indicator for the quality of communication. Due to this feature SNR is very important for the modern wireless communication. In this paper make a study on the SNR value for different digital modulation schemes through fading channels and AWGN are proposed. The existing model SNR estimation methods were degraded the performance for higher level modulation scheme. The proposed estimator is based on the moments of received signals at the receiver section and performance evaluated on different channel and modulation conditions. For the performances analysis take the SNR power and switch the channel to a low transmission power. Digital modulations like Bi polar phase shift keying (BPSK), Quadrature amplitude modulation (QAM) and quadrature phase shift keying (QPSK) are performed on the blind SNR estimator. Amplitude phase shift keying (APSK) modulation is used for data aided SNR estimator. The SNR estimator works on the fading channels like Additive White Gaussian Noise AWGN, Nakagami and Rayleigh. The bit error rate (BER) at the receiver section is varied due to the effect of fading. In this paper a comparison on SNR in terms of BER is taken. This comparison is done under OFDM system with different data rate id.SNR estimator on the OFDM system improving the performance with various rate ids. Paper indicates the result that SNR estimator works better in lower SNR conditions which are applicable to different communication scenarios especially in the case of cognitive radio scenarios.

Keywords: SNR estimator, channels, Digital modulation, OFDM.

I. INTRODUCTION

Knowledge of SNR at the receiver side is important due to its significance for several Maximum-Likelihood (ML) and Minimum-Mean-Square-Error (MMSE) techniques used in modern communication systems. The importance of knowing the instantaneous SNR increases with the use of adaptive techniques, power control, mobile-assisted hand-off, dynamic spectrum access, cognitive radio, and feedback-assisted resource allocation. SNR estimation techniques can be categorized into generally as Data-Aided (DA), Decision-Directed (DD), and Non Data-Aided (NDA) estimators. DA estimators are represented in use of transmitted pilot symbols to get their estimates. The existence of pilot symbols causes degradation in system throughput which is the main disadvantage of this type of estimators. Moreover, in cognitive radio systems where the primary user's pilot symbol locations might not be known to the secondary users. So that DA methods cannot be applied. DD estimators can be considered when the pilot symbols used in DA estimators are replaced with the output of the decoder. NDA estimators do not require knowledge of the transmitted signal for the SNR estimation. A blind (non-data-aided) SNR estimator using the statistical moments of the received signal is proposed in this project. This envelope-based non-data-aided estimator works for any time-domain Gaussian-distributed signal (e.g. OFDM signals). A closed-form expression for the estimated SNR as a function of the moments of the received signal is derived. Interestingly, the obtained expression shows that the proposed estimator operation and performance is independent of the constellation of the received signal. Moreover, the existence of the closed-form expression results in lower implementation complexity. Furthermore, to enable theoretical performance analysis, a general mathematical expression is derived for the even moments of the received signal in terms of SNR and BER. The performance of the proposed estimator is evaluated based on the mean-squared-error and bit error rate (BER) under different conditions of the channel. OFDM is one of the core technologies of the fourth generation mobile communication. The primary distinguish between conventional FDM (Frequency division multiplexing) and OFDM is that the subcarriers over lap to each other in OFDM. A major advantage of OFDM is that it can change the frequency selective fading channel in to flat fading channel. The guard interval can effectively restrain the inter symbol interference (ISI) and inter carrier interference (ICI).By using cyclic prefix of OFDM signals to estimate SNR and the premise of the method is that, the received signal has completely synchronized. The performance of the moment based SNR estimator is evaluated under different conditions of the channel. Fading channels like AWGN, Rayleigh and Nakagami are used in the SNR estimator which is working over OFDM technology. This shows how much the fading channel affected the transmitted signal in the data aided and non data aided transmission in the OFDM system. The modulated transmitted are transmitted through unknown multipath fading channel in the OFDM system. Most of existing OFDM SNR estimators is based on the knowledge of pilot sequences as a result they are not suited in some contexts such as cognitive radio system. The existing model SNR estimation methods were degraded for higher level modulation scheme. The existing SNR estimation technique depends on interpolation and look up tables to find SNR estimate, which implies mathematical complexity and more storage resources. The performance of the proposed estimator is evaluated under different conditions of the channel. Fading channels like AWGN, Rayleigh and Nakagami are used for evaluating the performances of the SNR estimator. This shows how much the fading channel affected the transmitted signal in the data aided transmission. The switching scheme according to the SNR power indicates the channel with low transmission power. As a result this estimator provides more efficiency in the wireless data transmission.

