Estimation of SNR, MSE and BER With Incremental Variation of Power for Wireless Channel

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Abstract - Measuring noise effect on the signal in channel is very much required to have an high efficient transmission. There by estimating the ratio of signal to noise, mean square error and bit error rate is necessary. In this paper we have developed two algorithms, first to estimate Signal to Noise ratio (SNR) with respect to Gaussian noise in the channel and then by incrementing power of the signal corresponding SNR is obtained. Mean Squarer Error (MSE) of the signal is also calculated for the same incremental values of power. Second algorithm obtains BER of the channel, to reduce this error rate power is increased until an acceptable BER of the channel is found for varies M of QAM technique in OFDM system. Simulation results of SNR, MSE and BER for incremental power has been shown using MATLAB.

***Key words - Signal to Noise ratio (SNR), Gaussian noise, Mean Squarer Error (MSE), incremental power*.**

I.INTRODUCTION

In Wireless communication systems orthogonal frequency division Mulitiplexing(OFDM) is a promising technique. High data rate is required for wireless multimedia services [2]. In OFDF system same signal constellation is used by all sub carriers. Throughput and performance of the system can be improved by employing bit and power allocation algorithms. Power variation and constellation can be varied according to the measured SNR of the subcarriers [1].

The search for a good SNR estimation technique is motivated by the fact that various algorithms require knowledge of the SNR for optimal performance. For instance, in OFDM systems, SNR estimation is used for power control, adaptive coding and modulation, turbo decoding etc. [3]-[6].

This paper is organized as follows:-
II. Problem definition
III. Explanation
IV. Algorithms
V. Simulation Results
VI. Conclusion.

II. PROBLEM DEFINITION

Transmission channel quality is measured by SNR and BER. Greater the ratio of SNR, easier it is to identify and subsequently isolate and eliminate the source of noise. A SNR of zero indicates that the desired signal is virtually indistinguishable from the unwanted noise. In digital transmission, BER is the percentage of bits with errors divided by the total number of bits that have been transmitted, received or processed over a given time period. The rate is typically expressed as 10 to the negative power. For example, four erroneous bits out of 100,000 bits transmitted would be expressed as 4 x 10-5, or the expression 3 x 10-6 would indicate that three bits were in error out of 1,000,000 transmitted. BER is the digital equivalent to signal-to-noise ratio in an analog system.

BER = (1/SNR)^K
Where k is a specific subcarrier index

Transmission of a signal through a channel with zero error is obtained only if its SNR and BER are known. During transmission if these parameters are known then the effect of the noise can be reduced by varying power of the input signal before transmitting the signal or by increasing the received signal at receiver before processing the signal. To vary the power we should know the incremental value of power which reduces the noise effect to an acceptable range. To obtain incremental algorithms are developed. One algorithm is for obtaining SNR of an analog signal and other for BER in digital communication with QAM technique.

III. EXPLANATION

To improve system performance and throughput, adaptive bit and power allocation algorithms has to be employed.

A. Part I.

In this algorithm Gaussian noise is added to the transmitted analog signal and SNR of this noisy signal is estimated. MSE of the signal is also calculated. For a constant incremental increase in the power corresponding SNRs are estimated and plotted. With the same increase in the incremental power corresponding MSE is calculated and plotted. It is observed that by increasing power to an extent noise effect can be reduced to nearly negligible. A linear increase in SNR was observed for same incremental.

B.. Part II.

Considering a channel with fixed SNR and random digital input signal BER is obtained. Power is increased by incremental value of 0.01 up to 0.1db and corresponding BER is calculated for all M array defined. Plot of BER v/s Marray value for different all incremental power shows that as power increases BER decreases and reaches 0.01 earlier for lower values of M. Decrease in BER is proportional to the value of M.

IV. ALGORITHMS

A) Algorithm for Estimation of SNR for different incremental Power and plot for variable power v/s MSE and SNR.

1. Initialization of i/p signal
    a. Frequency of i/p signal -- F
    b. Sampling frequency-- Fs
    c. Define i/p signal & PLOT X=Acos(2*pi*F*t)
2. Add Gaussian noise to the signal
3. Plot both input and noisy signal on a single graph.
4. Calculate the signal power
   sigPower = sum(abs(x).^2)/length(x)
   sigPower = 10*log10(sigPower).
5. Estimate the SNR of channel
   E_SNR= Estimate_SNR(x,input_SNR,Fs,0);
6. Calculate MSE
7. Increment power
8. Estimate the SNR of channel for incremented power by calling Estimate_SNR function
   E_SNR=Estimate_SNR(x,input_SNR,Fs,Inc_power);
9. Obtain Improved data with Inc_power
10. Plot graph for
    a) variable power v/s MSE
    b) variable power v/s improved SNR.

B) Algorithm for Estimate_SNR Function:*A function called in main algorithm to findSNR.*

1. Select input signal (x) and choose the SNR value and pass it through the Gaussian channel.
2. Receive the noisy signal (y)
3. Noise (n) = x-y
4. Find the number (n) of elements in input signal (x).
5. Define Welch power spectral density functions
6. Obtain the PSD objects by using the Welch power Spectral density functions for the input signal and Noisy signal (n). Here PSD objects represent
    a. Spectrum Type — 'one-sided' or 'two sided'
    b. Normalized Frequency — normalizes frequency between 0 and 1
    c. Fs — sampling frequency in Hz
    d. NFFT — number of FFT points
    e. Center DC — shifts data and frequencies to the center DC component
    f. Freq Points— 'All' or 'User Defined'
    g. Frequency Vector – frequencies at which spectrum has to be computed.
7. By using the PSD objects calculate the PSD of input signal (x) and noisy signal (n).
8. From PSD obtain the average powers Signal power (Px) and Noise power (Pn) noisy signals respectively.
9. The find the ratio SNR = Pin/Pn. So SNR is estimated.

C. Algorithm for BER estimation algorithm and comparision with M values for incremental power:

1. Initialize incremental power and fixed BER value as (BER-fix=0.01).
2. Define the incremental power array
   Inc_power1 = linspace(0,0.3,30)
3. Define data (random)
4. Define the fixed SNR
   SNR-fix = 15
5. Increment the incremental power.
6. define the M array values
   Marray = [256 128 64 32 16 8 4 2]
7. Define communication model with QAM for different of M-array.
8. Define number of symbols
9. Convert dat into symbols
10. Modulate the signal(by calling modulate function)
11. Calculate signal power
12. Apply Gaussian noise
13. Demodulate(by calling demodulate function)
14. Calculate BER(BER_{CAL}) for all M values.
15. Compare calculated BER and fixed BER .
16. Repeat 2 to 15 until BER-fix is equal to $BER_{CAL.}$.
17. Plot graph of Marray v/s BER for different values of incremental power.

V. SIMULATION RESULTS

Simulation was done for radio frequency(20hz) signal with SNR 10dB as noise model threshold and 15dB for average acceptable, as from Table.1[7], with respect to random data values. From this table noise is always observed to be around 10db.

Category	Decile	Variation with time (dB)	Variation with location (dB)
City	Upper	11.0	8.4
	Lower	6.7	8.4
Residential	Upper	10.6	5.8
	Lower	5.3	5.8
Rural	Upper	9.2	6.8
	Lower	4.6	6.8

Table 1[7]: Values of decibel deviations of man –made noise

There by the simulation of the algorithms are considered with reference to 10db noise.

A.. Initial values and simulation results for Part 1:

```
%% Parameters
% Define Input Signal Frequency
f = 10;
% Define the sampling rate
Ts = 0.001;
 % define the sampling frequency
Fs = 1/Ts;
 % Define the time duration
t = 0:Ts:1;
 % define the input signal
x = cos(2*pi*f*t);
 % Actual SNR
input_SNR = -10;
```

During simulation it was observed that the received noise signal was improved with increase in power.

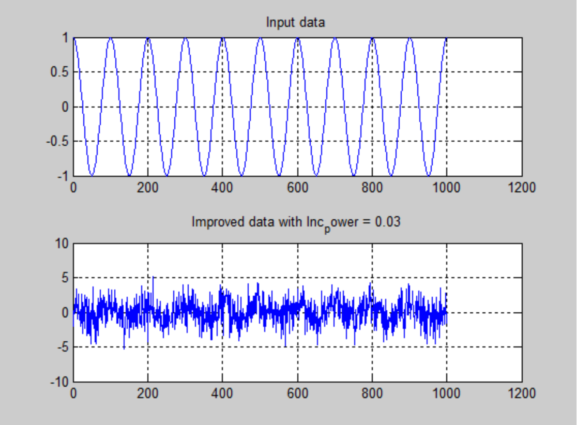

Fig 1: Input signal and improved data with incremented power of 0.03

Fig 1 shows the input signal and the noise signal with 0.03db increment in power. Fig 2 shows the output with the effect of 0.5db power increment which is exactly equal to the input signal.

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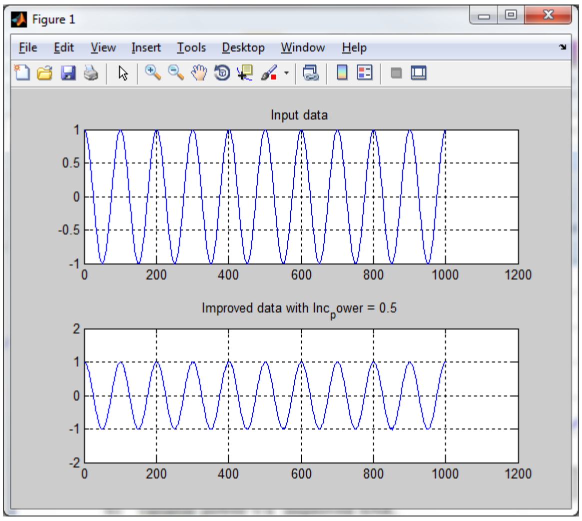

Fig 2: Input signal and improved data with incremented power of 0.5db.