In OFDM splits the high data rate into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. OFDM uses parallel data transmission. The OFDM symbol which is constructed in frequency domain can be converted in to time domain by using IFFT technology. The reverse operation (FFT) is occurred at the receiver side. The cyclic prefix act as a guard interval that eliminates inter symbol interferences from the previous input symbols. It is used for combat the multipath fading by making channel estimation easy. OFDM uses a modulation bank consists of BPSK, QPSK, QAM and APSK for different data rates .APSK modulation scheme is used for data aided SNR.

II. MODULE 1

A. Simulink Model for Non Data Aided Estimator

An end to end baseband model of the physical layer of a wireless local area network (WLAN) according to the IEEE 802.11a standard. The model supports all mandatory and optional data rates: 6, 9, 12, 18, 24, 36, 48, and 54 Mb/s. The model also illustrates adaptive modulation and coding over a dispersive multipath fading channel, whereby the simulation varies the data rate dynamically. The model uses an artificially high channel fading rate to make the data rate change more quickly and thus make the visualization more animated and instructive. The demonstration contains components that model the essential features of the WLAN 802.11a standard. The top row of blocks contains the transmitter components while the bottom row contains the receiver components. Generation of random data at a bit rate that varies during the simulation. The varying data rate is accomplished by enabling a source block periodically for a duration that depends on the desired data rate. Coding, interleaving and modulation using one of several schemes specified in the standard. In particular each modulator block in the bank performs these tasks. Convolutional coding and puncturing using code rates of 1/2, 2/3, and ¾.Data interleaving BPSK, QPSK, 16-QAM and 64-QAM modulation. OFDM (Orthogonal frequency division multiplexing) transmission using 52 subcarriers, 4 pilots, 64-point FFTs, and a 16-sample cyclic prefix. PLCP (physical layer convergence protocol) preamble modelled as four long training sequences. Dispersive multipath fading channel and configure channel properties using the dialog box of the multipath Channel block. Receiver equalization and viterbi decoding are done at the receiver. The PER block in the model shows the packet error rate as a percentage. The SNR block at the top level of the model shows an estimate of the SNR based on the error vector magnitude. The SNR block in the Multipath Channel subsystem shows the SNR based on the received signal power. The Bit Rate block shows which of the bit rates specified in the standard is currently in use. Configure the channel properties. In this model Nakagami channel properties are configured. Channel coefficient will be added to the transmitted signal and thus noise will be generated. The below fig 1 shows 16 QAM constellation signal points are there with minimum distance between the symbols will be 2. Each symbol represents in the binary form. The coded data will be distributed by the QAM modulation. It is available at high data rates also.

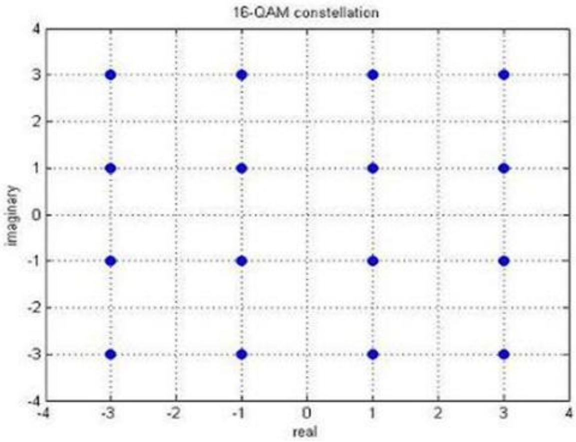

Fig. 1. 16 QAM constellation signal

The fig 2 shows the spectrum of fading channel. That will be in peak level only at one particular time. It indicates Nakagami fading channel distribution .By compared to other fading channel, the PDF of Nakagami will be maximum at one particular time. Beyond that peak value the probability will be less. The distributions of channel coefficients are added to the QAM constellation signal.