An exponential decrease in mean square error (MSE) is observed in fig 3, as the power increases initially. At 0.2db increase in power MSE is approaching nearly zero

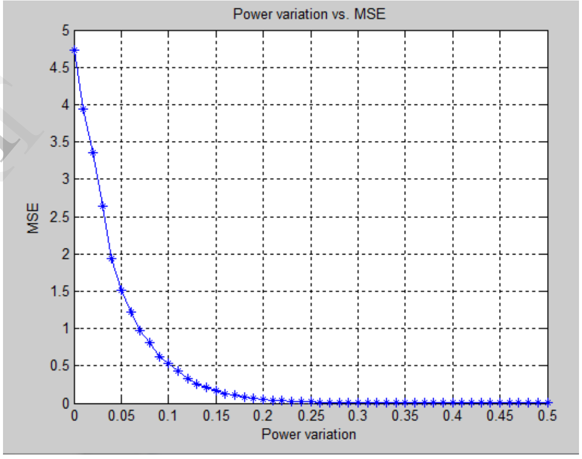

Fig 3: Plot of power variation v/s MSE.

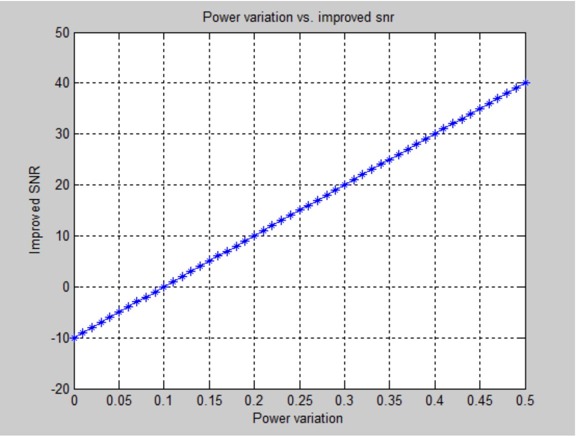

Fig 4: Plot of power variation v/s improved SNR.

Simultaneous increase is observed in fig 4 for the same power variation. Comparing both the plots the incremental power for the signal can be decided with respected acceptable noise in the channel.

B. Initial values and simulation results for Part II:

```
% fix the bit error rate
BER_fix =0.01;
% define the incremental power array
Inc_power1 = linspace(0,0.3,30);
% define the dictionary of colors
% rand('twister',1234);
colors = rand(length(Inc_power1),3);
% define the data
bits = round(rand(1,1024*150));
% Define the fixed SNR
SNR = 15;
% define the empty array for legends
Leg = [];
```

Simulation of second algorithm made easy to analyze the power increment required for different values of M and acceptable BER.

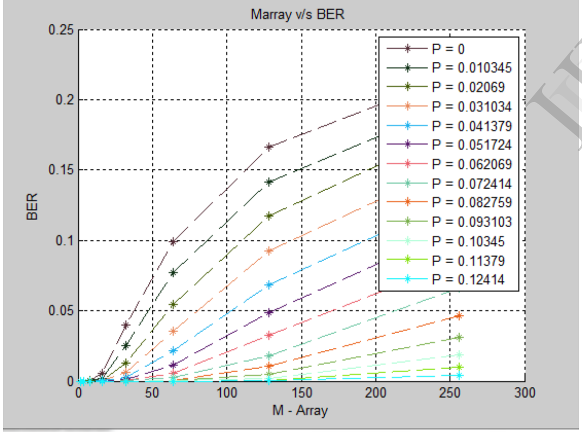

Fig 5: Plot of M-array v/s BER for different values of incremental power.

Fig 5 shows the comparison of BER for all M values with incremental power values with maximum power of 0.1db, which can be fixed according to requirement.

CONCLUSION

In this paper we have developed algorithms which are used to estimate SNR and BER of the channels. These noise effecting parameters are improved by varying power of the signal. From fig 3 and 4 it is observed that at the incremental value of 0.2 db, MES is negligible and SNR is 10db[9] which are acceptable values in wireless channel. By using this algorithm we can justify the required increment in the power of the signal which has to be transmitted. The same incrementing can also implement on the received signal before further process at receiver.

The required increment of power with effect of BER can be obtained by observing fig 5 of BER v/s Marry. By implementing the algorithms in the systems noise effect can reduce and there by throughput can be increased.

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