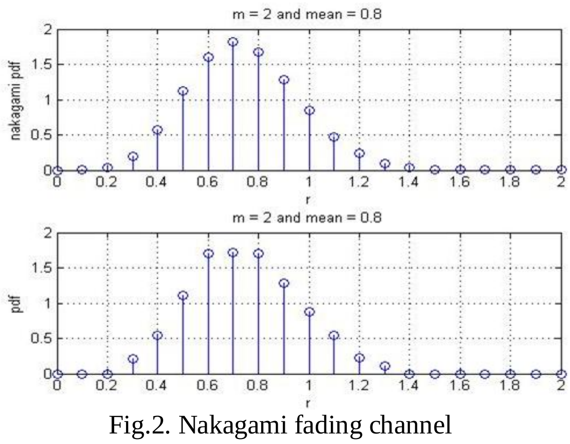

Fig.2. Nakagami fading channel

The signal constellation of the receiver will be distributed randomly due to the fading effect. The signal points get

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increased as the QAM constellation signal gets increased. For the estimation the output during the simulations are taken out. And fed in to the SNR estimator. This will provide the estimation of SNR value by taking the second and fourth moment of the received signal. Second moment is obtained through the square of the absolute value of the received signal. Fourth moment is obtained through the square of the second moment.SNR will be the inverse of estimation parameter. From the fig 3 theoretical SNR will be constant. But estimated SNR will be having variations but it slows down to a constant low value.

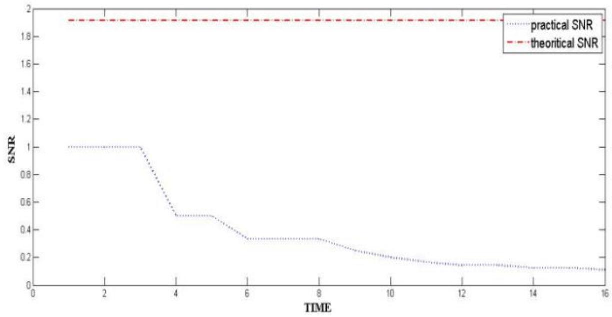

Fig.3. Theoretical and practical comparison on SNR value

III.MODULE 2

A. Modulation Bank in Non Data Aided SNR Estimator

In BPSK the phase of a constant amplitude carrier signal is switched between two values according to two possible values M_1 and M_2 corresponding to binary 1 and binary 0.Normally these two phases are separated by 180^0.In QPSK which has twice the BW efficiency of BPSK. Since two bits are transmitted in a single modulation symbol. The phase of the carrier takes on one of the four equally spaced values $0,\pi/2, \pi,3\pi/2$ where each value of the phase corresponds to a unique pair of messages.QAM allowing the amplitude also vary with the phase, new modulation scheme called QAM is acquired. This type of modulation consists of square lattice of signal points. It conveys two digital bit streams by modulating the amplitude of the carrier waves using ASK. The two carrier waves are sinusoids are out of phase with each other by 90^0 and thus are called quadrature carrier or quadrature components. The modulated waves are summed and final waveform is a combination of PSK and ASK. Rate id is used for packing in the modulation scheme .Each rate id have its own package. Fig 4 indicates that as the SNR increases BER get decreased in the case of AWGN channel and SNR value having very slight variation with the theoretical value during the simulation.

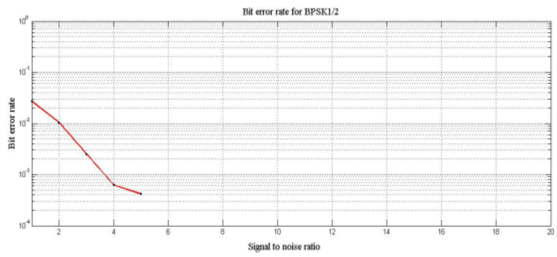

Fig. 4. SNR vs BER over AWGN channel using BPSK ½

Taking 100 OFDM input symbols for the simulation purpose. In the case of QPSK ½ BER will be high compared to BPSK ½ .It also decreases with the increase of SNR value .Fig 5 shows the SNR graph will be similar to look like BPSK ½. Recommended font sizes are shown in Table 1.

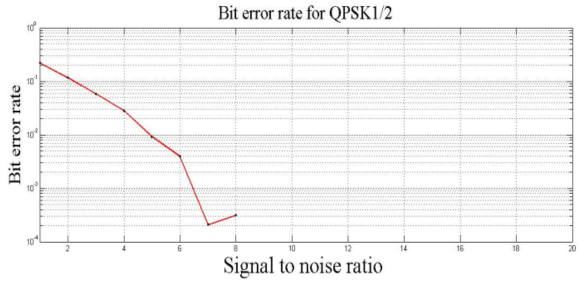

Fig.5. SNR vs BER over AWGN channel using BPSK ½

Fig 6 shows that BER much more high in QPSK ¾.SNR having high variation only at the beginning time, then it is lied down to theoretical path. As the rate id increases the SNR value get decreased. Fig 7 indicates the case of QAM, in which BER will be high compared to QPSK and BPSK. It will be constant to a particular SNR value and then the BER value get decreased .The variation in SNR will be quite large compared to BPSK and QPSK.

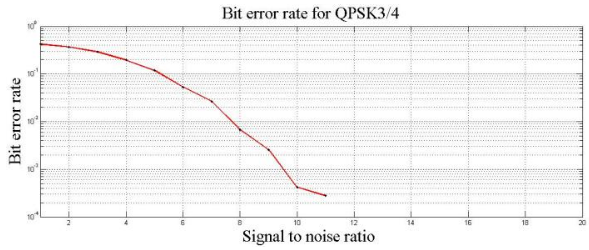

Fig.6. SNR vs BER over AWGN channel using QPSK ¾

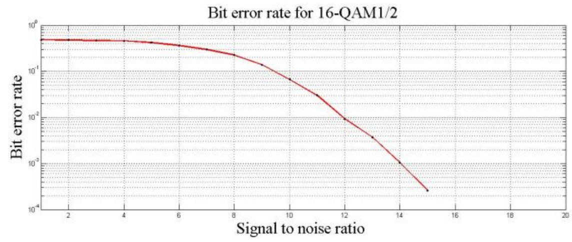

Fig.7. SNR vs BER over AWGN channel using 16QAM ½

As the data rate increased in the case of QAM ¾ the BER will be constant at high level and the variation in the SNR value with the theoretical value also get increased. This shows in fig 8. Fig 9 and fig 10 uses 64 QAM 2/3 and 64 QAM ¾ respectively .In these cases BER get increased as the data rate increased.

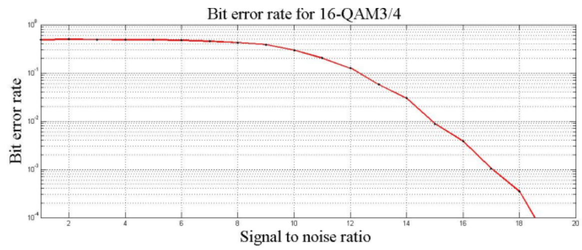

Fig.8. SNR vs BER over AWGN channel using 16QAM ¾

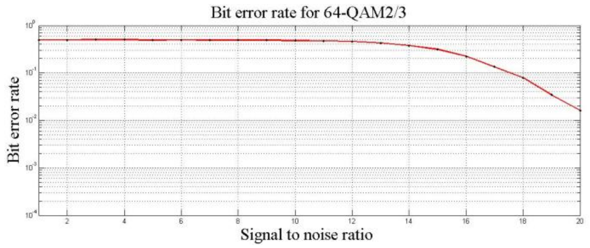

Fig.9. SNR vs BER over AWGN channel using 64 QAM 2/3

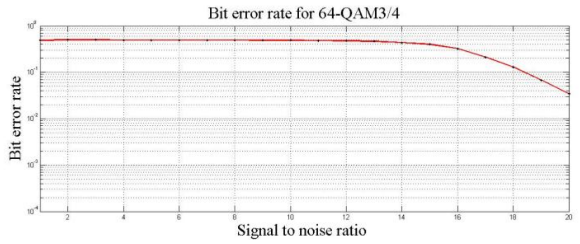

FIG.10. SNR VS BER OVER AWGN CHANNEL USING 64QAM ¾

IV. MODULE 3

A. Data Aided SNR Estimation Using APSK Modulation
Data aided SNR estimator depends on the pilot symbols of transmitter side. It could not be as much efficient as non data aided SNR estimator. Because the data aided SNR estimator will be degraded for high level of signal constellation. As a result QAM and QPSK with high signal constellation cannot be implemented for the data aided SNR estimator. In that case APSK modulator is used. APSK is also known as asymmetric phase shift keying. This digital modulation conveys the data by changing or modulating both the amplitude and phase of the carrier signal. So that this modulation can be consider as the super class of QAM .The main advantage over the conventional QAM scheme is that lower number of possible amplitude levels .APSK is a constellation depended modulation scheme because the data size get varied during simulation.

Steps for the snr estimation

1. Generating the random data for a particular range.
2. Convolution encoder is used for encoding a sequence of binary input vectors to produce a sequence of binary output vectors.
3. Interleave the input symbols. Interleave accepts a set of symbols and rearranges them, without repeating or omitting any of the symbols in the set. The number of symbols in each set is fixed for a given interleaver. The interleaver's operation on a set of symbols is independent of its operation on all other sets of symbols.
4. 16APSK modulation is added to the interleaving data.
5. APSK modulation is done over the AWGN channel and the noise effects are added.
6. A corresponding deinterleaver uses the inverse mapping to restore the original sequence of symbols. Interleaving and deinterleaving can be useful for reducing errors caused by burst errors in a communication system.
7. Then decoded the signal.
8. Bit error rate is calculated from the received signal.
9. The SNR estimator exploits the a posteriori probabilities of coded bits from the output of channel decoder to improve estimation performance at low SNRs.

Normalized bias of the moment based SNR will be mean of ratio of difference between the theoretical SNR and estimated SNR to theoretical SNR. Fig 3 shows the normalized SNR value of the APSK SNR estimator.

V. MODULE 4

A. Switching Scheme for Channel by Using SNR Power
Cognitive radio introduces a new technique like spectrum sharing and sensing. So that it is an intelligent radio that can be programmed and configured dynamically. This kind of design is used for selecting best channels in its spectrum. This kind of switching scheme is programmed here by using average noise power of channel. The average noise power of channel will be compared with the threshold value .According to comparison the channel will be switched in to AWGN and Rayleigh.

Algorithm of switching scheme for channel by using snr power

1. Sample points are generated for the SNR power calculation.
2. Convert the SNR db value to a linear value.
3. Loop iteration is started along with the false alarm for detecting the channel power.
4. Setting a threshold value for the false alarm.
5. According to the sample points transmitting a single tone.
6. Add AWGN and Rayleigh channel effects.
7. Calculate the average noise power of AWGN.
8. AWGN channel noise will be the square root of the average noise power f AWGN.
9. Received signal will be the sum of the data and AWGN channel noise.
10. Accumulate for each AWGN received signal power.
11. Compared this value with the threshold simulation value.
12. If the accumulated power is greater than the threshold value then increase the AWGN channel counter for the channel detection probability computation.
13. Register the accumulated power value of AWGN in to variable A.
14. The same procedure is repeated for Rayleigh channel in order to calculate the power.
15. The accumulated power of Rayleigh is assigned to the variable B.
16. Detecting AWGN and Rayleigh channel probability computation by the ratio of counter value and simulation time value.
17. End of the loop iteration.
18. Check condition for the channel selection
If A==B, then A=0 and B=0 not valid condition
Else if A>B, then A=1 and B=0 AWGN channel
Else if A<B, then A=0 and B=1 Rayleigh channel
Else not valid condition

19. Under these condition channel will be switched and added to the transmitted signal.
20. Channel switching condition.
    If A==0 or B==0
    Then AWGN channel is added to the transmitted signal. It is a default operation.
    If A=0 and B=1
    Then the accumulated power of AWGN will be lesser than Rayleigh power. So that Rayleigh channel effect is added to the transmitted signal.
    If A=1 and B=0

Then the accumulated power of AWGN will be higher. So that AWGN channel effect is added to the transmitted signal. Other conditions are invalid.
Fig 11 shows the energy distribution of different channels like AWGN and Rayleigh. This result taken under the simulation as well as theoretical outcome of SNR estimator

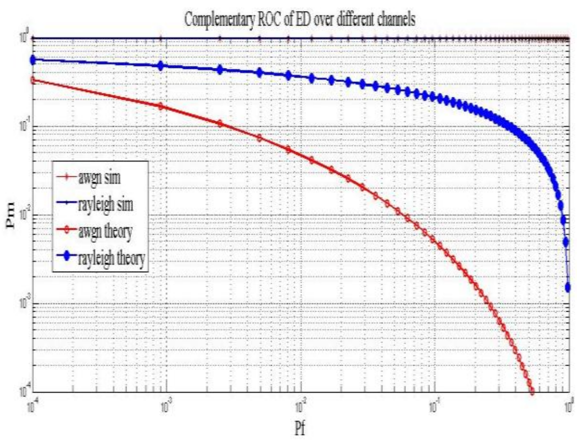

Fig.11. Energy distribution over different channel

VI. CONCLUSION

A blind, constellation independent, SNR estimator that works in time domain for Gaussian distributed signal, has been implemented during different digital modulation with different rate id in the OFDM system. Generalized formulas for the estimator and the moments of the received signal are used for the calculation of SNR and BER. The transmitted signal having different fading channel effects like AWGN, Rayleigh and Nakagami. 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. A code aided SNR estimator based on M-ary amplitude phase shift keying is also implemented in the OFDM system .Based on the channel power the transmitted signal can be switched in to different in order to decrease the transmission power with a threshold value during simulation. This switching scheme of estimator can be used in cognitive radio like applications.

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